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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

- Climate change is already occurring
  - Projected change in annual mean temperature (2080s under HadCM3/B2)

- Some species are already responding
  - Species moving northward and uphill in UK
  
- Is the same thing happening in Africa?
  
**Guess the Country?**
We can predict what might happen as climate changes

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

Relate the current distribution to climate

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

Test the ability to predict current distribution

- Assess the agreement between the observed and the simulated distribution

Use the relationship to predict what might happen in future

- Observation
- Simulation

- K = 0.813
  - Burchell’s Courser
  - Cursorius rufus

- K = 0.945
  - Long-tailed Hawk
  - Urotriorchis macrourus

African bird simulations

Huntley et al. (2006) Ibis

African bird simulations

Huntley et al. (2006) Ibis
High latitude

High elevation

2085 Range Shifts for Trigger Species for Individual EBAs

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

(1) Simulating range changes that have recently occurred

Simulating recent changes in population sizes

2 new UK breeding bird species in 2010

By end of current century we simulate:
- suitable climate for 44 new species,
- loss of climate for 10 species

Since 1990:
- 9 of the 44 projected species have bred for first time
- 5 have shown signs of breeding.

i.e. over 25% of the species that we project as potential colonists have already shown signs of breeding in the first decade of the current century.
25-yr population trends match climate change trends:

Green et al. (2008) Biology Letters

Oriolus oriolus
Plectrophenax nivalis

Calculating a climate change index

Gregory, Willis et al. (2009) PLoS ONE

Indicators of population change

Gregory, Willis et al. (2009) PLoS ONE

Calculating a summary index of population changes

Fine-scale modeling in 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 modelling

Projected species richness of 14 AR endemics across time periods:

PRESENT
2025
2085

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
Chapter 2. An introduction to climate change vulnerability assessments

Climate change vulnerability assessments

- Adaptation is necessary to cope with these changes

Climate change vulnerability assessments

- To plan & implement adaptation we need to understand likely impacts of climate change
- This requires an assessment of vulnerability
- Here we focus on vulnerability assessment for biodiversity

Climate change vulnerability assessments

- Climate change is happening: people, communities, species and ecosystems are already experiencing its impacts

Climate change vulnerability assessments

- Species are the ‘nuts and bolts’ for biodiversity conservation
- Habitats and ecosystems are communities of species – understanding how climate change will impact communities requires an understanding of how it will impact the component species
- So how can we assess climate change vulnerability of species?
Climate change vulnerability assessments

Two approaches:
1. Species Distribution Modelling ("Climate envelope modelling")
2. Trait-based Assessments

Combine data on distribution of species & climate to model simulated occurrence.

Observed distribution

Future potential distribution

Use models of projected climate to identify future suitable climate space.

Swallow-tailed Bee-eater
Merops hirundineus

Range contraction = 3%

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

0 - 20
21 - 40
41 - 60
61 - 80
81 - 100

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
**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.

**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 (and therefore how they may be helped to adapt)

**What is the spatial pattern?**

- Sensitivity
- Exposure
- Unadaptiveness

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

**Total no. species**

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
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<tbody>
<tr>
<td>Sensitive</td>
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<tr>
<td>Adapted</td>
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<tr>
<td>High risk</td>
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**Proportion of species**

<table>
<thead>
<tr>
<th>Category</th>
<th>Proportion</th>
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<tbody>
<tr>
<td>Sensitive</td>
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<td>Adapted</td>
<td></td>
</tr>
<tr>
<td>High risk</td>
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</tbody>
</table>
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.
Chapter 3. Species-climate models: How we produce them and how we can use them

Topics I will cover today:

- Relating the distribution of wildlife to climate
- Predicting how species might respond to future climate change: species distribution models
- The ways in which species distribution models can be used to prepare for the future
- The importance of monitoring for change

Different Biomes:

- Characterised by different combinations of climate variables
  - e.g. deserts: very low precipitation, in combination with high temperatures

We know how species have responded before

Notes: From preserved pollen (plant remains) in e.g. soil, we can see how trees colonised Europe over the last 10,000 years as the climate changed.
but we are altering the climate at an alarming rate

Notes: Recent CO₂ 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.

Many species are already responding

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.

So, how well do climate simulations work?

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

Global climate change projections

Notes: Projected change in annual mean temperature (between now and 2085) from four different climate prediction models:
1) HadCM3/B2a
2) CSIRO/B2a
3) ECHAM4/B2a
4) GFDL99/B2a

Regional climate models: an example for temperature

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

Regional precipitation projections: 2010-2090

Notes: Average changes in precipitation are less severe.
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%).

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'.

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'.

Present climate suitability

Notes: Suitability models can be applied to the current climate, as displayed above...

Simulating current present distribution

Notes: Suitability can be converted to simulated presence of a species and compared to the known range.
Future climate suitability (2085)

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.

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.

Evidence that these models are useful ...

Accounting for uncertainty

Different models produce different simulations

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

Range contraction
= 15%
5%
3%
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.

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)

Regional scale models

Generate future climate projections – PRECIS Regional Climate Model

Uncertainty in the change in species richness

Notes: In this project we will use ‘regional climate simulations’ which better simulate local patterns across landscapes – ideal for regions like West Africa.
**Example - Tockus hartlaubi**

- Substantial decline in region but not until second half of century
- Disappearing from interior

**Example - Ploceus aurantius**

- Some potential to expand in next 40 years but then substantial decline in next 50 years

**Example - Pterocles quadricinctus**

- Potential loss much greater than potential expansion
- Original range almost entirely unsuitable by end of century

**Potential Species Turnover**

A measure of both new species colonising and area plus species disappearing from an area. A measure of change.

**Simulated species turnover across West Africa**

Change in species richness (1970-1999 to 2070-2099)
Next steps for species modelling:
Repeat analyses for mammals, reptiles, amphibians …

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

Climate suitability x Habitat availability x Dispersal = Realistic changes

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

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 analyses
- How effective will the network be under climate change – what modifications are required?

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

Colonists and movement
Hole et al. (2009) Ecology Letters

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.

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 to provide more realistic estimates
3. Combining such changes with other land-use changes, e.g., agriculture, urbanization

Categorize changes in protected area assemblages

- Proportion of priority species emigrating and colonizing; n = 803 IBAs
- Hole et al. (2011) Cons Biol

Estimating direction of movement

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

Projected impact of climate change on the Indochinese tropical moist forests

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 projections of future climate to predict climate suitability for each species in 2025, 2055 and 2085.
This preliminary analysis projects that the PA networks in the Upper Mekong region will experience a large turnover of their priority species due to climate change.

- Projected impact of climate change on PAs in Mekong
  - 2025
  - 2055
  - 2085

- 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.

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

- The Future Role of Protected Areas – result from Africa
  - Highlighting new areas for protection
  - Simulated diversity of 14 African endemic birds.
Are changes currently occurring in West Africa?

OR

The need for baseline data and capacity building

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

Lessons learned from vulnerability assessment and adaptation planning in the tropics

Stuart Butchart, BirdLife International

Vulnerability assessments & adaptation planning:

• Conservation practitioners have begun to address concerns about the impact of climate change by:
  1. Assessing vulnerability of species, sites, habitats & local communities
  2. Planning & implementing adaptation i.e. adjusting conservation approaches and interventions to reduce the vulnerability of biodiversity and increase its resilience to climate change

Climate change vulnerability assessment and adaptation planning is particularly challenging in the tropics because of:

1. High diversity of species
2. Little baseline data on climate & biodiversity
3. Limited resources for conservation
4. Fast growing human populations & high rates of land conversion & other threats

By 2011, the MacArthur Foundation had invested >$6.5 million in climate change adaptation projects in Africa, Asia & Americas to support efforts to adapt conservation strategies to climate change.

In March 2012, MacArthur, BirdLife, NatureServe & IUCN co-hosted a workshop to convene project leaders to share lessons learned, synthesize best-practice & identify future priorities.

5-day workshop in Colombia
Representatives of 23 projects led by 16 different organizations with a combined budget of c.$8 million

Climate change adaptation project cycle

1. Identify risks, gaps & objectives
2. Identify & assess climate change threats
3. Assess climate impacts & vulnerabilities
4. Identify options for adaptation
5. Improve adaptive capacity & resilience
6. Monitor & evaluate & adapt planning & interventions
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.)

Lessons learned
3. Span spatial scales – don’t consider single protected areas/sites in isolation but as part of wider networks
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
6. Link adaptation actions to vulnerability assessment - don’t do adaptation without understanding vulnerability & determine how current actions contribute to adaptation
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
8. Act despite uncertainty - implement "low regrets" adaptation strategies, which are robust to uncertainty, or to draw cautiously from generic best-practice recommendations.

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.

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.

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 on vulnerability assessment, adaptation planning, implementation and monitoring.

Priorities for further work on vulnerability assessment, adaptation planning, implementation and monitoring.
Chapter 5. Monitoring in the light of climate change

Monitoring in the light of climate change

Stuart Butchart, BirdLife International

Why monitor?

At individual protected areas/sites:
- To ensure biodiversity features (populations, species, habitats) remain intact and in good condition
- To identify & track intensity of threats
- To assess effectiveness of conservation efforts including protection

Across sites:
- To ensure national commitments on biodiversity are being met
- To ensure development is sustainable

Why monitor?

With reference to climate change:
- To detect when climate is changing & how
- To determine if/when projected impacts on biodiversity happen
- To determine effectiveness of adaptation
- Because there is uncertainty in:
  - Which species will be affected
  - Where & when they are projected to move
  - How interactions between species will change
  - How community composition will change
  - What adaptation actions we should implement
  - How human adaptation will impact all of this

What to monitor?

- State/condition of species of conservation concern (distribution, abundance, demography, phenology) & their habitats (extent, condition)
- Pressures – identity and intensity of threats
- Responses - conservation actions, policy interventions, adaptation measures

BirdLife’s approach to monitoring

Bird population monitoring – systematic censusing of species’ abundance

Site monitoring – simple framework for scoring State, Pressure & Response at important sites for biodiversity

Why birds?
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!

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

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

Responses (action)

- Conservation designation: all/most/some/none of site under appropriate protection designation
- Management planning:
  - a current and comprehensive 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 indices

- Trends for Kenyan IBAs (n=36) for 1999-2005
- Mwangi et al. (2010)
- Mean scores
- Protected Areas vs Non-Protected Areas
- Mean scores for Pressure, Response, State
- Greater threats Better condition More conservation
- Mean scores

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

Simple system suitable for application by local community groups, park staff, volunteers etc
- Requires limited training
- Produces adequate & robust data
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
Chapter 6. PARCC Project Progress: Species distribution modelling

Current Protected Areas in West Africa

Change in species turnover

Turnover of birds in protected areas

Species distribution modelling – using range polygons

• Methodology
  — Following Bagchi et al. (2013)
  — Model species distribution as a function of climatic variables
  — Four modelling methods (General Linear Models, Generalised Additive Models, Boosted Regressions, Random Forests)
  — Built and tested models on independent data sets
  — Five Regional Climate Model climate datasets
  — Sample uncertainty in projections from across these combinations

• For species that gave narrow climatic niche – these climates will be poorly represented in protected areas, even by mid-century
• For species with wider climatic niches, these climates will be well represented in West African PAs, even at the end of the century
• So, the challenge will be to ensure that specialist species are adequately protected in the future.

Species distribution modelling – using range polygons

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  — Following Bagchi et al. (2013)
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• For species with wider climatic niches, these climates will be well represented in West African PAs, even at the end of the century
• So, the challenge will be to ensure that specialist species are adequately protected in the future.

A 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).

Also modelled uncertainty in projections for species.

Example: *Tockus hartlaubi*

- Potential loss much greater than potential expansion.
- Original range almost entirely unsuitable by end of century.

Example: *Ploceus aurantius*

- Some potential to expand in next 40 years but then substantial decline in next 50 years.

Example: *Pterocles quadricinctus*

- Substantial decline in region but not until second half of century.
- Disappearing from interior.

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.
Uncertainty in the change in species richness (1970-1999 to 2070-2099)

Change in species turnover

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

Potential Species Turnover

Sylvia communis
Blues = future only; Yellow/Green = present only; Red/Magenta = both

Climate change affecting migrants

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

Example bioclimatic variable (e.g. mean temperature of the warmest month)
Projected land-use (2050) (LandSHIFT Model – University of Kassel)
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 flora (i.e. Hole et al. 2009)?
  - Vulnerable species (i.e. Araujo et al. 2011)?
  - Impacts of climate and biodiversity?

Current Distribution
Loss of Suitable Climate
All Future Suitable Climate
Areas of Spread with Dispersal

What next?

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

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 land use?

Measures of impacts of climate change - Protected Area Specific

- Potential options:
  - Downscale climate data to fine resolution
    - Pros: easier to access for the specific protected area; likely differs from surrounding cells.
    - Cons: uncertainty in climate data likely to be high at these smaller scales (e.g. county).
  - Weighted average of climate cells overlapped by PA
    - Pros: more conservative, simple assumptions (i.e. climate suitability distributed evenly across the PA).
    - Cons: may overestimate the differences between PA and cell, i.e., PA lies at altitudinal extreme.
  - Compare altitudinal profiles of PA with cell, highlight when PA lies in tails of altitudinal distribution
    - Pros: represents potential range change, but highlights the extreme likely to be very different depending on the PA’s elevation.
    - Cons: doesn’t adjust projections for these differences, only highlights likely high uncertainty.
Chapter 7. Modelling climate change impacts on biodiversity

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
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 projected to experience the greatest change in climate parameters = regions of greatest projected change (+ve or –ve)

Use climatic variables such as:
- summer warmth
- winter cold
- moisture availability
- seasonality

Species - climate model - Ostrich

Current distribution

Simulated future change - Ostrich

West Africa is also important for migratory species

African bird simulations

Observation: K = 0.945
Simulation: Long-tailed Hawk - Urotriorchis macrurus

Huntley et al. (2006) Ibis

African bird simulations

Observation: K = 0.945
Simulation: Long-tailed Hawk - Urotriorchis macrurus

Huntley et al. (2006) Ibis
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

Range contraction:

- 2080 HadCM3: 15%
- 2080 ECHAM4: 5%
- 2080 GFDL-R30: 3%

Projected turnover across Africa

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 distribution 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 IBA 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:

- Species ability to respond is variable.

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.
- 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
  
  - Climate and habitat determine distribution
  
  - For other species a variety of factors are influential
  
  - Suggest climate is the limiting factor
  
  - Simulating useful additions to the PA network

We are currently developing similar models for South African birds, European mammals etc.
## Species Distribution Modelling

### Include projected changes in land-use

(LandSHIFT Model – University of Kassel)

- 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)
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### 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
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