



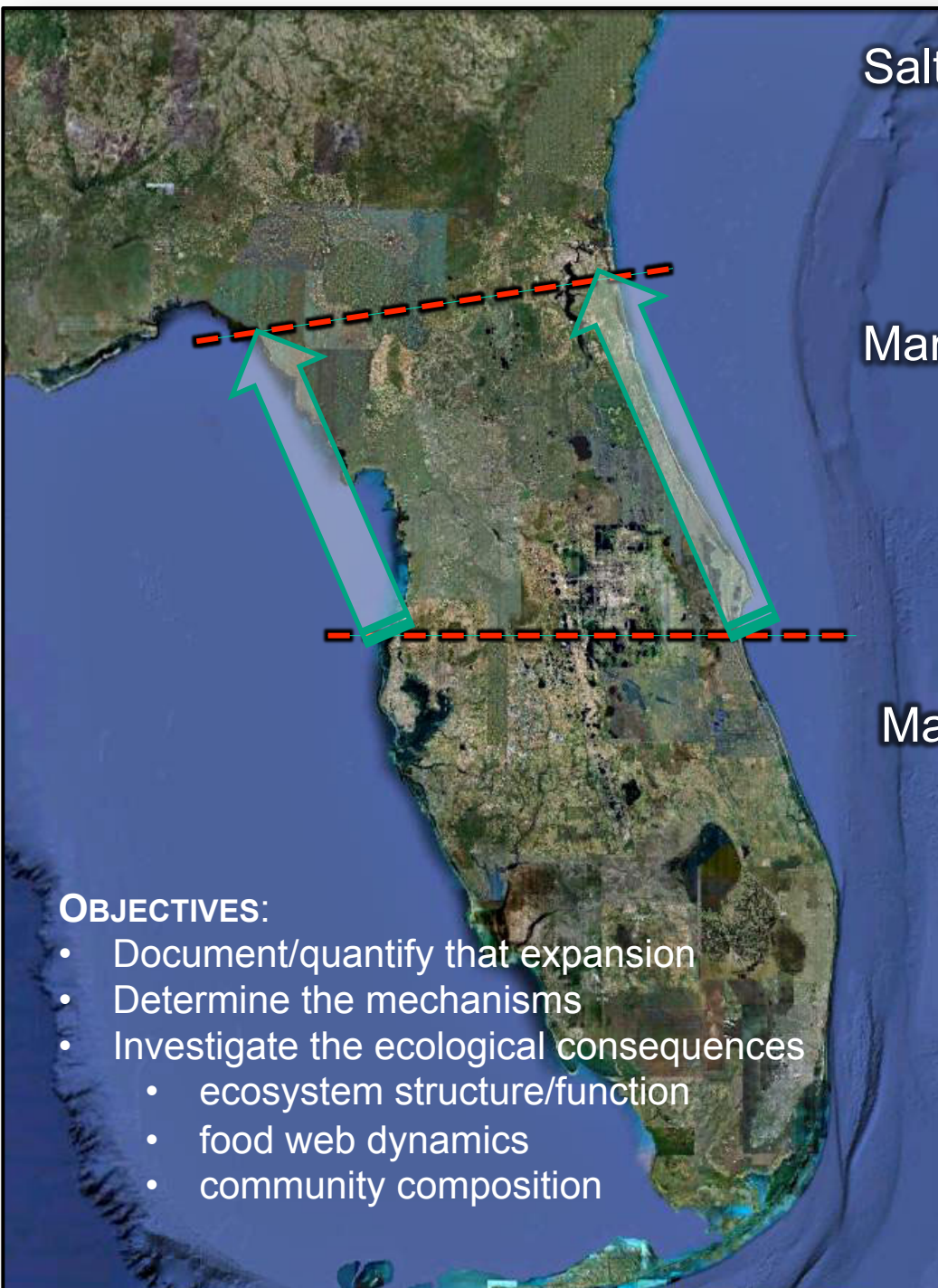
Sensitivity of Mangrove Ecosystems to Climate Change

ILKA C. FELLER, PI

DAN GRUNER, RICK OSMAN, JOHN PARKER,
WILFRID RODRIGUEZ (Co-PIs)

Smithsonian Environmental Research Center
University of Maryland

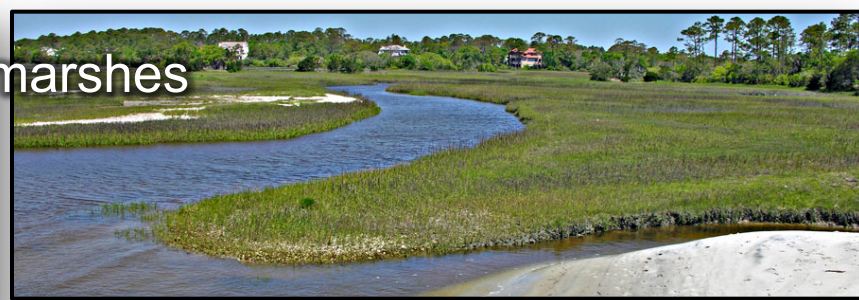




OBJECTIVES:

- Document/quantify that expansion
- Determine the mechanisms
- Investigate the ecological consequences
 - ecosystem structure/function
 - food web dynamics
 - community composition

Saltmarshes



Mangrove-Saltmarsh Ecotone

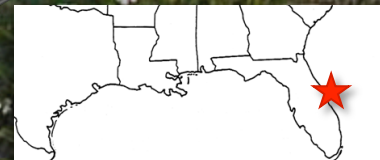


Mangroves

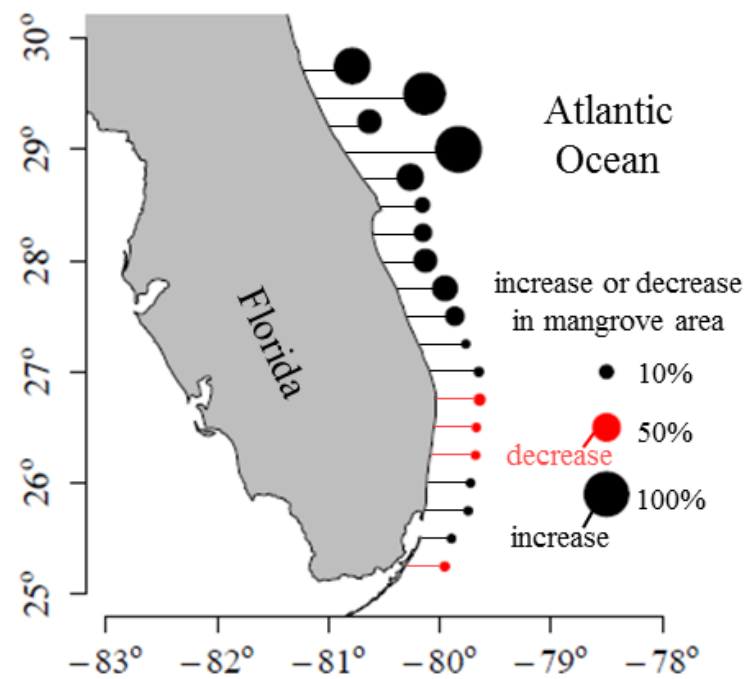
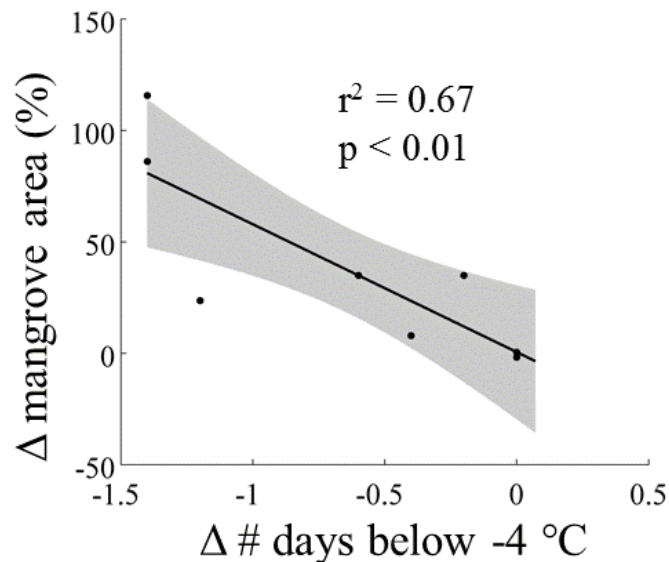
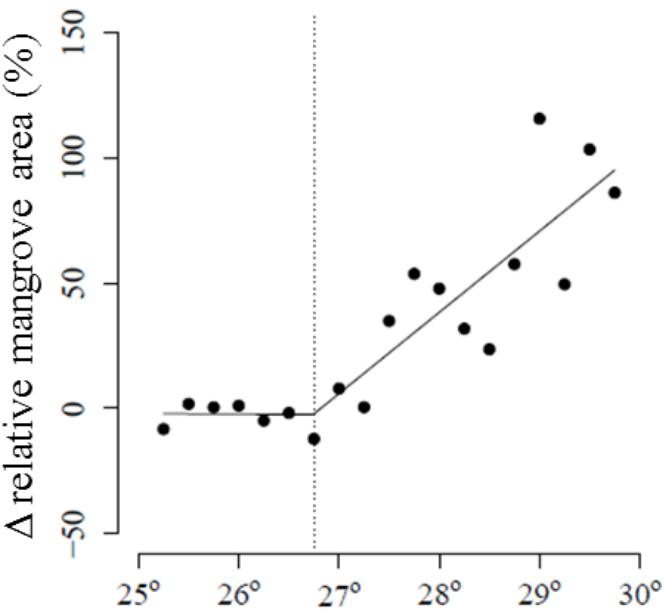


...28°68' N, Merritt Island National Wildlife Refuge

2016



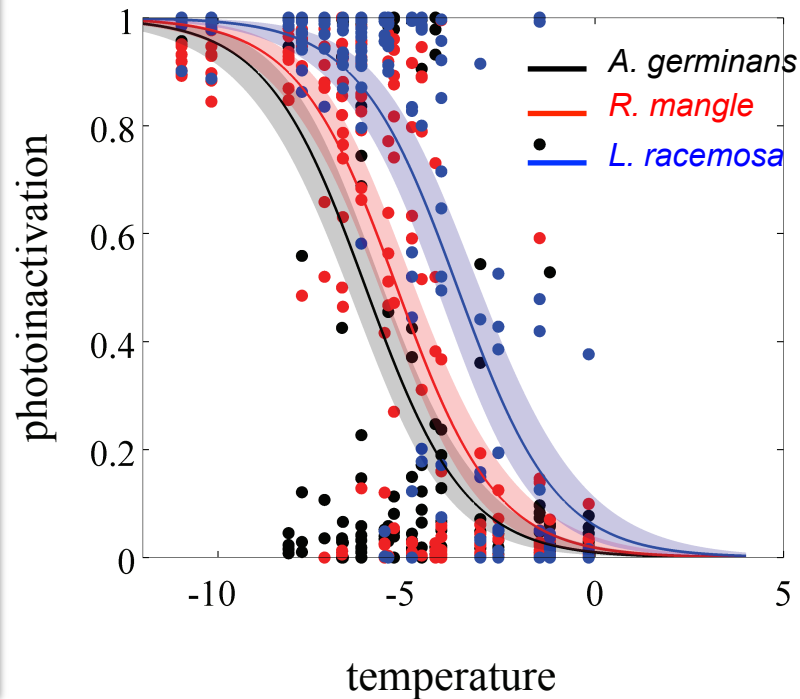
Mangrove area expanded within the ecotone, 1984-2011



- Based on analysis of Landsat images
- 25.25° to 29.75°N
- Increase● or Decrease● in mangrove area

Lab experiments: How do mangroves respond to freezing temperatures?

Photosynthetic yield, before and after freezing



Black mangroves (*Avicennia germinans*)
29.92° N, 81.31° W

Red mangroves (*Rhizophora mangle*)
29.73° N, 81.24° W

White mangroves (*Laguncularia racemosa*)
29.66° N, 81.22° W

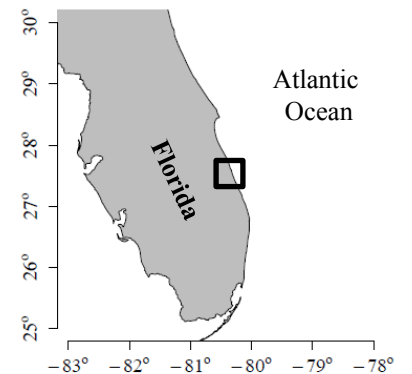
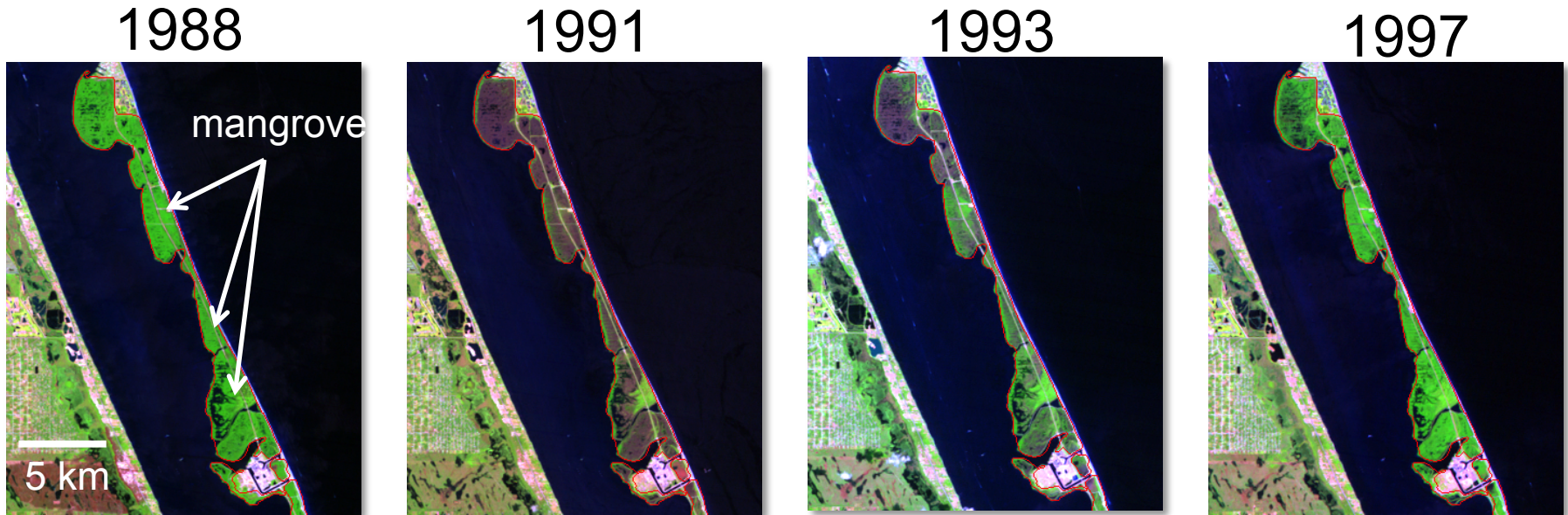
Mangroves have species-specific threshold responses to freezing temperatures

Timeline of Major Florida Freezes; Florida Citrus Mutual, Inc (2012)

*1835	The impact freeze February 2-9; lowest temperatures that had ever been recorded in north and central Florida.
*1894-1895	The first freeze December 29-30, 1894, a month of warm weather, followed by second freeze February 8-9, 1895
1899	February 13-14 was one of the most severe in the history of the state and was a *near-impact freeze; -2°F (~-19°C) recorded in Tallahassee.
1917	February 2-6 and was the most serious freeze between 1899 and 1934.
1934	December 12-13
1940	January 1940 is the coldest month on record in Florida history.
1957	December 12-13 and was the most severe since 1940.
*1962	5 years after the freeze of 1957.
1977	January 18-20 and is comparable to the 1962 freeze.
1981	Hard freezing, January 12-14.
*1983	More severe than the 1977 and 1981 freezes.
1985	January 20-22
*1989	December 22-26. This freeze was the fifth impact freeze recorded in Florida history; second impact freeze in a single decade,

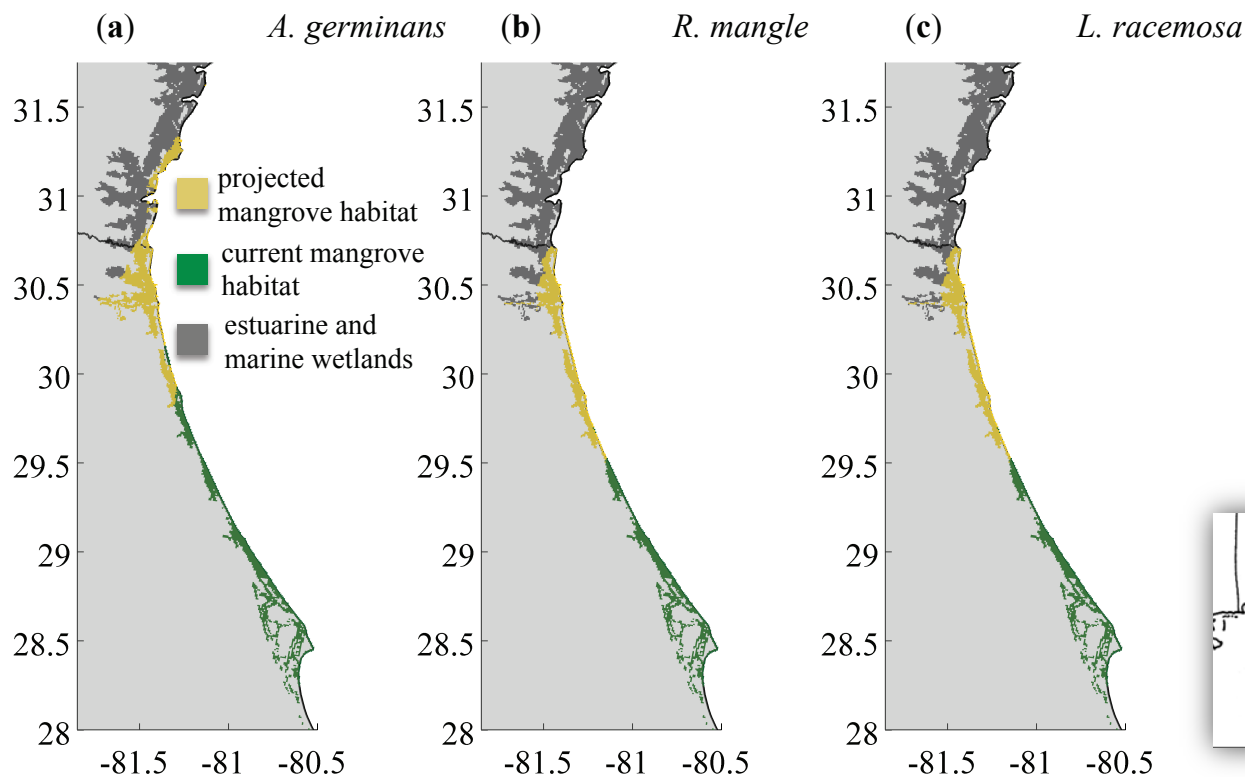
* Impact Freeze: ...annihilates entire groves across the state, kills mature and young citrus trees, causes profound economic impact on citrus industry; prompts growers to replant farther south.

Landscape scale response of mangroves to past freeze events...

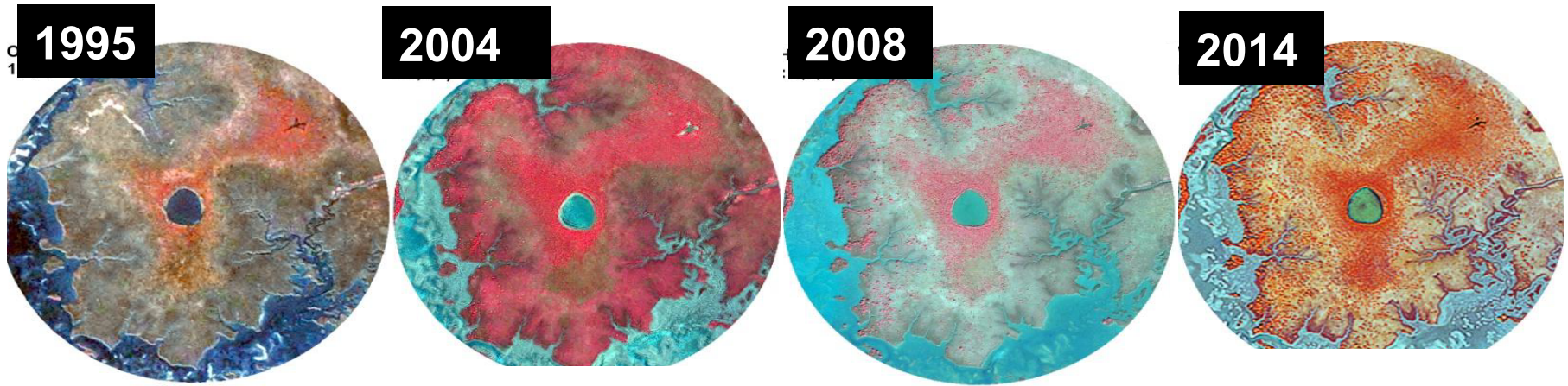
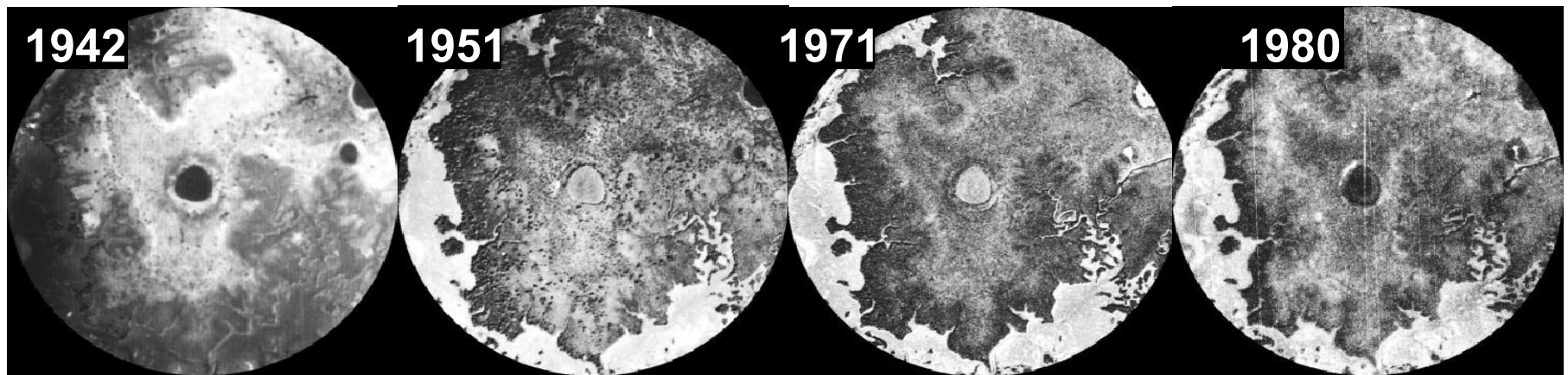


Mangrove distribution models project continuing poleward expansion of mangroves over next 50 years

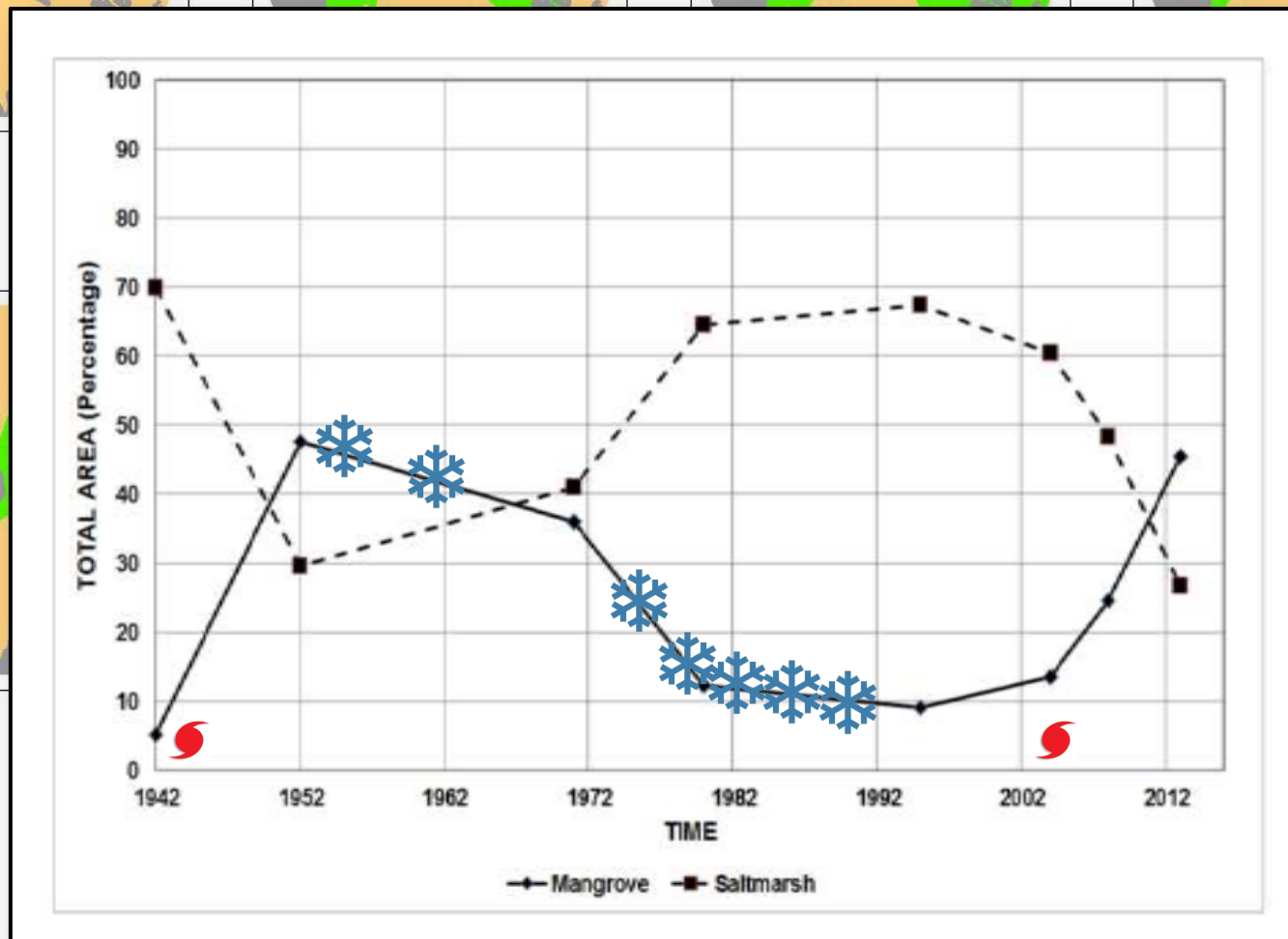
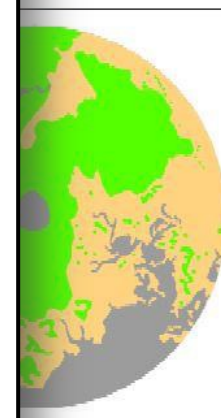
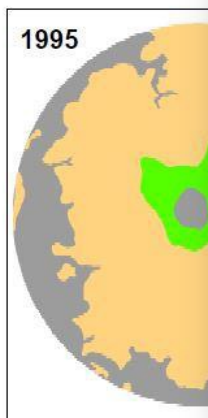
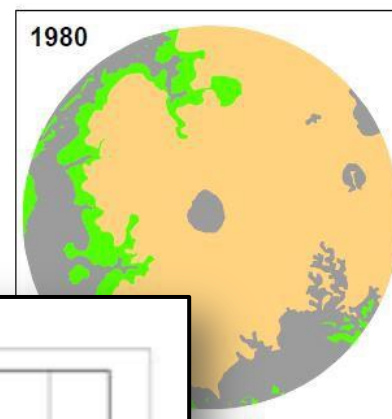
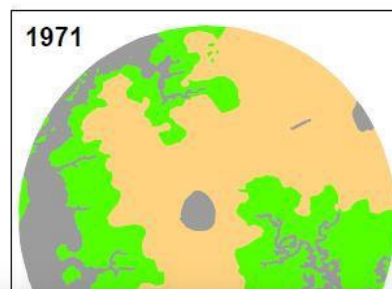
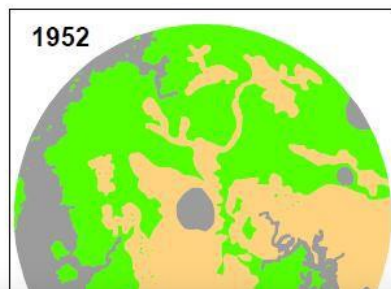
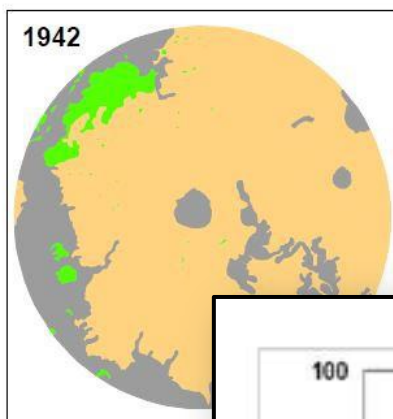
Projected mangrove distributions for 2060



- Species-specific migration modeled based on 21 general circulation projections (CMIP5) of changes in freezing degree days along east coast of FL
- Projected poleward migration rates: 2.2 km/yr (*R. mangle* & *L. racemosa*) to 3.2 km/yr (*A. germinans*)



Rodriguez et al. in review



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Black mangrove 2014

Black mangrove 2004



Red mangrove 2014



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Red mangrove 2006



...as in 2014

Established Fall 2004



Spring 2004

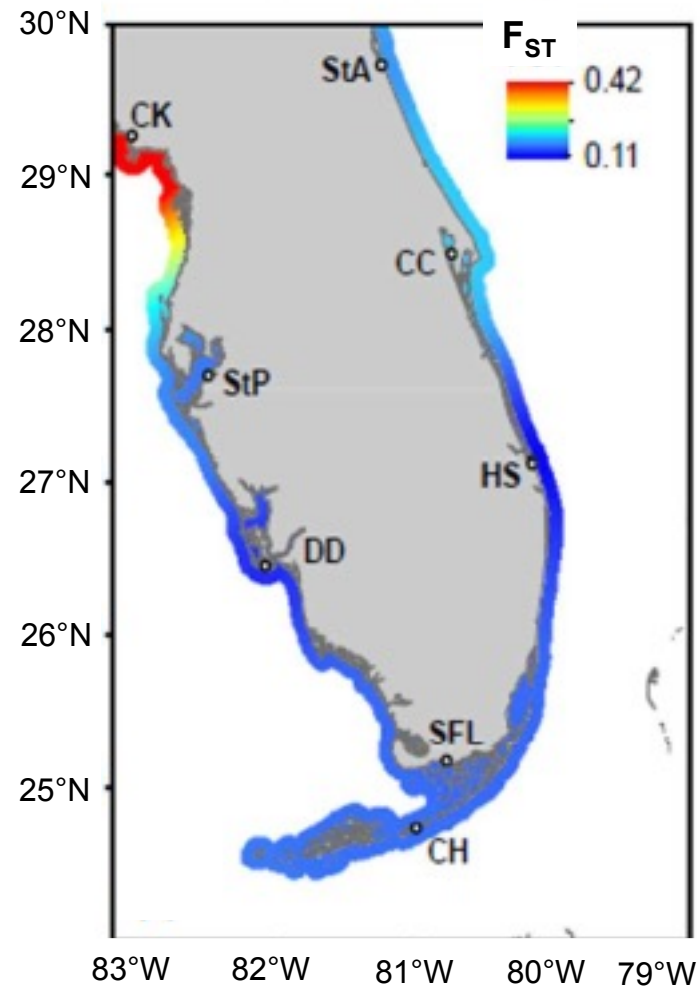
Image Landsat

Data SIO, NOAA, U.S. Navy, NG

Mangrove population genetic structure with a combination of genetic analyses using 7 microsatellite loci

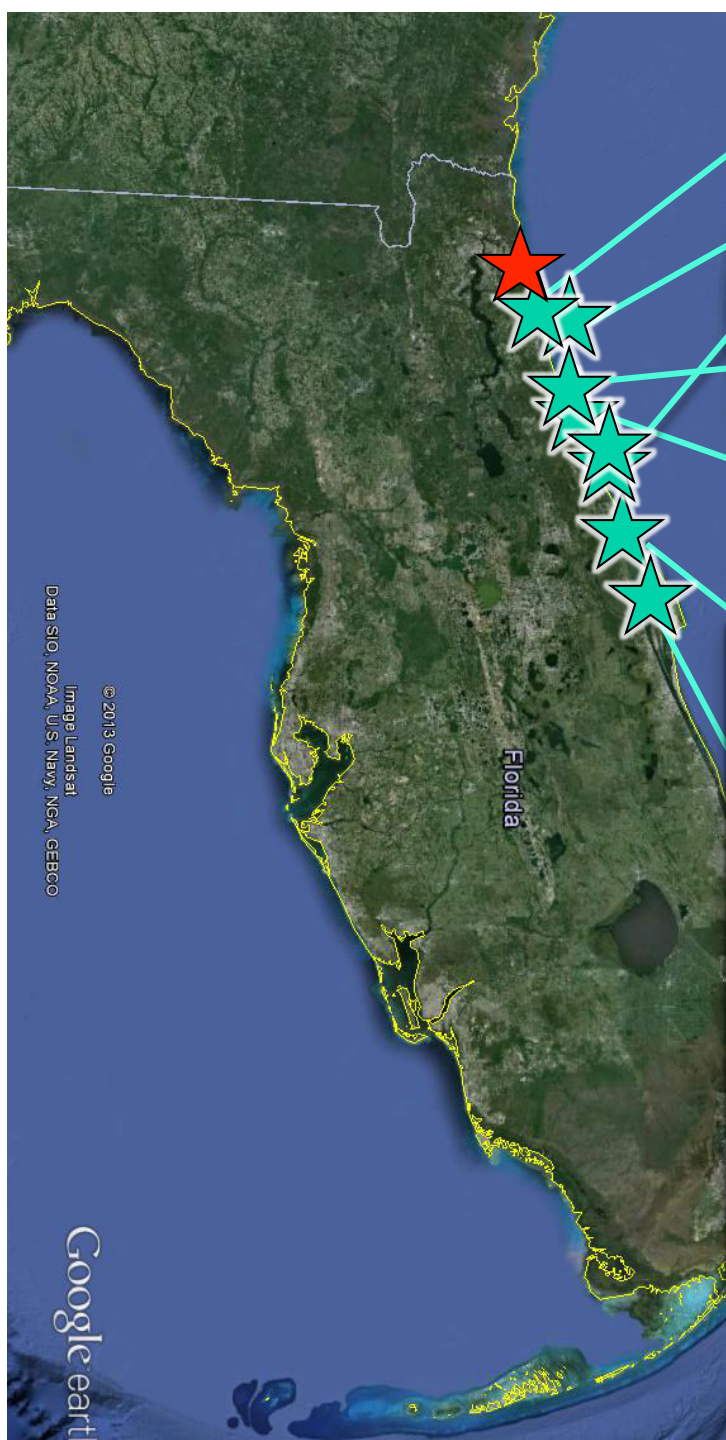
Hypothesis: Founder effects or genetic bottlenecks result in reduced gene diversity and increased population differentiation along the expansion axis

Interpopulation genetic differentiation using F_{ST} , the fixation index, as a measure of population differentiation due to genetic structure



Kennedy et al. 2016, *Journal of Biogeography*

Historical records of mangrove distribution



Bartram 1765-66, reported *Avicennia germinans* at Anastasia Island

Michaux 1788, reported *Avicennia germinans* and *Rhizophora mangle* at Anastasia Island and Turtle Mound

Vignoles 1823 reported mangrove islands, ~2 km N of Dunlawton Bridge ****

Audubon 1835, spent a very cold night aground... on a "mangrove island" in the Halifax River, north of Ponce Inlet; in search



....photo from this 1928 paper; shows salt marsh with big dead *Avicennia germinans* tree in foreground

SUMMARIZING...

- Expansion of mangroves is occurring along coastlines around the world at temperate-tropical ecotones.
- There are species specific rates of expansion because not all species are equally cold tolerant or flood tolerant
- Between 1984 and 2011, mangrove cover increased >100% along Atlantic coast of Florida
- Based on modeled climate predictions, mangroves will continue to expand poleward; by 2060, and they will be almost to Sapelo Island, GA
- Within the mangrove ecotone, the spatial coverage of mangrove is also expanding; but at times, it is also contracting
- Expansion seems to be a function of both fewer freeze events and availability of propagules supplied by long distance dispersal, aided by hurricanes
- Contraction seems to be a function of severe freeze events
- Mangroves are not so much creeping poleward as they are jumping.



Mangrove &
Macrobenthos Meeting

MMM4

SAVE THE DATE

July 18-22, 2016

Flagler College
St. Augustine, FL

JOIN US

for an international discussion
on the causes and consequences
of mangrove ecosystem expansion in
an ever-changing climate.

FOR MORE INFORMATION VISIT:

www.conference.ifas.ufl.edu/mmm4



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