

The Watershed Index Online User Manual

The Watershed Index Online (WSIO) User Manual

An Enhanced Scoring
Application for Comparative
Watershed Assessment



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Disclaimer and User Requirements

- **Software requirements:** At least a Windows 7 operating system and Microsoft .NET Framework 4.5 and above. Mention of product names does not denote endorsement by the EPA.
- **The WSIO is intended to be used as a decision-support tool** by government, professional, academic, and community users with a basic understanding of how the ecological condition of a watershed and the stressors that act upon it can affect hydrology, biology, and water quality. The WSIO data and tool outputs do not represent, change or substitute for any statute, regulation, policy, EPA decision or position.
- **It is the responsibility of the user to read and evaluate dataset limitations, restrictions, and intended use.** To the best of our knowledge, the data, information, and supporting materials on the WSIO website are accurate; however, no warranty expressed or implied is made regarding the accuracy or utility of the data for general or scientific purposes, nor shall the distribution constitute any such warranty. All modeled geographic data are, by their nature, imperfect. The data provided by this tool shall not be taken as absolute truth, but rather as an approximation made in good faith based on the best available data.
- **For site-specific data, WSIO data will not replace “boots-on-the-ground” measurements or local knowledge.** Better local data may be available from local sources.
- **Neither the EPA, EPA contractors, nor any other organizations cooperating with the EPA assume any responsibility for damages or other liabilities** related to the accuracy, availability, use or misuse of the information provided on this website. The EPA reserves the right to change information at any time without public notice. Any errors or omissions should be reported to the WSIO team using “Contact Us” on the WSIO website. We are always happy to hear your feedback and use that feedback for future enhancements.

Abbreviations

EA	Environmental Atlas
EEA	Essential Environmental Attributes
EPA	Environmental Protection Agency
GIS	Geographic Information System
HCZ	Hydrologically Connected Zone
HUC	Hydrologic Unit Code
HWI	Healthy Watershed Initiative
MS	Microsoft Corporation
NHD	National Hydrography Dataset
NLCD	National Land Cover Data
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
RPI	Recovery Potential Index (Score)
RPS	Recovery Potential Screening
RZ	Riparian Zone
SAB	Scientific Advisory Board
TMDL	Total Maximum Daily Load
WBD	Watershed Boundary Data
WS	Watershed
WSI	Watershed Index (Score)
WSIO	Watershed Index Online

I. Introduction

A. Comparative Watershed Assessment

Federal, State and Local water quality programs are increasingly using comparative watershed assessment tools to inform their decisions about how to prioritize watersheds for restoration and protection activities in the context of their overall water quality goals. Comparative watershed assessment involves systematically evaluating large numbers of watersheds, in order to identify and communicate the similarities and differences among them. This type of assessment requires that data on various watershed attributes (such as land cover, hydrology, slope, soils, biology, water quality, etc.) be consistently translated into “indicators” of watershed condition and drivers of change (stressors) for the watersheds being compared. The Watershed Index Online (WSIO) is a free, publically available data library of watershed indicators and a decision-support tool, developed by the EPA, to assist resource managers with evaluating, comparing, and prioritizing watersheds to support the user’s objectives.

B. About the Watershed Index Online Project and Tool

1. The Watershed Index Online Project

The Watershed Index Online (WSIO) project was initiated in 2008 by the EPA Region 4 WPD and collaborators, to improve ways to compare, prioritize and target watersheds for a broad range of watershed management purposes. The EPA Office of Water Recovery Potential Screening (RPS) project is the primary partner in the WSIO’s development. During the past several years, Region 4’s WSIO team and others compiled a substantial national database of watershed characteristics; while, the RPS project developed and applied an Excel-based watershed comparative scoring tool for each of the 48 contiguous US states. The WSIO merges these efforts into a single product by combining the WSIO indicator database and an enhanced version of the RPS tool; creating a watershed analysis application resource that is able to cross state boundary lines.

2. The WSIO Tool

The WSIO Tool was developed to assist federal, state, and local partners in prioritizing activities based on watershed condition and suitability or need for protection, restoration, improved monitoring, and other management activities. The goal of the WSIO project is to increase the capacity for states and others to perform comparative watershed analysis by providing a watershed comparison tool and a library of more than 300 of the most popular watershed indicators. These attributes have been measured consistently for all 83,015 12-digit Hydrologic Unit Code (HUC12) watersheds (e.g., 40-square mile average size) in the contiguous United States and is hosted as a map service (<https://gispub.epa.gov/arcgis/rest/services/r4/wsio/MapServer>). The WSIO Tool allows users to easily choose uniformly measured watershed indicators for a defined project area, to generate and assess comparative rankings for those watersheds based on ecological, stressor, and social context indicators selected by the user, and to save a variety of watershed comparative screenings for further analysis or export of tables, maps, and plots.

C. Preparing to use the WSIO Tool

1. Obtaining the WSIO Tool

The WSIO Tool is available for download directly from the WSIO website located here:

<https://www.epa.gov/wsio/introducing-wsio-national-watershed-library-and-tools>, by clicking on the **WSIO Tool** link at the bottom of the page.

2. Selecting a Project Area

There are two steps in the WSIO process where the user can specify a geographic area, there are different considerations for each stage. The first time the user is selecting watersheds within a State, HUC6, EcoRegion, or EPA Region. This step is performed on the **Project** page of the application and it defines the selectable project area. It is recommended that the user be inclusive and that the project area be hydrology-based (i.e. river basin), although geographic areas such as a state boundary may also provide suitable project areas. It is recommended to avoid selecting too small of an area because smaller project areas do not provide sufficient hydrologic, ecological, topographic, and physical variety to provide context for normalizing indicators and ranking watersheds.

The second time the user can select a geographic area is when selecting HUC12 watersheds on which to perform a screening. This step is performed on the **Map** tab and it defines the screening area, allowing the user to focus on sub-set(s) of the larger project area selected in the first step. Multiple screenings can be performed and saved by clicking on **Save As** in the **Project** menu and renaming your project file. The project area provides the setting (context) for the analysis, the screening area allows the user to focus in on a sub-set of the larger project area.

3. Selecting Indicators

a) *About Indicators*

A watershed indicator is an attribute of a watershed that is useful for watershed comparison and can be consistently measured throughout the geographic area of interest. Most of the WSIO's several hundred indicators are derived from geospatial data analysis, although some come from field monitoring and other information sources that have been geospatially referenced to watersheds. Indicators in the WSIO database are grouped by three Indicator Types: Ecological, Stressor, or Social classes which encompass the most desired data used in many watershed comparisons. Indicators also include different spatial extents, depending on whether the indicator represents the entire HUC12 watershed (WS), or just the stream corridor, as represented by the Hydrologically Connected Zone (HCZ) or the Riparian Zone (RZ) (See: **Glossary**). A comparison of the RZ and HCZ masks applied to the same waterbody is shown in Error! Reference source not found. For more information on WSIO Indicators, a list of available indicators and their definitions can be downloaded from the WSIO website, in addition to Indicator Data tables (<https://www.epa.gov/wsio/data-tables-and-map-services>). Indicators specific to a region or project area can also be developed by the user and incorporated into the Tool (See: Build a User Database of Indicators).

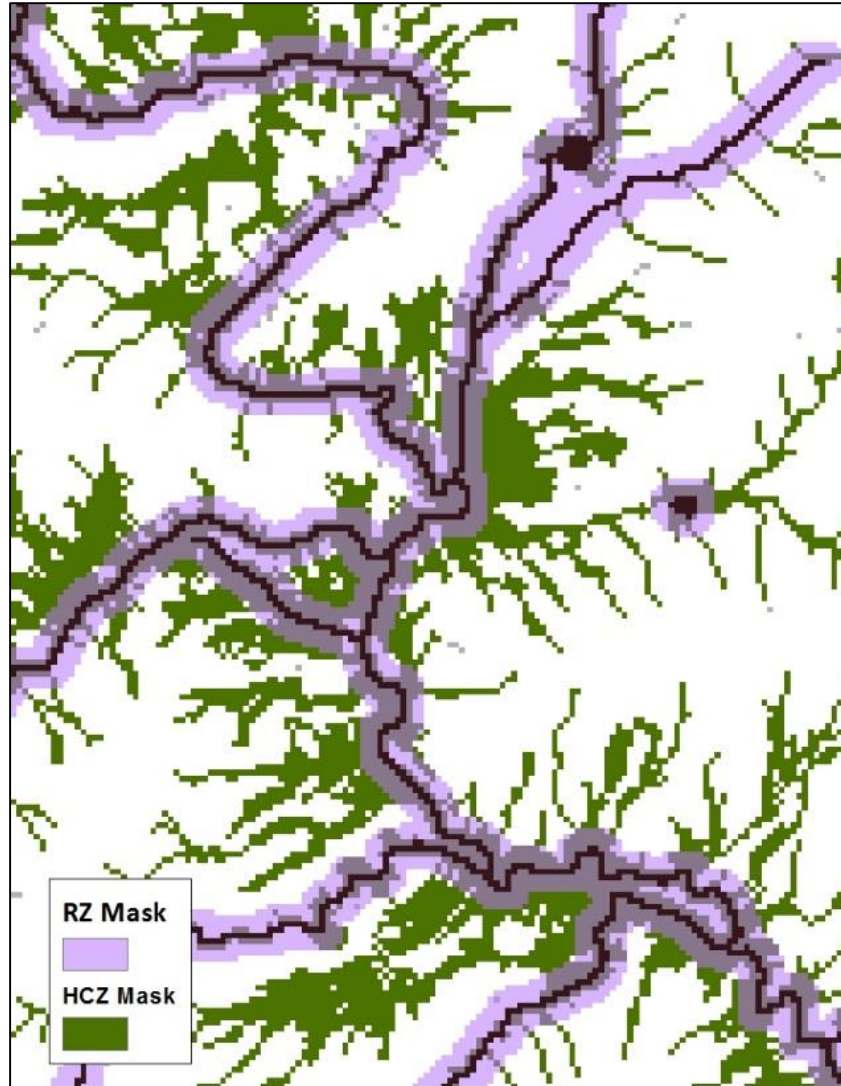


Figure 1: Riparian Zone and Hydrologically Connected Zone mask applied to the same waterbody.

b) Indicator Correlations

The WSIO Tool allows the user to see correlations among the same type of selected Ecological and Stressor indicators. This function is included to aid in the selection of indicators by providing the user the ability to see the strength and direction of the relationship between them. The value of correlation coefficients ranges from 1 to -1. The closer the value is to ± 1 , the stronger the relationship between the two indicators; the closer the value is to 0, the weaker the relationship. Positive values indicate that the variables change in the same direction, while negative values express an inverse relationship. The Tool provides results for two correlation types: Pearson and Spearman Correlations.

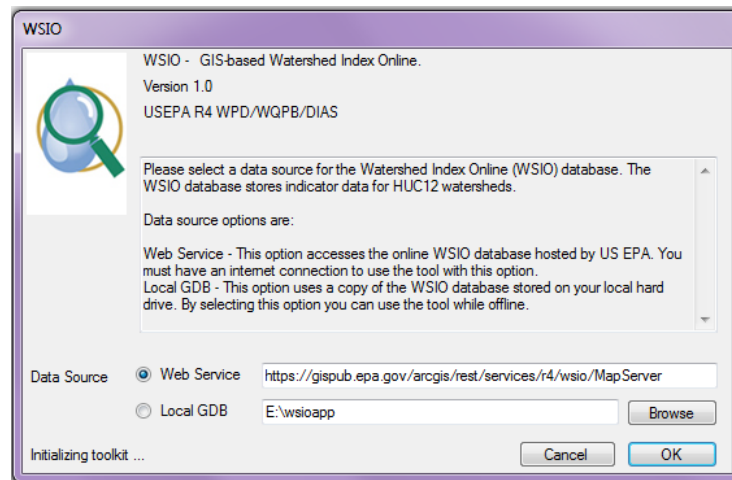
The Pearson Correlation assumes that both variables are normally distributed, have a straight line relationship between them, and are normally distributed about the regression line. The Spearman Correlation is a nonparametric version of the Pearson Correlation, and is useful when the relationship

between two variables is expected to be non-linear. A small p-Value of <0.05 , indicates that you can reject the null hypothesis that these two indicators do not have a relationship. The higher the p-value, above 0.05, indicates that you can accept the null hypothesis that these two indicators do not have a direct relationship.

II. WSIO Tool Step-by-Step Instructions

A. RUN WSIO Tool and Select Data Source

Run the WSIO Tool by opening the executable file, '**WSIO.exe**.' The application will open with the option to use a 'Web Service' or a 'Local Geodatabase' to pull in indicators to the tool. The Web Service requires an internet connection for data transmittal. The most current version of these indicators will be available through the Web Service and for download from the WSIO website. Once you have selected your data source, click '**OK**.'



B. Build or Open a Project

The application will open with a blank workspace. Click on the '**Project**' tab to be able to start a new project, open an existing project, or to build a user database of indicators.

1. A new project

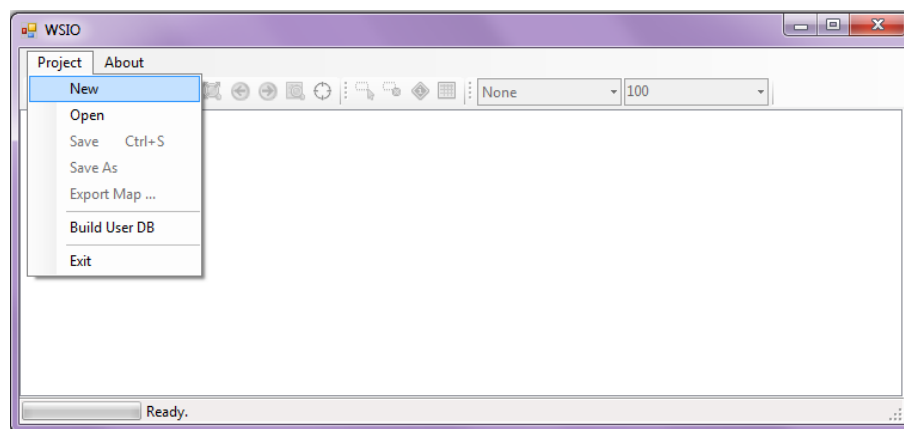
Click on 'New' and continue to **WSIO Project Description and Select Geography**

2. Open an existing project

Go to **Open an Existing Project**

3. Build a user database of indicators

Go to **Build a User Database of Indicators**



C. WSIO Project Description and Select Geography

A **'Project'** window opens, allowing you to name your project, choose where to save it, add a description, and begin to select your geographic area of interest. The selections made below will create a boundary for your project.

First, use the geography buttons to select the category (States, Basin (HUC6), EcoRegion, and EPA Region) that best suits your needs. The lower left table will populate with selection options. This selection will determine the broadest geographic area of HUC12s that will be available for use in a WSIO project. It is recommended to select the largest possible area of HUCs you may need for a screening at this step; to select more than one option (two states, for example), hold the CTRL button down while making multiple selections. Once complete, click **'Get HUC12s' (#1)** to populate the lower right table. A subset of HUCs from this list may be selected at this step for a screening run (although all HUCs within this table will be brought into your project), or within the map window of your project. Once finished with this list click **'Select HUC12s' (#2)**, then **'Create Project' (#3)**.

The screenshot shows the 'WSIO Project' window. The 'Project' tab is active. The 'Project Name' field contains 'Untitled.wsio'. The 'Project Folder' field contains 'E:\wsioapp\data' with a 'Browse' button. The 'Description' field contains 'Untitled'. Below these fields is a text box with instructions: 'The selections made below will create a boundary for your project. First, use the geography buttons to select the category (States, Basin (HUC6), EcoRegion, and EPA Region) that best suits your needs. Highlight one or more areas of interest for that geography - this will create the largest selectable area for your project - and click the 'Get HUC12s' button. The HUC12s table will populate; by default, all HUC12s are selected. You can reduce the number of selected HUCs here in the HUC12s table, or in the map window of your project. Click on 'Create Project' to finalize a WSIO project setup.'

The 'Geography' section has four radio buttons: 'States' (selected), 'Basin (HUC6)', 'EcoRegion', and 'EPA Region'. Below this is a list of US states: Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana. 'Alabama' is selected.

To the right is a table titled 'HUC12s (1484 selected)'. It has three columns: 'WATERSHED', 'HUC12', and 'SUBWTRSHED'. The table contains 14 rows of data, all of which are highlighted in blue. The first row is: Middle Chattahoochee..., 031300020601, Hillabahatchee Creek. The last row is: Middle Chattahoochee..., 031300020903, Barrow Creek-Chattah...

At the bottom of the window are three buttons: 'Clear Selection', 'Get HUC12s' (labeled 1), 'Clear Selection', 'Select All', 'Select HUC12s' (labeled 2), and 'Create Project' (labeled 3).

The HUC12 watersheds that will be downloaded, and therefore made available for inclusion in a screening run, are the ones that are wholly or partially included in whatever area is defined by the filter geography type selected, even if the HUC12s intersect the state line, ecoregion, or EPA Region boundary. For example, if the user selects to filter based on a "State," selects "Tennessee" as the only value, and then filters for HUC8 "05110002 (Barren)" (a watershed that crosses the state line with Kentucky), the watersheds retrieved by the download will be any HUC12 (05110002####) that

lies wholly or partially within the state of Tennessee, but will not include HUC12s wholly within the state of Kentucky (see Figure 2). If the user intended to download/screen the entire HUC8, regardless of the state it drains, the options include filtering based on a State(s), including both “Tennessee” and “Kentucky” as values, and then selecting HUC8 “05110002 (Barren).” Another way of accomplishing this would be to filter based on the HUC6 “River Basin,” select “051100 (Green),” and then filter for HUC8 “05110002 (Barren).” As long as the filtered geographic area encompasses the entire HUC8 watershed, the downloaded dataset should include all of the HUC12s that comprise the parent HUC8.

It is also important to note that, since the watershed indicators are calculated at the HUC12 scale, any indicator data brought into the project represents the entire areal extent of the associated HUC12, even if the watershed crosses a political boundary outside of the filter area. The exception to this is when the political boundary is the U.S. border with Canada or Mexico. For any HUCs that cross the U.S. border, the data for an area of the HUC only represent the portion within the U.S.

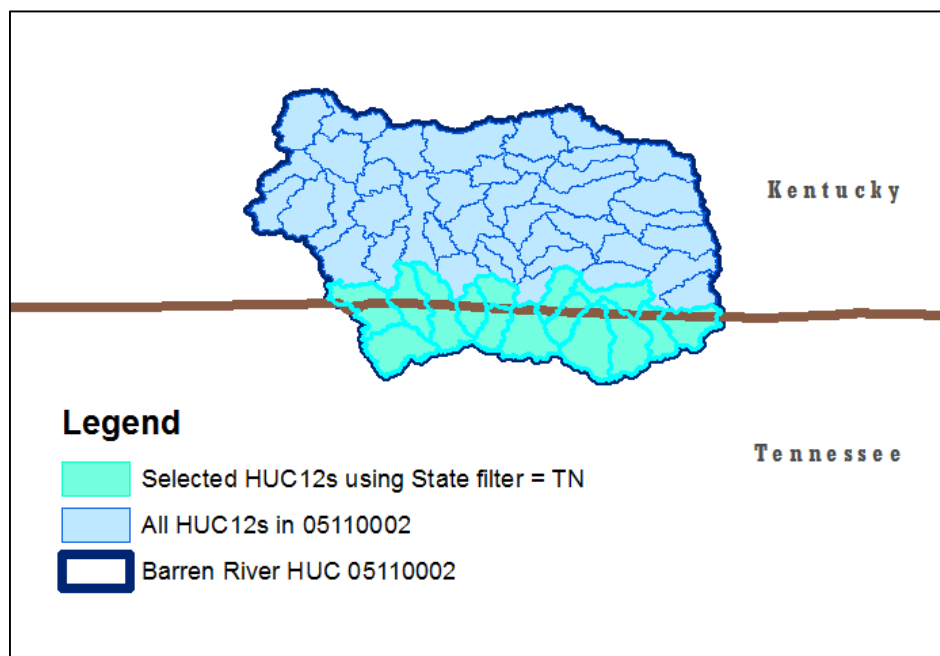


Figure 2. Example project area selection using a State filter.

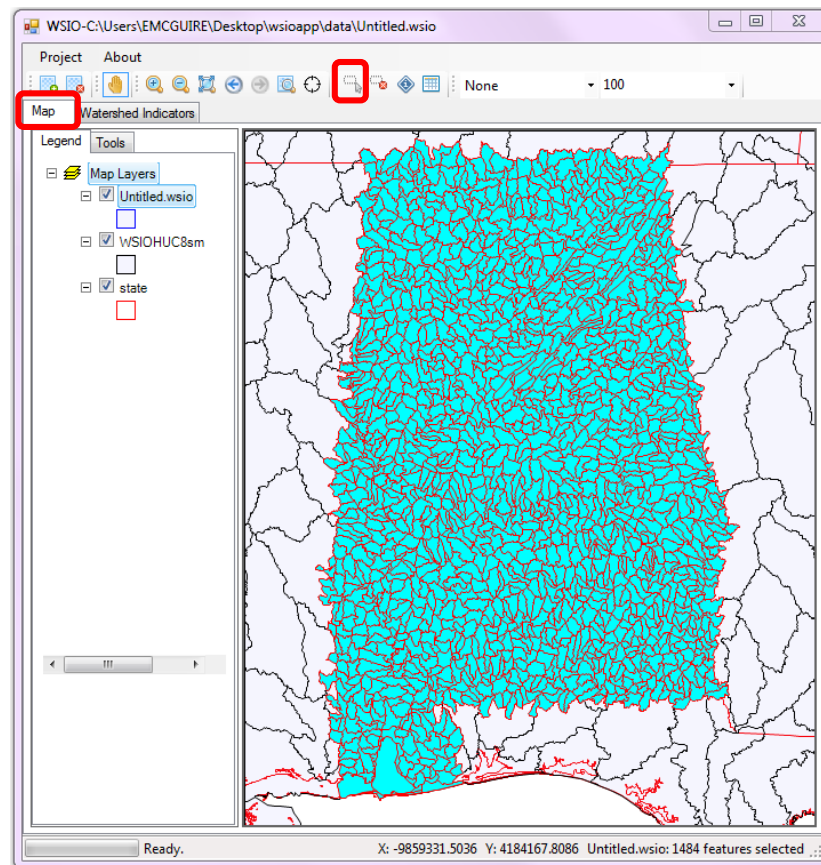
D. Save Your Project

Save your project often by clicking on ‘**Project**’ in the main header menu, then ‘**Save.**’

E. Finalize HUC Selection

Use the map within the ‘**Map**’ tab to finalize or change HUC12 selections for a screening run. The map contains all HUC12s listed in the HUC12 table from the previous ‘**Project**’ window. Selected HUCs from the previous window will appear shaded in aqua. Here you are able to add or remove HUCs from

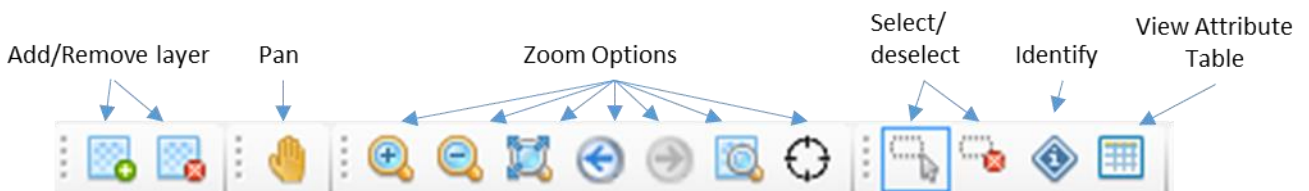
selection, as long as they were part of the initial geography. Use the **'Select'** icon in the map menu bar and hold down the CTRL button when selecting multiple HUCs on the map, or else all other HUC selections will be removed. HUC12 selections will automatically update within the project. Once you have HUCs selected, click on the **'Watershed Indicators'** tab to choose indicators to use with the HUCs that have been selected. See below for a few map use and HUC search/selection tips.



1. Map window hints

a) Navigation menu

Click on the various GIS icons to pan, zoom in and out of an area, make HUC selections or browse the attribute table of a layer.

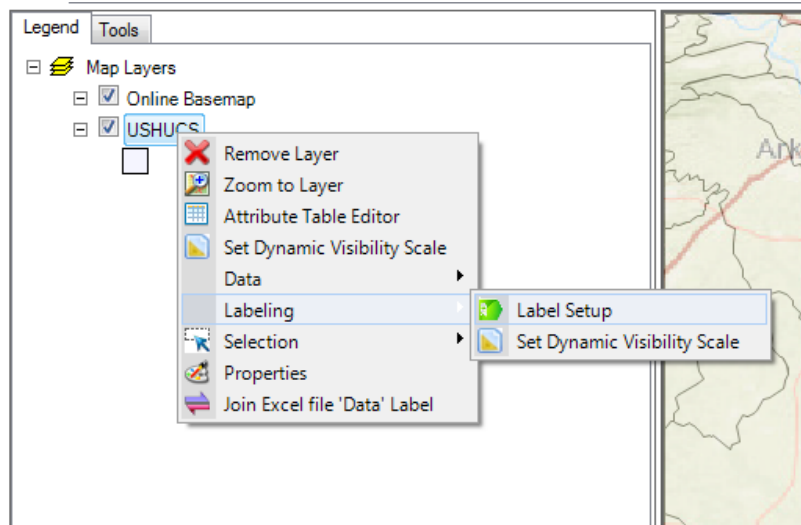


b) *Identify*

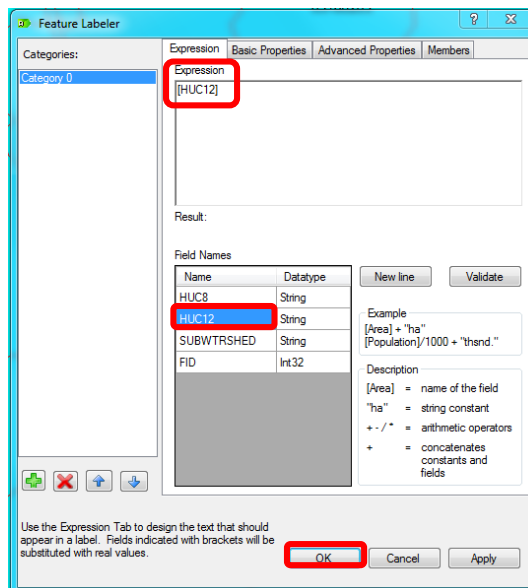
Click this and then a map feature to identify. Map labeling may serve as a good alternative to using this tool.

c) *Map labeling*

Right click on the HUC layer within the legend for additional symbology options. To enable labelling of the layer, click on '**Labeling**,' then '**Label Setup**.'

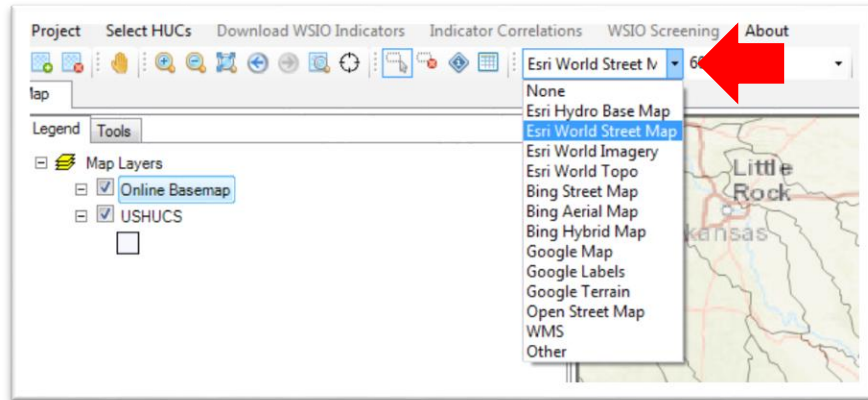


In the window that appears, you can select the field that you wish labeled. In this example, 'HUC12' was selected and it appears in the 'Expression' window. Click '**OK**.'



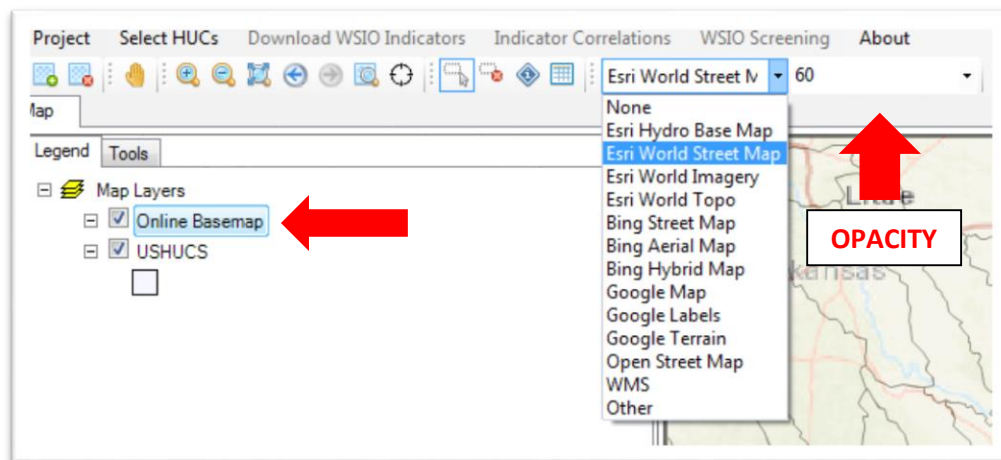
d) *Add a basemap*

Click on the list in the navigation menu and choose your desired basemap.



e) *Set basemap Transparency*

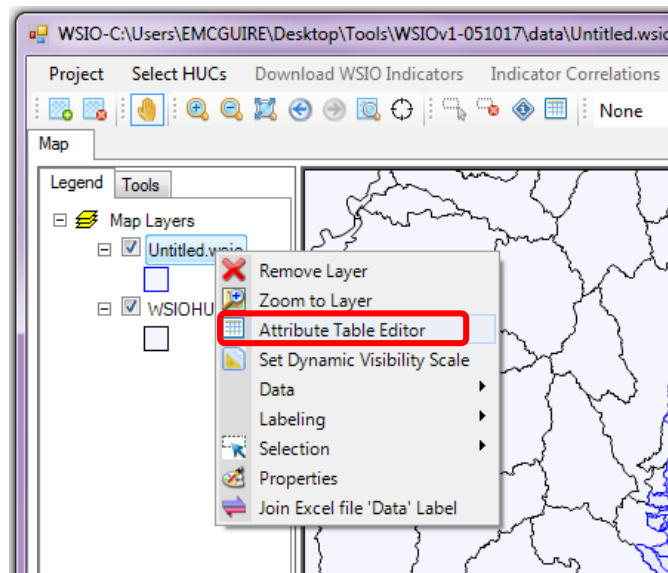
Once a basemap has been selected, click on the opacity dropdown list to select the level of transparency desired.



f) *Select HUCs using the attribute table*

****Warning**** When you open the Attribute Table, the HUC12 Selections that have been made will be unselected. This is something we are hoping to fix in a future version.

Right click on HUC12 layer in the Legend and select '**Attribute Table Editor.**' Select the HUC12s for your project by holding the CTRL button, or select everything between two HUC12s by using the Shift key. Using the Attribute Table is also the best way to select all the HUC12s within a HUC8 or HUC10 watershed.



Attribute Table Editor

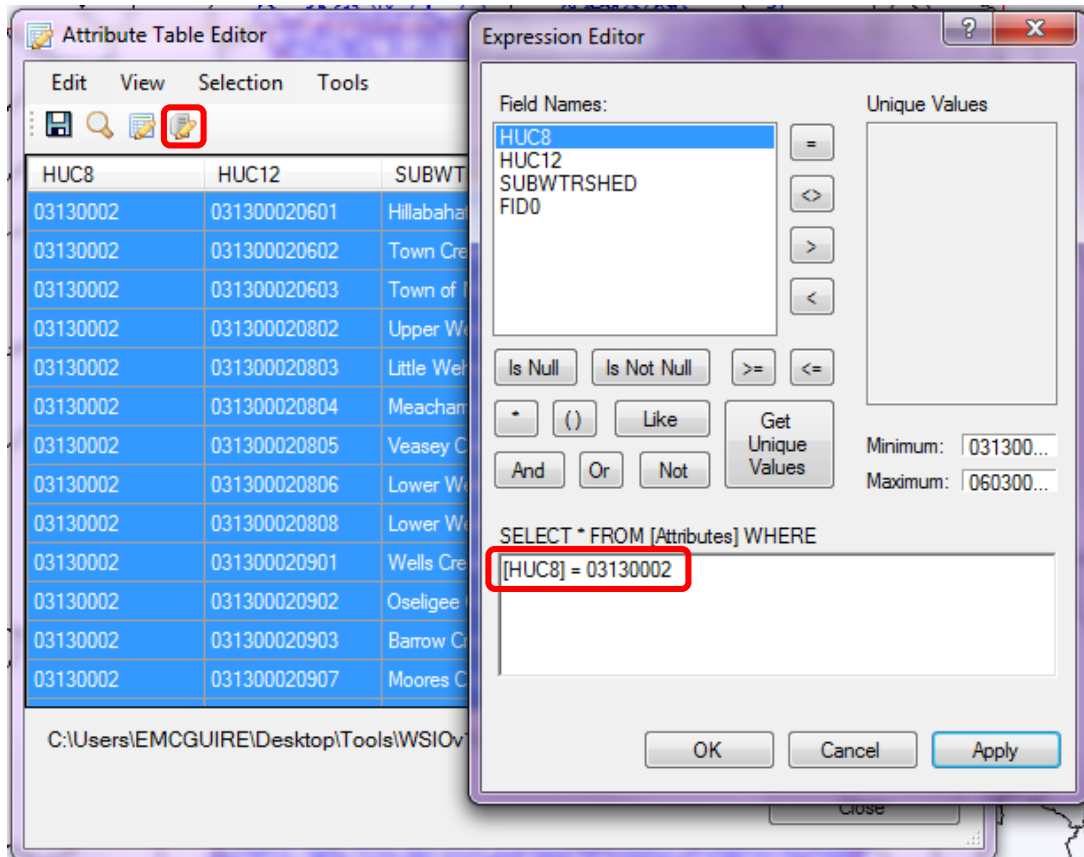
Edit View Selection Tools

HUC8	HUC12	SUBWTRSHED	FID0
03130002	031300020601	Hillabahatchee Creek	0
03130002	031300020602	Town Creek-Hillabahatchee Creek	1
03130002	031300020603	Town of Mason-Cedar Creek	2
03130002	031300020802	Upper Wehadkee Creek	3
03130002	031300020803	Little Wehadkee Creek	4
03130002	031300020804	Meacham Creek-Cuss Creek	5
03130002	031300020805	Veasey Creek-West Point Lake	6
03130002	031300020806	Lower Wehadkee Creek	7
03130002	031300020808	Lower West Point Lake	8
03130002	031300020901	Wells Creek	9
03130002	031300020902	Oseligee Creek	10
03130002	031300020903	Barrow Creek-Chattahoochee River	11
03130002	031300020907	Moore's Creek	12

C:\Users\EMCGUIRE\Desktop\Tools\WSIOv1-060717\data\Untitledec 1 of 1484 selected.

Close

1. You can also search the Attribute Table using a query to select all the HUC12s within a HUC8 watershed. Click on '**Query**' in the menu bar to open the '**Expression Editor**' window. You can then create an equation to easily find your HUCs of interest, like the below example, where all HUC12s within the HUC8 03130002 were selected.



III. Indicator Selection

An indicator is a simplified measure of the state or condition of something that is too complex to measure directly. Since it is not possible to measure every aspect of the natural environment, indicators are used to gain insight into what is happening, such as whether environmental conditions are improving, deteriorating, or holding steady. As used in the WSIO, an indicator is an attribute of a watershed that is relevant to its ecological condition and/or the natural or anthropogenic forces either supporting - or stressing - its health. For example, the percentage of natural cover in a watershed may be used to indicate the extent to which its natural habitats are undisturbed, as well as expected levels of anthropogenic pollution and alteration of natural runoff and infiltration patterns over the landscape. Similarly, the percent impervious cover in a watershed may be used to indicate the extent to which the natural overland flow to the streams has been altered. Since protection of drinking water is an issue that typically engages public concern, the percentage of drinking water source protection areas in a watershed may be used to represent the likely level of public support and involvement in restoration and protection activities. For indicators to be useful for comparing and contrasting watersheds, it is important that they be consistently measured for each watershed within the geographic area of interest.

The WSIO's watershed indicators are grouped based on the type of influence they have on watershed condition. The WSIO Tool identifies these groups as Ecological, Stressor, and Social Indicators (See the [Glossary](#) for definitions). A logical starting point for developing a list of potential indicators for a screening is to think about the project's objectives and what factors might be important in those watersheds. The WSIO Tool requires at least one indicator be selected in the ecological, stressor and social indicator categories, but it is recommended that a screening include a variety of indicators. However, keep in mind that the indicator values are effectively averaged in the Index score, so the more indicators included in the screening calculations, the less influence each individual indicator will have on the score.

The usefulness of any screening analysis is dependent on the relevance of the indicators used to the purpose of the screening, as well as the applicability of those indicators to the watersheds and communities comprising the project area. Familiarity with the project area and an understanding of how the landscape and hydrology affect the fate and transport of pollutants will help the user identify factors that are likely important in those watersheds. The purpose of the screening, and the questions being asked, will also inform indicator selection. If the project is investigating nutrient enrichment in purely urban watersheds, there is almost certainly no need to include an indicator related to agricultural water use. However, if the purpose of the screening is to help identify the most stressed agricultural watersheds, that indicator may be a good selection. As another example, a project that aims to screen an entire state to identify the relative condition of all of its watersheds will likely pick a different set of screening indicators than projects that are focused on waters impaired by bacteria. If projects are focused on different pollutants (e.g. nutrients vs. bacteria vs. metals), they will probably select different indicators based on the expected pollutant sources and the fate and transport of the pollutants in watersheds.

Since there are many factors affecting watershed condition and recoverability, most screening analyses will benefit from using a variety of indicators that represent different types of influence. Some indicators represent similar attributes, for example: % Woody Vegetation in Watershed, % Forest in Watershed, % Mixed Forest in Watershed, and % Evergreen Forest in Watershed. It is preferable to select the forest indicator that best represents the type or amount of forested land desired for the project objectives. It is not recommended to use both RZ and HCZ for the same indicator in the same screening; generally, the user should choose the corridor representation that best suits their objectives.

A. Select Ecological, Stressor and Social Indicators

The **'Watershed Indicators'** tab has tables on the left side of indicators available for selection grouped by Ecological, Stressor, and Social categories. From the list of the WSIO Indicators in each section, select the indicators you would like to process by clicking on rows of the grid while holding down the CTRL key. When you have selected an indicator you will see it appear in the box on the right. Once you have completed your indicator selections, click on the upper left navigation menu **'WSIO Screening'** to download the corresponding indicator data into your project.

The screenshot shows the WSIO Screening application window. The 'WSIO Screening' tab is selected in the top navigation bar. The interface is divided into three main sections on the left for indicator selection: Ecological Indicators, Stressor Indicators, and Social Indicators. Each section contains a table with 'IndicatorName' and 'Type' columns. The 'Selected Indicators' table on the right lists the chosen indicators, their weights, and their types. Below this table, a description for 'Slope, Standard Deviation in WS' is provided.

Indicator	Weight	Type
Soil Stability, Mean in WS	1	Ecological
% Wetlands in HCZ (2011)	1	Ecological
% N-Index1 in HAZ (2011)	1	Ecological
% Forest in WS (2011)	1	Ecological
Count Road-Stream Crossings, 1st-3rd Order (2015)	1	Stressor
% Imperviousness, Median in WS (2011)	1	Stressor
% Human Use, U-Index1 in HCZ (2011)	1	Stressor
% Developed, Medium Intensity in RZ (2011)	1	Stressor
% Urban Change in WS (2001-11)	1	Stressor
% Urban in WS (2011)	1	Stressor
% Waterbody Area with Sediment TMDLs (2015)	1	Social
NPDES Permit Count	1	Social
Drinking Water Source Protection Area, Total	1	Social
Drinking Water Source Protection Area, Cumulative	1	Social
% GAP Status 1 and 2	1	Social
% of HUC12 Instate (AL)	1	Social

Slope, Standard Deviation in WS
Standard deviation of slope in the HUC12 (in degrees). Source data was the NHDPlus2 National Elevation Dataset (NED) Snapshot. (See also NED Snapshot glossary definition).

1. Indicator selection helpful hints

a) Indicator definitions

When your mouse hovers over an indicator on the left, the definition will appear in the lower right box. A list of all indicators and their definitions can also be found on the WSIO website.

b) To select multiple indicators

CTRL-left click together on each indicator.

c) To remove indicators from selection

Find the indicator to be removed from selection in the tables on the left; then using CTRL-left click together, click on the indicator to remove it from the right 'Selected Indicators' box.

d) To remove all indicators from a category selection

There is a 'CLEAR SELECTION' button under each indicator category grouping. Click this, and all indicators that have been selected will be removed.

e) Using a 'Neutral Variable'

The last indicator in each list is called a '**neutral variable**.' Use this when you do not wish to select any indicators in a certain category. A category that uses the neutral variable indicator will not have influence on the WSI Score.

f) Applying a weight factor

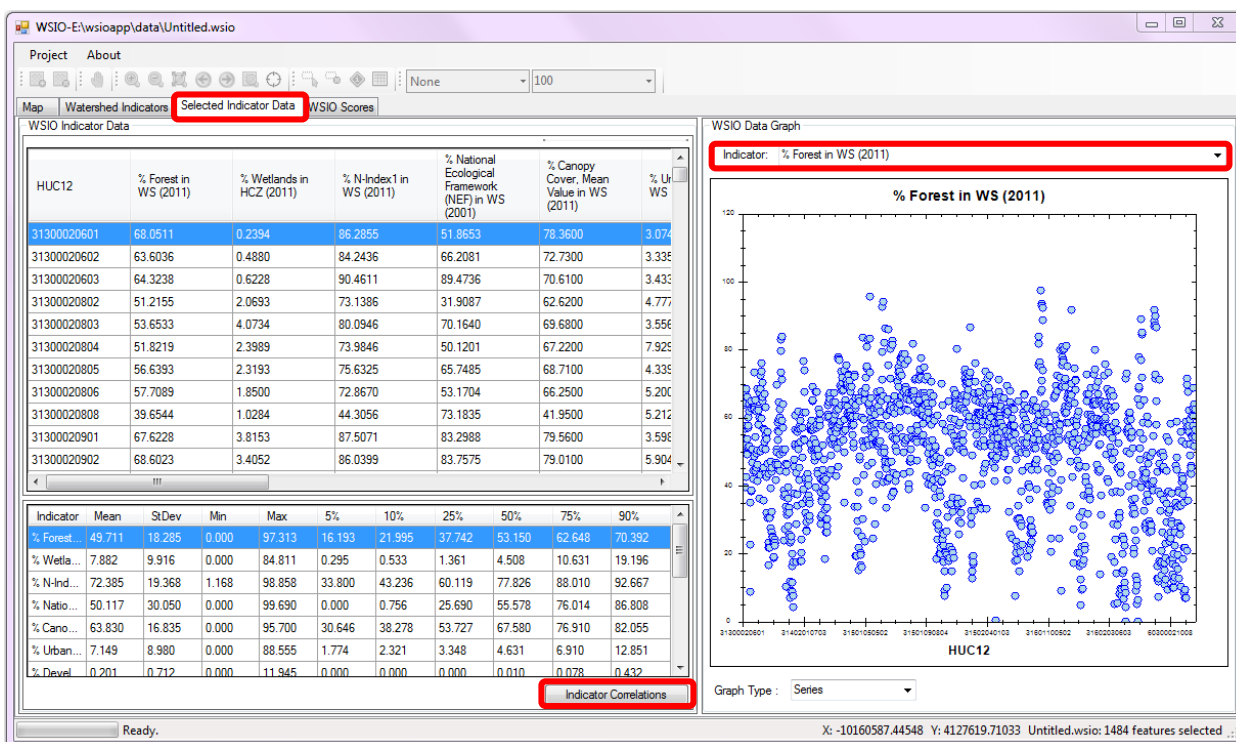
You can also apply a weight factor to indicators within the table to the right. Weights assigned to each indicator are set to one (1) automatically, but they may be changed by the user simply by typing a new weight value to replace it. Typical weights range from 0.5 to 3, with higher weight values giving the indicator more influence on the final Index score, and lower weight values making the indicator have less influence. It is recommended that the user perform an initial screening run with the weights set to their default values for each indicator, and only increase or decrease the weights with valid reason. Statistical correlation analysis may provide a basis for showing which indicators are – or are not - correlated with each other, and which indicators have the strongest relationship to the health of the watershed.

IV. WSIO Screening Results

A. Indicator Data

The 'Selected Indicator Data' tab is now enabled and shows indicator data (upper left box), summary statistics (lower left box) and a graph of the indicator data (right side). This information is displayed here so you can familiarize yourself with the data that has been pulled into your project. Users can select from the dropdown list above the graph to select an indicator to plot (**HINT:** highlight the list then use mouse wheel to scroll). You can also change the graph type between 'Series' and 'Probability' in the dropdown under the graph. The Series option, will graph the HUC on the x-axis and the indicator value on the y-axis (upper left table). The Probability option, will graph the lower left table where the probability is on the x-axis and the value of the indicator is on the y-axis.

Next, click on the '**Indicator Correlations**' button (located in the lower, middle of the window).



B. Run Indicator Correlations

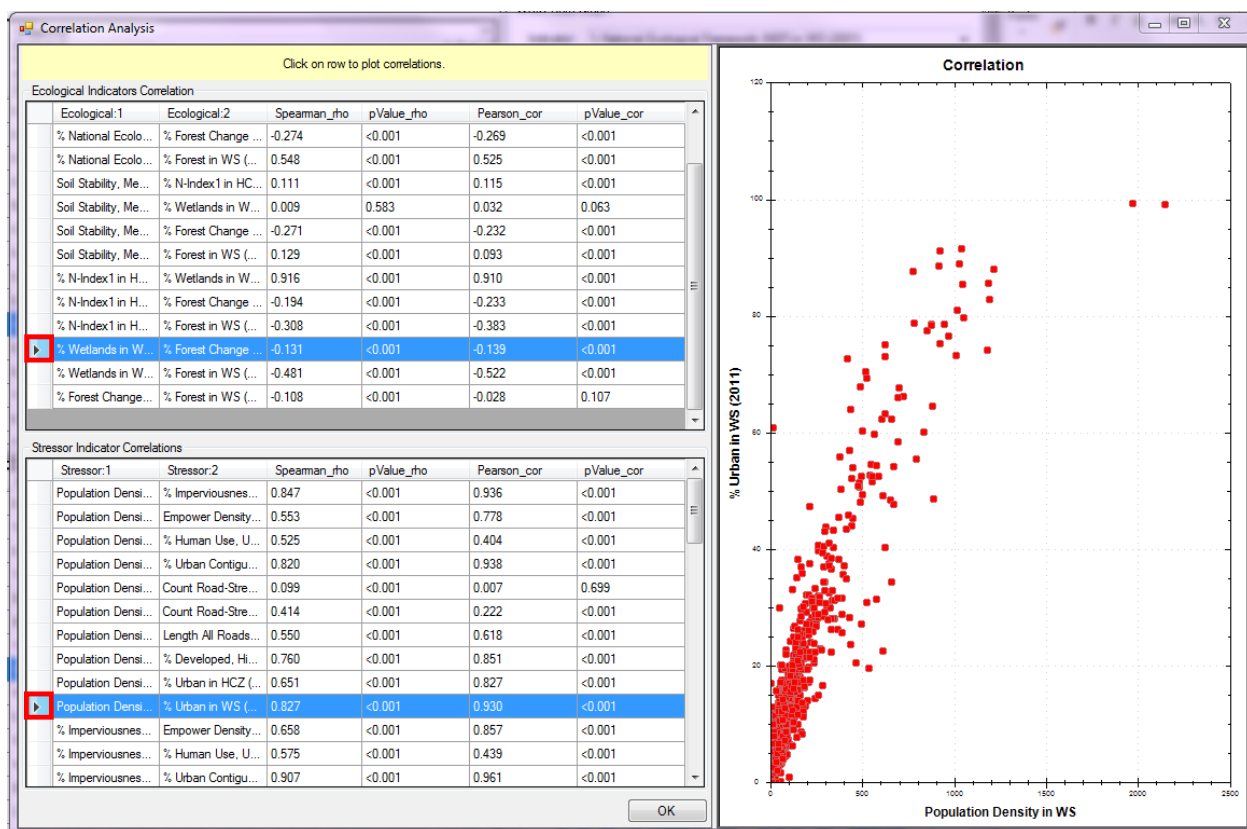
This is an optional, but important step that has been provided to help in the selection of Ecological and Stressor indicators. The tables provided on the left are separated by indicator type. They provide correlation information on all the indicators you have selected. Click on a row to see the data graphed. You can use this information to see, for example, if two indicators are highly correlated or not; and then decide if both are needed in your WSIO project. The selection of indicators should be a very thoughtful process, and will likely require some trial and error.

1. Change your indicator selection

Return to the **'Watershed Indicators'** tab and change the indicator selections that are highlighted. Only selected indicators will be included in the WSIO screening and calculations. Click on **'WSIO Screening.'**

2. Change your HUC selection

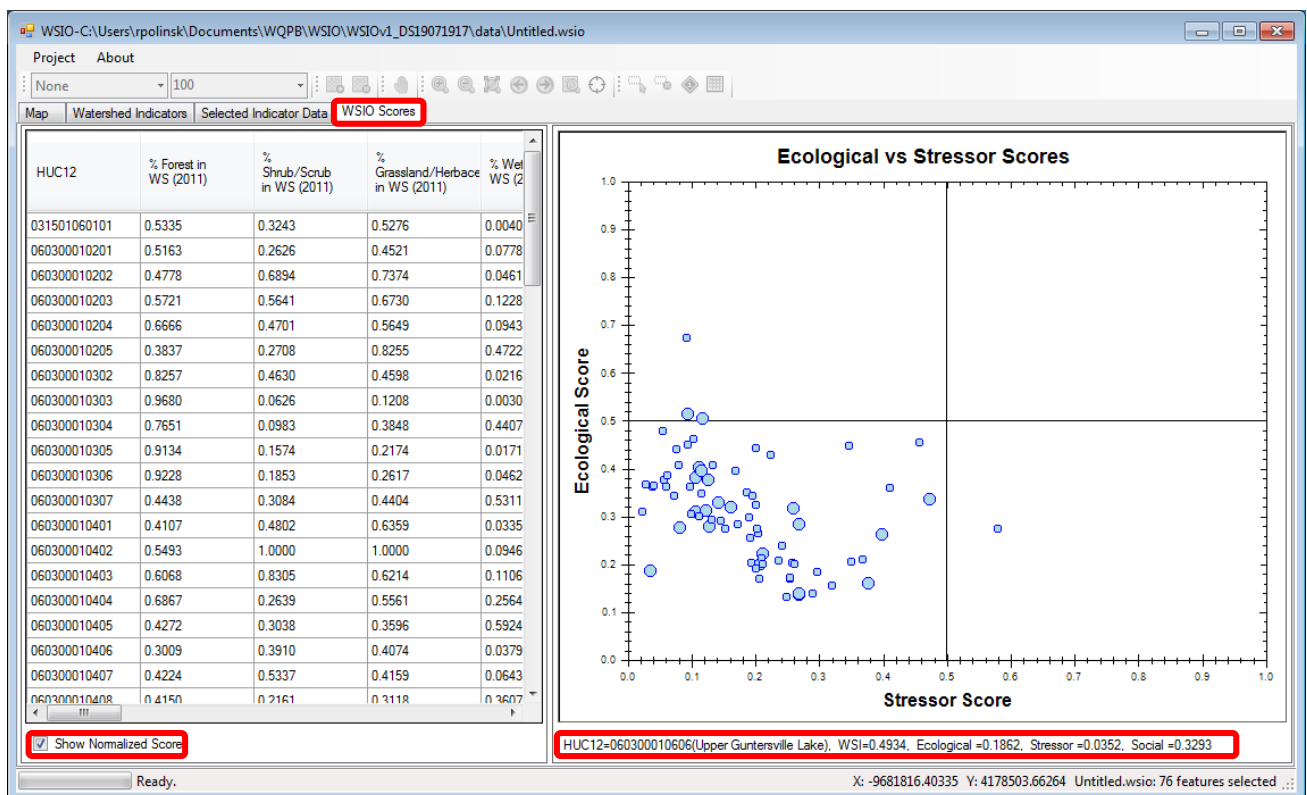
Return to the **'Map'** tab and change the HUC selections that are highlighted either by selecting them directly on the map or using the attribute table. Only selected HUCs will be included in the WSIO screening and calculations. Return to the **'Watershed Indicators'** tab and make any indicator adjustments, then click **'WSIO Screening.'**



V. WSIO Screening Results

The WSIO Tool will automatically calculate Ecological Index, Stressor Index, Social Index and combined Watershed Index (WSI) scores for each HUC12 analyzed as part of the screening calculations. These results may be examined as a table, map, or bubble plot within the WSIO Tool, or exported for use in other software. The values for individual watershed indicators included in a screening run may also be viewed in a table or map.

Looking at the '**WSIO Scores**' tab, the 'WSIO Data Graph' on the right displays the Ecological Scores and the Stressor Scores for the set of HUC12s selected and allows users to visualize the relative influence of the ecological, stressor and social index factors in each watershed. WSIO uses a min-max normalized scoring for each indicator. Normalization using the minimum and maximum value of the indicator is equivalent to the assumption of an empirical uniform distribution. A three-dimensional plot displays screening results as waters plotted relative to X (Stressor Index), and Y (Ecological Index), with the dot size varying by Social Index score. Click on '**Show Normalized Scores**,' in the lower left, to display the summary Indicator Scores in the grid.



A. WSIO Scores page helpful hints

All of the **watershed indicator** values are normalized to have a maximum value of 1.0.

For the **Ecological and Social Index** values, higher index scores imply a higher probability that the watershed will support ecological services and higher probability that the social setting is favorable to action, respectively.

For the **Stressor Index**, a lower score implies that there are fewer stressors driving negative change in the watershed.

For the combined **WSI** score, higher scores imply a higher likelihood that conditions are favorable to the user's objectives.

It is important to understand that small differences in index scores are probably not important. However, the index scores provide a simple, easy to understand way to compare the relative condition of a group of screened waters, and to organize them from higher to lower likelihood of meeting users objectives based on their scores. The summary information provided on the WSIO Scores tab makes it easy to look at the range of scores, and to see whether any of the screened watersheds had especially high or low scores for any of the indices or individual indicators.

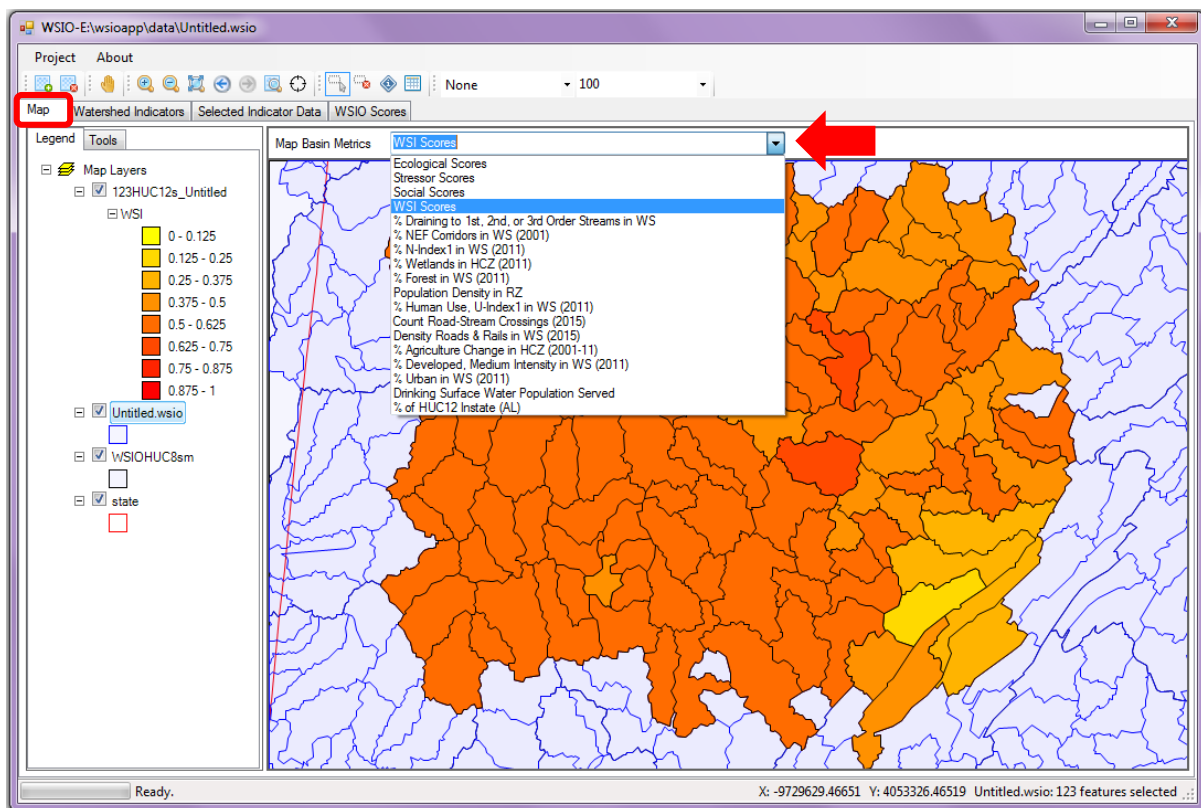
This information may be used to group rank-orders into classes- typically by quartile- or to select a specific number or percentage of the watersheds for further investigation. Results may be sorted to parse and view data in a variety of ways.

1. Clicking the mouse cursor on a bubble will show information about that watershed under the graph, including its name and 12-digit HUC ID, the calculated Ecological, Stressor, and Social Index scores, as well as the Watershed Index Score.
2. The upper left quadrant would contain waters that have high ecological and low stressor scores.
3. Waters in the upper right quadrant have high ecological and stressor scores.
4. Waters in the lower left quadrant will have lower stressor index scores, but also low ecological index scores.
5. The lower right quadrant shows watersheds with high stressor and low ecological scores.
6. Larger dot sizes indicate better social scores based on the indicators chosen.

7. You can right-click the WSIO Scores Graph and select 'Copy,' then copy the image to another document.

B. Map Indicator Scores

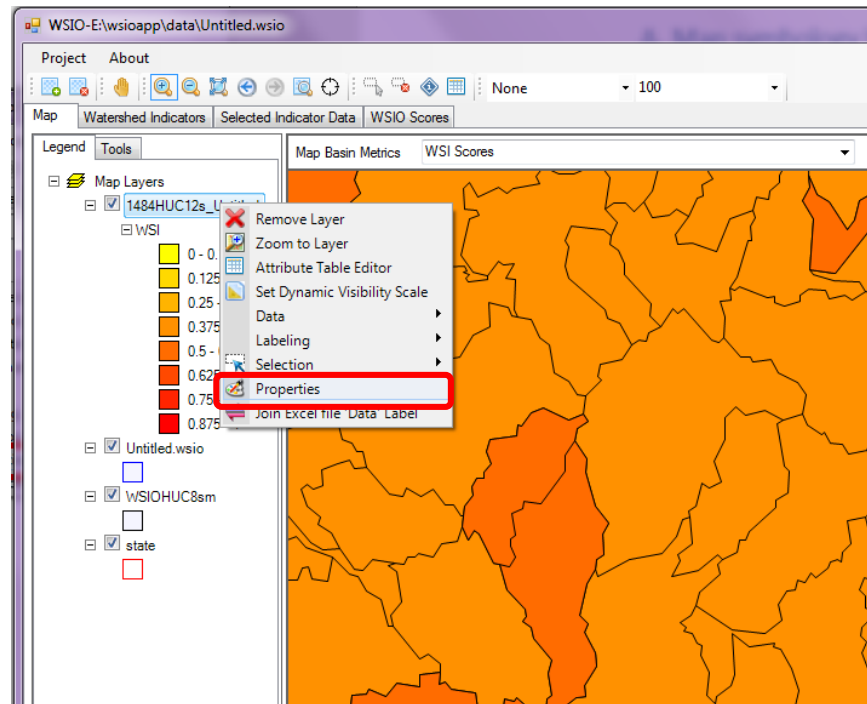
Click on the **'Map'** tab to display a thematic map of indicator scores. This map provides a way to visualize indicator data and screening results to better understand any geographic factors that may be influencing index scores. Select from the Map Basin Metrics dropdown list located at the top of the map to select an indicator or score to map. See below for some map symbology and use hints.



1. Map symbology hints

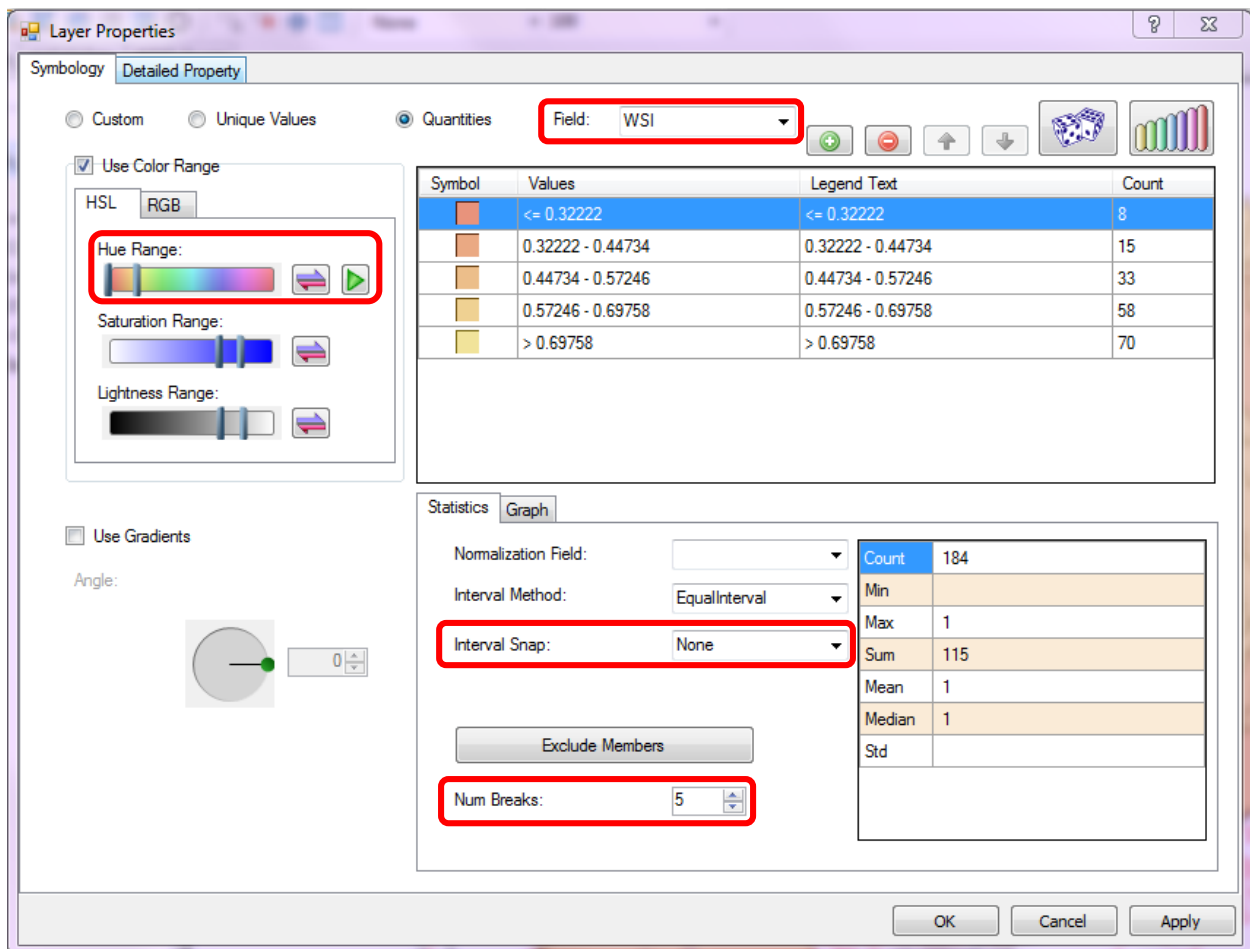
a) *Change Map Symbology*

Right click on the HUC layer in the legend and select '**Properties.**' The 'Layer Properties' window will open allowing you to make changes to the map symbology.



b) *Layer Properties Window*

1. **Field** In this dropdown, choose the indicator or score you would like to symbolize.
2. **Change HUC symbology color** Use the '**Hue Range**' to change the color gradient of the scores. Move the sliders for a smaller range of colors. Click '**Apply.**'
3. **Adjust data interval groupings** Under Statistics, change the Interval Snap to 'none,' This will populate the Values and Legend Text columns in the table as a range of values.
4. **Change the Results Categories** Under Statistics, change the 'Num Breaks' value to change the number of results categories. You can view these breaks by clicking on the 'Graph' tab.
5. Click '**Apply**' when complete.



C. View Watershed Index Scores and Indicator Values for each HUC12 watershed

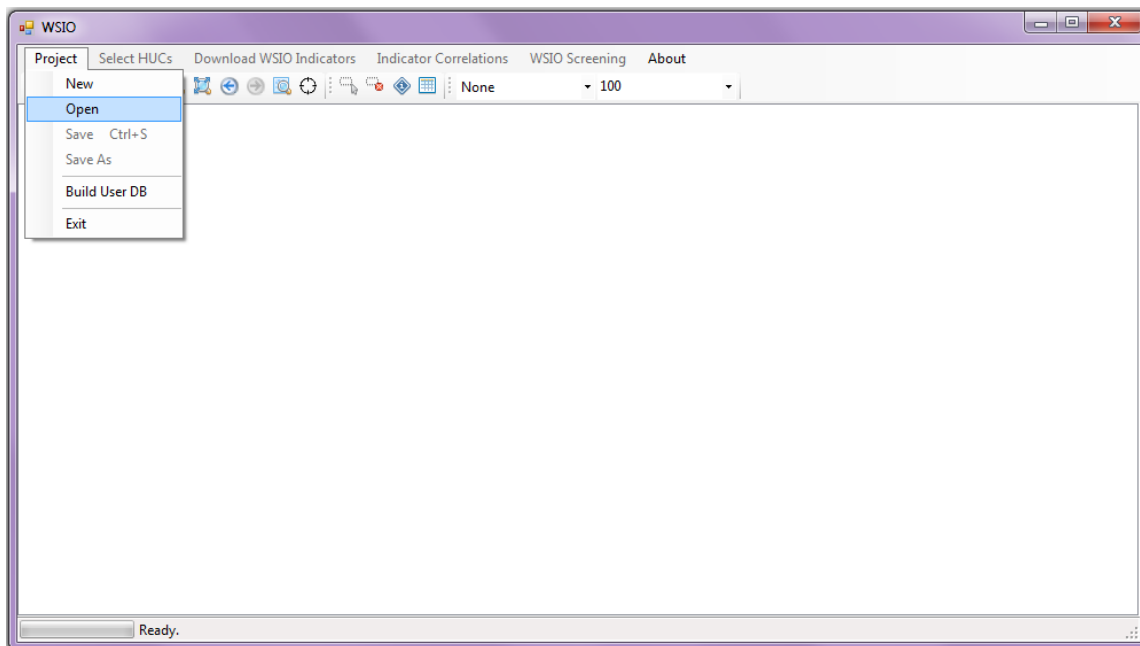
The WSIO Scores tab contains the table of Ecological, Stressor, Social indicator values, and combined Watershed Index (WSI) Scores for each watershed included in the screening run. This table is a great reference to see the values that went into the calculation of WSI Scores. Users can select all the data within the table (use the SHIFT key to select all values between the first and last entry) then copy (CTRL-C) and paste (CTRL-V) it into other software for further filtering and analysis. (HINT: by highlighting and copying all entries into an Excel worksheet, the header row will paste with the data)

VI. Open an Existing Project

Run the WSIO.exe (See Section 1). The application will open with the option to use a 'Web Service' or a 'Local Geodatabase' to pull in indicators to the tool. Make a choice, then click '**OK.**' In the 'Project' window, select '**Open.**' Navigate to your saved project (the default will place your project in the 'Data' folder of your application folder). Open the *yourprojectname*.WSIO file. This file will contain the geography and indicators that were selected and saved.

A. Save-As

Save-as your project with a new name to be able to compare results to another WSIO screening run. Click on 'Project' in the upper left navigation menu and select 'Save As.'

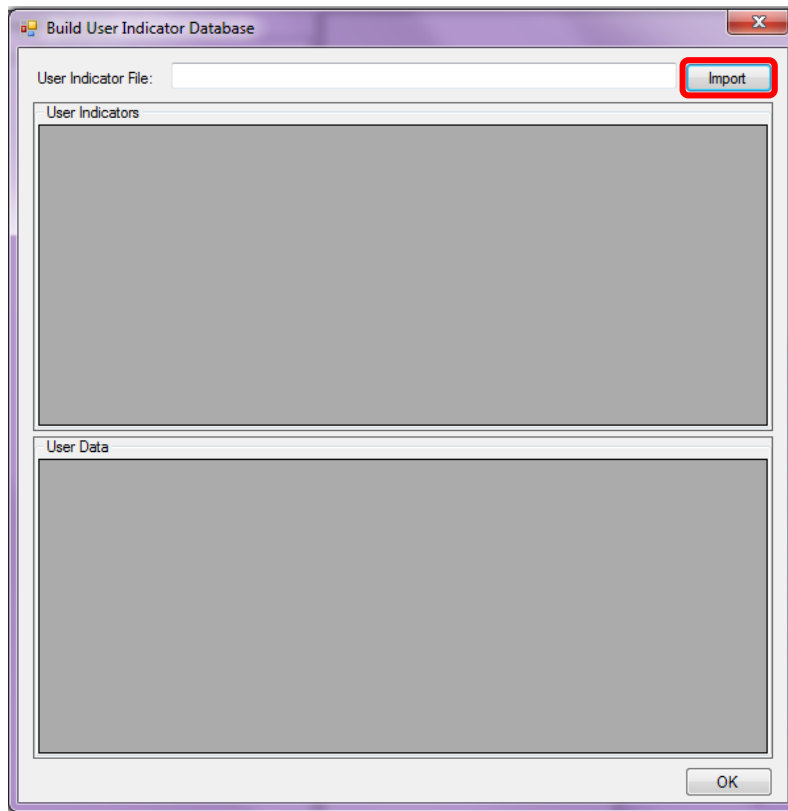
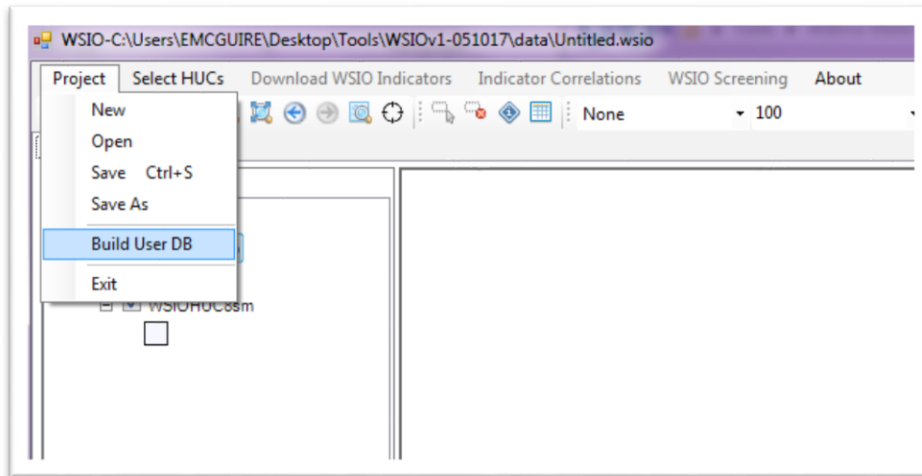


VII. Build a User Database of Indicators

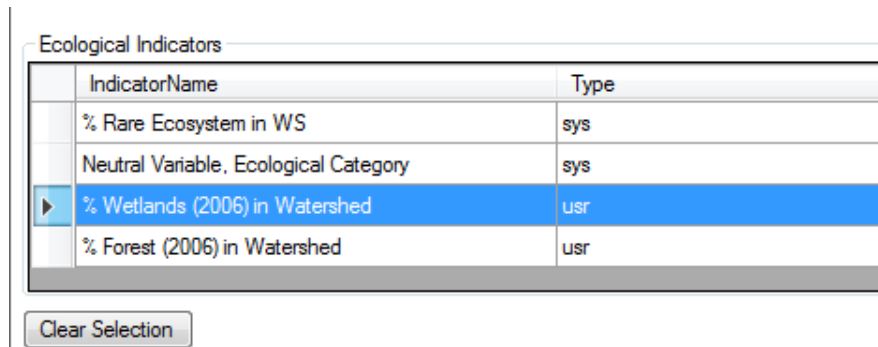
The WSIO Tool allows a user to bring in indicators of their own. These may be region or state specific indicators, for example, that have been identified and calculated for a specific area. In order to incorporate these regional specific indicators, the information about them needs to be put into the WSIO Tool as described in this section. A template has been created and provided for this purpose. Refer to the excel template (sample-userdata.xlsx) that is located in the 'Data' folder of the application package. There are two tabs that must be filled out completely – 'user_indicator' (this is requesting information on each indicator) and 'user_indicator data' (this is requesting indicator data for each HUC12). Once complete, this file can be imported into your project.

INDICATOR_FIELD	INDICATOR_NAME	TYPE	DESCRIPTION
WETLANDS_NLCD_PCT_WS	% Wetlands (2006) in Watershed	Ecological	Percent Wetlands (2006) in Watershed
FOREST_NLCD_PCT_WS	% Forest (2006) in Watershed	Ecological	Percent Forest (2006) in Watershed
U_INDEX_NLCD_PCT_WS	% Human Use, U-index (2006) in Watershed	Stressor	Percent Human Use index (2006) in Watershed
AG_NLCD_PCT_WS	% Agriculture (2006) in Watershed	Stressor	Percent Agriculture (2006) in Watershed

Within the application, click on 'Project', then 'Build User DB.' In the new window that opens, click on 'Import' and navigate to your Excel file.



User imported indicators will be located at the end of the indicator list and identified in the type column as 'usr.'



	IndicatorName	Type
	% Rare Ecosystem in WS	sys
	Neutral Variable, Ecological Category	sys
▶	% Wetlands (2006) in Watershed	usr
	% Forest (2006) in Watershed	usr

Clear Selection

Refer back to Section 3 for instructions on how to build a project.

For additional information please refer to the WSIO webpage and user manual available here:
<https://www.epa.gov/wsio>.

VIII. References

EPA Science Advisory Board (SAB), 2002. *A Framework for Assessing and Reporting on Ecological Condition* (EPA-SAB-EPC-02-009).

Moore, I. D., Grayson, R. B., and Ladson, A. R., 1991, Digital terrain modelling: A review of hydrological, geomorphological and biological applications. *Hydrological Processes*, **5**, 3± 30.

Norton, DJ et al (2009). A method for comparative analysis of recovery potential in impaired waters restoration planning. *Environmental Management* 44:356–368. DOI 10.1007/s00267-009-9304-x. <http://www.springerlink.com/content/d51523tq8784643k/>

USEPA, 2011. *Fact Sheet: Recovery Potential Project – Landscape Screening Tools and Resources for Comparing the Restorability of Impaired Waters*. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA-841-F-11-002, March 2011.

Wollock, D.M., 1993. Simulating the variable-source-area concept of streamflow generation with the watershed model TOPMODEL: *U.S. Geological Survey Water-Resources Investigations Report*, 93-4124, 33 p.

IX. Glossary

Catseed:

Raster hydrology data. See: **National Hydrography Dataset CatSeed**.

Ecological Index (Ecological Index Score):

A value calculated to reflect the overall condition and capacity of the watershed to provide ecological services, based on metrics related to natural watershed processes and structure.

Ecological Indicator:

One of the classes of watershed indicators used in the WSIO. Ecological Indicators are measurable characteristics of a watershed related to the structure, composition, or function of its ecological systems. Examples include the number of aquatic species, percent natural cover, mean elevation, and mean slope of a watershed.

Ecoregion:

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing the spatial differences in the capacities and potentials of ecosystems, ecoregions stratify the environment by its probable response to disturbance. These general purpose regions are critical for structuring and implementing ecosystem management strategies across federal agencies, state agencies, and nongovernment organizations that are responsible for different types of resources within the same geographical areas.

Empower Density:

Empower density is the flow of emergy released per unit time by a unit volume. Emergy is the available energy of one kind previously used up directly and indirectly to make a product or service.

EnviroAtlas:

Ecosystems, such as forests and wetlands, provide many essential benefits, including clean air and water, food, fiber, and recreational opportunities. These and other benefits from nature, referred to as “ecosystem services,” are multifaceted, often intertwined, and can be difficult to quantify because of their complexity. Due to this complexity and a lack of information, planning efforts often discount or overlook the impacts of decisions on the full suite of ecosystem services. To help fill this information gap, the EPA and its partners researched effective ways to measure and communicate the type, quality, and extent of services that humans receive from ecosystems so that their true value can be considered in decision-making. These research efforts and data are incorporated into the EnviroAtlas, a web-based tool that combines maps, analysis tools, and interpretive information on ecosystem services. Data are provided for subwatersheds

across the contiguous United States and at a higher resolution for selected communities. More information can be found here: <http://enviroatlas.epa.gov/enviroatlas/atlas.html>

Healthy Watershed Initiative

EPA created the Healthy Watersheds Program to proactively protect aquatic ecosystems as dynamic systems across landscapes in order to maintain the natural structure and function of ecosystems as intended by Congress in the 1972 Federal Water Pollution Control Act amendments. This systems approach protects aquatic biota and their habitat as well as watershed characteristics and processes that support them such as vegetative riparian corridors and headwaters, hydrology, geomorphology, and natural disturbance regimes. The holistic protection approach provided by the Healthy Watersheds Program is essential for addressing the pervasive threats to healthy watersheds, including loss and fragmentation of habitat, hydrologic alteration, invasive species, and climate change. More information can be found here: <http://water.epa.gov/polwaste/nps/watershed/index.cfm>

HUC (Hydrologic Unit Code):

HUC is an acronym for Hydrologic Unit Codes, which is a numeric system for uniquely identifying all of the drainage basins in the United States. HUCs represent multiple, hierarchical levels of nested geographic units, from the largest unit (Hydrologic Region), to the smallest (Subbasin). The scale of the watershed can be determined by the number of digits in the HUC, such that smaller watershed scales have more digits in their codes, representing additional sub-divisions. The United States has been divided into 21 Hydrologic Regions, which are further divided into 221 Subregions. The Subregions are divided into Basins, and then Subbasins. Many geographic datasets use six levels, resulting in 12-digit HUCs. A 12-digit HUC indicates the hydrologic Region (first two digits), hydrologic Subregion (second two digits), Basin (third two digits), Subbasin (fourth two digits), Watershed (five two digits), and Subwatershed (last two digits).

HUC8:

One level in a hierarchically nested series of surface drainage-based geographic units identified by their Hydrologic Unit Codes (HUC) and the number of digits in that level's identifier (in this case, eight). HUC8s may be referred to as Subbasins, or sometimes Cataloging Units. A typical HUC8 Subbasin is around 700 square miles.

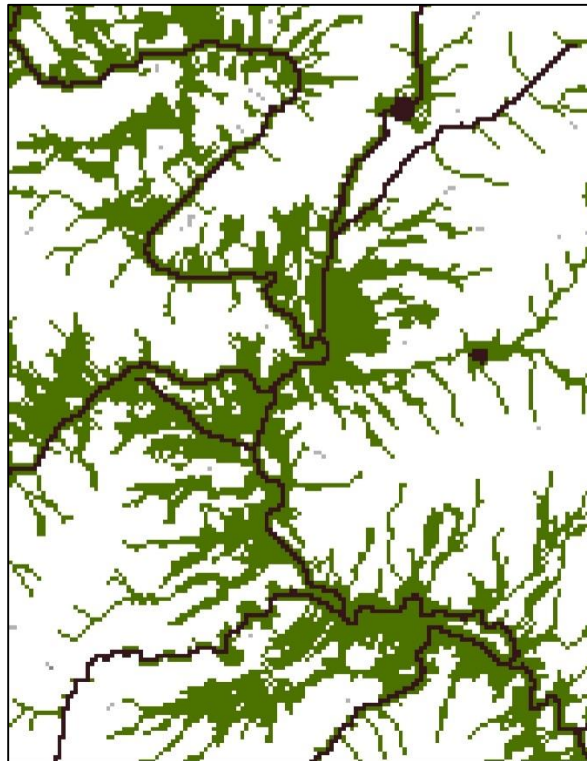
HUC12:

One level in a hierarchically nested series of surface drainage-based geographic units identified by their Hydrologic Unit Codes (HUC) and the number of digits in that level's identifier (in this case 12). HUC12s average roughly 40 square miles in area, and there are about 83,000 HUC12s covering the lower 48 states. Together, the geospatial data on the several levels of HUCs comprise the Watershed Boundary Dataset (WBD). As the WBD is frequently modified through mapping updates, a "WBD snapshot" was benchmarked and integrated with the National Hydrography Dataset's most recent major update (see *National Hydrography Dataset Plus Version 2*). Although the terms "watershed" and "HUC" are often used synonymously, HUCs may be either a true watershed or a drainage-defined portion of a larger watershed that includes

many HUCs. Multiple HUC levels have been used in RPS and WSI projects, but the WSIO indicator data are all compiled at HUC12 scale.

Hydrologically Connected Zone:

This term is used to describe indicators that are measured only within a specified part of the HUC12 – in this case, only the HUC12 areas that have a compound topographic index score greater than 550 and are contiguous to the Water Mask. The naming convention for these indicators includes the abbreviation “HCZ.” For example, the ***Hydrologically Connected Zone percent urban land cover*** in the HUC12 is calculated by first measuring the urban area in the HUC12 only within the HCZ as defined above, and then dividing by the total area of the HUC12 (including all land and water). Because the HCZ is based on a topographic index rather than as a zone of assigned proximity to waters mapped at 1:100,000 scale, it sometimes can differ substantially from the RZ -- such as when river floodplains far exceed the RZ’s standard 100 meters-per-side width, or when moist HCZ areas occur along small tributaries not mapped at 1:100,000 scale (see also **Riparian Zone**).



Hydrologically-Connected Zone

Indicator(s) (and Indicator Type):

As used in the WSIO, an attribute of a watershed that is useful for watershed comparison and can be consistently measured throughout the geographic area of interest. Most of the WSIO’s several hundred indicators are derived from geospatial data analysis, although some come from field monitoring and other information sources that have been geospatially referenced to watersheds. Indicators in the WSIO data table are grouped by **Indicator Type** into Ecological,

Stressor, Social, or Base (i.e. value-neutral) classes that make up the primary data used in watershed comparisons. See also: Base Indicator, Ecological Indicator, Stressor Indicator, and Social Indicator.

N-Index:

An index of natural cover, not urban or agricultural, by the NLCD. N-index Land cover classifications include 'Barren Land (Rock/Sand/Clay)' (code 31), 'Deciduous Forrest' (code 41), 'Evergreen Forest' (code 42), 'Mixed Forest' (code 43), 'Shrub/Scrub' (code 52), 'Grassland/Herbaceous' (code 71), 'Woody Wetlands' (code 90), and 'Emergent Herbaceous Wetlands' (code 95). N-index is consistent with the Analytical Tools Interface for Landscape Assessments (ATtILA) version 2004. ATtILA user guide can be found here: http://www.epa.gov/esd/land-sci/attila/pdf/user_guide.pdf.

N-index 2:

A modified N-index of natural cover (excludes barren, urban or agricultural classifications). N-index 2 cover classifications include 'Deciduous Forrest' (code 41), 'Evergreen Forest' (code 42), 'Mixed Forest' (code 43), 'Shrub/Scrub' (code 52), 'Grassland/Herbaceous' (code 71), 'Woody Wetlands' (code 90), and 'Emergent Herbaceous Wetlands' (code 95) by the 2006 National Land Cover Database. N-index 2 was modified from the Analytical Tools Interface for Landscape Assessments (ATtILA) version 2004. ATtILA user guide can be found here: http://www.epa.gov/esd/land-sci/attila/pdf/user_guide.pdf.

National Ecological Framework:

The National Ecological Framework (NEF) is a GIS based model of the connectivity of natural landscapes in the lower 48 United States. It was developed to provide a guide for the protection of the natural ecosystem processes that give us clean air, pure water and protected lands that are part of EPA's mission to protect. The purpose was to develop a mapped data set of ecologically important areas that could be connected with a hub/corridor model. See EPA's Geoplatform.

National Hydrography Dataset CatSeed:

Raster data of the flowline and waterbody features only from the National Hydrography Dataset (NHD) Plus version 2.

National Hydrography Dataset Plus Version 2:

The current standard for EPA and many other users of nationally consistent geospatial data on surface waters at 1:100,000 scale. *NHDplus2* represents the most recent major update of national surface waters mapping (the NHD), but in addition contains several value-added attributes on other environmental parameters. Further, *NHDplus2* was integrated with the Watershed Boundary Dataset (WBD) snapshot to benchmark a standard, watershed and surface waters dataset at a specific point in time (see also *HUC12*).

National Land Cover Database:

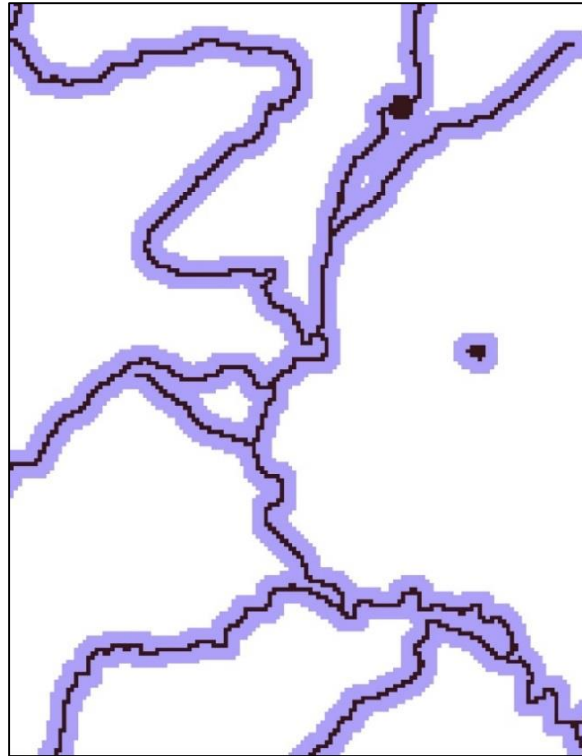
Serves as the definitive Landsat-based, 30-meter resolution, land cover database for the Nation. NLCD provides spatial reference and descriptive data for characteristics of the land surface such as thematic class (for example, urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover. Multiple years are available at about 5 year intervals.

Recovery Potential Screening:

A watershed comparative assessment method using ecological, stressor, and social indicators in each watershed to compare restorability differences among the watersheds and set priorities for action. The Recovery Potential Screening (RPS) tool is a customized Excel workbook that houses all the watershed indicator data and auto-calculates four RPS indices, displaying the watershed comparison results as rank-ordered tables, graphics, and maps. Users can select the watersheds to be screened, indicators and their weights, and customize the graphic and map outputs as well as save the latter as images for later use. As of 2014, the RPS data from the WSIO and statewide RPS tools cover the entire lower 48 states at the HUC12 and HUC8 watershed scales (tools for remaining states and territories are planned), and over 20 states have applied the RPS tool in watershed screenings for a variety of purposes since 2005.

Riparian Zone:

This term is used to describe indicators that are measured only within a specified part of the HUC12 – in this case, within only the HUC12 lands that occur within 100 meters of the Water Mask; then summed to provide one total value for the HUC12. The naming convention for these indicators includes the abbreviation ‘RZ.’ For example, the ***Riparian Zone percent urban land cover*** in the HUC12 is calculated by first measuring the urban area in the HUC12 only in the riparian zones as defined above, and then dividing by the total area of the HUC12 (including all land and water). As a standard-width measurement generalized to include shorelands for any size or type of water body, the RZ may be wider than floodplains of small streams and narrower than floodplains of larger rivers (see also **Hydrologically Connected Zone**).



Riparian Zone

Social Index (or Social Index Score):

A value calculated to account for social factors, such as community involvement, incentives, economics, governance, regulation, and planning status that, while not directly reflective of watershed condition, often strongly influence the level of effort and complexity of making improvements in a given watershed.

Social Indicator:

One of the classes of watershed indicators used in the WSIO. Social Indicators are metrics of socially-related parameters that may affect prospects for success of restoration or protection efforts. Examples include measures related to TMDLs, NPDES permit counts, drinking water sources, and size of natural areas, etc.

Stressor Index (or Stressor Index Score):

A value calculated to reflect the pressures (drivers of change) on watershed condition from several primary sources of pollutants and water quality impairments.

Stressor Indicator:

One of the classes of watershed indicators used in the WSIO. Stressor Indicators relate to pressures on the watershed from either natural or anthropogenic sources, such as watershed- or corridor-level disturbances, hydrologic alteration, and measures of pollutant emissions, etc.

Examples include the percent imperviousness, road density, and the percentage of agriculture in a watershed.

U-Index:

An index of urban and human disturbed land-uses, including agricultural or urban classifications by the NLCD. U-index Land cover classifications include 'Developed, Open Space' (code 21), 'Developed, Low Intensity' (code 22), 'Developed, Medium Intensity' (code 23), 'Developed, High Intensity' (code 24), 'Pasture/Hay' (code 81), and 'Cultivated Crops' (code 82) by the 2006 National Land Cover Database. U-index is consistent with the Analytical Tools Interface for Landscape Assessments (ATtILA) version 2004. ATtILA user guide can be found here: http://www.epa.gov/esd/land-sci/attila/pdf/user_guide.pdf.

U-Index 2:

A modified U-index of urban and human disturbed land-uses that includes barren, agricultural and urban land-uses. U-index 2 cover classifications include 'Developed, Open Space' (code 21), 'Developed, Low Intensity' (code 22), 'Developed, Medium Intensity' (code 23), 'Developed, High Intensity' (code 24), 'Barren Land (Rock/Sand/Clay)' (code 31), 'Pasture/Hay' (code 81), and 'Cultivated Crops' (code 82) by the 2006 National Land Cover Database. U-index 2 was modified from the Analytical Tools Interface for Landscape Assessments (ATtILA) version 2004. ATtILA user guide can be found here: http://www.epa.gov/esd/land-sci/attila/pdf/user_guide.pdf.

Water Mask:

Represents all surface waters, including lakes, rivers, streams, wetlands, estuaries, and nearshore ocean waters, as mapped in the 1:100,000-scale National Land Cover Database (NLCD) and National Hydrography Dataset (NHD). Surface water features from the 2006 NLCD included are 'Open Water' (code 11), 'Woody Wetlands' (code 90) and 'Emergent Herbaceous Wetlands' (code 95). Flowline and waterbody features included are consistent with the catseed grid from the NHD Plus version 2. In developing the WSIO, the Water Mask was a geospatial dataset specially produced for use in measuring many of the indicators in terms of their proximity to surface waters (see also *Riparian Zone and Hydrologically Connected Zone*).

Watershed:

This term is used to describe indicators that are measured throughout the entire geographic area of the HUC12; the naming convention for these indicators includes the abbreviation 'WS.' For example, the **watershed percent urban land cover** is calculated by measuring the total urban area in the HUC12 and dividing by the total area of the HUC12 (including all land and water). Although all indicators in the WSIO are expressed as attributes of HUC12s, many indicators (such as Riparian Zone metrics) are measurements of only part of the HUC12 (e.g., only the riparian zones throughout the HUC12). Note that the use of this term in an indicator name implies measurement within the HUC12 only and does not imply that the indicator value was calculated cumulatively from the entire watershed (e.g., full drainage basin above the HUC12) unless specifically noted.

Watershed Index (Watershed Index Score):

A value calculated from the combined effects of the Ecological, Stressor and Social Index values to reflect the overall condition of a watershed. The Watershed Index is calculated as:

$$\text{Watershed Index} = \frac{\text{Ecological} + \text{Social} + (100 - \text{Stressor})}{3}$$

Watershed Index Online:

The Watershed Index Online (WSIO) project was initiated in 2008 to improve ways to compare, prioritize and target watersheds for a broad range of watershed management purposes on local, state, regional, and national scales. Developed to assist federal, state, and local partners in prioritizing activities based on watershed condition and suitability or need for protection, restoration, improved monitoring, and other management activities. The goal of the WSIO is to increase the capacity for states and others to perform comparative watershed analysis by providing a library of hundreds of the most popular watershed indicators, already processed and compiled for roughly 83,000 12-digit Hydrologic Unit Code (HUC12) watersheds throughout the contiguous United States. These attributes have been measured consistently at a small watershed scale (e.g., 40-square mile average size – see *HUC12*.) The WSIO Tool allows users to easily download uniformly measured watershed indicators for a defined project area, to generate comparative rankings for those watersheds and sub-watersheds based on ecological, stressor, and social context indicators selected by the user, and to save a variety of watershed comparative screenings for further analysis or export of tables, maps, and plots.

Wetness Index:

The wetness index, also known as the compound topographic index (CTI), is a steady state wetness index. It was derived from the NHDPlus flow accumulation and slope of the Digital Elevation Model (DEM) to represent topographic areas that are typically wet. The Wetness Index used for the WSIO tool was created using the following equation:

$$\text{grid wet_ndx} = 100 * (\ln (\text{flow accumulation} / \tan(\text{slope})) + 3 \times 3 \text{ mean of } \ln (\text{flow accumulation} / \tan(\text{slope})) / 2$$

The values were not scaled by an area factor and were smoothed by ½ to make up for some inconsistencies across the national DEM, because of differences in the resolution of the DEM by USGS quad sheet. The data were then compared to the 2001 NLCD wetland classes, Region 4 FEMA flood zone classes, and Georgia National Wetlands classes. The threshold for value of 800, of the wetness index, represents areas which are usually wet. This was primarily based on the 2001 NLCD comparison, but also supported by the other analyses (Moore, 1991 and Wollock, 1993). The wetness index, tends to overestimate wet areas, in part because it does not consider precipitation and evaporation water balances. It will also overestimate wetness in areas with highly permeable soils that do not retain water. Finally, CTI indicates wet areas based entirely on topography and surface water flow and will miss wet areas created by other factors such as heavy precipitation or irrigation outflow.