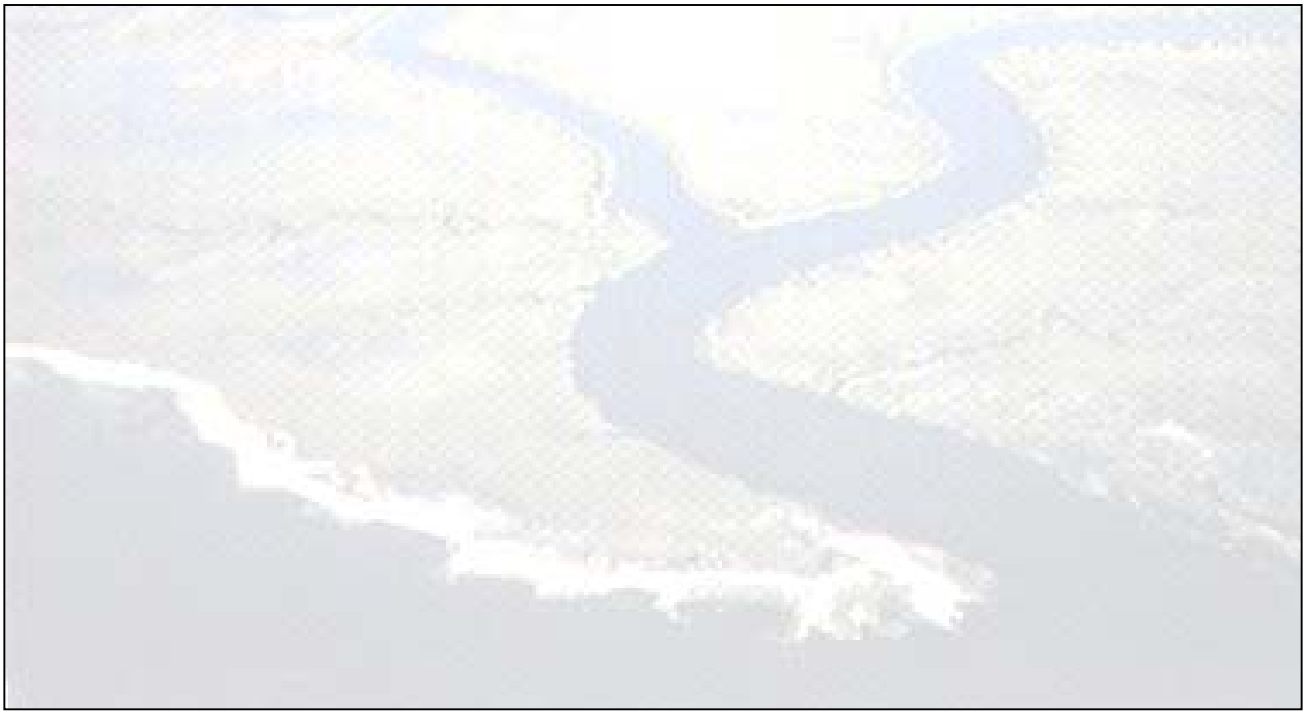
Spatial Wetland Assessment for Management and Planning (SWAMP): Tutorial



Coastal Services Center
National Oceanic and Atmospheric Administration

December 2001

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Overview

Spatial Wetland Assessment for Management and Planning (SWAMP) is a tool for examining wetland functions. SWAMP has two modules, tidal and riverine, that examine how individual wetlands within a watershed contribute to three wetland functions: water quality, hydrology, and habitat. SWAMP uses site-specific characteristics (obtained from soil, vegetation, and land use descriptions) and landscape characteristics (obtained from geographic information system analyses) to derive the parameters used for examining these wetland functions. The analyses used to derive the parameters are coded in Avenue® and require use of the ArcView® Spatial Analyst®, produced by the Environmental Systems Research Institute (ESRI). After data layers describing the basic parameters are derived, a unique interface allows users of SWAMP to determine how these parameters are assembled into overall assessments of water quality, hydrology, and habitat functions. Microsoft Visual Basic® was used to develop this interactive interface.

SWAMP was developed for the Ashepoo-Combahee-Edisto (ACE) River Basin, South Carolina (Figure 1), and is transferable to other locations provided that appropriate knowledge about the local wetland systems is obtained. This tutorial reviews the SWAMP's user interface and operation. A technical report, which also is on the SWAMP CD-ROM that contained this tutorial, defines terminology and describes the overall logic behind SWAMP. The technical report also provides details about the input data. There is no external documentation of the code, however, Appendix II provides an example of the steps used to calculate one of the parameters.

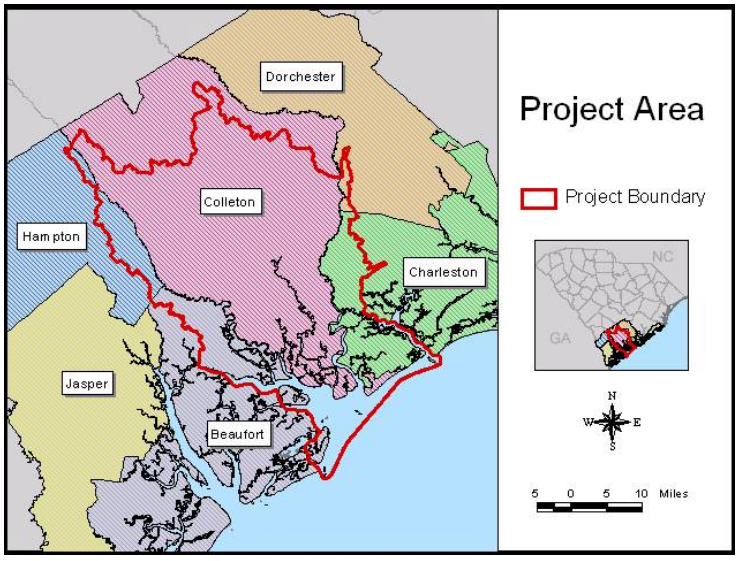


Figure 1. The Ashepoo-Combahee-Edisto River Basin (ACE Basin).

Technical Requirements and Issues

SWAMP requires the Spatial Analyst® extension and ArcView® 3.1 or 3.2. SWAMP is designed to run on a Microsoft Windows® platform. Testing has been successful on Pentium® P2 and P3 processors with 256 megabytes of RAM. Less powerful computers will require additional time to run this model.

SWAMP will write grids to the working directory designated within ArcView, usually *c:\temp*. We suggest that you establish a separate working directory for SWAMP. The number of SWAMP features that you run will determine the amount of disk space necessary. To complete the exercises in this tutorial, we recommend that you have 100 megabytes available in your working directory.

The sample data from the ACE Basin that are provided with this CD-ROM should be copied to your local hard drive; 115 megabytes of space will be needed for the data. Copying data to a local hard drive will decrease processing time. If you copy the sample data to your local hard drive, also copy the *swamp.ini* file to the same relative location of the data as they exist on the CD-ROM. The *swamp.ini* file is simply a text file pointing to the location of the data and can be edited if necessary.

Several files on the CD-ROM are necessary for the successful operation of SWAMP. **The *swamp.exe* file should not be invoked by the user, but allowed to remain in the project directory so SWAMP can access this file as necessary.**

Tutorial

Installation

To install SWAMP, click on *setup.exe* located at the root directory of the CD-ROM and follow the installation instructions provided. This program will place files in the installation directory that you defined and in the system directories. The files that will be placed in these locations include:

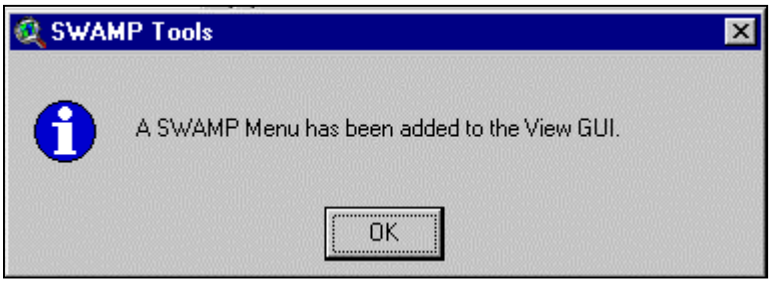
- *Swamp.avx*. This file is the ArcView extension containing the Avenue® code necessary to run SWAMP. It is written to the installation directory that you designated. You will need to copy this file to the *ext32* directory in your ArcView home directory, usually *c:\esri\arcview_30\Arcview\ext32*.
- *Swamp.exe*. This file is the executable program that provides the interface that allows users of SWAMP to define parameter combinations when finalizing the output from the model. This interface was written in Visual Basic and may require that some additional system files be installed on your computer (see next bullet). This file is written to the installation directory and will be copied to the *c:\TEMP* directory when called by ArcView.
- *System files*. These are Dynamic Link Libraries (DLL), object references (OCX), and related files (TLB) that are required to run Visual Basic. These files are installed into the Windows system directory. If these files already exist on your computer, the install program will compare dates and will not over-write a newer version unless instructed to do so.

Running SWAMP

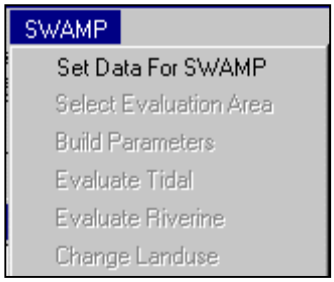
To run SWAMP:

- Open an ArcView session.
- With the **Project Window** active, select **Extensions** under the file menu.
- Scroll down to **SWAMP Wetland Model** and check the box to load the extension. The Spatial Analyst extension will be loaded automatically when you select SWAMP.

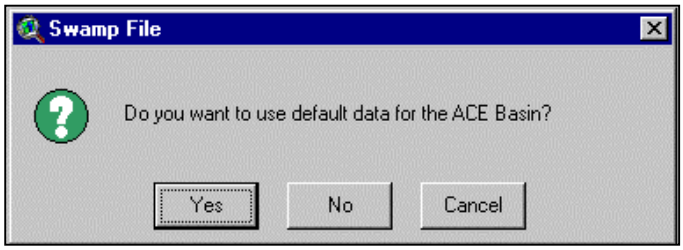
You will be notified that a new menu item has been added to your project. Click **OK**.



Open a new **View**. Go to the **SWAMP menu** and select **Set Data for SWAMP**.



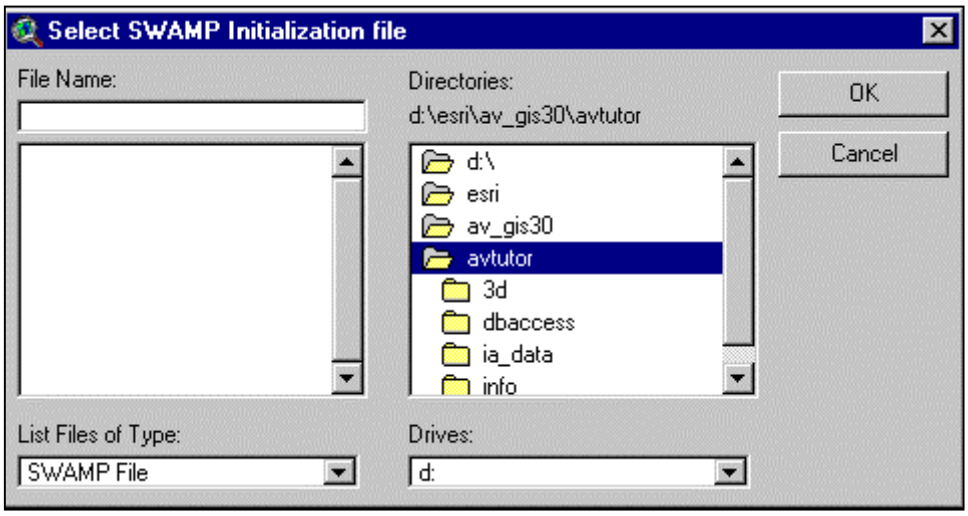
When prompted, if you wish to use default data, enter **Yes**.



If you wish to use data other than those provided on this CD-ROM, you will need to consult Appendix I to load and configure your data and then return to this page when you have finished following those instructions. If you load data other than the sample data provided, select **No** when asked if you wish to use default data. This step will not need to be repeated once completed. *If you choose to use your own data, all data entered must have consistent map units. Also, please note that as the parameters and defaults suggested within SWAMP were developed with coastal ecology of South Carolina in mind, and should be carefully reviewed before applied to another location.*

When you select the default data, you will be asked to select the SWAMP initialization file (*swamp.ini*). This file is located in the root level of the CD-ROM. If you copied it elsewhere, simply navigate to wherever you placed the data—a duplicate *swamp.ini* file is located within the data directory. The *swamp.ini* is simply a text file containing the path to the data required in SWAMP.

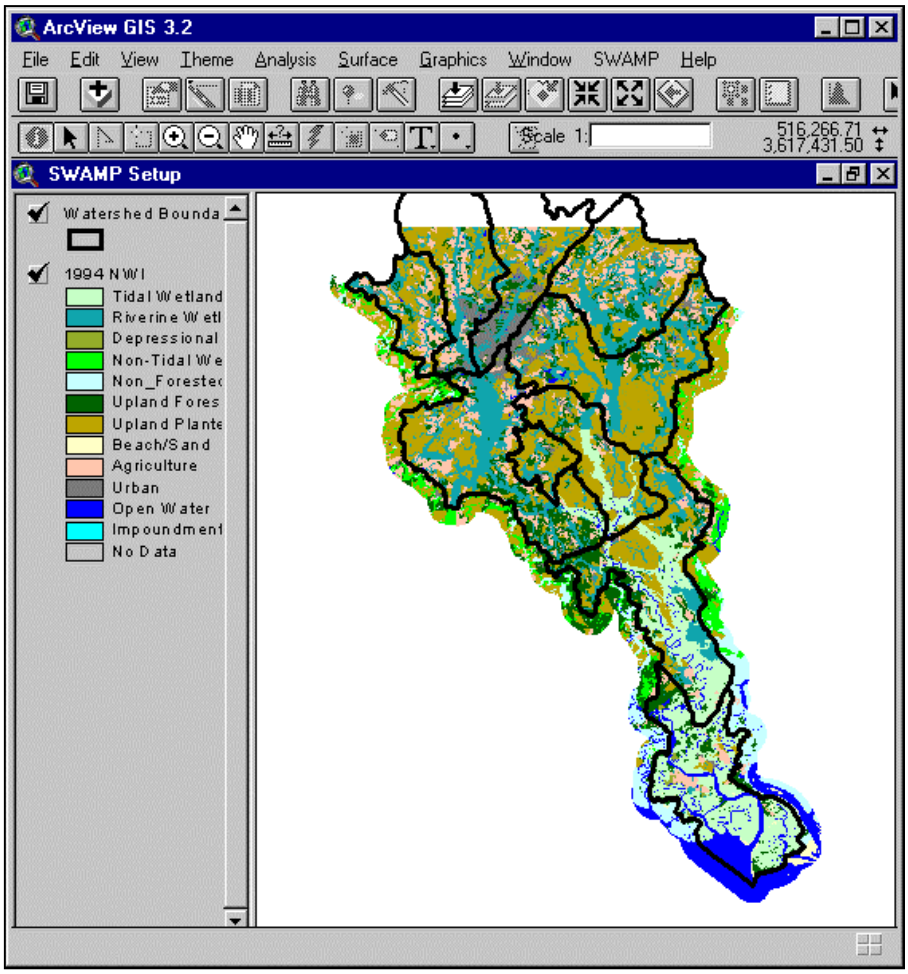
Please note that the hydrologic data used in the ACE Basin sample were taken from the National Hydrography Dataset. The attribute for Strahler stream order has not been checked for errors.



You may also be asked to locate the *swamp.exe* file, which also was placed in your installation directory. If you moved it, either return the file to the installation directory or point to the new location.

You will be notified that the data paths have been established, and you will be instructed to proceed to the next step. If the data are taking a while to be drawn within the **View**, there may be a delay before this option becomes available under the **SWAMP menu**.

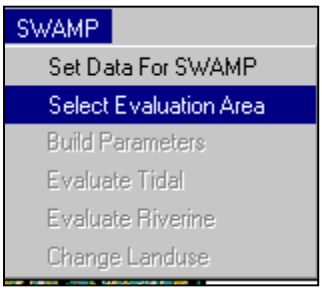
When the default data have been located, you should get the **View** that appears below:



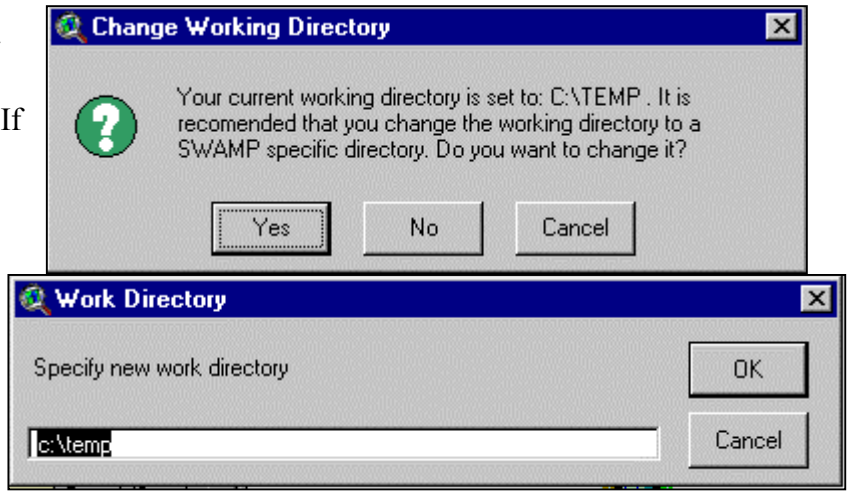
As SWAMP performs various processes, grids will be created and stored in your working directory. The grids will be placed in one of many **Views**. Grids required for analyses are written to a **View** entitled **Results View – Do Not Delete**. It is essential that this **View** remain in the project and not be manipulated. We recommend that the user ignore its presence.

Selecting a Watershed

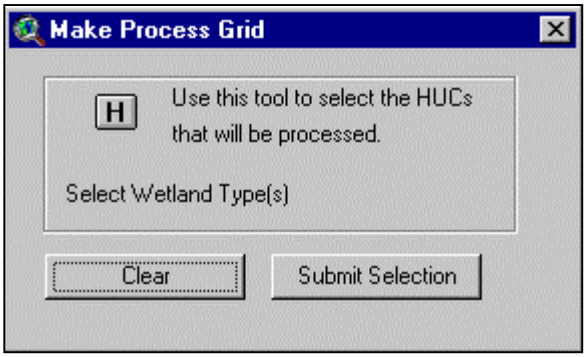
The first step in the process is to identify the watershed that will be examined. Since SWAMP is a relative ranking of wetlands within a watershed, each watershed must be processed independently. To select the watershed, choose **Select Evaluation Area** under the **SWAMP menu**.



Throughout the following steps, SWAMP will create several grids that will be written to the working directory defined within ArcView (usually *c:\temp*). Using *c:\temp* is not recommended because this directory is often purged during routine maintenance of a computer, which will loose your results. Consider setting your working directory to a safe location. If you choose to change your working directory, a dialog will be presented which allows you to set a new working directory. Type in the complete path for where you would like grids to be written. The name of the working directory should **not** include any blank spaces.



At this point, a new window will appear. Click on the **H button**, and then place your mouse over the watershed you wish to evaluate. Click anywhere within this watershed and click **Submit Selection** in the popup window. SWAMP will now create the data layers needed to run the model. Depending on the computer, this process should take less than 5 minutes to complete.

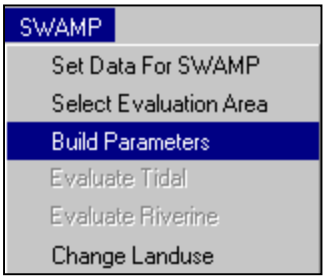


SWAMP will notify you when the processing is completed. Click **OK** to dismiss this window.

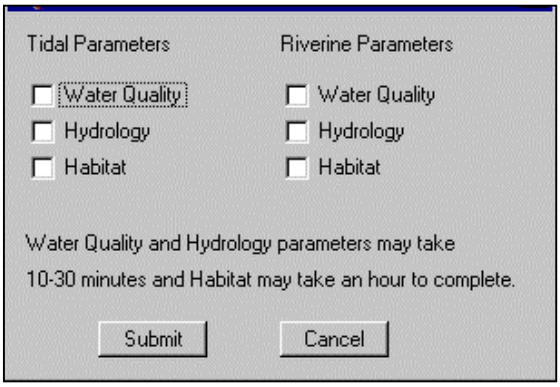
Building Parameters

Based on the general class of wetlands within the watershed, you can choose the components (water quality, hydrology, or habitat, alone or in combination) you wish to run. The module of SWAMP that will be used (riverine or tidal) will be determined by the value of the HGM attribute that appears in the data that designate land cover and wetlands ("T" is for the tidal module and "R" is for the riverine module). Analyses will run only for those wetlands with the appropriate code, and each component runs independently of the others.

To start the analyses for a given component, click on **Build Parameters** under the **SWAMP menu**. You will then see another interface allowing you to chose the module and components you wish to run.



Select any combination of components to run. Note the time required to run each component—ArcView will not be available to you when the model is building the parameters. The time described is applicable to each of the components within the appropriate module on a Pentium III computer with 256 megabytes of RAM. For example, if you select only **Tidal Water Quality**, you might expect the process to complete in 10 to 30 minutes, depending on the speed of your computer. If you select **Tidal Water Quality** and **Tidal Hydrology**, the time becomes additive. After the components are selected and you choose **Submit,** SWAMP will prompt you for the location to save the ArcView project.



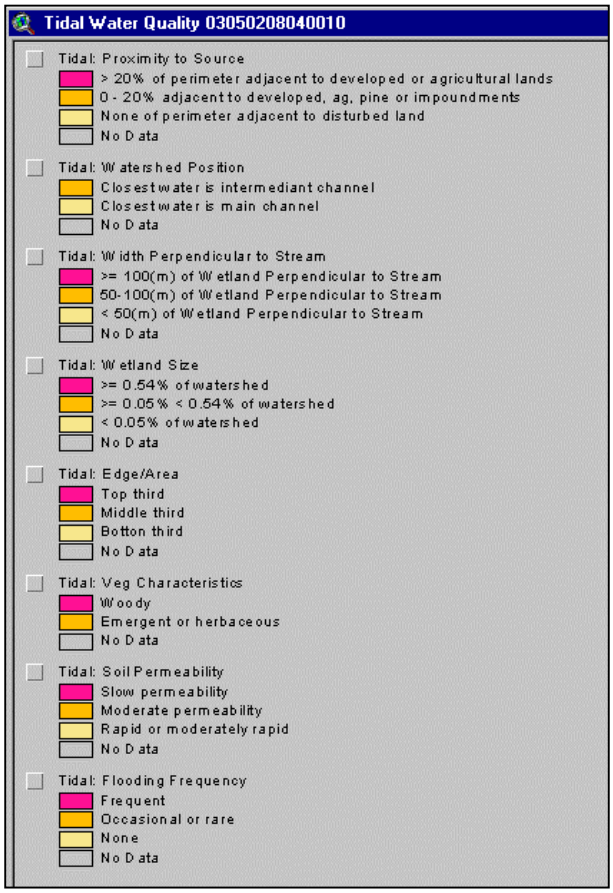
SWAMP will now begin performing the analyses necessary for the component(s) you have selected. For example, if you selected **Tidal Water Quality**, SWAMP will create eight new grids in a new **View** within your ArcView project. The View will be titled with the module, component, and unique watershed code (e.g., Tidal Water Quality 03050208030030).

Once you have selected a watershed, the analyses you request will be calculated only for that watershed. To change the watershed, you must return to the first step of **Selecting a Watershed** and continue. The **Selecting a Watershed** option is available only from the **View** that originally appeared after you set your data. Although a watershed may have more than one class of wetland, only those wetlands falling into the class selected (e.g., tidal or riverine wetlands) are evaluated for their contribution to each function.

SWAMP has now created a new **View** for each component containing many output grids resulting from the analyses. Each grid theme is labeled in the **View Table of Contents** as to which parameter it represents with the thresholds of evaluation.

If you would like to run additional components or modules after this is complete, you may return to the SWAMP menu and select **Build Parameters** again. You may also select a different watershed and run the model for it.

Because SWAMP stores the results of this step (i.e., the parameters) in the working directory, you should not have to run this step again unless you change the input data, chose to include new components, or chose to examine a new watershed. So while this step may take some time, it often will not have to be repeated.

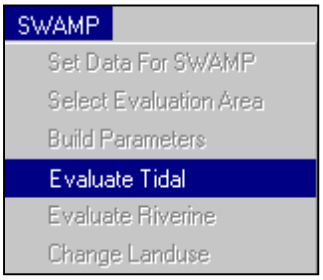


Assembling Parameters

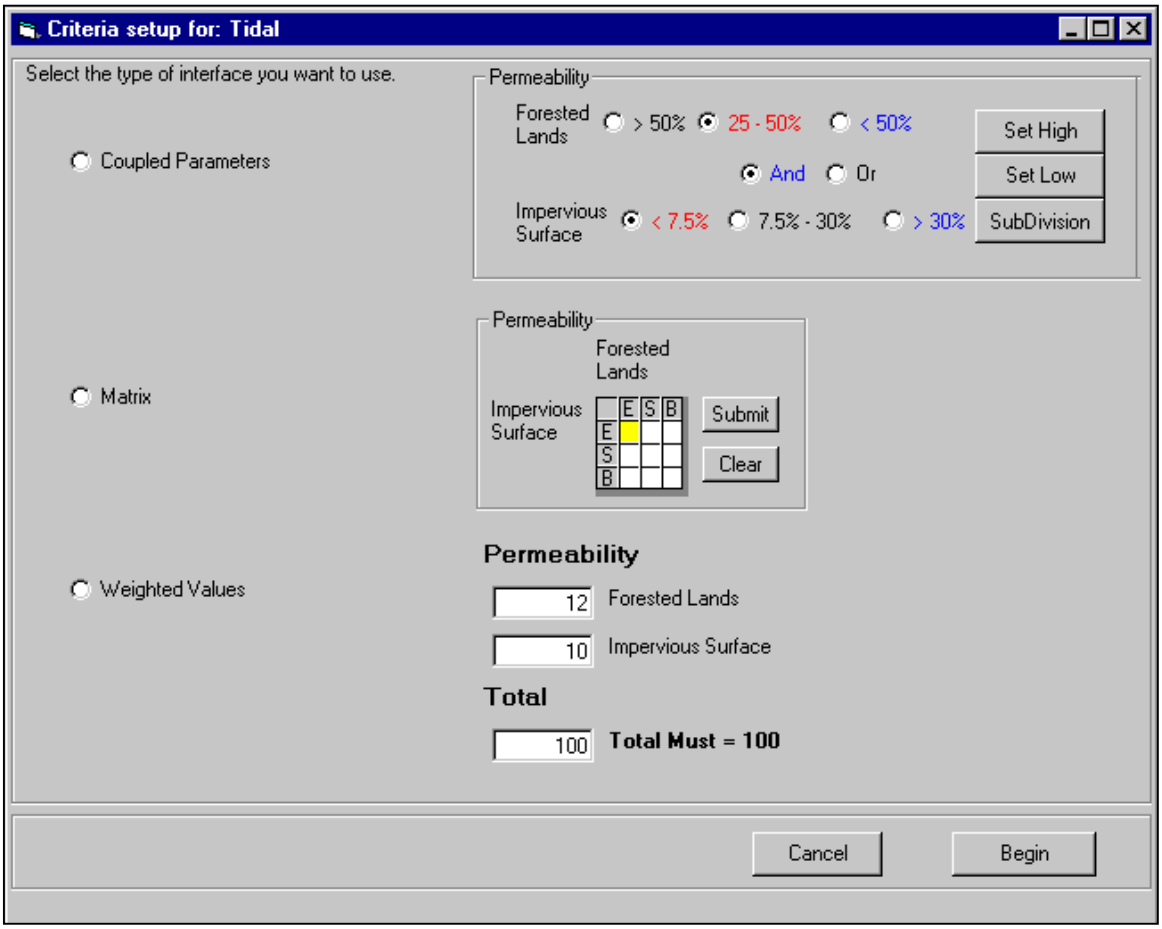
You have just completed measuring the base statistics of the parameters within your watershed. You will now establish the criteria for setting the relatively ranking of the wetlands. Users have the opportunity to determine the rules that place a wetland in the "exceptional" (highest) or "beneficial" (lowest) ranking categories. Those wetlands not considered in these categories are assigned to the middle category, "substantial." These assignments are done with an interactive interface, and this is the point where SWAMP calls the *swamp.exe* file that you located earlier. Once called, you will see an option to choose one of three interfaces—weighted values, matrix, or coupled parameters—which will allow you to select criteria and priorities for examining the wetlands. Each of these interfaces accomplishes the same result, they just provide different approaches to getting there. Choose the one that you are most comfortable with.

Open one of the **Views** that has the results from a watershed that interests you.

From the **SWAMP menu**, select **Evaluate Tidal** or **Evaluate Riverine**. You will only have these options if you have analyzed the parameters that are necessary to perform the analyses and are in the **View** with the resulting parameters built.



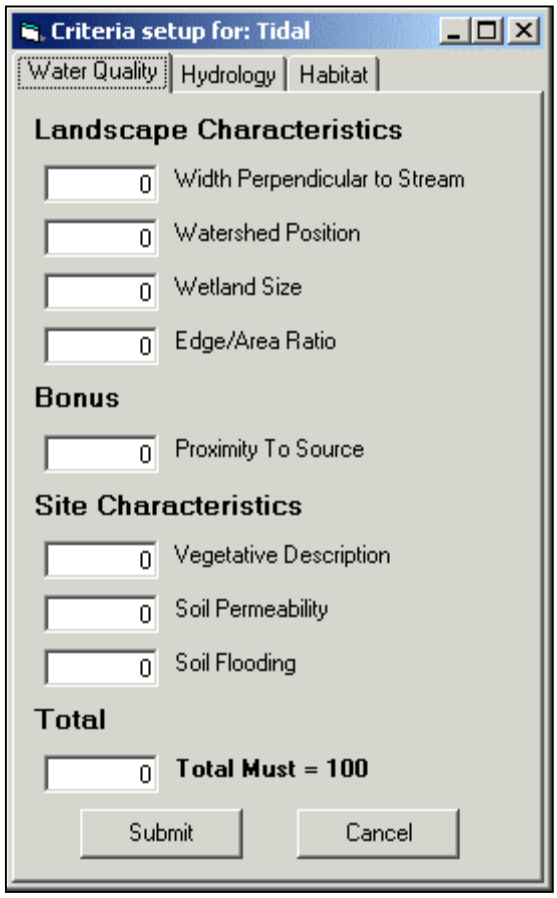
An interface will appear allowing you to select which interface you wish to use for combining the parameters—these interfaces are described in the next few pages. Select the option you prefer and then select the **Begin** button.

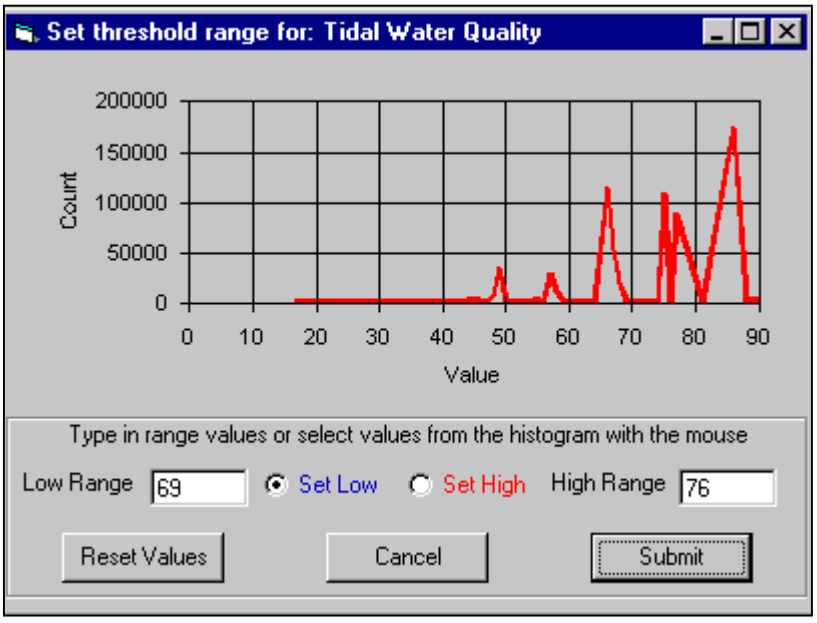


You must select the **tab** of the function you are interested in examining. Only the tabs that reflect the functions whose parameters were calculated will be shown on this interface. Once you select **Evaluate…**, you will see all the parameters available to examine that function.

Weighted Values Interface

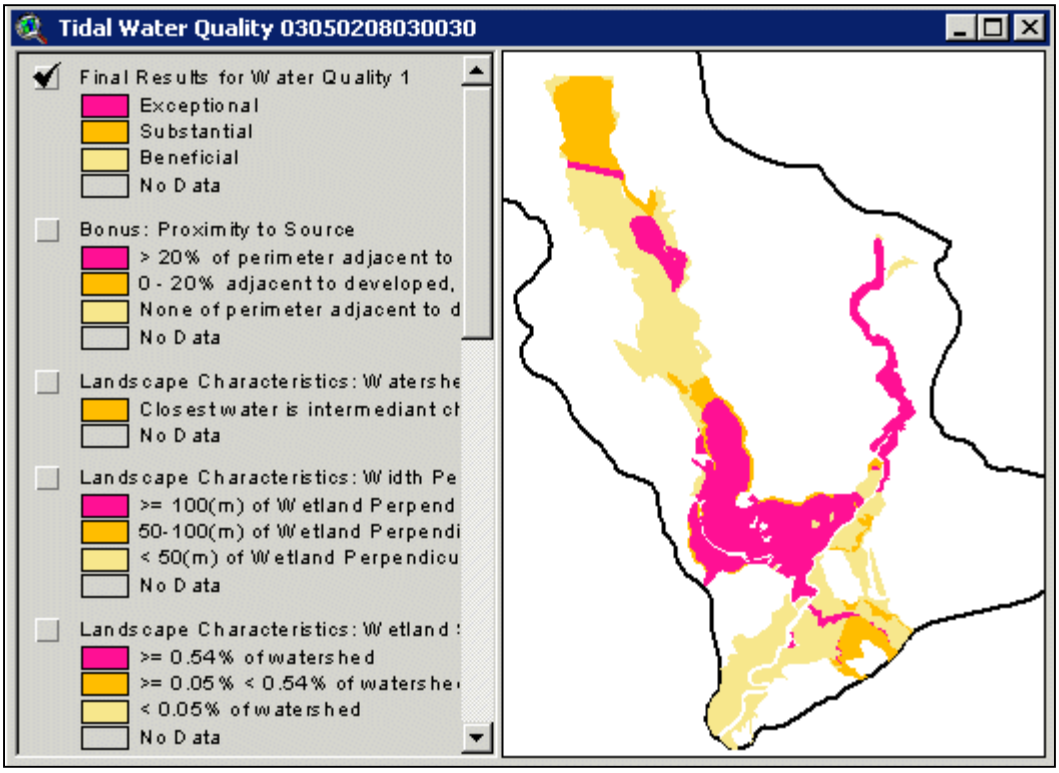
The most common approach to combining parameters into an overall assessment assigns relative weights to each parameter grid. With this approach, all weights must add up to 100, and the weights are then multiplied with the parameter grid. The parameter grids are then summed to provide an overall rating for water quality, hydrology, or habitat.





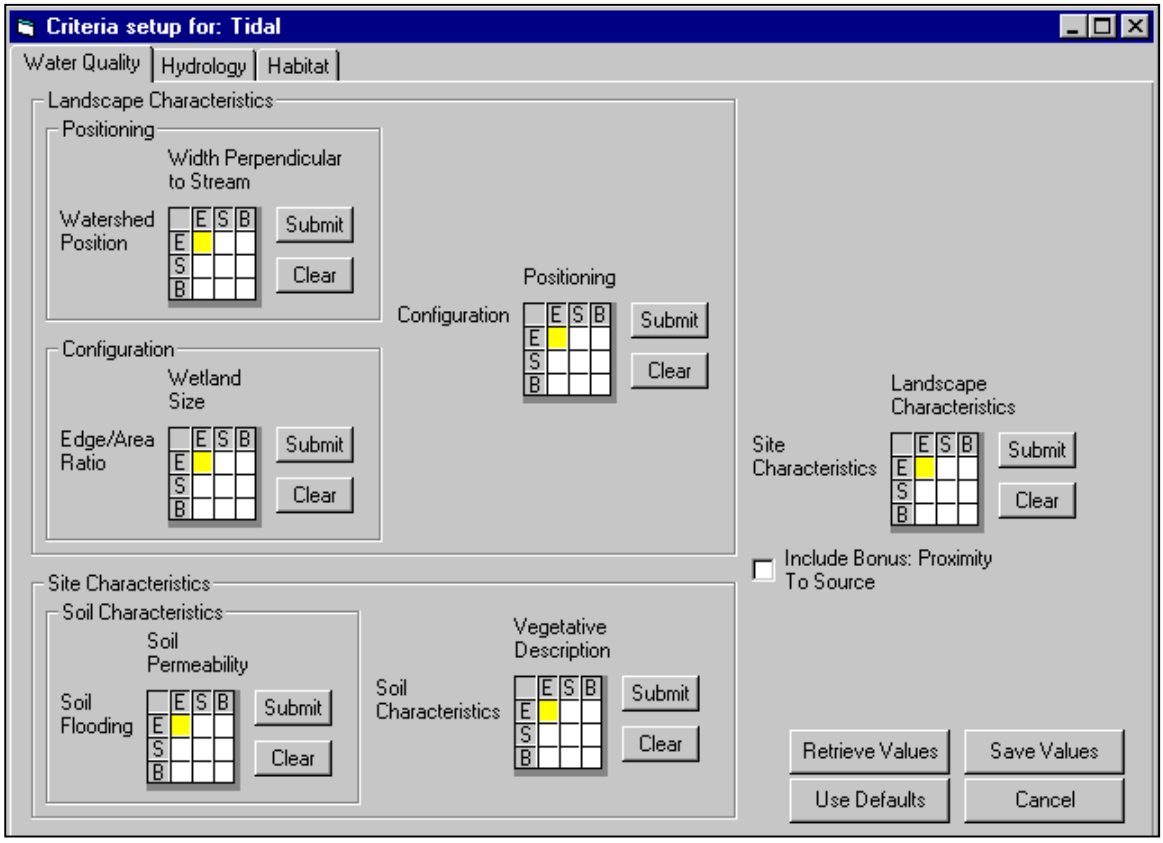
Next, a crude histogram appears that allows you to inspect the data before assigning the final thresholds that will be used to break the output into three categories.

As with the other options, this process calculates the results and displays them in a grid.



Matrix Interface

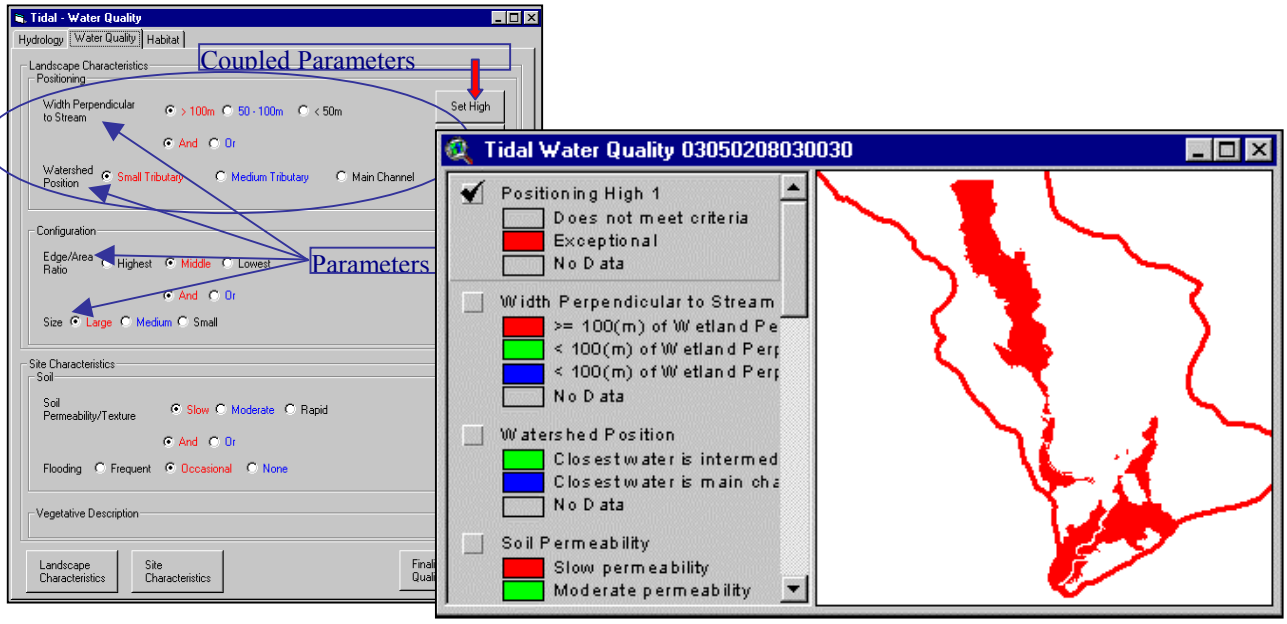
The second option for the interface presents a matrix that compares related parameters to one another. Because the ecology of these systems is complicated, it is important to be thoughtful about the relationships defined. Through the matrix interface, the user enters the result that they wish to be calculated when coupled parameters coincide. Starting at the left of the screen, you may enter the relationship that each of the parameters has with one another to get to the next level of analysis. For example, in a pixel where **Width Perpendicular to Stream** is rated "exceptional" (E) and **Watershed Position** is also "E," you may wish for that coupled relationship also to be an "E." You may note that result by typing "E" in the matrix where those parameters occur coincidentally. You must do this for every relationship that is shown in the matrix. SWAMP will only accept values of "E," "S" (substantial, or "B" (beneficial). You may save values in this matrix and later retrieve them to allow you to track the decisions you have made.

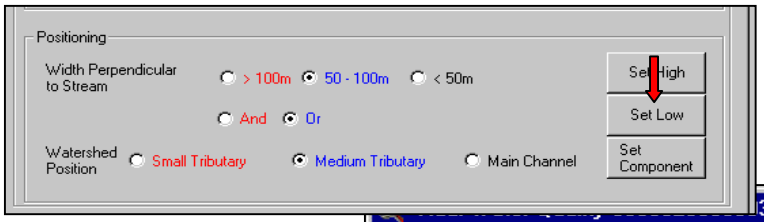


Coupled Parameters Interface

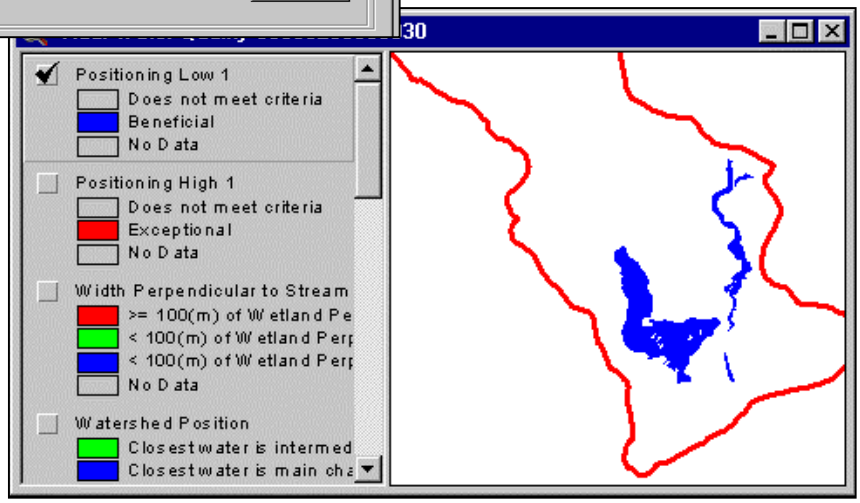
This is the most complicated interface for combining parameters. In this approach, the user chooses the descriptors that define an "E" and "B" wetland on the landscape for each group of coupled parameters; after defining "E" and B" wetlands, all remaining wetlands are assumed to be "S," the middle category.

When the **Set High** button is pushed, a grid will be written to the appropriate **View**. Each combination results in a grid, and the rules that the user defined will be stored in the **Theme Properties** window for reference. The resulting grids can be used in the next level of grouping or ignored.



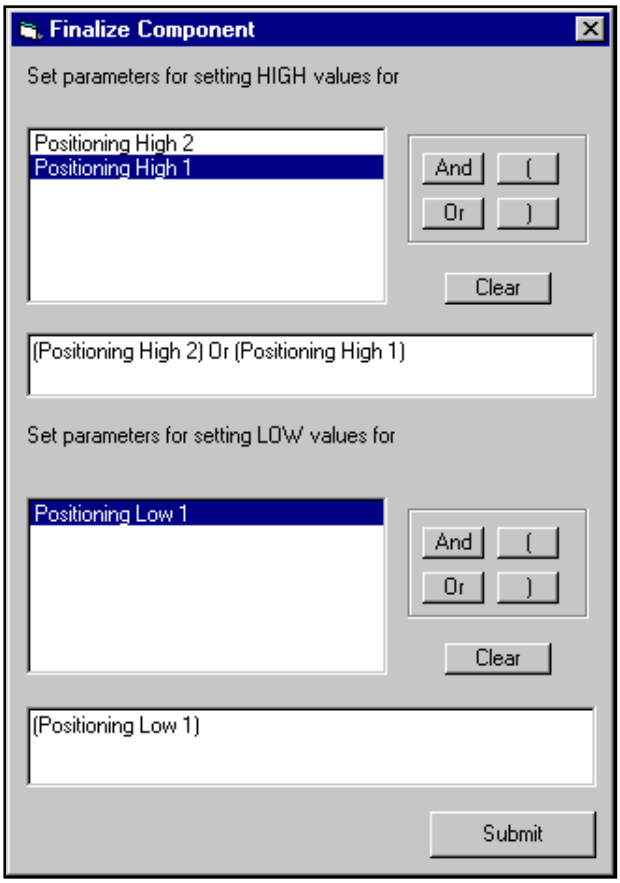


The same process is completed for the "B" (or lowest) rated wetlands.



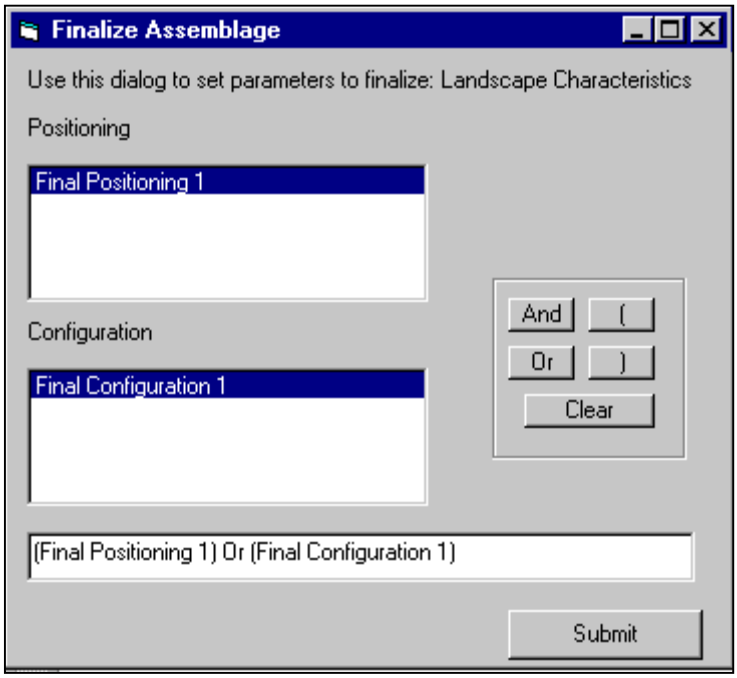
The recommended defaults for combining the parameters are shown on the interface. Those colored red are the recommended settings for the essential rating; those in blue are the beneficial rating. When only one color appears on one of the parameters, it is the same default for both ratings.

If you select a combination of criteria where the resulting grid is empty, SWAMP will notify you that the grid is empty, but it will be loaded to the **View** as an empty grid. If you wish to make another grid representing different options, you may do so.



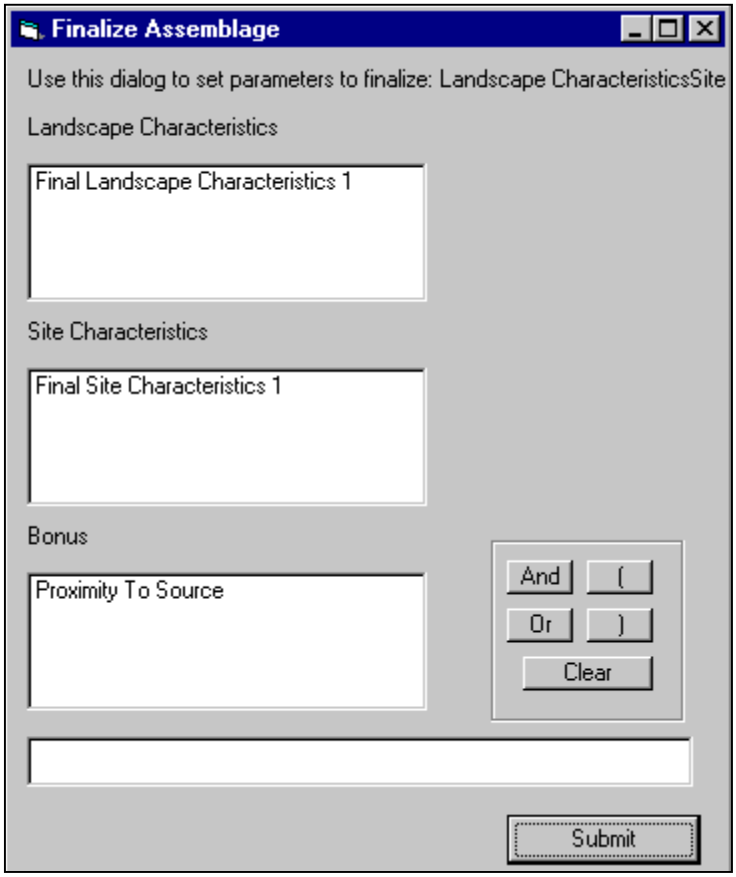
Once you have selected the highest and lowest criteria, you will have the opportunity to finalize each subdivision. If you have only one option calculated within each subdivision, you will not be asked to make a choice. To allow users to incorporate results from more than one combination, they are afforded the logical operators "and" and "or" as well as parenthesis to force the order of the operations. In other words, you may choose to combine the results of two or more runs of each of the coupled parameters with other coupled parameters. SWAMP combines the results of your logical statement. Each area on the ground is queried as to the results of the runs you make, and assigns the highest or lowest ranking to the pixel, based on the rule statement you provide.

The process is replicated up the hierarchy toward a final result for water quality, and eventually hydrology and habitat.

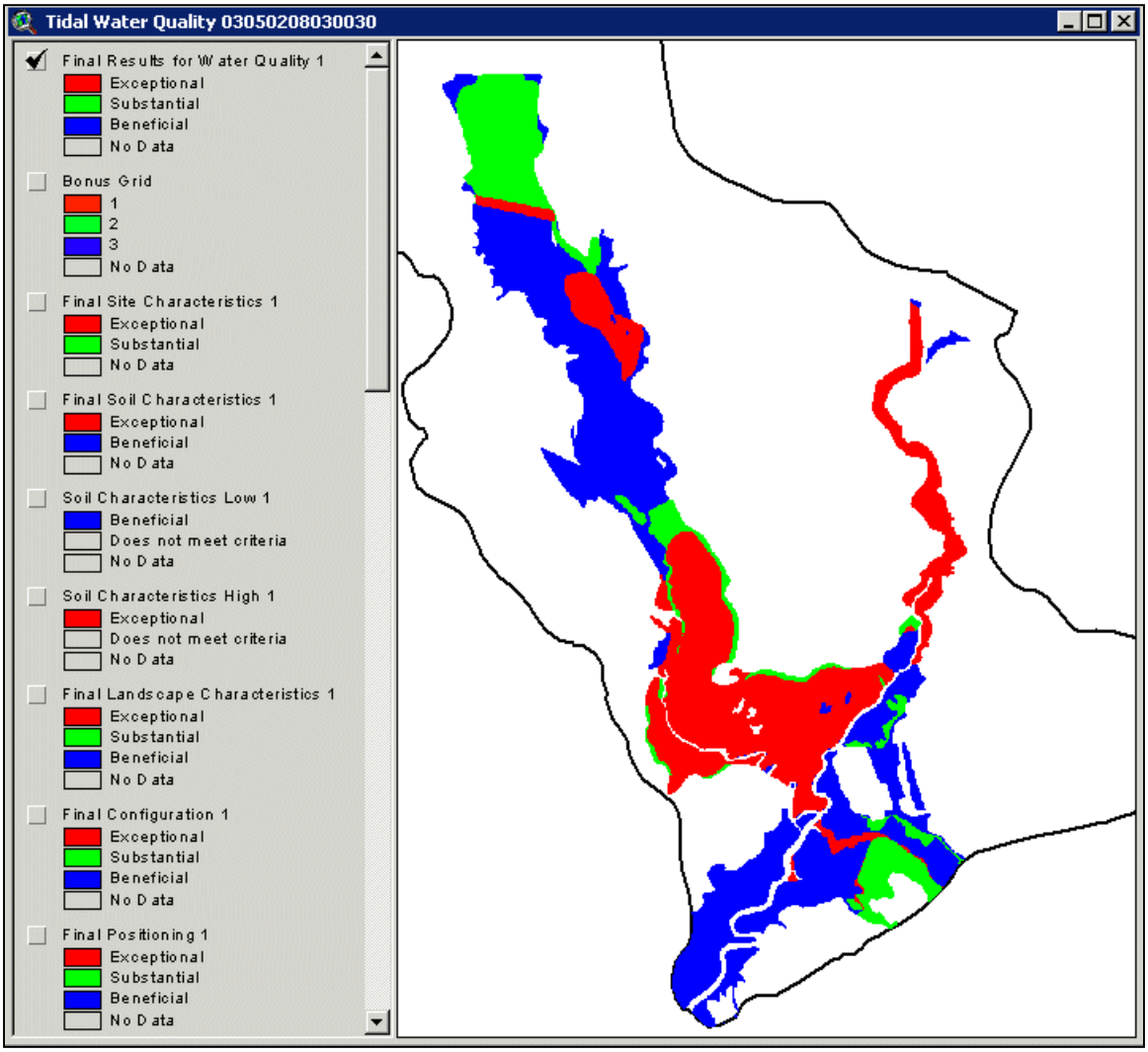


Using logical operators and parenthesis, you may now design a statement that combines the data in the most meaningful way for your application. Behind the operation you establish, the calculation assumes that in a conflict, essential ratings take priority, then beneficial ratings, and finally substantial ratings.

In the same manner as the previous steps, groupings are created to allow flexibility in the decisions all the way up the hierarchy.

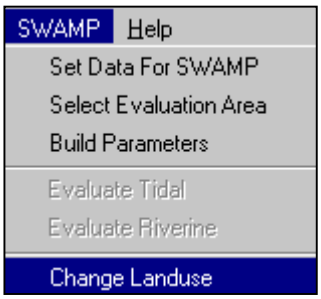


Results along the way are assigned to the appropriate **View** and the final results can be seen.



The same process is followed for the hydrology and habitat components. Additionally, the riverine module may also be run in the same manner.

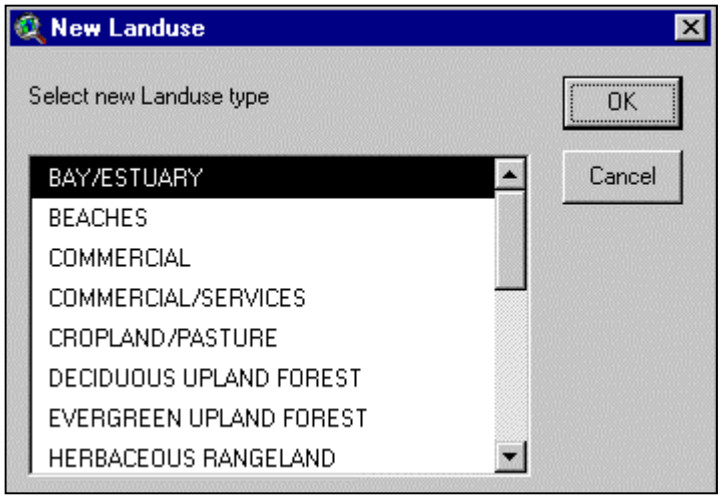
Changing Land Use



SWAMP allows the user to alter the existing land use data to appraise what effects these changes might have on wetland function. Land use can only be changed from the original **View** called **SWAMP View for Huc xyz**. Select the **SWAMP menu**, drag your mouse over **Change Land Use** and release. You will be given another interface.

You may draw a box, polygon or point on the current land use data displayed within the **View**. You may also use an existing shapefile with areas of land use change already delineated.

Once you have drawn or imported an area, you will be given a list of land uses.



Select the one that appropriately describes your new land use and press **OK**.

When you have made all the changes you wish to make, click the button to **Update Landuse**. A temporary grid will be written. You may move or rename this grid at your discretion using standard ArcView procedures.

You may now rebuild parameters and evaluate the model with your new land use choices.

Appendix I: The Data Loader

Please proceed cautiously if you opt to use your own data. Read this information carefully.

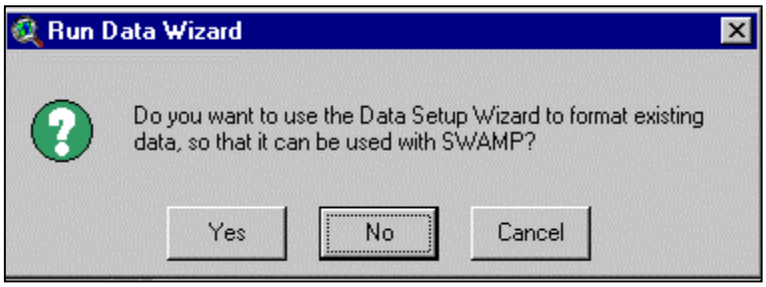
The **data setup interface** will walk you through the steps needed to format your data for SWAMP. All data must be represented in consistent units and share a common datum and projection. All data, except for watershed boundaries, should be in grid format; watershed boundaries must be represented as a polygon shapefile. Some flexibility is built into this tool to allow data commonly provided in vector format to be converted to raster format. SWAMP will not overwrite any grids you have loaded, but will save copies and notify you of the location. The extents of the grids may be altered slightly to ensure that the grids align directly with one another.

Open a new **View** and load all of the required data into that View. Required data (with required attributes listed) include:

- land cover (in raster format)
  - classes of land cover
- wetland boundaries and types (in raster format)
  - HGM class
  - vegetative cover type
- soils (in raster format)
  - flooding frequency
  - hydrologic group
  - permeability
  - hydric
- hydrography (in raster format)
  - Strahler stream order
  - sinuosity (can be calculated from a vector layer)
  - mouth of estuary (in vector shapefile format)
- roads (in vector or raster format)
- watershed boundaries (in vector shapefile format)

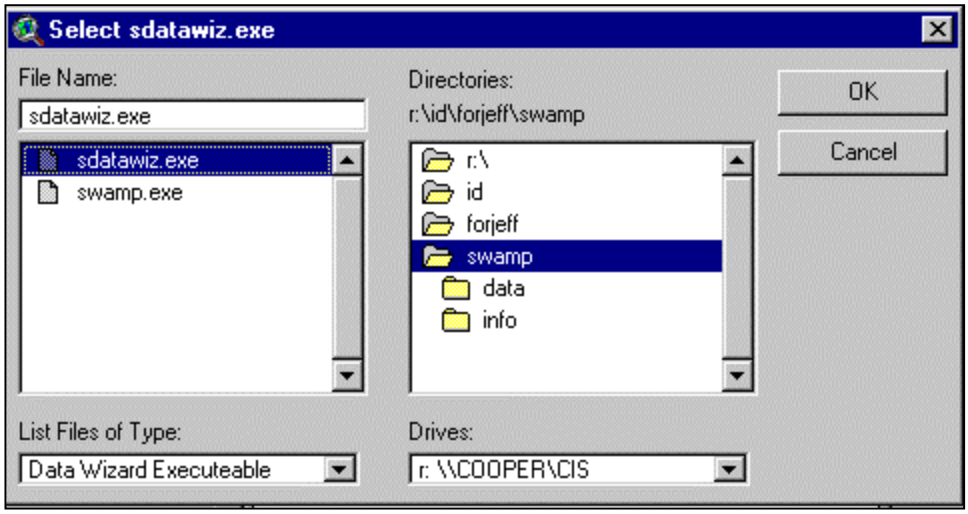
From the SWAMP menu item, select **Set Data for SWAMP**.

You will be asked if you wish to use the **Data Setup Wizard**. The **Wizard** is strongly recommended to establish the appropriate format and attributes for your data. If you are certain your data already meet the format and contain all the attributes necessary to safely run SWAMP (unlikely unless you have used SWAMP before), select No. You will be asked to locate the file created from previous uses of the **Wizard** (an **.ini* file).



Selecting **Yes** will rename the **View** in your project. After a brief delay and some instructional popup boxes, the **Swamp Data Wizard** will appear. You should see the themes from your **View** as layers, and all data that you load will be available. If you are missing a layer, simply add it to the View and refresh the layer listing in the **Data Loader**.

SWAMP will search your project directory for a file called *sdatawiz.exe* which was loaded to the installation directory. If



that file cannot be found by SWAMP, you will be asked to locate it. If you do not have it saved locally, it is available on the SWAMP CD-ROM. If you are not asked to locate the file, then SWAMP successfully located the file in the directories that it searched.

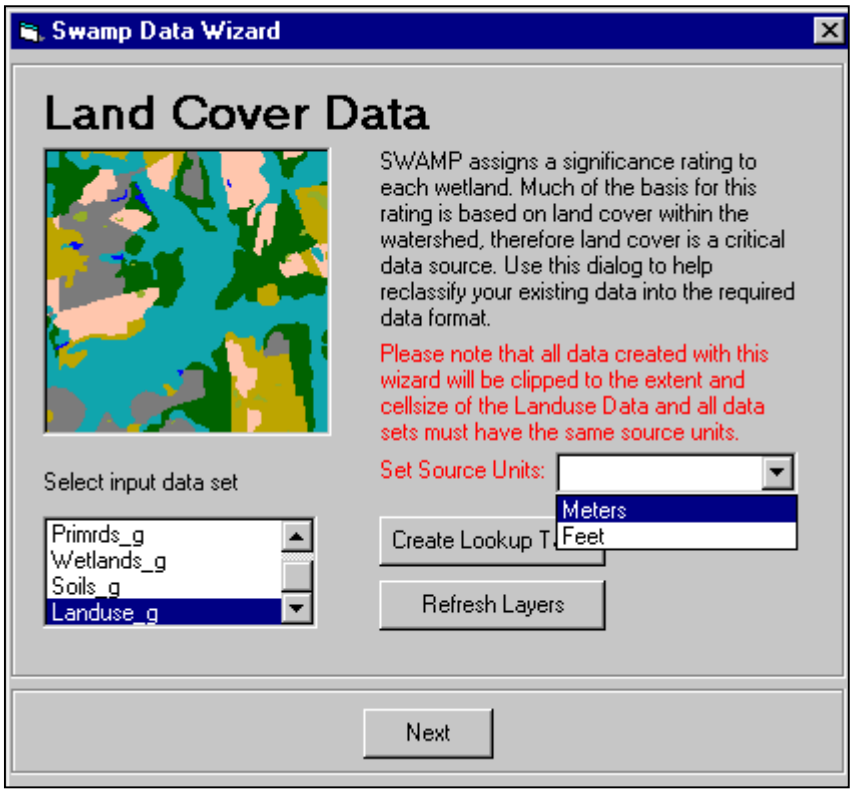
When SWAMP has located this file, you will again be reminded to add data to the **View** entitled **Data Update View**. Click **OK** and load the data into the **View** if you have not already done so.

The **Wizard** may take a while to load. Please be patient. When you select the wizard, the themes that you loaded into your data **View** will appear in a scroll down menu at the bottom left corner of the interface. If they do not, select **Refresh Layers**.

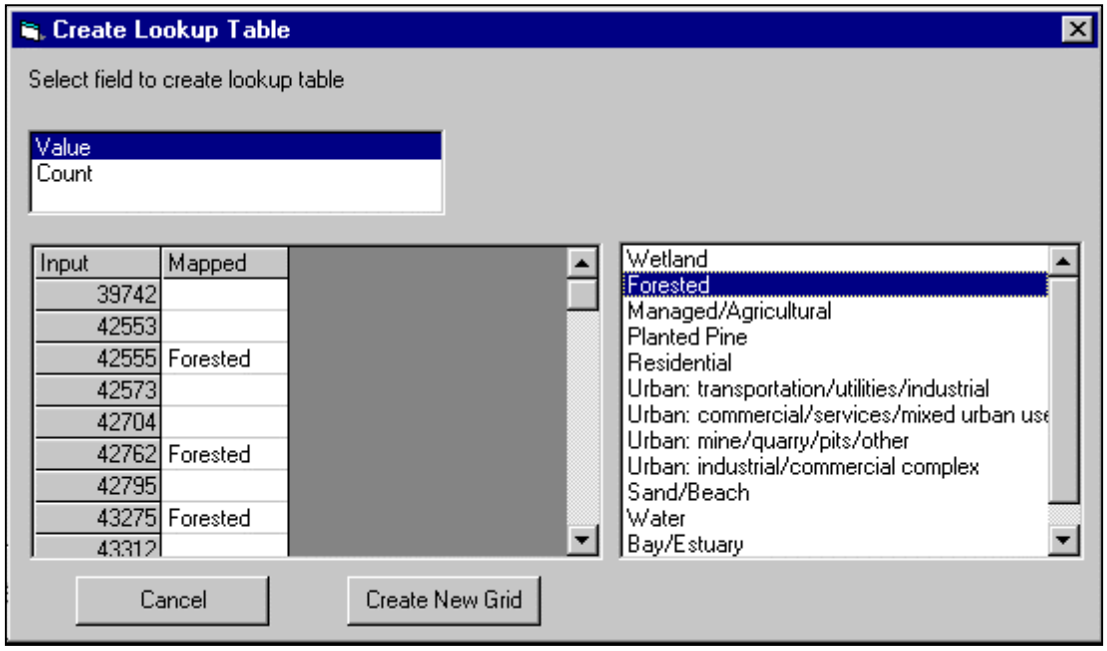
Select the **source units** (meters or feet) of the data.

Select the **input data** that represent the feature listed in bold at the top of the interface (Land Cover data, in this case).

Press the **Create Lookup Table** button to create attributes for SWAMP analyses.



The **Wizard** will then present you with a list of attributes found in your grid, and the data classes for that layer that are required to run SWAMP. You must highlight the attribute in your grid representing the required attribute. SWAMP will then read the data layer and provide a list of all the unique entities found within that field. You must then select the entities (multiple entries may be selecting while holding down the CTRL key while clicking on the entry) and match them to the appropriate entry on the right.



When you have populated all of records, press **Create New Grid**. At this time, you will be notified that the data have been saved and the new grid name.

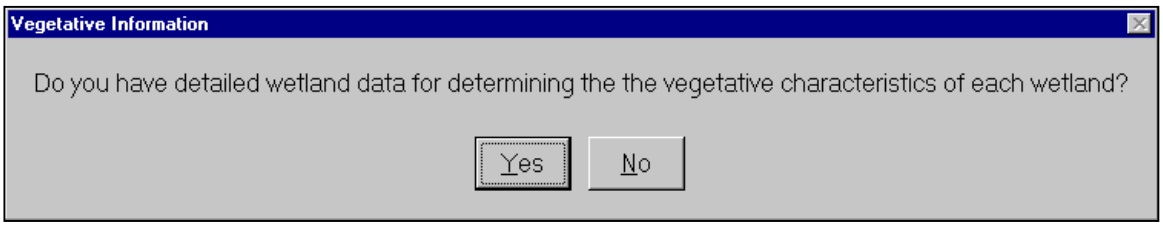
When you return to the main interface, you may press **Refresh Layers** and see that your new input data set has been added to your list. Pressing **Next** will take you to the next required data source. SWAMP will not allow you to proceed to the next step until it recognizes the required components of the grid.

The **Wetland Interface** requires additional information in the attributes written to the wetland grid. This interface will assess the attributes in your selected coverage and list the entities of those attributes. After selecting the **Wetland Grid** and choosing to create a **Lookup Table,** you will be asked if you have detailed information about the vegetative characteristics of the wetland. SWAMP needs the following information provided in different attributes:

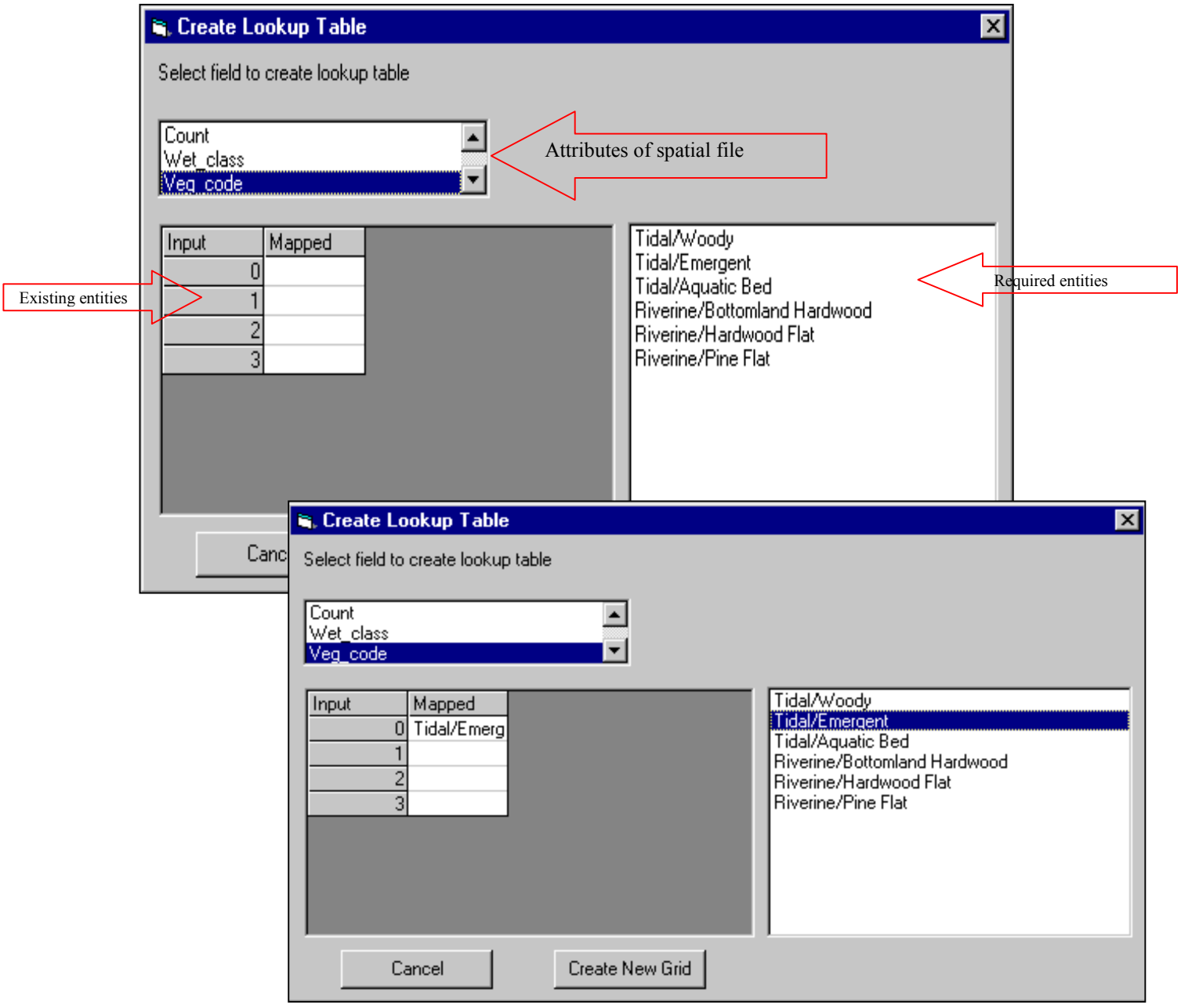
- *HGM class*. This instructs SWAMP whether to run the tidal or riverine module of the model. This can be coded in any way in your original data, but you will have to map this relationship for SWAMP to be able to use your data.

- *Vegetative characteristics*. SWAMP is looking for a broad classification of the structure of the wetland vegetation: woody, emergent or aquatic bed. These data are discernible from the Cowardin classes in the National Wetland Inventory data.

When asked if the data have detail, enter **Yes** if you have a single field that SWAMP can process to locate both the HGM field and vegetative structure. Indicating **No** instructs the model only to inquire about HGM class, and you will not be asked for vegetative information. Note that by not providing vegetative information, many of the parameters of SWAMP will not be available to you and will limit your examination options.



Following the same procedure that was used in the land cover wizard, create a **Lookup Table** for values within your existing data that match the values that SWAMP requires. Assign values from the required entities into the mapped field shown adjacent to the existing entities. Simply click on the **records** (using CTRL+click to select more than one at a time) and then click on the description at the right. The record(s) will be populated with the value chosen from the right.



Select **Create New Grid** when you have completed all fields. SWAMP will save this new grid to your working directory, notifying you of the new grid name and location in a popup box.

Continue this process with soils data. You may need to join databases to your grids to ensure that you have attributes for flooding frequency, soil infiltration, soil permeability and hydric properties. Once you can spatially recognize these attributes, fill in the fields under each of the four tabs before creating a new grid and moving to the next data source. SWAMP notifies you where it has saved the new grid.

Hydrography data must next be formatted to meet SWAMP requirements. Select the hydrography layer previously added to your **View** and format it for SWAMP. This ensures that the extent matches that of the land cover. You will then need to identify the attributes representing stream order (SWAMP follows the Strahler stream ordering convention) and sinuosity. Sinuosity can be calculated using the **Wizard** if a vector version of the hydrography layer exists. If there is no vector layer, SWAMP will need an attribute within the grid that represents sinuosity. After **Creating a New Grid**, SWAMP notifies you where it has saved the new grid.

SWAMP next searches for a grid representing the mouth of the estuary. You may select this if it already exists in grid format. Because shoreline data are often represented as vectors, SWAMP allows you to convert this shapefile to a grid by selecting **Create Mouth from Vector** button. SWAMP notifies you where it has saved the new grid.

SWAMP next searches for a grid representing roads. You may select this if it already exists in grid format, and then press the SWAMP format button to convert it to the acceptable format for SWAMP. Because road data are often represented as vectors, SWAMP allows you to convert this shapefile to a grid by selecting **Create Roads from Vector** button. SWAMP notifies you where it has saved the new grid.

Finally, SWAMP asks you to identify the watershed boundaries that were loaded into your **View**. This should be a shapefile, not a grid. Once located, select **Finish** and write the new file out to your project or working directory. Note the location of this file as you may be asked to locate it again.

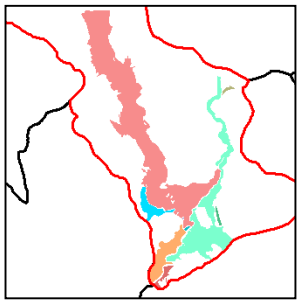
After saving your file, return to the SWAMP menu, select **Set Data for SWAMP**, choose **No** when asked to use the sample data, and then choose **No** again when asked if you would like to use the **Wizard**. You will be asked then to navigate to the **.ini* file that you just saved. You will not have to step through this procedure more than once if you have provided all the information required.

Return to your **View**, and pull the land cover and watershed data to the very top of your **View**, with watershed on top of land cover. Turn both of these themes on, and proceed to select evaluation area and follow the remainder of the instructions provided in the body of this tutorial.

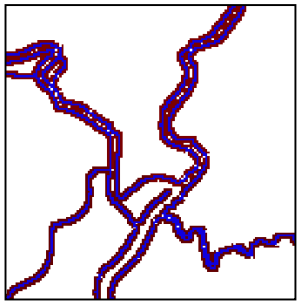
Appendix II: Tidal Module/Water Quality Function/Width Perpendicular to Stream Example

In order to provide an example of the GIS processing techniques that are used in this model, a detailed description of a single parameter is presented. The parameter that is discussed is **width perpendicular to stream**, which is one of the parameters evaluated for the water quality function of the tidal wetland module. The premise of the width perpendicular to stream parameter is that the wider the wetland is adjacent to the channel, the more surfaces there will be for soil exchange, thereby removing the nutrients that would otherwise end up in the water. For this parameter, wetlands are grouped into contiguous wetland complexes, assuming that these wetlands will work together as a system.

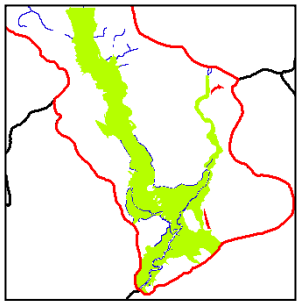
Words shown in **bold** are commands available within the Spatial Analyst extension of ArcView.



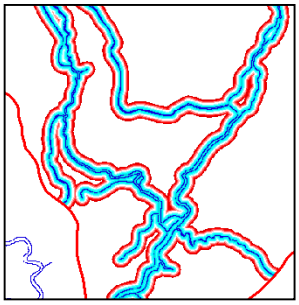
The first step in analyzing this parameter is to group contiguous wetlands together to form a wetland complex. A complex is analyzed rather than an individual wetland because contiguous wetlands act as a system, and water will continue moving through the system. In contrast, the individual wetland type difference may only reflect a change in vegetative cover. The **RegionGroup** function is used to determine which wetlands are contiguous. In the image to the left, the different colors represent the zones or groups of wetlands that are the results of running the **RegionGroup** function. All wetlands within each zone receive the same rating for this parameter.



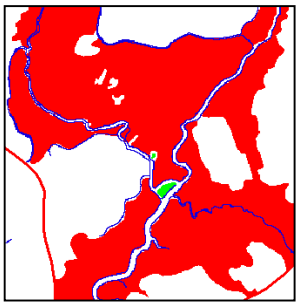
The next step uses the **FocalStats** function to buffer the stream data by one cell (10 meters in this case). This buffer is implemented to overcome some of the inconsistencies that might exist between the hydrography and wetland data sources, essentially widening the area recognized as a stream channel. The image to the left is zoomed in to a larger scale to depict the widened stream that is used to determine adjacency.



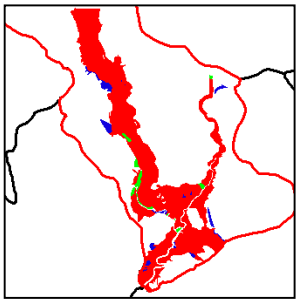
SWAMP next relies upon the **ZonalStats** function to determine which wetland complexes are immediately adjacent to the streams. This step is necessary to separate the adjacent wetlands from the nonadjacent wetlands. Those wetlands NOT considered adjacent receive the lowest rating and are excluded from further analyses. In the image to the left, those wetland complexes that are shaded red are not adjacent to a stream and will receive the lowest rating.



In order to determine the width perpendicular to a stream, the **EucDistance** function is used to calculate the distance (width) from the stream. The result of this function is a grid consisting of cells with values reflecting the distance from the original source (the stream). Euclidian distance does not take into account topography, and it measures the diagonal distance across the cell. This image, which zooms into a small section of the watershed, depicts the results of running the **EucDistance** function from the stream to 110 meters. Values range from 10 meters (light blue) to 110 meters (red).



The **ZonalStats** function is then used to determine the maximum width (or distance) of any wetland that is adjacent to a stream. Wetlands that extend to the edge of the previous step are at least 100 meters wide and are afforded the highest rating. The remaining wetlands that are within the adjacent stream buffer but not 100 meters wide are given the middle category of rating. This image, which shows the same extent as above, shows how the euclidian distance values are assigned to the wetland complexes. The wetlands in red have a width perpendicular to the stream that is greater than 100 meters, while the wetlands in green are less than a 100 meters wide, but greater than 50 meters wide.



This image depicts the final results for the width perpendicular to stream parameter. Wetlands in red received an essential rating and have a width perpendicular to stream greater than 100 meters. Wetlands in green received a significant rating and have a width perpendicular to stream greater than 50 meters and less than 100 meters. Wetlands in blue received a beneficial rating and have a width perpendicular to stream less than 50 meters or are wetlands that are not adjacent to a stream.