Aquatic Resources in North Carolina:

An examination of the spatial relationship between approved impacts and compensatory mitigation

FINAL REPORT

USEPA Wetland Program Development Grant # CD 95415709-01:

Examination of wetland and stream mitigation versus impact in North Carolina

Tammy L. Hill[1], Amanda M. Mueller[2], John R. Dorney[3], Breda Muñoz[4]

[1]NC Division of Water Quality
1621 Mail Service Center
Raleigh, NC 27699-1621
Tammy.L.Hill@ncdenr.gov

[2]NC Division of Water Quality
1650 MSC
Raleigh, NC 27699-1650
Amanda.Mueller@ncdenr.gov

[3]Atkins Global
1616 East Millbrook Street
Raleigh, NC 27609
John.dorney@atkinsglobal.com

[4]RTI International
221 Cox Building
3040 Cornwallis Road
Research Triangle Park, NC 27709-2194
breda@rti.org

Abstract

This project examines the landscape-scale relocation of wetland, stream and riparian buffer resources in North Carolina resulting from the state's 401 Certification and riparian buffer regulatory programs. Data documenting the amounts and locations of resource impacts approved and mitigation projects initiated during the July 1, 2005 through June 30, 2010 timeframe were queried from multiple state-level databases. Data quality assurance was conducted by referencing NC Division of Water Quality permitting records and US Department of Agriculture aerial imagery. Impact and compensatory mitigation values were calculated and reported on an eight-digit hydrologic unit (also known as cataloging unit, or CU) basis to examine achievement of No Net Loss of aquatic resource goals. The raw data showed that wetland and riparian buffer mitigation outpaced impacts statewide, but individual cataloging units displayed a range of potential losses and gains. Potential stream losses were most concerning and may have been due to lower mitigation ratios, regulatory mitigation thresholds, inclusion of preservation in mitigation packages, and a lack of mitigation requirements for intermittent stream impacts during most of the study timeframe. Impact and compensatory mitigation locations were classified as urban or rural based on land use categories derived from the North Carolina Gap Analysis Project. Values were calculated on an eight-digit hydrologic unit code basis to compare the percentage of impacts and mitigation occurring in urban vs. rural settings. Relocation of aquatic resources, especially wetlands and riparian buffers, from urban to rural areas was observed in most cataloging units. Loss of streams and concentration of riparian buffer impacts in urbanizing areas within the Piedmont physiographic province were especially concerning due to lower rates of stream mitigation success observed in the province in previous studies. Project results may have policy applications as natural resource agencies consider the ecological implications of spatial shifting of aquatic resources due to permitting and mitigation of impacts to the state's wetlands, streams and riparian buffers.

Table of Contents

Table of Tables

Table of Figures

Introduction

Regulatory requirements for compensatory wetland and stream mitigation placement have changed over time as scientific understanding of the ecological benefits of these projects has developed. During the early years (c. 1990) of mitigation requirements, there was a preference for mitigation sites to be located on-site or as close to the impacted wetland area or stream reach as possible, theoretically directly offsetting any negative effects on local water quality that resulted from the permitted activity (Department of the Army and Environmental Protection Agency, 1990). However, when appropriate on-site mitigation opportunities were not available, mitigation requirements were determined on a permit-by-permit basis, and could be located large distances from permitted impacts if approved by the regulatory agencies. In a few instances, compensatory mitigation in North Carolina was allowed to occur over 250 miles from associated permitted impacts (BenDor, et al., 2009).

Over time, it was recognized that ecological success was often limited with small, spatially separate mitigation projects, with higher value to larger mitigation projects that compensated for aggregated requirements associated with multiple impacts. Although consolidated projects did not directly improve water quality in the immediate area of each impact, the pooling of mitigation requirements from multiple permits allowed for wetland and stream restoration on larger tracts of land. A 2001 report by the National Research Council (2001) Committee on Mitigating Wetland Losses expressed a preference for wetland mitigation site selection to occur in:

> 1.) Locations in which mitigation wetlands will provide ecosystem services on a watershed scale, and
>
> 2.) Landscape positions in which mitigation wetlands will likely be permanent, self-sustaining and able to evolve with the local landscape over the long term.

A 2008 rule published by the US Army Corps of Engineers (USACE) and the US Environmental Protection Agency (EPA) emphasized a watershed context to strategic site selection for compensatory mitigation projects, explaining that "the primary objective of the watershed approach…is to maintain and improve the quantity and quality of wetlands and other aquatic resources in watersheds" (Department of Defense and Environmental Protection Agency, 2008). The rule defined watershed broadly as "a land area that drains to a common waterway, such as a stream, lake, estuary, wetland, or ultimately the ocean," and stated that "in general, the required compensatory mitigation should be located within the same watershed as the impact site, and should be located where it is most likely to successfully replace lost functions and services..." The rule stated that "the appropriate watershed scale to use for the watershed approach will vary by region, as well as the particular aquatic resources under consideration," and "will be determined to be appropriate by the district engineer based on the factors specified in the rule." The rule required in-lieu fee programs to develop a compensation planning framework that supports a watershed approach (*Ibid*).

8-digit hydrologic unit codes (8-digit HUC's, also known as cataloging units, or CUs) describe watersheds of approximately 600 to 2900 square miles (for those within and overlapping NC state boundaries), based on a drainage organizational system established by the US Geological Survey (USGS; Seaber, et al., 1987). River basins within NC boundaries are each made up of all or part of one to seven CU watersheds. It has become generally accepted among regulatory agencies and aquatic restoration ecologists that mitigation should be placed in the same basin, and ideally in the same watershed, as associated impacts in order to best contribute to water quality improvements and landscape-scale conservation planning goals (Department of Defense and Environmental Protection Agency, 2008; Wilkinson, et al., 2009). Most USACE regulatory districts, including North Carolina's USACE, Wilmington District have adopted the USGS 8-digit HUC as the standard geographic area in which mitigation must be sited, and as the default geographic service area (GSA) for mitigation banks (Womble and Doyle, 2012). North Carolina's 401 Water Quality Certification Rules implemented in 1996 (15A NCAC 2H .0506 (h)(1)) accept USACE requirements as adequate compensatory mitigation as long as lost wetland acreage is replaced at a minimum 1:1 ratio through restoration or creation. In 2009, the North Carolina General Assembly established mitigation banks with available credits within the same 8-digit HUC as the preferred option to provide compensatory mitigation for approved impacts for non-governmental entities (Session Law 2009-337). A policy adopted by the NC Department of Environment and Natural Resources (NCDENR) Division of Water Quality suggests mitigation multipliers when compensatory mitigation occurs in a CU adjacent to the impacted CU (North Carolina Division of Water Quality, Surface Water Protection Section, 2005). Since 2003, the policies of the NC Ecosystem Enhancement Program (NCEEP) have specified that mitigation credits provided by NCEEP will be located within the same CU as associated aquatic resource impacts for NC Department of Transportation (NCDOT) projects (North Carolina Department of Environment and Natural Resources, et al., 2003).

The CU continues to be the primary GSA in NC and many surrounding states, and the vast majority of compensatory mitigation for approved impacts is provided on an in-CU basis through mitigation banks or the state's in-lieu fee program, NCEEP. This approach to compensatory mitigation generally facilitates larger mitigation projects than permit-specific on-site mitigation, and may provide greater ecological uplift than several smaller mitigation projects scattered across the landscape. In theory, this system allows mitigation to be placed where it will have the greatest benefit to the targeted local watershed system. However, this system may also have implications for local water quality in areas with the most approved aquatic resource impacts. Among the concerns to this approach are:

> 1.) The process of compensatory mitigation may be moving aquatic resources from urbanizing areas into rural areas (BenDor, et al., 2009), and
>
> 2.) Land availability and acquisition costs in developing areas exacerbate this trend and preclude urban restoration projects due to prohibitive costs.

Members of the NC Environmental Management Commission (EMC) have raised questions regarding the location of mitigation on the landscape relative to impacts, whether current state wetland and stream impact permitting processes (including mitigation requirements) were relocating aquatic resources on the landscape from urban and urbanizing areas into rural settings, and whether this type of relocation had implications for water quality. They observed that many impacts had occurred in areas that were becoming urbanized while many restoration opportunities existed in rural areas where wetlands were historically drained, streams were moved and riparian buffers were cleared for conversion to farmland. At a 2007 EMC meeting, an opinion was expressed that the current mitigation methodology in NC was limiting opportunities for mitigation in urbanizing areas (Waldroup, 2007). However, the current methods of tracking impacts and mitigation in NC made it difficult to obtain the data necessary to respond to these questions and concerns.

The objective of this project was to add a spatial dimension to the impact and mitigation tracking databases currently maintained by the North Carolina Division of Water Quality (NCDWQ) in order to explore the landscape-scale relocation of stream, wetland and riparian buffer resources that occurred as a result of the state's 401 Certification and riparian buffer protection programs. Because aquatic resource impacts and their associated mitigation are largely disaggregated in NC, the analysis could not be completed for impact locations and the exact location(s) of required mitigation offsetting each impact. Instead, analysis was conducted on a dataset including all approved impacts and mitigation projects during the same five-year timeframe. The project was conducted in three parts: 1.) identification and filling of data gaps, and evaluation of the dataset through a quality assurance procedure, 2.) quantification of impacts and mitigation by CU, which allowed an evaluation of statewide net loss for each resource type, and 3.) classification, and quantification by CU, of impacts and mitigation based on the land use type (urban or rural) at which each point occurred.

Methods

Data Collection

Two datasets were considered in this study. The first dataset, approved aquatic resource impact data, referred to wetland, stream and riparian buffer impacts approved through the 401 Certification and riparian buffer protection programs. The second dataset, aquatic resource mitigation data, was comprised of compensatory mitigation projects initiated through 401 Certifications and Buffer Authorizations, establishment of mitigation banking instruments and addenda, and NCEEP's governing Memorandum of Agreement between NCDENR, NCDOT and USACE (North Carolina Department of Environment and Natural Resources, et al., 2003) and Memorandum of Understanding between NCDENR and USACE (North Carolina Department of Environment and Natural Resources and United States Army Corps of Engineers, Wilmington District, 1998) for wetlands, streams and riparian buffers. Both datasets contained information for the five-year period from July 1, 2005 through June 30, 2010. Data sources included NCDWQ's Basinwide Information Management System (BIMS) database, an Access database developed to track compensatory mitigation projects as part of an EPA Wetland Program Development Grant (WL 9643505-01) awarded to NCDWQ during 2007-2009, and NCEEP's online Interactive Map and mitigation credit database.

Impact Data

During the timeframe of interest, impact data were entered into the BIMS database by NCDWQ staff based on information included in the Pre-Construction Notification (PCN) for Nationwide Permits or Public Notice (PN) for Individual Permits submitted to NCDWQ and USACE by permit applicants, then updated with details regarding approved impacts and required mitigation described in the 401

Certification. Each PCN submittal was assigned a unique identifier, an NCDWQ Project ID. Further, each PCN was assigned a version number, and an applicant may have submitted multiple versions of the same Project ID as project plans and requested impacts changed over time. Requested and approved impact amounts were entered for each individual wetland, stream and riparian buffer impact location included in the PCN, creating a one-to-many relationship between Project ID and impact records. Single geographic coordinates in BIMS usually sourced from the PCN and PN were based on data provided by the applicant. Coordinates may have been generated by GPS, online or paper maps, or other sources; therefore, accuracy was generally unknown. BIMS contained one field each for latitude and longitude (decimal degrees) for each version of every DWQ project identification number, providing a one-to-one relationship between each Project ID/version combination and geographic coordinates. Fields for tracking Individual impact coordinates did not exist in BIMS; instead, a single set of coordinates representing a central location for all project impacts was generally recorded.

Data were queried from BIMS using Business Objects (SAP Business Objects: Enterprise XI, Product: 12.1.0 © 2010) software. Queried fields included the project name, NCDWQ project number, version number, project type (e.g. roads, residential, landfills), impact category (i.e. wetland, stream or buffer), impact type (e.g. Zone 1, Zone 2, Fill), wetland type (if applicable), event date, requested area, approved area, improved area, basin name, subbasin number, subbasin description (e.g. Neu03, CPF07), county, latitude, longitude, owner last name, owner organization, Corps of Engineers ID number, NCDOT Transportation Improvement Project number, permanent/temporary, and perennial (Yes/No).

The initial data pull consisted of 14,752 records (4,759 individual wetland impacts, 5,939 stream and 4,054 riparian buffer impacts). A Microsoft Access query was utilized to summarize impacts in similar resource categories (i.e. wetland, stream, riparian buffer) for each Project ID and PCN version. This process yielded 7,720 consolidated wetland, stream or buffer impacts by Project ID and version (2,261 wetland, 3,197 stream and 2,262 riparian buffer impacts). The dataset included 5,227 unique Project ID numbers.

Missing geographic coordinates were inputted by matching scanned NCDWQ project files and maps stored in the Laserfiche® Client 7.2.1 document management system with Google Earth, Google maps, county tax maps, NCDOT permitting records and/or the NCDOT secondary roads database. Missing approved values were filled by referencing scanned project files. Due to time constraints, a small number (i.e. less than 20 per resource type) of empty geographic coordinate data fields were left blank for projects with the smallest impacts, totaling 3.3 acres of wetlands, 2,806 linear feet of stream and 59,342 square feet of buffers statewide. Exemption of these projects from the analysis was expected to have little influence on analytical outcomes due to the extremely small percentage (i.e. <0.01% of each resource type) of overall impacts they represented. The final impact dataset consisted of 7,679 impact records, including 2,246 approved projects with wetland impacts, 3,182 with stream impacts and 2,251 with buffer impacts.

Project data were loaded into a geographic information system (GIS) using ESRI ArcGIS 9.3.2 for processing. ESRI Analysis Tools were used to locate impact points within the corresponding CUs. Forty-six wetland, thirty-six stream and nine riparian buffer impact points had geographic coordinate data that fell outside of cataloging units that fall entirely or partially in NC, and were excluded from further analysis. In total, 61 approved projects with wetland impacts (14 acres), 51 with stream impacts (11,872 linear feet) and 20 with buffer impacts (140,044 square feet) were excluded from quantification by 8-digit HUC. The remaining impact data points were summarized by resource type per CU.

Impact data points outside of the NC state boundary were excluded from analysis involving land use classification. In all, 78 approved projects with wetland impacts (totaling 23 acres), 79 with stream impacts (36,628 linear feet) and 32 with buffer impacts (333,407 square feet) were excluded from the analyses involving land use categorization. The final project dataset used for classification and quantification included 96 to over 99 percent of the impacts in each aquatic resource category extracted from BIMS during the timeframe of interest (Appendix A).

Mitigation Data

Mitigation data were obtained from multiple database sources. BIMS was queried using Business Objects for on-site permittee-responsible mitigation for both private applicants and NCDOT. The BIMS data fields also captured some, but not all, of the mitigation requirements for impacts of less than one acre for which DWQ may not require mitigation, but USACE may. When mitigation requirements for a given approved impact were to be met via the purchase of mitigation bank credits and/or payment into NCEEP, the mitigation requirements were not included in the project dataset. Instead, the total amounts of wetland, stream and riparian buffer mitigation generated by mitigation banks and NCEEP during the evaluated timeframe were queried from a database developed and populated by NCDWQ staff (EPA Wetland Program Development Grant, WL 9643505-01). The mitigation tracking database had been populated based on BIMS records, DWQ's paper and electronic files including approved mitigation plans and annual mitigation project monitoring reports, and information available on the NCEEP and NCDOT websites related to mitigation projects initiated and monitored by both agencies. Geographic coordinates were likely generated through GPS measurements or GIS mapping, but sources and accuracy for individual mitigation sites were unknown. Missing coordinate data were imputed from corresponding PCN data including mitigation plans using LaserFiche® software, estimating bank locations based on Google Earth imagery and cross-referencing with GIS data provided by NCEEP.

Mitigation project data fields that were queried included project name, NCDWQ project number, latitude, longitude, responsible party, provider type (i.e. mitigation bank, NCEEP, NCDOT or private), county and amount of wetland, stream and/or riparian buffer resource approved to be generated by the site.

Mitigation projects in the dataset were initiated from July 1, 2005 to June 30, 2010, and included:

- Private applicant-provided on-site or off-site mitigation projects approved in conjunction with a 401 Certification or Buffer Authorization issued during the target timeframe
- NCDOT on-site mitigation projects approved in conjunction with a 401 Certification issued during the target timeframe

- Mitigation banks with a mitigation banking instrument (MBI), Umbrella MBI addendum, 401 Certification, Buffer Authorization and/or mitigation plan approved by NCDWQ during the target timeframe
- NCEEP design-bid-build (DBB) and full-delivery (FD) projects with a 401 Certification or Buffer Authorization issued, deemed issued or waived with a mitigation plan approved by NCDWQ during the target timeframe
- NCEEP DBB and FD projects that may or may not have required a 401 Certification or Buffer Authorization, but that were instituted[1], had a design finalized and advanced to the construction, monitoring and/or long-term stewardship phase during the target timeframe

Mitigation projects not included in the dataset or study analyses were:

- Private mitigation projects proposed, but not approved, in conjunction with a 401 Certification or Buffer Authorization application during the target timeframe
- Mitigation banks that were proposed, but not approved, during the target timeframe
- EEP DBB projects that were instituted, but for which a project design had not yet been finalized, during the target timeframe
- EEP DBB and FD projects that were issued a 401 Certification or Buffer Authorization before or after the target timeframe, regardless of institution date
- Mitigation projects with a 401 Certification or Buffer Authorization issued during the target timeframe, but that were known (as of the time of the study) to have been withdrawn or dropped from consideration by the provider, or placed on hold by NCDWQ

Using ArcGIS Analysis Tools, an 8-digit HUC value was assigned to each set of mitigation point coordinates based on their location within a hydrologic unit layer. Nearly all of the wetland, stream and riparian buffer mitigation projects queried from both BIMS and the mitigation database included coordinates located within the NC state boundary. One private one-acre wetland mitigation project was excluded from the land cover analysis because it was recorded as occurring outside of the NC state boundary. All other mitigation projects were documented with coordinates existing within state boundaries, and were included in all analyses.

Similar to the structure within BIMS, the mitigation tracking database utilized a unique Project ID field for each mitigation project (i.e. site) with a one-to-one relationship between Project ID and a centrally-located set of latitude and longitude (decimal degrees) coordinates. The database included a one-to-many relationship between Project ID and "component" records for distinct mitigation areas (e.g. "4 acres of riparian wetland enhancement" or "1000 linear feet of perennial stream restoration") within each project.

Mitigation components are considered to offset permitted aquatic resource losses differently, depending upon the anticipated amount of ecological uplift associated with various mitigation activities

[1] Instituted: "A mitigation site has been identified and acquired and a contract has been issued for the design and implementation of the mitigation project." (North Carolina Department of the Environment and Natural Resources, 2010)

(i.e. restoration, creation, enhancement and preservation). North Carolina natural resource regulatory agencies utilize mitigation ratios corresponding to the various mitigation activities to convert mitigation amounts (wetland acres, stream linear feet and riparian buffer square feet) into credit values for each resource type at a mitigation site. Resource amounts were converted to credits using mitigation credit ratios commonly utilized in North Carolina (Table 1) based upon the type(s) of mitigation activity conducted at the site. Individual components within the mitigation dataset were weighted by the ratios in Table 1 prior to summing by Project ID, thereby allowing analysis of both total mitigation amounts and mitigation credits. Exceptions to the values in Table 1 were two permittee-responsible stream mitigation projects that had been granted credit ratios based on site-specific conditions. For the purposes of this study, one aquatic resource unit (i.e. acre of wetland, linear foot of stream or square foot of riparian buffer) of impact will be considered equivalent to one mitigation credit of the same resource type, but results will be presented to allow comparison of impacts with both amounts and credits of mitigation.

Table 1. Generalized mitigation ratios applied to convert mitigation amounts to mitigation credits.

	Restoration	Enhancement	Creation	Preservation
Wetlands	1:1	2:1	3:1	5:1
Streams	1:1	2:1	1:1 (relocation)	5:1
Buffers	1:1	3:1	NA	NA

Data collection and processing yielded a mitigation dataset as described in Table 2.

Table 2. Mitigation dataset details: project counts, total mitigation amounts and credits.

	Project Count	Component Count	Total Amount	Credits
Wetlands	148	299	19,050 acres	11,886
Streams	249	491	2,129,080 feet	1,142,777
Buffers	54	72	31,859,897 sq ft	31,532,325

Data Limitations

In accordance with 15A NCAC 2H .0506(h) and 15A NCAC 2H .1305(g), NCDWQ generally required mitigation for approved impacts exceeding one acre of wetlands or 150 linear feet of stream (only perennial streams during most of the study timeframe). It was expected that all impacts approved and mitigation required in a 401 Certification were included in BIMS; however, impacts and associated mitigation below those thresholds may or may not have been entered. During the permitting process, projects with multiple PCN versions occasionally received approval for the same impact(s) more than once. The study dataset included all versions of each Project; therefore, some impacts and mitigation requirements may have been counted more than once. Attempts were made to merge BIMS data with impact and mitigation records provided by USACE in order to obtain a more complete dataset (due to USACE's lower thresholds for wetland impact reporting and mitigation). However, the lack of common fields between the two agencies' tracking systems made data merging impracticable.

Riparian buffer impacts in hydrologic units not subject to riparian buffer rules were not required to be reported to NCDWQ during the project timeframe, and were therefore not comprehensively catalogued in the BIMS database. Buffer impact values in such CUs may have been included in BIMS if they were voluntarily enumerated on a PCN or PN by a project applicant. Known buffer impact values, and all riparian buffer mitigation credit values, were included in statewide total calculations and appendices for informational purposes, but it should be noted that total riparian buffer impacts were expected to be underestimated, especially in river basins without riparian buffer protection rules.

Data Quality Assurance

The project included a quality assurance (QA) procedure to evaluate the accuracy of the geographic coordinates and approved resource area and length values in the impact and mitigation datasets. All BIMS data records were assumed to have an equal probability of accurately reflecting approved impacts and required mitigation. Similarly, the DWQ mitigation database records were assumed to have an equal probability of documenting the number of wetland acres, riparian buffer square feet and/or linear feet of stream provided by any given mitigation project. Within both the impact and mitigation populations, three strata (i.e. wetlands, streams and riparian buffers) were evaluated. A probabilistic quality assurance sample was selected from each dataset using an optimal sampling size formula provided by RTI International. The formula takes the variability within each stratum into account and produces the minimum sample size needed to detect differences between strata or achieve a specified precision for a given estimator with a given confidence level (95%) and power (80%). Based on the outcome of the sampling size formula, approved impact and mitigation projects were randomly selected within each stratum for verification of the impact or mitigation amount and geographic coordinates sourced from BIMS and NCDWQ's mitigation tracking database.

Spatial point features were created based on latitude and longitude data for each impact and mitigation project. The geographic coordinate system was defined as North American Datum of 1983 (NAD83), North Carolina State Plane (meters). ESRI's Create Random Points tool for ArcGIS was utilized to select the predetermined number of QA points from each resource dataset. Attribute fields were added to record QA values for impact or mitigation amount, latitude and longitude.

Impact amounts in the QA sample were compared with those found in 401 Certification approval letters. Mitigation amounts were compared with the most current approved acreage, linear feet or square feet for each mitigation project based on 401 Certification letters, approved mitigation plans and project monitoring reports. NCEEP's Interactive Map and mitigation credit database were also used to verify the mitigation amounts for NCEEP projects. Desired minimum accuracy was 90% of QA values within ±10% of dataset values for both impact and mitigation QA samples. Statistical comparisons of the original and QA values were performed using ArcGIS Summary Statistics, R for Windows 2.13.2, and JMP® 8.0.2 (statistical software from SAS Institute, Inc.).

Each impact and mitigation project in the QA sample was located within the GIS based on National Agriculture Imagery Program (NAIP) aerial images (six-meter horizontal accuracy; United States Department of Agriculture, 2010) which provided a consistent resource for coordinate generation. Observed point coordinates were entered into, or calculated within, the QA attribute table. ESRI Analysis tools (e.g. Spatial Join) were used to assign CU values to each set of QA coordinates. Since this project sought to quantify and classify impacts and mitigation values on a CU basis, the CU locations for the randomly-selected impact and mitigation points and their corresponding QA locations were compared to determine the frequency of equivalence. Desired minimum accuracy was 90% CU commonality.

Some resource values and site coordinates could not be located because available data files were unavailable or inconclusive. Of 724 impacts (238 wetland, 245 streams, 241 buffers) randomly selected for quality assurance, 646 impacts (217 wetland, 215 streams, 214 buffers) were verified through the QA process for approved impact amount, and 703 (232 wetland, 238 streams, 233 buffers) were located using NAIP imagery for latitude and longitude verification. Of 213 mitigation components (76 wetland, 96 streams, 41 buffers) selected for QA verification, 210 (76 wetland, 95 streams, 39 buffers) were checked for approved mitigation amount, and 192 (69 wetland, 91 streams, 32 buffers) were located using NAIP imagery for latitude and longitude verification.

Impact and Mitigation Quantification

Spatial analyses were conducted using ESRI's ArcGIS 9.3.2 ArcInfo license with Spatial Analyst extension. Point layers were created for impact and mitigation data, with fields to differentiate wetlands, streams and riparian buffers. An ESRI Model was developed to assist with data processing. Based on the layers of approved impacts, mitigation totals and mitigation credits occurring in North Carolina CUs, summary statistics (e.g. the number; total area, length and/or credit amount; mean value and standard deviation) of approved wetland, stream and buffer impacts and mitigation projects in each CU were calculated. The summary statistics were added to the CU layer in ArcMap to create summary tables of approved impacts, mitigation totals and mitigation credits (including null values) for each resource type in all North Carolina CUs during the timeframe of interest.

Calculations were performed in attribute tables for each resource type to 1.) determine the differences between impact amounts and both mitigation amounts and credits in each CU, and 2.) express mitigation amounts and credits as a percentage of impact amounts in each CU. Map figures were created to visually communicate results, using color-coded classified symbologies to distinguish CUs that experienced varying levels of differences between mitigation credit values and impact amounts, as well as to note CUs in which no impacts or mitigation occurred during the study timeframe.

Land Use Classification

The project's main objective was to quantify, then compare, approved impacts and mitigation credits that occurred in areas of varying degrees of urbanization and development. As previously discussed, due to the disaggregation of impacts and associated mitigation in NC, a direct comparison of impact and mitigation amounts in each land use type may have been inconclusive. To better evaluate the urbanization status of the location of impacted resources and mitigation projects, the percentages (rather than the total amounts and credits) of impacted resources and mitigation projects that were approved or initiated on urban and rural land use types were compared. If the percentage of mitigation credits initiated on urban land was lower than the percentage of impacts approved on urban land, then a relocation of aquatic resources from urban to rural areas might have occurred.

The national USGS Gap Analysis Program has produced land cover data for ecological planning and management purposes (http://gapanalysis.usgs.gov/). The North Carolina Gap Analysis Project (NC-

GAP) was a state affiliate of the national program. NC-GAP land cover data were based on 1991-1992 Landsat TM satellite imagery, classified into general land cover types based on the 1992 National Land Cover Dataset, and vegetated land cover classes were refined to reflect community composition and other ecological factors (McKerrow, et al., 2006; Figure 1). Overall accuracy for generalized land cover was reported as 87.7% (95% confidence interval 84.9 to 90.6%).

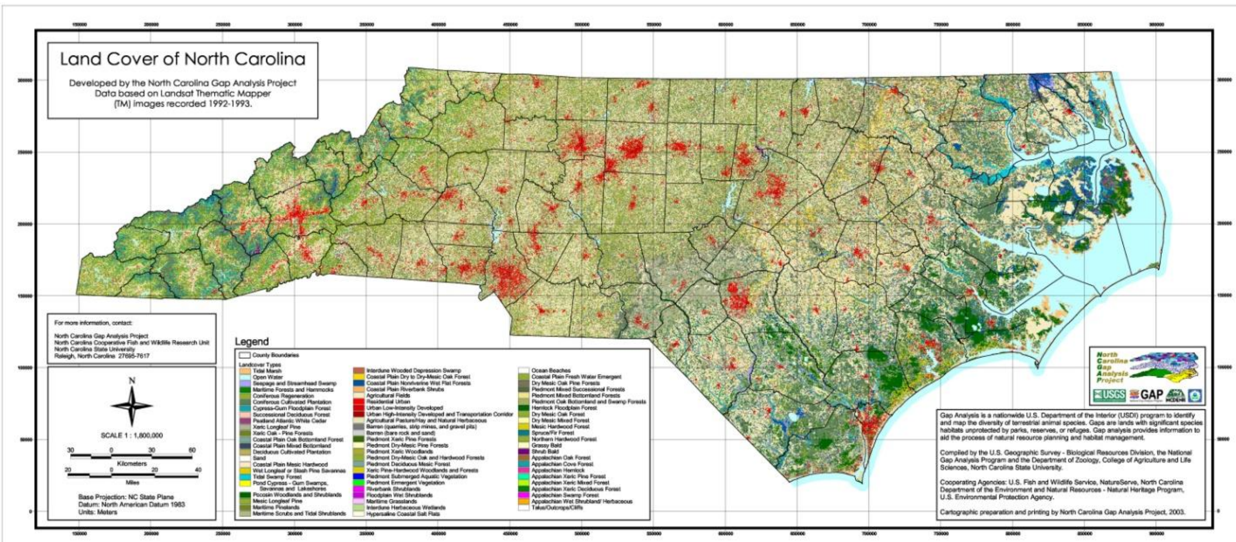

Figure 1. NC-GAP land use classifications. Figure from North Carolina Gap Analysis Project (McKerrow, et al., 2006).

For the current project, land cover classifications developed by NC-GAP were reclassified to consolidate impact and mitigation locations into generalized urban and rural categories in the project datasets. Reclassification included four levels of development, ranging from a relatively undisturbed natural state to areas with up to 100% impervious surface coverage (Table 3, Figure 2).

Table 3. Reclassification values for NC-GAP land cover types.

Land Cover Type	Reclassified Value	Description
Urban	11	High- and medium-density development
	12	Low-density development, utilities & developed open space
Rural	21	Managed vegetative cover (e.g. agriculture, silviculture, grazing)
	22	Natural state cover (e.g. forest, water bodies, sand dunes, rock outcroppings)

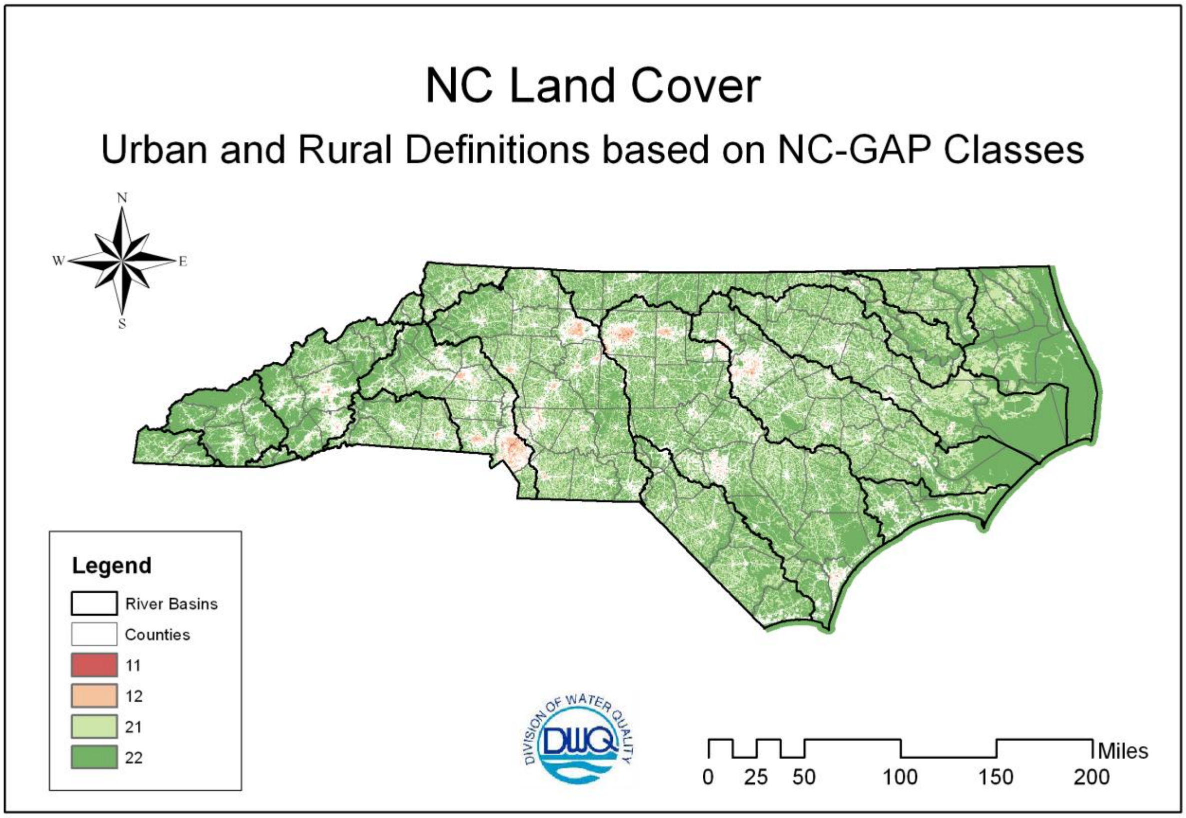

Figure 2. Reclassified urban and rural land use classifications, NCDWQ.

Categories 12 and 21 were considered to have the highest potential for future development. Open space/low-intensity development (category 12) involved less than 50% impervious surface coverage; therefore opportunity existed for further development and addition of imperviousness. Category 12 also included vegetated areas maintained for access to utilities, such as electrical lines and sewer and water systems, which service residential and/or commercial development of varying densities and can encourage additional development in close proximity. Category 21 included lands in active agricultural (crops or livestock grazing) or silvicultural production, which were the most likely land uses to be converted from their present uses in NC (Natural Resources Conservation Service, 2011). Category 11 had less potential to change because 50 to 100 percent of the land was already covered by impervious surfaces. Therefore, there was less opportunity for additional development, and a low likelihood of reversion to natural cover (United States Department of Agriculture, 2005; Platt, 2004). Natural state cover (category 22) included forested and open water coverage, as well as sand dunes and beaches, rocks and cliffs, and some portion of this class was considered a less likely candidate for development. While large amounts of natural land covers were subject to conversion to other uses in NC every year (Natural Resources Conservation Service, 2011), this category included lands (e.g. large contiguous tracts of dense forest, open waters, vegetated wetlands, steep mountain slopes) that were more difficult to convert, from both construction and regulatory standpoints, to traditional urban uses. Platt (2004) observed that while "rural lands … tend to occur in large, relatively homogenous spatial units…, the urban landscape, by contrast, is a vast mosaic of buildings, paved areas, parks, vacant land, private yards, and even residual agriculture and natural areas. … Drawing a boundary between urban and nonurban areas is a matter of definition and subjective judgment." Visual comparison of the reclassified land use raster with NAIP aerial imagery suggested that while the more clear-cut categories of high-density urban, forested rural and large-scale agricultural lands were more consistently classified as 11 or 22, there appeared to be more variability in classification of low-density urban areas, utilities, city parks and other smaller managed lands in the 12 and 21 categories.

Reclassified NC-GAP land cover values were appended to the impact and mitigation datasets for each resource type using an ESRI Spatial Analyst tool (Extract Values to Points). One buffer impact point (0.006 square feet) in CU 03050101 fell within the NC boundary polygon, but just outside the edge of the NC-GAP raster. It was assigned the value (12) of the nearest NC-GAP cell. All other impact and mitigation points fell within the extent of the NC-GAP raster, and were classified with the value of the cell within which each point occurred. No interpolation was applied.

The four classes were consolidated into two: 0 (urban) denoted classes 11 and 12, while 1 (rural) corresponded to classes 21 and 22. Summary Statistics tables were generated for a simplified comparison of urban vs. rural impacts and mitigation amounts for each resource type in each CU. Fields were added to the Summary Statistics tables to combine CU number with urban or rural classification value to link the impact and mitigation-related statistical outputs. Impact and mitigation datasets were inspected for accuracy against previously-developed layers quantifying impacts and mitigation in each CU within the NC boundary. After joining the datasets, the CU layer was clipped with the NC boundary to allow presentation of only the watershed areas examined in further analyses (i.e. only the portions of CUs that fell within the NC boundary). Analyses were performed using ArcGIS to compare the percentages of urban and rural land approved for impact and utilized for mitigation in each CU.

Results

Data Quality Assurance

Impact and Mitigation Amounts

The quality assurance process showed that approved impact values for over three quarters (504 out of 646) of the impact data points exactly matched the impact values approved in the Project ID's 401 Certification letter. Two sample t-tests failed to find a significant difference between the mean of approved impact values randomly selected from the population and the mean of approved impact values determined through the QA process for wetlands, streams or riparian buffers (**Table 4**).

Table 4. Two sample t-tests comparing approved impact value sourced from BIMS vs. approved impact value in 401 Water Quality Certification; results did not indicate a statistically significant difference at the 0.05 level for any resource type.

Resource	t-value	p-value	Impact Mean	Impact QC Mean
Wetlands	0.2839	0.78	0.68 ac	0.61 ac
Streams	-0.0995	0.92	229 feet	235 feet
Buffers	-0.1154	0.91	8537 sq ft	8776 sq ft

Similarly, the quality assurance process showed that mitigation project values (i.e. acres of wetlands, linear feet of stream, square feet of riparian buffer) for over three quarters (165 out of 210) of the mitigation project data points exactly matched the values documented in the most current mitigation project documentation. Matched pairs analysis failed to find a significant difference at the 0.05 level between the means of mitigation values randomly selected from the population and the means of mitigation values determined through the QA process for wetlands, streams or riparian buffers (Figure 3).

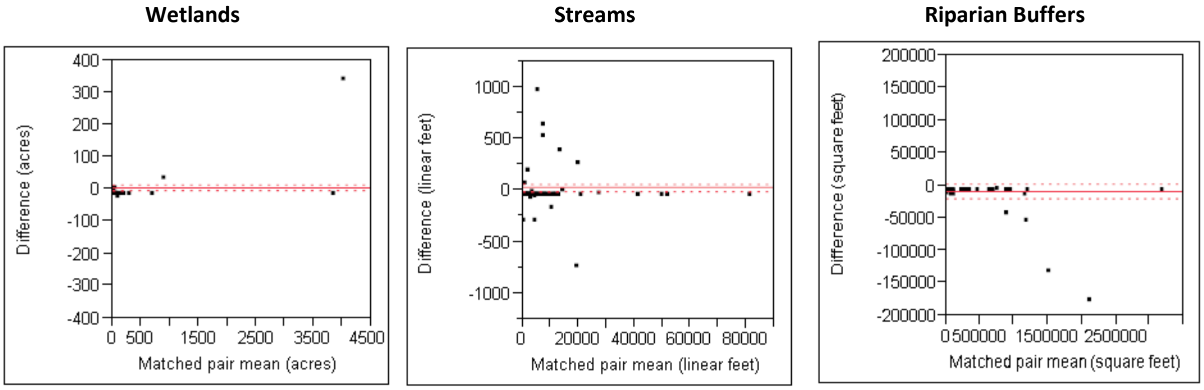

Figure 3. Matched pairs: mitigation values in the NCDWQ database and mitigation values determined via QA documentation. Matched pairs analysis examined the mean vs. the difference between each pair. Dashed lines indicate the 95% confidence interval. A statistically significant difference was not found for any resource type.

Geographic Coordinates

Of the 703 impact points for which QA coordinates were located using NAIP imagery, only ten (five wetland impacts totaling 19 acres, plus five stream impacts totaling 4,964 linear feet) were found to exist in a different CU than the one indicated by the geographic coordinates queried from BIMS.

Of the 192 mitigation project points for which QA coordinates were located using NAIP imagery, four (one wetland mitigation project of 0.12 acre, and three stream mitigation projects totaling 34,205 linear feet) were found to exist in a different CU than the one indicated by the geographic coordinates queried from BIMS.

Quality Assurance Summary

Quality assurance outputs suggested a high correlation between values recorded in NCDWQ approved aquatic resource impact and mitigation tracking databases and values detailed in 401 Certifications, mitigation plans and other project documentation. Datasets detailing the amounts and locations of approved impacts and mitigation for all resource types met the targeted accuracy requirements, and were included in further analyses.

Impact and Mitigation Quantification

Wetlands

The vast majority of the state, per CU, had mitigation credits within 50 credits of the impact acres amount for approved impact and mitigation activity during the five-year timeframe (Figure 4, Appendix B). Impact amount totals greater than initiated mitigation totals were primarily attributed to a large number of projects within a CU that had impact values less than the DWQ 1.0 acre mitigation threshold (except Cape Fear 03030007, Lumber 03040204 and White Oak 03020301 and 03020302).

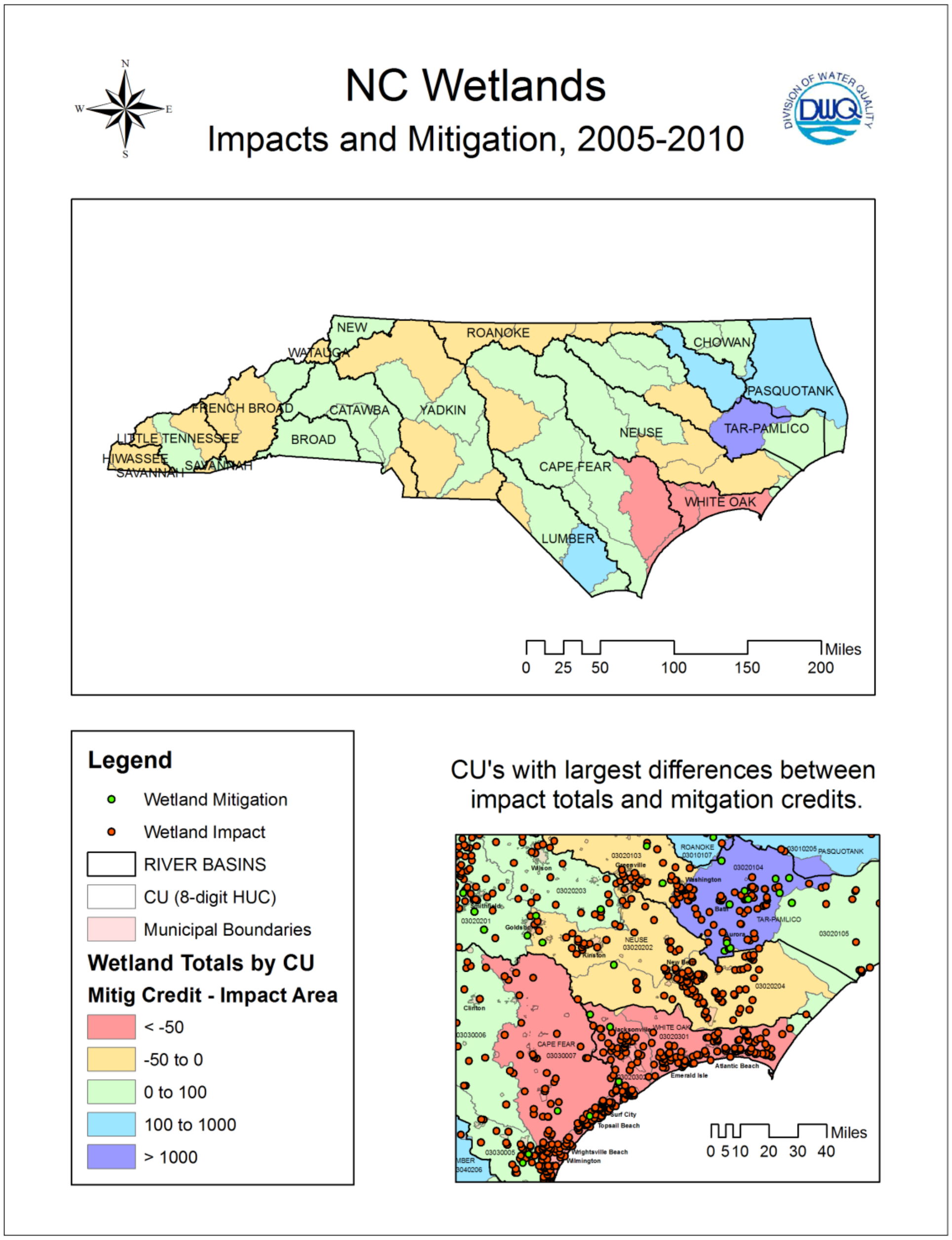

Figure 4. Differences (mitigation credits – impact acres) between initiated wetland mitigation and approved impacts by 8-digit hydrologic unit.

Differences between approved impacts and newly instituted mitigation of 50 to 100 acres in three CUs along the southeastern coast (Cape Fear 03030007, White Oak 03020301 and 03020302) were dominated by 191 acres of wetland impact for a machine gun range, operations center and other improvement projects on Camp Lejeune. These impacts were mitigated largely with wetland area on the base that had been restored prior to 2005 and determined by the regulatory agencies to provide successful mitigation. Due to the time lag, there appeared to be a loss of wetlands in these CUs even though mitigation was provided. The White Oak River Basin experienced other impacts greater than one acre in size for public facilities (e.g. water and wastewater treatment plants and public schools) as well as five residential and/or commercial development projects. Remaining impacts in these CUs were less than one acre per 401 Certification.

Tar-Pamlico 03020104 saw a gain of over 3700 acres of mitigation over approved impact amounts due to the mitigation package required through the permitting of a nearly 4000-acre wetland impact for the PCS Phosphate, Inc. (PCS) mine expansion. PCS began design and construction of many of the proposed mitigation sites while the permit was being considered by the regulatory agencies during the study timeframe. Other large gains resulted from the initiation of the 860-acre Stone Farm Regional Mitigation Bank in Lumber 03040206, EEP's restoration and preservation activities on a 3800-acre Carolina Bay (Roquist Pocosin in Bertie county) along with smaller EEP design-bid-build and full-delivery projects in Roanoke 03010107, and the 986-acre Timberlake portion of the Great Dismal Swamp Mitigation Bank in Pasquotank 03010205.

Streams

For streams, the mitigation credit amounts were within 25,000 linear feet (roughly 5 miles) of the amount of approved impact linear footage for the majority of NC cataloging units (Figure 5, Appendix B).

The largest potential gain occurred in Cape Fear 03030003 due to a large mitigation project involving the removal of Carbonton Dam which, at the time of mitigation plan approval, had the potential to generate over 125,000 linear feet of stream restoration credit.

CUs that showed the greatest differences between approved impacts and initiated mitigation were those in the Charlotte (Catawba 03050103) and Raleigh (Neuse 03020201) areas. The largest impacts in Catawba 03050103 were associated with expansion and improvements at the Charlotte-Douglas International Airport. Neuse 03020201 did not contain any single impact site that was especially large. Both the Raleigh and Charlotte areas experienced many smaller impacts related to maintenance of municipal services (e.g. utilities, stormwater, roads), streambank stabilization, and residential and commercial development projects.

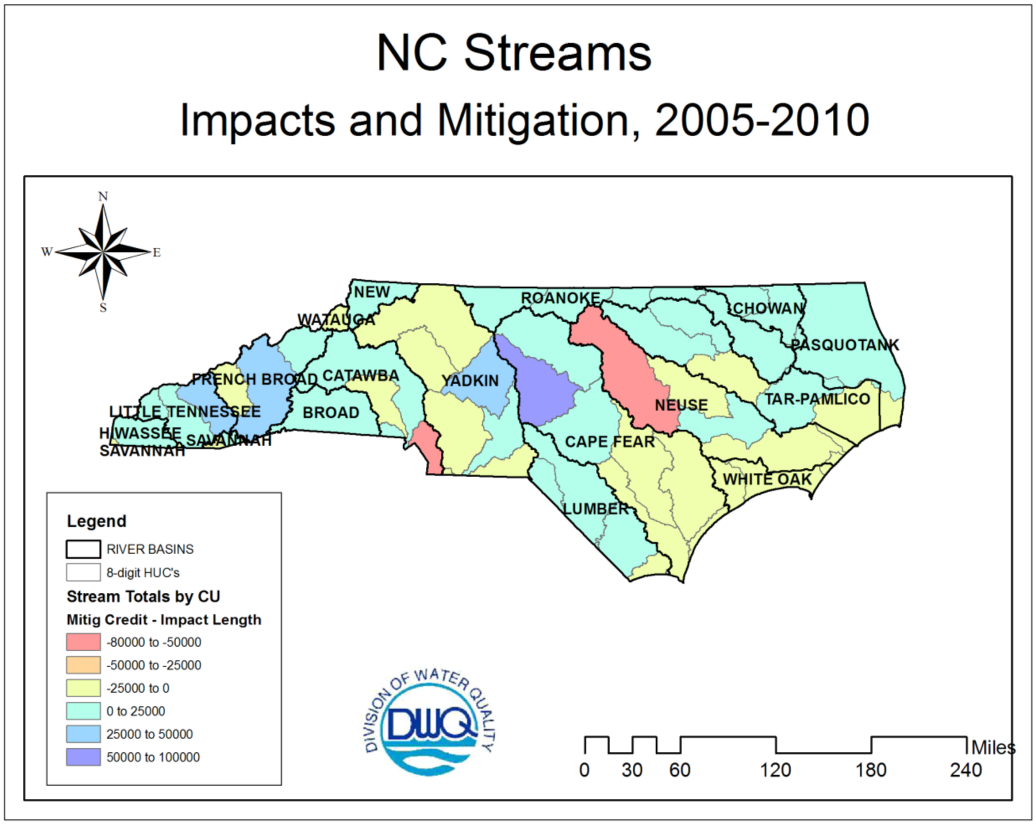

Figure 5. Differences (mitigation credits – impact linear feet) between initiated stream mitigation and approved impacts by 8-digit hydrologic unit.

Riparian Buffers

Riparian buffer rules came into effect in certain watersheds and river basins in NC as early as 1997 and as recently as 2009 (15A NCAC 2B .0229 through .0282 and 15A NCAC 2B .0601 through .0609). Of the fifteen CUs that were partially or entirely subject to requirements for riparian buffer mitigation (Table 5), nine (60%) of them had differences between the approved square footage of buffer impacts and the square footage of initiated mitigation within 1.1 million square feet (approximately 25 acres). Three (20%) CUs (Cape Fear 03030003, Neuse 03020201 and Tar-Pamlico 03020101) returned negative values showing a loss of greater than 1.1 million square feet. Three (20%) others (Neuse 03020203 and 03020204, Tar-Pamlico 03020104) returned positive values showing a gain of greater than 1.1 million square feet (Figure 6, Appendix B). Impacts in Cape Fear 03030003 were dominated by construction of the I-74 highway. Impacts in Neuse 03020201 were largely driven by development activities in the Raleigh metropolitan area during the study timeframe.

As previously discussed, riparian buffer impacts were likely underestimated in hydrologic units not subject to riparian buffer rules. Since no riparian buffer mitigation credits were generated in CUs without buffer rules, the impact values in those CUs were not depicted in Figure 6. All data available in BIMS were included in statewide totals (next section) and Appendices A through C.

Table 5. CUs entirely or partially subject to North Carolina riparian buffer rules.

Drainage Area	Associated CUs	Applicable NCAC Rules
Neuse River Basin	03020201, 03020202, 03020203, 03020204	15A NCAC 2B .0233, 15A NCAC 2B .0242
Tar-Pamlico River Basin	03020101, 03020102, 03020103, 03020104, 03020105	15A NCAC 2B .0259, 15A NCAC 2B .0260
Catawba River Basin	03050101, 03050102, 03050103	15A NCAC 2B .0243, 15A NCAC 2B .0244
Randleman Watershed	Cape Fear 03030003	15A NCAC 2B .0250, 15A NCAC 2B .0252
Jordan Lake Watershed	Cape Fear 03030002	15A NCAC 2B .0267, 15A NCAC 2B .0268
Goose Creek Watershed	Yadkin 03040105	15A NCAC 2B .0605 through 15A NCAC 2B .0609

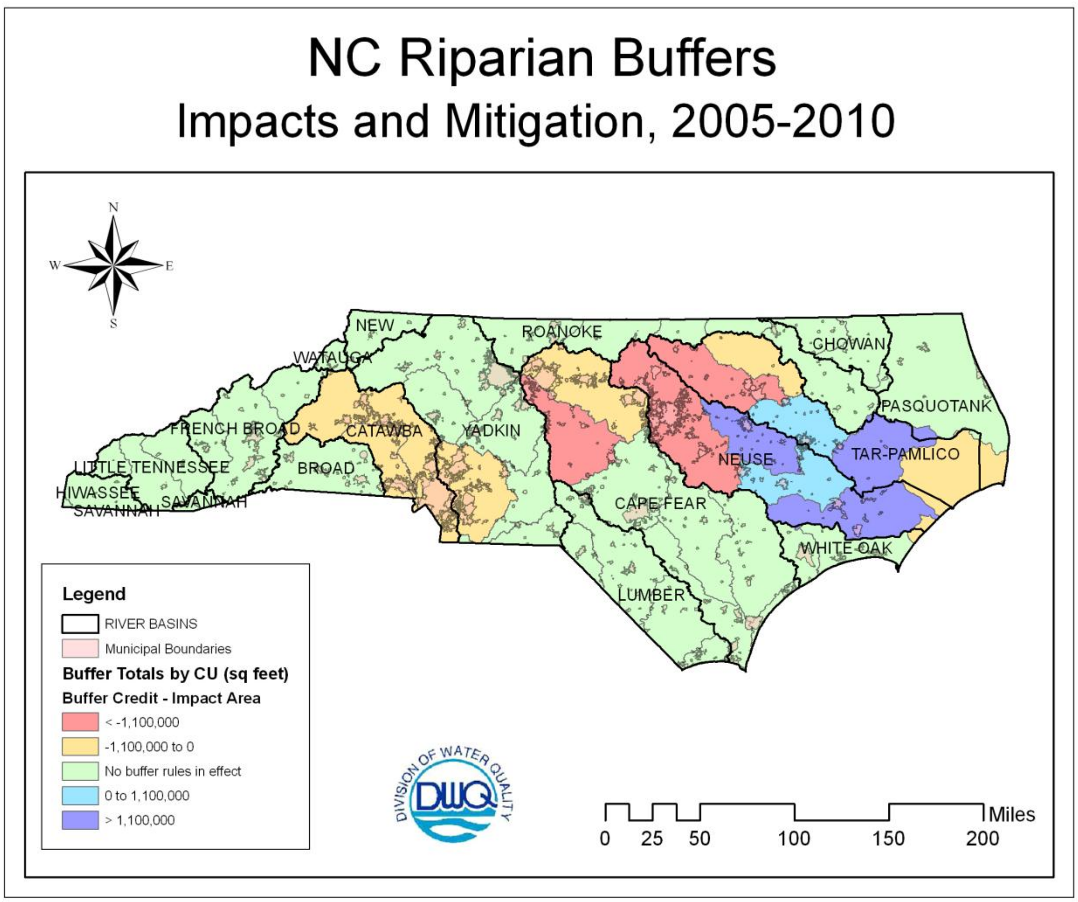

Figure 6. Differences (mitigation credits - impact square feet) between initiated riparian buffer mitigation and approved impacts by 8-digit hydrologic unit.

Statewide Totals

On a statewide basis, all three resource types demonstrated positive differences between mitigation credits and impact amounts (Table 6). Tables detailing total impact and mitigation values by CU are available in Appendix B. For Wetlands, 27 (47%) of the CUs had gains, 24 (41%) of CUs experienced losses and seven (12%) of the CUs had no impacts or mitigation. Streams had 29 (50%) of the CUs with gains, 26 (45%) of CUs with losses and three (5%) of the CUs with no impacts or mitigation. Riparian buffers in the 15 CUs in the basins subjected to buffer mitigation requirements had five (33%) of the CUs with gains and ten (67%) of the CUs with losses.

Table 6. Statewide totals and differences between wetland, stream and riparian buffer impacts and mitigation.

	Approved Impacts		Mitigation Projects			Difference (Mitig-Impacts)	
	Count	Area or Length[1]	Count	Area or Length[1]	Credits	Area or Length[1]	Credits
Wetlands	2199	5,830	299	19,050	11,886	13,220	6,057
Streams	3146	976,590	491	2,129,080	1,142,777	1,152,490	166,187
Buffers	2242	26,201,696	72	31,859,897	31,532,325	5,658,201	5,330,629

[1]Area or length values expressed in wetlands (acres), streams (linear feet), buffers (square feet)

No Net Loss (NNL) Evaluation

Since preservation does not contribute to No Net Loss goals, there was interest in applying the same quantification methods to the impact and mitigation datasets, exclusive of mitigation credits generated by the preservation of existing aquatic resources. Restoration and creation mitigation activities add wetland acres and/or replace degraded stream reaches with more stable, and usually longer, stream footage, thereby increasing aquatic resource function on the landscape. Enhancement projects are designed to provide some level of functional uplift to an existing resource. Preservation, on the other hand, simply prevents future anthropogenic impacts of a wetland area or stream reach. Generally, preservation parcels are not actively managed; they are simply protected from trespass and infringement by a long-term legal mechanism, such as a conservation easement.

Wetlands

When preservation was included in the quantification of wetland mitigation, 24 (41%) out of the 58 cataloging units in NC experienced fewer wetland mitigation credits than wetland acres approved for impact during the study timeframe. When preservation was excluded, 52% of the CUs experienced fewer wetland mitigation credits than wetland acres approved for impact, with differences between wetland mitigation credits and approved impact acres ranging from 0.1 to 98.4 wetland units, indicating a potential net loss of both wetland area and function in those CUs (Figure 7).

Preservation was utilized for wetland mitigation credit in 26 (45%) CUs during the study timeframe, and it accounted for <0.1 to 769 wetland mitigation credits per CU. Cataloging units utilizing the greatest amounts of preservation for wetland mitigation credit were Roanoke 03010107 (769 credits, which equaled 70% of wetland mitigation credits in the CU during the study timeframe), Tar-Pamlico 03020104 (561 credits, 7% of wetland mitigation credits) and Neuse 03020201 (86 credits, 57% of wetland mitigation credits). Of these three hydrologic units, only the Neuse CU appeared to experience a potential net loss in wetland function based on the difference between approved wetland impacts and non-preservation mitigation credits.

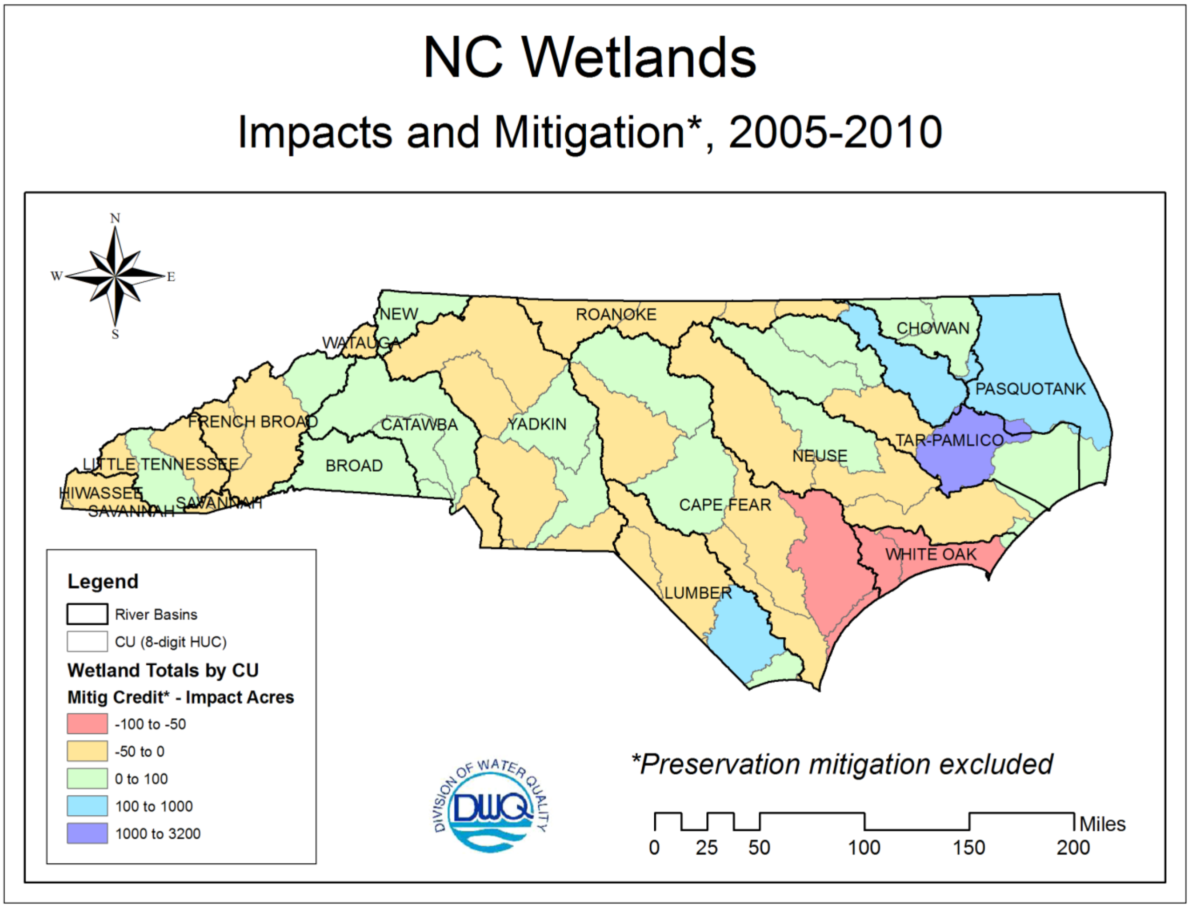

Figure 7. Differences (mitigation credits - impact acres) between initiated non-preservation wetland mitigation credits and approved impacts by 8-digit hydrologic unit.

Streams

When preservation was included in the quantification of stream mitigation, 25 (43%) out of the 58 cataloging units in NC experienced fewer stream mitigation credits than linear feet of stream approved for impact, with differences ranging from 18 to 78,246 stream mitigation credits, during the study timeframe. When preservation was excluded, 28 (48%) out of the 58 CUs experienced fewer stream mitigation credits than impacted stream feet, with differences ranging from 18 to 82,594 stream mitigation credits, indicating a potential net loss of both stream length and function in those 8-digit hydrologic units (Figure 8).

Preservation had been utilized for stream mitigation credit in 32 (55%) CUs during the study timeframe, and accounted for 155 to 40,066 stream mitigation credits per CU. Cataloging units utilizing the greatest amounts (over 25,000 credits) of preservation for stream mitigation credit were Little Tennessee 06010203 and Cape Fear 03030002 (40,066 and 29,011 credits, making up 93% and 29% of stream mitigation credits in each CU, respectively). Additional cataloging units with preservation constituting over 50% of stream mitigation credits in the CU were Savannah 03060101 (79%; 17,399 credits from preserved streams), Roanoke 03010102 (70%; 2,972 credits) and Tar-Pamlico CUs 03020101 and 03020102 (67% and 58%; 19,137 and 3,993 credits, respectively). Of these hydrologic units, Little Tennessee 06010203, Cape Fear 03030002 and Tar-Pamlico 03020101 appeared to experience a potential net loss of stream resource based on the difference between approved stream impacts and non-preservation mitigation credits.

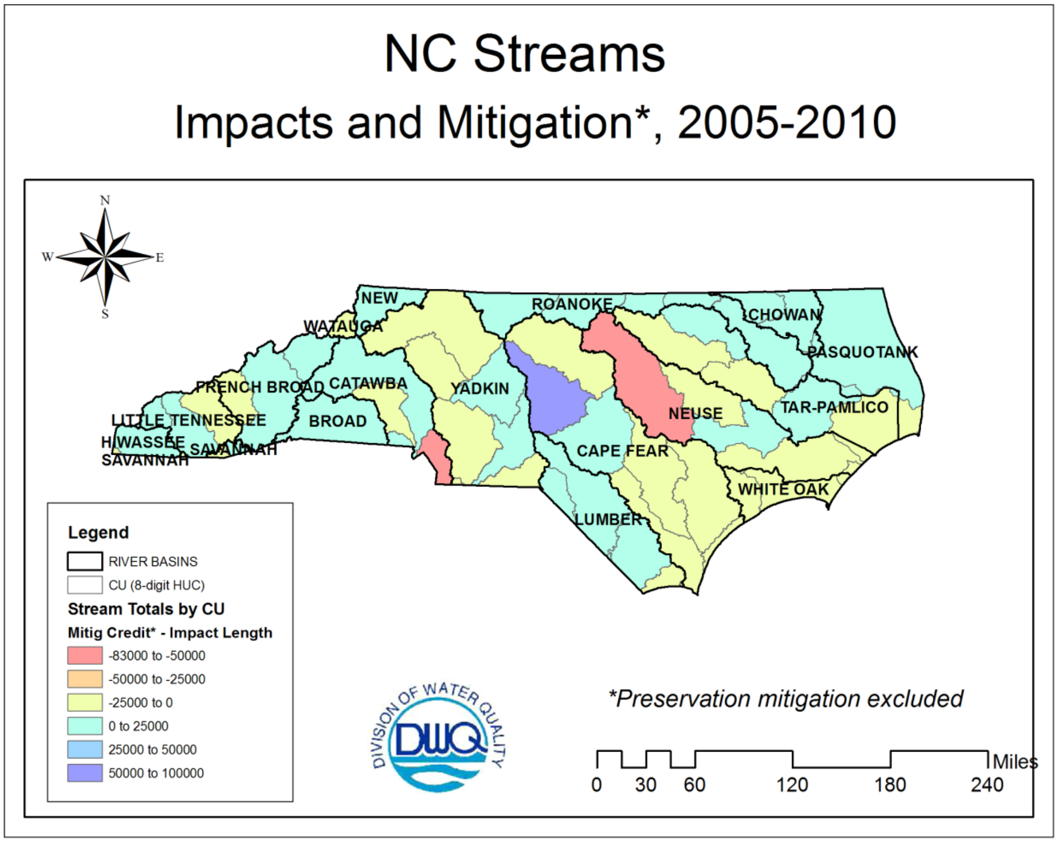

Figure 8. Differences (mitigation credits - impact acres) between initiated non-preservation stream mitigation credits and approved impacts by 8-digit hydrologic unit.

Riparian Buffers

During the timeframe of this project, North Carolina's state rules (see Table 5 for citations) only allowed for riparian buffer mitigation credits to be generated through buffer restoration or enhancement activities, rather than through preservation of existing buffers; therefore, riparian buffer net loss evaluation was based on the differences previously displayed in Figure 6. A potential net loss of riparian buffer area and function was indicated in 10 out of the 15 cataloging units subject to riparian buffer rules in NC during the study timeframe. These CUs experienced fewer buffer mitigation credits than square feet of buffer approved for impact, with negative differences ranging from 359 to 2,619,420 riparian buffer mitigation credits. Cataloging units with the greatest approved riparian buffer losses (greater than 1.1 million square feet) were Neuse 03020201 (2,619,420 square feet), Tar-Pamlico 03020101 (1,886,819 square feet) and Cape Fear 03030003 (1,840,122 square feet).

A potential net gain of riparian buffer area and function was indicated in 5 out of the 15 cataloging units subject to riparian buffer rules in NC during the study timeframe. These CUs experienced greater buffer mitigation credits than square feet of buffer approved for impact, with positive differences ranging from 979,329 to 5,826,840 riparian buffer mitigation credits. Cataloging units with the greatest potential riparian buffer gains (greater than 1.1 million square feet) via mitigation during the study timeframe were Tar-Pamlico 03020104 (1,745,413 square feet), Neuse 03020204 (3,277,238 square feet) and Neuse 03020203 (5,826,840 square feet).

Statewide NNL Evaluation

With regards to loss of aquatic resource area or length and function on a statewide basis, wetlands demonstrated a positive difference (a gain in acreage) and streams demonstrated a negative difference (a loss in linear feet) between mitigation credits and impact amounts when mitigation through preservation was excluded from consideration (Table 7). For wetlands, 36% (21) of the CUs had gains, 52% (30) CUs experienced losses and 12% (seven) of the CUs had no impacts or mitigation. Streams had 47% (27) of CUs with gains, 48% (28) of CUs with losses and 6% (three) of the CUs with no impacts or mitigation. Riparian buffer mitigation credits did not include preservation, so statewide values were the same as those previously indicated in Table 6.

Table 7. Statewide totals and differences between wetland and stream impacts and mitigation, exclusive of preservation.

	Approved Impacts		Mitigation[2] Projects			Difference (Mitig-Impacts)	
	Count	Area or Length[1]	Count	Area or Length[1]	Credits	Area or Length[1]	Credits
Wetlands	2199	5,830	215	10,813	10,239	4,983	4,409
Streams	3146	976,590	343	1,066,031	924,628	89,441	-51,962
Buffers	2242	26,201,696	72	31,859,897	31,532,325	5,658,201	5,330,629

[1]Area or length values expressed in wetlands (acres), streams (linear feet) and riparian buffers (square feet)
[2]Restoration, creation and enhancement mitigation only (preservation excluded)

Riparian buffers demonstrated a positive difference, representing a gain, between mitigation credits and impact amounts among the hydrologic units subject to riparian buffer rules. No mitigation credits were generated in CUs not subject to riparian buffer rules. Mitigation was generally not required by NCDWQ for upland riparian buffer impacts in non-subject basins, and riparian wetland impacts were generally not required to be mitigated within a riparian zone. Therefore, throughout much of North Carolina, allowable riparian buffer impacts often resulted in an unmitigated loss of buffer resources, except for any post-impact replacement of riparian vegetative cover and buffer function that may have been required by natural resource agencies other than NCDWQ. Statewide net loss values were unknown, since comprehensive riparian buffer impact data were not collected or tracked.

Land Use Classification

Wetlands

A general statewide trend of wetland resource relocation from urban to rural areas was observed. Most (67%) of the CUs in NC demonstrated lower percentages of wetland mitigation occurring in urban areas than of wetland impacts approved in urban areas (Figure 9, Appendix C).

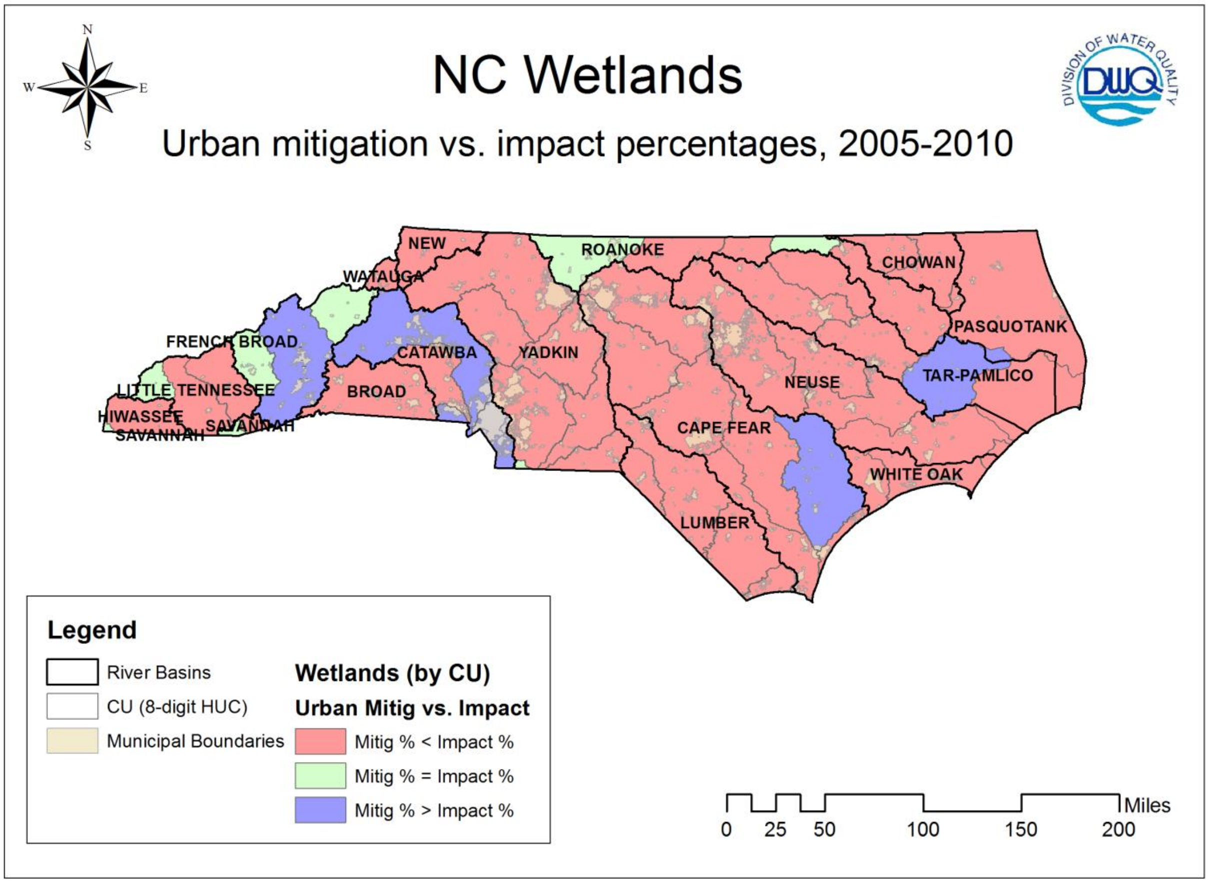

Figure 9. Comparison of urban wetland mitigation and impact percentages by 8-digit hydrologic unit.

Much of the wetland mitigation in the CUs containing Greensboro, Winston-Salem and Wilmington appeared to occur around the metropolitan areas, rather than within them (Figure 10). Similar observations were made for the Raleigh-Durham metropolitan area.

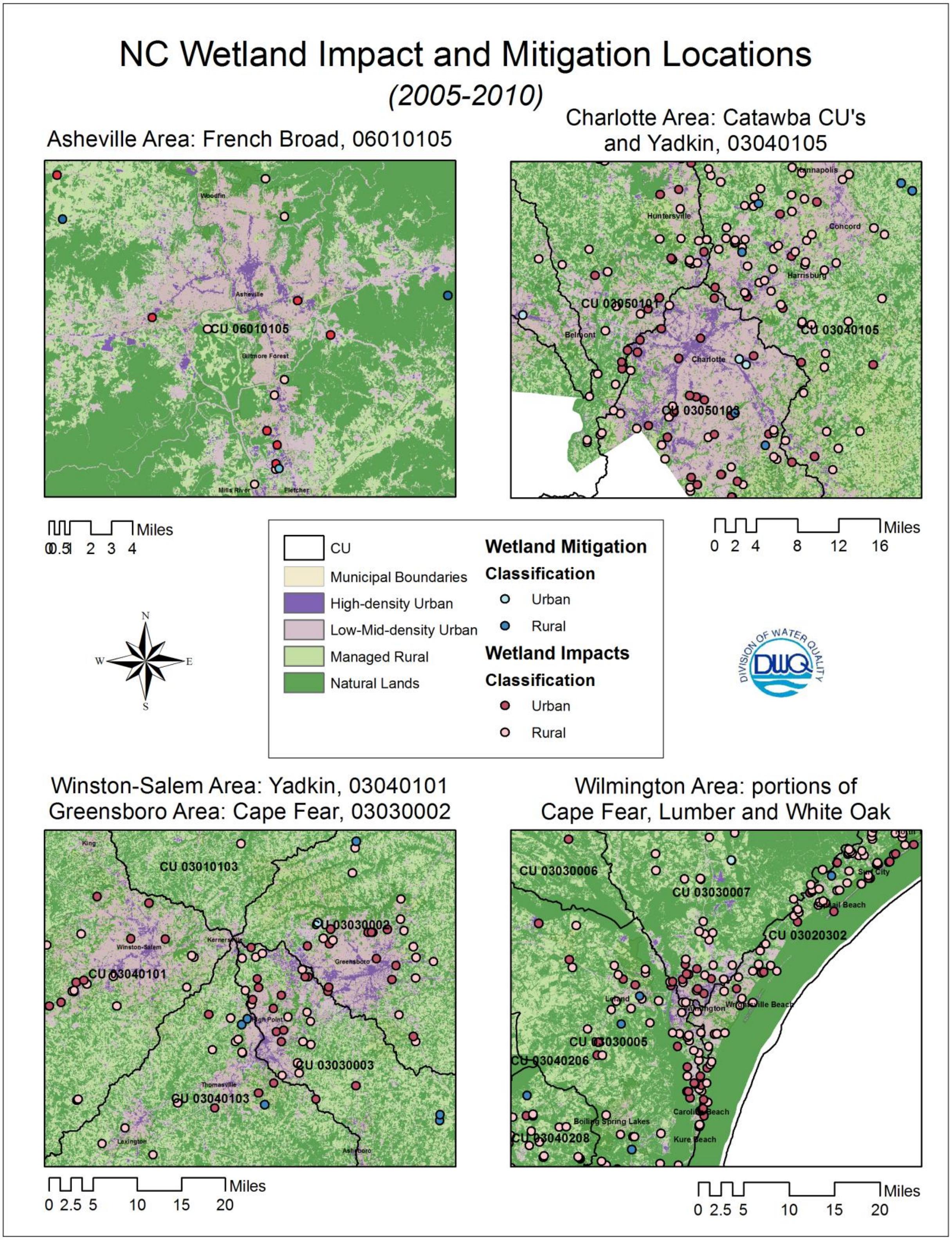

Figure 10. Wetland impact and mitigation locations in developing areas of NC.

Five CUs had percentages of urban mitigation that outpaced that of approved urban impacts (Tar-Pamlico 03020104, Cape Fear 03030007, Catawba 03050101 and 03050103, and French Broad 06010105). Two of the CUs contained the Charlotte (Catawba 03050103) and Asheville (French Broad 06010105) metropolitan areas. Urban wetland mitigation initiated in the Asheville area involved one relatively large (nearly two acres) wetland creation project constructed on private land near a mall development. Wetland mitigation in Catawba 03050103 included wetland enhancement and preservation projects instituted in urban areas by Charlotte-Mecklenburg Storm Water Services under its municipal umbrella mitigation bank (City of Charlotte, et al., 2004), which focused on stream and wetland mitigation projects to offset impacts resulting from public infrastructure and stormwater management projects (City of Charlotte and Mecklenburg County Government, 2012). Other urban mitigation in the Charlotte area involved wetland creation and preservation projects initiated under mitigation plans approved as part of the 401 Certifications for several residential and retirement community development projects (Figure 10).

Two other CUs that returned a higher percentage of urban wetland mitigation were each due to a single provider in the CU. In Tar-Pamlico 03020104, rural wetland impacts and both urban and rural mitigation values were heavily weighted by the PCS Phosphate, Inc. approved impact and mitigation projects (PCS Phosphate Company, Inc. and CZR Incorporated, 2008). In Cape Fear 03030007, the only wetland mitigation project (classified as urban) instituted during the project timeframe was a 0.94-acre on-site wetland restoration conducted by NCDOT at a bridge crossing on NC Highway 210 (North Carolina Department of Transportation, 2006).

There were CUs in which urban mitigation and impact values were equal because there were no impacts or mitigation (Chowan 03010201 and 03010202, Yadkin 03040202, Broad 03050109, Savannah 03060102, French Broad 06010107, Little Tennessee 06010201, Watauga 06010102, Hiwassee 06020003)[2]; all impacts and mitigation occurred in rural areas (French Broad 06010106 and 06010108); or cumulative impacts were less than one acre, occurred only in rural settings, and no mitigation was initiated in the CU (Roanoke 03010103 and 03010106, Little Tennessee 06010204) (Figure 9).

Streams

As with wetlands, streams had a similar statewide trend of aquatic resource relocation from urban to rural areas. Sixty-four percent of the CUs in NC demonstrated lower percentages of stream mitigation initiated in urban areas than of stream impacts approved in urban areas (Figure 11, Appendix C). However, CUs in the eastern part of the state and much of the Neuse river basin, including the developing areas around Wilmington and Raleigh, showed urban mitigation percentages that were greater than impact percentages in urban areas. There were CUs in which there were no impacts or mitigation (Chowan 03010201 and 03010202, Yadkin 03040202, Broad 03050109, Watauga 06010102, French Broad 06010107, Little Tennessee 06010201, and Hiwassee 06020003)[2] and CUs in which all impacts and mitigation occurred in rural areas (Chowan 03010203 and 03010204, Cape Fear 03030005).

[2] All of the CU's demonstrating no wetland and/or stream impacts were watersheds with extremely small land areas within NC. The bulk of these CU's exist in neighboring states, but small areas cross the state border and are subject to North Carolina's impact permitting and mitigation programs.

The Triad area around Greensboro and Winston-Salem demonstrated both higher and lower percentages of urban mitigation as compared with urban impacts, depending upon CU. The western part of the state, including the developing areas around Charlotte and Asheville, generally had higher percentages of mitigation than impacts in rural areas, indicating a potential shift from urban impacts to rural mitigation (Figure 11).

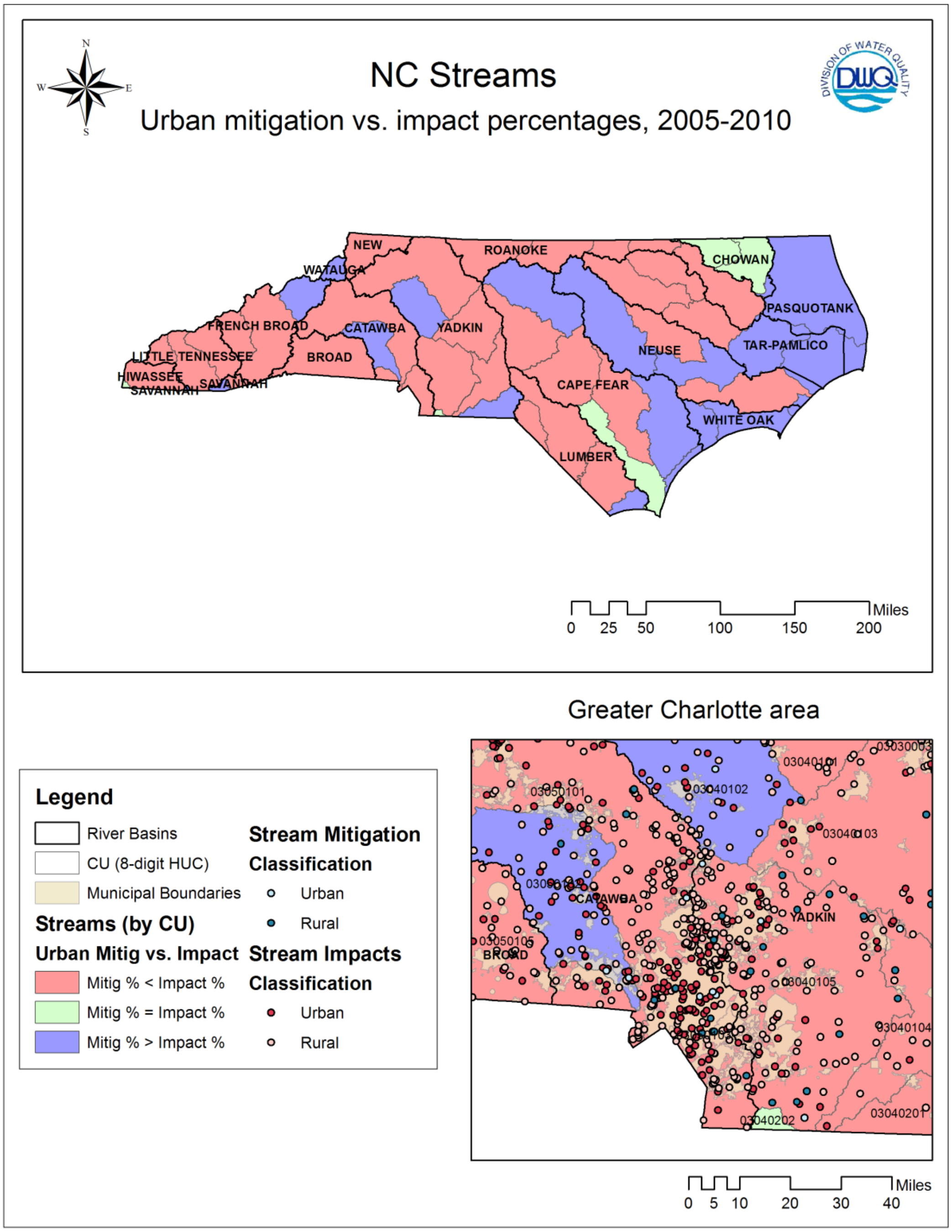

Figure 11. Comparison of urban stream mitigation and impact percentages by 8-digit hydrologic unit.

Riparian Buffers

The statewide trend for riparian buffer mitigation and impacts was similar to that for wetlands, with an apparent shift of buffer resources from urban to rural areas (Figure 12). In CUs subject to riparian buffer rules (Table 5), all but two (Neuse 03020202, Tar-Pamlico 03020104) showed a lower percentage of mitigation than impacts in urban areas. The difference in Tar-Pamlico 03020104 was again due to the relatively large influence of both impacts and mitigation associated with the rural PCS Phosphate, Inc. mining project in the CU. In Neuse 03020202, there was a single urban buffer mitigation project of nearly one million square feet of riparian buffer restoration instituted by NCEEP as part of a mitigation project involving stream restoration, wetland creation and nearly 42 acres of reforestation of stream banks, floodplains and upland slopes (Williams, 2007). All other buffer mitigation undertaken in the CU was classified as rural.

Neuse River Basin impacts were concentrated in Raleigh and the surrounding, growing metropolitan areas. While 1.25 million urban buffer mitigation credits (equivalent to the same number of square feet, or 28.7 acres, of riparian buffer restoration) were initiated in Durham, Holly Springs and on the south side of Raleigh, the remaining nearly 8.5 million buffer mitigation credits in Neuse 03020201 were located in more rural settings outside of municipal areas (Figure 12).

Statewide Totals

On a statewide basis, all three resource types demonstrated greater total amounts for impacts and for mitigation in rural areas (Table 8), and greater proportions of mitigation than impacts in rural areas (52% of the CUs for wetlands, 53% of the CUs for streams, and 53% of the buffer CUs). Tables detailing total impact and mitigation values by classification type and CU are available in Appendix C.

Table 8. Statewide NC totals of wetland, stream and riparian buffer impacts and mitigation classified as urban or rural, 2005-2010.

	Approved Impacts		Mitigation Credits		Mitigation Area or Length[1]	
	Urban	Rural	Urban	Rural	Urban	Rural
Wetlands	418	5,402	980	10,906	1,159	17,891
Streams	286,084	665,750	165,003	977,775	254,131	1,874,949
Buffers	7,210,371	18,797,962	4,776,285	26,756,041	4,776,285	27,083,612

[1]Area or length values expressed in wetlands (acres), streams (linear feet) and riparian buffers (square feet)

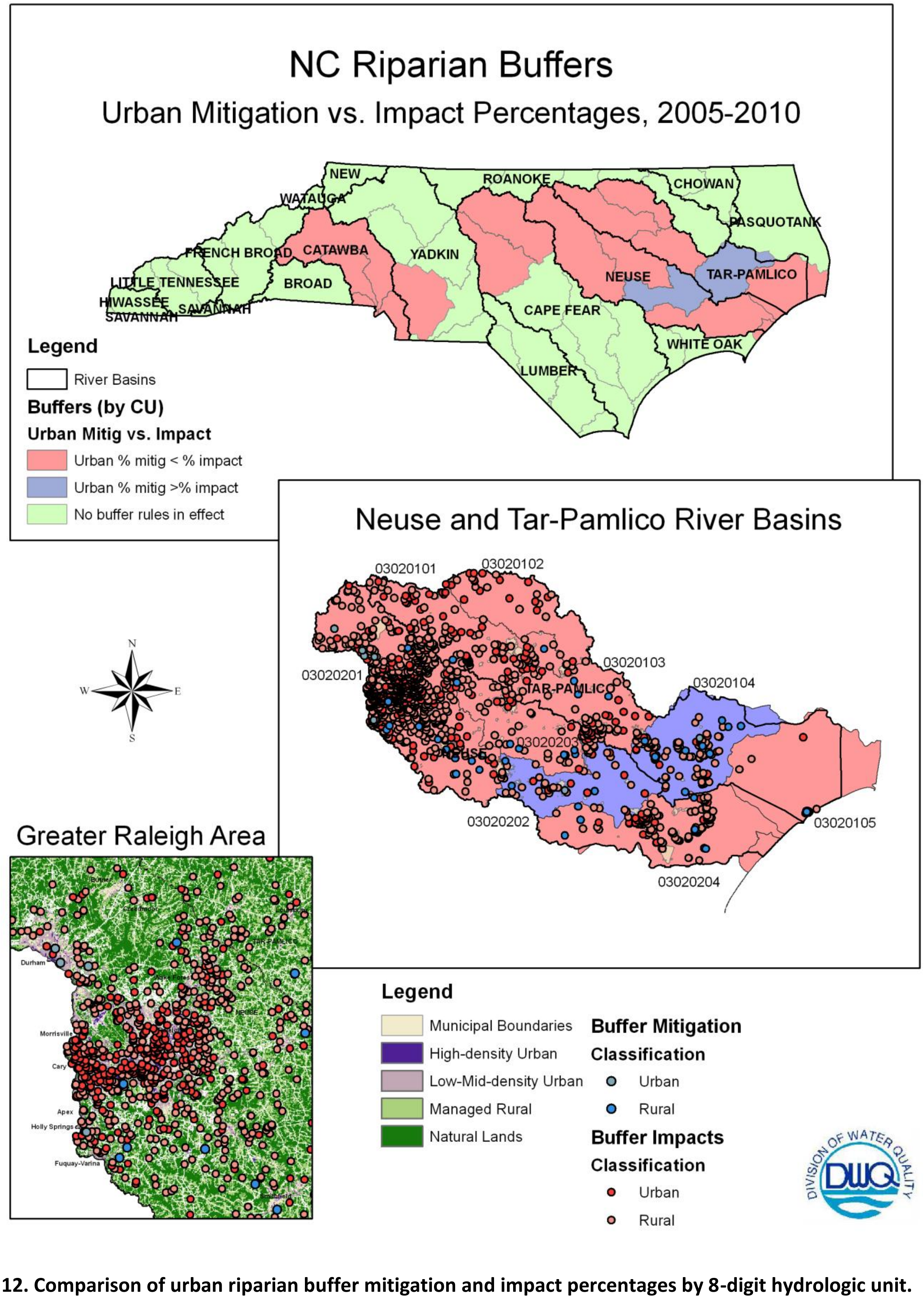

Figure 12. Comparison of urban riparian buffer mitigation and impact percentages by 8-digit hydrologic unit.

Discussion and Recommendations

Data Management

Imputation of missing data, especially missing geographic coordinate data, and verifying location data for quality assurance purposes became monumental tasks during the course of this project. While latitude and longitude (decimal degrees) were fields on the PCN, many applications were submitted with empty coordinate fields generating the corresponding empty fields in the BIMS. It is critical for DWQ to require permit applicants to provide location information for every project. Requiring permit applicants to complete these fields would contribute to more complete data in BIMS, allowing greater opportunities for regulatory data analysis and a smoother transition when a spatial dimension is added to BIMS at some point in the future. When present, geographic coordinates typically provided reliable data on a CU-scale. There are many user friendly resources available to the public that would allow applicants to determine fairly accurate latitude and longitude values for a proposed impact or mitigation site.

Data extracted from the BIMS and NCDWQ mitigation databases were extremely valuable for this analysis, although both sources required additional data entry to create a nearly complete dataset. USACE data queried from the Operations and Maintenance Business Information Link (OMBIL) Regulatory Module (ORM-2) were also robust, but could not be linked with NCDWQ data due to data incompatibility. Utilization of a common project identification name or number field by the permitting agencies (USACE, NCDWQ and NC Division of Coastal Management) would facilitate data sharing and provide greater opportunities for analyses related to aquatic resource impacts and mitigation over time and space. At the time of this report, impact data continued to be entered into BIMS as previously described. However, funding for supporting NCDWQ staff to maintain the mitigation database into the future had not been obtained. Since comprehensive mitigation project data cannot be tracked in BIMS, a plan should be devised to continue long-term development of this supplemental database.

Aquatic Resource Quantification

Lower values of mitigation than impacts in a CU may be cause for concern; however, it does not necessarily indicate a net loss of aquatic resources. Mitigation to offset permitted losses may have been drawn from mitigation sites initiated prior to July 1, 2005 whose credits were previously unallocated. Similarly, a larger amount of mitigation did not necessarily indicate a long-term gain in aquatic resources, since the initiated mitigation could be used to offset future losses. Further analysis involving pairing of mitigation projects with the specific impacts they were offsetting, without restrictions on event dates, would be necessary to confirm the presence or absence of a net gain or loss in any given CU. State personnel, academic researchers and public citizens could benefit from the development of a simplified and unified database across regulatory agencies and mitigation providers for accessing this kind of paired impact-mitigation information (BenDor, et al., 2009, Hill, et al., 2011).

Of the three resource types, streams resulted in the smallest overall difference between approved impact and mitigation credit amounts, and returned a negative value when preservation mitigation was excluded from the calculation. While Table 6 above indicated gains in mitigation over approved impact amounts, a recent study (funded by an EPA Wetland Program Development Grant, WL 9643505-01) returned moment-in-time mitigation success rates of 74% for wetlands and 75% for streams (riparian buffers were not evaluated) in North Carolina (Hill, et al., 2011). If these values were applied to the wetland and stream mitigation totals, including preservation, during 2005-2010, a net loss of streams statewide would be indicated (**Table 9**). If preservation mitigation credits were excluded, the net loss would have been even greater.

Table 9. Statewide totals and differences between wetland and stream impacts and mitigation; mitigation weighted by success rates.

	Approved Impacts		**Mitigation Components (weighted by success rates)**			**Weighted Difference (Mitig-Impacts)**	
	Count	Area or Length	Count	Area or Length	Credits	Area or Length	Credits
Wetlands	2,199	5,830	299	14,097	8,796	8,267	2,966
Streams	3,146	976,590	491	1,596,810	857,083	620,220	-119,507

Notes:
Area or length values expressed in wetlands (acres), streams (linear feet)
Wetland mitigation area and credits weighted by 74% success rate
Stream mitigation length and credits weighted by 75% success rate

Several factors could have contributed to the potential loss of streams. Multipliers for stream mitigation requirements were generally lower than those applied to wetlands. While approved wetland impacts exceeding mitigation thresholds were usually required to be mitigated at two credits per one acre of impact, stream impacts exceeding 150 linear feet may have required only 1:1 replacement, depending upon the permitting agencies' policies and the quality of the impacted stream (NCDENR, 2009; US Army Corps of Engineers, et al., 2003). While the USACE mitigation threshold captured most wetland impacts ≥ 0.1 acre, many stream impacts were below the regulatory agencies' general stream mitigation threshold of 150 linear feet. Of the 3182 projects with approved stream impacts during the study timeframe, 72% had total stream impacts below 150 linear feet per project, and therefore generally did not require compensatory mitigation. Mitigation for impact to any length of intermittent stream was not required by NCDWQ before October 16, 2009 (NCDENR, 2009). Given the difficulties recently noted in regards to Piedmont stream mitigation (Hill, et al., 2011) it was especially concerning that North Carolina may have been losing stream length in the Raleigh and Charlotte metropolitan areas.

Over 90% of North Carolina's wetlands exist in the Coastal Plain physiographic province. Understandably, this is the province with the most wetland impact and mitigation activity, including both the greatest losses and gains in wetland area. Statewide wetland totals, while showing a positive gain, were heavily influenced by the large amount of wetland mitigation undertaken by PCS Phosphate, Inc., as previously discussed. Without consideration of PCS Phosphate, Inc. impacts or mitigation, wetland values would have been 2198 impacts totaling 1977 acres, and 274 mitigation project components totaling 9905 acres or 4728 credits (over 3000 of which were generated via wetland restoration); thus yielding a positive difference between mitigation credits and approved impacts with or without weighting by a mitigation success factor, and with or without the inclusion of preservation mitigation credits.

Aquatic Resource Classification by Urban and Rural Land Use Types

Responses to comments published with the 2008 federal mitigation rule suggested that "third-party mitigation should focus on the ecological benefits that the…projects will provide to the watershed. This may or may not result in migration of aquatic resources from urban to rural areas within that watershed" (Department of Defense and Environmental Protection Agency, 2008). BenDor, et al. (2009) reported that "wetland mitigation programs commonly promote shifts…of wetlands across space, including movements from urban to rural areas," and found that in NC "while the compensation sites were spread throughout the state, impact sites were concentrated in the rapidly developing urban areas." Based on the current study results, it appears that North Carolina's system of impact permitting and mitigation approval has relocated aquatic resources from urban areas into more rural settings. Some loss of local wetland function may have been replaced by stormwater best management practices required to be incorporated into the designs of residential and non-residential development projects in which land disturbance area and/or impervious surface cover exceeded regulatory thresholds (North Carolina Division of Water Quality, 2007). However, these systems were designed with an expectation of perpetual maintenance, while compensatory mitigation projects were expected to become self-sustaining, natural, preserved ecosystems over the long-term. Further, engineered stormwater treatment devices provide little in the way of stream and riparian buffer functional replacement.

The higher percentage of rural stream mitigation in the Charlotte area was surprising due to the presence of a large municipal mitigation bank that had embarked on many urban stream restoration projects. However, an explanation was found in comparing the amounts of urban impacts (over 79,000 linear feet) and rural impacts (nearly 9,000 linear feet). While urban and rural mitigation amounts were similar, there was likely not enough opportunity for urban stream mitigation to offset the magnitude of approved urban impacts in and around CU 03050103. If opportunities had been created in this CU, they may have been prohibitively expensive and would have removed desirable land from developed status or development possibilities. The far western areas of NC such as Asheville faced different limitations in achieving urban mitigation: the area of urbanized lands was very small compared to the amount of rural land. While most of the impacts were approved in growing areas, there were few previously-impacted urban streams to be restored, and the relatively few mitigation opportunities that did exist were located on private lands in more rural settings (e.g. CU 06010202 in the Little Tennessee River Basin, Table 10).

Table 10. Stream impacts classified as urban and rural in the Little Tennessee River Basin, CU 06010202.

CU 06010202	Impacts (feet)	Mitigation (credits)
Urban	1935	190
Rural	2431	6602

While questions about mitigation service areas and proximity to impacts have been largely addressed with the current watershed-scale emphasis on the CU, there has been relatively little discussion among natural resource agencies with regard to the spatial and ecological relationships between land use type and impact and mitigation locations. The current study pointed to the likelihood of a general relocation of aquatic resources across the landscape from urban and urbanizing areas into more rural settings. The implications of this relocation are unclear, and likely vary depending upon the scale of consideration and the location of impacts relative to their compensatory mitigation. If water quality, wildlife habitat and other ecological services were enhanced on a watershed scale, then perhaps the results of this shift were net positives in terms of aquatic resource functions. However, there are likely aquatic function reductions occurring in developing areas. Further studies correlating spatial relocation with environmental metrics, such as trends in water quality measurements or biotic indices, may be useful in determining whether or not the landscape-scale relocation is an issue at local, regional and/or statewide levels. Results will be presented to the NC Interagency Review Team, Environmental Management Commission and other interested parties to inform discussions about possible related policy or rule changes as well as to suggest additional research necessary to support decision-making about the future direction of compensatory mitigation in the state.

Acknowledgements

This project was made possible through the support of the US Environmental Protection Agency and funded by an EPA Wetland Program Development Grant (CD 95415709-01) to the NC Division of Water Quality. This is the final report for that grant. Many thanks to external agencies' staff who met with NCDWQ project staff and provided impact and mitigation data: Henry Wicker, US Army Corps of Engineers, Wilmington District and Colleen Kiley, NC Ecosystem Enhancement Program. NCDWQ staff and volunteers participated in a heroic effort to complete and QA the dataset: Eric Kulz, Greg Rubino and Bill Herring; and to review and comment on the draft project report.

References

BenDor, T., J. Sholtes and M. W. Doyle, 2009. *Landscape characteristics of a stream and wetland mitigation banking program*. Ecological Applications 19(8):2078-2092.

City of Charlotte and Mecklenburg County Government, 2012. *Stream and Wetland Mitigation Bank (City)*. http://charmeck.org/stormwater/StormWaterAgencies/Pages/StreamandWetlandMitigationBank%28City%29.aspx.

City of Charlotte (sponsor), US Army Corps of Engineers, US Environmental Protection Agency, US Fish and Wildlife Service, NC Division of Water Quality and NC Wildlife Resources Commission, June 16, 2004. *Agreement to Establish the City of Charlotte Umbrella Stream and Wetland Mitigation Bank in Mecklenburg County, North Carolina*.

Department of Defense (Department of the Army, Corps of Engineers) and Environmental Protection Agency, 2008. *Compensatory mitigation for losses of aquatic resources*. 33 CFR Parts 325 and 332, 40 CFR Part 230. Federal Register, Vol. 73, No. 70, April 10, 2008.

Department of the Army and Environmental Protection Agency, 1990. *Memorandum of Agreement: The Determination of Mitigation Under the Clean Water Act Section 404(b)(1) Guidelines*. http://water.epa.gov/lawsregs/guidance/wetlands/mitigate.cfm.

Hill, T., E. Kulz, B. Muñoz and J. Dorney, 2011. *Compensatory stream and wetland mitigation in North Carolina: An evaluation of regulatory success*. NC Division of Water Quality: Raleigh, NC.

McKerrow, A.J., S.G. Williams and J.A. Collazo, 2006. *The North Carolina Gap Analysis Project: Final Report.* North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University, Raleigh, North Carolina. xiv + 110 pp. + appendices.

National Research Council, 2001. *Compensating for wetland losses under the Clean Water Act*. Washington, D.C.: National Academy Press.

Natural Resources Conservation Service, 2011. *National Resource Inventory (search: North Carolina)*. http://www.nc.nrcs.usda.gov/technical/nri/index.html.

NCDENR, Division of Water Quality, August 12, 2009. *Update on permitting programs for Waters of the State administered by the Division of Water Quality*. http://portal.ncdenr.org/web/wq/swp/ws/401/publicnotices/archives#2009.

North Carolina Department of Environment and Natural Resources and United States Army Corps of Engineers, Wilmington District, 1998. *Memorandum of Understanding*. http://www.nceep.net/images/WRP_MOU.pdf.

North Carolina Department of Environment and Natural Resources, North Carolina Department of Transportation and United States Army Corps of Engineers, Wilmington District, 2003. *Memorandum of Agreement*. http://www.nceep.net/images/Final%20MOA.pdf.

North Carolina Department of Environment and Natural Resources, 2010; *Ecosystem Enhancement Program In-Lieu Fee Instrument*, July, 28, 2010. http://www.nceep.net/pages/pdfs/interim_final_instrument_8_2_10.pdf.

North Carolina Department of Transportation, January 11, 2006. *Restoration Plan for Northeast Cape Fear River Wetland at Bridge No. 21 on NC 210*. Pender County TIP B-4223. Federal Aid Project No. BRSTP-210(4). WBS No. 33467.1.1

North Carolina Division of Water Quality, Surface Water Protection Section, 2005. *Guidance on the Use of Compensatory Mitigation in Adjacent Cataloging Units*. http://portal.ncdenr.org/web/wq/swp/ws/401/certsandpermits/mitigation/memos.

North Carolina Division of Water Quality, July 2007. *Stormwater Best Management Practices Manual*. http://portal.ncdenr.org/web/wq/ws/su/bmp-manual.

PCS Phosphate Company, Inc. Environmental Affairs Department and CZR Incorporated, April 2008. *Compensatory Section 404/401 Mitigation Plan: Comprehensive Approach, In support of the PCS Phosphate Company, Inc. L Alternative Mine Continuation (First 15 Years-NCPC and Bonnerton Tracts)*. Aurora, North Carolina: PCS Phosphate, Inc.

Platt, R.H., 2004. *Land Use and Society: Geography, Law, and Public Policy*, revised ed. Washington, DC: Island Press, pp. 10-21.

SAP Business Objects: Enterprise XI, Product and Sales Information Product: 12.1.0 © Copyright 2010 SAP AG. All rights reserved. http://www.sap.com/solutions/sapbusinessobjects.

Seaber, P.R., Kapinos, F.P. and Knapp, G.L., 1987. *Hydrologic Unit Maps*. U.S. Geological Survey Water-Supply Paper 2294, 63 p.

United States Department of Agriculture, Economic Research Service, 2005. *Land Use, Value, and Management: Agricultural Land Use Change*. http://www.ers.usda.gov/Briefing/LandUse/agchangechapter.htm.

United States Department of Agriculture, Farm Service Agency, 2010. *National Agriculture Imagery Program (NAIP)*. http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai.

US Army Corps of Engineers, Wilmington District; NC Division of Water Quality; US Environmental Protection Agency, Region IV; Natural Resources Conservation Service and NC Wildlife Resources Commission, 2003. *Stream Mitigation Guidelines*. Wilmington, NC.

Waldroup, K., September 13, 2007. In *Meeting of the North Carolina Environmental Management Commission minutes*. http://h2o.enr.state.nc.us/admin/emc/2007/documents/Sept13-2007Minutes.pdf.

Wilkinson, J.B., J.M. McElfish, Jr., R. Kihslinger, R. Bendick and B.A. McKenney, August 4, 2009. *The Next Generation of Mitigation: Linking Current and Future Mitigation Programs with State Wildlife Action Plans and Other State and Regional Plans.* Washington, D.C.: Environmental Law Institute and The Nature Conservancy.

Williams, R.K., March 28, 2007. *Restoration Plan: Adkin Branch Stream Restoration Project*. Raleigh, NC: Ko And Associates, P C.

Womble, P., and M. Doyle, 2012. *The Geography of Trading Ecosystem Services: A Case Study of Wetland and Stream Compensatory Mitigation Markets*. Harvard Environmental Law Review 36(1).

Appendix A: Impact Dataset

	Resource Type	BIMS Indiv Impacts	Impact sum by Proj ID	Impacts (removed empty coords)	Impacts (removed out of CUs)	**Total excluded from CU quantif**	Impacts (removed out of NC bound)	**Total excluded from NC bound**	% Included in analysis
Count	Wetlands	4759	2261	2246	2199	**62**	2183	**78**	97%
	Streams	5939	3197	3182	3146	**51**	3118	**79**	98%
	Buffers	4054	2262	2251	2242	**20**	2230	**32**	99%
Size	Wetlands	5962	5962	5959	5830	**132**	5820	**142**	98%
	Streams	890822	890822	888016	878950	**11872**	854194	**36628**	96%
	Buffers	26341740	26341740	26282398	26201696	**140044**	26008333	**333407**	99%

Note: Size expressed in wetlands (acres), streams (linear feet) and buffers (square feet)

Appendix B: Quantification of Impacts and Mitigation by CU

River Basin	CU	Impacts		Mitigation			Mitigation - Impacts		Mitigation (as % of Impacts)	
		Count	Size (acres)	Count	Size (acres)	Credit	Size (acres)	Credit	By Size	By Credit
Roanoke	03010102	6	0.22	0	0.00	0.00	-0.22	-0.22	0%	0%
Roanoke	03010103	4	0.20	0	0.00	0.00	-0.20	-0.20	0%	0%
Roanoke	03010104	7	0.58	0	0.00	0.00	-0.58	-0.58	0%	0%
Roanoke	03010106	4	0.44	0	0.00	0.00	-0.44	-0.44	0%	0%
Roanoke	03010107	31	92.70	14	4173.57	1091.97	4080.87	999.27	4502%	1178%
Chowan	03010201	1	0.07	0	0.00	0.00	-0.07	-0.07	0%	0%
Chowan	03010202	1	0.08	0	0.00	0.00	-0.08	-0.08	0%	0%
Chowan	03010203	16	19.98	8	163.85	84.22	143.87	64.24	820%	421%
Chowan	03010204	5	2.11	2	13.00	12.45	10.89	10.34	615%	589%
Pasquotank	03010205	169	242.82	12	1080.65	1056.96	837.83	814.15	445%	435%
Tar-Pamlico	03020101	60	32.97	9	151.79	84.92	118.82	51.95	460%	258%
Tar-Pamlico	03020102	7	2.03	11	75.50	34.46	73.47	32.43	3723%	1699%
Tar-Pamlico	03020103	39	14.76	4	7.58	5.39	-7.18	-9.37	51%	37%
Tar-Pamlico	03020104	77	4312.05	36	10551.93	8015.45	6239.88	3703.40	245%	186%
Tar-Pamlico	03020105	54	5.95	2	36.00	36.00	30.05	30.05	605%	605%
Neuse	03020201	296	98.95	19	497.55	152.48	398.60	53.54	503%	154%
Neuse	03020202	39	66.05	4	34.98	30.38	-31.07	-35.66	53%	46%
Neuse	03020203	36	7.97	4	67.92	30.89	59.95	22.92	853%	388%
Neuse	03020204	87	44.48	1	47.10	15.70	2.62	-28.78	106%	35%
White Oak	03020301	102	87.96	0	0.00	0.00	-87.96	-87.96	0%	0%
White Oak	03020302	157	110.57	7	24.75	21.69	-85.82	-88.88	22%	20%
Cape Fear	03030002	126	45.96	25	124.00	84.79	78.04	38.83	270%	184%
Cape Fear	03030003	44	22.53	8	34.62	15.66	12.09	-6.87	154%	70%
Cape Fear	03030004	129	118.81	17	355.45	217.15	236.64	98.34	299%	183%
Cape Fear	03030005	99	37.05	9	212.55	69.18	175.50	32.12	574%	187%
Cape Fear	03030006	24	3.12	2	64.40	12.88	61.28	9.76	2065%	413%
Cape Fear	03030007	62	99.31	1	0.94	0.94	-98.37	-98.37	1%	1%
Yadkin	03040101	36	5.78	0	0.00	0.00	-5.78	-5.78	0%	0%
Yadkin	03040102	12	1.08	3	24.80	4.96	23.72	3.88	2290%	458%
Yadkin	03040103	22	8.25	8	15.69	9.38	7.44	1.12	190%	114%
Yadkin	03040104	9	1.43	1	1.70	1.70	0.27	0.27	119%	119%
Yadkin	03040105	83	81.43	11	47.16	33.05	-34.27	-48.38	58%	41%

Quantified by 8-digit hydrologic unit

River Basin	CU	Impacts		Mitigation			Mitigation - Impacts		Mitigation (as % of Impacts)	
		Count	Size (acres)	Count	Size (acres)	Credit	Size (acres)	Credit	By Size	By Credit
Yadkin	03040201	3	1.79	0	0.00	0.00	-1.79	-1.79	0%	0%
Yadkin	03040202	0	0.00	0	0.00	0.00	0.00	0.00	100%	100%
Lumber	03040203	26	63.40	8	134.46	64.76	71.06	1.36	212%	102%
Lumber	03040204	7	48.50	1	5.00	5.00	-43.50	-43.50	10%	10%
Lumber	03040206	30	6.70	5	860.00	510.30	853.30	503.60	12838%	7617%
Lumber	03040208	56	40.88	3	86.00	83.00	45.12	42.12	210%	203%
Catawba	03050101	61	14.38	21	64.42	45.10	50.04	30.72	448%	314%
Catawba	03050102	8	2.48	9	20.45	7.90	17.97	5.42	823%	318%
Catawba	03050103	58	56.02	8	13.35	7.32	-42.67	-48.71	24%	13%
Broad	03050105	18	4.44	2	9.40	9.40	4.96	4.96	212%	212%
Broad	03050109	0	0.00	0	0.00	0.00	0.00	0.00	100%	100%
Savannah	03060101	3	0.07	1	1.60	0.32	1.53	0.25	2192%	438%
Savannah	03060102	0	0.00	0	0.00	0.00	0.00	0.00	100%	100%
New	05050001	19	1.70	13	30.31	17.40	28.61	15.70	1780%	1022%
Watauga	06010102	0	0.00	0	0.00	0.00	0.00	0.00	100%	100%
Watauga	06010103	7	0.54	0	0.00	0.00	-0.54	-0.54	0%	0%
French Broad	06010105	31	11.12	3	2.64	1.03	-8.48	-10.09	24%	9%
French Broad	06010106	6	0.88	2	1.06	0.83	0.18	-0.05	120%	94%
French Broad	06010107	0	0.00	0	0.00	0.00	0.00	0.00	100%	100%
French Broad	06010108	5	0.62	2	4.80	3.65	4.18	3.03	772%	587%
Little Tennessee	06010201	0	0.00	0	0.00	0.00	0.00	0.00	100%	100%
Little Tennessee	06010202	4	6.07	2	8.29	7.69	2.22	1.62	137%	127%
Little Tennessee	06010203	5	0.37	0	0.00	0.00	-0.37	-0.37	0%	0%
Little Tennessee	06010204	3	0.47	0	0.00	0.00	-0.47	-0.47	0%	0%
Hiwassee	06020002	5	1.71	1	0.30	0.15	-1.41	-1.56	18%	9%
Hiwassee	06020003	0	0.00	0	0.00	0.00	0.00	0.00	100%	100%

Quantified by 8-digit hydrologic unit

River Basin	CU	Impacts		Mitigation			Mitigation - Impacts		Mitigation (as % of Impacts)	
		Count	Size (feet)	Count	Size (feet)	Credit	Size (feet)	Credit	By Size	By Credit
Roanoke	03010102	14	1136	4	17400	4242	16264	3106	1532%	373%
Roanoke	03010103	31	4115	2	10873	10727	6758	6612	264%	261%
Roanoke	03010104	21	2664	5	34209	17086	31545	14422	1284%	641%
Roanoke	03010106	13	755	2	5079	5079	4324	4324	673%	673%
Roanoke	03010107	22	4259	3	22969	17553	18710	13294	539%	412%
Chowan	03010201	1	18	0	0	0	-18	-18	0%	0%
Chowan	03010202	0	0	0	0	0	0	0	100%	100%
Chowan	03010203	20	327	4	15549	10094	15222	9767	4755%	3087%
Chowan	03010204	10	355	2	5492	3418	5137	3063	1547%	963%
Pasquotank	03010205	37	4143	3	9867	9867	5724	5724	238%	238%
Tar-Pamlico	03020101	116	20298	20	104990	28395	84692	8098	517%	140%
Tar-Pamlico	03020102	22	910	9	23254	6913	22344	6002	2555%	759%
Tar-Pamlico	03020103	37	5261	2	6519	4344	1258	-917	124%	83%
Tar-Pamlico	03020104	21	33387	15	75689	57078	42302	23691	227%	171%
Tar-Pamlico	03020105	8	609	0	0	0	-609	-609	0%	0%
Neuse	03020201	517	100180	19	41123	21935	-59057	-78246	41%	22%
Neuse	03020202	45	21712	6	31258	28141	9546	6429	144%	130%
Neuse	03020203	34	3686	1	311	311	-3375	-3375	8%	8%
Neuse	03020204	28	2603	1	1850	1850	-753	-753	71%	71%
White Oak	03020301	18	1665	0	0	0	-1665	-1665	0%	0%
White Oak	03020302	59	26887	8	18623	17263	-8264	-9624	69%	64%
Cape Fear	03030002	240	82704	42	230684	99826	147980	17122	279%	121%
Cape Fear	03030003	84	65742	26	199768	162932	134026	97190	304%	248%
Cape Fear	03030004	100	27965	16	62563	51929	34599	23964	224%	186%
Cape Fear	03030005	15	1241	1	777	155	-464	-1086	63%	13%
Cape Fear	03030006	17	897	2	331	331	-566	-566	37%	37%
Cape Fear	03030007	28	3557	2	2799	1994	-758	-1563	79%	56%
Yadkin	03040101	165	43946	13	54500	25907	10554	-18039	124%	59%
Yadkin	03040102	67	13906	5	17344	8753	3438	-5153	125%	63%

North Carolina Stream Impacts and Mitigation, July 2005 - June 2010

NC Division of Water Quality, September 2011

Quantified by 8-digit hydrologic unit

River Basin	CU	Impacts		Mitigation			Mitigation - Impacts		Mitigation (as % of Impacts)	
		Count	Size (feet)	Count	Size (feet)	Credit	Size (feet)	Credit	By Size	By Credit
Yadkin	03040103	50	8180	25	97763	39308	89583	31128	1195%	481%
Yadkin	03040104	23	4905	9	45479	26854	40574	21949	927%	547%
Yadkin	03040105	180	68885	37	91804	68100	22919	-785	133%	99%
Yadkin	03040201	10	742	0	0	0	-742	-742	0%	0%
Yadkin	03040202	0	0	0	0	0	0	0	100%	100%
Lumber	03040203	33	2439	9	41813	19092	39374	16653	1714%	783%
Lumber	03040204	3	62	2	5004	5004	4942	4942	8028%	8028%
Lumber	03040206	16	1890	4	20335	20335	18445	18445	1076%	1076%
Lumber	03040208	20	2820	0	0	0	-2820	-2820	0%	0%
Catawba	03050101	226	59377	42	96621	71146	37244	11769	163%	120%
Catawba	03050102	64	12704	8	12362	7476	-342	-5228	97%	59%
Catawba	03050103	117	87942	17	35049	27275	-52893	-60668	40%	31%
Broad	03050105	96	45394	50	110461	62644	65067	17250	243%	138%
Broad	03050109	1	20	0	0	0	-20	-20	100%	100%
Savannah	03060101	11	3219	6	91485	21889	88266	18670	2842%	680%
Savannah	03060102	8	3281	0	0	0	-3281	-3281	100%	100%
New	05050001	79	14676	13	22960	17842	8284	3166	156%	122%
Watauga	06010102	1	1175	0	0	0	-1175	-1175	100%	100%
Watauga	06010103	30	4488	0	0	0	-4488	-4488	0%	0%
French Broad	06010105	148	46913	19	194987	74920	148074	28007	416%	160%
French Broad	06010106	55	6399	2	4269	3990	-2130	-2409	67%	62%
French Broad	06010107	0	0	0	0	0	0	0	100%	100%
French Broad	06010108	35	11309	16	27493	20155	16184	8846	243%	178%
Little Tennessee	06010201	1	290	0	0	0	-290	-290	100%	100%
Little Tennessee	06010202	50	4366	4	9129	6792	4763	2426	209%	156%
Little Tennessee	06010203	62	6961	3	203337	43075	196377	36114	2921%	619%
Little Tennessee	06010204	7	476	9	18054	5626	17578	5150	3793%	1182%
Hiwassee	06020002	29	5047	3	6854	5135	1807	88	136%	102%
Hiwassee	06020003	1	60	0	0	0	-60	-60	100%	100%

North Carolina Riparian Buffer Impacts and Mitigation, July 2005 - June 2010

NC Division of Water Quality, September 2011

Quantified by 8-digit hydrologic unit

River Basin	CU	Impacts		Mitigation			Mitigation - Impacts		Mitigation (as % of Impacts)	
		Count	Size (sq feet)	Count	Size (sq feet)	Credit	Size (sq feet)	Credit	By Size	By Credit
Roanoke	03010102	8	172234	0	0	0	-172234	-172234	0%	0%
Roanoke	03010103	0	0	0	0	0	0	0	100%	100%
Roanoke	03010104	1	1444	0	0	0	-1444	-1444	0%	0%
Roanoke	03010106	1	83	0	0	0	-83	-83	0%	0%
Roanoke	03010107	2	2650	0	0	0	-2650	-2650	0%	0%
Chowan	03010201	0	0	0	0	0	0	0	100%	100%
Chowan	03010202	0	0	0	0	0	0	0	100%	100%
Chowan	03010203	0	0	0	0	0	0	0	100%	100%
Chowan	03010204	1	20859	0	0	0	-20859	-20859	0%	0%
Pasquotank	03010205	4	4358	0	0	0	-4358	-4358	0%	0%
Tar-Pamlico	03020101	195	2566355	2	679536	679536	-1886819	-1886819	26%	26%
Tar-Pamlico	03020102	29	195282	0	0	0	-195282	-195282	0%	0%
Tar-Pamlico	03020103	56	810551	3	1789880	1789880	979329	979329	221%	221%
Tar-Pamlico	03020104	113	2608849	13	4429766	4354262	1820917	1745413	170%	167%
Tar-Pamlico	03020105	27	116006	1	1026	1026	-114980	-114980	1%	1%
Neuse	03020201	825	12428855	19	9809435	9809435	-2619420	-2619420	79%	79%
Neuse	03020202	59	2373531	11	3393496	3393496	1019966	1019966	143%	143%
Neuse	03020203	57	940891	8	6883891	6767731	5943000	5826840	732%	719%
Neuse	03020204	152	528644	6	3805882	3805882	3277238	3277238	720%	720%
White Oak	03020301	0	0	0	0	0	0	0	100%	100%
White Oak	03020302	1	27444	0	0	0	-27444	-27444	0%	0%
Cape Fear	03030002	22	253115	0	0	0	-253115	-253115	0%	0%
Cape Fear	03030003	22	2681895	4	977681	841774	-1704215	-1840122	36%	31%
Cape Fear	03030004	3	18103	0	0	0	-18103	-18103	0%	0%
Cape Fear	03030005	1	340	0	0	0	-340	-340	0%	0%
Cape Fear	03030006	1	5837	0	0	0	-5837	-5837	0%	0%
Cape Fear	03030007	1	6015	0	0	0	-6015	-6015	0%	0%
Yadkin	03040101	3	24413	0	0	0	-24413	-24413	0%	0%
Yadkin	03040102	2	836	0	0	0	-836	-836	0%	0%
Yadkin	03040103	3	878	0	0	0	-878	-878	0%	0%
Yadkin	03040104	6	728	0	0	0	-728	-728	0%	0%
Yadkin	03040105	8	3400	0	0	0	-3400	-3400	0%	0%
Yadkin	03040201	0	0	0	0	0	0	0	100%	100%
Yadkin	03040202	0	0	0	0	0	0	0	100%	100%

Quantified by 8-digit hydrologic unit

River Basin	CU	Impacts		Mitigation			Mitigation - Impacts		Mitigation (as % of Impacts)	
		Count	Size (sq feet)	Count	Size (sq feet)	Credit	Size (sq feet)	Credit	By Size	By Credit
Lumber	03040203	2	6867	0	0	0	-6867	-6867	0%	0%
Lumber	03040204	0	0	0	0	0	0	0	100%	100%
Lumber	03040206	3	1955	0	0	0	-1955	-1955	0%	0%
Lumber	03040208	0	0	0	0	0	0	0	100%	100%
Catawba	03050101	605	388936	5	89304	89304	-299632	-299632	23%	23%
Catawba	03050102	24	9244	0	0	0	-9244	-9244	0%	0%
Catawba	03050103	2	359	0	0	0	-359	-359	0%	0%
Broad	03050105	1	140	0	0	0	-140	-140	0%	0%
Broad	03050109	0	0	0	0	0	0	0	100%	100%
Savannah	03060101	0	0	0	0	0	0	0	100%	100%
Savannah	03060102	0	0	0	0	0	0	0	100%	100%
New	05050001	2	600	0	0	0	-600	-600	0%	0%
Watauga	06010102	0	0	0	0	0	0	0	100%	100%
Watauga	06010103	0	0	0	0	0	0	0	100%	100%
French Broad	06010105	0	0	0	0	0	0	0	100%	100%
French Broad	06010106	0	0	0	0	0	0	0	100%	100%
French Broad	06010107	0	0	0	0	0	0	0	100%	100%
French Broad	06010108	0	0	0	0	0	0	0	100%	100%
Little Tennessee	06010201	0	0	0	0	0	0	0	100%	100%
Little Tennessee	06010202	0	0	0	0	0	0	0	100%	100%
Little Tennessee	06010203	0	0	0	0	0	0	0	100%	100%
Little Tennessee	06010204	0	0	0	0	0	0	0	100%	100%
Hiwassee	06020002	0	0	0	0	0	0	0	100%	100%
Hiwassee	06020003	0	0	0	0	0	0	0	100%	100%

Highlighted areas represent the CUs entirely or partially subject to Riparian Buffer Rules, including mitigation requirements. Values shown in other CUs are NOT comprehensive, and are expected to underestimate the quantity of riparian buffer impacts in most hydrologic units.

Appendix C: Resource classifications using condensed NC-GAP

North Carolina Wetland Impacts and Mitigation, July 2005 - June 2010
Classified as "Urban" and "Rural" based on condensed NC-GAP Land Cover classification

NC Division of Water Quality
September 2011

River Basin	CU	Impacts			Impacts (%)		Mitigation Credits			Mitigation (%)		Mitigation Area (acres)		
		Urban	Rural	Total	Urban	Rural	Urban	Rural	Total	Urban	Rural	Urban	Rural	Total
Roanoke	03010102	0.005	0.007	0.012	41%	59%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Roanoke	03010103	0.0	0.2	0.2	0%	100%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Roanoke	03010104	0.1	0.5	0.6	9%	91%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Roanoke	03010106	0.0	0.1	0.1	0%	100%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Roanoke	03010107	0.5	92.2	92.7	1%	99%	0.0	1092.0	1092.0	0%	100%	0.0	4173.6	4173.6
Chowan	03010201	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Chowan	03010202	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Chowan	03010203	<0.1	20.0	20.0	<1%	100%	0.0	84.2	84.2	0%	100%	0.0	163.9	163.9
Chowan	03010204	0.0	2.1	2.1	1%	99%	0.0	12.5	12.5	0%	100%	0.0	13.0	13.0
Pasquotank	03010205	221.7	20.9	242.6	91%	9%	26.6	1030.4	1057.0	3%	97%	49.5	1031.2	1080.7
Tar-Pamlico	03020101	13.2	19.8	33.0	40%	60%	9.0	75.9	84.9	11%	89%	45.0	106.8	151.8
Tar-Pamlico	03020102	1.3	0.7	2.0	65%	35%	0.0	34.5	34.5	0%	100%	0.0	75.5	75.5
Tar-Pamlico	03020103	6.4	8.4	14.8	43%	57%	1.3	4.1	5.4	24%	76%	1.3	6.3	7.6
Tar-Pamlico	03020104	2.8	4309.3	4312.0	0%	100%	909.2	7106.3	8015.5	11%	89%	971.0	9580.9	10551.9
Tar-Pamlico	03020105	0.9	5.1	6.0	15%	85%	0.0	36.0	36.0	0%	100%	0.0	36.0	36.0
Neuse	03020201	13.8	85.1	98.9	14%	86%	9.3	143.1	152.5	6%	94%	41.1	456.5	497.5
Neuse	03020202	6.4	59.6	66.0	10%	90%	0.0	30.4	30.4	0%	100%	0.0	35.0	35.0
Neuse	03020203	2.1	5.9	8.0	26%	74%	0.0	30.9	30.9	0%	100%	0.0	67.9	67.9
Neuse	03020204	5.6	38.8	44.5	13%	87%	0.0	15.7	15.7	0%	100%	0.0	47.1	47.1
White Oak	03020301	7.0	81.0	88.0	8%	92%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
White Oak	03020302	4.4	98.9	103.3	4%	96%	0.0	21.7	21.7	0%	100%	0.0	24.7	24.8
Cape Fear	03030002	6.7	39.3	46.0	15%	85%	2.5	82.3	84.8	3%	97%	8.0	116.0	124.0
Cape Fear	03030003	6.8	15.7	22.5	30%	70%	1.5	14.2	15.7	9%	91%	7.4	27.2	34.6
Cape Fear	03030004	13.6	105.2	118.8	11%	89%	0.0	217.2	217.2	0%	100%	0.0	355.5	355.5
Cape Fear	03030005	20.7	16.3	37.1	56%	44%	0.0	69.2	69.2	0%	100%	0.0	212.6	212.6
Cape Fear	03030006	0.3	2.8	3.1	10%	90%	0.0	12.9	12.9	0%	100%	0.0	64.4	64.4
Cape Fear	03030007	3.4	95.9	99.3	3%	97%	0.9	0.0	0.9	100%	0%	0.9	0.0	0.9
Yadkin	03040101	1.4	4.3	5.8	25%	75%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Yadkin	03040102	0.6	0.5	1.1	54%	46%	0.4	4.6	5.0	8%	92%	1.9	22.9	24.8
Yadkin	03040103	3.0	5.2	8.3	37%	63%	0.0	9.4	9.4	0%	100%	0.0	15.7	15.7
Yadkin	03040104	0.3	1.2	1.4	20%	80%	0.0	1.7	1.7	0%	100%	0.0	1.7	1.7
Yadkin	03040105	3.4	78.0	81.4	4%	96%	0.0	33.0	33.0	0%	100%	0.0	47.2	47.2
Yadkin	03040201	0.2	0.5	0.7	30%	70%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0

North Carolina Wetland Impacts and Mitigation, July 2005 - June 2010
Classified as "Urban" and "Rural" based on condensed NC-GAP Land Cover classification

NC Division of Water Quality
September 2011

River Basin	CU	Impacts			Impacts (%)		Mitigation Credits			Mitigation (%)		Mitigation Area (acres)		
		Urban	Rural	Total	Urban	Rural	Urban	Rural	Total	Urban	Rural	Urban	Rural	Total
Yadkin	03040202	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Lumber	03040204	19.4	29.1	48.5	40%	60%	0.0	5.0	5.0	0%	100%	0.0	5.0	5.0
Lumber	03040206	1.4	5.3	6.7	20%	80%	0.0	510.3	510.3	0%	100%	0.0	860.0	860.0
Lumber	03040208	2.7	37.9	40.6	7%	93%	0.0	83.0	83.0	0%	100%	0.0	86.0	86.0
Catawba	03050101	4.6	9.8	14.4	32%	68%	15.2	29.9	45.1	34%	66%	22.1	42.3	64.4
Catawba	03050102	0.9	1.6	2.5	34%	66%	0.7	7.2	7.9	9%	91%	2.1	18.3	20.5
Catawba	03050103	16.3	39.7	56.0	29%	71%	3.1	4.3	7.3	42%	58%	6.7	6.6	13.4
Broad	03050105	<0.1	4.2	4.2	<1%	100%	0.0	9.4	9.4	0%	100%	0.0	9.4	9.4
Broad	03050109	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Savannah	03060101	0.0	0.1	0.1	18%	82%	0.0	0.3	0.3	0%	100%	0.0	1.6	1.6
Savannah	03060102	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
New	05050001	0.6	1.1	1.7	33%	67%	0.1	17.3	17.4	1%	99%	0.1	30.2	30.3
Watauga	06010102	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Watauga	06010103	0.1	0.4	0.5	17%	83%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
French Broad	06010105	1.9	9.2	11.1	17%	83%	0.6	0.4	1.0	57%	43%	1.8	0.9	2.6
French Broad	06010106	0.0	0.9	0.9	0%	100%	0.0	0.8	0.8	0%	100%	0.0	1.1	1.1
French Broad	06010107	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
French Broad	06010108	0.0	0.6	0.6	0%	100%	0.0	3.7	3.7	0%	100%	0.0	4.8	4.8
Little Tennessee	06010201	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Little Tennessee	06010202	5.8	0.3	6.1	96%	4%	0.0	7.7	7.7	0%	100%	0.0	8.3	8.3
Little Tennessee	06010203	0.2	0.1	0.4	61%	39%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Little Tennessee	06010204	0.0	0.5	0.5	0%	100%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0
Hiwassee	06020002	1.7	0.0	1.7	97%	3%	0.0	0.2	0.2	0%	100%	0.0	0.3	0.3
Hiwassee	06020003	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0	0%	0%	0.0	0.0	0.0

North Carolina Stream Impacts and Mitigation, July 2005 - June 2010
Classified as "Urban" and "Rural" based on condensed NC-GAP Land Cover classification

NC Division of Water Quality
September 2011

River Basin	CU	Impacts			Impacts (%)		Mitigation Credits			Mitigation (%)		Mitigation Length (linear feet)		
		Urban	Rural	Total	Urban	Rural	Urban	Rural	Total	Urban	Rural	Urban	Rural	Total
Roanoke	03010102	365	183	548	67%	33%	0	4242	4242	0%	100%	0	17400	17400
Roanoke	03010103	407	3568	3975	10%	90%	0	10727	10727	0%	100%	0	10873	10873
Roanoke	03010104	282	2382	2664	11%	89%	0	17086	17086	0%	100%	0	34209	34209
Roanoke	03010106	75	593	668	11%	89%	0	5079	5079	0%	100%	0	5079	5079
Roanoke	03010107	79	4180	4259	2%	98%	0	17553	17553	0%	100%	0	22969	22969
Chowan	03010201	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Chowan	03010202	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Chowan	03010203	0	327	327	0%	100%	0	10094	10094	0%	100%	0	15549	15549
Chowan	03010204	0	66	66	0%	100%	0	3418	3418	0%	100%	0	5492	5492
Pasquotank	03010205	1185	2958	4143	29%	71%	4344	5523	9867	44%	56%	4344	5523	9867
Tar-Pamlico	03020101	4233	16065	20298	21%	79%	1150	27245	28395	4%	96%	5750	99240	104990
Tar-Pamlico	03020102	547	363	910	60%	40%	0	6913	6913	0%	100%	0	23254	23254
Tar-Pamlico	03020103	953	4308	5261	18%	82%	0	4344	4344	0%	100%	0	6519	6519
Tar-Pamlico	03020104	2117	31270	33387	6%	94%	19480	37598	57078	34%	66%	19480	56209	75689
Tar-Pamlico	03020105	104	505	609	17%	83%	0	0	0	0%	0%	0	0	0
Neuse	03020201	29665	70515	100180	30%	70%	15341	6594	21935	70%	30%	23032	18091	41123
Neuse	03020202	700	21012	21712	3%	97%	10137	18004	28141	36%	64%	10137	21121	31258
Neuse	03020203	1626	2060	3686	44%	56%	0	311	311	0%	100%	0	311	311
Neuse	03020204	899	1704	2603	35%	65%	0	1850	1850	0%	100%	0	1850	1850
White Oak	03020301	455	1210	1665	27%	73%	0	0	0	0%	0%	0	0	0
White Oak	03020302	3159	23334	26493	12%	88%	3835	13428	17263	22%	78%	3835	14788	18623
Cape Fear	03030002	21776	60928	82704	26%	74%	39529	60297	99826	40%	60%	83971	146713	230684
Cape Fear	03030003	43740	22003	65742	67%	33%	6881	156051	162932	4%	96%	14413	185355	199768
Cape Fear	03030004	3603	24362	27965	13%	87%	0	51929	51929	0%	100%	0	62563	62563
Cape Fear	03030005	0	1241	1241	0%	100%	0	155	155	0%	100%	0	777	777
Cape Fear	03030006	345	552	897	38%	62%	0	331	331	0%	100%	0	331	331
Cape Fear	03030007	299	3258	3557	8%	92%	1994	0	1994	100%	0%	2799	0	2799
Yadkin	03040101	6146	37800	43946	14%	86%	0	25907	25907	0%	100%	0	54500	54500
Yadkin	03040102	1757	12149	13906	13%	87%	6110	2643	8753	70%	30%	12754	4590	17344
Yadkin	03040103	1635	6545	8180	20%	80%	0	39308	39308	0%	100%	0	97763	97763
Yadkin	03040104	1247	3658	4905	25%	75%	4174	22680	26854	16%	84%	4174	41305	45479
Yadkin	03040105	15090	53795	68885	22%	78%	11795	56305	68100	17%	83%	11795	80009	91804
Yadkin	03040201	107	313	420	25%	75%	0	0	0	0%	0%	0	0	0

North Carolina Stream Impacts and Mitigation, July 2005 - June 2010
Classified as "Urban" and "Rural" based on condensed NC-GAP Land Cover classification

NC Division of Water Quality
September 2011

River Basin	CU	Impacts			Impacts (%)		Mitigation Credits			Mitigation (%)		Mitigation Length (linear feet)		
		Urban	Rural	Total	Urban	Rural	Urban	Rural	Total	Urban	Rural	Urban	Rural	Total
Yadkin	03040202	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Lumber	03040203	364	2076	2439	15%	85%	0	19092	19092	0%	100%	0	41813	41813
Lumber	03040204	0	62	62	1%	99%	0	5004	5004	0%	100%	0	5004	5004
Lumber	03040206	282	1608	1890	15%	85%	0	20335	20335	0%	100%	0	20335	20335
Lumber	03040208	210	2499	2709	8%	92%	0	0	0	0%	0%	0	0	0
Catawba	03050101	29371	29996	59367	49%	51%	13832	57314	71146	19%	81%	22784	73837	96621
Catawba	03050102	3471	9233	12704	27%	73%	3400	4076	7476	45%	55%	4157	8205	12362
Catawba	03050103	79066	8876	87942	90%	10%	11199	16076	27275	41%	59%	17159	17890	35049
Broad	03050105	6058	21464	27522	22%	78%	5864	56781	62644	9%	91%	6746	103715	110461
Broad	03050109	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Savannah	03060101	1613	1606	3219	50%	50%	440	21449	21889	2%	98%	440	91045	91485
Savannah	03060102	60	74	134	45%	55%	0	0	0	0%	0%	0	0	0
New	05050001	4331	10345	14676	30%	70%	0	17842	17842	0%	100%	0	22960	22960
Watauga	06010102	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Watauga	06010103	1397	2949	4346	32%	68%	0	0	0	0%	0%	0	0	0
French Broad	06010105	8429	38484	46913	18%	82%	425	74495	74920	1%	99%	425	194562	194987
French Broad	06010106	2341	4058	6399	37%	63%	0	3990	3990	0%	100%	0	4269	4269
French Broad	06010107	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
French Broad	06010108	663	10646	11309	6%	94%	4885	15270	20155	24%	76%	5746	21747	27493
Little Tennessee	06010201	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Little Tennessee	06010202	1935	2431	4366	44%	56%	190	6602	6792	3%	97%	190	8939	9129
Little Tennessee	06010203	2110	4851	6961	30%	70%	0	43075	43075	0%	100%	0	203337	203337
Little Tennessee	06010204	54	331	385	14%	86%	0	5626	5626	0%	100%	0	18054	18054
Hiwassee	06020002	1733	3314	5047	34%	66%	0	5135	5135	0%	100%	0	6854	6854
Hiwassee	06020003	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0

North Carolina Riparian Buffer Impacts and Mitigation, July 2005 - June 2010
Classified as "Urban" and "Rural" based on condensed NC-GAP Land Cover classification

NC Division of Water Quality
September 2011

River Basin	CU	Impacts			Impacts (%)		Mitigation Credits			Mitigation (%)		Mitigation Area (sq ft)		
		Urban	Rural	Total	Urban	Rural	Urban	Rural	Total	Urban	Rural	Urban	Rural	Total
Roanoke	03010102	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Roanoke	03010103	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Roanoke	03010104	0	1444	1444	0%	100%	0	0	0	0%	0%	0	0	0
Roanoke	03010106	83	0	83	100%	0%	0	0	0	0%	0%	0	0	0
Roanoke	03010107	0	2650	2650	0%	100%	0	0	0	0%	0%	0	0	0
Chowan	03010201	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Chowan	03010202	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Chowan	03010203	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Chowan	03010204	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Pasquotank	03010205	0	4358	4358	0%	100%	0	0	0	0%	0%	0	0	0
Tar-Pamlico	03020101	405392	2160963	2566355	16%	84%	0	679536	679536	0%	100%	0	679536	679536
Tar-Pamlico	03020102	80577	114705	195282	41%	59%	0	0	0	0%	0%	0	0	0
Tar-Pamlico	03020103	214458	596093	810551	26%	74%	0	1789880	1789880	0%	100%	0	1789880	1789880
Tar-Pamlico	03020104	70996	2537853	2608849	3%	97%	1785960	2568302	4354262	41%	59%	1785960	2643806	4429766
Tar-Pamlico	03020105	37414	78592	116006	32%	68%	0	1026	1026	0%	100%	0	1026	1026
Neuse	03020201	2674181	9754674	12428855	22%	78%	1311087	8498348	9809435	13%	87%	1311087	8498348	9809435
Neuse	03020202	175661	2197869	2373531	7%	93%	938718	2454778	3393496	28%	72%	938718	2454778	3393496
Neuse	03020203	680404	260487	940891	72%	28%	0	6767731	6767731	0%	100%	0	6883891	6883891
Neuse	03020204	123237	405407	528644	23%	77%	0	3805882	3805882	0%	100%	0	3805882	3805882
White Oak	03020301	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
White Oak	03020302	0	27444	27444	0%	100%	0	0	0	0%	0%	0	0	0
Cape Fear	03030002	83571	169544	253115	33%	67%	0	0	0	0%	0%	0	0	0
Cape Fear	03030003	2570083	111812	2681895	96%	4%	740520	101254	841774	88%	12%	740520	237161	977681
Cape Fear	03030004	0	18103	18103	0%	100%	0	0	0	0%	0%	0	0	0
Cape Fear	03030005	0	340	340	0%	100%	0	0	0	0%	0%	0	0	0
Cape Fear	03030006	0	5837	5837	0%	100%	0	0	0	0%	0%	0	0	0
Cape Fear	03030007	0	6015	6015	0%	100%	0	0	0	0%	0%	0	0	0
Yadkin	03040101	0	24413	24413	0%	100%	0	0	0	0%	0%	0	0	0
Yadkin	03040102	0	836	836	0%	100%	0	0	0	0%	0%	0	0	0
Yadkin	03040103	0	878	878	0%	100%	0	0	0	0%	0%	0	0	0
Yadkin	03040104	0	728	728	0%	100%	0	0	0	0%	0%	0	0	0
Yadkin	03040105	1797	1603	3400	53%	47%	0	0	0	0%	0%	0	0	0
Yadkin	03040201	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0

North Carolina Riparian Buffer Impacts and Mitigation, July 2005 - June 2010
Classified as "Urban" and "Rural" based on condensed NC-GAP Land Cover classification

NC Division of Water Quality
September 2011

River Basin	CU	Impacts			Impacts (%)		Mitigation Credits			Mitigation (%)		Mitigation Area (sq ft)		
		Urban	Rural	Total	Urban	Rural	Urban	Rural	Total	Urban	Rural	Urban	Rural	Total
Yadkin	03040202	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Lumber	03040203	0	6867	6867	0%	100%	0	0	0	0%	0%	0	0	0
Lumber	03040204	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Lumber	03040206	250	1705	1955	13%	87%	0	0	0	0%	0%	0	0	0
Lumber	03040208	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Catawba	03050101	91622	297184	388806	24%	76%	0	89304	89304	0%	100%	0	89304	89304
Catawba	03050102	286	8959	9244	3%	97%	0	0	0	0%	0%	0	0	0
Catawba	03050103	359	0	359	100%	0%	0	0	0	0%	0%	0	0	0
Broad	03050105	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Broad	03050109	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Savannah	03060101	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Savannah	03060102	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
New	05050001	0	600	600	0%	100%	0	0	0	0%	0%	0	0	0
Watauga	06010102	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Watauga	06010103	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
French Broad	06010105	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
French Broad	06010106	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
French Broad	06010107	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
French Broad	06010108	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Little Tennessee	06010201	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Little Tennessee	06010202	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Little Tennessee	06010203	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Little Tennessee	06010204	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Hiwassee	06020002	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0
Hiwassee	06020003	0	0	0	0%	0%	0	0	0	0%	0%	0	0	0

Highlighted areas represent the CUs entirely or partially subject to Riparian Buffer Rules, including mitigation requirements. Values shown in other CUs are NOT comprehensive, and are expected to underestimate the quantity of riparian buffer impacts in most hydrologic units.