Protected Areas Resilient to Climate Change, PARCC West Africa

2015

PARCC Project Training Manual Module 5. Species Distribution Modelling

ENGLISH

Durham University

2015

The United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) is the specialist biodiversity assessment centre of the United Nations Environment Programme (UNEP), the world's foremost intergovernmental environmental organisation. The Centre has been in operation for over 30 years, combining scientific research with practical policy advice.

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Photo cover: River Number Two Beach, Freetown Peninsula, Sierra Leone. *Copyright: Elise Belle*.

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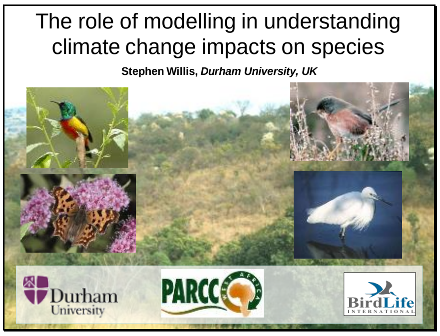
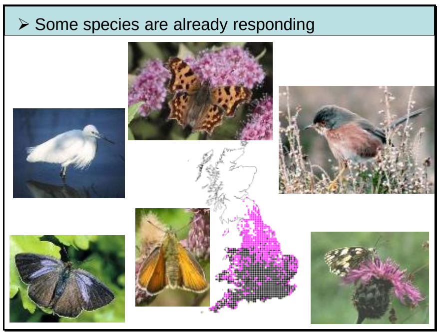
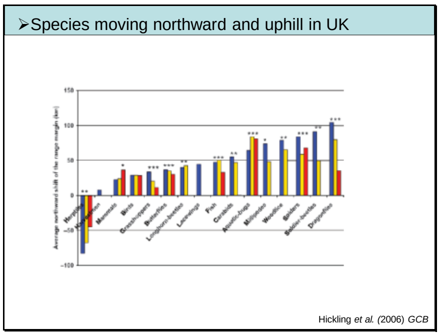
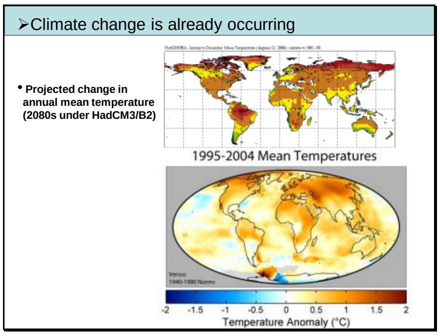
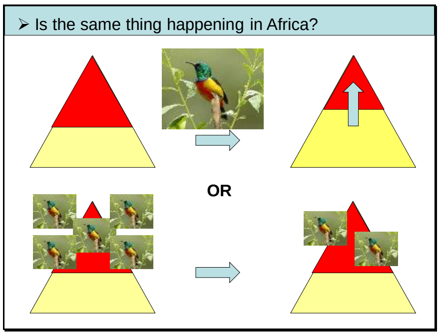
Chapter 1. The role of modelling in understanding climate change impacts on species





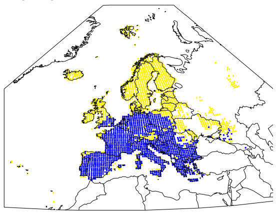






➢ We can predict what might happen as climate changes

Nightingale

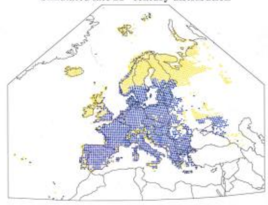


Present recorded distribution

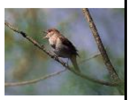
• Climatic data is used with species distribution data to produce a model simulating occurrence in relation to climate

➢ Use the relationship to predict what might happen in future

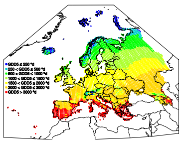
Simulated late 21st century distribution

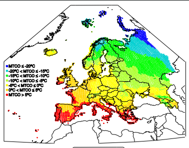


Current distribution



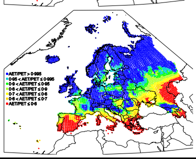
➢ Relate the current distribution to climate





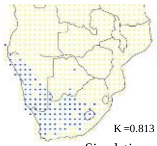
• Climatic variables

GDD5 – summer warmth
MTCO – winter cold
AET/PET – moisture availability



African bird simulations

Observation



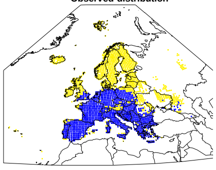
K =0.813
Simulation

Burchell's Courser
Cursorius rufus

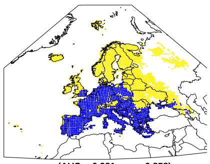
Huntley *et al.* (2006) *Ibis*

➢ Test the ability to predict current distribution

Observed distribution



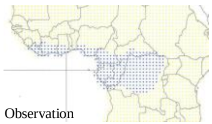
Simulated distribution



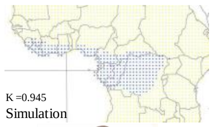
(AUC = 0·981; κ = 0·858)

Assess the agreement between the observed and the simulated distribution

African bird simulations



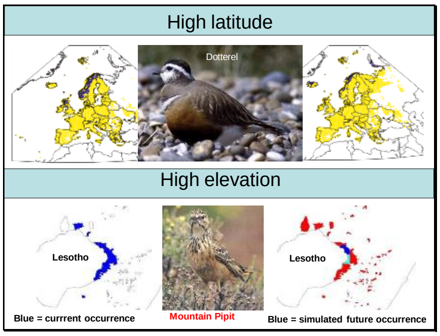
Observation

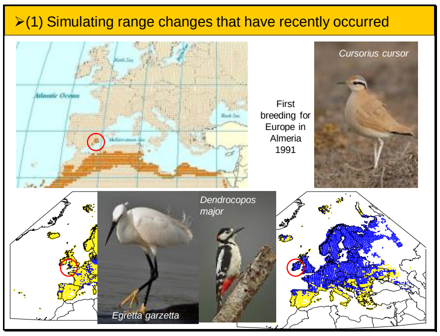


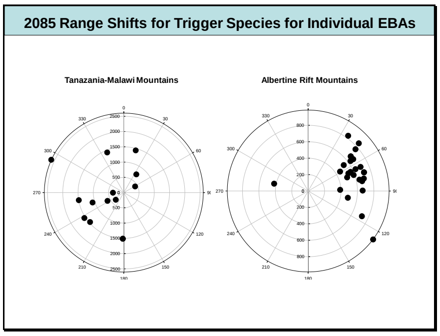
K =0.945
Simulation

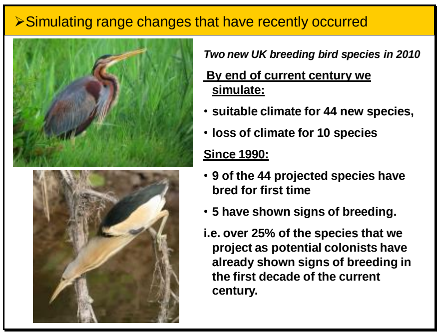
Long-tailed Hawk
Urotriorchis macrourus

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





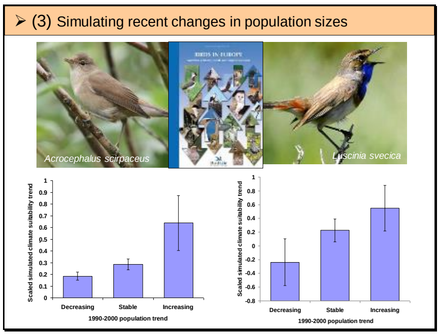


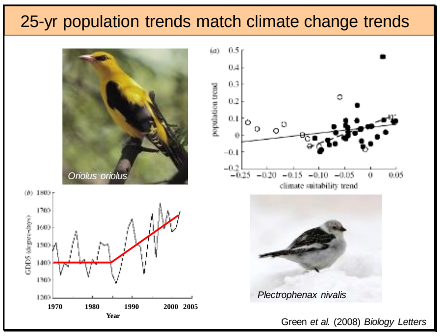


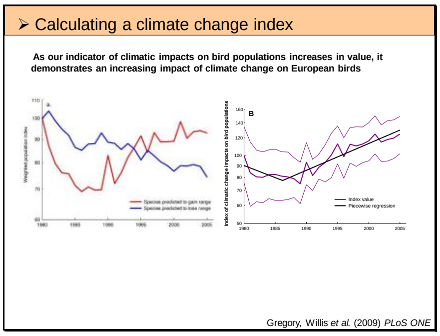
➢ But we need to know if changes are occurring

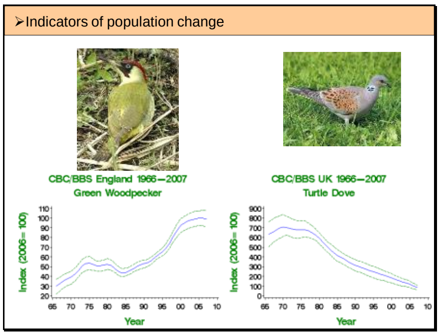
- We need baseline distribution/abundance data to compare to in the future
- We need to know the local-scale species-climate relationships, if they exist
- We need to know if non-climatic factors are determining species ranges

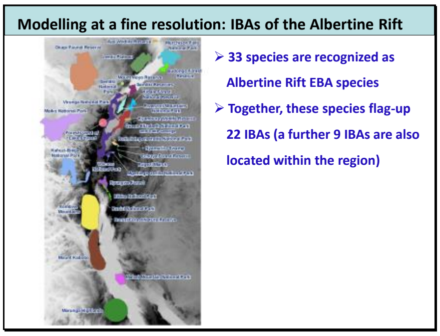
The research component of this project aims to answer these problems for key forest birds in the Albertine Rift

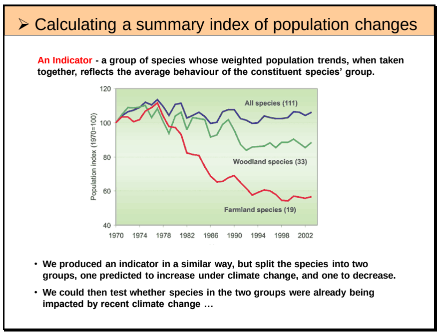


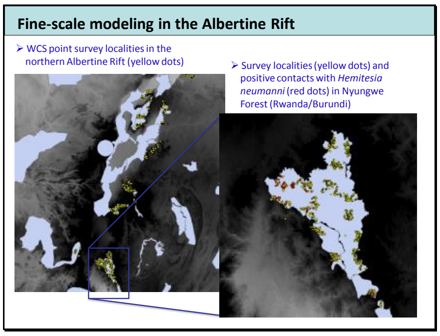

25-yr population trends match climate change trends
Oriolus oriolus
population trend
climate suitability trend
Year
Plectrophenax nivalis
Green et al. (2008) Biology Letters


Calculating a climate change index
As our indicator of climatic impacts on bird populations increases in value, it demonstrates an increasing impact of climate change on European birds
Gregory, Willis et al. (2009) PLoS ONE

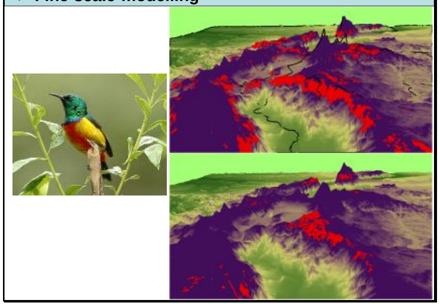

Indicators of population change
CBC/BBS England 1966–2007
Green Woodpecker
CBC/BBS UK 1966–2007
Turtle Dove
Index (2006 = 100)
Year


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)


Calculating a summary index of population changes
An Indicator - a group of species whose weighted population trends, when taken together, reflects the average behaviour of the constituent species' group.
Population index (1970=100)
All species (111)
Woodland species (33)
Farmland species (19)
We produced an indicator in a similar way, but split the species into two groups, one predicted to increase under climate change, and one to decrease.
We could then test whether species in the two groups were already being impacted by recent climate change …

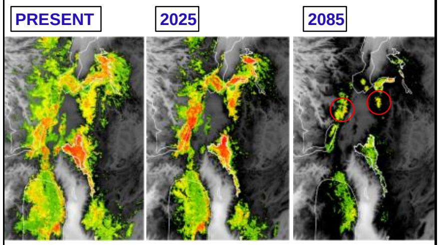

Fine-scale modeling in the Albertine Rift
WCS point survey localities in the northern Albertine Rift (yellow dots)
Survey localities (yellow dots) and positive contacts with Hemitesia neumanni (red dots) in Nyungwe Forest (Rwanda/Burundi)

➢ Fine-scale modelling

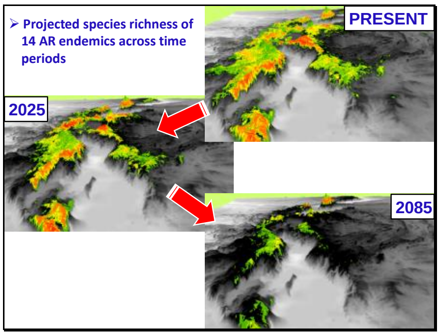


AR projected species richness

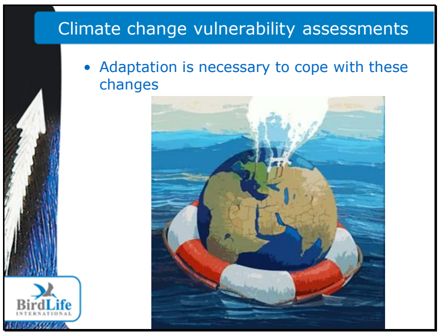
➢ Species richness of 14 AR endemics (models are for HADGEM A1b); white polygon outlines are IBAs; background is a 30 arc sec DEM

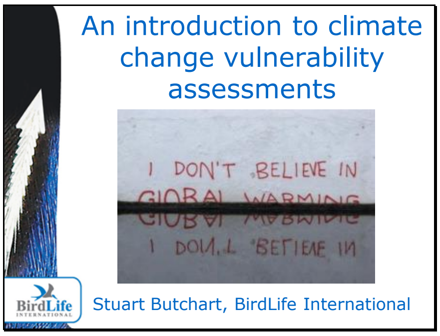


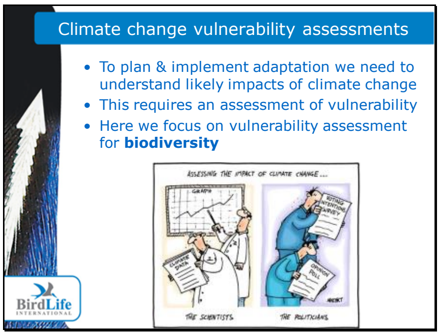
➢ Projected species richness of 14 AR endemics across time periods

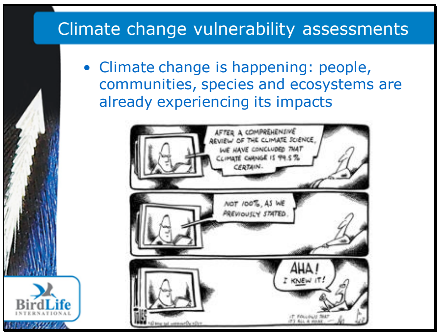


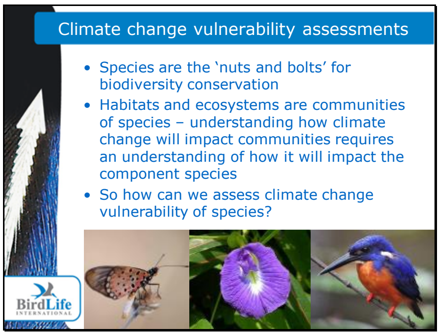
Chapter 2. An introduction to climate change vulnerability assessments

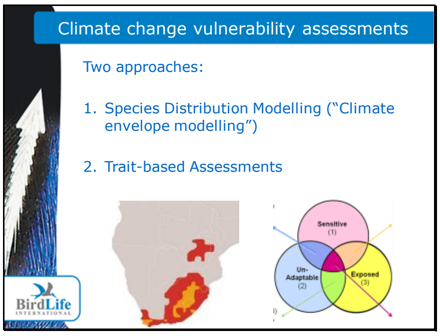


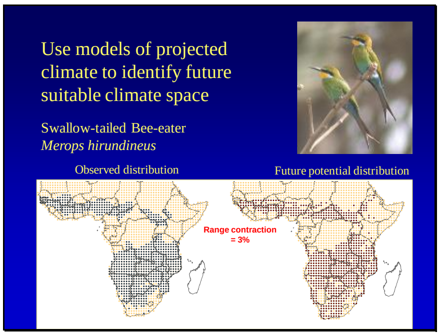


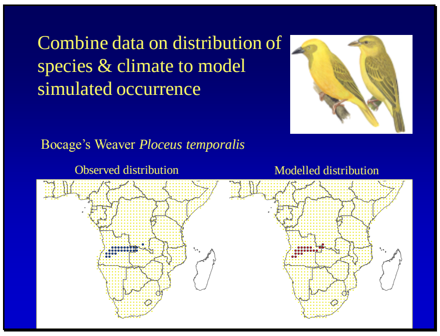


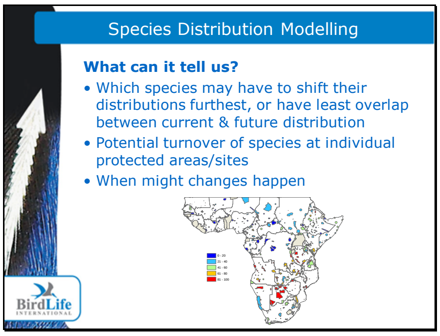


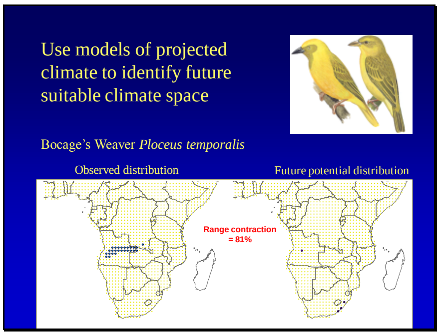


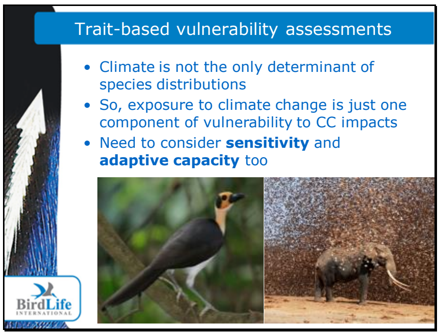

Climate change vulnerability assessments
Two approaches:
1. Species Distribution Modelling ("Climate envelope modelling")
2. Trait-based Assessments
Sensitive (1)
Un-Adaptable (2)
Exposed (3)
BirdLife


Use models of projected climate to identify future suitable climate space
Swallow-tailed Bee-eater
Merops hirundineus
Observed distribution
Future potential distribution
Range contraction = 3%


Combine data on distribution of species & climate to model simulated occurrence
Bocage's Weaver Ploceus temporalis
Observed distribution
Modelled distribution


Species Distribution Modelling
What can it tell us?
• Which species may have to shift their distributions furthest, or have least overlap between current & future distribution
• Potential turnover of species at individual protected areas/sites
• When might changes happen
BirdLife


Use models of projected climate to identify future suitable climate space
Bocage's Weaver Ploceus temporalis
Observed distribution
Future potential distribution
Range contraction = 81%


Trait-based vulnerability assessments
• Climate is not the only determinant of species distributions
• So, exposure to climate change is just one component of vulnerability to CC impacts
• Need to consider sensitivity and adaptive capacity too
BirdLife

Trait-based vulnerability assessments

- **Climate sensitivity**: the potential for species to cope with climate change in situ
  - assessed by scoring habitat specialisation, narrow environmental tolerances, potential for disruption of environmental triggers, interspecific interactions, rarity etc
- **Adaptive capacity**: extent to which species is capable of mitigating impacts through dispersal and/or microevolutionary change
  - assessed by scoring dispersal ability & barriers, low genetic diversity, long generation time, low reproductive output etc

Trait-based vulnerability assessments

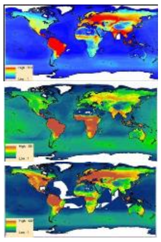
What can it tell us?

- Which species may be most vulnerable within each taxonomic group
- Which species may be able to cope vs which will be in trouble under climate change
- Which areas may contain highest numbers of highly susceptible species
- Within particular protected areas, why some species are highly susceptible (& therefore how they may be helped to adapt)

Trait-based vulnerability assessments

- **Climate exposure:** the degree of environmental change expected based on projected changes in monthly temperature and precipitation (means and variability) across species' ranges + sea-level rise
- Score each species for each trait
- Species scoring high for exposure, sensitivity & 'unadaptiveness' = highly susceptible

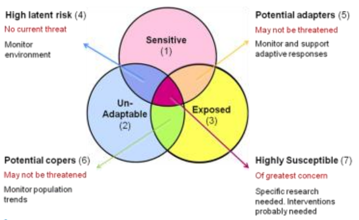
Trait-based vulnerability assessments



Foden *et al.* 2013 PloS ONE

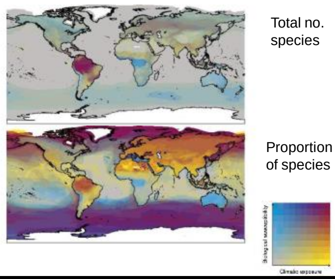
i.e. the spatial patterns differ, which is good news...

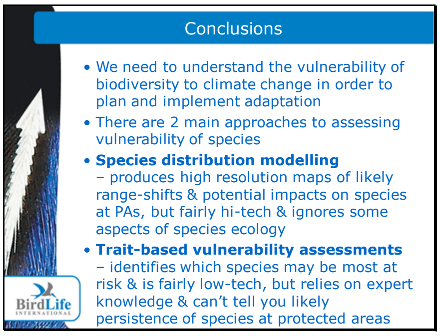
Trait-based vulnerability assessments



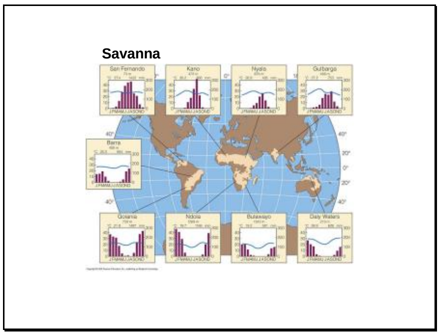
Foden *et al.* 2013 PloS ONE

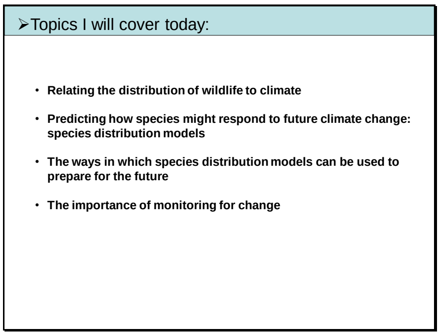
Trait-based vulnerability assessments

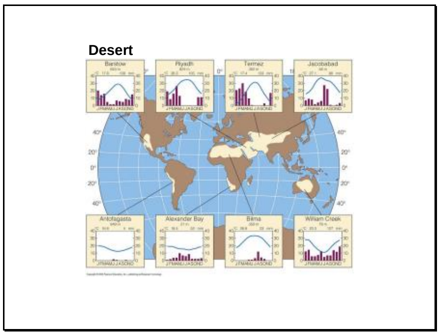


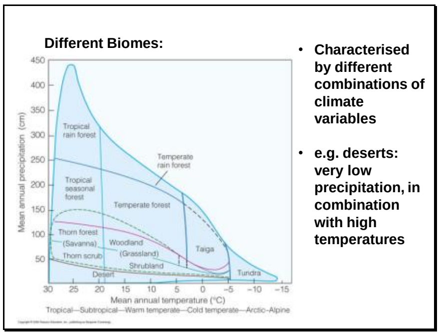

Conclusions
• We need to understand the vulnerability of biodiversity to climate change in order to plan and implement adaptation
• There are 2 main approaches to assessing vulnerability of species
• **Species distribution modelling** – produces high resolution maps of likely range-shifts & potential impacts on species at PAs, but fairly hi-tech & ignores some aspects of species ecology
• **Trait-based vulnerability assessments** – identifies which species may be most at risk & is fairly low-tech, but relies on expert knowledge & can't tell you likely persistence of species at protected areas
BirdLife

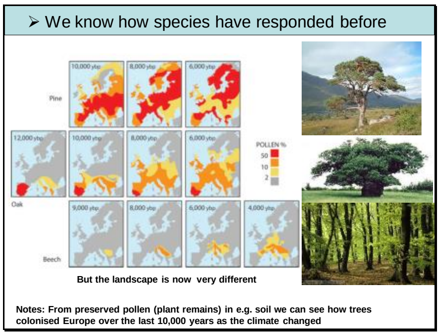
Chapter 3. Species-climate models: How we produce them and how we can use them



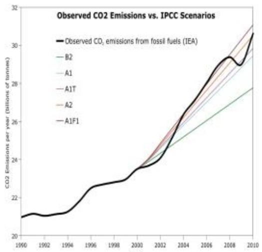








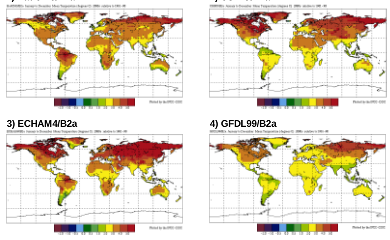
➢ but we are altering the climate at an alarming rate



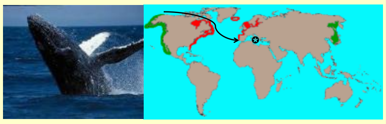
Notes: Recent CO_2 emissions are at the top end of the scenarios used in the climate models. So, climate is changing much more rapidly than it has done for 1000s of years

➢ Global climate change projections

- Projected change in annual mean temperature (between now and 2085) from four different climate prediction models



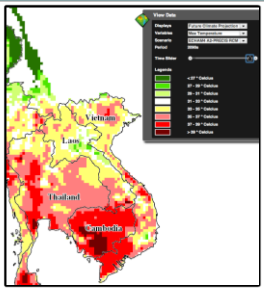
➢ Many species are already responding



So, how can we project what might happen in the future?

Notes: A Grey whale appeared in Europe for the first time in 2011. New species are colonising the UK. But, many species may not be able to keep up with the rapid change

Regional climate models: an example for temperature



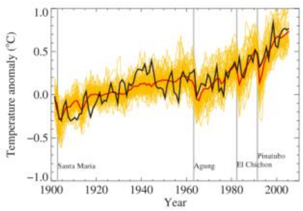
Notes: Regionally, annual temperatures are projected to increase, particularly noticeable in Cambodia

1.5 - 4.7ºC increase in temperature for the region by 2085

SE Asia START RC

➢ So, how well do climate simulations work?

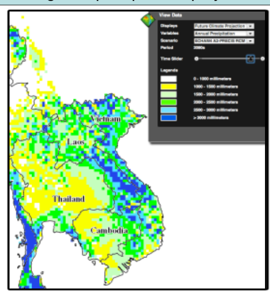
FAQ 8.1, Figure 1. *Global mean near-surface temperatures over the 20th century from observations (black) and as obtained from 58 simulations produced by 14 different climate models driven by both natural and human-caused factors that influence climate (yellow). The mean of all these runs is also shown (thick red line). Temperature anomalies are shown relative to the 1901 to 1950 mean. Vertical grey lines indicate the timing of major volcanic eruptions. (Figure adapted from Chapter 9, Figure 9.5. Refer to corresponding caption for further details.)*



Notes: Climate models have already been shown to predict changes over the last 100 years successfully

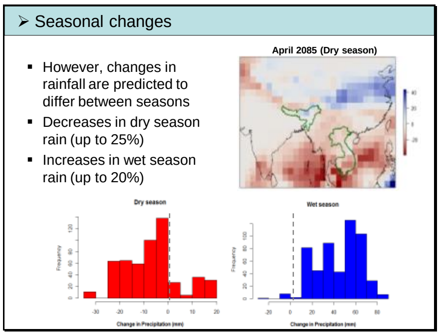
IPCC 2007

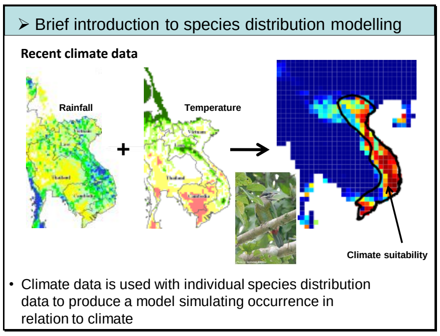
Regional precipitation projections: 2010-2090

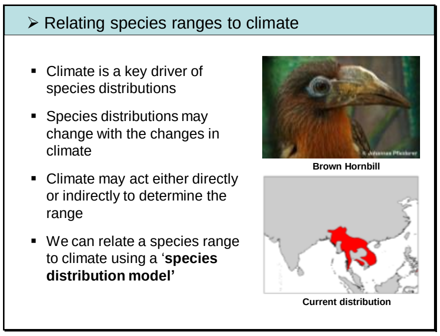


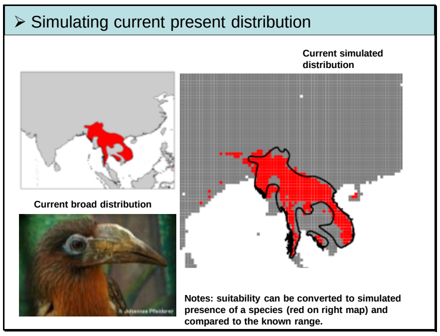
Notes: Average changes in precipitation are less severe

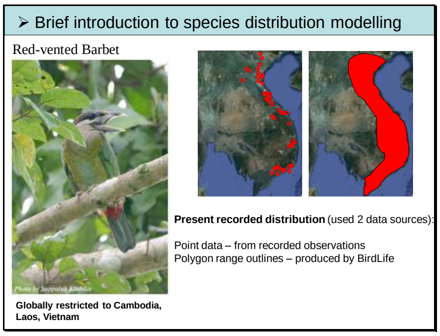
SE Asia START RC

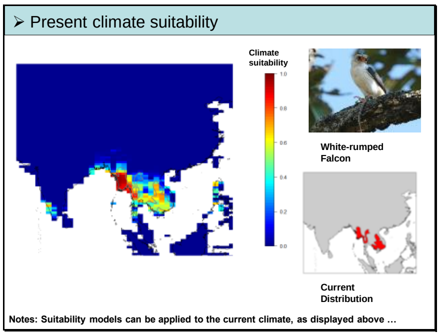

Seasonal changes
However, changes in rainfall are predicted to differ between seasons
Decreases in dry season rain (up to 25%)
Increases in wet season rain (up to 20%)
April 2085 (Dry season)
Dry season
Wet season

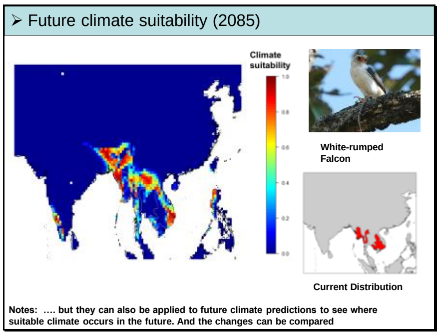

Brief introduction to species distribution modelling
Recent climate data
Rainfall
Temperature
Climate suitability
Climate data is used with individual species distribution data to produce a model simulating occurrence in relation to climate

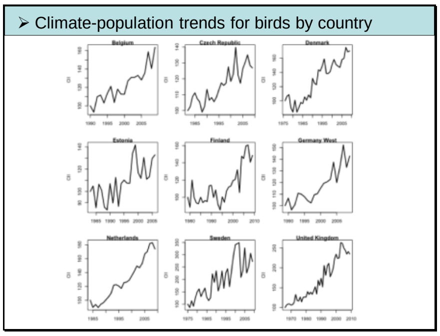

Relating species ranges to climate
Climate is a key driver of species distributions
Species distributions may change with the changes in climate
Climate may act either directly or indirectly to determine the range
We can relate a species range to climate using a 'species distribution model'
Brown Hornbill
Current distribution

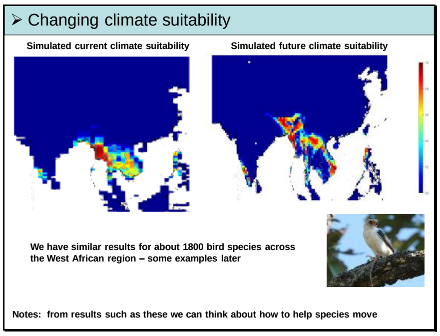

Simulating current present distribution
Current simulated distribution
Current broad distribution
Notes: suitability can be converted to simulated presence of a species (red on right map) and compared to the known range.

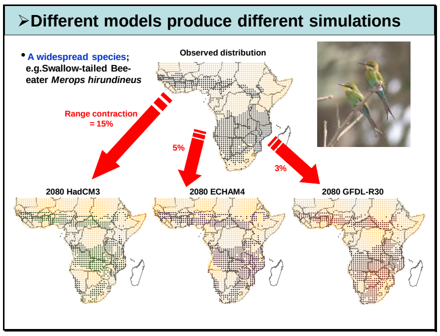

Brief introduction to species distribution modelling
Red-vented Barbet
Globally restricted to Cambodia, Laos, Vietnam
Present recorded distribution (used 2 data sources):
Point data – from recorded observations
Polygon range outlines – produced by BirdLife

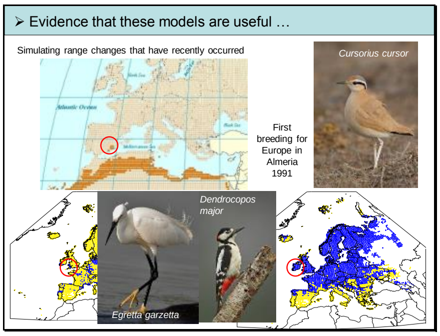

Present climate suitability
Climate suitability
White-rumped Falcon
Current Distribution
Notes: Suitability models can be applied to the current climate, as displayed above …

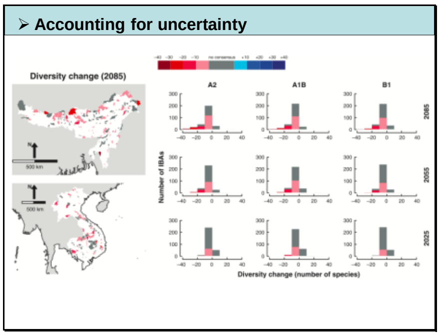

Future climate suitability (2085)
Climate suitability
White-rumped Falcon
Current Distribution
Notes: .... but they can also be applied to future climate predictions to see where suitable climate occurs in the future. And the changes can be compared


Climate-population trends for birds by country


Changing climate suitability
Simulated current climate suitability
Simulated future climate suitability
We have similar results for about 1800 bird species across the West African region – some examples later
Notes: from results such as these we can think about how to help species move


Different models produce different simulations
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


Evidence that these models are useful …
Simulating range changes that have recently occurred
Cursorius cursor
First breeding for Europe in Almeria 1991
Dendrocopos major
Egretta garzetta

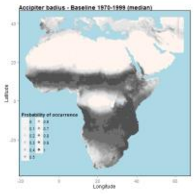

Accounting for uncertainty
Diversity change (2085)
A2
A1B
B1
Number of IBAs
Diversity change (number of species)

➢ What exactly do these simulations show?

- We produce a model that describes a species range solely in terms of climate across its range.
- These models work most successfully at larger scales
  - At smaller scales non-climatic effects start to predominate
- Future simulations indicate only where similar climate will occur
  - They say nothing about the likelihood of occupancy
- Species traits such as dispersal ability and habitat connectivity are vital to simulate future changes realistically

For more accurate predictions we must combine these maps of changing suitable climate with other models of e.g. habitat and dispersal

Model for an individual species: *Accipiter badius*



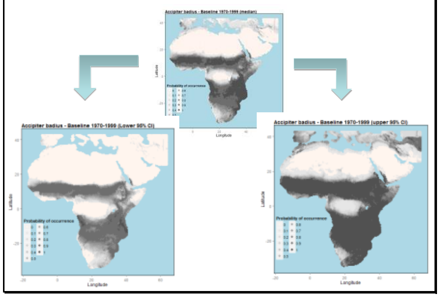
- Modelled ca. 1800 species distributions of species whose distribution overlap with the Regional Climate Models developed by the Meteorological Office
- Projected potential distributions for future time periods (centred on 2045, 2085)

➢ Research Plan For This Project

Theme 1 - Developing regional-scale species distribution models at conservation relevant resolutions

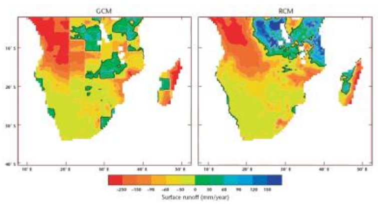
- **Methodology**
  - **Following methods of Asia project (previous slide)**
  - **Model species distribution as a function of climatic variables (growing season warmth, seasonality, water availability etc.)**
  - **Four modelling methods (General Linear Models, Generalised Additive Models, Boosted Regressions, Random Forests)**
  - **Developed and tested models on independent data sets**
  - **Five Regional Climate Model climate datasets**
  - **Sample uncertainty in projections from across these combinations (200 simulations per species)**

Also modelled uncertainty in projections for species



➢ Regional scale models

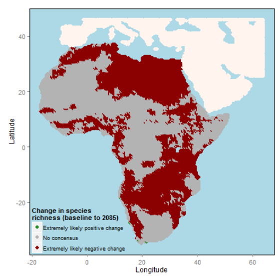
Generate future climate projections – PRECIS Regional Climate Model

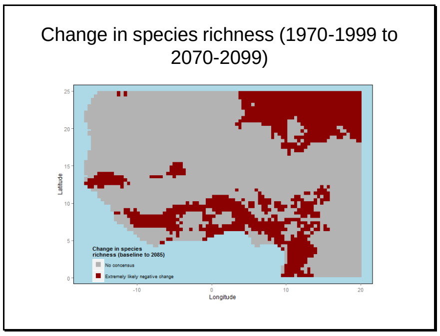


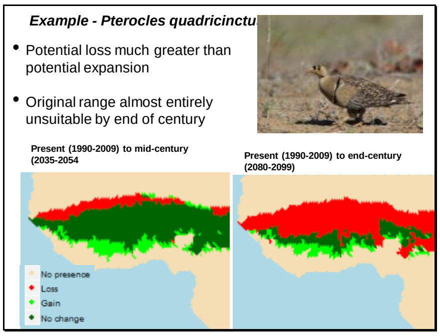
Notes: In this project we will use 'regional climate simulations' which better simulate local patterns across landscapes – ideal for regions like West Africa

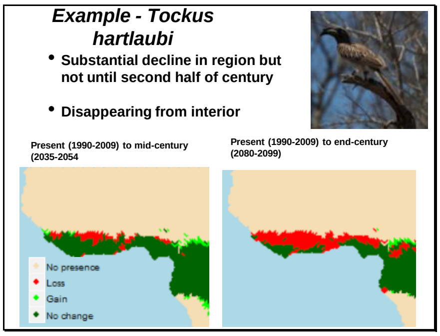
Uncertainty in the change in species richness

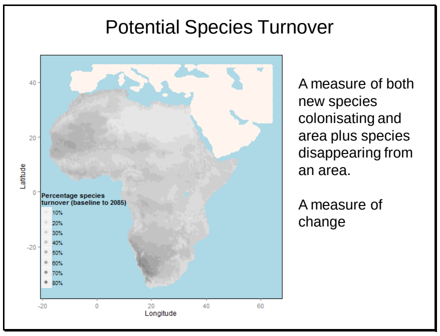
(1970-1999 to 2070-2099)

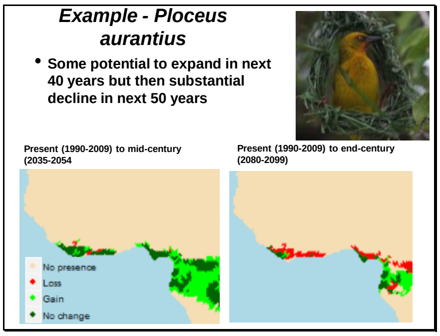


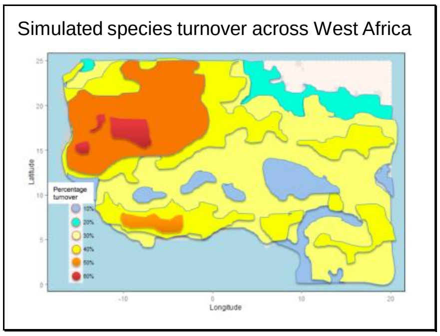

Change in species richness (1970-1999 to 2070-2099)
Latitude
Longitude


Example - Pterocles quadricinctu
Potential loss much greater than potential expansion
Original range almost entirely unsuitable by end of century
Present (1990-2009) to mid-century (2035-2054
Present (1990-2009) to end-century (2080-2099)
No presence
Loss
Gain
No change


Example - Tockus hartlaubi
Substantial decline in region but not until second half of century
Disappearing from interior
Present (1990-2009) to mid-century (2035-2054
Present (1990-2009) to end-century (2080-2099)
No presence
Loss
Gain
No change


Potential Species Turnover
A measure of both new species colonisating and area plus species disappearing from an area.
A measure of change
Latitude
Longitude


Example - Ploceus aurantius
Some potential to expand in next 40 years but then substantial decline in next 50 years
Present (1990-2009) to mid-century (2035-2054
Present (1990-2009) to end-century (2080-2099)
No presence
Loss
Gain
No change

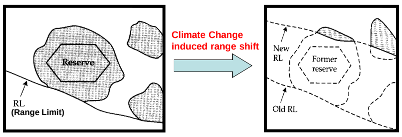

Simulated species turnover across West Africa
Latitude
Longitude

Next steps for species modelling:

Repeat analyses for mammals, reptiles, amphibians …

➢ Research Plan

Theme 2 - Incorporating the risks of climate change induced range shifts into conservation prioritization



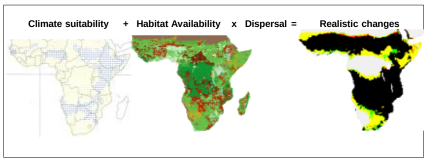
- **Crucial flaw in past conservation planning = static viewpoint**
- **How effective is the West African PA network? – GAP analysis**
- **How effective will the network be under climate change – what modifications are required?**

Next steps for species modelling:

Run dispersal simulations for more realistic changes in species ranges

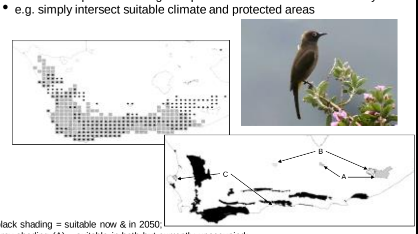
Combines climate suitability information for a species with:

(1) Dispersal models for species
(2) Habitat availability for each species



➢ Simplistic Measure of Impacts on Protected Areas

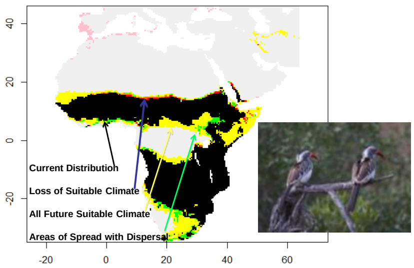
- We can infer potential changes in protected areas in a number of ways:
- e.g. simply intersect suitable climate and protected areas



black shading = suitable now & in 2050;
grey shading (A) = suitable in both but currently unoccupied;
stippling (B) = suitable only in the future;
cross hatching (C) currently present but simulated unsuitable by 2050

Willis *et al.* (2008) *Env. Man.*

Projecting future range changes



➢ Colonists and movement

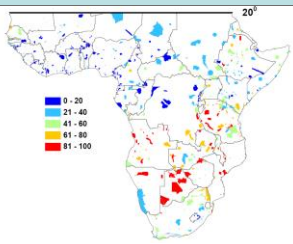


Figure 4: Simulated turnover of species (a measure combining colonisation and extinction) across African protected areas between now and the end of the current century. *Note the high turnover in Botswana through to Tanzania and low turnover in the Guinea-Congo forests.*

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

➢ Stage 3 – Moving from research to action

A landscape-scale approach: developing an Adaptive Management Framework to mitigate impacts of climate change

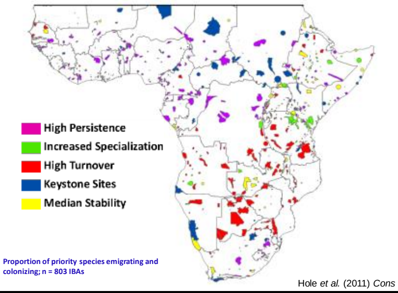
- **Leading stakeholders now recognize need for landscape-scale approach in face of twin risks – habitat loss and climate change**
- **Utilize data from Themes 1 & 2 to assess broad-scale options for mitigating impacts of climate change**

➢ What useful information could these models provide?

1. **Simulating changes in species range, including projected changes in occurrence in protected areas**
2. **Combine with species dispersal ability etc to provide more realistic estimates**
3. **Combining such changes with other land-use changes, e.g. agriculture, urbanisation**

1. **Estimate species under threat from extinction**
2. **Highlight species that might need translocating (and where to move them)**
3. **Adapting conservation management: within reserves, and also in terms of where to place reserves**

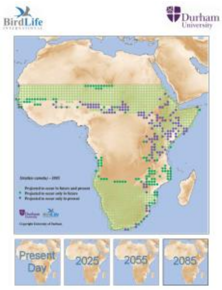
➢ Categorize changes in protected area assemblages



Proportion of priority species emigrating and colonizing; n = 803 IBAs

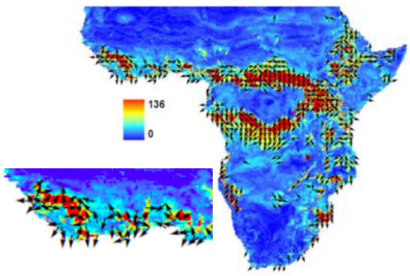
Hole *et al.* (2011) *Cons Biol*

LC Ostrich *Struthio camelus*



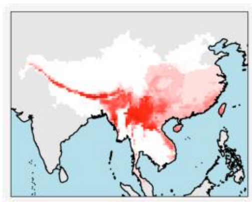
Key facts	
Current IUCN Red List status	Least Concern
Family	Struthionidae (Ostriches)
Species name author	Linnaeus, 1758
Population estimate	unknown
Population trend	unset
Range estimate (breeding/resident)	9,980,000 km^2
Country endemic?	No
links to further information	
- Summary information on this species - Additional Information on this species	

➢ Estimating direction of movement

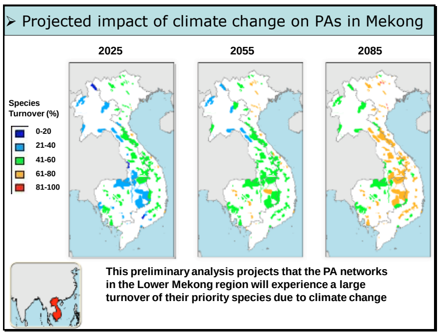


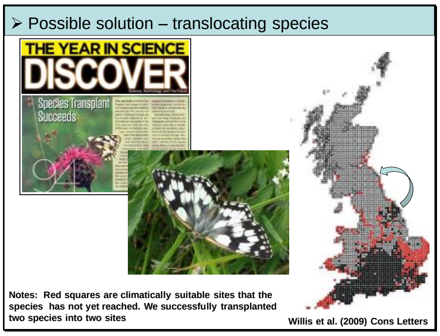
Projected impact of climate change on the biome-restricted species of the Indochinese tropical moist forests

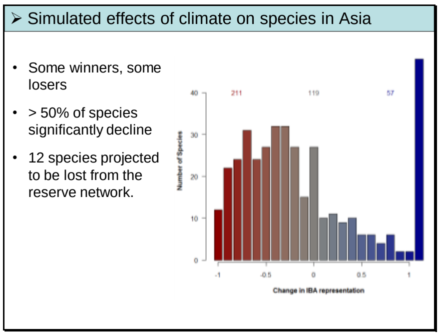
2000-2085

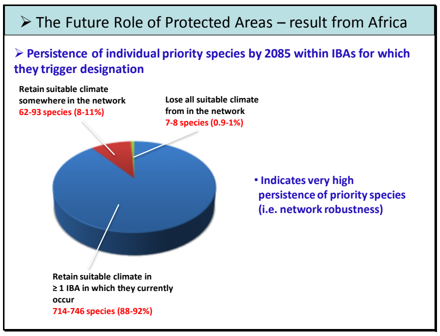


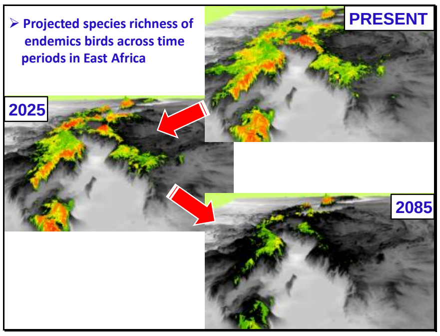
These maps show the combined distributions of the 39 bird species that are confined to the Indochinese tropical moist forests biome. They were generated by relating their current ranges to the present climate, and then applying these relationships to simulations of future climate to predict climate suitability for each species in 2025, 2055 and 2085.

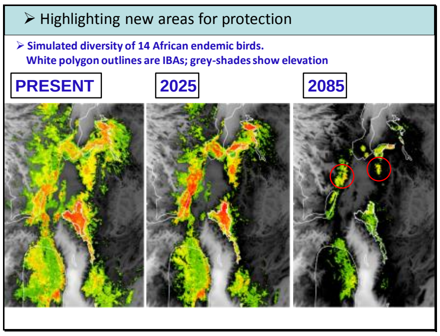

Projected impact of climate change on PAs in Mekong
2025
2055
2085
Species Turnover (%)
0-20
21-40
41-60
61-80
81-100
This preliminary analysis projects that the PA networks in the Lower Mekong region will experience a large turnover of their priority species due to climate change

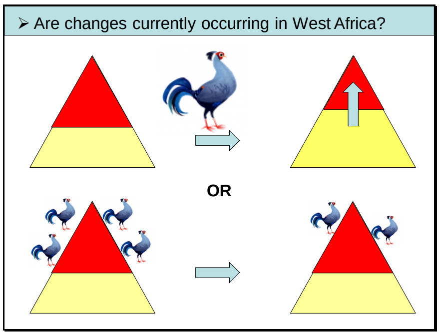

Possible solution – translocating species
THE YEAR IN SCIENCE
DISCOVER
Species Transplant Succeeds
Notes: Red squares are climatically suitable sites that the species has not yet reached. We successfully transplanted two species into two sites
Willis et al. (2009) Cons Letters


Simulated effects of climate on species in Asia
Some winners, some losers
> 50% of species significantly decline
12 species projected to be lost from the reserve network.
Number of Species
Change in IBA representation

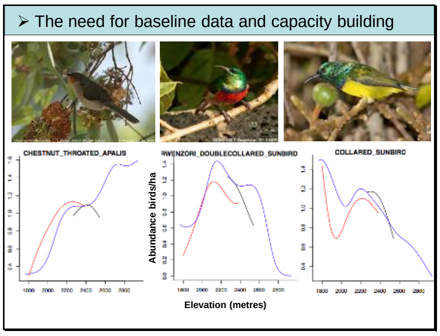

The Future Role of Protected Areas – result from Africa
Persistence of individual priority species by 2085 within IBAs for which they trigger designation
Retain suitable climate somewhere in the network
62-93 species (8-11%)
Lose all suitable climate from in the network
7-8 species (0.9-1%)
Indicates very high persistence of priority species (i.e. network robustness)
Retain suitable climate in ≥ 1 IBA in which they currently occur
714-746 species (88-92%)


Projected species richness of endemics birds across time periods in East Africa
PRESENT
2025
2085

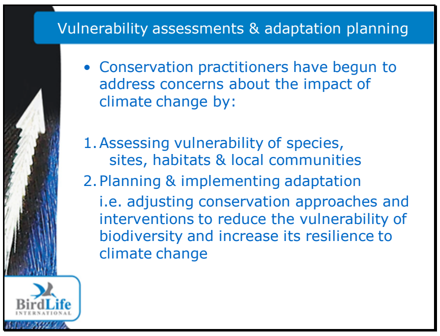

Highlighting new areas for protection
Simulated diversity of 14 African endemic birds.
White polygon outlines are IBAs; grey-shades show elevation
PRESENT
2025
2085

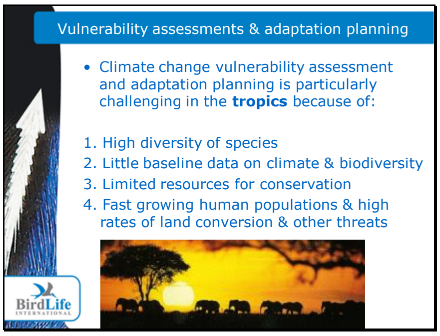

➢ Are changes currently occurring in West Africa?
OR

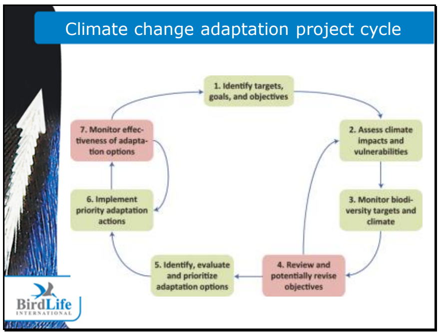

Thank you

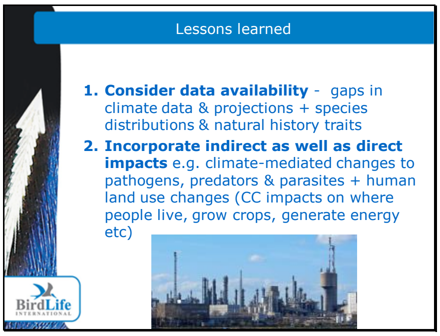

➢ The need for baseline data and capacity building
CHESTNUT_THROATED_APALIS
RWENZORI_DOUBLECOLLARED_SUNBIRD
COLLARED_SUNBIRD
Abundance birds/ha
Elevation (metres)

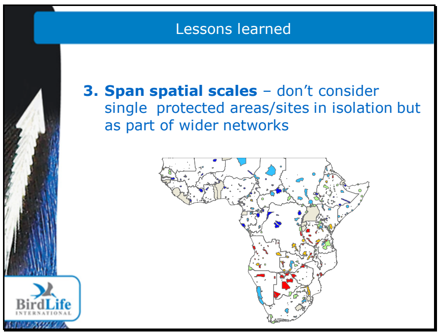
Chapter 4. Lessons learned from vulnerability assessment and adaptation planning in the tropics

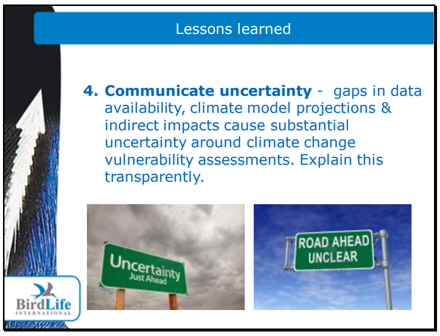


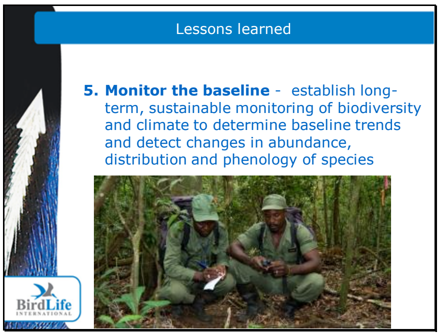


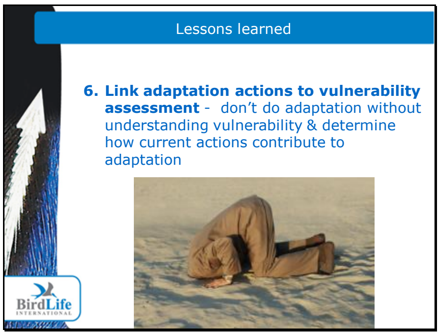


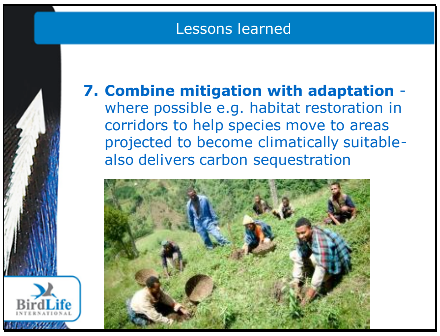

Lessons learned
1. Consider data availability - gaps in climate data & projections + species distributions & natural history traits
2. Incorporate indirect as well as direct impacts e.g. climate-mediated changes to pathogens, predators & parasites + human land use changes (CC impacts on where people live, grow crops, generate energy etc)
BirdLife


Lessons learned
3. Span spatial scales – don't consider single protected areas/sites in isolation but as part of wider networks
BirdLife


Lessons learned
4. Communicate uncertainty - gaps in data availability, climate model projections & indirect impacts cause substantial uncertainty around climate change vulnerability assessments. Explain this transparently.
Uncertainty
Just Ahead
ROAD AHEAD
UNCLEAR
BirdLife


Lessons learned
5. Monitor the baseline - establish long-term, sustainable monitoring of biodiversity and climate to determine baseline trends and detect changes in abundance, distribution and phenology of species
BirdLife


Lessons learned
6. Link adaptation actions to vulnerability assessment - don't do adaptation without understanding vulnerability & determine how current actions contribute to adaptation
BirdLife


Lessons learned
7. Combine mitigation with adaptation - where possible e.g. habitat restoration in corridors to help species move to areas projected to become climatically suitable- also delivers carbon sequestration
BirdLife

Lessons learned

8. Act despite uncertainty - implement "low regrets" adaptation strategies, which are robust to uncertainty, or to draw cautiously from generic best-practice recommendations

Lessons learned

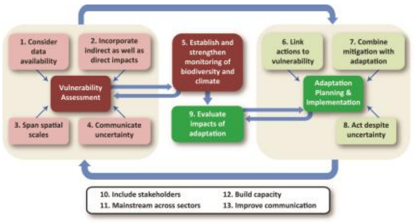
11. 'Mainstream' across sectors - biodiversity adaptation actions need to be embedded into energy, agriculture, forestry, fisheries, industry policies etc.

12. Build capacity to assess vulnerability, understand uncertainties, interpret assessments, & prioritize & implement adaptation actions

13. Communicate effectively e.g. with others working on related projects in the same region to maximize synergy, catalyze action, and reduce redundancy

Lessons learned

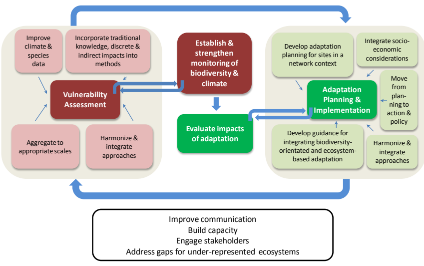
9. Monitor impact of actions implemented e.g. compare changes with control sites beyond the project area to provide scenarios of what would have happened in the absence of intervention



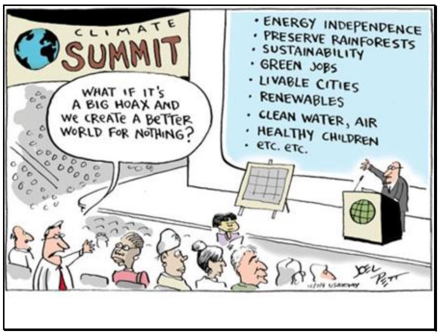
Lessons learned on vulnerability assessment, adaptation planning, implementation and monitoring

Lessons learned

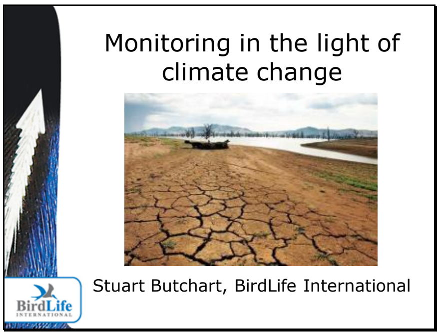
10. Engage stakeholders throughout - incorporate views of those likely to affect biodiversity targets and be affected by adaptation interventions, e.g. local communities, field practitioners, park staff, scientists, and policy makers

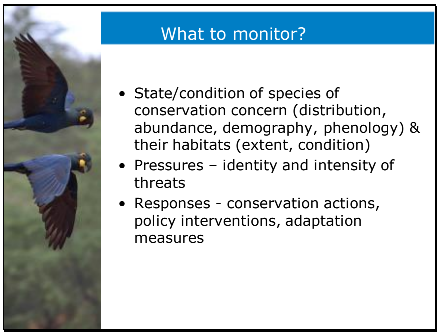


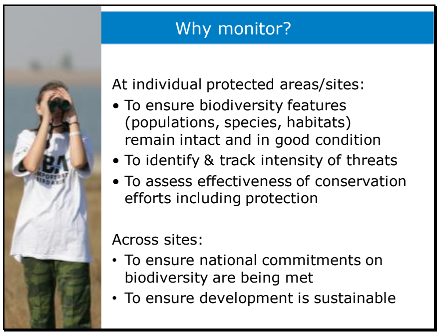
Priorities for further work on vulnerability assessment, adaptation planning, implementation and monitoring

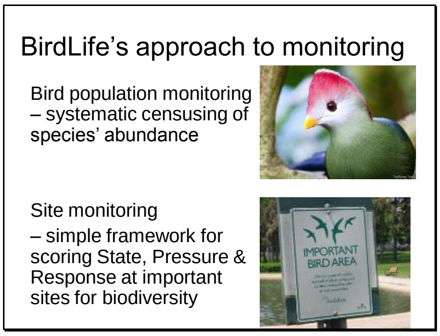

CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• etc. etc.

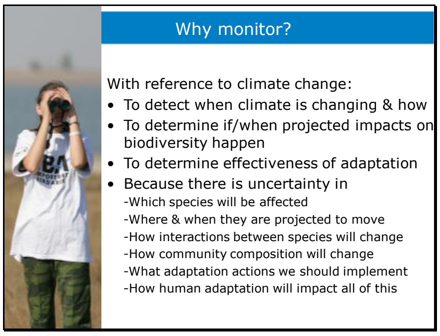
Chapter 5. Monitoring in the light of climate change











Ten reasons why birds are useful as indicators

1. Bird taxonomy is well known and relatively stable
2. Bird distribution, ecology and life history are well understood
3. Birds are generally easy to identify, survey and monitor, and there are a manageable number of species
4. Birds are diverse, found in nearly all habitats and occur across the world:
5. Bird habitat requirements are typically fairly specialised
6. Birds usually occupy high trophic levels in food webs and are relatively sensitive to environmental change:
7. Bird population trends often mirror those of other species
8. Bird distribution generally reflects that of many other wildlife groups
9. Birds are economically important
10. Birds are flagships for nature—they are popular, engage the public and resonate with decision-makers

….but they aren't perfect!

NatureKenya

BirdLife Botswana

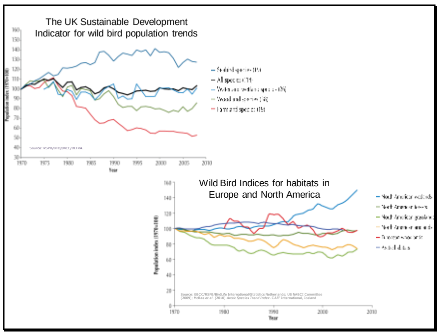
NatureUganda

NCF

Bird population monitoring

- Randomised or semi-randomised locations across country/region
- Stratified sampling
- Standardised methods: area-based censuses, line transects or point transects
- Trained volunteers
- Local & national coordinators
- Statistical analysis of data (software freely available online)

Important Bird Areas

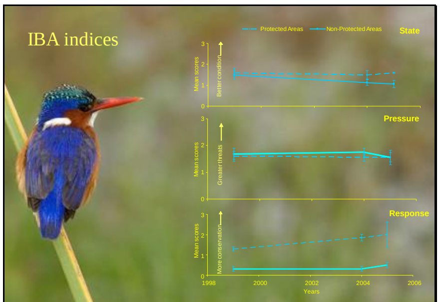


IBA monitoring

State (condition)

- Species: current population as % of reference population, based on population counts, surveys, proxies (e.g. nests at colonies)
- Habitat (as proxy for species population): current extent & quality vs reference levels
- Favourable, near favourable, unfavourable, very unfavourable
- Overall score = lowest score for any species of conservation concern for which site has been identified

IBA indices



Trends for Kenyan IBAs (n=36) for 1999-2005
Mwangi *et al.* (2010)

Pressure (threats)

- Which threats impact the site (IUCN classification scheme)
- Timing: past, present, near or distant future
- Scope: proportion of site/population affected: little (<10%), some (10-49%) majority (50-90%), all (>90%)
- Severity of declines/deterioration: no or little deterioration, slow deterioration, moderate deterioration, fast deterioration
- Impact calculated automatically & overall score = highest score for any threat

IBA monitoring

- Simple system suitable for application by local community groups, park staff, volunteers etc
- Requires limited training
- Produces adequate & robust data

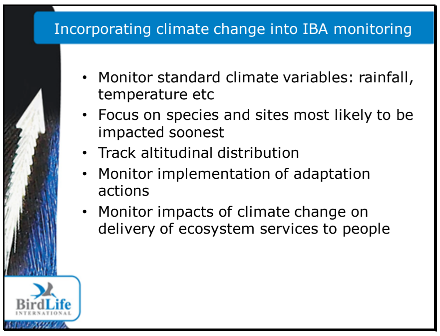
Responses (action)

- Conservation designation: all/most/some/none of site under appropriate protection designation
- Management planning:
  - a current and comprehensive plan exists
  - an out-of-date or incomplete plan exists
  - management planning is underway
  - no plan exists
- Conservation action:
  - all appropriate action is being taken
  - most of appropriate action is being taken
  - some limited action is being taken
  - no action is being taken

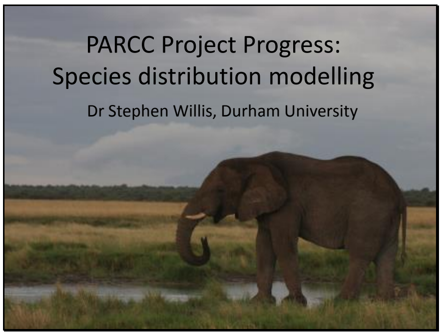
Final score: High, Medium, Low, Negligible

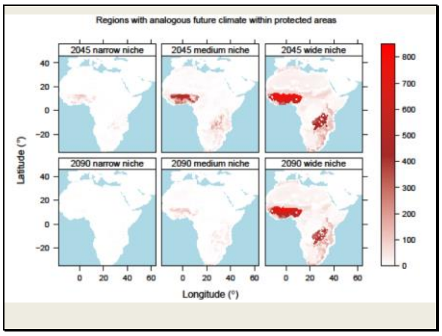
IBA monitoring & protected areas

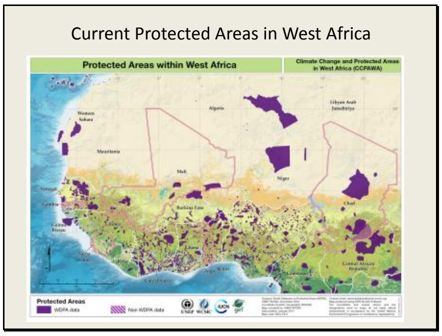
- Already being applied at some protected areas in West Africa
- Similar approaches could be used at other protected area for monitoring in the light of climate change

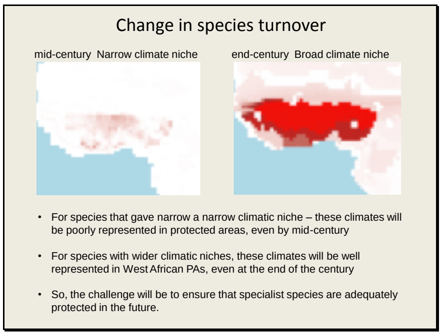

Incorporating climate change into IBA monitoring
• Monitor standard climate variables: rainfall, temperature etc
• Focus on species and sites most likely to be impacted soonest
• Track altitudinal distribution
• Monitor implementation of adaptation actions
• Monitor impacts of climate change on delivery of ecosystem services to people
BirdLife

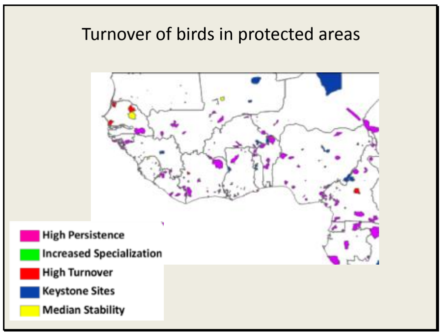
Chapter 6. PARCC Project Progress:Species distribution modelling

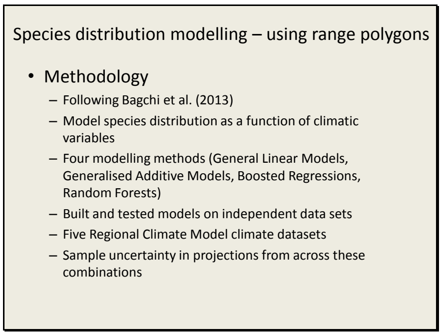


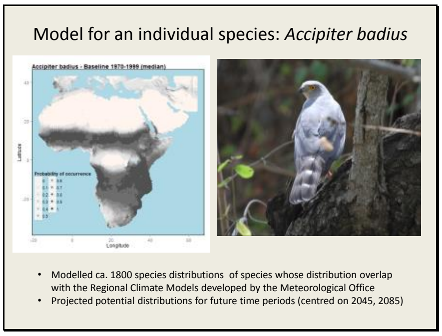


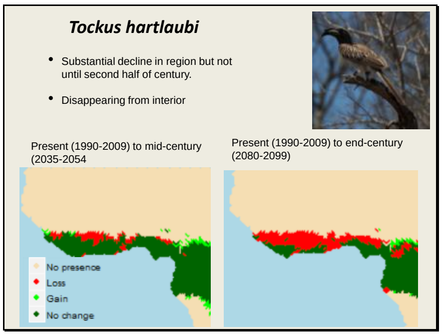


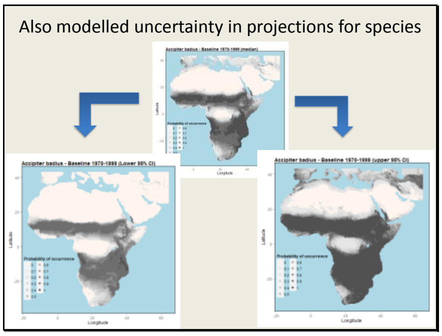


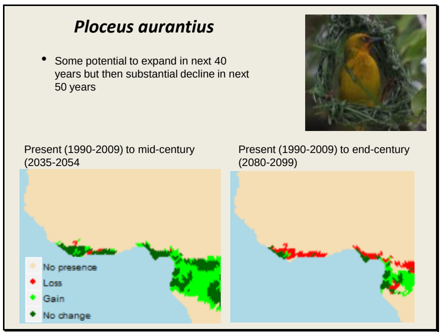


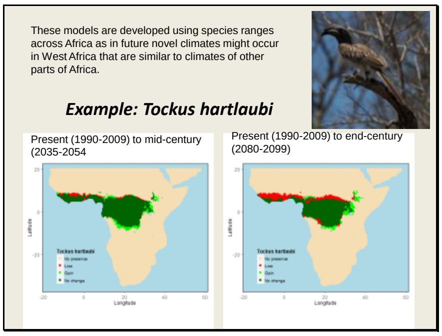


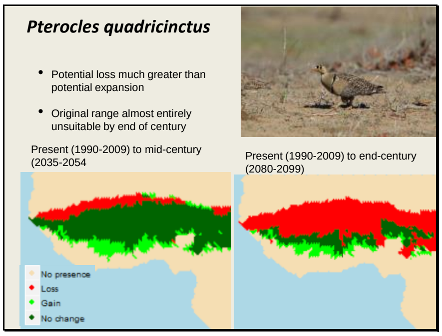

Model for an individual species: *Accipiter badius*
Accipiter badius - Baseline 1970-1999 (median)
Probability of occurrence
Longitude
Latitude
Modelled ca. 1800 species distributions of species whose distribution overlap with the Regional Climate Models developed by the Meteorological Office
Projected potential distributions for future time periods (centred on 2045, 2085)

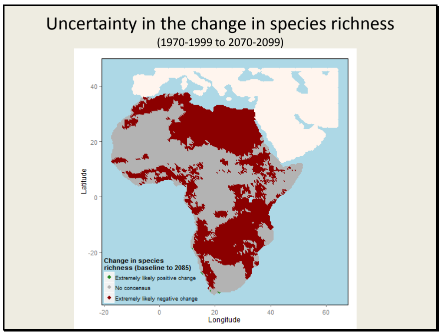

Tockus hartlaubi
Substantial decline in region but not until second half of century.
Disappearing from interior
Present (1990-2009) to mid-century (2035-2054
Present (1990-2009) to end-century (2080-2099)
No presence
Loss
Gain
No change

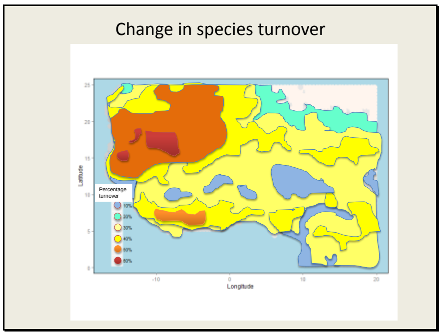

Also modelled uncertainty in projections for species
Accipiter badius - Baseline 1970-1999 (median)
Accipiter badius - Baseline 1970-1999 (Lower 95% CI)
Accipiter badius - Baseline 1970-1999 (upper 95% CI)
Probability of occurrence
Longitude
Latitude

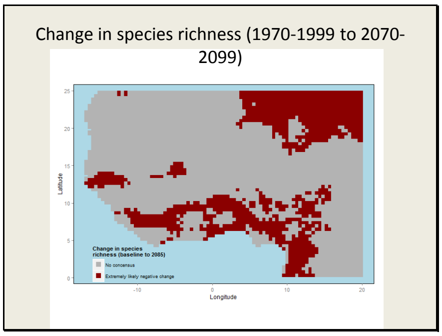

Ploceus aurantius
Some potential to expand in next 40 years but then substantial decline in next 50 years
Present (1990-2009) to mid-century (2035-2054
Present (1990-2009) to end-century (2080-2099)
No presence
Loss
Gain
No change

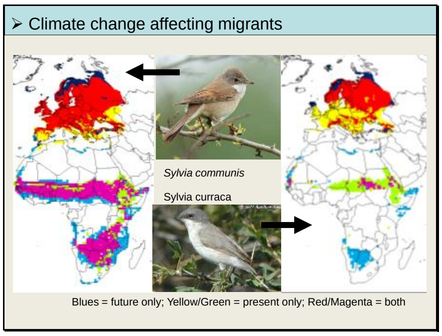

These models are developed using species ranges across Africa as in future novel climates might occur in West Africa that are similar to climates of other parts of Africa.
Example: *Tockus hartlaubi*
Present (1990-2009) to mid-century (2035-2054
Present (1990-2009) to end-century (2080-2099)
Tockus hartlaubi
No presence
Loss
Gain
No change
Longitude
Latitude

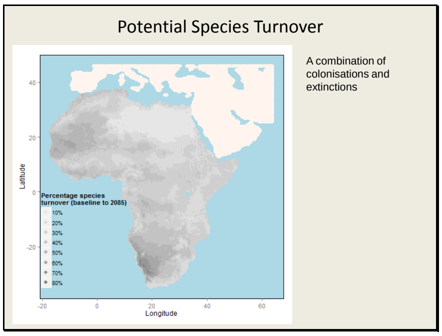

Pterocles quadricinctus
Potential loss much greater than potential expansion
Original range almost entirely unsuitable by end of century
Present (1990-2009) to mid-century (2035-2054
Present (1990-2009) to end-century (2080-2099)
No presence
Loss
Gain
No change

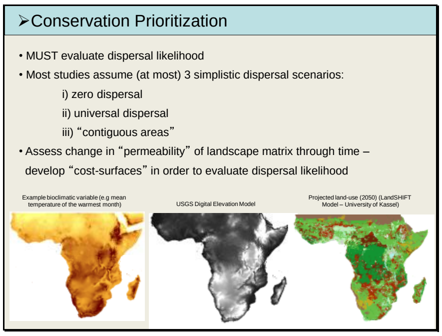

Uncertainty in the change in species richness
(1970-1999 to 2070-2099)
Latitude
Longitude
Change in species richness (baseline to 2085)
Extremely likely positive change
No concensus
Extremely likely negative change


Change in species turnover
Latitude
Longitude
Percentage turnover

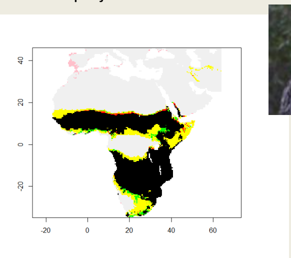

Change in species richness (1970-1999 to 2070-2099)
Latitude
Longitude
Change in species richness (baseline to 2085)
No concensus
Extremely likely negative change


Climate change affecting migrants
Sylvia communis
Sylvia curraca
Blues = future only; Yellow/Green = present only; Red/Magenta = both


Potential Species Turnover
A combination of colonisations and extinctions
Latitude
Longitude
Percentage species turnover (baseline to 2085)


Conservation Prioritization
• MUST evaluate dispersal likelihood
• Most studies assume (at most) 3 simplistic dispersal scenarios:
i) zero dispersal
ii) universal dispersal
iii) "contiguous areas"
• Assess change in "permeability" of landscape matrix through time – develop "cost-surfaces" in order to evaluate dispersal likelihood
USGS Digital Elevation Model

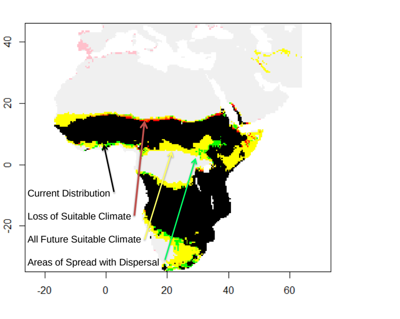
Next Steps: Use dispersal model to constrain future projections of suitable cells



- Annual dispersal
- update climate data during simulation
- Include landscape permeability
- Clip projected distribution using dispersal model

What next?

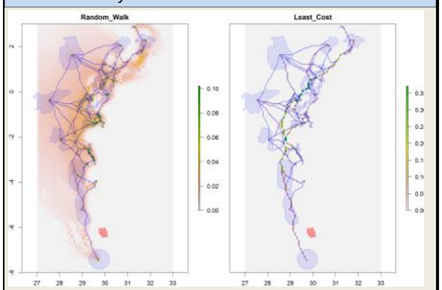
- Set results in a protected area context
- What do we want to know?
  - Vulnerable PAs (i.e. Hole et al. 2009)?
  - Vulnerable species (i.e. Araujo et al 2011)?
  - Impacts of climate AND landuse?



What next?

- All species – mammals, reptiles etc
- Changes in community turnover

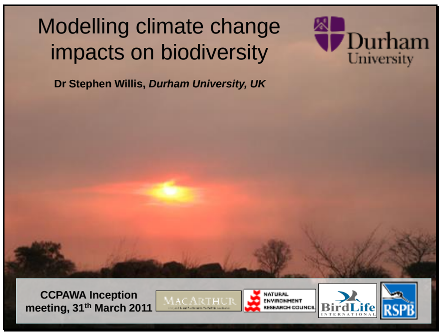
Connectivity in the Albertine Rift

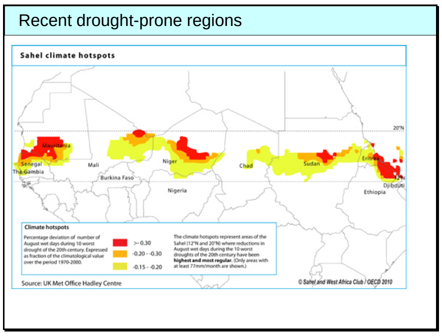


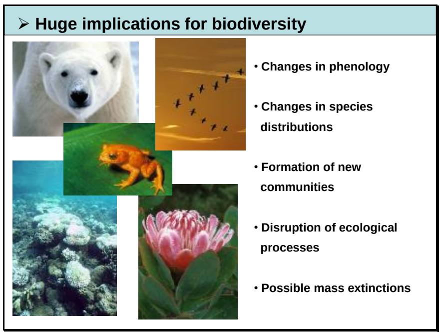
Measures of impacts of climate change - Protected Area Specific

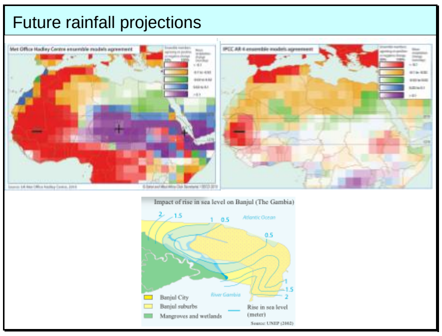
- Potential options:
  - Downscale climate data to fine resolution
    - Pros: tries to account for PA specific climate, which may differ from surrounding cell.
    - Cons: uncertainty in climate data likely to be high at these smaller scales (esp. precip.).
  - Weighted average of $50km^2$ cells overlapped by PA
    - Pros: conservative, transparent assumptions (i.e. climate suitability distributed evenly across cell, climate suitability in PA = climate suitability of cell(s)).
      - See Alagador et al. 2010 (Biological Conservation) & Araujo et al. 2011 (Ecology Letters).
    - Cons: no accounting for differences between PA and cell, i.e. PA lies at altitudinal extreme.
  - Compare altitudinal profile of PA with cell, highlight when PA lies in tails of altitudinal distribution
    - Pros: maintains pros of weighted average, but highlights PAs that are likely to be very different from cells in which they are embedded.
    - Cons: doesn't adjust projections for these differences, just highlights likely high uncertainty.

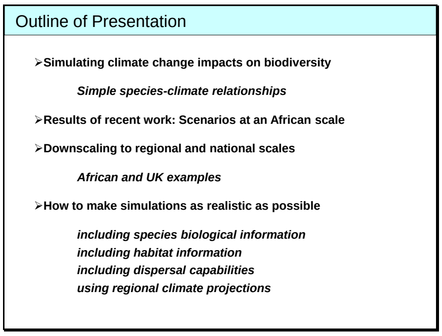
Chapter 7. Modelling climate change impacts on biodiversity

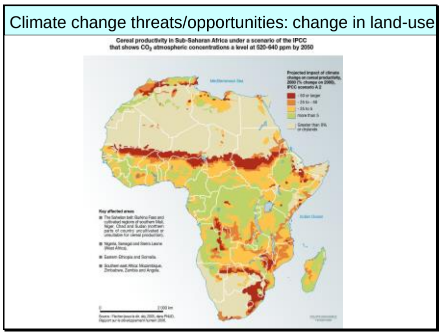






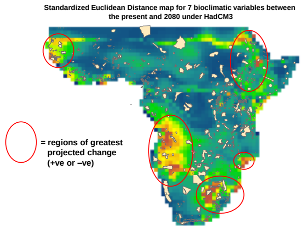




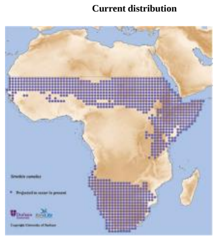


➢ Predicted Changes in Future Climate

Regions projected to experience the greatest change in climate parameters



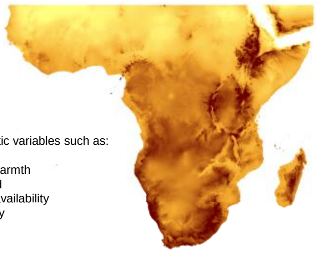
➢ Species-climate model - Ostrich



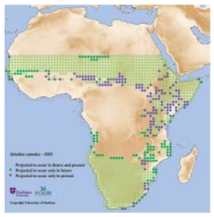
Relating species to climate

Use climatic variables such as:

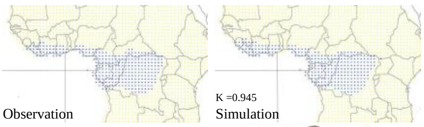
summer warmth
winter cold
moisture availability
seasonality



➢ Simulated future change - Ostrich



African bird simulations

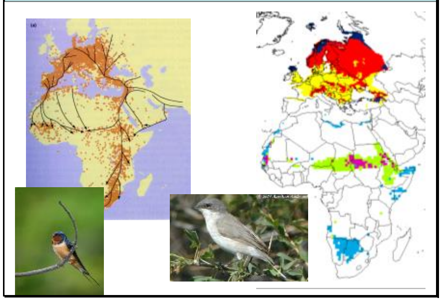


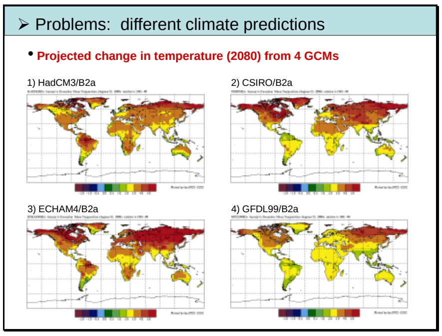
Long-tailed Hawk

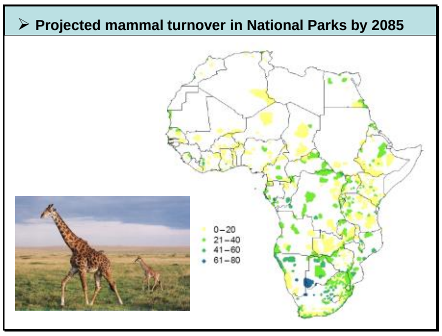
Urotriorchis macrourus

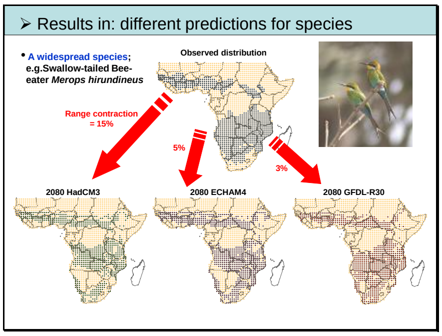
Huntley *et al.* (2006) *Ibis*

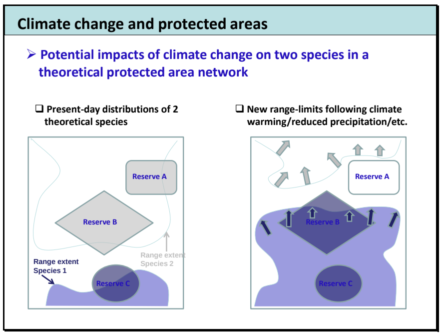
West Africa is also important for migratory species

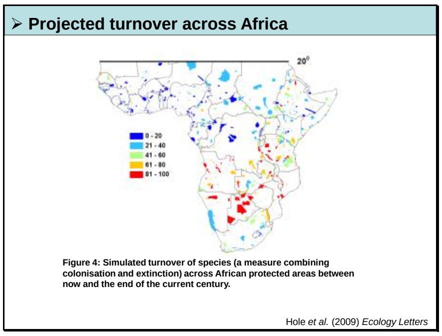


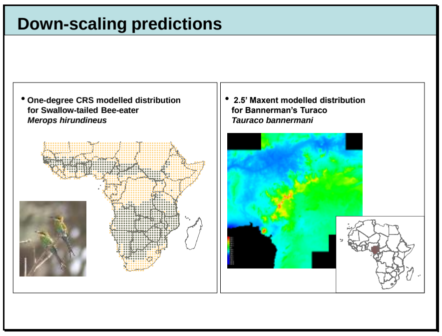

Problems: different climate predictions
Projected change in temperature (2080) from 4 GCMs
1) HadCM3/B2a
2) CSIRO/B2a
3) ECHAM4/B2a
4) GFDL99/B2a

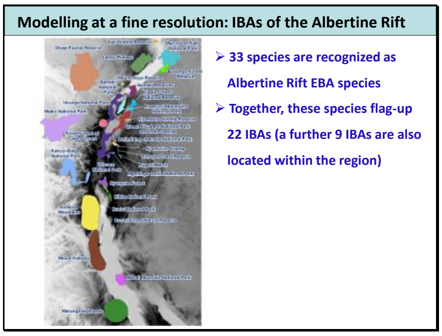

Projected mammal turnover in National Parks by 2085
0 – 20
21 – 40
41 – 60
61 – 80

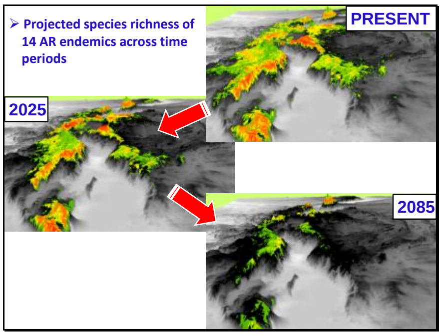

Results in: different predictions for species
A widespread species; e.g.Swallow-tailed Bee-eater Merops hirundineus
Observed distribution
Range contraction = 15%
5%
3%
2080 HadCM3
2080 ECHAM4
2080 GFDL-R30

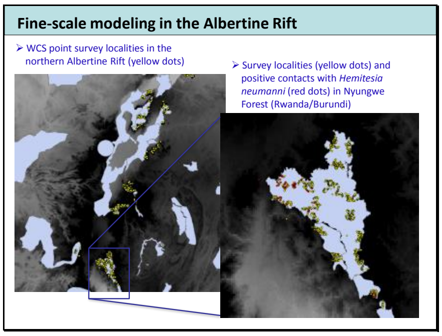

Climate change and protected areas
Potential impacts of climate change on two species in a theoretical protected area network
Present-day distributions of 2 theoretical species
New range-limits following climate warming/reduced precipitation/etc.
Reserve A
Reserve B
Reserve C
Range extent Species 1
Range extent Species 2

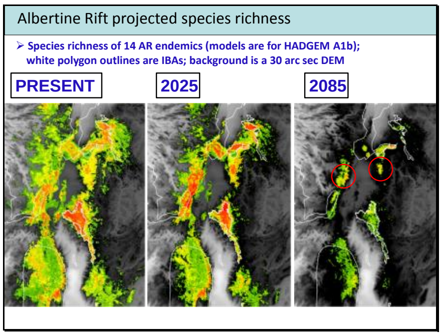

Projected turnover across Africa
0 - 20
21 - 40
41 - 60
61 - 80
81 - 100
Figure 4: Simulated turnover of species (a measure combining colonisation and extinction) across African protected areas between now and the end of the current century.
Hole et al. (2009) Ecology Letters

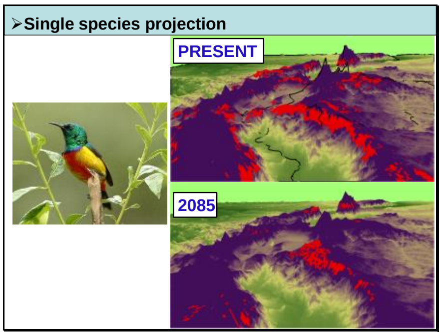

Down-scaling predictions
One-degree CRS modelled distribution for Swallow-tailed Bee-eater Merops hirundineus
2.5' Maxent modelled distribution for Bannerman's Turaco Tauraco bannermani

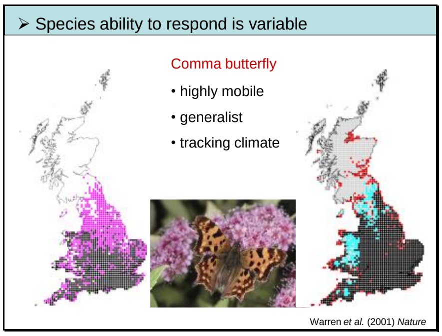

Modelling at a fine resolution: IBAs of the Albertine Rift
➢ 33 species are recognized as Albertine Rift EBA species
➢ Together, these species flag-up 22 IBAs (a further 9 IBAs are also located within the region)

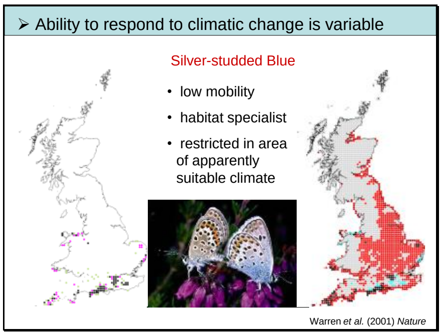

➢ Projected species richness of 14 AR endemics across time periods
PRESENT
2025
2085

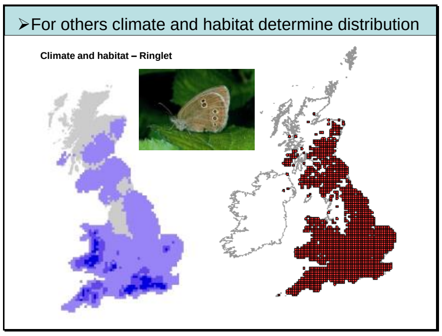

Fine-scale modeling in the Albertine Rift
➢ WCS point survey localities in the northern Albertine Rift (yellow dots)
➢ Survey localities (yellow dots) and positive contacts with Hemitesia neumanni (red dots) in Nyungwe Forest (Rwanda/Burundi)

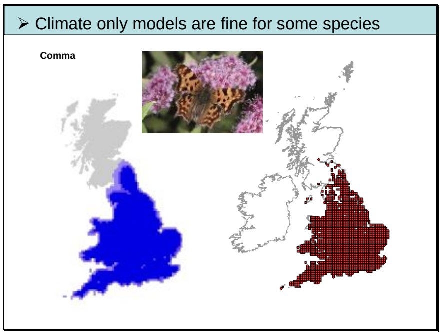

Albertine Rift projected species richness
➢ Species richness of 14 AR endemics (models are for HADGEM A1b); white polygon outlines are IBAs; background is a 30 arc sec DEM
PRESENT
2025
2085

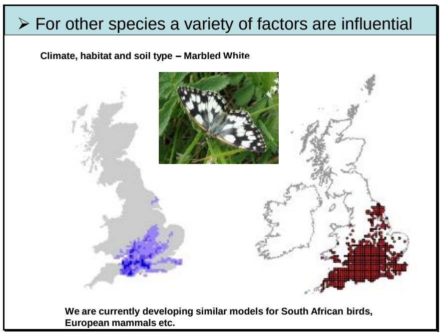

➢Single species projection
PRESENT
2085

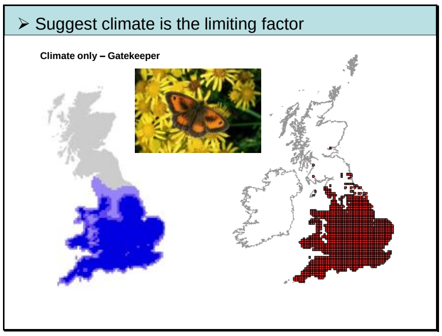

➢ Species ability to respond is variable
Comma butterfly
• highly mobile
• generalist
• tracking climate
Warren et al. (2001) Nature

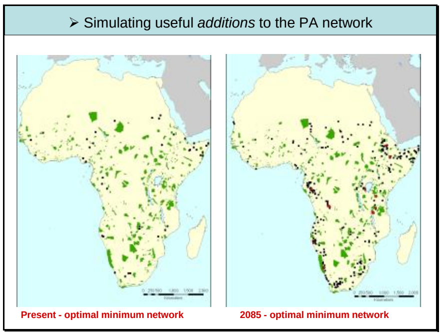

Ability to respond to climatic change is variable
Silver-studded Blue
low mobility
habitat specialist
restricted in area of apparently suitable climate
Warren et al. (2001) Nature


For others climate and habitat determine distribution
Climate and habitat – Ringlet


Climate only models are fine for some species
Comma

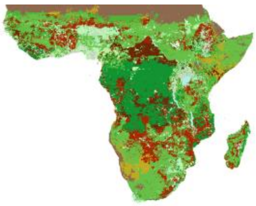

For other species a variety of factors are influential
Climate, habitat and soil type – Marbled White
We are currently developing similar models for South African birds, European mammals etc.


Suggest climate is the limiting factor
Climate only – Gatekeeper


Simulating useful additions to the PA network
Present - optimal minimum network
2085 - optimal minimum network

➢ Include projected changes in land-use

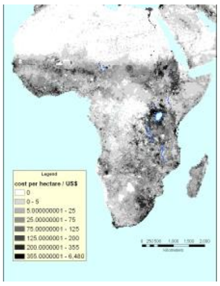
(LandSHIFT Model – University of Kassel)



➢ 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

➢ Incorporating land value into RSAs



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