

The evolution of species' niches: insights from SDMs

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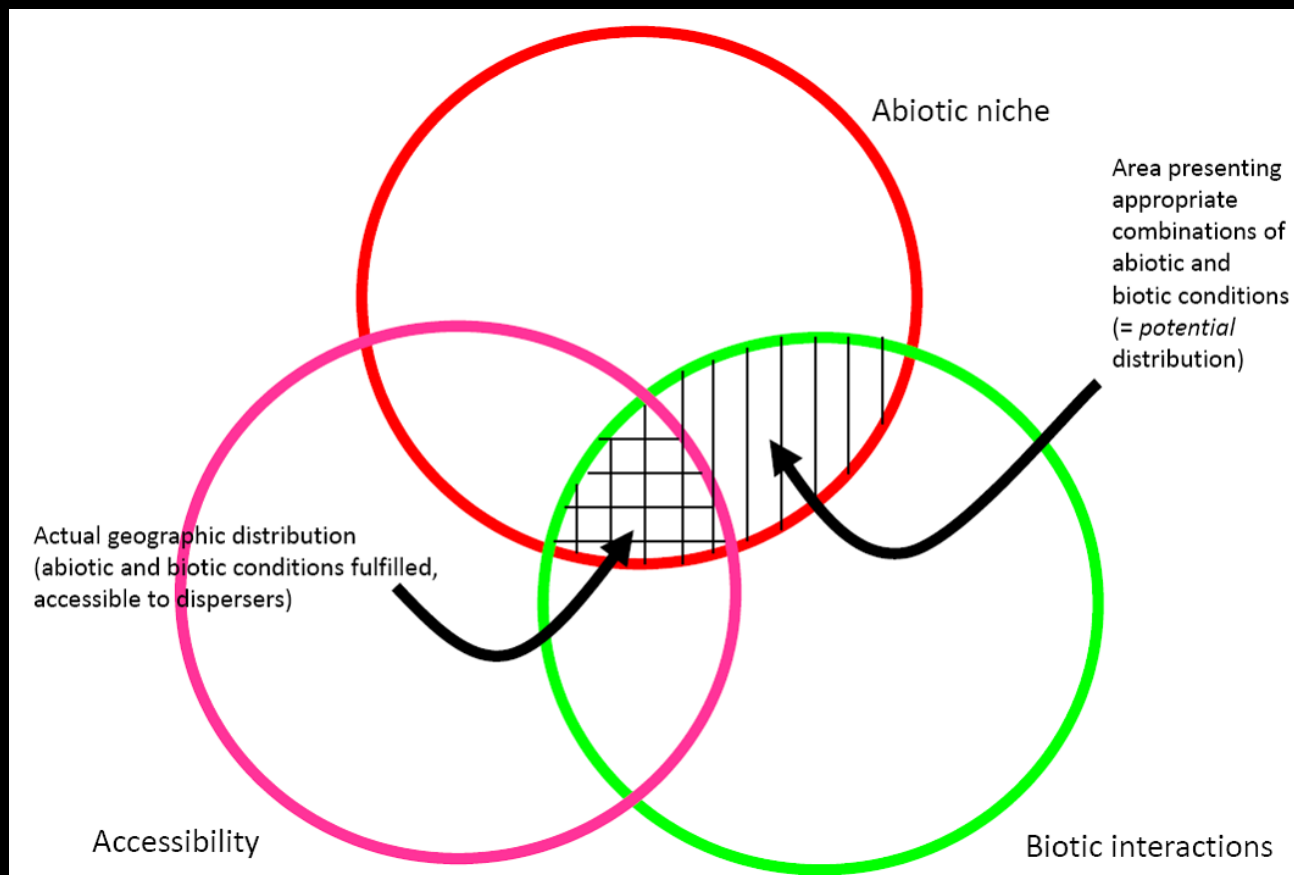
frodriguez@us.es



*PhD Course on Species Distribution Modelling
Sandbjerg, Denmark, August 2010*

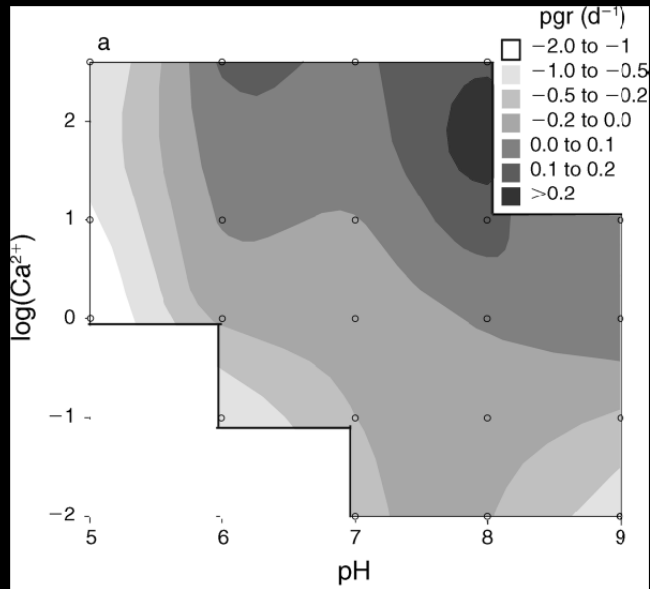
What is the niche?

Set of environmental conditions for which population growth rate is positive (but see Chase & Leibold, 2003; Soberón, 2007; Holt, 2009)



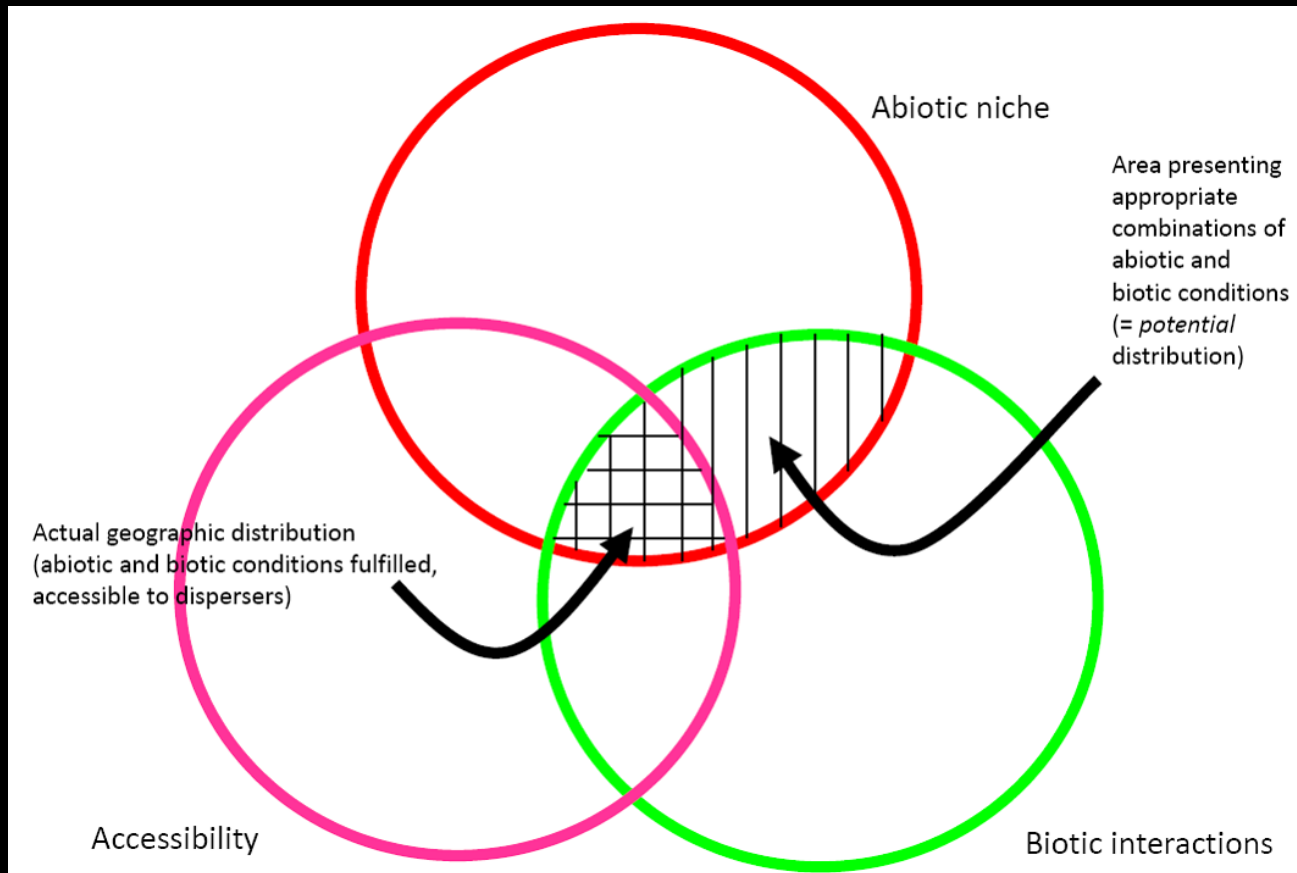
Soberón & Peterson (2005)
Biodiv Informatics

The fundamental niche of *Daphnia magna*

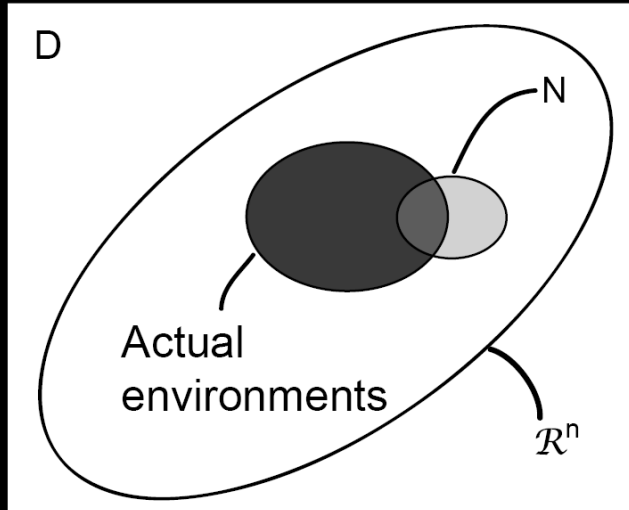


Hooper et al. (2008) *Ecology*

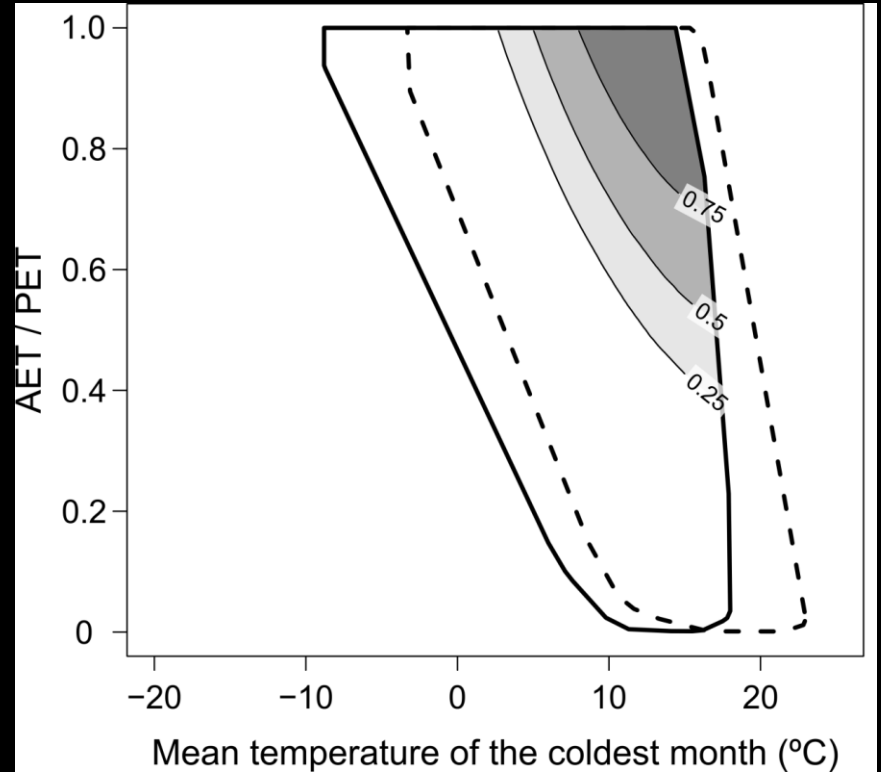
What are we measuring?



What are we measuring?

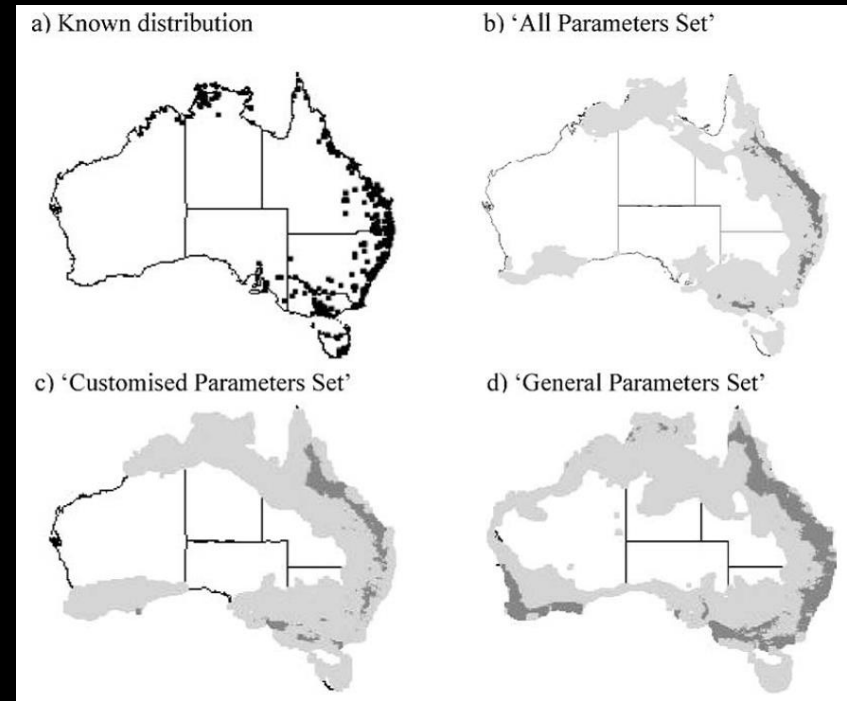
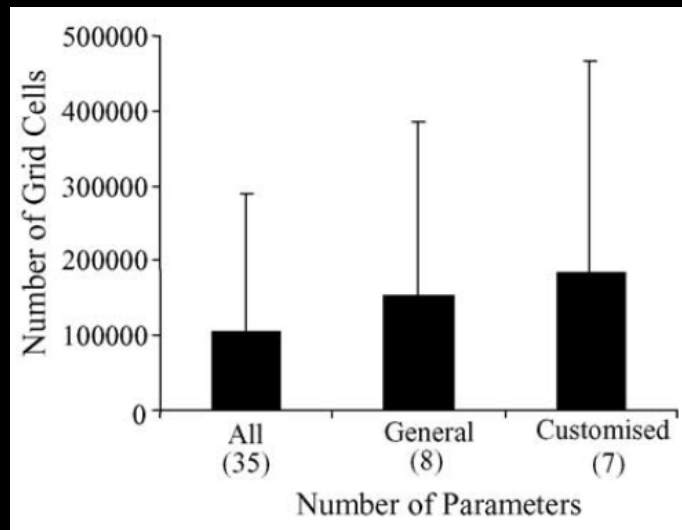


Godsoe (2010) *Oikos*

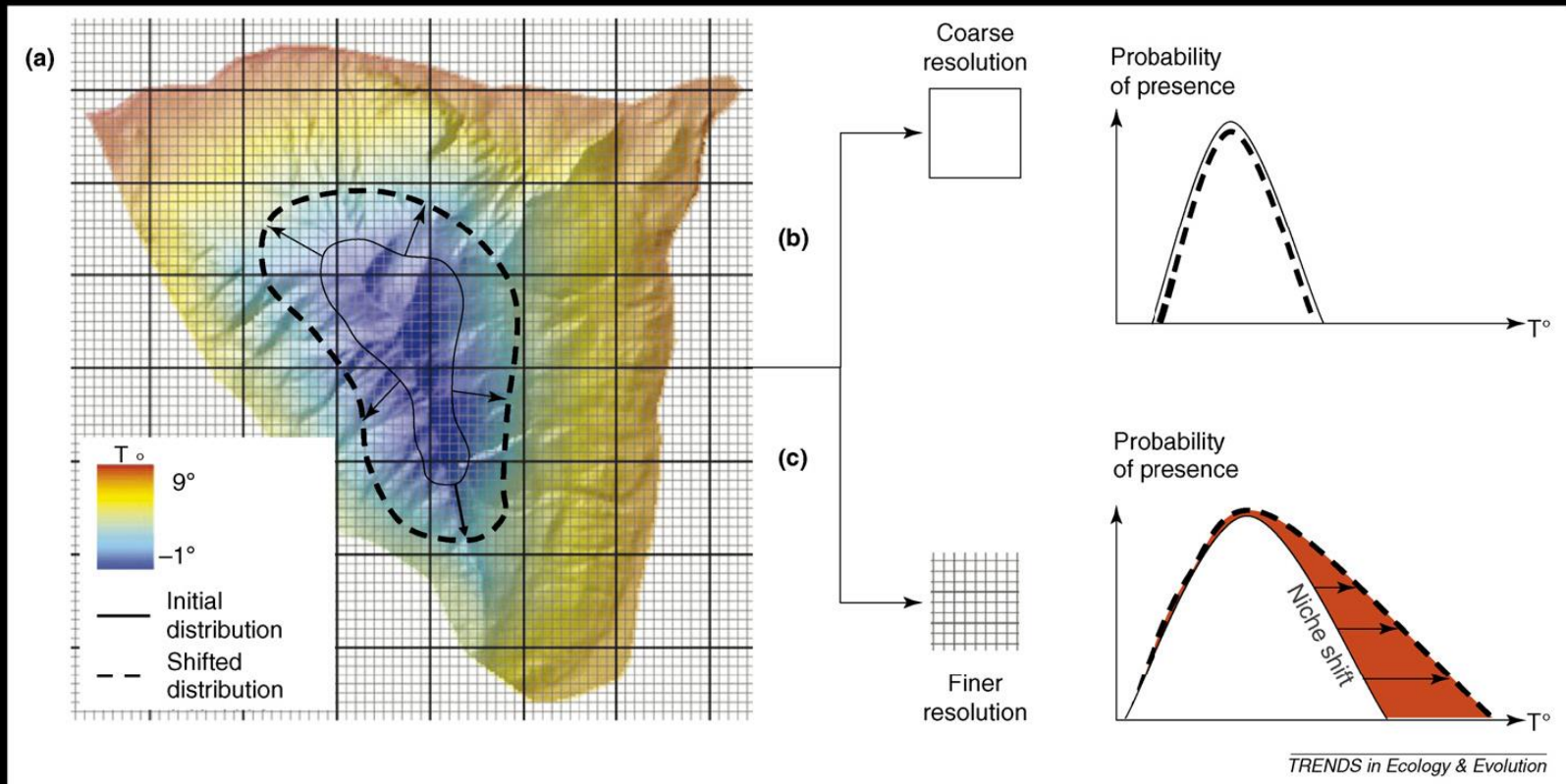


Rodríguez-Sánchez & Arroyo (2010)
Clim Ch, Ecol & Syst

The estimated niche depend on the number of predictors



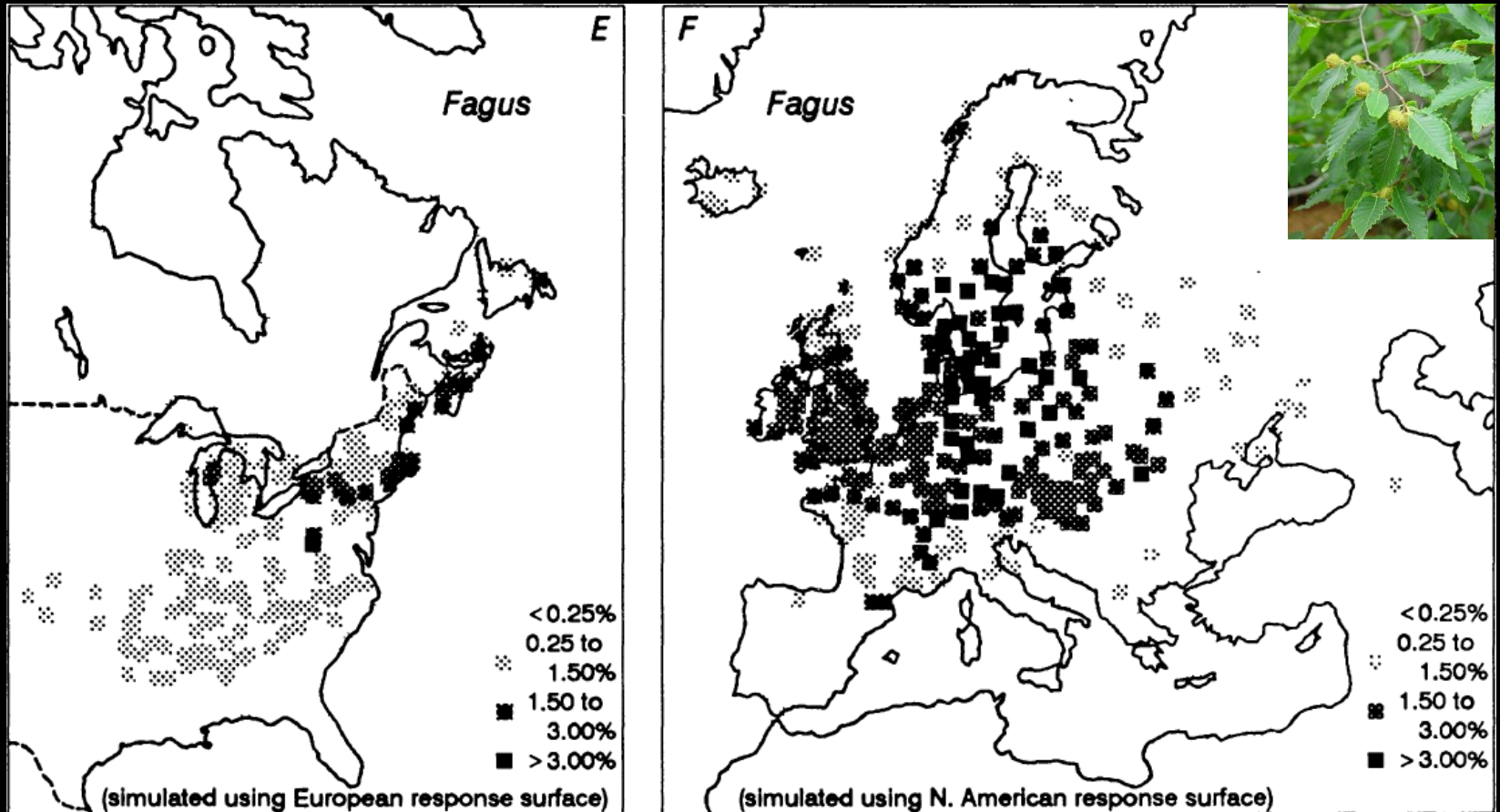
Scale effects



Pearman et al. (2008) *TREE*

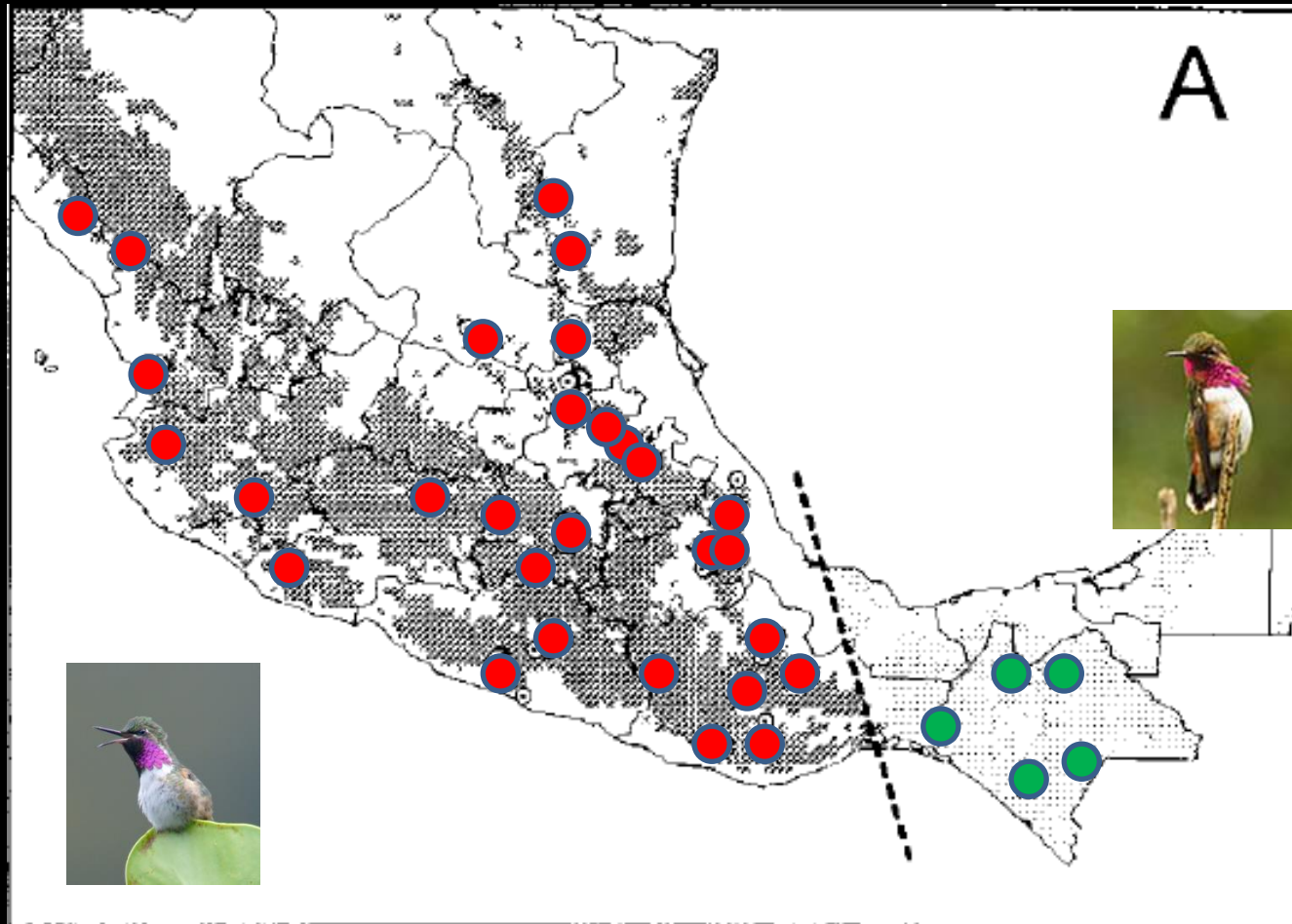
SDMs provide an imperfect
(and unstable) estimation
of the niche!

Are niches conserved?



Huntley et al. (1989) *J Biog*

Are niches conserved?



Peterson et al. (1999) *Science*

Are niches conserved?

nature

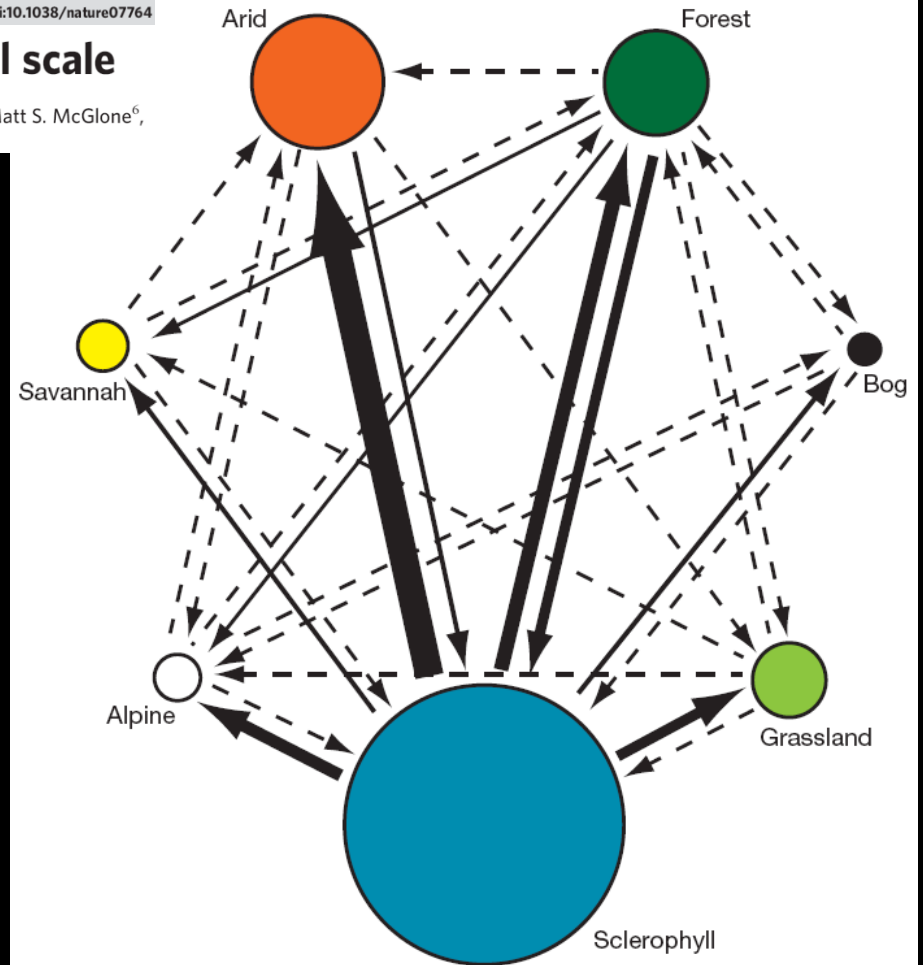
Vol 458 | 9 April 2009 | doi:10.1038/nature07764

Phylogenetic biome conservatism on a global scale

Michael D. Crisp¹, Mary T. K. Arroyo², Lyn G. Cook³, Maria A. Gandolfo⁴, Gregory J. Jordan⁵, Matt S. McGlone⁶, Peter H. Weston⁷, Mark Westoby⁸, Peter Wilf⁹ & H. Peter Linder¹⁰

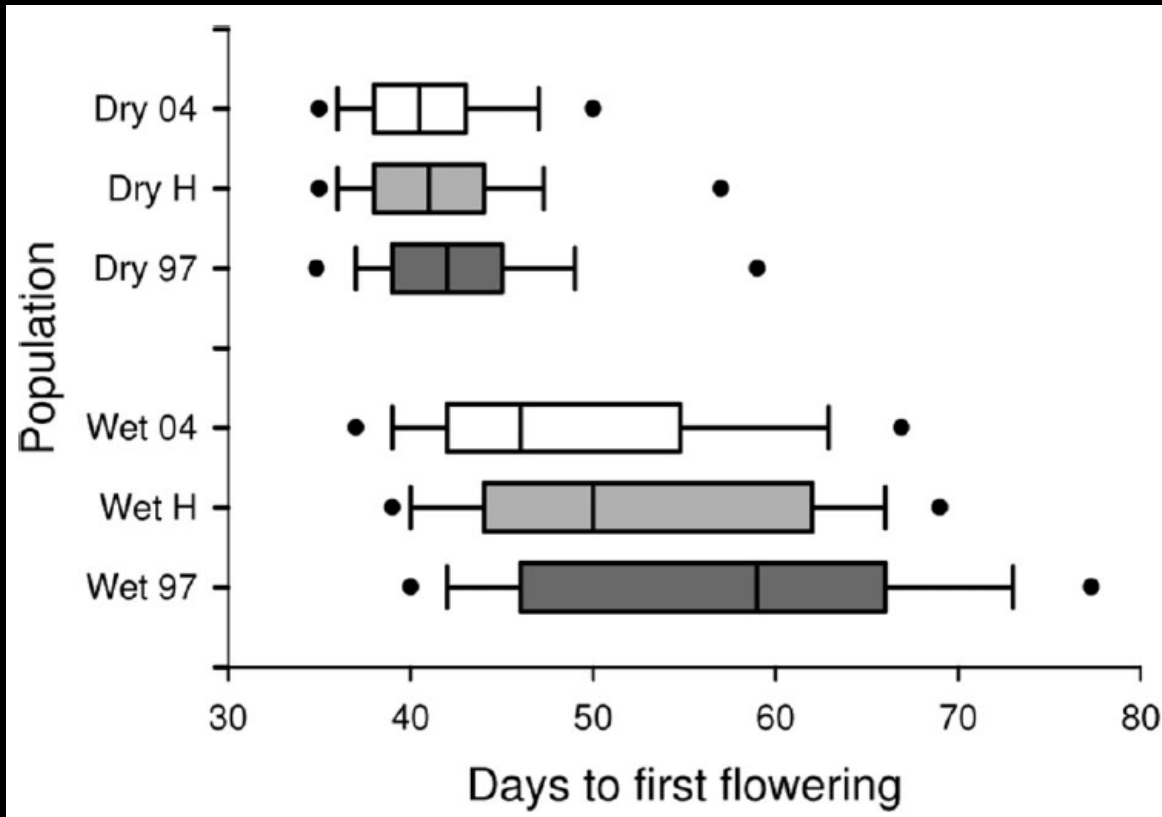
Only 356 biome shifts
in 10800 speciation events
($< 1:25$)

Directional bias



Are niches conserved?

Rapid evolution after climate fluctuation



Brassica rapa

Franks et al. (2007) *PNAS*

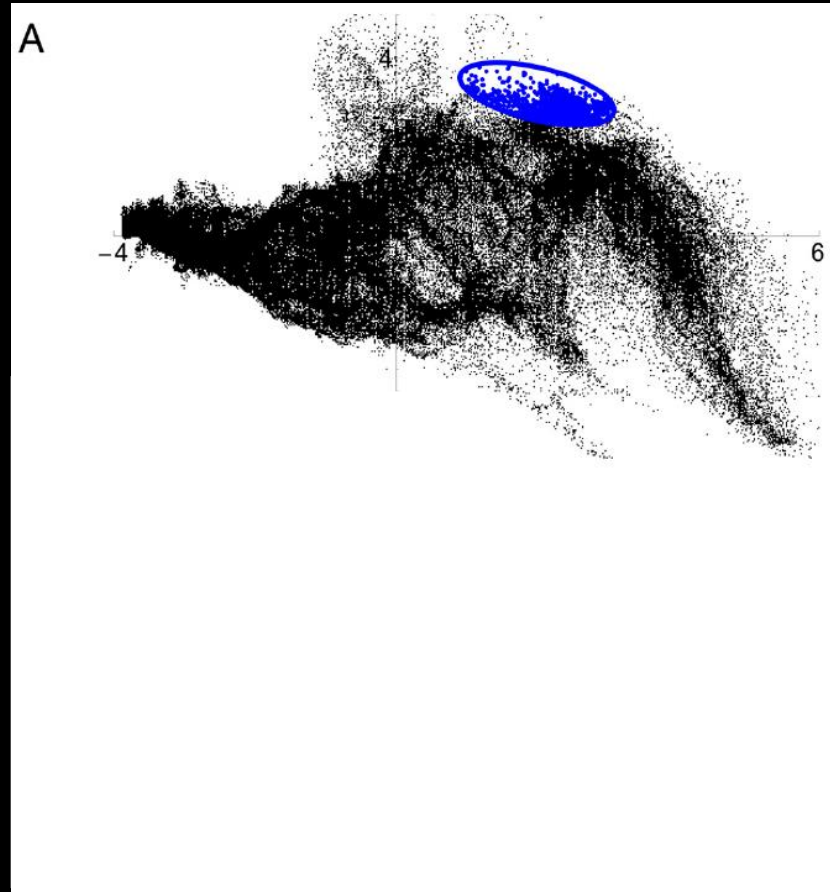
Reformulate the question:

- How much do niches change?
- Does conservatism differ among environmental factors?
- How long does it take?

Clarifying the terminology

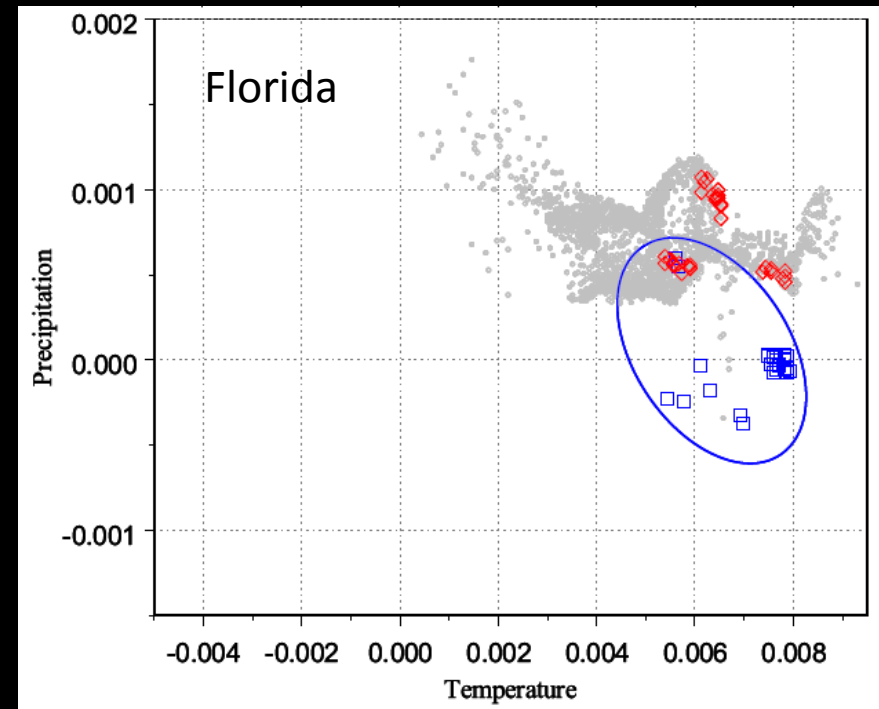
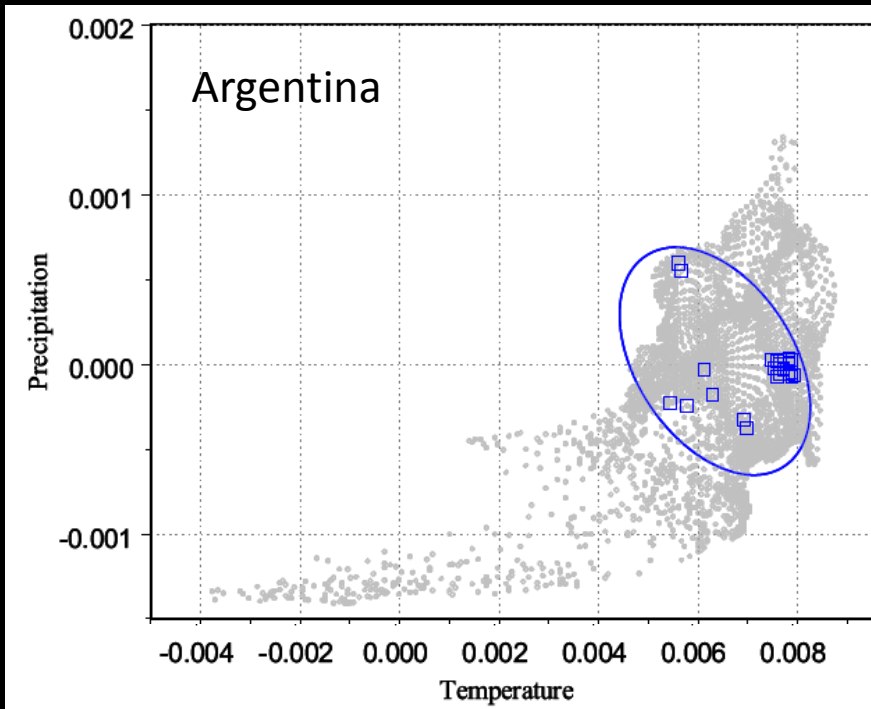
- Niche stasis (no change)
- Niche shift
- Niche evolution
- Niche conservatism (phylogenetics)

The duality of environmental and geographical spaces



Soberón & Nakamura (2009) *PNAS*

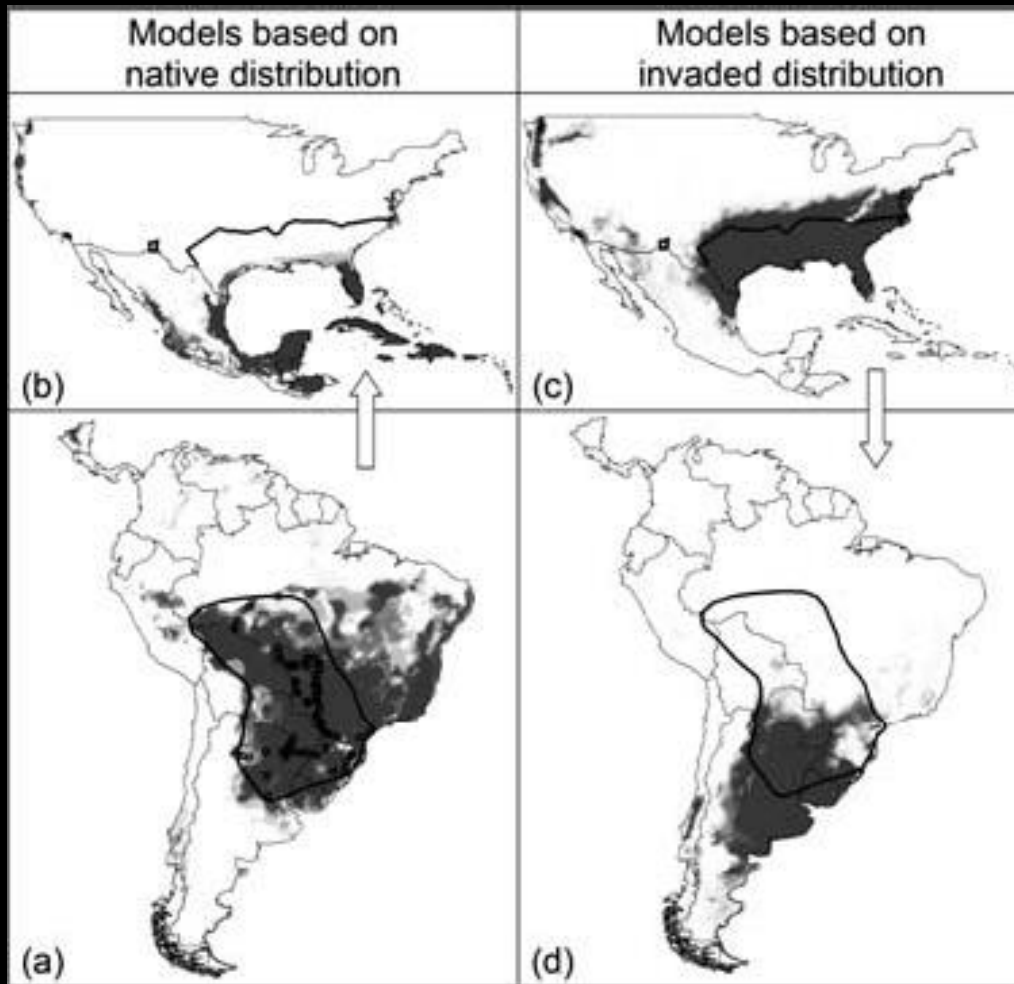
Estimating niche change in environmental space



Cactoblastis cactorum

Soberón & Nakamura (2009) *PNAS*

Estimating niche change in geographical space

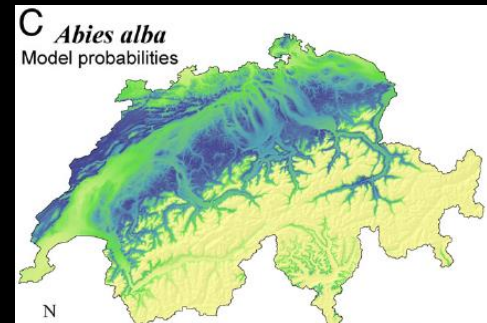
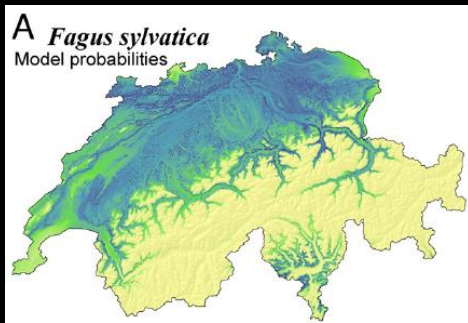


Solenopsis invicta

Fitzpatrick et al. (2007)
Global Ecol & Biog

Niche overlap

Having SDMs for two species (X and Y)



Niche overlap:

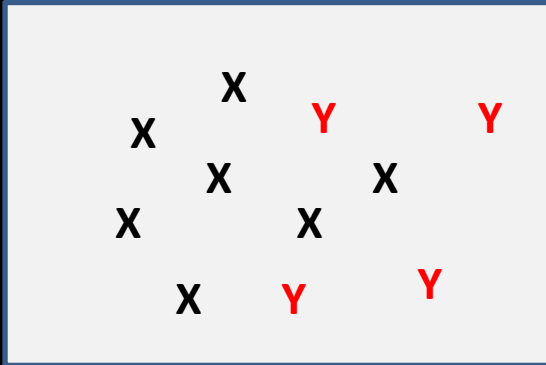
$$I(p_X, p_Y) = 1 - \frac{1}{2} \sqrt{\sum_i (\sqrt{p_{X,i}} - \sqrt{p_{Y,i}})^2}$$

0 = No overlap

1= Complete overlap

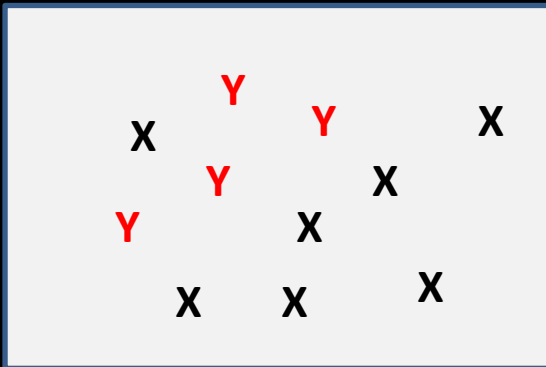
Warren et al. (2008) *Evolution*

Tests of niche equivalency



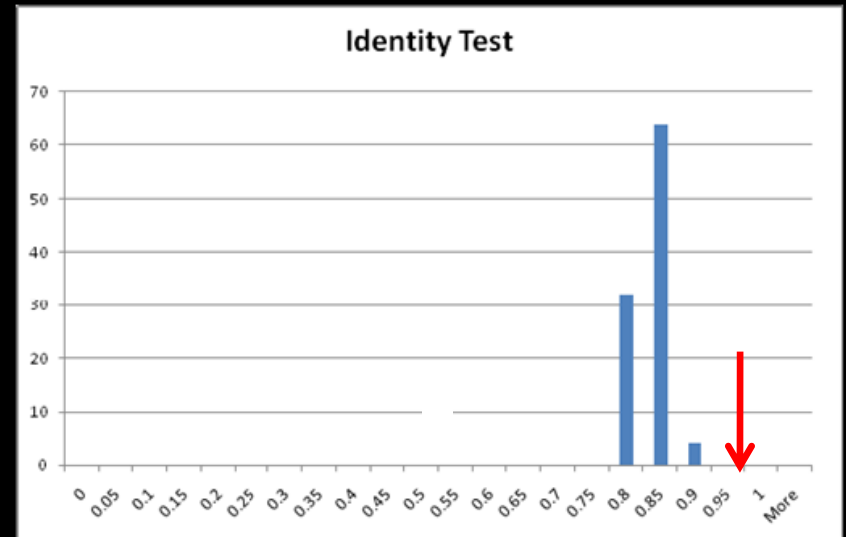
Actual occurrences of X and Y

$$I = 0.97$$



Randomized pseudoreplicate

$$I = 0.86$$



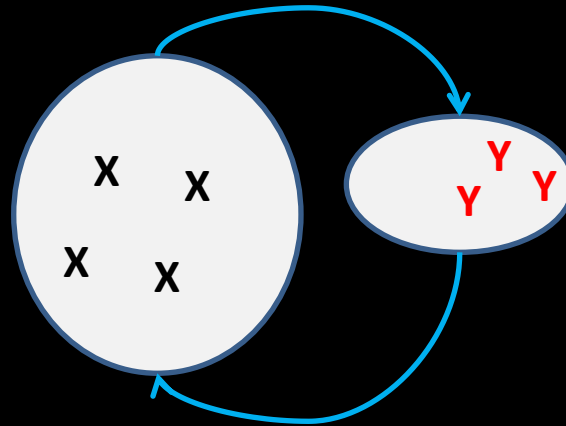
Regional Variation Exaggerates Ecological Divergence in Niche Models

WILLIAM GODSOE*

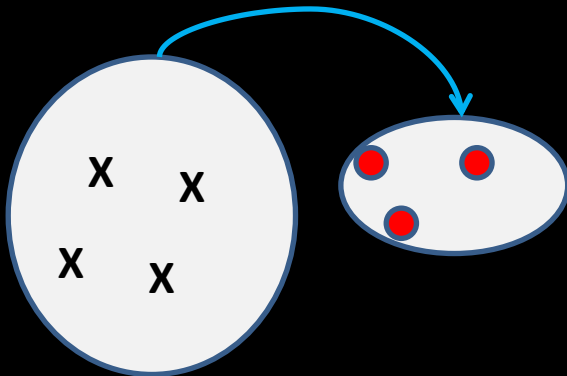
Tests of niche similarity

ENMTools
Phyloclim (R)

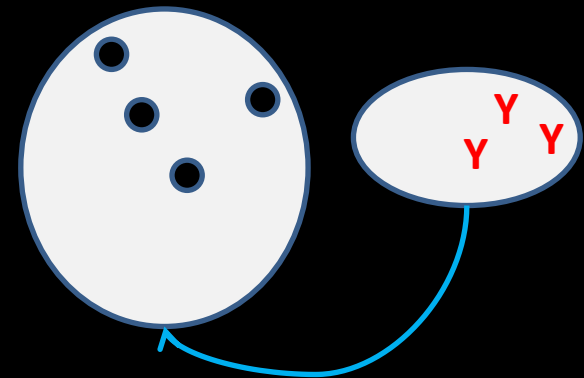
SDM of X vs SDM of Y



SDM of Y vs SDM of X



SDM of X vs background of Y



SDM of Y vs background of X

Approaches to study niche dynamics

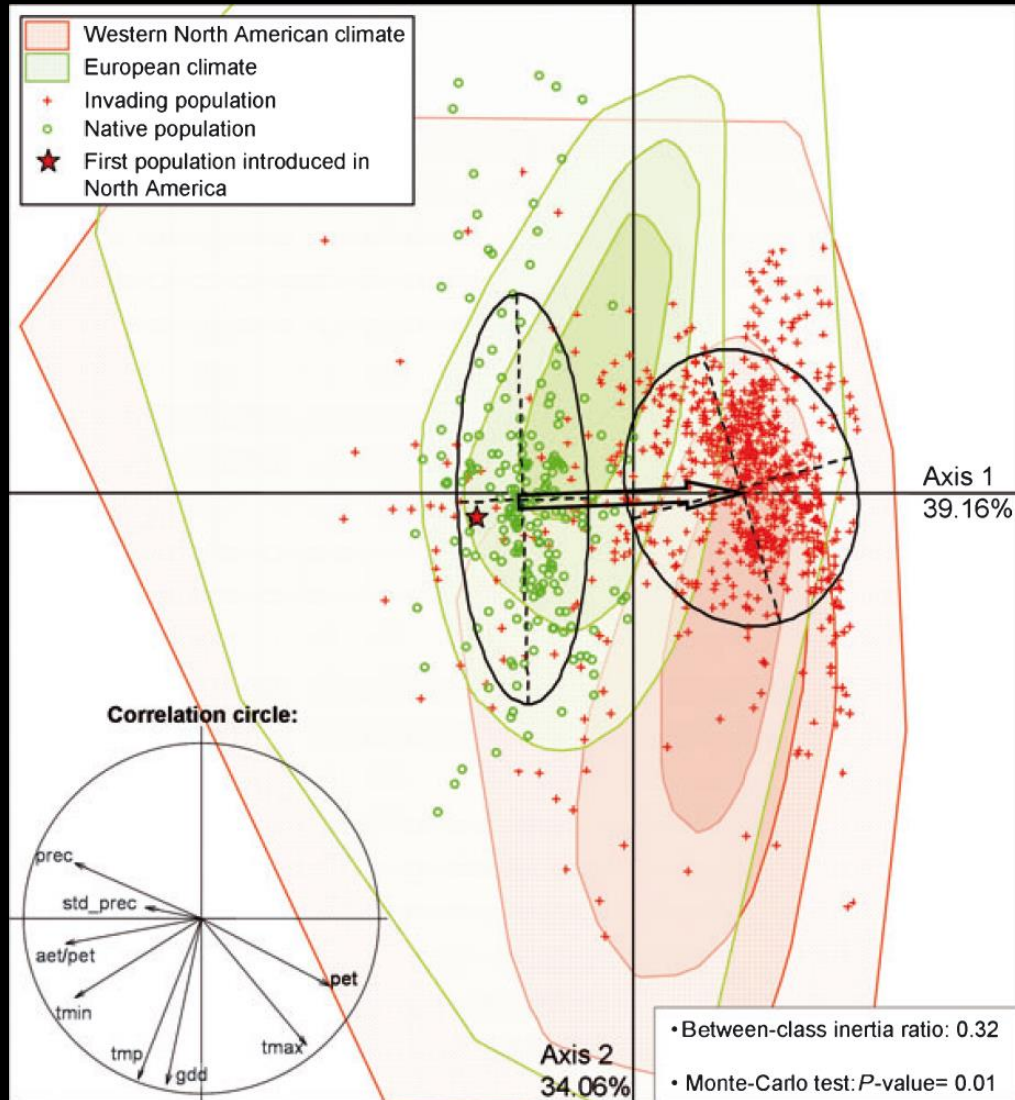
1. Within species

- a) across space (invasives, subspecies, ecotypes)
- b) across time

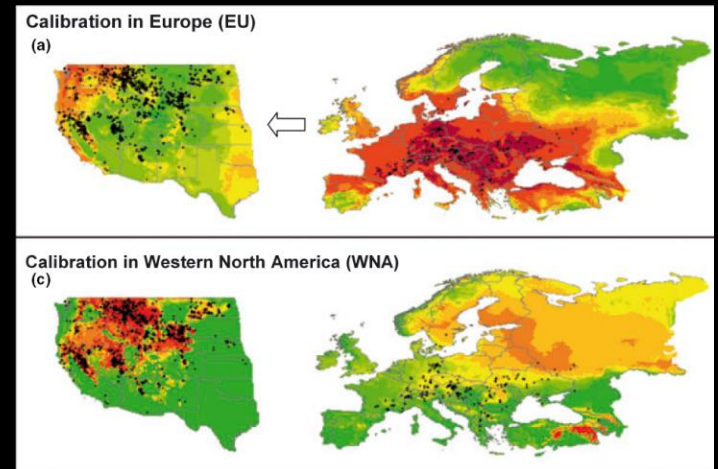
2. Between species

- a) phylogenetic
- b) non phylogenetic

Niche shifts of invasive species

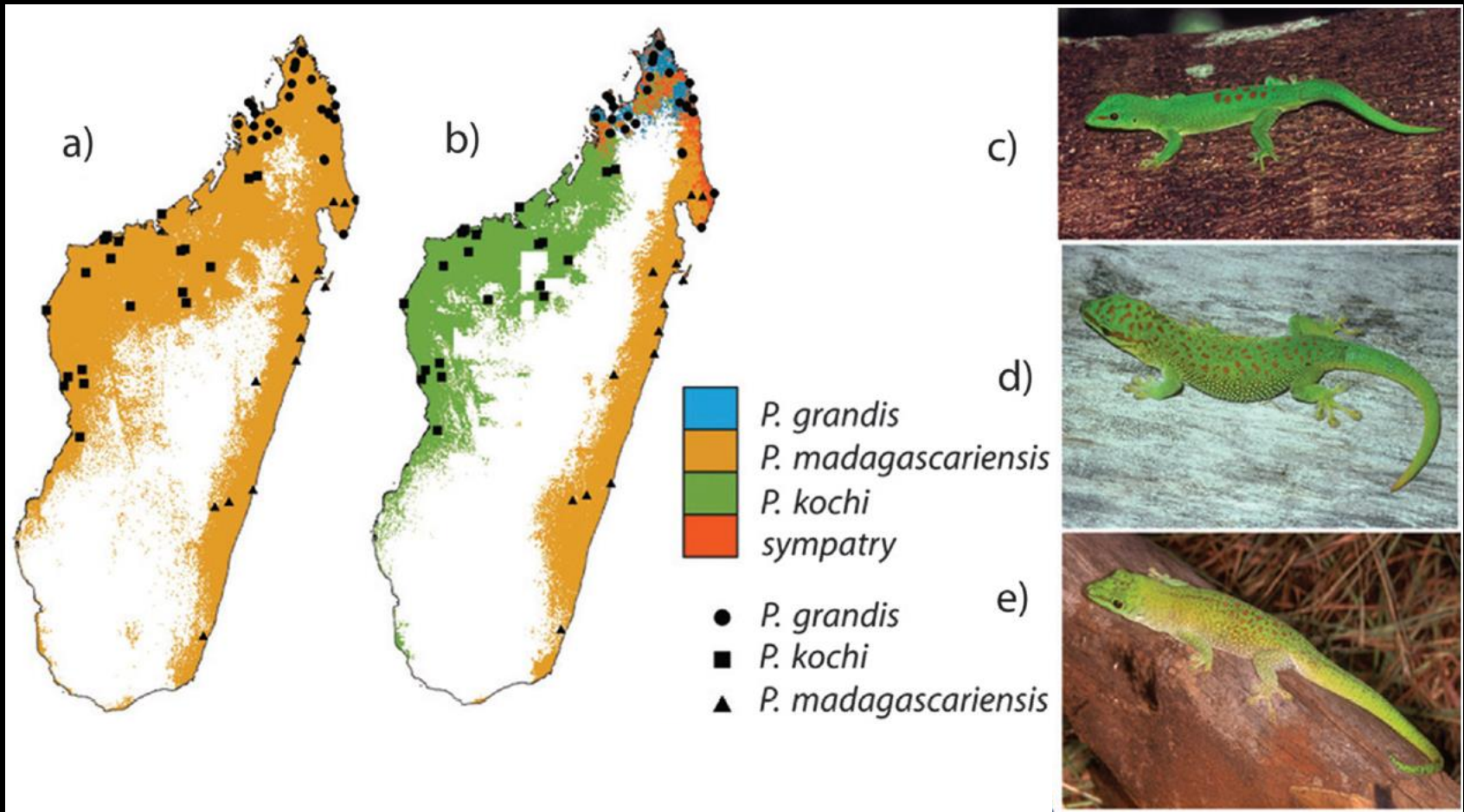


Centaurea maculosa

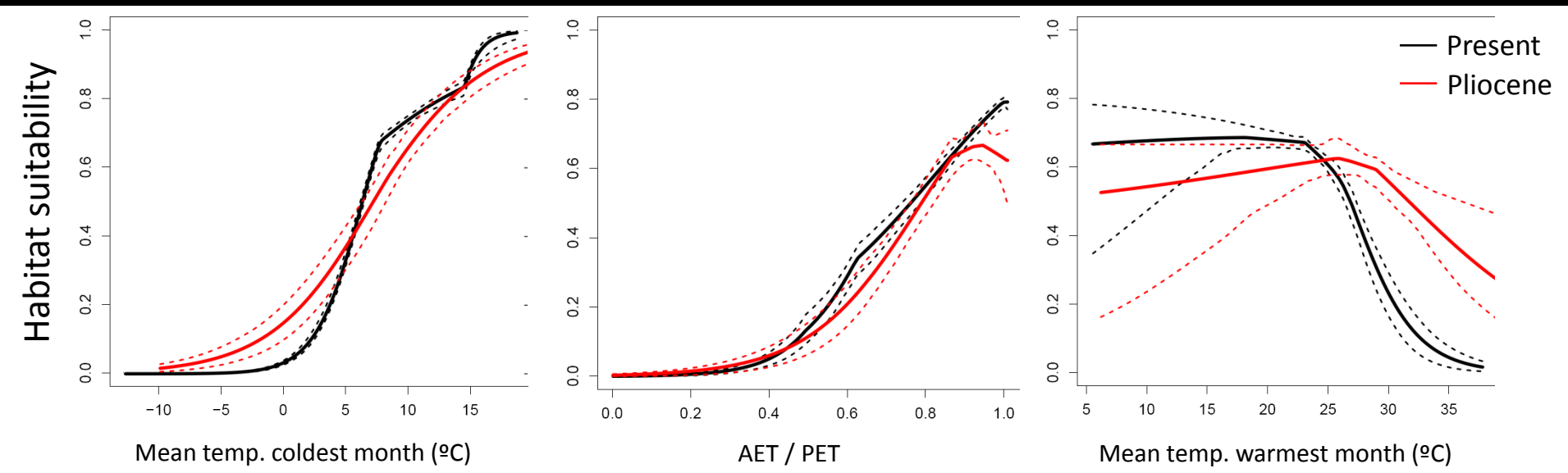


Broennimann et al. (2007) *Ecol Lett*

Niche differentiation in *Phelsuma madagascariensis* subspecies

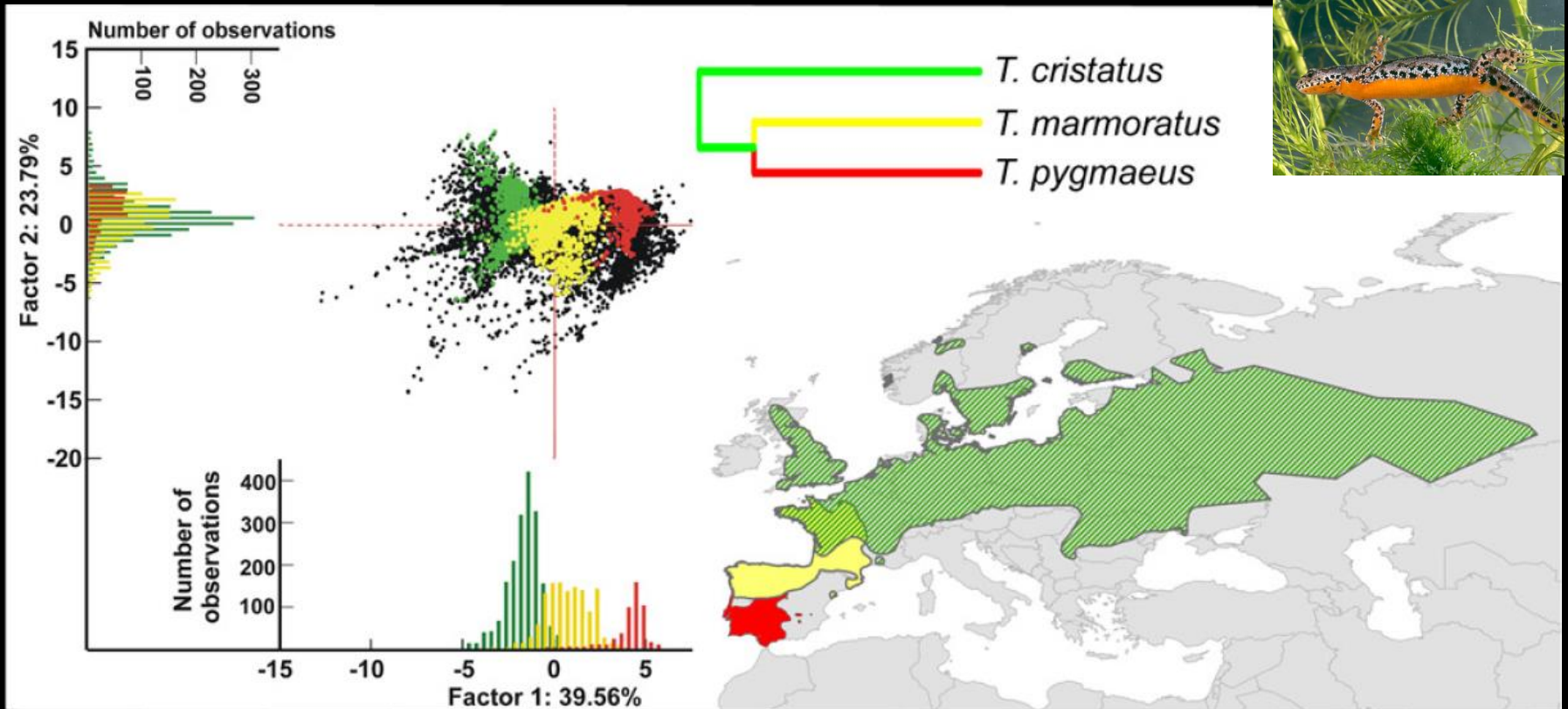


Climatic niche conservatism in *Laurus*



Rodríguez-Sánchez & Arroyo (2008) *Global Ecol & Biog*

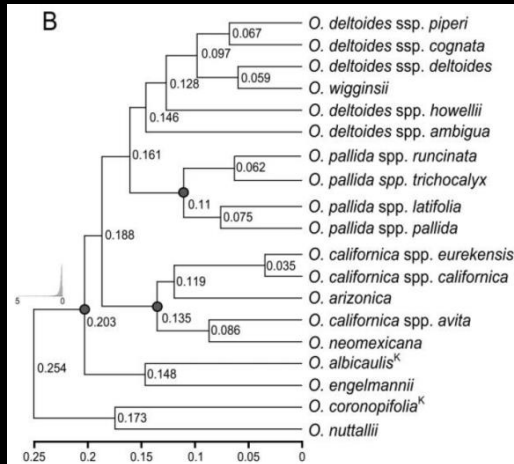
Phylogenetic analyses: climatic niche evolution in *Triturus*



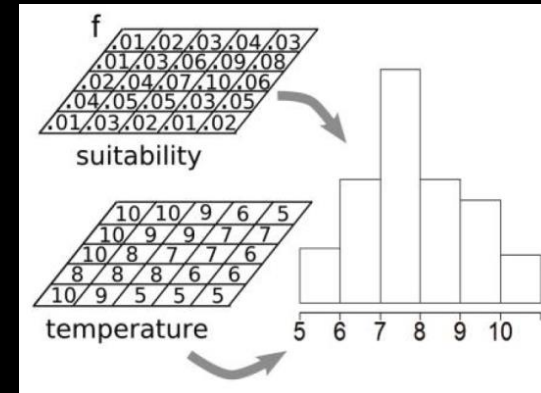
Vieites et al. (2009) *PNAS*

Climatic niche evolution in *Oenothera*

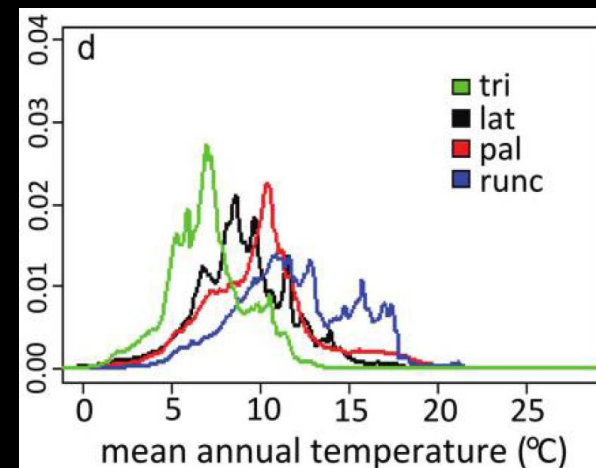
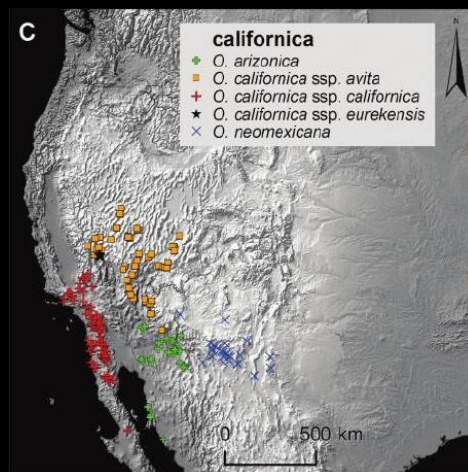
Phylogeny



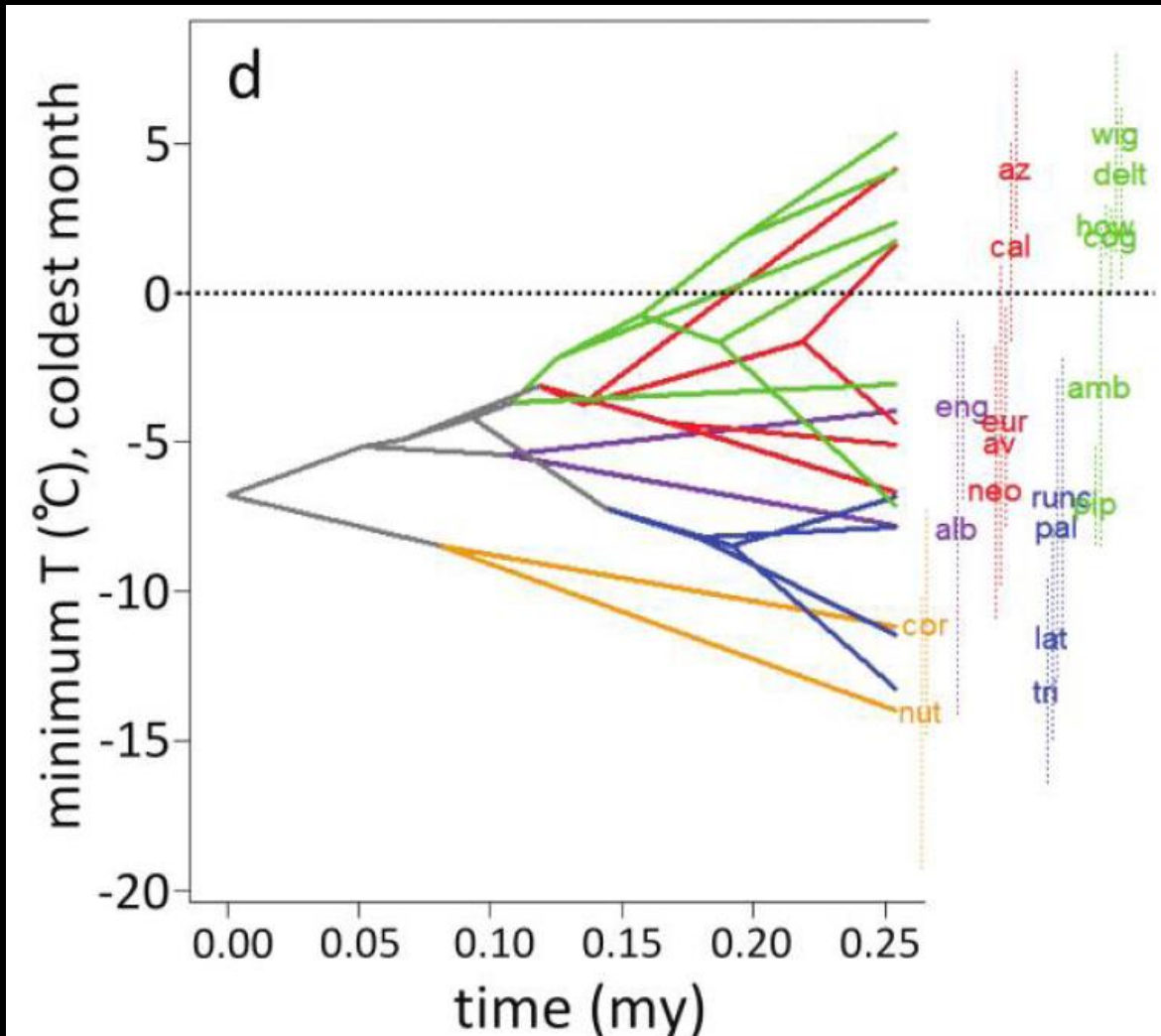
Climate profiles



Distribution data

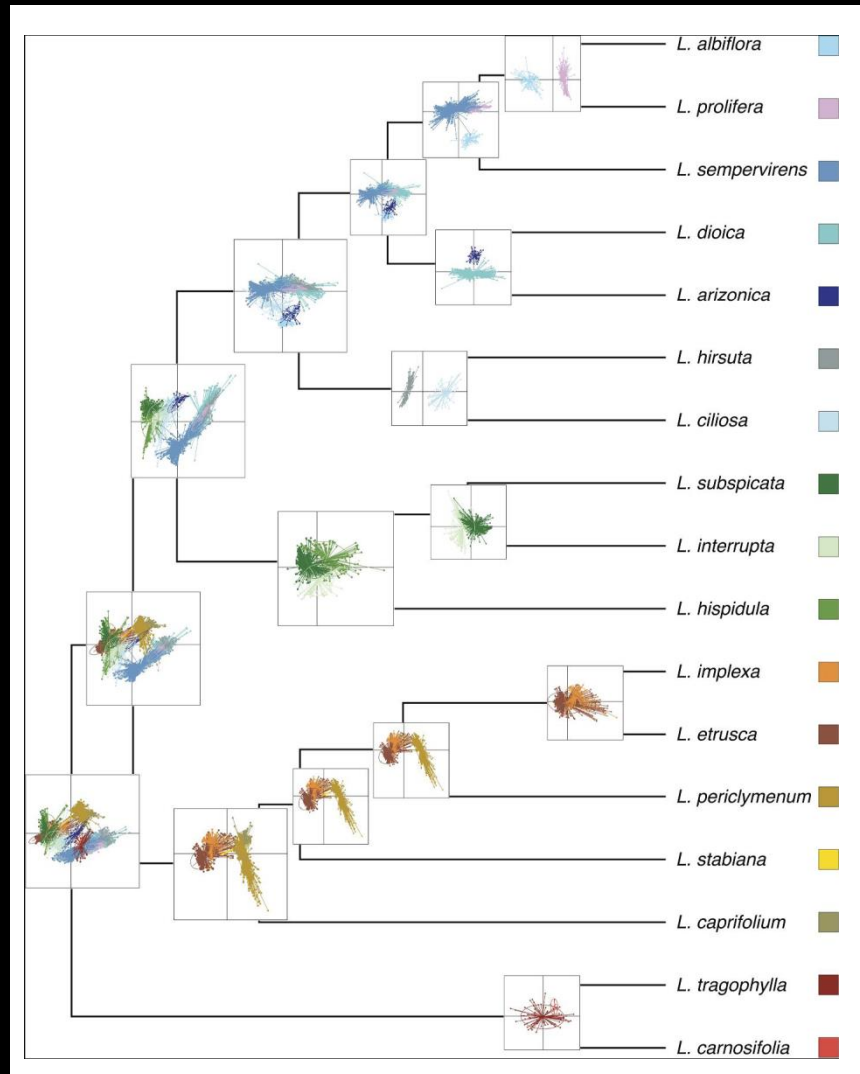


Climatic niche evolution in *Oenothera*



Evans et al. (2009)
Am Nat

Climatic niche evolution in *Lonicera*



Smith & Donoghue
(2010) Syst Biol

Factors promoting niche conservatism

- 1) Lack of suitable genetic variation
- 2) Genetic constraints (pleiotropy)
- 3) Gene flow (swamping)
- 4) Stabilizing selection

(habitat tracking, source-sink dynamics, biotic interactions)

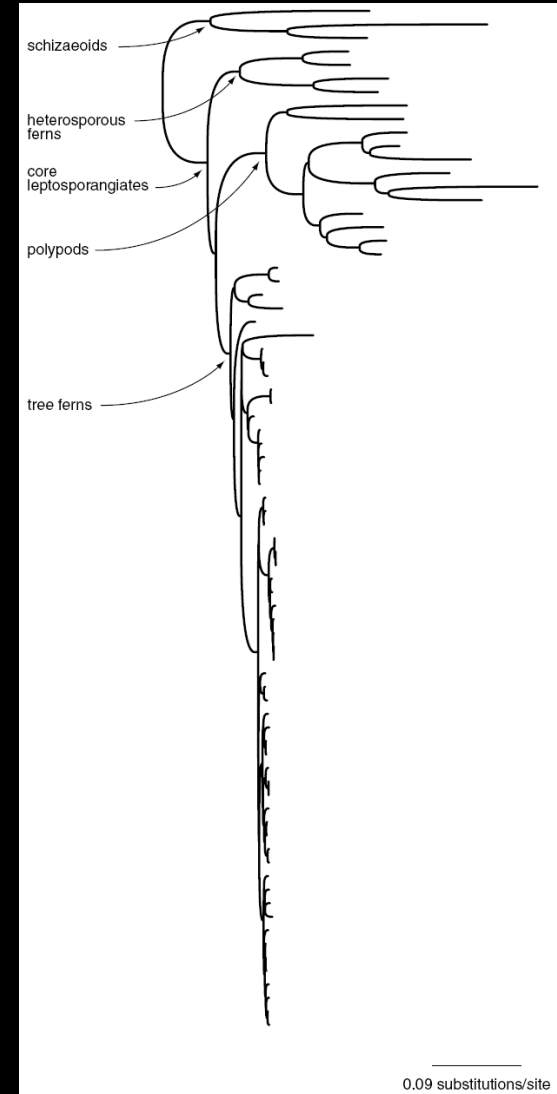
Genetic variation

a) Preexistent

- Small populations
- Demographic bottleneck

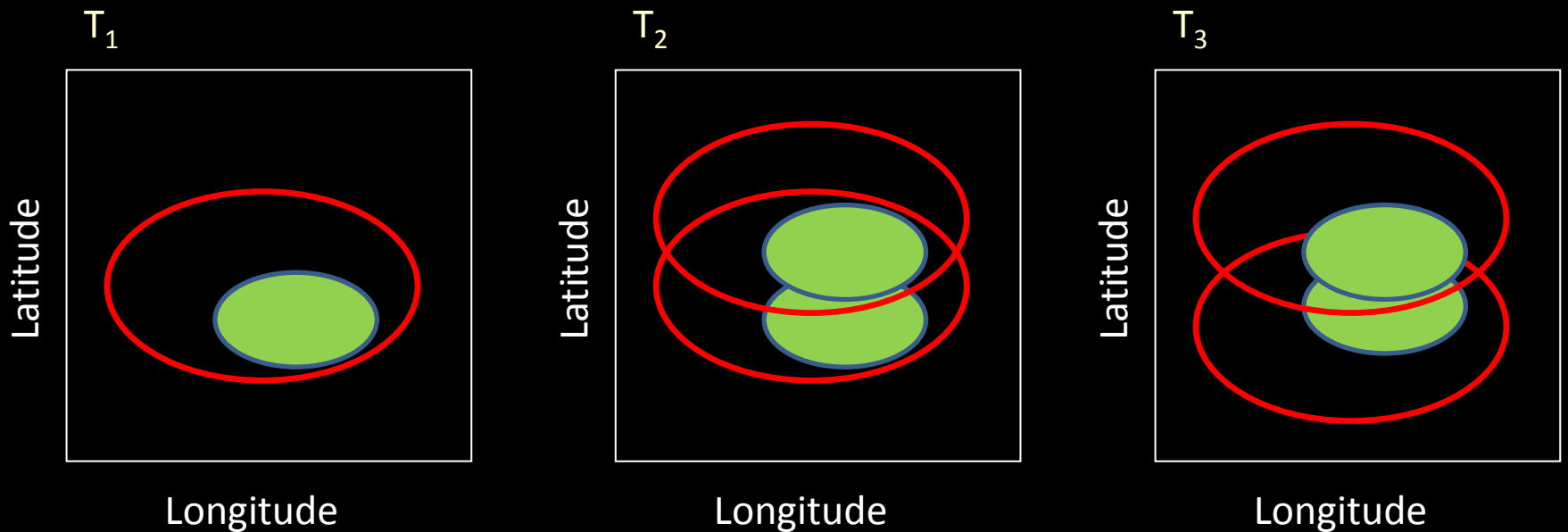
b) Newly originated

- Evolutionary rates vary across species

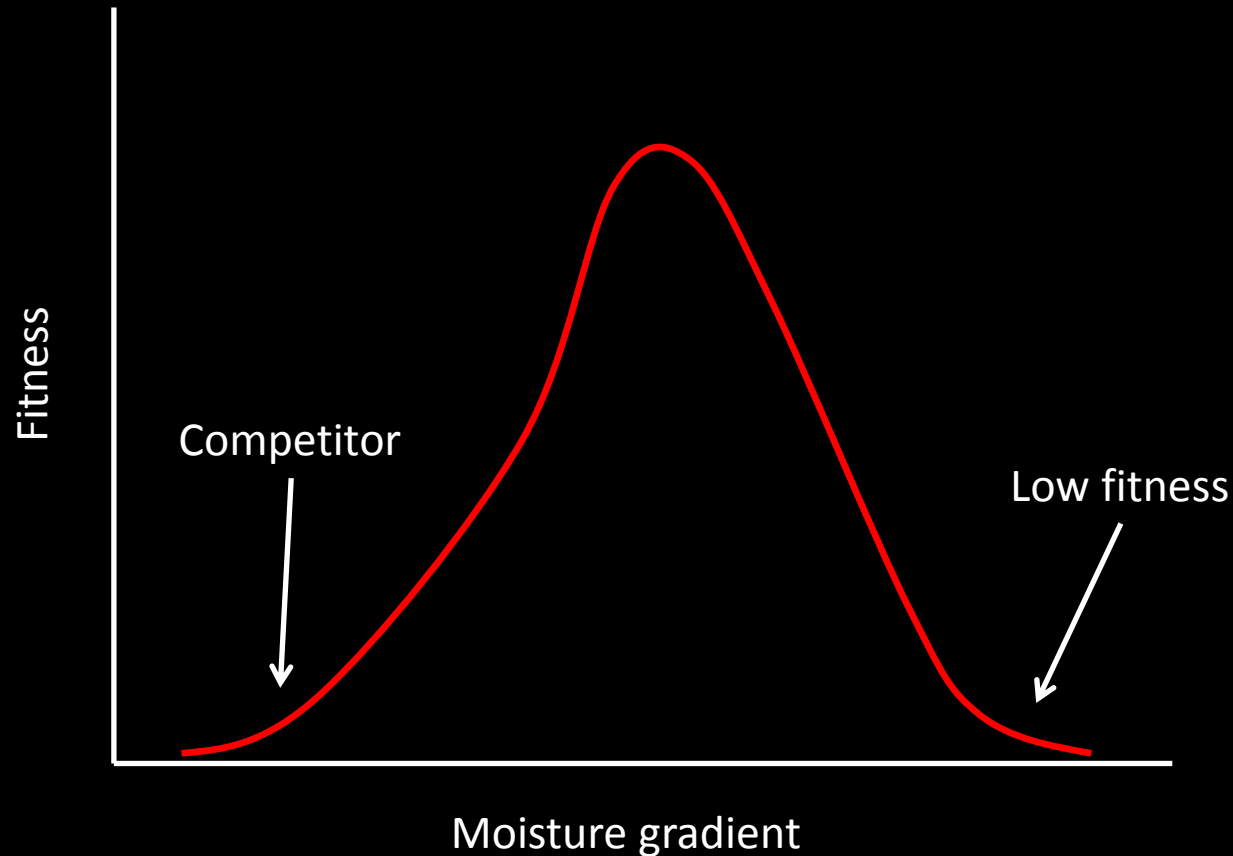


Korall et al. (2010) *Evolution*

Habitat tracking reduces selective pressure to adapt to new climates



Biotic interactions and demography may prevent adaptation



Conclusions

- SDMs provide an imperfect approach to species niches
- SDMs can provide useful insights on niche evolution and/or conservatism
- Actual niche evolution is difficult to infer from SDMs
- Powerful integration with phylogenetics