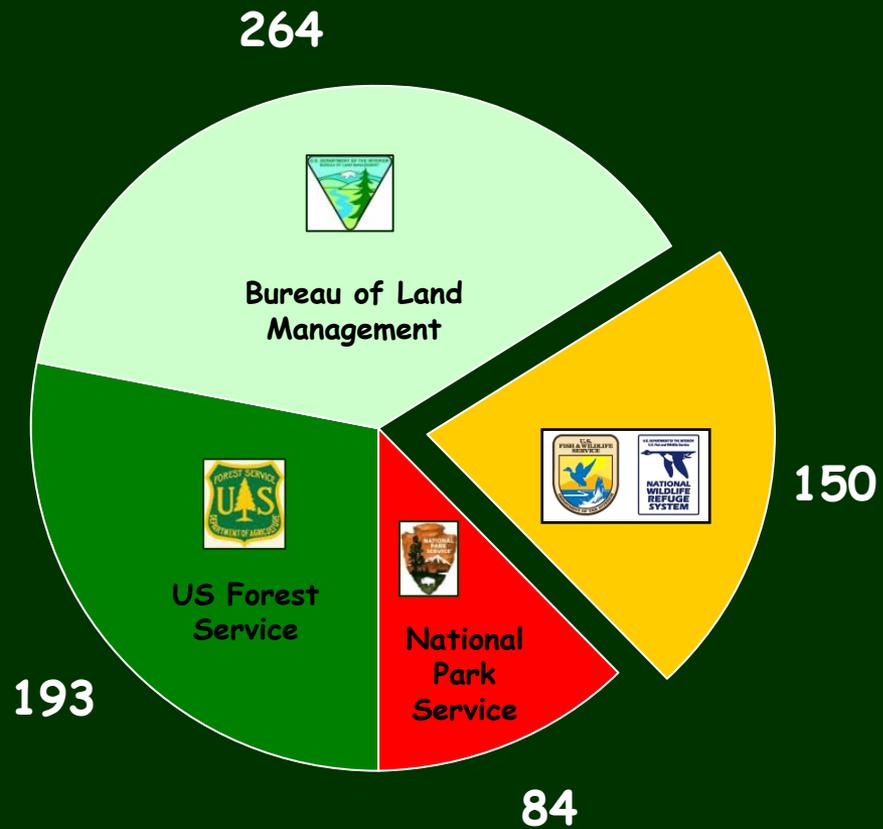


Climate Changes Everything



Raye Nilius, Project Leader
South Carolina Lowcountry Refuges Complex

National Wildlife Refuge System



Department of Interior
US Fish & Wildlife Service
**National Wildlife Refuge
System**

150 M Acres, 556 Refuges

(Mission: “. . . national network of lands and waters for . . . fish, wildlife, and plant resources and their habitats . . . for Americans.)

A Journey



Black Bellied
Whistling Ducks

Global Warming's Six Americas

Perceptions on Climate Change

Demographic Results

State: Florida, Virginia and North Carolina respondents more likely to be more concerned and alarmed than Gulf states respondents

Political Leaning: Conservatives more likely to be dismissive; Liberals more likely to be concerned

Gender: Women more likely to be concerned

Coastal Influence: Respondents serving coastal counties more likely to be alarmed or concerned.

Age: Respondents age 60 or older most likely to be alarmed or concerned. Respondents age 21-30 and 41-50 most likely to be dismissive or doubtful.

Education: Those with education beyond a Master's degree more likely to be more alarmed and less disengaged.

How Does Climate Change Affect National Wildlife Refuges?

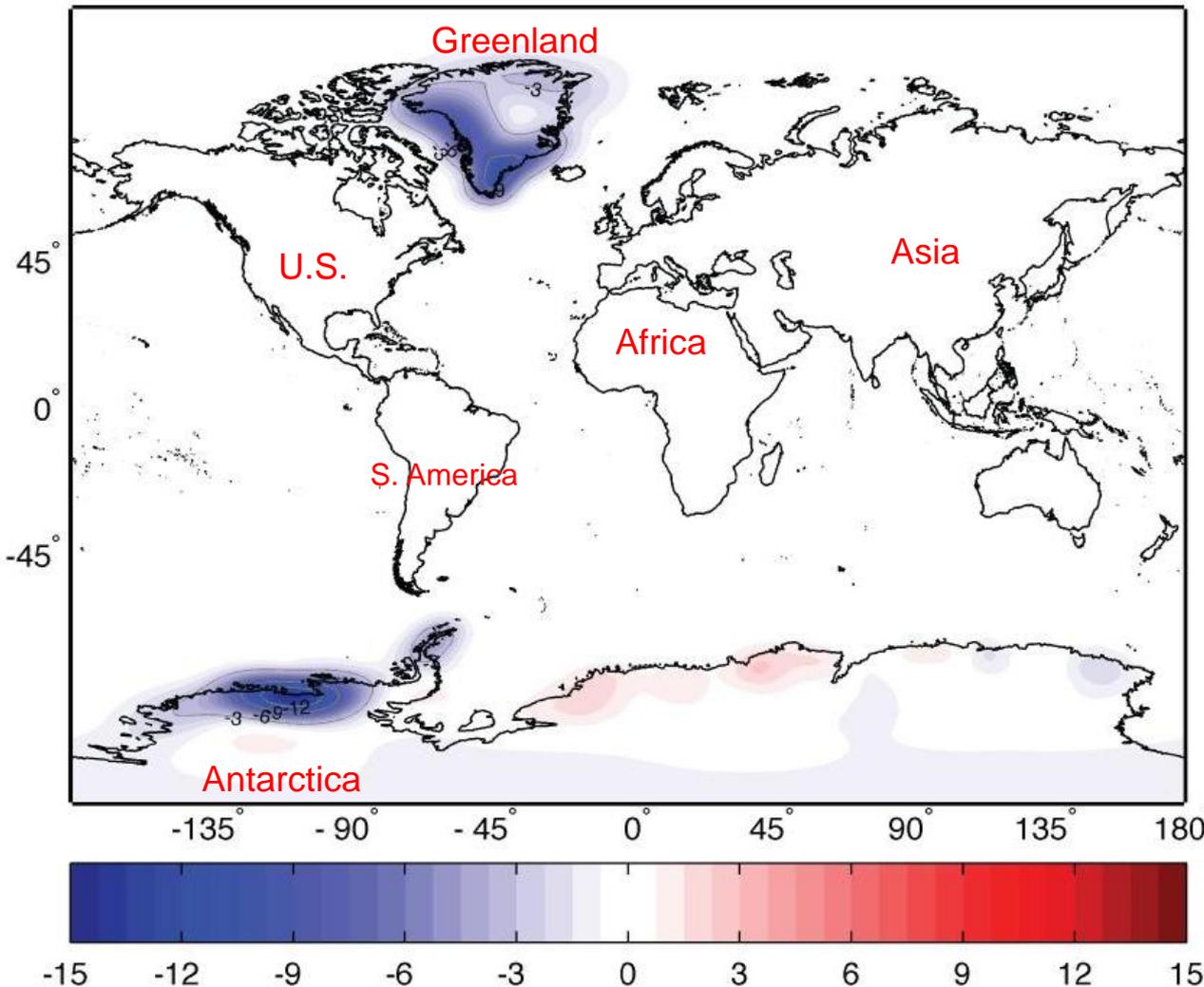


Habitat is our Mission: "... a national network of lands and waters for ... fish, wildlife, and plant resources and their habitats ...for ... Americans."

- Changes in climate alter habitat
- Changing habitats support different assemblages of species
- Climate change = habitat in motion

Melting Ice → Rising Seas

Melting Greenland and Antarctic Ice Sheets and Mountain Glaciers



- 2003-2010: Greenland, Antarctic ice sheets, mountain glaciers and ice caps lost ~ 4.3 trillion tons (1,000 cubic miles) of ice mass.
- Enough to add ~ 0.5 inches (12 millimeters) to global sea level.
- Ice sheet losses account for $\frac{3}{4}$ of the total (385 B tons per year) with $\frac{1}{4}$ from glaciers (148 B tons)

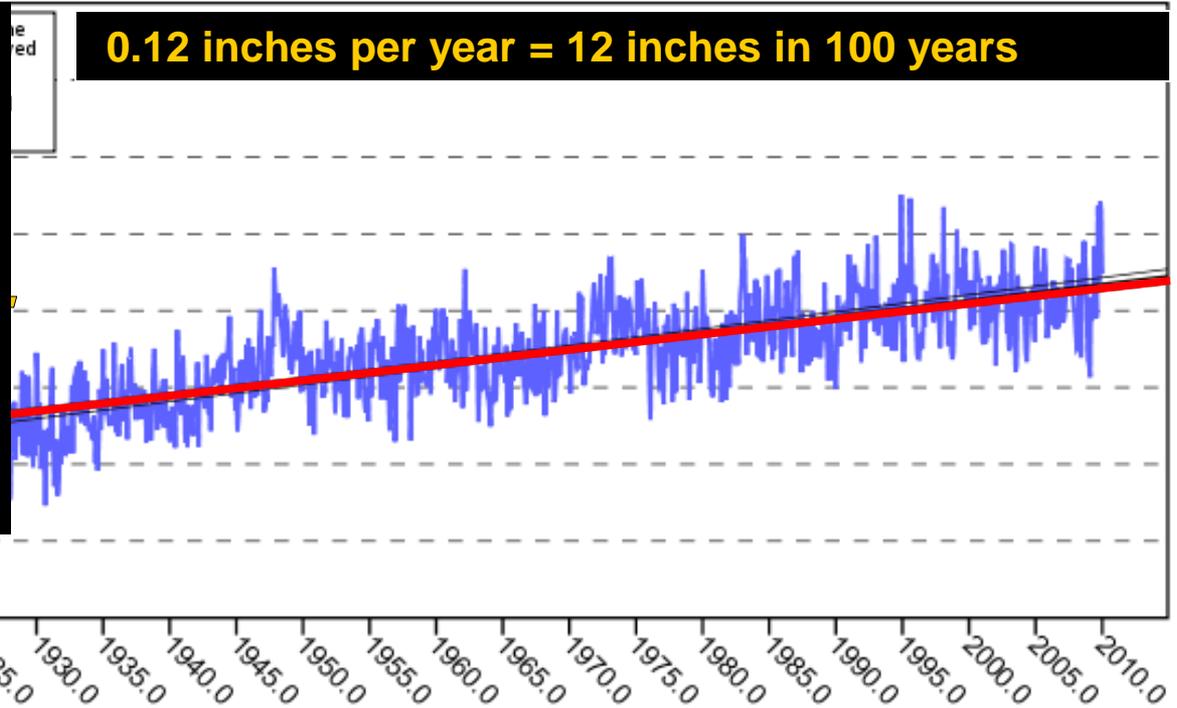
Mean Sea Level Trend Since 1923 in Charleston Harbor, SC

Charleston, SC 3.15 +/- 0.25 mm/yr

Compare: Inches/
100 Years

0.12 inches per year = 12 inches in 100 years

Charleston, SC	+12
Cedar Key, FL	+7
San Diego, CA	+8
Juneau, AK	-50
Skagway, AK	-70
Galveston, TX	+30
Grand Isle, LA	+40



Other Factors Influencing Sea Level

1. Isostatic change due to gravity. **Changes in mass can cause subsidence or uplift.**

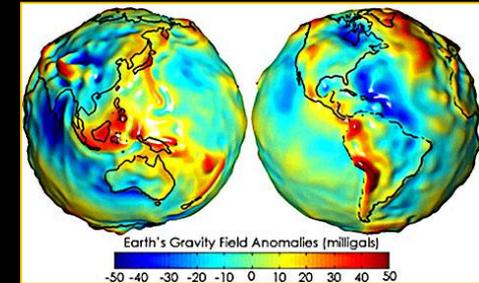
2. Subsidence due to compaction, withdrawals

- **Compaction:** **Marsh substrates tend to compact and subside**
- **Withdrawals:** **Water, oil, gas.**

Groundwater pumping for ag irrigation, drinking water, and industry*

- **Evaporates into the atmosphere**
- **Runs off into rivers and canals**
- **Empties into the world's oceans.**

By 2050, groundwater pumping will cause a global sea level rise of about 0.8 mm per year



Red = stronger gravity
Blue = weaker gravity



Marsh compaction

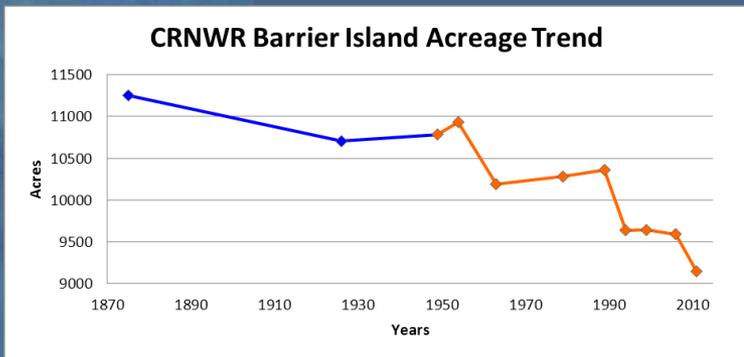
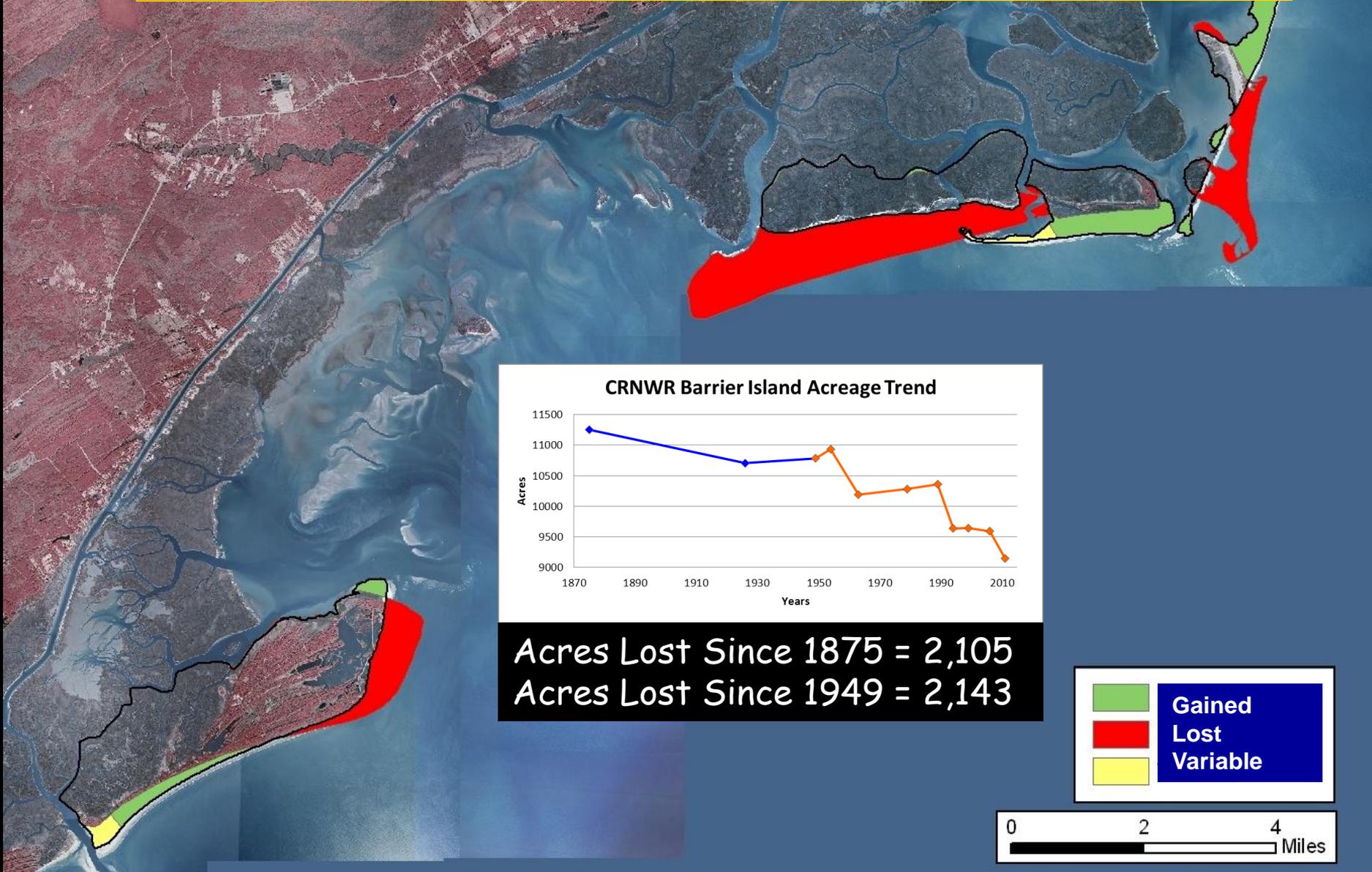


Groundwater pumping

**Past and future contribution of global groundwater depletion to sea-level rise. Geophysical Research Letters, 2012; 39 (9), Yoshihide Wada et al*



Crystal Ball View for Cape Romain



Acres Lost Since 1875 = 2,105
Acres Lost Since 1949 = 2,143

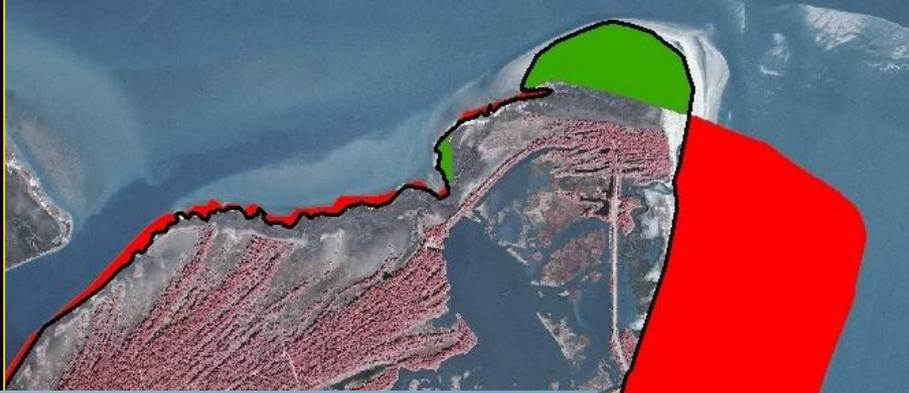
	Gained
	Lost
	Variable



Bulls Island 1875-2011

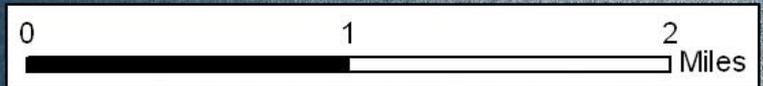
Pattern: Ongoing losses north end since 1875, accretion central, variable southern end

Acres lost since 1875 = 321
Acres lost since 1949 = 425

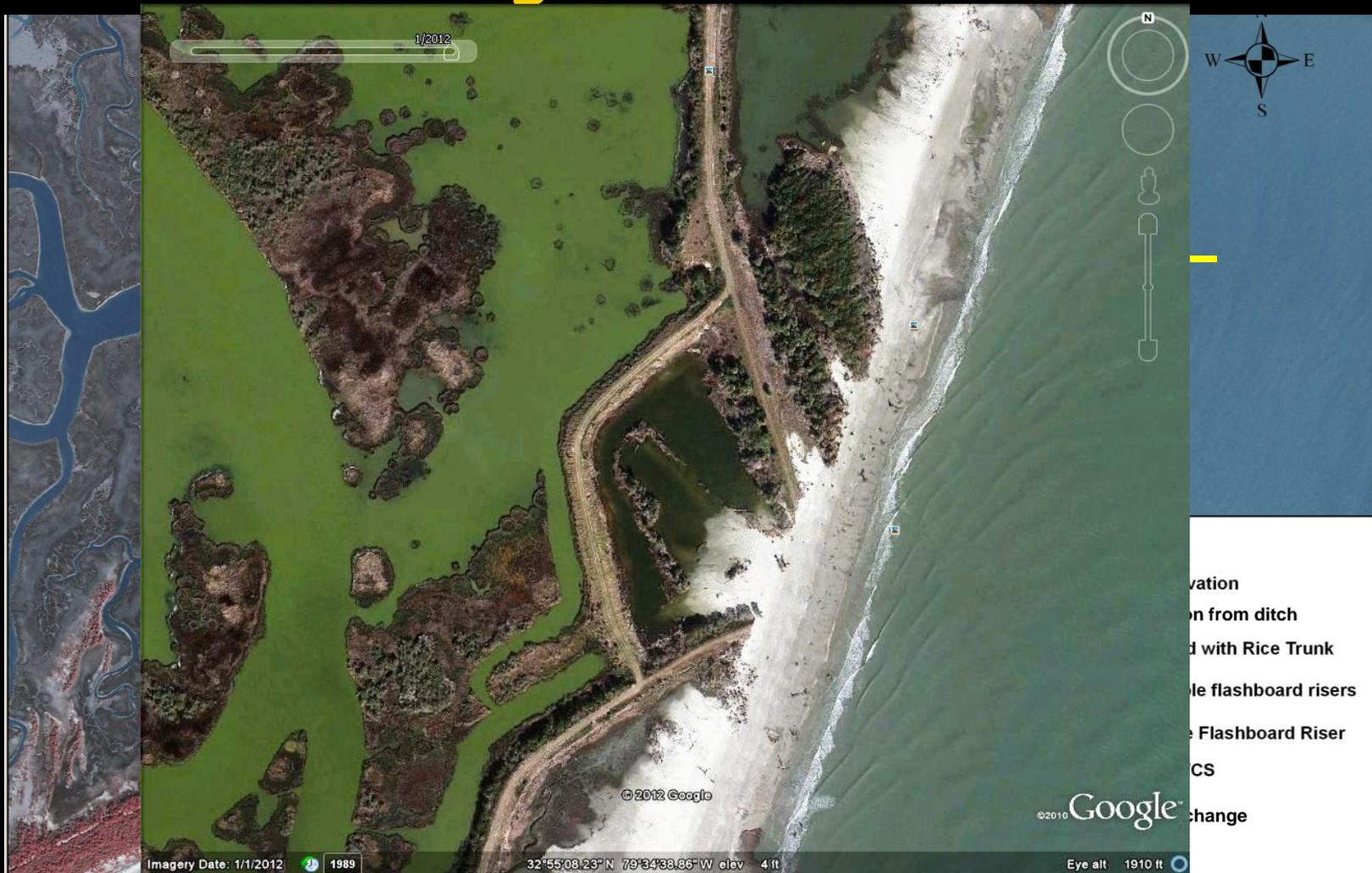


Boneyard Beach

Variable
Loss: 708 acres
Gain: 387 acres
Net change: -321 acres



Adaptation to Safeguard Habitat



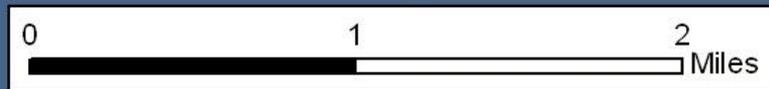
2011 Bulls Island Jacks Pond Levee

Raccoon Key 1875 - 2011

Pattern: Ongoing losses since 1875
Acres lost since 1875 = 2,201
Acres lost since 1949 = 1,155



Loss: 2,249 acres
Gain: 48 acres
Net change: -2,201 acres





Sandy Point - Spring, 2009

Adaptation Strategy?



Sandy Point - Autumn, 2009

Cape Island 1875 - 2011

- Pattern: Variable and dramatic. Island rotation and elongation. Erosion along ocean facing beach, accretion on north end.

- Acres lost since 1875 = 42
- Acres lost since 1954 = 588



Punctuated Losses with Intense Storms

Hurricane Irene 2011:

- Destroyed Cape Island Dock
- Eliminated 132 acres, split Island into 3 segments
- Washed away 200 sea turtle nests (~24,000 hatchlings)
- Long term implications for recovery program: we can rebuild the dock, but we can't rebuild the island



Lighthouse Island

1875 - 2011

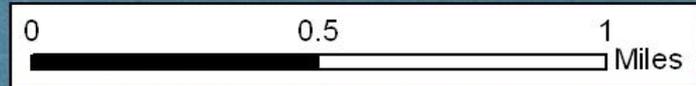
Pattern: Accreting

Acres gained since 1875 = 459

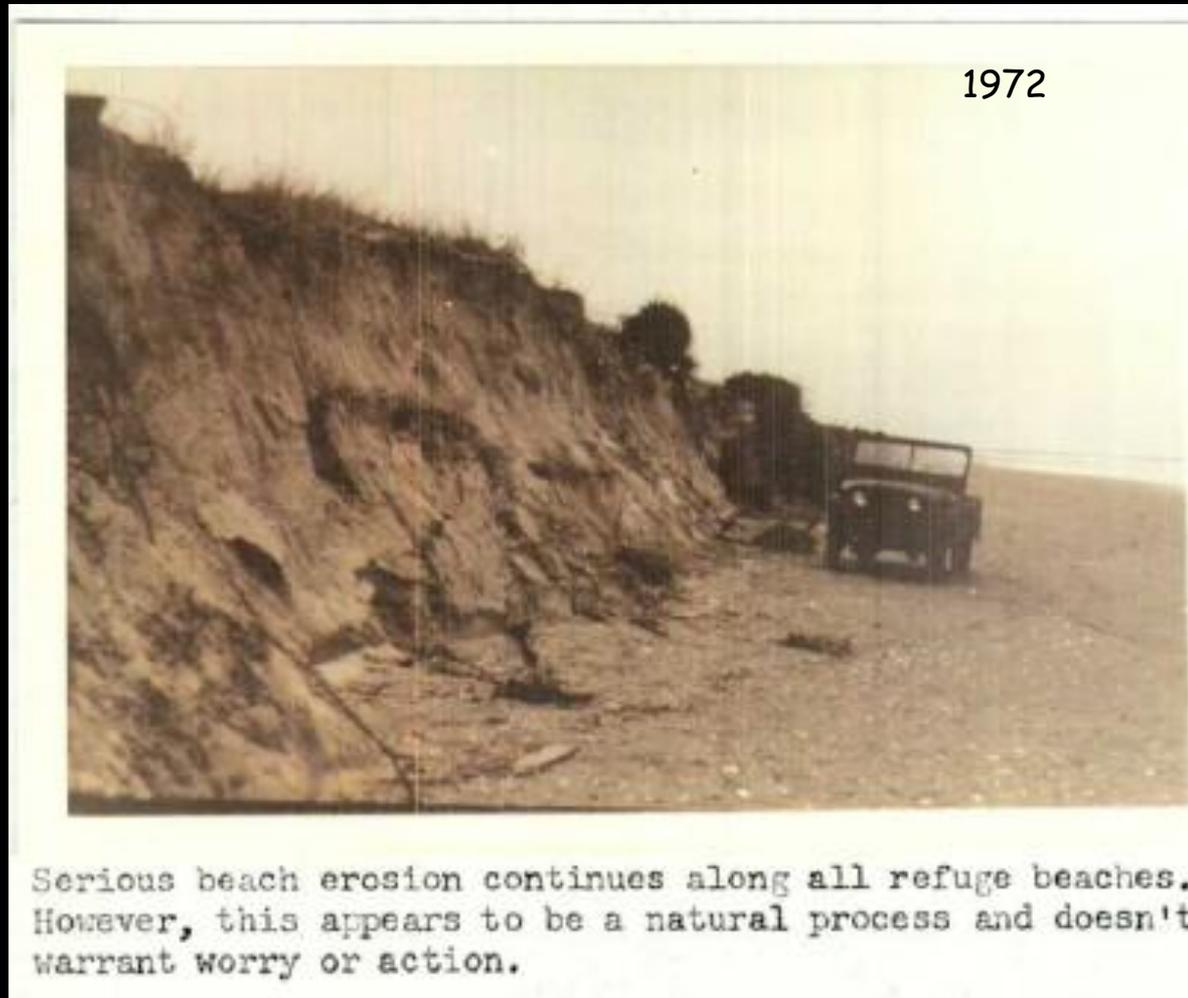
Acres gained since 1949 = 368



Winning



Historic Perspective on Erosion



Erosion Causes Loggerhead Sea Turtle Mortality

- Erosion exposes eggs to predation by mink, raccoon, ghost crabs, gulls
- Erosion washes away entire nest
- Impact significant - Cape Romain supports 23% of N. subpopulation of threatened loggerheads

2012 Record Year for Nesting

Cape Island	1,138
Lighthouse Island	350
Bulls Island	157
Raccoon Key	26
<hr/>	
Total	<u>1,671</u>



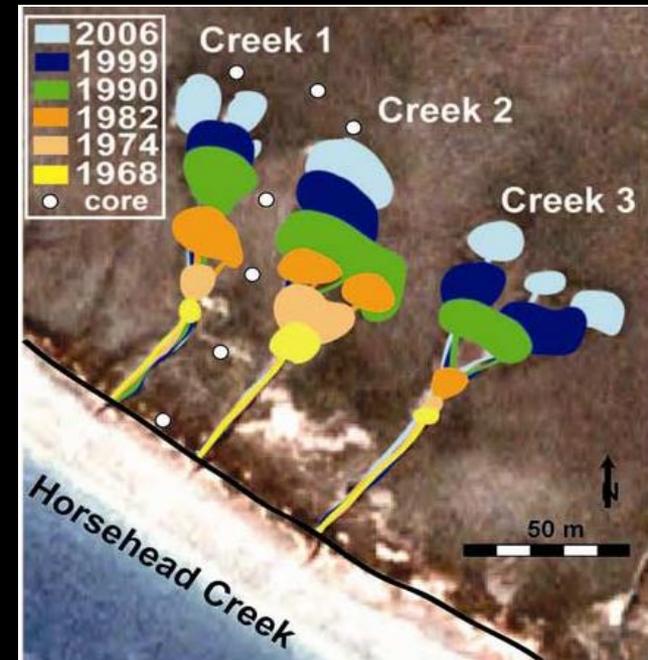
Adaptation Strategy:
Relocate the Nests

Higher Sea Levels and Higher Tides Impact Cape Romain Marsh

Aha! Moment - Rapidly advancing tidal creeks - 6.2 feet year into marsh platform

1. High local relative sea level rise (3.1mm/yr SLR plus marsh compaction and subsidence)
2. Salt marsh fragmentation as creeks grow
3. Fiddler crabs play a role at the creek heads
4. Sea level is rising faster than the salt marsh can accrete

Hughes, Z. J., D. M. FitzGerald, C. A. Wilson, S. C. Pennings, K. Wieski, and A. Mahadevan (2009), Rapid headward erosion of marsh creeks in response to relative sea level rise, *Geophys. Res. Lett.*, 36, L03602, doi:10.1029/2008GL036000.





Climate Change Impacts to Cape Romain NWR

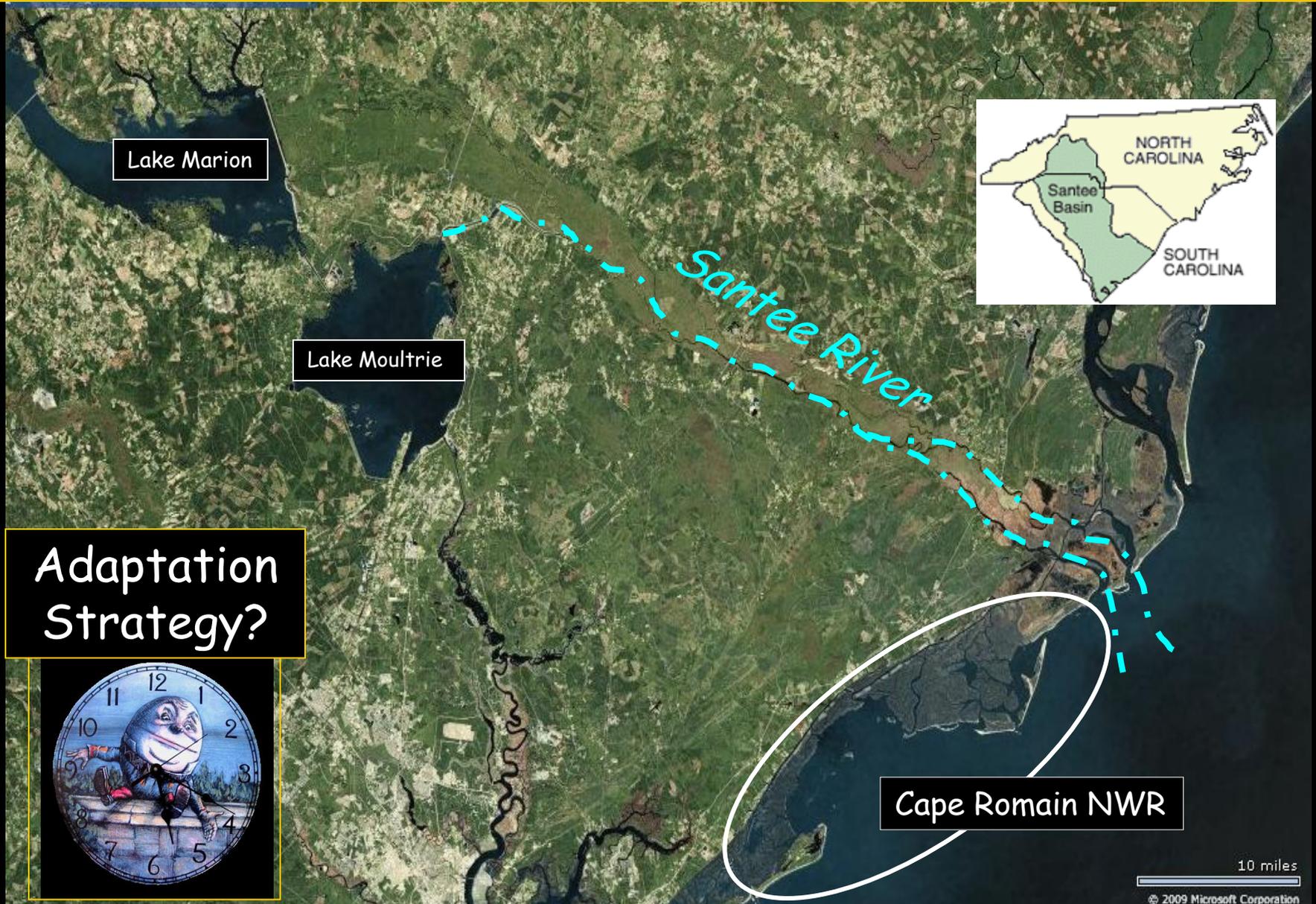
1. Sea Level Rise (1 ft in past 100 yrs) is accelerating barrier island erosion and drowning salt marsh. Since 1949, erosion has converted 2,143 acres of beach/dune habitat to open ocean.
2. Intense storms and accompanying storm surges punctuate erosive losses, flatten dune systems, and flood low areas
3. Long term seasonal drought reduces water quantity and degrades water quality in freshwater and brackish water managed wetlands. Reduced flow in feeder rivers alters salinity in the river and in refuge estuaries



Climate Change Impacts to Cape Romain NWR

4. Warming air temperatures influences species migration patterns, plant life cycle patterns, and other factors controlled by temperature.
5. Warming ocean temperatures affect species with narrow temperature niches, like coral reefs, and influences migration patterns in pelagic species.
6. Ocean acidification interferes with species shell and exoskeleton formation and slows coral reef building
- 7, 8, 9, 10. ??

The Dammed Watershed



Lake Marion

Lake Moultrie

Santee River



Adaptation Strategy?



Cape Romain NWR

10 miles

What to Do?



Piping Plovers, Lighthouse Island, 9-6-2012
(Photo by Charleston ES Office)

Resourcefulness



Flexibility



Innovation



Creativity





Cape Romain NWR Climate Change Adaptations

- Improve water management in interior Bulls Island impoundments
- Repair Bulls Island levee breaches. Rebuild if possible
- Continue to relocate sea turtle nests
- Monitor habitat losses and changes in species composition
- Search for land on the mainland to create a wildlife migration corridor from the sea islands inland
- Acquire relevant science
- Engage partners (elected officials, Friends group, to expand awareness, gain support, and work toward mutual goals)

Thank You!

Next up, Nicole
Rankin

