UNIVERSITY OF LEEDS

Pollinator declines:
Assessing and monitoring change

Prof. William Kunin

University of Leeds

Late 2000's: Pollinators in crisis?

2006: CCD, Wild pollinator declines

2007: Bumblebee declines

By 2008: even Dr Who is worried…

Fall Dwindle Disease: A preliminary report
December 15, 2006

"Fall-Dwindle Disease": Investigations into the causes of sudden and alarming colony losses experienced by beekeepers in the fall of 2006.

Preliminary Report:

Decline and Conservation of Bumble Bees

D. Goulson, G.C. Lye, and B. Darvill

School of Biological & Environmental Sciences, University of Stirling, Stirling, FK9 4LA, United Kingdom; email: Dave.Goulson@stir.ac.uk

Annu. Rev. Entomol. 2008. 53:191–
First published online as a Review
September 5, 2007

Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands

J. C. Biesmeijer,[1]* S. P. M. Roberts,[2] M. Reemer,[3] R. Ohlemüller,[4] M. Edwards,[5] T. Peeters,[3,6] A. P. Schaffers,[7] S. G. Potts,[2] R. Kleukers,[3] C. D. Thomas,[4] J. Settele,[8] W. E. Kunin[1]

Despite widespread concern about declines in pollin
patterns of change in

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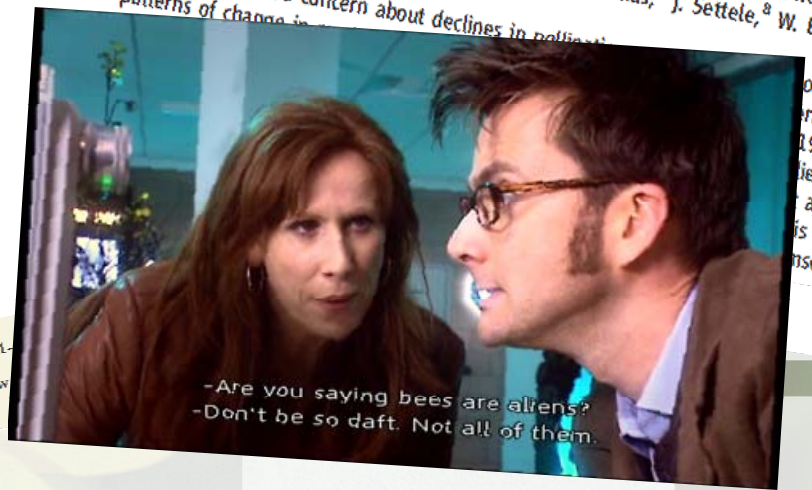
351



EU FP7 Projects (2008 – present)

COLOSS: Prevention of honeybee colony losses

BEEDOC: Bees in Europe & the decline of honeybee colonies

STEP: Status & Trends of European Pollinators

LIBERATION: Linking farmland biodiversity to ecosystem services for effective ecological intensification

UK: Insect Pollinators Initiative

- Multiple bodies joined forces to fund research: £10 M
- Initial call 2009, decisions 2010
- 9 projects funded
- Most running 2011-2014… beginning to show results.

Living With Environmental Change

wellcome trust

BBSRC bioscience for the future

NATURAL ENVIRONMENT RESEARCH COUNCIL

defra Department for Environment Food and Rural Affairs

The Scottish Government

Insect Pollinator Initiative Projects

1. The impact of the mite Varroa destructor on the interaction between the honeybee and viruses
2. Modelling systems for managing bee disease: the epidemiology of European foulbrood
3. Impact and mitigation of emergent diseases on major UK insect pollinators
4. Impact of sublethal exposure to pesticides on the learning capacity and performance of bees
5. Can bees meet their nutritional needs in the current UK landscape?
6. Investigating the impact of habitat structure on queen and worker bumblebees in the field
7. Sustainable pollination services for UK crops
8. Linking agriculture and land use change to pollinator populations
9. Urban pollinators: their ecology and conservation

A complicated problem…

Multiple potential drivers

- Novel pests & diseases
- Pesticides
- Loss of floral resources
- Loss of nesting habitat
- Climate change

Diverse Pollinators





Honeybees (1 sp) · Bumblebees (ca. 25 spp) · Solitary bees (ca. 225 spp) · Hoverflies (ca. 250 spp) · Other insects (many spp…)

Multiple outcomes of interest

- Abundance
- Diversity
- Pollination services
- Crop yields & quality
- Conservation

Insect Pollinator Initiative Projects

	Honey bees	Bumble bees	Other groups
1. The impact of the mite Varroa destructor on the interaction between the honeybee and viruses	✓		
2. Modelling systems for managing bee disease: the epidemiology of European foulbrood	✓		
3. Impact and mitigation of emergent diseases on major UK insect pollinators	✓	✓	
4. Impact of sublethal exposure to pesticides on the learning capacity and performance of bees	✓	✓	
5. Can bees meet their nutritional needs in the current UK landscape?	✓	✓	
6. Investigating the impact of habitat structure on queen and worker bumblebees in the field		✓	
7. Sustainable pollination services for UK crops	✓	✓	✓
8. Linking agriculture and land use change to pollinator populations	✓	✓	✓
9. Urban pollinators: their ecology and conservation	✓	✓	✓

Insect Pollinator Initiative Projects

	Pests & Disease	Pest-icides	Resources
1. The impact of the mite Varroa destructor on the interaction between the honeybee and viruses	✓		
2. Modelling systems for managing bee disease: the epidemiology of European foulbrood	✓		
3. Impact and mitigation of emergent diseases on major UK insect pollinators	✓	(✓)	
4. Impact of sublethal exposure to pesticides on the learning capacity and performance of bees		✓	(✓)
5. Can bees meet their nutritional needs in the current UK landscape?			✓
6. Investigating the impact of habitat structure on queen and worker bumblebees in the field			✓
7. Sustainable pollination services for UK crops		✓	✓
8. Linking agriculture and land use change to pollinator populations		✓	✓
9. Urban pollinators: their ecology and conservation			✓

Insect Pollinator Initiative Projects

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9. Urban pollinators: their ecology and conservation			✓

Pesticide Impacts on Bees

nature COMMUNICATIONS

ARTICLE

Received 8 Oct 2012 | Accepted 25 Feb 2013 | Published 27 Mar 2013

DOI: 10.1038/ncomms2648

Cholinergic pesticides cause mushroom body neuronal inactivation in honeybees

Mary J. Palmer[1], Christopher Moffat[1], Nastja Saranzewa[1], Jenni Harvey[1], Geraldine A. Wright[2] & Christopher N. Connolly[1]

Exposure to multiple cholinergic pesticides impairs olfactory learning and memory in honeybees
Journal of Experimental Biology (2013) 216:1799

LETTER

doi:10.1038/nature11585

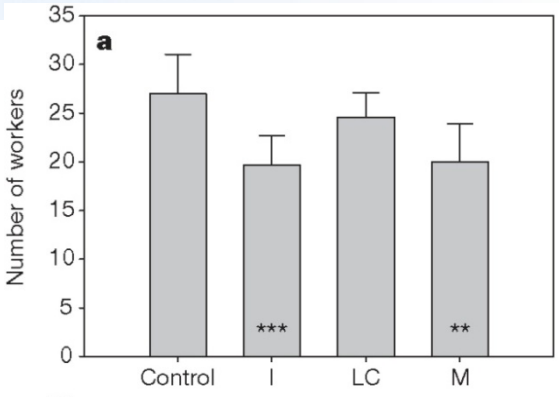
Combined pesticide exposure severely affects individual- and colony-level traits in bees

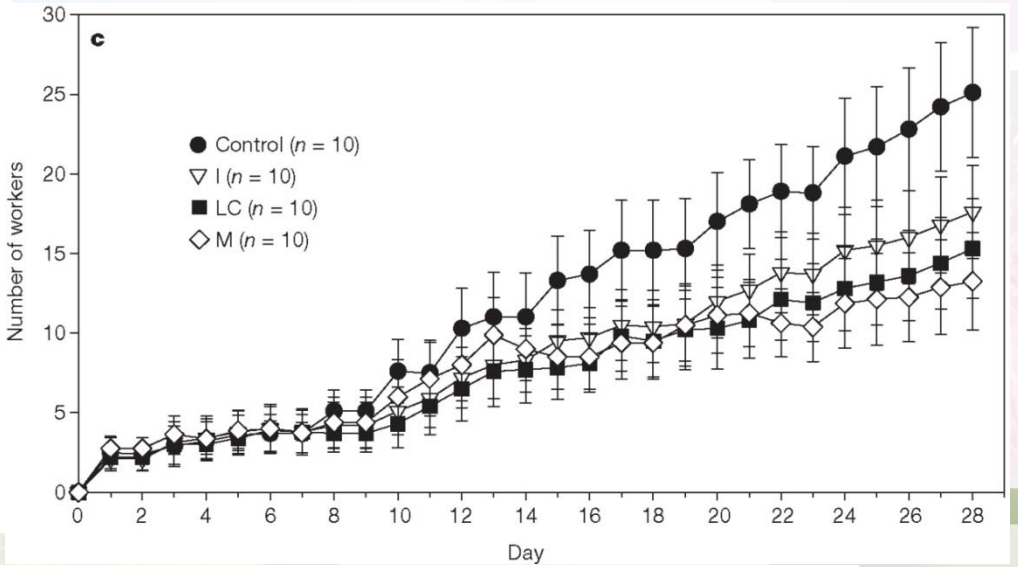
Richard J. Gill[1], Oscar Ramos-Rodriguez[1] & Nigel E. Raine[1]

Pesticide Impacts on Bumblebees

- **Clearly: insecticides can kill insects**
- **Growing evidence of sub-lethal effects & interactions**

- Worker production lower in imidiacloprid treated colonies than controls
- Workers spent more time per foraging trip, but returned with less pollen.
- Nest box mortality 4x higher in λ-cyhalothrin treatments than controls
- Each affected colony growth. Combo worst.





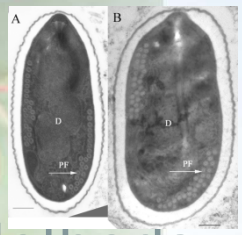
RJ Gill *et al. Nature* (2012) 491, 105-109 doi:10.1038/nature11585

Interacting effects of HB pathogens

Vincent Doublet
Maureen Labarussias

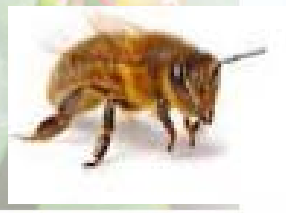
Submitted: PLoS Biology

Material :



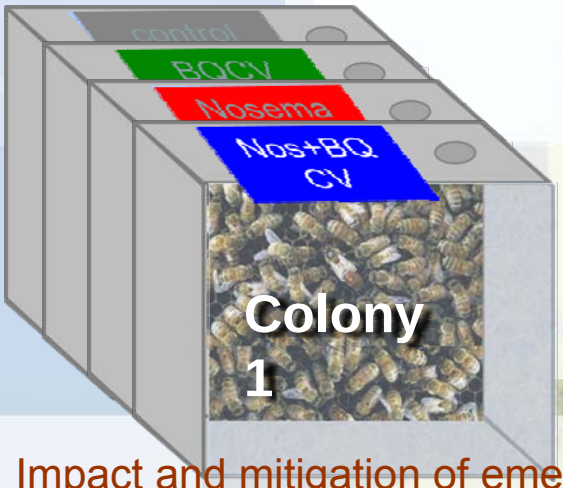
- ✓ Black Queen-Cell Virus (BQCV)
- ✓ *Nosema ceranae* from *in vivo* culture

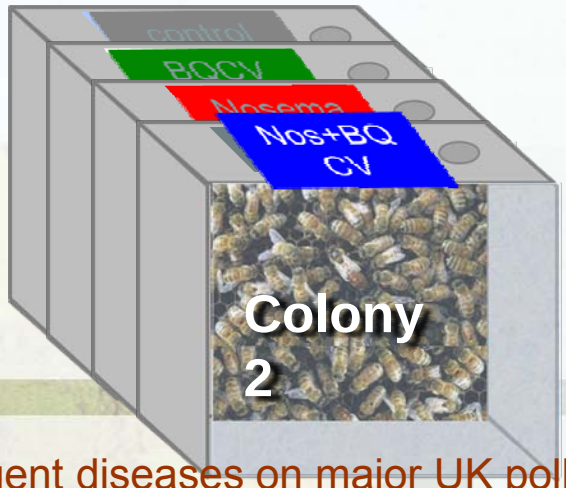
Methods:

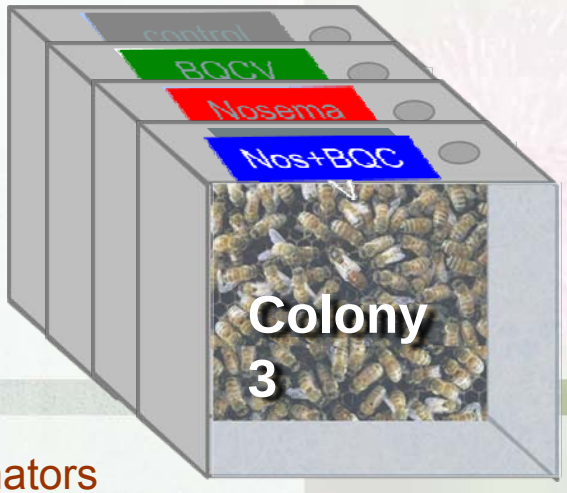


- ✓ 30 worker honey bees per cage
- ✓ Fed individually with…..
- ✓ Mortality recorded every day

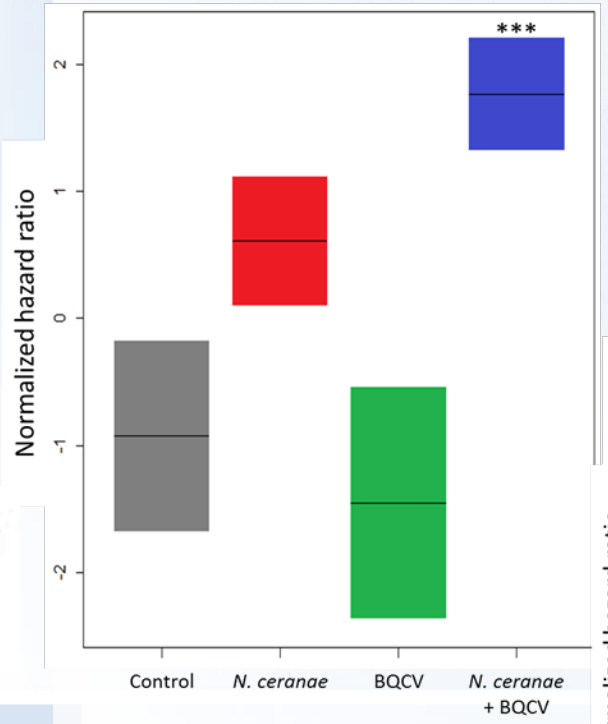
- ***Nosema* + BQCV**
- ***Nosema*** (10^5 spores per bee)
- **BQCV** ($5x10^9$ viral particles/bee)
- **Control** (virus extraction buffer)

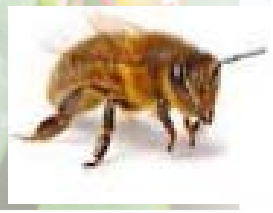






Interacting effects of HB pathogens & pesticides

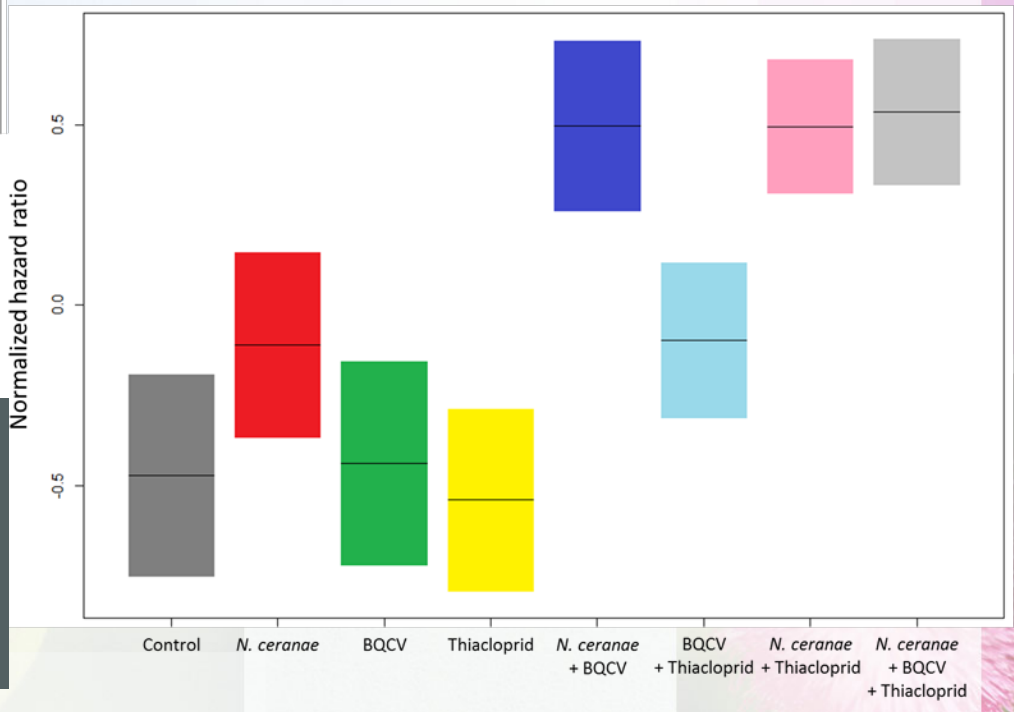




Parasite *Nosema ceranae* alone: increased hazard

Black queen-cell virus: no effect

But BQCV + Nosema: much worse!



Pesticide (Thiacloprid: a "neonic") : no impact by itself

Pesticide + parasite or virus: substantially increased hazard

IPI: Impact and mitigation of emergent diseases on major UK pollinators

SEVENTH FRAMEWORK PROGRAMME

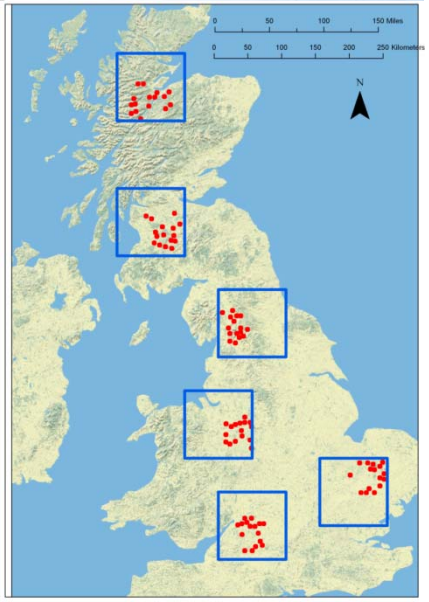
BEE DOC

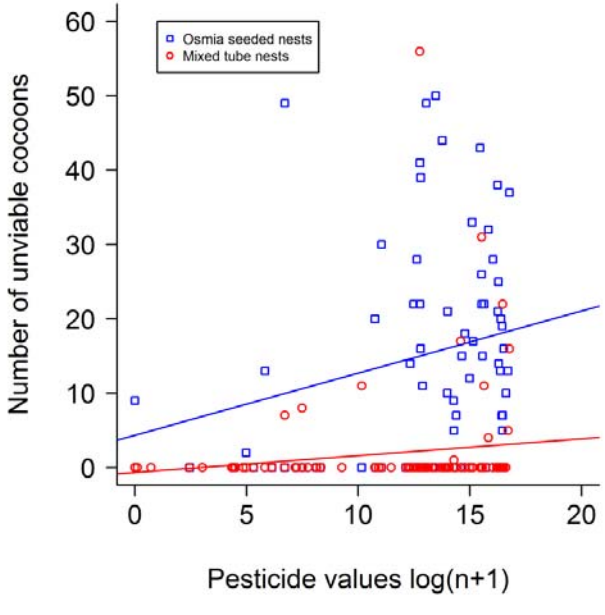
Bees in EuropE & the Decline Of honeybee Colonies

Pesticide impacts on solitary bees (preliminary results)

Tube nests set out in 96 contrasting UK landscapes:

- Habitat complexity + effect on *Megachile* presence
- Floral resources + effects on *Megachile* & *Osmia* presence
- Bee-keeping + effects on *Osmia* presence
- Pesticide usage + effects on MORTALITY of larvae & pupae





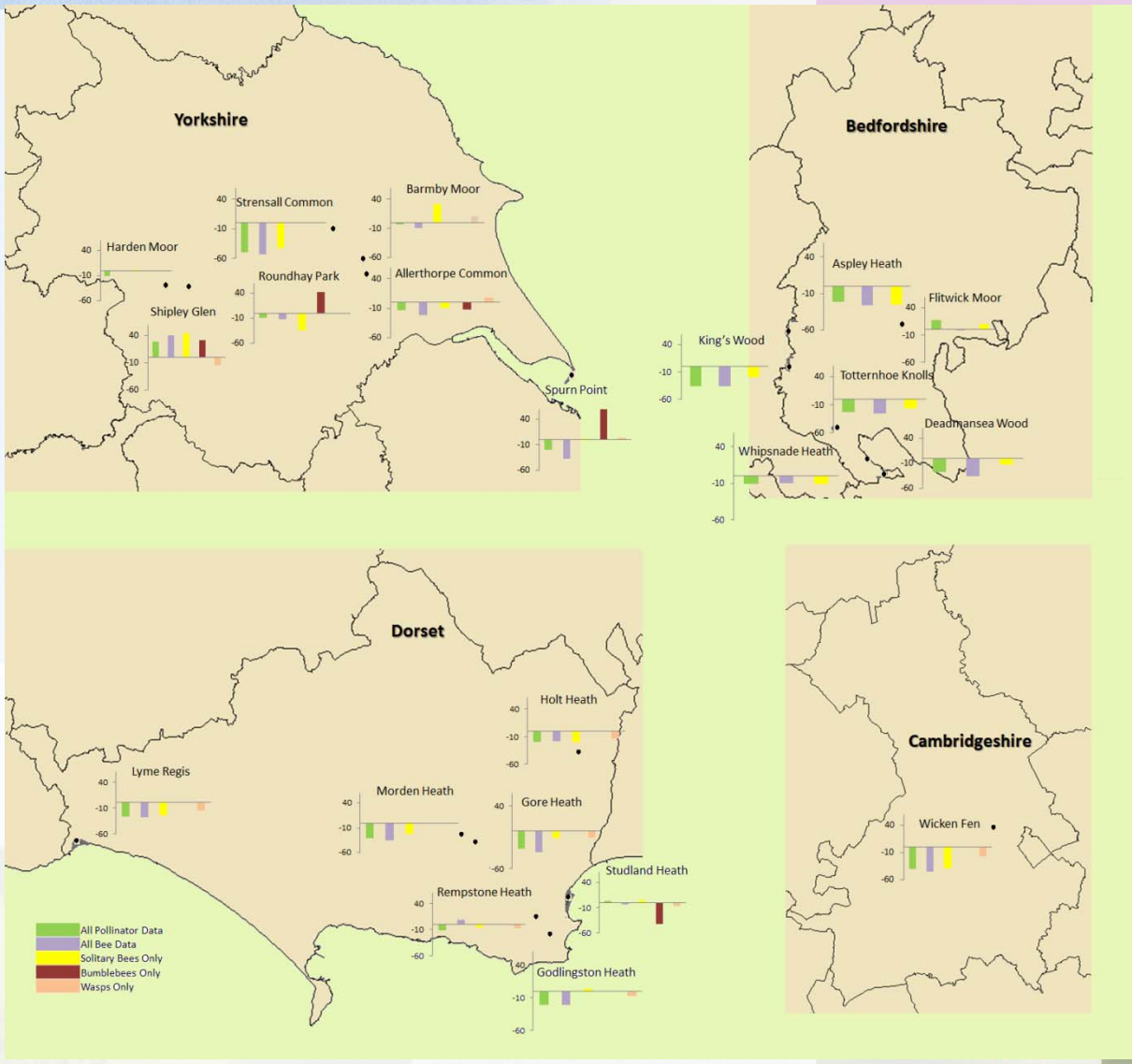
IPI AgriLand project

Historical resurveys

21 sites with good historical pollinator records (1921 – 1950).

Sites were resurveyed with common methods in 2011-12

85% showed decreased pollinator spp richness

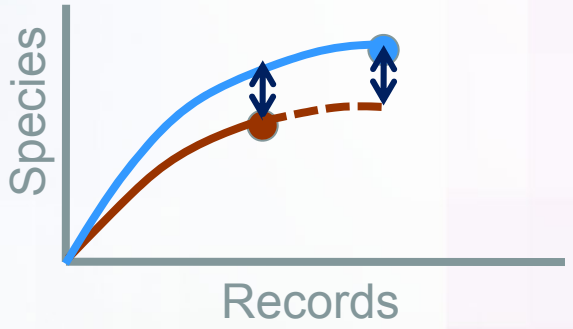


IPI AgriLand project

Manuscript in preparation

Using biodiversity records

- **To assess change more broadly: spp records from biodiversity databases for UK, NL & Belgium**
  (For UK: BWARS, BRC, Butterfly Conservation;
  Bees: 300 k, Hoverflies: 500 k, Butterflies: 1.5 M records)
- **Four time periods:**
  - **1930 – 1949 (P0)**
  - **1950 – 1969 (P1)**
  - **1970 – 1989 (P2)**
  - **1990 – 2009 (P3)**



- To correct for differences in sample size: combined rarefaction (Colwell et al. 2004) and extrapolation (Colwell et al. 2012) methods.
- Multiple spatial scales: 10 km – national, plus spatial turnover (β diversity) analyses

STEP

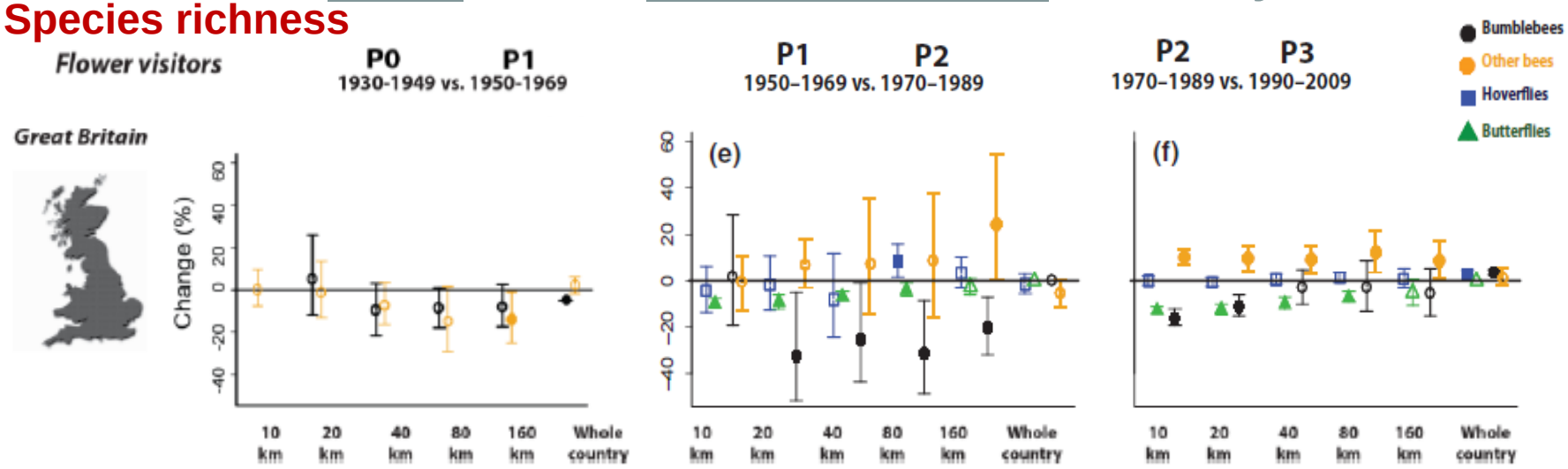
+ IPI AgriLand project

Carvalheiro et al. (2013) *Ecology Letters*

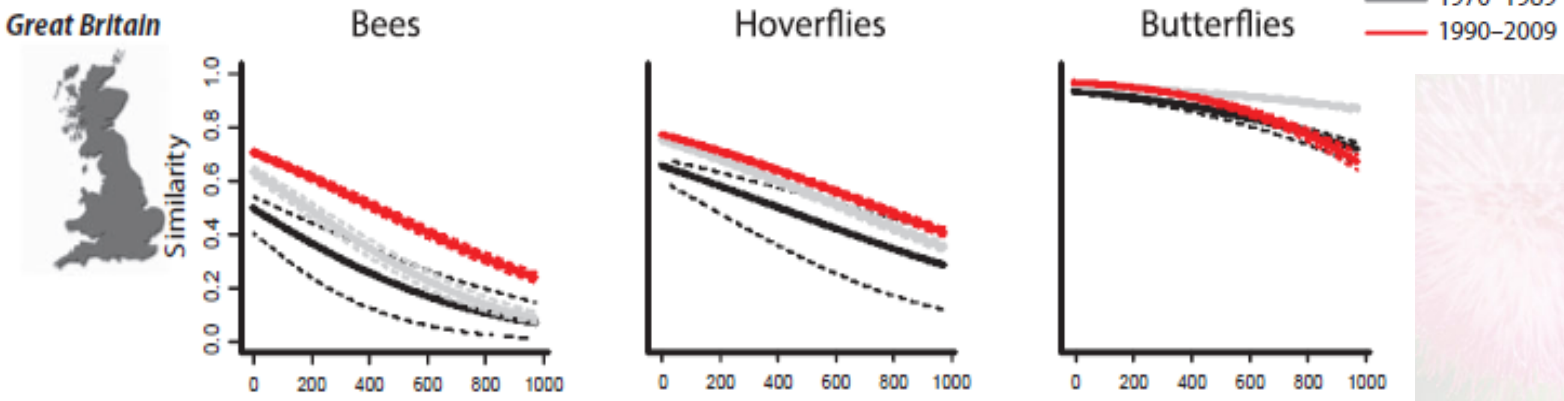
Recent trends: good news?

- **Diversity declines in plants & pollinators have slowed down or been partially reversed in the 20 yrs since Rio**

Species richness



Spatial homogeneity



STEP

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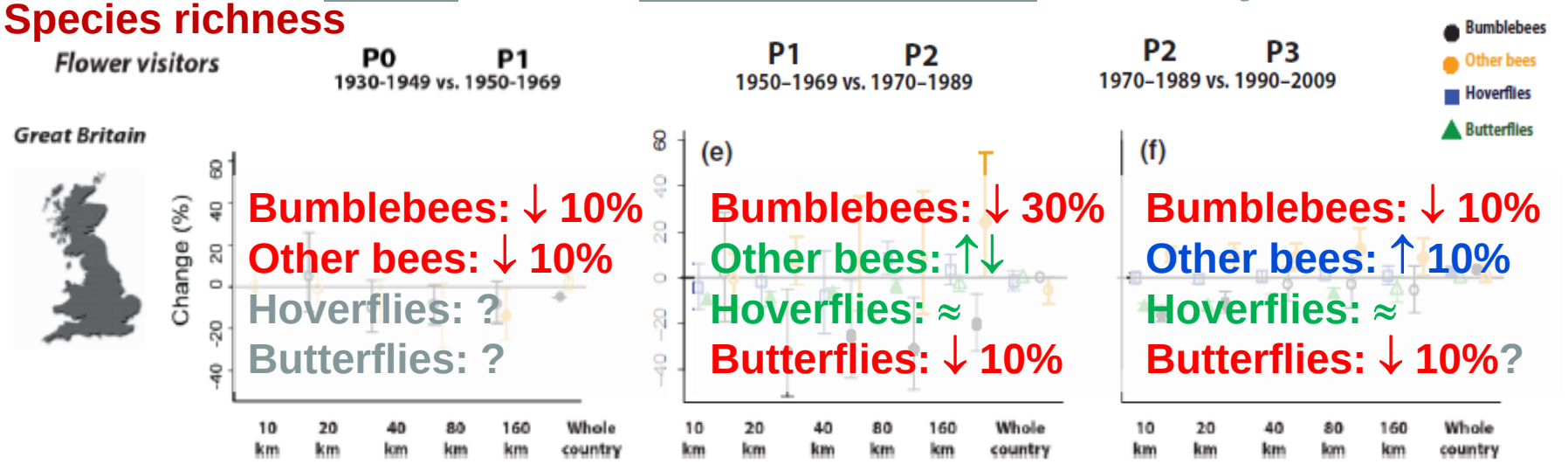
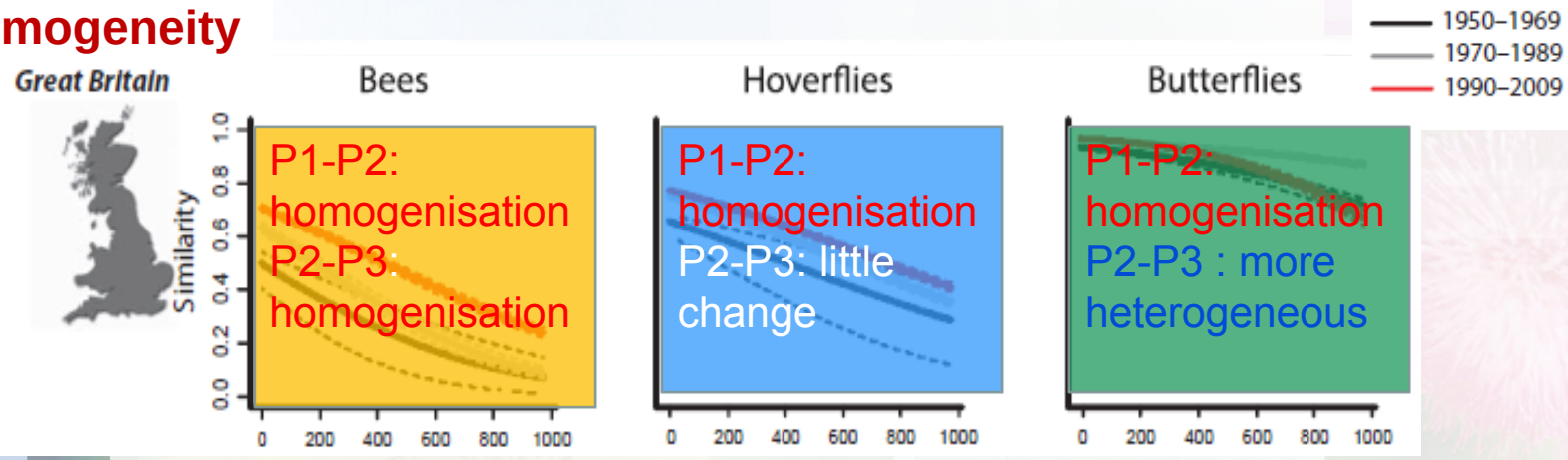


Spatial homogeneity



STEP

+ IPI AgriLand project

Carvalheiro et al. (2013) *Ecology Letters*

Recent trends: mixed signals

Carvalheiro et al. *Ecol Lett* 22 May 2013

Ecology Letters, (2013) doi: 10.1111/ele.12121

LETTER

Species richness declines and biotic homogenisation have slowed down for NW-European pollinators and plants

Luísa Gigante Carvalheiro,[1,2]* William E. Kunin,[1] Petr Keil,[3,4] Jesus Aguirre-Gutiérrez,[2] Willem Nicolaas Ellis,[2,5] Richard Fox,[6] Quentin Groom,[7] Stephan Hennekens,[8] Wouter Van Landuyt,[9] Dirk Maes,[9] Frank Van de Meutter,[8,10] Denis Michez,[11] Pierre Rasmont,[11] Baudewijn Ode,[12] Simon Geoffrey Potts,[13] Menno Reemer,[14] Stuart Paul Masson Roberts,[13] Joop Schaminée,[15] Michiel F. WallisDeVries[16,17] and Jacobus Christiaan Biesmeijer[1,2,18]

Abstract

Concern about biodiversity loss has led to increased public investment in conservation. Whereas there is a widespread perception that such initiatives have been unsuccessful, there are few quantitative tests of this perception. Here, we evaluate whether rates of biodiversity change have altered in recent decades in three European countries (Great Britain, Netherlands and Belgium) for plants and flower visiting insects. We compared four 20-year periods, comparing periods of rapid land-use intensification and natural habitat loss (1930–1990) with a period of increased conservation investment (post-1990). We found that extensive species richness loss and biotic homogenisation occurred before 1990, whereas these negative trends became substantially less accentuated during recent decades, being partially reversed for certain taxa (e.g. bees in Great Britain and Netherlands). These results highlight the potential to maintain or even restore current species assemblages (which despite past extinctions are still of great conservation value), at least in regions where large-scale land-use intensification and natural habitat loss has ceased.

Keywords

Accumulation curves, biodiversity loss, community ecology, plant–flower visitor communities, pollination, similarity, spatial homogenisation, species richness estimations, temporal and spatial patterns.

- Rate of bumblebee decline slowing
- Solitary bee diversity now increasing slightly

State of Nature Report 22 May 2013

- More than half of bee spp declining
- About 20% in “strong” decline

Note: for bees, both studies use the SAME dataset, covering (mostly) the same years. BOTH are correct!

	Site A	Site B	Site C	Site D
Sp 1	X	X	X	
Sp 2		X		
Sp 3	X		X	X
Sp4		X	X	

Site diversity change

	Site A	Site B	Site C	Site D
Sp 1	X	X	X	
Sp 2		X		
Sp 3	X		X	X
Sp4		X	X	

Species’ occupancy change

Recent trends: mixed signals

Carvalheiro et al. *Ecol Lett*
22 May 2013

State of Nature Report
22 May 2013

- **How can <u>most spp decline</u>, but <u>most sites increase diversity</u>?**
- Because the (relatively few) "winners" are increasing more that the many "losers" are decreasing

spp required to make up top ½ of the records:
1950-1969: **<u>58</u>** (of 217) 1970-1989: **<u>28</u>** (of 225) 1990-2009: **<u>23</u>** (of 231)

- Is this a <u>real trend</u> towards greater inequality, or a <u>change in recorder effort & behaviour</u>?

	Site A	Site B	Site C	Site D
Sp 1	X	X	X	
Sp 2		X		
Sp 3	X		X	X
Sp4		X	X	

Site diversity change

	Site A	Site B	Site C	Site D
Sp 1	X	X	X	
Sp 2		X		
Sp 3	X		X	X
Sp4		X	X	

Species' occupancy change

The need for monitoring

- **Existing records can be used to infer diversity change, but:**
  - Only indirectly: Subject to possible errors & biases
  - Tell little or nothing about species' abundances
  - Tell nothing about pollination services

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House of Commons
Environmental Audit Committee

Pollinators and Pesticides

Seventh Report of Session 2012–13

13. **The available evidence indicates that wild insect pollinators, such as hoverflies, moths, midges, butterflies and wild bees, are experiencing serious population declines, but there is insufficient data to be precise about the extent of such declines due to inadequate monitoring.** ***Defra must introduce a national monitoring programme to generate and monitor population data on a broad range of wild insect pollinator species to inform policy making.***

The need for monitoring

Information required

- Spp richness
- Spp abundance status & trends
- Overall abundance of pollinator groupings
- Pollination service

Monitoring options

Biodiversity databases

Professional monitoring

Citizen science

The need for monitoring

- IPI research suggests (limited) pollinator monitoring could be done on a modest budget
  (IPI AgriLand: 120 sites for 2 yrs)

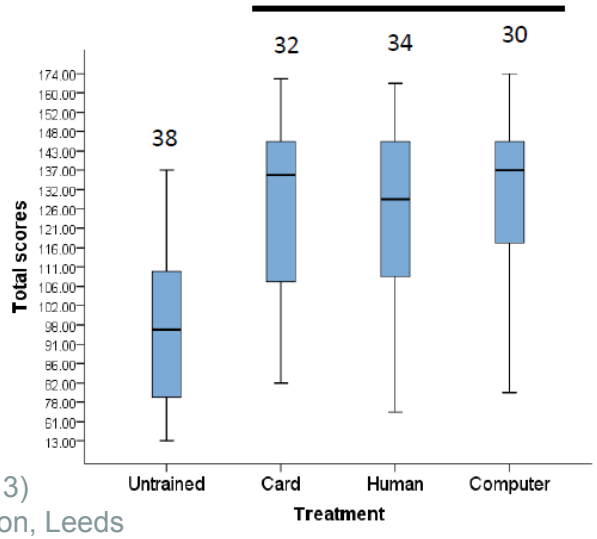
- With well-designed structures and training, citizen scientists can make a useful contribution

Monitoring options

Biodiversity databases

Professional monitoring

Citizen science



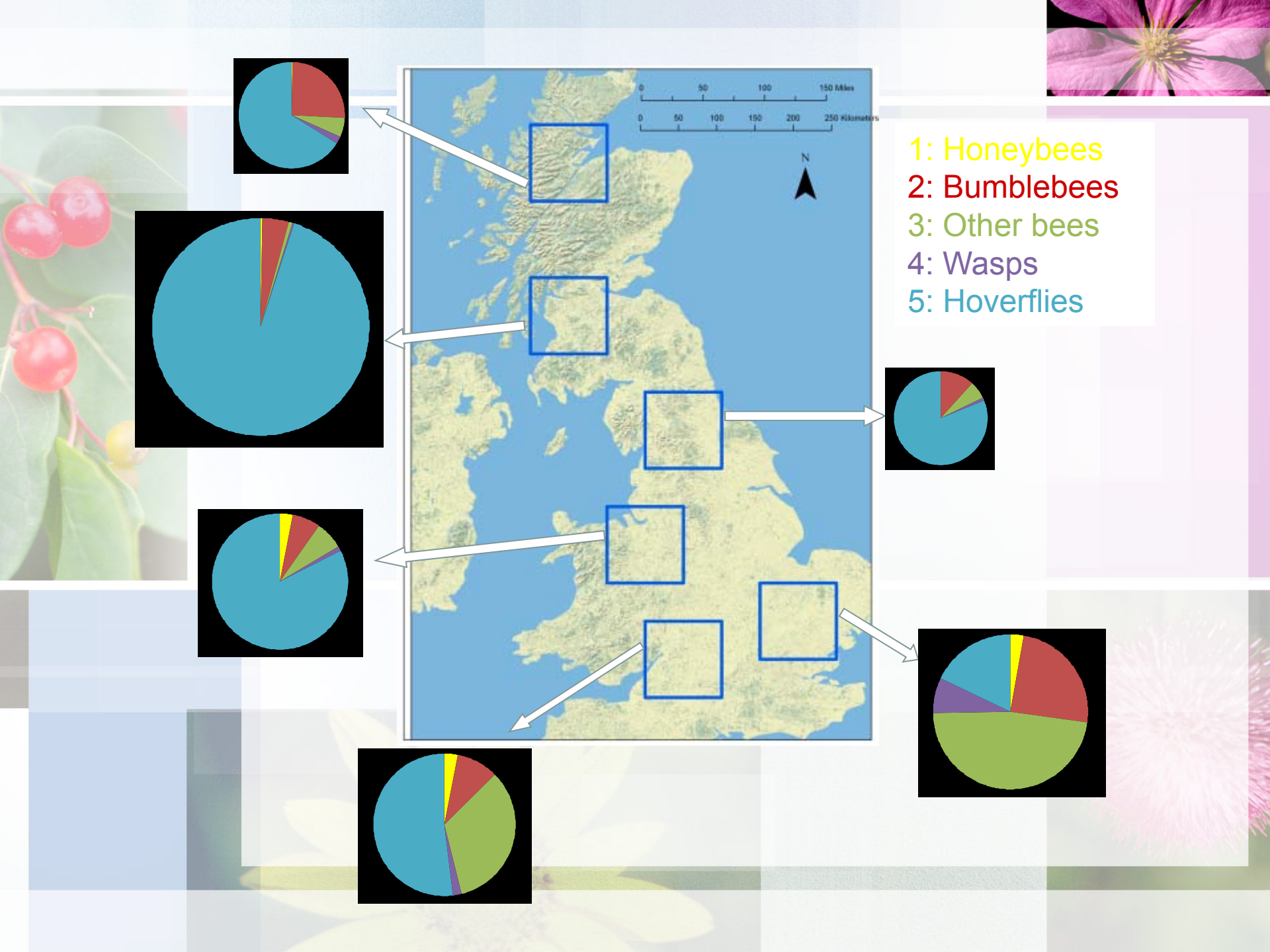
PJ Taylor (2013)
MSc dissertation, Leeds

In summary

- Evidence of historic declines in diversity of bees and other pollinators
- Substantial research work in progress to ascertain patterns & causes
- For honeybees, interacting effects of pesticides and parasites
- Growing evidence that wild bees also affected by pesticides, losses of habitat & floral resources
- Recent slowing of rates of diversity loss, but many spp still at risk
- Trends in abundance & services unknown:Pollinator monitoring is a priority

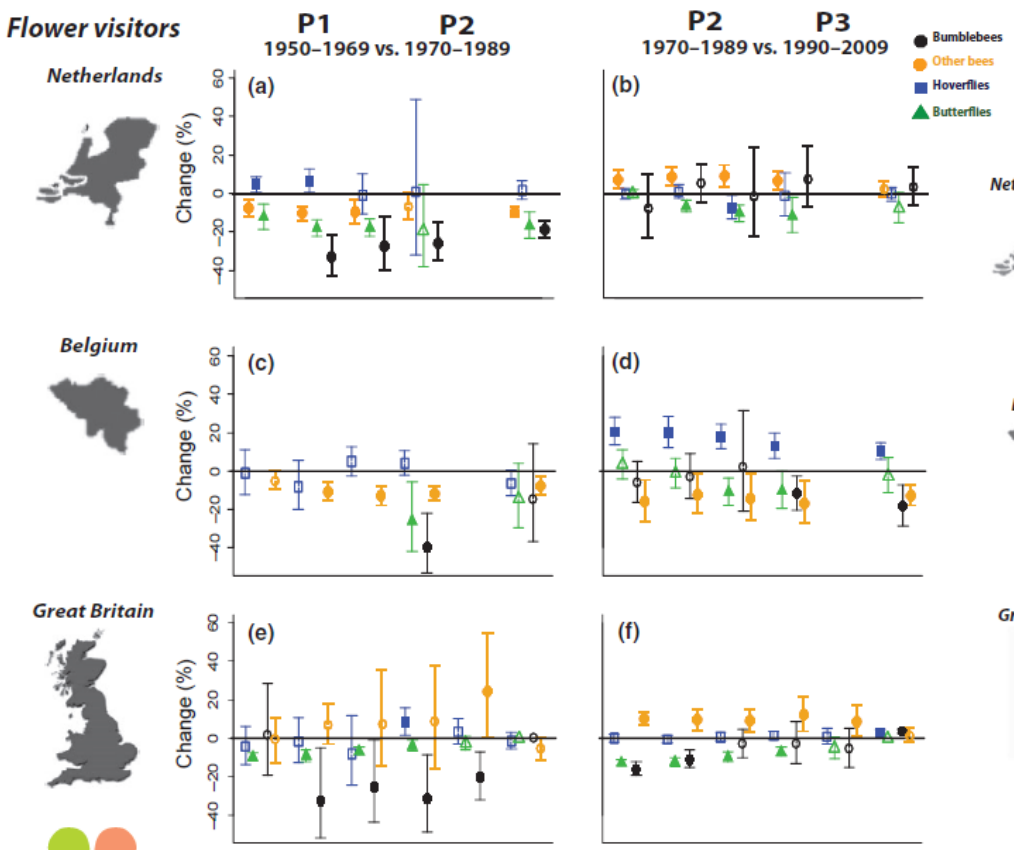
Thank you

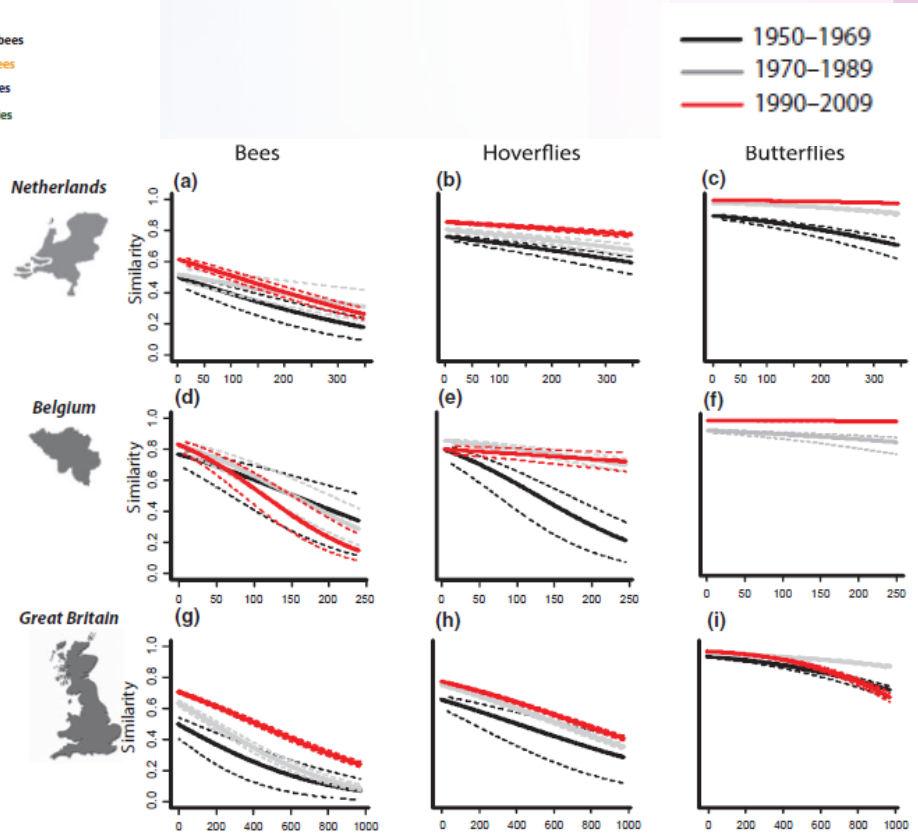

Thank you!


1: Honeybees
2: Bumblebees
3: Other bees
4: Wasps
5: Hoverflies
N

Recent trends:good news?

- **Diversity declines in plants & pollinators have slowed down or been partially reversed in the 20 yrs since Rio**





STEP

+ IPI AgriLand project