Prospects for habitat management in mitigating climate change driven species extinction

Ilya Maclean

i.m.d.maclean@exeter.ac.uk

Environment and Sustainability Institute, University of Exeter

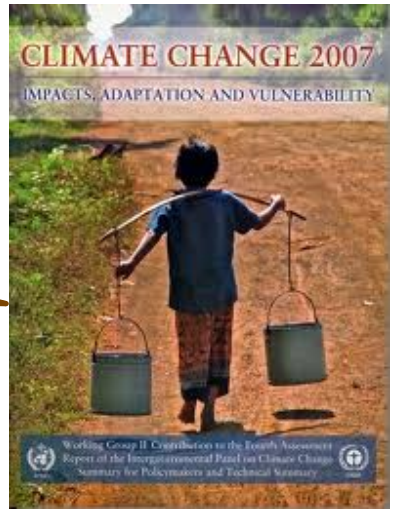



Outline

- Evidence of species extinctions
- Macroclimates and microclimates
- Evidence that habitat management might work
- Knowledge gaps

Extinction risk: future projections

"Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C."



"..on the basis of mid-range climate-warming scenarios for 2050... 15–37% of species... will be 'committed to extinction'."

letters to nature

Extinction risk from climate change

Chris D. Thomas[1], Alison Cameron[1], Rhys E. Green[2], Michel Bakkenes[3], Linda J. Beaumont[4], Yvonne C. Collingham[5], Barend F. N. Erasmus[6], Marinez Ferreira de Siqueira[7], Alan Grainger[8], Lee Hannah[9], Lesley Hughes[4], Brian Huntley[5], Albert S. van Jaarsveld[10], Guy F. Midgley[11], Lera Miles[5]*, Miguel A. Ortega-Huerta[12], A. Townsend Peterson[13], Oliver L. Phillips[8] & Stephen E. Williams[14]

Climate change over the past ~30 years has produced numerous shifts in the distributions and abundances of species[1,2] and has been implicated in one species-level extinction[3]. Using projections of species' distributions for future climate scenarios, we assess extinction risks for sample regions that cover some 20% of the Earth's terrestrial surface. Exploring three approaches in which the estimated probability of extinction shows a power-law relationship with geographical range size, we predict, on the basis of mid-range climate-warming scenarios for 2050, that 15–37% of species in our sample of regions and taxa will be 'committed to extinction'. When the average of the three methods and two dispersal scenarios is taken, minimal climate-warming scenarios produce lower projections of species committed to extinction (~18%) than mid-range (~24%) and maximum-change (~35%) scenarios. These estimates show the importance of rapid implementation of technologies to decrease greenhouse gas emissions and strategies for carbon sequestration.

Observed extinctions

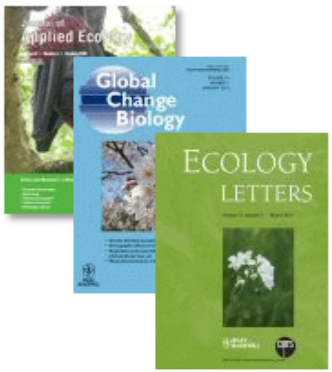
- Very few global extinctions
  (but implicated in the extinction of at least five Anurans)[1]
- Is there a mismatch?
- Large number of population level extinctions:
  e.g. 12% of Lizard populations in Mexico (4% Worldwide)[2]
- Numerous studies show species declines / range contractions

[1] IUCN Red List (2011)
[2] Sinervo *et al.* (2010) *Science*, 328: 894–899

Validating predictions

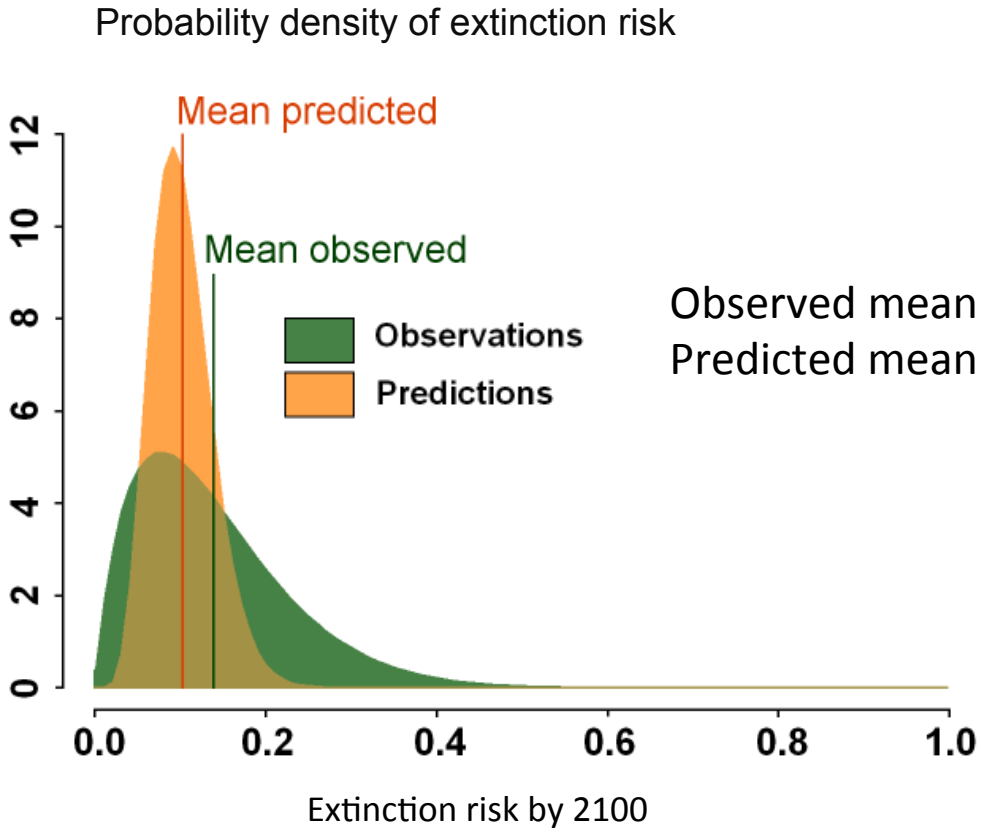
Possible to convert range and population changes to extinction risk using IUCN Red List criteria

Global meta-analysis of studies on observed and predicted range & population changes due to climate change



Maclean & Wilson (2011) *PNAS,* 108: 12337–12342

Validating predictions



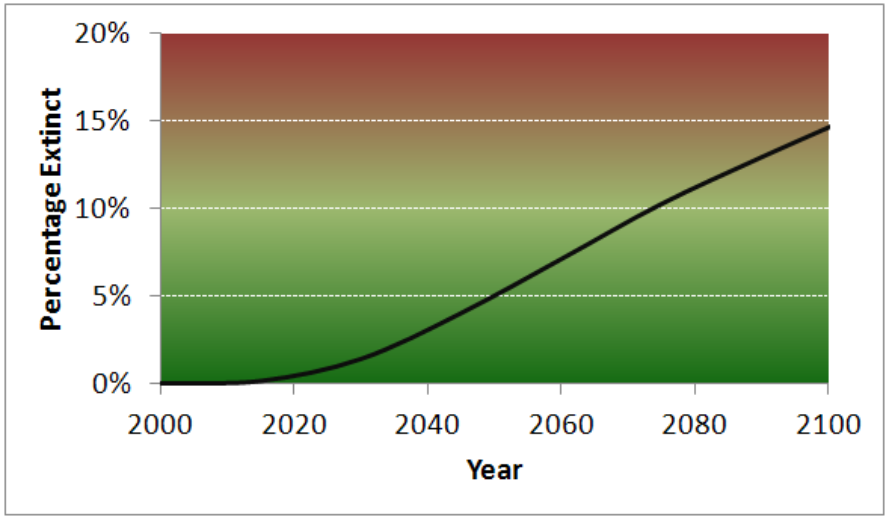
Observed mean: 14%
Predicted mean:10%

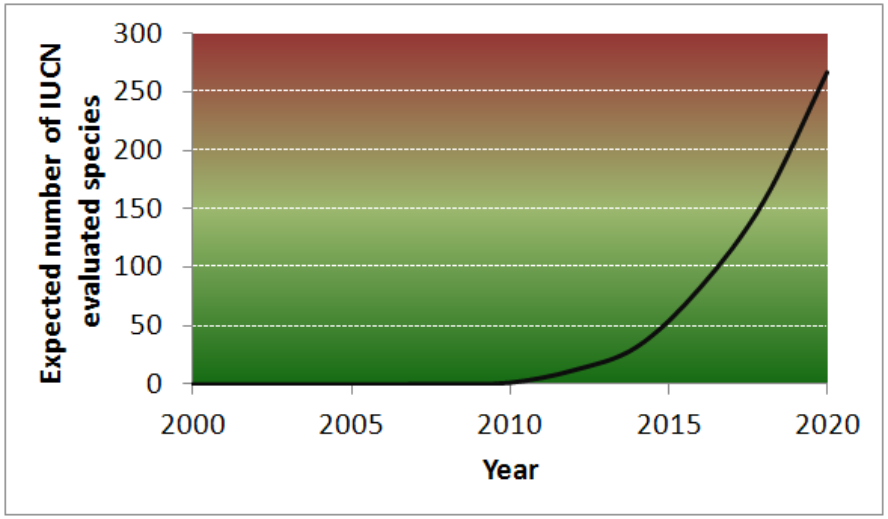
Observed responses slightly more deleterious than predicted responses!

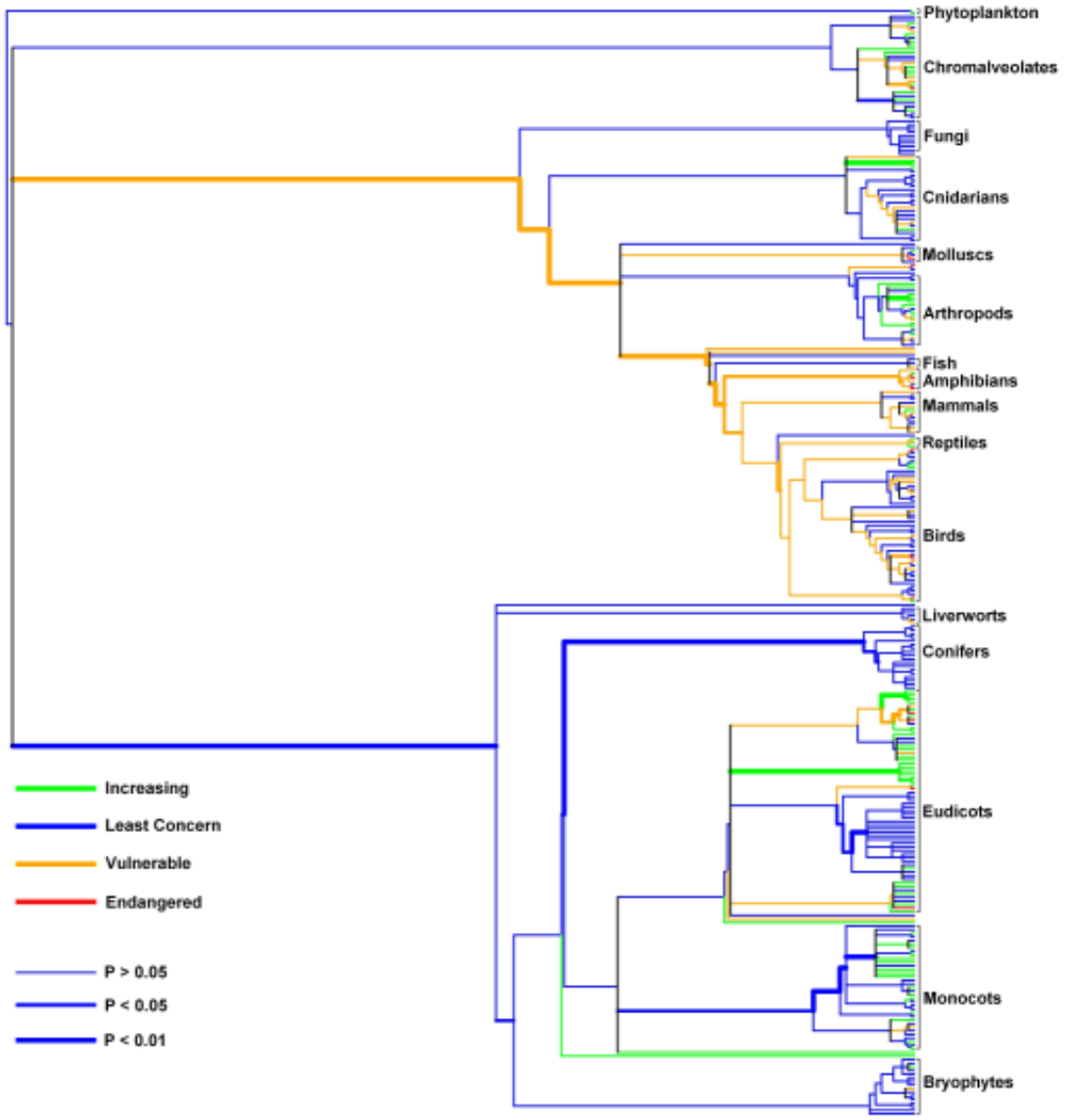
Maclean & Wilson (2011) *PNAS,* 108: 12337–12342

Validating predictions

- Future range size for different time periods?
  - *Current range size x documented range changes (all expressed as frequencies)*
- Future extinction risk?
  - *Convert from range size using IUCN Criteria and if > 0.5, then assumed to go extinct*







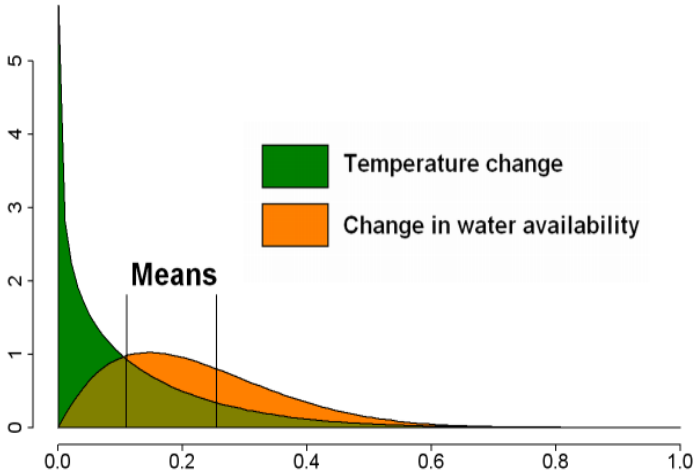
Observations and predictions show similar taxonomic patterns:

- Animals particularly at risk

- Plants less at risk

Relative threats

Probability density of extinction risk



Extinction risk by 2100

Mean extinction risk:
Temperature: 12%
Water availability: 26%

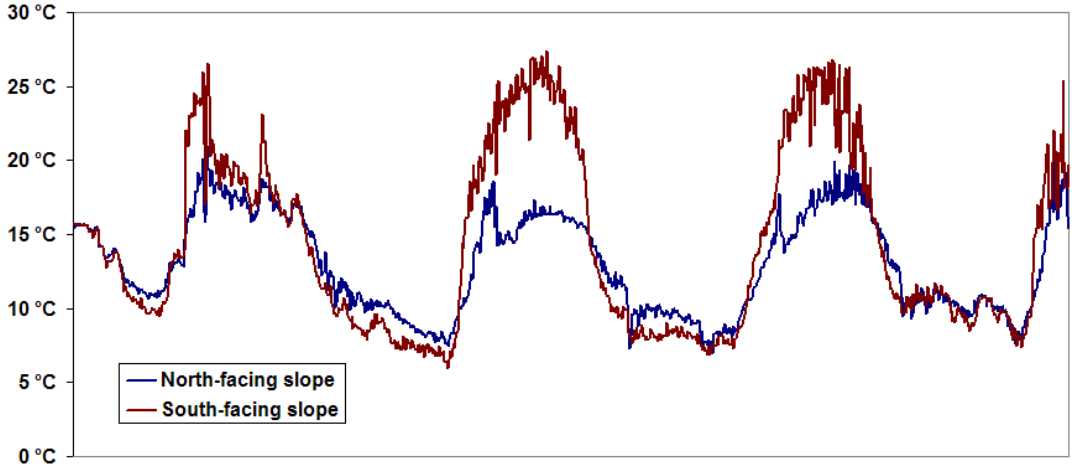
Percentage of terrestrial studies focusing on:
Temperature alone: 68%
Water availability: 2%

- **Water availability greater threat than temperature**

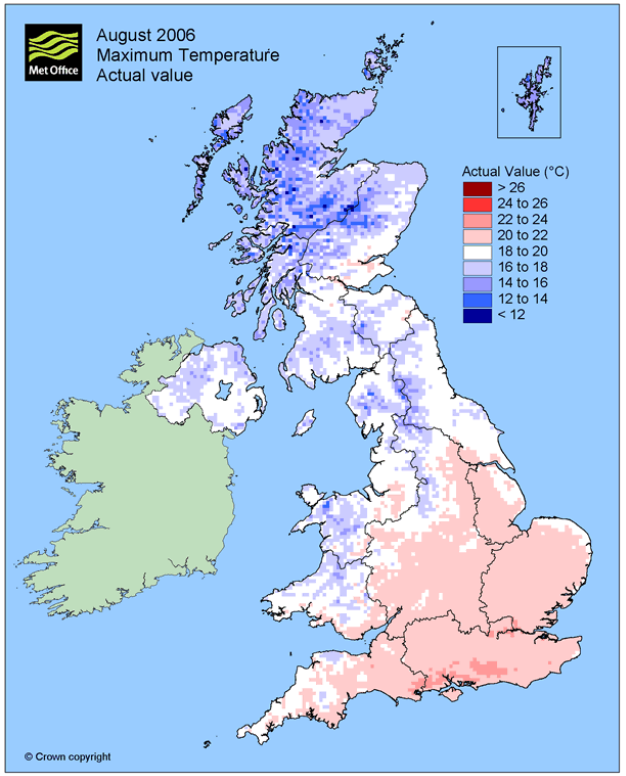
Summary

- Numerous species predicted to go extinct
- Predictions backed-up by observed responses
- Vertebrates (particularly Anurans) more threatened than plants
- Water a greater threat than temperature

Microclimatic variation



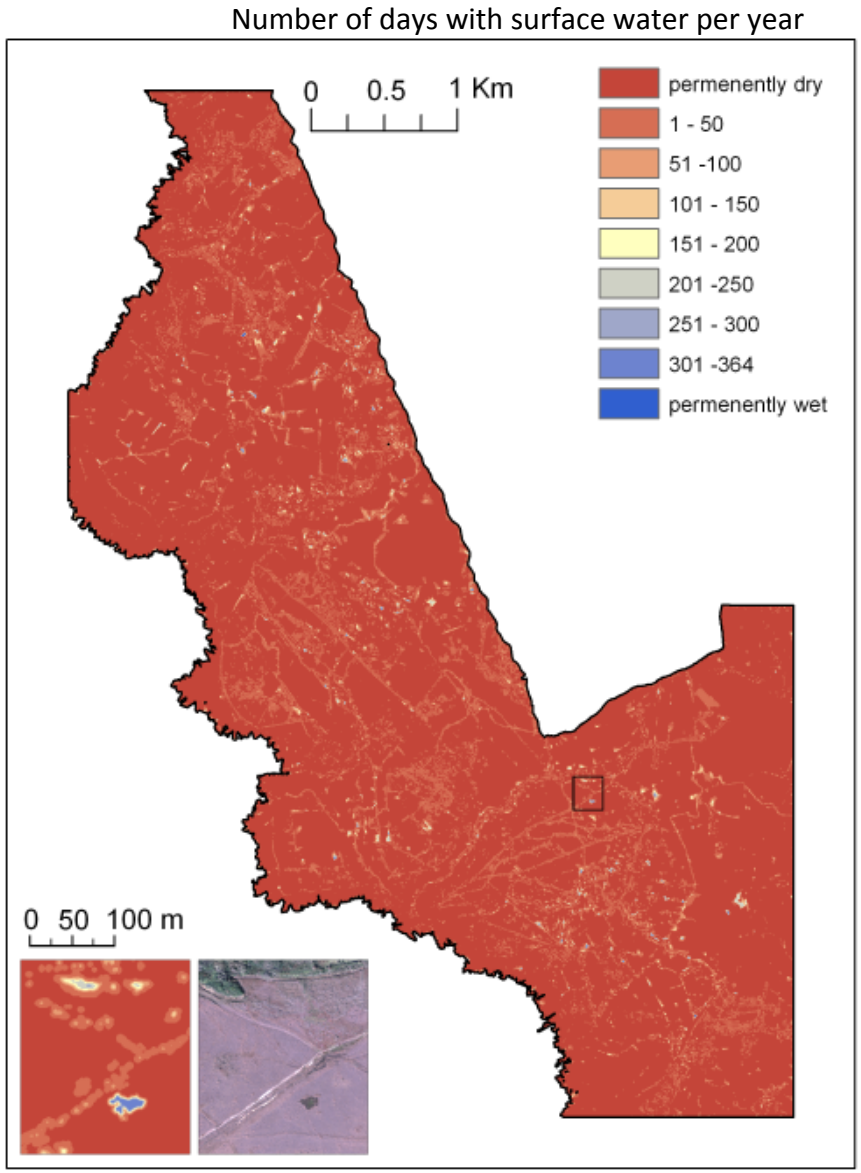
Temperature at 15 cm in grassland on two opposing slopes
(Hampshire, 9-12th Sep 09)

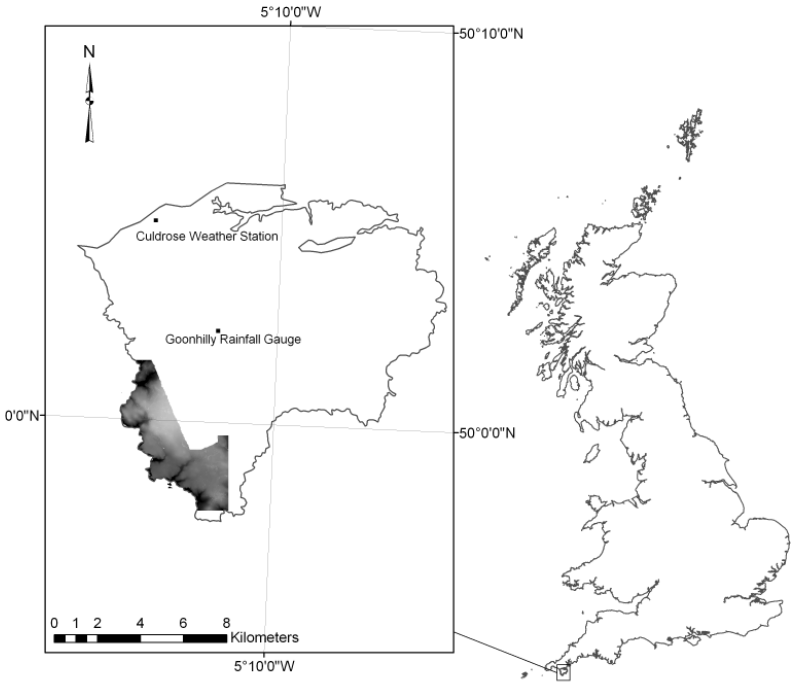


- **Temperature differences: local fine-scale comparable to national coarse-scale**

e.g. Bennie *et al.* (2006) *J. Ecol* 94: 355-368
Bennie *et al.* (2009) *Ecol.Mod.* 216: 47-59.
Suggitt *et al. (2011) Oikos,* 120: 1-8.

Microclimatic variation





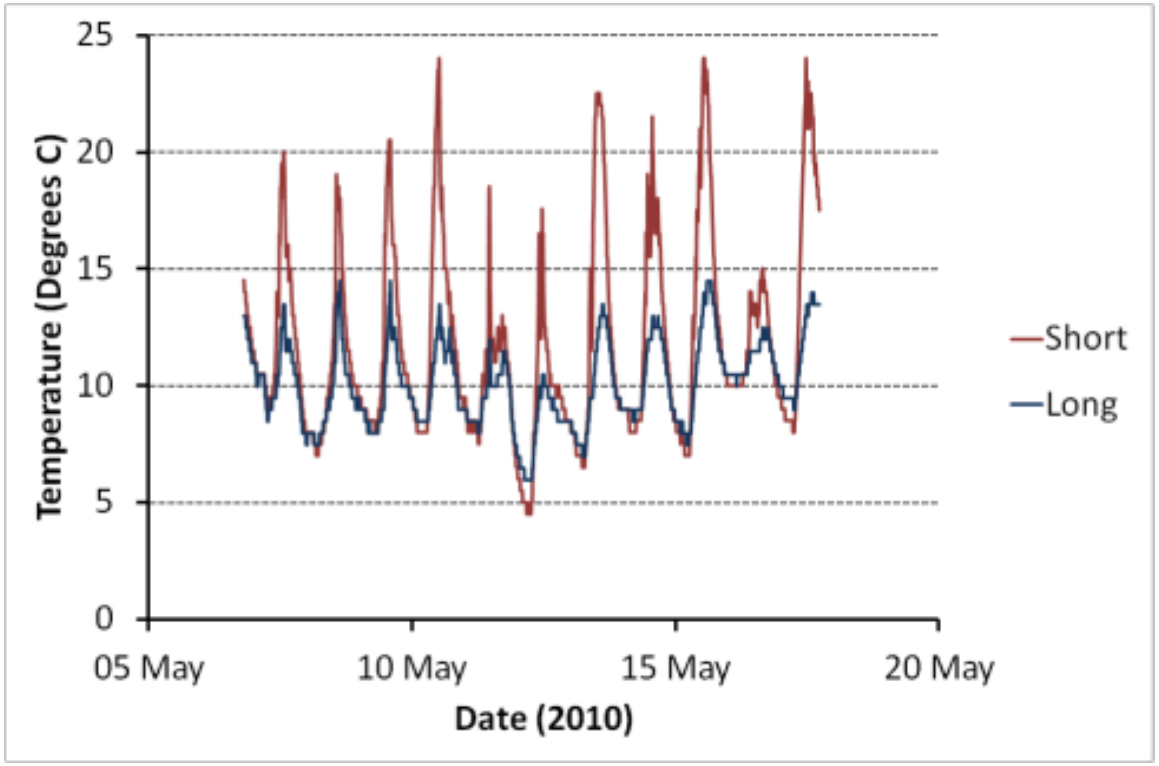
Locations vary from permanently wet to permanently dry at fine-scales

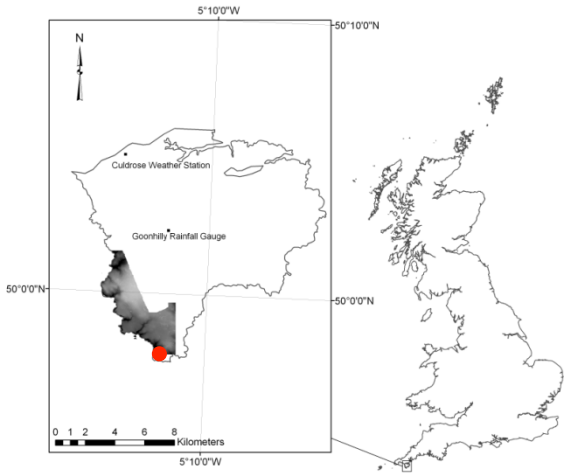
Maclean *et al.* (2012) *Ecological Modelling*

Microclimatic manipulation by habitat management?

- **Does habitat management influence microclimate?**
- **Are species macroclimatic associations reflected at a microclimate level?**
- **Can species persist in manipulated microclimates?**

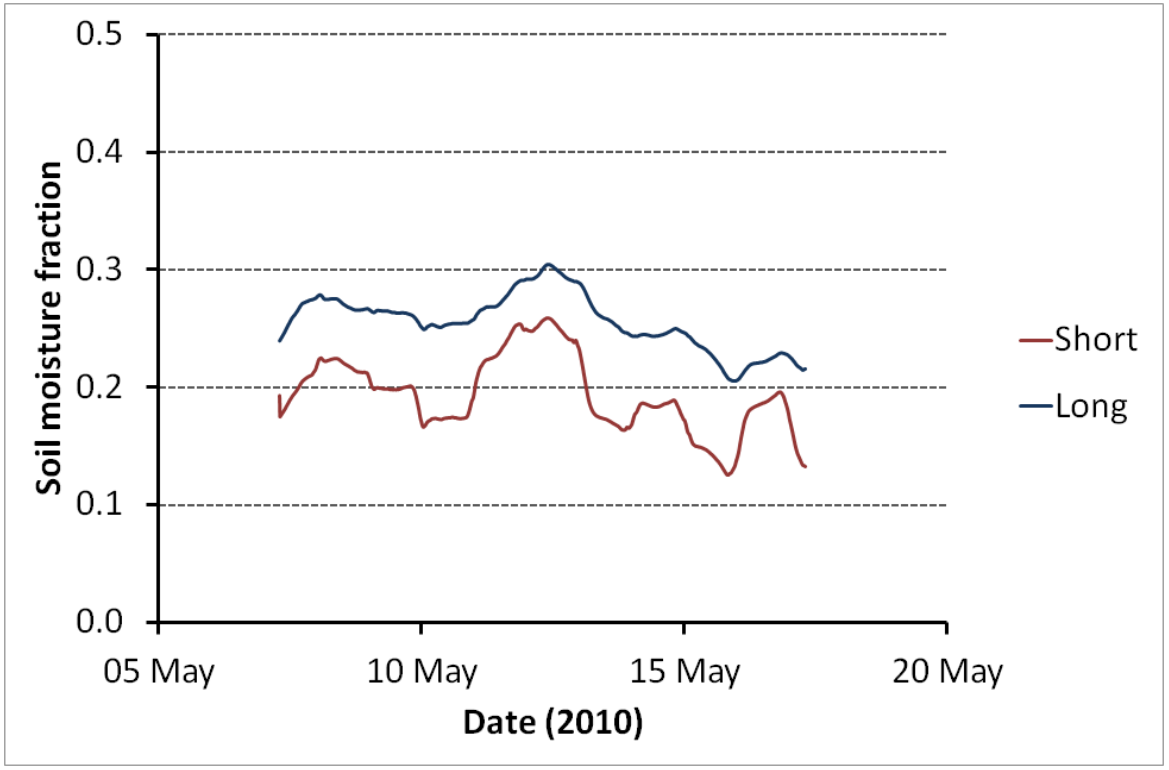
Does habitat management influence microclimates?

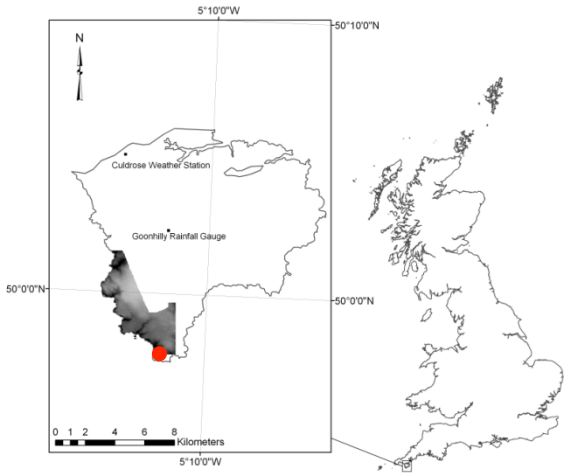




Ground-level spring temperatures over 11 days in May 2010 in short (5cm) and long (20 cm) grazed grassland

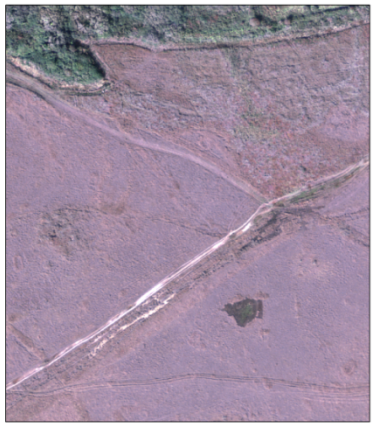
Does habitat management influence microclimates?



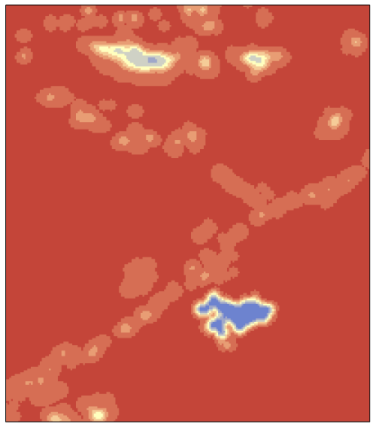


Soil moisture fraction over 8 days in May 2010 in short (5cm) and long (20 cm) grazed grassland

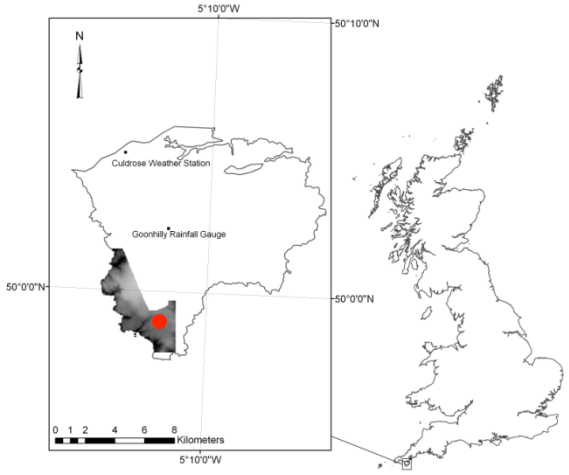
Does habitat management influence microclimates?



0 25 50 100 Meters



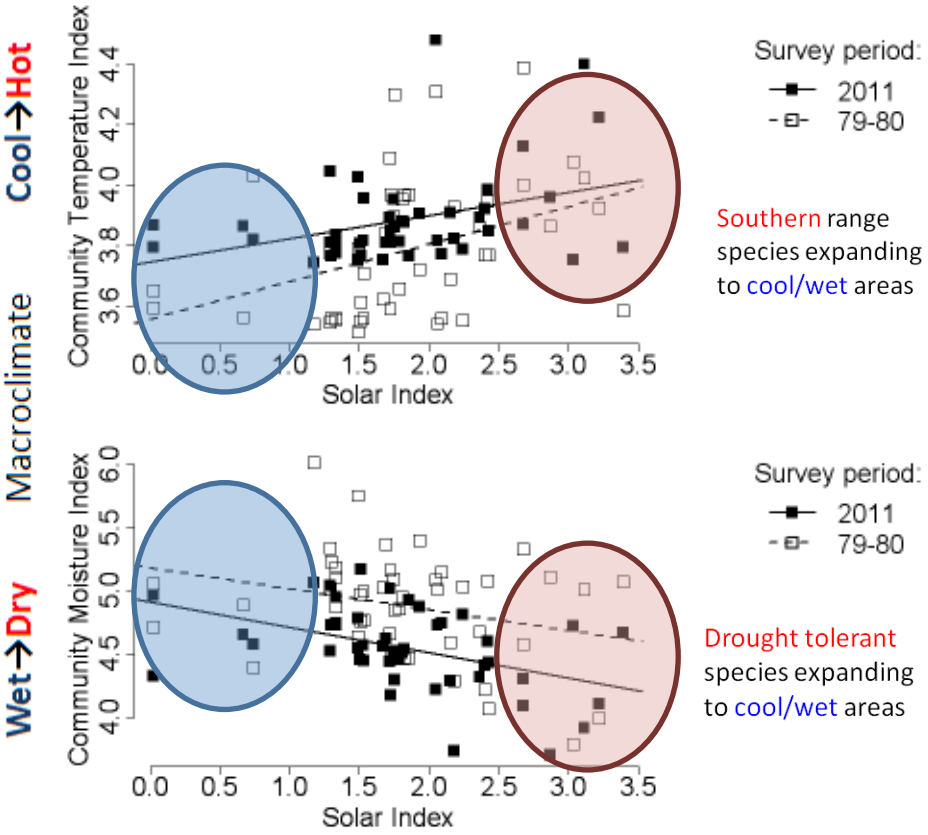
0 25 50 100 Meters



Maclean *et al.* (in press) *Ecological Modelling*

Are macroclimatic associations reflected at a microclimate level?

30 year changes in grassland plant communities



Southern range species expanding to cool/wet areas

Drought tolerant species expanding to cool/wet areas

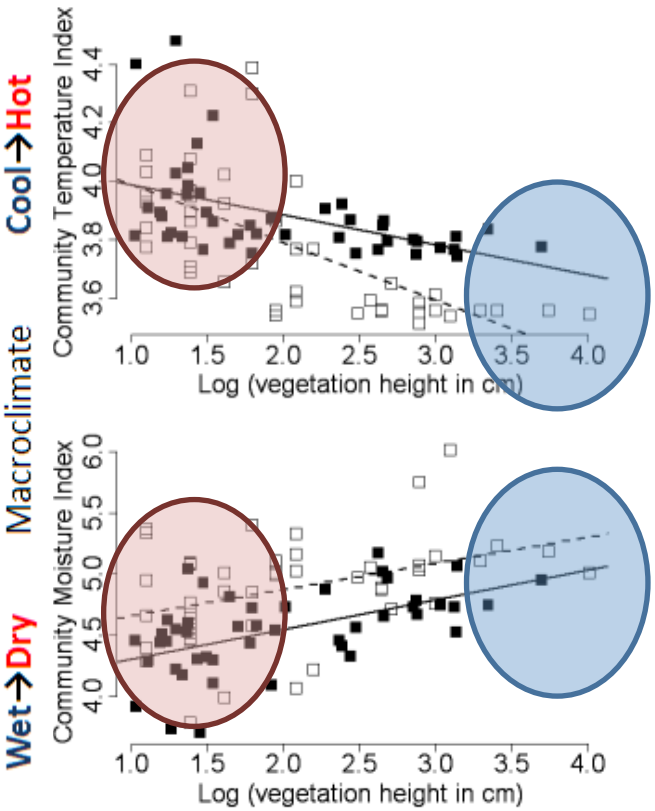
- Continental species associated with warm/dry microclimates
- Boreal species associated with cool /wet microclimates

Northern range species not retracting from warm/dry areas

Water needing species retracting from warm/dry areas

Can species persist in manipulated microclimates?

30 year changes in grassland plant communities



Survey period:
2011
79-80

Southern range species expanding to long grass

Survey period:
2011
79-80

Drought intolerant species expanding to long grass

- Reduced grazing could (probably?) offset effects of climate change

Northern range species not retracting from short grass

Water needing species retracting from short grass

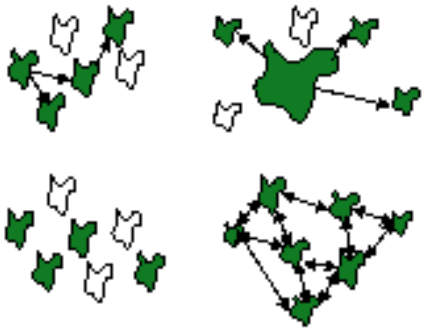
Cool /Wet Habitat **Warm/Dry**

Summary

- Fine-scale microclimate variation over short (<< 1km^2) distances ≈ national differences measured at coarse-scale
- Habitat structure and manipulation excerpt strong influences on microclimates
- Water availability of key importance
- Some suggestion that species could find refuge from climate change in cool/damp microclimates

Knowledge gaps

- Does reduced grazing results in increased competition?
- How does being confined to small pockets affect persistence?
- More work on ecological effects of changes in water availability
- More work on non-plant species)
- Assessment of trade-offs between increased heterogeneity and patch size



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