COASTAL PROTECTION AND BLUE CARBON: NORTH CAROLINA

Duke NICHOLAS INSTITUTE FOR ENVIRONMENTAL POLICY SOLUTIONS

UNITED STATES CLIMATE ALLIANCE

OVERVIEW

Coastal habitats provide many benefits to people, including protecting shorelines from storm damage and storing carbon that would otherwise be released into the atmosphere. States, communities, and other decision-makers need information about the location and magnitude of these benefits, as well as how they may change in the future, so that their planning efforts can support the continued provision of all these benefits.

This project, led by the Nicholas Institute in collaboration with six mid-Atlantic states and funded by the U.S. Climate Alliance, involved spatial modeling that considers both the current status of coastal habitats and potential future changes due to sea level rise to assess habitats' ability to store carbon long-term and protect vulnerable ecological and human communities into the future. Adapting existing InVEST models developed by the Natural Capital Project kept the amount of data and computing power required relatively small, so that this work can easily be updated or extended to new areas.

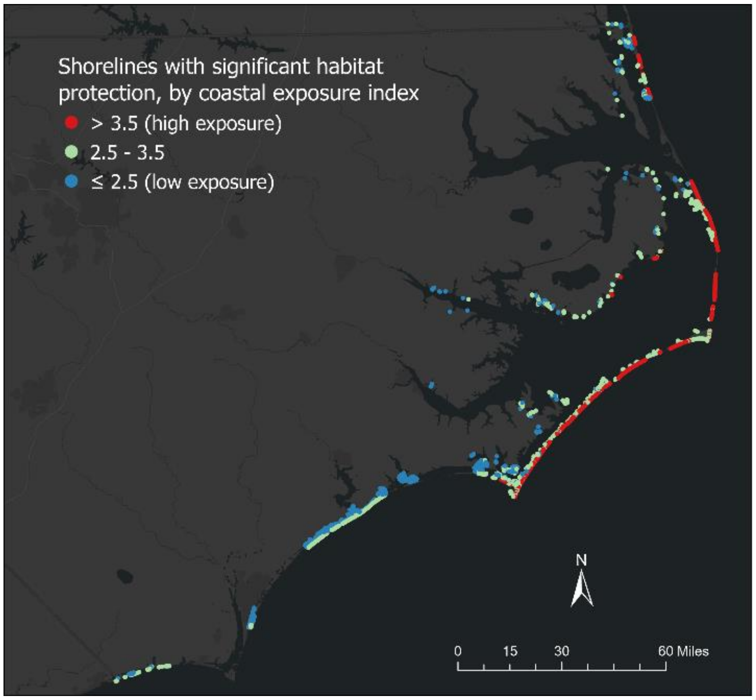
COASTAL PROTECTION

The InVEST coastal vulnerability model (Sharp et al. 2018) calculates the coastal exposure index, a relative index of coastal areas' exposure to flooding and erosion caused by storms, based on seven factors (listed to the right) that influence coastal processes leading to flooding and erosion. Coastal habitats are included in the model as a mitigating influence on coastal hazards (the presence of coastal habitats lowers the coastal exposure index). The coastal exposure index is calculated twice, once with coastal habitats included, and once as if there were no coastal habitats present, to assess the impact of coastal habitats on exposure to coastal hazards.

Coastal vulnerability factors

- Wave exposure
- Wind exposure
- Storm surge
- Sea level rise
- Geomorphology
- Relief
- Coastal habitats

With input from the state team, we adjusted the model to account for the likelihood that wider areas of marshes and coastal forests provide better protection, and reduced the weight of the sea level rise factor due to the limited geographic scope of sea level rise projections. Details on the methodology and datasets used are available here.



This map shows the parts of the North Carolina shoreline that benefit from strong habitat protection from hazards. These protected areas are color-coded to show how exposed to coastal hazards each part of the coastline is – higher scores (red) indicate greater exposure to threats such as storm surge and erosion, where the habitat protection is especially important. The Outer Banks are particularly well-protected by their dunes, marshes, and seagrass beds.

You can explore the coastal protection maps for North Carolina, including the scores for each individual factor and the effects of specific habitat types, here.

This table shows how much of the North Carolina shoreline is receiving protection from each type of coastal habitat. The middle column includes all shoreline close enough to the habitat to get some protective benefit. The right column only counts shoreline that is significantly protected by habitat (its coastal exposure index increases by at least 20% without the existing coastal habitats). Some habitat types, like seagrass, are widespread but don't have a high protective capacity, so the total length of shoreline they protect is much more than the length of shoreline with significant habitat protection that they help to protect. Other habitat types, like dunes, are concentrated in specific areas but provide strong coastal protection.

Habitat type	Total length of shoreline protected, km	Length of shoreline with significant habitat protection protected, km
Marsh 100-1000 m wide	3,498	417
Seagrass	2,747	185
Coastal forest	1,729	417
Marsh 10-100 m wide	619	106
Oyster	525	76
Low dunes	296	178
High dunes	223	104

COASTAL HABITAT CHANGE WITH SEA LEVEL RISE

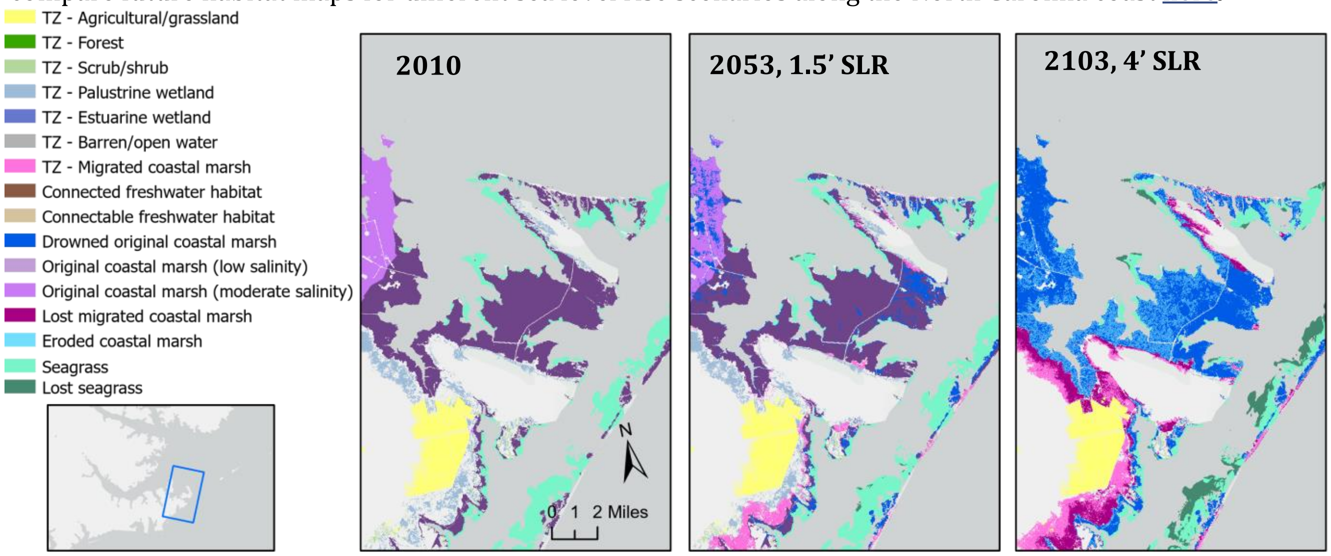
Climate change is causing sea level to rise globally; in North Carolina, sea levels are projected to rise by four feet over 2010 levels by the end of the century (Sweet et al. 2017, intermediate scenario). Coastal marshes are very sensitive to sea level, and most of those around NC are expected to drown because they will not be able grow vertically to keep up with rising seas. Sea level rise can also inundate new areas, making them suitable for marsh migration if they are not already developed.

We mapped future coastal habitat extent and location under sea level rise, incorporating the three possible responses of marshes to rising seas: vertical accretion, loss via drowning or erosion, and inland migration as sea level rise inundates new areas and replaces existing habitats. Additional details on the data and methodology for this analysis are available here.

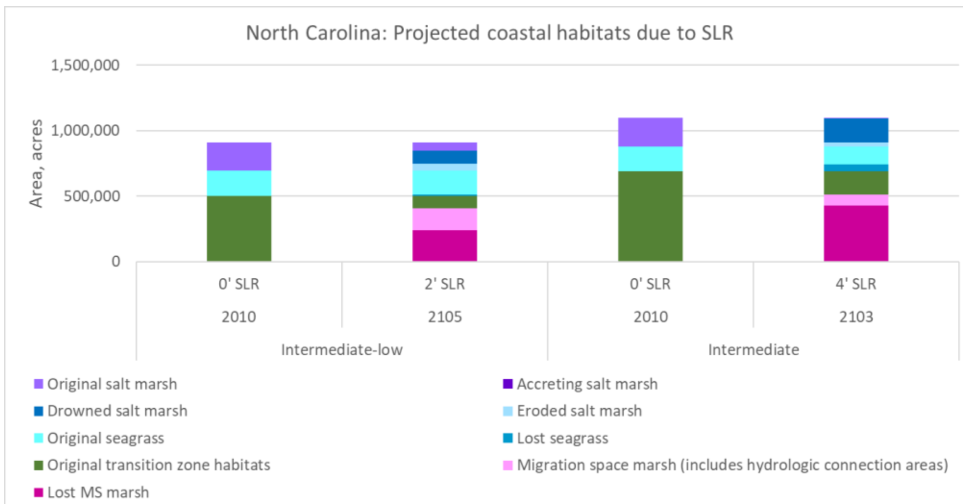
The rate of sea level rise that the North Carolina coast will experience is not certain. We created future coastal habitat maps for two different sea level rise scenarios: regional mean intermediate-low and intermediate scenarios from a national assessment (Sweet et al. 2017), which project about 2 and 4 feet of sea level rise by 2100, respectively.

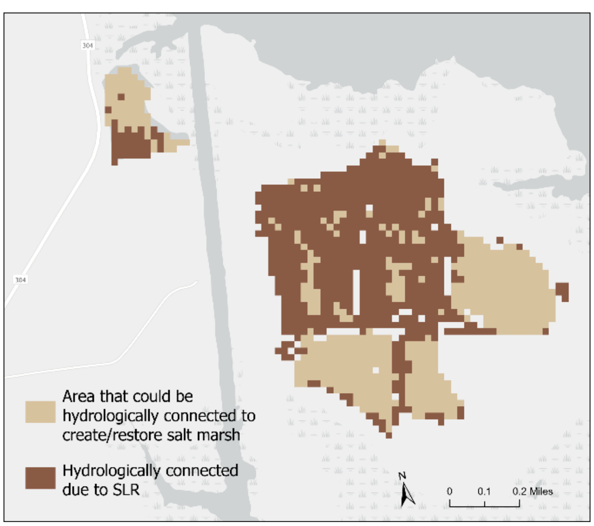
Also included in this analysis are areas that could be hydrologically connected to saline waters to restore or create salt marsh. Freshwater wetlands and open bodies of freshwater, whether they were disconnected from tidal flows by infrastructure, purposely blocked for waterfowl or mosquito management, or naturally freshwater, likely emit large amounts of methane, a potent greenhouse gas. Hydrological connection is expected to reduce methane emissions by increasing salinity; in some places, sea level rise is likely to cause this connection without additional human intervention. Some of these areas overlap with places where marsh is expected to migrate due to sea level rise; the key difference is that these areas are identified as having potential for salt marsh creation or restoration currently, even without sea level rise.

This map shows projected coastal habitat changes around Cedar Island National Wildlife Refuge. You can compare future habitat maps for different sea level rise scenarios along the North Carolina coast here.



North Carolina's coastal marshes are vulnerable to sea level rise. Under the modeled sea level rise scenarios, 72-98% of present-day marshes are projected to drown or erode – up to 212,000 acres of marsh loss (about 160,000 football fields) under the highest sea level rise scenario. Large areas of migration space in the coastal plain provide an opportunity to compensate for some of that loss – in the lowest SLR scenario, there may be slightly more coastal marsh in 2100 than currently exists – but the potential for marsh migration decreases at higher sea level rise elevations. These projections include estimates of increased development over time, reducing the area available for marsh migration. In addition, North Carolina is projected to lose 6-27% of present-day seagrass beds due to increased water depth from sea level rise.



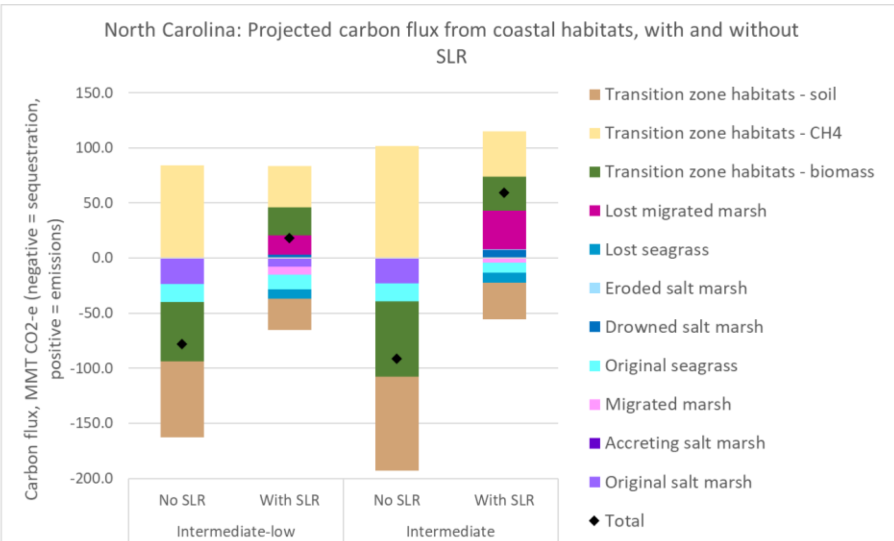


In total, we identified about 5,400 acres where hydrological connection could create or restore salt marsh. Just under 10% of this area is predicted to be connected by sea level rise for each of the three scenarios, leaving about 4,900 acres where connection projects could be targeted to reduce methane emissions.

This map shows hydrologic connections due to sea level rise (under the intermediate scenario) by the end of the century, and remaining areas that could be hydrologically connected to create or restore salt marsh, near Jones Bay.

BLUE CARBON MODELING

Coastal marshes and seagrass store large amounts of carbon in their sediment, preventing its release into the atmosphere, where it would contribute to global warming. So do terrestrial and freshwater wetland habitats coastal areas. While these habitats persist, they accumulate additional carbon; the effective rate of accumulation in wetland habitats depends on their salinity, because low-salinity habitats emit much more methane than high-salinity areas. North Carolina coastal marshes and seagrass currently store about 80 million metric tons CO_2-e and sequester an additional 308,000 metric tons each year. When marshes drown or erode, and when marshes migrate inland and replace freshwater and terrestrial habitats, a portion of the carbon stored in the original habitat type is emitted. Therefore, the projected coastal habitat changes due to sea level rise have significant implications for future blue carbon storage and emissions. We modified the InVEST coastal blue carbon model to explore these effects. Details on the data and methods are available here.



Over the next 100 years, North Carolina's coastal habitats are projected to sequester up to 165% less carbon than they would if they were not affected by sea level rise. This difference is greater than 100% because the coastal habitats may become net sources of carbon, rather than net carbon sinks, due to emissions from lost habitats. For the highest sea level rise scenario, the lost carbon sequestration potential due to sea level rise is approximately equal to the greenhouse gas emissions from 32.4 million cars driven for one year.

There is high uncertainty about how much stored carbon is lost when marshes drown or erode; the results shown here are from our primary model projection, modified with input from our North Carolina partners. See the research paper for more information on key sources of uncertainty.

USING THESE DATA

The maps and data shown here are available to use in online maps and to download for further analysis. This information can be used in a variety of ways, including communication with stakeholders, building blue carbon inventories, and long-term coastal planning.

ACKNOWLEDGEMENTS

This work was funded by the U.S. Climate Alliance. The analysis was conducted by Katie Warnell (Duke University). Thanks to Lora Eddy (TNC-NC), Stacey Feken (APNEP), and Sarah Spiegler (NC Sea Grant) for their feedback on the methods, data, and results, and to Lydia Olander (Duke University) and Carolyn Currin (NOAA) for their guidance on this project. Banner image credit: NC Wetlands.

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