Shifting populations and biodiversity in a changing world:

Using biodiversity records to monitor biotic change.

William Kunin

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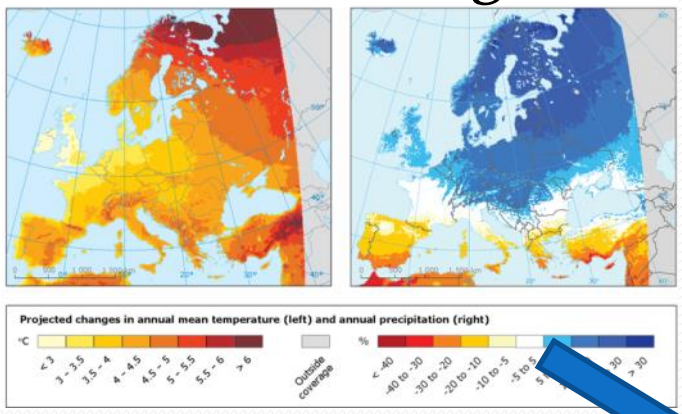
UNIVERSITY OF LEEDS

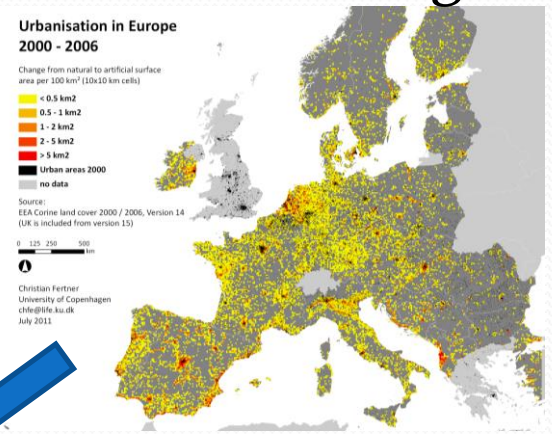
Monitoring biotic change

Climate change

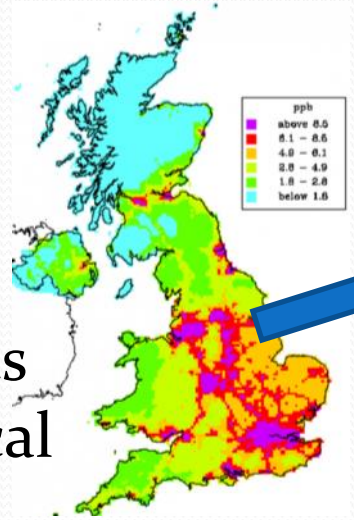


Biotic change

Land use change



Invasive alien spp



Pollutants & chemical inputs

Management changes

Monitoring biotic change

- Fortunately (thanks in large part to the NBN and its contributors), the UK has some of the best biodiversity data on Earth to help assess the nature of recent biotic change…

Outline of the talk

- Different aspects of biotic change to monitor
- Using occurrence data (directly & indirectly) in monitoring change
- The value of additional record classes
- Some remaining issues

Monitoring biotic change

- Species' distributions
- Species' populations
- Local species richness
- National species richness
- Local functional diversity
- Summed local abundance
- Ecosystem service provision

Many different aspect of natural populations, communities and ecosystems that may be of conservation interest – at local and national scales

Monitoring biotic change

- Species' distributions — Occurrence data
- Species' populations
- Local species richness
- National species richness — Occurrence data
- Local functional diversity
- Summed local abundance
- Ecosystem service provision

Monitoring biotic change

- Species' distributions — Occurrence data
- Species' populations — Occurrence data + downscaling?
- Local species richness — Occurrence data + modelling
- National species richness — Occurrence data
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Monitoring biotic change

• Species' distributions	Occurrence data Sampling event data
• Species' populations	Occurrence data + downscaling? Sampling event data
• Local species richness	Occurrence data + modelling Sampling event data
• National species richness	Occurrence data
• Local functional diversity	Sampling event data
• Summed local abundance	Sampling event data
• Ecosystem service provision	[Sampling event data??]

New GBIF Data classes…

Monitoring biotic change

- Species' distributions — Occurrence data
- Species' populations
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- National species richness — Occurrence data
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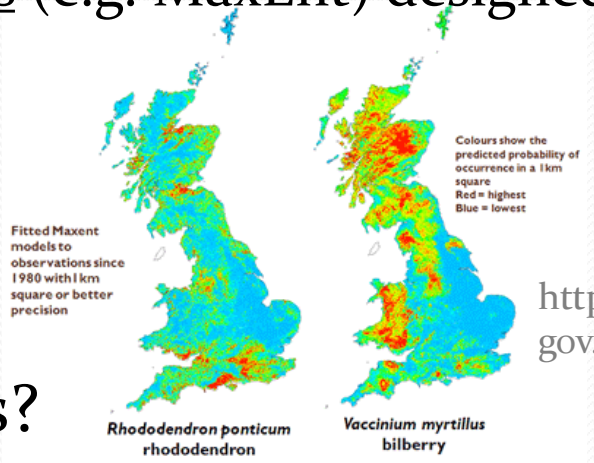
Let's start with the two most straight-forward cases…
Even these can be tricky.

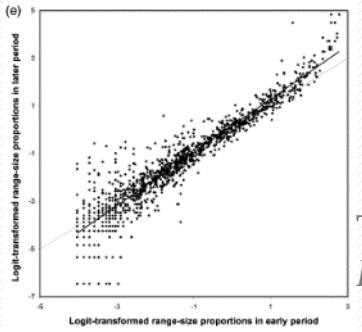
Species distributional change

- NBN data provide high quality "presence only" (+ some presence/absence) data on spp occurences:
  - Direct estimation of observed species distribution
  - Apply Species Distribution Models (e.g. MaxEnt) designed for use with presence-only data



http://jncc.defra.gov.uk/page-5091

- But note: Increased sampling intensity in recent decades; artefactual "expansion" in ranges?
  - Various solutions, ranging from simple (e.g. *New Atlas of British & Irish Flora*) to more sophisticated (e.g. work by Nick Isaac, David Roy, Anne Chao…)

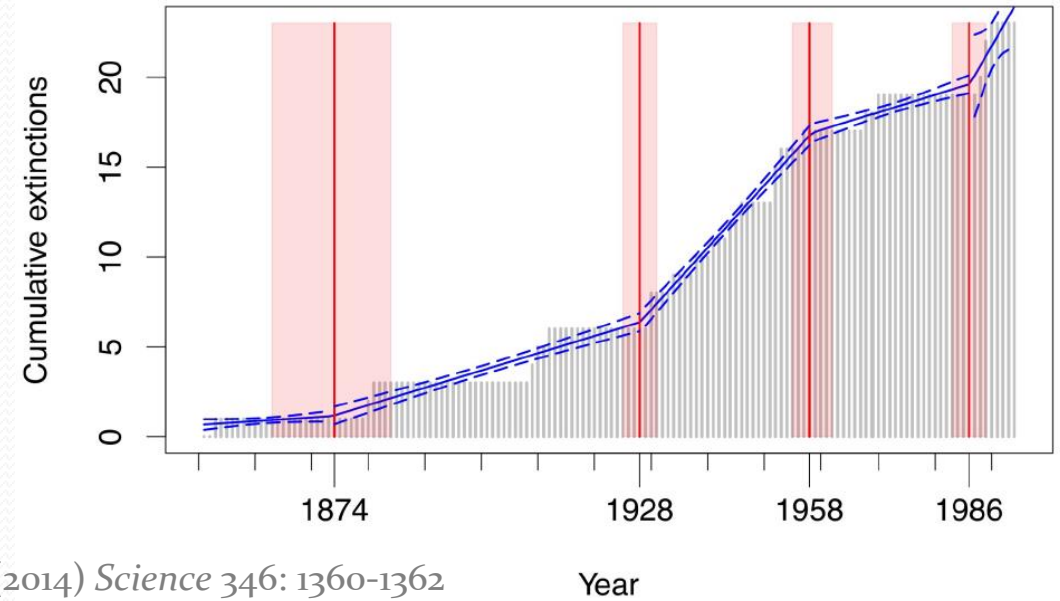


Telfer *et al.* (2002) *Biol. Cons.* 107: 99-109

National species richness change

- The UK recording community is remarkably good at spotting unusual spp – rarities, vagrants and invasions quickly reported.

- Less charismatic spp: Accumulate records over time – how long is enough?
- Trickier still to document spp LOSSES. How long without an observation to demonstrate extinction?
- Nonetheless: spp records provide good evidence of national richness change…



Ollerton *et al.* (2014) *Science* 346: 1360-1362

Monitoring biotic change

- Species' distributions — Occurrence data
- Species' populations — Occurrence data + downscaling?
- Local species richness — Occurrence data + modelling
- National species richness — Occurrence data
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Now slightly harder cases: using modelling

Species population change

- Generally no direct population observations (except for the few spp that are actively monitored)…
- However: it MAY be possible to use distributional scaling to estimate abundance…
- Population "downscaling" methods

Ecological Applications, 19(8), 2009, pp. 2038–2048

Methods in Ecology and Evolution

British Ecological Society

Methods in Ecology and Evolution 2014, **5**, 336–343 doi: 10.1111/2041-210X.12159

A simple method for estimating species abundance from occurrence maps

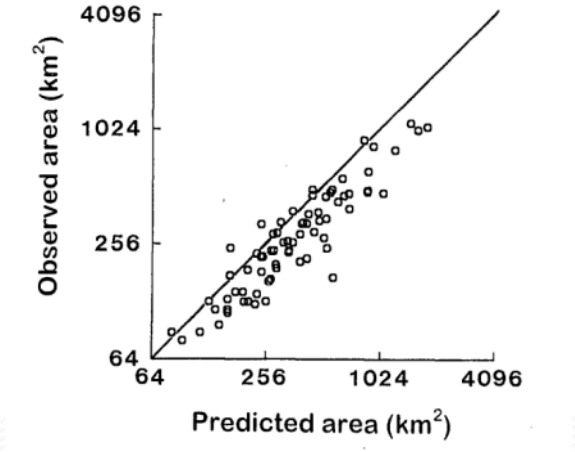
Deyi Yin[1] and Fangliang He[1,2]*

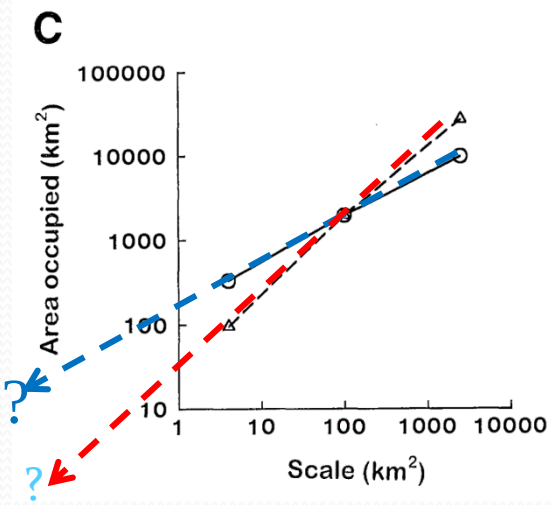
Extrapolating population size from the occupancy–abundance relationship and the scaling pattern of occupancy

Cang Hui,[1,5] Melodie A. McGeoch,[2] Belinda Reyers,[3] Peter C. le Roux,[1] Michelle Greve,[4] and Steven L. Chown[1]

Species population change

- Area occupied by a species (Area of Occupancy: AoO) is scale-specific: different scales reflect different aspects of abundance.
- Population size linked to very fine scale occupancy.
- "Downscaling" methods can predict finer scale occupancy from coarser-scale data…

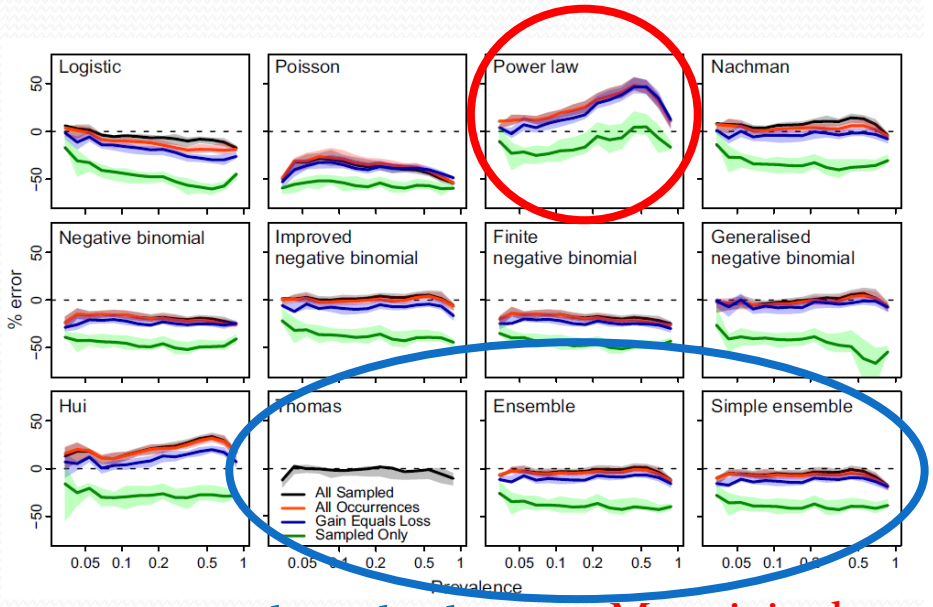




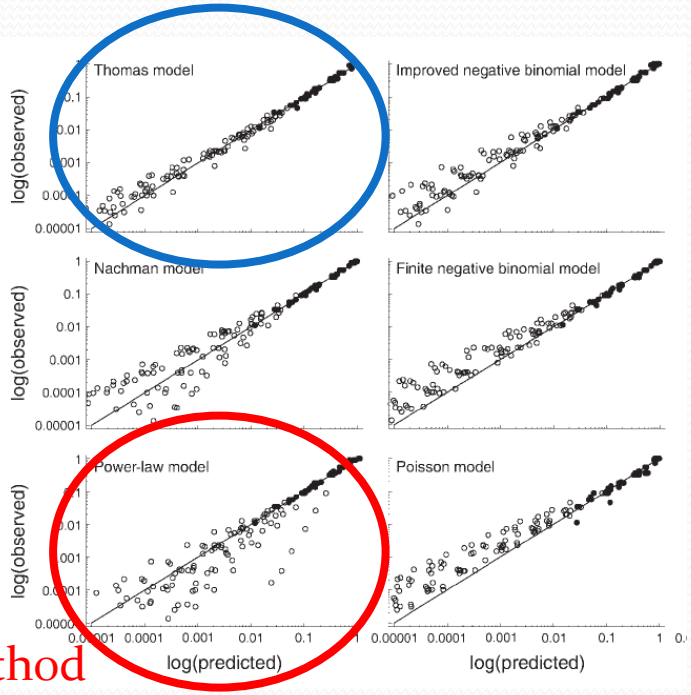
Kunin WE (1998) *Science* 281: 1513-1515

Species population change

- My original (1998) method has been superseded by many new approaches – and the best do reasonably well…
- Still at best an indirect inference of population size & change.



Some improved methods



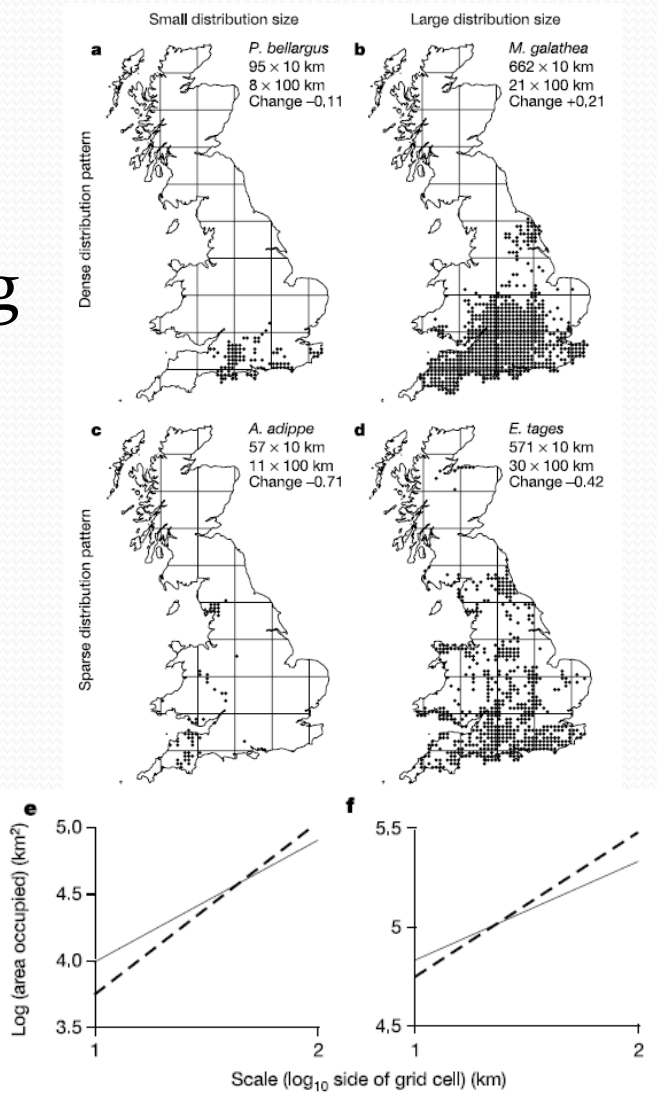
My original method

Groom et al. (2018) *Methods in Ecology & Evolution* DOI: 10.1111/2041-210X.13078

Azaele et al. (2012) *Ecol. Appl*. 22: 1004-14;

Scaling of occupancy linked to change

- In both butterflies[1] and plants[2], **declining species show sparser distributions** than do stable or growing species' populations.
- Metapopulations in flux? Local refugial populations persist – too small and isolated to be recolonised if lost.



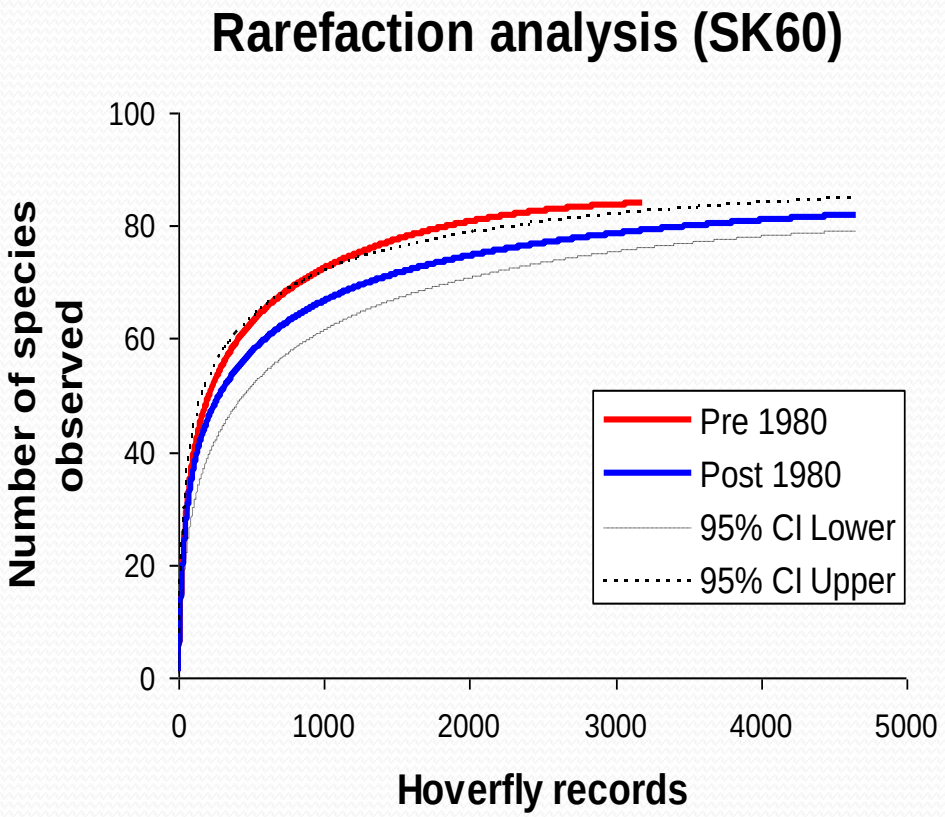
1. Wilson, RJ *et al.*(2004). *Nature* **432**: 393-396

2. Pocock MJO *et al.*(2006). *Journal of Ecology* **94**: 581-596.

Inferring species richness change

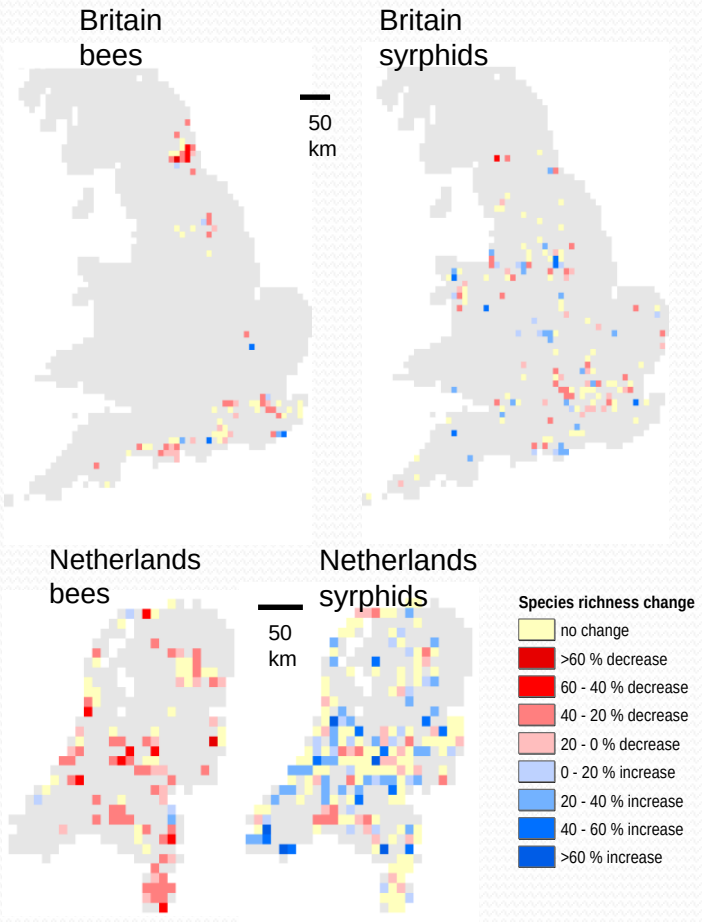
- Rarefaction approaches: correcting spp richness for shifts in sampling effort.

- Assess spp richness of random samples from dataset: plot richness as function of sample size.



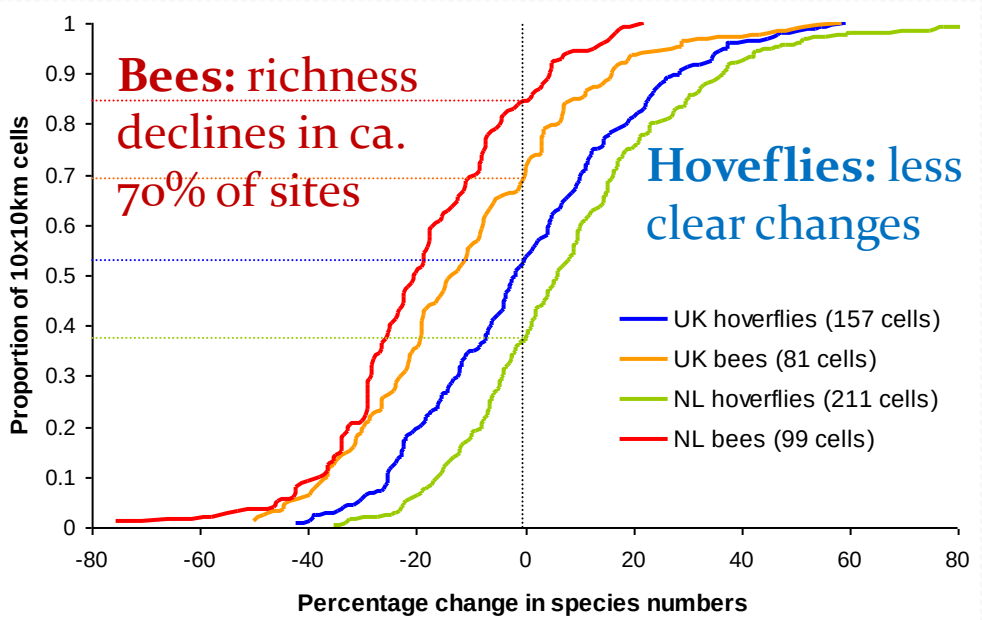
Using rarefaction methods:

- Shifts in local pollinator spp richness (pre vs. post-1980)

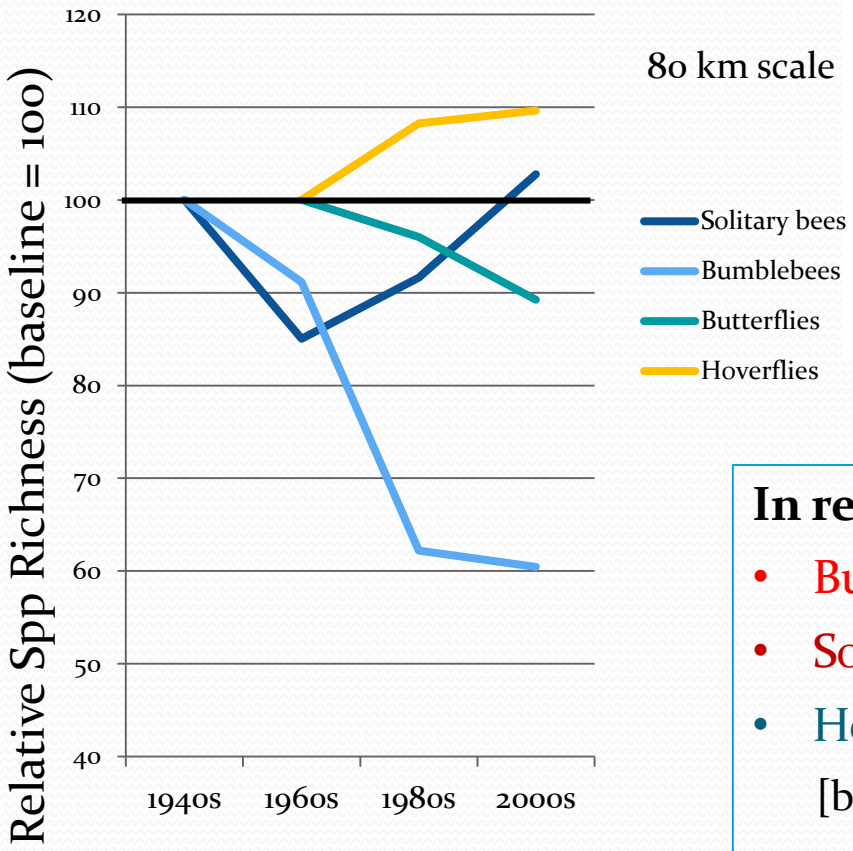


Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands

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]



Or later, with improved methods:



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,[9,10] 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.

In recent decades:

- Bumblebee declines have slowed
- Solitary bee declines have stopped, then reversed
- Hoverflies still seem to be stable

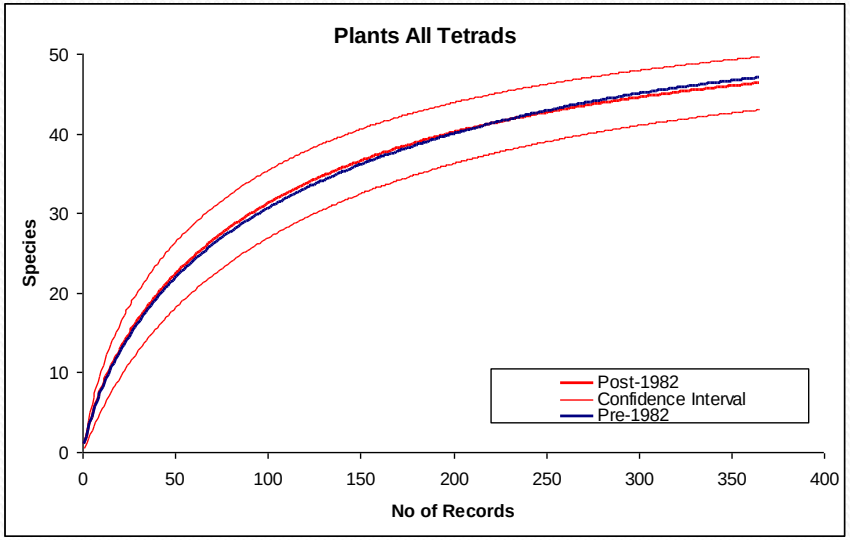
[but still no proper monitoring: hard to be certain]

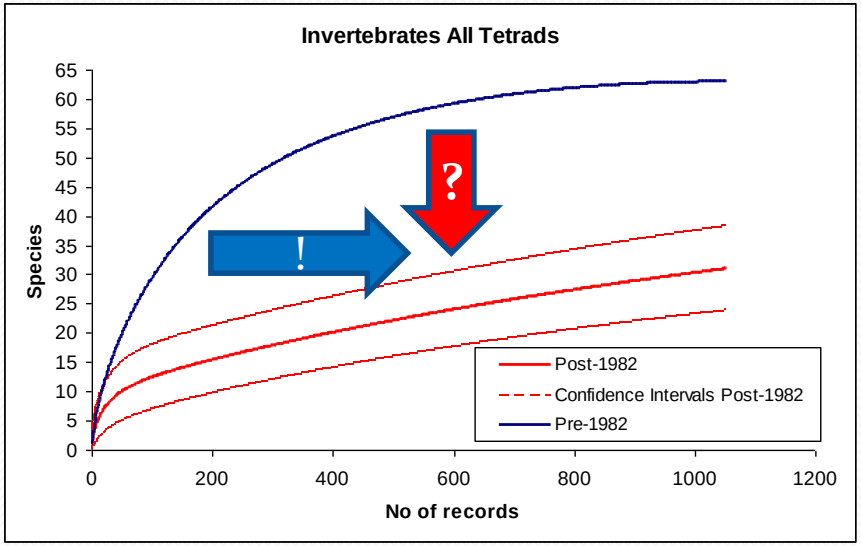
Worrying assumptions

- Must assume that past and current observations are statistically similar
- Note: doesn't necessarily assume that they're unbiased – but that biases have remained the same between periods.
- Where this is NOT true, can get SERIOUS artefacts…

Worrying assumptions

- Example: Yorkshire records of BAP plants & invertebrates, pre- and post- 1982

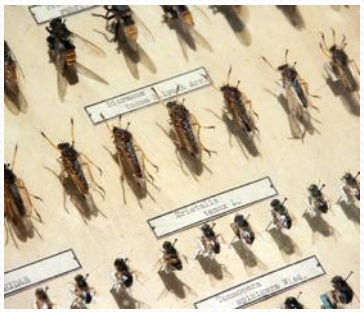




- Massive decline in Yorkshire invert diversity?!
  - No: great increase in white-clawed crayfish monitoring!

Source: C. StQ. W. Callaghan, PhD dissertation

The biases in data have changed




1800s 1900s 2000s

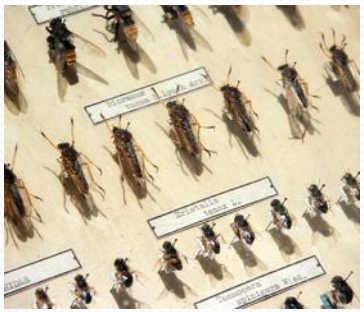
Museums & private collections:
GREATLY oversamples rare spp

e DNA: presence/absence data
Some effects of abundance…

Spp lists from site surveys;
somewhat oversamples rare spp

Standardised trapping or
observations: common spp dominate

The biases in data have changed





1800s 1900s 2000s 2100s

Museums & private collections:
GREATLY oversamples rare spp

e DNA: presence/absence data
Some effects of abundance…

Spp lists from site surveys;
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Automated ID? Remote sense spp?
Tricorders?? How will future technology change biases?

Standardised trapping or
observations: common spp dominate

Monitoring biotic change

• Species' distributions	Occurrence data Sampling event data
• Species' populations	Occurrence data + downscaling? Sampling event data
• Local species richness	Occurrence data + modelling Sampling event data
• National species richness	Occurrence data
• Local functional diversity	Sampling event data
• Summed local abundance	Sampling event data
• Ecosystem service provision	[Sampling event data??]

New GBIF Data classes…

What is a “Sampling event”?

- Quadrat
- Transect
- Trapping array
- Standardised site survey
- e DNA sample
- Timed count…
- Each with a set of spp observed, and (usually) counts of each.

- Upgrade from “**presence only**” to “**presence/absence**” data.
- Allows **spp co-occurrence** and (often) **abundance** estimates, and direct **spp richness**, **functional diversity** measurement.
- **Many NBN data already come from such “sampling events”, but are separated out into dataset – difficult to reassemble.**

Networks of standardised sampling

- Breeding bird survey
- Butterfly Monitoring Scheme
- BBCT BeeWalks
- National Plant Monitoring Scheme
- UK Pollinator Monitoring Scheme
- And many more…

BBS

UKBMS

Bumblebee Conservation Trust

National Plant Monitoring Scheme

PoMS

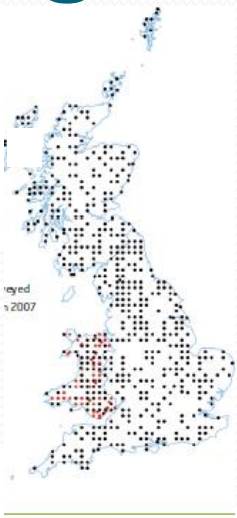
UK Pollinator Monitoring Scheme

Professional

Networks of standardised sampling

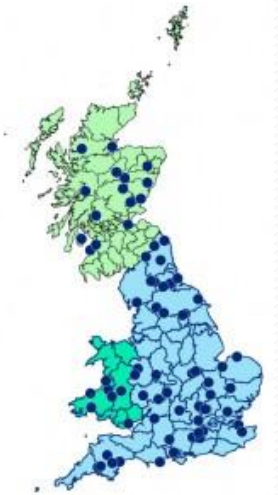
- CEH Countryside survey

Countryside Survey



- Rothamsted suction trap network

- Rothamsted Light trap network



Networks of standardised sampling

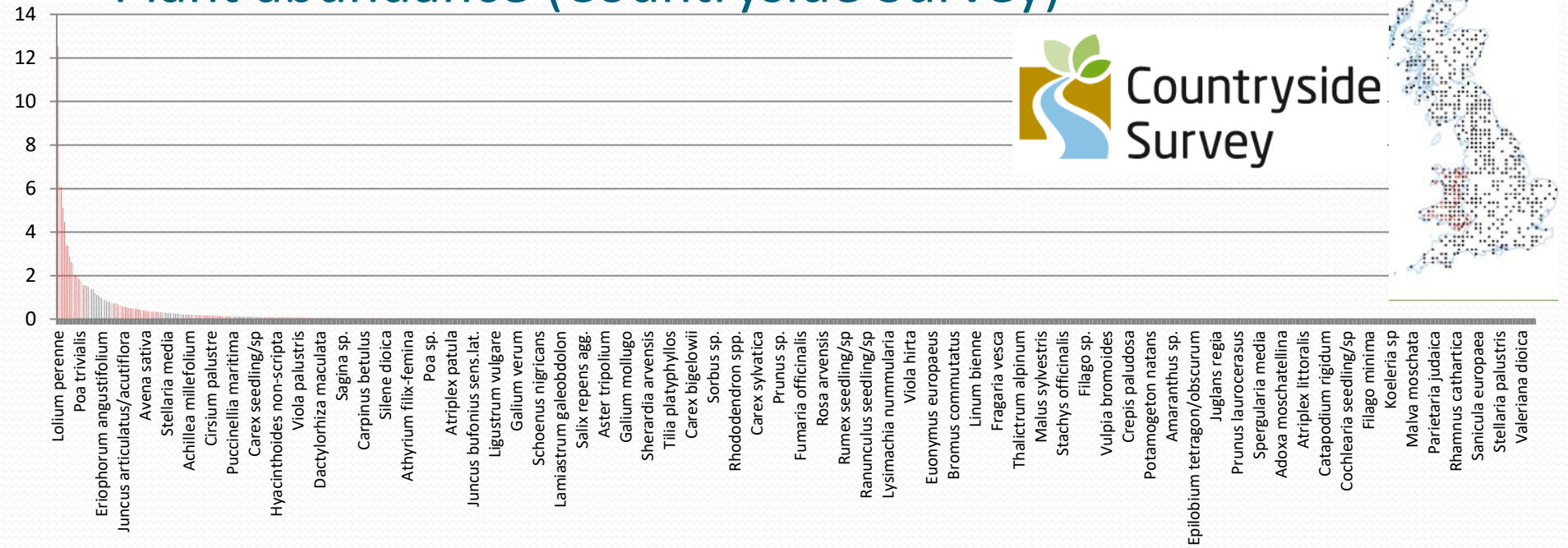
- Integrate such standardised observation datasets into NBN as linked sets of records ("sampling events")?

Networks of standardised sampling

- Integrate such standardised observation datasets into NBN as linked sets of records ("sampling events")?
- Could be as simple as adding a linking code to all records collected together (already possible), and facility to retrieve as groups.
- Ideally should allow attributes of the sample event (method, scale, etc) to be recorded, and set of associated species' records to be uploaded together.
- Would allow direct monitoring of spp population sizes, local richness, functional diversity, summed community abundance… and possible modelling of ecosystem service delivery.

But sampling events have their limits too…

Plant abundance (Countryside Survey)

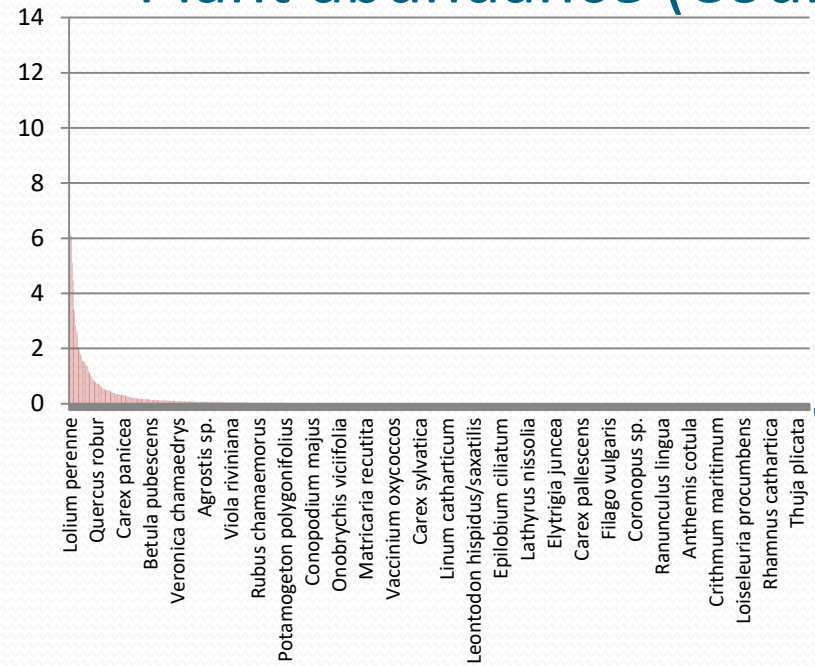


Countryside Survey

- 880 species recorded 2007
- **14 spp account for 50% of cover**, 384 make up 99%

But sampling events have their limits too…

Plant abundance (Countryside Survey)



Countryside Survey

∴ ca. 1920 more (rare) spp with 0 in sample!

Random or stratified sampling will not give us enough data to draw meaningful conclusions about **status & trends of rare spp**, even with immense sampling effort.

- A key out-standing challenge is to develop efficient methods for monitoring **change in RARE spp populations!**

In summary

- The UK has some of the best biodiversity data in the world – partly thanks to NBN!
- These data allow robust estimates of species' distributions, and of national scale spp richness (at least for well-known taxa)
- Modelling allows us to use the data to estimate population sizes and local species richness – but with worrying assumptions that are probably false!
- Incorporating "sampling event" data structures should greatly extend the set of biodiversity variables that can be assessed.
- Nonetheless, monitoring rare spp populations remains an important methodological challenge for the future…

Any Questions?

Many thanks to all of those whose biodiversity data I've made use of over the years!