Late Quaternary demographic changes and biodiversity prediction in the Brazilian Atlantic rainforest

What are we learning in the lowlands and higher up

Ana Carnaval, Craig Moritz, Miguel Rodrigues,

Renata Amaro, Celio Haddad

biological PROCESSES

biodiversity PREDICTION

biodiversity PROTECTION

biodiversity PATTERNS

Modeling amphibian response to former climate change

Distribution models under palaeoclimates are used to generate hypotheses

Hypsiboas albomarginatus

H. semilineatus

H. faber

- **Broad range**
- **Pond breeders**
- **Tolerant to edge habitats**
- **2 taxa at low to mid-altitudes, *H. faber* up to 1200+ m**

Modeling amphibian response to former climate change

Distribution models under palaeoclimates are used to generate hypotheses

Diversity distribution Modeling

Generate species distribution models under 3 climatic scenarios (current, 6 kypb, 21 kypb)

Hypothesis Formulation

Intersect maps to identify location of stable areas (refugia for biodiversity) and unstable areas (recently colonized)

Model Validation

Test with multi-species molecular data

Hypsiboas albomarginatus

H. semilineatus

H. faber

- **Broad range**
- **Pond breeders**
- **Tolerant to edge habitats**
- **2 taxa at low to mid-altitudes, *H. faber* up to 1200+ m**

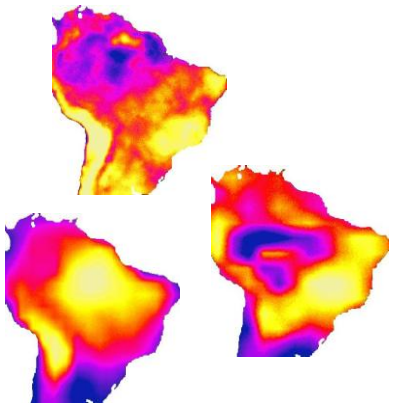
Modeling distributions based on climate data

Distribution model under current climate

Projection under past climatic conditions (e.g. 21,000 years bp)

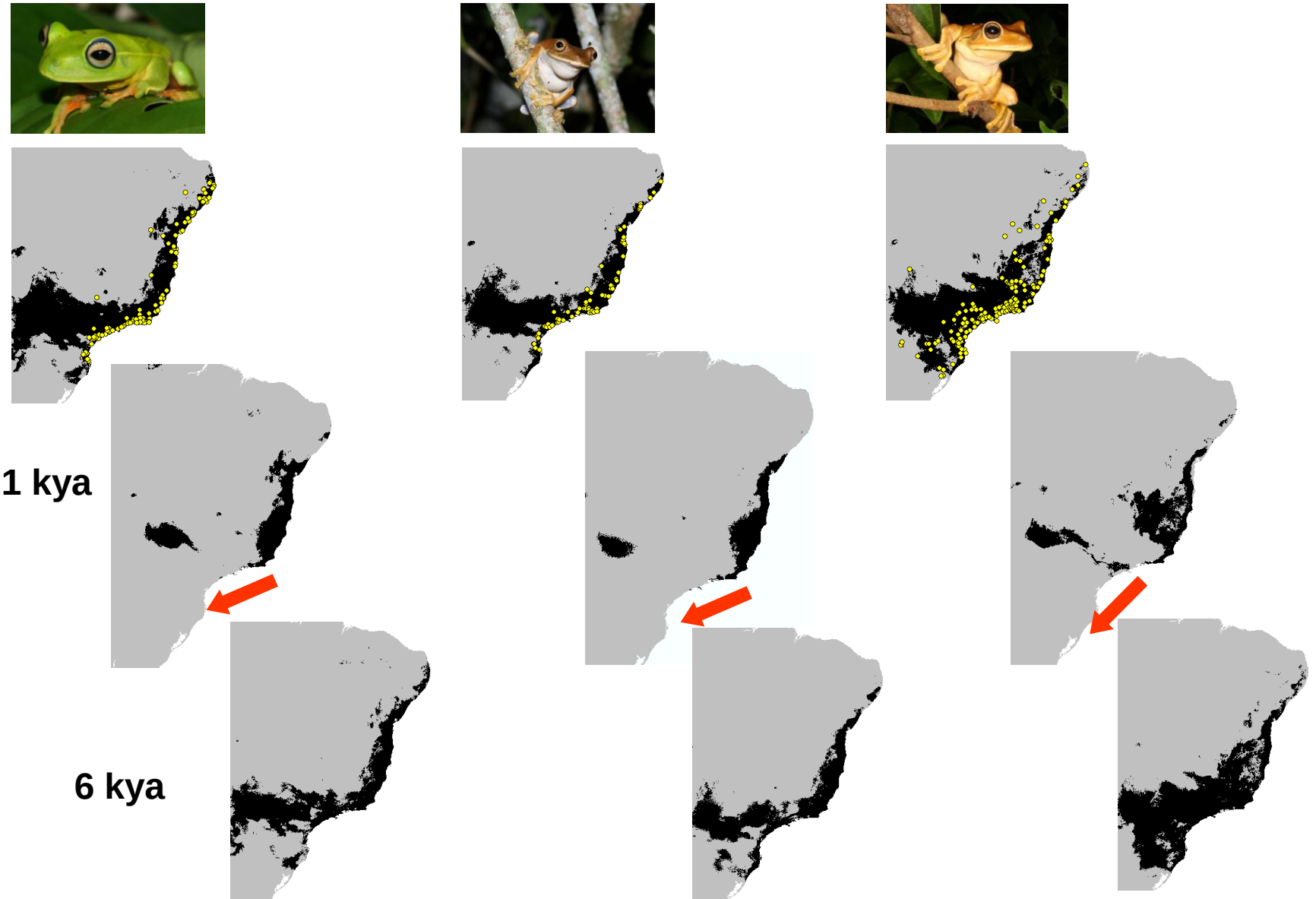
occurrence data

+



climate data

Modeling amphibian response to former climate change



Current

21 kya

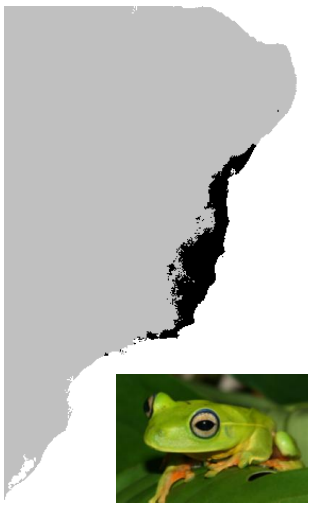
6 kya

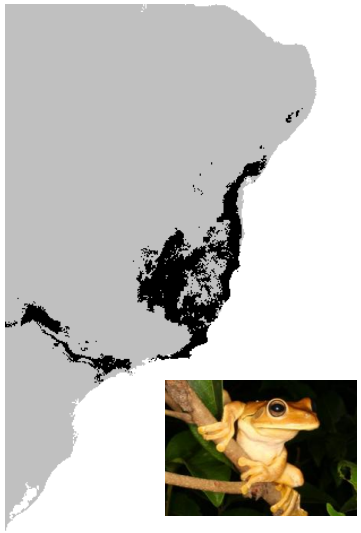
INTERSECT

proposed refugia

Expected genetic patterns given the palaeomodels

INFERRED STABLE AREAS (REFUGIA)





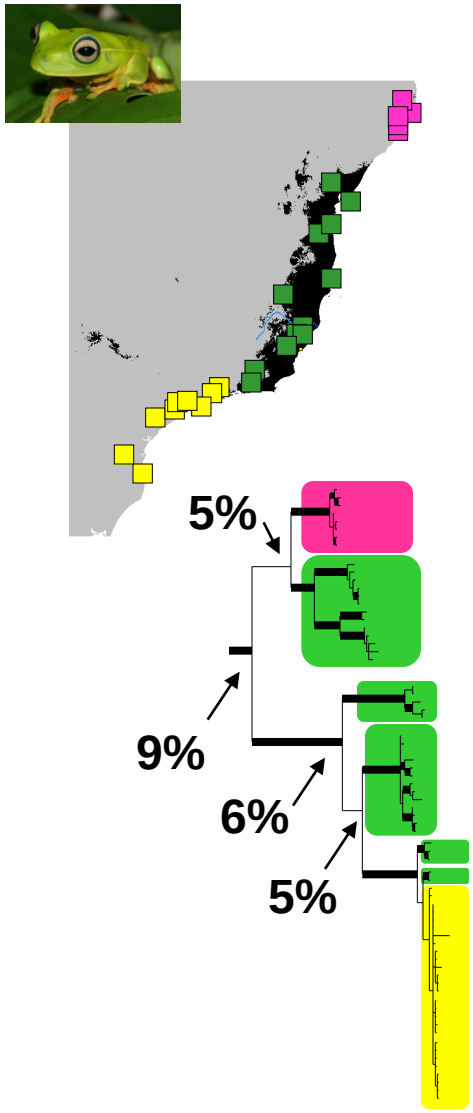
Expected outcomes from molecular data

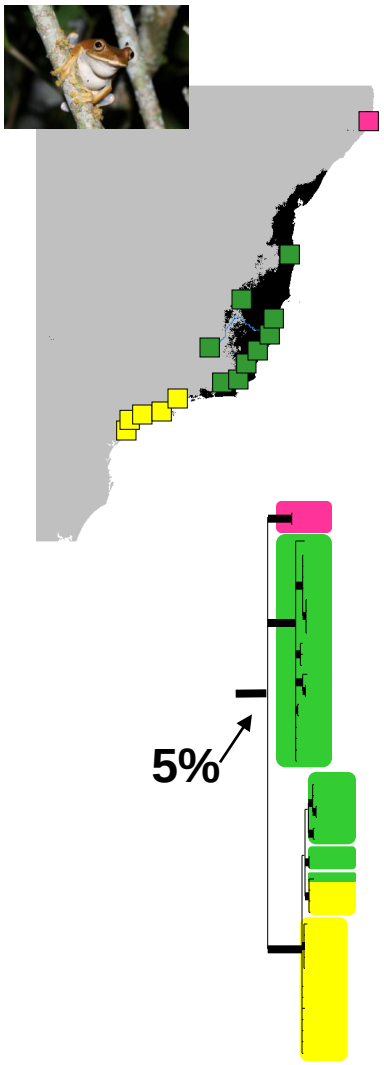
Comparatively higher genetic diversity within and among pops in refuge areas

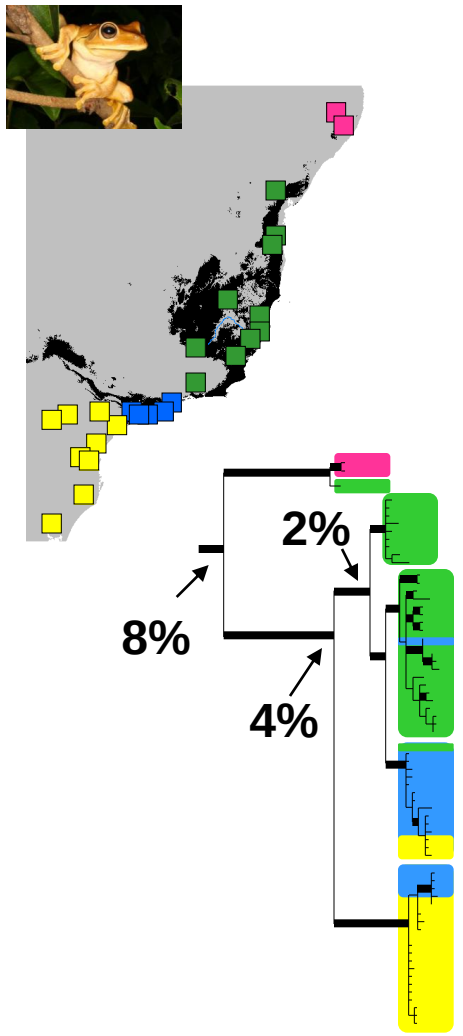
Population expansion out of refugia

Genetic structure among refugia

Mitochondrial (mtDNA) data



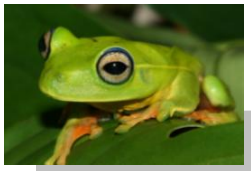


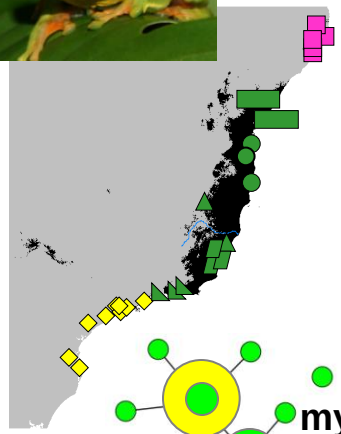


ND2 (700-1,000 bp)

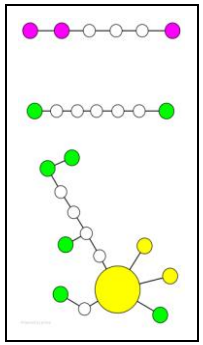
Comparative phylogeography of Atlantic rainforest frogs

nuclear data

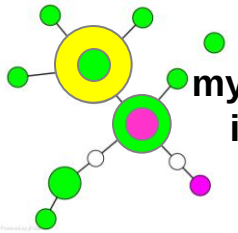




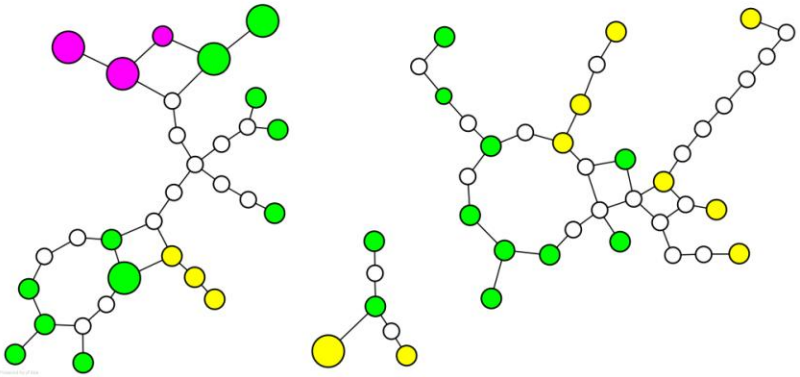
B crystallin

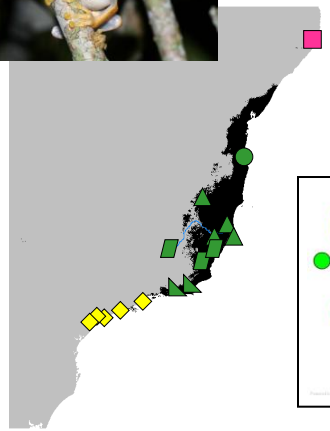


myosin light chain intron 6 (275 bp)



glyceraldehyde 3-P dehydrogenase intron 4 (394 bp)





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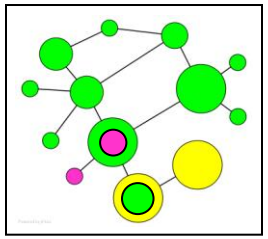
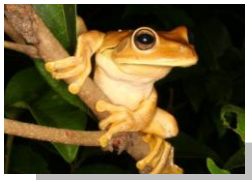
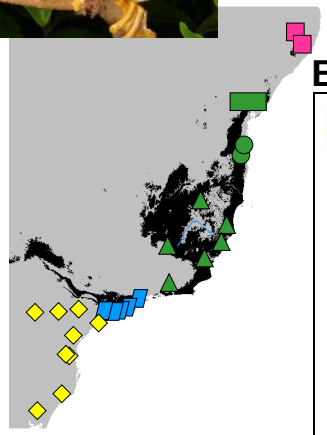
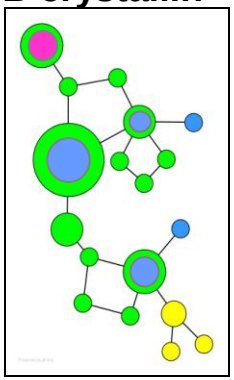


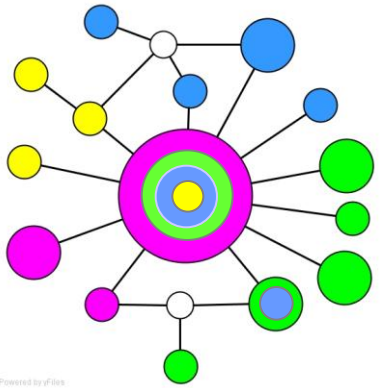




B crystallin

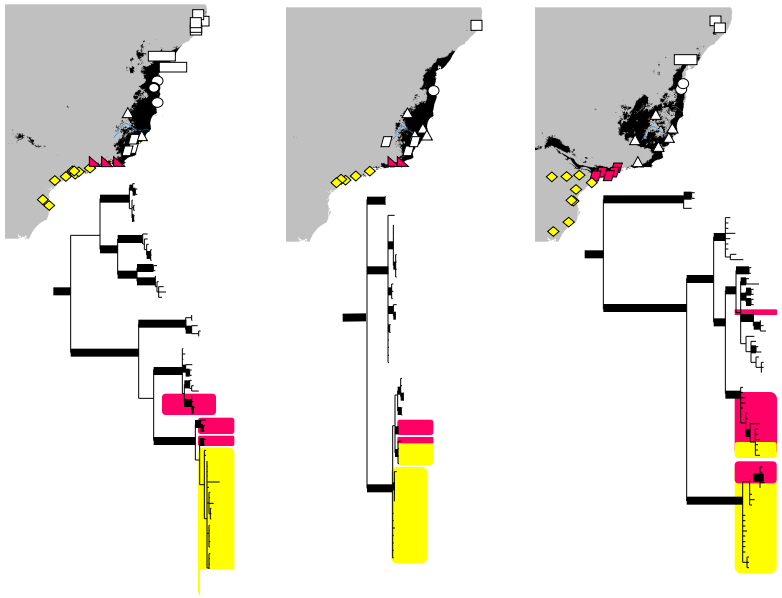


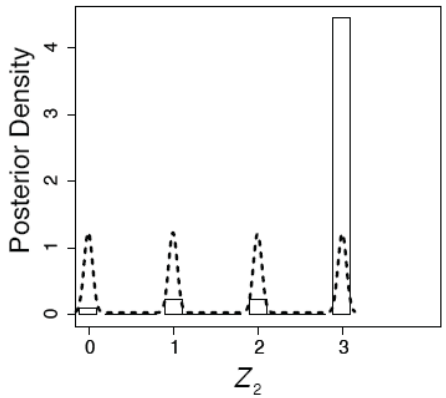
glyceraldehyde 3-P dehydrogenase (388 bp)



Testing for “assemblage-wide” responses to climate change with ABC

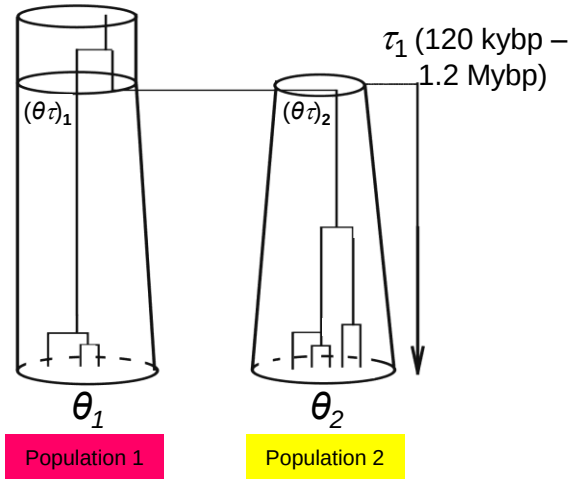
Population expansion into unstable areas



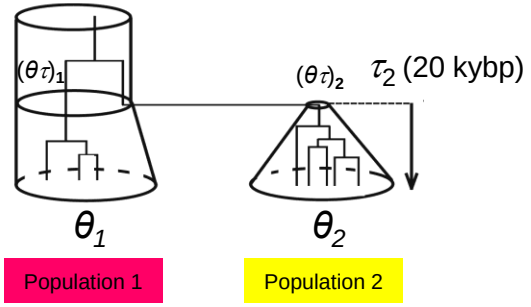


Where Z_2 = # of species evolved under H_2

***H*$_1$**: long-term persistence

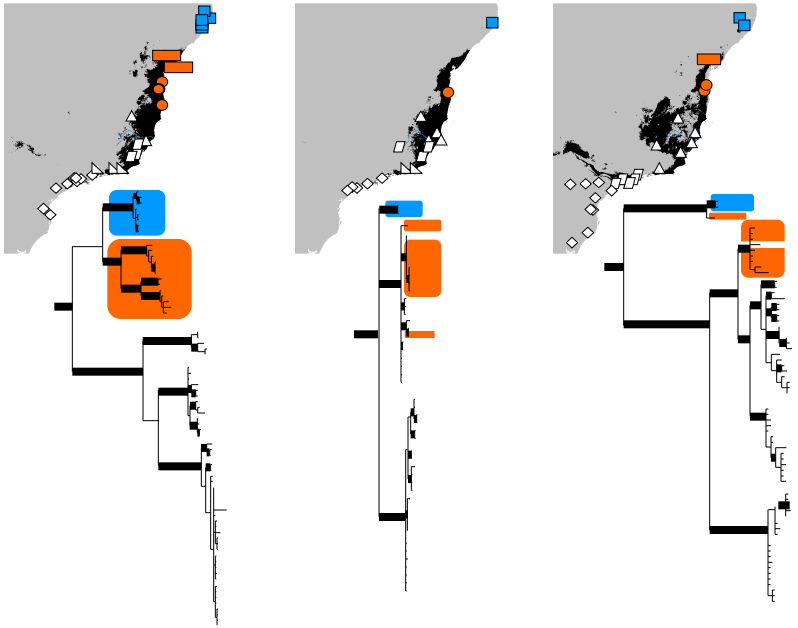


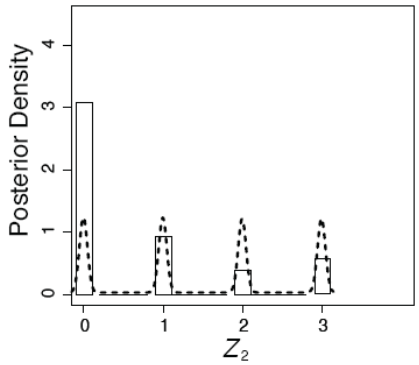
***H*$_2$**: recent colonization



Testing for “assemblage-wide” responses to climate change with ABC

Long-term persistence in isolated refugia





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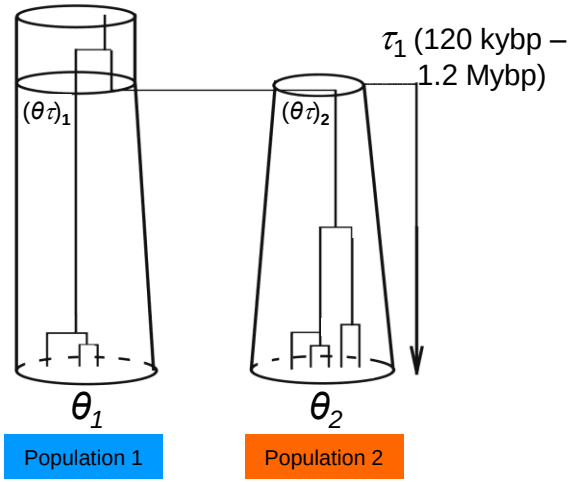

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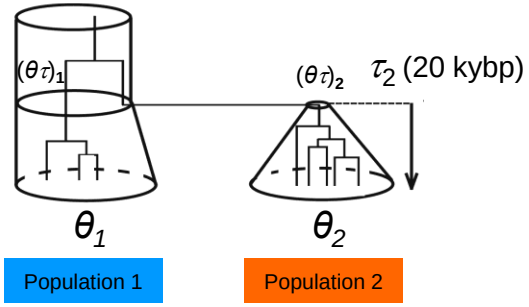
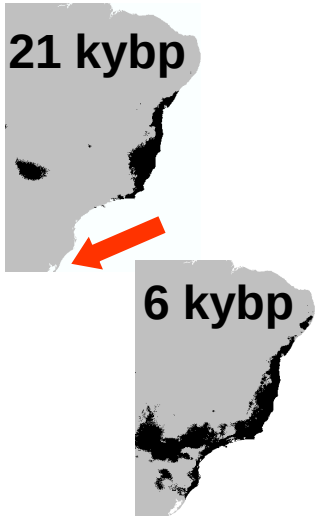
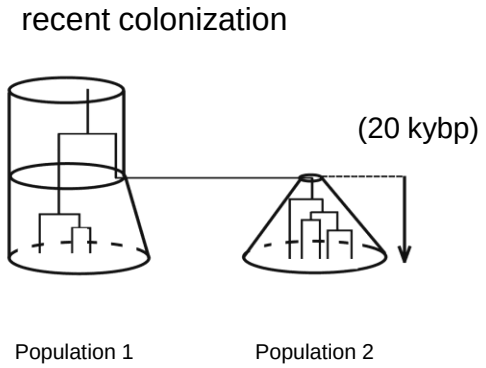


Conclusions from Approximate Bayesian Computation analysis

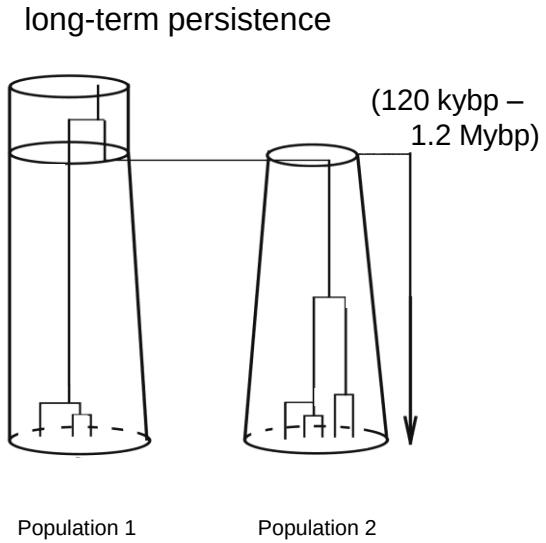
Results support both model-driven hypotheses of

(i) simultaneous, multi-species colonization of unstable areas from adjacent refugial populations since the LGM

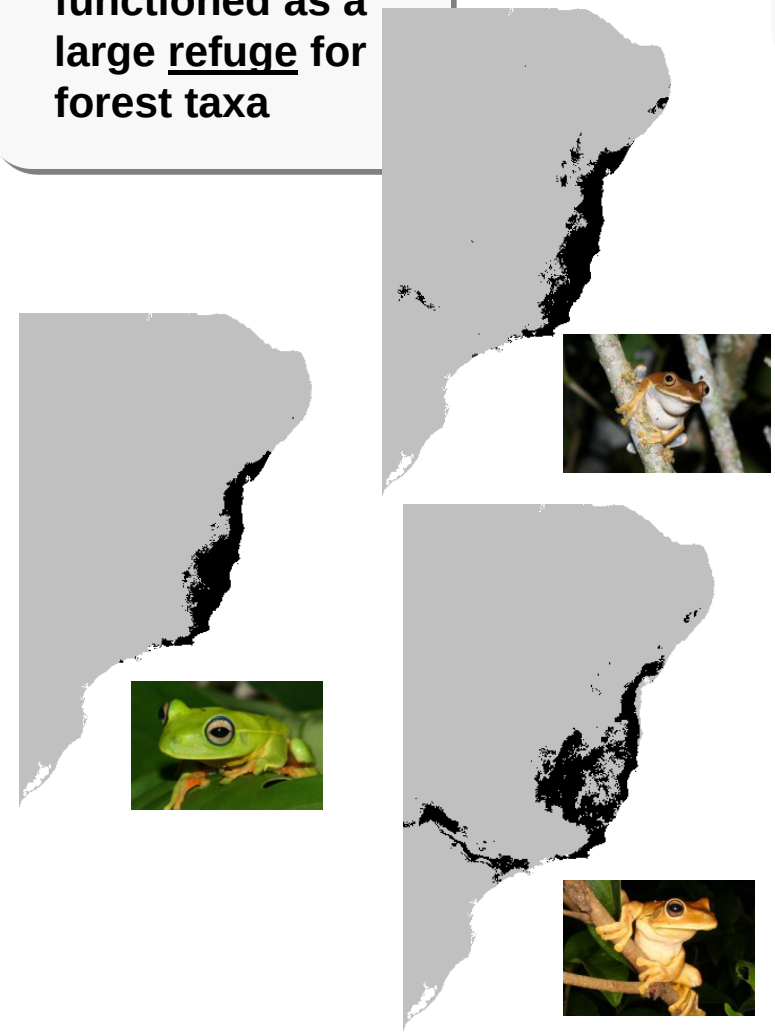




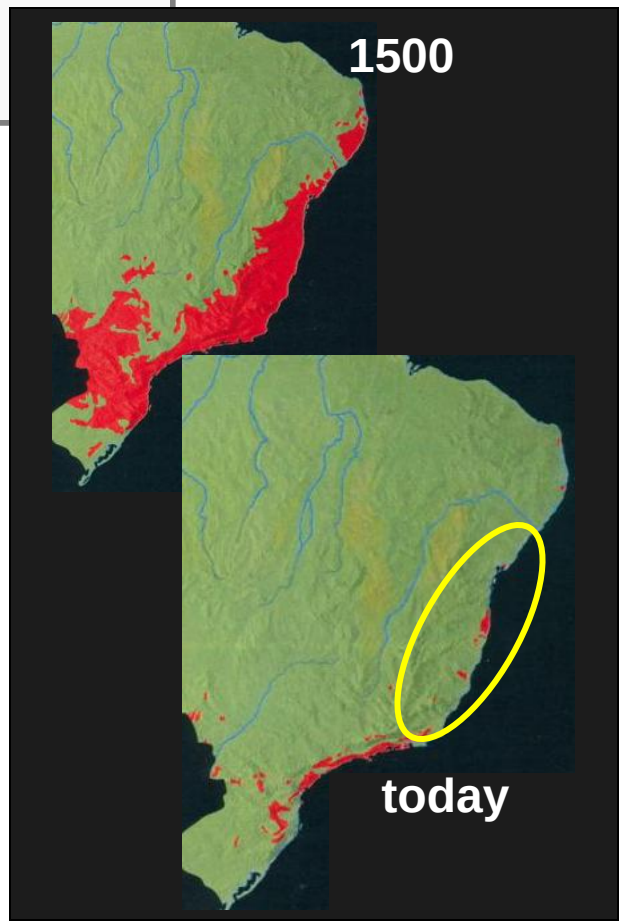
(ii) assemblage-scale, long-term persistence of populations in isolated refugial areas



Central corridor functioned as a large refuge for forest taxa



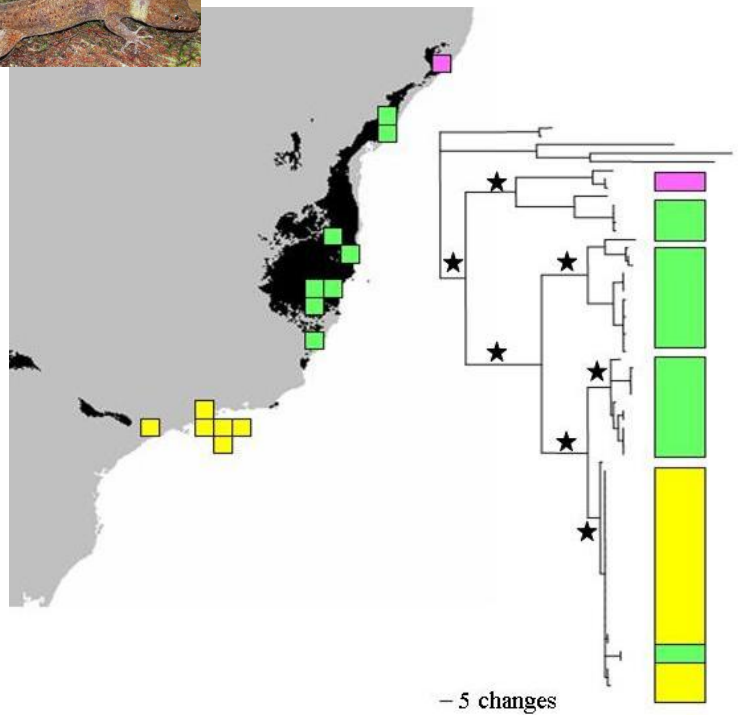
Yet, it is poorly known and under much higher threat relative to southern forests

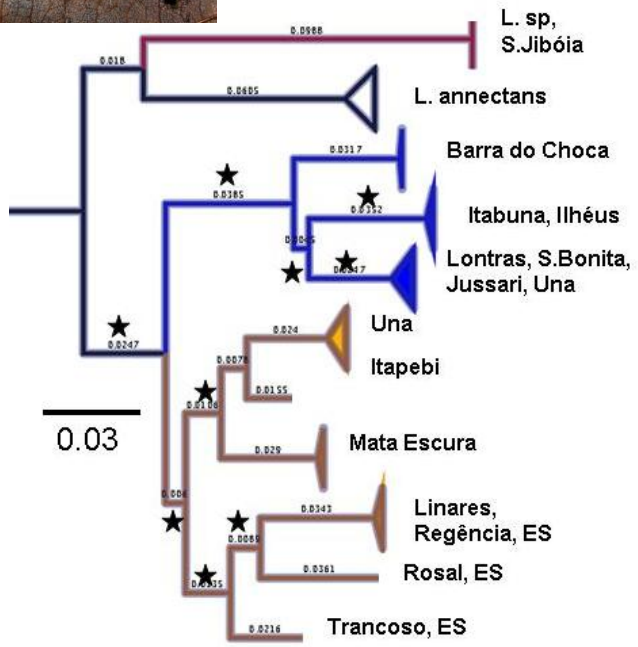


Carnaval et al. 2009. Science.

Historical climate change and prediction of endemism in the central corridor of the Brazilian Atlantic rainforest

Historical climate change and prediction of endemism in the central corridor of the Brazilian Atlantic rainforest





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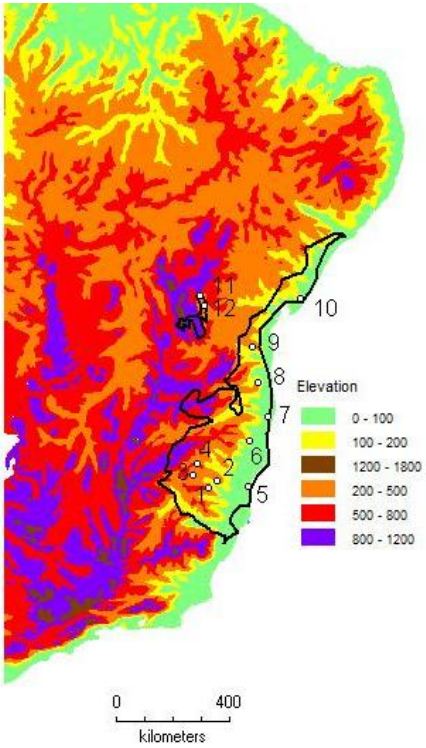

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A new species of *Dendrophryniscus* (Amphibia, Anura, Bufonidae) from the Atlantic Rainforest of southern Bahia, Brazil

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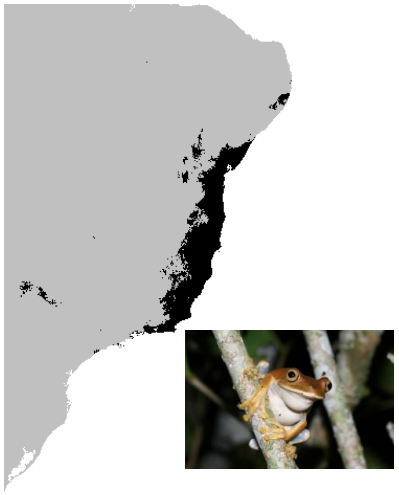
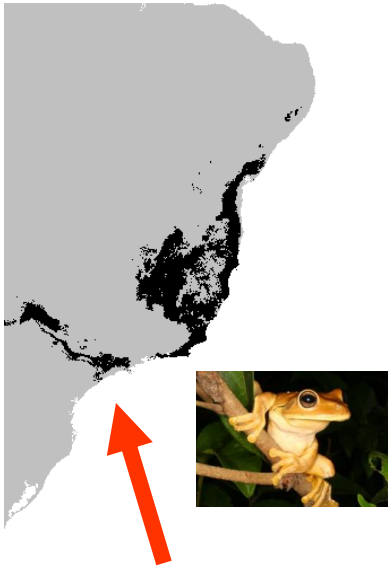
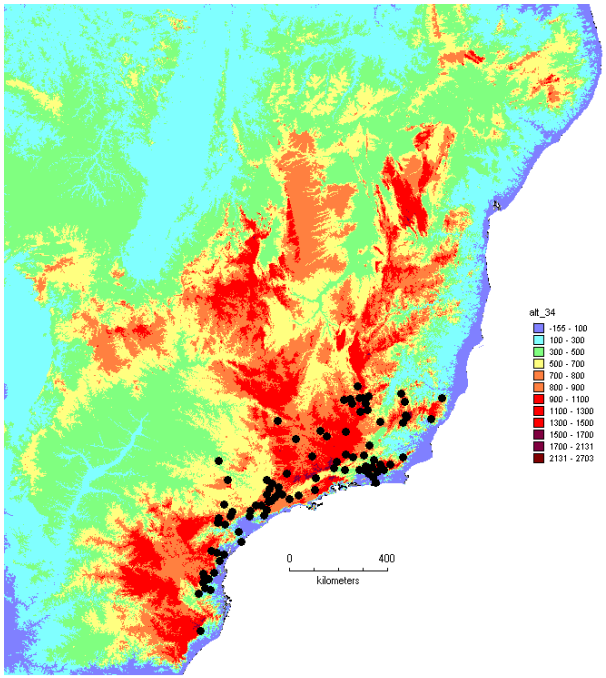
What goes on at higher altitudes (or colder forested areas)?

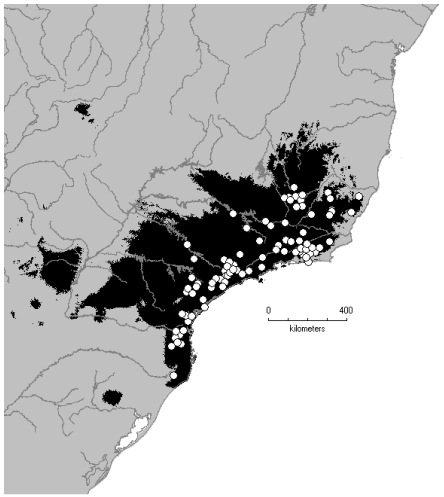




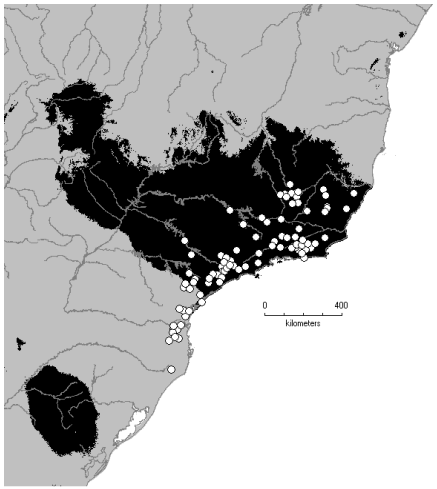
What goes on at higher altitudes (or colder forested areas)? A case study with *Proceratophrys boiei*



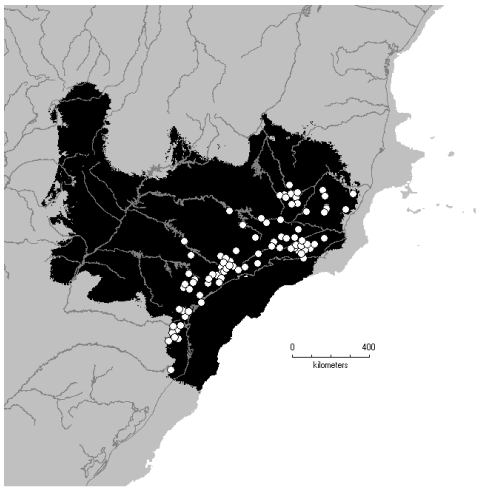
CURRENT



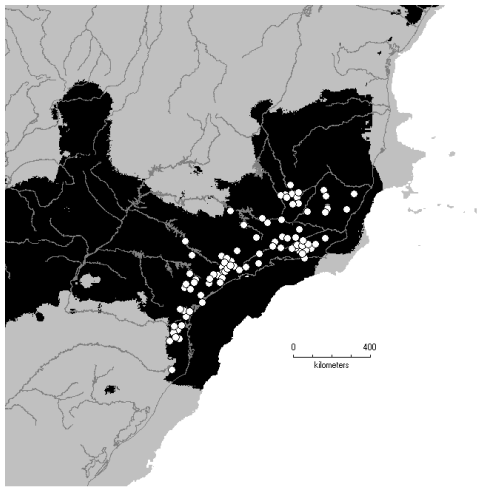
ECHAM3 21k



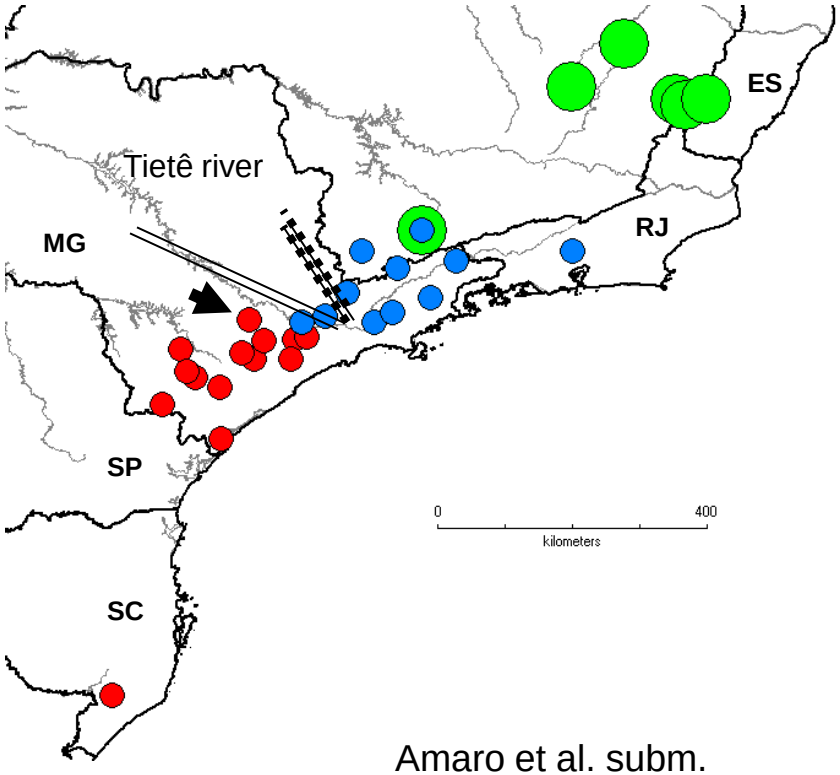
MIROC 21k



CCSM 21k



Amaro et al. subm.



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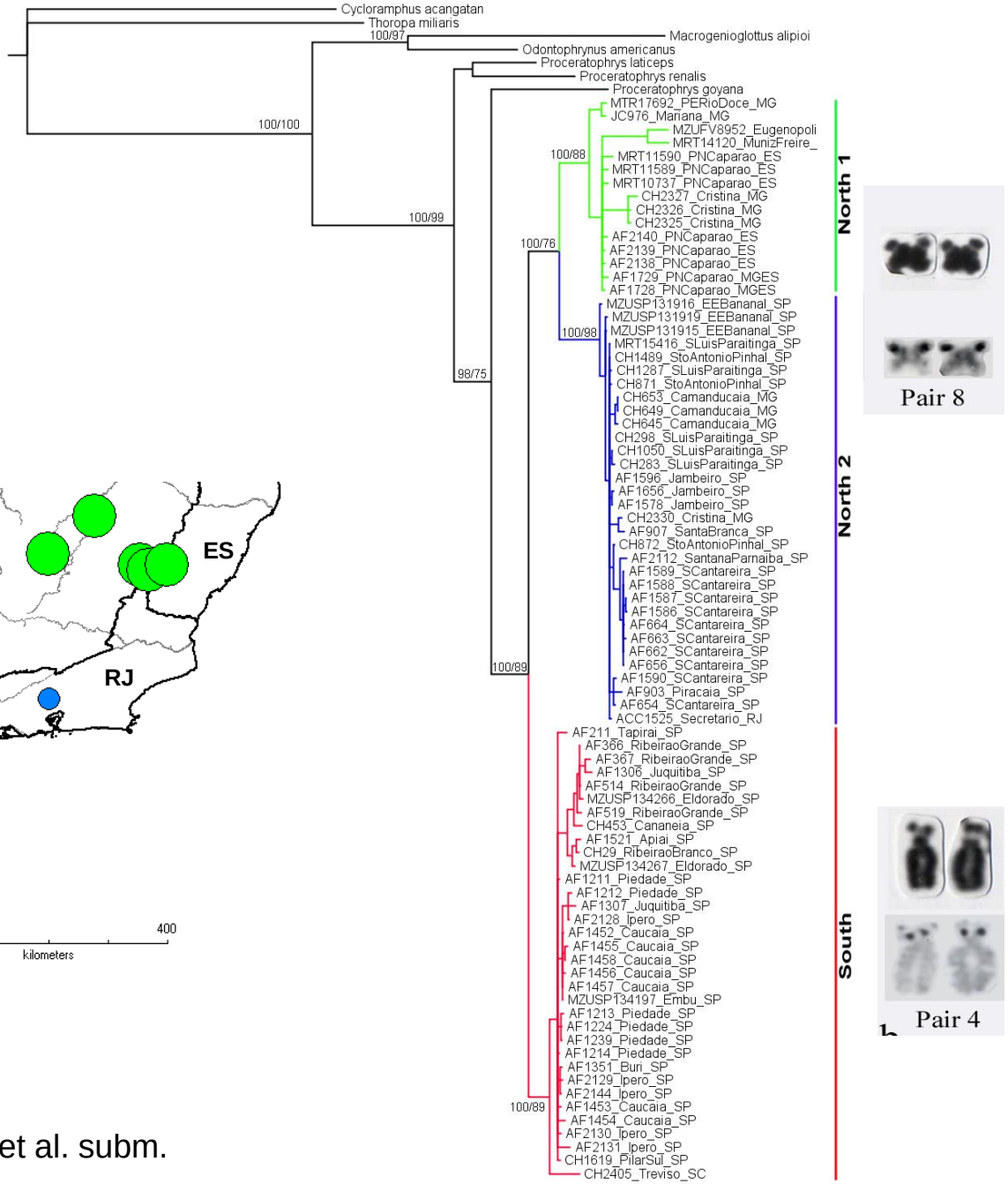
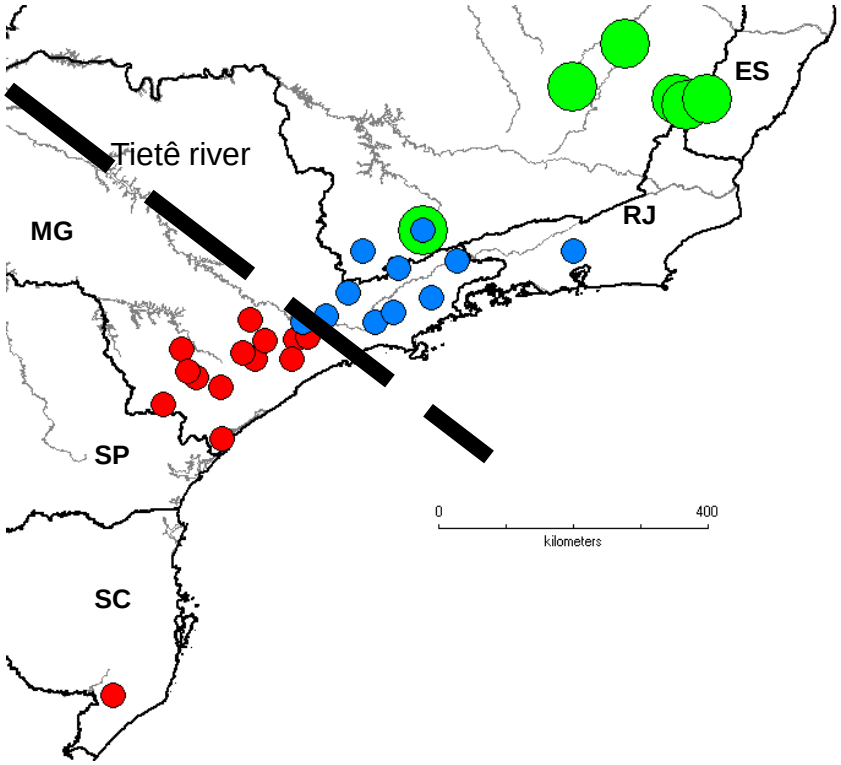
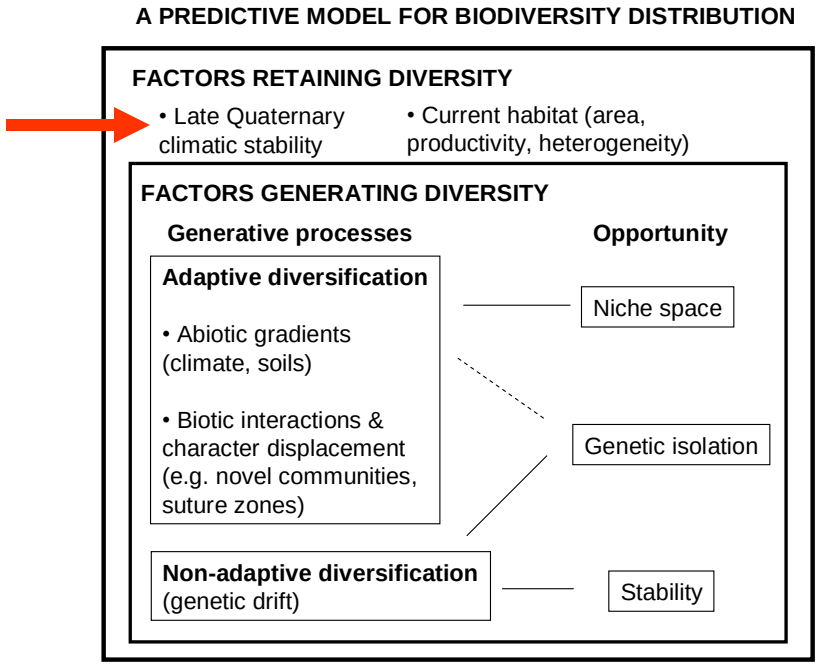


P. boiei study recovers a well-documented phylogeographic break in São Paulo



Climate-based models and molecules suggest that distinct processes impacted diversity distribution in lowland and montane Atlantic forest:

lowland taxa retracted to lower latitudes during colder periods (northern refugia)
montane taxa maintained or expanded ranges (now in high-elevation refugia)



Congruent patterns/processes observed across vertebrate groups in lowlands and also at higher altitudes

Should we attempt at a first synthesis of phylogeographic processes and patterns in the Brazilian Atlantic rainforest?









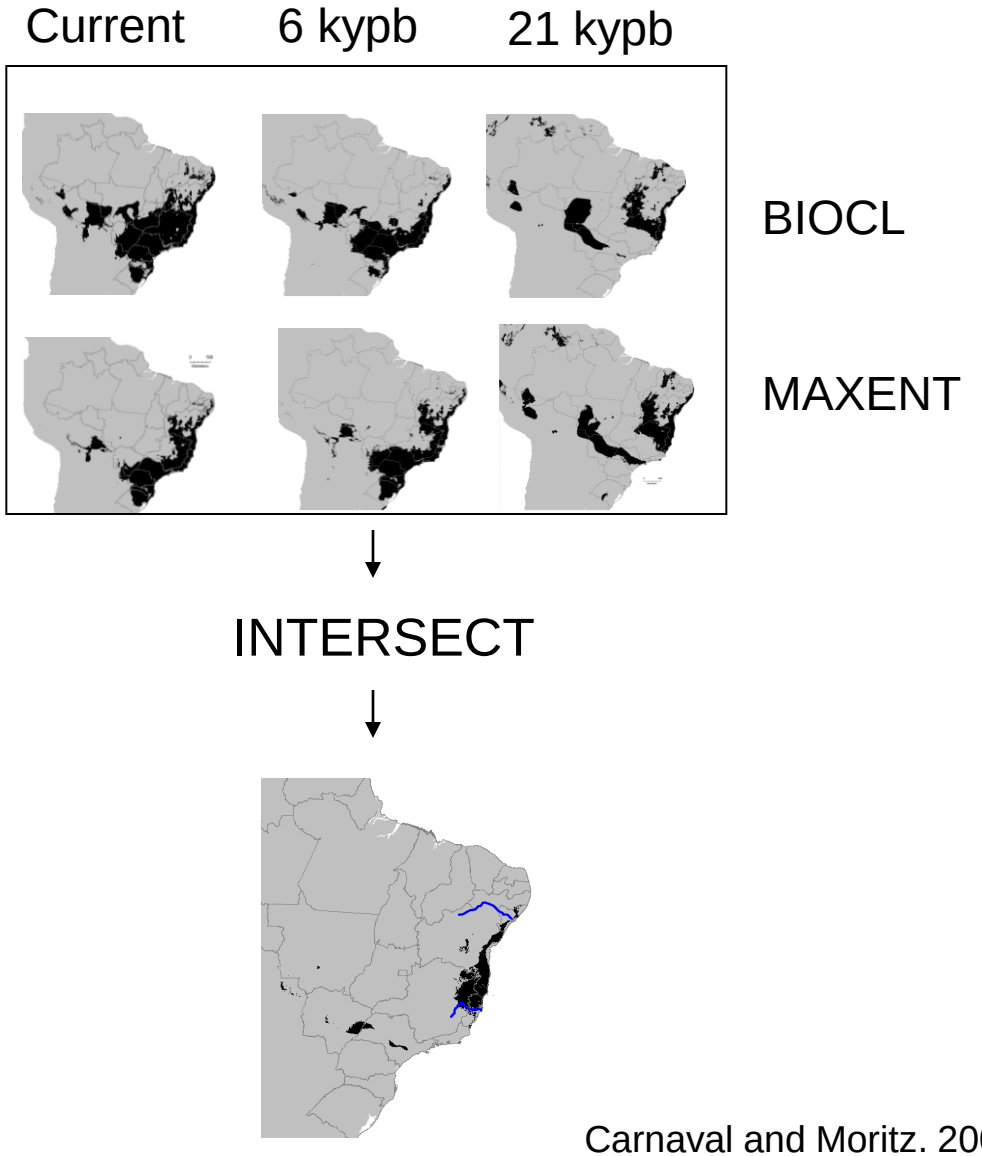






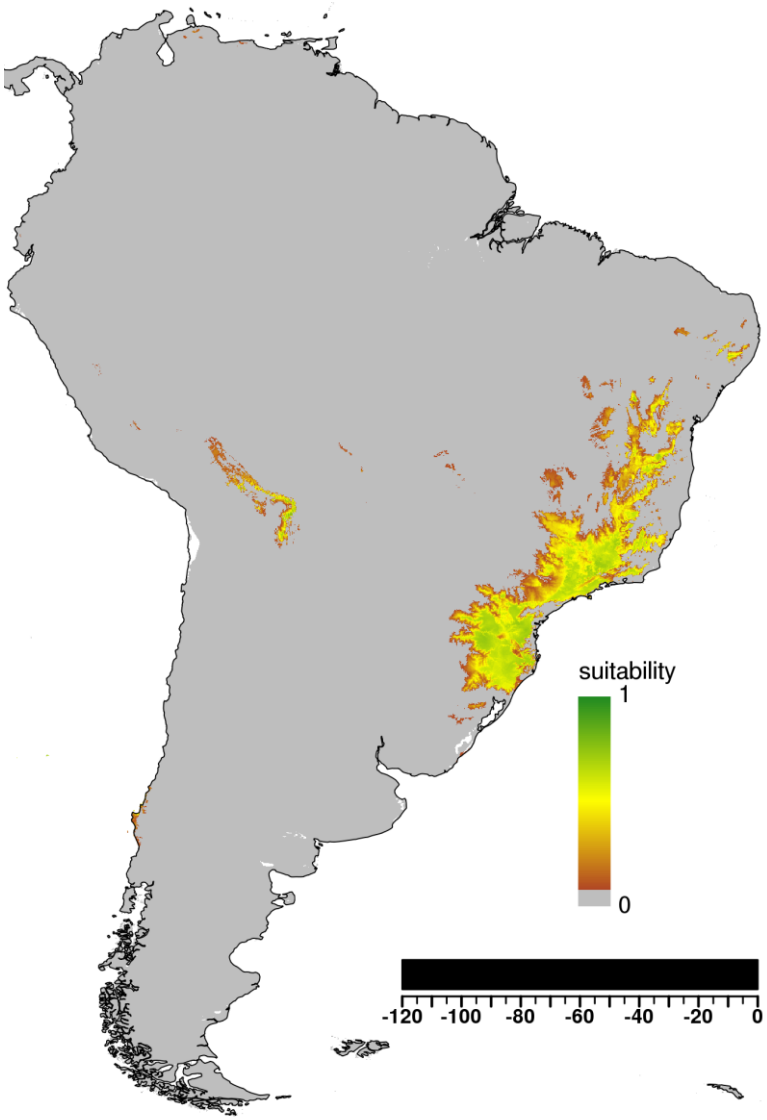



New directions: re-assessing first models of Atlantic rainforest stability



Carnaval and Moritz. 2008. *J. Biogeography.*

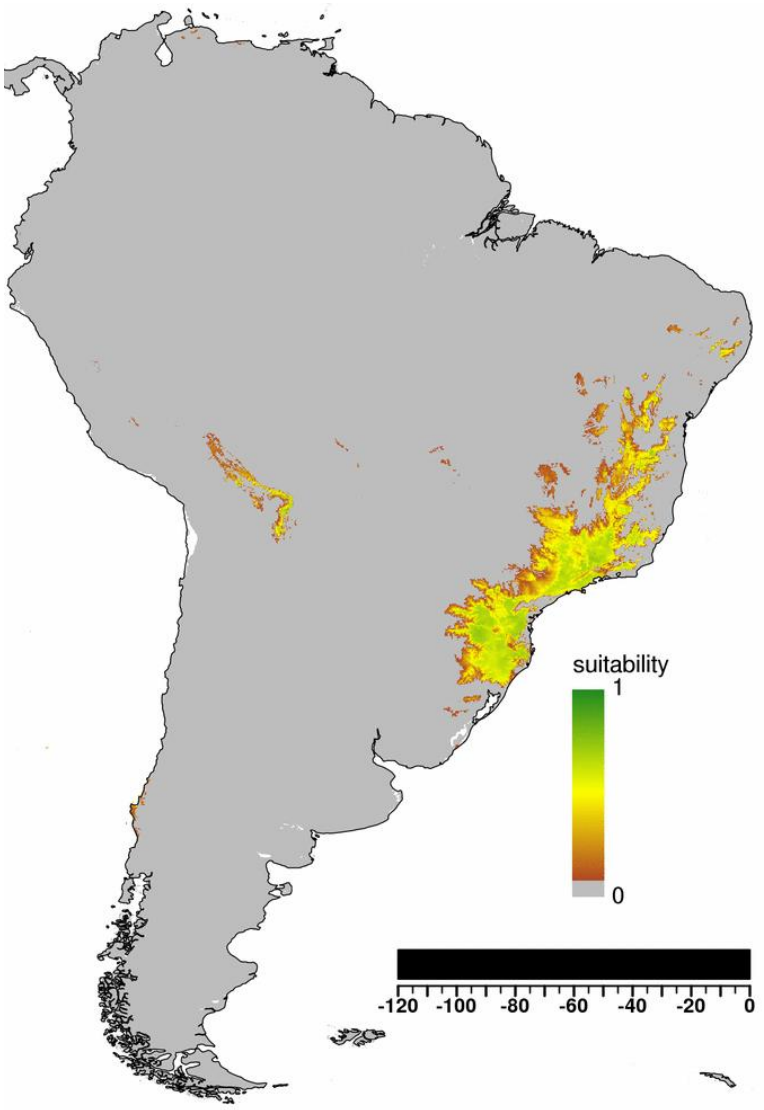
New directions: improving models of Atlantic rainforest stability



montane forest models (700m+),
Including sea-level changes,
Every 4 ky, back to 120kya

Bristol Research Initiative for the Dynamic Global Environment (BRIDGE) (http://www.bridge.bris.ac.uk/)

New directions: improving models of Atlantic rainforest stability



montane forest models (700m+),
Including sea-level changes,
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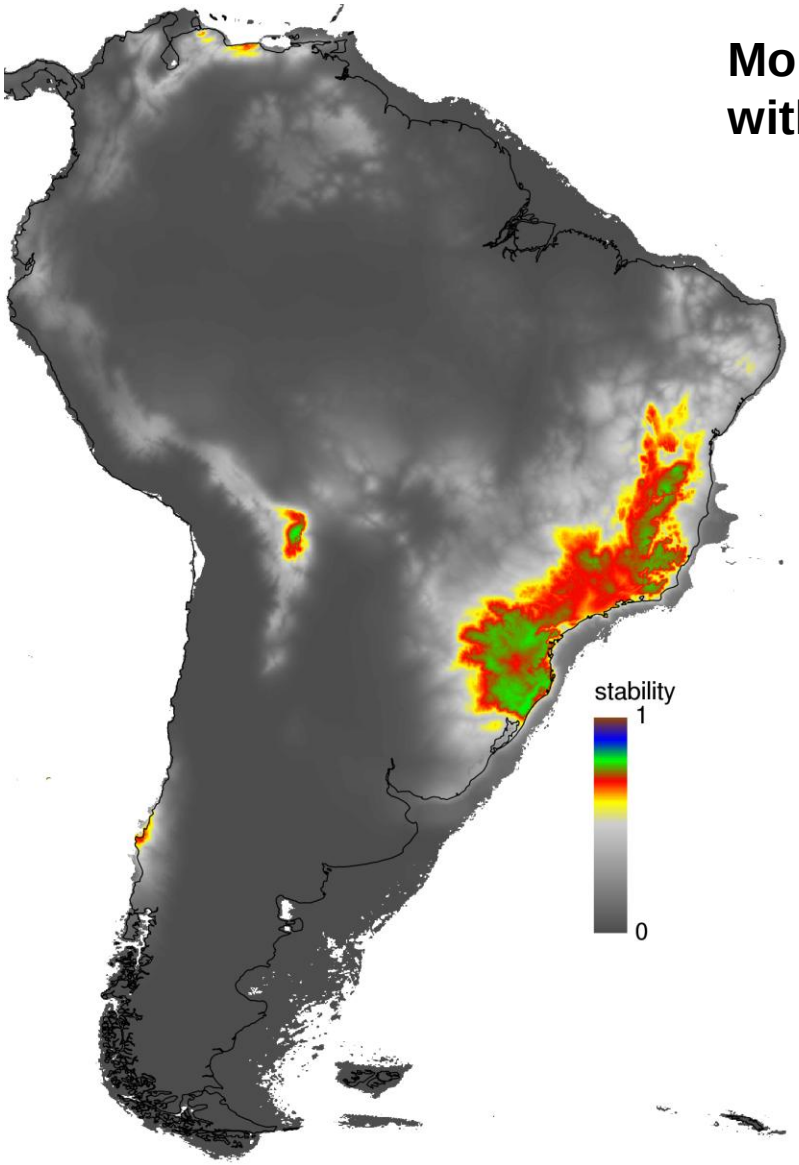
J. VanderWal, James Cook Univ.



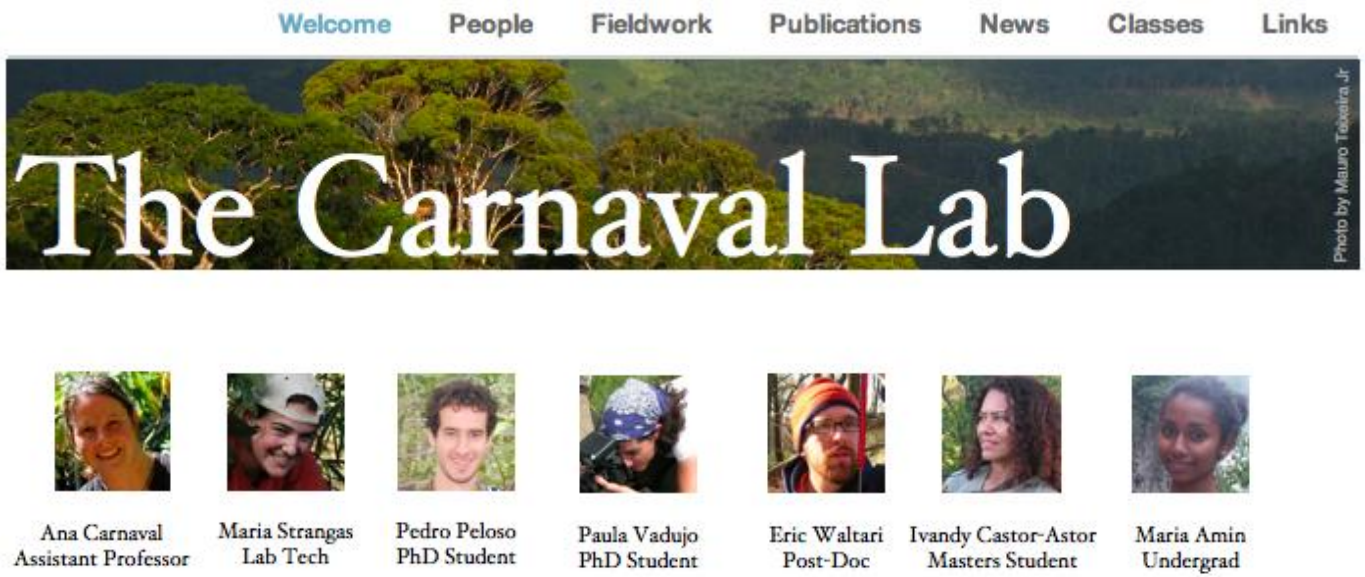
Montane refugia now starting to be tested with multiple montane taxa

- Vitreorana

- Placosoma

- Heterodactylus, Colobodactylus, Caparaonia

acarnaval@ccny.cuny.edu



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Marcia Laguna
Roberta Damasceno

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Lydia Smith
Diane Truong
Brian Lavin
Katia Pellegrino
Cassimiro
Lauren Zeidler

HABC models
Mike Hickerson

Palaeomodels
Jeremy VanderWal

Photos!
Mauro Teixeira
Agus Camacho
Ivan Sazima

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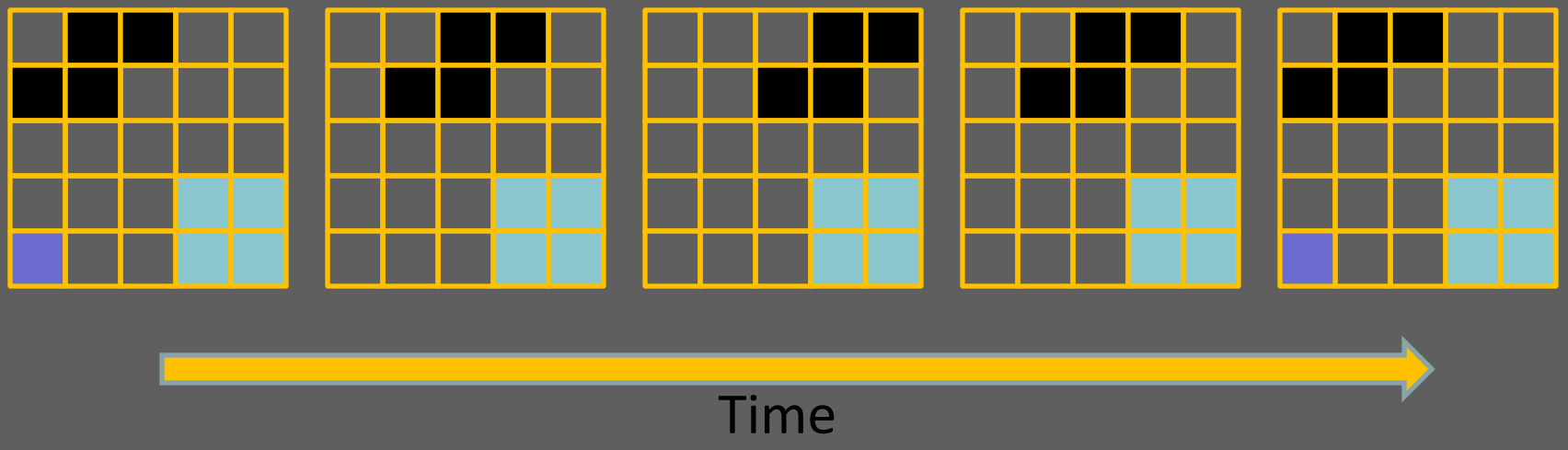
FAPESP

CNPq

Shifting concept

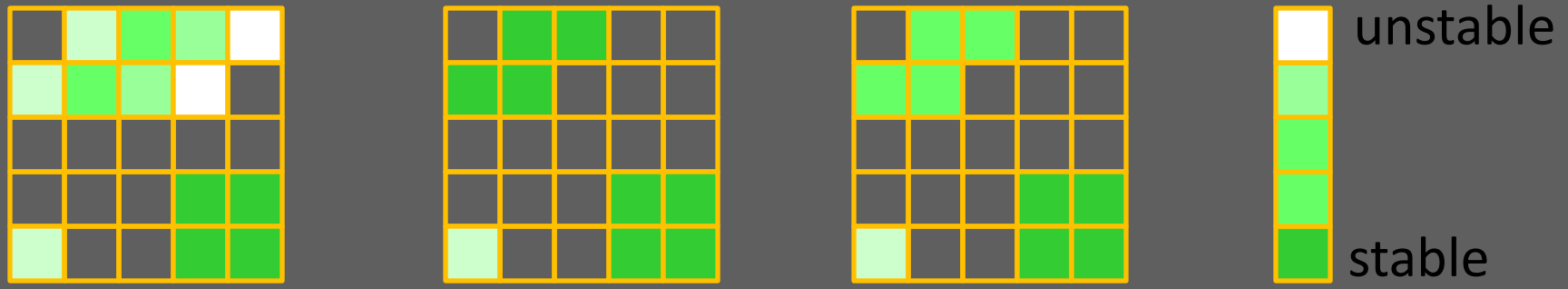


Static view

Shifting concept

No dispersal cost

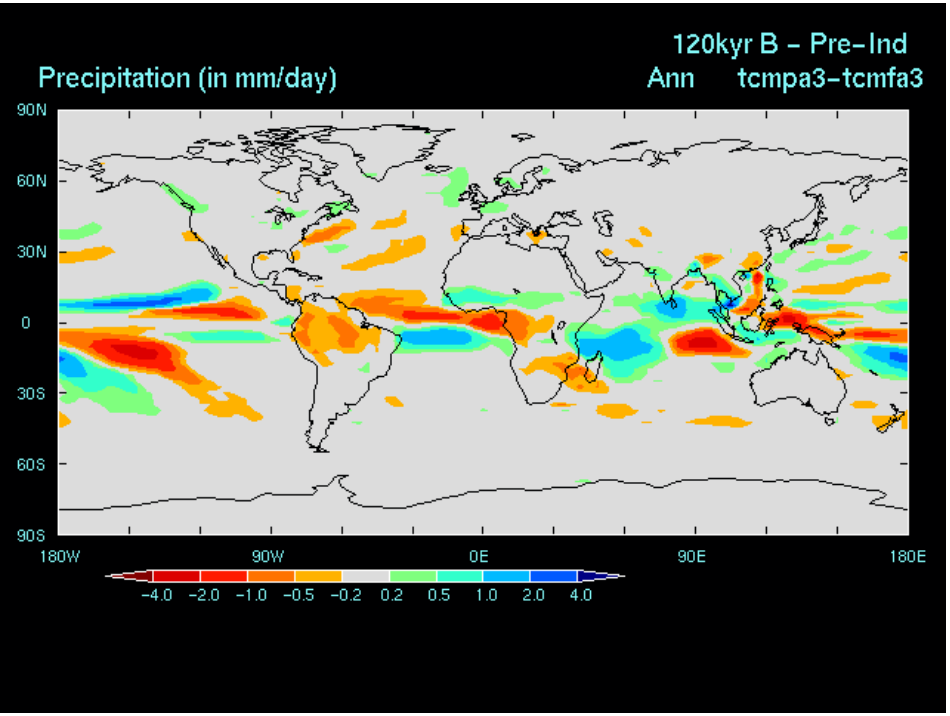
Dispersal cost



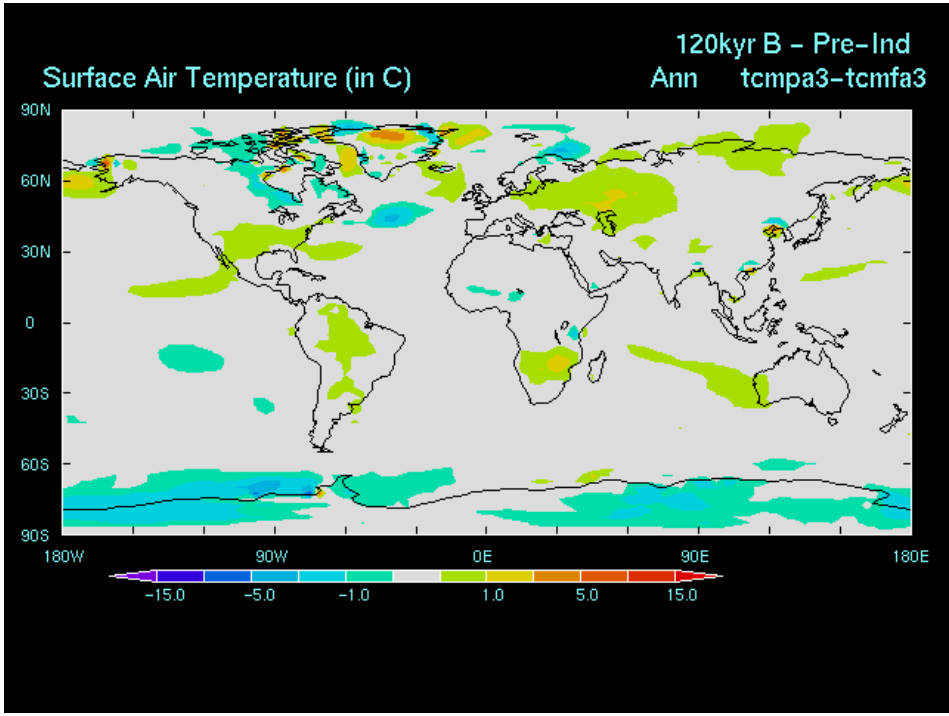
Graham et al. in print.

0 – 120 kybp

Precipitation



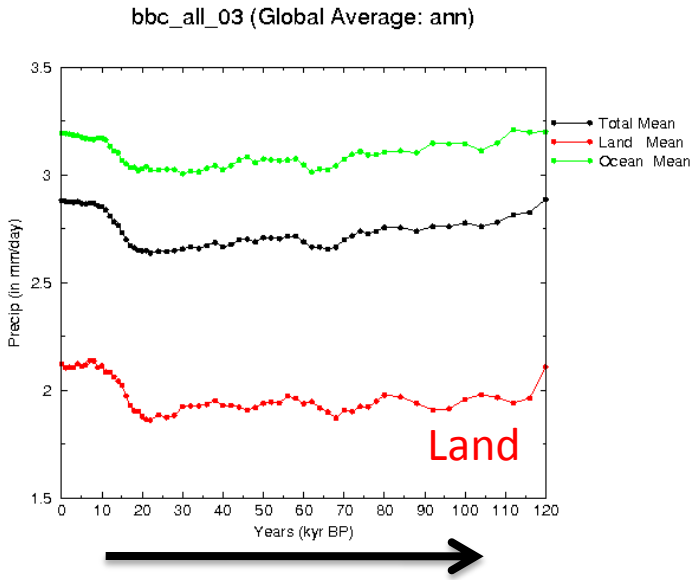
Temperature



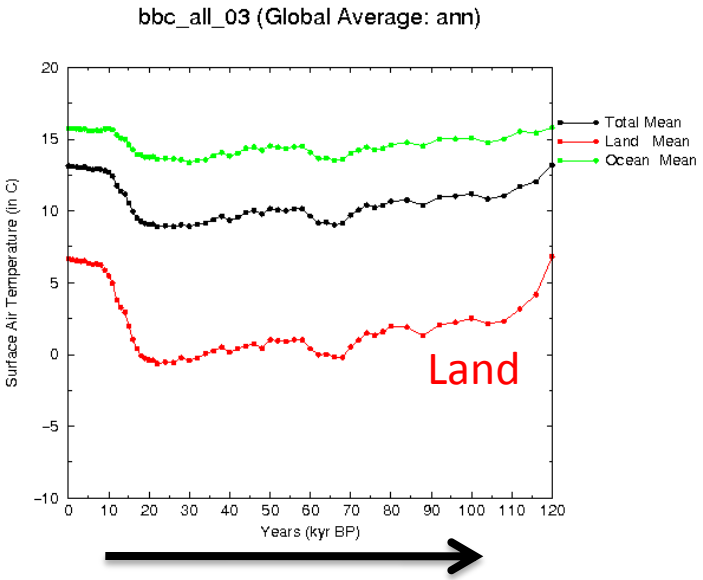
Prof Paul Valdes at the Bristol Research Initiative for the Dynamic Global Environment (BRIDGE) (http://www.bridge.bris.ac.uk/)

0 – 120 kybp

Precipitation



Temperature



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What does this mean for us?

- Global GCM for :
  - 0 – 24 kybp @ 1000 year intervals
  - 24 – 80 kypb @ 2000 year intervals
  - 80 – 120 kybp @ 4000 year intervals

- Monthly precip & mean temperature

- Create anomalies → downscale → apply anomalies to current climate → recreate bioclim variables
  - 1, 4, 10, 11, 12, 15, 16, 17