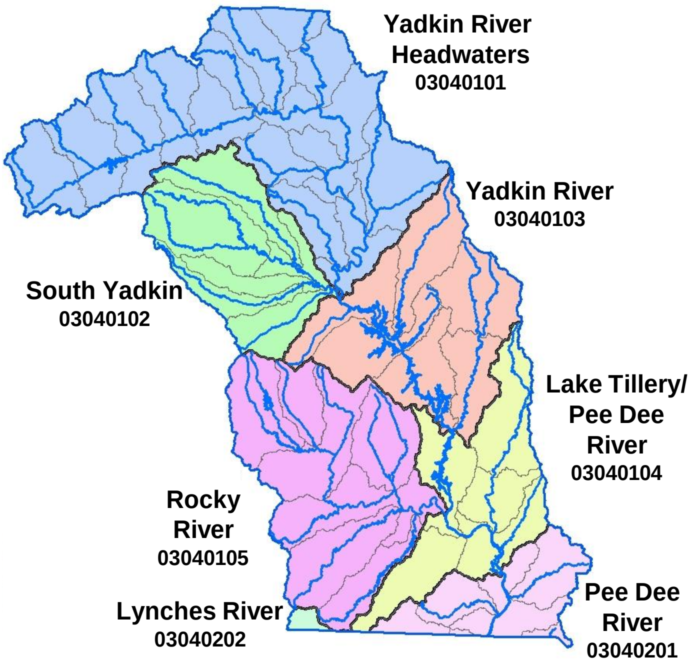

YADKIN-PEE DEE RIVER BASIN 2022 BASIN PLAN

Chapter 2 Yadkin-Pee Dee River Basin Overview - DRAFT

BASINWIDE WATER RESOURCES MANAGEMENT PLAN

Cycle 4 – Yadkin Pee Dee River Basin Report

NC Department of Environmental Quality
Division of Water Resources
Basin Planning Branch

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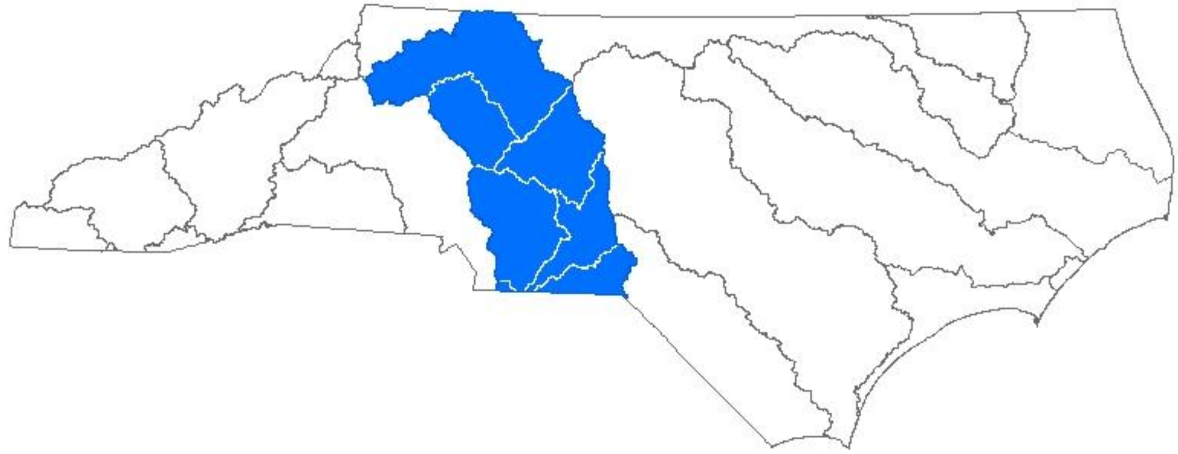
2 Yadkin-Pee Dee River Basin Overview



2.1 General Description

2.1.1 Geography

The Yadkin-Pee Dee River basin is the second largest river basin in North Carolina, covering 7,221 square miles across 24 counties and 93 municipalities. Within North Carolina, the basin contains 6,287 miles of streams and 43,206 acres of lakes. The North Carolina portion of the river basin covers seven US Geological Survey (USGS) 8-digit Hydrologic Unit Code (HUC) watersheds including the Yadkin River Headwater (03040101), South Yadkin (03040102), Yadkin River (03040103), Lake Tillery / Pee Dee River (03040104), Rocky River (03040105), Pee Dee River (03040201), and Lynches River (03040202). Lynches River is located primarily within South Carolina (see Figure 2.1.1-1).

The entire Yadkin-Pee Dee River basin spans three states and drains 18,864 square miles of land that originates from a dense network of headwater streams in the Blue Ridge Mountains of southern Virginia and northwestern North Carolina and ends in the Atlantic Ocean in South Carolina. In North Carolina, the Yadkin River flows southeast from its headwaters then northeast passing through the Kerr Scott Reservoir and the towns of Wilkesboro and Elkin. When the river reaches Winston-Salem, it turns southeast and passes through Lexington and Salisbury and six more man-made reservoirs, merging with the Uhwarrie River between Badin Lake and Lake Tillery to form the Pee Dee River. The river continues southeast through the expansive South Carolina coastal plain where it merges with the Lynches, Little Pee Dee, Waccamaw, and Black rivers, and ultimately drains into Winyah Bay near Georgetown and Myrtle Beach. By the end of the journey, the river has traveled over 400 miles from the mountainous headwaters to the Atlantic Ocean through a varied and changing landscape. Both the Lumber, which merges into the Little Pee Dee, and the Waccamaw rivers originate in North Carolina (see Figure 2.1.1-2).

Figure 2.1.1-1: Yadkin-Pee Dee River Basin 8-Digit HUC Watersheds and Counties

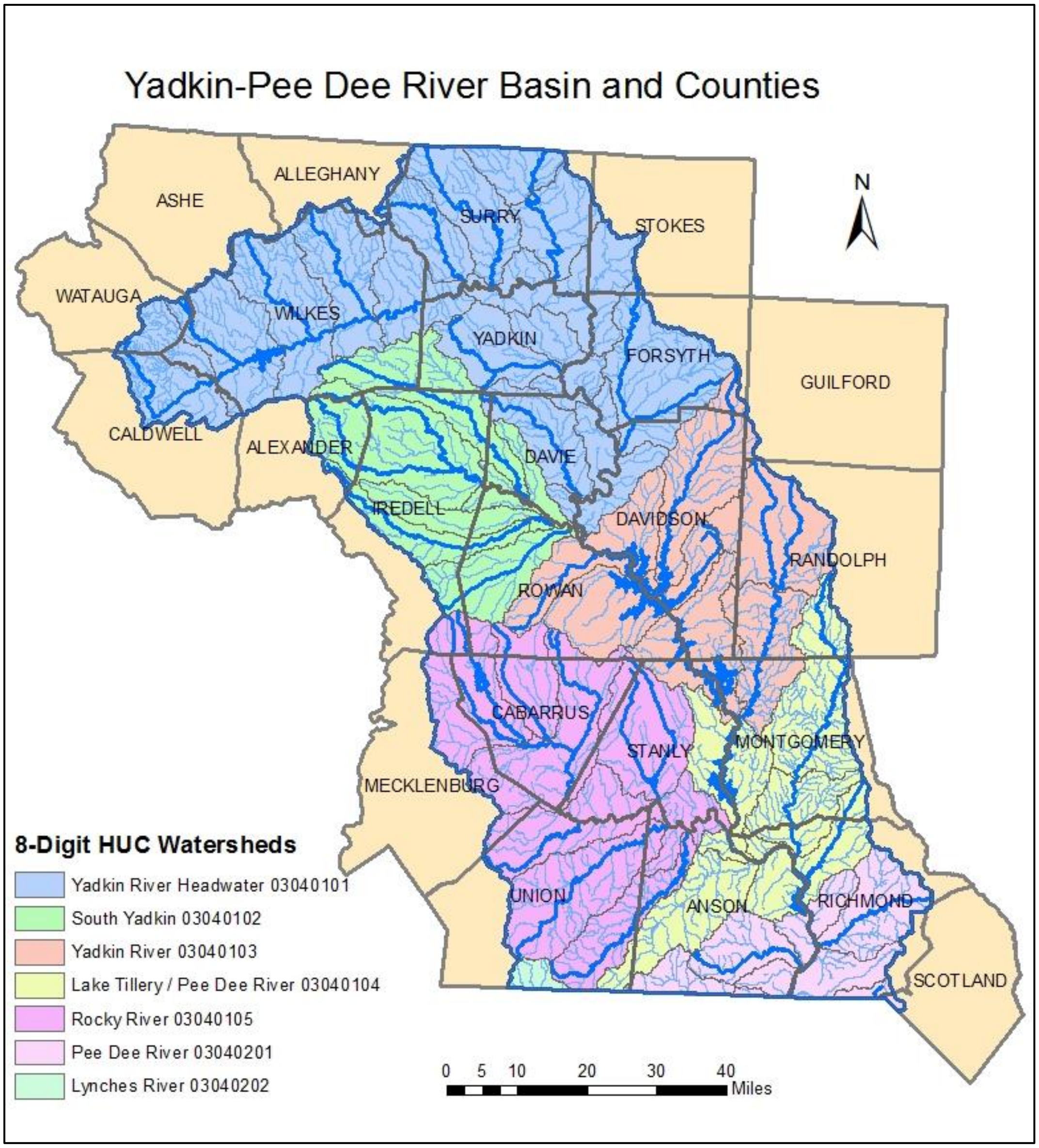
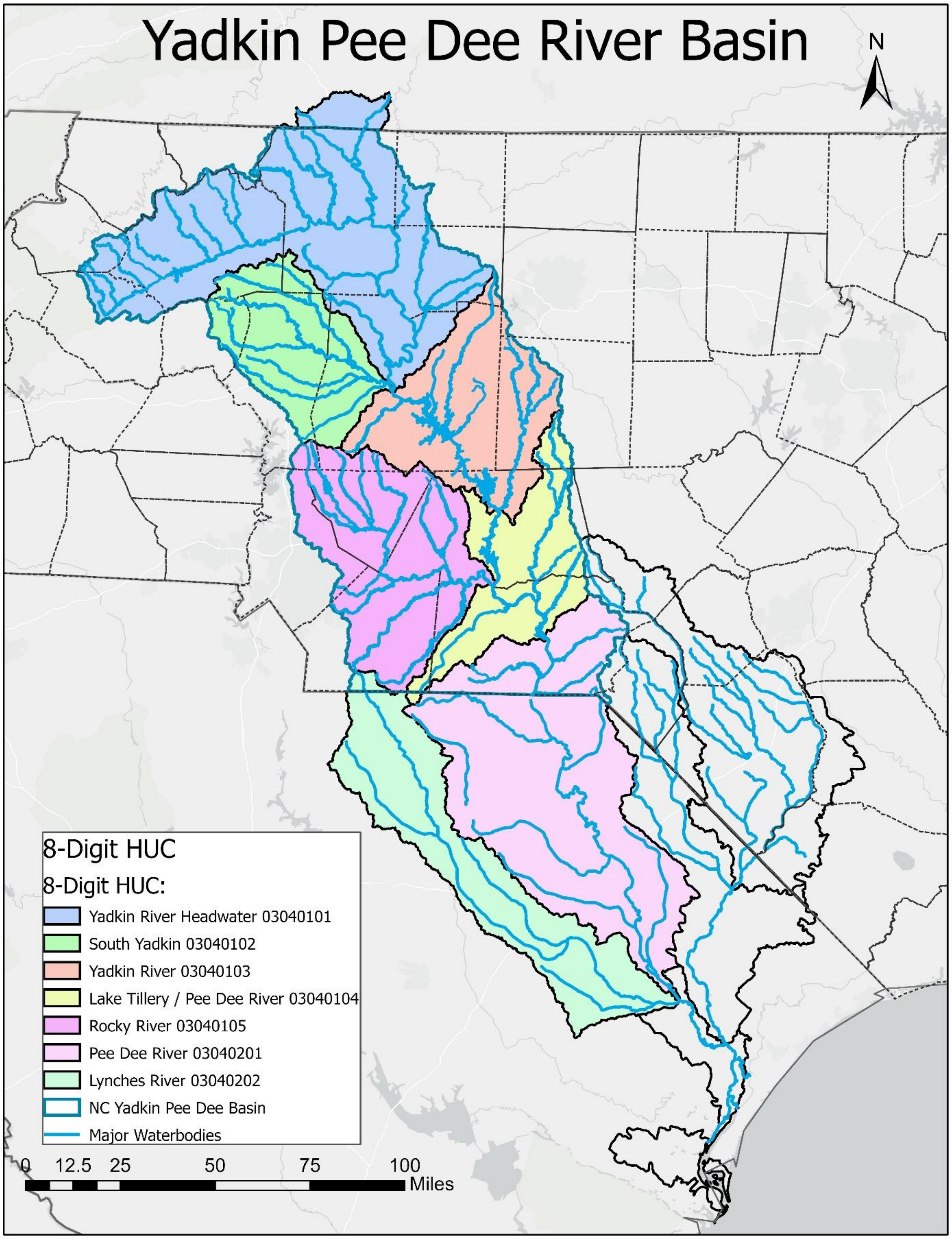


Figure 2.1.1-2: Entire Yadkin-Pee Dee Watershed



Major tributaries in the North Carolina portion of the Yadkin-Pee Dee River basin include the Ararat, South Yadkin, Rocky, Uwharrie, and Little rivers and Muddy, Abbott, and Brown creeks. The reservoirs along the mainstem of the Yadkin River begin with the Kerr Scott Reservoir in Wilkes County in the Yadkin River Headwater watershed. There are six large reservoirs, known as the Yadkin-Pee Dee chain lakes. They are located in the Yadkin and Lake Tillery/Pee Dee watersheds and include High Rock, Tuckertown, Badin Falls (or Narrows), Tillery, and Blewett Falls. All six chain lakes are used for hydropower generation. Badin Lake, the oldest of the upper four chain lakes, began operation in 1917 just below the gorge. It is often referred to as “the narrows” and it provided power to the predecessor of the Aluminum Company of America (Alcoa) to smelt aluminum at the Badin plant. The oldest of the six chain lakes is Blewett Falls, which began operation in 1912 by a predecessor to Duke Energy. The oldest production of transmitted hydroelectric power in North Carolina occurred at the Idols Dam in 1898 on the Yadkin River, west of Clemmons.

Besides hydropower generation, reservoirs are also used for municipal and industrial water supply, agricultural irrigation, flood control, and recreation, and there are several small reservoirs, or man-made lakes, located on tributaries throughout the basin. There are over thirty reservoirs and lakes used for municipal water supply in the Yadkin-Pee Dee, including Lake Tillery (Town of Norwood and Montgomery County), Blewett Falls Lake (Anson and Richmond counties), and Badin Lake (City of Albemarle). The number of reservoirs in the basin provides plentiful opportunities for recreation, including boating and fishing. High Rock Lake, the second largest reservoir in North Carolina behind Lake Norman, is considered one of the best fishing lakes in the state and has been the location of many Bassmaster Tournaments (VisitNC, 2019). Chapter 5 includes a list of dams that are inspected and overseen by the Division of Energy, Mineral, and Land Resources (DEMLR) Dam Safety Program.

2.1.2 Ecoregions

Ecoregions (ecological regions) 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. Ecoregions provide scientists and land managers a spatial framework for research, assessment, management, and monitoring of ecosystems and ecosystem components (EPA https://www.epa.gov/eco-research/ecoregion). US ecoregions have hierarchical levels with Roman numerals assigned to denote the geographic level (Omernik, 1987). North Carolina’s ecoregions are generally known at “Level III” hierarchy and include the Blue Ridge Mountains, Piedmont, Southeastern Plains (also referred to as the Inner Coastal Plain), and Mid-Atlantic Coastal Plain. These Level III ecoregions are oriented at a northeast to southwest orientation in North Carolina (Figure 2.1.2-1). The Piedmont ecoregion covers most of the Yadkin-Pee Dee River basin (85%) with a section of Blue Ridge Mountains and Southeastern Plains occurring in the most northwest corner and most southeast corner, respectively (Figure 2.1.2-1). Level III ecoregions are subdivided into Level IV ecoregions, which have more specific regional characteristics (Figure 2.1.2-2, Griffith et al.).

Figure 2.1.2-1: Yadkin-Pee Dee River Basin Level III Ecoregions

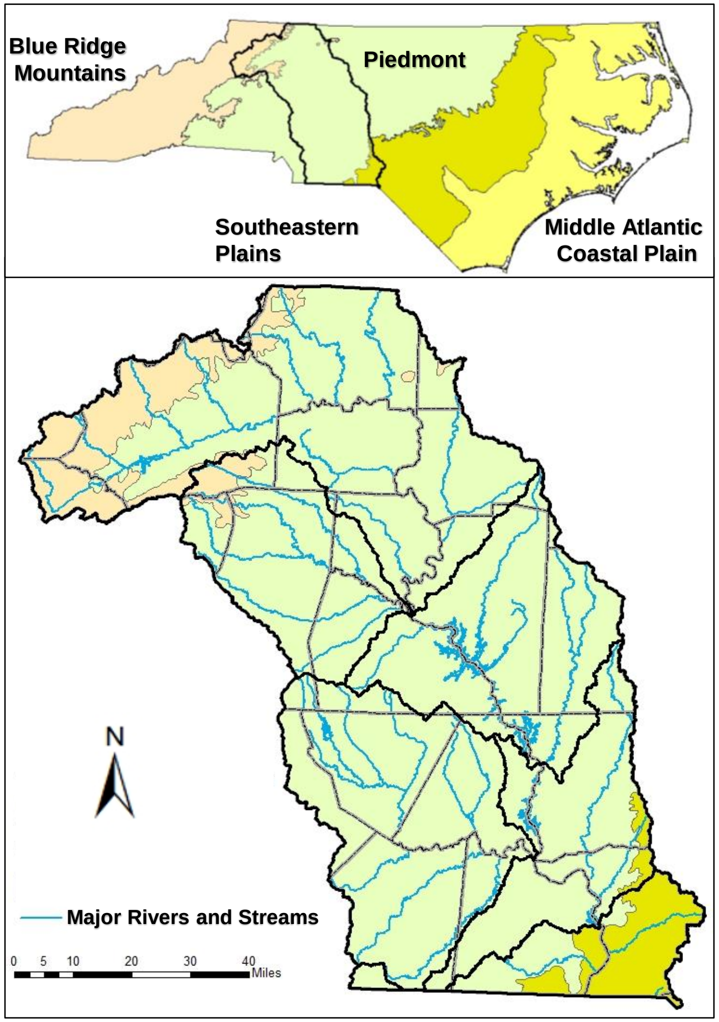
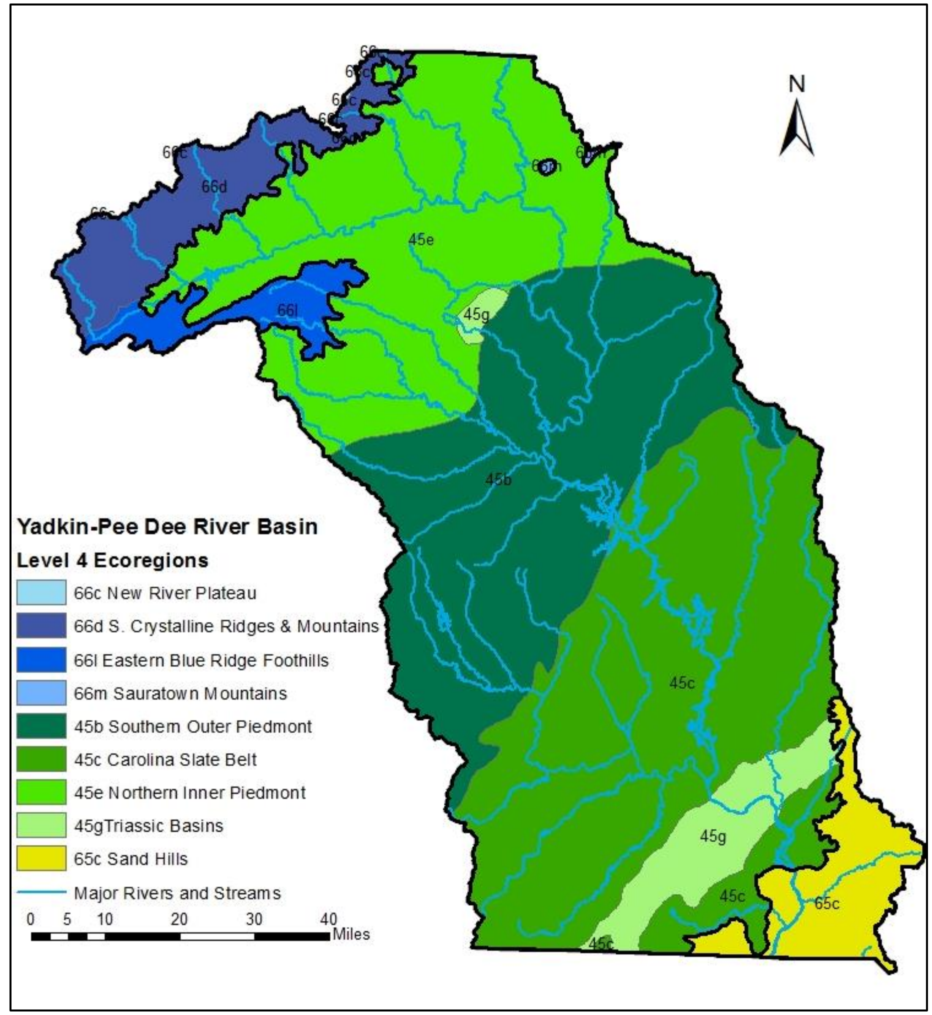


Figure 2.1.2-2: Yadkin-Pee Dee River Basin Level IV Ecoregions



In North Carolina, the Blue Ridge Mountain ecoregion is more forested with fewer areas of pasture and cultivation then other ecoregions. Streams have a higher gradient, are cooler and clearer, and the terrain is more rugged. The section of the Blue Ridge Mountains in the Yadkin-Pee Dee River basin is composed of two-Level IV ecoregions that straddle the natural valley formed by the Yadkin River. The Southern Crystalline Ridges and Mountains is in the very upper part of the basin on the northwest side of the Yadkin River valley in Surry, Wilkes, Watauga, and Caldwell counties. This region is defined by higher elevation and greater relief, gneiss and schist crystalline rocks covered with well-drained acidic loamy soils, and a forest community dominated with chestnut oak (*Quercus michauxii*), which was populated historically by the American chestnut (*Castanea dentata*). The Eastern Blue Ridge Foothills ecoregion (the Brushy Mountains) is located on the southeast side of the river valley in Caldwell, Alexander, and Wilkes counties. This region has more elements of the Piedmont with lower relief and elevation, a slightly warmer and drier climate, and a mixed oak/oak-hickory forest species association (Figure 2.1.2-2, Omernik et al., 2002).

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 the North Carolina Piedmont was cultivated but now has a mix of pasture lands, grasslands, and crops with fragmented successional oak-hickory-pine forests and growing urban centers. The Yadkin-Pee Dee River basin within the Piedmont is subdivided into three primary Level IV ecoregions that cover wide bands with the similar northeast to southwest orientation: the Northern Inner Piedmont, the Southern Outer Piedmont, and the Carolina Slate Belt. The Northern Inner Piedmont, the most northern Level IV ecoregion of the Piedmont, has a more rugged landscape with cooler temperature, mesic soils, and higher stream gradients that support a mixed assemblage of mountain and piedmont benthic species. Within this ecoregion, isolated Blue Ridge Mountain outliers (the Sauratown Mountains Level IV ecoregion), called monadnocks, have formed, in part, by caps of erosion-resistant quartzite. These mountain outliers are found at Pilot Mountain State Park in Surry County and Sauratown Mountain in Stokes County, just west of Hanging Rock State Park. The Southern Outer Piedmont, which is found between the other Level IV Piedmont ecoregions, is flatter, has irregular plains, warmer temperatures, and less precipitation with more thermic soils. The Carolina Slate Belt, the southern-most Level IV ecoregion in the Piedmont, has rugged areas in the Uwharrie National Forest. Soils are silty or silty clay and streams in this region tend to dry up in warmer months. Groundwater wells installed have low water yields due to low water yielding rock units. The lower Carolina Slate Belt region is also bisected by a narrow strip of the Triassic Basin ecoregion, which has a more unusual Piedmont geology defined by unmetamorphosed shales, sandstones, mudstones, siltstones, and conglomerates. In the Triassic Basin, the clayey soils with low permeability give rise to streams that tend to have low base flow. Erosive rocks and the high shrink-swell potential of clayey soils in combination with a changing landscape have promoted unstable streambanks in this region (Figure 2.1.2-2, Omernik et al., 2002).

The Southeastern Plains region is composed entirely of the Sand Hills Level IV ecoregion. The Sand Hills is a rolling to hilly region with primarily droughty, low-nutrient thick beds of sandy soil. Stream flow is more consistent than the neighboring Carolina Slate Belt, rarely drying up or flooding due to the better infiltration capacity of sandy soils. This region also has a greater groundwater storage capability with the sand aquifer. Communities of longleaf pine with turkey and blackjack oak species and wire grass ground cover occur in the drier areas. Shortleaf-loblolly pine and oak-pine forests have also become more common due to years of fire suppression. The Sandhills are also a center of rare plant diversity in the Carolinas (Figure 2.1.2-2, Omernik et al., 2002).

2.1.3 Land Cover

Land cover information can assist local, state and federal managers and officials assess ecosystem status and health. Land cover 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. Land use may have some of the largest impacts to water quality. For example, in municipal areas, impervious surfaces can prevent rainfall from filtering into the ground. Filtering can remove some of the nutrients and bacteria found in stormwater before the water enters the nearest waterbody. It also recharges groundwater supplies. In impervious areas, much of the stormwater is sent directly to storm drains and culverts. Many of the storm drains and culverts empty into the nearest waterbody. The direct delivery of stormwater to a stream can have multiple negative impacts to water quality and aquatic habitat, including elevated water temperature, increased sediment, and nutrient delivery laden with chemical compounds that can be found on highways, city streets and neighborhood driveways, and excess erosion due to increased stream velocity. Slowing and diverting stormwater from streams can, in some cases, protect streams from severe erosion and sedimentation.

North Carolina uses land use and land cover (LULC) datasets available from the National Land Cover Database (NLCD). The 2006 and 2016 LULC spatial distributions in the Yadkin-Pee Dee River basin are shown in Figure 2.1.3-1. Aggregated land use classifications and associated land area (square miles) and percent coverage for 2006, 2011, and 2016 are shown in Table 2.1.3-1.

The Yadkin-Pee Dee River basin's overall spatial distribution and percent coverage of LULCs and aggregated land use classifications did not change significantly between 2006 and 2016. Land cover in the Yadkin-Pee Dee River basin has remained predominantly rural with over 54% of the basin remaining forested. Denser and more extensive forested land cover occurs in the Blue Ridge Mountain ecoregion in the basin's headwaters and in the Uwharrie National Forest in the southeastern Piedmont ecoregion in Montgomery and Randolph counties. Close to 25% of the basin's land cover is used for agricultural purposes, which is especially prevalent throughout the Piedmont ecoregion. Between 2006 to 2016, agriculture coverage was reduced by 1.5% (26 square miles). Combined, shrub cover (formed by early successional forest in silviculture areas or abandoned agricultural lands) and grassland (pasture or herb-covered areas) comprise around 5% of the land use in the basin and had some variability over the ten-year time span. Open water and wetland, combined, are about 2.5% of the land cover. Almost 14% of land use in the basin is developed with the urban centers of Winston-Salem, Charlotte, Statesville and Lexington evident along the I-85 and I-40 transportation corridors (Table 2.1.3-1). Developed land had a 3.7% increase between 2006 and 2016, which resulted in 35 additional square miles, much of it likely being agricultural land converted to development (Table 2.1.3-1).

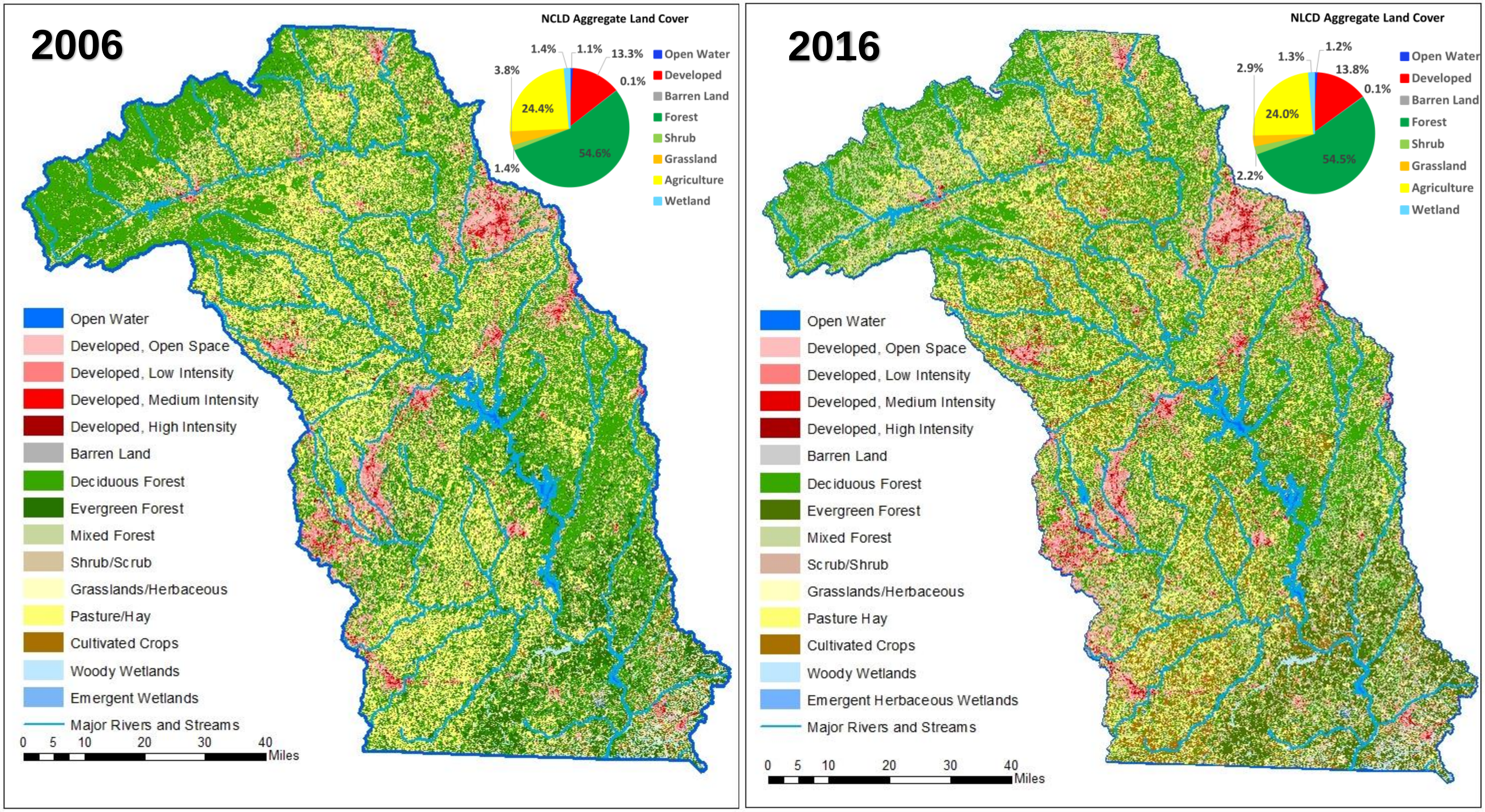
Subdividing land cover classifications by watershed (see watershed chapters) shows which areas of the basin had more notable changes and where the shifts in land cover type occurred between 2006 and 2016. Over half of that new development (18 square miles) occurred in the Rocky River watershed, which is also the eastern section of the Charlotte suburban metropolitan area. A similar amount of agricultural and pasture (grassland) was also lost. The Yadkin River Headwater watershed, where the City of Winston-

Salem is located, had a more modest 7 square miles of new development added while losing over 9 square miles of agriculture land. The Yadkin River watershed, where Thomasville, Lexington, Salisbury, and the west side of High Point are located, also had over 5 square miles of new development. More information about land use changes can be found in the watershed chapters.

Table 2.1.3-1: Yadkin-Pee Dee River Basin Aggregated Land Cover 2006 to 2016

Aggregated NLCD Land Cover Classes	2006 NLCD % Land Cover	2006 (mi2)	2011 NLCD % Land Cover	2011 (mi2)	2016 NLCD % Land Cover	2016 (mi2)	Cover % Change 2006-2016
Open Water	1.1%	82.5	1.2%	85.2	1.2%	82.8	0.34%
Developed	13.3%	957.3	13.5%	976.2	13.8%	992.8	3.71%
Barren Land	0.1%	8.5	0.1%	8.4	0.1%	9.9	15.36%
Forest	54.6%	3939.3	54.6%	3942.7	54.5%	3938.2	-0.03%
Shrub	1.4%	102.3	2.0%	146.0	2.2%	155.7	52.21%
Grassland	3.8%	273.9	3.2%	229.4	2.9%	211.0	-22.97%
Agriculture	24.4%	1760.8	24.1%	1736.9	24.0%	1734.4	-1.50%
Wetland	1.4%	97.3	1.3%	97.0	1.3%	97.1	-0.16%

Figure 2.1.3-1: Yadkin-Pee Dee NLCD Land Use Classification for 2006 and 2016



2.1.4 Population

Information on population density is useful in determining what watersheds are likely to have the most impacts due to population and growth. Concentrated populations in urban areas have dense housing, roads, industrial, and commercial development that creates increased impervious surfaces, which in turn increases stormwater runoff that can negatively impact water quality. Identifying concentrated populations and areas that are projected to grow can also help inform 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.

Population information is intended to present an estimate of expected population growth in the watersheds, counties and municipalities located within the Yadkin-Pee Dee River basin. Population data was obtained from the US Census Bureau and North Carolina Office of State Budget and Management (OSBM). These data sources have comparable results for population size, density, and distribution across the basin, however, data was collected on different scales so results are variable, especially at the watershed level.

The US Census Bureau collects population data every 10 years at the most accurate and finest scale with a census block. Census blocks can be as small as a city block in urban areas but are larger and many square miles in rural areas. The Yadkin-Pee Dee River basin HUC 8 watershed population sizes were calculated by summing the census block populations found in each watershed (Table 2.1.4-1). Census block populations with partial watershed coverage were weighted by land area within the watershed. Based on the US Census data, the population for the entire Yadkin-Pee Dee River basin in 2010 was over 1,675,000 people with an average population density of 232 people per square mile. The Yadkin River Headwaters watershed (03040101), which is also the largest watershed in the basin, had the highest population followed by Rocky River. The Rocky River watershed (03040105), has a similar population, but is 40% smaller than the Yadkin River Headwaters resulting in the highest density of population per square mile. The US Census Bureau block data shows the most populated areas were in and around Charlotte in Mecklenburg, Cabarrus and Union counties, and Winston-Salem in Forsyth County with a notable band of population density running between the metropolitan areas (Figure 2.1.4-1). Pockets of population density are evident where other small cities in the basin are located, including Salisbury, Statesville, Lexington, Thomasville, High Point, Wilkesboro, Mount Airy, and Rockingham. Overall, the basin is still sparsely populated and rural with less than 150 people per square mile (Figure 2.1.4-1).

NC OSBM provides county population estimates for current years and projections to 2037. Like the US Census Bureau population data, the Yadkin-Pee Dee River basin watershed population sizes were calculated by summing the county populations found in each watershed with counties that had partial watershed coverage being weighted by land area. Using county level NC OSBM data, the total Yadkin-Pee Dee River basin population was estimated to be about 1,750,000 in 2010 (Table 2.1.4-1). This was 4.5% higher than the US Census Bureau population estimate from the same year. The distribution of population density across the basin for the county level NC OSBM dataset was similar to the US Census Bureau and showed the densest populations were near Charlotte and Winston-Salem with a population corridor between the two cities (Figure 2.1.4-1). The watershed level population and density sizes of the two datasets were more variable, specifically for the Lynches (03010202) and South Yadkin (03040102) watersheds. The NC OSBM population size and density were over four times larger than the US Census Bureau in the Lynches watershed and over 50% larger in the South Yadkin watershed. These discrepancies indicate that population projections in these watersheds are less accurate due to how the data is collected.

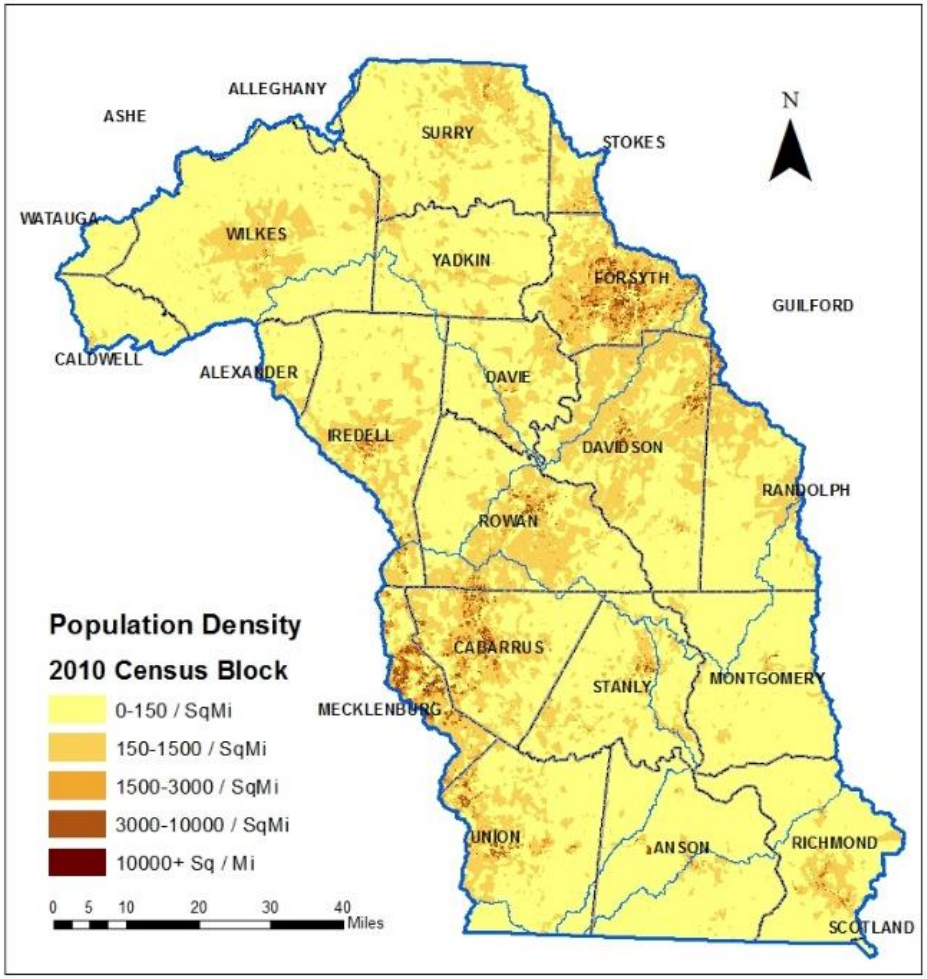
According to NC OSBM data, the total population in the Yadkin-Pee Dee River basin grew by 12% from July 2007 to July 2017. The projected growth over the next 20 years (2017 to 2037) is expected to be 24%, taking the current population from 1.7 million to 2.3 million in 2037. The Rocky River watershed experienced the most growth with an 18% increase between 2007 to 2017 and a projected increase by 27% by 2037. The South Yadkin watershed is also expected to grow by 21% in the next 20 years.

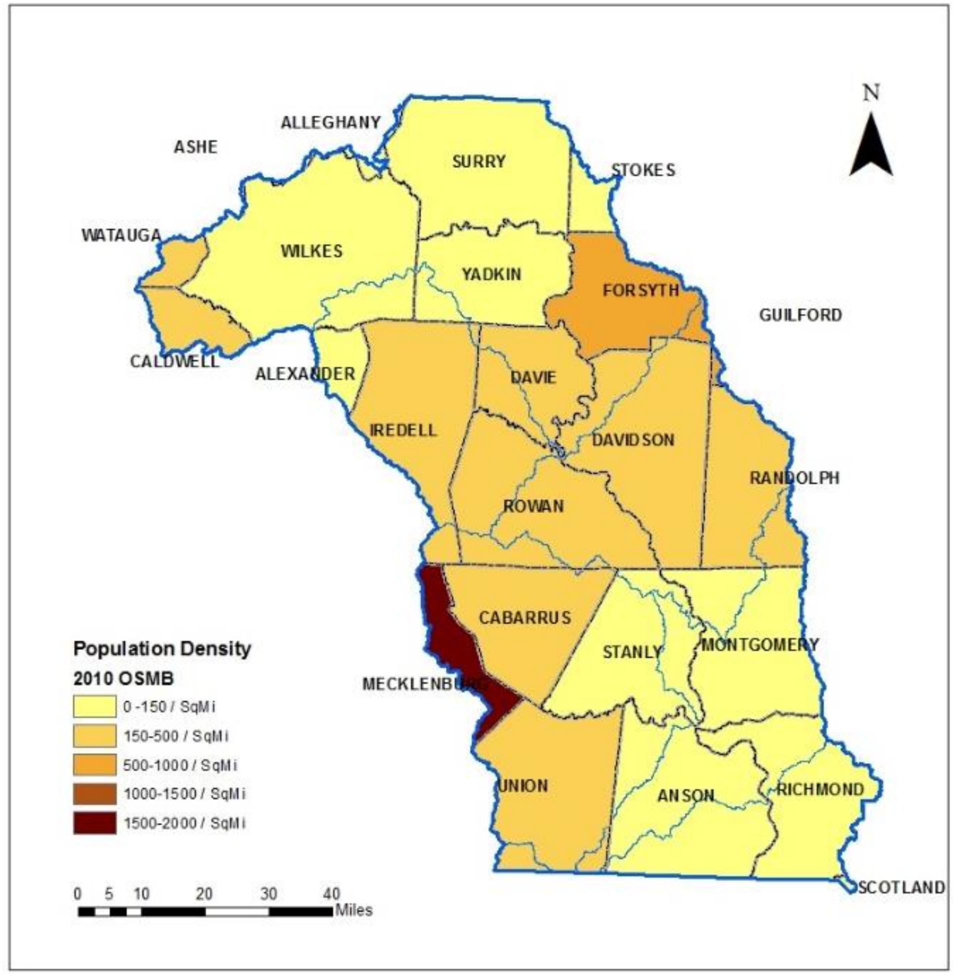
The Charlotte metropolitan area in the Rocky River watershed had high population growth from 2007 to 2017 with Mecklenburg, Union, and Cabarrus counties growing 24, 25, and 25% respectively. These same counties are expected to grow an additional 37 to 41% by 2037. Other counties with urban areas also grew significantly and are projected to continue to grow at a rapid rate. Forsyth County, with Winston Salem, grew 11%, and is expected to grow another 21%. Davidson and Randolph counties, with High Point, grew 7% and 5%, respectively, and are expected to grow 12% and 13%, respectively. Rowan County, with Salisbury, grew 6% and is expected to grow 13%. More information including the data used to calculate these growth numbers can be found in the appendix.

Table 2.1.4-1: Estimated Population in the Yadkin-Pee Dee River Basin Based on Data Available from US Census Bureau and NC OSBM

Watershed	HUC 8	US Census Bureau Population 2010	Population per Square Mile (mi2)	NC OSBM Population 2010	Population per Square Mile (mi2)
Yadkin River Headwaters	03040101	569,819	244	512,810	215
South Yadkin	03040102	125,526	138	200,690	216
Yadkin River	03040103	304,351	256	292,903	242
Lake Tillery / Pee Dee River	03040104	50,983	59	71,449	82
Rocky River	03040105	568,650	402	627,218	426
Pee Dee River	03040201	54,311	112	37,314	77
Lynches River	03040202	1,791	68	8,284	301
	Total	**1,675,431**	**232**	**1,750,668**	**236**

Figure 2.1.4-1: Population Density Maps Yadkin-Pee Dee 2010 US Census Bureau and NC OSBM





2.2 Point Source and Nonpoint Source of Pollution

Water quality stressors can be caused by point and non-point 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 Basin Planning (DWQ 2008) provides additional general information on point and non-point sources of pollution.

There are several programs within DEQ that monitor and regulate point and nonpoint sources of pollution. Table 2.2-1 summarizes permitted point and non-point facilities from the previous plans plan and as of 2018 (see the appendix for permitted facilities as of June 2021). In many cases, the 2008 basin plan double-counted NPDES discharge and stormwater permits with multiple outfalls. Numbers in this plan were updated accordingly, but the previous plan may have also counted permits in draft and/or review status as well as active and expired status. The current plan takes into account active and expired permits since permittees can continue to operate under current permit conditions until a new permit is issued., but because of the discrepancies in methodology used to count the number of permits in the previous basin plan, a direct comparison between permit numbers cannot be used to determine if there are more or less permitted facilities within the basin.

Table 2.1.42-1: Yadkin Pee Dee Permitted Facilities

Permit Type[1]	2008 Plan	2018
NPDES Major Discharger[2]	33	32
NPDES Minor Discharger[2]	178	145
Single Family Domestic Waste Treatment Systems	Not Given	114
Non-Discharge	80	49
Residual Management[3]		31
NPDES Stormwater	586	631
Animal Feeding Operations	347	108
Deemed Animal Feeding Operations[4]		236

[1]The 2018 permit numbers include Active and Expired Permits only, the 2008 plan may also have counted permits in Draft and/or Review status, therefore comparisons may not be exact.
[2]The 2008 plan had double counted permits with multiple outfalls for the NPDES Wastewater Treatment and Stormwater program permits so these numbers have been adjusted.
[3]Permitted residual solid land application fields may not be in the same HUC8 or basin as the facility.
[4]Includes all deemed permitted AFOs issued starting in 1980, which may or may not be active.

2.2.1 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. Information from the NPDES programs can be used alongside ambient water quality data to ensure that permit requirements are being met and are sufficient to protect the water quality of receiving waterbodies.

As of 2018, there are 177 NPDES wastewater discharge permits (32 major and 145 minor) and 631 NPDES stormwater permits in the Yadkin-Pee Dee basin (see Table 2.2-1). More information on NPDES permits can be found in Chapter 5.

2.2.1.1 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 accidently released. SSOs happen for a variety of reasons, including blockages, sewer line breaks, power failures, extreme weather events, and vandalism and can contaminate our waters resources. In some instances, an SSO can cause wastewater to flood homes, causing property damage and threatening public health (EPA, 2021).

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.

***2.2.1.2** Single-Family Domestic Wastewater Systems*

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 discharges 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 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. Because of their potential to impact water quality, DWR recommends regional office staff explore educational opportunities to inform real estate agents and homeowners on the location of single-family domestic wastewater systems and how to maintain or repair these systems. As of 2018, there were 114 of these permits in the Yadkin-Pee Dee River basin (see Table 2.2-1), primarily concentrated in Forsyth and Davidson counties.

2.2.2 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 are resulting 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, but data gaps exist. These unknowns include, but are not limited to, the amount of fertilizers, pesticides, herbicides, and animal waste applied to the land, as well as the level at which these same pollutants may be impacting groundwater and air quantity 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 stormwater, animal feeding operations, and managing wastewater using land application (non-discharge and residuals management) can be found in Chapter 5.

In the Yadkin-Pee Dee River basin, there are 49 non-discharge permits and 31 land application permits for residual solids. There were also 108 Animal Feeding Operations (AFOs). Further information on non-point source permits is available in chapter 5.

2.2.2.1 Stormwater

Stormwater runoff is rainfall or snowmelt that flows across the ground and impervious surfaces (e.g., buildings, roads, parking lots). In many 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 also cause flooding, damage infrastructure, and cause unnaturally high fluctuations in stream flow (NC DWR, 2008).

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 from runoff. 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 in natural areas (NC DWR, 2008). Green infrastructure (GI) can be used to minimize the impact from stormwater runoff. GI 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 urban development. These porous, natural landscapes hold rainwater and snowmelt and allow the water to infiltrate slowly. This slow infiltration also helps recharge groundwater supplies. Where feasible, establishing and protecting existing buffers, floodplains and wetlands should be considered, and the amount of impervious cover should be limited as much as possible. Preserving the natural streamside vegetation or riparian buffer is one of the most economical and efficient best management practices (BMPs) for reducing the amount of stormwater runoff reaching surface water. In addition, riparian buffers provide a variety of benefits including moderating water temperature by providing shade, holding water and decreasing the high temperatures often measured in stormwater runoff, preventing erosion and lose of land. providing flood control; moderating stream flow and providing food and habitat to aquatic and terrestrial life (Burgess, 2004).

In North Carolina, there are rules in place for new development to offset some of the impacts from stormwater runoff. New construction projects that are adjacent to protected riparian buffers in basins or watersheds that have riparian buffer rules are required to install Stormwater Control Measures (SCM) such as level spreaders, vegetated conveyances, or wetlands. SCMs disperse concentrated flow into "diffuse flow" before stormwater reaches the riparian buffer.

DWR also requires Stormwater Management Plans for new development projects that fall under the definition of "high density" development defined in 15A NCAC 02H .1003 or for new transportation projects permitted under the NC Department of Transportation's (DOT) Individual NPDES permit (NCS000250) (NC DEMLR n.d,; ACOE and NCDWR 2018). More information on stormwater and how to manage it can be found on the Division of Energy, Mineral and Land Resources (DEMLR) Stormwater website.

2.2.2.2 Agriculture

Approximately 24% of the land use in the Yadkin-Pee Dee River basin is identified as agriculture (Table 2.1.3-1). 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 and 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 2019a). Agriculture data was queried at the county scale for counties with more than 50% of their land area located entirely or partially within the Yadkin-Pee Dee River basin. This includes Anson, Cabarrus, Davidson, Davie, Forsyth, Iredell, Montgomery, Richmond, Rowan, Stanly, Surry, Union, Wilkes, and Yadkin.

Using Quick Stats, information about the number and types of animal operations, crops, and treatments for 2002, 2007, 2012, and 2017 was queried from Census of Agriculture (USDA 2019b). The total farms, harvested crops, and fertilizer treatments totals are shown in Table 2.2.2-1. Table 2.2.2-2 includes inventory and production animal numbers for all cattle, poultry, and swine farms. Individual county numbers can be found in the appendix. The USDA reports some county inventories for livestock, poultry and crops as "(D)", indicating that numbers are "withheld to avoid disclosing data for individual farms". Therefore, exact head counts or crop acreages cannot be calculated. Inventory data is a head count collected at just one point in time (at the end of December of the Census year). A production contract, however, is defined by USDA as "an agreement between a producer or grower and a contractor (integrator) setting terms, conditions, and fees to be paid by the contractor to the operation for the production of crops, livestock, or poultry. Crops and livestock inventory, production, and value of sales are the total of all production, both independent and raised under production contract" (USDA, 2017). More information on USDA Quick Stats NASS data for the Yadkin-Pee Dee River basin main counties is available in the Appendix.

Per the 2017 USDA Census of Agriculture, there is a total of 10,092 farms in the 14 counties with more than 50% land cover in the basin operating on over 1.3 million acres of land (Table 2.2.2-1). The total acreage farmed, and the number of farm operations has declined since 2002 with total farm operations decreasing by 8% and total number of acres farmed decreasing by 1.5% over the last ten years (2007-2017). Anson, Forsyth, Montgomery, Richmond, Yadkin, and Stanly counties experienced a decrease in the number of operations and number of acres farmed while Surry and Davie counties saw a slight increase. Individual county numbers can be found in the Appendix.

Table 2.2.2-1: USDA Farms and Treatments

FARMS / TREATMENT	2002	2007	2012	2017	2002	2007	2012	2017
FARMS AND LAND USE	NUMBER OF FARMS				NUMBER OF ACRES			
TOTAL FARM OPERATIONS[1]	12,113	11,393	11,026	10,092	1,428,070	1,312,616	1,326,611	1,327,221
TOTAL HARVESTED CROPS	7,860	7,081	7,429	6,918	542,824	525,999	618,248	604,866
FERTILIZER TREATMENT	NUMBER OF FARMS				NUMBER OF ACRES			
TOTAL MANURE	2,597	2,131	1,967	1,918	134,267	135,384	131,304	136,063
TOTAL ORGANIC	NA	NA	NA	271	NA	NA	NA	12,054
TOTAL FERTILIZER	6,931	5,840	5,245	5,170	525,306	504,959	463,301	468,284

[1]Farms include crops and livestock/poultry operations. NA Information not available (USDA, 2019b).

Based on inventory and production contract numbers for animal agriculture, there was an overall decrease in the total number of poultry across the basin between 2007 and 2017 (Table 2.2.2.-1) The overall inventory for beef cattle and dairy cows in the Yadkin-Pee Dee River basin counties shows there was minimal change from 2007 to 2017 with just a 5% reduction (Table 2.2.2.-1). For swine farms, many of the counties reported "(D)", or information withheld to avoid disclosing information about individual farms. Based on what was reported, however, there was a significant decline in swine farming from 2007 to 2017 with a 26% decline for inventory and 62% decline for yearly production contracts (Table 2.2.2.-1). See the Appendix for more information on individual county inventories and contract numbers.

Table 2.2.2-2: USDA Inventory and Production Contract Totals for Poultry, Cattle, and Swine 2002-2017

County[1]	Inventory[2] / Contract[3]	2002		2007		2012		2017	
		Farms	Inventory	Farms	Inventory	Farms	Inventory	Farms	Inventory
Poultry[4]	**Inventory**	2,005	69,317,886	1,793	67,382,505	2,322	61,031,505	2,234	62,578,331
Poultry[5]	**Contract**	1,090	311,119,281	812	315,579,827	880	272,943,389	774	279,742,553
Cattle[6]	**Inventory**	6,099	255,988	4,239	243,070	4,722	241,689	4,613	230,433
Swine	**Inventory**	198	168,775	213	159,160	254	92,954	278	118,430
Swine	**Contract**	36	877,521	25	629,857	16	344,259	18	239,439

[1]County totals include counties with >50% land coverage in the Yadkin-Pee Dee River basin
[2]USDA Inventory numbers represent a point in time (End of December) when the census data was collected.
[3]USDA Contract Production Numbers represent totals for the portion of livestock and poultry raised and delivered by contract. Contracts numbers may be changed and are therefore not representative of yearly head count numbers.
[4] Poultry Inventory include Broilers, Pullets, Layers, Roosters, and Turkeys
[5]Poultry Contracts include Broilers, Pullets, Layers, and Turkeys
[6]Cattle Inventory includes Beef cattle and Dairy Cows

DEQ has regulatory authority over swine and cattle operations that use dry or liquid manure waste management systems and poultry operations that use a liquid waste management system. Animal operations are defined under General Statute 143.215.10B as feedlots that have more than 250 swine, 100 confined cattle, 75 horses, 1,000 sheep, or 30,000 confined poultry with a liquid waste management system. All permitted animal operations are required to have a Certified Animal Waste Management Plan (CAWMP). A CAWMP is required before a permit is issued or renewed. It defines the fields to which waste is land applied, the crops to be grown, and other details about the operation. All waste must be applied at no greater than agronomic rates (an amount that can be used productively by the crops that are planted) (General Statute 143-215.10C). The CAWMP is incorporated into the animal permit issued by DWR and permitted animal operations are inspected annually.

Per agricultural statistics and the 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). Most poultry operations in North Carolina use a dry waste management system and are often referred to as dry litter poultry operations. Such operations are deemed permitted under administrative code (NCAC) 15A NCAC 02T .1303. Deemed permitted is defined under 15A NCAC 02T .0103 as a facility that is "considered to have a needed permit and to be 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." 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. These requirements include minimum stream setbacks, land application rates, soil and waste analysis, and recordkeeping. This information is included in a waste utilization plan (WUP) (also known as a nutrient management plan (NMP)). Producers are required to keep WUPs (NMPs) on file at the farm. They do not have to submit the plan to DWR for review.

Regardless of permit status, there are statutes and rules in place that require that the application of animal waste be made at agronomic rates (an amount that can be used productively by the crops that are planted). 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). Records must be maintained on the type, amount, and location of where waste is land applied. If not effectively utilized by vegetation, nutrients can enter surface water by atmospheric deposition, groundwater transport, and stormwater runoff. Excess nutrients in surface water can impact aquatic ecosystems, and the type and amount of treatment required to ensure that water is safe for human consumption.

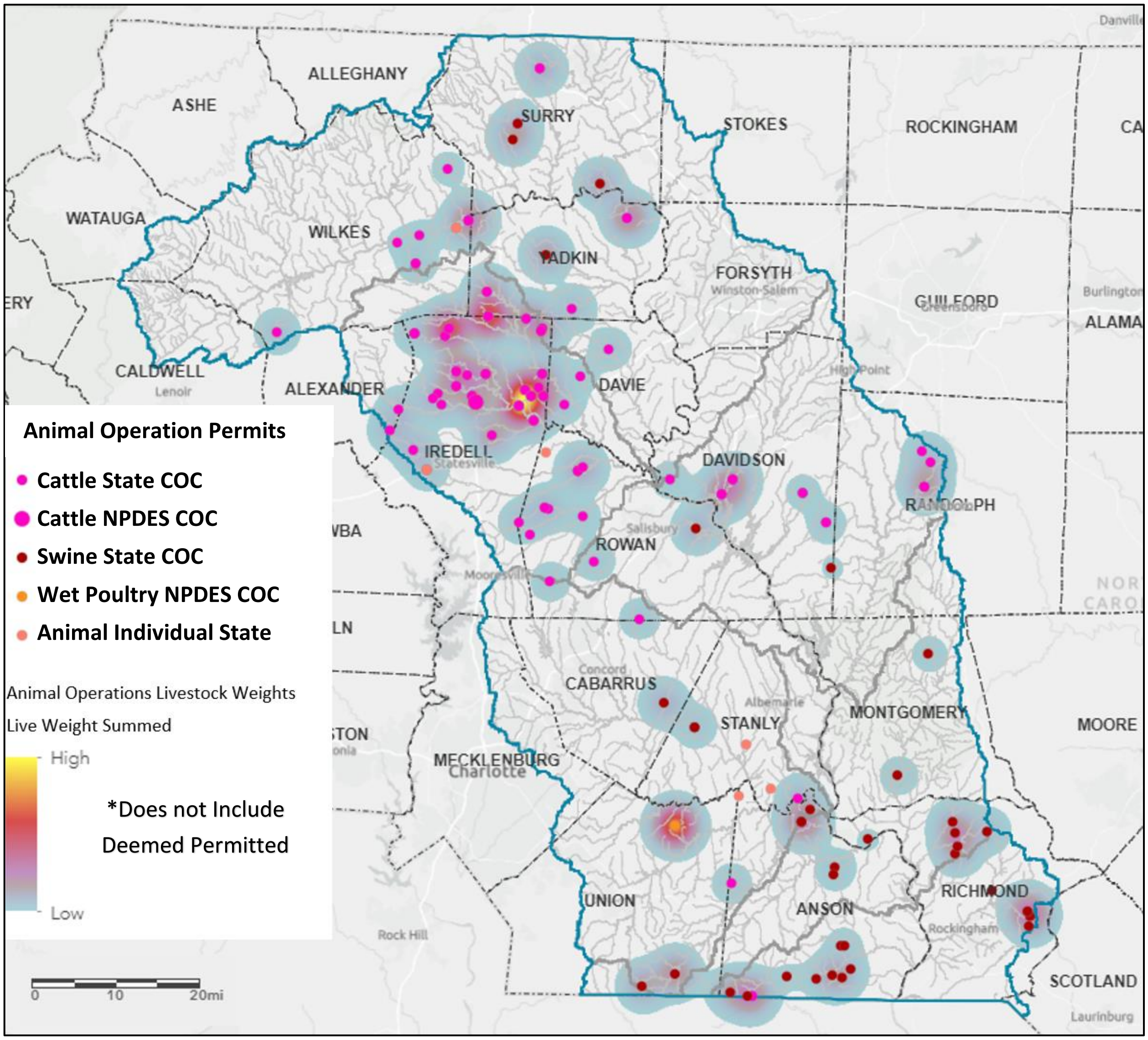
As of 2018, there were 108 AFO permits in the Yadkin-Pee Dee River basin. The majority fall within the requirements of the general permit and are given Certificates of Coverage (COCs). Seven were issued individual permits and two were issued a federal (NPDES) permit. Most of the cattle operations are in the upper portion of the basin while most of the swine operations are in the lower part of the basin. Between 2007 and 2018, 22 permit numbers were assigned to deemed permitted animal operations. Detailed information about these facilities is limited and not readily available. More information about AFOs can be found on the program's webpage and in Chapter 5.

Permit Type	Number
Animal Individual State	7
Cattle State COC	62
Cattle NPDES COC	1
Swine State COC	37
Wet Poultry NPDES COC	1

COC – Certificate of Coverage

Understanding the impacts from large-scale waste application can be challenging due to minimal monitoring in the watersheds in which they are located. The distribution and general location of the DWR permitted animal operations are shown in Figure 2.2.2-1. Figure 2.2.2-1 also shows a "heat map" which displays geographically where there are concentrations of livestock based on permit reporting numbers for each livestock type and the associated weight factor. Swine operations are concentrated primarily in the southern part of the basin in Anson and Richmond counties in the Lake Tillery / Pee Dee River (03040104) and Pee Dee River (03040201) watersheds. Cattle farm operations (including both beef cattle and dairy) are more prevalent in the basin than swine operations and are densest in the South Yadkin (03040102) watershed. Cattle farm operations have the heaviest concentration of live weights in Iredell County along the South Yadkin River, and Rocky and Hunting creeks.

Figure 2.2.2-1: NC DWR Permitted Animal Operation Live Weight Totals (2017) in the Yadkin-Pee Dee River Basin



USDA NASS Quick Stats data was used to map the distribution of beef and dairy cows, poultry, and crop treatments in the counties with greater than 50% land cover in the Yadkin-Pee Dee River basin for 2007 and 2017 (Figures 2.2.2-2 to 2.2.2-6). Understanding geographic shifts over time can help identify where agriculture may be a potential source of water quality pollution in a basin. Figure 2.2.2-2 shows that the geographic distribution for USDA beef cattle and dairy cow inventories are comparable to the distribution of permitted AFO cattle (and dairy cow) permits and live weights shown in Figure 2.2.2-1. Iredell County had the highest number of cattle and cows reported per the USDA inventory in both 2007 and 2017 followed by Wilkes County. The distribution of cattle and dairy cows remained similar from 2007 to 2017. There were, however, more notable geographical shifts in poultry inventory and production contracts (Figure 2.2.2-3 and Figure 2.2.2-4). In 2007, Union and Wilkes counties had the highest poultry inventory and productions numbers in the basin. Combined, these two counties accounted 51% of the annual inventory and 58% of the production contracts. By 2017, the combined county totals decreased to 39% for both inventory and production contracts. In 2007, Anson and Surry Counties combined accounted for 16% of both the inventory and production contracts. By 2017 the combined total had increased to 27% and 30% for the inventory and production contracts, respectively. Individual county numbers for 2002, 2007, 2012, and 2017 can be found in the Appendix. Use of fertilizer in the basin counties decreased by 7% (505,000 to 468,000 treated acres) from 2007 to 2017 while the use of manure as a fertilizer type remained about the same (135,000 to 136,000 treated acres) from 2007 to 2017 (Table 2.2.2-1). Fertilizer use was heaviest in the counties with the highest harvested crops, Union, Rowan, Stanly, and Iredell in 2007 and Surry, Rowan, and Union counties in 2017 (Figure 2.2.2-5). The use of manure as a fertilizer was also heaviest in Union County both years (Figure 2.2.2-6). Relatively higher levels of manure treatment were also used in Wilkes, Surry, Yadkin, and Iredell counties with some shifts from 2007 to 2017 (Figure 2.2.2-6). The manure treatment distribution by county (Figure 2.2.2-6) has some similarities with the poultry and cattle distributions (Figure 2.2.2-3 and Figure 2.2.2-4).

Figure 2.2.2.2 -2: USDA NASS Beef Cattle and Dairy Cow Annual Inventory Yadkin-Pee Dee River Basin

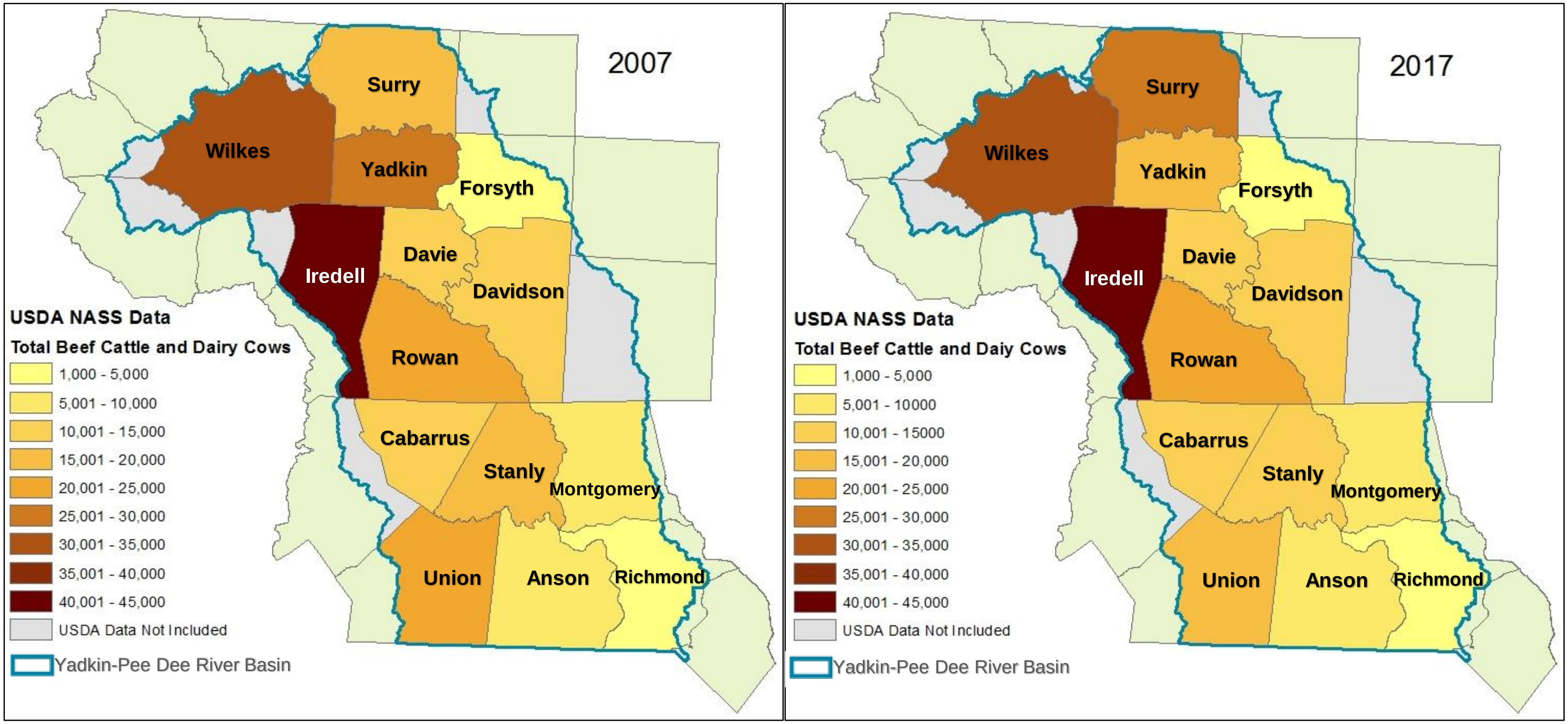


Figure 2.2.2.2-3: USDA NASS Annual Poultry Inventory for 2007 and 2017 Yadkin-Pee Dee River Basin

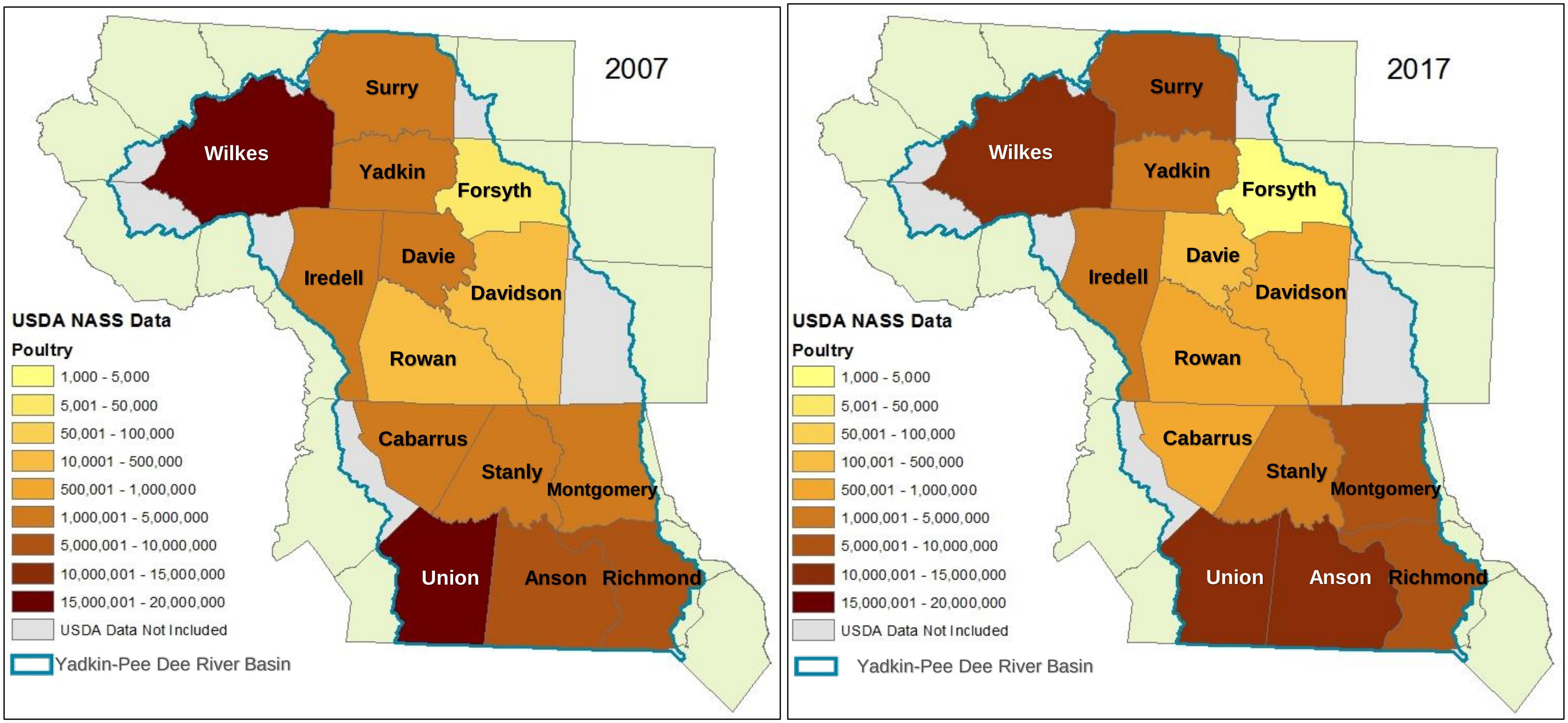


Figure 2.2.2.2-4: USDA NASS Poultry Production Contracts for 2007 and 2017 Yadkin-Pee Dee River Basin

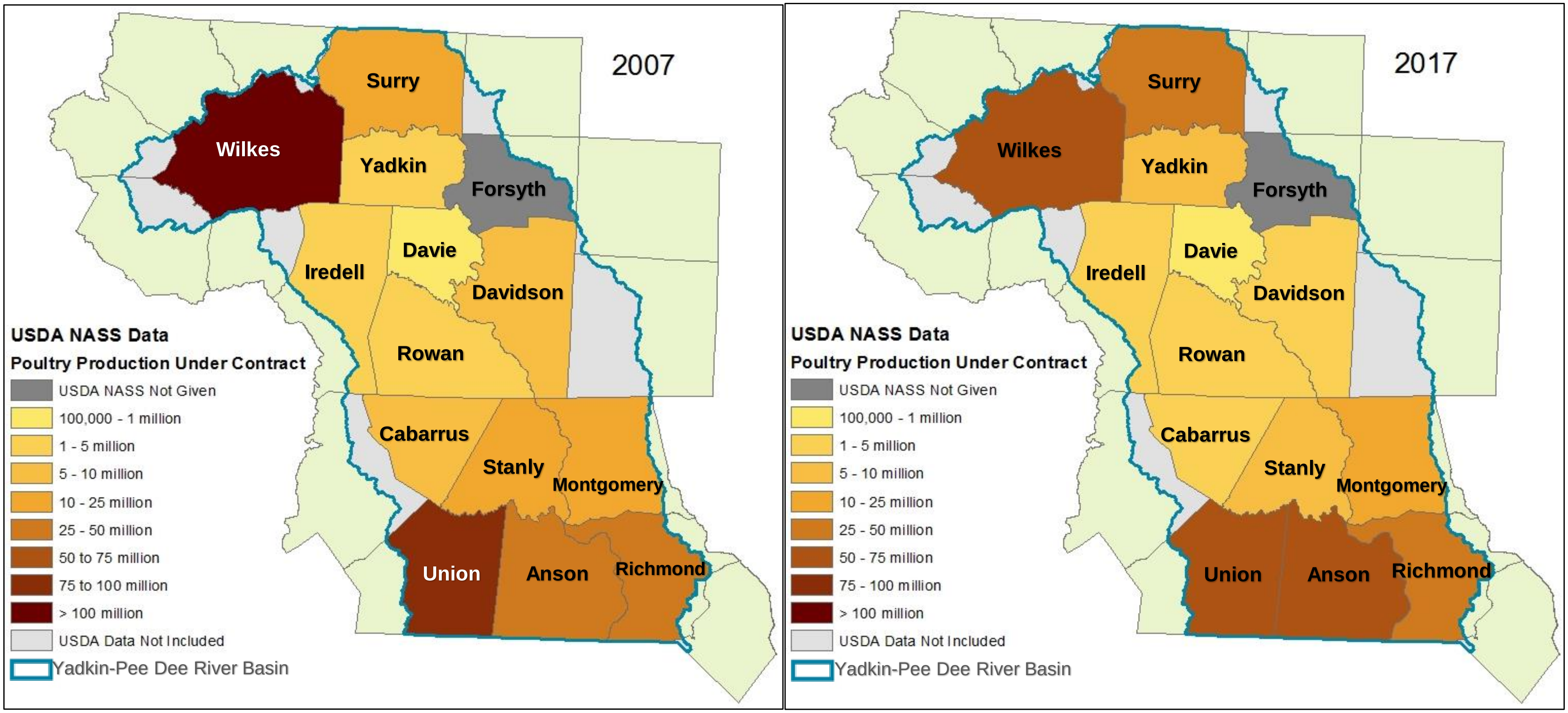
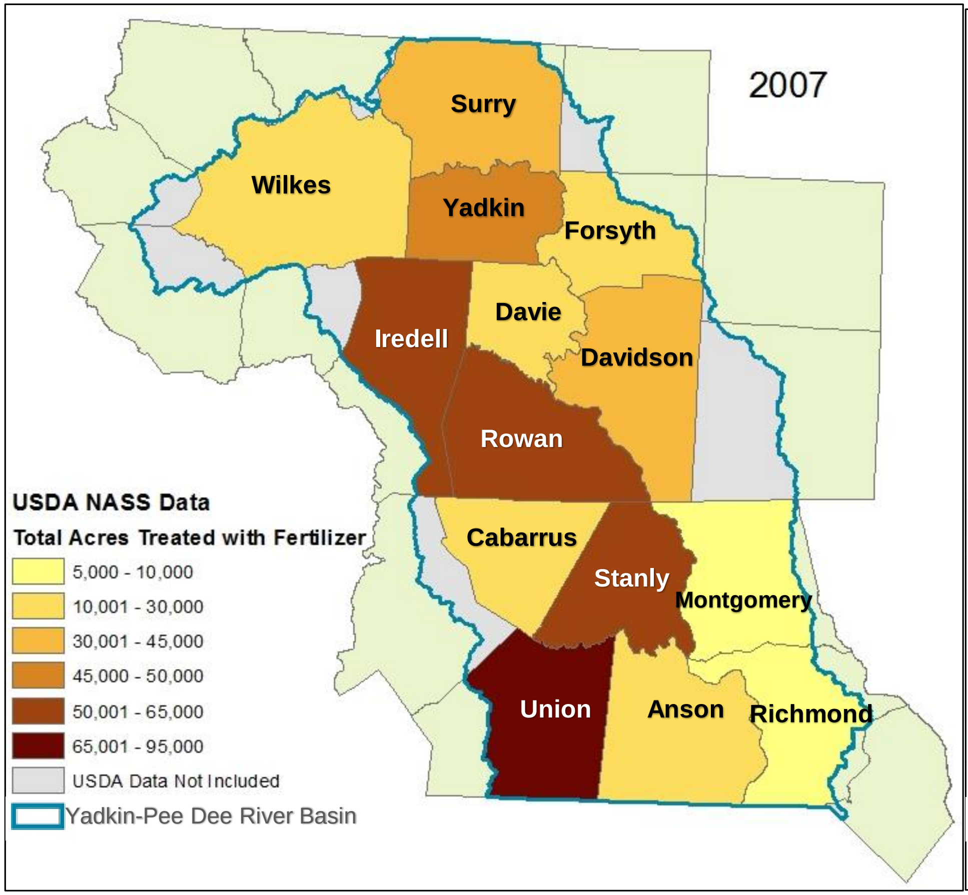


Figure 2.2.2.2-5: USDA NASS Yearly Total Acres Treated with Total Fertilizer in the Yadkin-Pee Dee River Basin



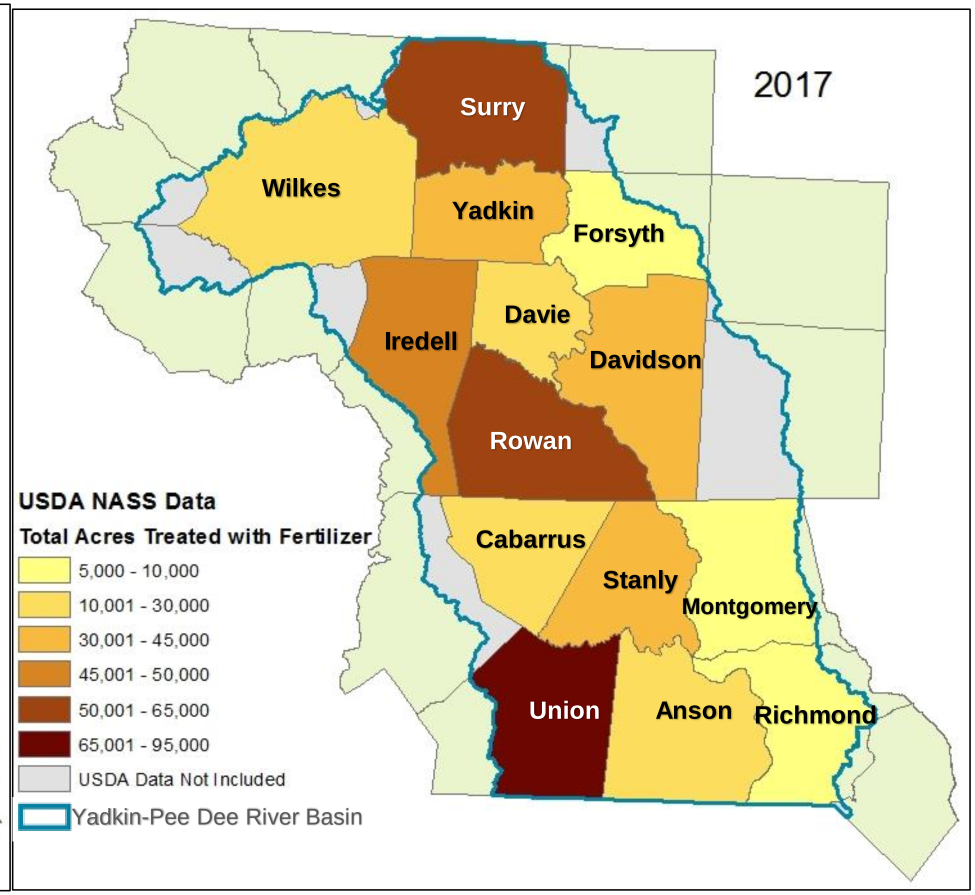
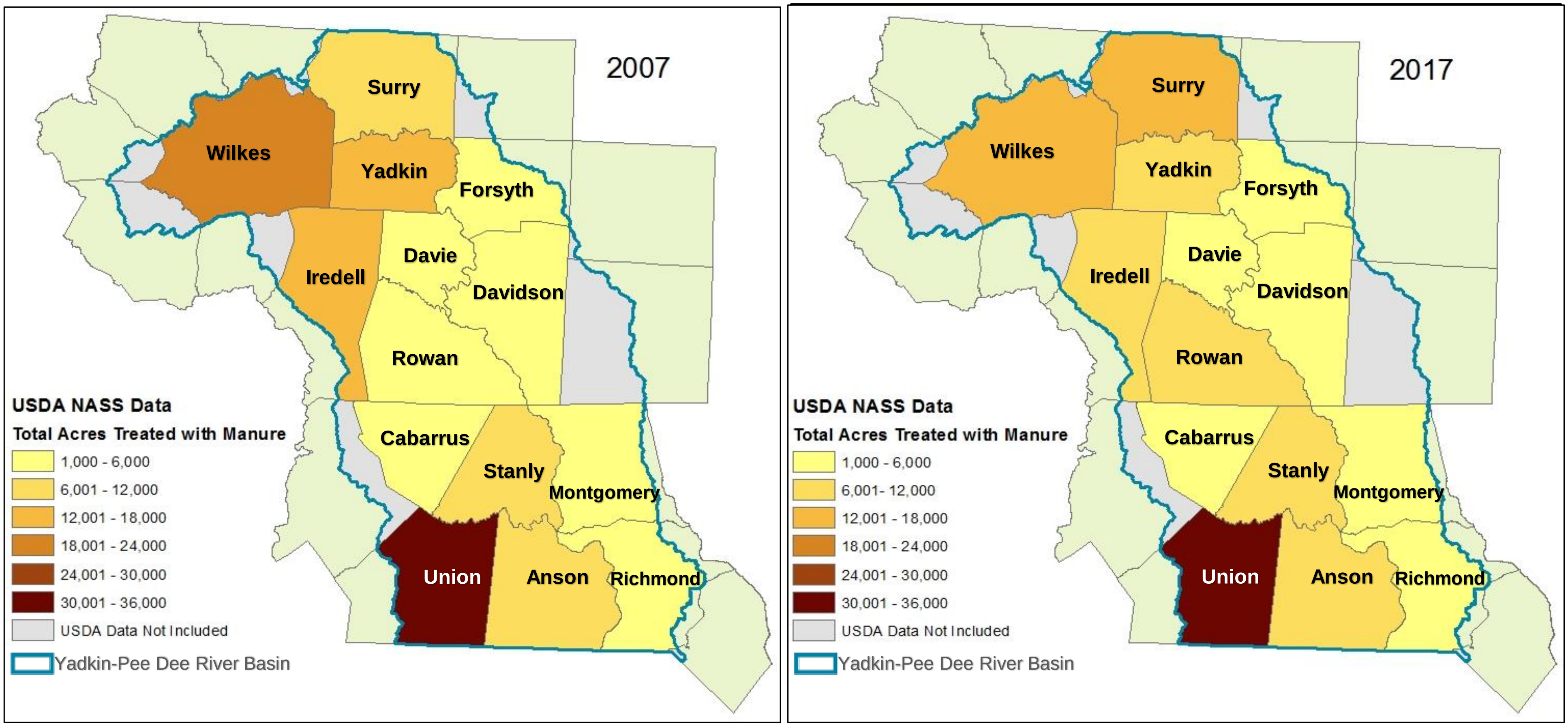


Figure 2.2.2.2-6: USDA NASS Yearly Total Acres Treated with Manure in the Yadkin-Pee Dee River Basin



2.2.2.3 Forestry

Over 50% of the land use in the Yadkin-Pee Dee River basin is identified as forest (Table 2.1.3-1,) and forestry is a common land management practice in the southern part of the basin, particularly in Anson, Richmond, and Montgomery counties. This includes portions of the Uwharrie National Forest as well as significant land areas of privately owned forests which support several sawmills in the region (NCFS, 2020).

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. Forests also provide watershed ecosystem services (i.e., nutrient cycling, carbon storage, erosion and sediment control, water filtration and storage, flood control, recreational opportunities, etc.). Properly planned and executed forest management practices 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 forestry Best Management Practices (BMPs) to protect water resources.

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." 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, 2017). Per rule, there are nine FPGs. Each has a narrative performance standard associated with it. One example is the establishment of a Streamside Management Zone (SMZ) along the margins of intermittent and perennial streams and perennial waterbodies. Per 02 NCAC 60C. .0201, the SMZ shall "confine visible sediment resulting from accelerated erosion." The FPGs also prohibit stream obstructions, require installation of effective erosion and sedimentation control measures and site stabilization 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.

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 details specific tools and methods that can be used to attain compliance with the FPGs. The use of temporary bridges during timber harvesting is an example of a BMP that has shown to 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 sub-set 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. More information about bridgemats is available on the NCFS website: https://www.ncforestservice.gov/water_quality/bridgemats.htm.

From 2013 to 2016, the NCFS conducted surveys across the state to assess the implementation of BMPs on timber harvests. These surveys provide a snapshot of practices used in different areas of the state, and help identify where targeted assistance, education or training may be needed. In the Yadkin-Pee Dee River basin, surveys were conducted on 30 sites, assessing 4,981 total BMPs, which were implemented at an 83% rate. Given the non-regulatory approach of forestry BMPs, this relatively high rate of BMP usage indicates that forestry operations are largely being conducted in a manner that supports water resource protection (NCFS, 2020).

Compliance Inspections

NC Forest Service (NCFS) staff regularly inspect timber harvests for compliance with the FPGs. Some inspections often require NCFS to visit the same site multiple times, providing forest operators and landowners with BMP technical assistance, and minimizing any impacts of forestry on water quality. The NCFS is made aware of timber harvests through local knowledge, requests, and periodic analyses of satellite imagery to locate areas of forest cover change. Figures 2.2.2-7 and 2.2.2-8 illustrate locations of where NCFS inspected timber harvests between July 2007 and June 2012 and July 2012 and June 2017. Tables 2.2.2-3 includes the total number of inspections, total acreage, and number of harvests that were found to be out of compliance.

Table 2.2.2-3*: Number of timber harvests inspected by NCFS in the Yadkin-Pee Dee River basin (2007-2020)*

Time Period	# Inspected Timber Harvests	Acres	# Recorded Out of Compliance
7/2007 - 6/2012	4,041	184,226	127
7/2012 - 6/2017	4,277	207,060	89
7/2017 – 6/2020	2,140	25	25

Figure 2.2.2-7: Timber harvests inspected by NCFS in the Yadkin-Pee Dee River basin between July 2007 and June 2012

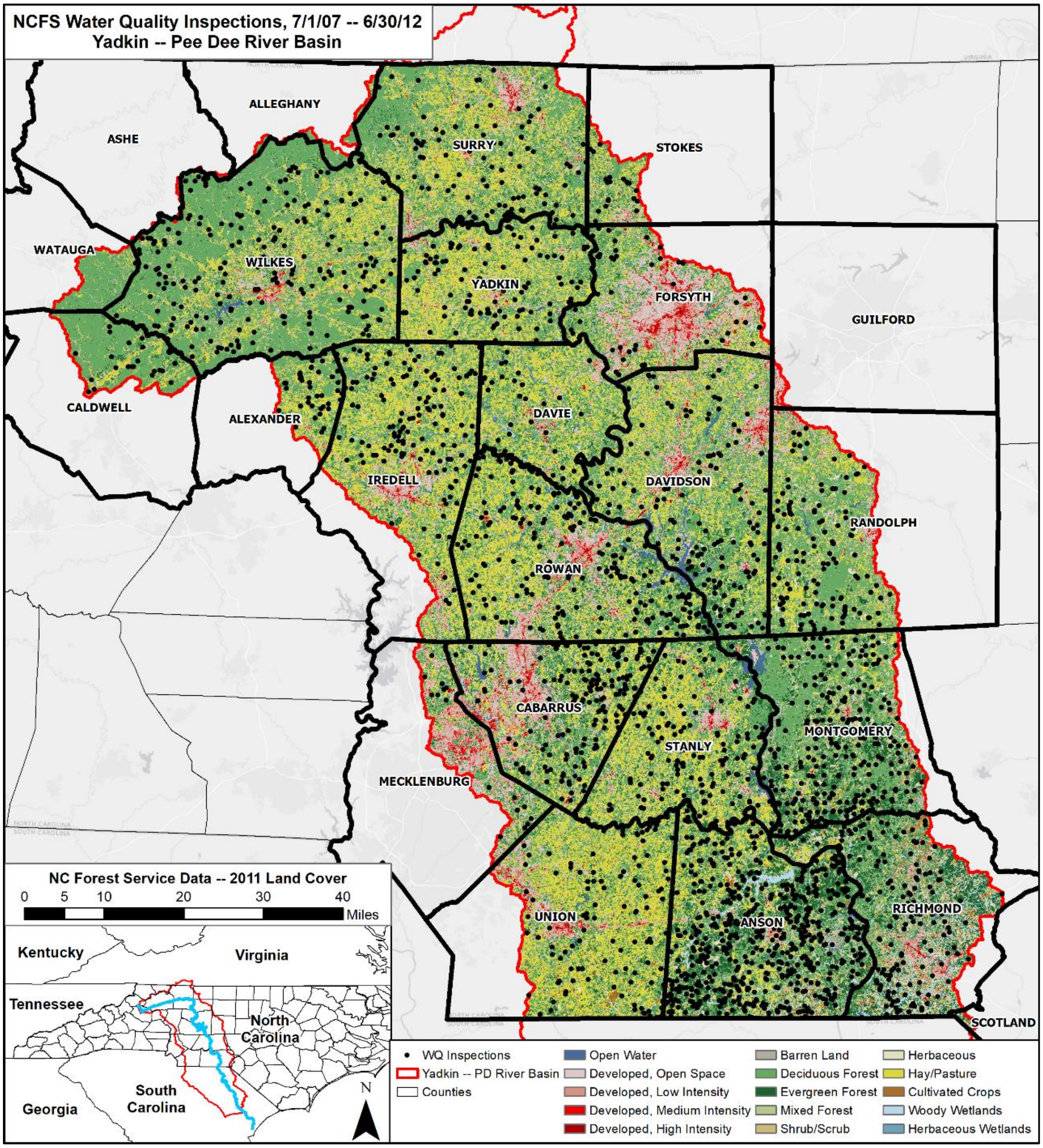
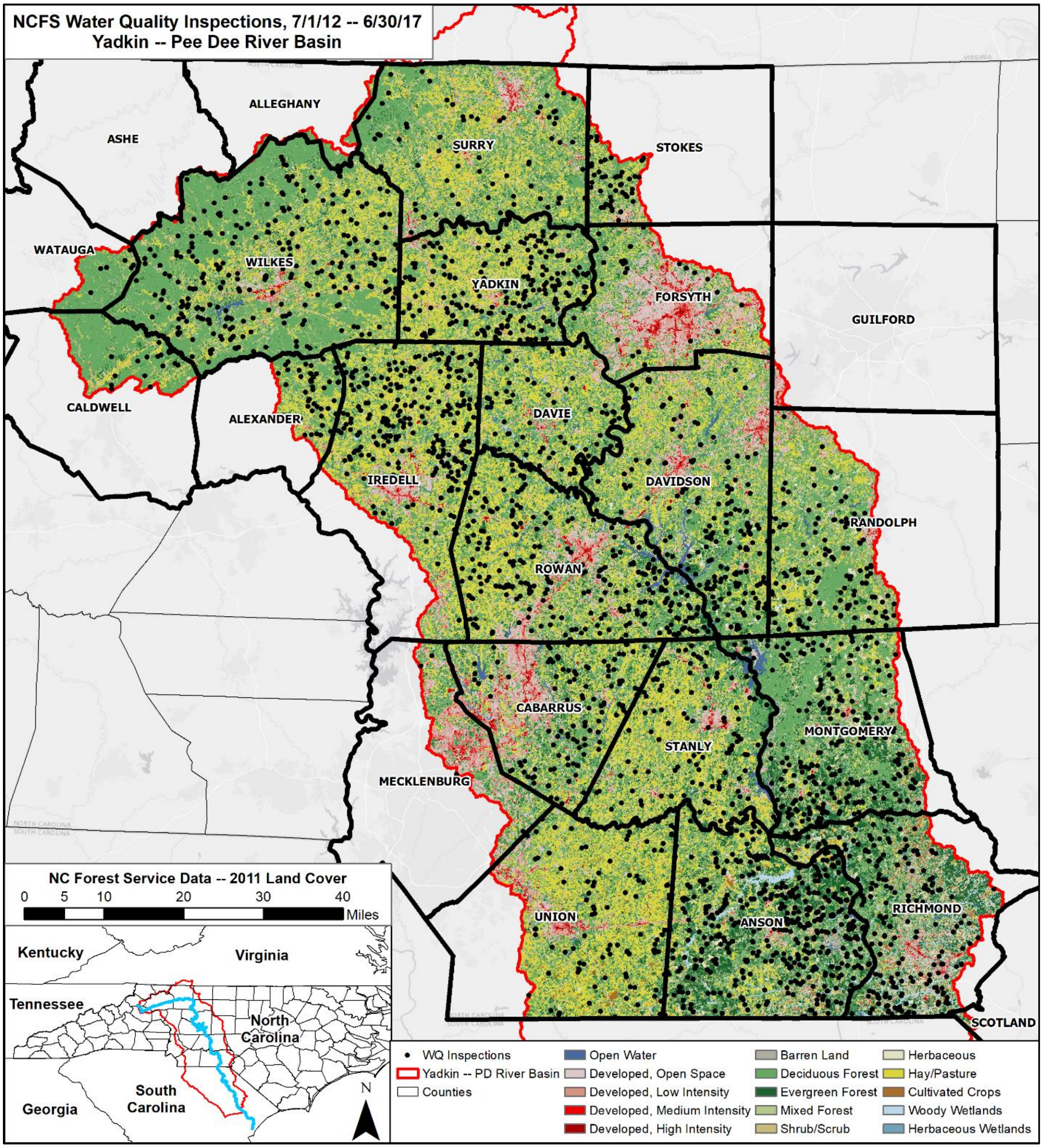


Figure 2.2.2-8: Timber harvests inspected by NCFS in the Yadkin-Pee Dee River basin between July 2012 and June 2017



Outreach & Education

The NCFS assists with training workshop statewide on topics of BMPs, harvest planning, and water quality rules. In 2016 and 2017, the NCFS hosted a series of water quality refresher workshops, including three in this basin (Yadkinville, Statesville, and Albemarle), with an estimated total of 115 attendees.

Over the past several years, the USDA Forest Service has been working on a multi-faceted study of the Yadkin-Pee Dee River basin to assess the effects of increased urbanization and climate change on streamflow. Specifically, the conversion of land from forest to urban land use. The studies' findings thus far indicate that this type of land use change can intensify changes in the streamflow, with baseflow decreasing and peakflow increasing. Summaries of the findings are available from the USDA Forest Service Southern Research Station's blog *Compass Live* and include:

- Sustainable Growth & the Future of Forested Watersheds. (2017).
- The Future of Fish in the NC Piedmont. (2018).
- (2018).
- Climate Change, Streamflow, and Social Vulnerability: Locating Increased Risks. (2020).

2.3 Stream Flow, Ecological Flow, and Impoundments

Streamflow varies hourly, daily, seasonally, and annually based on changes to its source, including precipitation, groundwater level, evapotranspiration, and upstream water and land uses. Streamflow is monitored by the USGS at constructed gaging stations across the nation, including North Carolina. Flow (Q) is measured in terms of volume of water per unit of time, usually cubic feet per second (cfs). Insight into the flow characteristics of a stream is aided by the presence of USGS gaging stations with a record of flow that spans multiple years or decades. Established gages and long-term flow records can be used to assist in early flood warning, help in the revision of floodplain maps, monitor drought conditions, inform recreational boaters, determine assimilative capacity of a waterbody receiving a permitted discharge, and support decisions on water withdrawal and allocation for drinking water, irrigation, and industry. Long-term flow records also help resource agencies understand environmental changes associated with a changing climate, aid in establishing flow requirements, and assist in monitoring compliance with established flow requirements. Flow statistics are not static but will change over time due to natural and human-caused conditions such as intakes, water discharge from industry or WWTP, and water control structures (reservoirs and dams). .

Stream flow information is essential for many uses, including: hydrologicmodeling, water balance estimation,; engineering designs, flood forecasting,; environmental management,; reservoir operation, navigation, water supply, and recreation; and environmental management. Adequate flow provides a suitable environment for organisms, their various life stages and their life-sustaining prey, biological cue triggers, aquifer recharge, wastewater discharge assimilation, support of water quality classifications, transport of nutrients, detritus, sediment, eggs and larvae, wetland and floodplain connectivity, and benefiting the economy through recreation and commerce. There are five critical components that need to be considered when assessing streamflow: magnitude, timing, frequency, duration, variability, and rate of change (Poff et al., 1997). The magnitude refers to a particular amount, or height of water, within the range of low to high flows at a moment in time at a particular location within a stream channel. The frequency is how often a particular magnitude occurs during a designated period of time within a period of recorded flows. The duration refers to the length of time that a particular magnitude is sustained during an episode. The timing refers to the predictability of a particular magnitude over a period of record, and the rate of change refers to the deviation above or below a particular magnitude within a given amount of time.

From a planning and water management perspective, it is important to understand flow variability and trends. Trend analysis is useful to detect and attribute long-term flow patterns of a stream to natural climate variability and human interference. Hence, streamflow records remain a key indicator for long-term hydro-climatic variability and changes associated with it. Equally, the length of period over which a stream-flow record is used to estimate the current and future dynamics of the stream system affects the accuracy of calculating estimates and has direct implication on the growing and competing priorities of water uses and management.

2.3.1 Ecological Flow

The term "instream flow" is often used to describe a flow requirement, but it is sometimes used in a more general sense to refer to the amount of water flowing in a stream without providing any established level of protection. A flow regime that protects ecological integrity is often referred to as an “ecological flow”. Ecological integrity is defined in North Carolina General Statute (NCGS) 143-355(o) as “the ability of an aquatic system to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to prevailing ecological conditions and, when subject to disruption, to recover and continue to provide the natural goods and services that normally accrue from the system” (NCGS, 2017). Adequate freshwater flow regimes are necessary to maintain a suitable environment for organisms, their life-sustaining prey and other nutritional requirements, their various life stages, and their habitats.

In unaltered watersheds, stream flows represent natural flows. Flow-dependent organisms adapt in terms of density and species diversity to the natural flows and deviations associated with seasonal and cyclical flow patterns. However, in a developed watershed with significantly altered water quality and quantity, the diversity and densities of normally occurring aquatic organisms become altered based on each species’ ability to adapt. Some species may be lost while others may flourish. More mobile species, such as insects, may reestablish themselves within a few reproduction cycles if quality and quantity conditions improve; however, less mobile species, such as fishes and mussels may never return to the watershed. To help sustain the density and diversity of aquatic species in streams, a flow regime mimicking unaltered conditions is necessary. Hence, as any activity occurs (dam construction or water withdrawals for agriculture, industry or public uses) that significantly alters the existing flow regime, a percent of the flow regime may be required to be maintained in the impacted stream. More information about ecological flow is available in Chapter 6.

2.3.2 Impoundments

Although reservoirs provide considerable benefits to communities, agriculture, and industry, there are still significant and permanent effects when flowing river and stream systems are flooded and converted to still, non-flowing waterbodies. The changes in temperature, chemical composition, and dissolved oxygen levels and the physical properties of a reservoir are not suitable to many species of fish, amphibians, and macroinvertebrate species that require a flowing creek system for survival. Dams also act as a barrier for migratory river species. Stream and river systems are dynamic by nature and are constantly changing and evolving in the landscape, and dams can have a negative impact on this natural stream and river evolution by holding back sediments that would normally replenish downstream ecosystems. Rivers and streams with altered sediment loads downstream of dams can be more unstable and erode banks which in turn causes incision that can ultimately lower the water table and result in a disconnect from the floodplain. These issues can be magnified in urban settings with rapid stormwater runoff and flashy streams. Unstable, eroding streambanks also have the capacity to destabilize bridges and roads. Within larger reservoirs, sediment build-up behind the dam will reduce storage capacity and water supply availability, which if left unchecked could decrease its intended uses .

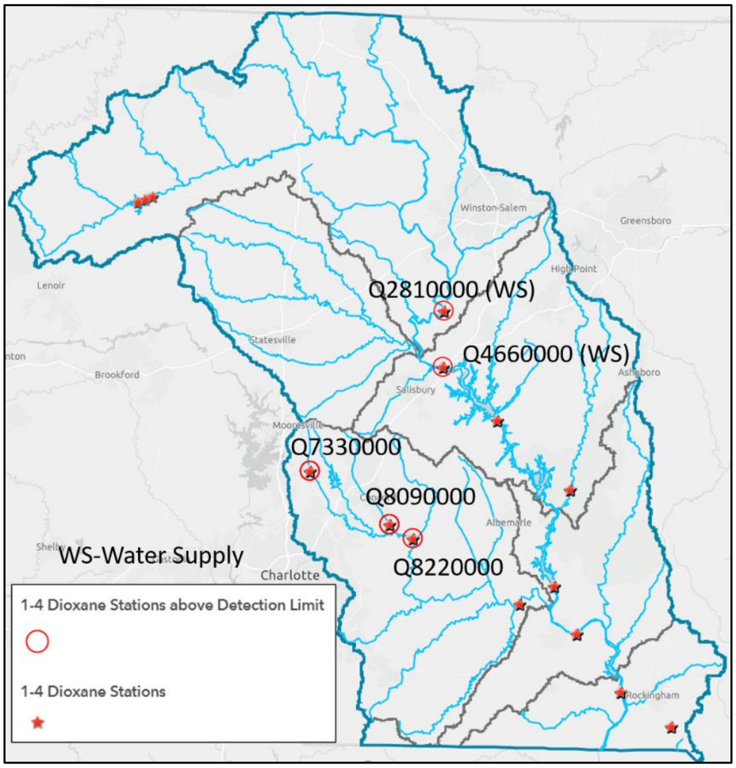
The build-up of reservoir sediment deposits can cause long-term retention of contaminants attached to sediment, especially clay and silt particulates. Sediment-associated contaminants include phosphorous, metals, PCBs, and certain pesticides in watersheds with agricultural, urban, and industrial areas. High Rock Lake currently has impairments for pH, turbidity, PCBs in fish tissue, and chlorophyll *a* (which is often an indicator of high nutrients), phosphorous and nitrogen. As of 2018, all the lakes on the mainstem and some of the smaller lakes higher up in the watersheds (Lake Monroe, Lake Twitty, Lake Tom-A-Lex, and Coddle Creek Lake), particularly in urban areas, are not meeting state water quality standards for one or more of the following parameters: chlorophyll *a*, PCBs in fish tissue, pH, temperature, and dissolved oxygen. More information about impoundments and dam safety can be found in Chapter 5. More information about water quality parameters can be found in Chapter 3.

2.4 Contaminants of Emerging Concern (CEC)

Contaminants of emerging concern (CECs), or emerging compounds, are increasingly being detected in surface and ground water. They come from a wide range of sources including pesticides, lawn and agricultural products, disinfection by-products, wood preservatives, pharmaceutical and personal care products (PPCPs), industrial chemicals as well as their by-products (EPA, 2019). GenX, per- and polyfluoroalkyl substances (PFAS), and 1,4-dioxane are examples of emerging compounds identified in North Carolina waterbodies. They often go undetected and untreated because facilities do not have the analytical tools, methods, or treatment systems in place to detect or eliminate them.

While a compound may be unique to a specific source or river basin, many are widespread. The effects of CECs on aquatic ecosystems and on human health are mostly unknown, and the lack of appropriate analytical methods and monitoring techniques makes identification and management a challenge. The uncertainty of whether CECs are present, their effects on human health, and their impacts to aquatic ecosystems is a growing public concern. To better understand the presence, concentration, and behavior of CECs, states and EPA are working on test methods to identify the compounds in a variety of media (e.g., water, wastewater, biosolids, soils, sediment, agricultural products). There is also work underway to identify and develop treatment options for public water supply systems.

In the Yadkin-Pee Dee River basin, a study by researchers at North Carolina State University (NCSU) found PFAS in every step of the food chain in the mainstem of the river in North and South Carolina even though a known industrial input of these chemicals does not exist. The study found strong links between ecosystem groups that lead to biomagnification, a process that leads to greater concentrations of these substances in animals that sit higher on the food chain (NC State University, 2020).



Between 2014 and 2016, DWR's Water Sciences Section (WSS) conducted a special study on 1,4 dioxane and bromide in the surface waters of the Cape Fear River basin. In 2017, the study expanded to include the Yadkin-Pee Dee and Neuse river basins. Although there is no North Carolina surface water quality standard for 1,4 dioxane, North Carolina has a calculated human health criterion of 0.35 µg/L for drinking water supplies and 80 µg/L for all other waterbodies (NC DWR, 2016). Additionally, North Carolina has a groundwater standard of 3.0 µg/L for 1,4 dioxane (15A NCAC 02L .0202). Stations upstream of public drinking water treatment facilities were targeted for the special study in all three river basins, including 16 stations in the Yadkin-Pee Dee. More details on the monitoring plan and 1,4 dioxane can be found here.

As of March, 2020, out of 271 samples collected, there were 13 samples from five stations with results at or above the detection limit of 1.0 µg/L for 1,4 dioxane. None of the stations were substantially above the detection limit and ranged from 1.0 to 3.3 µg/L. Two of the stations located along the Yadkin River are in waters classified as water supply: station Q2810000 in the lower part of the Yadkin River Headwater watershed (HUC 03040101) and station Q4660000, located further downstream just above High Rock Lake near Spencer (HUC 03040102). In the fall of 2018, both stations had one elevated result out of 23 samples that were collected: Q2810000 at 2.1 µg/L on October 31, 2018, and Q4660000 at 3.3 µg/L on November 7, 2018. No stations sampled in the Yadkin-Pee Dee River basin had bromide results above the detection limit.

2.5 Climate Risk & Resiliency

In October 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 (NC DEQ, 2020).

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" (NC DEQ et al., 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 (NC DEQ, 2020).

One of the first steps in developing the 2020 Resiliency Plan was for DEQ to work with the North Carolina Institute for Climate Studies (NCICS), representatives from many major higher education institutions, and subject matter experts to develop the North Carolina Climate Science Report (NCCSR). 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. 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.
- 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 and wildfires: It is ***likely*** there will be more frequent and intense droughts across the state and that this increase will ***likely*** increase wildfires.
- Ecosystem and 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 buffers capacity to attenuate nonpoint source pollution runoff, and reduce the resilience of coastal communities. Due to warmer temperatures, harmful algal blooms may increase impacting 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, and loss due to flooding, heat-related illnesses, and increased areas where 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; NC DEQ, 2020).

Several programs within DEQ's DWR may be impacted by climate change including (but not limited to):

- 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.
- Non-Point 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.

In North Carolina, many of the reservoir impoundments have sedimentation issues that have diminished holding capacity over time. This is particularly true in the Yadkin-Pee Dee River basin. Reservoirs in the basin have lost and will continue to slowly lose storage capacity due to sedimentation (Normandeau Associates, Inc and PB Power, 2004; Petryniak and Loveless, 2013). The NCCSR found that "it is likely that future severe droughts in North Carolina will be more intense due to the higher temperatures leading to increased evaporation". North Carolina reservoir surfaces that experience increased evaporation due to climate change during severe droughts will have diminished supplies available for consumption. These challenges of diminished water supplies from more severe drought-related evaporation and reduced storage capacity of reservoirs will be compounded by regional population growth. Including climate change metrics in future hydrologic models could help resource managers to better plan for future water use (Chapter 6).

Basinwide planning can contribute to climate resilience by identifying natural resources that may be affected by climate change, providing recommendations for adaptive management, recognizing nature-based solutions to climate impacts, and mitigating impacts from increased precipitation and flood events caused by climate change. One example of overlap between basin plans and the 2020 Resiliency Plan can be found in Chapter 5. In the 2020 Resiliency Plan, intact, naturally vegetated riparian areas are identified as one strategy that can provide resiliency. This is also one of several strategies identified in basin plans to increase North Carolina's resilience to water quality impacts from flooding and stormwater runoff. Chapter 5 in the 2020 Resiliency Plan also 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 (NC DEQ, 2020). Since inland flooding is projected to increase, it is critical to adopt practices that reduce storm-driven nonpoint point source pollution.

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 (GI), low-impact development and living shorelines (Atkins, 2015; US EPA, 2016; NC DEQ, 2020). Many of these same strategies fall in line with those identified in the 2020 Resiliency Plan. 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 and encourage the use of natural and working lands (NWL). The basin plans will continue to be a source of this information and will increasingly analyze North Carolina'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 (https://nca2018.globalchange.gov/). For more information on North Carolina's efforts to address climate change, visit https://deq.nc.gov/energy-climate/climate-change. More information about NWL can be found here: https://nicholasinstitute.duke.edu/project/north-carolina-natural-and-working-lands.

2.6 Protecting Water Resources in the Yadkin-Pee Dee River Basin

Through cooperation with federal, state, and local agencies and stakeholders, DWR supports following recommendations to better protect water resources for all residents and aquatic habitat throughout the Yadkin-Pee Dee River basin.

NPDES Permitting

- Work collaboratively with NPDES permitting staff during permit renewal to ensure that dischargers are collecting appropriate effluent and in-stream data to help with understanding their potential nutrient contribution throughout this nutrient-impacted basin (as seen by the impaired lakes for nutrient related response variables like chlorophyll-*a.*).

- Explore opportunities for educational opportunities for operators of smaller package plants to ensure proper maintenance and operational procedures are being followed to gain maximum permit compliance. Increase DWR oversight and inspection of WWTP package plants as resources and staffing allows.

Agriculture

- 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.

- Provide new funding to hire additional Division of Soil and Water Conservation (DSWC) personnel to promote BMPs in the region and work with landowners on new and innovative practices that can reduce nutrients, turbidity, and fecal coliform in waterways.

- Reduce nonpoint source pollution from large-scale animal operations by ensuring proper oversight and management of animal waste management systems, and certified operator compliance with permit and operator requirements and management plan for animal waste management systems.

- Most poultry operations in North Carolina use a dry waste management system and are referred to as dry litter poultry operations. Such operations are deemed permitted under administrative code (NCAC) 15A NCAC 02T .1303. 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. These requirements include minimum stream setbacks, land application rates, soil and waste analysis, and recordkeeping. This information is included in a waste utilization plan (WUP) (also known as a nutrient management plan [NMP]). Producers are required to keep WUPs (NMPs) on file at the farm and do not have to submit the plan to DWR for review. To better understand where potential nutrient sources may be contributing to the increases in organic nitrogen or the resurgence of harmful algal blooms in the basin, information on the location of potential nutrient sources (including dry litter poultry operations and manure hauling) could help DWR adapt the basinwide stream monitoring program, identify new water quality monitoring stations, and help create a mass balance of nitrogen and phosphorus for the basin. Stream monitoring data has historically been valuable in understanding and addressing nutrient related impacts to recreational use, the economic wellbeing, and overall ecological integrity of the basin (Deerhake, personal communication). DEQ will continue to work collaboratively with federal, state, and local agencies as well as stakeholders in the basin to identify information sharing opportunities to target water quality monitoring and BMP implementation throughout the basin.

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