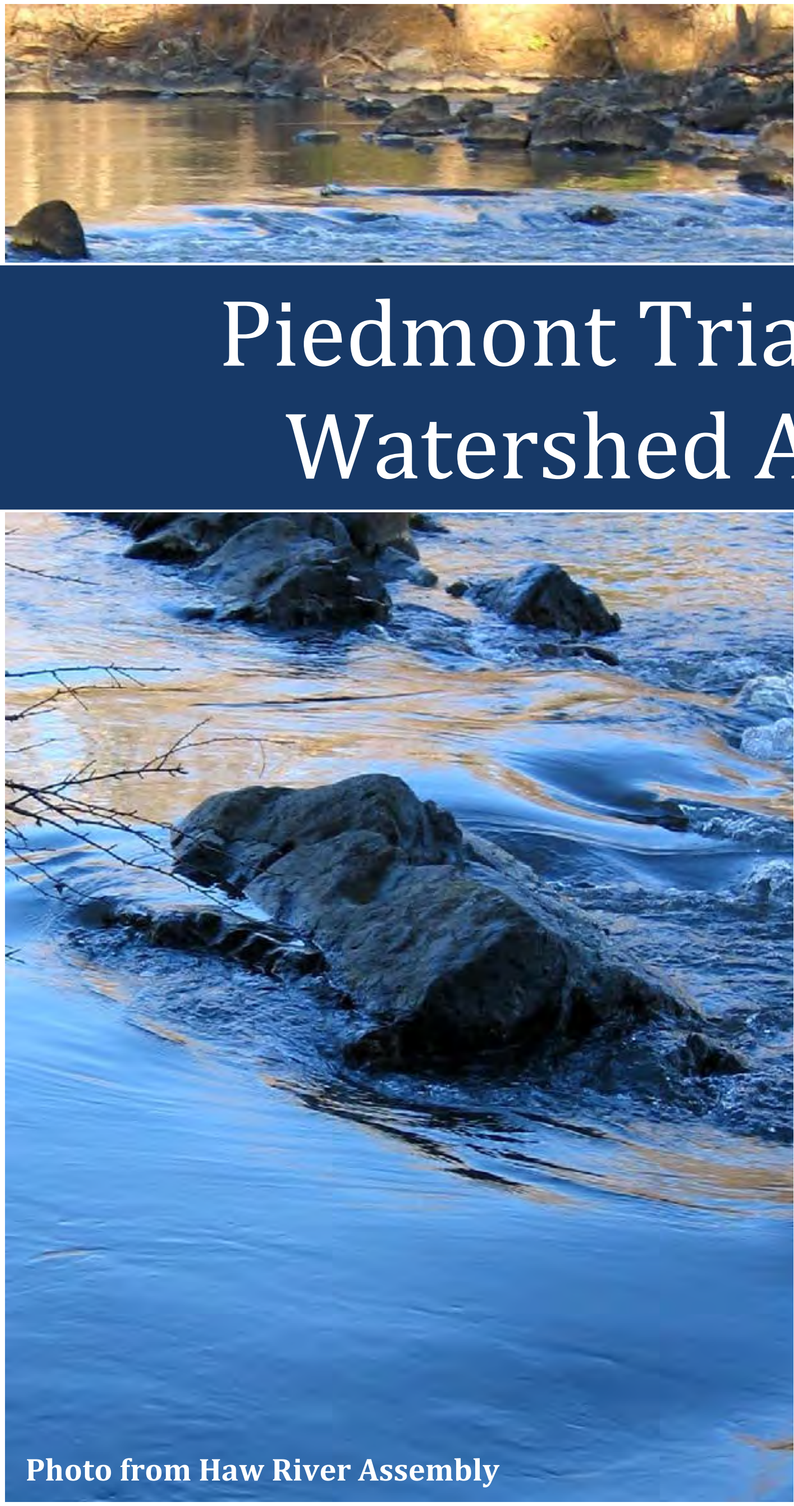

Piedmont Triad Regional Watershed Assessment

Photo from Haw River Assembly

PIEDMONT TRIAD REGIONAL COUNCIL

Piedmont Triad Regional Council

September 2013

This Project Was Supported with

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

Piedmont Triad Regional Council

Malinda Ford
GIS Manager

Cy Stober
Water Resources Manager

This project was generously supported by the
North Carolina Division of Water Resources 205(j)/604(b) program

"To preserve, protect and enhance North Carolina's water..."

September 2013

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Project Overview

Since 2009, the Piedmont Triad Regional Council (PTRC) has utilized 205(j) fund to collect North Carolina environmental, economic, and recreational data to inform a GIS-based watershed assessment of its resident river basins. The purpose of this GIS model is to better characterize the 12-digit hydrologic units (HUCs) of the Triad region in terms of conservation and stress, leveraging this information for local watershed planning that protects healthy waters and rehabilitates impaired waters. The data inputs and model structure have evolved as the PTRC has applied these models to each of its three river basins over the past four years.

The current watershed assessment model is the indirect product of four separately funded projects by the North Carolina Division of Water Resources' (NCDWR) 205(j) program – including this 2012 grant – in an attempt to refine this model for greater value. These efforts relied upon partnerships with Centralina Council of Governments (CCOG), the Dan River Basin Association, High Country COG, and Triangle J COG. The model would not exist in its current form without the input and constructive criticism of multiple stakeholders, representing federal, state, regional, and local government organizations, as well as the private, non-profit, and academic sectors (Table 1). We are indebted to them for their time and efforts on the project's behalf, as well as to Elon University for the use of their facilities for meetings TJCOG facilitated with the stakeholders in 2012.

Table 1: UCFRB model stakeholders

Upper Cape Fear River Basin Watershed Model Stakeholder Committee	
Alamance County S&WCD	NC Division of Water Quality
American Rivers	NC Natural Heritage Program
Town of Cary	NC Wildlife Resources Commission
Town of Chapel Hill	Orange County
Conservation Trust of NC	Orange Water And Sewer Authority
Elon University	Rockingham County S&WCD
City of Greensboro	Triangle Land Conservancy
City of High Point	US Army Corps of Engineers
NC A&T University	US Fish & Wildlife
NC Department of Forest Resources	

Background

The PTRC serves the twelve county Triad region of sixty-two municipalities that is focused on the cities of Greensboro, High Point, and Winston-Salem and is defined by the economic service region of the Interstate 40 and 85 corridors. It is home to 1.6 million people and, like, most of North Carolina's former industrial areas of, has an abundance of impaired waters. It has many valuable drinking water and recreation reservoirs and rivers, perhaps most significantly, Lake Randleman on the Deep River and High Rock Lake and Lake Badin on the Yadkin-Pee Dee River. The Haw River flows to Everett B. Jordan Reservoir, which has a state nutrient management strategy that governs land use to address it eutrophic conditions.

The Piedmont Triad has three resident river basins within its twelve-county region: the Cape Fear, the Roanoke, and the Yadkin-Pee Dee Rivers (Figure 1). The Cape Fear and Yadkin-Pee Dee Rivers are the longest and largest river basins in North Carolina. Both the Cape Fear and Roanoke Rivers originate in the Piedmont Triad, and a more accurate description of the regional hydrography is that it is partly or fully within eight river basins: the Deep and Haw River Subbasins of the Cape Fear River; the Upper Dan and Lower Dan River Subbasins of the Roanoke River; and the Yadkin River Headwaters, South Yadkin River, Yadkin River, Lake Tillery, Rocky River and Pee Dee River Subbasins of the Yadkin-Pee Dee River. The total area of these river basins (and that covered within this project) is 13, 931 square miles, larger than the State of Maryland.

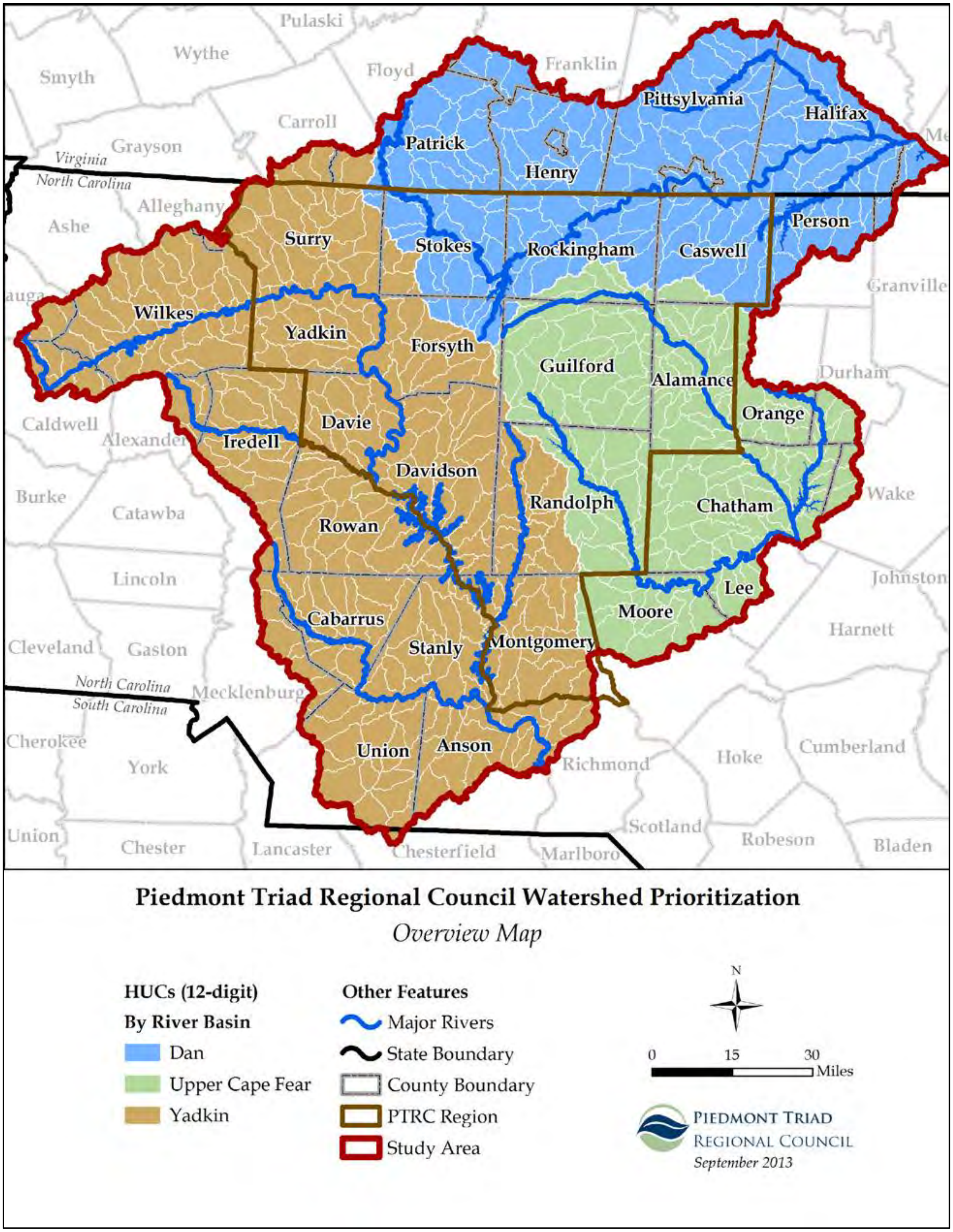


Figure 1: PTRC River Basins

Upper Cape Fear River

The Upper Cape Fear River Basin is composed of two major drainages: the Haw River and the Deep River, and contains 11 subbasins. It drains approximately 3,135 square miles of the North Carolina piedmont and includes portions of 10 counties and 42 municipalities (Figure 2). 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. According to the 2010 NC NCDWR 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 NCDWR 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 NCDWR 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.

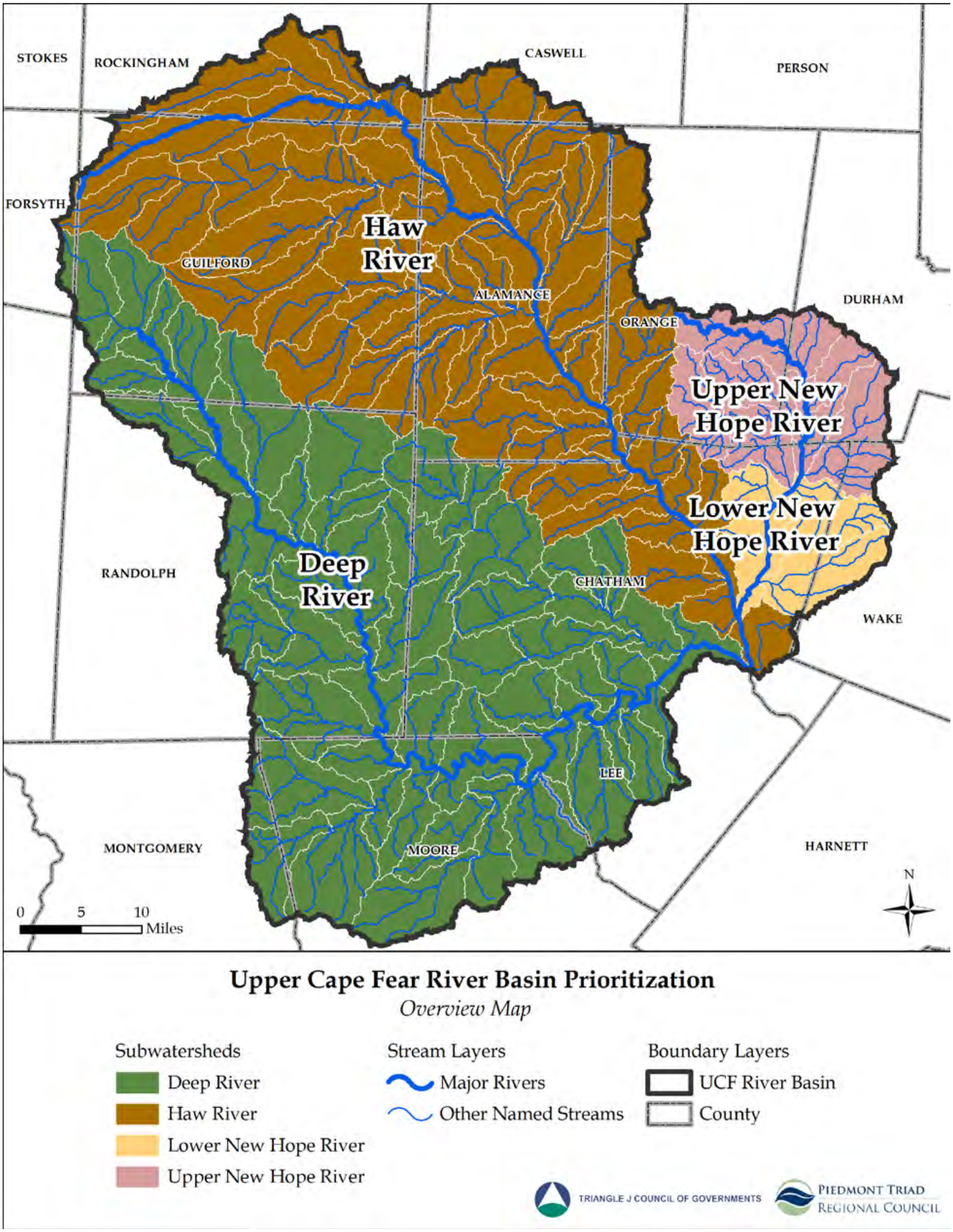


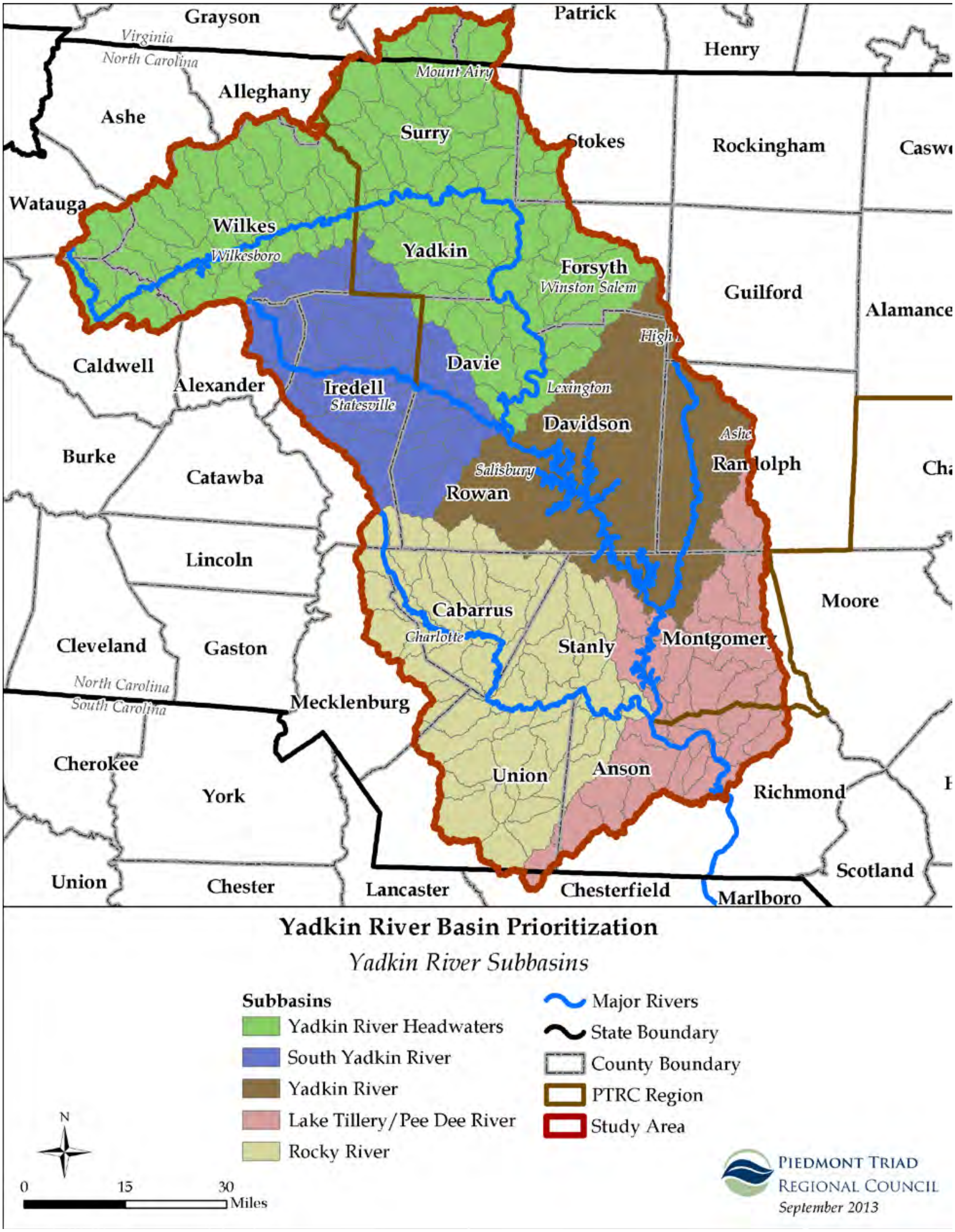
Figure 2: Upper Cape Fear River Basin Subwatersheds

Yadkin-Pee Dee River

The Yadkin-Pee Dee River Basin is the second-largest river basin in North Carolina after the Cape Fear River, covering twenty counties and totaling 7,213 square miles and 5,946 linear river miles. The river basin covers a diverse landscape from Blue Ridge Mountain headwaters to the expansive Charlotte metropolitan area, crossing much of the Piedmont region and including parts of the unusual geology and ecology in the sandy Uwharrie Mountains. The topography, geology, and land use throughout the Yadkin River basin are diverse, presenting a patchwork of land uses, aquatic habitats (including trout-sensitive waters), and urban growth, and challenging the development of a uniform management strategy. Thirty-nine percent (39%) of all rivers and streams, and thirty-six percent (36%) of all lakes and reservoirs within the Yadkin River basin are listed as “impaired” by the NCDWR. The Yadkin River is also known for its outstanding resource waters, primarily found in the Uwharrie National Forest in Montgomery County and the headwater tributaries of Wilkes and Surry Counties.

Kerr Scott Reservoir, High Rock Lake, Tuckertown Reservoir, Badin Lake, Lake Tillery, and Blewett Falls Lake were all formed by dams erected on the Yadkin-Pee Dee River during the twentieth century. The USACE owns and operates Kerr Scott Reservoir. The Aluminum Company of America (ALCOA) owns operates most of the other lakes on the Yadkin River, having built them to generate energy that supported its aluminum smelting operations in North Carolina for decades. Dam construction and adjacent industrial use and land development fundamentally altered water quality and water use of the river, affecting hydrology and ecology historically found within the river basin. The impacts of these dams in combination with the diversity of historical features, especially land use, cannot be overstated when discussing current water quality conditions within the river basin.

There are several active citizen groups and non-profits that focus on water quality active in this river basin, including the Yadkin Riverkeeper, the Elkin Valley Trails Association, and the High Rock Lake River Rats. They all have different focuses, but are all potential partners for protecting and improving water quality throughout the basin, regardless of the scale of the effort.


Grayson
Patrick
Henry
Virginia
North Carolina
Mount Airy
Alleghany
Ashe
Surry
Stokes
Rockingham
Watauga
Wilkes
Wilkesboro
Yadkin
Forsyth
Winston Salem
Guilford
Alamance
Caldwell
Alexander
Davie
Iredell
Statesville
Lexington
Davidson
Burke
Catawba
Salisbury
Rowan
Lincoln
Cabarrus
Charlotte
Moore
Cleveland
Gaston
Stanly
North Carolina
South Carolina
Mecklenburg
Cherokee
York
Union
Anson
Richmond
Union
Chester
Lancaster
Chesterfield
Marlboro
Scotland
Yadkin River Basin Prioritization
Yadkin River Subbasins
Subbasins
Yadkin River Headwaters
South Yadkin River
Yadkin River
Lake Tillery/Pee Dee River
Rocky River
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County Boundary
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Piedmont Triad Regional Council
September 2013

Dan River

The Dan River Basin is the headwaters subbasin of the Roanoke River, which originates in the Appalachian foothills and discharges to the Albemarle Sound at Bertie and Martin Counties in North Carolina (NC DWQ 2011). The Dan River Basin occupies the 3,937 square miles and 11,123 linear stream miles of the headwaters for this large river basin. The subbasin has been separated into three 8-digit Hydrologic Unit Code (HUC) watersheds by the US Geologic Survey: the Upper Dan River, the Lower Dan River, and the Banister River (see Figure 3). The US Army Corps of Engineers (USACE) built and operates Philpott Dam on the Smith River upstream of Martinsville, VA. This impoundment and its management have a profound effect upon downstream water quality and health, especially for river levels and temperatures that the stocked trout rely upon. The river basin has 706.5 stream miles and 5,727 lake acres rated as Impaired by the NC DWQ and the Virginia Department of Environmental Quality (VA DEQ); over 7% of the Dan River Basin's water is impaired for human or ecological uses (NC DWQ 2012; VA DEQ 2012).

The Dan River Basin Association (DRBA) is the lead non-profit organization in this basin, working with a diverse community of stakeholders to enhance the river for drinking water, recreation, and ecological uses. They have been highly successful in collaborating with the VA Department of Conservation and Recreation (VADCR) to create numerous blueways, greenway, and river access points throughout the river basin.

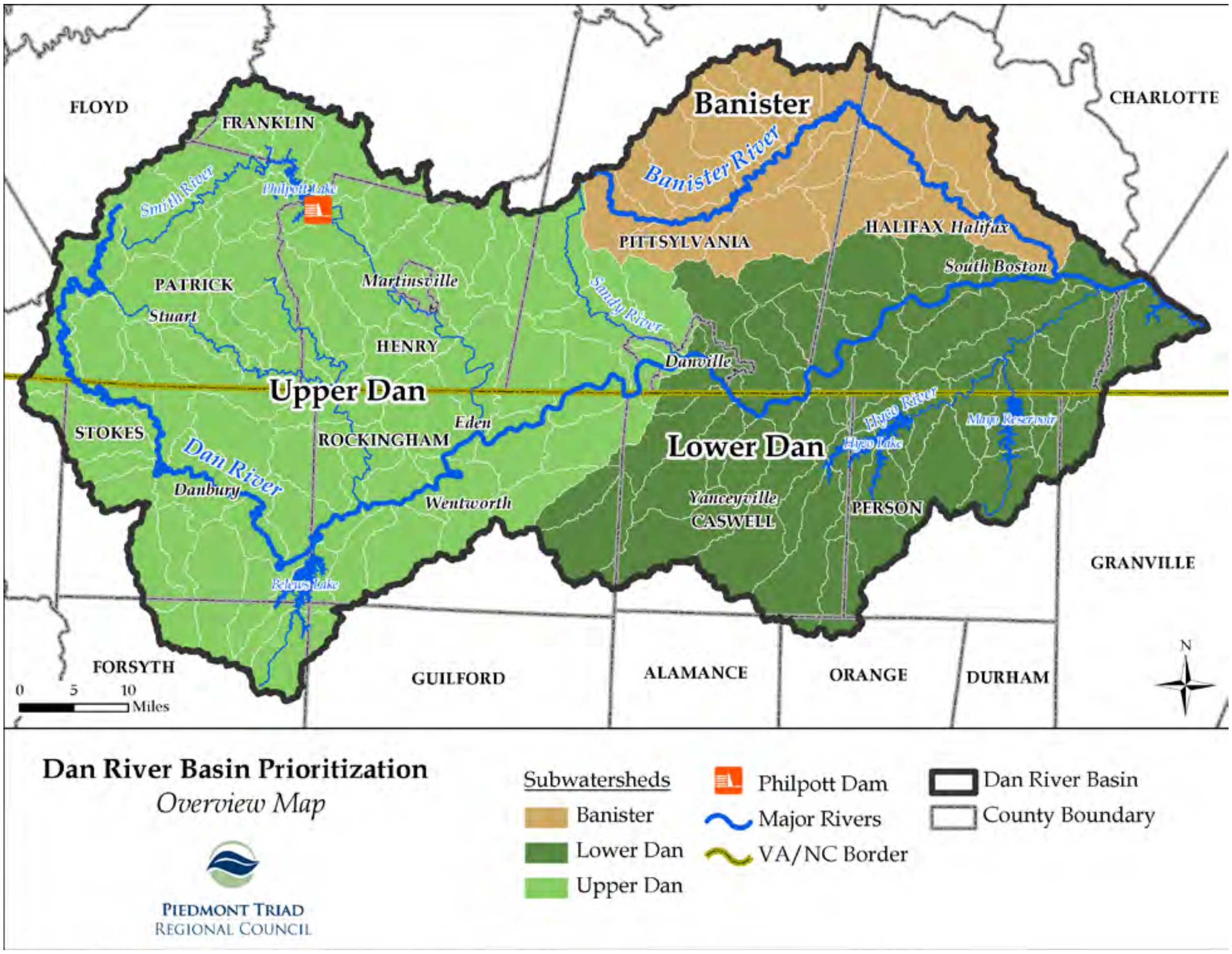


Figure 3: Overview of the Dan River Basin

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 among an array of agencies and groups. For example, the NCDWR Basinwide Planning Unit exhaustively reviews the water quality, land uses, and growth patterns within each river basin regularly, documenting river basin conditions and notable improvements or degradations. It is a synthesis of the best-available data characterizing basin conditions, but offers less guidance on water quality priorities, or a comprehensive strategy to improve or protect water quality. This project's goal is to assess current water quality needs accurately and give river basin stakeholders guidance with a GIS-based watershed-scale analysis on the watershed protection and restoration needs in the Piedmont Triad's river basins. The intended use for this planning effort is to provide the many stakeholders and stewards of water quality in the Triad data that they can utilize as leverage for resources and funding to support 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 Dan River, Upper Cape Fear River, and Yadkin River Basins, including those areas residing in Virginia. Local agencies and groups can now use this data to prioritize their restoration and conservation efforts, and this project's standardized and validated analysis methods provide credibility in applications for local watershed restoration or protection funding. The purpose of this project is to provide a model that serves watershed needs for stakeholder groups at multiple scales: from the US EPA and US Forest Service to small towns, local watershed groups, and farmers to prioritize efforts and utilize limited resources most effectively for long-term watershed health and function. This data can also be used as a stimulus for creating partnerships within all river basins in the greater Piedmont Triad megaregion for more focused efforts.

The current model was validated using NCDWR and VADEQ water assessment data, and appears to accurately reflect water quality and watershed conditions, confirming its value to prioritize regional and basinwide water quality efforts. As such, the PTRC is happy to recommend the current model's use for watershed prioritization efforts throughout the Piedmont and Sandhills ecoregions of North Carolina. This report may serve as the final output of these models, but the model described here is useful for assessing watershed protection and restoration efforts. The PTRC intends to refine and improve the models for better accuracy and assessing its regional needs.

Methods

The goal for this watershed assessment was to assess the 428 12-digit HUCs within the three river basins that cover the Piedmont Triad Regional Council boundary (the Upper Cape Fear, Yadkin Pee Dee and Dan River Basins) 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. The methods in this analysis were based on those established in the *Upper Cape Fear Watershed Assessment (2012),* where 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 and weighted according to a stakeholder driven voting process. 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. The results from this process will create a uniform analysis for PTRC's three river basins.

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 watersheds. A stress raster was also created where each cell contained a value representing the stress vulnerability for that point within the watersheds.

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 U.S. Geological Survey in raster format with a 1 arc-second resolution (about 30 meters). 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 2: Stress Analysis Input Layers and Weighting System (determined by stakeholders)

Stress Layers				
Criteria	**Data Source**	**Factors**	**Integer Values**	**Layer Percentage**
High Impervious Surface Cover	NLCD 2006 Percent Developed Imperviousness	1 - 4%	26	45.5%
		5 - 9%	141	
		> 10%	288	
Highly Erodible Soils	SSURGO (K factor)	0 - 0.23	0	8.7%
		0.24 - 0.39	24	
		0.40 - 0.49	62	
High Density of Impact Sites	NCDWR & VA DEQ	Low (1-7 per sq. mile)	27	8.1%
		High (8-48 per sq. mi)	54	
High Road Density	NCDOT & VDOT	Low	0	7.6%
		Med	0	
		High	76	
Low Forest Cover	NLCD 2001 update	< 50%	66	6.6%
High Population Density Change (2000 to 2010)	U.S. Census Bureau	1 - 9%	3	5.9%
		10 - 24%	5	
		25 - 49%	8	
		> 50%	44	
High 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	USGS NED (1 arc second)	> 15%	37	3.7%
Small Parcel Size	Counties	< 10 Acres	16	1.6%
Zoning (High Impact)	Counties/Municipalities	Commercial, Industrial, High Density Residential, Multi-family & Office	14	1.4%
Floodplain	NC Floodplain Mapping Program & VA DCR	Within 500 Year Floodplain	12	1.2%

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

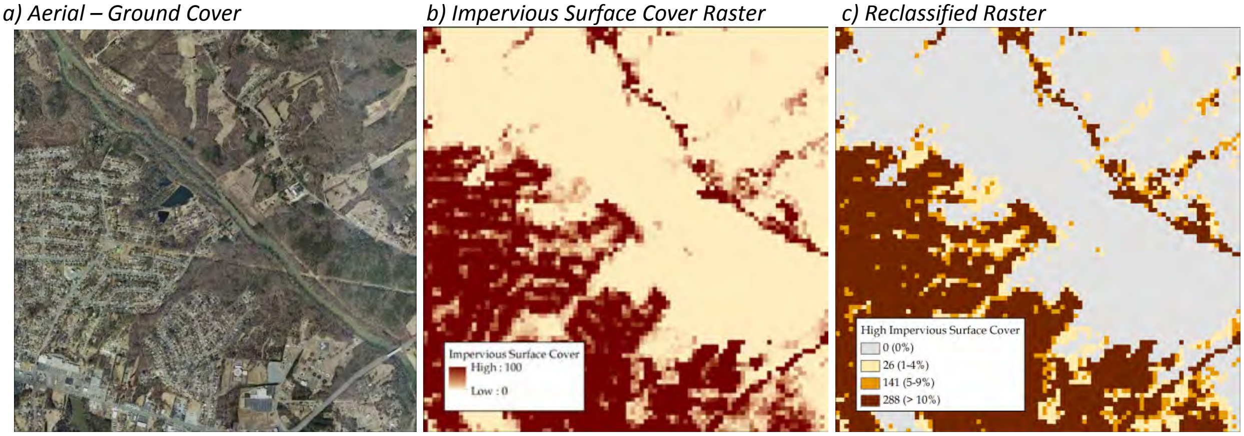


Figure 4: Steps performed on impervious surface data

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*

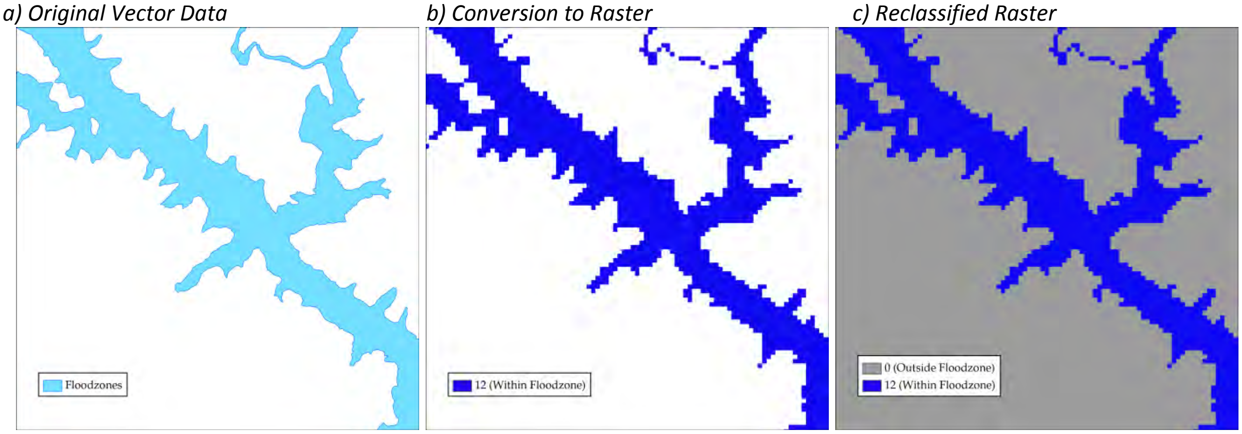


Figure 5: Steps performed on floodzone data layer

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.

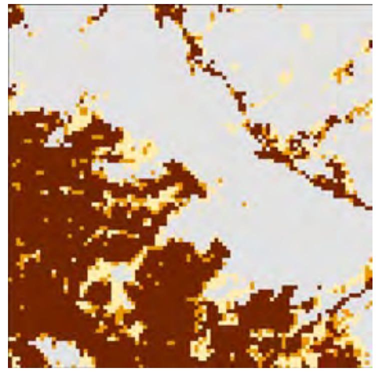
a) Aerial – Ground Cover *b) Original Census Blocks* *c) Reclassified Raster*

Figure 6: Steps performed on population density data layer

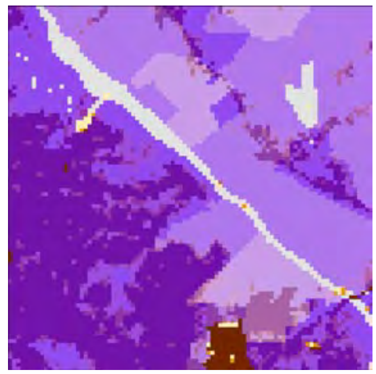
All 12 reclassified rasters were then input into the ArcGIS Weighted Sum Tool. This tool overlaid the input rasters on top of one another and summed the respective cells into one output stress value raster (see Figure 5). This tool works similar to the ArcGIS Plus tool, except that it provides an option 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 landscape in the three river basins on a continuous array of values, ranging from 0 to 665 (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 watersheds obtained this high of a stress value. This process attempted to identify the highest stress areas with the river basins that require additional analysis and consideration.

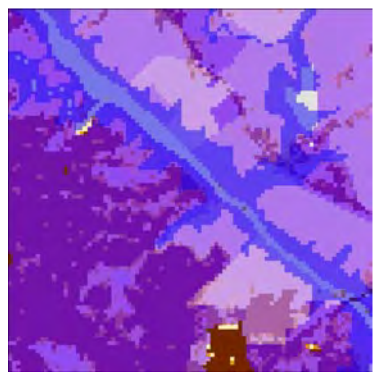
a) Reclassified Impervious Surface Cover Raster



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)

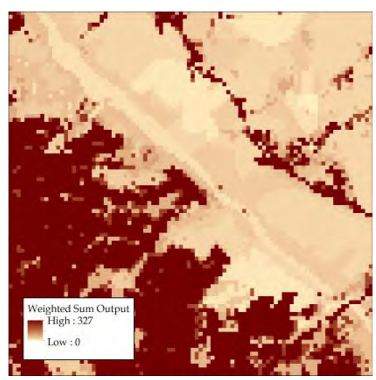


Figure 7: Example of Input Layers into Weighted Sum Tool

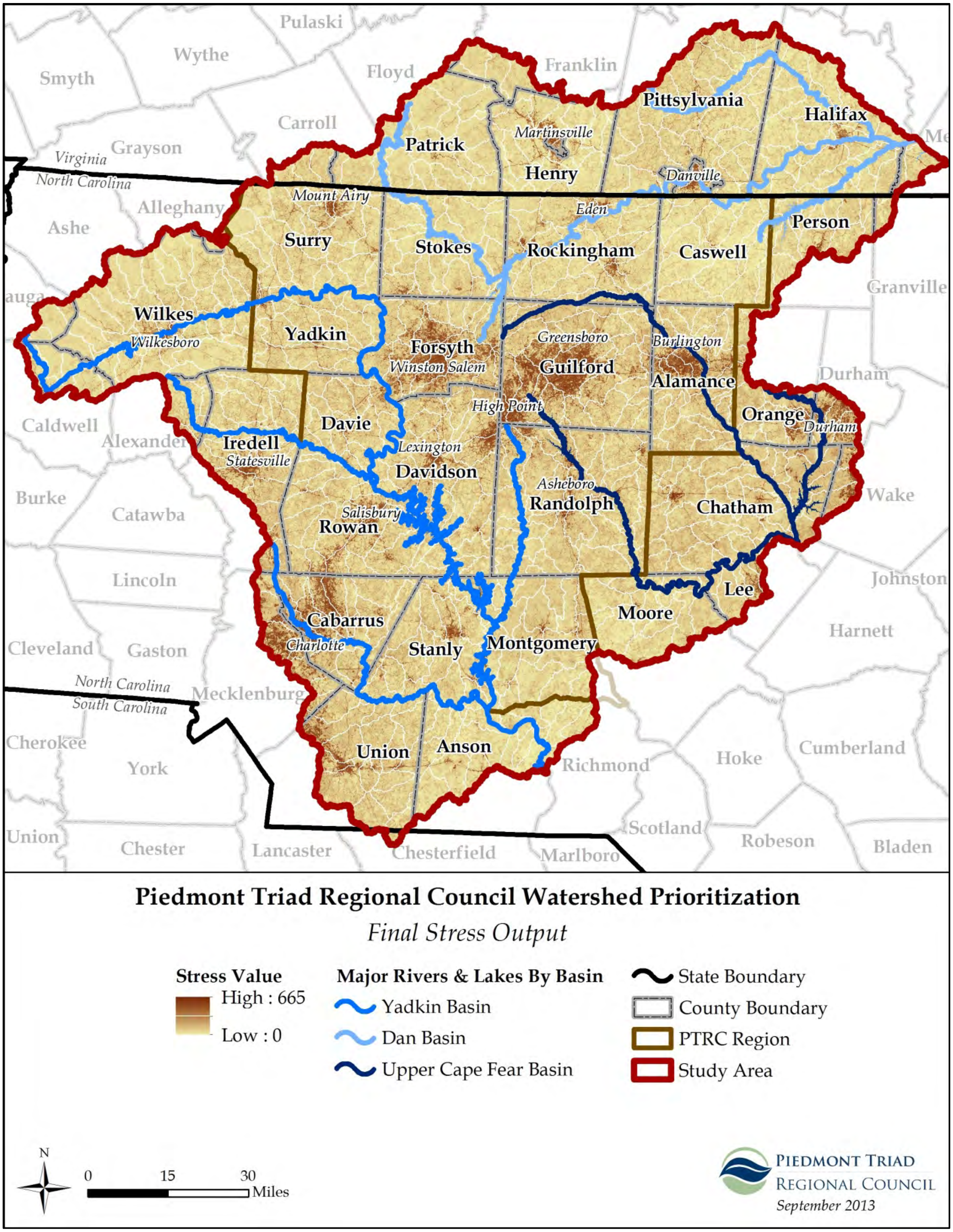


Figure 8: Output Stress Value Raster

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 45 to 367.

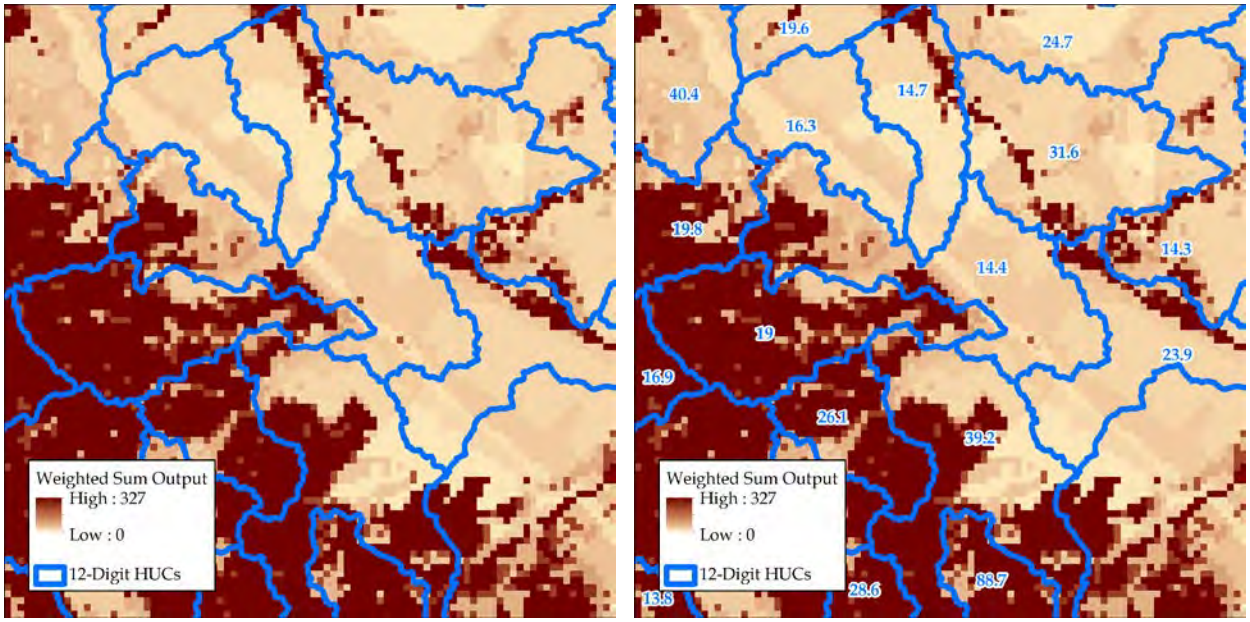


Figure 9: Zonal Statistics tool calculated mean stress value for each 12-digit HUC

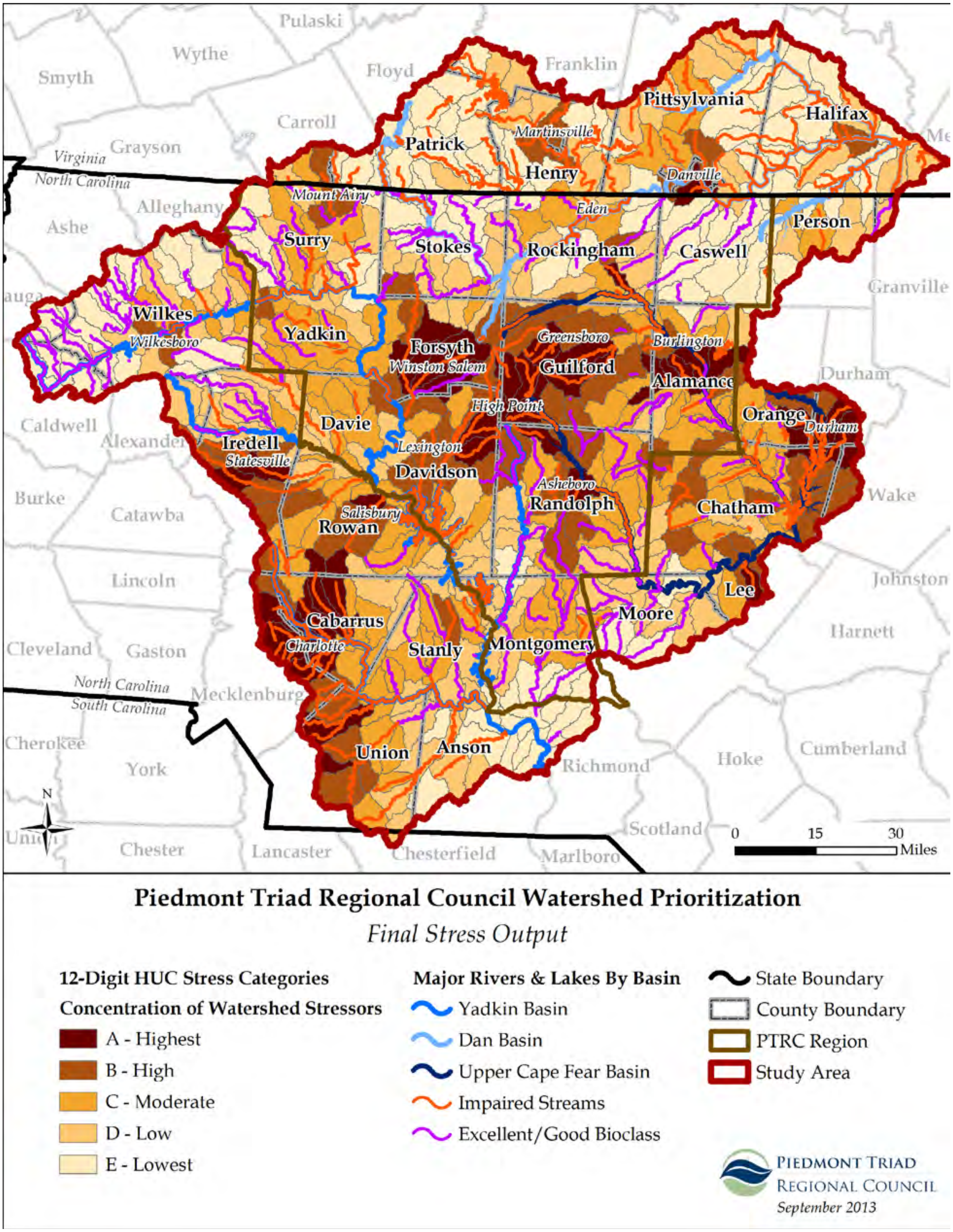


Figure 10: 12-digit HUCs grouped by stress category

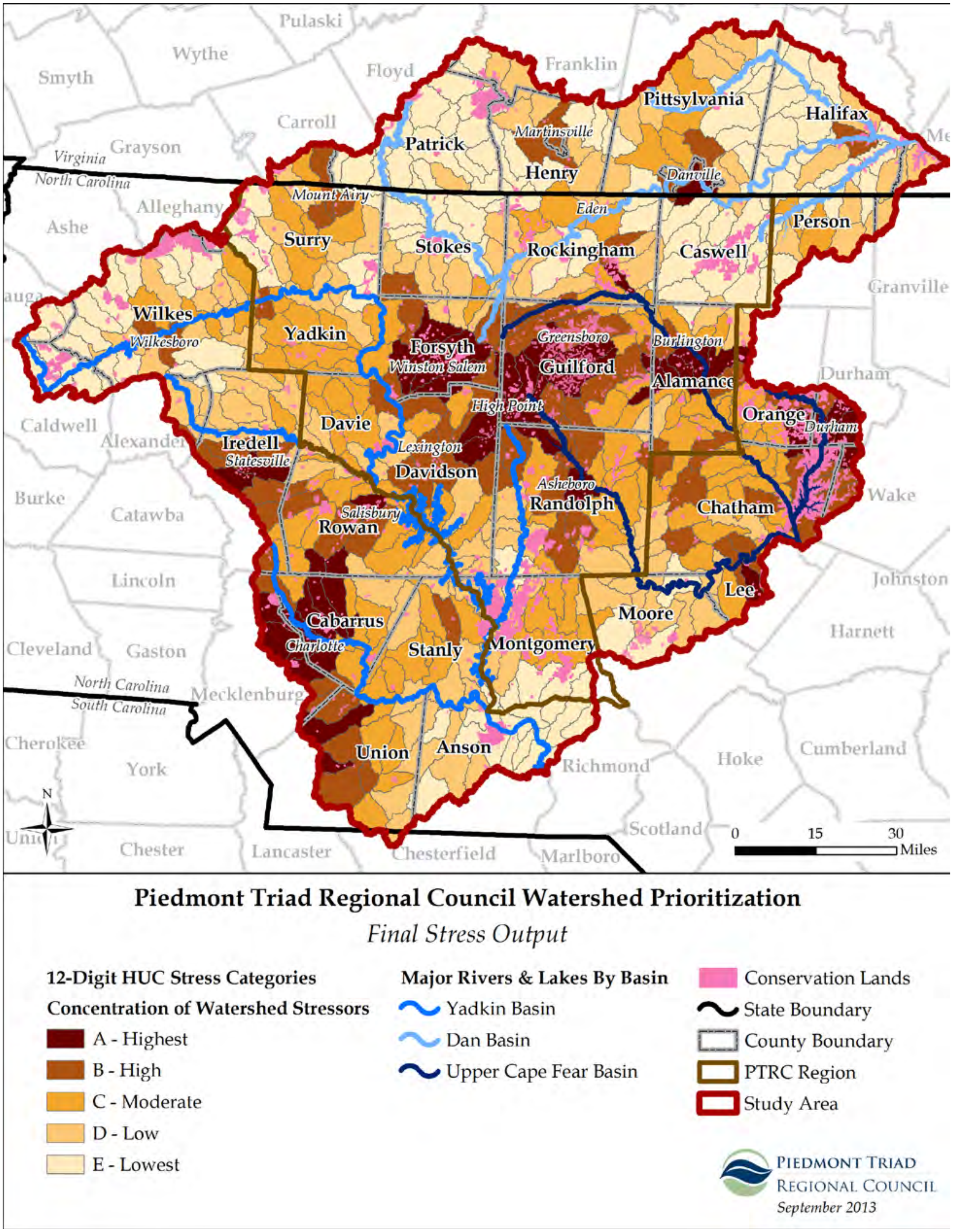


Figure 11: 12-digit HUCs grouped by stress category, overlaid with conservation lands

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 3: 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	NC NHP & VA Natural Landscape Network	1 - 4	65	31.9%
		5 - 6	65	
		7 - 8	79	
		9 - 10	110	
Low Impervious Surface Cover	NLCD 2006 Percent Developed Imperviousness	> 10%	0	22.9%
		5 - 9%	54	
		0 - 4%	174	
High Forest Cover	NLCD 2001 update	> 50%	134	13.4%
Hydric Soils	SSURGO	Partially Hydric	22	7.8%
		All Hydric	56	
Highly Erodible Soils	SSURGO (K factor)	0 - 0.23	0	7.1%
		0.24 - 0.39	14	
		0.40 - 0.49	57	
Floodplain	NC Floodplain Mapping Program; VA DCR	Within 500 Year Floodplain	65	6.5%
Low Population Density (Persons Per Square Mile)	Census Bureau, 2010	High (250 +)	0	4.9%
		Med (50-249)	20	
		Low (1 -49)	29	
Steep Slopes	USGS NED (1 arc second)	> 15%	37	3.7%
Large Parcel Size	Counties	> 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 NCDWR stream bioclassification removed so that we could later use the stream bioclassification data as a validation layer for our output conservation value raster.

Table 4: 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 Virginia Natural Landscape Assessment (2007) best matches the BWHA layer for use in the Dan River Basin that extends across state lines. The Virginia Natural Heritage Program developed this network of natural lands and assessed them for nine ecological attributes related to rare species habitat, environmental diversity and water quality benefits. Similar to the removal of stream bioclassification in the BWHA layer, PTRC removed the water quality benefit factors in rating the Virginia natural lands network.

Slope data was obtained from the U.S. Geological Survey in raster format with a 1 arc-second resolution (about 30 meters). 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 boundaries 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 three river basins' landscape on a continuous array of values, ranging from 0 to 650 (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 watersheds obtained this high of a conservation value. This process attempted to identify areas within the watersheds 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 101 to 422.

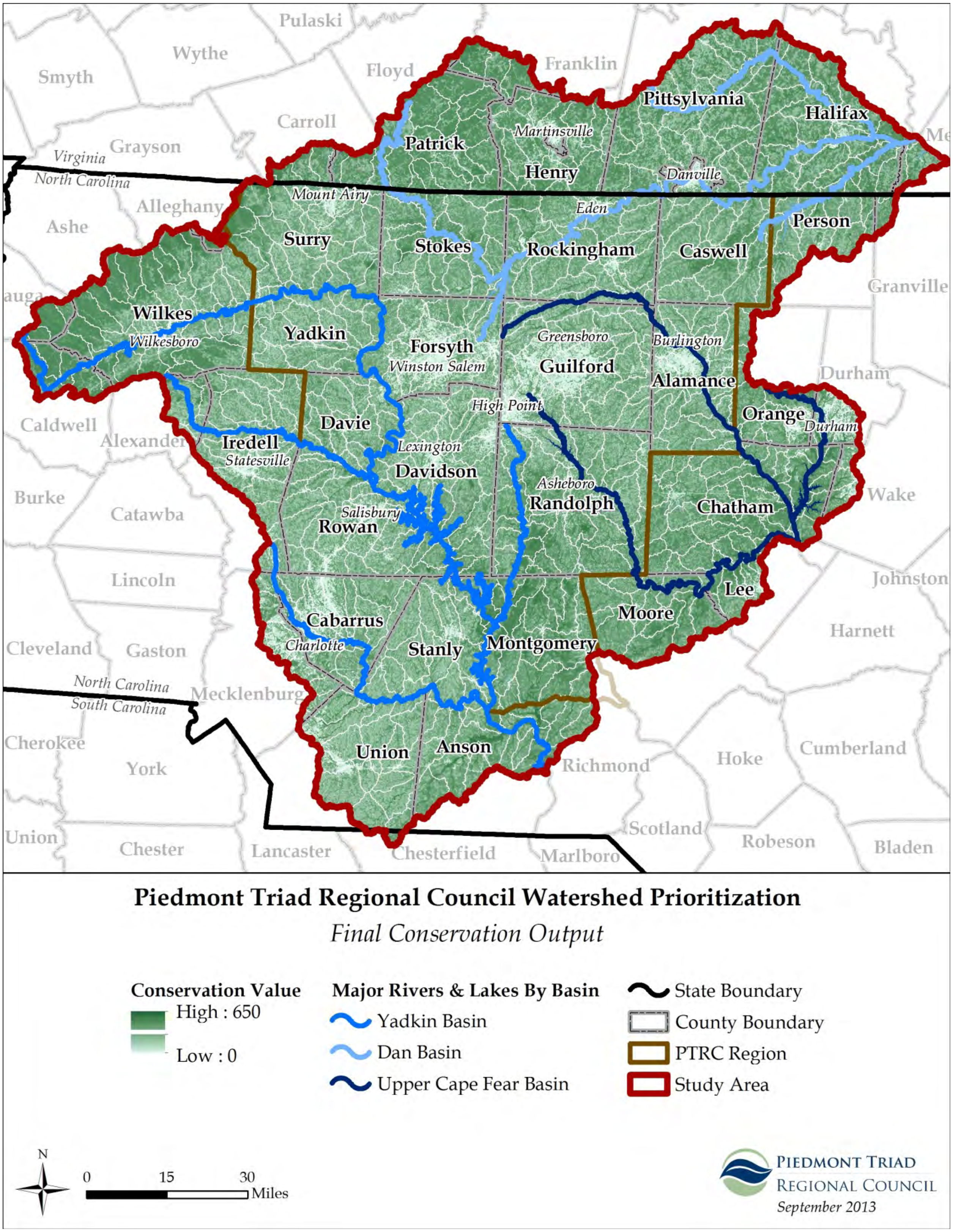


Figure 12: Output Conservation Value Raster

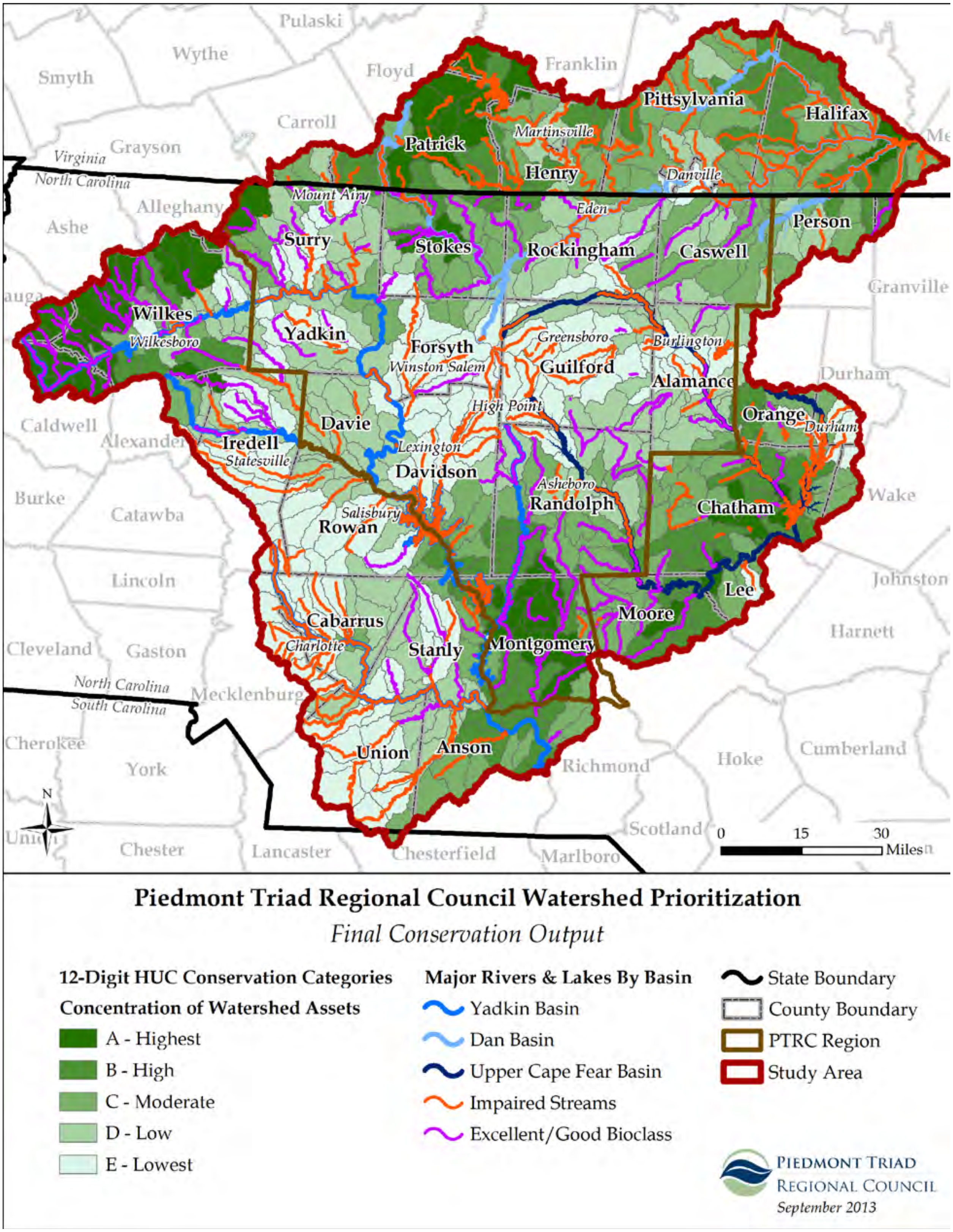


Figure 13: 12-digit HUCs Grouped by Conservation Category

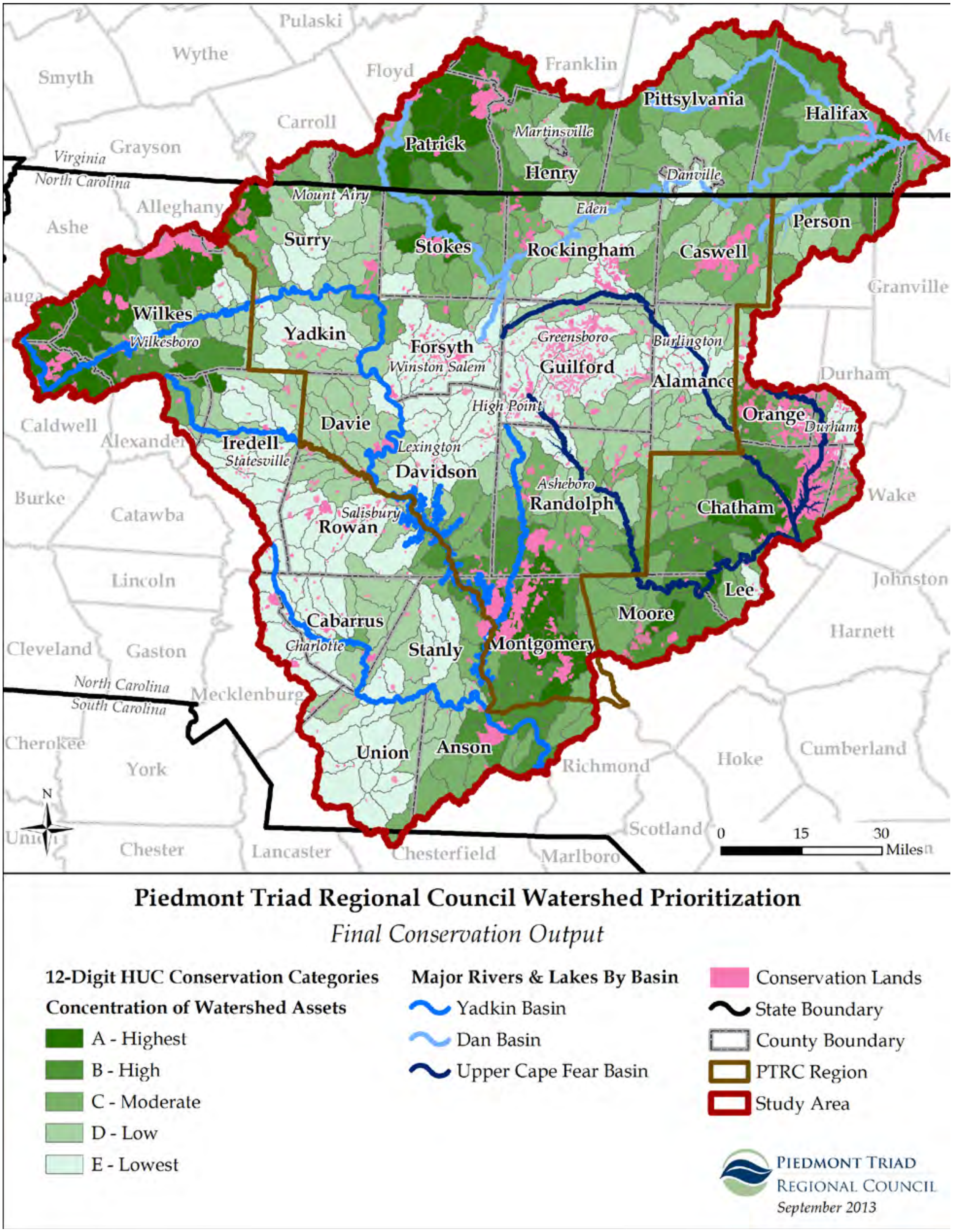


Figure 14: 12-digit HUCs grouped by conservation category, overlaid with conservation lands

Stress HUC Groupings

As noted in the Project Overview section, environmental, economic, and recreational data in both North Carolina and Virginia were 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 1 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. Based on this table, the 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.

Watersheds were broken down into five categories that reflect their general shared trends in land use and history. Table 4 shows the details of these five categories and the number of watersheds they feature. The categories are briefly described on the following pages.

Table 5

PIEDMONT MEGAREGIONAL STRESS MODEL WATERSHED CATEGORIES		
Category	**Number of Watersheds**	**Proportion of Total Watersheds**
Highest Concentration of Watershed Stressors	43	10%
High Concentration of Watershed Stressors	64	15%
Moderate Concentration of Watershed Stressors	107	25%
Low Concentration of Watershed Stressors	107	25%
Lowest Concentration of Watershed Stressors	107	25%

Table 6

PIEDMONT TRIAD REGIONAL STRESS MODEL WATERSHED CATEGORIES		
Category	**Number of Watersheds**	**Proportion of Total Watersheds**
Highest Concentration of Watershed Stressors	17	10%
High Concentration of Watershed Stressors	26	15%
Moderate Concentration of Watershed Stressors	43	25%
Low Concentration of Watershed Stressors	43	25%
Lowest Concentration of Watershed Stressors	43	25%

Stress Category A - Highest Concentration of Watershed Stressors

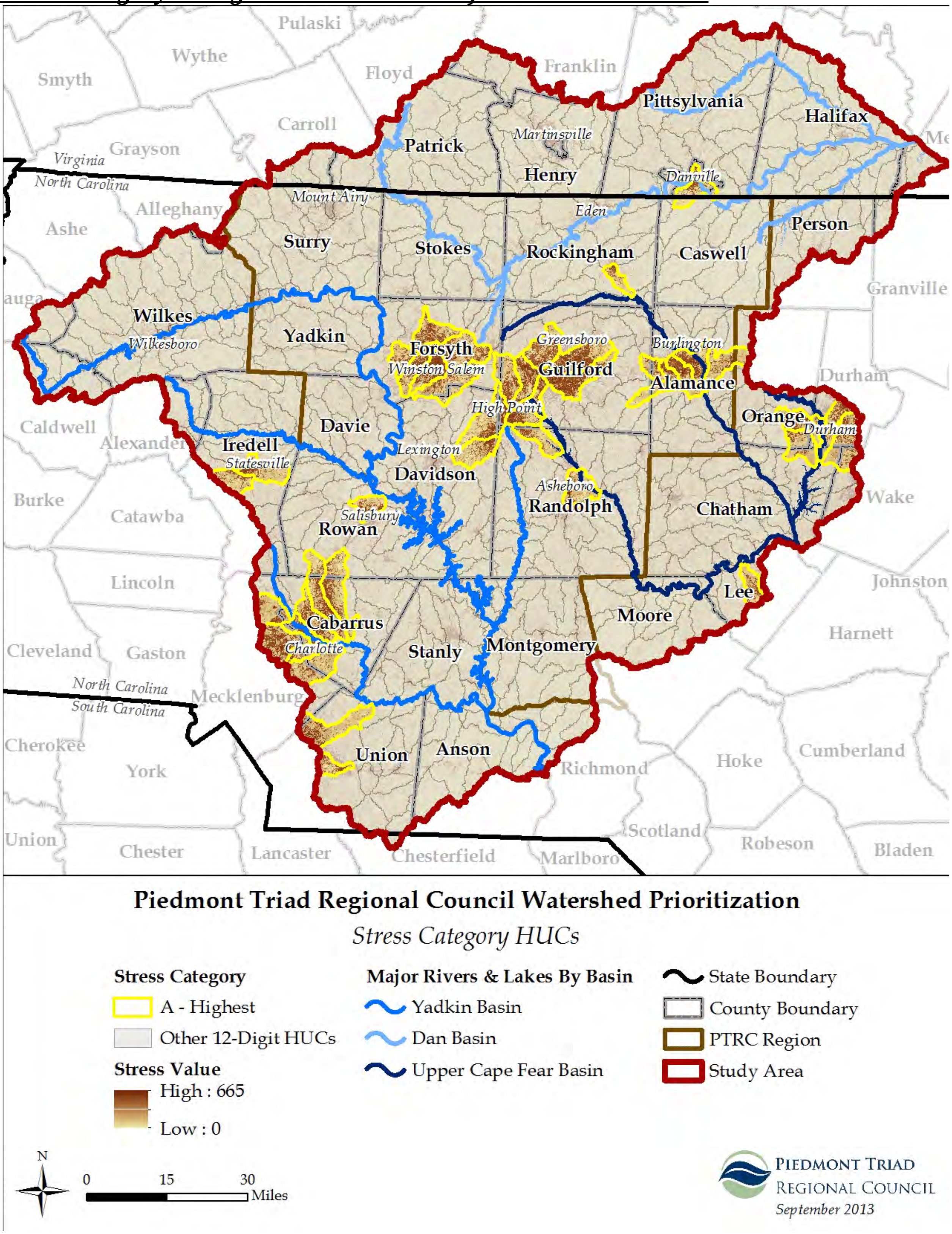


Figure 15: Stress Category A - Highest Concentration of Watershed Stressors

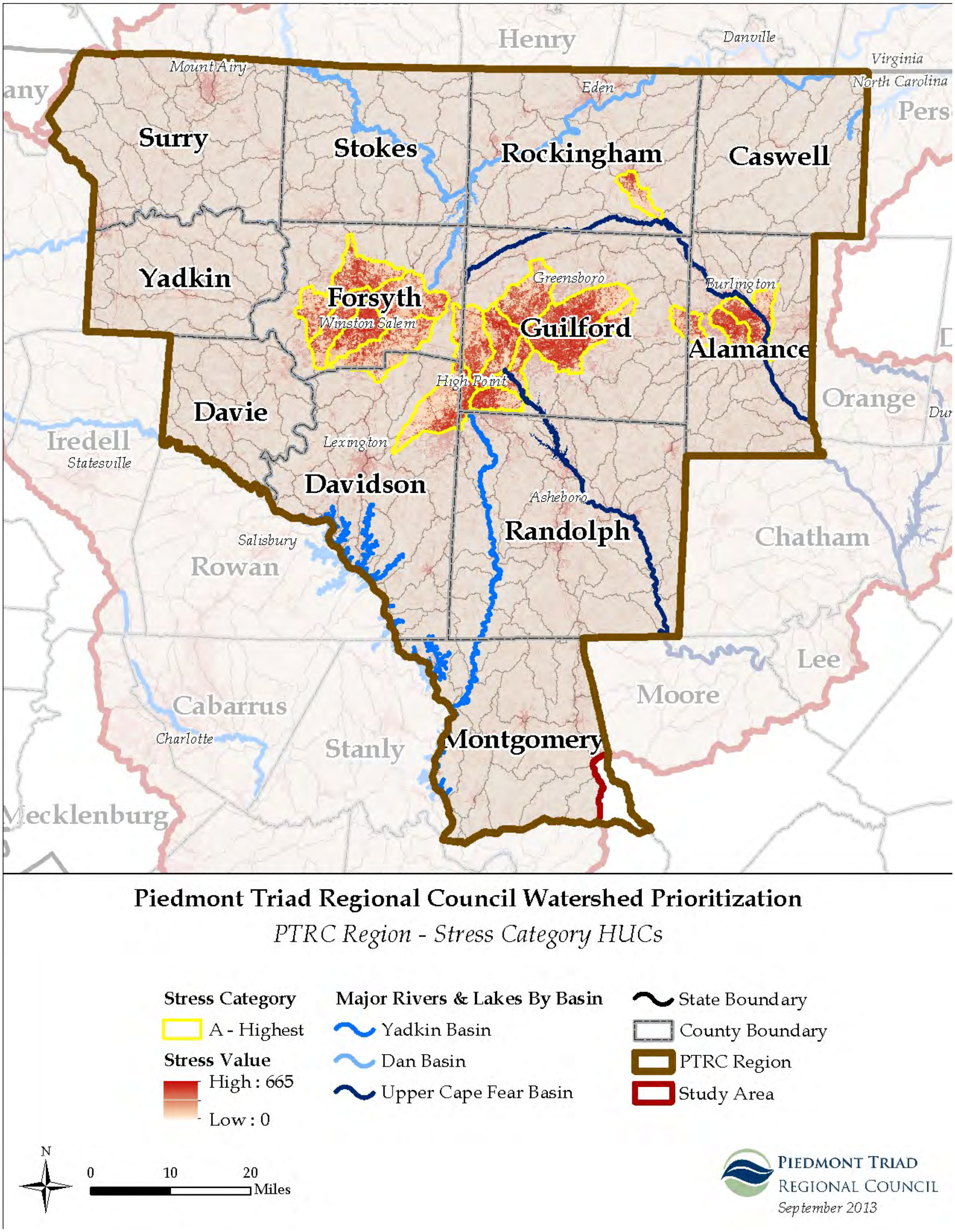


Figure 16: Stress Category A - Highest Concentration of Watershed Stressors – Piedmont Triad region

Key Watershed Characteristics

- Urban centers & transportation hubs
- Regulated communities (NPDES, Jordan & Randleman Buffer Rules)
- Long legacy of land use impacts
- Existing stormwater programs

Key Management Recommendations

- Using LID for all new development
- Increase monitoring efforts
- Update watershed restoration plans
- Retrofit and redevelop urban cores
- Establish or increase partnership efforts
- Restoration will require significant financial support

Overview

These watersheds exist entirely in the urban centers. The Center for Watershed Protection's (2003) research suggests a decline in both species abundance and diversity at or around 10% impervious surface cover. Most – if not all – of these watersheds have impervious coverage ratios at much higher proportions than this. This is not surprising given that impervious coverage was almost 50% of the determining factors in the Stress model.

The results from the model seem to justify this high relative weight. Approximately 17% of all impaired streams representing 13.5% of all impaired stream miles in the region occur in these watersheds. This suggests stormwater runoff 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 urban pollution and carries it through the storm sewer system or deposits it untreated into nearby waters.

These watersheds also have high potential densities of impact sites including, but not limited to, from animal operations, NPDES permits, old landfill sites, and PCBs. Other factors, including high road densities, high population densities, and low canopy cover also influence the high ratings of these watersheds.

History

The watersheds in Category A exist along the major metropolitan transit corridors of I-85 and/or I-40 and they all serve as major transportation hubs in the North Carolina Piedmont region. They also include the urban sprawl of residential and commercial growth surrounding these urban cores. These watersheds share histories of textile and furniture manufacturing, and feature established cities, some of which are reeling from a decades-long economic recession brought about by globalization and the decline of the tobacco economy. They include some of the fastest-growing communities in the United States, and the largest population centers in North Carolina.

Most of these counties and municipalities within these watersheds are regulated under US EPA's the National Pollutant Discharge Elimination System (NPDES) as either Phase I or Phase II communities, required to develop and implement a stormwater management plan to reduce the contamination of stormwater runoff and prohibit illicit discharges. Many of these communities have additional obligations to protect water quality through total maximum daily load (TMDLs) assessments and/or state legislation such as the Jordan Lake Rules. TMDLs are specified in the US Clean Water Act as a recovery strategy for impaired waters in which the pollutant(s) determined to be the cause(s) of impairment is put on a diet should be sufficient to recover healthy water quality conditions. States may develop alternatives like the Jordan Lake Rules to TMDLs that capture pollution sources other than stormwater and wastewater. Of note are the high number of watersheds that drain to High Rock Lake, currently the subject of a special study by NCDWR to reduce its nutrient levels, similar to the study that directly informed the Jordan Lake Rules.

Current Practices

Category A 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 stream buffer rules.

As larger Phase I and II communities, the municipalities of Winston-Salem, 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. As many communities around the United States are discovering, though, local fees are frequently insufficient to support robust stormwater management. In several communities such as Philadelphia and Chicago, the US EPA has dedicated significant support to assist these metropolises with stormwater management, which is estimated to cost billions of dollars, largely due to their use of a single infrastructure to pipe sewage and stormwater. North Carolina communities have not seen the same level of federal support and perhaps should not expect to, given the outstanding national needs for greater infrastructure investment. In this case, the state and/or local government will assume the total financial burden of these responsibilities.

Most of these communities are implementing practices based on existing local watershed plans. The PTRC has actually led planning efforts in the three of these watersheds. Whether they are doing it through a well-funded stormwater program, partnering with other organizations (e.g. EEP, COGs, associations, etc.), or contracting with a private firm, 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 BMPs are effective, a consistent, long-term monitoring program can help determine water quality conditions and trends in a given water body. The *Piedmont Nutrient Reduction Sourcebook* is a resource that provides guidance on how to utilize BMPs effectively.

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.

While these larger municipalities are able to fund implementation projects through stormwater fees, the project demand is overwhelming, and estimated to be well in the billions of dollars. 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). Obviously, greater support from federal and state agencies is needed and will be highly appreciated in these watersheds.

Key Stakeholders and Resources
NPDES cities
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
NC Stormwater Utility Dashboard
NCSU Water Quality Group

Stress Category B - High Concentration of Watershed Stressors

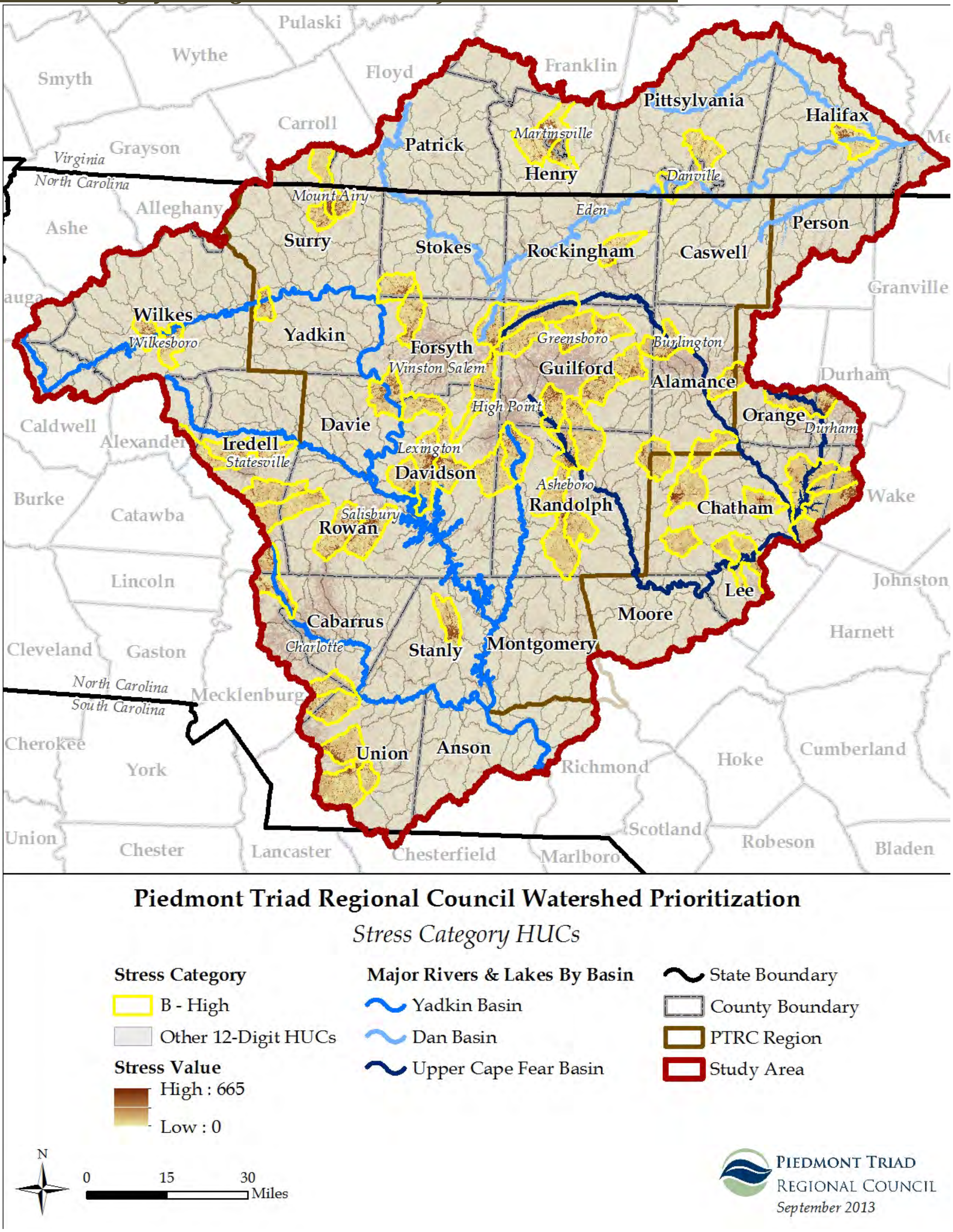


Figure 17: Stress Category B - High Concentration of Watershed Stressors

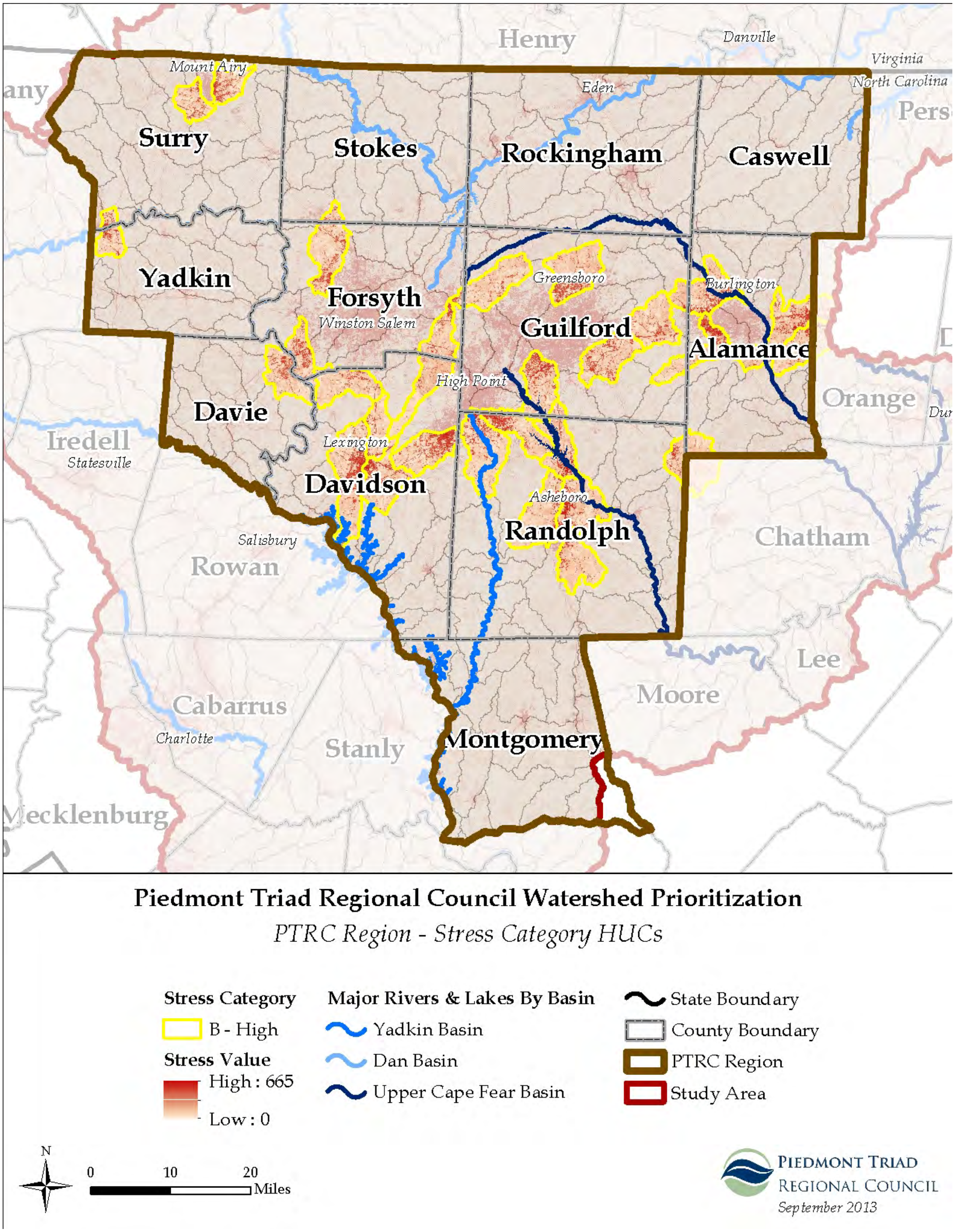


Figure 18: Stress Category B - High Concentration of Watershed Stressors – Piedmont Triad region

Key Watershed Characteristics

- Regulated communities (NPDES, Jordan & Randleman Rules)
- Smaller cities, towns, and suburban communities
- Access to non-urban area

Key Management Recommendations

- Requiring or incentivizing LID for all new development
- Develop stormwater utility fee
- Develop watershed restoration plans
- Develop long-term monitoring plans
- Ideal research opportunities for NCSU Water Quality Group
- Use the WRC's Green Growth Toolbox to guide development

Overview

These watersheds are primarily located adjacent to HUCs with the highest concentration of watershed stressors or in smaller urbanized areas. These watersheds are rapidly absorbing much of the sprawl from larger cities and commuter communities. With a few exceptions, these watersheds are proportionally distributed throughout the region when considering concentrations of population. Category B watersheds show the highest change in population density making the need to take proactive policy steps more immediate than perhaps other categories. 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 greater with less funding.

Stress Category B watersheds have similar 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 sources that can impact water quality. Their smaller size and greater access to open space makes many of these communities ideal candidates for implementing BMPs that yield results more immediately.

History

The history of Category B and C watersheds is actually two separate but related stories. Some 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 (Lexington), or established small towns that serve specific purposes (Mt. Airy, Elkin).

The impact of such growth is to allow people to not live at high densities, but its impacts upon water quality is to effectively impact (and often degrade) watersheds at lower population densities (and, therefore, at lower economic return). Such communities can be developed with a limited impact upon their surrounding environment, but that is not their history. New standards for such growth should be employed (as in Huntersville, NC), and existing communities should be retrofitted with stormwater management features that mitigate the existing impacts upon watershed health and function.

Similar to many of the larger cities in Category A, most of these Category B watersheds flow into waters that either have a nutrient management strategy that is supervised by the State of NC and/or a TMDL administered by the US EPA. The costs of these smaller communities to take actions are proportional with their environmental footprint, which is another way of saying that their administrative and financial responsibilities are lesser than larger communities. That is not to say that these costs are insignificant – many of the strategies call for most of these cities and towns to dedicate millions of dollars over a fairly short timeline to improve water quality.

Current Practices

Only a few 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 fee, 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.

Most of these communities are too small to be required to comply with NPDES regulations. 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. Virginia, which requires the creation of an implementation plan of all TMDLs, is currently addressing fecal sources on the Dan and Smith Rivers, which will require a combination of stormwater and agricultural BMPs to effectively execute.

Next Steps & Partnerships

Though there are many challenges in implementing BMPs in Category B watersheds, the cost-effectiveness of the benefits are only surpassed in those watersheds that need one project for remediation. Communities, regardless of size, need to begin discussing the creation of a stormwater utility. Though it is located more on the coastal plain, the Town of Wilson offers an exemplary model of the value of responding to a TMDL in this manner, having created a name for itself through leadership on stormwater management issues that have resulted from collaborations with NC State University's Water Quality Group. 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.

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.

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. State and federal authorities and private funding institutions need to recognize the cost-effectiveness of investing in Category B watersheds, where they may be able to see a faster return for their investments than in more urbanized environments.

Without a stormwater utility fee, the need for partnerships increases greatly. Partnerships such as stormwater authorities allow smaller jurisdictions to work together at a watershed scale. The new Granville Stormwater Authority has shown success with this approach. 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.

Key Stakeholders and Resources
Cities and towns
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
Blue Ridge Conservancy
Dan River Basin Association
LandTrust for Central NC
Piedmont Land Conservancy
Triangle Land Conservancy
Upper Neuse Clean Water Initiative

Stress Category C - Moderate Concentration of Watershed Stressors

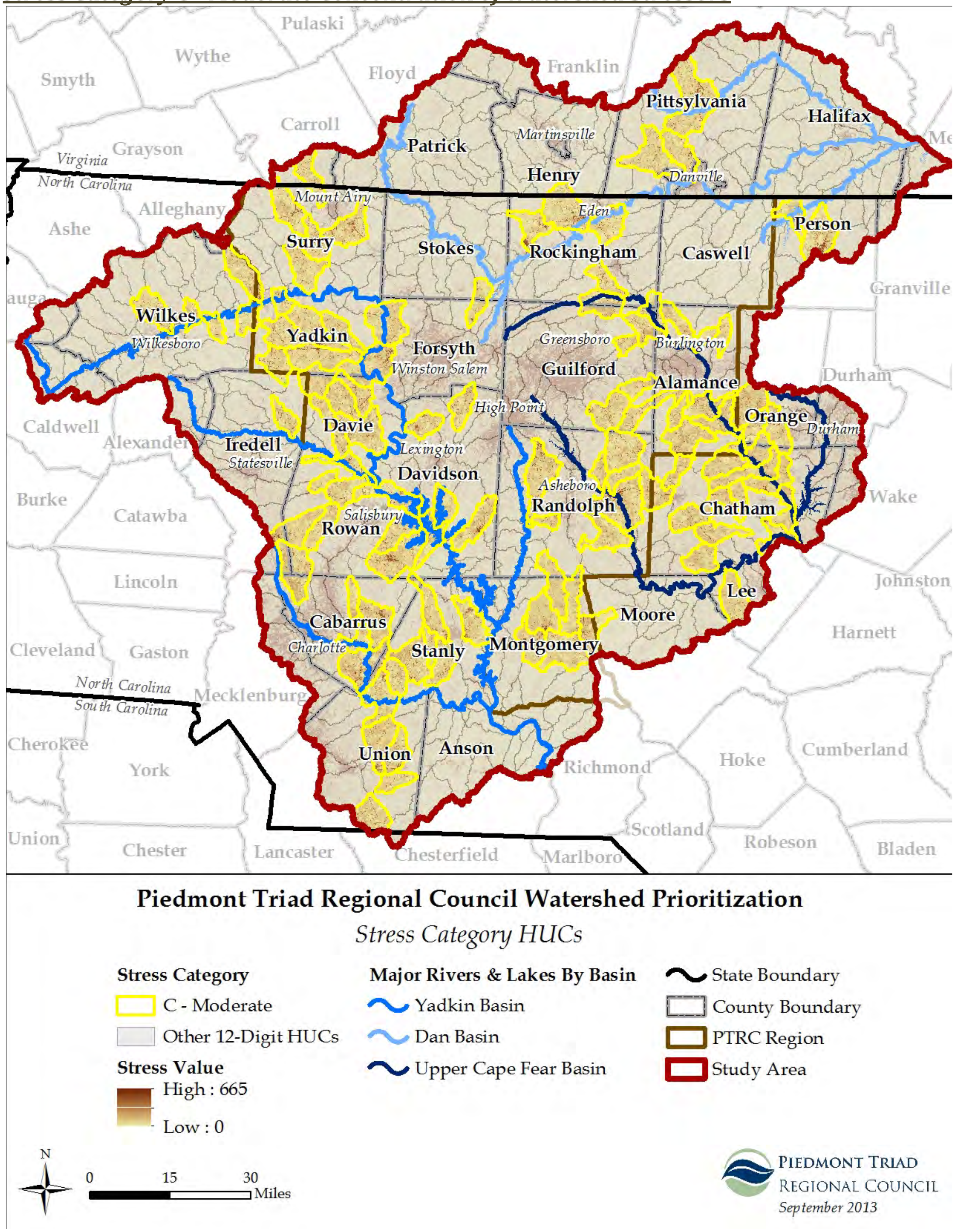


Figure 19: Stress Category C - Moderate Concentration of Watershed Stressors

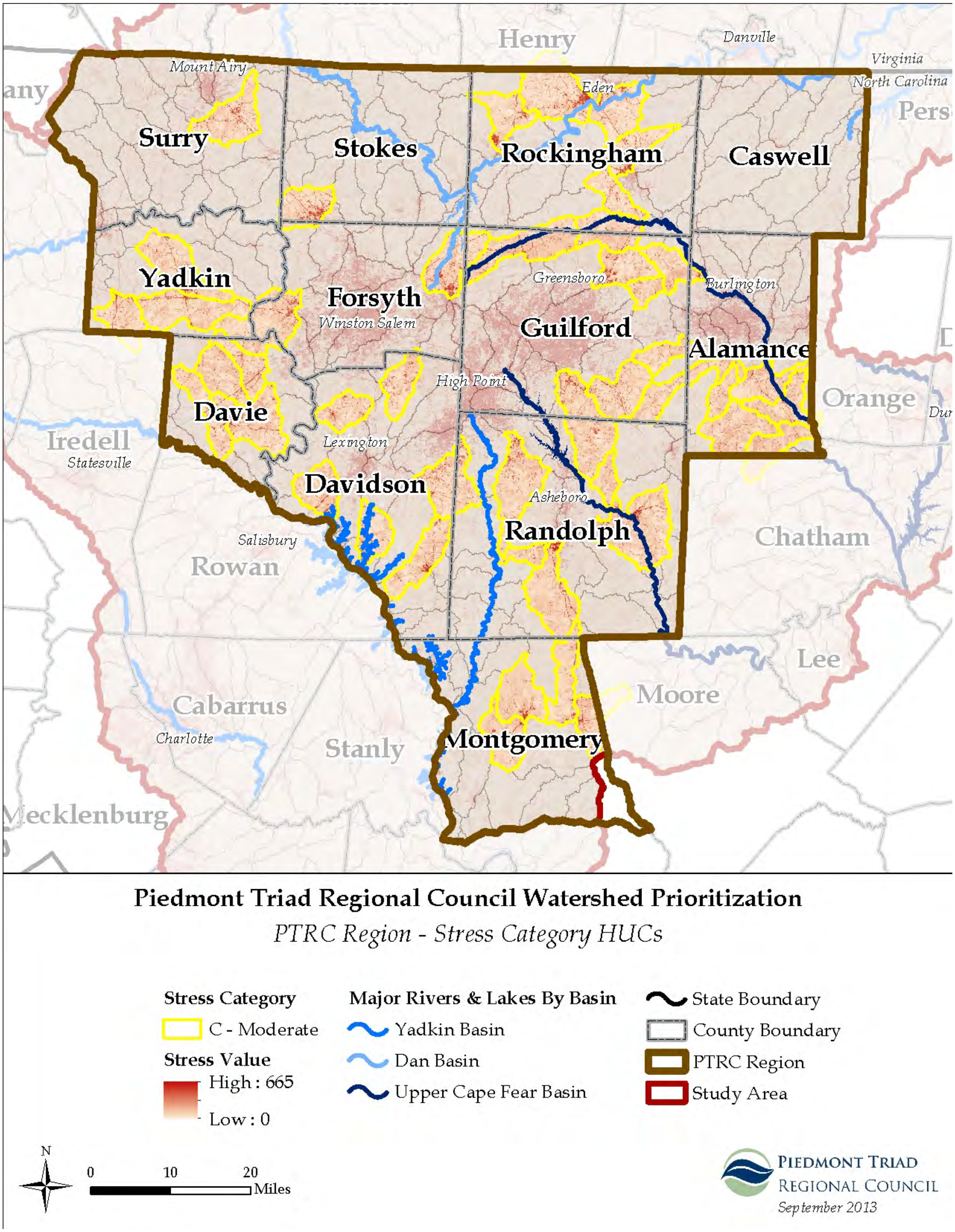


Figure 20: Stress Category C - Moderate Concentration of Watershed Stressors – Piedmont Triad region

Key Watershed Characteristics

- High proportion of potential impact sites
- Small towns & suburban communities
- Impacts from transit corridors
- Several extremely eutrophic lakes
- Several watersheds in US Forest Service lands

Key Management Recommendations

- Work with agricultural partners to recover and stabilize watersheds
- Initiate planning efforts in the Graham-Mebane Reservoir watershed
- Jordan Lake Water Users Group should consider an ecosystem services market to restore healthy waters to the lake
- High value landscapes that would benefit from land trust or public action

Overview

Category C watersheds are largely represent non-urban land uses throughout Piedmont Triad, though they do include several small towns and suburban communities. Most of these watersheds are rural, and have been selected due to factors other than impervious cover. High road density, erodible soils, high densities of potential impact sites, and low forest cover are all likely factors in nominating these watersheds to the level of having moderate levels of watershed stressors. While no definitive source of stress can be attributed to all of these watersheds, runoff from farmland and highways may be impacting these streams – 30% of impaired streams are intersect these watersheds. The density of potential impacts also reflects a level of risk that these watersheds may possess. While these potential impacts are immediate hazards, they also have the possibility of being hazards, and represent a management need in all of these watersheds.

History

These watersheds all lie outside the suburban belt that surrounds the Triad, Triangle, and Charlotte. These are landscapes that appeal to those wishing for a rural lifestyle convenient to urban job centers. They possess endangered open space and contiguous forests, but fewer valuable ecological habitats or species compared with the rich and diverse areas in Wilkes, Montgomery, and Lee Counties. Consequently, they are persistently slipping through the cracks for environmental investment. Over the twentieth century, the endemic ecology of these watersheds has been damaged by modest development, transit corridor construction, and industrial use of waters. As such, they have received few conservation resources from the state or the federal governments, and have had to invest in these natural resources at the local scale.

An exception to this description are those watersheds in Montgomery County that largely lie within the Uwharrie National Forest. These watersheds are likely within Category C due erodible soils, steep slopes, and potential contaminant sites. Their prioritization, however, brings up the need for the use of forestry practice guidelines (FPGs) throughout the state, but especially in steep-sloped watershed harboring endangered species such as the Schweinitz sunflower. FPGs are guidance for forestry operations that proactively prevent water quality impacts through BMPs such as riparian buffers and perpendicular stream crossings.

Current Activities

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. Partnering to address these needs and conserve costs may be the most cost-effective and feasible strategy for many of these small, rural communities. Such partnerships also make easement acquisitions easier to execute. UNCWI provides a large-scale model of how to develop such a program, and one that is also needed for the High Rock Lake watershed. The presence of endangered species and potential recreation argues for partnerships with the NC Wildlife Resources Commission (NC WRC) and the US Fish and Wildlife Service (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. It allows communities to grow without degrading the natural assets that might be an attractive element of life in the Triad. These are resources that require minimal investment and support to provide for residents and visitors. Most local water quality benefits will almost certainly also benefit Jordan Lake and High Rock 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.

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
Dan River Basin Association
Blueridge Conservancy
LandTrust for Central NC
Piedmont Land Conservancy
NC WRC

Stress Category D - Low Concentration of Watershed Stressors

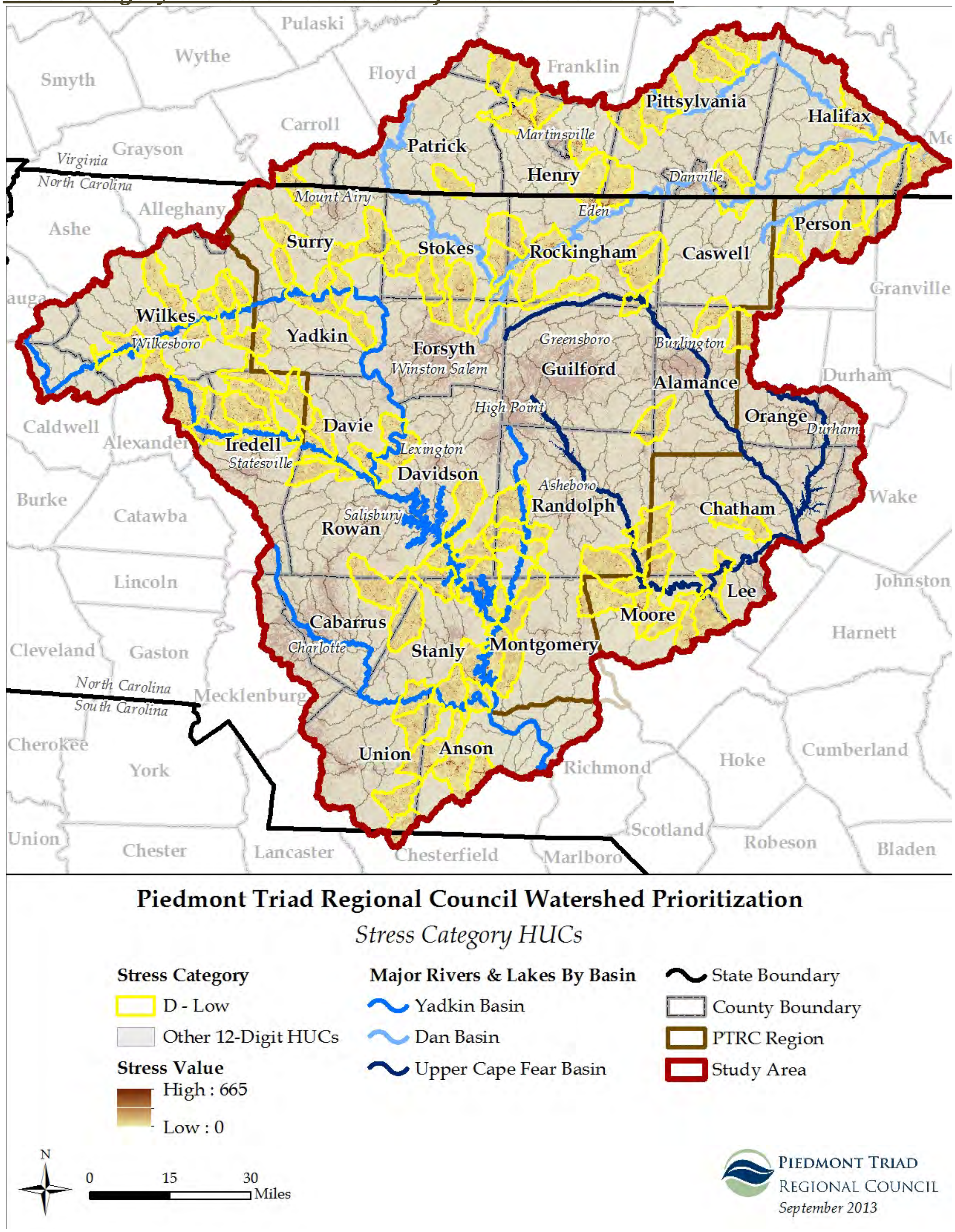


Figure 21: Stress Category D - Low Concentration of Watershed Stressors

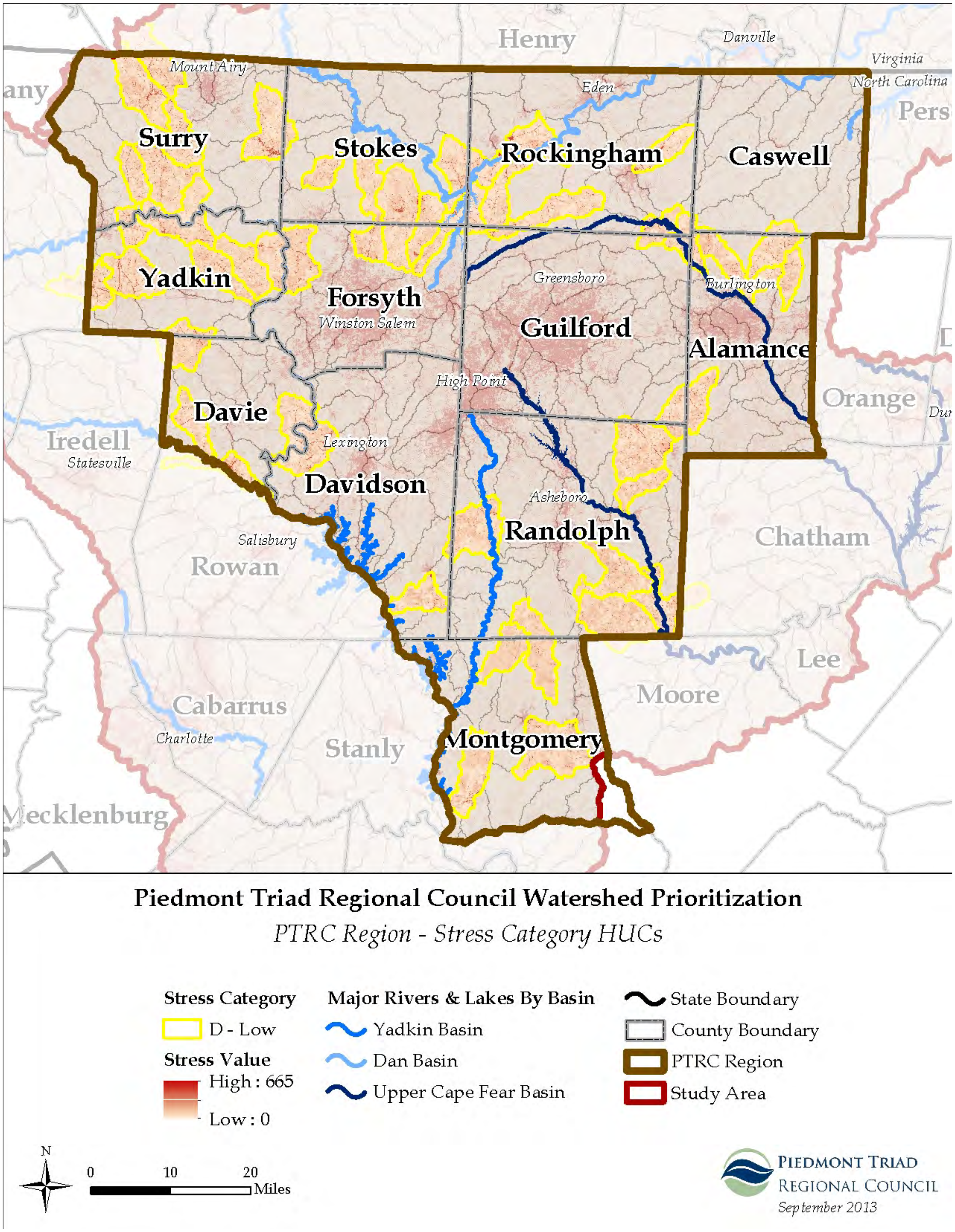


Figure 22: Stress Category D - Low Concentration of Watershed Stressors – Piedmont Triad region

Key Watershed Characteristics

- These watersheds receive little state or federal support
- Large areas of open space
- Largely agricultural watersheds
- Streams that drain to small cities (Wilkesboro, Eden)

Key Management Recommendations

- Support locally-driven open space and conservation programs
- Enhance state and federal funding for watershed restoration
- Use the WRC's Green Growth Toolbox to guide development

Overview

Category D watersheds are almost entirely located rural areas. Urban sprawl impacts are minimal, making these opportunities to support community development and growth that does not degrade the natural environment. Almost all of these watersheds are still used primarily for agriculture, but residential uses are equally important. Agriculture is predominant in these watersheds, and partnering with the federal and state agents working on the ground will be critical to securing long-term water quality health. Whether or not this is done sustainably with regard to water quality and other natural resources is a fate that will be determined by local and regional stakeholders.

History

There is a significant amount of agriculture in these counties, which is largely ethanol corn, tobacco, and non-dairy cattle farms. The mountainous landscapes of Wilkes County and the Deep River Subbasin focus on poultry operations. Many of these rural areas do not have regulations on new development beyond what is featured in nutrient management strategies or TMDLs, which don't affect most of these watersheds directly.

Current Activities

These watersheds contain roughly equal numbers and stream miles of impaired and healthy waters. 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. It is likely that many of the impaired waters in these watersheds could be rehabilitated with minor investments in a small number of BMPs. However, without a more intensive local watershed plan, there is no way of knowing how complex or simple the needed solutions may be. Similarly, the healthy waters may be on the verge of being lost due to one or two small but potent poor practices that degrade an entire water resource for many people and ecosystems. At the least, a more robust ambient water quality monitoring network would be able to answer some of these questions.

Many of the counties with these watersheds 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. The Dan River Basin has partnered with many of the counties in Virginia to create blueways on the river that support economic development through ecotourism. 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 been seen recently in both Chatham and Guilford Counties.

Next Steps & Partnerships

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 potentially high ecological value make them extremely vulnerable to development. Should an ecosystem services market for drinking water supplies be developed as it has in the Falls Lake watershed, protection of these lands and waters 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.

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.

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 have been a leader in removing dams on the Uwharrie River that have restored fish passage, paddle trails, and ecological health that river system. They are an ideal partner to address the impairment concerns in similar situations throughout the Piedmont, particularly as they relate to its dammed 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.

Those impaired streams within this group 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
Dan River Basin Association
Blueridge Conservancy
LandTrust for Central NC
Piedmont Land Conservancy
American Rivers
NC WRC

Stress Category E - Lowest Concentration of Watershed Stressors

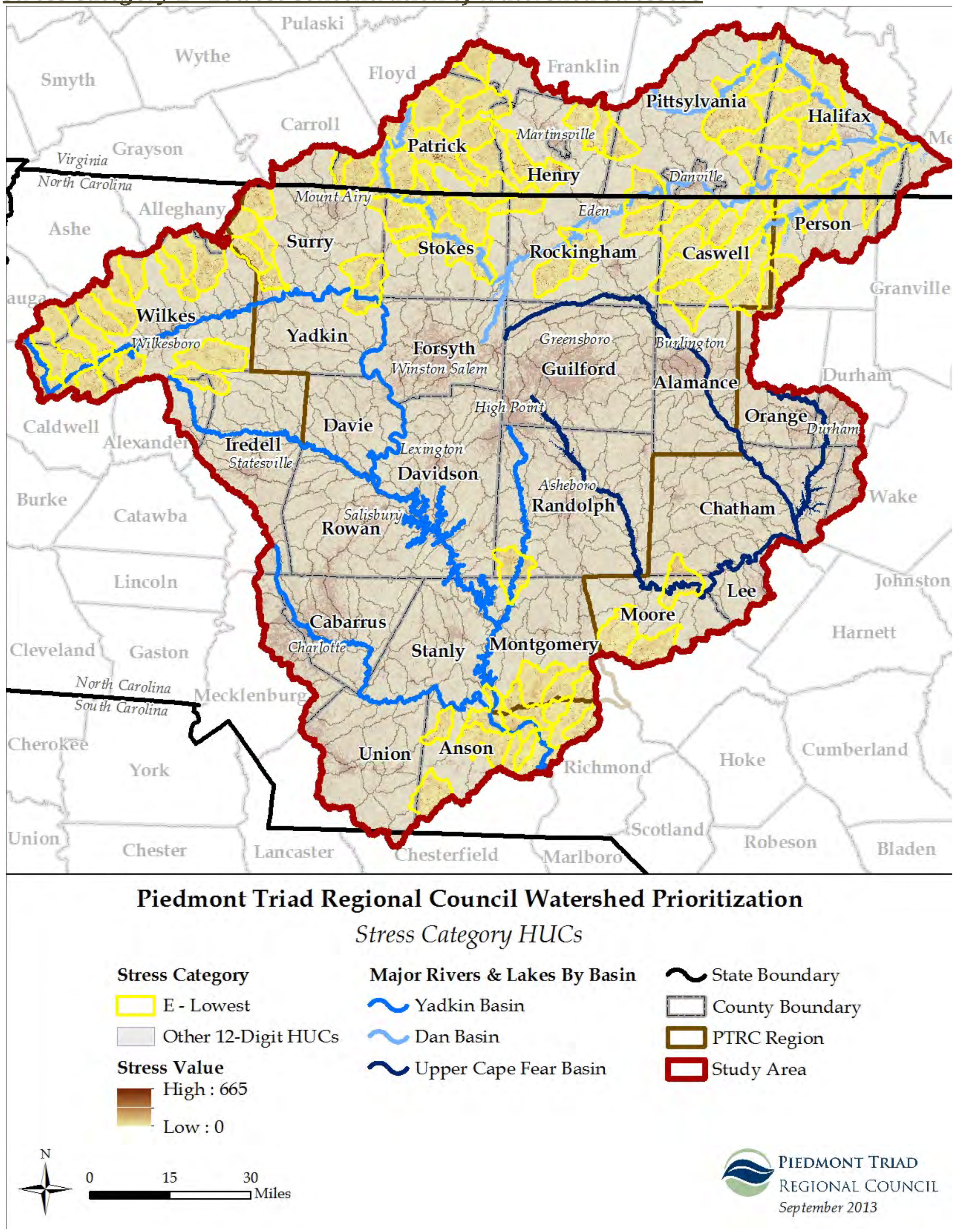


Figure 23: Stress Category E - Lowest Concentration of Watershed Stressors

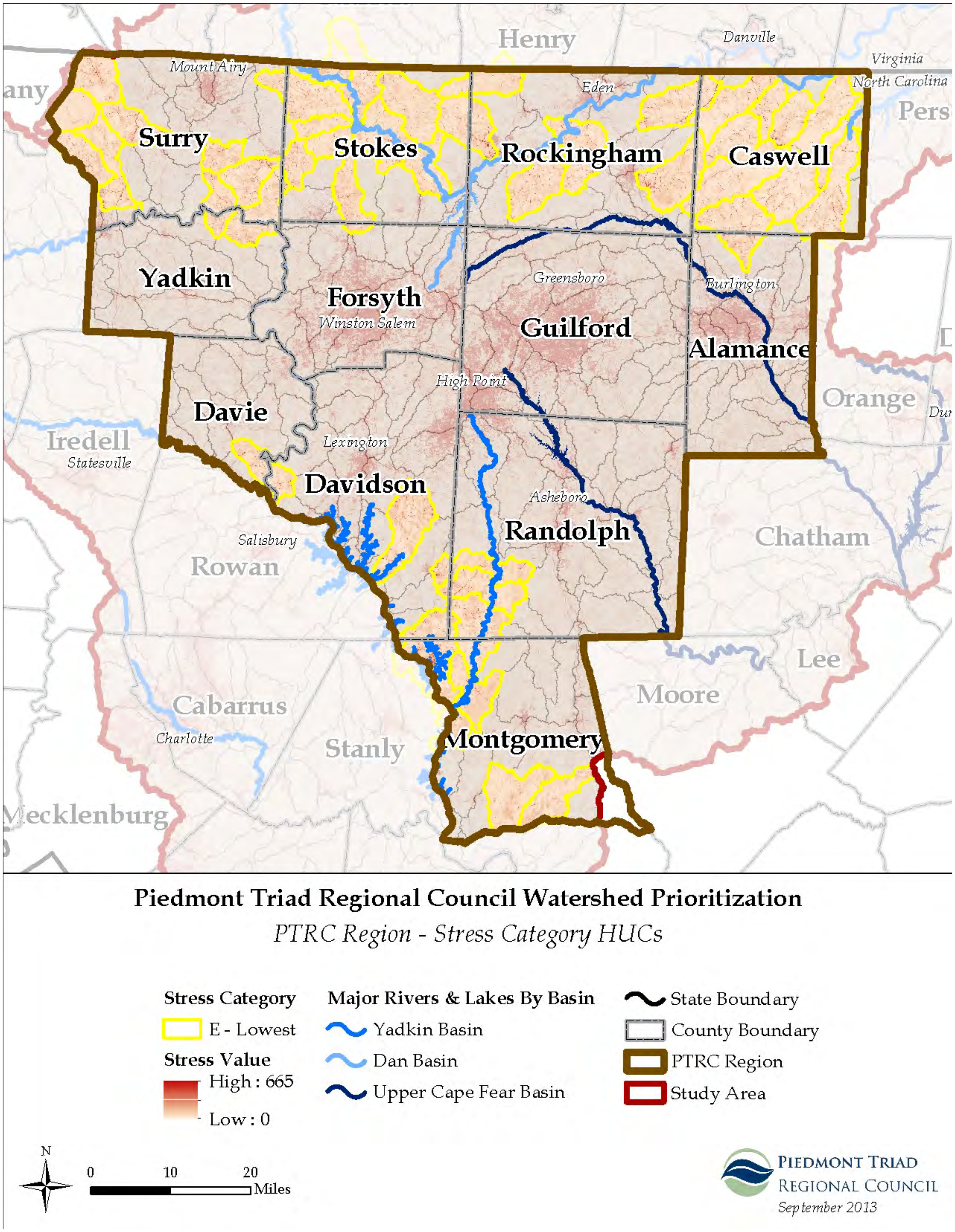


Figure 24: Stress Category E - Lowest Concentration of Watershed Stressors – Piedmont Triad region

Key Watershed Characteristics

- High concentration of Significant Natural Heritage Areas
- Very low levels of development
- Healthiest waters throughout the Upper Cape Fear River Basin
- Almost entirely rural
- Similar – but not the same – as the Conservation Model's Category A

Key Management Recommendations

- Pursue Healthy Watersheds Initiative funding for protection efforts
- Partnerships with NCWRC, USFWS, and land trusts to protect ecological habitat

Overview

Nearly all of the Category E watersheds do not reside in the Piedmont – they are in the Blue Ridge, Sauratown, Shenandoah, or Uwharrie Mountains. Even those in Stokes County are in the Sauratown Mountain range that features Hanging Rock and Pilot Mountain. These are more rural watersheds with less roads and industry, but they are also more forested, have high numbers of small headwater streams, and small populations that are not growing. They have a minimal impact on the sensitive areas they cover. What impacts exist in these watersheds are likely from forestry or agriculture.

The high density of watersheds in Caswell both reflects an extremely low-impact land use of low-density agricultural county as well as a failure of this model. Both models are only as good as their data, and Caswell County is missing a significant number of datasets, including soils and natural heritage data.

History

The land use history of most of the Piedmont is largely agricultural. Tobacco, ethanol corn, cattle and poultry farms continue to dominate this region, 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.

The Piedmont is 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. The conifer-covered mountains of the Blue Ridge escarpment mildly yield to the mixed hardwood forests of the Piedmont, which give way to the NC Sandhills region that intermingle with the clay soils and granite stone that define the unusual lRocky River. The richness and diversity of the biology of these watersheds and their ecosystems are unparalleled elsewhere in the Piedmont. Among the globally–endangered species present are the Cape Fear Shiner, the Schweinitz's sunflower, and the Carolina pigtoe. The lack of development in these watersheds is a root cause of this perseverance and vitality.

Current Activities

There are some impaired streams within this category of watersheds, but many of them are in Virginia, where they have highly protective *E. coli* standards that render many of their streams impaired. In the cases of impaired water quality conditions, 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 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.

Next Steps & Partnerships

The high ecological value and rural heritage of these 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 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.

The regional land trusts as well as the Conservation Trust for NC, American Rivers, and The Nature Conservancy are available to protect these watersheds, especially those that are also highly valuable conservation watersheds and/or home to rare species. The USEPA's underfunded 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 NCDWR should be immediately prioritized by the NCDWR, the non-profit sector, all county SWCDs, and local and regional governments for funding, planning, and restoration due to the high likelihood of their speedy recovery.

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
Dan River Basin Association
Blueridge Conservancy
LandTrust for Central NC
Piedmont Land Conservancy
The Nature Conservancy

Conservation HUC Groupings

As noted in the Project Overview section, environmental, economic, and recreational data in North Carolina and Virginia were 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 2 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. Based on this table, 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. 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.

Watersheds were broken down into five categories that reflect their general shared trends in land use and history. Table 5 shows the details of these five categories and the number of watersheds they feature. The categories are briefly described on the following pages.

Table 7

PIEDMONT MEGAREGIONAL CONSERVATION MODEL WATERSHED CATEGORIES		
Category	Number of Watersheds	Proportion of Total Watersheds
Highest Concentration of Watershed Assets	43	10%
High Concentration of Watershed Assets	64	15%
Moderate Concentration of Watershed Assets	107	25%
Low Concentration of Watershed Assets	107	25%
Lowest Concentration of Watershed Assets	107	25%

Table 8

PIEDMONT TRIAD REGIONAL CONSERVATION MODEL WATERSHED CATEGORIES		
Category	Number of Watersheds	Proportion of Total Watersheds
Highest Concentration of Watershed Stressors	17	10%
High Concentration of Watershed Stressors	26	15%
Moderate Concentration of Watershed Stressors	43	25%
Low Concentration of Watershed Stressors	43	25%
Lowest Concentration of Watershed Stressors	43	25%

Conservation Category A - Highest Concentration of Watershed Assets

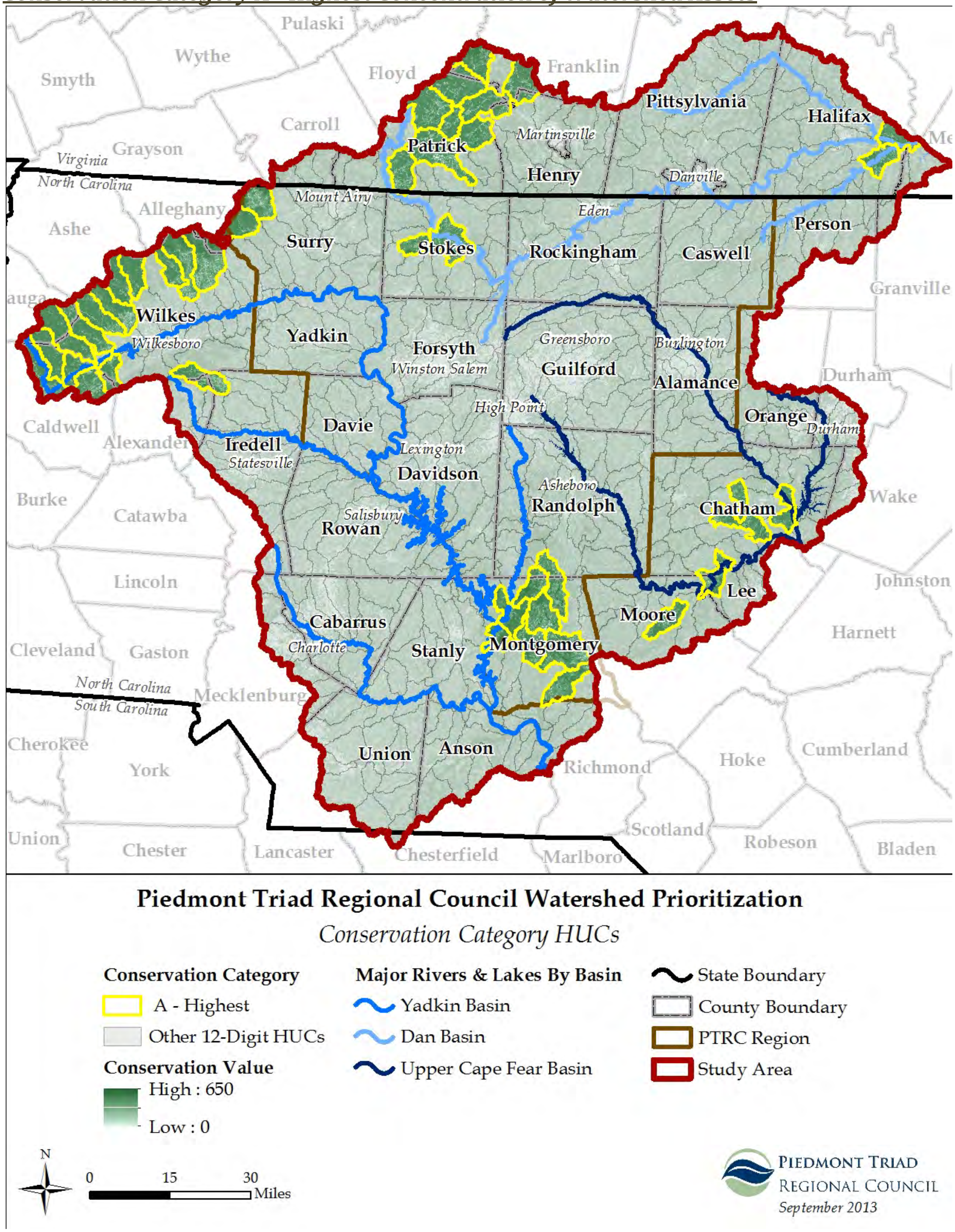


Figure 25: Conservation Category A - Highest Concentration of Watershed Assets

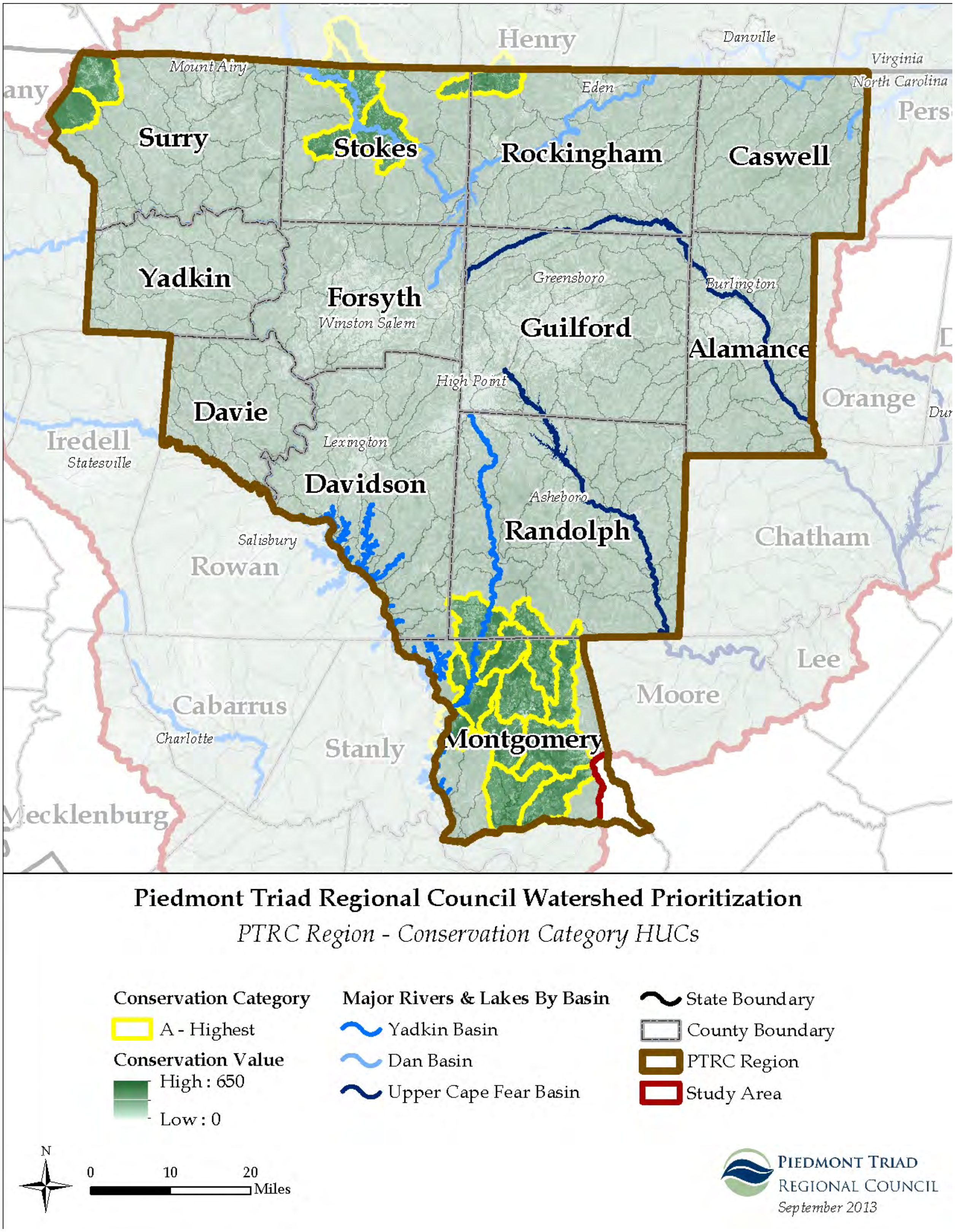


Figure 26: Conservation Category A - Highest Concentration of Watershed Assets – Piedmont Triad region

Key Watershed Characteristics

- Predominantly rural
- Large areas of unmanaged lands
- Large areas of game lands
- USACE lands on Jordan & Philpott dams
- High density of globally- and state-significant natural element occurrences
- Captures 30% of all trout waters

Key Management Recommendations

- Work with existing conservation groups
- Create contiguous cover for conservation areas
- Engage local landowners
- Develop local watershed plans
- Focus on preservation
- Enhance and build ecotourism economy in these watersheds

Overview

The watersheds characterized by Category A are almost entirely located within the rural areas of the Piedmont, with the majority of them being found in the Blue Ridge, Sauratown, Shenandoah, and Uwharrie Mountain ranges, though there are high-value watersheds on lands surrounding Jordan Lake and Philpott Reservoir. Most of these watersheds lie within state parks or federally-owned lands, making their management simpler, should the responsible agencies wish to take steps to better protect these assets. These are predominantly rural areas with a strong agricultural presence and have large areas of unmanaged lands and game lands.

Watersheds in this category are characterized by high Biodiversity/Wildlife Habitat Assessment values in both North Carolina and Virginia, low impervious cover, and high canopy cover. Table 4 provides a description of the criteria considered in developing the Biodiversity/Wildlife Habitat Assessment value. These watersheds also capture about 30% of all trout waters in both states, a strong support for local tourism-driven economies. These watersheds are generally very healthy: within this category, representing 10% of all watersheds in the study area, about 25% of all waters with a "Good" or "Excellent" bioclassification rating are captured. Furthermore, only seven listed impaired streams are found in these forty-three watersheds.

History

The land use history of most of the Piedmont is largely agricultural. Tobacco, ethanol corn, cattle and poultry farms continue to dominate this region, 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.

The Piedmont is 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. The conifer-covered mountains of the Blue Ridge escarpment mildly yield to the mixed hardwood forests of the Piedmont, which give way to the NC Sandhills region that intermingle with the clay soils and granite stone that define the unusual Rocky River in Chatham County. The richness and diversity of the biology of these watersheds and their ecosystems are unparalleled elsewhere in the Piedmont. Among the globally–endangered species present are the Cape Fear Shiner, the Schweinitz's sunflower, and the Carolina pigtoe. The lack of development in these watersheds is a root cause of this perseverance and vitality.

The areas surrounding both Jordan and Philpott Reservoirs in North Carolina and Virginia, respectively, are mostly owned and managed by the US Army Corps of Engineers. These reservoirs were built for flood control to ensure the safety of residents living downstream of these large river systems. They now provide additional values as recreational and drinking water resources. While most of the lands are dedicated to recreation and not developed, some forestry and agricultural practices do occur in these watersheds that – if done improperly – can degrade water quality conditions. The US ACE has a decent track record with managing these lands and working with other partners on occasion – it would be a relief if the long-term management of these reservoirs for ecological, recreational, and drinking water supply uses was codified in writing.

Current Activities

Many Significant Natural Heritage Areas are located within Category A. Additionally, 30% of the designated trout waters in this region are found within this category of watersheds. Both the Heritage Areas and trout streams have the potential to generate revenues for local communities that can support an ecotourism economy. Trout streams are protected by mandated stream buffers that shade and cool these waters. However, many of the other ecological areas have no permanent protections unless they lie within a state park or private easement. Even then, the impacts upon the natural environment can vary depending upon the managing agency's individual policy.

The Virginia Department of Conservation and Recreation (VADCR) has conducted *E. coli* TMDLs on many of the tributaries of the Dan River, including several found in these watersheds. Their water quality standard is highly protective, rendering most of the streams impaired for high *E. coli* levels. However, unlike North Carolina Virginia is required to draft and execute TMDL implementation plans that reduce pollutant loads to these waters. The actions being taken in this regard in the Dan River Basin are encouraging for the long-term health and function of these watersheds.

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.

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 Piedmont 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 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. The Dan River Basin Association has worked closely with many of the communities in that river basin to utilize the rivers as fishing and paddling resources that generate millions of dollars of annual revenue. All land trusts in the Piedmont 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 underfunded Healthy Watersheds Initiative should be prioritizing the work discussed here to maintain these exemplary rural watersheds in their current states.

The regional land trusts as well as the Conservation Trust for NC, American Rivers, and The Nature Conservancy are available to protect these watersheds, especially those that are also highly valuable conservation watersheds and/or home to rare species. The USEPA's underfunded 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 NCDWR should be immediately prioritized by the NCDWR, the non-profit sector, all county SWCDs, and local and regional governments for funding, planning, and restoration due to the high likelihood of their speedy recovery.

Key Stakeholders and Resources
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 Forest Service
NC Division of Water Resources
NC Ecosystem Enhancement Program
NC Natural Heritage Program
NC Sandhills Conservation Partnership
NC Wildlife Resources Commission
Sandhills Area Land Trust
Soil and Water Conservation Districts
Triangle Land Conservancy
US Army Corps of Engineers
US Fish and Wildlife Service
Dan River Basin Association
Blueridge Conservancy
LandTrust for Central NC
Piedmont Land Conservancy
The Nature Conservancy

Conservation Category B - High Concentration of Watershed Assets

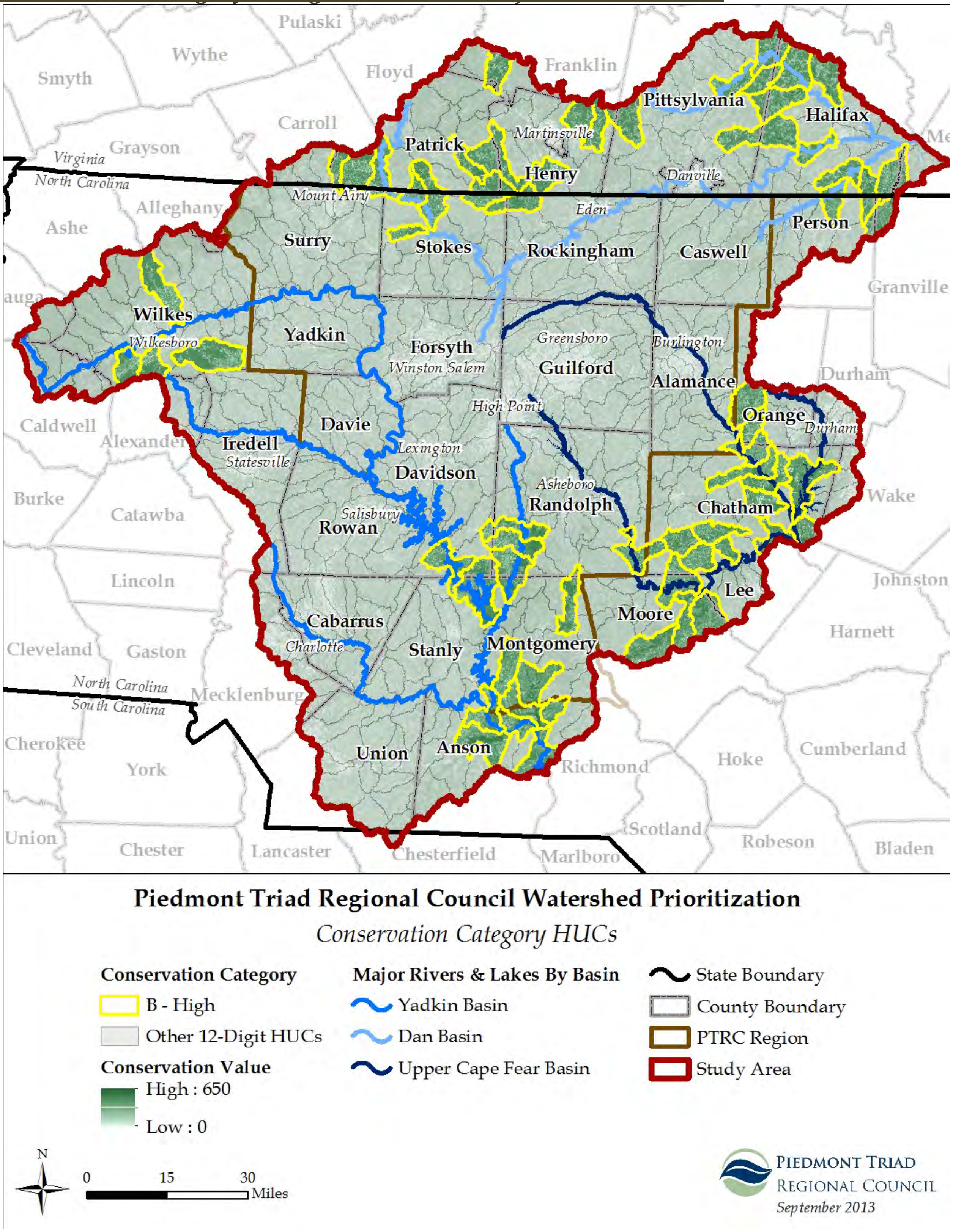


Figure 27: Conservation Category B - High Concentration of Watershed Assets

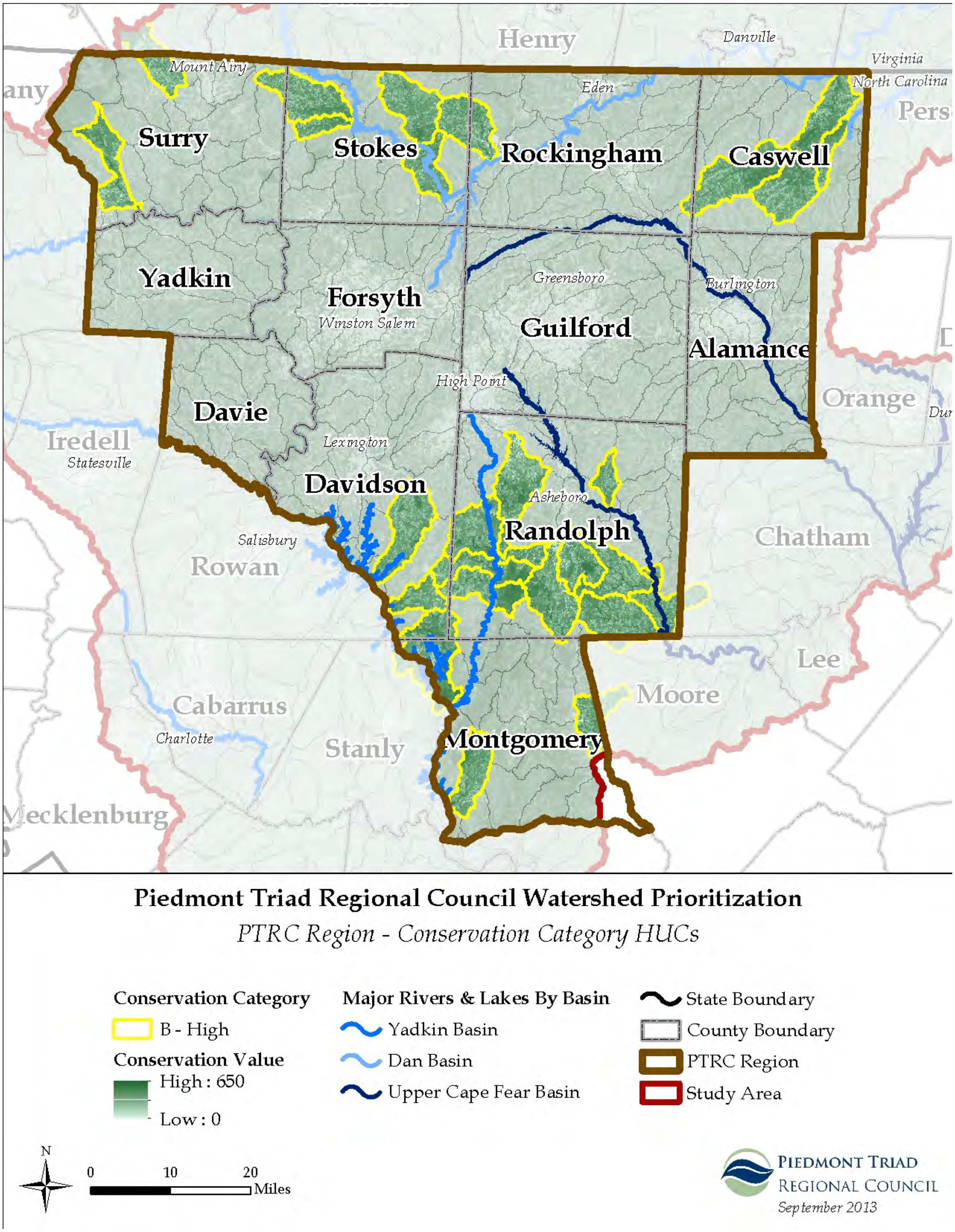


Figure 28: Conservation Category B - High Concentration of Watershed Assets – Piedmont Triad region

Key Watershed Characteristics

- Predominantly rural
- Large areas of unmanaged lands
- Large areas of game lands
- Some impaired stream miles
- Impaired impoundments
- High density of globally- and state-significant natural element occurrences

Key Management Recommendations

- Work with existing conservation groups
- Contiguous cover for conservation areas
- Engage local landowners
- Develop local watershed plans
- Focus on preservation
- Enhance and build ecotourism economy
- Use the WRC's Green Growth Toolbox to guide development

Overview

This group of watersheds is almost entirely located in rural areas of all Piedmont Triad river basins, and features most of the Piedmont's recreational reservoirs. For the most part, these watersheds are characterized by large rural and agricultural tracts, with hilly landscapes and a high density of ecological assets and forest cover. There may be some development, but much of it will be oriented towards summer and retirement homes. While residential and commercial land uses may start having a significant influence on these landscapes in the future, the distance of these watersheds from most urban centers indicates that this will not happen soon. Within this conservation group, we begin to see impaired stream miles, but they are proportional to the number of watersheds within this category (about 15% of the total).

History

Agriculture is an historic and current economic engine in the Piedmont Triad. There is a significant amount of agriculture in these watersheds, which is largely livestock-driven, primarily poultry and cattle farms. Many of these rural areas do not have regulations on new development beyond what is featured in the Jordan Lake Rules or VADCR's *E. coli* TMDLs. However, such regulations give little guidance to local government in regard to preventative measures they can take to protect healthy waters. This is especially relevant in counties with little to no zoning ordinances, like Wilkes and Montgomery. Without proactive policies, there is a danger that development can degrade the rural heritage of these watersheds, impacting local water quality and preventing capitalization of potential local economic resources.

Current Activities

Many sensitive and valuable ecological habitats are located within these watersheds, as are many recreational resources like Jordan Lake, the Uwharrie Mountains, and Wilkes County's trout streams. Much of this land is owned and managed by federal entities like the USACE and the USFS. However, these larger lakes are impaired for high algal growth and the watersheds that drain to them need to address specific issues such as reducing pollution from wastewater discharges, stormwater runoff from new and existing development, and agriculture and fertilizer application. Any efforts in this category's watersheds should focus on preventing impacts to water quality. Similarly, existing recreational resources like the hiking and equestrian trails of the Uwharrie Mountains and trout streams.

The non-profit community has taken leadership in several of these watersheds to protect and improve the water quality conditions for local communities. The Dan River Basin Association has worked closely with many of the communities in that river basin to utilize the rivers as fishing and paddling resources that generate millions of dollars of annual revenue. American Rivers has worked with individual landowners on the Uwharrie River to remove several older small mill dams and restore fish passage, potential paddle trails, and healthy water quality conditions to that rural river system.

Many of these counties have invested local resources and funds to address the absence of larger funding sources. Orange County has invested heavily in natural resources protection and instituting sustainable development practices through official codes and ordinances. Chatham County has invested in a Conservation Plan that identifies all vulnerable habitats in the County, and outlines sustainable practices to protect them. 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. All land trusts in the Piedmont are available to protect lands in these watersheds, especially those that are also highly valuable conservation watersheds and/or home to rare species.

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 for these lakes – especially the drinking water supplies – protection of these watersheds will be cost-effective, eliminating the need for more expensive watershed and drinking water resource restoration.

The regional land trusts as well as the Conservation Trust for NC, American Rivers, and The Nature Conservancy are available to protect these watersheds, especially those that are also highly valuable conservation watersheds and/or home to rare species. The USEPA's underfunded 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 NCDWR should be immediately prioritized by the NCDWR, the non-profit sector, all county SWCDs, and local and regional governments for funding, planning, and restoration due to the high likelihood of their speedy recovery.

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.

The USEPA's underfunded Healthy Watersheds Initiative should be prioritizing the work discussed here to maintain these exemplary rural watersheds in their current states. 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
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 Forest Service
NC Division of Water Resources
NC Ecosystem Enhancement Program
NC Natural Heritage 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
Dan River Basin Association
Blueridge Conservancy
LandTrust for Central NC
Piedmont Land Conservancy
The Nature Conservancy

Conservation Category C - Moderate Concentration of Watershed Assets

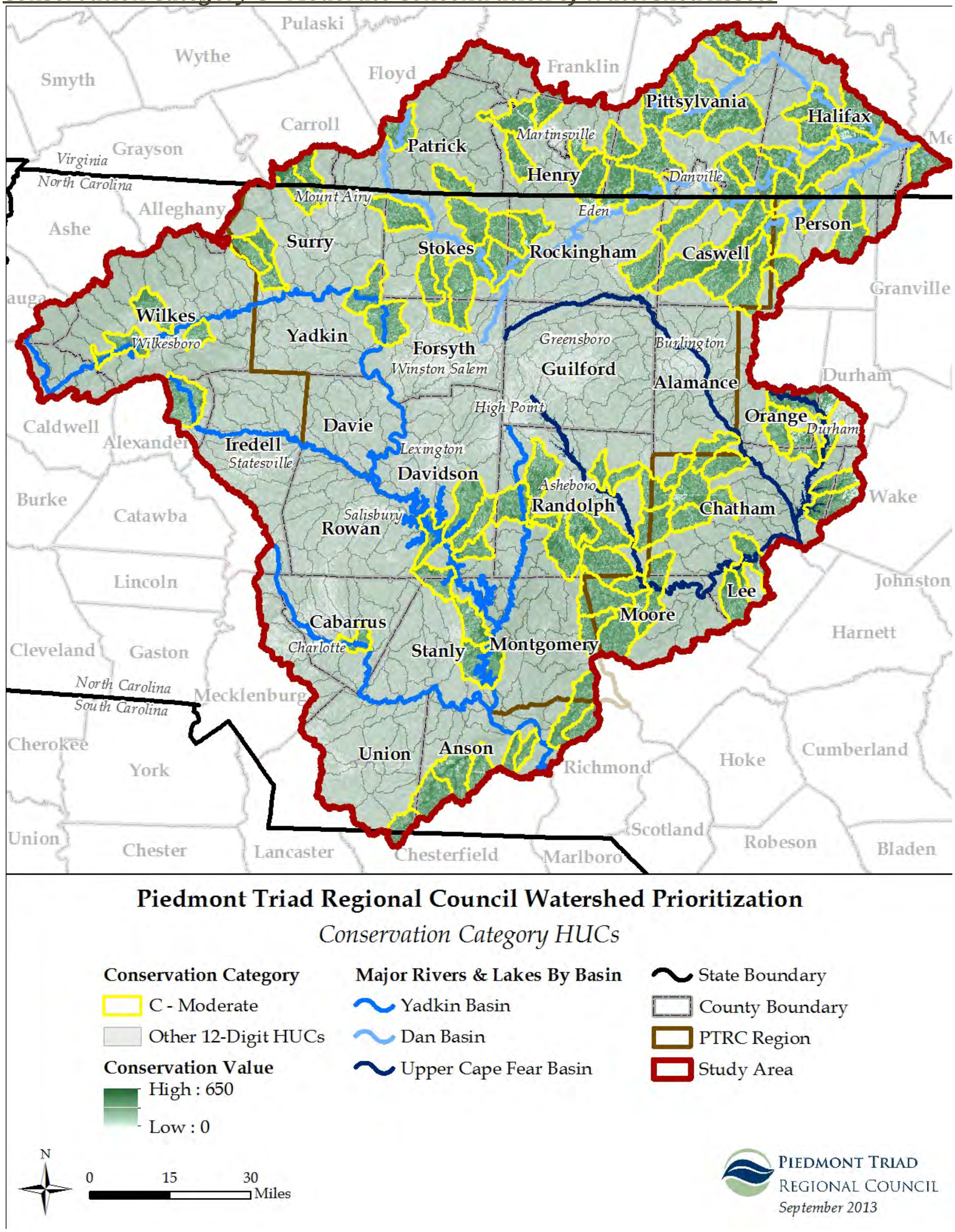


Figure 29: Conservation Category C - Moderate Concentration of Watershed Assets

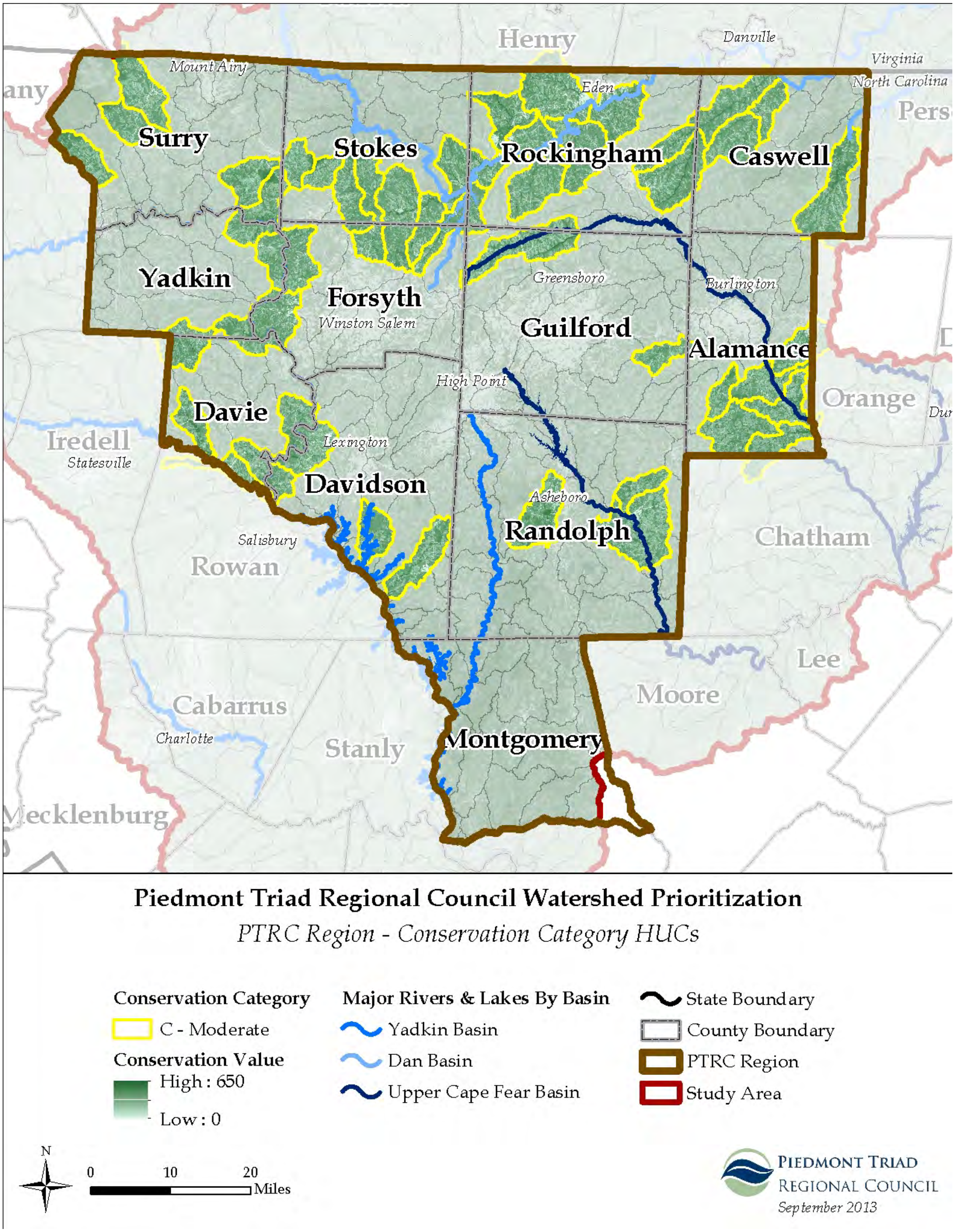


Figure 30: Conservation Category C - Moderate Concentration of Watershed Assets – Piedmont Triad region

Key Watershed Characteristics

- Mix of small towns, rural, & agriculture
- More impaired stream miles
- High density of globally- and state-significant natural element occurrences

Key Management Recommendations

- Engage local municipalities
- Engage local watershed groups
- Build off of existing efforts of conservation groups
- Public education campaigns
- Develop/implement local watershed plans
- Use the WRC's Green Growth Toolbox to guide development

Overview

Category C watersheds are representative of the Piedmont Triad's suburban and small urban land uses, though some very rural areas are also included. They can also be agricultural areas in dangers of transitioning to residential and suburban development. These are areas with substantial populations that are fast-growing, often due to the economic centers of the Triad and the Triangle.

History

For the most part, these watersheds lie outside the suburban belts that surround the Triad, Triangle, Charlotte, and Interstate-40/85 corridors. The watersheds in Category C have had a predominantly rural agricultural history, relying upon row crops such as corn and tobacco, along with livestock cattle. Some 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 water, such as in northern Forsyth County or Henry County, VA. It is this level of development, population growth, and lack of forest cover that prevents these watersheds to be more valuable in the Conservation Model. These are some of the more rural areas in the Piedmont, but they have few ecological assets, and, therefore, are a lot less appealing to federal, state, or non-profit agency investments. Consequently, sensitive watersheds are being degraded and minimally-impaired waters are not being recovered, both patterns that will only be exacerbated with time.

These watersheds offer an opportunity to grow while minimizing environmental costs. Very few developments in the Piedmont 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. These lessons could be directly transferred to suburban communities associated with impaired streams elsewhere in this group. The *Piedmont Nutrient Reduction Sourcebook* provides local governments with guidance on how to grow using such strategies and practices.

Current Activities

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.

The value of taking such steps is potentially enormous. As Virginia has seen with the growth of their blueway network on the Dan River, ecotourism offers an immediate economy for recovering mill towns. However, developing such an economy requires investments in the protection and restoration of these natural resources. It also takes small investments in developing an infrastructure and marketing to attract tourists to these assets. In all cases, though, the returns have been shown to outweigh these immediate costs.

Next Steps & Partnerships

If communities are dedicated to addressing local water quality concerns, they will need to invest in BMPs that will directly reduce loadings to receiving streams from both stormwater and agricultural runoff. As such, these mildly-impacted watershed offer an ideal collaboration opportunity for local governments and the Water Quality Group at NC State University. 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.

Local watershed planning will be necessary to identify impacts, stressors and sources, and implement restoration projects to remediate stressors and improve function. 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.

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.

Key Stakeholders and Resources
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 Resources
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
Dan River Basin Association
Blueridge Conservancy
LandTrust for Central NC
Piedmont Land Conservancy
The Nature Conservancy

Conservation Category D - Low Concentration of Watershed Assets

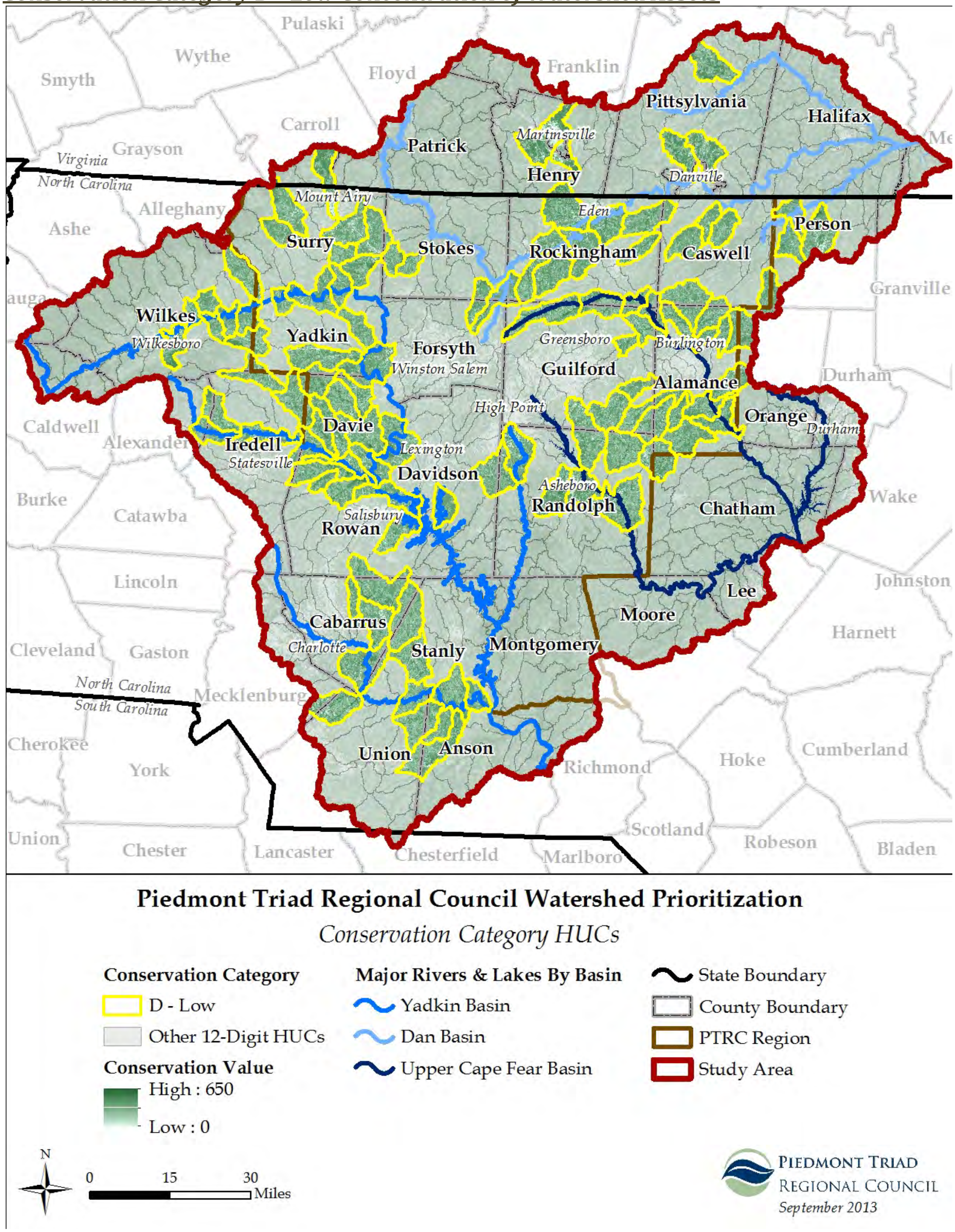


Figure 31: Conservation Category D - Low Concentration of Watershed Assets

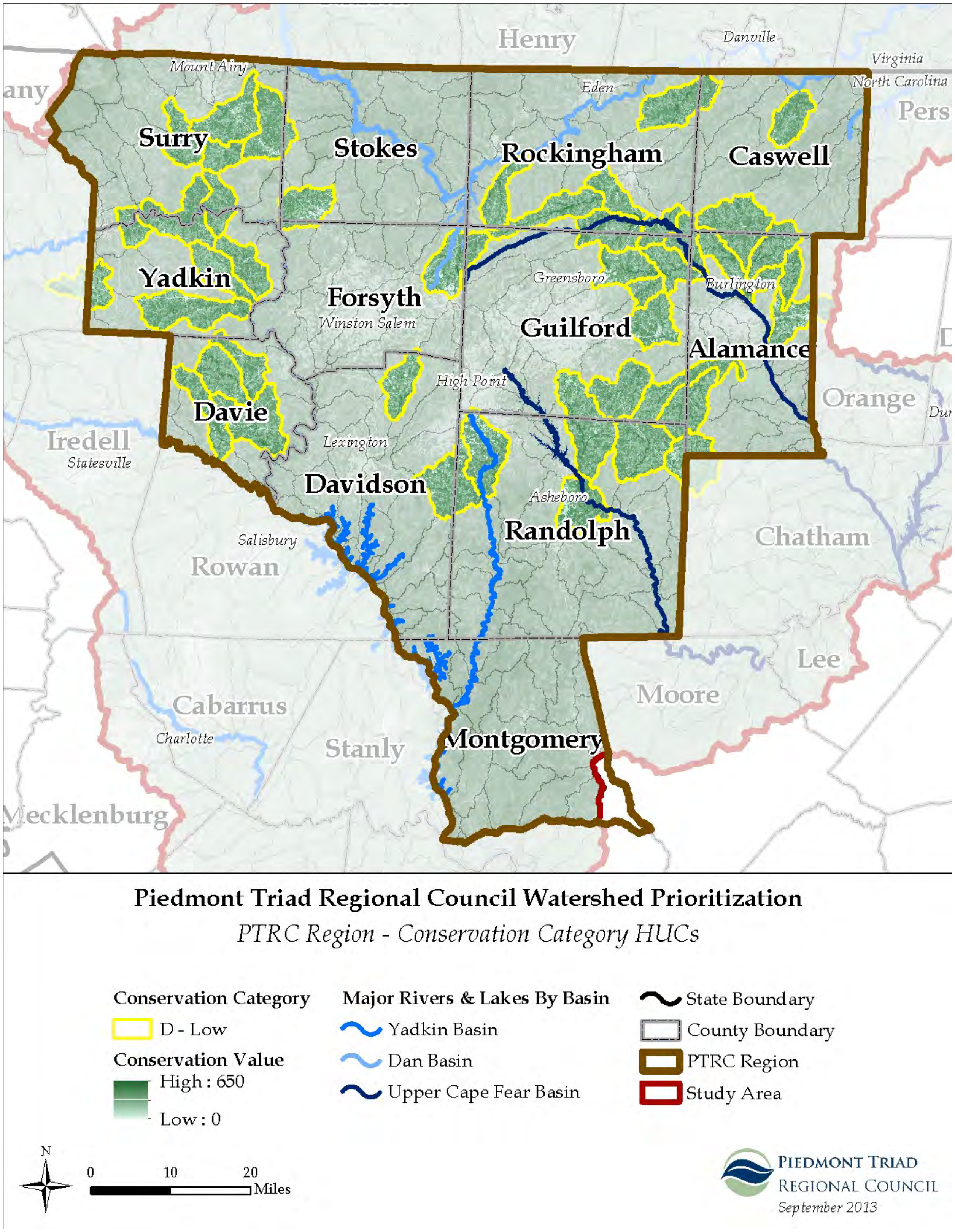


Figure 32: Conservation Category D - Low Concentration of Watershed Assets – Piedmont Triad region

Key Watershed Characteristics

- Predominantly suburban
- Large areas of unmanaged lands
- Large areas of agricultural lands
- Few state and federal conservation investments
- Crossed by transit corridors
- Increases in impervious surfaces

Key Management Recommendations

- Invest in watersheds with impaired waters
- Work with existing local conservation efforts
- Focus on protection in watersheds with healthy water quality
- Develop local water quality monitoring
- Develop local watershed plans
- Use the WRC's Green Growth Toolbox to guide development
- Focus on improving WSW watershed quality

Overview

Category D watersheds are predominantly clustered at the suburban fringe surrounding the Piedmont urban centers. While a few municipalities are included in this group, most are excluded due to their high concentration of impervious surfaces. However, many of those who commute to these economic centers reside in this category of watersheds. Unfortunately, the consequences of this development are apparent: about 30% of all impaired streams are found in or downstream of these watersheds.

These communities 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 Piedmont Triad 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, but utilizing such an approach proactively could yield more exciting (and less onerous) results.

History

Most of these watersheds have been developed for single-family residences and dispersed commercial centers. 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. These smaller cities in these watersheds have different origins, with some being old mill towns that are transitioning to a different purpose with the loss of industry, or established small towns that serve specific, local economic purposes.

Current Activities

Many of these communities have additional obligations to protect water quality through total maximum daily load (TMDLs) assessments and/or state legislation such as the Jordan Lake Rules. TMDLs are specified in the US Clean Water Act as a recovery strategy for impaired waters in which the pollutant(s) determined to be the cause(s) of impairment is put on a diet should be sufficient to recover healthy water quality conditions. States may develop alternatives like the Jordan Lake Rules to TMDLs that capture pollution sources other than stormwater and wastewater. Of note are the high number of watersheds that drain to High Rock Lake, currently the subject of a special study by NCDWR to reduce its nutrient levels, similar to the study that directly informed the Jordan Lake Rules.

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.

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. The Granville County Stormwater Authority has demonstrated a good model for multiple communities to invest in a single program that can satisfy such regulatory needs. 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.

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. 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. All land trusts in the Piedmont are available to protect lands in these watersheds, especially those that are also highly valuable conservation watersheds and/or home to rare species.

Next Steps & Partnerships

Maintaining healthy water quality conditions in these communities and implementing good planning and development practices should prevent degradation of water quality. Communities may want to begin discussing the creation of a stormwater utility, especially in those watersheds that are governed by a nutrient management strategy or a TMDL. 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.

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
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 Resources
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
Dan River Basin Association
Blueridge Conservancy
LandTrust for Central NC
Piedmont Land Conservancy
The Nature Conservancy

Conservation Category E - Lowest Concentration of Watershed

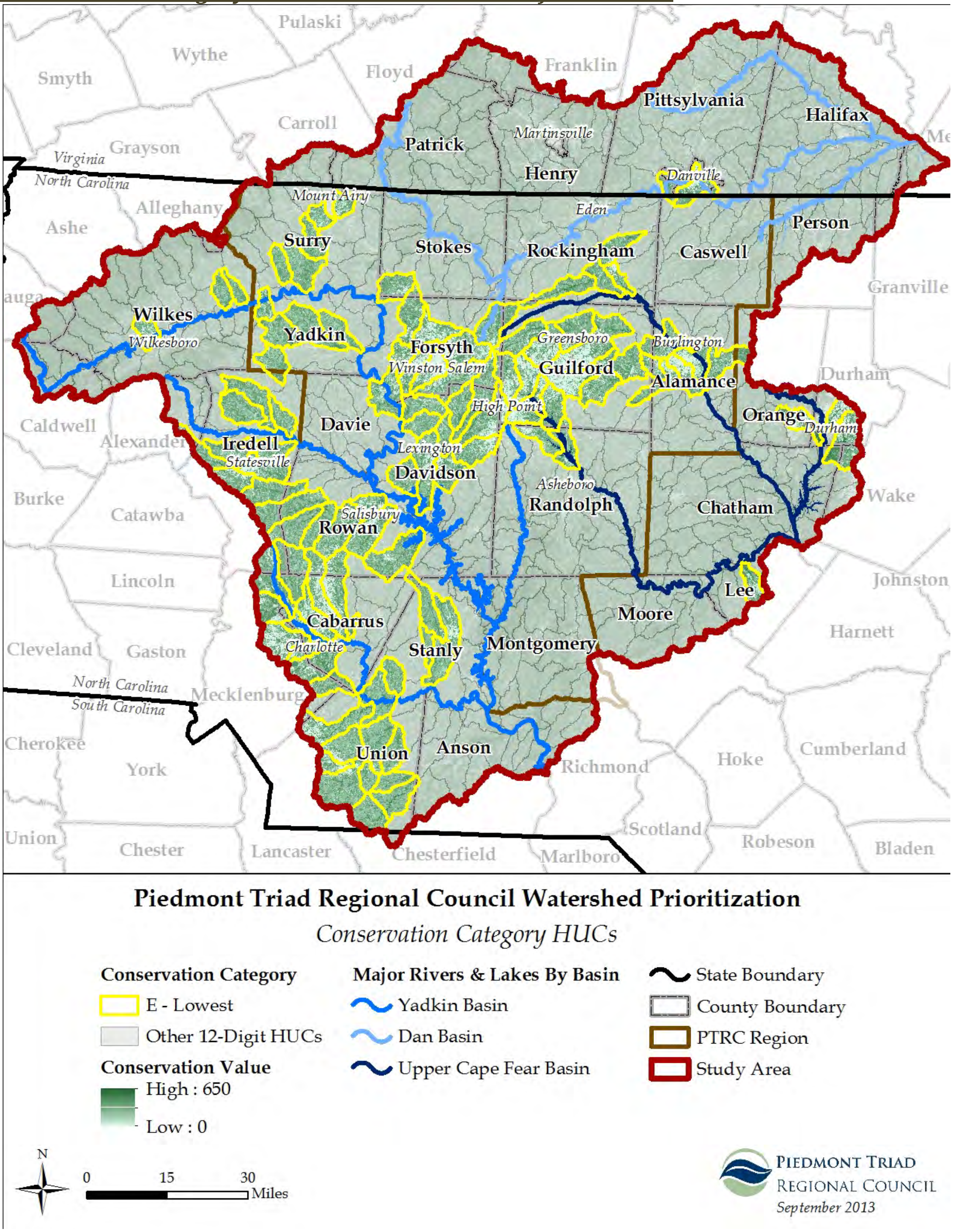


Figure 33: Conservation Category E - Lowest Concentration of Watershed

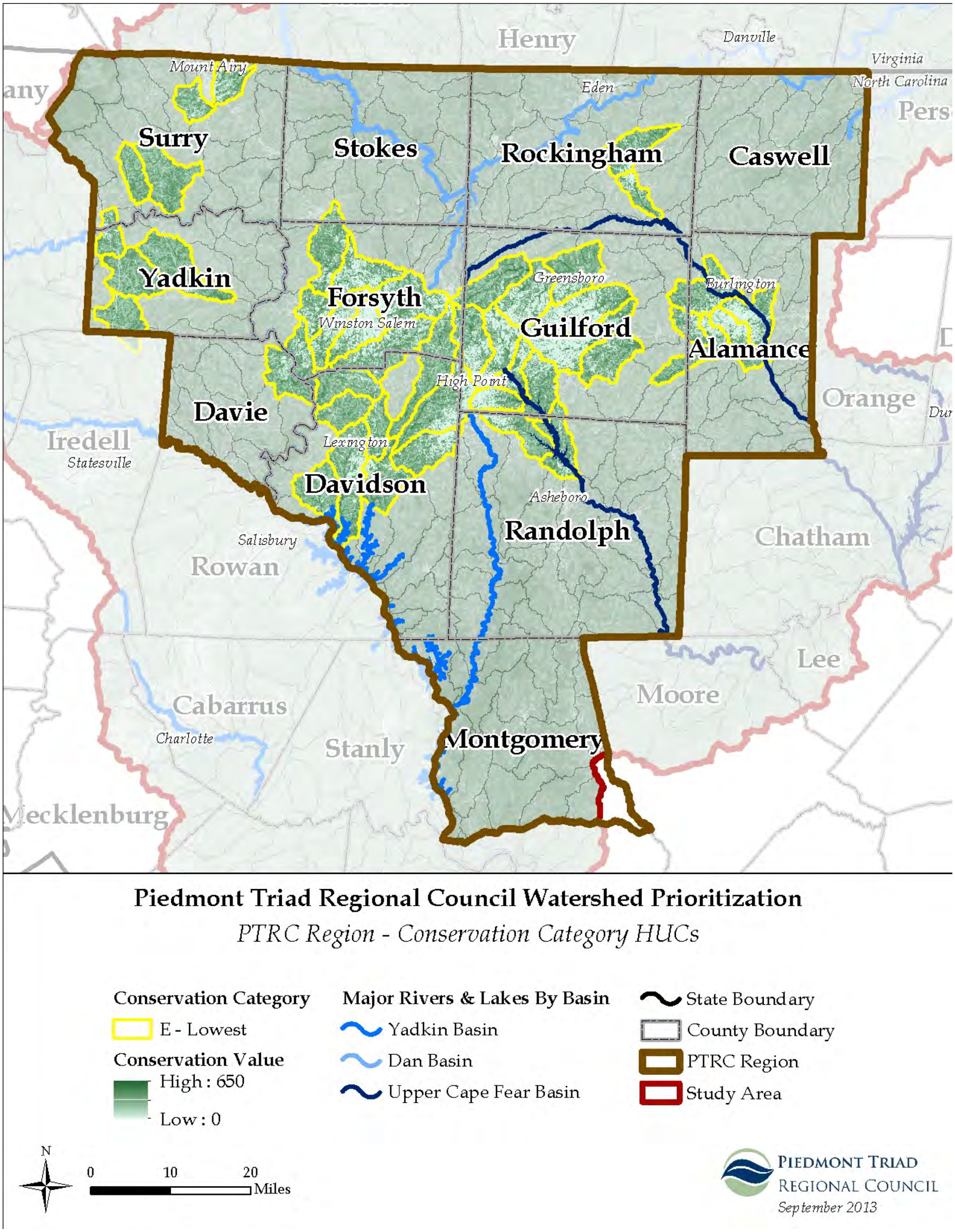


Figure 34: Conservation Category E - Lowest Concentration of Watershed Assets – Piedmont Triad region

Key Watershed Characteristics

- Predominantly developed lands
- High density of impaired waters
- Mostly urban centers and transit hubs
- NPDES Phase I & II communities
- High levels of impervious cover

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
- Develop local water quality monitoring
- Utilize available funding effectively (i.e. UNCWI)

Overview

In general, these watersheds are in highly-developed areas of the Piedmont where development has degraded water quality in ways that will be very expensive to remediate. Management efforts should focus on improving water quality and minimizing impacts. These watersheds are predominantly in the Yadkin River Basin, but all of the major urban areas of the Haw and Deep River Subbasins are also prominently featured in this category. There are only two watersheds from the Dan River Basin included in this category, and they are both in Danville, VA, that watershed's largest city. Watersheds in this category are generally characterized at having low Biodiversity/Wildlife Habitat Assessment values, high impervious cover, and low canopy cover. Many – but not all – of these watersheds had relatively low percentages of agricultural lands About 45% of all impaired streams are found within this category.

History

Category E watersheds are located in the major urbanized centers of the Piedmont, especially along the I-85, I-40 and I-77 corridors, but also include areas in more rural Iredell, Rowan, Surry, and Yadkin Counties. The history of these areas includes textile manufacturing and furniture, and they currently 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.

The more rural areas are currently experiencing high levels of economic pressure to convert lands for residential developments after centuries of agriculture use. Both culturally and environmentally, there are incentives to preserve these historic land uses, provided they employ BMPs on the farms.

Current Activities

As federally-regulated communities under the US EPA's NPDES program, most of these watersheds have programs for 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.

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. The purpose of this tool is to ensure that stormwater utilities are employing fees that can adequately support a program that satisfies state and federal mandates. It also can provide guidance on how to invest funds for future capital improvements and program enhancements that may all benefit water quality conditions.

Next Steps & Partnerships

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. The *Piedmont Nutrient Reduction Sourcebook* provides good reference material on existing partnerships and efforts, and provides good references for how other NC communities are addressing water quality. Randleman Lake communities are subject to additional buffer rules. 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.

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.

An ecosystem services market similar to that seen in UNCWI in the Falls Lake watershed that supplies Raleigh, NC, with drinking water, would be appropriate and valuable within this watershed. Such a market can offset historic development impacts by allowing cities to invest in rural landscapes that treat and absorb water, cleaning it before it reaches drinking water and recreational water supplies. It rewards those landowners who are stewards of watershed health and function through direct investments by those who rely upon that stewardship.

Key Stakeholders and Resources
American Rivers
Center for Watershed Protection
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 Resources
NC Ecosystem Enhancement Program
NC Nonpoint Source 319 Grant Program
NC Wildlife Resources Commission
NCSU BAE/Water Quality Group
Soil and Water Conservation Districts
Triangle Greenways Council
Triangle Land Conservancy
UNC Environmental Finance Center
US Army Corps of Engineers
US Fish and Wildlife Service

Discussion

These analysis models are 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. They 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*.

Thus far, the models have been validated only at the entire megaregional scale. There was not enough time or resources to assess them at finer scales, although cursory assessments indicate that their relevance is consistent throughout the region and in all three river basins. When assessing the Category A watersheds for Stress, the data are convincing that this model reflects the highest needs for watershed restoration planning and actions (Figure 23, Table 6). Within just 10% of all of the Piedmont watersheds are 17% of all impaired streams representing 13.5% of all impaired stream miles. 3.5% of all impaired streams representing 30.5% of all stream miles in the Piedmont intersect this category of watersheds. If VADEQ used a less stringent fecal coliform bacteria proxy (fecal coliform concentrations vs. *E. coli*) and standard, then this ratio would be much higher, as many of VADEQ's impairments are rural. Conversely, this same category of watersheds shows no relationship with healthy water quality conditions, capturing less than 5% of any metric used ("Good" and "Excellent" bioclassification, Outstanding Resource Waters, Trout Waters).

There are some weaknesses in the model, especially in rural, sparsely-populated areas. However, this weakness, especially in the conservation model, may be due as much to the validation data as it is to the model used. In North Carolina, the ambient water quality monitoring program has historically focused on large rivers and areas with known water quality concerns, thereby limiting data collection 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 NCDWR 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. 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 NCDWR. Both models appear to have predictive value and are recommended for use as the best available tools to evaluate watershed restoration and protection needs in the NC Piedmont. Their application in other ecoregions is contingent upon input from water quality stakeholders in those river basins on what data should be used and how the data should be weighted. For example, the Coastal Plain has an economy somewhat dependent upon shellfish harvesting. Stakeholders in that region would want to ensure that any GIS models used to anticipate watershed restoration or protection could anticipate the impacts of farms, septic tanks, and wastewater facilities upon shellfish health.

In discussing the validation of these models, it is necessary to acknowledge some limitations of the ESRI ArcEditor “Selection” tool. When “Selecting By Location,” a user has two options to select shapefiles that “Intersect” the source layer (the watersheds in a designated category), or shapefiles that are “Within” the source layer. In this case the “Intersect” option selects all waters that touch, cross, are within, or share a border with any of the watersheds in the selected category being assessed. This overestimates the number of relevant water features that are relevant to the actual hydrology of the watershed (having the Yadkin River as a watershed boundary does not necessarily mean that watershed drains directly to the Yadkin River – it may drain to a tributary), as well as double-counting the same water feature that may be listed in that watershed for multiple reasons (impaired for turbidity and pH, or “Excellent” for fish habitat and “Good” for benthic macroinvertebrates).

Conversely, using the “Within” option certainly underestimates the number of waters relevant to the hydrology of the selected watershed category, as those waters must be contained within a watershed to be selected – those that are fed by a watershed (and should be counted) are omitted. Exhaustive review can be employed to screen these waters and ensure that all relevant waters are included without being double counted, but this project’s budget did not permit this additional step. For the purposes of this discussion, though, both the Intersect and

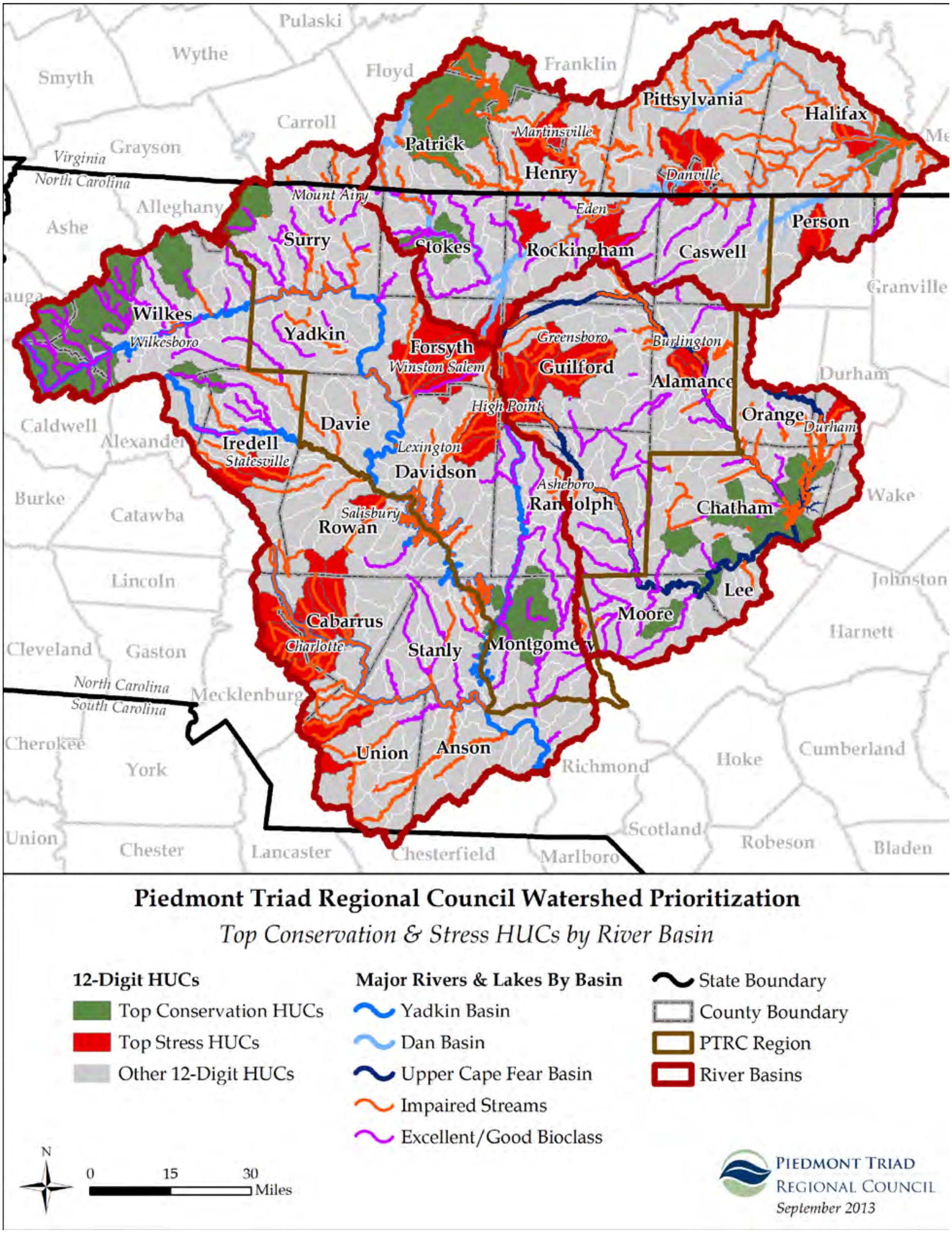


Figure 35: Category A Stress & Conservation Watersheds in the Dan, Upper Cape Fear, and Yadkin-Pee Dee River Basins

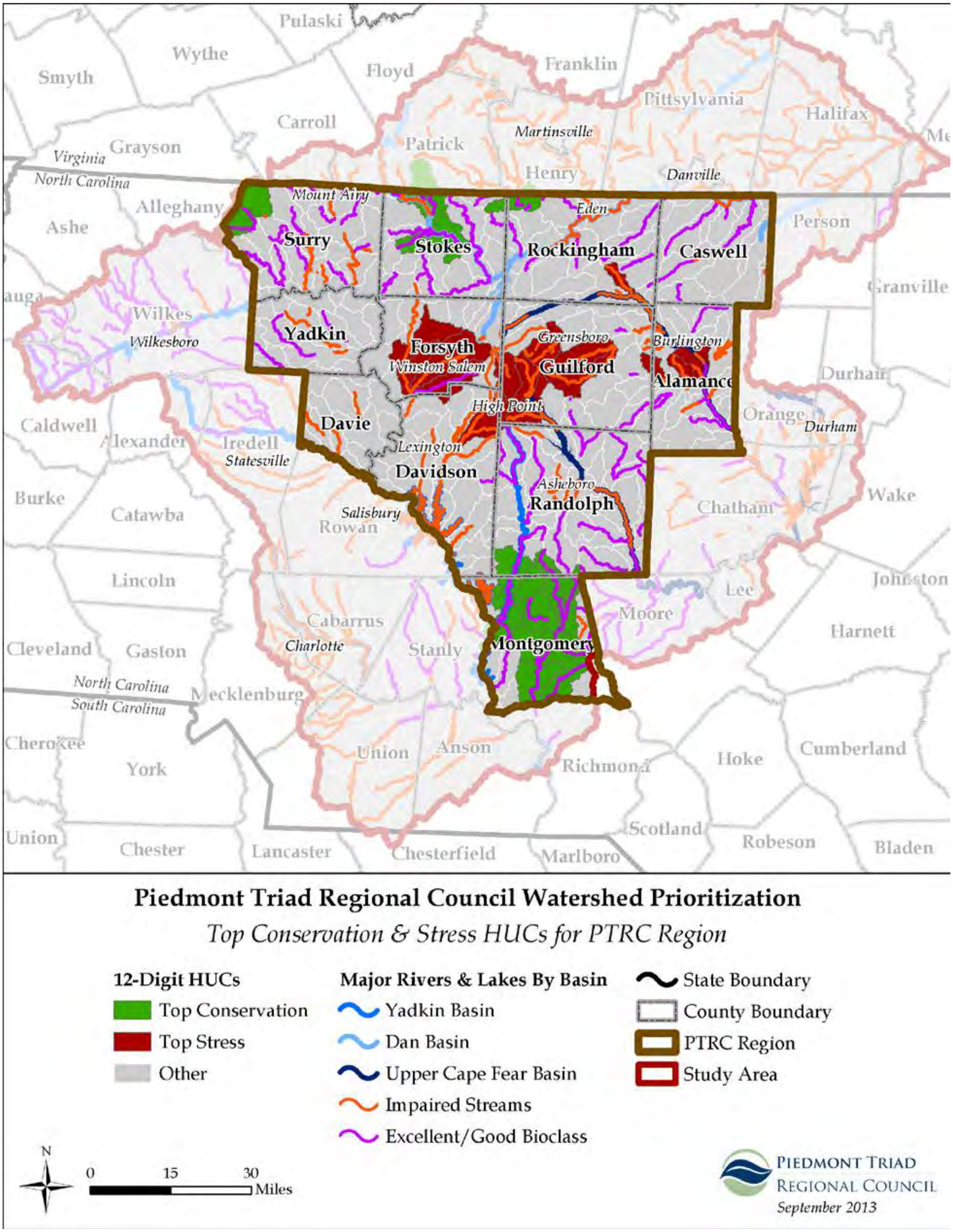


Figure 36: Category A Stress & Conservation Watersheds in the PTRC service region

Within values will be mentioned as relevant metrics in discussing model performance and value in reflecting actual water quality conditions.

All other Stress model categories demonstrate similar values in reflecting impaired water quality conditions if using the ArcGIS Intersect tool to assess Category A watersheds and the impaired waters of the Piedmont, having a greater than proportional value in demonstrating restoration needs. Assessing those waters and Category A watersheds using the Within tool, though, shows a lower-than-proportional return for these watersheds. In other words, 25% of impaired waters are not found in 20% of watersheds when land use conditions become less stressful. This should make sense upon reviewing Categories D and E, where there are few to very few watershed stressors, but it appears that the best use of the Stress model is to assess those waters that are most stressed by watershed land uses and land covers. However, the less direct relationship between the watersheds and impaired waters in these other categories may be construed to still reflect a relationship that bears closer assessment. Less accuracy may be due to a need for more water quality data, which may add a value to this model in directing investments in ambient and field-based water quality monitoring efforts.

The Conservation model displays a similar but more accurate ability to reflect water quality conditions. Category A of the Conservation watersheds intersect with 6.5% of all “Healthy” waters that have 31% of all the Piedmont’s healthy stream miles. If only assessing those waters within these watersheds, the numbers slightly fall to 6% and 19%, respectively. This intersection includes over 90% of all Outstanding Resource Waters, 83% of all trout waters, 30% of all NC waters rated to have “Good” or “Excellent” bioclassifications, and 14% of all VA waters rated to have “Good” or “Excellent” bioclassifications.

When using the ArcGIS Intersect tool to assess streams with Category A watersheds for other Conservation categories, there is still a greater than proportional value for Categories B and C. Category B, representing 15% of all watersheds, intersects with 2% of all healthy waters that possess 18% of all healthy stream miles; Category C, representing 25% of all watersheds, intersects with 5% of all healthy waters that have 41% of all the Piedmont’s healthy stream miles. Assessment of healthy waters using the Within tool and the watersheds in these categories does not demonstrate a similar relationship. Similar to the recommended use of the Stress model, a further refinement of this model may be to assess those watersheds in these categories that do have healthy waters within them and prioritize them and their adjacent neighbors for more intensive assessments. Similar to the Stress model, the Conservation model has no value in reflecting impaired water conditions.

Neither model appears to have a high value in reflecting where protection and/or restoration work is needed for non-flowing water features. Given their size and hydrology, lake needs cannot be accurately anticipated using the models applied for anticipating the needs of linear flowing waters. They are simply too large; are fed by too many watersheds; affected by too many types of land use decisions; and are too discrete to be identified with this somewhat sensitive model. More simply put, lakes are either there or they aren’t – if a watershed touches or includes one, then many acres of impaired or healthy waters could be claimed for that category of watersheds. Just as easily, lake acres could be omitted from a model's selection simply because they are not there. Perhaps if lakes were a part of the Piedmont's natural hydrology their health would be reflected better by the model. However, all significant lakes in the NC Piedmont are artificial impoundments on flowing rivers.

Both models are based upon the PTRC staff's best opinion on how LULC can potentially impact water quality, with significant input from TJCOG, DRBA, CCOG, and HCCOG. It is the product of nearly four years of similar, but less successful efforts in the Yadkin-Pee Dee and Dan River basins. Those earlier models had some success (discussed below), but still failed to accurately reflect water quality conditions satisfactorily. With TJCOG's leadership, two day-long meetings were held with water quality stakeholders in the Upper Cape Fear River Basin, in which the models were edited to omit irrelevant data layers (e.g. greenways) and include more relevant data (i.e. road density), as well as to edit these data to accurately reflect the role land use and land cover play in determining water quality conditions. The application of this revised model to all of the river basins that transect the Piedmont Triad demonstrates that, while somewhat muted in its value for rural areas, the models have value in anticipating water quality needs, as reflected in NC DWR and VA DEQ water assessment data.

Upper Cape Fear River Basin

The results of this effort for the Piedmont, including entire Piedmont Triad and parts of the Triangle and Charlotte-Mecklenburg regions – representing a total population of over 3 million people – can be seen in this report. The model used for this project is identical to that employed for the Upper Cape Fear River basin, and the categorization of watersheds based upon model application is the same. No changes have been made since their use for this river basin and, as reflected in that project report, the model has a good to excellent value in anticipating watershed needs, especially for the Stress model. The results are the same as what was previously reported to NCDWR (Figures 37 and 38).

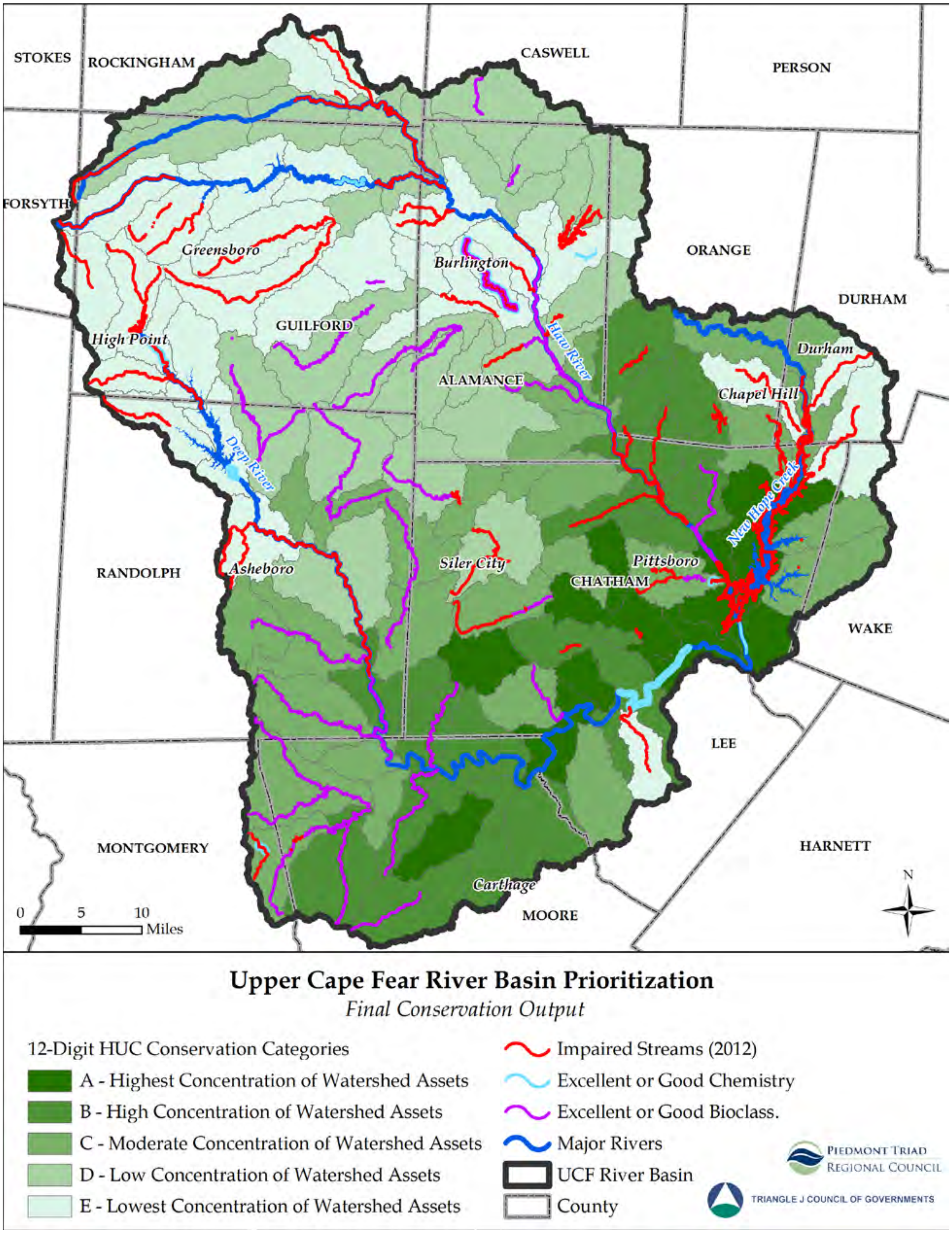


Figure 37: Upper Cape Fear River Basin Conservation Assessment

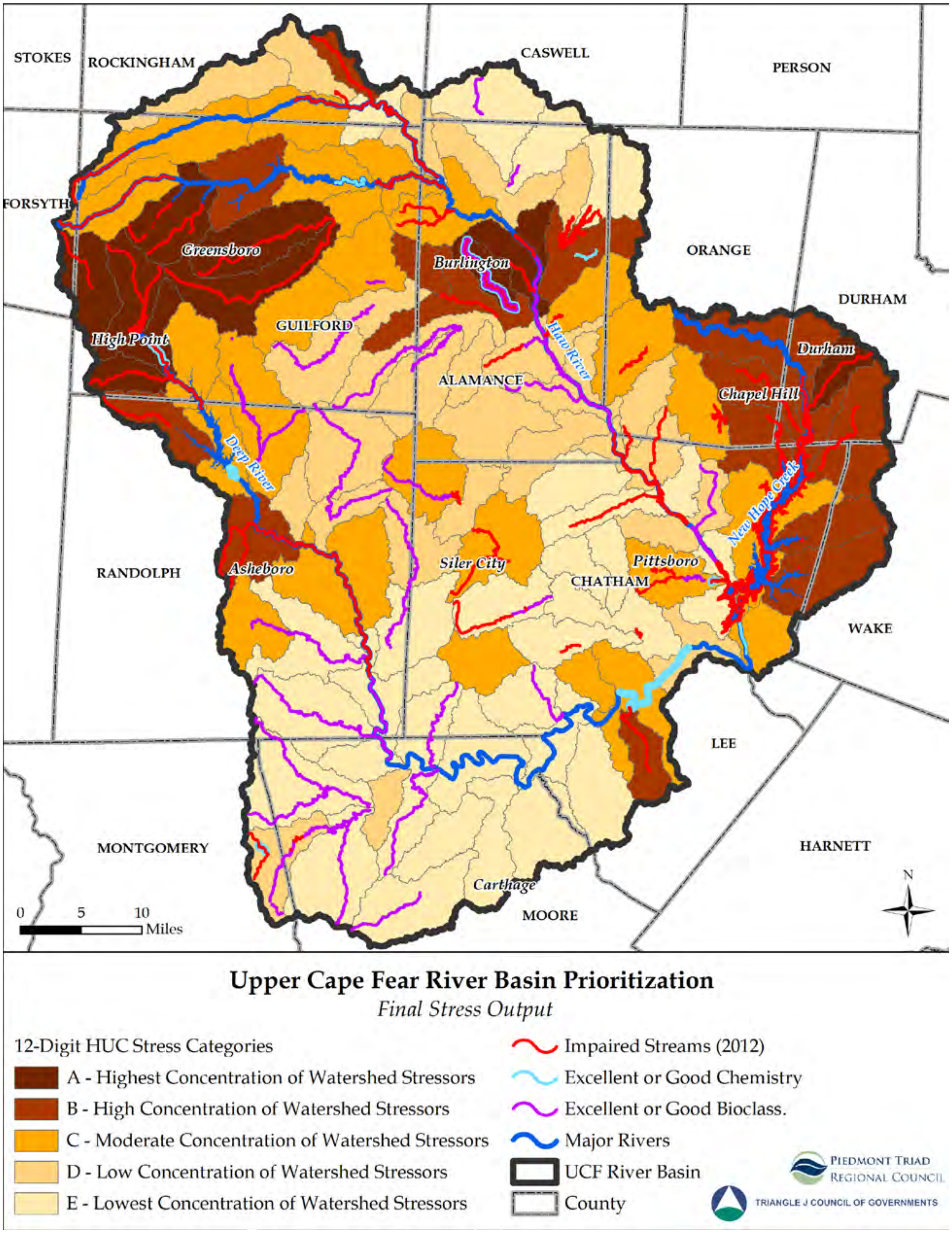


Figure 38: Upper Cape Fear River Basin Stress Assessment

Yadkin-Pee Dee River Basin

The Yadkin-Pee Dee River Basin was the initial attempt by CCOG, HCCOG, and the PTRC at using land use and land cover data in a GIS to reflect and anticipate watershed needs for water quality restoration and natural resources protection. The PTRC was the project's technica while CCOG administered the project. These models used a much less nuanced, three-tiered approach that still demonstrated value in reflecting basinwide water quality conditons recorded by NC DWR (then the Division of Water Resources). Its Category A watersheds (10% of the total watersheds for both Stress and Conservation models) still captured a disproprtionate percentage of impaired and healthy waters, respectively.

In contrast to the models used for this project, the original watershed prioritization model essentially used three tiers of data weighting (Table 7). The most weighted data for that Stress model was still impervious cover, but it was only 15% of the determinants of watershed value. This weight was equal to that applied to population density change and minor streams.

Yadkin-Pee Dee River Basin Watershed Prirotization Stress Model Data (2010)		
Tier	Weight	Data
I	3	High Impervious Cover
		Population Density Change
		Minor Streams
II	2	Erodible Soils
		Hydric Soils
III	1	Animal Operation Permits
		High Impact Zoning
		Steep Slopes
		500-yr. Floodplain
		Wetlands

Yadkin-Pee Dee River Basin Watershed Prirotization Conservation Model Data (2010)		
Tier	Weight	Data
I	3	Low Impervious Cover
		Minor Streams
II	2	Erodible Soils
		Hydric Soils
III	1	High Forest Cover
		Conservation Lands
		Steep Slopes
		500-yr. Floodplain
		Wetlands
		Significant Natural Heritage Areas
		Greenways
		Trout Streams
		High Quality Waters
		Outstanding Resource Waters

Compared to the 31% of impaired streams representing 40% of all impaired waters in this river basin seen with the use of this model, the original Yadkin-Pee Dee River Basin Stress model captured 38% of all impaired waters, which represents 30% of all impaired stream miles in this watershed. The Conservation model captured 60% of all healthy waters, which represented 47% of all Outstanding Resource Waters and High Quality Waters watershed area, as compared to 9% of the streams which represent 42% of all healthy streams in the Piedmont using the new model. It is important to note that the Yadkin-Pee Dee River Basin model did not use bioclassification or trout waters to validate its model performance. It also did not include Virginia data, which appears to be less robust than North Carolina data. Regardless, the value of the data captured at every level by the newer model appears to have greater value for water quality stakeholders, intersecting with a smaller number of streams that have a greater percentile of needs both positive and negative.

While the two models validation data indicate similar performances, two qualifiers must be noted. The first, and most important, is that the Conservation model used its validation data in its model generation. While weighted at the lowest tier (with about a 3% weight in determining watershed values), both Outstanding Resource Waters and High Quality Waters were determinants in watershed evaluation, giving the models inherent bias. Secondly, all waters, lakes and streams were assessed together, so the areage and mileage was assessed in combination rather than separately. Given that High Rock Lake intersects with some of the Category A watersheds in the original model, this could skew its value. Lastly, with a greater number of inputs, some of the awkward differences of some counties (e.g. Wilkes County's lack of zoning data) are less noticeable because they have been smoothed over and integrated into a more cohesive weighted landscape as they are in the current model.

In assessing the differences between the two models outputs for the Yadkin-Pee Dee River Basin, a few significant changes can be noted (Figures 39 & 40). In the Conservation model output, the new, more nuanced model focuses more on watersheds with steep slopes, prioritizing headwater stream watersheds in the mountains and the Uwharrie National Forest. Furthermore, greater credit is given to agricultural and rural lands in the new model for conservation purposes, especially in the High Rock Lake watershed.

The new Stress model's greater weight of impervious cover in better able to recognize urban centers distant from the core of Triad's metropolitan district that are along transit corridors (i.e. Statesville) than the older model. The new model generally seems to recognize the impacts of population growth and transit corridors better. This makes sense, as they were not included in the original watershed prioritzation Stress model.

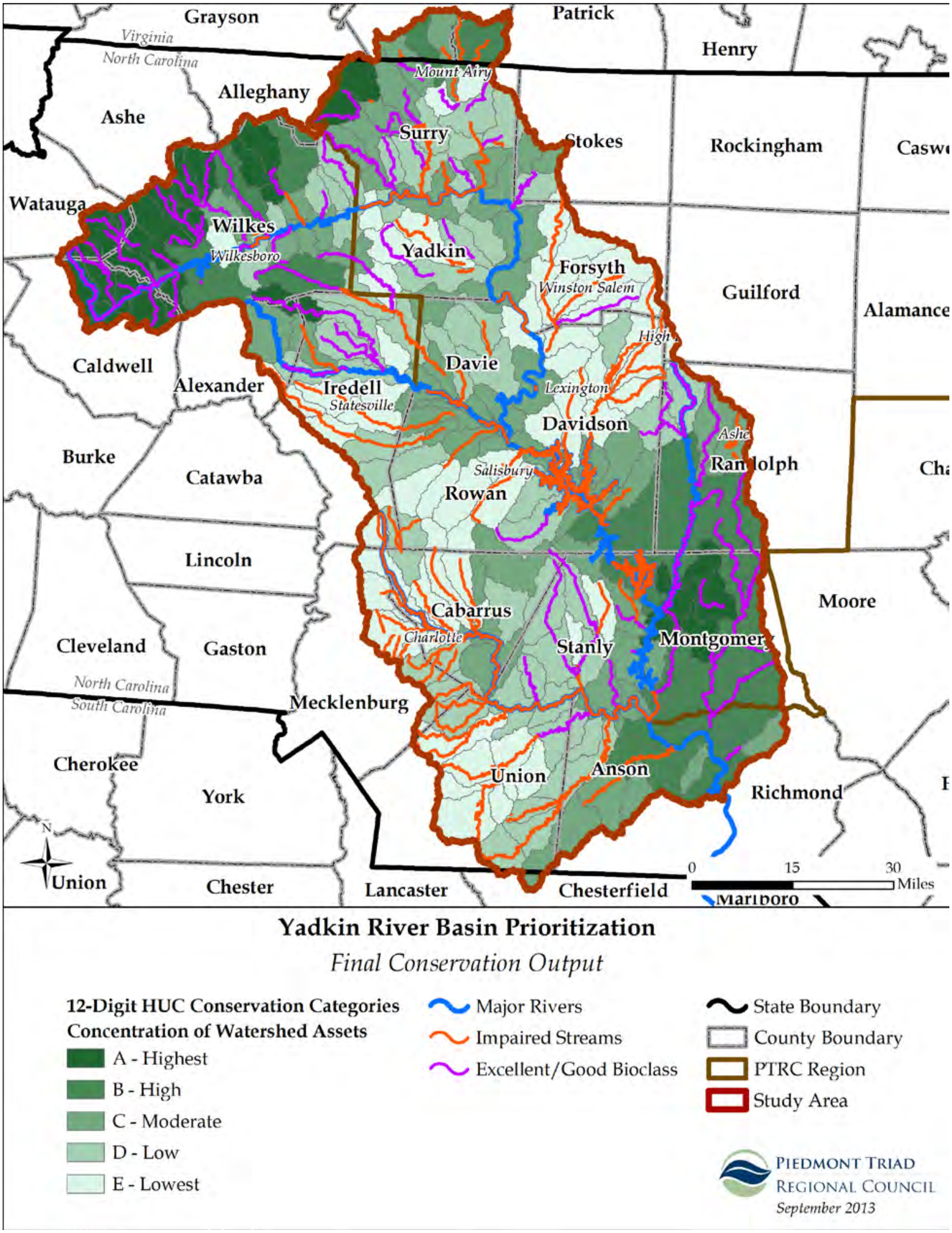


Figure 39: 2013 Conservation Assessment for the Yadkin-Pee Dee River Basin

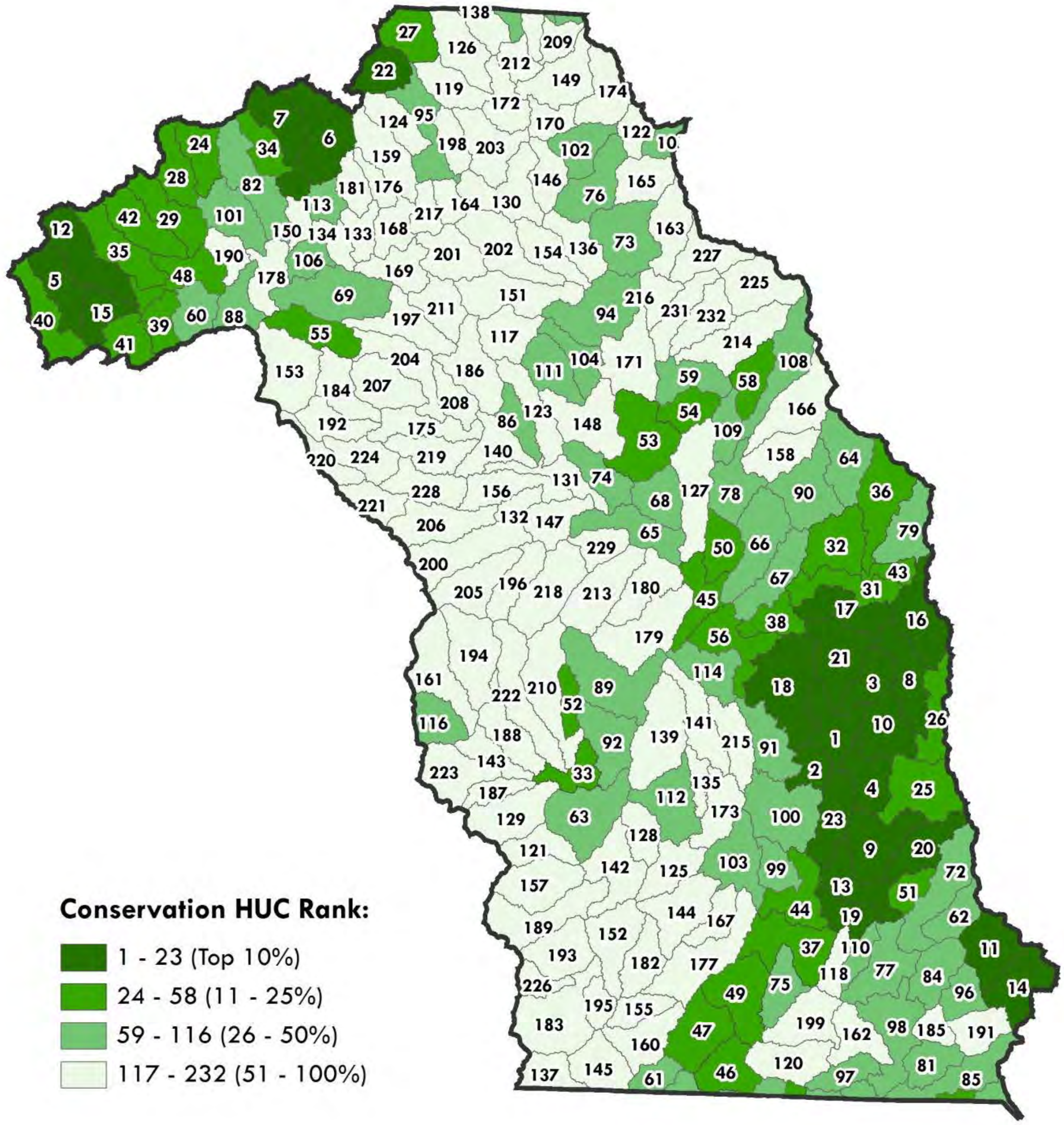


Figure 40: 2010 Conservation Assessment for the Yadkin-Pee Dee River Basin, *Yadkin-Pee Dee River Basin Priority Watershed Atlas, 2010*

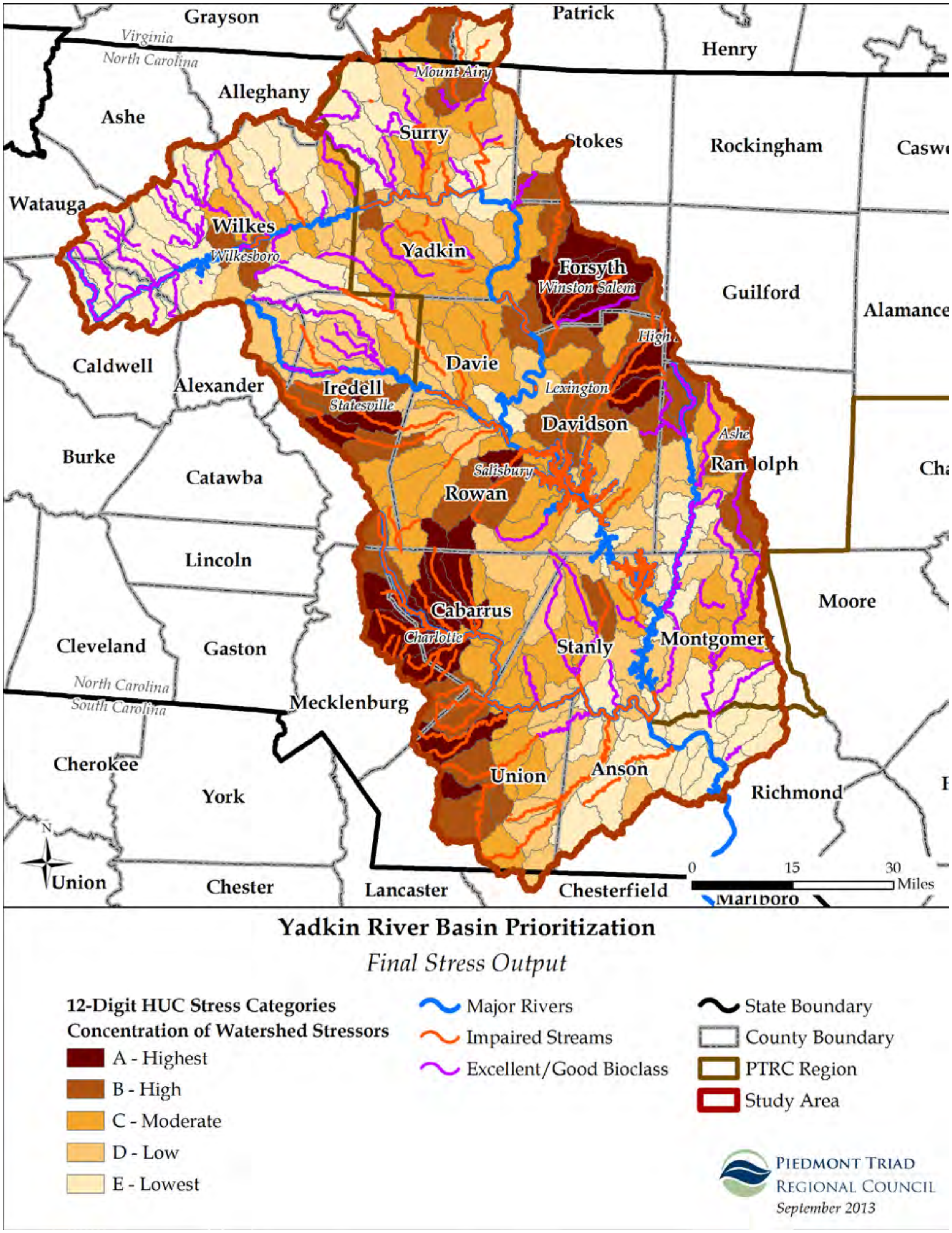


Figure 41: 2013 Stress Assessment for the Yadkin-Pee Dee River Basin

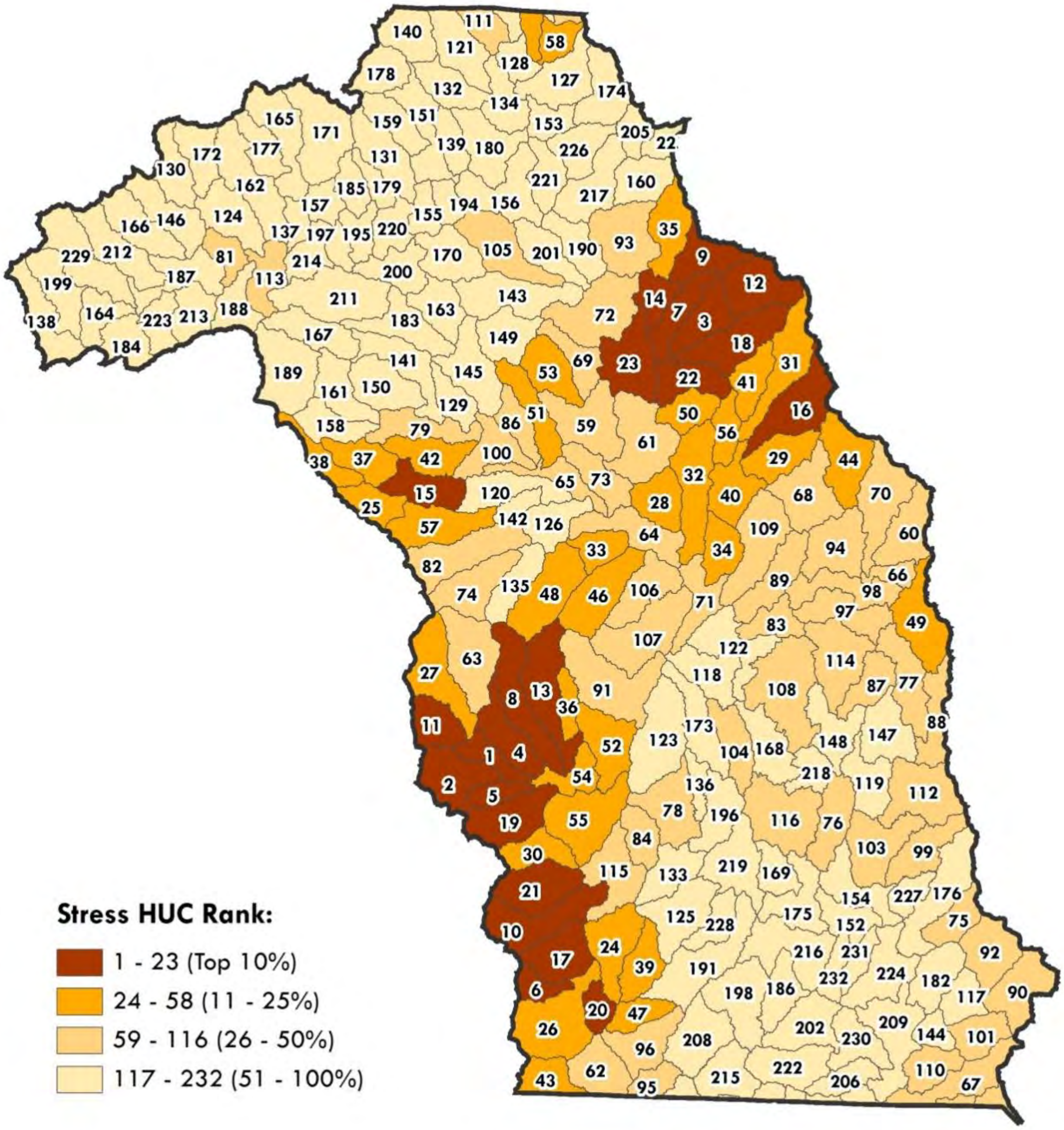


Figure 42: 2010 Stress Assessment for the Yadkin-Pee Dee River Basin, *Yadkin-Pee Dee River Basin Priority Watershed Atlas, 2010*

Dan River Basin

The PTRC was awarded 2010 205(j) funds in 2011 to apply the modeling approach that was successful in the Yadkin-Pee Dee River Basin to the Dan River Basin of the Roanoke River headwaters in North Carolina and Virginia. To assist with data acquistion and reporting on watershed conditions, the PTRC partnered with the Dan River Basin Association. The models used in the Dan River Basin were edited in an attempt to enhance their value in reflecting watershed health and needs in this more rural watershed. This revised model added greater weightings for impervious cover and integrated existing popultaion densities to accurately reflect the historic but depressed mill towns that reside throughout this river basin. Rather than three tiers of weighting, this model used five for the Stress model and four for the Conservation model (Tables 9 & 10).

Dan River Basin Watershed Prirotization Stress Model Data (2012)		
Tier	**Weight**	**Data**
I	6	High Impervious Cover
II	4	Population Density
		Population Density Change
III	3	Major Roads
		Minor Streams
		Large Parcels
IV	2	Animal Operation Permits
		High Impact Zoning
		Erodible Soils
		Hydric Soils
V	1	Low Forest Cover
		Steep Slopes
		500-yr. Floodplain

Yadkin-Pee Dee River Basin Watershed Prirotization Conservation Model Data (2010)		
Tier	**Weight**	**Data**
I	6	Natural Heritage Program SNHA & NHEO
II	3	Low Impervious Cover
		Minor Streams
		Large Parcels
III	2	Erodible Soils
		Hydric Soils
		Low Impact Zoning
		Trout Waters
		Conservation Lands
IV	1	High Forest Cover
		Steep Slopes
		500-yr. Floodplain
		Wetlands
		Greenways

These models were nearly complete failures in their abilities to reflect water quality conditions in the Dan River Basin, let alone anticipate the basin's watershed needs. The Stress model's Category A watersheds captured only 12.5% of all impaired waters in the basin, and none of them were in North Carolina, which is generally more urbanized than Virginia. However, the Stress model Category A watersheds did do a better job of capturing healthy waters than the Conservation model's Category A watersheds (6% vs 4%). Conversely, 100% of the Category A Conservation watersheds were associated with impaired waters.

In contrast, the new model is valuable, though not disproportionately valuable. If only assessed within the Dan River Basin, the Category A watersheds (10% with the highest added values) of the Stress model captured 23% of impaired streams representing 26% of all impaired waters in the Piedmont. The new Conservation model captured 10% of the streams which represent 3% of all healthy streams in the Piedmont. Within the Dan River Basin, the rest of the model is valuable generally proportional to known data – when the mid 10% of watersheds are assessed for stressful land uses, they will likely have about 10% of all impaired waters in the river basin. While disappointing, the model is still valuable, it just does not have the potent predictive value it has demonstrated elsewhere in the Piedmont Triad region. With further review and enhncement, the model may have greater application for anticipating water quality needs in more rural landscapes. Currently, it may hold value in watersheds without water quality data.

It is worth noting, though, that the initial model applied in the Dan River Basin did not use bioclassification data as a metric of healthy streams, so the older model may be underestimating the value of that Conservation model. Regardless, the models needed extensive improvements if they were to be of any value for their intended use: accurately representing actual water quality conditions so that their characterization of a watershed could be stated with confidence as an objective need for local watershed planning and estimating water quality conditions in data-poor watersheds.

The new model is fundamentally different from what was used and reported a year ago. Five of the ten watersheds in Category A are the same, but the five new watersheds are significant in their character. The new Stress model's greater emphasis on impervious surfaces is immediately apparent – all municipalities are in Category A, including small towns like Madison, NC. The greater weight given to population density changes and road density is also apparent, though a little less significant. It is important as reflection of rural transition watersheds such as those seen in Person and Forsyth Counties. Still a persistent problem in the Dan River Basin, though, is simply a lack of federal, state, and local data. For instance, Caswell County does not have federal soils data, a Natural Heritage Inventory, or zoning data. This demonstrates a failure of government at all levels to serve a poor, rural, predominantly African-American community.

Five of the Conservation model's ten Category A watersheds remain the same, as with the Stress model. But also as with the Stress model, it is the character of these watersheds that is important. Those that remained the same are largely in protected areas in and near state and federal lands, including Hanging Rock State Park and Staunton River State Park in North Carolina and Virginia, respectively. The new models' Category A watersheds drain to high-value trout streams in the Blue Ridge foothills upstream of Philpott Dam in Virginia. The greater emphases on ecological habitat needs and recreational potential are reflected in this new model, and the ramifications of that evolution of idelogy are potent.

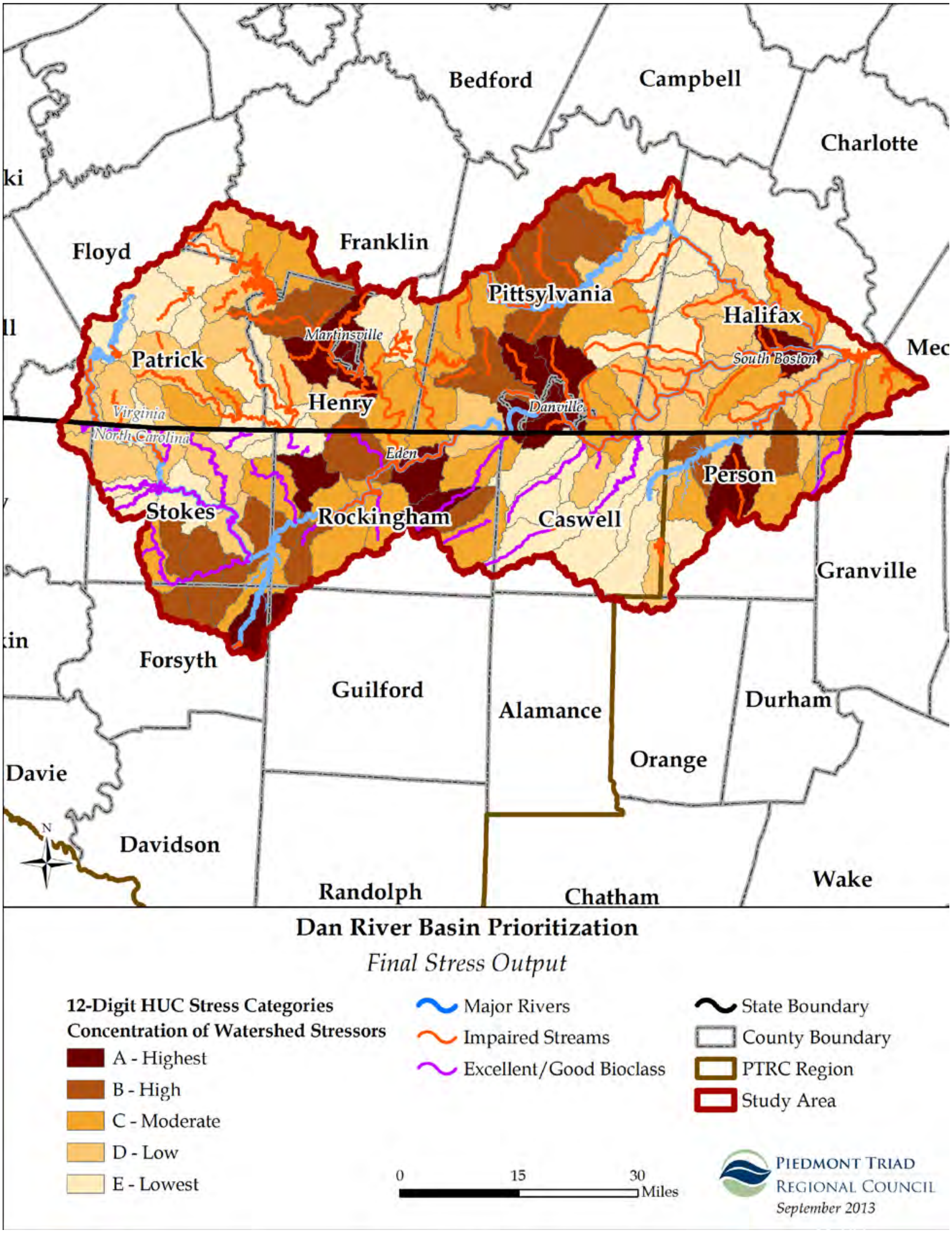


Figure 43: 2013 Stress Assessment for the Dan River Basin

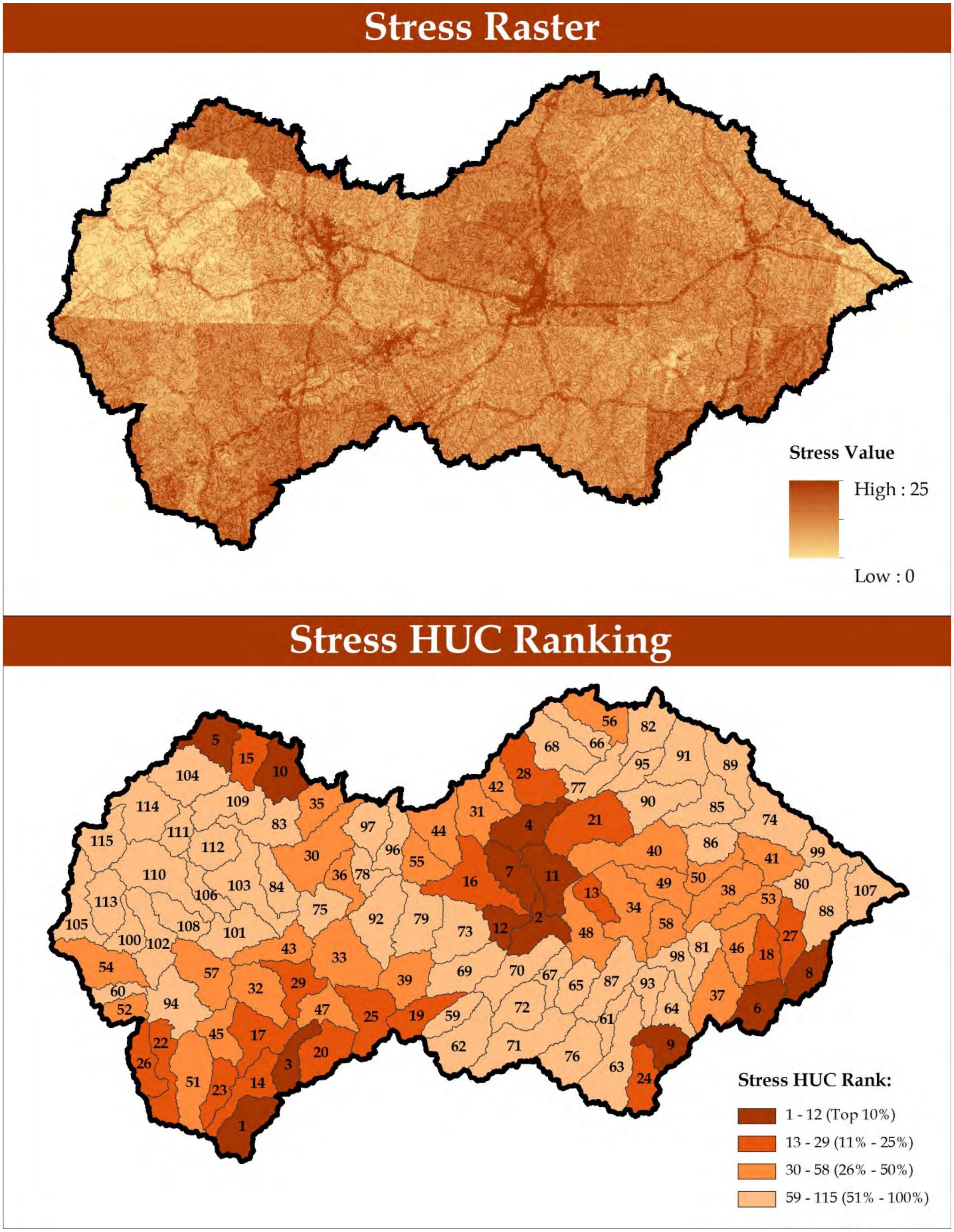


Figure 44: 2013 Stress Assessment for the Dan River Basin, *Dan River Basin Conservation and Restoration Analysis and Strategy, 2012*

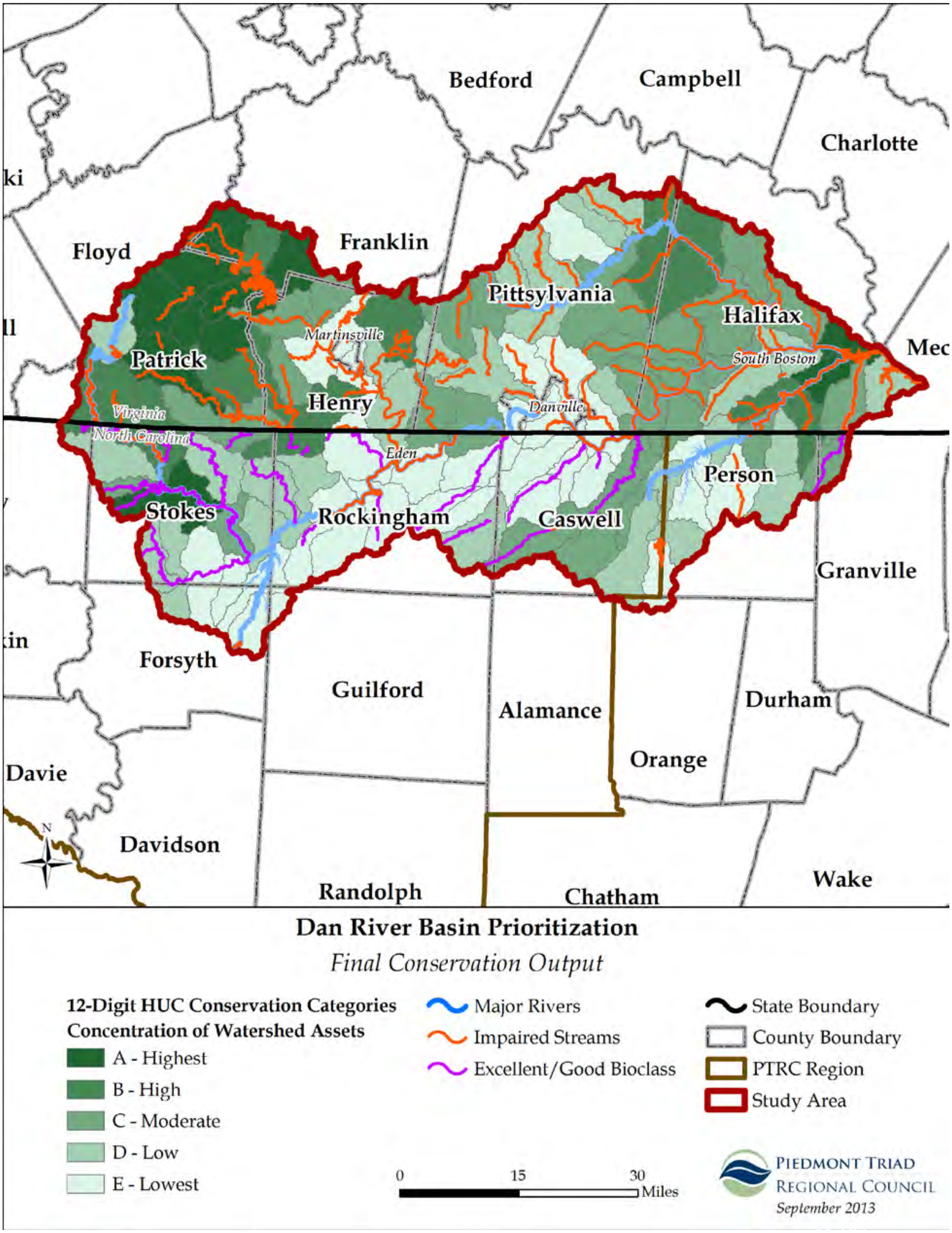


Figure 45: 2013 Conservation Assessment for the Dan River Basin

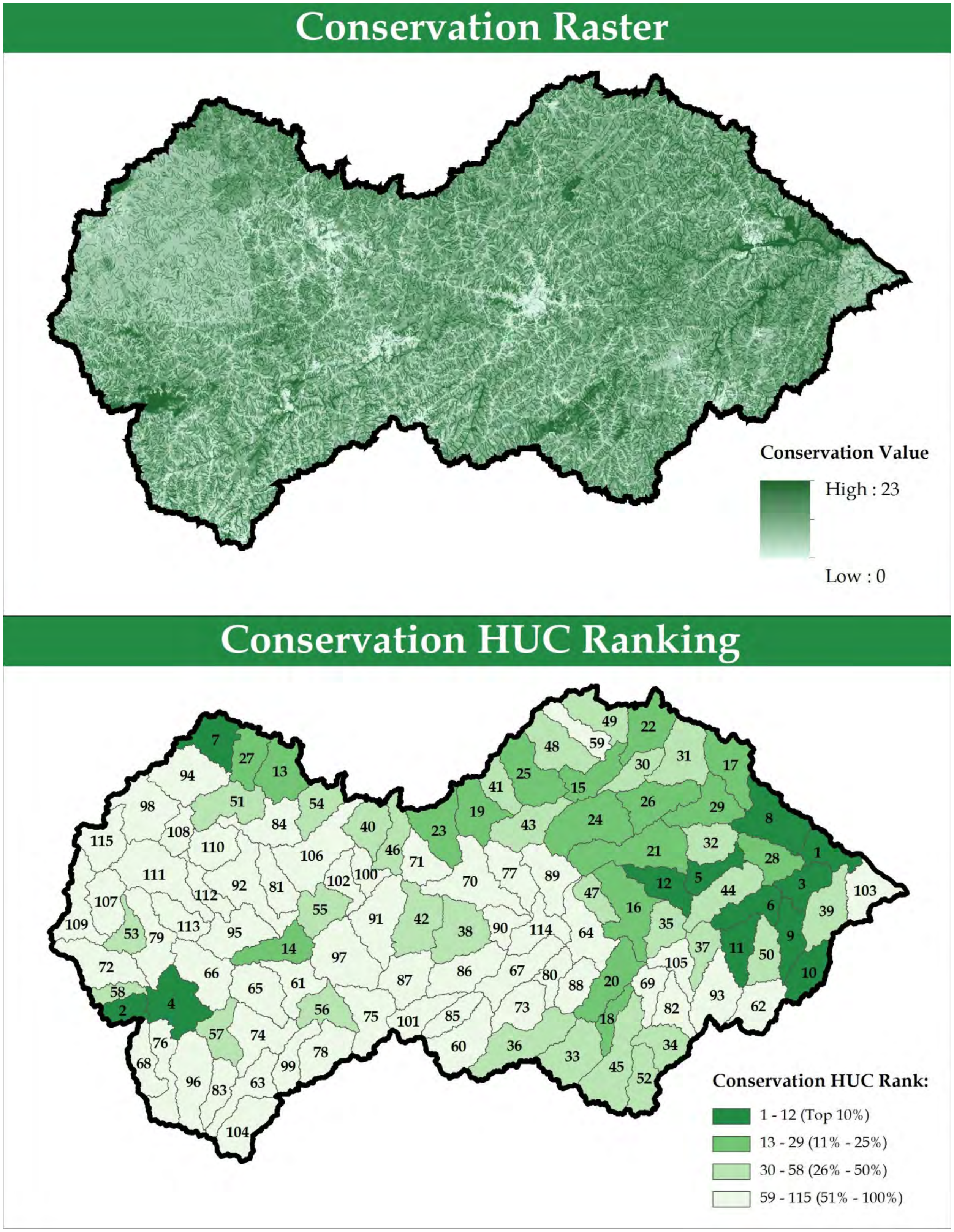


Figure 46: 2012 Conservation Assessment for the Dan River Basin, ***Dan River Basin Conservation and Restoration Analysis and Strategy, 2012***

Summary

The conceptual models that were used for this watershed prioritization project are the product of ongoing efforts at the PTRC since 2009. All work has been supported by grants from the NCDWR 205(j) program. The Stress model's value in reflecting actual water quality conditions has been evaluated using the 303(d) impaired waters list that the NC DWR provides to the US EPA every two years; the Conservation model's relevance to actual water quality conditions has been evaluated with several metrics, though it was determined that the "Good" and "Excellent" designation in the assessed waters dataset that NC DWR maintains is the most useful. By those metrics, the latest model used in this planning project is a success, and can be considered an accurate reflection of water quality conditions in Piedmont rivers and streams. The validation of the models gives enough confidence to users that it could be used to presume water quality conditions in watersheds with little to no assessment data, and perhaps inform investments in monitoring and field work by non-profit, state, and federal stakeholders. Despite these successes, the PTRC intends to refine the models to enhance their value as a tool to select hydrologic priorities at a range of scales and extents, pending future funding.

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 Piedmont Triad's river basins. 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 Dan River, Upper Cape Fear, and Yadkin-Pee Dee River Basins. 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. The PTRC is proud to deliver it to NCDWR and the USEPA for broader application.

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