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Identification, Mitigation and Adaptation to Salinization on Working Lands in the U.S. Southeast

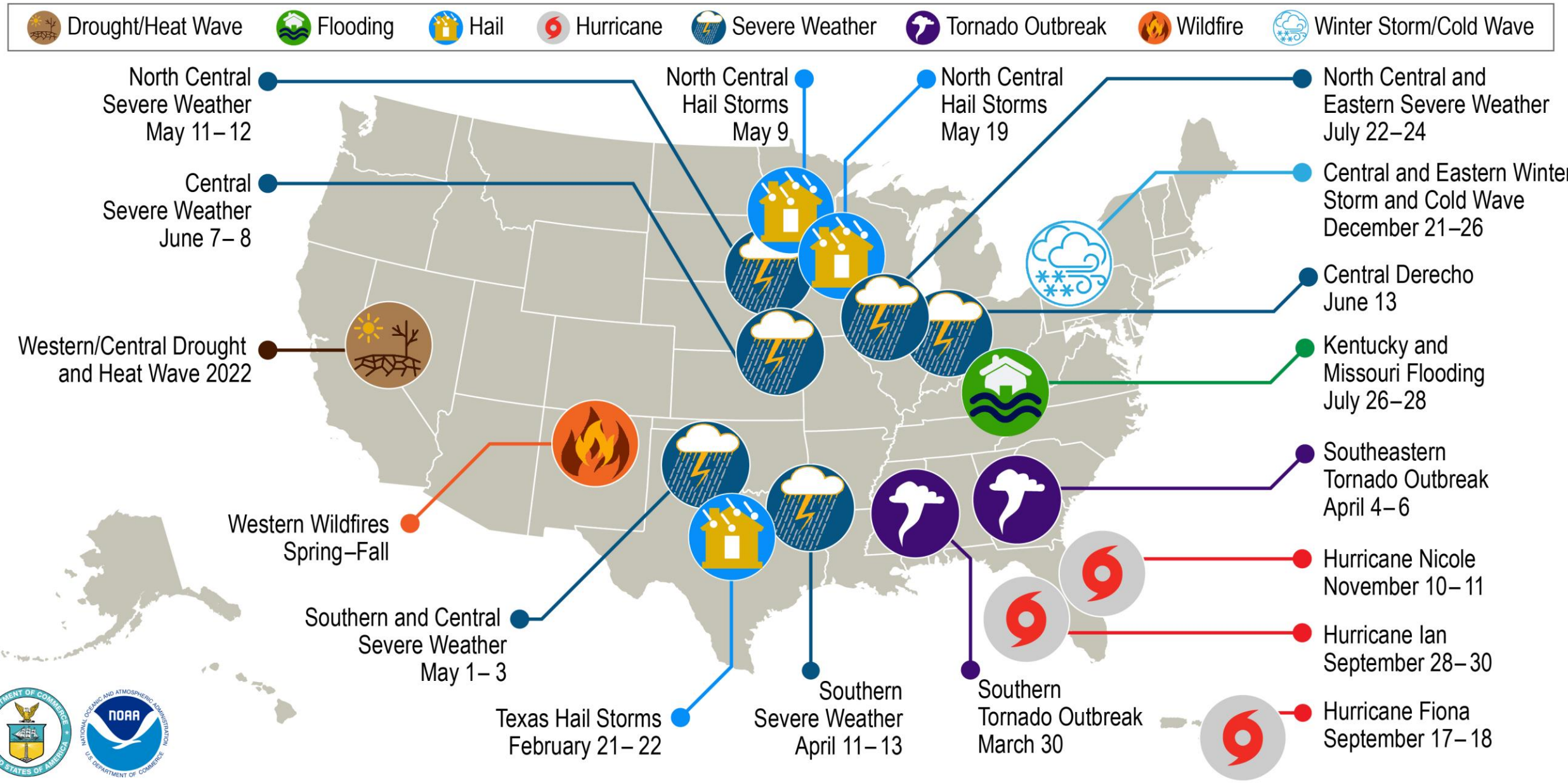
Steven McNulty
USDA Southeast Climate Hub

Southeast Climate Hub

Mission: To increase resilience of working lands to climate variability and change through adaptive management


Northern Forests Hub
Northwest Hub
Northern Plains Region
Northeast Hub
Northwest Region
Midwest Hub
Northeast Region
California Hub
Northern Plains Hub
Southwest Region
Midwest Region
California Region
Southeast Hub
Southwest Hub
Southern Plains Hub
Southeast Region
Southern Plains Region
Northwest Region
Caribbean Hub
Southwest Region
Caribbean Region

U.S. 2022 Billion-Dollar Weather and Climate Disasters



*This map denotes the approximate location for each of the **18 separate billion-dollar weather and climate disasters that impacted the United States in 2022.***

Hurricane Ian

Completed Guides:

- Beef Cattle Producers Guide
- Beekeepers Guide
- Citrus Producers Guide
- Commercial Nursery Producers Guide
- Corn Producers Guide
- Cotton Producers Guide
- Crawfish Producers Guide
- Dairy Producers Guide
- Finfish Producers Guide
- Forage Crop Producers Guide
- Onion Producers Guide
- Peanut Producers Guide
- Pine Forest Landowners Guide
- Poultry Producers Guide
- Rice Producers Guide
- Soybean Producers Guide
- Strawberry Producers Guide
- Sugarcane Producers Guide
- Swine Producers Guide
- Tobacco Producers Guide
- Tomato, Pepper, and Eggplant Producers Guide

Watermelon Producers Guide

Manatee County agriculture takes big hit from Hurricane Ian

Ranchers, farmers, orange growers all suffered losses.

Damaged grow-houses are shown at Tropiflora, a major grower of bromeliads, Tuesday, Oct. 18, 2022, in Sarasota, Fla. (Tiffany Tompkins/The Bradenton Herald via AP) [TIFFANY TOMPKINS | AP]

Hurricane Irma Storm Surge

Photo by Slate Magazine

Coastal Salinization

- Build up of salinity in soil
- Sources are storms, tides and sea level rise
- Complex, depends on local conditions
- Emerging issue

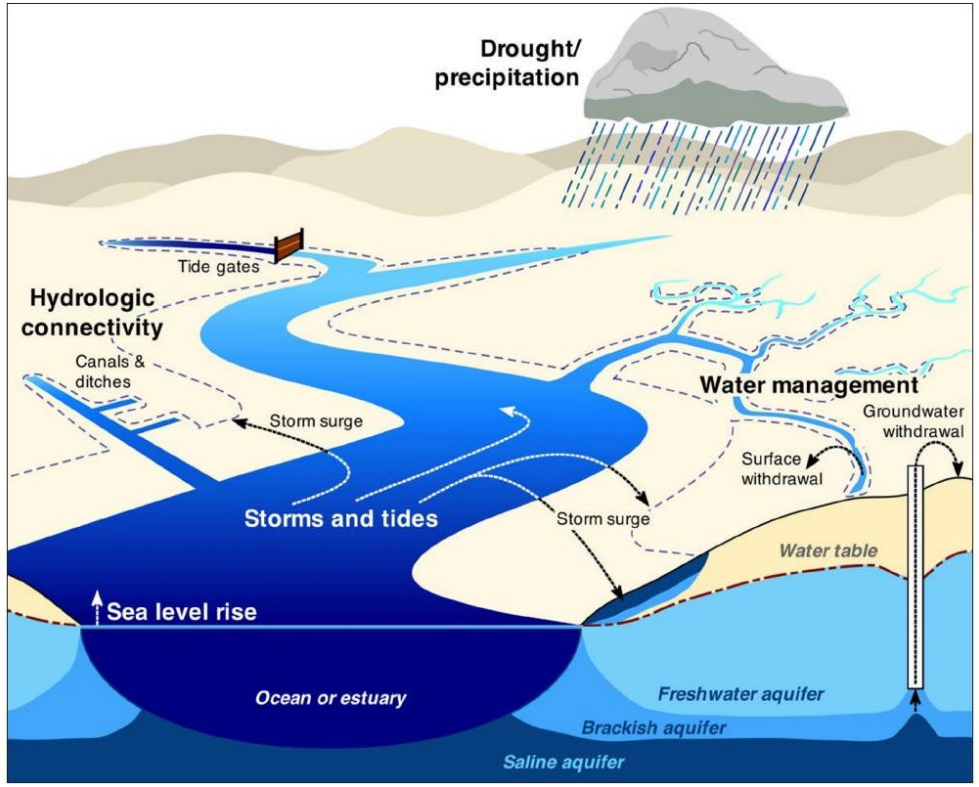
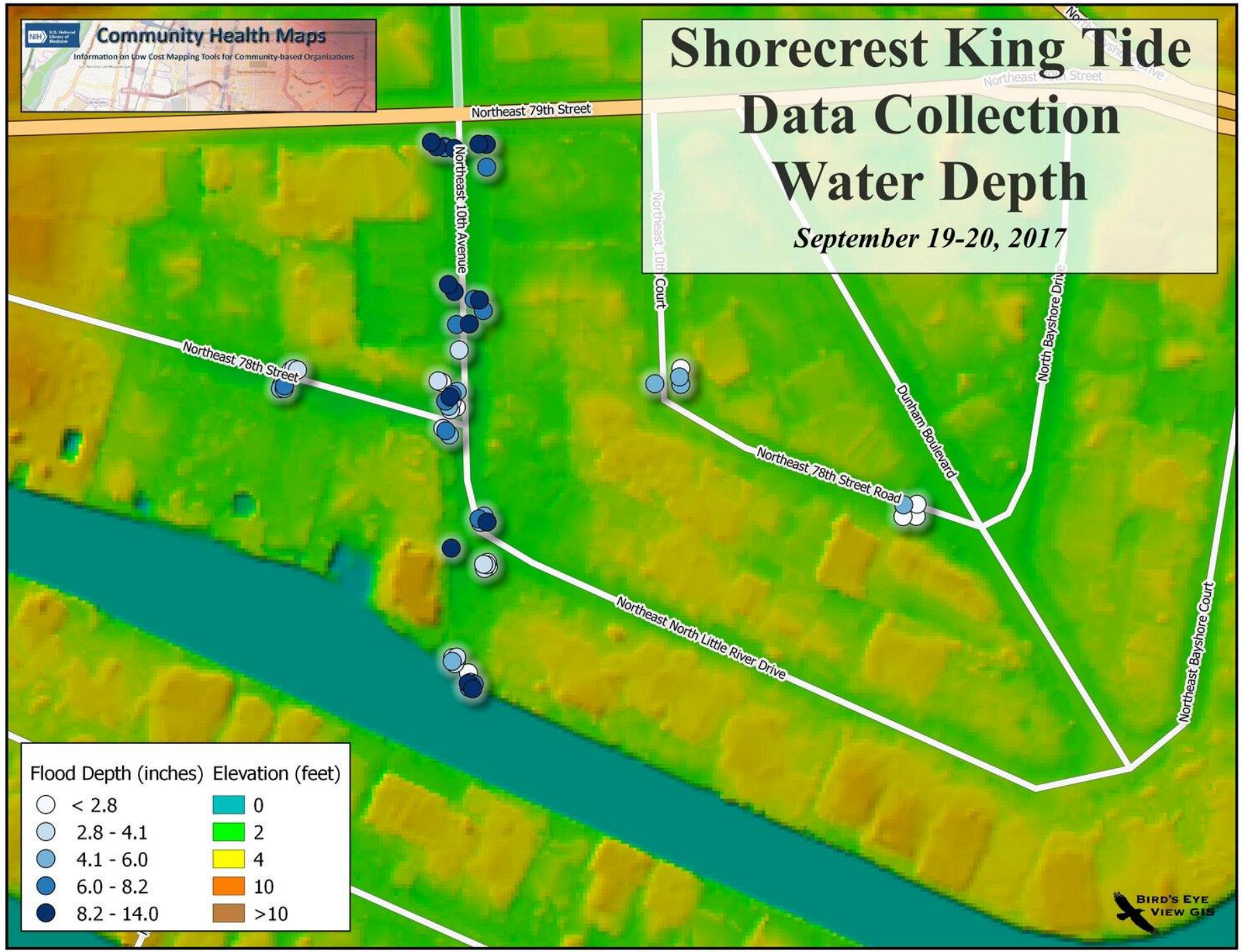


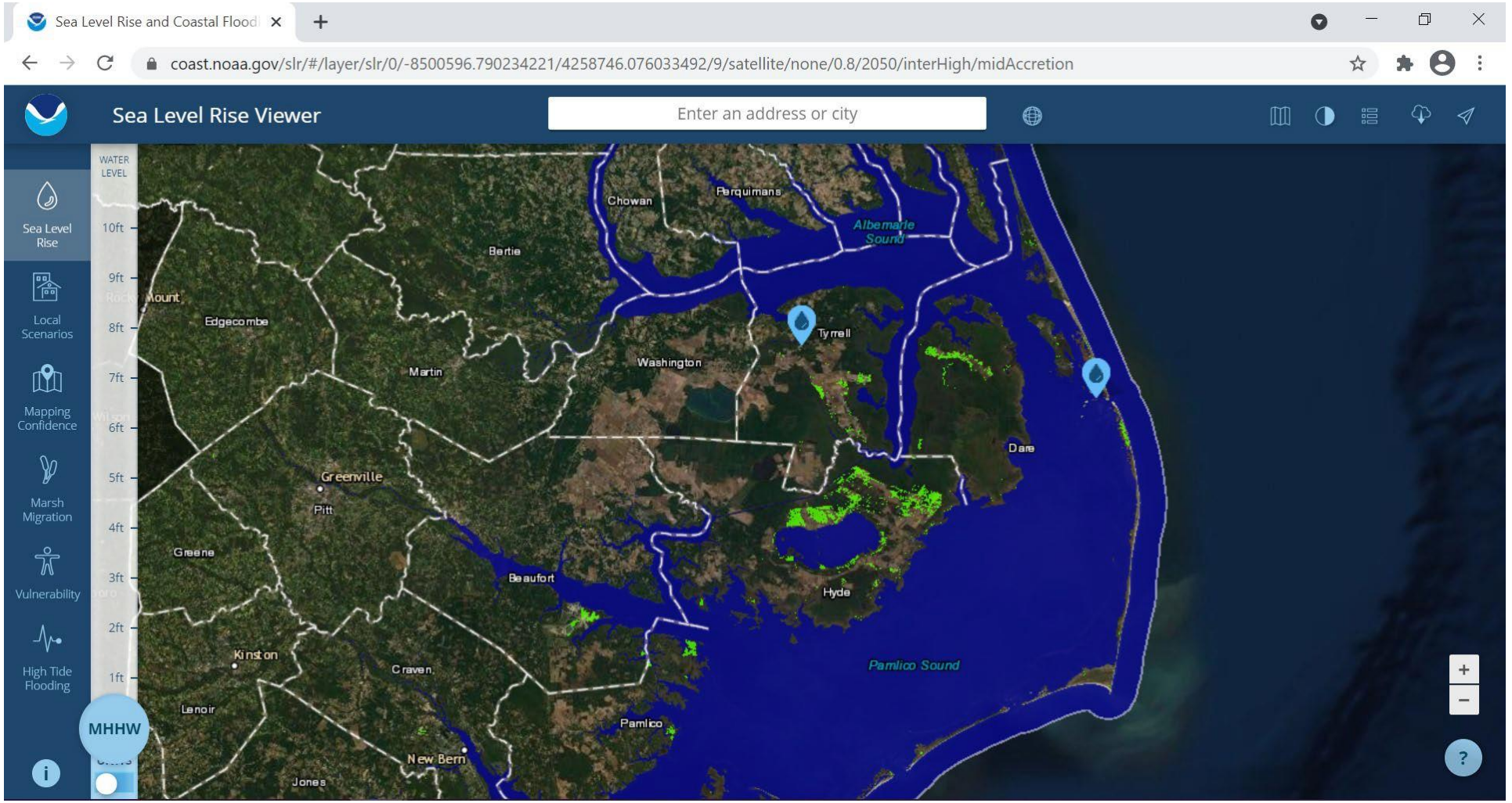
Figure 2. Illustration of shallow coastal system undergoing saltwater intrusion. Coastal saltwater intrusion (dashed lines) is caused by relative sea-level rise, water management (e.g., water withdrawals), the connectivity of creeks and ditches to the source of saltwater, the frequency of rainfall and drought events, and storms and tides.

Tully et al. 2019


NE 79 ST
AHEAD
KING TIDES - 2022
ARE ANTICIPATED FOR THE FOLLOWING DATES:
SEPTEMBER 10-12 & 27-28 | OCTOBER 7-12 & 24-28
NOVEMBER 6-9
miamidade.gov/resilience

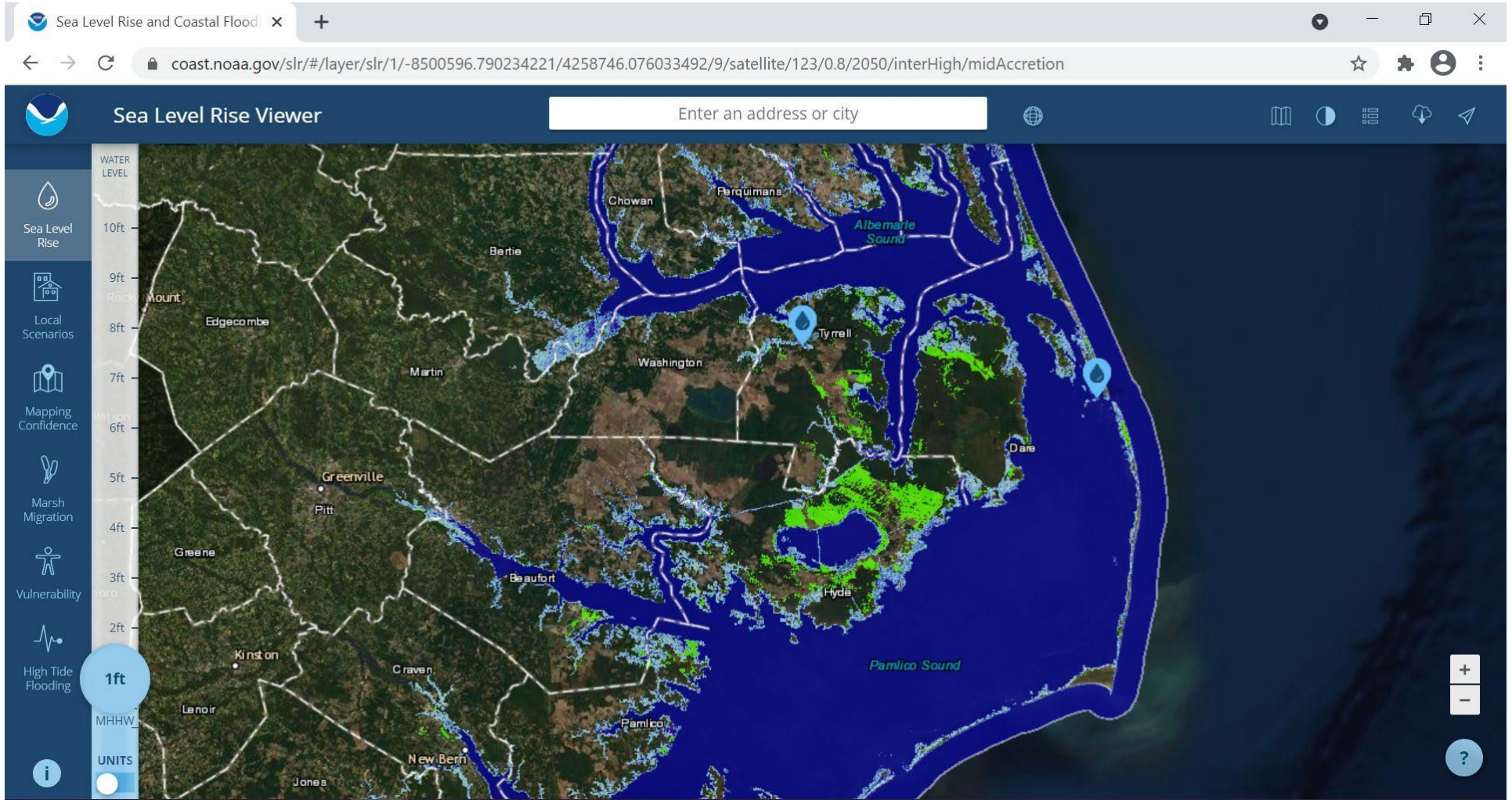

Community Health Maps
Information on Low Cost Mapping Tools for Community-based Organizations
Shorecrest King Tide
Data Collection
Water Depth
September 19-20, 2017
Northeast 79th Street
Northeast 10th Avenue
Northeast 10th Court
Northeast 78th Street
Northeast 78th Street Road
Dunham Boulevard
North Bayshore Drive
Northeast North Little River Drive
Northeast Bayshore Court
Flood Depth (inches)
< 2.8
2.8 - 4.1
4.1 - 6.0
6.0 - 8.2
8.2 - 14.0
Elevation (feet)
0
2
4
10
>10
Bird's Eye View GIS

Current sea level, 0 feet rise



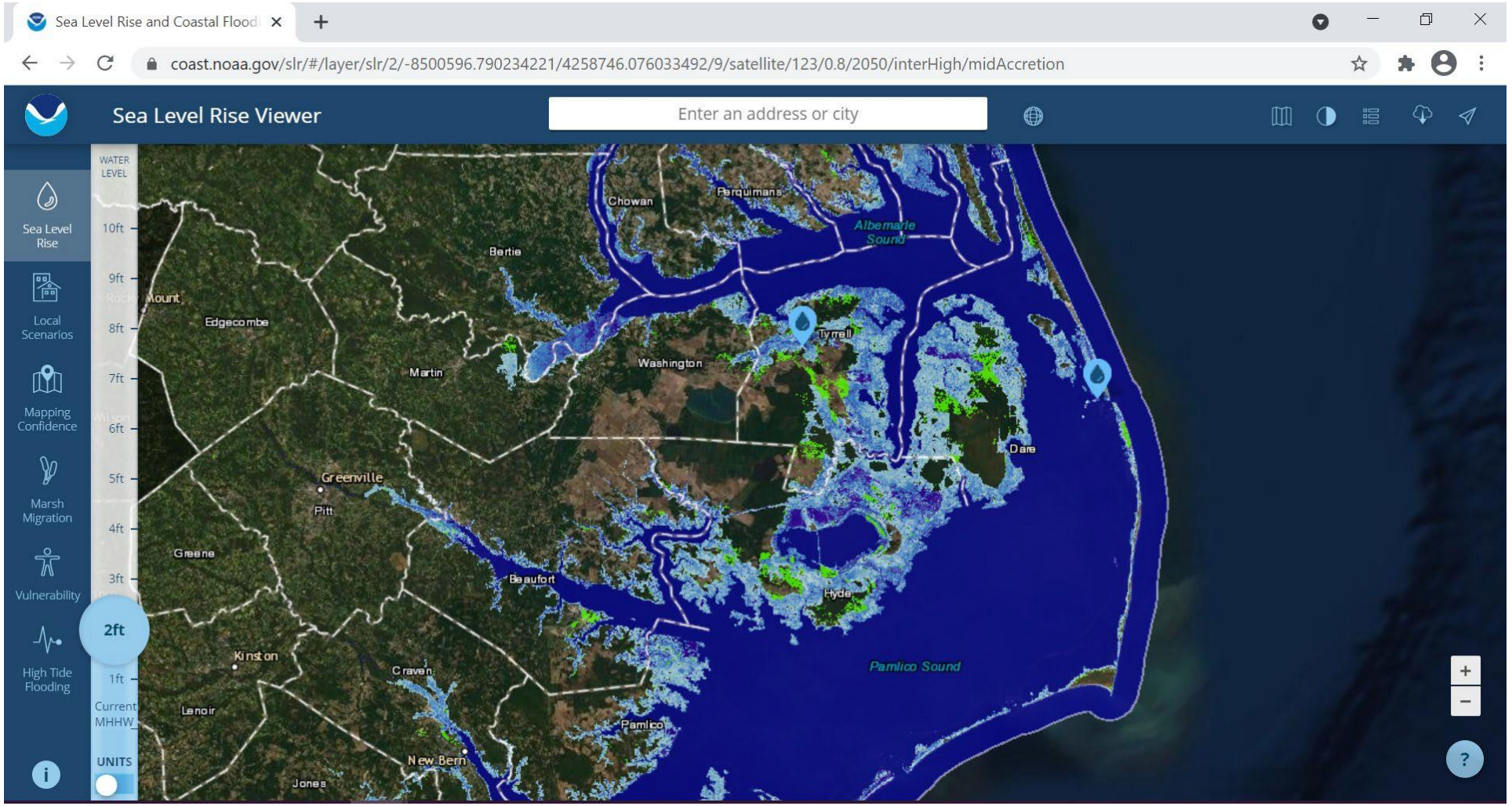
NOAA Sea Level Rise Viewer

1 foot of sea level rise



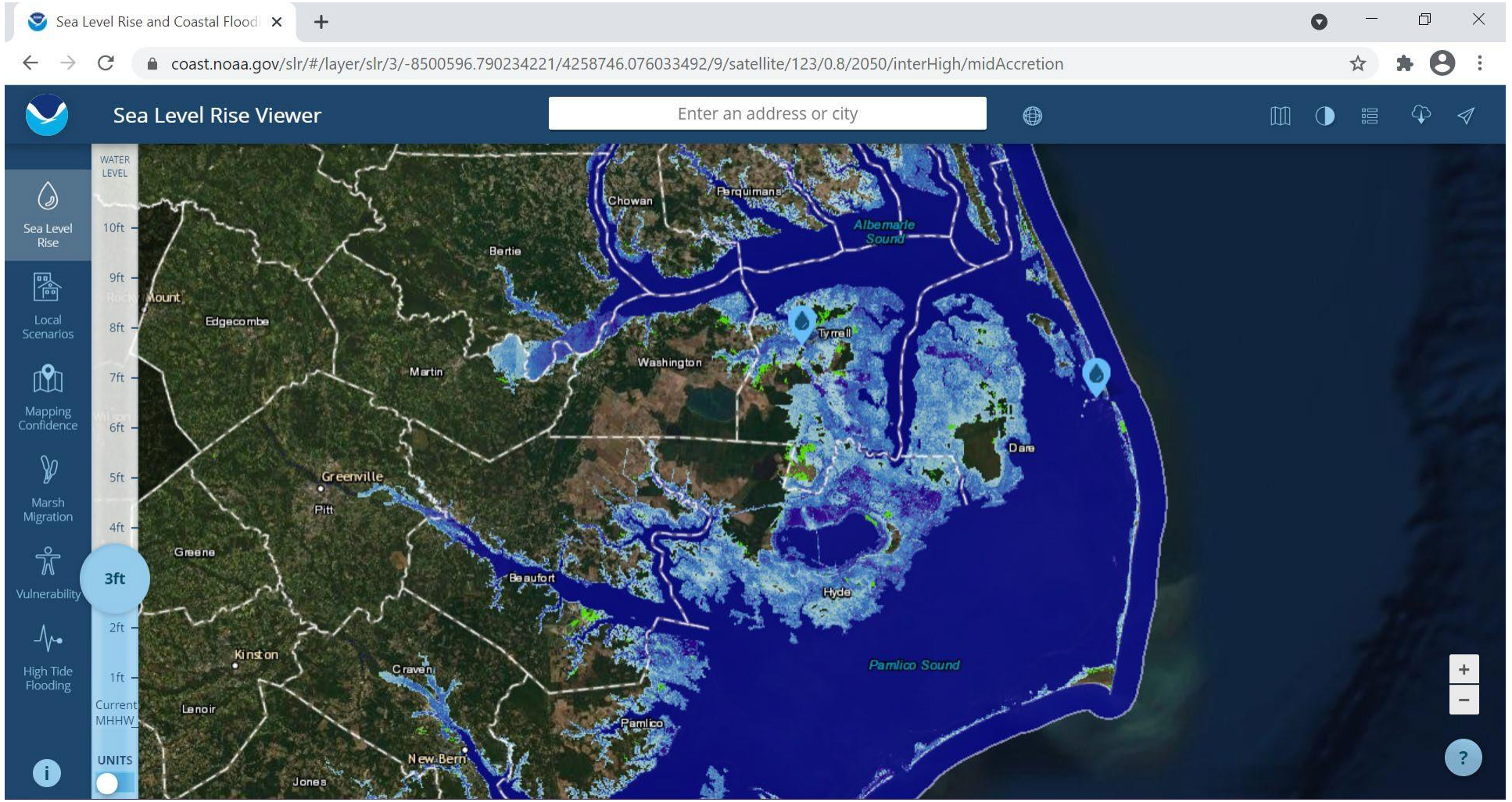
NOAA Sea Level Rise Viewer

2 feet of sea level rise



NOAA Sea Level Rise Viewer

3 feet of sea level rise



NOAA Sea Level Rise Viewer

Why is Coastal Salinization Important?

- Causes plant stress or death, prevents drainage, changes carbon dynamics, reduced carbon storage, nutrient mobilization
- Hurricanes are increasing in frequency and intensity and can bring saltwater
- The extent of salinization will increase with sea level rise

Lindsay Smart

Lindsay Smart

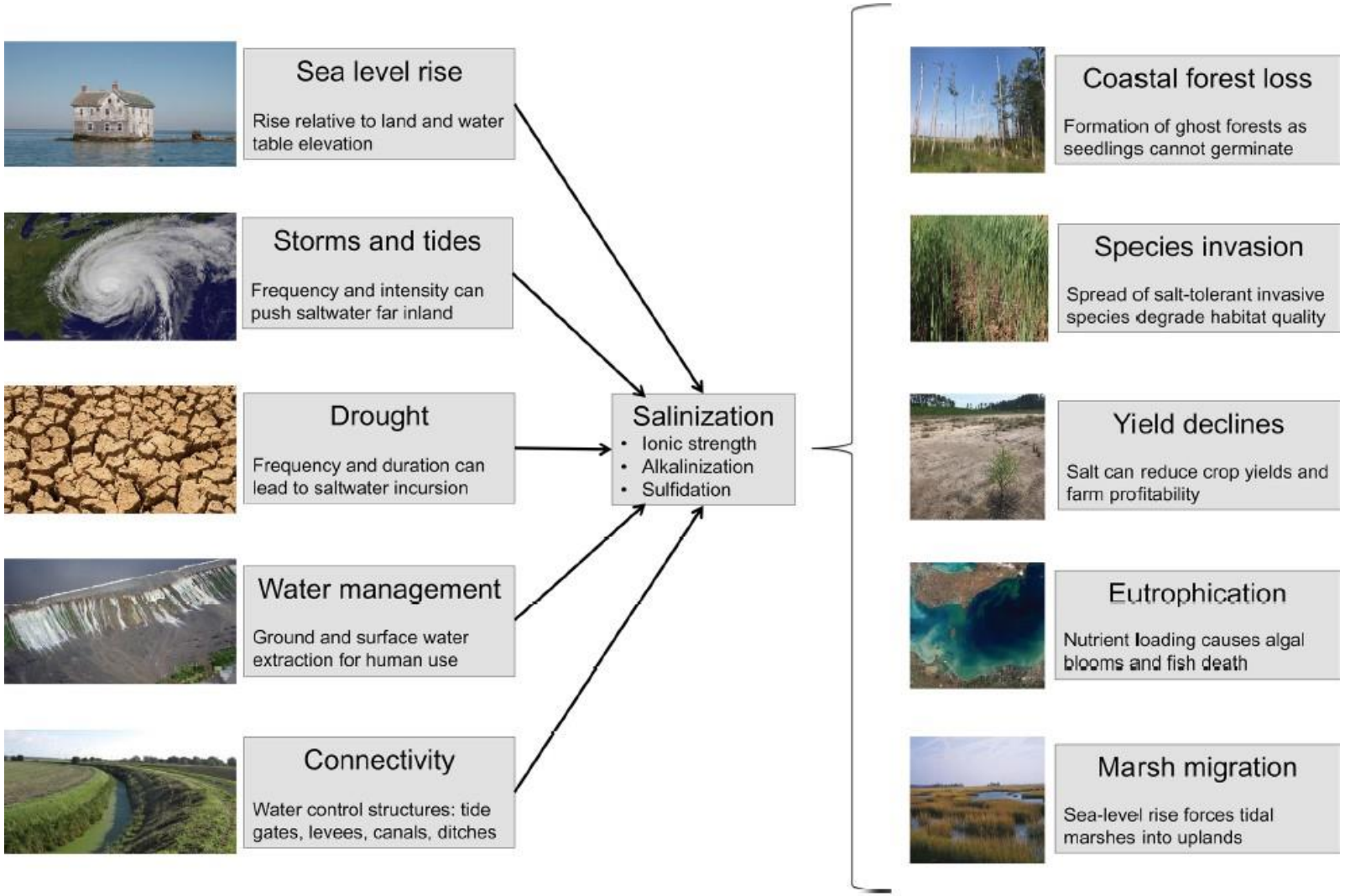
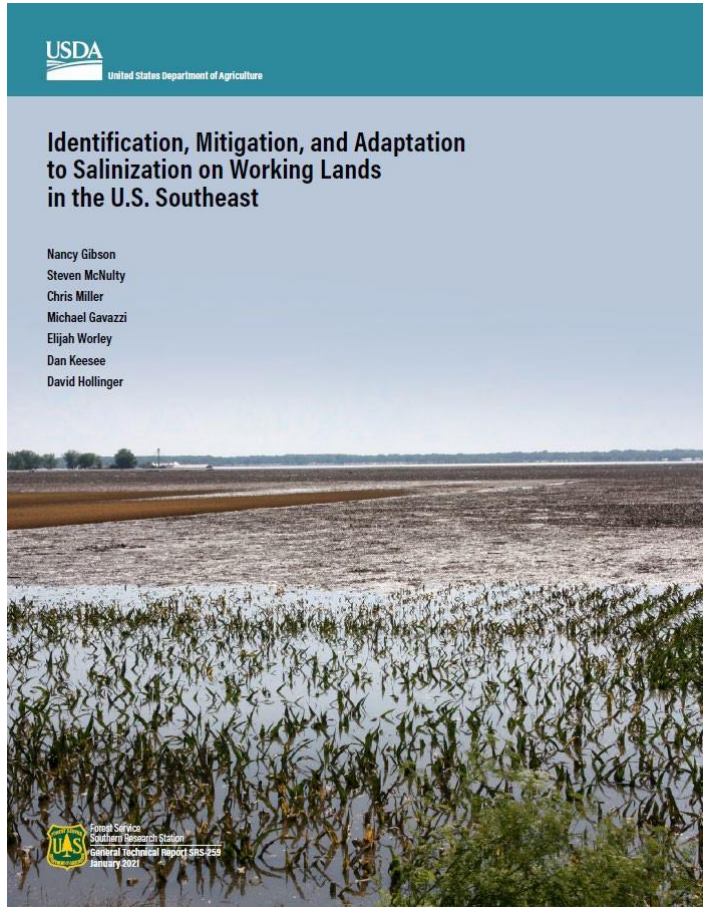


Figure 1. Drivers of salinization in uplands, three primary components of salinization, and their effects on biogeochemistry, plant communities, and ecosystem services.

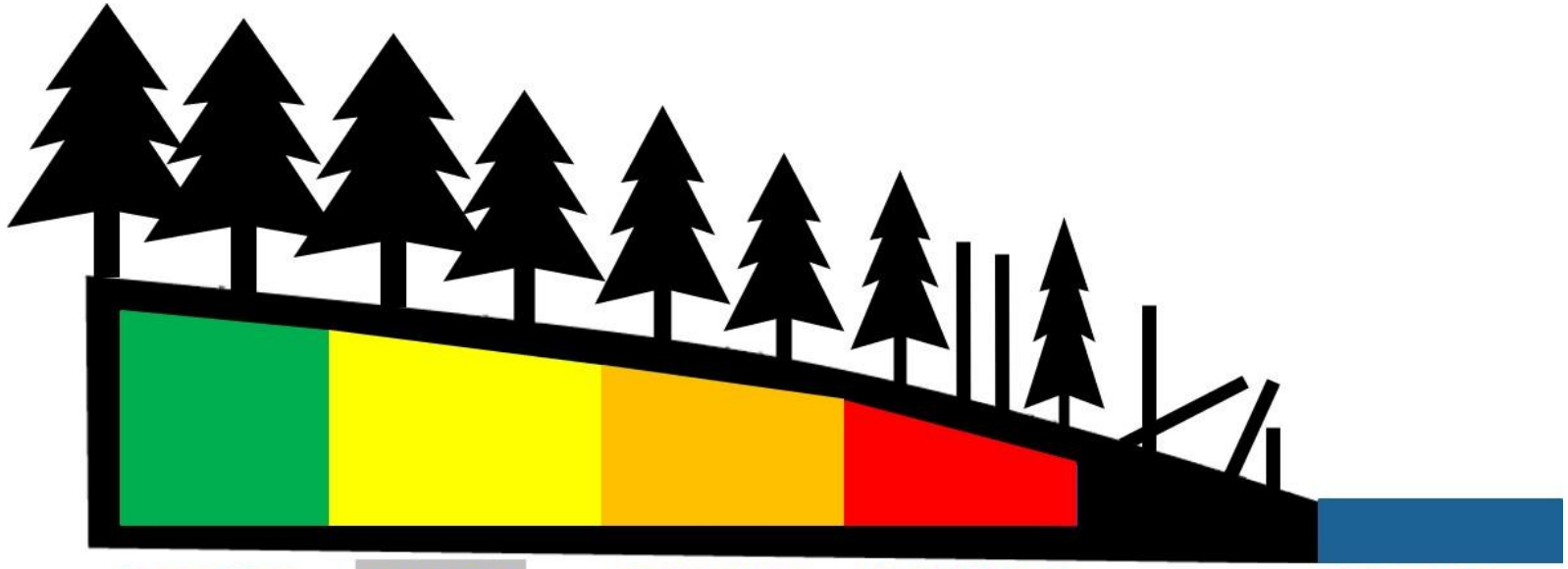
Tully et al. 2019

Background, Assessing and Minimizing Salinity Risk

- Understanding the processes of salinization
- Soil salinity stress in trees
- Description of adaptation and preventative measures
- Soil testing for salt
  - Quick bioassay method
  - Salinity survey techniques
  - Soil potential rating classes (very low to high)
- Soil salinity stage progression
- Soil health conservation practices for maintaining cropland resiliency to salinization
- Applying appropriate conservation practices



Stages of Salinization



	Stage Zero	Stage One	Stage Two	Stage Three	Stage Four	Stage Five
	Non-Impacted EC = < 2 dSm^{-1}	Sporadic Salinity EC = 2 < 4 $dS\ m^{-1}$	Recurring Episodic Salinity EC = 4 < 8 $dS\ m^{-1}$	Low Chronic Salinity EC = 8 < 16 $dS\ m^{-1}$	High Chronic Salinity EC = 16 < 25 $dS\ m^{-1}$	Chronic Surface Water EC = >25 $dS\ m^{-1}$
Uses	**Commercial**	**Commercial**	**Commercial**	**Commercial**	**Non-Commercial**	**Saltwater Marsh**
Mitigation:	No	Yes	No	No	No	No
Adaptation:	No	Yes	Yes	Yes	No	No
Wetland Restoration/Easement:	No	No	No	No	Yes	Yes

Figure 5—The stages and causes of coastal soil salinity.

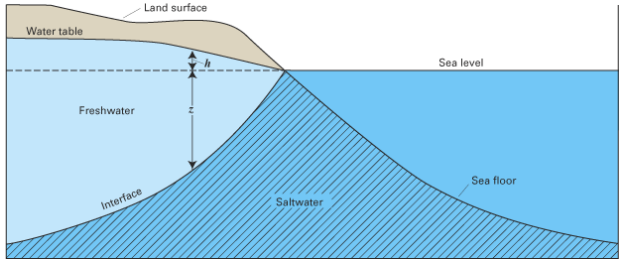
Stage Zero: Non-Impacted Uplands in Proximity to Impacted Lands

- Productivity and economic limitations - negligible
- Mitigation and adaptation measures – none needed
- Probable outcomes for stage zero land – eventual salinization
- Applications: recognize when your land is in proximity to a saltwater source and understand that salinization may occur in the future. Test soil for salinity

NCwetlands.org

Stage One: Introduction of Salinity

- Low Salinity – Forest stands and soil are likely to recover, elevation and drainage plays a significant role in recovery
- Mitigation and adaptation measures – Water control structures, irrigation, soil health, conservation practice standards, change planted species
- Probable outcomes for Stage One land – saltwater intrusion is expected to impact a growing extent on the Southeast coast
- EC= 2 < 4 dS/m



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Stage Two: Recurring Episodic Salinization

- Moderate Salinity – Forest stands begin to exhibit signs of salinity stress, recovery depends on frequency and intensity of salinity events
- Adaptation measures –Conservation practices, wetland conservation easements, salt-tolerant crops, crop-pasture rotation
- Probable outcomes for Stage Two land – Sea level rise will continue to bring saltwater further inland
- EC = 4 < 8 dS/m

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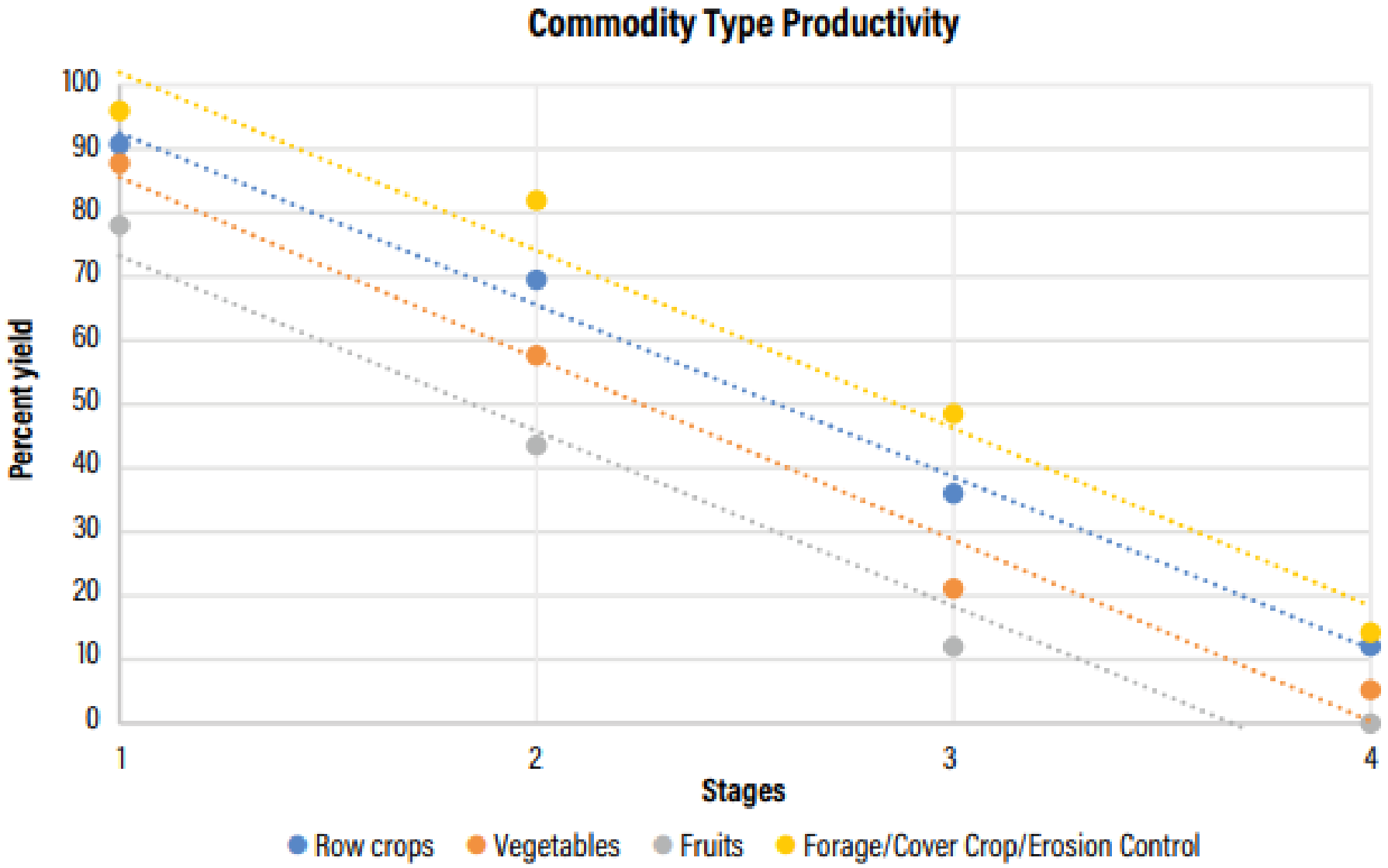
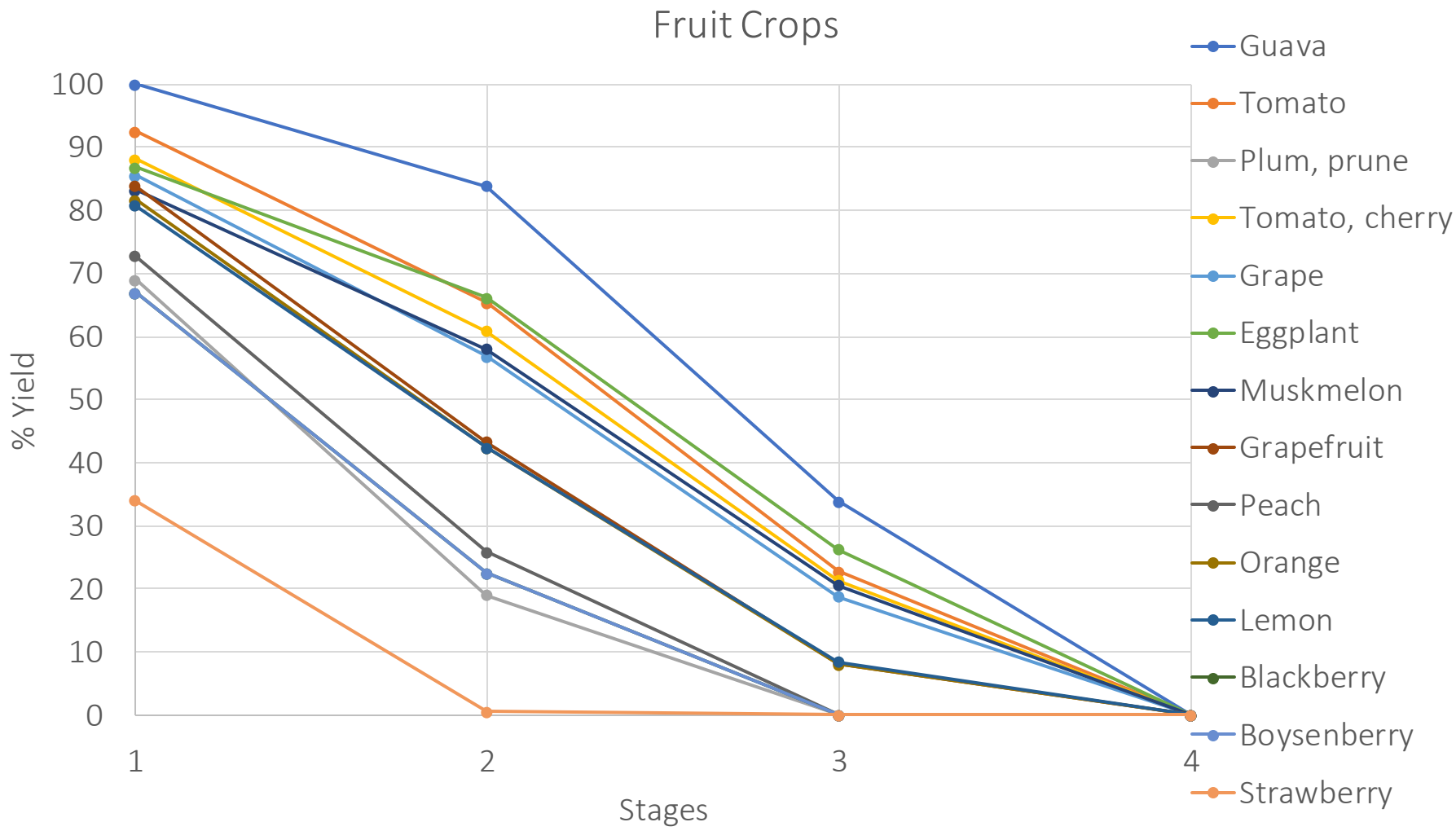
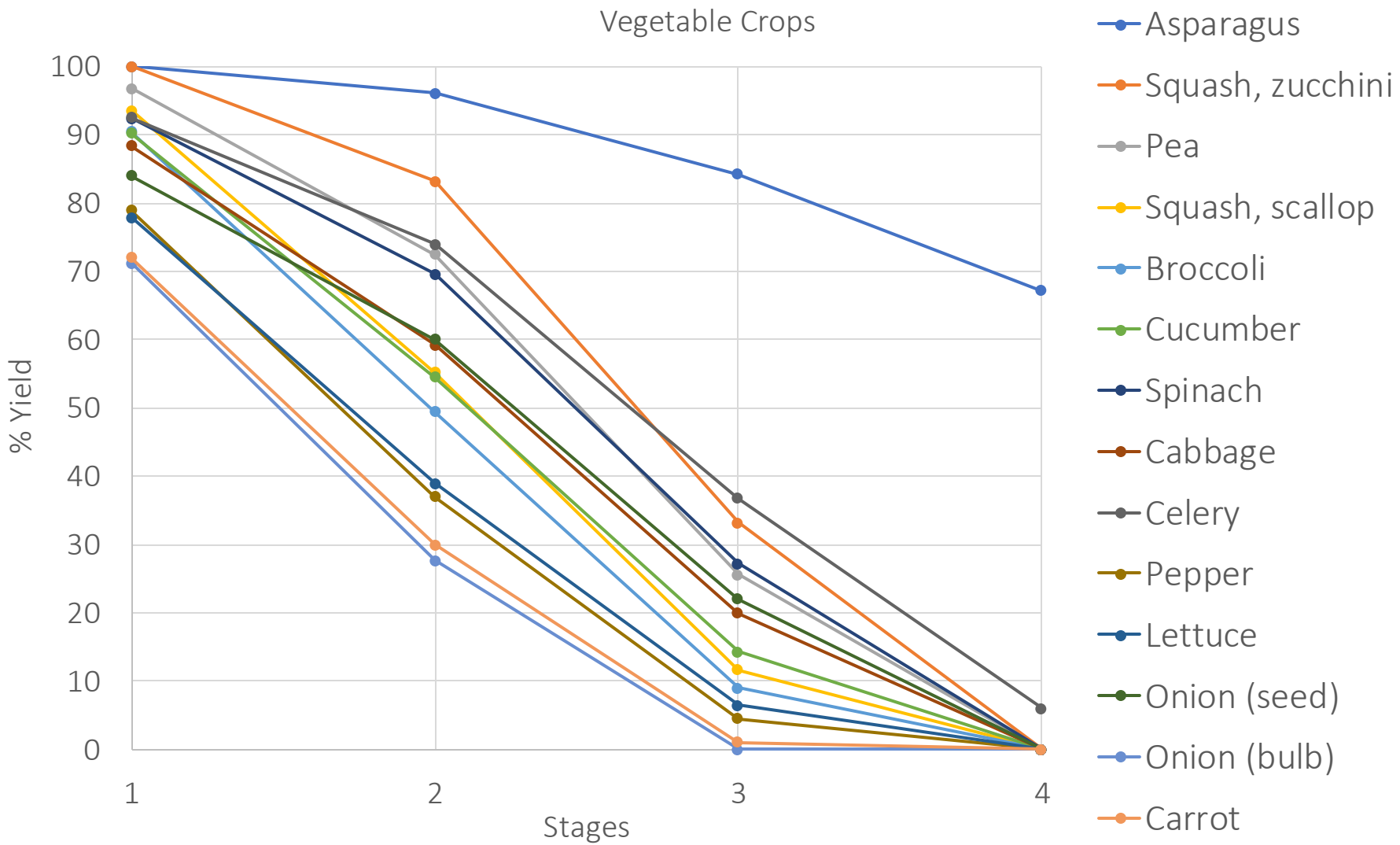


Figure 1—Generalized commodity average of the decrease in yield across four stages of soil salinity.

Crop Productivity Loss



Crop Productivity Loss



Stage Three: Well-Established, Chronic Salinization

- Strongly Saline– Forest stands exhibit severe decrease in overall vigor, increase in insect problems, sparse crown, inferior growth, increased mortality, and increased overall appearance of poor health
- Begin planning for the possibility of converting land into non-commercial use; other crops may need to be considered
- Adaptation measures –Alternative crops, conservation easements
- Probable outcomes for Stage Three land –
  At the higher salinity end of Stage Three forestry will no longer be economically profitable
- EC = 8 < 16 dS/m

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Stage Four: Noncommercial Upland

- Highly saline – Very low productivity
- Marginal economic benefit, seedlings unlikely to grow
- Adaptation Measures – conservation easement will protect inland areas, provide recreational opportunities
- Probable Outcomes – soil-water content and regular standing water will become too high and frequent to maintain many plant species
- EC = 16 < 25 dS/m

Lindsay Smart

Stage Five: Saltmarsh

- Very high salinity – influenced by the tides
- Conservation and ecosystem services
- Marsh migration
- Salt Marsh conversion to open water depends on local accretion rates and sea level rise
- EC = >25 dS/m

Nancy Gibson

Needpix

Mitigation Measures

- Water Control. Water control infrastructure such as flood gates, dikes, levees, and valves can be used to prevent some saltwater intrusion. However, these structures can also trap salinity behind them when they are overtopped.

- Irrigation Methods. Leaching soils with quality freshwater can reduce salinity in well-drained soils and conditions. In these cases, irrigation with 6 inches of freshwater can reduce salinity by up to 50 percent, though the leaching process can be slow and take several years.

- Soil amendments such as gypsum may help remove soluble salts when combined with leaching with quality water.

- Soil Health Utilize soil health management techniques described in Stage 0 by utilizing no-till or minimum tillage, improve year-round cover, adding organic amendments, and diversifying crop rotations. Refer to Conservation Practice Standards 329/345, Residue, and Tillage management.

- Shift planting dates to avoid field operations during wet/flooded conditions, control/limit heavy machinery traffic to minimize soil compaction, consider land leveling, or subsurface drainage if hydrologic conditions allow.

- Leave a field fallow for a season with weeds controlled through herbicides or shallow mechanical tillage (disking). Leaving the field fallow for a season will reduce plant transpiration which promotes leaching of salt deeper into the soil profile through increased drainage.

- Plant crops on shallow ridges or raised beds to keep plant roots above the more saline soil zone.

- Dredge or spoil material may be available for land application to add elevation to low lying fields.

- Deep Tillage. If salt is **only concentrated in the upper 5.08-10.16 centimeters (2-4 inch) depth of the soil,** deep tillage (plowing) may be a viable method to reduce salts at the surface.

- Organic amendments such as mulch, leaf compost, or biochar can be incorporated into the soil to reduce the salt concentration. These amendments help to improve soil organic carbon as well as "dilute" the salt effect by reducing sodium on a large percentage of the soil exchange sites. (clays and silts).

Adaptation Practices

- Agroforestry techniques using short-rotation woody crops (SRWC) may be utilized to increase annual harvesting frequency due to their rapid growth rates.
- Switch to growing more salt tolerant crops
- Make use of the disaster assistance programs (e.g., USDA Noninsured Crop Disaster Assistance Program (NAP))

The Human Cost

- Rural areas with high salinization (i.e., flooding) risk are often economically disadvantaged.
- Forestry and agriculture are often the primary source of county tax revenues.
- A loss of productivity reduces funding for support services
- A lack of health and medical care, nutrition programs and other and other state and county support results in a lower life expectancy, quality of life, educational opportunities and other conditions that support a cycle of impoverishment.
- Frequent flooding can reduce the availability of housing needed for land workers, compounding the problems associated with reduced land productivity.

Conclusions and Moving Forward

- Salinization will continue to impact coastal areas
- There are options for resilience to salinization
- Sea-level rise will remove thousands of acres of productive land by 2100
- The ultimate loss will be in the human quality of life in these impacted areas

Contact Information

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