Modelling climate change impacts on biodiversity

Dr Stephen Willis, *Durham University, UK*

Durham University

CCPAWA Inception meeting, 31th March 2011

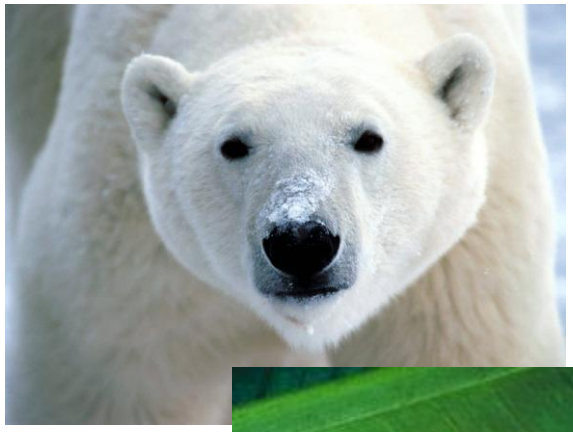
MacArthur
The John D. and Catherine T. MacArthur Foundation

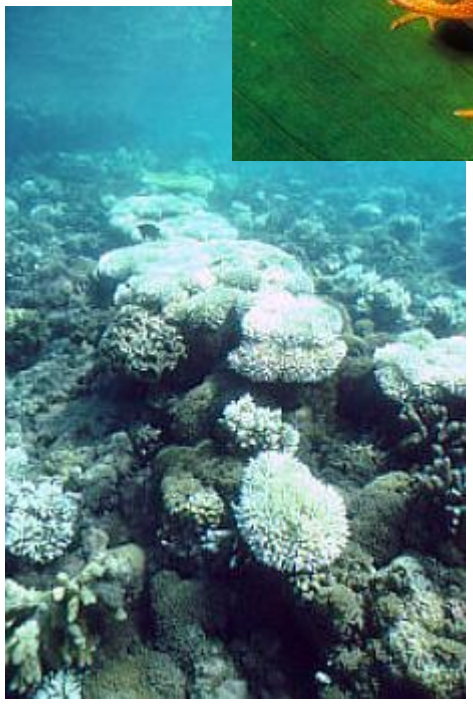
NATURAL ENVIRONMENT RESEARCH COUNCIL

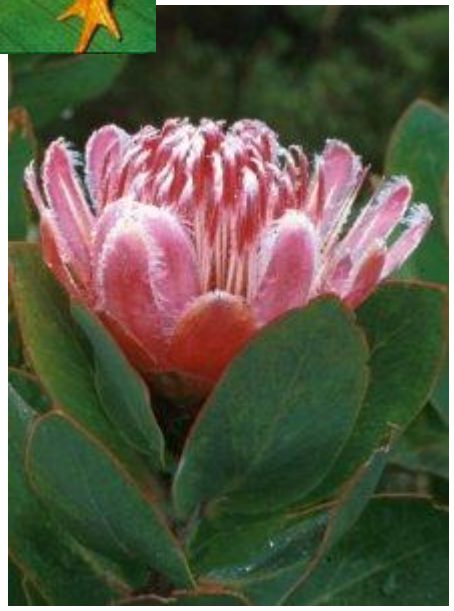
BirdLife INTERNATIONAL

RSPB

➢ Huge implications for biodiversity







- Changes in phenology
- Changes in species distributions
- Formation of new communities
- Disruption of ecological processes
- Possible mass extinctions

Outline of Presentation

- **Simulating climate change impacts on biodiversity**

  Simple species-climate relationships

- **Results of recent work: Scenarios at an African scale**

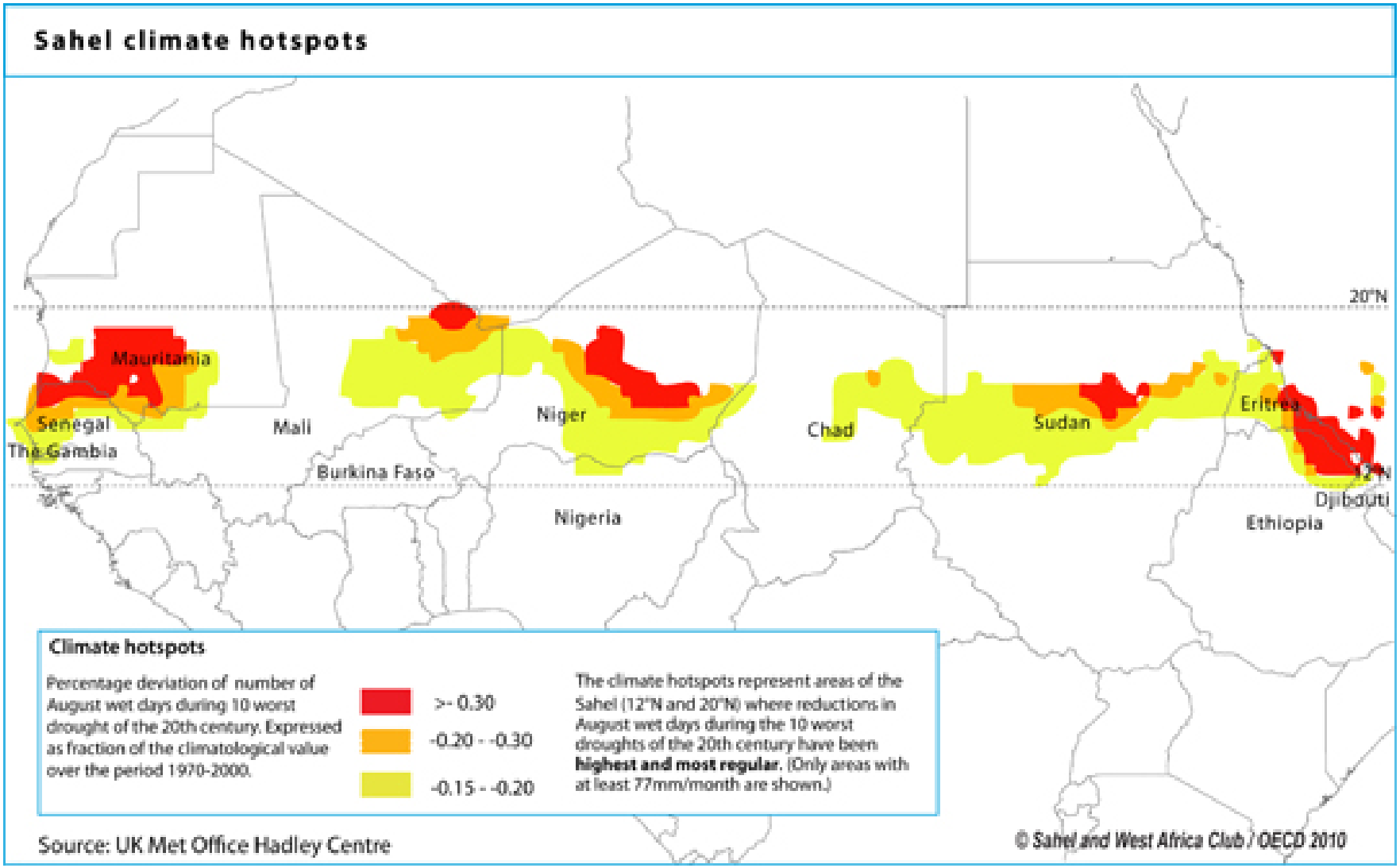
- **Downscaling to regional and national scales**

  African and UK examples

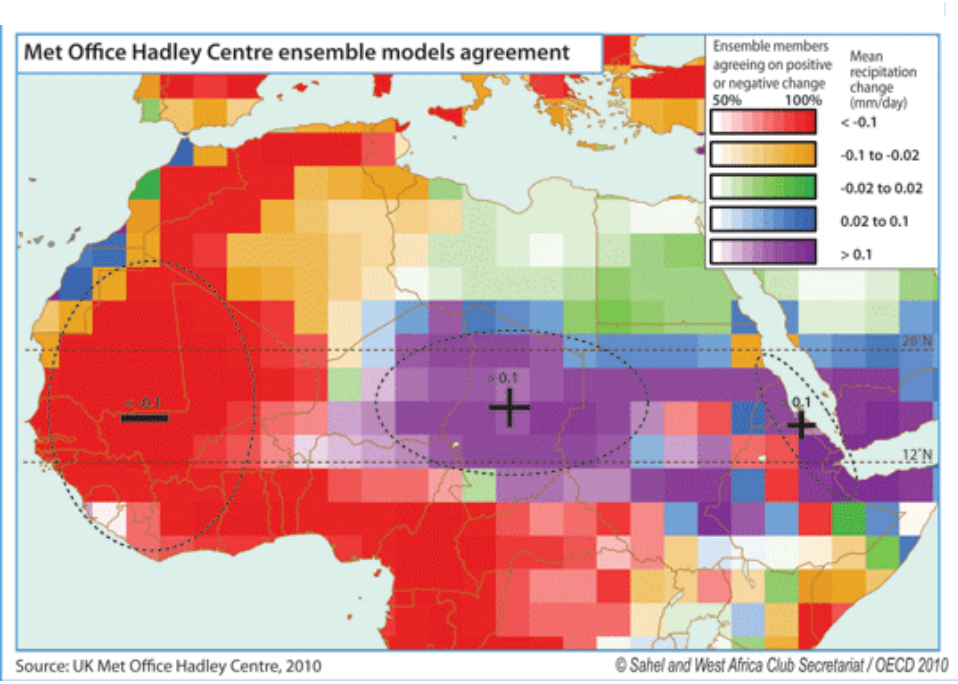
- **How to make simulations as realistic as possible**

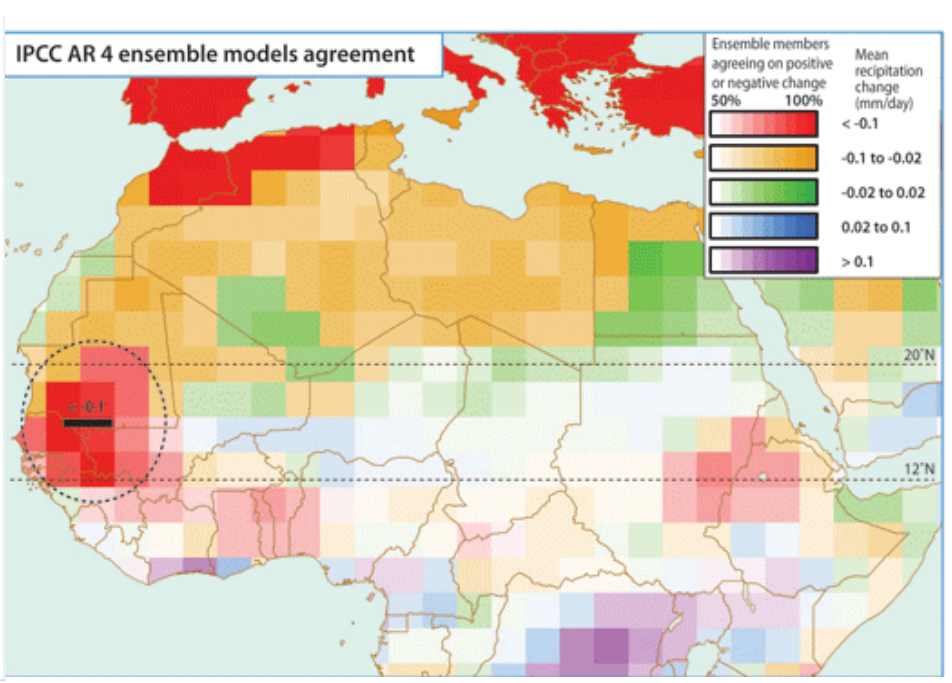
  including species biological information
  including habitat information
  including dispersal capabilities
  using regional climate projections

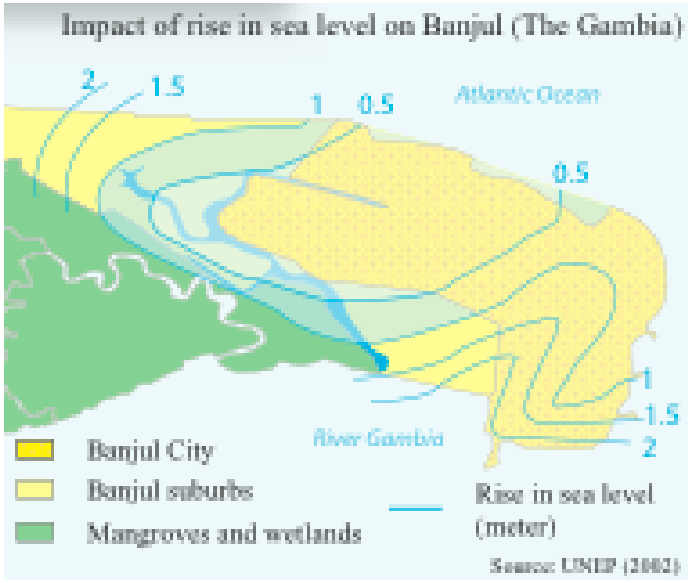
Recent drought-prone regions



Future rainfall projections

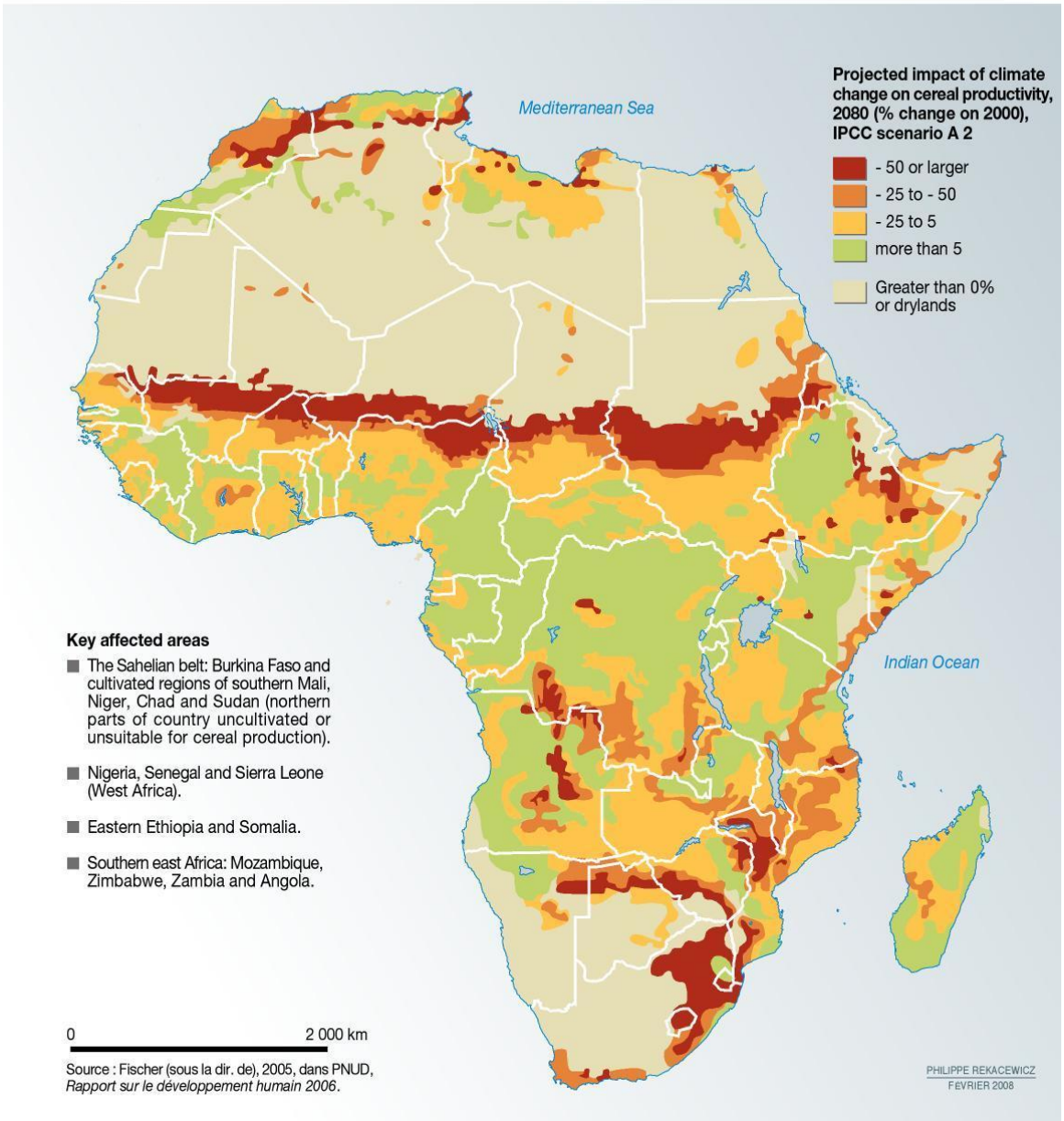






Climate change threats/opportunities: change in land-use

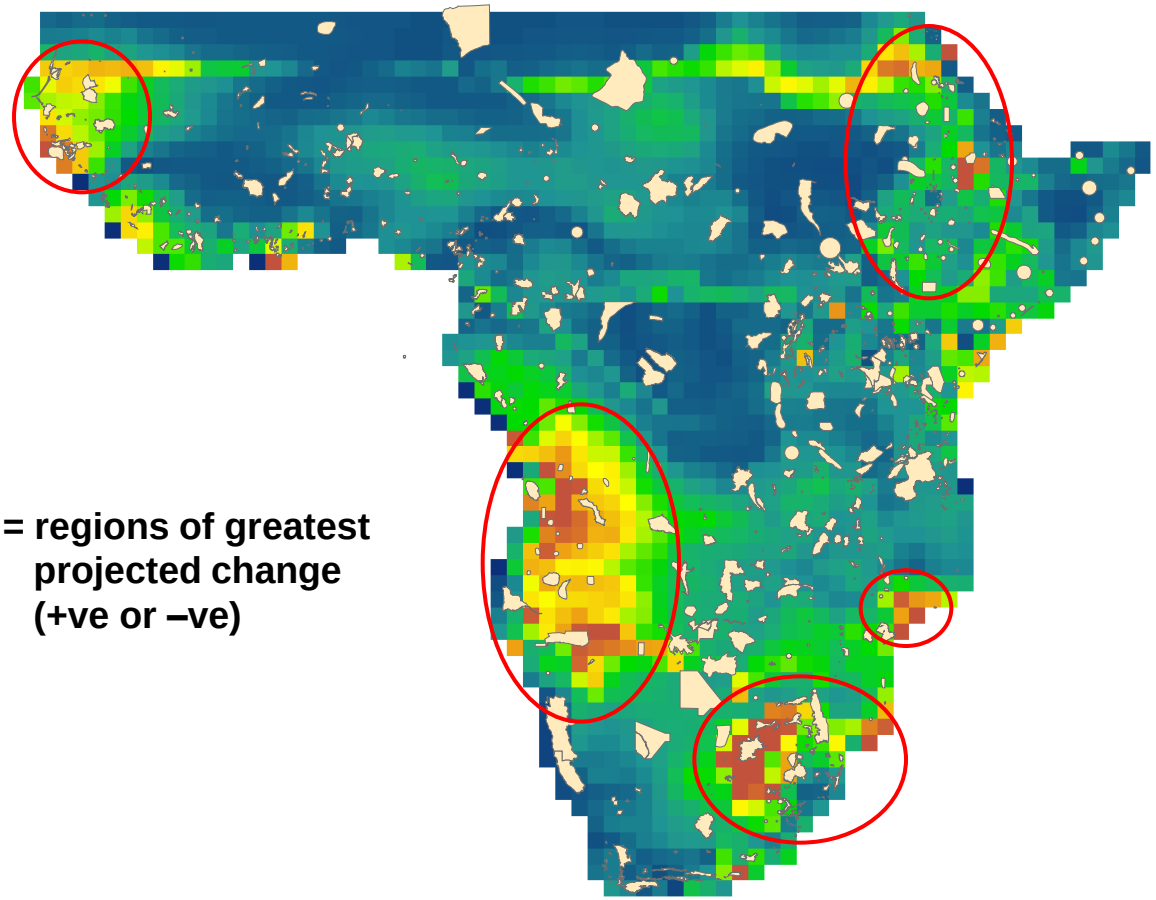
Cereal productivity in Sub-Saharan Africa under a scenario of the IPCC that shows CO_2 atmospheric concentrations a level at 520-640 ppm by 2050



➢ Predicted Changes in Future Climate

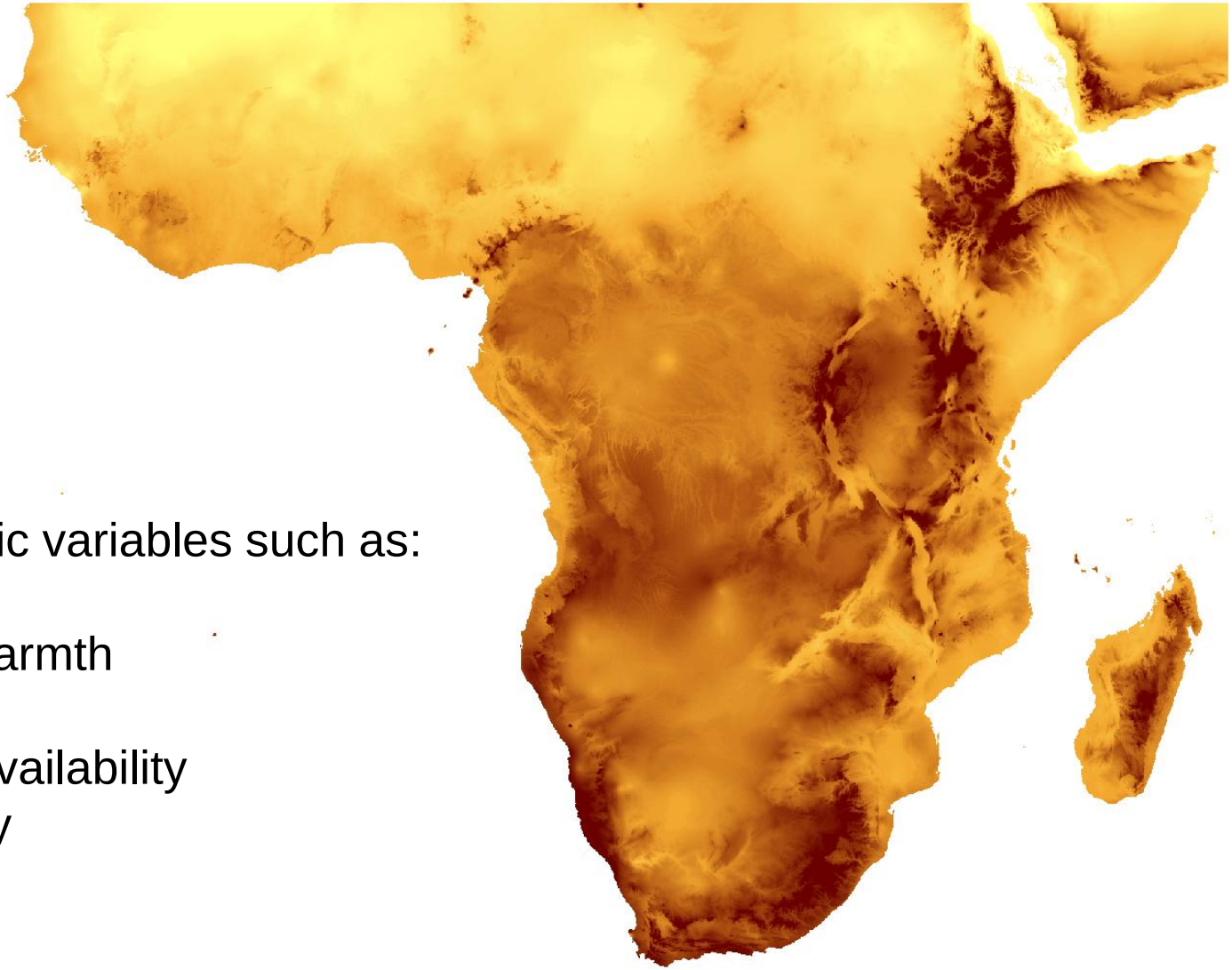
Regions projected to experience the greatest change in climate parameters

Standardized Euclidean Distance map for 7 bioclimatic variables between the present and 2080 under HadCM3



= regions of greatest projected change (+ve or –ve)

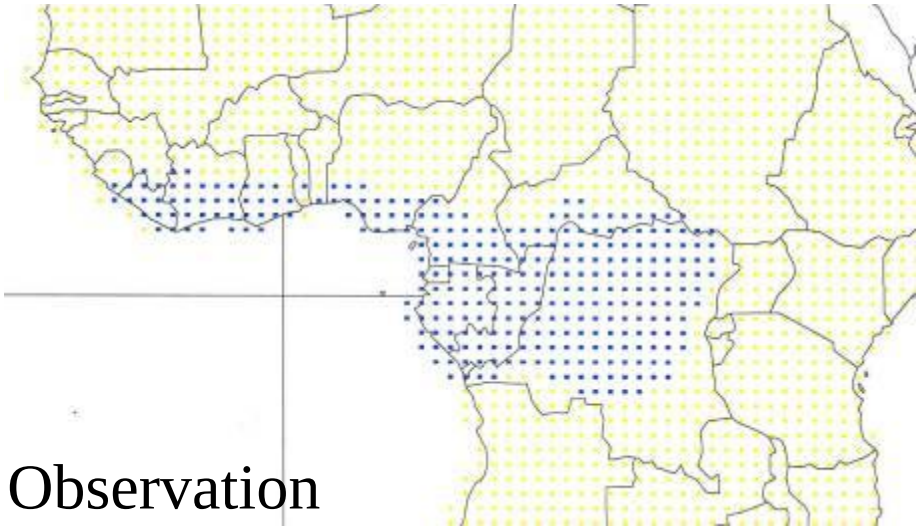
Relating species to climate



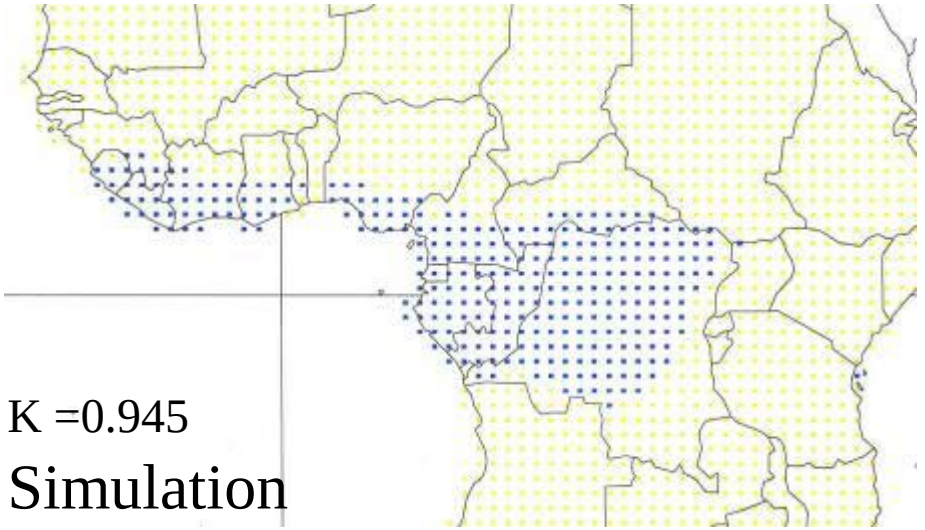
Use climatic variables such as:

summer warmth
winter cold
moisture availability
seasonality

African bird simulations



Observation



K =0.945

Simulation

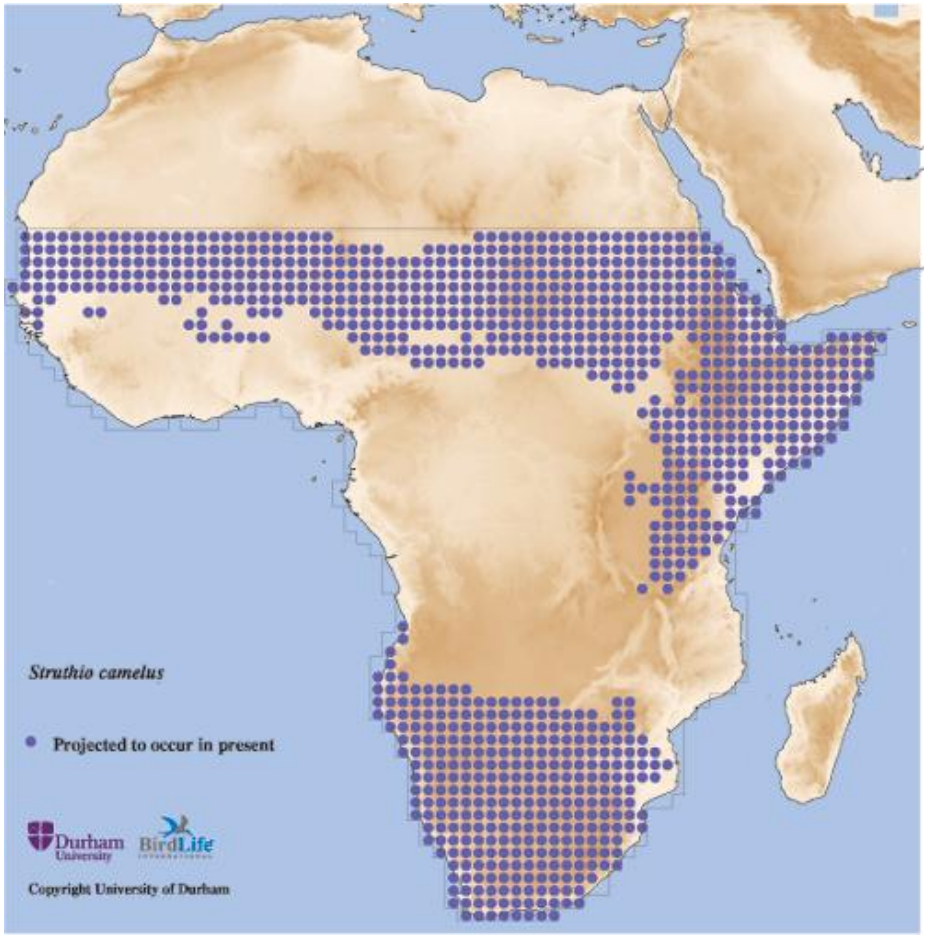
Long-tailed Hawk

Urotriorchis macrourus

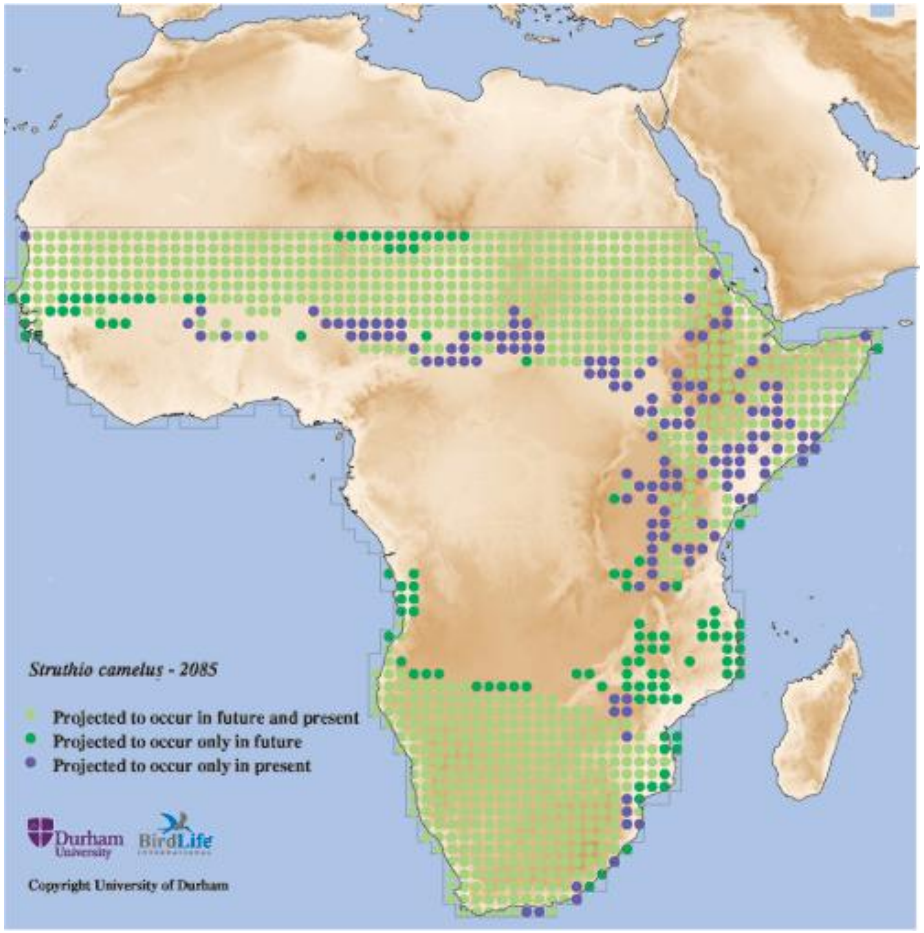
Huntley *et al.* (2006) *Ibis*

➢ Species-climate model - Ostrich

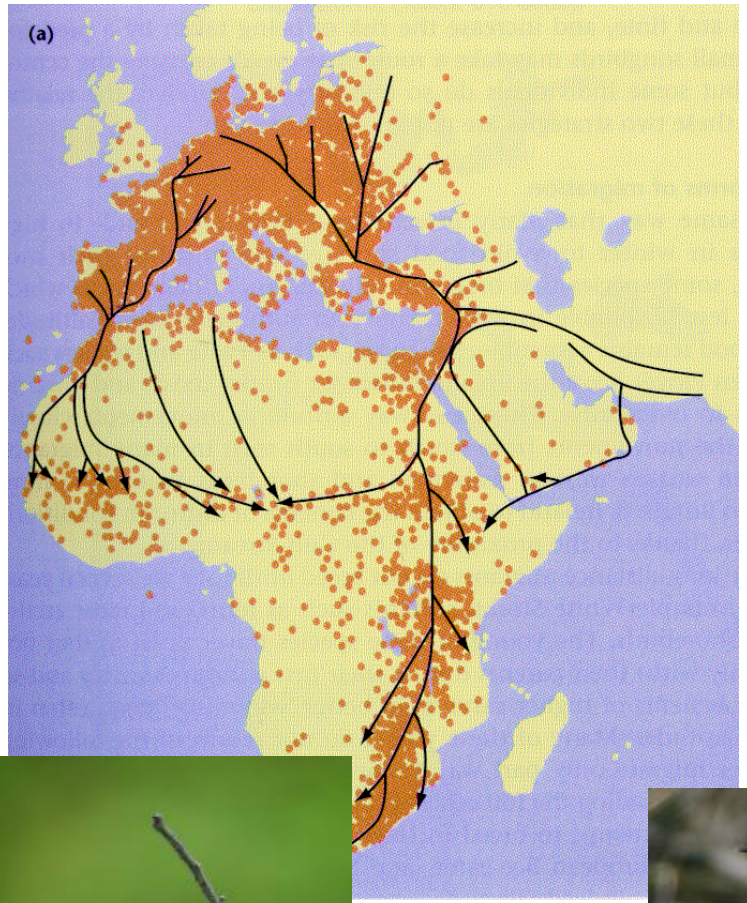
Current distribution

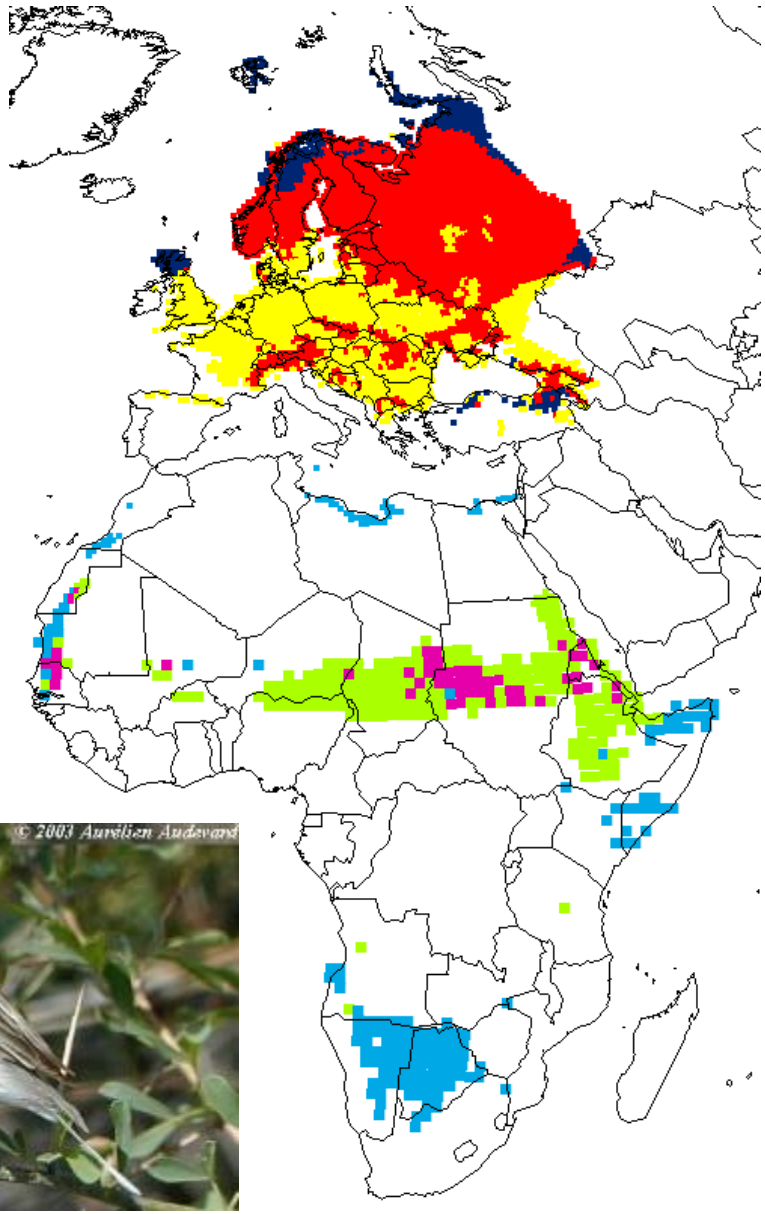


➢ Simulated future change - Ostrich



West Africa is also important for migratory species

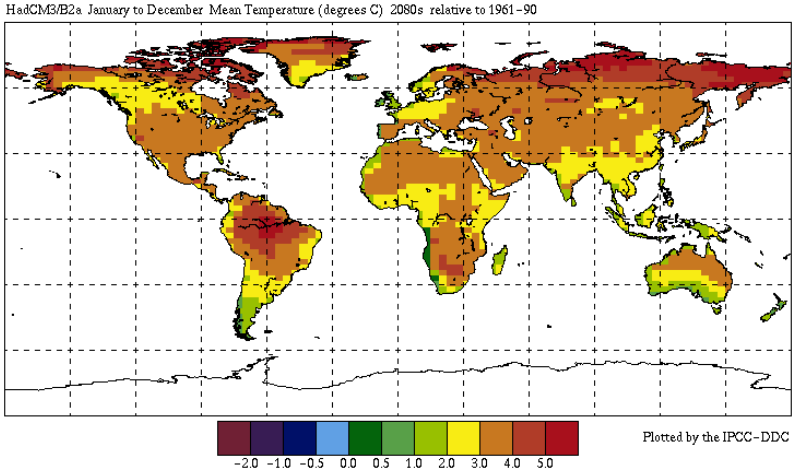




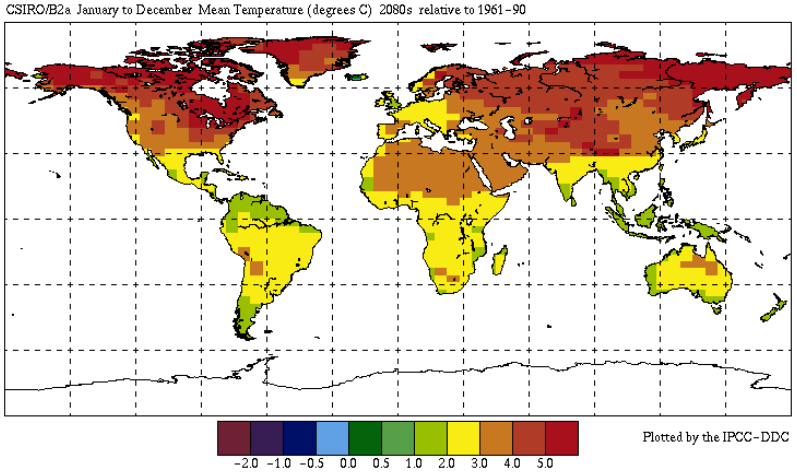
➢ Problems: different climate predictions

- **Projected change in temperature (2080) from 4 GCMs**

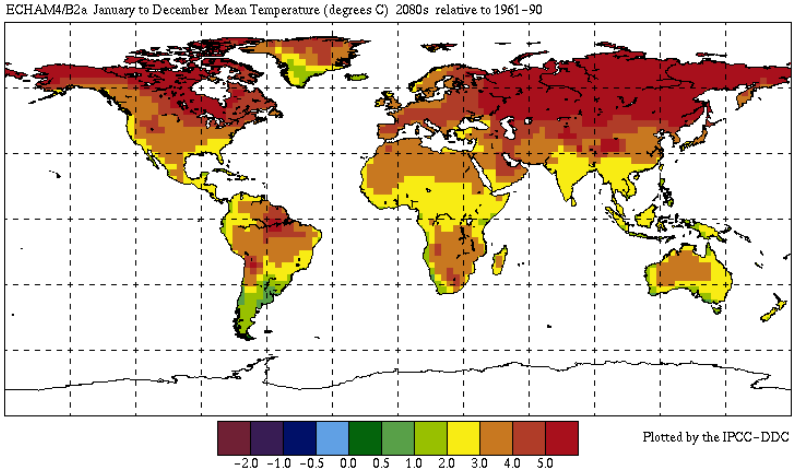
1) HadCM3/B2a



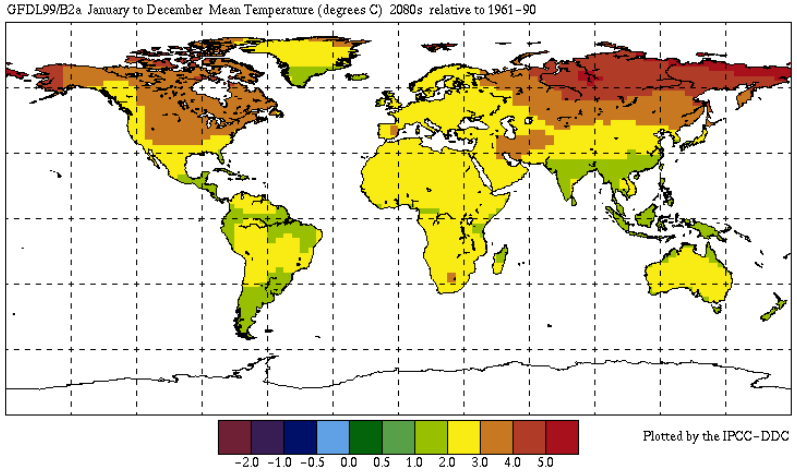
2) CSIRO/B2a



3) ECHAM4/B2a



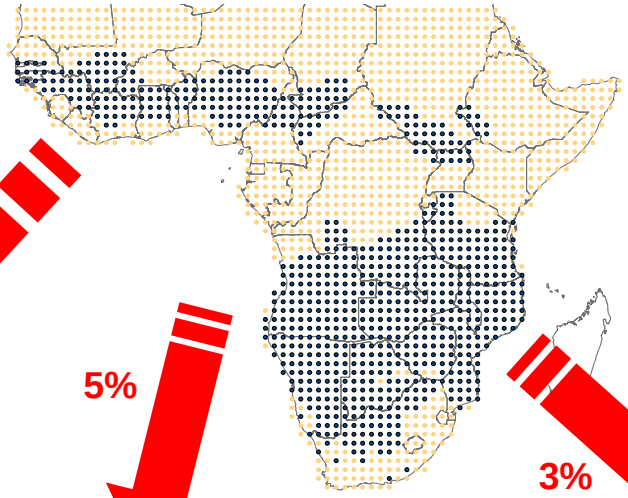
4) GFDL99/B2a



➢ Results in: different predictions for species

- **A widespread species; e.g.Swallow-tailed Bee-eater *Merops hirundineus***

Observed distribution

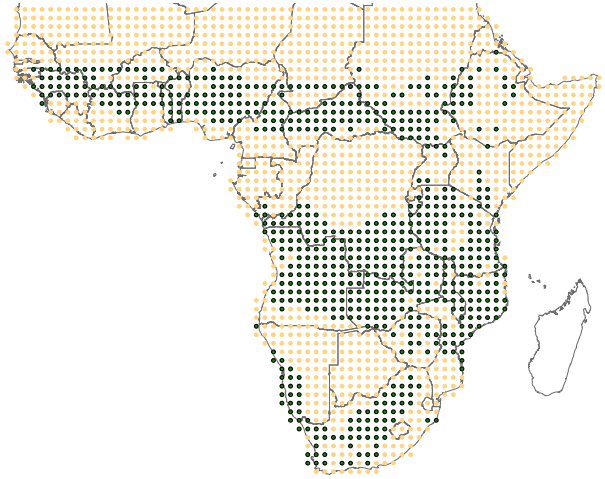


Range contraction = 15%

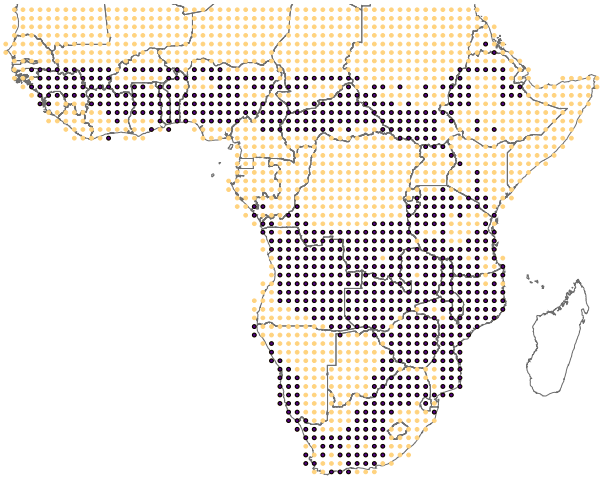
5%

3%

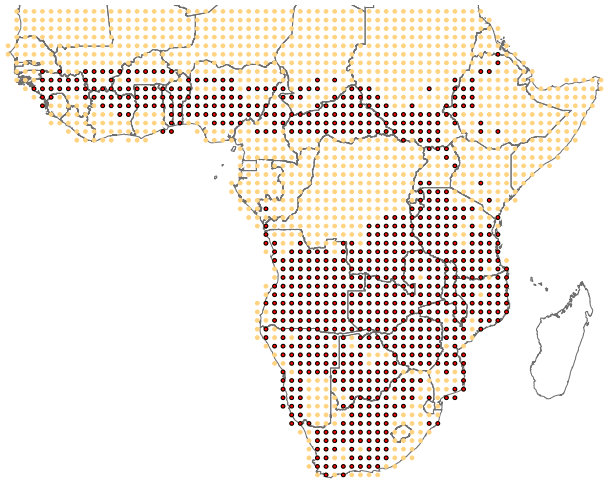
2080 HadCM3



2080 ECHAM4



2080 GFDL-R30



➢ Projected turnover across Africa

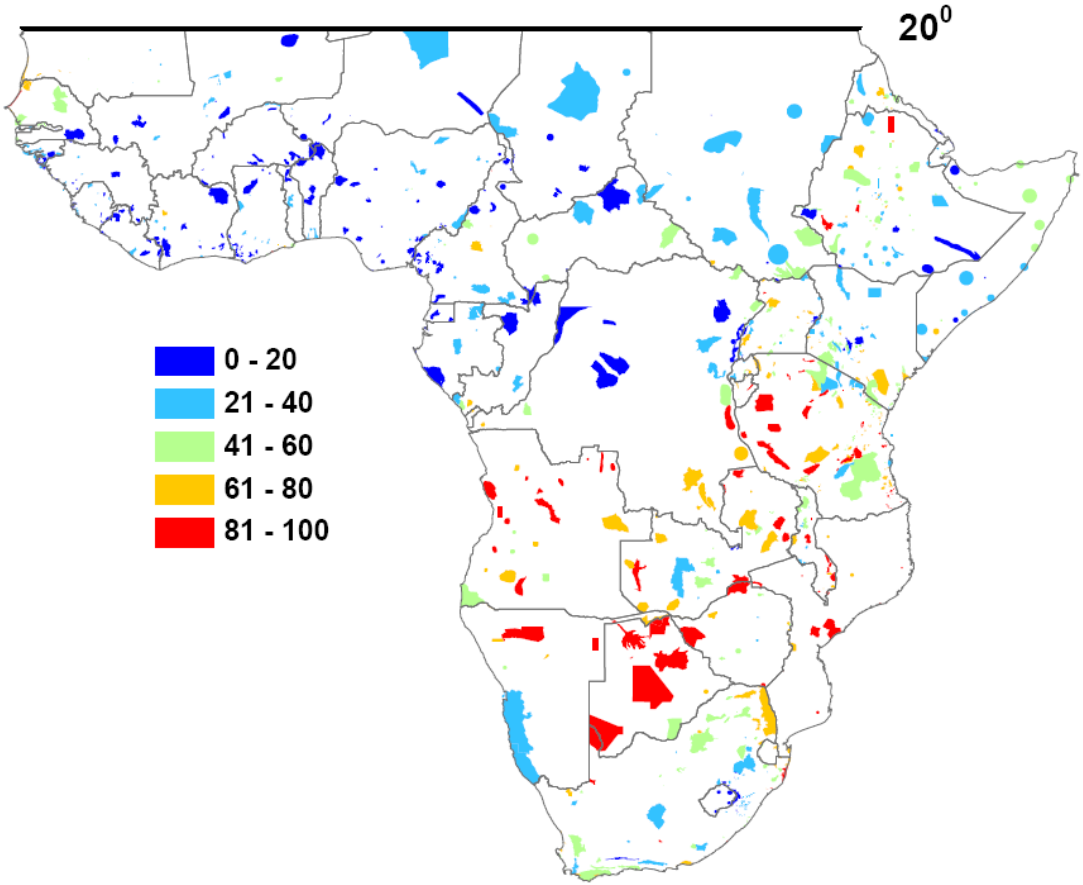
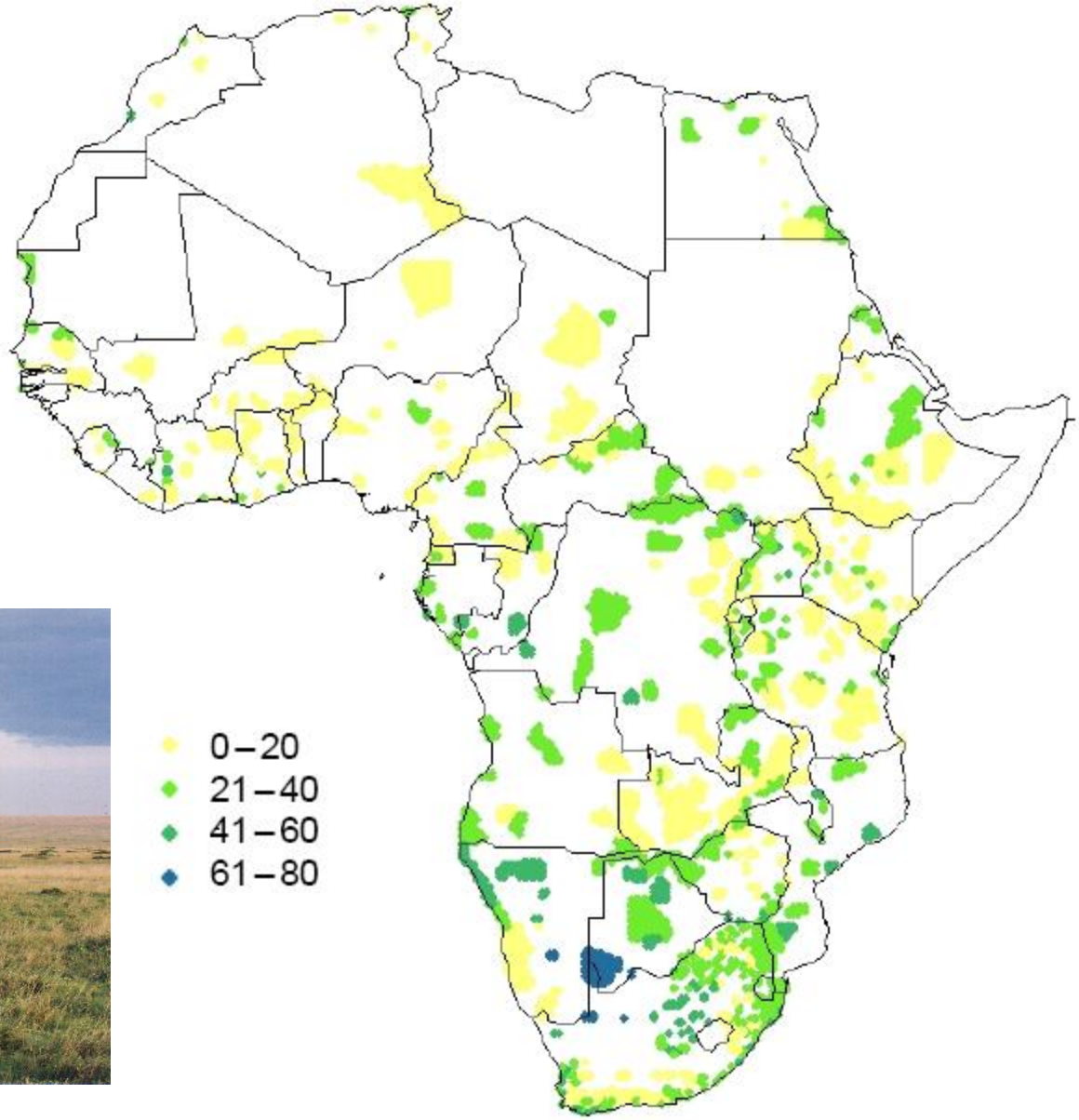


Figure 4: Simulated turnover of species (a measure combining colonisation and extinction) across African protected areas between now and the end of the current century.

Hole *et al.* (2009) *Ecology Letters*

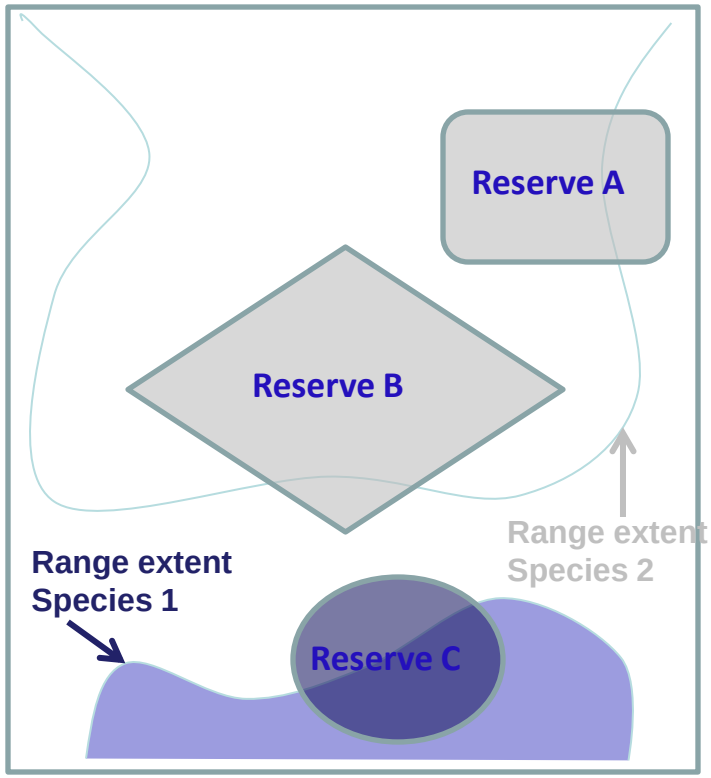
➢ Projected mammal turnover in National Parks by 2085



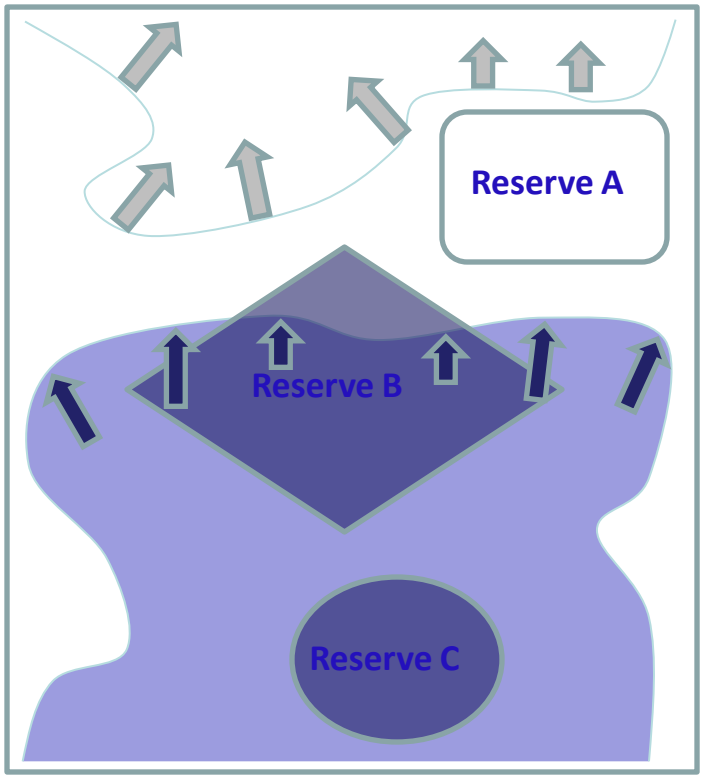
Climate change and protected areas

➢ Potential impacts of climate change on two species in a theoretical protected area network

❑ Present-day distributions of 2 theoretical species

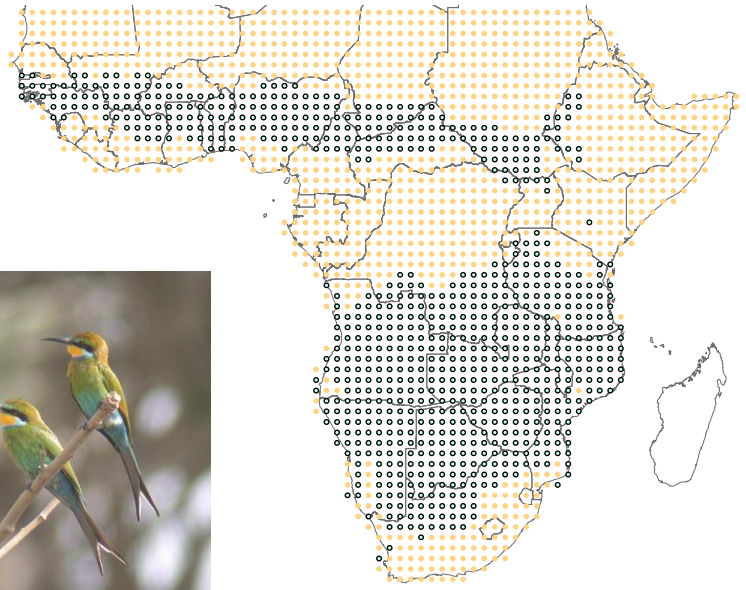


❑ New range-limits following climate warming/reduced precipitation/etc.

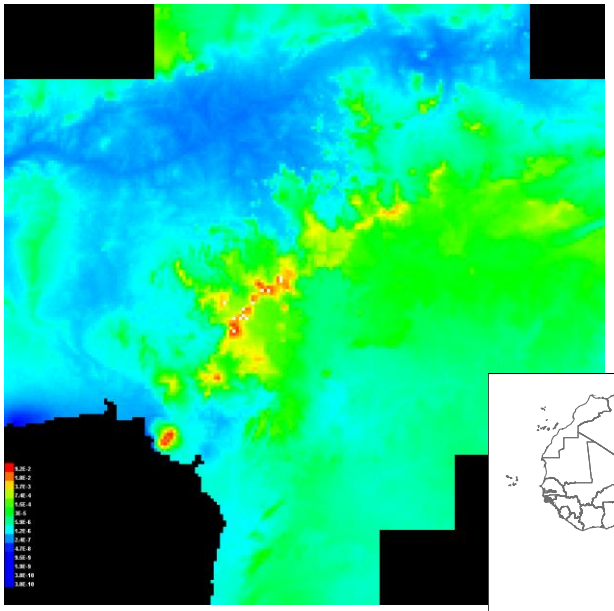


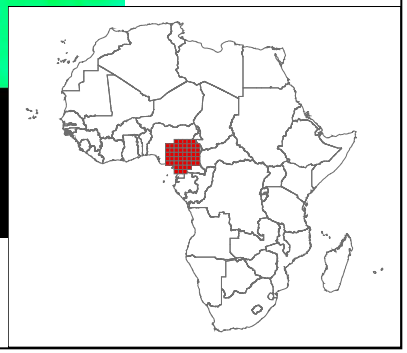
Down-scaling predictions

- **One-degree CRS modelled distribution for Swallow-tailed Bee-eater *Merops hirundineus***

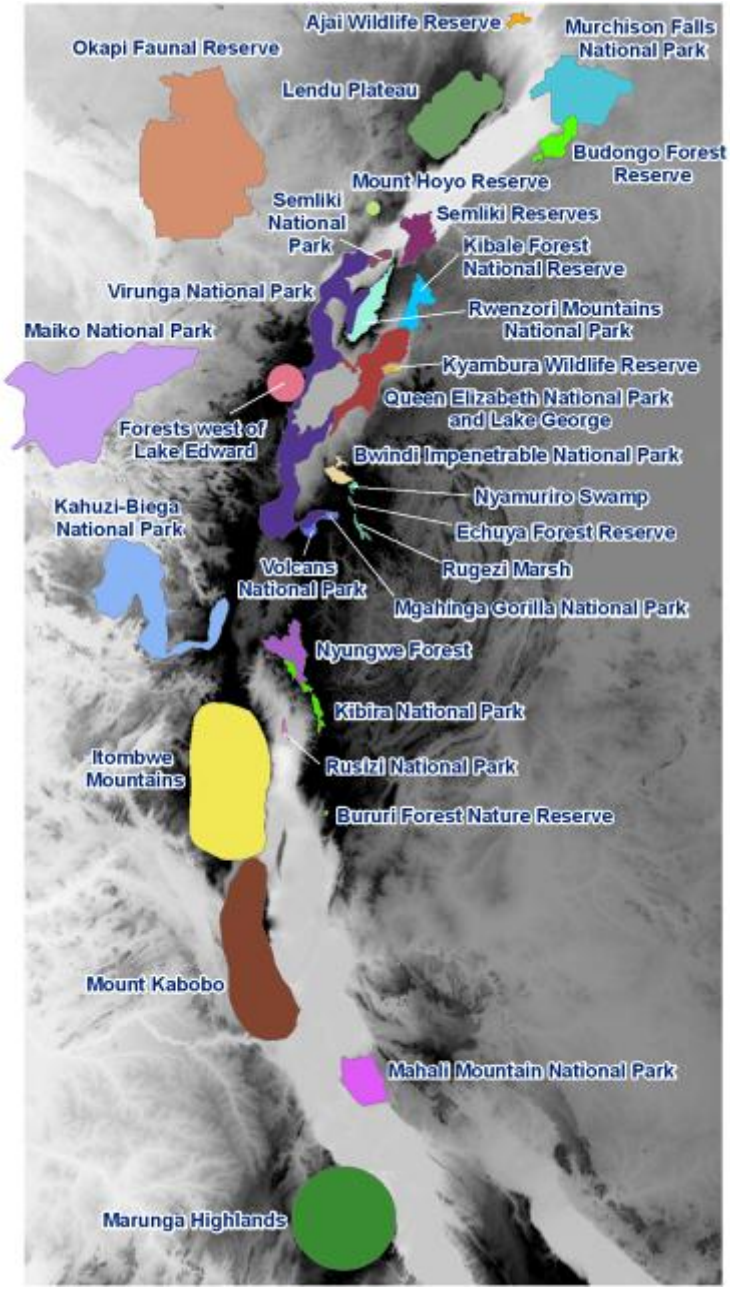


- **2.5’ Maxent modelled distribution for Bannerman’s Turaco *Tauraco bannermani***





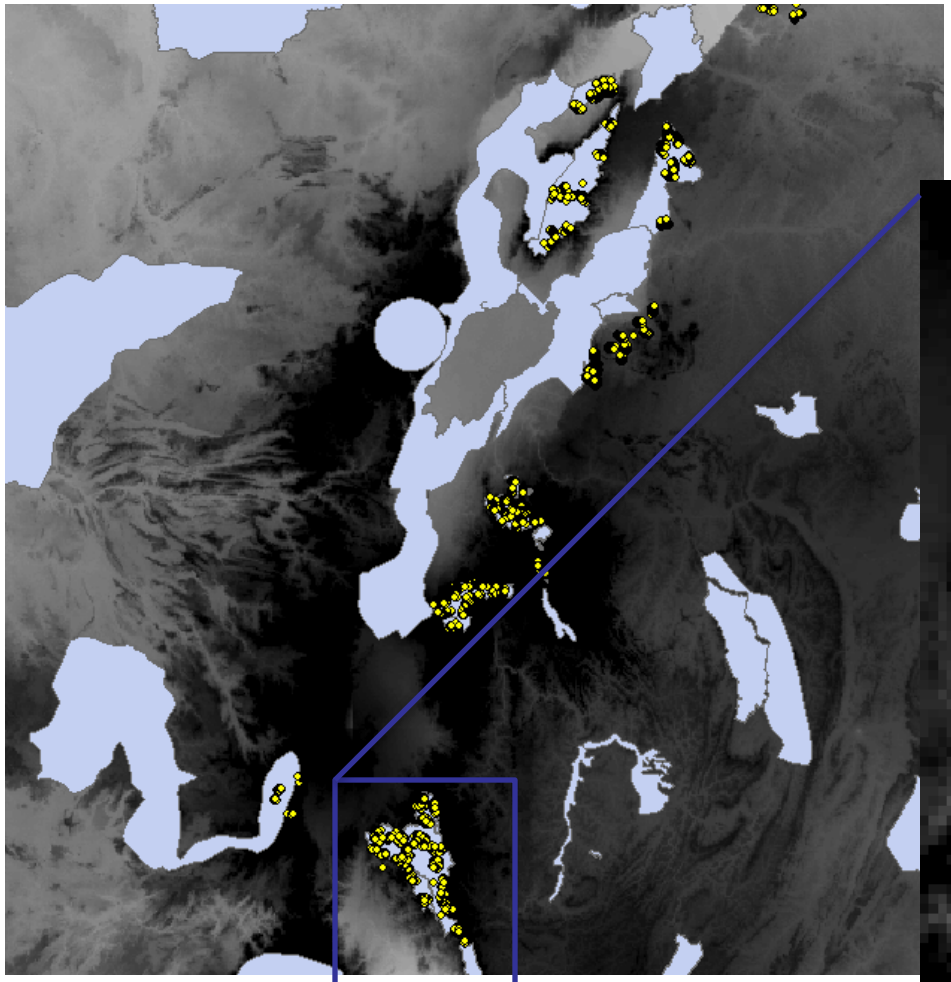
Modelling at a fine resolution: IBAs of the Albertine Rift



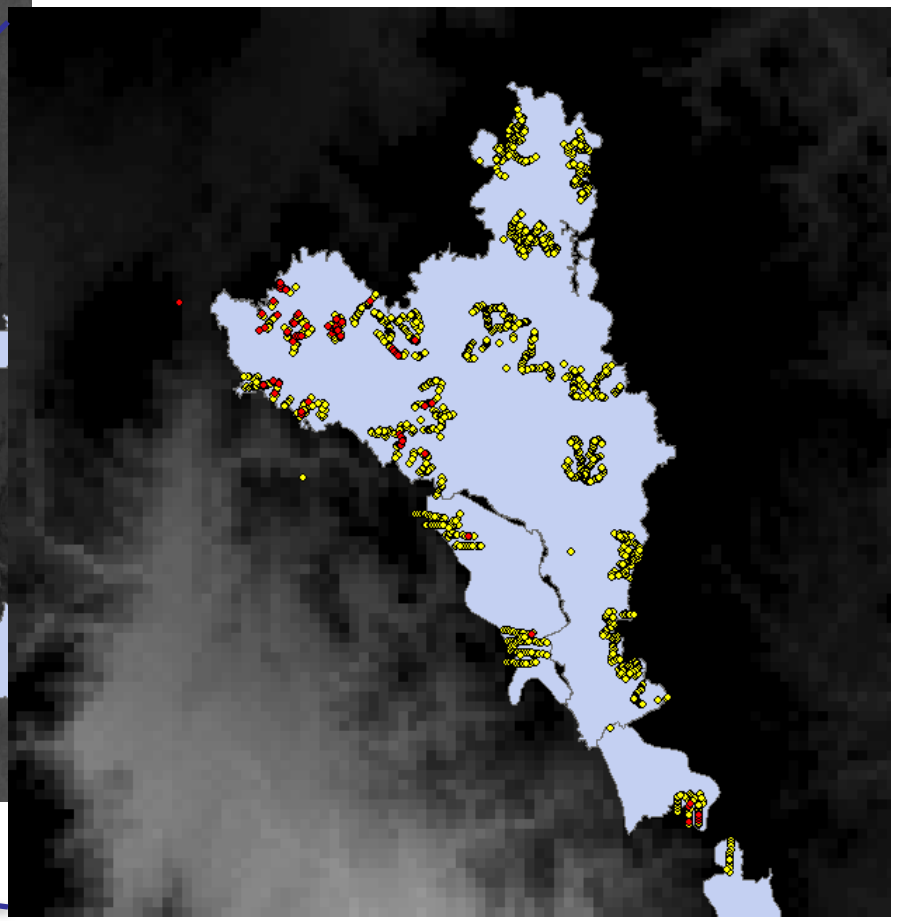
- 33 species are recognized as Albertine Rift EBA species
- Together, these species flag-up 22 IBAs (a further 9 IBAs are also located within the region)

Fine-scale modeling in the Albertine Rift

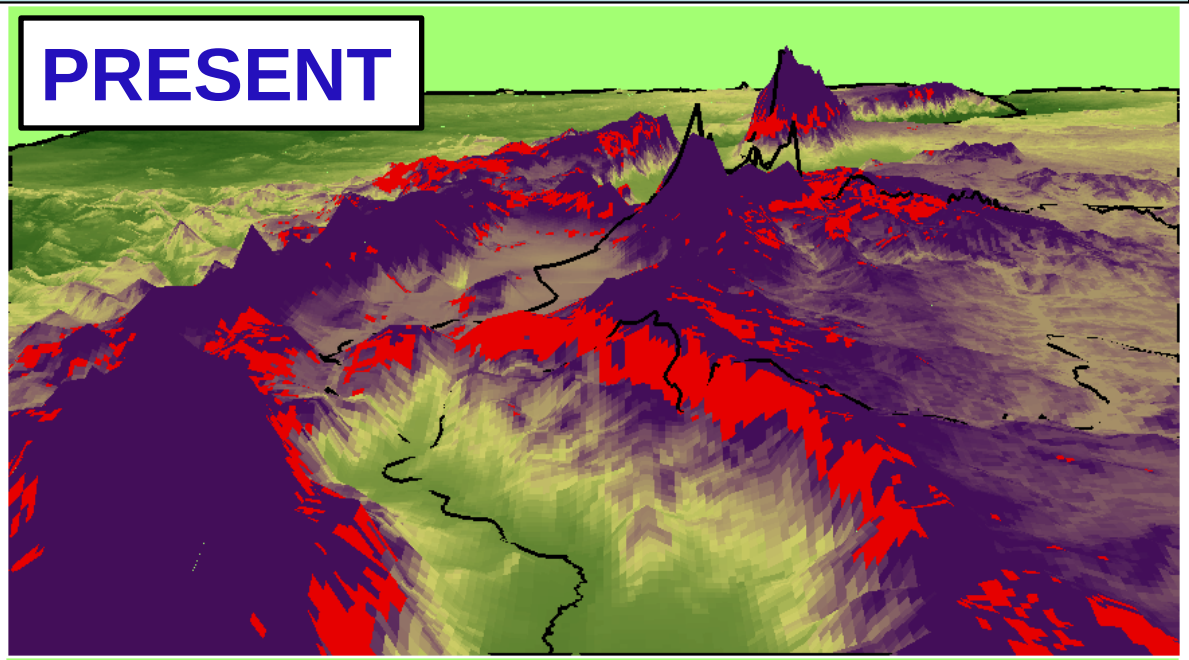
- WCS point survey localities in the northern Albertine Rift (yellow dots)

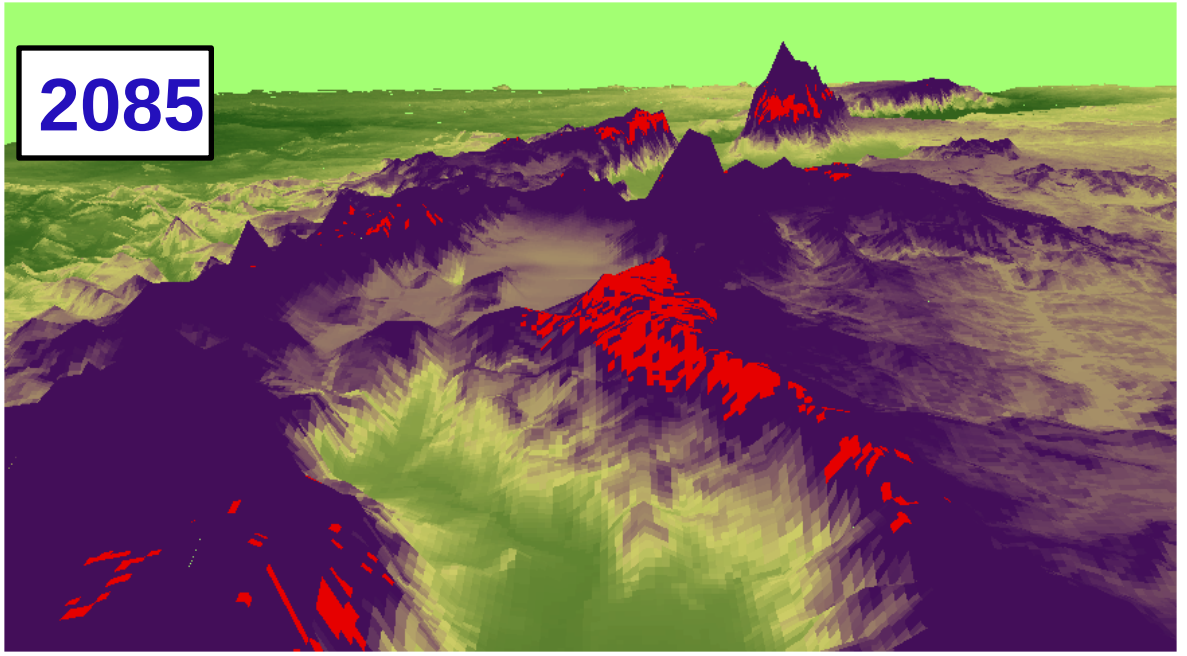


- Survey localities (yellow dots) and positive contacts with *Hemitesia neumanni* (red dots) in Nyungwe Forest (Rwanda/Burundi)

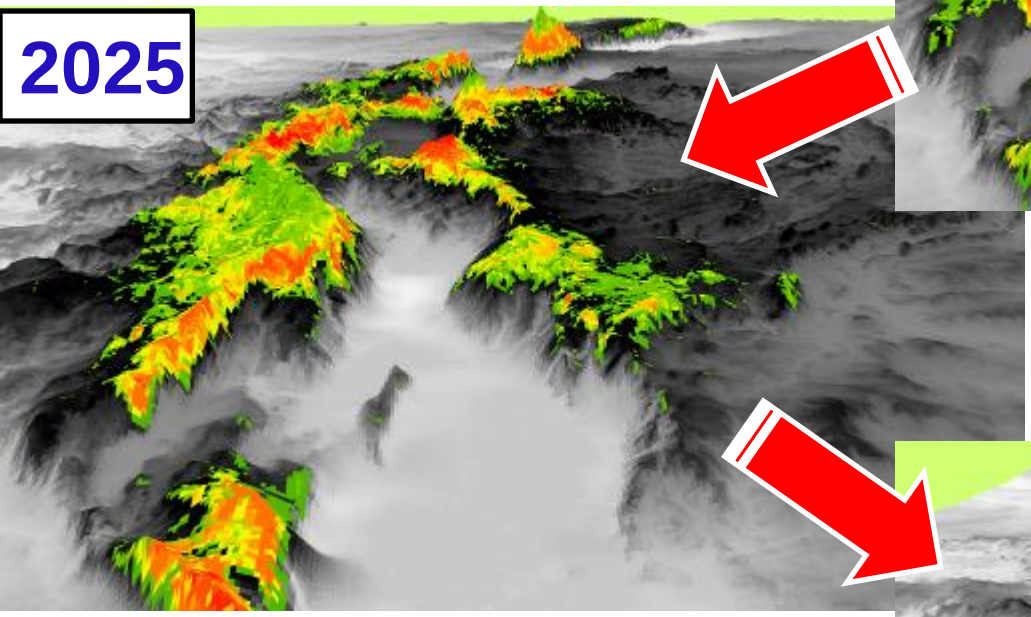


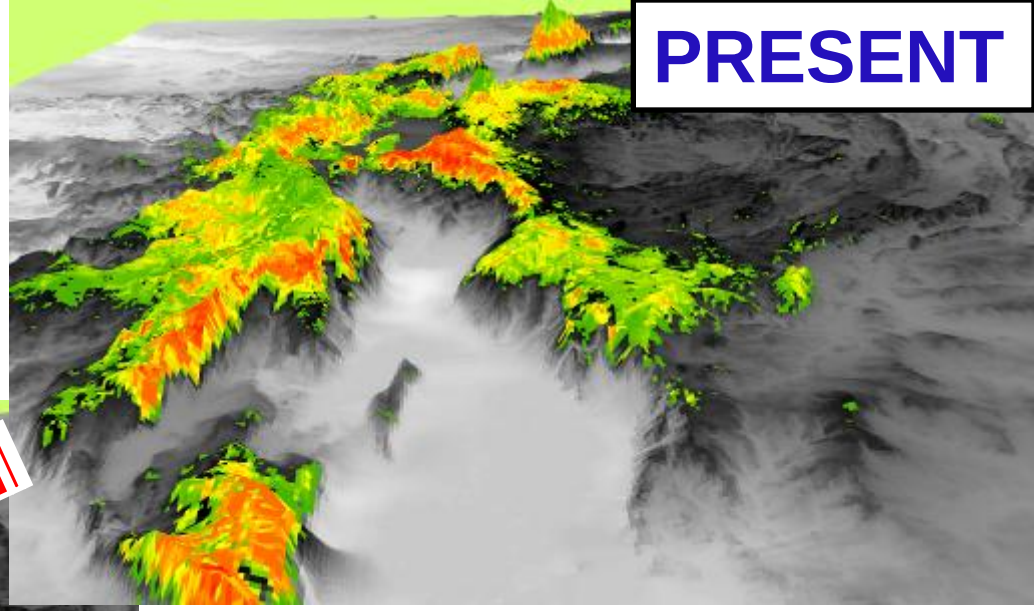
➢Single species projection

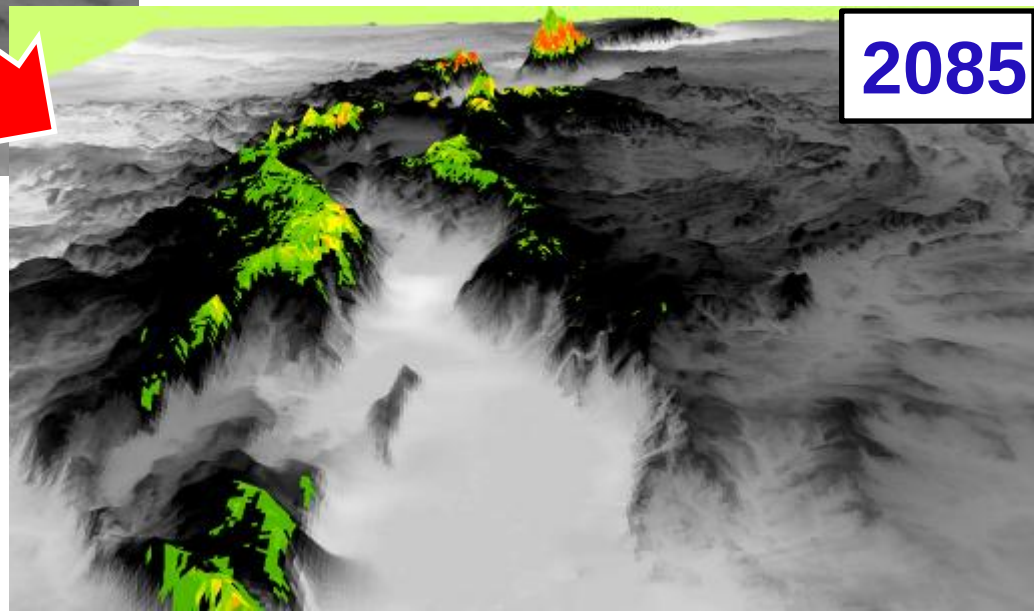




- **Projected species richness of 14 AR endemics across time periods**



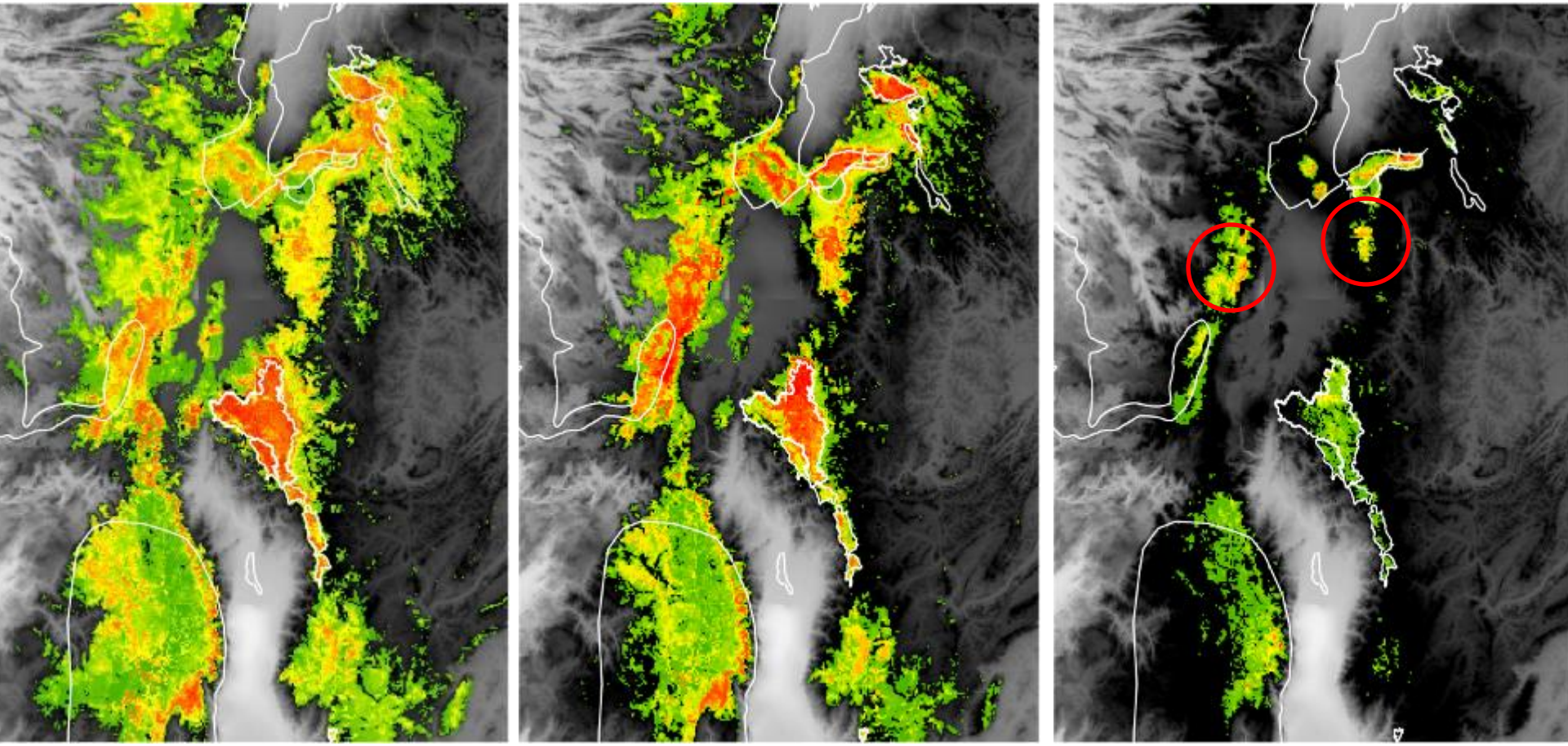




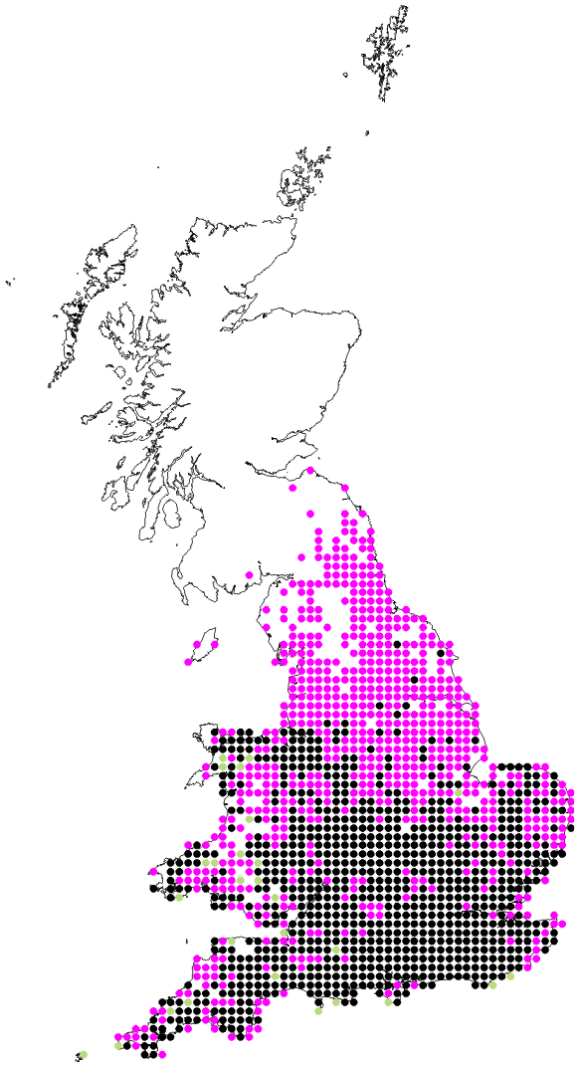
Albertine Rift projected species richness

- **Species richness of 14 AR endemics (models are for HADGEM A1b); white polygon outlines are IBAs; background is a 30 arc sec DEM**

PRESENT **2025** **2085**

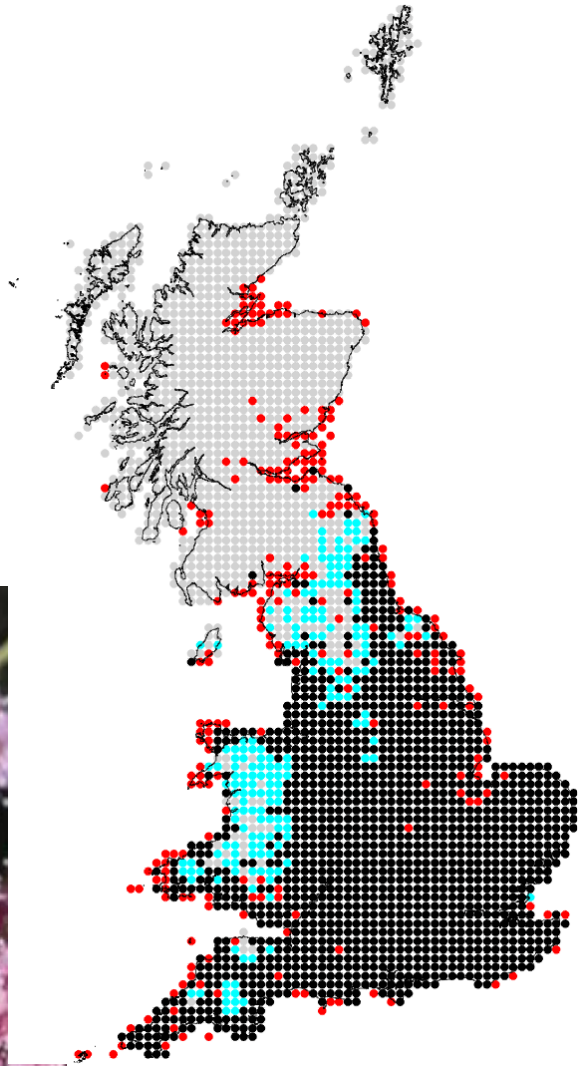


➢ Species ability to respond is variable



Comma butterfly

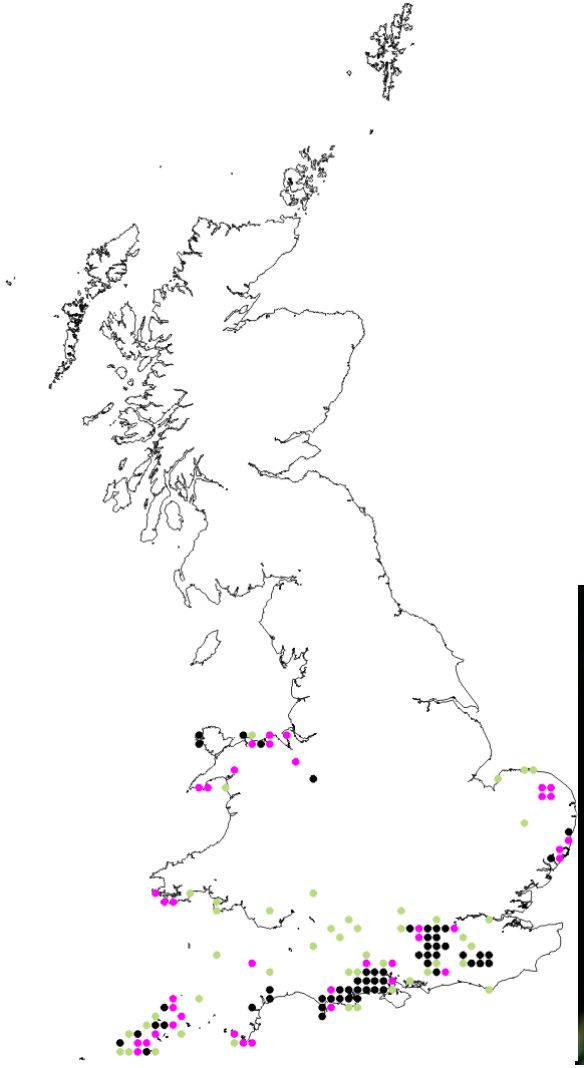
- highly mobile
- generalist
- tracking climate



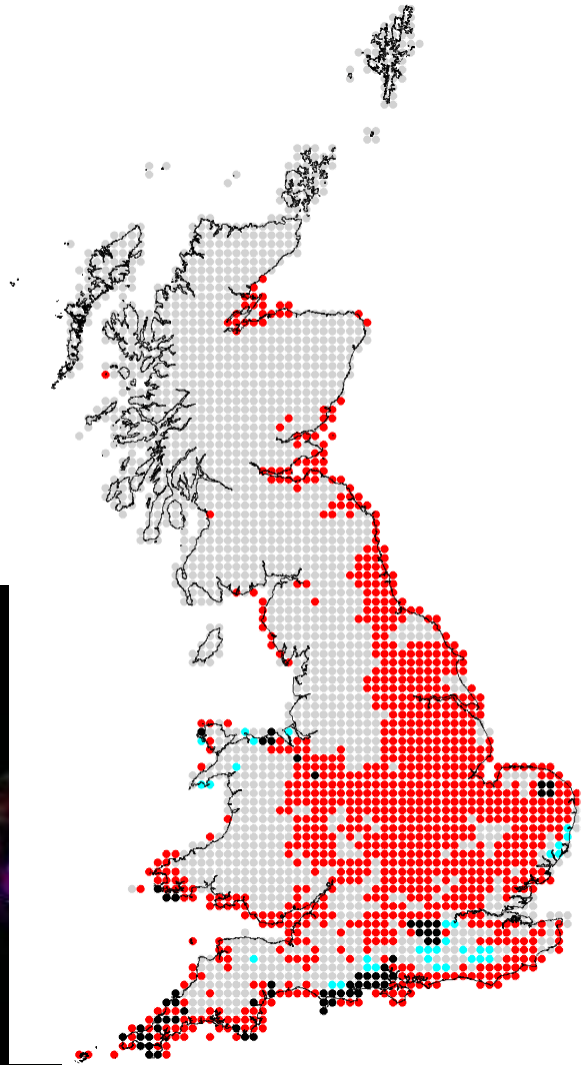
Warren *et al.* (2001) *Nature*

➢ Ability to respond to climatic change is variable

Silver-studded Blue



- low mobility
- habitat specialist
- restricted in area of apparently suitable climate



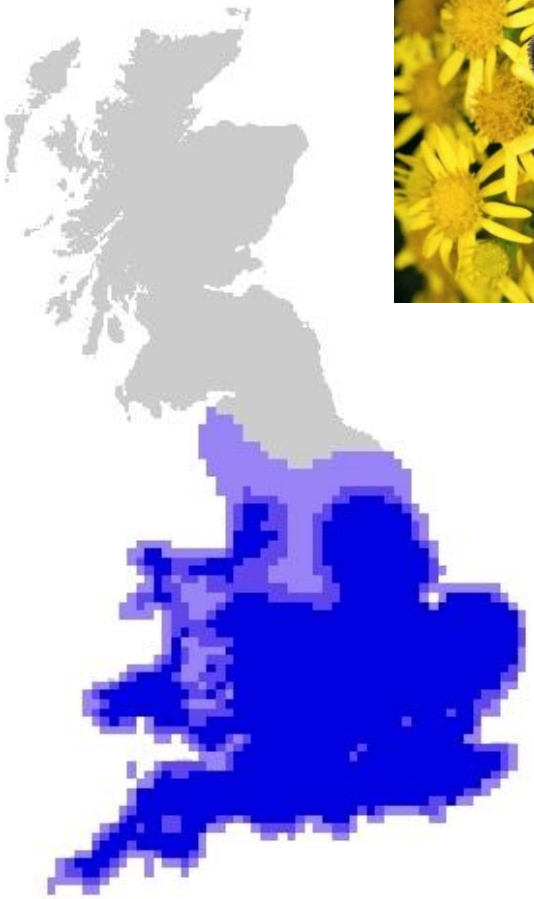
Warren *et al.* (2001) *Nature*

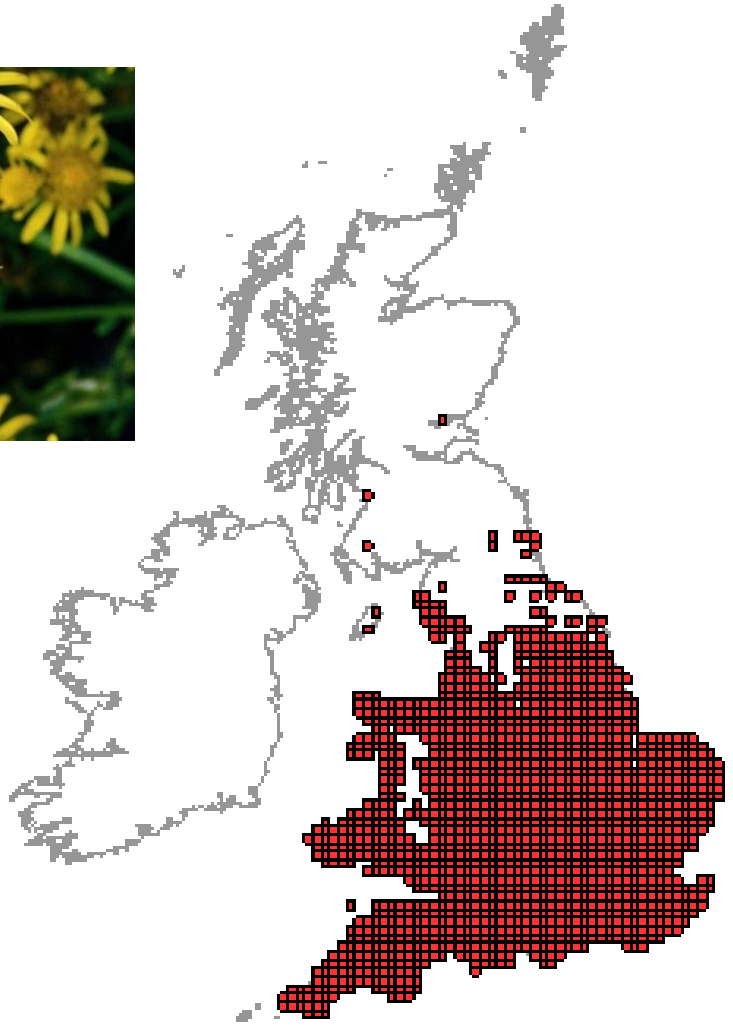
➢ Climate only models are fine for some species

Comma

➢ Suggest climate is the limiting factor

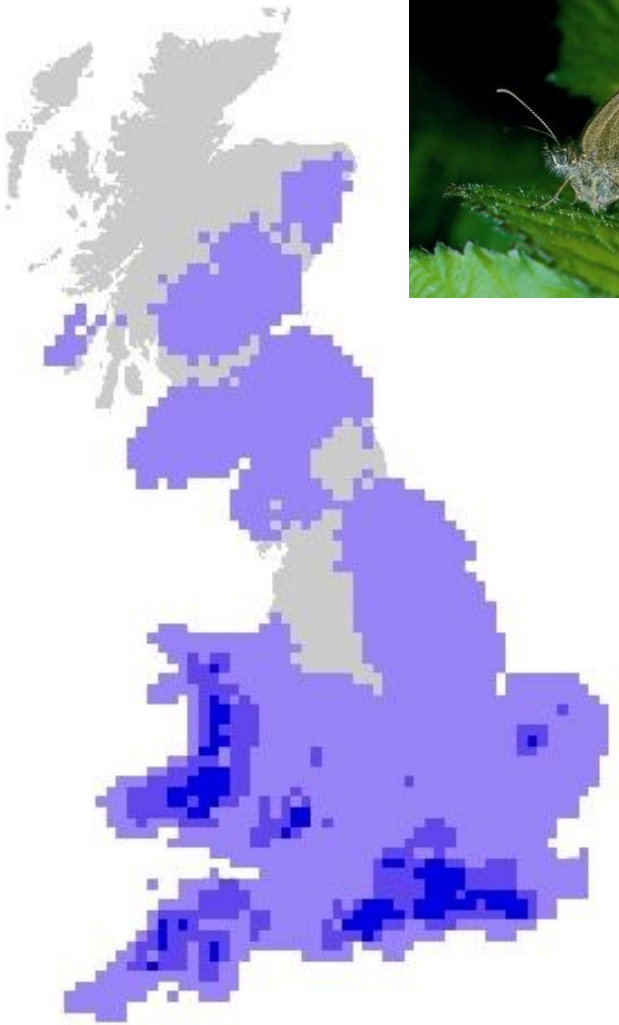
Climate only – Gatekeeper

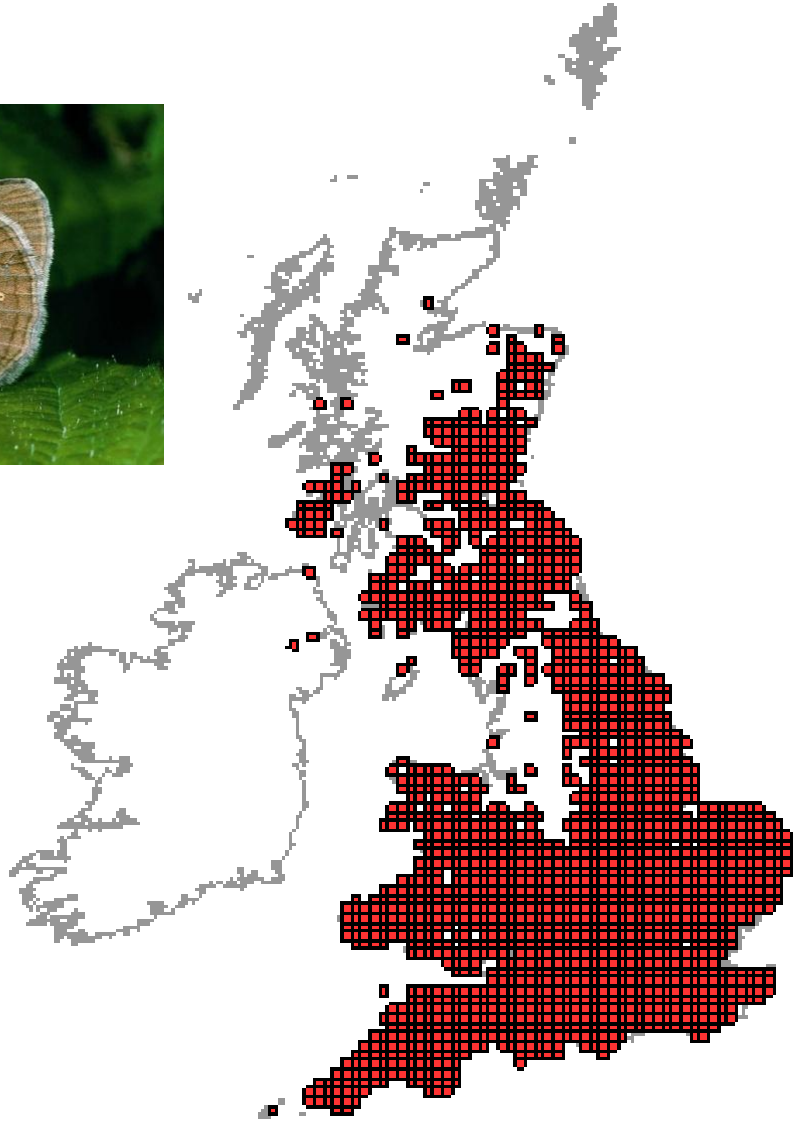




➢For others climate and habitat determine distribution

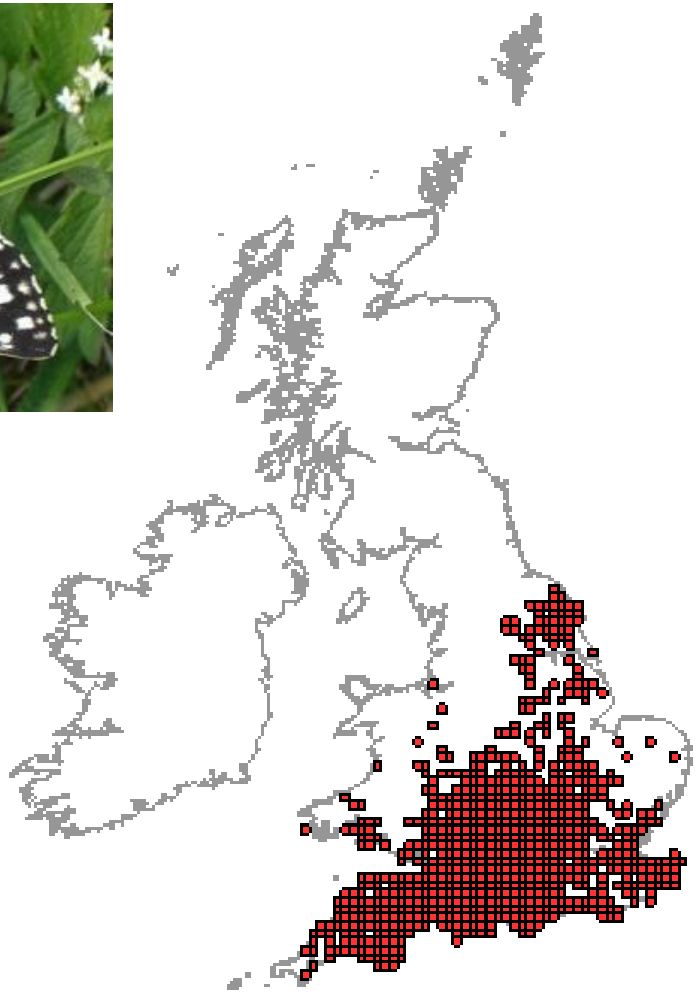
Climate and habitat – Ringlet





➢ For other species a variety of factors are influential

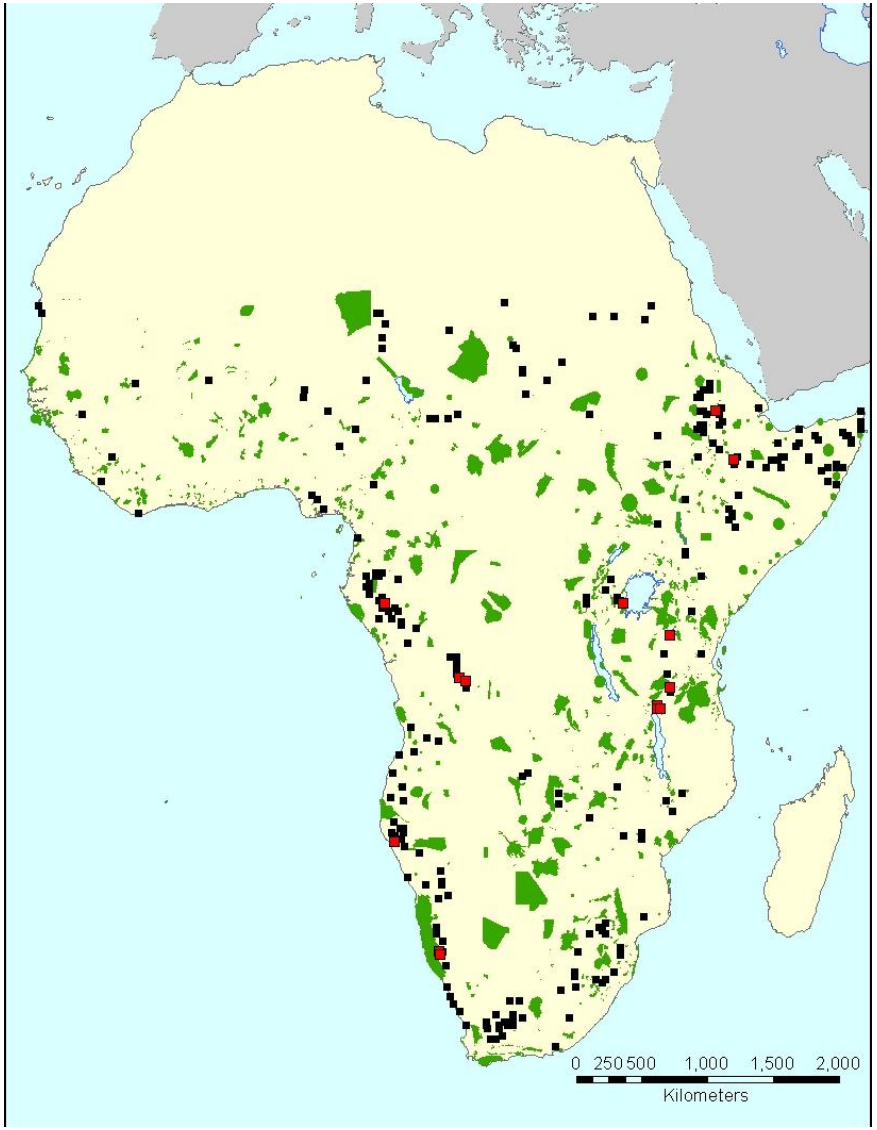
Climate, habitat and soil type – Marbled White



We are currently developing similar models for South African birds, European mammals etc.

➢ Simulating useful *additions* to the PA network

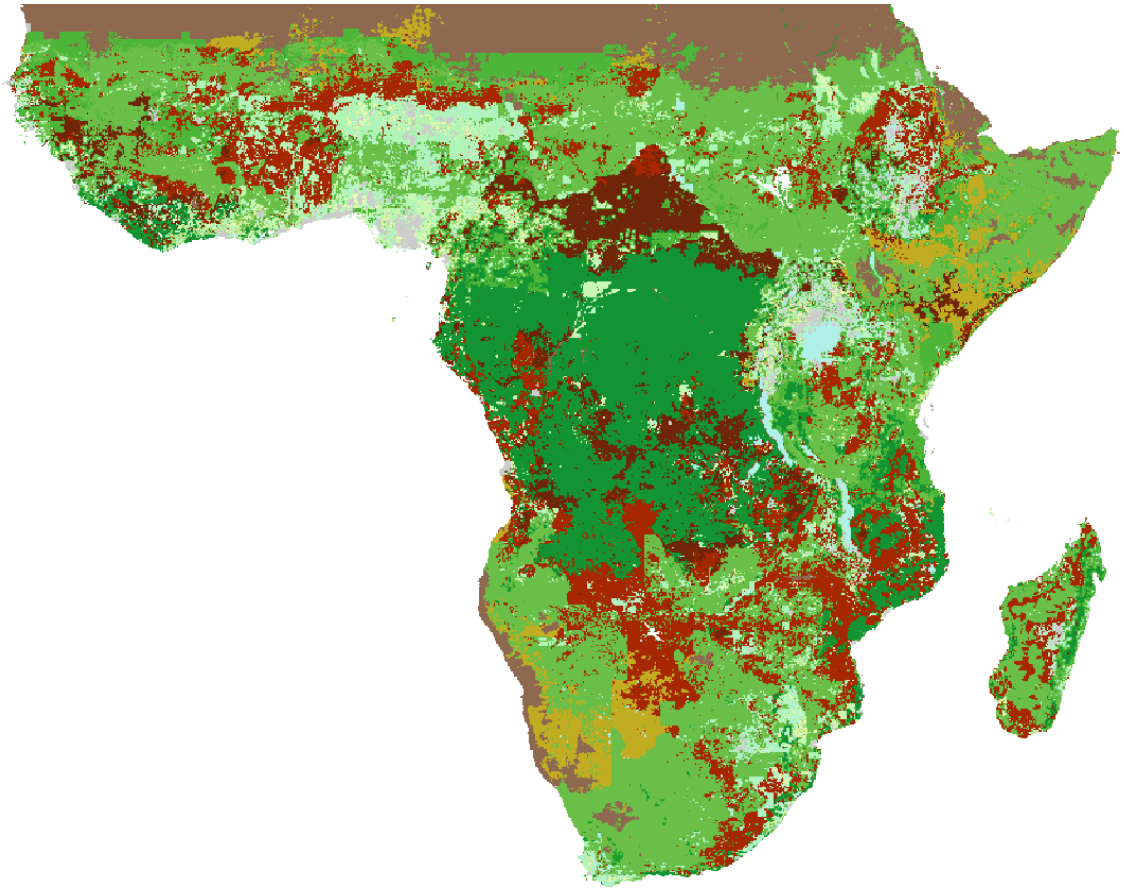
Present - optimal minimum network



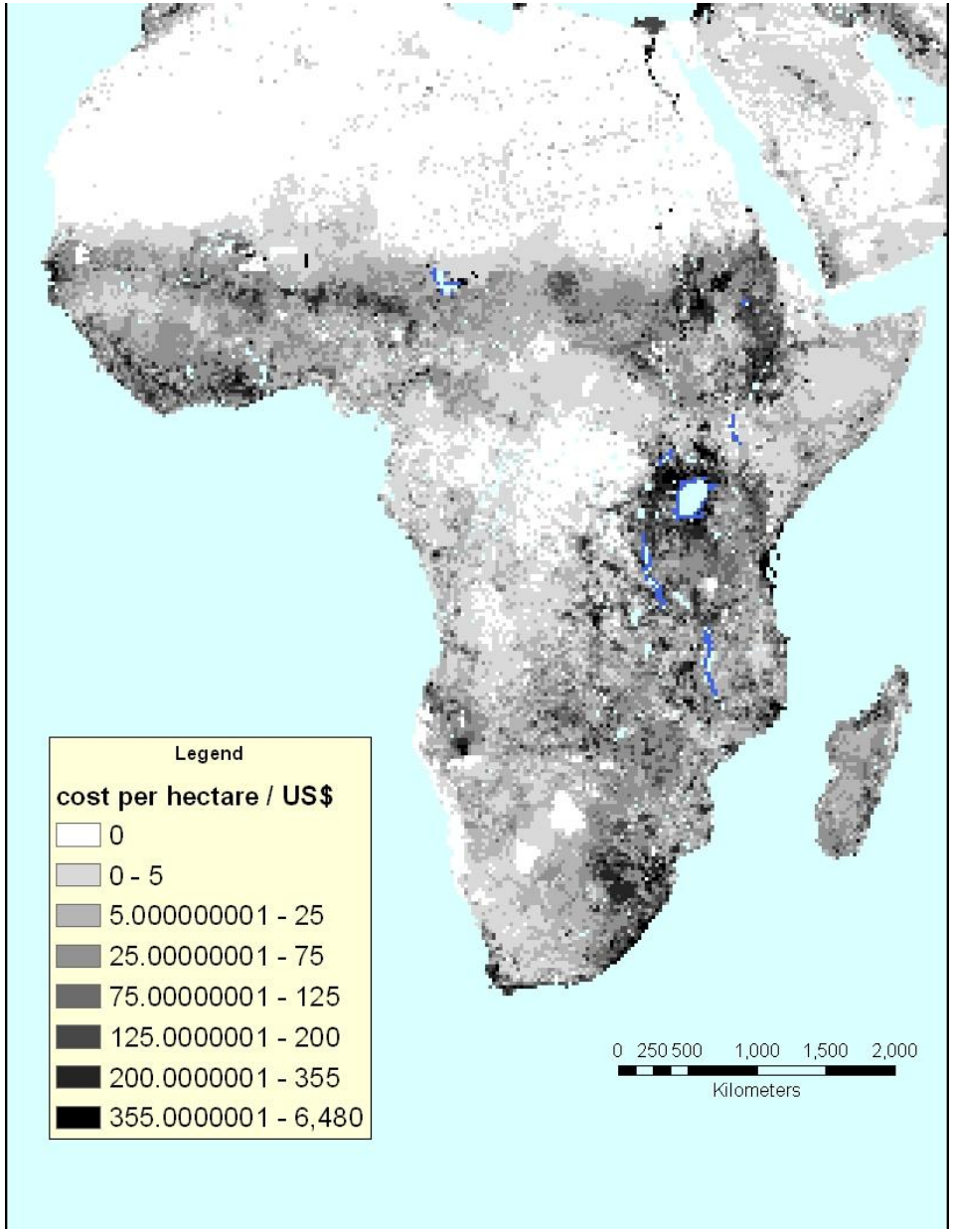
2085 - optimal minimum network

➢ Include projected changes in land-use

(LandSHIFT Model – University of Kassel)



➢ Incorporating land value into RSAs



- Agricultural opportunity costs for quarter-degree cells across Africa based on data from Naidoo & Iwamura (2007).

➢ What could this project deliver?

- Simulations of change based on regional climate models for West Africa
- Simulations that include species traits, and habitat availability to predict which species and ecosystems could be most threatened
- Regional capacity on understanding CC impacts
- A basis on which to develop adaptation and mitigation strategies that work best in each region
- Other possibilities (perhaps beyond this project) include:
  - baseline censusing to detect if and when CC is having a discernible impact on protected areas
  - An assessment of CC impacts on ecosystem services for people