Projecting the impacts of climate change on biodiversity: are bioclimate envelope models useful?

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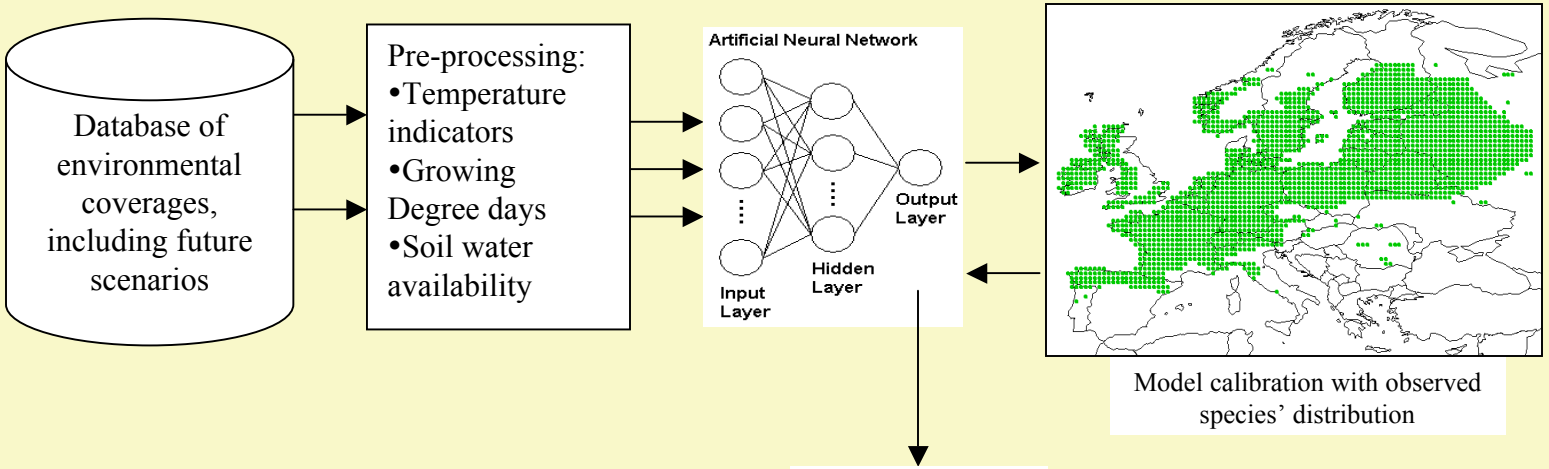
Correlative vs. Mechanistic approaches

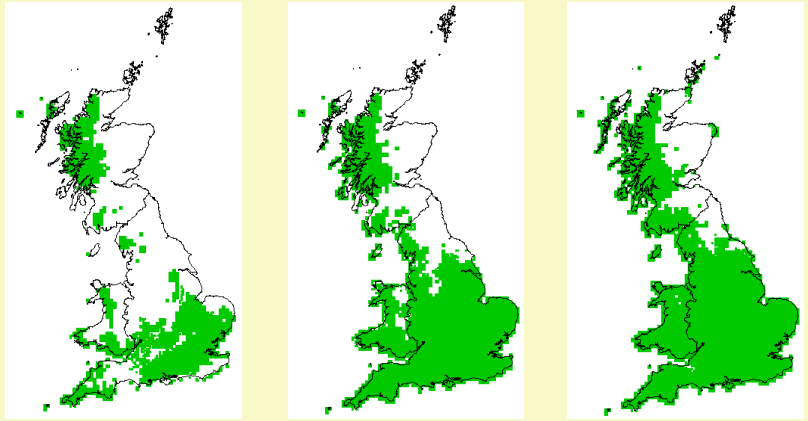
- ‘Bioclimate envelope’ models
- Assume current distribution gives a good indicator of ecological requirements
- Enable rapid ‘first pass’ assessments

- ‘Dynamic Global Vegetation Models’ (DGVMs)
- Do not rely on ‘realised’ ecological niches
- Require detailed physiological data

The ‘bioclimate envelope’ approach

… or ‘ecological niche’… or ‘distribution model’ … or ‘climate matching’





current 2020s high 2050s high

(Pearson et al 2002, *Ecol. Model.*)

Some common modeling algorithms

Presence-only:

- Climate envelope range
- BioClim
- DOMAIN
- ENFA (Biomapper)
- Maxent

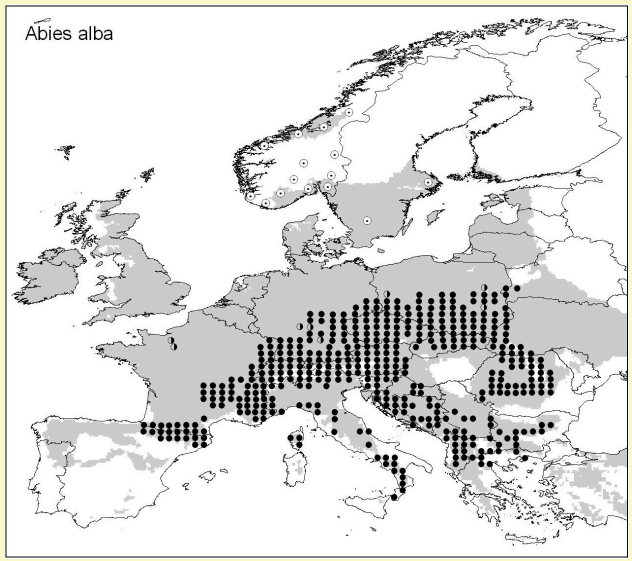
Presence-absence:

- GLMs
- GAMs
- CTA
- ANNs
- GARP

Equilibrium between climate and species' distributions

Degree of range filling (Svenning and Skov 2004, *Ecol. Letters*):

mean realized/potential range size ratio
for 55 tree species in Europe = 38.3%



Patterns of covariation between species' assemblages and climate
(Araújo and Pearson 2005, *Ecography*):

Plants: _ = 0.70, Birds: _ = 0.69, Reptiles: _ = 0.55, Amphibians: _ = 0.47

Sources of uncertainty in bioclimate models

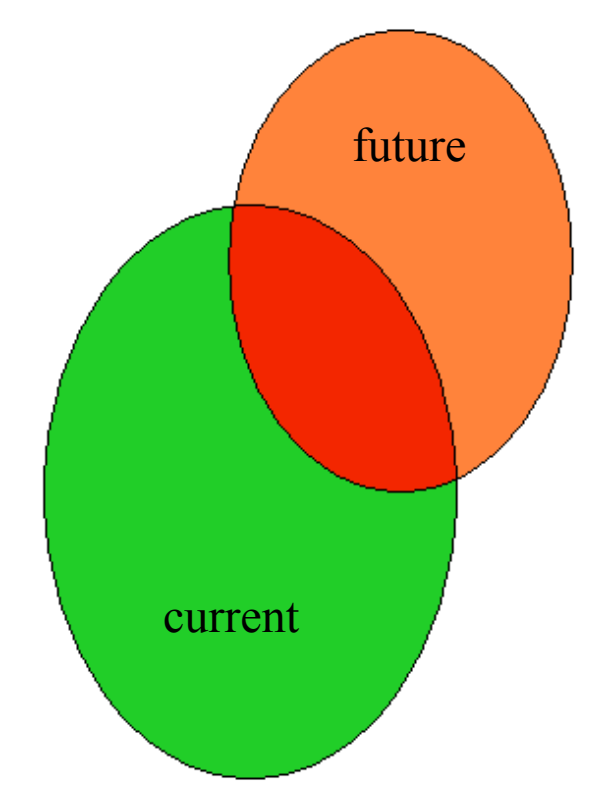
Ecological versus Algorithmic

- Dispersal limitation
- Biotic interactions
- *In situ* adaptation
- *Existing* adaptation
- Direct impacts of CO_2

- Model-based uncertainty
- Thresholding
- Climate scenarios

(Pearson and Dawson 2003, 2004, *Gl.Ec.Biogeog.*)

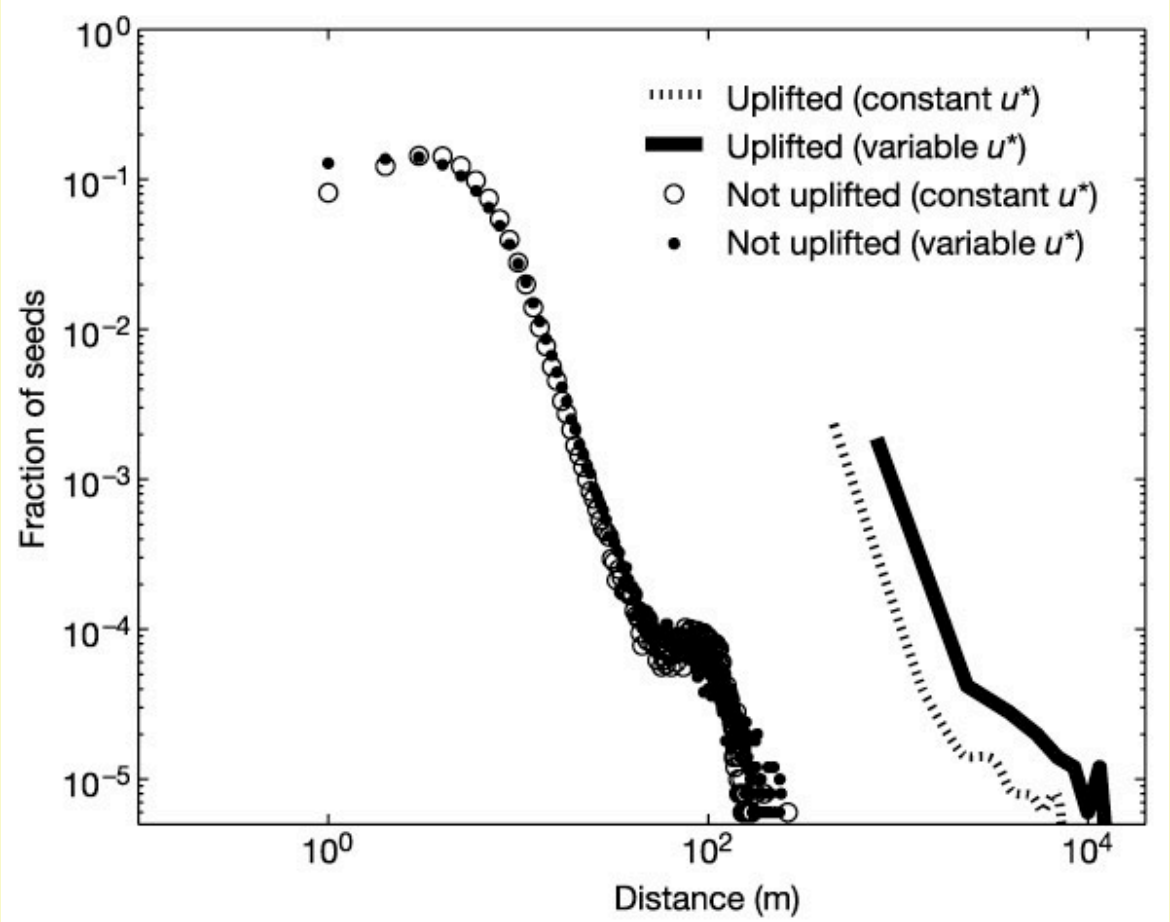
Dispersal ability – will species be able to 'keep up' with changing climate envelopes?



Thomas *et al* (2004, *Nature*):

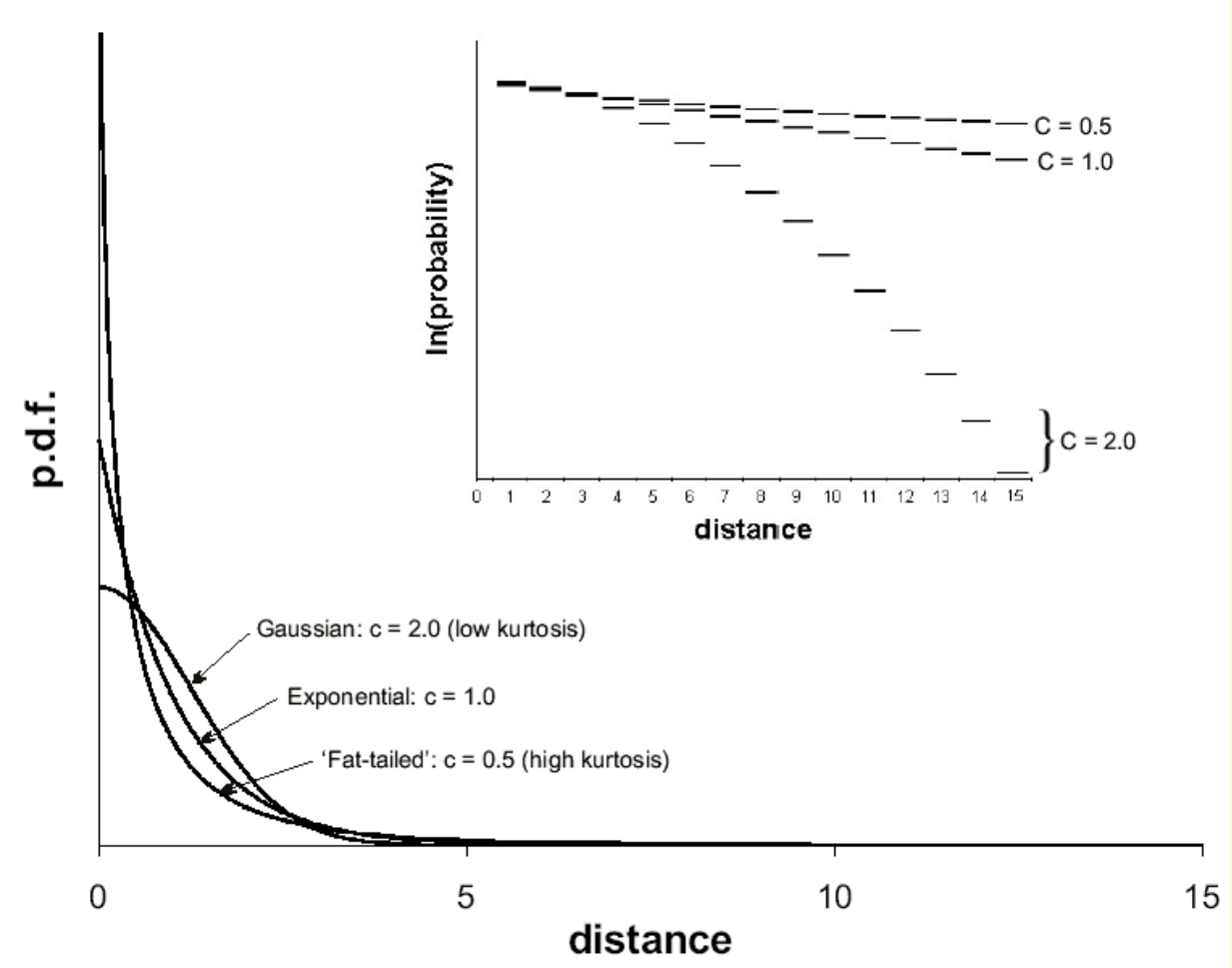
species-level extinction estimated to be 21-32% with universal dispersal, and 38-52% with no dispersal (under maximum projected climate change)

Large-scale dispersal mechanisms: the role of rare stochastic events



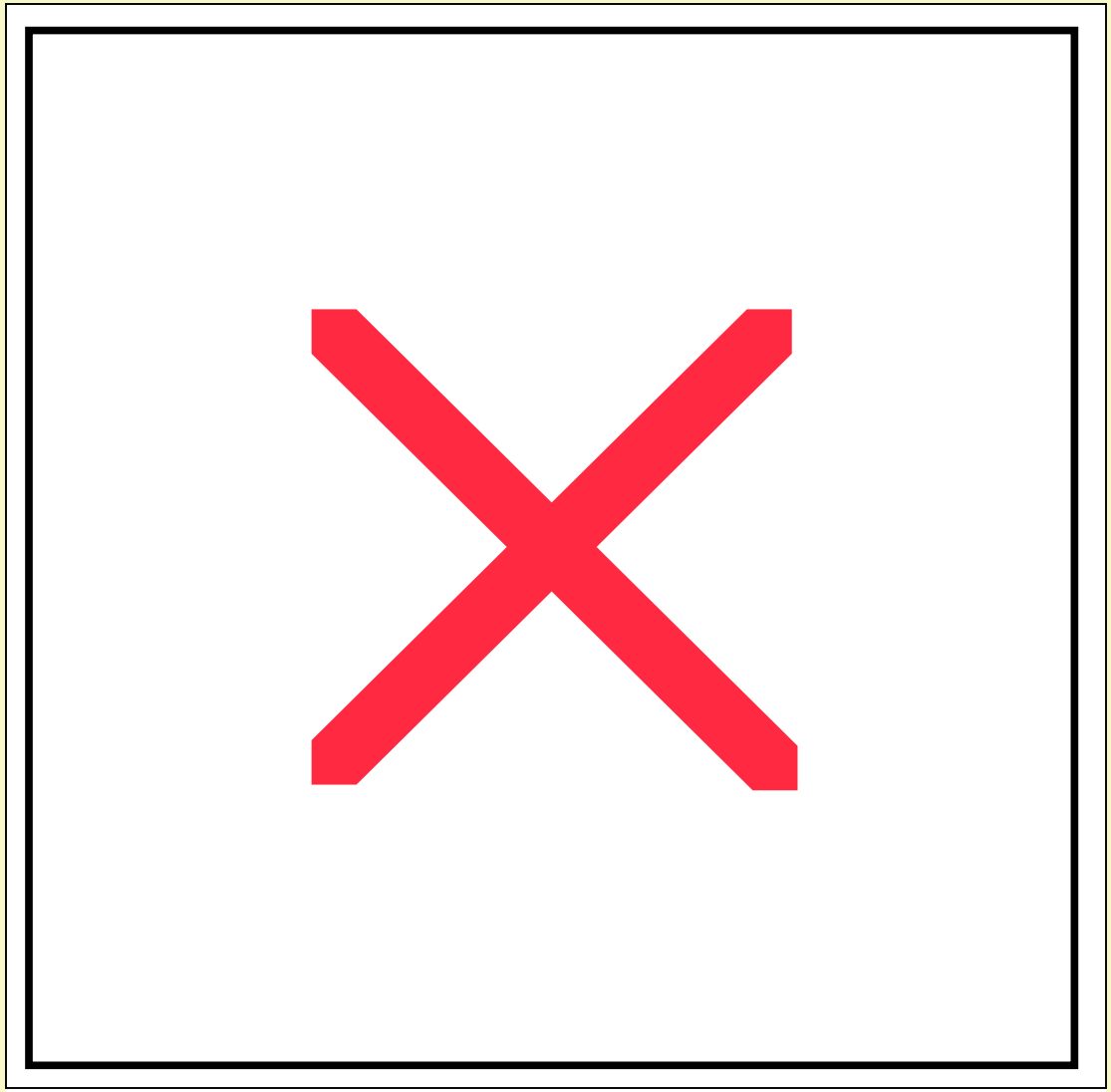
Bimodal dispersal kernel for yellow poplar (Nathan *et al* 2002, *Nature*)

Modeling dispersal through fragmented landscapes

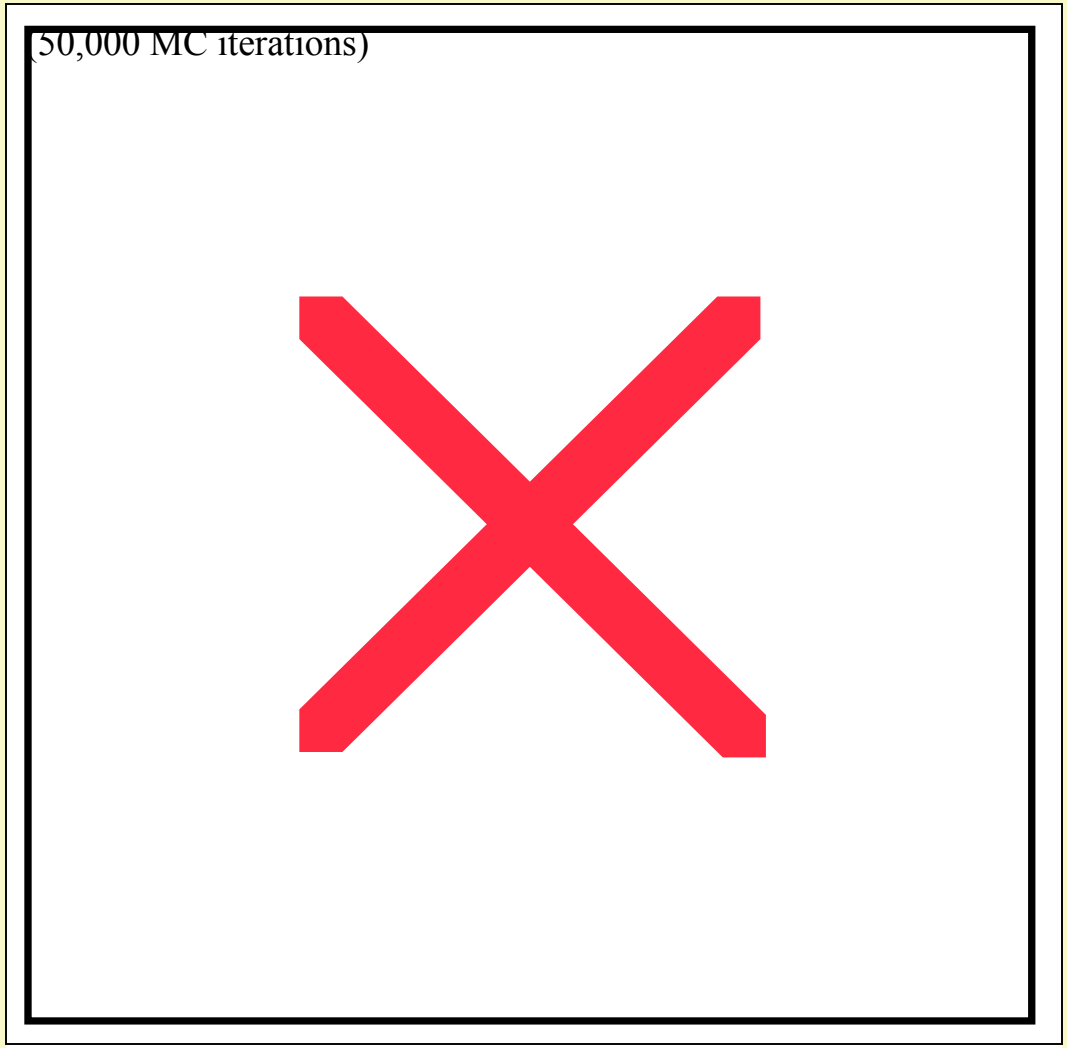


(Pearson and Dawson 2005, *Biol.Cons.*; after Clark *et al* 1998, *Bioscience*)

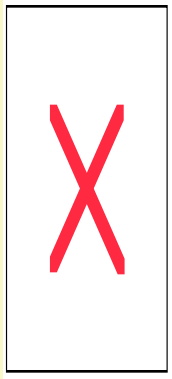
Modeling dispersal through fragmented landscapes



Modeling dispersal through fragmented landscapes

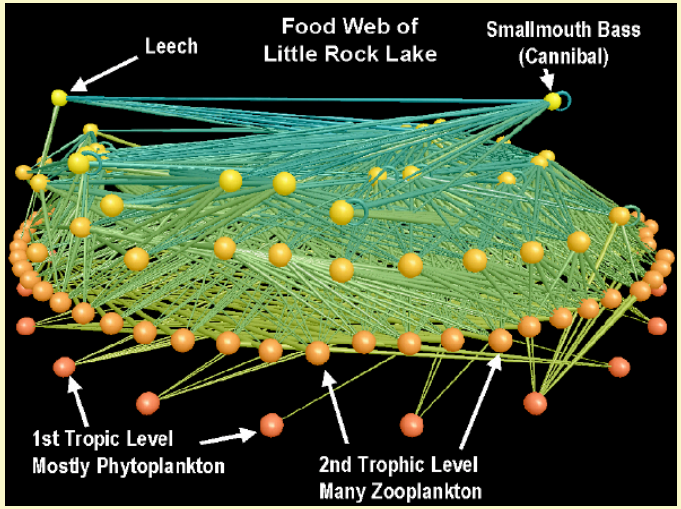


probability

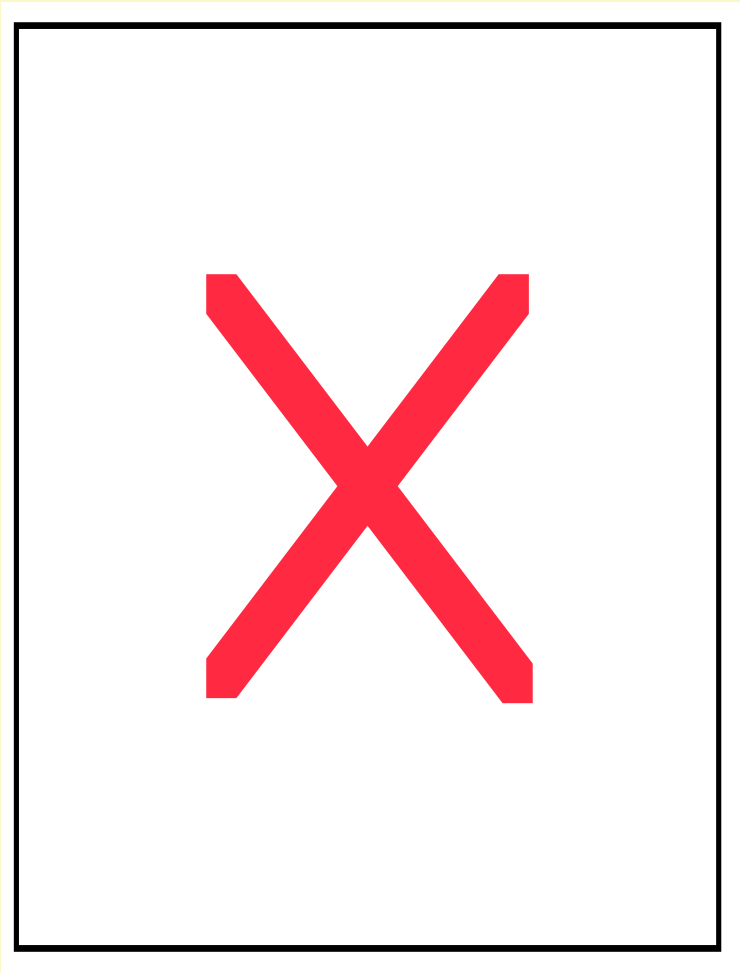


(Pearson and Dawson 2005, *Biol.Cons.*)

Biotic interactions: community-level impacts



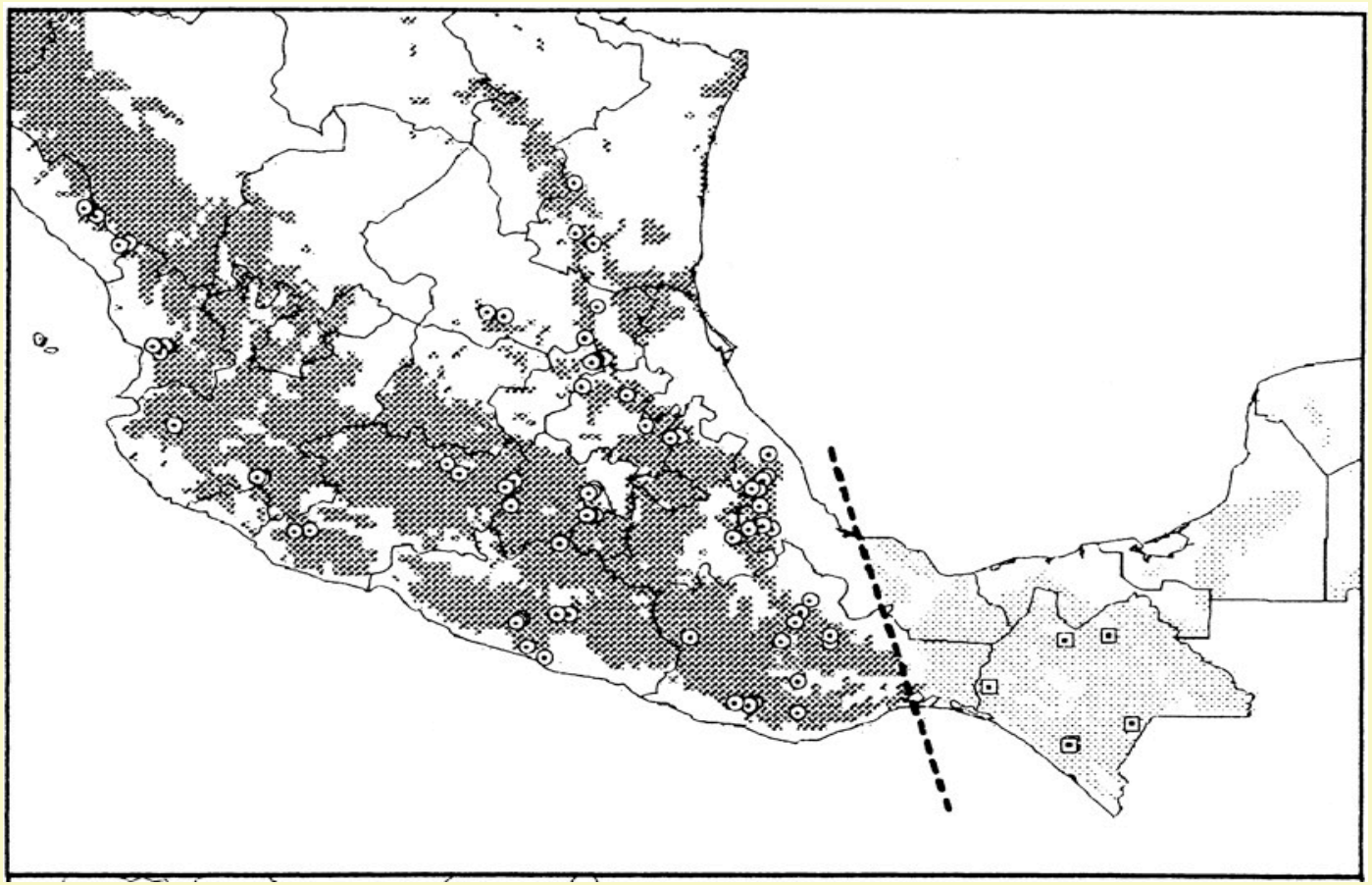
(Neo Martinez)



Comparison of *Drosophila* populations in experimental clines (Davis *et al* 1998, *Nature*)

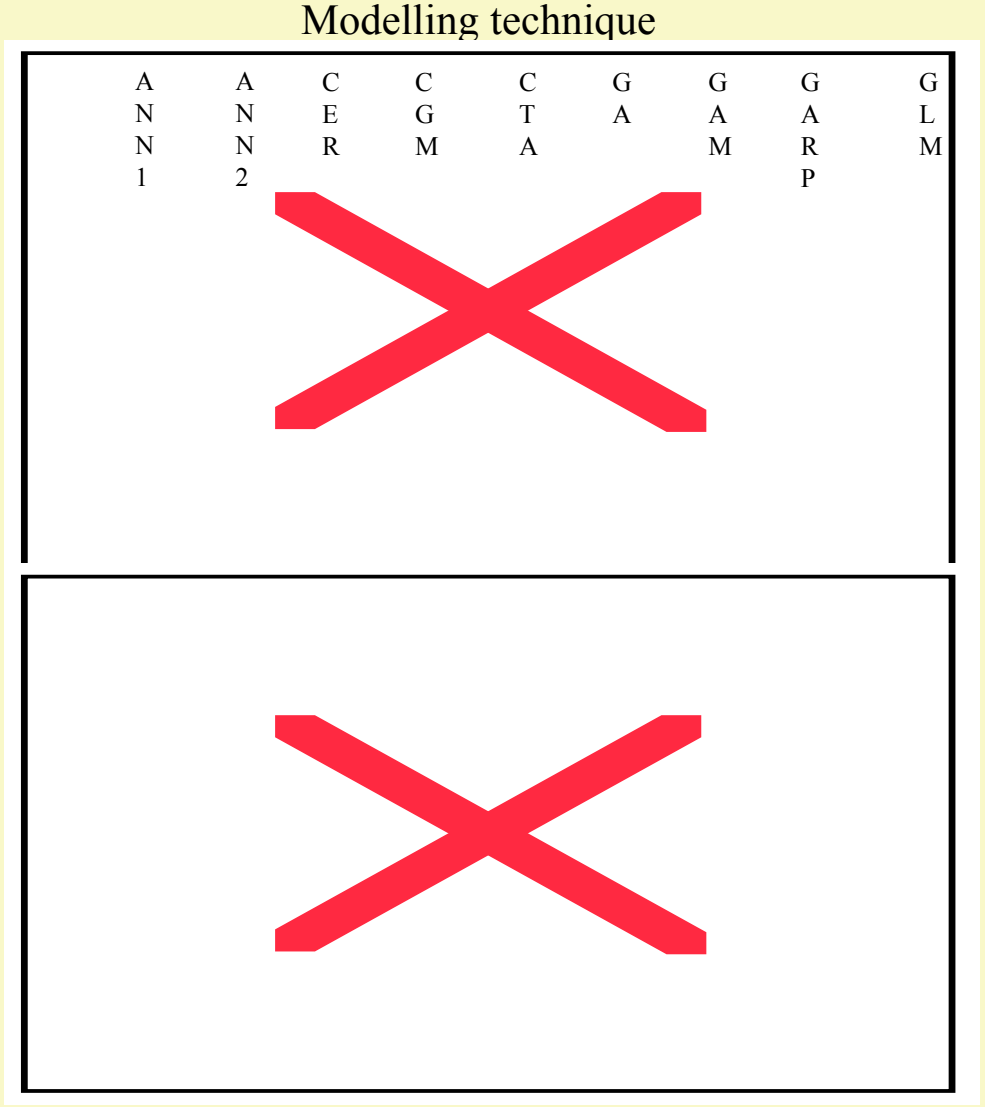
Rapid evolutionary change?

Niche conservatism over evolutionary timescales:



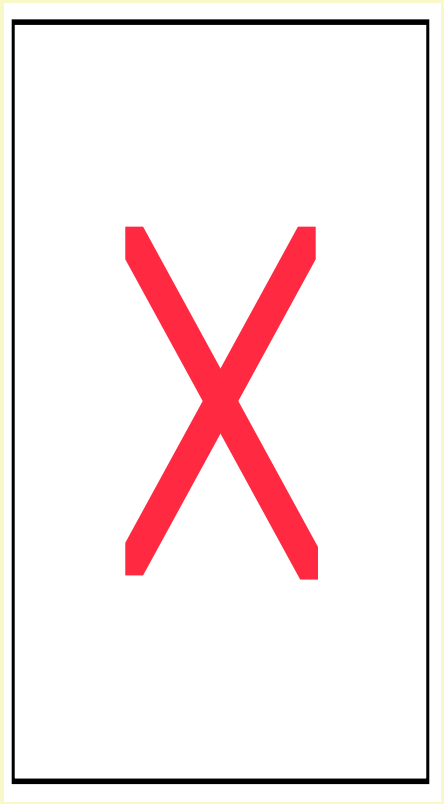
(Peterson *et al* 1999, *Science*)

Model-based uncertainty

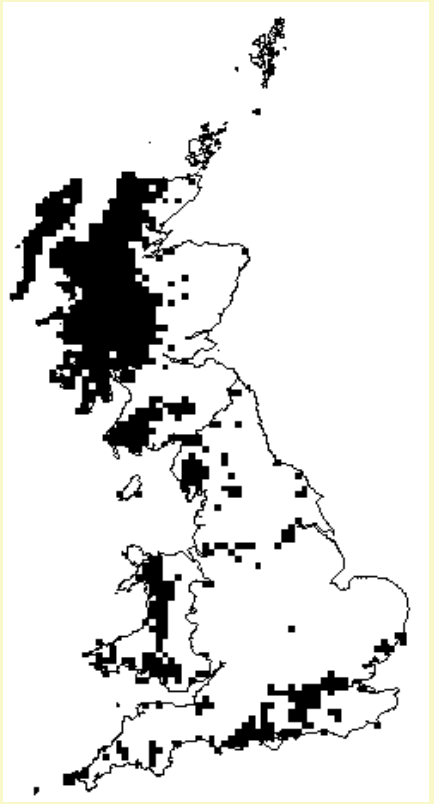


(Pearson *et al* in review)

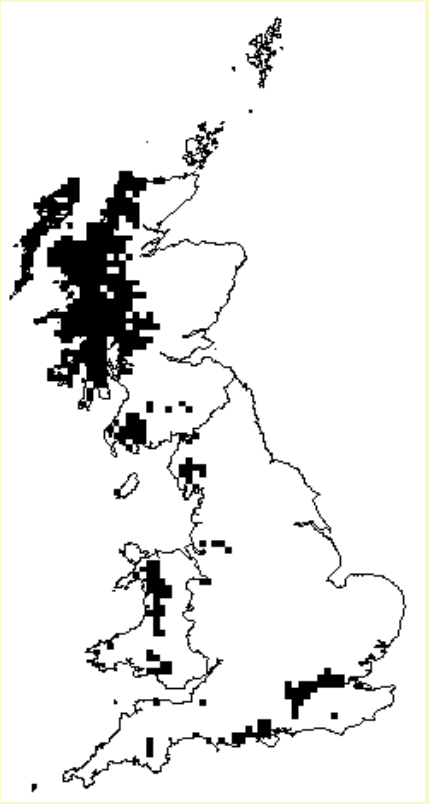
Uncertainty due to the use of alternative decision thresholds



Observed distribution



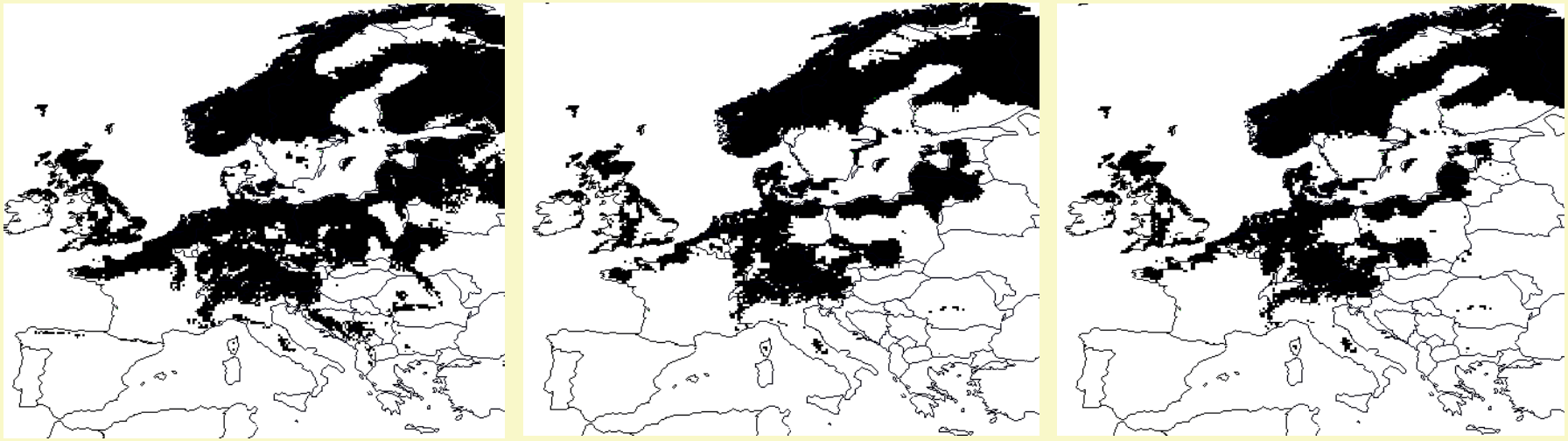
Simulated suitability (sensitivity/specificity defined: 0.11)



Simulated suitability (Kappa defined: 0.30)

Observed and simulated distributions of *Rhynchospora alba* at different thresholds

Uncertainty due to alternative climate projections



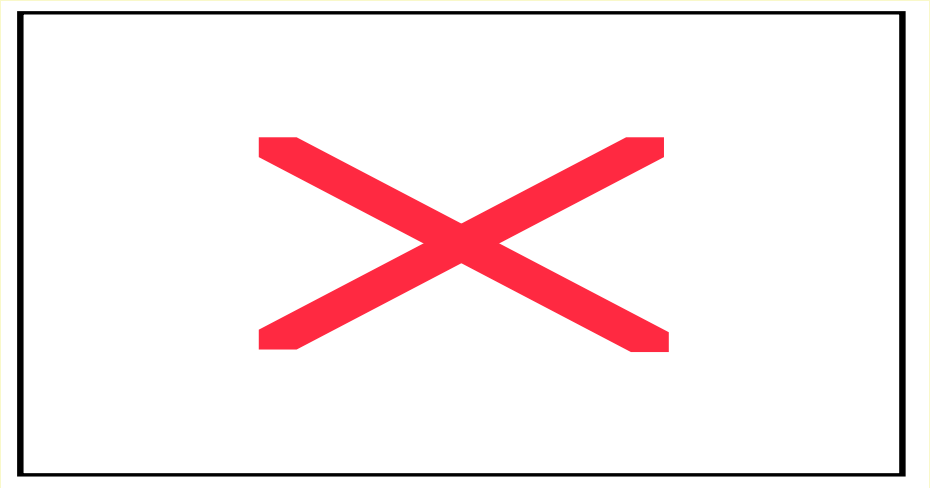
PCM A2

HADCM3 A2

HADCM3 B1

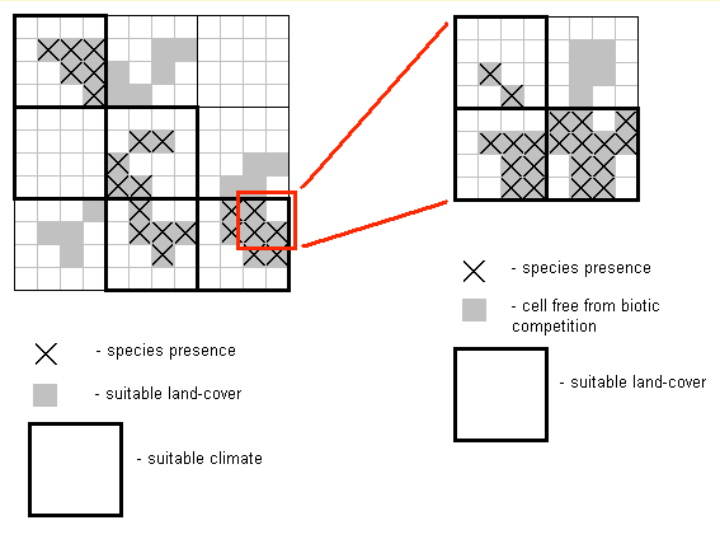
Simulated distributions for *Sphagnum cuspidatum* using two alternative GCMs and two alternative emissions scenarios or the 2050s

So… are bioclimate envelope models useful?



Areas of over-prediction can predict unknown distributional areas and new species

(Raxworthy *et al* 2003, *Nature*)



A scale-dependent hierarchical modeling framework?

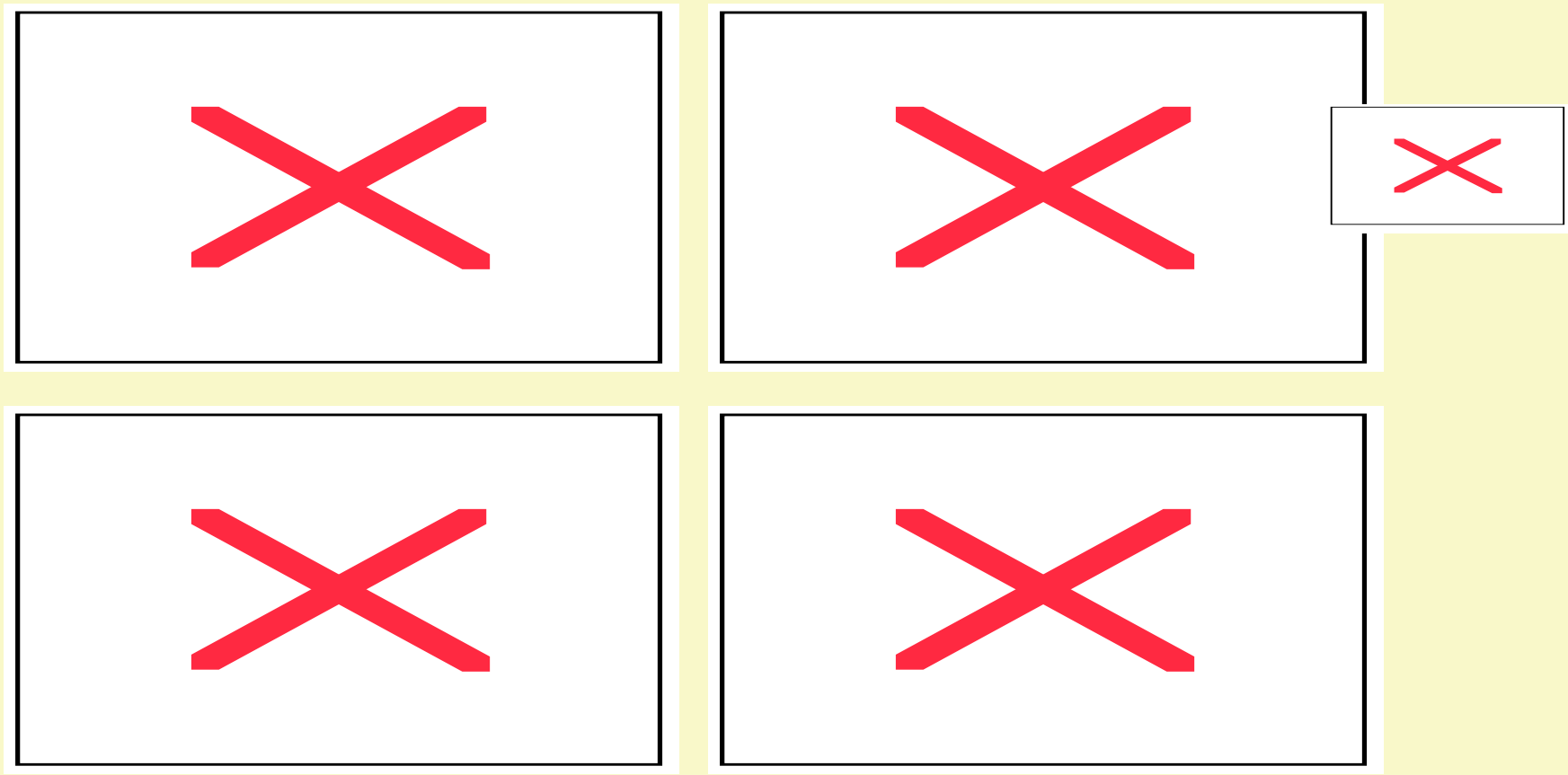
(Pearson and Dawson, 2003, *Gl.Ec.Biogeog.*)

So… are bioclimate envelope models useful?

What is ‘useful’ for conservation planners?

- accurately predicting future distributions; or
- identifying potentially suitable areas under future climates

Long-distance seed dispersal, climate change and the design of natural reserves



(Pearson and Dawson 2005, *Biol.Cons.*)