University of East Anglia

NERC SCIENCE OF THE ENVIRONMENT

# How much flower-rich habitat is enough for wild pollinators?

## Answering a key policy question with incomplete knowledge

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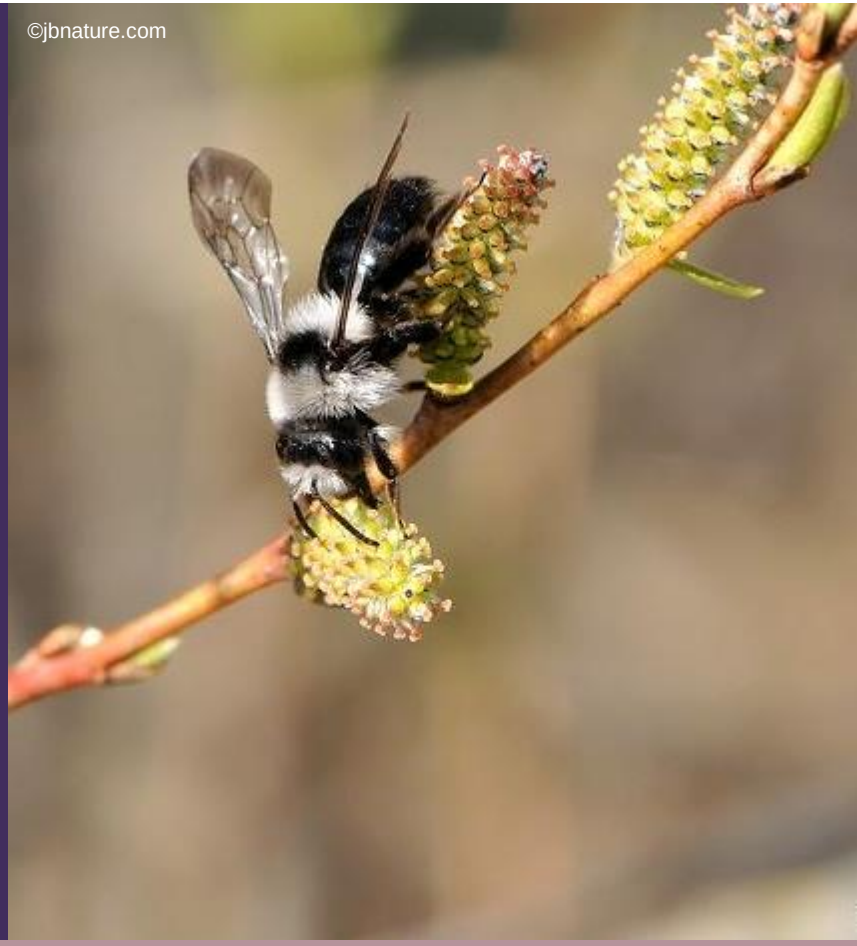
7 December 2017, Copenhagen

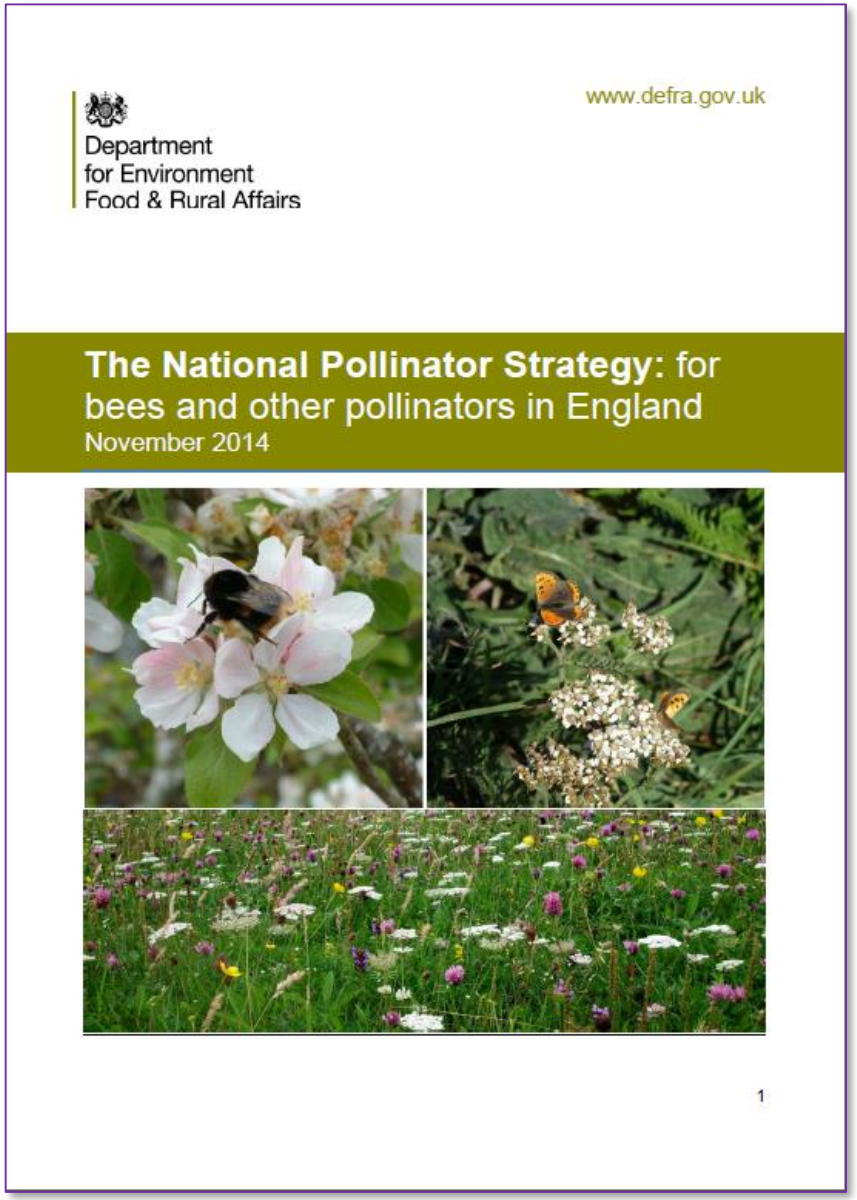



@LynnDicks

From what we know so far, the number of **wild bee and other pollinator species** has fallen as their flower-rich habitat has been built over or used for intensive farming.
Today I am launching our new <u>Bee and Pollinator strategy</u> to analyse and reverse that trend.



Elizabeth Truss MP
UK Secretary of State for Environment, Food and Rural Affairs



www.defra.gov.uk

Department
for Environment
Food & Rural Affairs

**The National Pollinator Strategy:** for bees and other pollinators in England

November 2014

1

A 10-year strategy (2014-2024), **five key areas**:

- Supporting pollinators on farmland
- Supporting pollinators in towns & cities
- Enhancing the response to pest and disease risks
- Raising awareness of what pollinators need
- Improving evidence on the status of pollinators and the service they provide

**A key outcome**: “More ….flower-rich habitats supporting our pollinators across the country”

# Agri-environment schemes

- Voluntary financial incentives
- Can deliver management objectives in farmland
- Some options deliver flower-rich habitat
- Being re-designed in England at the time

# Policy makers wanted to know...

… how *much* flower-rich habitat is needed to support pollinators?

# What do we mean by pollinators?

- Crop pollinators → yield (quantity, quality, stability)
- Wild plant pollinators → plant seeds and communities
- Rare and declining pollinators → protection of diversity

# What are the dominant wild crop pollinators?

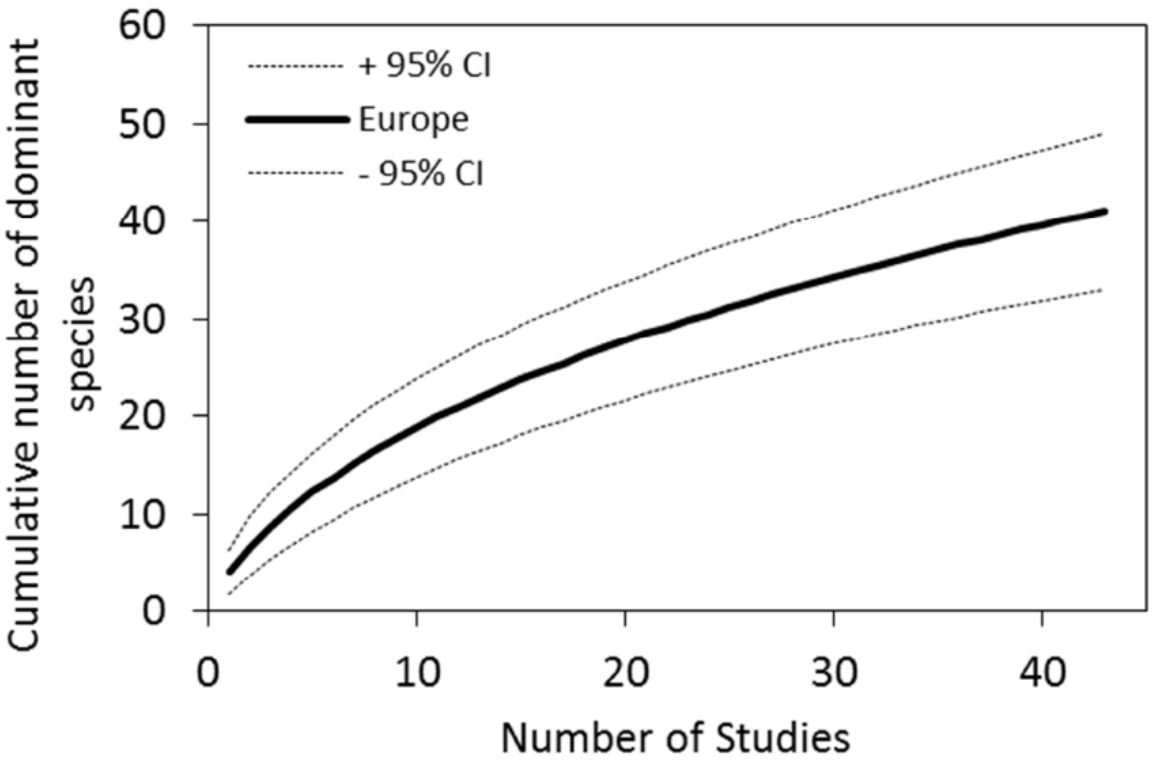



**Figure 1.** The cumulative number of dominant species (i.e. accounting for more than 5% of the total flower visitation rate) in 42 European studies examining visitation of crop flowers by wild bees. Honey bees were excluded from these analyses. CI: Confidence Interval.

Source: Kleijn & Scheper (2013) STEP project Deliverable 4.5

For UK crops, just **six** wild bee species were recorded as dominant visitors in multiple studies (>4)

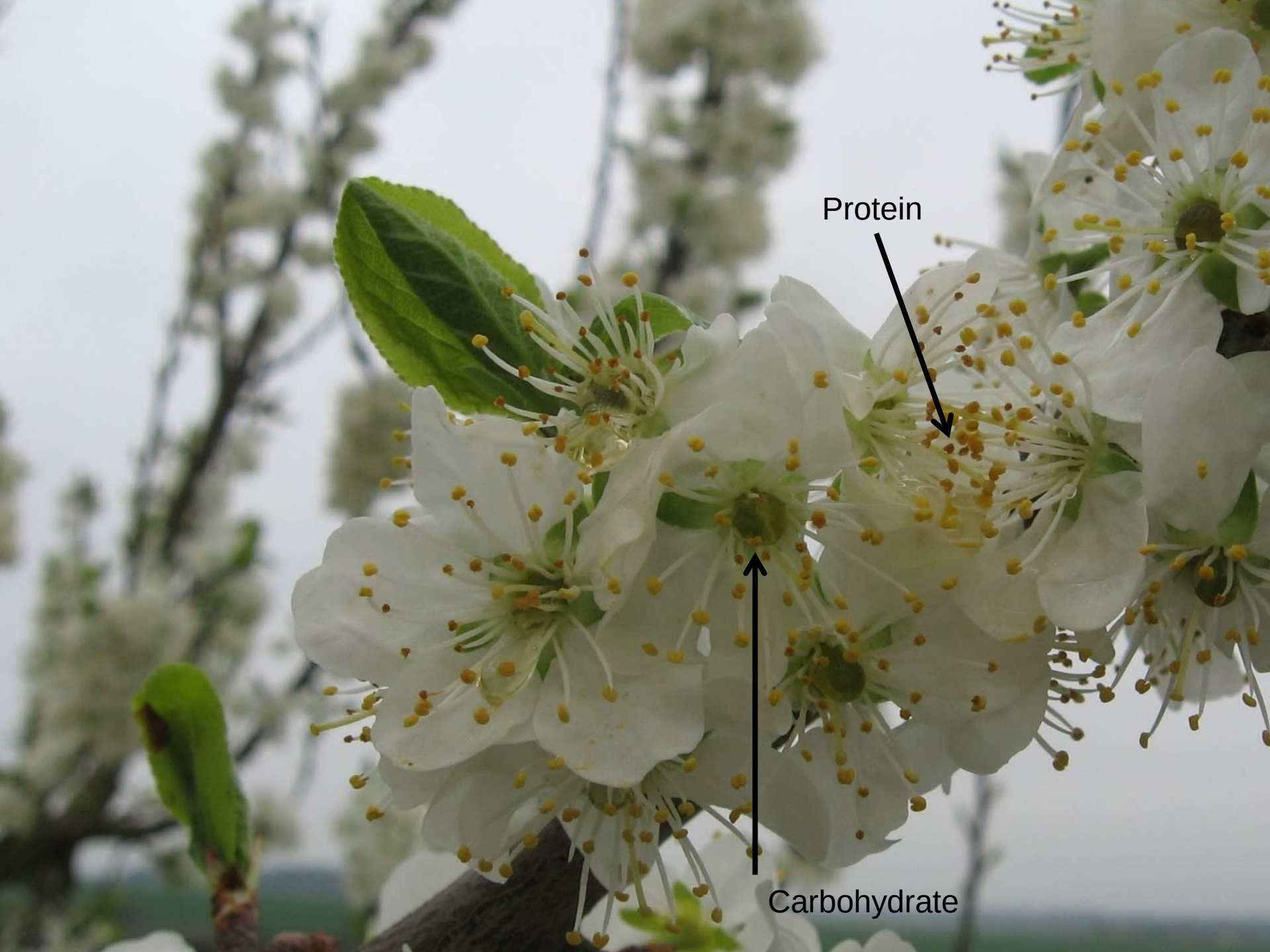
- *Bombus terrestris*
- *Bombus lapidarius*
- *Bombus pascuorum*
- *Andrena flavipes*
- *Andrena haemorrhoa*
- *Andrena cineraria*





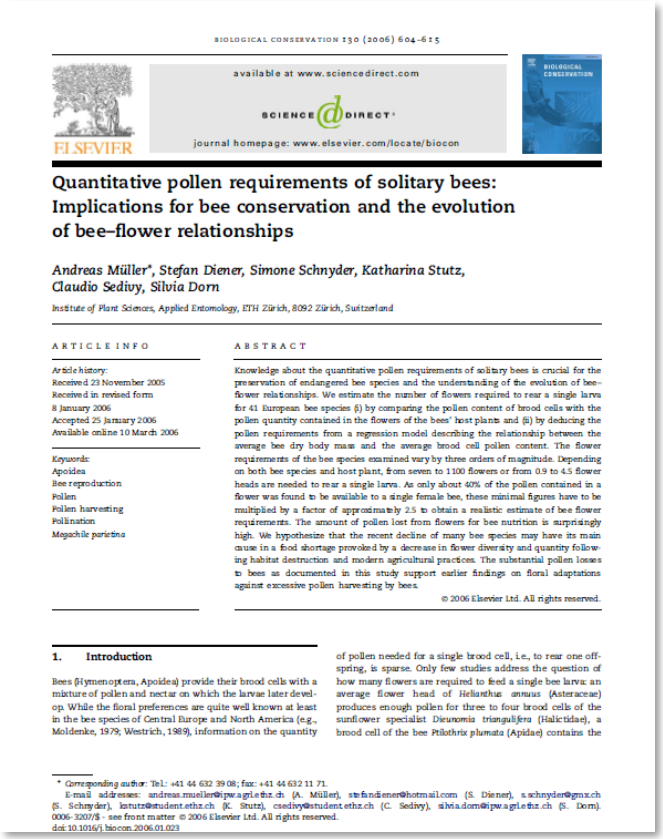


How many flowers do these bees need?


Protein
Carbohydrate

# How much pollen per 100 ha per month?

**Pollen demand / bee larva** x **No. bee larvae / month / nest** x **Density of colonies or nests / 100 ha** → **Pollen demand / month / 100 ha**



BIOLOGICAL CONSERVATION 130 (2006) 604–615

available at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/biocon

## Quantitative pollen requirements of solitary bees: Implications for bee conservation and the evolution of bee–flower relationships

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ARTICLE INFO

*Article history:*
Received 23 November 2005
Received in revised form
8 January 2006
Accepted 25 January 2006
Available online 10 March 2006

*Keywords:*
Apoidea
Bee reproduction
Pollen
Pollen harvesting
Pollination
*Megachile parietina*

ABSTRACT

Knowledge about the quantitative pollen requirements of solitary bees is crucial for the preservation of endangered bee species and the understanding of the evolution of bee–flower relationships. We estimate the number of flowers required to rear a single larva for 41 European bee species (i) by comparing the pollen content of brood cells with the pollen quantity contained in the flowers of the bees' host plants and (ii) by deducing the pollen requirements from a regression model describing the relationship between the average bee dry body mass and the average brood cell pollen content. The flower requirements of the bee species examined vary by three orders of magnitude. Depending on both bee species and host plant, from seven to 1100 flowers or from 0.9 to 4.5 flower heads are needed to rear a single larva. As only about 40% of the pollen contained in a flower was found to be available to a single female bee, these minimal figures have to be multiplied by a factor of approximately 2.5 to obtain a realistic estimate of bee flower requirements. The amount of pollen lost from flowers for bee nutrition is surprisingly high. We hypothesize that the recent decline of many bee species may have its main cause in a food shortage provoked by a decrease in flower diversity and quantity following habitat destruction and modern agricultural practices. The substantial pollen losses to bees as documented in this study support earlier findings on floral adaptations against excessive pollen harvesting by bees.



### 1. Introduction

Bees (Hymenoptera, Apoidea) provide their brood cells with a mixture of pollen and nectar on which the larvae later develop. While the floral preferences are quite well known at least in the bee species of Central Europe and North America (e.g., Moldenke, 1979; Westrich, 1989), information on the quantity of pollen needed for a single brood cell, i.e., to rear one offspring, is sparse. Only few studies address the question of how many flowers are required to feed a single bee larva: an average flower head of *Helianthus annuus* (Asteraceae) produces enough pollen for three to four brood cells of the sunflower specialist *Dieunomia triangulifera* (Halictidae), a brood cell of the bee *Ptilothrix plumata* (Apidae) contains the

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doi:10.1016/j.biocon.2006.01.023

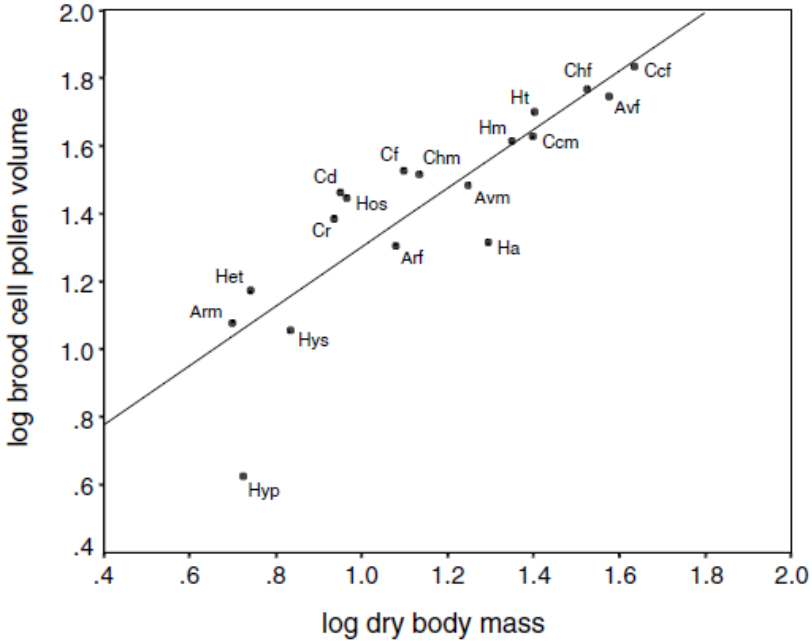



**Fig. 1 – Relationship between the average brood cell pollen volume and the average dry body mass of the 14 bee species examined. Linear regression $\log y = 0.868 \log x + 0.433$ ($F = 45.49$, $df = 17$, $p < 0.001$, $R^2 = 0.74$). Arf, *Andrena ruficrus***

Source: Muller, A., *et al*. 2006. *Biological Conservation* **130**:604-615.


*Andrena flavipes*
10-14 mm long
30-75 mm$^3$ pollen per larva
©BWARS.com

***Bombus terrestris***

**357-842 mg pollen per larva**

**= 210 - 772 mm$^3$ pollen per larva**

Sources:

Genissel et al (2002*). Entomologia Experimentalis et Applicata* **104**:329-336.

Ribeiro *et al*. (1996). *Apidologie* **27**:133-144.

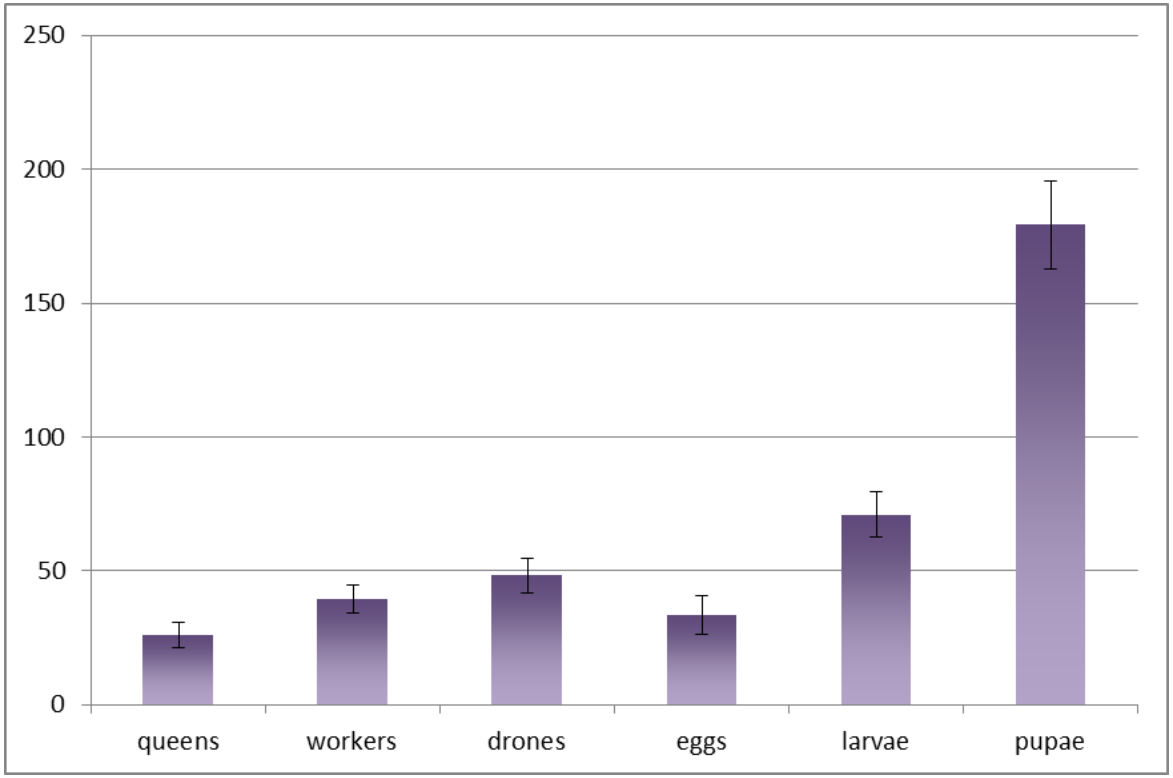
# How much pollen per 100 ha per month?

**Pollen demand / bee larvae** x **No. bees / month / nest** x **Density of colonies or nests / 100 ha** → **Pollen demand / month / 100 ha**


*Bombus terrestris*
around 400 individuals/colony

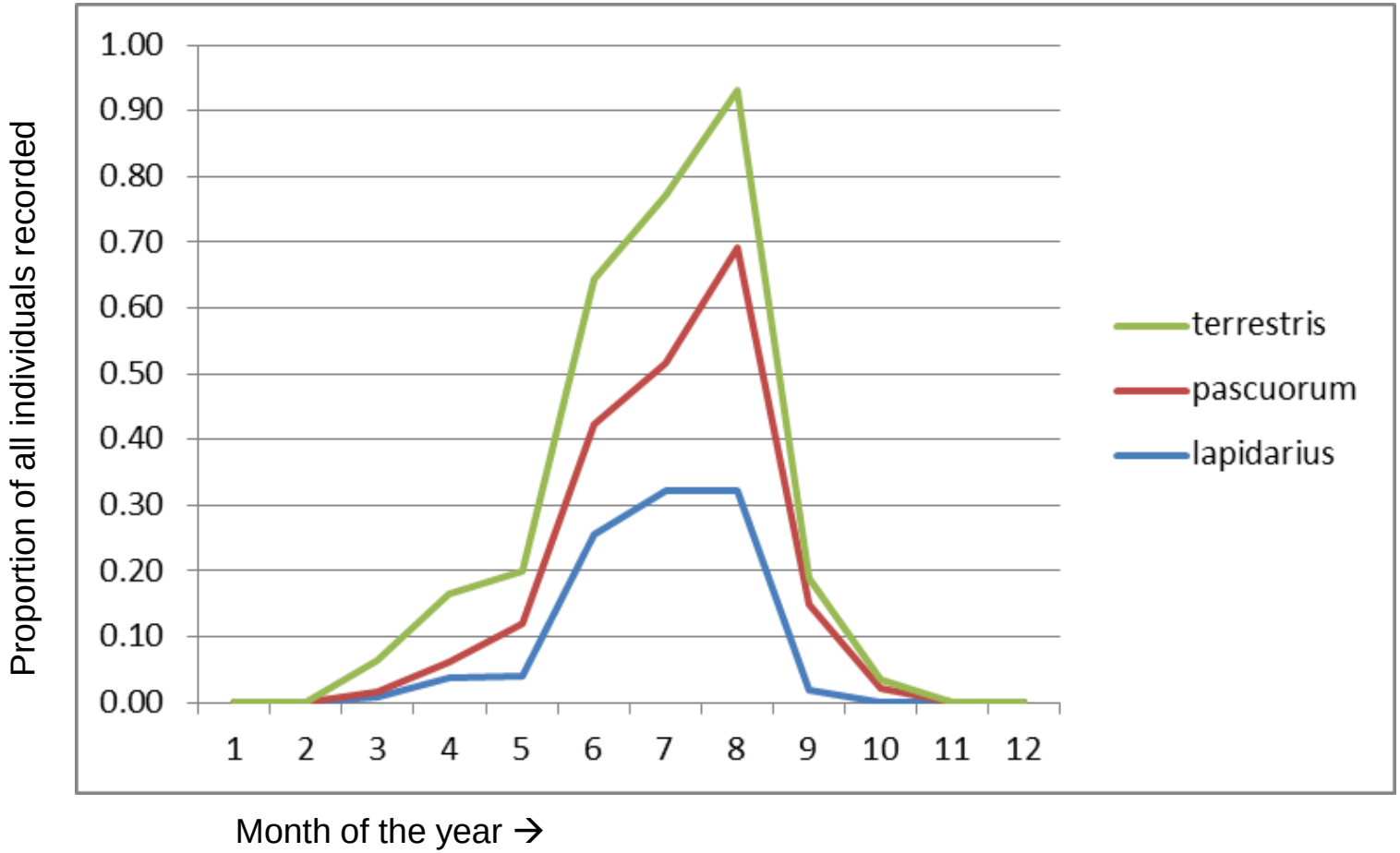
*Osmia lignaria*
around 3 offspring/nest

Williams and Kremen (2007).
*Ecological Applications* **17**:910-921




Source: Food and Environment Research Agency (2013)

# How many bees per month?

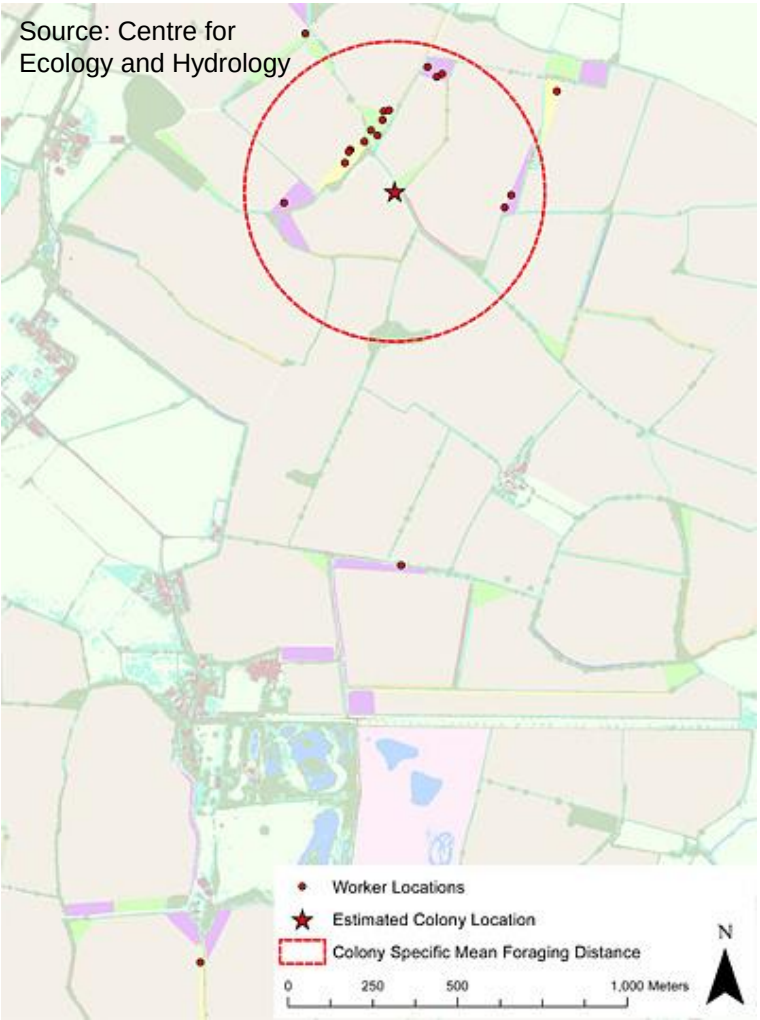



Bumblebee Conservation Trust

| | **UK flight period** |
|---|---|
| *Andrena flavipes* | Mar-Oct |
| *Andrena haemorrhoa* | Mar-Jul |
| *Andrena cineraria* | Mar-Jul |

# How much pollen per 100 ha per month?

**Pollen demand / bee larvae** x **No. bees / month / nest** x **Density of colonies or nests / 100 ha** → **Pollen demand / month / 100 ha**




*Bombus terrestris* **13-79** colonies/100 ha

*Bombus lapidarius* **35-117** colonies/100 ha

*Bombus pascuorum* **8-193** colonies/100 ha

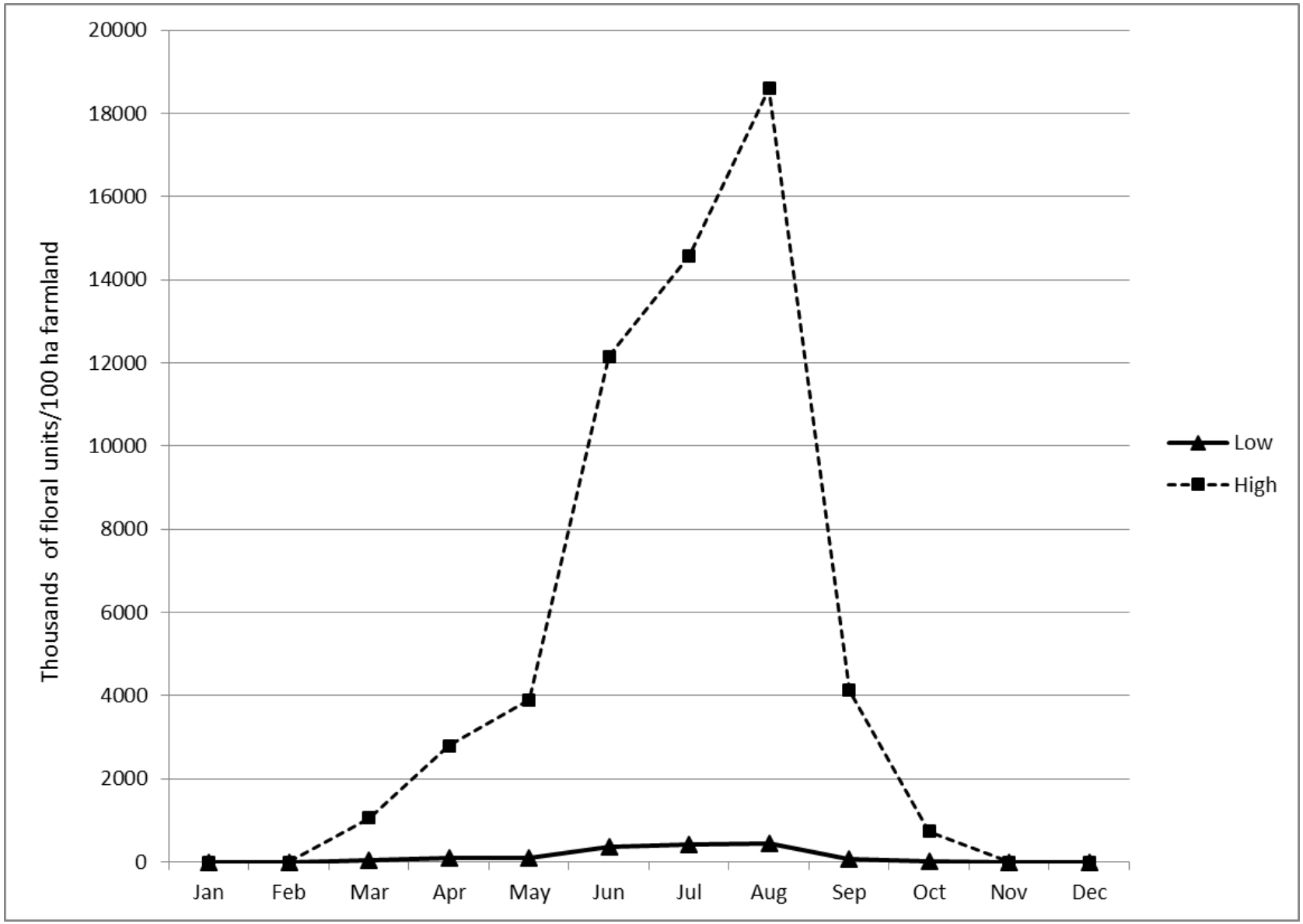
*Andrena* sp. **879-1,230** nests/100 ha

Average pollen production per **floral unit:**

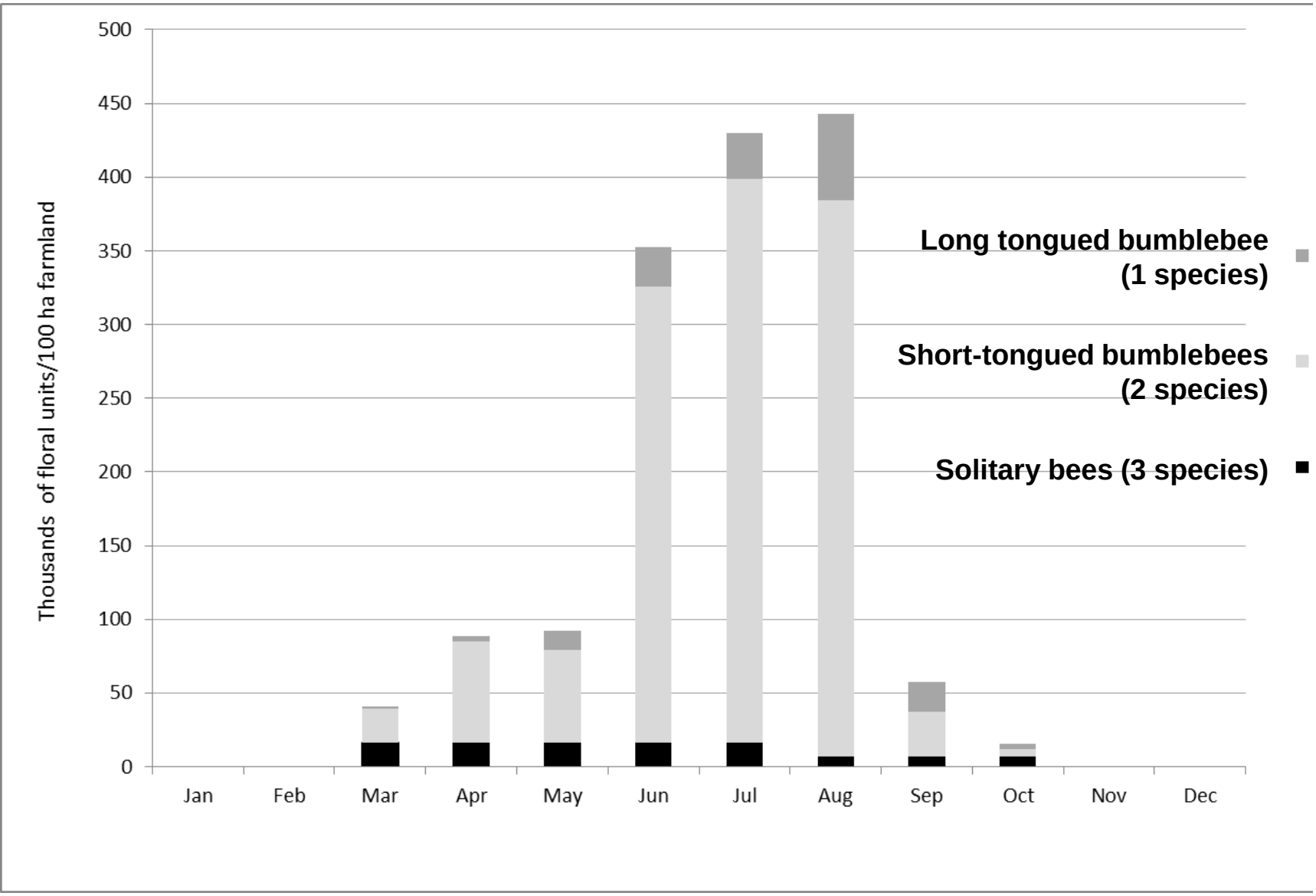
1.8 $mm^3$ (Dicks *et al.* 2015) or
3.2 $mm^3$ (Muller *et al*. 2006)

$$Number\ of\ floral\ units\ per\ 100\ ha = \frac{pollen\ demand\ per\ 100\ ha\ (mm^3)}{pollen\ per\ floral\ unit\ (mm^3)}$$

In the summer months, just six common bee species need between **350,000** and **18.6 million** average floral units per month per 100 ha to provide enough pollen for their young.



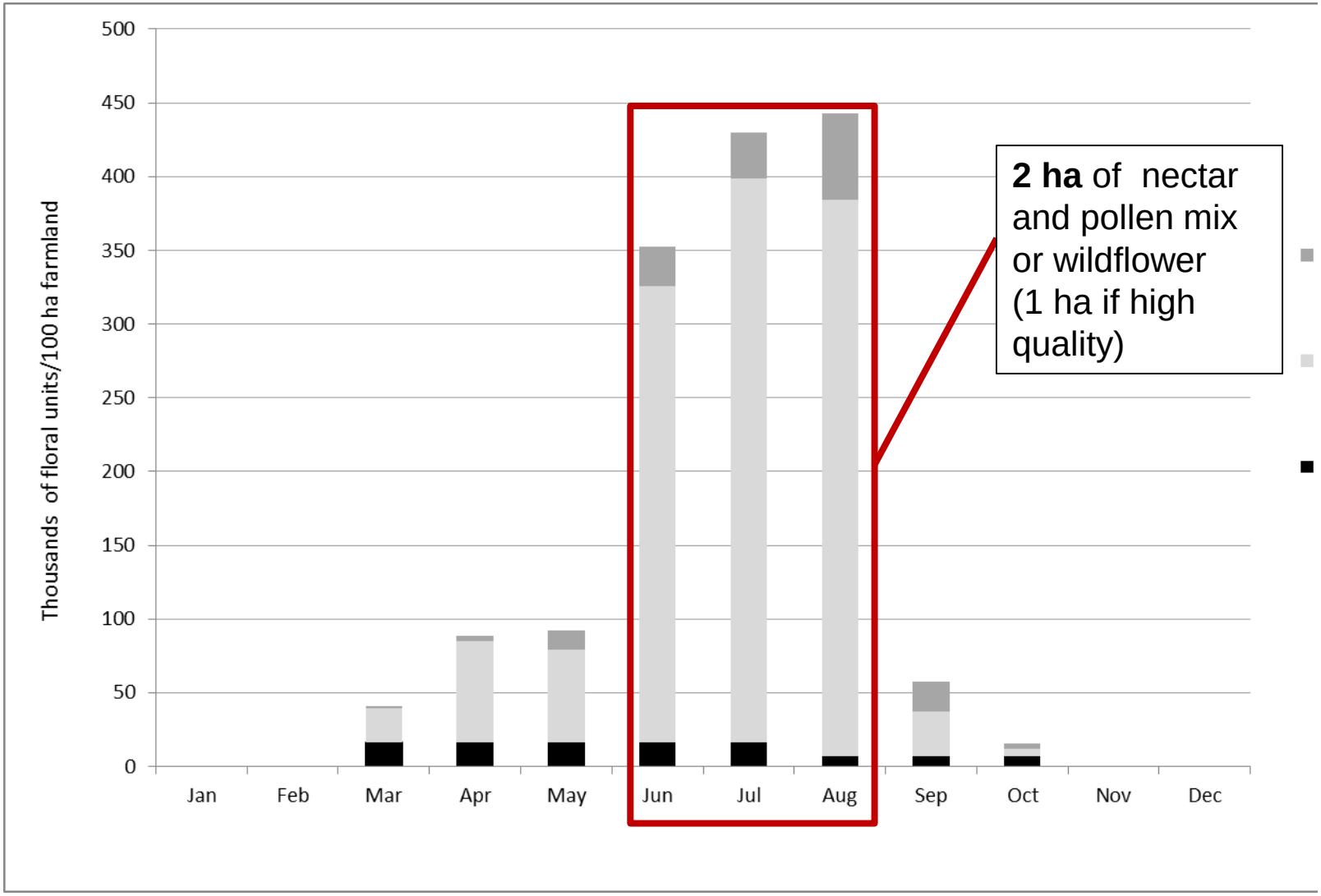

**Combined pollen demand for larval rearing, in floral units/100 ha, for six dominant crop-pollinating wild bee species**




**Low estimates of pollen demand for larval rearing, in floral units/100 ha, for the six wild bee species, broken into crude functional groups**

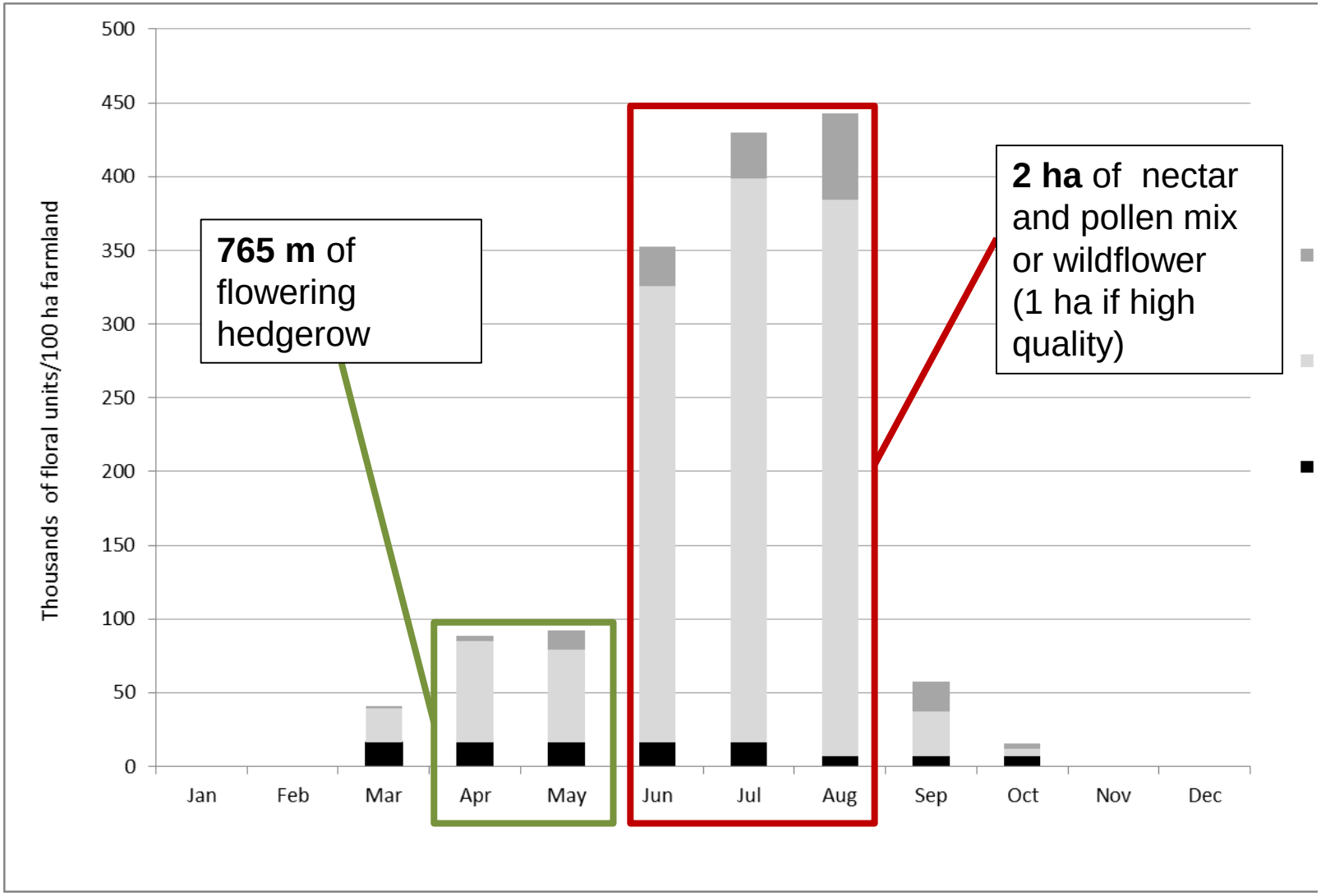
| Option and Entry Level Stewardship code | Source | Floral units /ha/month |
|---|---|---|
| Nectar flower mixture EF4 | Carvell *et al*. (2007) | 215,342 |
| Nectar flower mixture EF4 | Carvell *et al*. (2011) | 419,970 |
| Wildflower mixture EE3/ HE10 | Carvell *et al*. (2007) | 244,841 |
| Tussocky grass mixture EE3 | Carvell *et al*. (2007) | 19,525 |
| Uncropped natural regeneration EF11 | Carvell *et al.* (2007) | 73,124 |
| Cropped cereal headland EF9 | Carvell *et al*. (2007) | 34,916 |

# Low estimates of pollen demand for larval rearing, in floral units/100 ha, for the six wild bee species




| Hedgerow species | Month of flowering | Floral units/$m^2$ of 2m high hedge | Pollen/floral unit ($mm^3$) |
|---|---|---|---|
| *Prunus spinosa* | April | 1,328 | 0.28 |
| *Crataegus monogyna* | May | 5,585 | 0.33 |

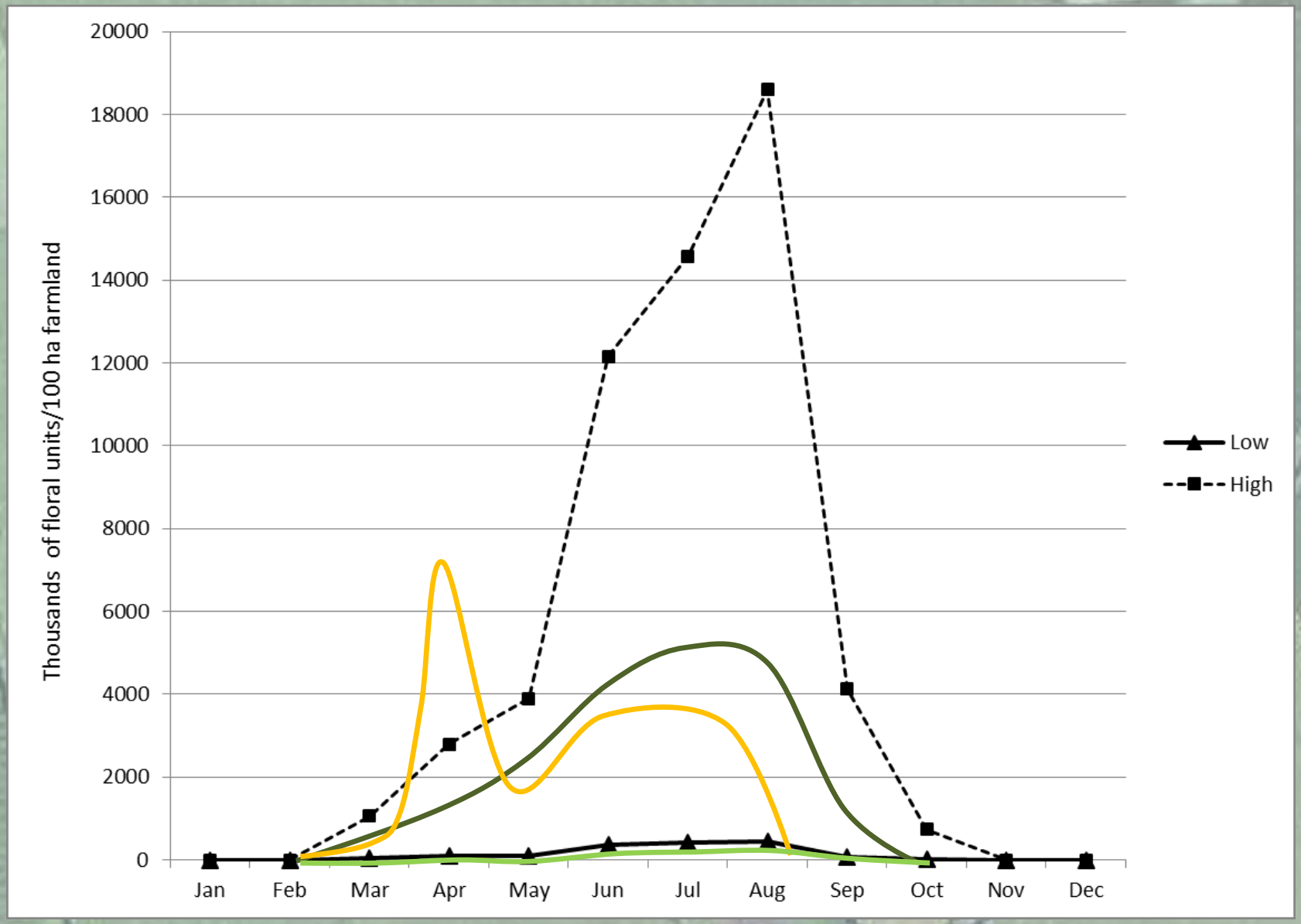
# Low estimates of pollen demand for larval rearing, in floral units/100 ha, for the six wild bee species




# The Wild Pollinator and Farm Wildlife Package

- 1-3 ha of flower-rich habitat for pollinators per 100 ha
- 500 m to 2 km of flowering hedgerow per 100 ha
- Sufficient to supply six common bee species with enough pollen to feed their larvae *at lowest estimates only,* with parameters at minimum levels

# How does the estimated pollen demand compare to existing provision of floral resources in real landscapes?



# Conclusions

How much flower-rich habitat is enough for wild pollinators?

- We answered, by providing a **bare minimum** pollen requirement, matched to areas of available management options
- We reveal a key knowledge need: **how much floral resource** is there in existing farmed landscapes?

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# Thank you

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Dicks *et al*. (2015) How much flower-rich habitat is enough for wild pollinators? Answering a key policy question with incomplete knowledge. *Ecological Entomology.*