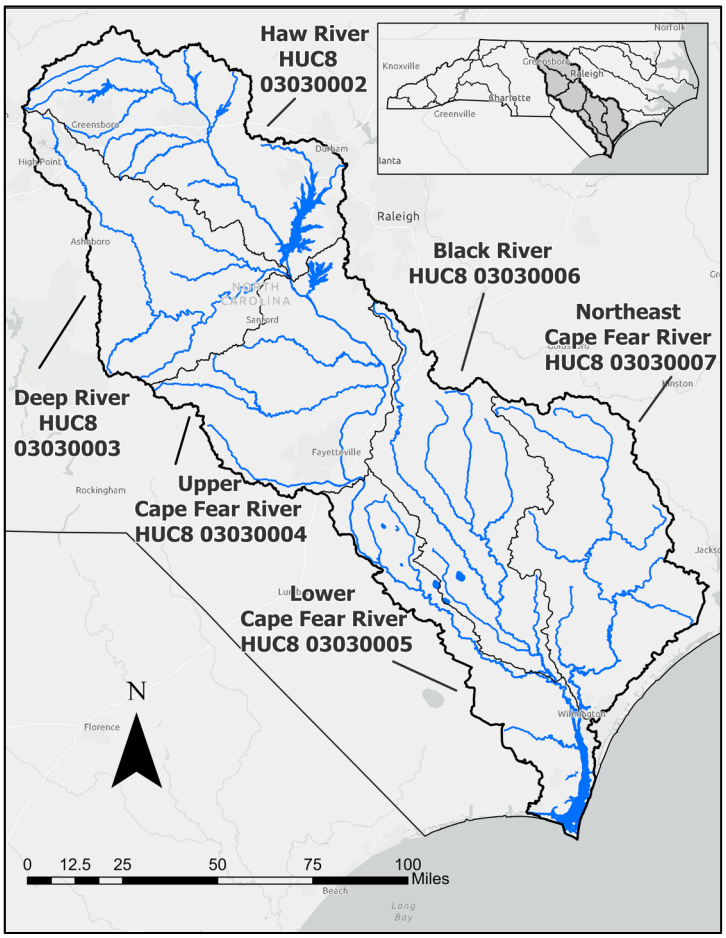


**DRAFT**

# Chapter 1
# Overview of Cape Fear River Basin Characteristics

## BASINWIDE WATER RESOURCES MANAGEMENT PLAN

## CYCLE 4 – CAPE FEAR RIVER BASIN 2026

North Carolina
Department of Environmental Quality
Division of Water Resources
Basin Planning Branch

NORTH CAROLINA
Department of Environmental Quality

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# Chapter 1 Overview of Cape Fear River Basin Characteristics

## 1.1 Geography and Ecoregion Characteristics

Covering 9,164 square miles ($mi^2$), the Cape Fear River Basin is the largest of the seventeen river basins in the State of North Carolina and is one of four river basins contained completely within the state. The Cape Fear River begins at the confluence of the Deep and Haw rivers in Chatham County just below the dam for B. Everett Jordan Lake and ends as a coastal estuary draining to the Atlantic Ocean. In the Lower Cape Fear River, there are three historic lock-and-dam structures that were once used by barges and large boats to navigate shallow waters. While no longer used for navigation, the water behind the dams is used by municipalities to provide water to people within their service area (*Figure 1-1*). Besides the Deep and Haw rivers, major tributaries include the Rocky, Upper Little, Lower Little, Black, and Northeast Cape Fear Rivers (*Figure 1-2*).

There are 29 counties and 115 municipalities located entirely or partially in the basin (*Table 1-1* and *Figure 1-3*). The most populated regions of the basin are located in the Triad area (Greensboro, High Point, Winston-Salem), Triangle area (Durham-Chapel Hill, Raleigh, Cary-Apex), Fayetteville, and Wilmington area. Because of excess nutrients in many of the headwaters, Jordan Lake and the Haw River have been designated as Nutrient Sensitive Waters (NSW) by the state. Management strategies are in place to help reduce the amount of point and nonpoint source pollution entering these waters. In the lower part of the basin, many of the waters are designated as Swamp (Sw) Waters because of their water chemistry and water quality characteristics. Water Supply (WS) Watersheds and Primary Recreational Waters (Class B) can also be found in the basin.

There are close to 30 reservoirs in the basin and several natural lakes monitored by DWR used for multiple purposes including water supply, flood control, hydropower, cooling water source, recreation, and aquatic habitat. The largest reservoir, B. Everett Jordan Lake (Jordan Lake), is over 12,000 acres. Constructed in the 1970s, it is the main source of drinking water for the Town of Cary. It also controls flooding and is a major recreational spot for many people living in the area (*Figure 1-2* and *Figure 1-1*). Other large reservoirs of note include Harris Lake on Buckhorn Creek, which provides cooling water for the Shearon Harris Nuclear Plant, and Randleman Reservoir on the Deep River, which provides drinking water for the Triad Region (*Figure 1-2* and *Figure 1-1*).

The previous basin plan used subbasin boundaries that were numbered based on the number assigned to the river basin and the location of the subbasin within the river basin (*Figure 1-4*). In 2009, the Division of Water Quality (now the Division of Water Resources) adopted the National Watershed Boundary Dataset (NBD) which moved away from the subbasin boundaries and instead uses the federal cataloging unit known as hydrologic unit codes (HUCs) based on the U.S. Geological Survey (USGS) 1:24,0000 scale. Each HUC is identified by a unique number. The largest HUC is two digits (region) which is then subdivided into smaller areas or watersheds with the addition of two digits. The HUCs are nested within each other from the largest geographic area (region) to the smallest geographic area (cataloging unit) (USGS, 2020). Each HUC represents the area of the landscape that drains to a portion of the stream network (USGS, 2020). The Cape Fear River Basin now includes all the former Cape Fear subbasins, except 03-06-24, which is now part of the White Oak River Subbasin (*Figure 1-4*). There are six USGS HUC8 watersheds in the Cape Fear River Basin referred to as subbasins in this plan, including (moving upstream to downstream): Haw River

(HUC 03030002), Deep River (HUC 03030003), Upper Cape Fear (HUC 03030004), Lower Cape Fear (HUC 03030005), Black River (HUC 03030006), and the Northeast Cape Fear River (HUC 03030007) (*Figure 1-2*, *Figure 1-3*, and *Figure 1-4*).

*Table 1-1: Cape Fear River Counties and Percent in Basin*

| COUNTY | % in Basin | COUNTY | % in Basin |
|---|---|---|---|
| CHATHAM | 100.0 | BRUNSWICK | 45.4 |
| LEE | 100.0 | DURHAM | 26.9 |
| HARNETT | 100.0 | ROCKINGHAM | 18.8 |
| ALAMANCE | 99.9 | ONSLOW | 17.9 |
| DUPLIN | 99.8 | WAKE | 15.3 |
| SAMPSON | 99.2 | COLUMBUS | 10.4 |
| CUMBERLAND | 98.0 | CASWELL | 9.6 |
| GUILFORD | 97.0 | WAYNE | 8.6 |
| PENDER | 92.8 | MONTGOMERY | 6.3 |
| MOORE | 78.6 | FORSYTH | 2.3 |
| BLADEN | 69.4 | JOHNSTON | 2.1 |
| NEW HANOVER | 68.4 | LENOIR | 0.7 |
| HOKE | 56.7 | ROBESON | 0.5 |
| RANDOLPH | 55.6 | JONES | 0.04 |
| ORANGE | 48.7 | | |

The Cape Fear River Basin covers three ecoregions as defined by EPA: the Piedmont, Southeastern Plains, and Middle Atlantic Coastal Plain (*Figure 1-5*). Ecoregions are spatially defined regions that contain characteristic and geographically distinct natural communities and species. Other characteristics used to define ecoregions include geology, landforms, vegetation, climate, soils, land use, wildlife, and hydrology. US ecoregions have hierarchical levels with Roman numerals assigned to denote the geographic level (Griffith et al. 2002). North Carolina's ecoregions are best known at "Level III" hierarchy and include the Blue Ridge Mountains, Piedmont, Southeastern Plains, and Mid-Atlantic Coastal Plain. The Southern Plains and Mid-Atlantic Coastal Plain are also referred to as the "Inner" and "Outer" Coastal Plain or collectively as the "Coastal Plain". At the HUC8 level, the Haw River and most of the Deep River subbasins are in the Piedmont ecoregion, the Upper Cape Fear is primarily in the Southeastern Plains, the Lower Cape Fear is primarily in the Middle Atlantic Coastal Plain, and the Black and Northeast Cape Fear subbasins straddle the two Coastal Plain ecoregions (*Figure 1-5*). The rolling hills of the Piedmont ecoregion is a transition zone in the landscape between the rugged terrain of the Blue Ridge Mountains and the relatively flat Coastal Plain. Historically, much of North Carolina's Piedmont was cultivated but now has a mix of pasturelands, grasslands, and crops with fragmented successional oak-hickory-pine forests and growing urban centers (Griffith et al. 2002). Level IV ecoregions of note in the Piedmont are the Triassic Basin, a narrow band on the southeast side of the Haw and Deep subbasins, and the Carolina Slate Belt, located on an adjacent wider band though the middle of these same subbasins. The Triassic Basin has erodible rocks that promote unstable stream banks and low permeable clay rich soils that cause low baseflows especially during warm seasons when many streams completely dry up. The Carolina Slate Belt also has

low warm season stream flows and the lowest water yielding rock units in the state, which creates challenges for groundwater wells installed in this region (Griffith et al. 2002). The Southeastern Plains has irregular plains with broad interstream areas with a mosaic of cropland, pasture, woodland, and forest. The Sandhills Level IV ecoregion, located in and around the Fayetteville area, is a unique area of the Southeastern Plains with its rolling hills, sandy soils, open pine and oak forests, and many rare plant species. Stream flow remains consistent through the seasons due to the large infiltration capacity of the sandy soil and excellent groundwater storage capability of the sand aquifer (Griffith et al. 2002). The Middle Atlantic Coastal Plain consists of low elevation, flat plains, with many wetlands and coastal estuaries, and high biological diversity (Griffith et al. 2002). The Coastal Plain ecoregions contain both brownwater river systems that originate in the Piedmont and parts of the Southern Plains, as well as slow-moving tannin-stained blackwater systems that drain Coastal Plain swamp wetlands.

*Figure 1-1: Cape Fear River Basin Dams of Significance*

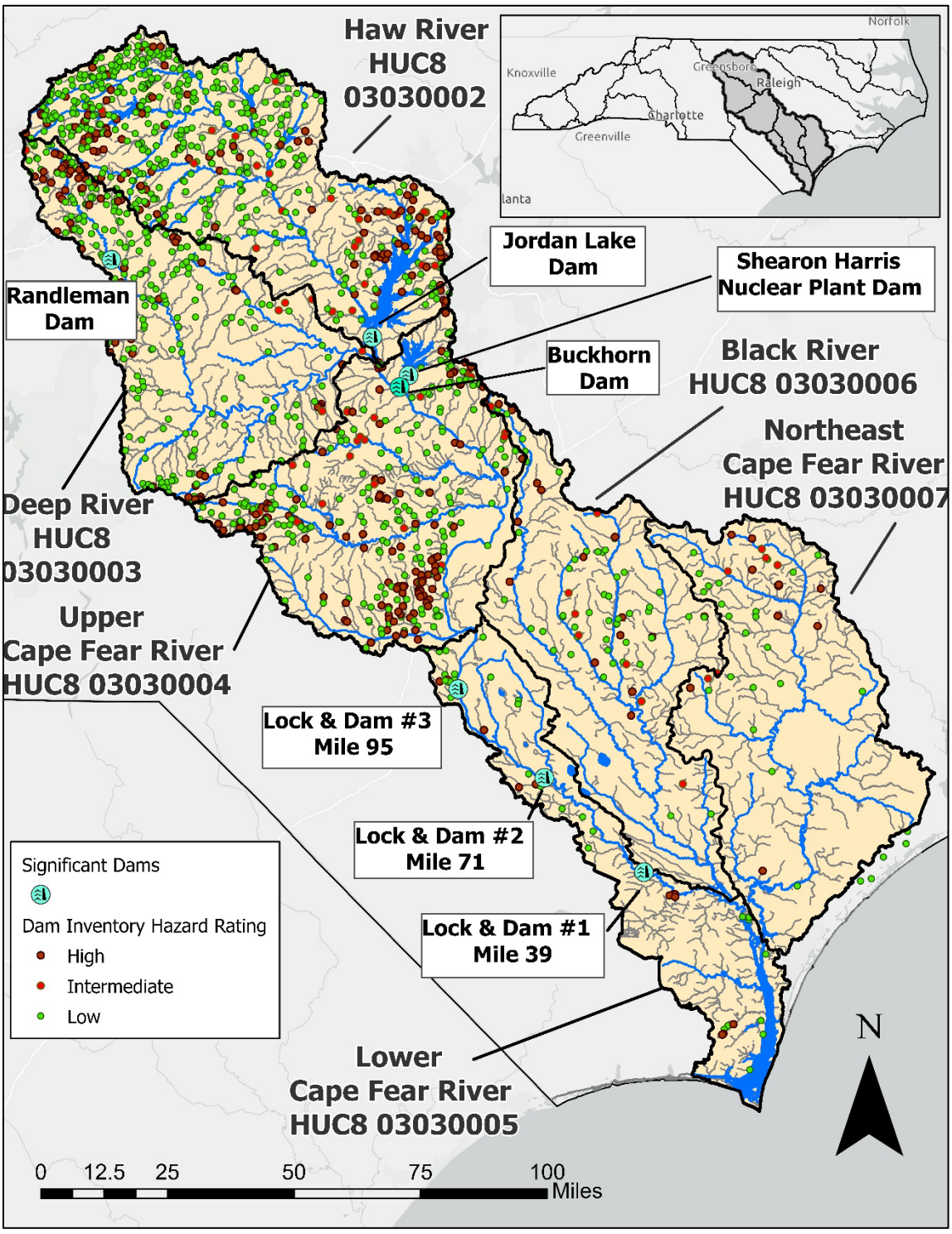


*Figure 1-2: Cape Fear River Basin Major Rivers and Creeks*

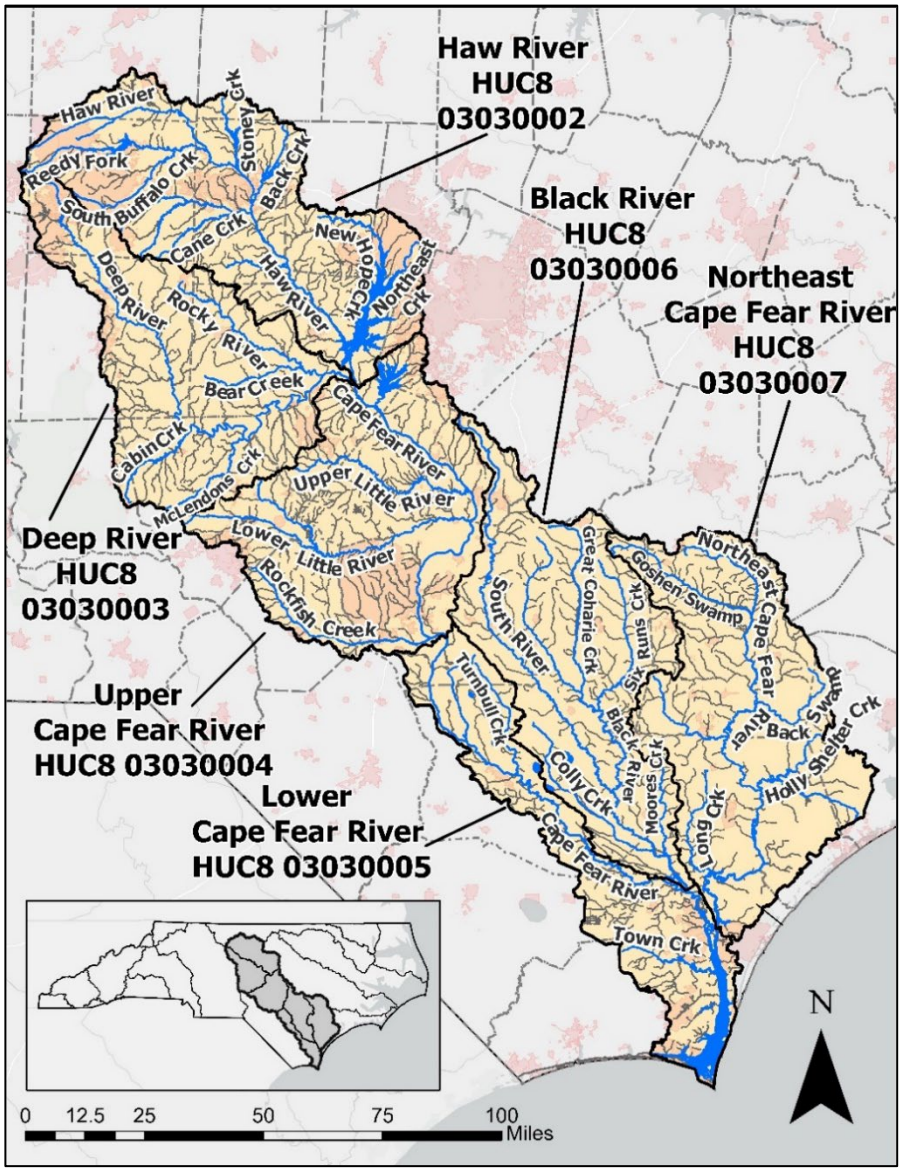



*Figure 1-3: Cape Fear River Counties*

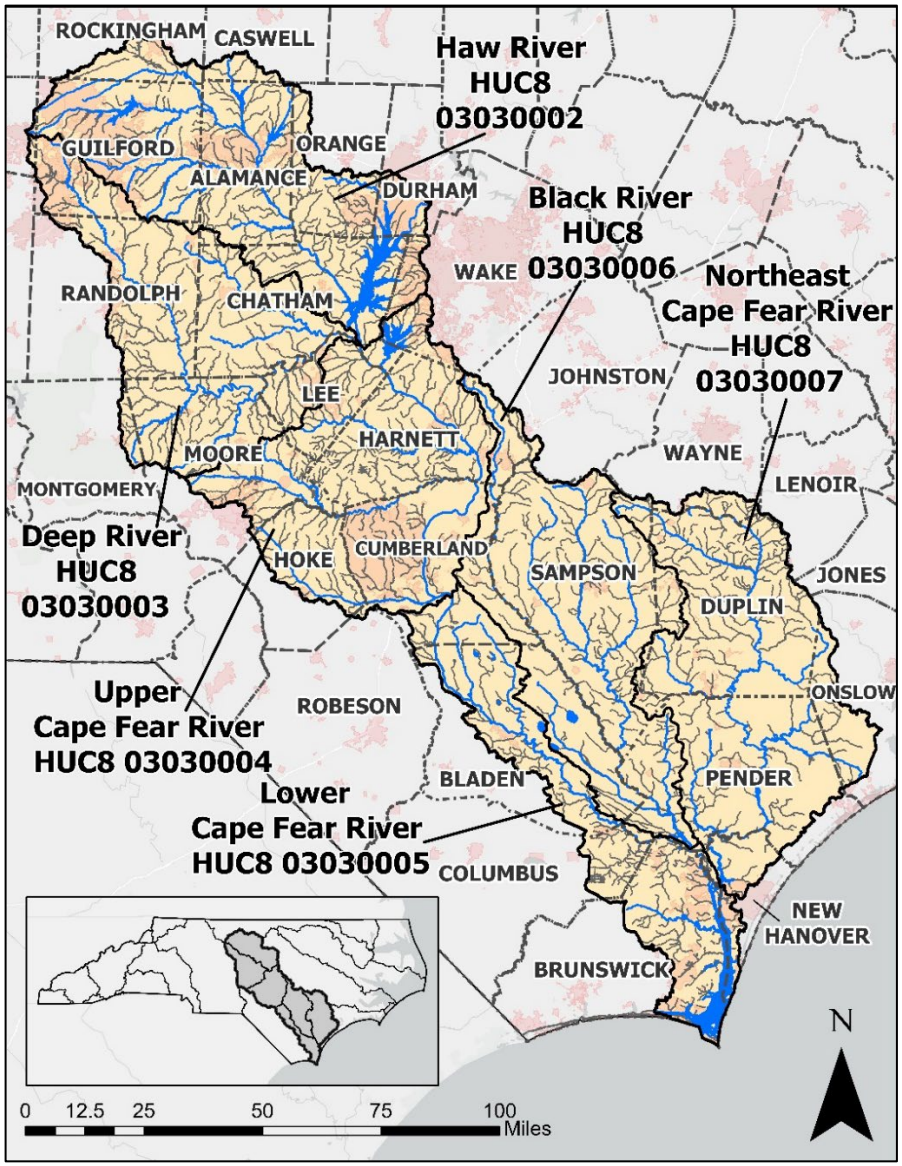


*Figure 1-4: Cape Fear River Basin USGS HUC8 Subbasins and DWR Old Subbasins*

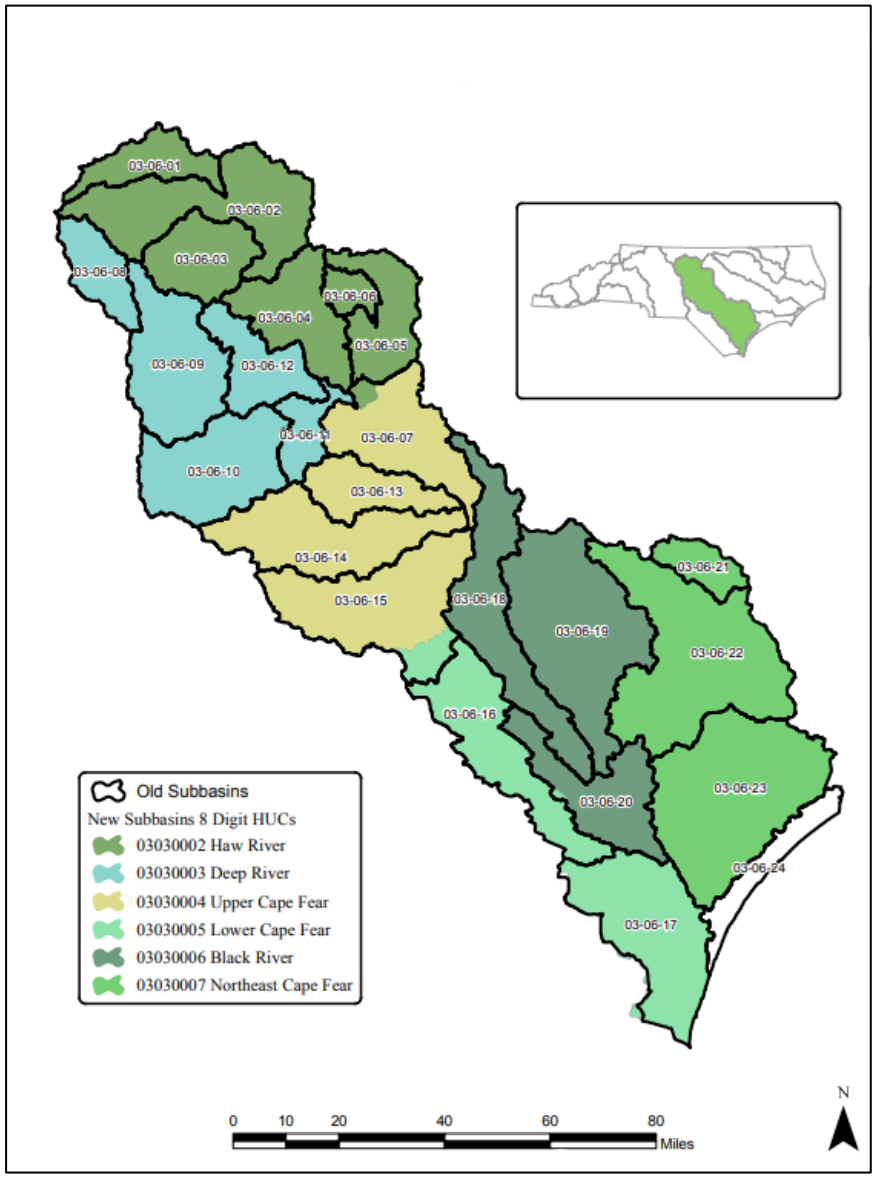
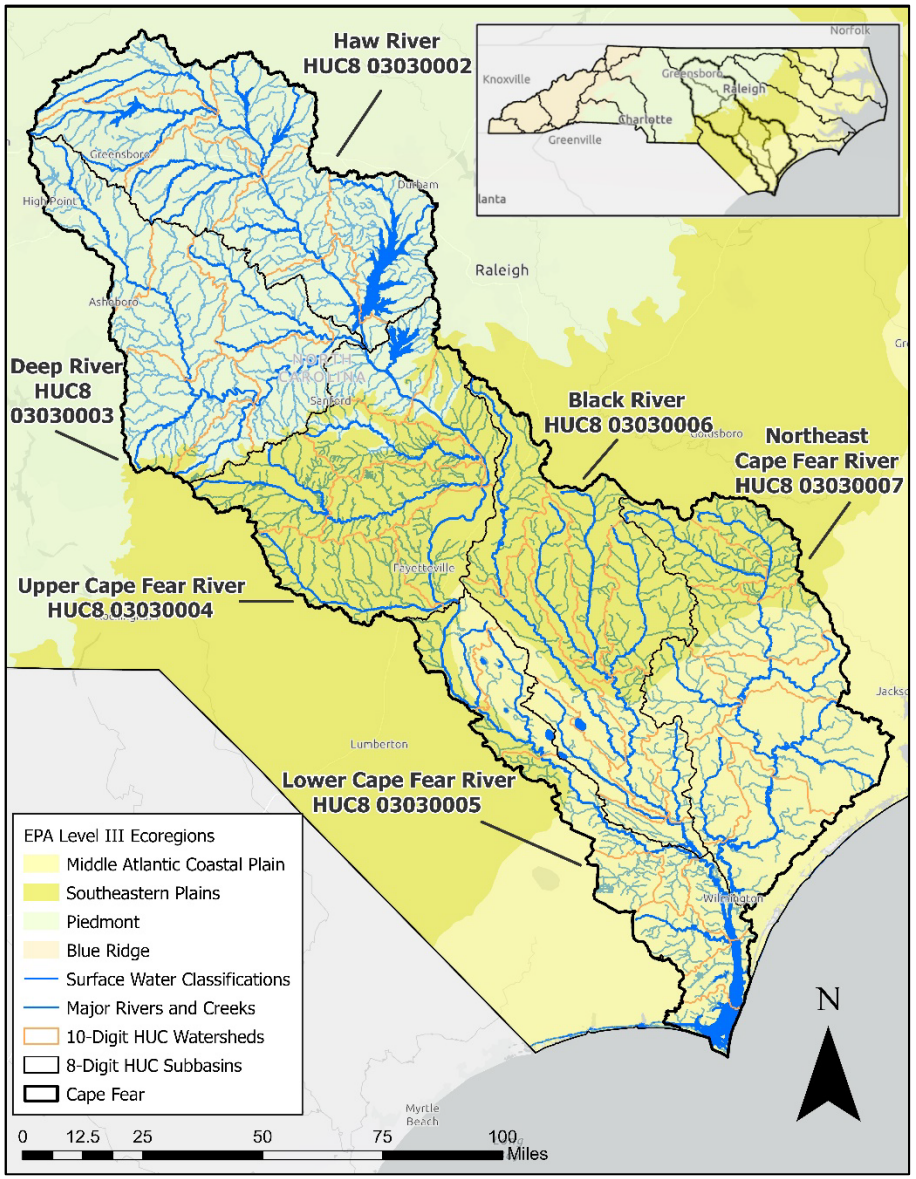



*Figure 1-5: Cape Fear River Basin EPA Level III Ecoregions*



## 1.2 Population and Land Cover

### 1.2.1 Population

Information on population density is useful in determining what watersheds are likely to have the most impacts as a result of population growth. Concentrated populations in urban areas have dense housing, roads, and industrial and commercial development that creates increased impervious surfaces, which in turn increases stormwater runoff that can negatively impact water quality. Information on population densities and projected growth rates can identify where there may be opportunities for preservation or restoration activities. Population growth can also be factored into land use planning. Proper land use planning can assist local leaders in establishing long-range goals, help control the rate of development and growth patterns, and ensure open space is conserved throughout the basin.

The US Census Bureau collects population data every 10 years with census blocks being the smallest geographic units. Census blocks can be as small as a city block in urban areas, but also large, covering many square miles in rural areas. US Census block GIS data was used to estimate population totals for the total population in the basin as well as population on the individual HUC8 subbasin and HUC10 watershed scale for the 2000, 2010, and 2020 census years (*Table 1-2* and *Figure 1-6*). Based on the US Census data, the Cape Fear River Basin population in 2020 was 2.3 million with a 12% increase over the last 10 years and 18.5% increase over the previous 10 (*Table 1-2*). The Haw River subbasin is by far the most densely populated with 586 people per square mile. The Upper Cape Fear subbasin is the second most densely populated at 354 people per square mile. The Lower Cape Fear subbasin had the fastest growth rate between census years (36% from 2000 to 2010 and 16% from 2010 to 2020), while the Haw River subbasin gained the most population, with over 300,000 people moving into the region over the 20-year period from 2000 to 2020. The Black and the Northeast Cape Fear subbasins are the least populated subbasins and have lost population during the last 10 years (*Table 1-2*).

At the HUC10 watershed scale, the most densely populated watersheds (*Figure 1-6*) are associated with major urban centers; Greensboro and High Point in the Triad (Reedy Fork - HUC10 0303000201 and Headwaters Deep River - HUC10 0303000301), Durham, Chapel Hill, and the western Raleigh suburbs of the Triangle (B Everett Jordan Lake-New Hope River - HUC10 0303000206), Fayetteville (Rockfish Creek - HUC10 0303000406), and Wilmington (Brunswick River-Cape Fear River – HUC10 0303000505). The highest population change from 2010 to 2020 occurred in three of the Haw River subbasin watersheds: 84,503 to B Everett Jordan Lake-New Hope River; 27,390 to Reedy Fork; and 16,498 to Big Alamance Creek (HUC10 0303000203) where Burlington is located. *Figure 1-7* displays the population growth rate at the HUC10 watershed scale from 2010 to 2020. The Roberson Creek-Haw River watershed (HUC10 0303000207), to the west of Jordan Lake in the Haw River subbasin, grew by 52%. Buckhorn Creek-Cape Fear River (HUC10 0scale303000401) in the Upper Cape Fear River subbasin, where Holly Springs and Fuquay-Varina are located, grew by 45%, and the Cape Fear River watershed (HUC10 0303000508) in Brunswick County, where Southport and Oak Island are located, grew by 41%.

*Figure 1-6: Cape Fear River US 2020 Census Population HUC10 Watershed*

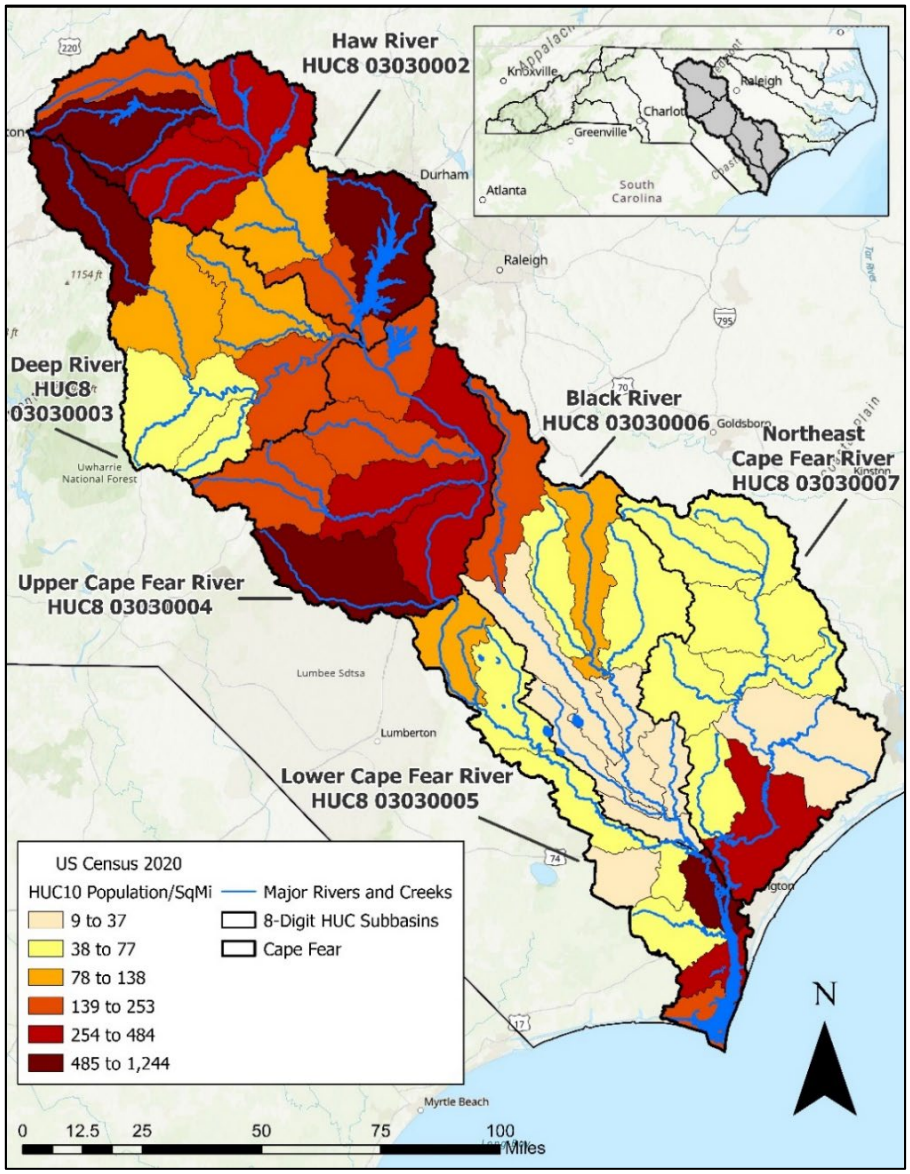



*Figure 1-7: Cape Fear River US Census Population Growth Rate 2010-2020 (% Change) HUC10 Watershed*

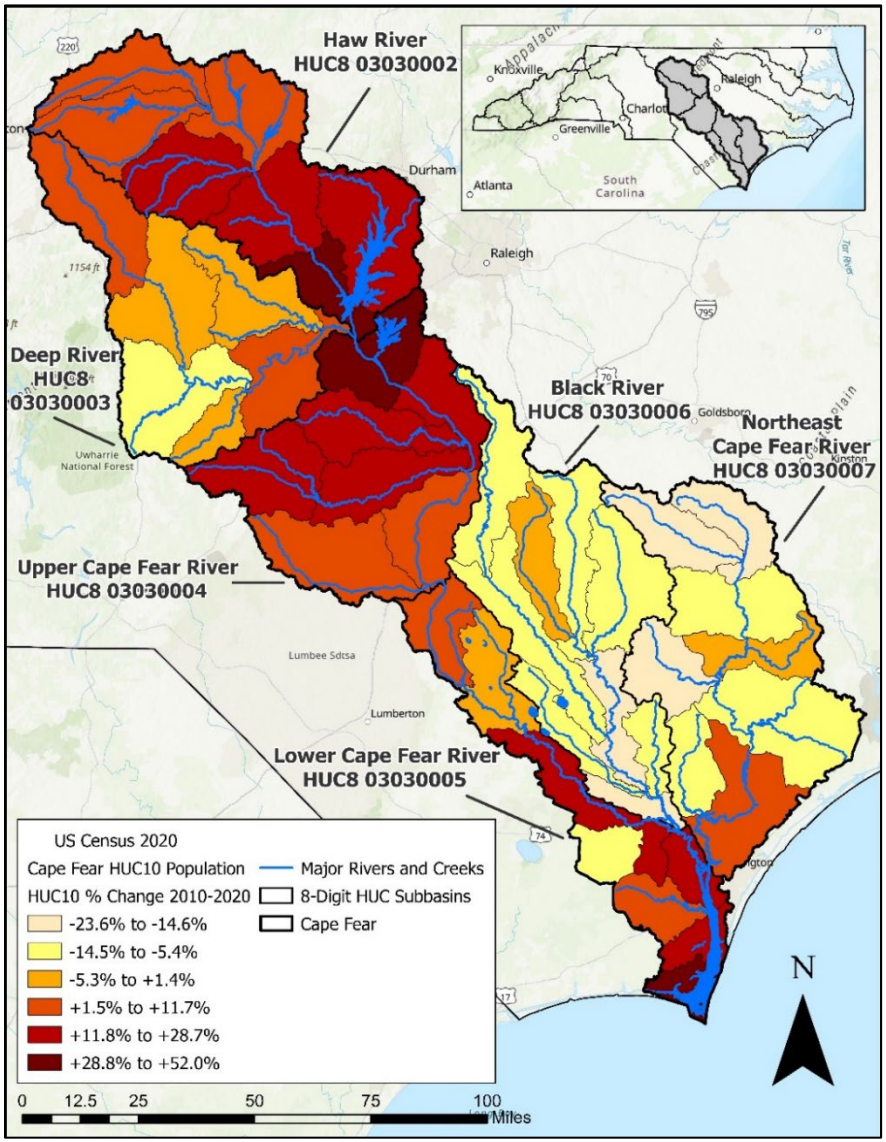


*Table 1-2: Estimated population for Cape Fear River Basin and HUC8 Subbasins*

| HUC8 | HUC8 Name | 2000 Population | 2010 Population | 2020 Population | 2000 - 2010 Pop. Change | 2010 - 2020 Pop. Change | Area ($mi^2$) | 2020 Population per Square Mile ($mi^2$) |
|---|---|---|---|---|---|---|---|---|
| 03030002 | Haw | 696,110 | 846,200 | 1,000,759 | 150,090 | 154,559 | 1,708 | 586 |
| 03030003 | Deep | 265,578 | 299,359 | 311,579 | 33,781 | 12,220 | 1,450 | 215 |
| 03030004 | Upper Cape Fear | 443,889 | 510,529 | 577,652 | 66,640 | 67,123 | 1,630 | 354 |
| 03030005 | Lower Cape Fear | 102,467 | 139,273 | 165,663 | 36,806 | 26,390 | 1,061 | 156 |
| 03030006 | Black | 104,395 | 111,987 | 104,199 | 7,592 | -7,788 | 1,574 | 66 |
| 03030007 | Northeast Cape Fear | 138,385 | 167,203 | 164,048 | 28,818 | -3,155 | 1,741 | 94 |
| **Total** | | **1,750,824** | **2,074,551** | **2,323,900** | **323,727** | **249,349** | **9,165** | |

Table data is from NC One Map US Census Block Data for 2000 and 2010 and Esri Living Atlas for 2020 USA Census Redistricting Blocks processed for Cape Fear River Basin HUC8s.

### 1.2.2 Land Cover – National Land Cover Data

Land cover information can assist local, state and federal managers and officials as they assess ecosystem status and health. It can also assist with modeling nutrient and pesticide runoff, understanding spatial patterns in biodiversity, developing land use management policies and evaluating the effects of land use changes on water quality. North Carolina uses land cover datasets available from the National Land Cover Database (NLCD) (USGS, 2019). The changes in land cover basinwide from 2001 to 2019 are summarized in *Table 1-3*. *Figure 1-8* shows the spatial distribution of land cover as of 2019 in the Cape Fear River Basin. A comparison of land cover at the HUC8 subbasin scale for 2019 is summarized in *Table 1-4.* More information about land cover at the subbasin scale and changes over time is available in the subbasin chapters. In 2019, the NLCD Land Use Land Cover (LULC) data showed 13.8% development, 20.7% agriculture, 37.3% forest, 18.7% wetlands, 7.3% grassland/shrub, 0.3% barren land, and 1.9% open water in the Cape Fear River Basin (*Figure 1-8* and *Table 1-2*). Land cover and changes in land cover over time closely follow population patterns across the basin. Developed lands changed the most significantly with over 150 $mi^2$ being developed between 2001 and 2019 in the Cape Fear River Basin, likely from the conversion of forested and agricultural lands which lost 130 $mi^2$ and 67 $mi^2$, respectively, during the same time-period. Grass/shrub cover also increased by 42 $mi^2$ from 2001 to 2019.

Basinwide, there was a 12% increase in development from 2001 to 2019 (152 $mi^2$). Developed areas associated with urban centers surrounding the communities of the Triangle (i.e., Durham, Chapel Hill, Cary, Morrisville, Apex, Holly Springs, Fuquay-Varina) the Triad (i.e., Greensboro, High Point), Burlington, Fayetteville, Wilmington, and other smaller communities are shown in *Figure 1-8*. The most development is located in the upper part of the basin with nearly a quarter (24.4%) of the Haw River subbasin, 18% of the Upper Cape Fear River subbasin, and 15% of the Deep River subbasin developed (*Figure 1-8* and *Table 1-4*). The other subbasins ranged from about 7-10 % development in 2019. The Lower Cape Fear River (19% or 17 $mi^2$), the Haw River (15.9% or 57 $mi^2$) and Upper Cape Fear River (17.6% or 44 $mi^2$) subbasins had the highest percent increase in development from 2001 to 2019. At the HUC10 watershed scale, the

B Everett Jordan Lake-New Hope River watershed (0303000206) which includes the city of Durham and Raleigh suburbs, had the largest increase in development, 24 $mi^2$ from 2001 to 2019. Other watersheds that had a significant increase in development include the Rockfish Creek watershed (0303000406, 17 $mi^2$), where Fayetteville is located, and the Reedy Fork watershed (0303000201, 12 $mi^2$), where Greensboro is located.

Across the state, stormwater in highly developed/urban watersheds is sent directly to storm drains and culverts. Many of the storm drains and culverts empty into the nearest waterbody. Stormwater can pick up and deposit harmful pollutants like trash, chemicals and dirt/sediment and deliver them directly to streams, lakes and rivers. Construction sites, lawns, hazardous waste sites, highways and neighborhood streets are potential sources of stormwater pollutants. This direct delivery of stormwater to a stream can have multiple negative impacts to water quality and aquatic habitat including elevated water temperature, excess erosion due to increased stream velocity, excess nutrients and habitat degradation. Slowing and diverting stormwater from streams can, in some cases, protect waterbodies from severe erosion and sedimentation.

Agriculture is most prevalent in the upper half of the Black (32%) and the Northeast Cape Fear river subbasins (24%) followed by the upper parts of the Deep (19.6%) and Haw (19.9%) river subbasins (*Figure 1-8* and *Table 1-4*). Agricultural has been decreasing basinwide with a 3.6% change decrease in agricultural lands which is equivalent to 67 $mi^2$, since 2001 with the most loss occurring in the Haw (-8.9% and -33 $mi^2$) and Deep (-6.8% and -20.6 $mi^2$) river subbasins. At the HUC10 watershed scale, the Headwaters Deep Creek River watershed (0303000301), also located in the Greensboro area, lost the most agriculture, 8 $mi^2$. Other watersheds that lost more significant agricultural lands include three watersheds located in the Haw River subbasin, Reedy Fork (0303000201, 7 $mi^2$), Big Alamance Creek (0303000203, 6 $mi^2$) and Black Creek-Haw River (303000204, 6 $mi^2$) watersheds.

Forested land cover, like agriculture, has decreased since 2001 by 3.8% (130 $mi^2$). Forested lands are most prevalent in the lower parts of the Deep (55%) and Haw River (47%) subbasins and the Upper Cape Fear River (42%) basin (*Figure 1-8* and *Table 1-4*). The Haw River subbasin has had the largest loss of forested land since 2001, a 5.8%, equivalent of 50 $mi^2$. The Deep and Upper Cape Fear River subbasins lost 2.7% (22 $mi^2$) and 3.7% (26 $mi^2$) of their forested lands, respectively, since 2001. HUC10 watersheds that saw a significant drop in forested land include the Rockfish Creek (12 $mi^2$), Reedy Fork (10 $mi^2$) and Headwaters Deep Creek River (10 $mi^2$) watersheds.

Shrub cover, often formed by early successional forest in silviculture areas or abandoned agricultural lands, and grassland (herb-covered areas) comprise around 7.3% of the land use in the basin and have had some variability in cover change since 2001. Overall, shrub/grassland increased by 6.3% change or 42 $mi^2$ basin wide, likely due to forested land harvests.

Wetlands are most prevalent in the low-lying Middle Atlantic Coastal Plain ecoregion (see *Figure 1-5*) in the lower half of the basin in the Lower Cape Fear (35%), Black (28%), and Northeast Cape Fear (37%) river subbasins (*Figure 1-8* and *Table 1-4*). Many of the Cape Fear wetlands are forested or shrub covered. More information about wetlands in the Cape Fear River Basin can be found in Section *1.7*.

*Table 1-3: Cape Fear River Basin Land Use Land Cover Changes Over Time*

| Land Cover[1] | 2001 | 2004 | 2006 | 2008 | 2011 | 2013 | 2016 | 2019 | Net Change[4] 2001-2019 | % Change[5] 2001-2019 | mi² Change 2001-2019 | Total mi² 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Agriculture** | 21.46% | 21.32% | 21.12% | 21.01% | 20.83% | 20.80% | 20.70% | 20.72% | -0.74% | **-3.55%** | **-67.4** | **1,899.1** |
| **Barren Land[3]** | 0.33% | 0.33% | 0.33% | 0.33% | 0.33% | 0.32% | 0.31% | 0.33% | 0.00% | **-0.18%** | **-0.1** | **30.2** |
| **Developed** | 12.12% | 12.26% | 12.87% | 13.05% | 13.29% | 13.37% | 13.59% | 13.77% | 1.65% | **+12.01%** | **151.5** | **1,262.0** |
| **Forest** | 38.75% | 38.42% | 37.36% | 37.23% | 37.83% | 38.04% | 37.32% | 37.33% | -1.41% | **-3.79%** | **-129.6** | **3,421.4** |
| **Grassland/Shrub** | 6.86% | 7.16% | 7.84% | 7.86% | 7.20% | 6.95% | 7.54% | 7.31% | 0.46% | **+6.25%** | **41.9** | **670.4** |
| **Open Water** | 1.80% | 1.85% | 1.87% | 1.86% | 1.88% | 1.90% | 1.97% | 1.85% | 0.05% | **+2.61%** | **4.4** | **169.7** |
| **Wetlands** | 18.69% | 18.66% | 18.61% | 18.66% | 18.63% | 18.63% | 18.57% | 18.68% | -0.01% | **-0.04%** | **-0.8** | **1,712.3** |
| **Total mi²** | | | | | | | | | | | | **9,165.0** |

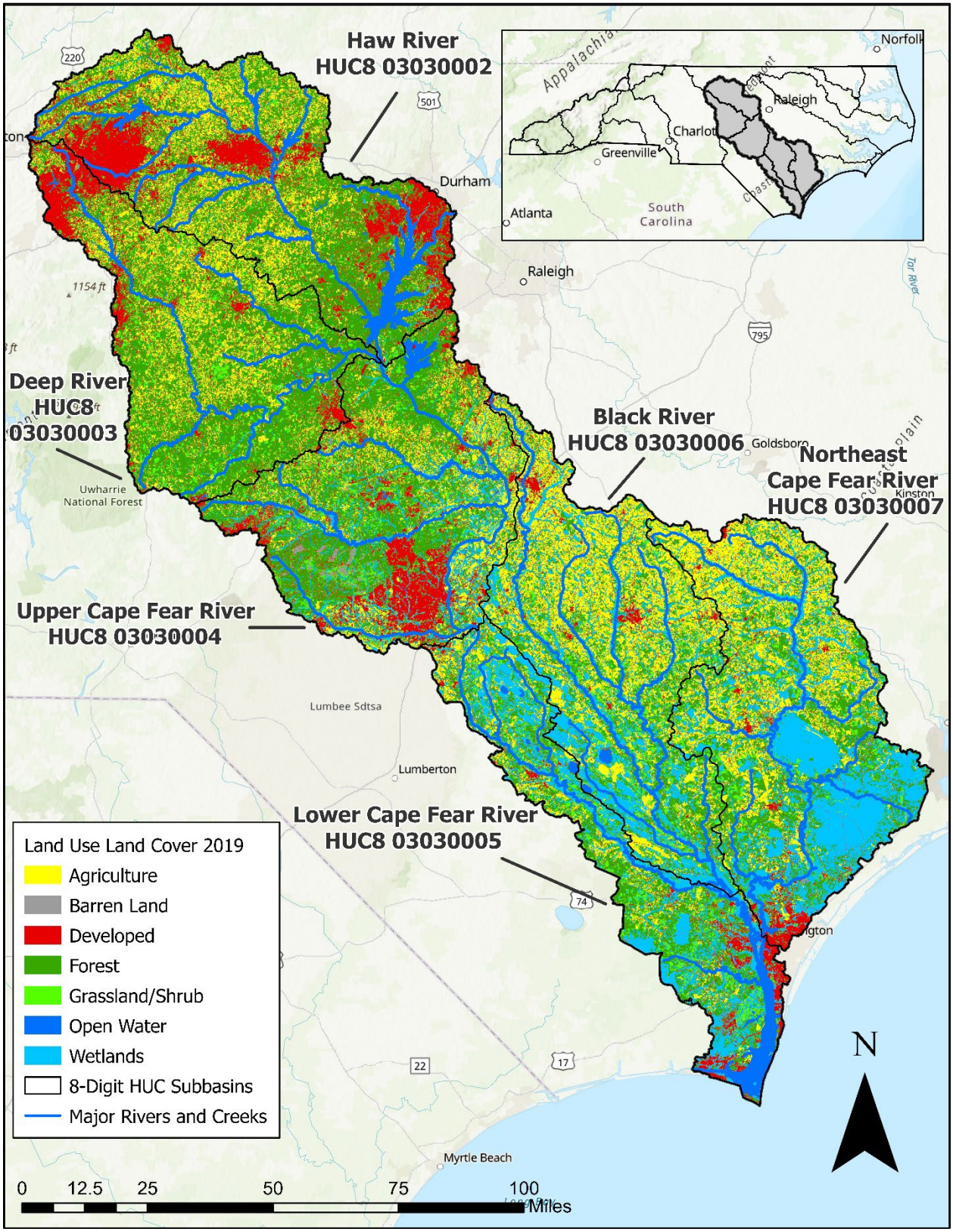
1 Data was downloaded from the Multi-Resolution Land Characteristics NLCD website and processed for the entire Cape Fear River Basin in 2022.
3 Barren Land is a catch-all category for tilled land, new development, cutover, bare rock areas.
4 Net change is the difference between 2019 and 2001 % land cover or (2019% - 2001%).
5 The % Change in square miles and is calculated as [((2019 mi² – 2001 mi²) / 2001 mi²) * 100].

*Table 1-4: Cape Fear 2019 Land Use Land Cover by HUC8 Subbasin*

| HUC8[1] | Subbasin[1] | Agriculture % | Barren[2] % | Developed % | Forest % | Grassland/ Shrub % | Open Water % | Wetlands % |
|---|---|---|---|---|---|---|---|---|
| **3030002** | **Haw** | 19.85% | 0.10% | 24.38% | 47.46% | 3.68% | 2.70% | 1.84% |
| **3030003** | **Deep** | 19.61% | 0.13% | 14.80% | 55.37% | 8.02% | 1.10% | 0.97% |
| **3030004** | **Upper Cape Fear** | 14.72% | 1.18% | 18.16% | 42.12% | 9.34% | 1.59% | 12.89% |
| **3030005** | **Lower Cape Fear** | 10.18% | 0.38% | 9.99% | 28.73% | 9.97% | 5.40% | 35.34% |
| **3030006** | **Black** | 32.12% | 0.06% | 6.73% | 24.20% | 8.03% | 0.77% | 28.08% |
| **3030007** | **Northeast Cape Fear** | 24.25% | 0.13% | 7.06% | 25.02% | 6.14% | 0.70% | 36.71% |
| **Cape Fear Total** | | 20.72% | 0.33% | 13.77% | 37.33% | 7.31% | 1.85% | 18.68% |

[1]Data was downloaded from the Multi-Resolution Land Characteristics NLCD website and processed for each Cape Fear River Basin HUC8s in 2022.
[2] Barren Land is a catch-all category for tilled land, new development, cutover, bare rock areas.

*Figure 1-8: Land Use Land Cover – Cape Fear River Basin (NCLD, 2019)*



### 1.2.3 Growth and Development

Industrial development, particularly mega sites, industrial business parks and data centers are economic and budgetary drivers for local governments across NC. These developments generate substantial capital investments, create large scale temporary construction and permanent operational jobs and provide for increased local and state tax revenue. They are generally followed by incremental regional growth in commercial and residential sectors that demand sufficient public and environmental resources. Substantial growth in demand for water and wastewater capacity has resulted from this growth, with demand also driven by natural population increases. Individually, even well-resourced municipalities experience substantial funding and engineering challenges in maintaining effective, reliable water and wastewater infrastructure, making regionalization – the collective pursuit of water resource financing, maintenance, and distribution – an attractive option for many.

The "US 421 Corridor" region of the of the state – a geographic area stretching from Greensboro into Lee and Chatham Counties – is experiencing rapid growth. In 2023, the NC legislature passed Session Law 2023-134 (Section 12.16.(b)) which directed DEQ to develop a Regional Water and Wastewater Infrastructure Master Plan for the Corridor, mainly in the upper and central portion of the Cape Fear River Basin. DEQ utilized external contractors to deliver the study in under 7 months with the goal of "prioritizing a study of options for the regionalization of water and wastewater systems and making recommendations for long-term economic growth and environmental protection of the region" (Session Law 2023-134).

The study projected growth in water and wastewater demands and flow using the 2022 Local Water Supply Plans, recent and ongoing studies, and information provided by the NC Department of Commerce regarding anticipated growth due to ongoing, rapid economic development. At the time of the report (2024), six incentivized mega site projects were approved or underway within the study area, including: Amgen (Holly Springs), Boom Supersonic (Greensboro), FUJI Diosynth Biotechnologies (Holly Springs), Toyota (Liberty), Wolfspeed (Siler City) and VinFast (Moncure) (DEQ, 2024, section 3).

One major challenge in the study area is nutrient (nitrogen and phosphorus) enrichment, driven by existing and intensifying watershed activities such as municipal and industrial wastewater, stormwater and agricultural runoff. These inputs have overwhelmed the natural assimilative capacity of surface waters in the Cape Fear River Basin. The 421 study incorporated the assumption that the Cape Fear River Basin would likely be subject to nutrient removal criteria by 2050. This assumption guided exploration of how regionalization efforts offer a solution to water and wastewater challenges while also addressing environmental and health issues in the greater Cape Fear River Basin. The regional nature of the study allowed for the evaluation of opportunities for public water and wastewater providers to collaborate to improve efficiencies, reduce costs (routinely in the billions of dollars), improve overall water management and water quality and meet the needs of underserved areas. The study further recommended the integration of water reuse programs to address both water supply demands and increased wastewater loading.

Data center development projects are also increasing across NC. As of October 2025, NC ranked ninth nationally in the number of data centers, with 91 (MacMillian, 2025). Data centers can pose unique environmental challenges, stemming primarily from their traditionally intensive use of water for cooling servers and subsequent management challenges with wastewater and chemical byproducts. The main focus is often on the volume of water consumed through evaporative cooling, but the remaining

"blowdown" wastewater – waste generated by emptying large cooling systems for cleaning and maintenance – can also become a concern. The blowdown wastewater can contain concentrated dissolved minerals, heavy metals and chemicals used to prevent the growth of bacteria, mold and algae (biocides) and prevent corrosion in pipes and cooling towers. There is also the possibility of concentrating emerging contaminants in the waste stream due to the presence of these compounds in the water supply. Occasional proposals from developers to consider direct discharges of treated, non-contact coolant water directly into rivers and lakes can pose further challenges to surface waters, due to both chemical content and discharge temperatures often being above the level of the receiving waters. This can cause biological impairments such as algal blooms.

Fortunately, many of the water quality and quantity concerns surrounding data centers can be overcome by embracing innovative technologies such as closed-loop liquid cooling, water-free cooling systems, and advanced wastewater recycling and treatments. DWR acknowledges that these advanced technologies often come at a higher cost to the data center owner, ultimately passed down to the consumer. However, by encouraging innovative technologies, North Carolina can ensure a sustainable balance between economic and environmental wellbeing.

## 1.3 Point and Nonpoint Source Pollution

Water quality stressors can be caused by point and nonpoint sources of pollution. Individually, a single pollutant source may seem insignificant, but when combined with multiple sources, the impact can cause significant impairments to our water resources. The Supplemental Guide to Basinwide Planning (DWQ 2008) provides additional general information on point and nonpoint sources of pollution.

There are several programs within the DEQ that monitor and regulate point and nonpoint sources of pollution. *Table 1-5* summarizes permitted facilities as of May 2022 in the Cape Fear River. Chapter 3 includes more information on permitting programs and the appendix includes a list of permitted facilities located in the basin.

*Table 1-5: Permitted Facilities in the Cape Fear River Basin (BIMS[1], May 2022)*

| **Number of Permits[1]** | | **Permit Information[1]** | |
|---|---|---|---|
| **NPDES Wastewater Discharge[2]** | | | |
| **Major** | **Minor** | **Permitted As-Built (MGD)** | |
| 50 | 168 | 425.3902 | |
| **Single-Family Domestic Wastewater Discharge** | | | |
| **Number of Permits** | | **Permitted As-Built (MGD)** | |
| 252 | | 0.078305 | |
| **Non-Discharge and Land Application[3]** | | | |
| **Major** | **Minor** | **Field Number** | **Field Acres** |
| 88 | 77 | 1,628 | 21,691.53 |
| **Single-Family Residence Wastewater Irrigation** | | | |
| **Number of Permits** | | **Field Number** | **Field Acres** |
| 251 | | 252 | 79.84 |
| **Stormwater** | | | |
| **State** | **NPDES** | **NPDES Outfalls** | |

| Number of Permits[1] | | Permit Information[1] | |
|---|---|---|---|
| 3,931 | 690 | 1,298 | |
| **Animal Feeding Operations** | | | |
| **Number of Permits** | **Allowable Headcount[4]** | **Allowable Weight[5] (lb)** | **Number of Lagoons/ Waste Ponds** |
| 1,188 | 5,517,021 | 749,509,148 | 2,250 |

[1]Active and expired permitted facilities and associated permit data were queried from the NC DWR Basinwide Information Management System (BIMS) in May 2022. Expired permits remain in effect until a renewed permit is issued by DWR.

[2] Permitted NPDES Discharge facility numbers are based on the number of facilities and as-built totals that discharge to the Cape Fear River Basin. Single-Family Domestic Wastewater Discharge permits were excluded from the NPDES Wastewater Discharge permit numbers and as-built total.

[3]Some permitted fields are associated with facilities located outside of the Cape Fear River Basin. Single Family Residence Wastewater Irrigation permits were excluded from the Non-Discharge and Land Application permit numbers and field acre totals.

[4]Allowable Count is the maximum number of individual animals allowed in the facility/farm at any one time.

[5]Allowable Live Weight represents the total pounds of animal biomass permitted on the facility/farm, calculated by applying a conversion factor to the number of animals based on USDA-NRCS guidelines based on animal type and life stage of the animals grown.

## 1.4 Point Source Pollution

Point source pollution refers to pollution that enters surface waters through "any discernable, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container" (US EPA, 2019). Point source pollutants are primarily associated with wastewater and stormwater discharges from municipal (city and county) and industrial wastewater treatment facilities. They can also originate from small, domestic wastewater systems that serve schools, commercial properties, residential subdivisions, and individual homes.

To ensure that point source pollution does not negatively impact water quality or human health, wastewater and stormwater point source pollutants are regulated through the National Pollutant Discharge Elimination System (NPDES) program. The NPDES permitting program sets monitoring and treatment requirements for facilities discharging wastes directly to surface waters (US EPA, 2019). The program also keeps records of the spatial location of point sources of pollution. This information from the NPDES program can be assessed alongside ambient water quality data to ensure that both permit requirements are being met and are sufficient to protect the water quality of receiving waterbodies.

As of May 2022, there are 218 NPDES wastewater discharge permits (50 major and 168 minor) and 690 NPDES stormwater permits in the Cape Fear River Basin (*Table 1-5*). More information about permitted programs can be found in the Permitted and Registered Activities chapter (Chapter 3).

### 1.4.1 Wastewater Effluent

Sanitary sewer systems collect and transport domestic, commercial, and industrial wastewater to wastewater facilities for treatment (i.e., removal of solids, human waste, bacteria, etc.). In some cases, stormwater and groundwater can infiltrate sanitary sewer systems. When this happens, the volume of water being transported to and entering a treatment facility increases, potentially resulting in a Sanitary Sewer Overflow (SSO). SSOs occur when raw sewage is released. SSOs happen for a variety of reasons, including blockages, sewer line breaks, power failures, extreme weather events, and vandalism and can

contaminate our water resources. In some instances, an SSO can cause wastewater to flood homes, causing property damage and threatening public health. DEQ has an on-line application to track SSOs that occurred after August 2022 [DEQ DWR Sanitary Sewer Overflow Reports].

In North Carolina per General Statute 143-215.1C, an SSO spill of domestic or municipal waste of over 1,000 gallons or a spill regardless of size that reaches surface waters must be reported as soon as possible to DWR but not more than 24 hours after the event was reported. In addition, a press release to the public is required within 24 hours. Since this is a self-reporting system to DEQ, it is possible that not all spills are reported.

### 1.4.2 Single-Family Domestic Wastewater System

Single-family domestic wastewater systems are installed when soil types preclude the installation of a traditional septic system. These systems require a general permit (NCG550000) from NPDES for discharges less than 1,000 gallons per day (gpd) of treated domestic wastewater to surface waters. Provisions are also in place for systems that discharge 3,000 gpd. The maintenance (and cost) of these systems is different than an onsite wastewater septic system and property owners may need to be educated on the associated costs and care for these treatment systems. Because ownership changes constantly, some property owners may not even be aware that they have a permitted NPDES effluent discharge on their property. Current North Carolina real estate disclosure forms do not have a check box option for single-family domestic wastewater treatment systems; however, septic systems are disclosed. When homes are sold, information about the treatment system is not always conveyed unless by word of mouth from seller to buyer. As of May 2022, there were 252 of these permits in the Cape Fear River Basin (see *Table 1-5*), primarily concentrated in Chatham, Orange, and Durham counties.

*There is a need for homeowner education on how to properly maintain and operate single-family wastewater treatment systems to reduce their impact on water quality. Connecting single-family NPDES waste management systems to regional wastewater facilities* would likely improve water quality as many of these systems are not well maintained and are known to contribute nutrient and bacterial loading to local streams and to Jordan Lake. For NCG550000 general permit operation and maintenance information see the October 2020 DEQ technical bulletin and the NPDES general permits website.

## 1.5 Nonpoint Source Pollution

Nonpoint source pollution (NPS) is defined as “any source of water pollution that does not meet the legal definition of “point source” in Section 502(14) of the Clean Water Act (CWA)” (US EPA, 2020). NPS can result from any number of activities and land uses. Construction and land clearing activities, agriculture, golf courses, mining operations, solid waste disposal sites, urban landscapes, and on-site wastewater treatment systems (septic systems) all contribute to NPS and can add sediment, nutrients, bacteria, heavy metals, oil, and grease to a waterbody. Stream habitat degradation and impairments to fish and benthic communities are increasingly obvious in urban and suburban areas where large impervious surface areas result in greater stormwater runoff, higher peak flows and lower baseflows.

NPS is difficult to monitor and account for. DWR works with several state and local agencies to identify potential NPS and the types of activities that may be impacting water quality in the area, but data gaps exist. These unknowns include, but are not limited to, the amounts of fertilizers, pesticides, herbicides,

and dry-litter animal waste applied to land, as well as the level at which these same pollutants may be impacting groundwater and air quality and eventually reaching surface waters through base flow or atmospheric deposition.

There are several programs in place through various organizations that protect water resources from NPS. Many include funding for best management practices (BMPs) that can reduce the amount of sediment, nutrients, and bacteria entering a waterbody, as well as protect streambanks, reduce erosion, and manage waste. More information about these programs can be found in the Statewide, Regional and Local Initiatives chapter (Chapter 4).

### 1.5.1 Agriculture

Based on the 2019 NLCD data, approximately 21% of the land use in the Cape Fear River Basin is identified as agriculture (*Table 1-3*). Excess nutrients, pesticides, herbicides, bacteria, and sediment are often associated with agricultural activities in a watershed. To understand how agriculture has changed over the past 10 to 15 years, the United States Department of Agriculture (USDA) National Agricultural Statistic Service's (NASS) Census of Agriculture was reviewed. The Census of Agriculture is published every five years by the USDA. The data collected by and reported in the census provide an overview of agricultural operations on a national, state, county, or county equivalent scale to show the importance and value of agriculture to a particular region. It is a complete count of farms/ranches in the United States and the people that operate them. It can be used to help evaluate historic agricultural trends to formulate policies, develop programs, and identify and allocate local and national funds for agricultural programs. Any rural or urban farm/ranch that grows fruit, vegetables, or a food animal is counted if $1,000 or more of such products were raised and sold or normally would have been raised or sold during a census year (USDA, 2017).

Information about the number and types of animal operations, farm crops, and treatments for 2007, 2012, 2017 and 2022 was obtained from the USDA's National Agricultural Statistics Service (NASS) Quick Stats (USDA, 2024) for 15 counties located in the Cape Fear River Basin. Counties queried have greater than 45% land area in the Cape Fear River Basin. These include Alamance, Bladen, Brunswick, Chatham, Cumberland, Duplin, Guilford, Harnett, Lee, Moore, New Hanover, Orange, Pender, Randolph, and Sampson counties. Per the 2022 USDA Census of Agriculture, a total of 9,362 farm operations consisting of a total of 1,593,062 acres (2,489 $mi^2$) are located in these counties (*Table 1-6*). While most of the land area in Hoke County is located in the Cape Fear River Basin, it was not included in the query. Much of the county land area in Hoke County is occupied by Fort Liberty Military Reservation.

The number of farms and acres, as well as the number of animals have varied between the four census years (*Table 1-6*, *Table 1-7* and *Table 1-8*). The total number of chickens (inventory) in the basin fluctuated but remained relatively constant between the 2007, 2012, and 2017 census years with a 1.7% increase in chicken inventory numbers between 2007 and 2017. There was however a large increase of about a 40% in chicken inventory numbers between 2017 and 2022 with a total of almost 76 million chickens in inventory on December 31, 2022 (*Table 1-6* and *Table 1-7*). The total number of chicken farm operations reporting inventory increased by 958 farms, increasing from 1,506 in 2007 to 2,464 farms in 2022 (64% increase)(*Table 1-7*). The number of chickens reported in inventory in the Cape Fear River Basin represents

36% of the total NC statewide chicken inventory (209.6 million) and 24% of the total chicken farm operations reporting inventory in 2022 (*Table 1-7*).

Sampson, Duplin, Bladen, and Randolph counties contain 51.7% of the total number of acres for the 15 counties queried. In most cases, these same four counties contained the highest density of crop and animal numbers. In 2022, Duplin and Sampson counties reported the most chicken (broilers, layers, pullets and roosters) inventory basinwide (22 million and 19.2 million, respectively) (*Figure 1-9*), which is approximately 54% of the total 76 million chickens in inventory reported in the Cape Fear River Basin on December 31, 2022. Duplin County also had the highest reported number in production (96 million) followed by Sampson (76.8 million) and Randolph (43.1 million) counties (*Figure 1-10*).

The Cape Fear River basin reported a total turkey inventory of 6.4 million which represented 41% of the statewide turkey inventory (15.5 million) report on the 2022 USDA Census of Agriculture (*Table 1-7*). Sampson County had the highest turkey inventory (3.3 million) as well as production with contracts (9.2 million) reported (*Figure 1-11* and *Figure 1-12*).

The overall number of farms reporting Swine/Hog inventory and production numbers declined in 2022 in the Cape Fear River Basin (*Table 1-7*). The total swine inventory reported in 2022 was 4.9 million head, which represents 62% of the NC statewide total of 7.9 million head. Duplin and Sampson counties reported (2022) the highest number of swine inventory basinwide and statewide, with a combined total of 3.7 million head (76% of the basin total, 47% of the statewide total) (*Figure 1-13*). The total swine production numbers reported in 2022 was 14.8 million head which is 62% of the statewide total of 23.76 million head (*Table 1-7* and *Figure 1-14*). Duplin and Sampson county production totals (11.7 million) account for 79% of the basinwide and 49% of the statewide production totals.

Cattle farms are more prevalent in the Piedmont and upper portion of the Cape Fear River Basin (*Figure 1-15*). The number of Cattle in the Cape Fear River Basin accounts for 24% of the NC statewide inventory. In 2022, Randolph and Chatham counties combined had over 74,000 head of cattle (42.7% of the basinwide total and 10.4% of NC statewide totals). Additional tables and figures showing the distribution of crops and animals across the 15 counties can be found in the appendix.

*Table 1-6: Total number of operations, acres, crops, and animals for counties located in the Cape Fear River Basin (USDA, 2022)*

| Data Items | Number of Operations | | | | Number of Acres | | | |
|---|---|---|---|---|---|---|---|---|
| | 2007 | 2012 | 2017 | 2022 | 2007 | 2012 | 2017 | 2022 |
| TOTAL FARM OPERATIONS | 10,769 | 10,251 | 9,624 | 9,362 | 1,619,081 | 1,567,174 | 1,611,622 | 1,593,062 |
| **ANIMALS** | **Number of Operations** | | | | **Inventory** | | | |
| TOTAL CATTLE | 4,074 | 4,097 | 3,906 | 3,316 | 208,810 | 208,128 | 183,993 | 174,225 |
| TOTAL HOGS/SWINE | 1,185 | 817 | 910 | 885 | 5,874,892 | 4,762,023 | 5,111,355 | 4,924,165 |
| TOTAL TURKEYS | 326 | 310 | 249 | 284 | 9,129,571 | 10,023,276 | 7,328,558 | 6,430,041 |
| TOTAL CHICKENS[1] | 1,506 | 1,727 | 2,086 | 2,464 | 53,361,938 | 47,429,276 | 54,286,271 | 75,983,865 |
| **CROP/COMMODITY** | **Number of Operations** | | | | **Number of Acres** | | | |
| TOTAL CORN | 1,790 | 1,309 | 1,125 | 1,089 | 205,925 | 141,780 | 157,949 | 162,438 |
| TOTAL COTTON | 148 | 197 | 94 | 108 | 47,410 | 65,766 | 27,660 | 35,190 |
| TOTAL HAY & HAYLAGE | 3,855 | 3,830 | 3,658 | 3,236 | 161,363 | 144,670 | 143,715 | 139,216 |
| TOTAL SOYBEANS | 1,515 | 1,510 | 1,364 | 1,088 | 206,525 | 223,484 | 258,144 | 242,647 |
| TOTAL TOBACCO | 508 | 338 | 287 | 181 | 37,538 | 32,801 | 35,422 | 23,958 |
| TOTAL WHEAT | 594 | 886 | 458 | 430 | 69,293 | 119,416 | 55,168 | 65,414 |

[1] Poultry Inventory includes broilers, pullets, layers, and roosters.

*Table 1-7: Total number of farms and animals for chicken, turkey, swine/hogs and cattle (reported in the 2022 USDA Census of Agriculture for the 15 counties located in the Cape Fear River Basin). Including change between 2007 and 2022 and percent of statewide 2022 census animal totals.*

| Animal Type[1] | 2007 | 2012 | 2017 | 2022 | Change from 2007 to 2022 | Percent Change from 2007 to 2022 | 2022 Statewide USDA Animal Totals | 2022 CFRB Percent of Statewide Totals |
|---|---|---|---|---|---|---|---|---|
| **Chickens[4] Inventory[2]** | 53,361,938 | 47,429,276 | 54,286,271 | 75,983,865 | +22,621,927 | + 42.39 % | **209,561,611** | 36.26 % |
| **Chickens[4] Inv. Operations** | 1,506 | 1,727 | 2,086 | 2,464 | +958 | + 63.61 % | **10,195** | 24.17 % |
| **Chickens[5] Production[3]** | 243,683,545 | 226,125,275 | 242,082,775 | 332,177,146 | +88,493,601 | + 36.31 % | **966,345,547** | 34.37 % |
| **Chickens[5] Prod. Operations** | 661 | 566 | 566 | 687 | +26 | + 3.93 % | **2,124** | 32.34 % |
| | | | | | | | | |
| **Turkey Inventory[2]** | 9,129,571 | 10,023,276 | 7,328,558 | 6,430,041 | -2,699,530 | - 29.57 % | **15,516,238** | 41.44 % |
| **Turkey Inv. Operations** | 326 | 310 | 249 | 284 | -42 | - 12.88 % | **791** | 35.90 % |
| **Turkey Production[3]** | 32,224,319 | 30,909,194 | 18,189,783 | 17,323,609 | -14,900,710 | - 46.24 % | **37,504,418** | 46.19 % |
| **Turkey Prod. Operations** | 302 | 239 | 152 | 132 | -170 | - 56.29 % | **298** | 44.30 % |
| | | | | | | | | |
| **Swine[6] Inventory[2]** | 5,874,892 | 4,762,023 | 5,111,355 | 4,924,165 | -950,727 | - 16.18 % | **7,927,842** | 62.11 % |
| **Swine[6] Inv. Operations** | 1,185 | 817 | 910 | 885 | -300 | - 25.32 % | **2,492** | 35.51 % |
| **Swine[6] Production[3]** | 19,052,749 | 12,573,032 | 14,000,328 | 14,757,073 | -4,295,676 | - 22.55 % | **23,752,768** | 62.13 % |
| **Swine[6] Prod. Operations** | 848 | 527 | 578 | 549 | -299 | - 35.26 % | **910** | 60.33 % |
| | | | | | | | | |
| **Cattle[7] Inventory[2]** | 208,810 | 208,128 | 183,993 | 174,225 | -34,585 | - 16.56 % | **718,631** | 24.24 % |
| **Cattle[7] Inv. Operations** | 4,074 | 4,097 | 3,906 | 3,316 | -758 | - 18.61 % | **14,980** | 22.14 % |

[1] Animal Type was queried for 15 counties with >45% land coverage in the Cape Fear River Basin. Excludes Hoke County.
[2] USDA Inventory numbers represent a point in time (End of December) when the Census data was collected.
[3] USDA Production Contract numbers are "totals for the portion of agriculture production raised and delivered under production contract" (USDA, 2017). Production Contract and Inventory represent different data items and should not be combined.
[4] Chicken Inventory includes broilers, pullets, layers, and roosters. [5] Chicken Production includes broilers, layers, and pullets for 2012 to 2022 and boilers and pullets for 2007.
[6] Swine includes Hogs, Inventory (Total). There are no new or expanding permitted swine (hog) operations in the basin. The numbers reported here are most likely associated with farms that are below the animal threshold defined under North Carolina's General Statute 143-215.10B and are deemed permitted.
[7] Cattle Inventory includes Catte, Including Calves (Total)

*Table 1-8: Total number of farms and acres by county (USDA, 2022)*

| County | Operations (2007) | Acres (2007) | Operations (2012) | Acres (2012) | Operations (2017) | Acres (2017) | Operations (2022) | Acres (2022) | Change in Acres 2007 to 2022 | Percent Change in Acres 2007 to 2022 |
|---|---|---|---|---|---|---|---|---|---|---|
| ALAMANCE | 753 | 87,888 | 732 | 83,551 | 720 | 80,042 | 724 | 68,769 | -19,119 | -21.75 |
| BLADEN | 500 | 127,171 | 492 | 117,323 | 512 | 180,340 | 423 | 146,195 | +19,024 | 14.96 |
| BRUNSWICK | 264 | 44,084 | 254 | 45,442 | 231 | 44,693 | 238 | 45,150 | +1,066 | 2.42 |
| CHATHAM | 1,089 | 104,171 | 1,138 | 111,778 | 1,116 | 105,995 | 1,076 | 114,051 | +9,880 | 9.48 |
| CUMBERLAND | 500 | 88,353 | 389 | 82,317 | 336 | 65,995 | 327 | 65,919 | -22,434 | -25.39 |
| **DUPLIN** | **1,159** | **248,026** | **940** | **230,925** | **820** | **243,098** | **949** | **254,164** | **+6,138** | **2.47** |
| GUILFORD | 963 | 96,519 | 962 | 90,750 | 854 | 76,352 | 775 | 94,798 | -1,721 | -1.78 |
| HARNETT | 727 | 111,770 | 797 | 119,775 | 643 | 106,262 | 563 | 109,179 | -2,591 | -2.32 |
| LEE | 272 | 36,210 | 246 | 39,081 | 250 | 35,170 | 264 | 31,204 | -5,006 | -13.82 |
| MOORE | 804 | 80,075 | 718 | 82,462 | 733 | 89,375 | 802 | 106,258 | 26,183 | 32.70 |
| NEW HANOVER | 73 | 4,416 | 50 | 2,881 | 59 | 879 | 60 | 1,898 | -2,518 | -57.02 |
| ORANGE | 604 | 60,057 | 645 | 56,666 | 686 | 69,908 | 687 | 53,068 | -6,989 | -11.64 |
| PENDER | 357 | 61,571 | 335 | 55,775 | 336 | 64,484 | 354 | 78,903 | +17,332 | 28.15 |
| RANDOLPH | 1,501 | 147,316 | 1,486 | 156,813 | 1,368 | 147,781 | 1,238 | 131,301 | -16,015 | -10.87 |
| **SAMPSON** | **1,203** | **321,454** | **1,067** | **291,635** | **960** | **301,248** | **882** | **292,205** | **-29,249** | **-9.10** |
| **TOTALS** | **10,769** | **1,619,081** | **10,251** | **1,567,174** | **9,624** | **1,611,622** | **9,362** | **1,593,062** | **-26,019** | **-1.61** |

Throughout the years, numerous complaints have been reported to DEQ about animal agriculture and its impacts to the environment and public health. In May 2018, NC DEQ entered into a Settlement Agreement with the NC Environmental Justice Network (NCEJN), the Rural Empowerment Association for Community Help (REACH), and the Waterkeeper Alliance to "improve regulatory oversight of swine operations and better protect neighboring communities from health and environmental impacts." In May 2020, a preliminary report for the Cape Fear River Animal Feeding Operations Monitoring Study was included in Appendix G of the *Title VI: Increasing Equity, Transparency, and Environmental Protection in the Permitting of Swine Operations in North Carolina* report. The report evaluated water sample data collected from eleven surface water quality monitoring stations in Duplin and Pender counties and represents monitoring results from April 2018 to October 2019. One reference station was located in the Harrisons Creek watershed in Pender County. The remaining 10 stations were located in watersheds with high concentrations of permitted swine animal feeding operations (AFOs). Seven were in the Stocking Head Creek watershed, one was in the Rockfish Creek watershed, one was in the Muddy Creek watershed, and one was located in the Six Runs Creek watershed. More information about each of these watersheds can be found in the Northeast Cape Fear River subbasin chapter (Chapter 11).

*Figure 1-9: 2022 USDA Census of Agriculture Chicken Inventory*

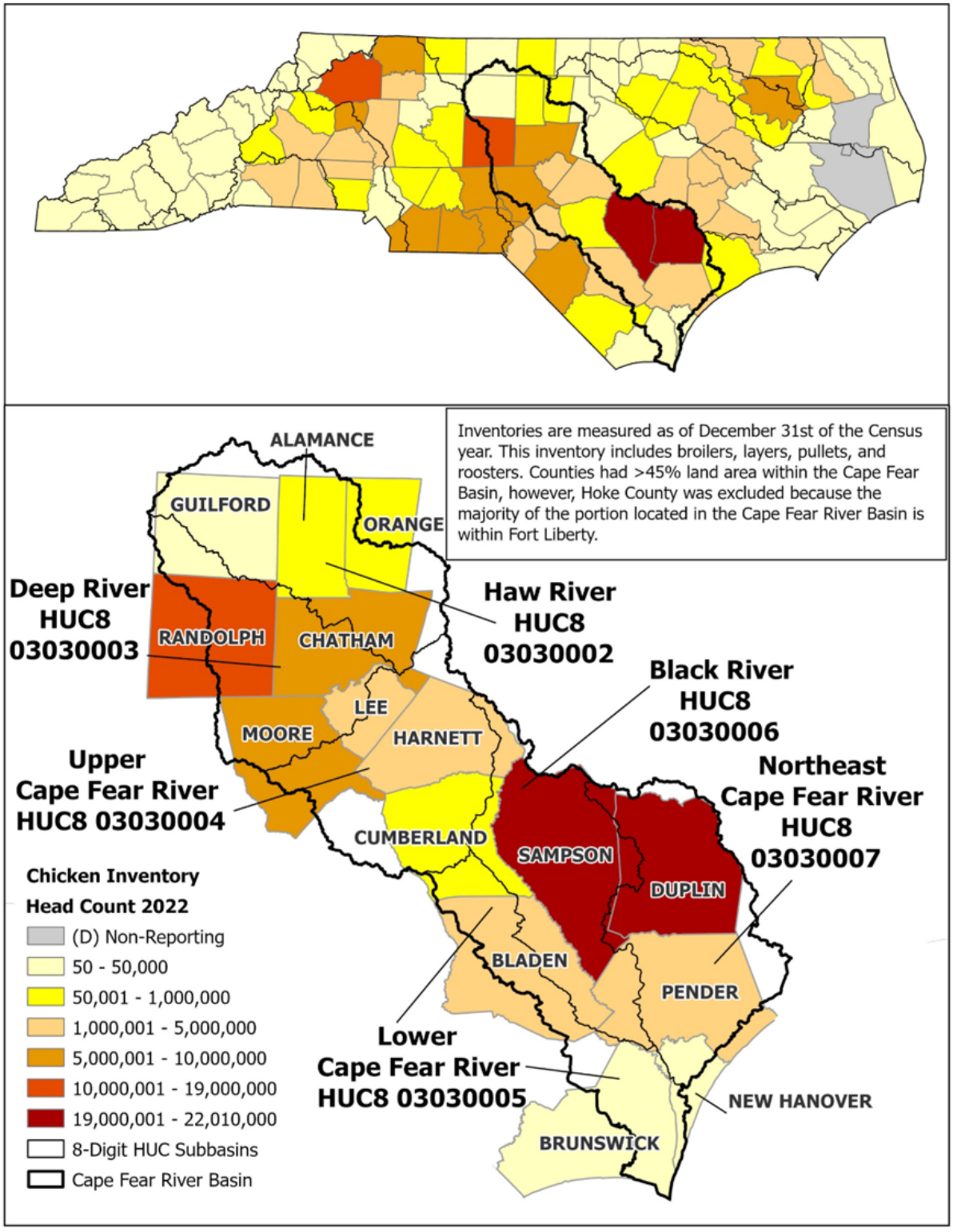


*Figure 1-10: 2022 USDA Census of Agriculture Chicken Production*

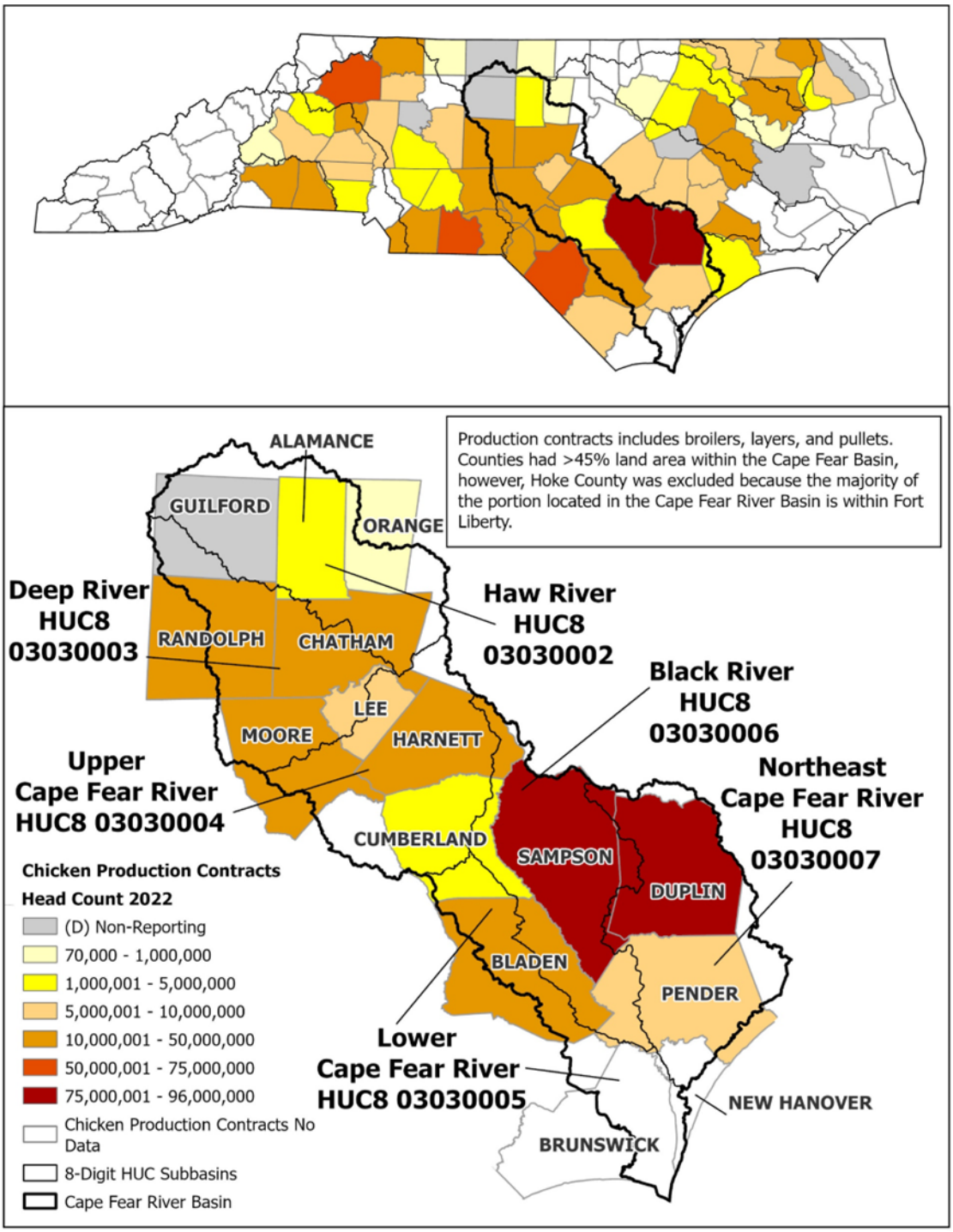


*Figure 1-11: 2022 USDA Census of Agriculture Turkey Inventory*

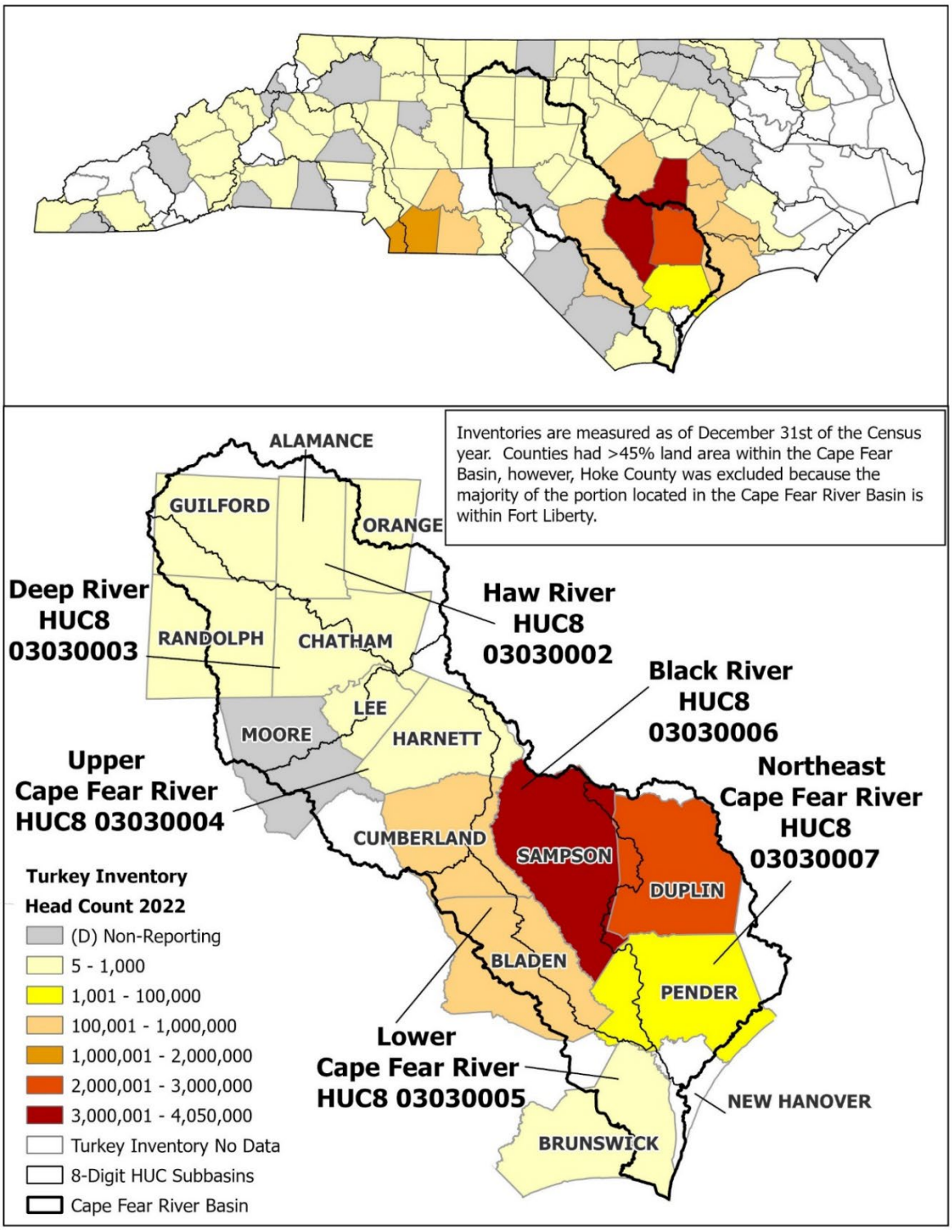


*Figure 1-12: 2022 USDA Census of Agriculture Turkey Production*

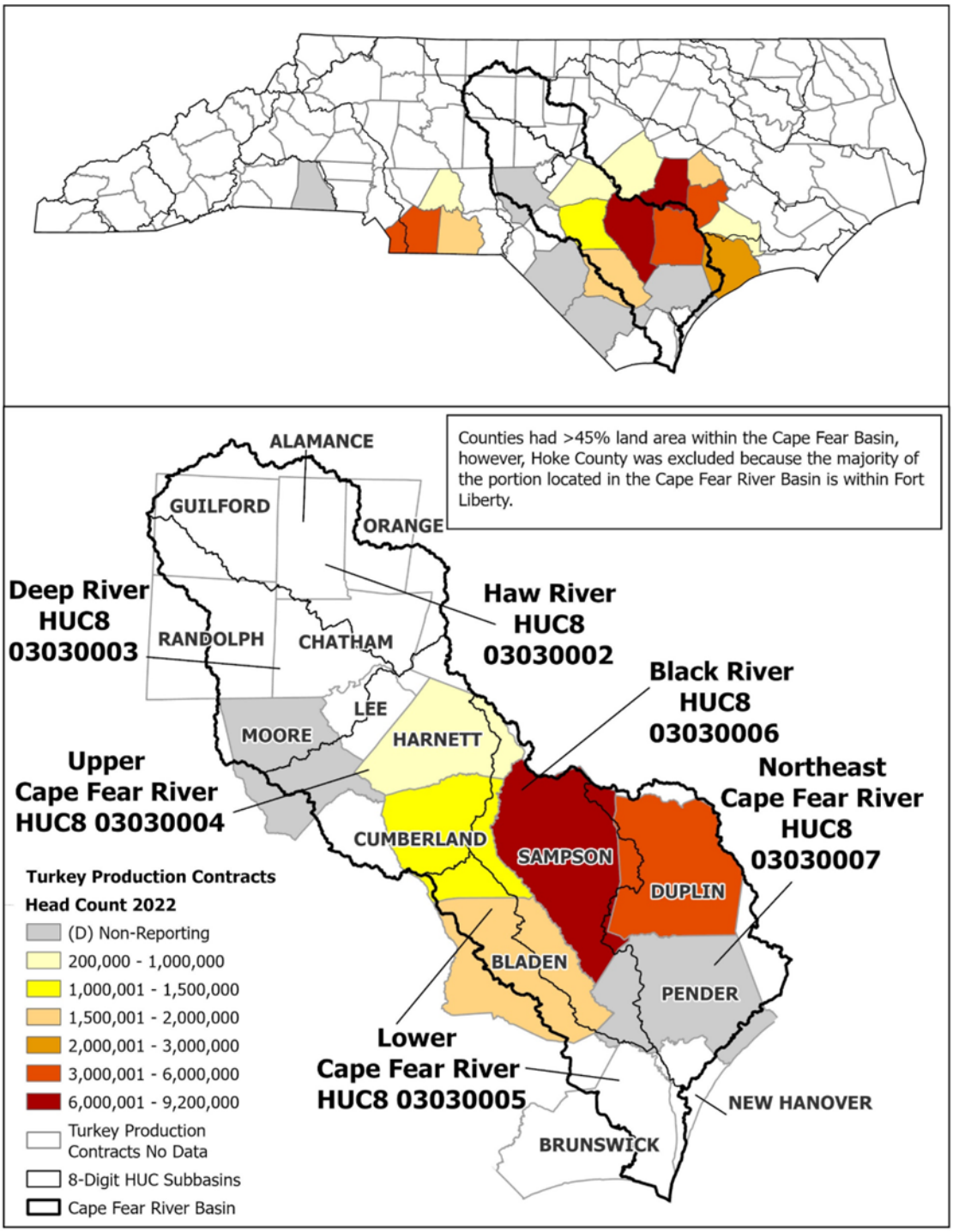


*Figure 1-13: 2022 USDA Census of Agriculture Swine (Hog) Inventory*

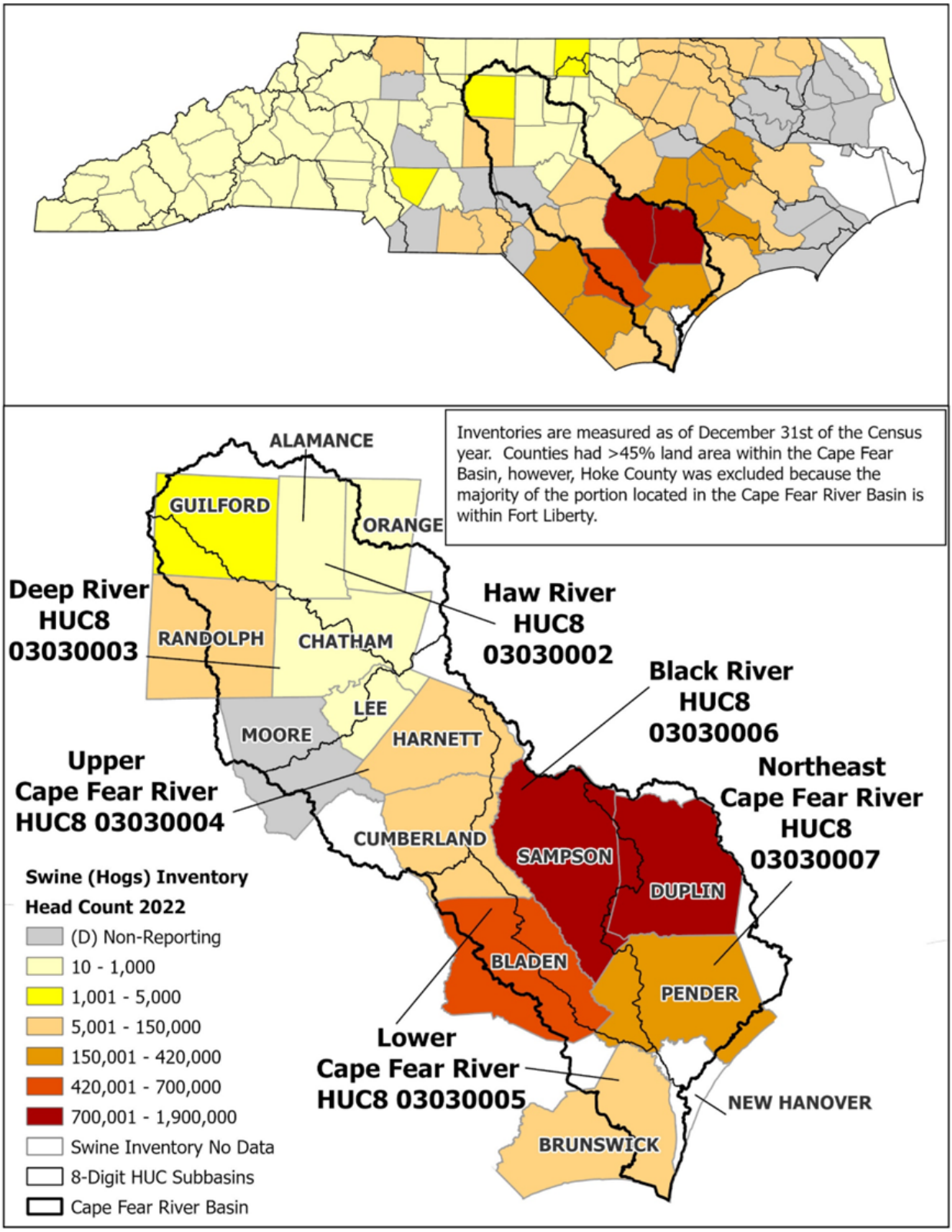


*Figure 1-14: 2022 USDA Census of Agriculture Swine (Hog) Production*

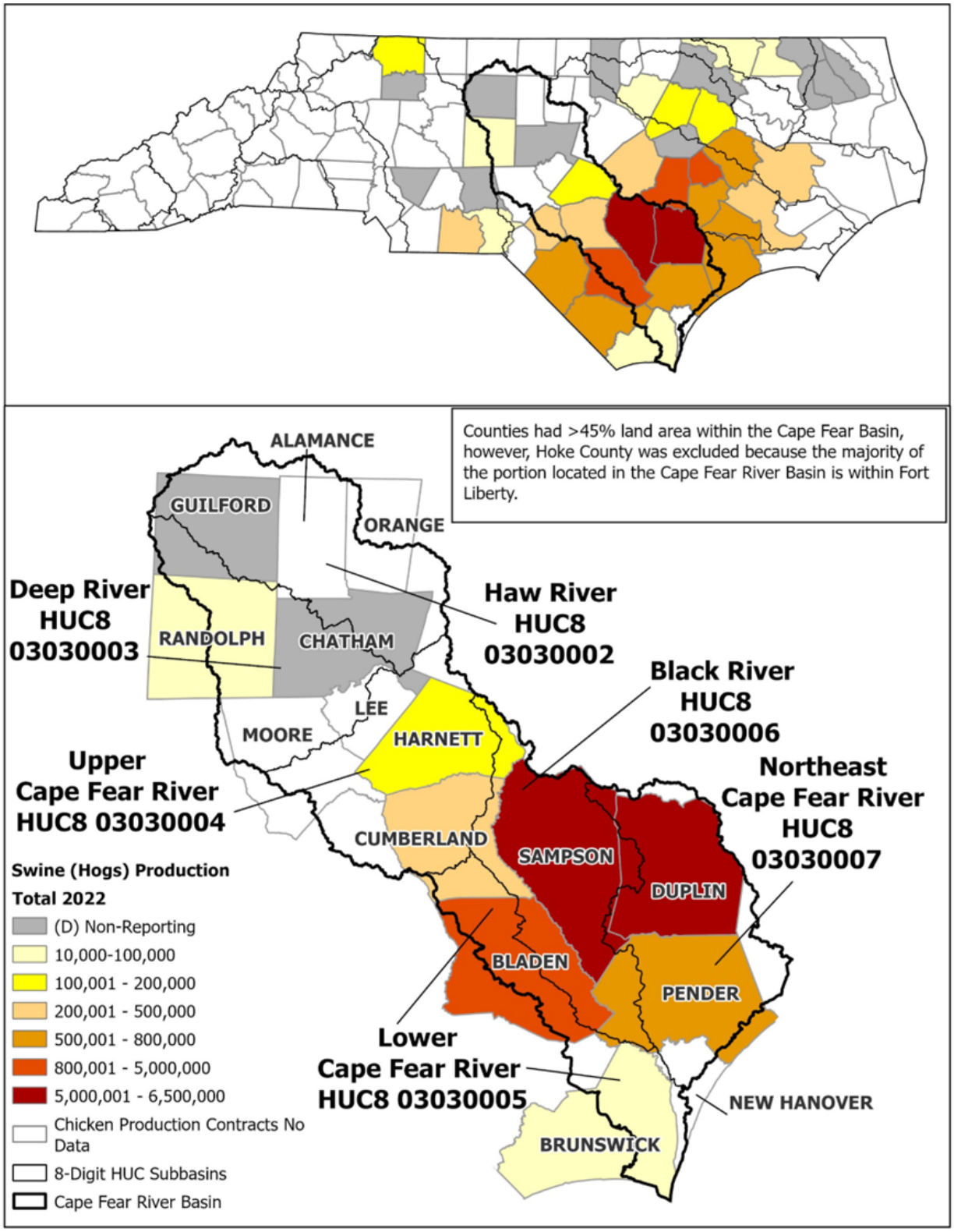
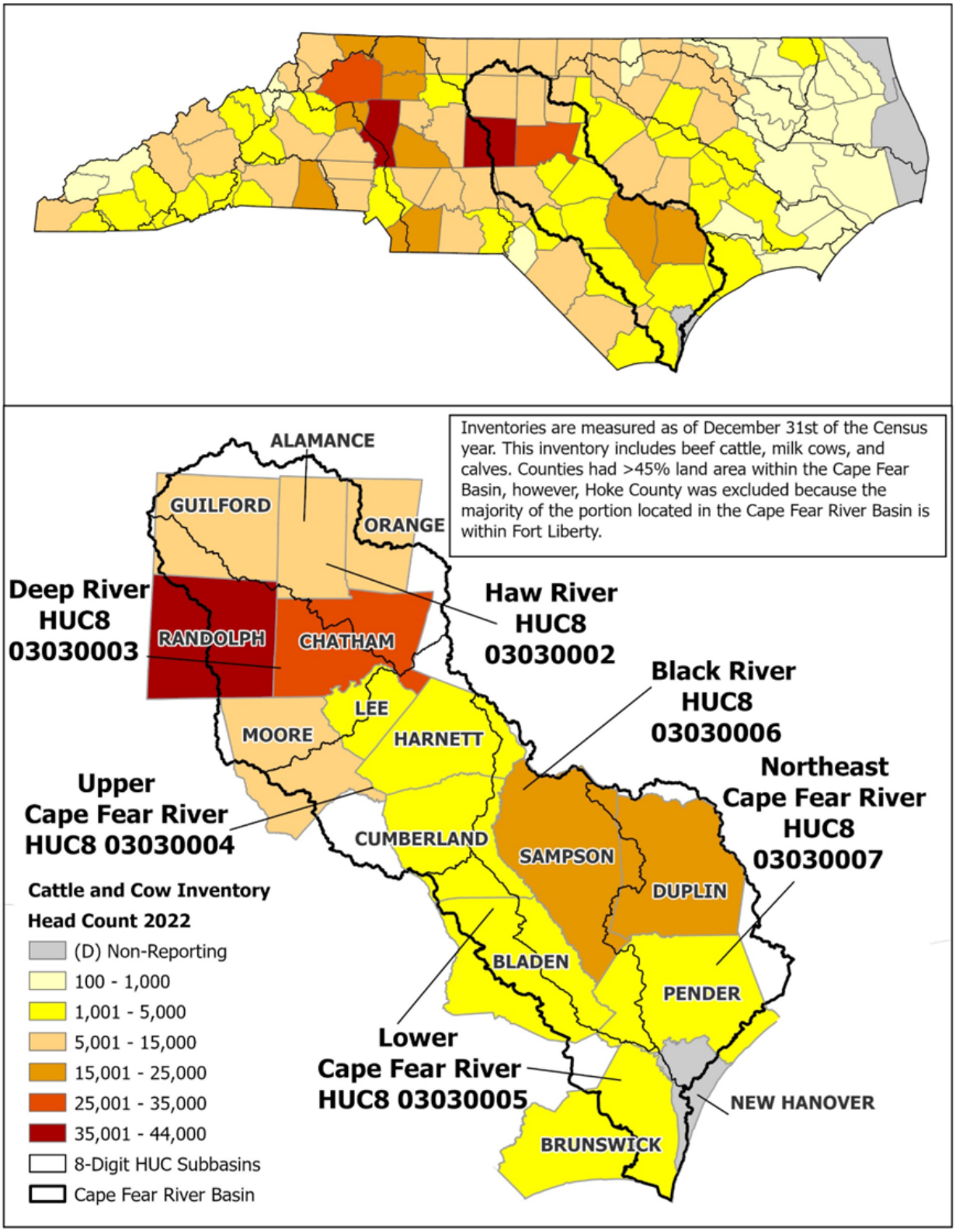


*Figure 1-15: 2022 USDA Census of Agriculture Cattle Inventory*



The results of the preliminary study report indicated that the nutrient and pathogen concentrations are generally significantly higher for the monitoring stations located in the watersheds with high concentrations of AFOs when compared to the reference station in Harrisons Creek where there are no permitted AFOs. More information is needed about the source of the nutrients and pathogens, but source identification can be difficult. DWR is working to identify the next step to take when resources allow. A new, permanent water quality monitoring station was established in Stocking Head Creek (B9245000). The station was incorporated in DWR's Ambient Monitoring System (AMS). Data continues to be collected and used to assess water quality.

Many of the animal operations identified in the Census of Agriculture are "deemed permitted". Operations that are deemed permitted have fewer animals than what the state requires to obtain a permit, or they have a waste management system that does not require a state or federal permit. Under North Carolina Administrative Code (NCAC) 15A NCAC 02T .0103, "deemed permitted" is defined as "a facility that is considered to have a needed permit and to be in compliance with the permitting requirements of General Statute 143-215.1(a) even though it has not received an individual permit for its construction or operation."

Most poultry operations in North Carolina use a dry waste management system. Because of this, they are considered deemed permitted under current statutes and are often referred to as dry litter poultry operations. Per agricultural statistics and the North Carolina Poultry Federation, poultry is one of the top agricultural industries in North Carolina, ranking second in the nation for total turkey production and third in the nation for total poultry production (Poultry Federation, 2021). Owners or operators of dry litter poultry operations with 30,000 or more birds are required to adhere to rules set forth under 15A NCAC 02T .1303 and General Statute 143-215.10C (*Table 1-9*). These requirements include minimum stream setbacks, testing, and land application rates. This information is included in a waste utilization plan (WUP) [also known as a nutrient management plan (NMP)]. Per statute, records must be maintained on the farm for three years. Records must include the waste type, amount, soil and waste analysis, and location of where waste is land applied. The WUPs are not submitted to DWR for review.

There are statutes and rules in place that require that the application of animal waste be made at agronomic rates. Per statute, nitrogen shall be the rate-determining nutrient, but phosphorus shall also be evaluated according to the nutrient management measure approved by the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) and Natural Resources Conservation Service (NRCS). In cases where phosphorus needs to be limited, phosphorus shall be the rate-determining nutrient (General Statute 143-215.10C). If not effectively utilized by vegetation, nutrients (nitrogen and phosphorus) can enter surface water by atmospheric deposition, groundwater transport, and stormwater runoff. Fecal material or bacteria can also be transported to nearby waterbodies during rain and runoff events. Research from North Carolina State University (NCSU) estimates that the amount of nitrogen utilized by plants is generally between 30% and 75% of the applied nitrogen and will vary depending on the crop and soil types, as well as the season (Osmund, 2018). Excess nutrients and bacteria in surface water can impact aquatic ecosystems. It can also impact the type and amount of treatment required to ensure that water is safe for human consumption. Similar nutrient impacts can often be seen downstream of non-discharge waste sludge application fields.

*Table 1-9: Federal and state rules and regulations for animal waste management*

| Federal | State | |
|---|---|---|
| | **Animal Feeding Operations (AFO): Swine, Cattle, Wet Poultry** | **Deemed Permitted Animal Operations: Dry Litter Poultry Operations** |
| Concentrated Animal Feeding Operations (CAFOs) are required to obtain NPDES permit if discharge to waters of the US (40 CFR 122.23). | **15A NCAC 02T .1305: NPDES Permitting Requirements.** Applies to animal waste management systems subject to regulations. | **15A NCAC 02T .1305: NPDES Permitting Requirements.** Applies to animal waste management systems subject to regulations. |
| States can be granted the authority to designate AFOs as CAFOs for permitting (40 CFR 123.25) | **143-215.10C: Applications and permits for animal waste management systems.**<br><br>**15A NCAC 02T .1304: State Permitting Requirements.** Applies to animal waste management systems that meet the definition of an animal operation (more than 250 swine, 100 confined cattle, 75 horses, 1,000 sheep, or 30,000 confined poultry with a liquid waste management system).<br><br>• Waste Utilization Plan (WUP) developed by a Certified Technical Specialist and submitted to DWR.<br>• Apply waste at agronomic rates.<br>• 25-foot setback from perennial waterbodies for land application.<br>• Soil test every three years.<br>• Manure storage has specific requirements and management measures.<br>• Annual inspections by DWR. | **143-215.10C: Applications and permits for animal waste management systems.**<br><br>**15A NCAC 02T .1303: Permitting by Regulation.** Applies to deemed permitted operations (animal operations that do not meet the criteria of an animal operation). Poultry operations with more than 30,000 birds and have dry litter waste must:<br><br>• Develop and maintain a Waste Utilization Plan (WUP) (Nutrient Management Plan). Recommended but not required that the WUP be developed by a Certified Technical Specialist. Not submitted to DWR.<br>• Apply waste at agronomic rates.<br>• 25-foot setback from perennial waterbodies for land application.<br>• Cannot be stockpiled within 100 feet of perennial waterbodies or wells.<br>• Soil test every three years.<br>• Stockpiled litter shall not be left uncovered for 15 days.<br>• No routine inspections. |

Due to the cost of hauling liquid or solid waste long distances, cattle and swine wastes are mostly applied to fields near where the waste is generated. Consequently, growers supervising cattle or swine production typically oversee the application of waste generated from their operation on nearby agricultural land owned or leased for this purpose. Dry litter poultry waste, however, is less costly to haul, which makes it a popular organic fertilizer, especially during periods of high inorganic fertilizer cost. Dry litter poultry waste produced in North Carolina can be removed from the place of generation by third-party haulers. As a result, dry litter poultry waste may be applied further afield, possibly outside of the watershed where it is generated. Manure haulers that annually carry or land apply more than 100 tons of animal waste must register their manure hauling operation and submit annual reports to DWR. Manure haulers are defined in 15A NCAC 02T .1400 as "any person who accepts or purchases animal waste and land applies the animal waste on land not covered by the generator's permit." As of October 2022, there were a total of 75

manure hauler certificates issued statewide by DWR. Nineteen are held by individual operators or companies in counties located in the Cape Fear River Basin.

Example of uncovered dry litter stockpiled on edge of field. (Photo Credit: DWR, Fayetteville Regional Office, 2/17/2021)

Inspections of dry litter poultry operations are mostly complaint-driven, and by law, information is only available to the public if it is determined that a violation has occurred (G.S. 143-215.9D). Over the past several years, DEQ's Fayetteville Regional Office has documented several instances of improper waste management (i.e., disposing of dry litter waste on residential properties or leased properties with no record of origin, left uncovered for more than 15 days, stockpiled within 100-feet of a perennial waterbody or well, etc.). Regional office staff photograph and mark the location of instances of improper waste management. Using publicly available information (e.g., parcel identification numbers managed by county offices), staff can identify the person or entity that owns the property. In most instances, a property owner is identified, notified of the concern and what action needs to be taken, and a follow-up visit is conducted. In other instances, a property owner cannot be identified and/or the land is leased, and the owner is unaware of waste management issues or its potential impact to water quality.

| Calander Year | Number of Complaints |
|---|---|
| 2021 | 14 |
| 2022 | 43 |
| 2023 | 11 |
| 2024 | 17 |
| 2025* | 13 |
| *Complaints received between 1/1/2025 – 7/16/2025 | |

Between January 2021 and July 2025, the Fayetteville Regional Office recorded a total of 98 complaints related to animal agriculture. (BIMS July 2025). Not all complaints resulted in notices of violations being issued. They did, however, allow for education and outreach between the regional office and the agriculture community. While developing the Cape Fear River Basin plan, many resource technicians also indicated that the cost of constructing waste storage structures, or dry stacks, for dry litter poultry operations is high and often not prioritized in their region. A dry stack is defined as "a fabricated structure for temporary storage of animal waste" (BMP Manual Agriculture Cost Share Program, March 2020). In some cases, there is not enough land to spread the waste at agronomic rates and storage structures are needed to avoid stockpiling dry litter on land adjacent to fields, drainage ditches, or waterbodies. More information about agricultural complaints and violations can be found on DEQ's website.

Understanding the impacts from large-scale waste application on water quality, recreational opportunities, and public health can be challenging due to limited monitoring in the watersheds or counties in which the waste is generated and land applied. Information about the amount of animal and treated municipal (or biosolids) waste that is land applied could be mutually beneficial to several resource agencies. With improved and better locational information on where waste is land applied, DWR can evaluate the location of existing monitoring stations and identify where new or additional monitoring is needed to assess nutrients, turbidity and fecal coliform bacteria. It could also help local resource agencies

target BMP implementation to reduce the amount of pollutants entering a waterbody or identify new BMPs that may be needed on agricultural fields where waste is land applied.

Because animal agriculture plays a critical role in North Carolina's economy and recreational opportunities, aquatic ecosystems, and public water supplies are also important and critical for citizens of the state, *NC DEQ should lead an interagency workgroup to study the existing regulatory framework and potential technological solutions for addressing waste generated at deemed permitted operations.* Because dry litter poultry waste is portable, the workgroup could *explore methods on how best to manage data collection* including farm origin, disposal method, and land application rates. The workgroup should include water resource professionals, the agricultural community, research professionals (academia), database managers, and interested community members, with the goal of ensuring that inspectors and resource agencies have the data and tools necessary to protect public health. The workgroup could also consult with basin planners to *identify new water quality monitoring stations to collect instream data to better understand impacts* to surface and ground water quality and *identify what BMPs to implement to reduce impacts*. The workgroup could involve existing agricultural committees to *review possible manure transport incentives* to move dry litter poultry to additional areas where it can be used as a fertilizer and ways to address the cost of waste storage structures. It could also inform the rules readoption process that should begin during fiscal year 2024-2025. Rules related to AFOs and animal waste management are scheduled to be complete by 2028.

### 1.5.2 Forestry

Over 37% percent (3,421 $mi^2$) of land cover in the Cape Fear River Basin is identified as forest. Forests across the state provide watershed ecosystem services (i.e., nutrient cycling, carbon storage, erosion and sediment control, water filtration and storage, flood control, recreational opportunities, etc.). Forestry (silviculture) activities are identified as a potential nonpoint source of pollution because poorly implemented or managed forestry practices can impact water quality by altering stream habitat, introducing sediment, debris, and nutrients into waterbodies, and changing watershed functions. Properly planned and executed forest management practices, however, facilitate the sustainable harvest of forest products while also protecting water quality. There are multiple federal and state-adopted rules and standards governing silviculture, and the state has a suite of Forest Practices Guidelines (FPGs) and Best Management Practices (BMPs) to protect water resources.

The upper three basins in the Cape Fear River Basin, the Haw River (HUC8 0303002), the Deep River (HUC8 03030003), and the Upper Cape Fear River (HUC8 03030004) have the highest percent forest cover and have had the largest loss of forest cover since 2001 as compared to the lower three subbasins (see *Section 1.2.2*, *Table 1-4*). More information about forestry for these subbasins is available in Chapters 6, 7, and 8.

#### *1.5.2.1 Forest Practices Guidelines (FPG) Related to Water Quality*

The North Carolina Forest Service (NCFS) is delegated the authority to monitor forestry operations in North Carolina for compliance with the "Forest Practice Guidelines (FPGs) Related to Water Quality" (NCFS 2017). The FPGs are a set of results-based guidelines meant to protect water quality and are mandatory, statewide requirements defined by North Carolina Administrative Code (02 NCAC 60C .0100-.0209). All forestry-related, site-disturbing activities must comply with the FPGs if that activity is to remain exempt from permitting and other requirements specified in the North Carolina Sedimentation Pollution Control

Act (SPCA) of 1973 (NCFS, 2022). Per rule, there are nine FPGs. Each has a narrative performance standard associated with it. The FPGs require, among other things, that a protective streamside management zone (SMZ, or stream buffer) be established along intermittent streams, perennial streams, and perennial waterbodies. In addition, there are prohibitions of stream obstructions, and requirements to install effective erosion & sedimentation control measures and stabilize the site upon job completion. FPGs are not BMPs. BMPs can be used to ensure that the forest operators and landowners remain in compliance with the FPGs. Inspections often involve NCFS staff visiting the same site multiple times to provide forest operators and landowners technical assistance for BMPs to minimize impacts of forestry on water quality. On average, the NCFS conducts approximately 5,000 to 6,000 statewide inspections annually, including initial visits and follow-up re-inspections (NCFS 2022).

#### *1.5.2.2 Forestry Best Management Practices (BMPs)*

Implementing forestry BMPs is strongly encouraged to protect the water and soil resources of North Carolina efficiently and effectively. The NC Forestry BMP Manual was revised in 2021. It describes specific tools and methods which can be used during forestry operations to attain compliance with the FPGs. The NCFS also provides a free online Forest Preharvest Planning Tool (NCFS 2022).

From December 2018 until November 2020, the NCFS conducted site surveys across the state to assess the implementation of BMPs on timber harvests. These surveys give a reliable snapshot of practices used in different areas of the state and help the forestry community understand where additional attention may be needed. In the Cape Fear River Basin, surveys were conducted on 35 sites, assessing 4,591 total BMPs, of which 4,017 were implemented at a rate of 87.5%. In those surveys, a potential risk to water quality was observed 1.6% of the time when a BMP was not implemented correctly (NCFS 2022).

The use of temporary bridges during timber harvesting is an example of a BMP that has shown to be an effective alternative solution for crossing waterways. The temporary bridges keep equipment and logs out of the stream channel and reduce the impacts to water quality and aquatic habitat. A subset of temporary bridges are portable 'bridgemats' which can be fabricated from steel or heavy timbers. To help protect waterways and encourage their use, the NCFS loans bridgemats to loggers from several of its offices across the state. More information about bridgemats is available on the NCFS website (NCFS 2022).

#### *1.5.2.3 Timber Harvest Water Quality Compliance Inspections*

The NCFS conducts site surveys across the state to assess the implementation of FPGs on timber harvests. These surveys give a reliable snapshot of practices used in different areas of the state and help the forestry community understand where additional attention may be needed. *Figure 1-16* illustrates locations where the NCFS inspected timber harvests from May 1, 2005, to October 31, 2021, in the Cape Fear River Basin and *Table 1-10* summarizes the key findings during the same time-period. During this 15.5-year time-period, surveys were conducted on over 470 thousand acres basinwide, assessing 8,708 total sites, only 148 of which (just 1.7%) were out of compliance (NCFS, 2022). The most sites were out of compliance during the 2005 to 2010 timeframe, 3.2% (89 of 2,812 sites). Since then, fewer sites have been out of compliance, 1.1% from 2011 to 2015 (30 of 2,784) and 0.9% from 2016 to 2021 (29 of 3,112) (*Table 1-10*) (NCFS 2022). More information can be found in the subbasin chapters for the Haw (Chapter 6), Deep (Chapter 7), and Upper Cape Fear (Chapter 8) rivers.

*Figure 1-16: Timber Harvest FPG Site Inspections in the Cape Fear River Basin May 2005-October 2021 (NCFS, 2022)*

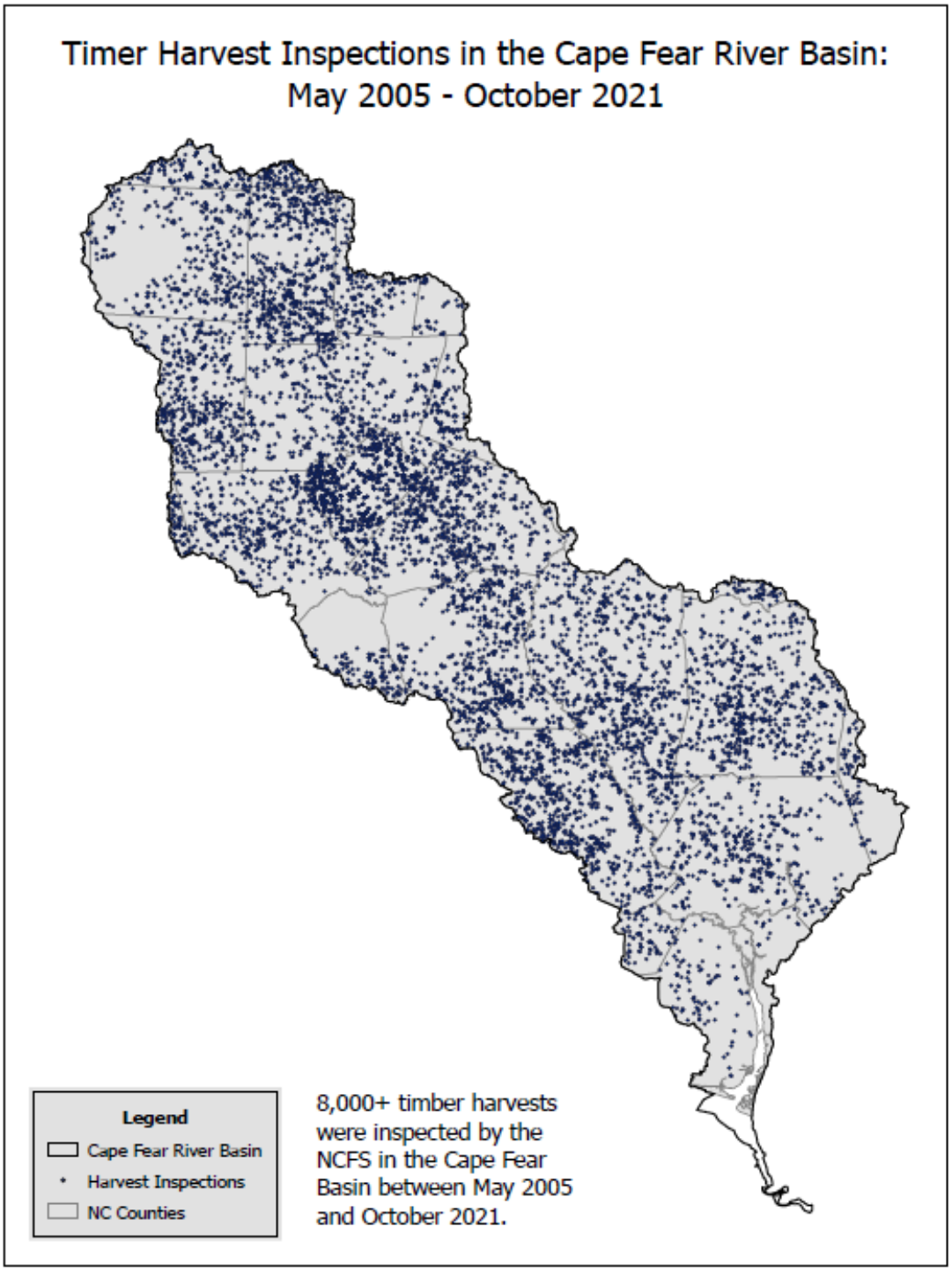


*Table 1-10: FPG Timber Harvest Inspections by NCFS in the Cape Fear River Basin, May 1, 2005, to October 31, 2021 (NCFS 2022).*

| Time Period | Number of Inspected Timber Harvests | Total Acres | Number of Harvests Recorded Out of Compliance (FPGs) |
|---|---|---|---|
| May 1, 2005 – December 31, 2010 | 2,812 | 141,912 | 89 |
| January 1, 2011 – December 31, 2015 | 2,784 | 166,887 | 30 |
| January 1, 2016 – October 31, 2021 | 3,112 | 164,561 | 29 |
| **Total ~15.5 years** | **8,708** | **473,360** | **148** |

The most common observed FPG violations were associated with stream crossings and stream obstruction. *Using temporary bridges called bridgemats or other stream crossing BMPs can help to reduce risks to water quality*. More information and BMP recommendations can be found in the NC Forestry BMP Manual (NCFS 2022).

#### *1.5.2.4 North Carolina Forest Service Recommendations*

- *The NCFS recommends pre-harvest planning to identify water resources on the tract*, understand any complications posed by terrain and topography, identify locations where important features like skid trails, stream crossings, decks and other BMPs will be installed, and ensure that no threatened or endangered species will be impacted by the harvest. The Forest Pre-Harvest Planning Tool (https://www.ncforestservice.gov/water_quality/fppt.htm) is a free resource available on the NCFS website and can aid landowners in completing their planning checklist (NCFS 2022).
- Landowners should be aware of the rules and regulations that apply to their property and *consult with experts as needed to ensure that water resources are identified and protected*. In addition to the FPGs, buffer rules and wetland harvesting regulations may also apply. The NCFS maintains a web page outlining the water quality rules that may apply to forestry activities: https://www.ncforestservice.gov/water_quality/regulations.htm (NCFS 2022).
- Remember that communication with project stakeholders is key. Landowners should share their objectives and plans with their contractor and/or consultant to ensure that everyone is on the same page. It's also a good idea to physically mark water resources onsite with flagging to ensure it's visible in the field and not just on paper. Streams, ponds, wetlands and SMZs or buffers are all good resources to flag (NCFS 2022).
- *Avoid crossing streams whenever possible.* The preferred method for temporary crossings is portable steel or timber bridgemats, which span over the waterway channel and minimize impacts. In lieu of culverts, the installation of properly designed fords can allow movement of aquatic life and allow stormflow surges of water to more easily pass. The N.C. Forestry BMP Manual includes a chapter on stream crossings, https://www.ncforestservice.gov/water_quality/bmp_manual.htm (NCFS 2022).

### 1.5.3 Golf Courses

The NLCD classifies golf course land cover as developed land. These facilities utilize intensive turf management practices that often rely heavily on the use of fertilizers and chemical pesticides. Stormwater runoff then carries these pollutants to nearby streams, impacting aquatic life and habitat. The construction of golf courses can also introduce sediment into streams and destabilize streams that are straightened or altered to meet the design of the golf course. There are approximately 19 public and semi-private golf courses in the Cape Fear River Basin with most located in coastal recreation areas (NCGolf, n.d.). Eight golf facilities reported water use to the Water Withdrawal and Transfer Registration program in 2018 (Chapter 5). Because there is little information on stormwater management and the number of commercial fertilizers or pesticides used for turf management on golf courses, it is difficult to assess the impact they may be having on water quality in the Cape Fear River Basin.

### 1.5.4 Stormwater

Stormwater runoff is rainfall or snowmelt that flows across the ground and impervious surfaces (e.g., buildings, roads, parking lots, etc.). In urbanized areas, stormwater systems often concentrate stormwater runoff into smooth, straight conduits. The runoff gathers speed and volume as it travels through the system before it is released. The outfall is often directed to a surface waterbody where the high velocity can scour streambeds, damage streambanks and vegetation, and destroy aquatic habitat. The volume can cause flooding, damage infrastructure, and cause unnaturally high fluctuations in stream flow.

Many daily activities have the potential to cause stormwater pollution, and in an area where activities (e.g., construction, land clearing) have the potential to contribute more pollutants through stormwater runoff, measures should be taken to minimize impacts. One major component in reducing impacts from stormwater runoff involves planning up-front during the design process. *New construction designs should include plans to prevent or minimize the amount of runoff leaving the site.* Wide streets, large cul-de-sacs, long driveways, and sidewalks lining both sides of the street are all features of urbanizing areas that create excess impervious cover and consume natural areas. Green infrastructure can be used to minimize the impact from runoff. Green infrastructure has several definitions but generally involves the use of natural landscape features (e.g., soil, vegetation, forests, wetlands, etc.) to help maintain ecological processes, sustain natural resources, and contribute to community and individual health and quality of life (Firehock, 2013).

The presence of intact riparian buffers, floodplains and/or wetlands in urban areas can also reduce the impacts of development. These porous, natural landscapes hold rainwater and snowmelt and allow the water to infiltrate slowly. This slow infiltration also helps recharge groundwater supplies. Preserving the natural streamside vegetation or riparian buffer is one of the most economical and efficient BMPs for reducing the amount of stormwater reaching surface waters. In addition, riparian buffers provide a variety of benefits including moderation of water temperature by providing shade, holding water, and decreasing the high temperatures often measured in stormwater runoff; preventing erosion and loss of land; providing flood control; moderating streamflow; and providing food and habitat to aquatic and terrestrial life (Burgess, 2004). For more information on stormwater and how to manage it, refer to DEQ's Division of Energy, Mineral and Land Resources (DEMLR) Stormwater website. Additional urban stormwater recommendations are included in the Haw River subbasin chapter (Chapter 6, Sections 6.6.7.5 and 6.8).

## 1.6 Biodiversity in the Cape Fear River Basin

The enormous size and diverse landscape of the Cape Fear River Basin, covering multiple ecoregions, supports a wide variety of aquatic systems and diverse species. The Cape Fear River itself has the character of three river types, including: the clearwater piedmont stream that rises at the confluence of the Deep River and the Haw River; a meandering coastal "brownwater" river draining farmlands at its mid-section; and a 30-mile-long brackish estuary at its lower end. Also, in the basin are "blackwater" tributaries such as the Black and Northeast Cape Fear Rivers. The diverse habitats of the Cape Fear River Basin are home to many rare species. Additionally, there is a high rate of endemism (found in a single defined geographic location) throughout the Coastal Plain and Sandhills ecoregions in the Carolinas, including the imperiled Cape Fear Shiner (*Notripis mekistochalas*), a small minnow fish species found only in the Cape Fear River Basin (NC Wildlife Plan 2015).

### 1.6.1 Natural Heritage Program

The mission of the NC Natural Heritage Program (NHP) as defined in the Nature Preserves Act, General Statute 143B-135.250, is to inventory, catalogue, and facilitate the protection of the rarest and most outstanding elements of North Carolina's natural diversity. Information collected on hundreds of rare species and natural communities is inventoried and catalogued by NHP using field and data management standards and protocols developed by the Nature Conservancy and maintained by NatureServe. NatureServe is a non-profit based in Arlington VA that coordinates with natural heritage programs throughout the US and in many other countries. NHP gathers information through systematic county surveys conducted by the organization and from outside sources. The NHP tracks three types of information (NC NHP July 25, 2018):

- **Element Occurrences**: an area of land or water where a species or high-quality natural community is or was (i.e., where an element occurs/occurred on the landscape).
- **Natural Heritage Program Natural Areas**: terrestrial and aquatic areas that are of special biodiversity significance. A site's significance may be due to the presence of rare species, rare or high- quality natural communities, or other important ecological features.
- **Managed Areas**: properties and easements where natural resource conservation is one of the primary management goals or areas of open space where open spaces is scarce (See Chapter 4, Land Conservation).

The Cape Fear River Basin is home to many types of rare animal and plant species and high-quality communities currently tracked by NHP. As of 2022, the Element Occurrence records indicate there are 232 rare animal species, 316 rare plant and lichen species, and 149 high quality natural community types found in the Cape Fear River Basin. Of the rare animal and plant species, 283 are state and/or federally listed. There are 17 endangered and nine threatened federally listed plant and animal species found in the Cape Fear River Basin. Additionally, four other plant and animal species are either proposed or candidates for federal listing. State listings in the basin include 280 species: 109 endangered, 89 threatened, and 82 special concern animal and plant species. Aquatic rare animal species are often highly sensitive to water quality and are used as an indicator of the health of the waterbody. NHP currently tracks 45 federal or state listed animal taxa that are entirely or primarily aquatic (see *Table 1-11*). There are also several listed amphibians that require freshwater habitat for reproduction and several listed bird species associated with freshwater and saltwater habitats not included on *Table 1-11* (NC NHP 2022a). Also see Chapter 5, Section 5.3.2 on endangered species as they pertain to streamflow in North Carolina.

*Table 1-11: Cape Fear River Basin Aquatic Taxa with State and Federal Listing Status and NC Wildlife Resource Commission Species of Greatest Conservation Need Aquatic Taxa*

| Taxon Group | Scientific Name | Common Name | NC Status[1] | USA Status[2] | WRC SGCN[3] |
|---|---|---|---|---|---|
| Freshwater Bivalve | *Alasmidonta undulata* | Triangle Floater | T | | ✓ |
| | *Alasmidonta varicosa* | Brook Floater | E | | ✓ |
| | *Anodonta couperiana* | Barrel Floater | E | | ✓ |
| | *Anodonta implicata* | Alewife Floater | T | | |
| | *Elliptio folliculata* | Pod Lance | SC | | |
| | *Elliptio marsupiobesa* | Cape Fear Spike | SC | | ✓ |
| | *Elliptio roanokensis* | Roanoke Slabshell | SC | | |
| | *Fusconaia masoni* | Atlantic Pigtoe | E | T | ✓ |
| | *Lampsilis cariosa* | Yellow Lampmussel | E | | ✓ |
| | *Lampsilis radiata* | Eastern Lampmussel | T | | |
| | *Lasmigona subviridis* | Green Floater | | | ✓ |
| | *Ligumia nasuta* | Eastern Pondmussel | T | | |
| | *Strophitus undulatus* | Creeper | T | | |
| | *Toxolasma pullus* | Savannah Lilliput | E | | |
| | *Villosa constricta* | Notched Rainbow | T | | |
| | *Villosa vaughaniana* | Carolina Creekshell | E | | |
| Freshwater Gastropod | *Helisoma eucosmium* | Greenfield Rams-horn | E | | ✓ |
| | *Lioplax subcarinata* | Ridged Lioplax | SC | | |
| | *Planorbella magnifica* | Magnificent Rams-horn | E | C | ✓ |
| Crustacean | *Cambarus catagius* | Greensboro Burrowing Crayfish | SC | | ✓ |
| | *Lynceus gracilicornis* | Graceful Clam Shrimp | SC | | |
| | *Procambarus ancylus* | Coastal Plain Crayfish | | | ✓ |
| Freshwater Fish | *Acipenser brevirostrum* | Shortnose Sturgeon | E | E | ✓ |
| | *Acipenser oxyrinchus oxyrinchus* | Atlantic Sturgeon | E | E | ✓ |
| | *Ameiurus brunneus* | Snail Bullhead | | | ✓ |
| | *Ameiurus platycephalus* | Flat Bullhead | | | ✓ |
| | *Carpiodes sp. cf. velifer* | Atlantic Highfin Carpsucker | SC | | ✓ |
| | *Cyprinella sp. cf. zanema* | Thinlip Chub | SC | | ✓ |
| | *Elassoma boehlkei* | Carolina Pygmy Sunfish | T | | |
| | *Elassoma evergladei* | Everglades Pigmy Sunfish | | | ✓ |
| | *Enneacanthus chaetodon* | Blackbanded Sunfish | | | ✓ |
| | *Enneacanthus chaetodon* | Banded Sunfish | | | ✓ |
| | *Etheostoma collis* | Carolina Darter | SC | | ✓ |
| | *Etheostoma mariae* | Pinewoods Darter | SC | | |

| Taxon Group | Scientific Name | Common Name | NC Status[1] | USA Status[2] | WRC SGCN[3] |
|---|---|---|---|---|---|
| | *Heterandria formosa* | Least Killifish | SC | | ✓ |
| | *Moxostoma robustum* | Robust Redhorse | E | | |
| | *Moxostoma pappillosum* | V-lip Redhorse | | | ✓ |
| | *Moxostoma sp. 1 [sp. Carolina]* | Carolina Redhorse | | | ✓ |
| | *Moxostoma sp. 3* | Carolina Redhorse | T | | ✓ |
| | *Notropis chalybaeus* | Ironcolor Shiner | | | ✓ |
| | *Notropis mekistocholas* | Cape Fear Shiner | E | E | ✓ |
| | *Noturus sp. 2 [cf. leptacanthus]* | Broadtail Madtom | SC | | ✓ |
| | *Semotilus lumbee* | Sandhills Chub | SC | | ✓ |
| **Amphibian** | *Eurycea quadridigitata* | Dwarf Salamander | SC | | N/A |
| | *Rana heckscheri* | River Frog | E | | N/A |
| **Reptile** | *Alligator mississippiensis* | American Alligator | T | T(S/A) | N/A |
| | *Caretta caretta* | Loggerhead Seaturtle | T | T | N/A |
| | *Chelonia mydas* | Green Seaturtle | T | T | N/A |
| | *Deirochelys reticularia reticularia* | Eastern Chicken Turtle | SC | | N/A |
| | *Dermochelys coriacea* | Leatherback Seaturtle | E | E | N/A |
| | *Lepidochelys kempii* | Kemp's Ridley Seaturtle | E | E | N/A |
| | *Malaclemys terrapin* | Diamondback Terrapin | SC | | N/A |
| | *Seminatrix pygaea paludis* | Carolina Swamp Snake | SC | | N/A |
| **Mammal** | *Trichechus manatus* | West Indian Manatee | T | T | N/A |

[1]E – Endangered, T – Threatened, SC - Special Concern

[2]E – Endangered, T – Threatened, T(S/A) - Threatened due to Similarity of Appearance, C is Candidate

[3]SGNC - NC WRC Wildlife Action Plan SGNCs (Species of Greatest Conservation Need (SGCN) does not include amphibian, reptile or mammal species.

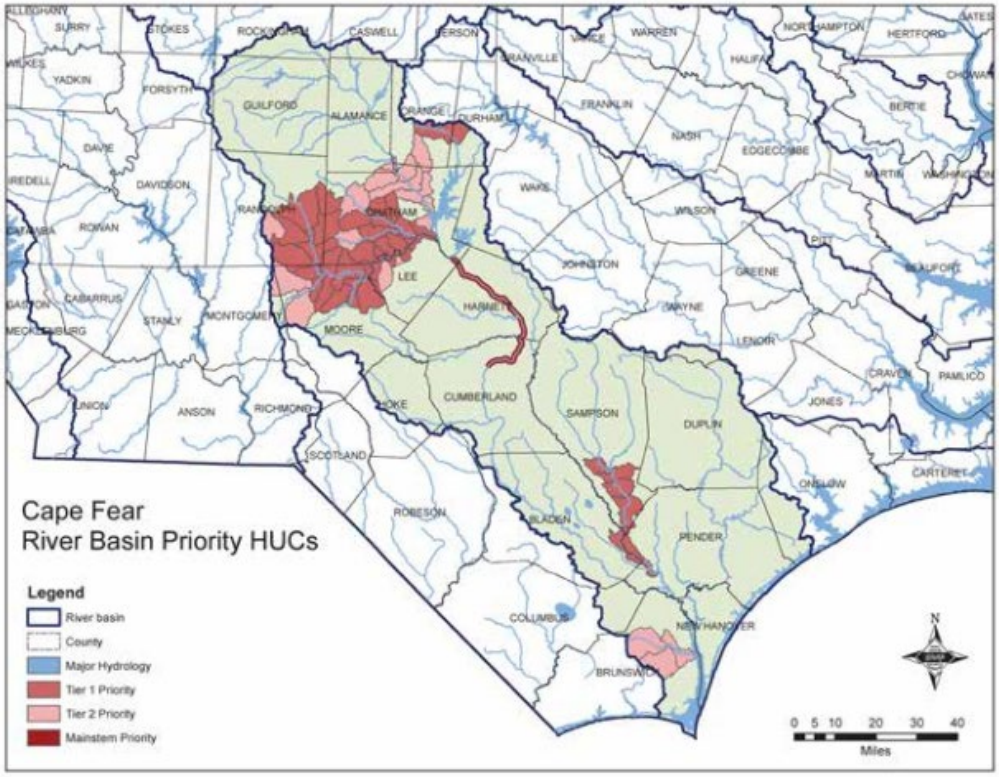
The NHP also identifies terrestrial and aquatic sites that are of special biodiversity significance. A natural area's significance may be due to the presence of rare species, exemplary natural communities, or important animal assemblages, referred to collectively as "Elements" of biodiversity. These areas of biological significance may be publicly or privately owned and may or may not have some kind of protection status (NHP 2022b).

### 1.6.2 Wildlife Resource Commission Wildlife Action Plan

The North Carolina Wildlife Resource Commission's (WRC) 2015 North Carolina Wildlife Action Plan (NCWAP) focuses on the conservation needs and management plans for non-game species in North Carolina. The NCWAP is a comprehensive planning tool developed in cooperation with numerous partners. This plan is an update to the 2005 plan which qualifies the WRC to receive federal US Fish and Wildlife funding to assist with plan implementation. The plan identifies Species of Greatest Conservation Need (SGCNs) which were determined by a panel of taxonomic experts and include species that are known to be rare, threatened, or endangered; species specific knowledge deficiencies that hinder conservation efforts; species that are biologically vulnerable based on current status and trend data; and species that have not received adequate conservation measures. The 2015 NCWAP named 33 aquatic SGCNs in the Cape Fear River Basin: two aquatic snails, two crayfish, 17 freshwater or anadromous fishes, and 12 mussel species (*Table 1-11*).

*The 2015 NCWAP makes specific recommendations for species surveys, long-term monitoring, research, and management practices to reduce environmental impacts. It also recommends that conservation programs and partnerships work synergistically with other conservation actions to enhance the "resilience of natural resources" throughout the region.* The 2015 NCWAP wildlife management priority HUC12 watersheds are displayed in *Figure 1-17*. The Deep River watershed has the highest concentration of priority HUC12 watersheds in the Cape Fear River Basin.

*Figure 1-17: NCWRC Wildlife Action Plan Cape Fear River Basin Priority HUC12 Watersheds (NC WRC 2015)*



The NCWAP identifies numerous problems within the Cape Fear River Basin that are linked with detrimental effects to sensitive aquatic species and their habits. Specific issues identified were impacts to water quality, invasive species, and barriers to migration. Water quality concerns outlined in the plan stemmed from concentrated animal feeding operations (CAFOs), sedimentation from agriculture, forestry, construction practices, and stormwater discharge. Invasive species, such as the flathead catfish (*Pylodictis olivaris*), blue catfish (*Ictalurus furcatus*), and red swamp crayfish (*Procambarus clarkii*) out-compete and predate native species. The mainstem of the Cape Fear is interrupted by three lock and dams in the middle and lower portions of the river. The upper Cape Fear River has large barriers at the Buckhorn Dam and Jordan Dam. There are also many smaller dams and man-made barriers on smaller tributaries. These man-made barriers block fish migration, reduce recolonization and dispersal for multiple aquatic species, and promote an unnatural flow regime below the managed dams.

### 1.6.3 Deep, Rocky, and Haw River Critical Habitat Areas

Sections of three piedmont rivers, the Rocky, Deep, and Haw, form the primary population centers for the very rare and endangered Cape Fear shiner, a small minnow endemic to the upper part of the Cape Fear River Basin. Because of this, stretches of these rivers have been designated by the US Fish and Wildlife Service as critical habitat. The Cape Fear shiner is known or believed to occur in: Alamance, Chatham, Cumberland, Guilford, Harnett, Hoke, Lee, Montgomery, and Moore counties (US FWS n.d.-a). The Cape Fear shiner is mostly found in shallow, rocky shoals within the main river channels, but in winter months they may migrate into smaller tributary streams. They prefer habitat with large islands and bars of water willow (*Justica americana*) or other aquatic vegetation and clean substrates composed of gravel, cobble and boulders (NC WRC 2022).

*The Cape Fear shiner has been impacted by the negative effects of dams* that block migration, cause the loss of biodiversity, degrade water quality by trapping sediments and nutrients, and alter the natural flow pattern that drives the productivity of downstream floodplains and wetlands (US FWS 2022). Cape Fear shiner abundance has been shown to correlate with stream connectivity, permeable land area in the watershed, and natural floodplain cover. *The removal of dams can restore the natural flow and condition of a river and promote fish migration.* Three dams have been removed in the past 16 years in the Upper Cape Fear River: Carbonton Dam on the Deep River in 2005, Upper Swepsonville Crib Dam on the Haw River in 2014, and Hoosier Dam on the Rocky River in 2018. The occurrence of the Cape Fear shiner upstream and in the former impounded areas of the Rocky and Deep rivers has recently been documented. Several other dams have been identified and prioritized by the Cape Fear River Partnership [see Chapter 4 for removal or fish passage projects including Ramseur (already partially breached), High Falls, and Lockville Dams on the Deep River, Lower Swepsonville and Bynum Dams on the Haw River, and Buckhorn Dam on the Cape Fear River (US FWS 2022)]. In 2023, American Rivers received grant funding to remove the lower four dams on the Deep River including Lockville, High Falls, Coleridge, and Ramseur and start the process for the removal of Buckhorn Dam on the Cape Fear River mainstem below the confluence with the Deep and Haw rivers.

These three rivers (the Deep, Rocky and Haw) also support a number of other rare aquatic animals, including fish such as the Carolina redhorse (*Moxostoma* sp.) and the Roanoke bass (*Ambloplites cavifrons*); freshwater mussels such as the brook floater (*Alasmidonta varicosa*), triangle floater (*Alasmidonta undulata*), Atlantic pigtoe (*Fusconaia masoni*), yellow lampmussel (*Lampsilis cariosa*),

squawfoot (*Strophitus undulatus*), notched rainbow (*Villosa constricta*), and eastern creekshell (*Villosa delumbis*); and dragonflies such as Septima's clubtail (*Gomphus septima*). Also found here is one of just two North Carolina populations of the endangered plant harperella (*Ptilimnium nodosum*), found on an island in the Deep River in Chatham County.

### 1.6.4 Cape Fear River Migratory Fish

The Cape Fear River Basin is home to several species of anadromous fish. Anadromous fish are born in freshwater, migrate to the sea, then back to freshwater to spawn. Examples of anadromous fish in the Cape Fear River Basin include the stiped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), and two species of endangered sturgeon, the Atlantic (*Acipenser oxyrinchus*) and shortnose (*Acipenser brevirostrum*) sturgeon (Talton 2022, NOAA n.d.-a). These sturgeon species are also some of the largest freshwater fish in North Carolina (Bryn 2021). Unfortunately, similar to the Cape Fear shiner, the many man-made dams and other blockages in the Cape Fear River have caused a decline in sturgeon and other migratory fish populations including the American eel (*Anguilla rostrata*), a catadromous species that migrates from freshwater to the sea to spawn. Additionally, poor habitat and water quality have also impacted fish populations. According to officials at the National Oceanic and Atmospheric Administration (NOAA), the Cape Fear River is the only river to have a population of sturgeon existing with these man-made barriers.

In 2013, the Cape Fear River Partnership led the effort to construct a rock arch fish passage 39 miles above Wilmington at Lock and Dam No. 1 (Talton 2022, NCWRC 2015). The structure improves passage for several species (NCWRC 2015). The rapids were modified in 2021 and the partnership hopes to install similar features at lock and dams Nos 2 and 3 in the future (Talton 2021).

Also see Chapter 5, Section 5.3 on Stream Flow in North Carolina and how it pertains to ecological flow (Section 5.3.1) and endangered species (Section 5.3.2). The Nature Conservancy (TNC) has partnered with the US Army Corps of Engineers (USACE) to create a Sustainable Rivers Program (SRP). Each spring, the goal is to release mini pulses of water from Jordan Lake dam to cover the USACE controlled locks and dams on the mainstem Cape Fear River. This will allow spawning migratory fish to migrate upstream over the barriers in order to reach their historic spawning grounds. (See Section 5.4.3 for more information on the SRP).

### 1.6.5 Cape Fear River Basin Regions of Ecological Significance and Significant Aquatic Habitats

This section covers several of the regions and the associated flora and fauna in the Cape Fear River Basin that have unique ecological significance. Regional areas discussed in this section include the Sandhills, Bladen Lakes, Black and South rivers, Lower Cape Fear, Northeast Cape Fear floodplain, pine savannas, Holly Shelter and Angola Bay, and Boiling Spring Lakes wetlands. Significant Aquatic Habits identified by the NHP in collaboration with other agencies are also included in this section. Information in this section was also included in the 2005 Cape Fear River Basin plan.

#### *1.6.5.1 Regions of Ecological Significance*

**Sandhills Megasite** - The diverse natural communities of the sandhills region, such as hillside seeps, upland longleaf pine forests, streamhead pocosins, and mixed hardwood-Atlantic white cedar swamps,

provide habitat for many rare and endemic species including perhaps the largest remaining concentration of the endangered red-cockaded woodpecker (*Picoides borealis*) in the state. Endangered plants include Michaux's sumac (*Rhus michauxii*), chaffseed (*Schwalbea americana*), and rough-leaf loosestrife (*Lysimachia asperulifolia*). The publicly owned Sandhills Game Land, Camp MacKall and Fort Bragg contain some of the largest remnants of the sandhills in natural condition in North Carolina.

**Bladen Lakes Megasite -** Occurring on ancient terraces of the Cape Fear River, the Bladen Lakes area contains the greatest concentration of relatively unaltered Carolina bays in North Carolina. The bays contain lakes and a diversity of peatland communities. The surrounding landscape is an irregular mosaic of shallow peatlands and sand longleaf pine communities. Many of the significant natural areas are in public ownership, either as game lands, state forests, or state parks. The bay lake sites include White Lake, Jones Lake, Singletary Lake, Little Singletary Lake, Bay Tree Lake, Bakers Lake, Horseshoe Lake, and Salters Lake.

**Black and South Rivers -** The Black and South rivers contain significant aquatic communities with two rare fish species – the broadtail madtom (*Noturus* sp.) and the Santee chub (*Cyprinella zanema*); and several rare mussels – pod lance (*Elliptio folliculata*), Cape Fear spike (*E. marsupiobesa*), Atlantic pigtoe (*Fusconaia masoni*), and yellow lampmussel (*Lampsilis cariosa*). The Black River is also one of the best remaining examples of a blackwater river system in the southeast coastal plain. Particularly notable is an ancient cypress-gum swamp, which contains the oldest stand of trees east of the Rocky Mountains; some cypress trees in this swamp have been core-dated to 364 AD. The swamp forest of the Black River supports several colonies of the rare Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), a bat that is dependent on large hollow trees found in old-growth forests.

**Lower Cape Fear River -** The lower reach of the Cape Fear River is brackish and supports numerous rare marine fishes, including the endangered shortnose sturgeon (*Acipenser brevirostrum*), as well as freckled blennies (*Hypsoblennius ionthas*), marked gobies (*Gobionellus stigmaticus*), spinycheek sleepers (*Eleotris pisonis*), and opossum pipefish (*Microphis brachyurus*). The endangered manatee (*Trichechus manatus*) is an occasional visitor, especially in summer.

**Northeast Cape Fear River Floodplain -** The Northeast Cape Fear River floodplain is a drowned blackwater river corridor characterized by tidal freshwater marshes at the lower end and extensive tidal cypress-gum swamp communities upstream. Encompassing more than 22,000 acres, the Northeast Cape Fear River floodplain contains some very high-quality natural communities, including rare types such as peatland Atlantic white cedar forests and longleaf pine forests. At least one portion of the site contains old-growth longleaf pine communities and mature examples of nonriverine wetland communities. Though not thoroughly explored, a number of rare plant and animal species have been found here. The southeastern myotis (*Myotis austroriparius* – a bat that roosts in hollow trees near water) is widespread along the upper portion, and alligators are present throughout. The rare estuarine fishes lyre goby (*Evorthodus lyricus*) and spinycheek sleeper (*Eleotris amblyopsis*) have been found in the marshes at the lower end. The site is a major forested connector between other large sites.

**Pine Savannas -** The Cape Fear River Basin contains a high concentration of savanna habitats. These wet, generally flat areas have an open to sparse tree canopy, with few shrubs and a dense herb layer. The pine

savannas of southeastern North Carolina have among the highest species diversity of any natural community in temperate North America, and more rare species are associated with the pine savanna than any other natural community type in the state. Only a few examples of this natural community are protected through public ownership or conservation easement.

**Holly Shelter/Angola Bay Megasite -** The Holly Shelter/Angola Bay region is one of the largest, nearly contiguous natural areas in the state. The Holly Shelter Game Land has a large domed peatland in its center that supports one of the largest pocosin community complexes in the state. On the southeast side of the game land is an extensive relict beach ridge system with associated longleaf pine communities and great concentrations of rare species, including one of the largest populations of Venus flytrap (*Dionaea muscipula*) in the state and several dozen red-cockaded woodpecker colonies. To the north is Angola Bay, one of states most inaccessible interior wetlands. The bay has a diameter of more than ten miles with no roads or trails. Most of the area is low pocosin with scattered pond pine in an otherwise near-treeless expanse of evergreen shrubbery.

**Boiling Spring Lakes Wetland Complex -** The Boiling Spring Lakes wetland complex is another large, hydrologically intact complex of relict beach ridges and swales interspersed with Carolina bays. The extensive pine flatwoods, pine savannas, pond pine woodlands, and pocosin communities of this area support a number of rare plant species including several carnivorous species. This ecologically significant natural area was, until 2000, the largest unprotected natural longleaf pine/pocosin landscape complex in the state. Establishment of the 6,942-acre Boiling Springs Lakes Preserve in Brunswick County was the result of the combined efforts of the North Carolina Department of Agriculture & Consumer Services – Plant Conservation Program, The Nature Conservancy, the City of Boing Springs Lakes, and the NC NHP.

#### *1.6.5.2 Significant Aquatic Habitats*

The Natural Heritage Program collaborates with a number of freshwater ecologists in other agencies and organizations to identify Significant Aquatic Habitats in North Carolina. Significant Aquatic Habitats are stream segments or other bodies of water that contain significant natural resources, such as a high diversity of rare aquatic animal species. The impact from lands adjacent and upstream of these stream reaches will determine their water quality and the viability of their aquatic species.

**Bear Creek Aquatic Habitat** – Bear Creek is a regionally significant stream that adjoins the Rocky River-Lower Deep River aquatic habitat at its downstream end. This medium-sized stream supports a diverse mussel fauna, including the brook floater (*Alasmidonta varicosa*) and Atlantic elktoe (*Fusconaia masoni*).

**Black River Aquatic Habitat** – The Black River aquatic habitat is a state-significant aquatic habitat containing four rare mussels: the Cape Fear Spike (*Elliptio marsupiobesa*), Atlantic pigtoe *(Fusconaia masoni*), yellow lampmussel (*Lampsilis cariosa*), and pod lance (*Elliptio folliculata*). Other rare aquatic animals known from the Black River include the river frog (*Rana hecksheri*), American alligator, and the American sand burrowing mayfly (*Dolania americana*). The American sand burrowing mayfly is a predaceous mayfly that is able to dig rapidly into sandy substrates. It is known from only a few places in the southeast, and in North Carolina has only been found in one location – the Black River.

**Deep River (Moore/Randolph) Aquatic Habitat** - Considered to be nationally significant, the Deep River (Moore/Randolph) aquatic habitat is home to a population of the Cape Fear Shiner (*Notropis mekistocholas*), as well as the Carolina redhorse (*Moxostoma* sp. 2), Roanoke bass (*Ambloplites cavifrons*), and a number of mussels, including the triangle floater (*Alasmidonta undulata*), brook floater (*Alasmidonta varicosa*), Atlantic pigtoe (*Fusconia masoni*), yellow lampmussel (*Lampsilis cariosa*), squawfoot (*Strophitus undulatus*), and notched rainbow (*Villosa constricta*).
**Haw River Aquatic Habitat** - The nationally significant stretch of the Haw River contains one of just a few known sites for the endemic and federally endangered Cape Fear shiner (*Notropis mekistocholas*). The globally rare Septima's clubtail (*Gomphus septima*) is also found here.

**Lower Cape Fear River Aquatic Habitat** - The state-significant lower Cape Fear River is brackish and contains numerous rare animals. Records of the shortnose sturgeon (*Acipenser brevirostrum*) indicate that it occurs here rarely, while manatees (*Trichechus manatus*) are found more occasionally, especially in summer. Alligators are present mainly in tributary streams. Freckled blenny (*Hypsoblennius ionthas*) and spinycheek sleeper (*Eleotris amblyopsis*) are rare marine fishes of this section of the river.

**Rocky River/Lower Deep River Aquatic Habitat** - This nationally significant habitat is separated from the Upper Rocky River Aquatic Habitat by an impoundment. The federally endangered Cape Fear shiner (*Notropis mekistocholas*) has its primary population center in this area. The aquatic plant harperella (*Ptilimnium nodosum*) only has two known populations in North Carolina, one of which occurs on an island in the Deep River.

**South River Aquatic Habitat** - A state-significant site discussed above in association with the Black River, this high quality blackwater river contains two undescribed and rare fish species, *Noturus* sp. and *Hybopsis* sp. and a diversity of other aquatic biota.

**Town Creek Aquatic Habitat** - This nationally significant site is a short creek that flows eastward in eastern Brunswick County and empties into the Cape Fear River. Despite its short length, it contains the only known population of the Greenfield ramshorn snail (*Helisoma eucosmium*), a globally rare and imperiled mollusk, as well as several other rare animals and plants.

**University Lake Aquatic Habitat** - This state-significant site contains the largest population in the state, by far, of the rare mussel Savannah lilliput (*Toxolasma pullus*).

**Upper Cape Fear River Aquatic Habitat** - This state-significant site passes through Harnett, Chatham and Lee counties. This site contains seven rare mussels and two rare fishes: the Carolina redhorse (*Moxostoma* sp. 2) and occasional reports of the federally endangered Cape Fear shiner (*Notropis mekistocholas*).

**Upper Rocky River Aquatic Habitat** - This state-significant site is separated from the Rocky River/Lower Deep River Aquatic Habitat (see above) by the Reeves Lake impoundment. The site has a population of the federally endangered Cape Fear shiner (*Notropis mekistocholas*), along with two rare mollusks and one rare stream insect.

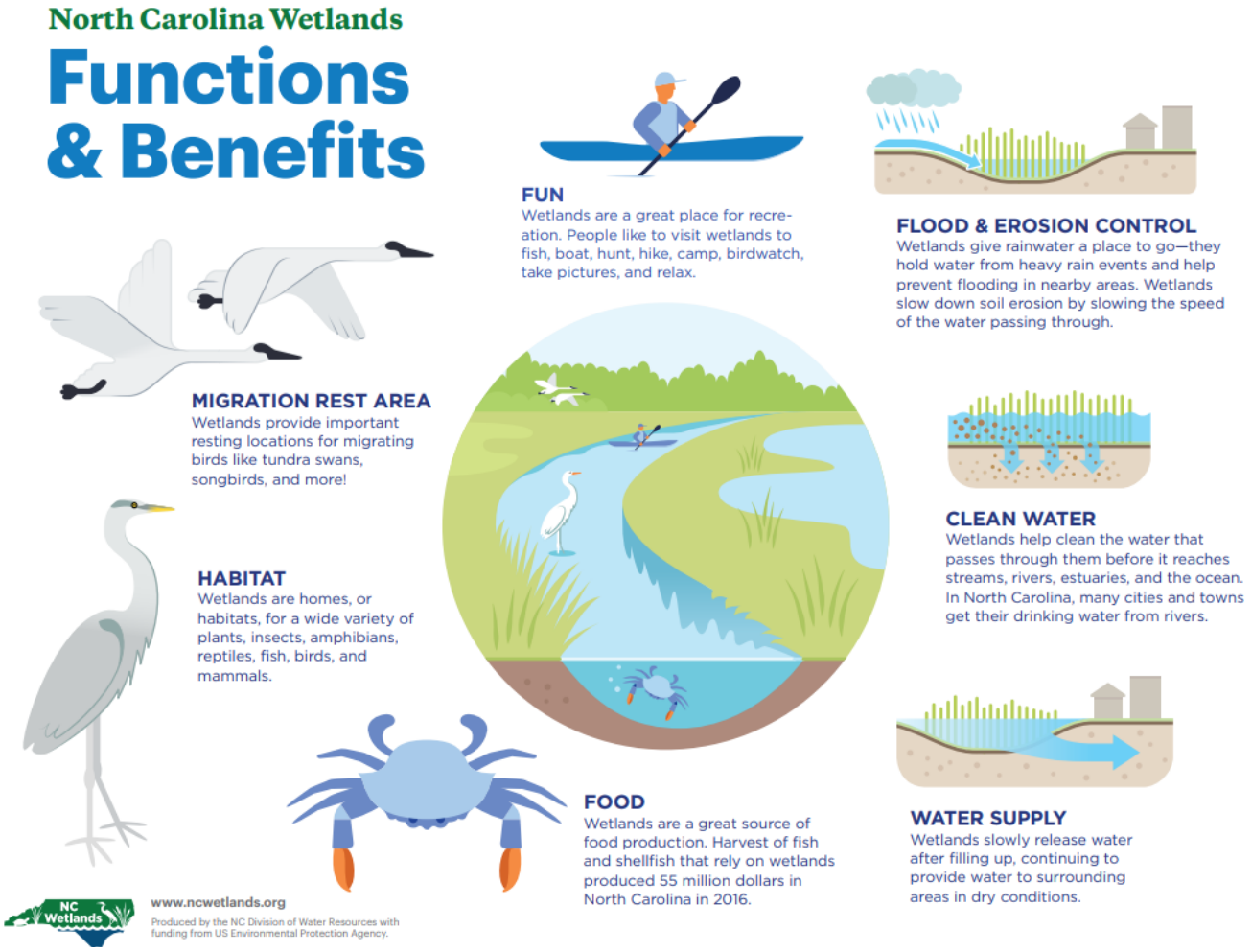
**Upper Black River Aquatic Habitat** - This site contains lower portions of Six Runs and Great Coharie and Little Coharie Creeks, where biologists have found three rare mussels: eastern creekshell (*Villosa delumbis*), eastern lampmussel (Lampsilis radiata radiata), and pod lance (*Elliptio folliculata*), as well as two rare fishes: Santee chub (*Cyprinella zanema*) and broadtail madtom (*Noturus sp. 1*).

## 1.7 Wetlands in the Cape Fear River Basin

North Carolina's wetlands are diverse habitats found in natural depressions in the landscape or transitional areas where land meets water in low-lying flat areas or near streams, rivers, lakes, and estuaries. Wetlands have three key characteristics: hydrology, wetland soils that form under wet conditions, and wetland plants adapted for growing in water or wet soils (Mitch and Gosselink, 2000). Healthy wetlands are an integral component of healthy watersheds and provide many essential ecosystem services that benefit humans, natural communities, and watershed functions (*Figure 1-18*).

*Figure 1-18: North Carolina Wetland Functions and Benefits*

*Image source: https://www.ncwetlands.org/*



The U.S. Fish and Wildlife Service (USFWS) is the principal federal agency tasked with providing information to the public on the extent and status of the nation's wetlands and deep-water habitats and how they have changed over time (USFWS n.d.-b). According to the USFWS National Wetland Inventory (NWI) data, there are close to 1,600 $mi^2$ (USFWS n.d.-c) of wetlands in the Cape Fear River Basin. The 2019 NLCD data, covered in *Section 1.2* of this chapter, reported there were over 1,700 $mi^2$ of wetlands within this basin. A mapping comparison of the two datasets shows many of the discrepancies occurred in riverine floodplain areas. 2019 was an extremely wet year so the NLCD dataset may have an inflated estimation of wetlands due to flood events.

Different wetland habitat types are identified by hydroperiod (i.e., water depth and duration), water source and whether it is freshwater or saltwater, landscape position, soil type, and dominant vegetation (NC FAT, 2016). The Cape Fear River Basin has many diverse wetland habitats with close to 90% located in the lower half of the basin in the Coastal Plain ecoregion of the Black, Lower Cape Fear, and Northeast Cape Fear subbasins (*Figure 1-19*, *Figure 1-20*).


NC wetland photos from ncwetlands.org
https://www.ncwetlands.org/

*Figure 1-19: Cape Fear River Basin Wetland Distribution and Ecoregions*

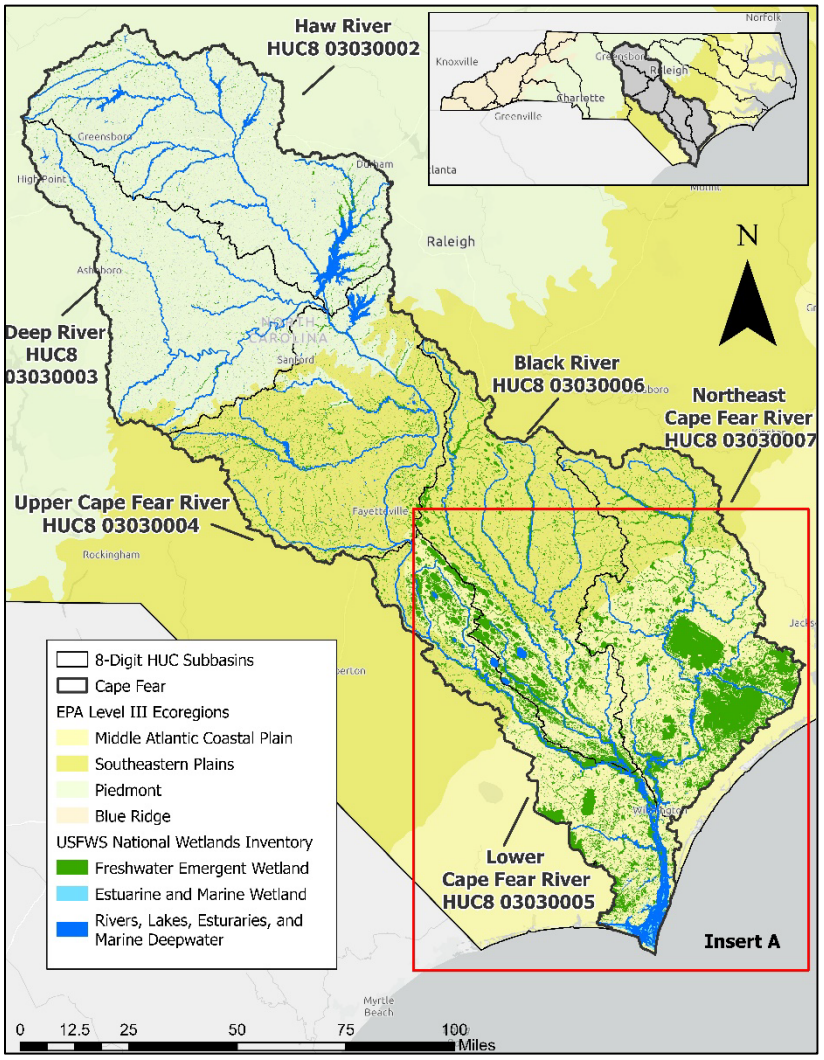
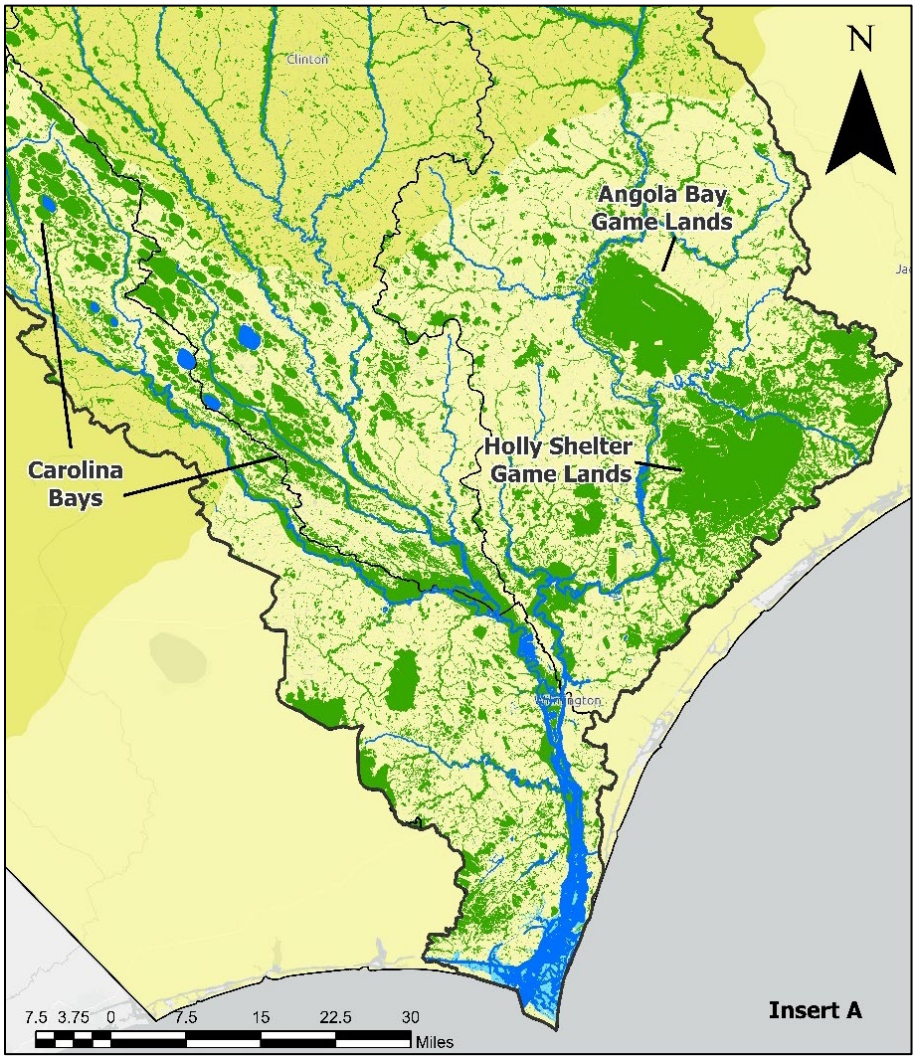



*Figure 1-20: Cape Fear River Basin Wetland Distribution and Ecoregions – Insert A*



### 1.7.1 Types of Wetlands in the Cape Fear River Basin

Common freshwater wetland types in the Cape Fear River Basin include riverine swamp forests, bottomland hardwoods, pocosins, Carolina bays, and pine flatwoods. There are also 11,000 acres of estuarine wetlands in the Lower Cape Fear River subbasin. Additional information on some specific wetland habitats is provided in *Section 1.6.5* - Cape Fear River Basin Regions of Ecological Significance.

Estuarine wetlands made up of saltwater marshes and mudflats fringe the mouth of the Cape Fear River near Bald Head Island and Fort Caswell. These highly productive wetlands have rapid-growing vegetation that promote carbon sequestration at a faster rate than other terrestrial ecosystems (NOAA, n.d.-b). Saltmarshes transition to brackish marshes then tidally influenced freshwater marshes further up the Cape Fear River mainstem and within the tidal creek tributaries.

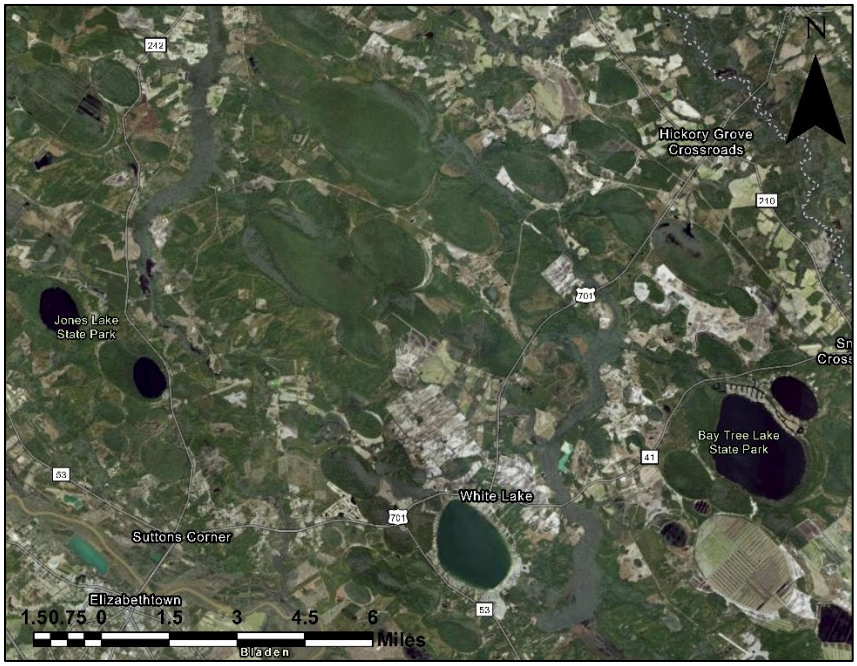
Riverine swamps and bottomland hardwood forests buffer many of the rivers and creeks in the basin. Riverine swamps are more common in the Coastal Plain and bottomland hardwoods are more common in the Piedmont. The Haw River subbasin has several sizable tracts of bottomland hardwood protecting the water quality along tributaries draining to Jordan Lake, an important source of water supply for local communities in the upper part of the basin. In the Coastal Plain, larger tracts of riverine swamp forests occur along the Northeast Cape Fear River and its Goshen Swamp tributary and the Black River and its Little Coharrie, Greater Coharrie, and South River tributaries (*Figure 1-19*). The most expansive areas of swamp forest occur at the Cape Fear and Black rivers' confluence and along the lower part of the Northeast Cape Fear River (*Figure 1-19*). Freshwater marshes, both tidal and non-tidal, develop in places where riverine swamp or bottomland hardwood wetlands have been flooded causing trees to die off.

Pocosin wetlands and Carolina bays have an important presence in the Cape Fear River Basin. These wetlands are found in the Coastal Plain ecoregion in the flat low-lying areas between river systems. Although Carolina bays and pocosins are rainwater driven and do not usually have a direct natural connection to rivers and streams, they are still highly important for flood control and maintaining the ecological equilibrium in a watershed by storing large amounts of freshwater that slows the discharge to estuaries. They also provide important wildlife and waterfowl habitat (Waterkeeper Alliance n.d.).

Carolina bays are distributed along the Atlantic coast from New York to North Florida but are primarily found in the Carolinas with the most concentrated presence in Bladen County (Powell 2006) between the Cape Fear River and South River (*Figure 1-19* and *Figure 1-20*). These unique landscape features were first discovered in the 1930s with the invention of aerial photography by their distinct elliptical shape, northwest-southeast orientation, and sandy rims (*Figure 1-21*). Their origins have been mysterious, but formation from windstorm scouring is currently the favored theory (ncwetlands.org, Wikipedia 2022). Carolina bays are highly diverse, varying in size, depth, substrate, hydroperiod, and vegetation (Wikipedia 2022). Most bays are wetlands, but several of the deeper bays in the Cape Fear River Basin are entirely or partially filled with water and have formed lakes. Other than Lake Waccamaw, these rare Carolina Bay lakes are located in the Cape Fear River Basin (also see the Bladen Lakes Megasite description in *Section 1.6.5.1*, Howell et. al. 2016). Bays can range from a few hundred feet to the six-mile-long Lake Waccamaw in the Lumber River basin and can be as deep as 15 meters (O'Dale n.d.). Many of the smaller bays overlap or are contained within larger bays (O'Dale n.d., Howell et. al. 2016). Bays are generally peat-based, including those in the Cape Fear River Basin (Howell et al. 2016), and have a large buildup of organic

matter and peat and may even have a convex surface (NCFAT 2016). “Carolina bays” are named for their geographic location as well as the thick forests of bay trees, sweet bay (*Magnolia virginiana*), red bay (*Persea palustris*), and loblolly bay (*Gordonia lasianthus*), that often inhabit them (Howell et al. 2016). Wetter bays may be forested with pond cypress (*Taxodium ascendens*) and gum trees (*Nyssa aquatica* and *Nyssa biflora*) while other bays may be shrub covered with pocosin-like vegetation (NCFAT 2016, Howell et al. 2016).

*Figure 1-21: Carolina Bays in Bladen County*




Pocosins, an Algonquin Indian word meaning “Swamp-on-A- Hill”, are evergreen shrub bogs found along the Atlantic Coastal Plain from Virginia to north Florida (Richardson, 1983). Although pocosins are rainfall driven and hydrologically isolated from major rivers on the landscape, they are often found adjacent to estuaries and have surface hydrological connections that are linked to regional water quality and salinity gradients found in estuarine areas along the coast (Ingram & Otte, 1982; Richardson, 2012). Pocosins are also an extremely important carbon sink due to their deep organic peat soils (Kozak, 2019). In the Cape Fear River Basin, pocosin wetlands are most common in the Northeast Cape Fear subbasin, where more than a third of the basin’s wetlands are found. The two largest tracts of pocosin are located at the Holly Shelter Game Land in Pender County and Angola Bay Game Land (*Figure 1-20*) just to the north on the Pender-Duplin County line. (See *Section 1.6.5.1* Regions of Ecological Significance.) Although pocosin-like vegetation can form in Carolina bays, pocosins wetlands have structurally different origins (Howell 2016).

Other types of wetlands found in the of the Cape Fear River coastal plain include pine flats, hardwood flats, non-riverine swamp forests, and rare pine savannahs (see *Section 1.6.5.1*). Most pine flats are successional in nature and represent altered variants of pine savannas, hardwood flats, or non-riverine

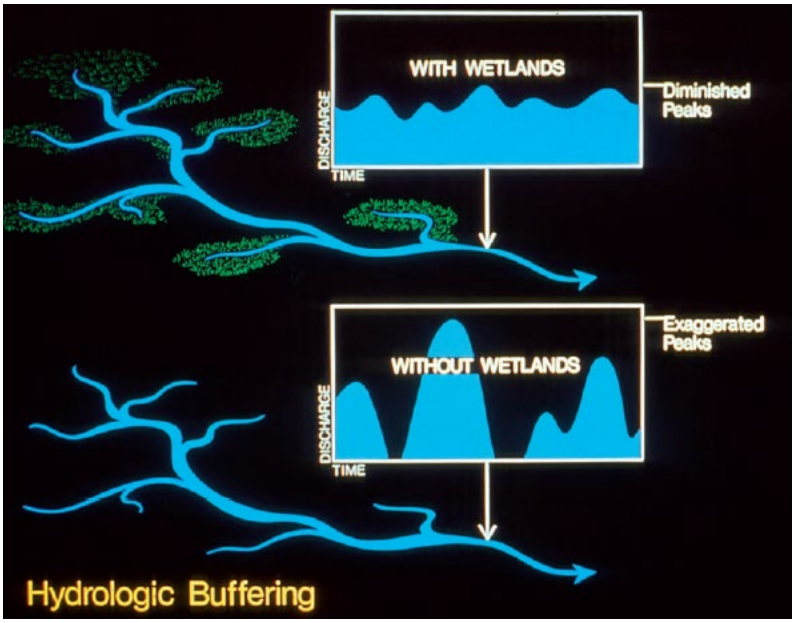
swamp forests. Some pine flats are managed forests of slash pine (*Pinus elliotti*) or loblolly pine (*Pinus taeda*).

### 1.7.2 Wetland Loss and Alteration

*Wetlands are highly important for water quality because they filter water by assimilating and processing nutrients and other pollutants, thereby protecting adjacent and downstream waterbodies* (DWR, 2018). The loss or alteration of wetlands (i.e., through ditching, drainage tiles, non-native vegetation, soil compaction, vegetation removal, and fill), however, inhibits them from performing water quality and water storage functions and can greatly reduce or eliminate wetland hydrologic function. Ground-disturbing activities, such as farming, logging and construction can also stress wetlands through soil compaction or the introduction of invasive plant species (Native Plant Society, n.d.).

Vegetation removal resulting in permanent loss and conversion of a forest land cover to a non-forest land cover type can also decrease or eliminate the ability of wetlands to reduce flood peaks (*Figure 1-22*) (Wolkowski & Lowery, 2008). Loss of mature forested areas also reduces habitat for migratory bird species and wildlife that depend on tree cavities (WWF, 2019). Landscapes with a mosaic of diverse mature forests, successional uplands, and wetlands offers the best variety of wildlife habitat.

*Figure 1-22: Wetland Hydrologic Buffering (Welsch et al. 1995)*




Currently, under Section 404 of the Clean Water Act (CWA), administered by the US Army Corps of Engineers (USACE), it is unlawful to discharge dredged or fill material into jurisdictional waters of the United States without federal approval, unless the discharge is covered under an exemption (refer to Chapter 3 for more information about Wetland and Stream Permitting Programs). Although federal and state regulations have slowed the loss of wetlands since the mid-1980s, approximately one-third of alterations to wetlands in the Coastal Plain have occurred since the 1950s, primarily due to agricultural

and managed forest conversion (USGS 1996). The Food Security Act of 1985 is often referred to as the 1985 Farm Bill. The Highly Erodible Land and Wetland Conservation provisions of the Act (16 U.S.C. 3801-3862) are administered by the USDA's Farm Service Agency (FSA). The Wetland Conservation provision, commonly called "Swampbuster," was written to discourage the conversion of wetlands to non-wetland areas to produce commodity crops. If a farmer converts wetlands to non-wetland areas after December 23, 1985, the farmer becomes ineligible for benefits through the federal farm program (commodity price support, farm storage facility loans, disaster payments, and several other benefits) (USGS 1996). Other provisions of the Act include the Highly Erodible Land provisions, commonly referred to as the "Sodbuster" and "Conservation Compliance" provisions. Under these provisions, farmers become ineligible for federal farm program benefits if, after December 23, 1985, they convert or produce crops on highly erodible land without adequate conservation practices in place to control erosion and sedimentation.

Most routine farming, ranching, or silviculture activities that are part of an "on-going" farming or forestry operation and do not convert a wetland area to an upland are considered exempt and do not require a Section 404 permit or certification from DWR. There are provisions that must be followed in order to retain that exemption. Those provisions include required BMPs for forest roads and skid trails and that the silviculture activity must also not immediately or gradually convert a wetland to a non-wetland. The requirements may be found in 33 CFR 323.4: https://ecfr.federalregister.gov/current/title-33/chapter-II/part-323/section-323.4. If a wetland is being harvested to convert it to a non-forestry land use, then permitting and compensatory mitigation may be needed.

Sea-level rise and dredging in the lower part of the Cape Fear River Basin near Wilmington have been altering tidally influenced wetlands. Forested wetlands have been rapidly transitioning to tidal marshes full of dead or dying trees, named "ghost forests" due to their gray skeleton-like appearance. They form when saltwater intrusion kills off trees that require freshwater to survive. Trees in the wettest areas of the swamp, like cypress, that are particularly sensitive to saltwater, are often the first to die (Holman 2022, Breisinger 2021). Although the formation of ghost forests is a natural process, it has been happening at an alarming rate, especially along the Cape Fear River (Gaertner 2021). Sea level rise and storm surges from severe weather events drive saltwater further up the Cape Fear River and its network of tidal creek tributaries (Breisinger 2021). Drought also causes increased saltwater intrusion as when the river level drops, the freshwater volume is replaced by ocean water. There is usually not much saltwater above the northern edge of the Wilmington city limits but during the 2007 drought, salinity levels increased as far up the Cape Fear River as the confluence with the Black River, just a few miles downstream from Lock and Dam Number One (Holman 2022).

The deepening of the Cape Fear River channel for shipping has also dramatically increased the effects of tides and storm surges along the riverbank (Holman 2022). This shipping channel has been widened and deepened numerous times so larger ships could access the Wilmington Port. The earliest documented depth of the shipping channel was 3.7m in 1871. The depth in 2020 was 12.8m [at mean lower low water (MLLW), Magolan and Halls 2020]. The deeper channel means the volume of sea water that enters the river increases with incoming tides. The tides cause the saltwater water to slosh up and down causing an amplification of the tidal range at the top of the estuary. In this way, dredging mimics the effects of sea level rise by pushing tides and salinity further upstream. The tidal range in Wilmington has increased by 0.41m since the installation of the NOAA tide gage in 1936. Of the 0.41 m increase, 0.202 m is attributed

to sea level rise and the other 0.208m was likely the result of frequent dredging in the Cape Fear River (Magolan and Halls 2020). Models have shown that a storm surge from a category five hurricane in the 19th century when the shipping channels were half the depth would have been around 12ft. Today the estimation is 18ft (Holman 2022). Saltwater intrusion can also raise groundwater and cause the corrosion of essential infrastructure like underground sewer pipes (Holman 2022).

### 1.7.3 Protecting Wetlands

Protecting and recovering benefits that have been lost due to wetland impacts or conversions can help sustain long-term watershed functions. Restoring wetlands helps recover lost wetland functions, improve watershed function, and improve water quality. Preservation of existing wetlands can also safeguard a watershed from further negative impacts from wetland loss/change. Additionally, creating more living shorelines (in place of hardened bulkheads or walls) can provide more protection from wave energy while providing additional habitat and space for valuable coastal marshes to migrate inland with sea level rise.

The 2021-2025 North Carolina Wetland Program Plan (WPP) identifies DEQ's wetland goals and specific activities for the next five years. The WPP states that "*North Carolina state agency support for voluntary restoration and protection includes project guidance, low-interest loans, and grant funding for proposed projects*." In addition, conducting research and sharing resultant data can provide guidance and assist with implementing successful restoration and protection methods to help improve water quality. *The WPP commits state agency staff expertise to assist with outreach and education efforts and encourage the use of nature-based solutions to meet wetland protection and restoration goals within North Carolina*. The WPP also suggests that *restoration efforts should prioritize areas that are strategically located to protect or improve water quality (i.e., headwater or riparian areas), mitigate local flooding issues, have connectivity to existing wetland or upland wildlife habitat, or have deep organic soils which can serve as a carbon sink and support climate resiliency*. *Preservation efforts should prioritize areas that serve as corridors between upland and wetland habitats, protect communities or agricultural areas from flooding or storm surges, protect water quality, have mature forests or a mosaic of mature and successional forest, or have deep organic soils.*

On May 25, 2023, the Supreme Court, ruling in Sackett v. Environmental Protection Agency, sharply limited the scope of the federal Clean Water Act's protection for the nation's waters by redefining "Waters of the United States" (WOTUS). The majority opinion decided that WOTUS include only those waters that are described "in ordinary parlance" as "streams, oceans, rivers, and lakes," and wetlands only if those wetlands have a "continuous surface connection" to such waters "making it difficult to determine where the water ends and the wetland begins" (Environmental Law Institute 2023). This leaves many of North Carolina's valuable wetlands (pocosins, headwater forests, seeps, hardwood flats, pine flats and Carolina bays) without federal protection. Even some riverine wetlands, like bottomland hardwoods or riverine swamp forests, that lack a direct surface water connection due to a natural or man-made barrier like a levee or berm, will no longer have federal protection. The Sackett Rule has left the responsibility of protecting these wetlands, no longer defined by WOTUS, to individual state authority. On June 27, 2023, the NC General Assembly approved the annual Farm Act (Senate Bill 582/SL 2023-63) with provisions that "wetlands classified as waters of the State are restricted to waters of the United States…", limiting existing protections (promulgated by the Environmental Management Commission in 1996) to apply only to wetlands that are defined by federal law as Waters of the United States. The Sackett and Farm Bill

combined have the potential to significantly reduce the benefit that wetlands have on water quality in North Carolina. These recent regulatory changes make it that much more imperative to *find voluntary opportunities to restore and protect wetlands in North Carolina and the Cape Fear River Basin*.

## 1.8 Climate Risk and Resiliency

In October of 2018, Governor Roy Cooper signed Executive Order 80 (EO80), "North Carolina's commitment to address climate change and transition to a clean energy economy". Section 9 of EO80 was a directive to the cabinet agencies to integrate climate adaptation and resilience planning into cabinet agency policies, programs, and operations.

In June 2020, the North Carolina Climate Risk Assessment and Resiliency Plan (2020 Resiliency Plan) was published by DEQ. It defined a resilient North Carolina as "a state where our communities, economics, and ecosystems are better able to rebound, positively adapt to, and thrive amid changing conditions and challenges, including disasters and climate change; to maintain quality of life, healthy growth, and durable systems; and to conserve resources for present and future generations" (DEQ, 2020). The 2020 Resiliency plan includes the recommendations of the agencies involved with executing EO80, as well as stakeholders throughout the state, on how to integrate climate adaptation and resiliency planning into their policies, programs, and operations. It provides the state's best understanding of projected change in climate; considers climate justice issues; evaluates state infrastructure, assets, programs, and services that are vulnerable and at risk to climate and non-climate stressors; and includes preliminary actions currently underway or which can be taken to reduce risk. It also includes nature-based solutions and recommendations to enhance ecosystem resiliency and sequester carbon through natural and working lands (NWL). The plan concludes by describing next steps for implementing and updating the 2020 Resiliency Plan as well as strategic resilience initiatives (DEQ, 2020). Since 2020, the cabinet agencies have published annual resilience and climate strategy reports with updates on implementation efforts.

One of the first steps in developing the 2020 Resiliency Plan was for DEQ to work with the North Carolina Institute for Climate Studies (North Carolina State University), representatives from many major higher education institutions, and subject matter experts to develop the North Carolina Climate Science Report (NCCSR). Projected key findings were categorized by percent probability and, except where noted, referred to future changes through the end of the century. Definitions for *virtually certain, very likely, likely, unlikely*, etc. are included in the NCCSR as well as Chapter 3 and Appendix A of the 2020 Resiliency Plan.

Projected key findings of the NCCSR include:

- Sea Level: It is ***virtually certain*** that sea level will continue to rise along North Carolina's coast due to the expansion of ocean water from warming and melting of ice in Greenland and the Antarctic ice sheets.
- Flooding: It is ***virtually certain*** that rising sea level and increasing storm intensity will lead to an increase in storm surge flooding in coastal North Carolina. Inland flooding is also ***likely*** to increase due to extreme precipitation events.
- Temperature: It is ***very likely*** that temperatures in North Carolina will increase substantially in all seasons and that the number of warm and very warm nights will increase and that the summer heat

index will increase due to increases in absolute humidity. It is **likely** that the number of hot and very hot days will increase and that the number of cold days (daytime maximum temperatures below 32°F) will decrease.

- Precipitation: It is ***very likely*** that extreme precipitation frequency and intensity will increase statewide due to increases in atmospheric water vapor content, and it is ***likely*** that total annual precipitation will increase.
- Drought & Wildfires: It is ***likely*** there will be more frequent and intense droughts across the state and that this increase will ***likely*** increase wildfires.
- Ecosystem & Habitat Loss: Sea level rise will result in a loss of wetlands and the habitats associated with them. The loss of wetlands will impact not only commercial and recreational fisheries, but also adversely impact water quality, decrease a buffer's capacity to attenuate nonpoint source pollution runoff, and reduce the resilience of coastal communities. Due to warmer temperatures, harmful algal blooms may increase which will impact aquatic organisms and human health.
- Public Health: Saltwater intrusion due to climate change will impact both groundwater and surface water drinking water sources and impact the amount of freshwater available to irrigate agricultural crops. Extreme weather events will put more stress on emergency management, public services, and institutions, and require more resources to address the impacts. Poor air quality, injuries, loss due to flooding, heat-related illnesses, and increased areas of disease-carrying vectors (such as mosquitoes) will all impact human health.
- Non-Climate Stressors: Many of these impacts will be compounded by non-climate stressors such as population growth, urbanization, and economic inequality. Climate-related impacts will likely have greater effects on vulnerable populations, exacerbating disparities that already exist (Kunkel, et al., 2020; DEQ, 2020).

Programs with DEQ's DWR that may be impacted by climate change include:

- Nonpoint Source Pollution: More frequent and severe precipitation events can increase the delivery of nonpoint source pollution loads to surface waters impacting aquatic habitats, water supply intakes, dam maintenance (i.e., sediment build up and removal), etc.
- Water Quality: Increases to temperature and the length of the warm season can result in increased algal production, lower dissolved oxygen concentrations, degraded aquatic communities, and impacts to commercial and recreational fisheries (i.e., fish kills, trout reproduction, shellfish harvesting).
- Water Supply Planning: Water supply planning will be affected by decreased water availability from more frequent drought conditions.
- Water and Wastewater Facilities: More frequent and intense rain events increase the flood risk to many facilities that DWR regulates such as wastewater treatment plants and animal operations. Discharges permitted through NPDES are currently based on low-flow statistics calculated with historical stream flow data. Variable precipitation in the future could affect typical low flows, changing the capacity of receiving streams to assimilate pollutant loads.

Basinwide planning can support climate resilience by identifying natural resources that may be affected by climate change, providing recommendations for adaptive management, and recognizing nature-based solutions to climate impacts. *Basin plans frequently recommend protecting wetlands and floodplains, installing stormwater BMPs, identifying and retrofitting high-risk infrastructure, projecting and planning*

*for changes in water use and availability, identifying areas that are disproportionately burdened with environmental hazards, and implementing green infrastructure, low-impact development, and living shorelines* (Atkins, 2015; US EPA, 2016; DEQ 2020). Many of these same strategies fall in line with those identified in the 2020 Resiliency Plan.

Many of the recommendations presented in basin plans have also been identified as means to mitigate impacts from increased precipitation and flood events caused by climate change. One example, found in Chapter 5 of the 2020 Resiliency Plan, is land use guidance which includes protecting riparian buffers. This is also one of several strategies identified in basin plans to increase North Carolina's resilience to water quality impacts from flooding. Chapter 5 in the 2020 Resiliency Plan notes that several watersheds have rules in place that protect riparian buffers. Many of these rules were put into place to reduce the amount of nutrients entering waterways from point and nonpoint sources of pollution, but they can also help alleviate impacts from flooding. In addition to rules to protect riparian buffers, the NC Flood Act of 2000 required that communities regulating land use "prohibit certain uses in the 100-year floodplain". Prohibited uses include new solid waste disposal facilities, hazardous waste management facilities, salvage yards, and chemical storage facilities. By expanding and enforcing these protections statewide, state and local governments increase the capacity of the natural landscape to assimilate pollutants before they enter a waterbody (DEQ, 2020). Since inland flooding is projected to increase, *it is critical to adopt practices that reduce storm-driven nonpoint and point source pollution.*

*Basin plans also encourage the collection of more data for many different DWR programs to garner a deeper understanding of current conditions and changes over time. They also encourage the use of natural and working lands (NWL) to protect water resources.* The basin plans will continue to be a source of this information and will increasingly analyze NC's major river basins with a lens towards climate resiliency. More information about the global impacts of climate change can be found on the Fourth National Climate Assessment website. For more information on North Carolina's efforts to address climate change, visit DEQ's climate change website. More information about NWL can be found here.

The National Fish and Wildlife Foundation (NFWF) funded a *Cape Fear Watershed Coastal Resilience Assessment* focused on "identifying areas of open space where the implementation of restoration or conservation actions could build human community resilience and improve fish and wildlife habitat in the face of increasing storms and flooding impacts" (NFWF and NEMAC, 2019). The assessment included stakeholder engagement and resulted in a report and mapping tool [Coastal Resilience Evaluation and Siting Tool (CREST), available at https://resilientcoasts.org]. The assessment identified many areas of "particularly high potential for offering natural and nature-based resilience" options.

### 1.8.1 Planning for Changes in Sea Level

Sea level rise is expected to adversely impact North Carolina's coastline and will likely intensify already existing natural hazards and impacts associated with flooding, storm surges, shoreline erosion, eutrophication, and shoreline recession (Moorman, 2014). Natural or human modifications to the elevation of barrier islands are also predicted to accelerate the erosion of coastal and estuarine shorelines leaving these areas vulnerable during storm events (Riggs and Ames, 2003).

The Salinization Adaptive Capacity Building for Land Use and Tourism Development project is an interdisciplinary group from North Carolina State University (NCSU), University of North Carolina-Chapel Hill (UNC-CH), and Duke University funded by the National Science Foundation (NSF). This group aimed to "answer key questions about climate change and its effects on the people and natural resources of coastal North Carolina" (NCSU, n.d.). The location of their study was the Albemarle-Pamlico Peninsula, but findings are also applicable to counties in the Cape Fear River Basin. Several publications were produced on impacts to land and water resources including (NCSU, n.d.):

- *Rural Coastal Community Resilience: Assessing a Framework in Eastern North Carolina*
- *Sea Level Rise Impacts on Rural Coastal Social-Ecological Systems and the Implications for Decision Making*
- *Marsh Bird Occupancy Along a Shoreline-to-Forest Gradient as Marshes Migrate from Rising Sea Level*
- *Use of Autonomous Recording Units Increased Detection of a Secretive Marsh Bird*
- *Bird Community Shifts Associated with Saltwater Exposure in Coastal Forests at the Leading Edge of Rising Sea Level*
- *Decadal-Scale Vegetation Change Driven by Salinity at Leading Edge of Rising Sea Level*
- *Evaluating the Effects of Land-Use Change and Future Climate Change on Vulnerability of Coastal Landscapes to Saltwater Intrusion*
- *'A Commons Before the Sea:' Climate Justice Considerations for Coastal Zone Management*

A multi-state collaborative project funded by the US Climate Alliance led to the Coastal Protection and Blue Carbon: Mid-Atlantic States project. The project "considers both the current status of coastal habitats and potential future changes due to sea level rise to assess habitats' ability to store carbon long-term and protect vulnerable ecological and human communities into the future" (Warnell K., n.d.). Additional information about sea level rise can be found on the Coastal Resource Commission's (CRC) website and in the associated North Carolina Sea Level Rise Assessment Report (2015).

### 1.8.2 Hurricanes and Flooding

North Carolina has been affected by 413 tropical or subtropical cyclones (of which 47 became hurricanes) from 1851 to the present. Many hurricanes have hit the state directly, while others have caused extensive damage merely passing near the state. Historically, North Carolina ranks fourth nationally in number of hurricanes that have impacted the state. Estimated cost in lives is almost 1,000 fatalities and over $11 billion dollars in damage.

According to statistical research from the North Carolina State Climate Office (SCO), a hurricane makes landfall along the North Carolina coast about every four years and an estimated 17.5 percent of all North Atlantic hurricanes have affected the state. Cape Hatteras is most affected by hurricanes, followed by Cape Lookout and Cape Fear. The Outer Banks are also heavily impacted by hurricanes because of their location along the easternmost edge of the state. Although the eastern portion of the state frequently bears the brunt of Atlantic hurricanes, remnants from Gulf Coast and other southeastern hurricanes have historically caused significant damage in both the Piedmont and Mountain regions of the state.

Hurricanes have typically affected North Carolina between May and December, although the official hurricane season for North Carolina is June 1 to November 30, with the 80 percent of the hurricanes that have affected the state arriving between August and October. The earliest storm to hit the state was Subtropical Storm Andrea on May 7, 2007. The latest was a tropical storm that hit the Outer Banks on December 2, 1925. The most powerful hurricane to hit the state was Hurricane Hazel, a Category 4 hurricane that landed on October 15, 1954.

One of the most active and the costliest eras of hurricane activity in North Carolina occurred between 1980 and 2010. Of these, Hurricane Fran stands out as the strongest hurricane as a Category 3, and Hurricane Florence as the deadliest with 53 fatalities attributed to this storm and record-breaking flooding in the eastern region of the state.

The list below (from NOAA's National Hurricane Center website) captures significant North Carolina hurricane history since 1954.

**1954 -** Hurricane Hazel on October 15 became the most intense hurricane to make landfall in North Carolina during the 20th century. The Category 4 hurricane swept inland near South Carolina, making shambles of many North Carolina beach communities. Destructive winds affected the eastern quarter of the state, with reports of 100 mph+ gusts north to the Virginia border. Isolated flash flooding occurred west of Hazel's track.

**1955 -** Hurricanes Connie, Diane and Ione struck within six weeks causing epic flooding in eastern sections. Connie on August 11-12, Diane on August 16-17 and Ione on September 19 dumped a combined 48.9 inches at the Maysville cooperative weather station. Connie and Ione were Category 2 hurricanes at landfall, while Diane was a Category 1.

**1960 -** Hurricane Donna (Category 3) plowed just inside the Outer Banks region on September 12, making landfall at Cape Fear. Sustained winds were 115 mph at Cape Fear and remained above hurricane force throughout Donna's 150-mile trek through the state. Rainfall totals were generally 4 to 8 inches, with some higher amounts.

**1972 -** Hurricane Agnes made landfall on the Florida Gulf coast, before tracking through the southeastern US. Torrential rainfall pummeled the western two-thirds of North Carolina on June 20-22 causing extensive flooding.

**1989 -** Hurricane Hugo struck near Charleston, South Carolina, on September 21-22, then gradually swung northwest, north and northeast. The Category 4 weakened to a Category 1 as it plunged more than 200 miles inland before tracking through the Charlotte area. It caused extensive damage with winds still gusting near 100 mph.

**1996 -** Hurricane Bertha struck the state on July 12, with a peak gust of 108 mph. Hurricane Fran churned through eastern North Carolina on September 5, with sustained winds up to 115 mph. Not since 1955 had the state experienced two hurricane landfalls in the same season.

**1999 -** Hurricane Dennis soaked the state in late August and early September followed by Hurricane *Floyd* on September 16. Floyd, a Category 2 storm that made landfall just west of Cape Hatteras, dumped 10 to more than 20 inches in eastern North Carolina causing record flooding and an environmental catastrophe.

**2003 -** Hurricane Isabel slammed Ocracoke on September 18 and proceeded to plow through northeastern North Carolina. Category 2 Isabel caused widespread power outages and coastal flooding. It blew down countless trees.

**2011 -** Hurricane Irene came ashore in eastern North Carolina on August 27 as a Category 1 storm, with 85 mph sustained winds. More than 1100 homes were destroyed. Irene became only the third hurricane to make landfall on the U.S. East Coast north of Florida in this century.

**2012 -** Hurricane Sandy passed by the state dropping heavy rain and causing a significant storm surge.

**2016 -** Hurricane Matthew hugged the NC coast after making landfall in South Carolina, causing torrential rains. Wilmington set a new storm tide (water level measured relative to high tide) record at 3.53 ft (1.08 m), beating the previous one of 3.47 ft (1.06 m) set during Hurricane Hazel on October 15, 1954. Matthew caused total devastation in Robeson County, especially Lumberton. At least 28 people were killed, making Matthew the deadliest hurricane in North Carolina since Floyd killed 35 in 1999. Five counties located entirely or partially within the Cape Fear River were affected by Hurricane Matthew including: Wayne, Cumberland, Robeson, Bladen and Columbus.

**2018 -** Hurricane Florence made landfall near Wrightsville Beach early on Friday, September 14, and weakened further as it slowly moved inland. Florence caused significant storm surge flooding in portions of eastern North Carolina. Florence produced extensive wind damage along the North Carolina coast from Cape Lookout, across Carteret, Onslow, Pender and New Hanover counties. Florence resulted in 22 direct deaths and was also associated with 31 indirect fatalities. The state now estimates that Hurricane Florence did nearly $17 billion in damage to homes, businesses, farms and governments in North Carolina. Estimates from the state Department of Insurance found that the physical and economic harm caused by Hurricane Florence has outstripped the combined damages of two previous storms, Hurricanes Matthew and Floyd. Matthew did an estimated $4.8 billion in damage in 2016, while Floyd, which caused similar flooding in Eastern North Carolina in 1999, did between $7 billion and $9.4 billion, when adjusted for inflation. Nine counties located entirely or partially within the Cape Fear River were affected by Hurricane Florence, including: Duplin, Onslow, Pender, New Hanover, Brunswick, Cumberland, Robeson, Bladen, and Columbus.

**2019** – Hurricane Dorian was the strongest and most destructive storm of the 2019 hurricane season, devastating the islands of the Bahamas as a category 5 storm with winds over 180 mph. Dorian slowly weakened to a category 2 storm which traveled north just offshore along the eastern Atlantic shoreline of the US from central Florida to North Carolina. The eye of the storm missed the Cape Fear River inlet by 30 miles and made landfall on Ocracoke and Hatteras Islands on September 6. The storm heavily damaged the southern Outer Banks with wind and substantial storm surge. Rainfalls ranged from about 4" near Cape Fear River Lock and Dam #1 to 13" near Wilmington.

**2020** – Hurricane Isaias made landfall at Ocean Isle Beach as a category 1, with maximum sustained winds near 85 mph. The storm moved quickly, limiting the rainfall amounts, however there was a significant storm surge which caused damage throughout the area. "The storm surge moved up the tidal portion of the Cape Fear River into downtown Wilmington, causing significant street flooding and damaging some first-floor businesses along Water Street. The downtown river gauge reached its highest level in history at 9.03 feet MLLW (Mean Lower Low Water, which is the average level of the lowest tide for each date computed over a 19-year period), eclipsing the previous record of 8.28 feet set just two years earlier during Hurricane Florence." (National Weather Service, Hurricane Isaias2020).

Find additional information on significant weather and climate events impacting Southeast NC on the National Weather Service's website.

In 2016, the General Assembly established the North Carolina Resilient Redevelopment Planning Program to provide a guide to rebuild communities damaged by Hurricane Matthew. This program produced Hurricane Matthew Resilient Redevelopment Plans for 50 counties available through North Carolina Office of Recovery and Resiliency (NCORR). Also see Chapter 4 for more information on NCORR proposed resiliency projects developed by Council of Governments (COGs) located in the Cape Fear River Basin region. To continue to build resiliency in North Carolina, a workgroup was formed to produce the Action Plan for Nature-based Stormwater Strategies: Promoting Natural Designs that Reduce Flooding and Improve Water Quality in North Carolina. This action plan offers recommendations to make our communities more resilient by protecting, restoring, and mimicking our state's natural watershed hydrology. The workgroup's recommendations encourage collaborative, efficient approaches so that efforts consider both reduced flooding and improved water quality as objectives, and can be effectively sited and designed (NCCF, 2021).

Stakeholders working on resiliency in their community also have web-based mapping resources such as the Department of Public Safety (DPS) North Carolina Flood Risk Information System (FRIS). This tool enables local and regional stakeholders to more accurately predict flood hazards and prepare for flood risks (https://fris.nc.gov/fris/Home.aspx?ST=NC). DPS has also developed the Flood Inundation Mapping and Alert Network (FIMAN) which provides rain and stage gage information, flood inundation maps, flooding impacts and alerts in real-time to support risk-based decisions regarding flooding (https://fiman.nc.gov/).

### 1.8.3 High Tide/Sunny Day Flooding

According to NOAA, "high-tide flooding", often referred to as "king tides", "nuisance" or "sunny day" flooding, is becoming increasingly common due to years of sea level rise. high tide flooding (HTF) is defined as the overflow or excess accumulation of ocean water at high tide that covers low-lying areas, and typically occurs when tides reach anywhere from 1.75 to 2 feet above the daily average high tide and start spilling onto streets or bubbling up from storm drains. As sea level rise continues, damaging floods that happened decades ago only during a storm now happen more regularly, like during a full-moon or with a change in prevailing winds or currents." NOAA has developed a tool to predict high tide flooding which projects Wilmington will experience between 40 and 65 HTF days/year by 2050 (National Water Level

Observation Network Station #8658120 in Wilmington; NOAA – State of High Tide Flooding and 2022 Outlook; NOAA 2022-a). The long-term projections developed by NOAA are based on the range of expected relative sea level rise by 2050 using information from the 2022 Sea Level Rise Technical Report (NOAA 2022-b). To see local Cape Fear River impacts near Wilmington NC, see Dr. Rodger Shew from UNC Wilmington describe fair weather flooding to local Spectrum News Reporter on March 13, 2022 – Link to video.

### 1.8.4 DEQ/DMS Flood Resiliency Blueprint

In 2021, the North Carolina General Assembly directed the DEQ to develop a Statewide Flood Resiliency Blueprint (Blueprint). The Blueprint is intended to serve as the backbone of NC's flood resiliency planning based on the best available science, stakeholder engagement, and sound decision-making. The Blueprint should ultimately lead to a prioritized set of projects and funding strategies that the State can implement. The goal is to make North Carolina more resilient to flooding disasters, by reducing the likelihood and extent of flooding, reducing vulnerability and impacts from flooding, and increasing community ability to maintain and quickly resume pre-storm activities following flooding.

In 2024, DEQ published the Draft Flood Resiliency Blueprint document (Draft Blueprint), which provides a structured, comprehensive framework to make it easier for local communities to get started with or advance their planning and mitigation efforts. The Draft Blueprint includes an inventory of existing data, tools, models, and processes as well as critical limitations that the Blueprint Program needs to address to be successful. Based on this evaluation, the Blueprint has made important investments in model improvements in the six target basins and the development of a decision support tool.

The **Blueprint Tool** is designed to be a resource for communities, local governments, and other partners for the planning and implementation of resilience actions. It will provide users with accurate, data-driven flood risk and vulnerability assessments, allow users to explore, develop, and define flood resilience actions, and help users to evaluate and prioritize effective flood resilience actions. The Blueprint Tool will be publicly available in Spring 2025.

**The Decision Support Tool**

The Blueprint online interactive decision-support Tool will provide:

- multi-scale flood modeling for future conditions;
- the consolidation of existing flood risk data, projects and action strategies;
- multi-level mitigation/project planning to support implementation;
- Watershed prioritization enhancement that would includ~~ing~~ such factors as social vulnerability, local needs, nature-based solutions, traditional mitigation methodologies, and cost-benefit analysis

The Blueprint is working diligently with local, state, and regional partners to develop **River Basin Flood Resiliency Action Strategies in 6 priority basins.** A draft Action Strategy has been completed for the Neuse River Basin. Blueprint staff and DEQ leadership have hired consultants and are working with identified local and regional partners in the process of developing River Basin Flood Resiliency Action Strategies in the Cape Fear, Lumber, Tar-Pamlico, White Oak, and French Broad basins. The Cape Fear River Basin Action Strategy is scheduled to be completed in early 2026.

The General Assembly allocated $96 million for Blueprint to assist with the **implementation of flood resiliency projects**. As a first step in administering this funding, DMS has partnered with fellow state agencies and programs with overlapping resilience priorities such as Department of Agriculture – Streamflow Rehabilitation Assistance Program (StRAP), NC Office of Recovery & Resiliency (NCORR), NC Land and Water Fund (NCLWF), and the NC Emergency Management (NCEM) in the Department of Public Safety. Blueprint staff are vetting projects solicited through other programs to identify those that best meet Blueprint goals, including potential projects identified in Hazard Mitigation Plans and other Resiliency Plans. As of January 2025, DMS has identified more than 50 resilience projects totaling over $17M to fund through these interagency partnerships, committing $5,631,775 to the implementation of 10 projects in the Cape Fear River Basin (*Table 1-12*).

The 2025 session of the General Assembly will be critical to the future of the Blueprint program. The Blueprint's enabling legislation and mission envision a statewide program serving 17 river basins in North Carolina. To accomplish that important goal the Blueprint requires additional authorization and funding, not just to expand flood resilience planning and project implementation to all basins, but to refine and improve the data, tools, and planning process to better support our local partners. Critically, without action, the temporary Blueprint staff terms will end in late 2025. The Blueprint staff manage the basin action strategies, administer funding for resilience projects, and serve as the primary liaisons with local governments. The development of the Flood Resiliency Blueprint and the Blueprint Tool has laid the foundation for future success in making the State more resilient to flooding. For the latest information please visit the DEQ Flood Resiliency Blueprint website at https://www.deq.nc.gov/energy-climate/flood-resiliency-blueprint.

*Table 1-12 Cape Fear River Basin DMS Flood Resiliency Blueprint projects (As of January 2025).*

| Project Name | Applicant | County | Project Type | Supporting Partner[1] | DMS Award |
|---|---|---|---|---|---|
| Pender Soil & Water Cons District | Pender Soil & Water Cons District | Pender | Stream Debris Removal | NCDACS | $334,625 |
| Town of Beulaville, N.C. | Town of Beulaville, N.C. | Duplin | Stream Debris Removal | NCDACS | $33,000 |
| Town of Magnolia | Town of Magnolia | Duplin | Stream Debris Removal | NCDACS | $10,000 |
| Town of Leland | Town of Leland | Brunswick | Stream Debris Removal | NCDACS | $344,000 |
| Loves Creek Tributary 2 - Section 4 | Siler City | Chatham | Stream Restoration | NCDACS | $85,150 |
| Nickelson Branch | Town of Wallace | Duplin | Stream Debris Removal/Restoration | NCDACS | $115,000 |
| Wilmington - Wisteria and Clearbrook - Restoration | City of Wilmington | New Hanover | Restoration | NCLWF | $800,000.00 |
| Little Buffalo Creek MIT | Sanford | Lee | Infrastructure | NCDPS | $1,500,000.00 |

| Project Name | Applicant | County | Project Type | Supporting Partner[1] | DMS Award |
|---|---|---|---|---|---|
| Lyon & Ivy Culvert Replacement | Fayetteville | Cumberland | Infrastructure | NCDPS | $910,000.00 |
| Hanna's Pond Dam & Floodplain | Harnett County | Harnett | Restoration | NCDPS | Pending $1,500,000.00 |

1 NCDACS – NC Department of Agriculture and Consumer Services, NCLWF - NC Land and Water Fund; NCDPS – Department of Public Safety Emergency Management.

## 1.9 Protecting Water Resources in the Cape Fear River Basin

The Basin Planning Branch (BPB) continually works with the Nonpoint Source Planning Branch (NPSPB), Soil and Water Conservation Districts (SWCD), Natural Resources Conservation Service (NRCS), and various stakeholders throughout the region to improve our understanding of point and nonpoint sources of pollution and encourage continued efforts to implement best management practices (BMPs) and restore beneficial nutrient concentrations, sediment loads, and flow volumes to the receiving waterbodies.

Nutrient enrichment is a major water quality concern across much of the state, and data collected over the past several years shows that nutrients are impacting many of the waterbodies found in the Cape Fear River Basin. Several NC river basins and smaller watersheds have been officially classified as Nutrient Sensitive Waters (NSW). The NSW designation is given to waters that have been identified as ones that "are experiencing or are subject to excessive growths of microscopic or macroscopic vegetation" to the point where the EMC (Environmental Management Commission) has determined that the growth can "impair the best usage of the water as determined by the classification applied to such waters" (15A NCAC 02B .0223). This supplemental classification comes with a default wastewater discharge annual mass limit requirement for nitrogen and phosphorus. In the Cape Fear River Basin, the Jordan Lake watershed was classified as NSW in 1983 by the EMC due to water quality concerns (Chapter 6, 6.6.6.8).

In addition to Jordan Lake, there are many other waterbodies within the Cape Fear River Basin which are identified as nutrient enriched due to excess nutrients causing water quality concerns but do not carry the NSW designation. These concerns include low dissolved oxygen in the Cape Fear River Estuary, excessive growths of microscopic or macroscopic vegetation during the critical growing season and low flow periods, and high chlorophyll *a* and algal numbers in many of the basin's lakes and reservoirs. Excessive biological productivity can negatively impact the uses of these waterbodies including recreation (i.e., boating, swimming, fishing), water supplies, and aquatic life. Increasing incidence of algal blooms, some associated with harmful algal blooms (HABs) and known cyanotoxins, have been occurring in the Cape Fear River Basin since 2009.

Currently, North Carolina does not have an instream nitrogen or phosphorus water quality standard. Instead, the state utilizes chlorophyll *a* criteria as a response variable to assess for nutrient impacts to a waterbody. The results provided in the watershed chapters have shown that the current water quality standard of 40 µg/L for chlorophyll *a* is not protective of the designated uses of all waterbodies. Large

segments of the Cape Fear River Basin currently meet the chlorophyll *a* criteria or the criteria is not assessed because the standard is not appropriate for the waterbody type (i.e., flowing stream and rivers). The mainstem Cape Fear River from the confluence of the Haw and Deep rivers down past Lock and Dam #1 (LD#1) near East Arcadia, as well as much of the Deep River and the lower Haw River, have elevated chlorophyll *a* levels under certain environmental conditions, but they do not exceed the water quality standard. New research is showing that during low flow conditions, algal growth in the mainstem Cape Fear River forms in the surface layer due to hydrologic and thermal stratification (Hall, 2021 and Hall and Rosman, 2022). Current sampling protocols do not allow for an accurate assessment of the instream water quality conditions which can lead to a measurement that underestimates biological productivity and impacts to water quality.

Many small stream systems in the Cape Fear River Basin (e.g., Rocky River) are also impacted by micro- and macroscopic vegetation known as periphyton which grow on substrates in the rivers and streams. This periphytic growth is not captured using the traditional chlorophyll *a* criteria and sampling methods. Periphytic growth has been found to impact recreational uses, instream habitats, and aquatic life.

In addition to the rivers and streams, nutrients are also impacting many of the drinking water and recreational lakes and reservoirs throughout the basin. Along with chlorophyll *a*, a North Carolina Trophic State Index (NCTSI) value is used to help resource managers understand how biologically productive these systems are. There are eight reservoir/lakes in the Cape Fear River Basin that are identified in the 2022 Integrated Report (IR) as not meeting the chlorophyll *a* water quality standard. Due to limited resources, many of the lakes are not monitored at a frequency (minimum of 10 samples over a 5-year period) that allows for a full water quality assessment to be completed. However, of the 35 reservoir/lakes monitored in 2018, the trophic status indicated that 26 were classified as eutrophic, indicating elevated biological productivity, and 2 were hypereutrophic (extremely productive) (Section 2.6, Table 2-17). This includes 13 lakes assessed in the Haw River subbasin in 2018 which were classified as eutrophic and four were officially listed as impaired. All the lakes in the Jordan Lake watershed will benefit from nutrient reductions that are required by the EPA approved Jordan Lake TMDL and the nutrient management strategy, which are in the process of being readopted.

To address these nutrient enrichment issues, several steps are being taken by DWR. These include, but are not limited to, watershed modeling, development of appropriate instream water quality criteria (e.g., nitrogen, phosphorus, chlorophyll *a*, periphyton, etc.) with the Science Advisory Council (SAC), possible development of TMDLs or watershed specific strategies to address nutrient contributions from all sources in the watersheds, supporting additional research to understand the driving factors for the development of HABs and other factors influencing the low dissolved oxygen in estuary. NC Session Law 2016-94 established the NC Collaboratory at UNC Chapel Hill to conduct research on natural resources management. NC Collaboratory has developed recommendations to support improved water quality and water resource management in nutrient sensitive waterbodies (chapter 6, 6.6.9.3). DWR will utilize study findings to help inform and guide the use of appropriate nutrient management measures developed to address water quality concerns and restore designated uses.

Many recommendations are included throughout the Cape Fear River Basin plan chapters to address nutrient enrichment issues resulting from point and nonpoint sources across the landscape. The

recommendations vary widely depending on land uses and ecoregions. Most of the recommendations that address nutrients also provide a secondary benefit by reducing sedimentation/turbidity and bacteria, two additional primary water quality concerns throughout the Cape Fear River Basin and identified in the watershed chapters.

Through cooperation with federal, state, and local agencies and stakeholders, *DWR supports the following recommendations to better protect water resources for all residents and aquatic habitats throughout the Cape Fear River Basin.*

### Point Source Pollution

- DWR's Basin Planning Branch (BPB) and Modeling and Assessment Branch (MAB) will continue to work collaboratively with permit writers and the ambient and coalition water quality monitoring programs to ensure that dischargers are collecting appropriate effluent and instream data. This data is critical for water resource managers to understand and potentially address nutrient contributions to waterbodies throughout this nutrient-impacted basin.

- DEQ strongly encourages public water and wastewater providers and pretreatment system operators to know the level of emerging contaminants in industrial waste in order to protect the environment, downstream users of water resources, and rate payers across the state. DWR may recommend pretreatment requirements or add monitoring or reporting requirements to permits as needed.

- DWR will encourage existing WWTPs to pursue nutrient optimization to improve nutrient removal processes at existing treatment works, especially in areas identified as nutrient sensitive or enriched. This could include an evaluation of existing treatment components and operations, determining if there are issues areas with infiltration or exfiltration, and identifying additional opportunities to improve and optimize nitrogen and phosphorus reduction. It is also recommended that standard operating procedures be developed to mitigate treatment inefficiencies associated with staff turnover and promote consistent high performance.

- As resources allow, DWR should identify and provide educational opportunities for operators of smaller wastewater package plants to ensure proper maintenance and operational procedures are being followed. It is also recommended that DWR increase oversight and inspection of these smaller package plants.

- Homeowner education is needed on how to properly maintain and operate single-family wastewater treatment systems to reduce their impact on water quality. Many of these systems are not well maintained and are known to contribute nutrient and bacterial loading to local streams and Jordan Lake. Connecting single-family wastewater treatments systems to municipal wastewater facilities is encouraged when or if they become available.

### Nonpoint Source Pollution - Urban and Rural

- Encourage and support implementation of existing sediment and erosion control local programs and local stormwater control ordinances while also evaluating the need to improve them. Current

state stormwater rules include minimum requirements, but do not provide for sufficient volume control or water quality treatment for large storm events nor do they address the overall reduction measures needed in nutrient sensitive watersheds (NSW). New construction designs should include practices that prevent or minimize the amount of runoff leaving the site and establishing and protecting existing buffers, floodplains, and wetlands.

- Encourage local governments to evaluate local ordinances for ways to better protect surface water sources from nonpoint source runoff, improving building requirements to utilize BMPs that encourage infiltration and nutrient reduction, floodplain and buffer protections, and sediment and erosion control measures that protect water quality during larger storms. Existing stormwater ordinances should be tailored to the watershed and/or basin and consider the amount of impervious surface, precipitation, slope, soil type, and the nature and ownership of the conveyance system across the land.

- Encourage the implementation of the 2021-2025 North Carolina Wetland Program Plan which includes prioritizes wetland restoration efforts in areas that are strategically located to protect or improve water quality (e.g., headwater or riparian areas), mitigate local flooding issues, have connectivity to existing wetland or upland wildlife habitat, or have deep organic soils. Preservation efforts should prioritize areas that serve as corridors between upland and wetland habitats, protect communities or agricultural areas from flooding or storm surges, protect water quality, have mature forests or a mosaic of mature and successional forest, or have deep organic soils.

- Identify and expand educational opportunities to work with private landowners on nutrient management and the benefits of implementing BMPs, maintaining riparian buffers, and conducting soil tests to prevent fertilizer over-application.

### Nonpoint Source Pollution – Agriculture and Forestry

- Encourage agricultural operations to work with their local soil and water conservation districts to evaluate the need for BMPs or conservation measures to reduce or eliminate any impacts their operation may be having on the local environment and neighboring communities.

- Encourage deemed permitted agricultural operations to use certified technical specialist to develop or review their waste utilization plan to ensure waste management practices will not impact surface waters where animal waste is land applied.

- Encourage the use of waste management structures (dry stacks) to reduce potential impacts from dry litter poultry waste to water quality. DWR continues to receive complaints regarding uncovered dry litter waste piles from poultry operations. Uncovered waste piles can lead to concentrated nutrients and bacteria runoff to surface waters. Nutrients and bacteria can also impact groundwater if the waste pile is left on a permeable surface (i.e., the ground). Per North Carolina Administrative Code (15A NCAC 02T .1303), litter may not be stockpiled uncovered for greater than 15 days.

- Provide sufficient funding to existing state and federal cost share programs (urban, agriculture, and forestry) for technical assistance and the voluntary implementation of BMPs. This includes cost share programs managed by the NCDA&CS Division of Soil & Water Conservation (DSWC) and NC Forest Service (NCFS) and federal programs managed by the USDA Natural Resources Conservation Service (NRCS). Programs should promote BMPs that reduce nutrients, turbidity, and bacteria in waterways.

- Expand existing data collection (including source identification) to include agricultural watersheds with high concentrations of deemed permitted animal operations. DWR has little to no information on deemed permitted facilities. More information is needed to better understand their impact on water resources throughout the basin. Data collected could be used by an interagency workgroup consisting of water resource professionals, the agricultural community, researchers (academia), database managers, and interested community members to review the existing regulatory framework, identify which BMPs are most effective at reducing the amount of sediment, bacteria, and nutrients leaving a site, and how best to manage and track waste generated on the farm.

- Encourage forest landowners and loggers to be aware of the rules and regulations that apply to their property and consult with experts as needed to ensure that water resources are identified and protected. The NCFS recommends pre-harvest planning to identify water resources on the tract, understand any complications posed by terrain and topography, identify locations where important features like skid trails, stream crossings, decks and other BMPs will be installed, and ensure that no threatened or endangered species will be impacted by the harvest. Utilize the Forest Pre-Harvest Planning Tool on the NCFS website to aid in completing pre-harvest planning checklist.

- NCFS recommends avoiding crossing streams when harvesting timber. If a stream crossing is necessary, the preferred method for temporary crossings is portable steel or timber bridgemats, which span over the waterway channel and minimize impacts. In lieu of culverts, the installation of properly designed fords can allow movement of aquatic life and allow stormflow surges of water to pass more easily. The N.C. Forestry BMP Manual includes a chapter on stream crossings. In addition to the FPGs, buffer rules and wetland harvesting regulations may also apply. The N.C. Forest Service maintains a web page outlining the water quality rules that may apply to forestry activities.

**Wetlands, Biodiversity, and Ecological Resources**

- Basin planning supports the removal of dams or other man-made barriers where appropriate and economically feasible or the installation of fish ladders or stream bypass channels to encourage the passage of migratory fish and promote biodiversity and the sustainability of healthy fish populations.

- Encourage land conservation, especially in headwater areas and adjacent to rivers, creeks, and streams. Prioritizing conserving tracts of land with wetlands, rare habitats, and/or rare species (including tracts of land adjacent to migratory fish habitat) is also encouraged.

- The State of North Carolina Wetland Program Plan (WPP) has committed state agency staff expertise to assist with outreach and education efforts to encourage the use of nature-based solutions to meet wetland protection and restoration goals within North Carolina. The WPP also suggests that restoration efforts should prioritize areas that are strategically located to protect or improve water quality (i.e., headwater or riparian areas), mitigate local flooding issues, have connectivity to existing wetland or upland wildlife habitat, or have deep organic soils which can serve as a carbon sink and support climate resiliency. Preservation efforts should prioritize areas that serve as corridors between upland and wetland habitats, protect communities or agricultural areas from flooding or storm surges, protect water quality, have mature forests or a mosaic of mature and successional forest, or have deep organic soils.

- The NC Wildlife Resource Commission's 2015 North Carolina Wildlife Action Plan (WAP) makes specific recommendations for species surveys, long-term monitoring, research, and management practices to reduce environmental impacts. It also recommends that conservation programs and partnerships work synergistically with other conservation actions to enhance the "resilience of natural resources" throughout the region.

**Climate Risk and Resiliency**

- DWR supports protecting wetlands and floodplains; installing stormwater BMPs; identifying and retrofitting high-risk infrastructure; projecting and planning for changes in water use and availability; identifying areas that are disproportionately burdened with environmental hazards; and implementing green infrastructure (GI), low-impact development and living shorelines (Atkins, 2015; US EPA, 2016; DEQ 2020). Many of these same strategies fall in line with those identified in the 2020 NC Climate Risk Assessment and Resiliency Plan.

- DWR supports research studies to gain a better understanding of climate change impacts on septic system performance as the function of these subsurface systems has been shown to be impacted by heavy rains and flooding, sea-level rise, rising groundwater tables, and other climate related impacts.

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