



postnote

January 2010 Number 348

INSECT POLLINATION

Many plants, including crops, depend on insects to transfer pollen between flowers. Maintaining enough insect pollinators is therefore vital for biodiversity and a diverse food supply. Declines in pollinators, particularly in Europe and the USA, have provoked claims of a global pollination crisis. This POSTnote examines the risks of pollinator decline for the UK and explores strategies to provide stable pollination services into the future.

Background

About 80% of British plant species¹, including many crops, make use of insects to transfer pollen between flowers producing seeds and fruits. Without their pollinating insects these plants would reproduce less well, or not at all. This could resonate through ecosystems, for example affecting seed-eating birds which depend on insect-pollinated plants for food. Pollination is therefore an essential ecosystem service which maintains biodiversity and supports other vital ecosystem functions, including soil protection, flood control and carbon sequestration. Pollination services are a public good, and many pollinators are charismatic insects that generate strong public interest. The priorities of the Department for the Environment, Food and Rural Affairs (Defra) include “a thriving farming sector” and “dealing with environmental risks”. In addition, the UK is committed to halting the loss of biodiversity by 2010.

There are thousands of insect species in the UK which may contribute to pollination, including bees, hoverflies, butterflies and moths. Pollinators may be generalists, pollinating many species effectively, or specialists that visit only a few species. Different flower types have different pollinators. Several characteristics of bees, such as their size, hairiness and foraging behaviour, indicate they pollinate flowers more efficiently than other insects (Box 1). British bee species comprise the honeybee, about 20 bumblebee species and over 200 solitary bee species. Honeybees are intensively managed by humans, whereas native bumblebees and solitary bees are wild and unmanaged. Bumblebees have been domesticated in other countries, including Slovakia and New Zealand. In the UK, over 10,000 colonies are imported each year to pollinate crops growing in glasshouses and polytunnels.

Box 1. Comparison of Bee Species as Pollinators

- The relative contribution of different insect species to providing pollination services has never been systematically assessed in the UK.
- Honeybees are often cited as the most important crop pollinators, however the role of wild bees is being increasingly recognised.
- Honeybees are a practical solution to pollinating several intensively farmed crops as they can be reliably managed to be locally common when crops are in bloom.
- Wild bees can be more effective on particular crops than honeybees. In apple orchards, 600 solitary bees can pollinate as well as 2 hives (30,000 honeybees)².
- Wild bee species can be more abundant than honeybees, particularly in semi-natural ecosystems away from hives. A study in British rape fields found bumblebees were twice as abundant as honeybees³.
- Wild bees may act synergistically with managed bees to increase yields⁴.

Risk to Pollination Services Declines in Pollinators

The overall abundance of pollinators has probably decreased in the countryside since the 1970s, and certain groups have declined dramatically (Table 1). Similar trends in other countries have contributed to claims of a global pollination crisis (Box 2).

Table 1: Recent Trends in British Pollinators

Pollinator	Status
Honeybees	Managed hives have declined by 50% in England between 1985 and 2005 ⁵ . High winter colony losses recently, but not unprecedented. Wild honeybees thought to be rare as they are severely affected by an introduced parasite, varroa mite.
Bumblebees and solitary bees	Good data are lacking to assess changes in abundance. 50% of areas surveyed have lost species compared with pre-1980, only 10% have gained species ⁶ . Seven bumblebee species are UK Biodiversity Action Plan priorities, but six remain relatively common and widespread.
Butterflies	No change in abundance of generalist species since the 1970s, but specialist species have declined ⁷ .
Moths	67% of common widespread species have declined since the 1970s ⁸ .
Hoverflies	Data from the <i>Hoverfly Recording Scheme</i> indicates that 25% of species have declined since the 1980s while 10% have increased.
Others	Insufficient data.

Costs of Pollinator Loss

Pollination has a direct economic value through increasing the yield and quality of insect-dependent crops. In the UK, this includes oilseed rape, orchard fruit, soft fruit and beans. Total loss of pollinators could cost up to £440m a year, about 13% of UK income from farming⁹. Insect-dependent crops can be pollinated by hand, but the cost of this would be prohibitive (initial estimate of labour costs is £1500m a year)⁹. Pollination, through its essential role in maintaining biodiversity and ecosystem functioning, also provides indirect benefits to agriculture. These benefits have not been valued, but probably exceed its direct value.

Box 2: A Global Pollination Crisis?

Attention has been drawn to pollinator health recently by unusually high mortality rates of managed honeybees in the USA and Europe. In the USA, high mortality rates have been ascribed to a new syndrome, Colony Collapse Disorder (CCD). CCD has not yet been observed in the EU countries. US research found CCD is linked to a combination of factors that place stress on honeybees, including varroa, poor nutrition, pesticides and long-distance transportation by humans.

Pollinator decline is unlikely to threaten global food security as cereal crops are wind-pollinated. It has been estimated that total pollinator loss would only reduce world agricultural production by 5%¹⁰. However it would noticeably reduce the diversity of food available, particularly affecting 'Five-a-Day' crops. Globally, cultivation of insect-pollinated crops has increased at a greater rate than the number of honeybee hives. This creates a growing imbalance between pollination supply and demand which, without sufficient wild pollinators, could limit yields in future¹⁰.

Current Effects on Agriculture and Biodiversity

Shortage of wild pollinators already affects the yield of crops which are highly insect-dependent. For example apple and raspberry growers put extra honeybee and bumblebee colonies in fields to get the best yield. Evidence for impacts on wildflowers is lacking, but it is known that insect-pollinated plants are declining faster than wind-pollinated plants⁶. The Rothamsted Research Centre found that bumblebee abundance is higher in suburban areas than arable areas and this affects the seed production of wildflowers.

Future Concerns

The number and diversity of pollinators necessary to maintain pollination services is not known, so it is hard to predict when serious consequences will arise due to pollinator loss. The effect of losing pollinator species can be explored through computer models of plant-pollinator networks. These suggest that networks are fairly robust to the removal of specialist pollinators; plant species diversity is maintained until 70% of pollinator species are lost, provided the most specialist are lost first¹¹. Losing generalist pollinators, like honeybees, has more severe consequences for diversity.

Requirement for pollinators may increase in the future as:

- demand for insect-pollinated crops is increasing; the area cultivated has risen by 38% since 1989 in the UK.
- demand for food and biofuel is increasing, placing more pressure on land and yields.

Given the recognised importance of pollinators, levels of decline and the uncertainty surrounding pollination requirements, the precautionary principle would suggest acting to conserve pollinators.

Pressures on Pollinators

Agricultural Intensification

Intensification has reduced the availability of food plants and nesting sites through conversion of semi-natural land to intensive farmland and changing agricultural practices. The UK has lost 97% of its wildflower meadows since the 1930s. Such changes affect wild pollinators most because they are totally reliant on resources available in the landscape; the number of visits to crop fields by wild pollinators tends to drop with distance from semi-natural areas¹². Therefore, effective pollination by wild pollinators requires crop land to be interspersed with natural areas. Managed honeybees are less at risk from lack of suitable habitat as they can be given substitute feed.

Pests and Diseases

Pests and diseases are the main threat to honeybees, particularly an introduced parasitic mite, varroa, which is showing resistance to some treatments. Beekeeping associations feel that successful disease management is limited by lack of effective treatments and training in appropriate pest management. The National Bee Unit, which delivers honeybee health programmes on behalf of Defra and the Welsh Assembly Government, lacks the resources to offer in-person training to all beekeepers. Beekeeping associations also provide training but the quality depends on the expertise of local volunteers. Access to treatments can also be a problem as drug manufacturers have previously been unwilling to incur the financial cost of registering honeybee medicines in the UK where the market for these products is quite small.

The impact of pests and diseases on other pollinating insects has not been well studied, but is probably less severe than on honeybees as they are particularly exposed to novel diseases spread by human activity. Bumblebees may be affected by disease transfer from imported bumblebees that have been released in glasshouses and polytunnels. This was linked to severe declines in some American bumblebee species, but has not been investigated in the UK.

Agrochemicals

Insecticides, by their nature, can be toxic to insect pollinators. The EU Pesticides Authorisation Directive (91/414/EEC) requires that pesticides should not be used if they pose an unacceptable risk to honeybees¹³. This is tested through laboratory and field trials. Since 2003, there have been no recorded incidents of honeybee poisoning in the UK resulting from the approved use of pesticides. Some conservation groups are calling for a ban on neonicotinoid pesticides, which were the cause of bee poisoning incidents in mainland Europe due to misapplication of seed coatings (Box 3).

EU legislation does not require risk assessments for wild pollinators. Those for honeybees cannot be generalised to other pollinators as they may be more susceptible to pesticides. Measures to protect honeybees, such as restricted spraying times, may not protect unmanaged pollinators that are active at different times of the day. Therefore, risks to wild pollinators remain difficult to assess. Herbicides and fertilisers may indirectly affect pollinators by reducing wildflower abundance and diversity. However, a recent study on organic farming in the UK found it had limited benefits for pollinators¹⁴.

Urbanisation

Urban gardens, parks and trees can provide good habitat for a diversity of pollinators, for example bumblebee nests are more common in the suburbs than in arable areas¹⁵. Increased building density and redevelopment of allotments and brownfield sites threatens pollinators.

Box 3: Neonicotinoids

These are a family of insecticides that disrupt insect neurological functions. A few neonicotinoids are highly toxic to honeybees. They are systemic, which means they are absorbed and transported throughout a plant. This can improve pest control efficiency. However bees and other pollinators may ingest pesticide residues when feeding on treated plants. Unlike contact pesticides, this may occur over several days, or longer if contaminated pollen and nectar are stored in the hive, thus increasing cumulative pesticide exposure. This is not addressed in the current pesticide assessment process. The European Food Safety Authority is considering an improved evaluation process. If this is accepted, neonicotinoids would be reassessed within ten years.

At predicted exposure levels, laboratory tests on honeybees have proved inconclusive as some experiments found lethal or sublethal effects, for example impaired navigation, but most did not. Field trials on some crops in Europe found no differences in health between pesticide-exposed honeybee hives and unexposed hives. Four EU countries have restricted the use of some neonicotinoids, as has the Co-op, a major UK farming concern. However, the National Farmers' Union is concerned that a UK-wide ban would lead to increased resistance to other pesticides and render sugar beet cultivation unprofitable, while not necessarily improving honeybee health.

Climate Change

There is uncertainty about the potential impact of climate change on UK pollinators. Pollinators that have a broad climatic distribution, like honeybees, may adapt. However, there could be a mismatch between flowering dates of food plants and emergence dates of pollinators if they respond differently to environmental cues¹⁶. Blackcurrant and its pollinators have diverged by 28 days since the 1970s. This could expose pollinators to periods of starvation, affecting particularly wild pollinators that have little food stores.

Reduction in Beekeeping

Most honeybees are farmed animals dependent on beekeepers. Unlike other countries, British beekeeping is dominated by amateurs. The increased difficulty of keeping honeybees healthy, including the cost of treatments for pests and diseases, has reduced the attractiveness of beekeeping as a hobby. The number of UK beekeepers halved in the last 60 years⁴, although it is now rising. The long-term sustainability of reliance on hobbyists to maintain honeybee numbers is questionable.

Government Policies

There is no co-ordinated government strategy to maintain pollination services but several agencies and research councils have relevant initiatives.

- *Healthy Bees* is a ten year strategy to protect and improve the health of honeybees in England and Wales. Defra and the Welsh Assembly Government provided £2.8m to fund it to 2011. Most of the money is for assessing the health of hives, but some is allocated for enhancing the beekeeper education programme. Scotland is also developing a honeybee health strategy.
- The *Insect Pollinators Initiative* is a five year, £10m research programme into pollinator decline funded by

Defra, two research councils (BBSRC and NERC), the Scottish Government and the Wellcome Trust. Awards will be announced in summer 2010.

- Natural England's Environmental Stewardship (ES) scheme includes some measures to benefit pollinators on farmland. About 65% of English farmland is on farms which are in the ES scheme.
- Natural England has set minimum disease screening standards for imported bumblebee colonies released in glasshouses and polytunnels.
- The Veterinary Medicines Directorate has recently launched an action plan to facilitate licensing of new honeybee medicines, including those already authorised in other EU Member States.

Strategies to Maintain Effective Pollination

In theory, requirement for pollinators for agriculture could be reduced by not growing insect-pollinated crops; but this would increase reliance on imports, affecting food security and consumer choice.

To Bee or Not to Bee?

Pollination services to agriculture could be maintained through managed pollinators, principally bees. However this is not a desirable strategy as huge numbers of colonies would be required and managed pollinators are prone to diseases, for example large-scale honeybee losses have occurred more than 30 times in the last 200 years. Moreover, the pollination needs of most wild plants and future potential crops are not known, and they may depend on wild pollinators. Therefore, to provide stable pollination services, policies to maintain both wild and managed pollinators are needed. This would also conserve wild pollinators as a valued part of biodiversity.

Additional Strategies

Pursuing the following strategies alongside existing policies would provide additional support to pollinators.

Developing New Managed Pollinators

Mason bees, which are a type of solitary bee, are being investigated as alternative pollinators for fruit trees. Preliminary field trials suggest they are a more efficient pollinator than honeybees and require little husbandry. Breeding British bumblebee colonies, rather than importing them, would reduce risks from disease spread.

Deployment of Pollinator Habitat in Agricultural Land

Providing new habitat with forage and nesting sites is the best way of safe-guarding a diversity of pollinators. This has other benefits, including providing a refuge from agrochemicals and helping pollinators to migrate in response to climate change. Sowing wildflower seed mixes is a quick and relatively cheap way of creating habitat that benefits pollinators (Box 4). The amount of pollinator habitat needed in the landscape is not known, but expert opinions range from 1.25% to 2.5%. Estimated costs of creating these wildflower meadows varies depending on whether compensation is paid for income foregone through Environmental Stewardship (ES), £50-100m per year, or whether seed costs alone are paid, £3.3-6.7m per year.

ES could provide a framework to deliver more pollinator habitat. However, uptake of pollinator-targeted options in ES is low, covering about 0.05% of English agricultural land. An incentive payment to encourage uptake is not feasible as the EU sets payment rates to cover only actual

costs and income foregone. However, the experience of Operation Bumblebee (Box 4) and farmer attitude surveys suggests that a more targeted approach can encourage farmers to choose options that offer particular biodiversity benefits, even if they are more demanding to carry out. In addition to creating wildflower meadows, promoting the inclusion of clover leys in crop rotations and restoring habitats like woodlands, hedgerows and grassland is advantageous for pollinators. These measures would also provide a range of wider social and environmental benefits, beyond pollination services.

Box 4: Optimising Benefits from Habitat Creation

Sowing wildflower seed mixes in field margins and corners can significantly benefit pollinators. Field trials run by the Centre for Ecology and Hydrology found that bumblebee abundance was 14 times higher in wildflower margins than in the conventionally managed cereal crop. Pollinator abundance was 12 times higher in farmed landscapes that were managed using targeted agri-environment schemes for pollinators and other wildlife, compared with areas outside the schemes (standard cross-compliance). These trials indicate that maximum benefit to pollinators from sowing seed mixes can be achieved by:

- sowing more diverse mixtures which provide pollen and nectar throughout the bee season and are long-lasting.
- a landscape-scale approach which provides connectivity between flower patches and enough habitat to sustain viable populations of pollinators.
- targeting habitat creation to the most intensively farmed landscapes.
- providing support and training to farmers

One example of this in action is *Operation Bumblebee*, a three-year project funded by Syngenta and Sainsbury's to plant 1000 hectares of British farmland with wildflower seeds. It worked with 600 farms across the UK and almost half the wildflower habitat created by farmers in ES was delivered through *Operation Bumblebee*. Knowledge transfer from research to implementation was central to its success.

Planting Programmes in Urban Areas

The government, under Planning Policy Statement 9, is committed to enhancing biodiversity in urban green spaces. However, managers of such urban green spaces have been criticised in the past for adopting a 'lawn and lollipop' approach of amenity grass and isolated trees. Programmes to replace this with wildflower meadows are being trialled (Box 5). Wildflower meadows are not more expensive than amenity grass, but require developers and local government to commit to long-term management.

Box 5: Case Study – Pictorial Meadows

This is the first large-scale deployment of an innovative approach to urban landscape planting designed to appeal equally to people and wildlife. Since 2004, about 30 sites in Sheffield have been sown each year with a colourful, long-flowering and low-maintenance mix of native wildflowers and garden plants in meadow-like areas. Sites chosen include housing regeneration projects, parks and road-sides. The scientific advisor to the scheme says it has proved very popular with residents and has biodiversity benefits, attracting a wide range of insects. Research currently underway will provide a formal assessment of the scheme. Other UK cities, including London and Newcastle, are adopting similar strategies.

Improving the Health of Honeybees

Treating varroa and other health problems effectively and breeding more resistant bees are important long-term goals of research programmes, both in the UK and abroad.

However the relatively small market for bee health products results in little interest from industry. In the short term, improvements in honeybee health are possible through raising husbandry standards, which have been identified as a weakness. This could be achieved by developing an evidence-based best practice for beekeepers and disseminating this widely by working with the existing framework of local beekeeping associations.

Areas of Uncertainty

Improved understanding of the following areas would help in designing optimal additional strategies:

- the relative contribution of different insect species to pollinating wildflowers and crops and the abundance of pollinators needed to provide adequate pollination.
- the amount of habitat needed in the landscape to maintain stable pollinator populations.
- the causes of honeybee hive loss, particularly the interaction of disease, genetics and other stressors.

It is also desirable to generate baseline abundance data for wild pollinators to enable accurate monitoring of changes.

Overview

- Insect pollination contributes an estimated £400m per year to the UK economy and is essential for maintaining biodiversity.
- Bees (honeybees and wild bees) are thought to be the most important pollinators. They have declined significantly in the last 20 years. This could pose a risk to future pollination services.
- Shortage of suitable food plants and nesting sites is the main cause of the decline of wild pollinators. This could be offset by large scale restoration of pollinator habitat, for example by sowing wildflower meadows.
- Pests and diseases are the main causes of declines in managed honeybees. In the long-term, research to improve treatments and breed resistance is needed. Short-term benefits could be achieved through improving husbandry standards among beekeepers.

Endnotes

- 1 *Pers. comm.*, Ollerton J., University of Northampton, 2009.
- 2 Delaplane K.S. and Mayer D.F., 2000, *Crop Pollination by Bees*.
- 3 Data from GM farm-scale trials, www.farmscale.org.uk.
- 4 Elmquist T. and Maltby E., 2009, TEEB *Ecological and Economic Foundation Report*, Ch. 2.
- 5 Potts S.G. *et al.*, 2010, *Journal of Apicultural Research*, in press.
- 6 Biesmeijer J.C. *et al.*, 2006, *Science* 313, 351-354.
- 7 JNCC, 2009, *Biodiversity Indicators in Your Pocket*.
- 8 Conrad K. F. *et al.*, 2006, *Biological Conservation* 132, 279-291.
- 9 *Pers. comm.*, Potts S. G., Reading University, 2009.
- 10 Aizen M. and Harder L., 2009, *New Scientist* 2731, 26-27.
- 11 Memmott J. *et al.*, 2004, *Proc Roy Soc B* 271, 2605-2611.
- 12 Ricketts T. H. *et al.*, 2008, *Ecology Letters* 11, 499-515.
- 13 POSTnote 336 *Crop Protection*.
- 14 *Pers. comm.*, Benton T., Leeds University, 2009.
- 15 Osborne J. *et al.*, 2007., *Applied Ecology* 45, 784-792.
- 16 Memmott J. *et al.*, 2007, *Ecology Letters* 10, 710-717.

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of public policy issues that have a basis in science and technology. POST is grateful to Rebecca Ross for researching this briefing, to the British Ecological Society for funding her parliamentary fellowship, and to all contributors and reviewers. For further information on this subject, please contact the co-author, Dr. Jonathan Wentworth, at POST. Parliamentary Copyright 2010. The Parliamentary Office of Science and Technology, 7 Millbank, London, SW1P 3JA; Tel: 020 7219 2840; email: post@parliament.uk

www.parliament.uk/parliamentary_offices/post/pubs2010.cfm