Summary Report: Recovery Potential Screening of Tennessee Watersheds in Support of Nutrients Management

INTRODUCTION

The US Environmental Protection Agency's (EPA's) Total Maximum Daily Loads (TMDL) Program, in cooperation with state water quality programs, released a long-term TMDL Vision document in December 2013. Part of the TMDL Vision involves increasing states' identification of priority watersheds for restoration and protection efforts over a several-year time frame, and better linkage of TMDLs to these priorities. Previously, a 2011 Office of Water policy memorandum on nutrients had also recommended systematic watershed analysis, comparison and priority setting to obtain better results. EPA's TMDL program has provided watershed data, comparative assessment tools and state technical assistance for the past ten years through the Recovery Potential Screening (RPS) approach and tools (see Attachment 1). In support of state requests for assistance in nutrients-related prioritization, the TMDL program has partnered with several states, including Tennessee, to jointly carry out RPS assessments and develop results to help states consider their watershed nutrients management options systematically with consistent data. These RPS assessments were designed to address primary nutrients issues identified by each state using state-specific indicators and data relevant for watershed comparison. This report summarizes the Tennessee project approach and findings, and identifies multiple additional products (e.g., RPS Tools and data files) that were developed along with this overview document.

Background

Recovery Potential Screening (RPS) is a systematic, comparative method for identifying differences among watersheds that may influence their relative likelihood to be successfully restored or protected. The RPS approach involves identifying a group of watersheds to be compared and a specific purpose for comparison, selecting appropriate indicators in three categories (Ecological, Stressor, Social), calculating index values for the watersheds, and applying the results in strategic planning and prioritization. RPS was developed to provide states and other restoration planners with a systematic, flexible tool that could help them compare watershed differences in terms of key environmental and social factors affecting prospects for restoration success. As such, RPS provides water programs with an easy to use screening and comparison tool that is user-customizable for the geographic area of interest and a variety of specific comparison and prioritization purposes. The RPS Tool is a custom-coded Excel spreadsheet that performs all RPS calculations and generates RPS outputs (rank-ordered index tables, graphs and maps). It was developed several years ago to help users calculate Ecological, Stressor, Social, and Recovery Potential Integrated index scores for comparing up to thousands of watersheds in a desktop environment using widely available and familiar software. RPS Tools with embedded indicator data have been developed for each of the conterminous states and other selected geographic areas of interest.

Tennessee Department of Environmental Conservation (TDEC) requested assistance from EPA in 2012 due to their interest in a more systematic, data-supported comparison of watersheds for restoration investments. An RPS assessment project was jointly undertaken by EPA's TMDL program, the Cadmus Group (EPA contractor), TDEC, and TDEC collaborators. 121 base, ecological, stressor, and social indicators were initially measured from state and federal data sources at the HUC12 scale, and compiled in a Tennessee statewide RPS tool (Excel file). A multi-day RPS workshop at TDEC in 2013 hosted trainees from several TDEC water program units (303(d)/TMDLs, Drinking Water, Permitting), other state and federal agencies (e.g., TDOT, NRCS, TVA, TDA's 319 program), and non-governmental collaborators (universities, TNC). This workshop marked the completion and delivery of the State's first RPS tool and enabled TDEC to begin its routine use. In 2014, TDEC requested follow-on assistance in RPS tool enhancement and application as one of several state nutrients demonstration projects using RPS. New national-scale data made available in 2014 in addition to datasets from the State enabled development of the current (2015) Tennessee statewide RPS Tool for this project. This RPS tool contains 310 indicators with full statewide coverage at HUC12, HUC8, or both scales. The assessment findings and most of the figures in this document were generated by the Tennessee RPS Tool.

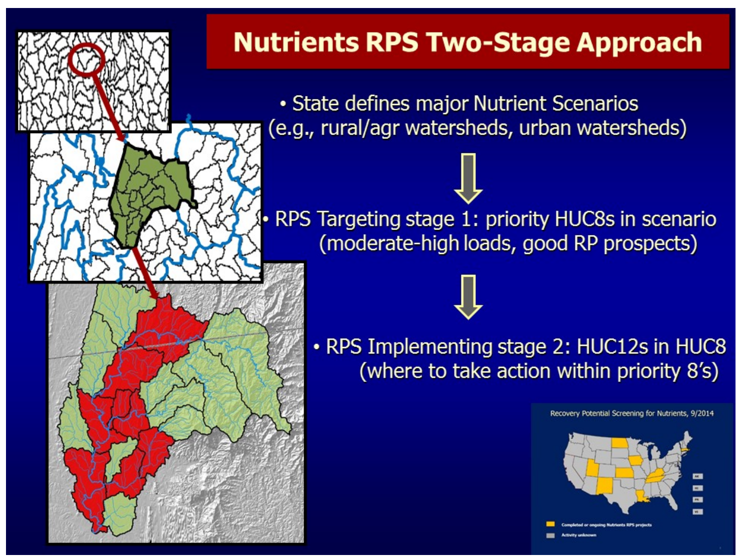
APPROACH

As a starting point, each RPS nutrients project was designed to apply recommendations from the EPA Office of Water 2011 nutrients policy memorandum, which reads in part:

> *Prioritize watersheds on a statewide basis for nitrogen and phosphorus loading reductions*
>
> *A. Use best available information to estimate Nitrogen (N) & Phosphorus (P) loadings delivered to rivers, streams, lakes, reservoirs, etc. in all major watersheds across the state on a Hydrologic Unit Code (HUC) 8 watershed scale or smaller watershed (or a comparable basis.)*
>
> *B. Identify major watersheds that individually or collectively account for a substantial portion of loads (e .g. 80 percent) delivered from urban and/or agriculture sources to waters in a state or directly delivered to multi-jurisdictional waters.*
>
> *C. Within each major watershed that has been identified as accounting for the substantial portion of the load, identify targeted/priority sub-watersheds on a HUC 12 or similar scale to implement targeted N & P load reduction activities. Prioritization of sub-watersheds should reflect an evaluation of receiving water problems, public and private drinking water supply impacts, N & P loadings, opportunity to address high-risk N & P problems, or other related factors.*

The two-stage approach implicit in the text above fits well with the RPS Tool, which easily supports comparing HUC8 watersheds in a first, targeting stage and then focuses on screening and comparing HUC12s in a second, implementation-oriented stage. All the RPS nutrients projects utilized the same general two stage approach (HUC8 or similar larger-scale unit in Stage 1, HUC12 in Stage 2), while encouraging state-specific customizing of the approach in identifying stage 1 scenarios, establishing state approaches for priority watershed identification, and selection and weighting of the most nutrients-relevant indicators for use in both stages. In this project, the data sources and indicators compiled in the RPS tool, the selections of indicators, choice of demonstration watersheds, and weighting of indicators in the nutrients-related screening runs all took place collaboratively among TDEC, EPA and its contractor. Nevertheless, this technical project's findings and outputs are not meant to represent decisions or policies of TDEC, EPA, or other entity.

Figure 1: Two-stage conceptual approach utilized in RPS projects for supporting state nutrients management.



Stage 1

Identifying Nutrient Scenarios. The RPS Tool is most effective in comparing groups of watersheds that have something in common, such as generally similar landscapes, nutrient sources, impacts and possible management options; for this reason, Stage 1 begins by engaging the state in defining specific types or groups of watersheds with something in common regarding their primary nutrients management challenges. The term "scenario" is used here to describe these sets of shared characteristics that provide a basis for groups of similar watersheds to be compared and contrasted with one another effectively. Nutrient management challenges in any given state can be complex and involve multiple scenarios. Breaking down a large group of watersheds statewide into smaller, more similar groups and focusing on scenarios most relevant to each group enables a narrower focus on nutrient issues and possible solutions. At a minimum, nutrients scenarios usually differentiate between groups of watersheds with primarily agricultural/rural loading sources and groups of more urban-suburban watersheds with wastewater and urban runoff nutrient sources. Screening these scenarios separately enables selection of indicators that can be more specific to each scenario.

For Tennessee, two scenarios of interest were initially selected in a conference call between EPA, TDEC, and Cadmus:

Rural-agricultural watersheds scenario. Watersheds in this scenario contain a mixed land use pattern typically including cropland, grazing land, low-density residential areas and forested land. Isolated, small urban areas of moderate density may also occur, as well as mining or other land uses not listed, but these are not defining characteristics of this target scenario. Contiguous cropland areas are more frequent on the larger low-gradient areas, and thus may occur near the moderate to larger rivers and streams, but smaller cropland patches also are common and limited in extent by adjacent steep slopes. Grazing and pasture areas are not as slope-limited as cropland and may include moderately steep areas as well as areas near rivers and streams. Human population and typically urban-suburban nutrients sources probably are secondary to agriculture in this scenario's watersheds, but rural residential patterns in or near the stream corridors might be capable of a significant effect on loading at more local, subwatershed scales.

Urban-suburban watersheds scenario. Watersheds in this scenario contain a substantial urban and suburban presence, but typically are not urbanized over a majority of area. Urbanization may comprise a small percentage of HUC8 scale watersheds due to their relatively large watershed area, but can still be the source of significant nutrient loads. Few Tennessee HUC8s contain large, high-density urbanized areas, but several more do contain extensive suburban and smaller high-density urban components. With urbanization seldom dominating, a mosaic of cropland, pasture, forest and other uses makes up the remainder of this watershed scenario. Indicator selection favors the urban and suburban nutrient source-related elements that typify this scenario, but the presence of agriculture in the outskirts of many urban watersheds suggests including indicators that help discern between watersheds with exclusively urban-suburban nutrient sources and those with more mixed sources.

Selection of Stage 1 indicators. Because the two scenarios differ fundamentally in land use patterns, nutrient source types and exposure pathways, watersheds within each scenario can be compared to one another with more scenario-specific indicator selections. Indicators for Stage 1 need only to be sufficient for generally comparing watersheds across the state, identifying which watersheds to include in each scenario, and revealing major differences in condition and estimated nutrient loading magnitude as a state selects its first watersheds to assess within each scenario. Using the RPS Tool, two different (scenario-specific) selections of recovery potential indicators equally weighted at TDEC request (see indicator lists in Table 1 and definitions in Attachment 2) were used to screen all the Tennessee HUC8s.

Selecting Stage 1 demonstration watersheds. Typically, several Stage 1 watersheds in each scenario are selected by the state as an initial 'focus group' in which to demonstrate the RPS assessment approach. Identifying a demonstration group may target early adopters or high-interest watersheds, but is not meant to assign priority or preclude a state's assessment of their remaining watersheds over time. Selections can be based on a Stage 1 screening, expert opinion, or a combination of both. The Stage 1 approach allows inclusion of specific watersheds that did not fully meet these scenario criteria if a compelling reason existed for their inclusion (e.g., significant progress in planning or addressing nutrient issues typical of the scenario). Ideally, Stage 1 indicators, criteria and expert judgment combine to identify watersheds that not only have loading issues, but also show traits relevant to better restorability.

For each scenario, Tennessee's Stage 1 selections were made by TDEC and validated with a Stage 1 screening. These statewide screenings each provided an independent (from TDEC selection) basis to identify the group of HUC8s that best fit the defining characteristics of each scenario. These two groups of scenario-specific 'best fit' watersheds were identified by applying threshold criteria (e.g., % specific land use categories, N or P loading > state median) to further refine the two statewide scenario screenings.

Stage 2
Selection of Stage 2 Indicators. Stage 2 assessment is intended to compare smaller watersheds (HUC12s) for a more specific planning purpose (i.e., considering where best to implement control efforts) than Stage 1. Stage 2 continues Stage 1's orientation toward scenarios, as different sets of Stage 2 indicators are selected for assessing the HUC12s

within the rural-agricultural HUC8s and the urban-suburban HUC8s. Indicator selection at this second, more detailed stage can draw from the much lengthier and varied set of indicators compiled statewide at the HUC12 scale, and thus is capable of being tailored to address more specific land use settings or control practices. Indicator selections and weights assigned by TDEC (see Table 4) were used for screening the HUC12s within the HUC8s of each scenario.

Within-HUC8 Comparison of HUC12s. In addition to the difference in purpose, a second important difference between Stage 2 and Stage 1 is in geographic scope. Stage 1 compared larger watersheds statewide using rather general indicators and criteria at statewide scales, thus Stage 1 results were meaningful in the context of the state. In contrast, Stage 2 compared subwatersheds (meaning HUC12s in this document) in the context of their larger HUC8 watershed alone, not in the context of the state's entire group of HUC12s. This difference means that Stage 2 screening identifies subwatersheds that may influence the health and future of the larger watershed, as well identifying opportunities for action within these subwatersheds individually. Comparison of all HUC12s statewide is appropriate for some purposes, but within-HUC8 comparisons of HUC12s are frequently more useful because they reveal HUC12 relative differences within the context of a smaller, more homogeneous setting rather than a highly variable statewide setting.

Potential Stage 2 priority watersheds. RPS Tool screening runs performed on each demonstration HUC8 identify a gradient of conditions among the HUC12s within the HUC8. Each screening run generates an Ecological, Stressor, Social and Integrated Index score for every HUC12; those four indices, and even single indicators of exceptional interest, may be used in contrasting differences among a HUC8's subwatersheds and thus helping to inform strategies for where to invest nutrient management and control resources. As the purpose of this report is to demonstrate procedures and alternatives for identifying potential watershed priorities that states may follow and adapt to their planning, the Stage 2 results presented in this document should be considered a demonstration of alternatives rather than final selections.

STAGE 1 RESULTS

Rural-Agricultural Watersheds Scenario

This scenario identified HUC8s with significant rural and agricultural sources of nutrients that are of higher interest for rural nutrient management efforts. A copy of the RPS Tool populated with this scenario's screening results is among project deliverables. Twenty HUC8 watersheds were included in this scenario based on the following criteria:

- ≥50% instate
- ≥25% agriculture in watershed
- ≥ Statewide median SPARROW-predicted agricultural nitrogen (N) or phosphorus (P) loads

Eight HUC8 watersheds in this scenario were specifically requested by TDEC. Six of these (asterisked) also met all scenario criteria from the Stage 1 screening.

- NOLICHUCKY (06010108)
- HIWASSEE (06020002)
- UPPER ELK* (06030003)
- CANEY* (05130108)
- OBION* (08010202)
- SOUTH FORK OBION* (08010203)
- SOUTH FORK FORKED DEER* (08010205)
- NORTH FORK FORKED DEER* (08010204)

Table 1. Stage 1 RPS indicator selections and weights for screening and comparing HUC8 watersheds for the Rural-Agricultural Scenario (upper) and the Urban-Suburban Scenario (lower) in Tennessee. See Attachment 2 for indicator definitions.

Stage 1 Rural-Agricultural Scenario

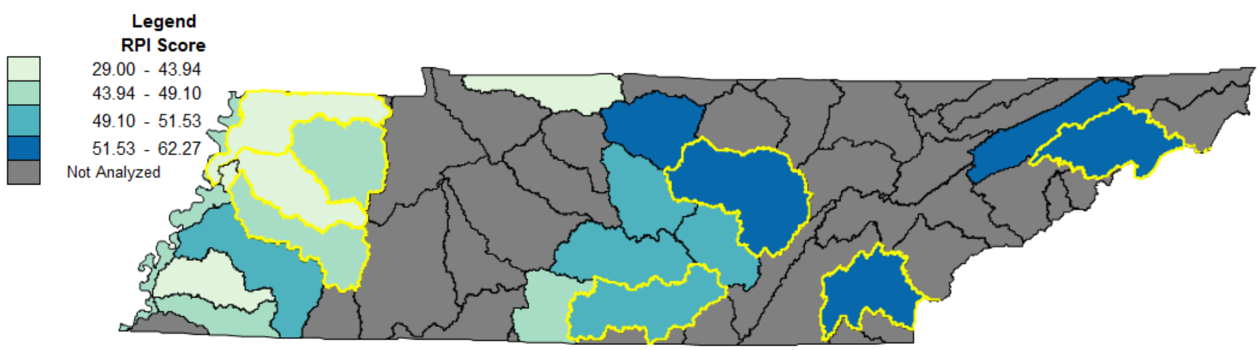
Ecological Indicators	wt	Stressor Indicators	wt	Social Indicators	wt
% NEF2001, National Ecological Framework, WS	1	Empower Density 2001, Mean Value in Watershed	1	% of HUC8 Instate	1
% Woody Vegetation (2006) in Riparian Zone	1	% Agriculture (2006) in HCZ	1	ADOPT Watershed Groups Count	1
% Natural Cover, N-index1 (2006) in HCZ	1	% Agriculture (2006) in Riparian Zone	1	Percent GAP status 1, 2, and 3 WS	1
Ratio of Natural to Recycled N Inputs	1	Agricultural water use WS	1	Anthropogenic Recycled N Effort (Inverse)	1
Ratio of Natural to New N Inputs	1	Domestic water use WS	1	Anthropogenic New N Effort (Inverse)	1
		SPARROW Predicted Incremental N Yield	1	Percent Drinking Water Source Protection Area WS	1
		SPARROW Predicted Incremental N Yield Delivered	1		
		SPARROW Predicted Incremental P Yield	1		
		SPARROW Predicted Incremental P Yield Delivered	1		
		SPARROW Predicted Incremental Agr N Yield (2012)	1		
		SPARROW Predicted Incremental Agr P Yield (2012)	1		
		Anthropogenic Recycled N Effort	1		
		Anthropogenic New N Effort	1		
		Nutrient Impaired Segment Count	1		

Stage 1 Urban-Suburban Scenario

Ecological Indicators	wt	Stressor Indicators	wt	Social Indicators	wt
% NEF2001, National Ecological Framework, WS	1	% Human Use, U-index 2 (2006) in Watershed	1	% of HUC8 Instate	1
% Woody Vegetation (2006) in Riparian Zone	1	Empower Density 2001, Mean Value in HCZ	1	ADOPT Watershed Groups Count	1
% Natural Cover, N-index1 (2006) in HCZ	1	% Agriculture (2006) in Watershed	1	Percent GAP status 1, 2, and 3 WS	1
Ratio of Natural to Recycled N Inputs	1	% Urban (2006) in HCZ	1	Anthropogenic Recycled N Effort (Inverse)	1
Ratio of Natural to New N Inputs	1	Watershed Likely N/P NPDES Discharger Count	1	Anthropogenic New N Effort (Inverse)	1
		Agricultural water use WS	1	Percent Drinking Water Source Protection Area WS	1
		Domestic water use WS	1		
		SPARROW Predicted Incremental N Yield	1		
		SPARROW Predicted Incremental N Yield Delivered	1		
		SPARROW Predicted Incremental P Yield	1		
		SPARROW Predicted Incremental P Yield Delivered	1		
		Anthropogenic Recycled N Effort	1		
		Anthropogenic New N Effort	1		
		Centralized Sewage N Input	1		
		Nutrient Impaired Segment Count	1		

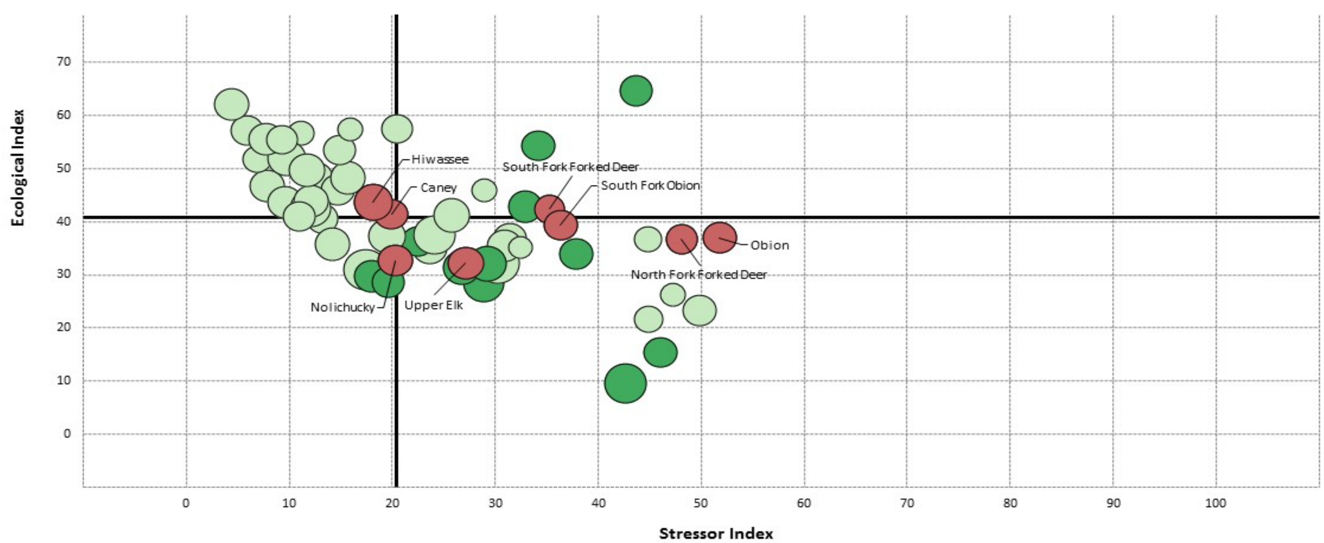
Recovery Potential Integrated (RPI) index scores for the rural scenario are displayed in map form in Figure 2, showing the relative geographic distribution of the scenario and demonstration watersheds. RPI scores are a composite of scores for the Ecological, Stressor, and Social indices. Top scoring HUC8s include Hiwassee (06020002), Caney (05130108), Holston (06010104), Lower Cumberland-Old Hickory Lake (05130201), and Nolichucky (06010108). RPI scores are generally lower in the western portion of the State, and demonstration watershed selection is well-distributed around the State.

Figure 2. Recovery Potential Integrated (RPI) index scores for the rural-agricultural scenario. The most intense colors in RPS maps denote the "best" scores. HUC8s requested by TDEC for this scenario are outlined in yellow.



The bubble plot in Figure 3 displays the relative value differences among HUC8s in Ecological, Stressor and Social Index scores by each bubble's size and position on the graph, also showing how these compare to statewide medians (the horizontal and vertical median lines). Further, this figure enables the scenario (dark green and red) and demonstration (red with labels) HUC8s to be compared with the rest of the State's HUC8s. Most of the scenario HUC8s have higher than average Stressor scores than the State overall, but the group varies markedly in Ecological score, including the highest and lowest in the State. Most of the demonstration HUC8s for this scenario remain close to the average in Ecological score but vary from average to very high in Stressor score. Two HUC8s (Lower Hatchie and Lower Mississippi-Memphis) within the scenario have Ecological Index scores that are well above average but were not selected as demonstration HUC8s. As these also have high Stressor Index scores, they may be good candidates for future screening because they appear to combine some positive ecological features with evidence that action in these watersheds would also address significantly high stressor levels.

Figure 3. Bubble plot for all Tennessee HUC8s based on RPI score derived from the rural-agricultural scenario indicators. This plot highlights rural-agricultural scenario watersheds (dark green and red) and demonstration watersheds (red with name labels). Axes are set to statewide median Ecological index and Stressor index scores.



Note: Circle size increases with Social Index score

Maps of Ecological and Stressor Index scores for the rural-agricultural scenario are displayed in Figure 4. The Ecological Index map shows that, unlike RPI scores, high Ecological Index scores are scattered throughout the State. Western HUC8s have the highest Stressor Index scores due to high agricultural land cover and other related stressors, such as agricultural phosphorus loads (Figure 5). These maps suggest that, despite high stressor levels, some HUC8s in western Tennessee may still retain parts of the ecological infrastructure needed to support restoration efforts.

Figure 4. Ecological Index (top) and Stressor Index (bottom) scores for the rural-agricultural scenario. The most intense colors in RPS maps denote the "best" scores. HUC8s requested by TDEC are outlined in yellow.

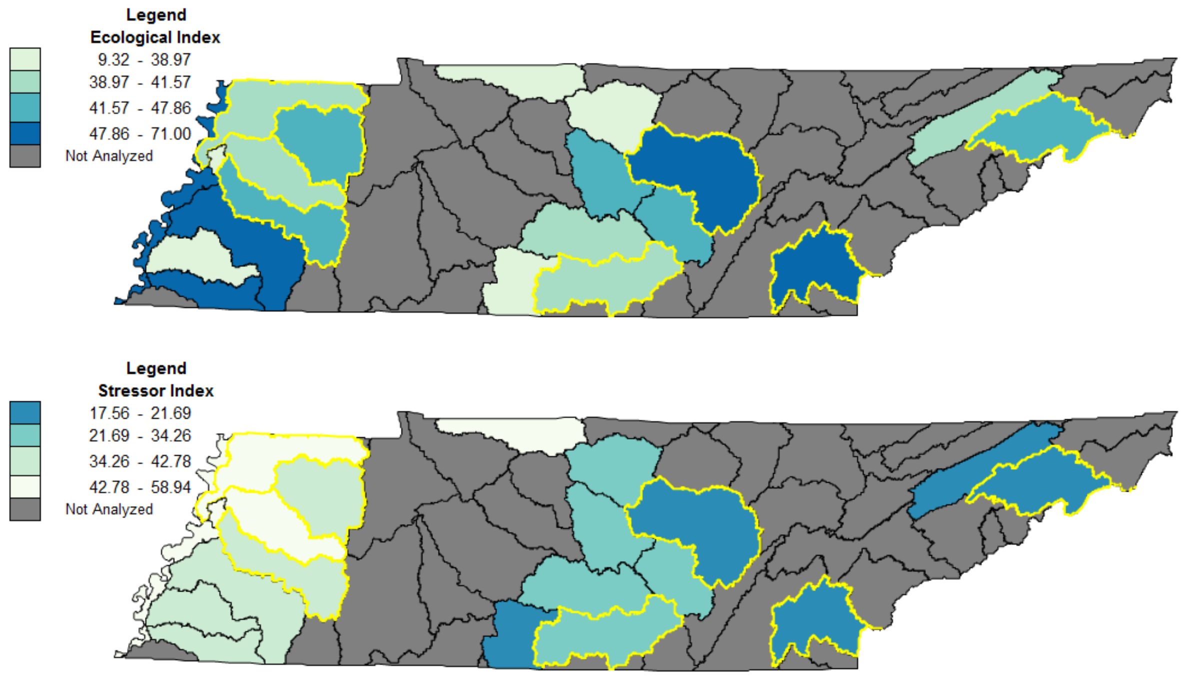


Figure 5. Agricultural phosphorus yields for HUC8s in the rural-agricultural scenario predicted by the USGS SPARROW model. The most intense colors in RPS maps denote the "best" scores. HUC8s requested by TDEC are outlined in yellow.

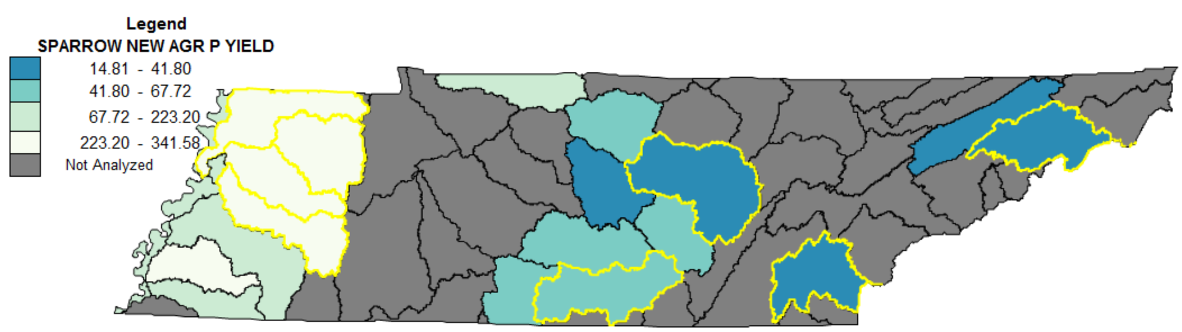


Table 2 contains Ecological, Stressor, Social, and RPI scores for the rural-agricultural scenario HUC8s, in order of descending RPI score and color-coded by quartile per RPS index. This tabular format is another option for presentation of Stage 1 results that can be used to compare and contrast HUC8s for rural nutrient management efforts. In interpreting this table, preferred HUC8s for rural nutrient management do not necessarily have to be those with the highest RPI scores but instead could consider one or more of the component index scores. For example, the Lower Mississippi-Memphis ranks outside the top quartile in RPI score but has the highest Ecological Index score.

Table 2. Index and RPI scores for the rural-agricultural scenario. HUC8s are ordered by RPI score. Cells are shaded according to rank (green = 76 -100th percentile; yellow = 51-75th percentile; orange = 26-50th percentile; pink = 0-25th percentile). Demonstration HUC8s requested by TDEC for the rural-agricultural scenario are marked with an asterisk (*). Scores and quartiles derived from screening rural-agricultural scenario HUC8s only.

Watershed ID	Watershed Name	Ecological Index	Stressor Index	Social Index	RPI Score
06020002	Hiwassee*	61.04	18.53	44.30	62.27
05130108	Caney*	55.04	20.15	29.70	54.86
06010104	Holston	40.52	17.56	32.98	51.98
05130201	Lower Cumberland-Old Hickory Lake	37.86	32.27	49.90	51.83
06010108	Nolichucky*	43.84	20.04	30.98	51.59
08010208	Lower Hatchie	60.40	36.24	30.37	51.51
05130107	Collins	45.88	22.21	29.57	51.08
06040002	Upper Duck	40.50	32.23	42.50	50.26
05130203	Stones	41.64	29.59	38.43	50.16
06030003	Upper Elk*	41.50	29.34	35.30	49.15
08010100	Lower Mississippi-Memphis	71.00	50.69	26.82	49.04
06030004	Lower Elk	35.18	18.76	27.12	47.84
08010210	Wolf	49.06	37.88	30.03	47.07
08010205	South Fork Forked Deer*	47.46	38.13	23.80	44.38
08010203	South Fork Obion*	42.44	40.14	30.22	44.17
08010209	Loosahatchie	37.72	40.56	32.58	43.25
08010204	North Fork Forked Deer*	39.34	54.17	27.57	37.58
08010202	Obion*	40.26	58.94	31.12	37.48
08010206	Forked Deer	9.32	49.44	50.00	36.63
05130206	Red	16.48	54.37	24.90	29.00

Urban-Suburban Watersheds Scenario

This scenario is intended to identify HUC8s with significant urban and suburban sources of nutrients that are of higher interest for urban nutrient management efforts. A copy of the RPS Tool populated with this scenario's screening results is among project deliverables. Thirteen HUC8 watersheds are included in this scenario based on the following criteria:

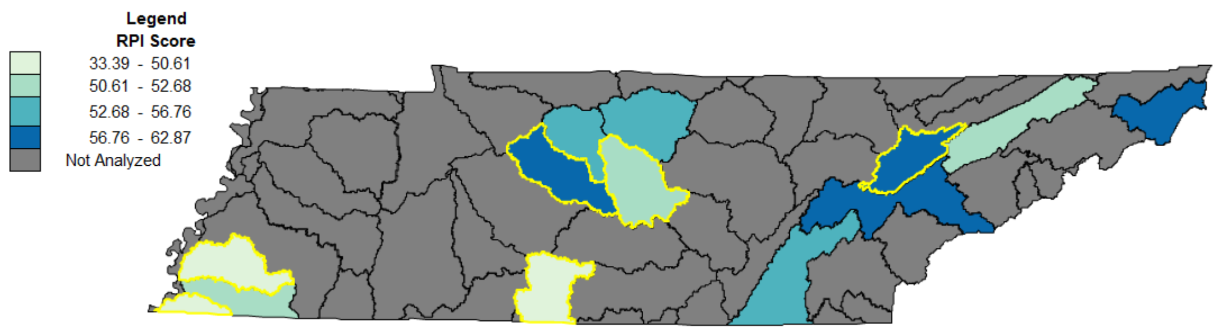
- ≥50% instate
- ≥10% developed land cover in watershed
- ≥ Statewide median estimated nitrogen loading from centralized sewer systems

Six HUC8 watersheds in this scenario were specifically requested by TDEC as demonstration HUC8s; five (asterisked) also met all scenario criteria from the RPS Stage 1 screening.

- LOWER CLINCH* (06010207)
- LOWER ELK RIVER (06030004)
- HARPETH RIVER* (05130204)
- STONES RIVER* (05130203)
- HORN LAKE-NONCONNAH* (08010211)
- LOOSAHATCHIE RIVER* (08010209)

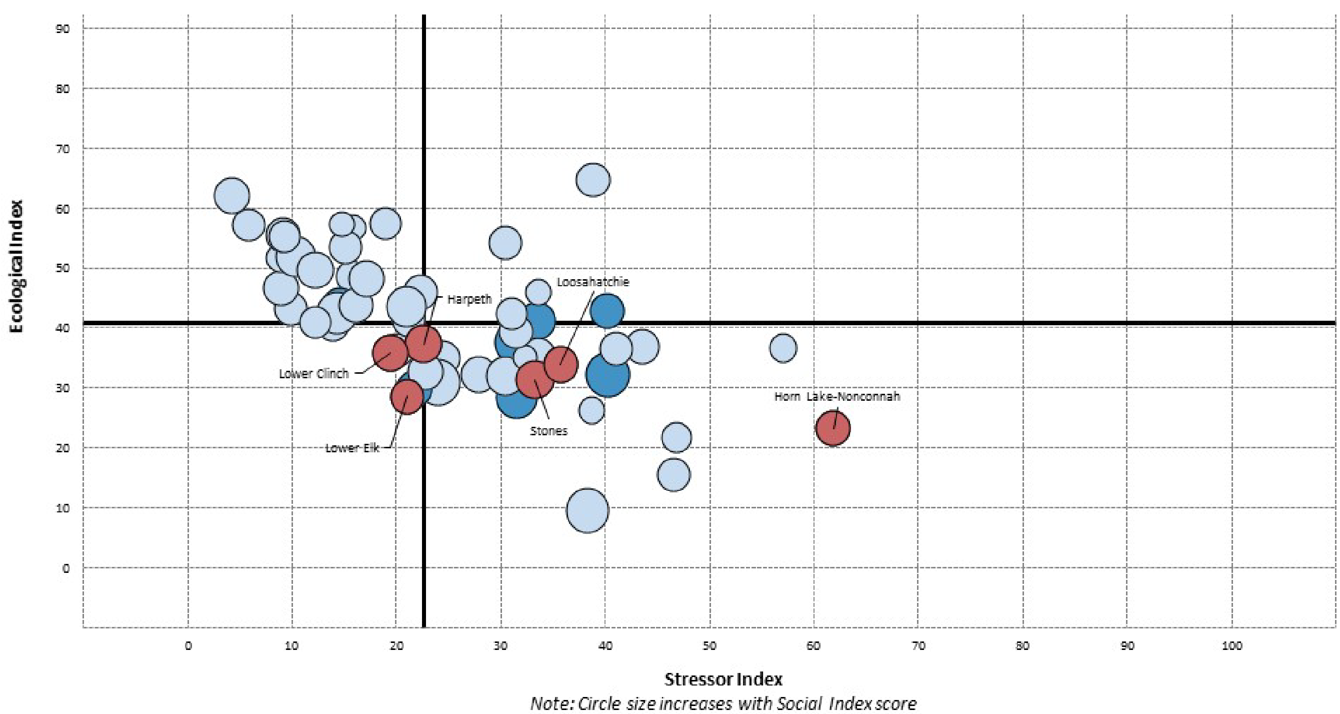
Recovery Potential Integrated (RPI) index scores for the urban scenario are displayed in map format in Figure 6. RPI scores are a composite of scores for the Ecological, Stressor, and Social Indices based on the urban-suburban scenario's indicator selection and weighting. Top scoring HUC8s include Watauga (06010103), Watts Bar Lake (06010201), and Harpeth (05130204). HUC8s with the lowest RPI scores include the Wolf (08010210), Loosahatchie (08010209), and Horn Lake-Nonconnah (08010211) in the southwest corner of the State.

Figure 6. Recovery Potential Integrated (RPI) index scores for the urban-suburban scenario. The most intense colors in all RPS maps denote the "best" scores. HUC8s requested by TDEC for this scenario are outlined in yellow.



The bubble plot for the urban-suburban scenario (Figure 7) reflects the relative value differences among HUC8s in Ecological, Stressor and Social Index scores by each bubble's size and position on the graph, also showing how these compare to statewide medians (the horizontal and vertical median lines). Further, this figure enables the scenario (dark blue and red) and demonstration (red with labels) HUC8s to be compared with the rest of the state's HUC8s. For these scenario and demonstration HUC8s, Ecological Index scores mostly cluster near or below the statewide median. Stressor index scores of demonstration as well as scenario HUC8s vary widely from below average to the highest in the State; this broad range of conditions among demonstration HUC8s may imply differences in degree of difficulty in nutrient management efforts from place to place. One non-demonstration scenario HUC8 (Sequatchie) exhibits the lowest Stressor score in the scenario along with average or above average Ecological and Social scores, suggesting that it may merit consideration for future screening.

Figure 7. Bubble plot for all Tennessee HUC8s based on RPI score derived from the urban-suburban scenario indicators. This plot highlights the urban-suburban scenario watersheds (dark blue and red) and demonstration watersheds (red with name labels). Axes are set to statewide median Ecological and Stressor index scores.



Maps of Ecological and Stressor Index scores for the urban-suburban scenario are displayed in Figure 8. HUC8s with high Ecological Index scores are spread throughout the State. Stressor Index scores generally follow patterns of the extent of urban cover in each HUC8 (Figure 9), with high scores (high stressor presence) in the vicinity of Memphis and Nashville, and lower scores in other parts of the State.

Figure 8. Ecological Index (top) and Stressor Index (bottom) scores for urban-suburban scenario. The most intense colors in all RPS maps denote the "best" scores. HUC8s requested by TDEC for this scenario are outlined in yellow.

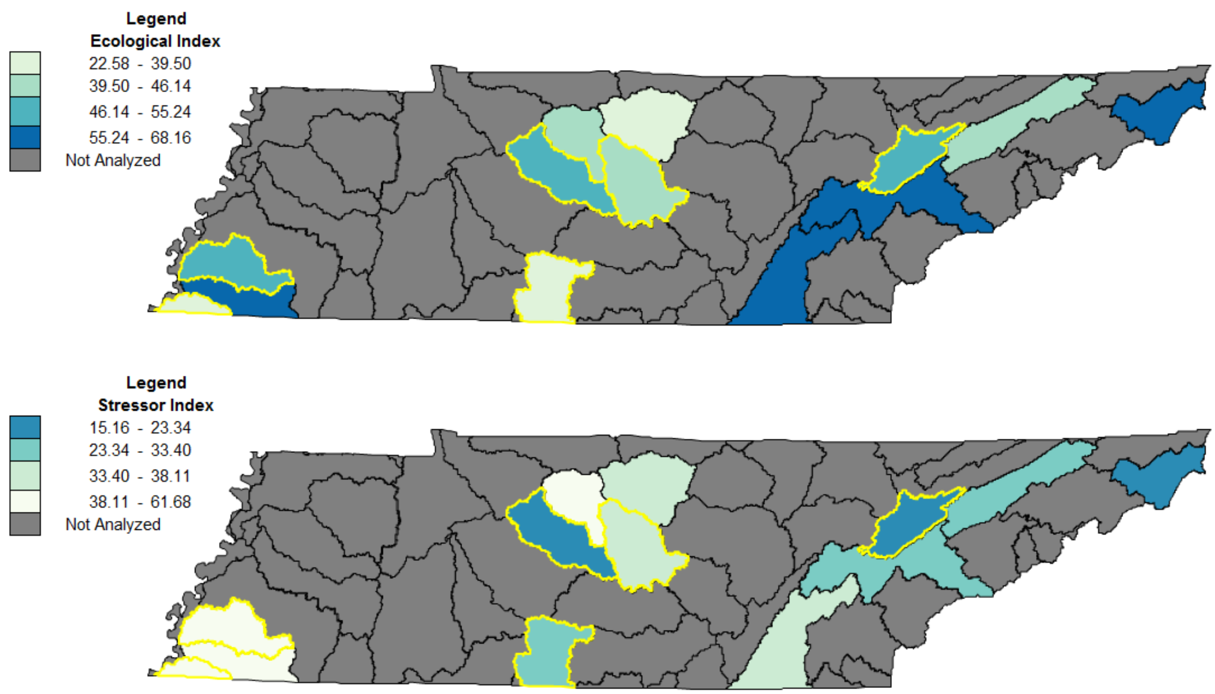


Figure 9. Percentage of urban land cover in the Hydrologically Connected Zone (HCZ) of each HUC8 in the urban-suburban scenario. The most intense colors in all RPS maps denote the "best" scores. The HCZ is a topographically-derived estimate of areas with greater hydrologic connectivity to surface waters.

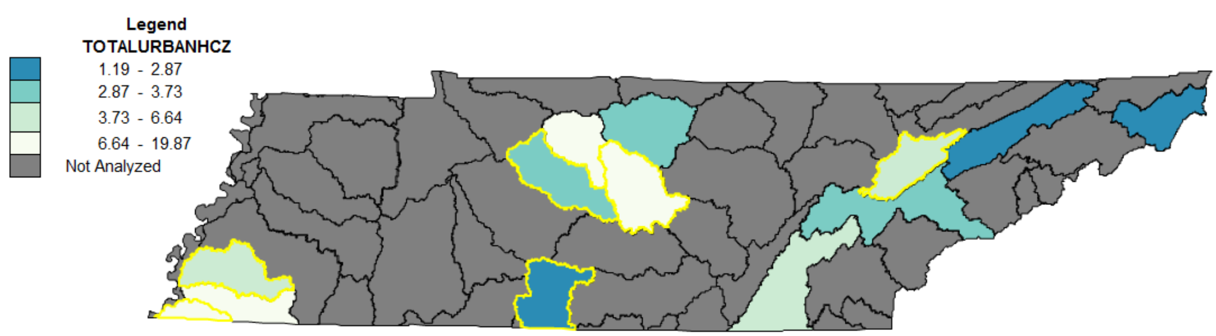


Table 3 contains Ecological, Stressor, Social, and RPI scores for the urban-suburban scenario, in order of descending RPI score and color-coded by quartile per RPS index. This tabular format is another option for presentation of Stage 1 results that can be used to compare and identify HUC8s for urban-suburban nutrient management efforts. Demonstration HUC8s for nutrient management do not necessarily have to be those with the highest RPI scores, but could consider one or more of the component index scores. For example, some HUC8s within the urban scenario do appear to have relatively good ecological scores and moderate stressor levels. Other considerations such as prior nutrient management activity or the extent of nutrient impairments might also help to identify HUC8s of higher interest for urban nutrient management.

Table 3. Index and RPI scores for the urban-suburban scenario. HUC8s are ordered by RPI score. Cells are shaded according to rank (green = 76 -100th percentile; yellow = 51-75th percentile; orange = 26-50th percentile; pink = 0-25th percentile). HUC8s requested by TDEC for the urban-suburban scenario are marked with an asterisk (*). Scores and quartiles derived from screening urban-suburban scenario HUC8s only.

Watershed ID	Watershed Name	Ecological Index	Stressor Index	Social Index	RPI Score
06010103	Watauga	68.16	15.16	35.60	62.87
06010201	Watts Bar Lake	55.24	32.95	57.45	59.91
05130204	Harpeth*	52.80	22.01	43.90	58.23
06010207	Lower Clinch*	52.96	17.35	34.68	56.76
05130202	Lower Cumberland-Sycamore	43.38	38.11	60.52	55.26
06020001	Middle Tennessee-Chickamauga	62.64	38.00	34.62	53.09
05130201	Lower Cumberland-Old Hickory Lake	35.32	33.40	56.13	52.68
06010104	Holston	39.50	23.34	41.00	52.39
05130203	Stones*	43.24	34.79	47.85	52.10
08010210	Wolf	61.28	43.69	34.23	50.61
08010209	Loosahatchie*	35.46	23.63	29.93	47.26
06030004	Lower Elk*	46.14	43.98	37.40	46.52
08010211	Horn Lake-Nonconnah*	22.58	61.68	39.28	33.39

STAGE 2 RESULTS

As described in the Approach section, Stage 2 screening is performed on HUC8s individually and compares the HUC12s within a single HUC8 to each other. The much more extensive array of indicators available at HUC12 scale enables more specific targeting of indicators relevant to implementing nutrient management activities. These indicator selections and weights (see indicators in Table 4 and definitions in Attachment 3) were finalized by TDEC and used in the Stage 2 screenings carried out by EPA and Cadmus. Stage 2 screenings were completed on all eight rural-agricultural demonstration HUC8s and all six urban-suburban demonstration HUC8s. These fourteen HUC8 screenings are briefly summarized below, and a single HUC8 from each scenario is included in this document to serve as an example of Stage 2 methods and results. As with the Stage 1 screenings, a separate copy of the RPS tool for each of the 14 demonstration HUC8s in the two scenarios has been archived for delivery to TDEC with other products (see Attachment 4).

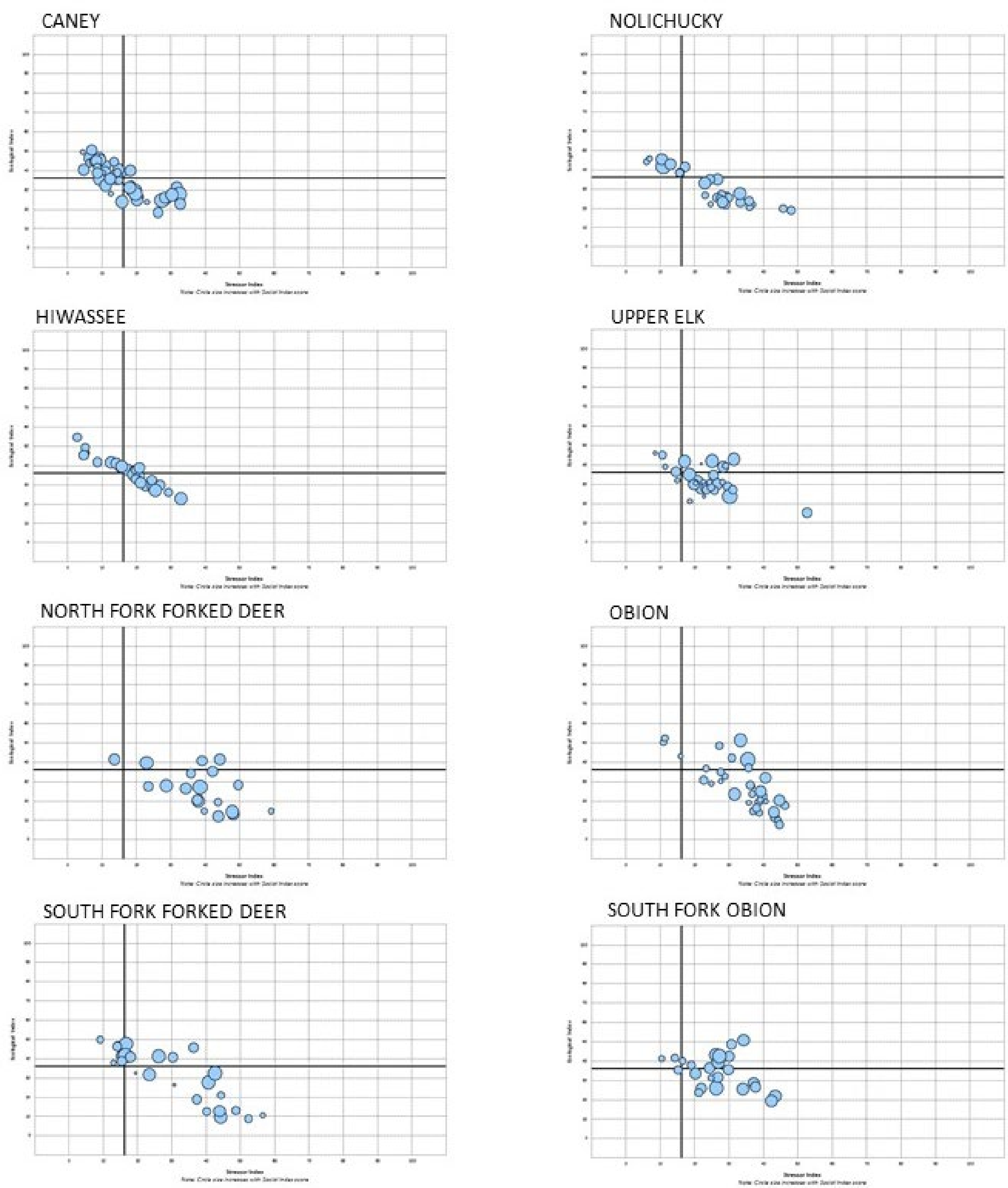
General Observations about Rural-Agricultural Scenario HUC8 Screenings

Eight HUC8s from this scenario were screened individually, enabling the comparison of the HUC12 subwatersheds within each HUC8 based on selected rural-agricultural indicators and weights submitted by TDEC. Figure 10 shows the bubble plots from all eight demonstration HUC8s together. It is important to note that the median lines on each HUC8 plot are the statewide median values for the Ecological and Stressor indices, not the median values for the individual HUC8's subwatersheds. This was done to provide context for the user to generally observe how each HUC12's index scores compare not only to the HUC8's other subwatersheds, but also how they compare to all HUC12s statewide. The RPS Tool provides the option to bubble-plot a subset of watersheds by themselves (i.e., showing scores and median lines only relative to the subset) or to bubble-plot the subset but with reference to statewide scores (i.e., showing the statewide median lines and the subset's scores relative to all statewide watersheds).

Table 4. Stage 2 RPS indicator selections and weights for screening and comparing HUC12 watersheds within HUC8s from the Rural-Agricultural Scenario (upper) and the Urban-Suburban Scenario (lower) in Tennessee. See Attachment 3 for indicator definitions.

Stage 2 Rural-Agricultural Scenario					
Ecological Indicators	**wt**	**Stressor Indicators**	**wt**	**Social Indicators**	**wt**
% Woody Vegetation (2006) in Riparian Zone	3	% Developed, Low intensity (2006) in Riparian Zone	2	% Watershed Streamlength Assessed	1
% Natural Cover, N-index 2 (2006) in HCZ	3	% Agriculture (2006) in Watershed	3	% Watershed Waterbody Area Assessed	1
HCZ Mean Soil Stability	2	% Contiguous Agriculture (2006) in WS	2	Count Ratio TMDLs to Impairments	1
NFHAP Disturbance Index (ISO)	2	% U-Index06 Contiguous H2O, in WS	2	Percent land with any IUCN status	1
		% of Stream length contiguous to 2006 IC ≥ 5% WS	2	% in Source Water Protection Area (ISO)	2
		Empower Density 2001, Mean Value in RZ	2	Watershed Groups (ISO)	1
		Total nitrogen deposition WS	2	Jurisdictional Complexity (ISO)	3
		Synthetic N fertilizer applic (kg N/ha/yr) WS	3		
		% Nutrient Impaired Streams (ISO)	3		
		Watershed 303d + TMDL Impairment Causes Count	3		
Stage 2 Urban-Suburban Scenario					
Ecological Indicators	**wt**	**Stressor Indicators**	**wt**	**Social Indicators**	**wt**
% Woody Vegetation (2006) in Riparian Zone	3	% Developed, Low intensity (2006) in Riparian Zone	2	% Watershed Streamlength Assessed	1
% Natural Cover, N-index 2 (2006) in HCZ	3	% Agriculture (2006) in Watershed	3	% Watershed Waterbody Area Assessed	1
HCZ Mean Soil Stability	2	% Contiguous Agriculture (2006) in Watershed	2	Watershed Count Ratio TMDLs to Impairments	1
NFHAP - Cumulative Disturbance Index (ISO)	2	% U-Index06 Contiguous H2O, in Watershed	2	Percent land with any IUCN status WS	1
		% of Stream length contiguous to 2006 IC ≥ 5% WS	2	% in Source Water Protection Area (ISO)	2
		Empower Density 2001, Mean Value in RZ	2	Watershed Groups (ISO)	1
		Total nitrogen deposition WS	2	Jurisdictional Complexity (ISO)	3
		Synthetic N fertilizer applic (kg N/ha/yr) WS	3		
		% Nutrient Impaired Streams (ISO)	3		
		Watershed 303d + TMDL Impairment Causes Count	3		

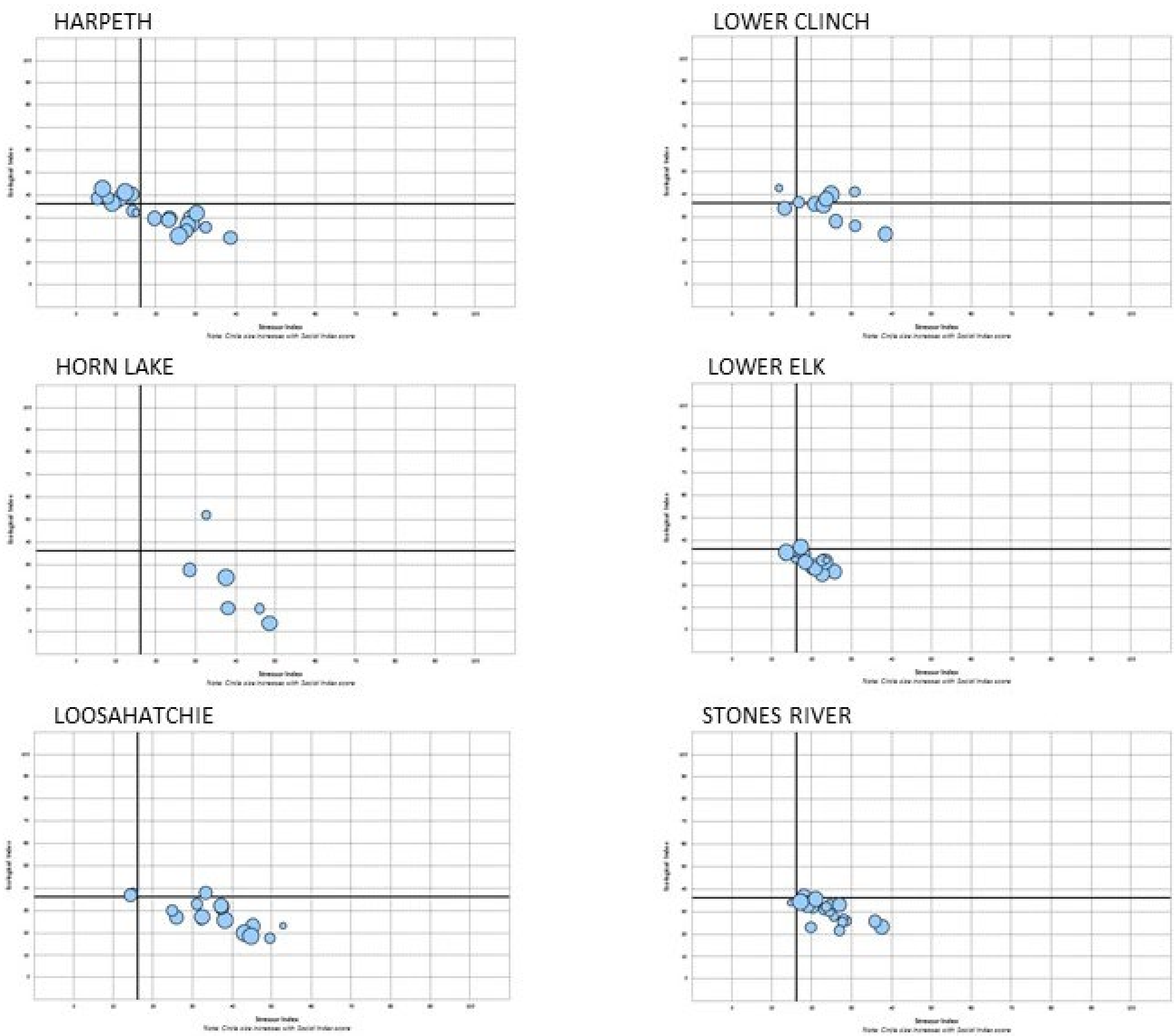
Figure 10. Bubble plots comparing the HUC12s within each demonstration HUC8 from the rural-agricultural scenario. Vertical and horizontal lines on each plot represent the Stressor and Ecological Index median values for all HUC12s statewide, respectively. Comparison to statewide medians reveals that these HUC8s vary markedly in what proportion of their HUC12s have higher than median ecological and stressor scores. Generally, most HUC12s in most of these HUC8s have consistently higher than median stressor scores, but their ecological scores are more variable with respect to the statewide median.



General Observations about Urban-Suburban Scenario HUC8 Screenings

Six HUC8s from this scenario were screened individually, enabling the comparison of the HUC12 subwatersheds within each HUC8 based on selected urban-suburban indicators and weights submitted by TDEC. Figure 11 shows the bubble plots from all six demonstration HUC8s together. It is important to note that the median lines on each HUC8 plot are the statewide median values for the Ecological and Stressor indices, not the median values for the individual HUC8's subwatersheds. This was done to provide context for the user to generally observe how each HUC12's index scores compare not only to the HUC8's other subwatersheds, but also how they compare to all HUC12s statewide.

Figure 11. Bubble plots comparing the HUC12s within each demonstration HUC8 from the urban-suburban scenario. Vertical and horizontal lines on each plot represent the Stressor and Ecological Index median values for all HUC12s statewide, respectively. Comparison to statewide medians reveals that these HUC8s vary markedly in what proportion of their HUC12s have higher than median ecological and stressor scores. Generally, most HUC12s in these HUC8s have consistently higher than median stressor scores, and with few exceptions their ecological scores are close to but below the statewide median.



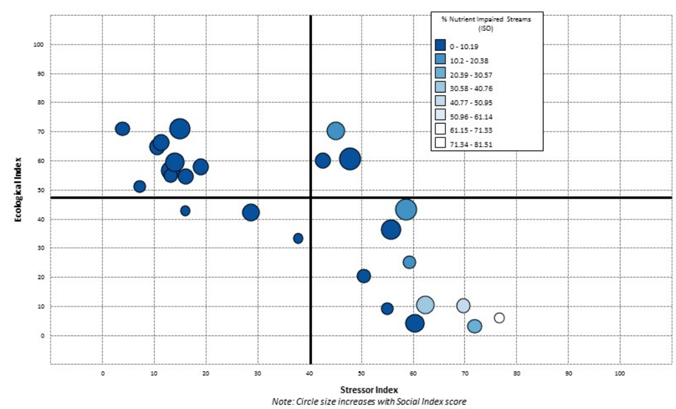
Stage 2 Rural-Agricultural Scenario Screening: South Fork Forked Deer River

The South Fork Forked Deer (SFFD) HUC8 was one of eight demonstration HUC8s selected from the rural-agricultural scenario analysis of Stage 1. Compared with all HUC8s statewide (see again Figure 3), this watershed displays a moderately high stressor score while still retaining a mid-range ecological index score that is higher than many of the rural-agricultural scenario HUC8s. Reexamining Figure 10 further contrasts the SFFD HUC8's subwatersheds with those of other HUC8s from this scenario. For example, almost all of SFFD's HUC12s exceed the statewide stressor median, and some have among the highest Stressor Index scores in the State. In addition, some of its 26 HUC12s (upper left quadrant of plot – quadrants formed by SFFD median lines) scored better than statewide medians in both the Ecological and Stressor indices. Highly variable dot sizes scattered throughout indicates a range in social index score that may present added insights on relative ease or difficulty of taking action.

The variety of conditions across the SFFD's HUC12s is thought provoking and invites further analysis as to how they differ, and what these differences may suggest regarding strategies from place to place. An example series of further analytical steps is offered below. Note that the Stage 2 screening plots below include SFFD, not statewide, medians.

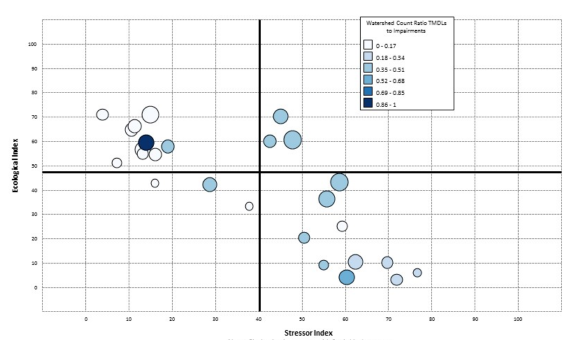
Where are the impairments relative to how the HUCs scored? Regardless of which indicators are used in a screening, the RPS Tool can color-assign a value gradient for any indicator in the data table and use this to gain insights into the bubble plot or map results. In Figure 12, the bubble plot result from the SFFD screening is further enhanced to display relative percent of stream length listed as nutrient-impaired. Seven of the 26 HUC12s have >10% listed for nutrients, and these vary in the proportion of listed streams with the heaviest listings at the lower right end. It is also evident, however, that the ecological and social scores vary widely among these watersheds with listings. Two in particular (upper right) are at or higher than median Ecological score and among the highest Social index scores of the group. If further study continues to reveal positive traits, these HUC12s might be good choices for implementing nutrient management.

Figure 12. South Fork Forked Deer HUC12s nutrients screening output, highlighting HUC12s with the highest nutrients listings as % of total stream length (paler blue shades).



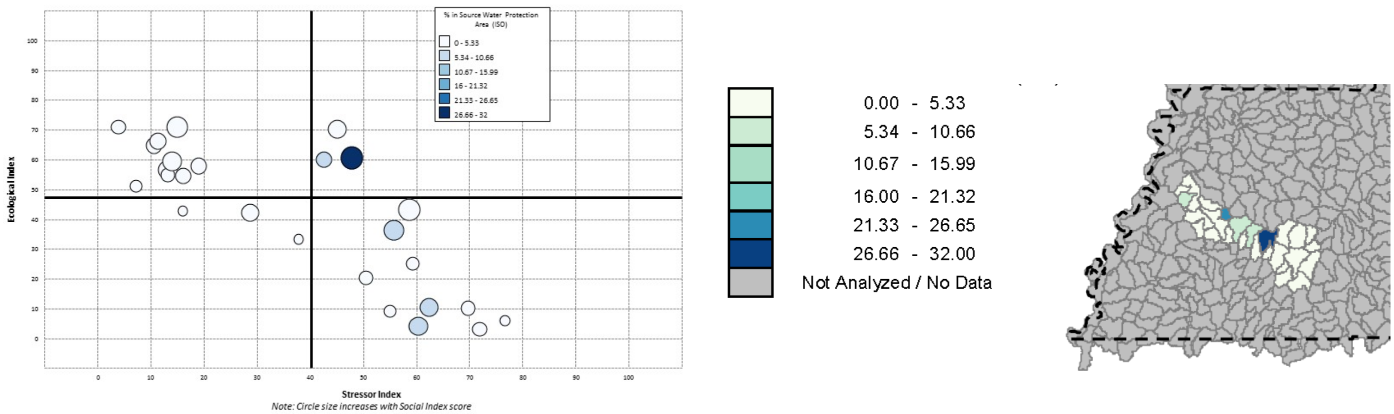
Where are we better prepared for action? In addition to where the impairments are found, the existence of TMDLs and other forms of technical information or plans can be displayed as a factor in RPS bubble plots. Figure 13 shows the SFFD plot output with color assignment based on the ratio of TMDLs to listings across all HUC12s. Note that several of the HUC12s discussed above as having nutrient listings also have TMDLs. Further study might seek to verify whether these are nutrients-relevant TMDLs, and whether other studies or activities (e.g., Nonpoint Source control projects) exist in any HUC12s and might add to their readiness for carrying out implementation actions.

Figure 13. South Fork Forked Deer output highlighting HUC12s with the highest TMDLs to impairments ratio (deepest blue shades).



Are there specific community motivators for some watersheds? Another technique for interpreting screening results is to compare index scores in conjunction with a selected social indicator of high importance to local communities. In Figure 14, the SFFD HUC12s are color-assigned by percent of the watershed that is within drinking water source/groundwater protection areas. As drinking water protection is easily communicated to most communities, this may be a factor in increasing the likelihood of community support for nutrient management control actions in specific watersheds. This comparison reveals that five HUC12s contain some source water/groundwater protection areas, and of these, all five contain some TMDLs and at least one contains nutrients listings (see again Figures 12 and 13). Further, it is noteworthy that all five scored relatively high on the Stressor Index.

Figure 14. South Fork Forked Deer bubble plot and map outputs highlighting HUC12s with the highest percentage in drinking water source and groundwater protection areas (deepest blue shades).



Where would specific types of control practices be appropriate, or effective? Building on questions like the above, continuing analysis may want to use the RPS Tool results to consider in which HUC12s might specific families of control practices be most appropriate while relating this observation to other recovery potential factors. Given that SFFD is one of the rural-agricultural scenario demonstration watersheds, it would be most relevant to compare its HUC12s' values for selected agricultural and low-density residential indicators as well as ecological metrics that may also influence management strategies and practices. In Table 5, selected indicator values of all the SFFD HUC12s are compared via a data table with five selected indicators from the RPS screening. Each indicator is color-assigned in quartiles from highest to lowest value in the order green, yellow, orange, and pink.

For the four stressor metrics (names in red), the highest scores (green cells) help identify HUC12s with the greatest amount of specific activities that may be nutrient sources. Low density residential in the riparian zone, for example, helps identify which HUC12s may be most likely to have loading contributions from leaky septics and residential lawn care runoff. Percent agriculture contiguous with surface waters provides insight into the HUC12s with greater amounts of cropland and pasture that may be appropriate for a variety of nutrient runoff management approaches. Two additional indicators – synthetic Nitrogen fertilizer application and percent human use index – integrate the agricultural and urban contributions and provide an alternative way of comparing the HUC12s. For Table 5's one ecological metric, the values imply HUC12 differences in erosion potential as an additional consideration along with the stressor factors above. These are selected examples of how, due to the ease of data retrieval from the RPS tool, any indicators for any set of watersheds can be compared in numerous ways with little effort in the desktop environment.

Table 5. HUC12 values for five selected indicators from the SFFD screening that may be useful in choice of management strategies and targeted subwatersheds. Each indicator is color-assigned in quartiles from highest to lowest value in the order green, yellow, orange, red. For stressor metrics (red names), the highest scores help identify HUC12s with the greatest amount of specific activities that may be nutrient sources. For the ecological metric, the values imply HUC12 differences in erosion potential as an additional consideration.

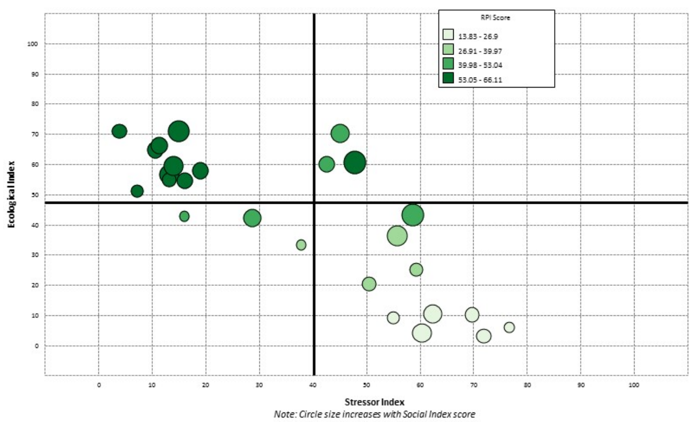
Watershed Name	**Mean Soil Stability in HCZ**	**% Developed, Low intensity in RZ**	**% Agriculture Contiguous H2O in WS**	**Synthetic N fertilizer application in WS**	**% U-Index Contiguous H2O in WS**
Huggins Creek	0.71	0.10	12.31	8.12	23.74
Sugar Creek	0.69	0.18	33.64	9.85	40.34
Jacks Creek	0.73	0.07	19.25	8.62	33.07
Turkey Creek	0.68	0.19	31.31	10.22	43.62
Clark Creek	0.61	0.22	24.25	11.22	41.82
Bear Creek	0.66	0.21	23.53	17.82	29.78
NFF Deer River Upper	0.67	0.00	35.28	18.54	47.20
Middle Fork Creek	0.64	0.01	22.65	12.92	33.51
NFF Deer River Middle	0.61	0.02	25.38	17.19	36.67
NFF Deer River Lower	0.61	0.12	20.78	20.93	32.94
Meridian Creek	0.60	0.40	19.29	18.08	32.07
Jones Creek	0.59	1.42	17.94	17.31	50.99
Johnson Creek	0.58	0.26	21.15	25.65	41.87
Cypress Creek	0.58	0.34	54.55	43.37	66.84
Cub Creek	0.58	0.78	33.68	31.28	54.48
Panther Creek	0.58	0.42	60.78	46.90	74.44
Nixon Creek Upper	0.58	0.75	71.92	48.52	87.19
Meridian Creek	0.57	0.40	83.28	55.44	90.02
Nixon Creek Lower	0.57	0.20	72.92	49.78	80.56
Mud Creek	0.57	0.40	74.55	49.70	82.54
Kail Creek	0.58	0.05	82.22	57.04	91.86
SFFD - Jacks Creek	0.57	0.14	57.16	39.55	63.16
Black Creek	0.56	0.09	82.49	58.95	91.35
Halls Creek	0.54	0.31	68.10	41.09	78.50
Mill Creek	0.57	0.15	67.77	40.95	78.81
SFF Deer River Outlet	0.66	0.23	67.14	39.66	78.66

Which HUC12s should be protected while others are restored? Although the RPS Tool is most often used to assist restoration planning, it is used to identify watershed protection candidates as well. The HUC12s in the SFFD ultimately all contribute to the same drainage, and thus targeted HUC12 protection affects the condition of this HUC8 just as targeted HUC12 restoration efforts do. The healthier HUC12s likely play an important role in attenuating nutrient loads from upstream or contributing cleaner flows that may dilute loads from other HUC12s downstream. When available, healthy watersheds identified from a statewide assessment will provide a highly useful data source for selecting protection priorities. Absent a healthy watersheds assessment and using currently available data, the HUC12s in relatively better condition for protection in a nutrients setting can be found using the RPI score or a selected indicator related to absence of impairment or presence of ecological attributes associated with ability to process nutrients.

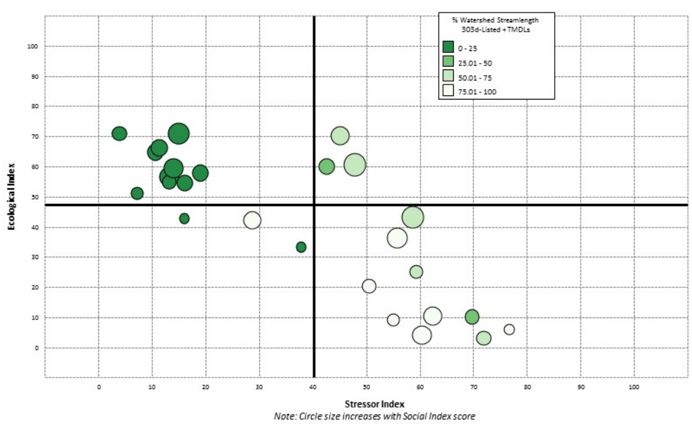
Three such options appear in Figure 15, and all are color-assigned to highlight the best prospects (top quartile) with the darkest shade of green. The first is the RPI Index score, an integrator of ecological, stressor and social factors chosen for

Figure 15. Options for identifying possible HUC12s for protection as part of a South Fork Forked Deer RPS screening to inform nutrients management (darkest green are best candidates). A: the RPI Index score from the nutrients screening; B: percent stream length with listings or TMDLs; C: percent natural cover in watershed. All point to many of the same HUC12s (upper left quadrant).

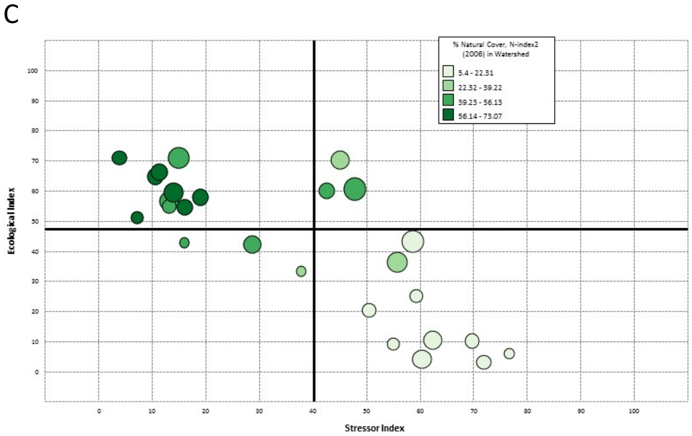
A



B



C



this screening to be relevant to nutrients management, whose high end scores may serve as a single predictor of the best protection candidates given a broad range of considerations. Although most of the best HUC12s cluster in or near the upper left quadrant of the plot where low stressor and high ecological scores combine, one HUC12 with a significantly higher Stressor index score is evident, probably balanced by its high Social index score (large dot). This HUC12 may merit protection with the others while being more vulnerable.

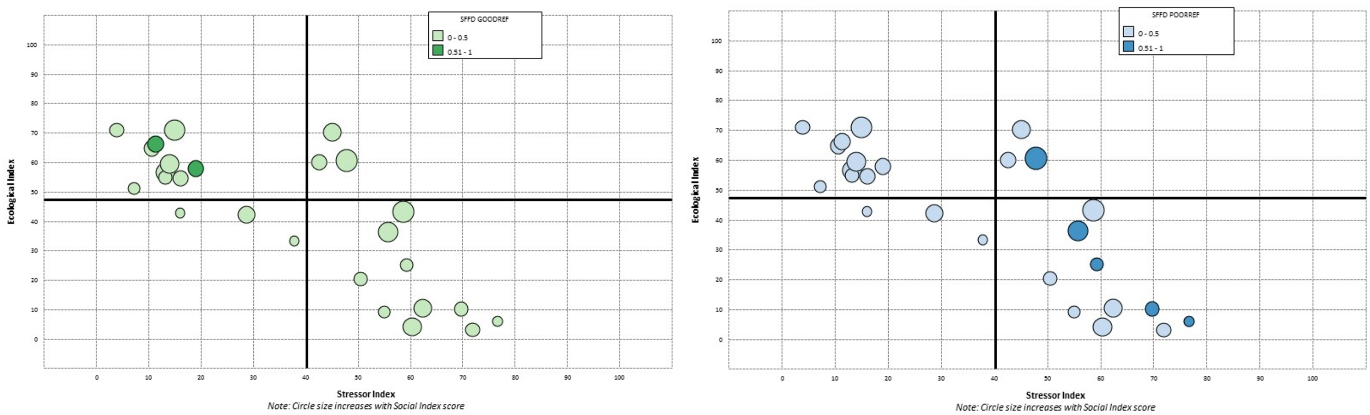
A second option uses a stressor indicator, percent stream length with listings and/or TMDLs, to detect the reportedly less-impaired HUC12s. This indicator was not used in the screening, but any indicators in the dataset are available for displaying with the screening results in the RPS Tool. Best prospects for protection based on this indicator again cluster in or near the upper left quadrant. A third option offered in Figure 15 examines one ecological indicator, the percent natural cover in the watershed, as a determinant for protection potential. This metric as well points to many of the same prospects as the others discussed above.

Does the screening make sense overall? Although all RPS indicators are QA/QC'ed during and after compilation individually, it is appropriate to test any RPS screening result as the product of selected indicators and formulae together. The usefulness of any screening is dependent on the relevance of the indicators selected to the purpose of the screening. If the indicators for a given screening purpose are performing as intended, 'good reference' HUC12s and 'poor reference' HUC12s from the 26 SFFD HUCs being screened should have predictably good and poor index scores, respectively. To test the screening result in this manner, indicators preferably independent from those in the screening but likely associated with relatively good or poor reference condition are selected and compared with the SFFD screening output.

Identifying suitable 'good reference' HUCs from the 26 involved in the screening relied on a combination of four indicators: % streams assessed, % forest in watershed, % national ecological framework, and unimpaired stream miles. Two suitable HUCs were selected using these criteria; although more may have been desirable, requiring a minimum % assessed limited qualifying HUCs. Suitable 'poor reference' HUCs were identified through a different set of indicators: % streams assessed, number of impairment causes, % urban in watershed, and % human use index in the riparian zone. Five HUCs met these criteria as assessments appeared to be more focused on the more impacted HUCs of the SFFD.

Figure 16 shows the results of plotting both types of reference HUC12s against the full set of SFFD HUC12s. Generally, their relative scores appear as expected with respect to all SFFD HUC12s. Avoiding use of indicators already used in the screening, and limiting the use of HUCs with less field assessment, may have prevented the identification of stronger (or additional) good and poor reference HUC12s but improved the independence of this verification step.

Figure 16. Testing ‘good reference’ (left) and ‘poor reference’ (right) HUC12s in association with the South Fork Forked Deer RPS screening results. Most intensely colored dots in each plot are the reference HUCs. Selection of good and poor reference HUCs was made only from HUC12s within the South Fork Forked Deer HUC8, and was based on indicators not used in the Stage 2 screening. Thus, ‘good’ and ‘poor’ are relative to this subset of HUC12s only.



<u>Stage 2 Urban-Suburban Scenario Screening: Stones River</u>

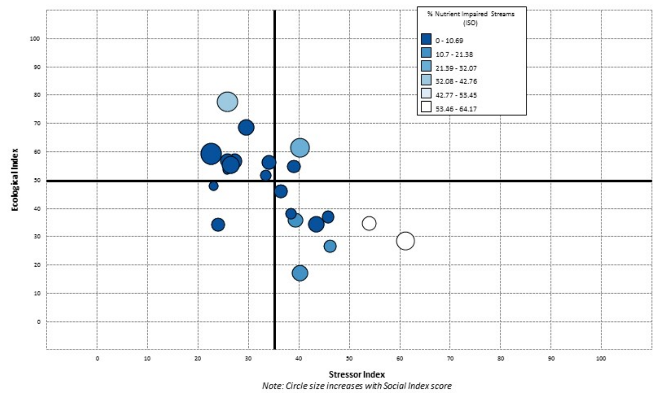
The Stones River HUC8 was one of six demonstration HUC8 selections from the urban-suburban scenario analysis of Stage 1. Compared with all HUC8s statewide (see again Figure 7) and other scenario and demonstration HUC8s, this watershed displays a moderately high stressor score and a lower than median ecological index score typical of many of the urban-suburban scenario HUC8s. Reexamining Figure 11 further contrasts the Stones HUC8’s HUC12s with those of other HUC8s from this scenario. For example, like other demonstration HUC8s, the Stone River HUC12s as a group combine consistently high stressor scores with Ecological Index scores mostly at or below the statewide median.

Looking closer at Figure 11, none of the Stones River’s 22 HUC12s scored ‘better’ (i.e., high eco, low stressor) than statewide medians in both the Ecological and Stressor indices (upper left quadrant of plot is blank). Many HUC12s in the Stones display high stressor scores compared with statewide conditions. A few HUC12s scored near the Ecological index statewide median (horizontal line), and variable dot sizes scattered throughout indicates a range in Social Index score that may present added insights on relative ease or difficulty of taking action. In fact, typical of suburban watersheds, some HUC12s appear to maintain high Social Index scores while also potentially being vulnerable to elevated stressors.

The variety of conditions across the Stones HUC12s invites further analysis as to how they differ, and what these differences may suggest regarding strategies for action. An example series of further analytical steps is offered below. Note that the Stage 2 screening plots below include Stones HUC12s, not statewide, medians.

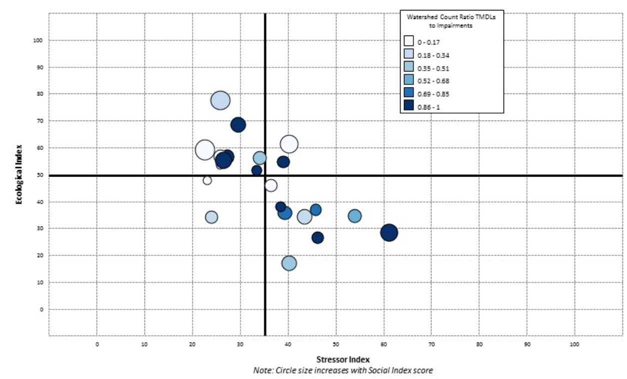
<u>*Where are the impairments relative to how the HUCs scored*</u>? In Figure 17, the bubble plot result from the Stones HUC8 screening is further enhanced to display the relative percent of stream length listed as nutrient-impaired. Seven HUC12s contained 10% or greater nutrients-listed stream length. Not surprisingly, these include several in the lower right quadrant of the plot (high stressor and low ecological scores), but two HUC12s that met this criterion also exhibit both Ecological and Social index scores well above the statewide medians. As an early impression, these two HUC12s may be more promising candidates for taking action based on their ecological and social positives.

Figure 17. Stones HUC12s nutrients screening output, highlighting HUC12s with the highest nutrients listings as % of total stream length (paler blue shades).



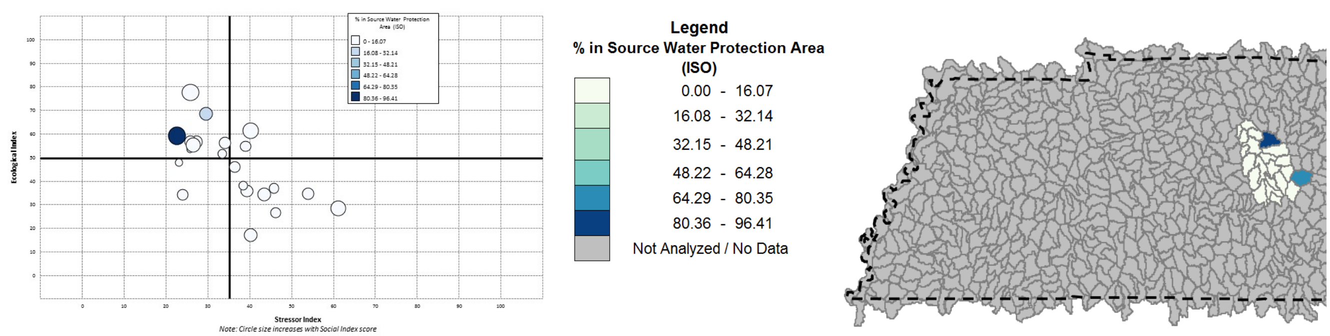
<u>*Where are we better prepared for action*</u>? In addition to where the impairments are found, the existence of TMDLs and other forms of technical information or plans can be displayed as a factor in RPS bubble plots. Figure 18 shows the Stones River HUC8 plot output with color assignment based on the ratio of TMDLs to listings across all HUC12s. Note that TMDL availability to guide action is extensive and includes many of the HUC12s noted in Figure 17 as having more extensive listings. Further study might seek to verify whether these are nutrients-relevant TMDLs, and whether other studies or activities (e.g., Nonpoint Source control projects) exist in any HUC12s and might add to their readiness for carrying out implementation actions.

Figure 18. Stones River RPS output highlighting HUC12s with the highest TMDLs to impairments ratio (deepest blue shades).



<u>*Are there specific community motivators for some watersheds*</u>? Another technique for interpreting screening results is to compare index scores in conjunction with a selected social indicator of high importance to local communities. In Figure 19, the Stones River HUC12s are color-assigned by percent of the watershed that is within drinking water source protection areas. As drinking water protection is easily communicated to most communities, this may be a factor in increasing the likelihood of community support for nutrient management control actions in specific watersheds. This comparison reveals that, although most Stones HUC12s do not play a role in source water protection, two do in greater than 50% of their total area. As one of these has nutrient TMDLs, its role in drinking water protection may be an important asset in developing community support for nutrient management efforts.

Figure 19. Stones River bubble plot and map outputs highlighting HUC12s with the highest percentage in drinking water source protection areas (deepest blue shades).



<u>*Where would specific types of control practices be appropriate, or effective*</u>? Building on questions like the above, continuing analysis can apply the RPS Tool results to consider where specific types of control practices might be most appropriate while relating this observation to other recovery potential factors. Given that Stones River is one of the urban-suburban scenario demonstration watersheds, it would be most relevant to compare its HUC12s' values for selected stressor indicators as well as ecological metrics that may also influence management strategies and practices. In Table 6, selected indicator values of all the Stones HUC12s are compared via a data table with selected indicators from the RPS screening. Each indicator is color-assigned in quartiles from highest to lowest value in the order green, yellow, orange, and red.

Table 6. HUC12 values for five selected indicators from the Stones River screening that may be useful in choice of management strategies and targeted subwatersheds. Each indicator is color-assigned in quartiles from highest to lowest value in the order green, yellow, orange, red. For stressor metrics (red names), the highest scores help identify HUC12s with the greatest amount of specific activities that may be nutrient sources. For the ecological metric, the values imply HUC12 differences in woody vegetation near streams as an additional consideration associated with better bank stability and runoff filtration than urban lawns or impervious cover.

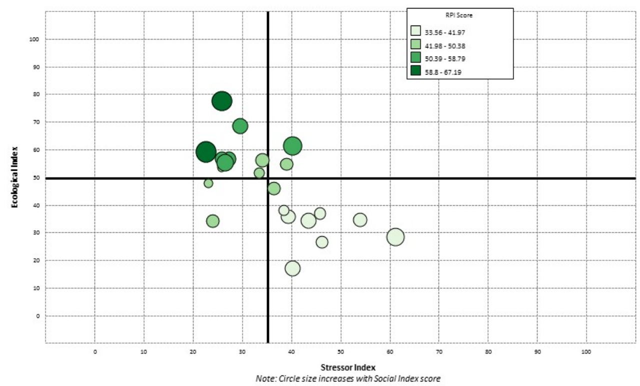
Watershed Name	% Woody Vegetation in RZ	% Developed, Low intensity in RZ	% Agriculture in WS	% U-Index06 Contiguous H2O, in WS	% of Stream length contiguous to IC ≥ 5% WS	Synthetic N fertilizer application in WS
Brawleys Fork	10.85	0.17	26.19	26.58	16.69	10.96
East Fork Stones River-Hollis Creek	13.53	0.37	26.56	29.23	23.73	11.16
Cripple Creek	6.00	0.11	36.28	37.79	10.75	6.53
East Fork Stones River-McKnight Branch	8.52	0.08	42.41	44.10	10.07	11.09
Bradley Creek	5.21	0.17	54.92	56.18	9.87	9.51
East Fork Stones River-Bear Branch	3.45	0.76	38.46	60.46	16.88	6.92
East Fork Stones River-Wades Branch	6.49	0.36	36.07	50.51	10.90	6.49
Middle Fork Stones River Headwaters	9.64	0.67	35.26	39.94	17.66	6.37
Middle Fork Stones River	7.56	0.66	46.36	59.09	19.16	8.34
Lytle Creek	4.68	1.41	40.20	71.83	25.82	7.24
Overall Creek	3.75	0.54	42.38	61.09	33.15	7.63
West Fork Stones River Upper	7.95	0.26	48.44	55.69	11.10	8.71
West Fork Stones River Lower	5.13	1.63	28.23	77.29	42.11	5.08
Stewart Creek	6.46	1.15	23.49	49.50	21.77	4.24
Fall Creek	5.89	0.13	39.22	41.43	13.65	5.72
Spring Creek	4.19	0.12	36.28	44.03	11.96	5.14
Hurricane Creek	5.53	3.19	12.65	61.88	62.21	2.38
Stones River Upper	10.96	0.37	13.72	33.03	31.53	2.43
Suggs Creek	7.71	0.18	42.23	47.95	11.20	5.97
Stones River Middle	9.17	1.51	4.34	25.56	65.84	0.83
Stoner Creek	6.34	2.60	19.44	64.39	38.62	2.92
Stones River Lower	8.10	2.21	14.13	62.94	26.40	2.68

For the stressor metrics (names in red), the highest scores (green cells) help identify HUC12s with the greatest amount of specific activities that may be nutrient sources worth addressing. These included low intensity development close to streams, the proximity of impervious cover that may accelerate and deliver urban runoff, the percent agriculture in the watershed (still a contributing factor in the urban-suburban scenario), and two integrative metrics (percent human use index contiguous with surface waters, and synthetic fertilizer application) that further clarify where specific control practices might best be applied to address significant nutrient sources. The ecological metric, percent woody vegetation in the riparian zone, offers insight into HUC12s with better bank stability and runoff filtration than urban lawns or impervious cover as an added consideration when planning management approaches.

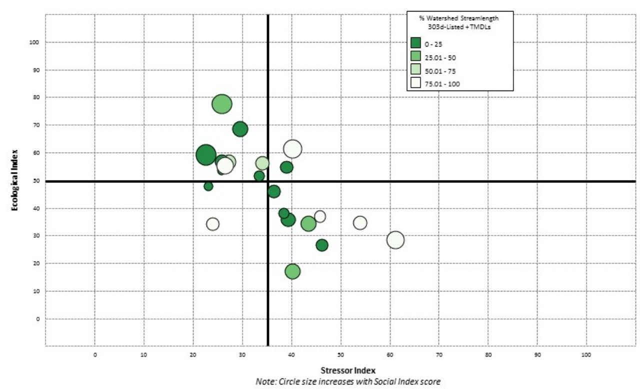
<u>*Which HUC12s should be protected while others are restored*</u>? Although the RPS Tool is most often used to assist restoration planning, it is used to identify watershed protection candidates as well. The HUC12s in the Stones HUC8 ultimately all contribute to the same drainage, and thus targeted HUC12 protection affects the condition of this HUC8 just as targeted HUC12 restoration efforts do. The healthier HUC12s likely play an important role in attenuating nutrient loads from upstream or contributing cleaner flows that may dilute loads from other HUC12s downstream. When available, healthy watersheds identified from a statewide assessment will provide a highly useful data source for selecting protection priorities. Absent a healthy watersheds assessment and using currently available data, the HUC12s in relatively better condition for protection in a nutrients setting can be found using the RPI score or a selected indicator related either to absence of impairment or presence of ecological attributes associated with greater ability to process nutrients. In an urban-suburban dominated watershed, truly healthy subwatersheds (e.g., HUC12s well into the low stressors – high ecological quadrant of the RPS bubble plot) may not exist or be the focus of protection efforts, yet protection of the relatively best HUC12s remains crucial for the recovery of the larger watershed even in impacted scenarios.

Figure 20. Options for identifying possible HUC12s for protection as part of a Stones River RPS screening to inform nutrients management (darkest green are best candidates). A: the RPI Index score from the nutrients screening; B: percent stream length with listings or TMDLs; C: percent natural cover in watershed. All point to many of the same HUC12s (upper left quadrant).

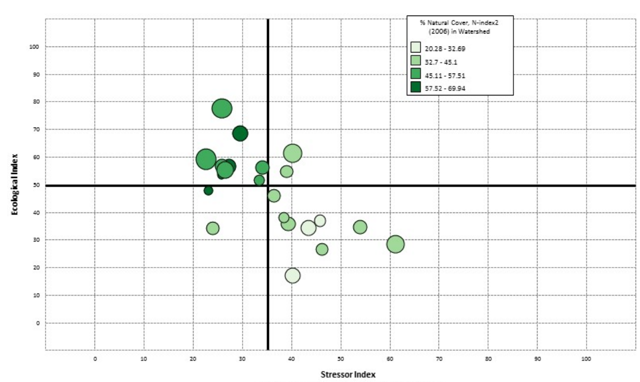
A



B



C



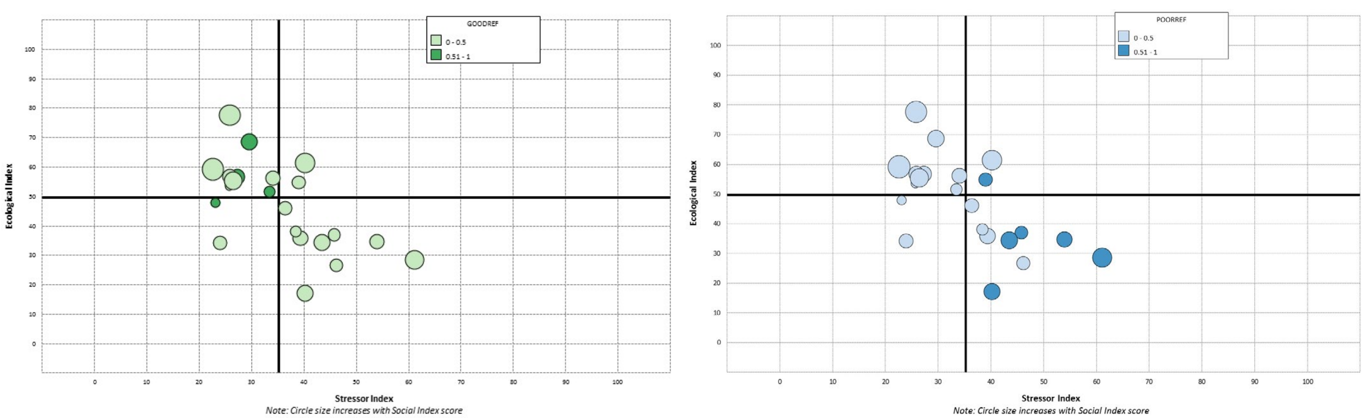
Three such options for considering protection priorities appear in Figure 20, and all are color-assigned to highlight the best prospects (top quartile) with the darkest shade of green. The first is the RPI Index score, an integrator of ecological, stressor and social factors chosen for this screening to be relevant to nutrients management, whose high end scores may serve as a single predictor of the best protection candidates given a broad range of considerations. In the Stones HUC8, one promising feature is the co-occurrence of high Ecological and Social index scores in several HUC12s. These watersheds may be good protection prospects.

A second option uses a stressor indicator, percent stream length with listings and/or TMDLs, to detect the less-impaired HUC12s. This indicator was not used in the screening, but all indicators are available for displaying the screening results in the RPS Tool. Several HUC12s denoted by dark green in Figure 20B have lower proportions of stream length impaired, providing another possible basis for protection choices.

A third option offered in Figure 20 examines an ecological indicator, the percent natural cover in the watershed, as a determinant for protection potential. Few HUC12s in this urban-suburban HUC8 would be expected to have substantial natural cover, but these should be recognized for their contribution to the HUC8's overall health and prospects for nutrient management and recovery.

Does the screening make sense overall? As discussed in the South Fork Forked Deer screening example, it is appropriate to test any RPS screening result as the product of selected indicators and formulae together. The usefulness of any screening is dependent on the relevance of the indicators selected to the purpose of the screening. If the indicators for a given screening purpose (urban-suburban nutrients management) are performing as intended, 'good reference' HUC12s and 'poor reference' HUC12s from the 22 Stones River HUC12s being screened should have predictably good and poor index scores, respectively. To test the screening result in this manner, indicators preferably independent from those in the screening but likely associated with relatively good or poor reference condition are selected and compared with the Stones River screening output. The results, presented in Figure 21, are generally as expected for good and poor reference watersheds selected from within the 22 Stones River HUC12s -- most bear urbanization impacts yet some retain ecologically useful structure to varying degrees. As with the South Fork Forked Deer screening, avoiding use of indicators already used in the screening may have prevented the identification of stronger good and poor reference HUC12s but improved the independence of this verification step.

Figure 21. Testing 'good reference' (left) and 'poor reference' (right) HUC12s in association with the Stones River RPS screening results. Most intensely colored dots in each plot are the reference HUCs. Selection of good and poor reference HUCs was made only from HUC12s within the Stones River HUC8, and was based on indicators not used in the Stage 2 screening. Thus, 'good' and 'poor' are relative to this subset of HUC12s only.



SUMMARY AND RECOMMENDATIONS

This document summarizes the usage of Recovery Potential Screening (RPS) to compare watersheds at two scales (HUC8 and HUC12) for purposes of informing possible watershed management options and priorities for nutrient management. Utilizing georeferenced data provided primarily by TDEC, EPA and additional sources, this project compiled 310 indicators (base, ecological, stressor and social) at one or both watershed scales that were used to screen and compare watersheds in a two-stage process. In the first stage, Tennessee's 57 HUC8s were screened with two separately developed sets of indicators selected to identify initial focus groups of rural-agricultural watersheds and urban-suburban watersheds with nutrient management challenges. Based on these first stage screenings and other criteria, eight of twenty rural-agricultural watersheds and six of thirteen urban-suburban watersheds were selected as demonstration HUC8s for further analysis in the second stage.

Stage two screenings were performed on each of the fourteen demonstration HUC8s, and scored and compared each HUC8's component HUC12s using more detailed sets of indicators that drew from HUC12-scale metrics. Whereas the purpose of Stage 1 was to compare and recognize like groups of scenario watersheds at the larger scale, Stage 2's purpose was to examine and reveal potential opportunities for nutrient management action at the more localized

HUC12 scale. As a demonstration of the RPS Tool, no priorities among HUC12s were selected in this project but numerous alternatives and analytical techniques were presented in one Stage 2 screening from each of the two Stage 1 demonstration groups. Products include this summary report, a master RPS Tool file, and sixteen separate screening files that archived the results from the two Stage 1 screenings, the eight Stage 2 rural-agricultural watershed screenings, and the six urban-suburban watershed screenings. Opportunities for TDEC and other users from this point forward may include:

Become adept at RPS Tool desktop use. Despite the extensive amount of data it holds and the wide variety of comparisons among watersheds that these data can support, the RPS Tool is actually a fairly simple spreadsheet tool. As novice users of Excel far outnumber GIS specialists, for many more people this tool opens the door to simple but useful forms of spatial data analysis, systematic comparisons among watersheds, and a variety of visualization tools – on their own desktops. A wider circle of users will be able to perform quick 'what-if' screenings to compare watersheds on the spur of the moment and gain insights on what may be worth a greater investment of time and effort with more technical analytical tools.

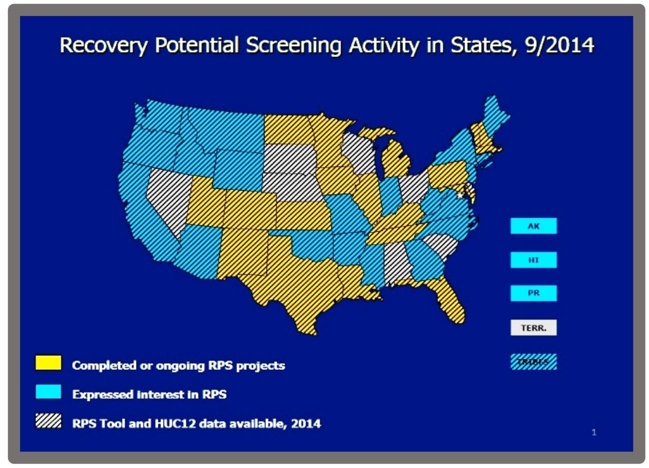
Apply the RPS Tool to other screening topics. Although this effort focused on a nutrients application of RPS, the Tennessee dataset would support numerous other screening themes and purposes that can be explored in the interest of long-term priority setting for restoration and protection. Other screening topics might include sediment, metals, pathogens, or any other prominent cause of impairment. Or in contrast, screenings might focus on a valued resource such as watersheds with coldwater fisheries, or drinking water sources, or major outdoor recreational sites. The RPS Tool might be used to develop a first-cut identification of healthy watersheds for protection, or rank likely eligibility for specific types of pollution control incentives. With both the TMDL Program and the Non-Point Source Control Program promoting watershed priority-setting, the range of opportunities is widespread.

Refine the available data and selection of indicators. Even within this nutrients application of RPS, opportunities always exist to add more relevant data or refine previous screenings as new insights are gained. The RPS Tool is structured to accept additional indicator data from a user that can then be made part of future screenings. New data needn't be statewide, and a local user may still use the tool after adding new data for a limited set of their local subwatersheds. Further, previous analyses can be refined by structured group processes to assign consensus weights to indicators, or by correlation analyses designed to narrow down indicator selections and better differentiate watersheds. For example, varying Tennessee's available HUC8 indicators and re-screening would allow for considering nutrient delivery to the Gulf of Mexico as well as comparing HUC8s based on instate effects only.

Galvanize state/local restoration and protection dialogue and partnering. RPS offers a mechanism for state-local collaboration. Rather than assume that the RPS indicators are a static dataset, or that the HUC8 screenings shouldn't be additionally adjusted or customized, further tailoring to the circumstances and data of each locale is appropriate and encouraged. Some HUC8s may host watershed groups, researchers and other sources of continued analysis and refinement of the available indicators and techniques that can be accommodated by this versatile tool. Further, if local organizations do engage with TDEC and enhance their RPS Tool copies, they may provide valuable dialogue on addressing local as well as statewide interests in watershed priority-setting and improved nutrient management.

Attachment 1

RECOVERY POTENTIAL SCREENING: SUMMARY



- Recovery Potential Screening (RPS) is a systematic, comparative method for identifying differences among watersheds that may influence their relative likelihood to be successfully restored or protected. The EPA Office of Wetlands, Oceans and Watersheds (OWOW) created RPS jointly with the EPA Office of Research and Development (ORD) in 2004 to help states and others use limited restoration resources wisely, with an easy to use tool that is customizable for any geographic area of interest and a variety of specific comparison and prioritization purposes.
- The main programmatic basis for RPS includes the TMDL Program (e.g., prioritized schedule for listed waters; where best to implement TMDLs; Integrated Reporting of Priority waters under the TMDL Vision) and the Nonpoint Source Program (e.g., annual program strategies; prioritization to aid project funding decisions; collaboration with Healthy Watersheds), but several other affiliations also exist.
- Since 2005, several hundred RPS indicators have been incrementally compiled through literature review, identifying states' indicator needs and preferences, and collaboration with others (ORD EnviroAtlas, Region 4 Watershed Index). Most have been applied in a series of statewide RPS projects. In 2009, an RPS paper was published in the refereed journal *Environmental Management*. The one-stop RPS Website hosts a library of indicators, RPS tools, case studies and step by step RPS instructions.
- As of September 2014, RPS projects and statewide databases have been either initiated or completed in 20 states (**see figure**). Approximately that many additional states have expressed interest in RPS usage, but Branch resources have not previously been able to support these requests.
- The RPS Tool is key to RPS' ease of use, widespread applicability and speed. This tool is an Excel spreadsheet that contains all watershed indicators, auto-calculates key indices, and generates rank-ordered tables, bubble plot graphics and maps that can be user-customized. Any novice Excel user can quickly become fluent in using the RPS Tool.
- Statewide RPS Tools and data have now been developed for each of the lower 48 states. These contain 207 indicators measured for every HUC12, and enable customizable desktop screening, rank ordering, graphics plotting and mapping without advanced software or training. Individual, state-specific RPS Tools were distributed to every lower 48 state and all EPA Regions in July 2014 (HI and AK in planning).
- RPS is playing/may soon play a pivotal role in each of the following:
  - Prioritizing watersheds for nutrient management (projects in 9 states)
  - Identifying state priority watersheds for TMDL Vision/Integrated Reporting 2016-2022
  - Improving state/local interactions in states with RPS projects
  - Enabling Tribes to screen and compare their watersheds for purposes similar to states
  - Helping the Healthy Watersheds program by providing a national preliminary assessment
  - Jointly (OW and EPA Region 4) creating the Watershed Index Online (WSIO) interactive tool
- Contact: Doug Norton, WB/AWPD/OWOW at norton.douglas@epa.gov or 202-566-1221.

Attachment 2: TN Stage 1 Rural-Agricultural and Urban-Suburban Scenario Indicator Descriptions

(Note: Green denotes ecological, red is stressor, blue is social. WS in indicator name always means based on watershed; HCZ always means based on hydrologically connected zones in the watershed; RZ always means based on 100-meter per side riparian zones in the watershed.)

HUC8 METRIC	DESCRIPTION
%NINDEX1WS	Watershed percent of total HUC area in natural land cover categories (land and water) including NLCD06 water and ice 11, 12; forested 41, 42, 43; shrub 52; grassland 71; wetlands 90 and 95. Differs from NINDEX2 by not including barren/rock/desert/mining; NINDEX1 is appropriate for use when mining cover types are a significant proportion of non-vegetated cover.
%NINDEX2WS	Watershed percent of total HUC area in natural land cover categories (land and water) including NLCD06 water and ice 11, 12; barren 31; forested 41, 42, 43; shrub 52; grassland 71; wetlands 90 and 95. Differs from NINDEX1 by including barren/rock/desert/mining, appropriate for use when non-mining cover types predominate.
%NEFWS	Watershed percent of total area within Region 4 Watershed Index's National Ecological Framework (NEF) of hydrologically significant and connected natural cover hubs and corridors.
%NINDEX1HCZ	Hydro connected zone percent of total HUC area in natural land cover categories (land and water) including NLCD06 water and ice 11, 12; forested 41, 42, 43; shrub 52; grassland 71; wetlands 90 and 95. Differs from NINDEX2 by not including barren/rock/desert/mining; NINDEX1 is appropriate for use when mining cover types are a significant proportion of non-vegetated cover.
%NINDEX2HCZ	Hydro connected zone percent of total HUC area in natural land cover categories (land and water) including NLCD06 water and ice 11, 12; barren 31; forested 41, 42, 43; shrub 52; grassland 71; wetlands 90 and 95. Differs from NINDEX1 by including barren/rock/desert/mining, appropriate for use when non-mining cover types predominate.
%NINDEX1RZ	Riparian zone percent of total HUC area in natural land cover categories (land and water) including NLCD06 water and ice 11, 12; forested 41, 42, 43; shrub 52; grassland 71; wetlands 90 and 95. Differs from NINDEX2 by not including barren/rock/desert/mining; NINDEX1 is appropriate for use when mining cover types are a significant proportion of non-vegetated cover.
%NINDEX2RZ	Riparian zone percent of total HUC area in natural land cover categories (land and water) including NLCD06 water and ice 11, 12; barren 31; forested 41, 42, 43; shrub 52; grassland 71; wetlands 90 and 95. Differs from NINDEX1 by including barren/rock/desert/mining, appropriate for use when non-mining cover types predominate.
%WOODYRZ	Percent of total HUC riparian zone area in NLCD06 forested or woody (e.g. shrub) land cover categories 41, 42, 43, 52 and 90.
INV_RENANIAB	The ratio of pre-European N inputs (natNfix + Nat_OxN) to recycled anthropogenic N inputs. Inverse of original ORD metric.
INV_NENANIAB	The ratio of pre-European N inputs (natNfix + Nat_OxN) to new anthropogenic N inputs. Inverse of original ORD metric.
NFHAPINDEX	Likelihood of suitable fish habitats, based on Cumulative Disturbance Index from National Fish Habitat Action Plan Assessment

HUC8 METRIC	DESCRIPTION
%UINDEX1WS	Percent of total HUC area in human-managed land cover, as represented by NLCD06 urban land cover categories 22,23, 24 plus agricultural categories 81 and 82.
%UINDEX2WS	Percent of total HUC area in human-managed land cover, as represented by NLCD06 urban land cover categories 21,22,23, 24 plus agricultural categories 81 and 82. This version of UINDEX includes category 21, which is an assortment of urban open space categories such as schools and hospitals with extensive lawn and maintained grounds.
MEAN EMPOWERDENSITYWS	Watershed: Values of transformities have been worked out for very many processes in the environment. Based on these values, we can calculate the emergy flow (empower) and emergy flow per unit area (empower density) for the land use characteristics of various landscape types. The non-renewable emergy flow (primarily from fossil fuels) drives our economy and structures our built infrastructure. By applying the transformities of various land use types, we can assign an empower density to the National Land Cover Database. When this is mapped, it gives a good idea of human disturbance on the landscape.
MEAN EMPOWERDENSITYHCZ	Hydro connected zone: Values of transformities have been worked out for very many processes in the environment. Based on these values, we can calculate the emergy flow (empower) and emergy flow per unit area (empower density) for the land use characteristics of various landscape types. The non-renewable emergy flow (primarily from fossil fuels) drives our economy and structures our built infrastructure. By applying the transformities of various land use types, we can assign an empower density to the National Land Cover Database. When this is mapped, it gives a good idea of human disturbance on the landscape.
MEAN EMPOWERDENSITYRZ	Riparian zone: Values of transformities have been worked out for very many processes in the environment. Based on these values, we can calculate the emergy flow (empower) and emergy flow per unit area (empower density) for the land use characteristics of various landscape types. The non-renewable emergy flow (primarily from fossil fuels) drives our economy and structures our built infrastructure. By applying the transformities of various land use types, we can assign an empower density to the National Land Cover Database. When this is mapped, it gives a good idea of human disturbance on the landscape.
%TOTALAGRWS	Watershed % of total area in cropland or pasture according to 2006 National Land Cover Dataset
%TOTALAGRHCZ	Hydro connected zone % of total area in cropland or pasture according to 2006 National Land Cover Dataset
%TOTALAGRRZ	Riparian zone % of total area in cropland or pasture according to 2006 National Land Cover Dataset
%TOTALURBANWS	Watershed % of total area in low, medium and high density urban use according to 2006 National Land Cover Dataset
%TOTALURBANHCZ	Hydro connected zone % of total area in low, medium and high density urban use according to 2006 National Land Cover Dataset
%TOTALURBANRZ	Riparian zone % of total area in low, medium and high density urban use according to 2006 National Land Cover Dataset
COUNT OF LIKELY N/P DISCHARGERS	From EPA's NPDAT website, the HUC8's number of NPDES-permitted dischargers whose permits contained terms related to nutrient discharge limits
AGR WATER USE	From EPA/ORD EnviroAtlas, agricultural usage estimates aggregated from HUC12 scale data
DOMESTIC WATER USE	From EPA/ORD EnviroAtlas, domestic water usage estimates aggregated from HUC12 scale data

HUC8 METRIC	DESCRIPTION
SPARROW N YIELD INCREMENTAL	From EPA's NPDAT website, NPDAT provides yields for Mississippi River Basin HUCs only [published in Robertson et al. (2009) (http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2009.00310.x/suppinfo)]. Output from several other SPARROW efforts available from SPARROW Decision Support System.
SPARROW N YIELD DELIVERED	From EPA's NPDAT website, NPDAT provides yields for Mississippi River Basin HUCs only [published in Robertson et al. (2009) (http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2009.00310.x/suppinfo)]. Output from several other SPARROW efforts available from SPARROW Decision Support System.
SPARROW P YIELD INCREMENTAL	From EPA's NPDAT website, NPDAT provides yields for Mississippi River Basin HUCs only [published in Robertson et al. (2009) (http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2009.00310.x/suppinfo)]. Output from several other SPARROW efforts available from SPARROW Decision Support System.
SPARROW P YIELD DELIVERED	From EPA's NPDAT website, NPDAT provides yields for Mississippi River Basin HUCs only [published in Robertson et al. (2009) (http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2009.00310.x/suppinfo)]. Output from several other SPARROW efforts available from SPARROW Decision Support System.
NEW SPARROW AGR N YIELD	Recalculation of SPARROW results for N incremental yield estimation developed in 2012-2013 at HUC12 scale using newer data; HUC12 data aggregated to HUC8 scale.
NEW SPARROW AGR P YIELD	Recalculation of SPARROW results for P incremental yield estimation developed in 2012-2013 at HUC12 scale using newer data; HUC12 data aggregated to HUC8 scale.
HUC8TOTRECYCN	The total recycled N rate (TOTRECYCNRATE) times the HUC8 area, then adjusted for better area reporting units.
HUC8RECYCNEFFORT	The value of TOTRECYCNEFFORT adjusted to consider HUC8 size; calculated by HUC8 area times TOTRECYCNEFFORT, then adjusted for better area reporting units. This metric estimates effort to achieve recycled N reductions for the whole HUC8 as influenced by both effort per unit area and size.
HUC8TOTNEWN	The total new N rate (TOTNEWNRATE) times the HUC8 area, then adjusted for better area reporting units.
HUC8NEWNEFFORT	The value of TOTNEWNEFFORT adjusted to consider HUC8 size; calculated by HUC8 area times TOTNEWNEFFORT, then adjusted for better area reporting units. This metric estimates effort to achieve new N input reductions for the whole HUC8 as influenced by both effort per unit area and size.
NUTRIENT IMPAIRED SEGMENT COUNT	From EPA's NPDAT website, the number of waterbody segments in the HUC8 reported under section 303(d) as impaired by listing causes grouped under the Parent Category Nutrients.
HUC8 INSTATE PERCENT	Proportion of HUC8 by total area found within the state being assessed; allows for setting higher state priorities on watersheds fully or mostly within their borders as well as identifying watersheds for multi-state cooperation.
NUTRIENT TMDL COUNT	From EPA's NPDAT website, the number of waterbody segments in the HUC8 with TMDLs developed for pollutant targets grouped under the Parent Category Nutrients.
ADOPT WATERSHED GROUPS COUNT	Number of active watershed organizations identified as in any way connected geographically with the HUC8, based on the EPA ADOPT website.
% GAP STATUS 1, 2, 3	Percent of HUC8 by total area that is in GAP analysis program's protection and conservation status categories 1, 2, and 3

HUC8 METRIC	DESCRIPTION
DEGDIFF_LARGESTANSOURCE	A value assigned by the specific state water program personnel as their best professional judgment whether the HUC's largest anthropogenic N source requires high (3), medium (2) or low(1) effort to reduce loads. Original rankings were inverted in this metric to be directionally consistent with other (higher=better) social metrics.
TOTRECYCNDIFFINDEX	A weighted average overall degree of difficulty based on the proportion of each N input source and its individual degree of difficulty, for recycled N sources per HUC. Does not consider HUC size. Based on values assigned by the specific state water program personnel as their best professional judgment whether the HUC's anthropogenic N sources require high (3), medium (2) or low(1) effort to reduce loads. Original rankings were inverted in this metric to be directionally consistent with other (higher=better) social metrics.
TOTNEWNDIFFINDEX	A weighted average overall degree of difficulty based on the proportion of each N input source and its individual degree of difficulty, for new N sources per HUC. Does not consider HUC size. Based on values assigned by the specific state water program personnel as their best professional judgment whether the HUC's anthropogenic N sources require high (3), medium (2) or low(1) effort to reduce loads. Original rankings were inverted in this metric to be directionally consistent with other (higher=better) social metrics.
% SOURCEWATER PROTECTION AREA	Representative of the relative amount of source water protection area (SPA) in the watershed. Original source data are available at HUC12 scale as SPA total % of HUC12 area; every SPA's percent area is summed to get the HUC12 total. Thus, due to multiple SPAs per HUC, it is possible to have values >100%. The HUC8 indicator is the mean of the HUC12 values.

Attachment 3: TN Stage 2 Rural-Agricultural and Urban-Suburban Scenario Indicator Descriptions

URBAN-SUBURBAN SCENARIO INDICATORS	WEIGHT	DESCRIPTION
% Woody Vegetation (2006) in Riparian Zone	3	% of HUC12 with woody vegetation in the Riparian Zone (2006 National Land Cover Dataset version 1; Land classes 41, 42, 43, 52, 90)
% Natural Cover, N-index 2 (2006) in HCZ	3	% of HUC12 with natural cover (not barren, urban or agriculture) in the Hydrologically Connected Zone (2006 National Land Cover Dataset version 1; Land classes 41, 42, 43, 52, 71, 90, 95)
HCZ Mean Soil Stability	2	Average soil stability in HCZ. Calculated as one minus average K factor in HCZ (HCZ_KFACTOR).
NFHAP - Cumulative Disturbance Index (ISO)	2	Cumulative Disturbance Index from National Fish habitat Action Plan Assessment.
% Urban (2006) in Riparian Zone	2	Riparian zone % of total area in low, medium and high density urban use according to 2006 National Land Cover Dataset
% Contiguous Urban (2006) in Watershed	2	Watershed percent urban that is contiguous with NHD waters; data from Region 4 WSI grid datasets
% U-Index06 Contiguous H2O, in Watershed	2	% of HUC12 that is agricultural or urban and is contiguous with water
% of Stream length contiguous to 2006 IC ≥ 5% WS	2	Percentage of WS stream length flowing through (contiguous to IC), ≥ 5% IC; (NLCD2006 imperviousness) Sum of ISstr_5_14 + ISstr_15_24 + ISstr_25 [ISstr5p]
Empower Density 2001, Mean Value in RZ	2	Mean value of non-renewable emergy flow per year in Riparian Zone
Road Density 2003, Mean Value (mi /sq mi) RZ	2	Mean Road Density (mi / sqmi) in Riparian Zone
Total nitrogen deposition WS	2	Estimated total annual deposition of nitrogen within each HUC12 in kilograms per hectare. Includes both dry and wet deposition of oxidized and reduced nitrogen.
Synthetic N fertilizer application (kg N/ha/yr) WS	3	The mean rate of synthetic nitrogen fertilizer application to agricultural lands within each HUC12 in kg N/ha/yr.
% Nutrient Impaired Streams (ISO)	3	% of stream length with nutrient impairments (TDEC).
Watershed 303d + TMDL Impairment Causes Count	3	Count of causes of impairment for waters with TMDLs or waters listed as impaired and requiring a TMDL under Section 303(d) of the Clean Water Act in HUC12. Calculated as the number of unique parent (grouped) causes of impairment in the EPA Office of Water "Impaired Waters with TMDLs" and "303(d) Listed Impaired Waters" NHD-indexed datasets.
% Watershed Streamlength Assessed	1	Percent of stream features in HUC12 assessed under Section 305(b) of the Clean Water Act. Calculated as length of assessed streams (STREAMLGTH_305B) divided by total stream length (STREAMLGTH_NHD + STREAMLGTH_305B_CUSTOM).
% Watershed Waterbody Area Assessed	1	Percent of lakes, estuaries, and other areal water features in HUC12 assessed under Section 305(b) of the Clean Water Act. Calculated as area of assessed waterbodies (WBAREA_305B) divided by total waterbody area (WBAREA_NHD + WBAREA_305B_CUSTOM).
Watershed Count Ratio TMDLs to Impairments	1	Ratio of number of TMDLs to impairments in HUC12. Calculated from TMDL count (CNT_TMDLS) and count of impairments for 303(d) listed waters/waters with TMDLs (CNT_303DTMDL_IMPAIRMENTS).
Percent land with any IUCN status WS	1	Percentage of land within each HUC12 that is protected. It includes all lands that have been classified by International Union for Conservation of Nature (IUCN) as protected areas.

URBAN-SUBURBAN SCENARIO INDICATORS	WEIGHT	DESCRIPTION
% in Source Water Protection Area (ISO)	2	% of area associated with drinking water (surface water and groundwater) resource protection (TDEC). ISO means this indicator is calculated for the In-State Only portion of border watersheds.
Watershed Groups (ISO)	1	# of active watershed groups. ISO means this indicator is calculated for the In-State Only portion of border watersheds.
Jurisdictional Complexity (ISO)	3	# of government jurisdictions (local, state, federal) within the HUC. ISO means this indicator is calculated for the In-State Only portion of border watersheds.

RURAL-AGRICULTURAL SCENARIO INDICATORS	WEIGHT	DESCRIPTION
% Woody Vegetation (2006) in Riparian Zone	3	% of HUC12 with woody vegetation in the Riparian Zone (2006 National Land Cover Dataset version 1; Land classes 41, 42, 43, 52, 90)
% Natural Cover, N-index 2 (2006) in HCZ	3	% of HUC12 with natural cover (not barren, urban or agriculture) in the Hydrologically Connected Zone (2006 National Land Cover Dataset version 1; Land classes 41, 42, 43, 52, 71, 90, 95)
HCZ Mean Soil Stability	2	Average soil stability in HCZ. Calculated as one minus average K factor in HCZ (HCZ_KFACTOR).
NFHAP - Cumulative Disturbance Index (ISO)	2	Cumulative Disturbance Index from National Fish habitat Action Plan Assessment.
% Developed, Low intensity (2006) in Riparian Zone	2	% of HUC12 with developed, low intensity cover in the Riparian Zone (2006 National Land Cover Dataset version 1)
% Agriculture (2006) in Watershed	3	Watershed % of total area in cropland or pasture according to 2006 National Land Cover Dataset
% Contiguous Agriculture (2006) in Watershed	2	Watershed percent agriculture contiguous with NHD surface waters; data from Region 4 WSI grid datasets
% U-Index06 Contiguous H2O, in Watershed	2	% of HUC12 that is agricultural or urban and is contiguous with water
% of Stream length contiguous to 2006 IC ≥ 5% WS	2	Percentage of WS stream length flowing through (contiguous to IC), ≥ 5% IC; (NLCD2006 imperviousness) Sum of ISstr_5_14 + ISstr_15_24 + ISstr_25 [ISstr5p]
Empower Density 2001, Mean Value in RZ	2	Mean value of non-renewable emergy flow per year in Riparian Zone
Total nitrogen deposition WS	2	Estimated total annual deposition of nitrogen within each HUC12 in kilograms per hectare. Includes both dry and wet deposition of oxidized and reduced nitrogen.
Synthetic N fertilizer application (kg N/ha/yr) WS	3	The mean rate of synthetic nitrogen fertilizer application to agricultural lands within each HUC12 in kg N/ha/yr.
% Nutrient Impaired Streams (ISO)	3	% of stream length with nutrient impairments (TDEC).
Watershed 303d + TMDL Impairment Causes Count	3	Count of causes of impairment for waters with TMDLs or waters listed as impaired and requiring a TMDL under Section 303(d) of the Clean Water Act in HUC12. Calculated as the number of unique parent (grouped) causes of impairment in the EPA Office of Water "Impaired Waters with TMDLs" and "303(d) Listed Impaired Waters" NHD-indexed datasets.

RURAL-AGRICULTURAL SCENARIO INDICATORS	WEIGHT	DESCRIPTION
% Watershed Streamlength Assessed	1	Percent of stream features in HUC12 assessed under Section 305(b) of the Clean Water Act. Calculated as length of assessed streams (STREAMLGTH_305B) divided by total stream length (STREAMLGTH_NHD + STREAMLGTH_305B_CUSTOM).
% Watershed Waterbody Area Assessed	1	Percent of lakes, estuaries, and other areal water features in HUC12 assessed under Section 305(b) of the Clean Water Act. Calculated as area of assessed waterbodies (WBAREA_305B) divided by total waterbody area (WBAREA_NHD + WBAREA_305B_CUSTOM).
Watershed Count Ratio TMDLs to Impairments	1	Ratio of number of TMDLs to impairments in HUC12. Calculated from TMDL count (CNT_TMDLS) and count of impairments for 303(d) listed waters/waters with TMDLs (CNT_303DTMDL_IMPAIRMENTS).
Percent land with any IUCN status WS	1	Percentage of land within each HUC12 that is protected. It includes all lands that have been classified by International Union for Conservation of Nature (IUCN) as protected areas.
% in Source Water Protection Area (ISO)	2	% of area associated with drinking water (surface water and groundwater) resource protection (TDEC). ISO means this indicator is calculated for the In-State Only portion of border watersheds.
Watershed Groups (ISO)	1	# of active watershed groups. ISO means this indicator is calculated for the In-State Only portion of border watersheds.
Jurisdictional Complexity (ISO)	3	# of government jurisdictions (local, state, federal) within the HUC. ISO means this indicator is calculated for the In-State Only portion of border watersheds.

Attachment 4: TN RPS Tool file names and contents

(note that the 6 digit date beginning each file name may change with subsequent updates)

The following are RPS Tool files completed during this project and delivered to TDEC for statewide and HUC8-specific use. Except for MASTER TN RPS, all these files contain archived results for each geographic area and scenario as named. Other than differences in their screening results, these files are otherwise identical to the master file.

RPS Tool File Name	Content
150519 MASTER TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with all HUC8 and HUC12 data, no screening content saved (master copy for all new screening statewide or on HUC subsets)
150519 ST1RURAL TN RPS-Scoring-Tool-051915.xlsm	TN RPS Tool with screening results for HUC8 Stage 1 rural-agricultural scenario
150519 ST1URBAN TN RPS-Scoring-Tool-051915.xlsm	TN RPS Tool with screening results for HUC8 Stage 1 urban-suburban scenario
150519 RURST2 CANEY TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Caney HUC8
150519 RURST2 HIWASSEE TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Hiwassee HUC8
150519 RURST2 NFFDEER TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within NF Forked Deer HUC8
150519 RURST2 NOLICHUCKY TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Nolichucky HUC8
150519 RURST2 OBION TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Obion HUC8
150519 RURST2 RED TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Red River HUC8
150519 RURST2 SFFDEER TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within SF Forked Deer HUC8
150519 RURST2 SFOBION TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within South Fork Obion HUC8
150519 RURST2 UPRELK TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Upper Elk HUC8
150519 URBST2 HARPETH TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Harpeth HUC8
150519 URBST2 HORNLK TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Horn Lake HUC8
150519 URBST2 LOOSA TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Loosahatchie HUC8
150519 URBST2 LWRCLINCH TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Lower Clinch HUC8
150519 URBST2 LWRELK TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Lower Elk HUC8
150519 URBST2 STONES TN RPS –Scoring-Tool-051915.xlsm	TN RPS Tool with Stage 2 results for HUC12 screening within Stones River HUC8