Integrating neontological and paleontological data to study species’ responses to global change
Outline:

(1) Study background

(2) Niche evolution

(3) Extinction selectivity
Learning from the fossil record
Pliocene SST (°C) Anomaly ~3.2 Ma
Study System

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

Physiological tolerances

Invadible Area

Occupied Area or Realized Niche

M_{movement}

A
(abiotic)

B
(biotic)

BAM diagram sensu Soberón 2007; Peterson et al. 2011
Outline:

(1) Study background

(2) Niche evolution

(3) Extinction selectivity
Frequency of niche shifts?

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

- *Crassostrea virginica*
- *Terebra dislocata*
- *Crepidula fornicata*
- *Dinocardium robustum*
- *Anomia simplex*
- *Bulla occidentalis*
- *Mercenaria campechiensis*
- *Neverita duplicata*
- *Lucina pensylvanica*
- *Oliva sayana*
### Study Interval

<table>
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<tr>
<th>EON</th>
<th>Era</th>
<th>Period</th>
<th>Epoch</th>
<th>Interval</th>
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<tr>
<td></td>
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<td>~130 Ka</td>
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<td>Triassic</td>
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Hypotheses

Species environmental preferences remained stable over this interval.

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

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

BAM diagram sensu Soberón 2007; Peterson et al. 2011

A (abiotic)

Physiological tolerances

Invadible Area

Occupied Area or Realized Niche

M (movement)

(biotic) B

BAM diagram sensu Soberón 2007; Peterson et al. 2011
### Occurrence data

<table>
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<td>All</td>
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*Georeferenced 3,104 records*
Model algorithm

Maxent

Median model
Pleistocene to Present

Niche evolution

Similarity 2 $\rightarrow$ 1

Similarity 1 $\rightarrow$ 2

Anomia simplex

Saupe et al. (2014) Proceedings of Royal Society B
### Geographic – ENM Tools

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### Environmental – PCA

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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
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
Outline:

(1) Study background

(2) Niche evolution

(3) Extinction selectivity
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
Physiological tolerances

A
(abiotic)

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Maxent

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(i) Geographic range

Merisca aequistriata

Saupe et al. 2015. Global Ecology & Biogeography
Testing whether species that survived:

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

Saupe et al. 2015. Global Ecology & Biogeography
Testing whether species that survived:

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

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

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

Saupe et al. 2015. *Global Ecology & Biogeography*
Extinction selectivity results

Hierarchical partitioning analyses

% independent effects

Geographic area (polygons)
FN breadth (MVE)
LGM projection (suitable area)
RN breadth (MVE from niche model)

Saupe et al. 2015. Global Ecology & Biogeography
Hypothesis i: still-extant species have greater fundamental niche breadth than now-extinct species

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

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

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

Saupe et al. (2015) Global Ecology and Biogeography
BAM diagram sensu Soberón 2007; Peterson et al. 2011

- A (abiotic)
- M (movement)
- B (biotic)
- Invadible Area
- Occupied Area or Realized Niche
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