The ‘so what’ question: when is an effect actually an effect?

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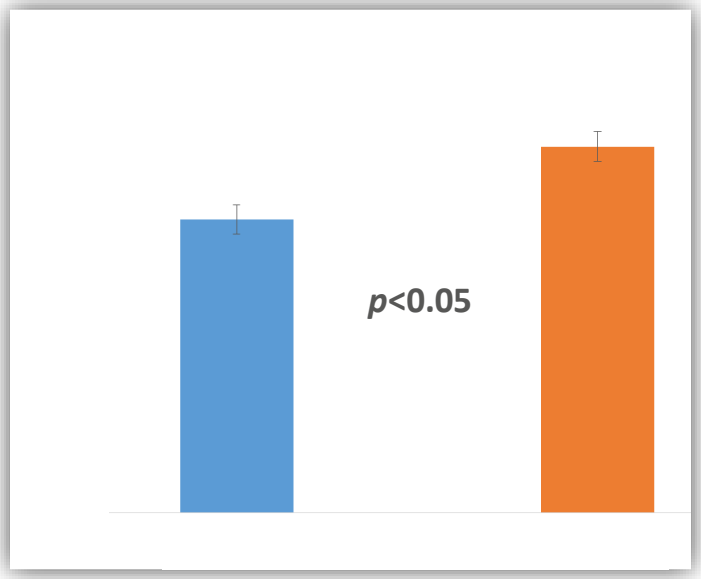
SETAC Brussels 2017

Cambridge Environmental Assessments

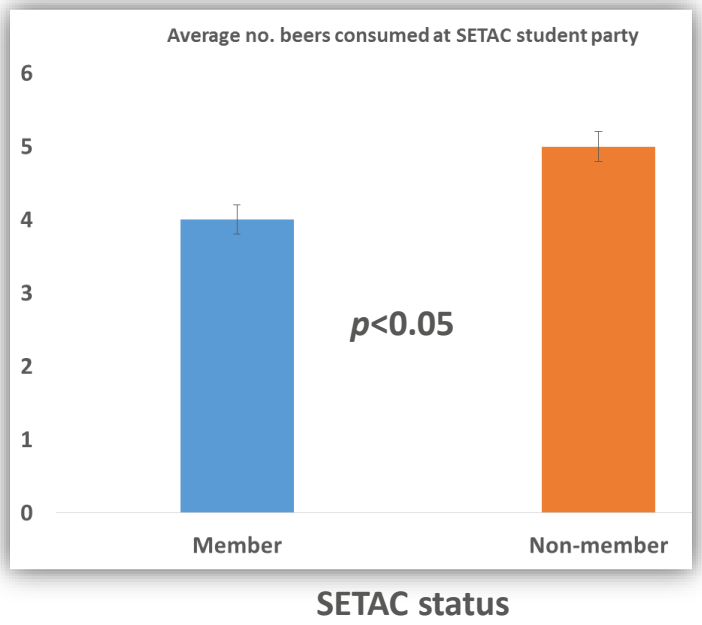
Scientists collect data and analyse results

- Plot some nice figures
- Visually look for trends/differences
- Usually use statistics to determine whether a difference exists
- Make conclusions
- But are these statistically significant differences actually of concern?



Does the difference matter? 'So what?'

- Depends what we are measuring…
- What impact would the difference have on a population?
  - Significant difference in ability to function the next day?
    - Probably not given the small difference (4 vs 5) → **not relevant**
    - If 4 vs 10…different story?!
- Illustrate that statistical significance doesn't always equal (biological) relevance
- These data are made up!



Some believe that statistically significant difference = (biological) relevance

- Not in line with recommendations in EFSA (2011)
- Distinction should be made between statistical significance and biological relevance
- Would such a difference have an adverse effect on the population?
- Need to contextualise the statistical analysis with the biology and ecology of the taxa in question
- Various factors that should be considered
- Look at some examples…

efsa
European Food Safety Authority
EFSA Journal 2011;9(9):2372

SCIENTIFIC OPINION

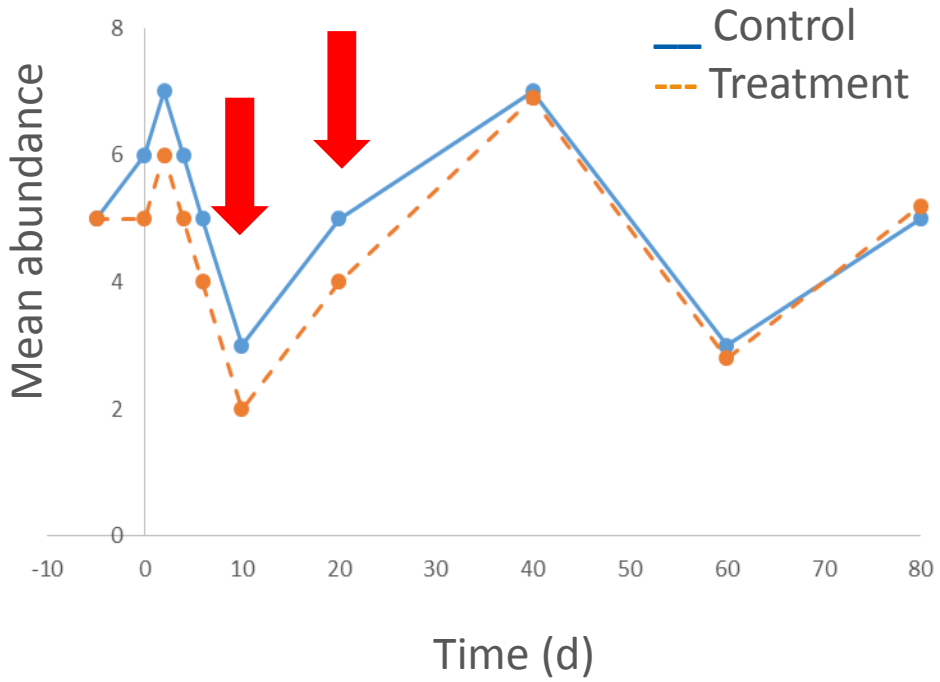
Statistical Significance and Biological Relevance[1]

EFSA Scientific Committee[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

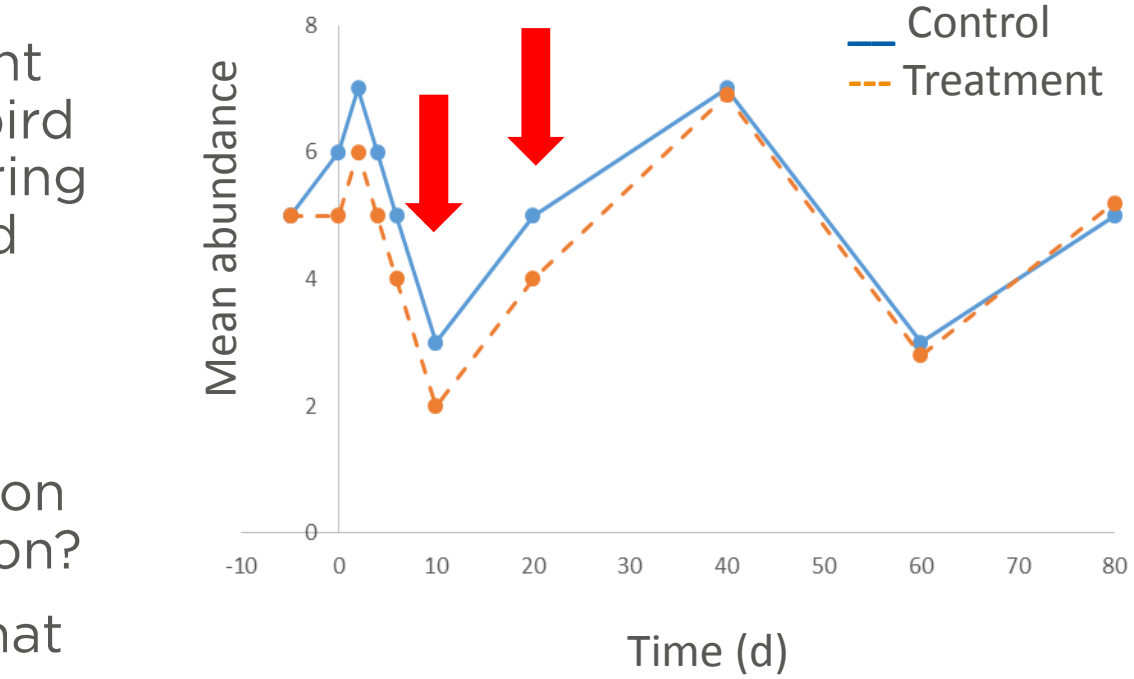
What is on the *y*-axis?

- Statistically significant reductions in a ladybird species occurred during non-target arthropod field study



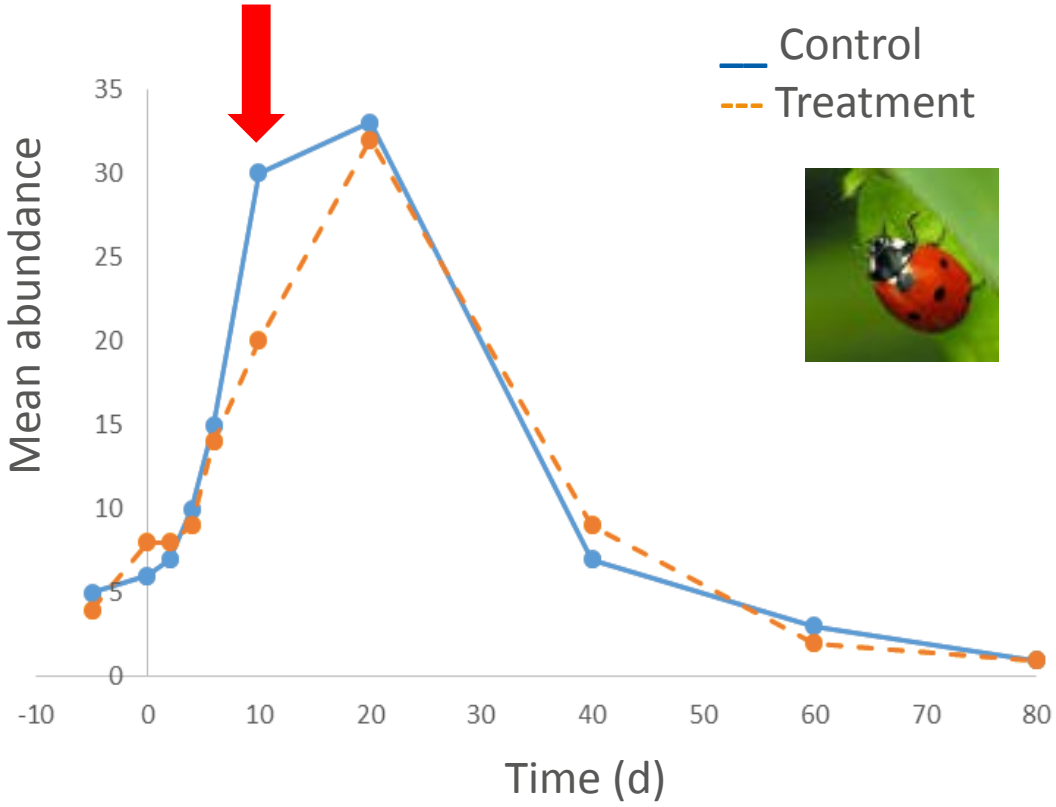
What is on the *y*-axis?

- Statistically significant reductions in a ladybird species occurred during non-target arthropod field study
- Maximum mean abundance was 7 → significant contribution to community function?
- NB. Does it matter that this is an invasive species in EU?

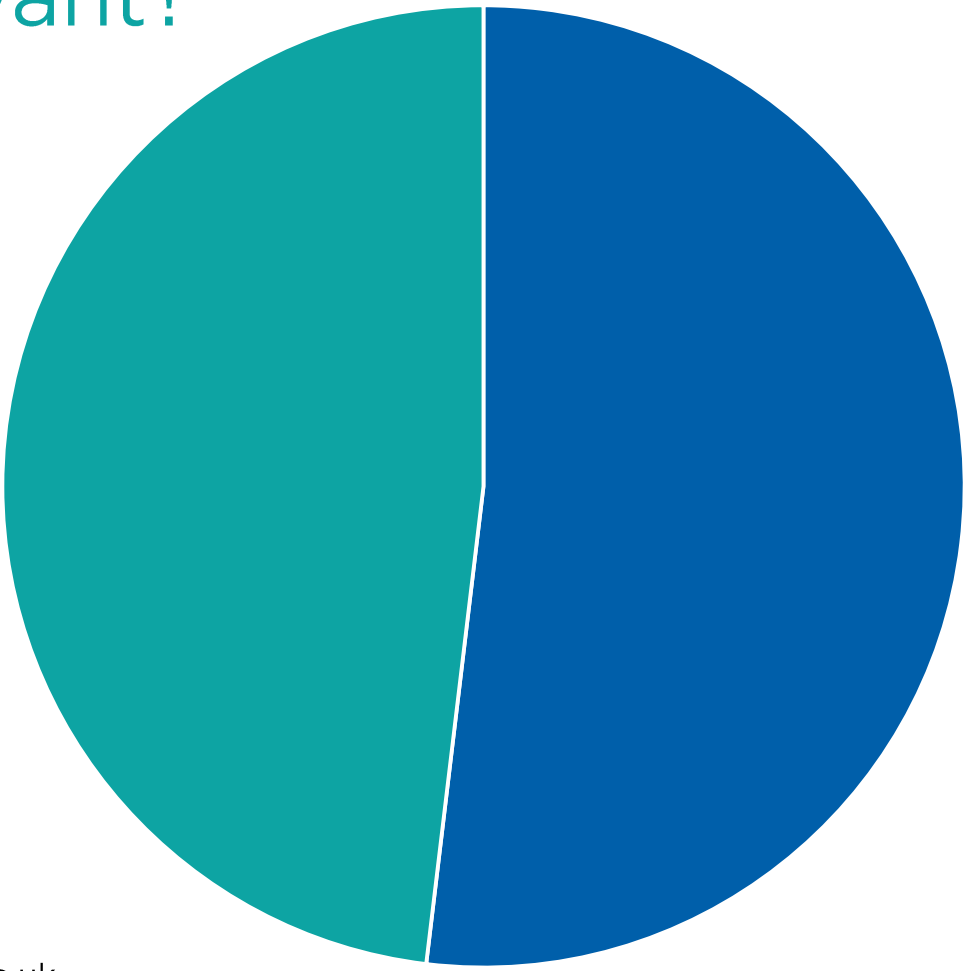


Duration of difference?

- Statistically significant difference at single time point
- Does this represent a biologically relevant impact on the ladybird population/ non-target arthropod community?
- i.e. could this still be the no-observed effect rate (NOER)?



How big does a difference have to be before it is relevant?



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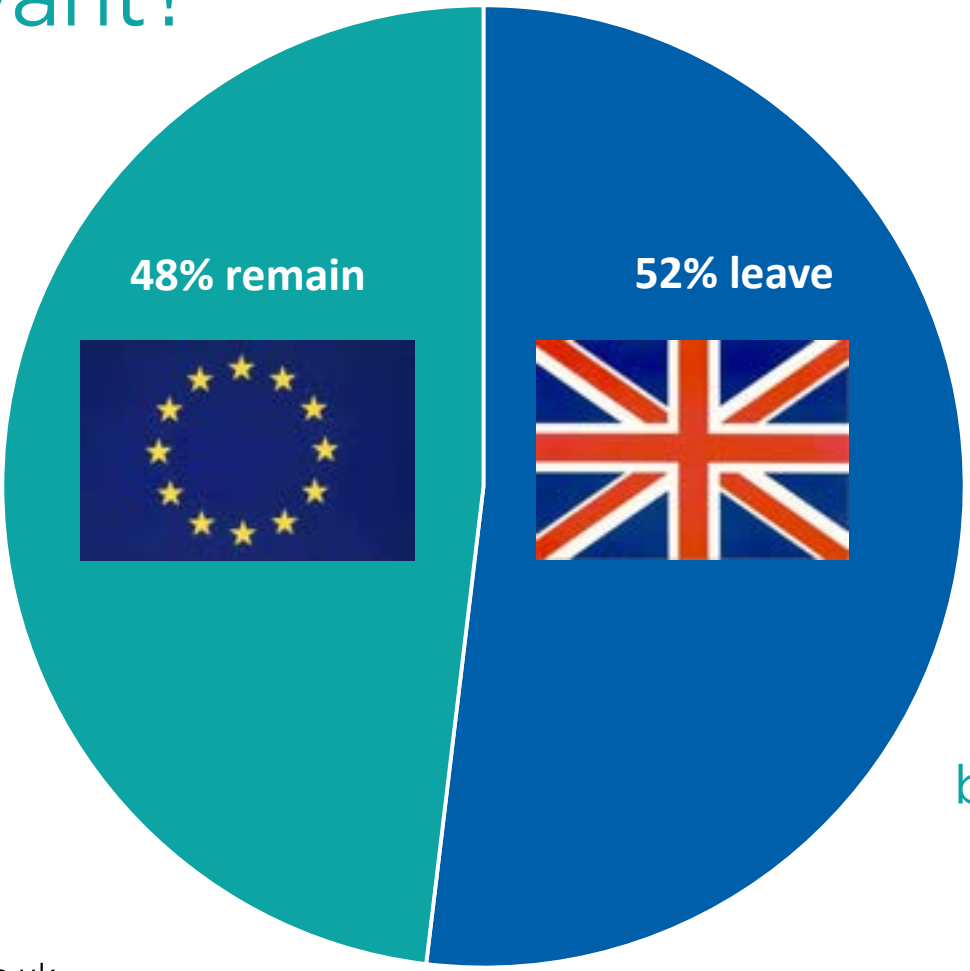
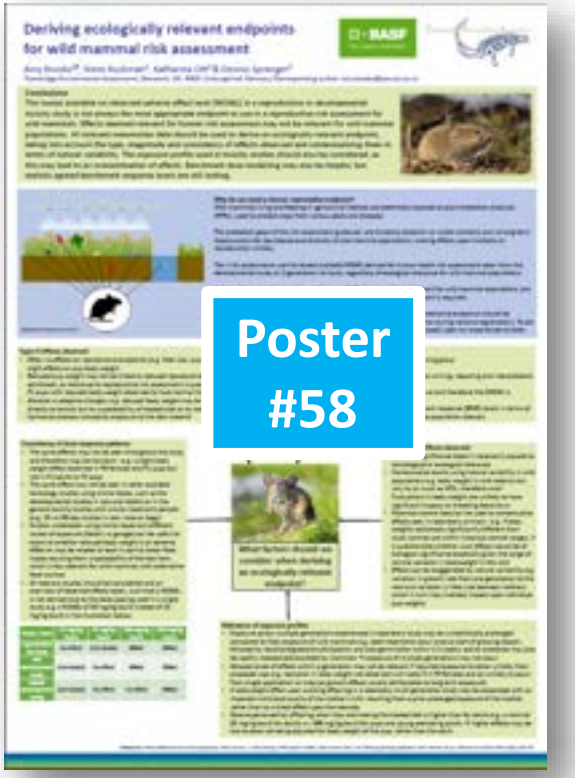


Sometimes small differences can have big consequences for a population and are therefore relevant...

Small differences not always (biologically) relevant…

- Endpoints from toxicology studies used in wild mammal repro risk assessments
- NOEL may be based on small differences e.g. <10% reduction in pup bodyweight in 2-generation rat study
- Biological relevance of <10% reduction in pup bw?

  Consistency of dose-response patterns, magnitude of effects vs natural/historical control variation, impact on fitness?
- Discussion ongoing regarding use of benchmark doses instead of NOEL
  - But what % effect is biologically relevant? 5%, 10%, 20%?

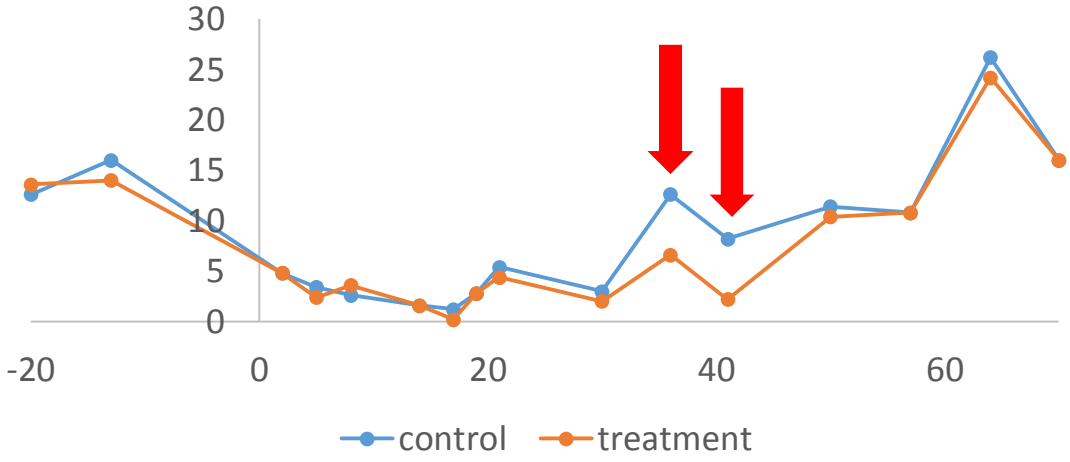


What geographical scale should we use?

- Statistically significant decrease in money spider (Linyphiidae) abundance following exposure to pyrethroid
- Ballooning behaviour of Linyphiids
- Potential for recovery from not only immediate off-field areas but from far away (several kms)
- Are localised reductions in abundance biologically relevant for wide-spread and mobile linyphiid populations?
- Geographical scale vs taxa traits

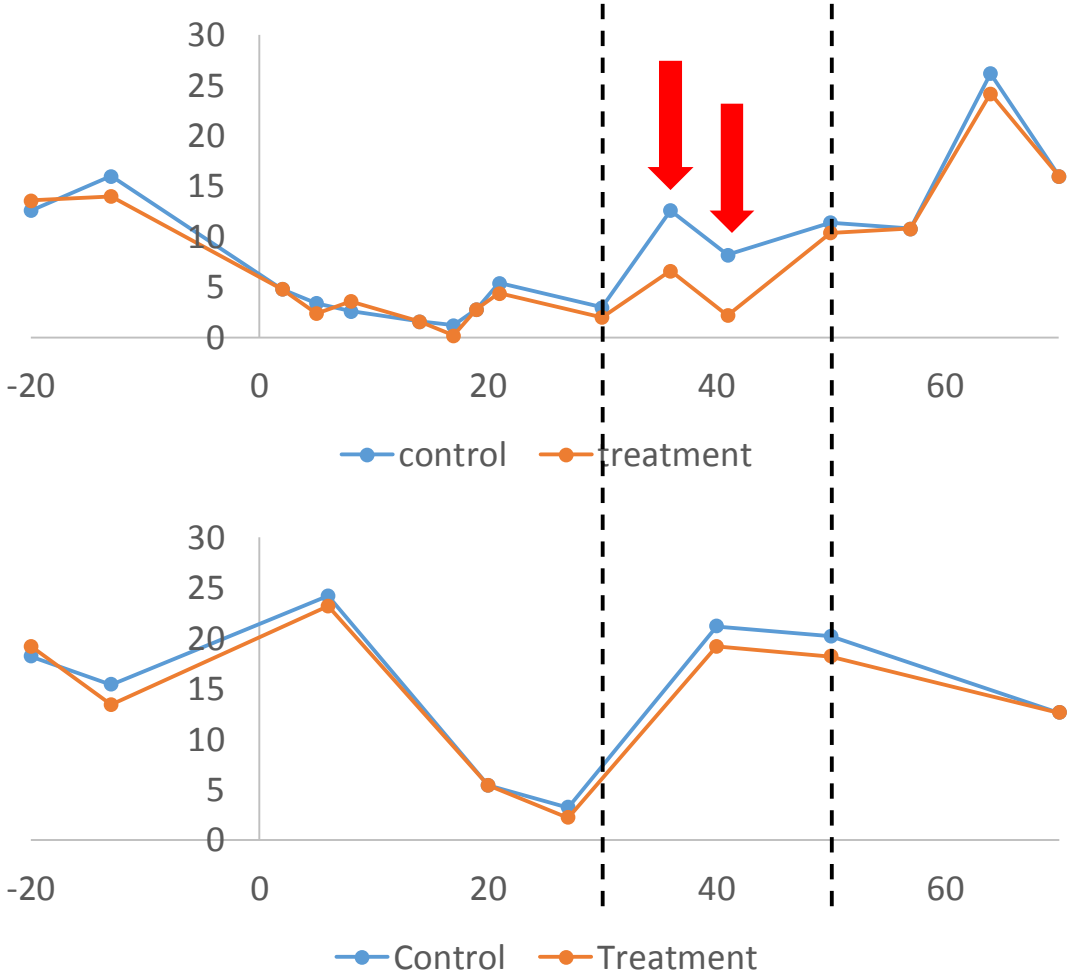
Consistent differences?

- Statistically significant reduction in mayfly larvae using drawnet samplers

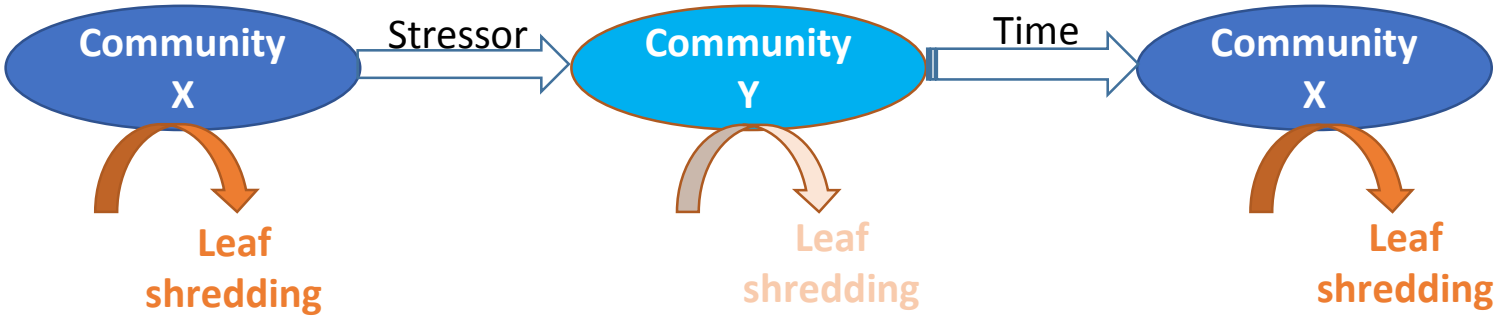


Consistent differences?

- Statistically significant reduction in mayfly larvae using drawnet samplers
- No statistically significant differences using macroinvertebrate samplers
- Lack of consistency → questionable biological relevance?



What are we trying to protect? The community or what it does?



Temporary difference and then **recovery to pre-stressor (control) state**

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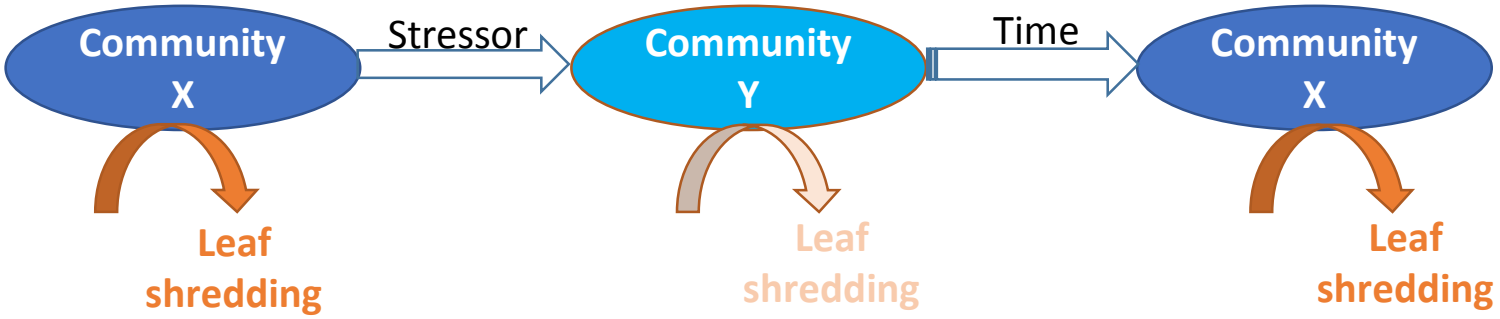

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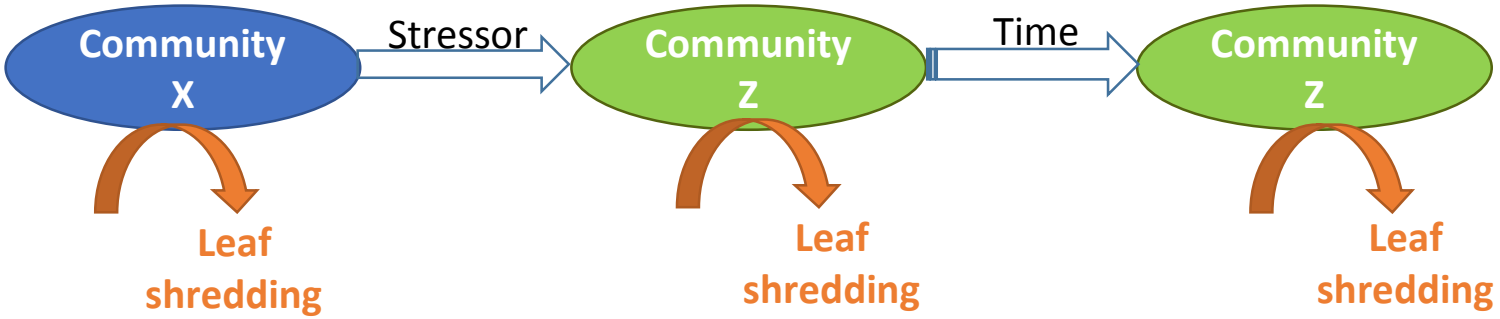

Regime shift without return to pre-stressor (control) state

Does this matter if function maintained?

Inspired by reading M. Bundschuh *et al* (submitted ET&C)

If we get statistically significant results let's…

- use statistics as one tool in the risk assessment tool box
- use statistics to help identify whether a difference *exists*
- use expert judgement to determine whether that difference is a *problem* i.e. is it biologically relevant?
    - E.g. what's on the y-axis?
    - E.g. duration of difference?
    - E.g. size of difference?
    - E.g. geographical scale?
    - E.g. consistent differences?
    - E.g. what trying to protect?
    - And lots more…!

Let's not forget the role of chance in statistics

- Statistical significance testing assesses the probability of something happening by chance alone
- Usually use $p \leq 0.05$ to indicate statistical significance
- Probability of difference occurring through chance alone (false positives/Type I errors) is ≤1 in 20 times
- Should always look at the data set as a whole and assess whether a statistically significant difference seems reasonable

"Let's put the **ECO** back in **eco**toxicology"

- People have been saying this for years – doesn't mean we don't need to keep saying it!
- We're assessing the risks to real agricultural landscapes, not simulated versions
- Aim for consistent interpretation of statistical significance vs biological relevance both *within* and *between* EU zones

Hopefully we can all agree that…

Statistically significant ≠ **Biologically relevant**

Meet us at Booth 11!

Email: Amy.Brooks@cea-res.co.uk

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www.cea.adas.co.uk

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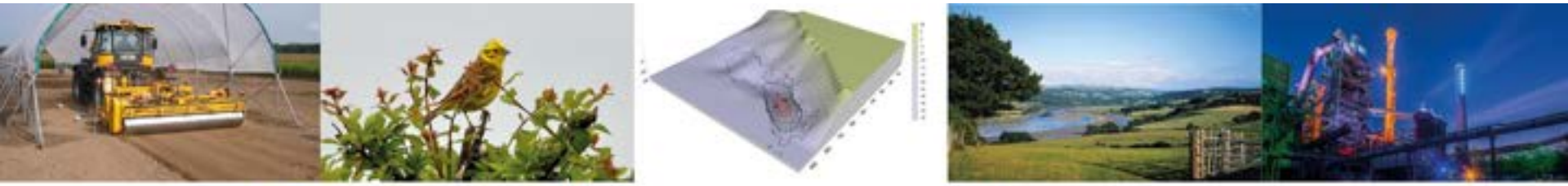

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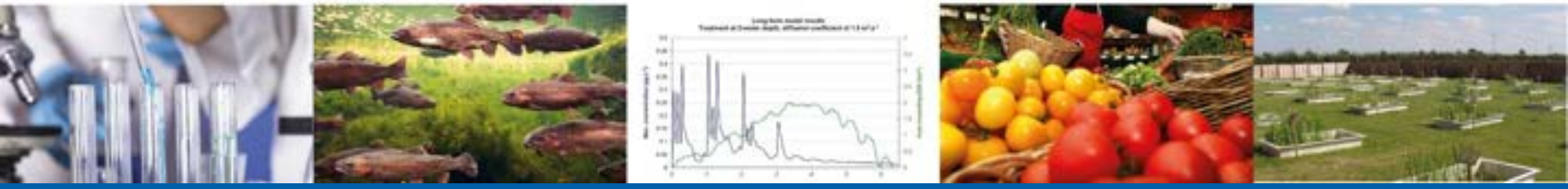
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