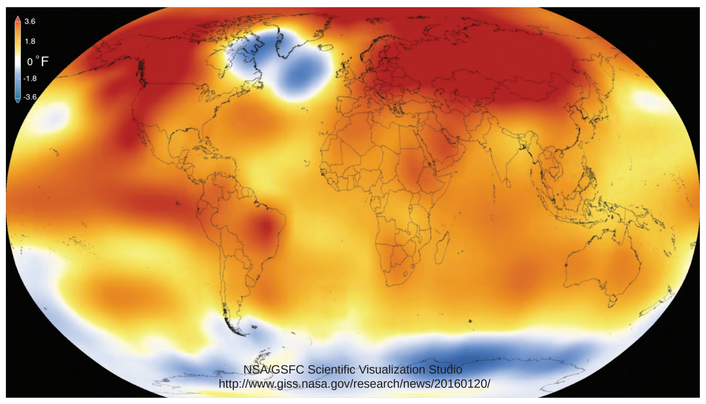
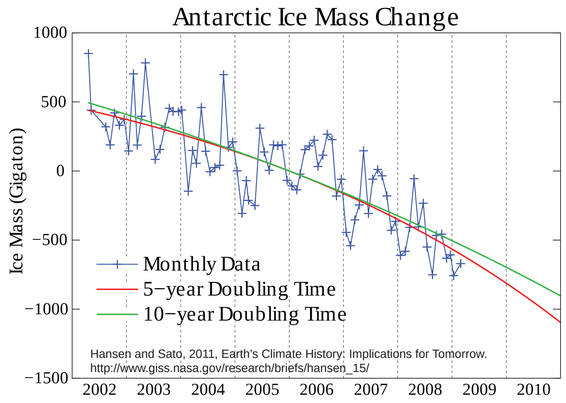
# Survival and Extinction During Past Climate Changes – Insights from the Paleontological Record

G. Lynn Wingard, U.S. Geological Survey, Reston VA

## Introduction

Change occurs on many time scales and is an inevitable and natural component of ecosystems. Current data and climate models indicate the next few centuries will bring significant changes to climate patterns and rising sea level as the ice sheets melt.


### Current and Future Changes

*Above:* Peninsular Florida with a <5m and <10m rise in sea level.

*Upper right:* Comparison of 2015 global surface temperatures to 1951-1980 baseline average. NASA and NOAA determined 2015 was warmest year on record since 1880 (when record keeping began). 15 of warmest 16 years on record have occurred since 2001.

*Right:* Change in Antarctic ice mass from gravitational field measurements. 5-year and 10-year mass loss doubling times from best-fit analysis.

Despite an understanding of past and predicted future change, the concept of restoration can lead to a mind-set of a static system as resource managers set targets and performance measures. Paleoecologic data and long-term research programs can be utilized to examine the nature and direction of changes in the biological, physical and chemical components of a system, but important questions remain:

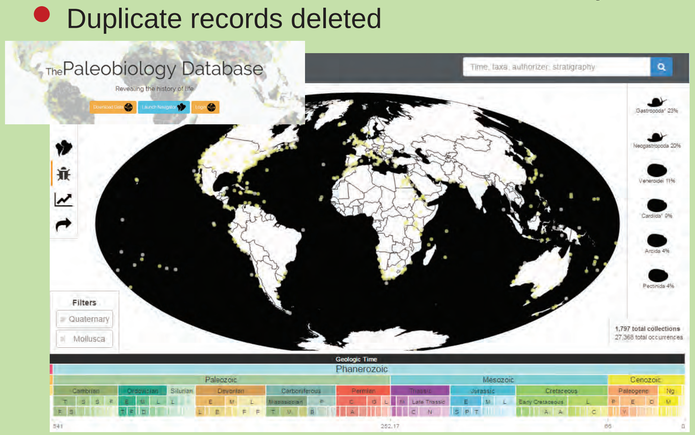
- How will ecosystems and individual species respond to changes in climate and sea level predicted for the next few centuries?
- Does the paleontological record provide insight into biological responses to changing conditions?

## Methods

As a first step in addressing these questions, records of molluscan taxa from the late Pleistocene (126,000 to 11,700 years before present) and Holocene (11,700 years to present) of south Florida were compared to living species from the same region.

Pleistocene data extracted from The Paleobiology Database

- Records checked for taxonomic consistency and validity
- Duplicate records deleted




Opening screen of Paleobiology Database (paleobiodb.org)

| Search Parameters: | |
|---|---|
| base_name | Mollusca |
| lngmin | -83.5 |
| lngmax | -79.5 |
| latmin | 24 |
| latmax | 27.5 |
| cc | NOA,US |
| interval | Pleistocene,Holocene |
| taxon_status | all |
| ident | all |

Filter / search parameters used to extract data.

List of 304 validated fossil taxa were compared to local, regional and global databases* of living mollusk species and placed in the following categories:

1) extant in South Florida today, indicating survival
2) extant, but no longer in South Florida, indicating local extinction/reduction in range or migration
3) not present in any current databases, indicating extinction

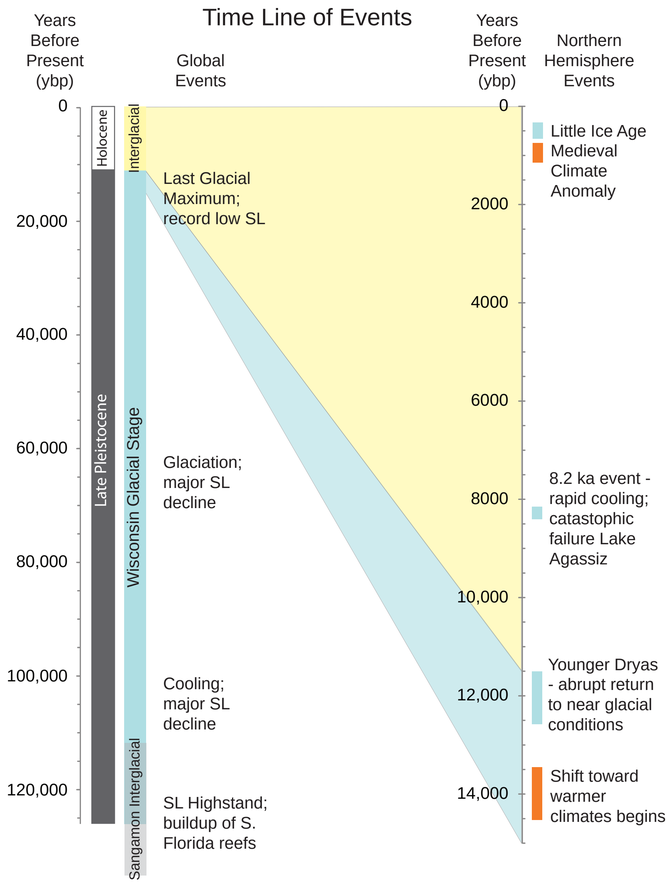

Map of The Paleobiology Database South Florida Pleistocene and Holocene locations (124 collections; 3982 occurrences).

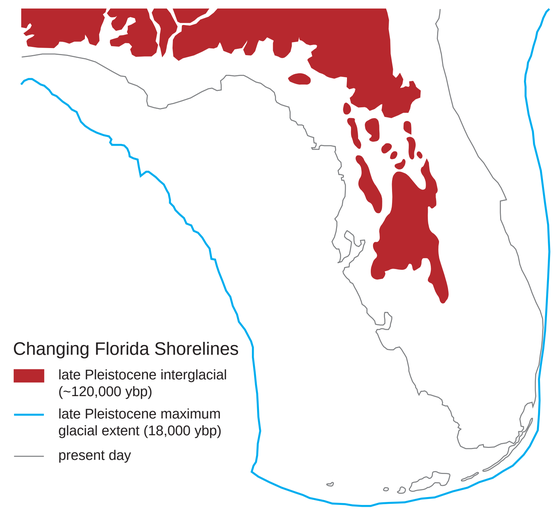
* References and Databases utilized to determine valid fossil names and extant species:

Turgeon, D.D. et al. (1998) Mollusks, 2nd edition. American Fisheries Soc. Spec. Pub. 26.
Lyons, W.G. (1998) Checklist of shallow-water marine Mollusca of Florida. FMRI Tech. Report TR-3.
FMNH Invertebrate Paleontology Catalog. http://www.flmnh.ufl.edu/invertpaleo/search.asp
ITIS – Integrated Taxonomic Information System. http://www.itis.gov/
WoRMS – World Registry of Marine Species. http://www.marinespecies.org/
Bailey Matthews Shell Museum Database. http://shellmuseum.emc2webs.com/collection/
FWGNA – Freshwater Gastropods of North America. http://www.fwgna.org/
Thompson, F. (2004) . . .Freshwater snails of Florida. www.flmnh.ufl.edu/malacology/fl-snail/snails1.htm
Encyclopedia of Life. http://eol.org/
Nature Serve Explorer. http://explorer.natureserve.org/
BGIF – Global Biodiversity Information. http://www.gbif.org/

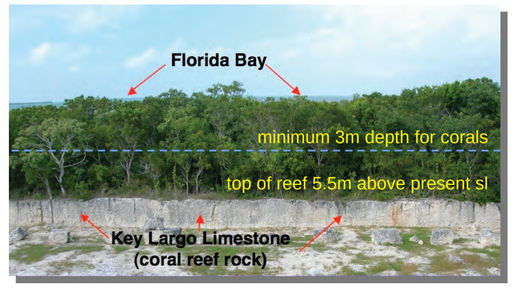
**Fossil and living *Chione***

## Climate and Sea Level – The Last 126,000 Years




Dramatic changes in elevation from 120 m below present day sea level during glacial maxima to 45 m above present day sea level during interglacial. (Adapted from Lane, 1994, FGS Spec. Pub. 35)




Coral reefs formed during the last interglacial when sea level was ~8.5 m above present in South Florida. Photo - Windley Key Quarry, FL Keys.

## Results

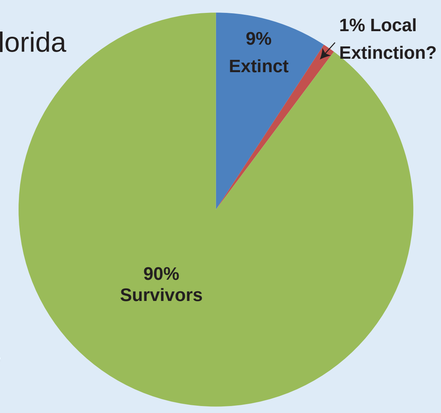
304 mollusk species validated for late Pleistocene of South Florida

- 28 species and 1 genus extinct by end of Pleistocene
- 3 species are living today, but not in South Florida
- 273 species (90%) still alive in South Florida today

*Caution:* fossil data typically under-represent rare species, which may be more susceptible to extinction.

Surviving taxa endured significant changes in climate and sea level during the last 126,000 years:

- Last glacial cycle - sea level ~100-120 m lower than today
- Younger Dryas - period of abrupt cooling
- Medieval Climate Anomaly - period of sustained drought
- Little Ice Age - period of abrupt cooling




Division of 304 valid late Pleistocene species into the 3 categories

## Discussion and Next Steps

Results indicate that the majority of preserved mollusk species survived significant and abrupt climate changes. From a resource management perspective it is important to understand how organisms survive change and what strategies can be utilized to increase the likelihood of species surviving future climate and sea level change.

Typical survival mechanisms under changing conditions include:

1) persisting, if species tolerances are high enough
2) adapting, through either physical (genetic) and/or behavioral change
3) migrating to new areas and/or a reduction in range

By comparing fossil mollusk taxa of south Florida to living taxa from the same area and from global species lists, migration and/or range reduction is eliminated as a mechanism of survival for all but three species. However, this preliminary look at survival does not distinguish persistance versus adaptation as survival strategies.

Typically, mollusk species are long lived and marine species are less susceptible to climatic changes. Also, the tropics and sub-tropics were less impacted by Pleistocene glaciation. In order to examine survival strategies such as robustness and resiliency, careful examination of finely-scaled stratigraphic sequences using multiple groups and proxies could provide information on causes and mechanisms for survival and extinction.

Understanding these processes is a management challenge that can be addressed by paleontological data and it is essential to achieve the ultimate goals of restoration – sustainable ecosystems and species survival.

## Acknowledgements

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