BSBI Plant Atlas 2020
Visualising results and communicating uncertainty

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UK Centre for Ecology & Hydrology

The *Plant Atlas 2020* survey

- **20 years** to complete (2000–2019)
- **>8,500** botanists
- Recording the locations of wild plants in the **3,893** 10 km grid squares in Britain and Ireland
- **~30 million** (new) records
- **3,495** taxa

Botanical Society of Britain & Ireland

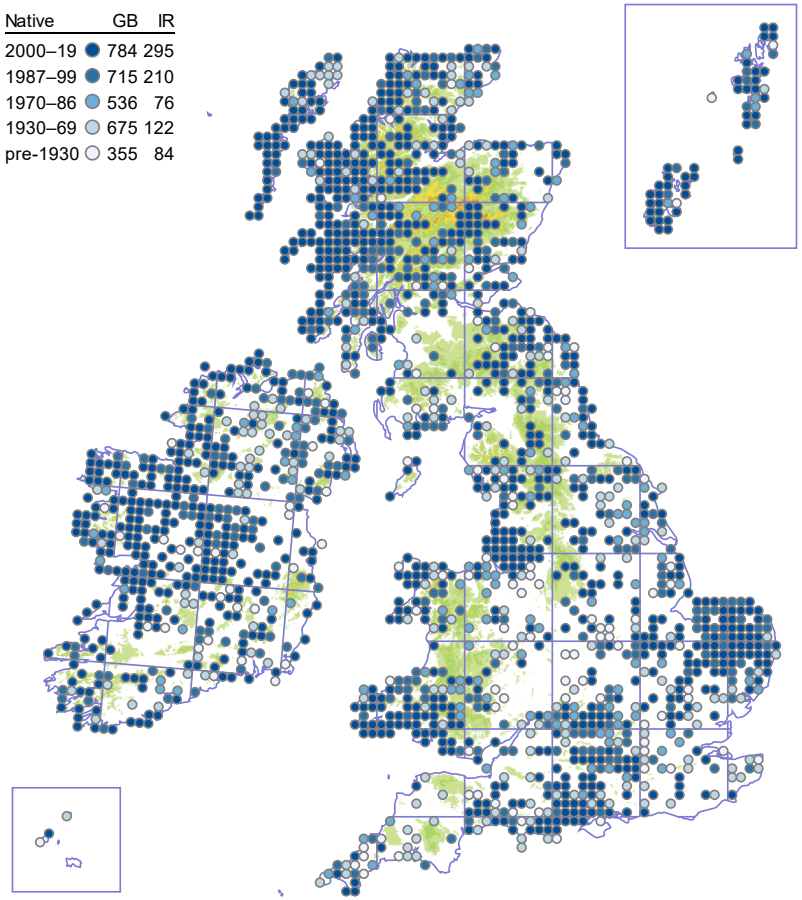
Biological Records Centre

UK Centre for Ecology & Hydrology

Aim 1: Map the distribution of *all* flowering plants and ferns growing in the wild in Britain and Ireland

Early Marsh Orchid

Dot-distribution maps (10 km scale)



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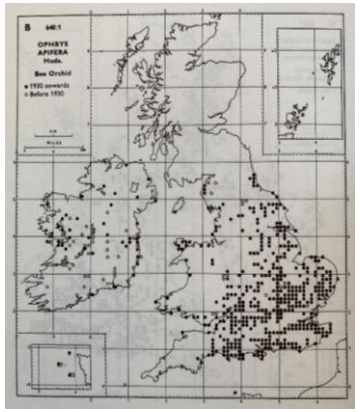
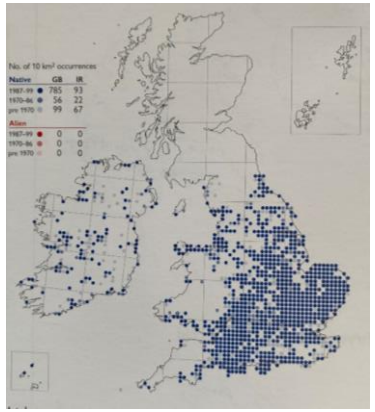
Aim 2: Measure changes in distribution

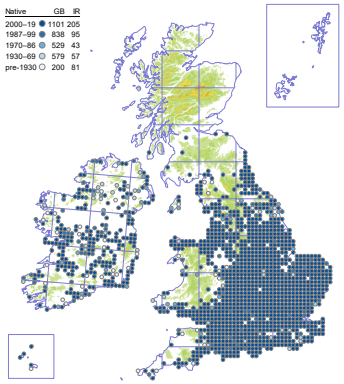
1. Change assessed using three atlases



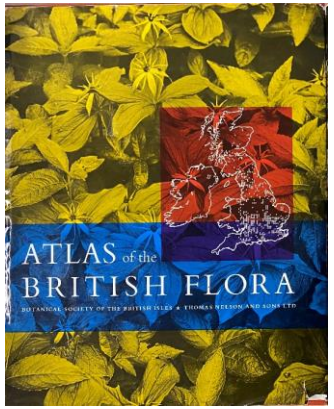
1962

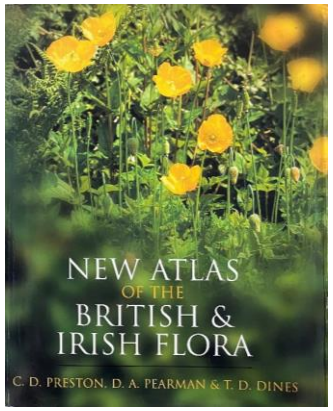


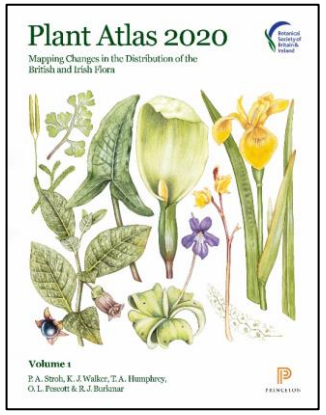
2002



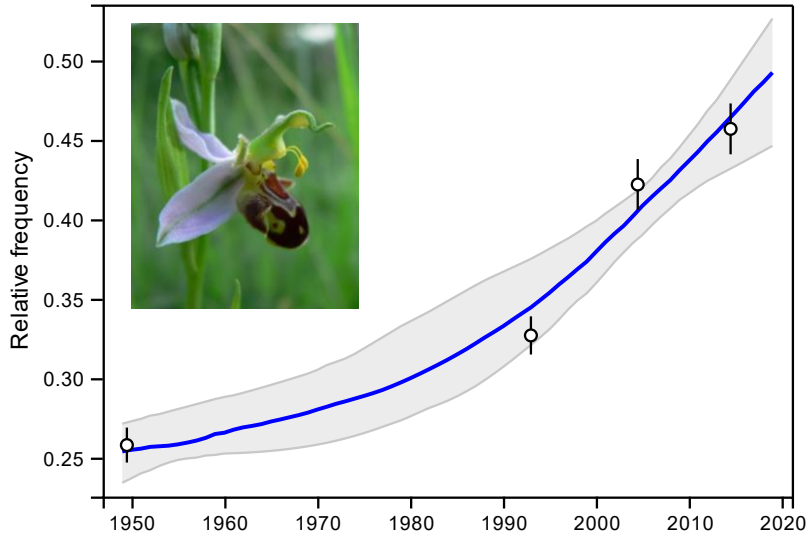
2023



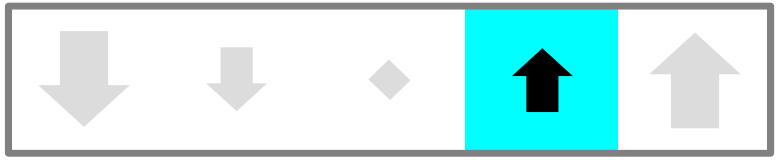




2. Trends estimated using Frescalo



3. Summarised as a 'trend bar'



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Aims and assumptions

- Changes in national distribution (range size)
- Appropriate taxonomic aggregation
- Appropriate spatial scale
- Appropriate date-classes (time periods)
- Assumptions about statistical model “data-generating process”
- Representing uncertainty in results?

Changing “effort”

Changing effort at small scales is frequently correlated with the changing probability of a species being recorded

Rare/critical taxa more likely to be recorded at finer scales historically; reverse often true for common taxa

This *guarantees* biased trends at these scales

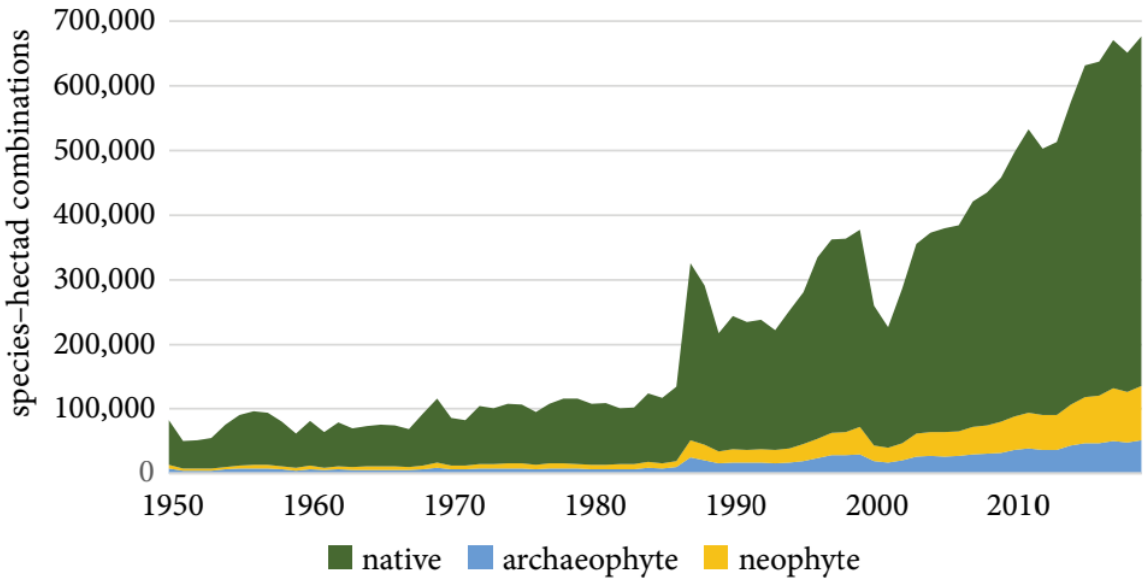
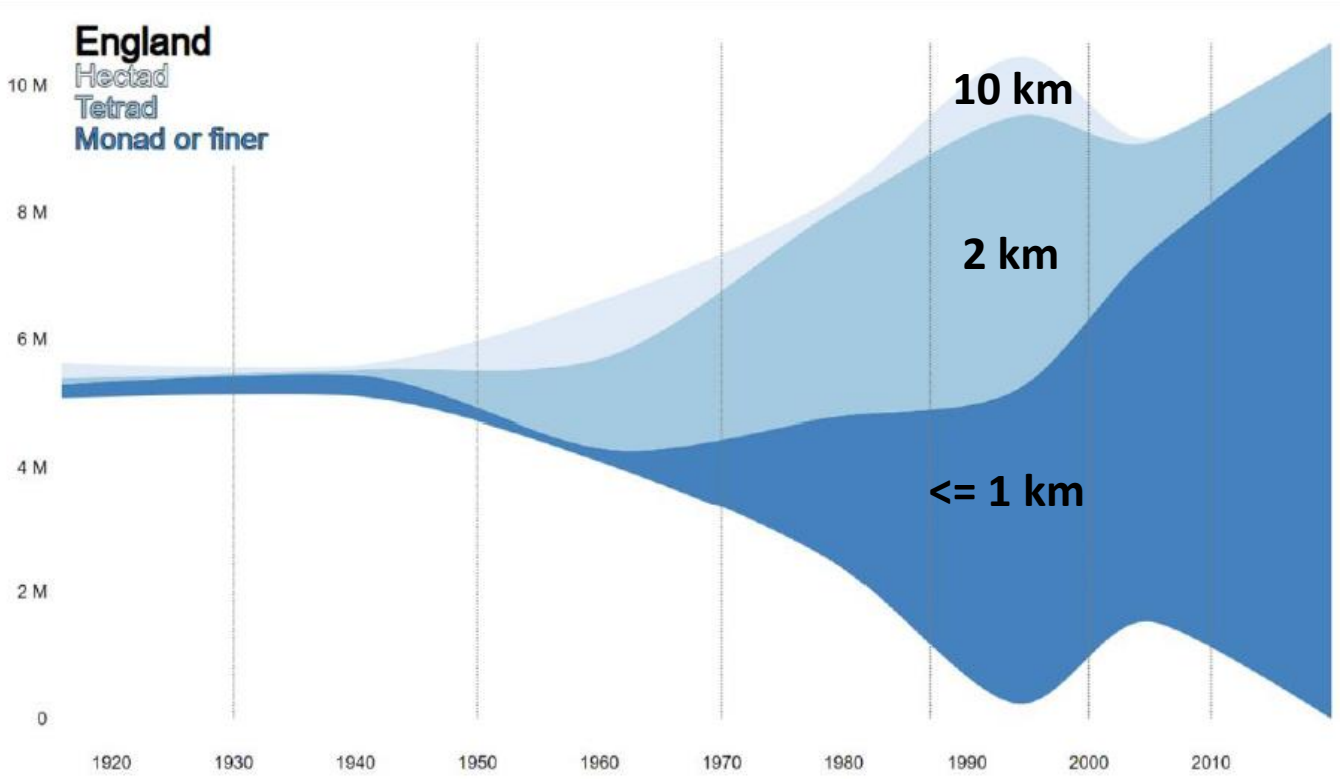


Figure 5.2. The number of hectad-species combinations submitted for all species in Britain and Ireland 1950–2019. Combinations assigned to date ranges have been attributed evenly across the years they span.



Pescott, O.L. et al. 2019. *British & Irish Botany*, *1*(4), pp. 250–282

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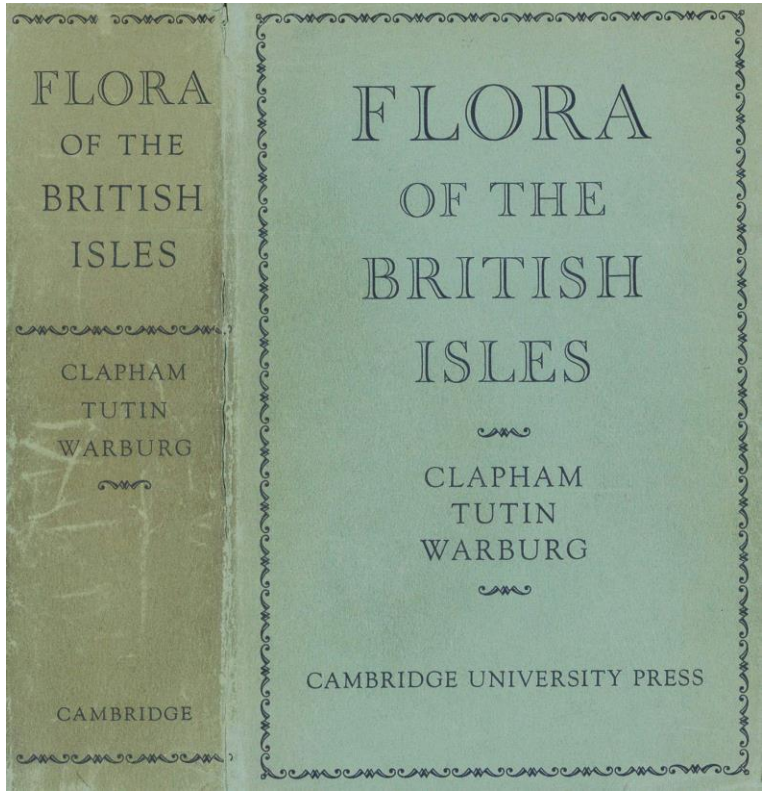
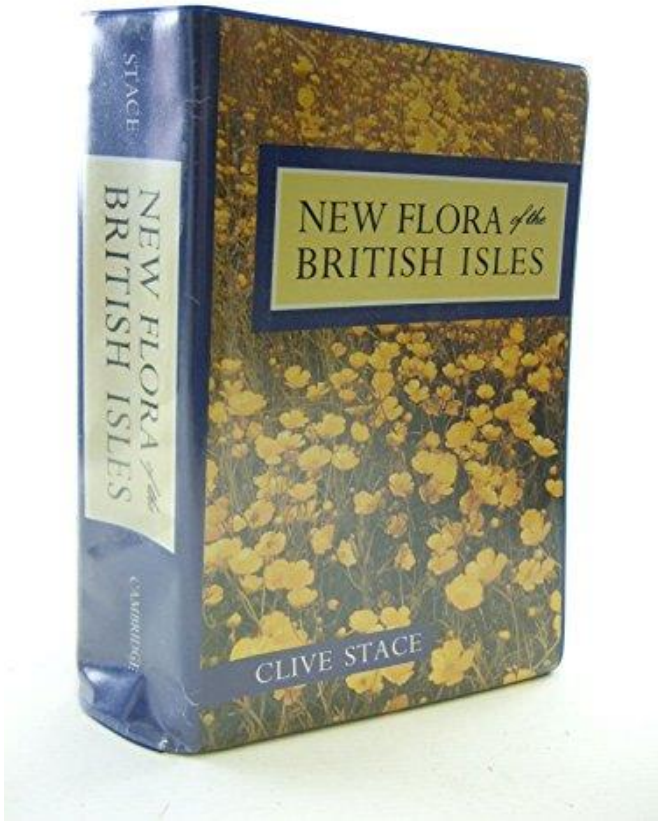
Changing knowledge and resources



1952: ~700 aliens, but only ~450 in keys

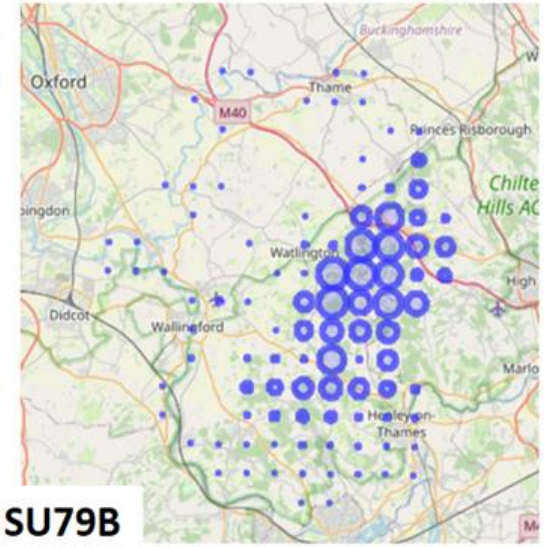


1991: Full treatment of ~1,500 aliens (1,770 in 3rd ed., 2010)

Stace & Crawley (2015) *Alien Plants*, London: HarperCollins

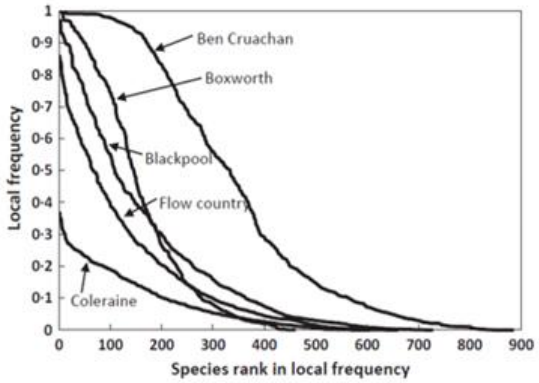
Adjusting for variable effort in time and space

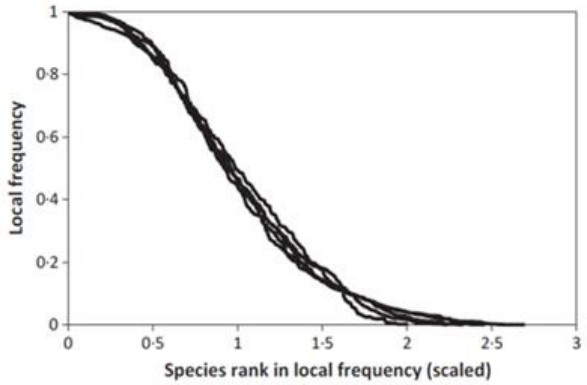
1. For each target grid cell, calculate a weighted frequency for every species based on a weighted "neighbourhood"



SU79B

2. For each neighbourhood, rescale the all-species (weighted) frequency curve to a standard value





3. For each (standardised) neighbourhood, define the top x% of spp. as "benchmarks". These will be used to index recording effort per site/time-period

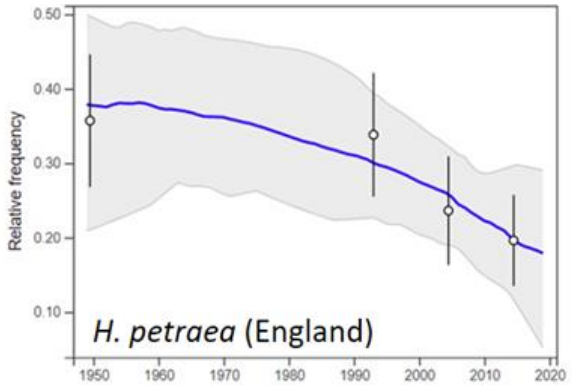
4. For each site/time-period, use the proportion of recorded benchmarks to adjust standardised spp. frequencies.

Difference between data and effort-adjusted frequencies are then estimates of time-period deviations.

That is, they tell us whether a species is more common or rare than expected, and so can be used to track temporal trends.

FREquency SCAling LOcal
"Frescalo" (Hill, 2012)

5. The across-neighbourhood distribution of time factors within a time period leads to a trend estimate (here a boot-strapped smoother, but could be linear)



How many estimates?

Status	Britain: long term	Britain: short term	Ireland: long term	Ireland: short term	Britain: slope comparison	Ireland: slope comparison
Native	1,136	1,165	819	847	1,244	859
Alien	-	-	2	3	-	2
Archaeophyte	144	149	95	93	148	101
Neophyte	226	836	254	460	227	334
Native or alien	28	26	4	4	32	5
Hybrid	11	52	10	35	9	8
Totals	**1,545**	**2,228**	**1,184**	**1,442**	**1,660**	**1,309**

6,399

- Another 15,691 only on website
- 22,090 in total — **“production scale” statistics**

Online trends

England

Short-term trend (post-1987)

Scale trends to species

Scale density plot to max

Rough Hawkbit *Leontodon hispidus* L.

Post-1987 effort-adjusted 10 km distribution trends for **England**

Figure 1. Smoothed time trend.

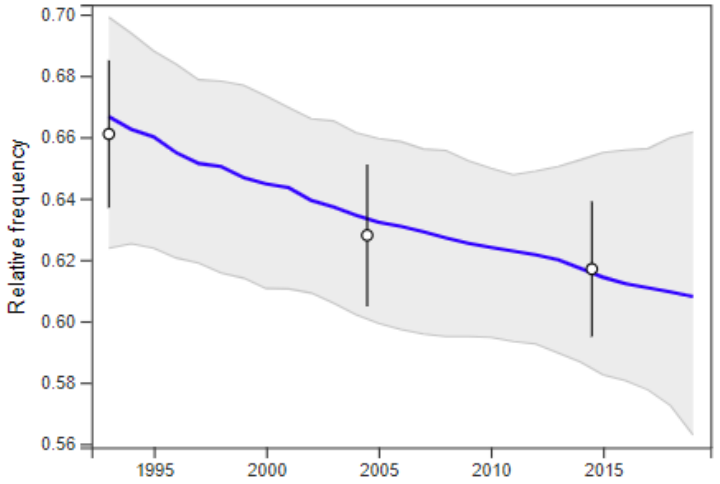


Figure 2. 100 compatible linear trends.

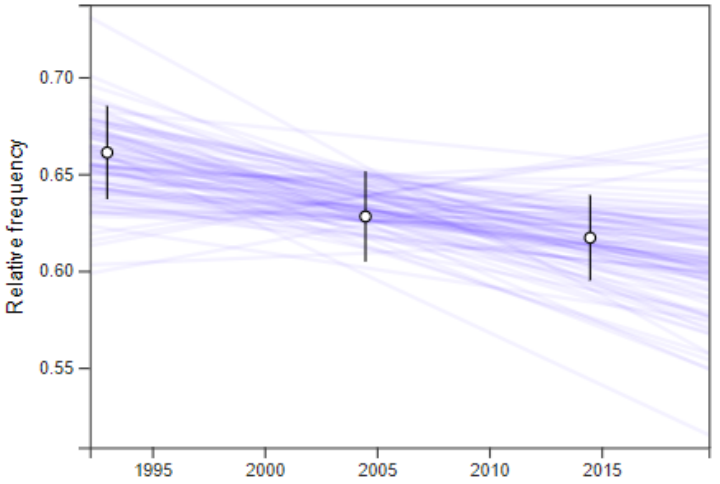


Figure 3. Distribution of linear slope estimates.

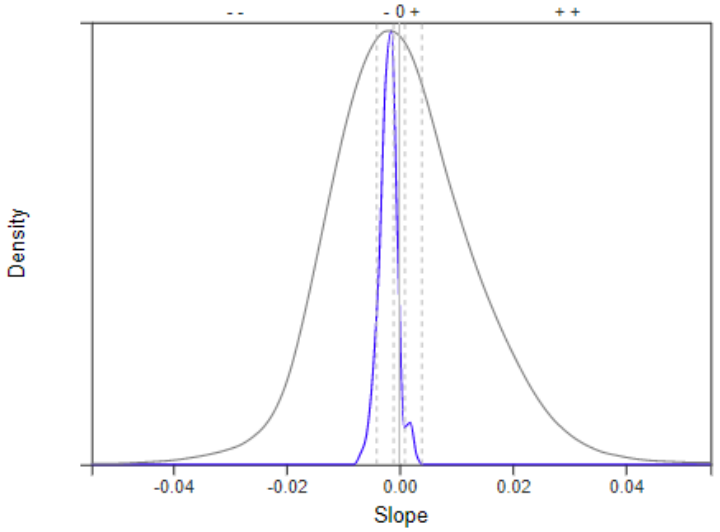
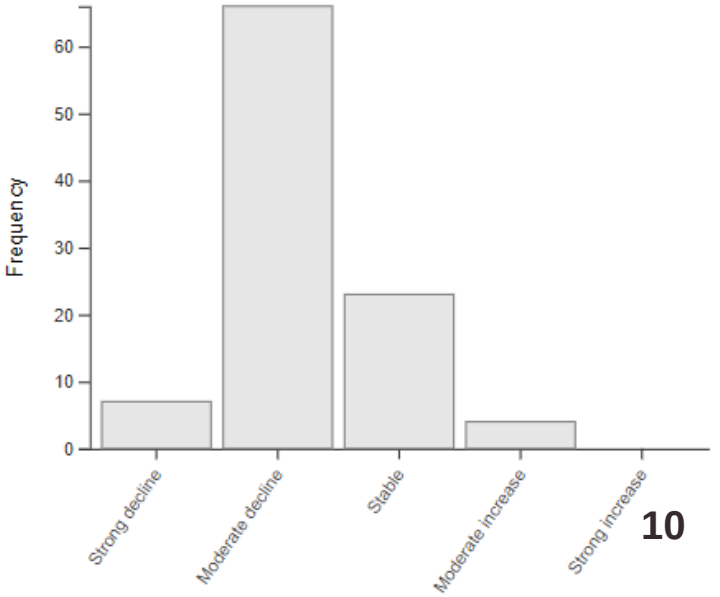


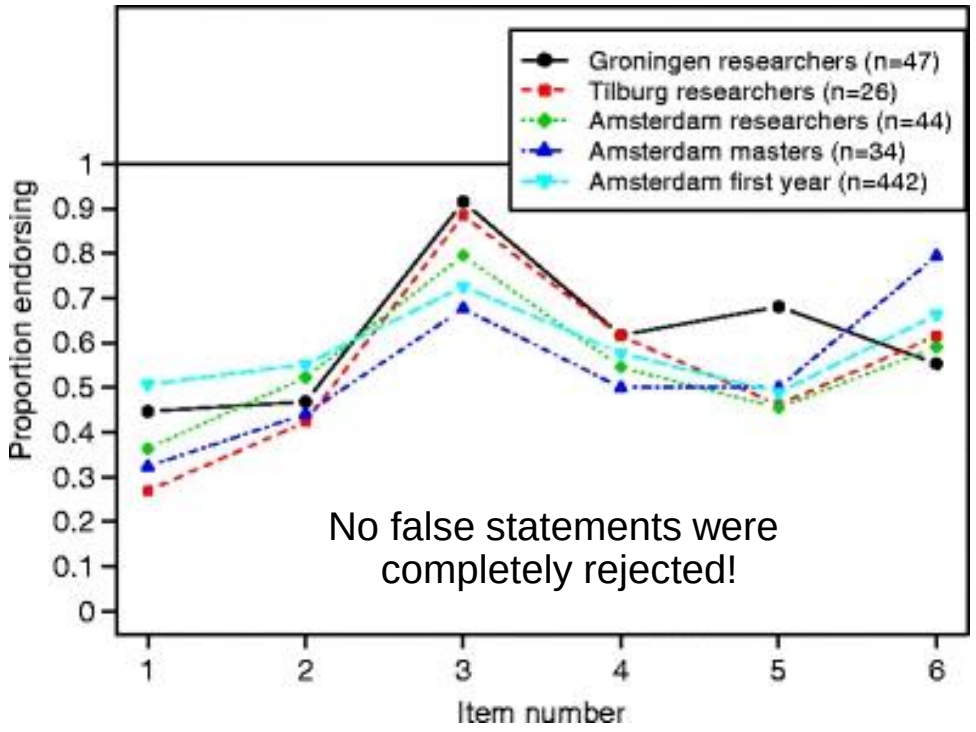
Figure 4. Classification of slope estimates.



Communicating model-based uncertainty

- Conventional model-based uncertainty statements (e.g. standard errors, confidence intervals, credible intervals) are hard to understand
  - Demonstrated repeatedly (e.g. Belia et al., 2005; Hoekstra et al. 2014; McShane & Gal, 2016)

- Viewers can assume that points outside of error bars/ribbons are impossible
- Viewers assume that trends are always parallel to the error ribbon
- Continuous probability information is misinterpreted as categorical and deterministic
- The same visual conventions can mean different things (e.g. error bars used to indicate different types of uncertainty estimate)
- (Also, model-based! Model assumption failure not captured at all)



(False statements)

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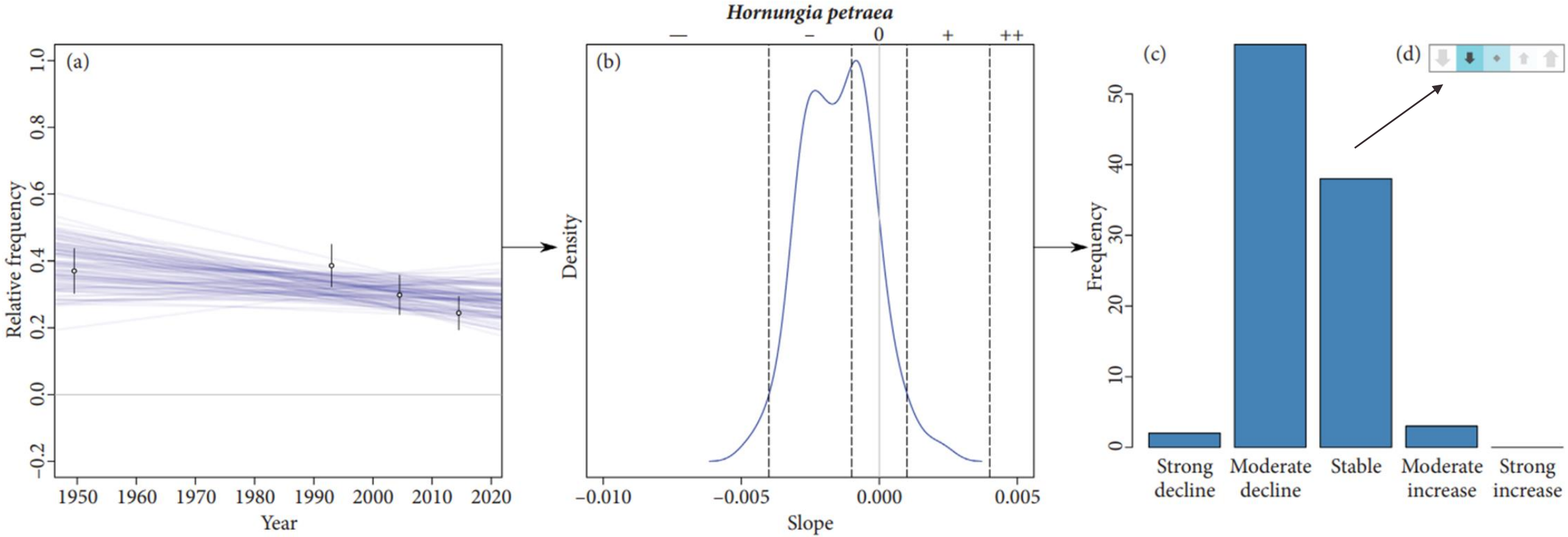
Plot from Hoekstra et al. (2014). Robust misinterpretation of confidence intervals. *Psychon. Bull. Rev.*, 21, 1157–1164.

Line ensembles offer “a more interpretable rendering of [model-based] uncertainty […], especially when viewers are unlikely to have statistical training”

– Kale et al., (2018)



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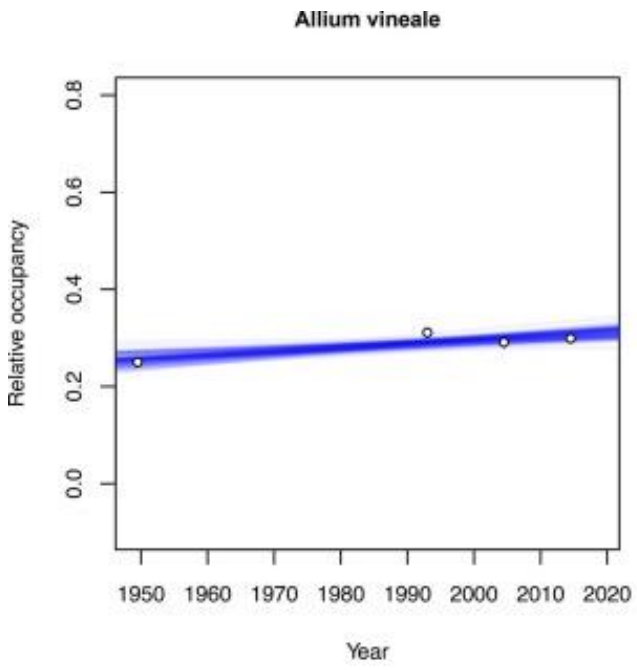
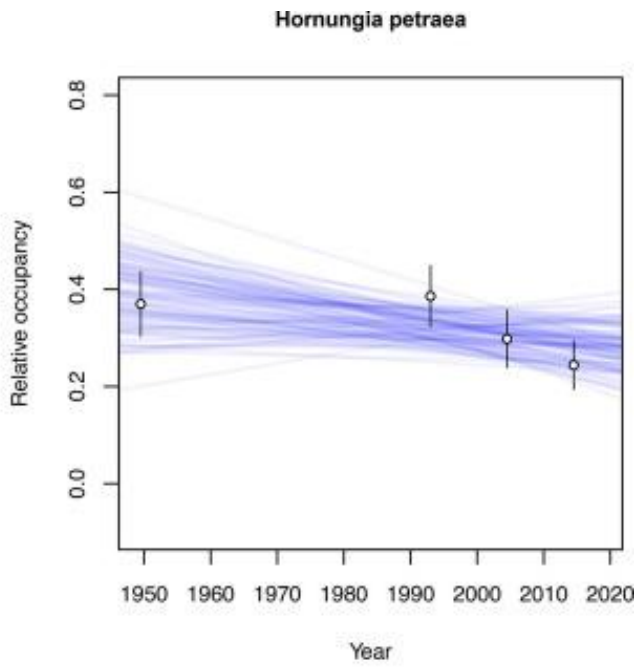
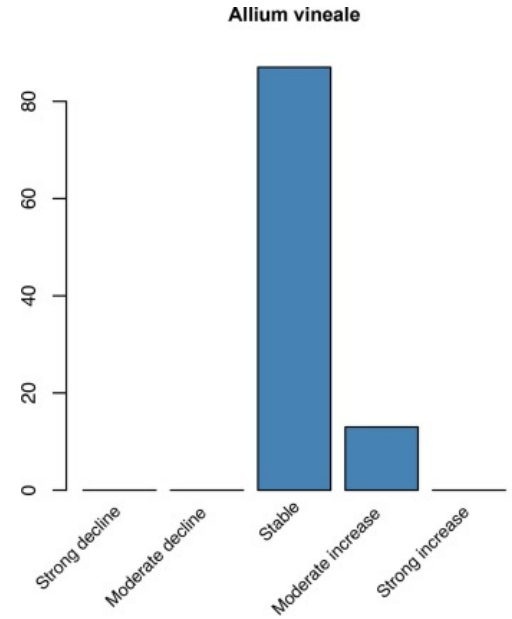
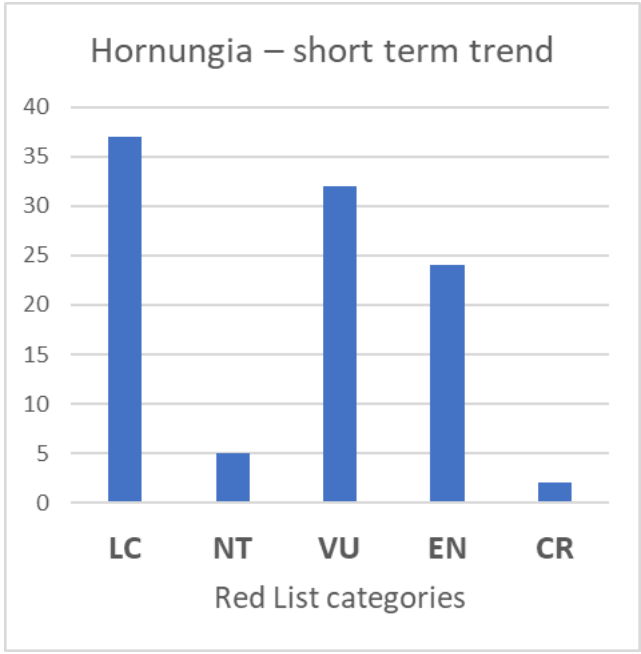
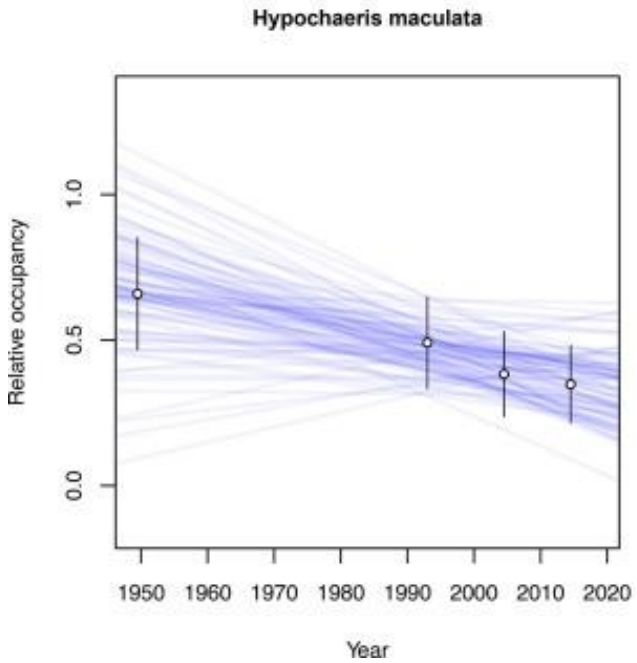
Kale, A., Nguyen, F., Kay, M. & Hullman, J., 2018. Hypothetical outcome plots help untrained observers judge trends in ambiguous data. *IEEE Transactions on Visualization and Computer Graphics*, *25*(1), pp. 892–902.

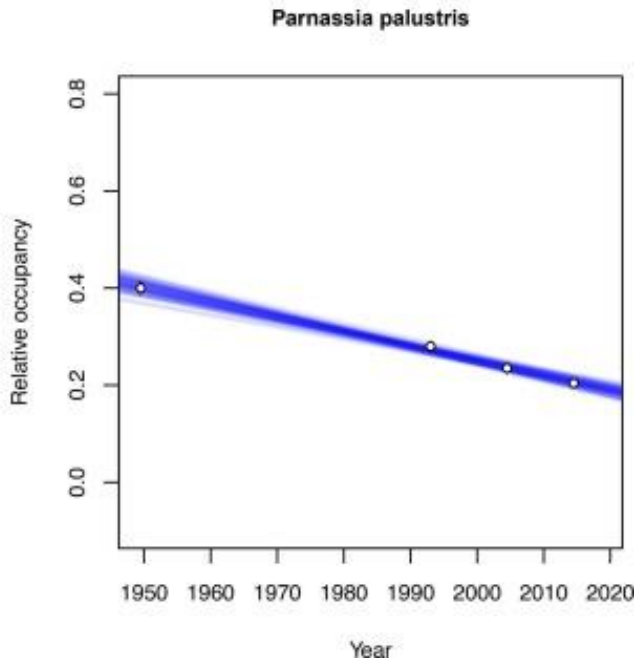

Allium vineale
Relative occupancy
0.0
0.2
0.4
0.6
0.8
1950 1960 1970 1980 1990 2000 2010 2020
Year

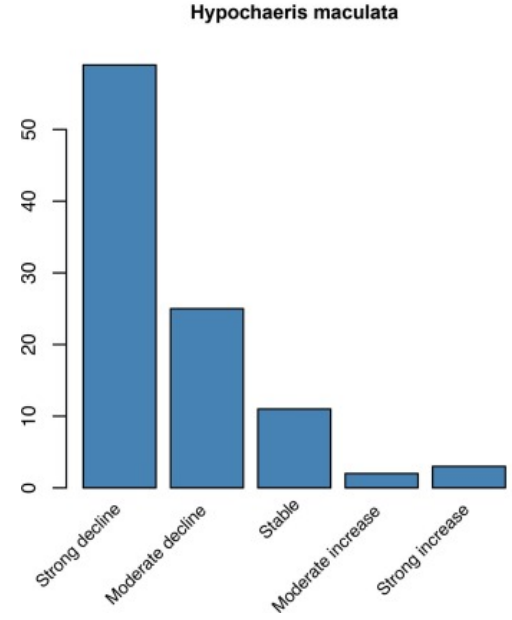

Hornungia petraea
Relative occupancy
0.0
0.2
0.4
0.6
0.8
1950 1960 1970 1980 1990 2000 2010 2020
Year

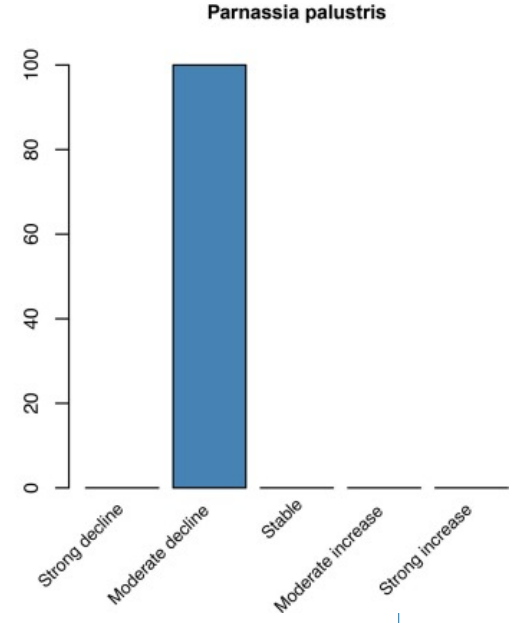

Allium vineale
0
20
40
60
80
Strong decline
Moderate decline
Stable
Moderate increase
Strong increase


Hornungia – short term trend
0
5
10
15
20
25
30
35
40
LC
NT
VU
EN
CR
Red List categories


Hypochaeris maculata
Relative occupancy
0.0
0.5
1.0
1950 1960 1970 1980 1990 2000 2010 2020
Year


Parnassia palustris
Relative occupancy
0.0
0.2
0.4
0.6
0.8
1950 1960 1970 1980 1990 2000 2010 2020
Year


Hypochaeris maculata
0
10
20
30
40
50
Strong decline
Moderate decline
Stable
Moderate increase
Strong increase


Parnassia palustris
0
20
40
60
80
100
Strong decline
Moderate decline
Stable
Moderate increase
Strong increase

But are we communicating *all* the uncertainty?

"Our findings add to others suggesting that communicators can be transparent about statistical uncertainty without undermining their credibility as a source but should endeavour to provide a quantification, such as a numeric range, where possible."
– Kerr et al. (2023)

Communicating scientific uncertainty

Baruch Fischhoff[a,b,1] and Alex L. Davis[a]

Departments of [a]Engineering and Public Policy and [b]Social and Decision Sciences, Carnegie Mellon University, Pittsburgh, PA 15213-3890

Edited by Dietram A. Scheufele, University of Wisconsin–Madison, Madison, WI, and accepted by the Editorial Board February 24, 2014 (received for review November 5, 2013)

All science has uncertainty. Unless that uncertainty is communicated effectively, decision makers may put too much or too little faith in it. The information that needs to be communicated depends on the decision

one hand, the uncertainties that it addresses must be reduced to their decision-relevant elements. On the other hand, the uncertainties that scientists fail to mention must be uncovered. Which

a signal (e.g., whether
ing among fixed optio
***(iii)* learning to create**
ogy)? We examine the
to characterize, assess
each. We then offer a
sources of uncertaint
a minimal burden on
whose decisions depe
sions, better science, a

science communication |
mental models

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Research

Cite this article: Kerr J, van der Bles A-M, Dryhurst S, Schneider CR, Chopurian V, Freeman ALJ, van der Linden S. 2023 The effects of communicating uncertainty around statistics, on public trust. *R. Soc. Open Sci.* **10**: 230604. https://doi.org/10.1098/rsos.230604

The effects of communicating uncertainty around statistics, on public trust

John Kerr[1,3,†], Anne-Marthe van der Bles[4,†], Sarah Dryhurst[1,2], Claudia R. Schneider[1,2], Vivien Chopurian[5], Alexandra L. J. Freeman[1] and Sander van der Linden[3]

[1]Winton Centre for Risk & Evidence Communication and [2]Department of Psychology, University of Cambridge, Cambridge CB2 1TN, UK
[3]Department of Public Health, University of Otago, Wellington, New Zealand

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The effects of communicating uncertainty on public trust in facts and numbers

Anne Marthe van der Bles[a,b,c,1], Sander van der Linden[a,b,d,1], Alexandra L. J. Freeman[a,b], and David J. Spiegelhalter[a,b]

[a]Winton Centre for Risk and Evidence Communication, University of Cambridge, Cambridge CB3 0WA, United Kingdom; [b]Department of Pure Mathematics and Mathematical Statistics, University of Cambridge, Cambridge CB3 0WA, United Kingdom; [c]Department of Social Psychology, University of Groningen, 19712 TS Groningen, The Netherlands; and [d]Cambridge Social Decision-Making Lab, Department of Psychology, University of Cambridge, Cambridge CB2 3RQ, United Kingdom

Edited by Arild Underdal, University of Oslo, Oslo, Norway, and approved February 20, 2020 (received for review August 7, 2019)

Uncertainty is inherent to our knowledge about the state of the world yet often not communicated alongside scientific facts and numbers. In the "posttruth" era where facts are increasingly con-

the general sense of honesty evoked [by uncertainty] . . . this did not seem to offset concerns about the agency's competence" (p. 491). In

tested, a common assum
will reduce public trust.
makes it difficult to evalu
iments—including one p
sample and one field exp
***n* = 5,780)—to examine**
tainty about facts across
migration), formats (verb
low) influences public tru
perceive greater uncertair
only a small decrease in tr
source, and mostly for
results could help reassu
that they can be more
human knowledge.

Five rules for evidence communication

Michael Blastland, Alexandra L. J. Freeman, Sander van der Linden, Theresa M. Marteau & David Spiegelhalter

Avoid unwarranted certainty, neat narratives and partisan presentation; strive to inform, not persuade.

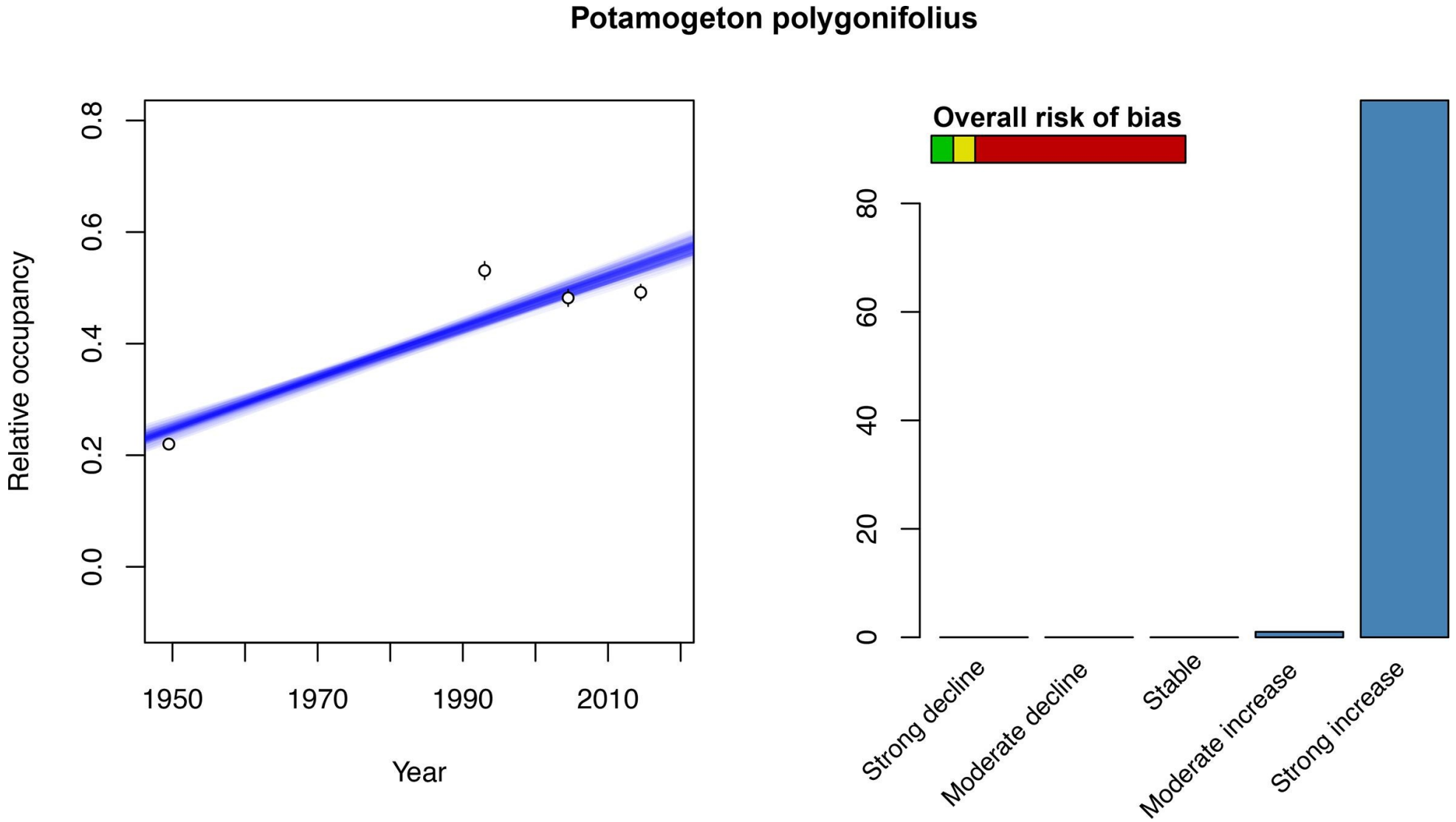
"Be persuasive", "be engaging", "tell stories with your science". Most researchers have heard such exhortations many times, and for good reason. Such rhetorical devices often help to land the message, whether that message is designed to sell a product or win a grant. These are the traditional techniques of communications applied to science.

This approach often works, but it comes with danger.

There are myriad examples from the current pandemic of which we might ask: have experts always been explicit in acknowledging unknowns? Complexity? Conflicts of interest? Inconvenient data? And, importantly, their own values? Rather than re-examine those cases, we offer ideas to encourage reflection, based on our own research.

Our small, interdisciplinary group at the University of Cambridge, UK, collects empirical data on issues such as how to communicate uncertainty, how audiences decide

What about violated model assumptions?



Pescott et al. 2022. Simple methods for improving the communication of uncertainty in species' temporal trends. *Ecol. Ind.* DOI:10.1016/j.ecolind.2022.109117

Expert- and model-based trends: Productive differences?

Myrrhis odorata (Sweet Cicely)

Trends

Post-1930 effort-adjusted 10 km trends

Britain:

Ireland:

Post-1987 effort-adjusted 10 km trends

Britain:

Ireland:

Introduced into cultivation by 1596, this species was first recorded from the wild in 1712 (near Bingley, Mid-west Yorkshire). Since the 1960s there is some evidence of increased frequency locally in the English lowlands but its overall 10 km square distribution is stable.

Sisymbrium officinale (Hedge Mustard)

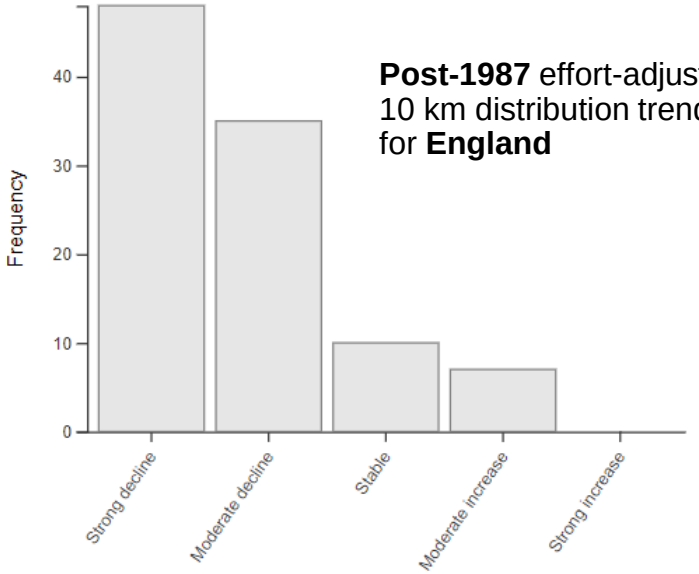
Post-1987 effort-adjusted 10 km trends

Britain:

Ireland:

There has been no significant change in the distribution of *S. officinale* since the 1960s in much of our area, although there have been substantial declines in western Scotland that mirror the loss of cultivated land.

Figure 4. Classification of slope estimates.



Post-1987 effort-adjusted 10 km distribution trends for **England**

Trichophorum germanicum (Deergrass)

Post-1987 effort-adjusted 10 km trends

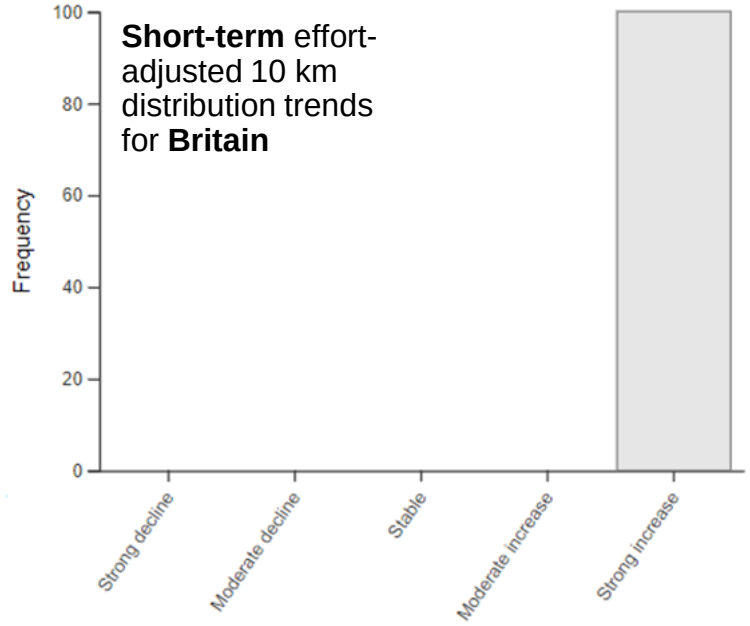
Britain:

Ireland:

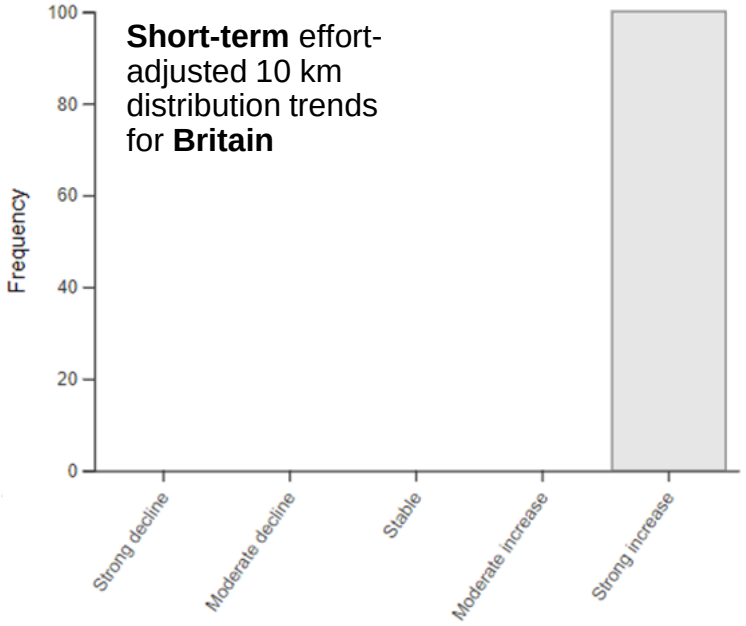
Botanists in Britain and Ireland were only made aware of the presence of *T. germanicum*, as distinct from *T. cespitosum* ***s.s.***, in 1999, and so earlier records are assignable only to *T. cespitosum* ***s.l.***. However, most records for this aggregate taxon are likely to be referable to *T. germanicum*. Consequently, its trends are expected to mirror the broad concept, with a continued long-term decline on the lowland heaths of southern and eastern England, mainly as a result of drainage, but maintenance

Neophytes — recent increasers

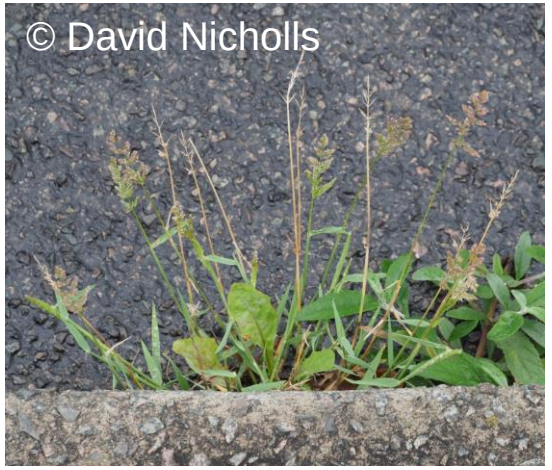
Garden Lady's-mantle
(*Alchemilla mollis*)

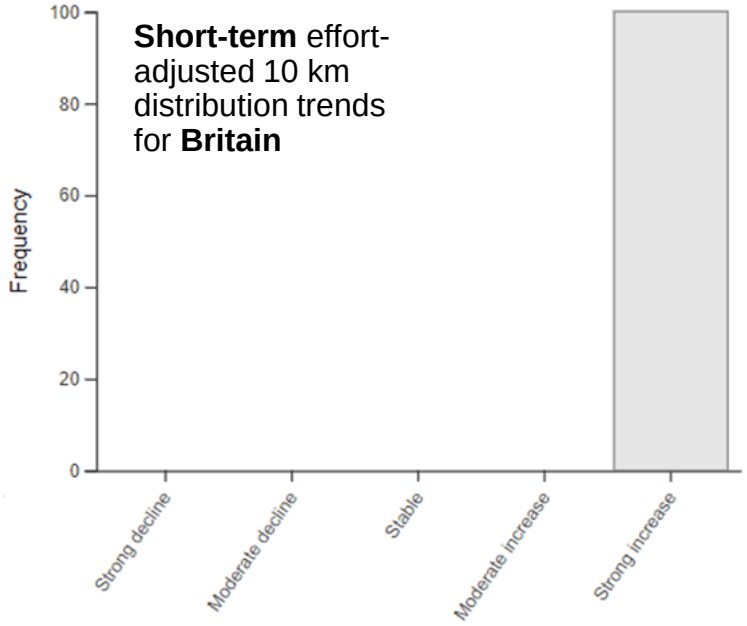


Narrow-leaved Ragwort
(*Senecio inaequidens*)

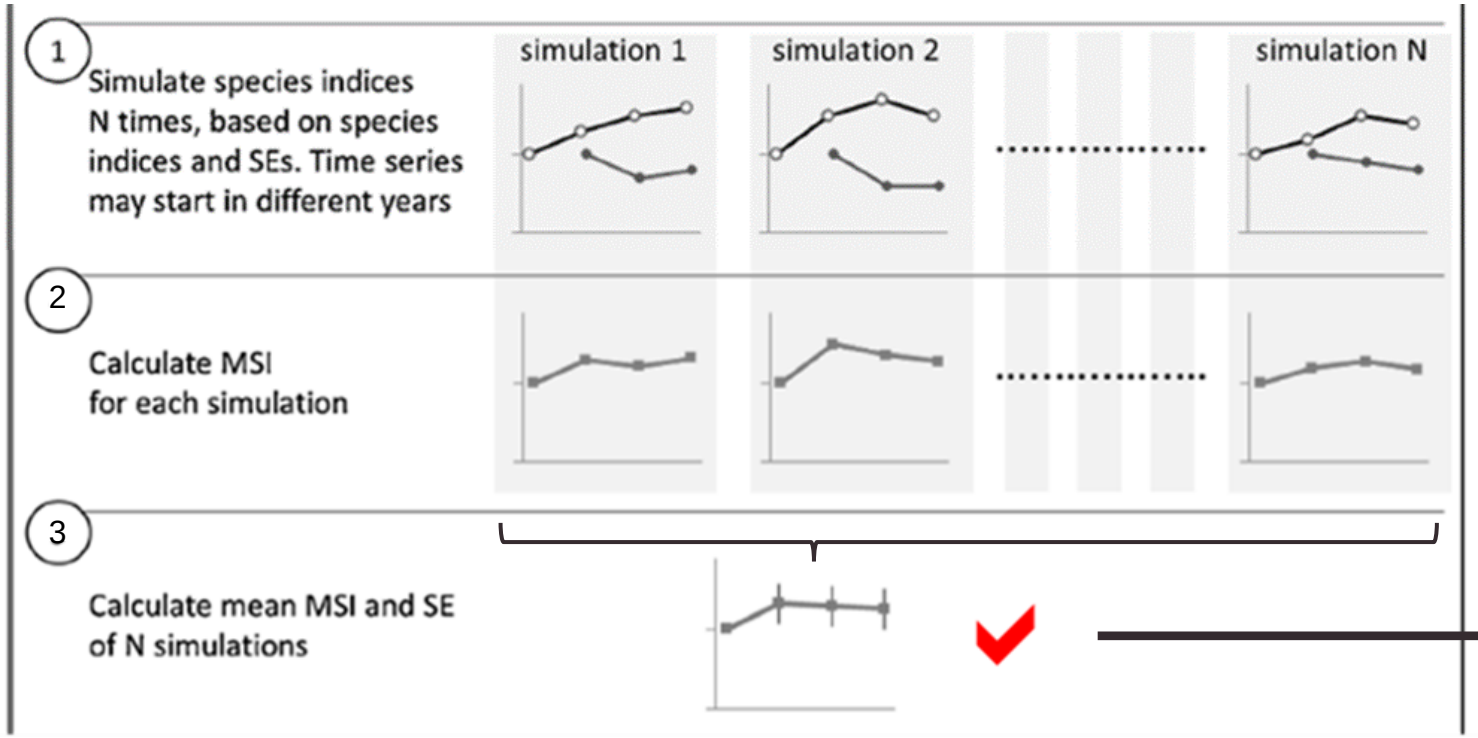


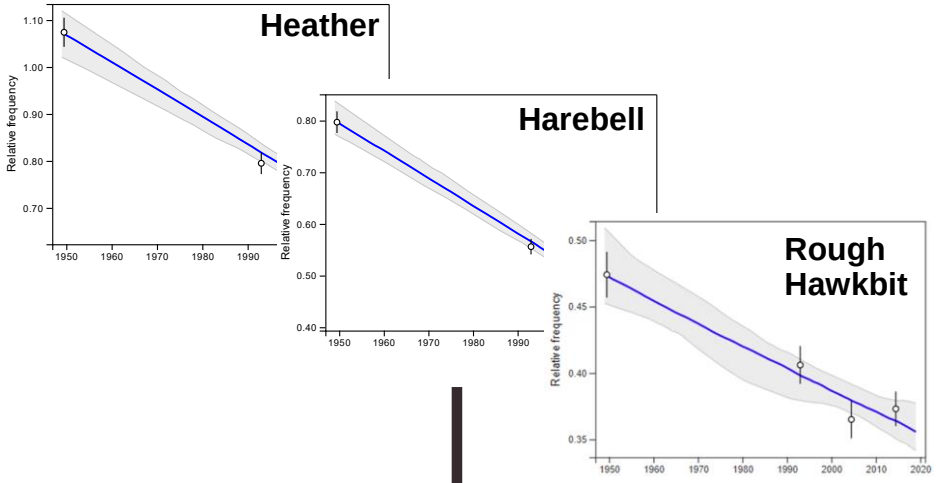
Water Bent
(*Polypogon viridis*)



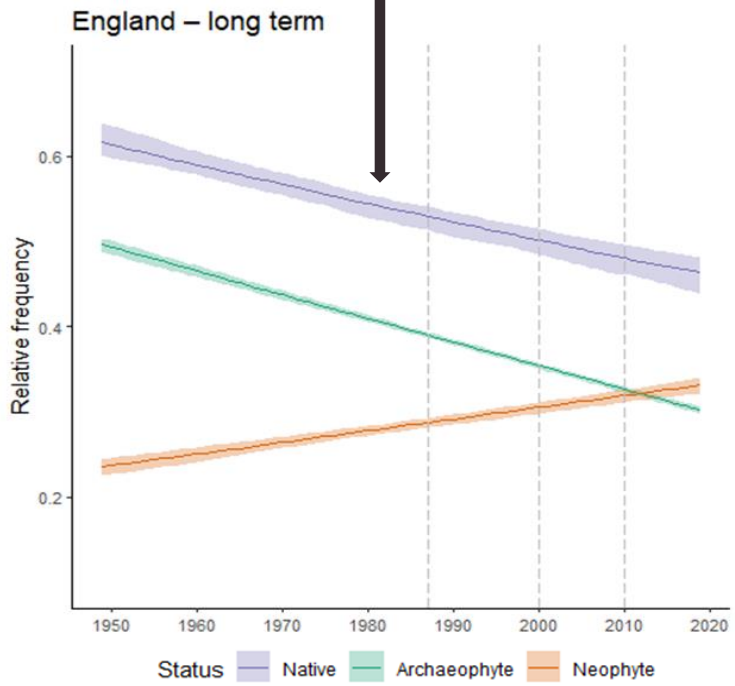


Aggregated trends with model-based uncertainty propagation



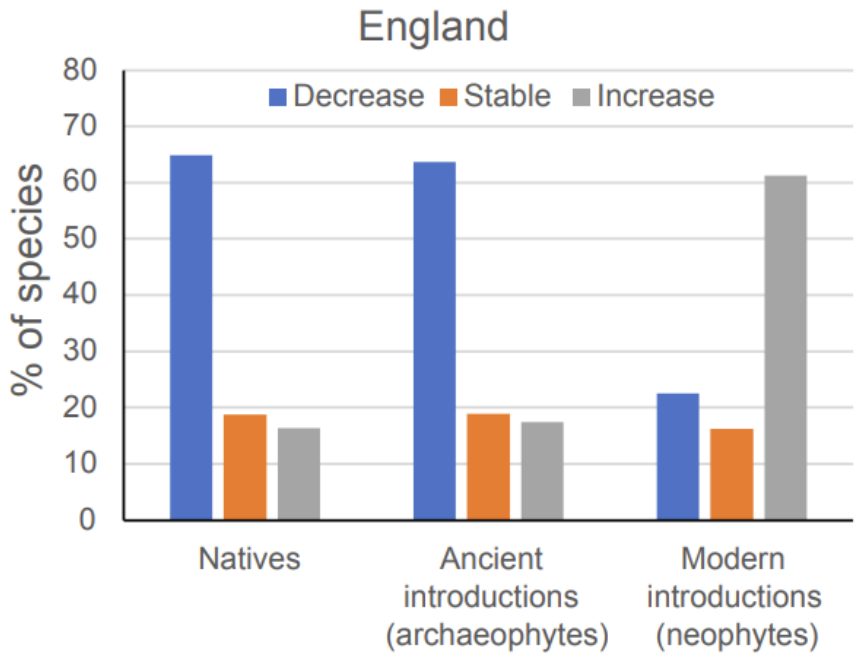


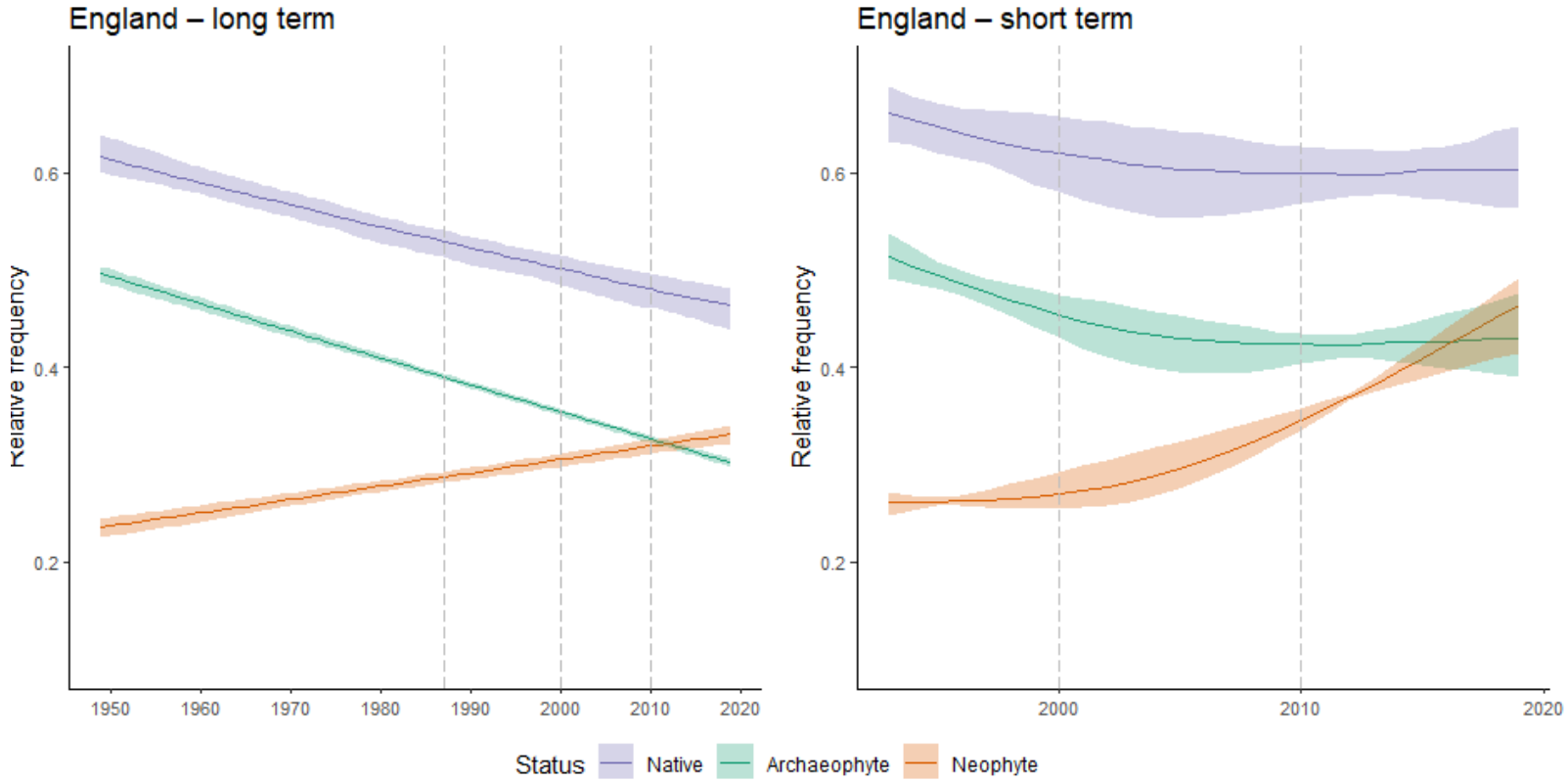
Etc. etc.



Graphic adapted from Soldaat et al. (2017). *Ecol. Ind.*

Trends in natives and non-natives





- **LEFT**: Species' linear trends summarised into 3 rather than 5 categories. So, "moderate" and "strong" declines collapsed into "decreasing" etc.
- **RIGHT**: Averaged smoothed trends (propagating species' level model-based uncertainty)

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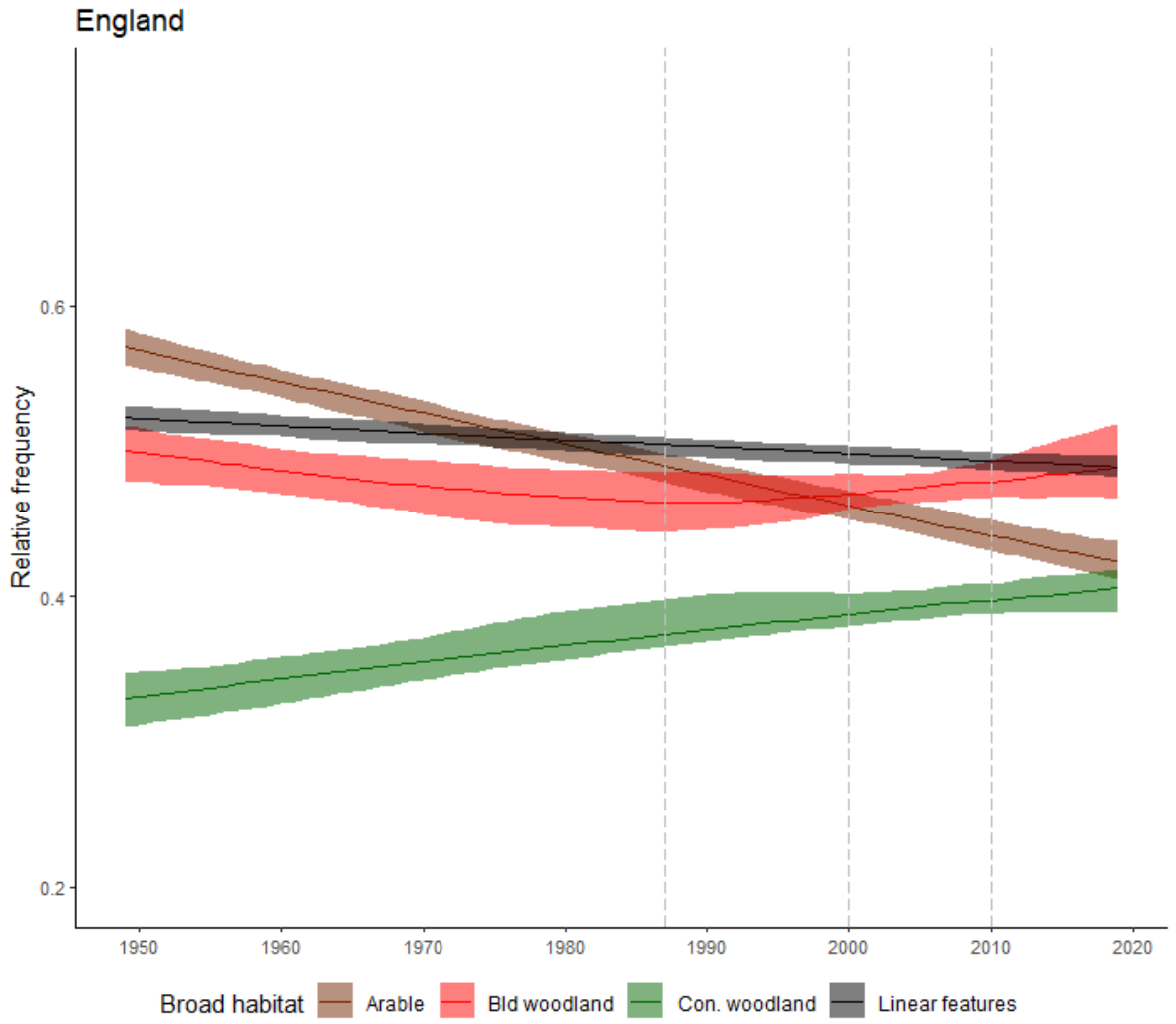
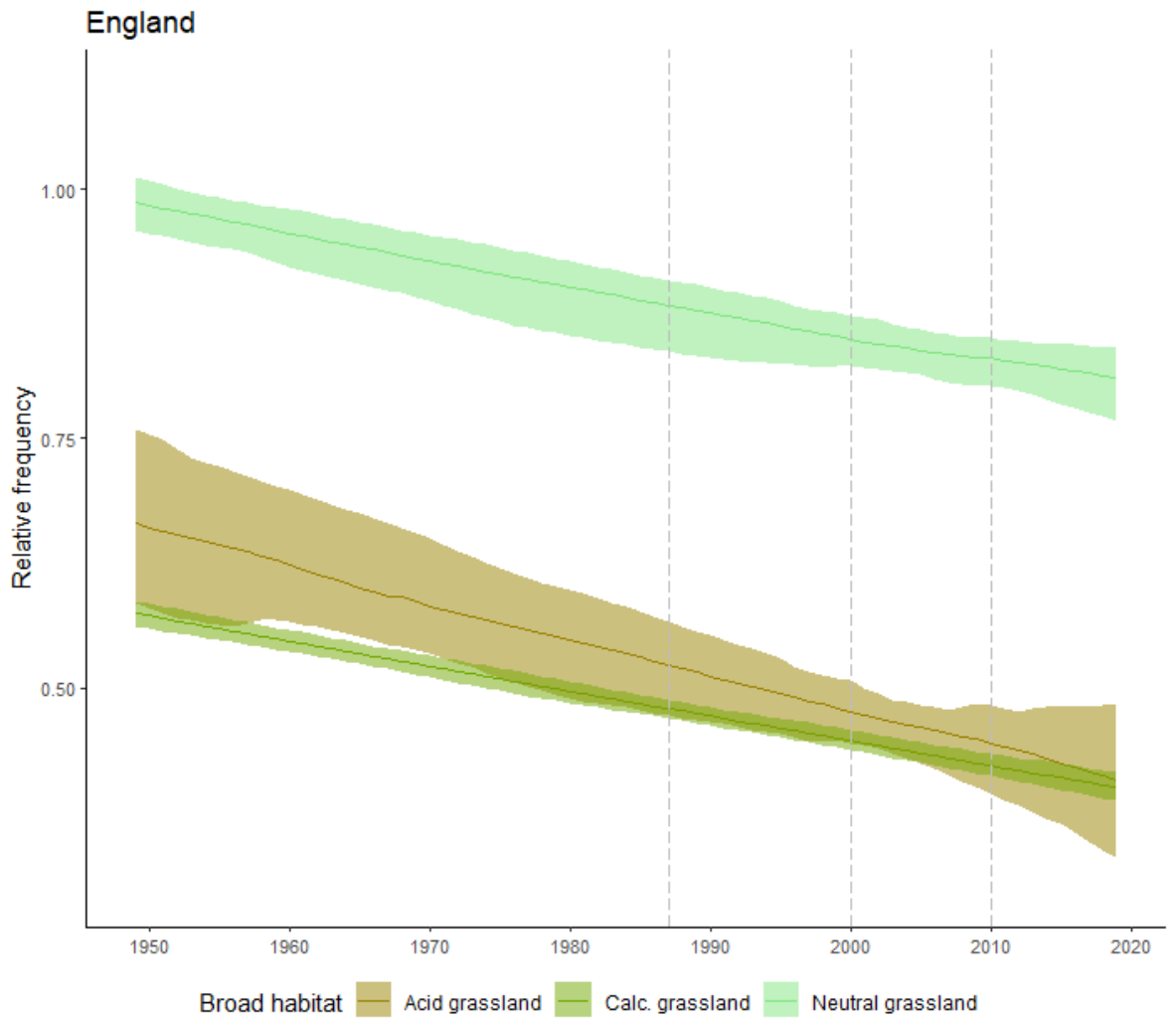
Walker, K., Stroh, P., Humphrey, T., Roy, D., Burkmar, R. and Pescott, O.L. (2023) *Britain's changing flora: a summary of the results of Plant Atlas 2020*. BSBI & UKCEH.

Species/habitat associations

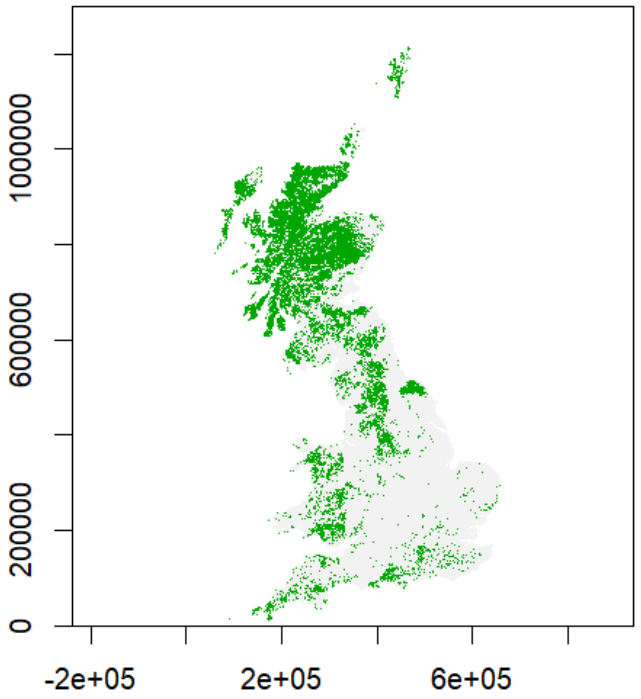




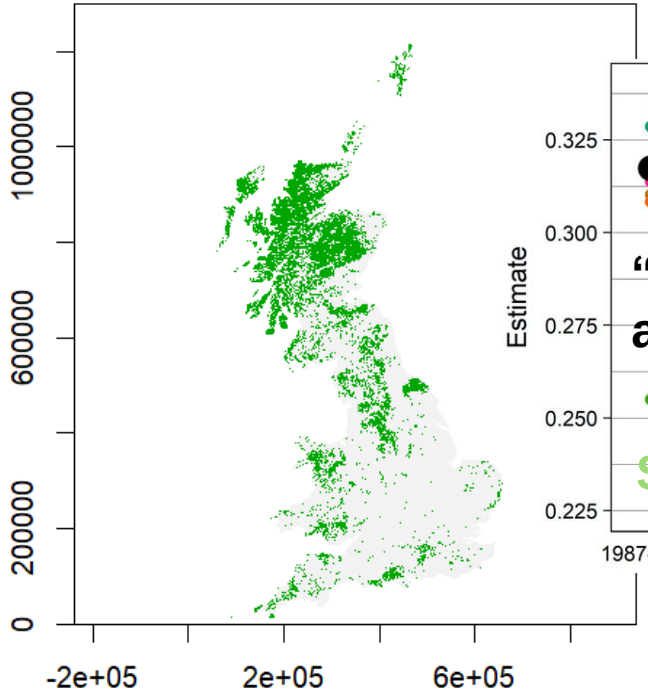
Towards better estimates of change at finer scales?

Survey sampling statisticians have already developed numerous methods of adjustment for unrepresentative sampling

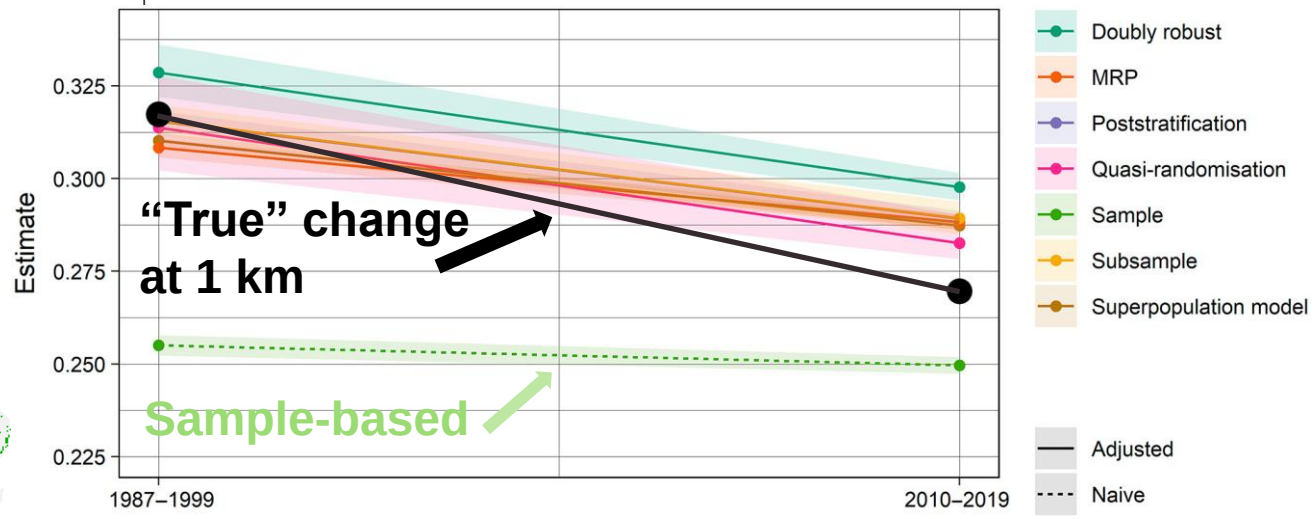
1987–1999



2000–2019



Calluna vulgaris 1 km distribution change estimates from atlas data + adjustments



Calluna vulgaris: estimates of **truth** from land cover mapping & 1 km atlas squares, constrained by known 10 km distribution 1950–2019

Boyd, R.J., Stewart, G.B. & Pescott, O.L. (2024) Descriptive inference using large, unrepresentative nonprobability samples: An introduction for ecologists. *Ecology*, *105*(2), e4214.

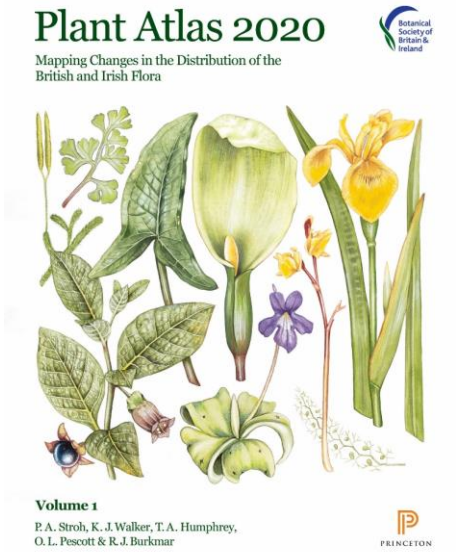
Allen's "unconscious tradition"

"The long and fruitful record of collaboration between [the professionals and the amateurs] is a justifiable boast of natural history in this country. Yet it is all too easy […] to underestimate how delicately it depends on a more or less unconscious tradition of compromise between conflicting interests. […] **Each group needs the other, and societies are the gainers by holding these mixtures in a state of perpetual mild tension.**"

David E. Allen (1976) *The Naturalist in Britain: A Social History.*

Some (hypo/hyper)-tensive questions for the future:

- Can we reconcile expert-based and model-based change estimates?
- Can we communicate these even more clearly?
- Can we capture more data on habitat/community-level processes?
- Can we do more nationally with smaller-scale data without increasing bias?



Plant Atlas 2020

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Buy the book: *princeton.press/plantatlas*
Find out more: *bsbi.org/atlas-2020*

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