Detecting interactions between global change drivers; the impact of the October 1987 storm on British broadleaved woodland

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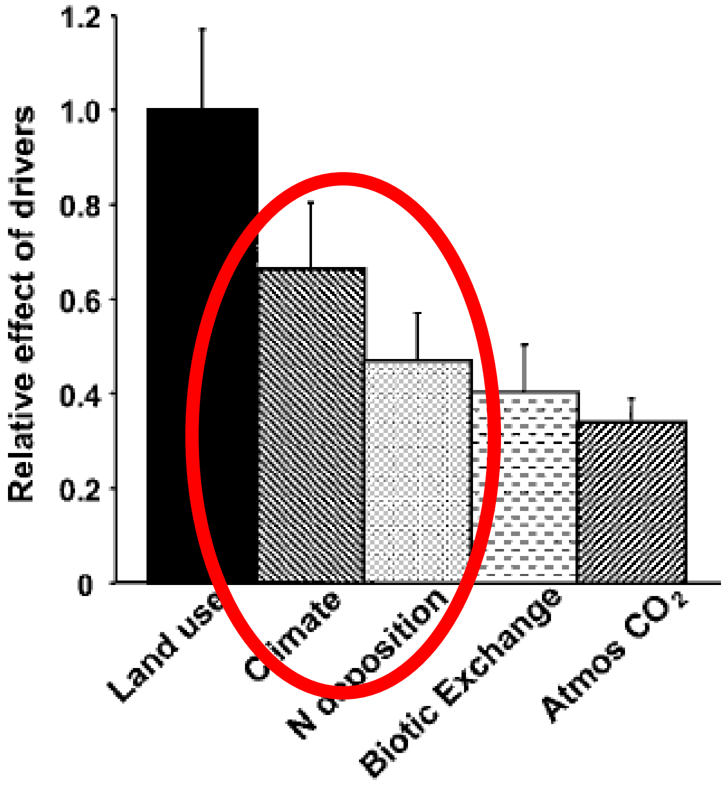


Fig. 1. Relative effect of major drivers of changes on biodiversity. Expected biodiversity change for each biome for the year 2100 was calculated as the product of the expected change in drivers times the impact of each driver on biodiversity for each biome. Values are averages of the estimates for each biome and they are made relative to the maximum change, which resulted from change in land use. Thin bars are standard errors and represent variability among biomes.

Drivers of global change

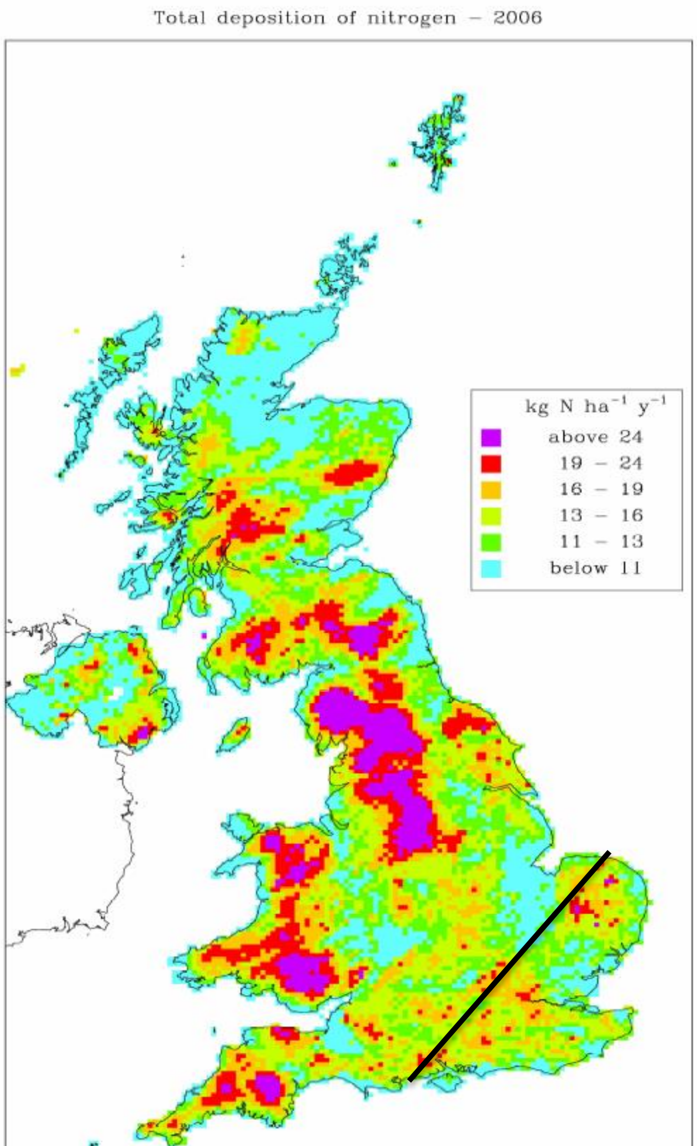
- Listed by Sala et al (2000) Global Biodiversity Scenarios for the Year 2100. *Science* **287**, 1770-1774.

- Uncertainties exist regarding how drivers will interact in specific ecosystems to produce novel outcomes in terms of biodiversity and ecosystem function.
- How have they interacted in British woodlands?

The October 1987 storm

- Local 100 mph winds; 81mph for 3-4 hours.
- Ground sodden and trees still in leaf.
- Est.15 million trees blown down.
- 11 of sample sites were in the storm track.

Atmospheric nitrogen and sulphur deposition in GB and the 1987 storm track



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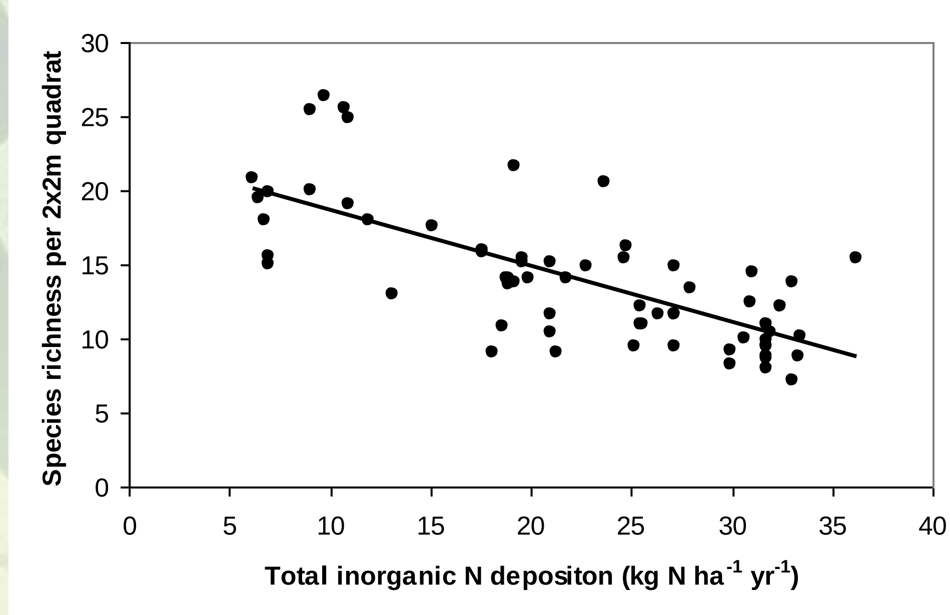
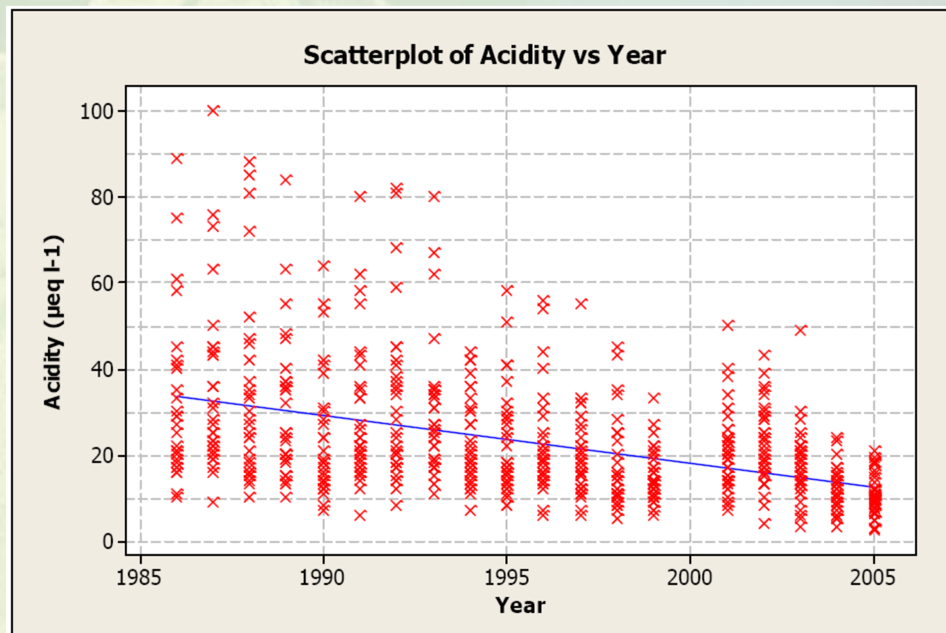


Stevens et al (2004) Science; Maskell et al (2010) GCB



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- **So.. storm sites often embedded in intensive land-use.**
- **Subject to increased macronutrients (N,P) and reduced acidification (S).**
- **Understorey light limitation alleviated by canopy damage.**

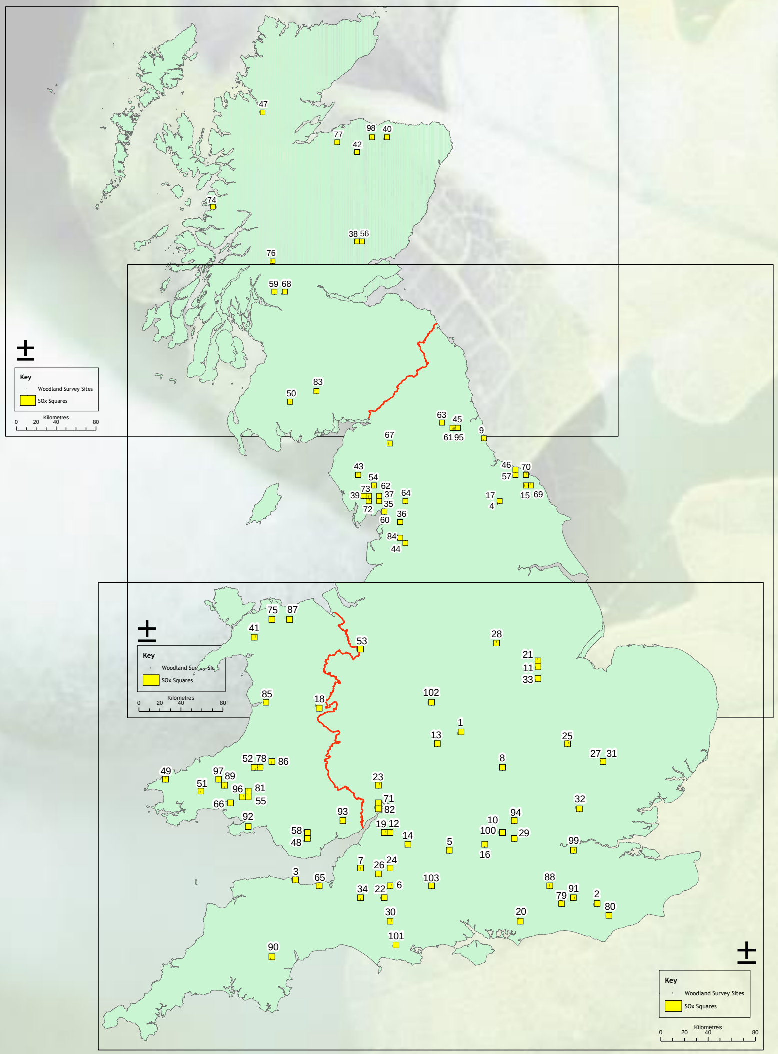
Hypotheses:

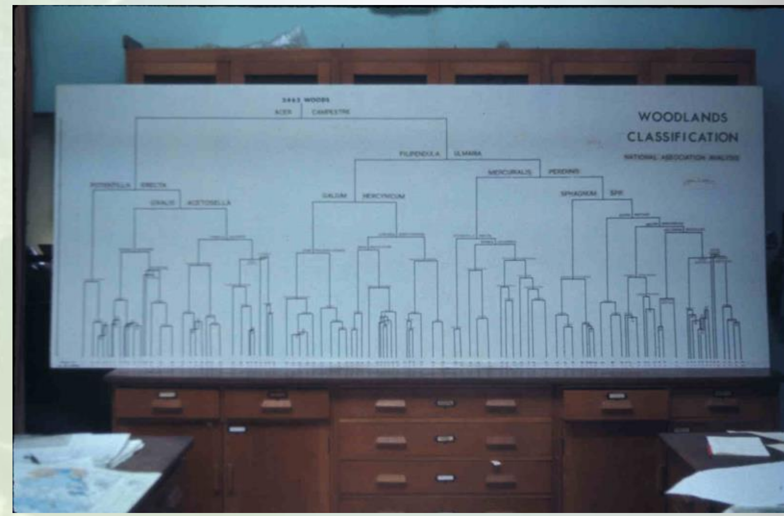
- Storm disturbance "unlocks" a eutrophication effect in N polluted woodlands recovering from acidifying deposition.

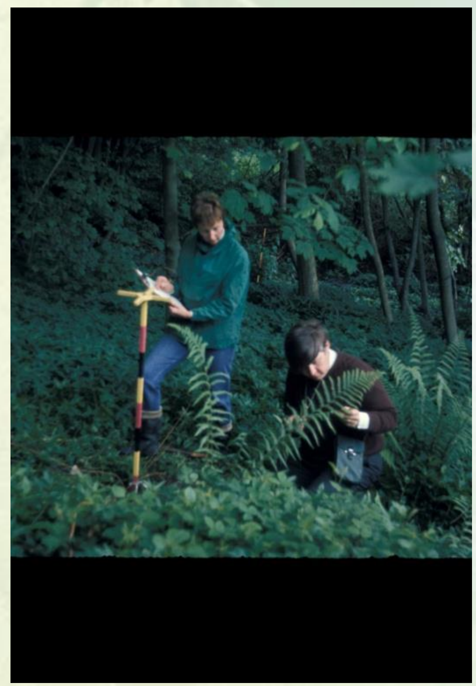
- Winners increase = generalists and invasive non-native species.
- Losers decrease = woodland specialists.

- Understorey species-richness increases in storm-sites.
- Nitrophiles increase (cover-weighted Leaf Dry Matter Content used as functional trait).

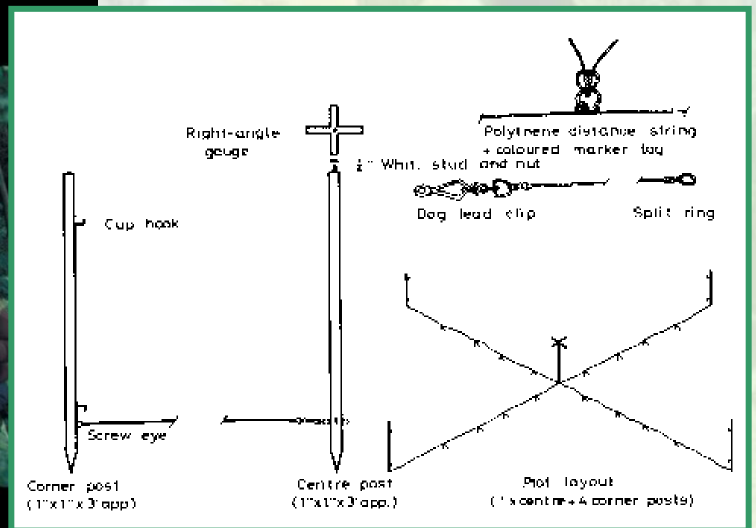
The GB Woodland Survey dataset (1971 repeated 2002)

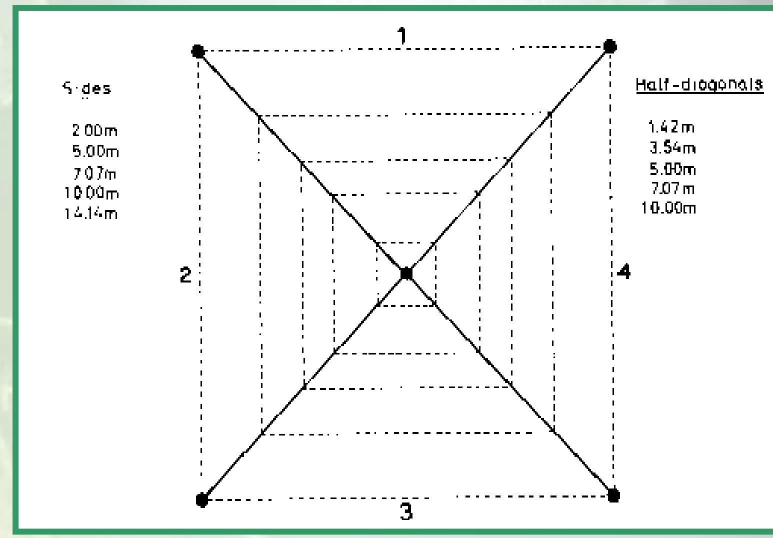






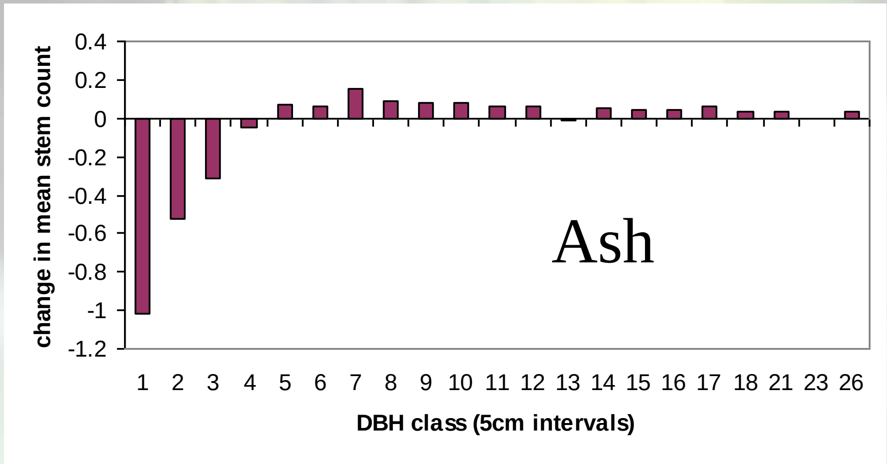
Field measurements (1971 repeated in 2002)

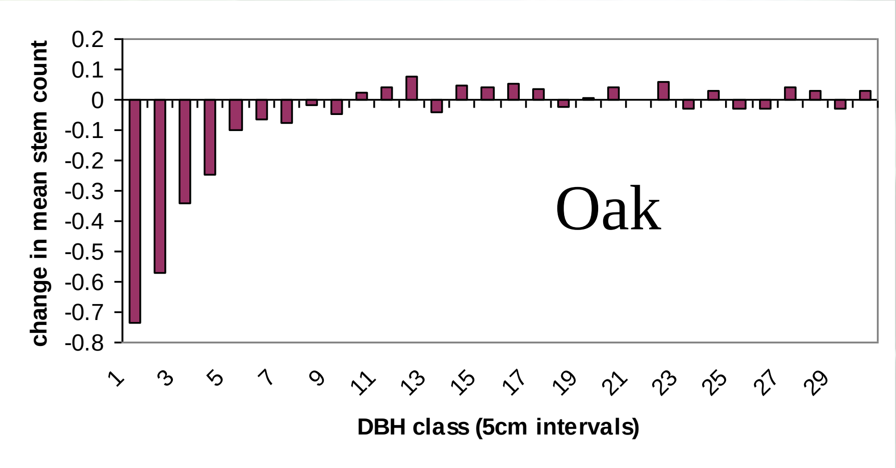




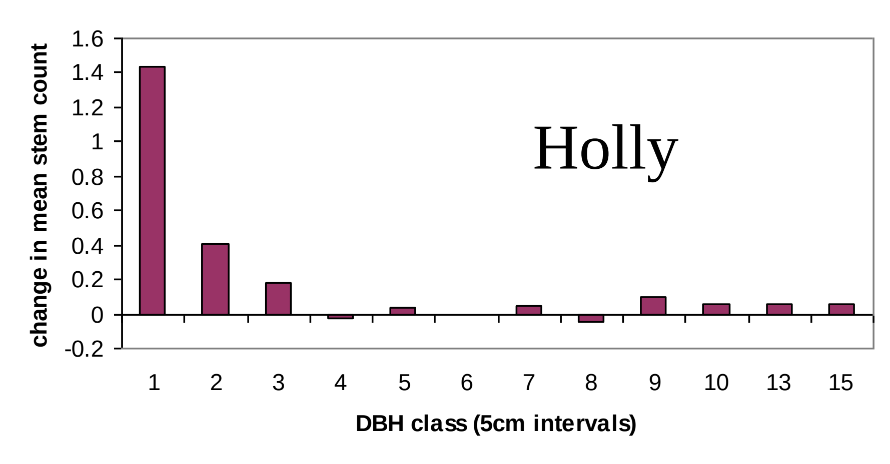
- 16 random plots in each woodland in 1971.
- Same plots visited again in 2002.
- Tree and shrub DBH measured and used to derive total woody basal area.
- Full plant species list with cover values.
- Soil pH and Loss-on-Ignition.

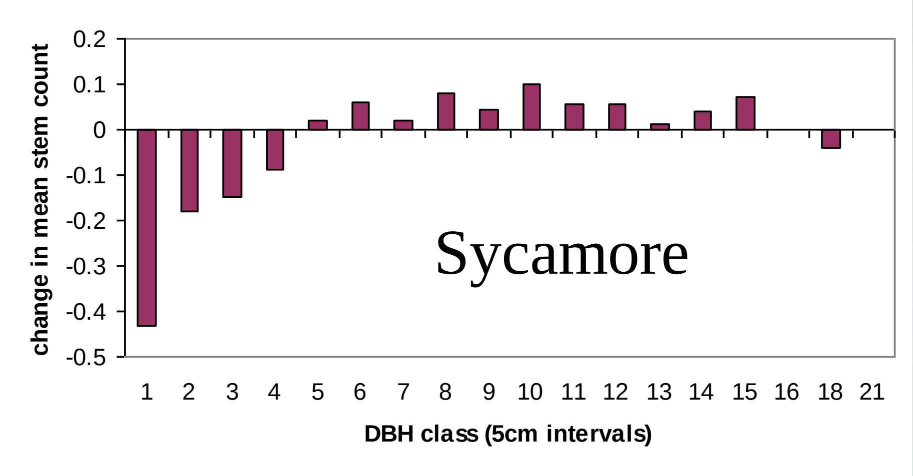
Results from all 103 sites; change in tree and shrub counts by DBH class, 1971-'02.





Younger Older Younger Older





- An ageing cohort across Britain.. But why?

Legacy effect of WWII timber extraction

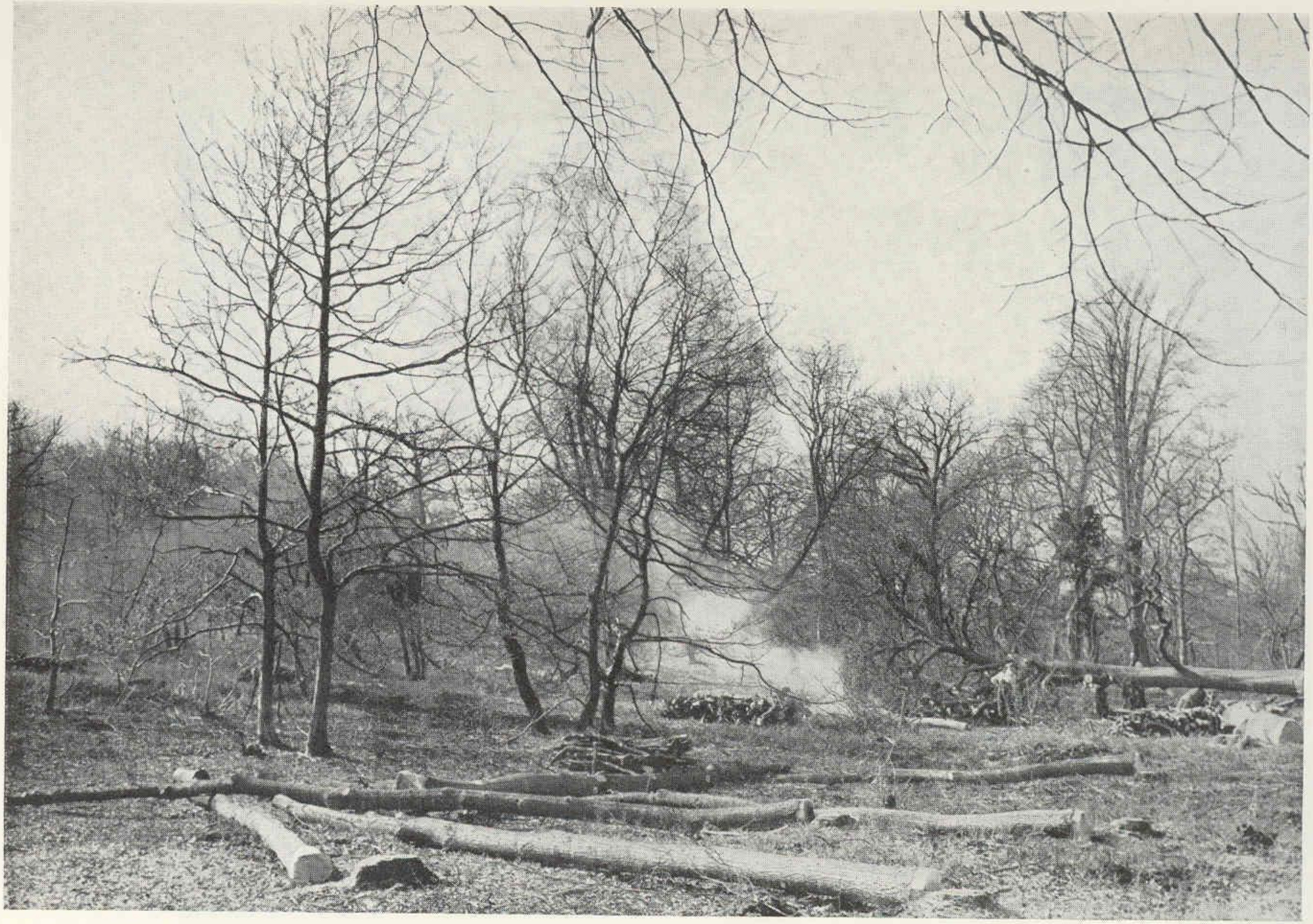
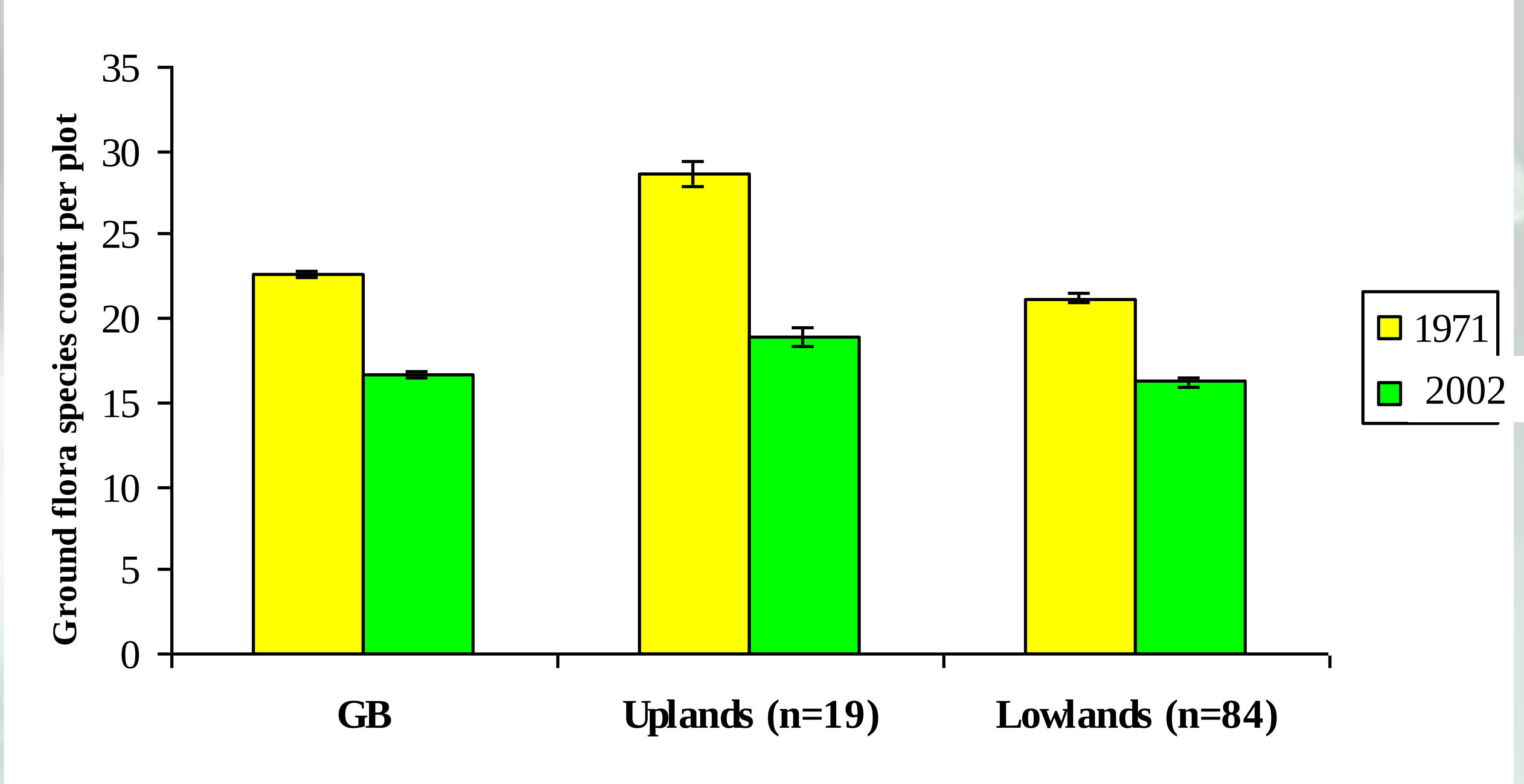


PLATE IX. Devastated woodland. The best stems of oak and sweet chestnut have been felled, leaving only small and crooked trees, too sparse to form a crop.

Ground flora started atypically rich in 1971

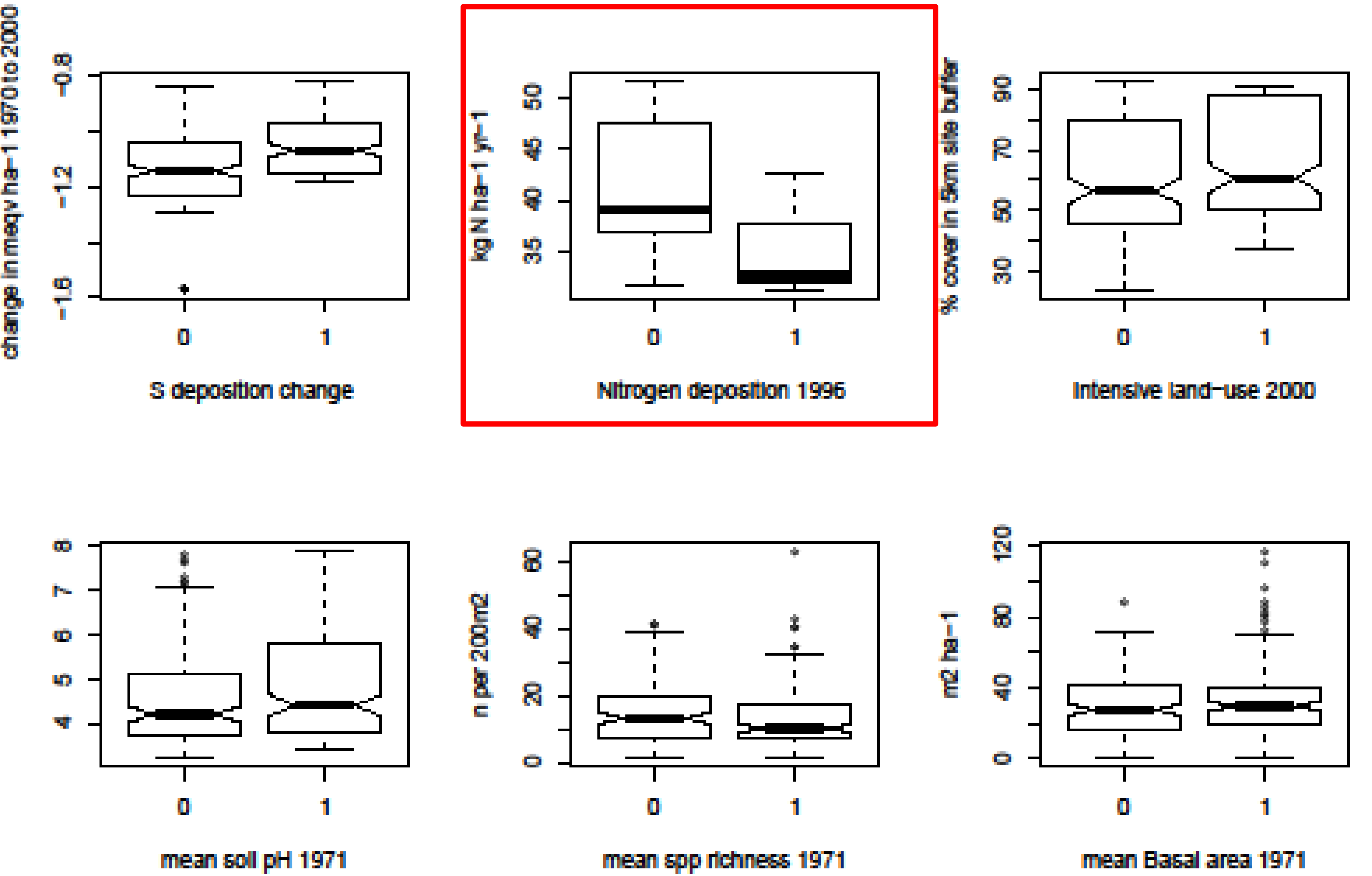


- Average of 8 species lost per 200m^2 plot across British broadleaved woodlands by 2002.

Over the next 50 years most sites became like A) while in1987 11 sites went to B)

We use an ecologically equivalent set of non-storm impacted sites to test our hypotheses about diverging trajectories.

Equivalence at start? N deposition higher in non-storm sites but empirical CL was greatly exceeded at all sites.



Structural Equation Model (SEM): a sequence of hypothesised regression relationships.

We model **Change in Species richness** and **cov-wtd LDMC (1971-'02)** as,

$= \beta_3$* Woody_BAΔ + β_4* Storm + β_5* Soil_pHΔ + ε_{s1} + ε_{p1}

Woody_BAΔ = β_1* Storm + ε_3

Soil_pHΔ = β_2* Storm + β_6 * start pH + ε_2

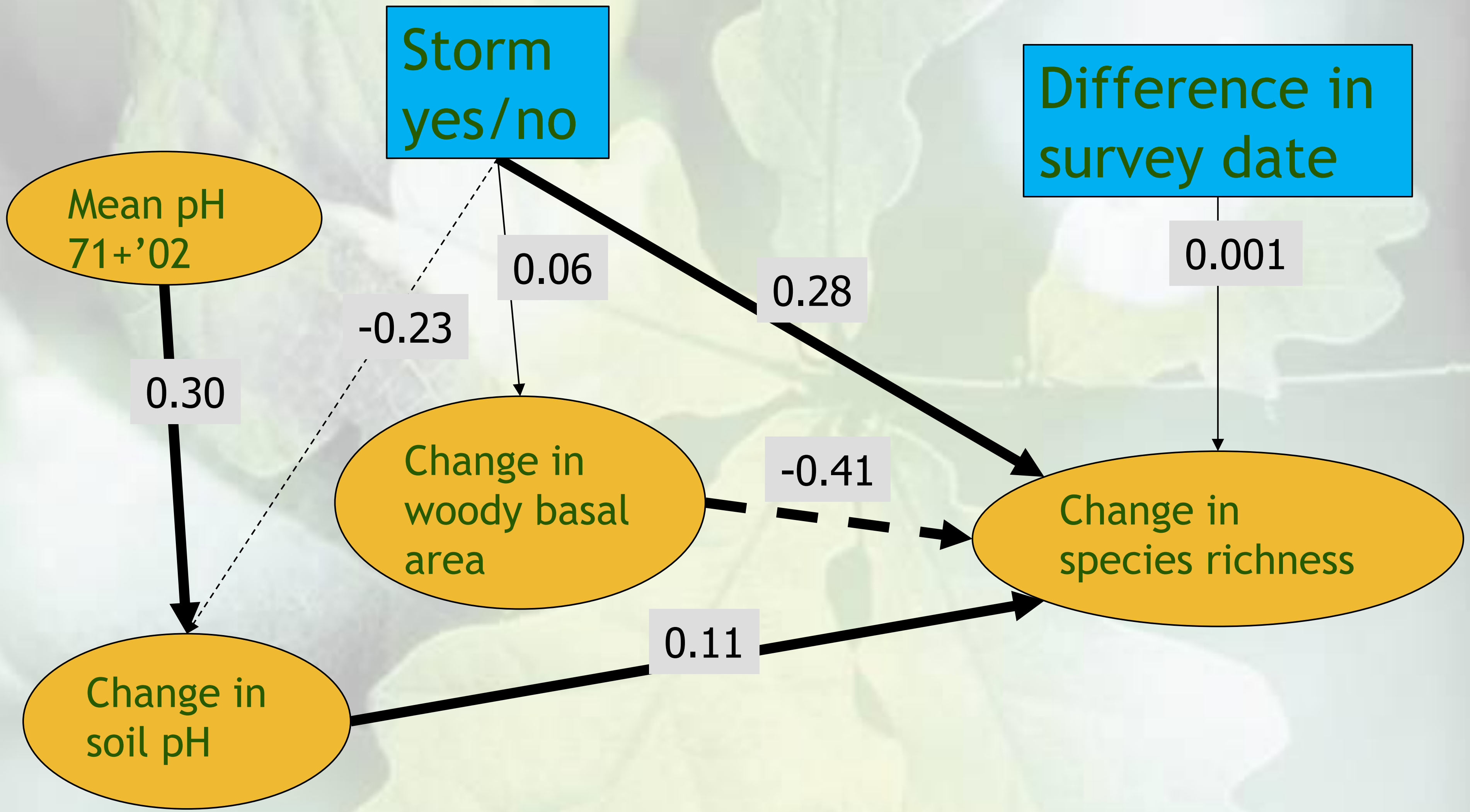
} Here we model the intermediate variables

- Total effect of Storm is as follows,

  $= \beta_4 + (\beta_1 * \beta_3) + (\beta_2 * \beta_5)$ … in words…

= direct effect of storm + (indirect effect of storm via woody basal area) + (indirect effect of storm via soil pH change)

Results; Oct '87 storm – species richness change 1971 to '02



- Positive effect of soil pH change on species richness change (+7%)
- No large indirect effect of the storm but SIG direct effects (+32%)
- No SIG relationships with cover-weighted LDMC (no eutrophication)

Plant species changes post-storm

LOSERS

- *Oxalis acetosella*
- *Ranunculus repens*
- *Hypericum humifusum*



WINNERS

- *Galium aparine*
- *Prunus laurocerasus*
- *Hyacinthoides non-scripta*
- *Anemone nemorosa*


- Local dominance in post-storm gaps reported by surveyors but evidence indicates no cross-site increase in non-native invasives nor nitrophilous generalists.



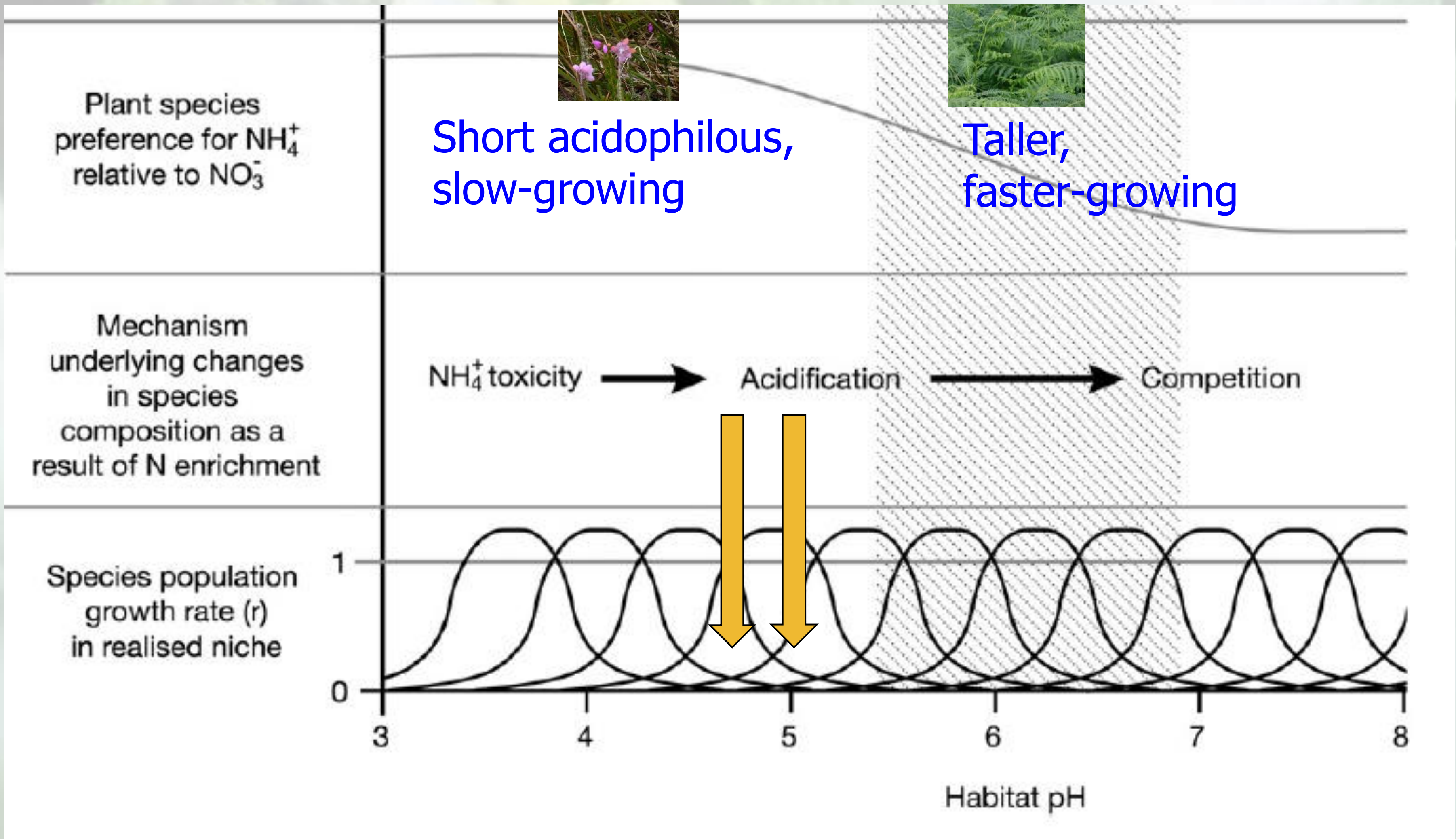
Results summary

- The 1987 storm increased species richness by 32% but there was no evidence of a trigger to widespread eutrophication or non-native species establishment.
- Woody basal area changes were highly variable and did not significantly differ with storm exposure.
- Increasing soil pH was associated with a 7% increase in richness but no interaction with storm disturbance.
- Historical legacy effects are critical in understanding the magnitude of more recent global change impacts.

Smart et al (2014) *J.Ecol.* **102**, 273-1287

What might the future hold?

- Storm-sites buffered by having low pH soils.
- We might see effects in higher pH forests but no storm impacts as yet!



Stevens et al (2011) *Env.Poll.* **159**, 665-676.


Thanks for listening. Thanks to Harvard University rest, CEH senior management and colleagu
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