North Carolina

# Climate Risk Assessment and Resilience Plan

## Impacts, Vulnerability, Risks, and Preliminary Actions

# Appendix B: North Carolina Natural and Working Lands Action Plan

June 2020

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# North Carolina
# Natural and Working Lands Action Plan

Turnball Creek Educational State Forest in Bladen County. (Photo courtesy of North Carolina Forest Service)

## June 2020


# Purpose of the
# North Carolina Natural and Working Lands Action Plan

The purpose of the North Carolina Natural and Working Lands Action Plan (referred to as the NWL Action Plan) is to identify and create opportunities and outline specific projects for North Carolina's natural and working lands (NWL) that sequester carbon, build ecosystem and community resilience, provide ecosystem benefits, and enhance our economy. This action plan can be used by 1) public and private landowners and managers; 2) impact partners such as universities, nonprofit organizations, corporations, land-use consultants and investors; and 3) federal, state and local planners, and policymakers to facilitate meeting North Carolina's goals identified under the plan. Specifically, the NWL Action Plan addresses the following issues:

- Define the stakeholders' shared goals developed for the NWL Action Plan;
- Present the current state of our NWL;
- Quantify the potential impact of various actions;
- Recommend specific actions that facilitate meeting the shared goals;
- Identify implementation pathways, partners, and funding to facilitate taking action;
- Discuss roadblocks currently preventing the use of certain action pathways; and
- Encourage working on broad policy initiatives that would greatly enhance meeting our goals.

The writers of this document recognize that working to improve NWL requires a great deal of time, planning, organizing, collaborating, and funding. This plan seeks to identify and prioritize short-term, cost-effective, and pragmatic solutions, as well as identifying longer-term actions that require more effort and funding, including potential legislative or programmatic changes. The writers also see this plan as a "living document" with periodic updates and progress reports.

## Acknowledgments

We are thankful to all the stakeholders, subcommittee members, and partner organizations who gave their time and effort freely to work on this plan. Without their support and guidance, the recommendations would not have taken shape. We specifically thank Rick Savage of the Carolina Wetlands Association for working on all the subcommittees, providing much-needed cohesion for the plan, and assisting on writing and editing the document. In addition, we thank the Nicholas Institute for Environmental Policy Solutions - Ecosystem Services Program for developing much of the data used in the plan and the Storymaps. We also thank the US Climate Alliance and its partners for peer-reviewing the draft plan.

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# 1.0 Overview of the NWL Action Plan Process

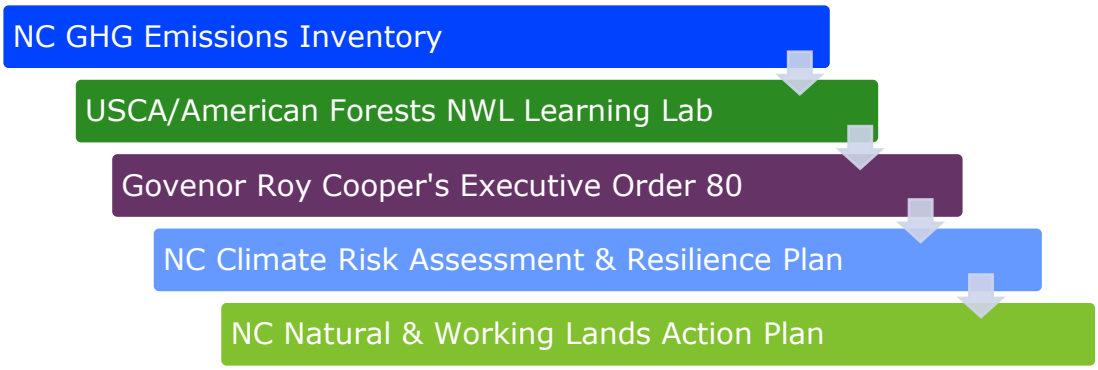
## 1.1 Directives Calling for the NWL Action Plan

The North Carolina Natural and Working Lands Action Plan (referred to as the NWL Action Plan) took shape in the summer of 2018. The North Carolina Department of Environmental Quality (DEQ) was in the process of building a statewide greenhouse gas (GHG) inventory that included the NWL sector. The inventory indicated that the NWL sector was sequestering significant amounts of carbon (See Section 4.3 North Carolina Greenhouse Gas Inventory).

In addition to this work, representatives from North Carolina attended the US Climate Alliance and American Forests' Learning Lab in Washington, DC, in July of 2018.[1] This lab assisted states with examining their current carbon mitigation strategies for NWL and identifying new policy, program, and finance mechanisms to create opportunities for NWL solutions to climate change. The lab was led by more than 50 leading experts in the field of land-based carbon mitigation from government, academia, nonprofits, landowners and industry. North Carolina's team members came away with some high-level examples of how to increase carbon sequestration in the State as well as a methodology for building the action plan.

Then, in October of 2018, Governor Roy Cooper issued Executive Order 80 (EO80).[2] This Executive Order presents Governor Roy Cooper's goals to reduce the impacts and risks of climate change in our State by 2025. Two of the primary goals are 1) to reduce statewide GHG to 40% below 2005 levels and 2) develop the North Carolina Climate Risk Assessment and Resilience Plan. Figure 1-1 shows how the NWL Action Plan fits into North Carolina's efforts to mitigate GHG emissions and build resilience.

**Figure 1-1: How the NWL Action Plan Supports EO80**




[1] American Forests Newsroom. (2018, July 16). "American Forests Hosts Unprecedented Collaborative Action on the Part of Government and Concerned Experts". Retrieved from https://www.americanforests.org/media-release/states-surge-ahead-on-plans-to-slow-climate-change-with-land/

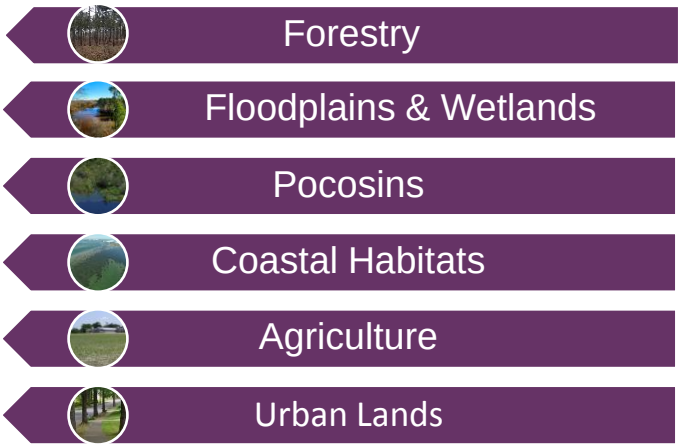
[2] North Carolina Governor's Office. (2108, October 29). *Executive Order No. 80: North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy*. Retrieved from https://governor.nc.gov/documents/executive-order-no-80-north-carolinas-commitment-address-climate-change-and-transition

The NWL sector is unique because it can 1) mitigate the impacts of climate change by removing carbon from the atmosphere and 2) build adaptive capacity and resilience to climate change-related weather events and stressors. The NWL Action Plan is being incorporated into the North Carolina Risk Assessment and Resilience Plan because many of the recommendations in this plan can be used by North Carolina's state and local government agencies to begin building resilience.

## 1.2 Overview of Stakeholder Process

In October and December of 2018, DEQ convened the NWL Stakeholder Group consisting of private and public landowners and managers, scientists, policymakers, and planners from state and local governments, universities, consulting firms, and nonprofit organizations. The purpose of the group was to discuss potential carbon sequestration opportunities available in the NWL sector. At the end of the December 2018 meeting, the group resolved to build an NWL action plan. One of the key decisions coming out of the meeting was to include building resilience to extreme weather events using NWL. The State was struggling with recovering from hurricane-related flooding events in 2016, 2017, and 2018.

After the December Stakeholder Workgroup meeting, attendees formed subcommittees that would focus on a particular land sector. The land sectors included the following:




The subcommittees met numerous times over a nine-month period in 2019 to develop a set of recommendations for actions North Carolina could take to both sequester carbon and build resilience to extreme weather events. To facilitate this process, the DEQ supplied each group with a matrix to document various aspects of each proposed recommendation, including;

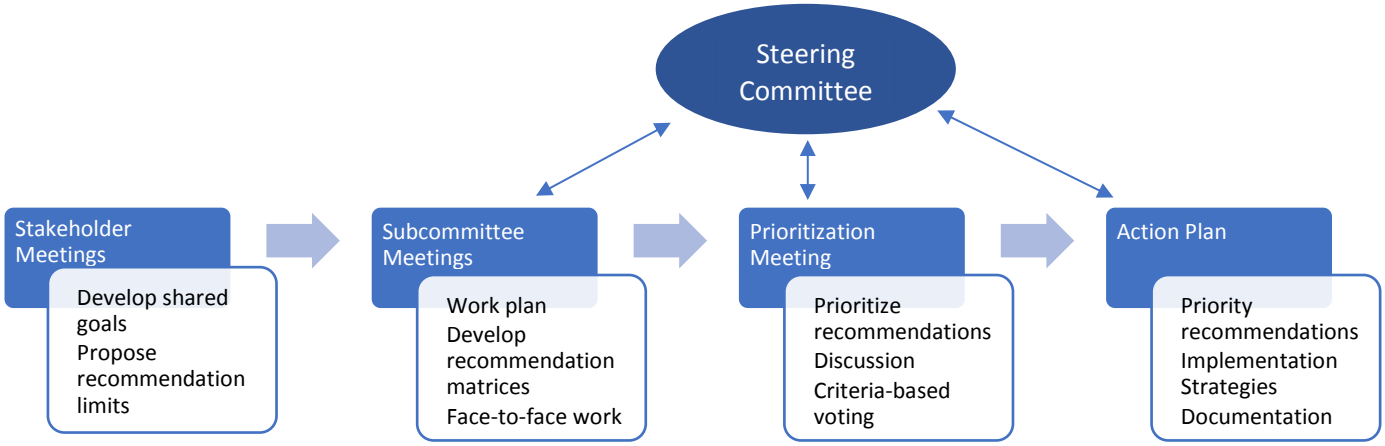
- Information on land and landowners,
- Feasibility of implementation, including a time frame, authority, and complexity,
- Barriers, including legal, cultural, and informational, and
- Required resources, including funding and staffing.

A steering committee was also formed consisting of the subcommittee leads, DEQ facilitators of the NWL Action Plan, and key facilitators of the North Carolina Risk Assessment and Resilience Plan. The steering committee guided the process and deliverables for the NWL Action Plan.

Over a two-day period in October of 2019, stakeholders prioritized the list of recommendations that would be included in the formal action plan. An evaluation criterion was set prior to the meeting that was created by the steering committee. Each recommendation was presented by a subcommittee representative and time was allotted for discussion and questions. Subcommittee members voted on all the recommendations, regardless of which subcommittee developed them. The recommendations that met the criteria and obtained a majority consensus as a priority are included in the plan.[3] Figure 1-2 shows the process for developing the NWL Action Plan.

*Discussions during the prioritization led to elevating social equity as a shared goal to ensure it is adequately addressed when implementing actions.*

**Figure 1-2: Process Flow for Development of NWL Action Plan**




## 1.3 Stakeholder Shared Goals for Natural and Working Lands

The stakeholders identified five shared core goals for the NWL Action Plan shown in Table 1-1. These goals helped to guide the subcommittee work in developing and prioritizing recommendations.

**Table 1-1: Stakeholders' Shared Goals for the NWL Action Plan**

| No. | Shared Core Goal |
|---|---|
| 1. | Enhance the ability of NWL to sequester carbon and mitigate GHG emissions. |
| 2. | Build resilience in ecosystems and communities. |
| 3. | Provide public health and ecosystem co-benefits. |
| 4. | Create economic opportunities for agribusiness, recreation, and tourism. |
| 5. | Ensure implementation of any action is a socially equitable process. |

[3] All the recommendations that were considered are documented in the matrices and are available on request.

In addition, the stakeholders also identified limitations on the types of recommendations that should be considered. These limitations also guided the recommendation development and prioritization process and are presented below in Table 1-2.

**Table 1-2: Limitations on Recommendations**

| No. | Limitation on Recommendations |
|---|---|
| 1. | Develop actions with large potential for both carbon benefits and resilience. |
| 2. | Focus on realistic options for North Carolina in the near-term by leveraging existing programs, authorities, resources. |
| 3. | Utilize cost-effective and pragmatic solutions. |
| 4. | Investigate long-term actions to create new and larger opportunities for NWL climate mitigation and resilience. |

These shared goals and recommendation parameters were used by DEQ to develop a work plan for developing recommendations. Each subcommittee lead was given the work plan to focus the efforts of the subcommittee members.

## 1.4 List of Participants

Table 1-3 lists the members of each subcommittee and their respective leads. The leads for the subcommittees facilitated the subcommittee meetings, developed work products and participated on the Steering Committee. Many members participated on multiple subcommittees; however, they are listed only once for brevity.

**Table 1-3: Subcommittee Members**

| Name | Organization | Subcommittee |
|---|---|---|
| Sushma Masemore | DEQ, Assistant Deputy Secretary for Environment | Facilitator |
| Paula Hemmer | DEQ, Division of Air Quality | Facilitator |
| Sarah Wiener | US Department of Agriculture, Southeast Climate Hub | Agriculture - Lead |
| Laura Lengnick, PhD | Cultivating Resilience, LLC | Agriculture - Lead |
| Tatjana Vujic, JD | Duke University | Agriculture - Lead |
| Bruce Fulford | City Soil | Agriculture |
| Amy Keister | Compass USA | Agriculture |
| Angie Maier | NC Pork Council | Agriculture |
| Debbie Hamrick | NC Farm Bureau | Agriculture |
| Jeana Myers | Wake County Extension | Agriculture |
| Joseph Hundycia | NC Department of Agriculture and Consumer Services | Agriculture |
| Justin Baker, PhD | Research Triangle Institute | Agriculture |
| Keith Larick | NC Farm Bureau | Agriculture |
| Dr. Lee Miller, JD | Duke University | Agriculture |
| Michael Gavazzi | US Department of Agriculture, Southeast Climate Hub | Agriculture |
| Michelle Lovejoy | NC Foundation for Soil and Water Conservation | Agriculture |

| Name | Organization | Subcommittee |
|---|---|---|
| Nancy Creamer, PhD | NC State University | Agriculture |
| Rafael Vega | USDA, Natural Resources Conservation Service | Agriculture |
| Sarah Blacklin | NC Choices | Agriculture |
| Sue Ellen Johnson, PhD | Regenerative and Resilient, LLC | Agriculture |
| Rick Savage | Carolina Wetlands Association | Agriculture |
| Maggie Monast | Environmental Defense Fund | Agriculture |
| Mike Yoder, Ph.D. | Associate Director, NC State Extension | Agriculture |
| Tom Hoban, Ph.D. | Environmental Communication Solutions | Agriculture |
| Jacob Boyd | DEQ, Division of Marine Fisheries | Coastal Habitats - Lead |
| Bill Crowell | DEQ, Albemarle-Pamlico National Estuary Partnership | Coastal Habitats |
| Paul Cough | DEQ, Albemarle-Pamlico National Estuary Partnership | Coastal Habitats |
| Anne Deaton | DEQ, Division of Marine Fisheries | Coastal Habitats |
| Brian Boutin | The Nature Conservancy | Coastal Habitats |
| Carolyn Currin, PhD | National Oceanic and Atmospheric Administration | Coastal Habitats |
| Casey Knight | DEQ, Division of Marine Fisheries | Coastal Habitats |
| Cat Bowler | National Audubon Society | Coastal Habitats |
| Heather Clarkson | Defenders of Wildlife | Coastal Habitats |
| Jimmy Johnson | DEQ, Albemarle-Pamlico National Estuary Partnership | Coastal Habitats |
| Lora Eddy | The Nature Conservancy | Coastal Habitats |
| Rebecca Ellin | DEQ, Division of Coastal Management | Coastal Habitats |
| Sarah Spiegler | NC Sea Grant | Coastal Habitats |
| Trish Murphey | DEQ, Albemarle-Pamlico National Estuary Partnership | Coastal Habitats |
| Rick Savage | Carolina Wetlands Association | Coastal Habitats |
| Lydia Olander, PhD | Duke University | Floodplains - Lead |
| Katie Warnell | Duke University | Floodplains - Lead |
| Caitlin Burke | Conservation Trust for North Carolina | Floodplains |
| Barbara Doll, Ph.D. | NC State University | Floodplains |
| Chris Canfield | Conservation Trust for North Carolina | Floodplains |
| Ana Barros, Ph.D. | Duke University | Floodplains |
| Danica Schaffer-Smith, PhD | The Nature Conservancy | Floodplains |
| Lauren Patterson | Duke University | Floodplains |
| Michael O'Driscoll, PhD | Duke University | Floodplains |
| Julie DeMeester, PhD | The Nature Conservancy | Floodplains |
| Paxton Ramsdell | Environmental Defense Fund | Floodplains |
| Periann Russell | DEQ, Division of Mitigation Services | Floodplains |
| Rick Savage | Carolina Wetlands Association | Floodplains |
| Will McDow | Environmental Defense Fund | Floodplains |
| Misty Buchanan | Department of Natural and Cultural Resources | Forestry - Lead |
| Jessie Birckhead | NC Wildlife Resources Commission | Forestry - Lead |
| Barry New | NC Forest Service | Forestry – Lead |
| Mark Megalos, PhD | NC State University | Forestry - Lead |
| Steve McNulty, PhD | US Department of Agriculture, Southeast Climate Hub | Forestry |
| Tatyana Ruseva | Appalachian State University | Forestry |

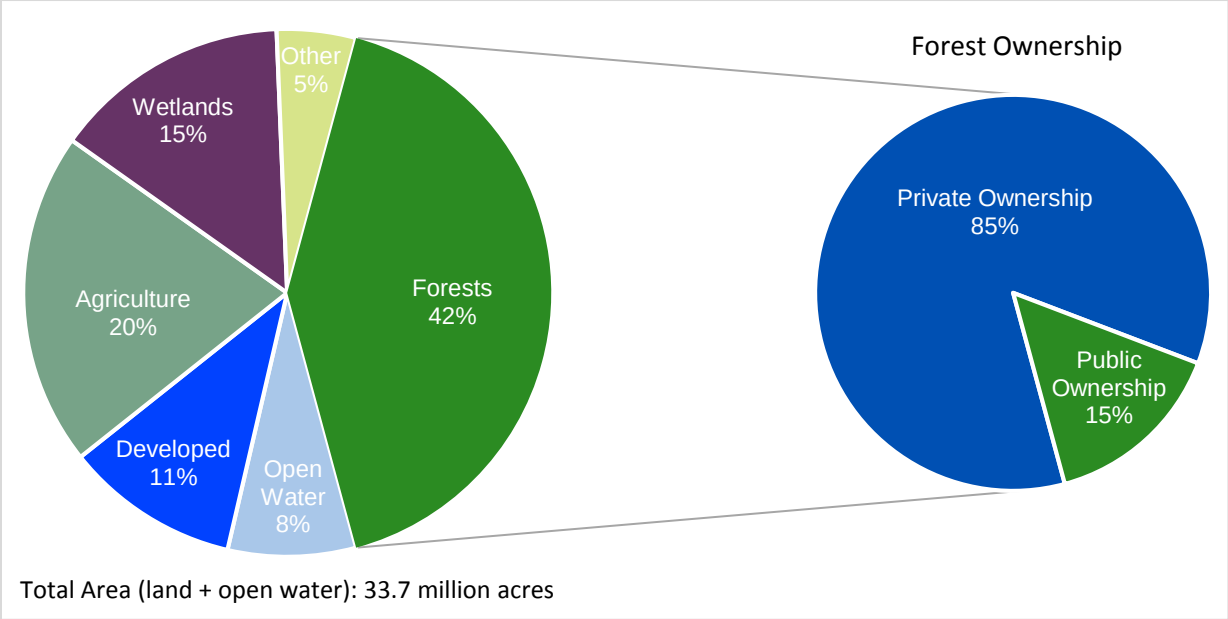
| Name | Organization | Subcommittee |
|---|---|---|
| Emily Zucchino | Dogwood Alliance | Forestry |
| Sam Davis | Dogwood Alliance | Forestry |
| Rickie White | Ellerbe Creek Watershed Association | Forestry |
| Grace Lawrence | Department of Commerce | Forestry |
| Christopher Galik, PhD | NC State University | Forestry |
| John Hatcher | NC Forestry Association | Forestry |
| Chris Canfield | Conservation Trust For North Carolina | Forestry |
| Rusty Painter | Conservation Trust for North Carolina | Forestry |
| Mary Lou Addor, PhD | NC State University | Forestry |
| Rick Savage | Carolina Wetlands Association | Forestry |
| Tony Doster | Resource Management Service, LLC | Forestry |
| Sara Ward | US Fish and Wildlife Service | Pocosins - Lead |
| Stacey Feken | DEQ, Albemarle-Pamlico National Estuary Partnership | Pocosins |
| Amin Davis | DEQ, Division of Water Resources | Pocosins |
| Bob Williams | Pine Creek Forestry | Pocosins |
| Chuck Peoples | The Nature Conservancy | Pocosins |
| Curt Richardson, PhD | Duke University | Pocosins |
| Emily Bernhardt, PhD | Duke University | Pocosins |
| Emily Pindilli, PhD | US Geologic Survey | Pocosins |
| Eric Hinesley, PhD | NC State University | Pocosins |
| Eric Soderholm | The Nature Conservancy | Pocosins |
| Kris Bass | Kris Bass Engineering | Pocosins |
| Lindsey Smart, PhD | NC State University | Pocosins |
| Marcelo Ardon-Sayao, PhD | NC State University | Pocosins |
| Mike Burchell, PhD | NC State University | Pocosins |
| Kim Matthews | Research Triangle Institute | Pocosins |
| Heather Clarkson | Defenders of Wildlife | Pocosins |
| Scott Pohlman | Department of Natural and Cultural Resources | Pocosins |
| Rick Savage | Carolina Wetlands Association | Pocosins |
| Wenhong Li, PhD | Duke University | Pocosins |
| Rick Savage | Carolina Wetlands Association | Urban Lands -Lead |
| Kim Matthews | Research Triangle Institute | Urban Lands -Lead |
| Emily Barrett | Town of Cary | Urban Lands -Lead |
| Chad Guthrie | Carolina Wetlands Association | Urban Lands |
| Amber Weaver | City of Asheville | Urban Lands |
| Donald Belk | City of Raleigh | Urban Lands |
| Kenneth Waldroup | City of Raleigh | Urban Lands |
| Marcus Lenz | City of Raleigh | Urban Lands |
| Megan Anderson | City of Raleigh | Urban Lands |
| Wayne Miles | City of Raleigh | Urban Lands |
| Andy Pleninger | NC Department of Agriculture and Consumer Services | Urban Lands |
| Madhusudan Katti, PhD | NC State University | Urban Lands |
| Leslie Moorman | NC Urban Forest Council | Urban Lands |
| Shawn Gagné | Urban Offsets | Urban Lands |
| Nancy Daley | Wake County | Urban Lands |

# 2.0 Natural and Working Land Basics

## 2.1 Data on Land Use Types

North Carolina consists of 31.1 million acres of land area and 2.9 million acres of coastal waters (marine and estuarine). Figure 2-1 presents the percentage of each land cover type in acres for 2016.[4] Forests make up approximately 14.0 million acres.[5] Agriculture makes up the next largest land area at 6.9 million acres. Wetlands, both woody and herbaceous, make up 4.9 million acres and 1.6 million acres fall under the "other use" category. The developed land area in the State is currently 3.6 million acres, only 12% of our land area use, indicating that the vast majority of North Carolina consists of NWL.[6] Proper use and management of these lands offer enormous opportunity for our State to avoid GHG emissions, sequester carbon and build resilience to extreme weather events.

**Figure 2-1: North Carolina Land Cover Types by Area in 2016**




[4] Multi-Resolution Land Characteristics (MRLC) Consortium. (2016). Data extracted from the National Land Cover Database (NLCD). Retrieved from https://www.mrlc.gov/ by Duke University's Nicholas Institute for Environmental Policy in 2019.
[5] The USDA Forest Inventory Analysis reports a total of 18.5 million acres covered in forests or 60% of North Carolina's land area. This is due to the inclusion of woody wetlands in the definition of forested area.
[6] Developed land in the NLCD is covered by a mix of constructed materials (creating impervious surface) and vegetation. It is divided into four classes based on the area of impervious surface coverage, ranging from less than 20% to more than 80%. Lawns, parks, and other vegetated areas within developed settings are included as developed land.

Between the year 2000 and 2017, the population in our State grew by 27%.[7] Many citizens are concerned about the land that has been converted from NWL to urban and rural development. Table 2-1 gives the changes in land cover type since 2001 from the National Land Cover Database (NLCD), the earliest consistent data set.[8] This table indicates that North Carolina's developed land use has increased by 9% over the last 15 years. This is an increase of approximately 312,000 acres, which is 1% of North Carolina's total land area. North Carolina has seen small shifts in its land use in the NWL sectors over the last 15 years, indicating that land-use changes overall have been minimal.

**Table 2-1: North Carolina Land Uses Changes 2001-2016 (million acres)**

| Land Cover Type | NLCD Land Cover Classification | 2001 Area (million acres) | 2016 Area (million acres) | Percent Change by Land Cover Type | Percent Change by Total Area |
|---|---|---|---|---|---|
| **Developed** | Developed, Open Space | 2.13 | 2.24 | | |
| | Developed, Low Intensity | 0.83 | 0.92 | | |
| | Developed, Medium Intensity | 0.24 | 0.32 | | |
| | Developed, High Intensity | 0.09 | 0.11 | | |
| Developed Subtotal | | 3.28 | 3.60 | 9.5% | 1.0% |
| **Forest** | Deciduous Forest | 6.53 | 6.18 | | |
| | Evergreen Forest | 4.36 | 4.44 | | |
| | Mixed Forest | 3.28 | 3.42 | | |
| Forest Subtotal | | 14.17 | 14.04 | -1.0% | -0.4% |
| **Agriculture** | Hay/Pasture | 2.74 | 2.49 | | |
| | Cultivated Crops | 4.39 | 4.41 | | |
| Agriculture Subtotal | | 7.13 | 6.90 | -3.1% | -0.7% |
| **Wetlands** | Woody Wetlands | 4.52 | 4.50 | | |
| | *Pocosin Wetlands (unaltered)* | *0.70* | *0.70* | | |
| | *Pocosin Wetlands (altered)* | *1.55* | *1.55* | | |
| | Emergent Herbaceous Wetlands | 0.40 | 0.39 | | |
| Wetlands Subtotal | | 4.92 | 4.89 | -0.4% | -0.1% |
| **Other Lands** | Shrub/Scrub | 0.81 | 0.82 | | |
| | Herbaceous | 0.70 | 0.73 | | |
| | Barren Land | 0.08 | 0.08 | | |
| Other Lands Subtotal | | 1.59 | 1.63 | 2.4% | 0.1% |
| **Total Land Area** | | **31.1** | **31.1** | | |
| Open Water Subtotal | | 2.61 | 2.64 | 1.2% | |
| **Total Area (land + open water)** | | **33.7** | **33.7** | | |

[7] North Carolina Office of State Budget and Management. (2017). North Carolina Census data provided to DEQ in January 2018.
[8] Multi-Resolution Land Characteristics (MRLC) Consortium. (2016). Data extracted from the National Land Cover Database (NLCD). Retrieved from https://www.mrlc.gov/ by Duke University's Nicholas Institute for Environmental Policy in 2019. See Appendix I for more information.

Fifteen years, however, is not a significant amount of time in the NWL sector. Since 1990, the population has increased by 55% while developed land area has increased by approximately 1.16 million acres, a 3.7% increase relative to the State's total land area.[9] Despite this high conversion rate, in 2015 the urban tree canopy was estimated at 54%, the fourth-highest urban tree canopy in the US.[10] While our canopy percentage is currently high, it is in decline. We are losing this canopy at a rate of 4,500 acres per year and increasing impervious surface.[11] Promoting the retention and proactive management of this canopy and avoiding conversion from pervious to impervious land surface should be two important goals for the State as our population continues to grow.

*Since 1990, our State's population has increased by 55% while developed land area has increased by 1.16 million acres or 3.7% of total land area.*

North Carolina also has a substantial amount of land that is connected to waterways and has 17 river basins. Table 2-2 presents the miles of coastline and rivers in the State.[12] Land adjacent to rivers and streams is referred to as riparian land. Restoration of riparian corridors has a large potential for both flood protection and carbon sequestration. These land areas also have important co-benefits for 1) protecting plant and animal habitats, 2) acting as corridors for species migration, 3) improving water quality, 4) preventing erosion, and 5) lowering water temperatures.

**Table 2-2: Miles of Coastline and Rivers in North Carolina**

| Waterways | Length (miles) |
|---|---|
| Miles of Ocean Beaches | 320 |
| Miles of Estuarine Shoreline | 12,000 |
| Miles of Rivers | 37,853 |

As shown in the table above, North Carolina has 320 miles of ocean beaches and over 12,000 miles of estuarine shoreline. The land adjacent to the coastline can provide many co-benefits to communities beyond carbon sequestration, including flood and storm surge protection, ecosystem preservation, improved water quality, increased water storage, habitat for fisheries, and corridors for species migration.

[9] North Carolina's developed land-use area was approximately 2.4 million acres in 1990 based on *Urban Forest Data for North Carolina*, US Forest Service, December 8, 2008. Retrieved from https://www.nrs.fs.fed.us/data/urban/state/?state=NC
[10] Nowak D. J., and E. J. Greenfield, (March 2018). US Urban Forest Statistics, Values, and Projections. *Journal of Forestry*. Retrieved on https://www.fs.fed.us/nrs/pubs/jrnl/2018/nrs_2018_Nowak_003.pdf.
[11] Ibid.
[12] Multi-Resolution Land Characteristics (MRLC) Consortium. (2016). Data extracted from the National Land Cover Database (NLCD). Retrieved from https://www.mrlc.gov/ by Duke University's Nicholas Institute for Environmental Policy in 2019.

## 2.2 New Ideas: Blue Carbon

Blue carbon is a new term for carbon stored in ocean and coastal ecosystems. These coastal systems, including submerged aquatic vegetation (SAV) – also known as seagrass – swamp forests, and coastal wetlands, capture and hold carbon, acting as a carbon sink. They have the potential to sequester carbon at a faster rate than forests but can also emit large amounts of GHGs through the decomposition process. Due to the complexity of estimating carbon flux in these systems, estimating the carbon sequestration potential from various actions taken in these ecosystems is still in the research phase.

North Carolina is home to numerous rivers, creeks, sounds, and inlets and contains the largest estuarine system of any single Atlantic coast state, with approximately 2.2 million acres of estuarine waters.[13] This diverse estuarine system is comprised of approximately 100,000 acres of high salinity SAV and approximately 228,000 acres of salt marsh (high salinity coastal wetlands). [14] Through photosynthesis, SAV or seagrass removes excess $CO_2$ and adds oxygen to the water. Salt marsh primarily stores carbon in organic sediments underlying the marshes, but some carbon can also be stored in the marsh vegetation. High salinity SAV and salt marsh provide higher levels of carbon sequestration than coastal wetlands and SAV in lower salinity areas. All coastal wetlands and SAV have stabilizing properties that reduce wave action and shoreline erosion, benefitting both estuarine and coastal communities. These coastal ecosystems also provide habitat for many marine and estuarine species while improving water quality.

The carbon sequestration potential of coastal habitats, including salt marshes and SAV, is currently receiving much attention. Research is being conducted to determine the actual carbon sequestration potential of these coastal habitats. Saltmarsh has one of the highest per unit area carbon sequestration rates of any vegetated habitat, 1.1 MT $CO_2$e/acre/yr. In addition, NOAA is acting to provide measurement methods that would make salt marsh restoration eligible for international carbon markets.[15] Carbon offset and restoration methodologies are becoming available for coastal habitats.[16]

Estimates for carbon storage and sequestration by salt marsh and all SAV were developed for North Carolina by Duke University's Nicholas Institute with help from the Coastal Habitats NWL subcommittee. Based on these estimates, North Carolina's salt marshes currently store about 61 MMT $CO_2$e, and SAV stores another 18 MMT $CO_2$e. Estimates were not developed specifically for high salinity SAV. The amount of carbon stored

[13] DEQ. 2016. *North Carolina Coastal Habitat Protection Plan*. NWI data (derived from imagery spanning 1977-2010). Cowardin classifications assigned by the NWI were reclassified into wetland types following (Sutter 1999). Retrieved from http://portal.ncdenr.org/c/document_library/get_file?uuid=5d02ccd2-3b9d-4979-88f2-ab2f9904ba61&groupId=38337
[14] Ibid.
[15] NOAA. 2018. "Reserves Advance Blue Carbon Approach to Conserving Wetlands", Office of Coastal Management. Retrieved from https://coast.noaa.gov/states/stories/first-carbon-market-guidance-for-wetlands.html.
[16] Restore America's Estuaries. (2019). "Carbon Markets and Standards". Retrieved from https://estuaries.org/bluecarbon/carbon-markets-and-standards/

in these intact habitats is continually increasing as they sequester an additional 0.390 MMT $CO_2e$ each year (0.25 MMT by salt marsh and 0.14 MMT by SAV) based on the model estimates.[17]

## 2.3 Economic and Social Value of NWL

### 2.3.1 Value of the Land and the Ecosystem Services

North Carolina's NWL contribute to the State's economy, as measured by gross state product (GSP), primarily through agricultural food and fiber products, harvested wood products, commercial and recreational fisheries, tourism, and recreation. Figure 2-2 presents some basic information on the economic value of NWL. [18,19,20,21,22,23]

**Figure 2-2: Economic Value of Natural and Working Lands to the State**


In addition to the direct contributions to the State's economy, these NWL provide numerous benefits that improve our communities and lifestyles in North Carolina but are more difficult to quantify. Some of these benefits are discussed below.

- Risk reduction: Upstream land including floodplains, croplands, pasturelands, forests, wildlands and wetlands located in flood prone areas capture and store water, reducing the extent of flooding and filtering out pollutants. Many coastal habitats attenuate the strength of incoming waves, reducing erosion and protecting infrastructure and homes. Restoring pocosin wetlands reduces the risk of fires in

[17] For more information about the methods used for these estimates, see Appendix I: Methods for Estimates of Natural and Working Lands Potential.
[18] Walden, Mike. (May 2019). *Agriculture and Agribusiness: North Carolina's Number One Industry*. NCSU, College of Agriculture and Life Sciences. Retrieved from https://cals.ncsu.edu/agricultural-and-resource-economics/wp-content/uploads/sites/12/2018/05/agribusiness2018brochure.pdf
[19] Parajuli, R. and R. Bardon. (2019). *2017 Income of North Carolina Timber Harvested and Delivered to Mills*. NCSU, College of Natural Resources. Retrieved from https://content.ces.ncsu.edu/economic-contribution-of-the-forest-sector-in-north-carolina
[20] DMF. 2019. *North Carolina Division of Marine Fisheries License and Statistics Section Annual Report*. North Carolina Department of Environmental Quality, Division of Marine Fisheries, Morehead City, NC. Retrieved from http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=33372974&name=DLFE-141802.pdf
[21] Ibid.
[22] NC Sea Grant and Duke Nicholas Institute for Environmental Policy. (2017, January). "North Carolina's Ocean Economy: A First Assessment and Transitioning to a Blue Economy". Retrieved from https://ncseagrant.ncsu.edu/ncseagrant_docs/products/2010s/NC_Ocean_Economy_White_Paper.pdf
[23] Hunt, Max (2015, May 14). "Cash cows: How national and state parks boost N.C. communities". *Mountain Express*. Retrieved from https://mountainx.com/news/cash-cows-how-national-and-state-parks-boost-n-c-communities/.

these peatlands and reduces saltwater intrusion that threatens coastal agriculture and ecosystems. One example comes from Hurricane Sandy, where coastal wetlands prevented about $625 million in flood damages and reduced flood levels on more than 1,200 miles of roads in the Northeastern US.[24]

- Supporting services: NWL support important pollinator species, which contribute to the health and productivity of NWL. The habitats of many NWL support important pollinator species, which increase the productivity of many agricultural crops. They also provide homes to endangered and iconic species like the red-cockaded woodpecker, red wolf, and Venus flytrap, as well as wildlife central to hunting, like deer and waterfowl. Coastal habitats are critical nurseries for juvenile fish that support our State's commercial and recreational fisheries. In addition, all these habitats capture and store carbon and can reduce risks associated with climate change.
- Personal or cultural connection: Natural areas and working lands throughout our State are meaningful to people for personal, family, cultural, and historic reasons. These can be places where people have tribal or community traditions, personal memories, or where they find ongoing enjoyment. Generational family farms and forests are an important aspect of our culture as well. Access to natural areas can have significant benefits to both physical and mental health through exercise, reduced stress, and improved concentration.[25]

*During the current COVID 19 pandemic, community natural and recreational areas have proved essential for the physical and mental wellbeing of people.*

Over the last decade, there has been a growth in markets for these ecosystem services, including carbon sequestration (carbon markets), water quality (nutrient trading), wetlands (wetland mitigation banking)[26], and biological diversity (endangered species banks). Purchases of US ecosystem credits from agriculture lands were estimated at $13.9 billion in 2018.[27] For more information on ecosystem services markets see the following references;

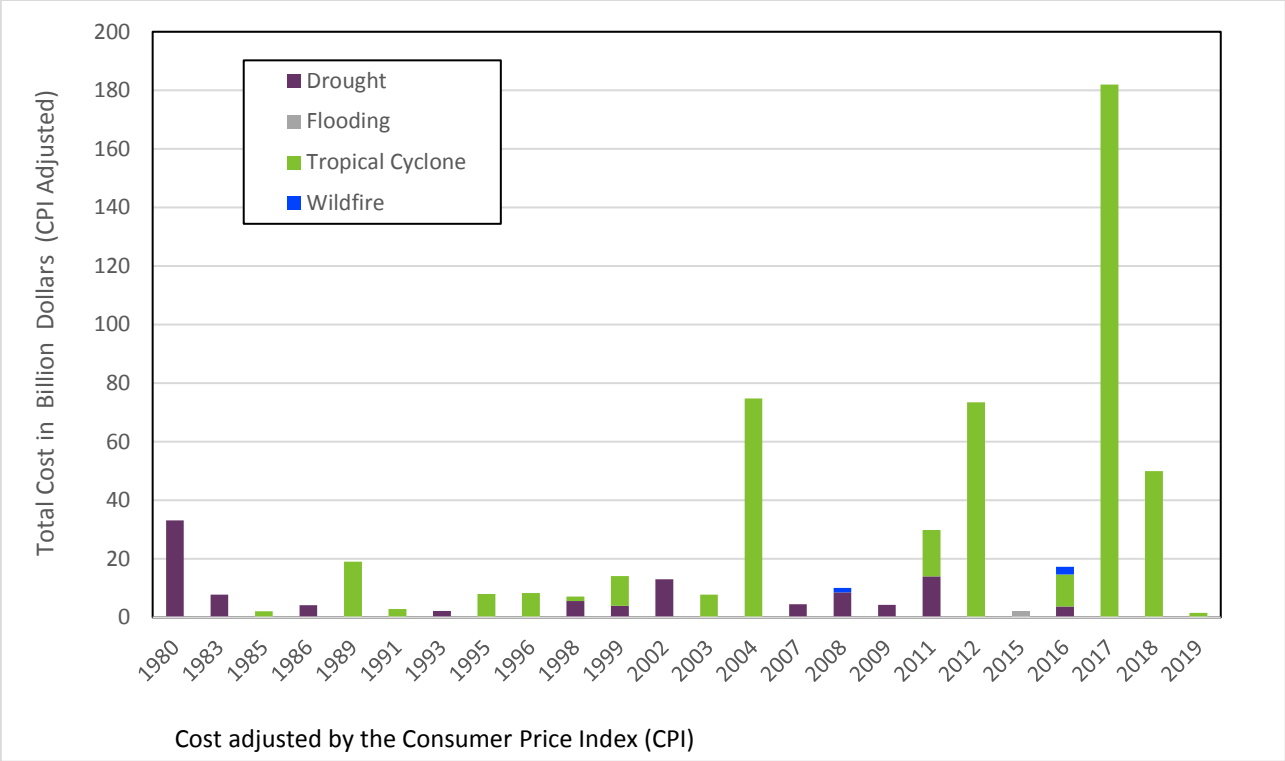
- "Ecosystem service markets 101: supply and demand for nature"[28],
- "The market for payment for ecosystems services is growing up"[29], and
- Ecosystem Services Market Consortium[30]

[24] Narayan, et al. (2017). The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. *Sci Rep* 7, 9463 Retrieved from https://doi.org/10.1038/s41598-017-09269-z
[25] Stigsdotter, Ulrika K., Ola Ekholm, Jasper Schipperijn, Mette Toftager, Finn Kamper-Jørgensen, and Thomas B. Randrup. (2010). Health Promoting Outdoor Environments - Associations between Green Space, and Health, Health-Related Quality of Life and Stress Based on a Danish National Representative Survey. *Scandinavian Journal of Public Health* 38 (4): 411–17. https://doi.org/10.1177/1403494810367468
[26] Wetland markets in 2017 in the US transacted over 3.2 Billion for over 5,000 ha of wetlands based on *State of Biodiversity Mitigation 2017:Markets and Compensation for Global Infrastructure Development*, Forest Trends, 2017. Retrieved from https://www.forest-trends.org/wp-content/uploads/2018/01/doc_5707.pdf
[27] Agribusiness Consulting. (2018, October). "Economic Assessment for Ecosystem Service Market Credits from Agricultural Working Lands", IHS Markit Economic Assessment. Retrieved from https://ecosystemservicesmarket.org/wp-content/uploads/2019/09/Informa-IHS-Markit-ESM-Study-Sep-19.pdf.
[28] Mazza, Rhonda; Kline, Jeff; Patterson, Trista (2012). Ecosystem service markets 101: supply and demand for nature. *Science Findings* 144. USDA, Forest Service, Pacific Northwest Research Station. Retrieved from https://www.srs.fs.usda.gov/pubs/40903
[29] Thiel, Anne. (2018, June 15). "The market for payment for ecosystems services is growing up". GreenBiz. Retrieved from https://www.greenbiz.com/article/market-payment-ecosystems-services-growing
[30] Ecosystem Services Market Consortium website https://ecosystemservicesmarket.org/

### 2.3.3 Value of Resilience

North Carolina has experienced escalating economic and societal losses due to weather and climate-related natural disasters. The State now ranks second in the nation for these losses.[31] Figure 2-3 gives the losses due to drought, wildfires, floods, and tropical cyclones from 1980 to 2019.[32] The figure shows that tropical cyclones account for most of these losses.

**Figure 2-3: Cost of Weather and Climate-Related Natural Disasters ($ billion)**




In the last four years (2016-2019), these natural disasters have cost North Carolina $251 billion dollars. This is roughly equivalent to the expense of natural disasters over the previous 20 years ($257 billion dollars, 1995-2015). NWL have the potential to mitigate the impact of climate change and natural weather disasters by increasing resilience to these events. While the cost of some of the solutions posed in the NWL Action Plan is in the $1 to $2 billion dollar range, the benefit of improved community and ecosystem resilience will offset those investments.

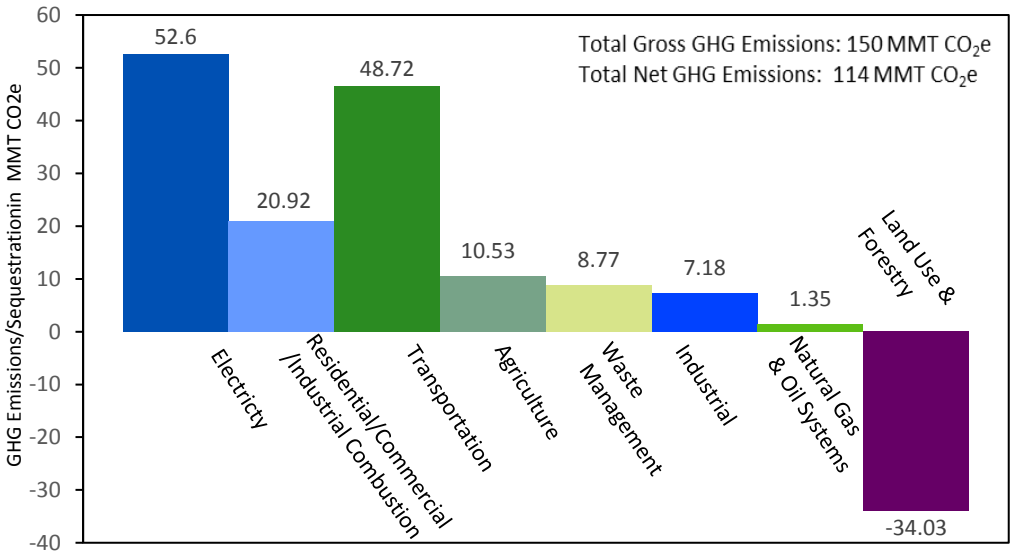
*In the last four years, climate and weather natural disasters have caused economic and societal losses of $251 billion.*

[31] NOAA. (2020). *U.S. Billion-Dollar Weather and Climate Disasters National*. Centers for Environmental Information (NCEI). Retrieved from https://www.ncdc.noaa.gov/billions/
[32] Ibid.

## 2.4 North Carolina Greenhouse Gas Inventory

The 2019 North Carolina GHG inventory is a detailed accounting of anthropogenic GHGs emitted or stored in North Carolina by key source categories from 1990 to 2017.[33,34] The methods used to prepare the State's GHG inventory are based on those used to prepare the Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2016, published annually by US EPA.[35] Figure 2-4 presents North Carolina's GHG emission sources and sinks for each economic sector in 2017. GHG emissions are presented in million metric tons as carbon dioxide equivalent emissions (MMT $CO_2e$).[36]

**Figure 2-4: DEQ Greenhouse Gas Emissions Inventory Data for 2017**




In 2017, activity on forestland and agricultural lands resulted in a net sequestration of approximately 34 MMT of $CO_2e$ and was reported as a "carbon sink." As shown in Figure 2-4, this is 23% of North Carolina's gross GHG emissions, meaning the NWL sector removed 23% of the State's GHG emissions in 2017. At the same time, North Carolina emitted 10.53 MMT $CO_2e$ from agricultural activities, the largest part of which was due to manure management emissions of 6.05 MMT $CO_2e$.

Table 2-3 presents the carbon sinks and GHG emissions for each activity in North Carolina. Each year, North Carolina sequesters about 33 to 36 MMT of $CO_2e$. The carbon sinks are primarily due to carbon sequestered in above ground biomass and long-term storage of carbon in wood products. Table 2-3 indicates there has been a 4% increase in the annual carbon sequestered between 2005 and 2017. This annual sequestration of carbon reflects North Carolina's sustainable management of its forests and their economic uses. The State's

[33] DEQ. (2019, January). *North Carolina Greenhouse Gas Inventory (1990-2030).* Division of Air Quality. Retrieved from https://deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory
[34] Anthropogenic refers to impacts or effects produced as the result of human activities.
[35] US EPA. (2019, April 11). *U.S. Greenhouse Gas Emissions and Sinks: 1990-2017.* EPA 430-R-19-001. Retrieved from https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2017
[36] Carbon dioxide equivalent means the number of metric tons of $CO_2$ emissions with the same global warming potential as one metric ton of another greenhouse gas. For more information see https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

timber inventory increased by 45% between 1974 and 2018 and increased by 19% in the last ten years alone, where North Carolina's timberland makes up over 96% of the State's total forestland.[37]

**Table 2-3: GHG Emissions & Sinks from Land Use/Land Use Changes/Forestry (MMT $CO_2e$)**

| Source/Sink | 1990 | 2005 | 2012 | 2015 | 2017 |
|---|---|---|---|---|---|
| *Aboveground Biomass* | *-19.89* | *-19.04* | *-21.23* | *-21.10* | *-21.01* |
| *Belowground Biomass* | *-4.23* | *-4.00* | *-4.41* | *-4.37* | *-4.34* |
| *Dead Wood* | *-0.20* | *-0.22* | *-0.22* | *-0.22* | *-0.21* |
| *Litter* | *0.70* | *0.61* | *0.50* | *0.52* | *0.53* |
| *Soil Organic Carbon* | *0.60* | *0.44* | *0.20* | *0.21* | *0.22* |
| *Wood Products**** | *-12.28* | *-12.96* | *-12.96* | *-12.96* | *-12.96* |
| Total Forest Carbon Flux* | -35.31 | -35.17 | -38.11 | -37.91 | -37.77 |
| Landfill Yard and Food Waste | -0.64 | -0.31 | -0.35 | -0.33 | -0.33 |
| Agricultural Soil Carbon Flux | -0.23 | 0.75 | 1.47 | 1.48 | 1.48 |
| Urban Trees** | - | - | - | - | - |
| **Carbon Sinks** | **-36.17** | **-34.73** | **-36.99** | **-36.76** | **-36.62** |
| Liming of Soils*** | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| Urea Fertilization | 0.007 | 0.011 | 0.006 | 0.007 | 0.007 |
| Forest Fires | 0.40 | 1.99 | 2.95 | 2.52 | 2.52 |
| $N_2O$ from Development Soils | 0.09 | 0.07 | 0.07 | 0.07 | 0.07 |
| **GHG Emissions** | **0.53** | **2.07** | **3.03** | **2.60** | **2.60** |
| **Net Carbon Sink** | **-35.64** | **-32.66** | **-33.97** | **-34.16** | **-34.03** |

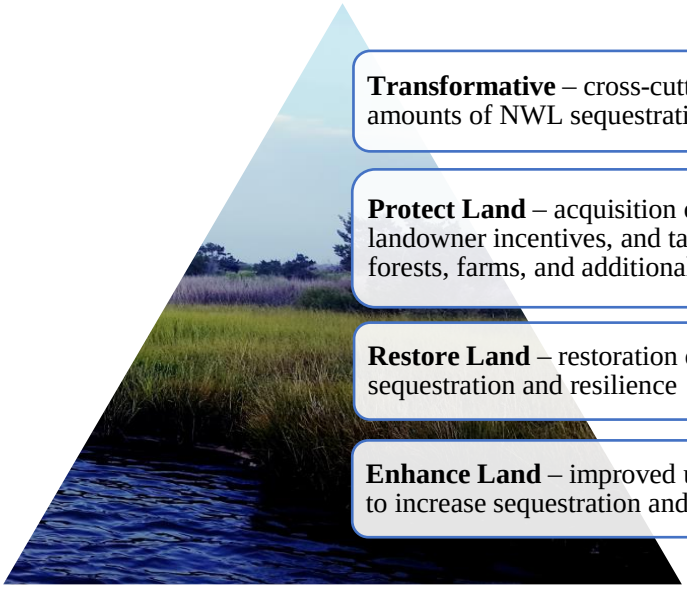
* Forest carbon flux is the sum of carbon-emitting and carbon-sequestering activities listed above in italics.
** Data quality is not sufficient for inclusion in the inventory.
***Data only available for select years

It is challenging to measure and quantify the carbon storage and flux associated with various land-use activities. The DEQ plans on improving the estimates of LU/LUC/F emissions and sequestration for the next published GHG inventory by collaborating with many of the experts that participated in developing the recommendations in this report. Improving the inventory will assist in prioritizing future NWL actions taken by our State.

[37] NCSU. (2016). "North Carolina's Forests and Forest Products Industry by the Numbers, 2016". College of Natural Resources, North Carolina Cooperative Extension Service. Retrieved from http://www.ncforestry.org/wp-content/uploads/2016/05/NC-Forest-Bulletin_Published.pdf. Spreadsheet of USDA Forest Inventory and Analysis (FIA) timberland data provided by Rajan Parajuli, PhD, Department of Forestry and Environmental Resources, North Carolina State University on April 21, 2020.

# 3.0 Stakeholder Recommendations

The sections below present the recommendations that members of the six NWL subcommittees voted to prioritize during the October 2019 meeting out of the larger list of recommendations developed and considered by the subcommittee members. Note that these recommendations do not necessarily have the support of all the subcommittee members. The recommendations are presented for each subcommittee and are placed into four different categories of actions listed below.



**Transformative** – cross-cutting actions that will result in large amounts of NWL sequestration and resilience

**Protect Land** – acquisition of land or conservation agreements, landowner incentives, and tax and policy incentives to protect forests, farms, and additional natural areas

**Restore Land** – restoration of land to a natural state to increase sequestration and resilience

**Enhance Land** – improved use and management of existing NWL to increase sequestration and resilience

**Appendix I: Methods for Quantitative Estimates of Natural And Working Lands Potential** presents the methods used by the Duke University's Nicholas Institute for Environmental Policy Solutions to estimate the potential geographic scope, carbon sequestration, resilience opportunities, and other co-benefits discussed in the recommendations.

The Nicholas Institute also produced a **Storymap** that presents data and map layers alongside other contextual information. Use the link on the map to access the Storymap.

Table 3-1 summarizes the priority recommendations developed by the NWL subcommittees.

**Table 3-1: Summary Table of Priority Recommendations**

| Recommendation Type | Strategy |
|---|---|
| **Transformative** | 1. Protect and restore forests and wetlands within flood prone areas. |
| | 2. Facilitate voluntary landowner participation in carbon offset and ecosystem services markets. |
| | 3. Build a multi-state NWL solutions toolbox. |
| | 4. Integrate climate adaptation and resiliency strategies into local government comprehensive plans. |
| **Protect Forest Lands** | 5. Conserve forest lands through easements and acquisition. |
| | 6. Modernize forest policy and tax incentives. |
| **Restore Forest Land** | 7. Expand restoration efforts on publicly owned lands. |
| | 8. Encourage restoration and reforestation on private lands. |
| **Enhance Forest Lands** | 9. Increase landowner access to forest management technical and financial assistance. |
| | 10. Support the wood products markets. |
| **Protect and Restore Floodplains and Wetlands** | 11. Coordinate the State's floodplain buyout and restoration program to increase resilience. |
| **Restore Pocosins** | 12. Rewet hydrologically altered peatlands to prevent soil loss and catastrophic fire. |
| | 13. Reforest peatlands with Atlantic White Cedar. |
| **Enhance Pocosins** | 14. Enhance soil health and retention on working peatlands via best management practices and drainage management. |
| | 15. Implement targeted interventions to protect peatlands from sea level rise and saltwater intrusion guided by scenario-based modeling. |
| **Protect Coastal Habitats** | 16. Provide incentives to stakeholders for coastal habitat protection. |
| | 17. Facilitate migration of coastal habitats through protection of migration corridors. |
| **Restore Coastal Habitats** | 18. Prioritize climate change and sea level rise in coastal habitat restoration planning. |
| **Protect and Restore Urban Lands** | 19. Promote urban forests through statewide programs to foster the retention of urban trees and their proper management. |
| | 20. Protect and restore forested lands in water supply watersheds. |
| **Enhance Urban Lands** | 21. Improve site preparation and soil amendment during land development. |
| | 22. Research urban forestry climate adaptation and canopy baseline needs. |
| **Enhance Agriculture** | 23. Encourage adoption of high mitigation agricultural conservation practices on croplands and pasturelands. |
| | 24. Improve manure management on farms. |
| | 25. Encourage food system efficiency through reduced food loss and waste. |

## 3.1 Transformative Recommendations

These recommendations represent actions that cut across sectors and require government and other implementors to enable policy, science, and/or markets. These recommendations result in significant changes to the "business as usual" approach to the NWL sector. They also create opportunities to sequester significant amounts of carbon and ensure additional ecosystem and community resilience during extreme climate and weather events. These recommendations were developed primarily by steering committee members based on the ongoing ideas and actions of stakeholders as well as the priority recommendations developed for the NWL Action Plan.

### 3.1.1 Protect and Restore Forests and Wetlands in Flood Prone Areas

Conservation and restoration of forests and wetlands (including pocosins) represent North Carolina's largest opportunity to sequester carbon and supports a suite of co-benefits. Our State is uniquely positioned to sequester large amounts of carbon in its forests due to its climate and ecosystems. As discussed previously, the US Department of Agriculture (USDA) Forest Inventory Analysis estimated North Carolina's total forest carbon in 2017 at 5.29 billion metric tons $CO_2e$ (MT $CO_2e$), which is 3% of the total carbon stored in US forests.[38]

Conservation: North Carolina has more than 15.3 million acres of forests (including forested wetlands) that are not in protected management areas.[39] These ecosystems store approximately 5.6 billion MT $CO_2e$ and sequester an additional 27 MMT $CO_2e$ each year[40].

- Approximately 8% of these forests and wetlands are in the floodplains of watersheds with more than 3,000 people at risk of flooding.[41]
- Around 5% of these forests and wetlands are in the floodplains of watersheds with more than 10 potential point-sources of water pollutants (wastewater treatment plants, animal waste lagoons, and hazardous waste sites). [42]

An increase of 5% to 8% in the number of acres of forests and forested wetlands (approximately one million acres) along with their habitats that are under state conservation programs and providing financial incentives to protect and manage these lands will ensure that we maintain and increase the carbon sequestration, flood resilience, and water quality benefits provided by these areas.

[38] Note the estimates for forest protection and restoration do not include the potential for forest loss in North Carolina due to climate change and population growth or how that rate of loss may be reduced through policy and other initiatives.
[39] Protected management areas as defined by the USGS Protected Areas Database.
[40] For more information about the methods used for these estimates, see Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.
[41] Ibid.
[42] Ibid.

Restoration: There is also an enormous opportunity for reforestation in North Carolina. About 5.1 million acres of land that is not currently forested or developed could support forests. While about 80% of this land is currently in agriculture (pasture or crops), if all the nonagricultural land and just a small proportion of the agricultural land that is less productive were reforested, that would be 1.1 million additional acres of forest.[43] Reforestation of the 1.1 million acres would sequester 3.4 MMT $CO_2e$ each year. This would increase North Carolina's annual carbon sequestration by 10% from the estimated 34 MMT of $CO_2e$ sequestered in 2017.[44]

- 7.7% of this potential forestland is in the floodplains of watersheds where more than 3,000 people are at risk of flooding.
- 4% of the land is in the floodplains of watersheds that have more than 10 point sources of water pollutants, which reforestation can help mitigate. [45]

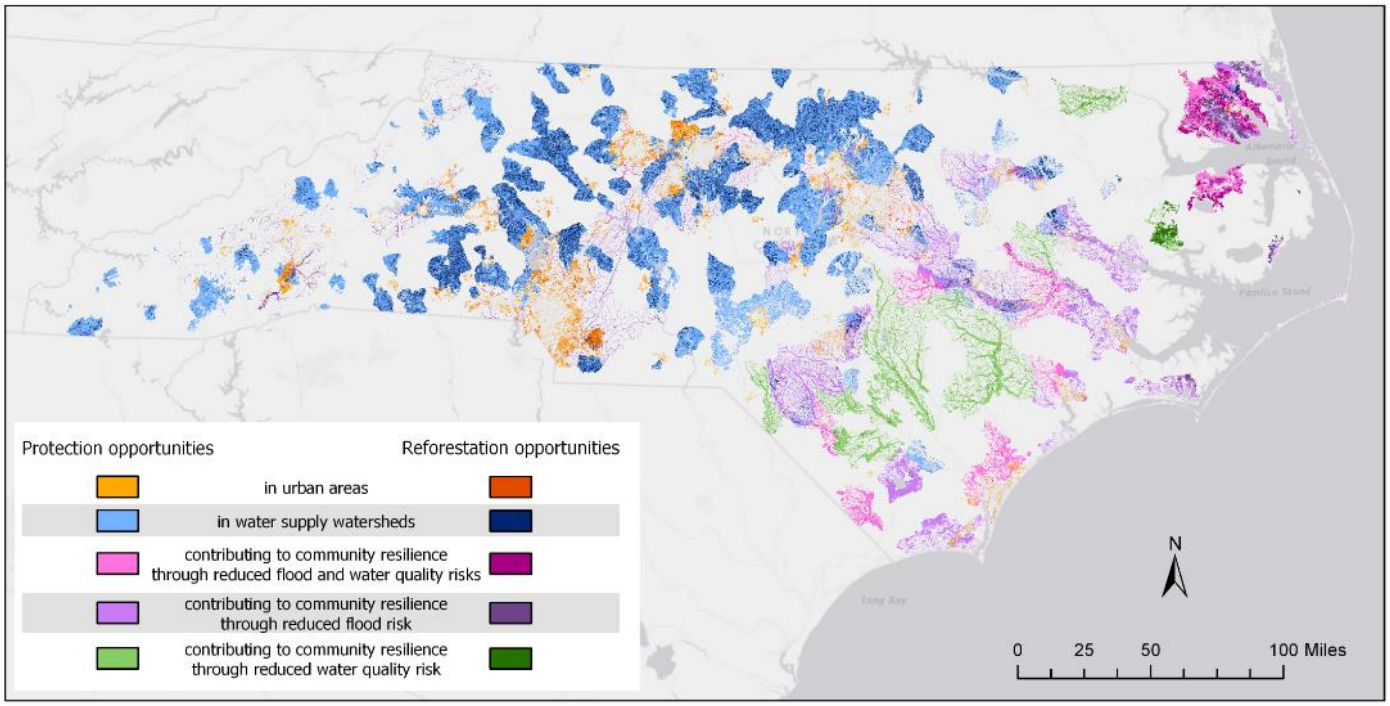
Reforestation could be achieved through active planting, improved management and maintenance of the land, or natural regeneration.

The North Carolina Forest Development Program (FDP) prevailing rates for tree planting for Hurricane Florence restoration are $65-160 per acre (depending on planting method and forest type). At these rates, the average cost to the State for reforestation of one million acres is estimated at $113 million using the CREP rate for planting hardwoods, longleaf, loblolly, and shortleaf. While this represents a very significant increase in the budget for conservation, the cost of flooding due to tropical cyclones has cost the State much more (See Section 4.2.2 Value of Resilience). Conservation and restoration of forest lands would lower the economic losses and recovery costs associated with the next storm. In addition, if carbon offsets could be obtained for these restoration projects, the costs could be recovered in approximately two years.[46]

Figure 3-1 presents the conservation opportunities for floodplain and wetland forests that would contribute to community resilience by 1) reducing flood risk in watersheds with many people living in flood-prone areas and 2) removing pollutants from floodwaters in areas with numerous water quality hazards. As shown, forests contributing to community resilience through reduced flood and water quality risks tend to be in the coastal plain, where there are wide, populated floodplains and a high concentration of water quality hazards. Approximately 98% of the land identified in this map is privately owned land. This figure also shows conservation opportunities in the Piedmont and mountains for 1) forests in water supply watersheds and 2) urban forests. More information on the methods used to identify these areas is available in the Appendix I: Methods for Quantitative Estimates of Natural And Working Lands Potential.

[43] Ibid.
[44] DEQ. (2019, January). *North Carolina Greenhouse Gas Inventory (1990–2030)*. North Carolina Division of Air Quality. Retrieved from https://deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory.
[45] For more information about the methods used for these estimates, see Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.
[46] Assumes annual sequestration of 3.4 MMT per year and a $15/MT forest carbon offset price based on California's current offset market.

**Figure 3-1: Forest Conservation Opportunities with Additional Resilience Benefits**




Source: Nicholas Institute for Environmental Policy Solutions at Duke University.
Explore these map layers alongside other contextual information in the **Duke University's Natural and Working Lands Storymap.**

**Recommendation to Protect and Restore Forests**

1) Expand legislative funding for North Carolina's land conservation programs. These funds could acquire 1.0 million acres of forest land with critical habitats and protect thousands of North Carolinians from climate change impacts. This will simultaneously ensure approximately 170 MMT $CO_2e$ remains stored in these forests and provide significant water quality co-benefits. Costs for climate-resilience land conservation efforts would be approximately $2 billion. When spread out over 20 years, this will be $100 million per year.
2) Provide legislative funding to restore 1.0 million acres of forests in North Carolina. This restoration could provide significant community and ecosystem resilience benefits and sequester 15.7 MMT $CO_2e$ each year. Costs for restoration of forests on this land would be approximately $135 million.

### 3.1.2 Facilitate Voluntary Landowner Participation in Carbon Offset and Ecosystem Services Markets

In response to government, business, and individual commitments to reduce carbon dioxide emissions, carbon is now a priced environmental commodity in the global marketplace. North Carolina's forest landowners and farmers are interested in selling carbon offsets to government entities and private companies that participate in these carbon offset markets.[47] Current programs are only feasible for larger conservation-oriented land owners, but work is underway in other states to develop programs more aligned with the needs of smaller and more diverse landowners.

The sale of carbon offsets can provide a revenue stream to landowners that helps make it financially feasible for them to manage their land to sequester carbon. When commodity prices are low, emerging ecosystem markets, including carbon offsets, become more attractive. In 2016 North America (primarily the United States) generated the second-largest number of offsets, totaling 10.1 MT $CO_2e$ for a total value of $29M.[48]

Carbon offset markets can be either compliance-based or voluntary. In compliance markets, regulated entities buy carbon offsets in order to comply with enforceable caps or limits on the total amount of GHGs they are allowed to emit. Examples of two such markets are California's cap-and-trade program under Assembly Bill 32 and the multi-state Regional Greenhouse Gas Incentive (RGGI).[49] Voluntary carbon offsets exist outside of these regulatory markets, and are more often used by entities with corporate, institutional, or personal GHG reductions goals to obtain carbon offsets.

Carbon offset projects are usually registered and tracked through independent registries such as American Carbon Registry (ACR), Climate Action Reserve (CAR), and the new Verra system developed by Verified Carbon Standard (VCS). The offsets are quantified and verified using various published forest carbon accounting protocols from different sources such as VCS and the State of California. A given project will result in different costs and revenues based on the protocol and registry chosen for the project. A new carbon offset methodology for restoration of Pocosin wetlands was recently approved by ACR, which allows one of North Carolina's highest carbon habitats to participate in carbon offset markets.

Currently, North Carolina's private landowner participation in carbon markets is low due to the complicated requirements and expenses associated with participation. For forestry projects, the landowners may be required to develop a detailed inventory and forest management plan, project future offsets using modeling tools, undergo a third-party audit, sign a long-term contract, undergo periodic reviews, and other requirements. These requirements result in costs on the order of $100,000 to develop a project.[50]

[47] A carbon offset is a reduction in GHG emissions from one economic activity that is used to compensate for GHGs emitted by another economic activity measured in metric tons of $CO_2e$.
[48] Hamrick, K., and M. Grant. 2017. Unlocking Potential - State of Voluntary Carbon Markets 2017. Ecosystem Marketplace. Retrieved from https://www.forest-trends.org/wp-content/uploads/2017/07/doc_5591.pdf
[49] For more information on compliance carbon markets see http://www.caclimateinvestments.ca.gov/, https://www.rggi.org/ and https://ww3.arb.ca.gov/cc/capandtrade/offsets/offsets.htm
[50] NCSU. (2019, July 10). "An Introduction to Forest Carbon Offset Markets". NC State Extension Publications. Retrieved from https://content.ces.ncsu.edu/an-introduction-to-forest-carbon-offset-markets

Forestry projects generally become cost-effective as an investment at about 1,500-2,500 acres. However, the majority of privately held land (80%) is held in ownerships of less than 500 acres.[51] Given this significant barrier, the carbon registries created guidelines for aggregating forest carbon projects. While private organizations and consultants have been working to aggregate projects for use in the registries, the number of successful aggregations is relatively few. This is because aggregated projects introduce additional complexities and risks. Several states are now working to assist landowners and project developers with project aggregation.[52]

Currently, Appalachian State University, in coordination with North Carolina State University (NCSU) and other institutions, is exploring the viability of small-scale forest carbon offsets in North Carolina to make carbon markets accessible to private forest owners with less than 1,000 acres.[53] The team is examining alternative methods for measuring and accounting for carbon that could potentially bring down the costs of project development and verification for small-scale forest owners. Parallel to this, Appalachian State and its partners are developing a business plan/portfolio to investigate potential project aggregation methods and ways to generate alternative revenue streams (beyond payments for carbon credits) for sustainable forestry practices which would enable participation in carbon projects.

There is limited expertise in the southeastern United States for developing and verifying carbon offset projects. This creates an economic opportunity for North Carolina to develop this expertise locally, especially in rural areas affected by recent flooding events. Carbon offset projects are most likely to be implemented in rural areas first because of the potential carbon storage of rural pocosins and restoration of floodplains. With this in mind, Duke University, Appalachian State University, North Carolina State University, and their partners are developing a "knowledge network" by reaching out to experts across the country to form a roadmap that would provide information for decisions related to establishing a state forest carbon market.

A proactive catalyst for addressing the barriers discussed above would be for the State to establish a carbon offset purchasing fund coupled with a GHG emissions reduction target that could be used to pay private landowners for voluntary practices that result in measurable GHG reductions. The fund/target could be established in such a way as to reflect a specific reduction tonnage target that could be achievable at relatively moderate prices per ton $CO_2e$ reduced, such as \$10/MT $CO_2e$. The GHG reduction targets could either be based on Governor Cooper's Executive Order 80 and/or DEQ's Clean Energy Plan or voluntary corporate emission reduction goals.

A fund developed to restore the wetlands in Louisiana by the Restore the Earth Foundation provides a good example of the direct and indirect benefits of forest carbon projects, and associated value streams that can encourage participation by landowners. This fund was supported by industry and institutional investors as well. There is evidence that North Carolina could have similar investor interest in North Carolina forest carbon projects.[54]

[51] USFS. (2016, March). "Forest Service National Woodland Owner Survey: National, Regional, and State Statistics for Family Forest and Woodland Ownerships with 10+ acres, 2011-2013". Retrieved from https://www.fs.fed.us/nrs/pubs/rb/rb_nrs99.pdf

[52] Pinchot Institute. 2019. Unlocking Carbon Markets for Family Forest Owners in the PNW. Regional Conservation Partnership Program. Retrieved from http://www.pinchot.org/gp/RCPP

[53] Appalachian State University. (2018, August, 28). "Appalachian Carbon Research Group awarded UNC System funding to develop accounting guidelines for forest carbon offset projects," *Appalachian Today.* Retrieved from https://today.appstate.edu/2018/08/28/forest-carbon-offset

[54] Restore the Earth Foundation. (2019, December 4). "Restore the Earth Foundation Awarded $2 million from the National Coastal Resilience Fund to support a Green-Gray Approach to Gulf Coast Resiliency" Retrieved from http://restoretheearth.org/2019/12/04/restore-the-earth-foundation-awarded-2-million-from-the-national-coastal-resilience-fund-to-support-a-green-gray-approach-to-gulf-coast-resiliency/

**Recommendation to Facilitate Voluntary Landowner Participation in Carbon Offset and Ecosystem Services Markets**

Given our potential to sequester carbon in forests and the growing carbon offset and ecosystem services markets, North Carolina should continue to research and then create a state-level program to coordinate and encourage private landowner participation in these existing markets. This first steps toward this is to remove barriers to participation including:

a. Create an entity and/or funding source to provide free or low-cost measurement and verification (M&V) services to qualifying landowners who utilize approved practices, where approved practices consist of those recognized by existing carbon offset organizations such as the American Carbon Registry;

b. Develop an aggregation process for small-acreage landowners to pool acreage and carbon reductions with other small-acreage landowners in a given region;

c. Provide technical assistance to landowners interested in pursuing carbon offset practices by 1) including information on requirements, measurement and verification, and revenue streams, 2) linking landowners of potential projects with owners/investors of existing offset projects and 3) developing a North Carolina training program for the rural workforce;

d. Establish an insurance program or offset buffer program for landowners participating in the carbon market to ensure that landowners who are not able to meet their sequestration obligations due to events outside of their control do not suffer financially;

e. Research the potential for a state-level ecosystem services market that could be used to finance NWL projects that build resilience in communities as well as other services.

A more ambitious goal could be to create a North Carolina carbon offset market as part of the larger ecosystem services market that would create a revenue stream to fund the various actions discussed in this report and assist the State in meeting its GHG reduction and resilience goals.

### 3.1.3 Build a Natural and Working Lands Solutions Toolbox

Many of North Carolina's communities continue to deal with the impacts from climate changes including extreme events such as wildfires, droughts, hurricanes, and floods that have occurred in recent years. Nature-based solutions (NBS), including protecting and restoring forests and wetlands and increasing conservation and management of land in coastal areas, pocosins, and floodplains, can enhance both ecosystem and community resilience. As discussed previously, building resilience with NWL solutions also provides substantial co-benefits by mitigating GHG emissions, improving water quality, creating recreational opportunities, and enhancing wildlife populations.

Expanding resilience requires a multi-state, multi-county effort because river and coastal systems cross both state and county lines. At the same time, planning and implementation of NBS to build resilience generally happen at the local scale. This complexity of a multi-state system combined with local scale actions required to mitigate impacts necessitates a coordinated effort between state and local governing bodies and the researchers and planners who work on these resilience issues. An NWL Solutions Toolbox, making data and information

from across the State available to governments and planners at the local and state levels, will provide a basis for the implementation of NWL solutions in North Carolina. This toolbox should be developed in concert with the North Carolina Climate Change Risk Assessment and Resilience Plan.

Many efforts to build tools for resilience and NBS are already underway in North Carolina. These efforts are listed below. Given the diversity of ongoing work in this space in North Carolina, a first step for creating a toolbox will be to bring together stakeholders and key players to ensure that the work is cohesive.

1. The Green Growth Toolbox is a guide to provide North Carolina's counties, towns, and cities with tools for growth that conserves wildlife and natural resources.[55] It was built by the North Carolina Wildlife Resources Commission (NCWRC) in collaboration with its conservation partners.
2. The Division of Coastal Management has created a Resiliency Roadmap/Storymap tool, which recently went live, to help coastal communities consider how to improve resilience.[56]
3. The US EPA has reached out to North Carolina about developing a state-specific version of its ARC-X platform, which provides communities and planners with information targeted to their interests about conducting a climate risk assessment and taking steps to improve climate resilience.
4. The Coastal Resilience Evaluation and Siting Tool (CREST) and Regional Coastal Resilience Assessments were developed by the National Fish and Wildlife Foundation (NFWF), in partnership with the National Oceanic and Atmospheric Administration (NOAA), the US Army Corps of Engineers, University of North Carolina (UNC) Asheville's National Environmental Modeling and Analysis Center, and NatureServe.[57] The tool and assessments allow NFWF and its partners to identify large public and private coastal lands ideal for restoration and analyze their potential to provide maximum protection to human communities while also restoring or improving habitat for fish and wildlife.
5. Duke University's Nicholas Institute for Environmental Policy Solutions compiled a set of spatial layers representing the geographic area where a range of NWL-related actions to benefit resilience and carbon could be taken in North Carolina; these data products will be published this spring.
6. The Duke University team recently received a grant to conduct spatial modeling of coastal protection and blue carbon for six mid-Atlantic states, including North Carolina, to create a spatial prioritization of areas where habitat protection or restoration have high potential to enhance human and natural community resilience as well as carbon storage.
7. Additional resources, tools and guides for municipal forestry planning and policy development are available from the North Carolina Forest Service (NCFS).[58]
8. The Nature Conservancy (TNC) has a Coastal Resilience decision-support tool that provides communities access to the best available science and local data on coastal hazards to visualize

[55] Green Growth Toolbox, North Carolina Wildlife Resources Commission (NCWCRC), Retrieved from https://www.ncwildlife.org/conserving/programs/Green-Growth-Toolbox.
[56] Tools for Coastal Adaptation & Resiliency, North Carolina Division of Coastal Management, Retrieved from https://deq.nc.gov/about/divisions/coastal-management/coastal-adaptation-and-resiliency/tools-coastal-adaptation.
[57] Coastal Resilience Evaluation and Siting Tool (CREST), National Fish and Wildlife Foundation, Retrieved from https://resilientcoasts.org/#Home.
[58] "Urban and Community Forestry", North Carolina Forest Service, Retrieved from https://www.ncforestservice.gov/Urban/Urban_Forestry.htm

their risks and examine where nature can increase resilience and reduce risk through conservation and restoration activities.[59]

9. TNC also has a Natural Solutions Toolkit that contains spatial decision tools and web apps to catalyze land conservation.[60]
10. USGS South Atlantic Water Science Center is undertaking a 3-year study of water availability and use to meet competing societal and ecological needs in Southeastern Atlantic Coastal Basins of the Carolinas.[61] The Coastal Carolinas study area includes lower parts of the Pee Dee/Waccamaw River and Cape Fear River Basins extending from Georgetown, South Carolina up through the greater Wilmington, North Carolina area. The study is divided into five main components: 1) Societal Water-Use Data Compilation and Refinement, 2) Land-use, Population, Water-use, and Climate Change Scenarios 3) Surface-water Modeling, 4) Ecological Response Modeling, and 5) Groundwater Modeling.
11. The North Carolina Wildlife Habitat Threat Data Viewer and Analysis Tool is a spatially-explicit decision support tool (DST) to support state-wide habitat acquisition and management decisions by projecting future probability of occurrence of specific threats relative to terrestrial and aquatic habitats, specifically climate change and urbanization. The DST allows users to explore individual or multiple threats in a spatial, and, for some threats, a temporal environment in user defined scenarios. This tool is intended to give managers, decision makers and other types of users an accessible and flexible tool to help assess risks to wildlife populations, and ultimately, inform decisions.
12. The American Farmland Trust has offered to work with North Carolina to develop spatially-explicit data at the state and county-level using their new interactive Carbon Reduction Potential Evaluation (CaRPE) Tool to support scenario analyses that identify potential agricultural conservation practices, practice combinations, and cropland/pastureland targets for climate co-benefits.

As shown above, numerous tools and techniques are available to help communities, especially coastal communities, ascertain exposure to climate amplified risks. What is really lacking is a toolbox that moves from vulnerability assessment to specific implementation techniques, funding opportunities, and technical assistance. An example of such a tool might be found in the Tool for Environmental, Agricultural and Military reporting (TEAM), which was developed by the North Carolina Department of Agriculture and Consumer Services (DA&CS) - Emergency Programs and can be used for a variety of functions, including modeling farmland conservation easements.[62]

The development of the toolbox is only part of the solution. Utilizing the information in the toolbox to solve planning problems requires technical staff to coordinate with the developers of the North Carolina Risk Assessment and Resilience Plan. It will also require outreach staff to help project developers and local planners interpret results to facilitate investments in cost-effective restoration and conservation of natural systems to increase resilience in the most vulnerable areas and communities.

[59] The Nature Conservancy Coastal Decision Tool, Retrieved from https://coastalresilience.org/project/north-carolina/.
[60] The Nature Conservancy Natural Solutions Toolkit, Retrieved from https://coastalresilience.org/natural-solutions/toolkit/.
[61] Coastal Carolinas Focus Area Water Availability and Use Study, U.S. Geological Survey (USGA), U.S. Department of the Interior, Retrieved from https://webapps.usgs.gov/watercensus/coastalcarolinas_fas/index.html.
[62] Tool for Environmental, Agricultural and Military Reporting (TEAM) Retrieved from https://www.ncmhtd.com/TEAM/

**Recommendation to Build a Natural and Working Lands Solutions Toolbox**

Establish ongoing funding for a state-supported toolbox that brings together these existing resources in a coherent way to help North Carolina communities move from vulnerability assessments to implementation and funding actions. This should include mapping capability that identifies the areas and communities most vulnerable to climate-related disasters and displays how NBS can reduce risks and impacts.

The interactive map will use current and historical data and predictive modeling to display vulnerability to flooding and wildfires for ecosystems, infrastructure, and local communities, as well as overlays for potential carbon and other ecosystem and community benefits.

The funding will also go toward training local community planners on using the toolbox to build long-term resilience and carbon mitigation plans. Lastly, the funding should be used to foster pilot projects that use the toolbox to develop and build NBS.

### 3.1.4 Integrate Climate Adaptation and Resiliency Strategies into Local Comprehensive Plans

This recommendation would require an amendment to North Carolina General Statutes, Chapter 160D, to mandate that all North Carolina counties and municipalities incorporate climate adaptation and resilience strategies as part of their comprehensive plan. A comprehensive plan is often called a land use plan and can provide a vision and strategies for the community's future. [63] NCGS 160D-5-1 (a) requires communities with current zoning regulations adopt a comprehensive plan by July 1, 2022.[64]

With the recommended mandate, comprehensive plans could be modified to support zoning and other development regulations that promote green infrastructure in a community. The plan could potentially promote efficient, equitable and sustainable public investment in infrastructure, including conservation of natural and cultural resources and the preservation of open space. Measures to reduce GHG emissions could also be incorporated in a plan.

Most North Carolina counties and municipalities have zoning ordinances and adopted comprehensive plans. There are many, however, who have not. In addition, many of the plans are outdated, especially in the context of North Carolina's urban growth management issues. Regional organizations such as Councils of Government can assist local governments in updating land use plans. The NCFS Urban and Community Forestry Program (U&CF), NCFS Firewise Communities Program and the North Carolina Department of Commerce Main Street and Rural Planning Center can also potentially provide technical assistance to local governments. Private sector planning and consulting firms can also provide the expertise to develop or modernize municipal and county comprehensive plans.

The comprehensive plan should be coordinated with capital improvements, hazard mitigation, transportation, economic development, and other local plans. Plan goals should be mutually reinforcing, with the alignment of

[63] Triangle J Council of Government. (2020, February 19). "Land Use Planning". Retrieved from https://www.tjcog.org/programs-land-use-transportation/land-use-planning

[64] Lovelady, Adam. (2019, September). "Chapter 160D and Other Zoning Legislation" Blog post on Coats' Canons: NC Local Government Law. University of North Carolina School of Government. Retrieved from https://canons.sog.unc.edu/chapter-160d-and-other-zoning-legislation/

performance metrics, indicators, and policy recommendations. Plans should include measures to ensure equity in climate adaptation strategies. Local planning programs should include appropriate public involvement processes to achieve consensus on an equitable development and resilience vision for the community. Plans can support and encourage public-private partnerships in planning and development practices.

Several North Carolina cities and counties are actively developing new zoning codes and updating comprehensive plans that address climate change and identify strategies for adaptation and resilience, drawing from a plethora of successful case studies and methodologies from other states, cities, and counties across the United States. We emphasize the need for robust community engagement and buy-ins to these plans.

Implementation of resilience strategies could result in increased acreage of green space preserved, thus increasing ecosystem resilience. Community resilience could be improved by the implementation of strategies that would address public health impacts, equity, and social vulnerability issues, as well as sustainable community development. Natural resource benefits that could result from this implementation are improved air quality, water quality/quantity, ecosystem biodiversity, ecosystem health, public health, and food and fiber production.

Updated, modernized, local comprehensive plans can provide a blueprint for communities to proactively address climate-related hazards through improved land management and development practices. These outcomes will both increase local resilience that could reduce future disaster relief costs.

**Recommendation to Integrate Climate Adaptation and Resilience Strategies into Local Government Comprehensive Plans**

The North Carolina Legislature should amend NC General Statutes, Chapter 160D, to require that all North Carolina counties and municipalities incorporate climate adaptation and resilience strategies into their comprehensive plan. Periodic update of the plans, every 10 years, should also be required.

Local governments should use their amended or newly adopted comprehensive plans as a basis for adopting new zoning codes that address climate change and identify strategies for adaptation and resilience. Local governments should be encouraged to use existing NWL programs, resources, and actions identified in this report to improve both new and existing plans, and should consider options that improve resilience, public health, and quality of life such as creating parks, trails, or greenways in floodplains.

## 3.2 Priority Recommendations Key

Each recommendation will provide some or all of the following information.[65]

Description: An overview of the issue and opportunity.

Geographic Scope: An estimate of all the potential land area encompassed by the recommendation; where it would be possible to implement the recommendation based on current conditions; this may not be a realistic estimate of extent of the implementation, due to practical considerations such as funding, landowner interest, or current statutes. In cases where more realistic estimates were conducted it will be noted.

Greenhouse Gas Impact: An estimate of the potential change in carbon stored and sequestered if the recommendation were implemented to its full extent, where it would be possible to implement the recommendation; this may not be a realistic estimate of extent of the implementation, due to practical considerations. In cases where realistic estimates were conducted it will be noted. Some sections also report this as carbon storage or sequestration per acre, rather than total carbon storage or sequestration if the recommendation were implemented to its full extent.

Ecosystem Resilience: An estimate of the potential land area encompassed by the recommendation that could help to protect important habitat, biodiversity, and watershed areas. This assumes the full land area is being protected and may not be a realistic estimate of probable implementation, due to other considerations.

Community Resilience: An estimate of the potential land area encompassed by the recommendation that also overlaps with significant areas of population at risk of flooding or water pollutant exposure during storms, and the number of people in these at-risk areas. This assumes the full land area being protected and may not be a realistic estimate of probable implementation, due to existing barriers.

Economic and Health Benefits: Descriptive overview of likely economic and health benefits with references.

Estimated Cost: The costs for recommended programs were estimated using comparable examples or literature; where not, a list of capacity needs was included.

Actors and Participants: The agencies, organizations, and stakeholders that will participate in implementation.

Road Map for Action: Details on the implementation of the recommendation.

Examples: Concrete examples of similar programs or activities in other places.

[65] Represents estimates of potential scope and impact to give a sense of the magnitude of these different opportunities. Modeling of individual strategies and implementation scenarios was not performed. See Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.

## 3.3 Priority Recommendations for Forest Lands

Introduction: More than 60% of North Carolina, over 18 million acres, is forested with a wide variety of forest ecosystems, ranging from rare high elevation spruce-fir forests to coastal maritime forests.[66] About 85% of North Carolina's forests are privately owned. North Carolina's forest lands currently pull 37.8 MMT $CO_2$e/year from the atmosphere, offsetting 25% of North Carolina's gross GHG emissions.[67] This level of carbon sequestration puts North Carolina far above the national average of 11% emissions offset by forest lands.[68] Conserving and restoring forests in North Carolina is one of the most important steps we can take to mitigate climate change and reduce overall emissions.

*Sustainable management and financial support of the 14 million acres of forest owned by North Carolina's private forest landowners must be a cornerstone of any actions taken by the State.*

Ecosystem and Community Resilience: Protecting the strong base of healthy and resilient forest land in North Carolina provides a multitude of co-benefits and ecosystem services such as drinking water supply protection, wildlife habitat conservation, outdoor recreation, air pollution abatement, reduced wildfire risk, forest products, and associated environmental and economic benefits. There are 3,170,000 acres of unprotected forest land in North Carolina that are highly rated (>5) on the North Carolina Conservation Planning Tool Biodiversity and Wildlife Habitat Assessment.[69] Protecting forests and wetlands in floodplains also results in substantially lower damages from hurricane-related flooding events and provides improved ecosystem services for North Carolina.[70,71]

Economic and Health Benefits: According to the most recent data released by NCSU Extension Forestry, the forest products industry was the State's top manufacturing industry as of 2017. North Carolina Extension Service analysis indicates that more than 1,000 companies in the forest products industry in North Carolina employed more than 70,000 individuals.[72] That same year, the industrial output from the forestry sector contributed $18.5 billion in gross sales and this sector paid a total of $912 million in local, state, and federal taxes.

Protecting forests from degradation and conversion to other uses also provides opportunities for recreation, tourism, and other economic benefits. The outdoor recreation economy already contributes 260,000 direct jobs

[66] USFS. (2019). Forests of North Carolina, 2018. doi:10.2737/FS-RU-225.
[67] DEQ. (2019, January). *North Carolina Greenhouse Gas Emissions Inventory: (1990 – 2030)*. North Carolina Division of Air Quality. Retrieved from https://deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory.
[68] US EPA. (2019, April 11). *U.S. Greenhouse Gas Emissions and Sinks: 1990-2017*. EPA 430-R-19-001. Retrieved from https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2017
[69] North Carolina Conservation Planning Tool, North Carolina Natural Heritage Program, DCNR. Retrieved from https://www.ncnhp.org/conservation/conservation-planning-tool
[70] Narayan, S. et al. The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. *Sci. Re*p. 7, 9463 (2017).
[71] Williams, T. M., Hitchcock, D., Song, B. & Halloran, T. O. (2019). Hurricane Florence Flooding in Georgetown County: A Qualitative Explanation of the Interactions of Estuary and Tidal River.
[72] NC Cooperative Extension. (2018). Economic Contribution of the Forest Sector in North Carolina 2017, Retrieved from https://content.ces.ncsu.edu/economic-contribution-of-the-forest-sector-in-north-carolina

to the North Carolina economy, equivalent to $28.0 billion in consumer spending, $8.3 billion in wages and salaries, and $1.3 billion in state and local tax revenue.[73]

Geographic Scope: Efforts to protect North Carolina's forests should occur statewide, across 11.7 million acres of currently unprotected forests. There are 2.2 million acres of wetland forests with high carbon-storage potential are not currently protected.[74,75] According to the Trust for Public Land Forest Carbon Map, counties with high carbon stocks in private land span the Piedmont, Mountains, and Coastal Plain, with the largest opportunities in Columbus, Bladen, Wilkes, Moore, and Pender Counties. Forest protection may also prioritize the 1.8 million acres of high biodiversity value areas identified by the Conservation Planning Tool, which are partially or fully owned by private landowners.

Greenhouse Gas Impact: According to the Trust for Public Land Forest Carbon report for North Carolina, privately-owned forests in North Carolina store 721 MMT of carbon.

### 4.3.1 Protect Forest Lands

#### Strategy 1: Conserve forests through easements and acquisition

Description: Protecting forests from conversion to other land cover types is one of the most important actions to reduce climate change because it maintains carbon stocks and sequesters additional $CO_2$ from the atmosphere.

Actors and Participants:

- State agencies – NCWRC, NCFS, Division of Parks and Recreation (DPR), DCM, state historic sites, North Carolina Plant Conservation Program, and others.
- Impact Partners– The Nature Conservancy, Conservation Trust for North Carolina, The Conservation Fund, Coastal Land Trust, and other land trusts and conservation organizations.
- Granting institutions – NFWF, Forest Legacy Program, NCLWF (formerly Clean Water Management Trust Fund), and private donors.
- Federal – US Forest Service, National Park Service (NPS), US Fish and Wildlife Service.

Road Map for Action:

Although a vast swath of North Carolina is forested, less than 10%[76] of those lands are explicitly managed for biodiversity and have substantial protection from degradation and conversion (GAP-1)[77]. Permanent protection of forested natural resources is a key element in resilience and climate change response. North Carolina should increase the rate and scale of land acquisition by public agencies and nonprofit conservation organizations through increased recurring funding for land acquisition grants. On average, costs for land acquisition for conservation begin at approximately ~$1,000 per acre. For example, the long-term average cost to the NCLWF for land acquisition is $1,200-$1,300 per acre (up to 50% of the cost of acquisition). These costs paid by the State are matched by other non-state funding sources, corporate partners, and philanthropists.

State land managing agencies already have legislative approval for land acquisition; more funding is needed to expand the existing funding and land stewardship programs within land managing agencies to help protect and enhance North Carolina's investment in forests. Land protected through conservation easements and

[73] Outdoor Industry Association, North Carolina, Retrieved from https://outdoorindustry.org/state/north-carolina/
[74] Managed Areas | Natural Heritage Program. Retrieved from https://www.ncnhp.org/activities/conservation/managed-areas
[75] Homer, C., C. Huang, L. Yang, B. Wylie, & M. Coan. (2004). Development of a 2001 National Land-Cover Database for the United States. *Photogrammetric Engineering & Remote Sensing* 70, 829–840
[76] Managed Areas | Natural Heritage Program. Retrieved from https://www.ncnhp.org/activities/conservation/managed-areas
[77] GAP Status Code. Retrieved from https://www.arcgis.com/home/item.html?id=f6f485703ffa49b4ad367f06b9501492

acquisitions would not necessarily be taken out of active management; most lands could benefit from stewardship activities such as prescribed fire and removal of invasive exotic species. Depending on the funding requirements and ecological characteristics of the land to be protected, some areas would be appropriate for forestry and timber production, while other areas will be set aside for permanent protection such as wilderness or protected natural areas.

A potential decrease in property valuation is a concern for local governments because property tax revenues account for the majority of local government general fund revenues. In some areas, concerns over the tax impact of forest conservation programs may limit local protection efforts. However, some studies have shown that encumbering high-priority lands may not greatly decrease the value of properties or the amount of county tax revenues. This is in part because decreases in county revenues are not proportional to the land area considered if the land already has a low tax valuation due to being unimproved land or already being enrolled in a present use program. In addition, for lands protected via an easement (instead of fee simple acquisition), a fraction of the land value would remain in the tax base (i.e., the land would remain taxable at a reduced value). Past research also suggests that decreases in property value are likely to be offset by increases in the value of nearby properties, the low demand on government services from NWL, and the benefits of ecosystem services provided to the local communities by open space.

Examples: North Carolina has a strong institutional framework in the form of conservation trust funds to support land and water conservation funding.[78]

- In the past two years, the NCLWF awarded nearly $50 million in grants to communities and conservation organizations.[79]
- Since its start in 1994, the Parks and Recreation Trust Fund (PARTF) has provided more than $200 million for 850 local government park, trail, and greenway projects and funded an additional $300 million for other projects.[80]
- Successful land acquisition projects involving state agencies partnering with local conservation organizations are found in every state. Some recent examples in North Carolina are:
- Salmon Creek State Natural Area,[81]
- The Carolina Thread Trail,[82] and
- Headwaters State Forest.[83]

### Strategy 2: Modernize forest policy and tax incentives

Description: Modify forest tax policy to improve the overall quality and scale of forests in NC.

Tax incentives can help reduce the tax burden for forest owners and reduce the threat of converting forests to more profitable land uses or to harvesting timber prematurely. Tax incentives can encourage landowners to retain their forestland and invest in targeted management and restoration. Reduced tax liability can make the difference between whether a forest owner chooses to conserve and manage their land or sell it for immediate financial gain.

[78] Interactive Database - Land for Tomorrow. Retrieved from http://www.land4tomorrow.org/learn/interactive-database/
[79] Clark-Sutton, K., J. Hofmann, S. VanLear, & M. Gallaher. (2018). North Carolina's Land and Water Yesterday, Today, and Forever: A Survey of North Carolina's Land and Water Funding. Retrieved from http://ncforever.org/wp-content/uploads/NCForever-NC-Land-and-Water_optimized-007.pdf
[80] For a complete list of PARTF projects see https://files.nc.gov/ncparks/partf-list-all-grant-recipients-by-county.pdf.
[81] Associated Press. (2019). "NC Mountains Get New State Park, 3 New State Trails". Retrieved from https://www.wfae.org/post/nc-mountains-get-new-state-park-3-new-state-trails
[82] Retrieved from https://www.carolinathreadtrail.org/
[83] Hubbard, A. Headwaters State Forest. NCFS. Retrieved from https://www.ncforestservice.gov/Headwaters/index.htm

### Actors and Participants:

- Policymakers – Governor's office, General Assembly, and associated staff.
- Stakeholders – Landowners, environmental nonprofits, NCFS, industry and trade associations, others.

### Road Map for Action:

Expand Present Use Value Program - Current use laws assess and tax forested land based upon current usage, rather than its "highest and best" use, providing significant savings while encouraging owners to resist development and other economic pressures, accumulate stored carbon, and maintain sequestration and environmental co-benefits. North Carolina already allows reduced property taxes for wildlife, agriculture, and forestry. While these valuation programs have made a positive impact, their scale of implementation and overall effectiveness have been limited and could be expanded to provide more benefits. The State should incorporate additional provisions to the Present Use Value system (GS 105-277, "PUV") to 11) reward landowners for protecting ecosystem services such as carbon sequestration and water quality, and 22) provide tax credits to landowners that currently don't qualify for PUV such as corporations and small-tract landowners.

Reinstate the Conservation Tax Credit – Conservation tax credits provide private landowners a tax break for voluntarily donating land or easements for conservation purposes. North Carolina was the first state to establish a conservation tax credit. Beginning in 1983, landowners used the tax credit to voluntarily protect more than 250,000 acres of conservation land, while leveraging six dollars in land or conservation easement donations for every dollar of tax credit granted.[84] The North Carolina Conservation Tax Credit program was repealed by the General Assembly effective January 1, 2014.

No Net Loss - Explore the feasibility of implementing a "No Net Loss" forest policy, similar to Maryland's Forest Conservation Act, enacted in 1991. This law creates a system of required forest mitigation for land use change (e.g., development) proposals that lead to loss of natural forest cover. Developers must gain approval at the county or municipal level for their proposals, with the requirement to mitigate 75% of the area of forest that will be lost due to developments that impact tree canopy. Mitigation is accomplished through reforestation. This program has significantly slowed the loss of forest in Maryland. A study of the feasibility for North Carolina could be a commissioned report or Governor's Office priority.

### Examples:

- Present Use Value for Wildlife [85]
- Maryland's No Net Loss Policy [86]

[84] CTNC. (2014). "CTNC Releases Report Detailing Importance of NC Conservation Tax Credit" Conservation Trust for North Carolina. Retrieved from https://ctnc.org/ctnc-releases-report-detailing-importance-nc-conservation-tax-credit/
[85] NCWRC. Wildlife Conservation Land Program. Retrieved from https://www.ncwildlife.org/Portals/0/Conserving/documents/Introduction-to-the-Wildlife-Conservation-Land-Program-2018-Update.pdf
[86] Highfield, C. "Maryland: The 'No-Net-Loss' of Forest State". Alliance for the Chesapeake Bay. Retrieved from https://www.allianceforthebay.org/2013/05/maryland-the-no-net-loss-of-forest-state/

### 3.3.2 Restore Forest Land

Description: Restoring forest lands (including reforestation and afforestation) offers one of the largest land sector pathways to carbon sequestration, by storing carbon aboveground in standing biomass as well as increasing soil carbon.

Geographic Scope: Efforts to restore forests should be statewide. In North Carolina, about 5.1 million acres of land that is not currently forested or developed could support forests.[87] Priorities within this area include;

- NCFS Forest Legacy Program Assessment of Need,
- North Carolina Forest Action Plan priority areas,
- Geographic regions and habitats naturally rich in carbon, such as pocosins, and
- Protected lands in the State.[88,89]

Greenhouse Gas Impact: Restoring forests and wetlands across North Carolina could create a carbon sequestration benefit of 3.08 MT $CO_2e$ /acre/year.[90]

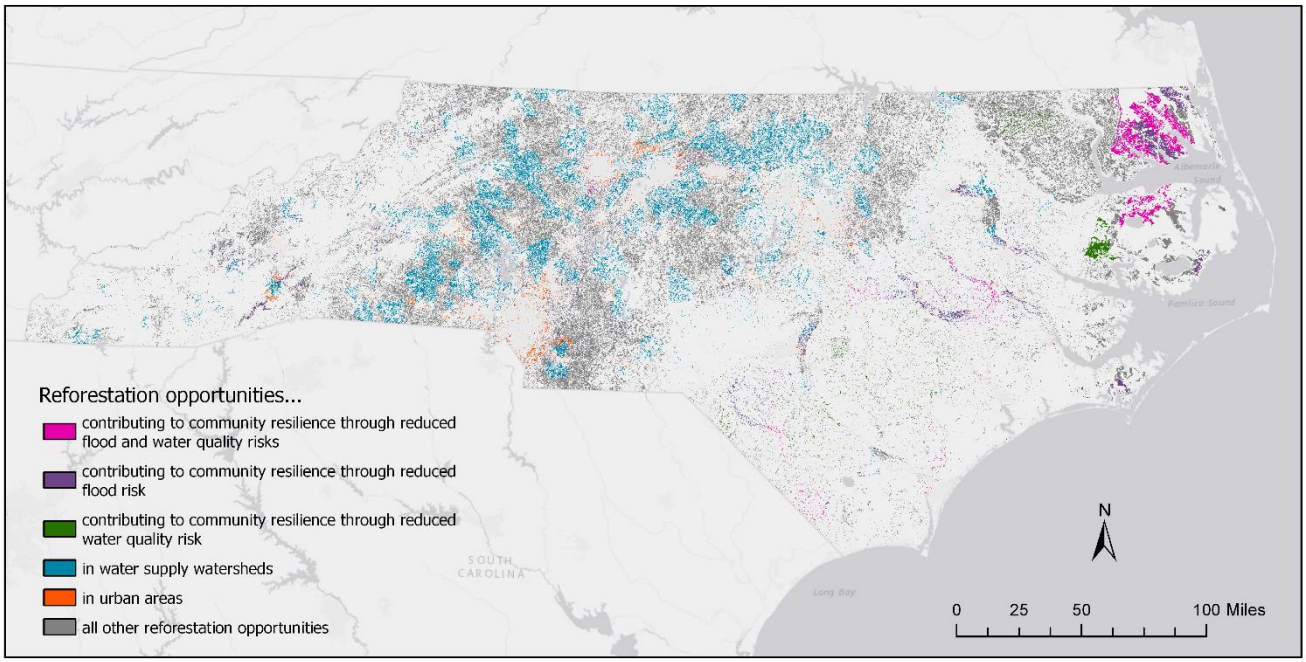
Ecosystem and Community Resilience: Forest restoration can dramatically increase the value of ecosystem services provided by forests. Strategically placed shoreline parks and natural lands buffer cities from rising seas, coastal storms, and flooding, a benefit that was seen by coastal cities during Hurricane Florence.[91] Restoring forest lands can increase biodiversity by providing food and habitat for native species. There are 441,000 acres of reforestable land in North Carolina that are highly rated (> 5) on the NHP Biodiversity and Wildlife Habitat Assessment.

Economic and Health Benefits: Reforestation can help make urban and rural areas more resilient to the effects of climate change by establishing parks and green spaces where they are needed most. Planting forests in urban areas can provide cooling effects. Climate change affects everyone, but in cities, low-income communities often face the greatest threats. According to the Trust for Public Land, on average, low-income neighborhoods have fewer parks and green spaces to absorb stormwater, provide cooling shade, and protect homes and businesses from flooding.[92] Urban forests can provide recreation, reduce the urban "heat island" effect, protect people from heat waves, reduce household energy demands for both heating and cooling, absorb rainfall, reduce flooding, and recharge drinking water supplies while saving energy for water management.[93] Natural areas can also positively influence real estate values and local tax revenue.[94]

[87] For more information about the methods used for these estimates, see Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.
[88] GAP Status Code. Retrieved from https://www.arcgis.com/home/item.html?id=f6f485703ffa49b4ad367f06b9501492.
[89] Managed Areas | Natural Heritage Program. Retrieved from https://www.ncnhp.org/activities/conservation/managed-areas.
[90] For more information about the methods used for these estimates, see Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.
[91] Williams, T. M., Hitchcock, D., Song, B. & Halloran, T. O. (2019). Hurricane Florence Flooding in Georgetown County: A Qualitative Explanation of the Interactions of Estuary and Tidal River.
[92] Trust for Public Land. Climate-Smart Cities. Retrieved from https://www.tpl.org/how-we-work/climate-smart-cities.
[93] Nowak, David J.; Appleton, Nathaniel; Ellis, Alexis; Greenfield, Eric. 2017. Residential building energy conservation and avoided power plant emissions by urban and community trees in the United States. *Urban Forestry & Urban Greening*. 21: 158-165.
[94] Yu, S.-M., Han, S.-S. & Chai, C.-H. Modeling the value of view in real estate valuation: A 3-D GIS Approach. *Journal of the Pacific Rim Real Estate Society* 11, 1–22 (2005).

Figure 3-2 presents reforestation opportunities in North Carolina that would promote rapid carbon sequestration while enhancing community resilience. Reforestation opportunities that would contribute to community resilience through reduced flood and water quality risks are concentrated in the northeast part of the State and along major rivers in the coastal plain. This figure also shows restoration opportunities in the Piedmont for 1) forests in water supply watersheds and 2) urban forests. More information on the methods used to identify these areas is available in Appendix I.

**Figure 3-2: Reforestation Opportunities with Additional Resilience Benefits**




Source: Nicholas Institute for Environmental Policy Solutions at Duke University
Explore these map layers alongside other contextual information in the **Duke University's Natural and Working Lands Storymap.**

## Strategy 1: Expand restoration efforts on publicly owned lands

Description: Public lands are ideal for restoration, as they offer opportunities for research, recreation, and public education, and long-term conservation. Publicly owned lands are suitable for forest restoration due to 1) land management prior to acquisition or 2) removal of invasive exotic species, diseased trees, or storm-damaged trees.

Actors and Participants:

- State – NCWRC, NCFS, DCM, DPR, North Carolina Plant Conservation Program, and other land managing agencies.
- Local governments – parks and open spaces, municipal water supply watershed lands.
- Restoration partners – local land trusts and community organizations.
- Federal – US Forest Service (USFS), US Fish and Wildlife Service (USFWS), NPS.

Road Map for Action:

Expand reforestation and restoration efforts on publicly owned lands, with a special focus on pocosin wetlands, riparian and coastal zones, or other areas with the highest potential for co-benefits in resilience, ecosystem services (including water quality and protection from flooding), and wildlife habitat. Reforestation and

restoration opportunities and practices are likely to be different, depending upon the landscape context and management objectives.

Examples:

- The America's Longleaf Restoration Initiative is a collaborative effort of public and private sector partners that supports range-wide efforts to restore and conserve longleaf pine ecosystems. Longleaf restoration has been progressing steadily in the last 5-10 years across the US South, resulting in increased habitat for endangered species, including red-cockaded woodpecker.
- The Shortleaf Pine Initiative represents an extensive group of conservation minded agencies and organizations with the common goal of restoring this imperiled ecosystem. The Initiative has developed a range-wide conservation plan to identify optimum restoration strategies, increase coordination among shortleaf proponents, and maximize the effectiveness of ongoing efforts.
- The Southern Appalachian Spruce Restoration Initiative works with local, state, and federal partners to help restore red spruce to the forests of Western North Carolina.

### Strategy 2: Encourage restoration and reforestation on private lands

Description: Many private lands may be improved for ecosystem services and carbon sequestration, when landowners have access to technical advice, funding, and resources for restoration.

Actors and Participants:

- State – NCFS
- Landowners and producers – Private forest landowners
- Restoration partners – local land trusts and community organizations
- Federal – USDA Natural Resource Conservation Service (NRCS)

Road Map for Action:

Increase State funding available to landowners, land trusts, and other conservation organizations for restoration and reforestation. Similar to publicly owned lands, a special focus on pocosin wetlands and riparian and coastal zones will maximize the potential for co-benefits in resilience, ecosystem services, and wildlife habitat.[95,96] Individuals and agencies should also encourage investment from corporate and philanthropic partners into restoration projects on private lands.

Examples:

- Longleaf restoration has been progressing steadily in the last 5-10 years across the US South, resulting in increased red-cockaded woodpecker habitat.

[95] Rey Benayas, J. M., Newton, A. C., Diaz, A. & Bullock, J. M. Enhancement of biodiversity and ecosystem services by ecological restoration: a meta-analysis. *Science* 325, 1121–1124 (2009).

[96] Kimball, S. *et al.* Cost-effective ecological restoration. *Restor. Ecol.* 23, 800–810 (2015).

### 3.3.3 Enhance Forest Land

#### Strategy 1: Increase landowner access to forest management technical and financial assistance

Description: Forest management practices that strengthen forests and enable them to sequester and store more carbon include fertilizing soils, extending forest rotations to let carbon accumulate, reforestation (through natural or artificial methods), accelerating restocking, managing competition to enhance overall growth, preventing spread of and loss to pests and pathogens, and producing climate-adapted native tree seedlings that are most likely to thrive. Increasing availability of technical and financial assistance to landowners who want to implement forest or wildlife management would help landowners achieve more carbon storage on more acres. Technical assistance for prescribed fire, prevention of wildfires, and removal of invasive species would also improve the quality of North Carolina's forests.

The FDP is a reforestation, afforestation, and forest stand improvement cost-sharing program in the NCFS under the Forest Development Act, GS 106-1010.[97] The FDP is primarily funded by an assessment on primary forest products produced from North Carolina timber and periodic legislative appropriations in some years as authorized by the Primary Forest Product Assessment Act, GS 106-1025. The goal of the program is to increase the productivity of privately owned forests through the application of forest renewal practices and other management that improves tree growth and overall forest health while ensuring protection of soil, air, and water resources. Private landowners in North Carolina are eligible to receive cost share funding on up to 100 acres of FDP cost-share annually. Under the FDP, a landowner is partially reimbursed for the costs of site preparation, seedling purchases, tree planting, the release of desirable seedlings from competing for vegetation, or any other approved practices necessary to establish a new forest. Additional practices aimed at improving existing forests may also be cost-shared under the program. Historically, the program has provided between 40 to 60 percent of the cost to implement the practices, with higher rates paid for establishing longleaf and shortleaf pine, hardwoods, and wetland species. To qualify for the FDP, a landowner must have a forest management plan approved by the NCFS.

Geographic Scope: 9.5-10.5 million forested acres are owned by ~ 162,000 families in North Carolina.[98]

Greenhouse Gas Impact: Forests managed for ecosystem services or wildlife may have higher sequestration potential and greater resilience to climate change.

Ecosystem and Community Resilience: Forest management can improve overall ecosystem resilience. Management treatments can be designed to promote overall health and reduce vulnerability to stresses that increase tree mortality, such as disease, insects, drought, and wildfire.

Economic and Health Benefits: Forest management has a high potential for economic co-benefits. Wood products from well-managed forests store forest carbon and offer lifecycle emissions benefits compared to alternative products that are more fossil-fuel intensive. The forestry sector in North Carolina directly contributes $20 billion in industry revenue, just over 2% of the state-wide economic output, and has a total (direct, indirect and induced) contribution of $32.8 billion. Increased forests in timber management may improve the availability of raw materials for the forest products industry, however, increased supply of raw materials may lower the profit for landowners. Increased timber production may have the effect of attracting

[97] NC Forest Development Program, North Carolina Forest Service, North Carolina Department of Agriculture and Consumer Services, Retrieved from https://ncforestservice.gov/Managing_your_forest/fdp.htm.
[98] Butler, B. J. & Butler, S. M. (2016). Supplemental Notes on National Woodland Owner Survey 2011-2013 Two-page Summary Reports. http://www.nrs.fs.fed.us/pubs/52393 doi:10.2737/NRS-RN-205.

additional wood-using industries, creating jobs, and increasing tax revenues, and strengthening rural communities.

Actors and Participants:

- State – NCFS, NCWRC, Governor's office and the legislature for expanded funding.
- Landowners and producers – Private forestland owners, local land trusts, and organizations that promote forest management.
- Information partners – universities and NGOs who may have data useful for planning or restoration .
- Federal – USFWS, US Forest Service, Natural Resource Conservation Service.

Road Map for Action:

Programs are already in place to introduce landowners to management plans and technical assistance. This strategy is focused on increasing access to that assistance. More funding for landowner outreach in existing tax-benefits (e.g., the Present Use Value) and increased funding for cost-sharing programs (e.g., the FDP) is needed. A large proportion of landowners are unaware of assistance available to them for developing forest management plans or sharing the cost of management activities. Currently, the problem is two-fold: many landowners don't know what programs are available to help them; and technical assistance bodies like the NRCS or North Carolina Extension Service do not have the staffing and resources to proactively engage with the thousands of private forest owners in the State. Providing more funding will solve part of the problem; it will also be important to have a plan for scaling up technical assistance capacity.

Examples:

- The University of Mount Olive, NCSU Forestry Extension, and North Carolina Tree Farm Program have hosted forestry workshops for landowners to learn more about taxes, timber markets, cost share programs, and estate planning.[99]
- The Sustainable Forestry and Land Retention Project of Roanoke Electric Cooperative holds annual conferences and works with an array of technical partners to assist more than 180 landowners owning 11,000 acres.[100]
- ForestHer North Carolina is a new North Carolina initiative created by conservation organizations, State agencies, and NCSU to provide women who are forest landowners with tools and training to help them manage their lands and become more engaged in forest stewardship.

### Strategy 2: Support the wood products markets

Description: North Carolina's economy is supported in part by the forest products industry. Trees store about 80 tons of carbon per acre when they are actively growing. When trees are turned into products, that carbon stays in those products and out of our atmosphere for long periods. Access to strong and diverse markets for forest products and ecosystem service markets provide financial incentives for forest landowners. Supporting wood products markets, especially in long-lived products such as furniture and building supplies, will support landowners managing and retaining their land as forests.

Ecosystem and Community Resilience: Promoting forest product utilization can provide a market-based incentive to stimulate forest practices where they are needed to achieve forest health and resilience, such as thinning overstocked forests to reduce fire risks. Promoting retention of long-term carbon storing wood

[99] Lois G. Britt Agribusiness Center, MOC, NC - Forestry Workshops. Retrieved from http://umoag.com/outreach/forestry.php.
[100] Projects | Sustainable Forestry. Sustainable Forestry. Retrieved from https://www.recforestry.org/projects.

products such as construction products, furniture, and old buildings will also delay carbon emissions from wood product decay.

Economic and Health Benefits: The forestry sector in North Carolina directly contributes $20 billion in industry revenue, just over 2% of the state-wide economic output, and has a total (direct, indirect and induced) contribution of $32.8 billion. Forest product usage helps revitalize rural communities that rely on the forest economy and incentivizes investments in forest management.

Actors and Participants:

- State – NCFS, NCWRC, NCSU Forestry Extension, state legislature for sustainable funding; state agencies for procurement policies requiring the use of renewable native natural resources, such as wood instead of concrete, steel, and other materials with higher carbon footprints.
- Local governments – support for PUV programs.
- Landowners/producers – Forestland owners who participate in available programs, industrial producers and small family tracts, construction industry.

Road Map for Action:

Continue to support diverse forest product markets, especially those products with longer carbon storage potential. Public awareness programs aimed at homeowners, architects, builders, and engineers, showcasing the benefits of forest products will help increase wood usage in construction of buildings. Public awareness programs focused on using real wood, substituting steel and concrete with wood or other sustainable products, retaining and upcycling furniture, and reducing the amount of wood products waste in landfills would all delay the inevitable carbon emissions from decaying wood products. Investments in campaigns promoting reusable household items like cups, napkins, and take-out containers will also reduce the overall carbon footprint associated with short-lived wood products.

This campaign should be coordinated with the following;

1. an education campaign in sustainable forest management for forest landowners,
2. support for landowners to certify their forests and harvested wood products as sustainable, and
3. a public awareness campaign to purchase sustainably harvested wood products.

Examples:

New York State has committed $600,000 to support state's forestry and wood products sector through investment in Cornell University's Arnot Teaching Forest to improv and expand processing and workforce development training.[101]

[101] NY Depart of Agriculture and Markets. 2020. "New York State Agriculture Commissioner Announces Key Investments to Support State's Forestry and Wood Products Industry". Retireved from https://agriculture.ny.gov/news/new-york-state-agriculture-commissioner-announces-key-investments-support-states-forestry-and

## 3.4 Priority Recommendations for Floodplains and Wetlands

Introduction: Floodplain and wetland protection, restoration, and enhancement are critical to North Carolina's carbon sequestration and disaster mitigation portfolio. These systems provide a multitude of benefits that span all NWL sectors. Overall, North Carolina's wetlands (including coastal and estuarine wetlands) cover 4.9 million acres[102] and floodplain areas cover 8.0 million acres of land. (Many wetlands are within floodplains, so the total area of wetlands and floodplains in North Carolina is less than the sum of their areas). While some types of wetlands and certain land uses in the floodplain may release carbon, forested floodplain areas and woody wetlands generally store and sequester carbon. In North Carolina, these lands cover 6.3 million acres and store approximately 2.1 billion MT $CO_2e$ and sequester 10 MMT $CO_2e$. each year.[103]

*Restoring properties that have experienced repeated flooding to natural conditions via a coordinated buyout process, reduces future flooding risk and costs for communities and has the potential to sequester 1 to 2 metric tons CO2e/acre/year.*

In addition, there are opportunities to restore floodplains and wetlands to promote carbon sequestration and other co-benefits. Restoring wetlands that can support forest cover is the best way to ensure that the restored wetlands will be a carbon sink, not a carbon source. In North Carolina, there are 775,000 acres of wetland restoration opportunities on agricultural land that could support forest cover, and an additional 4.3 million acres of reforestation opportunity in floodplain areas. If all this land were reforested, it would sequester 1.0 MMT $CO_2e$ each year.[104]

Natural resource co-benefits of protecting and restoring floodplains and wetlands include reduced risk of nearby flooding and wildfires; increased water quality, biodiversity, and wildlife habitat; ecosystem health; public health and expanded recreational opportunities, and reduced wildfire risk.

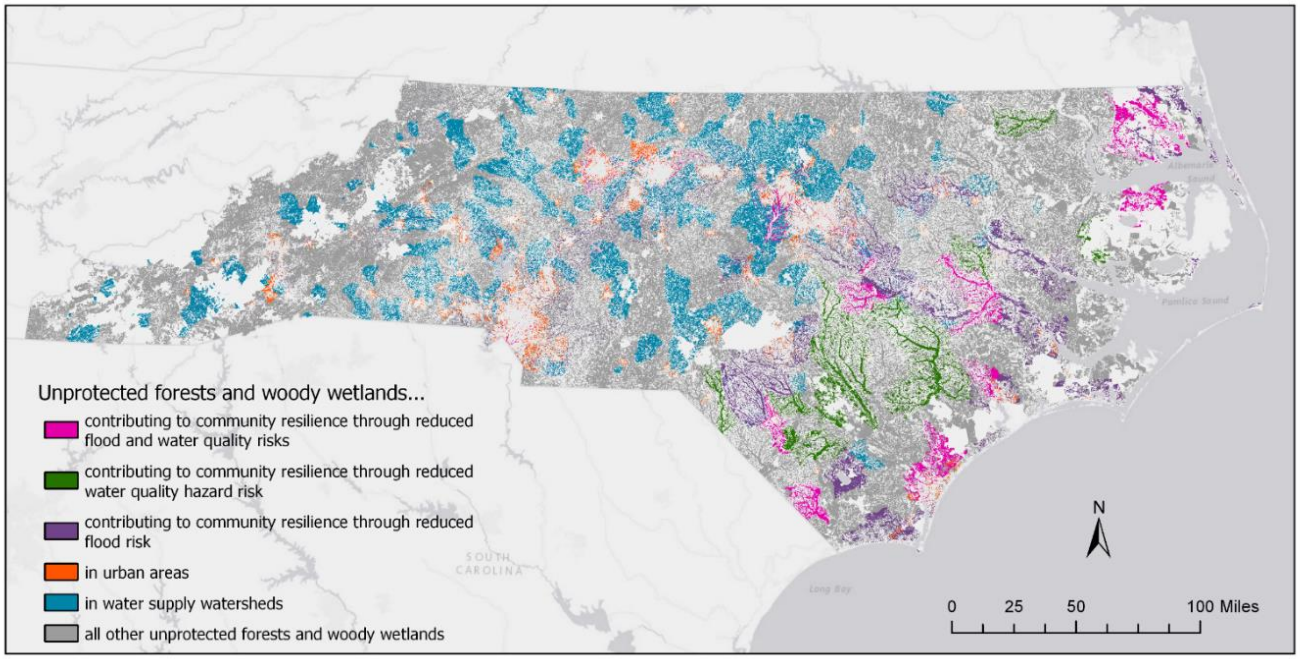
Recommendations for restoring and protecting floodplains and wetlands are included in other sections of this report, including Forestry, Urban Lands (especially in urban water supply watersheds), Pocosins (all Pocosins are wetland forests), and Coastal Areas Habitats (especially protecting land pathways for the migration of marsh and other habitat migration).

Figure 3-3 presents opportunities for restoration of forests and woody wetlands in North Carolina floodplains. Floodplain and wetland forests contribute to community resilience by reducing flood risk in watersheds with

[102]Multi-Resolution Land Characteristics (MRLC) Consortium. (2016). Data extracted from the National Land Cover Database (NLCD). Retrieved from https://www.mrlc.gov/ by Duke University's Nicholas Institute for Environmental Policy in 2019.
[103] For more information about the methods used for these estimates, see Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.
[104] Ibid.

many people living in flood-prone areas. They also remove pollutants from floodwaters in areas with water quality hazards. These opportunities tend to be in the coastal plain, where there are wide, populated floodplains and a high concentration of water quality hazards. This figure also shows restoration opportunities in the Piedmont for forests in water supply watersheds. More information on the methods used to identify these areas is available in Appendix I.

**Figure 3-3: Forest Conservation Opportunities with Additional Resilience Benefits**




Source: Nicholas Institute for Environmental Policy Solutions at Duke University
Explore these map layers alongside other contextual information in the Duke University's Natural and Working Lands Storymap.

## 3.4.1 Protect and Restore Floodplains

### Strategy 1: Coordinate the State's floodplain buyout and restoration program to increase resilience

Description: Develop state facilitated and coordinated voluntary buyout and easement programs coupled with restoration programs for private properties and farms that have experienced multiple flooding events.

Currently in North Carolina, the Federal Emergency Management Agency (FEMA) and the Department of Housing and Urban Development (HUD) are two primary pathways of funding for the government to buy flood-damaged properties from landowners who want to sell. FEMA allocates funding through its Hazard Mitigation Grant Program (HMGP) to reduce future disaster losses after a presidentially declared disaster. Local officials may request funding from the North Carolina Emergency Management, within the MS (DPS), to purchase properties that have either flooded or been determined substantially damaged.[105] Seventy-five percent of any buyout cost is paid by FEMA and the rest is paid by the State. This lengthy and sometimes

[105] FEMA. (2019). "FACT SHEET: Acquisition of Property After a Flood Event". Retrieved from https://www.fema.gov/news-release/2018/11/13/fact-sheet-acquisition-property-after-flood-event

complicated process requires an agreement among property owners, local government officials, the State, and FEMA.

It is important to note the following regarding current buyout processes;

- buyouts are strictly voluntary,
- many flooded properties do not qualify for a buyout,
- funding is limited, and
- other factors may be considered in addition to flooding.

Local governments can play a key role in the distribution of funding. When local governments have a buyout plan, they can use the plan to help allocate funding and coordinate buyouts most effectively. However, when no plan is in place (as is the case throughout NC), homeowners apply directly through the local government with no underlying plan or coordination. As a result, FEMA-supported buyouts of flood-damaged property are often in a patchy "checkerboard" pattern that leaves private inholdings where local governments are expected to continue providing services (such as water and sewer). This patchy buyout program also precludes restoration of the land as a functional floodplain that can provide flood attenuation and other co-benefits. Also, the FEMA buyout process often takes more than five years to complete, which can make it financially impossible for some property owners to participate.

The second pathway, Housing and Urban Development Community Development Block Grant (CDBG) – Disaster Recovery program, is administered through the North Carolina Office of Recovery and Resilience (NCORR) and has more flexibility for coordination. NCORR uses this flexibility to identify areas where flooding is a serious problem for the State, and coordinated buyout plans for these areas in cooperation with local governments and communities are being developed. State and local funding is needed to temporarily support these buyouts before reimbursement by HUD. State funding for bridging these grants should be provided at a level sufficient to keep these buyout programs moving forward as needed. The new coordinated buyout HUD-CDBG program is still being developed by NCORR.

For both FEMA and HUD processes, any structures on the property are removed, and the land is passed to the local government for management. Neither program provides funding for improvement or restoration of the land which may assist communities in mitigating future extreme events and in gaining other benefits (e.g., recreation such as creation of greenways or parks on these properties). Additional funding is needed to assist with restoration and land management.

Separate from post-flooding buyouts of private properties, the DA&CS implemented a voluntary program to decommission and close swine farms in the 100-year floodplain to prevent future flooding called the Swine Floodplain Program.[106] This program was prompted by flooding from Hurricane Floyd which led to the breach of farm lagoons and release of animal waste into waterways, affecting communities and water quality downstream and to the Coast. The farm buyout program placed parts of the enrolled farm in conservation easements, which 1) voluntarily limits the kinds of farming structures that can be built and 2) restricts future farming activities to crop production activities. The North Carolina General Assembly initially authorized $18.7 million to the program, which resulted in 43 buyouts out of 138 applicants. In 2017, prompted by more hurricanes, legislators allocated $5 million more to the program. This state funding is complemented by federal support through the NRCS, which funds easements and restoration on floodplain areas that have repeatedly flooded or could support a larger floodplain reclamation that will hold more water. This Emergency Watershed Protection program is voluntary, can involve land that has structures on it, and allows funding to be used for

[106] DA&CS. "Swine Floodplain Buyout". Retrieved from https://www.ncagr.gov/SWC/easementprograms/SwineFloodplainBuyout.html

restoration of the floodplain to improve its functionality.[107] North Carolina has not employed this program for buyouts and restorations as much as other states have.

Geographic Scope: Across North Carolina, 93,700 acres of developed land are within the active river area, in Census tracts with at least 100 National Flood Insurance Program (NFIP) claims between 1975-2019. There are 658 swine lagoons in flood-prone areas of North Carolina.[108]

Greenhouse Gas Impact: Qualifying wetlands and floodplains have the potential to sequester 1.88 MT $CO_2e$ /acre/year.[109]

Ecosystem and Community Resilience: Returning wetlands and floodplains to natural conditions has the potential to reduce the risk of flooding to nearby areas, improve water quality, provide habitat for biodiversity, improve ecosystem health, and reduce heat island effects in urban areas. Based on the 2010 Census data, 169,000 North Carolinians live within the active river area in Census tracts with at least 100 NFIP claims since 1975.[110] With respect to swine farm buyouts, capping or decommissioning lagoons protects against potential future lagoon breaches and subsequent release of animal waste into waterways, thereby protecting downstream communities and water quality throughout the watershed. There are farms in urban and rural areas where a portion of their land area could be restored to a wetland so that farming could continue with less risk on the remaining land.

Economic and Health Benefits: Cost savings to local governments can be achieved by coordinating voluntary buyouts of flood-damaged properties and/or voluntarily restrictions on land uses to allow local governments to discontinue services to high-risk areas if all properties are bought out within an area. Buyouts can also reduce costs related to cleanup and damage from future storms.

Estimated Cost: This work would require funding of full-time staff to support local government planning, bridge loans to pay for buyouts until CDBG funding is secured, and funding for restoration of buyout areas.

Actors and Participants:

- State – NCORR and North Carolina Emergency Management (NCEM) to coordinate program, state legislature for sustainable funding; Division of Mitigation Services (DMS), NCLWF, PARTF, and the DA&CS.
- Local governments – e.g., city councils, stormwater management agencies, planning offices, soil and water conservation districts.
- Landowners and producers – homeowners and businesses who reside in areas at high risk of flooding; and farmers whose properties are located in flood prone areas.
- Restoration partners – local land trusts, community organizations, soil and water conservation districts, and North Carolina Rural Center.
- Information partners – Universities and NGOs who may have data useful for planning or restoration
- Federal – FEMA, HUD, USDA, NRCS.

[107] NRCS. Retrieved from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/landscape/ewpp/?cid=nrcs143_008216
[108] For more information about the methods used for these estimates, see Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.
[109] Ibid.
[110] Ibid.

### Road Map for Action:

As the risk of flooding increases in North Carolina, the NWL group recommends coordinating the State's FEMA and CDBG programs to utilize these buyout processes to create functional floodplain areas and greater resilience across North Carolina, and to facilitate pathways for leveraging funding through other state programs (DMS, NCLWF, and PARTF) and federal (NFWF, NRCS) programs for restoration of these lands. Connected, natural, permeable floodplains will build flood resilience within at-risk communities while also reducing the costs to local governments and sequestering carbon. Additional co-benefits that could be achieved on these lands should be considered when developing this improved buyout and restoration process. These include improved water quality, wildlife habitat, connected greenways for recreation, and other human health and ecosystem benefits.

A state-facilitated and coordinated buyout and restoration program would need to link together the funding and watershed planning for multiple state programs (NCEM, NCORR, DMS, NCLWF, PARTF, NCD&ACS) and work in close partnership with local governments and communities. The goal is to buy multiple adjacent private properties and support the restoration and resilient use of these properties by increasing funding and building capacity. This program should help support the development of local government watershed plans that identify areas for preferred buyouts and relocation of communities, that maximize flood reduction benefits, and that take into account potential co-benefits, such as reduced water pollutant releases during flooding, reduced wildfire risk, improved wildlife or habitat corridors. This would result in additional benefits such as sequestration of carbon, economic uses of new natural areas (e.g., hunting and fishing), recreational opportunities (parks, hiking, biking, birding), and improved scenic vistas and property values.[111]

Local plans should be required before communities can receive buyout funding from this new program. We emphasize the need for robust community engagement and buy-in to these plans. These state programs should have staff available to provide technical and funding support for the restoration of those lands either directly (through DMS, PARTF, or NCLWF) or through partner organizations. Such support could include help with planning and grant-writing (see Recommendation 5.1.4 Integrate Climate Adaptation and Resilience Strategies into Local Government Comprehensive Plans).

The State should also consider supplementing these programs with a new program designed to offer proactive (rather than reactive) buyouts of properties, that are at very high risk of flooding in the next 10 years.

### Building Blocks for Success:

1. Sustained state-appropriated bridge funding for the CDBG program.
2. Support for local planning efforts for voluntary buyouts and voluntary land use restrictions in rural communities across North Carolina.
3. Analysis of costs to the State for a new building in the floodplains over the last decade (by third party).
4. Restrictions on building in floodplains.
5. Increased and coordinated funding of swine farm buyouts via DA&CS and NRCS.

[111] A viewshed is the geographical area that is visible from a location.

Examples:

- Mecklenburg County, North Carolina has a successful floodplain buyout and restoration program run by Charlotte Stormwater.[112]
- Lumberton, NC, plans to develop a greenway using land acquired in the buyout program.[113]
- A study by The Nature Conservancy in Texas after Hurricane Harvey shows the efficacy of clustered buyouts.[114]
- Harris County, TX, prioritizes buying land parcels around existing greenways and parks.
- State of New York uses bought-out land as coastal buffers.[115]
- Louisiana's Strategic Adaptations for Future Environments (LASAFE) has created a state-wide plan for resilience, which includes buyouts, but also worked with the most at-risk regions to create localized plans for each region.[116]
- New Jersey's Blue Acres is an example of a successful state program.[117]
- Report from Environmental Law Institute and University of North Carolina (UNC) give examples of projects on small parcels of land as well as restoration for clustered buyouts.[118]
- Massachusetts' proposed GreenWorks infrastructure program would provide $100 million/year in grants to cities and towns to increase resilience and adapt to climate change.[119]

[112] Retrieved from https://charlottenc.gov/StormWater/Flooding/Pages/FloodplainBuyoutProgram.aspx
[113] Retrieved from https://coastalresiliencecenter.unc.edu/files/2018/12/Lumberton-Recovery-Plan.pdf
[114] Retrieved from https://www.nature.org/content/dam/tnc/nature/en/documents/harveybuyoutsummary.pdf
[115] Retrieved from https://stormrecovery.ny.gov/housing/buyout-acquisition-programs
[116] Retrieved from https://s3.amazonaws.com/lasafe/Final+Adaptation+Strategies/Regional+Adaptation+Strategy.pdf
[117] Retrieved from https://www.nj.gov/dep/greenacres/blue_flood_ac.html
[118] Retrieved from https://www.eli.org/sites/default/files/eli-pubs/actionguide-web.pdf
[119] Retrieved from https://www.wbur.org/earthwhile/2019/07/25/deleo-cities-towns-climate-change-greenworks

## 3.5 Priority Recommendations for Pocosins

Introduction: Pocosins are naturally occurring freshwater evergreen shrub-dominated wetlands of the Southeastern Coastal Plain with deep, acidic, sandy, peat soils. Pocosins are formed by the accumulation of organic matter, resembling black muck, that is built up over thousands of years in the unique conditions that exist on these wetlands. Several inches to more than 10 feet of organic matter can be built up under the correct conditions, making these lands a carbon sink for North Carolina. Pocosins also support wildlife habitat.

*North Carolina contains the world's largest acreage of Pocosins. Proper management of Pocosins has the potential to sequester significant amounts of carbon while decreasing the risk of catastrophic fire on these lands.*

North Carolina's Albemarle-Pamlico Peninsula (APP) is the site of the greatest pocosin acreage in the US. In the 1960s pocosins covered 2.25 million acres in North Carolina, making up 75% of the pocosins nationally. By the 1980s, drainage of the lands for forestry and farming operations had totally or partially altered all but about 700,000 of these acres.[120] Under drained (or drought) conditions, the pocosins emit a significant amount of carbon as $CO_2$ but very little methane. Restoration of pocosins involves rewetting peat soil that was ditched and drained years ago.

Wildfire has also converted some pocosins from carbon sinks to carbon sources. Four catastrophic wildfires occurred on refuges in northeast North Carolina and southeast Virginia between 2008 and 2011. The wildfires burned 97,000 acres and cost $57 million to contain, each fire lasted several months, and resulted in losses of up to five feet of peat deposits (releasing approximately 20 million tons of carbon).[121] The Evans Road Wildfire was a smoldering peat fire in Eastern North Carolina that started on June 1, 2008, caused by a lightning strike during North Carolina's worst drought. It lasted for three months and burned 41,534 acres inside the Pocosin Lakes National Wildlife Refuge and released millions of tons of $CO_2$. These wildfires also had a negative effect on human health and safety. During the Evans Road Fire, emergency room visits for cardiopulmonary complications increased significantly in counties exposed to the smoke.[122]

Ecosystem and Community Resilience: Restoring pocosins to their natural condition has the potential to reduce the risk of coastal flooding, improve water quality, provide habitat for biodiversity, improve ecosystem health, protect against wildfires, and protect against sea level rise (SLR).

Economic and Health Benefits: The protection provided by restoring pocosins would result in reduced loss of property due to flooding and fire and provide a potential buffer to SLR.

[120] Richardson, C.J. 2003. Pocosins: Isolated or integrated wetlands on the landscape? *Wetlands* 23: 563-576.
[121] Mickler, R.A., Welch, D.P. & Bailey, A.D. (2017). Carbon Emissions during Wildland Fire on a North American Temperate Peatland. fire ecol 13, 34–57. Retrieved from https://doi.org/10.4996/fireecology.1301034
[122] Rappold AG, Stone SL, Cascio WE, Neas LM, Kilaru VJ, Carraway MS. (2011). Peat bog wildfire smoke exposure in rural North Carolina is associated with cardiopulmonary emergency department visits assessed through syndromic surveillance. *Environ Health Perspect*. 119(10):1415–1420. doi: 10.1289/ehp.1003206.

Geographic Scope: Historically, there were 2.25 million acres of pocosins in North Carolina with the majority in the northeastern section of the State. 500,000 acres were drained in eastern North Carolina, and 250,000 of those drained acres are now in public ownership.

Greenhouse Gas Impact: Estimated total carbon benefits from restoring pocosins are 3.08 MT $CO_2e$ /acre/year. Pocosins will sequester 1,080 MT $CO_2e$ /acre at year 100.

Estimated Cost: Restoration involves installing water control structures and low-level berms at strategic locations in the ditch system to stop the artificial drainage of rainwater from the soil. The cost of restoration is relatively low on conservation lands, less than $350/acre.[123] Restoration will also require staff to support planning for restoration and enhancement.

### 3.5.1 Restore Pocosins

#### Strategy 1: Rewet hydrologically altered peatlands to prevent soil loss and catastrophic fire

Description: Pocosins are extremely flat wetlands that are generally not associated with large streams so that their natural drainage is poor. This topography allows for the accumulation of deep, carbon rich organic soils (or Histosols). Histosols have a minimum of 20-30% organic matter and a depth of organic matter between 40 cm and 4 meters. They are approximately 42 to 49 percent carbon. Over time, about 70% of North Carolina's natural peatlands have been drained, primarily for agriculture and silviculture.[124] Draining organic soils promotes aerobic decomposition and the loss of soil carbon via gaseous $CO_2$ emissions and as both inorganic and organic carbon in surface and groundwater. Peat oxidation results in land subsidence. Artificial drainage alters the carbon balance such that natural peatlands that historically sequestered carbon become a source of carbon to the atmosphere and water upon their alteration.

Restoring peatlands through reintroduction of wetland hydrology (rewetting), however, stops the loss of carbon from these soils and, in fact, converts them from a source of carbon to a sink. In addition to the carbon benefits, replacing hydrologic conditions and restoring healthy pocosin wetlands is important for providing wildlife habitat; sequestering nitrogen, mercury, and carbon; protecting estuarine water quality; lessening the frequency and severity of wildfires; and limiting flooding. In low-elevation coastal areas, pocosin wetlands play a key role in the adaption of ecosystems and the resilience of human communities in the face of SLR due to climate change by stopping soil loss via oxidation while allowing soil accretion to resume. Rewetting altered pocosins can be achieved at a meaningful scale guided by an American Climate Registry (ACR)-approved verification methodology (2017) and existing examples of restoration success in North Carolina. Implementation can begin immediately on tens of thousands of state-owned lands while opportunities on private lands can benefit from the existing methodology and potential for return on restoration investments via offset credits.

Geographic Scope: Prior to ditching and draining of the North Carolina's pocosins, these unique wetlands comprised over 900,000 acres of the coastal plain.[116] While some restoration has occurred in recent years, it is estimated that upward of a half million acres have been sufficiently altered to necessitate restoration, and about half of those lands are already in conservation ownership.

[123] Ibid.

[124] Ash, A.N., C.B. McDonald, E.S. Kane and C.A. Pories. 1983. Natural and modified pocosins: Literature synthesis and manufacturing options. FWS/OBS-83/04. US Fish and Wildlife Service, Washington, DC.

Estimated GHG Impact: The emission reductions for a carbon demonstration project at Pocosin Lakes National Wildlife Refuge (NWR) using the ACR methodology (e.g., applying water level as a proxy for GHG flux and using a simple linear regression model incorporating data from Timberlake, Hofmann, and Pocosin Lakes) in the first year of restoration was about 6.3 MT $CO_2$e/acre/year.

It is important to note that this is not the same as the offset credits that would be created since this does not account for the required deductions for the ACRs permanence buffer and uncertainty discount. This is the steady-state avoided emissions due to oxidation; additional avoided catastrophic fire benefits can also be realized per the ACR methodology. For example, the magnitude of emissions during a single catastrophic fire was estimated by Turetsky et al.[125] for northern peatlands at 3,300 to 3,600 g C/$m^2$. In a 2011 Great Dismal Swamp NWR fire, Reddy et al. estimated 44,000 g C/$m^2$ (1.1 MMT C) was emitted.[126] Avoiding these fires would preserve the carbon stock and avoid $CO_2$e emissions. Using a state and transition model of habitat based on literature and field work, Sleeter et al. found a single catastrophic fire emitted 41,600 g C/$m^2$ (1.04 MMT C) in the Great Dismal Swamp NWR.[127] Based on the fire record, catastrophic fires are burning with increased frequency in wildlands including in forested peat systems. In the Great Dismal Swamp, it is an estimated doubling of catastrophic fire frequency, and with restored conditions (i.e., wetter peat) the benefit could be as high as 50% of the estimated lost emissions over a 100-year period. Similar estimates could be generated on a project specific basis to expand the available carbon offsets (and credits).

Richardson (2018) reports ranges of C values based on five years of research at Pocosin Lakes NWR where hydrologic conditions and C fluxes were quantified on reference, restored, and drained blocks from (2012-2017) have shown that restored sites have a positive sequestration rate and when calculated with the drained sites loss rates (NEE) they have a net annual C storage difference ranging from a low of 15 to a high of 27 tons $CO_2$ per acre per year.[128] These numbers are currently being verified at a nearby private farm in Hyde County NC.

Ecosystem Resilience: North Carolina's peatlands are ecologically significant as part of the State's tremendous natural community diversity and for the habitat they provide, as well as for their ecosystem services. There are twelve peatland pocosin natural communities classified in North Carolina. Three of these natural communities occur only in North Carolina. All have experienced significant degradation due to ditching and draining. When ecological function is restored via rewetting, ecosystem co-benefits including water quality filtration, flood attenuation, habitat and shelter provision, and soil retention services can resume. In low elevation peatlands, stopping soil loss due to oxidation is particularly important as the elevation loss exacerbates the impacts of SLR. See Figure 3-4 on the following page.

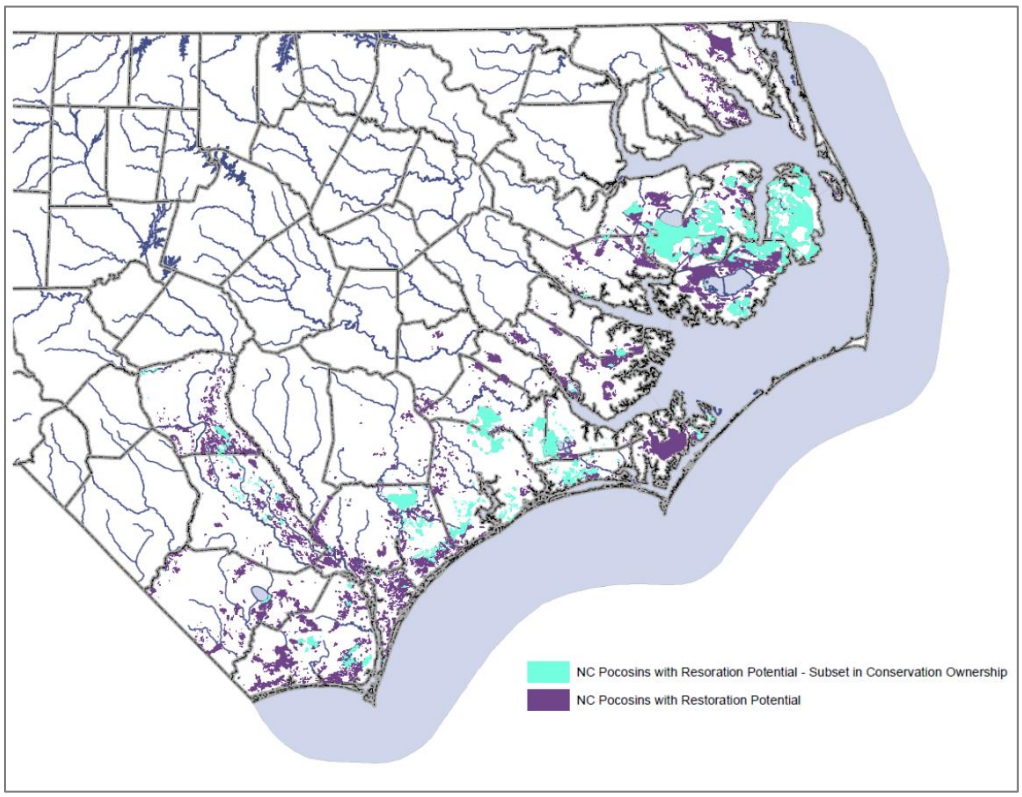
[125] Turetsky, M., Donahue, W. & Benscoter, B. (2011). Experimental drying intensifies burning and carbon losses in a northern peatland. *Nat Commun* 2, 514 https://doi.org/10.1038/ncomms1523

[126] Reddy, A & Hawbaker, Todd & Wurster, Frederic & Zhu, Zhiliang & Ward, S & Newcomb, Doug & Murray, R. (2015). Quantifying soil carbon loss and uncertainty from a peatland wildfire using multi-temporal LiDAR. *Remote Sensing of Environment.* 2015. 306-316. 10.1016/j.rse.2015.09.017.

[127] Sleeter, R., Sleeter, B.M., Williams, B. et al. (2017). A carbon balance model for the great dismal swamp ecosystem. *Carbon Balance Manage* 12, 2 https://doi.org/10.1186/s13021-017-0070-4.

[128] Richardson, C.J., et al. 2018. Peatland Carbon Farming in the Southeastern USA: A New ACR Approved Protocol Based on Long-term C Sequestration and GHG flux Measurements in Coastal Pocosins. American Geophysical Union, Fall Meeting 2018, abstract #B42A-04.

**Figure 3-4: Geographic Extent of Peatland Rewetting Opportunities and Associated Ecosystem Resilience Benefits**




Areas highlighted in blue-green illustrate subset already managed for conservation where potential project costs per acre might be reduced.

Community Resilience: Between 2008 and 2011, three fires on National Wildlife Refuges in eastern North Carolina collectively burned 54,000 acres releasing 170-250 t C/acre of carbon (Mickler et al. 2017) and causing pollutant impacts and safety risk to populations up to hundreds of miles distant. Community resilience benefits are realized through the potential to avoid large scale catastrophic fire effects. In low lying drained peatlands, restoration also allows soil genesis to resume and elevation loss due to fire and oxidation to be avoided providing added resilience in the face of rising river and sound waters.

Estimated Economic Opportunity: Avoided catastrophic fire and elevation loss has economic value; however, there is an additional need for quantification of that benefit. Pre-alteration fire frequency estimates exist[129] and could provide a rough estimate of potential avoided future losses (relative to post-drainage estimates of peatland fire carbon losses in the APP). The ACR methodology for peatland rewetting paves the way for securing an avoided catastrophic fire credit, but a project-specific determination is needed for those benefits to yield an economic opportunity for individual investors. The economic impact of inaction is calculable as well. Peat is an exhaustible resource that formed over geologic time but can rapidly be lost during fires. Repeated catastrophic fires cause significant budgetary burden to state and federal government agencies for

[129] Frost, Cecil C. 1995. Presettlement fire regimes in southeastern marshes, peatlands, and swamps. Pages 39-60 in Susan I. Cerulean and R. Todd Engstrom, eds. Fire in wetlands: a management perspective. Proceedings of the Tall Timbers Fire Ecology Conference, No. 19. Tall Timbers Research Station, Tallahassee, FL.

suppression[130] while reducing the potential uplift upon restoration (e.g., assuming as estimated market value of $10/ton carbon, peat soil losses equivalent to approximately $139M occurred during the Allen Road and Evans Road fires combined (USFWS 2010).

Estimated Cost: The cost of restoration is primarily a function of land acquisition (in fee or easement) costs when restoration is targeted to lands not already managed for conservation, plus the cost of design and installation of infrastructure (e.g., levees and water control structures) to rewet drained peat soils. Absolute costs will vary depending on the site (e.g., infrastructure needs are dependent on factors such as the degree of alteration and the topography of the site). Prior estimates[131] to rewet pocosins on conservation lands or other areas where land acquisition costs are not a factor range between an estimated $140 (if conducted by the land steward) and $310/acre or more (with contract support). Projects elsewhere could range between $810 and $11,810/acre depending on whether the targeted areas have been cleared of vegetation. Verification and monitoring costs for carbon crediting are not included in the above estimates and could vary considerably depending on the approach selected.

Economic and Health Benefits: Air quality, water quality/quantity, ecosystem biodiversity, ecosystem health, public health

Actors and Participants:

- State — state agencies managing peatlands with restoration potential include NCWRC, NCSP, NCFS, DCM; role for state funding sources (e.g., the NCLWF to incentivize peatland rewetting via changing selection criteria and weighting.
- Landowners/producers – private forestry and agricultural producers on peatlands.
- Corporations with climate goals – provide upfront rewetting and verification funding for carbon offsets.
- Impact partners– TNC, TCF, NC Costal Land Trust, North Carolina Coastal Federation (NCCF); facilitate identification of priority projects and relationships with landowners for implementation.
- Policy makers – prioritize legislation and policy to conserve and restore peat-based wetlands.

Road Map for Action:

Expansive rewetting efforts have been completed in the Albemarle Pamlico region of North Carolina and Virginia in the past two decades, but significant acreage in need of restoration remains both on public and private lands in eastern North Carolina. The following steps are recommended to achieve resilience and sequestration benefits at geographic scope commensurate with meaningful GHG benefits.

1. Prioritize restoration opportunities with focus on state-owned and largescale lands. Updated mapping of degraded, intact, and restored peat-based wetlands in North Carolina is needed due to the expanding footprint of completed restoration and the continued loss of lower elevation peatlands. This effort should be used to prioritize potential projects with the greatest potential for immediate action (e.g. degraded peatlands on state or other conservation lands with restoration potential), sequestration and resilience uplift (e.g., large, contiguous tracts of highly altered peatland with deep peat deposits), and avoided community impacts (e.g., areas where catastrophic peat fires have already occurred and fuel

[130] For example, over a three year period from 2008-2011 four catastrophic fires on three National Wildlife Refuges burned 38,000 ha, consumed over 1.5 m of peat in severely burned areas, and cost over $58 million to federal and state response agencies collectively.
[131] USFWS. 2010. Benefits of Wetland Hydrology Restoration in Historically Ditched and Drained Peatlands: Carbon Sequestration Implications of the Pocosin Lakes National Wildlife Refuge Cooperative Restoration Project. https://www.fws.gov/raleigh/pdfs/PeatlandRestoration_CSeqBenefits_Jan2010.pdfhttp://www.fws.gov/raleigh/pdfs/PeatlandRestoration_CSeqBenefits_Jan2010.pdf

loads persist, peatlands where restoration could be designed to improve attenuation of storm flows for adjacent/downslope areas).

2. Expand outreach and access to peatland restoration resources and technical support with workshops and virtual toolbox, including:

   - The ACR peatland rewetting methodology cited above provides applicability area and conditions defined for previously drained pocosins that are potentially eligible for carbon crediting. This methodology-based carbon verification project provides parties interested in market-based incentives with an opportunity to offset upfront project development costs. The methodology includes an option to address avoided wildfire carbon losses providing expanded potential for economic gains for investors. A demonstration project applying the ACR methodology is ongoing at Pocosin Lakes NWR and can be used, along with technical assistance by project partners, to support new projects on public and private lands.[132]

   - Financial resources beyond voluntary market incentives can be pursued to support restoration project development including budgetary restoration funding from state and federal agencies (USFWS, USDA, NOAA, US Department of Defense), grant opportunities (e.g., NCLWF, resilience/adaptation and post-storm recovery grants from impact partners and NGOs), and corporate investment (e.g., voluntary climate responsibility, future international airline offsets). There is potential for "stacking" of landowner incentive programs on private lands to further reduce project delivery costs and expand revenue potential for private citizens.

   - Technical resources for peatland restoration are also abundant in North Carolina and southeastern Virginia. Successful restoration efforts have been completed and provide a wealth of literature, design BMPs and hydrologic modeling. [133]

3. Engage private landowners and other interested parties. To expand awareness of the opportunity and benefit of peatland restoration, policy, guidance and outreach facilitated by state and federal agencies, policy makers, and impact partners is needed.

4. Explore dedicated funding and leveraging opportunities to expand scale of peatland restoration on state-owned lands. Given that the State currently owns degraded peatlands, and has begun to identify specific restoration needs on a subset of those lands (e.g., Holly Shelter Gamelands), and restoration costs are relatively low and provide co-benefits;; opportunities to create a funding stream for these efforts should be considered.

Examples:

- *Pocosin Lakes NWR pocosin restoration:*

  Carbon verification study (DUWC)

  - Richardson, C J. 2018. Carbon Farming on North Carolina Pocosin Peatlands. Duke University Wetland Center, unpublished white paper. December 2018.
  - Richardson, C.J., N. Flanagan, H. Wang, and M. Ho. 2014. Impacts of peatland ditching and draining on water quality and carbon sequestration benefits of peatland restoration. For the Eastern North Carolina/Southeastern Virginia Strategic Habitat Conservation Team, USFWS,

[132] Ward, S. and S. Settelmyer. 2014. Carbon Sequestration Benefits of Peatland Restoration: Attracting New Partners to Restore National Wildlife Refuge Habitats. National Wetlands Newsletter, Vol. 36, No. 1.
[133] Madden. 2005. NC Division of Coastal Management Best Management Practices for the Hydrologic Restoration of Peatlands in Coastal North Carolina.

Region 4 and The Nature Conservancy North Carolina Chapter. Final Project, November 2014. Duke University: https://nicholas.duke.edu/wetland/FWSreport13.pdf

- Wang, H., C.J. Richardson, and M. Ho. 2015. Dual controls on carbon loss during drought in peatlands. Nature Climate Change 5:584-587. doi:10.1038/nclimate2643
- Wang, H., C.J. Richardson, M. Ho, and N. Flanagan. 2016. Drained coastal peatlands: A potential nitrogen source to marine ecosystems under prolonged drought and heavy storm events-A microcosm experiment. Science of the Total Environment 566-567:621-626. DOI information: 10.1016/j.scitotenv.2016.04.211

- *Great Dismal Swamp NWR restoration:*

  Land Carbon Program: Great Dismal Swamp Project and Great Dismal Swamp NWR Restoration

- "Estimation and Uncertainty of Recent Carbon Accumulation and Vertical Accretion in Drained and Undrained Forested Peatlands of the Southeastern USA. " J.Z. Drexler, J.Z., C.C. Fuller, J. Orlando, A. Salas, F.C. Wurster, and J.A. Duberstein. 2017. Estimation and Uncertainty of Recent Carbon Accumulation and Vertical Accretion in Drained and Undrained Forested Peatlands of the Southeastern USA. Journal of Geophysical Research: Biogeosciences 2017, 17 p., doi:10.1002/2017JG003950.
- "Benefits of the Fire Mitigation Ecosystem Service in The Great Dismal Swamp National Wildlife Refuge, Virginia, USA. " B. Parthum, B., E. Pindilli, and D. Hogan. 2017. Benefits of the Fire Mitigation Ecosystem Service in The Great Dismal Swamp National Wildlife Refuge, Virginia, USA. Journal of Environmental Management 203:375-382.
- A Carbon Balance Model for the Great Dismal Swamp Ecosystem." R. Sleeter, B. Williams, D. Hogan, T. Hawbaker and Z. Zhu. 2017. A Carbon Balance Model for the Great Dismal Swamp Ecosystem. Carbon Balance and Management 12:: 20.
- Historic Simulation of Net Ecosystem Carbon Balance for the Great Dismal Swamp. US Geological Survey data release.
- Reddy, A.D., T.J. Hawbaker, F. Wurster, Z. Zhu, S.Ward, D. Newcomb, and R. Murray. 2015. Quantifying soil carbon loss and uncertainty from a peatland wildfire using multi-temporal LiDAR. Remote Sensing of Environment. 170:306-316.
- "Estimating the Societal Benefits of Carbon Dioxide Sequestration Through Peatland Restoration". E. Pindilli, E., R. Sleeter, and D. Hogan. 2018. Estimating the Societal Benefits of Carbon Dioxide Sequestration Through Peatland Restoration. Ecological Economics 154: 145-155.

- *Timberlake Restoration (agricultural lands restoration; shallow peatland management)*

- Ardón, M., J.L. Morse, M.W. Doyle, and E.S. Bernhardt. 2010. The water quality consequences of restoring wetland hydrology to a large agricultural watershed in the southeastern coastal plain. Ecosystems 13: 1060-1078.
- Morse, J.L., M. Ardón and E.S. Bernhardt. 2012. Greenhouse gas fluxes in coastal plain wetlands under contrasting land uses. Ecological Applications 22:264-280
- Riegel, J.B., E.S. Bernhardt, J Swenson. 2013. Estimating Above-Ground Carbon Biomass in a Newly Restored Coastal Plain Wetland Using Remote Sensing. PLoS ONE 8, e68251.

- *Alligator River NWR Peatland research (low elevation peatland restoration and resilience)*
    - Point Peter Road – TNC adaptation study
    - King, J. et al., Assessing resilience, carbon and water cycling of managed and unmanaged forests of the US Southeast coastal plain in response to changes in hydrology, extreme events, and climate. https://ncsutreephysiologylab.weebly.com/research.html
    - Berhardt, E., R Emanuel, T BenDor, M Ardon, J Wright, E Ury. The biogeochemical consequences of salt water intrusion on freshwater wetlands. Saltwater intrusion vulnerability index – https://www.elementascience.org/articles/10.1525/elementa.316/

### Strategy 2: Reforest peatlands with Atlantic White Cedar

Description: Large areas in eastern North Carolina will be flooded by rising sea level during the next century, resulting in major losses in plant and animal communities, some of which are rare and threatened. According to the North Carolina Climate Science Report,[134] sea level along the northeastern coast of North Carolina is rising about twice as fast as along the southeastern coast, averaging 1.8 inches per decade since 1978 at Duck and 0.9 inches per decade at Wilmington mainly due to different rates of land subsidence. A healthy forest sequesters 45 to 75 tons/acre of aboveground carbon during the life of the stand[135], and it is important to have trees that are adapted to wetter conditions so they will be healthy and continue to sequester carbon. Atlantic white cedar (AWC), a historically important obligate wetland tree species considered vulnerable in North Carolina (S3), occurs mostly in peatland swamps in the eastern part of the State. About 10,000 acres of AWC (5% of the original pre-European settlement acreage) still exists in North Carolina, mostly in Dare County at elevations ≤ 3 feet above mean sea level (msl). AWC does not tolerate salt water, so these stands will be lost if sea level rises as projected.

The following proposals anticipate and mitigate the projected loss of AWC stands in swamps and floodplains in eastern North Carolina. Other forest tree species (e.g., loblolly pine, red maple, sweetgum) are more abundant than AWC, and occur on a wider variety of sites. Consequently, rising sea level is not a significant threat to these species as with AWC. The industrial and private sector will continue growing these species on a massive scale owing to their economic value. AWC, on the other hand, now occurs mostly on federal and state land. While producing valuable timber, its failure to regenerate after earlier logging has left a resource too small for a significant commercial use.

Geographic Scope: See Strategy 1 in this section for the extent of degraded peatlands in North Carolina. Within these degraded peatlands, AWC reforestation is needed at elevations ≥ 6 feet above msl with appropriate soil series, hydrologic conditions, accessibility, presence or absence of fire breaks, type of land ownership (federal, state, industry, private), and prior presence of AWC.

Estimated GHG Impact: A typical forest in eastern North Carolina, including AWC, can sequester 45 to 75 tons/acre of carbon during its life. AWC restoration is anticipated to have GHG benefits commensurate with those associated with re-establishment of long-lived forest types and provides added carbon sequestration capacity to peatland restoration activities. AWC is particularly beneficial for carbon sequestration because its wood is extremely decay resistant. Many of the remaining AWC forests rest on piles of fallen logs, which continue to sequester carbon much longer than other kinds of down wood. The persistence of fallen logs may also help raise the ground surface faster than other kinds of forests.

[134] Kunkel, K.E., D.R. Easterling, A. Ballinger, S. Bililign, S.M. Champion, D.R. Corbett, K. D. Dello, J. Dissen, G.M. Lackmann, R.A. Leuttich, Jr., L.B. Perry, Stevens, B.C. Stewart, and A.J. Terando. 2020. North Carolina Climate Science Report. North Carolina Institute for Climate Studies, 233 pp. Reteived from https://ncics.org/nccsr

[135] DeBerry, J.W. and R.W. Atkinson. 2009. Forest metrics of four Atlantic white cedar swamp sites managed in the national wildlife refuge system. The Ecology and Management of Atlantic White Cedar (*Chamaecyparis thyoides*) Ecosystems. A Symposium held on June 9 - 11, 2009, Greenville, North Carolina.

Ecosystem Resilience: AWC is central to a diverse ecological community. Re-establishment of AWC on appropriate freshwater sites upgradient allows for this species to persist while simultaneously enhancing the carbon sequestration potential of peat-based wetlands.

Community Resilience: Improving the health of forested peatlands would have significant filtration and storm buffering capacity. AWC reforestation of degraded or prior converted lands enhances those functions and provides benefits to nearby communities.

Economic Opportunity: Currently, AWC has little economic impact in eastern North Carolina because the resource is too limited. The economic impact should increase with expansion of this historically commercially valuable resource.

Estimated Cost: The current cost of AWC seedlings (NCFS) is $85 for a box of 334 seedlings ($225 per 1000). With the objective of getting AWC onto the landscape, 500 seedlings per acre is desirable (or $127/ac). To make the cost of AWC comparable to that of loblolly pine seedlings ($70 per 1000), a subsidy to the NCFS of $185 per 1,000 AWC containerized AWC seedlings is needed (or $46,250 per year). This strategy allows NCFS to functionally produce numbers for reforestation in partnership with conservation agencies (e.g., total revenue to the NCFS would be $185 + $70 per 1000 seedlings, the same as in the past, for seedlings that the NCFS sells). Seedlings not sold by the 1st of October will be available to the cooperative at no cost, but the NCFS still will receive the subsidy of $185 per thousand. The cooperative could purchase seedlings prior to October 1st at a price of $70 per thousand.

It is anticipated that the above actions will allow the NCFS to consistently produce 250,000 AWC seedlings per year at the same cost as bare-root loblolly pine, and the proposed subsidy reduces the risk to the NCFS of losing money while producing AWC seedlings that might not sell. It will provide a consistent source of AWC seedlings for state and federal reforestation activities.

Economic and Health Benefits: Air Quality, Water Quality/Quantity, Ecosystem Biodiversity and Health

Actors and Participants:

- State — state agencies managing peatlands with AWC reforestation potential include NCWRC, DRP, NCFS, DCM; role for NCFS to produce AWC seedlings and develop extension and outreach to promote reforestation on public and private lands.
- Landowners and producers – private nurseries for AWC production; private landowner partnerships for restoration.
- Corporations with climate goals – provide upfront and verification funding for carbon offsets.
- Impact partners – TNC, TCF, NC Costal Land Trust, NCCF; facilitate restoration on conservation areas they manage and facilitate restoration on private lands.
- Policy makers – prioritize legislation and policy to promote cost sharing programs and tax incentives for production of AWC plantings.

Road Map for Action:

1. Anticipate the loss of AWC stands in Dare County and eastern Tyrrell County, and establish mitigation plantings further inland (500 acres per year for 20 years; total = 10,000 acres) on suitable sites at elevations ≥ 6 feet above msl. Establishment costs vary by treatment, with a minimum of $200 to $250 per acre, excluding seedlings costs. Cost sharing programs and tax incentives are recommended to offset these costs.
2. Prioritize potential planting sites for AWC based on factors such as prior presence of AWC, soil series, hydrologic conditions, accessibility, presence or absence of fire breaks, and type of land ownership (federal, state, industry, private). This can be done by land managers familiar with the ecology of AWC.

3. Currently, a lack of seedlings is a critical hindrance to restoration efforts with AWC. A recommended approach to address this bottleneck is to develop a partnership among state (e.g., NCFS), federal (e.g., USFWS), and NGO organizations (e.g., Nature Conservancy) to establish AWC on suitable sites in eastern North Carolina where these organizations have jurisdiction. Under the cooperative, the NCFS should be commissioned to produce 250,000 containerized AWC seedlings annually (500 seedlings/acre X 500 acres). Seedlings would be available to partners in the cooperative as well as the public.
4. To incentivize planting AWC, subsidize the production of AWC ($185 per 1000 seedlings) to make the price equivalent to that of loblolly pine seedlings ($70 per 1000 seedlings). The subsidy would total $46,250 to produce 250,000 seedlings per year.
5. To encourage reforestation with AWC, develop extension and outreach programs targeted at 1) managers of public refuges, parks and forests, 2) certified foresters, and 3) private and industrial landowners.

Examples:

- Pocosin Lakes AWC Restoration
- Great Dismal Swamp AWC Restoration
- New Jersey Natural Resource Damage Assessment and Restoration efforts for AWC[136]

### 3.5.2 Enhance Pocosins

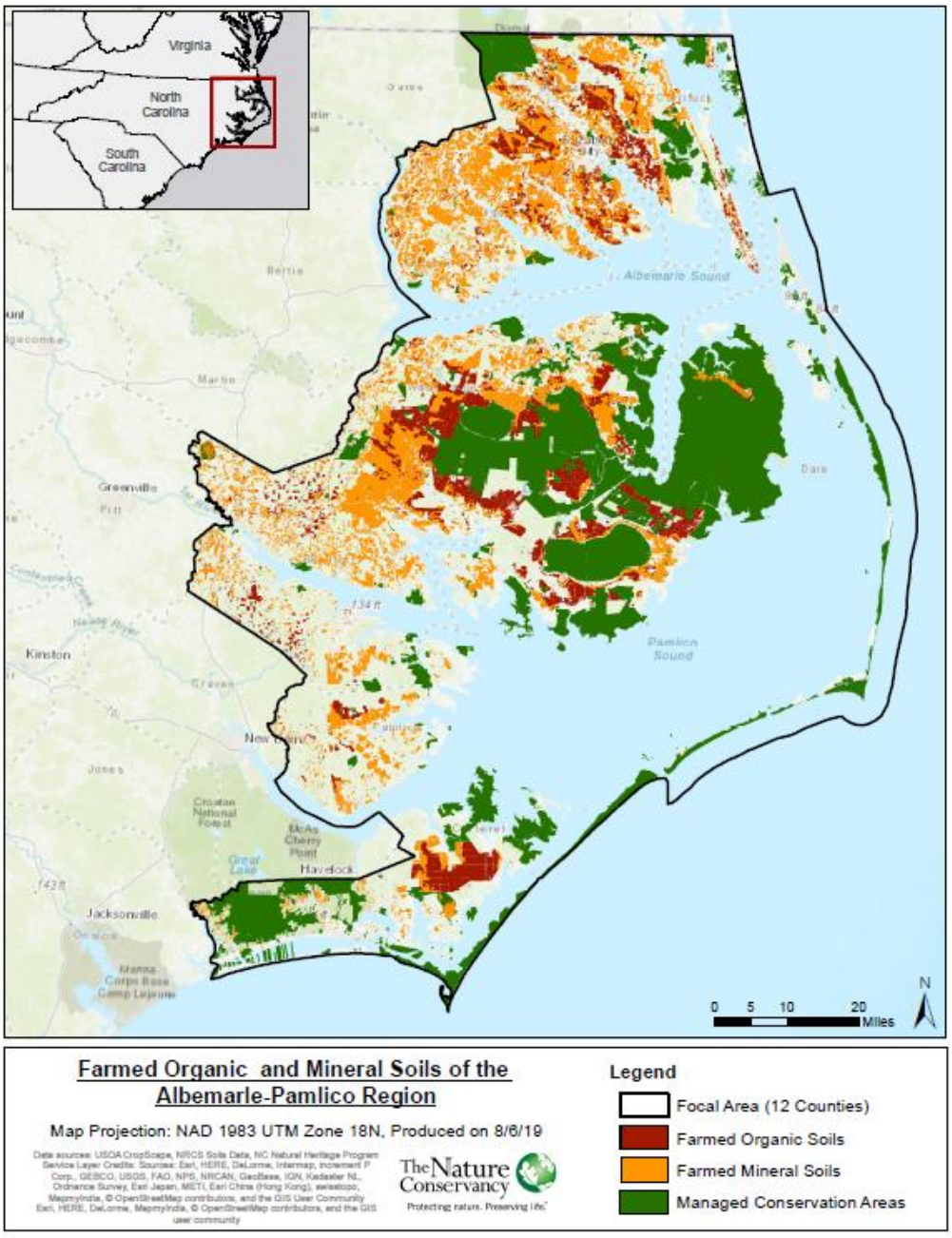
#### Strategy 1: Enhance soil health and retention of working peatlands via best management practices and drainage management

Description: Strategically enhance existing and implement new state-of-the-art integrated drainage water management systems. Provide incentives for best management practices (BMP) via cost-share programs and grant programs. Improve education and demonstration opportunities through NC Cooperative Extension Service (NCCES), NRCS, and other agricultural-based agencies. This strategy speaks to improved management on existing agricultural lands with "shallower" peat deposits (typically not exceeding 2-4 ft) to reduce the impacts of current free drainage or poorly managed controlled drainage that is in place. Many areas with deeper peats that were drained with the intention to farm them have been abandoned because crop production was not economically feasible (high input costs for suboptimal yield).

Geographic Scope: Figure 3-5 on the following page identifies areas with the highest soil carbon noted. There are 1.1 million acres of organic soils in eastern North Carolina with the most significant amounts in the northeast.

[136] Byers, Michele S. (2019, May 1). Restoring the Pinelands' Atlantic White Cedars. NJ Environmental News. Retrieved from https://njenvironmentnews.com/2019/05/31/restoring-the-pinelands-atlantic-white-cedars/

**Figure 3-5: Geographic Extent of Farmed Organic & Mineral Soils in Albemarle Pamlico Region**




Estimated GHG Impact:

- Sequestered: There is potentially 0.5 Mt $CO_2$e/acre/year [137] to 1.6 Mt $CO_2$e/acre/year[138] sequestered.
- Emitted: Up to 1.4 Mt $CO_2$e/acre/year emitted if drained.[139]

[137] From global estimate 0.37 billion metric tons over 3 million km$^2$
[138] Hu and Reddy, 2017; Hatala, Detto, & Baldocchi, 2012; Knox et al., 2015
[139] Ibid.

Ecosystem Resilience: Reduced peat fire, reduced forest loss through fire and salt-water intrusion, improved surface water quality through the reduced discharge of agricultural and silvicultural drainage water, reduced topsoil loss via wind erosion are ecosystem resilience possibilities by implementing this recommendation.

Economic Opportunity: This strategy does not entail taking land out of production. A 10-20% potential corn and soybean yield increases through drainage water management, with additional yield benefits by protecting soil organic matter.[140] Restoration projects will create more business for local construction and land grading companies and increase the potential for carbon trading markets and improved long-term forestry production. Ecotourism is another economic opportunity, for bird watching and wildlife viewing.

Estimated Cost: Costs are highly variable. BMPs can range from a single flashboard riser that could control 100 acres of drainage water ($5,000) to strategic relocation of a pump station to more efficiently manage drainage water and reduce saltwater intrusion for 2,000 acres ($500,000), to watershed-scale management projects that could include a suite of BMPs.

Economic and Health Benefits: Likely natural resource co-benefits include air quality, water quality and quantity, ecosystem biodiversity and health, public health, and food and fiber production. Economic benefits include a more sustainable farming system on these soils.

Actors and Participants:

- State and federal agencies — NCCES, Universities, DEQ, DCM, NCWRC, DA&CS, USFWS, USDA, US Army Corp of Engineers (USACE).
- Landowners and producers – state and federal lands, private landowners.
- Corporations with climate goals.
- Impact partners – NGOs like North Carolina Coastal Federation and TNC.
- Policymakers.

Road Map for Action:

Traditional agricultural practices on organic soils largely ignore the high cost of carbon and soil loss resulting from drainage. Substantial improvements to technology, planning, and production practices are needed in agricultural fields and protected lands with a goal to hold carbon in place, maintain or increase carbon sequestration if possible, reduce GHG emissions, and improve sustainability. Holistic planning of agricultural operations, water management, and widespread adoption of already existing technologies are needed and possible with targeted research, demonstration, and education.

Programmatic funding is needed to support improved practices and education for sensitive farmlands and conservation areas. These programs must include researchers, government agencies, and willing private participants. Demonstration sites on existing research farms and protected lands in North Carolina can also be conducted with available funding for implementation.

With this strategy, there is an opportunity to improve drainage and tillage practices on existing agricultural acres with shallower organic soil and, as such, they would remain in production. Certainly, cost-share programs play a critical role in defraying direct costs for controlled drainage infrastructure and other costs associated with the suite of best practices for preserving soil carbon. Directing greater funding to these practices on organic soil and the potential role of carbon finance should be considered as the most likely means for compensating costs to landowners/farmers.

[140] Poole, C., R.W. Skaggs, G. Cheschier, M. Youssef, and C. Crozier. 2013. Effects of drainage water management on crop yields in North Carolina. *Journal of Soil and Water Conservation*. 68: 429-437. 10.2489/jswc.68.6.429

For NCCES, NRCS, and Universities, funding could be made more available through NRCS cost-share programs. Existing state grant programs could further support this type of work for demonstration and research.

Examples: Several completed and ongoing projects in North Carolina demonstrate the co-benefits of controlled drainage, no-till, precision water management, and other technologies that have yet to be implemented widely on organic soils. These projects are listed below. However, additional project examples will be required if these techniques are to receive the attention and adoption level that is needed.

- Completed water management work at Pocosin Lakes, Dismal Swamp, and Timberland Mitigation Bank.
- Projects are underway in organic soil settings at Carolina Ranch, Lux Farms in Hyde County, and a precision drainage project spanning Hyde and Beaufort Counties.

### Strategy 2: Implement targeted interventions to protect peatlands from sea level rise and saltwater intrusion guided by scenario-based modeling

Description: Using a combination of preexisting hydrological models, landscape-scale saltwater intrusion vulnerability indices, and habitat conversion models, a scenario based model would be developed to generate predictions of 1) groundwater table dynamics, 2) saltwater intrusion potential on working peatlands, and 3) potential vulnerability of upslope peatlands under alternate scenarios to identify topographic thresholds and facilitate decisions regarding appropriate strategies (e.g., defense) and locations. Carbon balance implications of habitat conversion (e.g., ghost forests) can be considered. This recommendation applies spatial modeling to identify priority locations for the implementation of conservation and defense strategies to prevent loss and salt intrusion in peatlands and working lands with organic soils. Specific actions include the development of a spatially-explicit prioritization, expansion of monitoring to fill data gaps, and an evaluation of alternative interventions for prioritized locations.

This recommendation, in conjunction with other tightly coupled recommendations (i.e., rewetting hydrologically altered peatlands, etc.) has significant ecosystem and community resilience benefits. By prioritizing locations for defense and adaptation, the outcomes from this recommendation can help prevent economic loss for communities and prevent loss of ecological function in peatlands.

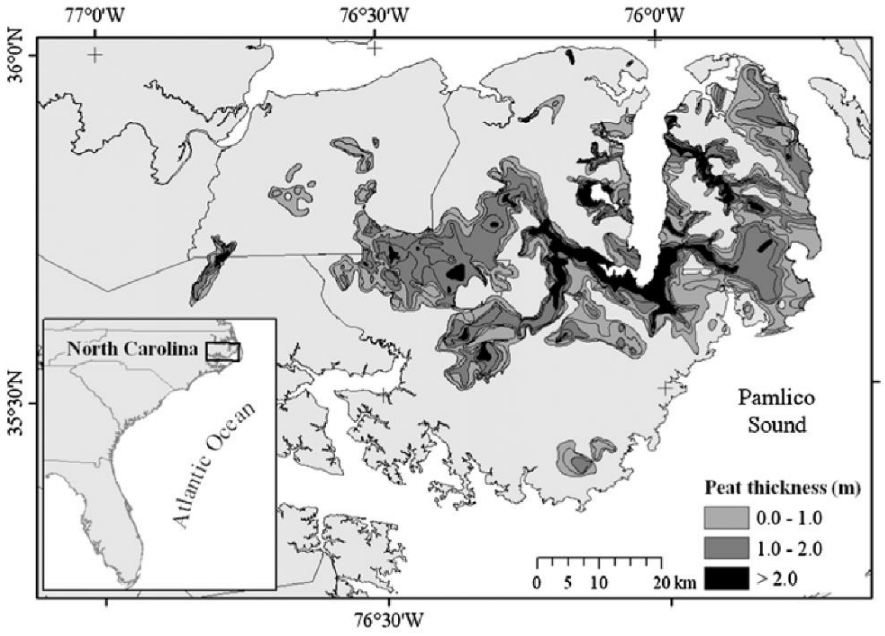
Geographic Scope: Peatlands cover approximately 1.4 million acres of the APP.[141] Given the APP covers only a portion of the coastal plain, this estimate may be conservative. However, most of the peatlands in the State can be found in this region. Most of these peatlands are less than 55 meters in elevation, making them vulnerable to impacts from SLR and saltwater intrusion and candidates for targeted interventions. This area is experiencing high rates of SLR (0.43 to 0.45 cm y-1) suggesting that many of these peatlands are vulnerable to inundation.[142, 143,144]

[141] Henman, J., and B. Poulter. 2008. Inundation of freshwater peatlands by sea level rise: Uncertainty and potential carbon cycle feedbacks. *Journal of Geophysical Research: Biogeosciences* 113: 1–11. https://doi.org/10.1029/2006JG000395.
[142] Horton, B. P., W. R. Peltier, S. J. Culver, R. Drummond, S. E. Engelhart, A. C. Kemp, D. Mallinson. 2009. Holocene sea-level changes along the North Carolina Coastline and their implications for glacial isostatic adjustment models. *Quaternary Science Reviews* 28: 1725–1736. https://doi.org/10.1016/j.quascirev.2009.02.002.
[143] Kemp, A. C., B. P. Horton, J. P. Donnelly, and M. E. Mann. 2011. Climate related sea-level variations over the past two millennia. Proceedings of the National Academy of Sciences 108: 11017–11022. https://doi.org/10.1073/pnas.1015619108.
[144] Kopp, R. E., B. P. Horton, A. C. Kemp, and C. Tebaldi. 2015. Past and future sea-level rise along the coast of North Carolina, USA. Climatic Change 132: 693–707. Retrieved from https://doi.org/10.1007/s10584-015-1451-x

Estimated GHG Impact: Existing carbon storage on the APP, including both peat and vegetation, ranges between 155.5 and 201.0 MMT C.[145] From this same study, researchers estimated that carbon emissions from inundation of peat and vegetation (approximately 1.4 m of SLR) range from 4.7-20.9 MMT (assuming preservation of peat deposits) to 99.4-128.0 MMT (assuming 100% emissions of inundated peat). Results suggest that interventions to prevent negative impacts from saltwater intrusion and inundation would provide significant benefits in terms of reducing GHG loss.

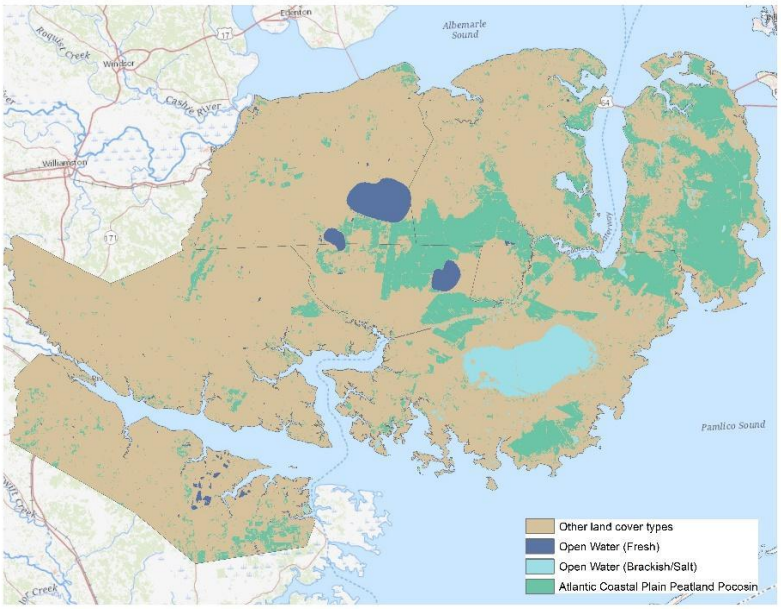
Ecosystem Resilience: From previous research and existing data, shown in Figures 3-6 and Figure 3-7, we know that peatland pocosins cover a significant portion of the APP and thus the coastal plain of NC.[146] Thus, the potential for ecosystem resilience is high. The ability of these peatlands to keep up with SLR will depend on vertical accretion and their ability to migrate inland.[147] Recent research suggests that the majority of these peatlands are accreting at rates lower than SLR (0.16 cm $y^{-1}$).[148] Increased saltwater intrusion could decrease the ability of these peatlands to keep up with SLR even further due to increased decomposition in response to higher salinity.[149] Ditches and agricultural fields will also make it hard for these systems to migrate inland. The data that would be generated from the scenario modeling can be used to identify the geographic locations that would most benefit from protection.

**Figure 3-6: Peat Depth on the Albemarle-Pamlico Peninsula**




[145] Henman, J., and B. Poulter. 2008. Inundation of freshwater peatlands by sea level rise: Uncertainty and potential carbon cycle feedbacks. *Journal of Geophysical Research: Biogeosciences* 113: 1–11. https://doi.org/10.1029/2006JG000395.
[146] Ibid. Henman, J., and B. Poulter. 2008. Inundation of freshwater peatlands by sea level rise: Uncertainty and potential carbon cycle feedbacks. *Journal of Geophysical Research: Biogeosciences* 113: 1–11. https://doi.org/10.1029/2006JG000395. Ibid.
[147] Kirwan, M. L., and J. P. Megonigal. 2013. Tidal wetlands stability in the face of human impacts and sea-level rise. *Nature* 504: 53–60.
[148] Gundersen, G. 2017. Long-term accumulation of sediments, carbon, and nitrogen by coastal wetlands in the Albemarle Sound, North Carolina. Master's Thesis. Department of Forestry and Environmental Resources, NCSU.
[149] Weston et al. 2006. Ramifications of increased salinity in tidal freshwater sediments: Geochemistry and microbial pathways of organic matter mineralization. *Journal of Geophysical Research: Biosciences* 111: G01009 Retrieved from https://doi.org/10.1029/2005JG000071

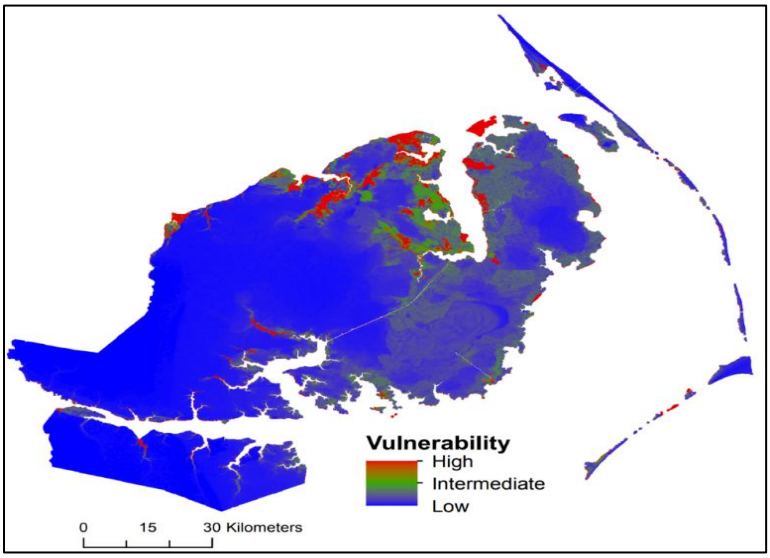
**Figure 3-7: Extent of Peatland Pocosin Vegetation Type (derived from Southeast GAP data)**




Peatland pocosins are areas in green.

Artificial drainage, the result of extensive timber and agricultural activities, has altered the natural hydrological processes of the region. These alterations further increase the vulnerability of freshwater-dominated landscapes to salinization and eventual loss of freshwater ecosystems if protective actions are not taken. The study also provided a spatially-explicit index of vulnerability to saltwater intrusion, as shown in Figure 3-8.[150] This, in combination with maps of the total extent of peatland pocosins, can provide a rough estimate of the total area with high potential for ecosystem resilience.

**Figure 3-8: Saltwater Intrusion Vulnerability Index (SIVI)**




[150] Bhattachan, A., M. D. Jurjonas, A. C. Moody, P. R. Morris, G. M. Sanchez, L. S. Smart, P. J. Taillie, R. E. Emanuel, and E. L. Seekamp. 2018b. Sea level rise impacts on rural coastal social-ecological systems and the implications for decision making. *Environmental Science and Policy* 90: 122–134. https://doi.org/10.1016/j.envsci.2018.10.006.

Community Resilience: There are approximately 100,000 residents on the APP. These are natural resource-dependent communities – a mix of large-scale agricultural landowners and economically distressed residents. Their reliance on natural resources for livelihoods makes the APP community especially vulnerable to the negative impacts of saltwater intrusion and inundation on the landscape. Scenario-modeling can aid in prioritizing locations for protecting peatlands from SLR and saltwater intrusion. Their protection can provide buffers to adjacent farmlands and residential areas. They can also provide protective services to the community against storm surge.

Economic Opportunity: It has been estimated that a SLR of 100 cm could lead to 42% of the APP to be inundated, leading to property losses of up to US $14 billion.[151]

Estimated Cost: Estimated cost will depend on the amount of land that is identified as a high priority for protection due to a combination of high vulnerability and high carbon storage.

Economic and Health Benefits: This action has multiple natural resource co-benefits, including improved ecosystem biodiversity, ecosystem health, public health (via protection from flooding and storms), sustained food and fiber production, and water quality improvements.

There are many actors or players that could be involved as part of this recommendation and other tightly coupled recommendations. These include the USFWS, NCWRC, Department of Defense, The Nature Conservancy, landowners with organic soils degraded by saltwater intrusion, and SLR, (large agricultural producers), and local drainage districts.

By developing landscape-scale models of vulnerability and identifying locations with the highest uplift potential, resources can be allocated more effectively. Interventions can be implemented in areas that will most benefit from them.

This recommendation would rely heavily on university partners and land managers to leverage existing research and data. University partners and land managers will be necessary for the implementation of this recommendation.

[151] Ibid.

## 3.6 Priority Recommendations for Coastal Habitats

Introduction: The protection and restoration of North Carolina's coastal habitats can provide carbon sequestration and contribute significantly to both ecosystem and community resilience as well as natural disaster mitigation. The coastal habitats requiring protection and restoration include coastal wetlands, swamp and tidal forests, seagrass (high salinity SAV), and vegetated shorelines. Though much smaller in size than upland forests, coastal wetlands sequester carbon at a faster rate. However, these ecosystems also emit GHGs when they deteriorate, making conservation important. It is important to note that high salinity coastal wetlands, or salt marshes, emit GHGs at a much lower rate than other wetlands. Estimating the carbon sequestration potential from various actions taken in these ecosystems is still in the research phase, as numerous factors – including wetland type, site salinity and tidal inundation – can influence carbon sequestration rates.

*North Carolina contains the largest estuarine system of any Atlantic coast state. These coastal habitats both sequester and store carbon. As sea level rises in North Carolina, the loss of coastal habitats will release hundreds or even thousands of years of stored carbon into the air.*

Estimates for carbon storage and sequestration by salt marsh and all SAV were developed for North Carolina by Duke's Nicholas Institute with help from the Coastal Habitats NWL subcommittee. Based on these estimates, North Carolina's salt marshes currently store about 61 million MT $CO_2e$, and SAV stores another 18 million MT $CO_2e$. Estimates were not developed specifically for high salinity SAV. The amount of carbon stored in these habitats is continually increasing as salt marshes sequester ~250,000 MT $CO_2e$/year and seagrass ~140,000 MT $CO_2e$/year[152].

Ecosystem and Community Resilience: Protecting and restoring coastal ecosystems and habitats will significantly improve both ecosystem and community resilience by protecting property, infrastructure, and the community from storm surge and flooding during tropical cyclones and heavy rain events. Ecosystem co-benefits of restoring and protecting coastal habitats include improving water quality, providing fish and wildlife food, habitat migration corridors, seafood production, game hunting and recreational fishing, and maintaining ecosystem health and biodiversity. Protecting and restoring coastal habitats can also protect communities and ecosystems from sea level rise.

Economic and Health Benefits: The protection provided by coastal habitats would reduce loss of property due to erosion, flooding, and SLR in both communities and nearby agriculture lands. It also provides additional natural and recreational areas, benefiting important commercial and recreational fisheries, game hunting, tourism, and local economies.

[152] For more information about the methods used for these estimates, see Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.

Geographic Scope: The 20 North Carolina coastal counties [as identified in as identified in the Coastal Area Management Act (CAMA); ~8,187,000 acres] as well as the State's 2.2 million acres of estuarine waters including ~100,000 acres of seagrass and ~228,000 acres of salt marsh.[153]

Greenhouse Gas Impact: Salt marshes sequester ~1.1 MT $CO_2e$ /acre/year, and seagrass sequesters ~0.7 MT $CO_2e$ /acre/year.[154]

Estimated Cost: Full-time staff, funding to support planning, funding for restoration activities.

### 3.6.1 Protect Coastal Habitats

#### Strategy 1: Provide incentives to stakeholders for coastal habitat protection

Description: Proposed actions to protect coastal habitats are listed below.

1. Develop incentives with state and local governments and other public and private stakeholders to protect coastal habitats.
2. Incentivize the protection of coastal habitats, such as natural shorelines, coastal wetlands, oyster beds, and seagrass (high salinity SAV),
3. Highlight the co-benefits of community and ecosystem resilience and carbon sequestration, and
4. Incentivize the protection of migration corridors to allow for the landward migration of coastal habitats in response to sea level rise.
5. Use conservation easements and innovative acquisition strategies to secure priority coastal wetland and other coastal habitat, migration pathways, and corridors.

Geographic Scope: The State's 20 coastal counties (as identified in CAMA; ~8,187,000 acres) and 2.2 million acres of estuarine waters including ~100,000 acres of seagrass and ~228,000 acres of salt marsh.[155]

Greenhouse Gas Impact: There is a high potential for carbon sequestration, which will vary based on the area of salt marsh and seagrass protected through incentives. The potential carbon sequestration per unit area of salt marsh is 1.1 MT $CO_2e$/acre/yr. Salt marsh has the highest per unit area carbon sequestration of any vegetated habitat.[156]

Ecosystem Resilience: Significant; currently ~228,000 acres of salt marsh and ~100,000 acres of seagrass in North Carolina provide ecosystem services and support ecosystem resilience.

Community Resilience: The potential for community resilience is significant. Coastal habitats provide valuable ecosystem services that serve to decrease exposure and risk to coastal communities. The current estimate for North Carolina's coastal population is approximately 1.2 million with 17% living below the

[153] DEQ. 2016. *North Carolina Coastal Habitat Protection Plan*. North Carolina Department of Environmental Quality, Raleigh, NC: NWI data (derived from imagery spanning 1977-2010), Cowardin classifications assigned by the NWI were reclassified into wetland types following (Sutter 1999)

[154] For more information about the methods used for these estimates, see Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.

[155] DE). 2016. North Carolina Coastal Habitat Protection Plan. North Carolina Department of Environmental Quality, Raleigh, NC: NWI data (derived from imagery spanning 1977-2010), Cowardin classifications assigned by the NWI were reclassified into wetland types following (Sutter 1999).

[156] Mcleod, E., Chmura, G. L., Bouillon, S., Salm, R., Björk, M., Duarte, C. M., & Silliman, B. R. (2011). A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2. *Frontiers in Ecology and the Environment*, 9(10), 552-560.

poverty line.[157,158] The 20% population growth rate from 2010-2020 in these counties have exposed more people at risk to coastal hazards. [159] These growing communities will directly and indirectly benefit from the protective services provided by the protection of coastal habitats.

Economic and Health Benefits: The economic opportunity potential is high, but not yet quantified. Providing incentives to landowners can ensure protection of coastal habitats and the ecosystem services they provide. This protection will result in decreased risk from hazard damage and will result in lower costs required to restore coastal habitats and repair assets and property after major storm events.[160] It is estimated that coastal wetlands have an economic value of $25.6 billion/yr for structure protection during hurricanes, excluding value of other ecosystem services. In addition to providing storm protection from hazard damage, protected coastal habitats provide valuable ecosystem services that have measurable economic value. For example, seagrass was valued at $3,000/acre/year for water quality improvements and $7,000/acre/year when considering all ecosystem services provided.[161] For every $1 invested in land conservation in North Carolina, there is estimated to be a $4 return in economic value from natural resource goods and services alone without considering numerous other economic benefits.[162]

Increased water quality (from flood and tidal water buffering, sediment and nutrient removal), increased ecosystem biodiversity (more habitat available for flora and fauna), increased ecosystem health (more protections for restoring and conserving coastal habitats, thereby increasing resilience for habitats to persist), stronger community resilience (from increased ecosystem services and shoreline stabilization and reduced risk to personal property), increased food and fiber production (more habitat for commercial and recreationally important finfish and shellfish), and an increase in carbon sequestration.

Estimated Cost: Funding needs and legislative changes may include incentives and conservation easements through tax changes or direct payment, including the reenactment of the Conservation Tax Credit (repealed in 2013). From 2003 to 2011, the North Carolina Conservation Tax Credit incentivized donations of conservation land with an estimated market value of over $1 billion in exchange for $122.5 million in claimed tax credits, resulting in a fiscal gain rather than cost from the program.[163]

Actors and Participants:

- State and local government –DCM, Division of Marine Fisheries, (DMF), Division of Water Resources (DWR), Albemarle-Pamlico National Estuary Partnership (APNEP); Department of Natural and Cultural Resources (DNCR), DPS, DA&CS, NCWRC, NCFS, NCLWF, Office of Environmental Education and Public Affairs; state ports, local governments, and others.
- Federal Partners – USFW, NPS, National Estuarine Research Reserves, NFWF, NOAA's National Ocean Service (NOS) and NOAA's National Marine Fisheries Service (NMFS), Beaufort, NC, and others.

[157] NOAA. 2020. "FAST FACTS: North Carolina" Office of Caostal Management, NOAA. Reirieved from https://coast.noaa.gov/states/north-carolina.html
[158] Map of North Carolina Poverty Rate by County. Map provided by Index Mundi using 2018 Small Area Income and Poverty Estimates (SAIPE) Program data from US Census Bureau. Retrieved from https://www.indexmundi.com/facts/united-states/quick-facts/north-carolina/percent-of-people-of-all-ages-in-poverty#map
[159] Haber, K. 2013. National coastal population report, population trends from 1970 to 2020. NOAA State of the Coast Report Series, US Department of Commerce, Washington. https://coast.noaa.gov/digitalcoast/training/population-report.html
[149]Costanza, R., O. Perez-Maqueo, M. L. Martinez, P. Sutton, S. J. Anderson, and K. Mulder. 2008b. The value of coastal wetlands for hurricane protection. Ambio 37(4):241-248.
[161] Piehler, M. F., and A. R. Smyth. 2011. Habitat-specific distinctions in estuarine denitrification affect both ecosystem function and services. Ecosphere 2(1):art12.
[162] Land, T. f. P. 2011. North Carolina's Return on the Investment in Land Conservation.35.
[163] RTI International. 2018. North Carolina's Land and Water Yesterday, Today, and Forever a Survey of North Carolina's Land and Water Funding. 65 pp.

- Academia – Coastal Studies Institute, Duke University Marine Lab, East Carolina University, NCSU Center for Marine Sciences and Technology, UNC-Institute for Marine Sciences, UNC-Wilmington, and others.
- Landowners and Producers – coastal wetlands and shoreline property owners (municipalities, public and private lands, commercial and residential properties).
- Corporations with climate goals– Industrial businesses (e.g. Nutrien Ag, Martin Marietta, state ports, Weyerhaeuser, Domtar, etc.). [164]
- Impact Partners – NC Coastal Federation, The Nature Conservancy, American Rivers, NC Wildlife Federation, Sound Rivers, Pew Charitable Trust, Audubon North Carolina, NC Coastal Land Trust, NC Sea Grant, and others.
- Policy Makers – NC legislators, NC Coastal Resources Commission, NC Environmental Management Commission, NC Marine Fisheries Commission, NCWRC, NC State Emergency Response Commission, and others.

### Road Map for Action:

Currently conservation agreements (easements) enable landowners to preserve their land and maintain ownership while potentially receiving tax incentives, such as tax deductions, tax credits or reduced estate taxes. There are several state programs that can purchase conservation agreements, such as the North Carolina Land and Water Fund, North Carolina Natural Heritage(formerly the Clean Water Management Trust Fund, North Carolina), NC Agricultural Development and Farmland Preservation Trust Fund, and PARTF. Tax incentives are tools that can be used to encourage landowners to protect coastal wetlands, salt marshes, and other coastal habitats. New tax incentives can target areas that may be important to protect as migration corridors for these habitats. Providing additional incentives such as grants for shoreline owners to build living shorelines will also help increase ecosystem and community resilience.

Additional state, federal, and local funding for programs is needed to purchase easements, provide tax incentives, and provide grants. Funding could come from impact fees from development in vulnerable areas, taxes on carbon emitting businesses, or from government savings by avoiding and minimizing climate-change-associated damages by taking proactive measures. More staff are needed to conduct outreach and education with property owners, developers, and stakeholders. Funding may be needed from federal, state, and local sources for implementation, which could come from programs such as the Conservation Grant Fund, DEQ Stewardship Program, Division of Mitigation Services, from restoring the Conservation Tax Credit program through legislation, the NCLWF, and from resilience grant funding for local communities.

There are many existing policies of the North Carolina Coastal Resources Commission (NCCRC) and NCEM that may need to be updated. There may be existing authority for some limited incentives, but additional authority may be required to establish incentive programs within these departments. The establishment of programs will need legislative and local government support and funding.

[164] DEQ. 2019. Retrieved from https://deq.nc.gov/climate-change/mitigation/business-industry

Examples:

- Preservation North Carolina promotes and protects the buildings and landscapes of our State's diverse heritage. Through its Endangered Properties Program, Preservation North Carolina acquires endangered historic properties and then finds purchasers willing and able to rehabilitate them.[165]
- North Carolina Land Trust brochure on Voluntary Conservation Agreements: An introduction for North Carolina Land Owners is designed to answer the basic questions that a landowner might have about conservation agreements.[166]
- The Community Conservation Assistance Program (CCAP) is a voluntary, incentive-based program designed to improve water quality through the installation of various best management practices (BMPs) on urban, suburban and rural lands not directly involved with agriculture production.[167]
- Coastal wetlands prevented $625 million in property damages and reduced damages by more than 22% in half of the areas affected by Hurricane Sandy, and by as much as 30% in some states. Source: The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA.[168]

### Strategy 2: Facilitate migration of coastal habitats through protection of migration corridors

Description: Develop ways to facilitate private, state, and federally owned land pathways to provide migration corridors (natural areas without barriers such as development) for salt marsh, coastal wetlands, and other coastal habitats. Ensuring that these migration spaces remain undeveloped is key to facilitating marsh migration with sea level rise, and therefore preserving the coastal protection and carbon benefits of North Carolina's coastal wetlands. Some steps to take include the following:

1. Identify and coordinate potential areas for buyouts in marsh migration corridors that also overlap with vulnerable coastal communities prone to flooding and storm surge.
2. Identify programs and strategies that will help provide resources for communities and populations living in the buyout areas.
3. Determine existing or potential state and private programs that could be responsible for holding and managing the lands acquired via buyouts.
4. Coordinate with federal agencies to identify state and federal lands that contain potential migration spaces and develop management strategies to facilitate the protection of these spaces.

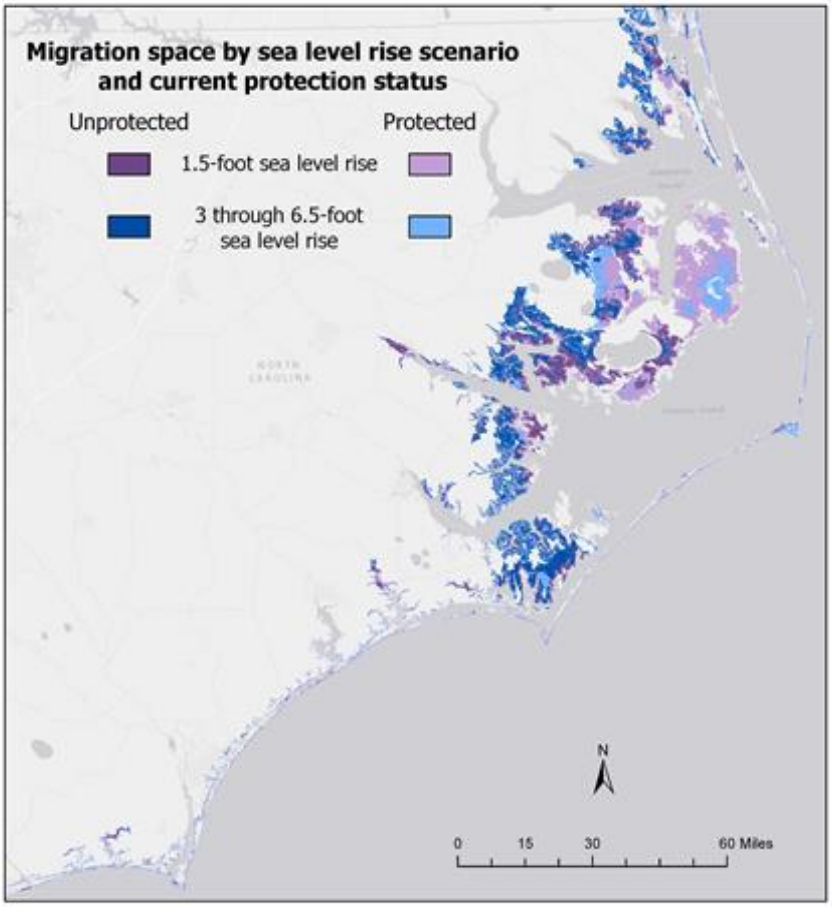
Geographic Scope: The State's 20 coastal counties (as identified in CAMA; ~8,187,000 acres) and 2.2 million acres of estuarine waters including ~228,000 acres of salt marsh.[169] The area for potential migration space includes undeveloped lands that have the appropriate topography to support marsh migration under low, medium and high SLR scenarios. As sea level rises, new areas of land will become inundated and may create suitable conditions for inland marsh migration. North Carolina has about 795,000 acres of potential migration space (345,000 acres expected to become available if 1.5 feet of SLR occurs, and 450,000 additional acres if up to 6.5 feet of SLR occurs). Within these migration spaces, 187,000 to 528,000 acres (for 1.5 feet of SLR

[165] NC Land Trust Voluntary Conservation Agreements: An introduction for North Carolina Land Owners. Retrieved from http://www.ncagr.gov/SWC/easementprograms/documents/CTR-019_VolConsBook_FINAL_2010.pdf
[166] NC Land Trust Voluntary Conservation Agreements: An introduction for North Carolina Land Owners. Retrieved from http://www.ncagr.gov/SWC/easementprograms/documents/CTR-019_VolConsBook_FINAL_2010.pdf
[167] Retrieved from http://www.ncagr.gov/SWC/costshareprograms/CCAP/index.html
[168] Narayan, S., Beck, M.W., Wilson, P. *et al.* The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. *Sci Rep* 7**,** 9463 (2017). https://doi.org/10.1038/s41598-017-09269-z
[169] DEQ. 2016. North Carolina Coastal Habitat Protection Plan. North Carolina Department of Environmental Quality, Raleigh, NC: NWI data (derived from imagery spanning 1977-2010), Cowardin classifications assigned by the NWI were reclassified into wetland types following (Sutter 1999).

and up to 6.5 feet of sea level rise) are not in currently protected areas.[170] Figure 3-9 on the following page presents the migration space as a function of potential sea level rise and the protection status of the areas.[171]

Greenhouse Gas Impact: The estimated impact is significant because salt marsh has the highest per unit area carbon sequestration of any vegetated habitat, 1.1 MT $CO_2e$ /acre/yr.[172] The total impact resulting from this recommendation will vary based on maintaining current salt marsh acreage (~228,000 acres) and potentially creating more habitat through marsh migration.

**Figure 3-9: Migration Space by Sea Level Rise Scenario and Current Protection Status**




Ecosystem Resilience: Significant; landward transgression of salt marsh has been identified as the key mechanism for the maintenance of or potential increase in salt marsh habitat area with SLR.

[170] For more information about the methods used for these estimates, see Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.
[171] Map produced by the Nicholas Institute for Environmental Policy Solutions at Duke University using migration space data from The Nature Conservancy's Resilient Coastal Sites project. Explore these map layers alongside other contextual information in the Natural and Working Lands StoryMap.
[172] Crossett, K., Ache, B., Pacheco, P., & Haber, K. (2013). National coastal population report, population trends from 1970 to 2020. NOAA State of the Coast Report Series, US Department of Commerce, Washington. Retrieved from https://coast.noaa.gov/digitalcoast/training/population-report.html
For more information about the methods used for these estimates, see Appendix I: Methods for Quantitative Estimates of Natural and Working Lands Potential.

### Actors and Participants:

- State Government –DCM, DMF, DWR, DPR, APNEP, NCLWF, DPS, DA&CS, NCFS, NCWRC, Office of Environmental Education and Public Affairs, state ports, local governments and municipalities, and others.
- Local governments and municipalities – Councils of Governments, county government, city government, and others.
- Federal – USFWS, NPS, National Estuarine Research Reserves, NFWF, NOS and NMFS Beaufort, NC, and others.
- Academia – Coastal Studies Institute, Duke University Marine Lab, East Carolina University, NCSU Center for Marine Sciences and Technology, UNC-Institute for Marine Sciences, UNC-Wilmington, and others.
- Landowners and producers – coastal wetlands and shoreline property owners (municipalities, public and private lands, commercial and residential properties).
- Corporations with climate goals – Industrial businesses (e.g. Nutrien Ag, Martin Marietta, state ports, Weyerhaeuser, Domtar, etc.). [173]
- Impact Partners – NC Coastal Federation, TNC, American Rivers, NC Wildlife Federation, Sound Rivers, Pew Charitable Trust, Audubon North Carolina, NC Coastal Land Trust, NC Sea Grant, and others.
- Policy Makers – State legislators, NCCRC, NC Environmental Management Commission (NCEMC), NC Marine Fisheries Commission, NCWRC, NC State Emergency Response Commission.

### Road Map for Action:

There are existing policies (NCCRC and NCEMC) for wetland protection in their current location, but no policies currently exist to facilitate salt marsh migration into new geographic locations. This will require reviewing and updating existing polices to facilitate protection for future marsh migration corridors and locations.

Other actions needed to facilitate marsh migration include developing management policies and best practices to support marsh migration and coordinating with local, state and federal governments and conservation groups to conduct outreach to landowners and coastal communities. Use of modeling tools is needed to provide guidance on protection and restoration activities in a manner that will minimize costs and maximize benefits. To be successful, new legislative funding for a state program and staff is needed. Encouragement of locally led efforts to plan coordinated area buyout programs would also be beneficial to maximize success. Partnerships and coordination are necessary among agencies that manage coastal wetland habitats and waterways (including DEQ, USACE, NMFS and USFWS) and uplands areas adjacent to current and potential coastal wetland habitats. New statutory authorities may be needed to initiate buyout efforts and provide funding.

### Examples:

- Initial modeling for marsh migration is underway with modeling efforts at minimal cost (TNC, Audubon).
- State run programs can be a successful alternative to the federal FEMA program, saving taxpayer dollars when repetitively damaged homes are not repaired, while also prioritizing properties that provide space for marsh migration. Buyouts in high risk coastal flood areas have been successful in New Jersey.[174]

[173] Retrieved from https://deq.nc.gov/climate-change/mitigation/business-industry
[174] Retrieved from https://www.renewjerseystronger.org/homeowners/blue-acres-buyout-program/ and http://www.rpa.org/sites/default/files/RPA-Wetland-Migration-Report%202.pdf

- A group of federal, state, and nonprofit conservation partners in Maryland worked to identify priority lands to support marsh migration and sustain wetlands in Blackwater National Wildlife Refuge.[175]
- In North Carolina, buyouts and targeted acquisitions have been proposed to reduce future exposure in flood-prone communities, while also having the potential to preserve coastal habitats. See North Topsail Beach Case Study from Western North Carolina.[176]
- Recently, TNC has completed a model that identifies marsh migration corridors and identifies both vulnerable coastal communities and resilient ecosystem habitats as priority targets for conservation and restoration.[177]

### 3.6.2 Restore Coastal Habitats

#### Strategy 1: Prioritize climate change and sea level rise in coastal habitat restoration planning

Description: Proposed actions to restore coastal habitats are listed below.

1. Facilitate coastal habitat restoration with state, federal, and local governments to incorporate climate change and SLR considerations into their planning processes.
2. Develop or revise existing planning and implementation processes that promote coastal habitats restoration efforts to include SLR and climate change scenarios.
3. Assess and promote processes that prioritize coastal resilience and carbon sequestration benefits and minimize risk from climate change and SLR.
4. Develop and implement coordinated landscape scale hydrological restoration strategies.
5. Identify innovative mitigation projects and appropriate crediting systems for coastal habitat restoration projects.
6. Examine and address state and federal regulatory frameworks that act as barriers for implementation of restoration strategies that prioritize planning for climate change and SLR (for example, the beneficial use of dredge materials for restoration projects).
7. Improve understanding of how land use decisions will impact restoration efforts, coastal resilience, and carbon sequestration regionally, considering future climate scenarios and impacts when building or rebuilding infrastructure.

Geographic Scope: The State's coastal counties (8,187,000 acres) and 2.2 million acres of estuarine waters, including ~100,000 acres of seagrass and ~228,000 acres of salt marsh.[178]

[175] Lerner, J.A., Curson, D.R., Whitbeck, M. and Meyers, E.J., Blackwater 2100: A strategy for salt marsh persistence in an era of climate change, 2013, The Conservation Fund (Arlington, VA) and Audubon MD-DC (Baltimore, MD). Retrieved from https://www.conservationfund.org/images/projects/files/Blackwater-2100-report_email.pdf
[176] Western Carolina University 2019. Coastal hazards and targeted acquisitions: a reasonable shoreline management alternative. North Topsail Beach, NC Case Study. 20 pp. Retrieved from http://shoreline2.wcu.edu/Katie/NTB%20July%201%202019.pdf
[177] Anderson, M.G. and Barnett, A. 2019. Resilient Coastal Sites for Conservation in the South Atlantic US. The Nature Conservancy, Eastern Conservation Science. Retrieved from http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/climate/CoastalResilience/Pages/Resilient-Coastal-Sites--for-Conservation-across-the-South-Atlantic.aspx
[178] DEQ. 2016. North Carolina Coastal Habitat Protection Plan. North Carolina Department of Environmental Quality, Raleigh, NC: NWI data (derived from imagery spanning 1977-2010), Cowardin classifications assigned by the NWI were reclassified into wetland types following (Sutter 1999).

*Salt marshes act as natural barriers to waves; 15 feet of marsh habitat can absorb up to 50% of the incoming wave energy.*

Estimated GHG Impact: The potential carbon sequestration per unit area of salt marsh is 1.1 MT $CO_2$e/acre/yr. Salt marsh has the highest per unit area carbon sequestration of any vegetated habitat.[179]

Ecosystem Resilience: There is significant opportunity for ecosystem resilience in the coastal plain. Currently there is ~228,000 acres of salt marsh and ~100,000 acres of seagrass in North Carolina providing ecosystem services and supporting ecosystem resilience. For example, salt marshes act as natural barriers to waves; 15' of marsh habitat can absorb up to 50% of incoming wave energy.[180]

Community Resilience: The potential for community resilience is significant. Coastal habitats provide valuable ecosystem services that serve to decrease exposure and risk to coastal communities. The current estimate for North Carolina's coastal population is approximately 1.2 million with 17% living below the poverty line.[181,182] The 20% population growth rate from 2010-2020 in these counties have exposed more people at risk to coastal hazards. [183] These growing communities will directly and indirectly benefit from the protective services provided by the protection of coastal habitats.

Economic and Health Benefits: The economic opportunity in the coastal plain is high but has yet to be quantified. Restored coastal habitat can minimize risk by decreasing damage and related costs from climate change and SLR. By using a damage avoided method, the economic benefit of natural infrastructure to communities due to reduced damages caused by climate change, SLR, and natural hazards can be estimated. For example, coastal wetlands prevented an estimated $625 million in property damages from Maine to North Carolina during Hurricane Sandy.[184]

Increased water quality (from flood and tidal water buffering, sediment and nutrient removal); enhanced ecosystem biodiversity (more habitat available for flora and fauna); enhanced ecosystem health (more protections for restoring and conserving coastal habitats increasing resilience for habitats to persist); higher levels of community resilience (from increased ecosystem services, shoreline stabilization, and reduced risk to personal property), enhanced food and fiber production (more habitat and ecosystem services for commercially and recreationally important finfish and shellfish) and an increase in carbon sequestration.

Estimated Cost: There is a high cost for restoration planning, but it will allow for more targeted and cost-effective efforts that will increase coastal resilience and carbon sequestration. The use of natural coastal

[179] Mcleod, E., Chmura, G. L., Bouillon, S., Salm, R., Björk, M., Duarte, C. M., & Silliman, B. R. (2011). A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2. Frontiers in Ecology and the Environment, 9(10), 552-560.
[180] Narayan, S., Beck, M.W., Wilson, P. *et al.* The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. *Sci Rep* Scientific Reports 7**,** 9463 (2017). https://doi.org/10.1038/s41598-017-09269-z
[181] NOAA. 2020. "FAST FACTS: North Carolina" Office of Coastal Management, NOAA. Retrieved from https://coast.noaa.gov/states/north-carolina.html
[182] Map of North Carolina Poverty Rate by County. Map provided by Index Mundi using 2018 Small Area Income and Poverty Estimates (SAIPE) Program data from US Census Bureau. Retrieved from https://www.indexmundi.com/facts/united-states/quick-facts/north-carolina/percent-of-people-of-all-ages-in-poverty#map
[183] Haber, K. (2013). National coastal population report, population trends from 1970 to 2020. NOAA State of the Coast Report Series, US Department of Commerce, Washington. Retrieved from https://coast.noaa.gov/digitalcoast/training/population-report.html
[184] Narayan, S., Beck, M.W., Wilson, P. *et al.* The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. *Sci Rep* Scientific Reports 7**,** 9463 (2017). Retrieved from https://doi.org/10.1038/s41598-017-09269-z

habitats for flood risk reduction strategies has benefit-cost ratios of 10:1 for oyster reefs and 8.7:1 for wetlands in comparison to 1:1 for alternative strategies such as levees.[185]

### Actors and Participants:

- State government – DEQ (DCM, DMF, and DWR, APNEP, Office of Environmental Education and Public Affairs), DPR and NCLWF), DPS, DA&CS, NCFS, state ports, and others.
- Local governments and municipalities – Councils of Governments, county government, city government, and others.
- Federal partners – USFWS, NPS, National Estuarine Research Reserves, NFWF, NOAA, and others.
- Academia – Coastal Studies Institute, Duke University Marine Lab, East Carolina University, NCSU Center for Marine Sciences and Technology, UNC-Institute for Marine Sciences, UNC-Wilmington, and others.
- Landowners and producers – coastal wetlands and shoreline property owners (municipalities, public and private lands, commercial and residential properties).
- Corporations with climate goals[186] – Industrial businesses (e.g. Nutrien Ag, Martin Marietta, state ports, Weyerhaeuser, Domtar, etc.).
- Impact Partners – NC Coastal Federation, TNC, American Rivers, NC Wildlife Federation, Sound Rivers, Pew Charitable Trust, Audubon North Carolina, NC Coastal Land Trust, NC Sea Grant, and others.
- Policymakers – NC legislators, NCCRC, NCEMC, NC Marine Fisheries Commission, NCWRC, NC State Emergency Response Commission, and others.

### Road Map for Action:

Federal habitat restoration programs currently consider the impacts of climate change and SLR. North Carolina should include climate change and SLR impacts when planning habitat restoration projects. Yet, presently, there are no requirements to consider climate change impacts. To facilitate incorporation of climate change and SLR in habitat restoration planning, policy and regulatory changes may be needed. Furthermore, existing programs and processes that do this should be promoted, and funding should be sought for new programs, research, restoration, protection, outreach, etc. that prioritize climate change and SLR in restoration planning.

A critical component of wisely planned wetland restoration priorities is having an accurate assessment/inventory of current salt marsh habitat distribution and condition in North Carolina. Siting tools that specifically prioritize coastal resilience and carbon sequestration and identify priority habitat areas should be used. Some siting tools that use SLR, carbon sequestration, and marsh migration factors already exist. Therefore, the State should assess the need for additional siting tools regionally in North Carolina and/or an inventory tool that easily identifies the correct tool or model for restoration decisions that consider climate change and SLR in North Carolina.

At a minimum, funding for existing restoration and land conservation programs, such as the NCLFW, should continue. The restoration community should be engaged, and partnerships should be formed at the local, state and federal levels in the funding and restoration process. It would be beneficial to examine the potential for a North Carolina state government program focused on habitat restoration to work with public and NGO properties, as well as the need for legislation and funding to support restoration activities beyond mitigation,

[185] Reguero, B. G., Beck, M. W., Bresch, D. N., Calil, J., & Meliane, I. (2018). Comparing the cost effectiveness of nature-based and coastal adaptation: A case study from the Gulf Coast of the United States. PloS one, *13*(4). Retrieved from https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0192132#sec006

[186] DEQ. Retrieved from https://deq.nc.gov/climate-change/mitigation/business-industry

with priority given to restoration projects that will incorporate adaptation to climate change and SLR. New state laws are needed to incorporate climate change and SLR in restoration planning processes. New planning processes that take climate change and SLR into account should be the top priority in restoration decisions. This will allow for more targeted and effective restoration projects while also increasing coastal community and ecosystem resilience and carbon sequestration.

Examples:

- At the federal level, NOAA and USFWS prioritize climate change and SLR in habitat restoration and research programs, including the NOAA Ecological Effects of Sea Level Rise program.[187]
- Prime Hook National Wildlife Refuge in Delaware has been hit by increasingly severe storms that have resulted in barrier island breaches, shoreline erosion, flooding and transformation of marsh habitat to open water. In 2013, the Refuge received funding from the Hurricane Sandy relief package to restore coastal habitat, which included transitioning a former freshwater impoundment system to a 4,000-acre back barrier salt marsh ecosystem, rebuilding the beach/dune complex to allow for the westward movement of the dune in response to SLR and storm surges, construction of 25 miles of re-configured tidal channels, and restoration of more than 1,500 acres of salt/brackish marsh vegetation, including 10 acres of new high marsh habitat by planting 270,000 salt meadow cordgrass (*Spartina patens*) plugs.[188]
- South Cape May Meadows Preserve in New Jersey has used restoration practices that includes restoring dunes and wetlands with levees and other engineered structures. Since completion of the project in 2004, the Preserve has withstood a series of storms, including Hurricanes Irene and Sandy in 2011 and 2012. Dunes and wetlands remained intact, there were no breaches, and the Preserve helped protect neighboring communities which experienced only minor flooding, unlike flooding that occurred post-hurricanes in similar towns up and down the coast.

[187] Retrieved from https://coastalscience.noaa.gov/research/coastal-change/ecological-effects-sea-level-rise-program/
[188] Retrieved from https://www.doi.gov/hurricanesandy/more-resilient-prime-hook-national-wildlife-refuge

## 3.7 Priority Recommendations for Urban Lands

Introduction: The protection, restoration and enhancement of Urban Lands are important for the sequestration of carbon for North Carolina and contribute significantly to disaster mitigation. According to a study published by the USFS Northern Research Station, North Carolina is one of the five states in the country with the greatest amount of carbon stored by trees in urban areas (37.5 million tons).[189]

Table 3-2 presents North Carolina's developed land use by type of use.[190] The total area of urban lands in North Carolina is 3.6 million acres. Low, medium and high-density development cover 1.35 million acres while developed open space covers 2.24 million acres. For this sector, urban lands are defined by municipal limits of cities and towns with a population greater than 5,000.

*Population growth and climate change will continue to stress urban areas. Nature-based solutions can be incorporated into local government plans to increase resilience while improving the carbon sequestration, tree canopy, air/water quality, natural areas and aesthetics of our cities.*

**Table 3-2: Developed Land Use Area in 2016**

| Land Sector | NLCD Land Cover Class | 2016 Area (million acres) |
|---|---|---|
| Developed | Developed, Open Space | 2.24 |
| | Developed, Low Intensity | 0.92 |
| | Developed, Medium Intensity | 0.32 |
| | Developed, High Intensity | 0.11 |
| Total Developed Area | | 3.6 |

Urban Lands include several types of ecosystems such as forests, wetlands and scrub shrub. Green space in urban areas provides critical wildlife habitat, recreational opportunities, shade and thermal regulation, and reduces air pollution. Protection of watersheds draining to urban areas is critical to reducing infrastructure flooding and protecting the quality of urban water supplies in developed areas. Urban soils are typically in poor condition, and soil amendments, site preparations for planting trees, and other natural landscape development are critical.

[189] US Forest Service. 2013. Retrieved from https://www.fs.usda.gov/news/releases/us-urban-trees-store-carbon-provide-billions-economic-value.

[190] Multi-Resolution Land Characteristics (MRLC) Consortium. (2016). Data extracted from the National Land Cover Database (NLCD). Retrieved from https://www.mrlc.gov/ by Duke University's Nicholas Institute for Environmental Policy in 2019.

Ecosystem and Community Resilience: Restoring urban floodplains to natural conditions has the potential to reduce the risk of flooding to nearby areas, improve water quality, provide habitat for biodiversity, improve ecosystem health, and reduce the heat island effects in urban areas.

Economic and Health Benefits: Cost savings to local governments can be achieved by coordinating buyouts of flood-damaged properties, as discussed in Recommendation 5.3.1 Coordinated buyout and restoration program. Buying flood-damaged properties allows local governments to discontinue services to high-risk areas if all properties are bought out within the area. Buyouts can also reduce costs related to cleanup and damage from future storms, and can spur creation of local parks, greenways, and other community amenities in areas that have been bought out. Watershed protection and restoration would also reduce the cost of water treatment and provide better water quality and water supply security, which will benefit human health.

Geographic Scope: Across North Carolina, 3.6 million acres of land are within developed areas. Certain percentages of these areas are still to be developed, and many urban areas are doing infill. Maintaining and expanding the State's urban forests are important for GHG mitigation while floodplain restoration and watershed protection and restoration in urban areas will be critical for both GHG mitigation and resilience. Site preparation and soil health are very important to support urban land tactics across the State.

Greenhouse Gas Impact: Based on urban forests, the current level of gross sequestration is estimated at 2.1 MT of carbon per year.

Estimated Cost: Full-time staff; funding to support local government planning; and funding for protection, restoration, and maintenance of forested areas in urban areas.

## 3.7.1 Protect Urban Lands

### Strategy 1: Promote urban forests through statewide programs to foster the retention of urban trees and their proper management

Description: We recommend expanding the NCFS's (U&CF) program to provide hands-on assistance to North Carolina communities to manage their urban canopy. The NCFS already has the process in place to assist communities, however, they are only able to provide general guidance and recommendations due to limited resources. There is a need to provide local governments with tools to help them work with developers to maximize forest retention during land development. Minimum canopy requirements are one such tool. Site design guidance that identifies priority forested area and clusters buildings to avoid these areas (i.e., conservation design development) is another tool that is appropriate on the rural/urban fringe. At a minimum, expansion of this program should support maintaining the current level of tree canopy and tree health in urban areas. Increasing urban tree canopy is essential for both carbon sequestration and community/ecosystem resilience. A goal to increase sequestration and resilience should be developed using baseline data for urban tree canopy and the current level of annual sequestration.

Geographic Scope: North Carolina has 385,000 acres of urban forests (area within municipal boundaries of communities with at least 5,000 people that are not currently part of protected areas). North Carolina is losing 4,510 acres per year of urban tree canopy cover.[191]

[191] Nowak D. J., and E. J. Greenfield. (March 2018). US Urban Forest Statistics, Values, and Projections. *Journal of Forestry.* Retrieved from https://www.fs.fed.us/nrs/pubs/jrnl/2018/nrs_2018_Nowak_003.pdf

Estimated GHG Impact: North Carolina's urban forest canopy sequesters 2.1 million tons of carbon per year and avoids the production of 1.2 MMT $CO_2$ per year through energy savings.[192,193]

Ecosystem Resilience: The ecosystem's resilience would be supported by the 385,000 acres of forested lands that are maintained plus any additional acres conserved and/or restored. Developed and managed urban forests reduce stormwater runoff, increase air and water quality, provide shade, increase wildlife habitat and diversity and increase resilience to pest/disease outbreaks.

Community Resilience: There are over six million people in North Carolina living in communities with urban forest programs. Developed and managed urban forests increase community resilience for droughts and stormwater impacts, and they provide shade, aesthetics, and recreational opportunities.

Economic and Health Benefits: Air quality, water quality/quantity, ecosystem health, and public health.

Economic benefits are unknown, but NCSU and the NCFS are starting an economic impact study of forestry and urban forestry for the State. The Carbon Action Reserve Urban Forest Project Protocol provides guidance to quantify and verify GHG reductions from tree planting, maintenance, and/or improved management activities implemented to permanently increase carbon storage through trees.

Estimated Cost: The estimated cost to protect urban forests is $500,000. This cost is what it would take to support four full-time positions within the U&CF program, which would allow for three regional urban foresters across the State and more hands-on assistance for municipalities managing their urban forests.

Actors and Participants:

- State – NCFS Urban & Community Forestry Program, NCCES.
- Local governments.
- Impact Partners – NC Urban Forest Council, tree care industry partners (Bartlett Tree Experts, Rainbow Tree Care, Davey Tree Experts, etc.).
- Policymakers.

Road Map for Action:

Currently, the NCFS has a 2-person team within its Urban & Community Forestry Program helping local governments and landowners better manage their urban tree canopy. It is recommended that this program be expanded to a minimum of three regional urban forestry specialists and one program manager to be local/regional experts to assist local governments with their community forestry programs and homeowners/landowners better manage their urban trees. The regional specialists would provide assistance to municipalities with tree ordinance development/revision needs, technical assistance and aid in the development of Community Tree Boards and training municipal tree-care workers, assist communities with long-range land use planning to minimize the impacts of development, and provide storm mitigation planning and post-storm evaluations.

The first step is to create regional urban forestry positions that can help local governments develop their community forestry program and policies. These positions would ideally be situated within NCFS; however, creating regional urban forestry specialists within the NCCES may also work. Once the positions are established, a partnership among NCFS, NCCES, NC League of Municipalities, tree care industry representatives, and municipal government representatives should develop statewide best management practices that would guide tree care protection policy, tree care standards, and urban forest

[192] Ibid.

[193] Nowak, D. J. 2017. Urban forest sustainability in the United States. In: Ning, Z.; Nowak, D.; Watson, G., eds. Urban forest sustainability. *International Society of Arboriculture*. 2-11. Retrieved from https://www.fs.usda.gov/treesearch/pubs/55771.

management/planning across jurisdictions. These standards would be used to set goals and ensure that proper tree care standards are being used.

The NCFS already has the mechanism in place within its Urban & Community Forestry Program to create regional specialists. Funding would be needed through the DA&CS and the Legislature to support the new positions permanently.

Examples:

- The North Carolina Urban Forest Council Legacy Tree Fund provides financial assistance to communities across North Carolina for tree planting projects that help educate citizens about the importance of trees and the role they play.
- NC U&CF program operates as a cooperative partnership between the NCFS and USFS Southern Region. It funds projects which lead to a more effective and efficient management of urban and community forests and improve public understanding of the benefits of conserving existing tree cover in communities.
- The Georgia Forestry Commission and the Texas Forest Service currently have regional urban forestry specialists that assist local landowners and municipalities with urban forest management needs.

### Strategy 2: Protect and restore forested lands in water supply watersheds

Description: Water supply watersheds (WSW) are designated by the NC Division of Water Resources and already have limitations for development to protect the quality of the water supply and to ensure an adequate quantity of water to support North Carolina populations on centralized water supply systems. However, added benefits could be achieved by creating incentives for the preservation and restoration of forested lands in water supply watersheds. Coordinated and planned efforts are needed to fund these mechanisms and balance potential negative impacts among beneficiaries (cities and counties). This recommendation mitigates the impacts of future urban and suburban population growth and water demand by offsets through land conservation and reforestation. This will also help urban areas maintain canopy cover and provide a host of co-benefits.

Geographic Scope: Statewide. 2.7 million acres of forest lands in WSW with 512,000 acres protected. There is another 1.2 million acres of potentially restorable lands within WSW.

Estimated GHG Impact: The estimated carbon sequestration is 193.9 MT $CO_2e$/acre for forest protection and 3.06 MT $CO_2e$ /acre for forest restoration.

Ecosystem Resilience: The ecosystem's resilience would be the 610,000 acres of forested lands within Water Supply Watersheds that are restored or protected.

Community Resilience: Forest protection in WSW not only benefits the millions of people served by the water supply but will provide ancillary benefits to people living in nonurban areas surrounding the watersheds. As urban areas continue to grow, there will be increased benefit from preservation of forests for recreation and public health.

Economic and Health Benefits: Conservation of forested lands in urban WSW can provide economic benefits to help offset the costs. Potential benefits include reduced water treatment costs from reduced sedimentation in reservoirs, and increased recreation revenue. Additional benefits to public health from improved air quality and from carbon storage could also be calculated.

Health benefits include the following;

- Water quality (less sedimentation and reduced treatment costs),
- Water quantity (attenuate delivery of runoff to the lake protecting water quantity),
- Ecosystem biodiversity (provide more forested land for habitat),
- Ecosystem health (habitat connectivity),
- Public health (from better air quality), and
- Recreation (more fishable days).

Estimated Cost: The cost of land is variable across the State. The recent study by Eddy et al. 2019 for the Catawba Basin in West-Central North Carolina reported eligible lands ranging from $1,095 to $12,496 per acre (10th and 90th percentiles).

Actors and Participants:

- State – Develop a generalized framework for prioritization and economic considerations and building programmatic support into agencies. Also, a standard method to account for the GHG offset is needed.
- Landowners and Producers – The target lands to be protected or restored are likely to be owned by a single landowner or groups of landowners with larger tracts of land.
- Corporations with climate goals – Partners who can donate for implementation of the prioritization framework and/or the purchase of land.
- Impact partners – Land Conservation organizations, watershed groups, and other groups are key partners in the prioritization and implementation process.
- Policymakers – Local city and county governments and regional planning groups need to implement rule changes to create sustainable funding mechanisms for land acquisition and long-term management.

Road Map for Action: There are 512,000 acres of forest lands that are currently protected. The total potential for restoration is five times this amount. The steps to take include the following.

1. Develop a generalized framework to prioritize areas with high hydrology/water quality benefits within the watershed. Estimate the average per acre benefit with land cost to prioritize areas to conserve.
2. Regional planning around water supply sources is needed and then can be implemented at the local municipality level.
3. Implement a multiple stakeholder approach to funding conservation. Examples are the Upper Neuse Clean Water Initiative that connects downstream beneficiaries with upstream providers.[194] Additional implementation will require public-private partnerships.
4. Different funding mechanisms could be applied. For example, funding could be generated by a development fee as new proprieties are developed, by a fee to all water supply users, or by funding from general funds.
5. State and local governments need to determine what agencies would be involved and if they have existing authority. The State also needs to determine if funding is needed and the feasibility of getting this funding and from what source. If changes to existing authorities or new authorities are needed, the State will need to take appropriate action and determine the feasibility of the legislature acting.

[194] Upper Neuse Clean Water Initiative. Retrieved from https://issuu.com/rebeccahankins/docs/2015-2045_conservation_strategy

Examples:

A recent study conducted by RTI International and published by Water Research Foundation[195] developed a framework and calculated the economic benefit s from land conservation on water supply resilience and other co-benefits such as carbon storage, air quality, and recreation in the Catawba-Wateree watershed in west-central North Carolina.[196] The framework combines a hydrology model considering future changes to climate and land use and an economic cost-benefit analysis to guide where forest preservation may provide the greatest benefit and community resilience.

The benefits of carbon storage from land conservation of forested lands were estimated at a present value of $2,300 to $6,000 per acre. The air-quality-related health co-benefits associated with forest conservation were estimated at an average present value of $212 per acre ($18 to $2,500 per acre). The other three co-benefits are associated with changes in water quality of reservoirs: recreation ($1 to $7,000 per acre), lakeshore property values ($1 to $1,500 per acre), and reduced water treatment costs ($3 to $270 per acre).

The assessment can be used to prioritize forested lands for conservation either by changes to hydrology/water quality or by the net economic cost/benefit. The framework is scalable such that prioritization can be done for an entire watershed or sub-watersheds. One use of the framework would be to coordinate a central fund or bank that connects downstream users or beneficiaries (i.e., urban populations) with upstream providers of land conservation activities. The centralized fund or bank would provide the mechanism to ensure that funds are collected and distributed in a manner to maximize co-benefits.

The Upper Neuse River contains nine public drinking water reservoirs and encompasses six counties and provides drinking water to eight municipalities. The Upper Neuse Clean Water Initiative is a partnership of conservation organizations and local governments coordinated by the Conservation Trust for North Carolina to protect water quality in these reservoirs through land conservation. A stakeholder-based prioritization model was developed in 2015 to evaluate projects for the City of Raleigh's Watershed Protection Program.[2] The model protects water sources and conveyances, conserves upland areas, promotes water infiltration/retention, and protects vulnerable areas such as wetlands, steep slopes, and erodible soils.

Funding is provided by a combination of state, local, and private funding. The City of Raleigh contributes revenue by a $.15 per 1,000-gallon rates on utility customers, whereas the City of Durham uses a tiered rate system to generate funding for this initiative. The State also provides funding through the North Carolina Land and Water Fund (formerly CWMTF), and nonprofit land conservation organizations and other NGOs provide resources as well.

## 3.7.2 Enhance Urban Lands

### Strategy 1: Improve site preparation and soil amendment during land development

Description: Healthy soils are necessary for healthy trees and native vegetation. North Carolina is a rapidly developing state, with both greenfield development and redevelopment occurring to meet the demands of our growing population. Modern development has many examples of the incorporation of standards to protect the environment and to seek a balance – allowing both development and protection of the environment, for example, the protection of stream buffers. The modern development process usually results in sites with very degraded soils, as the most expeditious way to grade and prepare a site for construction is to grade with heavy

[195] Water Research Foundation Report: Quantifying the Potential Benefits of Land Conservation on Water Supply to Optimize Return on Investments, Retrieved from https://www.waterrf.org/research/projects/quantifying-potential-benefits-land-conservation-water-supply-optimize-return

[196] Upper Neuse Clean Water Initiative. Retrieved from https://issuu.com/rebeccahankins/docs/2015-2045_conservation_strategy

equipment, removing the topsoil. Plants and trees planted in degraded soils often are unhealthy and fail to reach full maturity, and they require more maintenance and replanting, which is counterproductive and costly. To reap the benefits of replanted trees and vegetation after development, proper soil amendment after grading and before replanting should occur.

Healthy soils will also increase soil water holding capacity, reduce soil erosion, reduce stormwater runoff, reduce pollutant loading of waterways, sequester carbon, and reduce reliance on synthetic fertilizers and irrigation to establish and maintain constructed greenscapes.

Developers should be encouraged to amend topsoil with high grade soil with adequate organic content. Topdressing and blending compost with existing site soils in new and existing developments to achieve 5-10% organic matter should be a best practice. Additionally, emphasis should be given to the overall reduction in land impact caused by mass grading for large developments. This would include the addition of native vegetation to existing buffers, reduction of impervious areas by adding pervious pavement, and increasing root paths for trees planted in denser urban settings using modular suspended pavement systems (such as Silva Cells). Incentives need to be provided to developers to utilize such practices and to design-in green infrastructure and carbon sequestration and stormwater management for the future.

Geographic Scope: Site development and soil amendment strategies should be statewide but particularly concentrated in high developing urban areas as in the Piedmont crescent (Triangle to Triad to Charlotte). Anywhere from 5 to 30 percent of urban areas are subject to development/redevelopment, and this can be used as an estimate of acreage.

Greenhouse Gas Impact: Using Low Impact Development techniques, green infrastructure, proper site preparation, and soil amendments, much damage can be avoided (carbon loss and release through disturbance) and tremendous carbon gains can be realized. Using the geographic scope (5 to 30 percent of North Carolina's urban areas) carbon sequestration can be estimated.

Ecosystem & Community Resilience: Proper site development and soil amendments can increase water quality, reduce stormwater runoff, increase aesthetics and recreation, reduce urban heat effect, increase urban biodiversity, all of which will increase urban/community resilience. Furthermore, the use of compost for soil amendments will reduce food waste and landfills.

Estimated Costs: While there may be an initial increase in development costs to implement these processes, long term benefits will outweigh the costs. The implementation of green infrastructure is known to increase property values. The economic value and avoided costs in flood mitigation, storm protection, and water treatment from increased ecosystem service provisions on newly protected lands vary widely.

Economic and Health Benefits: Increased use of Green Infrastructure will increase benefits such as water quality, recreation, and aesthetics, all of which can improve human wellbeing.

Actors and Participants:

- Urban municipalities.
- Businesses who develop in urban areas.
- Nonprofits/NGOs who can help coordinate the players into action.

Road Map for Action:

Developers currently have an economic incentive to take the quickest and least expensive route to prepare a site for development, which typically leaves soils in a degraded state for the subsequent tenants and owners of the properties. This is a widespread practice that needs changing, and education of local municipalities and developers is needed. Local community involvement is critical for these changes to occur. So many benefits

can be gained if all the players buy into these soil site preparation objectives. Most developers want to have a good relationship with the community and are receptive to these concerns.

Examples:

- City of Fort Collins, Soil Amendment Requirements.[197]
- City of SeaTac, Soil Amendment Standards[198]

### Strategy 2: Research urban forestry climate adaptation and canopy baseline needs

Description: Research to help clarify the impact of climate change on our urban forests and what that means for ecosystem services is still needed. Developing a template for canopy studies for each region of the state is recommended. We recommend funding research that looks at impacts of climate change on urban vegetation, using Dave Nowak's broad-level data that show the high-level change in urban canopy cover over time, compiling existing urban tree canopy assessments (UTC) into a single database that would allow for state-level management and priority setting.[199] Funding additional urban tree canopy assessments within North Carolina communities and implementing the Urban Forest Inventory Analysis (FIA) study plots would be necessary.

Geographic Scope: Urban areas across the State with an emphasis on the Piedmont area.

Greenhouse Gas Impact: As discussed previously in Section 5.7.1, North Carolina's urban forest canopy sequesters 2.1 million tons of carbon per year and avoids the production of 1.2 MMT $CO_2$ per year through energy savings.

Ecosystem Resilience: As discussed previously in Section 5.7.1, the ecosystem's resilience would be the 385,000 acres of forested lands that are maintained plus any additional acres conserved and/or restored. Developed and managed urban forests reduce storm water runoff, increase air and water quality, provide shade, increase wildlife habitat and diversity and increase resilience to pest/disease outbreaks.

Community Resilience: As discussed previously in Section 5.7.1, there are over six million people in North Carolina living in communities with managing and developing urban forest programs. Developed and managed urban forests increase community resilience for droughts and stormwater impacts, and they provide shade, aesthetics and recreation opportunities.

Economic and Health Benefits: None – the benefits would come from any actions taken as a result of the study.

Estimated Cost: Unknown, but minor because a methodology and high-level data have already been developed.

Actors and Participants:

- State – NCFS, DEQ.
- Local governments.
- Impact partners – NC Urban Forest Council, tree care industry partners (Bartlett Tree Experts, Davey Tree Experts, etc.).
- Policymakers.

[197] Soil Amendment Requirements. City of Fort Collins. Retrieved from https://www.fcgov.com/utilities/business/builders-and-developers/development-forms-guidelines-regulations/soil-amendment-requirements/
[198] Soil Ammendment Standards. City of SeaTac. Retrieved from http://www.seatacwa.gov/Home/ShowDocument?id=5939
[199] Nowak D. J., and E. J. Greenfield, (March 2018). US Urban Forest Statistics, Values, and Projections. *Journal of Forestry*. Retrieved from https://www.fs.fed.us/nrs/pubs/jrnl/2018/nrs_2018_Nowak_003.pdf

### Road Map for Action:

Approximately 18 communities in North Carolina currently have a partial or full canopy assessment, with corresponding GIS data. Each of these canopy assessments will have been conducted with different parameters; however, they all have some sort of GIS component. The NCFS currently funds urban tree canopy assessments through the U&CF grant program. The NCFS FIA program manages and collects data on long-term forest plots across the State. The Southern Group of State Foresters has expressed interest in and a willingness to support the creation of Urban FIA plots in order to begin collecting long-term data that show changes in forest cover over time. Studies have been conducted by the US Forest Service, and North Carolina has some statewide, high-level data that show the change (decrease) in the forest canopy and increase in the urban areas across the State.

Successful implementation of this recommendation will include the following steps:

1. Compile existing Urban Tree Canopy Assessment data into a single database managed by a state entity. Create GIS data layers.
2. Create a template or a standardized guide for canopy assessment data and process to add consistency across jurisdictions. This will help municipalities begin the process of completing a UTC assessment.
3. Work with NCFS FIA program to determine needs for starting Urban FIA data collection.
4. Work with the UNC system and NCSU to start a collaborative effort to begin looking at urban tree canopies and street tree inventories within the municipalities and determine species in decline or significant changes in species.
5. The NCFS already has the mechanism in place through the Forest Inventory Analysis (FIA) program; adding long-term Urban FIA plots would show landscape-level changes to the natural resources in urban areas.

## 3.8 Priority Recommendations for Agriculture

Introduction: North Carolina agriculture is a significant portion of the State's economy and land use. In 2018, agriculture, food, and natural fiber industries contributed $91.8 billion to North Carolina's economy, while North Carolina's farms earned a total of $12.9 billion in annual cash receipts.[200] The State's 46,000 farms grow over 80 different commodities.[201] As shown in Table 2-1, agriculture is the second largest land use category, covering 6.9 million acres, or 20%, of the State's land and open water area.

*In recent years, farms have experienced billion-dollar losses from flooding events related to climate change. Farmers have existing tools and programs that build resilience and sequester carbon. Coordination and increased funding of these programs and other nature-based resilience efforts are needed to mitigate future impacts of extreme weather.*

Farm resilience to climate-related weather events is also important. Approximately 3.8 million acres of the State's farmland and seven of the top 10 counties in annual cash receipts were located in eastern North Carolina where many recent flooding events have occurred.[202] The agricultural losses from these flooding events include:

- $544 million in losses from Hurricane Matthew in 2016, and
- $2.4 billion in losses from Hurricane Florence in 2018.[203]

As shown in DEQ's GHG inventory, the agriculture sector emitted 10.5 MMT $CO_2e$ in 2017, which is 7% of the total gross emissions of the State. Over the last decade, the potential for agriculture to mitigate GHG emissions and provide climate resilience benefits to both farms and communities has been widely recognized.

Recent high-level analyses of agriculture and food as a climate change solution converge on three strategies to provide these mitigation and resilience benefits:

- On farms, adopt practices and technologies that result in GHG emissions avoidance or reductions and enhanced biological carbon sequestration;

[200] Walden, Mike. (May 2018). Agriculture and Agribusiness: North Carolina's Number One Industry. NC State College of Agriculture and Life Sciences. Retrieved from https://cals.ncsu.edu/agricultural-and-resource-economics/wp-content/uploads/sites/12/2018/05/agribusiness2018brochure.pdf
[201] DA&CS. (2019). NC Agriculture Statistics Book. Retrieved from http://www.ncagr.gov/stats/AgStat/NCAgStatBook.pdf and Agriculture and Agribusiness (2019). Retrieved from https://cals.ncsu.edu/agricultural-and-resource-economics/wp-content/uploads/sites/12/2019/05/agribusiness2019Brochure.pdf
[202] Multi-Resolution Land Characteristics (MRLC) Consortium. (2016). Data extracted from the National Land Cover Database (NLCD). Retrieved from https://www.mrlc.gov/ by Duke University's Nicholas Institute for Environmental Policy in 2019.
[203] DA&CS and DEQ. (2020, March). North Carolina Climate Risk Assessment and Resilience Plan: Impacts, Vulnerability, Risks, and Preliminary Actions, Chapter 5B. Agriculture and Forestry.

- Improve manure management practices at large-scale animal operations, and
- In the supply chain, improve the energy and material efficiency of food processing, distribution, consumption, and disposal.[204]

The kinds of public and private investments in cost-effective agriculture and food climate solutions most likely to produce the greatest mitigation and resilience benefits to the people of North Carolina will be those that promote local ownership of sustainable farm and food chain businesses, enhance the diversity of regional food supply chains, and encourage a transition to climate-resilient agriculture and food systems.[205]

### 3.8.1 Recommendations to Enhance Agriculture

#### Strategy 1: Encourage adoption of high mitigation agricultural conservation practices on croplands and pasturelands.

Agricultural systems that avoid or mitigate GHG emissions and/or sequester carbon are receiving growing attention in the media, from federal and state policymakers, in agribusiness, and in the agricultural community. These systems can also provide solutions to the challenges of producing food, feed, fiber, and fuel in a changing climate. Although they differ in broad social goals and in the degree to which ecosystem services are exploited, they draw on a common set of agricultural conservation practices that promote on-farm GHG emissions avoidance or reductions, and/or biological carbon sequestration.[206] They also produce a multitude of social and environmental benefits that enhance climate resilience of both the farms and the surrounding communities.[207]

Description: This recommendation extends existing voluntary agricultural conservation incentive programs to encourage agricultural landowners and managers in North Carolina to adopt conservation practices that have the potential to contribute to state mitigation goals while also enhancing the resilience of the farming operation, as appropriate. Some examples of these conservation practices include;

- cover crops
- conservation tillage;
- improved fertilizer management;
- integrated pest;
- more diversified crop and livestock production systems;
- the establishment of shrubs and trees in actively managed croplands and pasturelands, and
- the restoration of wetlands and riparian areas in agricultural landscapes.

Many of these practices are already in use on some North Carolina farms. However, data estimating the current state of conservation practice adoption on North Carolina croplands and pasturelands is incomplete and limited to a few selected practices in major commodity crops. Currently, the adoption of just two mitigation

[204] Project Drawdown: Food, Agriculture, and Land Use, Retrieved from https://drawdown.org/sectors/food-agriculture-land-use
[205] The Climate-Resilient Agriculture Initiative. 2019. Scenic Hudson. Retrieved from https://www.scenichudson.org/wp-content/uploads/2019/10/Climate-Resilient-Agriculture-in-the-Hudson-Valley.pdf and USDA. 2018. Cultivating Climate Resilience on Farms and Ranches, USDA Sustainable Agriculture Research and Education Program. Retrieved from https://www.sare.org/Learning-Center/Bulletins/Cultivating-Climate-Resilience-on-Farms-and-Ranches
[206] NRCS Practice Standards for Greenhouse Gas Emission Reduction and Carbon Sequestration GHG and Carbon Sequestration Ranking Tool: NRCS Practice Standards for Greenhouse Gas Emission Reduction and Carbon Sequestration. Retrieved from https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/air/quality/?cid=stelprdb1044982
[207] USDA. 2013. "Adapting to Climate Change". Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Bulletin 1935. Retrieved from https://www.usda.gov/oce/climate_change/effects_2012/CC%20and%20Agriculture%20Report%20(02-04-2013)b.pdf and Cost Effective Conservation Programs for Sustaining Environmental Quality. Choices. 2016. Retrieved from http://www.choicesmagazine.org/UserFiles/file/cmsarticle_518.pdf

conservation practices — cover crops on about 10% of North Carolina croplands and conservation tillage on about 69% — offset GHG emissions by an estimated 0.9 to 1.2 MMT $CO_2$e/year.[208]

Despite the many benefits of these programs, federal and state funding levels do not meet producer demand. For example, in North Carolina in FY2019, state funding was sufficient to support only 18% of eligible conservation assistance applications.[209] Therefore, increasing public/private technical and financial support for the adoption of agriculture conservation practices that reduce GHG emissions and build farm and community resilience are key steps for the State.

Geographic Scope: All of North Carolina, with an emphasis on eastern part of the state. There is a total of 4.4 million acres of cropland and 2.5 million acres of hay and pastureland in North Carolina. Currently, 69% of landowners are utilizing at least one practice, conservation tillage. Increasing both the number of practices and acres of farmland adopting conservation practices should be the goal.

Greenhouse Gas Impact: North Carolina's soil carbon sequestration potential in croplands and pasturelands ranges from 1.0 to 8.2 MMT $CO_2$e/year, based on the types and amounts of practices adopted by farmers.[210]

A recent analysis by American Farmland Trust (AFT) estimated a total mitigation potential of 1.1 to 2.9 MT $CO_2$e per year if just one of a group of seven mitigation conservation practices is adopted on 100% of the state's cropland. [211] The same analysis estimated a total mitigation potential of 0.7 to 1.3 MT $CO_2$e/year if just one of a group of three mitigation conservation practices is adopted on 100% of North Carolina's pasturelands.

One hundred percent adoption of any conservation practice is an unlikely scenario because the decision to adopt a conservation practice involves many considerations specific to each farm operation. In addition, farmers often adopt more than one conservation practice on the same acre. With these complexities in mind, the AFT estimated a maximum mitigation potential represented by a combination of cropland conservation practices (conservation till, cover crops, and nutrient management) of 2.5 (a moderate increase over current acres) to 6.4 MT $CO_2$e/yr (100% of acres).

Conservation practices may also conserve farmland by 1) increasing farm productivity and profitability, 2) enhancing the farm management skills, 3) restoring natural resource quality, and 4) building climate resilience. Keeping farms as farms maintains and potentially increases the carbon sequestered in them.

Ecosystem and Community Resilience: Conservation practices are proven to enhance soil, air, and water, quality, enhance wildlife habitat and biodiversity, and promote water conservation. Farms that use conservation practices contribute to community resilience by reducing flood risks and increasing adaptive capacity on the farm, in the local region, and in the watershed.[212]

Economic and Health Benefits: Adoption of conservation practices can increase the profitability and sustainability of farms and agricultural businesses. More profitable and resilient farms will also maintain and potentially create economic opportunities in both rural and urban communities. Health benefits include:

- Enhance soil, air, and water, quality,
- Promote water conservation,
- Enhance wildlife habitat, biodiversity, and health, and
- Promote sustainable intensification of food and fiber production.

[208] AFT. 2019. North Carolina: Potential Greenhouse Gas Reductions for Croplands, and the Draft North Carolina Opportunity Assessment, World Resources Institute and The Nature Conservancy, 2019, emailed to NC DEQ in October of 2018.
[209] Soil and Water Conservation Commission Cost Share Programs Annual Report Fiscal Year 2019.
[210] AFT. 2019. North Carolina: Potential Greenhouse Gas Reductions for Croplands.
[211] Ibid.
[212] Union of Concerned Scientists. (August 2017). Turning Soils into Sponges: How Farmers Can Fight Floods and Droughts. Retrieved from https://www.ucsusa.org/sites/default/files/attach/2017/08/turning-soils-into-sponges-full-report-august-2017.pdf

Estimated Cost: Implementation costs are difficult to estimate because the conservation practices that mitigate GHGs included in this recommendation have a wide range of costs and benefits. With effective technical and financial assistance, these practices can generate sufficient return on investment over time that in many cases exceeds the cost of implementation.

For example, the 2007 North Carolina Climate Action Plan estimated that conservation incentive programs that promote soil carbon sequestration had a return-on-investment (ROI) of $5/ton $CO_2e$ mitigated.[213] The Drawdown Project estimated an ROI of $33 for conservation practice adoption globally.[214] In addition, the AFT and NRCS published a series of case studies in 2019 showing the economic benefit of healthy soils/conservation practices.[215]

There is a growing opportunity for agriculture to participate in compliance and voluntary carbon offset markets and ecosystem services markets discussed in Section 5.1.2. Revenue from these markets may offset part of the costs of conservation practices. Note that participation in these markets have complexities, costs, and risks associated with them that must be considered on a project by project basis.

Road Map for Action:

North Carolina agriculture has the potential to contribute significantly to North Carolina's mitigation and community resilience goals; however, in order to reach this potential, the State must explore opportunities to expand agricultural technical and financial assistance programs.

The existing network of soil and water conservation districts promote agricultural GHG mitigation by assisting landowners with adopting conservation practices through various programs, which North Carolina producers are eager to adopt. These programs are funded by state and federal government, managed at the state level, and delivered locally.

While the soil and water conservation districts are well-positioned to implement the programs, they are chronically underfunded. In fiscal year 2019, cost-share programs funded by the State could only support 18% of eligible conservation assistance applications.[216] Additional funding from the Legislature and/or other public and private sources would allow the soil and water conservation districts to better meet the demand from farmers applying for assistance to implement conservation practices that would contribute to state GHG mitigation and resilience goals.

Examples:

Other emerging opportunities consist of innovative agricultural climate solution programs managed by public and private sector organizations and new public-private collaborations, including:

- Existing publicly funded voluntary agricultural conservation programs, for example, the Climate Resilient Farming Program in New York; [217]

[213] North Carolina Climate Action Plan Summary. 2007. Center for Climate Strategies. Retrieved from https://www.eesi.org/files/ccs_nc_summary.pdf
[214] Project Drawdown. 2018. Retrieved from https://ww.drawdown.org
[215] AFT. (July 2019). Quantifying Economic and Environmental Benefits of Soil Health. Retrieved from https://farmland.org/new-american-farmland-trust-nrcs-case-studies-show-soil-health-practices-increase-farm-profitability/
[216] Soil and Water Conservation Commission Cost Share Programs Annual Report Fiscal Year 2019.
[217] Retrieved from https://agriculture.ny.gov/soil-and-water/climate-resilient-farming

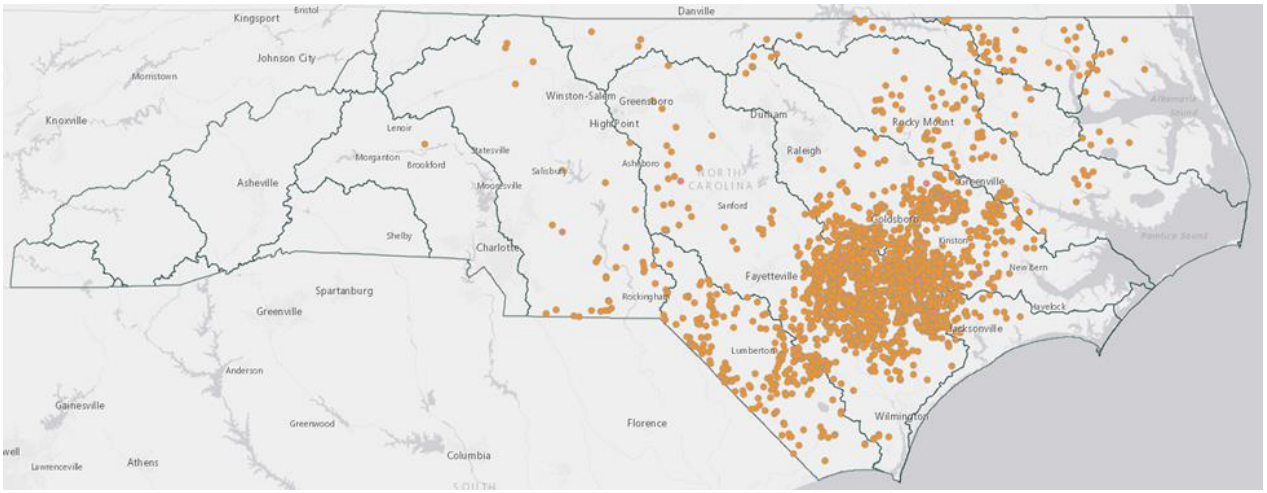
- Public, private and joint efforts to research, develop and promote voluntary GHG mitigation efforts in agriculture and food systems such as California's Healthy Soils Program,[218] the Carbon Cycle Institute,[219] the USDA Conservation Innovation Grant Program,[220] and a growing number of state and federal soil health policy initiatives;[221]
- State-led conservation incentive programs that utilize innovative financial support strategies such as revolving loan funds, double dividend fees, transferable tax credits, cover crop-crop insurance incentives and water allocation flexibility;[222]
- Corporate initiatives designed to reduce the carbon footprint of specific products and enhance supply chain resilience, such as those innovated by the members of Green America's Regenerative Supply Working Group,[223]Indigo Ag's Terraton Initiative, [224]and Applegate's Regenerative Agriculture Platform;[225] and
- Social impact investments designed to invest in agricultural businesses that use high mitigation agricultural conservation practices that improve soil health and enhance the ecosystem services of agricultural landscapes, such as Iroquois Valley Farmland.[226]

### Strategy 2: Improve manure management on farms

Background: North Carolina is the nation's second-largest pork-producing state, with about nine million pigs and 846 large farm operations (> 5,000 swine). [227] There are 2,794 permitted swine lagoons in the state as shown in Figure 3-10 on the following page.[228] Given the scale, structure, and location of the concentrated swine feeding industry in NC, this recommendation focuses on these operations.

[218] Healthy Soils Program. California Department of Agriculture. Retrieved from https://www.cdfa.ca.gov/oefi/healthysoils/
[219] Carbon Cycle Institute. Retrieved from https://www.carboncycle.org/
[220] USDA Conservation Innovation Grants. Retrieved from https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/cig/
[221] Eley, S., M. DeLonge, and R. Ferguson, "Policy Proposals to Build Soil Health and Combat Climate Change: A Federal and 50-State Landscape Analysis". Union of Concerned Scientists. Poster presented at the American Association of Geographers annual meeting, April 4. Retrieved from https://aag.secure-abstracts.com/AAG%20Annual%20Meeting%202019/abstracts-gallery/22912
[222] Innovative State-Led Efforts to Finance Agricultural Conservation. Environmental Defense Fund & National Association of State Departments of Agriculture. 2019. Retrieved from https://www.edf.org/sites/default/files/documents/innovative-state-led-efforts-finance-agricultural-conservation.pdf
[223] Regenerative Supply Working Group. Retrieved from https://www.greenamerica.org/centerforsustainability/regenerative-supply
[224] Terraton Initiative. Indigo Ag. Retrieved from https://terraton.indigoag.com/
[225] How Applegate is Developing its Regenerative Agriculture Platform Retrieved from https://www.hormelfoods.com/newsroom/company-news/how-applegate-is-developing-its-regenerative-agriculture-platform/
[226] Iroquois Valley Farmland. Retrieved from https://iroquoisvalley.com/
[227] 2017 and 2012 Census of Agriculture - Census Volume 1, Chapter 2: State Level Data, National Agricultural Statistics Service, United States Department of Agriculture. Retrieved on January 23, 2020 at https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_US_State_Level/
[228] Animal Feeding Operations Facility Map, NC DEQ. Retrieved on January 21 2020 at https://deq.nc.gov/about/divisions/water-resources/water-resources-permits/wastewater-branch/animal-feeding-operation-permits/animal-facility-map

**Figure 3-10: Location of Permitted Swine Farms in North Carolina**




The management of the manure is important due to its potential to release large amounts of methane ($CH_4$), which has a global warming potential 25-36 times higher than $CO_2$.[229] DEQ estimated historic GHG emissions from agricultural manure management systems as shown in Table 3-3.[230] Approximately 77% of the GHG emissions in 2017 were methane emissions from swine manure management in 2017.[231] This table also indicates that, in recent years, GHG emissions from all animals are growing at a slow pace while methane emissions from concentrated swine feeding operations are slightly decreasing. Based on this table and Table 2-2, methane emissions from swine manure management represent about 3% of the State's total GHG emissions.

**Table 3-3: Methane Emissions from Swine Manure Management in MMT $CO_2e$**

| Sector Emissions | 1990 | 2000 | 2010 | 2015 | 2017 |
|---|---|---|---|---|---|
| Swine - $CH_4$ | 1.328 | 4.451 | 4.567 | 4.668 | 4.632 |
| All Animals - GHGs | 2.586 | 5.603 | 5.723 | 5.902 | 6.050 |
| **Percent Swine $CH_4$** | **51%** | **79%** | **80%** | **79%** | **77%** |

Current Manure Management Strategies: Nearly all the existing swine farm operations in North Carolina utilize a "pull-plug" system that involves flushing manure and urine that collects in pits under the barns. The waste then moves into an open-air, manmade, storage pond or "lagoon." The lagoons, most of which are inground and may be lined or unlined based on their age, serve as receptacles for the storage and decomposition of manure.[232] The lagoons are designed for anaerobic treatment of manure, which produces biogas comprised of approximately 40% $CO_2$ and 60% methane. Because the lagoons are uncovered, the biogas is released to the atmosphere. The liquids that build up in the lagoon are sprayed on cropland, which serve to fertilize farm cropland and maintain the liquid level in the lagoon.

[229] For more information on global warming potential, see https://www.epa.gov/climateleadership/atmospheric-lifetime-and-global-warming-potential-defined
[230] DEQ. (January 2019). North Carolina Greenhouse Gas Inventory (1990-2030). North Carolina Division of Air Quality. Retrieved from https://deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory
[231] Note that this estimate does not account for reductions in emissions from new systems at 12 farms with methane capture and energy recovery.
[232] Older lagoons are generally unlined lagoons. Newer lagoons are required by NRCS to have clay-liners.

In addition to methane, the lagoon and spray-field systems pose other potential risks to surrounding communities as listed below:

- Potential inundation and breach of open lagoons during hurricanes and heavy rain events that results in contamination of downstream communities and waterways;
- Potential release of ammonia, nitrogen, phosphorous, metals (such as zinc and copper), and pathogens in organic byproducts and wastewater;
- Potential runoff of nutrients into the waterways, from over-application on spray-fields; and
- Potential emissions of nitrogen and ammonia that reduce local air quality and create objectionable odors.

The State currently operates a permit program for concentrated animal feeding operations to reduce the environmental risks of swine operations. The permits and requirements are listed below:

- General animal waste management permits;
- National Pollutant Discharge Elimination System (NPDES) permit;
- Siting requirements for application setbacks from property boundaries and perennial streams;
- Certified Animal Waste Management Plan (CAWMP) developed by a Certified Technical Specialist that addresses the land application of waste and requires accurate application records for all waste;
- Annual inspections of every facility; and
- Achievement of the environmental performance standards for all new and expanding swine farms.[233]

Alternative Manure Management Systems: As a result of a settlement agreement between the State and Smithfield Foods in 2000, NCSU was tasked with studying alternative manure management and treatment systems.[234] Five basic technologies were studied with various systems designs, and demonstration projects were conducted. Out of all the systems tested and installed on farms to date, the technology most employed at swine farms is anaerobic digestion with capture of the biogas produced and subsequent use of the biogas as either an on-farm or off-farm energy resource.

The use of gas as an energy source has three important advantages:

1. Potentially allows the farm to recover the costs of the management system;
2. Combustion converts the $CH_4$ generated by anaerobic manure management to $CO_2$, reducing the emissions' global warming potential by at least 25 times; and
3. Combustion of the methane displaces the combustion of fossil fuels for energy or electricity.

Add on technologies, such as aeration of the waste stream post-anaerobic digestion to remove ammonia emissions, can be coupled with the digesters to further treat the waste and byproducts, reducing their potential impact on the surrounding communities.

Incentives and Barriers: As discussed above, anaerobic digesters with biogas capture systems create economic opportunities for the farms while reducing GHG emissions. The methane can be used for energy several different ways, including:

- Produce energy or electricity for on-farm use,
- Produce and sell energy or electricity for off-farm use, and

[233] For more information on DEQ animal feeding operations rules and statutes see https://deq.nc.gov/about/divisions/water-resources/water-resources-regulations-guidance/animal-feeding-operations-rules.
[234] Retrieved from https://projects.ncsu.edu/cals/waste_mgt/smithfield_projects/smithfieldsite.htm

- Produce and sell renewable natural gas (RNG) for use in natural gas pipelines.

In addition, the gas or electricity can be used to meet government mandates and private mandates or goals for renewable energy which can also provide a revenue stream for the farms. Examples include:

- State and federal mandates for transportation fuel;
- Renewable Energy and Energy Efficiency Portfolio Standards (REPS); and
- Government and private entities purchase of carbon offsets.

North Carolina currently has incentives for electricity production by manure management systems via the REPS.[235] This law creates specific incentives to combust swine and poultry waste, or the biogas gas produced from the waste, for electricity generation. In recent years, several utilities, businesses, and organizations became interested in removing impurities in the biogas from manure management systems to produce renewable natural gas (RNG) so that it could be used in natural gas pipelines. The electric utilities can then meet their REPS swine waste requirement by using the RNG at specific combined cycle natural gas power plants. These plants are more efficient than on-farm electricity generators and greatly increase the electricity output per unit of biogas captured.

Despite the environmental and economic incentives for this management system, its implementation over the last 10 to 15 years has been extremely limited. There are nine swine operations, and one poultry operation receiving credits for electricity generation via since REPS became effective in 2007.[236]

A key barrier regarding the use of the gas to generate electricity and/or for use in natural gas pipelines is that such systems require infrastructure to 1) generate and transmit the electricity or 2) produce and transmit RNG to users. This may also require obtaining property rights for these transmission systems. The costs and regulatory policy barriers to access to these transmission systems are high, especially for areas where no infrastructure currently exists. The impacts to the rural community from these new systems must also be considered.

The RTI International, Duke University, and East Carolina University are conducting a study to determine the extent and location of available biogas resources in the state and the percentage of NC's GHG reductions that can be met with biogas. The analysis will include determining the climate, environmental, societal, and economic effects of the use of biogas and will recommend policy measures to accelerate biogas development, and the best uses for the gas (i.e., transportation fuel, RNG/pipeline, on-site energy generation). Implementation pathways for policy measures identifies in this study should address the benefits of biogas as well as environmental and societal impacts. Note the study includes all state RNG resources, including RNG capable of being produced from swine farms.

Another key barrier is that stakeholders have expressed concerns over air and water pollution from swine operations' use of biogas technology that rely on lagoons and sprayfield waste management systems. Pollution to waterways, odors, and public health concerns for nearby and downstream communities, including those felt disproportionately by minority populations, are the reasons for opposition to biogas production.

Description: Both the State and the NWL subcommittee members support improved manure management systems for swine farms that result in lower methane emissions and improved ecosystem and community resilience. All manure management systems have advantages and drawbacks. At this time, anaerobic digesters with methane capture coupled with the combustion of the methane either on-farm or off-farm for energy recovery is a near-term, cost-effective management system that will lead to substantial GHG emission

[235] For information on REPS, see https://www.ncuc.net/Reps/reps.html and https://programs.dsireusa.org/system/program/detail/2660.
[236] North Carolina Renewable Energy Tracking System (NC-RETS), North Carolina Utilities Commission. Retrieved from https://www.ncrets.org/.

reductions. It also allows additional add-on treatment systems to further reduce pollutants of concern to local communities.[237]

These biogas recovery systems are likely to be implemented at farms, given their current potential for near-term cost-recovery of installation costs. However, proper technical, financial and policy support is required to assist farmers with this more complex system. RTI International is currently tasked with studying the costs, impacts, resilience, and equity of large-scale implementation of off-farm use of RNG. Therefore, the NWL subcommittee members wait for the outcome of this study prior to recommending large-scale RNG off-farm use across the state.

In the long-term, alternative nonmethane generating manure management systems and add on technologies to further reduce pollutants should be explored and supported, both technically and financially, by the State and its university and impact partners. Management systems and add-on technologies that show potential for being cost-effective at reducing methane emissions and risks to nearby ecosystems and communities should be supported with 1) expedited demonstration projects, 2) access to capital, and 3) appropriate policy mechanisms.

*The discussion below is limited to the near-term goal of reducing methane emissions and improving resilience via installation of anaerobic digestors with biogas capture and energy recovery.*

Geographic scope: The recommendation applies statewide, with an initial emphasis on farms located in the floodplains of the Coastal Plain and Duplin, Sampson, Bladen, Wayne, Greene, and Johnston Counties due to large number of swine operations in those counties. About 67% of the waste lagoons are in these counties. Table 3-4 presents the number of swine waste lagoons in these counties.

**Table 3-4: Number of Swine Lagoons in Counties with Greater than 100 Lagoons**

| County | Number of Lagoons in Counties with > 100 Lagoons |
|---|---|
| Duplin | 800 |
| Sampson | 733 |
| Bladen | 250 |
| Wayne | 235 |
| Greene | 126 |
| Johnston | 124 |

Greenhouse Gas Impact: Swine and dairy manure offer approximately ~2 MMT $CO_2e$/year in GHG emission reductions.

Ecosystem Resilience: Supports ecosystem resilience through the prevention of water pollution by containing contaminants and reducing the risk of potential lagoon breaches during catastrophic flooding events.[238]

[237] These add-on treatments typically come at an additional cost and require dedicated focus and investment to advance them.
[238] American Jobs Project, NC Full Report at 45. Retrieved from http://americanjobsproject.us/wp-content/uploads/2016/04/NC-Full-report-update-4.13.pdf

Community Resilience: Supports community resilience with respect to future flooding events by reducing the risk of potential lagoon breaches during catastrophic flooding events and contamination of community water resources.[239, 240]

Economic and Health Benefits: Anaerobic systems that generate large amounts of methane and then capture and convert it to $CO_2$ provide potential economic opportunities for farms. Depending on the use of the biogas, the economic opportunities include:

- sale of organic byproducts from the management process;
- lower energy or electricity costs from on-farm use of the methane;
- sale of methane gas or the sale of electricity/energy produced by combusting methane;
- sale of the RNG as a renewable transportation fuel to meet state and federal mandates;
- sale of Renewable Energy Credits via North Carolina's Renewable Energy and Energy Efficiency Portfolio Standard (REPS);[241] and
- sale of carbon offsets to government and private entities to meet GHG reduction mandates or goals.

One study estimated that biogas development in North Carolina could generate an average of 2,200 jobs per year for the next 15 years.[242]

In addition, there are air quality, water quality, ecosystem health, and public health benefits.

Estimated Cost: Depending on the type of system employed, costs include the cost of retrofitting the lagoon (which would include covering the lagoon), installing a new in-ground digester, or building an above-ground digester system on existing lagoons or replacing the existing lagoons with above ground digester systems. There are additional costs associated with using the methane to produce electricity or energy on-farm and higher costs for off-farm RNG use. Cost estimates are currently being developed as part of a state-level biogas analysis recommended by the North Carolina Energy Policy Council, which not only should include the cost to develop RNG resources but also the cost and types of assistance (i.e., incentives, regulatory, legislative or otherwise) needed to achieve RNG's development potential. The analysis is expected to be released in July 2020.[243]

Actors and Participants:

- State – DA&CS (e.g., New Ag Markets Program, NC Division of Soil and Water Conservation), NCSU and NCA&T Cooperative Extension, and DEQ (permitting).
- Landowners and producers – Livestock, poultry and crop producers, specifically existing swine producers.
- Corporations and organizations with climate goals – Examples include Apple, Google, and Duke University, Duke Energy.
- Impact partners – NC Farm Bureau, NCCES- Agriculture & Food, USDA NRCS (NC Office and Headquarters), Duke University, NCSU, East Carolina University, NC Pork Council, American Biogas

[239] Ibid.
[240] There are other contaminants that may be released during flooding events, including human waste from municipal wastewater systems, septic systems, contaminated urban runoff, and industrial pollutants.
[241] For information on REPS, see https://www.ncuc.net/Reps/reps.html and https://programs.dsireusa.org/system/program/detail/2660
[242] North Carolina Jobs Project: A Guide to Creating Advanced Energy Job. American Jobs Project. Retrieved from http://americanjobsproject.us/wp-content/uploads/2016/04/NC-Full-report-update-4.13.pdf
[243] The draft NC Energy Policy Council's 2018 Biennial Report can be Retrieved from https://files.nc.gov/ncdeq/Energy%20Mineral%20and%20Land%20Resources/Energy/Energy%20Policy%20Council/DRAFT%202018%20EPC%20BiennialReport%20-%20For%20Review.pdf.

Council, Coalition for Renewable Natural Gas, BioCycle, USDA Renewable Energy for America Program, and EPA AgStar Program.

- Policymakers – NC Utilities Commission, NC Legislature, NC Energy Policy Council, Governor's Office.

### Road Map for Action:

*This road map only reflects the near-term goal of reducing methane emissions and improving resilience via installation of anaerobic digestors with biogas capture and energy recovery.*

The biggest pork producer in the state, Smithfield Foods, Inc., has committed to installing anaerobic digesters with methane capture as part of their corporate sustainability commitments. While there are strong financial incentives, there are also many barriers with respect to the deployment of on- and off-farm energy recovery. Issues include access to capital and easy and affordable access to electricity and natural gas pipeline transmission infrastructure. The hurdles to development often outweigh the incentives.

Duke University has produced a swine biogas analysis in 2013 that provides a roadmap for biogas development at the scale necessary to meet the North Carolina REPS swine waste-to-energy mandate.[244] Based on this report, a stepwise approach could include:

1. Provide technical and regulatory support for the installation of manure management systems that promote GHG reductions and community/ecosystem resilience, specifically anaerobic digesters and additional treatment to address pollutants other than methane.
2. Use the results of the RTI International study to determine the extent, location and development costs of available biogas/biomethane resources in the state to aid in determining appropriate policies and actions for biogas production;
3. Ensure community and equity issues related to electricity generation or natural gas production and their related transmission systems are addressed and mitigated.
4. Take steps to remove barriers imposed by utility systems and NCUC policies to facilitate electricity and RNG transport to end purchasers.
5. Identify barriers to additional treatment technology to address nutrients, odor, and pathogens and create dedicated funding mechanisms to enable farms to add any necessary technologies.
6. Establish technical support services for biomethane development, including turnkey farm-scale systems for local, on farm use, particularly for farmers/producers who own the waste resources but are not engaged in biomethane production as their primary source of income.

The required changes to policies discussed in No. 2 include;

- Require natural gas local distribution companies to accept and transport RNG,
- Include infrastructure costs in rate cases, and
- Allow and establish funding for cost-share payments, particularly for add-on technologies to control nutrients and other pollutants associated with waste management.

[244] Prasodjo, Vujic et al. 2013. A Spatial-Economic Optimization Study of Swine-Waste Derived Biogas Infrastructure Design in North Carolina,", Nicholas Institute for Environmental Policy Solutions Retrieved from https://nicholasinstitute.duke.edu/climate/spatial-economic-optimization-study-swine-waste-derived-biogas-infrastructure-design

Examples:

- The Loyd Ray Farms uses an anaerobic digester to produce and capture biogas. The biogas powers an on-farm 65-kilowatt microturbine. Liquid waste goes to an aeration system, reducing concentrations of ammonia and other pollutants. The resulting wastewater can then be used to flush the barns.[245]
- Optima KV aggregates and processes the biogas produced from the anaerobic digestion of swine waste from five farms. The resulting RNG is transported via pipeline to a Duke Energy combined cycle power plant for electricity production to meet its REPS requirement.[246]
- Currently, there is a 20-farm system seeking to get approval from the NCUC to inject RNG produced from the farms into a state-regulated pipeline.[247]

Table 3-5 presents the manure management systems located in North Carolina that report digester biogas end-use and reductions to the EPA AgStar Program.[248] There are nine systems mitigating approximately 0.2 MMT $CO_2e$ annually and producing 28,000 MWh of electricity and 110,000 cubic feet of biogas.

**Table 3-5: Manure Digester Systems in North Carolina Reporting to EPA AgStar Program**

| End Use of Methane | Biogas Generation Estimate (cu ft/day) | Electricity Generation (kWh/yr) | GHG Emission Reductions ($MTCO_2e$/yr) |
|---|---|---|---|
| Boiler/Furnace fuel | 28,000 | | 13,870 |
| Barham Farms Lagoon | 28,000 | | 2,441 |
| Murphy Brown LLC - Kenansville Farm | | | 11,430 |
| Electricity | 82,400 | 5,567,590 | 52,055 |
| Black Farms | | 341,000 | 5,961 |
| Butler Farms | 32,000 | 275,000 | 7,715 |
| Loyd Ray Farms | 50,400 | 483,990 | 8,579 |
| Storms Farm | | 4,467,600 | 29,800 |
| Electricity; Cogeneration | | 11,388,000 | 76,557 |
| RES Ag DM 2 - 1 LLC | | 4,380,000 | 43,044 |
| RES Ag DM 4 - 3 LLC | | 7,008,000 | 33,513 |
| Pipeline to Electricity | | 11,100,000 | 65,094 |
| Optima KV RNG Plant | | 11,100,000 | 65,094 |
| Grand Total | 110,400 | 28,055,590 | 207,576 |

* Cogeneration refers to the generation of both heat and electricity

[245] Swine Waste-to-Energy (Loyd Ray Farms) Retrieved from https://sustainability.duke.edu/offsets/projects/lrf.
[246] Optima-KV: North Carolina's First Swine Manure Renewable Natural Gas (RNG) Project. Retrieved from https://energy-vision.org/case-studies/Optima_KV_RNG_Profile.pdfhttps://energy-vision.org/case-studies/Optima_KV_RNG_Profile.pdf
247 Application Of Align RNG North Carolina, LLC, D/B/A Align Renewable Natural Gas to Participate in Pilot Program. Retrieved from https://starw1.ncuc.net/NCUC/PSC/DocketDetails.aspx?DocketId=72a6cea9-22da-40f7-a1c3-e4c9a9796222
[248] US EPA. Livestock Anaerobic Digester Database. Retrieved on January 31, 2020 from https://www.epa.gov/agstar/livestock-anaerobic-digester-database

## Strategy 3: Encourage food system efficiency through reduced food loss and waste

Introduction: Beyond the farm gate, actions taken to reduce food loss and waste (FLW) offer cost-effective GHG mitigation and climate resilience benefits. In the US, food is the second-largest source of landfilled material after paper, accounting for about 15% of municipal solid waste and representing approximately 35% of the edible food supply.[249] The USDA estimates the cost of FLW just to retailers and consumers each year to be over $161 billion.[250] In North Carolina, landfills contributed 5% of state gross GHG emissions in 2017.[251]

The actual GHG mitigation potential of various actions to improve the efficiency of food processing, distribution, consumption, and disposal are complex to estimate. Nonetheless, these actions are still recognized as highly cost-effective mitigation options that also generate environmental, social and economic benefits.[252,253,254] Increasing the energy and material efficiency of the food supply chain has the potential to simultaneously advance a number of GHG mitigation and community resilience objectives, including: improved food security and nutrition; improved energy efficiency; reduced costs of food processing, distribution, consumption, and disposal; enhanced natural resource conservation; and increased soil carbon sequestration in croplands and pasturelands.[255]

Description: Loss and waste occur in every step of the food supply chain;

- at the farm,
- within the logistical chain,
- during processing,
- at retail in the store or food service facility, and
- with the consumer.

Disposing of this food waste in landfills may contribute as much as 12% of GHG emissions from the food system. There are diverse opportunities for intervention at different points in the food system to reduce food loss and waste. Cost-effective interventions will depend on local conditions but will produce multiple sustainability and resilience benefits in addition to contributing to state mitigation goals.

To help galvanize national efforts to reduce FLW, the USDA, Environmental Protection Agency, and the Food and Drug Administration have collaborated to develop new programs designed to support actors across the food chain - farms, agricultural processors, food manufacturers, grocery stores, restaurants, universities, schools, and local governments – in an effort to:

- ***Reduce*** FLW by improving product development, storage, shopping/ordering, marketing, labeling, and cooking methods;
- ***Recover*** FLW by connecting potential food donors to hunger relief organizations such as food banks and pantries; and,

[249] EPA National Overview: Facts and Figures on Materials, Wastes and Recycling. 2017. Retrieved from https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials
[250] EPA Food Loss and Waste Fact Sheet 2019 Retrieved from https://www.epa.gov/sites/production/files/2019-12/documents/epafoodwaste_factsheet_dec2019-2.pdf
[251] DEQ. (2019, January). *North Carolina Greenhouse Gas Inventory (1990-2030)*, North Carolina Division of Air Quality. Retrieved from https://deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory
[252] USDA. 2013. Adapting to Climate Change, in Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Bulletin 1935. Retrieved from https://www.usda.gov/oce/climate_change/effects_2012/CC%20and%20Agriculture%20Report%20(02-04-2013)b.pdf.
[253] IPCC. 2019. IPCC Special Report: Climate Change and Land, Retrieved from https://www.ipcc.ch/srccl/
[254] Project Drawdown. 2018. Retrieved from https://www.drawdown.org/
[255] Why Does it Matter? Center for Food Loss and Waste Solutions. Retrieved from https://furtherwithfood.org/why-does-it-matter/#reduce-climate-change

- ***Recycle*** FLW to create compost, bioenergy, and natural fertilizers and for other reuse opportunities.[256]

North Carolina should utilize the work done by the federal government to develop a state-specific, cohesive approach to reduce FWL while also improving nutrition and access to food in low-income and vulnerable communities.

Geographic Scope: This recommendation applies statewide.

Estimated GHG Impact: While the complexities of estimating diverted GHG within each portion of the food system are challenging, the World Resources Institute has developed industry calculators that can help provide industry sector estimates.[257] Improving food system efficiency through reduction of loss and waste ranks high for GHG mitigation, adaptation, and food security co-benefits, according to the Intergovernmental Panel on Climate Change (IPCC).

Ecosystem Resilience: Composted post-consumer food waste creates a high-value product that can be marketed to urban and suburban consumer and landscape markets and farms near the compost facility. The addition of compost to urban and suburban soils and local farms can improve soil quality, which can increase water retention, reduce stormwater runoff, and reduce soil erosion and nutrient runoff. Compost--enhanced soils can also lower nitrogen and phosphorus input requirements and enhance soil carbon sequestration.

Community Resilience: In North Carolina, one in five children are considered food insecure, and obesity rates and diabetes are among the highest in the nation. Increasing efficiency of the food system through greater utilization of the food that has already been produced could improve these outcomes. Recently a study of food loss in North Carolina at the farm level on eight vegetable crops estimated that up to 42% of the crop that could have been consumed as the food was left unharvested in the field. By working with farmers, retailers, marketers, and nutritionists, strategies and incentives could stimulate a greater recovery of food that does not meet market or farm profitability metrics, but that could positively impact healthy food access and reduce food insecurity.

Economic and Health Benefits: Approaches to food recovery can be developed that provide economic opportunities for producers and other food system businesses. A significant economic benefit can also be realized by consumers that reduce food waste and so reduce their food expenditures by fully using the food they already purchase. Composting and wasted food conversion at multiple scale operations located close to points of generation offer multiple benefits to local communities.[258] The nonprofit consortium of Rethinking Food Waste Through Economics and Data (ReFED) has described the economic impact of solutions that reduce food waste. Out of 27 possible solutions, three create the most financial benefit. The three most beneficial solutions along with the estimated benefit per ton of food waste diverted are given below;

- consumer education campaigns with a benefit of $4,531/ton,
- standardized date labeling with a benefit of $4,547547, and
- packaging adjustments with a benefit of $3,443.

However, other solutions are also significantly beneficial as well. For example, an estimated 1,600 ancillary service jobs per million tons of processed compost will be needed if centralized composting was expanded in the state (ReFED, 2016).[259]

[256] EPA. 2019. Food Loss and Waste Fact Sheet. Retrieved from https://www.epa.gov/sites/production/files/2019-12/documents/epafoodwaste_factsheet_dec2019-2.pdf
[257] Greenhouse Gas Protocol. World Resources Institute & World Business on Sustainable Development. Retrieved from https://ghgprotocol.orghttps://ghgprotocol.org
[258] BioCycle. 2009. Investing in Integrated Organic Facilities. Retrieved from https://www.citysoil.org/fulford-biocycle-april2009.pdf
[259] Rethinking Food Waste Through Economics and Data, 2016. A Roadmap to Reduce U.S. Food Waste by 20 percent. Retrieved from https://www.refed.com/downloads/ReFED_Report_2016.pdf

Other benefits include improved air, soil and water quality; greater ecosystem biodiversity; and improved ecosystem health.

Estimated Cost: A cohort of six positions, one located at each of the various agencies listed below, designated to address food waste could focus statewide efforts to achieve the desired outcomes. The total cost would be approximately $600,000 per year, including benefits and travel support. Funding for positions could be redirected within the agencies listed, or new statewide funding could be provided. The Road Map for Action Step 4 discussed below, reducing food waste to landfills, would have associated costs of large-scale composting, collection, and distribution, which could vary greatly depending on the scope, but this action could significantly reduce GHG emissions. For example, supporting technologies, new facilities, and management practices for composting and bioconversion to animal feed can yield more than an 80% reduction in GHG losses from conventional composting processes.[260]

In contrast, practices that focus on processing waste materials to reduce emissions are among the highest cost mitigation options and produce few co-benefits.[261]

Actors and Participants:

- State agencies – Agencies including DA&CS, DEQ, NCCES Department of Health and Human Services (DHHS). DEQ's Division of Environmental Assistance and Customer Service has a organics composting education and business development.
- Academia – public and private universities, community colleges, and K-12 school systems. Many schools currently have compost programs that could be expanded to include FLW.
- Landowners and producers – Produce growers statewide
- Corporations – Many corporations, such as Compass Group USA (largest foodservice company in the world, based in Charlotte), have initiatives to reduce food waste and incorporate "ugly" or otherwise unmarketable produce.
- Impact partners – Many NGOs, including North Carolina's food banks and faith communities, agriculture organizations, health coalitions, and more, will value and contribute to this effort or already have ongoing initiatives.
- Policymakers – Reducing food loss and waste by increasing the efficiency of the food system is a nonpartisan issue and can improve the health and well-being of all North Carolinians, while providing economic opportunities, jobs, and business development.
- Consumers – Encouraging consumers to purchase what they will eat and education on food selection, handling, and preparation will help to reduce FLW.

Road Map for Action: Several steps have been identified to leverage the piecemeal strategies for reducing FLW currently used by NGOs, universities, businesses, agencies, etc., which all work independently to build a more organized and cohesive program. These steps include:

[260] A systemic approach for trade-off analysis of food loss reduction and greenhouse gas emissions, Working Paper no. 289. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security, 2019. Retrieved from https://cgspace.cgiar.org/bitstream/handle/10568/106247/http://WP289.pdf & Greenhouse gas balance for composting operations, Journal of Environmental Quality, 2008. Retrieved from https://pdfs.semanticscholar.org/54aa/08911a2751b02a5d53b156349df2ec8807e8.pdf

[261] EPA 2019. Food Loss and Waste Factsheet. Retrieved from, https://www.epa.gov/sites/production/files/2019-12/documents/epafoodwaste_factsheet_dec2019-2.pdf
Natural Climate Solutions, PNAS, 2017. Retrieved from https://www.pnas.org/content/114/44/11645;
Project Drawdown. 2018. Retrieved from https://www.drawdown.org/

1. Redirect existing staff or new hires within the DA&CS, DHHS, DEQ, and NCCES, NCSU and North Carolina Agricultural and Technical State University (NC A&T) to focus programming and education on mechanisms to reduce FLW.
2. Promote public-private partnerships to develop and deliver food waste reduction strategies.
3. Reduce on-farm food loss by working with the farming community to find solutions that enhance producer profitability and facilitates co-benefits of addressing food security and improving health outcomes. Examples include promoting field gleaning, tax credits provided to producers for donations, and financial support for farm to food bank initiatives.
4. Provide a mechanism to encourage reducing food waste in landfills, including food waste pickup (large generators and households) and the development of a large-scale composting network that includes existing and new compost facilities and end-users.
5. Facilitate food waste as animal feed, as appropriate, per EPA waste food management hierarchy recommendations, and prioritize animal feed conversion over composting. This strategy offers an easier regulatory pathway and produces greater GHG mitigation value.[262]
6. Develop a campaign to educate agriculture products markets and consumers on this issue to change perception and preferences.
7. Developing a multidisciplinary FWL team based within the agencies listed above can provide leadership and bring initiatives and stakeholders together for coordinated action informed by research and policy.

Examples:

- *Food Businesses:* A review of 1,200 business sites across 700 companies in 17 countries found that nearly every site evaluated achieved a positive return, with half seeing a 14-fold or greater return on investment.[263] DEQ's Division of Environmental Assistance and Customer Service has an organics composting education and business development program. This program could be expanded to address food loss and waste.
- *Households:* Between 2007 and 2012, the United Kingdom curbed household food waste by 21%, following a nationwide initiative led by the government, retailers, and the nonprofit organization WRAP. The UK is the only nation we could find with full financial cost-benefit data available. Findings show that for every £1 ($1.59 in 2012) invested in efforts to curb avoidable household food waste, households and local authorities saved £250 ($398 in 2012).[264]
- *Local Governments:* There are a variety of actions that can be taken, including: 1) an organic landfill ban, which has taken place in California, Connecticut, Massachusetts, Rhode Island, and Vermont, 2) a residential food waste collection program (used by over 300 US communities), 3) support for expansion of composting facilities and the upgrading of technology and management practices to reduce net energy use and GHG generated from the composting process. These activities value the waste as a feedstock for soil improvements in working lands, to increase carbon sequestration capacity, and to produce animal feed through industrial digestion, or bioconversion, energy through anaerobic digestion.

[262] Turning Food Waste into Animal Feed Could Take a Chunk out of Livestock Emissions, Horizon: The EU Research & Innovation Magazine, 2018. https://phys.org/news/2018-04-food-animal-chunk-livestock-emissions.html (2018-2019) Personal communications with DA&CS Joseph Hudyncia, NCDEQ DWM Donna Wilson, NCDEQ-DWR Christine Lawson and other DEQ personnel as participant in DEQ-DWM Composting regulatory review process & Fulford B. (2018, 2019) Personal communications with numerous active and prospective composters as NCDEQ-DEACS Organics Specialist, June 2018-May 2019.
[263] Retrieved from https://champions123.org/the-business-case-for-reducing-food-loss-and-waste/
[264] Retrieved from https://champions123.org/the-business-case-for-reducing-food-loss-and-waste/

- *Farm to Foodbank:* NCCES has a significant opportunity to increase farm to food bank donations by facilitating the relationships among growers, gardeners, food banks, food pantries, and donation recipients through successful programs that provide local meat or produce to food banks or food pantries.[265] This work can incorporate existing food recovery programs managed by private organizations in the state, such as Interfaith Food Shuttle.

# 4.0 Existing North Carolina NWL Plans and Resources

The plans and resources listed below represent the most recent action plans developed for the various land-use sectors in North Carolina. This list may not be inclusive of all plans or resources in the state.

2010 North Carolina Forest Action Plan[266]

The forest resource assessment and strategic plan constitute a coordinated plan for moving North Carolina forests into the future. The plan was developed to efficiently target efforts to address state and national priorities relating to forests. It is a broad vision for protecting and enhancing North Carolina forest values and benefits. The plan also addresses the public's desire for increased impact, accountability, and innovation from its state agencies. The plan was developed in 2010 using a stakeholder process that partnered with a committed group of NCFS staff, partners and sister agency personnel.

2015 North Carolina Wildlife Action Plan[267]

North Carolina's Wildlife Action Plan (NCWAP) is a comprehensive planning tool developed by the NCWRC to help conserve and enhance the state's full array of fish and wildlife species and their habitats. It was developed in cooperation with numerous partners, including federal and state agencies, conservation organizations, and stakeholders.

North Carolina Sentinel Landscapes[268]

The Sentinel Landscapes Partnership is a coalition of federal agencies, state and local governments, and nongovernmental organizations that work with private landowners to advance sustainable land management practices around military installations and ranges. The program began in 2013 and connects private landowners with voluntary assistance programs to sustain eastern North Carolina's landscape that supports three different and important sets of interests: working lands, conservation, and national defense.

In North Carolina, strategic partners include the US Marine Corps, US Department of Agriculture, NC Farm Bureau, NC State University, Texas A&M University, DA&CS, NC East Alliance, Environmental Defense Fund, NC State Grange, NC Forestry Association, NC DEQ, NC Foundation for Soil and Water Conservation, NC Association of Soil and Water Conservation Districts, and local soil and water conservation districts.

2019 Memorandum of Understanding for Shared Stewardship[269]

North Carolina federal, state, and private lands face a range of challenges, including increased population, catastrophic storms, droughts, flooding, fires, insect and disease outbreaks, invasive species, and lack of economic markets to drive investments inland management. Landowners and managers have similar goals including restoring fire-adapted communities and reducing wildfire risk, managing and reducing threats to forests and ecosystems, conserving working forestland. On September 25, 2019, the National Forests of North

[265] Farm to Food Bank Resource Guide for North Carolina Cooperative Extension. 2017. https://content.ces.ncsu.edu/farm-to-food-bank-resource-guide
[266] Retrieved from https://www.ncforestactionplan.com/
[267] Retrieved from https://www.ncwildlife.org/Plan
[268] Retrieved from https://sentinellandscapes.org/
[269] Retrieved from https://www.fs.fed.us/sites/default/files/NC-Shared-Stewardship-Agreement.pdf

Carolina entered into a Shared Stewardship Agreement with the DA&CS, NCFS, NCWRC, and USDA Natural Resources Conservation Service. The MOU establishes a framework for federal and state agencies to work collaboratively on accomplishing mutual goals and effectively respond to increasing ecological challenges and natural resource concerns in North Carolina.

2018 Farm Bill

The Agriculture Improvement Act of 2018 (i.e., 2018 Farm Bill) includes structural changes to existing USDA programs, which provide additional incentives to farmers and ranchers to implement practices that promote soil--health such as cover crops, no-till crop rotations, and nutrient management. It also enhances programs to support new, socially disadvantaged, and veteran farmers and ranchers with implementing soil health measures. Lastly, it requires data collection and reporting on soil health. Approximately $10 million a year in federal grant money is dedicated to soil health demonstration trials. These changes are expected to increase the number of acres managed with soil health and nutrient stewardship practices and to understand the impact of these practices. A review of the program was recently issued.[270] It found the 2018 Farm Bill had the potential to significantly improve the soil health of the US.

NC Coastal Community Resilience Guide[271]

This online interactive North Carolina Coastal Communities Resilience Guide is designed to walk users through some of the key steps and questions required for effective community-level resilience planning while pointing to relevant tools, resources, and examples. It outlines a process for building resilience and climate change considerations into existing efforts such as comprehensive land use, hazard mitigation, or capital improvement planning while also focusing on other co-beneficial strategies for reducing risk in your community.

Keeping North 'Carolina's Farms and Forests Vibrant and Resilient: An Adaptive Management Planning Strategy[272]

The mission of the plan mission was to explore the impacts of increasingly extreme weather events and changing climatic conditions on the agricultural and forestry sectors of North Carolina and determine whether producers were adequately prepared for what is coming. This report outlines NC-AdAPT's findings and recommendations and offers a roadmap for constructing an adaptive management plan to improve agriculture and forestry resilience and further enhance the economic viability of these sectors for decades to come.

Legislative Commission on Global Climate Change: final report to the General Assembly and the Environmental Review Commission[273]

The Legislative Commission on Global Climate Change (Commission) was established in S.L. 2005-442 to conduct an in-depth study of issues related to global climate change (completed in 2010). This effort also produced the Climate Action Plan Advisory Group Recommended Mitigation Options for Controlling Greenhouse Gas Emissions.

[270] Retrieved from https://sustainableagriculture.net/wp-content/uploads/2019/09/FINAL-DIGITAL-Impact-of-2018-Farm-Bill-Provisions-on-Soil-Health.pdf
[271] NC Coastal Community Resiliency Guide Online Tool, accessed on January 17, 2020 Retrieved from https://ncdenr.maps.arcgis.com/apps/MapSeries/index.html?appid=e2eb18546943471b93f0264659744a81
[272] Keeping North Carolina's Farms and Forests Vibrant and Resilient: An Adaptive Management Planning Strategy", North Carolina Agriculture and Forestry Adaptation Work Group, June 2015, Retrieved from https://www.sfldialogue.net/files/sfl_keeping_nc_f_f_resilient.pdf.
[273] Final Report to the General Assembly and the Environmental Review Commission. Legislative Commission on Global Climate Change. May 2010. Retrieved from http://www.climatechange.nc.gov/LCGCC_Final_Report_05-20-10.pdf

# 5.0 Acronym List

| Acronym | Title |
|---|---|
| ACR | American Carbon Registry |
| AFT | American Farmland Trust |
| APNEP | Albemarle-Pamlico National Estuary Partnership |
| APP | Albemarle-Pamlico Peninsula |
| AWC | Atlantic White Cedar |
| CDBG | Community Development Block Grant |
| $CH_4$ | methane |
| $CO_2$ | carbon dioxide |
| CWMTF | Clean Water Management Trust Fund (changed to North Carolina Land and Water Fund) |
| DA&CS | North Carolina Department of Agriculture and Consumer Services |
| DCM | Division of Coastal Management |
| DEQ | North Carolina Department of Environmental Quality |
| DHHS | Department of Health and Human Services |
| DMF | Division of Marine Fisheries |
| DMS | Division of Mitigation Services |
| DNCR | Department of Natural and Cultural Resources |
| DPR | Division of Parks and Recreation |
| FDP | Forest Development Program |
| FEMA | Federal Emergency Management Agency |
| FIA | Forest Inventory Analysis |
| FLW | food loss and waste |
| GHG | greenhouse gas |
| GS | General Statute |
| HUD | Housing and Urban Development |
| MT $CO_2e$ | metric tons of carbon dioxide equivalent emissions |
| MMT $CO_2e$ | million metric tons of carbon dioxide equivalent emissions |
| $N_2O$ | nitrous oxide |
| NCCES | NC Cooperative Extension Service |
| NCCF | North Carolina Coastal Federation |
| NCCRC | North Carolina Coastal Resources Commission |
| NCEM | North Carolina Emergency Management |
| NCEMC | North Carolina Environmental Management Commission |
| NCFS | North Carolina Forest Service |
| NCLWF | North Carolina Land and Water Fund (formerly Clean Water Management Trust Fund) |
| NCORR | North Carolina Office of Recovery and Resilience |
| NCSU | North Carolina State University |
| NCWRC | North Carolina Wildlife Resources Commission |
| NFIP | National Flood Insurance Program |
| NFWF | National Fish and Wildlife Foundation |

| Acronym | Title |
|---|---|
| NGO | non-governmental organization |
| NLCD | National Land Cover Database |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NOS | National Ocean Service |
| NPS | National Park Service |
| NRCS | Natural Resource Conservation Service |
| NWL | natural and working lands |
| PARTF | Parks and Recreation Trust Fund |
| ReFED | Rethinking Food Waste through Economics and Data |
| RNG | renewable natural gas |
| SAV | submerged aquatic vegetation |
| SLR | Sea level rise |
| SOC | soil organic carbon |
| TNC | The Nature Conservancy |
| ROI | return on investment |
| U&CF | Urban & Community Forestry |
| UNC | University of North Carolina |
| USACE | US Army Corps of Engineers |
| USDA | US Department of Agriculture |
| USFS | US Forest Service |
| USFWS | US Fish and Wildlife Service |
| UTC | urban tree canopy |
| WSW | water supply watershed |

# 6.0 Glossary

| Term | Definition |
|---|---|
| Anaerobic digestion | The decay of organic matter by bacteria in the absence of oxygen. |
| Biodiversity | A measure of variation at the genetic, species, and ecosystem levels. |
| Blue carbon | Carbon captured by the world's ocean and coastal ecosystems. |
| Buffer | An area between a managed and natural area. Specifically, buffers can limit environmental harm caused by the managed area. |
| Carbon flux | Amount of carbon exchanged between natural carbon pools annually, expressed as tons of carbon or tons of carbon dioxide equivalent ($CO_2e$) per year, such as carbon moving from the atmosphere into a growing tree. |
| Carbon offset | A reduction, avoidance, or sequestration in emissions of carbon dioxide or other greenhouse gases made in order to compensate for emissions made elsewhere, especially when quantified as part of a market program. Offsets are generally measured in metric tons of carbon dioxide equivalent ($CO_2e$) emissions. |
| Carbon offset market | A monetary structure that allows parties to buy, sell, and bank carbon offsets to comply with mandatory or voluntary greenhouse gas (GHG) reductions. The offsets are retired or surrendered when they are used for compliance. |
| Carbon sequestration | A process by which atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils. |
| Carbon storage | Long-term (+20 years) storage of carbon in terrestrial plants and soils, as well as coastal and ocean ecosystems. |
| Community resilience | The capacity of a community or business to prevent, withstand, respond to, and recover from a disruption. |
| Development lands | Land covered by a mix of constructed materials, impervious surface, and vegetation. |
| Easement | The right to cross over or use the property owned by another party or entity for a specified purpose. |
| Ecosystem resilience | The capacity of the natural environment to prevent, withstand, respond to, and recover from a disruption. |

| Term | Definition |
|---|---|
| Ecosystem services | Important benefits for human beings that arise from healthily functioning ecosystems, such as removal of pollutants from air and water. |
| Equity | Fair access to livelihood, education, and resources; full participation in the political and cultural life of the community; and self-determination in meeting fundamental needs. |
| Estuary | A partially enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea. |
| Fee simple acquisition | Purchase transferring full ownership of the property, including the underlying title, to another party. |
| Ghost forest | Areas of dead trees in former forests, typically in coastal regions where rising sea levels or sinking land have altered the height of a landmass relative to the ocean. |
| Greenhouse gas (GHG) | A gas that traps heat in the atmosphere by absorbing infrared radiation and contributes to the greenhouse effect, including carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). |
| Greenway | A strip of undeveloped land near an urban area, set aside for recreational use or environmental protection. |
| Heat island effect | Higher temperatures experienced by developed and urban areas compared to rural and undeveloped areas due to heating of manmade surfaces. |
| Mitigation | Processes that can reduce the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing them from the atmosphere. |
| Natural and working lands | Lands that are managed for natural purposes, to support food and fiber production, and for human communities. Examples include public and private forests, cropland, pastureland, grassland, wetlands, salt marsh, recreational areas, and “development lands”, which refer to natural and managed lands within urban and rural communities. |
| Natural resource co-benefit | Ancillary or additional benefits of Natural and Working Land carbon storage strategies such as improving water quality, creating nature-based recreational opportunities, storing floodwaters, and enhancing wildlife populations. |
| Peatland | A type of wetland formed by the accumulation of organic matter derived from plant material that decomposes slowly under anaerobic near-saturated conditions. |

| Term | Definition |
|---|---|
| Permeable | Having pores or openings that permit liquids or gases to pass through. |
| Pocosins | Peatland pocosins are saturated wetlands of Coastal Plain flats, swales, and Carolina bays, with organic matter accumulation, and with distinctive vegetation characterized by Pond Pine (*Pinus serotina*) and a suite of dense evergreen shrub species. These natural communities sequester and store a high volume of carbon per acre above and below ground. |
| Resilience | The capacity of individuals, a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption. |
| Riparian | The interface between land and a river or stream. |
| Saltwater intrusion | Movement of saline water into near-coastal freshwater aquifers or wetland soil that occurs in coastal aquifers, owing to the hydraulic connection between groundwater and seawater. |
| Soil organic carbon | Carbon associated with soil organic matter that is made up of decomposed plant and animal materials as well as microbial organisms. |
| Submerged aquatic vegetation (SAV) | Estuarine or marine habitat characterized by the presence of vascular plants that are rooted in the ground and remain under the surface of the water during all tidal stages, also referred to as seagrass or underwater grass. |
| Tree canopy | The layer of tree leaves, branches, and stems that provide tree coverage of the ground when viewed from above. |
| Vulnerable communities | Urban and rural populations that are threatened by extreme weather events, such as flooding and wildfire, or long-term ecosystem changes, such as saltwater intrusion or coastal erosion. |
| Watershed | Area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel. |

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# Appendix I
# Methods for Quantitative Estimates of Natural and Working Lands Potential

Many of the quantitative estimates of geographic scope, carbon potential, and co-benefits for the recommendations in the Natural and Working Lands action plan are derived from geospatial analysis conducted by the Nicholas Institute for Environmental Policy Solutions at Duke University. In general, this is an opportunities assessment focusing on all lands where a recommended action is possible given biophysical and ecological constraints. There is no consideration of social or economic constraints. Therefore, all of these estimates are expected to be significantly higher than what will be observed. **This assessment provides potential scale, not realistic estimates**. Methods used for this analysis are described below. Throughout the action plan, estimates that come from this analysis are flagged with footnotes pointing to this appendix.

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# 1.0 Definitions

These are all estimates of potential scale, not realistic estimates of what will happen on the ground.

**Geographic scope:** Total area in North Carolina where the on-the-ground action in the recommendation could be implemented. This is not an estimate of the actual on-the-ground impact of any recommendation, program, or policy; the amount of land where any recommendation is actually implemented is likely to be a small percentage of this geographic scope.

**Greenhouse gas impact:** Mean greenhouse gas impact of all of the land in North Carolina where the on-the-ground action in the recommendation could be implemented, in terms of the amount of carbon annually sequestered by the land or the amount of carbon currently stored by the land.

**Carbon sequestration:** Total amount of carbon annually sequestered by the land included in the geographic scope of the recommendation, metric tons $CO_2e$/acre/year. For protection recommendations, this represents the carbon annually sequestered by the land in its current state. For restoration recommendations, this represents the carbon that could be annually sequestered by the land following restoration.

**Carbon pool or carbon storage:** Total amount of carbon currently stored by the land included in the geographic scope of the recommendation, metric tons $CO_2e$/acre

**Ecosystem resilience:** Total area of overlap between the geographic scope of the recommendation and land scoring above 5 on the Biodiversity and Wildlife Habitat Assessment.

**Community resilience:** The amount of the geographic scope of the recommendation that contributes to community resilience. Recommendations can contribute to community resilience in several ways, such as by attenuating flooding in high-risk areas or by preserving water quality where many pollution sources exist.

**Active River Area:** Land that rivers and streams interact with frequently or occasionally that support processes that shape the river system. This is an alternative to the regulatory definition of floodplains that is more ecologically relevant. The idea and data used to represent the active river area comes from The Nature Conservancy.

# 2.0 Using Quantitative Estimates

It is important to note that there are often multiple actions that could be taken to increase carbon and resilience benefits on a given area of natural and working land in North Carolina. For example, a parcel of unprotected, privately-owned forested land in a water supply watershed could be used to implement several different recommendations, including protect and restore forests and wetlands (recommendation 5.1.1) and protect water supply watersheds (recommendation 5.4.1). The areas (geographic scope) for these recommendations overlap, so the acreages, greenhouse gas impacts, and other quantitative estimates for these recommendations also overlap. If you were to add the area (geographic scope) of all the recommendations together, the total would exceed the total area of NC.

# 3.0 Methods Used for Multiple NWL Recommendations

## Existing forests

Existing forests were extracted from a 30-meter land cover raster for North Carolina; evergreen forests, deciduous forests, mixed forests, and woody wetlands were considered forests (NLCD 2016).

## Reforestation opportunities

Reforestation opportunities in North Carolina were identified by combining information on land's ability to support forest cover (Fargione et al. 2018) with current land use information to exclude areas with incompatible land use. A national reforestation opportunities dataset provided by Fargione et al. includes a biophysical setting field indicating whether an area can support forest cover fully, partially, or not at all. Only land suitable for full reforestation was included (field BPS = 1). A recent land cover dataset for North Carolina was used to identify land that is not suitable for reforestation because it is already forested, or because it is being used for an incompatible purpose (development or wetlands). This unsuitable land was overlaid with the full reforestation layer, and only parts of the full reforestation layer that did not overlap with unsuitable land were included in the geographic scope for reforestation opportunity.

## Active river area

Active river area datasets for the Appalachian Landscape Conservation Cooperative and the Southeast Landscape Conservation Cooperative (Smith et al. 2008) were merged and clipped to the North Carolina boundary to cover the entire state. The active river area includes multiple components representing areas of land that contribute to key river processes; meander belts, riparian wetlands, floodplains, and terraces were included in the final active river area map for North Carolina as an ecologically relevant proxy for regulatory floodplains.

## Carbon storage in existing forests

Carbon stored by existing forests was estimated based on ecoregion, land cover, and protection status using information provided by Sleeter et al. from their work using a semi-spatial state-and-transition simulation model to estimate changes in total ecosystem carbon storage at a national scale (Sleeter et al. 2018). Land cover, ecoregion, and protection status data were combined to create a dataset identifying each unique combination of these three attributes. The resulting dataset was clipped to the extent of existing forests, identified by land cover (NLCD 2016); evergreen forest, deciduous forest, mixed forest, and woody wetlands were all considered forests. Carbon storage estimates from Sleeter were joined to the clipped dataset by matching unique combinations of ecoregion, land cover, and protection status.

## Carbon sequestration by existing forests

Carbon sequestration by existing forests was estimated based on forest type and age. A spatial forest age dataset for North America from 2006 was updated to reflect forest age in 2019; gaps in the dataset were filled by assigning all pixels missing forest age information to the geographically closest age class in the dataset. Forest type, based on US Forest Service (USFS) forest type categories, was extracted from a national reforestation opportunities dataset (Fargione et al. 2018). The forest type and age class datasets were combined to create a dataset identifying all combinations of forest type and age class in North Carolina; the resulting dataset was clipped to the extent of existing forests, identified by land cover (NLCD 2016); evergreen forest, deciduous forest, mixed forest, and woody wetlands were all considered forests. Average annual carbon sequestration for each forest type and age class in North Carolina was calculated using information in USFS yield tables (Smith et al. 2006). The carbon sequestration estimates

were joined to the clipped forest type/age class dataset by matching unique combinations of forest type and age class.

## Potential carbon sequestration from reforestation

Potential carbon sequestration from reforestation was estimated as the mean annual carbon sequestration for the first 20 years following reforestation, based on potential forest type (after Fargione et al. 2018). The potential forest type (USFS forest type categories) following reforestation was extracted from a national reforestation opportunities dataset provided by Fargione et al. Information from USFS yield tables (Smith et al. 2006) was used to calculate the mean annual carbon sequestration rate for the first 20 years of growth for each forest type in North Carolina. For forest types with a 20-year age class included in the yield tables, this is equal to the carbon storage in a 20-year-old forest divided by 20. For forest types without a 20-year age class included in the yield tables, this is equal to the average carbon storage for the two age classes bracketing 20 year (usually 15 and 25 years) divided by 20. The carbon sequestration rate information was joined to the spatial dataset of potential forest type by matching forest types.

## High flood risk watersheds

A 30-meter dasymetric population raster (EPA 2016) was clipped to only include populations in the active river area (Smith et al. 2008). Then, the number of people living in the active river area in each hydrologic unit code level 10 (HUC 10) watershed was calculated using zonal statistics. HUC 10 watersheds with at least 3,000 people in the active river area were considered high flood risk watersheds.

## Water quality hazard watersheds

Point source water quality hazards (swine lagoons, water treatment plants, and hazardous waste sites) in the active river area were identified (NC DEQ 2018, NC REDC 1997, North Carolina OneMap. 2020), and the total number of water quality hazards in the active river area of each hydrologic unit code level 10 (HUC 10) watershed was calculated using zonal statistics. HUC 10 watersheds with at least 10 point source water quality hazards in the active river area were considered water quality hazard watersheds.

## Ecosystem resilience areas

All areas scoring above 5 on the Biodiversity and Wildlife Habitat Assessment were considered ecosystem resilience areas. The BWHA rates each 30-meter pixel in North Carolina from 1-10 based on a variety input layers representing different conservation values.

# 4.0 Methods for Specific NWL Recommendations

## Protect and restore forests

### *a. Existing, unprotected forests*

#### Geographic scope:

To identify forests in unprotected areas, the *existing forests* map was overlaid with protected areas from PAD-US (USGS 2019). All forests that did not overlap with protected areas were considered unprotected.

***Geographic scope*** 15.3 million acres

***Carbon storage*** 5.6 billion metric tons $CO_2e$

***Carbon sequestration*** 27 million metric tons $CO_2e$/year

***Community resilience***

1.3 million acres in high flood risk watersheds

800,000 acres in water quality hazard watersheds

*Estimates used in NWL Action Plan section 5.1.1*

#### Carbon:

The *carbon storage in existing forests* map was clipped to the extent of existing, unprotected forests. The mean carbon pool for existing, unprotected forests was calculated as the mean of the clipped dataset, and the total carbon pool for existing, unprotected forests is the mean carbon pool multiplied by the total extent of existing, unprotected forests in North Carolina.

The *carbon sequestration by existing forests* map was clipped to the extent of existing, unprotected forests. Mean annual carbon accumulation for existing, unprotected forests was calculated as the mean of the final dataset, and the total annual carbon accumulation for existing, unprotected forests is the mean carbon accumulation multiplied by the total extent of existing, unprotected forests in North Carolina.

#### Community resilience:

Unprotected forests contributing to community resilience through attenuating flood risk were identified as a subset of the total geographic extent of unprotected forests in North Carolina. The *high flood risk watersheds* map was overlaid with the *active river area* and the unprotected forest layer; unprotected forests within the active river area in the high flood risk watersheds were counted as contributing to community resilience through flood risk. This method could also be used to estimate community resilience through attenuating flood risk for the floodplains and wetlands existing forest section (below).

Unprotected forests contributing to community resilience through reducing the effect of water quality hazards were identified as a subset of the total geographic extent of unprotected forests in North Carolina. The *water quality hazard watersheds* map was overlaid with the *active river area* and the unprotected forest layer; unprotected forests within the active river area in the water quality hazard watersheds were counted as contributing to community resilience through water quality. The number of people living in these areas was not included in this analysis since water quality issues can move downstream and affect people outside of the immediate area.

### *b. Reforestation*

#### Geographic scope (full):

The full geographic scope for reforestation in North Carolina is represented by the *reforestation opportunities* map.

### Geographic scope (limited):

Because much of the reforestation opportunity area is on agricultural lands that are unlikely to be removed from production, a smaller geographic scope for reforestation was calculated following methods from a national analysis of climate solutions for the United States, which assumed that only 1% of reforestable cropland and 7.6% of reforestable pastureland would be reforested. To calculate the geographic scope for reforestation in North Carolina following these assumptions, the land cover dataset was reclassified into three groups: cropland, pastureland, and all other classes. The reclassified land cover dataset was combined with the *reforestation opportunities* map to calculate the amount of reforestable land that fell into each current land cover category. The limited geographic scope for reforestation was calculated as the total area of reforestation opportunity in the "other" land cover category (which includes grassland, shrubland, and barren land), plus 1% of the area of reforestation opportunity in the cropland category, plus 7.6% of the area of reforestation opportunity in the pastureland category.

***Geographic scope (full)*** 5.1 million acres

***Geographic scope (limited)*** 1.1 million acres

***Carbon sequestration (full scope)*** 3.08 metric tons $CO_2$e/acre/year

***Carbon sequestration (limited scope)*** 3.4 million metric tons $CO_2$e/year

***Community resilience (full scope)***

390,000 acres in high flood risk watersheds

200,000 acres in water quality hazard watersheds

***Ecosystem resilience (full scope)*** 441,000 acres

*Estimates used in NWL Action Plan sections 5.1.1 and 5.2.2*

### Carbon

The *potential carbon sequestration from reforestation* map was clipped to the extent of the reforestation opportunity area. Mean annual carbon sequestration from reforestation was calculated as the mean of the final dataset. Total potential carbon sequestration from reforestation (full geographic scope) was calculated as the mean annual carbon sequestration multiplied by the total extent of reforestation opportunity. Total potential carbon sequestration from reforestation on the limited geographic scope was calculated as the mean annual carbon sequestration multiplied by the limited geographic scope extent.

### Community resilience

Reforestation opportunity areas contributing to community resilience through attenuating flood risk were identified as a subset of the full geographic scope of reforestation opportunity areas in North Carolina. The *high flood risk watersheds* were overlaid with the *active river area* and the *reforestation opportunity* map; reforestation opportunity areas within the active river area in the high flood risk watersheds were counted as contributing to community resilience through flood risk.

Reforestation opportunity areas contributing to community resilience through reducing the effect of water quality hazards were identified as a subset of the full geographic scope of reforestation opportunity areas in North Carolina. The *water quality hazard watersheds* were overlaid with the *active river area* and the *reforestation opportunity* map; reforestation opportunity areas within the active river area in the water quality hazard watersheds were counted as contributing to community resilience through water quality.

Neither of the community resilience estimates was done for the limited geographic scope for reforestation because the method for calculating the limited geographic scope is not spatially explicit. Therefore, there is no way to overlay the limited geographic scope with the other resilience-related maps (e.g., high flood risk watersheds, water quality hazard watersheds).

### Ecosystem resilience

Reforestation opportunity areas contributing to ecosystem resilience were identified as a subset of the full geographic scope of reforestation opportunity areas in North Carolina. The *ecosystem resilience areas* map was overlaid with the *reforestation opportunity areas*, and all reforestation opportunity areas that overlay the ecosystem resilience areas were counted as contributing to ecosystem resilience.

The ecosystem resilience estimate was not done for the limited geographic scope for reforestation because the method for calculating the limited geographic scope is not spatially explicit. Therefore, there is no way to overlay the limited geographic scope with the ecosystem resilience areas.

## Floodplains and wetlands

### *a. Existing forests*

#### Geographic scope

Forests in floodplains and wetlands were identified as a subset of existing forests in North Carolina. Floodplain and wetland areas were identified by merging the active river area dataset for North Carolina (Smith et al. 2008) with wetlands identified from the land cover dataset (NLCD 2016). The *existing forests* map was clipped to the extent of the floodplain and wetland areas layer.

***Geographic scope*** 6.3 million acres

***Carbon storage*** 2.1 billion metric tons $CO_2e$

***Carbon sequestration*** 10 million metric tons $CO_2e$/year

*Estimates used in NWL Action Plan section 5.3*

#### Carbon

The *carbon storage in existing forests* map was clipped to the extent of existing floodplain and wetland forests. Mean carbon pool for existing floodplain and wetland forests was calculated as the mean of the final dataset, and the total carbon pool for existing floodplain and wetland forests is the mean carbon pool multiplied by the total extent of existing floodplain and wetland forests in North Carolina.

The *carbon sequestration by existing forests* map was clipped to the extent of existing floodplain and wetland forests. Mean annual carbon accumulation for existing floodplain and wetland forests was calculated as the mean of the final dataset, and the total annual carbon accumulation for existing floodplain and wetland forests is the mean carbon accumulation multiplied by the total extent of existing floodplain and wetland forests in North Carolina.

### *b. Reforestation in floodplain and wetland areas*

#### Geographic scope

Floodplain and potential wetland areas were identified by merging the active river area dataset for North Carolina (a proxy for ecological floodplains; Smith et al. 2008) with areas of wetland restoration potential on agricultural lands from EnviroAtlas (EPA 2018). The *reforestation opportunities* map was clipped to this merged dataset to identify reforestation opportunities in floodplain and potential wetland areas.

***Geographic scope***

775,000 acres of reforestable wetland restoration opportunities

4.3 million acres of reforestation opportunities in active river area

***Carbon sequestration*** 1 million metric tons $CO_2e$/year

*Estimates used in NWL Action Plan section 5.3*

#### Carbon

The *potential carbon sequestration from reforestation* map was clipped to the extent of the reforestation opportunity in floodplains and wetlands. Mean annual carbon sequestration from reforestation in floodplain and wetland areas was calculated as the mean of the final dataset. Total potential carbon

sequestration from reforestation in floodplain and wetland areas was calculated as the mean annual carbon sequestration multiplied by the total extent of reforestation opportunity in floodplains and wetland areas.

### *c. Coordinated buyouts*

*Results from these methods are used in NWL Action Plan section 5.3.1.*

***Geographic scope*** 93,700 acres

***Carbon sequestration*** 1.88 metric tons $CO_2e$/acre/year

***Community resilience***

658 swine lagoons in the active river area

169,000 people living in the active river area in Census tracts with high historic flood damage

*Estimates used in NWL Action Plan section 5.3.1*

#### Geographic scope

The geographic scope of areas that might be suitable for coordinated buyouts was estimated by combining information on historic flood claims with information on developed land in flood-prone areas. First, the total number of National Flood Insurance Program claims in North Carolina was summarized by Census tract; Census tracts with at least 100 claims were considered high-risk for flood damage. Next, the 2016 NLCD was used to identify developed land, and overlaid with the active river area (Smith et al. 2008) to identify developed land in flood-prone areas. Finally, the developed land in flood-prone areas layer was clipped to the high-flood-risk Census tracts.

#### Carbon

The *potential carbon sequestration from reforestation* map was clipped to the extent of the coordinated buyout opportunity areas. Mean annual carbon sequestration for reforestation of coordinated buyout areas was calculated as the mean of the final dataset, and the total annual carbon sequestration for reforestation of coordinated buyout areas is the mean carbon sequestration multiplied by the total extent of reforestation of coordinated buyout areas in North Carolina.

#### Community resilience

The number of swine lagoons in the active river area was calculated by overlaying swine lagoons in North Carolina with the active river area dataset (NC DEQ 2018, Smith et al. 2008).

The number of people at risk of flooding was calculated as the number of people who live in flood-prone areas within Census tracts with high historic flood damage. People living in flood-prone areas were identified by overlaying a 30-meter dasymetric population raster in EnviroAtlas (EPA 2016) with the active river area dataset (Smith et al. 2008). The total number of National Flood Insurance Program claims in North Carolina was summarized by Census tract; Census tracts with at least 100 claims were considered to have high historic flood damage (FIMA 2019). The dataset of population within the active river area was clipped to only include areas within the high historic flood damage Census tracts, and the total population included in the final dataset was calculated.

## Urban lands

*Results from these methods are used in NWL Action Plan section 5.4.1.*

### *a. Existing urban forest*

***Geographic scope*** 385,000 acres

*Estimate used in NWL Action Plan section 5.4.1*

#### Geographic scope

The extent of unprotected urban forests was identified by overlaying municipal boundaries for municipalities with at least 5,000 people, the protected areas database, and *existing forests*.

Existing forests that were within municipal boundaries (of municipalities with at least 5,000 people) and that did not overlap with protected areas were included in the extent of unprotected urban forests.

## *b. Existing, unprotected forest in water supply watersheds*

***Geographic scope*** 2.7 million acres

***Carbon storage*** 336 metric tons $CO_2e$/acre

***Carbon sequestration*** 0.46 metric tons $CO_2e$/acre/year

*Estimates used in NWL Action Plan section 5.4.1*

### Geographic scope

The extent of unprotected forests in water supply watersheds was identified by overlaying water supply watersheds, the protected areas database, and the *existing forests* map. Existing forests that were within water supply watersheds and that did not overlap with protected areas were included in the extent of unprotected forests in water supply watersheds.

### Carbon

The *carbon storage in existing forests* map was clipped to the extent of unprotected forests in water supply watersheds. Mean carbon pool for unprotected forests in water supply watersheds was calculated as the mean of the final dataset, and the total carbon pool for unprotected forests in water supply watersheds is the mean carbon pool multiplied by the total extent of unprotected forests in water supply watersheds in North Carolina.

The *carbon sequestration by existing forests* map was clipped to the extent of unprotected forests in water supply watersheds. Mean annual carbon accumulation for unprotected forests in water supply watersheds was calculated as the mean of the final dataset, and the total annual carbon accumulation for unprotected forests in water supply watersheds is the mean carbon accumulation multiplied by the total extent of unprotected forests in water supply watersheds in North Carolina.

## *c. Reforestation in water supply watersheds*

***Geographic scope*** 1.2 million acres

***Carbon sequestration*** 3 metric tons $CO_2e$/acre/yr

*Estimates used in NWL Action Plan section 5.4.1*

### Geographic scope

The *reforestation opportunities* map was clipped to the extent of water supply watersheds in North Carolina.

### Carbon

The *potential carbon sequestration from reforestation* map was clipped to the extent of the reforestation opportunity in water supply watersheds dataset. Mean annual carbon sequestration from reforestation in water supply watersheds was calculated as the mean of the final dataset. Total potential carbon sequestration from reforestation in water supply watersheds was calculated as the mean annual carbon sequestration multiplied by the total extent of reforestation opportunity in water supply watersheds.

# Coastal habitats

## *a. Existing coastal habitats*

*Results from these methods are used in NWL Action Plan sections 4.2 and 5.6.*

### Geographic scope

The extent of salt marsh was obtained from the National Wetland Inventory (NWI); all salt/brackish marsh in the NWI (attribute field beginning with E2EM) was included. The extent of seagrass was obtained by combining the extent of aquatic beds from the National Wetland Inventory (attribute field beginning with E2AB or M2AB) with North Carolina-specific data from the Department of Marine Fisheries and the Albemarle-Pamlico National Estuary Partnership.

### Carbon

The carbon pool for salt marsh was estimated at 300.6 metric tons $CO_2e$/acre from a compilation of field measurements of carbon storage in salt marshes from the Atlantic coast, informed by expert opinion of the Natural and Working Lands coastal subgroup (C. Currin, personal communication). The carbon pool for seagrass was estimated at 106.15 metric tons $CO_2e$/acre from an international review of carbon storage in seagrasses (Siikamaki et al. 2013). To estimate the total carbon pool in salt marsh and seagrass, the per-area carbon pool for each habitat was multiplied by the extent of the habitat type.

Annual carbon accumulation for salt marsh was estimated at 1.1 metric tons $CO_2e$/acre/year from a compilation of field measurements of carbon storage in salt marshes from the Atlantic coast, informed by expert opinion of the Natural and Working Lands coastal subgroup (C. Currin, personal communication). Annual carbon accumulation for seagrass was estimated at 0.7 metric tons $CO_2e$/acre/year from an international review of carbon storage in seagrasses (Siikamaki et al. 2013). To estimate the total annual carbon accumulation by salt marsh and seagrass, the per-area carbon accumulation for each habitat was multiplied by the extent of the habitat type.

***Geographic scope***

Salt marsh: 228,000 acres

Seagrass: 100,000 acres

***Carbon storage***

Salt marsh: 61 million metric tons $CO_2e$

Seagrass: 18 million metric tons $CO_2e$

***Carbon sequestration***

Salt marsh: 250,000 metric tons $CO_2e$/year (1.1 metric tons/acre/year)

Seagrass: 140,000 metric tons $CO_2e$/year (0.7 metric tons/acre/year)

*Estimates used in NWL Action Plan sections 4.1 and 5.5*

### *b. Migration space*

#### Geographic scope

Migration space for four sea level rise scenarios (1.5, 3, 4, and 6.5 feet) was provided by The Nature Conservancy's Resilient Coastal Sites project and used to create a minimum migration space extent (including only the migration space for the 1.5-foot sea level rise scenario) and a maximum migration space extent (including migration space for all four sea level rise scenarios) (Anderson and Barnett 2019). To identify unprotected migration space, protected areas from PAD-US were overlaid on the two migration space extents. All migration space that did not overlap with protected areas was considered unprotected.

***Geographic scope***

187,000 acres (1.5-foot sea level rise)

528,000 acres (1.5-foot through 6.5-foot sea level rise)

***Community resilience***

314,000 people live within one kilometer of unprotected migration space

*Estimates used in NWL Action Plan section 5.5*

#### Community resilience

The number of people living within one kilometer of unprotected migration space was identified by creating a one-kilometer buffer around the unprotected migration space, then calculating the total population within that buffer area using a 30-meter dasymetric population raster created from 2010 Census data in EnviroAtlas (EPA 2018).

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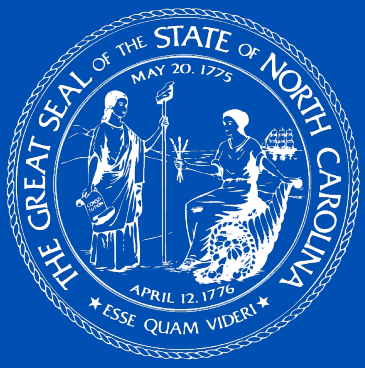


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