Valuing atmospheric nitrogen impacts on **'appreciation of biodiversity'** – Applying the ecosystem services approach in the UK

Laurence Jones, Gina Mills, Alice Milne,
Allan Provins, Mike Holland, et al.*

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

* With contributions from eftec, EMRC, Rothamsted Research, UK Defra & others

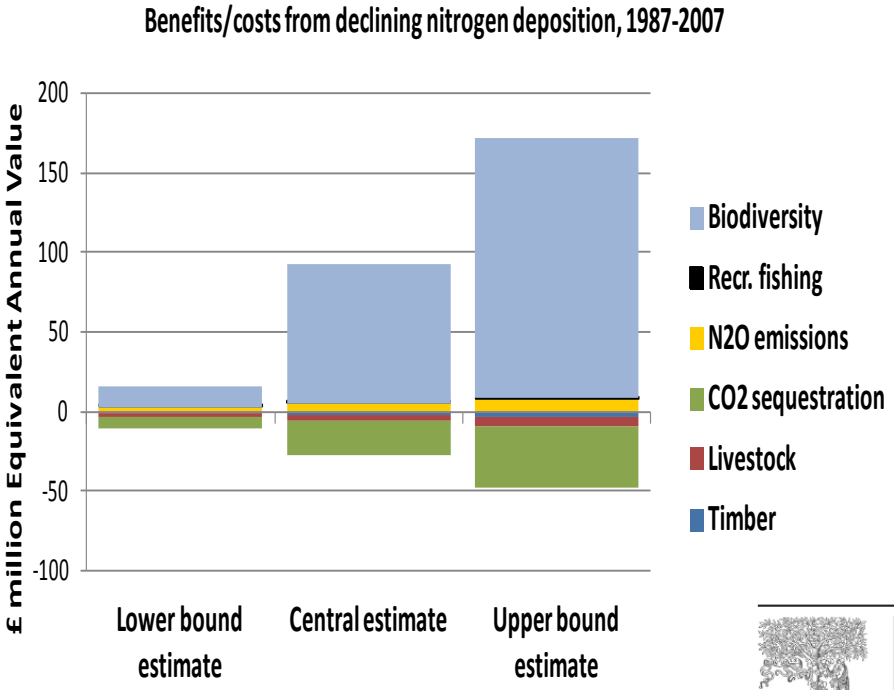
NATURAL ENVIRONMENT RESEARCH COUNCIL

Background – Building on previous work...

Three contracts for UK Department of the Environment, Food and Rural Affairs (Defra):

- Applying the Ecosystem Services Approach to value air pollution impacts on ecosystem services. *NEE0117 (2010).* ***Proof of concept****.*

.	***Provisioning Services***		***Regulating Services***				***Cultural Services***	
	Timber production	**Livestock**	**Net GHG emissions**			**Clean water**	**Recreational fishing**	**Appreciation of biodiversity**
			CO_2	N_2O	CH_4			
Nitrogen	Woodland	Improved grassland: Partially valued	Woodland, Heathlands	All semi-natural habitats	n.v.	n.v.	Upland rivers: Partially valued	Woodland, Heathland, Grasslands and Bogs.
Sulphur	n.v.	n.v.	n.v.	n.v.	Bogs	n.v.	n.v.	n.v.
Ozone	Woodland	n.v.	Woodland, Grasslands	n.v.	n.v.	n.v.	n.v.	n.v.



Jones et al. (2013). Ecosystem Services (online)

Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser

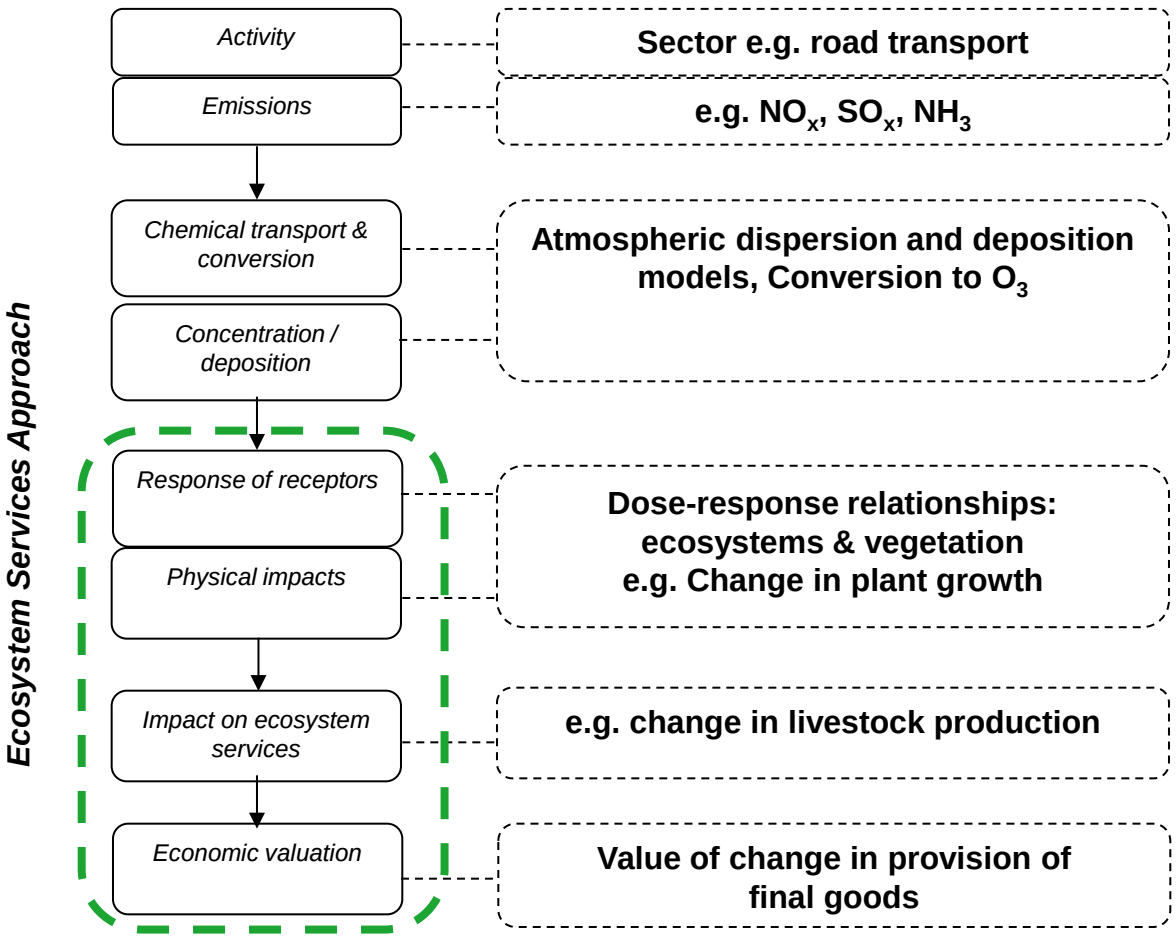
A review and application of the evidence for nitrogen impacts on ecosystem services

L. Jones [a,*], A. Provins [b], M. Holland [c], G. Mills [a], F. Hayes [a], B. Emmett [a], J. Hall [a], L. Sheppard [d], R. Smith [d], M. Sutton [d], K. Hicks [e], M. Ashmore [e], R. Haines-Young [f], L. Harper-Simmonds [b]

Background – Building on previous work...

- Valuing **ozone** impacts on ecosystem services. *AQ0815 (2011).* ***Spatial calculations of impact, uncertainty.***
- Developing valuation and knowledge gaps assessment. *AQ0827 (2012).* ***Further methodological development.***
- Calculation of **damage costs** for NHy and NOx for selected ecosystem services.

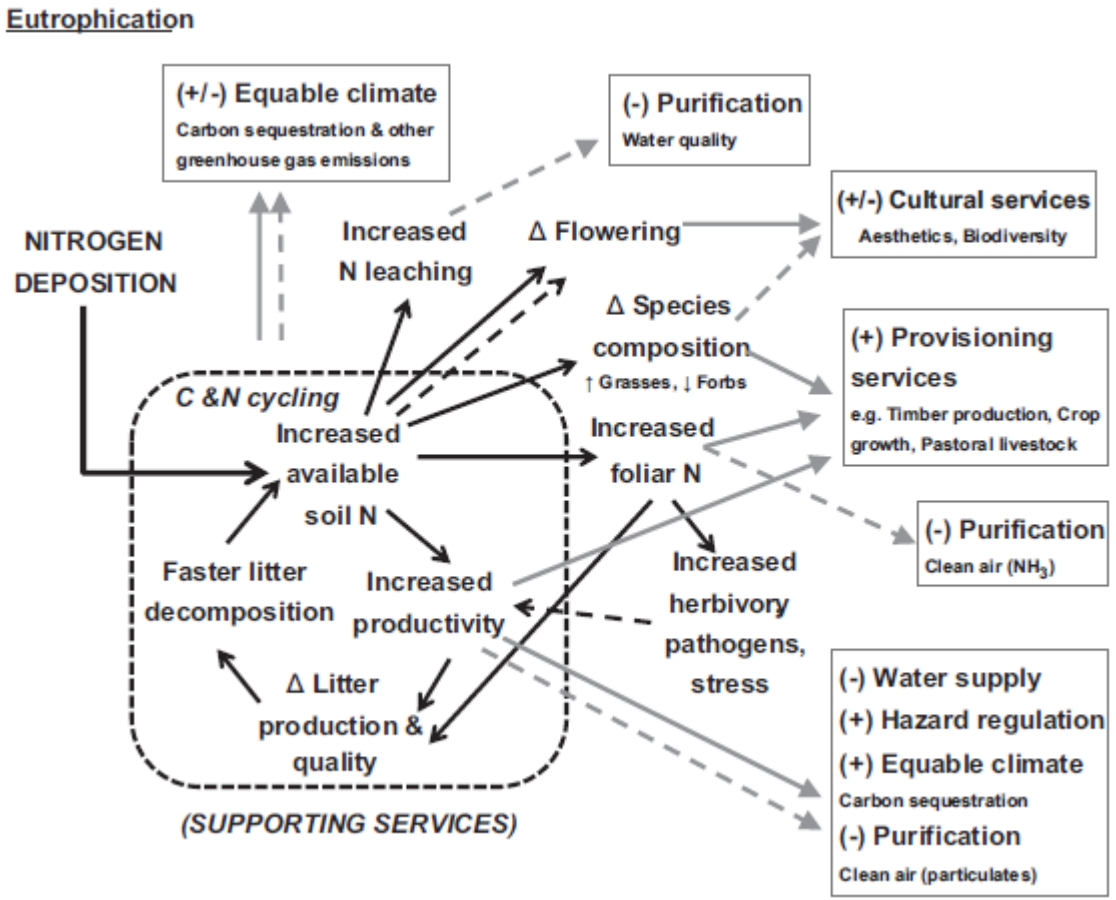
#1: The Impact Pathway



#2: Conceptual Model

Nitrogen impacts on ecosystem services, via:

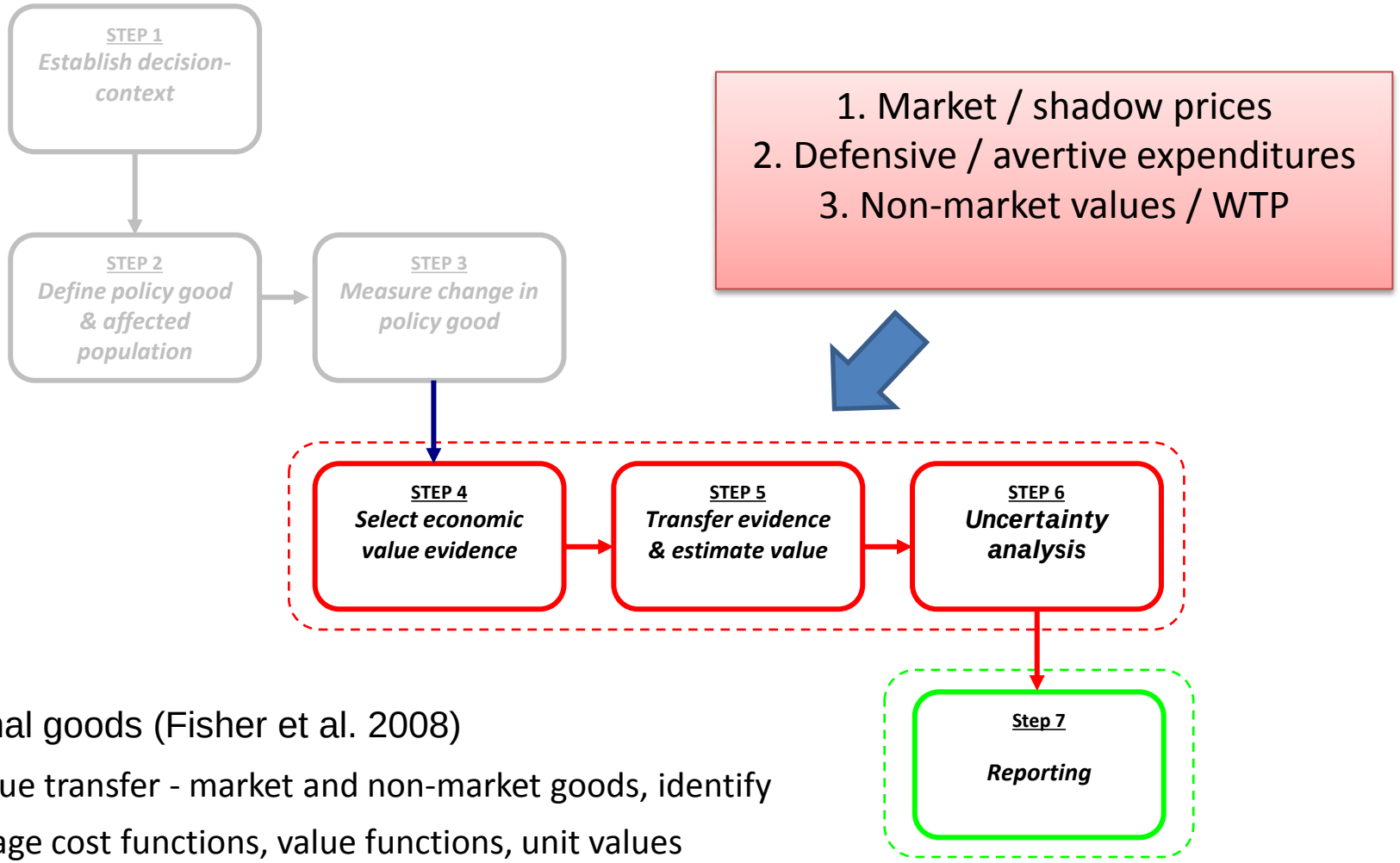
- Eutrophication
- Acidification
- Direct toxicity



Jones et al. (2013). Ecosystem Services (online)

#3: Valuation

Valuation: Value transfer steps

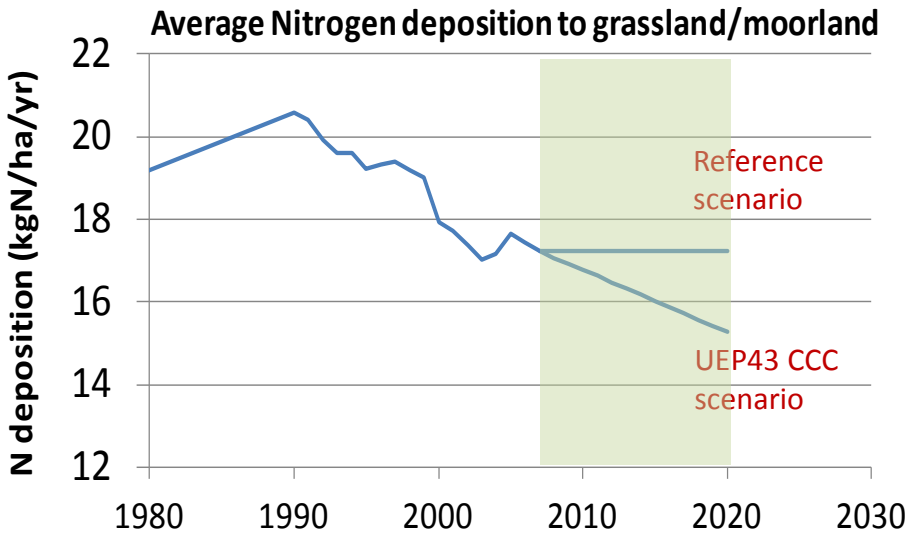


- Final goods (Fisher et al. 2008)
- Value transfer - market and non-market goods, identify damage cost functions, value functions, unit values

#4: Marginal costs in scenario analysis

Marginal cost approach - Scenarios

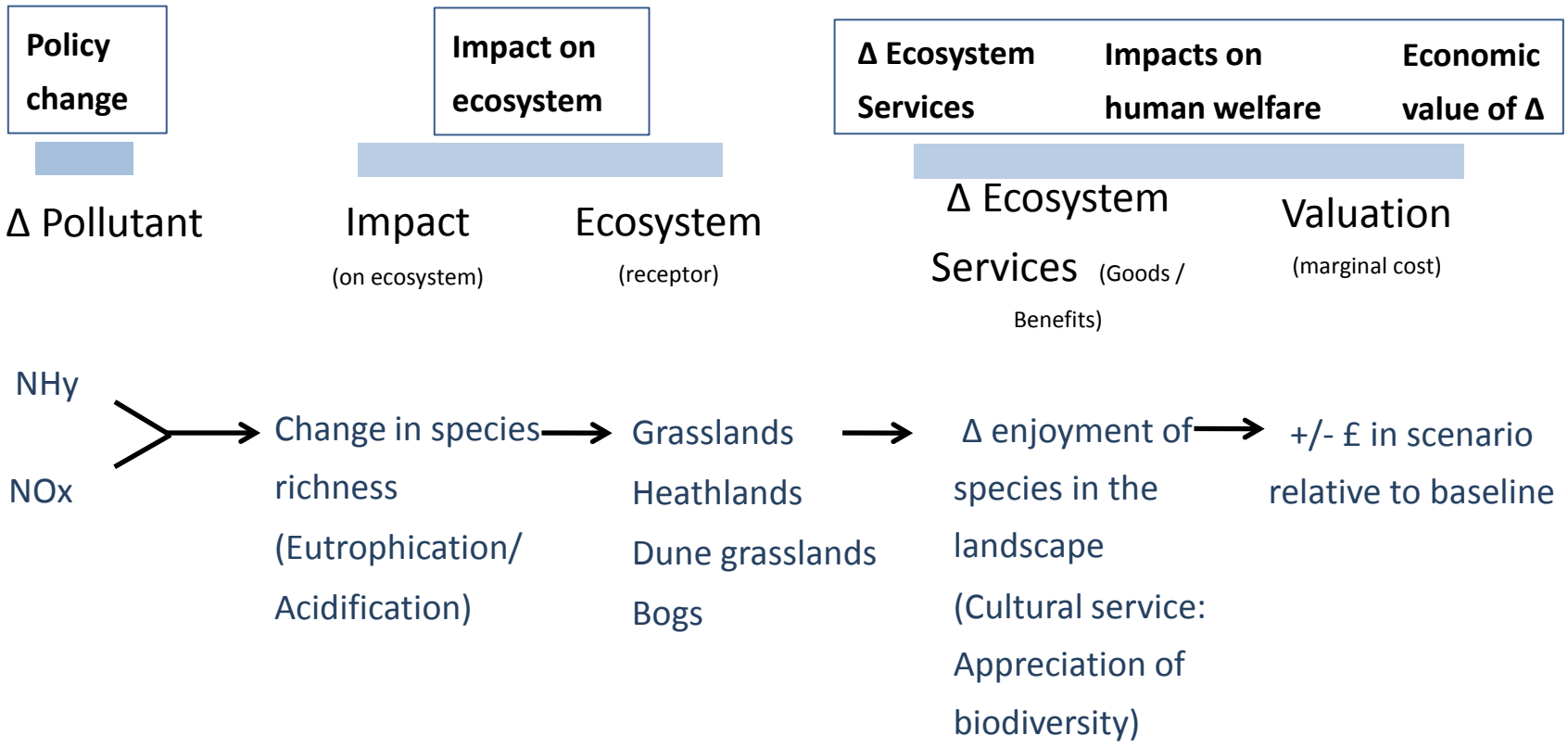
- Comparison of impact under a specified emissions scenario (DECC UEP43 CCC energy projection), against continued impact at deposition levels in the reference year.
- Declines in N deposition 2007 - 2020, using 2007 as the reference year



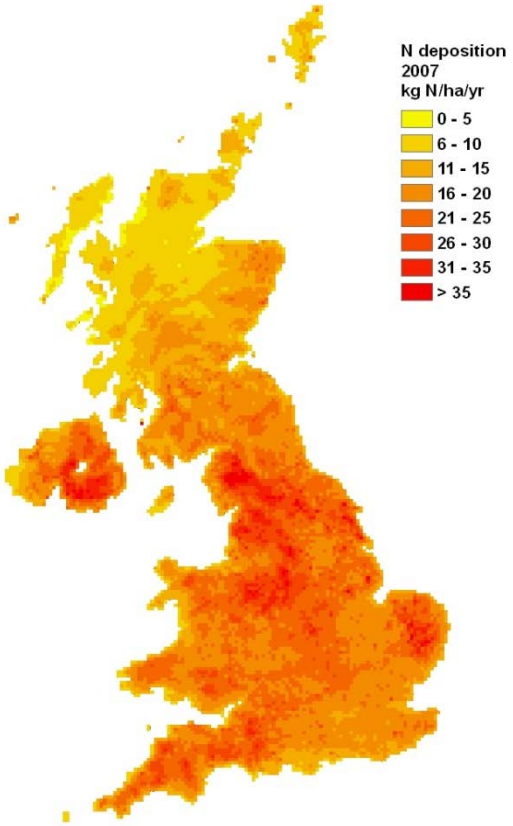
Aim

- What is the financial impact of changing nitrogen deposition on the ecosystem service: **"Appreciation of biodiversity"** in the UK ?

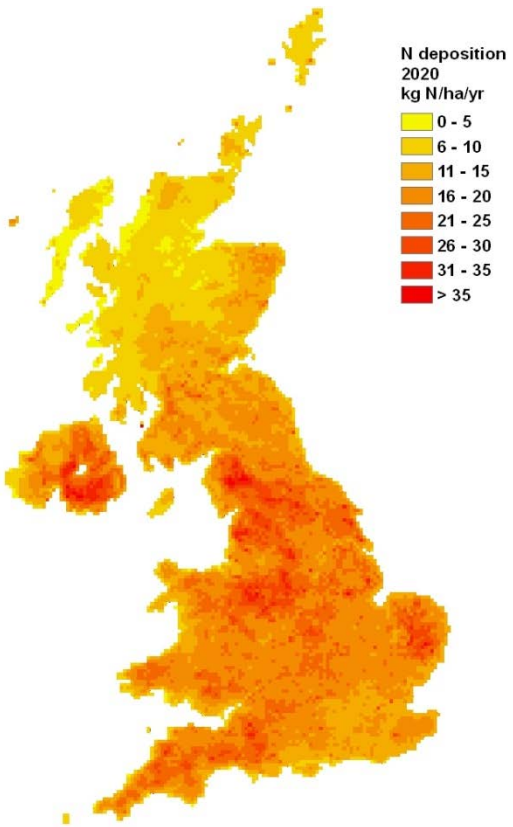
Impact pathway for: Nitrogen on 'Appreciation of Biodiversity'



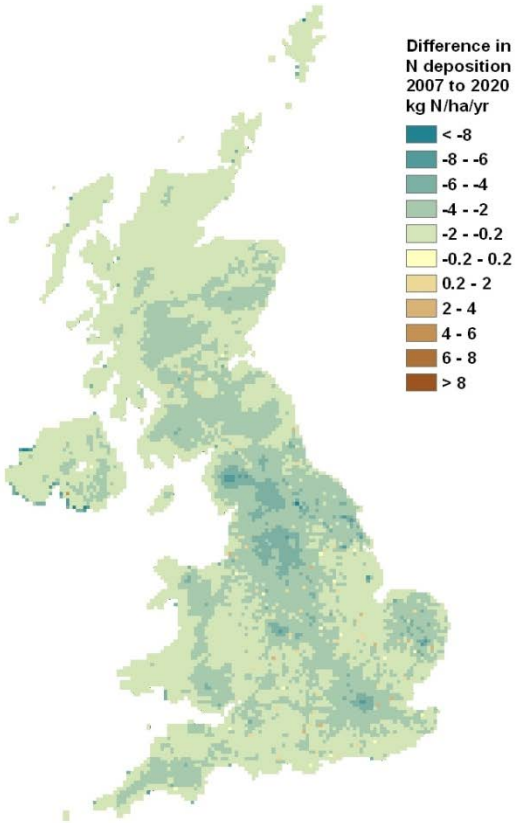
N deposition change: Future scenario



2007



2020

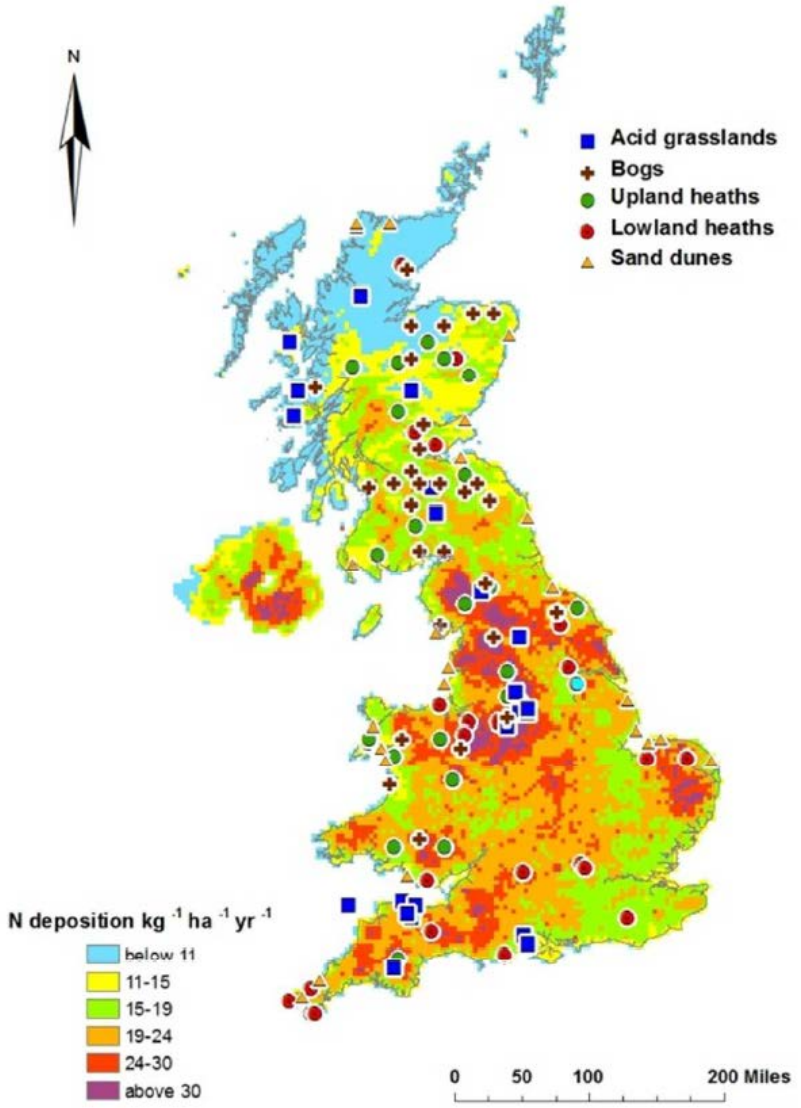


Difference,
2020 minus 2007

Dose-response relationships: #1

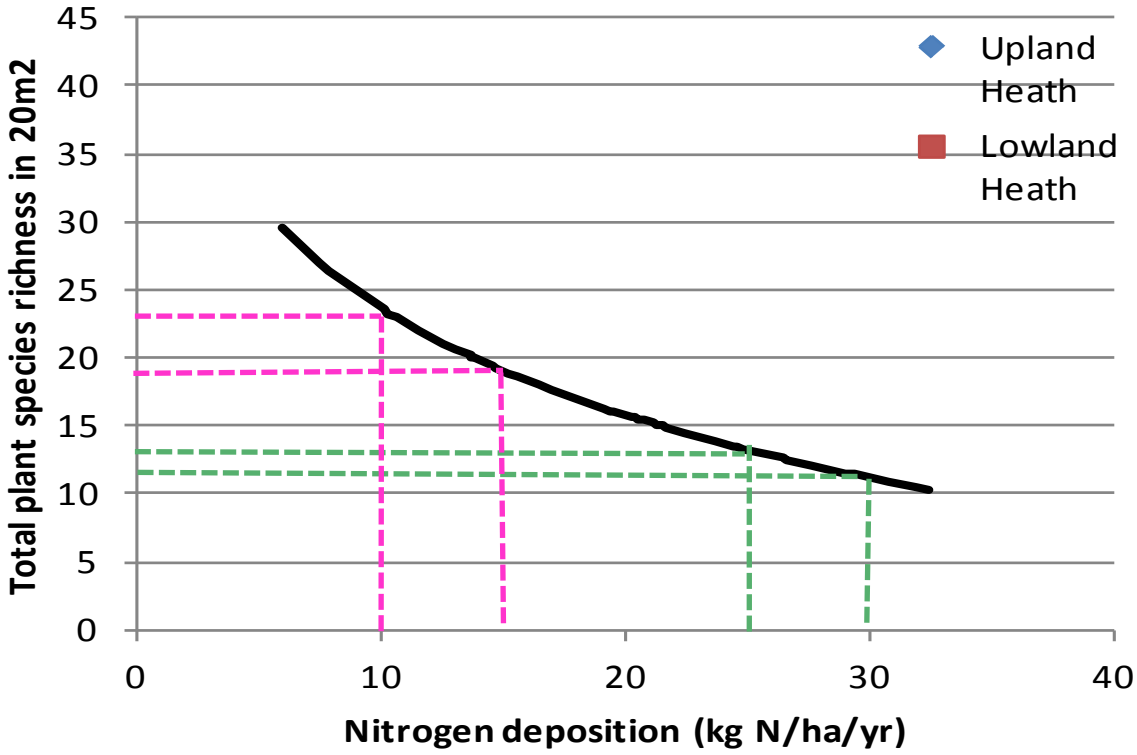
Nitrogen and plant species richness

- Gradient survey approach
- Five habitats:
  - Acid grassland
  - Heaths (upland and lowland)
  - Sand dune grassland
  - Bogs
- Controlled for co-correlating gradients (e.g. temperature, rainfall)

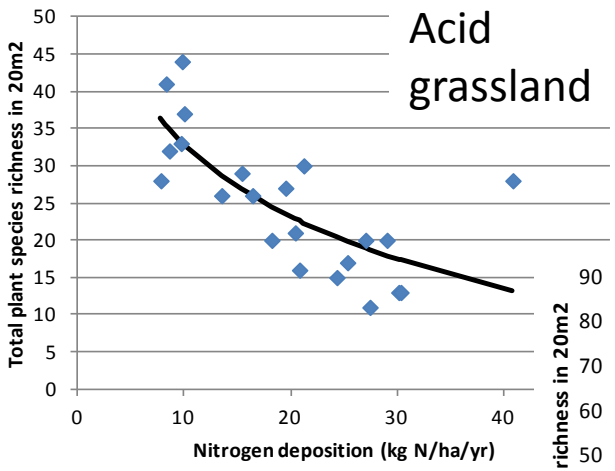


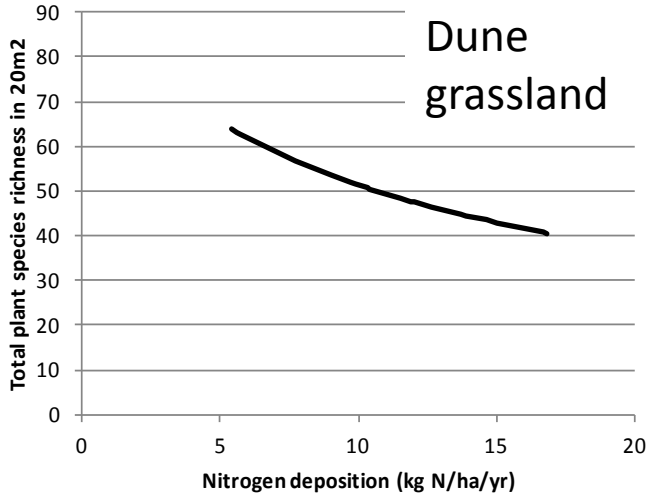
#2: N & species richness - heathlands

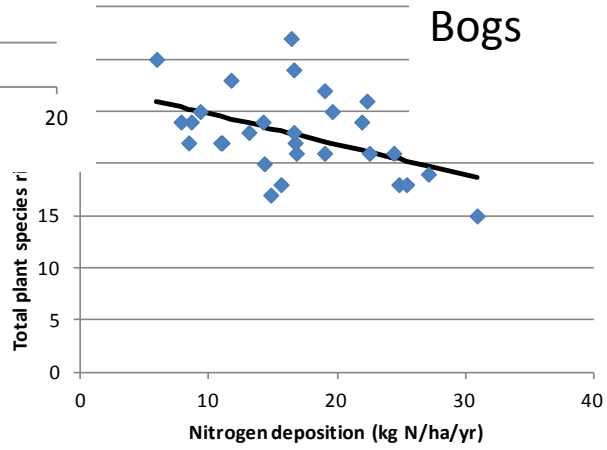
- Heathlands



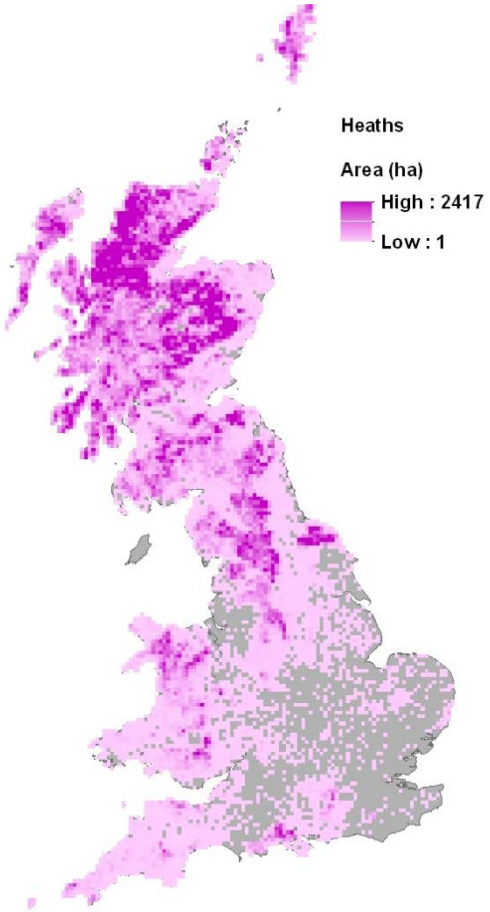
#3: acid grasslands, dune grassland, bogs



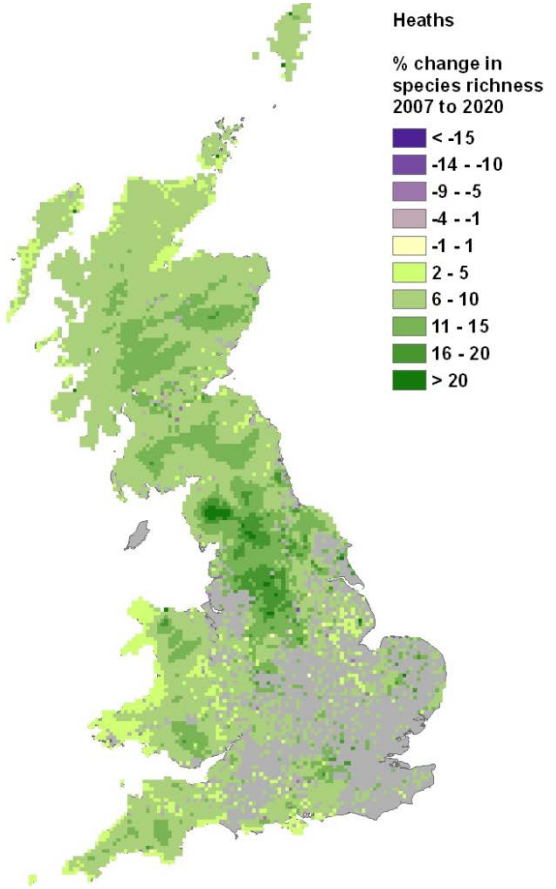




Changing plant diversity in heathlands

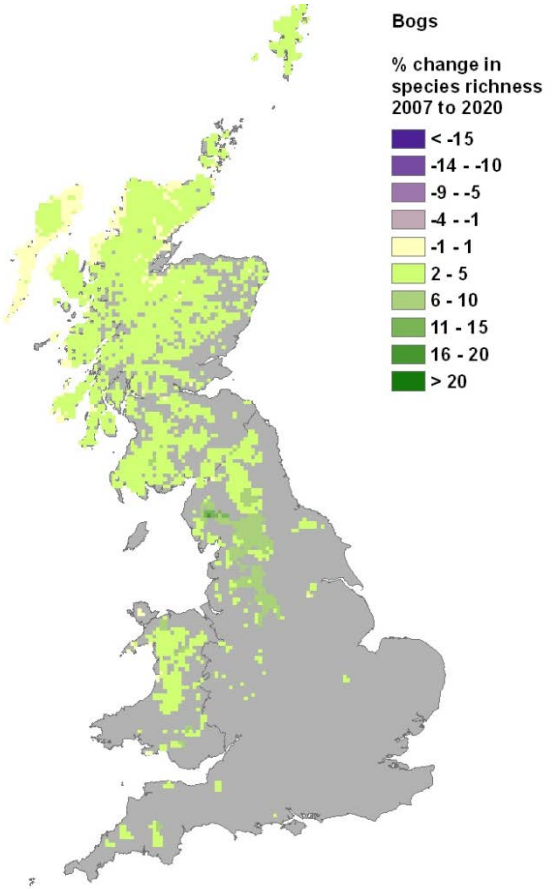


Density of heathland in a 5 x 5 km square

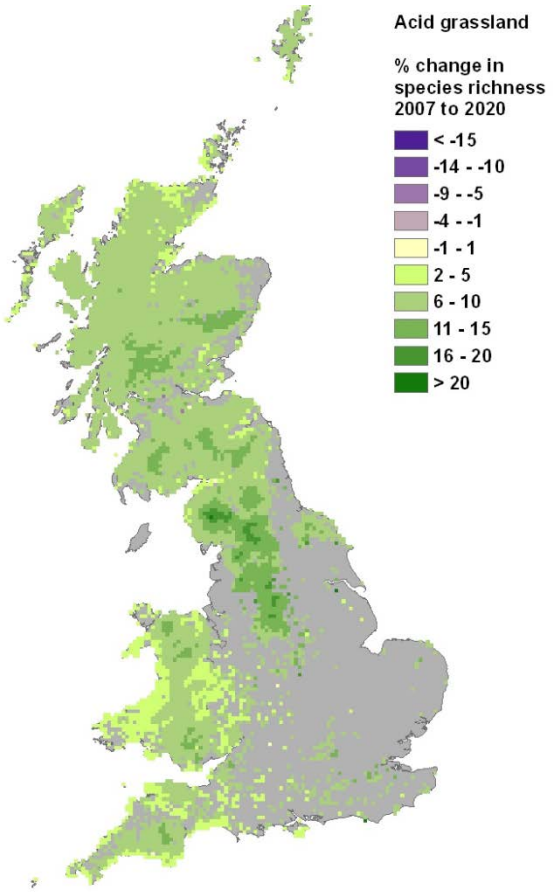


Change in species richness in 2020, compared with 2007

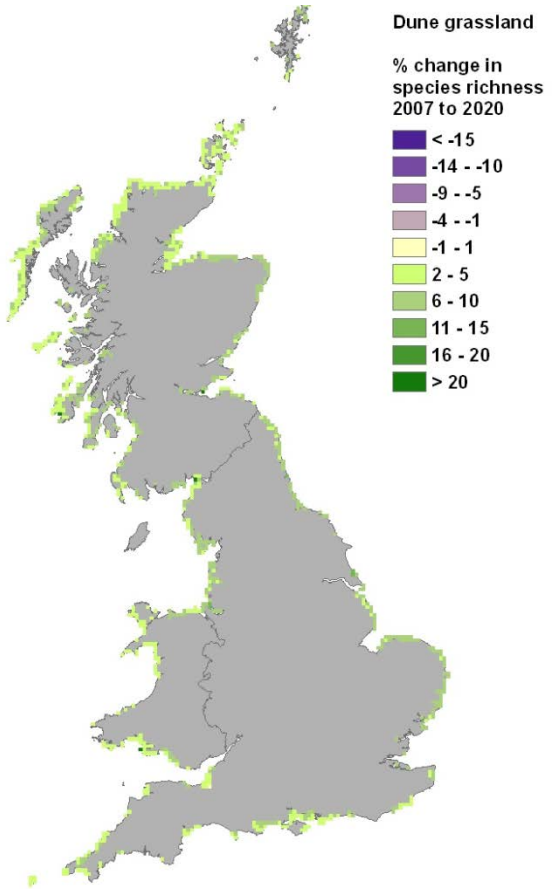
acid grasslands, dune grasslands, bogs



Bogs
Change in species richness, 2020 - 2007

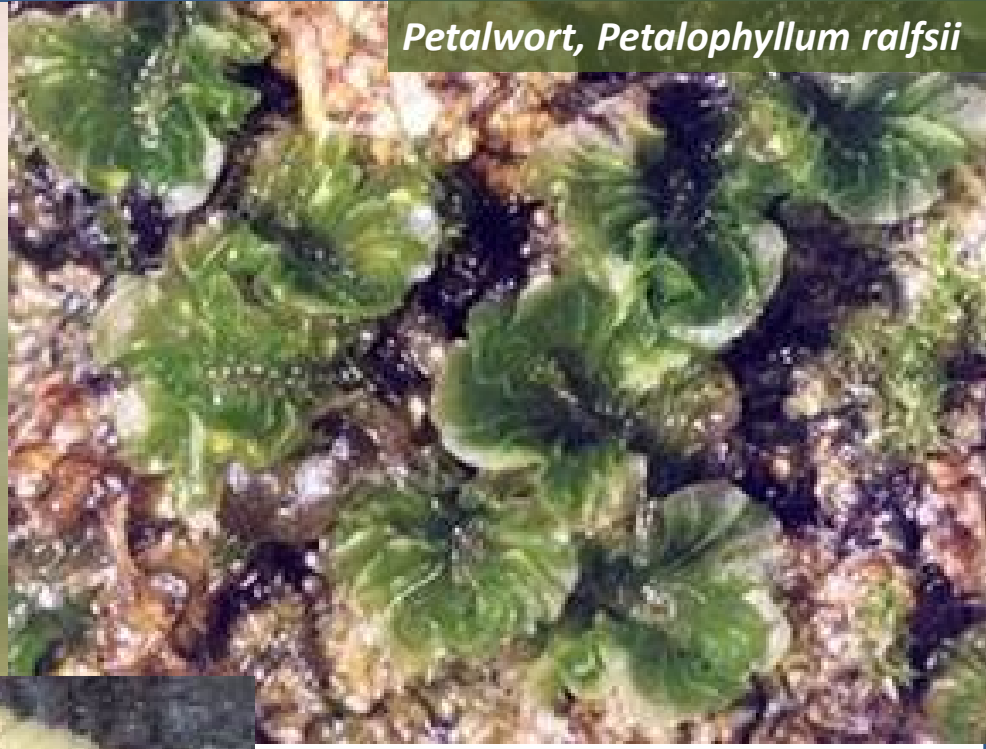


Acid grassland
Change in species richness, 2020 - 2007

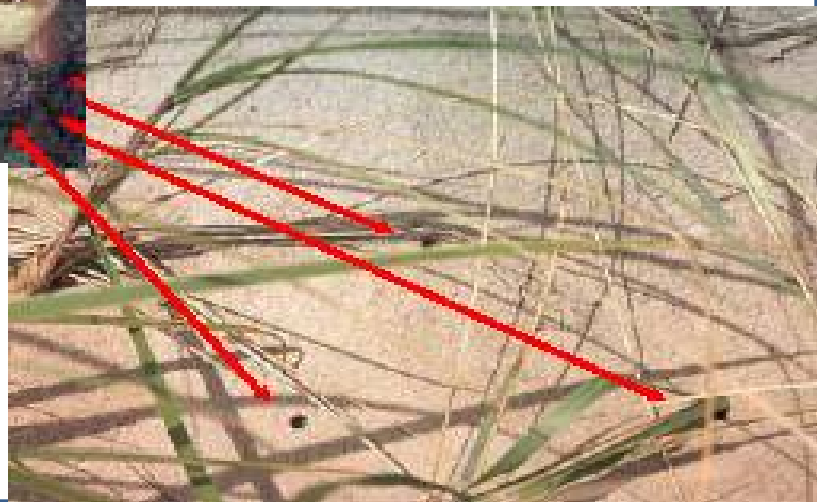


Dune grassland
Change in species richness, 2020 - 2007

Red-backed shrike, Lanius collu



Petalwort, Petalophyllum ralfsii



Value transfer

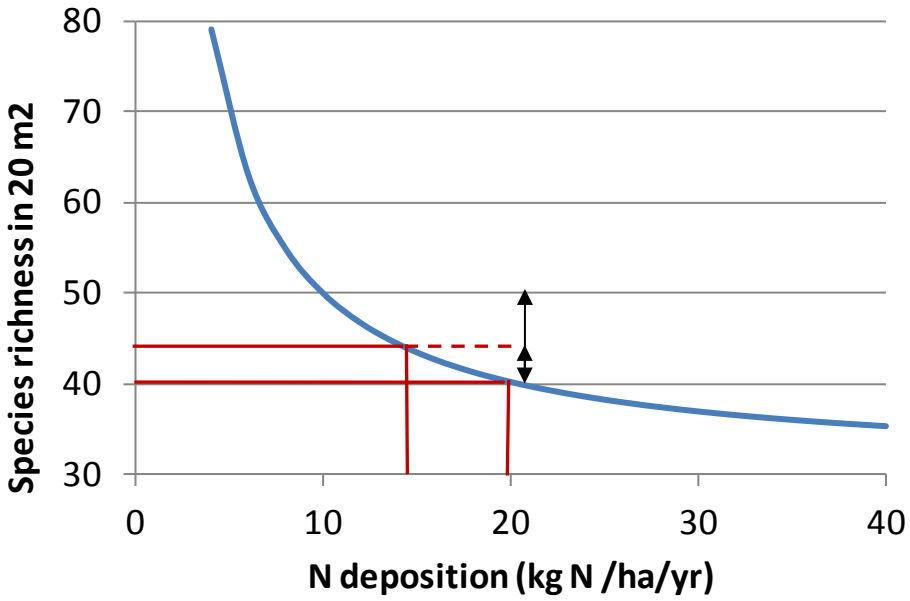
- Choice experiment (Christie & Rayment, 2012).
- Valuing benefits of SSSI management.
- Stated preference techniques - WTP

- £/ha of habitat to achieve **25%** increase in populations of **non-charismatic** species

Benefit category	Increase SSSI funding	Maintain funding	Remove funding
Nature's gifts	 **MORE NATURE'S GIFTS** You would see a ***25% increase*** in the variety and extent of wild foods and other natural products available compared to present levels.	 **NO CHANGE** You would see ***no change*** in the variety and extent of wild foods and other natural products available.	 **LESS NATURE'S GIFTS** You would see a ***50% reduction*** in the variety and extent of wild foods and other natural products available compared to present levels.
Research and education	 **MORE RESEARCH AND EDUCATION** The improved condition of the SSSI network would enable a ***35% expansion*** of research and educational activities; improving society's understanding and appreciation of the natural environment compared to present levels.	 **NO CHANGE** There would be ***no change*** in the SSSI resource for research and education purposes compared to present levels.	 **LESS RESEARCH AND EDUCATION** The deterioration of the SSSI network would result in a ***40% decline*** in research and educational activities; reducing society's understanding and appreciation of the natural environment compared to present levels.
Climate regulation	 **LESS CO_2** There would be a small increase in the capacity of the SSSI network to store carbon; resulting in the ***storage of an extra 100k tonnes of CO_2 per annum*** (equivalent to 0.1% of all UK CO_2 emissions). This would help to reduce global warming.	 **NO CHANGE** There would be ***no change*** in the capacity of the SSSI network to store carbon from present levels.	 **MORE CO_2** There would be a small reduction in the capacity of the SSSI network to store carbon, resulting in the ***release of an extra 100k tonnes of CO_2 per annum*** (equivalent to 0.1% of all UK CO_2 emissions). This would contribute to global warming.
Water regulation	 **LESS FLOODING** There would be a small increase in the capacity of SSSI habitats to regulate water. ***65,000 fewer people*** would be at lower risk of flooding.	 **NO CHANGE** There would be ***no change*** in the capacity of SSSI habitats to regulate water. 4.5 million people would remain at risk of flooding.	 **MORE FLOODING** There would be a small reduction in the capacity of SSSI habitats to regulate water. **65,000 more people** would be at a greater risk of flooding.
Sense of experience	 **MORE HABITATS MAINTAINED** There would be a ***33% increase in the area of SSSI habitats*** maintained in good condition. You might find that more of the countryside around you feels 'special'.	 **NO CHANGE** There would be ***no change*** in the area of SSSI habitats maintained in condition.	 **FEWER HABITATS MAINTAINED** There would be a ***40% reduction in the area of SSSI habitats*** maintained in good condition. You might notice that some of the natural areas that you visit feel less 'special' than they are now.
Charismatic species.	 **MORE CHARISMATIC SPECIES** There would be a ***20% increase in the populations and range*** of threatened mammals, birds, amphibians, reptiles, fish and butterflies in SSSIs. Populations of these species would be stabilised. You will therefore be more likely to see these species in the countryside.	 **NO CHANGE** There would be ***no change in the populations and range*** of threatened mammals, birds, amphibians, reptiles, fish and butterflies in SSSIs. Many of these species would remain under threat.	 **FEWER CHARISMATIC SPECIES** There would be a ***55% decline in the populations and range*** of threatened mammals, birds, amphibians, reptiles, fish and butterflies in SSSIs. You will therefore be less likely to see these species in the countryside. Some of these species may disappear from some SSSIs altogether.

Valuation scaling & Uncertainty

- Proportion of WTP
- Calculated for habitat area within each 5 x 5 km sq
- Summed for UK for each habitat



Uncertainty

- Monte Carlo approaches
- Spatial and temporal auto-correlation
- Depends on accurate specification of uncertainty in input variables

Valuation results

- Using a revised spatial assessment of impact, there is an estimated benefit of roughly €30 million for future declines in N deposition (2007 to 2020) for 'Appreciation of Biodiversity' based on valuation for non-charismatic species

  [Report nearing completion, estimated release date: March 2014]
- If response functions for charismatic species were available, these are likely to be a factor of 5 greater.
- Damage costs are being calculated, per unit **NH3**, **NO2** emitted.

- **Caveats**:
  - Doesn't account for other drivers of change in species richness
  - Assumes instantaneous response of species change to N deposition
  - Response functions for only 30% of UK semi-natural land area
  - No dose-response functions yet for Charismatic species

Conclusions

- High value for impacts on cultural services associated with biodiversity
- Quantification requires multi-disciplinary teams
- There remain knowledge gaps:
  - Dose-response functions for charismatic species
  - Dose-response functions for other cultural services
- Damage costs for NHy and NOx are coming ...