Habitat Creation and Management for Pollinators

Marek Nowakowski and Richard Pywell

Wildlife Farming Company
- Proven Wildlife Delivery -

CEH Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

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Insect pollinators are vital for supporting food production and biodiversity, but they face an ever growing range of pressures from habitat loss to pesticides and diseases. In response to these concerns the Government recently launched the National Pollinator Strategy[1] which outlined a 10-year plan of action to help pollinators survive and thrive in our countryside and cities. In particular, the Strategy calls on farmers and land managers to adopt its Call to Action[2] by increasing food resources, shelter and nest sites for pollinators in the countryside. To these challenges we should also add the importance of creating good quality habitats in order to maximise the potential benefits to pollinators. However, in order to achieve all this farmers will need clear and practical guidance, underpinned by high quality research.

I am therefore delighted to introduce this timely book on the creation and management of habitat for pollinators. As a fruit farmer I understand the importance of crop pollination, and I feel a particular affinity to this work given that some of the field trials were conducted on my own Estate at Blackmoor, Hampshire (pictured on the cover). This guide shows the clear benefits of practitioners working closely with research scientists to develop workable and tested solutions to a pressing need. It provides farmers with all they need to know about management for pollinators; from the basic facts about bee biology; the importance of season long flower resources; and then how, when and where to create different habitats to provide food, shelter and nesting. By working together, with the help of this guide, we can hopefully take these simple actions to improve the environment and see pollinators once again thrive in the countryside.

John Selborne

(The Earl of Selborne GBE FRS)

[1] www.gov.uk/government/publications/national-pollinator-strategy-for-bees-and-other-pollinators-in-england

[2] www.beesneeds.org.uk

This book is the distillation of a 20 year research partnership between Marek Nowakowski - a practitioner with a passion for wildlife conservation on farmland - and applied ecologists working for the Centre for Ecology & Hydrology. By bringing together practical skills with an in depth understanding of pollinator ecology, we hope to provide farmers with the best available advice on creating and managing habitats for bees on farmland.

In order to produce seed and fruit many plants, including crops, depend on insects to transfer pollen between flowers. Maintaining enough insect pollinators is therefore vital to ensure a diverse food supply and for biodiversity. Insect pollinators include honeybees, bumblebees, solitary bees, hoverflies, beetles, butterflies and moths. In this book we focus on bees because of their importance for pollination worldwide and our increasing awareness of their decline. However, many of the habitats and management techniques we describe are equally beneficial to other insect pollinators.

This book begins by describing the basic differences in biology between honeybees, bumblebees and solitary bees, and then outlines the key stages of their life cycles in terms of mating, nesting habitat and food resources (flowers).

In chapter two we provide details of the widespread plant species that provide food resources for bees in the countryside and describe the different types of seed mixes farmers can sow to create pollinator habitat.

In chapter three we provide guidance as to where on the farm to create pollinator habitat and how much will be required. We then describe the practicalities of when and how to sow pollinator seed mixes, and how to manage the problems of excessive soil fertility and weed pressure associated with farmland. We then go on to discuss how to fund wildlife habitat creation within a commercial farm business. At the end of the book we provide details of the scientific research and field trials that underpin this wealth of practical advice.

We hope you find this an informative and useful practical guide for conserving insect pollinators.

Photo - Lucy Hulmes, CEH

About the authors

Marek Nowakowski

Over 30 years practical experience of creating wildlife habitats.

From childhood Marek has had a passion for both wildlife and farming. Since 1970 he has worked in agriculture as a research scientist and agronomist. In 1998 he helped set up the Wildlife Farming Company dedicated to improving farmland habitats through research, practical experience and training. During his career he has worked with Government, research, policy and commercial organisations. He has demonstrated that wildlife can co-exist with modern, profitable agriculture and has communicated this widely on both television and radio.

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Richard Pywell

Photos - Heather Lowther, CEH

Richard leads research into sustainable land management at the Centre for Ecology & Hydrology (CEH) (www.ceh.ac.uk). He has over 20 years research experience in the restoration and management of habitats for wildlife conservation, with a particular focus on farmland. He has worked closely with Marek Nowakowski on many projects commissioned by Government departments to provide practical and scientific evidence for agri-environmental policies. In doing this he has also established strong collaborative links with university departments and the farming industry.

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Writing this book has been made possible thanks to long standing working relationships with farmers, practitioners, industry, policy makers, natural historians and scientists going back over 30 years. The combined skills of this diverse team have informed and advanced many aspects of wildlife habitat delivery on UK farmland.

From the farming community I am particularly grateful to Andrew and Anne Hichens who hosted the first field trials in the 1980s; Richard Brown who started what became the Wildlife Farming Company and William Wolmer who has supported much of our recent research on pollinators. We are also indebted to Andrew and Jane Ingram; Robin and Sue Faccenda; and staff at the Hillesden, Waddesdon and Upton estates who have supported long-term research and farmer training over many years.

I am grateful to many individuals and organisations from the farming industry for supporting environmental research and training, in particular Dr Jon Marshall (Marshall Agroecology), Geoff Coates and Belinda Bailey (Syngenta); David Langton and Claire Bend (AGRII); Simon Ward (Increment); Richard Brown (Emorsgate Seeds) and Ian Wilkinson (Cotswold Seeds). Our very great thanks also to Mike Green and Keith Porter (Natural England); Richard Brand-Hardy (Defra); Ken Slater and Bill Meek.

Special thanks to Mike Edwards for his technical input and fieldcraft relating to bee ecology, and David Bellamy for his continued encouragement - without his inspiration this book would not have been written.

Finally, thanks to Heather Lowther at CEH for her patience and skill in designing this book. The following kindly gave their permission to use their excellent images: Chris Shields; Tony Hopkins; Brigit Strawbridge; Mike Edwards; Emorsgate Seeds; Lucy Hulmes and Heather Lowther. Plant illustrations are reproduced with kind permission from the Philip's Guide to Wild Flowers of Britain and Northern Ireland, Bob Gibbons and Peter Brough, 2008 and the Philip's Guide to Trees of Britain and Europe, C.J. Humphries, J.R. Press, D.A. Sutton, 2006.

I have been fortunate enough to be an enthusiastic member of this 'team' and hope this book will provide insights into the fascinating world of pollinators and show how we can balance profitable farming with practical conservation.

Marek Nowakowski
Wildlife Farming Company

Illustration courtesy of Chris Shields. www.illustratedwildlife.com

FLOWERING PLANTS AND POLLINATORS

In chapter one we will first demonstrate the importance of insect pollinators to the health and stability of ecosystems[1], and their crucial role in producing our food. We will then go on to describe the different types of pollinator and their life cycle, and see how many rely on season-long supplies of pollen and nectar, which is often the limiting factor for their survival.

([1]ecosystem = a community of living organisms that interact with their environment.)

The 'pollination service'

Pollination is the means by which pollen is transferred from the male part (anther) of the flowering plant to the female part (stigma), thereby enabling fertilisation, and the production of seed and fruit. It is reckoned that 87% of wild plant species (and about 70% of our fruit, vegetables and crops) rely on insects and other animals for pollination. Indeed, it has been estimated that insect pollination contributes £630 million per year to the UK economy, and around £150 billion per year globally. In short, without insect pollinators our ecosystems would lose many of their flowering plants and simply cease to function, worse still there would be serious shortages of food.

Photo - Shutterstock

Pollinators in decline?

It is widely acknowledged that over the 20th Century the diversity of insect pollinators has declined in many areas of the British countryside, with several species now extinct.

There is considerable debate as to the causes of this decline. However, most commentators would agree that pollinators are under serious threat from a number of environmental pressures, acting either singly or in combination. These include habitat loss, increased pesticide use, pests and diseases, and a more extreme climate.

Since the Second World War government policy encouraged farmers to produce more food. Farmers successfully achieved this despite the rising cost of production, but wildlife often became a casualty due to the specialisation and intensification of agriculture. One of the aims of this book is to help farmers counter the effects of habitat loss on pollinators by creating high quality wildlife habitats on their farms with the skills and expertise they already have.

THE POLLINATORS

Although flowers seem to be visited by a great diversity of insects, the majority of pollinators are derived from only four insect orders: the bees and wasps *(Hymenoptera)*, the flies *(Diptera)*, the butterflies and moths *(Lepidoptera)*, and the beetles *(Coleoptera)*. Bees are easily the most important of these in terms of pollination.

Bees may be solitary or live together in colonies (social bees). Each bee species has a slightly different arrangement but basically honeybees and bumblebees have a society dominated by the queen. The workers, which are unfertilised females, perform most of the nest duties, regulating the nest temperature, foraging for food and protecting the colony. The males contribute little except for mating. Solitary bees have a different system in that males mate with females and die soon afterwards, leaving nest building, egg laying and provisioning solely to the females.

Photo - Richard Pywell, CEH

The table below summarises the characteristics of the **main pollinators** in the UK.

	Honeybees	Bumblebees	Solitary Bees
Scale 1:1			
No. of species	1	26	200+
Most common	1	7	20-30
Body size	12 mm	10-25 mm generally rounder and hairier than honey/ solitary bees	5-15 mm tend to be smaller and a little hairier than honeybees
Colony size	15,000	50-400	Solitary but can be found living close to each other
Queen	Yes	Yes Active spring and mid-late summer	No[1]
Workers (Unmated female)	Yes	Yes	No[1]
Mating season	April-June	May - September (Species dependent)	On emergence March - October (Species dependent)
Lifespan[2]	Queen: up to 2 years Worker: 4 to 6 weeks Male: up to 8 weeks	Queen: 1 year Worker: 5 to 6 weeks Male: dies 2 to 3 weeks after mating	Both sexes emerge at the same time. Females: live 4 to 8 weeks Males: die after mating
Food	Generalist	Different bumblebees use different plants	Different solitary bees use different plants
Carry pollen	Ball of wetted pollen carried on hind legs in pollen baskets	Ball of wetted pollen carried on hind legs in pollen baskets	Female solitaries are the only bees that carry dry pollen on their hind legs or on their abdomens

Illustrations courtesy of Chris Shields. www.illustratedwildlife.com

[1] Except for social Halictid mining bees. [2] Average lifespans. Note: Longevity of bees varies greatly depending on factors such as weather conditions.

The Life Cycle of bees

When considering the life cycle of bees it is useful to think of three fundamental requirements:

- A **MATE**.
- **HOME**. Nesting habitat.
- **FOOD**. Flower resources.

Honeybees and bumblebees have workers which are unfertilised females. Individual workers have a life span of approximately four to six weeks but are constantly replaced by new workers. This is not the case for most solitary bees which generally have no queens or workers, just males and females. These females live for four to eight weeks during which time they have to find a nest, mate, lay eggs, provision the eggs with pollen for the larvae. When the nest chambers are full and sealed her job is done. This means that it is imperative she finds pollen and nectar in her short life span or all is lost.

Mating

Mating takes place once in the life of a queen honeybee or bumblebee, and also once in the life of a female solitary bee. In all cases the sperm is stored by the females in a sperm sac.

Honeybees

Honeybees are distinguished from other bees as they are the only truly domesticated bee that produces honey, a valuable food source. The honeybee life cycle begins with a queen establishing a colonial nest or colony. After only one mating flight a queen can store enough sperm cells to enable her to lay eggs throughout her entire life. The queen dominates the hive and is essentially an 'egg-laying machine', producing female bees, or 'workers', from fertilised eggs. These worker bees live for around six weeks before they die and are replaced by new workers. Later in the season she lays unfertilised eggs that hatch into males. These go on to fertilise specially-fed females that become new queens. These new queens take over the colony and the old queen leaves to set up a new one. Honeybees are the only bees to overwinter as a colony, so producing an unbroken chain of occupancy.

Photos - Marek Nowakowski

Bumblebees

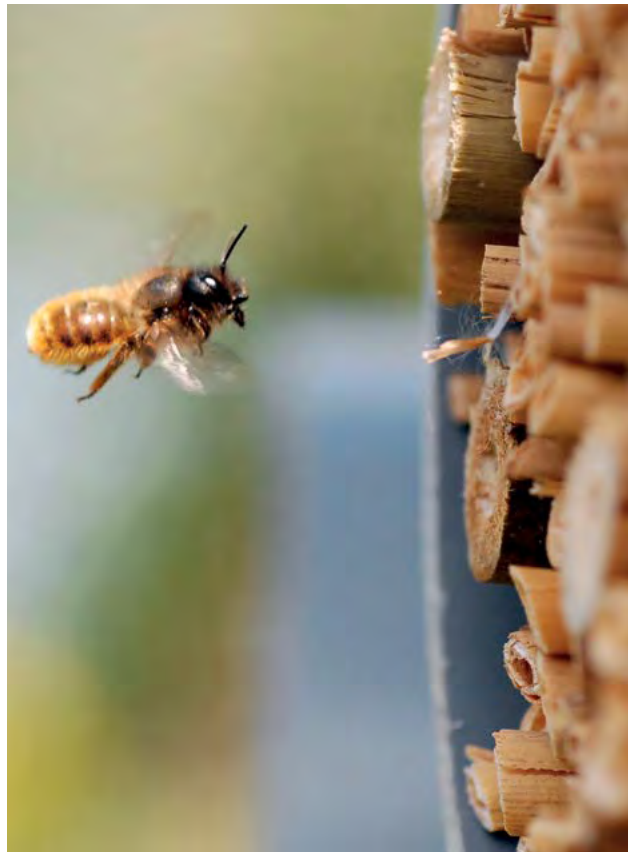
Bumblebees become active when the weather warms up in about mid-March. At this time new queens emerge from hibernation and begin new colonies by producing female workers, each also with about a six week life span. Males are produced in late summer, and these mate with new queens which then go into hibernation. The old queen, all workers and males die in the autumn. The new queen overwinters and emerges the following spring to begin the cycle again.

Unlike honeybees, queen bumblebees store only enough food reserves of nectar and pollen for a few days. It is therefore essential that there is an unbroken food supply from March to September.

Photos - Lucy Hulmes, CEH

Solitary bees

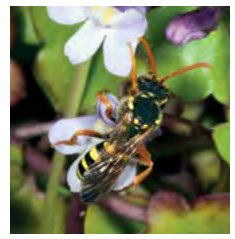
As their name implies, solitary bees generally have a more simple breeding system. There is no need for a queen[1], as the individual females do all that is necessary to secure the next generation. Males and females hatch at the same time; the males mate immediately with the females and die shortly afterwards.



Cuckoo bees

Bumblebees and solitary bees have their accompanying 'cuckoo-like' parasites. They generally look very similar to their host bee (see pictures below), but they have lost the ability to collect pollen and rear their own young, hence they do not need to produce workers, just males and females.

The female cuckoo bee infiltrates the nest of her host, either killing or overpowering the resident queen. She then coerces the workers to rear her brood. Ironically, the presence of cuckoo bees is a good sign, as they do not thrive in areas sparsely populated with their host bees.

	Honeybee	Bumblebees	Solitary Bees	
Bees		 *Bombus terrestris*	 *Lasioglossum*	 *Adrena nigroaenea*
Their cuckoo	No cuckoo	 *Bombus vestalis* cuckoo of *Bombus terrestris*	 *Sphecodes* female cuckoo of *Lasioglossum*	 *Nomada goodeniana* cuckoo of *Adrena nigroaenea*

Illustrations courtesy of Chris Shields. www.illustratedwildlife.com Photos - Mike Edwards

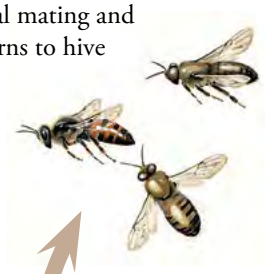
[1] Except for social Halictid mining bees.

Life Cycles of Bees

Honeybee life cycle

Perennial colony

New queen leaves for aerial mating and returns to hive



Old queen leaves hive to swarm

Queen on larval comb

Workers foraging

Solitary bee life cycle

Annual, with one or sometimes two generations a year

Pupae, in cavity nest of leaf cutter bee

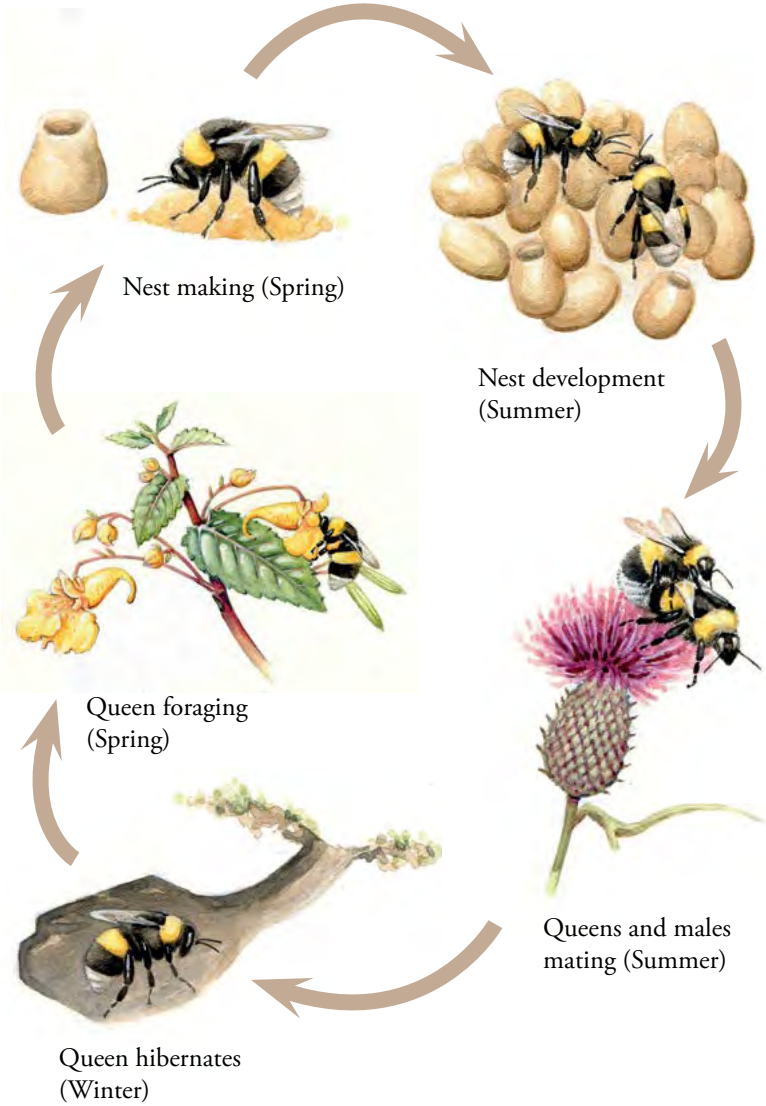
Mining bee burrow

Female foraging Spring or Summer

Male and female mating

Bumblebee life cycle

Annual, with one or two generations a year



Illustrations courtesy of Tony Hopkins

Nesting habitat (a home)

Honeybees usually set up their colonies in man-made hives, but feral bees can use cavities in trees or buildings. Honeybees' ability to use hives means they can easily be managed and moved round as domesticated pollinators, making them an easier insect to farm.

Bumblebees can be split into two groups:

- Those which weave or 'card' a nest of grass, moss and animal hairs on the soil surface in short, open, and warm grassland. These are called 'carder' bees such as the Common Carder-bee (*Bombus pascuorum)*, or its rarer cousins the Red-shanked Carder-bee (*B. ruderarius*), Large Carder-bee (*B. muscorum*), Shrill Carder-bee (*B. sylvarum*), and the Brown-banded Carder-bee (*B. humilis*).

- Other species, like the commonly seen Buff-tailed Bumblebee (*Bombus terrestris*), nest below ground in small mammal holes, generally found in tall, tussocky grass in warm sunny locations.

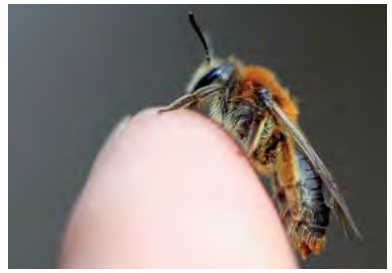
Unusual nests. The recently arrived Tree Bumblebee (*Bombus hypnorum*,) typically nests in tree holes, but will utilise spaces such as roof eaves, nest boxes and even a metal gate post!

Illustration courtesy of Chris Shields. www.illustratedwildlife.com . Photos - Heather Louther, CEH (left) and Marek Nowakowski

Solitary bees. This diverse group of bees can be split into **mining bees** (which make holes in the ground or walls), and **leaf cutter** and **mason** bees. The latter two of which use leaves and mud, respectively, to construct nests within existing cavities, such as plant stems.

Mining bees

Make holes in bare ground or very short, gappy grass. Example:



Andrena haemorrhoa

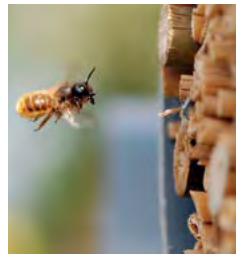
April to August. Signs of nesting.

Leaf cutters and mason bees

Use tubes, plant stems or masonry.

Example:

Megachile ligniseca



Osmia bicornis (rufa)

July. Inside some test tubes of *Osmia bicornis (Red Mason bee)*.

Illustration courtesy of Chris Shields. www.illustratedwildlife.com . Photos - Brigit Strawbridge, Mike Edwards, Lucy Hulmes and Marek Nowakowski

Flower resources (food)

> “Habitats need to provide an unbroken supply of pollen and nectar from March to September – the main period of activity for pollinators”

Bees must visit flowering plants to gather two vitally important food resources:

- **sugar-rich nectar** (used to provide energy for flying);
- **protein-rich pollen** (used by females to develop ovaries and feed their young).

Bumblebees and honeybees collect pollen and take it back to their colonies to feed their larvae. Solitary bees place dry pollen next to each egg to be eaten after hatching so there is no contact between the adult and the larva. In return for providing these rewards, the flower is often cross fertilised by the bee, enabling seed production. This is the basis of a mutually beneficial relationship between bees and flowers that began evolving over 100 million years ago.

Several interacting factors determine which flowers are preferentially visited by different bee species. These include bee tongue length, body size and shape, coupled with flower shape and colour, and the nutritional rewards on offer. You will see that the shapes of many flowers favour certain pollinator groups.

Photo - Shutterstock

Bees and their tongues

Bees’ tongues can vary greatly in size and have been formed into a tube for sucking up nectar, a bit like drinking through a straw. The Garden Bumblebee (*Bombus hortorum*, pictured right) has a tongue length (15mm) that is ¾ of its body length. This allows them to feed on flowers with a long flower tube (corolla), such as Red Clover. At the other end of the scale some of the mining bees (e.g. *Andrena* sp, pictured below) have a tongue length of 4 to 5mm. This enables them and flies (which have more of a pad than a tongue) to feed on open flowers, such as Daisies and Cow Parsley.

Photos - Top: Lucy Hulmes, CEH. Below: Brigit Strawbridge

The way different flower shapes attract different insects can be seen in the following examples:

- The 'umbellifers' (e.g. Wild Carrot, 1) and 'composites' (Daisies, 2) are similar in that their flower heads usually form a perfect landing pad for pollinating insects. Their individual flowers are open and shallow which makes them great for insects with short tongues, such as flies and some of the smaller solitary bees that can get their rewards from the top of the flowers.

Andrena flavipes *on Wild Carrot*

Andrena dorsata *on Oxeye Daisy*

- In contrast, many of the 'legumes' (e.g. Clover, 3) have long, deep flower tubes (corollae), that can only be accessed by insects with long tongues, such as butterflies and long-tongued bees.

Bombus hortorum *on Red Clover*

- However, some of the smaller bees are able to climb right inside different flowers and this scampering about within the flower can also result in effective pollination (eg. Red Campion, 4).

Lasioglossum *species on Red Campion*

Photos - Marek Nowakowski

How pollinators find food

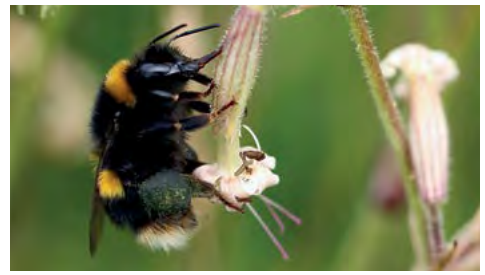
Certain characteristics of flowers, such as colour, shape, scent, nectar composition and time of blossoming, are all important in attracting insect pollinators.

Flowers pollinated by bees tend to have sweet scents whereas those pollinated by flies and beetles are fruity or musty smelling. Pollen and sucrose-dominated nectar are offered as rewards.

The visual spectrum of a bee is slightly different to that of humans in that they base their vision in ultra-violet, blue and green. Typically, bee-pollinated flowers tend to be red, yellow, blue and purple. Despite being 'red blind' bees are attracted to ultraviolet markings or 'nectar guides' on the petals of some red flowers.

Robbers and thieves. Insects can sometimes visit a plant for a drink of nectar without making contact with the anthers or stamens, which bear the pollen. In this way the bee receives the reward, but does not pollinate the plant in return. This process of robbing can become elaborate; some bees, whose tongues are not long enough to reach the reward via the 'front door', bite a hole in the base of the flower to get through to the nectar (via the 'back door'). This operation can sometimes destroy the flower's chances of setting seed. Indeed, nothing is as simple as it first seems in the fascinating world of insects!

Garden Bumblebee *(Bombus hortorum) has a long tongue so can use the 'front door' and affect pollination. Photo - Marek Nowakowski*



Buff-tailed Bumblebee *(Bombus terrestris) robbing nectar from a Nottingham Catchfly - 'back door'. Photo - Brigit Strawbridge*

Wet or dry pollen

> "How bees transport their pollen may influence how efficient they are as pollinators."

The bees collect pollen in different ways. Honeybees and bumblebees have a specially adapted pollen basket or 'corbiculum' on their hind legs for collecting pollen and returning it to the hive or nest. Pollen is cleaned from their bodies, moistened and formed into a ball and placed in the pollen basket (see pictures below, top right and top left). This cleaning and collection of pollen into a wet ball is thought to make honeybees and bumblebees less effective in transferring pollen between the male and female parts of the flower. Solitary mining bees are generally not as efficient in cleaning pollen from their bodies so they are often covered in dry pollen grains. They store dry pollen on their legs which more readily rubs off when they visit flowers. Similarly, leaf cutter bees collect dry pollen on a special pad under their abdomen which readily comes into contact with the female part of the flower (stigma) (see picture bottom right). Both strategies mean they are possibly more efficient pollinators.

Honeybee - pollen in pollen baskets
Photo - Shutterstock

Bumblebee - pollen in pollen baskets
Photo - Shutterstock

Mining bee - pollen on body and legs
Photo - Mike Edwards

Leaf cutter bee - pollen under abdomen
Photo - Brigit Strawbridge

Photo - Shutterstock

Bee Biology - key facts

- One honeybee species, 26 bumblebee species and over 200 different solitary bees.
- Honeybees are the only bees that make honey.
- Bumbles and solitary bees have their associated cuckoo bees.
- Honeybees have movable homes (hives) but wild bumbles and solitaries choose to nest in specific habitats.

Photo - Brigit Strawbridge

POLLINATION - KEY FACTS

- Insect pollinators provide a valuable 'pollination service' for certain crops estimated to be worth £630 million annually to British agriculture. They also pollinate many native and garden plants.
- Bees visit flowers for nectar (sugar for flying) and pollen (protein for their young).
- The type of flower a bee visits is controlled by factors such as colour, shape, scent.
- The length of a bee's tongue determines the ability to gain flower access.
- Solitary bees transport dry pollen on their body, possibly making them more efficient pollinators than bumblebees and honeybees.

Leafcutter bee on Ragwort

The need for season long flower resources

"In order to sustain a wide diversity of pollinators in the countryside it is vitally important to provide a range of flower resources throughout their active period – between March and September."

Intensive agriculture has resulted in the loss and degradation of large areas of wildlife habitat. For example, evidence suggests we have lost over 90% of our species-rich grasslands in the last 60 years. These provided a vitally important flower resource and nesting habitat for insect pollinators.

Wildlife conservation need not be at the expense of efficient and profitable farming, in fact a healthy and diverse environment is essential for sustainable food production. The majority of farms have areas that are low yielding or difficult to access that, with help from this book, can be profitably given over to valuable wildlife habitats.

From a practical farming point of view it helps to divide the provision of flower resources for pollinators into sections:

- **Starter.** Spring (March to end of May). Flowers at this time are vitally important for queen bumblebees founding nests and also early emerging solitary bees. Flowers are often scarce at this time and it can be a challenge to provide them – indeed this might be considered the pollinator 'hungry gap'. Most wildflowers we see at this time of year are not commercially available as seed, so value what comes for free in hedgerows and headlands and accommodate them whenever possible.
- **Main course.** Mid-summer (June to mid-August). An abundance of flowers is needed to ensure large and productive bumblebee and honeybee colonies, and successful second broods for solitary bees.
- **Dessert.** Late-summer (late-August to the end of September). Late season flowers can be easily forgotten. These are important for feeding mated queen bumblebees before Winter to increase their chances of survival to the following year.

Below and overleaf are tables of commonly found woody and herbaceous species that are attractive to bees. Both the flower colour and the period of flowering are shown as a guide. Where these species naturally occur in hedgerows, headlands and corners they should be conserved and, if possible, carefully managed to increase their abundance.

Some hedgerow species attractive to pollinators

	Early season					Mid season					
Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gorse												
Goat & Grey Willow												
Cherry Plum												
Blackthorn												
Cherry												
Apples												
Hawthorn												
Broom												
Field Maple												
Dogwood												
Blackberry												
Bryony												
Ivy												

Key: Coloured squares depict flower colour and flowering period.
Plants to the left of the dotted line provide important early season flower resources for bees.

Early season

Goat and Grey Willow

J F M A M J J A S O N D

Blackthorn

J F M A M J J A S O N D

Apples

J F M A M J J A S O N D

Cherry Plum

J F M A M J J A S O N D

Mid season

Hawthorn

J F M A M J J A S O N D

Broom

J F M A M J J A S O N D

Field Maple

J F M A M J J A S O N D

Dogwood

J F M A M J J A S O N D

Late season

Blackberry

J F M A M J J A S O N D

Bryony

J F M A M J J A S O N D

Ivy

J F M A M J J A S O N D

Gorse

J F M A M J J A S O N D

Hedgerow species illustrations reproduced with kind permission from Philip's Guide to Trees of Britain and Europe C.J. Humphries, J.R. Press, D.A. Sutton, 2006.

Some common farmland flowers attractive to pollinators - 'flowers for free'

This list contains many useful species whose seed is seldom commercially available.

	Early season					Mid season					Late season	
Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Red Deadnettle												
White Deadnettle												
Dandelion												
Coltsfoot												
Ground Ivy												
Beaked Hawks-beard												
Germander Speedwell												
Forget-me-nots												
Cow Parsley												
Garlic Mustard												
Bluebell												
Vetch species												
Hogweed												
White Clover												
Cats Ear												
Thistles												
Bristly Oxtongue												
Ragwort												
Burdock												
Angelica												
Fleabane												
Teasel												

Key: Coloured squares depict flower colour and flowering period.
Plants to the left of the dotted line provide important early season flower resources for bees.

Early season

Beaked Hawks-beard

J F M A M J J A S O N D

Red Deadnettle

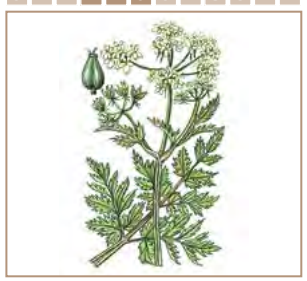
J F M A M J J A S O N D

Ground Ivy

J F M A M J J A S O N D

Cow Parsley

J F M A M J J A S O N D



Mid season

Dandelion

J F M A M J J A S O N D

Vetch

J F M A M J J A S O N D

White Clover

J F M A M J J A S O N D

Hogweed

J F M A M J J A S O N D

Late season

Teasel

J F M A M J J A S O N D

Fleabane

J F M A M J J A S O N D

Bristly Oxtongue

J F M A M J J A S O N D

Angelica

J F M A M J J A S O N D

Plant illustrations reproduced with kind permission from the Philip's Guide to Wild Flowers of Britain and Northern Ireland, Bob Gibbons and Peter Brough, 2008.

Pollinators and crops

Some field crops, fruit and vegetables provide important flower resources for insect pollinators. For example, Oil-seed Rape and Top Fruit (e.g. apples, pears, plums) provide important flower resources in Spring. The crops in the table below are, to a greater or lesser degree, reliant on insects for pollination.

Crop	Flower period	Honey -bee	Bumblebee	Smaller Mining Bees (e.g. *Lasioglossum* species)	Larger Mining Bees (e.g. *Andrena* species	Leaf-cutter/ Mason Bees	Reliance on pollinators
Oil-seed Rape	April - June	✓	✓	✓	✓	✓	Low
Field & Runner Bean	May - June	✓ [1]	✓				High
Red & White Clover	June - Aug	✓ [2]	✓	✓	✓	✓	High
Top Fruit	March - May	✓	✓	✓	✓	✓	High
Soft Fruit (bush & cane)	May - July	✓	✓	✓	✓	✓	High
Strawberry	May - July		✓ [3]	✓	✓		High
Courgette	July - Aug		✓				High
Sunflower	Aug - Sept	✓	✓	✓		✓	Medium
Raspberries	May - June [4]	✓	✓	✓	✓	✓	High
Glasshouse Tomatoes	All year		✓				High
Glasshouse Peppers	All year		✓				High
Horticultural (e.g Runner Beans)	June - Sept		✓ [5]				Variable (High to Medium)

[1] Sometimes. [2] Mostly White Clover. [3] Occasional pollinator of open field crops, important pollinator of tunnel crops. [4] Small requirement in Aug - Sept for some varieties. [5] Only larger, long-tongued Bumblebees.

FOOD SUPPLY - KEY FACTS

- Honeybee colonies can live for several years; bumblebees for three to four months and solitary bees four to eight weeks. It is therefore important to provide a continuous supply of flowers from March to September.
- Early flowers are vitally important for nest-founding bees in Springtime.
- Food is provided by some common trees and shrubs, wildflowers that survive on field edges, and certain crops.
- Habitat loss and simplification of farming systems mean that it is important to sow additional flower resources for pollinators.

Photo - Shutterstock

HABITAT CREATION FOR POLLINATORS

> "Variety and quality of pollinator habitats are more important than quantity. Simply taking land out of production is not enough, it's what you create that matters."

Based on the previous overview of the life cycle requirements of the different bee species, in chapters two and three we will provide some practical advice on the creation and management of the different habitats required to conserve insect pollinators on farmland.

We will first consider the most appropriate way of providing wildlife habitat on farmland – by either conserving existing flower-rich habitats or by sowing a seed mix. We will then focus on the characteristics and composition of seed mixes, developed over our 25 years of research and field experience, that are reliable, robust and capable of providing season long food supplies for pollinators. We will also consider how important habitats for hibernation and nesting can be easily provided.

Creating habitat by sowing or natural regeneration?

There is considerable debate as to whether we should let nature take its course and colonise naturally or introduce species as seed. There are no hard and fast rules, but here are some guiding principles to help with this decision[1]:

- Natural regeneration of wildflowers is most appropriate and likely to be successful immediately next to existing species-rich grasslands. Indeed only seed mixes collected from local meadows should be sown within 400m of grassland designated a Site of Special Scientific Interest.
- On infertile and light soils naturally regenerated habitats are likely to contain a greater range of wildflowers and fewer undesirable weeds. However, on most fertile arable land natural regeneration tends to be unreliable and rapidly becomes dominated by weeds (see picture top left opposite).
- On most farms experience suggests that the introduction of wildflower seeds is the best way to guarantee the establishment of good quality pollinator habitats.

[1] In this context, native means seed grown in the country you are sowing it in.

Three year old natural regeneration

Three year old sown wildflower mix

Photos - Richard Pywell, CEH

Sources of seeds: commercial seed mix or green hay?

There are essentially two sources of native wildflower seed available, either commercially produced seed mixes or 'green hay' collected from species-rich grassland.

Green hay is typically harvested at the time of maximum seed availability (in late June to July for species-rich hay meadows). The cut material should be collected immediately after cutting and spread onto a good recipient seed bed on the same day. This source of seed can provide some species which are not available in commercial mixes. However supply of green hay is limited depending on the proximity of remaining wildflower grasslands. This technique also requires access to specialist equipment and knowledge.

Collecting green hay immediately after cutting

Spreading green hay onto a carefully prepared seed bed using a muck spreader

Photos - Marek Nowakowski.

Seed of native wildflower species is available from a range of commercial seed merchants. These largely comprise species once found in old hay meadows and are typically purchased as mixes suited to different soils types. They have the advantage that their composition can be tailored to a specific requirement or budget. The mixes are generally expressed as a percentage by seed weight. Each type of seed can vary in size, ranging from 6,000 seeds per gram (eg Yarrow, below top) to 30 seeds per gram (eg Sainfoin, below bottom).

Yarrow seeds

Sainfoin seeds

Photos - Marek Nowakowski

Yellow Rattle, a special plant

Yellow Rattle or Hay Rattle often occurs naturally in older wildflower meadows. It is an interesting species because it is essentially a parasite on other plants, particularly grasses. This means it is able to reduce the competitive growth of grasses and maintain a more open and diverse sward – it is a bit like nature's growth regulator.

Rattle is an annual and its seed is readily spread by cutting, especially if this is delayed until July. For all these reasons it is worth including it in wildflower seed mixes, but freshly collected seed must be sown in the Autumn as Rattle rapidly loses its viability and requires Winter chilling to germinate.

On fertile soils where frequent cutting is anticipated then it might be worth delaying sowing of Yellow Rattle for a year or two as the frequent cutting in the first year will eliminate this useful annual species.

Designing a good wildflower seed mix

A good wildflower seed mix should provide a succession of flowers of different sizes, shapes and colours that will be attractive to the widest range of insect pollinators. It should also provide nesting and breeding habitat for some species, establish reliably and provide good weed control.

Brimstone butterfly on Yellow Rattle

Photos - Shutterstock

Commercially available wildflowers that are attractive to pollinators

This list will help you see flowering times and colours so you can better understand what a mix will deliver.

	Early season			Mid season			Late season	
Name	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Black Medick								
Primrose								
Cowslip								
Red Campion								
Meadow Buttercup								
Yellow Rattle								
Meadow Vetchling								
Hoary Plantain								
Common Vetch								
Wild Red Clover								
Agric Alsike Clover[1]								
Agric Red Clover[1]								
Bird's-foot Trefoil								
Cornflower								
Wild Carrot								
Oxeye Daisy								
Common Poppy								
Tufted Vetch								
Sainfoin								
Mignonette								
Kidney Vetch								
Autumn Hawkbit								
Yarrow								
Vipers Bugloss								
Common Knapweed								
Betony								
Rough Hawkbit								
Self-heal								
Hedge Woundwort								
Greater Knapweed								
Corn Marigold								
Devil's Bit Scabious								
Wild Basil								
Field Scabious								
Small Scabious								
Agrimony								
Marjoram								
Musk Mallow								

Key: Coloured squares depict flower colour and flowering period. [1] Agricultural cultivars of Clover. Plants to the left of the dotted line provide important early season flower resources for bees.

The key points in designing a good wildflower seed mix are:

- **Wildflower selection**. A good mix should be based around a core of affordable species that will reliably establish on a wide range of soil types. They should provide a variety of flower shapes, colours and flowering times, and include the following groups:

Legumes

Kidney Vetch

J F M A M J J A S O N D

Wild Red Clover

J F M A M J J A S O N D

Bird's-foot Trefoil

J F M A M J J A S O N D

Daisies

Rough Hawkbit

J F M A M J J A S O N D

Oxeye Daisy

J F M A M J J A S O N D

Common Knapweed

J F M A M J J A S O N D

Others

Wild Carrot

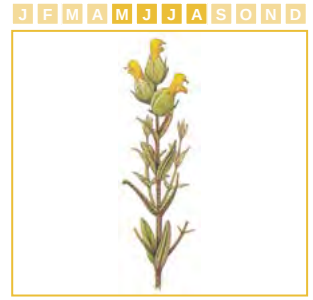
J F M A M J J A S O N D

Self-heal

J F M A M J J A S O N D

Yellow Rattle

J F M A M J J A S O N D



Plant illustrations reproduced with kind permission from the Philip's Guide to Wild Flowers of Britain and Northern Ireland, Bob Gibbons and Peter Brough, 2008.

- **Companion grasses for wildflowers**. Fine-leaved grasses should be sown to provide weed control, larval food plants for butterflies (e.g. Skippers and Browns) and reduce costs by bulking up the seed mix. Less competitive grasses are ideal, such as Chewings Red Fescue, Slender Red Fescue, Smooth-stalked Meadow Grass, Crested Dog's-Tail and Small Timothy. Avoid smothering species such as Strong Creeping Red Fescue.
- **Annuals and perennials**. Generally avoid sowing annual and perennial species in the same mix if regular mowing is needed to reduce weeds and excessive growth. Cutting will prevent the annual species from flowering so they will add little value and soon disappear. (See note on Yellow Rattle, page 32).
- **Ratio of flowers to grass**. This is dependent on soil fertility, seed bed quality, experience and expertise of the farmer in establishing wildflowers. The presence of slower growing grasses is especially important, so that a mix provides good ground cover and weed control without becoming dominated by competitive grasses. Seed ratios should not go below 90% grasses and 10% flowers or the flowers will be too few and may be swamped by grass. On challenging sites you should consider using 80% grasses and 20% flowers.
- **Sowing rate**. This should be around 20 kg/ha. On a good seed bed and with experience it is possible to reduce the rate to 15 kg/ha, but the above ratio of grasses to flower should be maintained. For example at 80% grass 20% flower sown at 20 kg/ha there are 4kg of flowers. Under ideal condition you may wish to drop the grass rate but keep the flowers at 4kg/ha.
- **Wild and agricultural cultivars of Clovers**. Wild Red Clover and Bird's-foot Trefoil tend to be longer-lived and flower for a longer period than the cheaper agricultural cultivars of these species. However, both types can be valuable if used appropriately.

The seed mixes detailed on the following pages are not definitive, but have all been used successfully on commercial farms to create a range of pollinator habitats. Many other good mixes exist, so please discuss the options with your seed merchant. Also, consult your scheme advisor and handbook if you are sowing a seed mix as part of your agri-environment agreement.

How to provide habitat for food (season long flowers)

As described in chapter one, it is vitally important to provide insect pollinators with season long flower resources. However, experience suggests there is no one approach or single seed mix that is capable of delivering these resources. Ideally farmers should sow three different mixes covering the full flowering period from March to September. As a bare minimum farmers should consider sowing TWO different seed mixes: one to deliver flowers in Spring and one in mid to late-summer. This is the same principle used in farming: no farmers would sow a single variety of wheat - they generally hedge their bets with a couple of varieties that mature at slightly different times. So why not implement the same technique with flower mixes to provide wildlife with choice and a season long food supply?

Experiment on Wildflower seed mix composition and sowing rate

Results of a field trial on four sites over four years testing how seed mix composition and sewing rate affect pollinator habitat quality. Key messages:

- As the sowing rate of grass reduced, weeds increased.
- Agricultural Red Clover dominated mixes, lasted for three years and then was replaced with thistles.
- Grass sown @ 18 kg/ha (90%) + wildflowers @ 2 kg/ha (10%) was the most affordable and consistent seed mix.
- Grass sown @ 16 kg/ha (80%) + wildflowers @ 4kg/ha (20%) was more costly, but provided far more flowers.
- Grass sown @ 10 kg/ha (83%) + wildflowers @ 2 kg/ha (17%) provided widest range of flower species, but required more cutting to manage weeds.

Photo - Marek Nowakowski. Illustration courtesy of Chris Shields. www.illustratedwildlife.com

The Starter - Early season Spring flowers (March to May)

"Flowers in Spring are vital for nest-founding bees - the 'hungry gap'. Many species have just come out of hibernation and need pollen and nectar to build up their energy reserves. Providing early season flowers is the greatest challenge faced in habitat delivery for pollinators."

Three complementary approaches should be considered:

1. **Planting early flowering trees and shrubs**

Goat (*Salix caprea*) and Grey (*Salix cinerea*) Willow provide some of the most important early season resources. The conspicuous yellow male catkins are an early spring lifeline for many pollinators. You can really appreciate this by standing next to one of these trees on a warm Spring day, and you will see and hear a number of recently emerged queen bumblebees foraging! See page 24.

Male Goat Willow. Photo - Shutterstock

Other important species include, Blackthorn, Hawthorn, Cherry Plum, Maple and Crab Apple.

Ensuring the best mix of trees on a farm is as simple as planting the right species in hedgerow gaps and no extra land is taken out of production.

2. **Encourage naturally occurring early wildflowers** – for example these early flowering species may survive in hedge bases, and on the edges of tracks and ditches, and are attractive to bees. These come for free and many can't be bought as seed. See page 26.

3. **Sow a specially designed wildflower seed mix** - seed of early flowering wildflowers is difficult to obtain, so the suggested mix opposite is something of a compromise. Nevertheless we have tried to select a number of robust and reliable wildflowers that begin flowering in April and May and will work well with the approaches suggested above. Mixes of these plants mentioned are expensive although the price can be reduced by removing some of the more costly flowers.

SEED MIX

An early wildflower mix

3.0% Kidney Vetch
2.5% Meadow Vetchling
1.8% Vipers Bugloss
1.5% Yellow Rattle
0.5% Cowslip
0.3% Wild Red Clover
0.3% Cat's Ear
0.1% Dandelion

10.0%

Grasses

40% Chewings Fescue
25% Slender Red Fescue
15% Crested Dogs-tail
10% Smooth-stalked Meadow Grass

90%

Sown at 20kg/ha.
Approx. cost[1] £560–580/ha.

[1] *Costs of seed mixes are estimates at the time of going to press. Costs will vary between seed merchants and in different years depending upon demand and the availability of seed.*

"Working together: A relatively cheap and easy way of creating early flower resources is to sow a south-facing, sheltered corner with Dandelions and Cowslip, and plant Goat or Grey Willow in the hedge."

The Main Course - Mid-summer flowers (June to mid-August)

This is the period of the year when flowering and insect activity are at a peak to ensure maximum pollination. Important mid-summer flowering resources are provided by a range of affordable and reliable wildflower species: Yarrow, Knapweed, Bird's-foot Trefoil, Oxeye Daisy, Red Clover, Musk Mallow, and Rough Hawkbit, are the backbone of reliable seed mixes.

Most commercially available wildflower species flower in mid-summer so there is a considerable choice of species that are attractive to bees and will suit most budgets. Overleaf are two examples that go from the basic to a multi-species 'Rolls Royce' mix. The latter is aimed at experienced growers sowing on the most favorable sites to deliver high quality habitat for the widest range of wildlife.

Photo - Emorsgate Seeds

SEED MIX

Mid-summer wildflower mix

Basic mix - Wildflowers

1.5% Common Knapweed
1.2% Meadow Buttercup
0.8% Common Sorrel
1.0% Bird's-foot Trefoil
0.8% Red Campion
0.8% Wild Red Clover
1.4% Self-heal
1.0% Wild Carrot
0.4% Lady's Bedstraw
0.6% Oxeye Daisy
0.5% Yarrow

10.0%

Grasses

31.5% Chewings Fescue
22.5% Slender Red Fescue
18.0% Crested Dogs-tail
18.0% Smooth Meadow Grass

90.0%

Sown at 20kg/ha.

Approx. cost £280–300/ha.

Multi-species mix - Wildflowers

0.8% Field Scabious
0.8% Meadow Cranesbill
0.8% Tufted Vetch
0.8% Meadow Vetchling
0.8% Salad Burnet
0.8% Yellow Rattle
0.5% Common Knapweed
0.5% Bird's-foot Trefoil
0.5% Musk Mallow
0.5% Meadow Buttercup
0.5% Common Sorrel
0.5% Hedge Woundwort
0.4% Red Campion
0.3% Wild Red Clover
0.3% Lady's Bedstraw
0.25% Rough Hawkbit
0.2% Self-heal
0.15% Cowslip
0.1% Oxeye Daisy
0.1% Yarrow
0.1% Hoary Plantain

10.0%

Grasses

31.5% Chewings Fescue
22.5% Slender Red Fescue
18.0% Crested Dogs-tail
18.0% Smooth Meadow Grass

90.0%

Sown at 20kg/ha.

Approx. cost £410–420/ha.

The Dessert - Late-summer flowers (late-August to end September)

Late season flowers are especially important for queen bumblebees which are building up reserves for Winter hibernation. Good Winter survival of queens is essential to ensure the next generation.

There are two practical ways of providing late season flowers:

1. **Cutting management to delay flowering**. Cutting part of a mid-summer mix in mid- or late-June can delay re-flower for five to eight weeks, and provide valuable late pollen and nectar. Delaying the next cut of these areas until the following March can provide hibernation sites for queen bumblebees, and other beneficial insects such as carabid beetles and spiders, and also provide seed for birds.
2. **Inclusion of late-flowering species in the seed mix**. Species such as Wild Carrot, Yarrow, Vipers Bugloss, Field and Devil's Bit Scabious and Meadow Cranesbill all flower in late Summer.

Mid-summer mix sown in a field corner
Photo - Lucy Hulmes, CEH

Photo - Heather Lowther, CEH

FLOWER MIXES FOR POLLINATORS - KEY FACTS

- Early season - Spring flowers are vitally important for nest-founding bees- the pollinator 'hungry gap'.
- Trees like male Goat and Grey Willow provide abundant early season flowers.
- Look after naturally occurring flowers.
- Mid-summer - abundant flowers in Summer are important for large, productive pollinator populations.
- Commercial wildflower seed mixes are good for providing mid-summer flowers.
- Late-summer - flowers in August and September are needed by new queens to ensure overwinter survival.
- Cutting half a wildflower margin or corner in early June can delay re-flowering until late-summer.

Other seed mixes

There are a number of other useful seed mixes that provide valuable habitat for pollinators around the farm.

Pollen & Nectar mixes

Pollen & Nectar mixes are simple, low cost mixes based on a few agricultural cultivars of Clover species, particularly Red Clover.

These agricultural cultivars are generally short-lived, meaning this mix only provides useful flowers for three to four years. This is in contrast to native Wildflower mixes that can last for 10 to 20 years.

Photo - Emorsgate Seeds

Nevertheless Pollen & Nectar mixes are very reliable and robust, and well suited to sites with high fertility and weed pressure. They also provide an abundance of flowers in mid-summer that are especially attractive to long-tongued bumblebees. Their short-lived nature means frequent re-establishment of this habitat is required, ideally on new sites. This habitat works particularly well if it is rotated with Wild Bird seed mixes every two to three years or so (see page 57).

The basic mix contains agricultural cultivars of Red Clover, Alsike Clover, Bird's-foot Trefoil and Sainfoin. Excluding grasses from the mix is recommended to reduce the amount of herbage produced. The disadvantage of this mix is the relatively short flowering period of the Red and Alsike Clover, mainly from mid-June to late July, and its lack of flower diversity. However, like the wildflower seed mixes, it is possible to prolong the flowering of these habitats by cutting half in late May to early June.

Our experience has shown that reducing the percentage of the Clovers down to around 25% and increasing the Bird's-foot Trefoil provides a better balance of flowering species. The addition of 2% Common Knapweed and 2% Musk Mallow will extend the flowering period later into the summer, and will also provide some life beyond year three when the Clovers have died out. Also, consider the inclusion of Crimson Clover to add a valuable early flower resource to the mix.

SEED MIX	
Other seed mixes	
Basic Pollen & Nectar mix The original agri-environment mix of agricultural cultivars[1] that only lives for three to four years. **Wildflowers** 40% Red Clover[1] 20% Alsike Clover[1] 20% Bird's-foot Trefoil[1] 20% Sainfoin[1] **100%** **No grass** **Sown at 10–12kg/ha.** **Approx. cost £80–90/ha.**	**Premium Pollen & Nectar mix** Our research has shown this mix has one of the best all round plant combinations for delivery and value. **Wildflowers** 30% Bird's-foot Trefoil[1] 26% Sainfoin[1] 15% Red Clover[1] 15% Crimson Clover[1] 10% Alsike Clover[1] 2% Common Knapweed 2% Musk Mallow **100%** **No grass** **Sown at 10–12kg/ha.** **Approx. cost £130–150/ha.**

Summary of the differences between wildflower & grass mixes and Pollen & Nectar (legume) mixes

	Wildflower & grass	Pollen & Nectar
Cost £/ha	£280-420	£80-90
Longevity	>10 years	3 to 4 years
Flowering	April to September	Mid-June to late July
Cutting	Best removed	Can be left
Habitat quality	Rich in plant species = rich in insects	Fewer plant species = fewer insects

Wild Bird seed mixes for pollinators ('Bumblebird' mix)

This low cost, annual seed mix is designed to provide both Spring and Summer flowers for pollinators, and insect and seed resources for farmland birds. It is the perfect partner for habitat rotation with the Pollen & Nectar mixes described opposite as it is robust and grows well on fertile soils.

SEED MIX
Bumblebird mix
Flowers 15% Fodder Radish 10% White Millet 10% Gold of Pleasure 10% Crimson Clover 7% Phacelia 8% Sunflower **60%** **Cereal** 20% Spring Barley 20% Spring Triticale **40%** **Sown at 40kg/ha.** **Approx. cost £65/ha.**

Photo - Marek Nowakowski

Cornfield annual mixes

Some cornfield annuals are among the rarest flowers in the UK and their wild populations require protection. The sowing of the rarer annuals, once considered as weeds, attracts some controversy as it may become difficult to distinguish between natural and introduced species. It is therefore a good idea to keep a record if plants such as Pheasant's Eye or Cornflower are sown.

Annual mixes are best suited to medium and light soils where they can be both reliable and showy, but they have to be cultivated and re-sown each year.

Some annual plants such as Crimson Clover and Cornflower, if sown in the Autumn, will flower early in the following Spring. This can help make up for the lack of flowering species at this critical time. Pictured below and opposite is an annual mix for pollinators.

SEED MIX

Annual mix for pollinators

Wild flowers

30% Crimson Clover
25% Common Vetch
20% Persian Clover
10% Phacelia
5% Borage
5% Cornflower
5% Corn Marigold

100%

No grass

Sown at 15kg/ha.

Approx. cost £210 - 230/ha.

Photo - Lucy Hulmes, CEH

Photo - Emorsgate Seeds

Enhancing resource protection buffer strips for pollinators

Protecting water resources from pollution by pesticides and fertilisers is essential for sustainable farming. This is often achieved by sowing buffer strips adjacent to ditches and streams with tall, tussocky grass species. These seed mixes are cheap and reliable, providing good weed control, and are able to tolerate challenging situations, such as north-facing, damp corners. They typically contain few flower resources for insect pollinators, but they do provide nesting and hibernation sites for bumblebees and other beneficial insects that eat crop pests, such as beetles and spiders. They are also good habitat for small mammals and Barn Owls.

The main tussocky grass species are Cocksfoot, and Tall and Meadow Fescue. These three grasses should comprise around 60% by seed weight of the basic mix. Red Fescue and Timothy are added to provide better ground cover for weed control. If they are planted on wetter soils the sowing rate of Cocksfoot should be reduced, and 2-3% Tufted Hair-Grass added. Seed of this species is quite expensive, but it tolerates wet soils. Flowers are not generally added to these buffer strips, but the inclusion of 5-10% of robust or scrambling wildflowers will significantly increase their value to insect pollinators.

Tussocky Grass
Photo - Richard Pywell, CEH

Tussocky Grass with flowers
Photo - Emorsgate Seeds

SEED MIX

Tussocky grass mix

Basic tussocky grass mix	**Tussocky grass mix enhanced for pollinators**
No wildflowers	**Wildflowers**
	3.5% Tufted Vetch
	2.2% Teasel
	2.0% Common Knapweed
	1.0% Wild Carrot
	1.0% Bird's-foot Trefoil
	0.3% Yarrow
	10.0%
Grasses	**Grasses**
30% Cocksfoot	15% Red Fescue
25% Meadow Fescue	20% Meadow Fescue
18% Red Fescue	15% Tall Fescue
15% Tall Fescue	10% Timothy
10% Timothy	30% Cocksfoot
2% Tufted Hair Grass (optional on wet soils)	**90%**
100%	
Sown at 20kg/ha.	**Sown at 20kg/ha.**
Approx. cost £85–105/ha.	**Approx. cost £360–390/ha.**

Illustration courtesy of Chris Shields. www.illustratedwildlife.com

Providing habitat for hibernation and nesting

Tall grass. This provides important sites for bumblebees and other insects to hibernate in during the Winter. It is therefore important to leave some existing areas uncut, or sow tussocky grass habitats on appropriate sites.

A typical "volcano" indicating the nest of a mining bee.

A good opportunity for bare ground mining bee nests. Photos - Marek Nowakowski

Bare ground. This is an often overlooked but essential nesting habitat for solitary mining bees due to the fact that its temperature is usually higher than ground covered by vegetation. Look out for these 'mini volcanoes' (top picture) which are the entrance holes of mining bee nests. They can be seen from April to August. The nest comprises a vertical shaft with side branches where the eggs are laid (see page 12).

Some bare soil is provided naturally on tracks and earth banks. The best sites are south-facing and sheltered spots that maximise warmth. Bare ground is not always easy to maintain and will require two or more herbicide treatments to retain its openness (though you MUST check the label regarding limitations of product use). Open, sunny field corners where the drill misses and leaves a triangle of bare ground are good places for some solitary bees to nest (bottom picture). Once created it is important to leave bare ground areas uncultivated until the following Summer or the developing young will be destroyed. If cultivation needs to take place before the following season, then avoid going deeper than 12cm so the nest chamber remains undisturbed. Finally, never attempt to create or maintain bare ground in areas vulnerable to soil erosion, for example on steep slopes or near a watercourse.

OTHER MIXES AND ADDITIONAL HABITATS - KEY FACTS

- Basic Pollen & Nectar lasts for three to four years with a relatively short season of flowering, but can be improved by additions to the mix.
- A 'Bumblebird mix' is two for the price of one, bird food and insects.
- Annual flower mixes can be eye catching and early flowering, but are not without their critics.
- Tussocky grass margins are cheap, long-lived and have a variety of uses. They are especially good for resource protection, and provide nest sites for bumblebees and small mammals. Adding a limited range of flowers can improve their value for pollinators.
- Bare ground nesting sites. These are often overlooked but essential habitats for mining bees.

Photo - Emorsgate Seeds

GROWING WILDLIFE HABITATS

> "Growing wildlife habitats is no different to growing crops - they need good management. Getting it right in the first year is the key to success."

Chapter three provides a comprehensive guide to the establishment and management of habitats for pollinators on farmland.

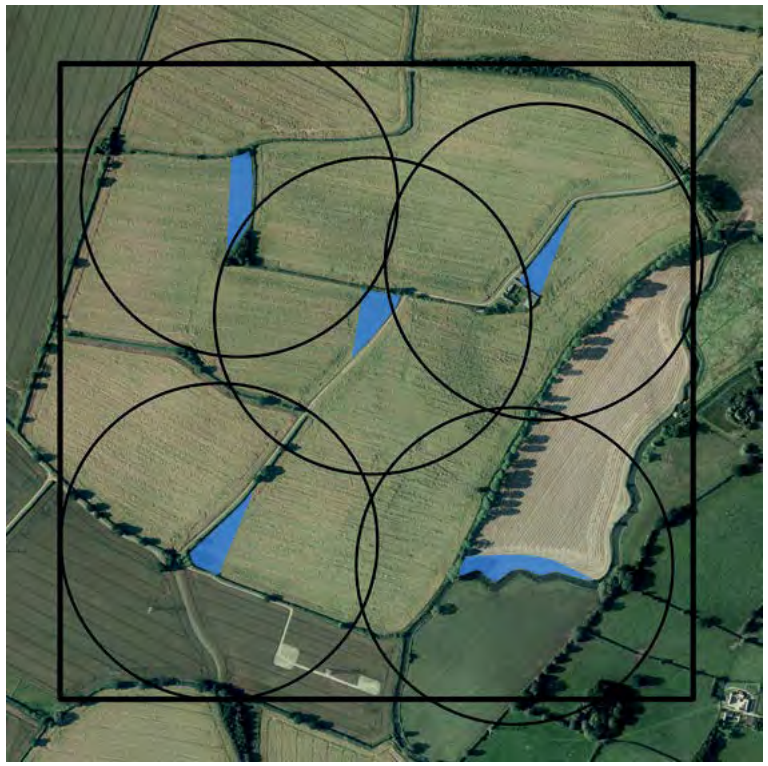
How much habitat is required?

There is no simple answer to this question as habitat requirements vary with bee species and the underlying quality of the surrounding landscape. Nevertheless a useful rule of thumb is to create five roughly evenly distributed patches of wildflowers of 0.25ha (blue in the diagram right), or 0.5ha in landscapes lacking in flowers, per 100ha.

The best available evidence suggests this should be sufficient to support pollinator populations in much of the UK countryside.

Distribution of the patches in the diagram below means that flower resources will always be within flying range of any nests of the smallest solitary bee (estimated to be 250m).

Photo - Licensed to: NERC Centre for Ecology & Hydrology for PGA, through Next Perspectives™



When to sow?

Sowing at the correct time maximizes the chances of success. Every year is different so there isn't an exact date but the following is a useful guide:

- **Autumn** (mid-July to late August) or **Spring** (mid-March to late April) are the most reliable periods for pollinator habitat establishment.
- The ground needs to have some moisture and warmth when the seed is sown.
- **Autumn sowing** is generally less demanding on heavy land as it is easier to achieve a good seed bed at this time of year.
- Lighter soils can be worked in Spring and Autumn. **Consider some Autumn and Spring sowing** as this spreads the risk and eases workload.
- To even out future workloads **do not sow all your short-lived Pollen & Nectar, and Bird Food mixes in the same year**. It is preferable to **stagger them over a couple of years**.
- Where Blackgrass is a problem, plough in late October and leave overwinter. In Spring spray off the re-growth with herbicide and sow using minimum soil disturbance.

Where to sow?

Choosing the best location for pollinator habitat is vitally important. Here are some important points to consider:

- **Rules and regulations:** any habitat management and creation must first abide by the legislation governing farm support payments. These vary between countries and are subject to change. In England, for example, it is important to consider the rules concerning Local Environment Risk Assessment for Pesticides (LERAPs)[1] and Cross Compliance[2].
- **Protection of water and soil resources:** protection of precious natural resources of soil and water is vitally important. Careful location of pollinator habitat can help achieve this aim – consider siting long-lived wildflower and tussocky grass margins against watercourses or across slopes vulnerable to soil erosion. Better still, add some robust wildflowers to the tussocky grass to increase the value for water protection AND provide pollinator food. Avoid situating annually cultivated habitats, such as Bumblebird or Annual seed mixes, near watercourses as this increases the risk of sediment run-off.

[1] *www.pesticides.gov.uk/guidance/industries/pesticides/topics/using-pesticides/spray-drift/leraps.* [2] *www.gov.uk/government/publications/cross-compliance-guidance-for-2015*

Illustration courtesy of Chris Shields. www.illustratedwildlife.com

- **Aspect and shelter:** Hedges and woodland are valuable components of our landscape. Their size and aspect can enhance shelter and warmth for pollinators or create shade. They therefore have an important influence on habitat creation. The diagram below shows the main differences in aspect. Any habitats containing flowers for pollinators are best located in sunny locations as this provides the heat insects need to forage (south and west-facing are best, followed by east-facing). In shady, north-facing locations it is advisable to sow tussocky grass habitat as this will still provide valuable hibernation sites for pollinators.

- **Utilising awkward corners and obstacles:** creation of wildlife habitats can be a good way of eliminating obstacles like telegraph poles and difficult to access field corners or wavy field edges from farming operations, making them more efficient. However, given some pollinator habitat will require regular access for management it is important not to surround them completely with crops.

Photos: Below: Shading from hedges and trees can have an important effect on the value of pollinator habitat.

Right, full page: Habitat creation in awkward areas of an intensively farmed landscape.

Main photo - Licensed to: NERC Centre for Ecology & Hydrology for PGA, through Next Perspectives™. Inset photo - Marek Nowakowski

Awkward field corners taken out of production for the creation of pollinator habitat

- **Soil fertility and weed pressure:** high soil fertility may represent a challenge for establishing wildflower seed mixes as it encourages rapid and excessive growth of weedy species. Available nitrogen drops away quite rapidly over the first two to three years after sowing. However, soils with phosphate indices >2 are likely to prove more problematic. In these situations it is worth considering sowing the more competitive seed mixes, such as Pollen & Nectar and Bumblebird. Establishing wildflower mixes is possible, but will require more frequent cutting, especially in year one. The removal of cuttings is always desirable as it helps reduce fertility and it stops the cuttings smothering the sown species.

Note on selective herbicides [1] *A small number of selective graminicides currently have label approval for application to non-crop areas such as green cover crops, fallow and field margins. As an alternative to cutting, these products offer potential to control some weed grasses selectively, that is, with safety to a limited range of sown grasses (see photo below). The selection of species for a mix may be influenced by a known weed problem and the expected effect of a given herbicide.*

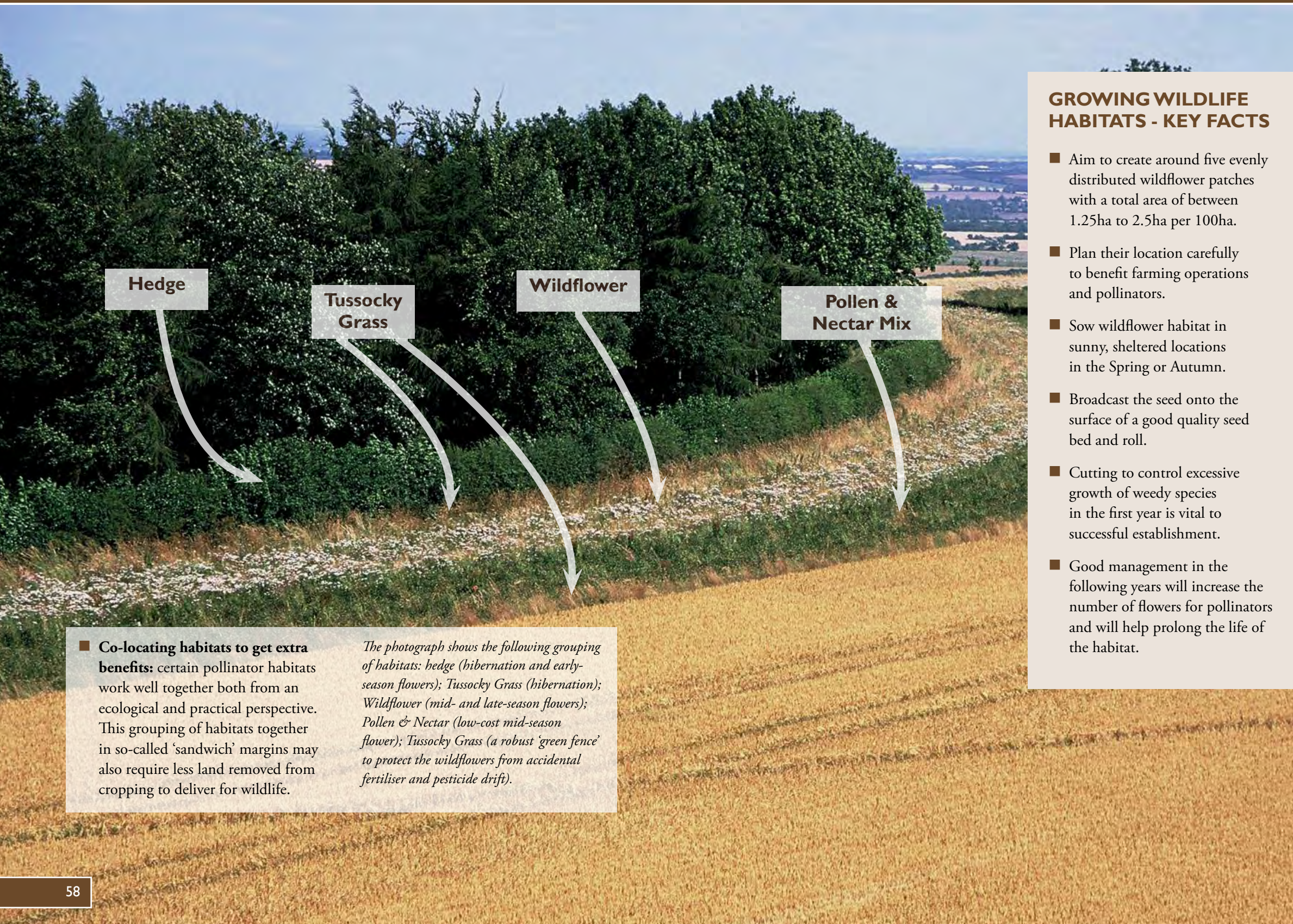
[1] Always follow the guidance specified on the pesticide product label and take professional advice on their use.

This pictures shows the effects of using a label-approved selective graminicide for removing tussocky grasses from a Pollen & Nectar margin. Photo - Richard Pywell, CEH

- **Wildlife habitat rotation to provide extra benefits:** short-lived habitats often benefit from re-establishment on 'clean' ground where weed pressure is lower. This can easily be achieved by pairing habitats with similar longevity, like Pollen & Nectar and Bumblebird or Wild Bird Seed, and rotating their location on a two to three year basis.

Swapping these habitats over mean both benefit - the Wild Bird Seed mixes will do well from the nitrogen fixed by the legumes and the weed-free seed bed; the Pollen & Nectar can be cut to eliminate the weeds that have accumulated on the former Wild Bird Seed site.

Rotate Pollen & Nectar and Wild Bird Seed every two to three years. Photos - Richard Pywell, CEH



- **Co-locating habitats to get extra benefits:** certain pollinator habitats work well together both from an ecological and practical perspective. This grouping of habitats together in so-called 'sandwich' margins may also require less land removed from cropping to deliver for wildlife.

The photograph shows the following grouping of habitats: hedge (hibernation and early-season flowers); Tussocky Grass (hibernation); Wildflower (mid- and late-season flowers); Pollen & Nectar (low-cost mid-season flower); Tussocky Grass (a robust 'green fence' to protect the wildflowers from accidental fertiliser and pesticide drift).

GROWING WILDLIFE HABITATS - KEY FACTS

- Aim to create around five evenly distributed wildflower patches with a total area of between 1.25ha to 2.5ha per 100ha.
- Plan their location carefully to benefit farming operations and pollinators.
- Sow wildflower habitat in sunny, sheltered locations in the Spring or Autumn.
- Broadcast the seed onto the surface of a good quality seed bed and roll.
- Cutting to control excessive growth of weedy species in the first year is vital to successful establishment.
- Good management in the following years will increase the number of flowers for pollinators and will help prolong the life of the habitat.

Photo - Marek Nowakowski

SOWING

Seed beds

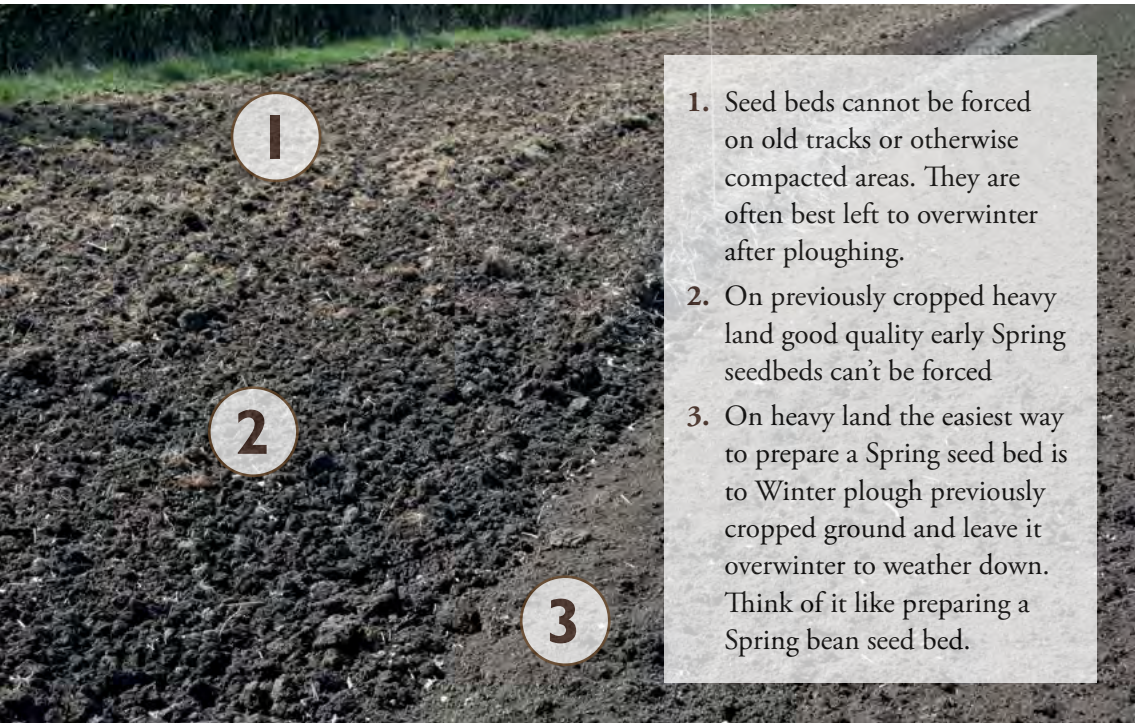
The preparation of a good quality seed bed is key to successful wildlife habitat creation.

Like any other crop a firm, fine and weed-free seed bed is required because wildflower and pollen & nectar seed is generally small.

Never try and force a poor quality Spring seed bed - it is better to wait until the following Autumn. Wildflower seed naturally falls onto the soil surface. If buried it will go dormant.

> "At sowing think of broadcasting NOT drilling."

Ring roll post-sowing in order to ensure good contact with the soil.



1. Seed beds cannot be forced on old tracks or otherwise compacted areas. They are often best left to overwinter after ploughing.
2. On previously cropped heavy land good quality early Spring seedbeds can't be forced
3. On heavy land the easiest way to prepare a Spring seed bed is to Winter plough previously cropped ground and leave it overwinter to weather down. Think of it like preparing a Spring bean seed bed.

This picture taken in the Spring illustrates facts to remember on heavy ground that needs to be Spring drilled. Photo - Marek Nowakowski.

Photo - Marek Nowakowski

NOTE ON BLACKGRASS MANAGEMENT:

- The latest advice suggests that rotational ploughing buries Blackgrass which, for a while, reduces the weed burden. The same applies to the sowing of a wildflower mix. In severe cases of Blackgrass infestation, delay ploughing until mid to late October. Overwinter the area until the Spring where sowing in April is preceded by a spray of glyphosate.
- The alternative is an August plough followed by sowing by the end of August. But be prepared to have lots of smothering Blackgrass to deal with by repeated cutting.
- In severe cases of Blackgrass infestation, try and avoid a shallow August cultivation followed by end of August sowing. Experience has shown that this is the least likely to succeed.

Managing habitat

> "Another cause of failure of wildlife habitat creation is insufficient mowing to control competition from weeds in the establishment year, especially on fertile sites."

On most arable farms cutting is the only practical means of managing pollinator habitats that comprise perennial species (Wildflower, Pollen & Nectar, Tussocky). Seed mixes comprising annuals (Bumblebird, Annual Pollinator mix) cannot be cut to control weeds in Summer.

The differences in cutting management requirements of the different pollinator habitats can be summarised as follows:

Habitat	Annual/ perennial	Cutting	Herbage
Wildflower with grass	Perennial	Cut often in yr 1 to control weeds, Apr and/or Sep thereafter.	Ideally remove[1]
Pollen & Nectar, no grass	Perennial	Cut often in yr 1 to control weeds, Apr and/or Sep thereafter.	Leave or remove
Bumblebird	Annual	Cut at end of Winter (Apr) before re-sowing.	Leave
Annual Pollinator	Annual	Sep or Apr before re-sowing.	Leave or remove
Basic Tussocky	Perennial	Once in yr 1 to control weeds. Every 3 to 5 years to prevent scrub.	Leave
Tussocky with Flowers	Perennial	Once in yr 1 to control weeds. Every 3 to 5 years to prevent scrub.	Leave

[1] Can be left if cut frequently

The establishment year

Frequent cutting of perennial seed mixes in the establishment phase is essential - you need to move the vegetation from an annual weed dominated state to a perennial state as quickly as possible.

> "As a rule of thumb when looking down at the sown species if they are obscured by weeds then cut."

In year one this can be repeated as often as necessary for these mixes. Repeated cutting generally will not kill perennial flowers (think of daisies and buttercups in your lawn!). This may mean that few flowers are produced for bees in year one, but good weed control is critically important.

Tussocky grass margins are more robust so require less management. A single cut in the establishment year will help reduce weed pressure and encourage tillering of the grass.

Sown annual species will be killed by cutting. Mowing is therefore not an option for weed control in annual mixes (Bumblebird and Annual Pollinator) so it is best to select sites with low weed pressure for these habitats and move location frequently.

The more fertile the soil the more often you need to mow. An Autumn sowing on a fertile site may need as many as four cuts in the first year.

By September most insects no longer need pollen/nectar so mowing may take place from then on. The aim is to go into Winter with a short sward height of around 10cm. However, another cut in late Autumn or early Spring may be necessary if the vegetation continues to grow through the Winter.

Ground-nesting birds. On sites where frequent cutting is required it is advisable to start mowing before ground-nesting birds begin breeding. A first cut in mid-March from the previous Autumn sowing will make pollinator habitat less attractive to ground nesting birds.

A well-established autumn sown grass and flower mix photographed the following May. Notice that plants are well-spaced with room to grow and few weeds are evident. The perfect situation with a good chance of success.
Photo - Marek Nowakowski

Management after year one

After the first year the frequency of cutting of Wildflower and Pollen & Nectar habitats will reduce as the available nitrogen declines, with one cut a year eventually becoming the norm. However, it is important to continue management in order to maximise habitat longevity and quality. In particular, cutting stops the grasses becoming dominant and helps retain an open structure so the slower growing wildflower species continue to have space to develop.

Tussocky grass requires less management. After the establishment year they may need cutting once every three to four years to stop scrub encroachment from the base of the hedge. For this reason it is often best to avoid locating tussocky grass margins adjacent to Blackthorn hedges which are very prone to suckering. When cutting these tussocky habitats, remember to keep the cut above the base of the grass tussocks so as not to destroy the valuable overwintering habitat for insects, hibernating bees and small mammals.

Rotational management - the best strategy. Cutting all habitats on a farm at the same time could instantly remove all late season flower resources for pollinators. It can also remove butterfly eggs and valuable overwintering sites. Perhaps the best strategy is to cut habitats on a rotational basis (some years Autumn cut, some years Spring cut), or consider cutting half a patch in Autumn, but leaving an uncut strip at the base of the hedge until the following Spring.

Leave or remove the cuttings?

On fertile soils it is advisable to remove the cut herbage from Wildflower mixes if at all possible because left *in situ* it can smoother the flowers. Most arable farmers do not have the equipment to remove the cut material, but they may have access to an old double chop forage harvester, or use a contractor (see picture below). Other possible options for removal include baling as hay or silage or even for anaerobic digestion. Alternatively, on very fertile sites consider sowing a Pollen & Nectar seed mix as this is more tolerant of cut material being left i*n situ*. This is because Red Clover, the dominant species, contains a high percentage of water, so their cuttings leave little by way of persistent residue.

If removal is not possible then consider topping the vegetation more frequently so that the amount of herbage returned each time is minimal until soil nutrients decline. In these situations the type of blade fitted to the topper can make an important difference. The 3Y blades (below, top) do a good clean cutting job (in warm weather a repeat cut after 10 days of wilting can render the cuttings to dust), the blunt hammer head (below, bottom), leaves a frayed finish to the grass and so does not perform as well.

Photos - Marek Nowakowski

Managing the crop and margin interface. A problem area?

The place where the pollinator habitat meets the crop is often an unmanaged gap that becomes a source of weed ingress into both. The picture below shows a good wildflower field margin. However, Brome and Blackgrass are encroaching from the margin and crop interface.

"I used to have a weed problem between the hedge and the crop… now I have a margin the problem has moved between the margin and the crop!"

In many cases the margin and the crop do not quite meet, resulting in a narrow strip of bare ground which becomes filled with annual weeds (see picture below). The main cause of this is that when the crop is drilled next to a field margin the drill wheel runs down the edge of the margin. This means that the first drill coulter is a few centimeters from the edge of the wildlife habitat, thereby leaving an unsown strip. Also, when applying fertiliser or herbicide, the operator tries to avoid drift onto the habitat so the gap tends to be unmanaged 'no man's land' providing an ideal site for weeds.

A simple solution is to run the drill wheel for the crop just on the wildlife habitat so the first coulter now meets the margin edge, thereby closing the gap. This generally solves the problem as the bare ground has now been filled.

Photo - Richard Pywell, CEH

Protecting pollinator habitat from fertiliser and pesticide drift

Once we have created good quality pollinator habitats it is vitally important to protect them from the damaging effects of fertiliser and pesticide drift. Indeed such damage to an agri-environment habitat can result in a hefty fine.

As well as a good operating procedure and the appropriate equipment to minimize the chance of drift, there are several practical tips to increase the level of protection:

- Consider sowing the margin slightly wider than needed in order to create an extra area of leeway.
- Create a sterile strip between the margin and the crop.

A wider buffer strip would reduce the risk of pesticide and fertiliser drift to this watercourse. Photo - Shutterstock

- Some go the extra mile and sow a narrow Tussocky Grass strip (a 'green fence') on the outside of the margin adjacent to the crop (see picture below).

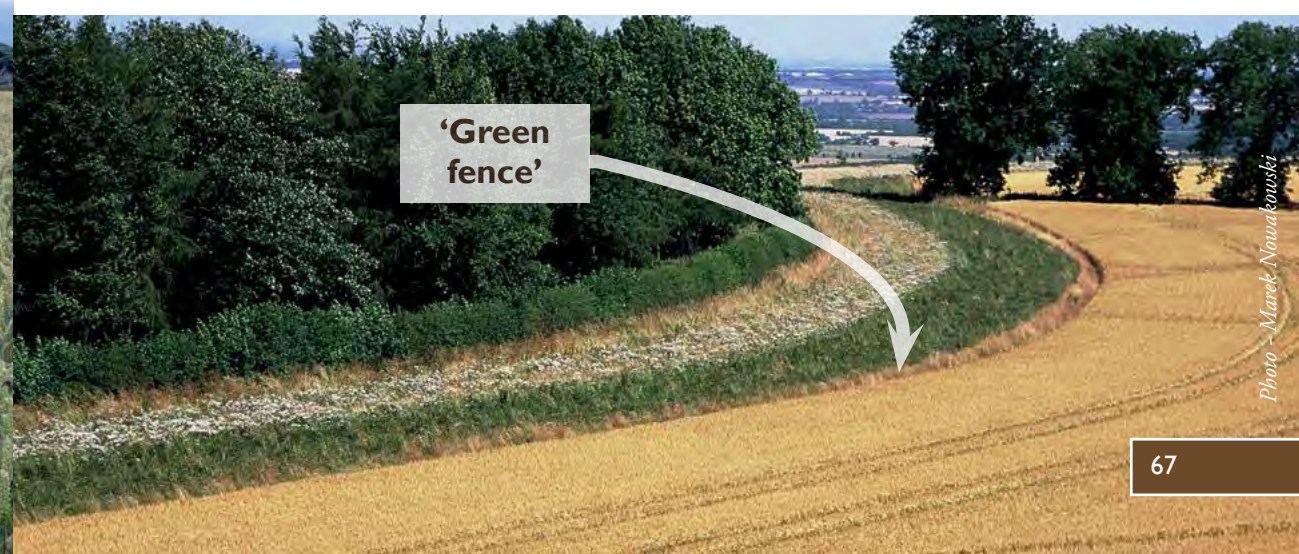


Photo - Marek Nowakowski

SOME CONCLUDING POINTS

We hope you have found this book useful and that it will help you create high quality habitats for insect pollinators on your farm. Below are some key points to remember:

- Bees and other insects provide a vitally important '**POLLINATION SERVICE**' to wildflowers and crops.
- Pollinators require **FOOD**, **HOME** and a **MATE.**
- Spring flowers (March to May) are vitally important for nest-founding bees – the pollinator 'hungry gap'.
- Conserve existing flower resources on your farm.
- Maintain or create some bare ground in sunny, dry locations for solitary mining bees to nest in.
- Leave some tall grass over Winter for bumblebees to hibernate and nest in.
- Planting Spring-flowering trees AND sowing three to four different habitats for pollinators can provide for many of their needs (see table page 70-71).
- Match the appropriate pollinator habitat to the right site.
- Create a firm, fine, weed-free seed bed and sow **ON THE SURFACE.**
- Sow in Spring (mid-March to end-April) or Autumn (mid-July to end-August).
- Spring sow where Blackgrass is a problem.
- Good management of sown habitats is **VERY** important.
- Lack of cutting is a major cause of failure.
- Wildflower and Pollen & Nectar habitat will require frequent cutting in year one. Cutting does not kill perennial wildflowers.
- Mow when weeds obscure sown species.
- Ideally remove the cuttings if they contain grass or cut more frequently and leave.
- Cutting half the margin in mid-season (end of May or early June) will extend the flowering period until late Summer.
- After year one consider rotational cutting so some tall grass is left overwinter.

Photo - Lucy Hulmes, CEH

HABITAT SELECTION SUMMARY

Illustration courtesy of Chris Shields. www.illustrateduwildlife.com

	Wildflower	Pollen & Nectar	Bumblebird	Annual mix for Pollinators	Basic Tussocky	Tussocky with flower
						
Features	Diversity of flowers; good for wide range of pollinators and other insects.	Good for long-tongued bumblebees.	Good for short-tongued bumblebees and birds.	Good for insects attracted to open flowers.	Good hibernation habitat.	Hibernation habitat and flower resources.
Peak flowering	April to September	June to July	June to September	June to September	Nil	June to September
Longevity	10 to 20 years	3 to 4 years	1 year	1 year	10 to 20 years	10 to 20 years
Cost	£280 - 500+	£80 - 90	£65	£210 - 230	£85 - 105	£360 - 390
Skill required	High	Low	Moderate	Low - Moderate	Low	Moderate
Cutting	Frequent in year one. Best removed.	Frequent in year one. Can be left.	N/A	N/A	Infrequent. Can be left.	Infrequent. Can be left.
Location	Warm, sunny and sheltered. Good for protecting watercourses.	Warm, sunny and sheltered. Tolerates high fertility and weed pressure.	Warm, sunny and sheltered. Avoid placing near watercourses. Tolerates high fertility.	Warm, sunny and sheltered. Avoid placing near watercourses.	Tolerates shaded and damp areas. Particularly good for protecting watercourses.	Particularly good for protecting watercourses.

Photos - Left to right: Emorsgate Seeds; Richard Pywell, CEH; Marek Nowakowski; Emorsgate Seeds

WILDLIFE HABITAT CREATION WITHIN THE FARM BUSINESS

By Paul Pickford
Agrii Business Consultant

> "A well-managed farm business provides profit sufficient for the requirements of the owners. Can it also provide for the environment within which it exists?"

For the last 30 years voluntary agri-environment schemes have offered payments to farmers to manage their land sympathetically to support biodiversity, enhance the landscape, and protect soil and water resources.

This section will demonstrate that creation and management of high quality habitat for pollinators and other wildlife using agri-environment support does not have a detrimental impact on the farm business. Indeed such schemes can secure income for five or ten years unaffected by changes to crop values, and provide a viable alternative use for the poorest land.

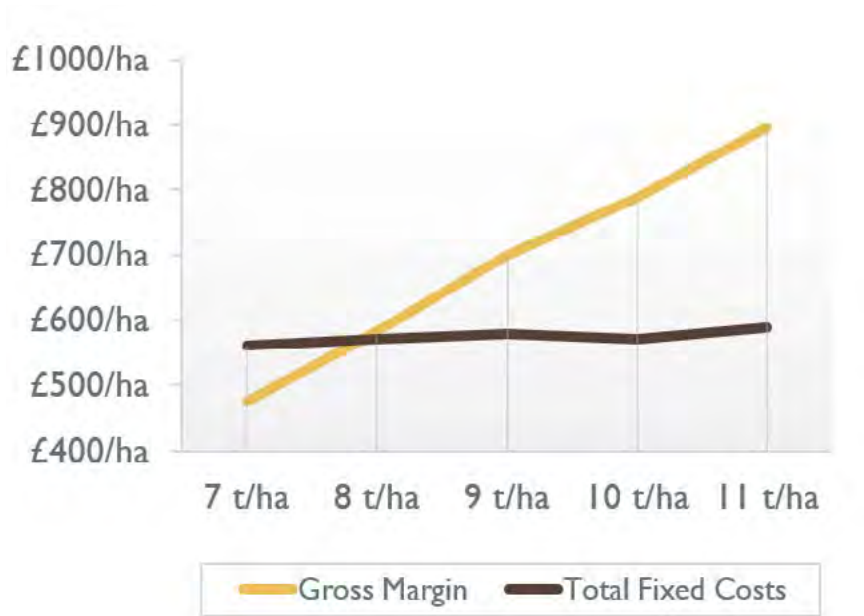
The current situation

The following business analysis is based on the payment rates provided for the voluntary English Entry Level Stewardship scheme (ELS - www.gov.uk/environmental-stewardship). One of the most widely implemented management prescriptions under the ELS is field corner management (option EF1) which typically involves removing corners from production and sowing a simple grass seed mix. For this farmers receive an effective annual payment rate of £400/ha. In terms of income foregone an average gross margin for combinable cropping is around £750–800/ha. When the costs of working the land (£350/ha) are deducted from this the income foregone falls to £400–450/ha. However, we must recognize corners and headlands are likely to be the least productive parts of the field due to factors such as soil compaction, shading and pressure from pests. If headland yields were only 10% less than the field average then the income foregone can be reduced by a further £100–150/ha. The advantages to the business of improved workload and timeliness of field operations are more difficult to quantify but probably equally valuable.

To put the impact of wildlife habitat management into a farm business perspective it is valuable to look at a range of gross margins for the most profitable crop on an arable farm. The total fixed costs for a higher yielding crop, like the variable costs, will be marginally higher as yield increases. Using this analysis it is clear that the break-even point for this wheat crop is between 8 t/ha and 9 t/ha:


Photo - Shutterstock

Winter Wheat Group 4 Break-even Point



In simple terms, where land yields less than 8 t/ha the returns from establishing pollinator or other wildlife habitat using agri-environment support will have very little effect on profitability. Moreover, should yield mapping identify areas yielding 7t/ha or below then the profitability will be improved if it is replaced by wildlife habitat.

Under the terms of ELS it is often only necessary to remove modest areas from production to achieve the required point targets (1-3%), and therefore whilst it will marginally increase the labour and machinery costs on the productive land, the profitability of the farm is likely to be at worst unaffected, but more likely improved.

Greening of the Common Agricultural Policy (CAP)

From 2015 onwards CAP will be reformed to increase the environmental sustainability of farming. For the first time basic environmental management will become mandatory for farms to attract 30% of the single (basic) payment subsidy. Meeting these criteria should prove, for the majority, a relatively simple process and involve very little change in farming practices, so the financial implications should also be minor. There are three principal components of the Green CAP: i) maintaining permanent pasture, ii) crop diversity and iii) the creation of Ecological Focus Areas (EFA). Currently EFAs are set at 5% of the farm arable area, however this may rise to 7% by 2015. Various landscape features count as EFAs, such as hedges, trees, ponds, forestry, nitrogen-fixing crops, catch/cover crops, buffer strips and fallow land. Voluntary management actions, such as sowing nectar and pollen-rich seed mixes, could provide significant additional benefits for insect pollinators.

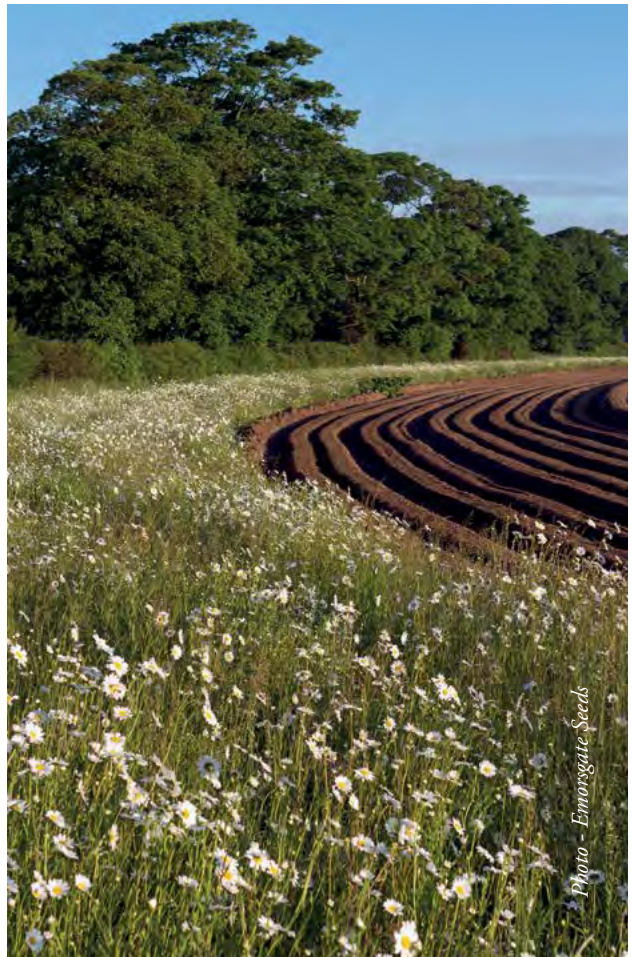


Photo - Emorsgate Seeds

Opportunities for pollinators in the new Agri-environment Schemes

In 2015 the new Countryside Stewardship Scheme (CSS) replaced the Environmental Stewardship Scheme in England (www.gov.uk/government/uploads/system/uploads/attachment_data/file/406212/CAPLF005v10_WEB.pdf). Over the next five years this scheme will distribute £925 million to farmers as incentives to adopt farm practices that conserve and enhance biodiversity, and improve the environment. The scheme will have two main elements:

Higher Tier	Higher Tier is similar to the current Higher Level Stewardship (HLS) and it is expected around 90% of existing HLS agreements will migrate to this tier. It is aimed at the environmentally most important sites requiring complex and demanding restoration and management tailored to the conservation of priority species.
Middle Tier	Middle Tier is set to replace Entry Level Stewardship with the aim of addressing widespread environmental issues, such as improving habitats for pollinators and farmland birds. Spatial targeting of the scheme and competitive scoring will encourage entrants to choose options most likely to benefit these species. There will be an opportunity to select a package of measures to support wild pollinators and **this book provides a useful guide to the selection, creation and management of these**. It is hoped that together this will improve the success of the scheme in achieving the desired outcomes.

Illustration courtesy of Chris Shields. www.illustratedwildlife.com

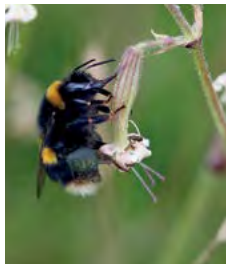
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Contributing to pollinator science

2000

Mapping pollinator decline

Triggered Biodiversity Action Plan and Agri-environment measures for bees.



BRC Biological Records Centre

BWARS Bees, Wasps & Ants Recording Society

See page 78 for more information.

2006

Identifying the causes of pollinator decline

Identified loss of key forage plants from the countryside, such as Clovers, Knapweed etc.

See page 79 for more information.

2007

Testing new pollinator habitats

Developed and tested Pollen & Nectar and Wildflower seed mixes.

the buzz project — Creating Pollinator Habitats

OPERATION Bumble Bee

See page 80 for more information.

2011

Increasing pollinator habitat quality

Cutting half of a Pollen & Nectar seed mix in late June extended flowering by 50 to 70 days.

See page 81 for more information.

Photos - L to R: Lucy Hulmes, CEH; Emorsgate Seeds; Richard Pywell, CEH; Marek Nowakowski;

2011

Importance of landscape context & habitat quality

Creating Pollen & Nectar habitat within intensively farmed landscapes provided the most benefits to bees.

See page 82 for more information.

2015

Habitat quality benefits from farmer training & experience

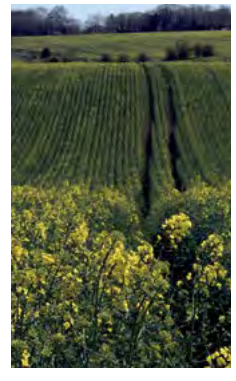
Farmer training and experience of habitat management for wildlife led to better outcomes for pollinators.

See page 83 for more information.

2015

Habitat creation for pollinators benefits food production

Creating habitat for pollinators and other farm wildlife increased the yield of some crops.



See page 84 for more information.

2016+

Future: monitoring change in pollinators and pollination services

Working in partnership with volunteer recorders and the farming industry to develop a long-term monitoring framework to act as an early warning of future change in bee populations.

See page 84 for more information.

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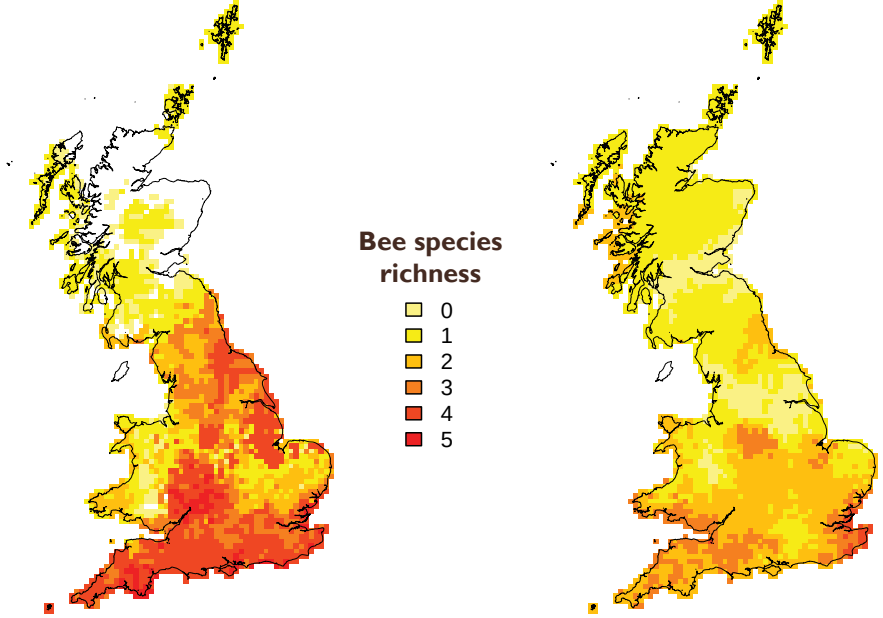
Photos: Heather Lowther, CEH. Illustration courtesy of Chris Shields. www.illustratedwildlife.com

Mapping pollinator decline

- **Science:** Analysis of volunteer-collected data showed marked decline of rare bees (esp. bumblebees) after 1960.
- **Impact:** Seven bumblebees and 13 other bees prioritised for conservation under the UK Biodiversity Action Plan (http://jncc.defra.gov.uk/ukbap).
- **Impact:** New agri-environment prescriptions to support insect pollinators first proposed.

Loss of species-rich grassland is one of several factors responsible for bee decline.
Photo - Lucy Hulmes, CEH

Change in estimated species richness for five rare bumblebee species between 1900 and 2010



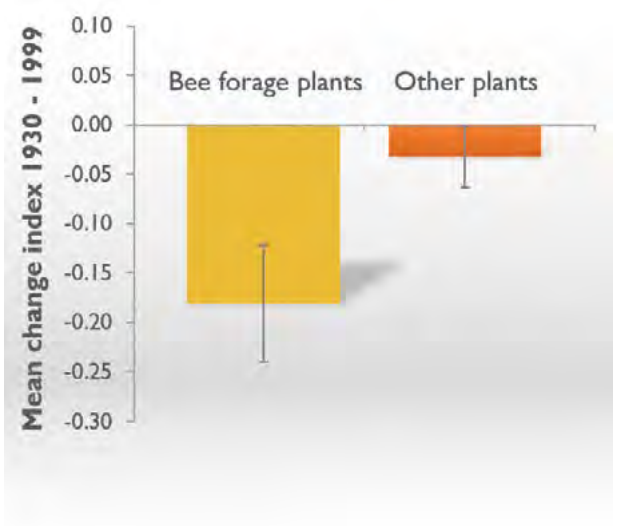
BRC Biological Records Centre

BWARS Bees, Wasps & Ants Recording Society

Identifying the causes of pollinator decline

- **Science:** Analysis of national-scale monitoring data showed first quantitative evidence for 20th Century declines in important forage plants for bumblebees in Britain.
- **Science:** 76% of bee forage plants shown to have declined since 1930.
- **Impact:** Informed agri-environment measures to create habitats in the farmed landscape containing bee forage plants.
- **Impact:** Several reliable, commercially available plant species, including Red Clover, Knapweed and Birds-foot Trefoil, were selected to form the core of the new agri-environment prescriptions for insect pollinators.

Disproportionate loss of bee forage plants like Red Clover (shown) may be an important factor in bee decline.
Photo - Lucy Hulmes, CEH



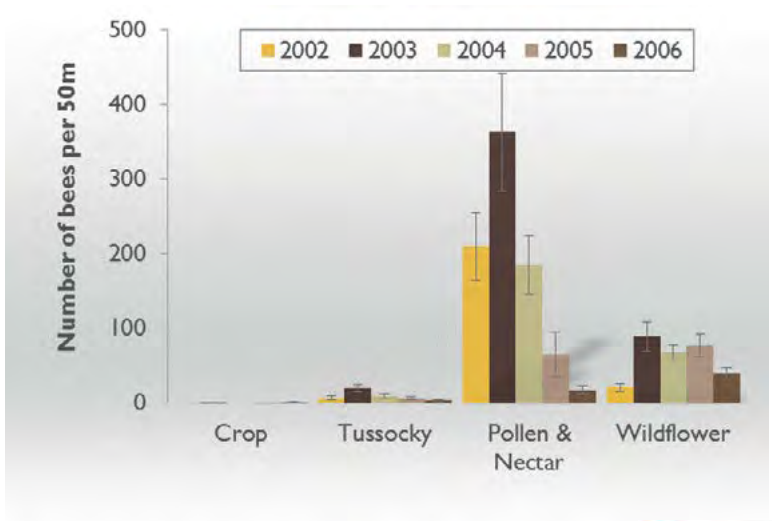
Carvell, C., Roy, D.B., Smart, S., Pywell, R.F., Preston, C.D. and Goulson, D. 2006. Declines in forage availability for bumblebees at a national scale. *Biological Conservation 132: 481-489.*

Bee forage plant diversity (red = high; blue = low)

Testing new pollinator habitats

- **Science:** Benefits of existing and new agri-environment management for insect pollinators were measured over five years.
- **Science:** Native wildflower seed mixes provided excellent continuity of forage resources, especially early in the season and were attractive to a wide range of bees.
- **Science:** Seed mixes based on Agricultural Clovers were quick to establish and provided abundant flowers for long-tongued bees, but were short-lived (three years).
- **Impact:** Science from the 'Buzz' project was used to train and encourage farmers across the UK and Europe to create habitat and manage their land sympathetically for insect pollinators.

Pollen & Nectar seed mix performed well but was short-lived. Photo - Claire Carvell, CEH



Carvell, C., *et al.* (2007) Comparing the efficacy of agri-environment schemes to enhance bumblebee abundance and diversity on arable field margins. *Journal of Applied Ecology, 44, 29-40.*

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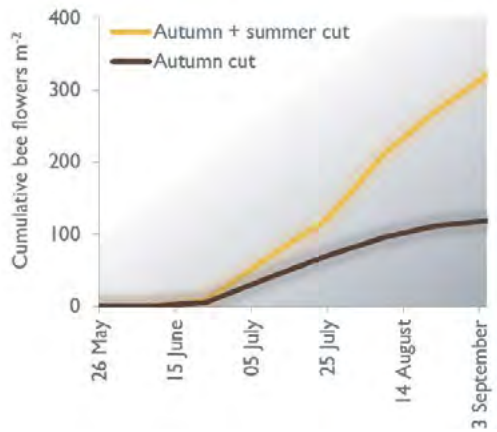
Increasing pollinator habitat quality

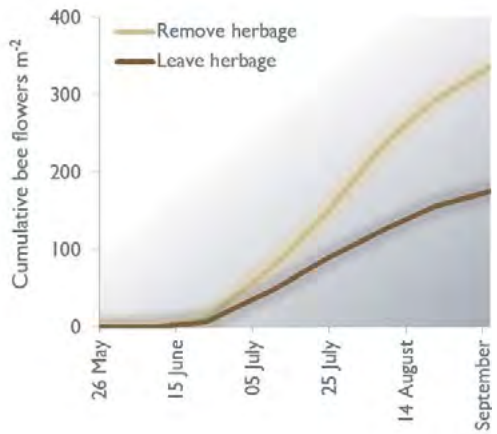
- **Science:** Summer cutting in late May or early June delayed the flowering season of basic Pollen & Nectar seed mixes by five to eight weeks.
- **Science:** Removal of cut material enhanced late-season flower abundance for pollinators.
- **Impact:** Practical recommendation to cut half of the area of Pollen & Nectar margins in May/June to extend the flowering season to late-summer for queen bumblebees and reduce damage to butterfly breeding habitat.

Flower margin being cut with the herbage removed. Photo - Marek Nowakowski

Summer cutting prolongs flowering



Removing cut material prolongs flowering



Pywell, R.F., Meek, W.R., Hulmes, L., Hulmes, S., James, K.L., Nowakowski, M., Carvell, C. (2011) Management to enhance pollen and nectar resources for bumblebees and butterflies within intensively farmed landscapes. *Journal of Insect Conservation, 15,853-284.*

Importance of landscape context & habitat quality

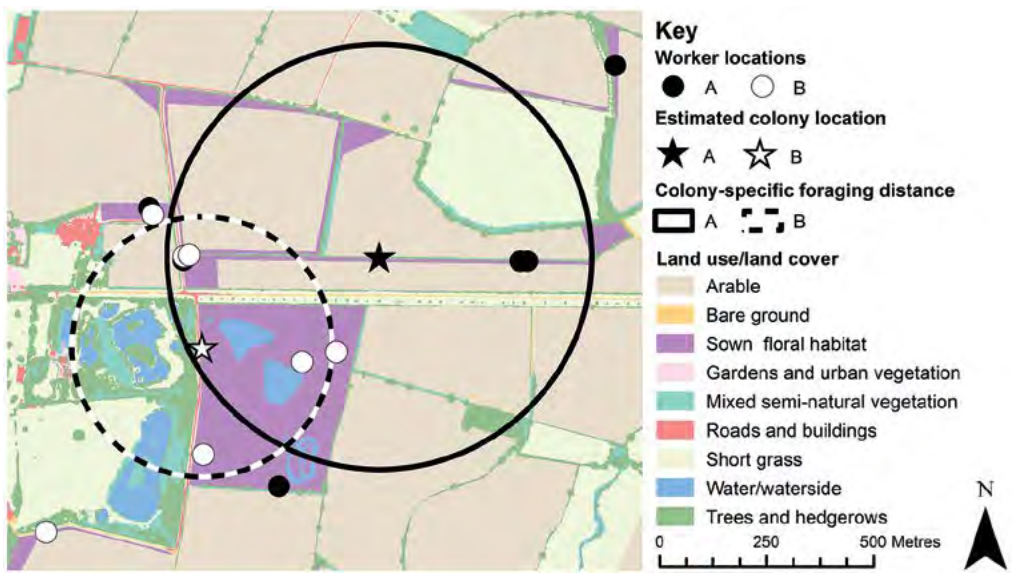
- **Science:** Field experiments showed newly created pollinator habitats delivered greater benefits to bees in intensively farmed areas than diverse landscapes where other foraging habitats exist.
- **Science:** DNA analysis and landscape mapping revealed that bumblebees forage closer to their nests in farmland with higher proportions of flower-rich habitats.
- **Impact:** This evidence informed the development of new 'packages' of measures for insect pollinators under the agri-environment schemes.

Small patch of good quality pollinator habitat in an intensively farmed landscape.
Photo - Claire Carvell, CEH

Carvell. C, *et al.* (2011) Bumblebee species' responses to a targeted conservation measure depend on landscape context and habitat quality. *Ecological Applications, 21, 1760-1771.*

JW Redhead, *et al.* (*in press*). Effects of habitat composition and landscape structure on worker foraging distances of five bumblebee species. *Ecological Applications. Doi:10.1890/15-0546.1.*

Bee foraging distances reduced where greater amounts of Pollen & Nectar habitat are sown (colony B)

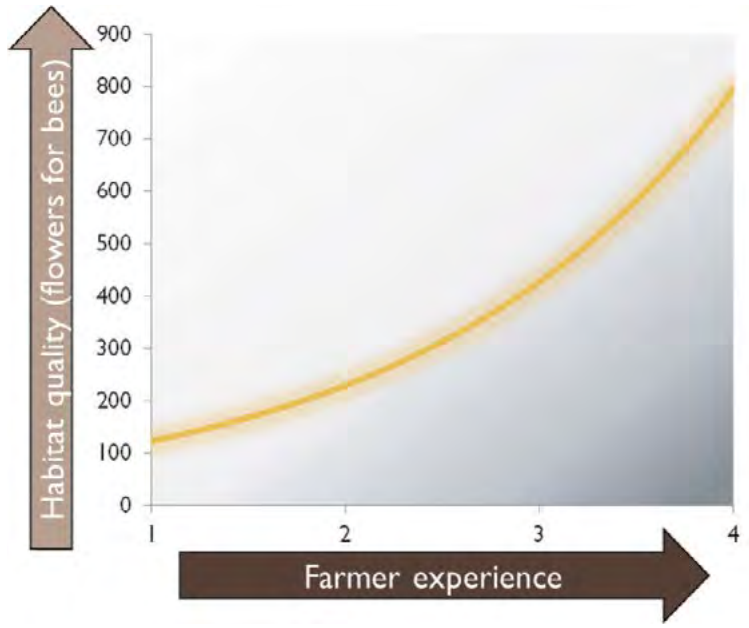


Habitat quality benefits from farmer training & experience

- **Science:** Farmer experience of agri-environment management and training had a strong positive effect on the quality of pollen and nectar habitat produced.
- **Impact:** Bee abundance and diversity was much higher on these better quality, farmer managed habitats.

Farmer advice on habitat creation.
Photo - Heather Lowther, CEH

Farmer experience improves environmental outcomes



McCracken, M.E., Woodcock, B.A., Lobley, M., Pywell, R.F., Saratsi, E., Swetnam, R.D., Mortimer, S.R., Harris, S.J., Winter, M., Hinsley, S. & Bullock, J.M. (2015) Social and ecological drivers of success in agri-environment schemes: the roles of farmers and environmental context. *Journal of Applied Ecology, 52, 696-705.*

FarmcaT
Improving agri-environment schemes

RURAL ECONOMY AND LAND USE

Habitat creation for pollinators benefits food production

- **Science:** A 900 ha experiment on a commercial farm tested the effects of removing 3% and 8% of lowest yielding cropped land from production (equivalent to 1% and 5% of land in the whole landscape) to create habitats for pollinators and other wildlife.
- **Impact:** Removal of land to create pollinator habitat significantly increased yield in the cropped areas of the fields, and this positive effect became more pronounced over six years.
- **Impact:** Yields at the field scale were maintained - and enhanced for some insect-pollinated crops - despite the loss of cropland for habitat creation.

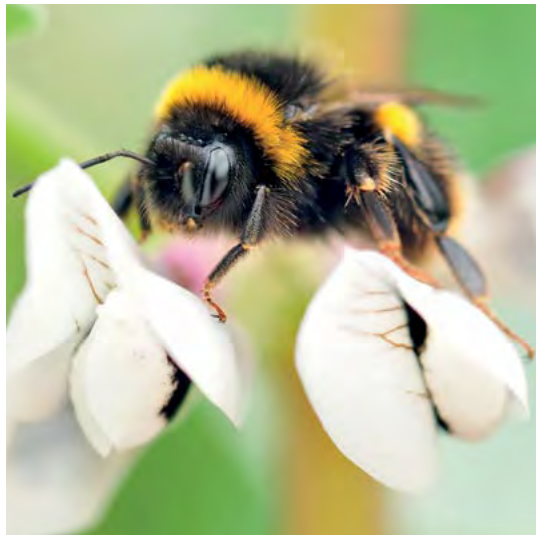
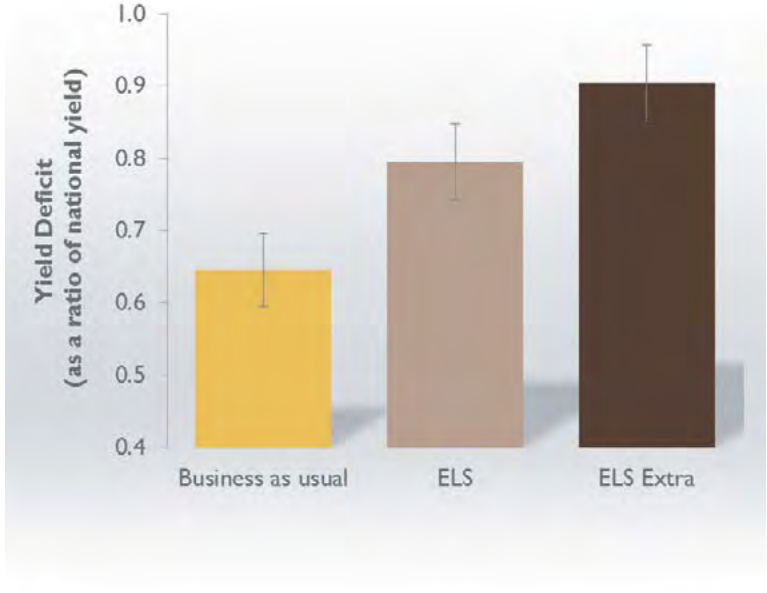


Photo - Lucy Hulmes, CEH

Pywell, R.F., Heard, M.S., Woodcock, B.A., Hinsley, S., Ridding, L., Nowakowski, M. & Bullock, J.M. (2015) Wildlife-friendly farming increases crop yield: evidence for ecological intensification. *Proceedings of the Royal Society of London B: Biological Sciences, 282. Doi:10.1098/RSPB.2015.1740.*

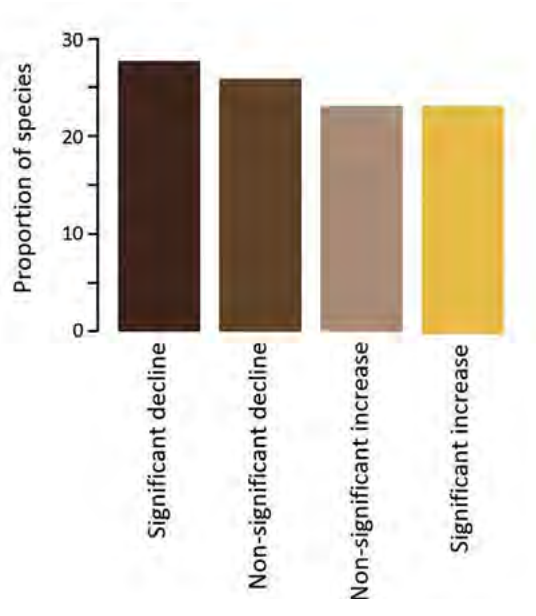
Wildlife friendly habitat increases bean yield



Future: monitoring change in pollinators and pollination services

- **Science:** Analysis of trends over four decades suggested there have been significant declines in almost a third of insect species that provide the vitally important pollination service to cropped and natural systems (see figure below).
- **Science:** Such analyses of records of individual species can tell us how their distributions are changing, but more structured and systematic surveys encompassing a wide range of pollinator groups are required to measure changes in pollinator populations over time.
- **Science:** CEH are leading a consortium of volunteer recorders, conservation organisations, universities and the farming sector to develop and test a national framework for monitoring changes in abundance of pollinators over time.
- **Impact:** This should provide early warning of future changes in pollinator populations and help us understand the causes of decline.

Photo - Heather Lowther, CEH



The proportion of 720 insect pollinator species (bees, hoverflies, butterflies and moths) showing significant changes in frequency of occurrence between 1970 and 2010.

Oliver, T.H., Isaac, N.J.B, August, T.A., Woodcock, B.A., Roy, D.B., Bullock, J.M. (2015) Biodiversity loss and the resilience of ecosystem functions. *Nature Communications. Doi:10.1038/ncomms10122.*

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Mapping pollinator decline (page 78)
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Identifying the cause of pollinator decline (page 79)
This analysis was funded by the Department for Environment, Food and Rural Affairs (Defra; project BD1617) and NERC.

Testing new pollinator habitats (page 80)
This experiment was carried out as part of the Buzz Project, funded by Syngenta, Unilever Plc and Defra (projects BD1624 and MA01017).

Increasing pollinator habitat quality (page 81)
This research was funded by Defra (project BD1623).

Importance of landscape context & habitat quality (page 82)
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Habitat quality benefits from farmer training & experience (page 83)
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Habitat creation for pollinators benefits food production (page 84)
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Future: monitoring change in pollinator populations and the pollination service (page 85)
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