A Comparison of PAN and P_2O_5 produced from Poultry, Swine and Cattle Operations in North Carolina

Water Resources
ENVIRONMENTAL QUALITY

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Basinwide Planning
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Introduction

The basinwide planning program within Department of Environmental Quality's Division of Water Resources (DEQ DWR) is charged with identifying and providing recommendations for improving water quality based on the cumulative impacts of all activities across a river basin (G.S. 143-215.8B). Point and nonpoint sources of pollution are to equitably share responsibility in reducing pollution. However, little information has been synthesized regarding the amount and fate of nutrients produced by different animal operations. Nutrients produced by animals, if not effectively utilized by vegetation, can enter our surface water systems by atmospheric deposition, groundwater or direct runoff to surface waters. Depending on the surface water system, excessive nutrients can lead to drinking water or aquatic life impairments.

In 1992, the Environmental Management Commission adopted a rule modification (15A NCAC 2H.0217), establishing procedures for managing and reusing animal wastes from intensive livestock operations (updated 2T.1300 Section effective September 1, 2006). The rule applies to new, expanding or existing feedlots with animal waste management systems designed to serve animal populations of at least the following sizes: 100 head of cattle, 75 horses, 250 swine, 1,000 sheep or 30,000 birds (chickens and turkeys) with a liquid waste system. Currently, DEQ has regulatory authority over waste management of swine and cattle feedlots that use dry or liquid manure systems and poultry feedlots using liquid waste management systems. These permitted facilities are inspected on an annual basis by DWR or the NC Department of Agriculture and Consumer Services' (NCDA&CS) Division of Soil and Water Conservation. Most poultry operations, however, produce a dry litter waste that typically falls under the deemed permitted category (NCAC 2T.1303). Poultry operations in this category are only inspected as result of complaints.

The location of swine and cattle animal feeding operations (AFOs) are known because a state or NPDES permit is required. However, the locations of dry litter poultry operations and the disposal of their waste are not known to environmental regulators, making it difficult to form a complete picture of possible non-point source contributions within a specific watershed. Knowing what nutrient sources exist in the watershed can help water quality managers better understand available water quality data and to formulate appropriate decisions and regulatory recommendations.

Objective

In 2015, DWR Groundwater Planning staff issued a report entitled "A Summary of Land Applied Nutrients from Livestock Waste in North Carolina" which estimated the amount of nutrients applied to land from DWR permitted swine and wet poultry operations (NCDWR, 2015). The report focused on liquid waste from anaerobic lagoons to determine the spatial distribution of phosphorus and nitrogen applied to fields. It also compared those values to other known quantities of land applied nutrients (e.g., wastewater treatment residuals, synthetic fertilizer applications, residential subsurface on-site septic systems). The report estimated that over 30.8 million pounds (lb) of total nitrogen (TN) and over 11.9 million lb of phosphorus (P_2O_5) are applied annually through DWR permitted animal operations utilizing an anaerobic lagoon and spray field system. It was determined during the study that less than 4% of the poultry population and less than 12% of cattle operations in the state utilize an anaerobic lagoon and spray field system; prompting an interest in the development of data on the management of waste nutrients from the vast majority of poultry and cattle in the state.

The objective of this project was to estimate the amount of nutrients generated by animal operations that were not accounted for in the DWR 2015 report and to evaluate the spatial distribution of dry poultry litter operations. The spatial distribution of animal operation types and relative magnitude of plant available nitrogen (PAN) and P_2O_5 produced by dry litter poultry operations versus permitted swine and cattle operations were compared. This report focuses on the poultry population in the state and percent changes in PAN and P_2O_5 produced in each river basin between 1992, 2000, 2006 and 2014.

Data Sources and Methodology

Poultry animal population numbers were retrieved from the US Department Agriculture's (USDA) National Agriculture Statistics Service Quick Stats query: http://quickstats.nass.usda.gov/ . Title 7 of the US Code of Federal Regulations prevents disclosure of information about specific operations of an individual farm and, therefore, information that can be identified to a specific farm in a county is withheld from compilation in the national agricultural statistics data. Counties with information withheld include those with operations that produce greater than 60% of the total production for that county or those counties which have three or less operations. The USDA collectively summarizes the county withheld data into the "Other Counties" category. For example, a known layer facility in Hyde County is permitted to house 4.75 million chickens; however, no data are available in the Agriculture Statistics data for that county, but the data are captured in the "Other Counties" category.

Table 1 lists the query parameter used to extract data from the Quick Stats database.

Table 1. Quick Stats Query Parameters

Query Parameters	Chicken Broilers	Chicken Layers	Turkeys
Program:	Survey	Survey	Survey
Sector:	Animals & Products	Animals & Products	Animals & Products
Group:	Poultry	Poultry	Poultry
Commodity:	Chickens	Chickens	Turkeys
Category:	Production	Inventory	Production
Data Item:	Chickens, Broilers-Production, Measured in Head	•1994, 2000 & 2006: Chickens (Excl Broilers)-Inventory •2014: Chicken, Layers- Inventory + Chickens, Pullets, Replacement-Inventory	Turkeys-Production, Measured in Head
Domain:	Total	Total	Total
Geographic Level:	County	County	County
Year:	2006, 2014	1994, 2000, 2006, 2014	2006, 2014

The same parameters were used to query "all chickens excluding commercial broilers" from Quick Stats to estimate chicken layer numbers for 1992, 2000, and 2006. However, this query includes pullet and rooster numbers that were not included in 2014 data. The 2014 data did not include estimates for rooster inventory. Data for broilers and turkeys for 1992 and 2000 were only published in the North Carolina Statistical Bulletin.

Swine and cattle (beef and dairy) numbers were pulled from DWR's BIMS database, querying permitted animal operations to include permits issued through 2015 and their allowable animal count. An existing 2006 BIMS query was used to generate swine and cattle 2006 manure numbers.

Manure production for animal types (poultry, cattle and swine) was derived from N.C. State University's Nutrient Management guidance found on their website: http://nutrients.soil.ncsu.edu/. This was the same method used in DWR's 2015 report except for the addition of a plant availability coefficient. The following formula was used to calculate total plant available nutrients:

Total Plant Available Nutrients = (# of Animals/ Year) x (Waste Weight or Volume/Animal) x (Total Nutrients/Waste Weight or Volume) x Availability Coefficient

Examples of the calculations and assumptions made for each of the different type of livestock are available in Appendix A.

The different types of animals were grouped by poultry (adult broilers, layers and turkeys), cattle (dairy calves, heifers and cows, and beef stockers, feeders and broods) and swine (farrow to feeder, farrow to finish, farrow to wean, feeder to finish, wean to feeder, and wean to finish). The nutrients were then summed for each of these groups by county. Each county was then assigned a river basin; no county was assigned to more than one river basin even though counties may be in multiple basins (Table 2). Figure 1 shows river basins and the counties that were used to summarize total manure production for the basin. Poultry numbers that were assigned to "Other Counties" by the Agriculture Census were not assigned to a river basin, but the amounts were used in the statewide totals. A geographic information system (ESRI ArcGIS) was used to show the spatial distribution of total animal numbers, PAN and P_2O_5 by river basin and by county.

Table 2. River Basins and Corresponding Counties

River Basin	Counties
Tar Pamlico	Granville, Vance, Franklin, Warren, Nash, Halifax, Edgecombe, Pitt, Beaufort, Hyde
Neuse	Orange, Durham, Wake, Johnston, Wilson, Wayne, Greene, Lenoir, Craven, Jones, Pamlico
Cape Fear	Alamance, Bladen, Chatham, Cumberland, Duplin, Guilford, Harnett, Hoke, Lee, Moore, New Hanover, Pender, Randolph, Sampson
Yadkin-PeeDee	Wilkes, Surry, Yadkin, Forsyth, Davie, Davidson, Iredell, Rowan, Cabarrus, Stanly, Montgomery, Richmond, Anson, Union
Catawba	Alexander, Catawba, Caldwell, Gaston, Lincoln, Mecklenburg, Burke, McDowell, Avery
Roanoke	Stokes, Rockingham, Caswell, Person, Bertie, Martin
White Oak	Onslow, Carteret
Lumber	Robeson, Columbus, Brunswick, Scotland
New	Ashe, Alleghany
French Broad	Buncombe, Haywood, Henderson, Madison, Mitchell, Transylvania, Yancey
Broad	Cleveland, Polk, Rutherford
Chowan	Chowan, Hertford, Northampton, Gates
Pasquotank	Currituck, Camden, Pasquotank, Perquimans, Washington, Tyrrell, Dare
Little Tennessee	Graham, Swain, Jackson, Macon

Hiwassee	Cherokee, Clay
Watauga	Watauga
Note: Not all NC river basins and counties have animal operations or have information that can be disclosed.	

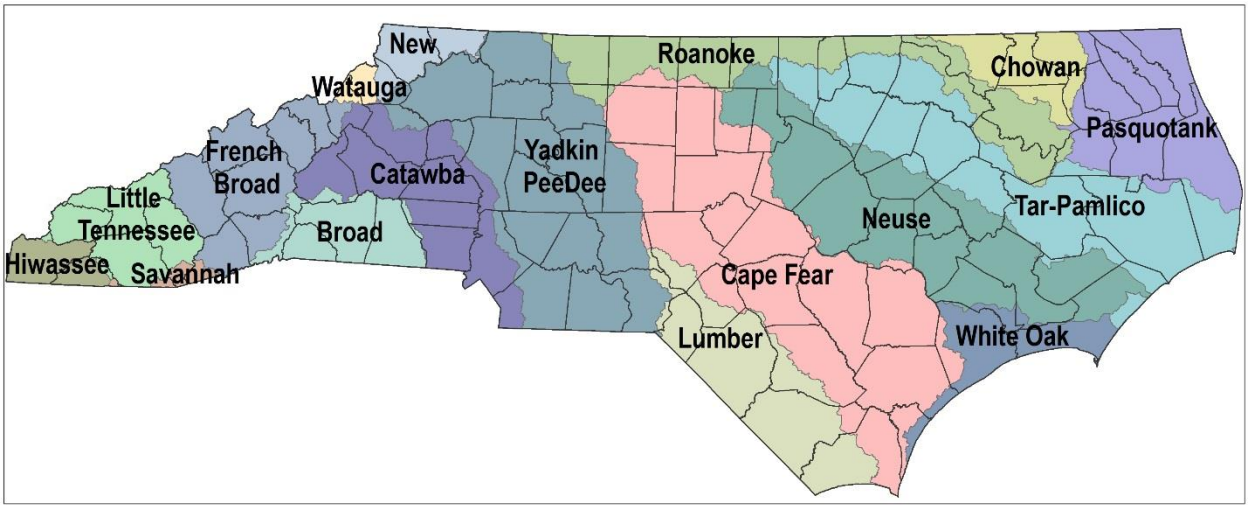

Figure 1: North Carolina Counties and River Basins

Results Summary

In terms of stock numbers, the greatest number of birds were found in Duplin, Union, Sampson and Wilkes counties leading to the Yadkin-Pee Dee and the Cape Fear river basins producing the most poultry nutrients. Swine in Duplin and Sampson counties in the Cape Fear River Basin produced the most swine nutrients statewide. Cattle in Iredell and Randolph in the Yadkin- Pee Dee and Cape Fear river basins accounted for the majority of cattle-produced nutrients statewide. In terms of changes in stock over time, estimates of statewide shifts between 2006 and 2014/15 indicated an overall 7% decrease in PAN and a 6% decrease in P_2O_5 produced by poultry, swine and cattle. Comparing nutrient production across animal types, poultry operations produced the greatest amounts of PAN and P_2O_5 with 56.6 million PAN lb and 79.8 million P_2O_5 lb, produced in 2014. Additional maps and summaries by animal type are found in Appendix B, C and D.

Statewide Poultry Population and Densities

The highest numbers of poultry since the 1990's have been in the Yadkin-Pee Dee and Cape Fear basins. The Yadkin-Pee Dee Basin had the highest poultry population with bird inventories over 15 million in Union County and over 11 million in Wilkes County in 2014 (Figure 2). The Cape Fear Basin had the second highest poultry population in 2014 with Duplin and Sampson counties having over 15 and 11 million birds, respectively. Evaluating poultry numbers by basin acreage indicates the Yadkin-Pee Dee and Cape Fear basins also have the highest bird densities (Table 3). At the county level, Alexander, and Union and Duplin counties have the highest bird densities (Table 10 Appx. B).

Table 3: Basin Poultry Density

River Basin	2014 Density (Poultry per Basin Acreage)
Yadkin-Pee Dee	13.2
Cape Fear	9.9
Chowan	7.2
Catawba	6.8
Lumber	6.0
Broad	5.7
Roanoke	3.3
Neuse	2.5
White Oak	1.9
Tar-Pamlico	1.7
Pasquotank	1.0

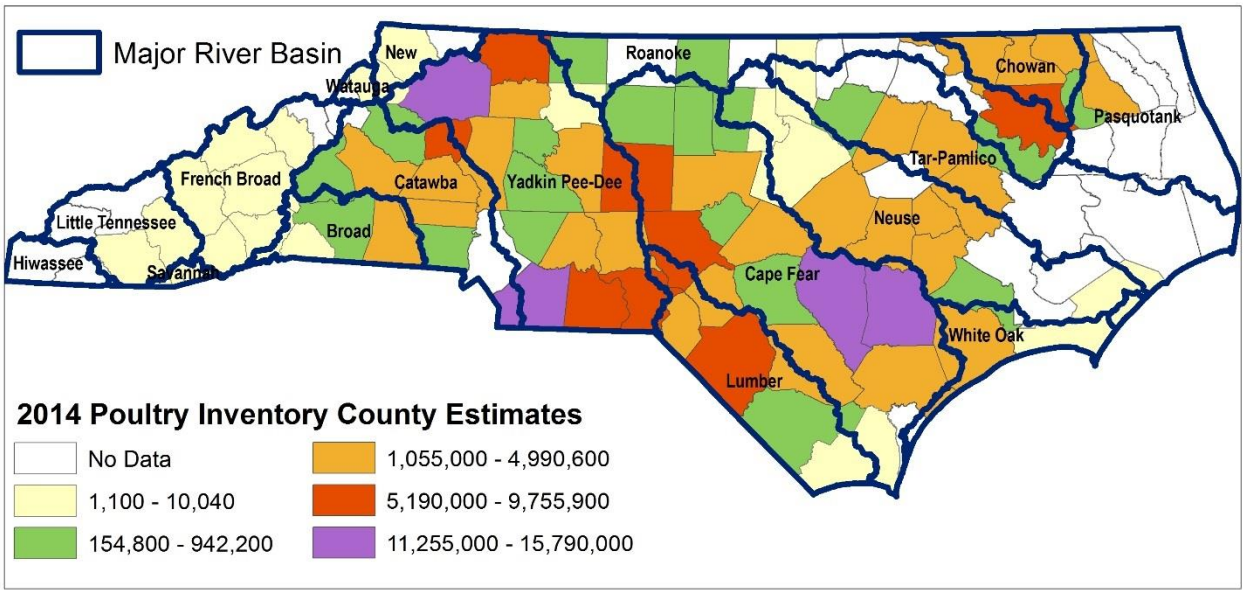

Figure 2: 2014 Poultry Inventory 2014 with River Basins

Poultry Changes by River Basin between 1992, 2000, 2006 and 2014

When evaluating growth of bird numbers by basin, the Broad, Lumber, Catawba and White Oak all had large increases in bird inventories between 2006 and 2014 (Table 4). The Lumber and Broad river basins each increased in poultry inventory since 1992 by over 300%; the Lumber poultry inventory increased by over 10 million birds since 1992. When comparing poultry inventory between 1992 and 2014, the Yadkin-Pee Dee Basin saw a 16% increase and the Cape Fear saw a 9% increase in birds. However, the type of poultry and manure management determines the amount of nutrients (PAN and P_2O_5) produced. Even with an increase in poultry numbers, the Yadkin-Pee Dee Basin had no change in PAN and a 5% decrease in P_2O_5, due to the increase in the number of broilers and layers and a decrease in turkeys from 1992 to 2014 (Table 5). The only basins with both a loss in poultry numbers and nutrients between 1992 and 2014 were the Neuse, Tar-Pamlico and Pasquotank basins.

Table 4: Basin Poultry Change in Inventory

	Poultry Inventory				Percent Inventory Change (Δ %)		
River Basin	**1992**	**2000**	**2006**	**2014[1]**	**1992-2014**	**2000-2014**	**2006-2014**
Yadkin-PeeDee	52,364,000	64,744,000	73,372,000	60,793,600	16	-6	-17
Cape Fear	52,975,000	54,445,000	56,208,000	57,906,600	9	6	3
Catawba	7,458,000	8,028,000	8,040,000	14,283,800	92	78	78
Lumber	2,604,000	4,540,000	6,628,000	12,829,700	393	183	94
Neuse	10,146,400	11,485,000	11,974,700	9,631,500	-5	-16	-20
Roanoke	5,180,000	5,000,000	6,225,000	7,465,000	44	49	20
Tar-Pamlico	9,375,400	8,240,000	7,536,000	6,601,301	-30	-20	-12
Chowan	4,540,000	5,460,000	5,680,000	6,020,000	33	10	6
Broad	1,270,000	1,850,000	2,340,000	5,475,400	331	196	134
Pasquotank	2,380,000	2,280,000	1,680,000	2,100,000	-12	-8	25
White Oak	1,122,000	1,060,000	1,064,000	1,681,300	50	59	58
Other	2,677,000	1,607,000	2,633,300	6,587,600	146	310	150

[1] 2014 data does not include rooster inventory.

Table 5: Basin Poultry Change in Nutrients Produced

	Percent PAN Change (Δ lb)			Percent P_2O_5 Change (Δ lb)		
River Basin	**1992 -2014**	**2000 - 2014**	**2006 -2014**	**1992 -2014**	**2000 - 2014**	**2006 -2014**
Yadkin-PeeDee	0	-4	-15	-5	-3	-14
Cape Fear	-2	-4	-5	-6	-7	-8
Catawba	91	71	66	91	68	62
Lumber	273	153	84	237	142	80
Neuse	-20	-17	-14	-22	-17	-12
Roanoke	63	69	20	73	80	20
Tar-Pamlico	-55	-37	-31	-61	-42	-37
Chowan	33	10	6	33	10	6
Broad	168	166	118	128	151	110
Pasquotank	-12	-8	25	-12	-8	25
White Oak	-5	-2	9	-12	-10	2
Other	139	298	172	138	296	179

Comparison of Poultry and Swine and/or Cattle Nutrient Production by Basin

In 2014, poultry operations produced three times more pounds of PAN and six times more pounds of P_2O_5 than swine operations and eight times more pounds of PAN and nine times more pounds of P_2O_5 than cattle operations. In river basins with known nutrient sensitivity, poultry operations produced more PAN and P_2O_5 than swine (Table 6).

Table 6: Nutrient Production Comparison

Basin	Poultry produced: X times as much **PAN** than Swine	Poultry PAN	Swine PAN	Poultry produced: X times as much **P_2O_5** than Swine	Poultry P_2O_5	Swine P_2O_5
Cape Fear	**2x**	16,873,187	9,574,482	**3x**	23,488,961	6,719,394
Tar-Pamlico	**1.5x**	1,795,074	1,166,176	**3x**	2,459,403	816,405
Neuse	**1 x**	3,520,717	3,309,586	**2x**	5,215,734	2,323,652
White Oak	**2x**	645,925	345,432	**4x**	963,207	243,471
Chowan	**4x**	1,377,906	349,883	**4x**	1,733,760	243,358
	X times as much PAN than Cattle	Poultry PAN	Cattle PAN	X times as much P_2O_5 than Cattle	Poultry P_2O_5	Cattle P_2O_5
Yadkin-Pee Dee	**6x**	17,499,432	3,106,075	**6x**	24,464,078	3,883,584

Total Manure Production Changes by Basin, 2006 vs. 2014

Combining poultry, swine and cattle manure production for each river basin, the Broad, Lumber and Catawba river basins had the highest increase in both PAN and P_2O_5 production from 2006 to 2014/15, which can be attributed to growing poultry populations in each of the basins. In the river basins with known nutrient sensitivity the Cape Fear, Yadkin-Pee Dee, Neuse, Tar-Pamlico and Chowan have seen decreases in animal nutrient production. Collectively animals in the Cape Fear produced the most nutrients, at an estimated 28,174,530 lb PAN and 32,371,778 lb P_2O_5 in 2014 (Table 7).

Table 7: Total Animal Manure Change in Nutrients Produced between 2006 - 2014.

River Basin	PAN (lb) 2006	PAN (lb) 2014	PAN Percent Change 2006 - 2014/15 (Δ%)	P_2O_5 (lb) 2006	P_2O_5 (lb). 2014	P_2O_5 Percent Change 2006 - 2014/15 (Δ%)
Broad	807,222	1,372,957	70	1,050,113	1,757,966	67
Catawba	4,206,106	5,013,378	19	5,767,631	6,990,469	21
Chowan	1,927,105	1,728,647	-10	2,083,450	1,978,213	-5
Cape Fear	30,181,069	28,174,530	-7	35,286,880	32,371,778	-8
French Broad	940,107	355,754	-62	1,173,453	450,428	-62
Lumber	3,583,363	4,360,776	22	3,618,961	4,727,819	31
Neuse	8,443,449	6,967,105	-17	9,306,720	7,710,389	-17
New	417,407	193,781	-54	521,329	243,288	-53
Pasquotank	924,797	654,891	-29	862,133	727,757	-16
Roanoke	2,215,000	2,177,539	-2	2,778,971	2,829,675	2
Tar-Pamlico	4,881,659	3,087,566	-37	5,765,663	3,434,644	-40
White Oak	970,860	991,357	2	1,217,610	1,206,678	-1
Yadkin-Pee Dee	25,312,857	20,912,523	-17	34,080,611	28,562,525	-16

Specific County and Basin Results Maps and Tables

The maps and tables provided in Appendix B show the poultry numbers by county and river basin, and the estimated available nutrients produced based on agriculture statistics available for 1992, 2000, 2006 and 2014. Cattle and swine numbers provided in Appendices C and D, respectively, are based on permits on record with DWR for 2006 and 2015 and show estimated available nutrients produced by county and river basin.

Discussion

Figure 3 was produced in 2015 by the N.C. Department of Agriculture and Consumer Services in preparation for management of a potential avian influenza outbreak. The map shows approximate locations of individual poultry farms and also shows farms that are not reported in the agriculture census data. The densities of farms shown in the Yadkin-Pee Dee and Cape Fear river basins are consistent with the spatial distribution of the agriculture census derived poultry maps provided in Appendix B.

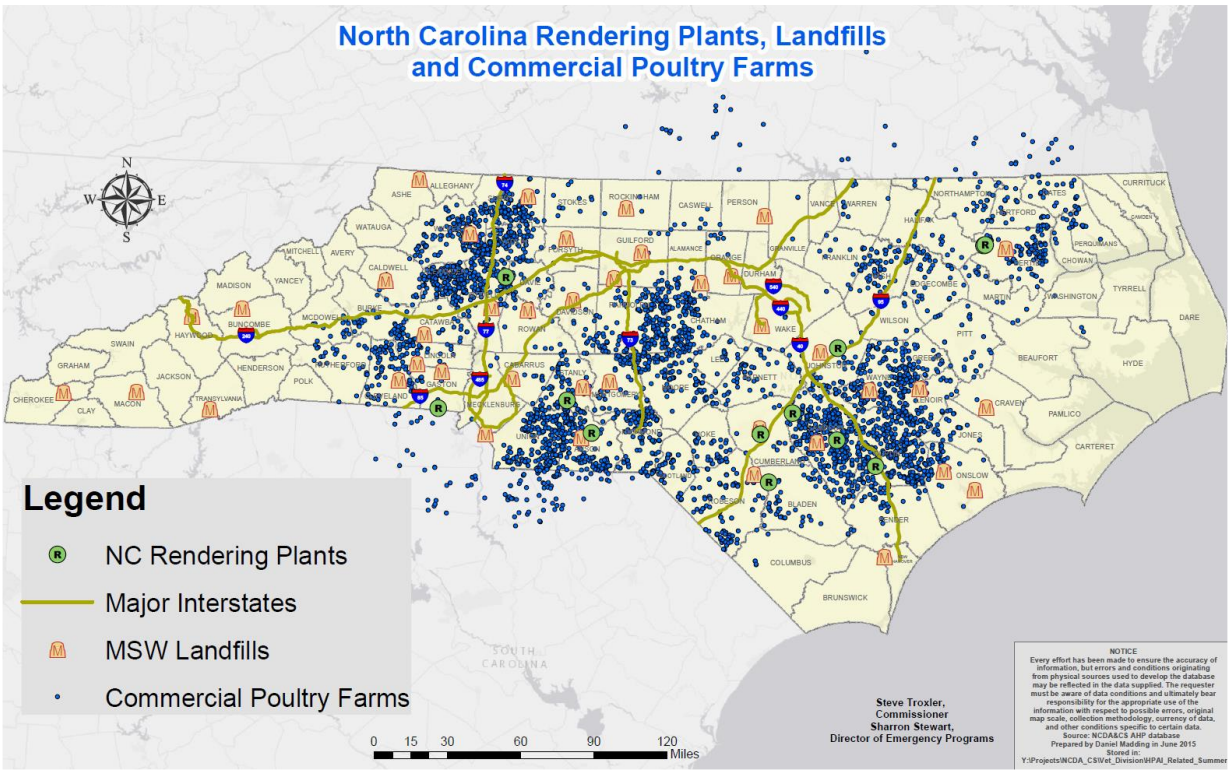

Figure 3: NCDA&CS Poultry Map

Identification of information from individual farm operators is protected by NC G.S. 106-24.1 and Title 7 of the US Code prevents disclosure of information regarding individual farm operations in development of the Agriculture Census; farm information is not disclosed when a county has three or less specific operations or those with operations that produce greater than 60% of the total production. Although this system provides security for individual farm operations it also limits the ability to accurately quantify animal numbers. The combination of the lack of permitting data and the agricultural statistics privacy laws adds significant uncertainty to assessment of nutrient loading contributions of poultry to the state's nutrient-impaired waterbodies. Since dry litter poultry operations are deemed permitted and inspections are conducted only after reported complaints, the maps provided in Appendix B provide the best information DWR has in regards to poultry nutrient production.

Manure management by AFOs is under increasing scrutiny as the application of waste has raised both human and environmental health concerns, while also proving to be a valuable fertilizer source. As animal agriculture has shifted to large confined feeding facilities, manure management has increasingly resulted in manure that is stored in lagoons, stockpiled, or composted. Using manure at agronomic rates requires suitable and available land for its application. North Carolina ranked number one nationally for

tons of manure generated per farmland acre (EPA, 2013). Due to a swine farm moratorium put in place in 1997 and a new law passed in 2007 prohibiting the construction of new swine farms that use waste lagoons and spray fields as the primary method of waste management (SB 1465), nutrient contributions from swine operations have remained fairly constant over the last several years. However, the shifts in both location and the type of poultry industry in NC is potentially adding to the current nutrient loading from nonpoint sources. This adds to the concerns over environmental impacts of manure application on a limited land base.

Cattle and swine manure sludge are generally applied to fields relatively close to its generation, while dry poultry litter is potentially transported much farther for use as fertilizer. In accordance with 15A NCAC 02T.1400, haulers that move and land apply over 100 tons of animal waste per year must submit an annual report to DWR. However, DWR generally does not have the capacity to review and investigate the management and distribution of dry poultry litter. This rule also does not address litter land applied by the poultry operation itself nor does it apply to haulers that transport the litter for other non-land applications, such as biogas energy generation. In 2012, the Environmental Defense Fund examined North Carolina's manure hauler data, compliance, and hauling locations from 2006-2011. The primary conclusions of this study were that only a small portion of poultry litter data was reported to DWR and much of that data was incomplete compared to the estimated amount of litter produced in NC. Based on limited data, the review suggested that poultry litter was most commonly hauled and applied within the same county where it was produced. The report also noted that very little information was provided to DWR for Sampson and Duplin counties which are leading poultry production counties. (EDF, 2012).

It is assumed that manure spread on land at agronomic rates is efficiently utilized by plants. The amount of nutrients not utilized is difficult to quantify given the application of unregulated animal waste and limited air and water ambient data collected. Animal waste not utilized by plants can be volatilized and lost to the atmosphere, stored in the soils, or transported to surface water or aquifers via surface runoff or groundwater. A U.S. Geological Survey study of nutrient source shares and loads estimates 45%, 25% and 16% percent of the nitrogen load to the Cape Fear Estuary, Pamlico Sound, and Albemarle Sound, respectively, calculated by SPARROW model estimates of 2002 data, is attributed to manure (Moorman et al., 2014).

The amount and availability of nutrients stored in the subsurface soils and movement of nutrients from the surface through the vadose zone to groundwater is not well documented in NC. A study of surface water samples in a AFO dominated land use watershed in the Cape Fear River Basin showed no difference between dry and rainy periods, indicating chronic pollution fed by groundwater instead of acute stormwater runoff events (Mallin et al., 2015). Another study found a 35-year nitrogen retention time in heavily agricultural watersheds in the Midwest (Van Meter et al., 2016). The lag time was attributed to lost nitrogen as either nitrate in the vadose zone, organic nitrogen in the soils or lost to groundwater aquifers (Van Meter et al., 2016). This delay in nitrogen being utilized or transferred to surface waters complicates land use management as the results of implementation of nitrogen reducing activities may not be realized for years.

Nutrient data collected from DWR ambient stations in the coastal plain have shown an increase in organic nitrogen while ammonia nitrogen and nitrate-nitrite have declined. These trends are described in the 2015 Tar-Pamlico and 2009 Neuse River Basin Plans: http://deq.nc.gov/about/divisions/water-resources/planning/basin-planning. A recent study in the Neuse River Basin focused on identifying sources of dissolved organic nitrogen(DON); poultry waste was detected as a dominant source, while swine sources were not detected as contributors to the DON (Osburn et al., 2016). The study indicated street runoff and poultry waste were the main anthropogenic sources with higher flows leading to

increased loads of these sources (Osburn et al., 2016). Detection of the poultry fraction of DON increased going downstream, which coincides with the increase in agricultural land use in the coastal plain (Osburn et al., 2016). The poultry-sourced DON at the Ft. Barnwell sample location was determined to be almost equivalent to the total point source load of organic nitrogen in the basin (Osburn et al., 2016).

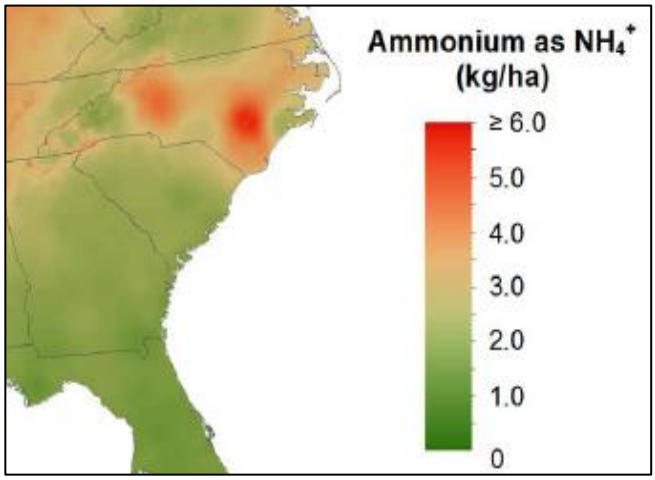

Figure 4: Ammonium Wet Deposition 2012
http://nadp.sws.uiuc.edu/maplib/ani/nh4_dep_ani.pdf

Reduction in nitrogen load to our surface waters is challenging without accurately quantifying atmospheric contributions to a watershed, and eventually seeking appropriate management measures on all significant emission sources. Emissions from confined animal operations comprise the great majority of atmospheric ammonia emissions (Aneja et al., 1998). Currently, these outputs are not directly regulated. However, in 2007, the NC Legislature enacted a law (SB 1465) requiring animal waste systems that serve new and expanding swine farms to meet or exceed five performance standards. One of the standards requires such farms to "substantially eliminate atmospheric emission of ammonia." This regulation does not require reductions from existing operations, nor does it apply to other types of AFOs, such as cattle and poultry operations. Thus, ammonia emissions from existing AFOs remain the largest unregulated source of atmospheric nitrogen emissions. The U.S. Environmental Protection Agency 2014 model estimates that livestock waste generates the most ammonia in North Carolina with over 155 thousand tons emitted (EPA, 2016). County data estimates for ammonia emissions from the 2014 model run are found in Appendix E. The U.S. Environmental Protection Agency estimates through 2030 that ammonia emissions from poultry operations will be the highest when compared to other animal operations (EPA, 2004). Figure 4 shows the highest deposition of ammonium within NC coinciding with the locations of concentrations of AFOs (National Atmospheric Deposition Program/National Trends Network, 2012).

A 2016 air quality study indicated a change in the dominant source of nitrogen deposition with an overall decline in nitrate and nitrite (NOx) emissions and an increase in ammonia emissions (Li et al., 2016). The study indicated that regulated reductions in fossil fuel combustion have reduced NOx emissions, while increasing ammonia emissions from agriculture exceed the impacts of emissions from fossil fuel combustion on the nitrogen cycle (Li et al., 2016). The 2011 National Emission Inventory data for NC indicated agriculture contributes over 95% of all ammonia emissions (EPA NEI 2011). However, unlike NOx emissions, agricultural ammonia emissions are not regulated and historically there are limited air quality sampling stations collecting ammonia data.

Knowing what the nutrient sources are and their application, storage and utilization rates are important for managing nutrients collectively on a basinwide scale. The spatial distribution of poultry, swine and cattle operations and estimates of their generated nutrients help provide guidance on where implementation efforts should be focused toward agricultural nutrient reduction.

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Appendix A:

The following are examples of the calculations for each of the different type of livestock so future updates are compared using the same method.

Broiler Assumptions:
Total county production (total produced/year)
Tons of litter produced = total production divided by 5 (5 cycles/year)
Accumulated whole house manure clean out per year = 7.2tons/1,000 bird capacity/year
Manure weights = 57.8 lb of N/ton, 40 lb of P_2O_5/ton
Production system waste application coefficient: N = 0.55, P = 1.0
Note: The nutrient coefficient for N was averaged to 0.55 because production system waste application management is unknown.

Example: PAN lb = SUM((animals#/5) * (7.2/1000) * 57.8 * 0.55)
P_2O_5 lb = SUM((animals#/5) * (7.2/1000) * 40 * 1.0)

SUM((5,950,000 animals/5 cycles/year) * (7.2tons/1000 birds) * (57.8lb/ton * 0.55) = 272,377 lb PAN
SUM((5,950,000 animals/5 cycles /year) * (7.2tons/1000 birds) * (40lb/ton * 1.0) = 342,720 lb TP (P_2O_5)

Chickens and Pullets Layer Assumptions:
Total Inventory used because bird house numbers are constant.
Accumulated manure=24tons/1,000 bird capacity/year
Manure weights = 47.6 lb of N/ton; 44.7 lb of P_2O_5/ton
Production system waste application coefficient: N = 0.55, P = 1.0
Note: The nutrient coefficient for N was averaged to 0.55 because production system waste application management was unknown.

Example: PAN lb = SUM((animals#/1) * (24/1000) * 47.6 * 0.55)
P_2O_5 lb = SUM((animals#/1) * (24/1000) * 44.7 * 1.0)

SUM(875,000*(24/1000)*47.6*0.55) = 549,780 lb PAN
SUM(875,000*(24/1000)*44.7*1.0) = 938,700 lb TP (P_2O_5)

Turkey Assumptions:
2.5 flocks per year
Accumulated manure =21 tons/1,000 bird capacity/year, 21= average of Hen (17) and Tom (25).
Manure weights= 54 lb of N/ton; 48.2 lb of P_2O_5/ton
Production system waste application coefficient: N = 0.55, P = 1.0
Note: The nutrient coefficient for N was averaged to 0.55 because production system waste application management was unknown.

Example: PAN lb = SUM((animals#/2.5) * (21/1000) * 54 * 0.55)
P_2O_5 lb = SUM((animals#/2.5) * (21/1000) * 48.2 * 1.0)

SUM((3,5000,000/2.5)*(21/1000)*54*0.55) = 873,180 lb PAN
SUM((3,5000,000/2.5)*(21/1000)*48.2*1.0) = 1,417,080 lb TP (P_2O_5)

Swine Assumptions:

Note: The nutrient coefficient for N was averaged to 0.55 (average of irrigated factor [0.5] and the incorporated factor [0.6]) because production system waste application management was unknown. Although, it is acknowledged that a majority of swine operations in NC apply their waste through spray irrigation.

Example: PAN lb = SUM((animals#) * accumulated manure# * (N manure weight#/1000) * 0.55)
P_2O_5 lb = SUM((animals#) * accumulated manure# * (P manure weight#/1000) * 1.0)

Farrow to Feeder

Accumulated manure = 3,861 gallons/animal/yr
Manure weights = 3.6 lb of N/1000 gallons; 1.4 lb of P_2O_5 /1000 gallons
Production system waste application coefficient: N = 0.55, P= 1.0
Example: SUM(2000/1*3861*(3.6/1000)*.55)= 15,290 PAN lb
SUM(2000/1*3861*(1.4/1000)* 1.0)=10,811 lb TP (P_2O_5)

Farrow to Finish

Accumulated manure = 10,478 gallons/animal/yr
Manure weights = 3.6 lb of N/1000 gallons; 1.4 lb of P_2O_5 /1000 gallons
Production system waste application coefficient: N = 0.55, P = 1.0
Example: SUM(200/1*10478*(3.6/1000)*.55)= 4,149 PAN lb
SUM(200/1*10478*(1.4/1000)* 1.0)=2,934 lb TP (P_2O_5)

Farrow to Wean

Accumulated manure = 3,203 gallons/animal/yr
Manure weights = 2.4 lb of N/1000 gallons; 0.9 lb of P_2O_5 /1000 gallons
Production system waste application coefficient: N = 0.55, P = 1.0
Example: SUM(2200/1*3203*(2.4/1000)*.55) = 9,302 PAN lb
SUM(2200/1*3203*(0.9/1000)* 1.0) =6,342 lb TP (P_2O_5)

Feeder to Finish

Accumulated manure= 927 gallons/animal/yr
Manure weights = 3.6 lb of N/1000 gallons; 1.4 lb of P_2O_5/1000 gallons
Production system waste application coefficient: N = 0.55, P = 1.0
Example: SUM(2400/1*927*(3.6/1000)*.55) = 4,405 PAN lb
SUM(2400/1*927*(1.4/1000)* 1.0) = 3,115 lb TP (P_2O_5)

Wean to Feeder

Accumulated manure = 191 gallons/animal/yr
Manure weights = 3.6 lb of N/1000 gallons; 1.4 lb of P_2O_5 /1000 gallons
Production system waste application coefficient: N= 0.55, P= 1.0
Example: SUM(2600/1*191*(3.6/1000)*.55) = 983 PAN lb
SUM(2600/1*191*(1.4/1000)* 1.0) = 695 lb TP (P_2O_5)

Wean to Finish

Accumulated manure= 776 gallons/animal/yr
Manure weights = 3.6 lb of N/1000 gallons; 1.4 lb of P_2O_5 /1000 gallons
Production system waste application coefficient: N = 0.55, P = 1.0
Example: SUM(2269/1*776*(3.6/1000)*.55) = 3,486 PAN lb
SUM(2269/1*776*(1.4/1000)* 1.0) = 2,465 lb TP (P_2O_5)

Cattle Assumptions

Example: PAN lb = SUM((animals#) * accumulated manure# * (N manure weight#/1) * 0.5)

P_2O_5 lb = SUM((animals#) * accumulated manure# * (P manure weight#/1) * 1.0)

Dairy Calf

Accumulated manure= 4.1 tons/animal/yr

Manure weights = 11.2 lb of N/ton; 7.0 lb of P_2O_5/ton

Production system waste application coefficient; N= 0.5, P= 1.0

Example: SUM(300*4.1*(11.2/1)*.5) = 6,888 PAN lb

SUM(300*4.1*(7/1)* 1.0) = 8,610 lb TP (P_2O_5)

Dairy Heifer

Accumulated manure = 12 tons/animal/yr

Manure weights = 11.2 lb of N/ton; 7.0 lb of P_2O_5 /ton

Production system waste application coefficient: N= 0.5, P= 1.0

Example: SUM(1400*12*(11.2/1)*.5)= 94,080 PAN lb

SUM(1400*12*(7/1)* 1.0)= 117,600 lb TP (P_2O_5)

Dairy Cow (including dry cows)

Accumulated manure= 17 tons/animal/yr

Manure weights= 11.2 lb of N per ton & 7.0 lb of P_2O_5 per ton

Production system waste application coefficient N= 0.5, P= 1.0

Example: SUM(1750*17*(11.2/1)*.5)= 166,600 PAN lb

SUM(1750*17*(7/1)* 1.0)= 208,250 lb TP (P_2O_5)

Beef Stocker

Accumulated manure= 1.5 tons/animal/yr

Manure weights= 13.0 lb of N per ton & 8.3 lb of P_2O_5 per ton

Production system waste application coefficient N= 0.5, P= 1.0

Example: SUM(200*1.5*(13/1)*.5)= 1,950 PAN lb

SUM(200*1.5*(8.3/1)* 1.0)= 2,490 lb TP (P_2O_5)

Beef Feeder

Accumulated manure= 2.2 tons/animal/yr

Manure weights= 13.0 lb of N per ton & 8.3 lb of P_2O_5 per ton

Production system waste application coefficient N= 0.5, P= 1.0

Example: SUM(200*2.2*(13/1)*.5)= 2,860 PAN lb

SUM(200*2.2*(8.3/1)* 1.0)= 3,652 lb TP (P_2O_5)

Beef Brood

Accumulated manure= 3 tons/animal/yr

Manure weights= 13.0 lb of N per ton & 8.3 lb of P_2O_5 per ton

Production system waste application coefficient N= 0.5, P= 1.0

Example: SUM(500*3*(13/1)*.5)= 9,750 PAN lb

SUM(500*1.5*(8.3/1)* 1.0)= 12,450 lb TP (P_2O_5)

Appendix B - Poultry

Poultry numbers based on agriculture statistics available for 1992, 2000, 2006 and 2014 and the estimated available nutrients produced by county and river basin are presented below. The county statistics show the Yadkin-Pee Dee and Cape Fear river basins as having the largest poultry populations. Even though Wilkes County maintains its status of having one the highest poultry populations in the state over the years, the poultry concentration has shifted from the upper portions of the Yadkin-Pee Dee to the lower portions of the basin. A similar shift has occurred in the Cape Fear Basin with the shift in poultry numbers from some of the upper counties to the lower basin. The shifts in poultry concentrations are likely linked to the locations of poultry processing plants and the supply demand of these facilities. Table 7 provides the summarized poultry inventory and percent change between comparison years for each of the river basins.

In 1992, Union and Wilkes counties each had a poultry inventory over 16 million, and Duplin, Chatham and Moore counties each had over 10 million birds; there were also 45 counties with either no birds or inventory information was not disclosed (Figure 5). Union and Wilkes counties each had over 17 million birds in 2000 and 19 million birds in 2006. Duplin and Randolph counties had over 10 million birds in 2000 and 2006, with 45 counties reporting no disclosed data in 2000 and 36 counties in 2006 (Figures 6 & 7). In 2014, the inventory population of birds dropped collectively in the top four producing counties although Duplin increased in bird inventory with over 15 million birds and Sampson county became the third top inventory county with over 11 million birds (Figure 8). Union and Wilkes counties dropped in inventory numbers from 2006 but still remain in the top four counties with over 15 million in Union and over 11 million in Wilkes; there were 25 counties with no data. Hyde County is one of the counties that reported no data because information would disclose information on the one poultry facility that is permitted for 4.75 million birds. Table 10 provides the estimated poultry inventory for each county and the 2014 county density of birds per acreage.

Table 7: Summarized Poultry data by Basin

River Basin	1992 Poultry Inventory	2000 Poultry Inventory	2006 Poultry Inventory	2014 Poultry Inventory[1]	% change 1992-2014 inventory (Δ %)	% change 2000-2014 inventory (Δ %)	% change 2006-2014 inventory (Δ %)
Yadkin-PeeDee	52,364,000	64,744,000	73,372,000	60,793,600	16	-6	-17
Cape Fear	52,975,000	54,445,000	56,208,000	57,906,600	9	6	3
Catawba	7,458,000	8,028,000	8,040,000	14,283,800	92	78	78
Lumber	2,604,000	4,540,000	6,628,000	12,829,700	393	183	94
Neuse	10,146,400	11,485,000	11,974,700	9,631,500	-5	-16	-20
Roanoke	5,180,000	5,000,000	6,225,000	7,465,000	44	49	20
Tar-Pamlico	9,375,400	8,240,000	7,536,000	6,601,301	-30	-20	-17
Chowan	4,540,000	5,460,000	5,680,000	6,020,000	33	10	6
Broad	1,270,000	1,850,000	2,340,000	5,475,400	331	196	134
Pasquotank	2,380,000	2,280,000	1,680,000	2,100,000	-12	-8	25
White Oak	1,122,000	1,060,000	1,064,000	1,681,300	50	59	58
Other	2,677,000	1,607,000	2,633,300	6,587,600	146	310	150

[1] 2014 data does not include rooster inventory.

Figure 5: 1992 Inventory of Poultry by County

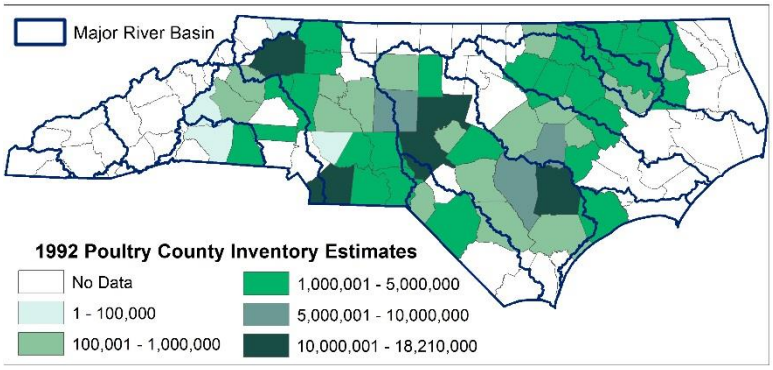


Figure 6: 2000 Inventory of Poultry by County

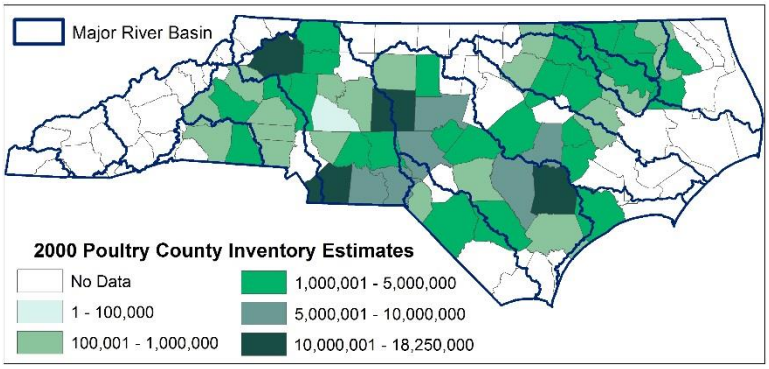


Figure 7: 2006 Inventory of Poultry by County

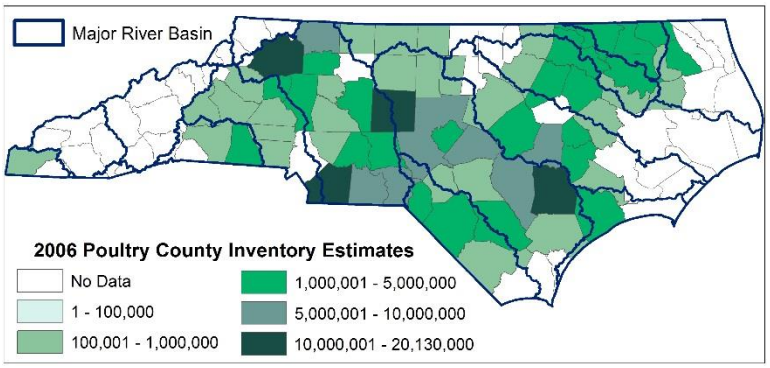
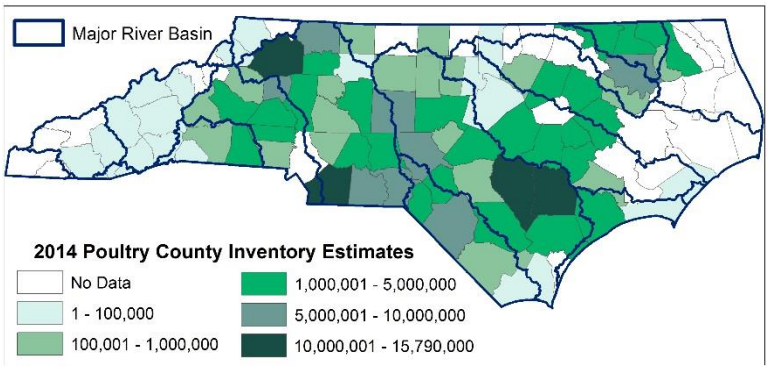


Figure 8: 2014 Inventory of Poultry by County



The amount of plant available nitrogen (PAN) produced by poultry depends on the type of poultry and the manure management scheme. The statewide patterns of PAN concentrations generally correspond with the populations of birds. Table 8 provides the estimated collective PAN by basin produced by poultry and Table 11 provides PAN estimates by county.

In 1992, Union County had the largest poultry inventory leading to a production of over 6.8 million pounds (lb) of PAN produced, while Duplin County had the fifth top poultry inventory and the second highest production of PAN at nearly 4.5 million lb (Figure 9). In 2000, the greatest production of PAN was in Union, Wilkes and Duplin counties with each over 4 million lb (Figure 10). Union, Wilkes and Duplin counties each had over 4.5 million lb of PAN produced by poultry in 2006, while Sampson County had the fifth highest poultry inventory and fourth highest PAN production rate at 3.4 million lb (Figure 11). In 2014, Union and Duplin counties produced over 4.5 million lb of PAN. The distribution of estimated PAN by river basin shows that the Yadkin-Pee Dee and Cape Fear basins overwhelming have the most nitrogen production statewide.

Table 8: Summarized Pounds of Poultry Plant Available Nitrogen (PAN) data by Basin

River Basin	1992 PAN (lb)	2000 PAN (lb)	2006 PAN (lb)	2014 PAN (lb)	% change 1992 - 2014 PAN (lb, Δ%)	% change 2000 - 2014 PAN (lb, Δ%)	% change 2006 - 2014 PAN (lb, Δ%)
Yadkin-PeeDee	17,583,211	18,240,459	20,576,381	17,499,432	0	-4	-15
Cape Fear	17,263,620	17,569,403	17,854,802	16,873,187	-2	-4	-5
Catawba	2,225,510	2,487,789	2,559,237	4,247,919	91	71	66
Lumber	795,010	1,173,388	1,614,983	2,968,058	273	153	84
Neuse	4,380,248	4,236,392	4,083,122	3,520,717	-20	-17	-14
Roanoke	1,185,640	1,144,440	1,610,563	1,930,333	63	69	20
Tar-Pamlico	4,007,269	2,828,695	2,594,063	1,795,074	-55	-37	-31
Chowan	1,039,151	1,249,728	1,300,084	1,377,906	33	10	6
Broad	487,998	491,346	599,506	1,306,726	168	166	118
Pasquotank	544,754	521,865	384,532	480,665	-12	-8	25
White Oak	680,050	661,122	592,551	645,925	-5	-2	9
Other	1,682,014	1,009,711	1,476,014	4,022,007	139	298	172

Figure 9: 1992 Estimated Total Pounds of PAN per County Produced by Poultry

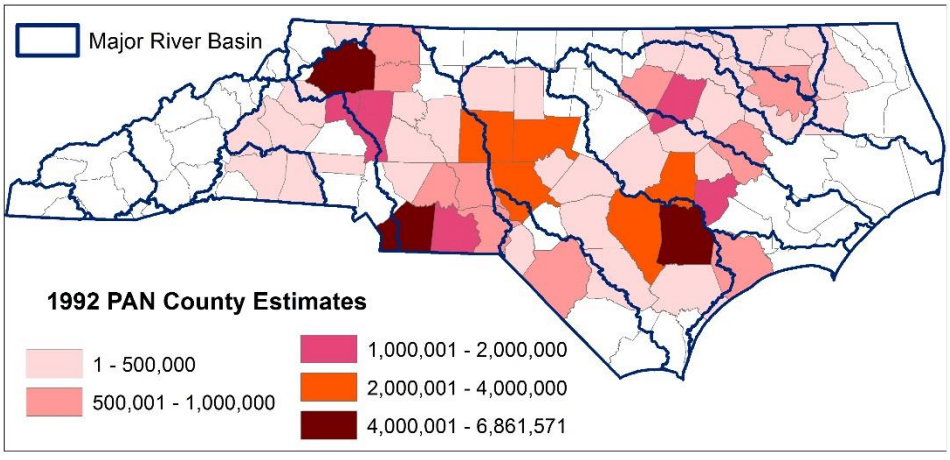


Figure 10: 2000 Estimated Total Pounds of PAN per County Produced by Poultry

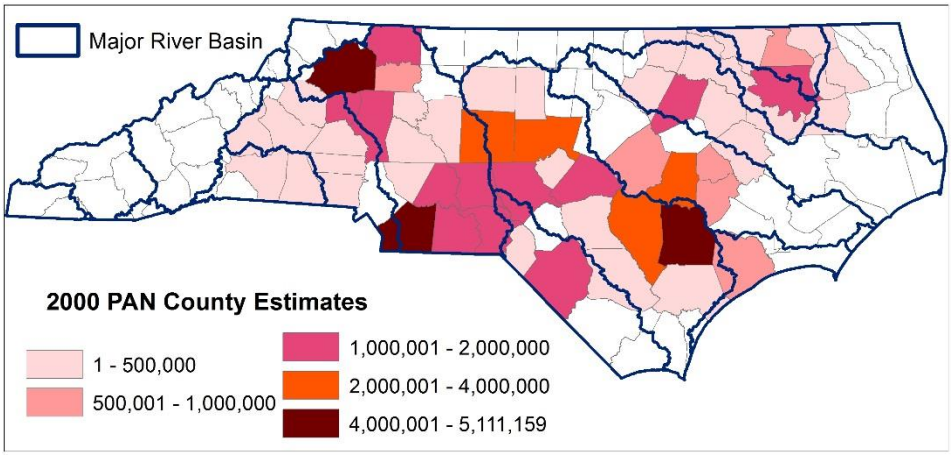


Figure 11: 2006 Estimated Total Pounds of PAN per County Produced by Poultry

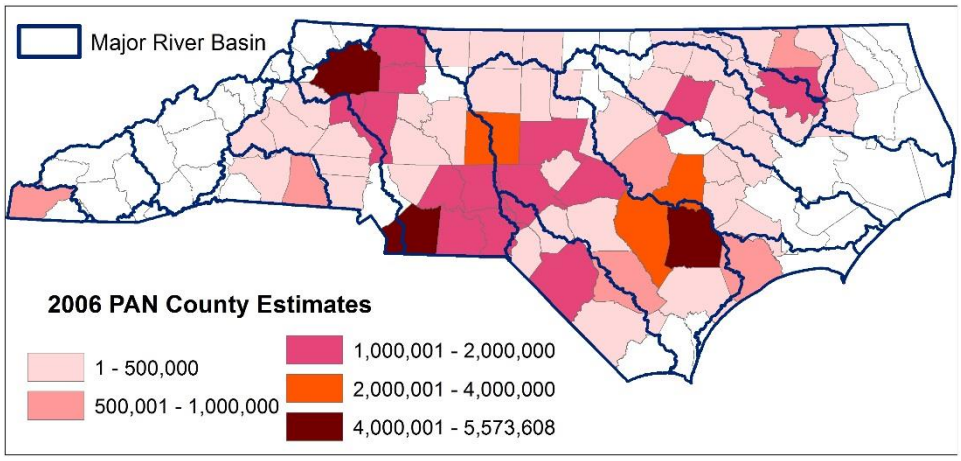
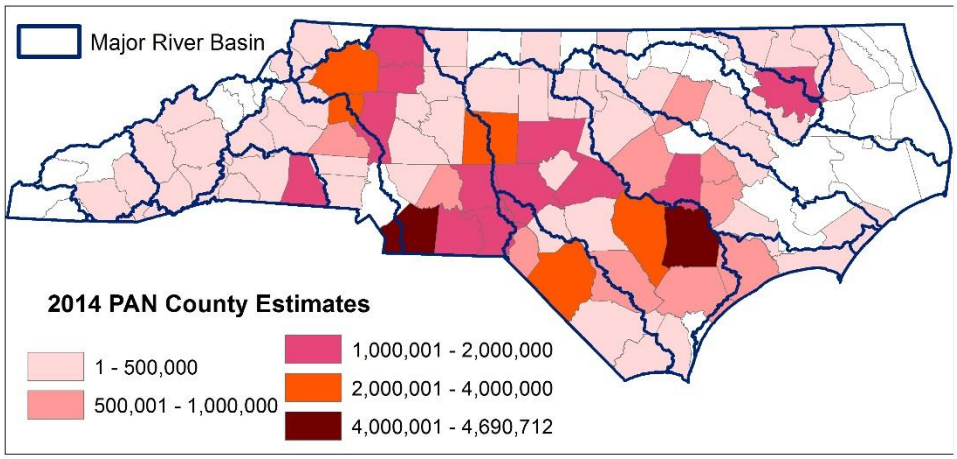


Figure 12: 2014 Estimated Total Pounds of PAN per County Produced by Poultry



The amount of phosphorus (P_2O_5) produced by poultry depends on the type of poultry and the manure management scheme. The statewide patterns of P_2O_5 concentrations generally correspond with the populations of birds. Table 9 provides the estimated collective basin P_2O_5 produced by poultry and Table 12 provides P_2O_5 estimates by county.

In 1992, Union County had the highest poultry inventory and nearly twice (~10 million lb) the amount of P_2O_5 produced in this inventory as the next highest inventory county of Wilkes with 5.9 million lb (Figure 13). In 2000 and 2006, Union, Duplin and Wilkes counties all produced over 6 million lb of P_2O_5 (Figure 14 & 15). In 2014, Union and Duplin counties produced over 6 million lb of P_2O_5, while Wilkes County fell to the fifth highest producer of P_2O_5 by poultry operations (Figure 16). The Yadkin-Pee Dee and Cape Fear basins, respectively, are the top two producers of P_2O_5.

Table 9: Summarized Poultry Phosphorus (P_2O_5) data by Basin

River Basin	1992 P_2O_5 (lb)	2000 P_2O_5 (lb)	2006 P_2O_5 (lb)	2014 P_2O_5 (lb)	% change 1992 - 2014 P_2O_5 (lb, Δ%)	% change 2000 - 2014 P_2O_5 (lb, Δ%)	% change 2006 - 2014 P_2O_5 (lb, Δ%)
Yadkin-PeeDee	25,679,153	25,286,036	28,462,409	24,464,078	-5	-3	-14
Cape Fear	24,857,820	25,279,632	25,560,836	23,488,961	-6	-7	-8
Catawba	3,166,574	3,589,718	3,728,160	6,036,338	91	68	62
Lumber	1,114,949	1,553,748	2,088,466	3,753,018	237	142	80
Neuse	6,722,938	6,287,004	5,933,256	5,215,734	-22	-17	-12
Roanoke	1,491,840	1,440,000	2,157,732	2,585,484	73	80	20
Tar-Pamlico	6,357,283	4,225,248	3,878,093	2,459,403	-61	-42	-37
Chowan	1,307,520	1,572,480	1,635,840	1,733,760	33	10	6
Broad	735,502	666,216	799,488	1,675,177	128	151	110
Pasquotank	685,440	656,640	483,840	604,800	-12	-8	25
White Oak	1,099,478	1,072,932	946,625	963,207	-12	-10	2
Other	2,871,886	1,723,989	2,443,090	6,824,606	138	296	179

Figure 13: 1992 Estimated Total lb P_2O_5 per County Produced by Poultry

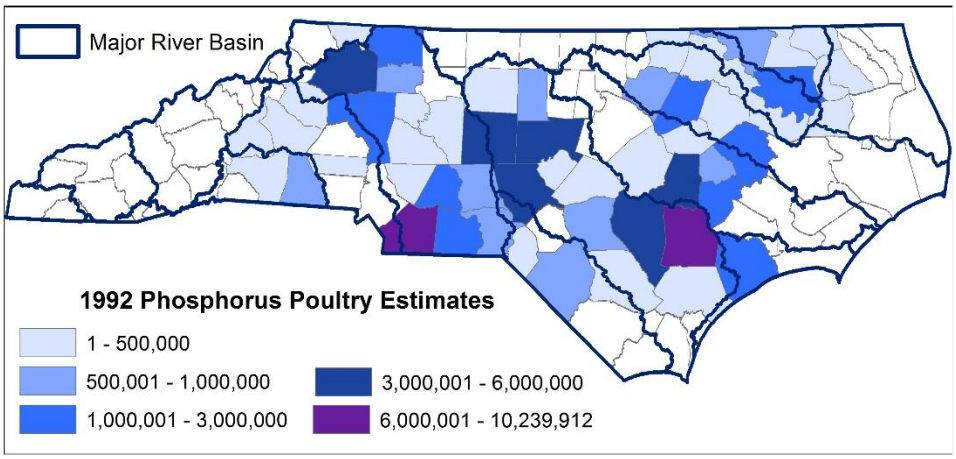


Figure 14: 2000 Estimated Total lb P_2O_5 per County Produced by Poultry

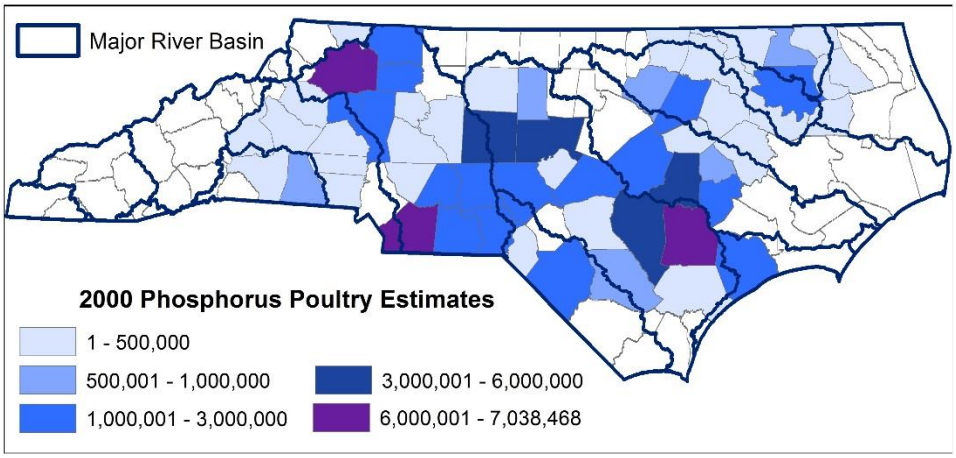


Figure 15: 2006 Estimated Total lb P_2O_5 per County Produced by Poultry

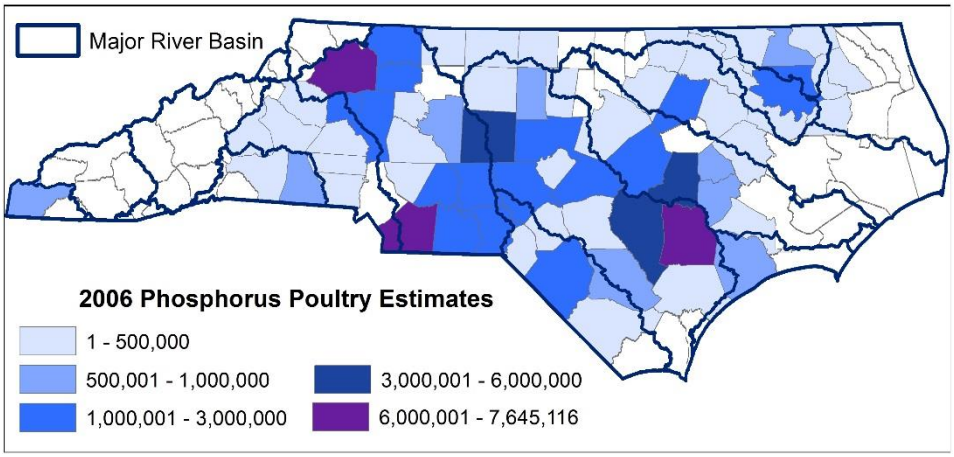


Figure 16: 2014 Estimated Total lb P_2O_5 per County Produced by Poultry

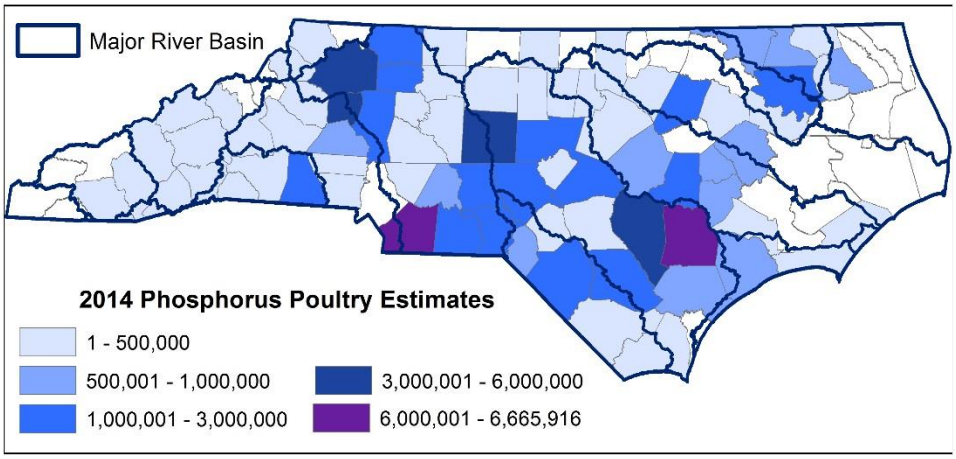


Table 10: County Poultry Inventory Estimates

County	Inventory 1992	Inventory 2000	Inventory 2006	Inventory 2014	Density (Poultry per Basin Acreage) 2014
ALAMANCE	1,325,000	1,125,000	940,000	284,000	1.0
ALEXANDER	4,880,000	3,955,000	4,740,000	8,305,000	49.2
ALLEGHANY	40,000				
ANSON	2,700,000	5,855,000	6,368,000	6,506,000	18.9
ASHE				2,800	0.0
AVERY					0.0
BEAUFORT					0.0
BERTIE	4,360,000	4,440,000	4,940,000	6,400,000	13.5
BLADEN	370,000	1,060,000	2,330,000	2,900,000	5.1
BRUNSWICK				1,400	0.0
BUNCOMBE				10,040	0.0
BURKE	480,000	1,140,000	780,000	1,200,000	3.7
CABARRUS	60,000	120,000	835,000	610,000	2.6
CALDWELL	918,000	560,000	160,000	250,000	0.8
CAMDEN					
CARTERET				1,300	0.0
CASWELL			220,000	270,000	1.0
CATAWBA		800,000	900,000	2,277,000	8.6
CHATHAM	10,950,000	8,340,000	7,199,000	4,335,000	9.6
CHEROKEE			800,000		
CHOWAN	400,000	560,000	600,000	510,000	3.4
CLAY					
CLEVELAND	1,198,000	1,490,000	2,040,000	4,532,000	15.1
COLUMBUS			860,000	592,400	1.0
CRAVEN					
CUMBERLAND	500,000	187,000	680,000	638,000	1.5
CURRITUCK					
DARE					
DAVIDSON	680,000	980,000	1,428,000	1,295,000	3.6
DAVIE	200,000	287,000	370,000	255,000	1.5
DUPLIN	10,394,000	10,670,000	11,248,000	15,790,000	30.1
DURHAM				2,300	0.0
EDGECOMBE	1,200,000	1,092,000	1,365,000	1,330,000	4.1
FORSYTH				2,600	0.0
FRANKLIN	1,220,000	995,000	450,000	340,000	1.1
GASTON		280,000	400,000	448,500	1.9
GATES	1,080,000	980,000	1,160,000	1,570,000	7.1
GRAHAM					0.0
GRANVILLE				1,300	0.0
GREENE	926,400	1,420,000	1,016,000	1,270,000	7.5
GUILFORD	110,000	173,000	247,000	335,000	0.8
HALIFAX	1,300,000	1,160,000	1,121,000		0.0
HARNETT	1,340,000	4,800,000	5,560,000	4,902,600	12.7
HAYWOOD				1,500	0.0
HENDERSON				2,080	0.0
HERTFORD	1,160,000	2,260,000	2,200,000	2,100,000	9.1
HOKE			600,000	1,122,000	4.5
HYDE					
IREDELL	1,720,000	2,240,000	1,730,000	2,030,000	5.3
JACKSON				1,800	0.0
JOHNSTON	380,000	2,700,000	2,864,000	1,960,000	3.8
JONES			800,000	676,000	2.2
LEE	700,000	1,400,000	1,420,000	780,000	4.7

County	Inventory 1992	Inventory 2000	Inventory 2006	Inventory 2014	Density (Poultry per Basin Acreage) 2014
LENOIR	2,060,000	1,805,000	1,084,000	1,055,000	4.1
LINCOLN	1,140,000	780,000	740,000	1,533,300	7.8
MACON				1,200	0.0
MADISON				3,800	0.0
MARTIN	820,000	560,000	820,000	510,000	1.7
MCDOWELL	40,000	513,000	320,000	270,000	0.9
MECKLENBURG					
MITCHELL					
MONTGOMERY	3,140,000	4,440,000	4,460,000	4,720,000	14.7
MOORE	12,255,000	7,600,000	7,200,000	5,190,000	11.5
NASH	3,810,000	3,380,000	3,580,000	2,870,000	8.3
NEW HANOVER					0.0
NORTHAMPTON	1,900,000	1,660,000	1,720,000	1,840,000	5.2
ONSLOW	1,122,000	1,060,000	1,064,000	1,680,000	3.2
ORANGE			119,000	157,800	0.6
OTHER COUNTIES	2,677,000	1,607,000	2,633,300	6,587,600	
PAMLICO					
PASQUOTANK					
PENDER	106,000	360,000	740,000	2,195,000	3.9
PERQUIMANS	1,260,000	1,160,000	1,420,000	2,100,000	10.0
PERSON					0.0
PITT	1,350,000	960,000	900,000	2,060,000	4.9
POLK				1,200	0.0
RANDOLPH	9,640,000	11,830,000	10,540,000	8,030,000	15.9
RICHMOND	2,540,000	5,440,000	6,300,000	7,070,000	23.0
ROBESON	1,744,000	3,840,000	4,048,000	9,755,900	16.0
ROCKINGHAM			110,000		0.0
ROWAN	380,000	61,000	332,000	927,000	2.8
RUTHERFORD	72,000	360,000	300,000	942,200	2.6
SAMPSON	5,285,000	6,900,000	7,504,000	11,405,000	18.8
SCOTLAND	860,000	700,000	1,720,000	2,480,000	12.1
STANLY	1,454,000	3,281,000	3,469,000	1,938,000	7.5
STOKES			135,000	285,000	1.0
SURRY	3,100,000	4,550,000	5,830,000	6,240,000	18.1
SWAIN					
TRANSYLVANIA				2,280	0.0
TYRRELL					
UNION	18,210,000	18,250,000	20,130,000	15,420,000	37.7
VANCE					0.0
WAKE			240,000	4,400	0.0
WARREN	495,400	653,000	120,000		0.0
WASHINGTON	1,120,000	1,120,000	260,000		
WATAUGA				1,600	0.0
WAYNE	6,460,000	5,560,000	5,851,700	4,506,000	12.6
WILKES	16,960,000	17,600,000	19,450,000	11,255,000	23.2
WILSON	320,000				0.0
YADKIN	1,220,000	1,640,000		2,525,000	11.7
YANCEY			2,670,000	1,100	0.0

Table 11: County Poultry Inventory Pounds of Plant Available Nitrogen (PAN) Estimates

County	PAN 1992 (lb)	PAN 2000 (lb)	PAN 2006 (lb)	PAN 2014 (lb)
ALAMANCE	481,023	419,269	374,928	126,917
ALEXANDER	1,596,292	1,470,449	1,803,907	2,749,708
ALLEGHANY	9,156			
ANSON	1,044,395	1,434,006	1,761,717	1,817,247
ASHE				1,759
AVERY				
BEAUFORT				
BERTIE	997,952	1,016,263	1,130,707	1,464,883
BLADEN	230,769	384,754	664,105	940,144
BRUNSWICK				880
BUNCOMBE				5,813
BURKE	109,866	300,876	178,533	334,580
CABARRUS	37,699	75,398	245,045	139,622
CALDWELL	233,287	128,177	36,622	57,222
CAMDEN				
CARTERET				817
CASWELL			138,230	169,646
CATAWBA		183,110	205,999	551,935
CHATHAM	2,757,966	2,307,434	1,934,956	1,181,960
CHEROKEE			502,656	
CHOWAN	91,555	128,177	137,333	116,733
CLAY				
CLEVELAND	471,518	408,946	530,840	1,089,435
COLUMBUS			196,844	136,552
CRAVEN				
CUMBERLAND	311,850	117,496	155,644	232,100
CURRITUCK				
DARE				
DAVIDSON	155,644	224,310	385,968	338,351
DAVIE	125,664	180,328	160,581	160,222
DUPLIN	4,544,375	4,146,878	4,572,164	4,576,631
DURHAM				1,445
EDGECOMBE	314,609	294,682	362,361	304,421
FORSYTH				1,634
FRANKLIN	598,789	425,462	194,869	77,822
GASTON		64,089	91,555	110,046
GATES	247,199	224,310	265,510	359,354
GRAHAM				
GRANVILLE				817
GREENE	388,286	530,323	380,999	543,367
GUILFORD	69,115	108,699	155,195	210,487
HALIFAX	297,554	265,510	296,926	
HARNETT	306,710	1,098,662	1,272,617	1,123,184
HAYWOOD				942
HENDERSON				1,195
HERTFORD	265,510	517,287	503,554	480,665
HOKE			137,333	285,238
HYDE				
IREDELL	1,080,710	1,303,585	1,023,084	1,127,700
JACKSON				891
JOHNSTON	237,006	783,819	759,766	507,971
JONES			183,110	192,630
LEE	160,222	320,443	325,021	178,533
LENOIR	1,119,925	802,795	478,685	500,610
LINCOLN	260,932	178,533	169,377	352,272

County	PAN 1992 (lb)	PAN 2000 (lb)	PAN 2006 (lb)	PAN 2014 (lb)
MACON				754
MADISON				2,388
MARTIN	187,688	128,177	187,688	116,733
MCDOWELL	25,133	162,555	73,244	92,156
MECKLENBURG				
MITCHELL				
MONTGOMERY	718,708	1,016,263	1,060,784	1,080,351
MOORE	2,866,935	1,859,378	1,647,994	1,199,912
NASH	1,794,751	1,436,698	1,458,510	940,505
NEW HANOVER				
NORTHAMPTON	434,887	379,954	393,687	421,154
ONSLOW	680,050	661,122	592,551	645,108
ORANGE			74,770	98,031
OTHER COUNTIES	1,682,014	1,009,711	1,476,014	4,022,007
PAMLICO				
PASQUOTANK				
PENDER	66,112	224,532	264,132	627,444
PERQUIMANS	288,399	265,510	325,021	480,665
PERSON				
PITT	848,232	219,732	205,999	471,509
POLK				754
RANDOLPH	2,565,969	3,262,956	2,867,832	2,209,443
RICHMOND	676,130	1,245,151	1,441,994	1,662,175
ROBESON	598,166	1,013,166	1,024,452	2,262,984
ROCKINGHAM			69,115	
ROWAN	126,921	38,328	128,716	234,947
RUTHERFORD	16,480	82,400	68,666	216,537
SAMPSON	2,902,574	3,318,902	3,482,881	3,981,194
SCOTLAND	196,844	160,222	393,687	567,642
STANLY	910,417	1,188,077	1,099,310	521,758
STOKES			84,823	179,071
SURRY	869,326	1,221,185	1,554,105	1,771,772
SWAIN				
TRANSYLVANIA				1,241
TYRRELL				
UNION	6,861,571	5,111,159	5,573,608	4,690,712
VANCE				
WAKE			54,933	2,286
WARREN	153,334	186,611	75,398	
WASHINGTON	256,355	256,355	59,511	
WATAUGA				1,005
WAYNE	2,561,787	2,119,455	2,150,859	1,674,377
WILKES	4,417,180	4,507,747	4,871,275	2,877,706
WILSON	73,244			
YADKIN	558,846	694,922		1,075,235
YANCEY			1,270,194	691

Table 12: County Poultry Inventory Pounds of Phosphorus (P_2O_5) Estimates

County	P_2O_5 1992 (lb)	P_2O_5 2000 (lb)	P_2O_5 2006 (lb)	P_2O_5 2014 (lb)
ALAMANCE	730,836	641,844	584,640	203,436
ALEXANDER	2,347,200	2,249,532	2,777,760	4,059,540
ALLEGHANY	11,520			
ANSON	1,559,736	1,870,668	2,402,532	2,497,975
ASHE				3,004
AVERY				
BEAUFORT				
BERTIE	1,255,680	1,278,720	1,422,720	1,843,200
BLADEN	374,514	565,992	916,692	1,342,140
BRUNSWICK				1,502
BUNCOMBE				9,798
BURKE	138,240	406,800	224,640	463,320
CABARRUS	64,368	128,736	346,428	175,680
CALDWELL	309,902	161,280	46,080	72,000
CAMDEN				
CARTERET				1,395
CASWELL			236,016	289,656
CATAWBA		230,400	259,200	716,206
CHATHAM	3,648,024	3,174,600	2,637,583	1,621,260
CHEROKEE			858,240	
CHOWAN	115,200	161,280	172,800	146,880
CLAY				
CLEVELAND	714,766	562,536	713,088	1,400,810
COLUMBUS			247,680	172,495
CRAVEN				
CUMBERLAND	506,100	200,614	195,840	341,620
CURRITUCK				
DARE				
DAVIDSON	195,840	282,240	527,414	455,364
DAVIE	214,560	307,894	255,672	273,564
DUPLIN	7,011,677	6,233,652	6,955,786	6,347,928
DURHAM				2,467
EDGECOMBE	424,080	402,394	491,220	383,040
FORSYTH				2,789
FRANKLIN	979,200	675,036	310,104	97,920
GASTON		80,640	115,200	143,687
GATES	311,040	282,240	334,080	452,160
GRAHAM				
GRANVILLE				1,395
GREENE	590,086	785,544	564,907	829,248
GUILFORD	118,008	185,594	264,982	359,388
HALIFAX	374,400	334,080	402,113	
HARNETT	385,920	1,382,400	1,601,280	1,413,989
HAYWOOD				1,609
HENDERSON				2,012
HERTFORD	334,080	650,880	633,600	604,800
HOKE			172,800	375,278
HYDE				
IREDELL	1,845,216	2,199,024	1,730,376	1,887,408
JACKSON				1,460
JOHNSTON	384,636	1,081,764	1,016,021	674,806
JONES			230,400	264,211
LEE	201,600	403,200	408,960	224,640
LENOIR	1,793,088	1,243,176	735,125	785,160
LINCOLN	328,320	224,640	213,120	444,180

County	P_2O_5 1992 (lb)	P_2O_5 2000 (lb)	P_2O_5 2006 (lb)	P_2O_5 2014 (lb)
MACON				1,287
MADISON				4,077
MARTIN	236,160	161,280	236,160	146,880
MCDOWELL	42,912	236,426	92,160	137,405
MECKLENBURG				
MITCHELL				
MONTGOMERY	904,320	1,278,720	1,362,960	1,359,360
MOORE	3,651,084	2,424,240	2,073,600	1,518,264
NASH	2,910,168	2,276,208	2,286,720	1,383,768
NEW HANOVER				
NORTHAMPTON	547,200	478,080	495,360	529,920
ONSLOW	1,099,478	1,072,932	946,625	961,812
ORANGE			127,663	167,090
OTHER COUNTIES	2,871,886	1,723,989	2,443,090	6,824,606
PAMLICO				
PASQUOTANK				
PENDER	107,293	364,392	386,928	869,070
PERQUIMANS	362,880	334,080	408,960	604,800
PERSON				
PITT	1,448,280	276,480	259,200	593,280
POLK				1,287
RANDOLPH	3,482,640	4,497,912	3,930,192	3,042,504
RICHMOND	905,328	1,566,720	1,814,400	2,122,488
ROBESON	867,269	1,352,148	1,345,426	2,864,781
ROCKINGHAM			118,008	
ROWAN	187,920	65,441	199,210	311,710
RUTHERFORD	20,736	103,680	86,400	273,080
SAMPSON	4,640,124	5,205,192	5,431,553	5,829,444
SCOTLAND	247,680	201,600	495,360	714,240
STANLY	1,518,401	1,773,845	1,578,101	701,536
STOKES			144,828	305,748
SURRY	1,206,720	1,663,560	2,110,680	2,472,048
SWAIN				
TRANSYLVANIA				2,069
TYRRELL				
UNION	10,239,912	7,038,468	7,645,116	6,665,916
VANCE				
WAKE			69,120	3,779
WARREN	221,155	261,050	128,736	
WASHINGTON	322,560	322,560	74,880	
WATAUGA				1,716
WAYNE	3,862,968	3,176,520	3,190,020	2,488,973
WILKES	5,936,112	6,010,560	6,425,640	3,833,964
WILSON	92,160			
YADKIN	900,720	1,100,160		1,704,276
YANCEY			2,063,880	1,180

Appendix C - Swine

The following maps show the swine numbers based on DWR permits in 2006 and 2015 and the estimated available nutrients produced by county and river basin. Duplin and Sampson counties house the majority of the state's swine population, each with over 2 million swine in 2006 and 2014 (Figures 17 & 18). Duplin and Sampson counties are both in the lower portion of Cape Fear River Basin.

In 2006, 20,027,418 pounds (lb) of plant available nitrogen (PAN) were produced and an estimated 14,050,526 pounds (lb) of phosphorus (P_2O_5) were produced statewide (Figures 19 & 21). In 2015, 16,740,186 lb of PAN and an estimated 11,741,819 lb of P_2O_5 were produced statewide (Figures 20 & 22). The decrease in nutrients produced between 2006 and 2015 is because of the 2.8% population drop from 9.9 million to 9.6 million swine. The coastal basins, predominately the Cape Fear Basin, receive the highest nutrient loads from swine waste. Table 13 shows the swine inventory change between 2006 and 2015 and the amount of nutrients produced per basin. Table 14 lists the counties with permitted swine facilities and their associated nutrient production.

Table 13: 2006 and 2015 Swine Numbers and Plant Available Nitrogen (PAN) and Phosphorus (P_2O_5) Produced per Basin

River Basin	Swine Numbers 2006	Swine Numbers 2015	Inventory % change 2006-15	PAN 2006 (lb)	PAN 2015 (lb)	P_2O_5 2006 (lb)	P_2O_5 2015 (lb)
Broad	850	-	-	17,634	-	12,469	-
Catawba	6,741	260	-96	35,967	5,394	24,890	3,814
Chowan	152,628	173,736	14	613,608	349,883	430,482	243,358
Cape Fear	5,820,698	5,772,082	-1	10,373,656	9,574,482	7,281,852	6,719,394
French Broad	925	-	-	5,976	-	4,140	-
Lumber	708,788	676,461	-5	1,692,819	1,392,718	1,185,955	974,801
Neuse	1,941,552	1,953,358	1	3,794,072	3,309,586	2,664,535	2,323,652
New	400	-	-	1,691	-	1,153	-
Pasquotank	166,359	78,958	-53	538,549	172,510	376,102	120,766
Roanoke	60,966	38,697	-37	246,535	116,990	172,617	81,296
Tar-Pamlico	646,128	571,108	-12	1,779,291	1,166,176	1,247,256	816,405
White Oak	205,253	211,799	3	368,789	345,432	259,085	243,471
Yadkin-PeeDee	227,968	189,731	-17	555,048	307,016	387,381	214,863

Figure 17: 2006 Swine Population by County

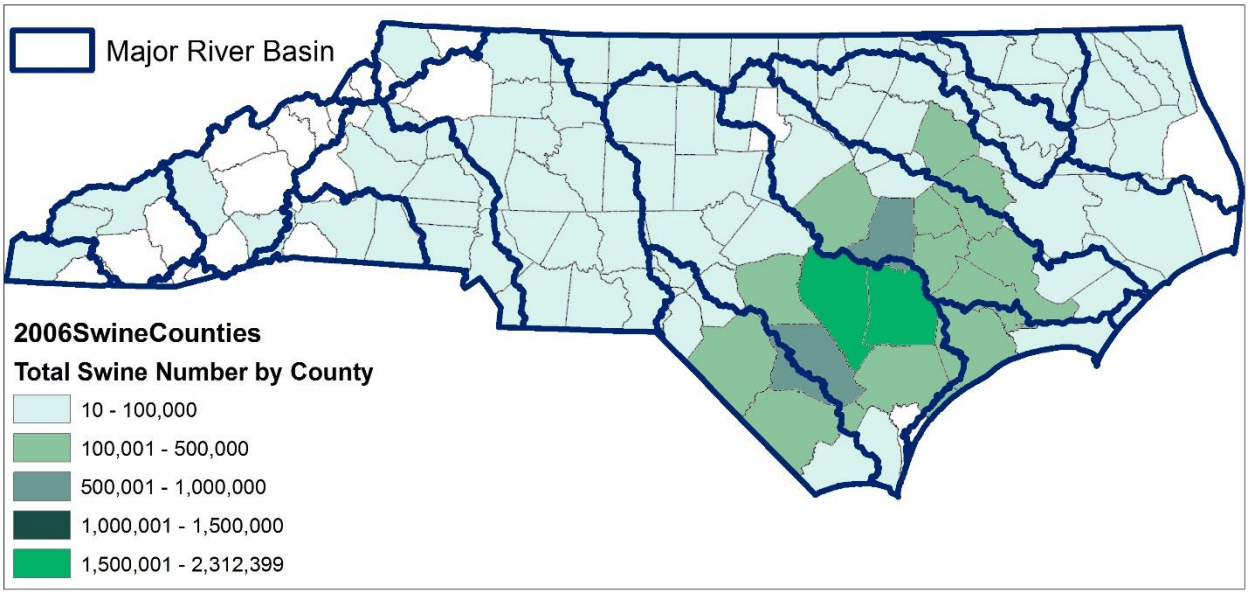


Figure 18: 2015 Swine Population by County

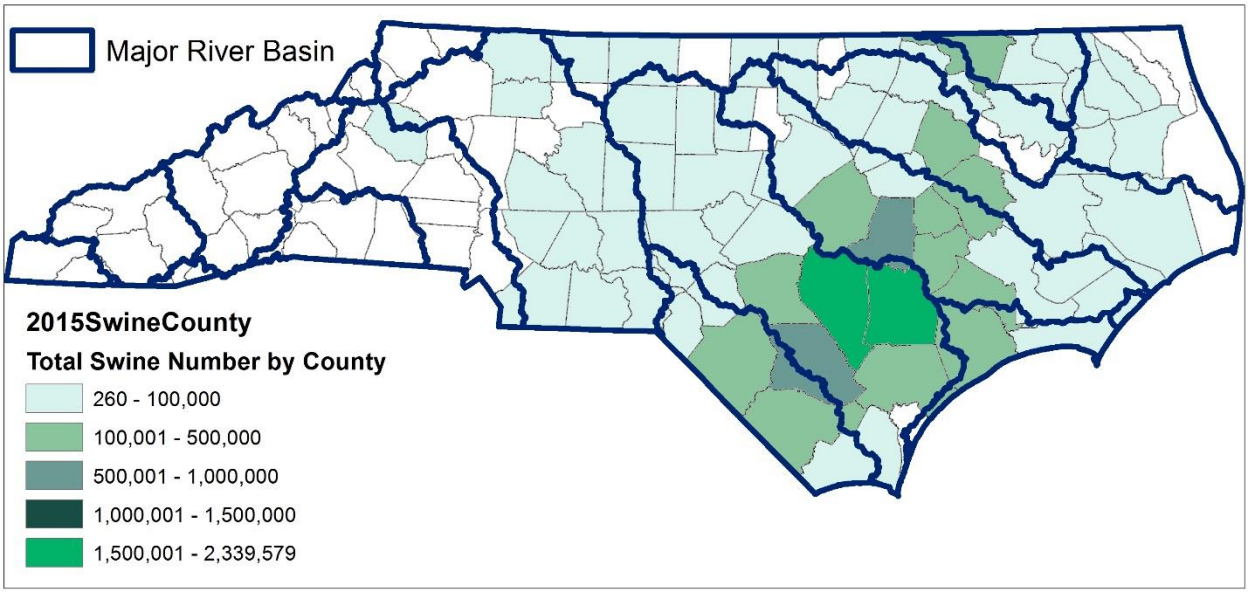


Figure 19: 2006 Estimated Total Pounds of Plant Available Nitrogen (PAN) per County Produced by Swine

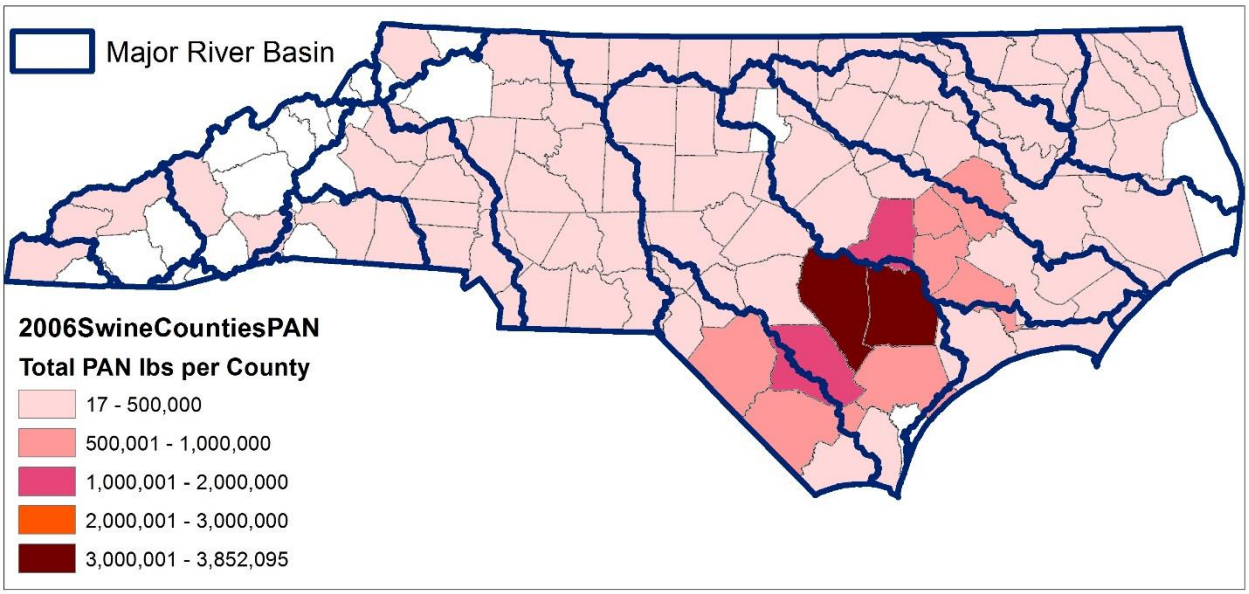


Figure 20: 2015 Estimated Total Pounds of Plant Available Nitrogen (PAN) per County Produced by Swine

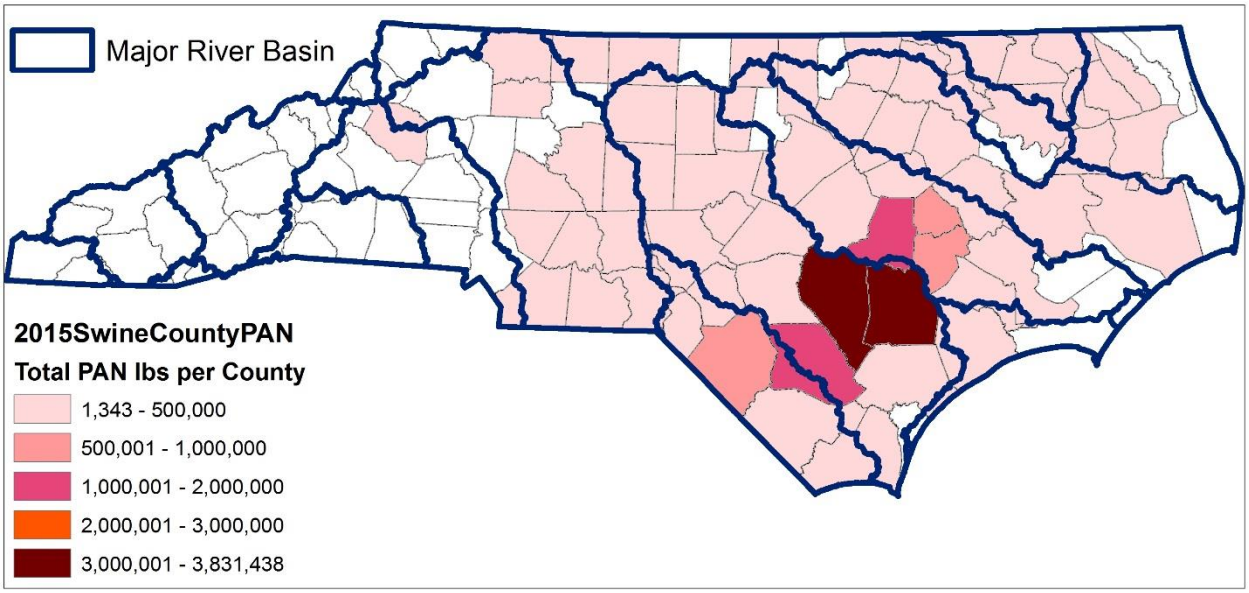


Figure 21: 2006 Estimated Total Pounds of Phosphorus (P_2O_5) per County Produced by Swine

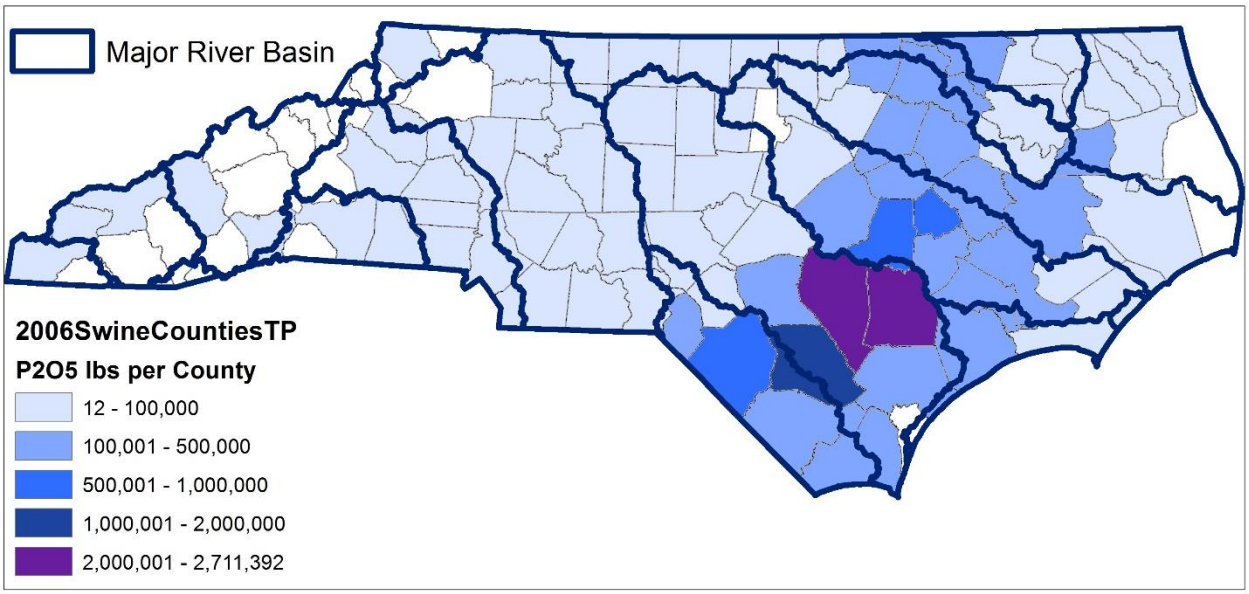


Figure 22: 2015 Estimated Total Pounds of Phosphorus (P_2O_5) per County Produced by Swine

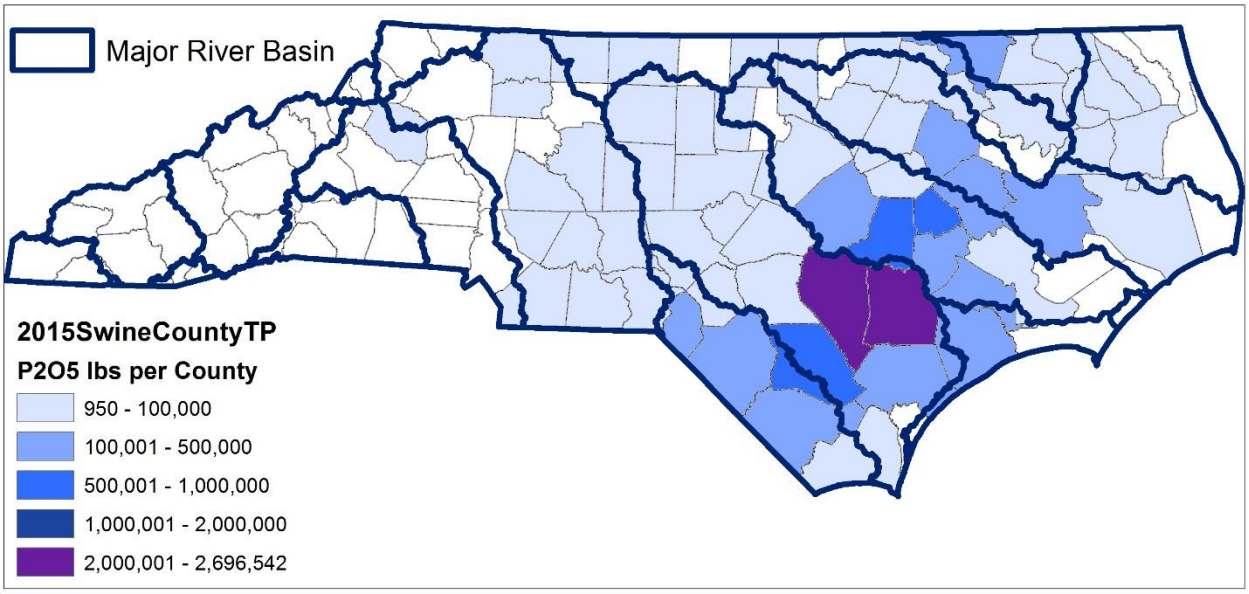


Table 14: County Swine Population and Pounds of Plant Available Nitrogen (PAN) and Phosphorus (P_2O_5) Produced

County	2006 Swine Number of Head	2006 PAN (lb)	2006 P_2O_5 (lb)	2015 Swine Number of Head	2015 PAN (lb)	2015 P_2O_5 (lb)
ALAMANCE	900	2,370	1,643	900	2,370	1,643
ALEXANDER	275	1,163	793			
ANSON	48,018	81,768	56,494	45,238	67,699	46,749
ASHE	400	1,691	1,153			
BEAUFORT	80,221	289,547	201,766	54,290	149,378	103,059
BERTIE	32,348	135,528	94,659	29,925	80,535	55,801
BLADEN	847,083	1,573,223	1,102,254	755,370	1,316,763	920,183
BRUNSWICK	80,451	166,301	116,094	69,966	118,003	82,699
BURKE	2,800	11,838	8,072			
CABARRUS	3,384	14,307	9,755	2,000	8,456	5,765
CALDWELL	960	7,397	5,198	260	5,394	3,814
CAMDEN	9,489	30,215	20,697			
CARTERET	1,051	6,982	4,850			
CASWELL	65	1,349	953			
CATAWBA	1,200	3,877	2,667			
CHATHAM	10,598	22,657	15,882	9,300	17,070	12,070
CHEROKEE	60	1,245	880			
CHOWAN	21,639	56,238	39,282	10,816	19,569	13,832
CLEVELAND	450	9,336	6,601			
COLUMBUS	250,779	512,589	360,045	240,796	453,653	318,543
CRAVEN	119,881	189,327	131,790	97,481	140,383	97,728
CUMBERLAND	127,689	296,917	207,216	104,801	143,284	99,816
CURRITUCK	16,112	71,662	49,634			
DAVIDSON	4,077	44,712	31,468	787	1,445	1,021
DAVIE	3,775	19,677	13,534			
DUPLIN	2,312,399	3,852,095	2,711,392	2,339,579	3,831,438	2,696,542
EDGECOMBE	117,221	300,266	210,287	119,387	269,256	188,388
FORSYTH	10	42	29			
FRANKLIN	26,202	112,555	78,479	36,643	43,082	30,230
GASTON	200	846	577			
GATES	32,637	132,423	92,643	20,852	37,786	26,203
GRAHAM	200	846	577			
GRANVILLE	2,216	11,593	8,165	1,256	2,305	1,630
GREENE	474,968	871,771	613,763	438,932	718,959	505,994
GUILFORD	14,870	24,797	17,427	5,820	12,135	8,580
HALIFAX	49,321	153,673	108,268	44,157	106,773	74,759
HARNETT	56,141	138,619	97,370	59,959	130,792	91,836
HAYWOOD	125	2,593	1,834			
HENDERSON	800	3,382	2,306			
HERTFORD	15,592	103,874	73,190	21,655	72,436	49,758
HOKE	69,163	141,737	99,186	66,878	132,154	92,409
HYDE	6,876	31,684	22,371	900	1,652	1,168
IREDELL	520	4,181	2,913			
JOHNSTON	212,970	397,799	279,188	212,195	341,740	239,787
JONES	255,355	530,244	371,323	250,655	447,299	312,140
LEE	4,742	3,760	2,658	3,552	1,343	950
LENOIR	299,599	545,285	384,159	299,397	506,921	357,232
LINCOLN	1,260	10,829	7,572			
MARTIN	14,216	53,230	37,473			
MECKLENBURG	46	17	12			
MONTGOMERY	39,363	37,457	26,485	22,908	8,663	6,126
MOORE	25,736	74,559	52,170	25,387	64,311	45,037
NASH	86,142	168,175	117,879	65,552	112,324	79,055
NORTHAMPTON	82,760	321,073	225,367	120,413	220,092	153,564

ONSLOW	204,202	361,807	254,235	211,799	345,432	243,471
ORANGE	4,850	12,268	8,625	4,000	7,342	5,191
PAMLICO	3,049	8,841	6,132			
PASQUOTANK	3,424	9,151	6,349	1,260	3,509	2,428
PENDER	264,749	527,260	368,283	254,316	487,330	339,397
PERQUIMANS	26,105	66,447	46,716	5,437	7,080	4,987
PERSON	9,295	36,025	25,355	3,827	17,120	12,074
PITT	255,639	543,271	380,981	241,223	401,984	282,039
RANDOLPH	33,878	78,832	55,586	32,318	62,189	43,844
RICHMOND	50,328	117,585	81,923	69,020	104,143	73,006
ROBESON	300,360	781,211	546,635	285,367	619,763	433,217
ROCKINGHAM	4,217	13,769	9,485	4,145	13,218	9,096
ROWAN	4,280	23,480	16,314	1,578	12,063	8,530
RUTHERFORD	400	8,299	5,868			
SAMPSON	2,052,750	3,636,829	2,550,782	2,113,902	3,373,304	2,367,086
SCOTLAND	77,198	232,718	163,181	80,332	201,300	140,342
STANLY	4,370	13,119	9,212	3,390	5,056	3,575
STOKES	825	6,634	4,691	800	6,116	4,324
SURRY	18,952	34,696	24,276	17,730	27,093	18,900
SWAIN	400	1,691	1,153			
TRANSYLVANIA	24,691	112,000	77,356	9,542	40,343	27,507
UNION	36,381	124,954	87,807	9,800	40,681	28,764
VANCE	5,090	3,805	2,690			
WAKE	2,843	19,203	13,471	263	5,456	3,858
WARREN	17,200	164,723	116,370	7,700	79,422	56,077
WASHINGTON	86,538	249,073	175,351	62,719	121,578	85,845
WAYNE	524,237	1,076,015	755,248	611,635	1,100,559	773,003
WILSON	43,800	143,318	100,836	38,800	40,926	28,719
YADKIN	14,510	39,070	27,171	17,280	31,717	22,426

Appendix D- Cattle

The following maps show the cattle numbers based on DWR permits in 2006 and 2015 and the estimated available nutrients produced by county and river basin. In 2006, Iredell County had over 19 thousand cattle, by 2014 Iredell County had over 24 thousand cattle (Figures 23 & 24). The county statistics also lend to the Yadkin-Pee Dee and Cape Fear river basins as having the largest cattle populations. Table 15 lists the cattle inventory change between 2006 and 2015 and the amount of nutrients produced per basin. Table 16 lists the counties with permitted cattle facilities and their associated nutrient production.

In 2006, 11,200,996 pounds (lb) of plant available nitrogen (PAN) were produced and an estimated 14,020,959 lb of P_2O_5 were produced statewide with Iredell County producing over 1.6 million lb PAN and over 2 million lb of P_2O_5 (Figures 25 & 27). The Yadkin-Pee Dee Basin has the highest estimated pounds of PAN and P_2O_5 produced.

In 2015, 6,609,687 lb of PAN and an estimated 8,269,901 lb of P_2O_5 were produced statewide. This is a decrease from the 2006 levels because the number of cattle with DWR permits statewide decreased from approximately 161 thousand to approximately 95 thousand. The decline in cattle numbers is also indicated in the NC Department of Agriculture & Consumer Services Livestock Statistics. In 2015, cattle in Iredell County produced an estimated 2 million lb PAN and an estimated 2.6 million lb of P_2O_5 (Figures 26 & 28). The highest amounts of phosphorus produced are in the Yadkin-Pee Dee Basin.

Table 15: Cattle Inventory change and Nutrients Produced per Basin.

River Basin	Cattle Numbers 2006	Cattle Numbers 2015	Inventory % change 2006-15 (Δ %)	PAN 2006 (lb)	PAN 2015 (lb)	P_2O_5 2006 (lb)	P_2O_5 2015 (lb)
Broad	3,250	840	-74	190,082	66,231	238,156	82,789
Catawba	19,133	9,166	-52	1,610,902	760,065	2,014,581	950,317
Chowan	938	60	-94	13,413	858	17,128	1,096
Cape Fear	28,078	31,788	13	1,952,611	1,726,861	2,444,192	2,163,423
French Broad	13,361	4,455	-67	934,131	343,484	1,169,313	429,683
Lumber	3,090			275,561		344,540	
Neuse	8,398	1,437	-83	566,255	136,802	708,929	171,003
New	5,573	2,583	-54	415,716	192,022	520,176	240,284
Pasquotank	120	120	0	1,716	1,716	2,191	2,191
Roanoke	6,506	1,644	-75	357,902	130,216	448,622	162,896
Tar-Pamlico	16,226	3,625	-78	508,305	126,317	640,314	158,836
White Oak	100			9,520		11,900	
Yadkin-PeeDee	53,255	38,881	-27	4,181,428	3,106,075	5,230,821	3,883,584

Figure 23: 2006 Cattle Population by County

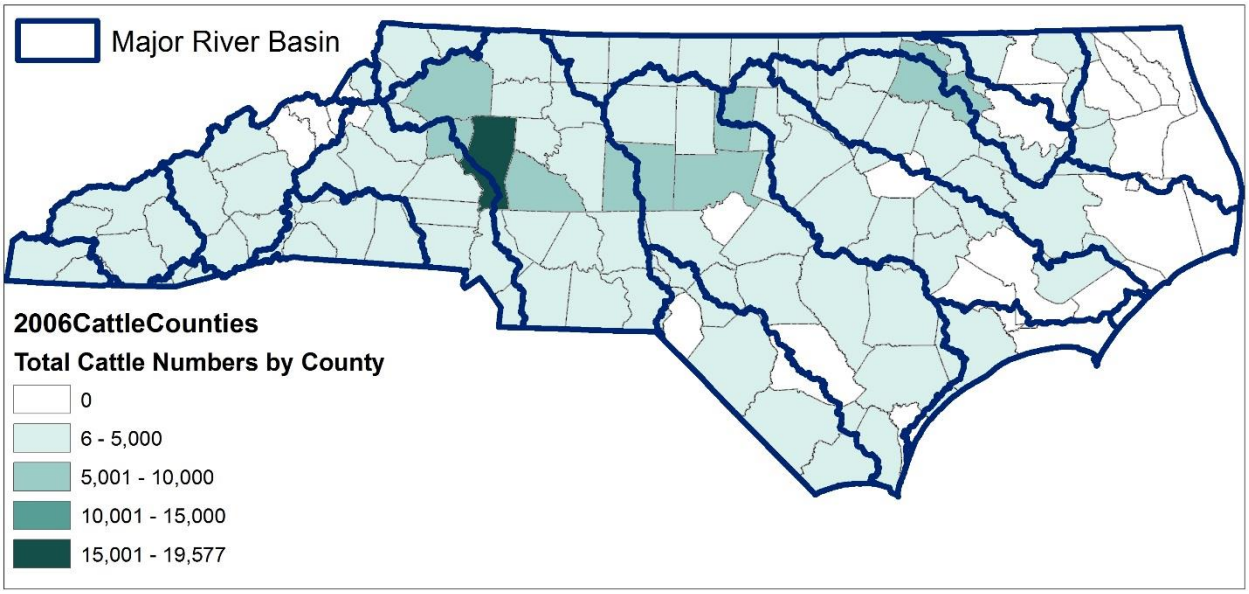


Figure 24: 2015 Cattle Population by County

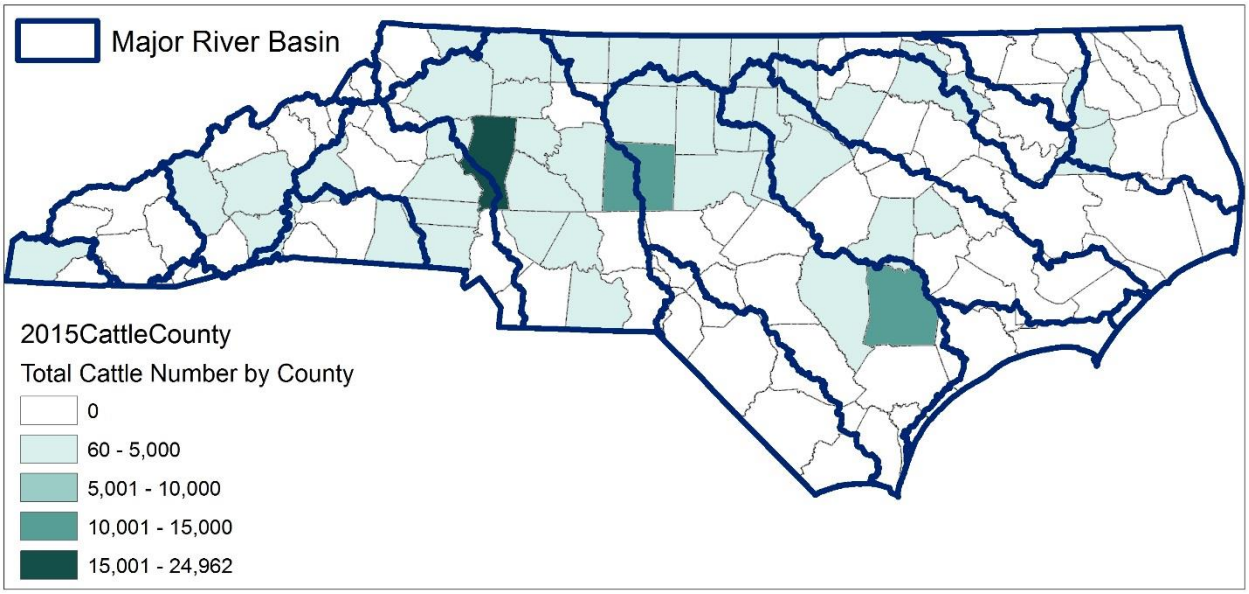


Figure 25: 2006 Estimated Total lb PAN per County Produced by Cattle

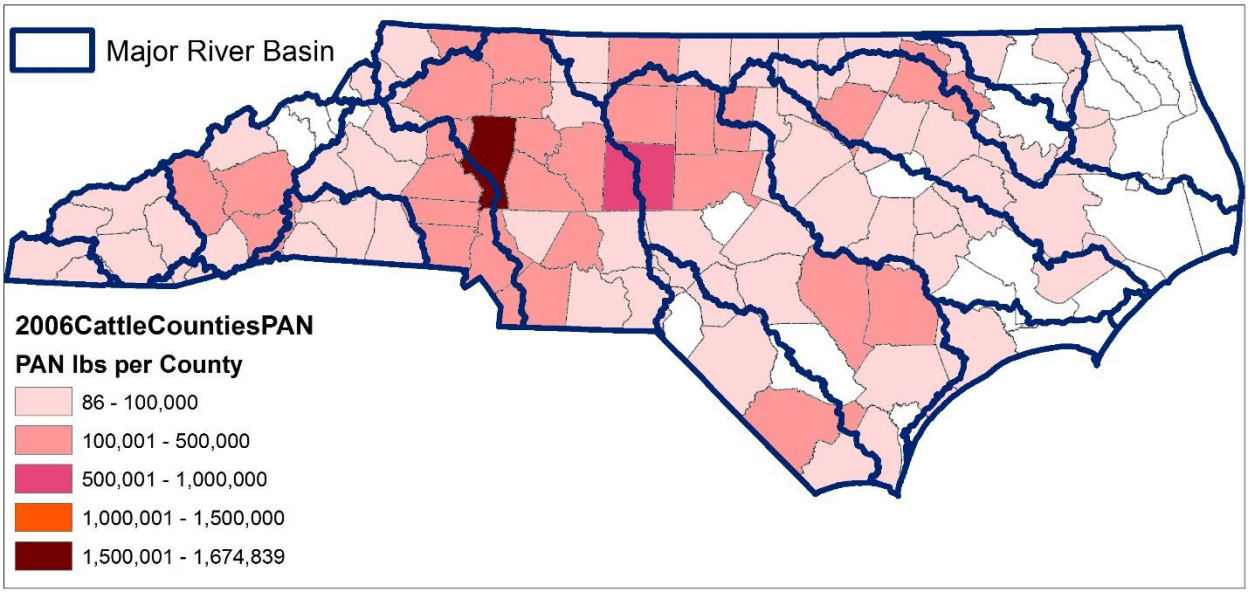


Figure 26: 2015 Estimated Total lb PAN per County Produced by Cattle

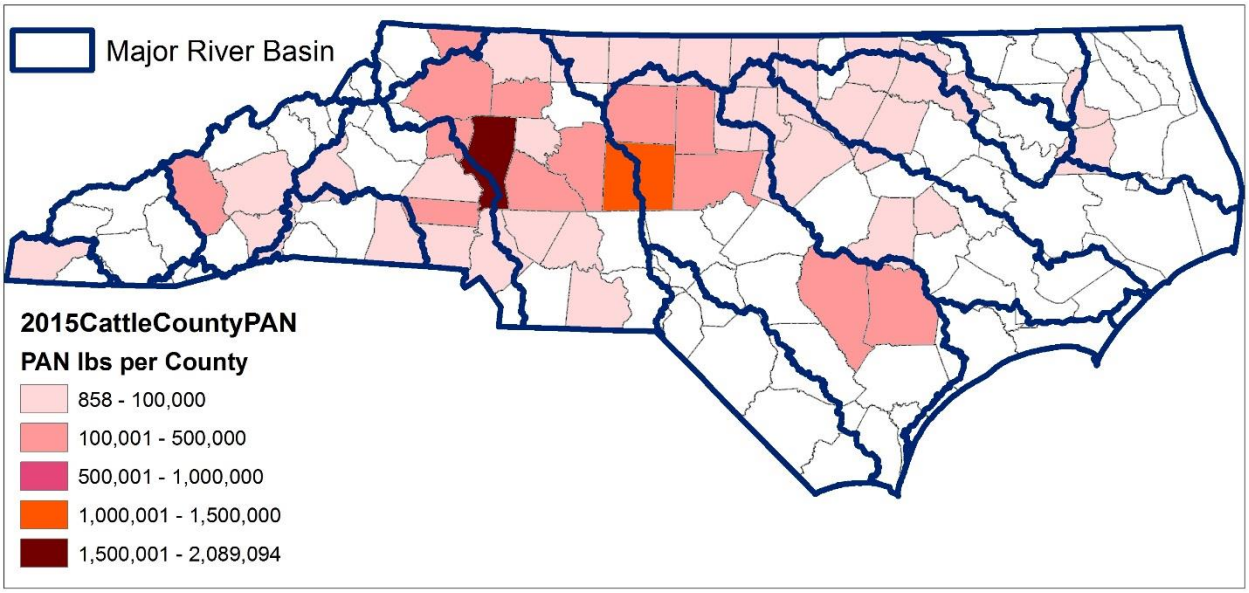


Figure 27: 2006 Estimated Total lb P_2O_5 per County Produced by Cattle

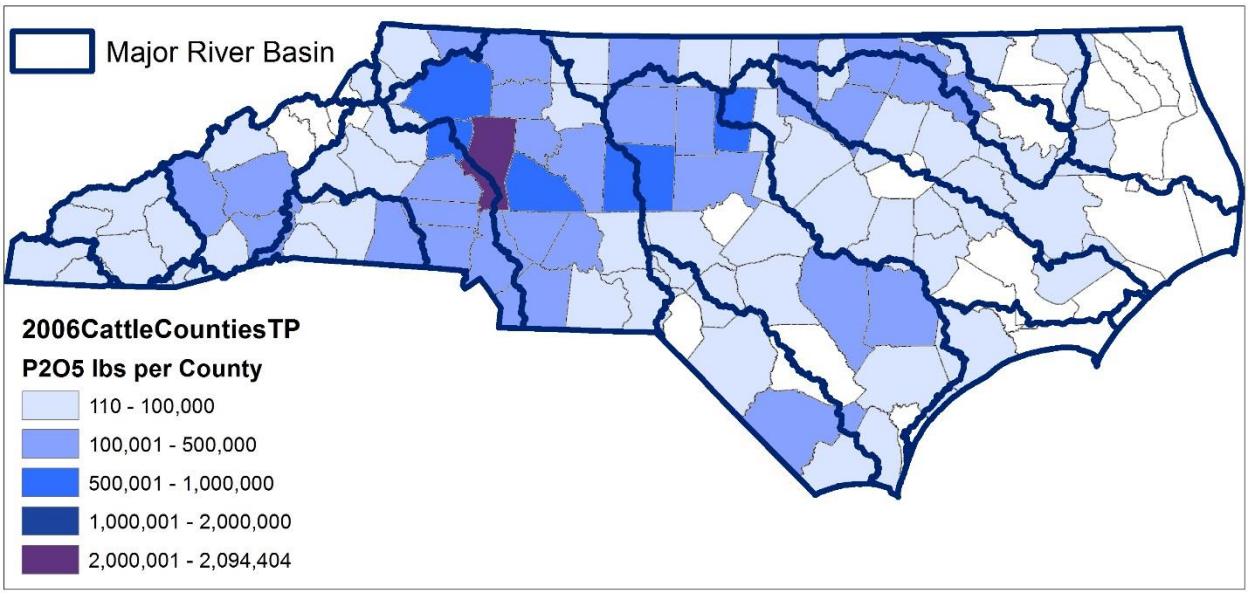


Figure 28: 2015 Estimated Total lb P_2O_5 per County Produced by Cattle

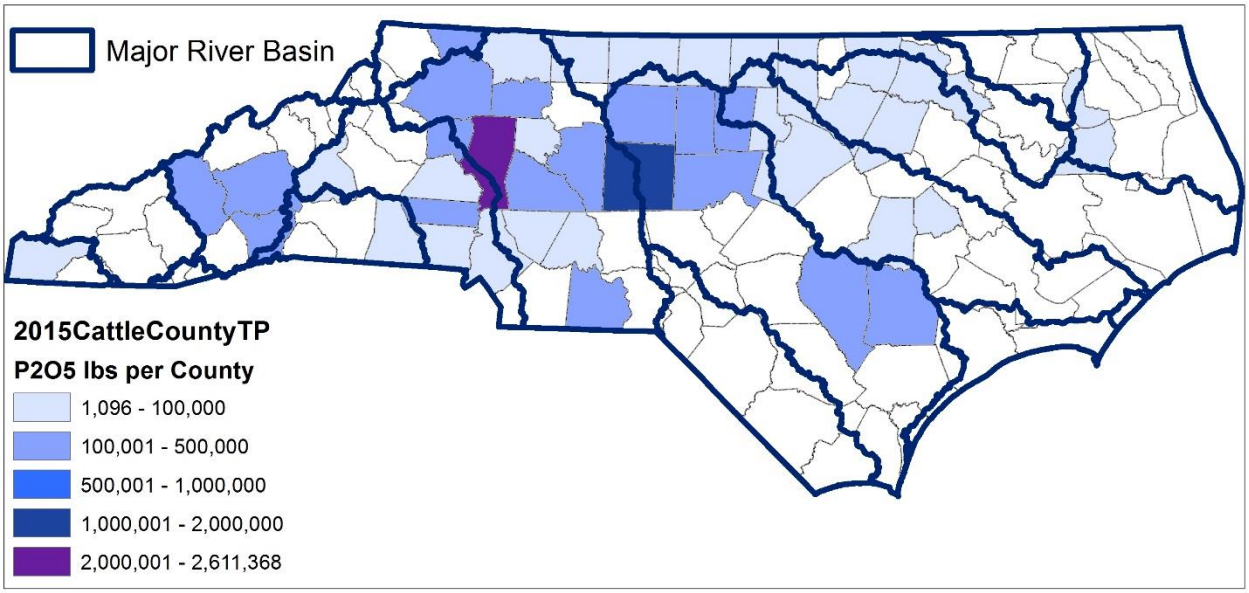


Table 16: Cattle Numbers per County and Plant Available Nitrogen (PAN) and Phosphorus (P_2O_5) Produced

County	2006 Cattle Number of Head	2006 PAN (lb)	2006 P_2O_5 (lb)	2015 Cattle Number of Head	2015 PAN (lb)	2015 P_2O_5 (lb)
ALAMANCE	4,325	345,159	431,766	1,425	111,390	139,353
ALEXANDER	5,018	442,522	553,320	2,950	280,840	351,050
ALLEGHANY	4,544	398,574	498,364	2,583	192,022	240,284
ANSON	320	30,464	38,080	1,000	86,800	108,500
ASHE	1,029	17,142	21,812			
BEAUFORT	290	27,608	34,510			
BRUNSWICK	170	16,184	20,230			
BUNCOMBE	3,517	313,301	391,771	1,210	94,375	118,113
BURKE	461	35,797	44,785			
CABARRUS	1,798	88,813	111,409	220	20,944	26,180
CALDWELL	800	75,040	93,800			
CASWELL	680	64,736	80,920	400	38,080	47,600
CATAWBA	3,160	271,708	339,774	560	53,312	66,640
CHATHAM	5,487	298,674	374,407	3,522	138,741	174,116
CHEROKEE	835	53,604	67,128	200	19,040	23,800
CHOWAN	92	1,316	1,680	60	858	1,096
CLAY	1,317	63,166	79,254			
CLEVELAND	1,490	95,340	119,382	840	66,231	82,789
COLUMBUS	2,690	256,088	320,110			
CUMBERLAND	1,010	18,488	23,480			
DAVIDSON	3,072	292,454	365,568	1,925	170,797	213,497
DAVIE	3,855	266,680	333,827	675	39,990	50,103
DUPLIN	2,035	111,214	139,410	10,514	130,273	166,349
DURHAM	520	7,436	9,495	660	22,688	28,514
EDGECOMBE	850	12,155	15,521			
FORSYTH	391	23,066	28,900			
FRANKLIN	3,405	109,367	137,730	1,690	20,982	26,792
GASTON	3,213	258,551	323,414	861	76,252	95,315
GATES	255	3,647	4,656			
GRAHAM	830	11,869	15,156			
GRANVILLE	1,195	99,202	124,072	700	66,640	83,300
GREENE	125	1,788	2,283	125	11,900	14,875
GUILFORD	2,776	248,095	310,196	1,585	150,892	188,615
HALIFAX	5,269	116,606	147,589	1,235	38,695	48,744
HARNETT	650	61,880	77,350			
HAYWOOD	4,788	237,064	297,371	2,195	149,149	186,620
HENDERSON	3,765	353,170	441,487	1,050	99,960	124,950
HOKE	437	10,294	13,017			
IREDELL	19,577	1,674,839	2,094,404	24,962	2,089,094	2,611,368
JACKSON	95	9,044	11,305			
JOHNSTON	170	10,521	13,178			
LENOIR	580	55,216	69,020			
LINCOLN	3,860	350,251	437,853	4,595	330,621	413,513
MACON	315	29,988	37,485			
MADISON	911	25,162	31,746			
MARTIN	825	64,383	80,546			
MCDOWELL	405	38,556	48,195	200	19,040	23,800
MECKLENBURG	2,216	138,477	173,441	0	0	0
MONTGOMERY	586	55,787	69,734			
MOORE	1,265	18,090	23,099			
NASH	1,107	27,965	35,325	0	0	0
NORTHAMPTON	591	8,451	10,792			
ONSLOW	100	9,520	11,900			

County	2006 Cattle Number of Head	2006 PAN (lb)	2006 P_2O_5 (lb)	2015 Cattle Number of Head	2015 PAN (lb)	2015 P_2O_5 (lb)
ORANGE	5,658	400,303	501,037	960	91,392	114,240
PAMLICO	60	858	1,096			
PENDER	500	7,150	9,130			
PERSON	400	38,080	47,600	200	19,040	23,800
PITT	1,860	26,598	33,964			
POLK	1,095	31,434	39,639			
RANDOLPH	8,343	714,567	893,588	12,274	1,000,756	1,251,325
RICHMOND	160	2,288	2,922			
ROBESON	230	3,289	4,200			
ROCKINGHAM	1,628	118,662	148,500	454	43,221	54,026
ROWAN	5,318	483,249	604,157	2,470	229,499	286,874
RUTHERFORD	665	63,308	79,135			
SAMPSON	1,250	119,000	148,750	1,808	172,122	215,152
STANLY	2,008	191,162	238,952	418	39,794	49,742
STOKES	2,973	72,042	91,057	590	29,876	37,470
SURRY	3,100	185,905	232,901	1,050	68,845	86,191
SWAIN	249	15,696	19,658			
TRANSYLVANIA	380	5,434	6,939			
UNION	1,439	136,993	171,241			
VANCE	60	5,712	7,140			
WAKE	985	72,900	91,224	192	18,278	22,848
WARREN	2,190	83,093	104,463	0	0	0
WASHINGTON	120	1,716	2,191	120	1,716	2,191
WATAUGA	6	86	110			
WAYNE	300	17,234	21,596	160	15,232	19,040
WILKES	7,482	402,179	504,186	3,576	168,579	211,344
YADKIN	4,149	347,550	434,541	2,585	191,733	239,787

Appendix E – Livestock Waste Ammonia Emissions

The US EPA estimated that cattle, swine and chickens account for 95% of national NH_3 emissions from livestock waste in 2014. These estimates used 2012 USDA county level animal census data for cattle, swine and chickens. The emissions model (2014 NEIv1) run by EPA estimates emissions from a typical farm, using a particular set of practices and for specific meteorological conditions. The model accounts for the nitrogen lost to the atmosphere and infiltrated into the soil. (EPA, 2016). The estimated emissions for 2014 model run are shown in Figure 29 and listed for each county in Table 17.

Figure 29: 2014 Estimated Ammonia Emissions per County Produced by Livestock

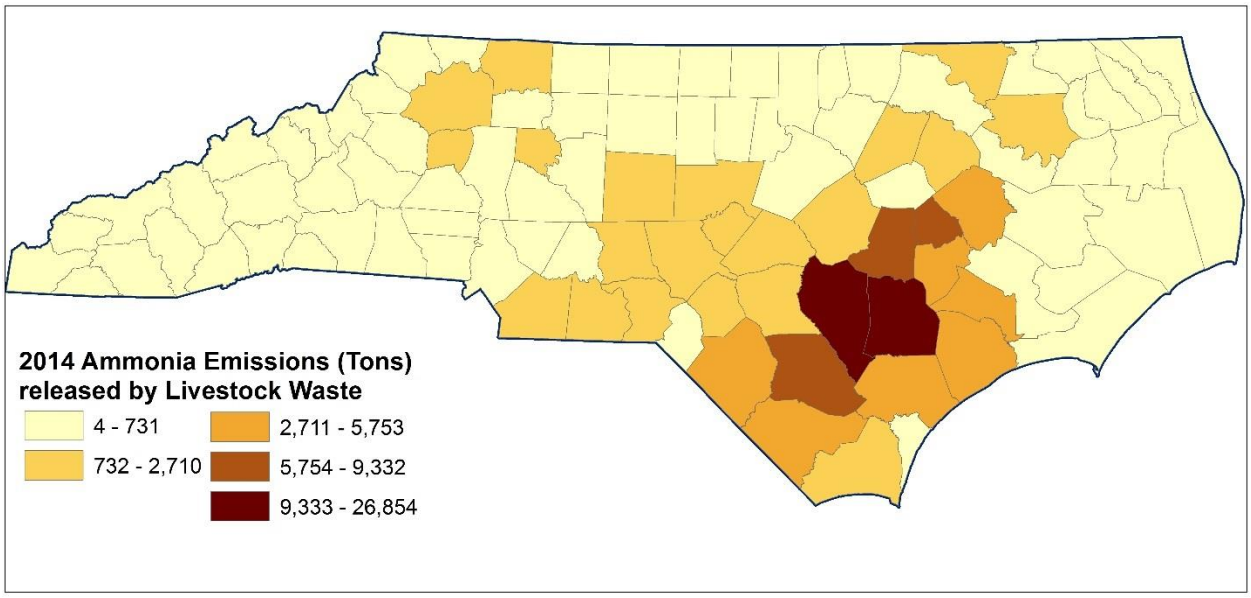


Table 17: County 2014 Ammonia Emissions from Livestock Waste

Alamance	Agriculture - Livestock Waste	149.4
Alexander	Agriculture - Livestock Waste	977.4
Alleghany	Agriculture - Livestock Waste	89.8
Anson	Agriculture - Livestock Waste	1,272.8
Ashe	Agriculture - Livestock Waste	42.6
Avery	Agriculture - Livestock Waste	27.7
Beaufort	Agriculture - Livestock Waste	575.1
Bertie	Agriculture - Livestock Waste	1,210.2
Bladen	Agriculture - Livestock Waste	9,322.9
Brunswick	Agriculture - Livestock Waste	1,092.8
Buncombe	Agriculture - Livestock Waste	104.2
Burke	Agriculture - Livestock Waste	194.8
Cabarrus	Agriculture - Livestock Waste	434.5
Caldwell	Agriculture - Livestock Waste	557.3
Camden	Agriculture - Livestock Waste	10.6
Carteret	Agriculture - Livestock Waste	9.8

Caswell	Agriculture - Livestock Waste	28.5
Catawba	Agriculture - Livestock Waste	639.4
Chatham	Agriculture - Livestock Waste	859.4
Cherokee	Agriculture - Livestock Waste	281.9
Chowan	Agriculture - Livestock Waste	130.1
Clay	Agriculture - Livestock Waste	16.2
Cleveland	Agriculture - Livestock Waste	695.1
Columbus	Agriculture - Livestock Waste	4,530.3
Craven	Agriculture - Livestock Waste	730.6
Cumberland	Agriculture - Livestock Waste	1,946.6
Currituck	Agriculture - Livestock Waste	3.7
Dare	Agriculture - Livestock Waste	7.6
Davidson	Agriculture - Livestock Waste	315.3
Davie	Agriculture - Livestock Waste	901.9
Duplin	Agriculture - Livestock Waste	25,984.7
Durham	Agriculture - Livestock Waste	39.5
Edgecombe	Agriculture - Livestock Waste	1,590.4
Forsyth	Agriculture - Livestock Waste	91.2
Franklin	Agriculture - Livestock Waste	407.6
Gaston	Agriculture - Livestock Waste	238.3
Gates	Agriculture - Livestock Waste	539.4
Graham	Agriculture - Livestock Waste	82.0
Granville	Agriculture - Livestock Waste	229.4
Greene	Agriculture - Livestock Waste	7,200.0
Guilford	Agriculture - Livestock Waste	345.1
Halifax	Agriculture - Livestock Waste	460.8
Harnett	Agriculture - Livestock Waste	1,750.6
Haywood	Agriculture - Livestock Waste	108.1
Henderson	Agriculture - Livestock Waste	32.5
Hertford	Agriculture - Livestock Waste	589.2
Hoke	Agriculture - Livestock Waste	1,318.3
Hyde	Agriculture - Livestock Waste	316.7
Iredell	Agriculture - Livestock Waste	106.0
Jackson	Agriculture - Livestock Waste	39.5
Johnston	Agriculture - Livestock Waste	2,710.3
Jones	Agriculture - Livestock Waste	5,241.6
Lee	Agriculture - Livestock Waste	846.2
Lenoir	Agriculture - Livestock Waste	4,069.2
Lincoln	Agriculture - Livestock Waste	290.3
Macon	Agriculture - Livestock Waste	41.4
Madison	Agriculture - Livestock Waste	43.9
Martin	Agriculture - Livestock Waste	449.2
McDowell	Agriculture - Livestock Waste	75.5
Mecklenburg	Agriculture - Livestock Waste	32.7
Mitchell	Agriculture - Livestock Waste	24.4
Montgomery	Agriculture - Livestock Waste	1,029.0
Moore	Agriculture - Livestock Waste	1,131.4
Nash	Agriculture - Livestock Waste	877.9
New Hanover	Agriculture - Livestock Waste	266.6
Northampton	Agriculture - Livestock Waste	1,710.6
Onslow	Agriculture - Livestock Waste	4,704.1
Orange	Agriculture - Livestock Waste	133.9

Pamlico	Agriculture - Livestock Waste	17.2
Pasquotank	Agriculture - Livestock Waste	260.0
Pender	Agriculture - Livestock Waste	3,209.5
Perquimans	Agriculture - Livestock Waste	533.3
Person	Agriculture - Livestock Waste	132.2
Pitt	Agriculture - Livestock Waste	3,407.8
Polk	Agriculture - Livestock Waste	304.2
Randolph	Agriculture - Livestock Waste	1,671.7
Richmond	Agriculture - Livestock Waste	1,874.9
Robeson	Agriculture - Livestock Waste	5,753.3
Rockingham	Agriculture - Livestock Waste	176.9
Rowan	Agriculture - Livestock Waste	203.5
Rutherford	Agriculture - Livestock Waste	198.9
Sampson	Agriculture - Livestock Waste	26,853.5
Scotland	Agriculture - Livestock Waste	599.2
Stanly	Agriculture - Livestock Waste	716.3
Stokes	Agriculture - Livestock Waste	39.3
Surry	Agriculture - Livestock Waste	1,177.9
Swain	Agriculture - Livestock Waste	13.0
Transylvania	Agriculture - Livestock Waste	28.8
Tyrrell	Agriculture - Livestock Waste	259.0
Union	Agriculture - Livestock Waste	2,297.6
Vance	Agriculture - Livestock Waste	46.7
Wake	Agriculture - Livestock Waste	164.8
Warren	Agriculture - Livestock Waste	611.9
Washington	Agriculture - Livestock Waste	94.9
Watauga	Agriculture - Livestock Waste	298.5
Wayne	Agriculture - Livestock Waste	9,332.3
Wilkes	Agriculture - Livestock Waste	2,001.1
Wilson	Agriculture - Livestock Waste	456.9
Yadkin	Agriculture - Livestock Waste	634.2
Yancey	Agriculture - Livestock Waste	152.7