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Subtask 2.8: Nature-Based Solutions Gap Analysis

North Carolina Flood Resiliency Blueprint

Prepared for the North Carolina Department of Environmental Quality by AECOM, ESP Associates, and Insight

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Definitions

A comprehensive list of definitions applicable to multiple Flood Resiliency Blueprint documents is provided in a separate document.

Acronyms

ADFP – Agricultural Development and Farmland Preservation (Trust Fund)

AGOL – ArcGIS Online

CIR – color infrared imagery

CREP – Conservation Reserve Easement Program

CS – Consumer Services

DA – Department of Agriculture

DEM – digital elevation model

DFIRM – Digital Flood Insurance Rate Map

DHHS – Department of Health and Human Services

DMS – Division of Mitigation Services

DWR – North Carolina Division of Water Resources

EPA – U.S. Environmental Protection Agency

FEMA – Federal Emergency Management Agency

FIS – Flood Insurance Study

FRIS – Flood Risk Information System

GIS – geographic information system

GSI – Green stormwater infrastructure

H&H – Hydrology and Hydraulics

HEC-HMS – Hydrologic Engineering Center Hydrologic Modeling System

HMP – hazard mitigation planning

HUC – Hydrologic Unit Code

I – Interstate

LiDAR – light detection and ranging

LWI – Louisiana Watershed Initiative

MRLC – Multi-Resolution Land Characteristics

NBS – Nature-based Solutions

NC – North Carolina

NCDA&CS – North Carolina Department of Agriculture and Consumer Services

NCDEQ – North Carolina Department of Environmental Quality

NCDOT – North Carolina Department of Transportation

NCEM – North Carolina Emergency Management

NCFMP – North Carolina Floodplain Mapping Program

NC NHP – North Carolina Natural Heritage Program

NHM – National Hydrologic Model

NLCD – National Land Cover Database

NRCS – Natural Resource Conservation Service

NWI – National Wetland Inventory

NWM – National Water Model

NWS – National Weather Service

PNNL – Pacific Northwest National Laboratory

RIFT – Rapid Infrastructure Flood Tool

SWAT – Soil and Water Assessment Tool

TMDL – Total Maximum Daily Load

TRA – targeted resource area

US – United States

USDA – U.S. Department of Agriculture

USFWS – U.S. Fish and Wildlife Service

USGS – U.S. Geological Survey

1 Introduction

Purpose: Subtask 2.8 - Assess existing datasets and methods for identifying natural infrastructure and estimating their functions.

The purpose of this document is to identify and evaluate existing datasets for all or portions of North Carolina (NC) that are available to identify potential projects to reduce the effects of flooding using nature-based solutions (NBS) as part of the North Carolina Flood Resiliency Blueprint (Blueprint). Specifically, this document is intended to provide a Gap Analysis for NBS datasets and methods available in the state. Nature-based solutions are one component of a robust, well-planned flood resiliency strategy, along with more traditional components such as upgrading or adding additional infrastructure, buyouts, and dredging of waterways. Therefore, available datasets useful in identifying opportunities for NBS must be leveraged as a key element of this planning effort, and additional data needed should be identified.

There is a wide variety of datasets and tools that already exist that can be used for the Blueprint. This document is not intended to provide an exhaustive review of every potential dataset that could be used to support planning and implementing NBS for flood reduction. It does not include a review of datasets specifically related to non-NBS flood reductions. Although one of the key features of NBS is that these measures often provide benefits to the environment such as improving water quality, promoting groundwater recharge, and providing ecological benefits, while also reducing flooding, it is beyond the scope of this document to review datasets related to analyzing ancillary benefits to NBS flood reduction measures. This document will provide an overview of the key data sources identified and note gaps in the datasets pertaining to age, scale, level of detail, potential use, and other shortcomings. All studies and datasets described in this document are publicly available, and links to webpages are included.

2 Background on Nature-Based Solutions

Nature-based solutions is a term that is often used interchangeably with similar terms such as natural infrastructure, green infrastructure, etc. To date, there is not a consistent definition. For the Blueprint, we have chosen to use the Federal Emergency Management Agency (FEMA) definition published in a 2021 guide on implementing nature-based solutions. The guide defined NBS as follows:

> "Nature-based solutions are sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience. These solutions use natural features and processes to combat climate change, reduce flood risks, improve water quality, protect coastal property, restore and protect wetlands, stabilize shorelines, reduce urban heat, add recreational space, and more."

Nature-based solutions may offer a wide range of secondary benefits depending on the type of NBS, such as spurring economic growth, increasing property values, and creating recreation opportunities.

A variety of practices is included in the NBS toolbox. Some of the practices most geared toward reducing flooding include:

- Wetland restoration
- Floodplain restoration
- Forest conservation
- Conversion of agricultural lands to forest
- Retention of stormwater on parklands
- Retention of stormwater on agricultural lands
- Green stormwater infrastructure (GSI) such as bioretention or permeable pavement
- Coastal-specific practices such as living shorelines, coastal wetlands, and marshes, dunes, and waterfront parks.

The FEMA guide to NBS can be accessed at:

https://www.fema.gov/emergency-managers/risk-management/nature-based-solutions#:~:text=Nature%2Dbased%20solutions%20are%20sustainable,Reduce%20flood%20risk

3 Recent Research and Planning Initiatives involving NBS in North Carolina

Other countries and multiple states in the U.S. have already developed flood resiliency plans that include NBS as part of their strategies. Some examples of states planning for implementation of NBS to alleviate flooding include South Carolina, Texas, and Louisiana. Various organizations have analyzed one or more types of NBS in North Carolina, or developed datasets that can be useful for assessing opportunities for implementing NBS. Some of the more pertinent studies are briefly described below.

3.1 North Carolina State University Report for the Environmental Defense Fund

NC State University researchers performed a modeling study using the U.S. Army Corps of Engineers' Hydrologic Engineering Center's River Analysis System for the Environmental Defense Fund to assess the use of three types of NBS to reduce downstream flooding in two case study watersheds around Goldsboro, NC. The NBS analysis included floodplain restoration, reforestation, and flood storage on agricultural lands. The study's results indicated that, for the specific watersheds analyzed, reforestation provided more significant flood reduction than the storage scenario. The study also found that floodplain restoration resulted in reduced flooding, but that other measures (such as increasing culvert capacities) were also necessary to solve the specific flooding problem analyzed. This study does not provide useful datasets outside of the particular watersheds studied but provides an engineering study to evaluate the effectiveness of the three types of NBS. The report can be accessed here:

https://ncseagrant.ncsu.edu/wp-content/uploads/2020/06/Natural_Infrastructure_final_JAN_2020.pdf

3.2 North Carolina State University Research on Natural Infrastructure for Flood Abatement

In a larger effort related to the North Carolina State University study described above, NC State University researchers have evaluated the most appropriate types of NBS for flood reduction using farmland in eastern North Carolina. The research also analyzed the payment structure to farmers to make use of their land practical. The most promising types of NBS from this research included cover cropping/no-till farming, hardpan soil breakup, afforestation, agroforestry, stream and wetland restoration, earthen retention structures, dry dams and berms, and controlled tile drainage. Another aspect of the research is to identify factors that influence landowner willingness to participate. The research recommends creating a FloodWise program in North Carolina to pay farmers for the use of their land and implement the types of NBS practices described.

Journal articles and a Ph.D. dissertation on this research can be accessed at the following links:

https://www.mdpi.com/2071-1050/13/16/9309
https://www.sciencedirect.com/science/article/pii/S2772411522000088
https://repository.lib.ncsu.edu/bitstream/handle/1840.20/39448/etd.pdf?sequence=1

3.3 The Nature Conservancy and Center for Biodiversity Outcomes Peer-Reviewed Study on Hurricanes Matthew and Florence: Impacts and Opportunities to Improve Floodplain Management

This research was published in 2020 and focused on two significant hurricane events in North Carolina. The research included the development of a remote sensing technique to map the extent of hurricane-related flooding and identified opportunities to reduce impacts and increase resilience to future storms. Specifically, a geographic information system (GIS) raster dataset based on land use was developed for the flood-affected areas to identify options for buyouts of floodplain properties, forest conservation, wetland conservation, and other unprotected open space appropriate for restoration. There is also a map of potential opportunities for flood mitigation for the Piedmont and Coastal Plains of North Carolina. This research provides example methodologies that could inform the development of the Blueprint, including techniques to map hurricane flooding, and identify opportunities to use NBS to reduce the impacts of flooding. The website for this project and data downloads is available at:

https://knb.ecoinformatics.org/view/doi%3A10.5063%2FF1JM280P#urn%3Auuid%3Ad09236fd-6c6c-4a12-ae5e-9b54c0006dd4

The publication is freely accessible here:

https://pubs.acs.org/doi/full/10.1021/acs.est.9b07815

3.4 NC Division of Mitigation Services Targeted Resource Areas

The North Carolina Department of Environmental Quality's (NCDEQ's) Division of Mitigation Services (DMS) is responsible for providing compensatory mitigation for impacts to streams, wetlands, and riparian buffers. DMS uses a watershed planning approach to identify the best opportunities to implement stream, wetland, and buffer restoration. Portions of each watershed are designated as targeted resource areas for water quality, habitat, and hydrology. These geographic areas represent the preferred locations to implement restoration projects to improve one or more of those three functions. The targeted resource areas (TRAs) are developed based on watershed modeling and planning. Currently, the TRAs have not been developed for the entire state, only for certain river basins. The TRA data are not publicly available but could be obtained from DMS. Eventually, DMS will be able to provide a statewide data set of the TRAs. The hydrology TRAs could be used to help prioritize locations to implement NBS specifically to improve natural hydrologic conditions such as functioning wetlands and floodplains.

3.5 Duke University Project on Conservation Planning Tools for North Carolina

To support conservation groups working in North Carolina, The Nicholas Institute at Duke University, working with the Conservation Trust for North Carolina, developed two online tools to prioritize areas for conservation activities and estimate the benefits of specific properties. The conservation prioritization tool allows users to quickly identify sub-watersheds in the state based on one or more user-selected metrics. Ten available conservation metrics can be used with this tool, including Demand for Downstream Flood Attenuation. Therefore, the tool may be useful for the Blueprint

because it can be used to prioritize areas in need of flood attenuation where NBS (or other types) projects would be most beneficial. This can be done with or without considering other conservation priorities. The other tool developed for this project is called the benefits calculator tool. This tool estimates the benefits of conservation activities for the user-defined areas analyzed. The benefits calculator tool does not include the metric Demand for Downstream Flood Attenuation, which is only mapped at a watershed scale rather than a smaller user-defined area. The website for this project is located here:

https://storymaps.arcgis.com/stories/6ac20916c67b4164901b50ac3e640d6a

3.6 Cape Fear Regional Watershed Plan

The consulting engineering firm VHB supported DMS in developing the Cape Fear Regional Watershed Plan. Development of this large-scale watershed plan involved assessing current conditions in the study area and identifying potential watershed improvement projects such as stream and floodplain restoration. The assessments and modeling for the project were done at the catchment scale using US Geological Survey (USGS) catchments. One portion of this planning study focused on the potential for improvements to hydrology for each catchment. Several datasets were used to rate each catchment for this metric, including hydrology model results, land use, and stream and wetland restoration potential. All datasets used in the planning study are available from NCDEQ's Open Data Portal. This watershed planning study and associated data sets could be useful for Blueprint efforts by prioritizing certain types of NBS projects for the planning study area, especially floodplain restoration. The webpage for this project is located here:

https://deq.nc.gov/media/30983/download?attachment

3.7 USGS SWAT Models of Cape Fear and Pee-Dee River Basins

The USGS recently produced Soil and Water Assessment Tool (SWAT) models of the Cape Fear and Pee Dee River Basins to analyze future streamflow and irrigation withdrawals considering future climate and future urban growth scenarios. Different future scenarios were modeled to predict streamflows under different land use scenarios and different climatic conditions. These models can be used to predict future streamflows for thousands of small watersheds in the river basins. The reports for these studies, the modeling files, and related information are available from the USGS Science-Base Catalog at the following link:

https://www.sciencebase.gov/catalog/item/5bcf30d9e4b0b3fc5cde1246

Links to individual reports for basin models are also available from this webpage. An additional study using a modified version of the Cape Fear River Basin model was completed to analyze water quality under potential extreme weather conditions, and locations of potential interventions to improve water quality in a changing climate. This report can be accessed at the following link:

https://essopenarchive.org/doi/full/10.1002/essoar.10512303.2

3.8 Nature Conservancy Coastal Resilience

The Nature Conservancy leads the Coastal Resilience Program to assess the use of nature-based solutions such as living shorelines to reduce coastal flooding risk. A major goal of the program is to determine when and where NBS can help protect coastlines. The program includes a toolkit, which is

a large suite of web-based applications that provide information to stakeholders and communities. These web apps are mapping tools that can be accessed here:

https://coastalresilience.org/tools/apps/

The North Carolina mapping tool displays information for areas of coastal North Carolina, including projected future sea level rise, flooding extents for large storms, and coastal areas suitable for implementation of different types of living shorelines. The North Carolina mapping tool can be accessed here:

https://maps.coastalresilience.org/northcarolina/

3.9 NC Coastal Federation Nature-Based Stormwater Strategies to Reduce Flooding and Improve Water Quality

The North Carolina Coastal Federation has developed an action plan for NBS stormwater management for new development, stormwater control measure retrofits, and working lands (farms, timber tracts, etc.). The goal of the strategy is to reduce flooding and stormwater runoff. This is a planning document that outlines broad recommendations to promote NBS implementation and identifies critical first steps to achieve the recommendations. The plan also identifies impediments to increasing the use of NBS for these purposes. This is expected to be an initial step in an on-going process. The website for this study can be accessed here:

https://www.nccoast.org/project/nbss/#:~:text=The%20Action%20Plan%20for%20Nature,new%20development%2C%20stormwater%20retrofits%2C%20roadways

3.10 North Carolina Watershed Restoration Plans

The NCDEQ 319 Grant Program provides funding obtained from the U.S. Environmental Protection Agency (EPA) for watershed restoration plans throughout the state. The money can be used to fund watershed restoration projects such as stormwater and agricultural best management practices and restoration of impaired streams. Watershed plans developed under the 319 programs must follow the U.S. EPA guidance on nine key elements that must be included in watershed plans. These plans are intended to document current watershed conditions, guide restoration efforts and improve water quality in these watersheds, and set goals for success. Many 319 watershed plans have been implemented in river basins across the state. The documents can be downloaded from NCDEQ at the following link:

https://www.deq.nc.gov/about/divisions/water-resources/water-planning/nonpoint-source-planning/319-grant-program/nc-watershed-restoration-plans

4 Federal Agency Datasets

4.1 USGS Study on Geomorphological Features of North Carolina

A study published in 2018 by the USGS includes raster datasets of "positive openness," for all 53 8-digit hydrologic units in North Carolina. Positive openness is a measure of how open a landform is using light detection and ranging (LiDAR). According to the project website, positive openness is determined by measuring eight zenith angles viewed from above the landscape surface out to a specified distance. A measure of 90 degrees indicates a flat surface, and less than 90 degrees would be concave. These data can be used to analyze large land areas for different types of landscape features. A related raster dataset of the ten most common geomorphic landscapes in North Carolina is also available. Both datasets can be helpful in identifying floodplains and streams throughout the state. The data can also determine where streams are incised and are good candidates for floodplain restoration. There are two websites for this project, and downloads of the raster datasets. Details of the USGS data are provided below in Table 1.

Table 1: Data Inventory of Geomorphological Features

Data Description	
Source of Information	US Geological Survey
Link to Online Data	https://www.sciencebase.gov/catalog/item/5b72fcf1e4b0f5d5787c5830 https://www.sciencebase.gov/catalog/item/5b72ee50e4b0f5d5787c5720
Date Created	October 2018
Date of Access	March 2023
Most Recent Update	October 2018
Update Needed?	No
GIS Data Format	Raster

Gap Analysis Criteria Description	
Age	The data are relatively recent.
Scale	The data coverage is statewide.
Level of Detail	The spatial resolution of this dataset is three meters.

Identified Gaps	
Age	The data are relatively recent at this point. However, it does not appear that updates for this project are planned. Over time, these data will become less dependable because geomorphic features change over time but will still be useful.

Identified Gaps	
Scale	The data are available statewide with no known gaps.
Level of Detail	The level of detail is high with no specific gaps identified.

4.2 U.S. Fish and Wildlife Service National Wetlands Inventory

The U.S. Fish and Wildlife Service (USFWS) provides geospatial data on wetlands at a national scale. Two related datasets are available, including the wetlands geospatial dataset (wetlands mapper) and wetlands status and trends reports. The online wetlands mapper can display the spatial extent, location, and type of wetland for areas of the United States identified by the user. "Areas of Interest" or wetlands of special ecological significance are also included in the dataset. The geospatial dataset integrates National Wetland Inventory (NWI) data by different classifications of wetlands, with additional natural resource data to create a decision-support planning tool. The Wetlands Mapper allows wetlands data to be downloaded at the state and eight-digit hydrologic unit scales. The NWI data can also be streamed through ArcGIS Online (AGOL) and downloaded. The Status and Trends Report tracks changes in wetland area by wetland type. These data can be used to identify where different types of wetlands exist and could be preserved or enhanced for NBS projects. These data are discussed below in Table 2.

Table 2: Data Inventory of Geospatial Data on Wetlands

Data Description	
Source of Information	U.S. Fish and Wildlife Service
Link to Online Data	https://www.arcgis.com/home/item.html?id=050d4dd33df7462db3ea3b76c1320462
Date Created	Unknown
Date of Access	March 2023
Most Recent Update	April 2022
Update Needed?	No
GIS Data Format	Image service layer (raster), feature service layer

Gap Analysis Criteria Description	
Age	The data are recent. The national dataset is updated biannually. However, the North Carolina portion of the dataset appears to be based on older data that have not been updated since the 1980s.
Scale	The data coverage is statewide.
Level of Detail	The spatial resolution of this dataset is 10 meters.

Identified Gaps	
Age	This national dataset is continually maintained by the USFWS; however, the North Carolina portion of the database has not been updated since the 1980s and should be used with caution.
Scale	The data are available statewide with no known gaps.
Level of Detail	The level of detail is high; however, the precision is limited due to the nationwide coverage of the dataset. Practitioners often use other datasets such as soils in conjunction with or instead of the NWI data when identifying wetland areas.

4.3 USDA Soils

The Natural Resource Conservation Service (NRCS), under the U.S. Department of Agriculture (USDA), curates' data on soils nationwide as the Soil Survey Geographic Database. A soils GIS layer is available through ESRI's Living Atlas that covers soil series across the entire U.S., including hundreds of soil attributes. A separate layer, for hydric soils only, is also available. These data also include farmland class to identify high-quality agricultural soils as prime farmland. These GIS data can be streamed through AGOL or can be downloaded by eight-digit hydrologic units. The data are updated inconsistently, and data for portions of the state may be older than for other areas. These data would be useful in identifying areas of hydric soils where wetland restoration projects could be implemented, or where wetland currently exist, and are described in Table 3. The Web Soil Survey is an online tool for viewing soils data that is available through USDA at:

https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Table 3: Data Inventory of Soil Quality

Data Description	
Source of Information	US Natural Resource Conservation Service
Link to Online Data	https://www.arcgis.com/home/item.html?id=2be45af986af4624839cedae883faf47
Date Created	Unknown
Date of Access	March 2023
Most Recent Update	December 2021
Update Needed?	No
GIS Data Format	Image service layer (raster)

Gap Analysis Criteria Description	
Age	The data are recent and are maintained by NRCS. The data are updated in selected areas annually.

Gap Analysis Criteria Description	
Scale	The data coverage is statewide.
Level of Detail	The spatial resolution of this dataset is 30 meters.

Identified Gaps	
Age	This dataset is continually maintained by the NRCS, so the data are current.
Scale	The entire state is covered with an equal level of detail.
Level of Detail	The level of detail is good for a national database and is useful for a planning level of analysis. However, for specific project assessment, fieldwork would be necessary to determine soil series.

4.4 EPA EnviroAtlas – Potentially Restorable Wetlands on Agricultural Land

The EPA maintains a suite of online decision support tools to help decision makers use ecosystem goods and services. This tool set, called EnviroAtlas, includes online mapping of a large number of natural resources and related geospatial data at the national scale. One of the geospatial datasets mapped by EnviroAtlas is potentially restorable wetlands on agricultural lands, shown as polygons of areas at 30-meter resolution, as identified in Table 4. Potentially restorable wetlands are "lands currently in agriculture that naturally accumulate water and historically had poor drainage and hydric soils." The online map includes a rating of the potential for restoration (low, moderate, or high). The wetland areas on the map were generated from 2011 NLCD data (described below). Most of the restorable wetland areas in North Carolina are east of the Interstate (I)-95 corridor. This online tool can be used along with other datasets to identify potential wetland restoration sites.

Table 4: Data Inventory of Restorable Wetlands

Data Description	
Source of Information	US Environmental Protection Agency
Link to Online Data	https://enviroatlas.epa.gov/enviroatlas/interactivemap/?eaLayer=eaLyrNum_257
Date Created	Unknown
Date of Access	September 2023
Most Recent Update	2017
Update Needed?	No
GIS Data Format	Image service layer (Raster)

Gap Analysis Criteria Description	
Age	Unknown. Data are developed from other existing government datasets.
Scale	The data coverage is nationwide.
Level of Detail	The spatial resolution of this dataset is 30 meters.

Identified Gaps	
Age	The data do not appear to be updated regularly. Other federal government datasets are used to develop these data. These data sets would need updating first, and then a rebuilding of the map would be required. However, these data cover rural areas where development is limited, and land cover change occurs slowly.
Scale	The entire state is covered with an equal level of detail.
Level of Detail	The level detail of this dataset is extremely high. It is commonly used for planning--level analysis.

4.5 National Land Cover Database

The Multi-Resolution Land Characteristics (MRLC) consortium is a group of federal agencies including the USGS, National Oceanic and Atmospheric Administration, US Forest Service, and others that coordinate to generate a land cover database at the national scale. This database, called the National Land Cover Database (NLCD), is available to download through the USGS and includes 28 different datasets that show land cover and land cover change. The database includes geographic information on various landcover types, including developed land, forested land, cultivated land, and wetlands. The database can also be viewed on the MRLC website. It can be streamed through ArcGIS online. There are many uses for this dataset, including identifying various types of nature-based projects such areas for reforestation, forest conservation, etc., as detailed below in Table 5.

Table 5: Data Inventory of Land Coverage

Data Description	
Source of Information	US Geological Survey
Link to Online Data	https://www.usgs.gov/centers/eros/science/national-land-cover-database
Date Created	Unknown
Date of Access	September 2023
Most Recent Update	2021
Update Needed?	No
GIS Data Format	Image service layer (Raster)

Gap Analysis Criteria Description	
Age	Data are updated every 3 to 5 years.
Scale	The data coverage is statewide.
Level of Detail	The spatial resolution of this dataset is 30 meters.

Identified Gaps	
Age	The data are updated regularly and therefore are recent.
Scale	The entire state is covered with an equal level of detail.
Level of Detail	The level detail of this dataset is extremely high. It is commonly used for planning-level analysis.

4.6 USGS GAP/LANDFIRE National Terrestrial Ecosystems

The USGS developed an inventory of terrestrial ecosystems that is available for download, as presented in Table 6. These data display U.S. National Vegetation Classification at various different scales, including state-level coverage. Dominant vegetation community type is mapped for the entire US. These data can be used to help determine the type of wetland and dominant type of vegetation in potential wetland restoration areas. At the time of review, the webmap features were not operational.

Table 6: Data Inventory of Terrestrial Ecosystems

Data Description	
Source of Information	US Geological Survey
Link to Online Data	https://www.usgs.gov/programs/gap-analysis-project/science/land-cover-data-download
Date Created	2011
Date of Access	September 2023
Most Recent Update	2011
Update Needed?	Yes. Data have not been updated since 2011.
GIS Data Format	Image service layer (Raster)

Gap Analysis Criteria Description	
Age	This dataset was developed in 2011 and is not regularly updated.
Scale	The data coverage is nationwide.

Level of Detail	The spatial resolution of this dataset is 30 meters.

Identified Gaps	
Age	The data do not appear to be updated regularly. Moving forward, age of the datasets will become a consideration.
Scale	The entire state is covered with an equal level of detail.
Level of Detail	The level of detail of this dataset is extremely high. It is commonly used for planning-level analysis.

4.7 USDA NRCS Conservation Easements

All NRCS conservation easements across the U.S. are included in a GIS dataset, as identified in Table 7. These data show where legally binding conservation easements exist on farmland. The easements prevent further development of agricultural lands to protect the ecology and rural character of the land. Many of these easements include restoration of degraded ecosystems and wetlands (Wetland Reserve Enhancement Partnership and Wetlands Reserve Easements). This information can be used to determine where agricultural conservation and preservation projects exist so that future projects can be planned where they can be linked with existing conservation lands to maximize benefits for flood reduction and other ecosystem services.

Table 7: Data Inventory of NRCS Conservation Easements

Data Description	
Source of Information	USDA Natural Resources Conservation Service
Link to Online Data	https://www.farmers.gov/data/easements-download
Date Created	2000
Date of Access	September 2023
Most Recent Update	2023. The most recent easement in North Carolina is dated 2017.
Update Needed?	This dataset is updated and maintained, but recent North Carolina easements may not have been added.
GIS Data Format	Point and polygon layer.

Gap Analysis Criteria Description	
Age	This dataset contains easements dating back to 2000, and is continually updated, although the frequency of updates is not known. The North Carolina data do not appear to have been updated recently.
Scale	The data coverage is nationwide.

Level of Detail	Newer easement location and extents are based on surveys, and older easements are digitized information.

Identified Gaps	
Age	The North Carolina data need to be updated for any easements newer than 2017.
Scale	The entire state is covered with an equal level of detail.
Level of Detail	The level of detail of this dataset is extremely high. All NRCS easements are or will be included, and locations and extents are highly accurate.

4.8 The USDA Farm Service Agency (FSA) Prior Converted Cropland Dataset

The FSA, in coordination with the Natural Resources Conservation Service (NRCS), maintain a dataset of prior converted cropland (also called farmable wetlands). "Prior converted cropland" is defined by the SCS (Section 512.15 of the National Food Security Act Manual, August 1988) as wetlands which were both manipulated (drained or otherwise physically altered to remove excess water from the land) and cropped before 23 December 1985, to the extent that they no longer exhibit important wetland values. Specifically, prior converted cropland is inundated for no more than 14 consecutive days during the growing season. The dataset is not publicly available, which resulted in a lack of specific details in this section, however, this data is available on commercial farm management software. This data can be used to identify where wetland restoration opportunities that can be funded through the federal farm bill are located.

Table 8 Data Inventory of FSA's Prior Converted Cropland Dataset

Data Description	
Source of Information	USDA Farm Service Agency
Link to Online Data	Data available upon request https://crsreports.congress.gov/product/pdf/IF/IF11136/10 https://www.nrcs.usda.gov/farmed-wetland-hydrology-indicators https://www.fsa.usda.gov/programs-and-services/conservation-programs/farmable-wetlands/index https://www.fsa.usda.gov/Internet/FSA_File/wetland_det_symbols.pdf
Date Created	Not Available
Date of Access	October 2023
Most Recent Update	Not Available
Update Needed?	Not Available

GIS Data Format	Not Available

Gap Analysis Criteria Description	
Age	Not Available
Scale	Not Available
Level of Detail	Not Available

Identified Gaps	
Age	Not Available
Scale	Not Available
Level of Detail	Not Available

5 State Agency Datasets

5.1 NC Office of Recovery and Resiliency Climate Resilience Data Website

The North Carolina Office of Recovery and Resiliency maintains a website with links to various datasets related to weather, climate, and flooding. Many of these datasets are directly applicable to planning for NBS-oriented flood reductions. Descriptions and gap analysis for these specific datasets are included in this document. However, other datasets linked from this webpage may be useful in certain circumstances or for specific purposes. The dataset links can be accessed from this webpage:

https://www.rebuild.nc.gov/resiliency/climate-data

5.2 Forest Land Cover

The North Carolina Department of Agriculture and Consumer Services created an imagery dataset of forested lands based on 2016 National Agriculture Imagery Program imagery. The imagery covers the entire state except for Fort Bragg. The resolution of this dataset is greater than the NLCD data. These data can be downloaded from the NC OneMap website and could primarily be used to determine locations for forest restoration or preservation, as directed on Table 9.

Table 9: Data Inventory of Forested Lands

Data Description	
Source of Information	NC Department of Agriculture and Consumer Services
Link to Online Data	https://www.nconemap.gov/datasets/ncagr::forest-land-cover-2016/about
Date Created	2016
Date of Access	March 2023
Most Recent Update	2016
Update Needed?	Yes
GIS Data Format	Raster

Gap Analysis Criteria Description	
Age	Data have not been updated since 2016.
Scale	The data coverage is statewide.
Level of Detail	The spatial resolution of this dataset is one meter.

Identified Gaps	
Age	This dataset is now 7 years old, and there is no plan for an update. It is still useful, but other sources of forest land cover data will be required for accuracy.
Scale	The entire state is covered with an equal level of detail.
Level of Detail	The detail level of this dataset is remarkably high; however, without regular updates, the data quality for some areas will diminish over time.

5.3 North Carolina Color Infrared Imagery

This dataset shows false color infrared imagery (CIR) of the whole State of North Carolina using the most recent 4-band imagery available from the North Carolina Orthoimagery Program. Processing has been minimized to preserve the ability to use these data for raster analysis. The near-infrared portion of the electromagnetic spectrum can be used to identify plant and hydrologic wetland conditions. The NWI uses aerial CIR photography to provide fine-scale maps of wetland distribution. These data can be downloaded from the NC OneMap website, as indicated in Table 10. This dataset can be used with other available datasets to identify areas of potential wetlands restoration or preservation.

Table 10: Data Inventory of Plant and Hydrologic Wetland Conditions

Data Description	
Source of Information	NC OneMap
Link to Online Data	https://www.nconemap.gov/datasets/nconemap::nc-orthoimagery-cir/about
Date Created	2020
Date of Access	March 2023
Most Recent Update	September 2022
Update Needed?	No
GIS Data Format	Image service layer (raster)

Gap Analysis Criteria Description	
Age	The data were updated recently.
Scale	The data coverage is statewide.
Level of Detail	The spatial resolution of this dataset is six inches.

Identified Gaps	
Age	The data are updated regularly and therefore should stay current.

Scale	The entire state is covered with an equal level of detail.
Level of Detail	The level detail of this dataset is extremely high because it is aerial imagery.

5.4 QL1/QL2 LiDAR

The North Carolina Department of Public Safety (NC DPS), in conjunction with North Carolina Geodetic Survey and the North Carolina Department of Transportation (NCDOT), provide statewide coverages of LiDAR remote sensing data with thirteen classification levels, including bare earth and three strata of vegetation. These data are widely used to develop digital terrain models and can also be used to identify forested and non-forested areas. The highest level of accuracy is quality level 1 (QL1), which is currently available for 81 counties in the state (see Figure 1, below). Quality level 2 (QL2) data are available for the central portion of the state and are also shown on Figure 1. The primary use of these data would be to identify streams and wetlands, and candidates for floodplain restoration; however, they can also be used to identify forested and non-forested areas, as described below in Table 11.

Table 11: Data Inventory of LiDAR Data

Data Description	
Source of Information	NC Emergency Management (with NC Geodetic Survey and NCDOT)
Link to Online Data	https://sdd.nc.gov/
Date Created	2014 to 2022
Date of Access	March 2023
Most Recent Update	2017
Update Needed?	No
GIS Data Format	LAS points, DEM tiles (raster)

Gap Analysis Criteria Description	
Age	The data are relatively recent.
Scale	The data coverage is statewide.
Level of Detail	The digital elevation model (DEM) is available everywhere as five feet, 10 feet, 20 feet, and 50 feet. Many counties also have three feet, but not all.

Identified Gaps	
Age	The data are recent at this time and are planned for continual updates going forward. NCMFP is working to secure long-term funding to collect LiDAR data on a 5-year cycle.
Scale	The entire state is covered at two different levels of detail.
Level of Detail	The level of detail is quite high for this dataset. However, the western portions of the state have QL1 LiDAR, which is a higher level of accuracy than the eastern portion of the state, which has QL2 LiDAR. The difference between the two datasets is the number of points per square meter.

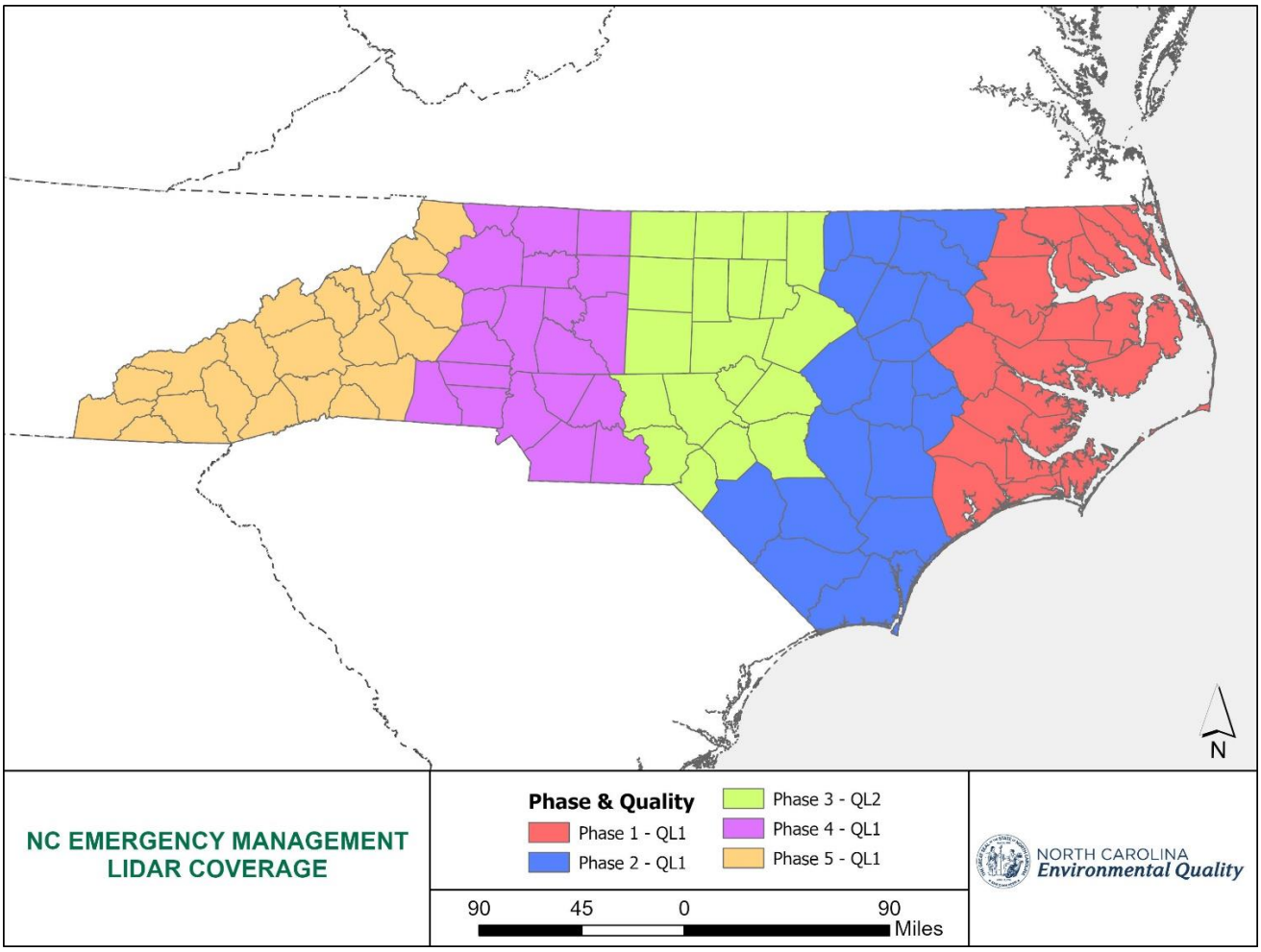

Figure 1: NC Emergency Management LiDAR Coverage

5.5 North Carolina Natural Heritage Areas

The North Carolina Natural Heritage Program (NC NHP) maintains a database of terrestrial and aquatic sites of special ecological significance. The significance of the sites is related to the presence of rare species, important natural communities, or important wildlife assemblages. The coverage of these data is statewide and can be accessed online through the North Carolina Natural Heritage Data Explorer, as indicated in Table 12. These data would be useful for prioritizing NBS that satisfy multiple objectives, such as the preservation or improvement of important ecological sites, in addition to reducing downstream flooding.

Table 12: Data Inventory of Terrestrial and Aquatic Sites of Special Ecological Significance

Data Description	
Source of Information	NC Natural Heritage Program
Link to Online Data	https://ncnhde.natureserve.org/arcgis/rest/services/NC_Public/Natural_Areas/MapServer
Date Created	Unknown
Date of Access	March 2023
Most Recent Update	January 2023
Update Needed?	No
GIS Data Format	Map service layer, shapefile

Gap Analysis Criteria Description	
Age	The data are very recent.
Scale	The data coverage is statewide.
Level of Detail	All natural heritage areas in the state are included as polygons. The data are integrated from many sources. These data are not surveyed and are not intended to indicate the authoritative location of projects.

Identified Gaps	
Age	The dataset is updated quarterly and therefore should never be out of date.
Scale	The entire state is covered at the same level of detail.
Level of Detail	The dataset is detailed and is the definitive source for this information. However, locations are not expected to be highly accurate.

5.6 North Carolina Managed Natural Areas

The NC NHP also provides a layer of managed natural areas. This layer shows properties and easements where resource conservation is a key site management goal. The data include nature preserves, conservation easements, heritage areas, and government-owned lands. The coverage of these data are statewide and can also be accessed online through the North Carolina Natural Heritage Data Explorer, as indicated in Table 13. The primary use of these data would be similar to the NC NHP dataset described above—to prioritize NBS that satisfy multiple objectives.

Table 13: Data Inventory of Managed Natural Areas

Data Description	
Source of Information	NC Natural Heritage Program
Link to Online Data	https://ncnhde.natureserve.org/arcgis/rest/services/NC_Public/Managed_Areas/MapServer
Date Created	Unknown
Date of Access	March 2023
Most Recent Update	January 2023
Update Needed?	No
GIS Data Format	Map service layer, shapefile

Gap Analysis Criteria Description	
Age	The data are very recent.
Scale	The data coverage is statewide.
Level of Detail	All managed areas in the state are included as polygons. The data are integrated from many sources. These data are not surveyed and are not intended to indicate the authoritative location of projects.

Identified Gaps	
Age	The dataset is updated quarterly, and therefore, should never be outdated.
Scale	The entire state is covered at the same level of detail.
Level of Detail	The dataset is detailed with no known gaps. However, locations are not expected to be highly accurate.

5.7 Farmland Preservation Areas

The North Carolina Department of Agriculture and Consumer Services (NC DA&CS) provides a GIS layer of statewide farmland conservation easements for the NC Agricultural Development and Farmland

Preservation (ADFP)Trust Fund, as indicated in Table 14. These are sites where existing farmland will be conserved in its current agricultural state in perpetuity. These data are available for download from ADFP Trust Fund. This dataset could be used to identify where farmland currently exists and will not be converted to a different land use; and could therefore be a potential site for long-term flood control or other NBS measures, and to provide information for clustering projects for maximum benefits.

Table 14: Data Inventory of Statewide Farmland Conservation Easements

Data Description	
Source of Information	NC Agriculture Development and Farmland Preservation (ADFP) Trust Fund
Link to Online Data	https://www.ncmhtd.com/arcgis/rest/services/AG_EP/FarmlandPreservation/MapServer
Date Created	Unknown
Date of Access	March 2023
Most Recent Update	December 2022
Update Needed?	No
GIS Data Format	Map service layer

Gap Analysis Criteria Description	
Age	The data are very recent.
Scale	The data coverage is statewide.
Level of Detail	The data are not surveying quality but are based on close approximations of property boundary lines.

Identified Gaps	
Age	The data are recent, but the frequency of updates is unknown.
Scale	The entire state is covered at the same level of detail.
Level of Detail	The dataset includes all ADFP Trust Fund's farmland easements.

5.8 Conservation Reserve Enhancement Program

The NC DA&CS also administers the State's Conservation Reserve Easement Program (CREP). This program focuses on long-term protection of environmentally sensitive cropland and marginal pastureland. Landowners in approved watersheds over 76 counties in the state may be eligible for the program, based on criteria related to historical use for crop land and suitability of pasture for planting riparian buffers. The program is intended to protect water quality and riparian zones on farmlands.

The program helps achieve the state's goals for nutrient reductions in the Nuese and Tar-Pamlico River Basins. Similar to the Farmland Preservation program, this dataset, discussed in Table 15, could be used to identify where farmland currently exists, and will not be converted to a different land use; and could therefore be a potential site for long-term flood control or other NBS measures, and to provide information for clustering projects for maximum benefits.

Table 15: Data Inventory for Environmentally Sensitive Cropland and Marginal Pastureland

Data Description	
Source of Information	NC Department of Agriculture and Consumer Services
Link to Online Data	CREP_Easements_Aug2020 (Feature Server) (arcgis.com)
Date Created	Unknown
Date of Access	September 2023
Most Recent Update	2017
Update Needed?	Yes
GIS Data Format	Map service layer, shapefile

Gap Analysis Criteria Description	
Age	The data are now slightly outdated.
Scale	The data coverage is statewide.
Level of Detail	All CREP easements in the state are included as polygons. Information on the spatial resolution or accuracy is not provided.

Identified Gaps	
Age	The dataset has not been updated for approximately 5 years.
Scale	The entire state is covered at the same level of detail.
Level of Detail	The dataset is detailed, with no known gaps. However, the accuracy of easement boundary polygons is not known.

5.9 North Carolina Parcel Data

Table 16 indicates locations of statewide data on parcels are available for download from NC OneMap. These data show parcel information such as land ownership and are available for all 100 counties in the state. These data can be used to identify public lands, large tracts of land, and other sites that might be used for NBS.

Table 16: Data Inventory of Statewide Parcel Information

Data Description	
Source of Information	NC OneMap
Link to Online Data	https://www.nconemap.gov/datasets/nconemap::north-carolina-parcels-polygons/explore?location=35.115794%2C-79.919650%2C7.91
Date Created	2016
Date of Access	March 2023
Most Recent Update	May 2022
Update Needed?	No
GIS Data Format	Feature service layer, geodatabase.

Gap Analysis Criteria Description	
Age	The data are very recent.
Scale	The data coverage is statewide.
Level of Detail	The source geometry is retained as published by individual county data producers. It is not based on survey data but is based on close approximations of property boundary lines.

Identified Gaps	
Age	Data for each county are updated at various times. All counties are updated frequently but are not on the same schedule.
Scale	The data coverage is statewide.
Level of Detail	All parcels in the state are included. Some county datasets have more attributes than other counties depending on what data each county have available.

5.10 North Carolina Division of Mitigation Services Conservation Easements

Statewide data on existing NC DMS conservation easements are available as a GIS layer, as indicated in Table 17. These data also include watersheds where NC DMS has done local and regional-scale watershed planning studies. These data can be useful when planning for NBS, because it is often desirable to group conservation areas to provide maximum benefits and help achieve other objectives besides reducing downstream flooding.

Table 17: Data Inventory of NC DMS Conservation Easements

Data Description	
Source of Information	NC Division of Mitigation Services
Link to Online Data	https://services.arcgis.com/iFBq2AW9XO0jYYF7/ArcGIS/rest/services/Drupal_Map/FeatureServer
Date Created	2017
Date of Access	March 2023
Most Recent Update	2019
Update Needed?	Yes
GIS Data Format	Feature service layer

Gap Analysis Criteria Description	
Age	The data are recent, but they are not updated frequently.
Scale	The data coverage is statewide.
Level of Detail	This data set is composed of electronic boundaries directly from the metes and bounds description associated with the recorded deeds. However, the viewable boundaries may vary from what is actually protected on the ground.

Identified Gaps	
Age	The dataset is not updated frequently. It will not include many recently implemented easements.
Scale	When updated, all DMS easements in the state are included.
Level of Detail	The level of detail is intended to be a complete coverage of all NC DMS easements in the state. However, with infrequent updates, newer easements will be left out until subsequent updates.

5.11 North Carolina Land and Water Fund Funded Projects Database

The North Carolina Land and Water Fund provides grant funding to support projects that improve water quality, sustain ecological diversity, and protect historic and military sites across North Carolina. The fund has existed (formerly known as the Clean Water Management Trust Fund) since 1997. Funds are awarded on an annual basis; and to date, the fund has conserved over 5,000 acres of land and restored 3,000 miles of streams and rivers across the state. Like other datasets described in this document, this dataset provides valuable information on where existing restoration and

conservation projects exist, as identified in Table 18. This information can be used to help plan future projects so that they can be clustered with existing projects to maximize the benefits.

Table 18: Data Inventory of Existing Restoration and Conservation Projects

Data Description	
Source of Information	NC Land and Water Fund
Link to Online Data	https://nclwf.nc.gov/funded-projects
Date Created	Unknown
Date of Access	September 2023
Most Recent Update	2022
Update Needed?	No
GIS Data Format	This dataset includes an online map and PDFs that show information about existing projects.

Gap Analysis Criteria Description	
Age	The data are recent and are updated annually.
Scale	The data coverage is statewide.
Level of Detail	The online mapping includes points representing locations of funded projects. The accuracy and spatial resolution of the points are unknown.

Identified Gaps	
Age	The dataset is up to date and is maintained on an annual basis.
Scale	The dataset covers the entire state.
Level of Detail	The level of detail is sufficient at the statewide scale to include all past funded projects.

5.12 North Carolina Division of Parks and Recreation

This dataset shows parkland owned and operated by the Division of Parks and Recreation. It also shows historical resources on the national register or on the State Historic Preservation Office within 1,000 feet of a park, as identified in Table 19. All of these datasets can be downloaded or viewed online. These data are up to date as of 2019. It is unknown how often they will be updated. This dataset could be useful to the Blueprint project by identifying open space and green space already owned by the state that could be used to implement NBS, such as floodplain restoration or conservation.

Table 19: Data Inventory of Parkland

Data Description	
Source of Information	NC Division of Parks and Recreation and NC Historic Preservation Office
Link to Online Data	https://www.arcgis.com/home/item.html?id=e4a33c54892f4d198036228b90fc3443
Date Created	2019
Date of Access	May 2023
Most Recent Update	2019
Update Needed?	No
GIS Data Format	Feature service layer

Gap Analysis Criteria Description	
Age	The data are recent but are not updated frequently.
Scale	The data coverage is statewide.
Level of Detail	The dataset will include all NC parklands and documented historic resources. Information on accuracy is not provided.

Identified Gaps	
Age	The dataset is relatively new, but likely will not be updated often.
Scale	The dataset covers the entire state.
Level of Detail	The level of detail is sufficient at the statewide scale to include all state parks and known historic sites.

5.13 North Carolina Division of Waste Management

This division has a GIS dataset that shows hazardous waste sites across the state, as identified in Table 20. The available GIS data can be viewed online, and include underground storage tanks, hazardous waste disposal sites, manufactured gas plants, pre-regulatory landfills, brownfield sites, and federal remediation sites. These data can be used to identify areas where hazardous wastes exist that could complicate the implementation of NBS.

Table 20: Data Inventory of Hazardous Waste Sites

Data Description	
Source of Information	NC Division of Waste Management

Link to Online Data	https://www.deq.nc.gov/about/divisions/waste-management/science-data-and-reports/waste-management-gis-data-and-maps
Date Created	2014
Date of Access	May 2023
Most Recent Update	Varies by dataset, but updates are recent.
Update Needed?	No
GIS Data Format	Feature service layer.

Gap Analysis Criteria Description	
Age	The data are recent and are updated frequently.
Scale	The data coverage is statewide.
Level of Detail	The dataset represents complete coverage of the NCDEQ databases. The data are collected from various sources with variable location accuracy.

Identified Gaps	
Age	The dataset is relatively new and appears to be updated often.
Scale	The dataset covers the entire state.
Level of Detail	The level of detail is sufficient at the statewide scale.

5.14 N.C. Division of Marine Fisheries (NCDMF) Submerged Aquatic Vegetation (SAV)

N.C. DEQ Division of Marine Fisheries produces the SAV dataset to support planning projects or research that contributes to better protection and restoration for SAV habitat. The available GIS dataset includes historical data from 1981-2021 covering a variety of geographic scales and coastal areas. The dataset includes information on relevant dates, water bodies, SAV regions, SAV density and area in acres.

Table 21 Data Inventory of Submerged Aquatic Vegetation

Data Description	
Source of Information	N.C. DEQ Division of Marine Fisheries
Link to Online Data	https://ncdenr.maps.arcgis.com/apps/View/index.html?appid=07a17353da014e87ac993b1923ea773c

	https://data-ncdenr.opendata.arcgis.com/datasets/ncdenr::nc-sav-mosaic-1981-to-2021/explore
Date Created	1981
Date of Access	October 2023
Most Recent Update	2021
Update Needed?	Yes
GIS Data Format	Feature Service Layer; Shapefile

Gap Analysis Criteria Description	
Age	The data are recent
Scale	Coastal zone of the Albemarle-Pamlico National Estuary Partnership (APNEP) and southern NC region. Varying extents based on historical data collection.
Level of Detail	Varies by year of data collection; most recent 2021 updated data scale was typically between 1:1,500 and 1:2,000 with a minimum mapping unit set at 15 m.

Identified Gaps	
Age	The data includes historical entries from 1981-2021
Scale	Coastal zone of the Albemarle-Pamlico National Estuary Partnership (APNEP) and southern NC region. Varying extents based on historical data collection; some areas may be missing.
Level of Detail	The level of detail is sufficient at the limited coastal scale of the dataset. However, level of detail may vary based on historical data entries and spatial coverage.

5.15 N.C. Division of Marine Fisheries (NCDMF) Shoreline Survey

The division has an ArcGIS StoryMap where an interactive map of the N.C. shoreline provides links to the most up to date, growing area specific, shoreline survey and water quality testing results. Shoreline surveys are conducted at least every three years. The resulting shellfish sanitation shoreline survey reports include information on sources of pollution, hydrographic factors, and bacteriological data analyses. A geospatial dataset, not openly available to the public, includes the growing area, survey type, relevant dates, as well as pollution categories, impact, and status. This information can be used to identify potential sites for nature-based solution implementation that would have the greatest overall positive environmental impact.

Data Description	
Source of Information	N.C. DEQ Division of Marine Fisheries
Link to Online Data	https://storymaps.arcgis.com/stories/946ba7399b2248578b01a86ea720adbb https://www.deq.nc.gov/about/divisions/marine-fisheries/shellfish-sanitation-and-recreational-water-quality/shellfish-growing-areas#SanitarySurveys-3997 https://data-ncdenr.opendata.arcgis.com/datasets/ncdenr::sga-current-classifications-4/explore?location=35.188240%2C-77.126197%2C9.38
Date Created	2023
Date of Access	October 2023
Most Recent Update	Surveys completed every three years
Update Needed?	No
GIS Data Format	This dataset includes an online map and PDFs that show information about existing projects. A feature service layer of Shellfish Growing Areas is also available.

Gap Analysis Criteria Description	
Age	The data are very recent, with new survey conducted every three years
Scale	Entirety of N.C. coastal shoreline with a focus on shellfish growing areas
Level of Detail	Information includes survey year and type, growing areas of concern as well as pollution categories, impact, and status. Information on accuracy is not provided

Identified Gaps	
Age	This dataset is frequently updated
Scale	The survey results and water quality data cover the entire coast of N.C.
Level of Detail	The level of detail is sufficient at the coastal/shoreline scale.

6 Municipal Agency Datasets

Many municipalities across the state maintain GIS data of their infrastructure. Generally, larger municipalities have more robust and well-maintained datasets. In addition to gray infrastructure such as stormwater pipe networks, many municipalities have GIS data on stormwater control measures and GSI. The degree to which these databases are maintained is highly variable between municipalities. Many municipalities such as Raleigh and Durham also perform watershed planning to prioritize capital improvement projects and water quality improvement projects such as stream and floodplain restoration, wetlands restoration, and implementation of GSI. Cities, towns, and counties also maintain information on their parks and other municipal-owned lands. Because of the number of municipalities across the state, a more detailed summary of available data is beyond the scope of this document.

7 State Policy Analysis

7.1 Peer-State NBS Policies

As part of the Blueprint literature review (subtask 1.5), five peer states were reviewed for their governance of state-wide flood resiliency programs. Of those, four states highlighted policies or practices specific to NBS.

The **Louisiana Watershed Initiative** (LWI) created a watershed-level governance structure to oversee floodplain management. This achieves the multi-stakeholder engagement approach recommended by FEMA and allows the LWI to prioritize NBS in its management approach. The initiative is based on a framework for stakeholder, data, and policy coordination created by the state's Coastal Protection and Restoration Authority. The LWI oversees an NBS program, which provides technical assistance, training, and resources to promote NBS to flooding and improving water quality. Please see subtask 1.5 "Peer State Flood Resiliency Programs" for further information on Louisiana's NBS-related programs.

Key policy action: Governor John Bel Edwards issued Executive Order JBE18-16 in 2018, forming the Council on Watershed Management, and leading to the launch of the LWI. The LWI pivots from traditional flood mitigation efforts siloed by politically defined jurisdictions. Instead, the LWI takes a watershed-based flood management approach, using watershed regions to oversee floodplain management work across their respective parishes. The cross-agency nature of the state's Council on Watershed Management, which draws from five different state agencies, makes LWI's innovative approach possible. More information is required to determine if the state made any additional policy changes to facilitate the implementation of NBS projects on a local level.

In **Massachusetts**, staff used the hazard mitigation planning process to create a Climate Adaptation Plan that incorporates NBS. The plan established Climate Resilience Design Standards and Guidance to integrate the best available statewide climate change projections and hazard data to inform project planning. With this tool, an Ecosystem Service Benefits score indicates the protection of natural resources and the implementation of NBS.

Key policy action: Governor Charlie Baker launched the Resilient Massachusetts Action Team in 2019, and tasked the team with implementing, monitoring, and maintaining the Hazard Mitigation and Climate Adaptation Plan. More information is required to determine if the state made any additional policy changes to facilitate the implementation of NBS projects on a local level.

South Carolina's Office of Resilience uses FEMA's guide for local communities on building community resilience with NBS, previously outlined in "Federal NBS Policy Best Practices."

Key policy action: The South Carolina Office of Resilience was established in September 2020 through Bill 48-62-10 of the South Carolina General Assembly's 123rd session. The office follows recommendations from the state's Floodwater Commission—created by Governor Henry McMaster in 2019—to prioritize the use of nature-based flood solutions to protect communities and infrastructure. More information is required to determine if the state made any additional policy changes to facilitate the implementation of NBS projects on a local level.

The **Texas Water Development Board** began developing the first-ever state flood plan for Texas in 2019 that included a ranked collection of recommended flood mitigation projects for the state. The

list of projects is compiled from individual plans submitted by 15 Regional Flood Planning Groups. NBS are one criterion in the board's Flood Project Ranking System. The criteria were developed through stakeholder feedback.

Key policy action: The development of the Texas State Flood Plan was mandated by the state legislature in 2019. Texas administrative code, adopted in 2020, specifically called for the ranking and prioritizing of flood mitigation projects and strategies. This policy move led to the board developing ranking criteria and the inclusion of NBS. In the fall of 2019, Texas voters approved a constitutional amendment to create the Flood Infrastructure Fund to assist in the financing of drainage, flood mitigation, and flood control projects. In addition, the legislature appropriated funds for the Water Development Board to collect more flood-related data, advance its river and coastal modeling capabilities, and distribute critical flood information through an online dashboard. The board recently launched a $450,000 project to "examine and describe the efficacy and cost-effectiveness of a variety of possible NBS for varying regions in Texas. The focus of this research is to identify the variety of NBS best suited for floods of varying magnitudes; the types of associated flood mitigation benefits, including additional co-benefits within social, ecologic, and economic categories; and the various methods by which these benefits may be described and quantified."

7.2 Summary of Peer State Strategies Used

The strategies used by NC peer states largely mirror the approach suggested in FEMA's guide for local communities on building community resilience with NBS. Louisiana and Massachusetts both took a multi-stakeholder engagement approach to planning that incorporated multiple government agencies. Using NBS as a prioritization factor, Texas and Massachusetts assess the most pressing flooding issues with a scoring methodology that considers the co-benefits of NBS. Louisiana goes further to provide technical assistance through its NBS program. At this point in time, peer-state actions set the stage for resilience governance at a high level, with a specified focus on NBS. However, these actions have not yet trickled down to policy changes on a local or regional level. Federal guidance is currently the best source for necessary policy changes related to NBS implementation. However, Texas' Flood Project Ranking System shows the greatest alignment with the NC Blueprint's intent. The overarching administrative code addition, constitutional amendment, and legislative mandates in Texas can serve as an example of the policy foundation needed to foster NBS from the top down.

North Carolina Governor Roy Cooper mandated the NCDEQ, NCDOT, NCEM, Office of Recovery and Resiliency, and other relevant state agencies to update the North Carolina Uniform Floodplain Management Policy within 18 months of Executive Order NO. 266, signed July 25, 2022. The updated plan will provide standards, options, and considerations for including nature-based infrastructure to reduce flood risk.

Lessons learned from the analysis of peer state approaches to NBS can be applied to the "Action Profile Analytics" module of the Blueprint Flood Resiliency Blueprint Tool. Subtask 4.5 will include more details on potential methodologies for developing ranking factors. Due to its potential to further the NBS-related goals of the mandated North Carolina Uniform Floodplain Management Policy update, the NCDEQ should explore policy changes demonstrated in the outlined FEMA guidance and peer state strategies to bolster the Blueprint's ability to consider NBS co-benefits.

7.3 Federal NBS Policy Best Practices

The Federal Government provides guidance on integrating NBS into traditional community planning processes and programs.

7.3.1 Federal Emergency Management Agency

In its "Building Community Resilience with Nature-Based Solutions" guide, FEMA identifies land use planning, hazard mitigation planning, stormwater management, transportation planning, and open space planning as segments. By following a three-step "engage," "assess," and "update" approach, communities can integrate NBS into the "Land Use Element" of community comprehensive planning.

The "Engage" and "Assess" phases serve a similar purpose in each planning segment. In land use planning, hazard mitigation planning, stormwater management, transportation planning, and open space planning, FEMA recommends the following two steps in updating comprehensive planning to capture NBS:

ENGAGE: To promote coordinated investment in NBS, comprehensive planning must involve stakeholders beyond the planners and government officials traditionally involved in the procedure. FEMA recommends engaging parks and recreation, public works, environmental protection, utility planning, transportation planning, floodplain management, emergency management, and the general public.

ASSESS: The community's most pressing problems should guide the prioritization of NBS. By first identifying the most pressing issues in each planning segment, planners can incorporate nature-based practices into a suite of solutions. Reference FEMA's NBS guide for a list of watershed, neighborhood, or site scale, and coastal area NBS practices.

Once these phases are complete, FEMA offers guidance on updating ordinances, policies, procedures, and training to reflect the identified priorities and coordinate investment in NBS.

7.3.2 Land Use Planning Best Practices

Based on the NBS prioritized by the community during the assessment phase, ordinance updates and procedure updates can drive investment in NBS by accomplishing the following actions: establish riparian buffers and protect stream corridors; direct development to previously developed areas and areas with existing infrastructure; promote compact (e.g., mixed-use and transit-oriented) development; reduce impervious cover; and modify landscape requirements, including tree protection requirements.

7.3.3 Hazard Mitigation Planning Best Practices

NBS can be incorporated into hazardous migration plans (HMPs) through both long-term objectives and precise mitigation measures. Although mitigation actions may involve specific nature-based projects, they should also advocate for the broader adoption of NBS. This can encompass the formulation of policies, regulations, educational initiatives, outreach efforts, and incentive programs. These initiatives should be collaboratively developed with relevant departmental staff, enabling them to seamlessly integrate NBS into their respective programs and planning procedures.

7.3.4 Stormwater Management Best Practices

To promote the adoption of NBS, numerous communities are introducing regulations regarding stormwater retention into their post-construction stormwater programs. According to the EPA, 28 states and two territories have embraced post-construction retention standards. However, this information originated in 2016, and may be outdated. Post-construction retention standards necessitate that a portion of runoff volume is controlled on the property where it originates. Additionally, some communities have established a hierarchy of preferred NBS. For instance, the Philadelphia Water Department categorizes these practices into three preference levels: Highest, Medium, and Low.

7.3.5 Transportation Planning Best Practices

Revise policies, procedures, and ordinances related to street and parking design. Customize these updates to align with the community's prioritized NBS. Consider measures such as incorporating NBS into transportation projects, making street trees part of public capital improvement projects, limiting road width, using impervious materials, and offering alternative parking solutions.

7.3.6 Open Space Planning Best Practices

Facilities management programs offer an opportunity to introduce neighborhood-scale NBS into existing parks and playgrounds. When local governments retrofit these facilities, they can integrate these solutions to reduce impermeable surfaces, increase tree coverage, and manage stormwater runoff effectively. Furthermore, park planning, and design provide a platform for implementing nature-based practices as communities expand their park networks, attracting new partners and funding.

7.4 The White House

The Biden-Harris Administration released the Nature-Based Solutions Roadmap in November 2022. The roadmap outlines strategic actions and recommendations to make NBS a go-to option for fighting climate change, including key policy updates to federal planning, permitting, cost-sharing, risk management, and benefit-cost analysis. Although applicable mainly to federal agencies, state bodies can glean direction and intent from these priorities. Actions include:

- Accelerate permitting and reviewing for NBS:
    - **Use general permits for NBS:** Using general permits like the U.S. Army Corps of Engineers' nationwide permits for living shorelines and aquatic habitat management can expedite the approval process for NBS, benefiting local communities, and allowing for the creation of new permits as knowledge about these solutions advances.
    - **Developing programmatic environmental reviews**: Some agencies have established programmatic reviews, such as the Federal Highway Administration's programmatic agreements and the National Marine Fisheries Service's environmental review, to streamline the implementation of NBS.
    - **Prioritize permitting for NBS:** Federal agencies and interagency permitting teams should prioritize expediting permitting for nature-based solution projects to encourage their deployment, using mechanisms like the FAST 41 process, and exploring new ways to prioritize such projects within existing authorities.

  - **Build interagency permitting and review teams with expertise in NBS:** Creating multi-agency permitting or review teams with relevant expertise, like the San Francisco Bay Restoration Regulatory Integration Team, can enhance the permitting process for NBS projects.

- **Reduce discretionary cost-share and match requirements for NBS, especially in underserved communities:** Agencies should re-evaluate discretionary cost-share requirements for nature-based solution funding, especially for historically underserved communities.
- **Strengthen the use of NBS in hazard mitigation decisions:** NBS can enhance or even replace traditional infrastructure systems in addressing climate-related risks, such as elevating homes to mitigate floods and protecting wetlands and floodplains to reduce the risk of flooding for various assets, and agencies responsible for setting standards, guidance, and risk management tools should incorporate NBS, especially in pre-disaster mitigation programs.
- **Consider nature-based solution alternatives:** Federal decisions often rely on analyses of different options for a policy or a program. Agencies should consider whether NBS, alone or combined with other options, would make appropriate alternatives.
- **Update Benefit-Cost Analysis Methodology**: Benefit-cost analysis guides a wide range of policy and project decisions. The Office of Management and Budget's circular A-4 provides guidance on benefit-cost methods, including NBS. Agencies should fully follow this guidance to conduct analyses that account for the cost savings and other benefits of NBS.

7.5 Recommended Path Forward

Although aimed at federal agencies, FEMA and White House guidance can serve as a roadmap for crafting policies and regulations that promote NBS to flood risk. Relevant federal guidance can be combined with examples from peer states to create a path forward for North Carolina's NBS policies. However, the state should first inventory current policies related or tangential to NBS. No comprehensive summary of policies and practices affecting the adoption of NBS currently exists for North Carolina. In accordance with guidance from Conservation International on implementing green-gray infrastructure, the state should **draft and maintain a policy digest that documents existing laws and regulations related to NBS, as well as identify needed modifications to remove barriers to implementation, building on previous work in the state.**

8 Summary

This document describes key data sources that are readily available that can be used to support planning and implementation of NBS as part of the overall statewide flood resiliency program. In particular, North Carolina has a wealth of existing GIS data that can be leveraged to support this program. These data, including land cover, topography, hydrography, aerial imagery, etc., provide a solid foundation on which to build this program, and will support the identification and assessment of potential flood mitigation projects. In addition, there are many ongoing efforts in the state to study and implement NBS for a variety of purposes that this effort can draw upon, collaborate with, and learn from. In some cases, such as The Nature Conservancy's Coastal Resilience Program, potential NBS projects have already been identified. NC State University and other organizations are also conducting ongoing research in this arena that should be coordinated with this effort. Federal guidance on NBS such as that provided by FEMA, as well as information from other states and countries that are working on similar programs, can also provide valuable insights and lessons learned.

Available data, guidance, and ongoing research will provide a solid foundation to support development of the NBS component of flood resilience. Even though extensive and diverse information is available to support this program, some clear gaps in available or readily accessible data exits. These include:

- A clearinghouse for municipal data. Municipalities collect data that could be valuable to this effort. However, there is no mechanism to access these data without reaching out to each municipality.
- A modeling framework. Modeling is an essential tool in planning engineering works. Existing watershed models such as the SWAT models developed by The Nature Conservancy are helpful, but only provide the spatial coverage for specific locations.
- Lessons learned from and datasets developed by Peer States. States that have already gone through the development of their programs may offer insights on additional datasets that would be beneficial.
- Summary of available funding sources for NBS projects. Although some funding sources are known and discussed in this document; at some point, a comprehensive list of funding sources to implement these types of projects will need to be assembled.