UNIVERSITY of GUELPH
CHANGING LIVES IMPROVING LIFE

THE W. GARFIELD WESTON FOUNDATION

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Rebanks Family Chair in Pollinator Conservation

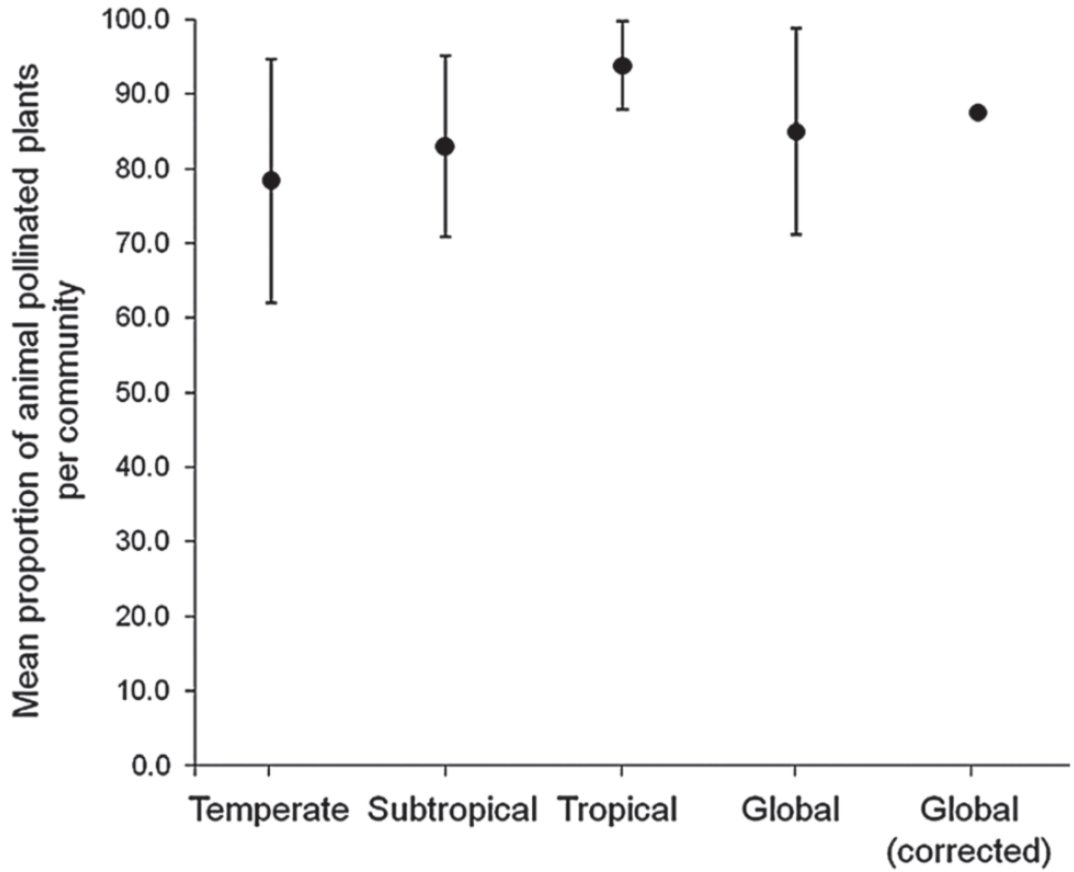
Protecting pollinators: why bees are struggling and how we can help

What are pollinators?

- Bees
- Hoverflies
- Other flies
- Beetles
- Wasps
- Butterflies
- Moths
- Birds

Pollination is a byproduct of animal foraging behaviour

Pollinators are essential for plant diversity



Around 87.5% of the 352,000 flowering plant species are pollinated by animals (Ollerton et al. 2011)

and food production

"**35%** of global production volume comes from crops that depend *to some extent* on pollinators"

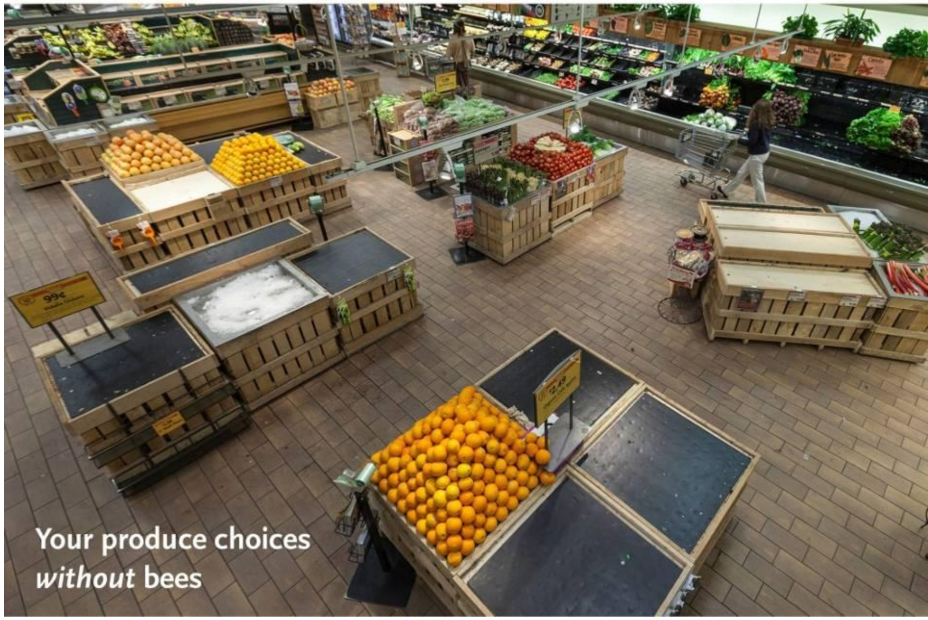
Klein *et al*. (2007) Proc Roy Soc B.

Yield losses without pollinators

25% **40-90%** **>90%**

Essential ecosystem services

"Every third mouthful of food we eat is dependent on the unmanaged pollination services of bees" (Buchmann & Nabham 1996)



Total global economic value of crop pollination was worth an estimated **$425 Billion** (Lauterbach et al. 2012)

PR Newswire/Whole Foods Market

Wild and managed bees

Honeybees

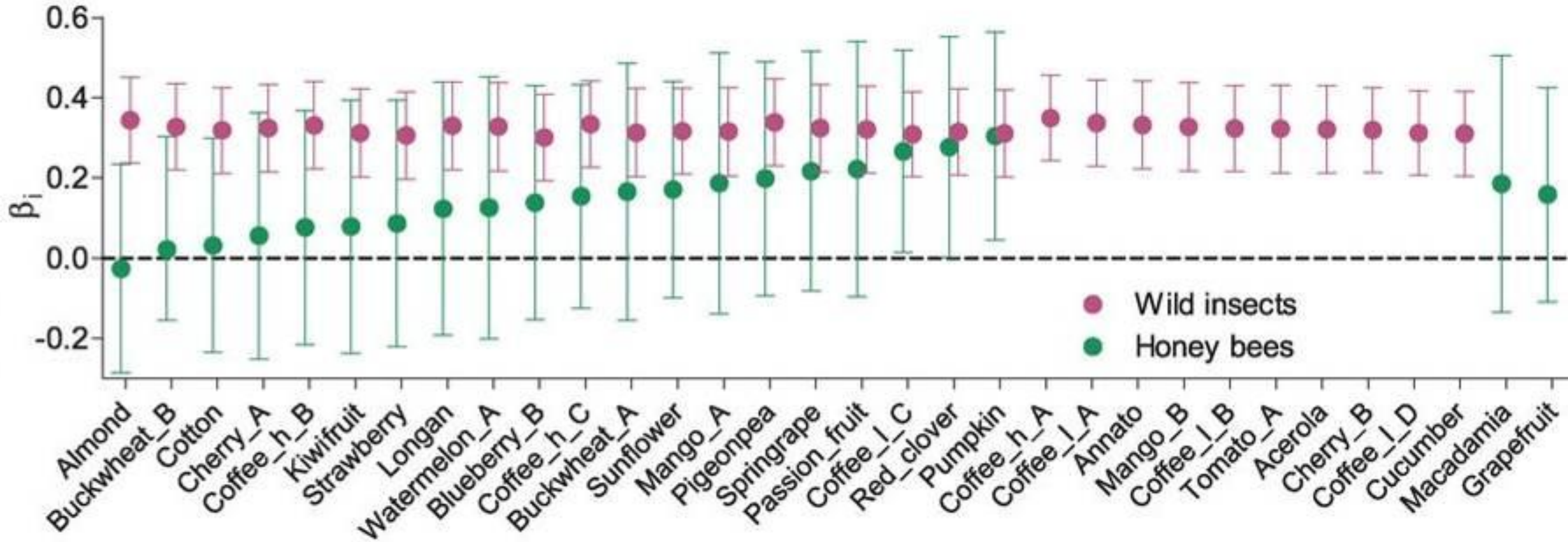
Managed

Bumblebees

Solitary bees

Wild

Wild insects pollinate crops



βi = regression coefficient

βi>0 means a positive slope between number of insects and fruit set

Garibaldi *et al.* (2013) *Science*

Food supply: a global challenge

	World Population *(billion)*	Arable Land & permanent Crops *(billion hectares)*	Farmland per Person *(hectares)*
1950	2.5	1.3	0.5
1975	4.0	1.4	0.4
2000	6.0	1.5	0.3
2020	7.5	1.5	0.2
	+200%	**+15%**	**-60%**

Source: United Nations

Feeding 9 billion people by 2043?

Global pollinator crisis

Plan BEE

OPERATION Pollinator

THE BEE CAUSE

Declines in bumblebees (UK)

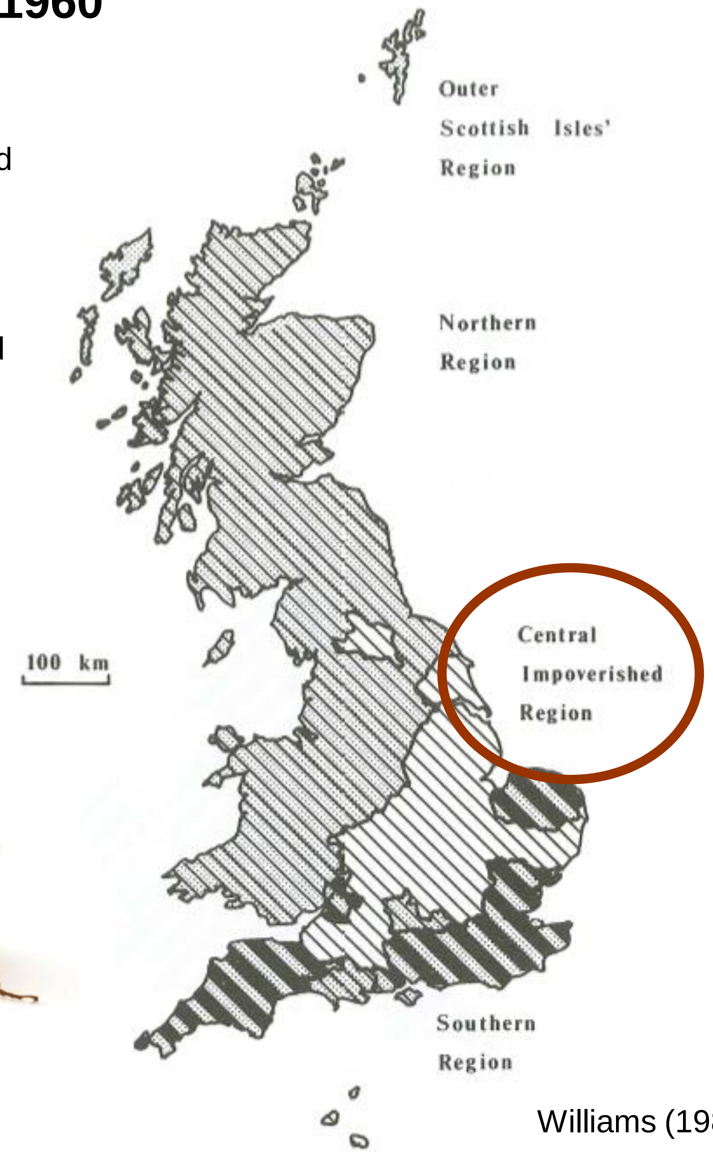
Before 1960

Widespread throughout

Local but widespread

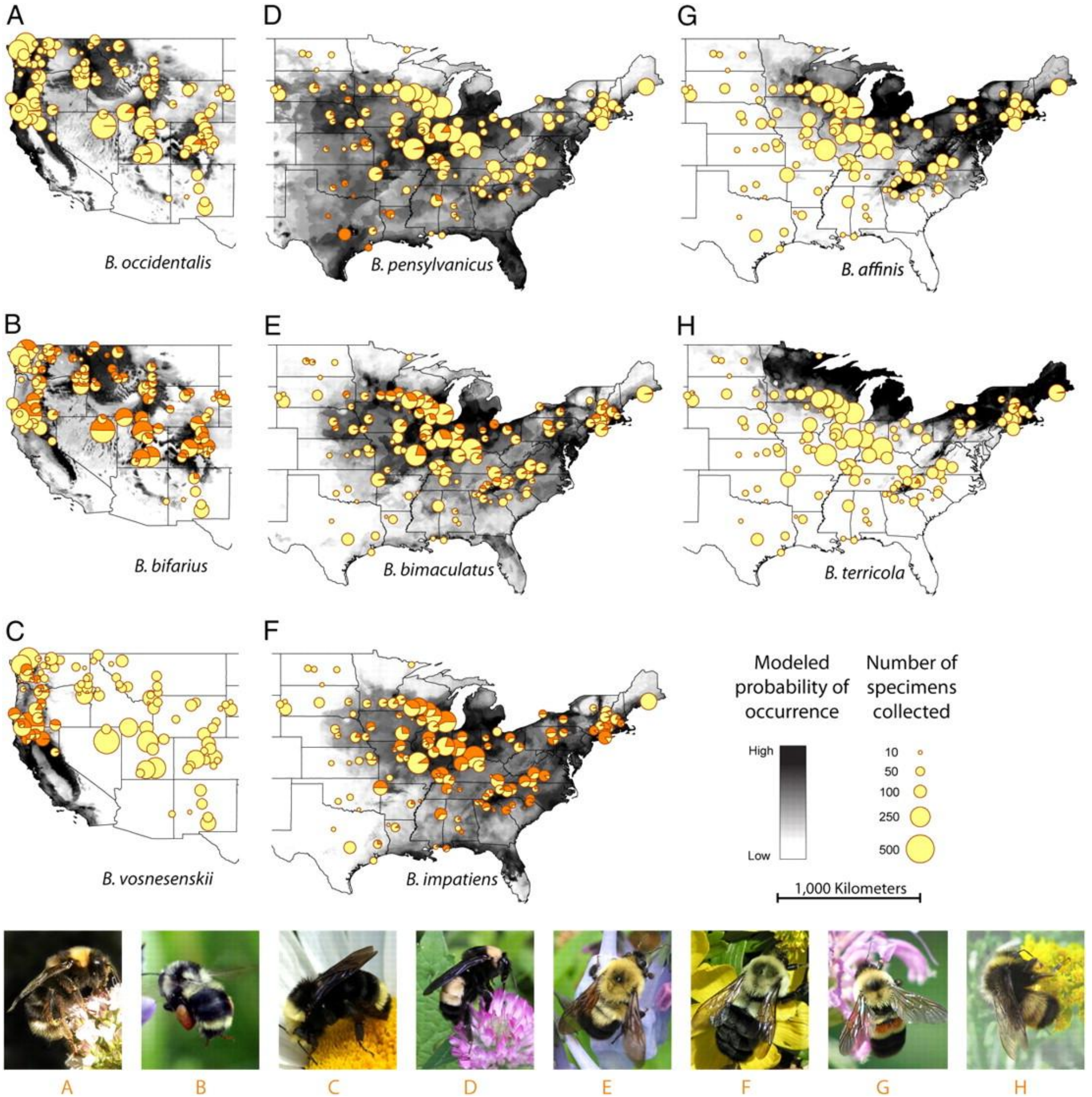
Local and southern

After 1960



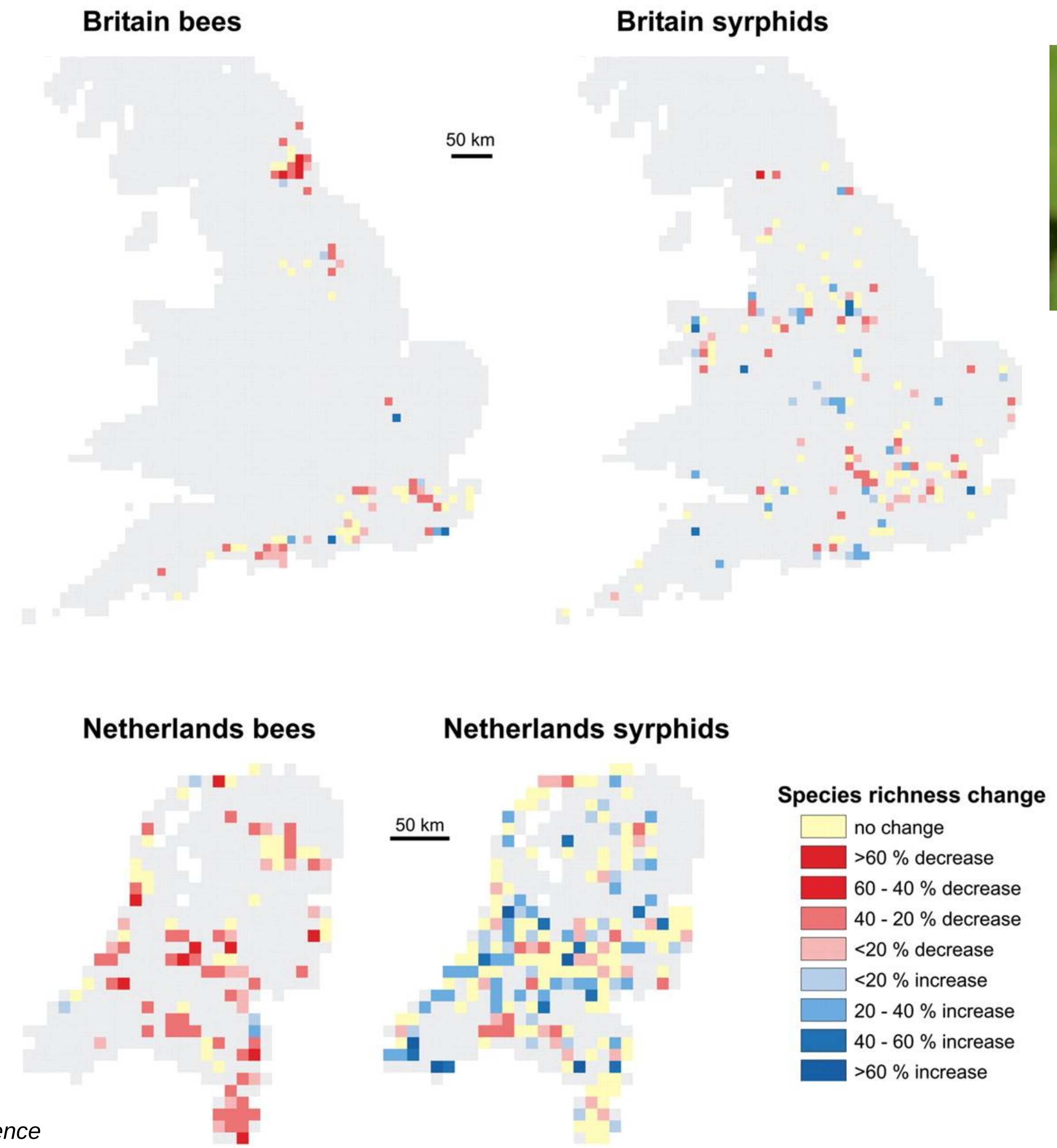
Williams (1982)

Declines in bumblebees (N. America)



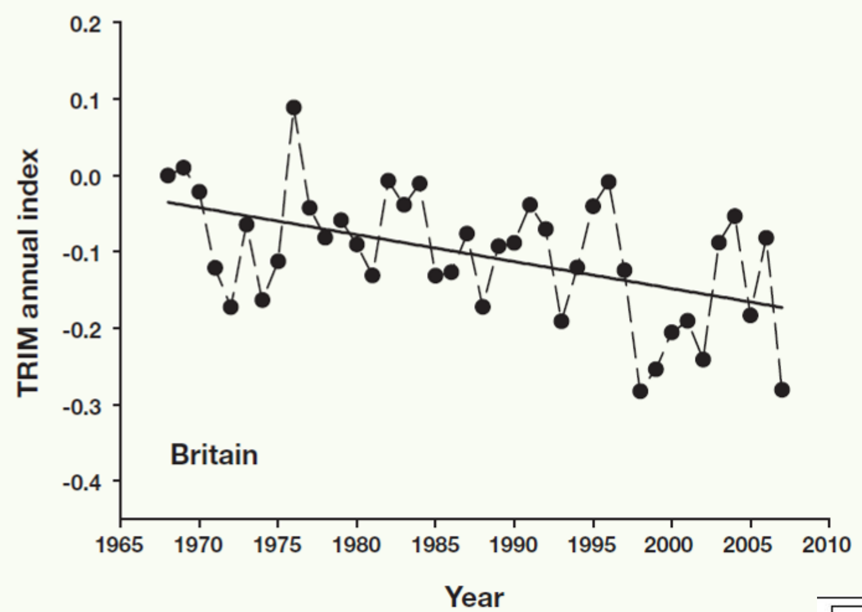
Cameron et al (2011) *PNAS*

Declines in wild pollinators



Biesmeijer *et al.* (2006) *Science*

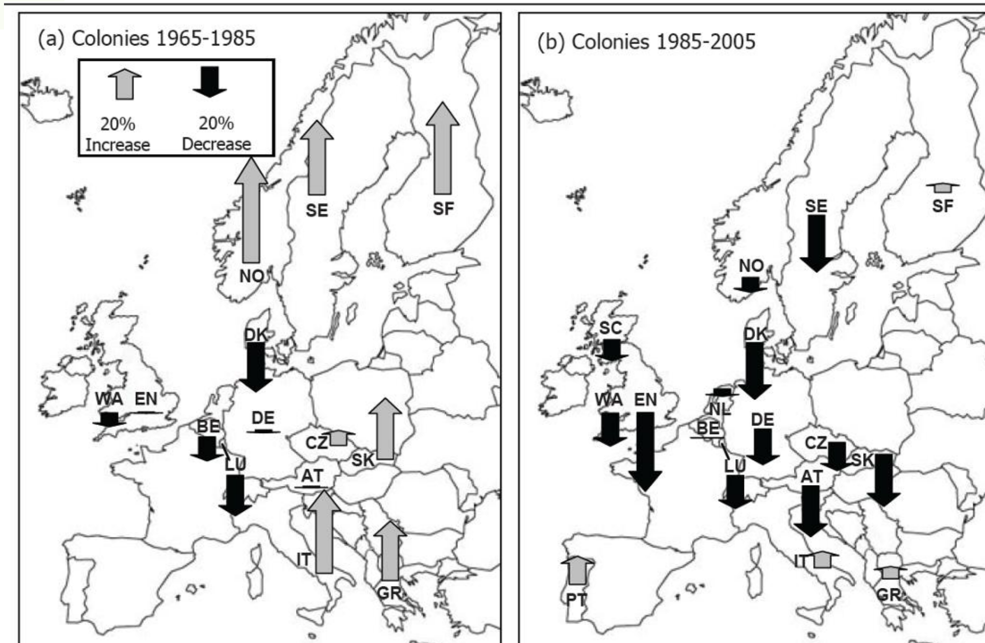
Figure 1 Change in the total abundance of all larger moths caught in the Rothamsted light-trap network 1968-2007.



And also... butterflies

Fox *et al.* (2013) *Butterfly Conservation*

Managed honeybees



Potts *et al.* (2009) *Journal of Apicultural Research*

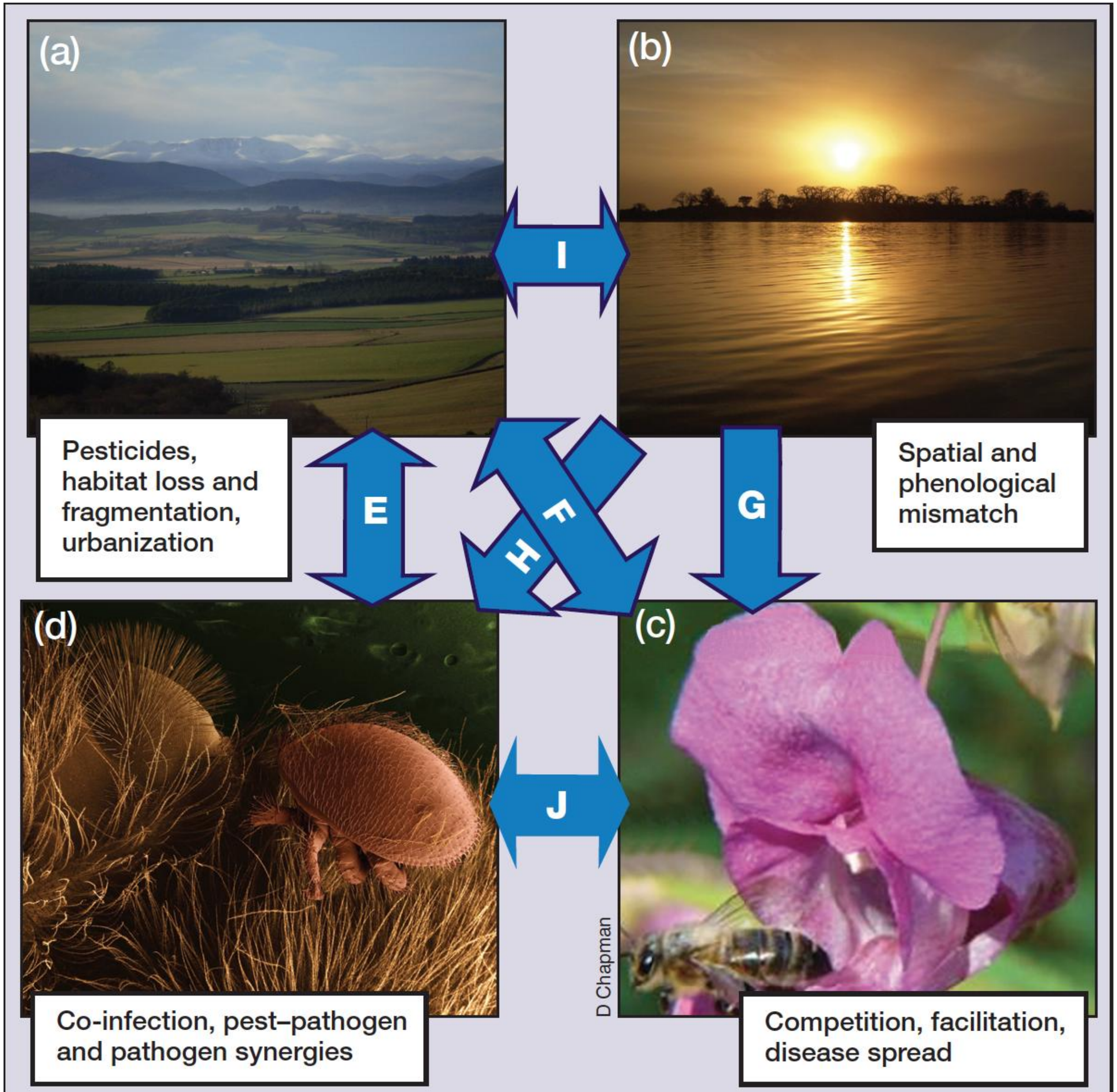
Key pressures on pollinators

Land use intensification

Climate change

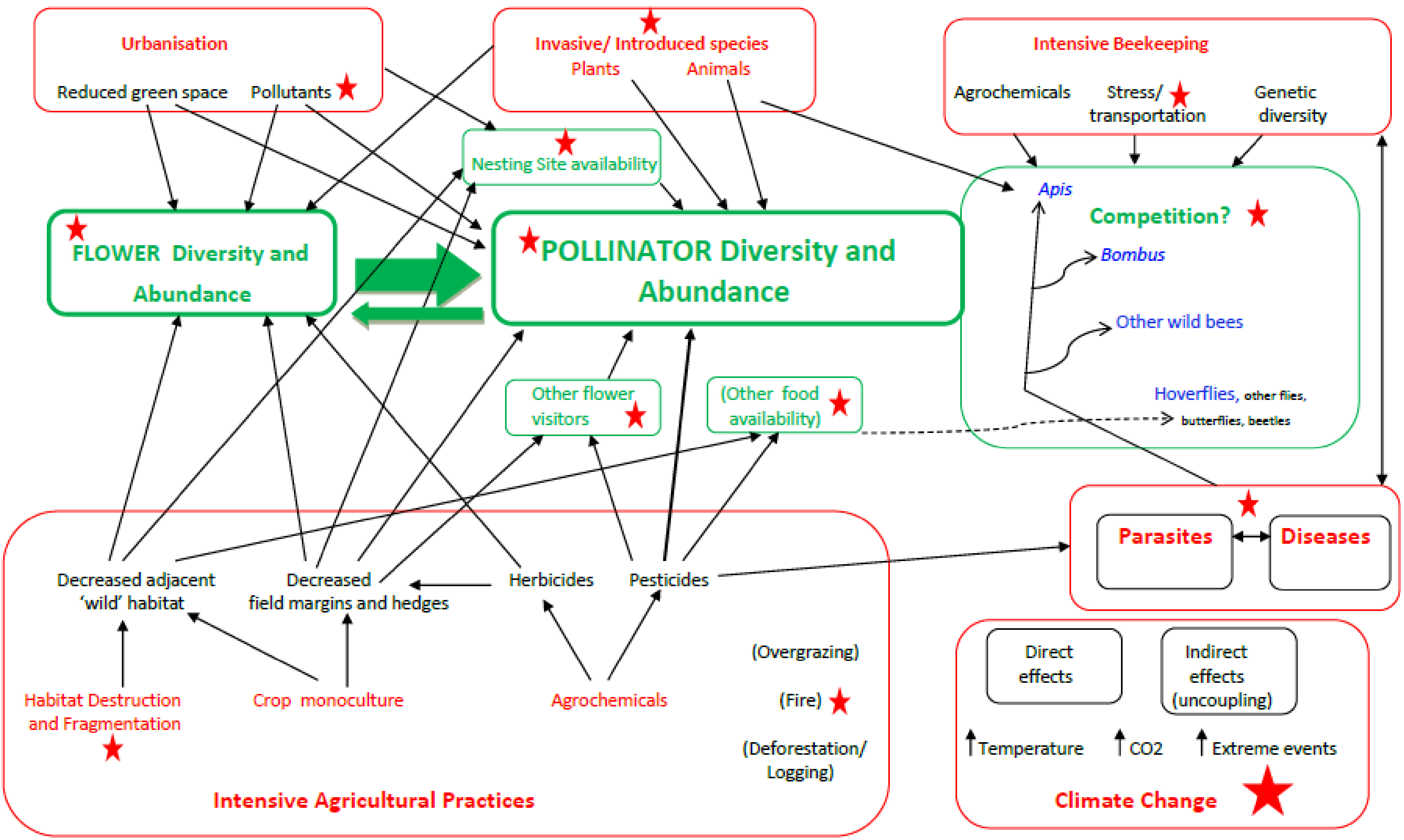
Parasites & pathogens

Alien species



Vanbergen et al (2013) Frontiers in Ecology and the Environment 11:251-259.

Key pressures on pollinators



Habitat Destruction and Fragmentation

Very obvious biodiversity effects, including:

- Potential loss of key animal-plant interactions (isolation & edge effects)
- Increased loss of specialist species
- Inbreeding depression and increased genetic drift
- Increased extinction risk for very small populations

Increased scale of monocultures

Fewer marginal lands and adjacent natural habitat, inevitably linked to loss of pollinator resources:

- Far fewer flowers and reduced floral diversity
- Loss of flower availability through full active season for pollinators; creates need for plants with long flowering seasons
- Fewer nest sites
- Fewer larval host plants (especially for butterflies)



How might agrochemicals affect bees?

Bees encounter multiple pesticides on crops which may affect individual behaviour and colony function

sprays, seed treatments and dust

Miticides

Herbicides

Sublethal behavioural effects

Motor function

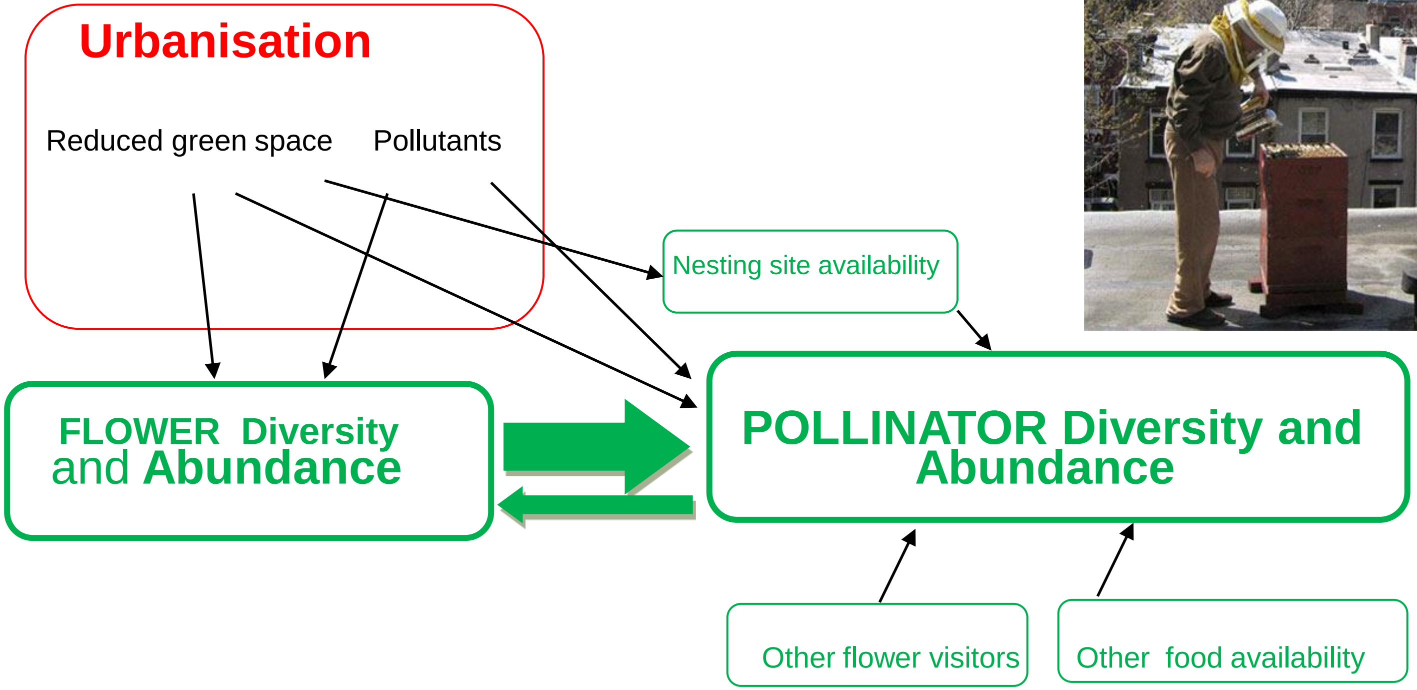
Feeding

Learning

Homing

Foraging

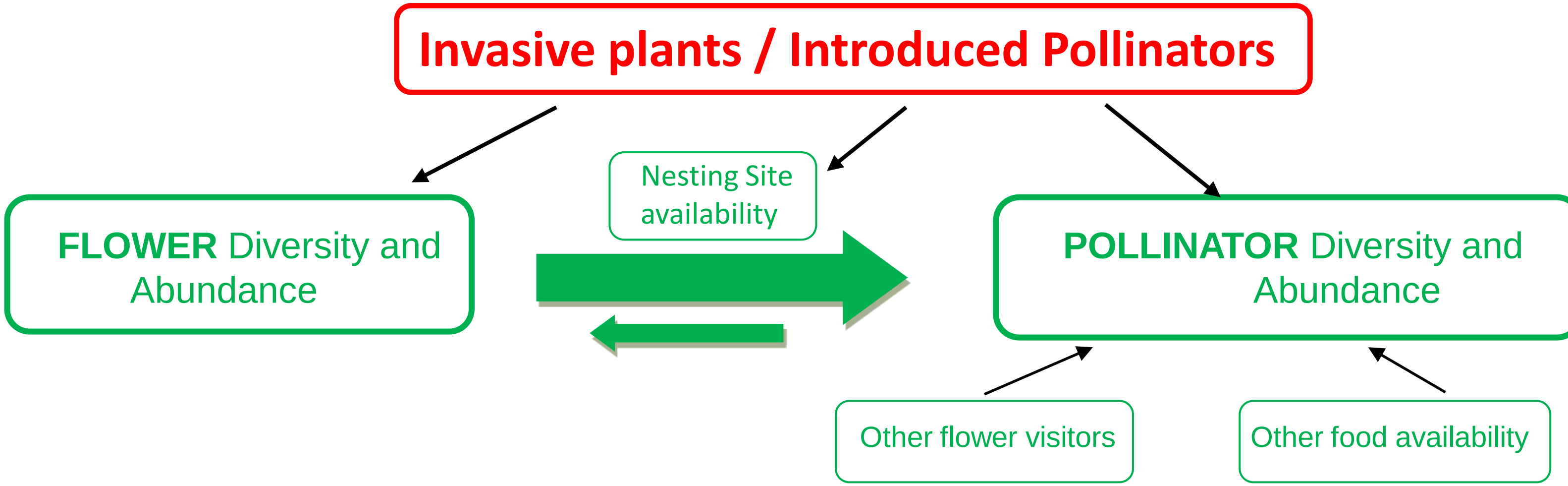
Reproduction



Larger insects (including bumblebees) do better than small bees and syrphids overall, small late-active bees also do well

Urbanisation may be the main driver of declines in more recently developing countries, eg. Brazil

Habitat enhancement: more ‘good’ flowers, for longer and nest sites and larval host plants.



Introduced species often act as ‘super-generalists’ and may disrupt normal animal-plant interactions

Honeybees may have impacts on native bees through competition, particularly africanised bees

Commercial bumblebees established outside native range: eg New Zealand, Tasmania, Japan, Chile, Mexico

Introduced plants

Invasive plants may 'swamp the pollination market', and reduce seed set in native plants.

Exotic introductions may promote local generalists but have negative effects on specialists

Introduced garden hybrids
complex, unusual + double/triple flowers: poor pollinator access to rewards

Education: garden-centre labelling, promoting heritage varieties

Honeybees

Bumblebees

Other wild bees

Hoverflies and others

Parasites and Diseases

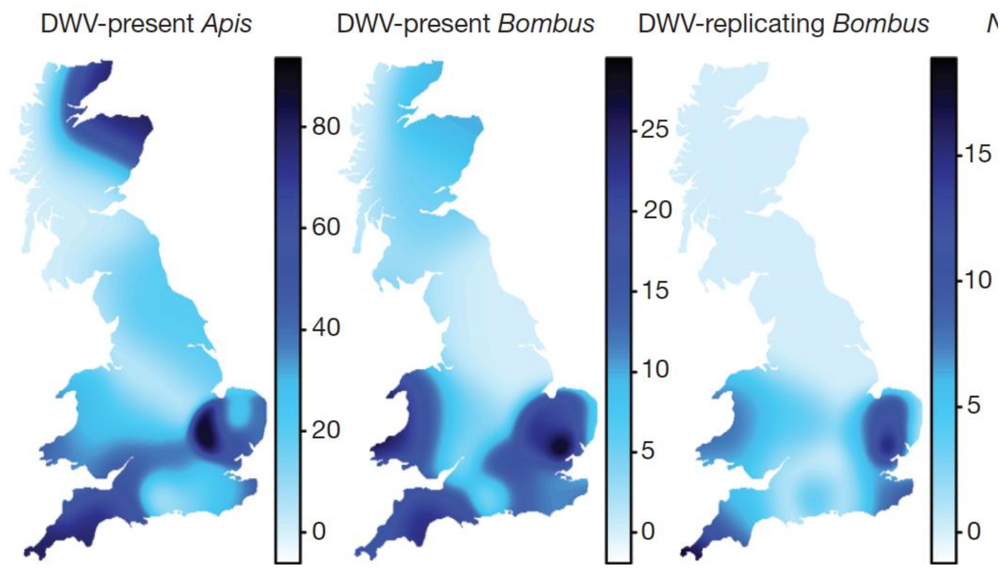
Varroa mite + viruses are a serious issue for honeybees

ion

d

mate

change, agrochemicals



Climate Change

Extreme event mortality (e.g. flooding ground nesters)

Warming causing pollinator range change - increased abundance or diversity at higher latitudes/altitudes?

Warming causing pollinator phenology & activity period changes (e.g. greater winter activity of urban bumblebees)

Specialists more at risk of loss

Maintenance of pollinator biodiversity is key to buffer these unpredictable effects

What can we do to help?

Nesting sites

Ground nests

Wood tunnel nests

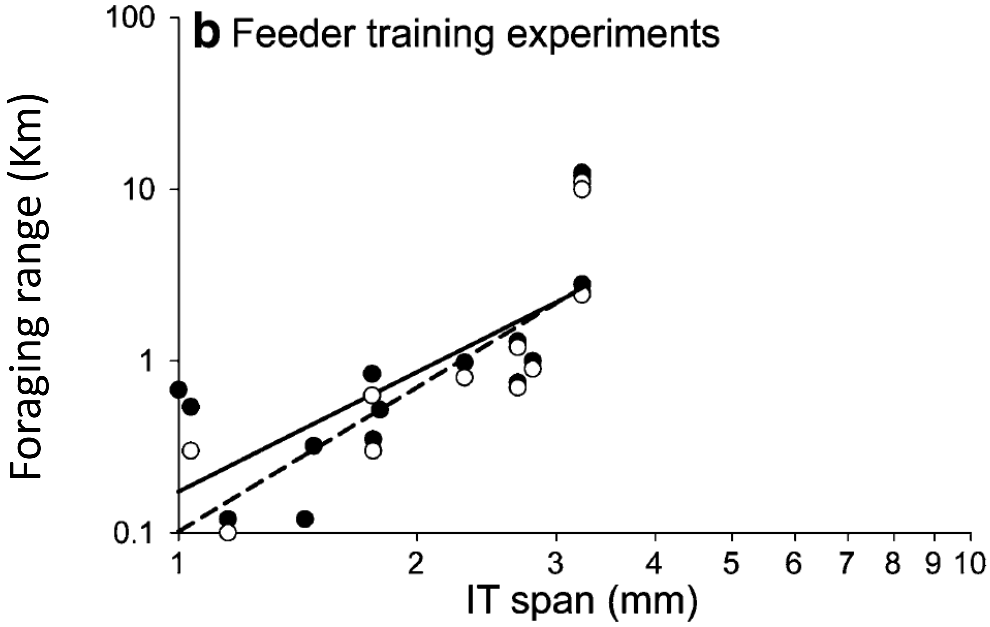
Brush piles, tussocky grass – great for hibernation sites

Nesting sites – bee hotels

Consider landscape from pollinator perspective

Connect the landscape:

Spatially – how far do pollinators move?



Hedgerow corridors

Consider the timing + duration of flowering when planting

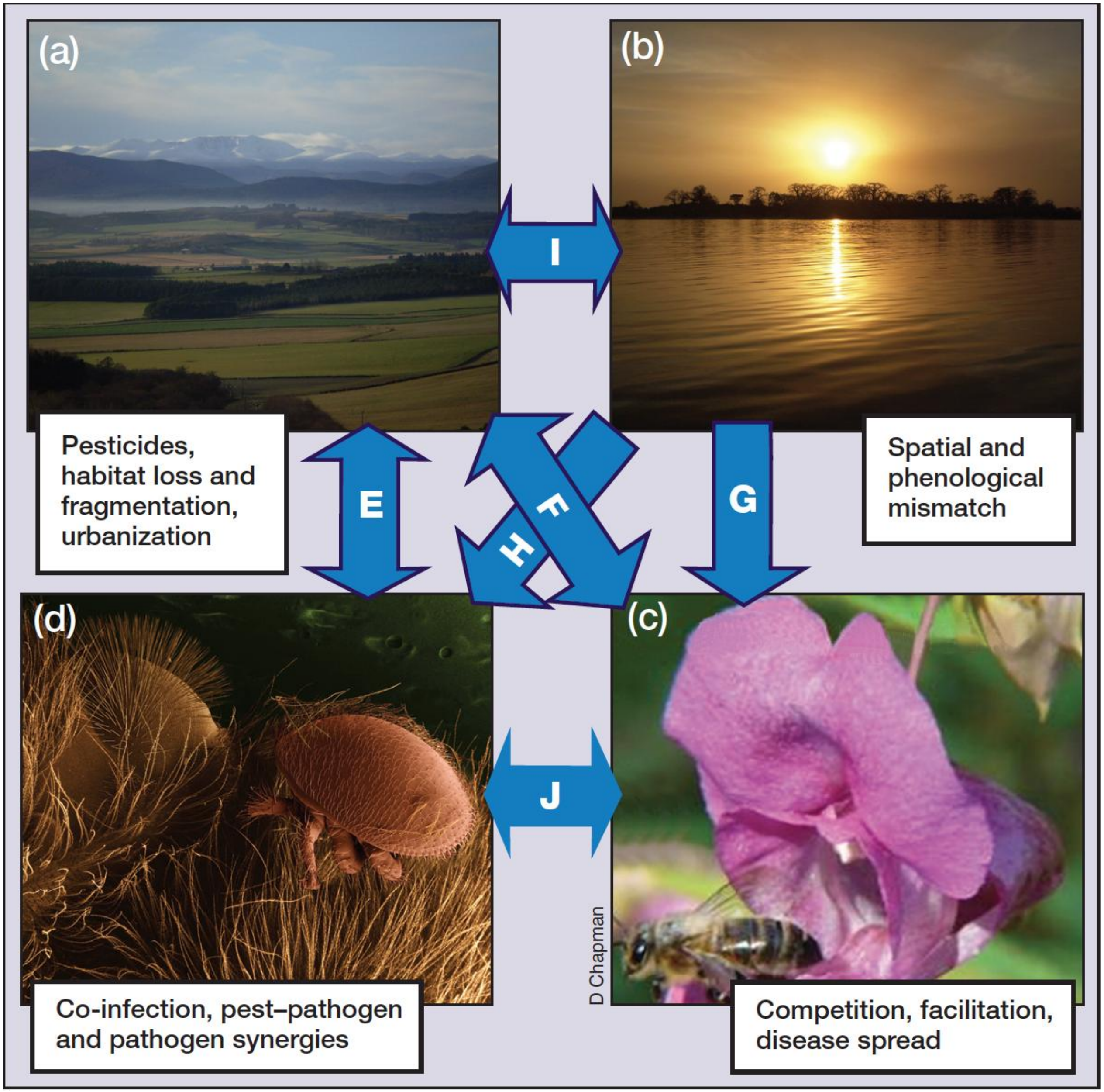
Reducing pressures for pollinators

Land use intensification

Climate change

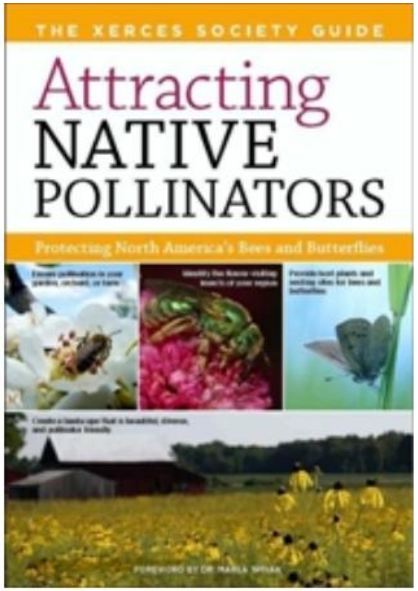
Parasites & pathogens

Alien species



Vanbergen et al (2013) Frontiers in Ecology and the Environment 11:251-259.

Pollinators, planting + management resources



Resources for Great lakes area:

http://www.xerces.org/pollinators-great-lakes-region/

POLLINATOR PARTNERSHIP
Protect their lives. Preserve ours.
NAPPC

Planting guide for S. Ontario:

http://www.pollinator.org/PDFs/Guides/LakeErieLowlands.ver8.hires.pdf

Take home messages

Evidence suggests insect pollinators are in decline around the world, irrespective of habitat type.

Animals, particularly bees, play a major role in pollination for majority of wild plants and numerous major food crops

Land use intensification, climate change, invasive species and pathogens/ parasites are likely key drivers of pollinator decline, either singly or in combination

What can we do to help halt and reverse declines? Preserve & augment existing habitat, connect patches of ‘good habitat’ and reduce other environmental stressors to improve pollinator health

Habitat for food security and biodiversity

What can we do (2)

Establishing new habitat – augment existing patches at personal level (yard)

Creating suitable patches on land under pylons, field margins (need stakeholder/ corporate) engagement.

Photos of wild flower strips (farm), established habitat under power lines (Vicki)

Pictorial meadows… reduced grass mowing (at a time when resources less abundant/ less srongly)

What can we do (3)

Reduce other environmental stressors

Pesticides – cosmetic pesticide ban (check terms/ scope)

Reduce ‘prophyllactic’ use for growing food?

Photo of Linden trees (Oregon bee kill) to show what happens over the border…

Herbicides – do all non crop plants need removing from ag system/ personal homes. More flowers in lawns…?

Documented effects in the developed world

Habitat fragmentation (e.g. Carvell et al 2004)

- UK has lost 40% of hedgerow since the 1930s
- Particularly high bee losses occur in species-rich regions (Vamosi et al 2006)
- Generalists increasing in abundance, specialists decreasing (Biesmeijer et al 2006)

Abandonment of fallow fields / rotations

Many leguminous plants are no longer planted. Specific declines of long-tongued bees linked to this (Biesmeijer et al 2006; Goulson et al 2008).

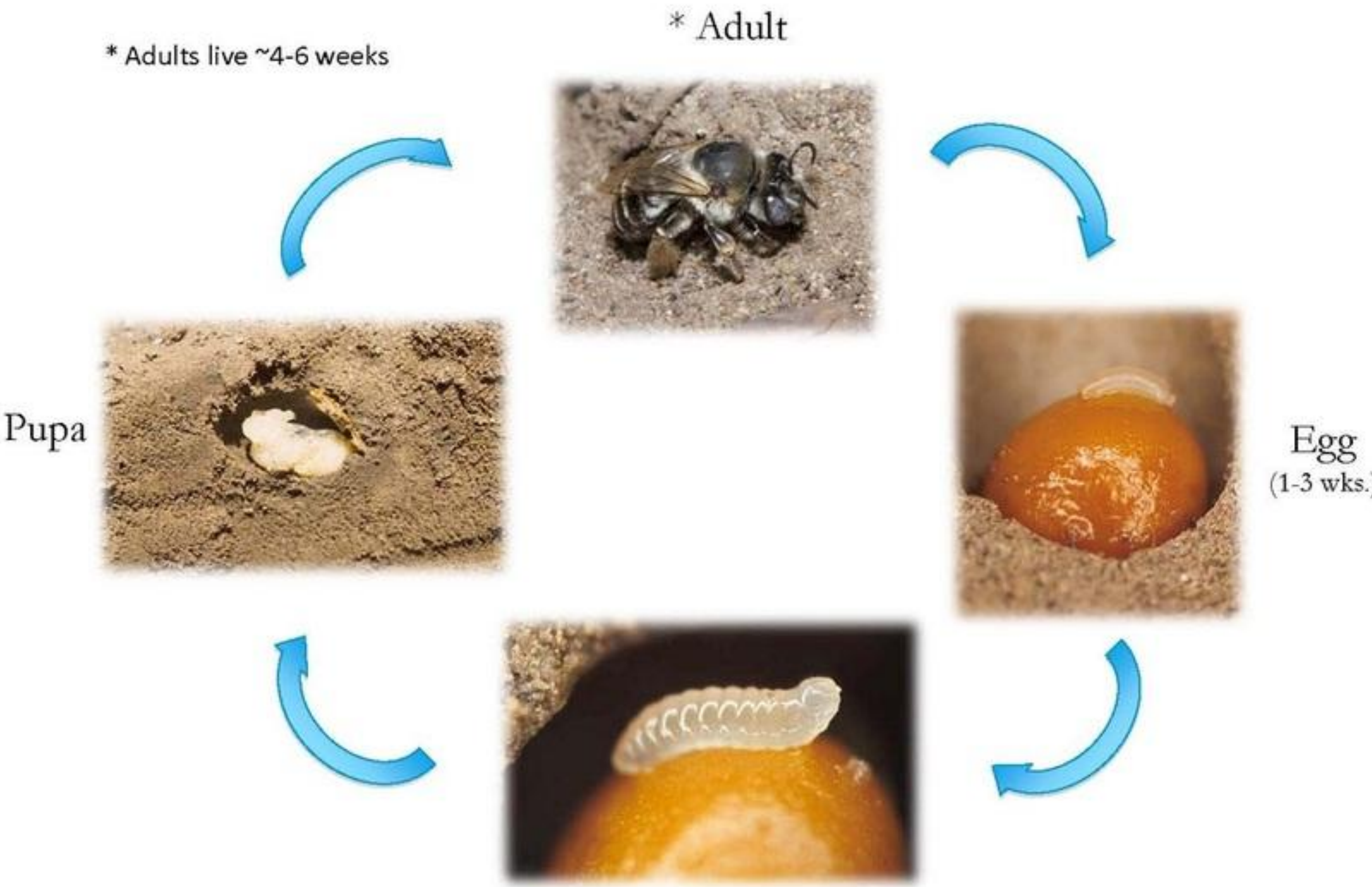
Biofuels

->15% increase 2005-2010; may require substantial pollinator activity (e.g. rape), potentially taking the service away from food crops and reinforcing need for good flower-rich field margins (e.g. Stanley & Stout 2013)

Agrochemicals

May persist in soil and/ or pollinator nests longer than previously thought

Solitary bee lifecycle

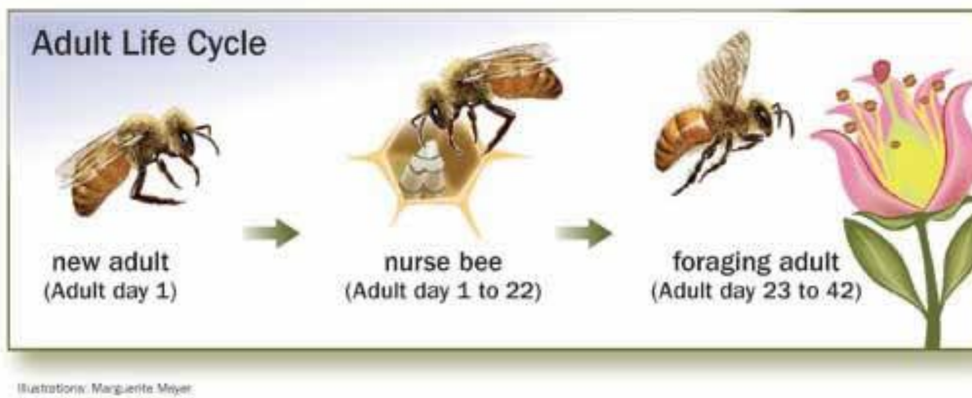


Photos by R. Thorp, R. Coville, and Dennis Briggs

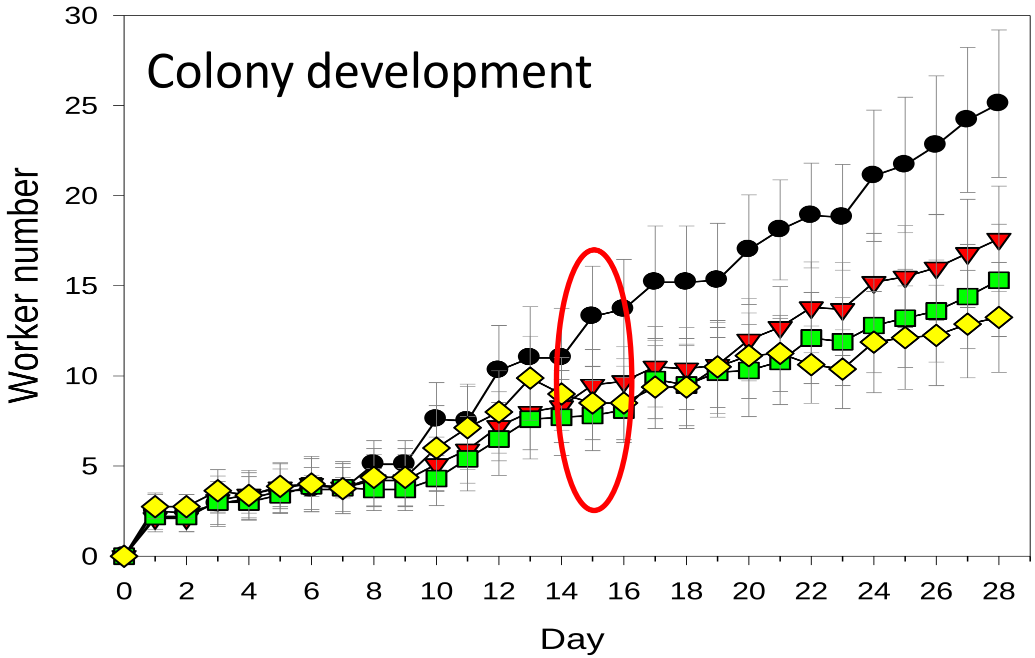
Bumblebee lifecycle

Colony maturation

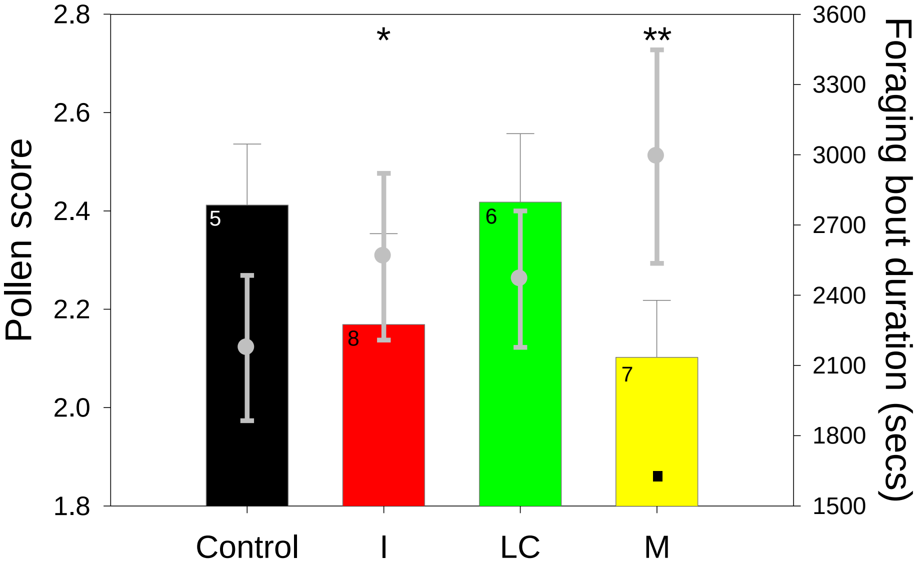
Honeybee lifecycle



Combined effects of pesticides



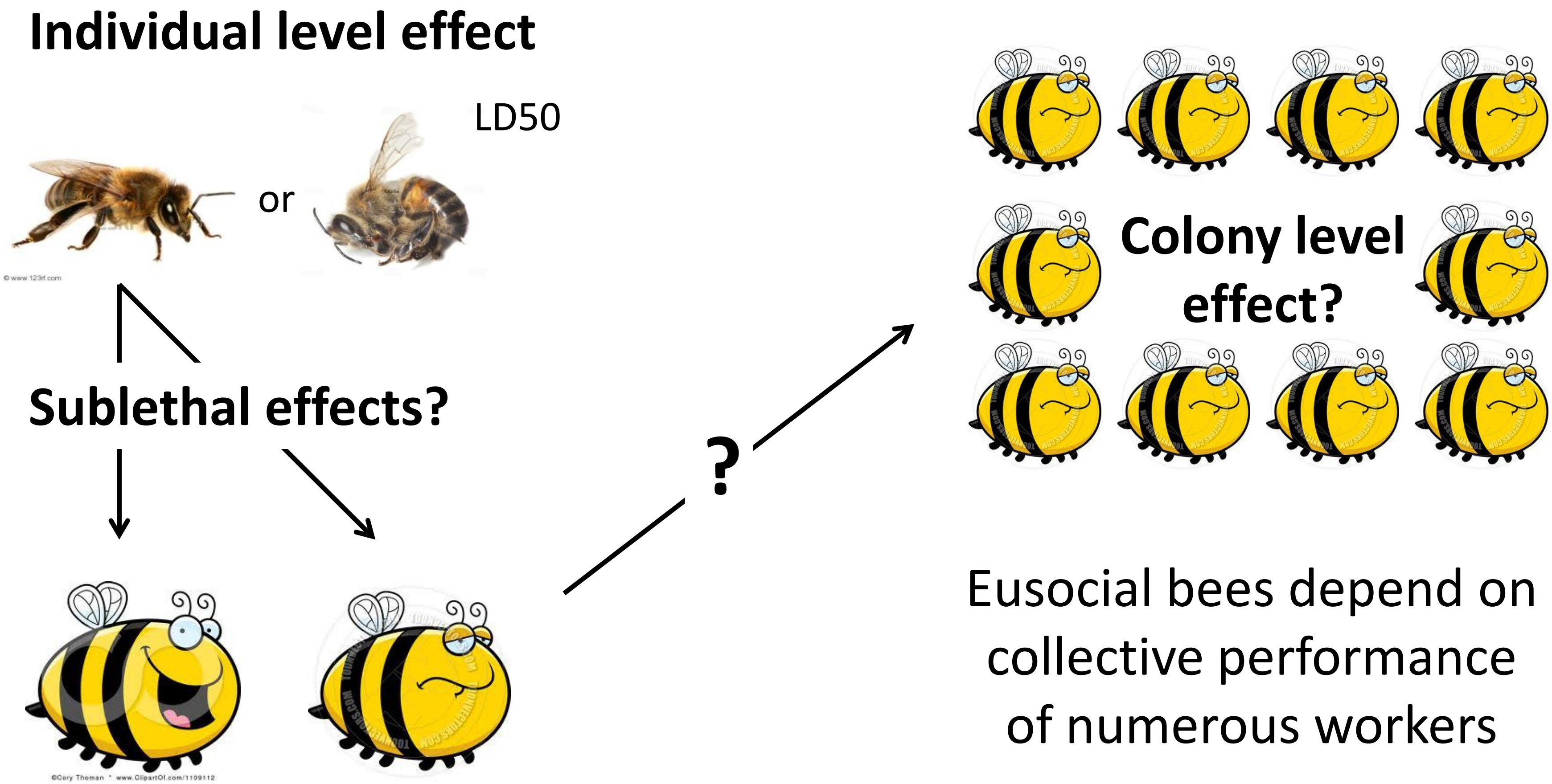
Pollen foraging



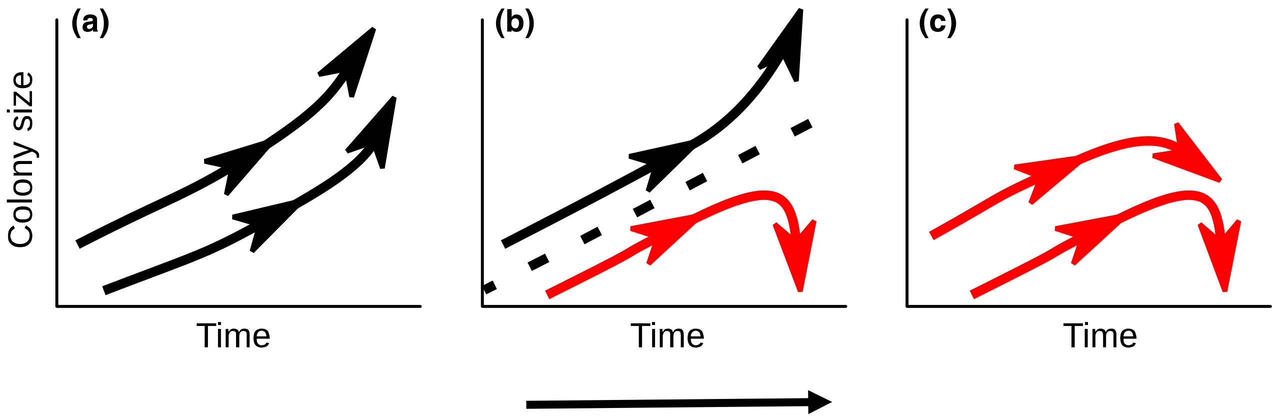
Gill et al (2012) *Nature* 491: 105-108

Gill & Raine (2014) *Functional Ecology*

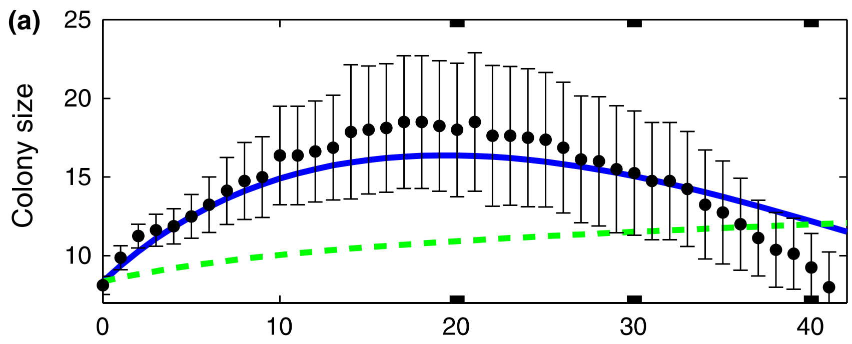
Individual effects with colony-level impacts?



Chronic sublethal stress causes colony failures?



Increasing rate at which bees are impaired by stressor



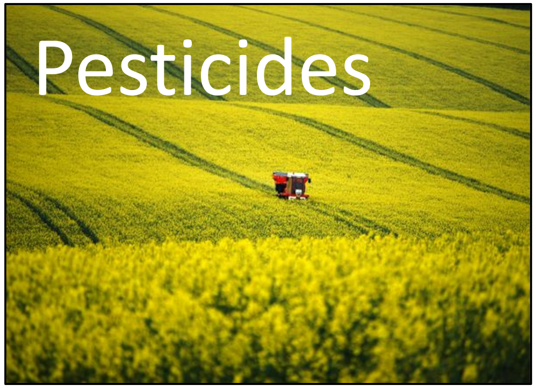
Chronic impacts of stress

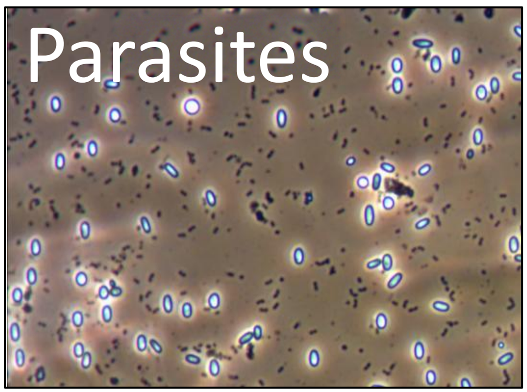
Earliest stages most vulnerable

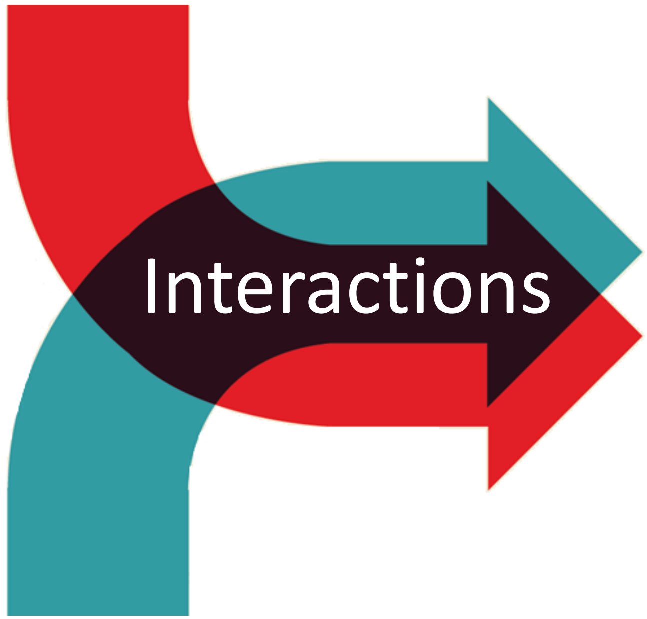
Models of this type have relevance for risk assessments

Bryden et al (2013) *Ecology Letters* 16: 1463-1469.

Interactions between stressors







Neonicotinoids and Nosema

Neonicotinoids or Pyrethroids and Trypanosomes

Interactions with other environmental stressors (e.g. nutrition, climate change, etc.)?

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29 April 2013 Last updated at 15:15

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Bee deaths: EU to ban neonicotinoid pesticides

COMMENTS (872)

The European Commission will restrict the use of pesticides linked to bee deaths by researchers, despite a split among EU states on the issue.

There is great concern across Europe about the collapse of bee populations.

Neonicotinoid chemicals in pesticides are believed to harm bees and the European Commission says they should be restricted to crops not attractive to bees and other pollinators.

Honeybees are vital for pollinating crops - a job that would be very costly without them

Will populations recover with the EU ‘ban’ on neonicotinoids?

Hard to tell without monitoring

Derogations to control flea beetle

Ontario – stated aims:

“… develop an action plan to meaningfully reduce neonicotinoid use for the 2015 growing season, including measurable targets.

…develop a system that requires a reduction in the use of seeds treated with neonicotinoid insecticides for the 2016 growing season through regulatory mechanisms….”

Food for thought

US EPA: “There is no increase in soybean yield using most neonicotinoid seed treatments when compared to using no pest control at all.”

Work to **reduce environmental stress** faced by bees:

Pollinator friendly landscapes: flowers and nests

Minimise agrochemical exposure: target/ reduce usage, mitigate when applying least harmful chemicals

Parasite and pathogen management

Gap: understand interactions between drivers of decline

Agro-Environmental Strategies work

Even narrow corridors of remnant land remaining between degraded zones allow the animal-plant interactions to persist.

Recent restoration projects and "ecological compensation areas" are showing good returns in UK and Europe (e.g. Forup & Memmott 2005).

Reinstating and supporting hedgerows and flowering field margins and set-aside/ fallow areas, even sown wildflower strips (preferably near some woodland or wild meadow) makes a real difference.

> Ideally with appropriate annual and perennial plants flowering across the season (e.g. Korpela et al 2013), good floral diversity, and native plants (Morandin & Kremen 2013).
>
> Linear hedges help structure bee movements (Cranmer et al 2012).

‘Wildlife friendly farming’ with mixed farms, smaller-scale fields, polyculture, rotations etc, supported with stewardship and similar schemes, giving **increased landscape complexity**, does help restore ecosystem services, and helps plants and birds and some natural enemies as well as pollinators (Pywell et al 2012)

Organic systems are especially good for insect-pollinated plant communities (Batary et al 2013), especially hoverflies, and best concentrated in biodiversity hotspots

Encouraging garden and park and roadside **urban floral diversity** is demonstrably good for pollinator abundance and diversity; getting ‘bee-hotels’ and small patches of wild meadow into urban gardens

Pollinator futures and sustainable food supply depend on

Better understanding of the core plant-pollinator interactions - distinguishing good pollinators from mere visitors

Improving and maintaining the **natural flower diversity** that supports the pollinators, thus

Improving and maintaining **natural** & **diverse** wild **pollinator communities**.

Removing stressors from the pollinators