Summary Report: Recovery Potential Screening of Kentucky 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 the Commonwealth of Kentucky, 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 Kentucky 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.

Kentucky Division of Water (KDOW) 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, Tetra Tech, Inc. (EPA contractor), KDOW, and KDOW collaborators. In Kentucky's first statewide RPS tool (Excel file), RPS indicators were compiled at HUC12 scale (78 metrics) and HUC14 scale (60 metrics). These base, ecological, stressor, and social indicators were initially measured from state and federal data sources after a February 2012 kickoff workshop and subsequent discussions about relevant data.

A multi-day RPS workshop at KDOW in August 2012 demonstrated a working Kentucky RPS Tool to trainees from several KDOW water program units (Watersheds, 303(d)/TMDLs, 319/Nonpoint Source Control, Monitoring), other state and federal agency collaborators (e.g., EPA Region 4 staff), and others. This workshop was followed in April 2013 by the completion and delivery of the Commonweath's first RPS tool and enabled KDOW to begin its routine use. In 2014, KDOW requested follow-on assistance in RPS tool enhancement and application from EPA and its contractor Cadmus, as one of several state nutrients demonstration projects using RPS. New national-scale data made available in 2014 in addition to datasets from the Commonwealth enabled development of the current (2015) Kentucky statewide RPS Tool for this project. This RPS tool contains 300 indicators with full statewide coverage at one or more of the HUC14, HUC12, or HUC8 scales (the majority – 281 of 300 - are at HUC12 scale). All the assessment findings and figures in this document were generated by the Kentucky RPS Tool.

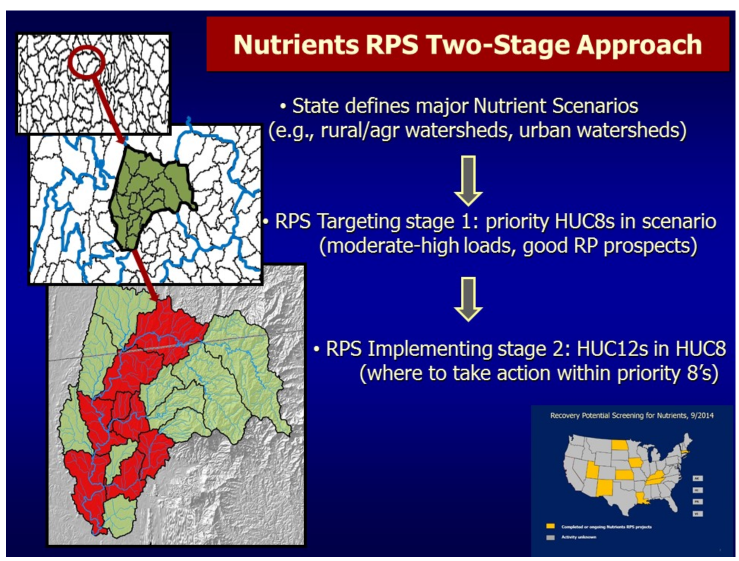
APPROACH

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 Stage2), 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 KDOW, EPA and its contractor. Nevertheless, this technical project's findings and outputs are not meant to represent final decisions or policies of KDOW, 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 subgroups enables a narrower focus on each subgroup's nutrient issues and possible solutions. At a minimum, nutrients scenarios usually differentiate between a group of watersheds with primarily agricultural/rural loading sources and a group of more urban-suburban watersheds with wastewater and urban runoff nutrient sources. Screening these two scenarios separately enables selection of indicators that can be more specific to each scenario and its watersheds, leading to project results of higher scenario-specific relevance.

For Kentucky, two scenarios relevant for nutrients management were initially identified jointly by EPA, KDOW, and Cadmus. These were used to filter Kentucky's 45 HUC8s and identify two HUC8 subsets of interest, whose members shared the general traits below. Please note that throughout the document, HUC8s are also called 'watersheds' and HUC12s are also called 'subwatersheds'.

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 nutrient loading at more local, subwatershed scales. Defining a subset of Kentucky's HUC8s for this scenario primarily considered the relative value of each watershed's N and P estimated loading (SPARROW incremental and delivered), percent cropland and pasture in the watershed and in its stream corridors, rural population distribution, and amount and distribution of natural cover.

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 it can still be the source of significant nutrient loads. A few Kentucky HUC8s contain large, high-density urbanized areas, and several more contain extensive suburban and smaller high-density urban components. With urbanization seldom dominating most or all of the area, a mosaic of cropland, pasture, forest and other uses makes up the remainder of HUC8 area typical 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, subwatersheds (i.e., HUC12, HUC14) 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 HUC8 watersheds across Kentucky, identifying which to include in each scenario, and revealing major differences in condition and estimated nutrient loading magnitude as a state considers its options for watersheds to assess. Using the RPS Tool, two different, scenario-specific selections of recovery potential indicators weighted by KDOW as 3 (high), 2 (medium) and 1 (low) were used to screen all the Kentucky HUC8s and determine which HUC8s would belong in each scenario. See indicator lists and weights in Table 1 and their definitions in Attachment 2.

Selecting Stage 1 demonstration watersheds. Typically after scenario watersheds are identified, several Stage 1 watersheds in each scenario are selected 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 all their remaining watersheds over time. Selections can be based on an RPS screening, expert judgment, or a combination of both. An additional screening can narrow down the choice of demonstration watersheds by comparing all the scenario HUC8s against a small number of key criteria or indicator value thresholds. The use of expert judgment allows selection of specific watersheds that may not fully meet scenario criteria, if a compelling reason exists for their inclusion (e.g., significant progress in planning or addressing nutrient issues typical of the scenario, other special circumstances). 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. Demonstration HUC8s are highlighted in the discussion of Stage 1 and Stage 2 screenings in this report.

Table 1. Stage 1 RPS indicator selections and weights for screening and comparing HUC8 watersheds statewide for the Rural-Agricultural Scenario (upper) and the Urban-Suburban Scenario (lower) in Kentucky. 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	3
% Woody Vegetation (2006) in Riparian Zone	3	% Agriculture (2006) in HCZ	2	ADOPT Watershed Groups Count	1
% Natural Cover, N-index1 (2006) in HCZ	2	% Agriculture (2006) in Riparian Zone	3	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)	2
Ratio of Natural to New N Inputs	1	Domestic water use WS	1	Anthropogenic New N Effort (Inverse)	2
		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)	3		
		SPARROW Predicted Incremental Agr P Yield (2012)	3		
		Anthropogenic Recycled N Effort	2		
		Anthropogenic New N Effort	2		
		Nutrient Impaired Segment Count	3		
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	2	% of HUC8 Instate	3
% Woody Vegetation (2006) in Riparian Zone	2	Empower Density 2001, Mean Value in HCZ	1	ADOPT Watershed Groups Count	1
% Natural Cover, N-index1 (2006) in HCZ	2	% 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	2	Anthropogenic Recycled N Effort (Inverse)	2
Ratio of Natural to New N Inputs	1	Watershed Likely N/P NPDES Discharger Count	2	Anthropogenic New N Effort (Inverse)	2
		Agricultural water use WS	1	Percent Drinking Water Source Protection Area WS	1
		Domestic water use WS	1		
		SPARROW Predicted Incremental N Yield	2		
		SPARROW Predicted Incremental N Yield Delivered	1		
		SPARROW Predicted Incremental P Yield	2		
		SPARROW Predicted Incremental P Yield Delivered	1		
		Anthropogenic Recycled N Effort	2		
		Anthropogenic New N Effort	2		
		Centralized Sewage N Input	1		
		Nutrient Impaired Segment Count	3		

Stage 2

Selection of Stage 2 Indicators. Stage 2 assessment compares smaller subwatersheds (in Kentucky's tool, potentially HUC12s or HUC14s) to one another within the same HUC8 for a more specific planning purpose (i.e., considering where best to implement control efforts). Stage 2 continues Stage 1's orientation toward scenarios, as separate 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 (282 metrics in Kentucky), and thus is capable of being tailored to address more specific land use settings or nutrient management techniques. Indicator and weight selections by KDOW (see Table 2, and definitions in Attachment 3) were used for screening the HUC12s within the demonstration HUC8s.

Table 2. Stage 2 RPS indicator selections and weights for screening and comparing HUC12 subwatersheds within selected HUC8s for the Rural-Agricultural Scenario and the Urban-Suburban Scenario in Kentucky. 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	1	Road Density 2003, Mean Value (mi /sq mi) RZ	2	% Watershed Streamlength Assessed	3
% Natural Cover, N-index 2 (2006) in HCZ	3	% Stream Channel Contacting Pasture (ISO)	3	% Watershed Waterbody Area Assessed	3
Riparian Corridor Mean Slope (ISO)	2	% Stream Channel Contacting Crops (ISO)	3	Watershed Count Ratio TMDLs to Impairments	1
HCZ Mean Soil Stability	2	% Contiguous Agriculture (2006) in Watershed	2	Percent land with any IUCN status WS	2
Watershed NFHAP Habitat Condition Index (ISO)	3	Riparian Corridor % Agriculture On Steep Slope (ISO)	3	Percent Drinking Water Source Protection Area WS	3
		% Agriculture (2006) in Watershed	3	# of Active Volunteers (ISO)	3
		Watershed % Septic with Water (ISO)	2	Low Jurisdictional Complexity (ISO)	3
		Synthetic N fertilizer application (kg N/ha/yr) WS	3		
		% Watershed Streamlength 303d-Listed Nutrients	3		
		Watershed 303d + TMDL Impairment Causes Count	2		
Stage 2 Urban-Suburban Scenario					
Ecological Indicators	**wt**	**Stressor Indicators**	**wt**	**Social Indicators**	**wt**
% Woody Vegetation (2006) in Riparian Zone	1	% Urban (2006) in Riparian Zone	3	% Watershed Streamlength Assessed	3
% Natural Cover, N-index 2 (2006) in HCZ	3	% Contiguous Urban (2006) in Watershed	2	% Watershed Waterbody Area Assessed	3
Riparian Corridor Mean Slope (ISO)	2	% of Stream length contiguous to 2006 IC ≥ 5% WS	3	Watershed Count Ratio TMDLs to Impairments	1
HCZ Mean Soil Stability	2	Proximity of 2006 IC ≥ 5% to water WS	2	Percent land with any IUCN status WS	1
Watershed NFHAP Habitat Condition Index (ISO)	3	Road Density 2003, Mean Value (mi /sq mi) RZ	2	Percent Drinking Water Source Protection Area WS	3
		Watershed % MS4 (ISO)	3	# of Active Volunteers (ISO)	3
		Watershed % Septic with Water (ISO)	2	Low Jurisdictional Complexity (ISO)	3
		% Watershed Streamlength 303d-Listed Nutrients	3		
		Watershed 303d + TMDL Impairment Causes Count	2		

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 (hereafter used interchangeably with 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 as identifying opportunities for action within these subwatersheds individually. Comparing all HUC12s statewide may be appropriate, 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. Nevertheless, also comparing the HUC12s within one HUC8 to the HUC12s statewide represents an important, broader geographic context within which the range of general HUC12 conditions in the HUC8 can be better understood. For example, it may reveal whether the HUC12s within the HUC8 are all exceptional, or all in very poor condition, or may vary from one another as much as the HUC12s statewide; these findings could have substantially different implications for management.

Potential Stage 2 priority watersheds. RPS Tool screening runs performed on each demonstration HUC8 identify multiple gradients of conditions among the HUC12s within the HUC8. Each screening run generates an Ecological, Stressor, Social and Integrated (RPI) 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 priorities that states may build into their planning, the Stage 2 results presented in this document should be considered a demonstration of alternatives rather than final selections. These examples were drawn from different indices and single indicators to emphasize the flexibility of the RPS Tool in considering options for priority setting and planning action.

STAGE 1 RESULTS

The following pages present and discuss the Stage 1 analysis of the rural-agricultural scenario HUC8s and the urban-suburban scenario HUC8s. Results are derived from the Stage 1 screening runs with the Kentucky RPS Tool and the indicators and weights listed in Table 1. Whereas one screening run per scenario was completed in the RPS tool, results are displayed in multiple ways using graphics generated directly in the RPS Tool. The techniques available for displaying results in the RPS tool include tabular display, bubble plotting, and mapping of RPS indexes and indicators. Throughout this section, values of the Recovery Potential Integrated (RPI) Index, Ecological Index, and Social Index for a given watershed are described as falling in the "top" quartile (75^{th}-100^{th} percentile), "second" quartile (50^{th}-75^{th} percentile), "third" quartile (25^{th}-50^{th} percentile), or "bottom" quartile (0-25^{th} percentile). For the Stressor Index, these descriptive labels are reversed since lower scores correspond to greater restorability: "top" quartile (0-25^{th} percentile), "second" quartile (25^{th}-50^{th} percentile), "third" quartile (50^{th}-75^{th} percentile), and "bottom" quartile (75^{th}-100^{th} percentile).

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 than other HUC8s throughout the Commonwealth. A copy of the RPS Tool populated with this scenario's screening results is among project deliverables. Twenty-two HUC8 watersheds were included in this scenario based on the following criteria:

- ≥25% instate
- ≥10% agriculture in watershed
- ≥ Statewide median new SPARROW-predicted agricultural nitrogen (N) or phosphorus (P) loads

Three HUC8 watersheds (asterisked) of the twenty-two in this scenario were requested by KDOW as demonstration HUC8s for this report. Many HUC8s in Kentucky combine enough rural-agricultural and urban-suburban traits that they qualified for both scenarios; the exclusively rural-agricultural HUC8s below are **bolded**:

05090201	Ohio Brush-Whiteoak	05130205	**Lower Cumberland**
05100101	Licking	05130206	Red
05100102	**South Fork Licking**	05140102	Salt

05100205	Lower Kentucky	05140103	**Rolling Fork***
05110001	Upper Green	05140104	**Blue-Sinking**
05110002	Barren	05140201	Lower Ohio-Little Pigeon
05110003	**Middle Green**	05140202	Highland-Pigeon
05110004	**Rough**	05140205	**Tradewater***
05110005	Lower Green	05140206	**Lower Ohio**
05110006	**Pond**	06040006	Lower Tennessee*
05130103	Upper Cumberland-Lake Cumberland	08010201	**Bayou De Chien-Mayfield**

Rural-Agricultural Scenario: RPS Indexes and Map Results. Recovery Potential Index scores for the rural scenario are displayed in map form in Figure 2, showing the geographic distribution of the scenario HUC8s and the demonstration HUC8s selected by KDOW, as well as how they differ in Ecological, Stressor, Social, and Integrated (RPI) Index scores. The rural-agricultural scenario watersheds are clustered strongly and dominate the western two-thirds of Kentucky, with non-scenario HUC8s mainly along the northwestern border and in eastern Kentucky.

Figures 2A through 2D suggest, however, that no specific part of this scenario's cluster of watersheds consistently scores highest with regard to the different elements of the screening. The top quartile of RPI scores in Figure 2A is scattered. In Figure 2B, the best Ecological Index scores tend to be located in the southwestern part of the Commonwealth. In Figure 2C, the Stressor Index is geographically scattered, whereas the Social Index displayed in Figure 2D shows a cluster of high scores in the north.

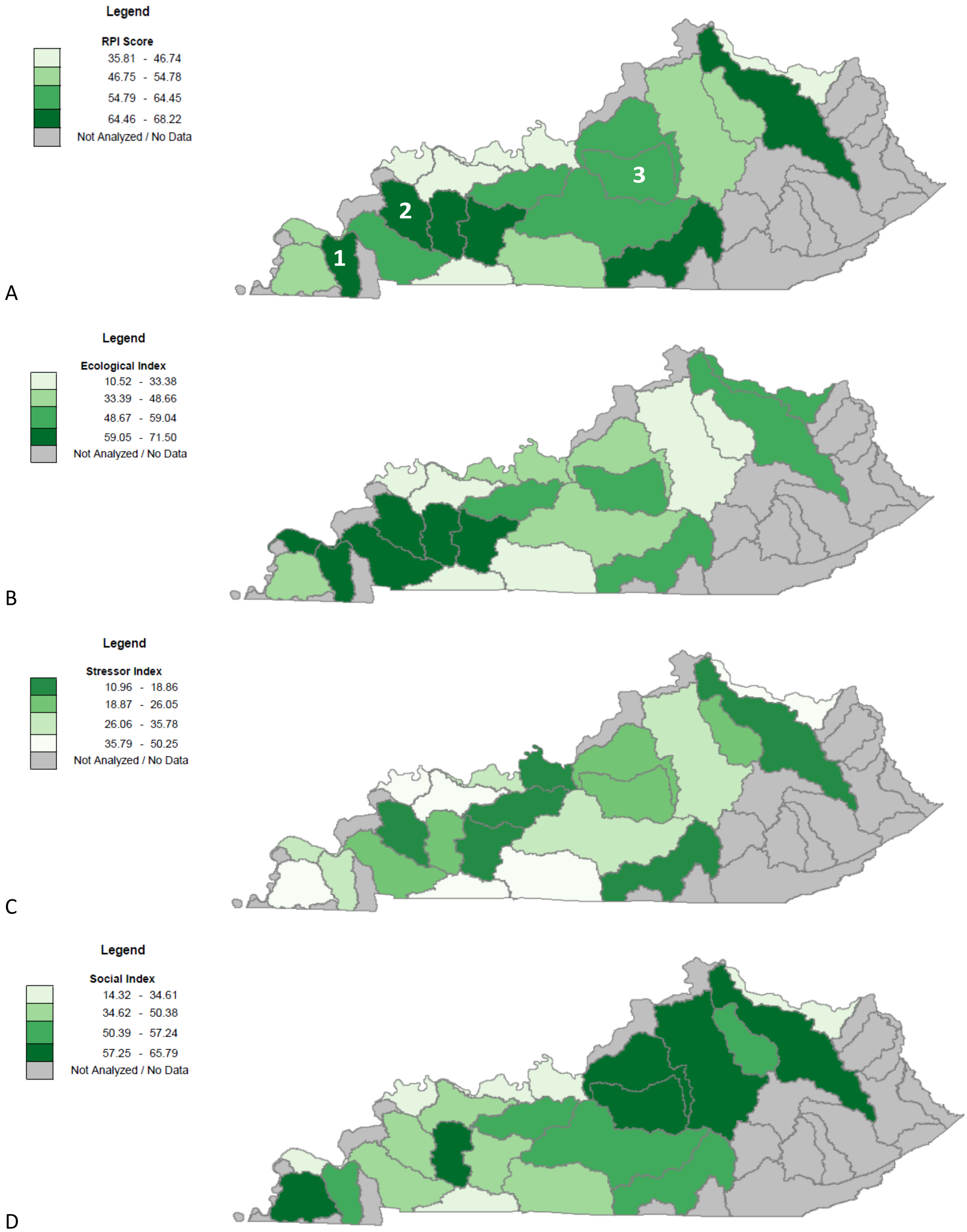
Figure 2 also offers some insight on how the three selected demonstration watersheds compare to the other scenario watersheds. The three are geographically distributed throughout the scenario HUC8s. Two of the three (Lower Tennessee and Tradewater) score in the top RPI quartile, with Rolling Fork scoring in the second quartile. Although it should be noted that Stage 1 comparisons are very generalized, these results suggest that the demonstration watersheds combine moderately high nutrient loads (having qualified for the scenario in the first place) with generally positive restorability traits as exemplified in the individual indexes.

In particular, Lower Tennessee (1) has a top quartile Ecological Index score and a second quartile Social score along with a third quartile Stressor Index score. High ecological and social scores combined with a mid-range stressor index score support the prioritization of a watershed for restoration because they indicate that sources of degradation are present but ecological and social traits are favorable for successful action.

In the Tradewater HUC8 (2), the Ecological Index and Stressor Index scores are in the top quartile along with the RPI score, and the Social Index is in the third quartile. As the Social score is influenced heavily by the selected indicators on assessment and TMDL completion (that may convey greater readiness to take action where scores are high), this suggests that the Tradewater may have ecological and stressor positives that are worthy of greater investment in assessment and TMDL completion in the future.

The Rolling Fork HUC8 (3) presents a less consistent picture of restorability compared to the Lower Tennessee and Tradewater. The Rolling Fork RPI, Ecological Index, and Stressor Index scores are all in the second quartile. Only the Social Index scores in the top quartile. This demonstration HUC8 appears to act as a 'middle of the pack' contrast to the more favorable traits of the other two demonstration HU8s.

Figure 2. Four Recovery Potential index scores for the rural-agricultural scenario HUC8s, including demonstration HUC8s selected by KDOW: 1. Lower Tennessee; 2. Tradewater; 3. Rolling Fork. The most intense colors in RPS maps denote the "best" scores for traits likely to be more favorable to restoration efforts. A: Recovery Potential Integrated (RPI) Index; B: Ecological Index; C: Stressor Index; D: Social Index.

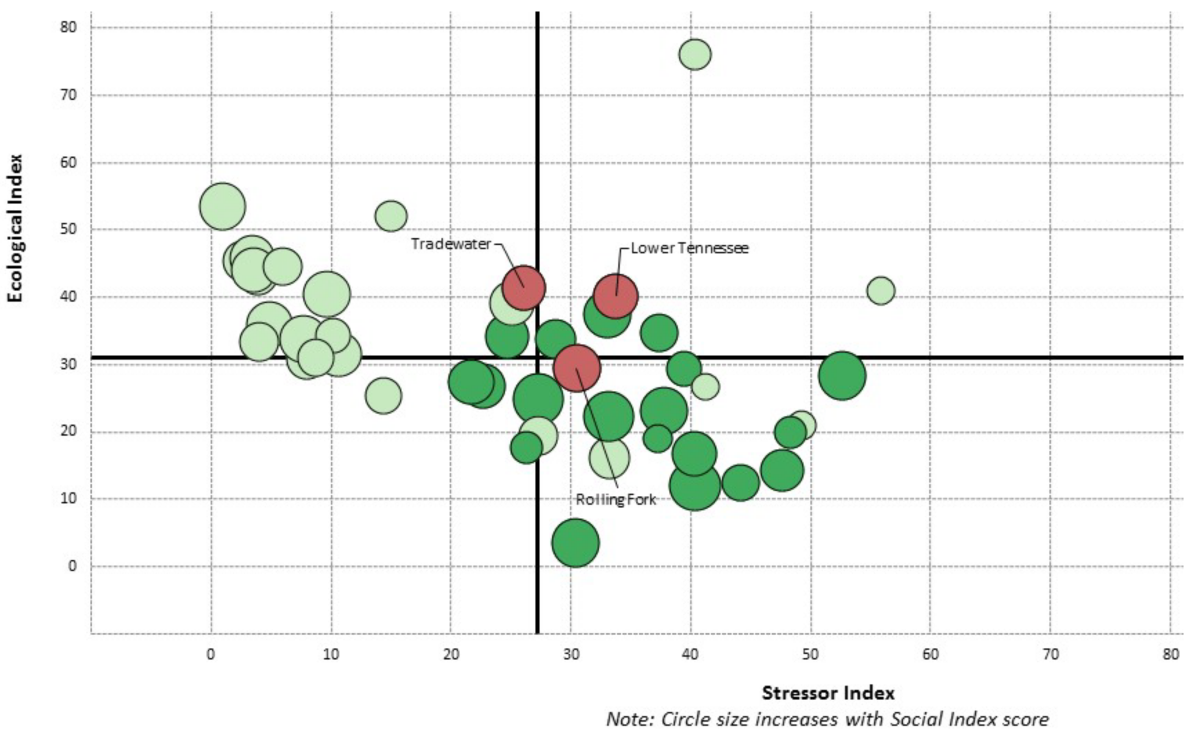


Rural-Agricultural Scenario: Bubble Plot Results. The bubble plot in Figure 3 displays relative differences among HUC8s in Ecological Index (y-axis), Stressor Index (x-axis), and Social Index (bubble size) scores, also showing how these compare to statewide medians (the horizontal and vertical solid lines). Further, this figure enables the scenario (dark green and red) and demonstration (red with labels) HUC8s to be compared with the rest of Kentucky's HUC8s.

The different methods for displaying RPS results (maps, bubble plots, tables) provide slightly different insights into how the watersheds compare to one another. The bubble plot enables a more instantaneous visualization of how watersheds compare among multiple indices at once. Properties of the rural-agricultural scenario watersheds in relation to other HUC8s in Kentucky are immediately evident in the bubble plot. In Figure 3, the majority of the scenario watersheds (dark green and red) have Stressor Index scores that are higher than the statewide median (solid vertical line) and Ecological Index scores that are lower than the statewide median (solid horizontal line). Social Index scores (as reflected in bubble size), vary but there are several HUC8s in the scenario with Social scores that are among the highest in the Commonwealth.

The bubble plot also allows for contrasting the three demonstration HUC8s with other scenario HUC8s and the rest of the HUC8s in the Commonwealth. The three demonstration HUC8s display Ecological Index scores that are at or above the statewide median. Stressor Index scores are also at or above the statewide median but are lower than most in the scenario overall. Social Index scores for all three demonstration HUC8s appear high compared to others in the Commonwealth, and moderate compared to others in the scenario. The demonstration HUC8s all appear to have a mix of significant nutrient loading and favorable recovery potential scores, with Tradewater noteworthy for having the highest Ecological Index score in the scenario along with a Stressor Index score that is lower than the statewide median.

Figure 3. Bubble plot for all Kentucky HUC8s based on 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.



Rural-Agricultural Scenario: Tabular Results. Table 3 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 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 Ecological, Stressor, or Social Index scores. For example, Lower Cumberland and Lower Ohio rank well below the top quartile in RPI score but have high Ecological Index scores.

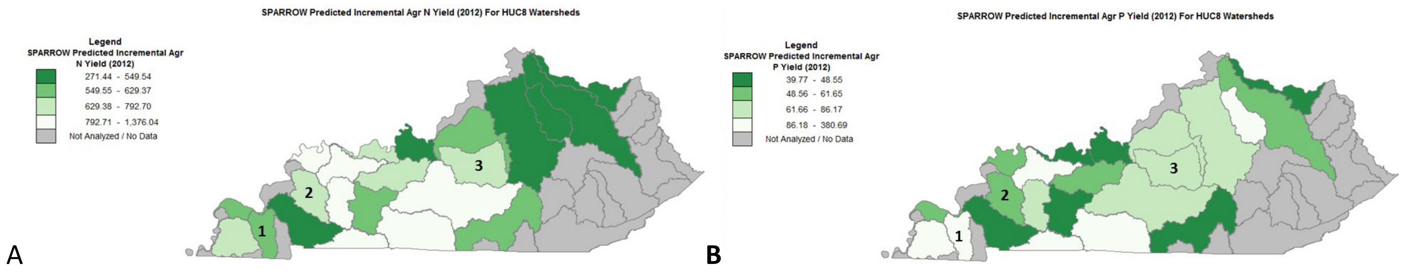
Table 3. Index and RPI scores for the rural-agricultural scenario. HUC8s are ordered by RPI score. Cells are shaded according to rank (green = 76 -100th percentile; yellow = 51-75th percentile; orange = 26-50th percentile; pink = 0-25th percentile). Scores and quartiles are derived from screening rural-agricultural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

Watershed ID	Watershed Name	Ecological Index	Stressor Index	Social Index	RPI Score
05140205	Tradewater*	71.50	16.79	49.92	68.21
05110006	Pond	65.44	25.43	61.87	67.29
05100101	Licking	50.04	17.99	65.54	65.86
05110003	Middle Green	61.43	14.85	49.94	65.51
05130103	Upper Cumberland-Lake Cumberland	52.95	10.96	52.83	64.94
06040006	Lower Tennessee*	69.38	26.48	51.86	64.92
05110004	Rough	50.53	12.21	50.83	63.05
05140103	Rolling Fork*	51.29	21.66	57.53	62.39
05130205	Lower Cumberland	64.70	22.21	39.41	60.63
05140102	Salt	41.34	25.61	65.79	60.51
05110001	Upper Green	42.58	31.16	56.35	55.92
05140206	Lower Ohio	60.64	31.77	32.03	53.63
08010201	Bayou De Chien-Mayfield	47.28	50.25	58.17	51.73
05100205	Lower Kentucky	24.83	34.44	63.94	51.44
05100102	South Fork Licking	10.53	21.45	56.37	48.48
05110002	Barren	30.90	36.23	46.98	47.22
05090201	Ohio Brush-Whiteoak	54.25	37.06	22.54	46.58
05140104	Blue-Sinking	34.79	16.84	20.50	46.15
05110005	Lower Green	24.18	43.96	44.48	41.57
05140201	Lower Ohio-Little Pigeon	33.49	31.13	14.32	38.89
05130206	Red	22.66	41.20	33.01	38.16
05140202	Highland-Pigeon	33.34	45.40	19.51	35.82

Rural-Agricultural Scenario: Examining Single Indicators. An additional way to use the Stage 1 scenario screening results is to examine the values of single indicators of interest for each HUC8. For the rural-agricultural scenario, two such indicators are estimated SPARROW incremental N and P loadings from agricultural sources (Figure 4). Since both are stressor indicators, note that in Figure 4 the darkest colors are assigned to the lowest stressor scores (best for restorability).

Figure 4 also enables a closer look at the three demonstration HUC8s relative to the primary nutrient sources for this scenario, separately for N and P. The Lower Tennessee score for P loading (Figure 4B) falls in the bottom quartile of the scenario HUC8s, while its N loading score (Figure 4A) ranks in the second quartile. The Tradewater and Rolling Fork N and P loading scores all fall in the second or third quartiles. Figure 4 also enables the opportunity to identify other relatively high-loading HUC8s from the scenario, independently for N and P.

Figure 4. Agricultural nitrogen (A) and phosphorus (B) 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 for traits likely to be more favorable to restoration efforts. As these are both stressor indicators, the lower scores are better. Numbered HUC8s include: 1. Lower Tennessee; 2. Tradewater; 3. Rolling Fork.



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. Fourteen HUC8 watersheds are included in this scenario based on the following criteria:

- ≥25% instate
- ≥10% developed land cover in watershed
- ≥ Statewide median estimated nitrogen loading from centralized sewer systems

Three of the fourteen HUC8 watersheds in this scenario (asterisked) were requested by KDOW as demonstration HUCs. Many HUC8s in Kentucky combine enough rural-agricultural and urban-suburban traits that they qualified for both scenarios; the exclusively urban-suburban HUC8s below are bolded:

05090201	Ohio Brush-Whiteoak	05130103	Upper Cumberland-Lake Cumberland*
05090203	**Middle Ohio-Laughery**	05130206	Red
05100101	Licking*	05140101	**Silver-Little Kentucky**
05100205	Lower Kentucky	05140102	Salt
05110001	Upper Green*	05140201	Lower Ohio-Little Pigeon
05110002	Barren	05140202	Highland-Pigeon
05110005	Lower Green	06040006	Lower Tennessee

Urban-suburban Scenario: RPS Indexes and Map Results. Recovery Potential Index scores for the Urban-Suburban scenario are displayed in map form in Figure 5, showing the geographic distribution of the scenario HUC8s and the demonstration HUC8s selected by KDOW, as well as how they differ in Ecological, Stressor, Social, and Integrated (RPI) Index scores. The urban-suburban scenario watersheds dominate the central third of Kentucky, with non-scenario HUC8s mainly to the east and west.

Figures 5A through 5D show some variation in which watersheds score highest in each of the four different indices. HUC8s in the top quartile of RPI scores (Figure 5A) are scattered across Kentucky, as are HUC8s with top quartile Ecological Index (Figure 5B) and Stressor Index (Figure 5C) scores. The Social Index map (Figure 5D) shows a cluster of high scores in the north.

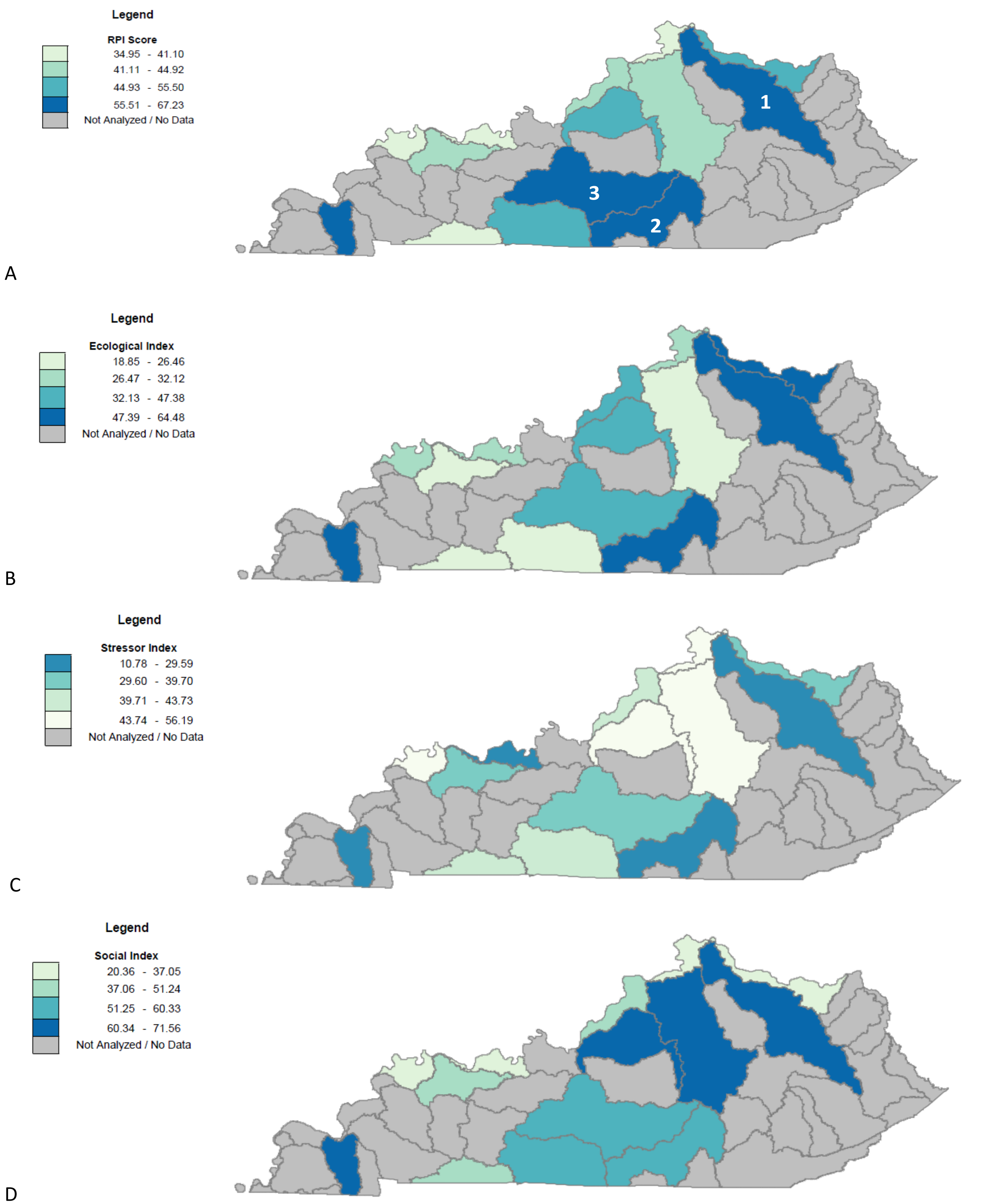
Figure 5 also offers insight into how the three demonstration HUC8s compare to other scenario watersheds. The three all scored in the top RPI quartile. None scored below the second quartile in the Ecological, Stressor or Social Indices. Although it should be noted that Stage 1 comparisons are very generalized, these results suggest that the demonstration HUC8s combine moderately high nutrient loads (having qualified for the scenario in the first place) with generally positive restorability traits as exemplified in the individual indexes.

In particular, Licking (1) has a top quartile Ecological Index score, a top quartile Social score, and a top quartile Stressor Index score. High ecological and social scores support the prioritization of a watershed for restoration because they indicate that ecological and social traits are favorable for successful action. Further, the high Stressor score indicates this HUC8 is not among the most heavily impacted in Kentucky and thus may have good prospects for recovery.

In the Upper Cumberland-Lake Cumberland HUC8 (2), the Ecological Index and Stressor Index scores are in the top quartile, and the Social Index is in the second quartile. As the Social score is influenced heavily by assessment and TMDL completion metrics that convey readiness to take action, this suggests that the Tradewater may have ecological and stressor positives that are worthy of greater investment in assessment and TMDL completion.

The Upper Green HUC8 (3) presents a less consistent picture of restorability compared to the Licking and Upper Cumberland-Lake Cumberland. The Upper Green Ecological Index, Stressor Index, and Social Index scores are all in the second quartile. This demonstration HUC8 may provide a ‘middle of the pack’ contrast to the more favorable traits of the other two demonstration HU8s.

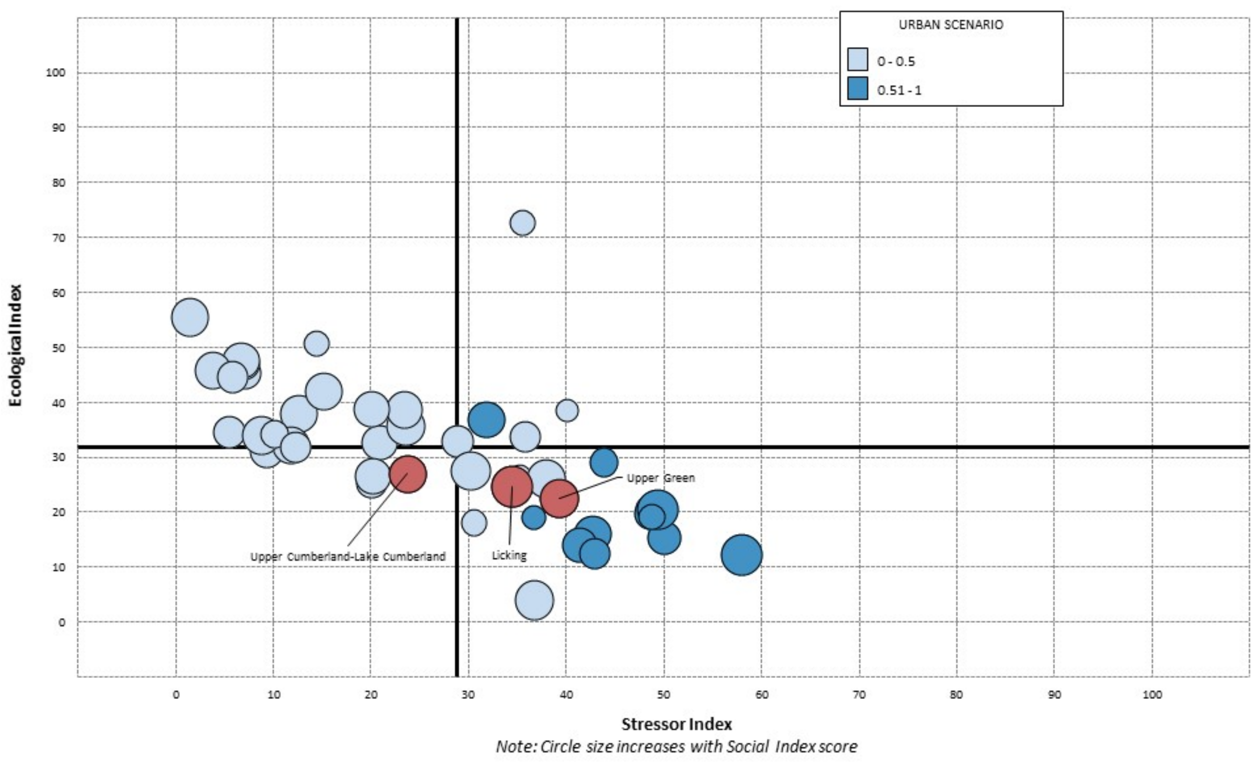
Figure 5. Four Recovery Potential index scores for the urban-suburban scenario HUC8s, including demonstration HUC8s selected by KDOW: 1. Licking; 2. Upper Cumberland-Lake Cumberland; 3. Upper Green. The most intense colors in RPS maps denote the "best" scores for traits likely to be more favorable to restoration efforts. A: Recovery Potential Integrated (RPI) Index; B: Ecological Index; C: Stressor Index; D: Social Index.



__Urban-suburban Scenario: Bubble Plot Results__. The bubble plot for the urban-suburban scenario (Figure 6) displays relative differences among HUC8s in Ecological (y-axis), Stressor (x-axis), and Social Index (bubble size) scores, also showing how these compare to statewide medians (the horizontal and vertical solid 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 Commonwealth's HUC8s.

Ecological Index scores for scenario and demonstration HUC8s are mostly below the statewide median, while Stressor Index scores are mostly above the statewide median. Scenario HUC8s in the extreme lower right quadrant of the plot have Stressor Index scores that are the highest in Kentucky and Ecological Index scores that are among the lowest. This combination of low Ecological Index and high Stressor Index scores suggests that these HUC8s may require a greater level of nutrient management effort and a longer recovery time relative to others. In contrast, the three demonstration HUC8s have more moderate Ecological and Stressor Index scores and may therefore be better candidates for directing nutrient management actions. The scenario HUC8s display a wide range of Social Index scores (illustrated with bubble sizes) whereas the demonstration HUC8s score consistently high.

Figure 6. Bubble plot for all Kentucky HUC8s based on 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.



Urban-suburban Scenario: Tabular Results. Table 4 contains Ecological, Stressor, Social, and RPI scores for the urban-suburban scenario HUC8s, in order of descending RPI score and color-coded by quartile per index. This tabular format is another option for presentation of Stage 1 results that can be used to compare and contrast HUC8s for urban nutrient management efforts. When interpreting this table, preferred HUC8s for urban nutrient management do not necessarily have to favor those with the highest RPI scores but instead could consider one or more of the Ecological, Stressor, or Social Index scores. For example, the Salt HUC8 ranks below the top quartile in RPI score but has a high Ecological Index score and a moderate Stressor Index score, and the Lower Ohio-Little Pigeon HUC8 has a top-quartile Stressor Index score despite ranking barely above the RPI bottom quartile.

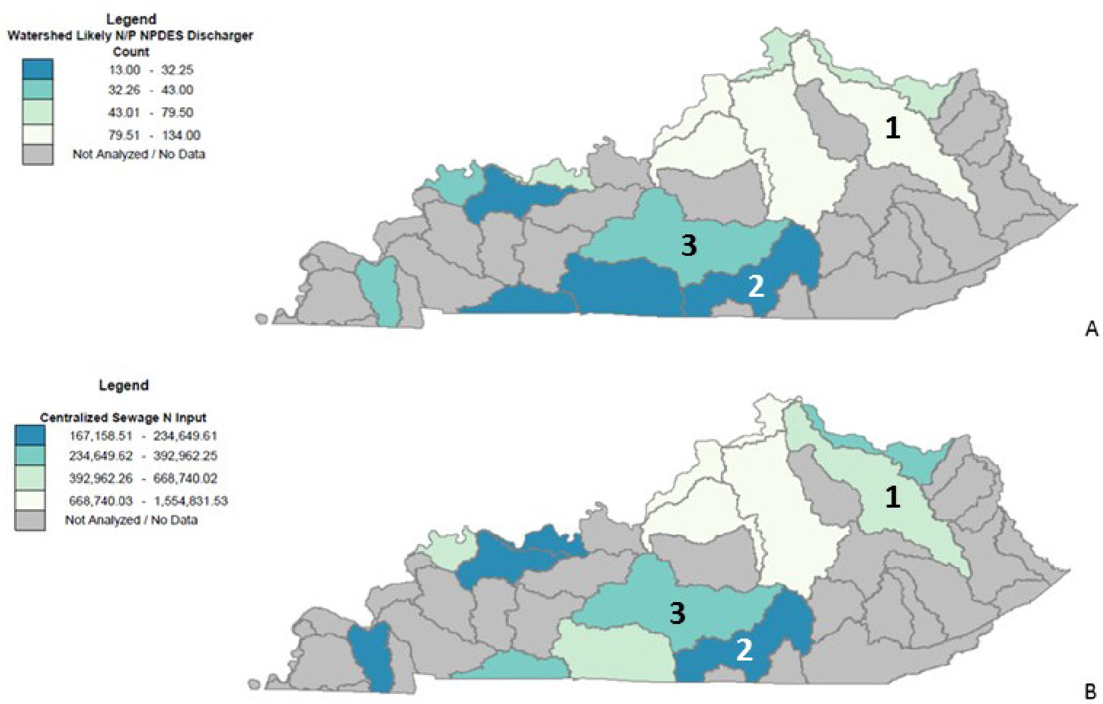
Table 4. Index and RPI scores for the urban-suburban scenario. HUC8s are ordered by RPI score. Cells are shaded according to rank (green = 76 -100th percentile; yellow = 51-75th percentile; orange = 26-50th percentile; pink = 0-25th percentile). Scores and quartiles derived from screening urban-suburban scenario HUC8s only.

Watershed ID	**Watershed Name**	**Ecological Index**	**Stressor Index**	**Social Index**	**RPI Score**
06040006	Lower Tennessee	64.47	23.14	60.35	67.23
05130103	Upper Cumberland-Lake Cumberland*	53.11	10.79	59.34	67.22
05100101	Licking*	49.77	24.20	68.66	64.74
05110001	Upper Green*	40.21	32.55	60.26	55.97
05140102	Salt	35.40	44.66	71.56	54.10
05090201	Ohio Brush-Whiteoak	54.80	39.68	23.86	46.33
05110002	Barren	26.21	41.61	52.58	45.73
05140101	Silver-Little Kentucky	34.26	39.72	37.83	44.12
05110005	Lower Green	18.86	37.10	49.91	43.89
05100205	Lower Kentucky	20.51	56.19	64.91	43.08
05140201	Lower Ohio-Little Pigeon	29.56	28.61	20.36	40.44
05090203	Middle Ohio-Laughery	27.20	44.35	36.79	39.88
05130206	Red	19.54	41.85	39.62	39.10
05140202	Highland-Pigeon	29.99	45.78	20.65	34.95

Urban-suburban Scenario: Examining Single Indicators. An additional way to use the Stage 1 scenario screening results is to examine the values of single indicators of interest for each HUC8. In an urban-suburban scenario, two such indicators could be the count of NPDES permitted facilities likely to discharge nitrogen and phosphorus and estimated nitrogen loads from centralized sewage systems (Figure 7). Since both are stressor indicators, note that in Figure 7 the darkest colors are assigned to the lowest stressor scores (best for restorability).

Figure 7 reveals that the three demonstration HUC8s vary substantially relative to the primary nutrient loading sources for this scenario. The number of likely N/P dischargers for the Licking HUC8 falls in the bottom quartile of the scenario HUC8s, and its centralized sewage N load ranks in the third quartile. The Upper Cumberland-Lake Cumberland and Upper Green HUC8s rank in the top and second quartiles, respectively, for both N/P discharge count and centralized sewage N. Figure 7 also enables the opportunity to identify other relatively high-loading HUC8s from the scenario. This use of the RPS Tool to view single indicators as well as compile multi-metric indices has revealed substantial differences in major loading sources among three HUC8s that had otherwise similar RPI scores.

Figure 7. Count of likely Nitrogen or Phosphorus dischargers among NPDES permittees (A) and estimated Nitrogen input from centralized sewage (B) for each HUC8 in the urban-suburban scenario. Includes demonstration HUC8s selected by KDOW: 1. Licking; 2. Upper Cumberland-Lake Cumberland; 3. Upper Green. The most intense colors in all RPS maps denote the "best" scores for traits likely to be more favorable to restoration efforts. Indicators of potentially high interest like these can be displayed singly in the RPS Tool for comparison with the RPS Indices and other factors.



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 one another. 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 2 and definitions in Attachment 3) were finalized by KDOW and used in the Stage 2 screenings carried out by EPA and Cadmus. Stage 2 screenings were completed on all rural-agricultural demonstration HUC8s and urban-suburban demonstration HUC8s. These 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 demonstration HUC8s in the two scenarios has been archived for delivery to KDOW with other products (see Attachment 4).

General Observations about Rural-Agricultural Scenario HUC8 Stage 2 Screenings

The three demonstration HUC8s from the rural-agricultural scenario (Lower Tennessee, Tradewater, and Rolling Fork) were screened individually, enabling the comparison of the HUC12 subwatersheds within the HUC8 based on selected rural-agricultural indicators and weights submitted by KDOW. Figure 8 shows the bubble plots from the three demonstration HUC8s. It is important to note that the solid horizontal and vertical lines on the Figure 8 plots 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), in order to display this broader geographic context whenever a small subset of watersheds is being plotted. In comparing all three demonstration HUC8's subwatersheds to the statewide means, it is noteworthy that none of the three have extremely unusual score patterns (e.g., with all subwatersheds substantially higher or lower than the statewide mean), and their component subwatersheds do differ from one another in Ecological and Stressor Index scores even when those scores are seen against statewide gradients of values.

General Observations about Urban-Suburban Scenario HUC8 Stage 2 Screenings

The three demonstration HUC8s from the urban-suburban scenario (Licking, Upper Cumberland-Lake Cumberland, and Upper Green) were screened individually, enabling the comparison of the HUC12 subwatersheds within each HUC8 based on selected urban-suburban indicators and weights submitted by KDOW. Figure 9 shows the bubble plots from all three demonstration HUC8s together. Like the plots in Figure 8, the solid horizontal and vertical lines on the Figure 9 plots 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. Also as above, in comparing all three demonstration HUC8's subwatersheds to the statewide means, it is noteworthy that none of the three have extremely unusual score patterns and their component subwatersheds do differ from one another even against statewide gradients of values.

Figure 8. Bubble plot comparing the HUC12s within the demonstration HUC8s from the rural-agricultural scenario (Lower Tennessee, Tradewater, and Rolling Fork). Vertical and horizontal axes on the plot represent the Stressor and Ecological Index median values for all HUC12s statewide, respectively. All three HUC8s contain HUC12s with Ecological Index scores that range from above-average to below-average. Stressor Index scores are generally above-average only in the Lower Tenessee HUC8 but are more varied in the Tradewater and Rolling Fork HUC8s.

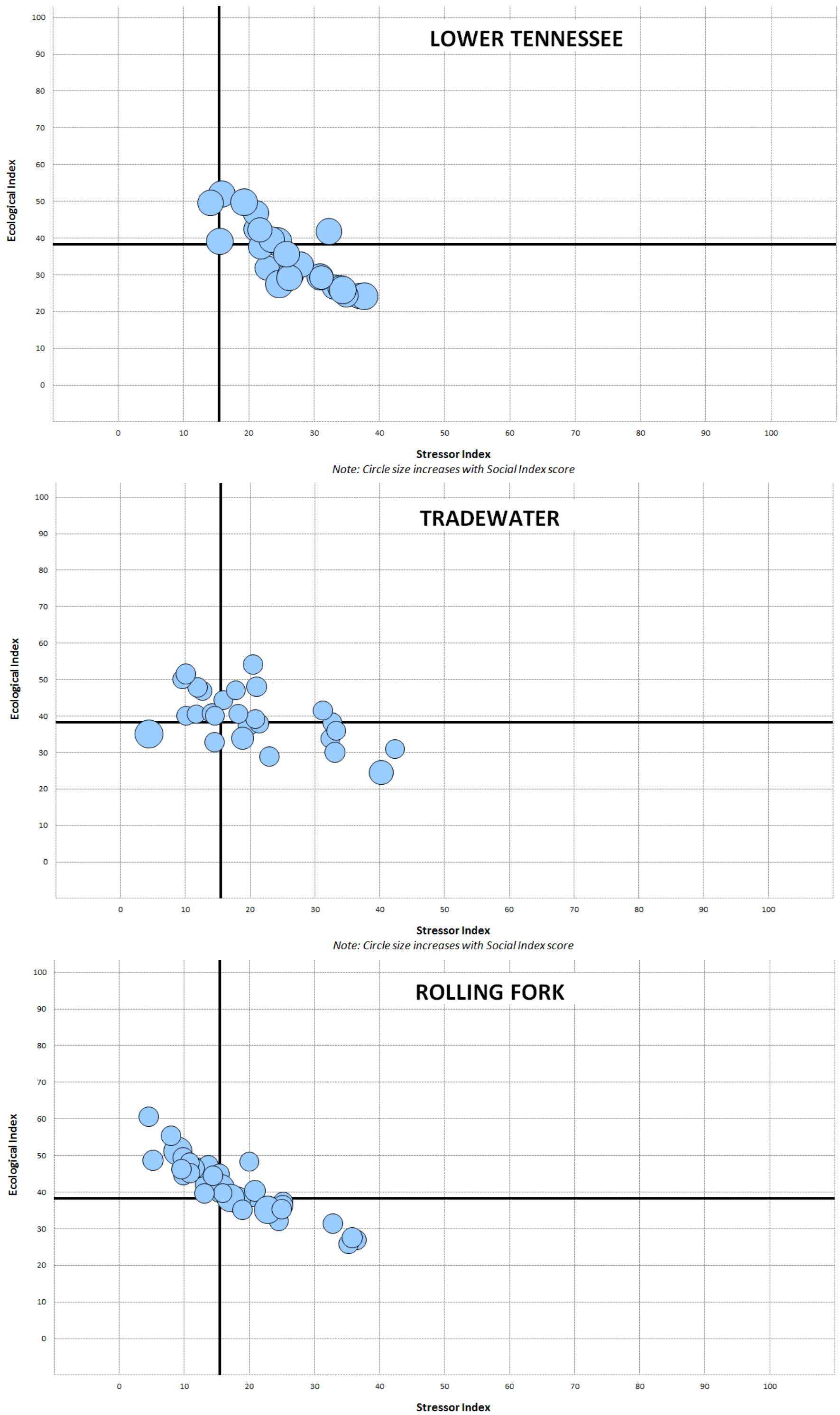
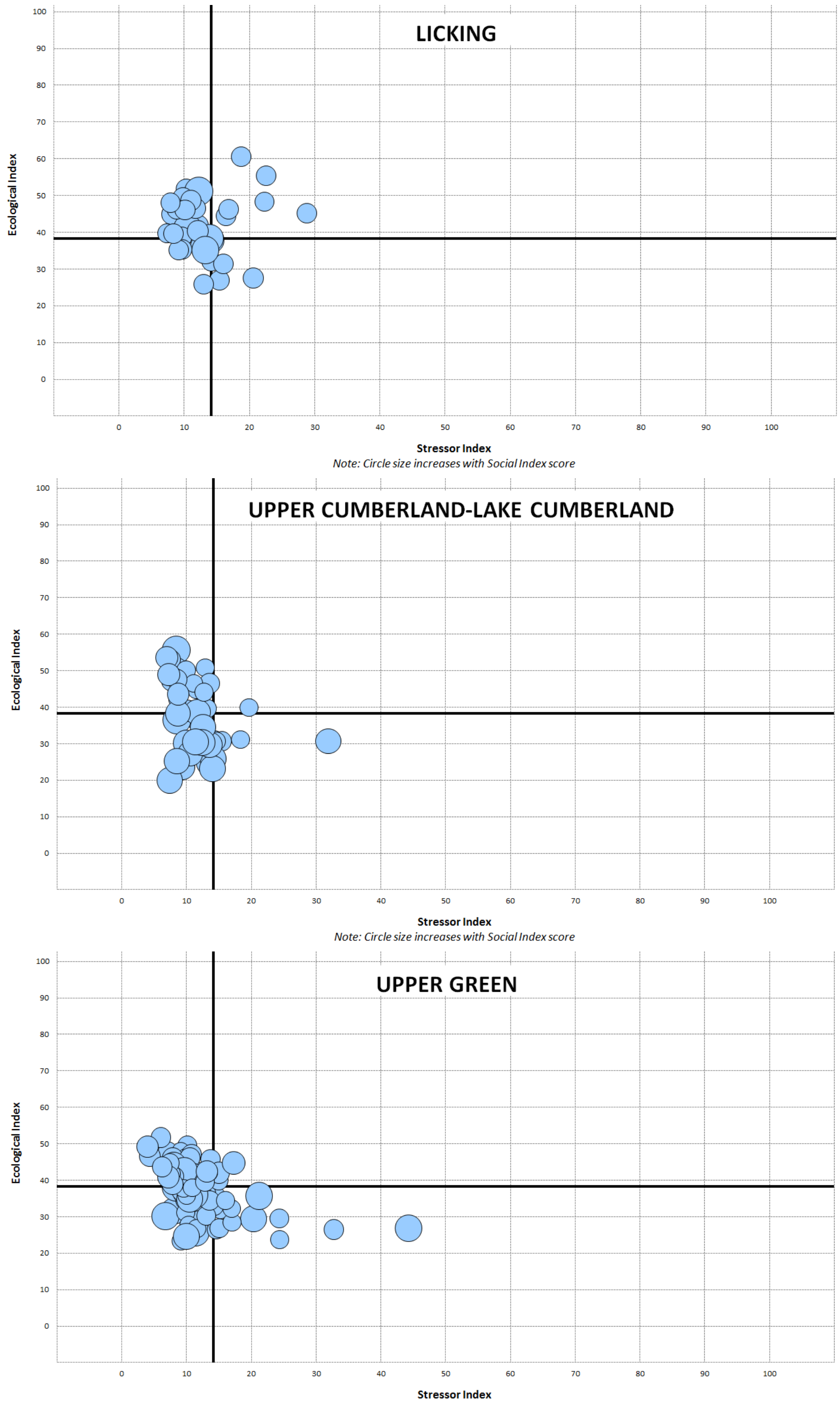


Figure 9. Bubble plot comparing the HUC12s within the demonstration HUC8s from the urban-suburban scenario (Licking, Upper Cumberland-Lake Cumberland, and Upper Green). Vertical and horizontal axes on the plot represent the Stressor and Ecological Index median values for all HUC12s statewide, respectively. All three HUC8s have HUC12s with Ecological Index and Stressor Index scores that range from above to below statewide averages.



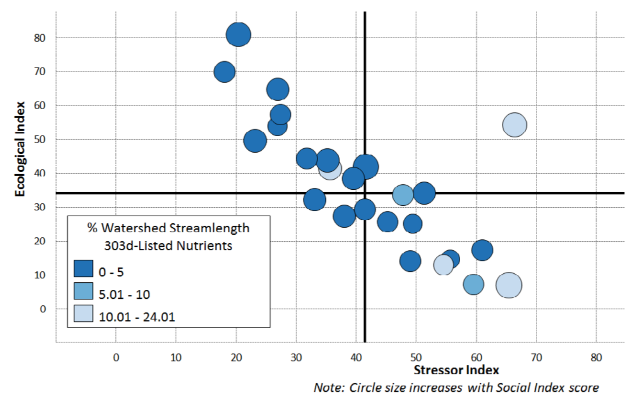
Stage 2 Rural-Agricultural Scenario Screening: Lower Tennessee

The Lower Tennessee HUC8 was one of three 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 8 contrasts the Lower Tennessee HUC8's subwatersheds with those of other HUC8s from this scenario. For example, almost all of the Lower Tennessee's HUC12s exceed the statewide Stressor Index median. In addition, some of its 25 HUC12s have Ecological Index scores that are above the statewide median. Bubble sizes are relatively consistent, indicating that Social Index scores are similar for the 25 Lower Tennessee HUC12s.

The variety of conditions across the Lower Tennessee'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 have axes located at Lower Tennessee HUC8, not statewide, median index scores.

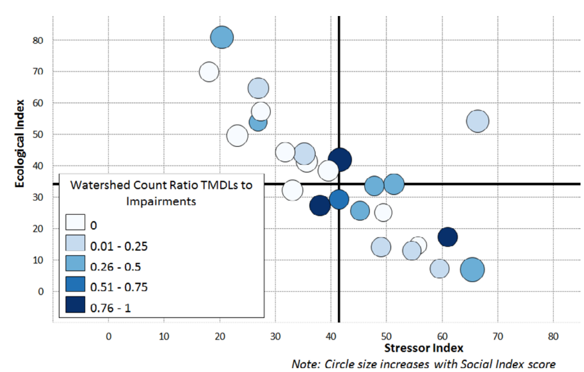
<u>Where are the impairments relative to how the HUCs scored</u>? Regardless of which indicators are used in a screening, the RPS Tool can color-assign a value gradient for any indicator in the data table and use this to gain insights into the bubble plot or map results. In Figure 10, the bubble plot result from the Lower Tennessee screening is further enhanced to display the relative percent of stream length 303(d)-listed as nutrient-impaired. Four of the 25 HUC12s have >10% of stream miles listed for nutrients. The ecological and stressor scores vary widely among these HUC12 with listings. Two in particular are at or higher than the median Ecological score. If further study continues to reveal positive traits, these HUC12s might be good choices for implementing nutrient management.

Figure 10. Lower Tennessee HUC12 nutrients screening output, highlighting HUC12s with the highest nutrients 303d listings as % of total stream length (paler blue shades).



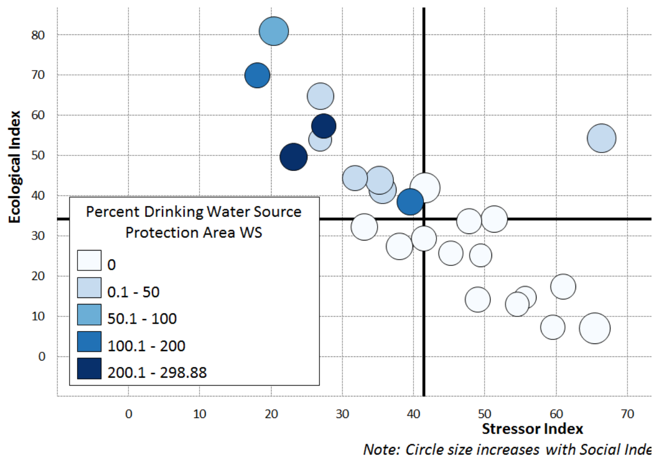
<u>Where are we better prepared for action</u>? In addition to where the impairments are found, the existence of TMDLs and other forms of technical information or plans can be displayed as a factor in RPS bubble plots. Figure 11 shows the Lower Tennessee plot output with color assignment based on the ratio of TMDLs to impairments across all HUC12s. Note that three of four HUC12s mentioned 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.

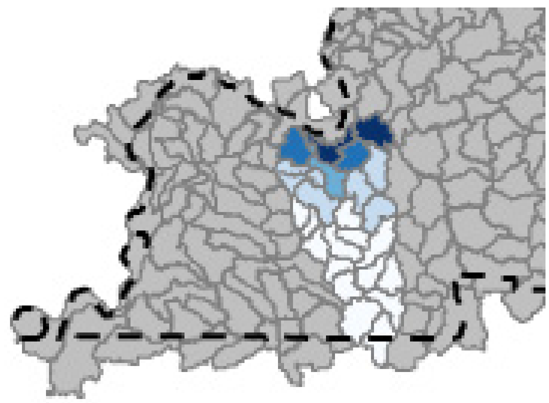
Figure 11. Lower Tennessee output highlighting HUC12s with the highest TMDLs to impairments ratio (deepest blue shades).



Are there specific community motivators for some subwatersheds? 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 12, the Lower Tennessee HUC12s are color-assigned by percent of the watershed that is within drinking water source protection areas (note that percentages can exceed 100% if multiple source protection areas overlap a HUC12 watershed). 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 eleven HUC12s contain some source water/groundwater protection areas. Of these, two contain nutrients listings and five contain TMDLs (see again Figures 10 and 11). Further, it is noteworthy that all eleven scored relatively high on the Ecological Index.

Figure 12. Lower Tennessee bubble plot and map outputs highlighting HUC12s with the highest relative amount of drinking water source protection areas (deepest blue shades).





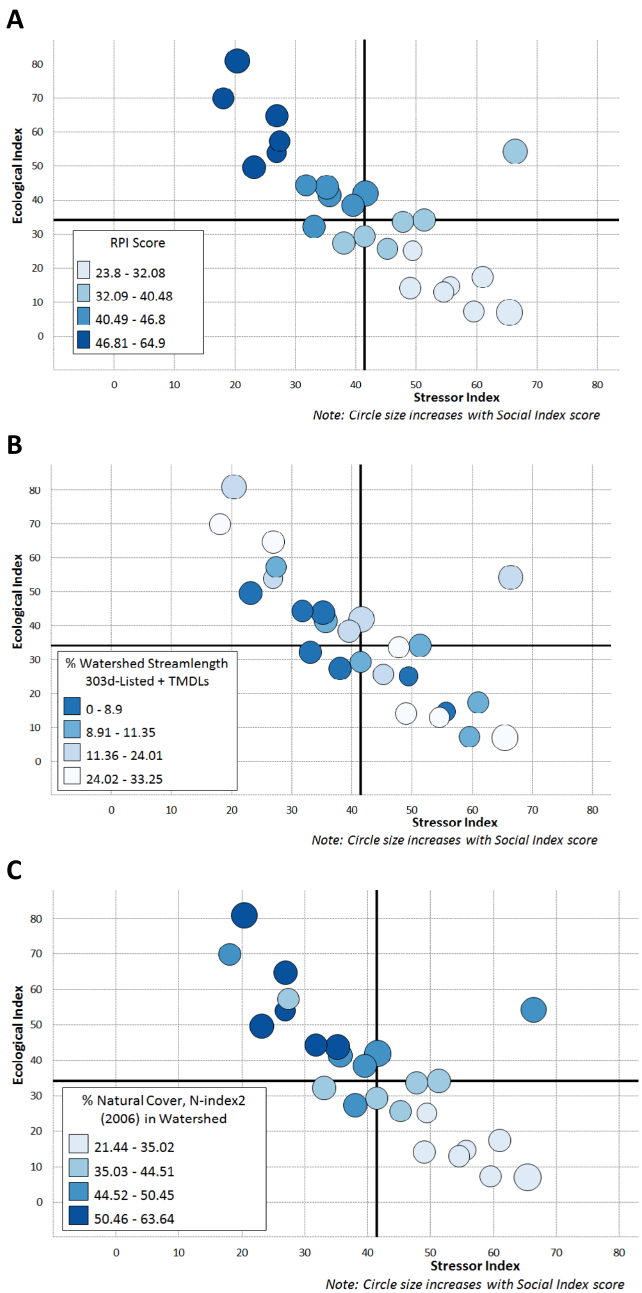
Where would specific types of control practices be appropriate, or effective? Building on questions like the above, planners may want to use RPS Tool results to evaluate which HUC12s might be most appropriate for specific families of control practices while also considering other recovery potential factors. Given that the Lower Tennessee is one of the rural-agricultural scenario demonstration watersheds, one approach would be to compare values of selected agricultural and low-density residential stressor indicators that are relevant to management strategies and practices. In Table 5, values of selected indicators for all Lower Tennessee HUC12s are displayed for comparison, with each indicator value color-assigned by quartile.

For the three stressor indicators (names in red), the highest scores (red-shaded cells) help identify HUC12s with the greatest amount of specific activities that may be nutrient sources. The "% Septic with Water" indicator, for example, helps identify HUC12s likely to have nutrient loading contributions from septic systems that may be good candidates for septic system upgrades or connection to sanitary sewers. The "Riparian Corridor % Agriculture on Steep Slope" indicator provides insight into HUC12s with greater amounts of agriculture in areas prone to erosion that may be priorities for nutrient, residue, and runoff management. The "Synthetic Nitrogen Fertilizer Application" indicator also could be used to highlight HUC12s where nutrient management planning may be needed. For the one ecological indicator in Table 5, the values highlight differences in woody vegetation in the riparian zone, which helps to stabilize streambanks and attenuate nutrients, as an additional consideration. These are just a few examples of how, due to the ease of data retrieval from the RPS tool, any single indicator for any set of watersheds can be readily compared.

Table 5. HUC12 values for four indicators from the Lower Tennessee screening that may be useful for choosing management strategies and targeting subwatersheds. Values of the ecological indicator (% Woody Vegetation in Riparian Zone) are color-assigned in quartiles from highest to lowest in the order green, yellow, orange, and red shading. For stressor metrics (red metric names), values are color-assigned in quartiles from lowest to highest in the order green, yellow, orange, red.

Watershed Name	**% Woody Vegetation in Riparian Zone**	**Riparian Corridor % Agriculture On Steep Slope**	**% Septic with Water**	**Synthetic N fertilizer application (kg N/ha/yr)**
East Fork Clarks River (060400060101)	8.0	0.05	0.02	52.0
Middle Fork Clarks River (060400060102)	8.5	0.07	0.01	58.6
Clayton Creek-Clarks River (060400060103)	6.5	0.08	0.03	53.0
Rockhouse Creek (060400060104)	7.6	0.15	0.02	60.0
Almo-Clarks River (060400060105)	11.0	0.04	0.02	54.7
Clear Creek-West Fork Clarks River (060400060201)	9.3	0.23	0.00	58.3
Damon Creek-West Fork Clarks River (060400060202)	9.8	0.15	0.01	48.7
Soldier Creek (060400060203)	12.1	0.15	0.00	28.8
Panther Creek (060400060204)	11.7	0.20	0.00	35.6
Duncan Creek-West Fork Clarks River (060400060205)	12.1	0.12	0.00	36.6
Trace Creek-West Fork Clarks River (060400060301)	26.0	0.16	0.00	34.4
Spring Creek (060400060302)	17.2	0.20	0.00	36.5
Sugar Creek-West Fork Clarks River (060400060303)	26.9	0.08	0.00	25.7
Blizzard Ponds (060400060304)	22.5	0.12	0.05	19.4
Camp Creek-West Fork Clarks River (060400060305)	26.6	0.11	0.01	24.3
Wades Creek-Clarks River (060400060401)	13.1	0.07	0.03	38.6
Watch Creek-Clarks River (060400060402)	22.3	0.05	0.06	19.4
Middle Fork Creek (060400060403)	13.2	0.17	0.02	27.5
Chestnut Creek-Clarks River (060400060404)	29.3	0.02	0.06	19.5
Dunn Slough Creek-Clarks River (060400060405)	38.6	0.03	0.05	13.9
Upper Cypress Creek (060400060501)	26.7	0.00	0.08	16.3
Guess Creek-Tennessee River (060400060502)	25.4	0.00	0.05	11.4
Lower Cypress Creek (060400060503)	24.0	0.01	0.07	23.2
Island Creek (060400060504)	28.5	0.03	0.05	7.8
White Oak Creek-Tennessee River (060400060505)	22.2	0.00	0.05	13.6

Figure 13. Options for identifying possible HUC12s for protection as part of a Lower Tennessee RPS screening to inform nutrients management (darkest blue are best candidates). A: the RPI Index score from the nutrients screening; B: percent stream length with 303d listings or TMDLs; C: percent natural cover in watershed. All point to many of the same HUC12s (upper left quadrant).



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 Lower Tennessee 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 13, and all are color-assigned to highlight the best prospects (top quartile) with the darkest shade of blue. The first (A) 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. All of the best HUC12s (top 50^{th} percentile RPI scores) cluster in or near the upper left quadrant of the plot where lower stressor and higher ecological scores combine.

A second option (B) 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 are more scattered throughout the plot relative to RPI scores.

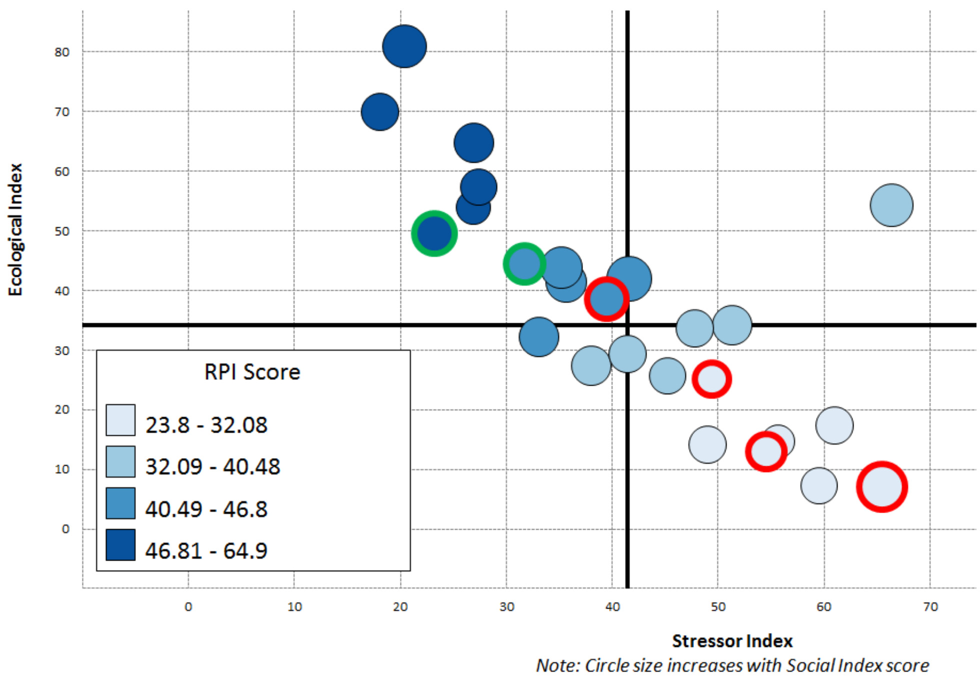
A third option offered in Figure 13 examines one ecological indicator, the percent natural cover in the watershed, as a determinant for protection potential. This indicator points to many of the same prospects as overall RPI scores.

<u>*Does the screening make sense overall*</u>? Although all RPS indicators are QA/QC'ed during and after compilation individually, it is appropriate to also test any RPS screening result as the product of selected indicators and screening 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 25 Lower Tennessee 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 Lower Tennessee screening output.

Identifying suitable 'good reference' HUCs from the 25 involved in the screening relied on a combination of three indicators: % forest in watershed, % national ecological framework, and unimpaired stream miles. Two HUC12s were selected as 'good reference' because they ranked in the top ten in % forest and % national ecological framework and had greater than 95% unimpaired stream miles. Suitable 'poor reference' HUCs were identified through a different set of indicators: % human use index in the hydrologically connected zone, mean empower density in the watershed, and number of stressors from 305b assessments. Four HUC12s were selected as 'poor reference' because they ranked in the top ten in all three indicators.

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

Figure 14. Testing 'good reference' (green outline) and 'poor reference' (red outline) HUC12s in association with the Lower Tennessee RPS screening results. Selection of good and poor reference HUCs was made only from HUC12s within the Lower Tennessee 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.



Stage 2 Urban-Suburban Scenario Screening: Licking

The Licking HUC8 was one of three demonstration HUC8 selections from the urban-suburban scenario analysis of Stage 1. Compared with all HUC8s statewide (see again Figure 6) 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 9 contrasts the subwatersheds within the Licking HUC8 to those of other HUC8s from this scenario and statewide median Ecological Index and Stressor Index scores. The Licking HUC12s generally cluster around above-median Ecological Index scores and below-median Stressor Index scores (upper left quadrant of bubble plot). However, some HUC12s with the highest Ecological Index scores in the group also have the highest Stressor Index scores. Different Social Index scores (displayed as bubble sizes) among Licking HUC12s with high Ecological Index scores suggests that social factors relevant to recovery vary across HUC12s that may be good candidates for restoration.

The variety of conditions across the Licking 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 Licking HUC12s, not statewide, medians.

Where are the impairments relative to how the HUCs scored? In Figure 15, the bubble plot result from the Licking HUC8 screening is further enhanced to display the relative percent of stream length 303d listed as nutrient-impaired. Five HUC12s contain 5% or greater nutrients-listed stream length. Not surprisingly, most of these fall in the lower right quadrant of the bubble plot (high stressor and low ecological scores). The values shown in Figure 15 are based on the 2010 303(d) list, and further investigation might seek to identify HUC12s with nutrient listings that have been added since the 2010 listing cycle.

Where are we better prepared for action? Figure 16 shows the Licking HUC8 plot output with color assignment based on the ratio of TMDLs to impairments across all HUC12s. Note that TMDL availability to guide action is minimal, as only one HUC12 has a ratio above zero. Further study might seek to identify whether other studies or activities (e.g., Nonpoint Source control projects, watershed plans, or other nutrient management projects) exist in any HUC12s and might add to their readiness for carrying out implementation actions.

Figure 15. Licking HUC12s nutrients screening output, highlighting HUC12s with the highest nutrients listings as % of total stream length (paler green shades).

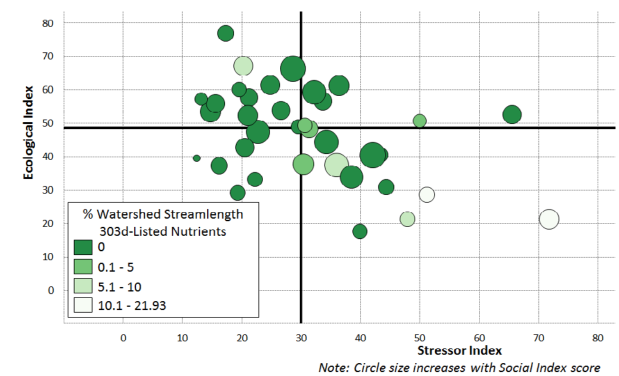
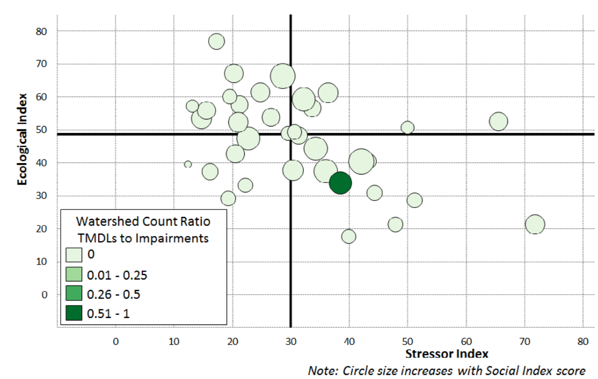
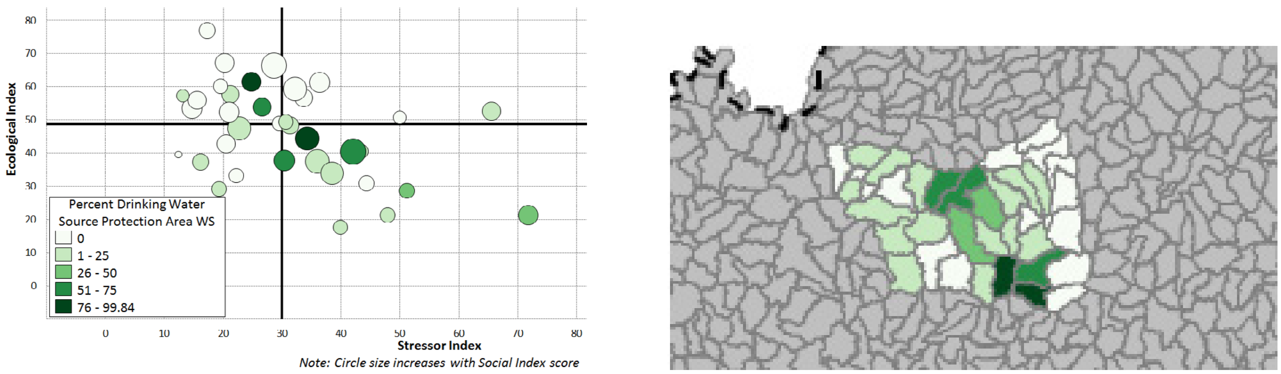


Figure 16. Licking RPS output displaying the TMDL to impairments ratio (high ratio = deepest green shades).



Are there specific community motivators for some subwatersheds? 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 17, the Licking HUC12s are color-assigned by the percent of the watershed that is within drinking water source protection areas. As the importance of 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 a number of Licking HUC12s do play a role in source water protection, with seven HUC12s having at least 25% of their total area overlapping sourcewater protection areas. Two of these have above-median Ecological Index scores and below-median Stressor Index scores (upper left quadrant of bubble plot) while the rest have lower Ecological Index scores and moderate to high Stressor Index scores.

Figure 17. Licking bubble plot and map outputs highlighting HUC12s with the highest relative amount of drinking water source protection areas (deepest green shades).



Where would specific types of control practices be appropriate, or effective? Building on questions like the above, planners may want to use RPS Tool results to evaluate which HUC12s might be most appropriate for specific families of control practices while also considering other recovery potential factors. Given that the Licking HUC8 is one of the urban-suburban scenario demonstration watersheds, one approach would be to compare values of selected urban and low-density residential stressor indicators that are relevant to management strategies and practices. In Table 5, values of selected indicators for all Licking HUC12s are displayed for comparison, with each indicator value color-assigned by quartile.

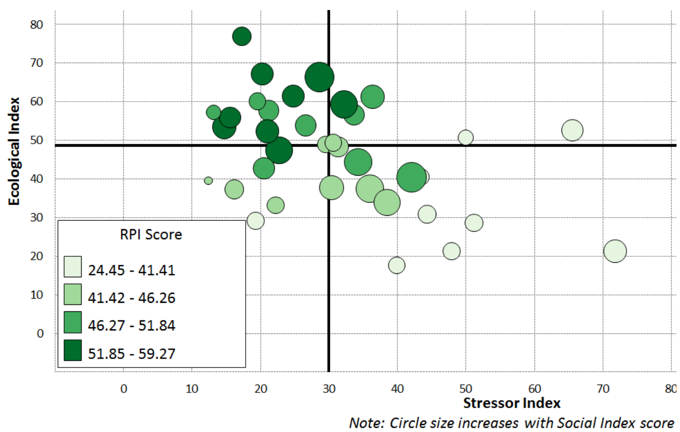
For the three stressor indicators (names in red), the highest scores (red-shaded cells) help identify HUC12s with the greatest amount of specific activities that may be nutrient sources. The "% Septic with Water" indicator, for example, helps identify HUC12s likely to have nutrient loading contributions from septic systems that may be good candidates for septic system upgrades or connection to sanitary sewers. The "% of Stream length Contiguous to Impervious Cover ≥ 5%" and "Road Density, Mean Value in Riparian Zone" indicators provide insight into HUC12s with greater amounts of connected impervious cover that may be priorities for stormwater management. For the one ecological indicator in Table 6, the values highlight differences in woody vegetation in the riparian zone, which helps to stabilize streambanks and attenuate nutrients, as an additional consideration. These are just a few examples of how, due to the ease of data retrieval from the RPS tool, any indicators for any set of watersheds can be readily compared.

Table 6. HUC12 values for four indicators from the Licking screening that may be useful for choosing management strategies and targeting subwatersheds. Values of the ecological indicator (% Woody Vegetation in Riparian Zone) are color-assigned in quartiles from highest to lowest in the order green, yellow, orange, red. For stressor metrics (red names), values are color-assigned in quartiles from lowest to highest in the order green, yellow, orange, red.

Watershed Name	% Woody Vegetation in Riparian Zone	% of Stream length contiguous to Impervious Cover ≥ 5%	Road Density, Mean Value in Riparian Zone (mi /sq mi)	% Septic with Water
Headwaters Chaplin River (051401030101)	5.3	15.3	2.3	0.06
Deep Creek-Chaplin River (051401030102)	9.0	8.3	1.8	0.06
Thompson Creek-Chaplin River (051401030103)	14.7	3.1	1.7	0.04
Glens Creek (051401030104)	15.8	4.4	1.7	0.05
Sulphur Creek-Chaplin River (051401030105)	18.8	1.3	1.7	0.04
Beaver Creek (051401030106)	18.6	5.6	2.0	0.06
Water Run-Chaplin River (051401030107)	18.2	3.2	1.9	0.05
Headwaters Beech Fork (051401030201)	9.4	14.1	2.0	0.05
Pleasant Run (051401030202)	4.3	13.0	1.8	0.05
Prather Creek-Beech Fork (051401030203)	16.0	1.5	2.0	0.04
Long Lick Creek (051401030204)	14.0	5.3	1.7	0.05
Mays Creek-Beech Fork (051401030205)	15.0	4.3	1.8	0.05
Upper Cartwright Creek (051401030301)	3.5	12.6	2.1	0.05
Lower Cartwright Creek (051401030302)	5.5	18.9	2.6	0.05
Hardins Creek (051401030303)	8.1	13.1	2.3	0.05
Short Creek-Beech Fork (051401030304)	12.5	6.6	1.8	0.04
Rowan Creek-Beech Fork (051401030305)	15.6	9.4	2.9	0.05
Buffalo Creek-Beech Fork (051401030306)	18.5	5.0	2.4	0.05
Lick Creek-Beech Fork (051401030307)	22.2	3.7	1.9	0.04
Upper Big South Fork (051401030401)	15.3	9.6	2.0	0.04
Lower Big South Fork (051401030402)	18.0	9.8	1.2	0.03
Upper North Rolling Fork (051401030403)	10.1	12.6	2.1	0.03
Lower North Rolling Fork (051401030404)	12.8	9.3	1.8	0.03
Pope Creek-Rolling Fork (051401030405)	9.9	11.4	1.9	0.04
Cloyd Creek-Rolling Fork (051401030406)	8.9	11.1	2.2	0.05
Clear Creek-Rolling Fork (051401030501)	9.1	6.8	1.6	0.05
Prather Creek-Rolling Fork (051401030502)	14.3	2.4	1.5	0.03
Otter Creek-Rolling Fork (051401030503)	17.5	1.8	1.7	0.04
Pottinger Creek (051401030504)	14.2	2.8	2.2	0.05
Knob Creek-Rolling Fork (051401030505)	14.6	2.3	1.7	0.03
Younger Creek-Rolling Fork (051401030506)	17.8	3.1	1.7	0.03
Clear Creek (051401030601)	14.8	20.3	2.7	0.04
Wilson Creek (051401030602)	25.2	2.4	2.2	0.02
Lebanon Junction-Rolling Fork (051401030603)	30.5	6.5	2.4	0.03
Crooked Creek (051401030604)	33.3	5.2	1.8	0.03
Cedar Creek-Rolling Fork (051401030605)	32.9	1.8	1.1	0.01

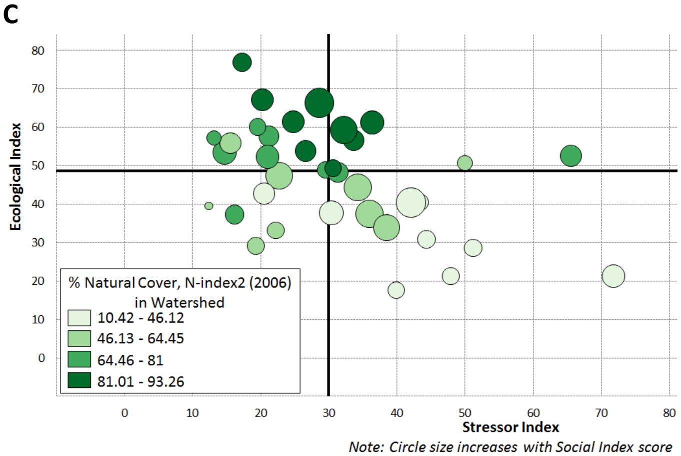
Figure 18. Options for identifying possible HUC12s for protection as part of a Licking RPS screening to inform nutrients management (darkest green are best candidates). A: the RPI Index score from the nutrients screening; B: percent stream length with listings or TMDLs; C: percent natural cover in watershed. All point to many of the same HUC12s (upper left quadrant).

A



B

C



<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 Licking 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.

Three such options for considering protection priorities appear in Figure 18, and all are color-assigned to highlight the best prospects (top quartile) with the darkest shade of green. The first (A) 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 Licking 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 (B) 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 have lower proportions of stream length impaired, providing another possible basis for protection choices.

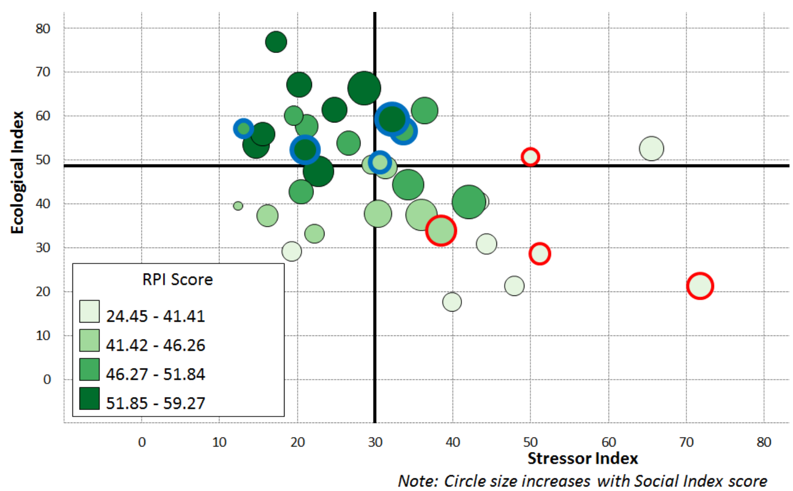
A third option (C) offered in Figure 18 examines an ecological indicator, the percent natural cover in the watershed, as a determinant for protection potential. HUC12s with substantial natural cover could be recognized for their contribution to the Licking HUC8's overall health and prospects for nutrient management and recovery.

<u>*Does the screening make sense overall*</u>? As discussed in the Lower Tennessee 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 36 Licking HUC12s being screened should have predictably good and poor index scores, respectively.

Identifying suitable 'good reference' HUCs from the 36 involved in the screening relied on a combination of three indicators: % forest in watershed, % national ecological framework, and unimpaired stream miles. Four HUC12s were selected as 'good reference' because they ranked in the top ten in % forest and % national ecological framework and had greater than 95% unimpaired stream miles. Suitable 'poor reference' HUCs were identified through a different set of indicators: % human use index in the hydrologically connected zone, mean empower density in the watershed, and number of stressors from 305b assessments. Four HUC12s were selected as 'poor reference' because they ranked in the top ten in all three indicators.

Figure 19 shows the results of plotting both types of reference HUC12s against the full set of Licking HUC12s. As with the Lower Tennessee example, 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 19. Testing potential 'good reference' (blue outline) and 'poor reference' (red outline) HUC12s in association with the Licking RPS screening results. Selection of good and poor reference HUCs was made only from HUC12s within the Licking 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 KDOW, EPA and additional sources, this project compiled 300 indicators (base, ecological, stressor and social) at one or more watershed scales that were used to screen and compare watersheds in a two-stage process. In the first stage, Kentucky's 45 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 KDOW input, 3 of the 22 rural-agricultural watersheds and 3 of the 14 urban-suburban watersheds were selected as demonstration HUC8s for further analysis in the second stage.

Stage 2 screenings were performed on each of these six demonstration HUC8s, and one per each scenario was utilized in this report's discussion of Stage 2 results. These screenings 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 this project was a demonstration of the RPS Tool and approach, no priorities among HUC12s were selected but numerous alternatives and analytical techniques were presented in one Stage 2 screening from each of the two Stage 1 scenarios. Products include this summary report, a master KY RPS Tool file, and separate screening files that archived the results from the two Stage 1 screenings, the three Stage 2 rural-agricultural watershed screenings, and the three Stage 2 urban-suburban watershed screenings. Opportunities for KDOW and other users from this point forward may include:

<u>Become adept at RPS Tool desktop use.</u> Despite the extensive amount of data it holds, its numerous product formats and the wide variety of comparisons among watersheds that these data can support, the KY 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.

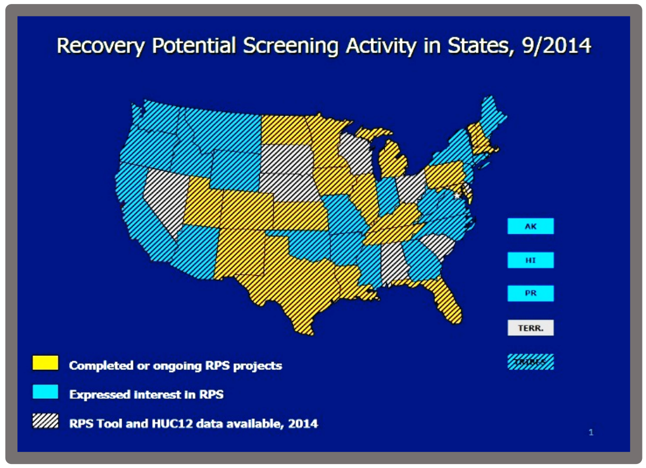
<u>Apply the RPS Tool to other screening topics.</u> Although this effort focused on a nutrients application of RPS, the Kentucky dataset would support numerous other screening themes and purposes that can be explored in the interest of long-term priority setting for restoration and protection. Pathogen impairments have been the focus of previous KDOW uses of the RPS Tool. Other screening topics might include sediment, metals, 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 specifically targeted pollution control settings such as leaky septics along inhabited stream corridors. With both the TMDL Program and the Non-Point Source Control Program promoting watershed priority-setting, the range of opportunities is widespread.

<u>Refine the available data and selection of indicators.</u> Even within this nutrients application of RPS, opportunities always will 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, re-running the Stage 1 screening to separately include SPARROW incremental and delivered nutrient load estimates would allow for considering HUC8 differences in relation to nutrient delivery to the Gulf of Mexico as well as to instate effects only.

Galvanize state/local restoration and protection dialogue and partnering. RPS offers an organized and accessible 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 KDOW 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: KY Stage 1 Rural-Agricultural and Urban-Suburban Scenario Indicator Descriptions

(Note: Black denotes base metrics not used in scoring, green is 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.)

Indicator Name	Description
Hydrologic Unit Code 8-Digit (HUC8)	HUC8 Code (TEXT)
Name HUC8 Watershed	Name of primary stream draining area or description of area bounded by HUC8 polygon. (TEXT)
% Woody Vegetation (2006) in Riparian Zone	Percent of total HUC riparian zone area in NLCD06 forested or woody (e.g. shrub) land cover categories 41, 42, 43, 52 and 90.
% Natural Cover, N-index1 (2006) in HCZ	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.
% NEF2001, National Ecological Framework, WS	Watershed percent of total area within EPA Region 4 National Ecological Framework (NEF) of hydrologically significant and connected natural cover hubs and corridors.
Ratio of Natural to Recycled N Inputs	The ratio of pre-European N inputs (natNfix + Nat_OxN) to recycled anthropogenic N inputs. Inverse of original ORD metric.
Ratio of Natural to New N Inputs	The ratio of pre-European N inputs (natNfix + Nat_OxN) to new anthropogenic N inputs. Inverse of original ORD metric.
% Urban (2006) in HCZ	Hydro connected zone % of total area in low, medium and high density urban use according to 2006 National Land Cover Dataset
% Agriculture (2006) in Watershed	Watershed % of total area in cropland or pasture according to 2006 National Land Cover Dataset
% Agriculture (2006) in HCZ	Hydro connected zone % of total area in cropland or pasture according to 2006 National Land Cover Dataset
% Agriculture (2006) in Riparian Zone	Riparian zone % of total area in cropland or pasture according to 2006 National Land Cover Dataset
% Human Use, U-index 2 (2006) in Watershed	% of HUC that is barren, agricultural, or urban in the Riparian Zone (2006 National Land Cover Dataset version 1; Land classes 21, 22, 23, 24, 31, 81, 82)
Empower Density 2001, Mean Value in Watershed	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.
Empower Density 2001, Mean Value in HCZ	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.
Agricultural water use WS	From EPA/ORD EnviroAtlas, agricultural water usage estimates.
Domestic water use WS	From EPA/ORD EnviroAtlas, domestic water usage estimates.

Indicator Name	Description
Watershed Likely N/P NPDES Discharger Count	From EPA's NPDAT website, the HUC8's number of NPDES-permitted dischargers whose permits contained terms related to nutrient discharge limits
SPARROW Predicted Incremental N Yield	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)].
SPARROW Predicted Incremental 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)].
SPARROW Predicted Incremental P Yield	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)].
SPARROW Predicted Incremental 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)].
SPARROW Predicted Incremental Agr N Yield (2012)	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.
SPARROW Predicted Incremental Agr P Yield (2012)	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.
Anthropogenic Recycled N Effort	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.
Anthropogenic New N Effort	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.
Percent GAP status 1, 2, and 3 WS	Percent of HUC8 by total area that is in GAP analysis program's protection and conservation status categories 1, 2, and 3
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.
% of HUC8 Instate	Percent of total HUC8 area within KY.; allows for setting higher state priorities on watersheds fully or mostly within their borders as well as identifying watersheds for multi-state cooperation.
Percent Drinking Water Source Protection Area WS	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.

Indicator Name	Description
Anthropogenic Recycled N Effort (Inverse)	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.
Anthropogenic New N Effort (Inverse)	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.

Attachment 3: KY Stage 2 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. ISO signifies indicators measured only to the state boundary, i.e., boundary HUC12s contain data only for the instate portion and proportional metrics relate only to the instate portion. All other metrics are on whole HUC12s only regardless of instate proportion.)

URBAN-SUBURBAN SCENARIO INDICATORS	**DESCRIPTION**
% Woody Vegetation (2006) in Riparian Zone	% 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	% 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	Average soil stability in HCZ. Calculated as one minus average K factor in HCZ (HCZ_KFACTOR).
NFHAP - Cumulative Disturbance Index (ISO)	Cumulative Disturbance Index from National Fish habitat Action Plan Assessment.
% Urban (2006) in Riparian Zone	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	Watershed percent urban that is contiguous with NHD waters; data from Region 4 WSI grid datasets
% U-Index06 Contiguous H2O, in Watershed	% of HUC12 that is agricultural or urban and is contiguous with water
% of Stream length contiguous to 2006 IC ≥ 5% WS	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	Mean value of non-renewable emergy flow per year in Riparian Zone
Road Density 2003, Mean Value (mi /sq mi) RZ	Mean Road Density (mi / sqmi) in Riparian Zone
Total nitrogen deposition WS	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	The mean rate of synthetic nitrogen fertilizer application to agricultural lands within each HUC12 in kg N/ha/yr.
% Nutrient Impaired Streams (ISO)	% of stream length with nutrient impairments (KDOW).
Watershed 303d + TMDL Impairment Causes Count	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	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	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	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	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	DESCRIPTION
% in Source Water Protection Area (ISO)	% of area associated with drinking water (surface water and groundwater) resource protection (KDOW). ISO means this indicator is calculated for the In-State Only portion of border watersheds.
Watershed Groups (ISO)	# of active watershed groups. ISO means this indicator is calculated for the In-State Only portion of border watersheds.
Jurisdictional Complexity (ISO)	# 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	DESCRIPTION
% Woody Vegetation (2006) in Riparian Zone	% 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	% 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	Average soil stability in HCZ. Calculated as one minus average K factor in HCZ (HCZ_KFACTOR).
NFHAP - Cumulative Disturbance Index (ISO)	Cumulative Disturbance Index from National Fish habitat Action Plan Assessment.
% Developed, Low intensity (2006) in Riparian Zone	% of HUC12 with developed, low intensity cover in the Riparian Zone (2006 National Land Cover Dataset version 1)
% Agriculture (2006) in Watershed	Watershed % of total area in cropland or pasture according to 2006 National Land Cover Dataset
% Contiguous Agriculture (2006) in Watershed	Watershed percent agriculture contiguous with NHD surface waters; data from Region 4 WSI grid datasets
% U-Index06 Contiguous H2O, in Watershed	% of HUC12 that is agricultural or urban and is contiguous with water
% of Stream length contiguous to 2006 IC ≥ 5% WS	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	Mean value of non-renewable emergy flow per year in Riparian Zone
Total nitrogen deposition WS	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	The mean rate of synthetic nitrogen fertilizer application to agricultural lands within each HUC12 in kg N/ha/yr.
% Nutrient Impaired Streams (ISO)	% of stream length with nutrient impairments (KDOW).
Watershed 303d + TMDL Impairment Causes Count	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	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	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	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).

RURAL-AGRICULTURAL SCENARIO INDICATORS	**DESCRIPTION**
Percent land with any IUCN status WS	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)	% of area associated with drinking water (surface water and groundwater) resource protection (KDOW). ISO means this indicator is calculated for the In-State Only portion of border watersheds.
Watershed Groups (ISO)	# of active watershed groups. ISO means this indicator is calculated for the In-State Only portion of border watersheds.
Jurisdictional Complexity (ISO)	# 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: KY 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 KDOW for statewide and HUC8-specific use. Except for MASTER KY 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
150224 MASTER KY RPS –Scoring-Tool-021015.xlsm	KY RPS Tool with all HUC8 and HUC12 data, no screening content saved (master copy for all new screening statewide or on HUC subsets)
150126 ST1RURAL KY RPS-Scoring-Tool-021015.xlsm	KY RPS Tool with screening results for HUC8 Stage 1 rural-agricultural scenario
150126 ST1URBAN KY RPS-Scoring-Tool-021015.xlsm	KY RPS Tool with screening results for HUC8 Stage 1 urban-suburban scenario
150224 RURST2 LWRTN KY RPS –Scoring-Tool-021015.xlsm	KY RPS Tool with Stage 2 results for HUC12 screening within Lower Tennessee HUC8
150224 RURST2 ROLLINGFK KY RPS –Scoring-Tool-021015.xlsm	KY RPS Tool with Stage 2 results for HUC12 screening within Rolling Fork HUC8
150224 RURST2 TRADEWTR KY RPS –Scoring-Tool-021015.xlsm	KY RPS Tool with Stage 2 results for HUC12 screening within Tradewater HUC8
150224 URBST2 LICKING KY RPS –Scoring-Tool-021015.xlsm	KY RPS Tool with Stage 2 results for HUC12 screening within Licking HUC8
150224 URBST2 UCUMLCUM KY RPS –Scoring-Tool-021015.xlsm	KY RPS Tool with Stage 2 results for HUC12 screening within Upper Cumberland-Lake Cumberland HUC8
150224 URBST2 UPRGREEN KY RPS –Scoring-Tool-021015.xlsm	KY RPS Tool with Stage 2 results for HUC12 screening within Upper Green HUC8