# Rising to the challenge:
## Will tidal marshes survive rising seas?

NERRA
National Estuarine Research Reserve ASSOCIATION

The National Estuarine Research Reserve System has developed a powerful approach to evaluate and compare the ability of tidal marshes to thrive as sea levels rise.

Using consistently collected data from their System-wide Monitoring Program, Research Reserves applied this approach at 16 sites in 13 coastal states to create the first national-scale comparison of marsh resilience to sea level rise.

While marshes in most regions exhibited moderate resilience overall, all but one showed signs of vulnerability. Pacific Coast marshes appeared better able to track rising seas than those along the Atlantic, where two marshes in southern New England were found to be particularly vulnerable.

This open source approach can be applied at different geographic scales to shape coastal policy and management decisions focused on protecting tidal marshes, and the benefits they provide, for generations to come.

## Rising seas threaten marshes and the communities they support

Tidal marshes provide many benefits to nearby communities. They protect people and property against storm surges and flooding, improve water quality, create habitat for commercially important fish and wildlife, and offer many opportunities for outdoor enjoyment. Their ability to capture and store large amounts of carbon dioxide also makes marshes important allies in efforts to address climate change.

For millennia, many tidal marshes have persisted by increasing in elevation to keep pace with gradually rising seas. With sea levels projected to increase much faster in the near future than they have in the past, the fate of many marshes—and the benefits they provide—is uncertain.

*Drowning marsh at low elevations at Elkhorn Slough, Calif.*

*Creek bank dieback at Narragansett Bay, R.I.*

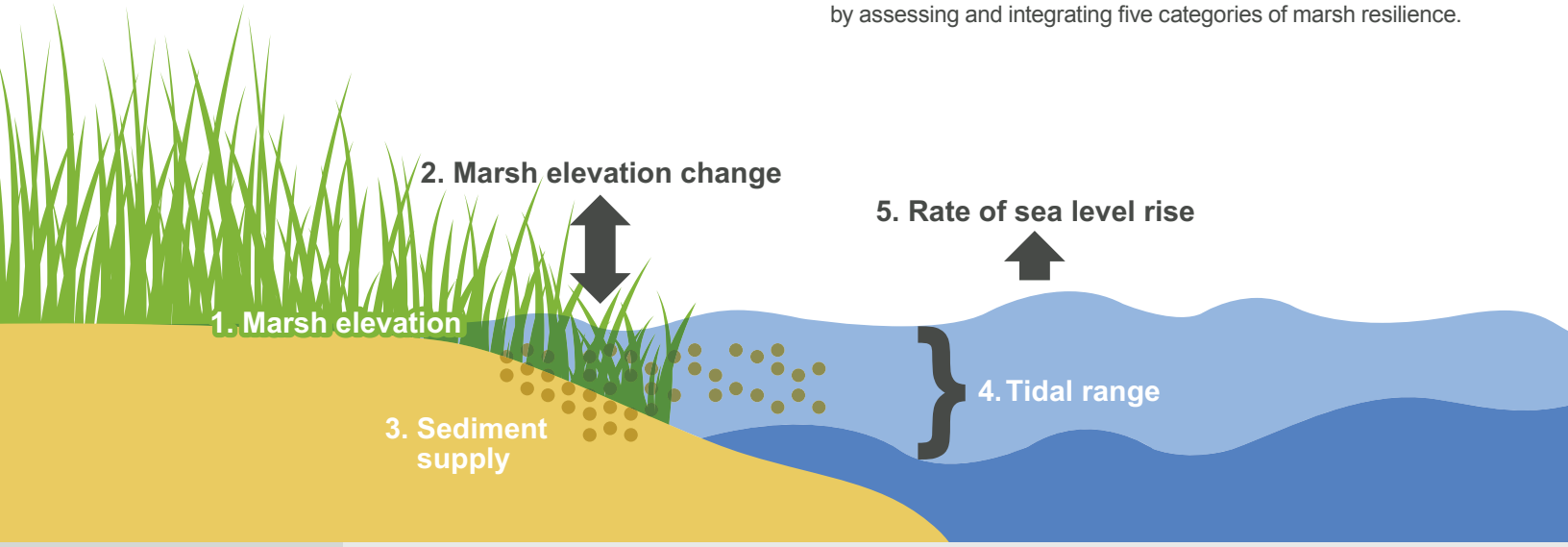
## Marshes are not equally resilient to sea level rise

Tidal marshes can only thrive within a narrow band of elevation along the coast. If they are too low, they flood with tidal water too often and their vegetation drowns. If they are too high, they dry up and are replaced by upland vegetation. Marshes maintain the right elevation by accumulating sediment carried in from a river or through soil produced by the marsh plants themselves.

Not all marshes are equally vulnerable to sea level rise. For example, the most resilient either have an ample sediment supply or can produce soil that builds up quickly enough to track with rising seas. They may also occupy a broader tidal range or experience a relatively low rate of local sea level rise. Conversely, more vulnerable marshes include those that have been disconnected from the rivers that deliver their natural sediment supply, are low-lying or sinking for reasons including excessive withdrawal of groundwater, or have already experienced rapid local sea level rise.

## Understanding differences in marsh resilience is critical

Until now, coastal decision makers have lacked effective tools to evaluate and compare the ability of marshes to persist in the face of rising seas. This information is critically needed to select the most appropriate strategies to manage a particular marsh. The Reserve System's new approach meets this need by assessing and integrating five categories of marsh resilience.




### CATEGORIES OF MARSH RESILIENCE TO SEA LEVEL RISE

1. **Marsh elevation:** Are the plants located at the high end of their tolerance to flooding so they are initially protected from inundation by rising seas?
2. **Change in elevation:** Is the marsh rising fast enough to keep pace with rising seas?
3. **Sediment supply:** Is there sufficient sediment to help build up the marsh?
4. **Tidal range:** Does the tidal range allow marsh plants to occupy a broad range of elevations so they are buffered against the effects of sea level rise?
5. **Rate of sea level rise:** Is the marsh more resilient because it has not yet been exposed to rapid local sea level rise or high water levels?

**How will tidal marshes fare in the face of sea level rise? A look at 16 marshes in the National Estuarine Research Reserve System indicates they face challenges.**

| | US State | Marsh Name and National Estuarine Research Reserve | CATEGORIES OF MARSH RESILIENCE TO SEA LEVEL RISE | | | | | Overall Resilience |
|---|---|---|---|---|---|---|---|---|
| | | | Marsh Elevation | Elevation Change | Sediment Supply | Tidal Range | Sea Level Rise | |
| EAST COAST | NH | Great Bay Discovery Center, Great Bay | | | | | | |
| | MA | Sage Lot Pond, Waquoit Bay | | | | | | |
| | RI | Nag West, Narragansett Bay | | | | | | |
| | NY | Outer Tivoli North, Hudson River | | | | | | |
| | DE | St. Jones Reserve, Delaware | | | | | | |
| | MD | Jug Bay, Chesapeake Bay | | | | | | |
| | VA | Goodwin Island Reserve, Chesapeake Bay | | | | | | |
| | NC | Masonboro Island, North Carolina | | | | | | |
| | SC | Crabhaul Creek, North Inlet-Winyah Bay | | | | | | |
| | SC | Big Bay Creek, ACE Basin | | | | | | |
| GULF | MS | Grand Bay, Grand Bay | | | | | | |
| WEST COAST | WA | Sullivan Minor, Padilla Bay | | | | | | |
| | OR | Hidden Creek, South Slough | | | | | | |
| | CA | China Camp State Park, San Francisco Bay | | | | | | |
| | CA | Upper Slough Marshes, Elkhorn Slough | | | | | | |
| | CA | Oneonta Slough, Tijuana River | | | | | | |

RESILIENCE TO SEA LEVEL RISE

Low — High

## Comparing how marshes will fare in the face of sea level rise

Research Reserves applied this approach to 16 tidal marshes in 13 states, using data collected consistently at each participating Reserve. This assessment indicated that marshes around the country face real risks as sea levels rise. All but one exhibited a low level of resilience in at least one category, even though most were found to be moderately resilient overall.

Marshes assessed along the Pacific Coast appeared more likely to persist in their current locations than Atlantic marshes, though the site with the highest overall resilience to sea level rise was an Atlantic marsh. Two marshes in southern New England were found to be the most vulnerable of those evaluated.

Resilience varied across the five categories for almost all marshes, as indicated by the combination of red and green scores in most rows in the table above. This finding highlights the importance of integrating different types of information to better understand resilience. For example, some sites with relatively high marsh elevation—generally considered to be a positive indicator of adaptation to sea level rise—are sinking. As a result, these marshes were characterized as moderately resilient once scores from each category had been integrated.

This assessment represents an initial characterization of a discrete set of marshes. As it collects more diverse sets of environmental monitoring data over time, the Reserve System is committed to building on this study to create a more robust understanding of the resilience of tidal marshes nationwide.

## Assessing resilience can help protect marshes for the future

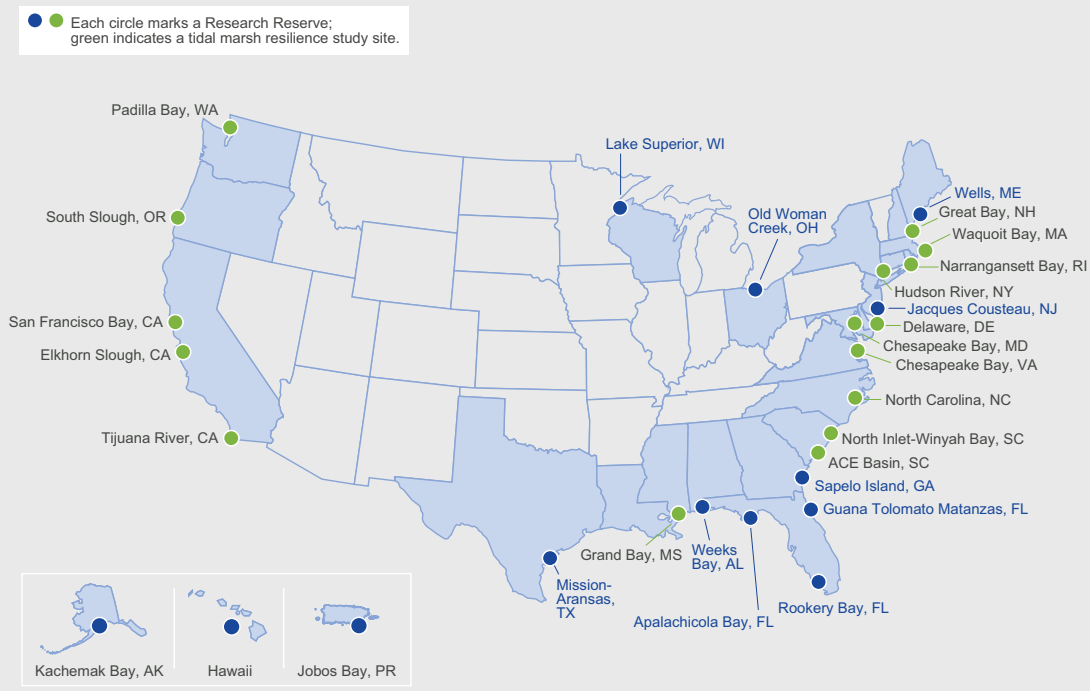
The National Estuarine Research Reserve System's new approach to assessing tidal marsh resilience to sea level rise can inform the most appropriate management strategies for a given marsh.

- **Highly resilient marshes** are likely to thrive and provide value for a long time. Ensuring that these marshes are protected through land acquisition and other means is a good investment for the future.
- **Moderately resilient marshes** can persist in their current locations if actions are taken to help them thrive, such as reconnecting them to the rivers that nourish them with sediment, decreasing the influx of polluted runoff, and removing invasive species.
- **The least resilient marshes** may not persist in their current locations. Some might be saved through intensive management strategies, such as sediment addition to raise elevation. Alternatively, managers can seek opportunities for them to migrate to higher ground. An important strategy in any region, supporting marsh migration is especially critical in areas where marshes are unlikely to survive in current footprints.

# Open source approach for assessing marsh resilience

Anyone with the relevant data can use this novel approach to compare the resilience of different marshes to sea level rise—from federal agencies managing national networks of refuges to managers of individual marsh sites. A free calculation tool is available at **www.nerra.org/marsh**. Resources there also include a detailed description of the method and the analysis of resilience in a recently published article in the journal *Biological Conservation*.

*At each Reserve across the System, scientists conduct consistent monitoring of tidal marsh plants, marsh elevation change, sedimentation, and water levels.*




National Estuarine Research Reserves collect and share timely, environmental data that reveal how estuaries respond to changes like sea level rise. This capacity for long-term monitoring across a national system allows Reserves to function as sentinel sites that can provide early warning signals to inform climate change adaptation and other management strategies.

## About the National Estuarine Research Reserve System

Established in 1972, the Reserve System is a network of special places along our nation's coasts. Reserve-based monitoring, research, education, outreach, stewardship, and decision-maker training programs provide much needed information and services to coastal communities.

Each Research Reserve is supported through a public partnership between a state and the National Oceanic and Atmospheric Administration's Office for Coastal Management.
Learn more at **https://coast.noaa.gov/nerrs**.

The National Estuarine Research Reserve Association works to strengthen the Reserve network so it can better address growing challenges to our nation's estuaries, coasts, and communities.
Learn more about what you can do to support your local Reserve at **www.nerra.org**.