The PALEONICHES-TCN

B.S. Lieberman, J.R. Hendricks, A.L. Stigall, U.C. Farrell, S. Butts, A. Molineux, J.H. Beach, R. Portell, B. Hunda, K. Hauer

U. of Kansas, San José State U., Ohio U., U. of Texas, Yale U., Cincinnati Museum, Miami University, Florida Museum

PALEONICHES – TCN : Data and Research

- ~ 700,000 specimens databased
- > 9,500 fossil localities georeferenced
- > 900 fossil species imaged (> 2,400 images)
- All data shared via iDigBio and institutional websites

PALEONICHES – TCN : Data and Research

- Scientific publications in various journals including:
  - *Global Biogeography and Ecology, Journal of Biogeography, Paleobiology,* and *Proceedings of the Royal Society, Series B*
- Used GIS and Ecological Niche Modeling to study macroevolutionary effects of climate change

Journal of Biogeography

Journal of Biogeography (*J. Biogeogr.*) (2014) **41**, 1352–13

ORIGINAL ARTICLE

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Climate
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INTRODUCTION

Predicting the impacts of future climate change on biodiversity is critical to preserving biological resour

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Research

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palaeontology, evolution, environmental science

Keywords:
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Global Ecology and Biogeography A Journal of Macroecology

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2015)

RESEARCH PAPERS

Niche breadth and geographic range size as determinants of species survival on geological time scales

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ABSTRACT

Aim Determining which species are more prone to extinction is vital for conserving Earth's biodiversity and for providing insight into macroevolutionary processes. This paper utilizes the Pliocene to Recent fossil record of mollusks to identify determinants of species' extinction over the past three million years of Earth history.

Location Western Atlantic.

Methods We focus on 92 bivalve and gastropod species that lived during the mid-Pliocene Warm Period (mPWP; ~3.264–3.025 Ma) and have either since gone extinct or are still extant. We used ecological niche modeling (ENM) to assess the vulnerability of these species to extinction as a function of both fundamental (FN) and realized (RN) niche breadth proxies, geographic range size, and amount of suitable area available to them during the Last Glacial Maximum (LGM; ~21 Ka).

Results Geographic range size emerged as a key predictor of extinction for the studied mollusk species, with RN breadth and amount of suitable area available during the LGM as secondary predictors. By contrast, FN breadth was not a significant predictor of extinction risk.

Main conclusions The failure to recover FN breadth as a predictor of extinction may suggest that extinction resistance is achieved when species are more successful in filling the geographic extent of their fundamental tolerances. That is, when it comes to species' survival, being a generalist or specialist *sensu stricto* may be secondary to the unique historical, dispersal, and biotic constraints that dictate a species' occupation of suitable environments, and consequently of geographic space, at a particular time. Identifying the factors that promote extinction is important because of the time-intensive nature of estimating extinction risk for individual species and populations, and because of the rising concerns about the future of marine ecosystems and biodiversity.

Keywords
ecological niche modeling, extinction selectivity, fossils, fundamental niche, last glacial maximum, macroecology, macroevolution, niche volume, realized niche.

INTRODUCTION

Determining which species are more prone to extinction is vital for conserving Earth's biodiversity (McKinney, 1997; Schwartz *et al.*, 2006; Lee & Jetz, 2011) and for providing insight into macroevolutionary processes over geological time scales (Kiessling & Aberhan, 2007; Payne & Finnegan, 2007; Meseguer *et al.*, 2014). Although several traits have been identified as correlating with extinction risk (e.g. McKinney, 1997; Mace *et al.*, 2008), one of the more robust is geographic range size. Both neontological (e.g. Thomas *et al.*, 2004; Schwartz *et al.*, 2006; Harris & Pimm, 2008) and paleontological (e.g. Kiessling & Aberhan, 2007; Payne & Finnegan, 2007; Harnik *et al.*, 2012) studies have found that large geographic range sizes enhance

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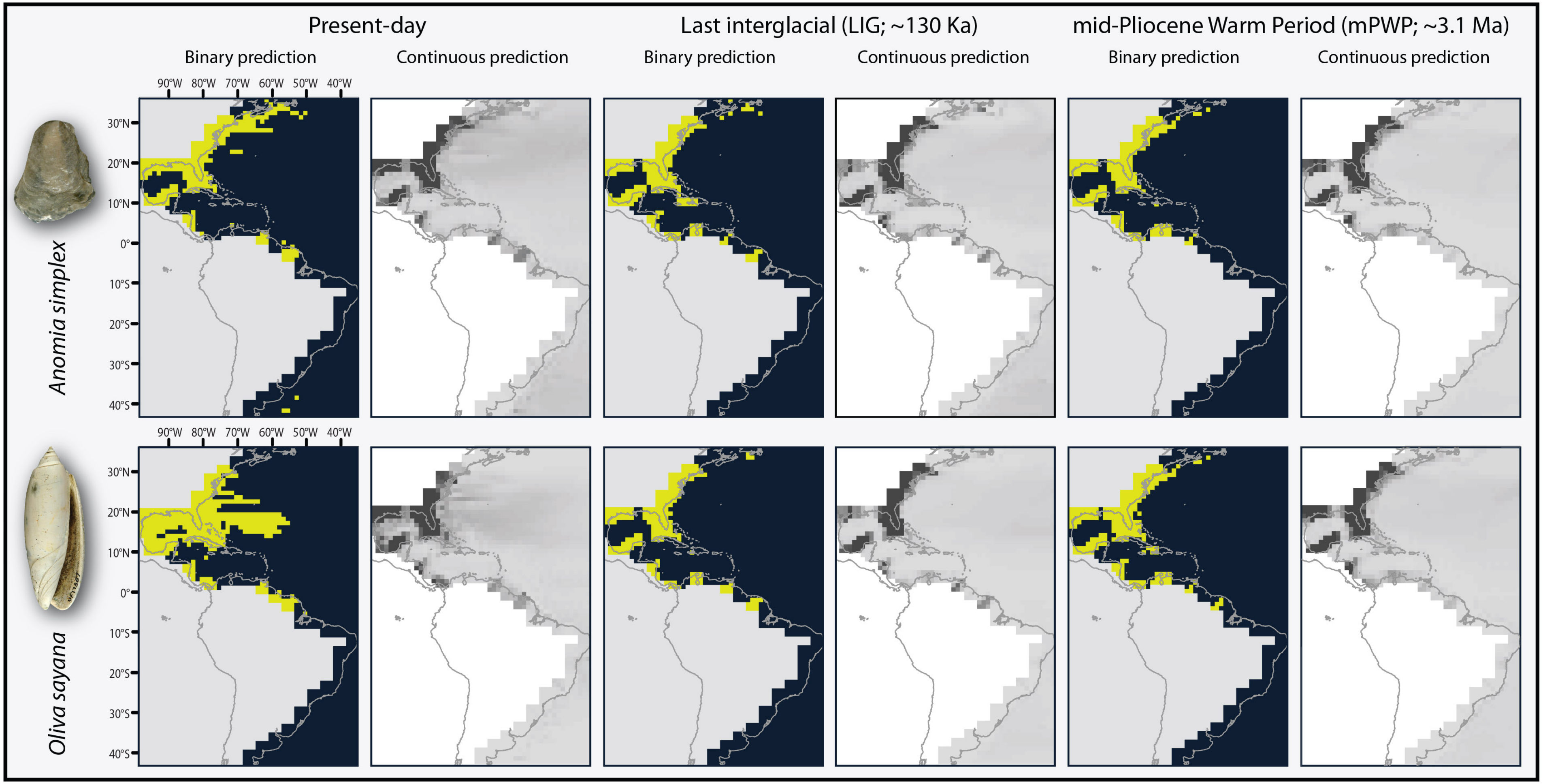
http://wileyonlinelibrary.com/journal/geb

Summarizing Results of Ecological Niche Modeling Studies

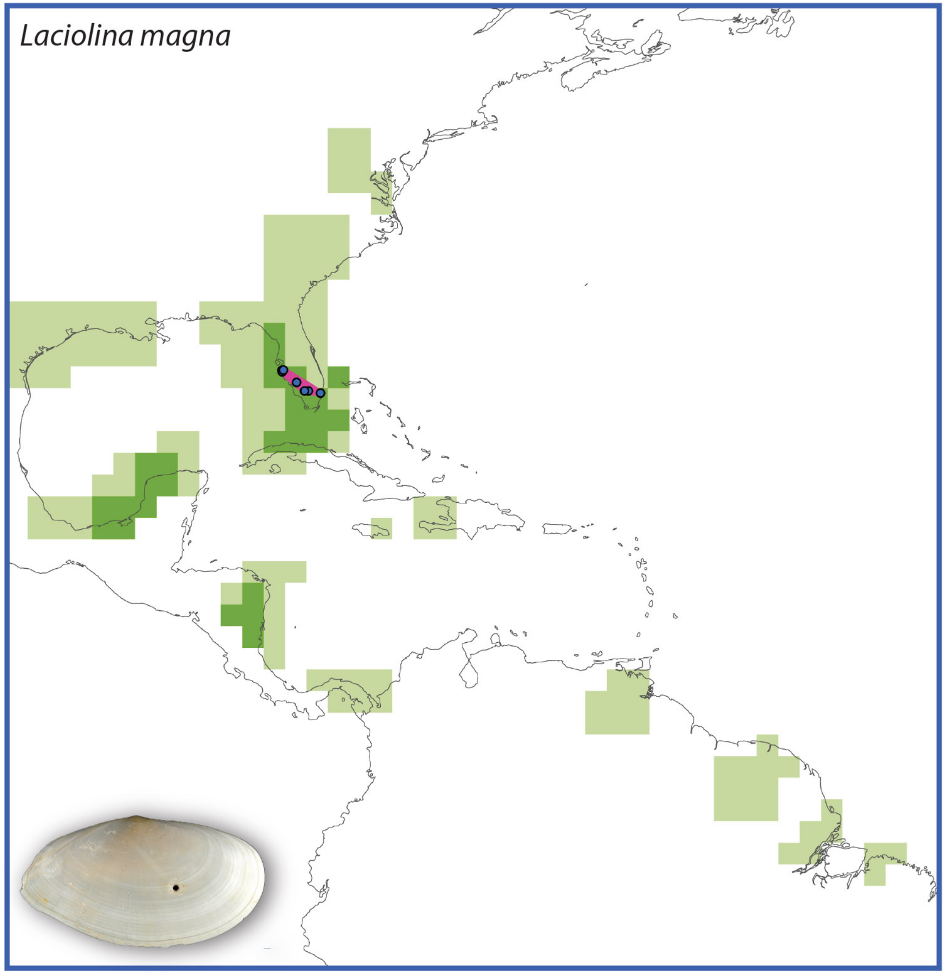
- Species niches conserved over millions of years and through major climate changes
- Climate is the primary factor controlling geographic distributions over millions of years, with biotic factors playing a much more limited role
- Many species of modern marine mollusks, some of them pivotal to marine ecosystems and the human economy, are at significant risk of extinction by 2100

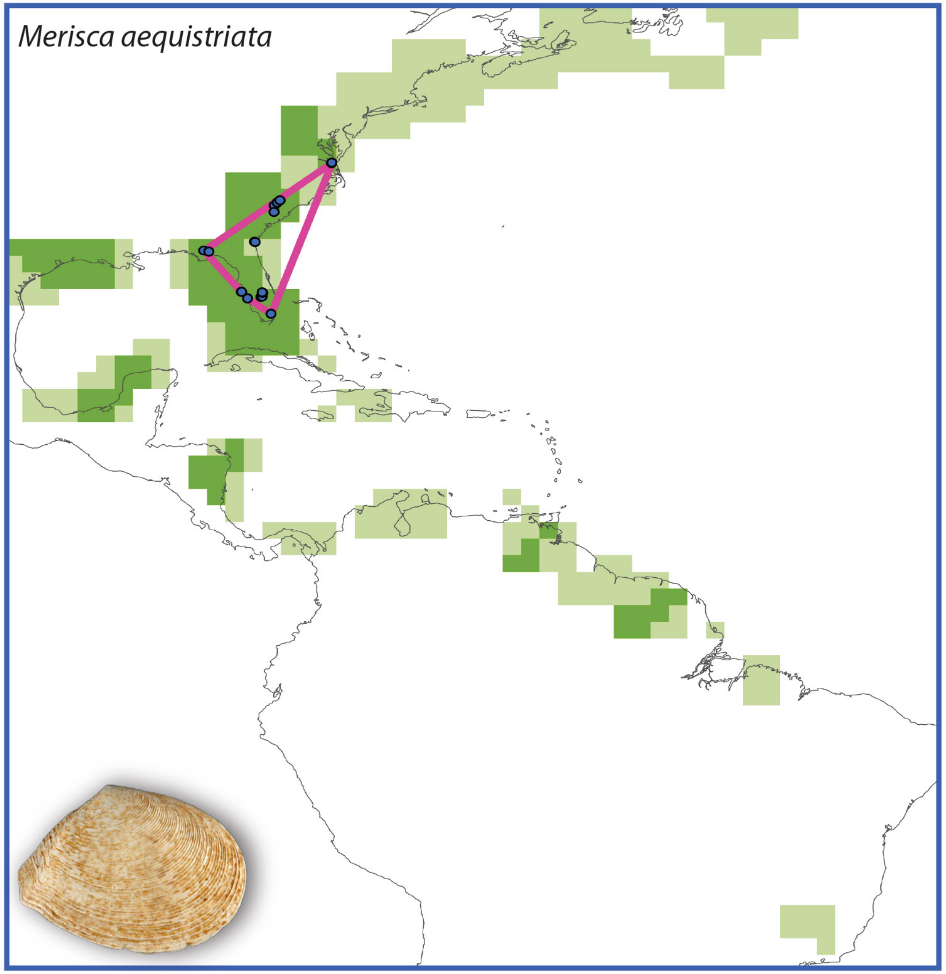
Species Niches Conserved Over Millions of Years and Major Climate Changes



Saupe et al. 2015. Proceedings of the Royal Society

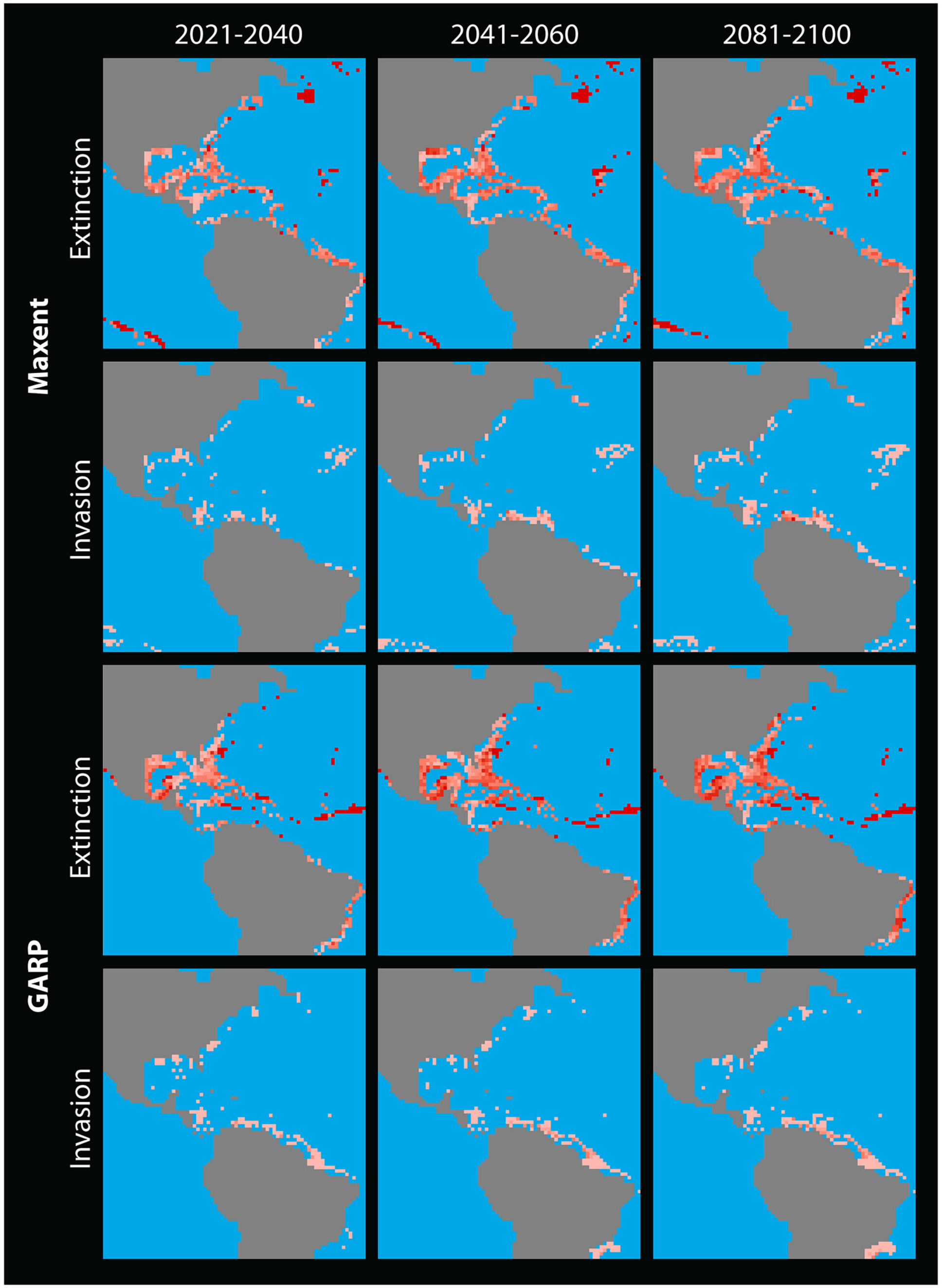
The Major Factor that Determines Where Species Occur is Climate, with Biotic Factors Playing a Much More Limited Role





Saupe et al. 2015. Global Ecology & Biogeography

Many modern marine mollusks will go extinct by 2100 due to climate change because niches can't change, modern climate change is rapid, and the marine biota is stressed by human activities



Saupe et al. 2014. Journal of Biogeography

PALEONICHES – TCN: Training

- 9 graduate students (7 female)
- 10 undergraduate students (8 female)
- 1 female post-doctoral fellow (now an assistant professor)

PALEONICHES – TCN: Outreach

Digital Atlas of Ancient Life

Guide to Ordovician, Pennsylvanian, and Neogene fossils

www.digitalatlasofancientlife.org

@PaleoDigAtlas

Digital Atlas App

Free for iPhone/iPad

PALEONICHES – TCN: Outreach

- *Digital Atlas of Ancient Life* Website: www.digitalatlasofancientlife.org
  - Described in Hendricks, Stigall, and Lieberman. 2015. *Palaeontologia Electronica*
- >350,000 visits; >1,200,000 hits
- More than 950 species represented

PALEONICHES – TCN: Outreach

- Fossil guide
- On Twitter   @PaleoDigAtlas

PALEONICHES – TCN: Outreach

Digital Atlas of Ancient Life *App*

- Derived from *Digital Atlas of Ancient Life* Website
- Works on both *iPad* and *iPhone*
- *App* is available for Free at *Apple App Store*
- Programmers Rod and Zach Spears
- More than 1,000 downloads in first month

Digital Atlas of Ancient Life *App*

- Provides means of accessing information when outside wireless zones and when cell service is absent or costly
- Opportunities for outreach to K-12 students and avocational paleontologists
- Paleontologists can use it to target specific sites for collection

Digital Atlas of Ancient Life Electronic Field Guide

Explore taxonomic information, images and maps for three Paleontological time periods.

START

BROWSE

TIME PERIOD

Ordovician

Pennsylvanian

Neogene

CC

Information

The Digital Atlas of Ancient Life Electronic Field Guide App is supported by a grant from the National Science Foundation to principal investigators Dr. Bruce Lieberman (University of Kansas), Dr. Alycia Stigall (Ohio University), and Dr. Jonathan Hendricks (San Jose State University). The grant is titled, "Digitizing Fossils to Enable New Syntheses in Biogeography - Creating a PALEONICHES-TCN" (TCN stands for Thematic Collections Network).

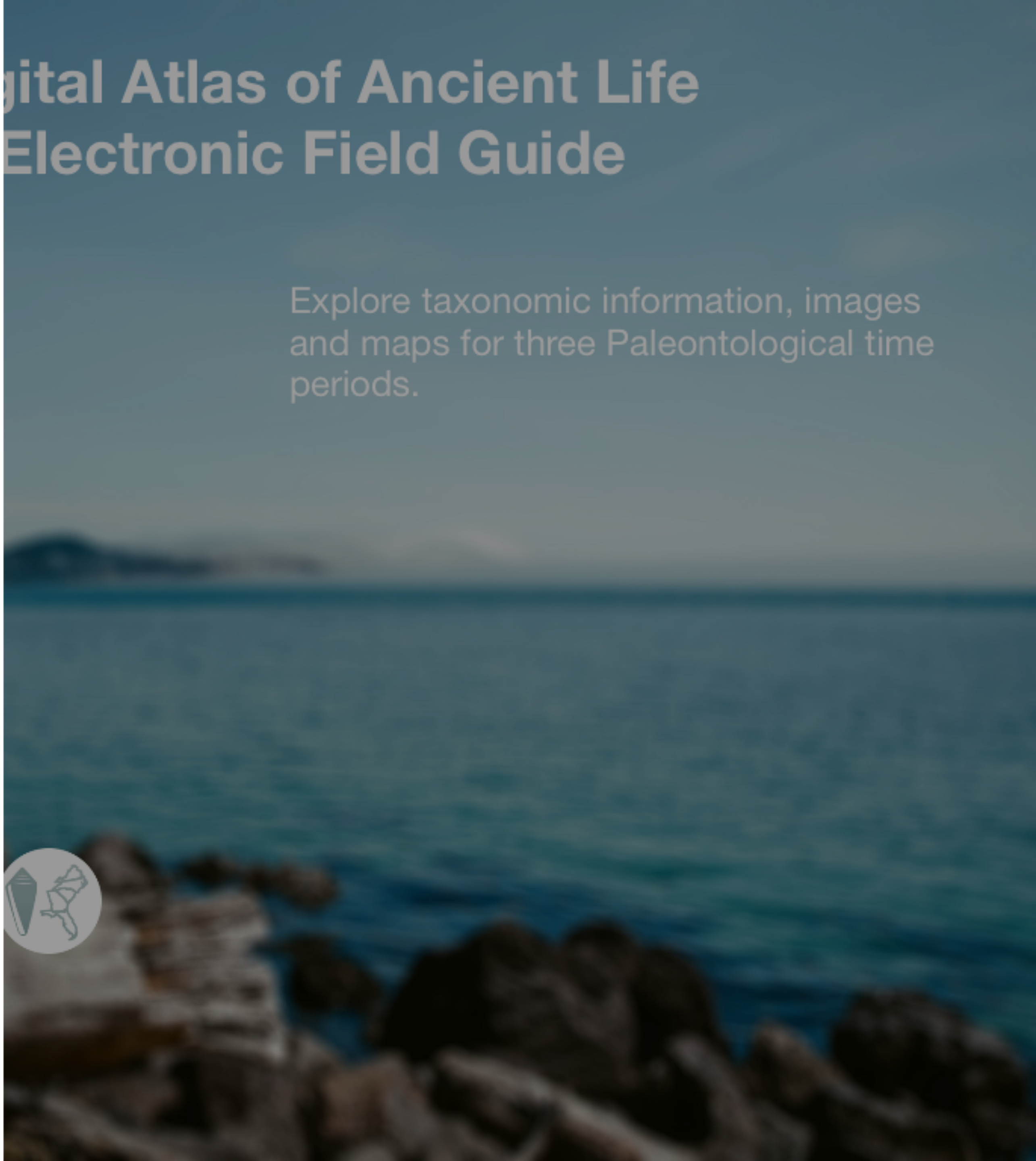
This project is related to a broader natural history specimen digitization effort supported by the National Resource for Advancing Digitization of Biodiversity Collections (ADBC) called Integrated Digitized Biocollections, or iDigBio.

The main portal page for the Digital Atlas of Ancient Life project can be accessed at www.digitalatlasofancientlife.org. For additional information about the project, please see the recently published open-access paper by Hendricks, Stigall, and Lieberman (2015) in Palaeontologia Electronica. The individual websites can be accessed at: Ordovician Atlas, Pennsylvanian Atlas, and Neogene Atlas.

Funding for development and construction of this webpage was provided by the National Science Foundation (EF-1206757, EF-1206769, and EF-1206750)

Version: 1.0 (26)

Created by Rod Spears
Designed by Zach Spears

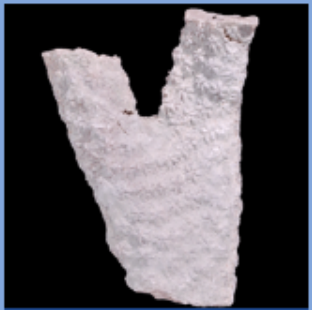


Tap on a fossil to dig deeper into the taxonomic information.

Phylum

Arthropoda

Brachiopoda



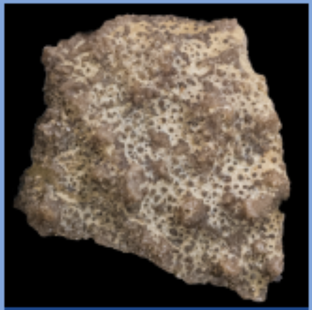
Bryozoa

Cnidaria

Echinodermata

Hemichordata

Mollusca



Porifera

Trace Fossils

Phylum
Arthropoda

Class
Trilobita

< Back

Class Trilobita

Asaphida

Lichida

Phacopida

Ptychopariida

Class
Trilobita

Order
Phacopida

Family
Calymenidae

Genus
Flexicalymene

Species
Flexicalymene me...

Back

Flexicalymene meeki

(Foerste, 1910)

Geological Range

Maysvillian to Richmondian Age, C2 to C6 sequences

Paleogeographical Distribution

Ohio, Indiana, Kentucky, Virginia, New York, and Minnesota

Remarks

The most commonly found trilobite in Cincinnatian strata. Characterized by 13 (rarely 12) segments, sub triangular glabella, three glabellar furrows, and blunt, rounded genal spines.

Stratigraphic Occurrences

Richmondian C6
- Bull Fork Formation
- Dillsboro Formation
- Elkhorn Formation
- Upper Whitewater Formation

Richmondian C5
- Bull Fork Formation
- Dillsboro Formation
- Liberty Formation
- Waynesville Formation
- Whitewater Formation

Richmondian C4
- Arnheim Formation

Maysvillian C3
- Corryville Formation
- Dillsboro Formation
- Gilbert Formation
- Grant Lake Formation
- Mount Auburn Formation

Maysvillian C2
- Bellevue Formation
- Calloway Creek Formation
- Fairmount Formation
- Fairview Formation
- Mount Hope Formation

Class
Trilobita

Order
Phacopida

Family
Calymenidae

Genus
Flexicalymene

Species
Flexicalymene me...

Back

Flexicalymene meeki

(Foerste, 1910)

Class
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(Foerste, 1910)

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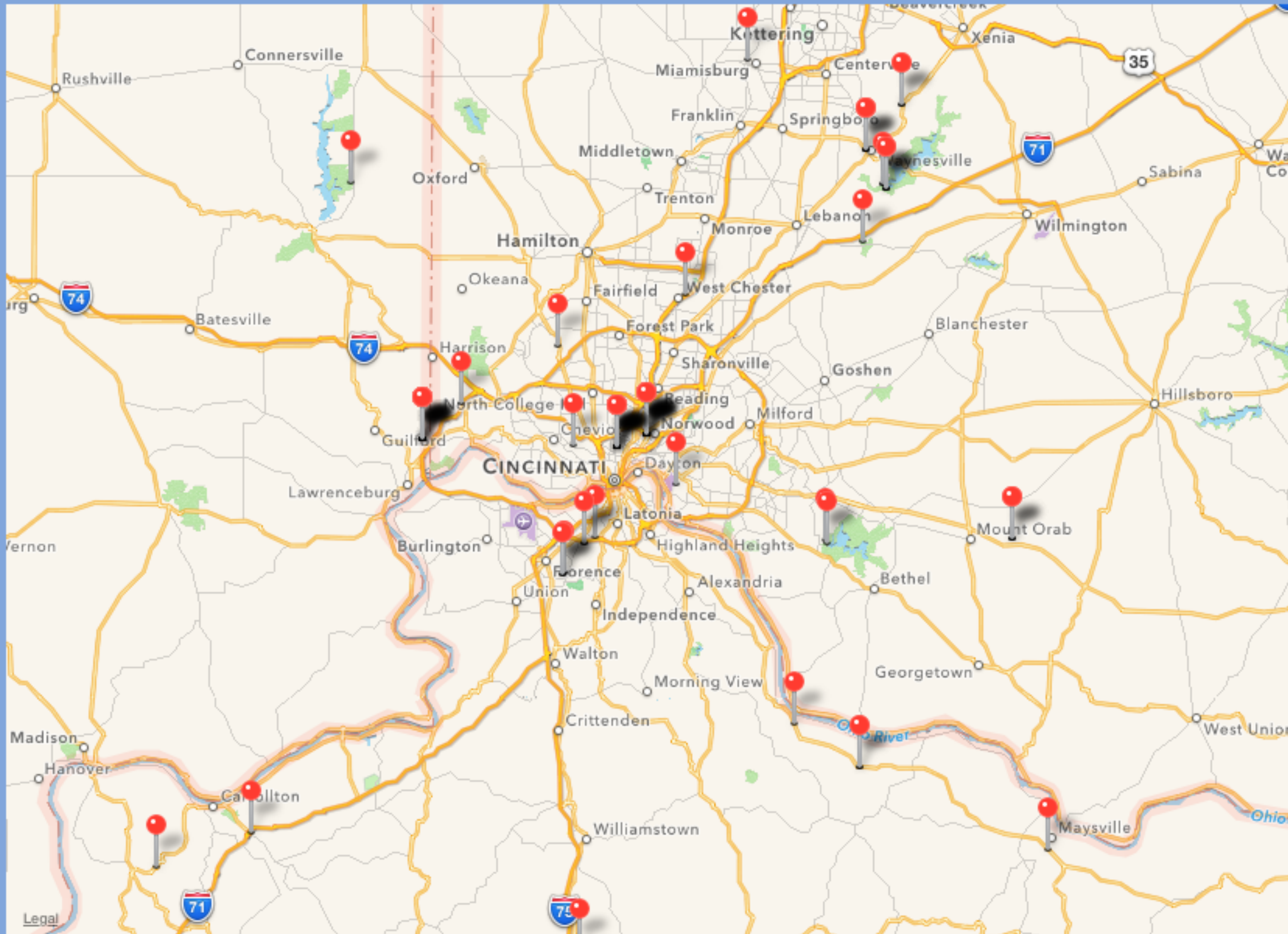

Acantholabia sarasotaensis

Agathotoma candidissima

Agladrillia aulakoessa

Agladrillia rabdotacona

Agnocardia acrocome

Architectonica chipolana

Architectonica nobilis

Arene agenea

Arene solariella

Arene tricarinata

Astralium phoebium

Bellaspira pentagonalis

Class
Gastropoda

Order
Heterobranchia

Family
Architectonicidae

Genus
Architectonica

Species
Architectonica no...

< Back

Architectonica nobilis

Roding, 1798

Geological Range

Late Miocene to Middle Pleistocene; Recent.

Paleogeographical Distribution

Panama to Virginia.

Remarks

For information on the modern distribution of the species, see Malacolog and WoRMS.

Stratigraphic Occurrences

Middle Pleistocene
- Bermont Formation (S. FL)

Early Pleistocene
- Caloosahatchee Formation (S. FL)
- Nashua Formation (N. FL)

Late Pliocene
- Duplin Formation (SC, NC)
- Duplin / Raysor formations (GA)
- Jackson Bluff Formation (N. FL)
- Mare Formation (Venezuela)
- Raysor Formation (SC)
- Tamiami Formation (S. FL)
- Tamiami Formation (Lower) (S. FL)
- Tamiami Formation (Ochopee Limestone) (S. FL)
- Tamiami Formation (Pinecrest Beds) (S. FL)
- Yorktown Formation (VA)

Early Pliocene
- Bowden Formation (Jamaica)
- Cayo Agua Formation (Panama)
- Playa Grande Formation (Maiquetia Member) (Venezuela)

Late Miocene
- Chagres Formation (Panama)
- Gatun Formation (Upper) (Panama)
- Gatun Formation (Middle) (Panama)
- Gatun Formation (Lower) (Panama)

Pleistocene				Pliocene		Miocene					
Late	Middle	Early		Late	Early	Late		Middle		Early	
Tarantian	Ionian	Calabrian	Gelasian	Piacenzian	Zanclean	Messinian	Tortonian	Serravallian	Langhian	Burdigalian	Aquitanian
0.126–0.0117	0.781–0.126	1.80–0.781	2.58–1.80	3.600-2.58	5.333-3.600	7.246-5.333	11.62-7.246	13.82-11.62	15.97-13.82	20.44-15.97	23.03-20.44

Class
Gastropoda

Order
Heterobranchia

Family
Architectonicidae

Genus
Architectonica

Species
Architectonica no...

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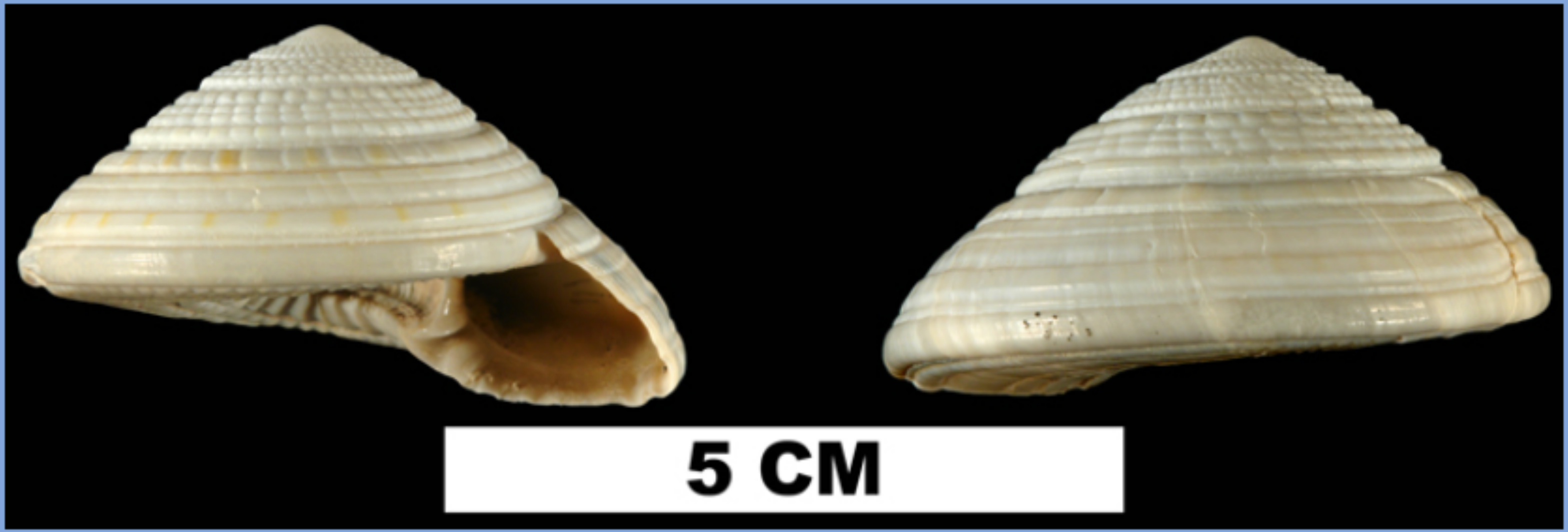
Architectonica nobilis

Roding, 1798



Class
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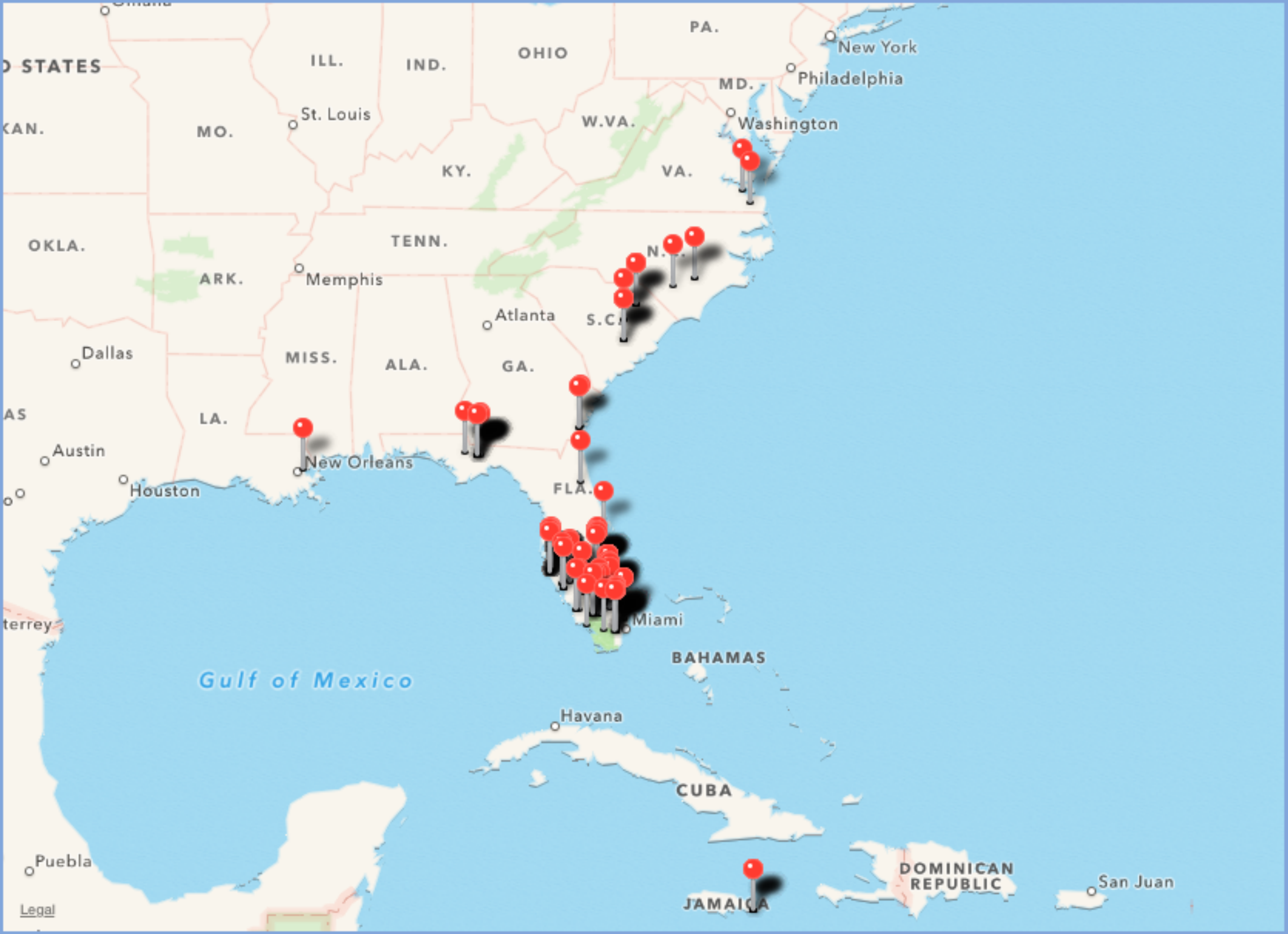
Architectonica nobilis

Roding, 1798



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Michelle Casey (Murray State)

Rod and Zach Spears (KU)

Jim Beach (KU)

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NSF Advancing the Digitization of Biological Collections

NSF Emerging Frontiers

NSF Sedimentary Geology & Paleobiology