# COASTAL PROTECTION AND BLUE CARBON: MID-ATLANTIC STATES

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.

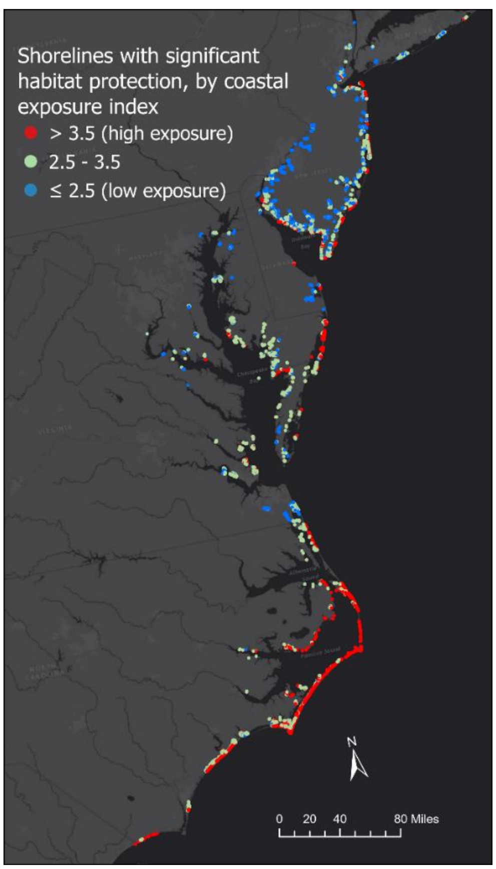
This project, led by the Nicholas Institute in collaboration with six mid-Atlantic states, involved spatial modeling that considers both the current status of coastal habitats and potential future changes due to sea level rise to assess habitats' ability to store carbon long-term and protect vulnerable 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 each 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. The final model parameters used for each state differed slightly; details on the methodology and datasets used are available here. The regional version of the model shown here used consistent parameters and compared shoreline areas across the entire study area rather than within each state.

This map shows the parts of the mid-Atlantic 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.  North Carolina has the most high-exposure shoreline protected by habitats due to its extensive barrier islands that are protected by dunes. New Jersey also has a large amount of shoreline protected by habitats; most of these areas are bays or inlets protected by marshes and coastal forests, so they have lower overall exposure scores. You can explore the coastal protection maps for each state, including the scores for each individual factor and the effects of specific habitat types, here.

This table shows how much of the 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 coastal forests and 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 | 15,802 | 1,630 |
| Seagrass | 7,609 | 562 |
| Marsh 10-100 m wide | 6,456 | 1,066 |
| Coastal forest | 3,916 | 981 |
| Low dunes | 1,016 | 368 |
| Marsh <10 m wide | 885 | 34 |
| High dunes | 727 | 219 |
| Oyster | 92 | 9 |

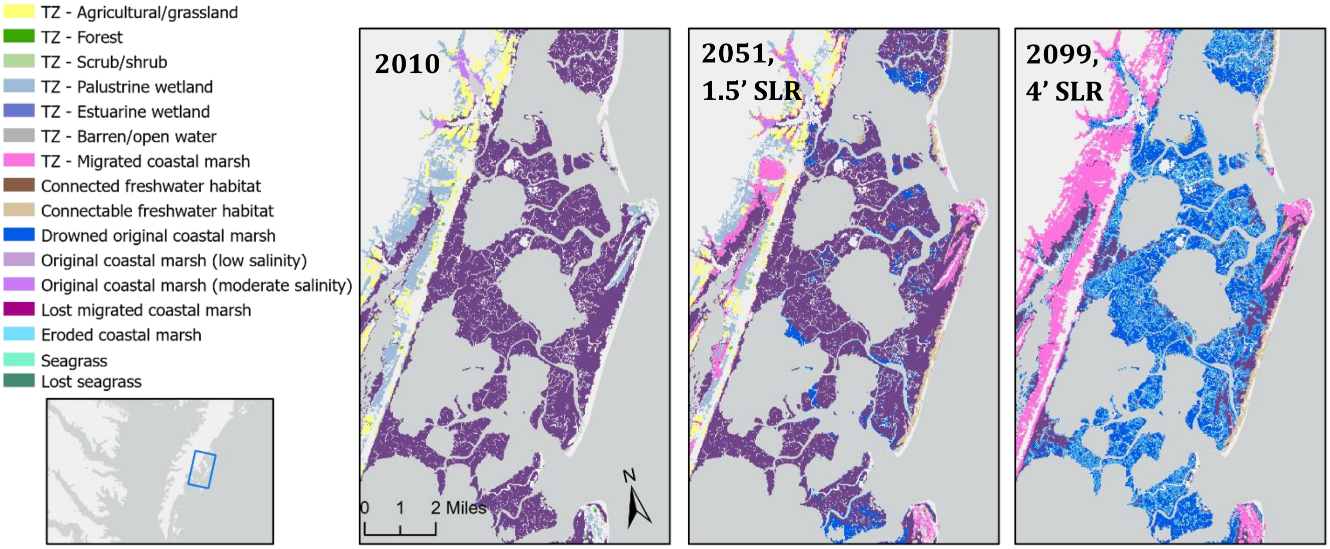
## COASTAL HABITAT CHANGE WITH SEA LEVEL RISE

Climate change is causing sea level to rise globally; in the mid-Atlantic region, sea levels are projected to rise by four feet over 2010 levels by the end of the century (Sweet et al. 2017, intermediate scenario). The rate of sea level rise that this area will experience is not certain. On the regional scale, we created future coastal habitat maps for an intermediate sea level rise scenario from a national assessment (Sweet et al. 2017), which project about 4 feet of sea level rise by 2100. Additional sea level rise scenarios were used for individual states.

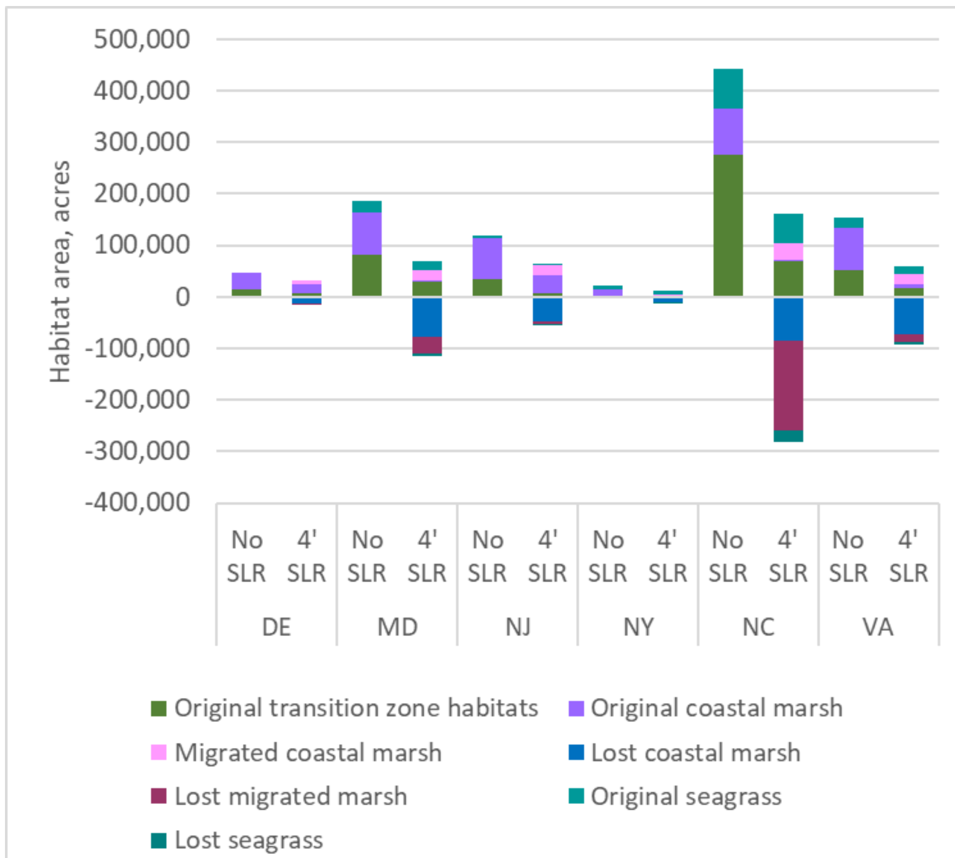
We mapped future coastal habitat extent and location under sea level rise, incorporating the three possible responses of marshes to rising seas: vertical accretion, loss via drowning or erosion, and inland migration as sea level rise inundates new areas and replaces existing habitats. Seagrass loss due to increased water depth, which limits light availability, was also included in the model. Additional details on the data and methodology for this analysis are available here.

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 Swash Bay, Virginia. You can compare future habitat maps for different sea level rise scenarios along each state's coast here.



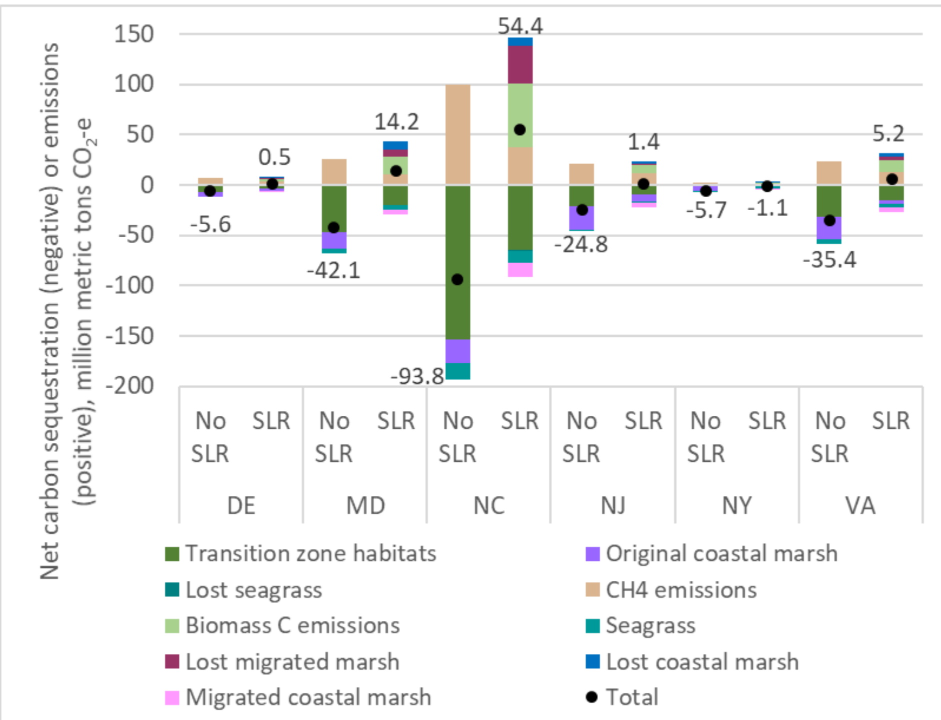

Mid-Atlantic coastal marshes are vulnerable to sea level rise. States are projected to lose 42% to 98% of present-day marshes to drowning or erosion under the 4' sea level rise scenario. This represents 759,000 acres of marsh loss (about 574,000 football fields) across all of the states. Migration space in the coastal plain provides an opportunity to compensate for some of that loss, especially in North Carolina and Maryland, but is not sufficient to offset the drowned and eroded marsh. These projections include estimates of increased development over time, reducing the area available for marsh migration. Mid-Atlantic states were also projected to lose 2% to 68% of present-day seagrass beds, or about 86,000 acres.




In total, we identified about 42,000 acres where hydrological connection could create or restore salt marsh. New Jersey and Virginia have the greatest amounts of these areas. Across all states, about 12% of this area is predicted to be connected by sea level rise for each of the three scenarios, leaving about 37,000 acres where connection projects could be targeted to reduce methane emissions.

## BLUE CARBON MODELING

Coastal marshes and seagrass store large amounts of carbon in their sediment, preventing it from being released into the atmosphere and contributing to global warming. While these blue carbon habitats persist, they accumulate additional carbon; the effective rate of accumulation depends on their salinity, because low-salinity habitats emit much more methane than high-salinity areas. Coastal marshes and seagrass in these six states currently store about 301 million metric tons $CO_2$-e and sequester an additional 1.1 million metric tons each year. Freshwater wetland and terrestrial habitats in the transition zone currently store about 447 million metric tons $CO_2$-e and sequester 732,000 metric tons annually. When habitat changes occur due to sea level rise, 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 used for this analysis are available here.




Over the next 100 years, the coastal zone in the mid-Atlantic states in our study area is projected to switch from a net carbon sink to a net source of carbon, emitting 74.6 million metric tons $CO_2$-e, due to carbon emissions from lost habitats. New York is the only state where the coastal zone is projected to remain a net carbon sink. For the 4' sea level rise scenario, the additional carbon emissions due to sea level rise, compared to an alternate scenario with no habitat change, is approximately equal to the greenhouse gas emissions from 60.7 million cars driven for one year.

There is high uncertainty about many of the habitat change and carbon processes included in the model; the results shown here are from our primary model projection. See the research paper for more information on key sources of uncertainty. The numbers above or below the bars are the net carbon flux through the end of the century, equal to carbon emissions (positive) minus sequestration (negative).

## 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 members of each state team 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: U.S. Fish & Wildlife Service.