Everglades Landscape Vegetation Succession Model (ELVeS)

User's Guide, Version 1.0

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Introduction

The Everglades Landscape Vegetation Succession model (ELVeS) is a spatially-explicit simulation of vegetation community change over time in response to changes in environmental conditions. The model uses empirically-based probabilistic functions of vegetation community niche space and temporal lags to evaluate expected community response within the model's domain. The model has been parameterized for the Everglades spatial domain, including the Water Conservation Areas and Everglades National Park.

ELVeS is written in Java as open source, freely distributed program executables and source code to facilitate sharing, expansion and modification by a wide and diverse end user clientele.

Hardware Requirements

- Operating System: Platform independent (tested on Ubuntu Linux and Windows XP)
- CPU: 1GHz or faster
- System Memory (RAM): 512MB or greater recommended
- Hard Disk: 400MB free space

Software Requirements

Java JRE 1.5 or greater is required to run the Everglades Landscape Vegetation Succession model.

Installation

There is no installer for the Everglades Landscape Vegetation Succession model. Simply unzip the directory to the desired location.

Getting Started

All of the input and output files are CERP-compliant netCDF format. At the time of this writing, CERP compliance was still being documented, however, CF-compliant netCDF is a documented superset that will work with this software as well. Contact the authors for more information.

The ELVeS model is parameterized via a graphical user interface (GUI). Parameters are saved for inclusion in the model in an .xml file. Multiple .xml files can be created for running the model under different conditions or for experimenting with parameters.

Running the Everglades Vegetation Succession Model

To run the Everglades Vegetation Succession model, navigate to the ELVeS directory.

In Windows, double click on ELVES.bat
or, at a Linux or Windows command line prompt, type: java -jar dist\ELVES.jar

When ELVeS starts, it will display the GUI. At the top of the GUI are two tabs, **Setup** and **Runtime**. **Setup** has four tabs underneath it, **Communities**, **Data Layers**, **Evaluation**, and **Output**.

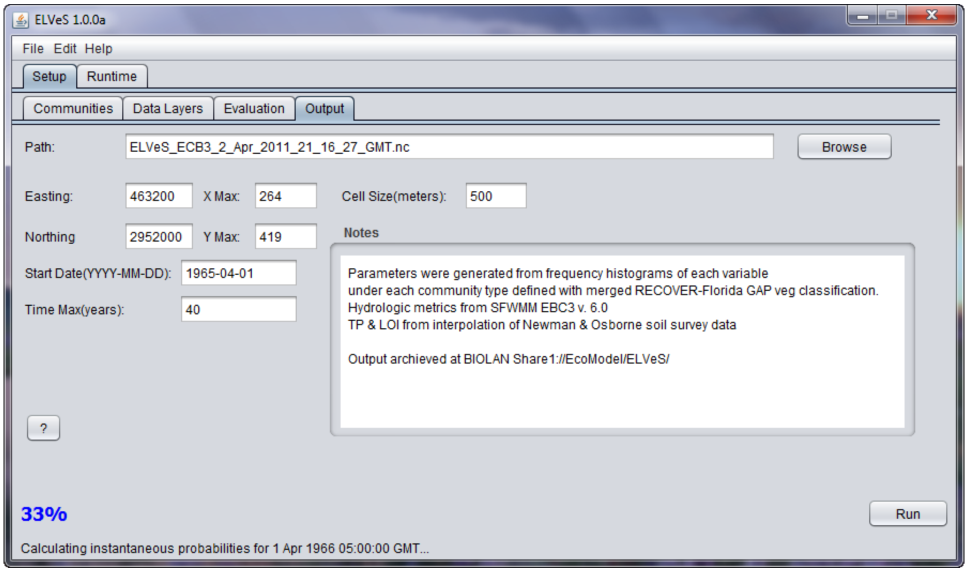
To start the model using the default communities and parameters, click on **File→Open**, navigate to the ELVeS folder and open the *parameters_03302011_Default_EDEN.xml* file (accepts EDEN hydrologic input) or the *parameters_03302011_Default_ECB3.xml* file (accepts South Florida Water Management Model ECB3 v.6.0 hydrologic input). When the parameter file is loaded, go to the **Setup→Output** dialog to rename the output file (if desired) and review the other options.

Easting, *Northing*, *X Max*, *Y Max*, *Cell Size*, *Start Date*, and *Time Max* default to the values for *ECB3Stats.nc* which is the default hydrological metrics input file. The *Easting* and *Northing* values correspond to the **upper left** corner of the grid. The *Start Date* field represents the date string in which the user wants output to start. *Time Max* is the number of years that are simulated. *X Max* and *Y Max* are the number of cells in the x and y direction respectfully. *Cell Size* is the size in meters of each cell.

Start Date and *Time Max* can be used to create an output subset of the input time sequence instead of running every year. Be careful that the values used for *Start Date* and *Time Max* does not exceed the range in the input file. *Easting*, *Northing*, *X Max*, and *Y Max* can be used to spatially subset the output file. *Cell Size* can also be arbitrarily set to any output cell size (*Caveat Emptor*).

The *Notes* text box is for remarks, sources, and any other comments that benefit the user by keeping them with the parameter file. Anything typed into *Notes* is ignored by the application.

Clicking on the **Run** button will start model processing.



The communities modeled and their parameters can all be changed by the user by using the other tabbed dialog boxes on the GUI (see the *Modifying the Parameters* section). If you experiment with new parameters, Use **File→Save As** to save your changes to a new parameter file.

Mapped Outcomes

Two output files are created: a file of intermediate results before modeling temporal lags in response and a file with the final ELVeS vegetation community outcomes that include temporally-lagged responses. The output files are projected, spatially-explicit netCDF file format containing annual time steps.

The **first file** contains all the intermediate results as multiple data layers that allow the user to drill-down and examine the individual probabilities that result in the final mapped classification. The first file is distinguished from the second by having "_iProb" appended to the file name.

The exact number of layers in the first file depends on the number of variables and number of communities used in the model. There are 4 categories of data layers in the first file:

1. Conditional occurrence of each of the vegetation communities given each input variable (number of data layers = number of communities x number of variables).

   For each grid cell:

   $$P(i \mid j) = Distribution\_Function\_Value$$

   where i = each of the vegetation communities and
   j = each of the input variables

2. Joint instantaneous probabilities of occurrence of each of the vegetation communities. Joint instantaneous probability of occurrence is the geometric mean of the conditional occurrences for the vegetation community.

   For each grid cell:

$P(i) = (P(i|\,j1)\ x\ P(i|\,j2)\ \ x\ P(i|\,j3)\ \ldots\ x\ P(i|\,jn))1/n$
where i = each of the vegetation communities and
j = each of the input variables
n = number of input variables

3. The dominant predicted instantaneous vegetation community
   For each grid cell:
   For the set of community probabilities ($P(i)$, i = 1 to n) select the community with the highest probability.

4. The secondary predicted instantaneous vegetation community
   For each grid cell:
   For the set community probabilities ($P(i)$, i = 1 to n) select the community with the second highest probability.

The **second file** is a single data layer deep and contains mapped output of the dominant predicted vegetation community when temporal lags are considered.

Model Description

ELVeS vegetation communities are evaluated against a probability distribution defined by the user. There are currently four types of distributions supported by ELVeS, a normal, skewed normal, logistic, and categorical distribution. At runtime, values are evaluated against the corresponding distribution. After a cycle is complete, the individual probabilities are combined via their geometric mean to give a total instantaneous probability of succession for a community for that year. Temporal lags in community transition are then evaluated to produce a final vegetation map.

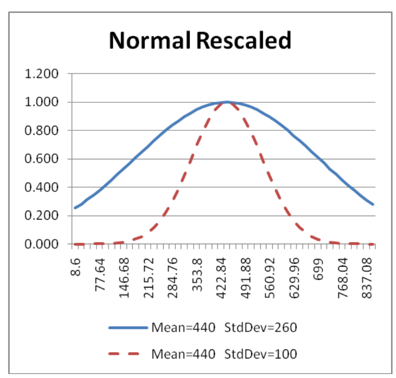
Normal Distributions

Normal distributions are defined by the following equation:

$$P(x) = 1/\ \mathrm{sqrt}(2\pi\sigma^2) * e^{-(x-\mu)^2)/2\sigma^2}$$

Where x is the random variable, μ is the mean, and σ is standard deviation defined by the user.

To rescale the distribution to vary between 0.0 and 1.0, a denominator is added that divides the above results by the maximum value (value at $x = \mu$):



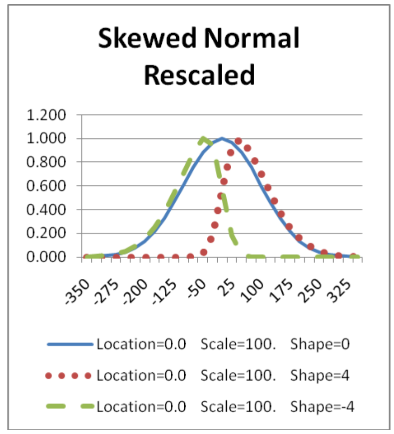
$$P(x) = \frac{1/\,sqrt(2\pi\sigma^2)*e^{-(x-\mu)^2)/2\sigma^2}}{1/\,sqrt(2\pi\sigma^2)*e^{0/2\sigma^2}}$$

Skewed Normal Distributions

Implementation of the skewed normal distribution is somewhat lengthier and the user is referred to the source code for the equation set. There are 4 variables input by the user to define a skewed normal distribution:

Location Determines shift of the distribution from the horizontal origin. If *Shape*=0, then Location is equal to the mean of the distribution.

Scale Determines the statistical dispersion of the distribution. If *Scale* is large the distribution will be more spread out than if *Scale* is small. If *Shape*=0, then *Scale* is equal to the standard deviation of the distribution. *Scale* must be a positive number.

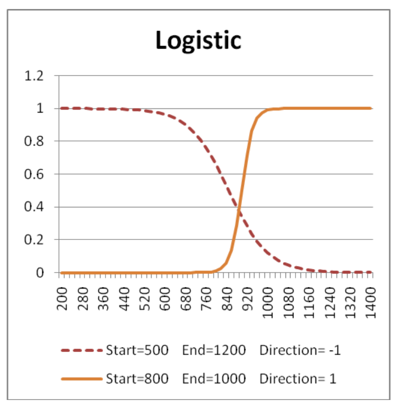


Shape Determines the asymmetry or skewness of the distribution. A positive Shape skews the distribution to the left of the mean (longer tail on the right).

Max The maximum value of the skewed normal distribution. *Max* is used to rescale the distribution to vary between 0.0 and 1.0.

One of the utilities distributed with ELVeS is the program, ELVeSkew, which provides a "best fit" estimate of these four variables from user-provided frequency histogram tables.

Logistic Distributions



Logistic distributions are defined by the following equation:

$$P(x) = 1/\,(1 + e^{-(x-\mu)/\,\sigma})$$

Where x is the random variable, μ is the mean, and σ is standard deviation.

The function used in ELVeS is a transformation of the logistic equation (Brandewinder 2008) that offers more intuitive control over when growth happens and the rate of growth. The equation is:

$$a = \ln(1/\,PValue1 - 1)$$

$$b = (a - \ln(1/\,PValue2 - 1)\,/(End - Start)$$

$$P(x) = Peak\,/(1 + e^{-b*(x-(a/b+Start))})$$

where:
Peak = maximum value that can be obtained = 1.0 (constant) for this application
Start = concentration (horizontal axis position) at start of logistic curve
End = concentration at end of logistic curve
PValue1 = the proportion of the Peak that has been reached at a concentration of *Mean1*
PValue2 = the proportion of the Peak that has been reached at a concentration of *Mean2*
x = concentration at which the function is being evaluated

For this application,
If the *Direction* = 1, then the function is increasing and *PValue1* is 0.01 and *PValue2* is 0.99
If the *Direction* = -1, then the function is decreasing and *PValue1* is 0.99 and *PValue2* is 0.01

Therefore, only *Start*, *End* and *Direction* needs to be input.

Categorical Distributions

Categorical relationships provide the option of using non-continuous data categories. The routine used in ELVeS needs the category numerical value and the probability of the community given that category. Examples include nominal categories or continuous data that has been grouped as interval categories as illustrated here:

Soil Type	**Category Value**	**Return Value**
Marl	1	0.8
Sawgrass_Peat	2	0.5
Mangrove_Peat	3	0.0
Sandy	4	0.5

Salinity Range	**Category Value**	**Return Value**
0.0-0.5	0	1.0
>0.5 & <3.0	1	0.4
>3.0	2	0.0

Categories can also be used to create processing masks; that is, regions to exclude from consideration. For example, *Muhlenbergia* Wet Prairie only occurs in the southern Everglades, but Sawgrass is found throughout the Everglades, so a categorical mask for these two communities might look like this:

Muhlenbergia**WetPrairie**

Geographic Area	**Category Value**	**Return Value**
North	0	0.0
South	1	1.0

Sawgrass

Geographic Area	**Category Value**	**Return Value**
North	0	1.0
South	1	1.0

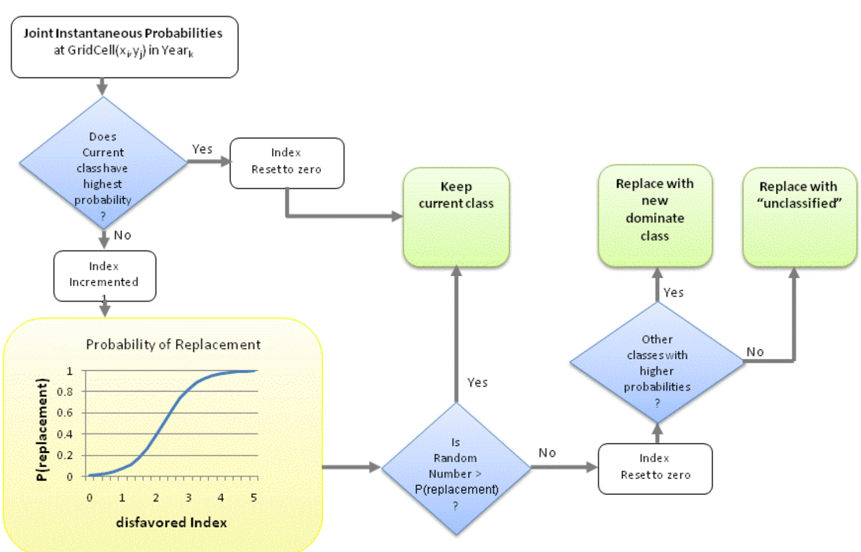
These examples are to illustrate potential uses of the categorical option and are not meant to represent actual parameters or parameter values used.

Temporal Lags

When conditions favor a new community, temporal lags are expected to accompany the transition from the existing vegetation community type to another. In the ELVeS model, the existing vegetation community is not immediately replaced when a different community has a higher probability of being at a location. If environmental conditions change such that the current community's probability of occurrence becomes low, it is increasingly likely to be replaced over time. This results from a stochastic simulation that assigns an increasing probability that the community will be replaced when there are an increasing number of years with low instantaneous probability that the current vegetation community should be dominant.

Probability of replacement is defined independently for each community. The probability of replacement determines how long the community retains dominance under unfavorable conditions. For each contiguous year in which the existing community is not the favored community, an index is incremented such that the index is equal to the previous year's index plus the proportional difference in the current year. The difference between the probability of the favored community and the current community gives the proportional difference. The probability of replacement is then determined by evaluating the index against a probability of replacement curve. If the probability of replacement is greater than a randomly drawn number from a uniform distribution, then the community is replaced. Otherwise, the existing community is retained and the index value is carried forward to the next year where it is again incremented.

Temporal Lag Routine



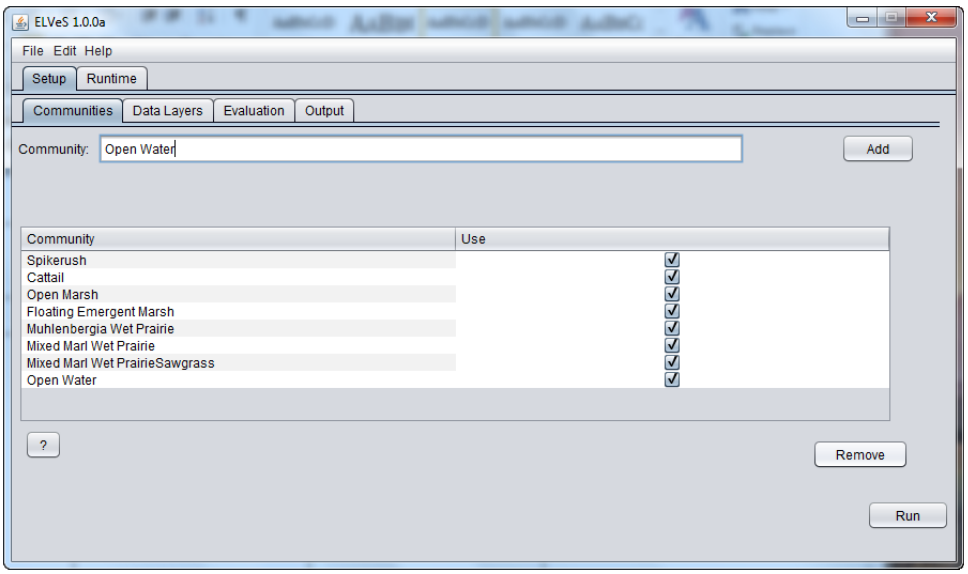
ELVeS uses an increasing logistic function to represent the probability of replacement relationship. The index values at the start and end of the logistic curve are the parameterized for each community. Because this is a stochastic process, the number of iterations is also an input and the final outcome is taken to be the majority response from the repeated runs.

Modifying the Parameters

The GUI dialogs and information that follow are not necessary to run the model if you are using pre-defined parameters files and do not plan to change any of the communities or community responses.

Communities

The **Communities** dialog contains a list of the communities to be modeled. Communities are added to the list by typing their name into the entry box along the top of the form and clicking on the **Add** button. Community names can be edited by double clicking on the name. Communities can be deleted by selecting the community and clicking on the **Remove** button. Check boxes in the **Use** column determine whether the community will be included in the model run. **Community names cannot contain spaces** in this version of the model.

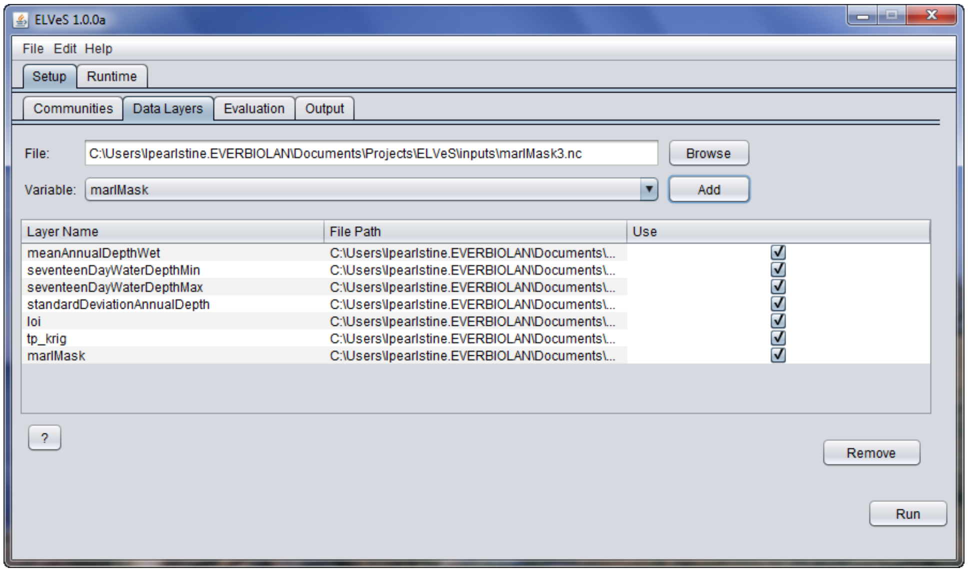


The **Use** check boxes are also present in the **Data Layers** and **Evaluation** dialogs. They give the user the opportunity to experiment with communities, data layers, and evaluations without having to remove and redefine the lists for each trial. This method of parameterization is particularly convenient in analysis of alternatives, where an analyst can simply define all data layers and their evaluation in one step and include them as needed in their simulation.

Data Layers

The **Data Layers** dialog contains data layers that are to be used in the simulation. Input data layer files contain the variables used by the model. All input files are CF-compliant netCDF format. Currently (v1.0) ELVeS requires UTM, zone 17, NAD83, but that will not be a requirement in future versions. Another temporary restriction on the netCDF files is that the eastings and northings must be labeled 'x' and 'y' and time must be labeled 'time'. The files do not have to have the same cell sizes or origin.

Data Layers are added by browsing to the file and using the drop-down list of variables to select the variable you want included. The same file can be used to select multiple variables, but they must be added one at a time to the list. Check boxes in the **Use** column determine whether the data layer will be included in the model run. Data layers cannot be edited because they are an inherent property of the selected file, but they can be removed from the list by selecting the name and clicking on the **Remove** button.

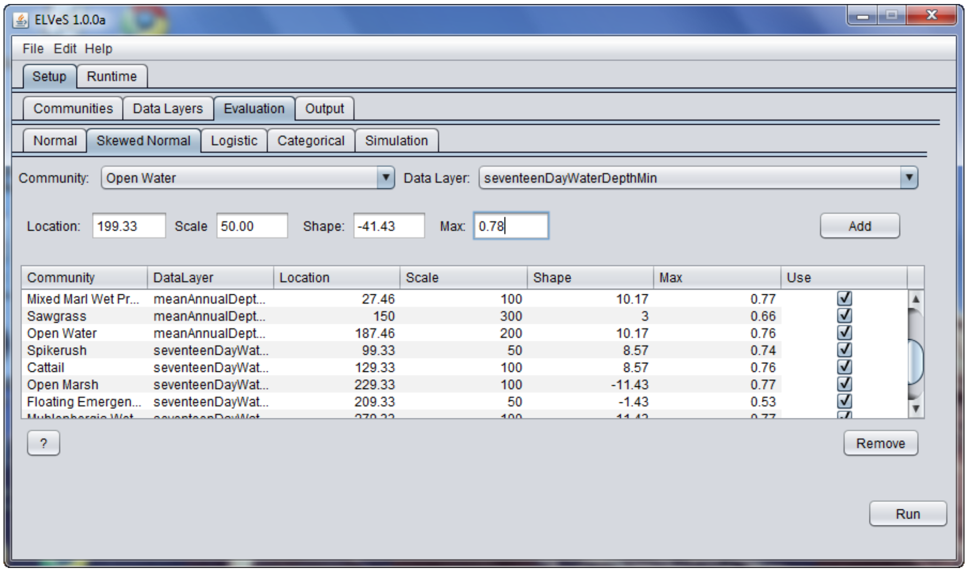


The hydrologic metrics used in the ELVeS freshwater marsh component as input data layers are annual metrics such as mean annual depth and 17-day running average maximum depth. A utility supplied with the ELVeS modeling package, ***HydroMetrics****, can be used to generate these data layers from daily hydrologic outputs such as SFWMM and EDEN.*

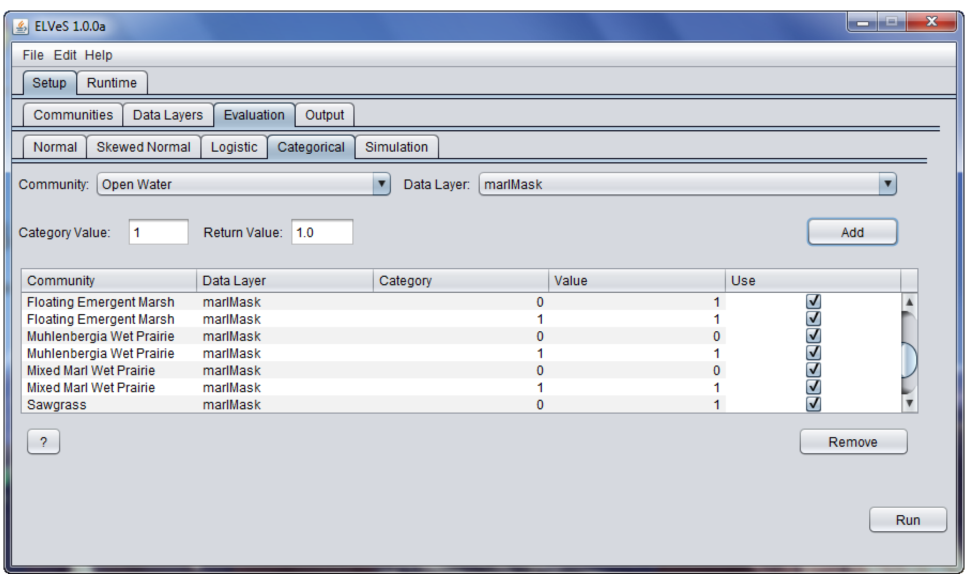
Evaluation

There are five tabs under the **Evaluation** tab. The first four- **Normal**, **Skewed Normal**, **Logistic**, and **Categorical**- define distributions that relate community response to each of the variables in the data layers. The fifth, **Simulation**, sets the temporal lag response of each community.

Entering the response distribution parameters is similar for each of the distribution types. The **Skewed Normal** dialog is shown below for illustration. At the top of the form, just below the tabs, select the community and the data layer from the drop down lists. For the **Skewed Normal** example, there are four parameters, *Location*, *Scale*, *Shape*, and *Max*, which the user supplies values for. Clicking on the **Add** button, adds the parameters for that community/ data layer combination to the list to be evaluated by the model. The user can then proceed to select additional community/ data layer combinations and enter their parameters for each of the communities and data layers the model will evaluate. **Normal**, with 2 parameters, and **Logistic**, with 3 parameters, work the same way.

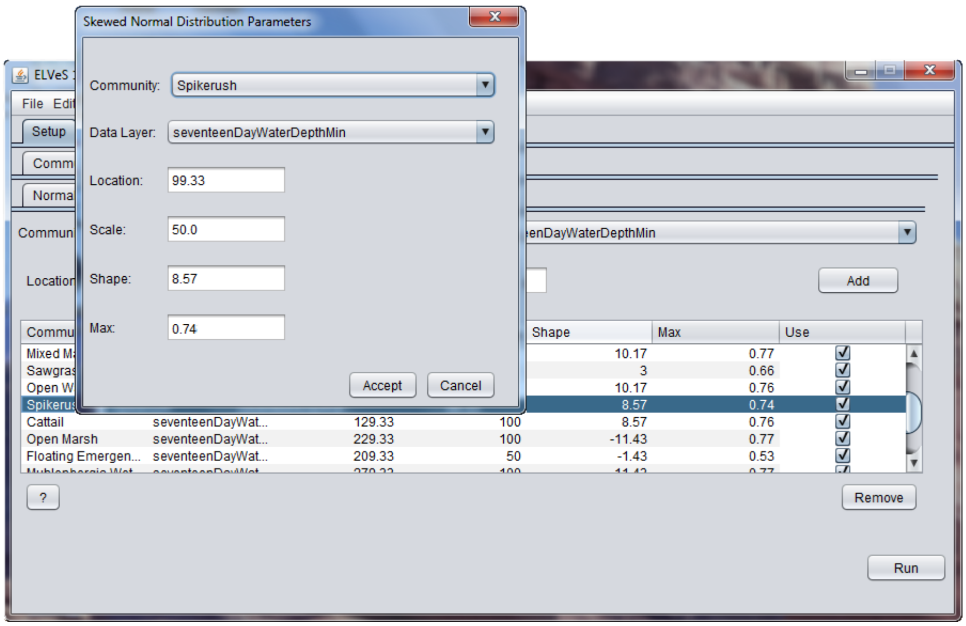


Categorical has the same user input structure, except that the other distributions are expressed as a single equation describing the continuous relationship between the data layer values and the community response. The **Categorical** distribution divides the community response into discrete, categories. When entering categorical parameters for a community, it is necessary to repeat each community and data layer as many times as there are categories. In the example below, the marlMask data layer has 2 categories with values of 0 and 1. For a community, parameters are given for the first *Category Value* and for the *Return Value* (response) for that category value. The same community is repeated to provide the *Category Value* and *Return Value* parameters for the second *Category Value*.



Check boxes in the **Use** column determine whether the listed relationship will be included in the model run.

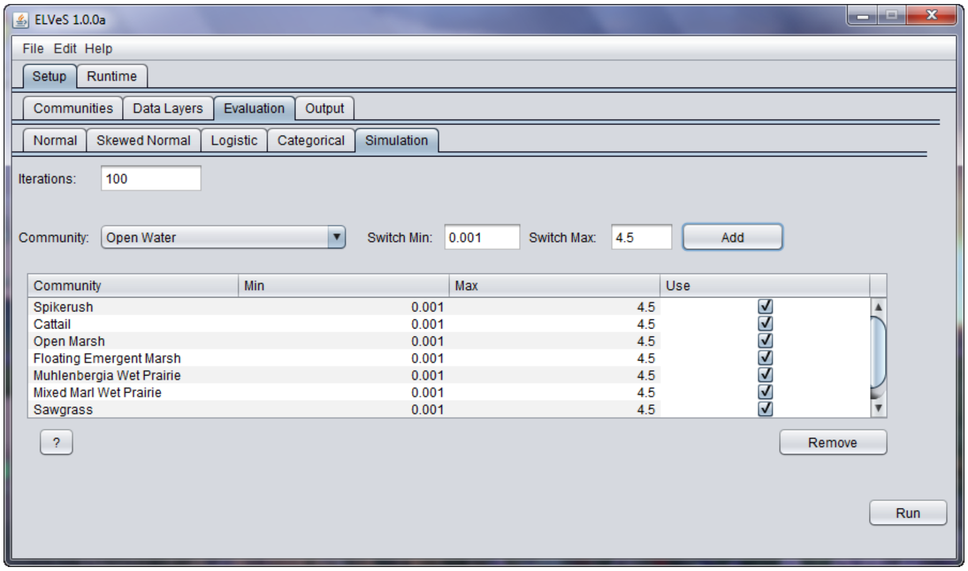
Double clicking on any community in the list opens a dialog box for editing the parameter values.



Simulation

The **Simulation** tab sets the parameters for temporal lags in community response to change. The temporal lag response is stochastic. The number of iterations to use is set by entering a value for *Iterations*. Increasing the number of iterations may substantially increase processing time. *Switch Min* and *Switch Max* are the starting and ending index values of the probability of replacement curve along the horizontal axis. The *Switch Min* and *Switch Max* parameters are set independently for each community type.

This version of ELVeS starts at year one of the simulation from a random distribution of vegetation communities.



RunTime

The **RunTime** tab opens a dialog box that is currently not used. It may be used in the future to provide additional information during model processing.

Mixed Models

Within any variable, some communities can be modeled with one distribution and other communities with another distribution. For example, Sawgrass could have a normal distribution in relation to phosphorous while Cattail has a logistic distribution.

Help

The **Help** menu item has four options: **Contents**, **About**, **Report Bug**, **Send Comment**. **Contents** displays this document. **About** provides displays the Model and GUI version number.

Report Bug and **Send Comment** are quick ways to send us an email. This application is in its first release and its use by a larger user group is the best way to discover what doesn't work, what could work better, and other comments that help us improve ELVeS. We have included these options to encourage you to share your observations. Thank you.

Viewing the Output

ELVeS ouput can be viewed and manipulated in any CF-compliant netCDF data tool (http://www.unidata.ucar.edu/software/netcdf/software.html). A recommended Joint Ecosystem Modeling (JEM) netCDF visualization application for south Florida is ***EverVIEW*** available at http://www.jem.gov/Modeling/EverView.

ELVeS netCDF files can also be imported into ERSI ***ArcGIS***. In ArcToolbox for ***ArcGIS*** version 9.x, use **Multidimension Tools→Make NetCDF Raster Layer**. After the file is loaded in ***ArcGIS***, right-click on the layer name in the Table of Contents and select *Properties…* and select the **NetCDF** tab on the **Layer Properties** dialog that appears. From this dialog, you can change the variable (if the file includes multiple variables) and time step of the data layer being viewed**.** ***ArcGIS*** version 9.x has a limited capacity to load large netCDF files. Only the first date from the time series may be available if the file has too many time intervals and layers. A work-around is to subset the netCDF file into small enough time series to be within the capacity of ***ArcGIS***. The netCDF ***Slice and Dice*** tool is available from JEM for that purpose (http://www.jem.gov/Modeling/SliceAndDice). ***ArcGIS*** version 10.x handling of netCDF files has not been tested.

References

Brandewinder, M. 2008. S-shaped market adoption curve. Available at: http://www. Clear-lines.com/blog/post/S-shaped-market-adoption-curve.com. Accessed February, 2010.

ELVeS License