Agriculture & Water Quality

in the Tar-Pamlico River Basin

OVERVIEW

Agriculture is North Carolina's leading industry and is especially strong in the Tar-Pamlico River Basin, where nonpoint source pollution from agricultural operations is a significant source of stream degradation. North Carolina has addressed this problem by combining a regulatory framework with voluntary assistance programs. These programs are aimed at helping farmers and other producers reduce their impact on waterways through the installation of best management practices (BMP) and establishment of conservation easements. By implementing a series of financial incentives and allocating technical assistance resources to various areas of the basin, the state has not only stimulated education and research programs but also encouraged the agricultural community to actively mitigate their impact on streams and rivers.

Due to the collective nutrient loading to the Pamlico Estuary, the Tar-Pamlico Agricultural Nutrient Control Strategy Rule and Law became effective September 2001, providing a collective strategy for farmers to meet the 30% nitrogen load reduction and no-increase phosphorus loss. Farmers in the basin are to implement land management practices that achieve certain nutrient reduction goals.

Agricultural practices in the Tar-Pamlico River Basin accounts for 29% of the land use activities; of that, 6% is estimated as pasture/hay land and 23% in cultivated crops based on 2011 National Land Cover Dataset (Figure 1). The primary crops being soybeans, corn and cotton. The USDA completed an agriculture census in 2012 indicating a ~10% decrease in the numbers of farms in the basin and a decrease ~10% in the acreage being farmed over since the 2002 census (Table 1). This census data also indicates an increase in farms and acreage using pasture and a decrease in overall fertilizer and chemical usage. Cattle and poultry animal numbers have increased, while hog numbers declined. A decrease in the hog farms and total hog numbers may indicate that these farms are converted to poultry or consolidated. The decrease in fertilizer usage is likely associated with costs; according to USDA economic research the cost of fertilizer has more than doubled since 1991 (http://www.ers.usda.gov/Data/FertilizerUse/).

Figure 1: 2011 Land Cover

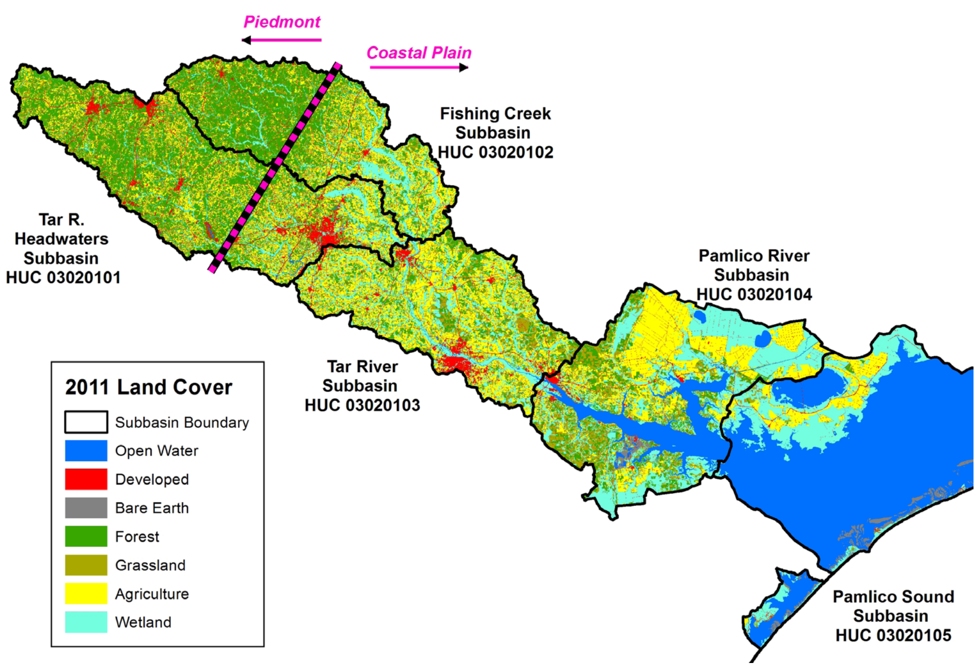

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Table 1: USDA Agriculture Census Data 2002, 2007 & 2012 for the Tar-Pamlico Basin

	2002 Farm #	2007 Farm #	2012 Farm #	2002 Acres	2007 Acres	2012 Acres
Farms	3,277	3,307	2,925	-	-	-
Land acreage in farms	-	-		1,191,263	1,077,822	1,072,603
Land Use						
Total cropland:	2,750	2,424	2155	801,219	716,603	714,285
Harvested cropland:	2,060	1,743	1,680	687,252	629,069	664,688
Cropland used only for pasture or grazing:	883	594	145	34,796	28,449	9,226
Cropland w/ failed crops or abandoned:	337	231	86	23,538	13,150	2,698
Cropland idle, cover crops, or soil improvement but not harvested and not pastured or grazed:	769	690	616	42,994	38,479	33,216
Cropland in cultivated summer fallow:	159	104	97	12,639	7,456	4,457
Total woodland:	1,977	2,039	1,813	303,507	264,435	249,938
Woodland pastured:	631	510	440	43,296	16,050	16,052
Woodland not pastured:	1,642	1,791	1,613	260,211	248,385	233,886
Permanent pasture and rangeland:	861	1,171	1,127	39,048	49,526	57,226
Land in farmsteads, buildings, livestock facilities, ponds, roads, wasteland, etc.:	1,899	1,716	1,816	47,489	47,258	51,154
Irrigated land:	576	443	312	38,181	29,464	25,089
Harvested cropland:	526	397	304	35,863	27,110	24,384
Pastureland and other land:	61	57	17	2,318	2,354	705
Land used for organic production:	16	21	?	477	399	?
Fertilizers and Chemicals						
Commercial fertilizer, lime, and soil conditioners:	1,939	1,738	1,406	664,245	586,969	527,897
Manure:	326	276	248	27,161	20,668	21,410
Acres treated with chemicals to control -						
Insects:	1,304	876	862	463,385	396,664	397,624
Weeds, grass, or brush:	1,539	1,182	1,305	579,941	473,456	594,511
Nematodes:	440	272	286	95,773	70,932	118,179
Diseases in crops and orchards:	312	208	291	85,442	67,351	118,172
Selected Crops						
Corn:	583	590	440	120,648	150,131	114,307
Soybeans:	897	800	780	207,993	223,933	253,504
Small grains (wheat, oats, barley, rye):	489	397	470	80,405	77,512	106,271
Cotton:	418	255	297	221,033	126,243	143,879
Vegetables harvested for sale:	241	262	167	26,468	24,612	22,344
Fruit and tree nuts:	63	74	64	330	328	246
Nursery, greenhouse, floriculture, and sod:	106	96	103	1,186	3,428	3,476
All other crops (other than those listed above):	1,449	1,043	965	83,390	69,327	85,332

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Table 1: USDA Agriculture Census Data 2002, 2007 & 2012 for the Tar-Pamlico Basin

Livestock	2002 Farm #	2007 Farm #	2012 Farm #	2002 Animal #	2007 Animal #	2012 Animal #
Cattle and calves:	885	786	655	42,152	40,473	48,440
Hogs and pigs:	179	136	102	530,017	557,371	330,244
Sheep and lambs:	56	76	66	1,928	1,921	1,558
Horses and ponies:	510	609	471	3,169	3,944	3,162
Goats:	225	332	252	6,540	7,724	4,943
Chickens (does not include farms with less than 1,000 chickens or farms that are the only producer in a county including a facility that has the capacity to house 4,750,000 birds)	302	309	322	6,484,314	7,370,874	8,508,279
http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Watersheds/sag03.pdf & http://www.agcensus.usda.gov/Publications/2012/Online_Resources/Watersheds/sag03.pdf						

Animal Operations & Recommendations

In 1992, the Environmental Management Commission (EMC) adopted a rule modification (15A NCAC 2H.0217) establishing procedures for managing and reusing animal wastes from intensive livestock operations. 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. Even though the rules adopted by the EMC are focused on managing and reusing animal waste in an environmentally and economically feasible manner, animal operation facilities can have many other impacts on local and downstream water quality.

Currently, DENR has regulatory authority over waste management of swine and cattle feedlots that use dry systems and applications of a wastewater or liquid manure. Most poultry operations produce a dry litter waste which typically fall under the deemed permitted category and are only inspected to meet NCAC 2T.1303 rules based on complaints. Other permitted animal operations are inspected by DWR on an annual basis. The locations of dry litter poultry operations and the disposal of their waste is not known to environmental regulators, making it very difficult to get a complete picture of the possible non-point sources, contributions within a specific watershed. This makes managing, protecting and enhancing water quality that much more challenging. The location of hog and cattle Confined Animal Feeding Operations (CAFOs) are known because a state or NPDES permit is required by DWR. While their direct nutrient contribution is not currently well understood, knowing that these sources exist in the watershed can help water quality managers to better understand the available water quality data and make better regulatory recommendations and decisions.

Due to a hog farm moratorium put in place in 1997 and a new law passed in 2007 prohibiting the construction of new hog waste lagoons and spray fields as the primary method of waste management (SB 1465), nutrient contributions from hog operations have remained fairly constant over the last several years. However, the continued growth in the poultry industry in the Coastal Plain of NC is continuing to add to the current nutrient loading from non-point sources. Based on the 2012 USDA Agriculture Census there was an 31% increase in birds numbers between 2002 and 2012 in the Tar-Pamlico Basin and this number would be over 100% increase if the 4.75 million unaccounted birds from one farm were included in the statistics. The increase in poultry operations are likely having an impact on the water quality in the Tar-Pamlico River Basin and other coastal basins.

Model estimates for the 1994 basin plan estimated 45% agriculture contribution of total nitrogen to the basin, while a more recent USGS study of nutrient source shares and loads estimates 70% of the nitrogen load to the Pamlico and Pungo River Estuaries is from manure or fertilizer (Moorman et al. 2014). The nitrogen load calculated by the SPARROW model to the Pamlico Sound attributed to manure or fertilizer is 75% (Moorman et al. 2014).

In North Carolina, animal agriculture is responsible for over 90 percent of all ammonia emissions; in turn, ammonia comprises more than 40 percent of the total estimated nitrogen emissions from all sources (Aneja et al., 1998;). The 2011 National Emission Inventory Data for NC indicates agriculture contributes over 95% of all ammonia emissions (EPA NEI 2011). The 2002 estimates of ammonia emissions for NC are 86,675 tons/yr coming from swine operations and 52,477 tons/yr coming from poultry facilities (EPA 2004). The 1994 Tar-Pamlico River Basin Plan noted atmospheric deposition as a major contributor of TN (33%) and TP (17%). While there are no recent studies indicating the overall amount of atmospheric deposition of nitrogen to the entire Tar-Pamlico River Basin, there are studies that suggest that up to 40 percent of the nitrogen entering the Albemarle-Pamlico Sound comes from atmospheric sources (DENR-DAQ, 1999; Costanza et al., 2008).

Several studies have indicated the atmospheric deposition of ammonia occurs relatively close to its source often within 50km (Robarge 2012; RTI 2003). A modeling study on the potential geographic distribution of atmospheric nitrogen deposition from CAFOs in NC reported that due to the high number of CAFO lagoons in the coastal plain and the prevailing southwest wind direction for 10 months of the year, the highest nitrogen depositional rates from CAFOs are in Neuse and Tar-Pamlico watersheds (Costanza et al., 2008). They also reported that between 24 and 47 percent of the Sound receives 50 percent of the atmospheric deposition from these CAFO lagoons (Costanza et al., 2008). Studies have been conducted to assess the direct and indirect contribution from wet atmospheric N deposition to the Neuse River Basin. The results of one such study completed in 2003 indicates that atmospheric contributions of nitrogen vary seasonally and spatially within the watershed but that overall it accounts for approximately 24% of the total nitrogen load to the Neuse River Estuary, and these contributions have risen over the last twenty years (Whitall et al., 2003). It is likely that these results are similar for the Pamlico River Estuary. Another study indicated that swine facilities contribute 28% of the atmospheric nitrogen in coastal NC with an estimated deposition rate of 0.009- 0.04lbs/ac/yr to the estuaries. (RTI 2003).

The US EPA estimates through 2030 that NH_3 emissions from poultry operations are the highest when compared to other animal operations (EPA 2004). The management of ammonia (NH_3) in poultry operations is extremely important to protect bird, human and environmental health. To reduce ammonia volatilization from poultry litter several practices such as regulating moisture, pH and temperature are used, along with special low nitrogen bird diets. Some litter treatments turn the NH_3 into ammonium (NH_4) which is no longer volatilized but can be used as a water-soluble fertilizer. Ammonia is usually volatilized and emitted from the poultry houses and from land application of litter. This NH_3 contributes to the overall atmospheric nitrogen and returns to land surfaces via deposition.

Ammonia emissions from CAFOs are not captured under the NSW agriculture rule, however some of the land-based portion of this loading is addressed through stormwater rules and adjustments to crop fertilization rates. Attaining the 30% reduction in nitrogen load to the Pamlico River Estuary may be challenging without first quantifying atmospheric contributions to the watershed

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more accurately, and eventually seeking appropriate management measures on all significant emission sources. The location of hog and cattle CAFOs are known due to the fact that an NPDES permit is required by DWR, but poultry locations are unknown. Knowing what nutrient sources exist in the watershed can help water quality managers to better understand the available water quality data and make better regulatory recommendations and decisions. Better solutions to nutrient loading via groundwater, surface runoff and atmospheric deposition from large scale farming activities are needed to protect water quality.

The agricultural Basin Oversight Committee (BOC) was established to oversee the required agricultural nutrient reductions in the Tar-Pamlico basin in response to the NSW strategy. The BOC develops and approves an annual report based on information provided by the Local Advisory Committees (LACs), summarizing local nitrogen and phosphorus loadings and estimated nutrient reductions based on implemented BMPs in the watershed. It is recommended that the BOC review their methodologies to incorporate adjusted N rates from ammonia deposition contributions from agriculture facilities in their annual accounting estimates.

Due to the nutrient sensitivity of the coastal basins and agriculture being a predominant industry within the basin, DWR encourages the agricultural community to voluntary establish BMPs to reduce any potential nutrients that could reach surface waters via groundwater, atmospheric deposition, tile drains or stormwater runoff. DWR also encourages existing and any new industry being developed in the basin to consider the environmental impacts and the cost of reducing/mitigating these impacts to be incorporated into their sustainable business model. As positive economic growth is dependent on access and availability of natural resources and clean water.

Additional impacts from agriculture include:

- Streambank Erosion & Sedimentation: Livestock grazing with unlimited access to the stream channel and banks can also cause severe streambank erosion resulting in sedimentation and degraded water quality.
- Loss of Riparian Vegetation: As livestock gather near streams, the riparian zone becomes trampled and thinned out. Establishing, conserving and managing streamside vegetation (riparian buffer) is one of the most economical and efficient BMPs.
- Excessive nutrients: Elevated nutrients levels occur when livestock have direct access to the waterbodies and also from stormwater runoff from pastures, feedlots, barnyards and fertilized fields. There are a variety of BMPs designed to prevent nutrient runoff from animal operations. Functioning riparian zones or buffers are known to reduce instream nutrient loads from stormwater runoff.

Buffer Width	NLEW (v5.53b) % N Reduction
20'	20%
30'	25%
50'	30%
70'	30%
100'	35%

NLEW= Nitrogen Loss Estimation Worksheet

- Animal waste is often stored in lagoons before it is applied to fields. Numerous environmental hazards exist from these lagoons including: ammonia emissions, overflows into surface waters, and groundwater contamination. Ensuring the proper closeout of lagoons no longer in use will protect water quality.

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DWR's Animal Feeding Operations Unit is responsible for the permitting and compliance activities of animal feeding operations across the state. Table 2 summarizes the number of registered livestock operations, total number of animals and number of facilities, in the basin. These numbers reflect only operations required by law to be registered and, therefore, do not represent the total number of animals in the subbasin (e.g., dry poultry operations, aquaculture facilities and operations with less than the permitted number of animals not counted).

Table 2: DWR Permitted Facilities

Type	Number of Facilities	Number of Animals
Animal Individual	15	4,750,000 poultry 9,600 swine
Cattle	6	2,975
Wet Poultry	6	726,716
Swine	88	406,737

Special Water Quality Studies

Special Study- Aquaculture

There are many aquaculture farms located in the Eastern portion of North Carolina. They range from small catfish farms to large hybrid striped bass production facilities. Citizen complaints about water quality in creeks (Bond, Muddy, Spring and Campbell Creeks) on the south side of the Pamlico River near Aurora initiated an inquiry by DWR to find potential pollution sources. As a result, the DWR Pamlico Response Team was requested to assist the DWR's Washington Regional Office with data collection and quantification of discharge from several hybrid striped bass aquaculture facilities. (Hybrid striped bass farms tend to be larger than other fish farms and can discharge over 30 times a year.) Water quality sample results found that discharges from three hybrid striped bass farms resulted in violation of water quality standards for DO and Chlorophyll a in the tributaries receiving fish pond drainage water. (DWQ PRT, 2007). As follow-up to the study, DWR's Washington Regional Office is working with hybrid striped bass farms requiring them to obtain general NPDES permits. The farms can continue to discharge with low flow drains and with the implementation of BMPs to reduce food and fecal waste release into streams/canals. The farms are required to take one water quality sample per year per pond; currently this sample data is kept onsite and not sent to DWR. It is recommended that their yearly pond sample results be submitted to DWR as part of their permitting requirements. There continues to be a need to examine how discharges from other types of aquaculture farms may or may not be impacting water quality. The amount of nutrients entering surface waters from aquaculture facilities is unknown and currently the Agriculture Nutrient Control Strategy does not account for added nutrients from fish farms. It is recommended the cumulative nutrient load numbers include estimates from aquaculture facilities in the agriculture annual progress report provided to DWR by the Basin Oversight Committee.

Drainage

Tile Drains

Export of land-applied nutrients to surface waters, whether originating from municipal, commercial, or animal facility is enhanced when the field in question has artificial drainage systems like tile drains. The interception of shallow groundwater beneath agricultural fields through tile drains to ditches can increase nitrogen and phosphorus loading into receiving streams by allowing the runoff to bypass BMP treatment (Harden and Spruill, 2008; Smith et al., 2014; King et al., 2014; Williams et al., 2015). Quantifying the extent of the drains has proven challenging because tile drain maps are either outdated or nonexistent. Additional research is needed to determine the location and geographic extent of tile drains along with mitigation options. Better management of tile drains represents an opportunity for improvement that could result in additional nutrient load reductions. Identification of functioning drainage districts and the types of activities being used to maintain drainage within agricultural lands is also needed to help describe conditions near DWR monitoring sites. The NLEW accounting tool used for agriculture rule compliance does not capture the effects of drain tiles nor does it reflect the research findings regarding nitrogen concentrations under waste-applied fields.

Drainage Districts

Principles for land and water management have changed significantly throughout history. The results of the previous land use management strategies still influence current practices and water quality (e.g., ditches, canals, sediment and nutrient accumulation). Removing water quickly and efficiently from the land was a public health and agricultural priority. To facilitate this, North Carolina General Statute Chapter 156 provides the right to establish local drainage districts.

> "§ 156-54. Jurisdiction to establish districts. The clerk of the superior court of any county in the State of North Carolina shall have jurisdiction, power and authority to establish levee or drainage districts either wholly or partly located in his county, and which shall constitute a political subdivision of the State, and to locate and establish levees, drains or canals, and cause to be constructed, straightened, widened or deepened, any ditch, drain or watercourse, and to build levees or embankments and erect tidal gates and pumping plants for the purpose of draining and reclaiming wet, swamp or overflowed land; and it is hereby declared that the drainage of swamplands and the drainage of surface water from agricultural lands and the reclamation of tidal marshes shall be considered a public use and benefit and conducive to the public health, convenience and welfare, and that the districts heretofore and hereafter created under the law shall be and constitute political subdivisions of the State, with authority to provide by law to levy taxes and assessments for the construction and maintenance of said public works. (1909, c. 442, s. 1; C.S., s. 5312; 1921, c. 7.)"

Drainage Districts are still in use in the Tar-Pamlico River Basin; however, little is known about the type of activities (where and how often) presently used to maintain drainage within agricultural lands. An inquiry with local governments indicated most county officials are not aware of operating districts within their jurisdiction. The knowledge of instream/in-ditch maintenance activities may be useful to understanding fluctuations in water quality samples that may have been taken near drainage district activities.

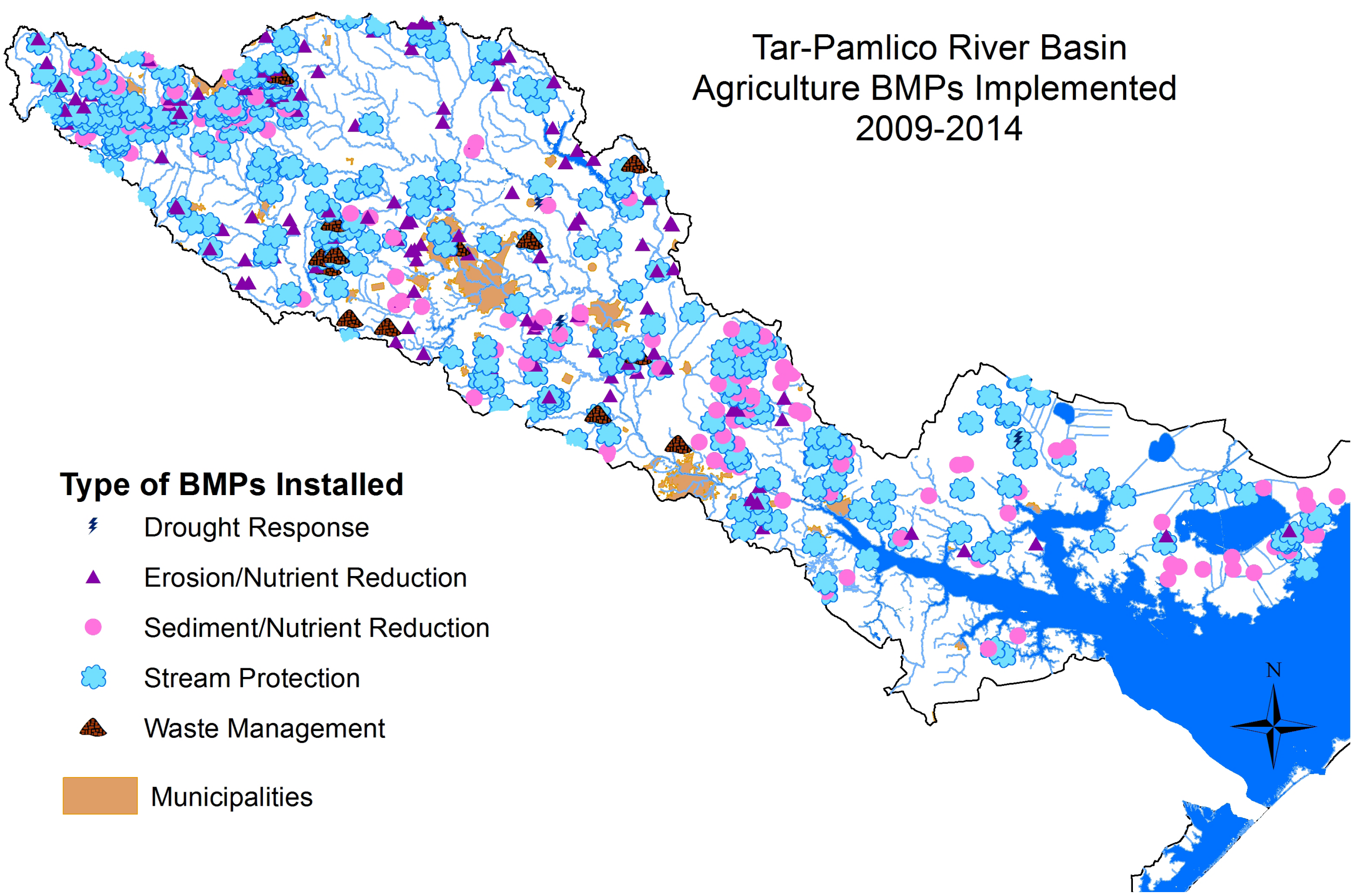
Farmland Preservation & Conservation

Land use change and the proliferation of impervious surfaces in the Tar-Pamlico River Basin have also contributed significantly to nonpoint source pollution problems. Some farmers and other landowners have elected to protect their crop and pasture land from future development through participation in the Conservation Reserve Enhancement Program (CREP). CREP is a voluntary program supported by federal and state resources that aims to conserve the present use of vegetated lands and counter the financial incentives that threaten to inhibit proper hydrologic cycling by converting functional soil regimes to impervious surfaces. This program provides a financial return for otherwise unproductive land in or near the buffer of a stream, and each easement is contracted for 10, 15, or 30 years, while permanent easements protect this land from development in perpetuity. In the Tar-Pamlico River Basin, approximately 16,274 acres of land have been protected by these conservation easements, all of which are for periods of 30 years or more.

North Carolina Agriculture Cost Share Program

Financial incentives are provided through North Carolina's Agriculture Cost Share Program, administered by the NC Department of Agriculture & Consumer Services' Division of Soil and Water Conservation (DSWC) to protect water quality by installing BMPs on agricultural lands. In the Tar-Pamlico River Basin, $2,771,254 was spent between 2009 and 2014 on BMPs to reduce nonpoint source pollution from agriculture. Approximately 37,072 acres were affected by BMPs that prevented an estimated 100,707 tons of soil, 372,849 lbs of nitrogen and 87,286 lbs of phosphorous from running off into surface waters. Animal waste BMPs also provided better management of an estimated 336,697 lbs of nitrogen and 480,067 lbs of phosphorous. The distribution of these BMPs are shown in Figure 2.

Figure 2: Agriculture BMPs implemented by DSWC between 2009-2014



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