A hard rain's gonna fall: How do deliberate and 'accidental' nitrogen inputs highlight interconnection in grasslands?

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Alternet Conference

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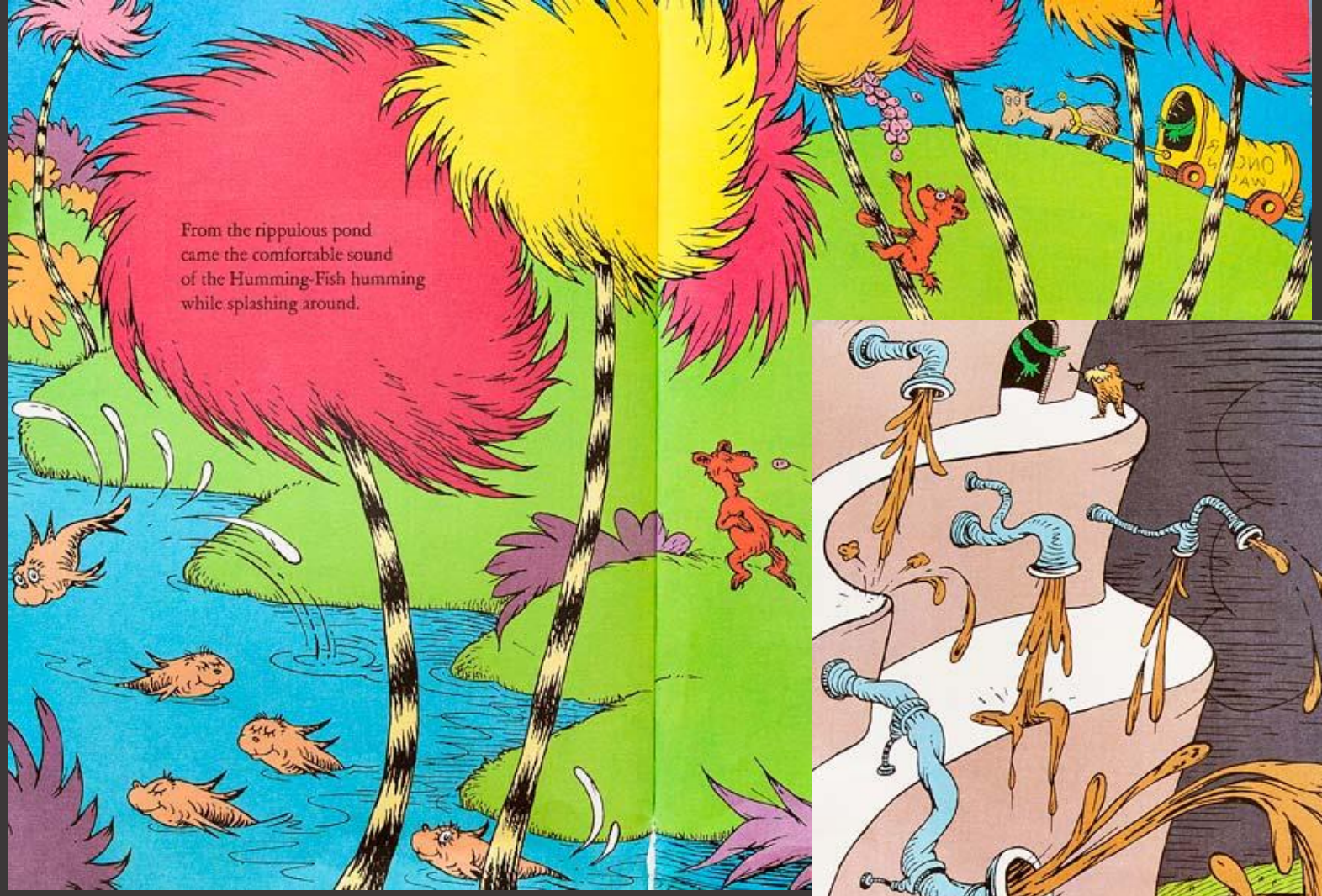

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Nitrogen interconnection, grasslands

- Past research into the nitrogen (N) cycle has provided well evidenced interlinkages across the natural world
  (Gruber and Galloway, 2008; Maskell et al., 2013; Zhang et al., 2015; Stevens et al., 2016)
- With N's importance for biological growth N enrichment in anthropogenic systems has provided an increase in crop production feeding humanity
  (Zhang et al., 2015; Metson et al., 2021)
- This makes the N cycle an ideal candidate for demonstrating interconnections across human and non-human nature
- Grassland ecosystems have been identified as places where biodiversity (non-human nature) and natural resource production (human nature) can be managed to create positive outcomes for both
  (Simons and Weisser, 2017)
- Here, we consider interconnections in grassland N pathways via an example in the UK using a nationally representative dataset as start point for modelling 10 years of N effects on grasslands

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Nitrogen molecule pathways?

Deliberate

^ Fertiliser application pathway ^

- Reactive N molecules (N_r) entering the UK landscape from fertiliser $\boldsymbol{N_{rF}}$
- Source from the Haber-Bosch process capturing atmospheric N and taking ~2% of global energy use (Kyriakou et al., 2020)
- Then sold as fertiliser for application by land managers to grassland systems
- Greater biomass production but erodes biodiversity as high fertility species outcompete others
- Enters the soil N pool also becoming captured within vegetation (biomass) and can then spread further

Accidental

^ Nitrogen deposition pathway ^

- Reactive N molecules (N_r) entering the UK landscape from atmospheric deposition $\boldsymbol{N_{rD}}$
- This is formed partly from N_r escape from the N_{rF} pathway but also from fossil fuel burning (and some natural processes, Gruber and Galloway, 2008)
- This occurs as both wet (rain) and dry (dust) deposition and leads to higher acidity in ecosystems as well as erosion of biodiversity through favouring high fertility species (Tipping et al., 2019; Stevens et al., 2016)
- Enters the soil and vegetation N pool (as for N_{rF}) but does not get offset by liming as chemical fertiliser does
- Not considered by land mangers

N_{rF} & N_{rD} illustrate 21st century terrestrial N conenctions, via different routes, forming the interconnected pathways modelled here.

Spray fertiliser application as well as nitrogen deposition, can be thought of as a ‘hard rain’ impacting vegetation chemically:
Positively with greater biomass
or
Negatively via lowering diversity

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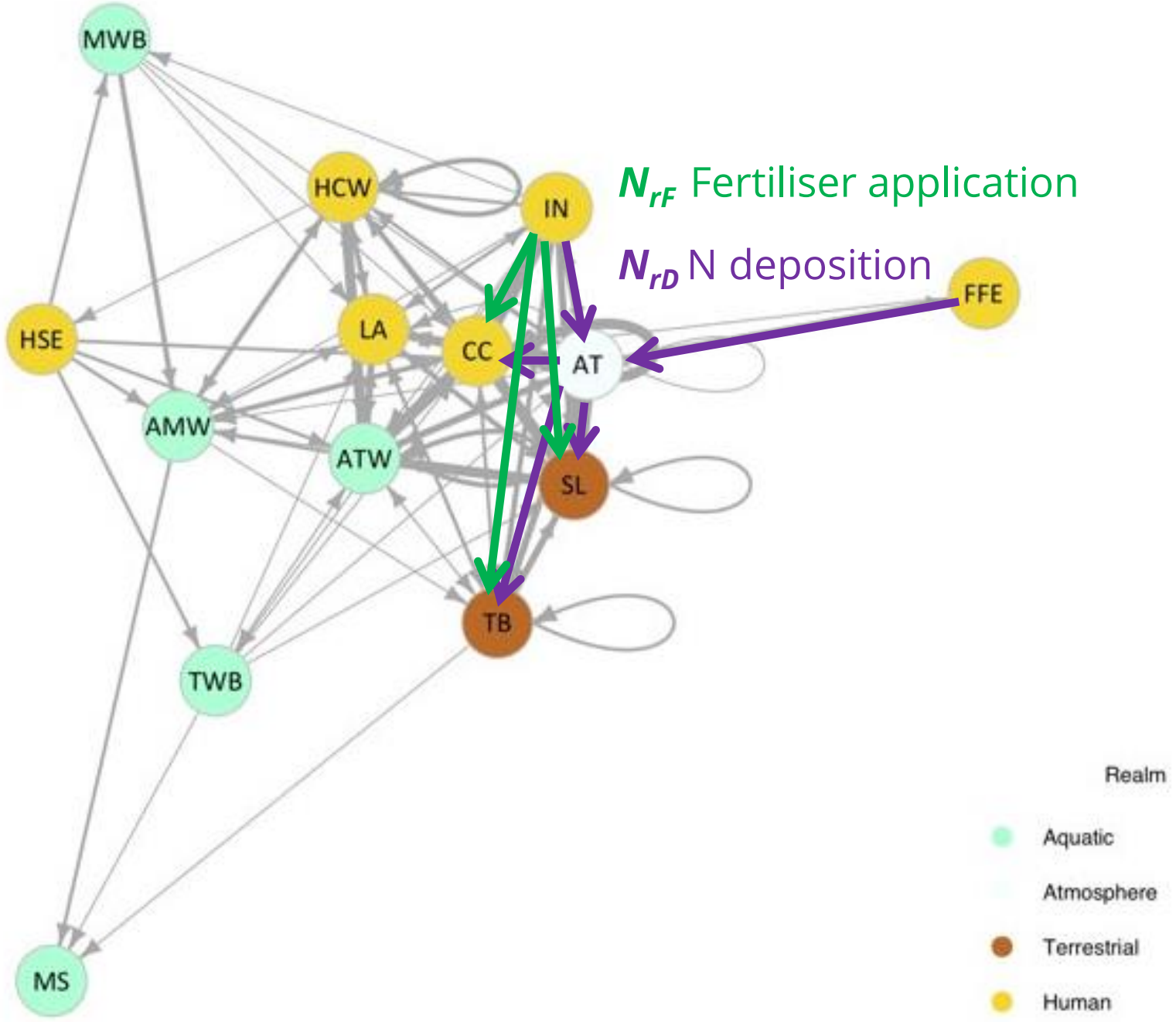
MWB
HCW
IN
FFE
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SL
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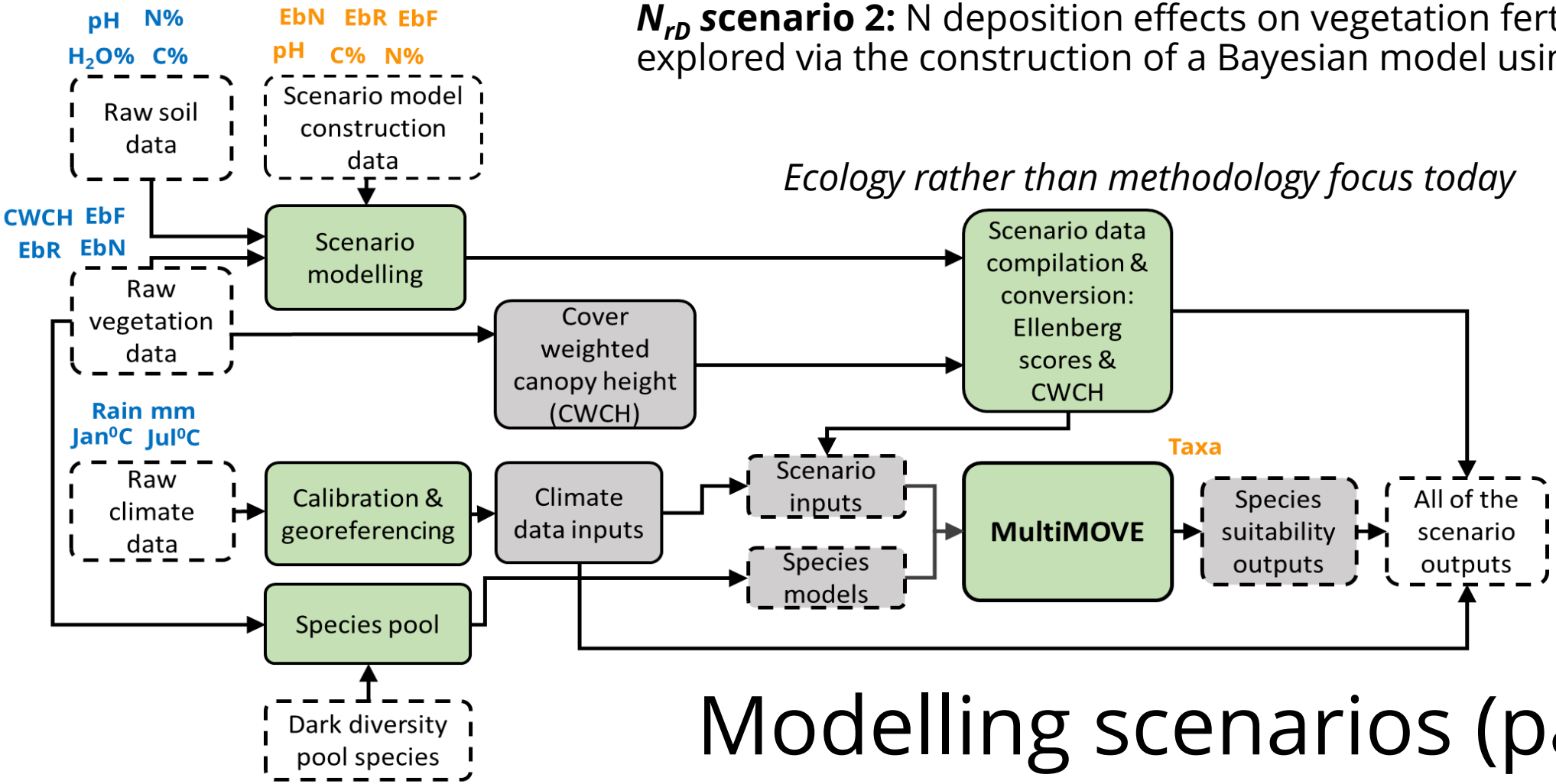
MS
N_{rF} Fertiliser application
N_{rD} N deposition
Realm
Aquatic
Atmosphere
Terrestrial
Human

N change is mechanistically tied to soil and plant community change, and this work explores fertiliser use and N pollution impact on them.

***N_{rF}* scenario 1:** The fertiliser scenario, was created using data from a literature review to construct fertiliser induced soil change generalised linear mixed effect models

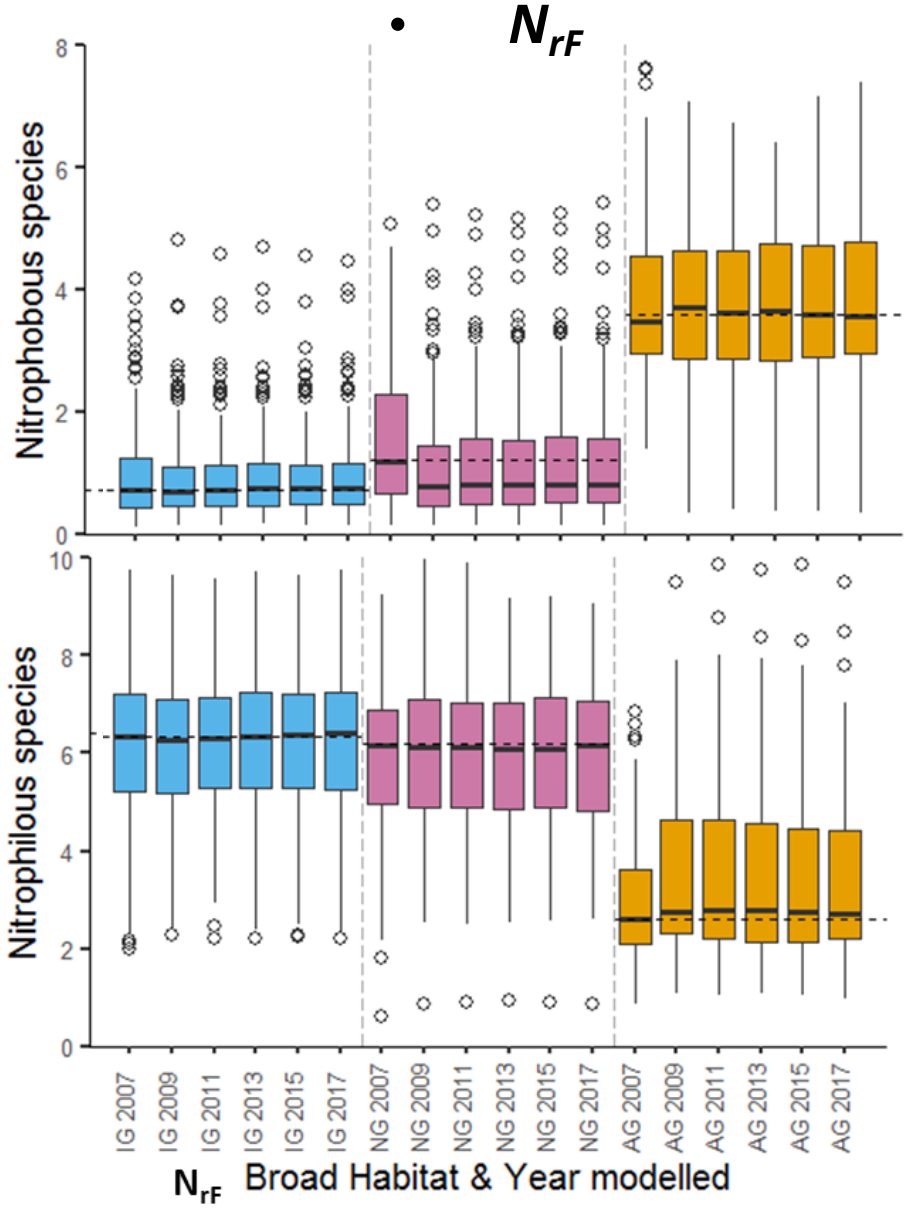
***N_{rD}* scenario 2:** N deposition effects on vegetation fertility scores were explored via the construction of a Bayesian model using N deposition values

Ecology rather than methodology focus today

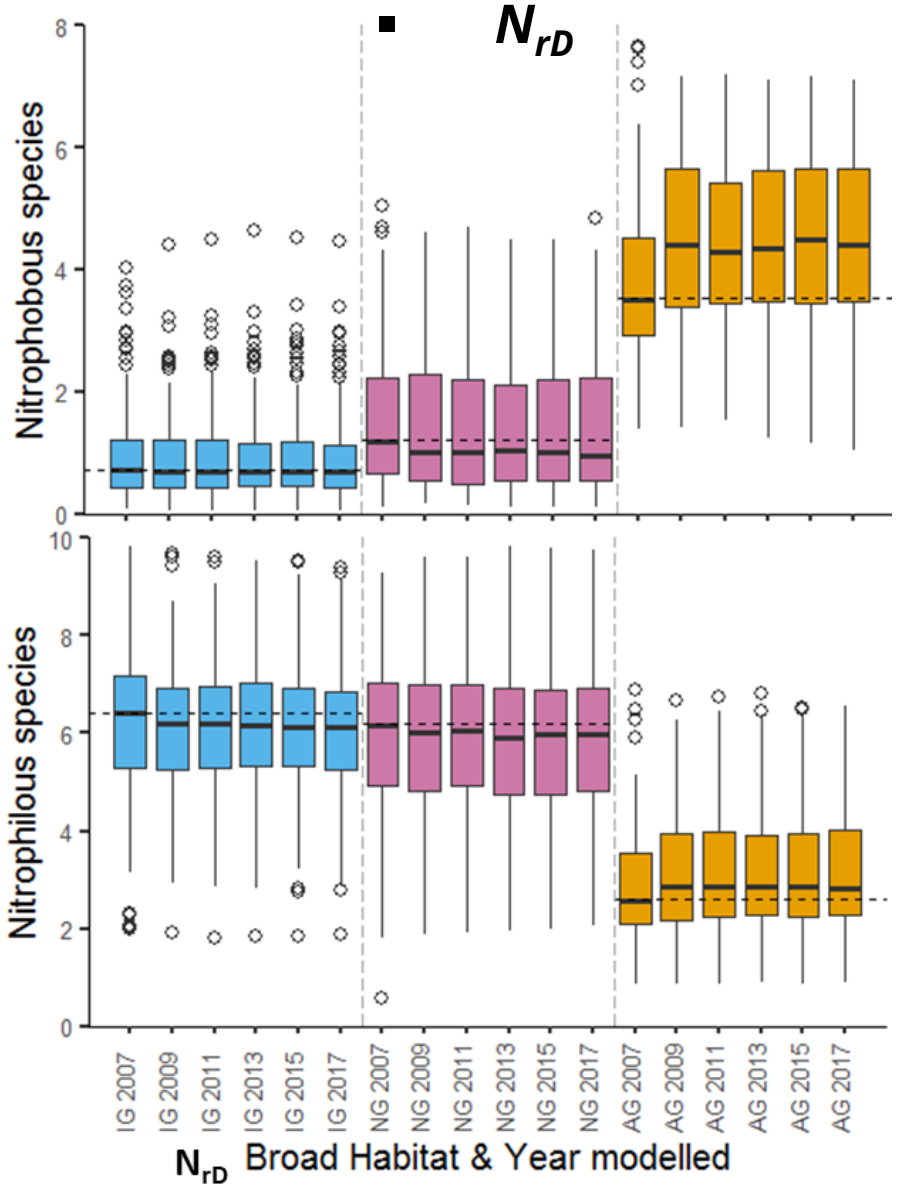


Modelling scenarios (pathways)

Nitrophbous and Nitrophilous species



(Valtinat, Bruun and Brunet, 2008; Dupouey *et al.*, 2002)



Conclusion

- Both scenarios constructed (N_{rF} & N_{rD}) provide a demonstration of how changing N abundance has an effect on fertility and plant species group diversity
- These results suggest that human production systems in their current state are dependent on high N inputs while the maintenance of biodiversity is dependent on stable states
- This demonstrates the interconnectedness of human and non-human nature in the N cycle; also creating a 'standoff' between biomass outcomes vs biodiversity outcomes as both depend of differing N abundance and constants
- However responses to changing N abundance is contextual to both the species groups explored and the habitat they are within

We know fertiliser effects biomass production and erodes biodiversity and we know N deposition has similar effects at a wider scale. We also know for grasslands and other ecosystems the N moves through and across them.

So should we acknowledge these interconnections and dependencies in policy and management decision making?

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Any Questions?

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