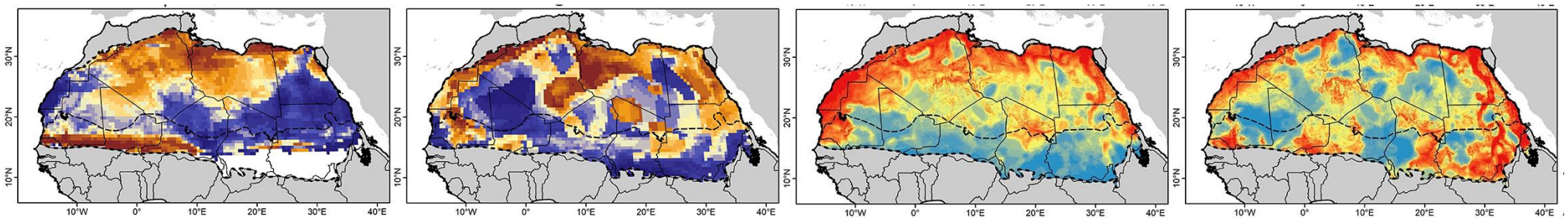
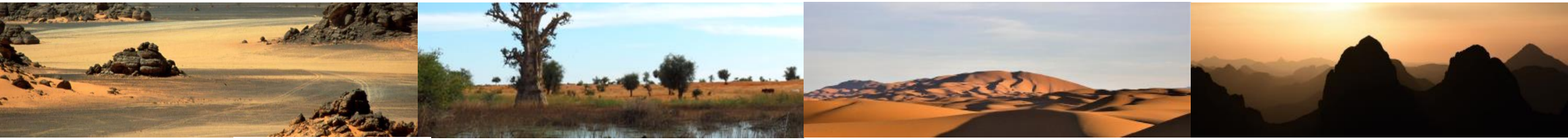
11th Biennial Conference of the International Biogeography Society; January 2024, Prague, Czechia

Genetic diversity and habitat stability in Sahara-Sahel vertebrates



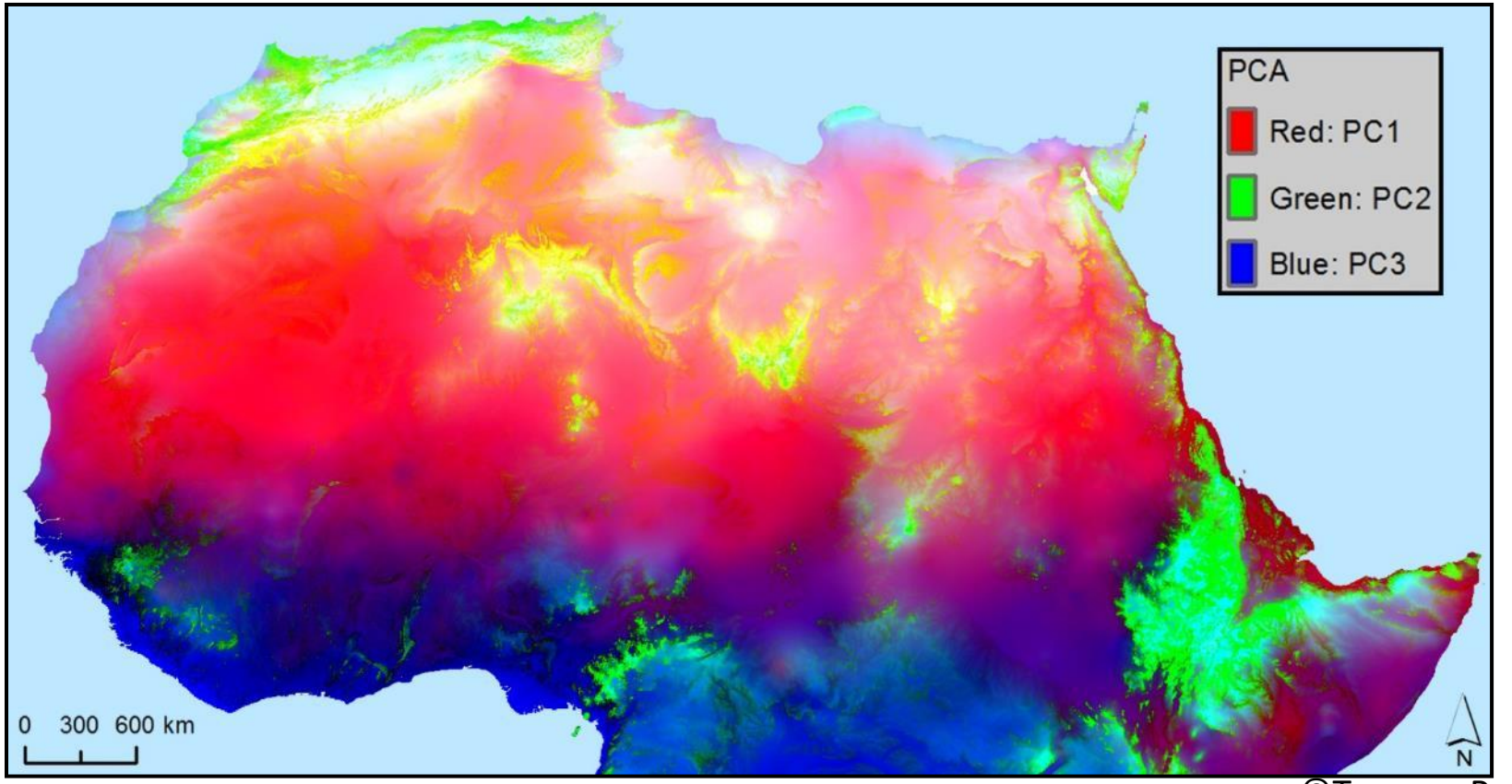
Duarte Vasconcelos Gonçalves, André Vicente Liz, Dennis Rödder (…) and José Carlos Brito



North Africa - Topoclimatic variability

- Climatic variability

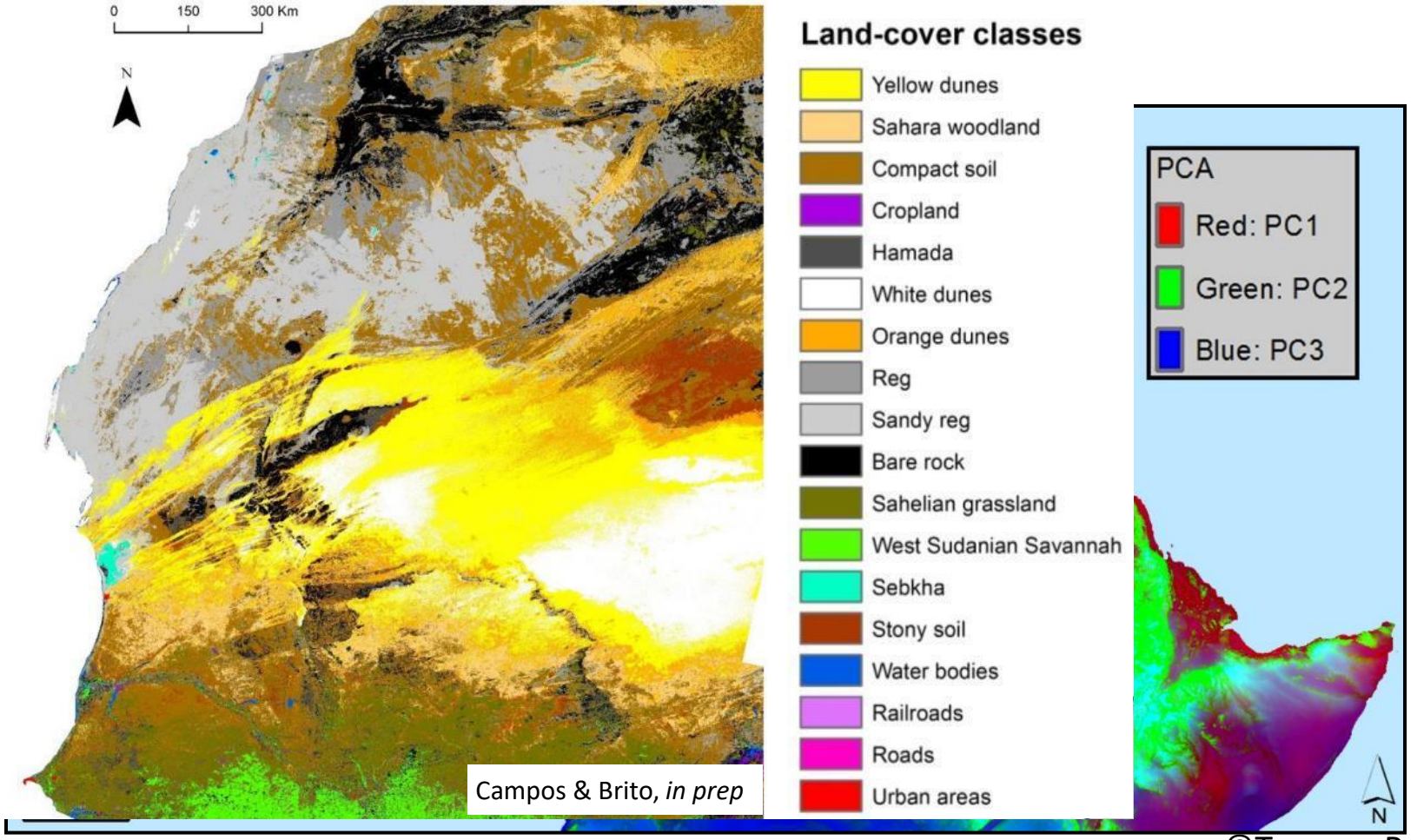
Topographic and climatic variability (Worldclim).



©Tarroso, P.

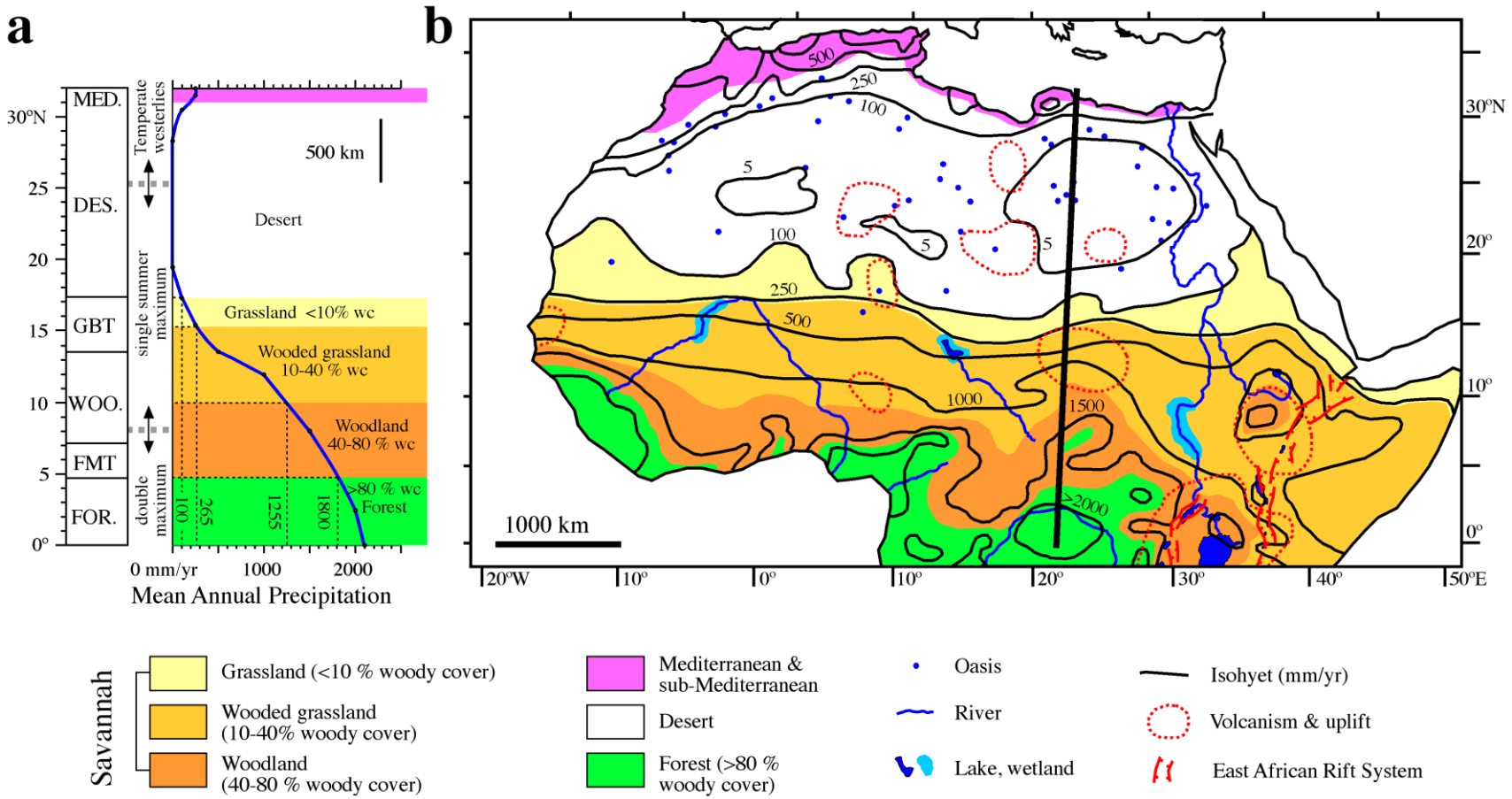
Topoclimatic variability

- Climatic variability
- Landscape variability



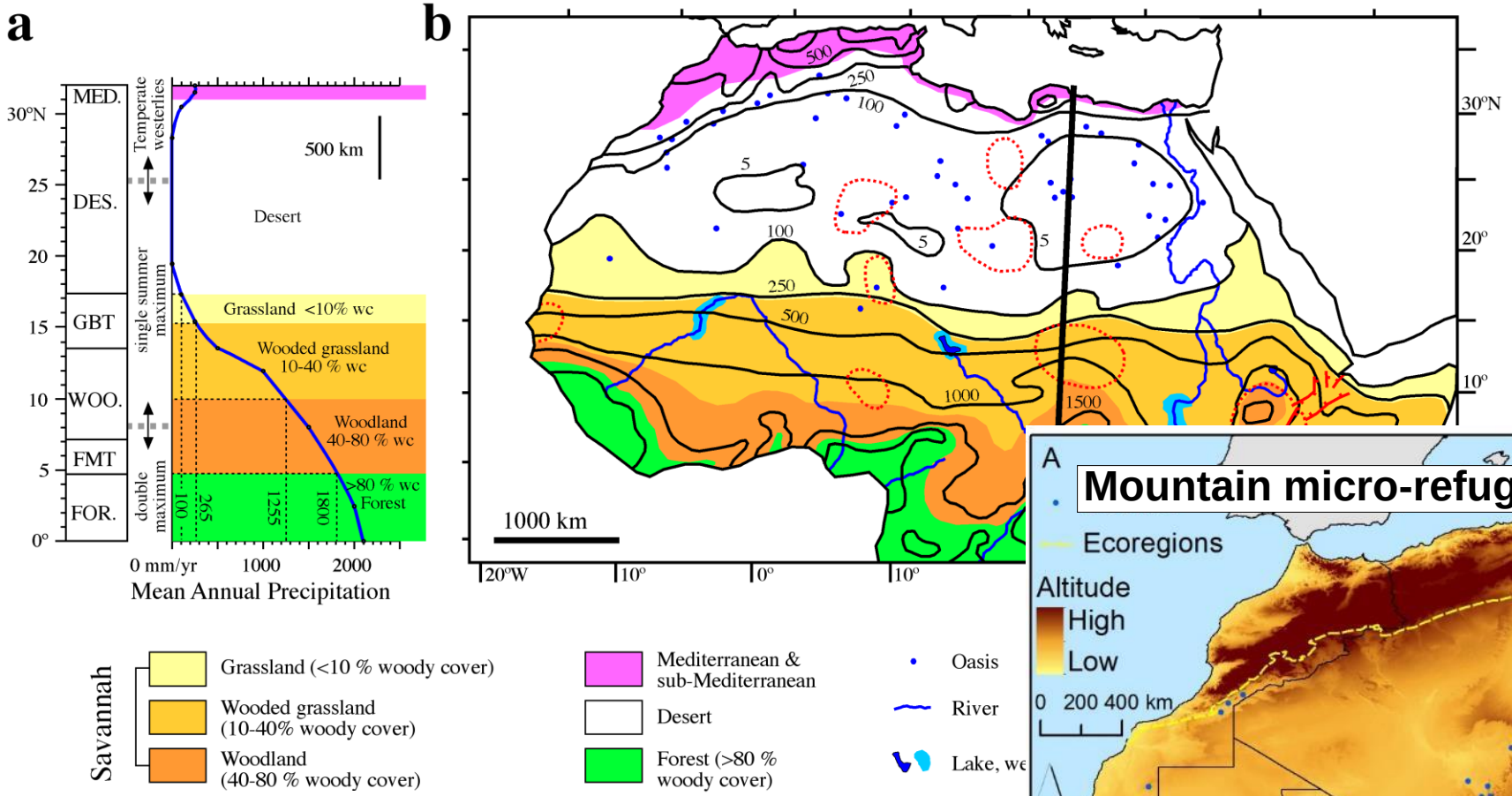
©Tarroso, P.

Topoclimatic variability

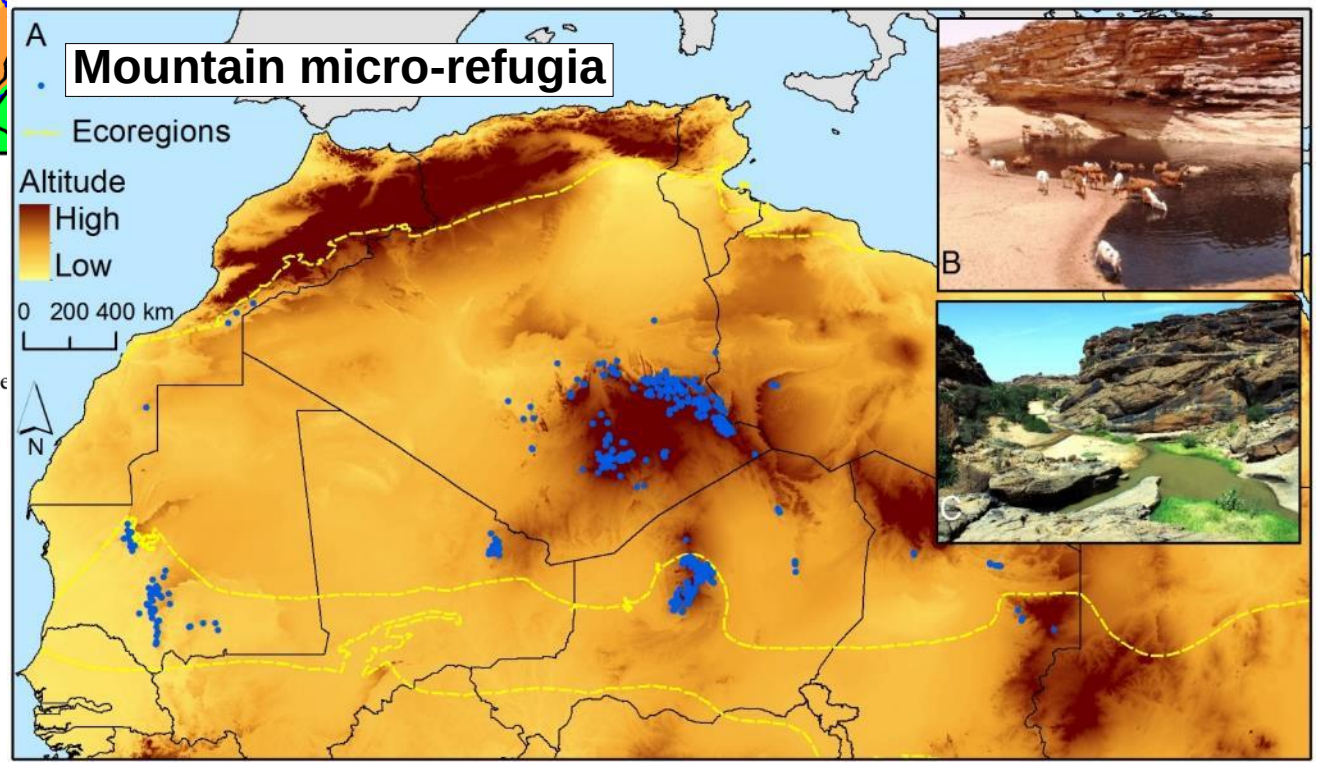


Larrasoaña et al., 2013. PlosOne, 8.

Topoclimatic variability



Larrasoaña et al., 2013. PlosOne, 8.

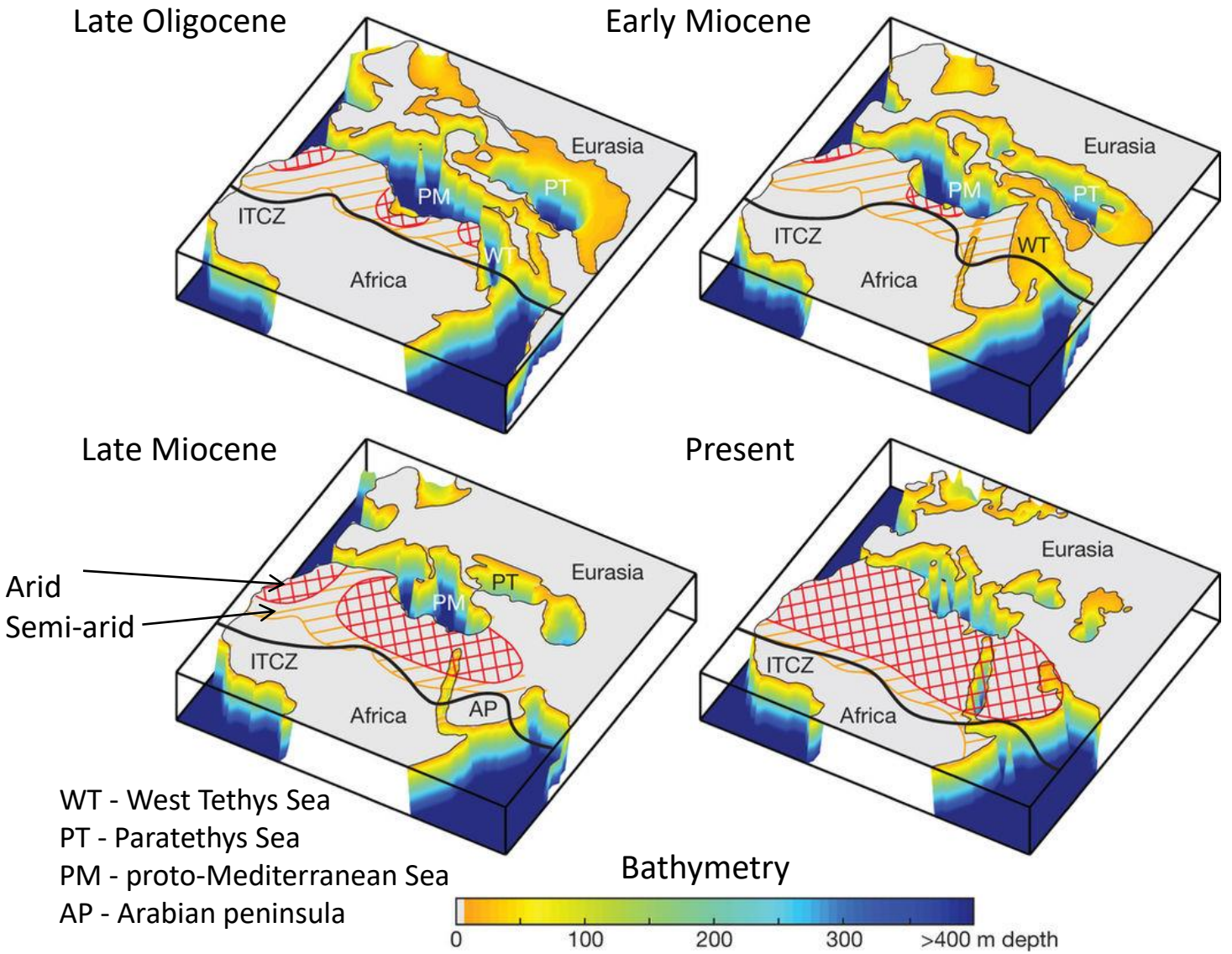


Brito et al., 2014. Biol. Rev. 89.

Past climatic cycles

- Geological events

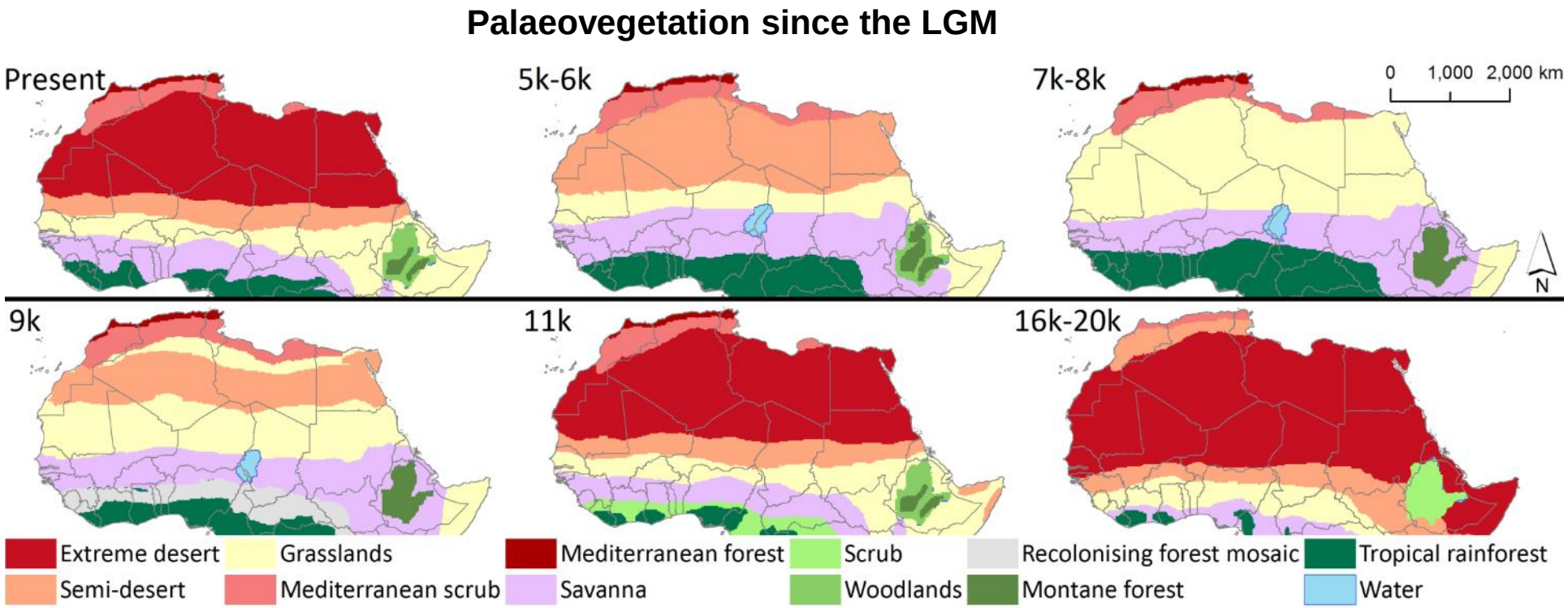
Tethys palaeogeography and N-Africa palaeoclimate



Zhang et al., *Nature* 513, 401 (2014).

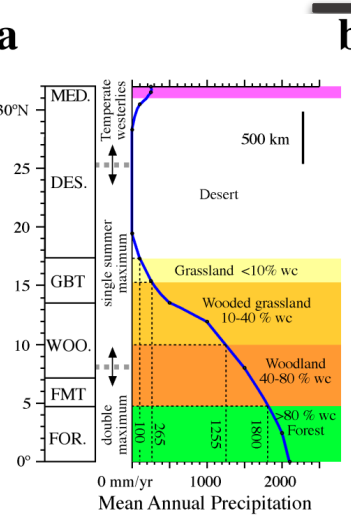
Past climatic cycles

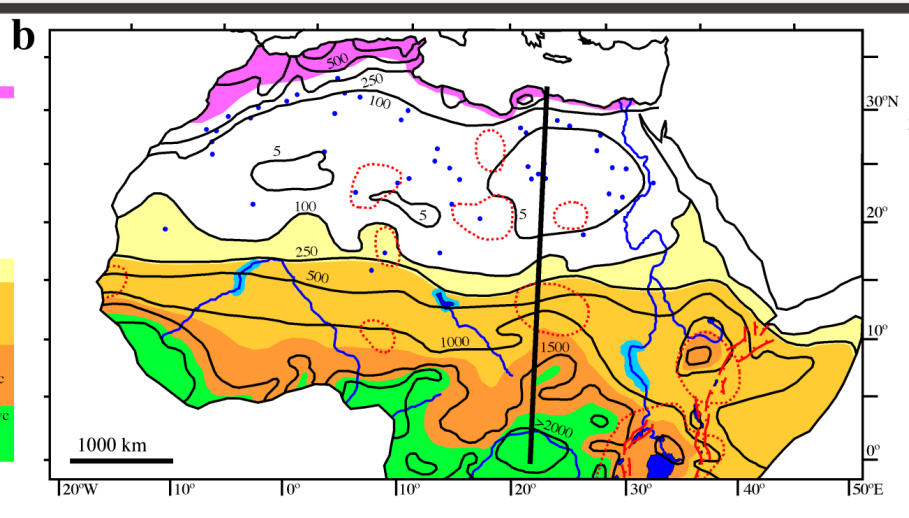
- Humid-Arid climatic cycles during Pliocene and Pleistocene

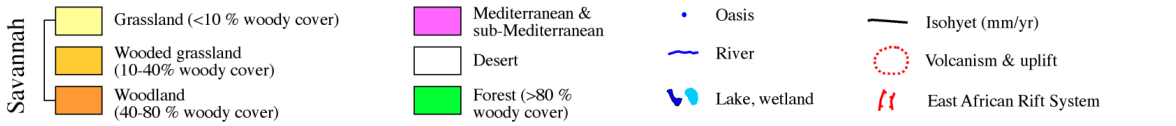


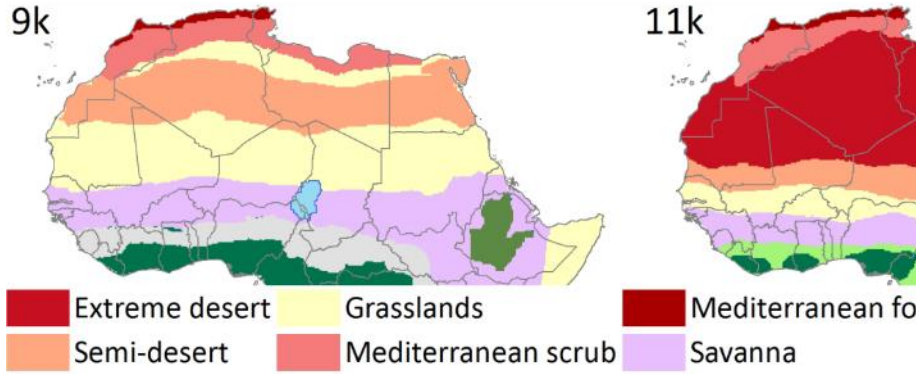
Adams & Faure, Review and Atlas of Palaeovegetation (1997).

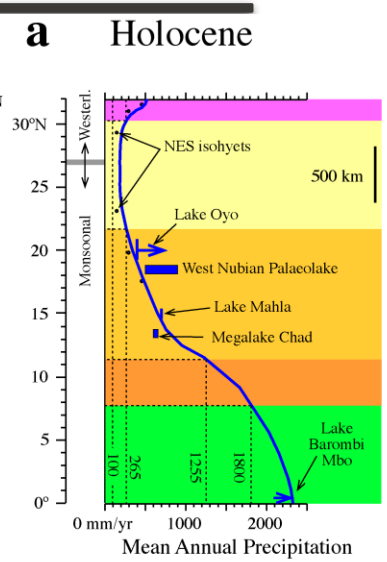
Past climatic cycles

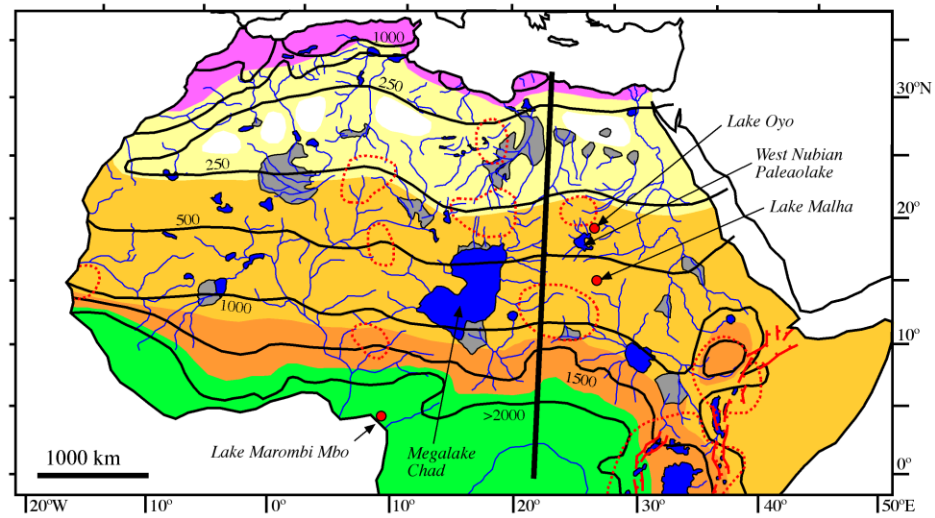


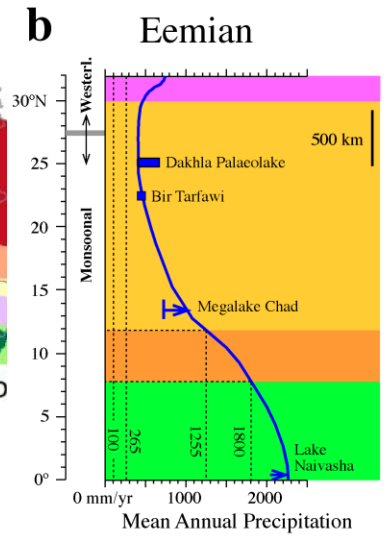


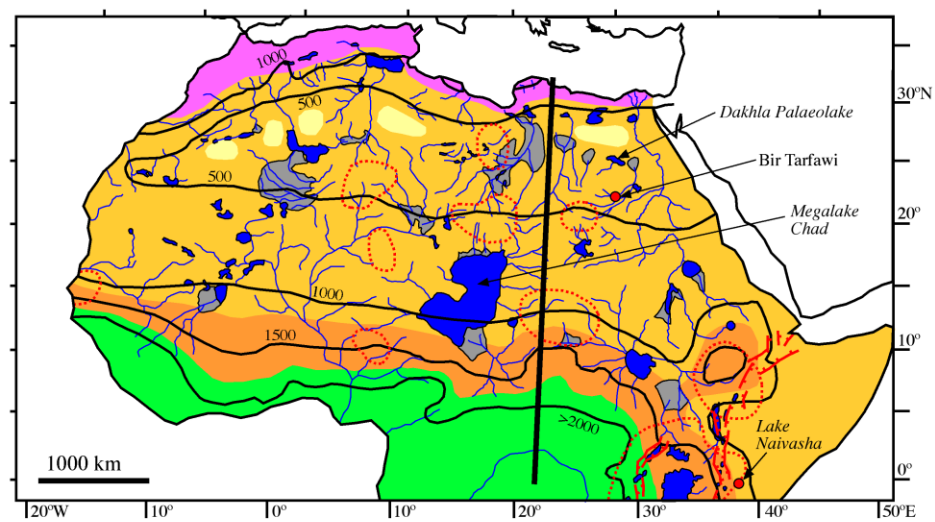


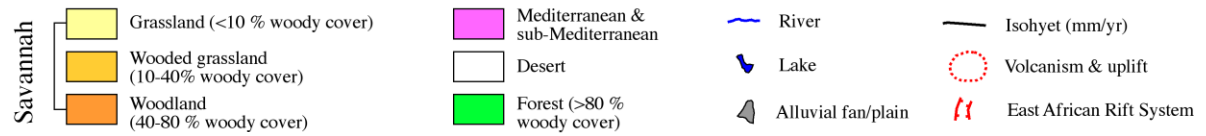








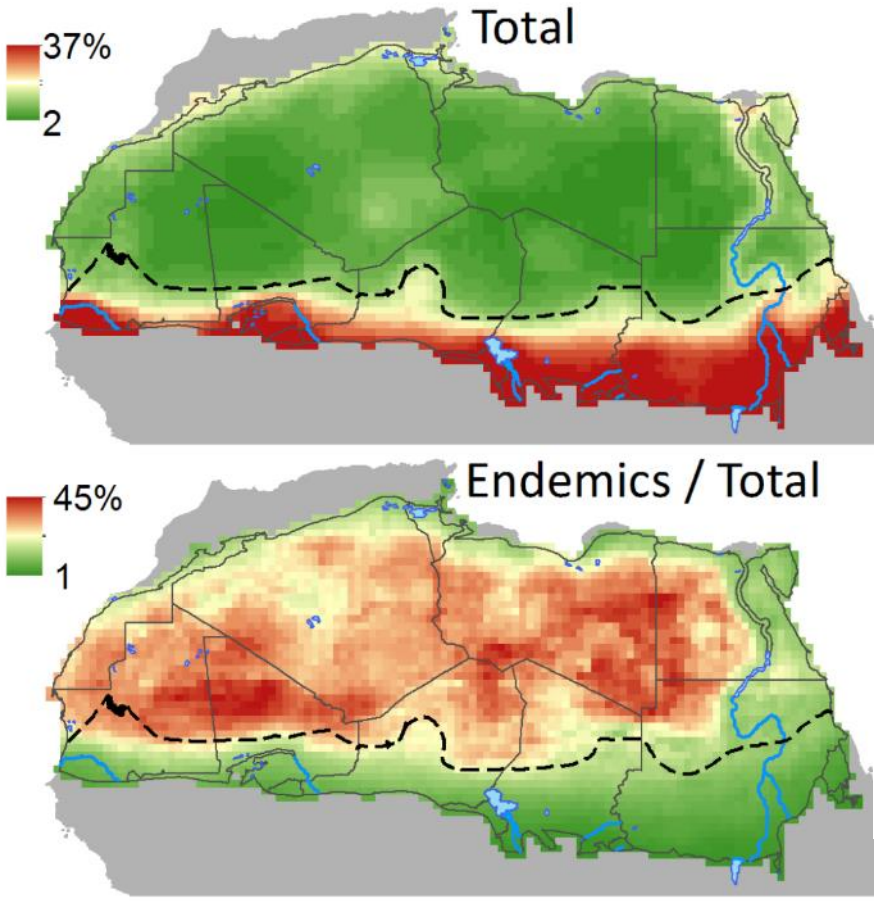




Larrasoaña et al., 2013. PlosOne, 8.

Biodiversity distribution in the Sahara-Sahel

- Sahara-Sahel has a rich biodiversity
- High relative endemism



Relative species richness

Sahara-Sahel border

Rivers Lakes Countries

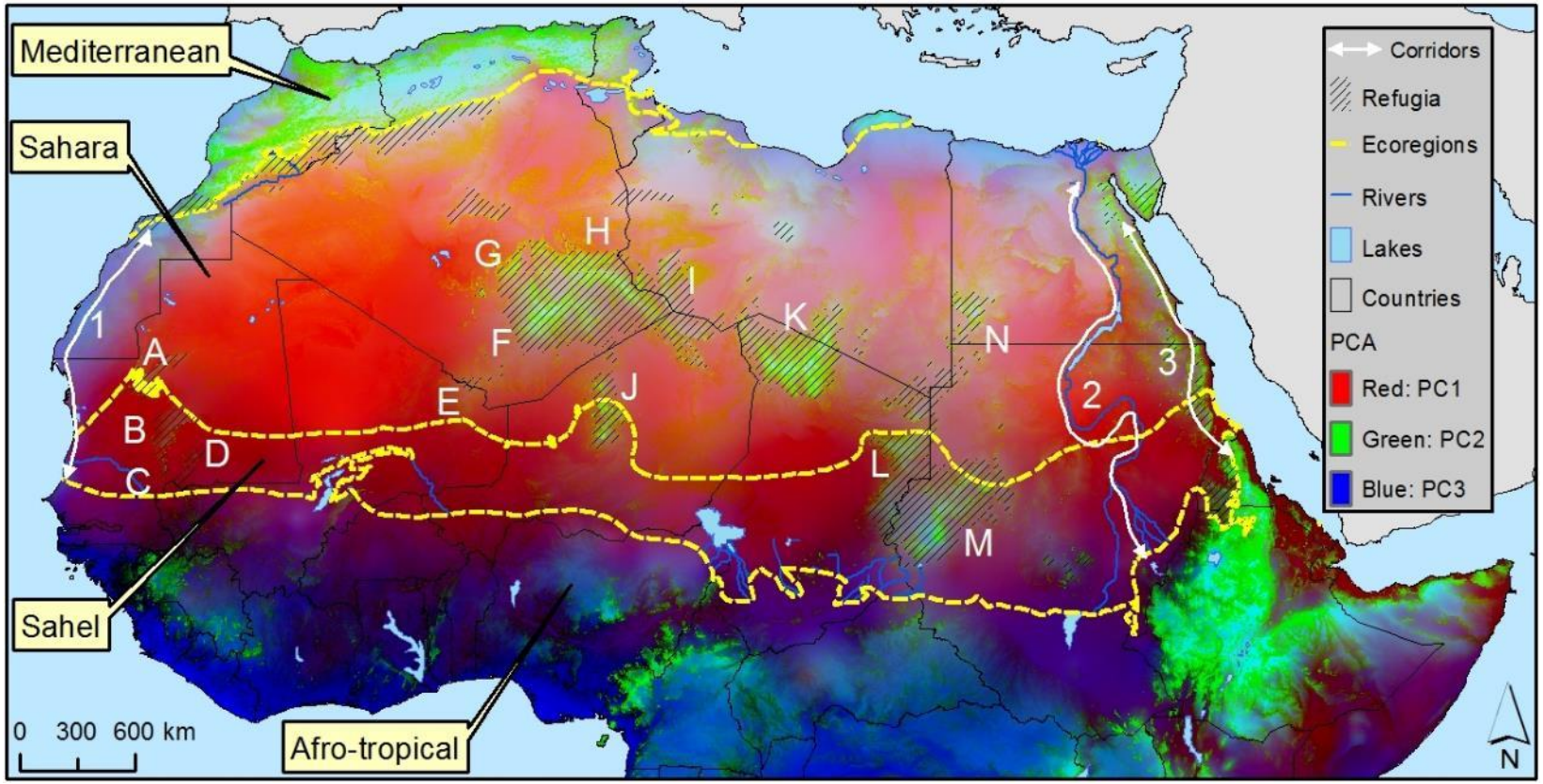
0 1,000 km

N

Brito et al., *Diversity Distrib.* 22, 371 (2016).

Refugia and dispersal corridors

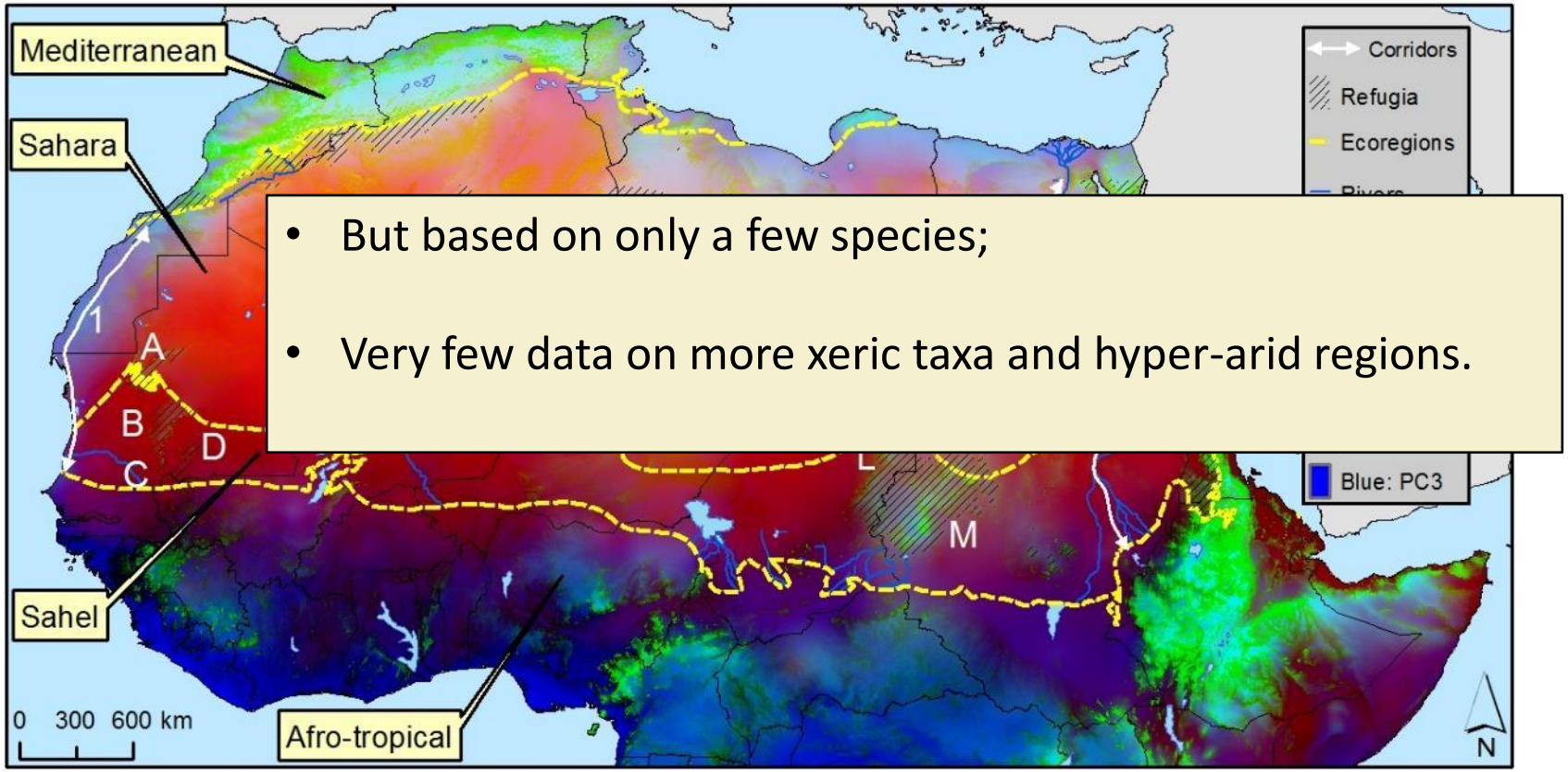
- Mesic refugia – mountains, water bodies, fringe regions
- Dispersal corridors



Environmental variability, putative trans-Saharan corridors and toponymy.
1, Atlantic Sahara; 2, Nile River valley; 3, Red Sea coast. A, Adrar Atar-Kediet ej Jill; B, Tagant; C, Assaba; D, Afolle; E, Adrar des Ifoghas; F, Hoggar; G, Mouydir; H, Tassili n'Ajjer; I, Fezzan; J, Aïr; K, Tibesti-Dohone; L, Ennedi-Borkou; M, Marra; N, Uweinat-Gilf Kebir. [Brito et al., *Biol. Rev.* 89, 215 (2014).]

Refugia and dispersal corridors

- Mesic refugia – mountains, water bodies, outer regions
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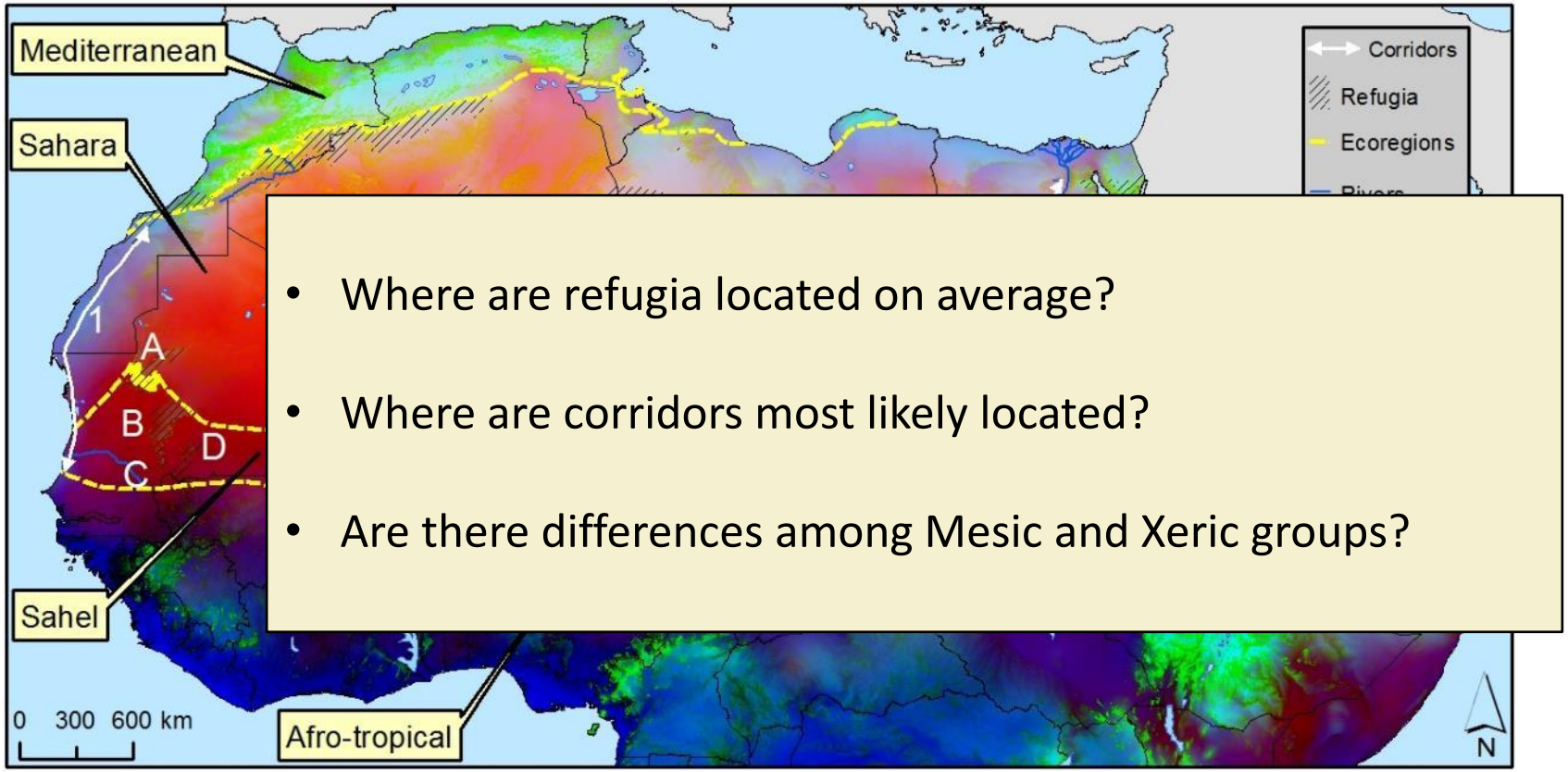


- But based on only a few species;
- Very few data on more xeric taxa and hyper-arid regions.

Environmental variability, putative trans-Saharan corridors and toponymy.
1, Atlantic Sahara; 2, Nile River valley; 3, Red Sea coast. A, Adrar Atar-Kediet ej Jill; B, Tagant; C, Assaba; D, Afolle; E, Adrar des Ifoghas; F, Hoggar; G, Mouydir; H, Tassili n'Ajjer; I, Fezzan; J, Aïr; K, Tibesti-Dohone; L, Ennedi-Borkou; M, Marra; N, Uweinat-Gilf Kebir. [Brito et al., *Biol. Rev.* 89, 215 (2014).]

Refugia and dispersal corridors

- Mesic refugia – mountains, water bodies, outer regions
- Dispersal corridors



- Where are refugia located on average?
- Where are corridors most likely located?
- Are there differences among Mesic and Xeric groups?

Environmental variability, putative trans-Saharan corridors and toponymy.
1, Atlantic Sahara; 2, Nile River valley; 3, Red Sea coast. A, Adrar Atar-Kediet ej Jill; B, Tagant; C, Assaba; D, Afolle; E, Adrar des Ifoghas; F, Hoggar; G, Mouydir; H, Tassili n'Ajjer; I, Fezzan; J, Aïr; K, Tibesti-Dohone; L, Ennedi-Borkou; M, Marra; N, Uweinat-Gilf Kebir. [Brito et al., *Biol. Rev.* 89, 215 (2014).]

Study design

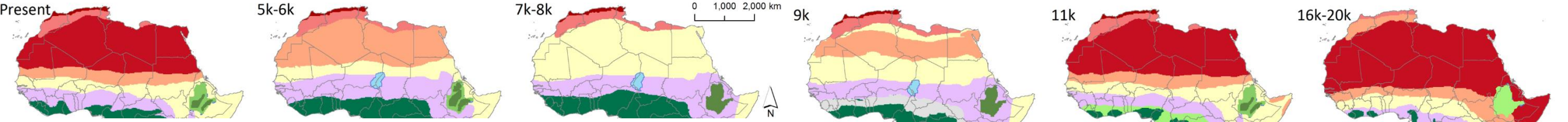
Key assumptions

Refugia

- long-term species presence -> high intra-specific genetic diversity
- confounding effect: areas of secondary contact
- stable habitat during Pleistocene -> high suitability in past climatic snapshots

Corridors

- intermittent connectivity -> intermittent habitat suitability
- recent connectivity, areas of continuous lineage distribution match continuous areas of recent habitat suitability;



Study design

Hypotheses

<u>Biogeographic refugia:</u>

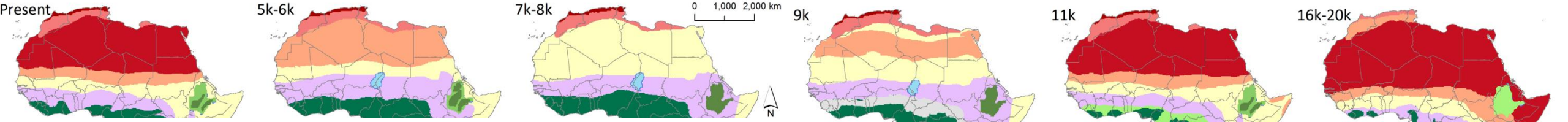
Mountains and coastal areas (mesic taxa);

Northern Sahara (xeric taxa);

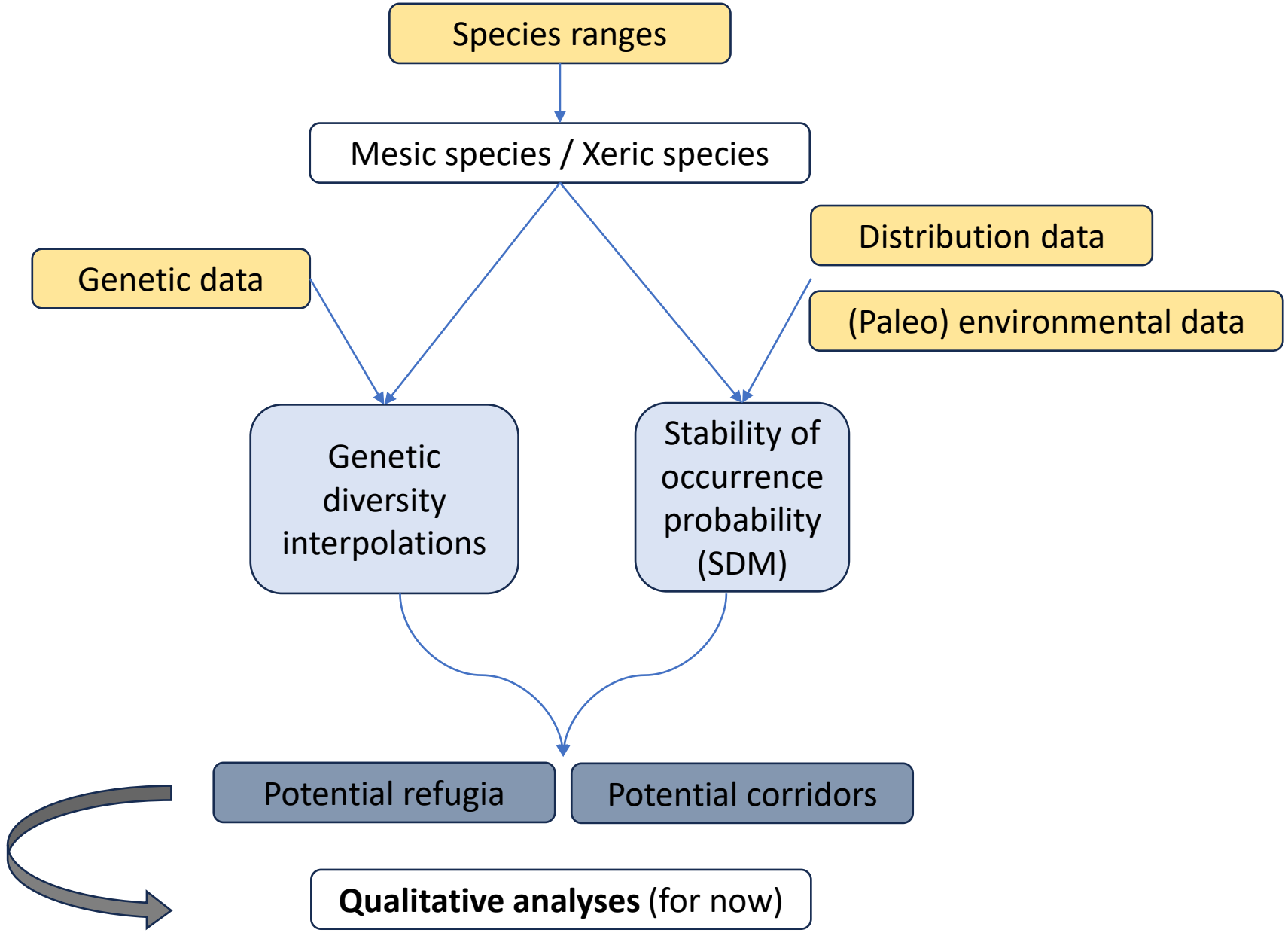
<u>Corridors:</u>

Atlantic Sahara corridor, the Nile Valley, and fringe areas (mesic taxa);

Southern Sahara (xeric taxa).

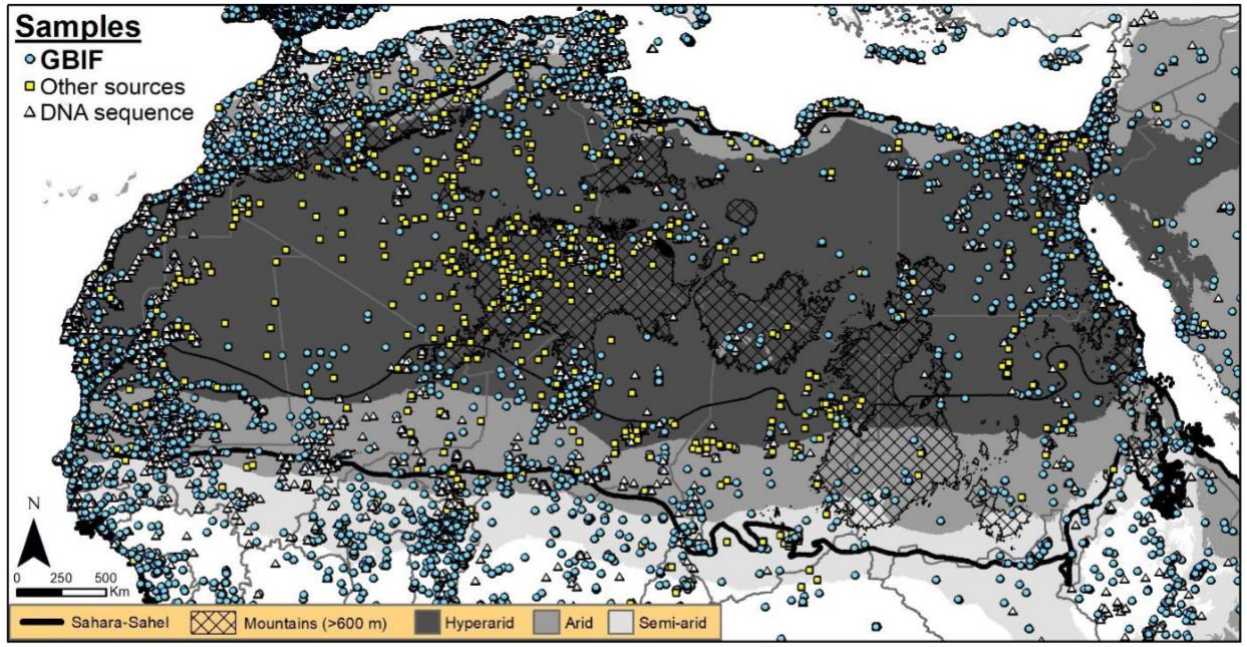


Methods summary

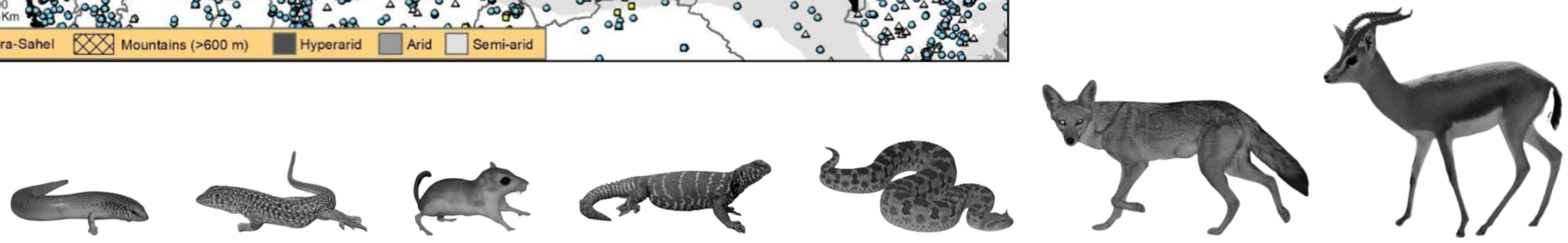


Study area, taxa and data

- 107 species post-filtering (59 reptiles, 7 amphibians, 37 mammals, and 4 scorpions)
- Xeric and mesic taxa
- Mostly vertebrates
- ~ 8500 geo-referenced specimens with sequence data
- >28 000 present occurrence data







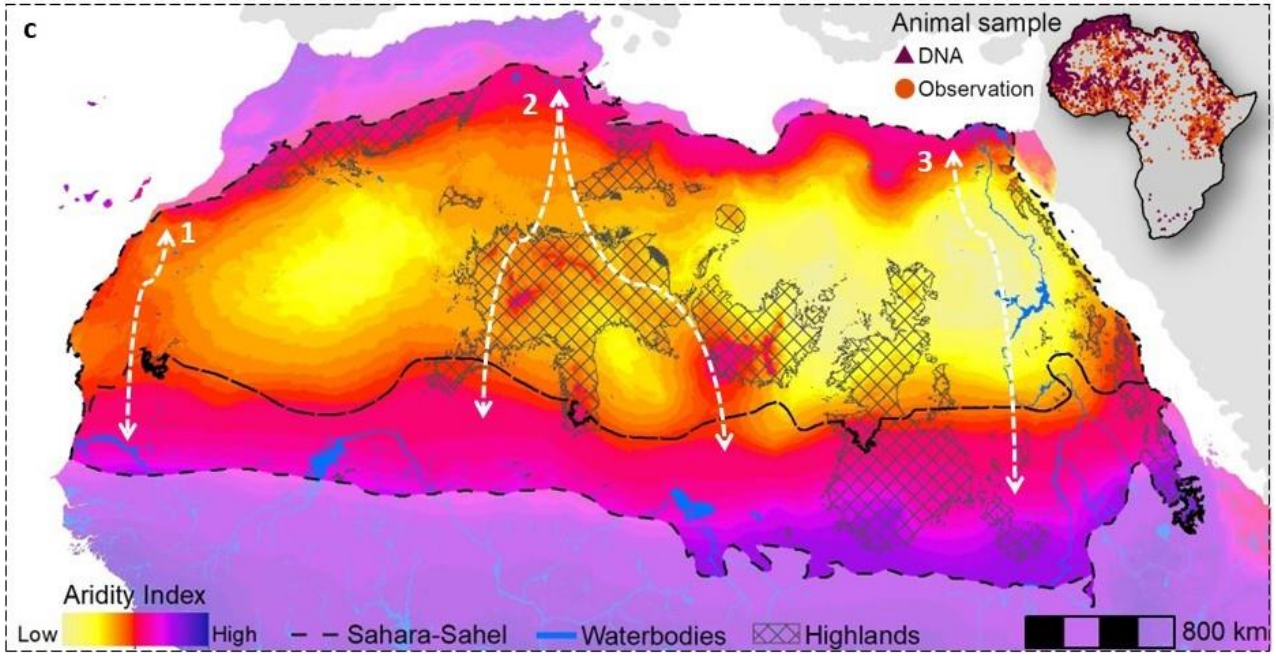
Data analyses

Taxa selection

- IUCN polygons (edited)
- >20% distribution inside study area
- >5 georeferenced sequences from distinct locations (same marker)

Xeric/mesic classification

- 65% distribution within hyper-arid region



Data analyses

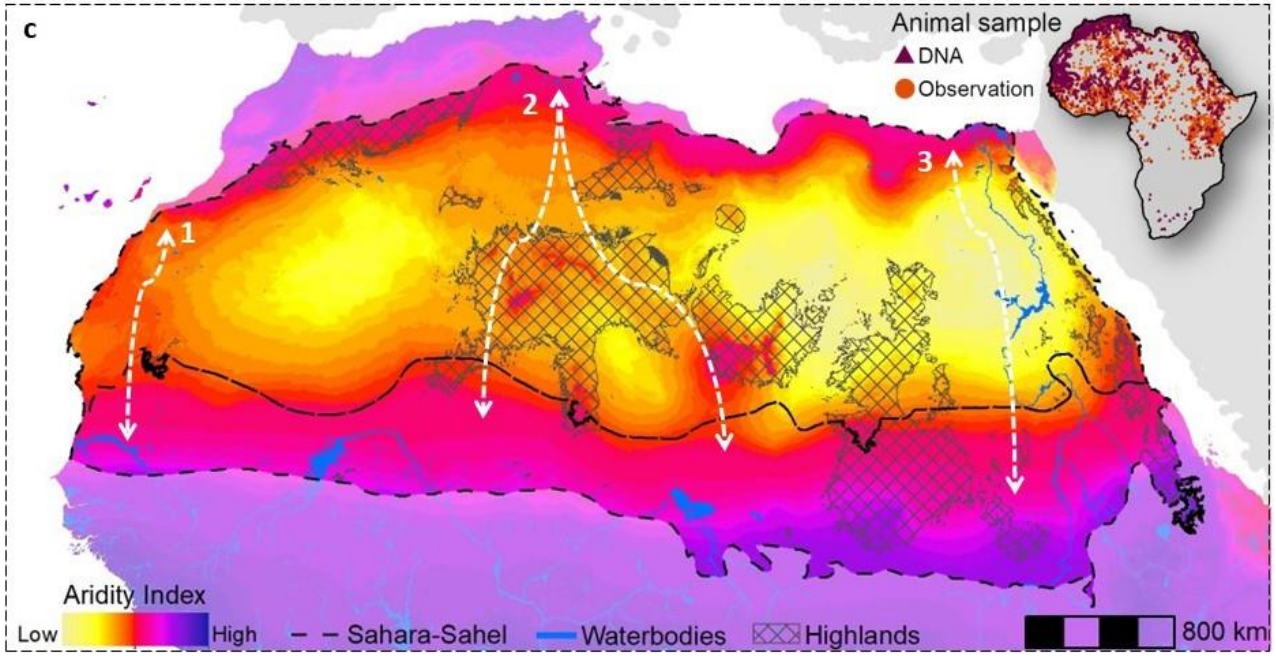
Taxa selection
- IUCN polygons (edited)
- >20% distribution inside study area
- >5 georeferenced sequences from distinct locations (same marker)

Xeric/mesic classification
- 65% distribution within hyper-arid region

Genetic data
- Genbank (mostly)
- Dominance of mtDNA

Lineage delineation and assignment
- IQ-Tree (Maximum Likelihood)

Lineage contact zones
- phylin spatial Interpolation

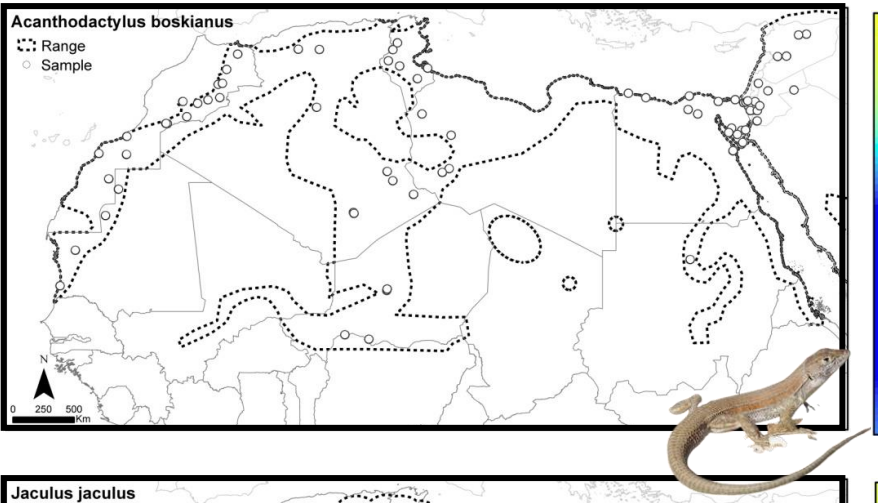


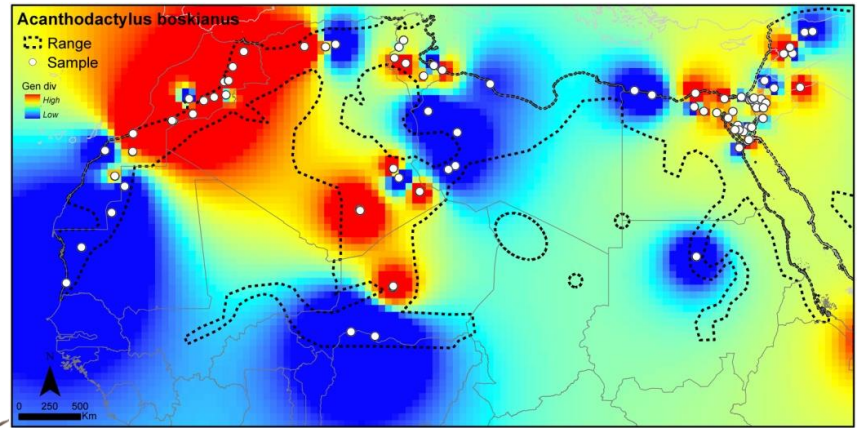
Data analyses

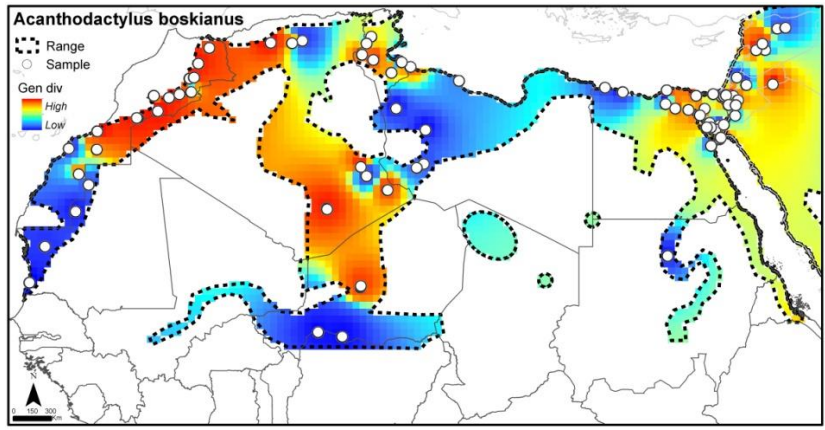
Genetic diversity mapping

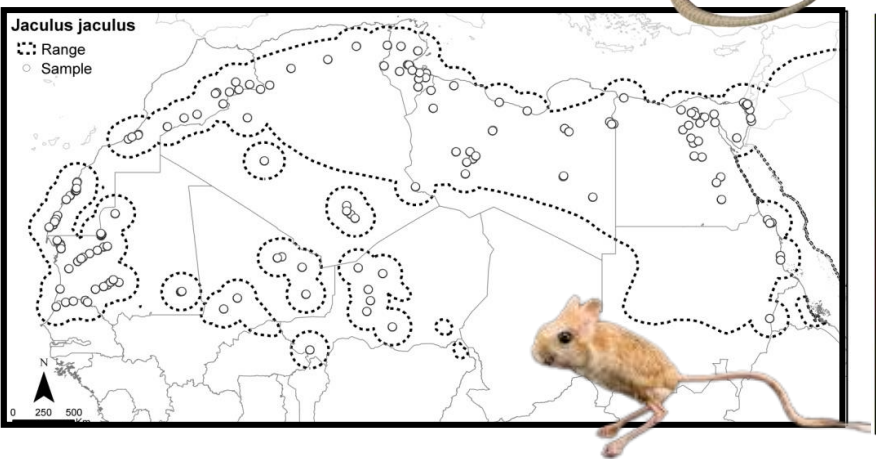
- Nucleotide diversity in 100km buffer (with replication)
- Spatial interpolation

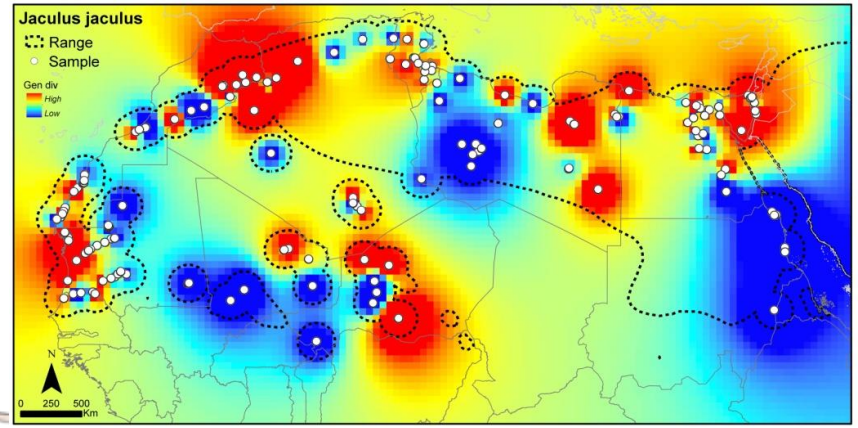
➢ Average among species

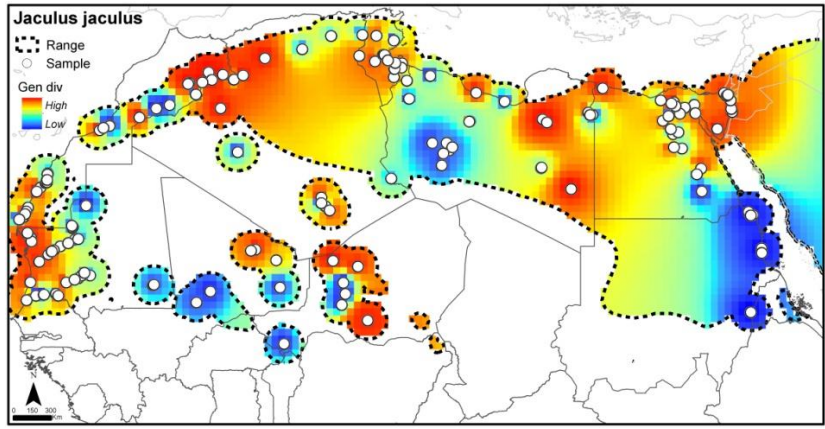












Data analyses

Species Distribution Models

Presence data points

- GBIF
- Bibliography

Environmental data

- (Paleo) Climate *
- (Paleo) Vegetation *
- Topography
- Substrate
- (Paleo) Hydrology

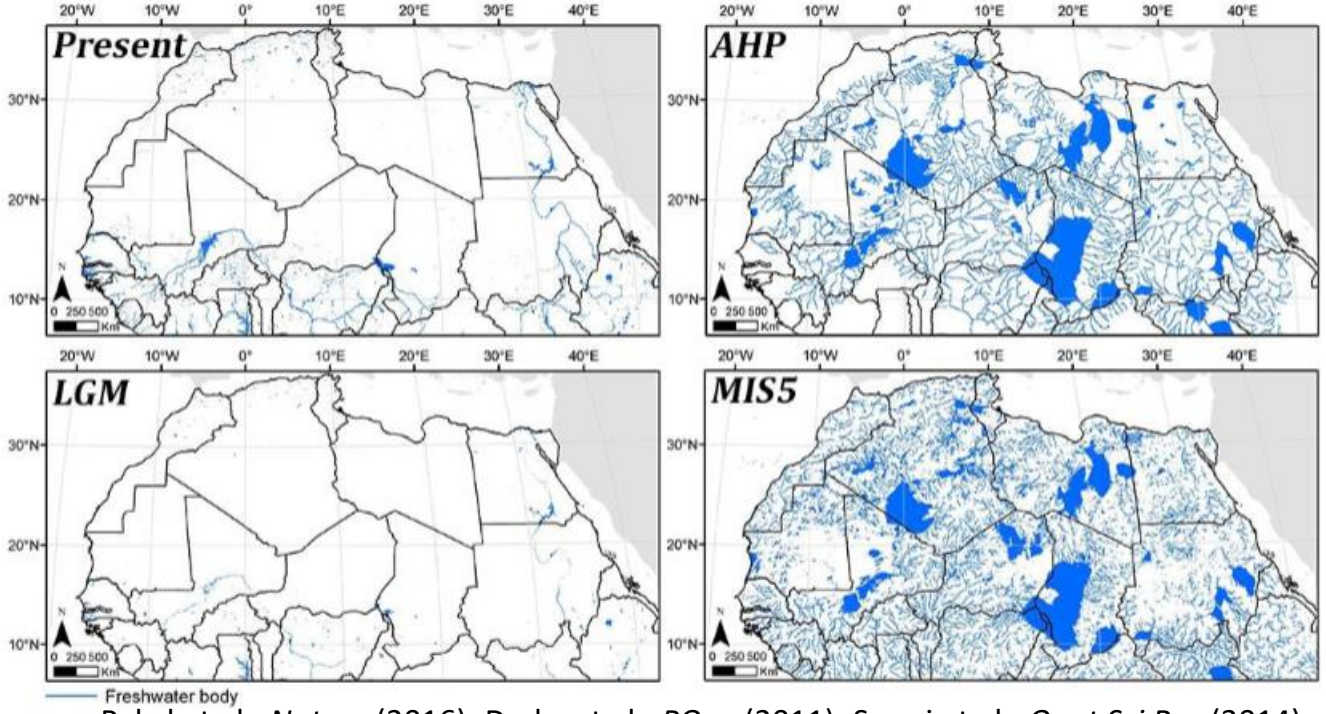
Time periods

- Present - dry
- Last Glacial Maximum (LGM) - dry
- last African Humid Period (AHP) - humid
- Stage5 (MIS5) – humid

➢ Average among species

Dataset 1 (1°)
HadCM3B-modelled climate and **paleo vegetation** (Armstrong et al., 2023. Nat Comms, 14)
…

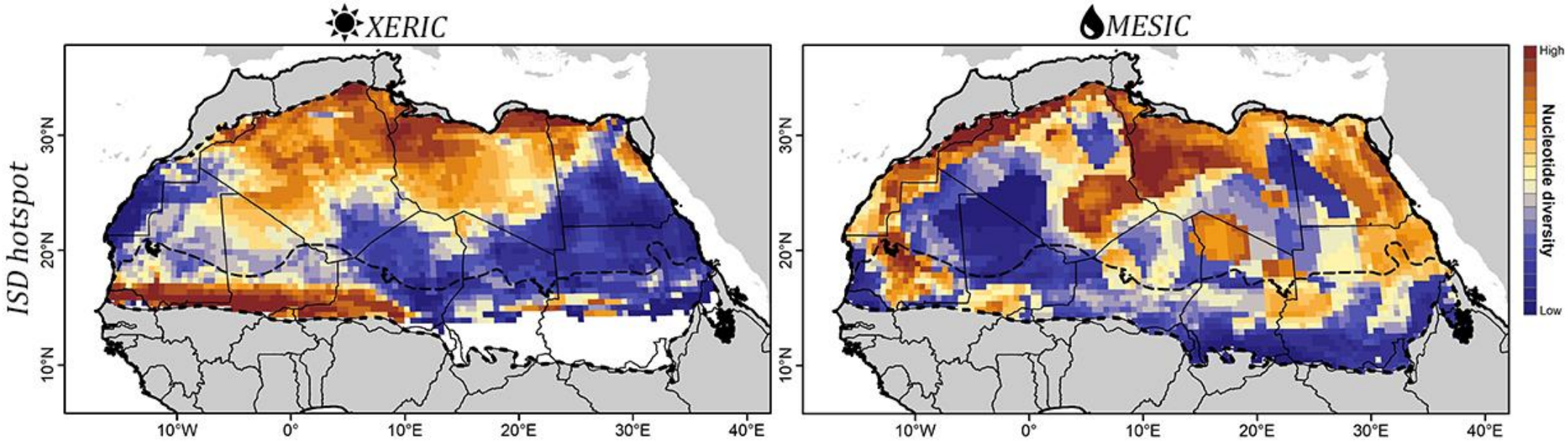
Dataset 2 (2.5')
CHELSA Bioclim (no vegetation)
…



Pekel et al., *Nature* (2016); Drake et al., *POne* (2011); Scerri et al., *Quat Sci Rev* (2014).

Results

Potential genetic refugia (high nucleotide diversity)

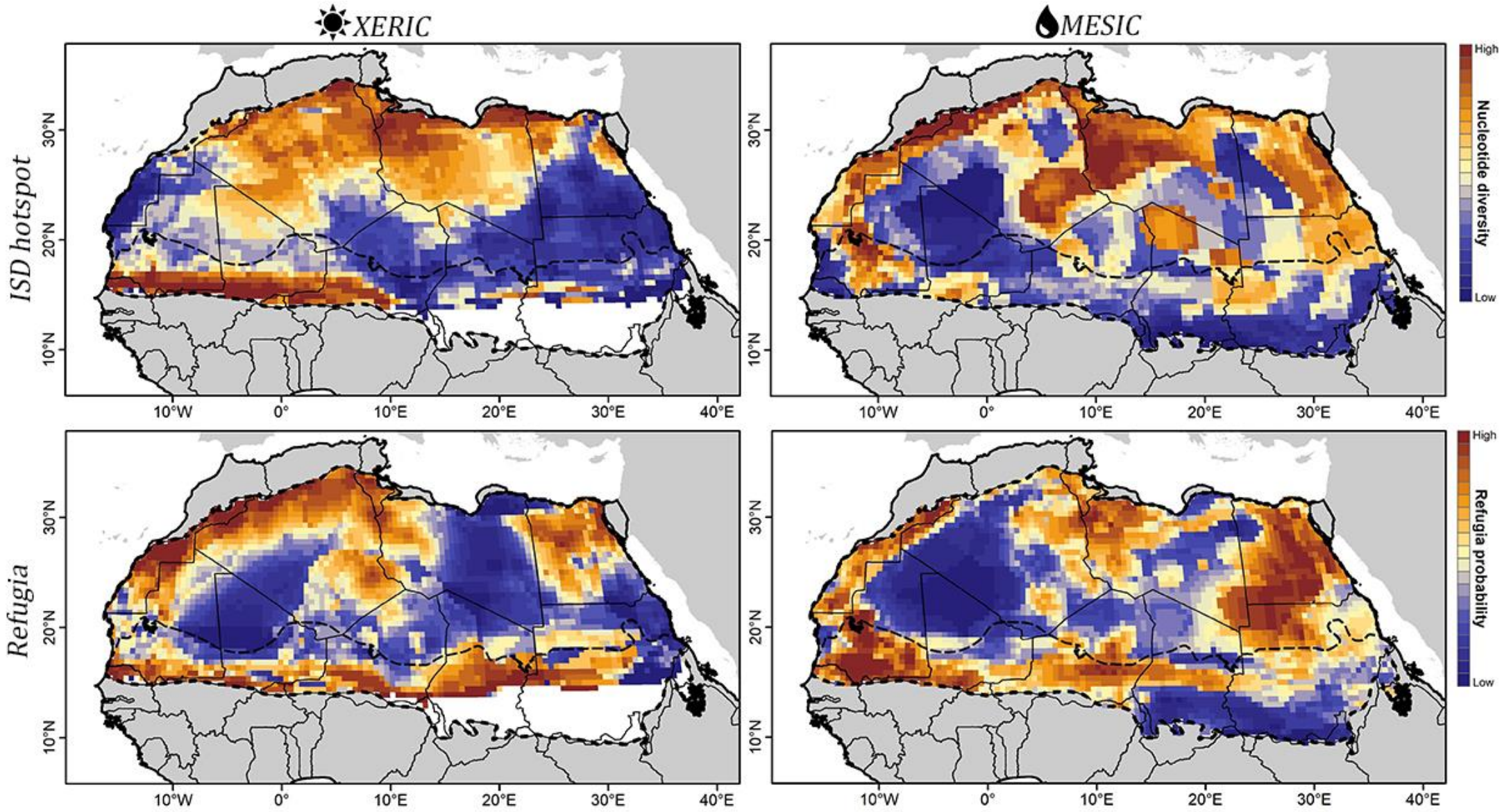


- Northern Sahara;
- Southwestern Sahel;

- Saharan highlands;
- the Nile Valley;
- coastal areas;
- Niger Delta

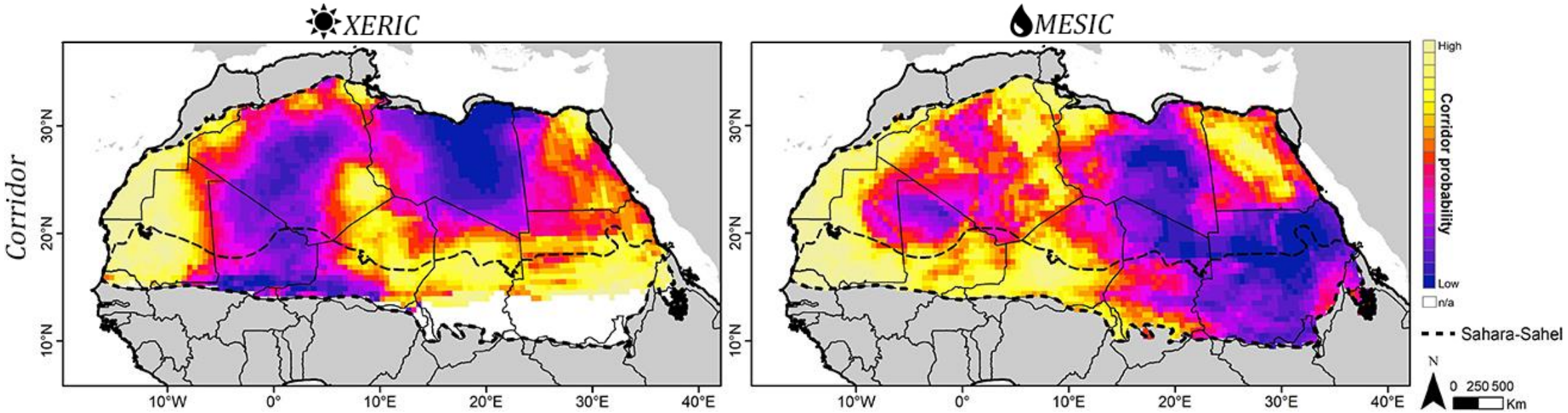
Results

Correction for by intra-specific contact zones



Results

Potential corridors (recent genetic connectivity)

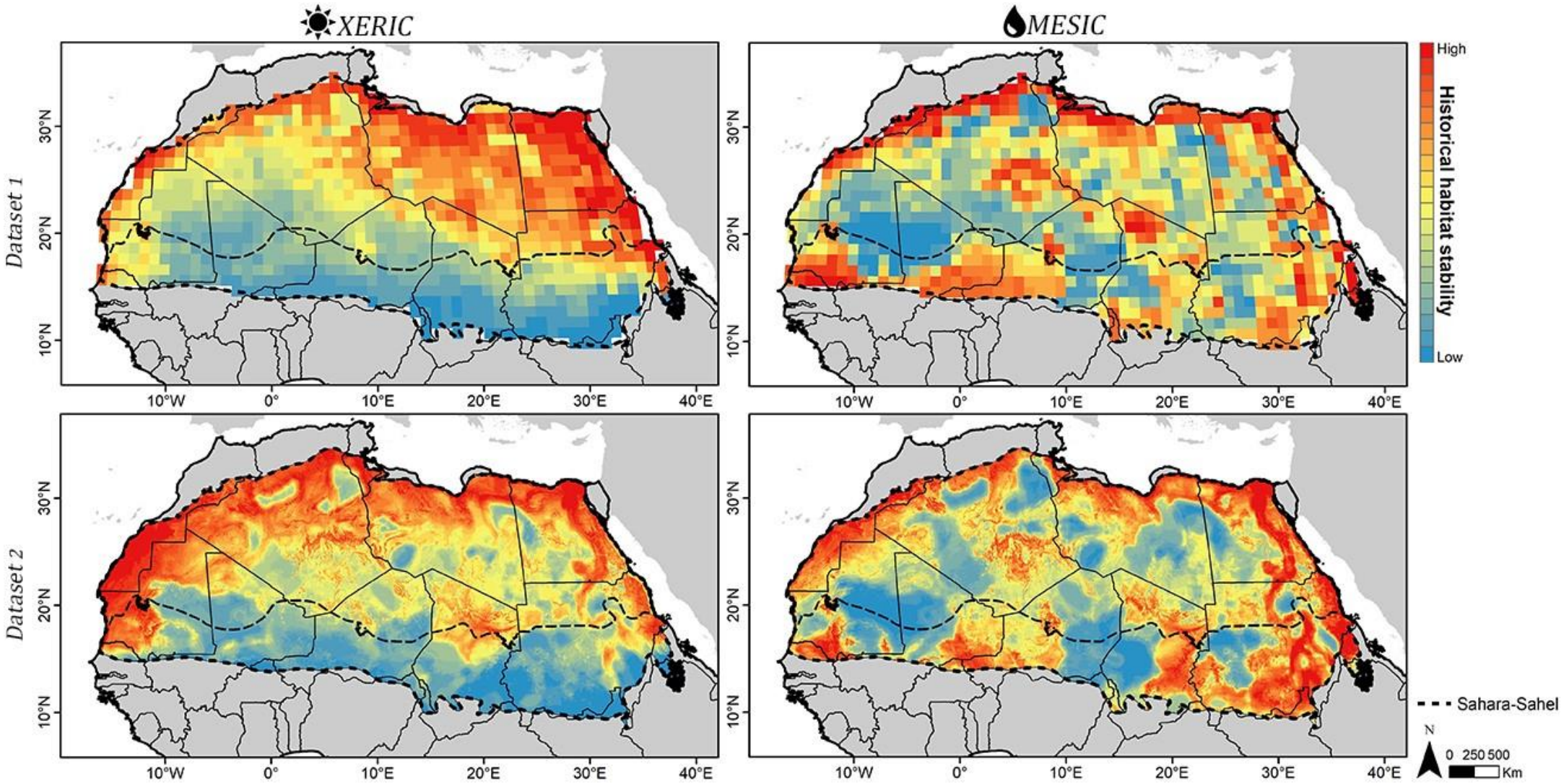


Atlantic Sahara;
Nile Valley outskirts;
Eastern Sahel.

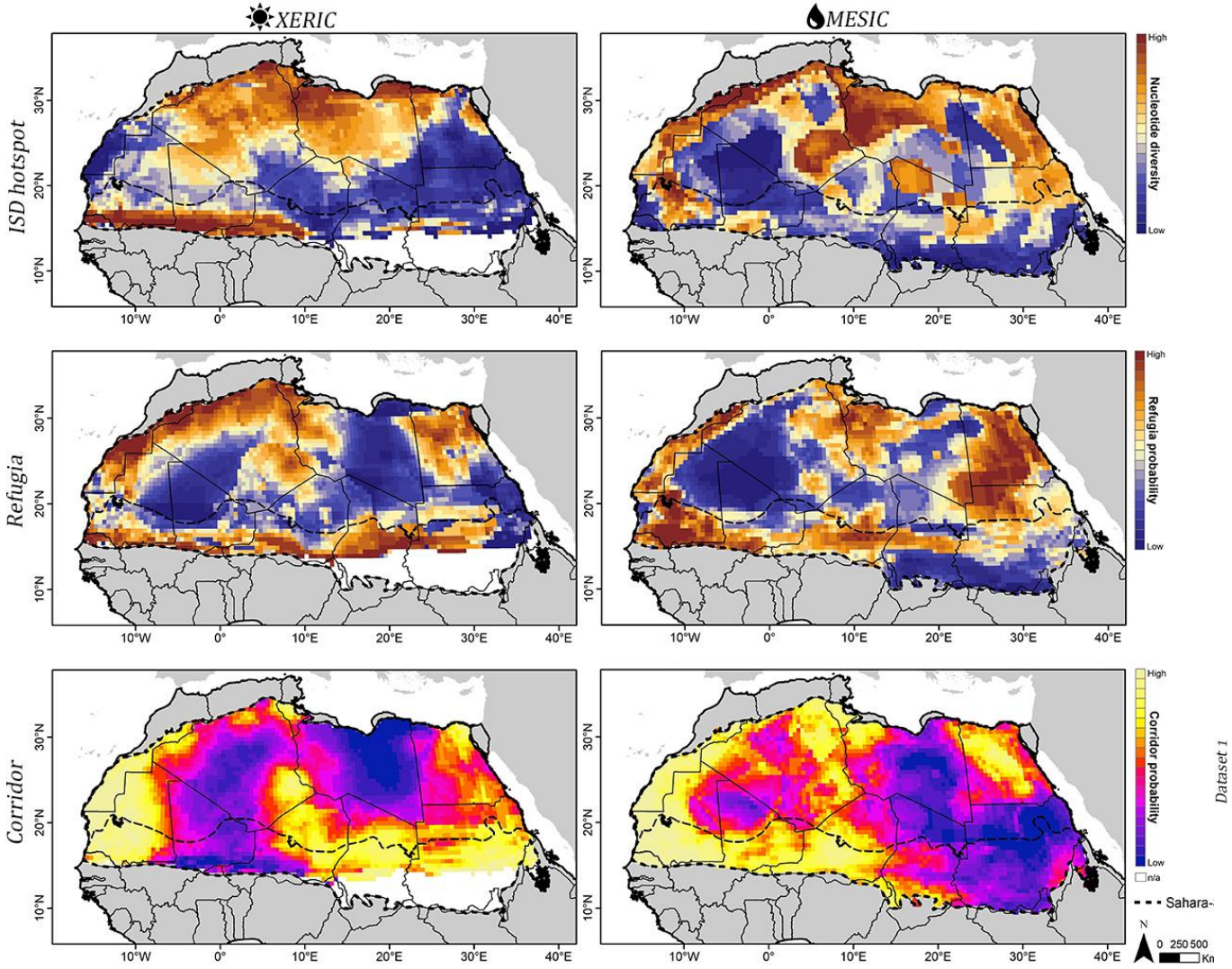
Atlantic coast;
Central Sahara highlands;
Western Sahel.

Results

Potential occurrence stability

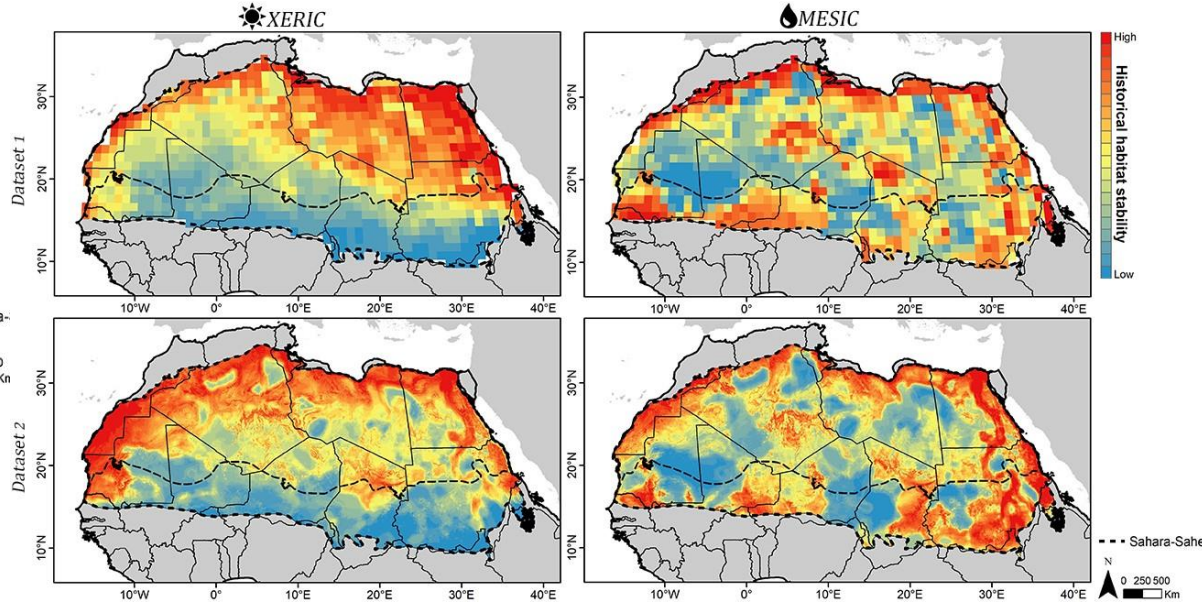


Discussion

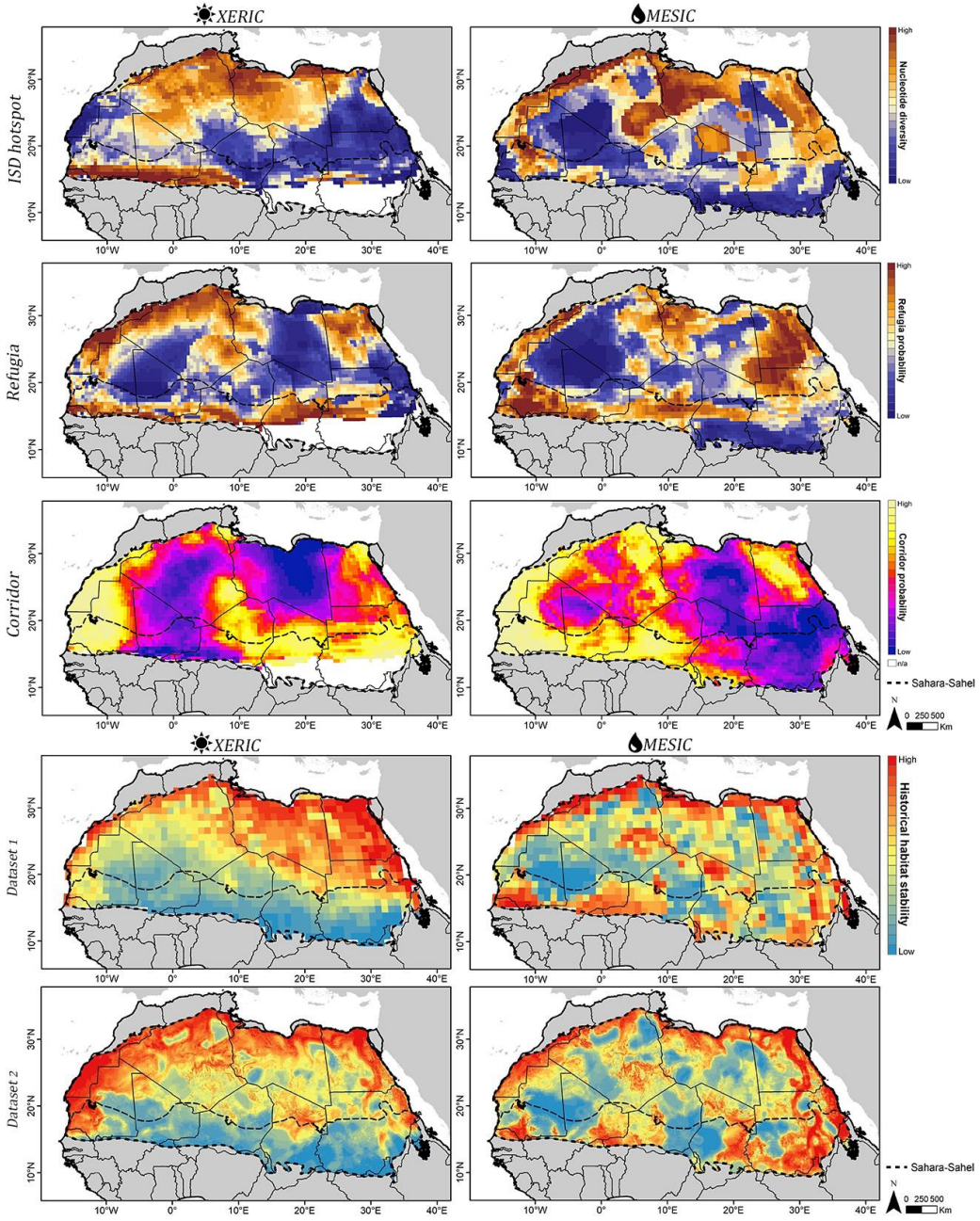


- Roughly consistent genetic and ecological patterns of refugia and recent connectivity;
  - Northern Sahara refugia, extending southwards;
  - Discrepancies in the Libyan desert and most of the Sahel.
  - Limited genetics support for E-W xeric corridors

- Relative genetic data scarcity;

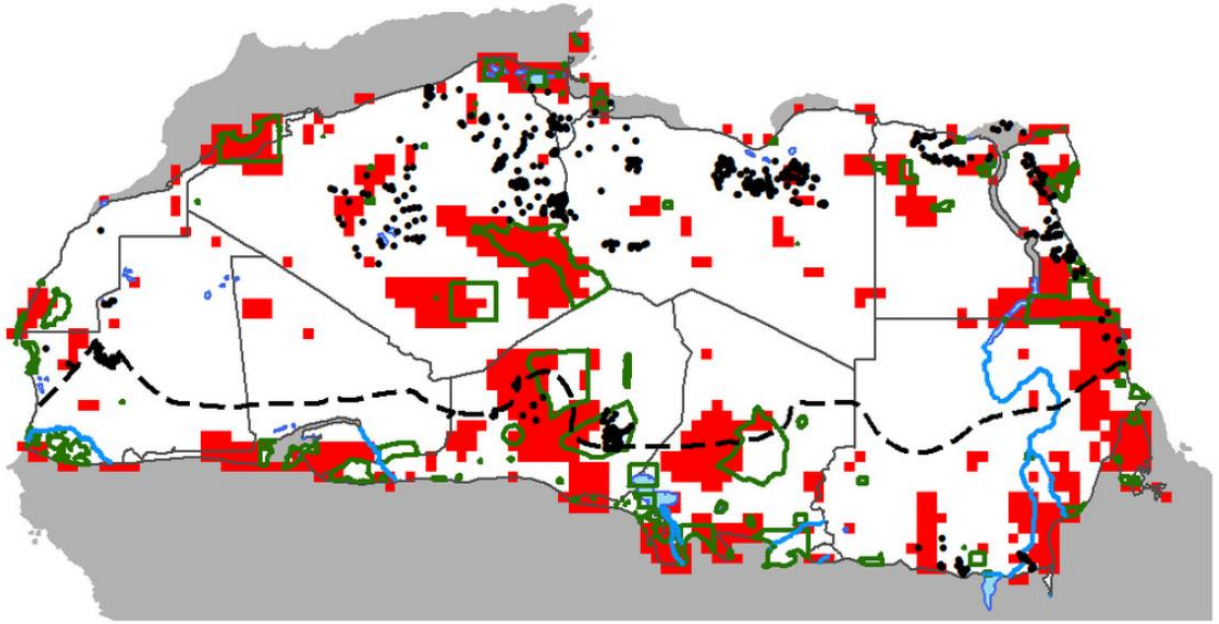


Discussion



Next steps…

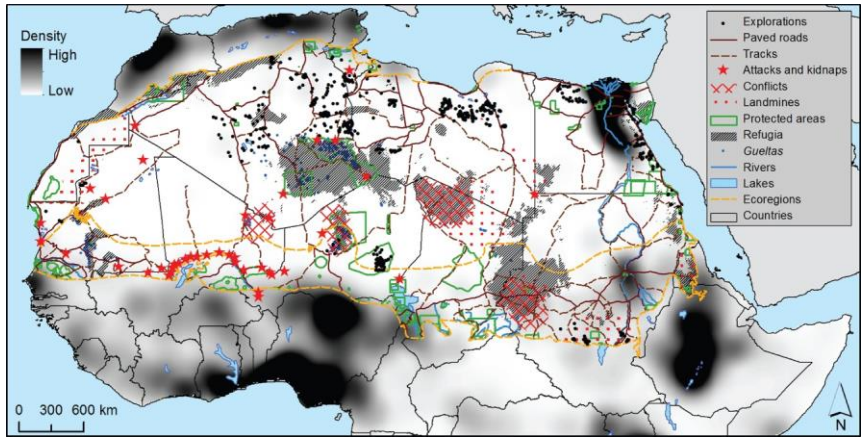
- Conservation prioritization



Brito et al., 2016. Diversity & Distributions 22.

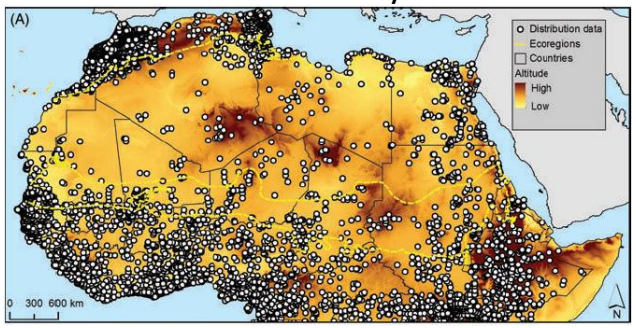
Discussion

Conservation threats and challenges

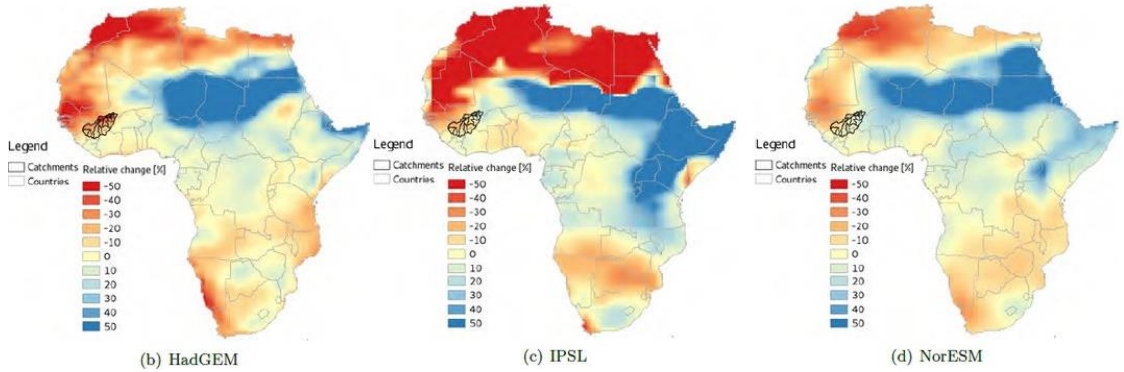


Brito et al., 2014. Biol. Rev. 89.

Data scarcity

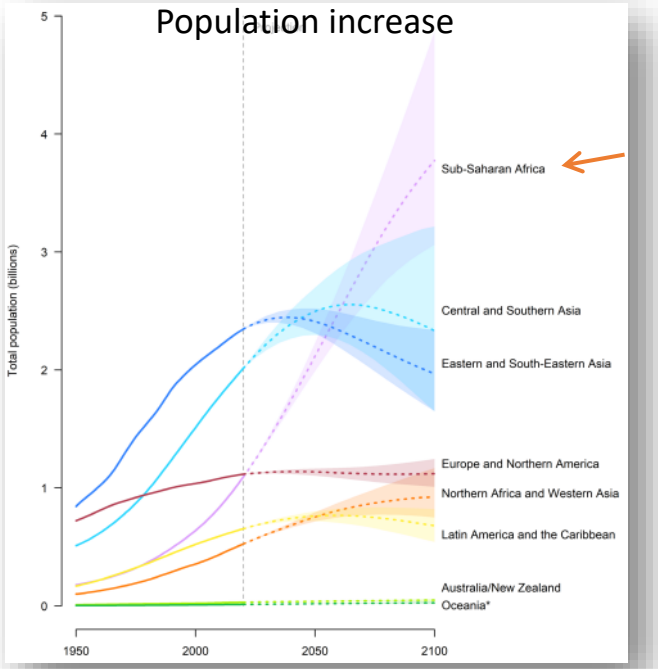


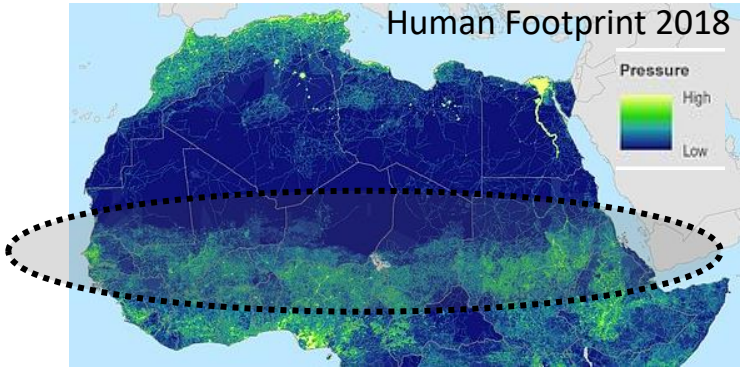
Distribution data available for vertebrates in North Africa (GBIF, 2012)

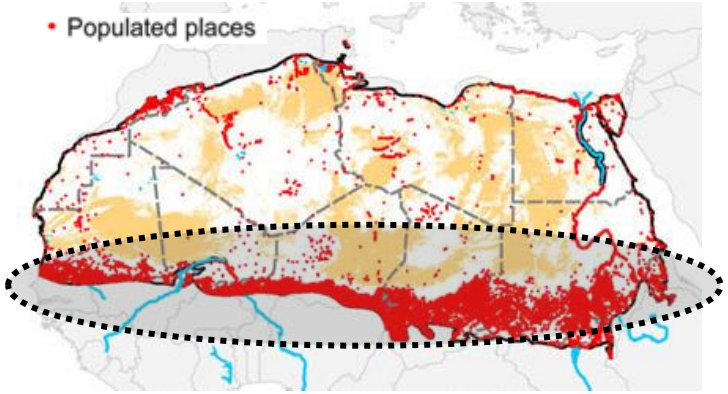


*Predicted relative change in **annual rainfall** (2070-2099 vs 1971-2000) according to three GCM*

Population increase







Brito et al (2018) *Conserv Lett*; IPCC (2021); UN (2019)

Acknowledgements



Comparative phylogeography of the Sahara-Sahel: a spatial-temporal approach to biodiversity dynamics in the largest warm desert on Earth

PhD

André Vicente Liz

Doutoramento em Biodiversidade, Genética e Evolução

Departamento de Biologia, Faculdade de Ciências da Universidade do Porto

2023

Orientador

José Carlos Brito

Coorientadores

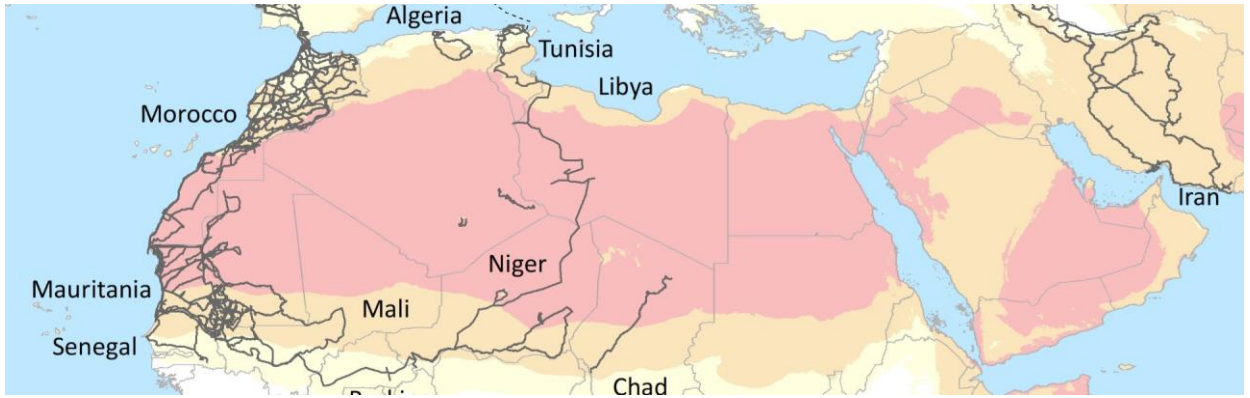
Dennis Rödder

Duarte Vasconcelos Gonçalves



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