2012

Upper Cape Fear River Basin Conservation and Restoration Analysis and Strategy

Photo from Haw River Assembly

Triangle J Council of Governments

Piedmont Triad Regional Council

September 2012

This page intentionally left blank.

This Project Was Supported with

North Carolina Division of Water Quality 205(j)/604(b) funds

Contributors

Piedmont Triad Regional Council

Malinda Ford
GIS Manager

Cy Stober
Water Resources Manager

Elizabeth Jernigan
Stormwater Education & Outreach Coordinator

Triangle J Council of Governments

Heather Saunders Benson
Water Resources Senior Planner

Mike Schlegel
Water Resources Program Manager

Table of Contents

List of Figures

List of Tables

Project Overview

The Triangle J Council of Governments (TJCOG) and Piedmont Triad Regional Council (PTRC) have been working together since October 2011 to collect environmental, economic, and recreational data in North Carolina and to perform a GIS-based watershed assessment of the Upper Cape Fear River Basin to better characterize the 12-digit hydrologic units (HUCs) in the Upper Cape Fear River Basin in terms of watershed assets (conservation-oriented) and watershed stressors (restoration-oriented). This effort aims to determine key management recommendations for restoration and conservation that are tailored to these different types of watersheds. This report serves as the final output of these efforts.

In order to maximize on existing efforts throughout the basin, TJCOG and PTRC identified and reached out to stakeholders in the basin to get their input on available environmental, economic, and recreational data. Subsequently, TJCOG and PTRC held two meetings during which these participants were able to provide input on criteria and determine the weighted rankings that criteria were allotted in the GIS analysis. The input gathered from stakeholders is reflected in the output of this process.

Background

The Upper Cape Fear River Basin drains approximately 3,135 square miles of the North Carolina piedmont and includes portions of 10 counties and 42 municipalities. It is the uppermost portion of the Cape Fear River Basin, the largest river basin in North Carolina, and one of four river basins that lies completely within the state. The upper basin is composed of two major drainages: the Haw River and the Deep River, and contains 11 subbasins. According to the 2010 NC Division of Water Quality (NCDWQ) 303(d) list, the Upper Cape Fear River and many of its tributaries are listed as impaired for fecal coliform, turbidity, ecological community, pH, copper, nitrite-nitrate nitrogen, zinc, low dissolved oxygen and Chlorophyll *a*. The 2005 NCDWQ Cape Fear River Basinwide Water Quality Plan associates most of these impairments with urban or impervious surface areas, construction sites, road building, land clearing, and agriculture and forestry operations.

Significant efforts are already being made to address water quality issues in the Upper Cape Fear River Basin. The Jordan Lake Rules developed by the NCDWQ were adopted in 2009 to reduce the amount of nutrient pollution entering the reservoir and multiple regional partnerships exist to monitor, track, and evaluate water quality issues in the basin including TJCOG, Cape Fear Arch Conservation Collaboration, Cape Fear River Assembly, Haw River Assembly, PTRC, Upper Cape Fear River Basin Association, and Upper Cape Fear River Watch, as well as many others.

Many watershed groups, partnerships, and agencies exist throughout the basin, and most of them are interested in water quality issues in the basin. However, despite the fact that there are so many organizations working to improve water quality in the basin, water quality and watershed information has remained compartmentalized amongst an array of agencies and groups rather than centralized. For example, the NCDWQ Basinwide Planning Unit exhaustively reviews the water quality, land uses, and growth patterns within each river basin approximately every five years, documenting river basin conditions and notable improvements or degradations. It is a synthesis of the best-available data characterizing the Cape Fear River Basin, but offers less guidance in regard to basinwide water quality priorities, or a comprehensive strategy to improve or protect water quality. This project's goal is to assess current water quality needs and give river basin stakeholders guidance on the watershed protection and restoration needs in the Upper Cape Fear River Basin through GIS-based watershed-scale analysis, thereby providing leverage for resources and funding in support of work at the local level.

Funding for this project was used to consolidate and organize all of this information and use it to evaluate watershed conservation and restoration priorities in the Upper Cape Fear River Basin. Local agencies and groups can now use this data to prioritize their restoration and conservation efforts, and the standardized analysis methods used provide credibility to groups applying for funding to implement these activities. Furthermore, this data can be used as a basis for creating partnerships and identifying watershed priorities within the Upper Cape Fear River Basin for more focused efforts.

This project and its outputs focus on planning and implementation efforts within the Upper Cape Fear River Basin for water quality improvement and protection. PTRC has completed a similar project for the Yadkin Pee-Dee River Basin through the 205j Water Quality Management Planning Grant Program and is in the process of completing a similar project in the Dan River Basin. Both projects anticipate identifying restoration and protection needs using a similar GIS-based model. NCDWQ staff has expressed support for efforts to complete similar prioritization schemes in all NC river basins. This project will be a pilot for this process and provide a consistent basis for further restoration and conservation efforts, including project implementation.

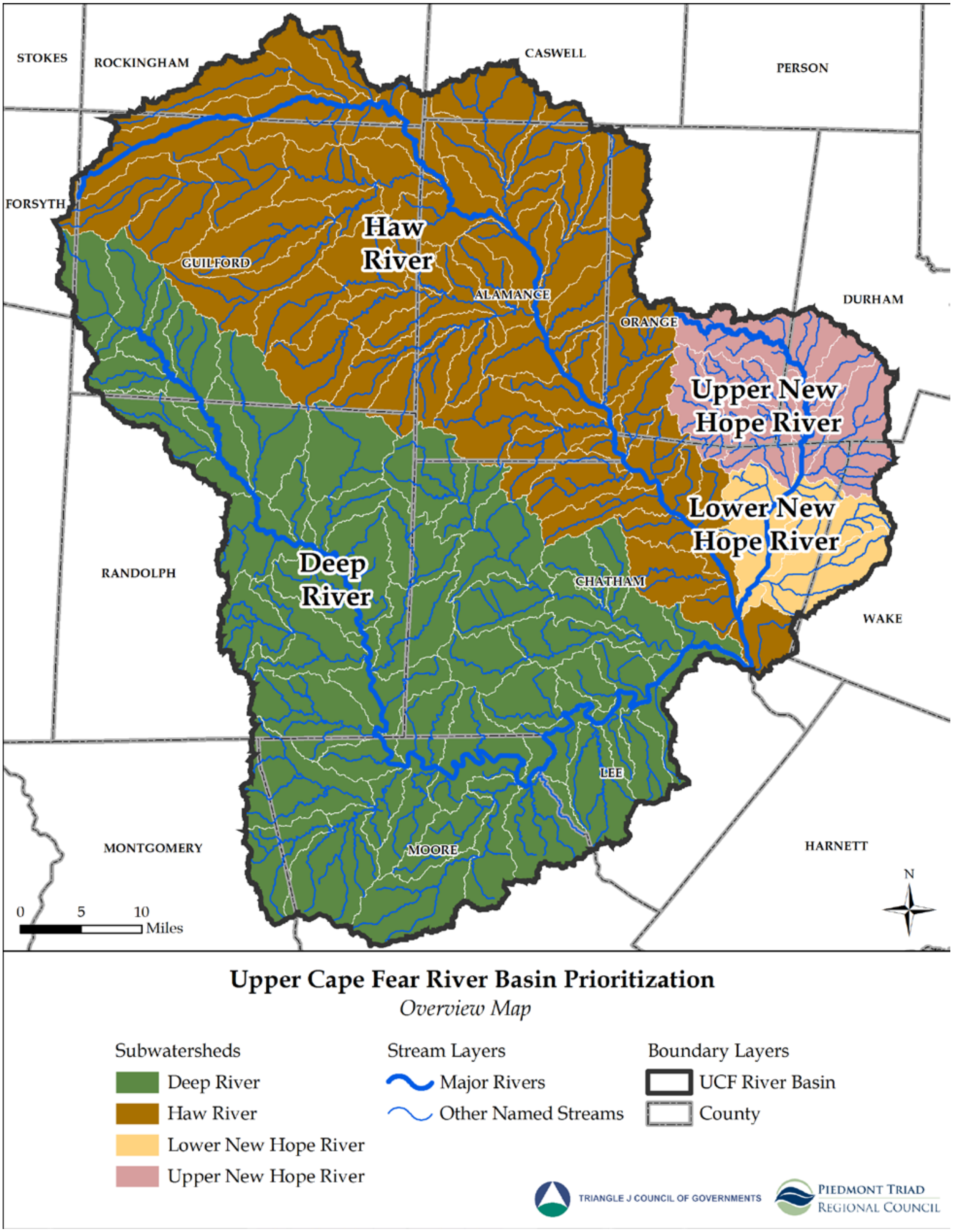

Figure 1: Upper Cape Fear River Basin Subwatersheds

Methods

The goal for this basinwide assessment was to assess the 103 12-digit HUCs within the Upper Cape Fear River Basin both for their conservation potential and their stress vulnerability. A HUC is a topographic-based definition of a watershed, as determined by the US Geological Survey (USGS). HUCs are available at different scales, which offer different scopes of resolution: 8-digit HUCs generally define river basins, 10-digit HUCs define river subbasins, and 12-digit HUCs are commonly accepted as delineating what the US Environmental Protection Agency (USEPA) refers to as "local watersheds" of approximately 40 square miles in area. A regional planning partnership between the TJCOG and PTRC analyzed the entire river basin and rated its restoration and conservation needs using publicly-available data. Land use and land cover (LULC) and qualitative water quality data were used to predict stressed or relatively pristine watershed conditions throughout the river basin.

In order to uniformly assess data from as many as twelve sources, the basin landscape was transformed into a raster grid, containing a matrix of 30 meter by 30 meter cells. A conservation raster was created where each cell contained a value representing the conservation potential for that site within the watershed. A stress raster was also created where each cell contained a value representing the stress vulnerability for that point within the watershed.

Stress Raster Creation

The first step in generating this stress raster was to gather the 12 data variables selected by the stakeholder group (see Table 1). Each data layer had to be converted to raster format with a resolution of 30 meters in order to create a consistent data format for all of the input stress layers. Impervious Surface Cover and Forest Cover were obtained from the National Land Cover Database (NLCD) already in this format. Slope data was obtained from the North Carolina Department of Transportation (NCDOT) in raster format with a 20 foot resolution, which had to be resampled using ArcGIS software to a 30 meter resolution. These three raster layers were then reclassified based on the factors and integer values assigned by the stakeholder group. Higher integer values were associated with higher stress value. For example, the original impervious surface cover raster consisted of a cell matrix with values ranging from 0 to 100, representing the percentage of impervious surface cover within each cell. In the reclassification process, cell values ranging from 1 to 4 percent were given a new value of 26; values ranging from 5 to 9 percent were given a new value of 141; values ranging from 10 to 100 percent were given a new value of 288 to signify a very high stress value in this analysis; and values of 0 percent were left at a value of 0 to signify no stress value (see Figure 2). The same concept was applied to each input raster data layer.

Table 1: Stress Analysis Input Layers and Weighting System (determined by stakeholders)

Stress Layers				
Criteria	**Data Source**	**Factors**	**Integer Values**	**Layer Percentage**
Impervious Surface Cover	NLCD 2006 Percent Developed Imperviousness	1 - 4%	26	45.5%
		5 - 9%	141	
		> 10%	288	
Erodible Soils	SSURGO (K factor)	0 - 0.23	0	8.7%
		0.24 - 0.39	24	
		0.40 - 0.49	62	
Density of Impact Sites	NCDWQ	Low (1-7 per sq. mile)	27	8.1%
		High (8-48 per sq. mi)	54	
Road Density	NCDOT	Low	0	7.6%
		Med	0	
		High	76	
Forest Cover	NLCD 2001 update	< 50%	66	6.6%
Population Density Change (2000 to 2010)	U.S. Census Bureau	1 - 9%	3	5.9%
		10 - 24%	5	
		25 - 49%	8	
		> 50%	44	
Population Density (2010)	U.S. Census Bureau	Low (1 -49)	6	5.2%
		Med (50-249)	19	
		High (250 +)	27	
Small Streams with Less than 50% Canopy Cover	NHD unnamed streams; NLCD canopy cover	Within 100 ft. buffer where forest cover <50%	45	4.5%
Steep Slopes	NCDOT LiDAR data	> 15%	37	3.7%
Parcel Size	Counties/Municipalities	< 10 Acres	16	1.6%
Zoning (High Impact)	Counties/Municipalities	Commercial, Industrial, High Density Residential, Multi-family, Office & Institutional	14	1.4%
Floodplain	NC Floodplain Mapping Program	Within 500 Year Floodplain	12	1.2%

a) Aerial – Ground Cover *b) Impervious Surface Cover Raster* *c) Reclassified Raster*

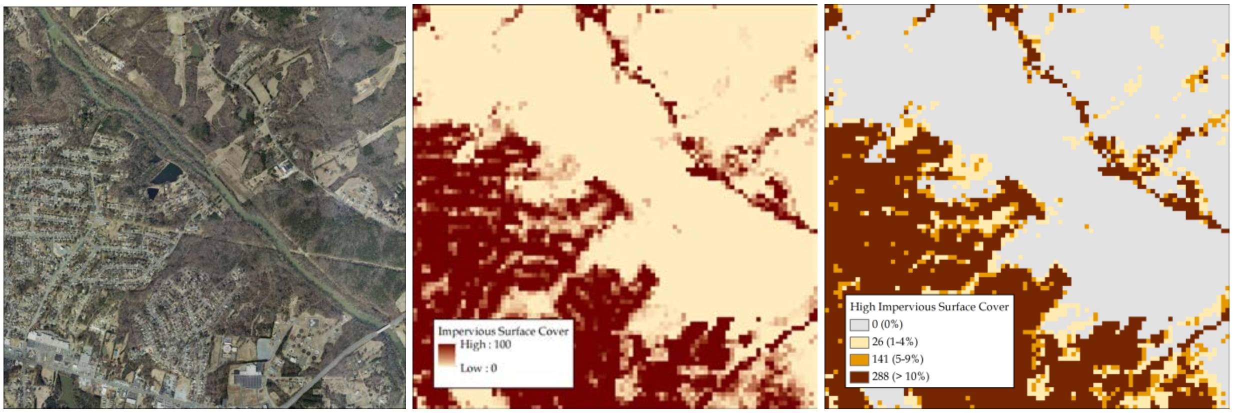

Figure 2: Steps performed on impervious surface data

The nine other data layers were received in vector format. Features in these layers were grouped by the factors in Table 1 and assigned integer values determined by the stakeholder group. Each layer was then rasterized to a 30 meter cell size using the “Polygon to Raster” tool in ArcGIS. Even though the output rasters already contained the correct integer values, the “Reclassify” tool was then used on each layer to assign a value of zero to null areas in the watershed. For example, polygon features in the floodzone data layer were given values of 12. This polygon layer was then converted to a 30 meter resolution raster preserving the integer values. Because this raster contained null values for areas outside the floodzone, this raster was then reclassified so that cells within the floodzone areas maintained a value of 12 and cells outside the floodzone areas were given a value of 0 (see Figure 3). Each cell within the watershed boundary must be represented in the raster dataset for input in the next step, as null values would not be accepted.

a) Original Vector Data *b) Conversion to Raster* *c) Reclassified Raster*

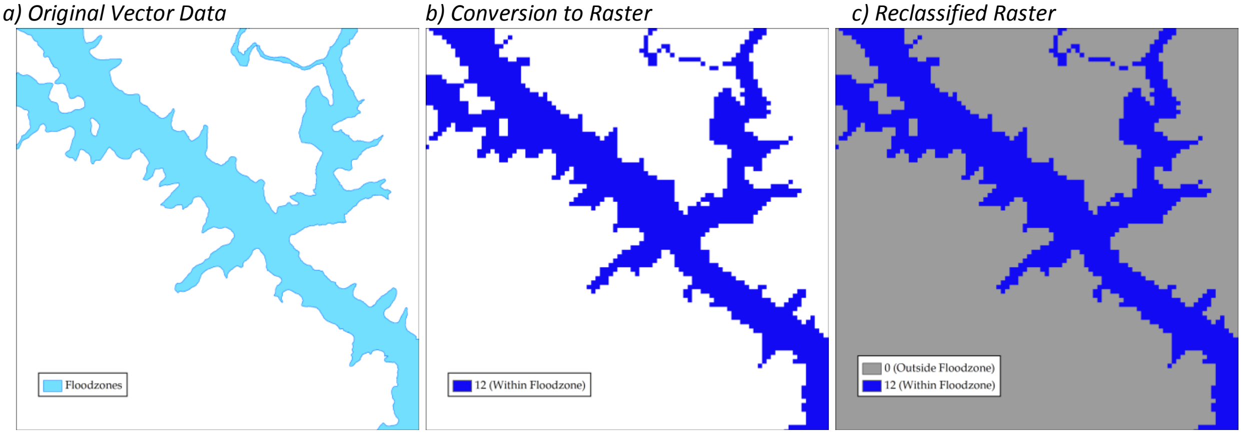

Figure 3: Steps performed on floodzone data layer

Figure 4 details another vector input example for population density. Total population values by census block were obtained from the 2010 Decennial Census. These population values were grouped by the factors in Table 1, given integer values determined by the stakeholders, converted to a raster data layer, and then reclassified.

a) Aerial – Ground Cover *b) Original Census Blocks* *c) Reclassified Raster*

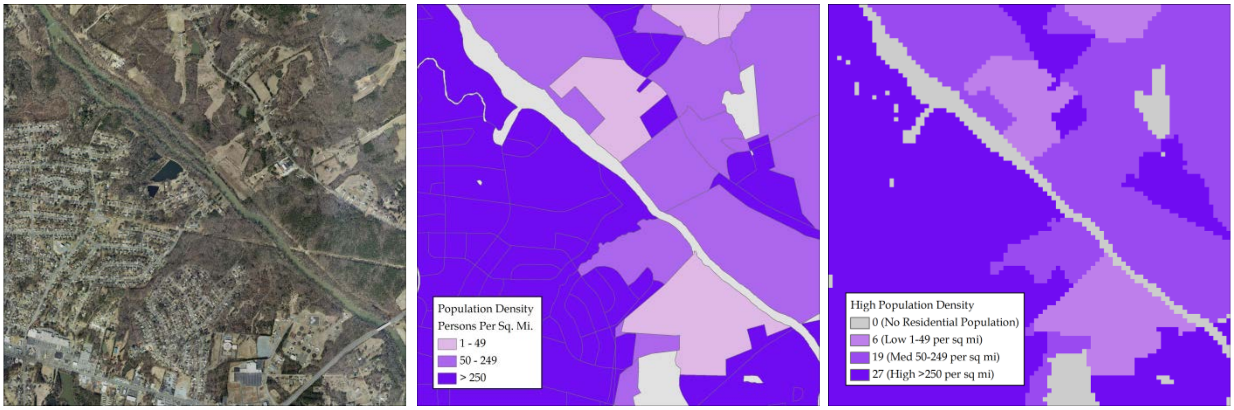

Figure 4: Steps performed on population density data layer

All 12 reclassified rasters were then input into the ArcGIS Weighted Sum Tool. This tool overlaid the input rasters on top of one another and summed the respective cells into one output stress value raster (see Figure 5). This tool works similar to the ArcGIS Plus tool, except that it provides an option to weight individual rasters. Since we already provided weight to the input rasters by adjusting their integer values, no additional weighting was needed in this step.

This stress value raster represents the stress vulnerability of the Upper Cape Fear River Basin landscape on a continuous array of values, ranging from 0 to 655 (see Figure 6). The maximum possible stress value that a cell could attain was 741 if that point in space possessed the highest factors for each input data layer, but no cells within the watershed obtained this high of a stress value. This process attempted to identify the highest stress areas with the Upper Cape Fear River Basin that require additional analysis and consideration.

a) Reclassified Impervious Surface Cover Raster

b) Reclassified Impervious Surface Cover Raster Overlaid With Reclassified Population Density Raster

c) Reclassified Impervious Surface Cover Raster Overlaid With Reclassified Population Density Raster and then Overlaid With Reclassified Floodzone Raster

d) Product of Weighted Sum Tool (Output Stress Value Raster)

Figure 5: Example of Input Layers into Weighted Sum Tool

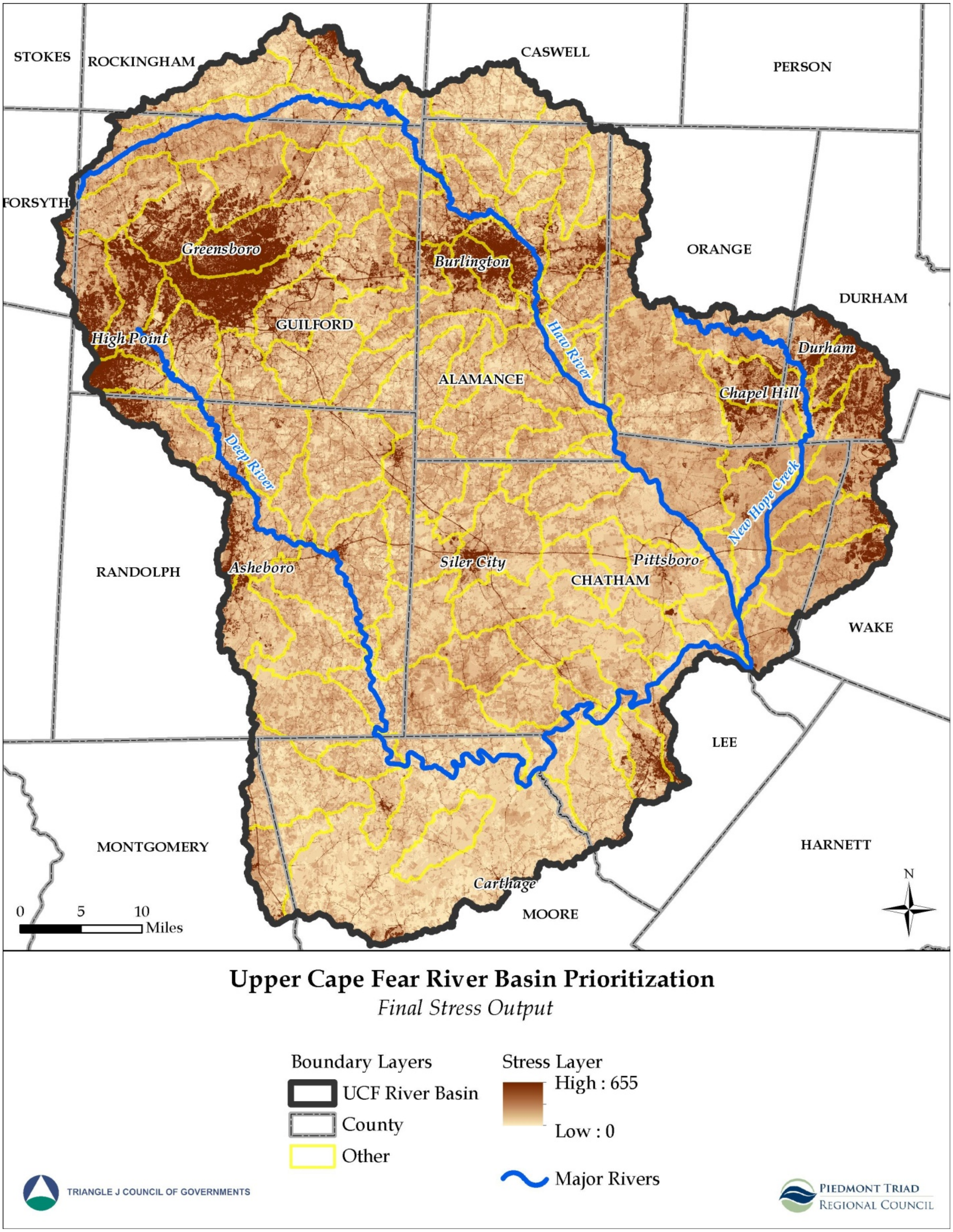

Figure 6: Output Stress Value Raster

In the final step, the 12-digit HUC boundaries were overlaid on top of the output stress raster. The ArcGIS "Zonal Statistics as Table" tool calculated the stress cell statistics (mean, minimum, maximum, range, etc.) for each 12-digit HUC boundary (see Figure 7). The HUCs were grouped based on mean stress value (see Figure 8). The mean values ranged from 48 to 342.

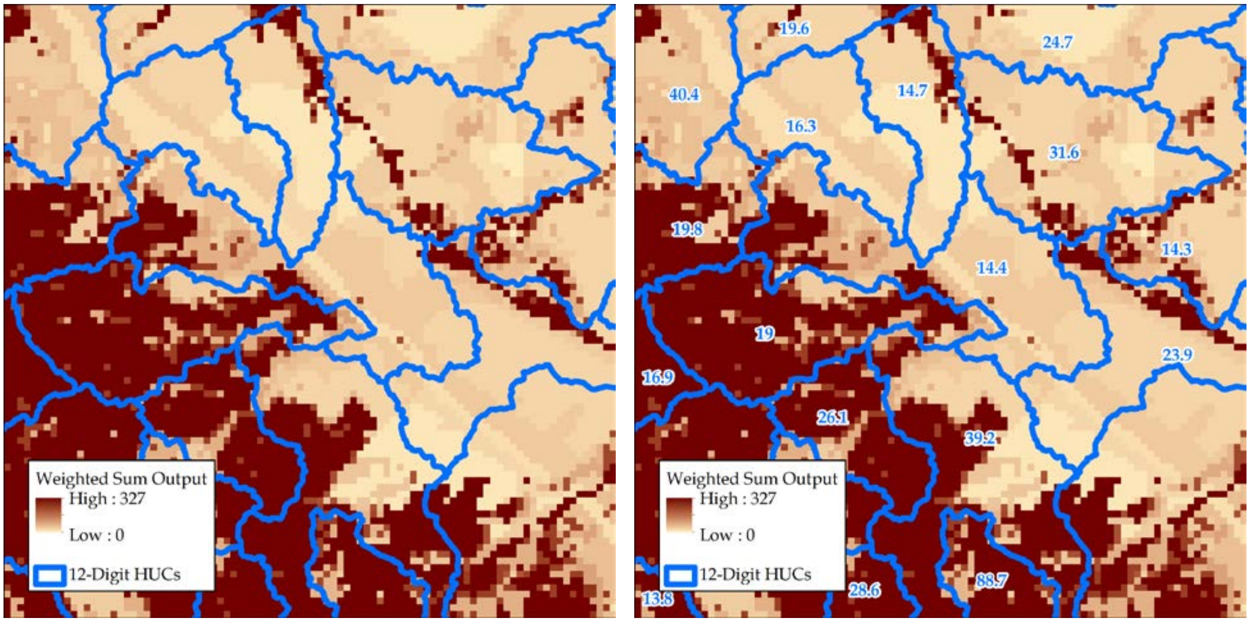

Figure 7: Zonal Statistics tool calculated mean stress value for each 12-digit HUC

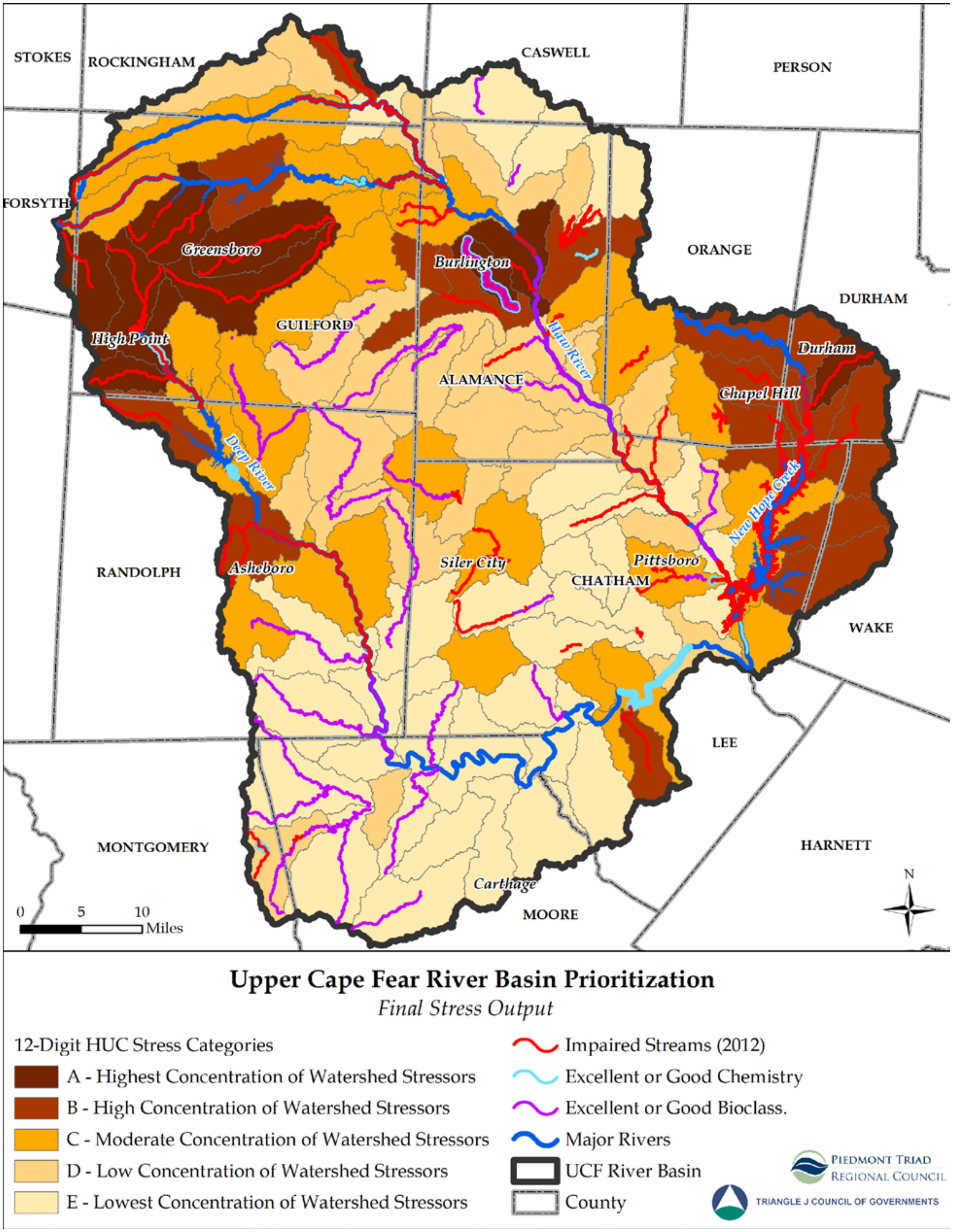

Figure 8: 12-digit HUCs grouped by stress category

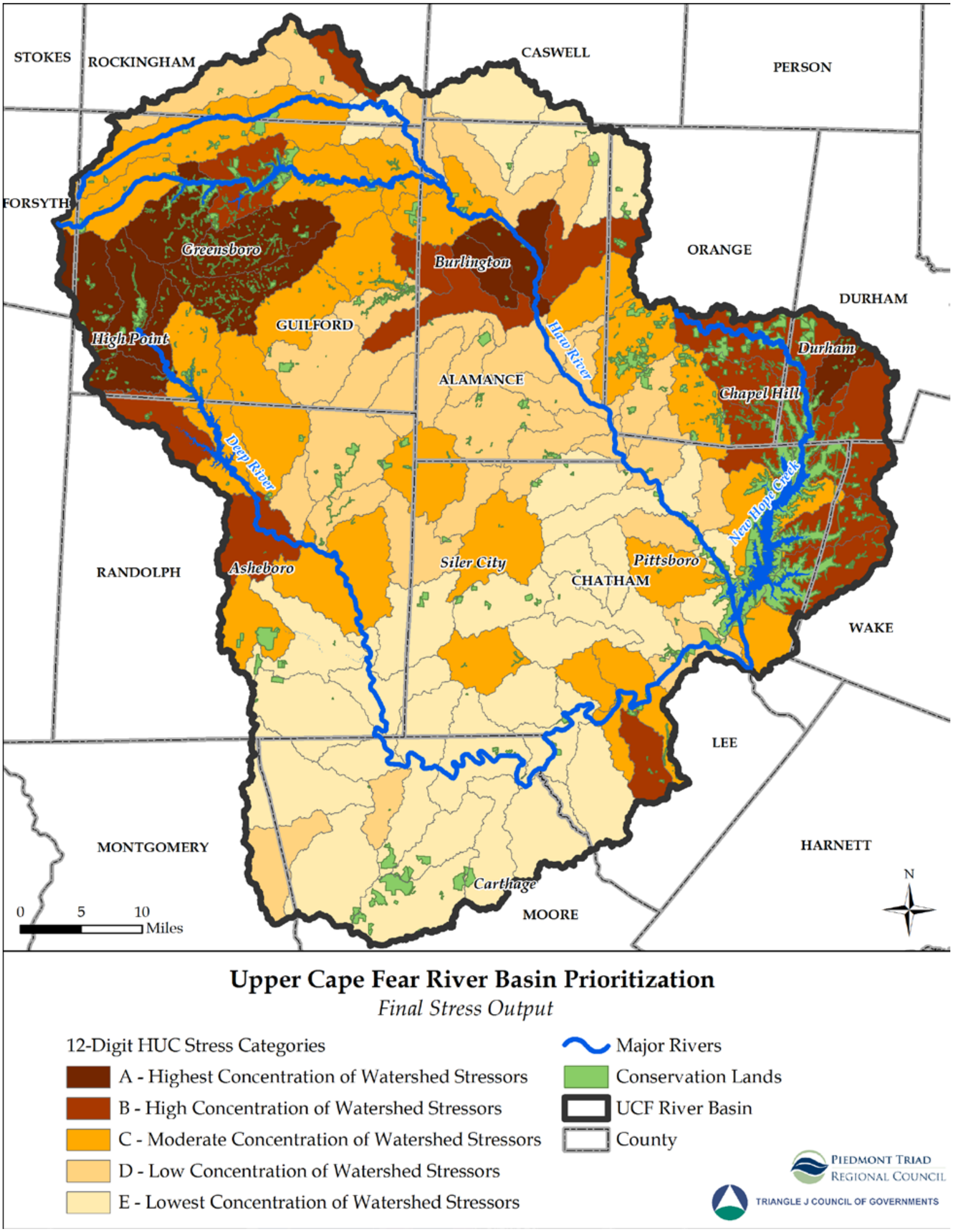

Figure 9: 12-digit HUCs grouped by stress category, overlaid with conservation lands

Conservation Raster Creation

The first step in generating this conservation raster was to gather the 10 data variables selected by the stakeholder group (see Table 2). Each data layer had to be converted to raster format with a resolution of 30 meters in order to create a consistent data format for all of the input conservation layers.

Table 2: Conservation Analysis Input Layers and Weighting System (determined by stakeholders)

Conservation Layers				
Criteria	**Data Source**	**Factors**	**Integer Values**	**Total Layer Value**
Biodiversity/ Wildlife Habitat Assessment	NCNHP	1 - 4	65	31.9%
		5 - 6	65	
		7 - 8	79	
		9 - 10	110	
Impervious Surface Cover	NLCD 2006 Percent Developed Imperviousness	> 10%	0	22.9%
		5 - 9%	54	
		0 - 4%	174	
Forest Cover	NLCD 2001 update	> 50%	134	13.4%
Hydric Soils	SSURGO	Partially Hydric	22	7.8%
		All Hydric	56	
Soil Erodibility	SSURGO (K factor)	0 - 0.23	0	7.1%
		0.24 - 0.39	14	
		0.40 - 0.49	57	
Floodplain	NC Floodplain Mapping Program	Within 500 Year Floodplain	65	6.5%
Population Density (Persons Per Square Mile)	Census Bureau, 2010	High (250 +)	0	4.9%
		Med (50-249)	20	
		Low (1 -49)	29	
Steep Slopes	NCDOT LiDAR data	> 15%	37	3.7%
Parcel Size	Counties/Municipalities	> 50 Acres	12	1.2%
Zoning (Low Impact)	Counties/Municipalities	Planned Unit Development, Low Density Residential, Conservation, VAD	5	0.5%

Impervious Surface Cover and Canopy Cover were obtained from the NLCD already in this format. The Biodiversity/Wildlife Habitat Assessment (BWHA) layer was also received from the North Carolina Natural Heritage Program (NCNHP) already in this format. The BWHA dataset illustrates the locations and conservation values of significant natural resources in North Carolina, and has been utilized to support land use, conservation, mitigation and transportation planning and decision-making (see Table 3) (NCNHP 2012). The NCNHP provided a BWHA layer to us with the NCDWQ stream bioclassification removed so that we could later use the stream bioclassification data as a validation layer for our output conservation value raster.

Table 3: Input layers to the NCNHP's Biodiversity/Wildlife Habitat Assessment

Key to Identify Tool results for the Biodiversity/Wildlife Habitat Assessment			
Category Name	**Value**	**Individual Input Layers**	**Source for Input Layers**
NHP	10	Significant Natural Heritage Areas – National or State Significance	NC Natural Heritage Program
	8	Significant Natural Heritage Areas – Regional Significance	
	6	Significant Natural Heritage Areas - Local Significance	
	5	Element Occurrences – High ranking	
	4	Element Occurrences – Other	
Wetlands	7	Coastal Region Evaluation of Wetland Significance (CREWS) – Exceptional	*NC Division of Coastal Management*
	6	Coastal Region Evaluation of Wetland Significance (CREWS) – Substantial	
	5	National Wetland Inventory	*US Fish and Wildlife Service*
	2	Coastal Region Evaluation of Wetland Significance (CREWS) – Beneficial	*NC Division of Coastal Management*
Guilds	1-10	Landscape Habitat Indicator Guilds	*NC Natural Heritage Program*
DWQ	10	Outstanding Resource Waters	*NC Division of Water Quality*
	9	~~Stream BioClass - Excellent~~ Removed for our analysis	
	8	High Quality Waters	
	7	~~Stream BioClass - Good~~ Removed for our analysis	
	1	All other streams	
FishHabitat	9	Wild Brook Trout	*NC Wildlife Resources Commission*
	8	Anadromous Fish Spawning Areas	*NC Division of Marine Fisheries*
FishNursery	8	Fish Nursery Areas	*NC Division of Marine Fisheries*
Watersheds	7	Stream buffer tributaries to Threatened & Endangered Species	*NC Natural Heritage Program*
	3	Priority Watersheds	*NC Natural Heritage Program, NC Wildlife Resources Commission, The Nature Conservancy*
Marine	8	Oyster Sanctuaries	*NC. Division of Marine Fisheries*
	6	Submerged Aquatic Vegetation	
Hardbottom	8	Open Shellfish /Shellbottom	*NC Division of Marine Fisheries*
	7	Hard Bottom	
	5	Closed Shellfish /Shellbottom	
IBA	6	Important Bird Area	*Audubon North Carolina*
Impervious	99	Impervious Surface above 20%	*US Environmental Protection Agency*

The Slope data was obtained from the NCDOT in raster format with a 20 foot resolution, which had to be resampled using ArcGIS software to a 30 meter resolution. These three raster layers were then reclassified based on the factors and integer values assigned by the stakeholder group. Higher integer values were associated with higher conservation value.

The seven other data layers were received in vector format. Features in these layers were grouped by the factors in Table 2 and assigned integer values determined by the stakeholder group. Each layer was then rasterized to a 30 meter cell size using the “Polygon to Raster” tool in ArcGIS. Even though the output rasters already contained the correct integer values, the “Reclassify” tool was then used on each layer to assign a value of zero to null areas in the watershed. Each cell within the watershed boundary must be represented in the raster dataset for input in the next step, as null values would not be accepted.

All 10 reclassified rasters were then input into the ArcGIS Weighted Sum Tool. This tool overlaid the input rasters on top of one another and summed the respective cells into one output conservation value raster. This tool works similar to the ArcGIS Plus tool, except that it provides an option to weight individual rasters. Since we already provided weight to the input rasters by adjusting their integer values, no additional weighting was needed in this step.

This conservation value raster represents the conservation potential of the Upper Cape Fear River Basin landscape on a continuous array of values, ranging from 0 to 631 (see Figure 10). The maximum possible stress value that a cell could attain was 680 if that point in space possessed the highest factors for each input data layer, but no cells within the watershed obtained this high of a conservation value. This process attempted to identify areas within the watershed with the highest conservation value for watershed health and function, so that these areas can continue to be preserved in future projects.

In the final step, the 12-digit HUC boundaries were overlaid on top of the output conservation raster. The ArcGIS "Zonal Statistics as Table" tool calculated the conservation cell statistics (mean, minimum, maximum, range, etc.) for each 12-digit HUC boundary. The HUCs were grouped based on mean conservation value (see Figure 11). The mean values ranged from 108 to 392.

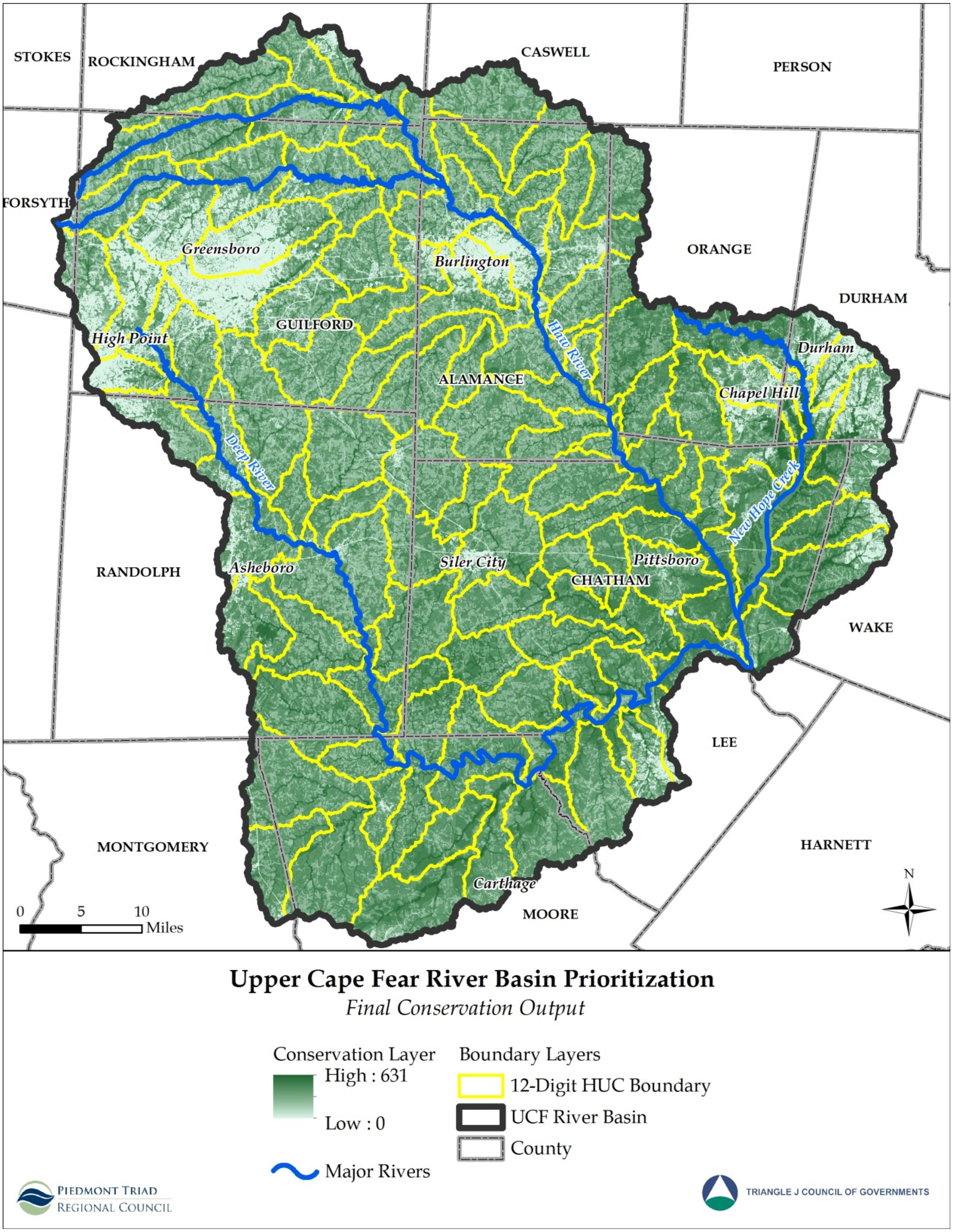

Figure 10: Output Conservation Value Raster

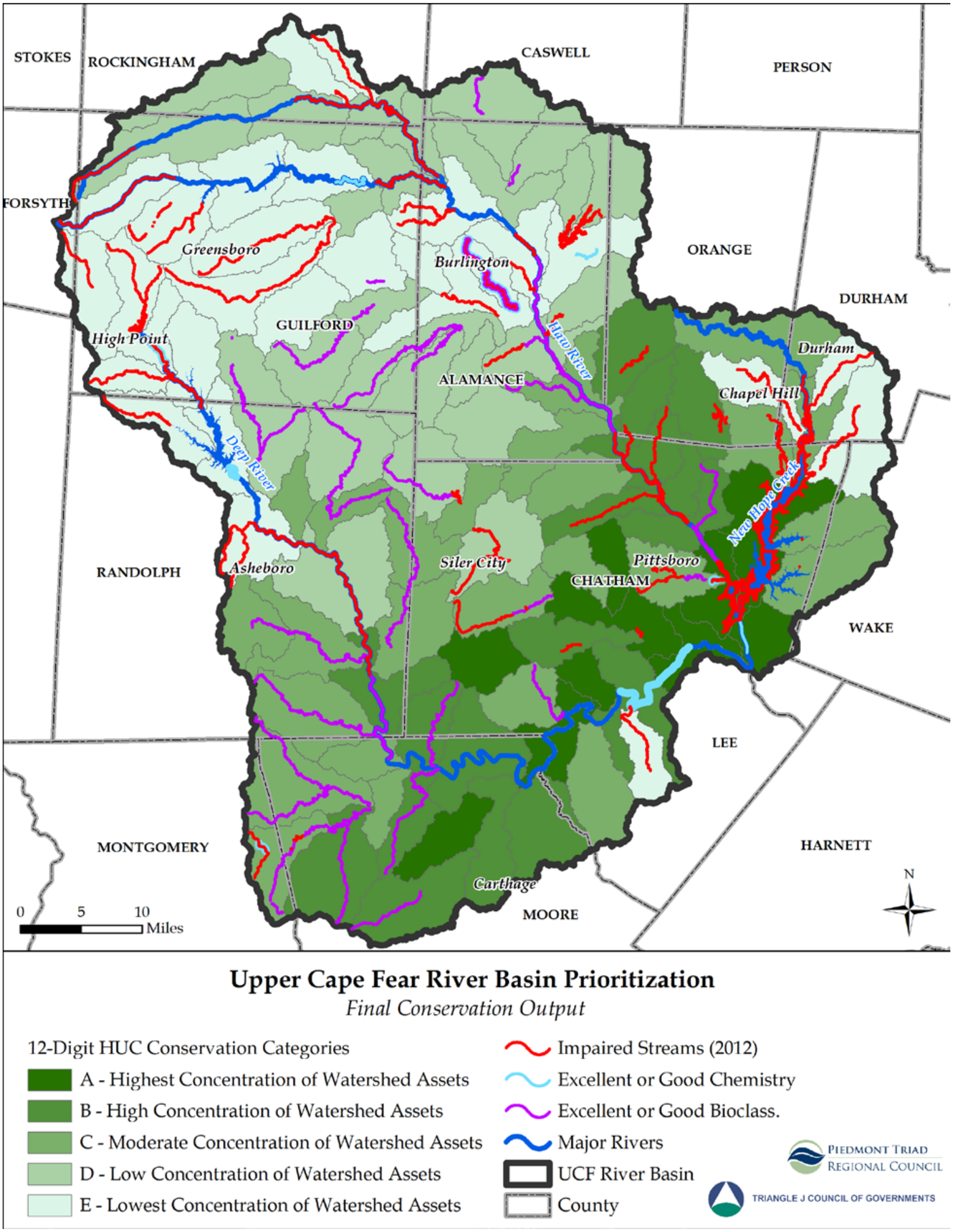

Figure 11: 12-digit HUCs Grouped by Conservation Category

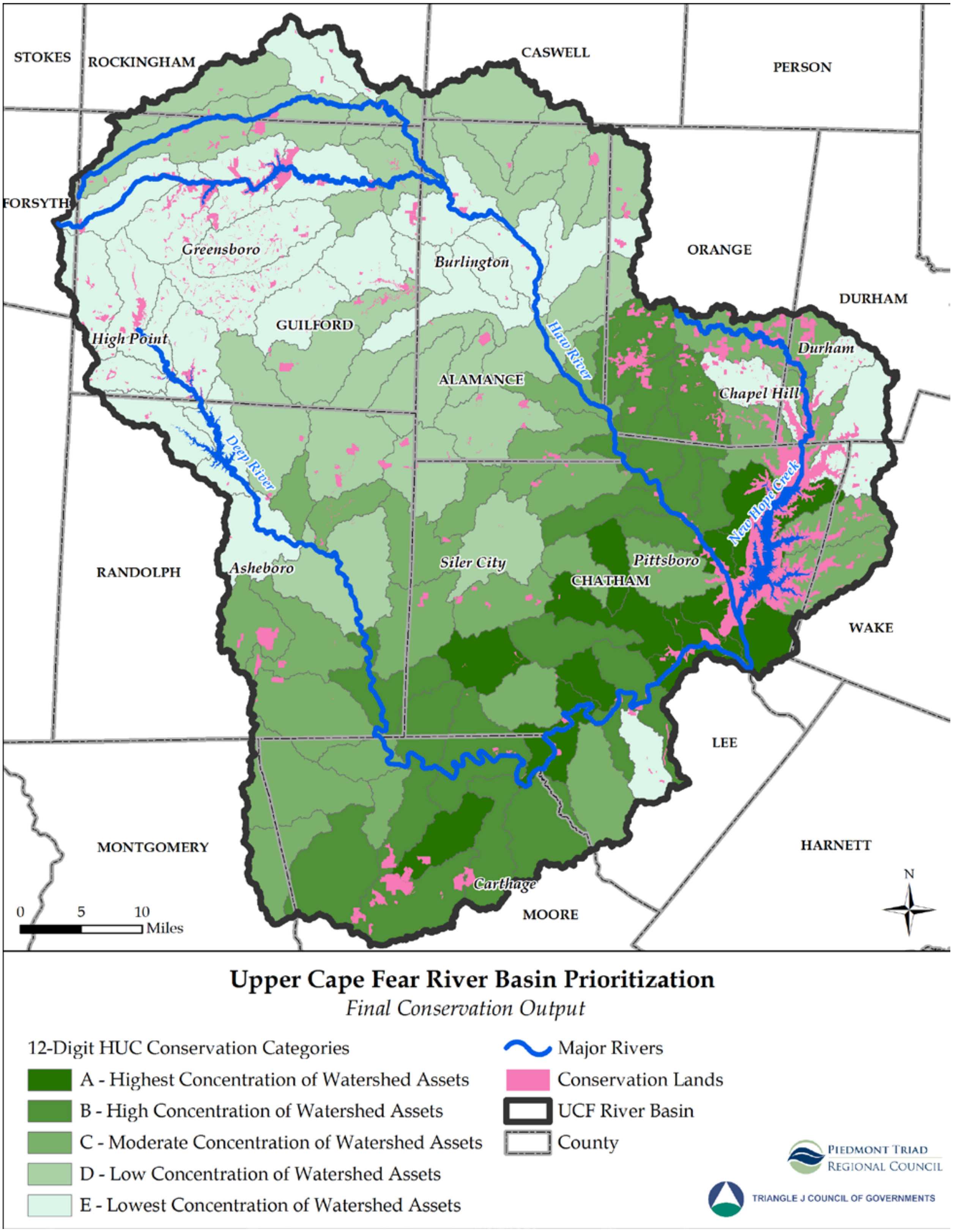

Figure 12: 12-digit HUCs grouped by conservation category, overlaid with conservation lands

Though the stress model shows high value in its ability to anticipate the presence of impaired waters, the conservation model and all validation data used by this project need some improvement. The stress model captured 32% of the impaired streams in the 10% of the most stressed watersheds, demonstrating a value in informing guidance for basinwide investments in more local planning and restoration efforts. The conservation model, however, did not display the same level of predictive accuracy in anticipating the presence of healthy waters (those rated “Good” or “Excellent” by NCDWQ staff and/or within an Outstanding Resource Water or High Quality Water watershed), anticipating the presence of only 2% of healthy waters in the most conserved watersheds.

Both models are based upon the TJCOG and PTRC staffs’ best opinion on how LULC can potentially impact water quality, based upon national and regional emerging research and planning. It is also nearly identical to the work that the PTRC did in collaboration with two other NC regional organizations in 2010 for the Yadkin-Pee Dee River Basin, which did have a high degree of predictive value using NCDWQ water quality data for anticipating impaired and healthy waters. The basis for those successful models was transferred to the Upper Cape Fear River Basin, but modified based upon stakeholder input. This analysis did face some data challenges unique to the communities within the basin (i.e. Caswell County has no soil survey data). The models may reflect the relationships between land coverage and some watershed conditions, but their sensitivities to rural landscapes appear to be somewhat muted, and currently fail to anticipate the presence of healthy waters with as much success as they can anticipate impaired waters.

However, this weakness in the conservation model may be due as much to the validation data as it is to the LULC model used. In North Carolina, the ambient water quality monitoring program has historically focused on large rivers and areas with known water quality problems, thereby limiting data on smaller streams. This leads to an abundance of samples in one watershed vs. samples more evenly distributed throughout a basin. Biological data is typically collected every five years per basin at selected sites, with additional biological samples collected for special studies. Fecal coliform bacteria assessments also require significant staff time and resources for a rating, with state standards stipulating that any impairment ratings must be supported by five samples at one site within thirty days (the “5-n-30 rule”) and show a geometric mean higher than 200 coliform forming units (cfu) per 100 milliliters (mL) or that 20% of the samples are greater than 400 cfu/100 mL.

Due to a lack of funding and legislative support, the NCDWQ does not have enough funding to comprehensively monitor waters and update these records. This is particularly notable for the assessment and ratings for fecal pollution and biological data, due to the high demands upon staff time these monitoring protocols require. The lack of political support for these programmatic investments has direct negative impacts upon the States’ abilities to adequately rate water quality conditions. Perhaps due to recent cuts in funding, there have been few water quality ratings since 2008.

The impacts upon healthy waters ratings (as determined for this project) are even greater than that for impaired waters. As stated in the US Clean Water Act, the USEPA charters states with the responsibility to monitor their waters for pollutants and rate them as impaired. There is no such responsibility within the Clean Water Act for healthy waters. In the Upper Cape Fear River Basin, there have been no healthy waters ratings since 2000. This leads to confusing situations where watersheds such as Little Alamance Creek are identified both as having "Good" water quality using older data, but as impaired for bioclassification using more recent data. Despite the incongruence, both water quality ratings remain for this creek which has the most stressful watershed conditions within the Upper Cape Fear River Basin. However, all water quality ratings data are used for validation of the GIS models used for this project. Without current water quality data that more comprehensively and consistently cover the Upper Cape Fear River Basin, it is difficult to draw conclusions on whether or not the model or the validation dataset is representative of actual current water quality conditions.

This is the best available water quality data, which was determined to be the best validation data for these models by both the project administrators and the solicited stakeholders. The value of the stress model in anticipating the location of impaired waters demonstrates that the approach used for this project has predictive value, which may be confirmed by a richer dataset for healthy waters from the NCDWQ. Both models appear to have predictive value – though the stress model is clearly more valuable – and are recommended for use as the best available tools to evaluate watershed restoration and protection needs in the Upper Cape Fear River Basin.

The purpose of these brief local watershed summaries provided in this document is to describe conditions that must be addressed through concentrated watershed planning and implementation efforts with further funding and support from state, federal, and private entities. This analysis tool is recommended for large-scale, low-resolution (river basin or sub-basin) water resource and water quality planning throughout the state as way to prioritize and guide restoration and conservation work by local stakeholders and funding agencies. It should be used to make initial determinations regarding basinwide water quality priorities and to leverage for further resources to conduct local watershed planning efforts. Immediate initiation of local watershed planning relying upon the USEPA's *Nine Elements of Local Watershed Planning* and the Center for Watershed Protection's research, literature, and watershed planning tools (2012) (i.e. the Codes and Ordinance Worksheet) is uniformly recommended for every priority watershed identified within this *Atlas*.

This page intentionally left blank.

Stress HUC Groupings

As noted in the Project Overview section, environmental, economic, and recreational data in North Carolina was collected in order to allow us to perform the GIS analysis. An initial listing of potential data layers was provided to stakeholders, which was subsequently refined and added to, based on local knowledge. Table 4 provides a list of the final data inputs used to perform the Stress Analysis, and the last column in the table indicates how much weight a layer was given. By reviewing the table, you can see that Impervious Surface Cover was considered to be the most important criteria by the stakeholders, comprising almost 50% of the total score. Other features included in the analysis included Erodible Soils, Density of Impact Sites, Road Density, Forest Cover, Population Density Change (2000 to 2010), Population Density (2010), Small Streams with Less than 50% Canopy Cover, Steep Slopes, Parcel Size, High Impact Zoning, and Floodplain Areas.

A detailed description of the actual stress analysis is included in the Methods Section.

Table 4: Stress Analysis Input Layers and Weighting System (determined by stakeholders)

Stress Layers				
Criteria	**Data Source**	**Factors**	**Integer Values**	**Layer Percentage**
Impervious Surface Cover	NLCD 2006 Percent Developed Imperviousness	1 - 4%	26	45.5%
		5 - 9%	141	
		> 10%	288	
Erodible Soils	SSURGO (K factor)	0 - 0.23	0	8.7%
		0.24 - 0.39	24	
		0.40 - 0.49	62	
Density of Impact Sites	NCDWQ	Low (1-7 per sq. mile)	27	8.1%
		High (8-48 per sq. mi)	54	
Road Density	NCDOT	Low	0	7.6%
		Med	0	
		High	76	
Forest Cover	NLCD 2001 update	< 50%	66	6.6%
Population Density Change (2000 to 2010)	U.S. Census Bureau	1 - 9%	3	5.9%
		10 - 24%	5	
		25 - 49%	8	
		> 50%	44	
Population Density (2010)	U.S. Census Bureau	Low (1 -49)	6	5.2%
		Med (50-249)	19	
		High (250 +)	27	
Small Streams with Less than 50% Canopy Cover	NHD unnamed streams; NLCD canopy cover	Within 100 ft. buffer where forest cover <50%	45	4.5%
Steep Slope	NCDOT LiDAR data	> 15%	37	3.7%
Parcel Size	Counties/Municipalities	< 10 Acres	16	1.6%
Zoning (High Impact)	Counties/Municipalities	Commercial, Industrial, High Density Residential, Multi-family, Office & Institutional	14	1.4%
Floodplain	NC Floodplain Mapping Program	Within 500 Year Floodplain	12	1.2%

Stress Category A - Highest Concentration of Watershed Stressors

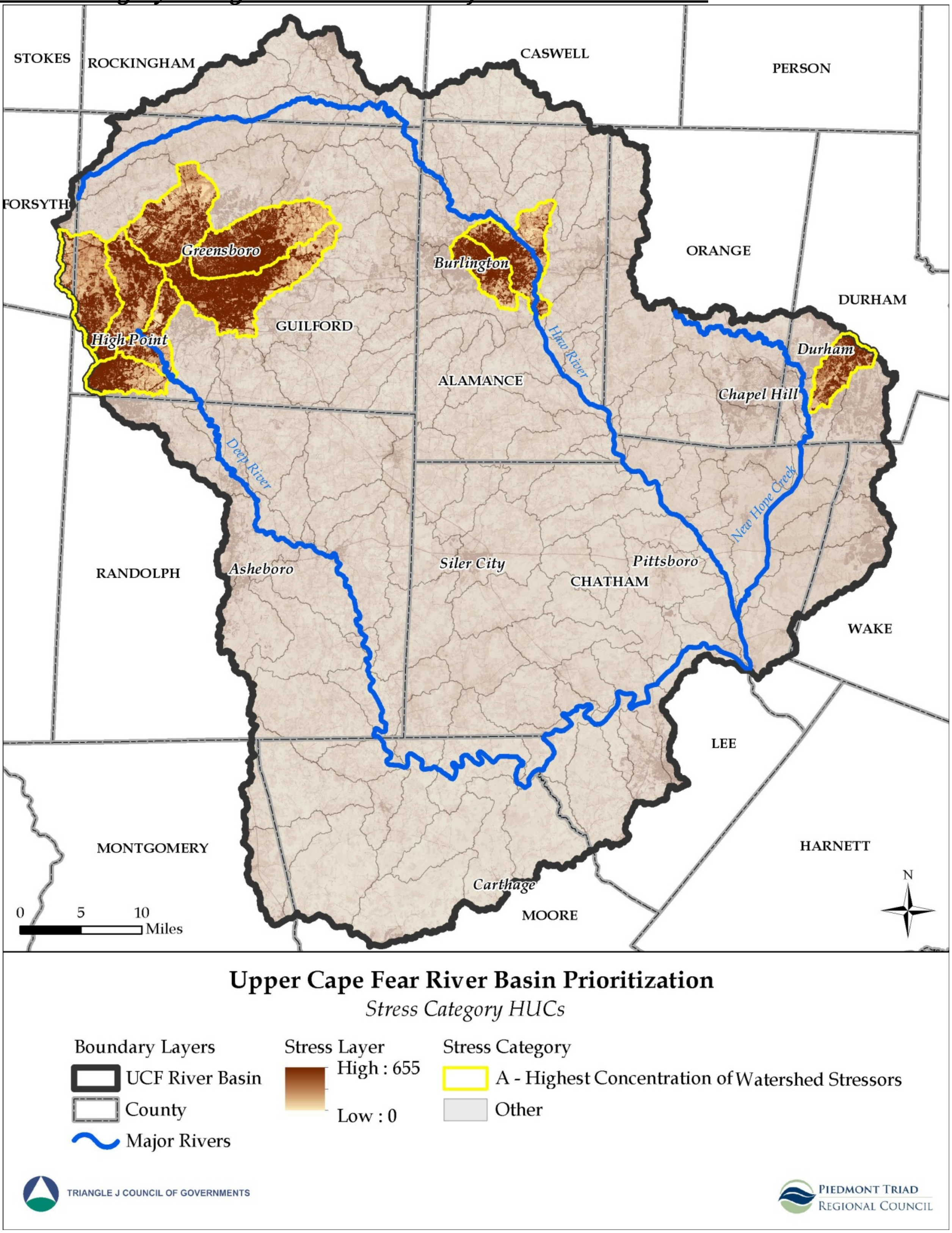

Figure 13: Stress Category A - Highest Concentration of Watershed Stressors

Key Watershed Characteristics

- Predominately urbanized centers & major transportation hubs
- Regulated communities (NPDES, Jordan & Randleman Buffer Rules)
- Stormwater Utility Fees

Key Management Recommendations

- Requiring or incentivizing LID for all new development
- Increase monitoring efforts
- Update watershed restoration plans
- Utilize NCWRCs Green Growth Toolbox
- Establish or increase partnership efforts

Overview

These ten watersheds exist entirely in the urbanized centers of the Guilford, Alamance, and Durham counties. Approximately 31.7 percent of all impaired streams in the Upper Cape Fear River Basin occur in these watersheds. CWPs (2003) research suggests a decline in both species abundance and diversity at or around 10% impervious surface cover. This suggests stormwater runoff or nonpoint source pollution is a major contributor to deteriorating water quality. Stormwater runoff occurs when precipitation flows over the ground picking up nutrients, chemicals, dirt, debris, and other pollution and carries it through the storm sewer system or deposits it untreated into nearby waters. The cumulative effects of stormwater runoff can impact a waterbody for its designated uses including recreation and drinking water and can have a significant impact on the local economy.

While impervious cover is recognized as a leading contributor to poor water quality, other characteristics found in these urban watersheds also have a major impact. These watersheds include the highest density of impact sites including, but not limited to, impacts from animal operations, NPDES permits, old landfill sites, PCB sites and other pollution incidents in the Upper Cape Fear River Basin. Other factors, including a high population density, low canopy cover and small parcel size also influence these rankings.

History

The watersheds in Category A exist along the major metropolitan corridors of I-85 and/or I-40. Their various histories include textile, manufacturing, and furniture, and they all serve as major transportation hubs in the North Carolina piedmont region. The counties and municipalities occupying these watersheds are regulated under the National Pollutant Discharge Elimination System (NPDES) as either Phase I or Phase II communities, both of which are required to develop and implement a stormwater management plan to reduce the contamination of stormwater runoff and prohibit illicit discharges. All these communities have additional obligations to protect water quality through either the Randleman Lake Water Supply Watershed Buffer Rules or the Jordan Lake Rules, both of which are designed to protect the classified uses of the lakes, especially from non-point source pollution.

Current Practices

These communities are currently implementing programs to comply with NPDES regulations including public education/outreach and participation/involvement, identifying and eliminating illicit discharges, controlling runoff from construction sites, post-construction runoff control and pollution prevention/good housekeeping measures. Communities in the Jordan Lake watershed are implementing additional rules for water quality including management of runoff from both new and existing development, riparian buffers, wastewater discharges, agriculture, and fertilizer management. Randleman Lake communities are subject to additional buffer rules.

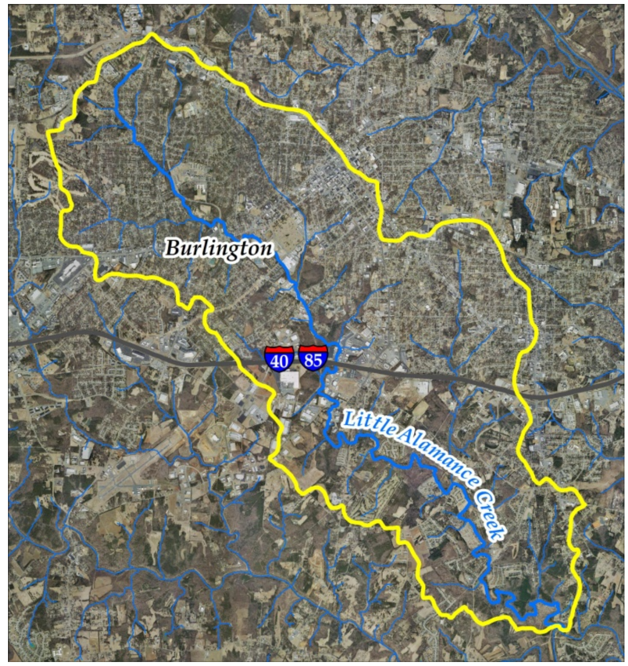

Figure 14: Little Alamance Creek Ortho

As larger Phase I and II communities, the municipalities of High Point, Greensboro, Burlington, and Durham all have stormwater programs funded through a stormwater utility fee. These fees are used to maintain and improve infrastructure and implement activities (e.g. public outreach) that improve the quality of discharged stormwater.

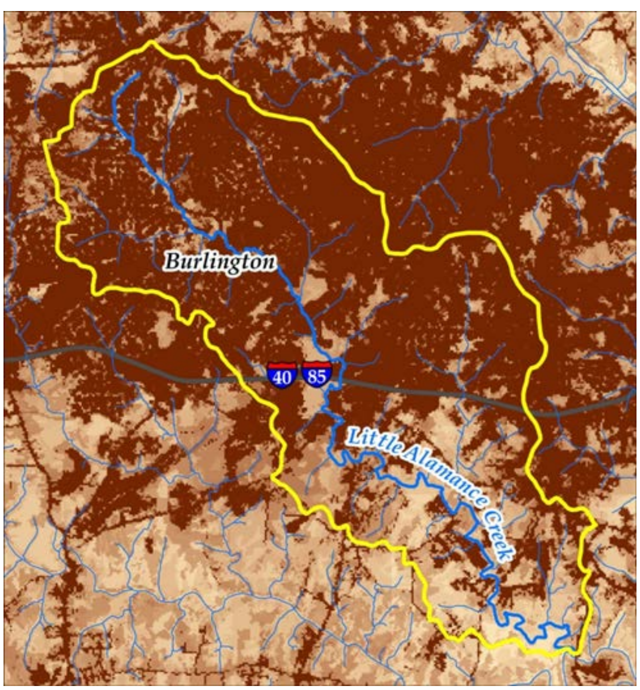

Figure 15: Little Alamance Creek Stress Raster

Most of these communities are implementing practices based on existing local watershed plans. Whether they are doing it in-house, partnering with other organizations (e.g. EEP, COGs, associations, etc.), or contracting it out, final plans involve identifying watershed impacts, stressors and sources, and implementing restoration projects to remediate stressors and improve function.

Next Steps & Partnerships

While these streams will likely never return to their original conditions, communities can take steps to develop or update existing local watershed plans to ensure maximum benefit from Best Management Practices (BMPs). To ensure practices implemented are effective, a consistent, long-term monitoring program can help determine water quality conditions and trends in a given water body. While dealing with existing development is necessary, communities in this category should strongly consider requiring or recommending low impact development (LID) for all new development. By "getting it right" the first time, the need to retrofit these projects in the future will be less likely and keep this from being a taxpayer responsibility. While the upfront costs are initially higher, the long-term benefits are much more cost-effective. There are various tools available to help communities estimate the benefits of LID including the DWQ Nutrient Loading Accounting Tool and the CWP's Watershed Treatment Model spreadsheet. Both can be used to estimate the pollution runoff, and what BMPs, or combination of BMPs, can best mitigate nutrient loads. Communities should also consider using the NCWRC Green Growth Toolbox. The Toolbox is a technical assistance tool designed to help communities understand where important wildlife habitats are located; create land use plans and policies that balance future development with natural resources protection, and; design development projects that will protect wildlife habitat alongside built areas.

Watershed restoration efforts are much more likely to succeed by partnering with other organizations and governments in the watershed. An excellent example of a partnership organization is the Upper Neuse Clean Water Initiative (UNCWI). The Initiative brings together landowners, conservation organizations, and local and state government programs to identify and protect those lands most critical for the long-term safety and health of all drinking water supplies communities in the Upper Neuse River Basin. In addition to intergovernmental partnerships, partnerships with area nonprofit and public organizations can be beneficial, particularly when leveraging grant funds.

While these larger municipalities are able to fund implementation projects through stormwater fees, the project demand is overwhelming. These municipalities should continue to seek funding through the NC State Revolving Fund, The North Carolina Clean Water Management Trust Fund (CWMTF), and the USEPA 319 Grant Program. Additional funding for smaller projects and outreach efforts is available through a variety of public and private organizations including the Community Conservation Assistance Program (CCAP) managed through the local Soil and Water Conservation District (SWCD).

Key Stakeholders and Resources
Durham; Greensboro; High Point and Burlington
CWPs Treatment Model spreadsheet
Councils of Government
County Soil & Water Conservation Districts
DWQ Nutrient Accounting Tool
Land Trust for Central NC
Ecosystem Enhancement Program
NC Clean Water Management Trust Fund

USEPA 319 Grant Program
NC LID Group
NC State Revolving Fund Green Infrastructure Loans
NCWRCs Green Growth Toolbox
Upper Cape Fear River Basin Association
North Carolina Stormwater Utility Dashboard
Triangle Land Conservancy
Upper Neuse Clean Water Initiative (UNCWI)

Stress Category B - High Concentration of Watershed Stressors

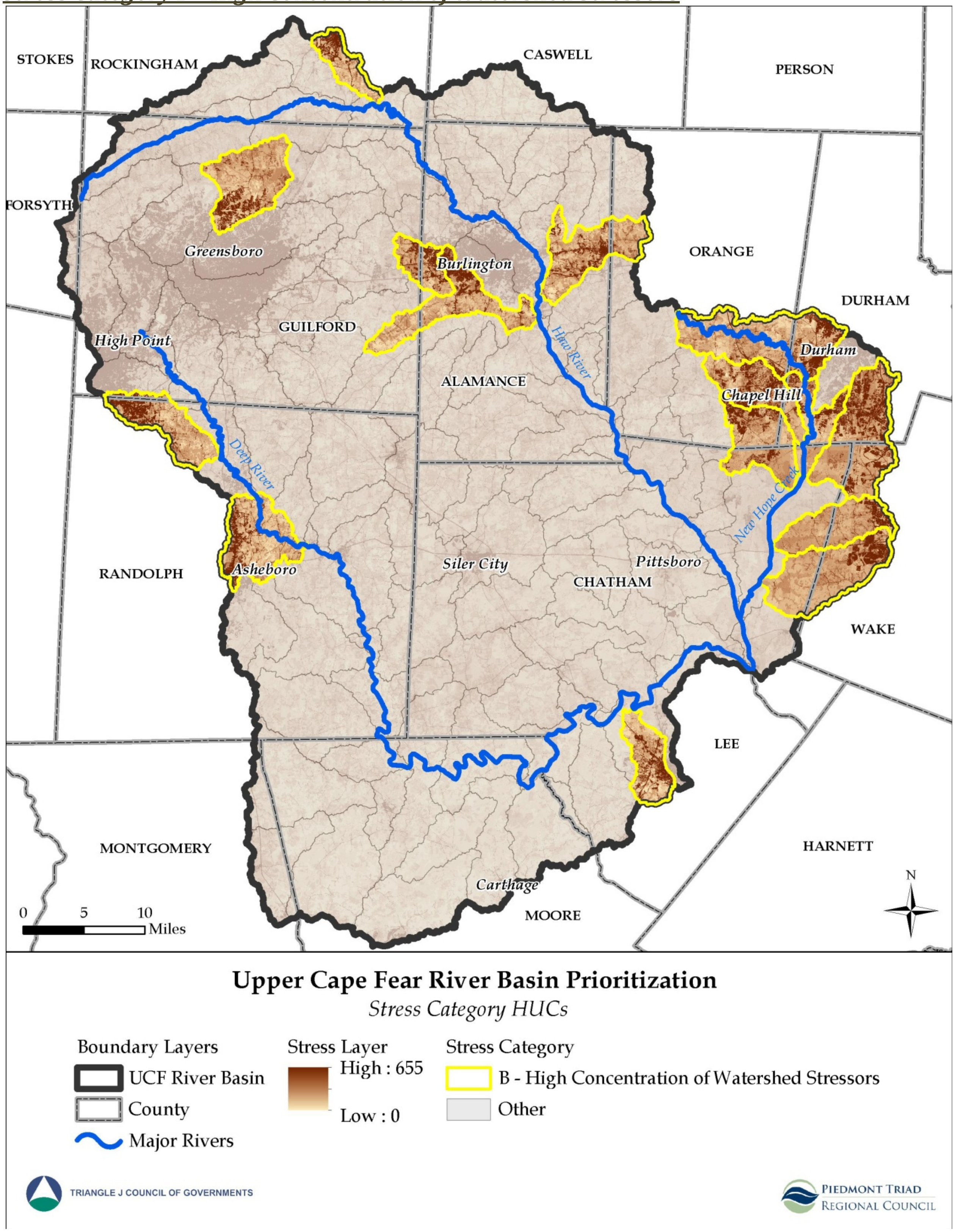

Figure 16: Stress Category B - Highest Concentration of Watershed Stressors

Key Watershed Characteristics

- Most potential for ecological uplift
- Regulated communities (NPDES, Jordan & Randleman Rules)

Key Management Recommendations

- Requiring or incentivizing LID for all new development
- Develop stormwater utility fee
- Develop watershed restoration plans
- Develop long-term monitoring plans

Overview

These twenty watersheds are primarily located adjacent to HUCs with the highest concentration of watershed stressors or in the smaller urbanized areas of the Upper Cape Fear River Basin. Touching on 26 municipalities, these watersheds are rapidly absorbing much of the sprawl from larger cities and commuter communities. With a few exceptions, these watersheds are fairly evenly distributed throughout the river basin and contribute to the Haw, the Deep, and the New Hope River subbasins. Category B watersheds show the highest change in population density making the need to protect them more immediate than perhaps any other watershed. While the investments needed to protect and restore Stress Category B watersheds may not be as extreme as the measures needed in Stress Category A, the potential for ecological uplift is tremendous.

Stress Category B watersheds have many of the same characteristics as found in Stress Category A, including a relatively high percentage impervious cover which indicates stormwater runoff is the major contributor to water quality impairments. In addition to impervious cover, low canopy cover, small parcel size, and a significant number of impact sites including, but not limited to, impacts from animal operations, NPDES permits, old landfill sites, PCB sites and other pollution incidents impact water quality in the Upper Cape Fear River Basin. Their relatively small size and larger percentage of green space makes many of these communities ideal candidates for implementing BMPs that have that have a maximum impact.

History

While land use cover in many of these HUCs is the result of urban sprawl, many of the smaller communities in the piedmont region grew out of the mill towns of the early 1900s. Situated along the banks of the Haw and Deep Rivers, these communities were once thriving economic centers. However, the decline of manufacturing and the recent economic downturn are evidenced by large abandoned lots occupying large tracts of land in and around these communities. While many of these sites have tremendous retrofit potential, the expense associated with such a retrofit is not realistic for many of these counties and municipalities.

Based on population size or proximity to a larger municipality, many of the communities in the Stress Category B watersheds are subject to NPDES Phase II regulations. These regulations require each community to develop and implement a stormwater management plan to reduce the contamination of stormwater runoff and prohibit illicit discharges. In 1999, communities in the Randleman Lake watershed were subject to the Randleman Lake Water Supply Watershed Buffer Rules, which require each jurisdiction to adopt a management strategy for maintaining and protecting riparian areas in the Randleman Lake watershed. In 2009, jurisdictions in the

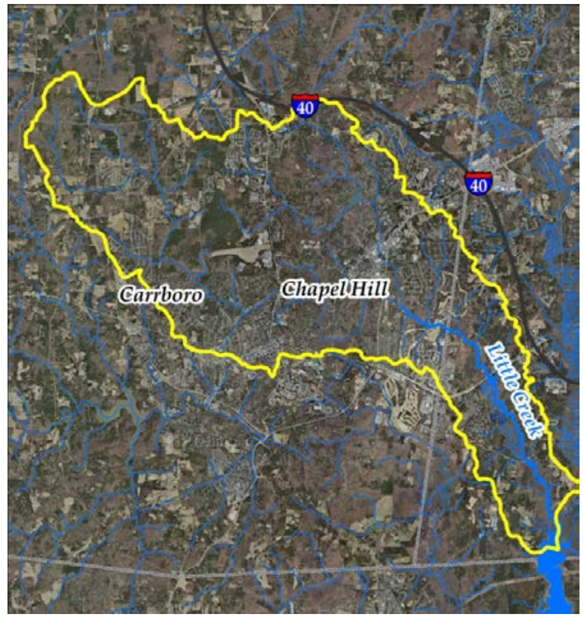

Figure 17: Little Creek Ortho

Jordan Lake Watershed, including the Haw River and New Hope Creek tributaries were mandated by the Jordan Lake Rules. The nutrient management strategy was designed to protect the lake for its classified uses as a drinking water source and prime recreation area, as well as protect critical habitat for many plant and animal species.

Current Practices

Many of these communities are currently implementing programs to comply with NPDES regulations including public education/outreach and participation/involvement, identifying and eliminating illicit discharges, controlling runoff from construction sites, post-construction runoff control and pollution prevention/good housekeeping measures. Communities in the Jordan Lake watershed are implementing additional rules for water quality including management of both new and existing development, riparian buffers, wastewater discharges, agriculture, and fertilizer management. Randleman Lake communities are subject to additional buffer rules.

Only a handful of the communities identified in Stress Category B watersheds have dedicated stormwater staff, and fewer have separate stormwater programs. The majority of these communities likely have a staff person only partially dedicated to meeting stormwater requirements, and a handful depend upon a town administrator or planner to meet their stormwater needs. The bulk of these communities do not implement a stormwater utility or tax, making it difficult to fund needed stormwater projects both to meet regulatory needs and to provide clean and safe water for their community. Only a handful of these communities have watershed restoration plans.

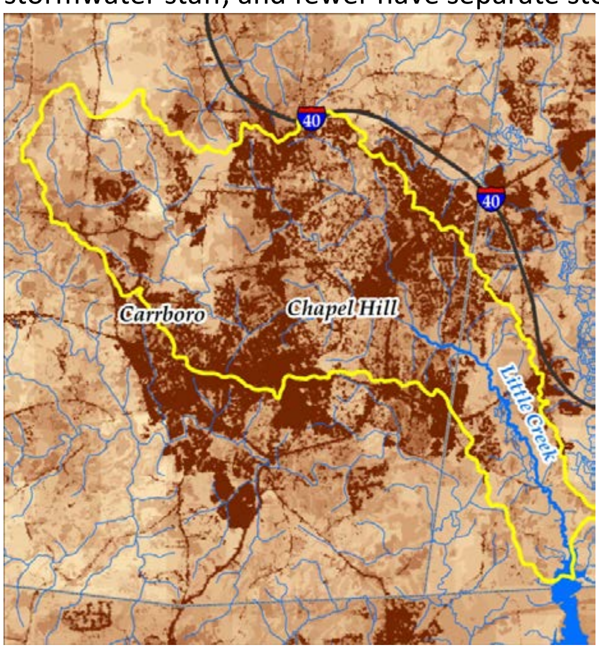

Figure 18: Little Creek Stress Raster

Next Steps & Partnerships

The importance of these watersheds cannot be emphasized enough. Improving conditions in Stress Category B communities may be the best opportunity to improve water quality in the Upper Cape Fear River Basin. Though there are many challenges in implementing BMPs in these communities, the cost-effectiveness of the benefits are unparalleled. Communities, regardless of size, need to begin discussing the creation of a stormwater utility. The UNC Environmental Finance Center has developed a dashboard to compare residential and non-residential stormwater utility fees across the state. The North Carolina Stormwater Utility Dashboard can be found on the Centers' website (http://www.efc.unc.edu/).

If they have not done so already, communities should begin a long-term water quality monitoring program as soon as possible. While there are many benefits to a sophisticated monitoring program, the data provided by citizen monitoring programs can be equally effective, with the added benefit of meeting public outreach and participation needs. These communities should also consider seeking funds for or establishing partnerships with other organizations (e.g. EEP, COGs, associations, etc.) to establish a local watershed plan (LWP) to guide implementation efforts. Jurisdictions or partnership organizations should also consider requiring or incentivizing LID for all new development. Funding for green infrastructure is primarily available through the NC State Revolving Fund Green Infrastructure Loans program, the CWMTF, and the USEPA 319 Grant program. Additional funding for smaller projects and outreach efforts is available through a variety of public and private organizations including CCAP.

Without a stormwater utility fee, the need for partnerships increases exponentially. Partnerships allow smaller jurisdictions to work together on a watershed scale. Not only do partnerships allow for a more comprehensive approach to watershed management, funders consistently favor partnership projects. In addition to intergovernmental partnerships, partnerships with area nonprofits, private organizations, landowners, and conservation organizations can be beneficial. An excellent example of a partnership organization is UNCWI. The Initiative brings together landowners, conservation organizations, and local and state government programs to identify and protect those lands most critical for the long-term safety and health of all drinking water supplies communities in the Upper Neuse River Basin.

Key Stakeholders and Resources
Alamance; Chatham; Durham; Guilford; Lee Orange; Randolph and Wake counties and associated municipalities
CWPs Treatment Model spreadsheet
Councils of Government
County Soil & Water Conservation Districts
DWQ Nutrient Accounting Tool
Land Trust for Central NC
Ecosystem Enhancement Program
NC Clean Water Management Trust Fund
NC LID Group
USEPA 319 Grant Program
NC State Revolving Fund Green Infrastructure Loans
NCWRCs Green Growth Toolbox
Upper Cape Fear River Basin Association
North Carolina Stormwater Utility Dashboard
Triangle Land Conservancy
Upper Neuse Clean Water Initiative

Stress Category C - Moderate Concentration of Watershed Stressors

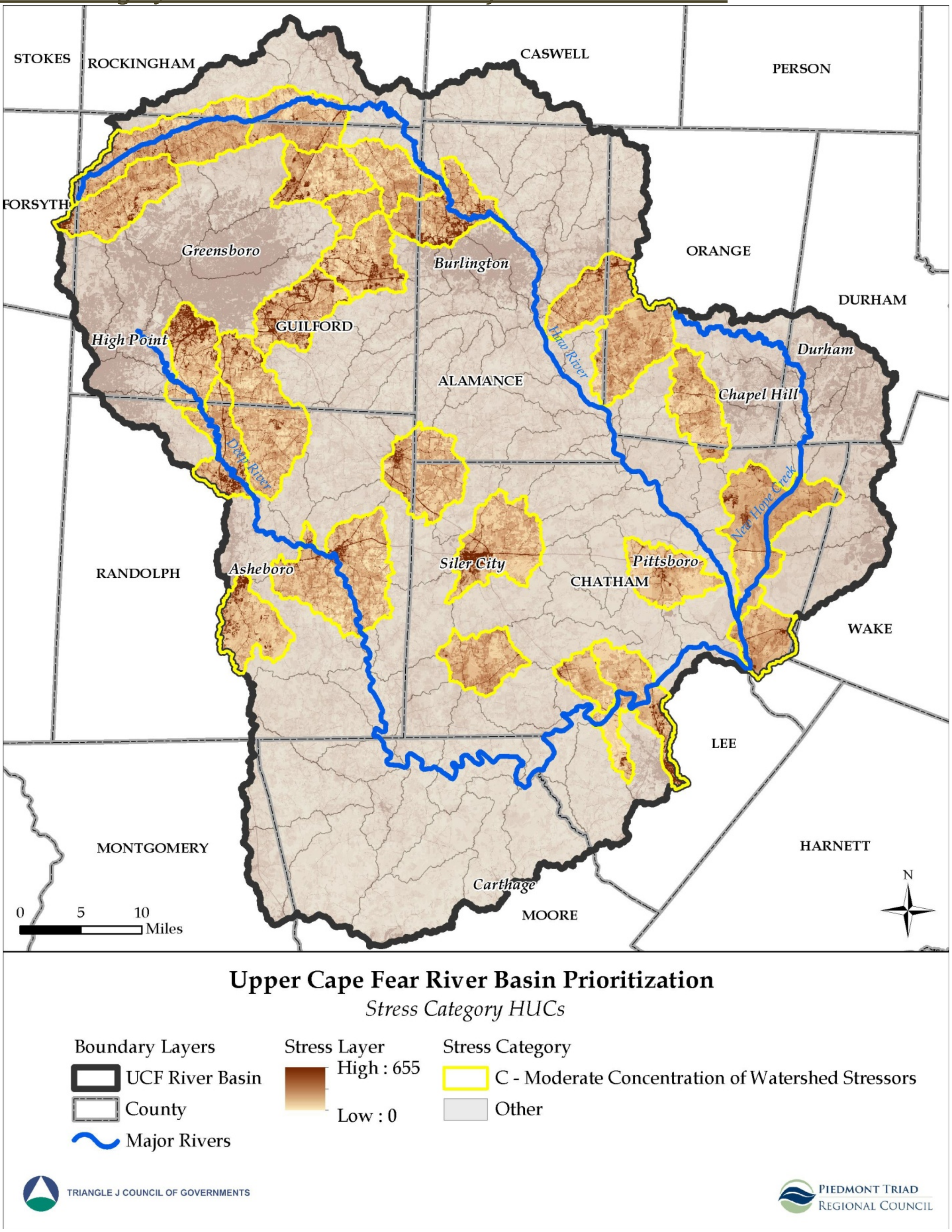

Figure 19: Stress Category C - Moderate Concentration of Watershed Stressors

Key Watershed Characteristics

- Highest percentage of impaired waters of any group
- High proportion of potential impact sites
- Deep River dams appear to play a role in causing chlorophyll-a impairment

Key Management Recommendations

- Small urban watersheds can be remedied cost-effectively
- Jordan Lake Water Users Group should consider an ecosystem services market to restore healthy waters to the lake
- Ideal research opportunities for NCSU Water Quality Group

Overview

This group of Upper Cape Fear River Basin watersheds is representative of suburban and small urban land uses throughout the basin, though there are very rural areas in the Deep River subbasin. These are areas with fast-growing populations, often focused on the Triad and the Triangle. The impacts of this growth can be seen in the the largest percentage of impaired waters associated with any Stress Assessment group, though this is largely is due to the inclusion of Jordan Lake, which occupies 7,733 impaired acres. The NC General Assembly issued nutrient management rules for this 1,686 square mile watershed in 2009 to address this eutrophication concern. However, there are also 87 miles of impaired streams in these watersheds, indicating a more pervasive concern associated with small urban centers.

History

Most of these watersheds have transitioned from rural lands to single-family homes, with mostly commuter communities. Many of these watersheds are sites of active transition, with farmland and forests being developed and impacting waters. The small cities and towns throughout these watersheds have different origins, with some being recent bedroom community developments (Pleasant Garden), old mill towns transitioning to different purposes due to loss of industry (Pittsboro), or established small towns that serve specific purposes (Chapel Hill and Salisbury).

These towns display on a small scale the relationship between land use and water quality. Equally, these towns serve as smaller examples of how to recover urbanized streams with a combination of restoration and LID. These streams have often been subjected to decades of degradation to their ecology, but many of them can be recovered with relatively small investments compared to those needed for denser developments. These lessons could also be directly transferred to this group’s suburban communities with impaired streams.

Very few developments in the Upper Cape Fear River Basin have been done using LID practices. Consequently, the cumulative impacts from stormwater runoff have degraded streams and rivers. The Jordan Lake Rules attempt to address these issues through mandatory development standards designed to redress lake eutrophication. The value of these measures to local waters, though, has not been considered, even though many of the Rules' requirements have demonstrated a value to smaller hydrologic systems. If communities are dedicated to addressing local water quality concerns, they will need to invest in retrofits to reduce both stormwater and agricultural runoff. Any community demonstrating such willingness should be prioritized for watershed planning and investment projects by funders. They should also be directly solicited for potential projects by research organizations, especially the NCSU Biological and Agricultural Engineering Department (BAE).

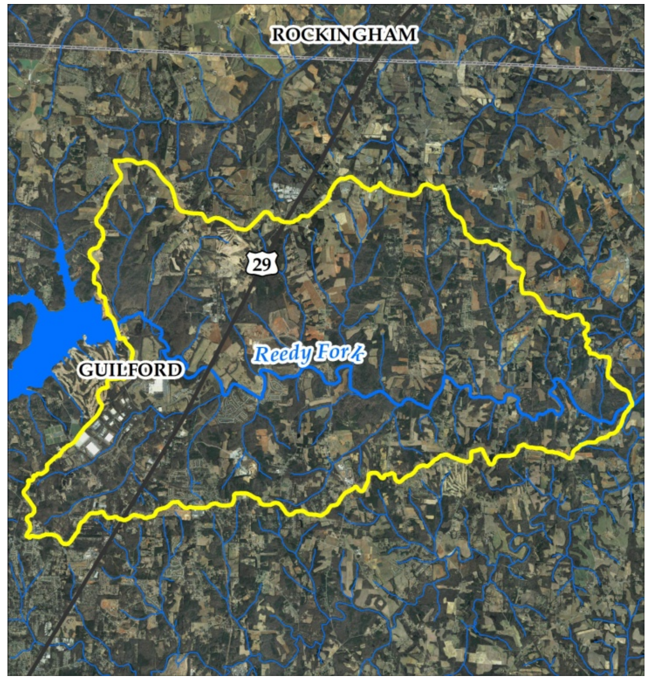

Figure 20: Reedy Fork Creek Ortho

The Deep River, however, presents different challenges from the other impaired waters within this group. The Deep River is impaired for high chlorophyll-a levels, a result of large contributions of nutrients from the mostly rural subbasin. Exacerbating the effects of these pollutants is the damming of the Deep River. There are at least thirteen small hydroelectric dams within the run of the Deep River, a couple of which are operational. Most are poorly maintained, slowing water flow and creating safety hazards for those using the river. The stagnant river flows allow algal growth and possible river eutrophication, which can lead to hypoxic water conditions and biological die-off. The rare and endangered species endemic to the Deep River may be driven from this river system under such conditions.

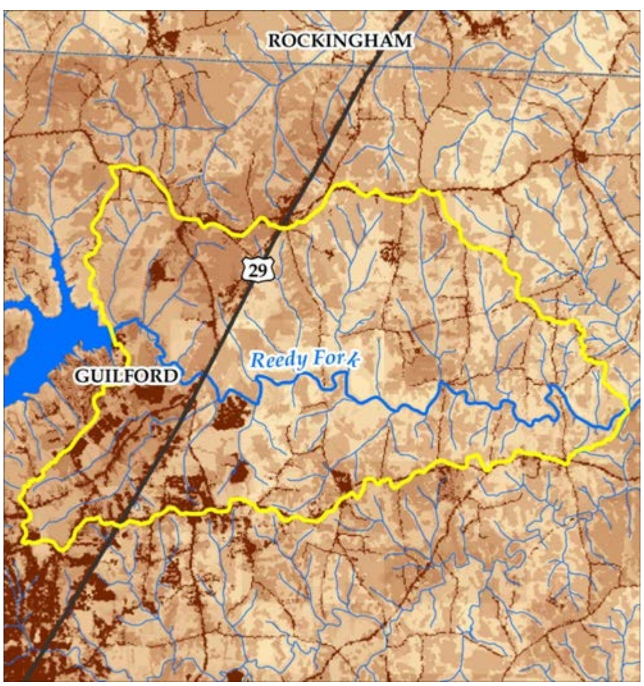

Figure 21: Reedy Fork Stress Raster

Current Activities

The lands around Jordan and Randleman Lakes have been acquired by public agencies to provide a floodzone and protect local water quality, inhibiting the development of these lands. Only one watershed has active ongoing planning, primarily funded by the Town of Chapel Hill and the Orange Water and Sewer Authority (OWASA). Jamestown and Asheboro have attempted to address their stormwater problems while also enhancing livability needs through greening investments such as street trees.

Given the small cities and suburban areas within many of these watersheds, there are multiple opportunities to partner with local non-profits and land trusts. Such partnerships make easement acquisitions easier to execute. UNCWI provides a large-scale model of how to develop such a program. The presence of endangered species and potential recreation argues for partnerships with the NCWRC and the USFWS that have not been seen yet.

Next Steps & Partnerships

There are multiple tools that can benefit water quality conditions in these communities, which frequently have a lot of green space in which to route and mitigate runoff. The NCWRC's Green Growth Toolbox is a valuable resource on how to balance community and environmental needs. Most local water quality benefits will almost certainly also benefit Jordan Lake, and a discussion of an ecosystem services market to incentivize such efforts should occur among local governments, the Jordan Lake Water Users group, and the land trust community. Finally, all future developments should be done with LID practices in mind. These impaired watersheds show the impacts that unmitigated development can have upon water quality. Efforts to prevent these degradations are a more cost-effective approach than future restoration, and can also address other community and economic needs. The *Piedmont Nutrient Reduction Handbook* is a good reference for local governments on how other North Carolina communities are addressing such needs.

American Rivers is a national advocacy group that focuses much of its efforts on removing dams and restoring freely-flowing waters to the nation's rivers and streams. They would be an ideal partner to address the impairment concerns on the Deep River, particularly as they relate to its stagnant flows. Interested communities should contact them and reach out to the Land Trust for Central NC and/or the Triangle Land Conservancy to discuss how to execute such projects, including recreational opportunities.

Key Stakeholders and Resources
NCSU BAE/Water Quality Group
NC Wildlife Resources Commission
NC Clean Water Management Trust Fund
USEPA 319 Grant Program
NC State Revolving Fund Green Inf. Loan
TJCOG & PTRC
US Fish & Wildlife Service

American Rivers
Haw River Assembly
Jordan Lake Water Users Group
Land Trust for Central NC
Triangle Land Conservancy
County SWCD
NC Ecosystem Enhancement Program

Stress Category D - Low Concentration of Watershed Stressors

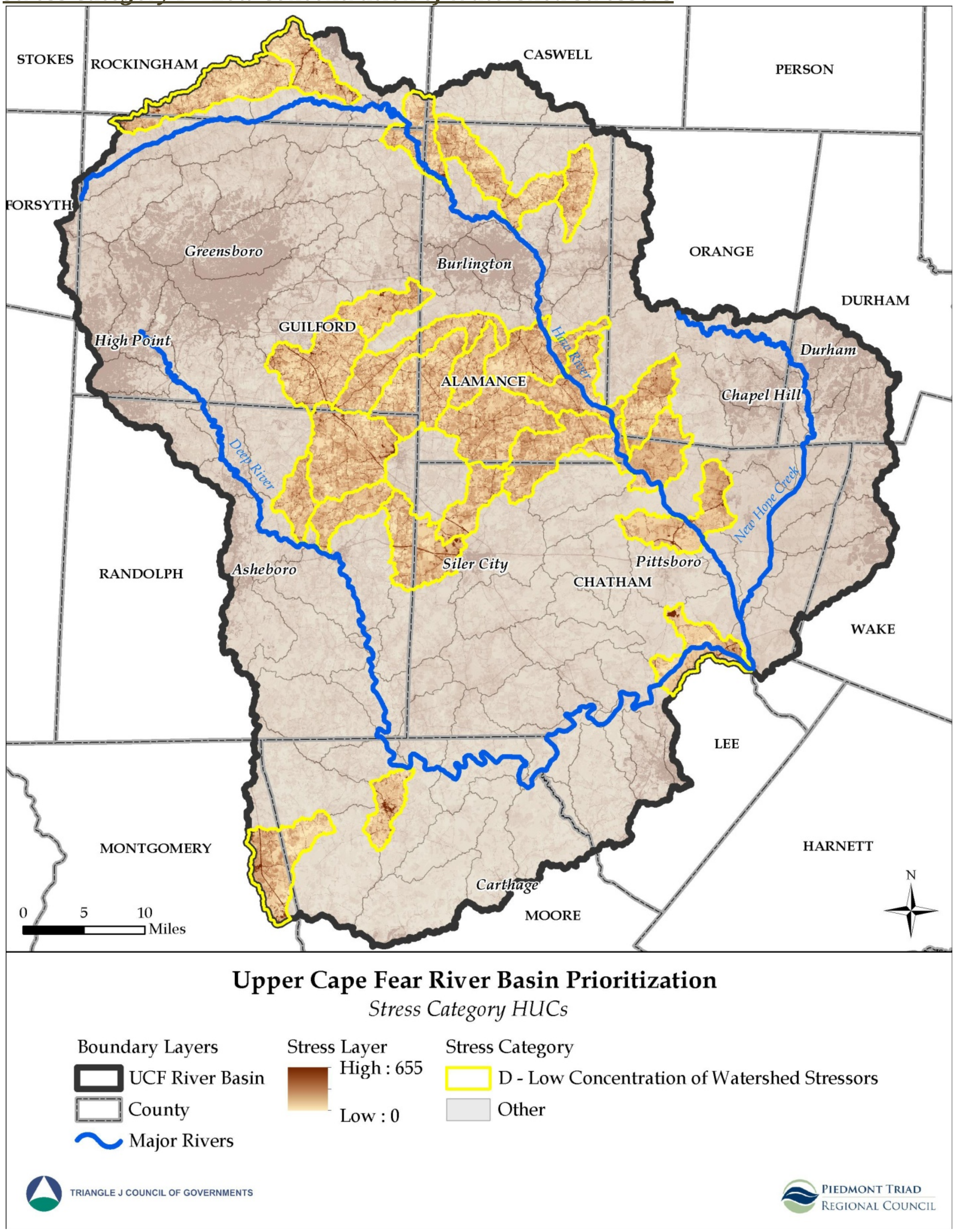

Figure 22: Stress Category D - Low Concentration of Watershed Stressors

Key Watershed Characteristics

- These watersheds receive little state or federal support
- Large areas of open space
- Largely agricultural watersheds

Key Management Recommendations

- Support locally-driven open space and conservation programs
- Initiate restoration planning efforts in the Graham-Mebane Reservoir watershed
- Enhance state and federal funding for watershed restoration

Overview

This group of twenty-five watersheds is almost entirely located in the very center of the Upper Cape Fear River Basin, in both the Haw and the Deep River Subbasins. There are several watersheds in the Haw River headwaters of Alamance, Caswell, and Guilford Counties as well, and their inclusion in this group appears to largely be aligned with the other watersheds. These are rural watersheds affected by growing urban development, but not yet in an intense way. Almost all of these watersheds are still used primarily for agriculture, but residential uses are equally important and may be changing these landscapes permanently. Whether or not this is done sustainably with regard to water quality and other natural resources is a fate that will be determined by the local and regional stakeholders. The two notable exceptions to this general categorization are the impaired Cabin Creek watershed in Montgomery County, and the Little Troublesome Creek watershed, which receives runoff from the City of Reidsville in southern Rockingham County and has a Total Maximum Daily Load (TMDL) for fecal coliform bacteria.

History

There is a significant amount of agriculture in these counties, which is largely crop- and cattle-driven, relying upon ethanol corn, tobacco, and non-dairy cattle farms. Many of these rural areas do not have regulations on new development beyond what is featured in the Jordan Lake Rules. These regulations may be sufficient to protect water quality in the larger reservoir, but it provides little guidance to developers on the types of communities the residents of these watersheds want. This is especially true in the counties with limited or no zoning ordinances. Without more guidance through policy, newer developments can run counter to the rural heritage of these watersheds, degrading the local quality of life and water.

These watersheds all lie outside the suburban belt that surrounds the Triad, Triangle, and Interstate-40 corridor. These are the most rural areas of many of the Upper Cape Fear River Basin's urban counties, and appeal to those wishing for a rural lifestyle convenient to urban job centers. Consequently, they are persistently slipping through the cracks for environmental investment and possess much of the open space and contiguous forests of the Upper Cape Fear River Basin, but fewer valuable ecological habitats or species compared with the rich and diverse areas in southern Chatham, northern Moore, and Lee Counties. Over time, the endemic ecology of these watersheds has been damaged by urban development and industrial use of the waters in the twentieth century. As such, they have received few conservation resources from the state or the federal governments (Haw River State Park is a notable exception), and have had to invest in these natural resources at the local scale.

Current Activities

There are several impaired waters in these watersheds, but less than in the twenty-eight watersheds of the Least-Intensive Land Use watersheds. There are, however, fewer healthy waters in these watersheds than in the Least Intensive watersheds. State and federal regulatory agencies deem many of these waters as unremarkable in any way, which has done a disservice to their water quality and the need to protect the ecologically-supportive waters that exist here. These impaired waters are spread throughout the Upper Cape Fear River Basin and include urban streams (Little Troublesome Creek) and rural streams (Cabin Creek) with different sources of pollution and which will require very different restoration efforts.

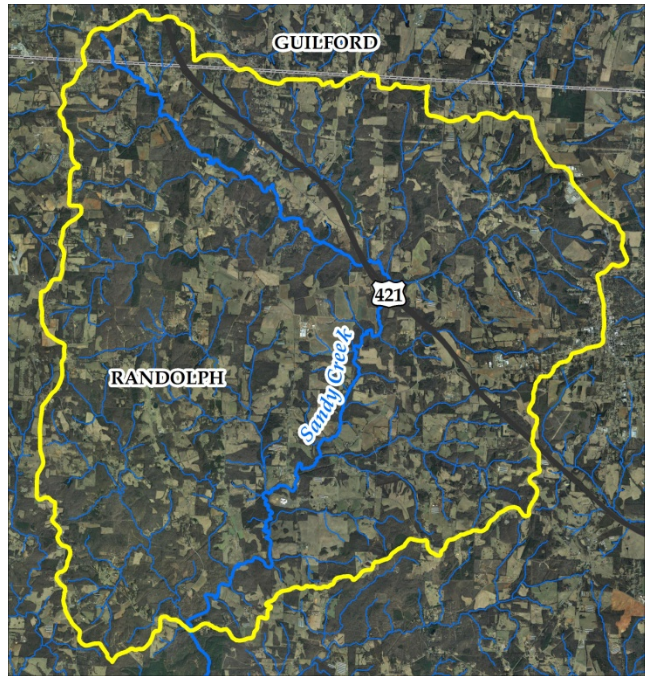

Figure 23: Upper Sandy Creek Ortho

All of these counties have invested local resources to address the absence of larger funding sources. Guilford County has an Open Space Preservation program to enhance the recreational options of County residents that uses a bond referendum to conserve unique and valuable open spaces throughout the county. Alamance County has partnered with Burlington and Graham to create the Haw River Trail, and collectively support a Coordinator position to work with landowners to create a contiguous trail and corridor of open space along the Haw River in Alamance County. Orange County has invested heavily in natural resources protection and instituting sustainable development practices through official codes and ordinances. They also have a strong partner in OWASA, which is dedicated to protecting watershed health for their drinking water supplies in the Upper Cape Fear River Basin. Chatham County has invested in a Conservation Plan that identifies all valuable habitats in the County and the sustainable practices needed to protect them. The only problem is that many of these programs rely upon local funding and support, which can be inconsistent. Fleeting program support has

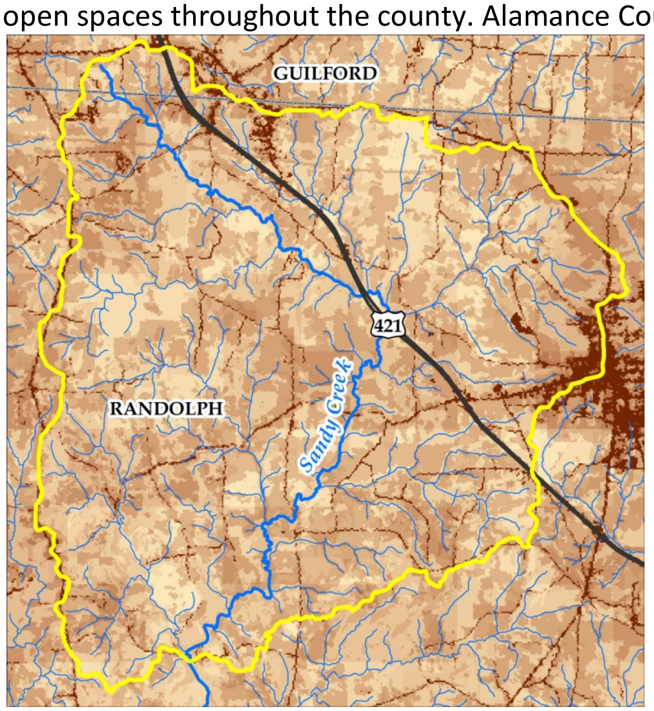

Figure 24: Upper Sandy Creek Stress Raster

been seen recently in both Chatham and Guilford Counties.

Next Steps & Partnerships

The Graham-Mebane Reservoir is within this tier of watersheds, and should be a top priority for watershed restoration funding and efforts. This small lake is the drinking water source for residents of both Graham and Mebane, and is impaired for (very) high levels of chlorophyll-a. Blue-green algae associated with toxins threatening to human and animal life have also been identified in this reservoir. Efforts to develop a non-point source management and restoration plan for this water body should begin immediately, and will require many small practices being implemented by the largely agricultural and residential watershed that drains to the reservoir. The Jordan Lake Rules may assist in rectifying these eutrophication concerns, but it will take time to determine the value of Rules' implementation in this smaller lake.

Private foundations, non-profits, and public institutions that are invested in healthy watersheds and protecting open space and agricultural lands should prioritize these watersheds for conservation efforts, recognizing that their relatively untouched conditions and high ecological value make them extremely vulnerable to development. Should an ecosystem services market for drinking water supplies be developed in either the Jordan Lake and/or Deep River, protection of these watersheds will not only be cost-effective, eliminating the need for more expensive watershed and drinking water resource restoration, but will be prescient to future watershed residents.

Those few streams within this group that are impaired should be prioritized for local watershed planning and investment by the 319 and CWMTF programs. Most of these streams are rural, and partnerships with the county SWCDs, local non-profits such as the Haw River Assembly, academic resources like UNC-Chapel Hill and Elon University, and local investment programs such as the Haw River Trail should be pursued by leading local stakeholders. These partnerships should be solidified through planning efforts and work in coalition to implement any watershed restoration needs. These streams should be prioritized for state and federal agricultural cost-share programs, private foundation investments, and community outreach and education programs as waters that could be quickly restored to ecological function and deliver a higher quality of life for the watershed residents.

Key Stakeholders and Resources
NC Wildlife Resources Commission
Conservation Trust for NC
NC Parks And Recreation Trust Fund
Jordan Lake Water Users Group
Land Trust For Central NC
Triangle Land Conservancy

County Soil & Water Conservation Districts
NC Ecosystem Enhancement Program
NC Clean Water Management Trust Fund
USEPA 319 Grant Program
Haw River Assembly
TJCOG & PTRC
US Fish & Wildlife Services

Stress Category E - Lowest Concentration of Watershed Stressors

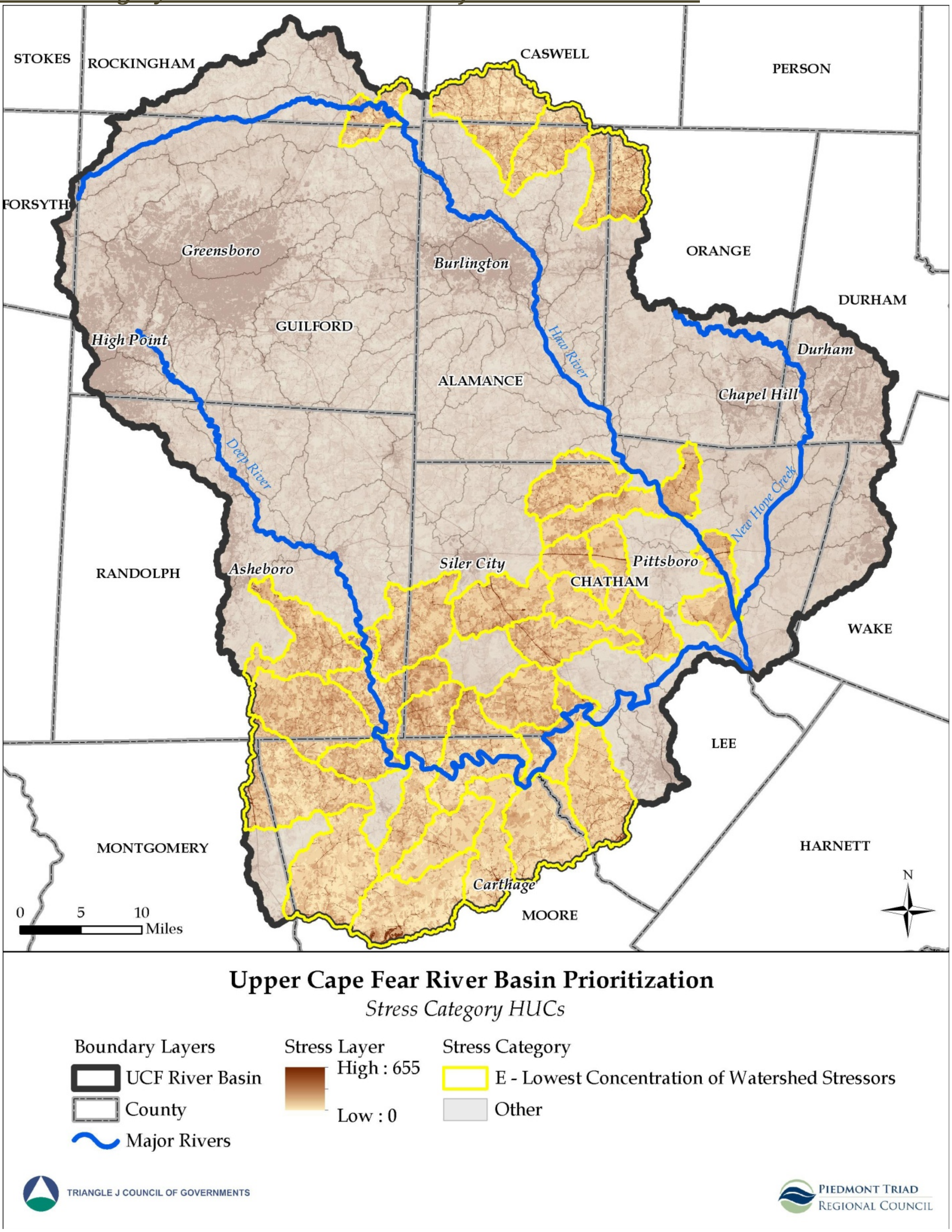

Figure 25: Stress Category E - Lowest Concentration of Watershed Stressors

Key Watershed Characteristics

- High concentration of Significant Natural Heritage Areas
- Very low levels of development
- Healthiest waters throughout the Upper Cape Fear River Basin

Key Management Recommendations

- Pursue Healthy Watersheds Initiative funding for protection efforts
- Partnerships with NCWRC, USFWS, and land trusts to protect ecological habitat
- Explore role of dams in Deep River impairment, and how to best rectify their role(s)

Overview

These watersheds are almost entirely drawn from the rural areas of the Upper Cape Fear River Basin, with the majority of them being found in the Deep River Subbasin counties of Chatham, Lee, Moore, and Randolph. Not surprisingly, these counties are also where the majority of watersheds with the highest conservation values and healthiest water quality conditions are found. These watersheds are largely undeveloped and retain healthy, functional landscapes, soils, and floodplains, and are the lowest concern in regard to watershed stress. As such, they serve as a guiding example of what all other Upper Cape Fear River Basin watersheds – especially those in rural settings – should aspire to.

History

The land use history of the Deep River Subbasin is largely agricultural. Cattle and poultry farms continue to dominate this subbasin, with Randolph and Chatham Counties being among the top poultry producers in the state. Timber also has an economic legacy in these counties, and continues to cover a majority of the region. This area lies at a fascinating geologic nexus of the Carolina Slate Belt, the Triassic Basin, and the Coastal Plain, leading to a staggering diversity of soils, ecological habitats, and watershed characteristics. Mixed hardwood forests give way to the NC Sandhills region, which intermingle with the clay soils and granite stone that define the Rocky River. The richness and diversity of the biology in this area and in its waters is unparalleled elsewhere in the entire Upper Cape Fear River Basin, and may be without peer within the entire NC Piedmont ecotome. Among the globally–endangered species present are the Cape Fear Shiner, the Schweinitz's sunflower, and the Carolina pigtoe. The lack of development in the Deep River Subbasin is a root cause of this perseverance and vitality. It is also a root cause of the struggling economy of these counties and their larger cities of Asheboro, Pittsboro, Sanford, and Siler City.

Current Activities

There are several impaired streams within this stress group of Upper Cape Fear River Basin watersheds, including the Deep River, Tick Creek, and Dry Creek. It is estimated that many of these are due to agricultural impacts to water quality. Poultry waste, in particular, is rich in ammonia and can quickly degrade water quality conditions. Most immediately, the individual county SWCDs should focus their efforts on addressing estimated non-point sources of pollution with state and federal agricultural cost-share funds. In the longer term, these watersheds serve as a readily available opportunity to address rural non-point sources of pollution with local watershed planning efforts, as supported by the federal 319 and CWMTF

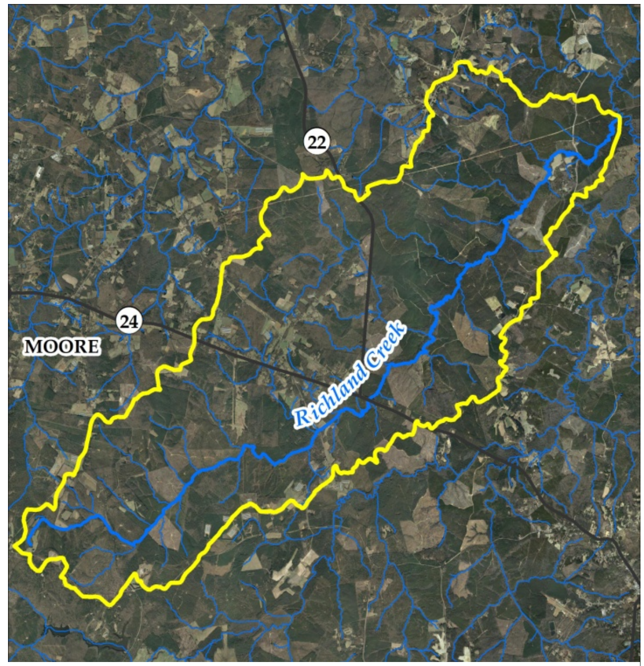

Figure 26: Richland Creek Ortho

programs. They may provide immediate ecological uplift, and could be claimed as water quality restoration victories by North Carolina with small investments, mostly dedicated to mitigating agricultural non-point sources of pollution.

The Deep River itself, however, presents different challenges from the other impaired streams. The Deep River is impaired for high chlorophyll-*a* levels, a result of eutrophication due to a large, collective contribution of nutrients in the forms agricultural waste, leaky septic systems, over-fertilization of grasses and crops, failing wastewater systems, and exposed riparian zones. Exacerbating the effects of these pollutants is the persistent damming of the Deep River. There are at least thirteen small hydroelectric dams within the run of the Deep River, only a couple of which are operational. They were built in the early twentieth century to power small grist and timber mills along the river, but are now poorly maintained or abandoned, slowing water flows and creating safety hazards for those trying to recreate on these waters. The more stagnant river flows allow greater opportunities for algal growth (measured indirectly with chlorophyll-a) and possible river eutrophication, which can, in a worst case scenario, lead to hypoxic water conditions and massive biological die-off. The endemic rare and endangered species that rely upon the Deep River may be directly affected and driven from this river system under these conditions.

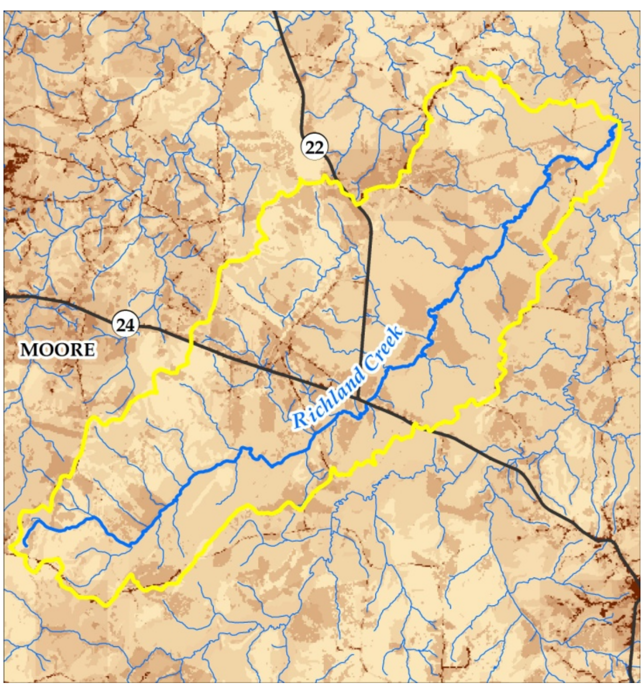

Figure 27: Richland Creek Stress Raster

Next Steps & Partnerships

The high ecological value and rural heritage of the Upper Cape Fear River Basin's least stressed watersheds should be the drivers for all efforts to protect these watersheds from degradation. Following the lead of Chatham County, it is recommended that all of the counties within these twenty-eight watersheds conduct Conservation Assessments of their lands, waters, and ordinances to both record the natural resources they have immediately on-hand and how they are protected within the public codes and ordinances. Such efforts can be expensive, but can be done gradually and through partnerships with local, regional, and state organizations. Randolph County has made significant progress in protecting these assets through viewshed and water quality policies that are directly integrated into their ordinances and codes, recognizing the value of their landscapes and history to visitors and residents.

Both the Land Trust for Central NC and TLC are available to protect these watersheds, especially those that are also highly valuable conservation watersheds and/or home to rare species. The USEPA's Healthy Watersheds Initiative should be prioritizing the work discussed here to maintain these exemplary rural watersheds in their current states. Support should also be sought from the NCWRC and the USFWS to restore or permanently protect aquatic, benthic, and terrestrial endangered species habitat. Those few streams listed as impaired by the NCDWQ (with the exception of the Deep River) should be immediately prioritized by the NCDWQ, the non-profit sector, all county SWCDs, and local and regional governments for funding, planning, and restoration.

American Rivers is a national advocacy group that focuses much of its efforts on removing dams and restoring freely-flowing waters to the nation's rivers and streams. They would be an idea partner to address the impairment concerns on the Deep River, particularly as they relate to its stagnant flows, and a partnership with the NCWRC and the USFWS to restore endangered species habitat to the river could be potent.

Key Stakeholders and Resources
American Rivers
Councils of Governments
Haw River Assembly
NCSU Water Users Group
NC Clean Water Management Trust Fund
NC SRF Green Infrastructure Loans

NC Ecosystem Enhancement Program
NC Nonpoint Source 319 Grant Program
NC Wildlife Resources Commission
American Rivers
US Fish & Wildlife Services
Soil and Water Conservation Districts

Conservation HUC Groupings

As noted in the Project Overview section, environmental, economic, and recreational data in North Carolina was collected in order to allow us to perform the GIS analysis. An initial listing of potential data layers was provided to stakeholders, which was subsequently refined and added to, based on local knowledge. Table 5 provides a list of the final data inputs used to perform the Conservation Analysis, and the last column in the table indicates how much weight a given layer was given. By reviewing the table, you can see that High Biodiversity/Wildlife Habitat Assessment values, Impervious Surface Cover, and Canopy Cover were considered to be the most important criteria by the stakeholders, comprising almost 70% of the total score. Values included in the Biodiversity/Wildlife Habitat Assessment layer are listed in Table 6. Other features included in the analysis included Hydric Soils, Soil Erodibility, Floodplain Areas, Population Density, Steep Slopes, Parcel Sizes, and Low-Impact Zoning.

A detailed description of the actual conservation analysis is included in the Methods Section.

Table 5: Conservation Analysis Input Layers and Weighting System (determined by stakeholders)

Conservation Layers				
Criteria	**Data Source**	**Factors**	**Integer Values**	**Total Layer Value**
High Biodiversity/ Wildlife Habitat Assessment	NCNHP	1 - 4	65	31.9%
		5 - 6	65	
		7 - 8	79	
		9 - 10	110	
Impervious Surface Cover	NLCD 2006 Percent Developed Imperviousness	> 10%	0	22.9%
		5 - 9%	54	
		0 - 4%	174	
Canopy Cover	NLCD 2001 update	> 50%	134	13.4%
Hydric Soils	SSURGO	Partially Hydric	22	7.8%
		All Hydric	56	
Soil Erodibility	SSURGO (K factor)	0 - 0.23	0	7.1%
		0.24 - 0.39	14	
		0.40 - 0.49	57	
Floodplain	NC Floodplain Mapping Program	Within 500 Year Floodplain	65	6.5%
Population Density (Persons Per Square Mile)	Census Bureau, 2010	High (250 +)	0	4.9%
		Med (50-249)	20	
		Low (1 -49)	29	
Steep Slope	NCDOT LiDAR data	> 15%	37	3.7%
Parcel Size	Counties/Municipalities	> 50 Acres	12	1.2%
Zoning (Low Impact)	Counties/Municipalities	Planned Unit Development, Low Density Residential, Conservation, VAD	5	0.5%

Table 6: Input layers to the NCNHP's Biodiversity/Wildlife Habitat Assessment

Key to Identify Tool results for the Biodiversity/Wildlife Habitat Assessment			
Category Name	**Value**	**Individual Input Layers**	**Source for Input Layers**
NHP	10	Significant Natural Heritage Areas – National or State Significance	*NC Natural Heritage Program*
	8	Significant Natural Heritage Areas – Regional Significance	
	6	Significant Natural Heritage Areas - Local Significance	
	5	Element Occurrences – High ranking	
	4	Element Occurrences – Other	
Wetlands	7	Coastal Region Evaluation of Wetland Significance (CREWS) – Exceptional	*NC Division of Coastal Management*
	6	Coastal Region Evaluation of Wetland Significance (CREWS) – Substantial	
	5	National Wetland Inventory	*US Fish and Wildlife Service*
	2	Coastal Region Evaluation of Wetland Significance (CREWS) – Beneficial	*NC Division of Coastal Management*
Guilds	1-10	Landscape Habitat Indicator Guilds	*NC Natural Heritage Program*
DWQ	10	Outstanding Resource Waters	*NC Division of Water Quality*
	9	~~Stream BioClass - Excellent~~ Removed for our analysis	
	8	High Quality Waters	
	7	~~Stream BioClass – Good~~ Removed for our analysis	
	1	All other streams	
FishHabitat	9	Wild Brook Trout	*NC Wildlife Resources Commission*
	8	Anadromous Fish Spawning Areas	*NC Division of Marine Fisheries*
FishNursery	8	Fish Nursery Areas	*NC Division of Marine Fisheries*
Watersheds	7	Stream buffer tributaries to Threatened & Endangered Species	*NC Natural Heritage Program*
	3	Priority Watersheds	*NC Natural Heritage Program, NC Wildlife Resources Commission, The Nature Conservancy*
Marine	8	Oyster Sanctuaries	*NC. Division of Marine Fisheries*
	6	Submerged Aquatic Vegetation	
Hardbottom	8	Open Shellfish /Shellbottom	*NC Division of Marine Fisheries*
	7	Hard Bottom	
	5	Closed Shellfish /Shellbottom	
IBA	6	Important Bird Area	*Audubon North Carolina*
Impervious	99	Impervious Surface above 20%	*US Environmental Protection Agency*

Conservation Category A - Highest Concentration of Watershed Assets

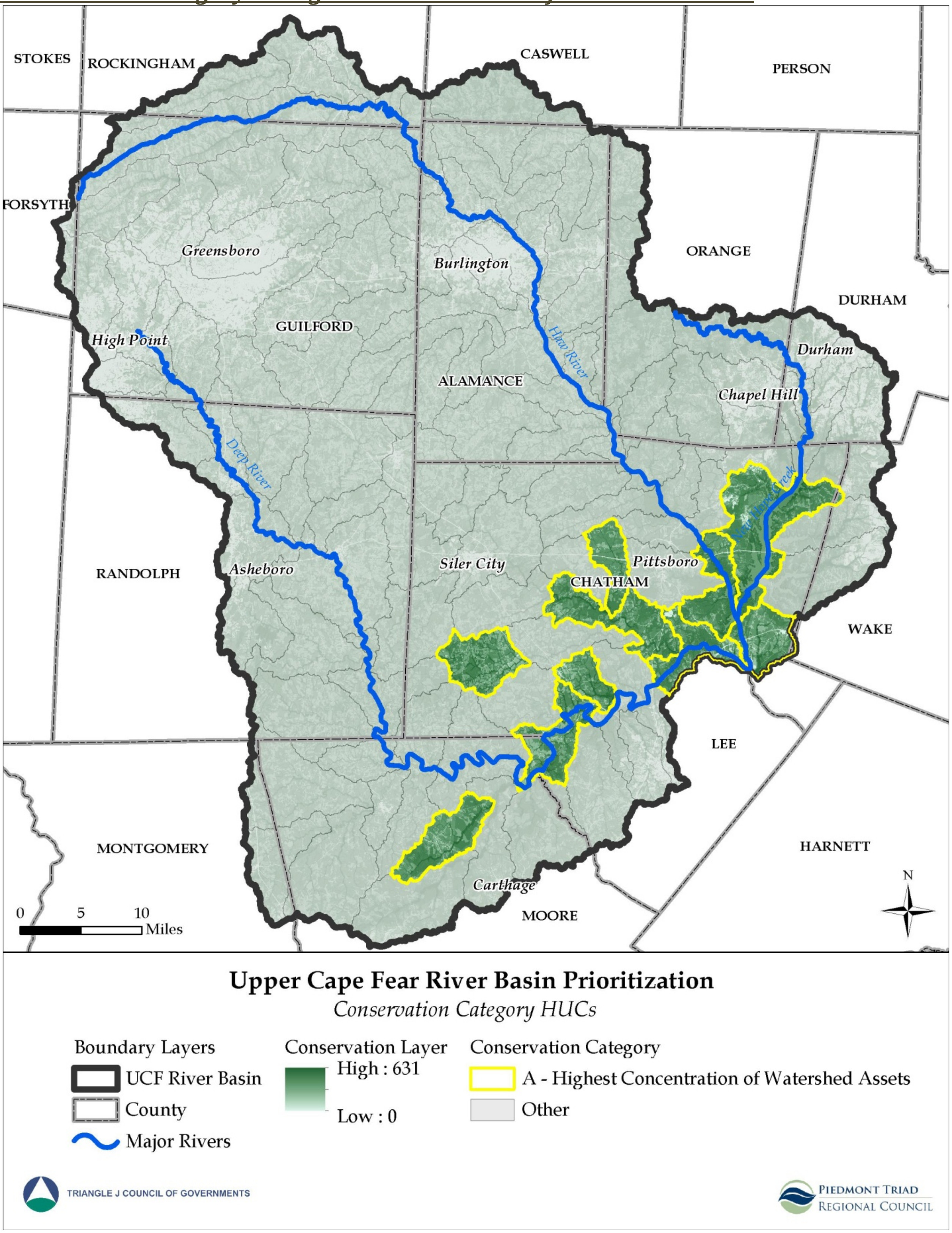

Figure 28: Conservation Category A - Highest Concentration of Watershed Assets

Key Watershed Characteristics

- Predominantly rural
- Large areas of unmanaged lands
- Large areas of game lands
- No impaired stream miles
- Large areas of USACE lands (Jordan)

Key Management Recommendations

- Work with existing conservation groups
- Create contiguous cover for conservation areas
- Engage local landowners
- Develop local watershed plans
- Focus on preservation

Overview

The watersheds characterized by Category "A" (Highest Concentration of Watershed assets) are almost entirely located within the rural areas of the Upper Cape Fear River Basin, with the majority of them being found in the Deep River Subbasin counties of Chatham, Lee, and Moore. Within this category, there are also a few watersheds located within the Haw and Lower New Hope watersheds. Watersheds in this category are characterized by high Biodiversity/Wildlife Habitat Assessment values, low impervious cover, and high canopy cover. Table 7 provides a description of the criteria considered in developing the Biodiversity/Wildlife Habitat Assessment value. In addition, they are predominantly rural with a strong agricultural presence and have large areas of unmanaged lands and game lands. Furthermore, none of the watersheds identified in this category have any listed impaired streams.

Based on these characteristics, management recommendations for maintaining water quality in these watersheds includes:

- Educating local landowners,
- Maximizing on the economic benefit of conserving natural areas (eco-tourism, forestry)
- Building off of existing efforts by working with existing conservation groups,
- Helping to create contiguous cover and forested corridors,
- Engaging the local landowners and creating local watershed groups if none exist,
- Developing local watershed plans,
- Encouraging good land-use planning that recognizes the value of conservation lands, and
- Focusing on preservation, rather than restoration.

In general, these watersheds exhibit large unmanaged areas and good water quality, and management efforts should focus on maintaining the good water quality conditions that they now have.

History

The land use history of the Deep River Subbasin is a largely agricultural one. Cattle and poultry farms continue to dominate this subbasin, with Randolph and Chatham Counties being among the top producers in the state. Timber also has an economic legacy in these counties, and continues to cover a majority of the area. This area lies at the geologic nexus of the Carolina Slate Belt, the Triassic Basin, and the Coastal Plain, leading to a diversity of soils, ecological habitats, and watershed characteristics. Mixed hardwood forests give way to the NC Sandhills region, which intermingle with the clay soils and granite stone. The species richness and diversity in this area and in its waters is unparalleled elsewhere in the entire Upper Cape Fear River Basin. Amongst other endangered species, these watersheds are home to the Cape Fear Shiner, the Schweinitz's sunflower, and the Carolina pigtoe. The lack of development in the Deep River Subbasin is a root cause of this perseverance and vitality.

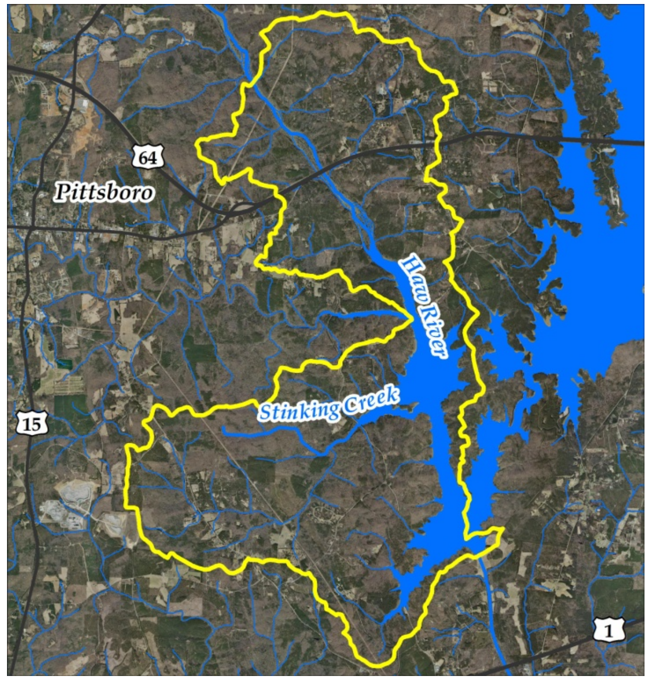

Figure 29: Stinking Creek-Haw River Ortho

Current Activities

Many Significant Natural Heritage Areas are located within this grouping with a large amount of element occurrences. In addition, portions of Jordan Lake are included in this grouping which indicates a large area of land that is managed by the US Army Corps of Engineers (USACE). However, Jordan Lake is also considered impaired for nitrogen and phosphorous and the Jordan Lake Rules are designed to protect and improve water quality in the lake by addressing specific issues such as reducing pollution from wastewater discharges, stormwater runoff from new and existing development, agriculture and fertilizer application. Any efforts in this category's watersheds should focus on preventing impacts from the sources listed above.

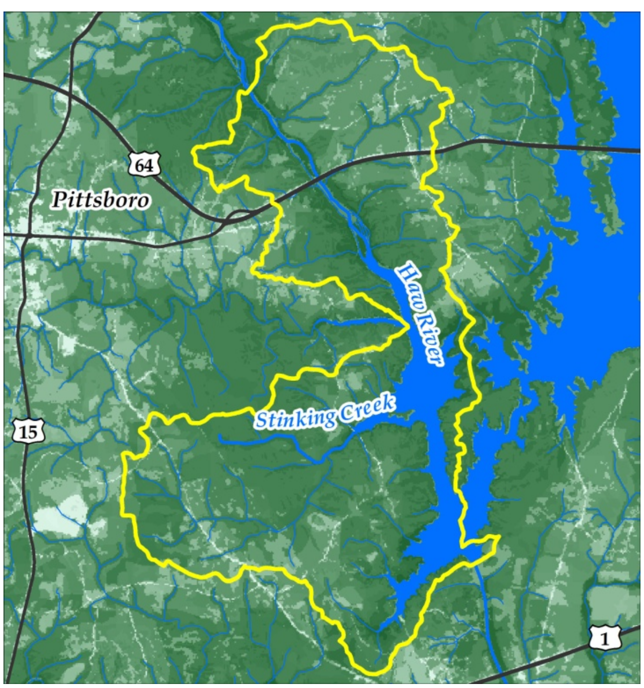

Figure 30: Stinking Creek-Haw River Conservation Raster

Other existing watershed stressors in this grouping are mainly present due to agricultural impacts. Poultry waste is rich in ammonia and can quickly degrade water quality conditions. Individual county SWCDs can focus their efforts on addressing any known or estimated non-point sources of pollution with state and federal agricultural cost-share funds.

The Deep River is impaired for high chlorophyll-a levels, a result of eutrophication due to a large, collective contribution of nutrients in the forms agricultural waste and fertilization, leaky septic systems, failing wastewater systems, and exposed riparian zones. Exacerbating the effects of these pollutants is the persistent damming of the Deep River. There are at least thirteen small hydroelectric dams within the run of the Deep River, only a couple of which are operational. They were built in the early twentieth century to power small grist and timber mills along the river, but are now poorly maintained or abandoned. Stagnant river flows allow greater opportunities for algal growth and possible river eutrophication. The endemic rare and endangered species that rely upon the Deep River may be directly affected under these conditions. American Rivers is a national advocacy group that focuses much of its efforts on removing dams and restoring freely-flowing waters to the nation's rivers and streams. They would be an ideal partner to address the impairment concerns on the Deep River, particularly as they relate to its stagnant flows.

Next Steps & Partnerships

In the longer term, these watersheds serve as a readily available opportunity to demonstrate the effectiveness of conservation measures and low impervious surface on water quality. The high ecological value and rural heritage of the Upper Cape Fear River Basin's watersheds should be the drivers for efforts to continue to protect these watersheds from degradation. Following the lead of Chatham County, it is recommended that all of the counties within these twenty-eight watersheds conduct Conservation Assessments of their lands, waters, and ordinances to both record the natural resources they have immediately on-hand and how they are protected within the public codes and ordinances. Such efforts can be expensive, but can be done gradually and through partnerships and support with local, regional, and state organizations. Randolph County has made significant progress in protecting these assets through viewshed and water quality policies that are directly integrated into their ordinances and codes, recognizing the value of their landscapes and history to visitors and residents. Both the Land Trust for Central NC and TLC are available to protect lands in these watersheds, especially those that are also highly valuable conservation watersheds and/or home to rare species. The USEPA's Healthy Watersheds Initiative should be prioritizing the work discussed here to maintain these exemplary rural watersheds in their current states.

Key Stakeholders and Resources
Chatham, Lee, and Moore Counties
Town of Pittsboro
American Rivers
Conservation Trust for North Carolina
Councils of Governments
Haw River Assembly
Jordan Lake Water Users Group
NC Clean Water Management Trust Fund
NC Clean Water State Revolving Fund
NC Forest Service
NC Division of Water Quality
NC Ecosystem Enhancement Program
NC Natural Heritage Program
NC Nonpoint Source 319 Grant Program
NC Sandhills Conservation Partnership
NC Wildlife Resources Commission
NCSU BAE/Water Quality Group
Orange Water and Sewer Authority
Sandhills Area Land Trust
Soil and Water Conservation Districts
Triangle Greenways Council
Triangle Land Conservancy
US Army Corps of Engineers
US Fish and Wildlife Service

Conservation Category B - High Concentration of Watershed Assets

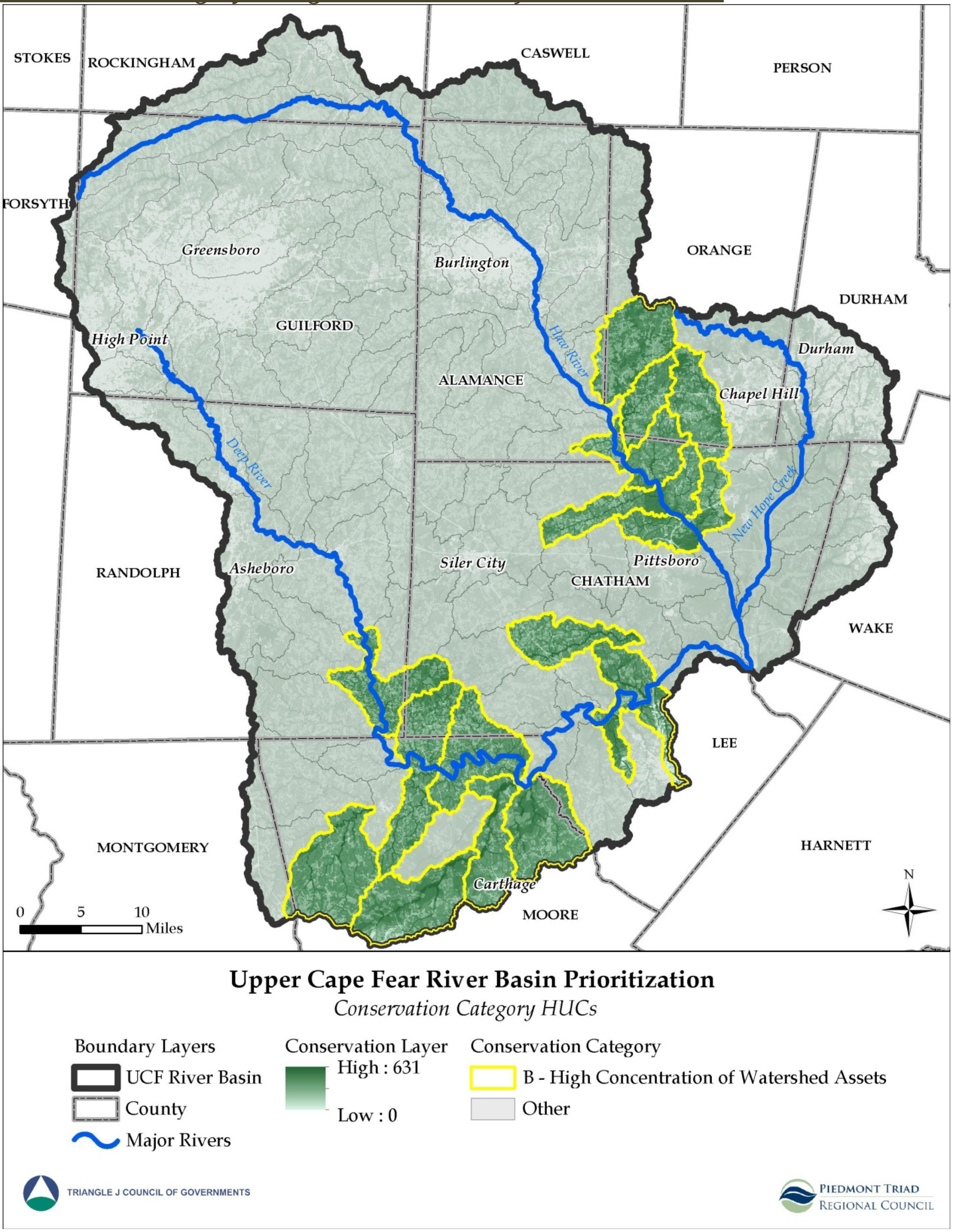

Figure 31: Conservation Category B - High Concentration of Watershed Assets

Key Watershed Characteristics

- Predominantly rural
- Large areas of unmanaged lands
- Large areas of game lands
- Some impaired stream miles
- Impaired impoundments
- Some development and sprawl

Key Management Recommendations

- Engage local municipalities
- Work with existing conservation groups
- Contiguous cover for conservation areas
- Engage local landowners
- Develop local watershed plans
- Focus on preservation

Overview

This group of watersheds is almost entirely located in both the Haw and the Deep River Subbasins. The majority of the watersheds are congregated in Orange, Chatham, and Montgomery counties, with smaller portions located in Randolph and Alamance counties. For the most part, these watersheds are characterized by large rural and agricultural tracts, with a high density of game and managed land. However, there is some development, and residential and commercial uses may start having a significant influence on these landscapes in the near-future. Within this conservation group, we begin to see some impaired stream miles, which may be a reflection of sprawl from the towns of Carthage, Pittsboro, and Chapel Hill.

Based on these characteristics, management recommendations for maintaining water quality in these watersheds includes:

- Working with local municipalities on land use planning and land ordinances,
- Educating local landowners,
- Maximizing on the economic benefit of conserving natural areas (eco-tourism, forestry)
- Building off of existing efforts by working with existing conservation groups,
- Helping to create contiguous cover and forested corridors,
- Engaging the local landowners and creating local watershed groups if none exist,
- Developing local watershed plans,
- Encouraging good land-use planning that recognizes the value of conservation lands, and
- Focusing on preservation, rather than restoration.

History

There is a significant amount of agriculture in these moderately-impacted counties, which is largely crop-driven, and many of these rural areas do not have regulations on new development beyond what is featured in the Jordan Lake Rules. These regulations may be sufficient to protect water quality in the larger reservoir, but it provides little guidance to developers on the types of communities the residents of these watersheds would welcome and would be proactive in maintaining good water quality. This is especially true in the counties with little to no zoning ordinances. Without more guidance in policy, there is a danger that incompatible developments that run counter to the rural heritage of these watersheds could be created, and that local water quality could be affected.

These watersheds constitute lands and waters appealing to those wishing for a more rural lifestyle that has a convenient proximity to these urban job centers. They possess much of the open space and contiguous forests of the Upper Cape Fear and Deep River Basins, as well as a high number of valuable ecological habitats and species associated with the rich and diverse areas in southern Chatham, northern Moore, and Lee Counties.

Current Activities

Many Significant Natural Heritage Areas are located within this grouping (mostly within the Deep River Basin) with a large amount of element occurrences. In addition, portions of Jordan Lake are included in this grouping which indicates a large area of land that is managed by the USACE. However, Jordan Lake is also considered impaired for nitrogen and phosphorous and the Jordan Lake Rules are designed to protect and improve water quality in the lake by addressing specific issues such as reducing pollution from wastewater discharges, stormwater runoff from new and existing development, agriculture and fertilizer application. Any efforts in this category's watersheds should focus on preventing impacts to water quality.

Figure 32: McLendon's Creek Ortho

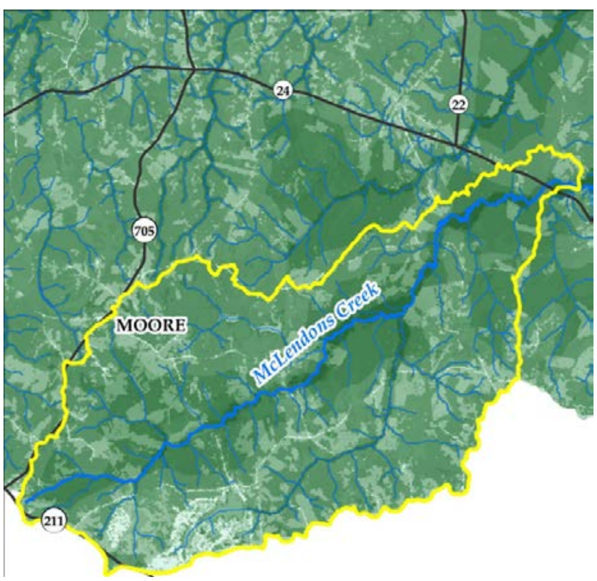

Figure 33: McLendon's Creek Conservation Raster

The Deep River is impaired for high chlorophyll-a levels, a result of eutrophication due to a contribution of nutrients in the forms agriculture, septic systems, failing wastewater systems, and exposed riparian zones. Exacerbating the effects of these pollutants is the persistent damming of the Deep River. There are at least thirteen small hydroelectric dams within the run of the Deep River, only a couple of which are operational. They were built in the early twentieth century to power small grist and timber mills along the river, but are now poorly maintained or abandoned. Stagnant river flows allow greater opportunities for algal growth and river eutrophication. The endemic rare and endangered species that rely upon the Deep River may be adversely affected under these conditions. American Rivers is a national advocacy group that focuses much of its efforts on removing dams and restoring freely-flowing waters to the nation's rivers and streams. They would be an ideal partner to address the impairment concerns on the Deep River.

All of these counties have invested local resources and funds to address the absence of larger funding sources. Alamance County has partnered with the Cities of Burlington and Graham to create the Haw River Trail, and collectively they support a Coordinator position to work with landowners to create a contiguous trail and corridor of open space along the Haw River in Alamance County. Orange County has invested heavily in natural resources protection and instituting sustainable development practices through official codes and ordinances. They also have a strong partner in OWASA, which is dedicated to protecting watershed health for their drinking water supplies in the Upper Cape Fear River Basin. Chatham County has invested in a Conservation Plan that identifies all vulnerable habitats in the County, and outlines sustainable practices to protect them.

Next Steps & Partnerships

Private foundations, non-profits, and public institutions that invest in healthy watersheds and protecting open space and agricultural lands can prioritize these watersheds for conservation efforts, recognizing that their relatively untouched conditions and high ecological value make them extremely valuable to maintaining water quality and vulnerable to development. Should ecosystem services investments for drinking water supplies ever be developed as a market system in the Jordan Lake and/or Deep River, protection of these watersheds can be cost-effective, eliminating the need for more expensive watershed and drinking water resource restoration.

Those few streams that are impaired can be prioritized for local watershed planning and investment by 319 and CWMTF programs. Most of these streams are rural, and partnerships with the SWCDs, local non-profits, academic resources like UNC at Chapel Hill, and local investment programs such as the Haw River Trail can be pursued. These partnerships can be solidified through planning efforts and work in coalition to implement any watershed restoration needs.

Key Stakeholders and Resources
Orange, Chatham, Montgomery, Randolph, and Alamance Counties
Chapel Hill, Carthage, Pittsboro
American Rivers
Conservation Trust for North Carolina
Councils of Governments
Haw River Assembly
Jordan Lake Water Users Group
NC Clean Water Management Trust Fund
NC Clean Water State Revolving Fund
NC Forest Service
NC Division of Water Quality
NC Ecosystem Enhancement Program
NC Natural Heritage Program
NC Nonpoint Source 319 Grant Program
NC Sandhills Conservation Partnership
NC Wildlife Resources Commission
NCSU BAE/Water Quality Group
Orange Water and Sewer Authority
Sandhills Area Land Trust
Soil and Water Conservation Districts
Triangle Greenways Council
Triangle Land Conservancy
US Army Corps of Engineers
US Fish and Wildlife Service

Conservation Category C - Moderate Concentration of Watershed Assets

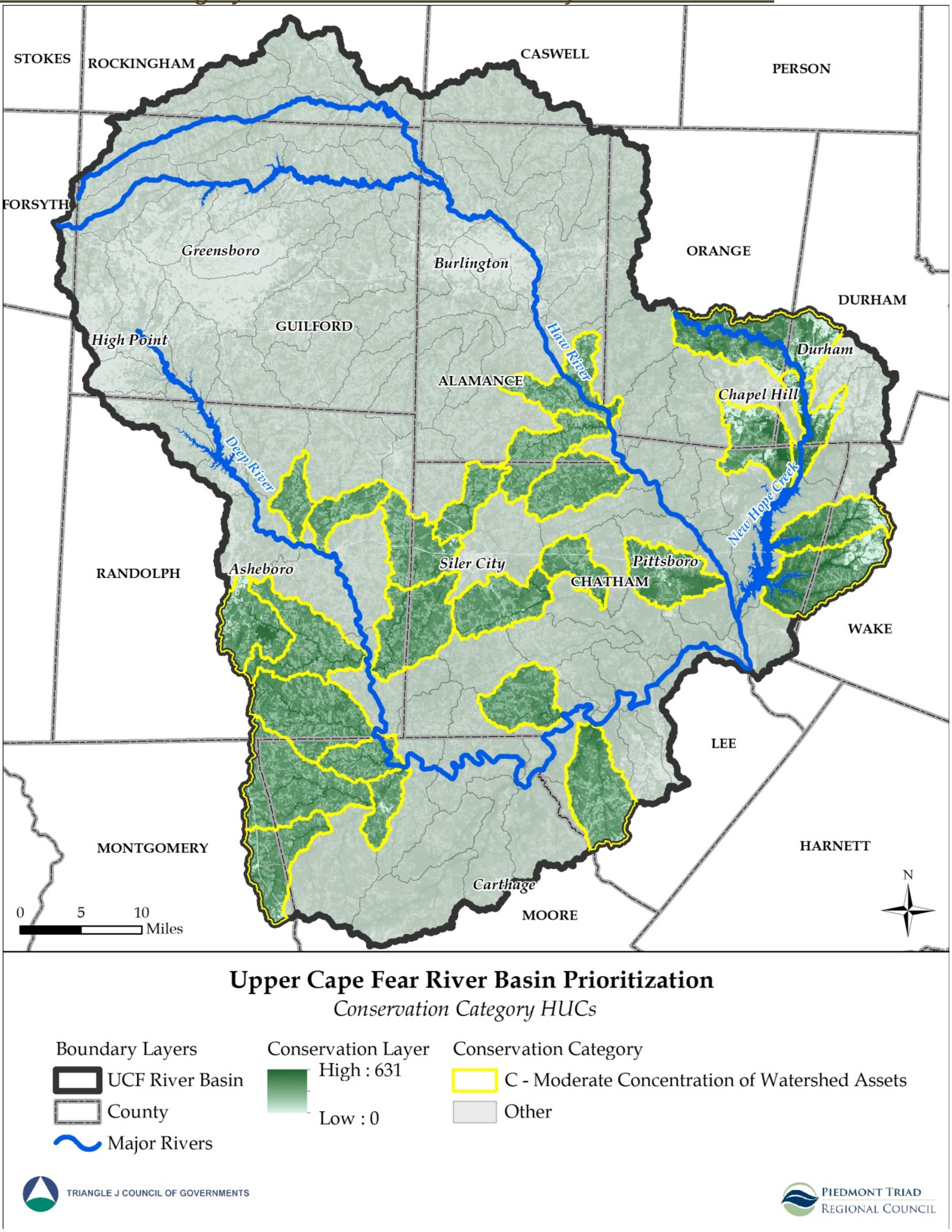

Figure 34: Conservation Category C - Moderate Concentration of Watershed Assets

Key Watershed Characteristics

- Mix of suburban, rural, & agriculture
- Many impaired stream miles
- Impaired impoundments
- Many low-density communities
- Good biodiversity/ habitat scores

Key Management Recommendations

- Engage local municipalities
- Public education campaigns
- Develop/implement local watershed plans
- Develop ordinance language
- Focus on development patterns
- Develop restoration plan

Overview

This group of watersheds has more representation throughout the Upper Cape Fear River Basin with portions in Orange, Chatham, Durham, Wake, Montgomery, Moore, Lee, Randolph and Alamance counties. For the most part, this group of watersheds in the Upper Cape Fear River Basin is representative of the suburban and small urban land uses throughout the entire river basin, though the very rural areas of the Deep River are all classified as less intensively used watersheds. These are areas with substantial populations that are fast-growing, often due to the economic centers of the Triad and the Triangle.

Based on these characteristics, management recommendations for maintaining and restoring water quality in these watersheds include:

- Working with local municipalities on land use planning and land ordinances,
- Educating local landowners,
- Developing public education campaigns
- Building off of existing efforts by working with existing conservation groups,
- Helping to create contiguous cover and forested corridors,
- Engaging existing local watershed groups,
- Developing new and implementing current local watershed plans,
- Developing nutrient management strategies where needed, and
- Encouraging good land-use planning that recognizes the value of both conserving and restoring lands.

History

Most of these watersheds have been developed for single-family residences and dispersed commercial centers over the twentieth century. Much of this land has transitioned from forested or agricultural lands to car-dependent residential land uses outside larger urban centers. Many of these watersheds are active sites of this transition, with farmland and forests being developed and altering the ways in which lands and their uses interact with waters. Many small cities and towns are also featured in these watersheds, including Chapel Hill, Pittsboro, Siler City, and Asheboro. These smaller communities have different origins, with some being old mill towns that are transitioning to a different purpose with the loss of industry (Pittsboro), or established small towns that serve specific, local economic purposes (Chapel Hill and Durham county).

These towns model on a small scale the impacts on water quality of denser urban developments but can also serve as smaller examples of how to recover urbanized streams with a combination of restoration and LID practices. These lessons could be directly transferred to suburban communities associated with impaired streams elsewhere in this group. Very few developments in the Basin have been done using LID practices, and local streams and rivers have become more degraded due to cumulative impacts from stormwater and its associated sediment and nutrient pollutants. The Jordan Lake Rules attempt to address these issues through BMPs and nutrient loading limits.

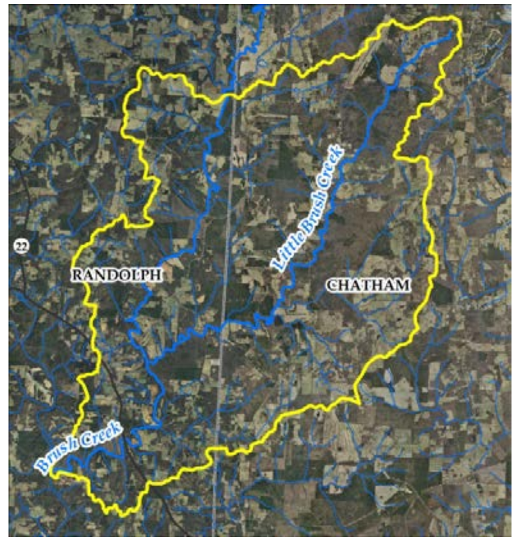

Figure 35: Lower Brush Creek Ortho

Current Activities

Many BMPs have been demonstrated to have value to smaller hydrologic systems elsewhere and could be employed here. If communities are dedicated to addressing local water quality concerns, they will need to invest in more retrofits that will directly reduce loadings to receiving streams from both stormwater and agricultural runoff. Communities demonstrating a willingness to make such investments should be recognized as a water quality leader by funders, prioritized for watershed planning and investment projects, and solicited for potential projects by research and technical organizations.

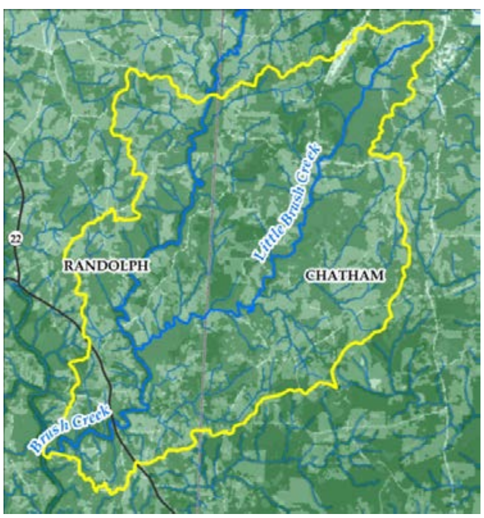

Figure 36: Lower Brush Creek Consv. Raster

There are multiple planning and engineering tools that can benefit water quality conditions in these communities, which frequently have a lot of green space in which to route and mitigate runoff impacts. Collaborations between towns and counties to guide development patterns that minimize water quality impacts are highly recommended. The NCWRC's Green Growth Toolbox is a valuable resource for such conversations and strategies. Finally, all future developments in these communities can be implemented with sustainable, low impact practices. As seen in many of these watersheds, small measures to prevent these degradations can be more cost-effective than restoration efforts in the future. It can also address other community and economic needs prioritized within these towns and counties.

Next Steps & Partnerships

Maintaining water quality conditions in these communities and implementing good planning and development practices may prevent degradation of water quality. Communities may want to begin discussing the creation of a stormwater utility. The UNC Environmental Finance Center has developed a dashboard to compare residential and non-residential stormwater utility fees across the state and can be accessed on the Centers' website.

Communities can develop a long-term water quality monitoring plan, which can be critical to identifying high priority restoration and conservation sites and determining water quality trends. While there are many benefits to a sophisticated monitoring program, the data provided by citizen monitoring programs can be equally effective, with the added benefit of meeting public outreach and participation needs.

In addition, these communities may consider seeking funds for or establishing partnerships with other organizations to establish LWPs that identify watershed impacts, stressors and sources, and implement restoration projects to remediate stressors and improve function. Using an LWP to guide BMP implementation helps ensure communities are getting the greatest cost-benefit for their investment in watershed projects. Communities in this category may also consider requiring LID for new development. There are several tools available to help communities estimate the benefits of LID including the DWQ Nutrient Loading Accounting Tool and the CWP's Watershed Treatment Model spreadsheet. Both can be used to estimate the pollution runoff, and what BMPs, or combination of BMPs, can best mitigate nutrient loads.

Without a stormwater utility fee, the need for partnerships increases exponentially. By establishing partnerships, smaller jurisdictions can work together on a watershed scale to meet water quality needs. Not only do partnerships allow for a more comprehensive approach to watershed management, grant funders consistently favor those projects with a strong partnership component. In addition to intergovernmental partnerships, partnerships with nonprofits, private organizations, landowners, and land trusts can be beneficial, and partnering on public outreach campaigns can be useful in ensuring the public message is clear and effective. The *Piedmont Nutrient Reduction Handbook* provides good reference material on existing partnerships and efforts, and provides good references for how other NC communities are addressing water quality.

Key Stakeholders and Resources
Orange, Montgomery, Chatham, Durham, Wake, Moore, Lee, Randolph and Alamance counties and associated municipalities
American Rivers
Conservation Trust for North Carolina
Councils of Governments
Haw River Assembly
Jordan Lake Water Users Group
NC Clean Water Management Trust Fund
NC Clean Water State Revolving Fund
NC Forest Service
NC Division of Water Quality
NC Ecosystem Enhancement Program
NC Natural Heritage Program
NC Nonpoint Source 319 Grant Program
NC Sandhills Conservation Partnership
NC Wildlife Resources Commission
NCSU BAE/Water Quality Group
Orange Water and Sewer Authority
Sandhills Area Land Trust
Soil and Water Conservation Districts
Triangle Greenways Council
Triangle Land Conservancy
US Army Corps of Engineers
US Fish and Wildlife Service

Conservation Category D - Low Concentration of Watershed Assets

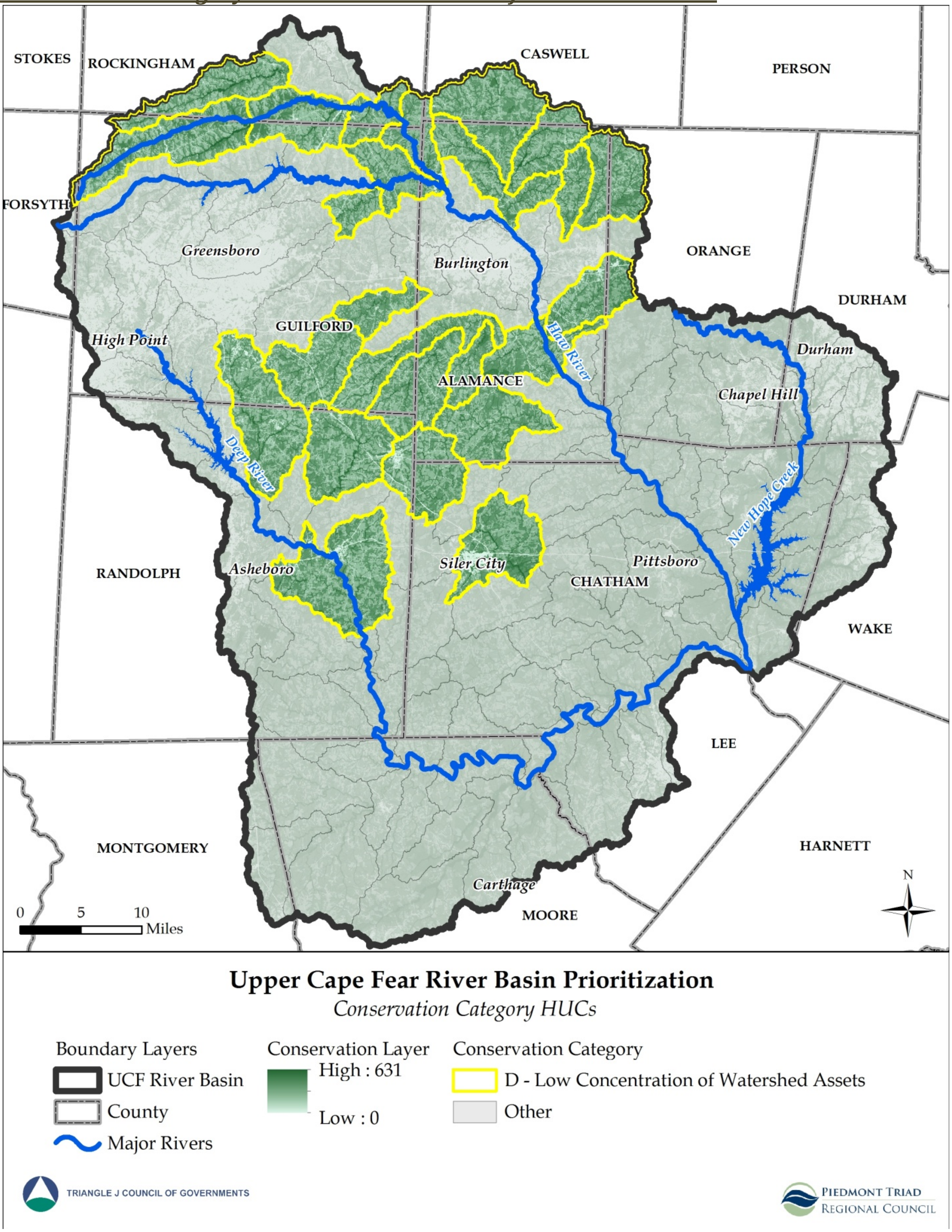

Figure 37: Conservation Category D - Low Concentration of Watershed Assets

Key Watershed Characteristics

- Predominantly rural
- Large areas of unmanaged lands
- Large areas of agricultural lands
- Large contiguous forests
- Few state and federal conservation investments

Key Management Recommendations

- Work with existing local conservation efforts
- Engage local landowners
- Develop local watershed plans
- Focus on improving WSW watershed quality
- Invest in watersheds with impaired waters
- Focus on protection in watersheds with healthy water quality

Overview

Watersheds in Category "D" (Low Concentration of Watershed Assets) are predominantly clustered near the center and northern edge of the Upper Cape Fear River Basin in Rockingham, Caswell, Guilford, Alamance, Orange, Randolph, and Chatham Counties. Five (5) of the watershed are in the Deep River Subbasin, while the remaining twenty (20) are in the Haw River Subbasin. Watersheds in this category are generally characterized at having lower Biodiversity/Wildlife Habitat Assessment values (Table 3), higher impervious cover, and/or lower canopy cover. All of these watersheds had lower percentages of developed areas (all less than 6% developed) and the agricultural lands varied between 25% and 50% agricultural, while unmanaged areas ranged from 50% to 70%. Just over half of the watersheds (13 of 25) had no impaired streams or open water, while the remaining watersheds had a total of 111.8 impaired stream miles and 479.3 acres of impaired open water.

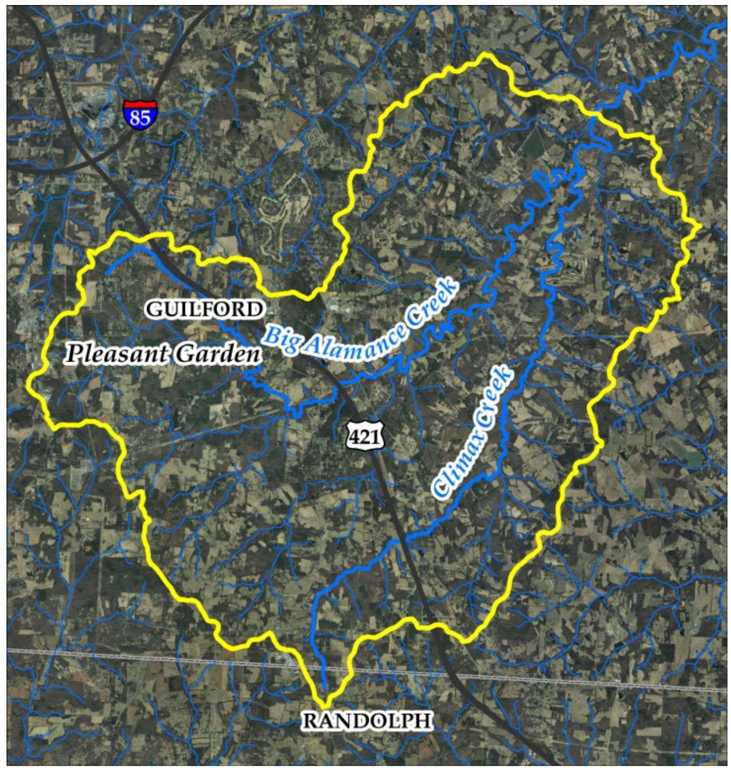

Figure 38: Big Alamance Creek Ortho

History

The watersheds in this category have had a predominantly rural agricultural history with common row crops such as corn and tobacco, along with livestock cattle. For the most part, these watersheds lie outside the suburban belt that surrounds the Triad, Triangle, and Interstate-40/85 corridors. These are some of the more rural areas in the Upper Cape Fear River Basin, and there has been less federal or state investment in conservation lands in these watersheds, though they contain large areas of open space and contiguous forests.

Current Activities

These counties have invested local resources to address the absence of federal and state funding sources. Guilford County has an Open Space Preservation program that uses a bond referendum to conserve unique and valuable open spaces throughout the county. Alamance County has partnered with Burlington and Graham to create the Haw River Trail, and collectively support a Coordinator position to work with landowners to create a contiguous trail and corridor of open space along the Haw River in Alamance County. Orange County has made major investments in natural resources protection and encourages more sustainable development practices through codes and ordinances. They also have a strong partner in OWASA, which is dedicated to protecting watershed health for their drinking water supplies in the Upper Cape Fear River Basin. Chatham County has invested in a Conservation Plan that identifies valuable habitats in the County and the sustainable practices needed to protect them. A significant challenge for these programs is that they rely primarily upon local funding and support, which can be inconsistent.

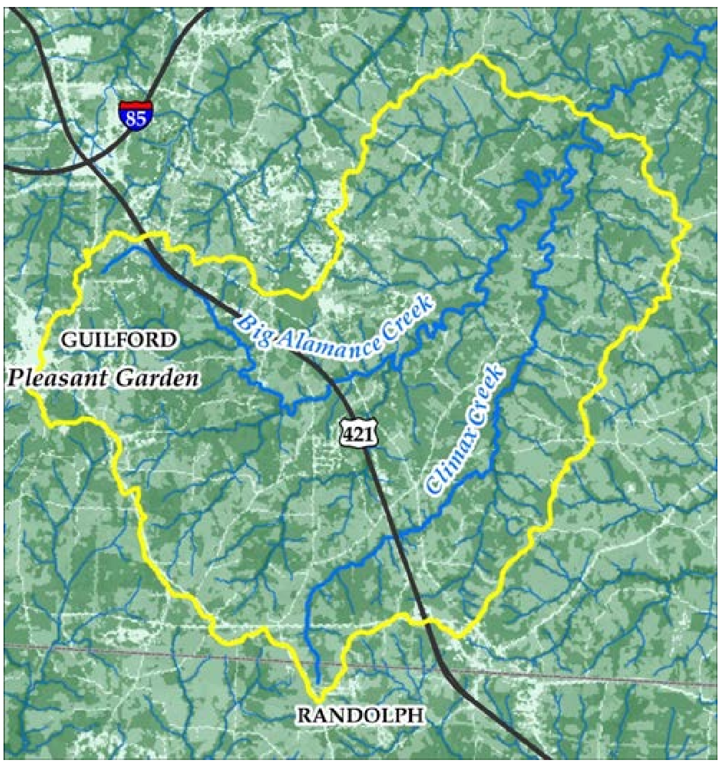

Figure 39: Big Alamance Creek Conservation Raster

Next Steps & Partnerships

Many of these rural areas do not have many regulations on new development beyond what is required by the Jordan Lake Rules. The Jordan Lake regulations are designed to protect water quality in the large reservoir, and as such, provides less guidance regarding the type of development that the communities within these watershed desire. This is especially true in the counties with little to no zoning ordinances.

The Graham-Mebane Reservoir is within this group of watersheds, and should be a top priority for watershed restoration funding and efforts. This small lake is the drinking water source for residents of both Graham and Mebane, and is impaired for high levels of chlorophyll-a. Toxic blue-green algae have also been identified in this reservoir. A non-point source management and restoration plan for this water body is needed, and will require many small practices being implemented in the agricultural and residential watershed that drains to the reservoir. The Jordan Lake Rules may assist in rectifying the eutrophication concerns.

Organizations that are interested in protecting watersheds, open space and agricultural lands should prioritize these watersheds for conservation efforts, recognizing that they are vulnerable to development. Furthermore, the watersheds with impaired streams can be prioritized for local watershed planning and investment by the 319 and CWMTF programs. Most of these streams are rural, and partnerships with the county SWCDs, local non-profits such as the Haw River Assembly, academic resources like UNC Chapel Hill and Elon University, and local investment programs such as the Haw River Trail should be pursued. These partnerships should be solidified through planning efforts and work in coalition to implement watershed restoration. These watersheds should be prioritized for agricultural cost-share programs, private foundation investments, and community outreach and education programs as waters that could achieve improved ecological function.

Key Stakeholders and Resources
Rockingham, Caswell, Guilford, Alamance, Orange, Randolph, and Chatham Counties
Siler City, Ramseur, Liberty, Mebane, Graham and Hillsborough
American Rivers
Conservation Trust for North Carolina
Councils of Governments
Haw River Assembly
Jordan Lake Water Users Group
NC Clean Water Management Trust Fund
NC Clean Water State Revolving Fund Green Infrastructure Loans
NC Forest Service
NC Division of Water Quality
NC Ecosystem Enhancement Program
NC Natural Heritage Program
NC Nonpoint Source 319 Grant Program
NC Sandhills Conservation Partnership
NC Wildlife Resources Commission
NCSU BAE/Water Quality Group
Orange Water and Sewer Authority
Sandhills Area Land Trust
Soil and Water Conservation Districts
Triangle Greenways Council
Triangle Land Conservancy
US Army Corps of Engineers
US Fish and Wildlife Service

Conservation Category E - Lowest Concentration of Watershed

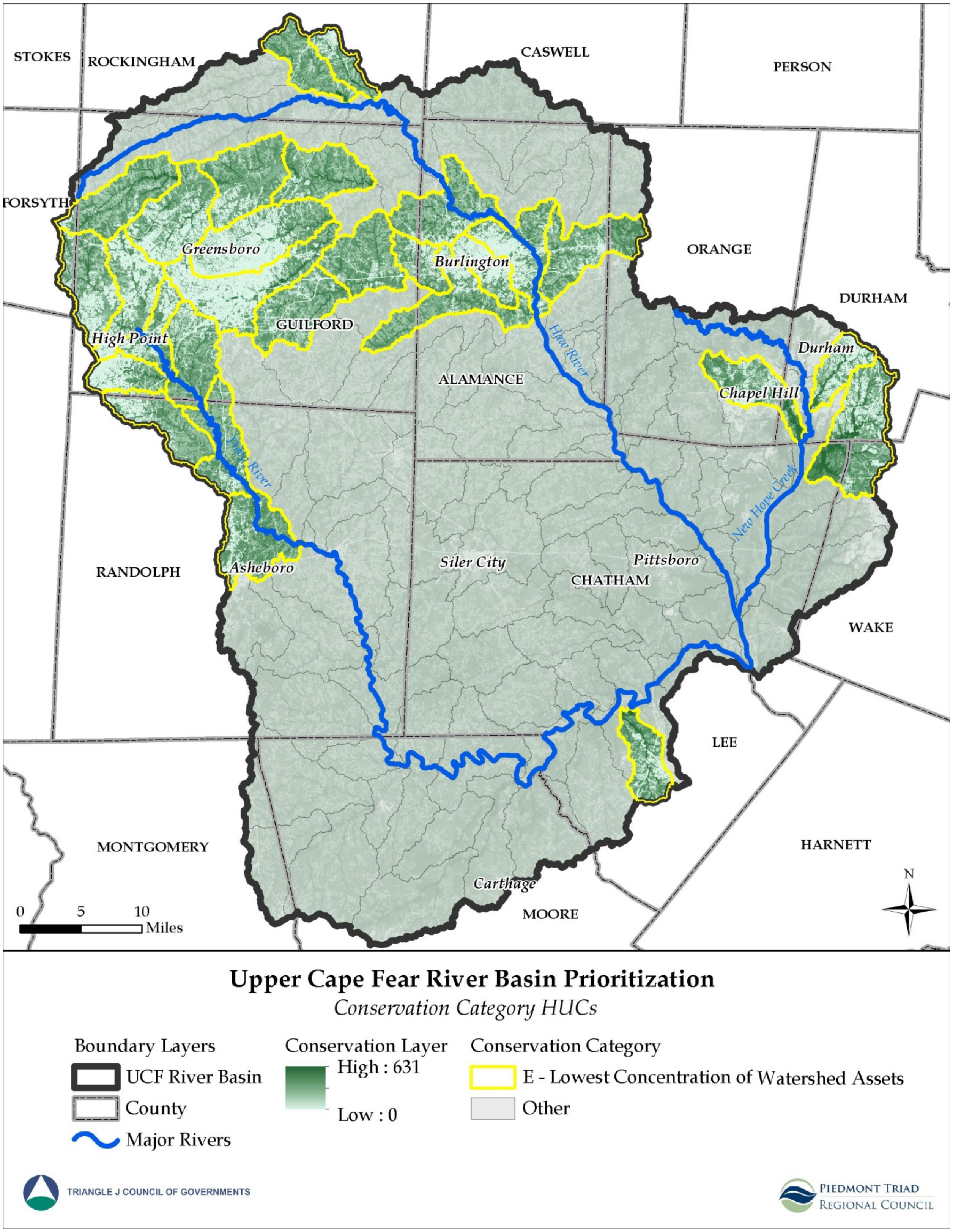

Figure 40: Conservation Category E - Lowest Concentration of Watershed

Key Watershed Characteristics

- Predominantly developed lands
- Large areas of unmanaged lands
- Impaired streams and open waters

Key Management Recommendations

- Consider development practices that reduce impacts to water quality
- Develop watershed restoration plans
- Focus on improving water quality, especially reducing impacts from stormwater

Overview

The 28 watersheds in Category "E" (Lowest Concentration of Watershed Assets) are located primarily near urbanized centers in Rockingham, Guilford, Alamance, Orange, Durham, Randolph and Lee counties. Nine (9) of the watershed are in the Deep River Subbasin, sixteen (16) are in the Haw River Subbasin and three (3) are in the Upper New Hope River Subbasin. Watersheds in this category are generally characterized at having low Biodiversity/Wildlife Habitat Assessment values (Table 3), high impervious cover, and low canopy cover. Seven (7) of the watersheds had less than 10% developed areas, whereas the remaining twenty one (21) watershed were more than 10% developed. All of these watersheds had relatively low percentages of agricultural lands (less than 36% agricultural lands) and high percentage of lands classified as unmanaged (all >38% unmanaged and 22 watersheds >50% unmanaged). Twenty-two (22) of the watersheds contained impaired streams or open water with a total of 236.8 impaired stream miles and 971 acres of impaired open water.

Based on these characteristics, management recommendations for improving water quality in these watersheds include:

- Consider development practices that reduce impacts to water quality
- Develop watershed restoration plans
- Focus on improving water quality, especially at reducing impacts from stormwater
- Educate local government policy makes, planner and area landowners.

In general, these watersheds contain highly-developed areas and impacted water quality. Management efforts should focus on improving water quality and minimizing impacts.

History

The watersheds in Category E are located in the major urbanized centers within the Upper Cape Fear River Basin, especially along the I-85, I-40 and I-74 corridors (Figures 41 and 42), but also include areas around Sanford in Lee County. The history of these areas includes textile manufacturing and furniture, and they serve as major transportation hubs. The communities within these watersheds are subject to various stormwater regulations including NPDES Phase I or Phase II or NC Water Supply Watershed Protection (WSWP), which require stormwater management and/or limits on development densities.

Current Activities

Communities in these watersheds are engaged in public education and outreach, public participation and involvement, identifying and eliminating illicit discharges, controlling runoff from construction sites, post-construction runoff control and pollution prevention/good housekeeping measures. Communities in the Jordan Lake watershed are implementing additional rules for water quality including management of both new and existing development, riparian buffers, wastewater discharges, agriculture, and fertilizer management. Randleman Lake communities are subject to additional buffer rules.

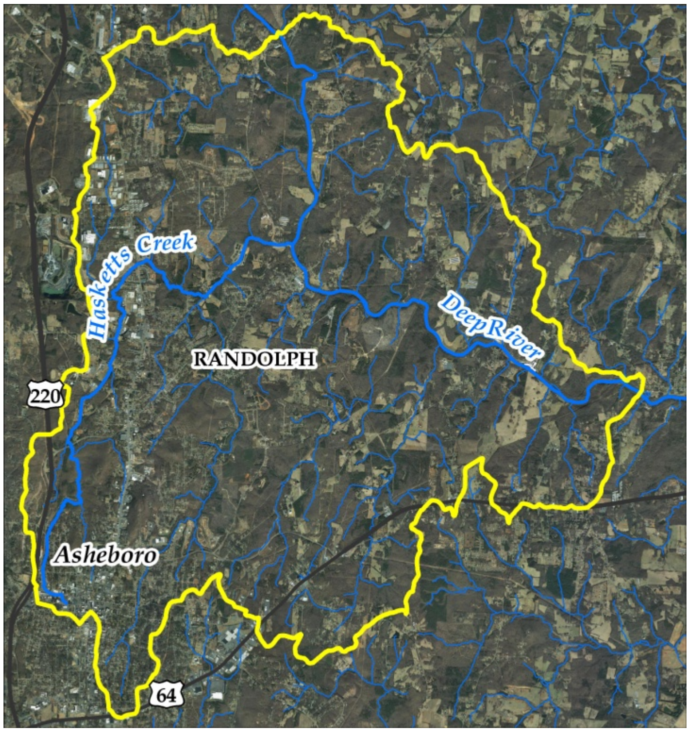

Figure 41: Hasketts Creek-Deep River Ortho

Next Steps & Partnerships

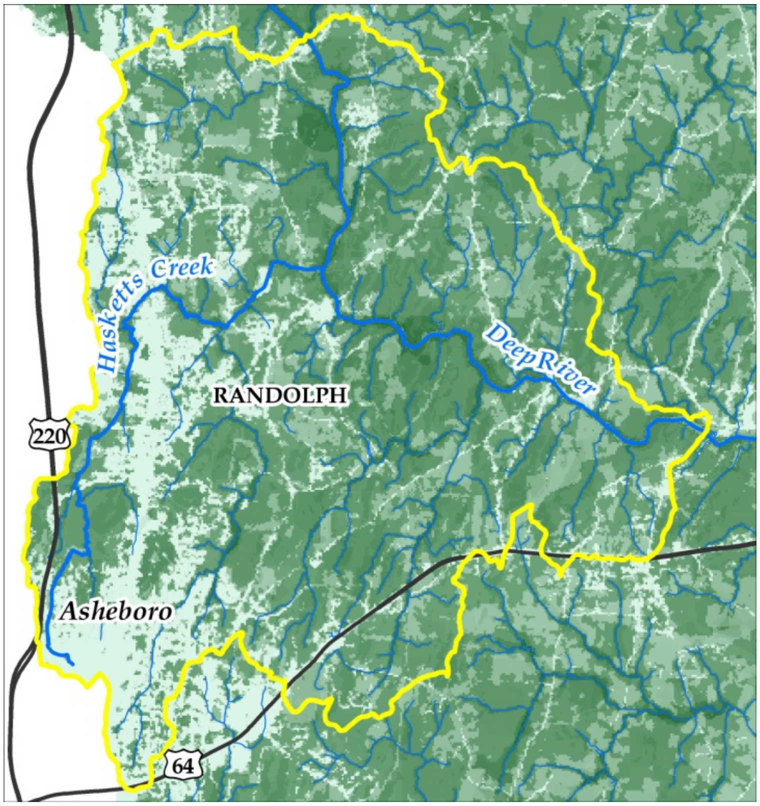

Figure 42: Hasketts Creek-Deep River Consv. Raster

Watershed restoration plans would be beneficial in watersheds without existing plans. Restoration planning involves identifying specific watershed impacts, stressors and sources, and implementing restoration projects to minimize stressors and improve function. Increased monitoring efforts may also help pinpoint specific sources in the watershed. Communities should continue implementing structural and non-structural BMPs and should consider LID for new development.

Key Stakeholders and Resources
Rockingham, Guilford, Alamance, Orange, Durham, Randolph, and Lee Counties
Chapel Hill, Carrboro, Durham, Sanford, Asheboro, High Point, Greensboro, Reidsville, Randleman, Archdale, Burlington, Graham, Mebane, Cary, and Apex
American Rivers
Conservation Trust for North Carolina
Councils of Governments
Haw River Assembly
Jordan Lake Water Users Group
NC Clean Water Management Trust Fund
NC Clean Water State Revolving Fund Green Infrastructure Loans
NC Forest Service
NC Division of Water Quality
NC Ecosystem Enhancement Program
NC Natural Heritage Program
NC Nonpoint Source 319 Grant Program
NC Sandhills Conservation Partnership
NC Wildlife Resources Commission
NCSU BAE/Water Quality Group
Orange Water and Sewer Authority
Sandhills Area Land Trust
Soil and Water Conservation Districts
Triangle Greenways Council
Triangle Land Conservancy
US Army Corps of Engineers
US Fish and Wildlife Service

Summary

The results of the *Upper Cape Fear River Basin Conservation and Restoration Analysis and Strategy* show the need for increased support of local and regional initiatives to protect and restore watersheds. While planning and implementation efforts are underway in several communities within the Upper Cape Fear River Basin, the capacity to improve water quality is hampered in part by limited funding and competing priorities within local governments and nonprofit organizations. Many jurisdictions in the watershed have adopted local ordinances and practices in an effort to comply with state and federal water quality regulations including NPDES Phase I and II requirements, the Jordan Lake Rules, and the Randleman Lake Water Supply Watershed Buffer Rules. Communities in the Basin should continue implementing watershed management practices and participate in watershed collaboration efforts. Additionally, communities should consider important watershed functions (like the provision of clean water, flood water attenuation and terrestrial and aquatic habitat) as critical ecosystem services.

While the HUCs with the highest concentration of watershed stressors offer numerous opportunities for implementing management practices, the likelihood of fully restoring these primarily urbanized systems to pre-development conditions is unlikely. Using available water quality monitoring data and local watershed management plans, communities should make every effort to ensure management practices are strategically located to ensure the highest water quality returns on their investment. Due to the high cost of retrofitting existing development, it may be in the best interest of the highly urbanized communities to consider requiring LID for future development. While development costs may be higher, there are long-term cost savings for the community and numerous benefits to hydrology, water quality and habitat watershed functions.

Implementing BMPs in the urbanized centers of Guilford, Alamance and Durham counties will help provide some improvement to water quality conditions in the Upper Cape Fear River Basin, but perhaps the most significant positive changes can be made in the watersheds represented in Stress Category B. Incorporating all or part of 26 municipalities, these watersheds have had a higher population density change between 2000 and 2010 than any other category. These watersheds exist primarily on the outskirts of major urbanized areas and in the smaller urbanized areas of the Basin. Investments in these HUCs are likely to help prevent streams from degrading and being 303(d) listed and/or restore streams that have recently become impaired. Additionally, improvements can generally be implemented at a lower cost than those in Stress Category A.

The Upper Cape Fear River Basin hosts two of the three fastest-growing regions in NC and, traditionally, residential development has followed a suburban pattern of growth. This sprawling land development pattern, while common, is largely unsustainable if we intend to maintain the high quality of life and abundant, high quality water resources that are essential underlying factors in making these regions desirable. Furthermore, the potential water quality impacts from land development and transportation projects should be recognized, and protections should be put in place in to ensure that valuable watershed functions are not lost. The stormwater, heavy metal, and nutrient burdens supplied by these projects should be

considered and aggressively addressed for both highly functioning and impaired watersheds. Water quality impacts from development and transportation projects within degraded watersheds can serve as an important lesson for communities in currently healthy watersheds as to the critical importance of recognizing and proactively addressing potential water quality impacts that can stem from unmitigated or poorly planned growth.

Some communities are proactively addressing their environmental footprints, applying Smart Growth and Low Impact Development tools to future development (Smart Growth Network, 2006; NRDC, 2001). The North Carolina Wildlife Resources Commission has also made available the "Green Growth Toolbox." The Toolbox is a technical assistance tool, handbook, GIS dataset and website developed to help North Carolina's towns and cities grow in ways that protect important habitats alongside new homes, businesses and shopping centers. It is far more cost effective to prevent water pollution and maintain high quality resources before they are significantly impacted than it is to try to remediate poor water quality after it has been degraded. However, it will still require strong political support on the part of local elected officials to minimize the environmental impacts of development while at the same time promoting economic growth and continued prosperity.

Successful watershed planning relies upon partnerships and collaboration among public sector, private sector, and non-profit interests. No one stakeholder can hope to fully protect or restore a watershed – it requires a local stewardship ethic amongst both the citizenry and the elected and staff-level decision makers who influence land use and water resource policy and determine where investments are made. Continued efforts should be made to foster collaboration and use the data developed in this project to pursue further support from state, federal, and private funding resources. Communities new to watershed management should leverage the knowledge and experience of existing watershed stakeholders and seek to build upon their previous success.

Sustainable planning approaches should be used in communities with healthy watersheds, and especially those with high concentrations of watershed assets. The ecosystem services of these watersheds for both local and downstream communities should to be recognized and valued through programs and funding so that there is an explicit incentive for protection. These services can be immediate and intrinsic (flood control, game lands, preservation of cultural heritage, recreation, open space, etc.) Some communities have developed successful working relationships with non-profits including land trusts to help protect valuable natural areas. However, there is a continued need for federal, state, or local policies to explicitly recognize the ecological services provided by healthy watersheds for the welfare of local or downstream communities.

The purpose of this project has been to consolidate, organize and analyze GIS-based information and use it to evaluate watershed conservation and restoration priorities within the Upper Cape Fear River Basin. This final document provides local agencies and stakeholders with a dataset to help prioritize their watershed-based restoration and conservation efforts. A standardized analysis method like the one presented here can also help provide objective credibility for those applying for implementation funding. Furthermore, this data can be used as a basis for additional watershed collaboration and for classifying the watershed priorities within the Upper Cape Fear River Basin. This project is intended to help aid in the restoration and sustainable management of clean and healthy waters. This planning process and GIS model are scalable and adaptable for use in any river basin in North Carolina, and could be used to prioritize watersheds statewide.

Works Cited

Center for Watershed Protection (CWP). 2003. Impacts of Impervious Cover on Aquatic Systems

Center for Watershed Protection (CWP). 2012. Watershed Protection and Restoration. Web site: http://www.cwp.org/your-watershed-101/watershed-protection-and-restoration.html.

Natural Resources Defense Council (NRDC). 2001. Stormwater Strategies: Community Responses to Runoff Pollution, Chapter 12: "Low Impact Development." Web site: http://www.nrdc.org/water/pollution/storm/chap12.asp.

NC Division of Water Quality (DWQ). NCDENR – Jordan Lake- Home. Web site: http://portal.ncdenr.org/web/jordanlake.

NC Division of Water Quality (NCDWQ). 2005. Cape Fear River Basinwide Water Quality Plan. Available at http://portal.ncdenr.org/web/wq/ps/bpu/basin/capefear/2005.

NC Division of Water Quality (NCDWQ). 2010. 2010 Integrated Report 305(b) and 303(d). Available at http://portal.ncdenr.org/c/document_library/get_file?uuid=a0208e7d-935c-4601-a8d7-8426cb67f169&groupId=38364

NC Natural Heritage Program (NCNHP). 2012. The North Carolina Conservation Planning Tool. Available at www.onencnaturally.org/PDFs/CHAPTER_4_BIODIVERSITY_WILDLIFE_HABITAT_Jan2012.pdf.

NC Wildlife Resources (NCWRC). 2012. Green Growth Toolbox. Available at http://www.ncwildlife.org/Conserving/Programs/GreenGrowthToolbox.aspx.

Piedmont Nutrient Reduction Sourcebook. 2011. Piedmont Triad Regional Council and Triangle J Council of Governments. Available at http://www.piedmontnutrientsourcebook.org/.

Smart Growth Network. 2006. This Is Smart Growth. Available at http://www.epa.gov/smartgrowth/tisg.htm.

Appendix A: Index of Upper Cape Fear 12-Digit HUCs

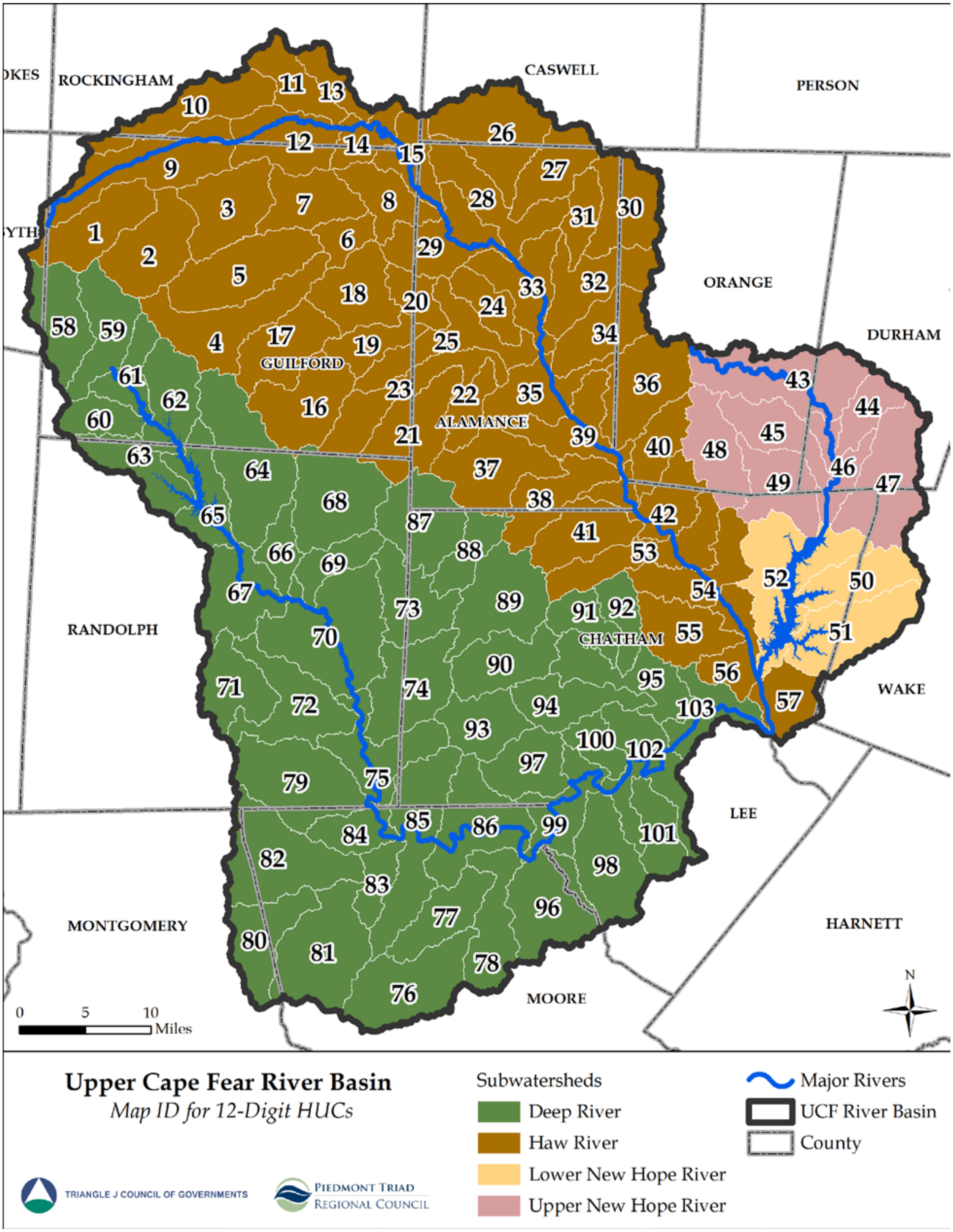

Figure 43: 12-Digit HUCs labeled with Map ID

Table 7: Upper Cape Fear 12-Digit HUCs

Map ID	12-Digit HUC Code	HUC Name	Stress Category	Stress Model Output Value	Consv. Category	Consv. Model Output Value
1	030300020101	Headwaters Reedy Fork	C	137.4	E	256.6
2	030300020102	Reedy Fork-Lake Brandt	A	241.8	E	174.8
3	030300020103	Reedy Fork-Lake Townsend	B	166.6	E	239.8
4	030300020104	South Buffalo Creek	A	330.0	E	122.5
5	030300020105	North Buffalo Creek	A	316.7	E	123.4
6	030300020106	Buffalo Creek	C	107.8	D	268.0
7	030300020107	Smith Branch-Reedy Fork	C	119.8	E	266.5
8	030300020108	City of Ossipee-Reedy Fork	C	104.7	D	275.1
9	030300020201	Mears Fork-Haw River	C	114.2	D	287.8
10	030300020202	Upper Troublesome Creek	D	87.9	D	268.0
11	030300020203	Lower Troublesome Creek	D	97.8	E	267.1
12	030300020204	Benaja Creek-Haw River	C	104.2	D	288.4
13	030300020205	Little Troublesome Creek	B	196.3	E	200.5
14	030300020206	Giles Creek-Haw River	E	79.5	D	284.7
15	030300020207	Town of Altamahaw-Haw River	D	87.2	D	280.2
16	030300020301	Upper Big Alamance Creek	D	93.8	D	272.0
17	030300020302	Upper Little Alamance Creek	C	155.4	E	240.5
18	030300020303	Lower Little Alamance Creek	C	127.8	E	263.2
19	030300020304	Middle Big Alamance Creek	D	94.6	D	290.3
20	030300020305	Back Creek	B	211.6	E	215.3
21	030300020306	South Prong Stinking Quarter Creek	D	85.1	D	281.7
22	030300020307	Rock Creek	D	90.8	D	293.2
23	030300020308	Stinking Quarter Creek	D	96.3	D	275.2
24	030300020309	Bowden Branch	A	342.3	E	108.0
25	030300020310	Lower Big Alamance Creek	B	171.1	E	234.8
26	030300020401	Stony Creek-Lake Burlington	E	66.9	D	285.5
27	030300020402	Jordan Creek	E	77.3	D	285.4
28	030300020403	Stony Creek-Stony Creek Reservoir	D	90.7	D	287.1
29	030300020404	Travis Creek-Haw River	C	154.7	E	245.8
30	030300020405	Upper Back Creek	E	83.2	D	292.8
31	030300020406	Quaker Creek-Quaker Creek Reservoir	D	92.0	D	284.0
32	030300020407	Lower Back Creek	B	166.1	E	255.2
33	030300020408	Boyds Creek-Haw River	A	252.4	E	175.1

Map ID	12-Digit HUC Code	HUC Name	Stress Category	Stress Model Output Value	Consv. Category	Consv. Model Output Value
34	030300020501	Haw Creek	C	135.8	D	283.2
35	030300020502	Meadow Creek-Haw River	D	96.4	D	292.9
36	030300020503	Cane Creek	C	108.5	B	346.8
37	030300020504	Upper Cane Creek	D	93.5	D	290.0
38	030300020505	Lower Cane Creek	D	97.6	D	294.3
39	030300020506	Marys Creek-Haw River	D	97.3	D	294.7
40	030300020507	Collins Creek	D	98.4	B	347.1
41	030300020508	Terrells Creek	E	75.3	C	312.2
42	030300020509	Terrells Creek-Haw River	D	90.9	B	341.7
43	030300020601	Headwaters New Hope Creek	B	160.5	C	316.1
44	030300020602	Third Fork Creek	A	302.1	E	161.3
45	030300020603	Little Creek	B	224.5	E	245.8
46	030300020604	New Hope Creek-B Everett Jordan Lake	B	175.3	C	322.6
47	030300020605	Northeast Creek	B	222.1	E	266.8
48	030300020606	University Lake	C	105.1	B	332.7
49	030300020607	Morgan Creek	B	184.5	C	305.8
50	030300020608	White Oak Creek	B	168.1	C	327.3
51	030300020609	Beaver Creek	B	162.3	C	326.3
52	030300020610	New Hope River-B Everett Jordan Lake	C	121.9	A	363.2
53	030300020701	Dry Creek-Haw River	E	83.4	B	345.7
54	030300020702	Pokeberry Creek-Haw River	D	93.1	B	346.2
55	030300020703	Roberson Creek	C	98.4	C	330.0
56	030300020704	Stinking Creek-Haw River	E	78.6	A	392.0
57	030300020705	Shaddox Creek-Haw River	C	121.7	A	350.5
58	030300030101	Oak Hollow Lake-Deep River	A	239.0	E	181.4
59	030300030102	High Point Lake-Deep River	A	316.5	E	137.0
60	030300030103	Richland Creek	A	308.9	E	141.6
61	030300030104	Bull Run-Deep River	A	247.3	E	191.7
62	030300030105	Hickory Creek-Deep River	C	157.4	E	242.6
63	030300030106	Muddy Creek	B	192.4	E	210.0
64	030300030107	Polecat Creek	C	107.9	D	273.7
65	030300030108	Town of Randleman-Deep River	C	146.6	E	250.1
66	030300030109	Bush Creek	D	95.3	C	302.7
67	030300030110	Hasketts Creek-Deep River	B	163.2	E	259.5
68	030300030201	Upper Sandy Creek	D	95.7	D	280.2

Map ID	12-Digit HUC Code	HUC Name	Stress Category	Stress Model Output Value	Consv. Category	Consv. Model Output Value
69	030300030202	Lower Sandy Creek	D	89.4	C	301.4
70	030300030203	Millstone Creek-Deep River	C	99.4	D	282.3
71	030300030204	Upper Richland Creek	C	116.4	C	305.2
72	030300030205	Lower Richland Creek	E	81.0	C	317.5
73	030300030206	Upper Brush Creek	D	96.4	C	296.3
74	030300030207	Lower Brush Creek	E	77.8	C	327.0
75	030300030208	Flat Creek-Deep River	E	83.9	B	349.4
76	030300030301	Upper Mclendons Creek	E	57.5	B	344.0
77	030300030302	Parkwood Branch-Richland Creek	E	48.3	A	362.1
78	030300030303	Lower Mclendons Creek	E	58.6	B	338.1
79	030300030401	Fork Creek	E	79.2	C	327.0
80	030300030402	Upper Cabin Creek	D	97.0	C	305.4
81	030300030403	Lower Cabin Creek	E	53.7	B	333.7
82	030300030404	Upper Bear Creek	E	70.4	C	312.6
83	030300030405	Lower Bear Creek	D	88.2	C	306.1
84	030300030406	Grassy Creek-Deep River	E	78.1	C	316.2
85	030300030407	Buffalo Creek-Deep River	E	75.3	B	337.5
86	030300030408	Tysons Creek-Deep River	E	61.8	B	343.1
87	030300030501	North Prong Rocky River-Headwaters Rocky River	C	113.7	D	273.9
88	030300030502	Lacys Creek-Rocky River	D	91.7	C	306.0
89	030300030503	Loves Creek-Rocky River	C	121.2	D	287.4
90	030300030504	Tick Creek-Rocky River	E	84.2	C	317.7
91	030300030505	Landrum Creek	E	74.6	C	317.2
92	030300030506	Harlands Creek	E	67.7	A	350.2
93	030300030507	Headwaters Bear Creek	C	110.2	A	355.1
94	030300030508	Harts Creek-Bear Creek	E	82.1	B	335.3
95	030300030509	Rocky River	E	65.7	A	373.1
96	030300030601	Big Govenors Creek	E	55.7	B	339.2
97	030300030602	Indian Creek	E	80.3	C	325.9
98	030300030603	Pocket Creek	E	71.8	C	312.9
99	030300030604	Smiths Creek-Deep River	E	71.5	A	363.2
100	030300030605	Cedar Creek	C	100.0	A	351.4
101	030300030606	Big Buffalo Creek	B	168.4	E	244.7
102	030300030607	Georges Creek-Deep River	C	106.2	B	330.0
103	030300030608	Rocky Branch-Deep River	D	85.2	A	362.8

Appendix B: Conservation Analysis Input Layer Maps

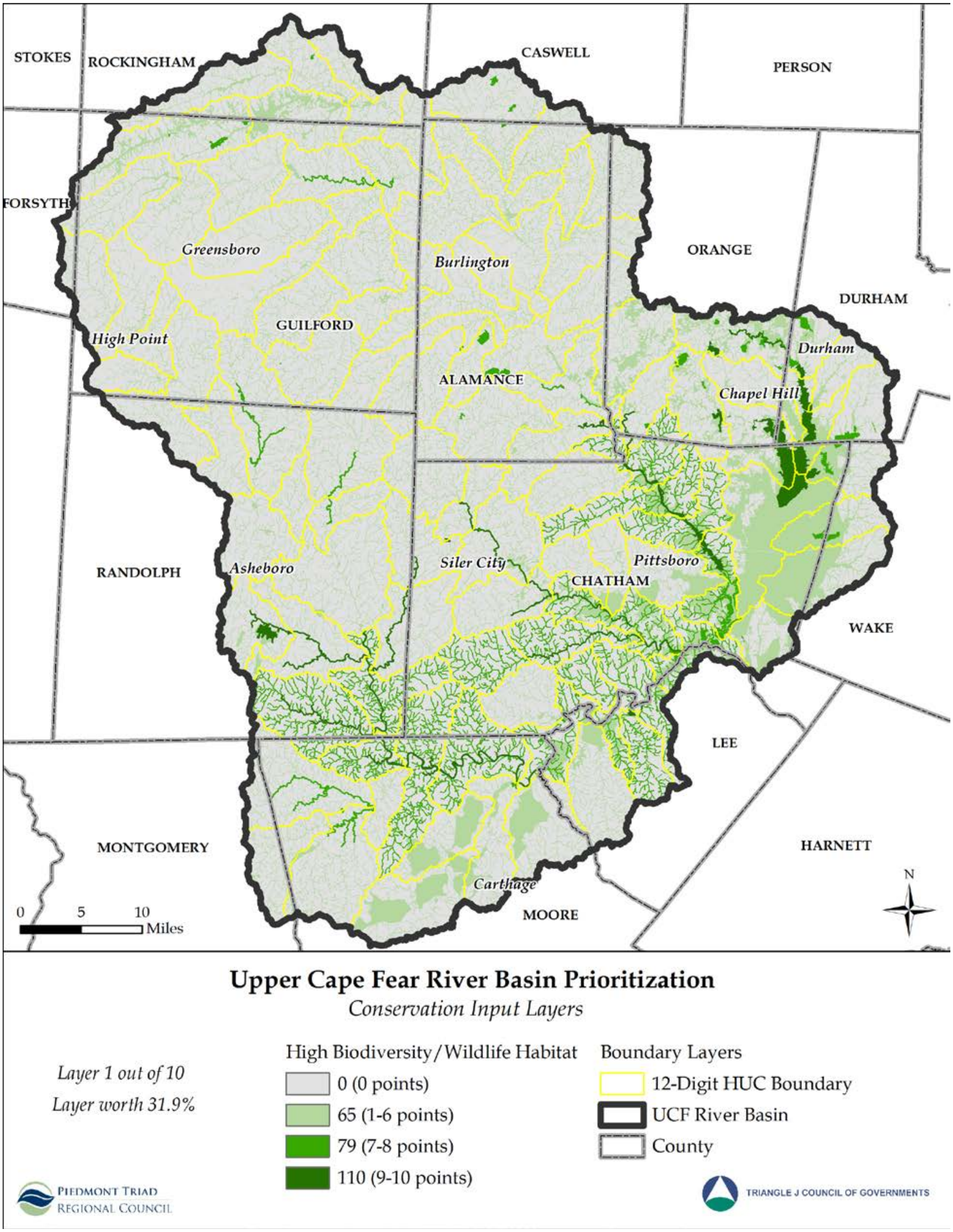

Figure 44: Input Conservation Layer - BWHA

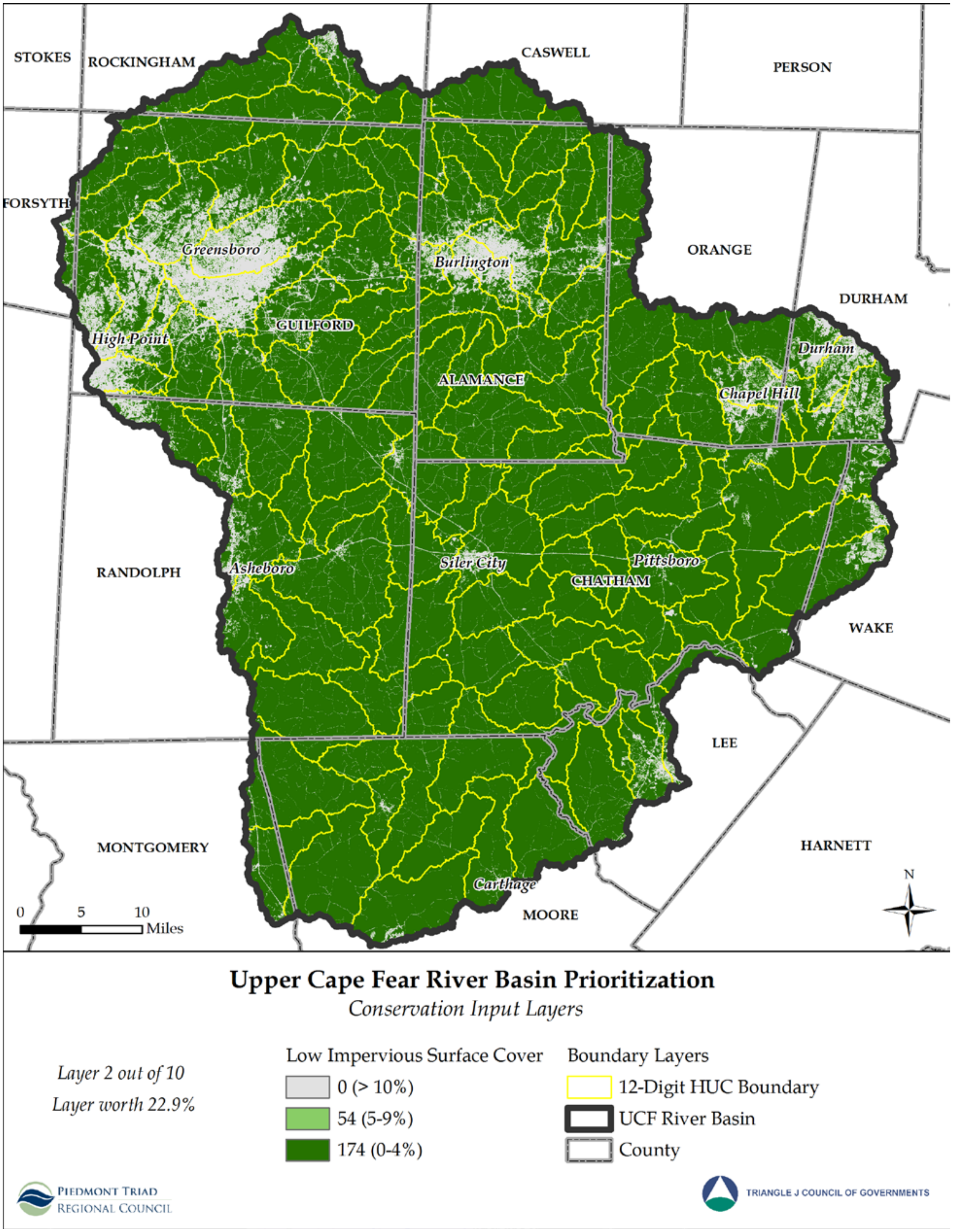

Figure 45: Input Conservation Layer - Impervious Surface Cover

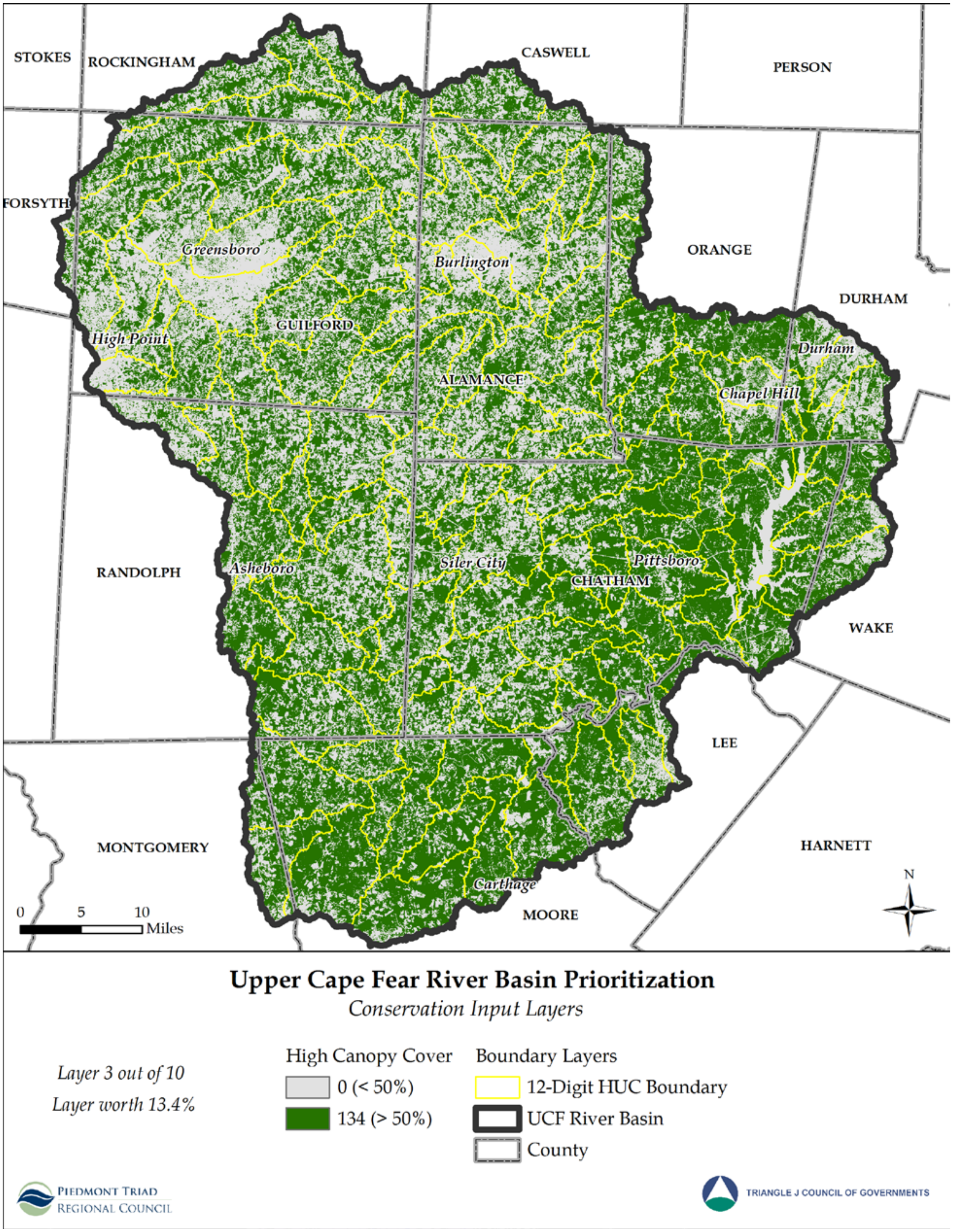

Figure 46: Input Conservation Layer - Canopy Cover

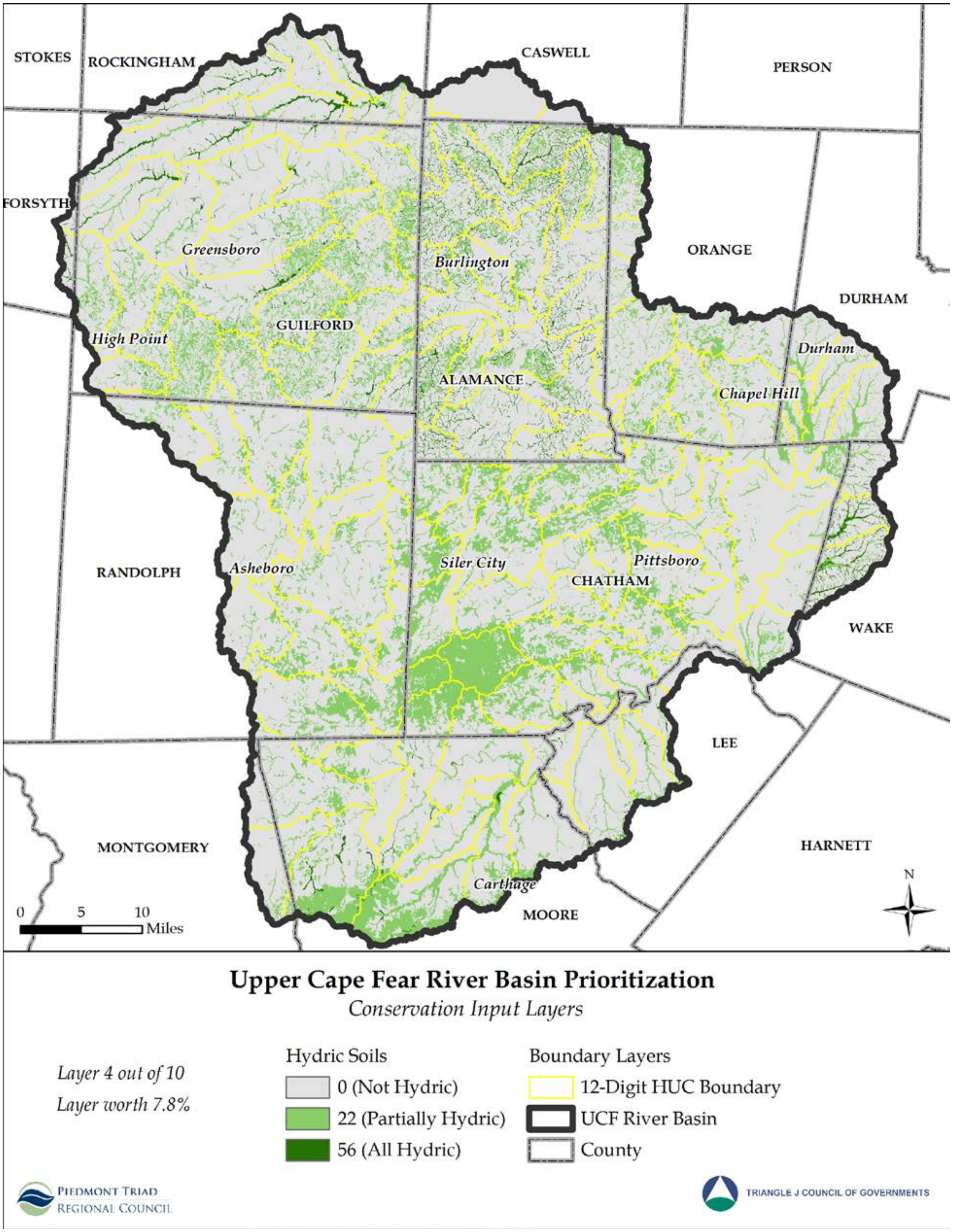

Figure 47: Input Conservation Layer - Hydric Soils

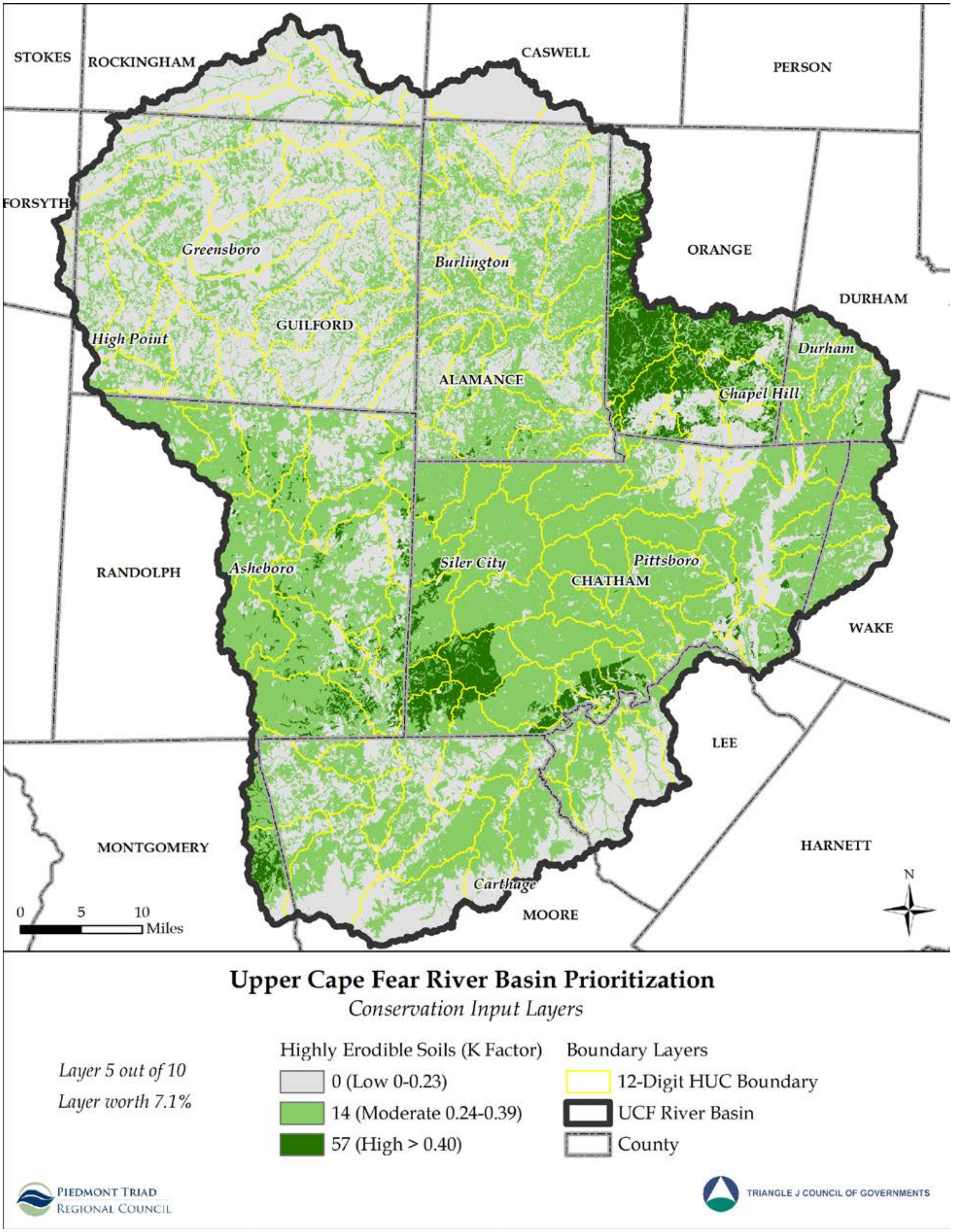

Figure 48: Input Conservation Layer - Erodible Soils

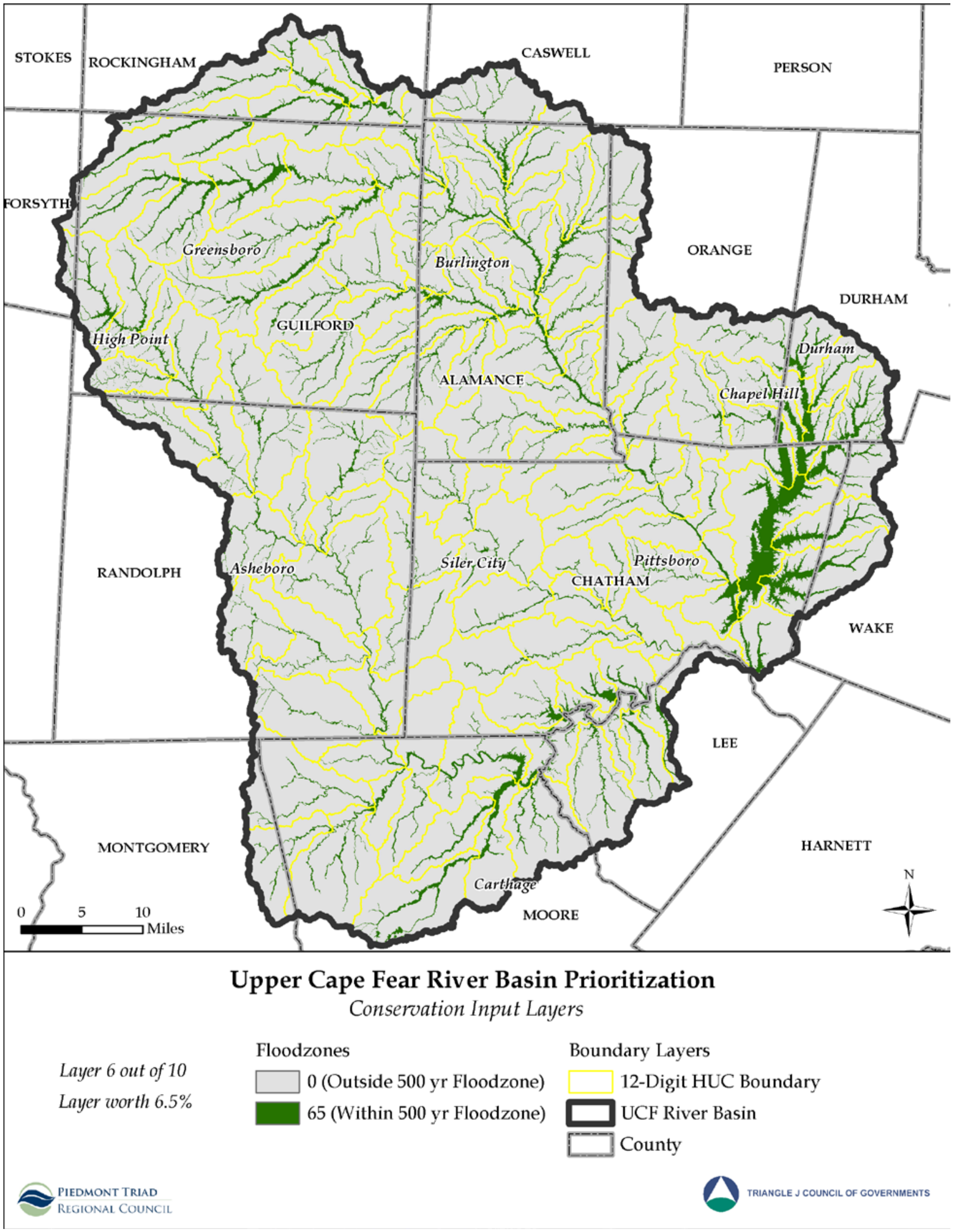

Figure 49: Input Conservation Layer - Floodzones

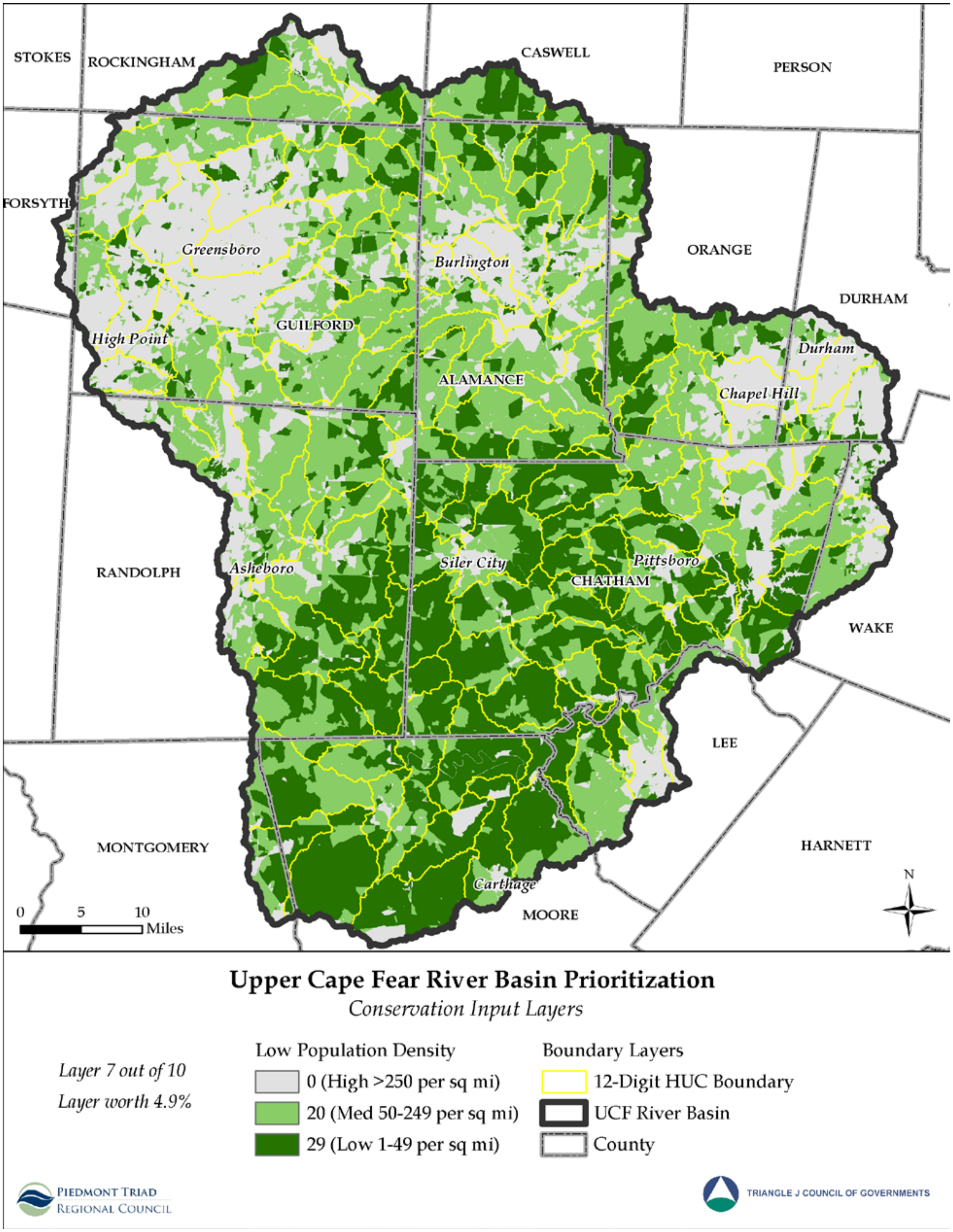

Figure 50: Input Conservation Layer - Population Density

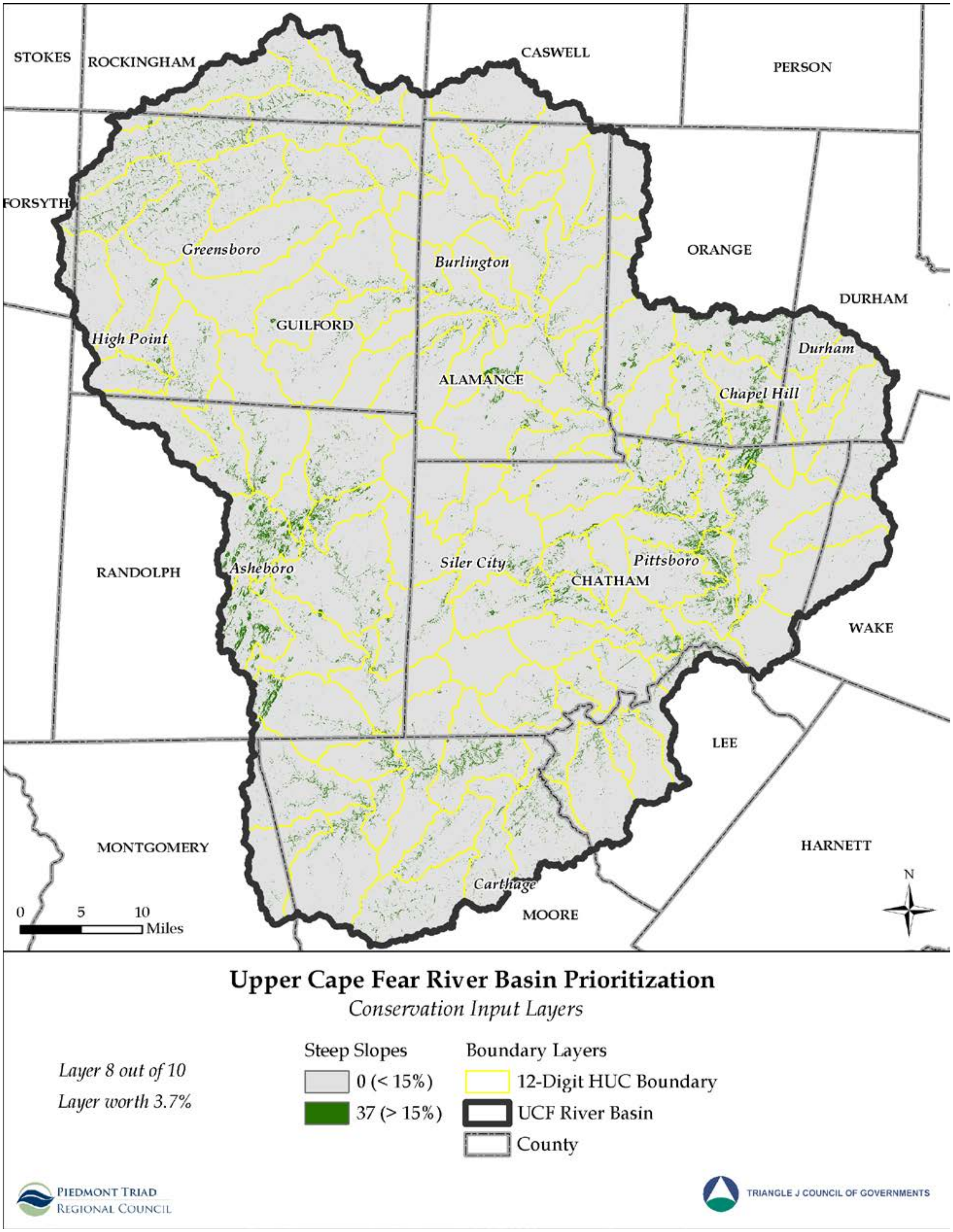

Figure 51: Input Conservation Layer - Steep Slopes

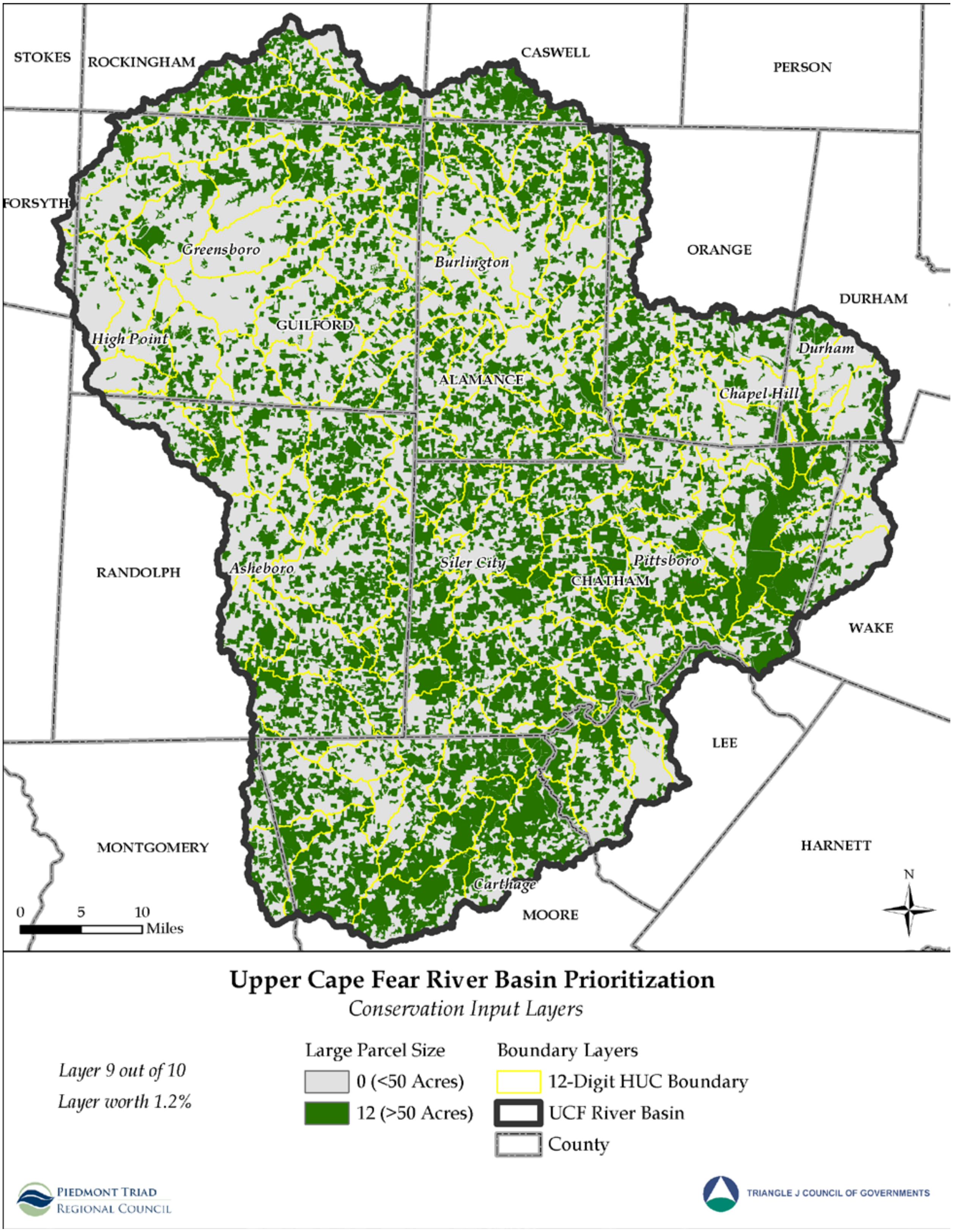

Figure 52: Input Conservation Layer - Parcel Size

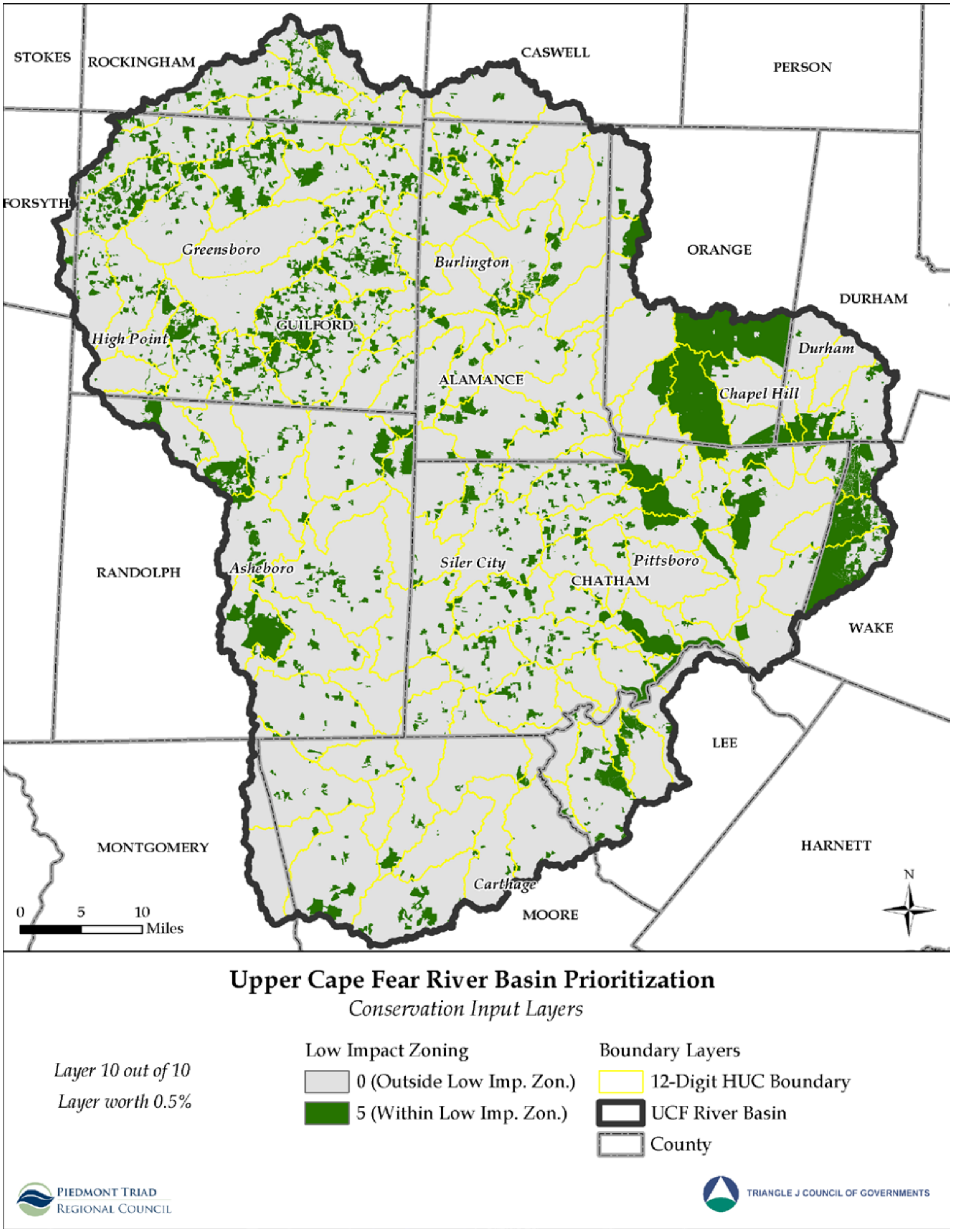

Figure 53: Input Conservation Layer - Low Impact Zoning

Appendix C: Stress Analysis Input Layer Maps

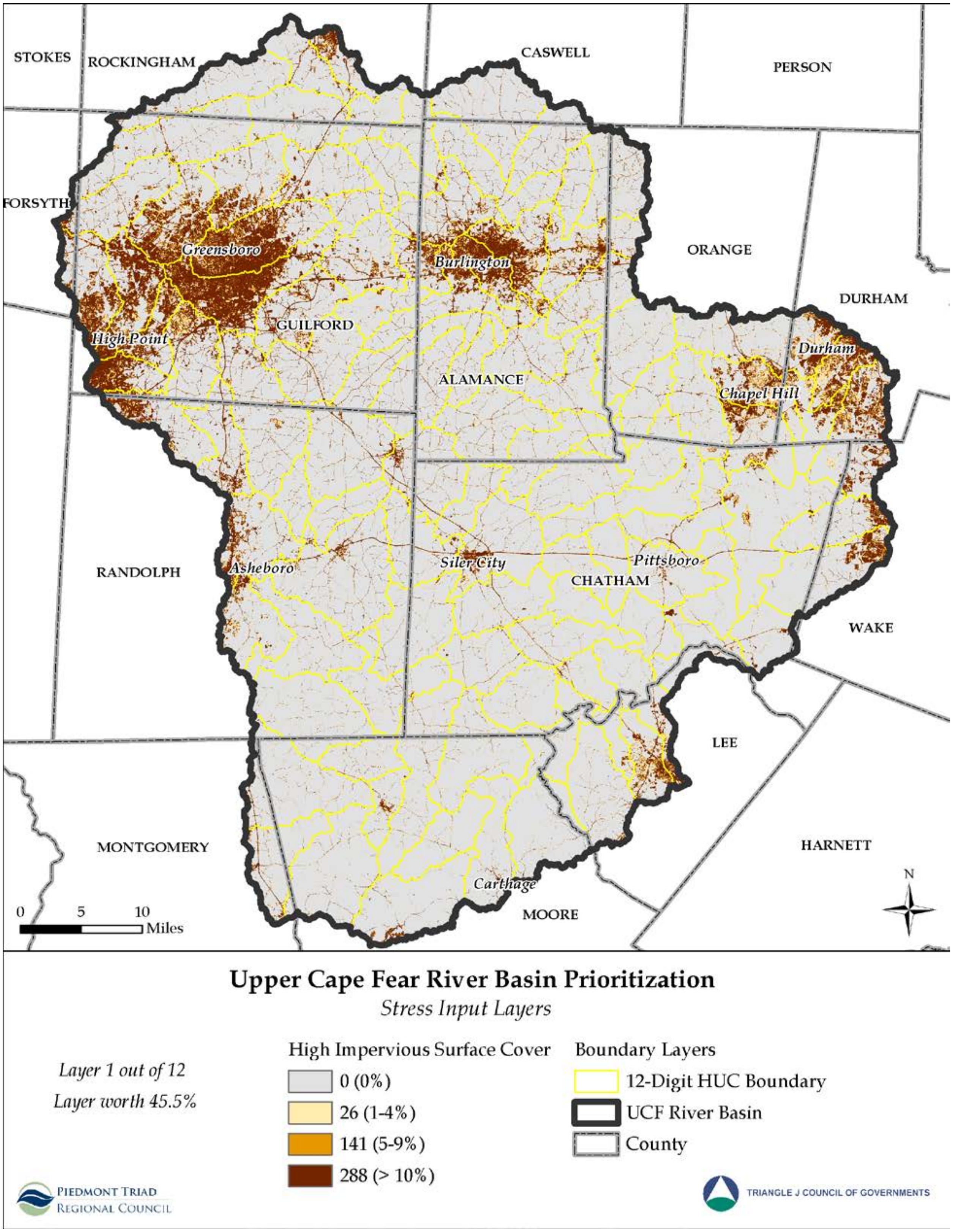

Figure 54: Input Stress Layer - Impervious Surface Cover

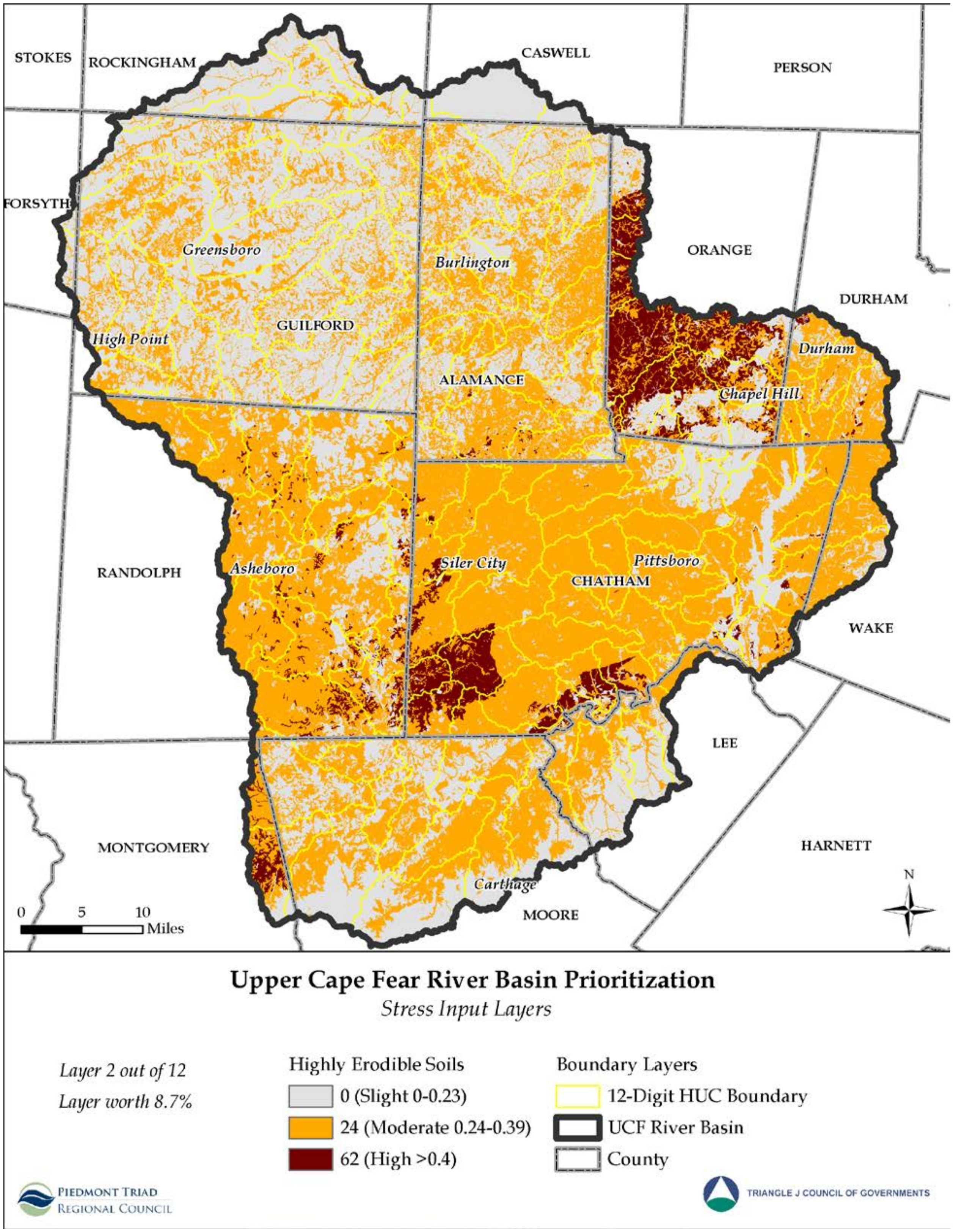

Figure 55: Input Stress Layer - Erodible Soils

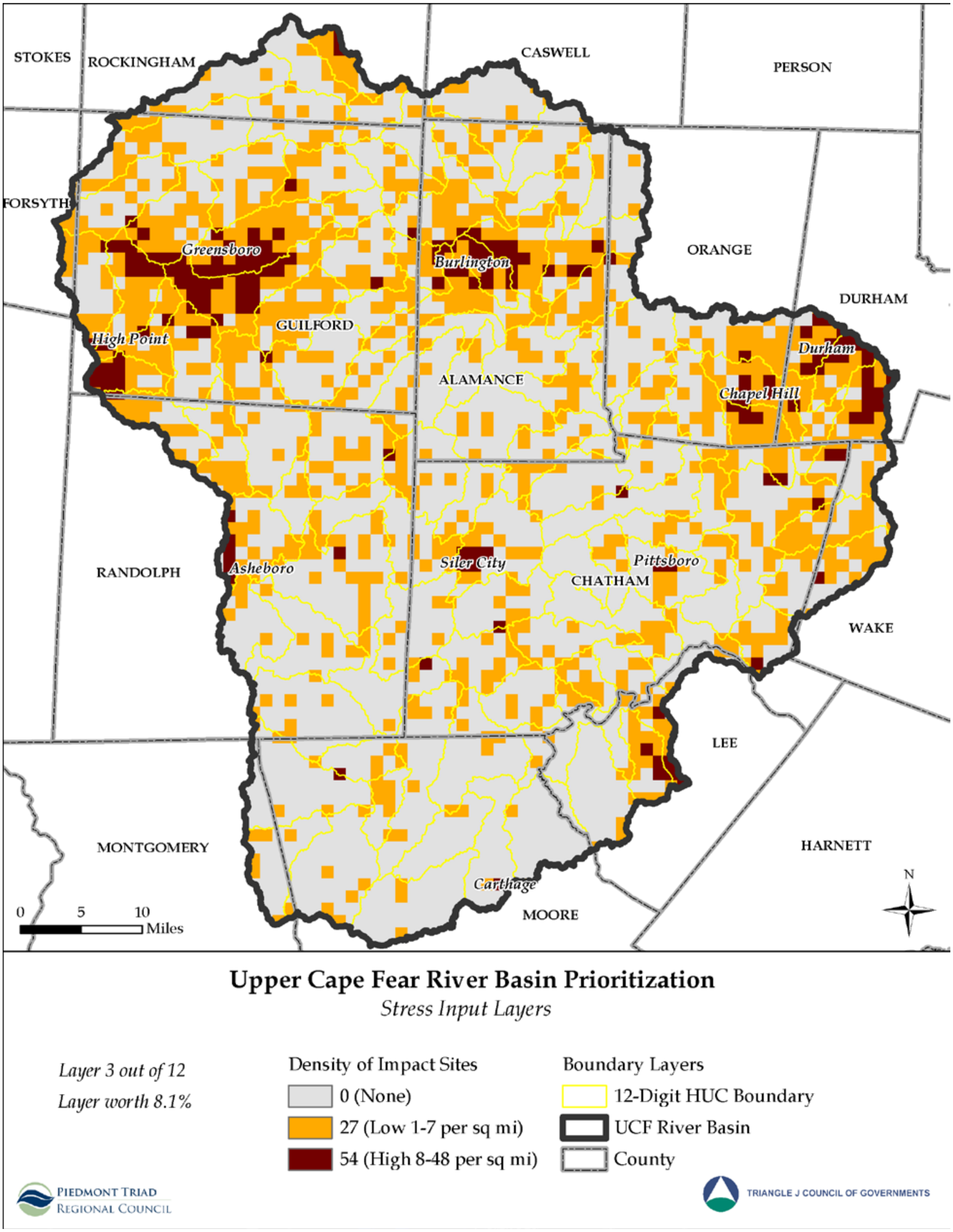

Figure 56: Input Stress Layer - Density of Impact Sites

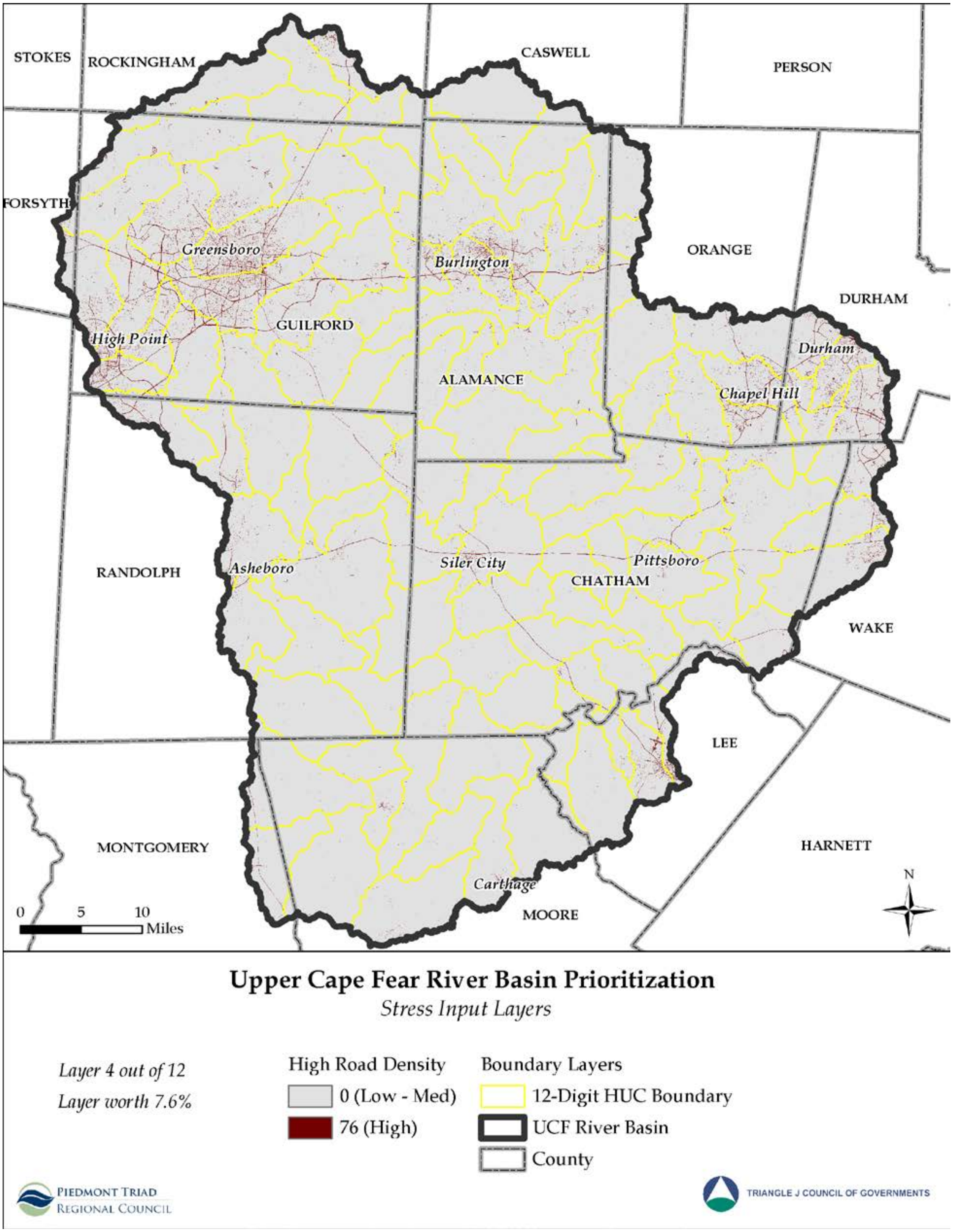

Figure 57: Input Stress Layer - Road Density

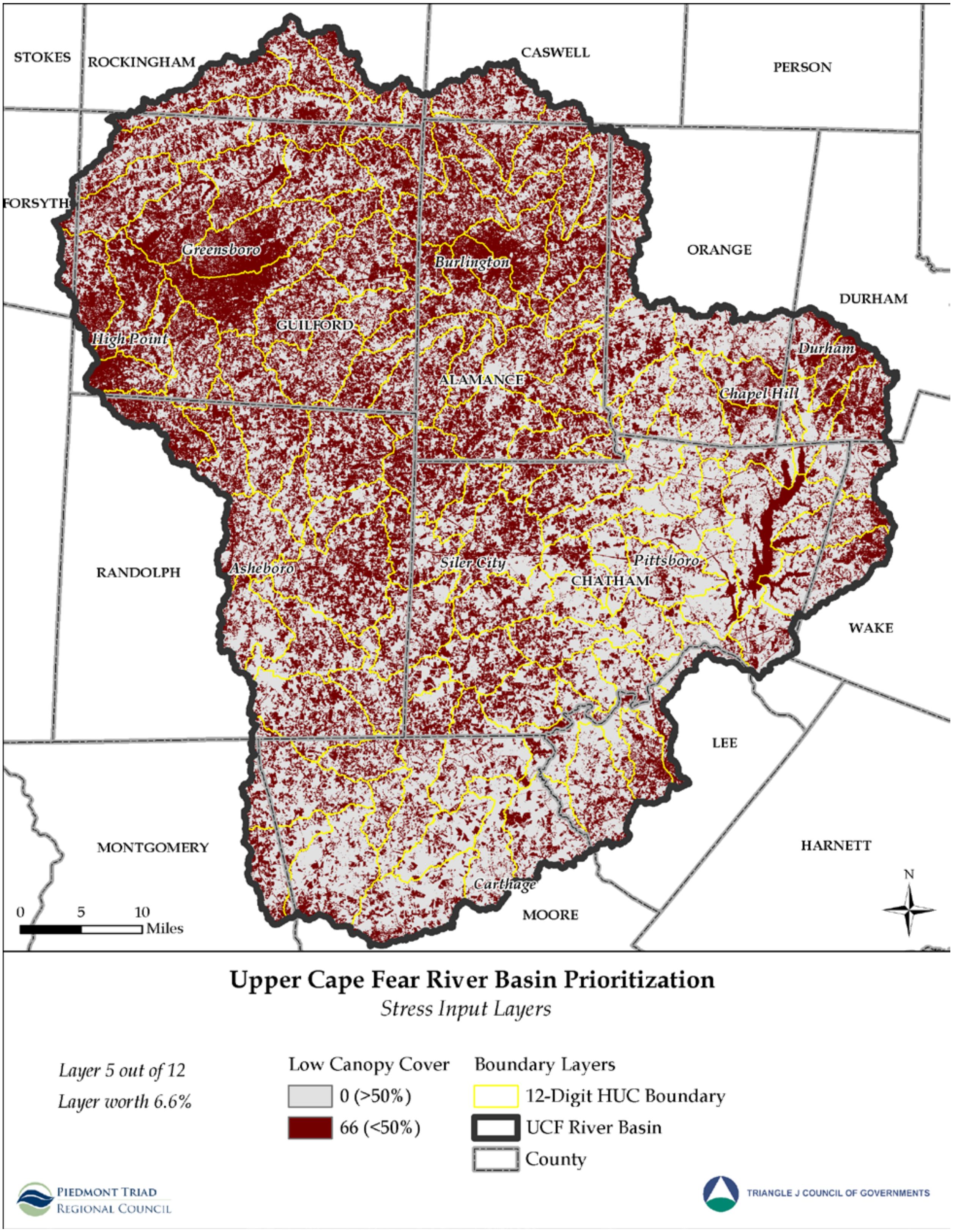

Figure 58: Input Stress Layer - Canopy Cover

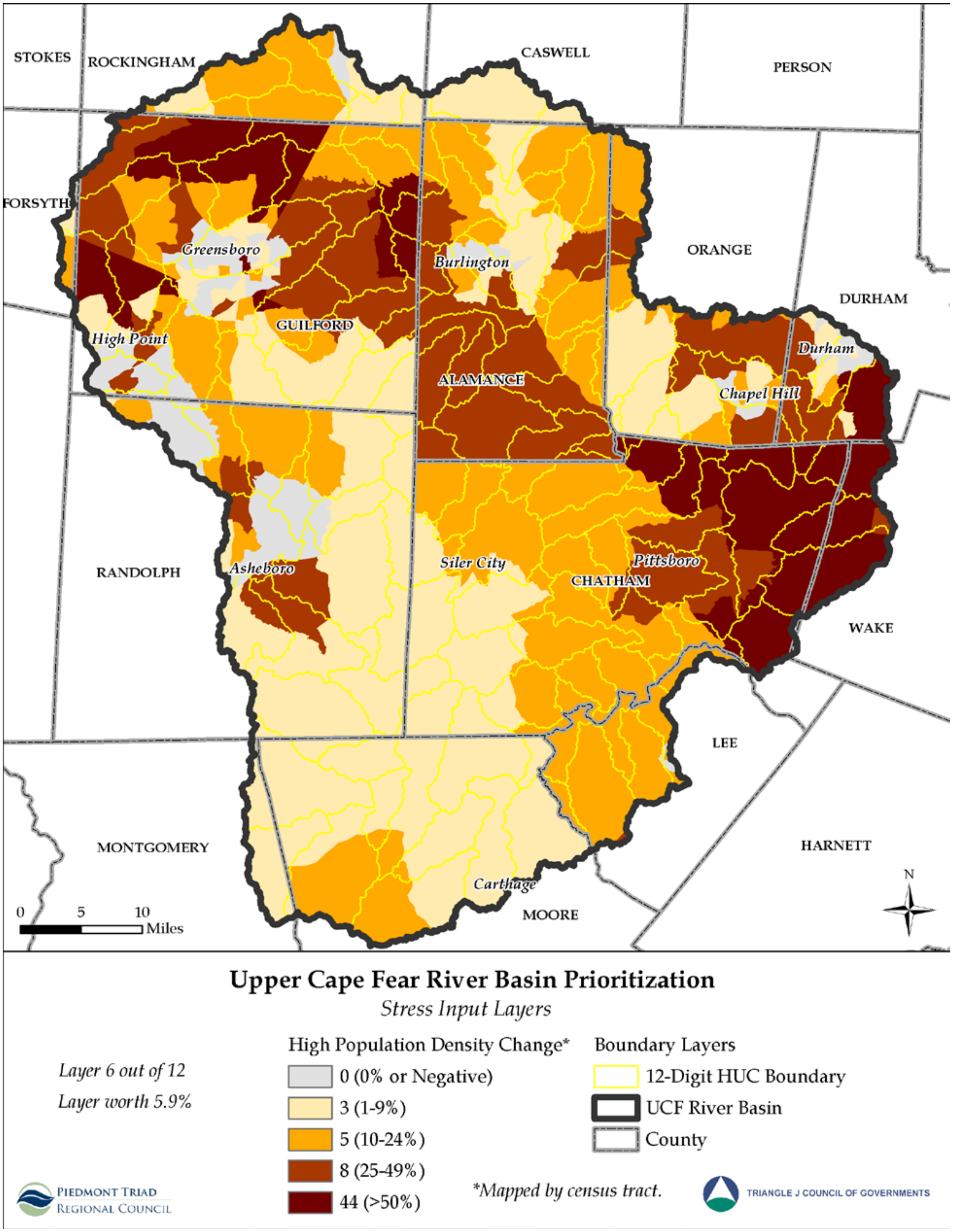

Figure 59: Input Stress Layer - Population Density Change

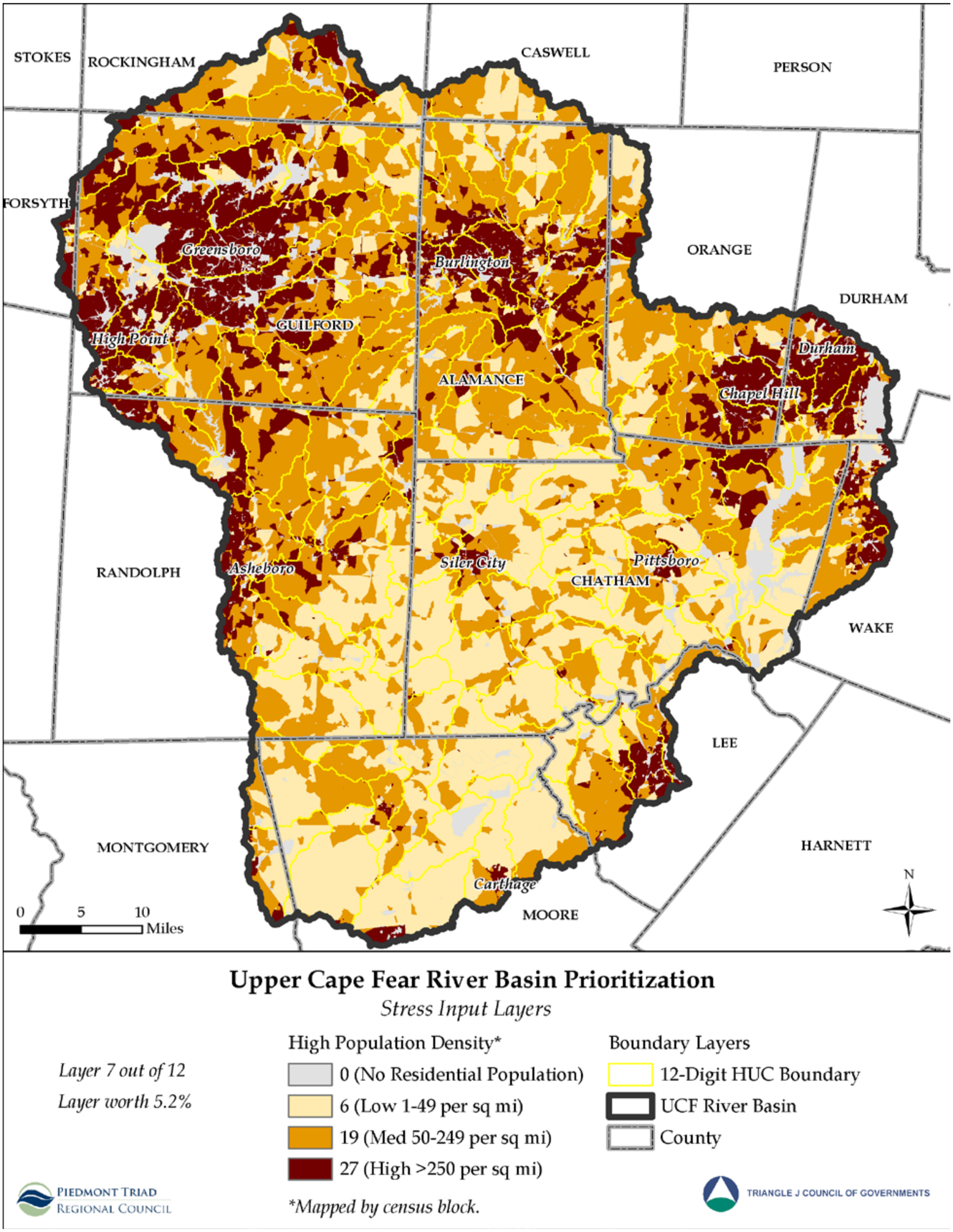

Figure 60: Input Stress Layer - Population Density

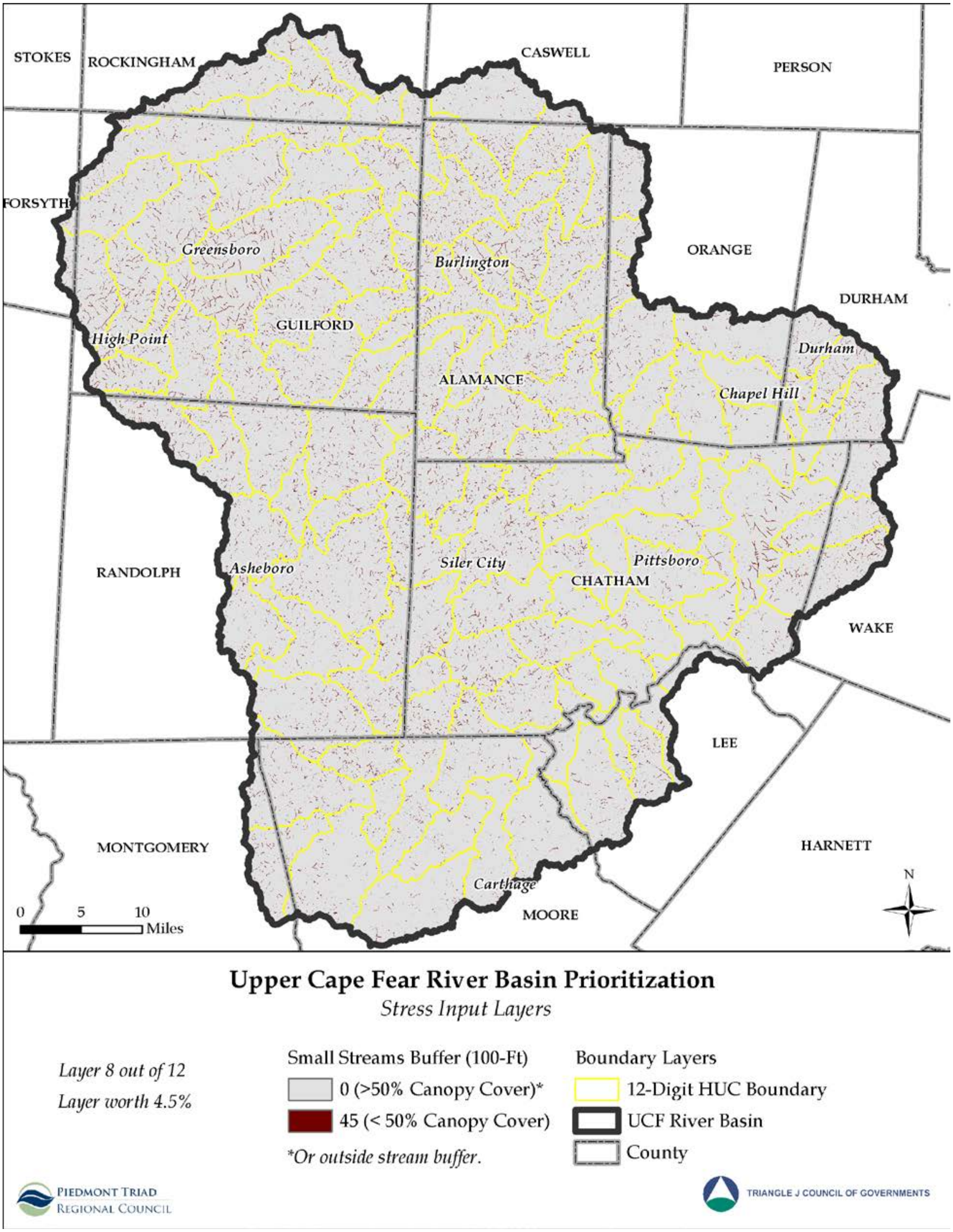

Figure 61: Input Stress Layer - Small Streams Buffer with Low Canopy Cover

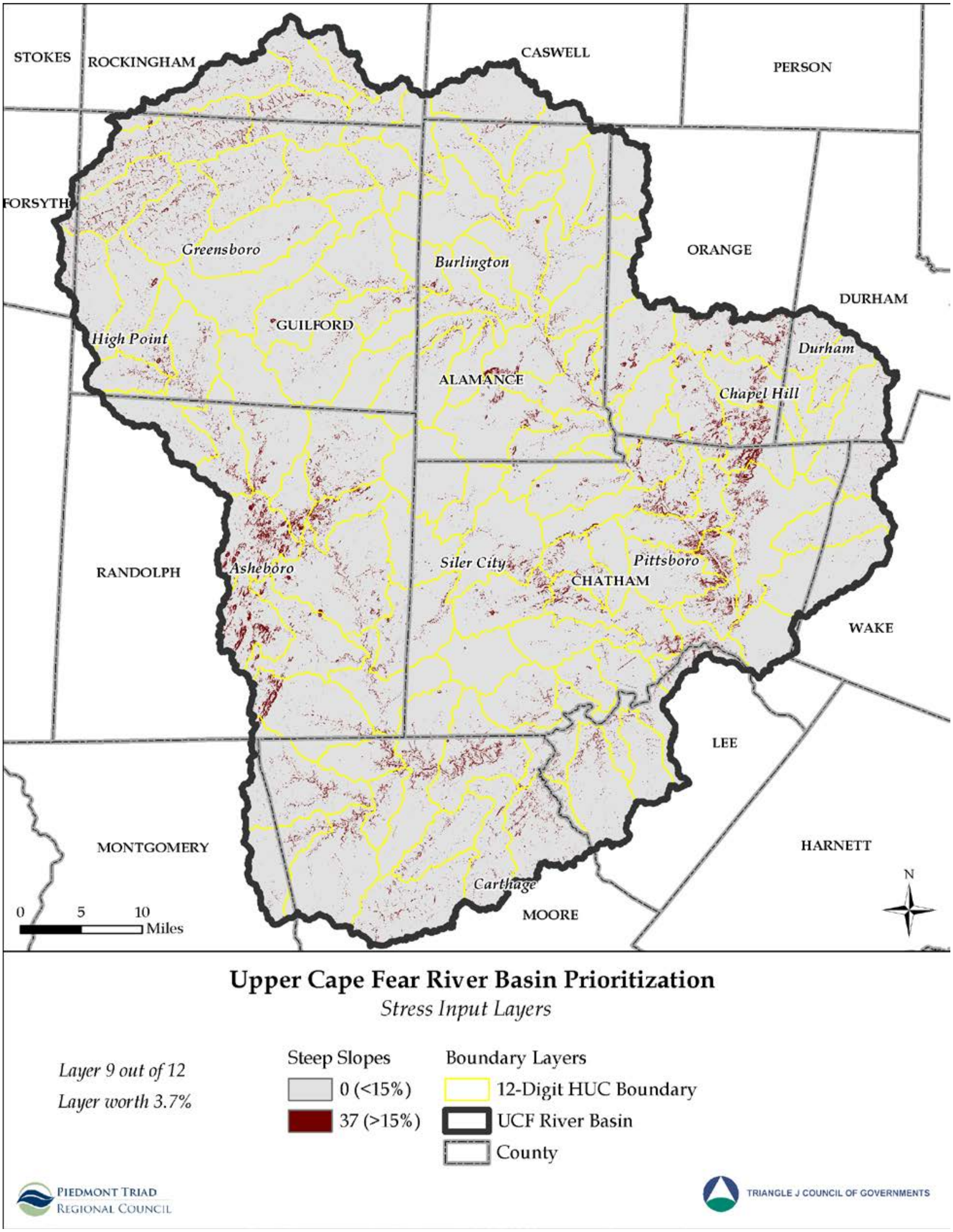

Figure 62: Input Stress Layer - Steep Slopes

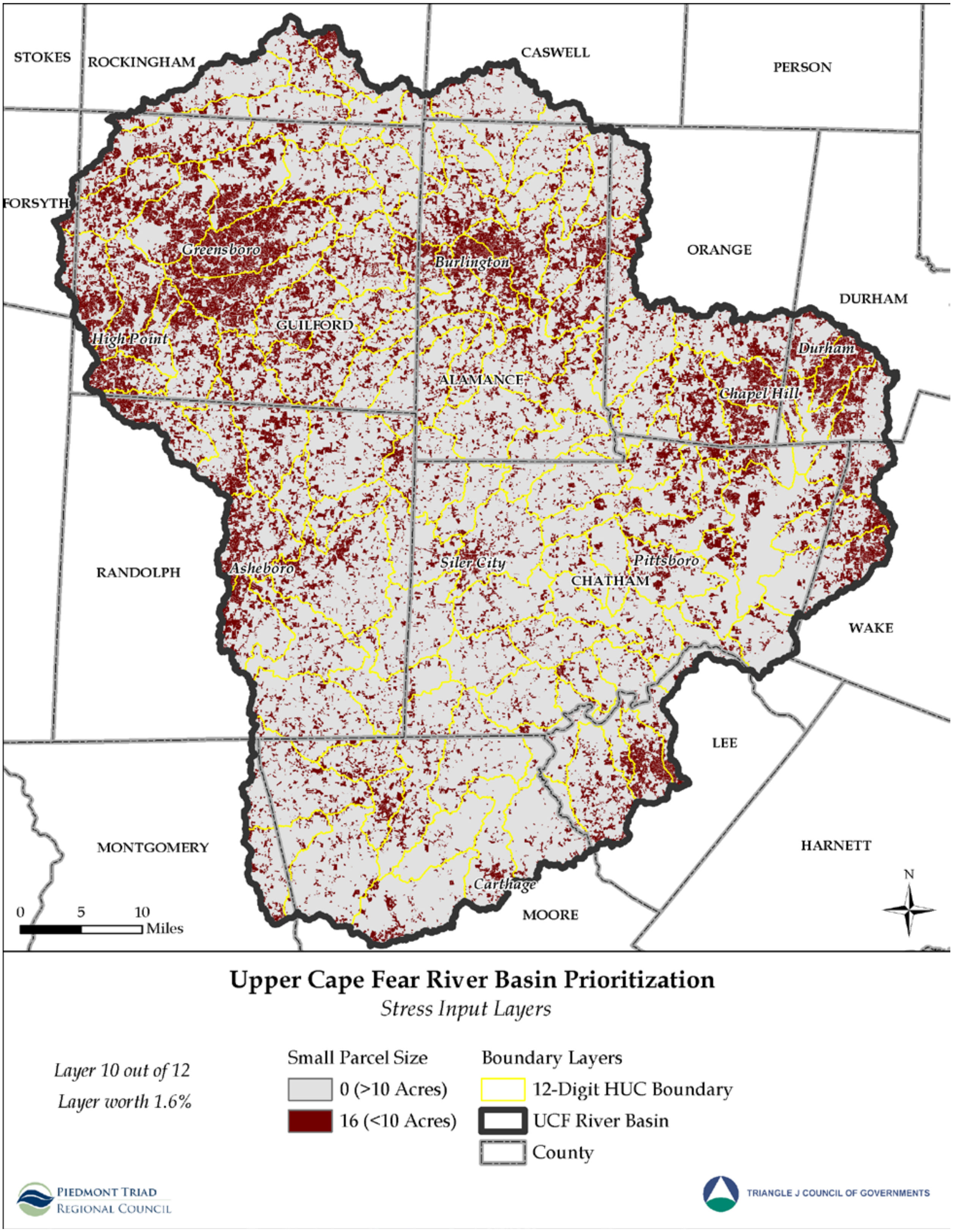

Figure 63: Input Stress Layer - Parcel Size

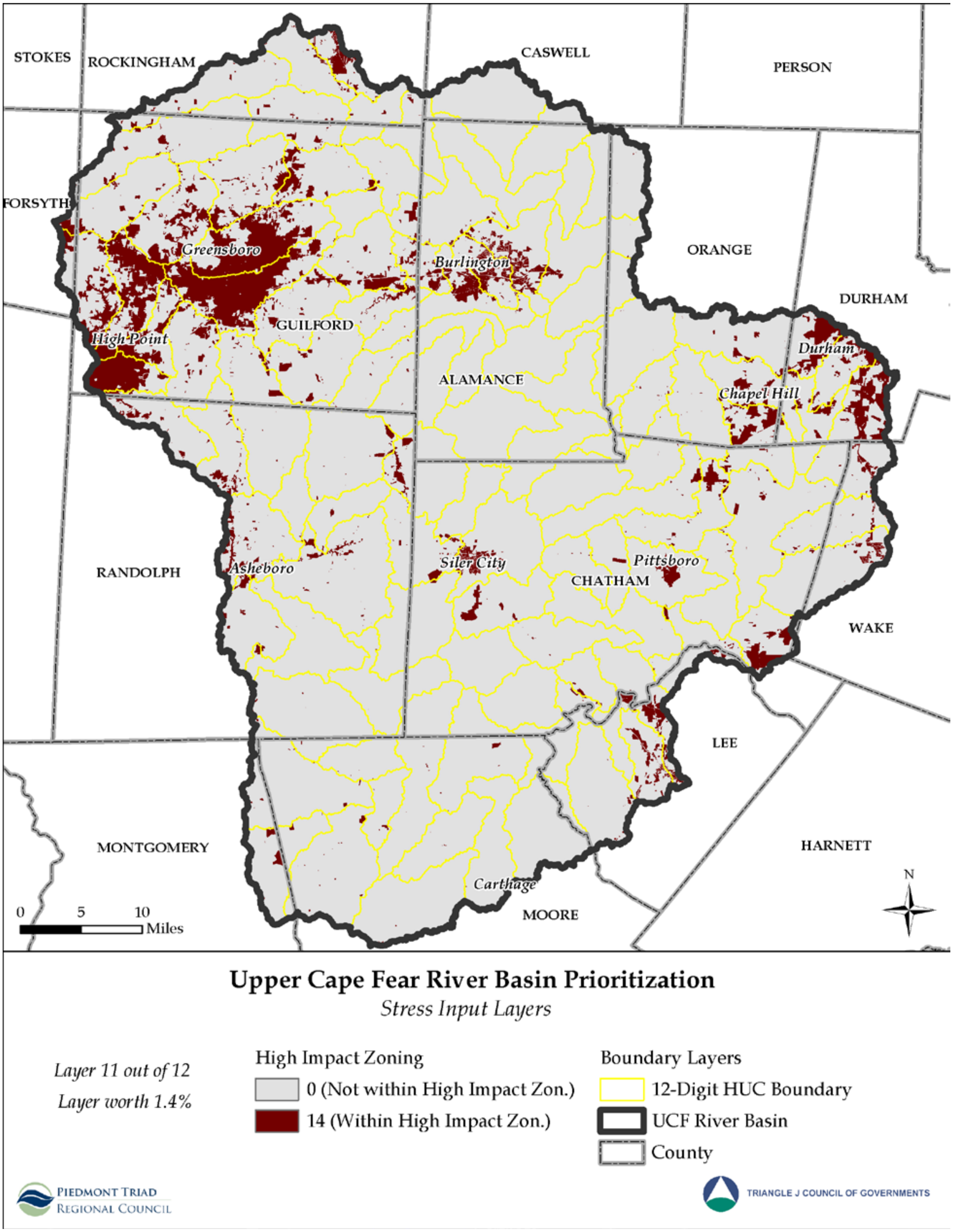

Figure 64: Input Stress Layer - High Impact Zoning

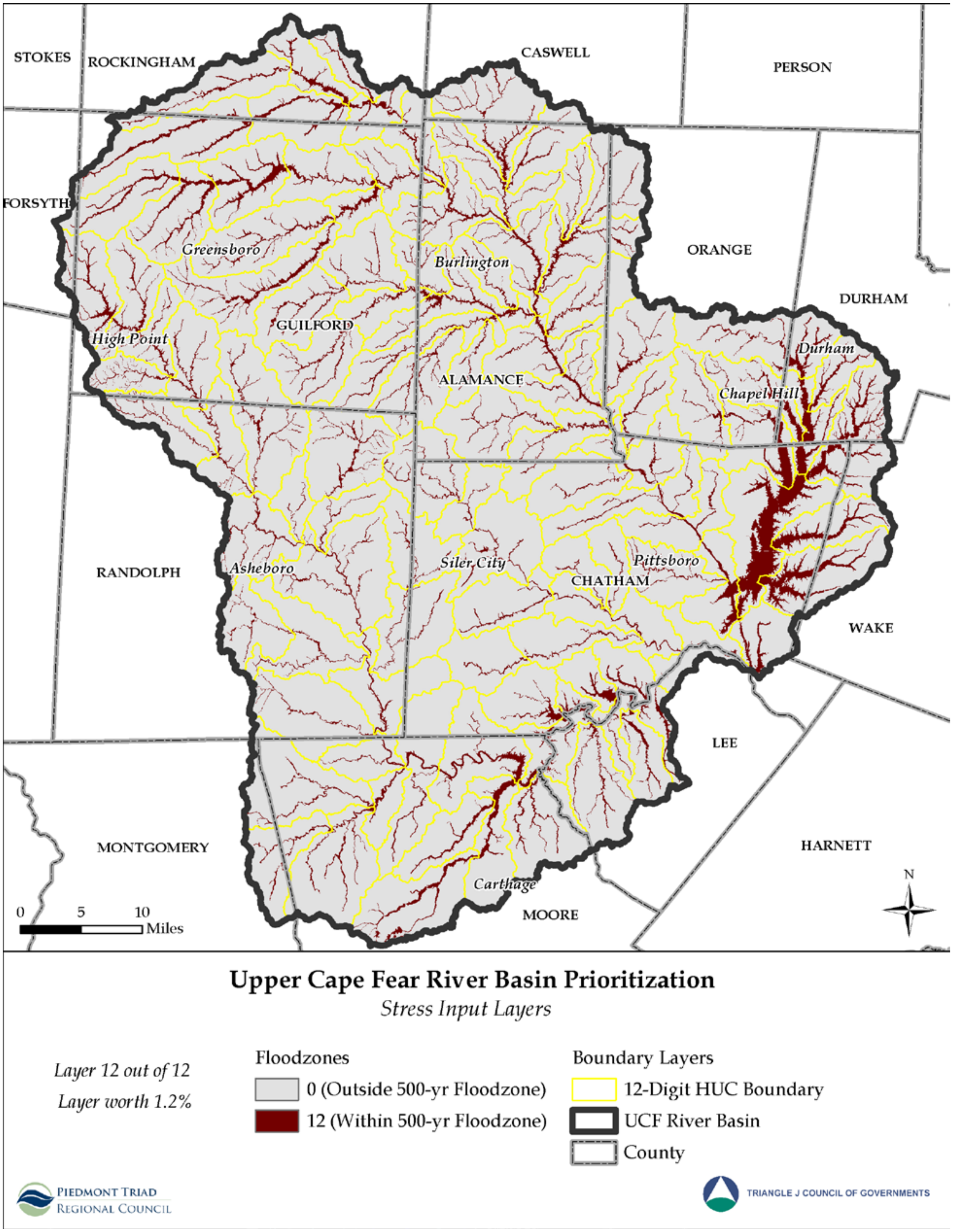

Figure 65: Input Stress Layer - Floodzones