WYSS ACADEMY FOR NATURE

UNIVERSITÄT BERN

OESCHGER CENTRE CLIMATE CHANGE RESEARCH

Combining Future Projections of Land-Use and Climate Change Impacts on Biodiversity

Chantal Hari

Thomas Hickler, Christian Hof, Christopher Reyer, Inne Vanderkelen, Alke Voskamp, Markus Fischer, Édouard Davin

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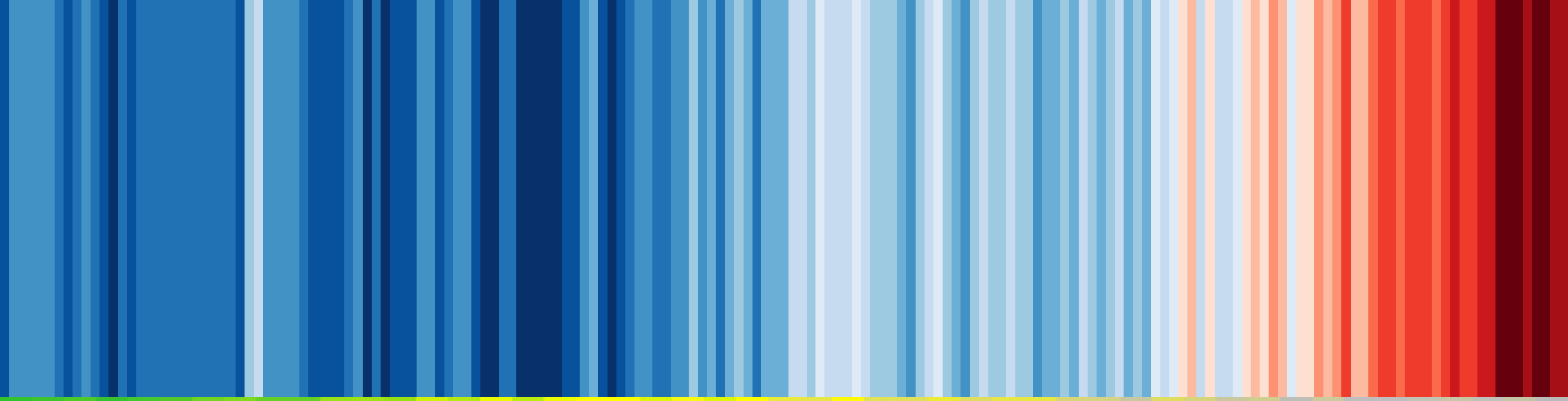
Prague, 07.06.2023



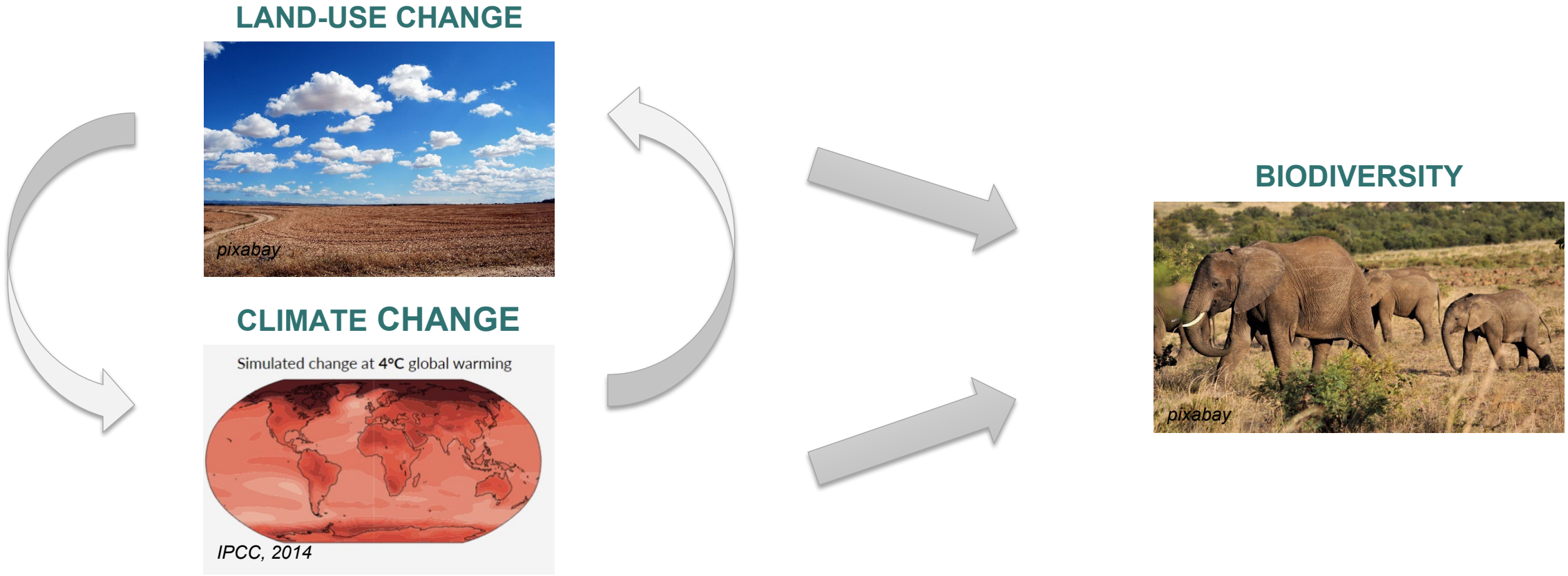
- “**Climate change** has altered marine, terrestrial and freshwater ecosystems all around the world (very high confidence).” [IPCC, AR6, 2022]
- “**Land-use and land cover change** reduces and fragments habitats and is currently the leading cause of terrestrial biodiversity loss.” [IPBES-IPCC, 2021]

Global biodiversity. 69% decline 1970 – 2018

From biodiversitystripes.info Data: LPI 2022. Living Planet Index http://stats.livingplanetindex.org/

The Combined Impact of Climate Change and Land-Use Change Projections on Biodiversity

Research Question: How do the combined stressors of climate and land-use change impact terrestrial biodiversity on a global scale under different scenarios and in different points in the future?



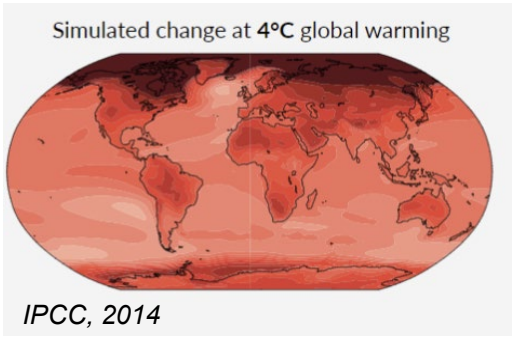
Research Gap: Land-use trajectories are mostly missing in climate change impact studies on biodiversity.

Methods Overview

1

ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

CLIMATE CHANGE



IPCC, 2014

Species Distribution Model (SDM)

Species range maps

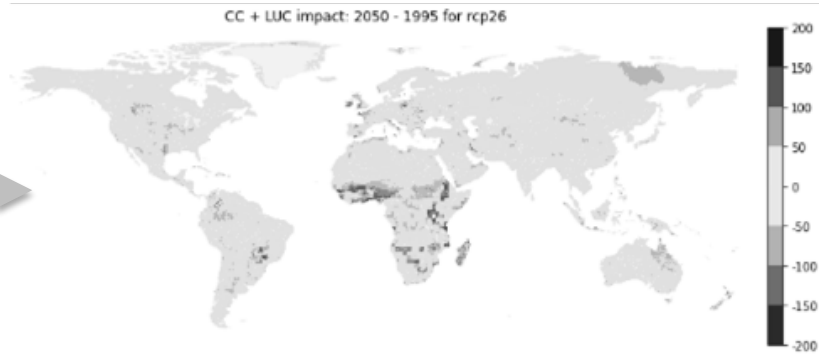
RED LIST

Probability of Occurrence

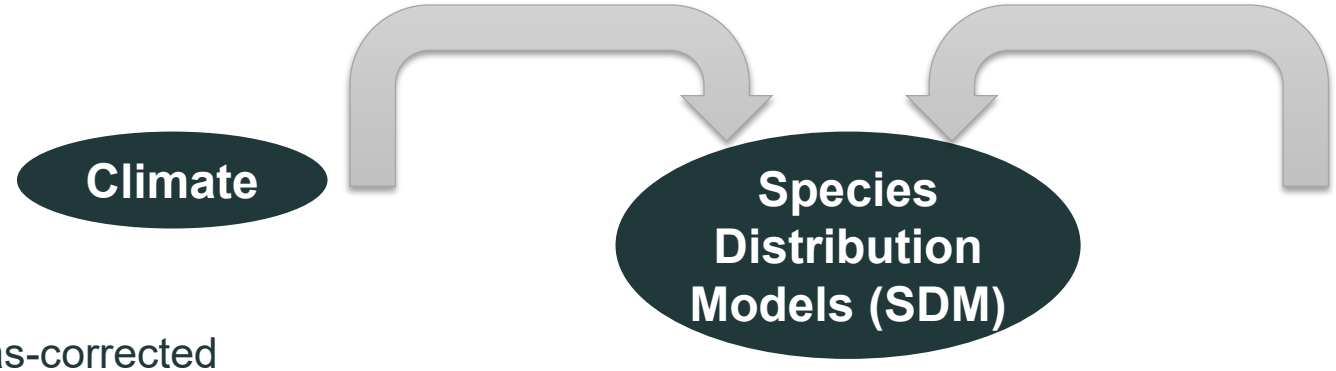
2

IUCN Habitat Classifications

LAND-USE CHANGE



Methods and Data for Species Distribution Models



- **ISIMIP2b:**
- **Current**: bias-corrected meteorological forcing dataset EWEMBI from 1980 - 2009
- **Future**: bias-corrected global climate data
  - for **four GCMs** (GFDL-ESM2M, IPSL-CM5A-LR, MIROC5, HadGEM2-ES) and
  - **two climate scenarios** (RCP2.6,RCP6.0),
  - at **0.5° x 0.5°** resolution
- **Bioclimatic variables**: annual mean temperature, temperature seasonality, annual precipitation, precipitation seasonality

- General Additive Models (GAM)
- Generalized Boosted Regression Model (GBM)

Probability of Occurrence

- 3941 Mammals
- 2705 Amphibians
- 6363 Reptiles
- 7262 Birds

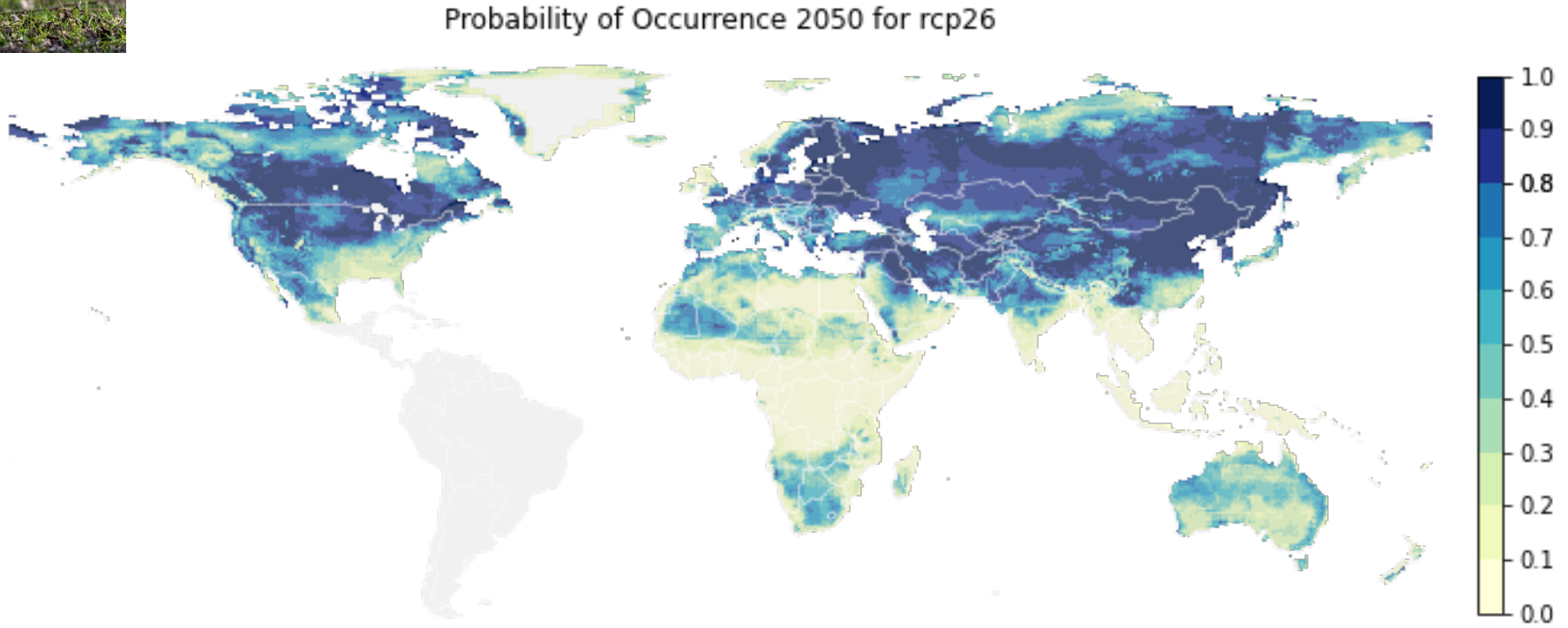
- IUCN Red List of Threatened Species
  - Mammals
  - Amphibians
  - Reptiles
- Birdlife International and NatureServe
  - Birds

Hof et al. 2018
Biber et al. 2023

SDM Output: Probability of Occurrence in 2050

Vulpes vulpes

RCP2.6



Methods Overview

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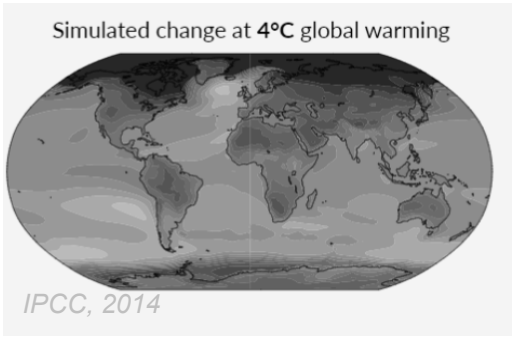

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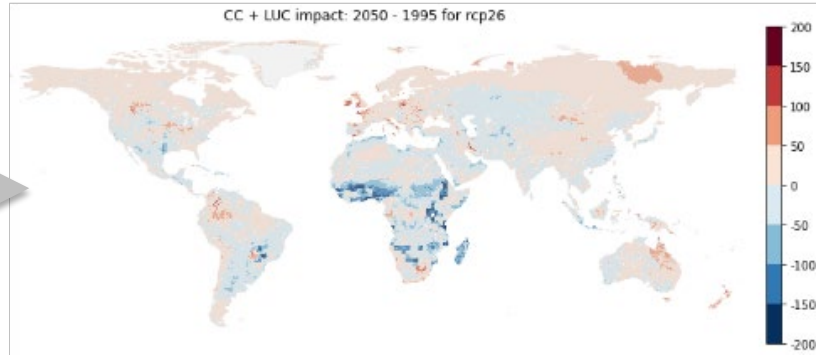
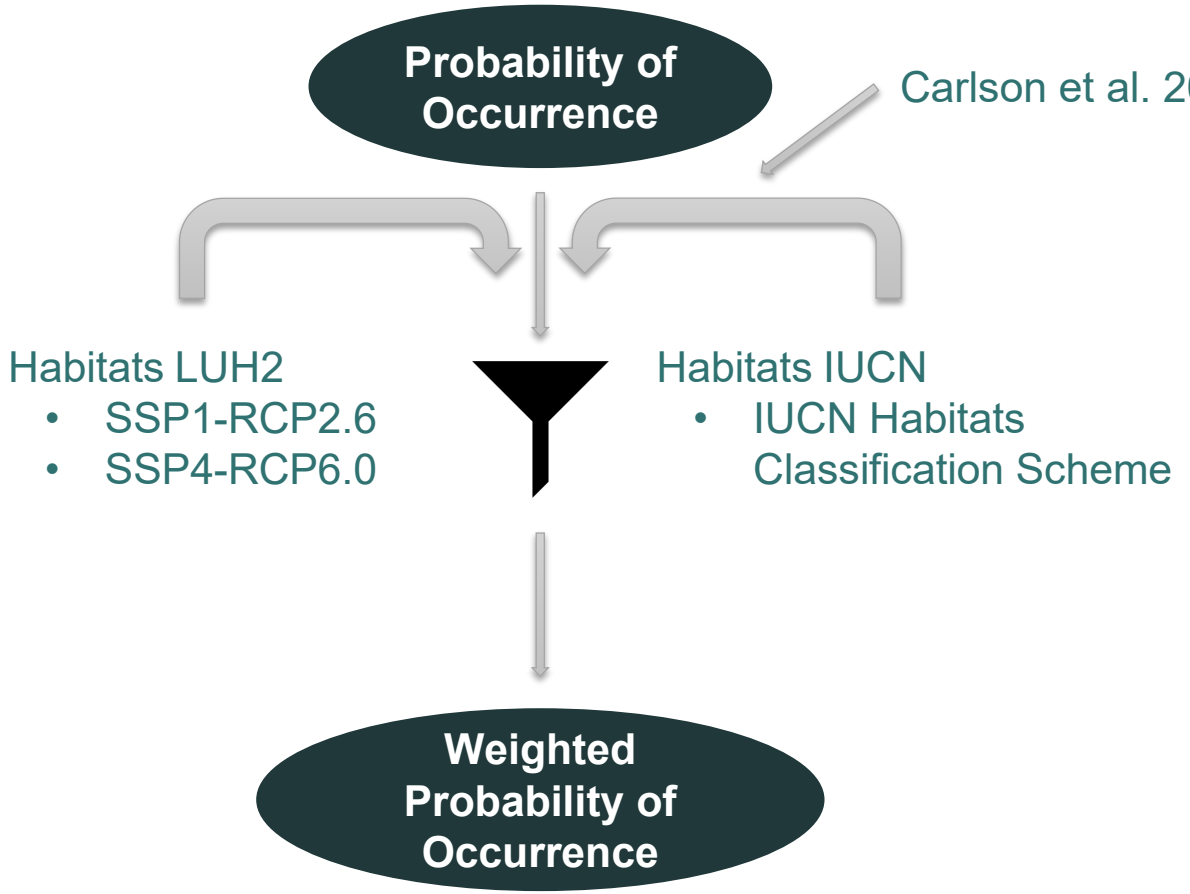


Applying a Land-Use Change Filter



$$LUC\ Weighted\ Probability\ of\ Occurrence = Probability\ of\ Occurrence\ x\ Fraction\ of\ Grid\ Cell$$

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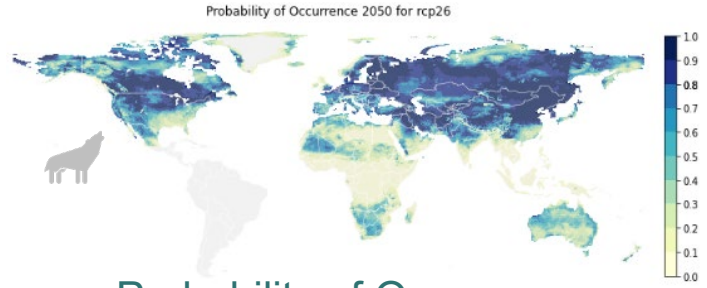

Probability of Occurrence

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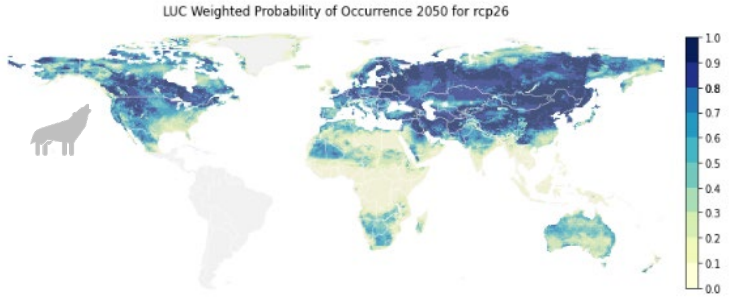
Habitats LUH2

Habitats IUCN



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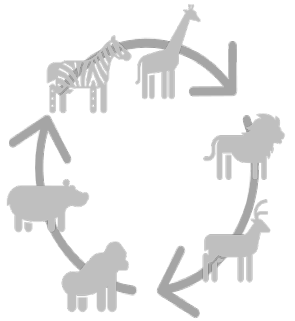
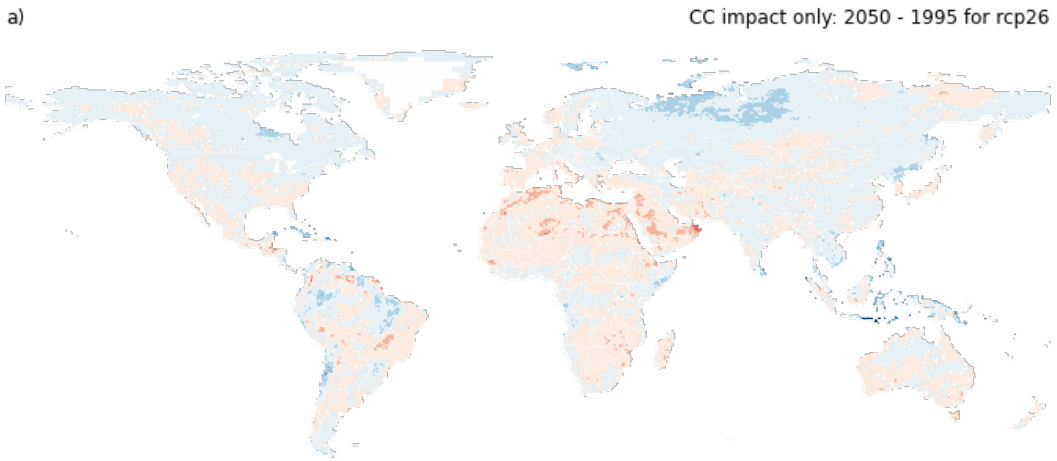


x

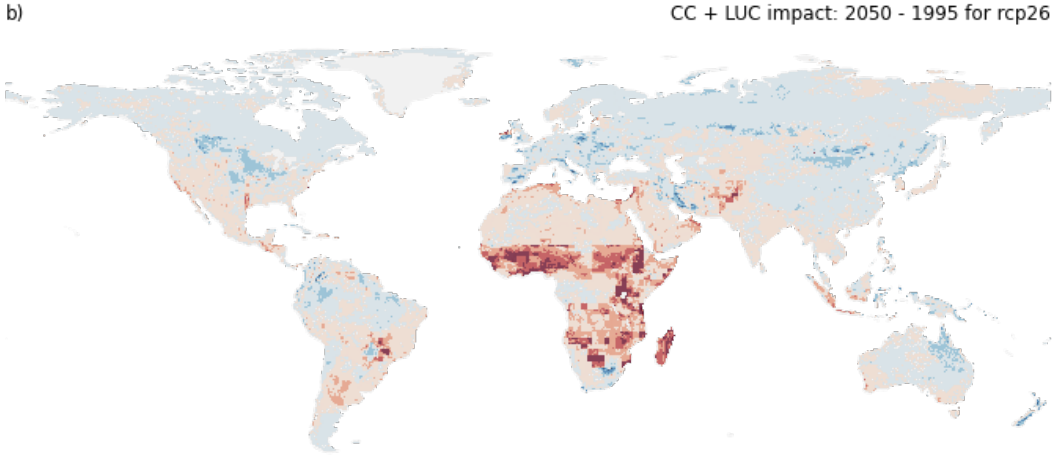
- Mammals
- Amphibians
- Reptiles
- Birds

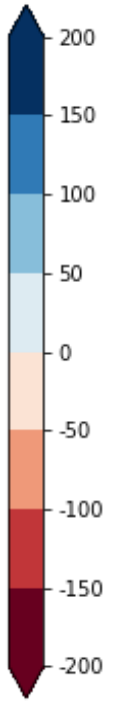
Results
Change in Species Richness in Mammals 2050-1995 for RCP2.6

Climate Change Impact



Climate and Land-Use Change Impact





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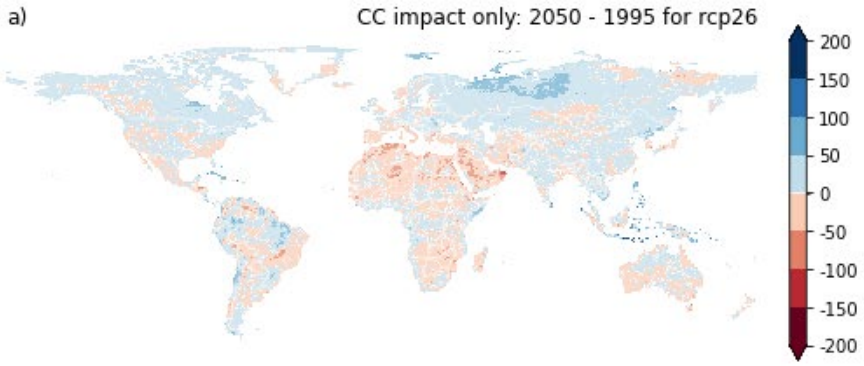
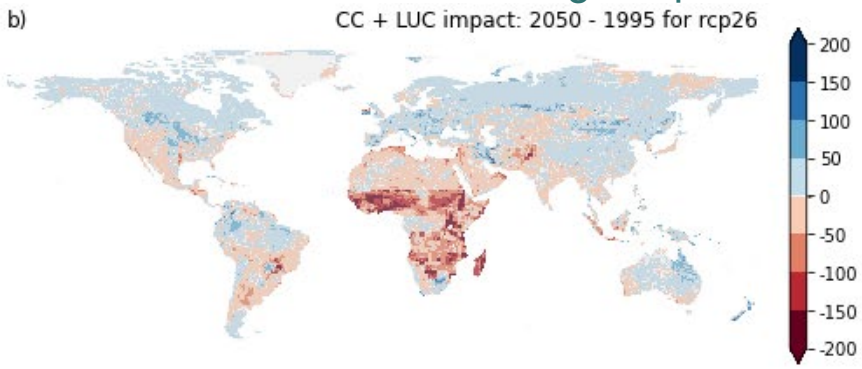
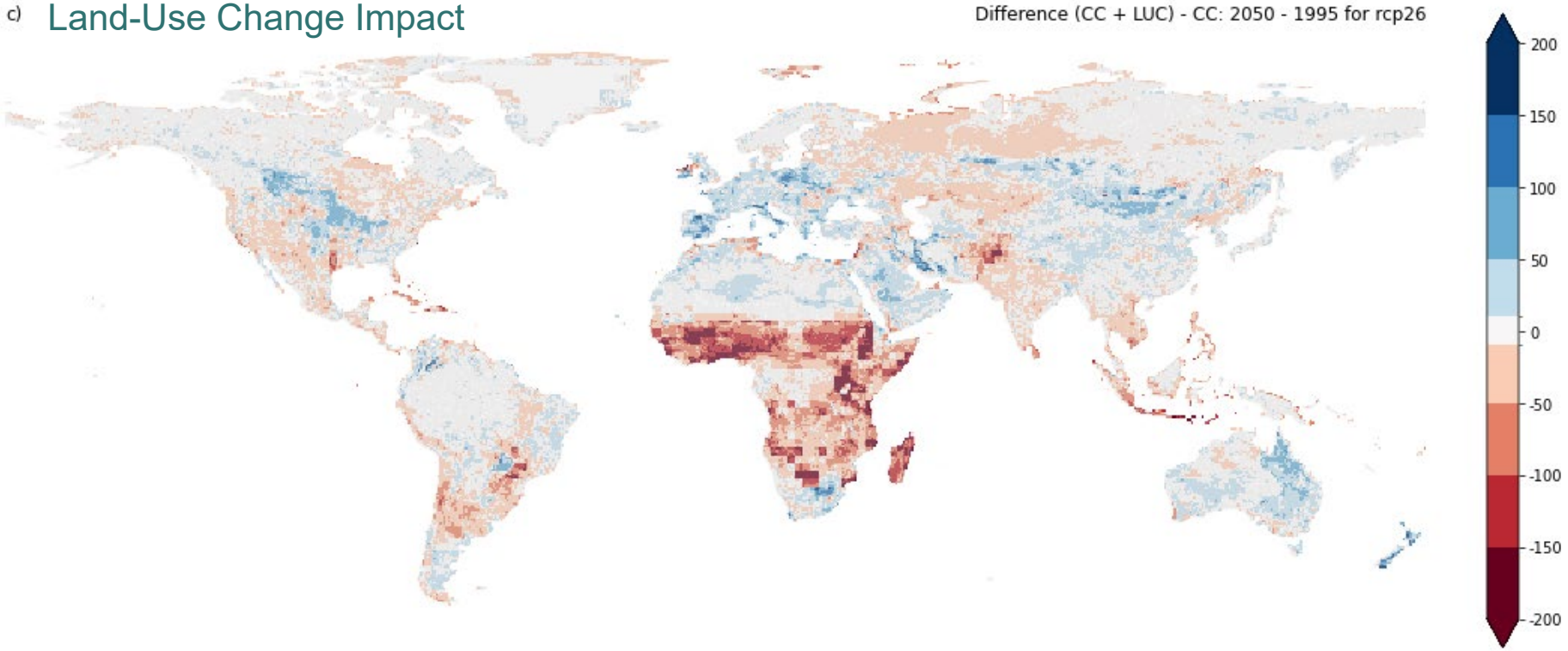


Climate and Land-Use Change Impact



Land-Use Change Impact



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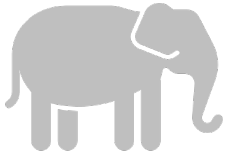
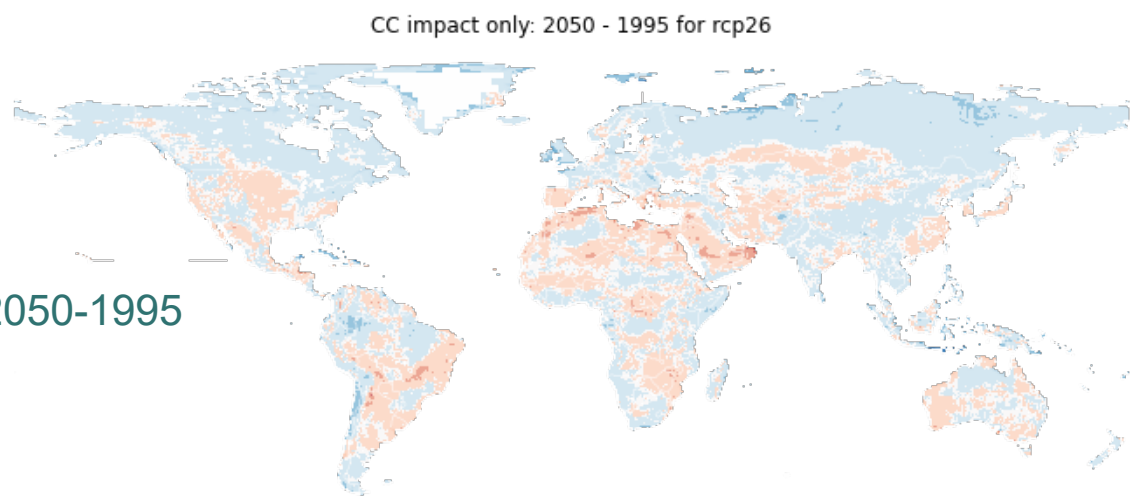


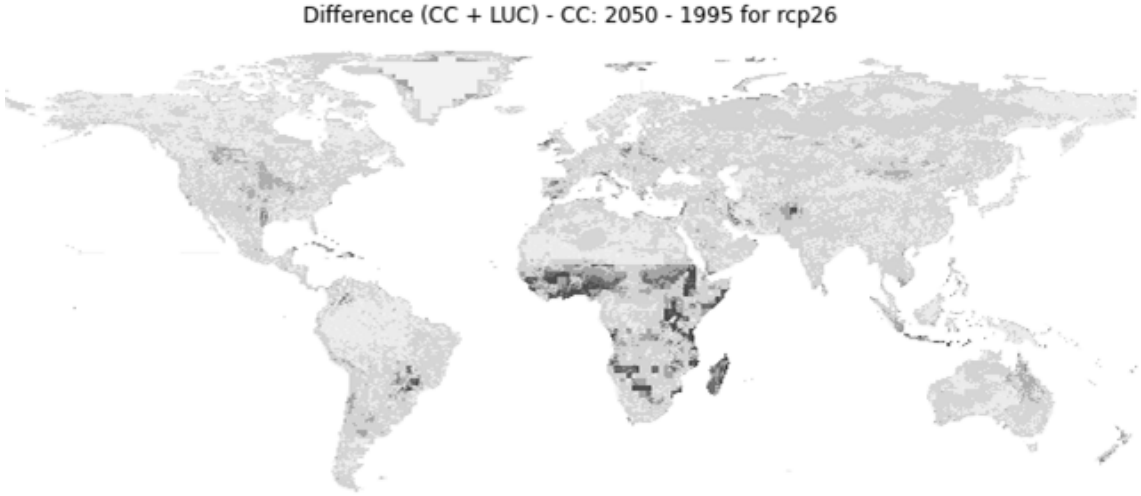
3941 Mammals

Climate Change Impact

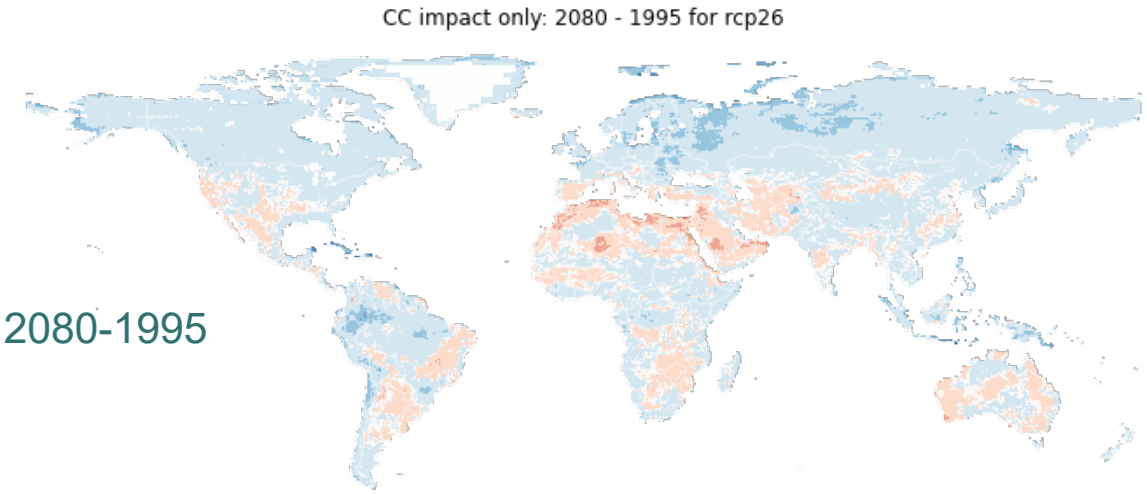
Land-Use Change Impact

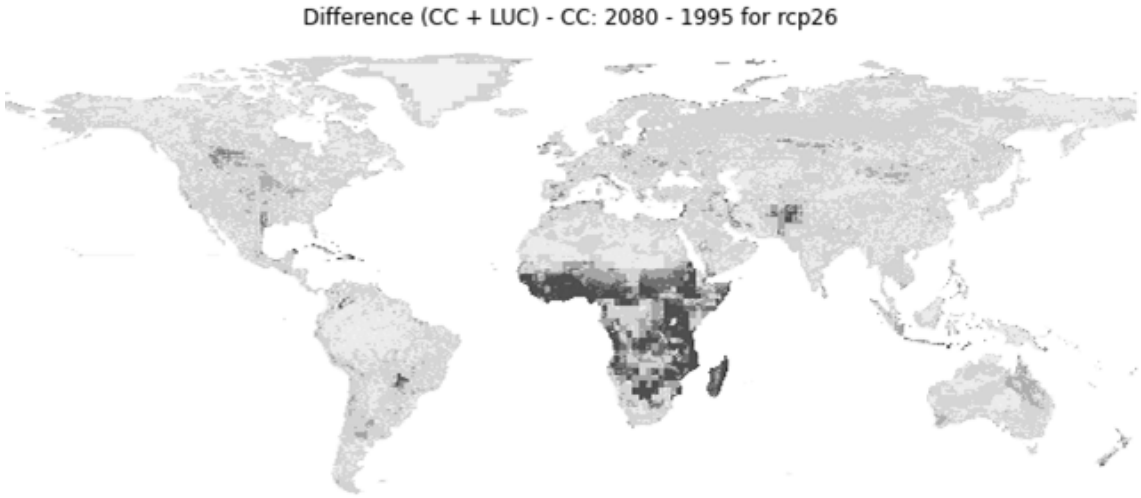
2050-1995

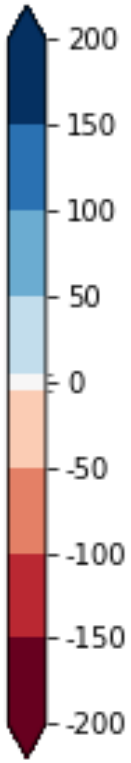




2080-1995







Results
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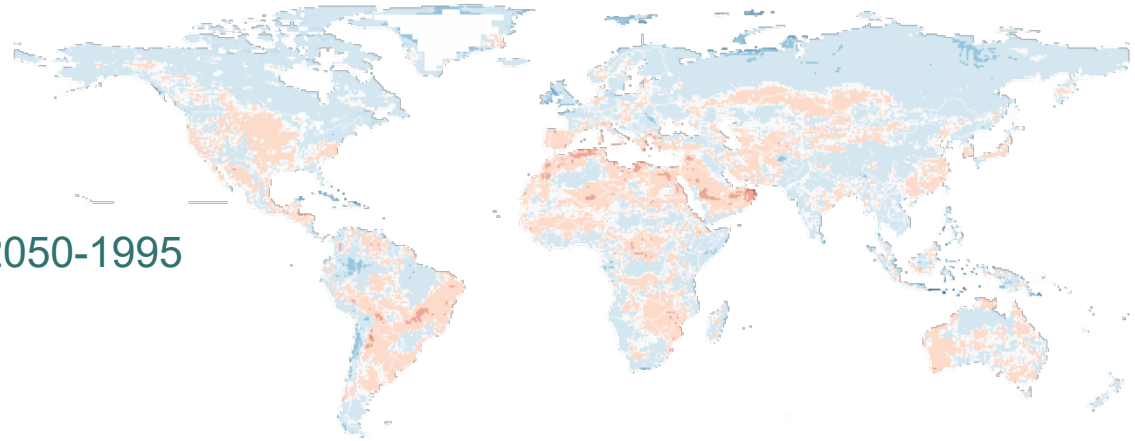

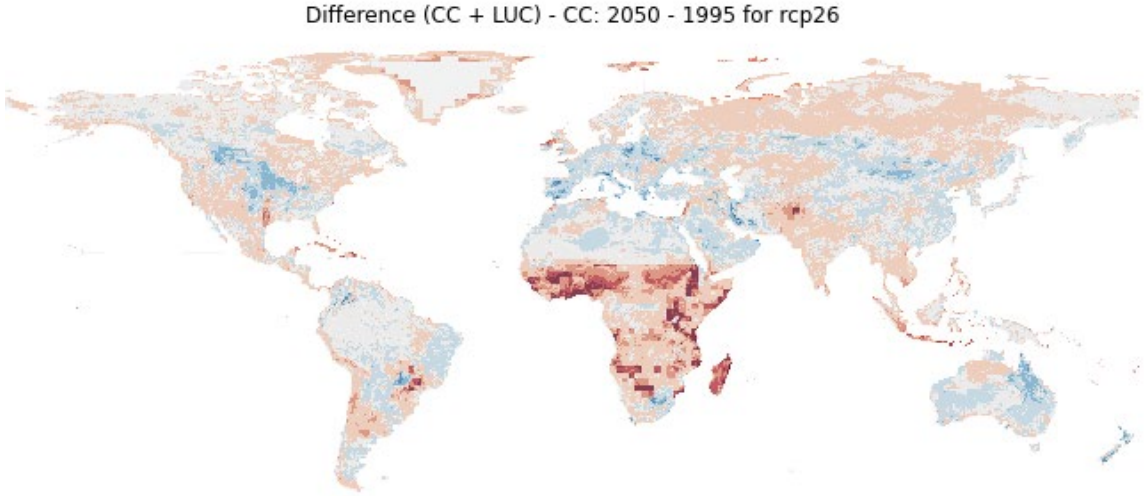

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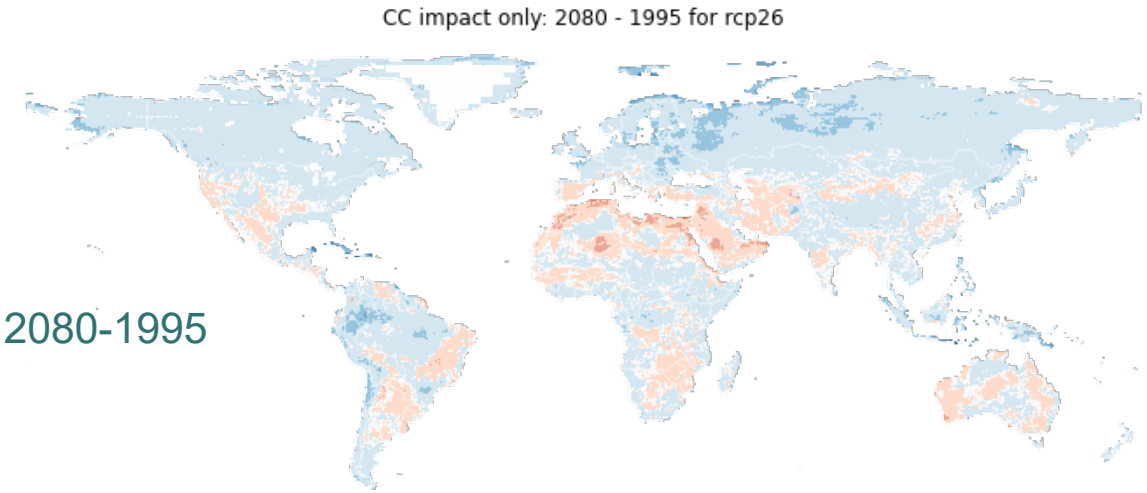
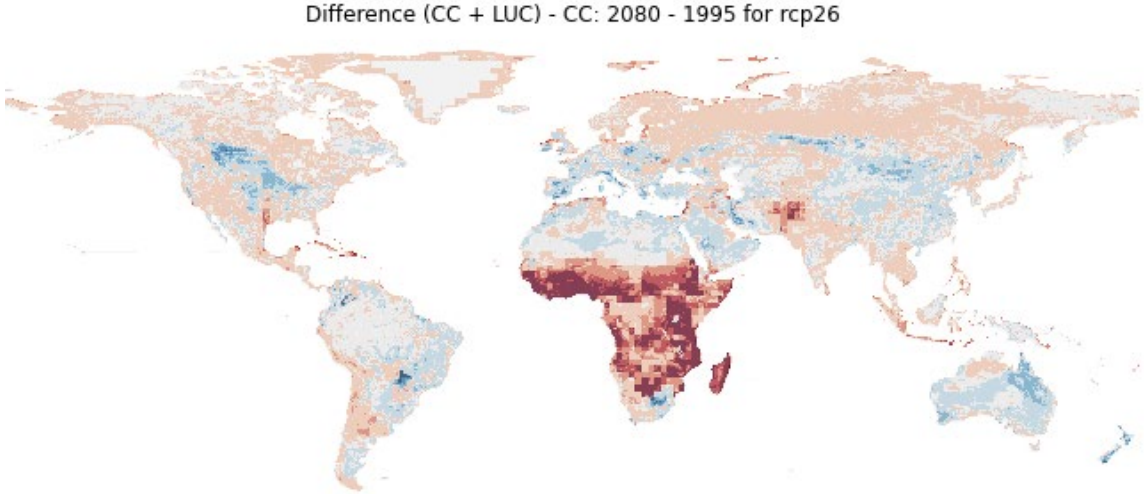
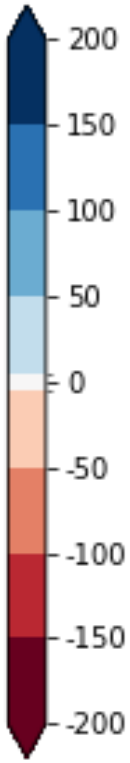






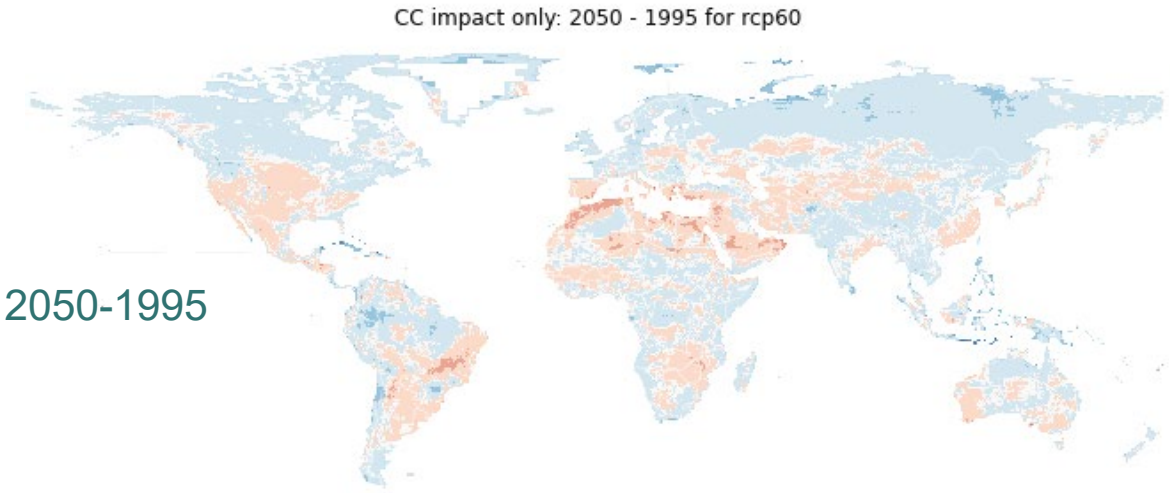
Results
Change in Species Richness in Mammals for RCP6.0

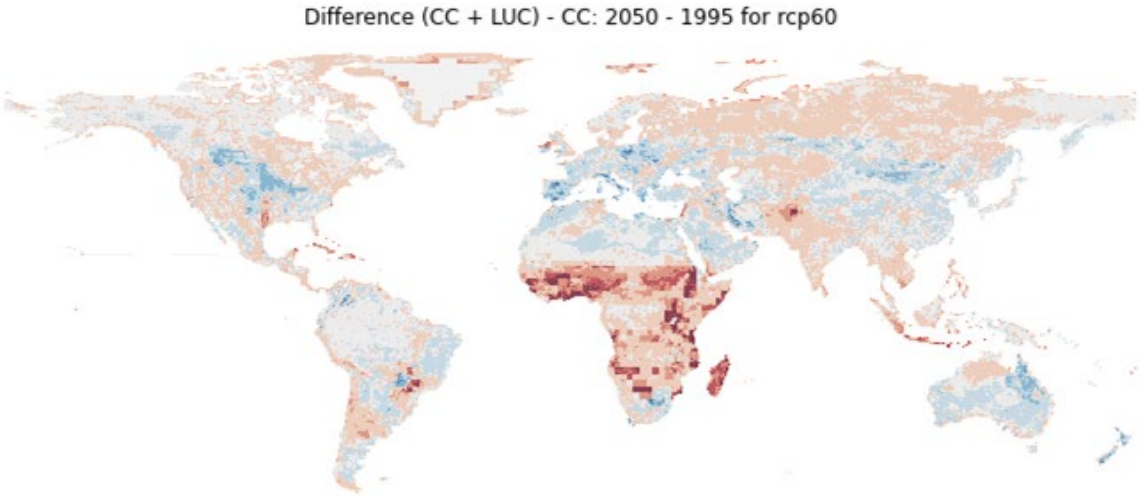
3941 Mammals

Climate Change Impact

Land-Use Change Impact

2050-1995





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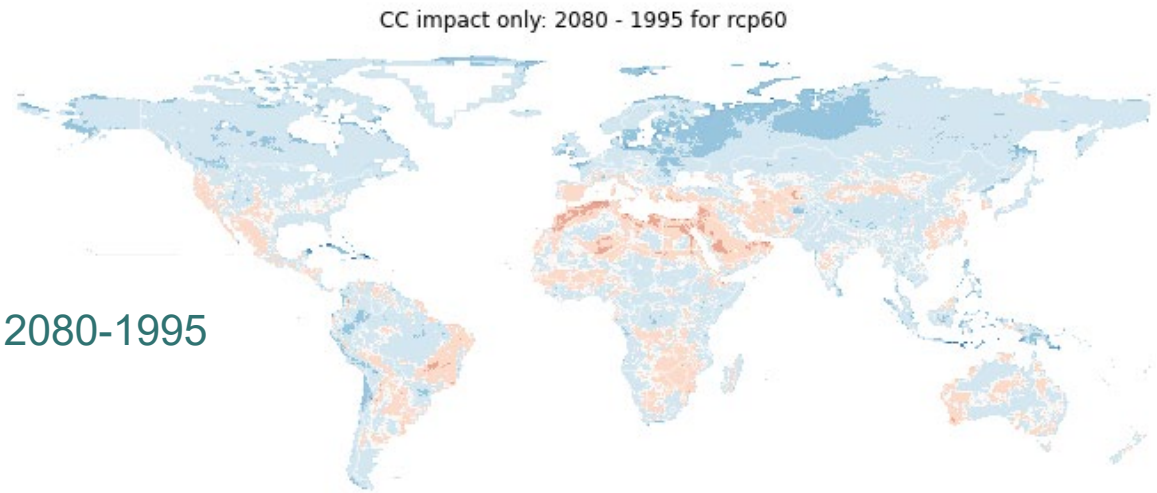
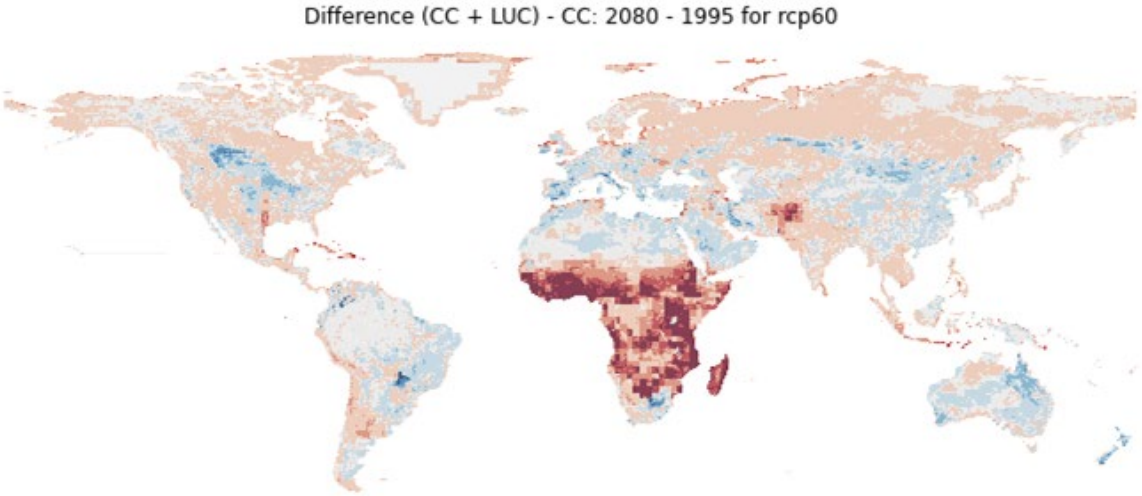
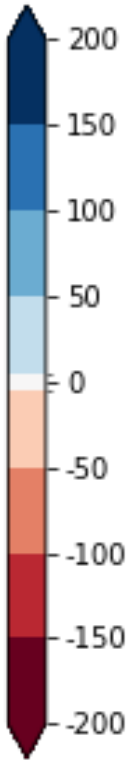






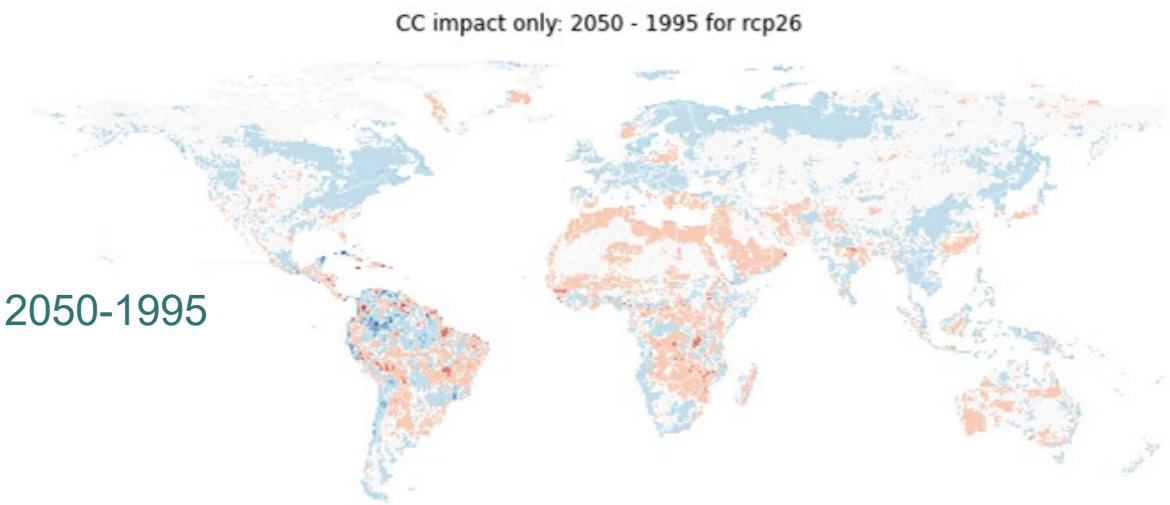
Results
Change in Species Richness in Amphibians for RCP2.6

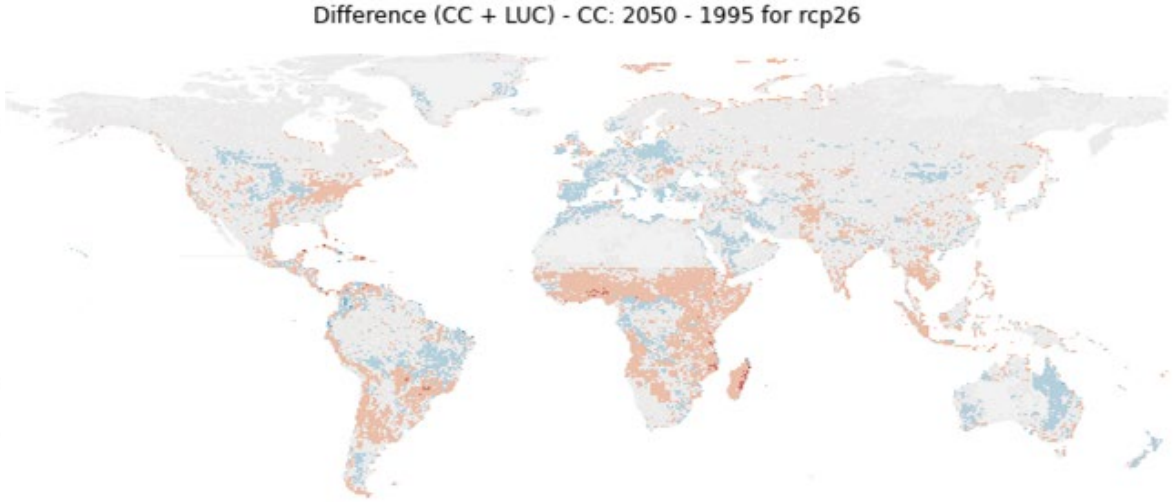
2705 Amphibians

Climate Change Impact

Land-Use Change Impact

2050-1995





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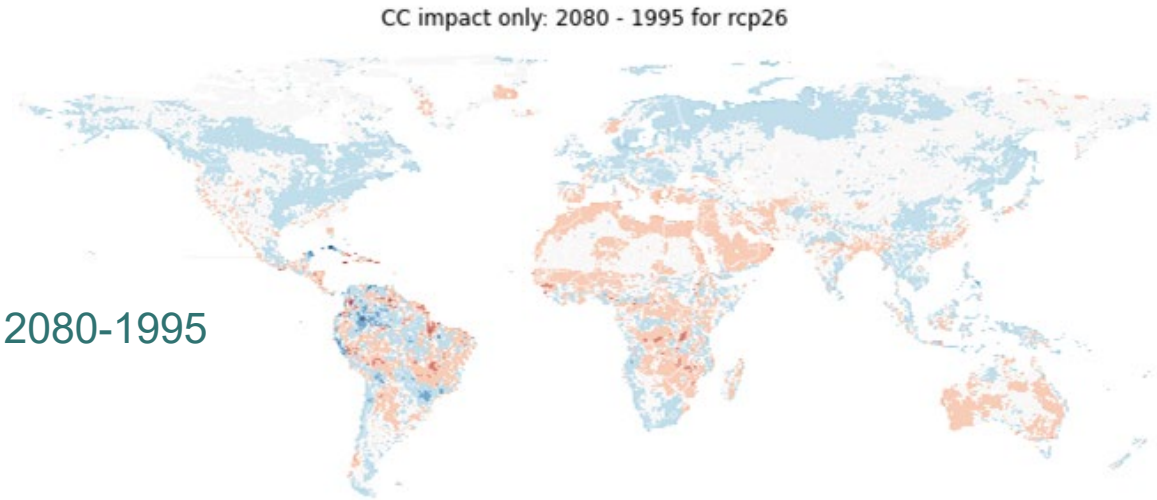

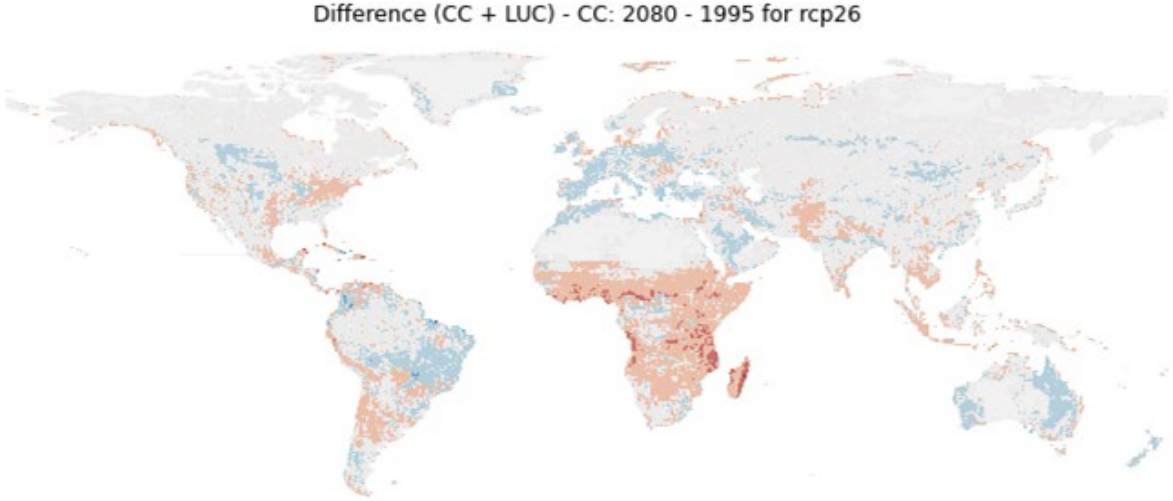

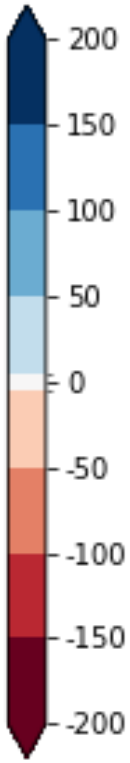

Results
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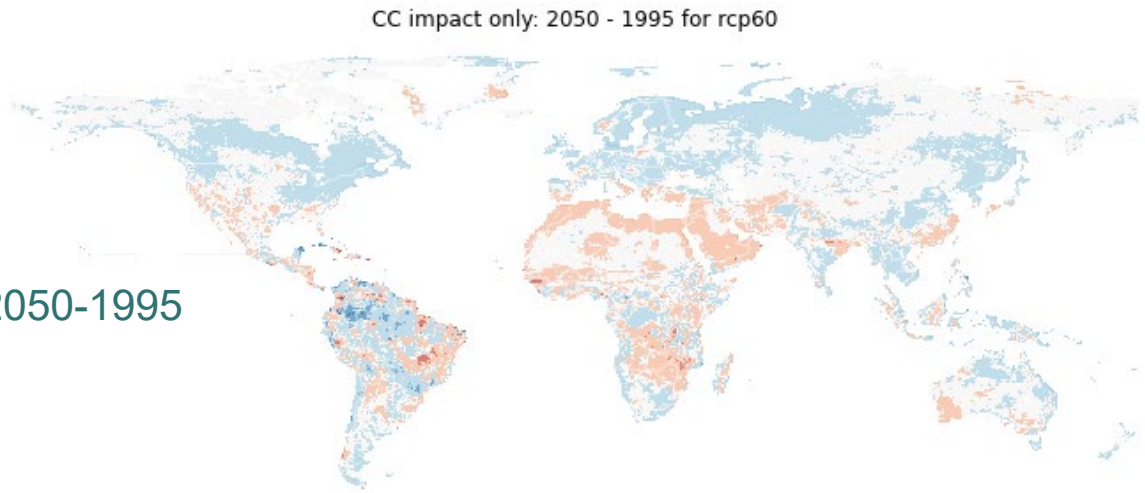
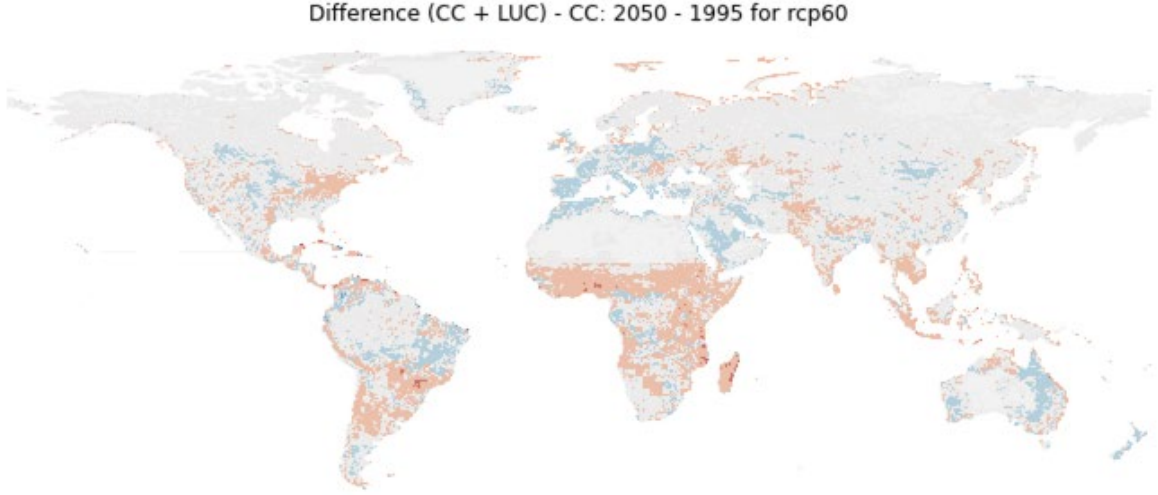
2705 Amphibians

Climate Change Impact

Land-Use Change Impact

2050-1995





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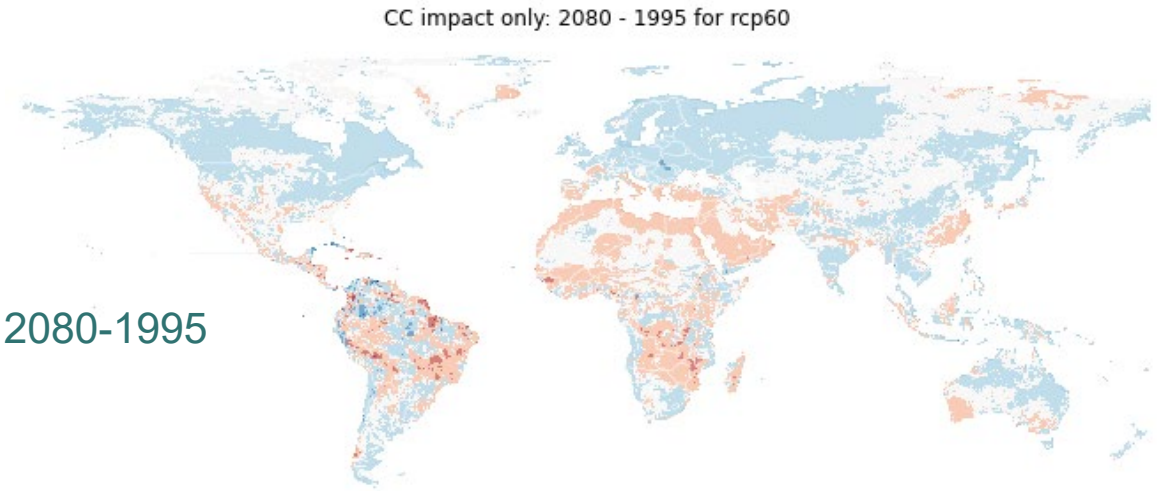

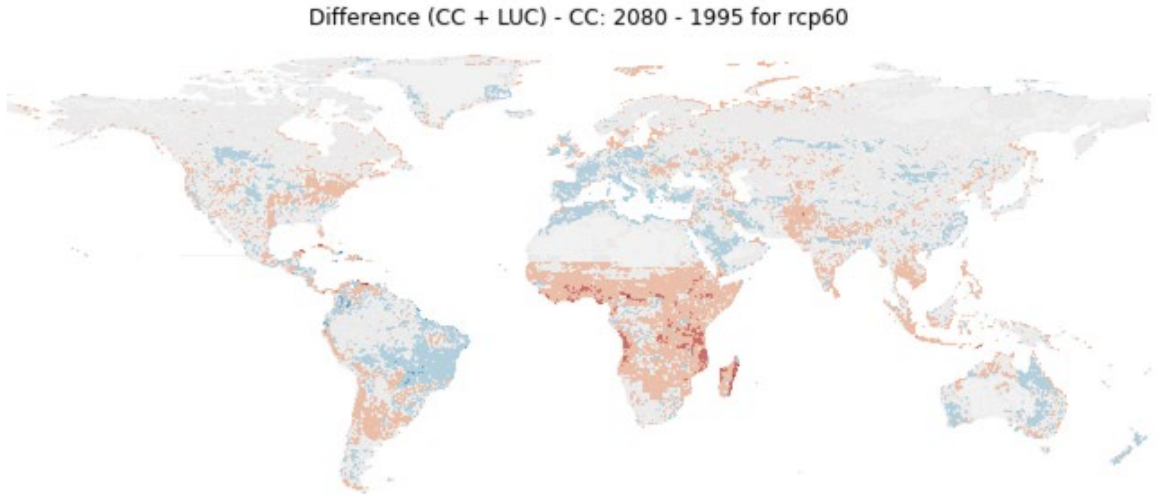

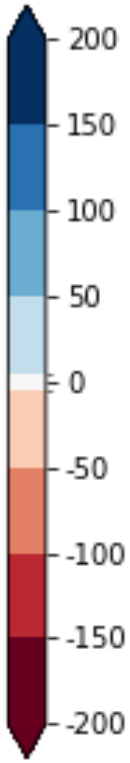

Conclusion and Outlook

- **Climate change** and **land-use change** are key stressors for biodiversity
- The **impact varies** geographically and between different taxa
- **Land-use change** is a driving force for biodiversity in many areas

Outlook:

- Sensitivity analysis
  - Model uncertainty
  - Assumptions in habitat selection
  - Dispersal scenarios
- Validation
- Use ISIMIP3b land use patterns

- Regional study in Kenya for elephant corridors

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Thank you!

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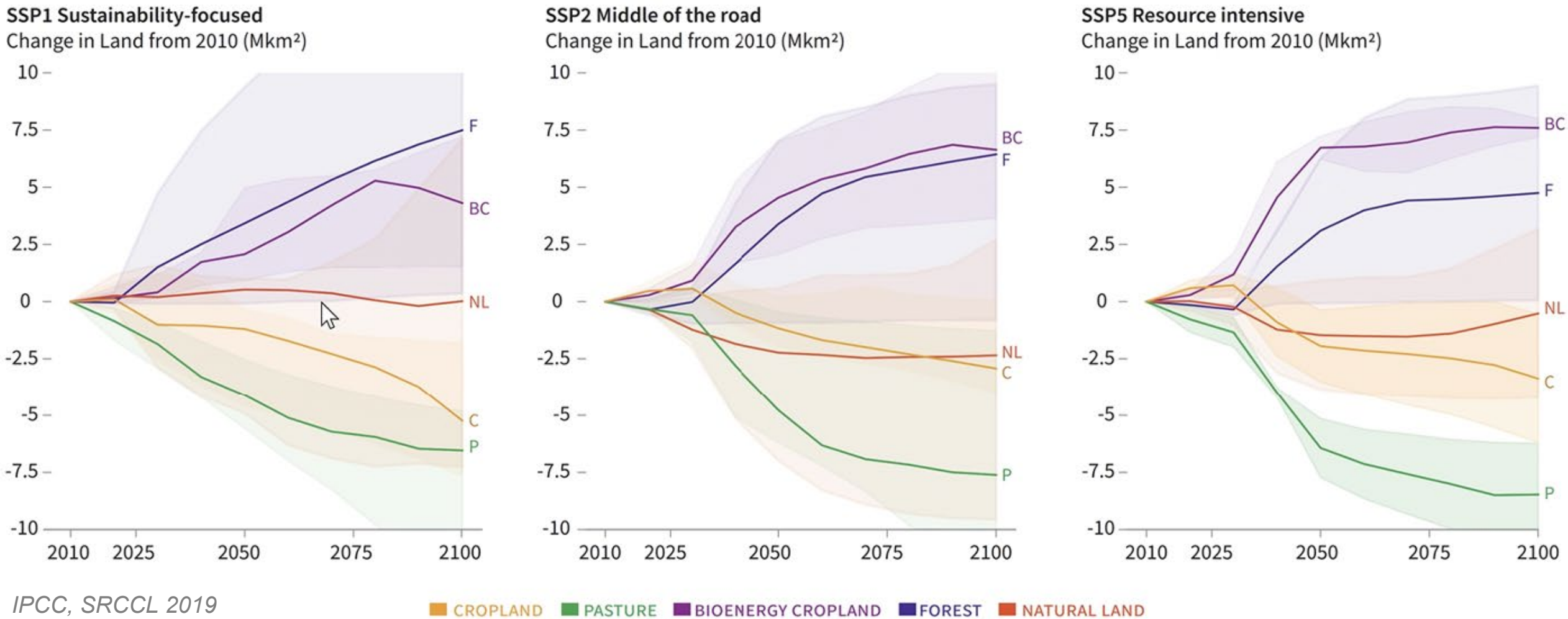

IPCC, SRCCL 2019

Habitat Classifications

	name	result.code	result.habitat	result.suitability	result.season	result.majorimportance
1	Martes melampus	1.4	Forest - Temperate	Suitable	NA	Yes
2	Martes melampus	14.5	Artificial/Terrestrial - Urban Areas	Marginal	NA	NA
3	Martes melampus	3.4	Shrubland - Temperate	Marginal	NA	NA

IUCN-LUH2 conversion table from Carlson et al. 2022

IUCN Habitats	IUCN_hab	LUH		LUH2	
1.1. Forest – Boreal	1.1	primf.secdf		primf	forested primary land
1.2. Forest - Subarctic	1.2	primf.secdf		primn	non-forested primary land
1.3. Forest – Subantarctic	1.3	primf.secdf		secdf	potentially forested secondary land
1.4. Forest – Temperate	1.4	primf.secdf		secdn	potentially non-forested secondary land
1.5. Forest – Subtropical/tropical dry	1.5	primf.secdf		pastr	managed pasture
1.6. Forest – Subtropical/tropical moist lowland	1.6	primf.secdf		range	rangeland
1.7. Forest – Subtropical/tropical mangrove vegetation above high tide level	1.7	primf.secdf		urban	urban land
1.8. Forest – Subtropical/tropical swamp	1.8	primf.secdf		c3ann	C3 annual crops
1.9. Forest – Subtropical/tropical moist montane	1.9	primf.secdf		c3per	C3 perennial crops
2.1. Savanna - Dry	2.1	primn.secdn		c4ann	C4 annual crops
2.2. Savanna - Moist	2.2	primn.secdn		c4per	C4 perennial crop
3.1. Shrubland – Subarctic	3.1	primn.secdn		c3nfx	C3 nitrogen-fixing crops
3.2. Shrubland – Subantarctic	3.2	primn.secdn		secma	secondary mean age (units: years)
3.3. Shrubland – Boreal	3.3	primn.secdn		secmb	secondary mean biomass density (units: kg C/m^2)
3.4. Shrubland –Temperate	3.4	primn.secdn			
3.5. Shrubland – Subtropical/tropical dry	3.5	primn.secdn			
3.6. Shrubland – Subtropical/tropical moist	3.6	primn.secdn			
3.7. Shrubland – Subtropical/tropical high altitude	3.7	primn.secdn			
3.8. Shrubland – Mediterranean-type shrubby vegetation	3.8	primn.secdn			
4.1. Grassland – Tundra	4.1	primn.secdn			
4.2. Grassland – Subarctic	4.2	primn.secdn			
4.3. Grassland – Subantarctic	4.3	primn.secdn			
4.4. Grassland – Temperate	4.4	primn.secdn			
4.5. Grassland – Subtropical/tropical dry	4.5	primn.secdn			
4.6. Grassland – Subtropical/tropical seasonally wet/flooded	4.6	primn.secdn			
4.7. Grassland – Subtropical/tropical high altitude	4.7	primn.secdn			