Integrating neontological and paleontological data to study species' responses to global change

Erin E. Saupe, Yale University

Outline:

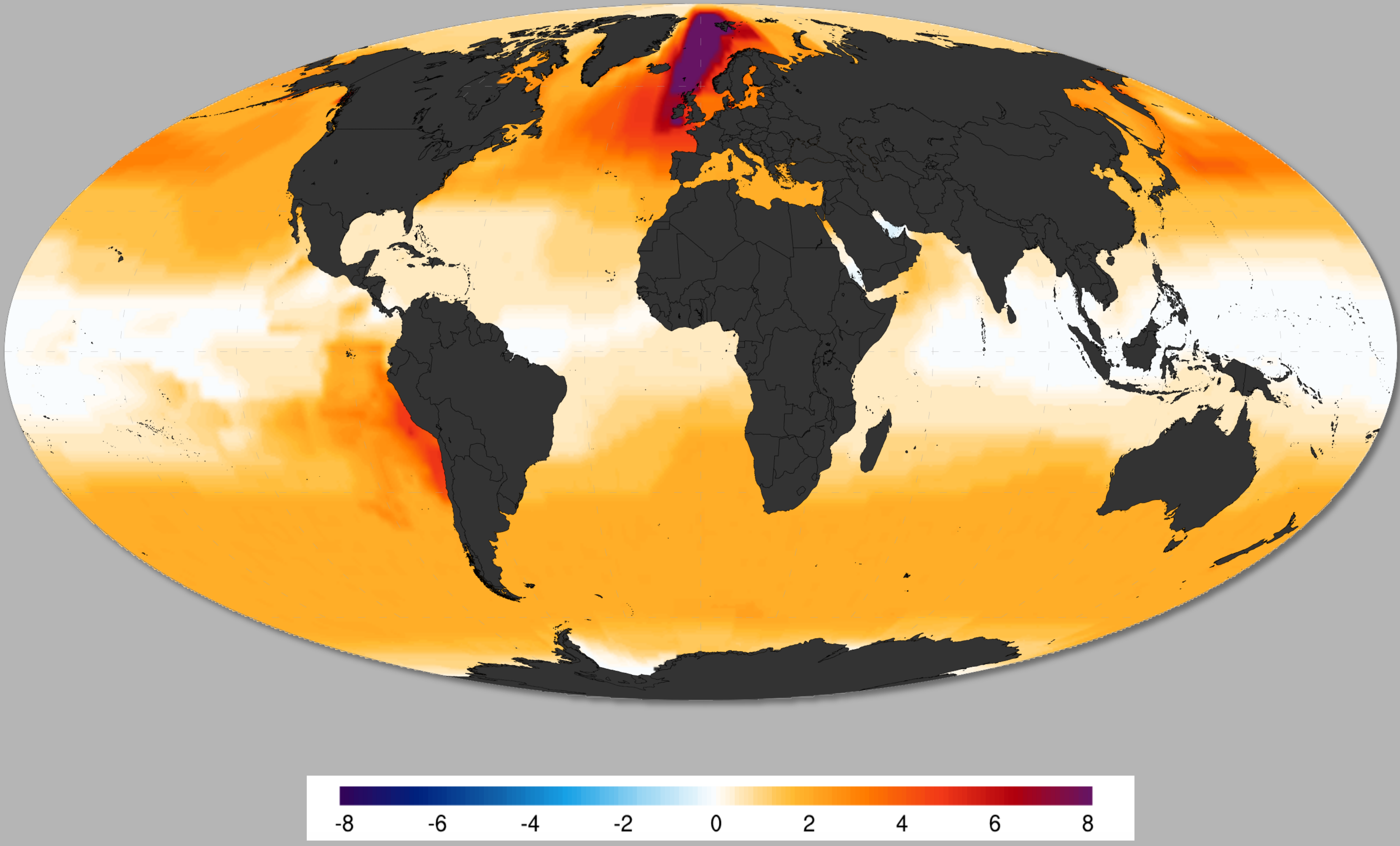
(1) Study background

(2) Niche evolution

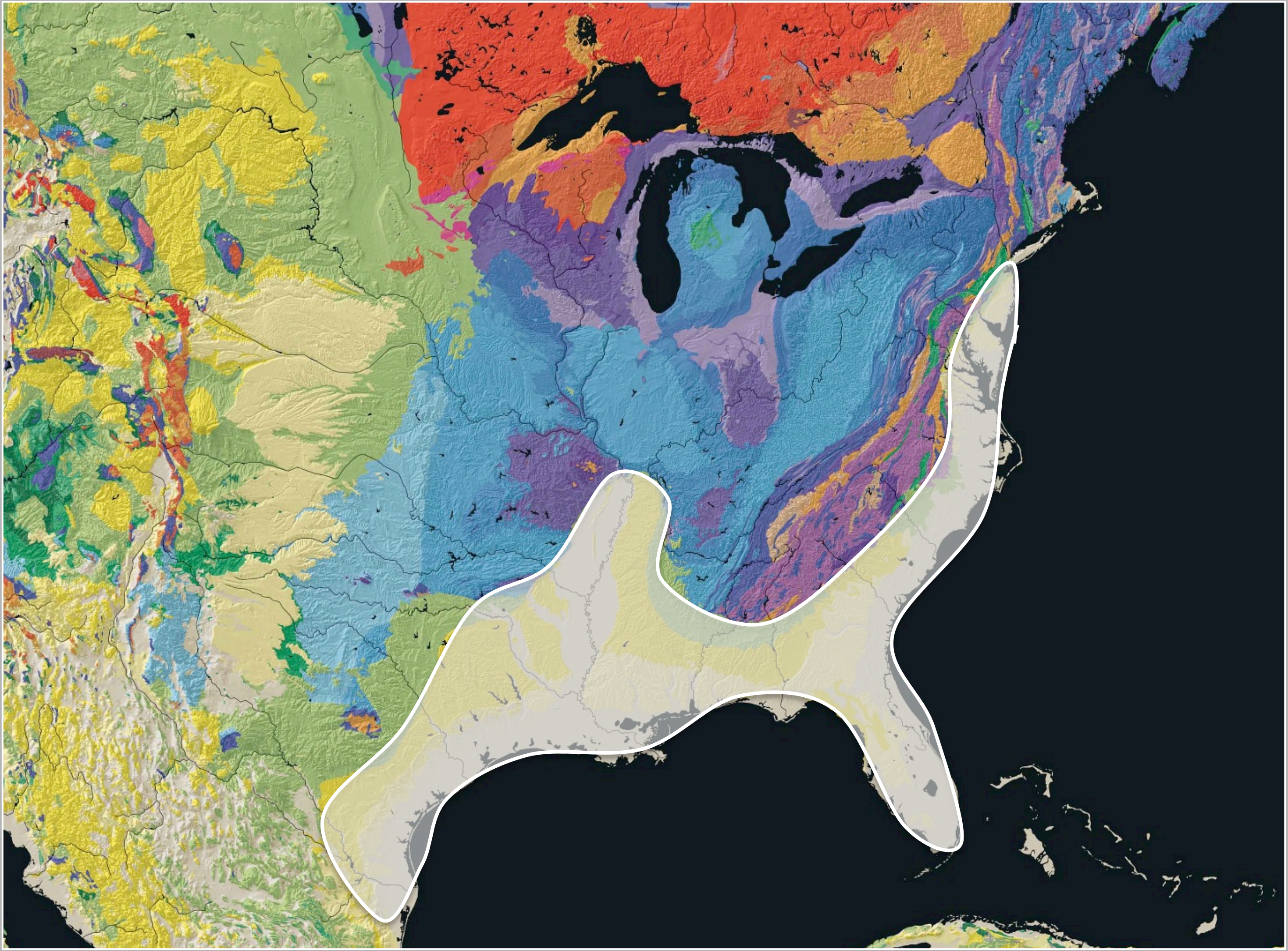
(3) Extinction selectivity


Learning from the fossil record

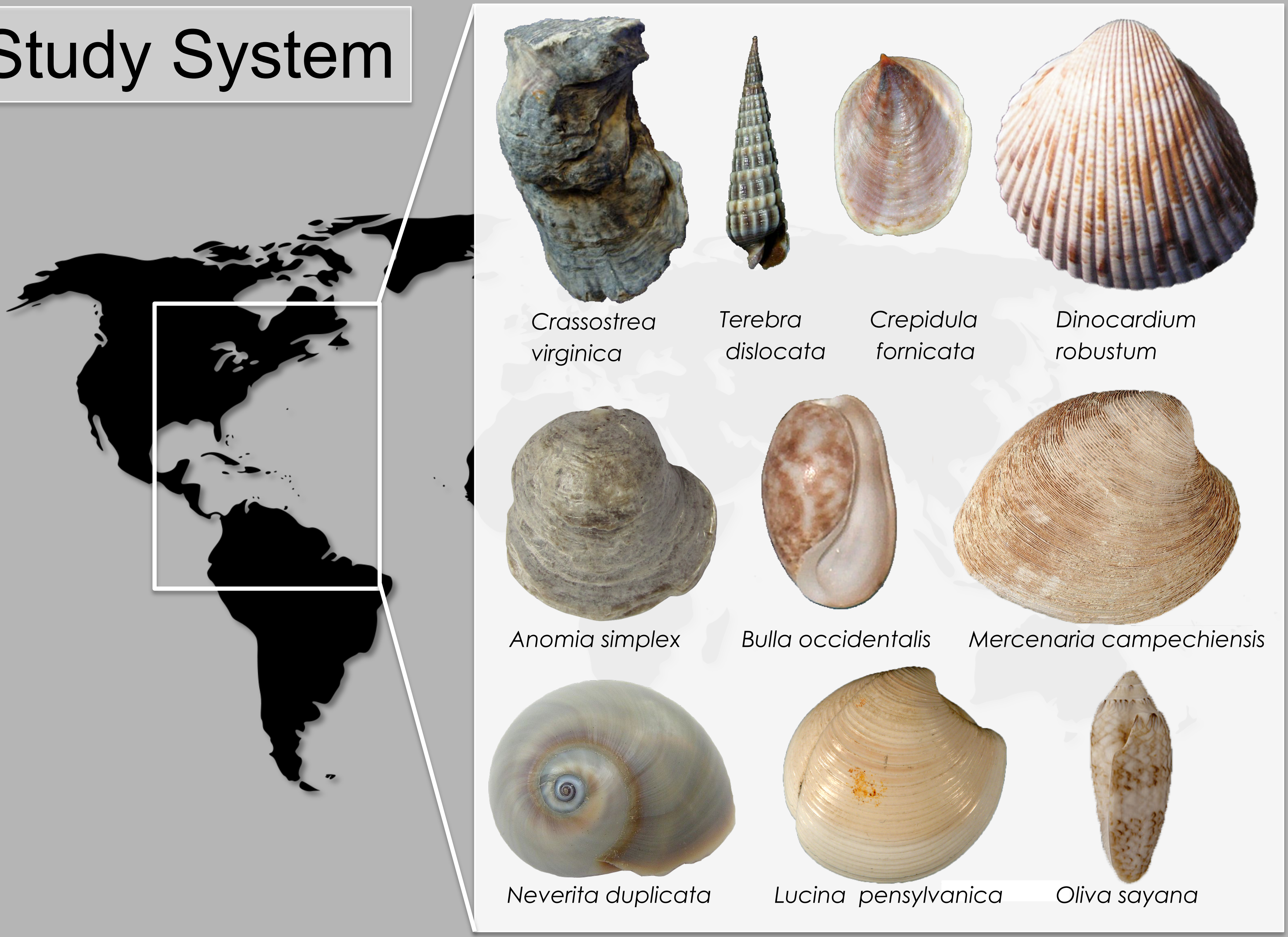
Pliocene SST (°C) Anomaly ~3.2 Ma

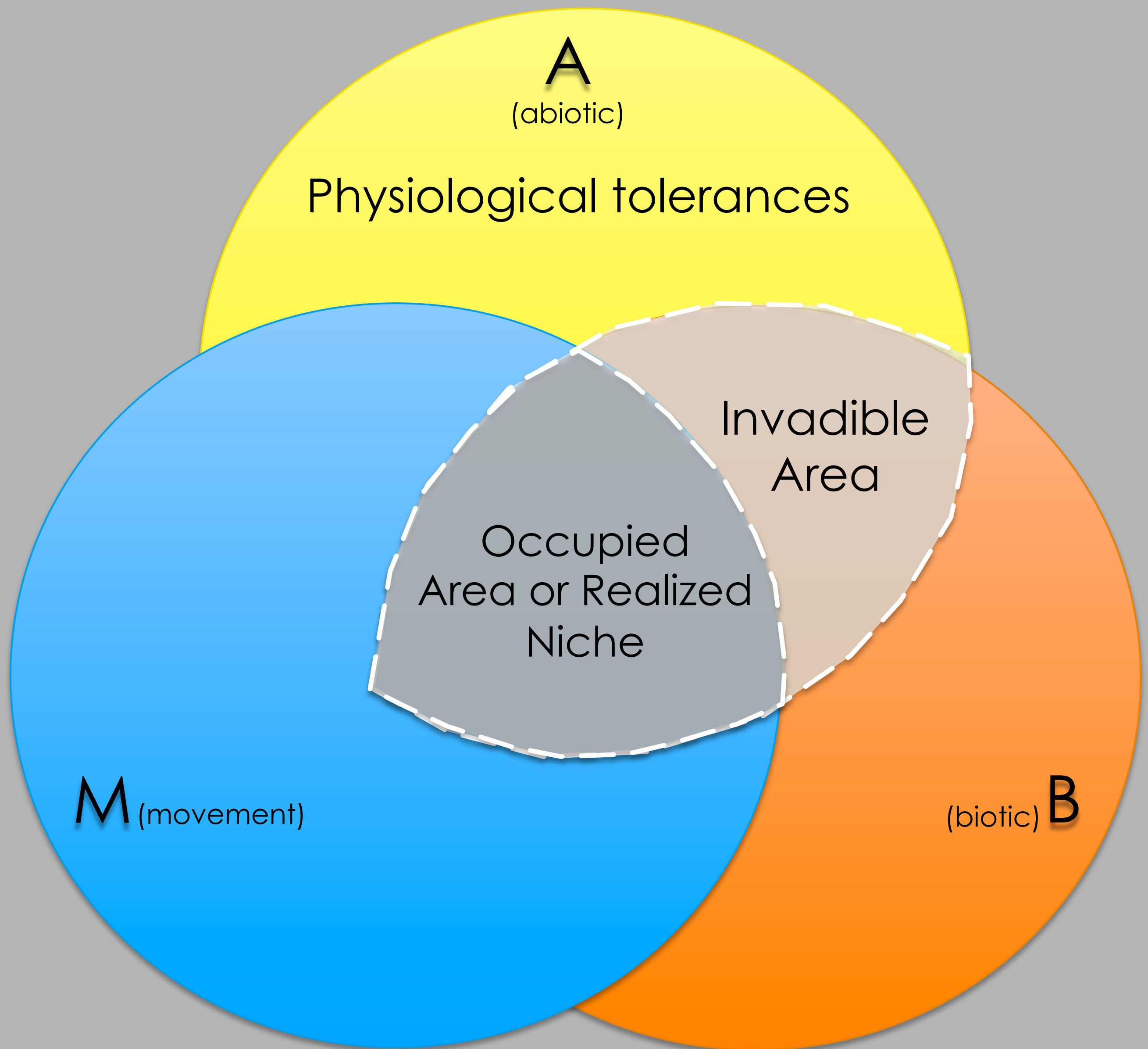


Atlantic & Gulf Coastal Plain



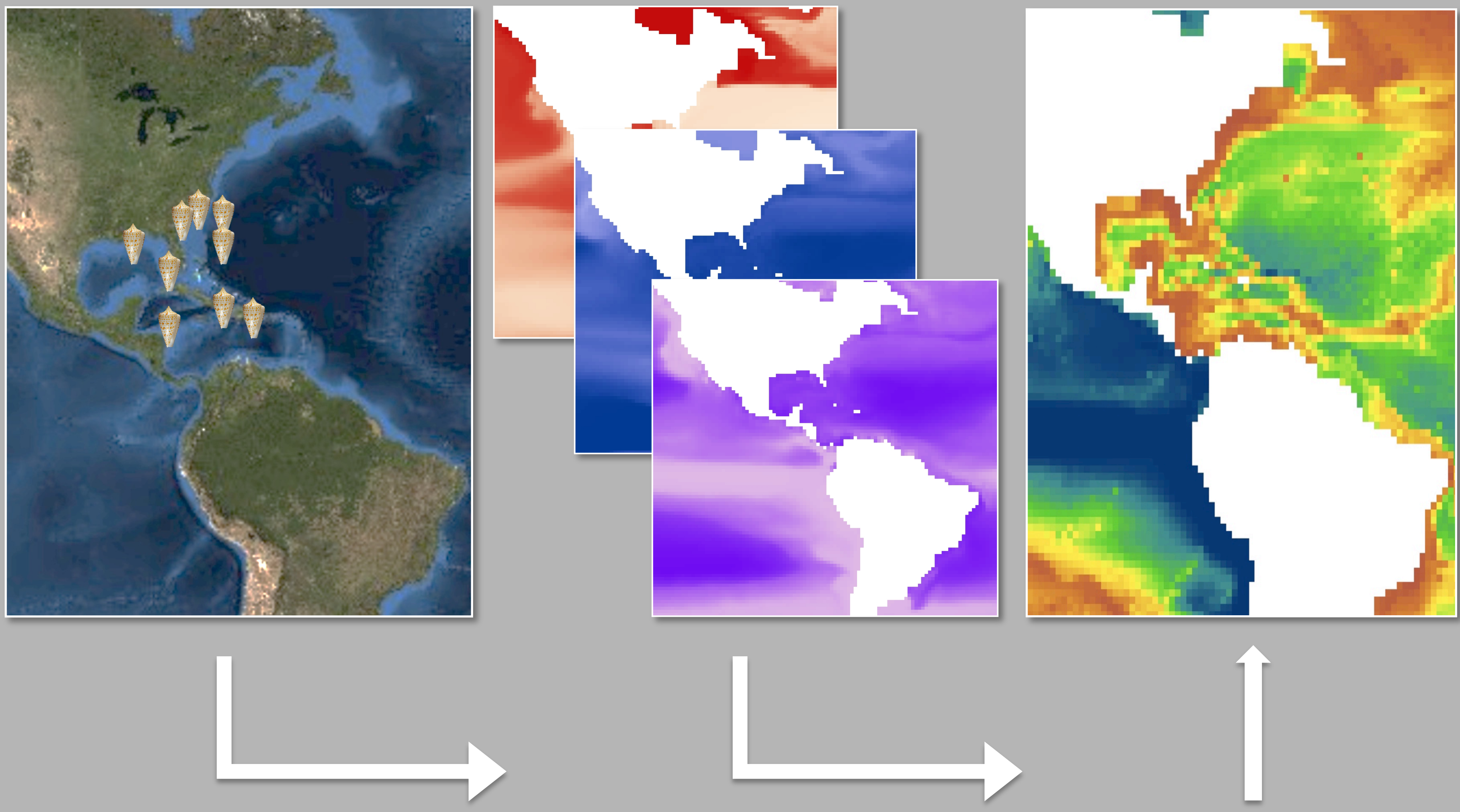
Study System





BAM diagram *sensu* Soberón 2007; Peterson *et al*. 2011

Ecological Niche Modeling



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Frequency of niche shifts?

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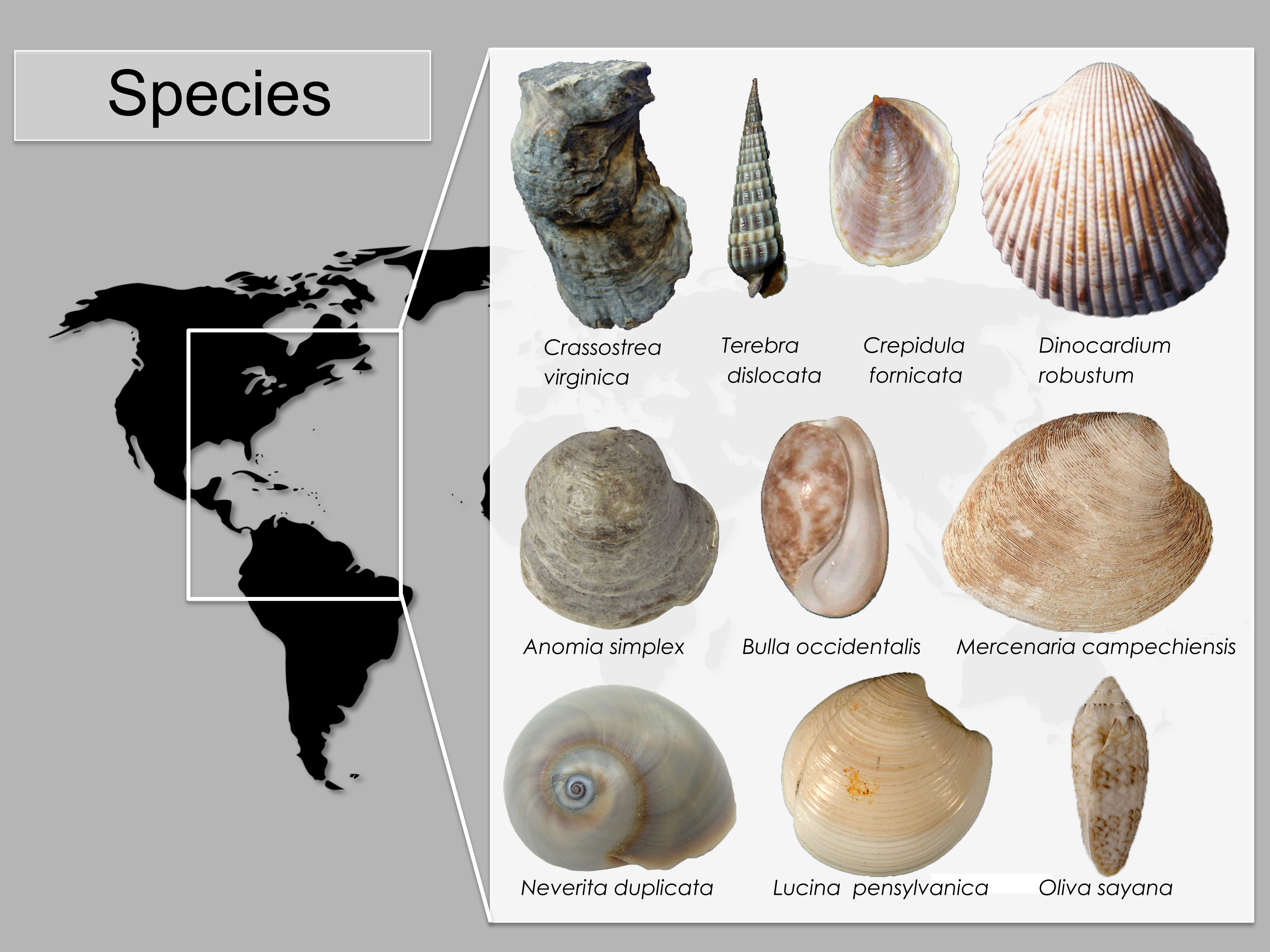
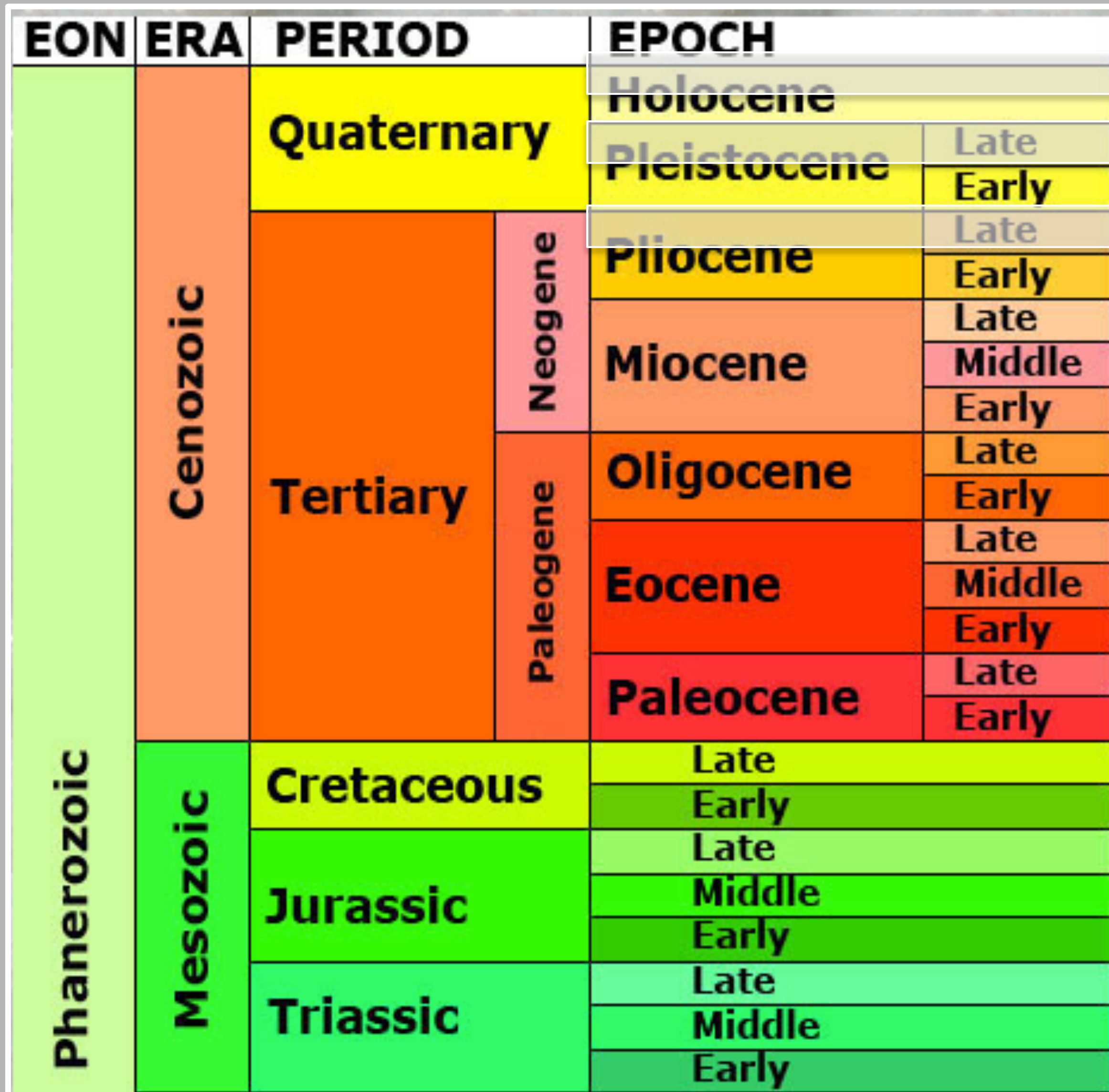
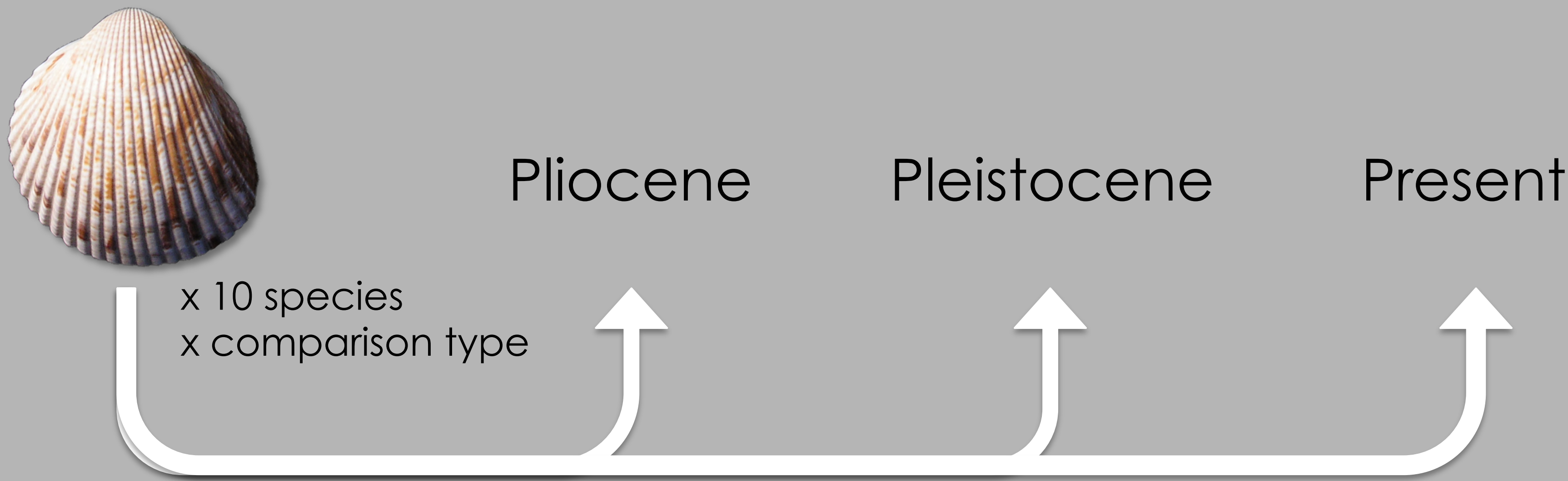

Species
Crassostrea virginica
Terebra dislocata
Crepidula fornicata
Dinocardium robustum
Anomia simplex
Bulla occidentalis
Mercenaria campechiensis
Neverita duplicata
Lucina pensylvanica
Oliva sayana

Study Interval



- Present
- ~130 Ka
- ~3.2–3.0 Ma

Hypotheses



Species environmental preferences remained stable over this interval

The upper and lower thermal tolerance limits for these species remained constant across the interval

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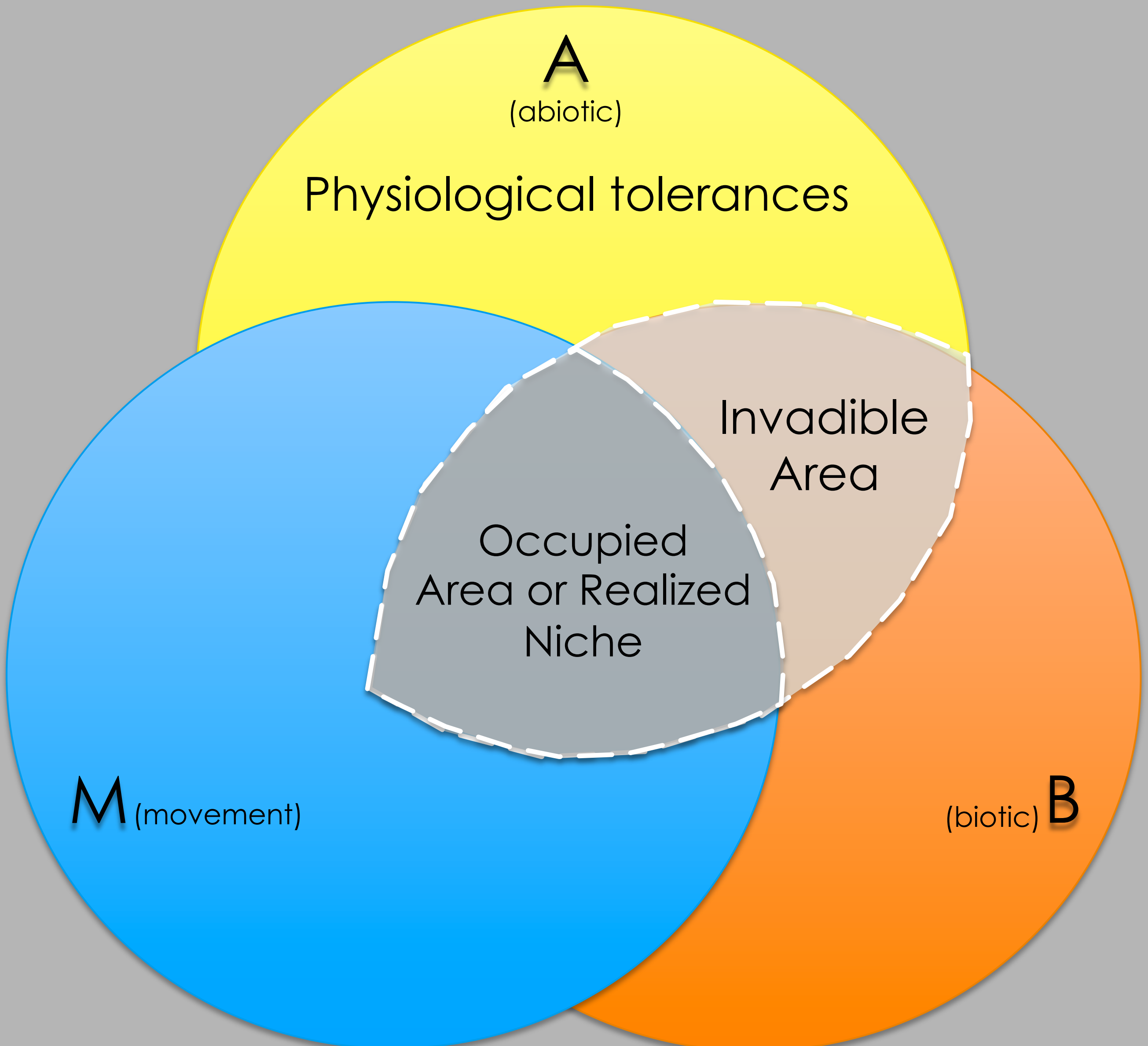


BAM diagram *sensu* Soberón 2007; Peterson *et al*. 2011

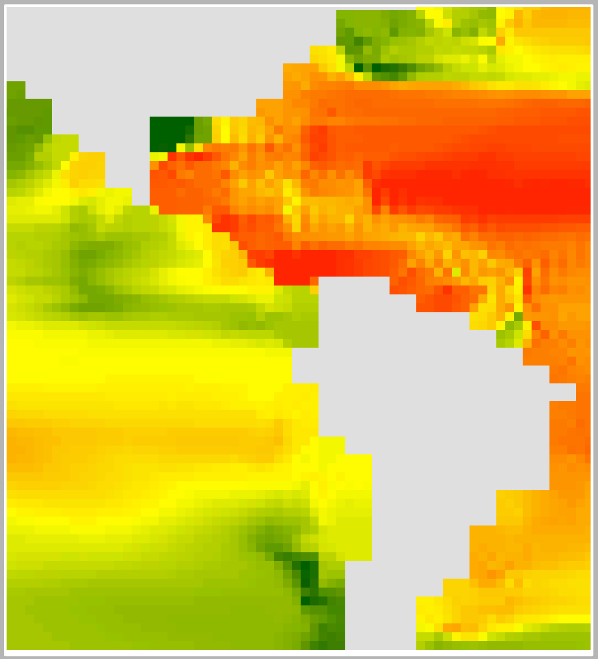
Occurrence data

Species	Pliocene All	Pliocene Unique	Pleistocene All	Pleistocene Unique	Present All	Present Unique
	219	13	39	15	157	31
	82	6	60	9	331	58
	42	7	24	10	73	37
	156	16	31	10	157	42
	59	7	46	11	119	22
	127	7	29	8	72	37
	187	14	94	12	120	24
	134	16	54	14	169	28
	76	9	28	8	177	25
	58	9	37	13	147	20

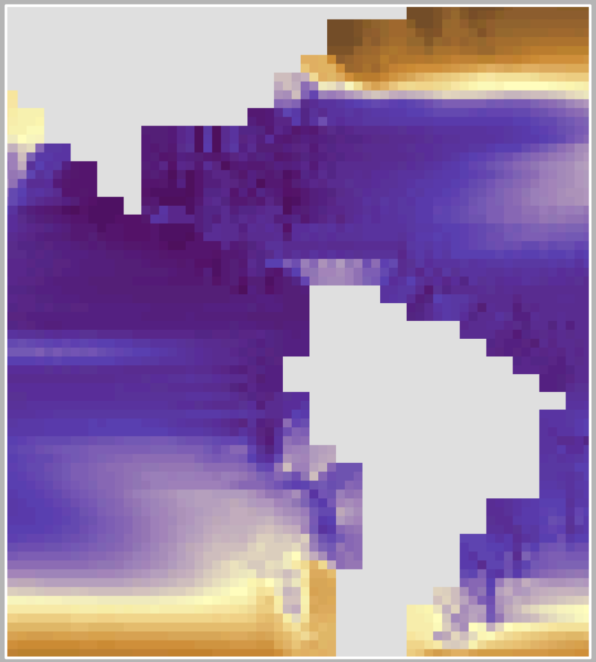
Georeferenced 3,104 records

Environmental Data

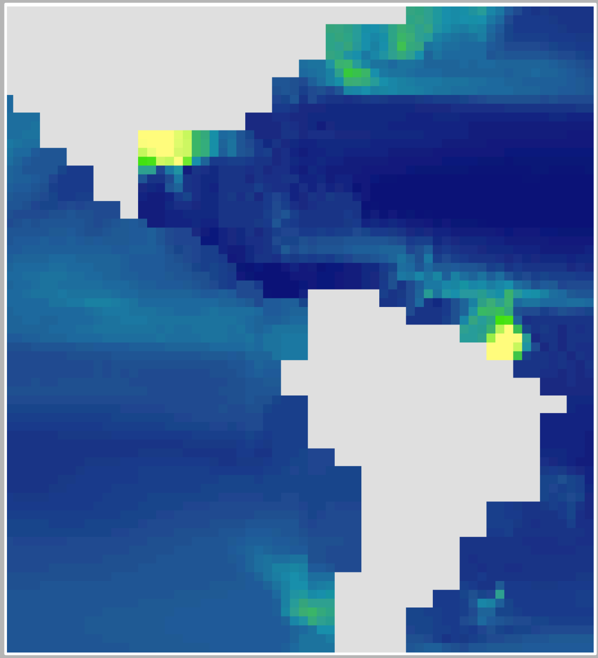
Max salinity



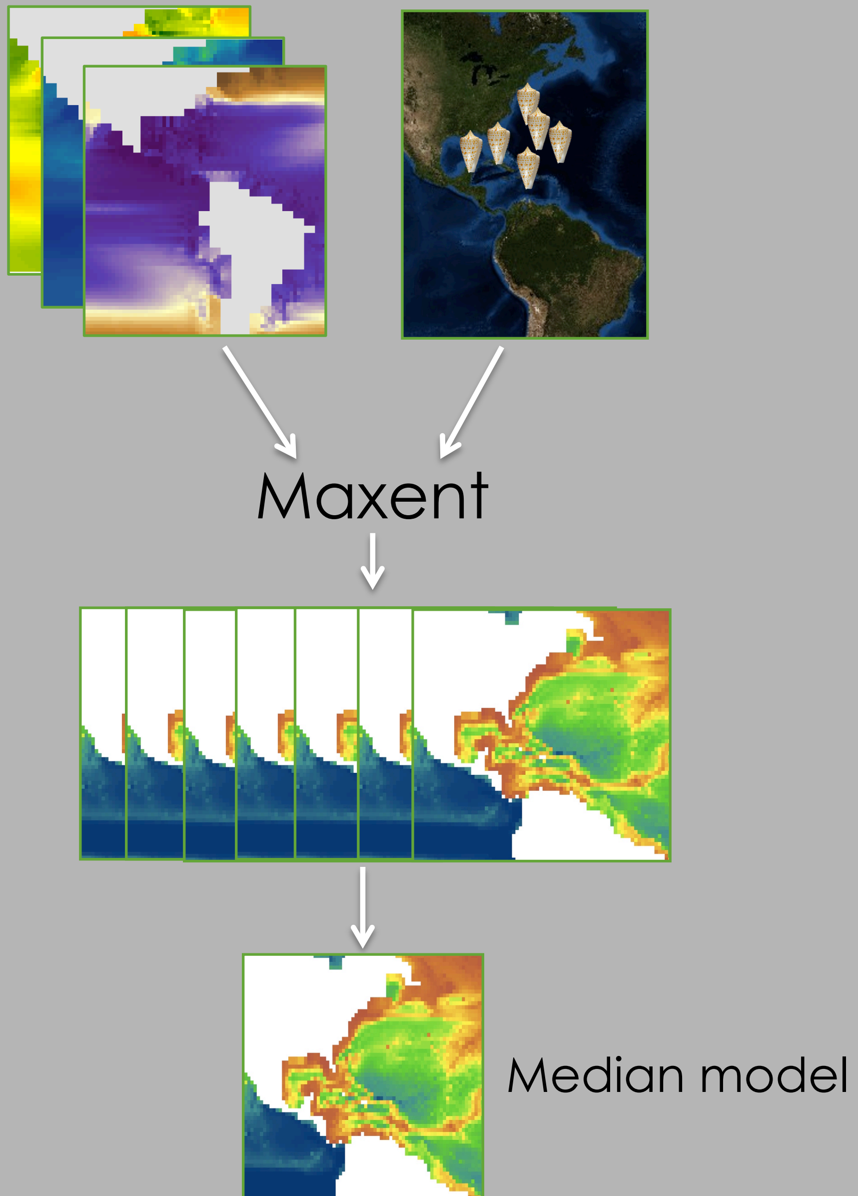
Max temperature



Min salinity

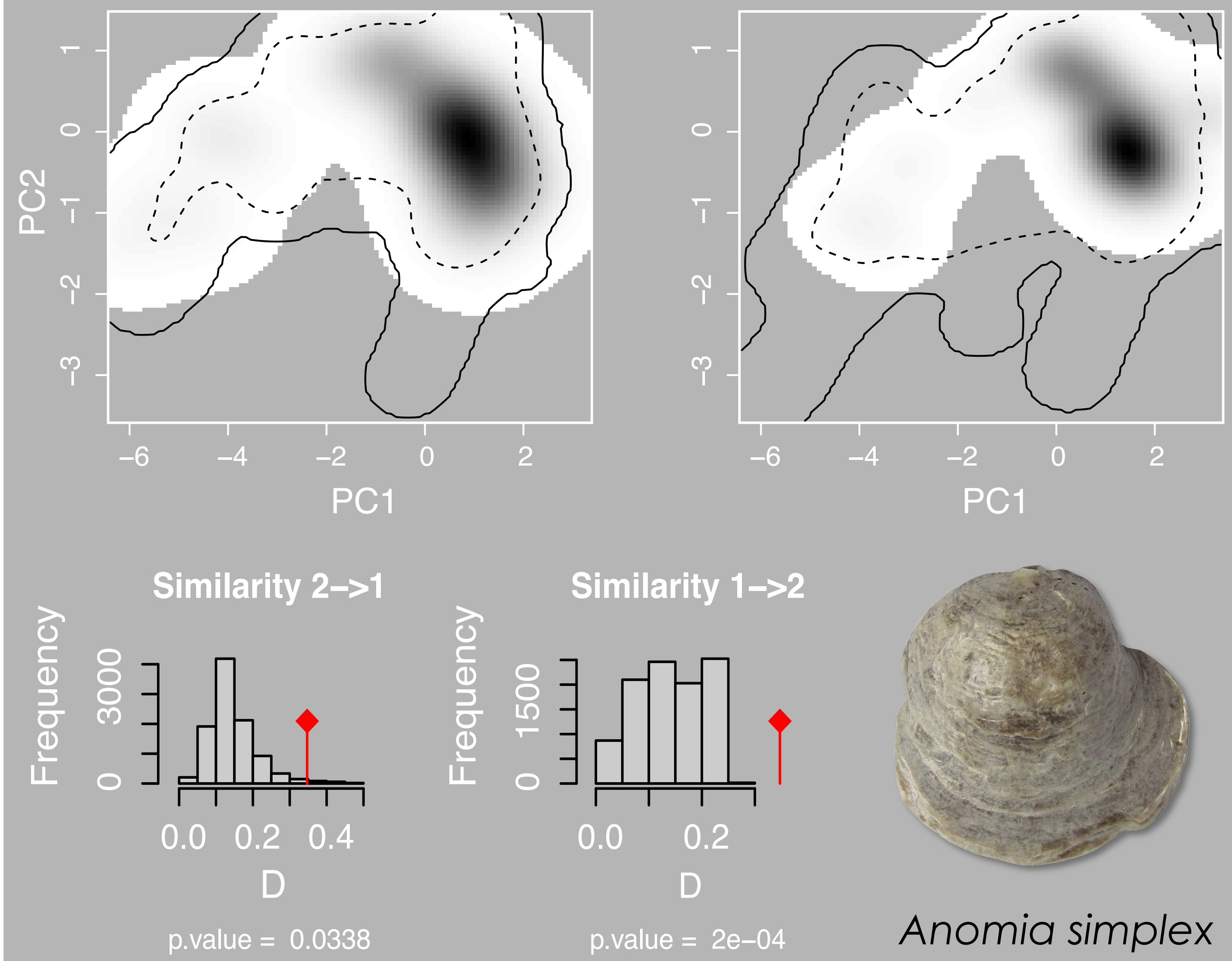


Model algorithm



Niche evolution

Pleistocene to Present



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Geographic – ENM Tools

Plio-Pleis		Pres-Pleis		Plio-Pres	
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	<.05	<.05
NS	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	<.05	NS
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	<.05	<.05

Environmental – PCA

Plio-Pleis		Pleis-Pres		Plio-Pres	
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	0.26	0.34
<.05	<.05	<.05	<.05	<.05	<.05
0.27	<.05	<.05	<.05	0.14	<.05
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	0.12	<.05
<.05	<.05	<.05	<.05	<.05	<.05
<.05	<.05	<.05	<.05	<.05	<.05

Saupe *et al.* (2014) *Proceedings of Royal Society B*

Species niche characteristics conserved within lineages

Buffeted by environment, not adapting to environment

Pattern congruent with habitat tracking in fossil record & modern distributional shifts

Saupe *et al.* (2014) *Proceedings of Royal Society B*

Conservation implications:

Extinction will result if environmental changes occur too rapidly

Validates ENM methodology to predict future responses of species to climate change

Saupe *et al*. (2014) *Proceedings of Royal Society B*

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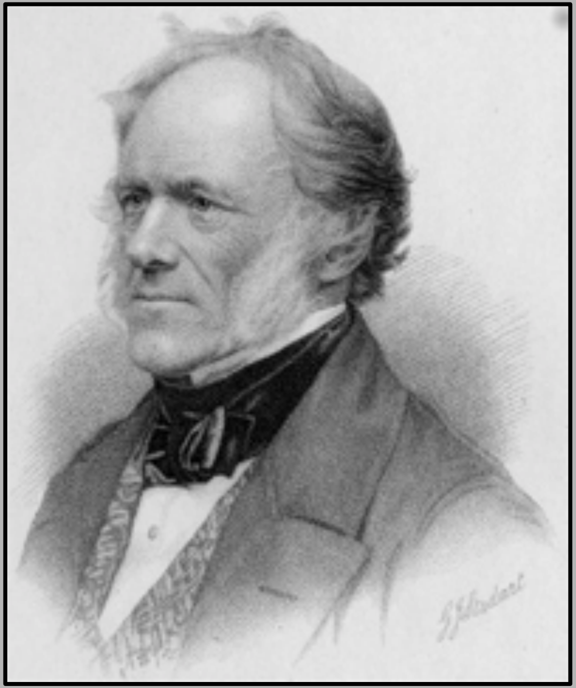
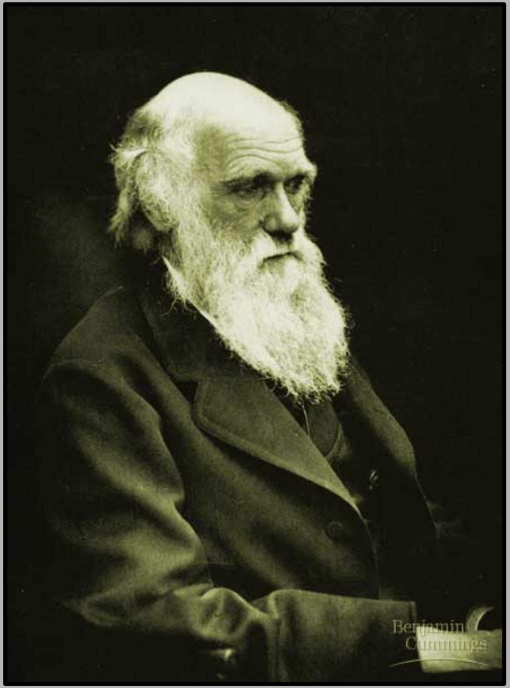
Extinction selectivity: historical perspective

Charles Lyell



Charles Darwin



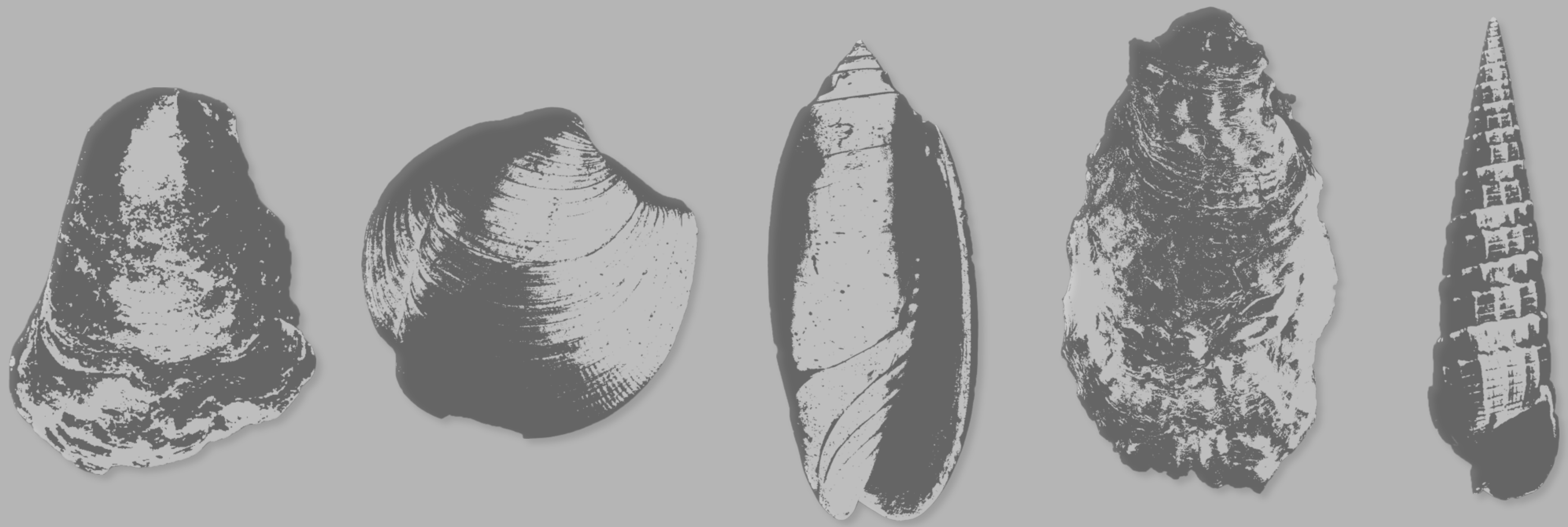
G.G. Simpson

50 bivalve genera (8 families)

Anomiidae
Arcidae
Cardiidae
Carditidae
Lucinidae
Ostreidae
Tellinidae
Veneridae

16 gastropod genera (8 families)

Bullidae
Calyptraeidae
Conidae
Fasciolariidae
Muricidae
Naticidae
Olividae
Terebridae



Collections & field work

Virginia Museum of Natural History

Florida Museum of Natural History

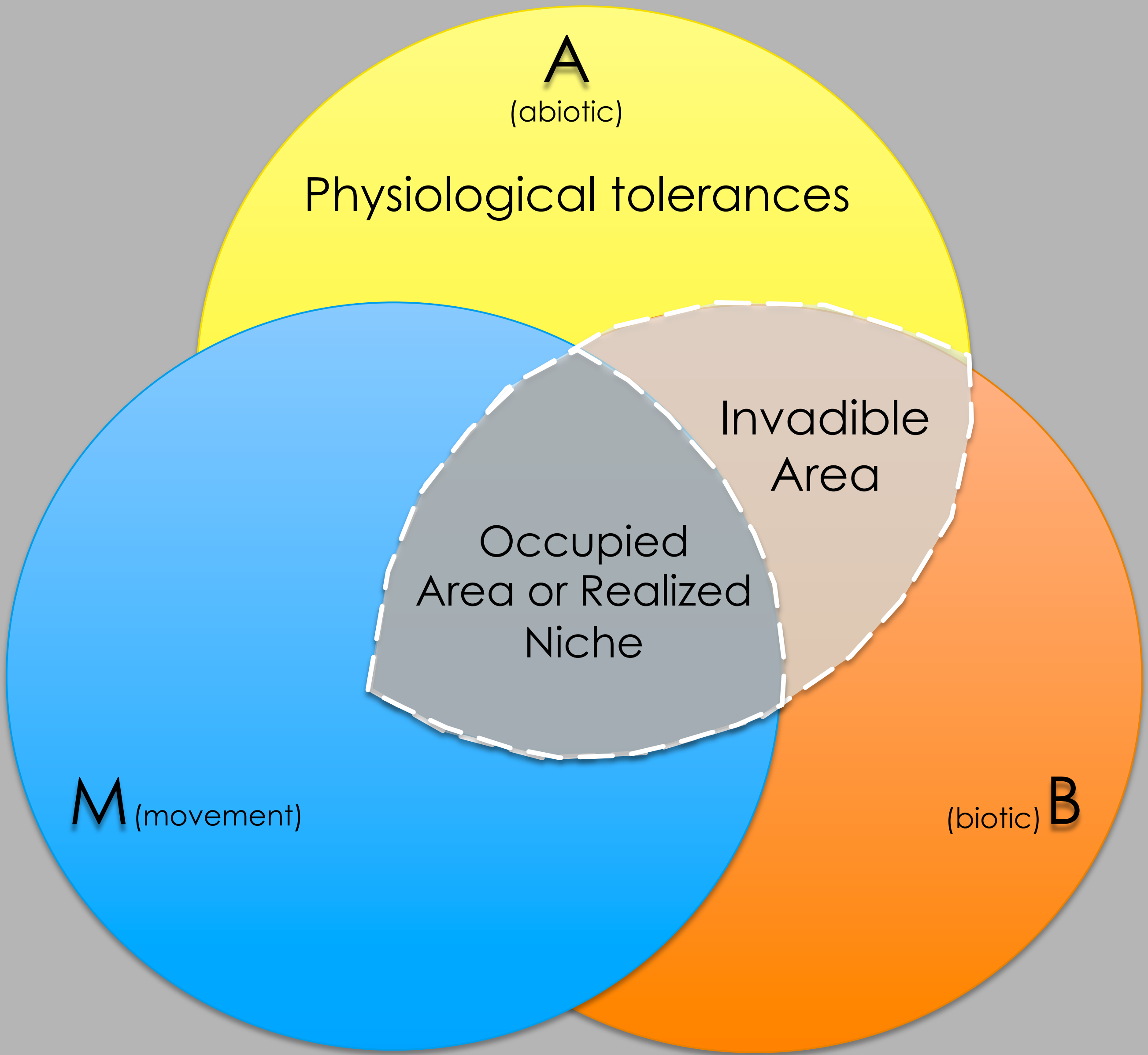
Testing whether species that survived:

(i) had larger geographic ranges than now-extinct species

(ii) had broader fundamental niche breadths than now-extinct species

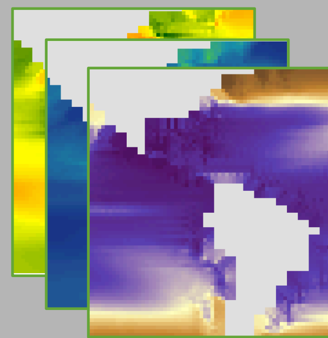
(iii) occupied broader realized environmental space than now-extinct species

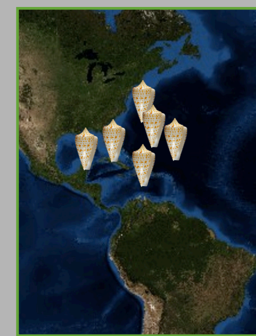
(iv) had more suitable area remaining during the LGM than now-extinct species



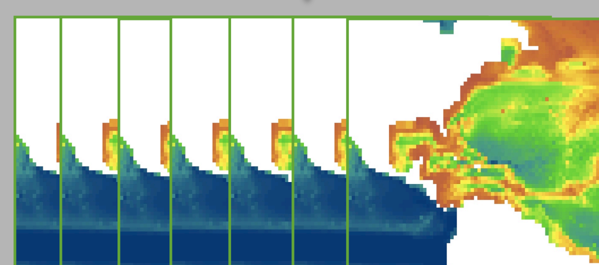
BAM diagram *sensu* Soberón 2007; Peterson *et al*. 2011

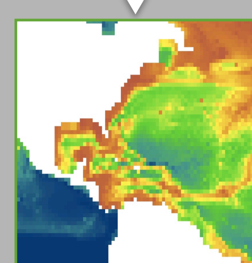
Model algorithm





Maxent





Median model

Testing whether species that survived:

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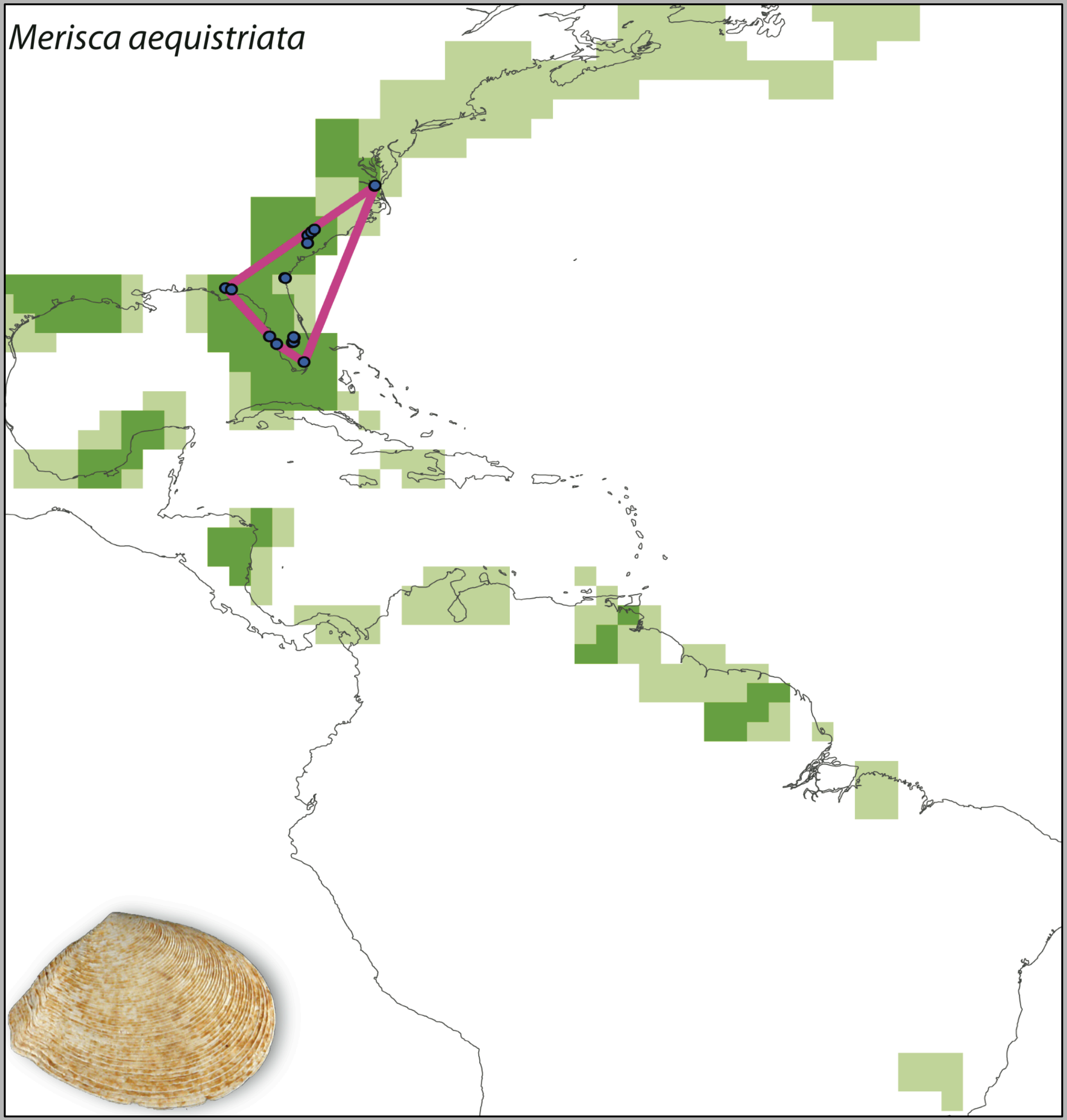
(iv) had more suitable area remaining during the LGM than now-extinct species

(i) Geographic range



Saupe et al. 2015. *Global Ecology & Biogeography*

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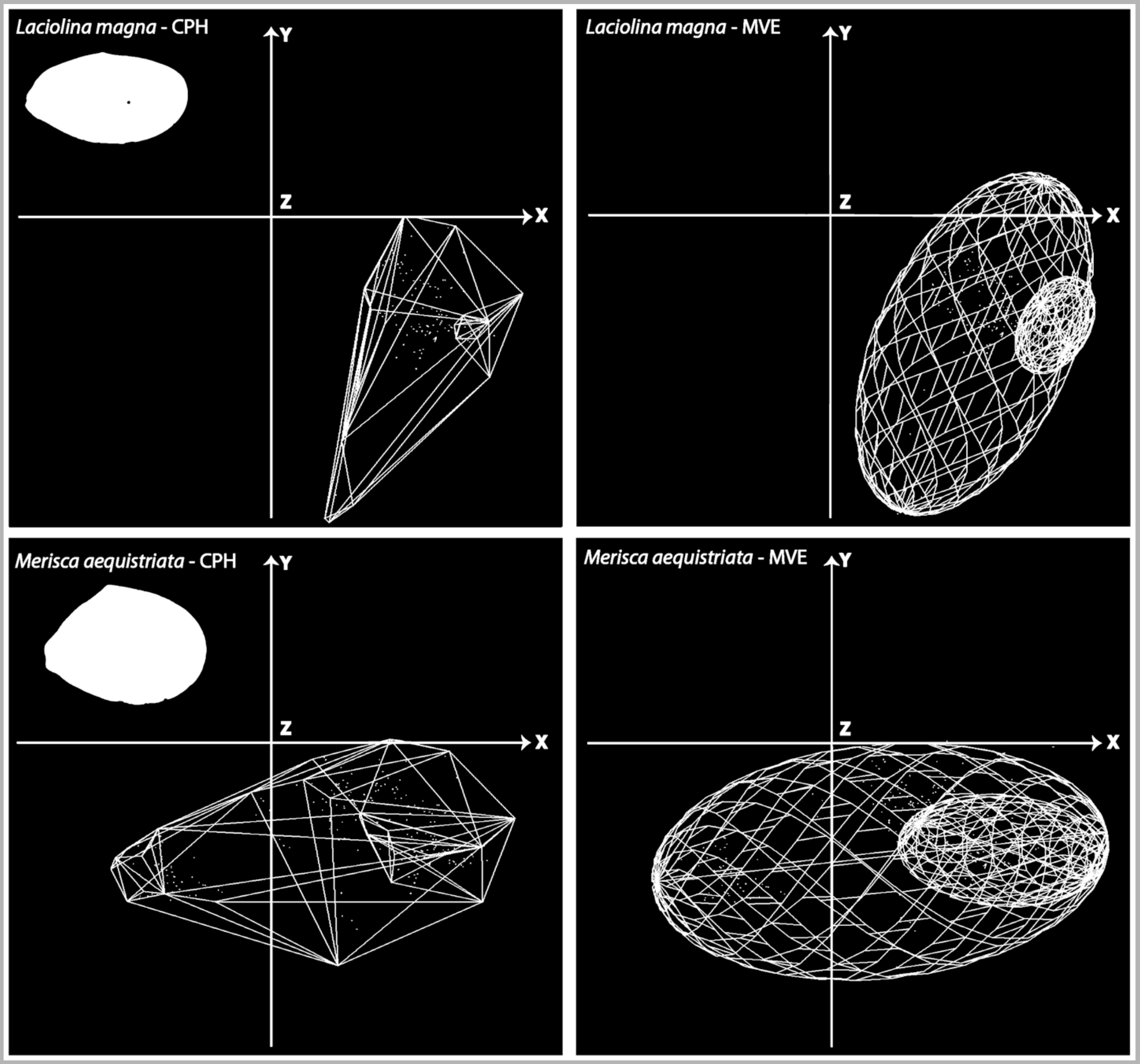
(ii-iii) Niche breadths



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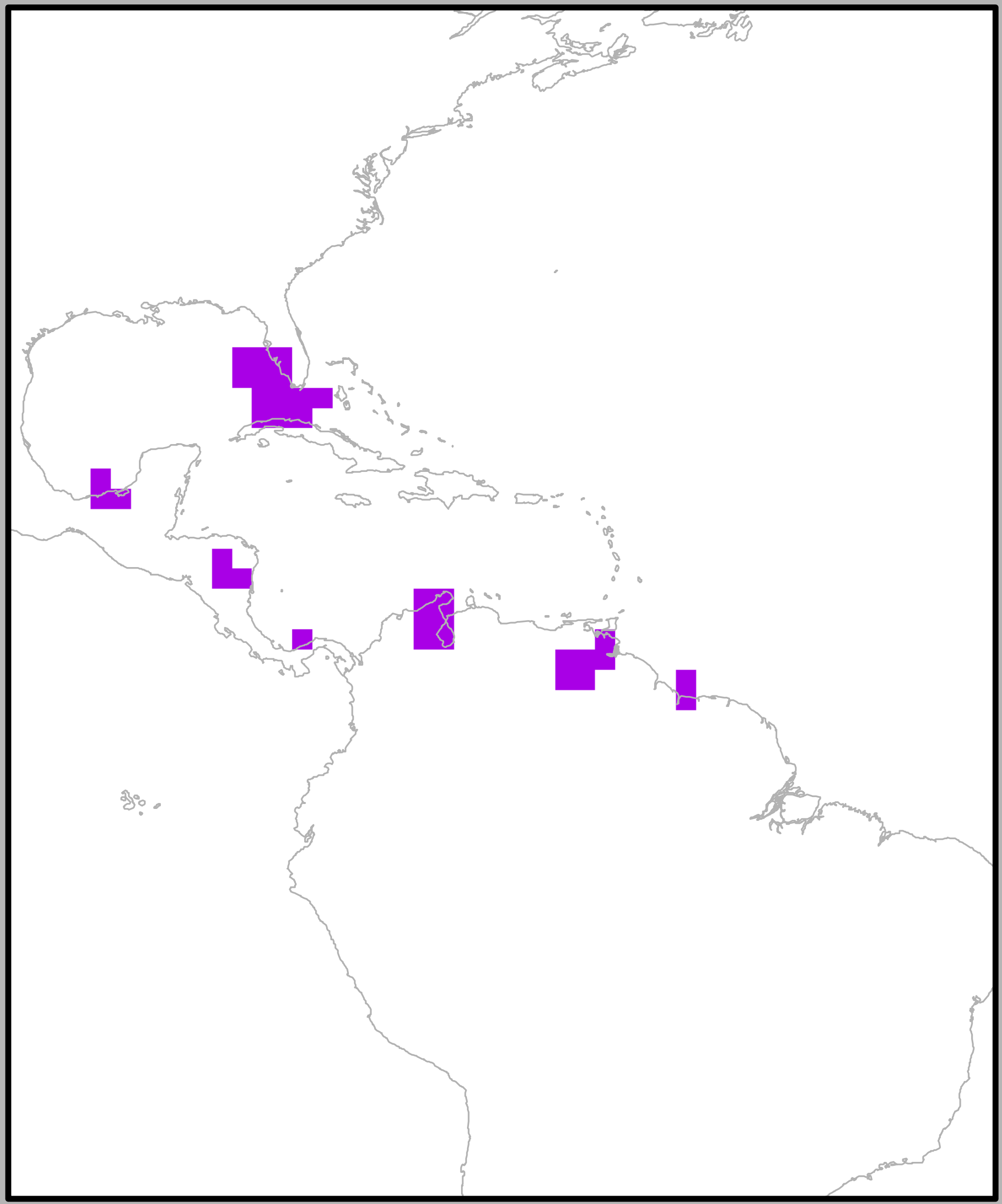
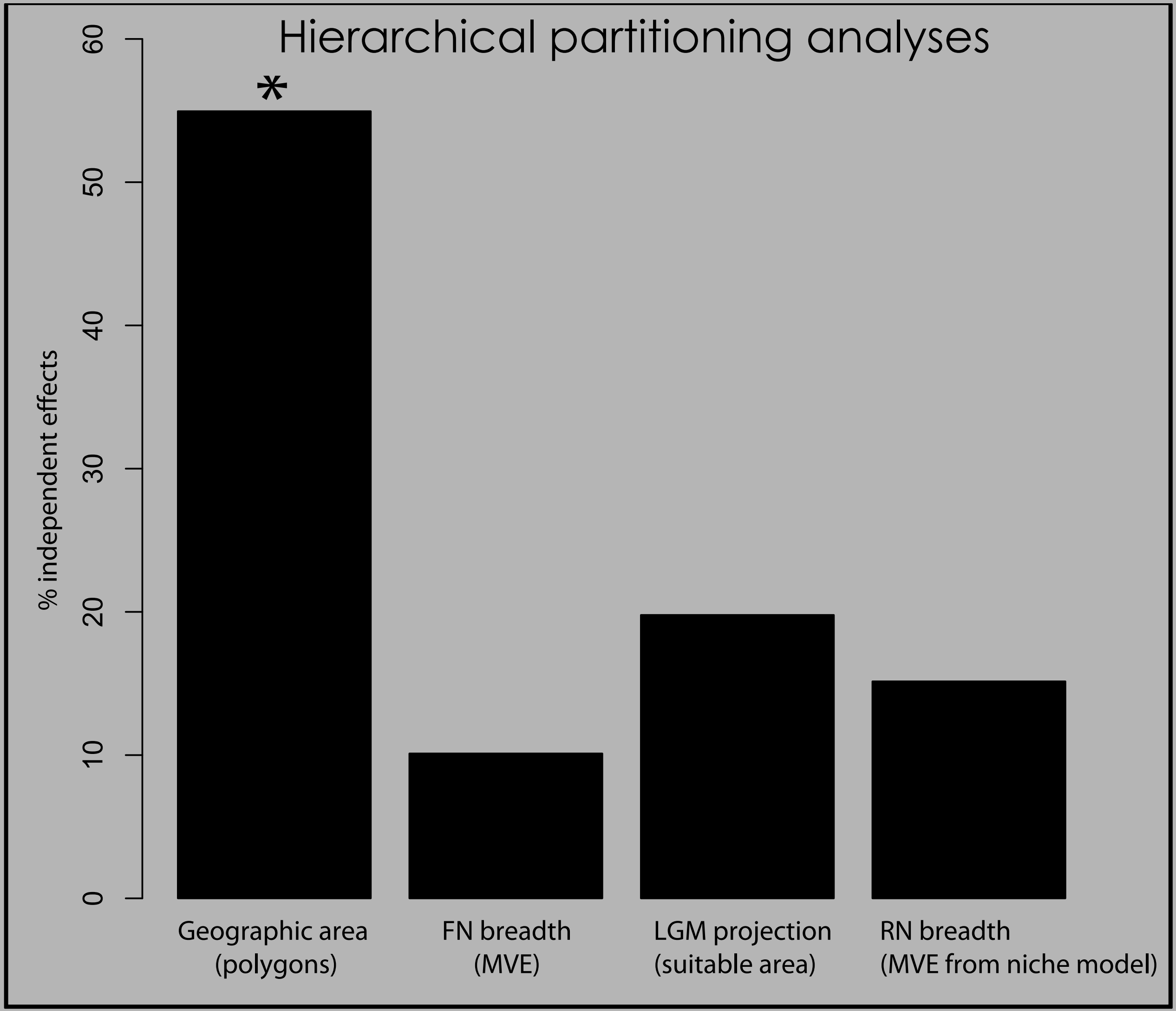
(iv) LGM Area



Saupe et al. 2015. *Global Ecology & Biogeography*

Extinction selectivity results



Saupe et al. 2015. *Global Ecology & Biogeography*

Hypothesis ii: still-extant species have larger geographic ranges than now-extinct species

Hypothesis ii: Supported

Hypothesis i: still-extant species have greater fundamental niche breadths than now-extinct species

Hypothesis i: NOT supported

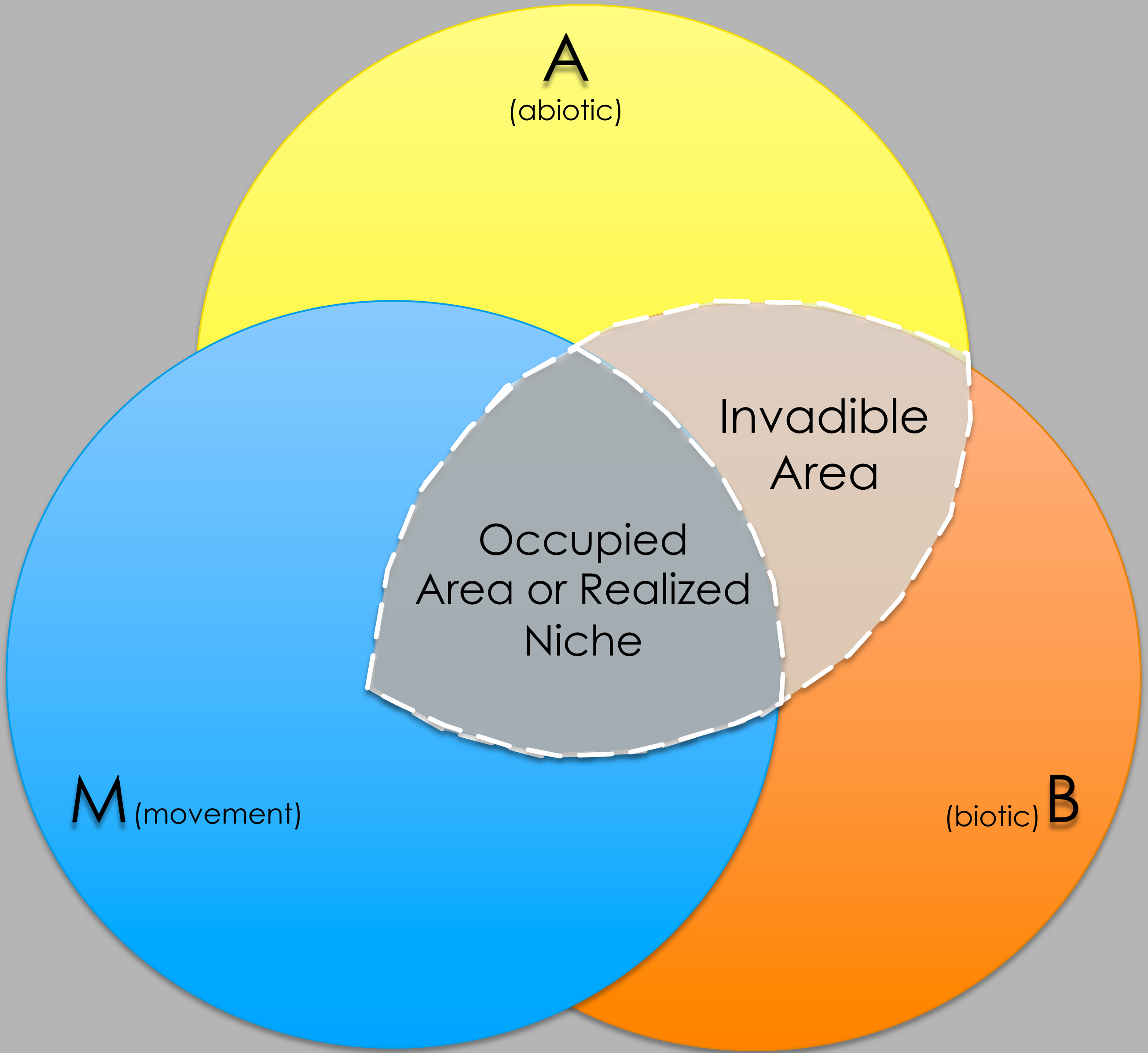
Hypothesis iii: still-extant species occupied broader realized environmental space than now-extinct species

Hypothesis iii: Supported

Hypothesis iv: still-extant species had more suitable area remaining during the LGM than now-extinct species

Hypothesis iv: Supported

Saupe *et al*. (2015) *Global Ecology and Biogeography*



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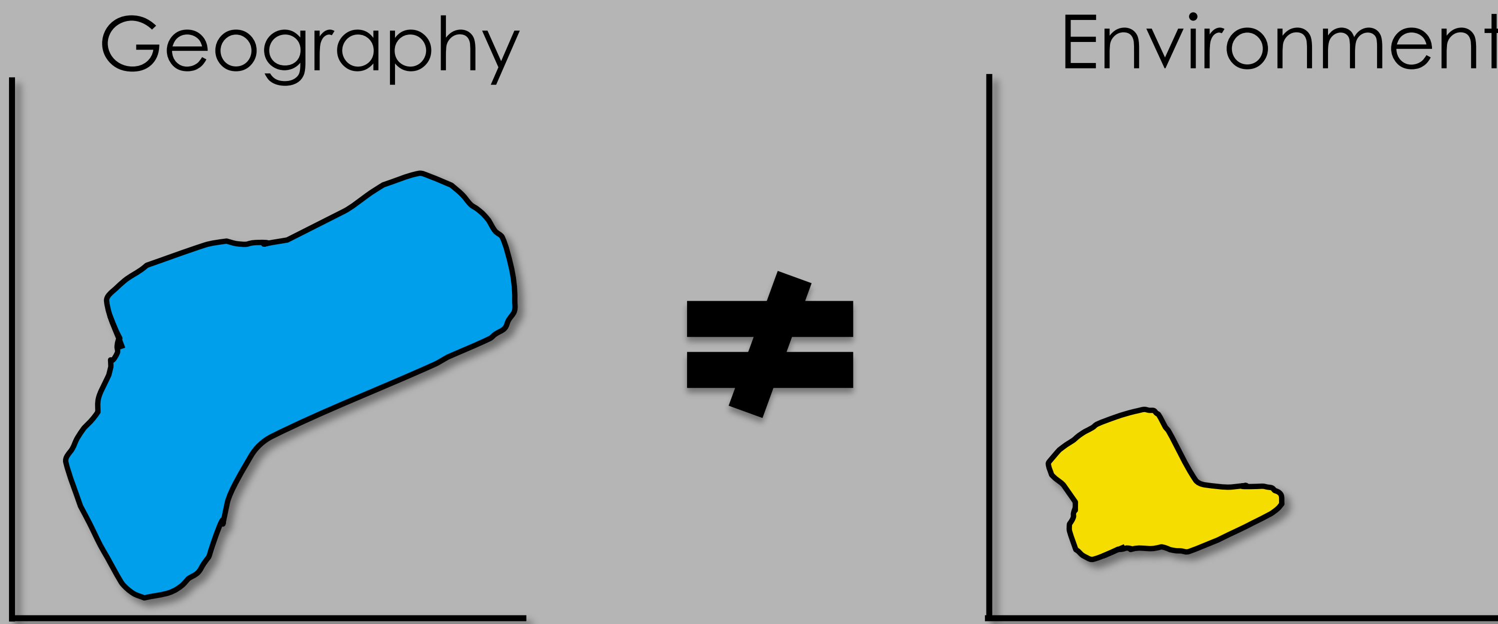
Geography
≠
Environment

Conclusions

Thanks to…

- Yale Institute for Biospheric Studies
- NSF Emerging Frontiers
- NSF Advancing the Digitization of Biological Collections
- NSF Systematic Biology
- NSF Sedimentary Geology and Paleobiology
- Bruce Lieberman, U of Kansas
- Corinne Myers, U of NM
- Huijie Qiao, Chinese Academy
- Jorge Soberon, U of Kansas
- Town Peterson, U of Kansas