Geographic Analysis and Monitoring Program

*Socia*l *V*alues for *E*cosystem *S*ervices, Version 2.0 (SolVES 2.0): Documentation and User Manual

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U.S. Department of the Interior
U.S. Geological Survey

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By Benson C. Sherrouse and Darius J. Semmens

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Abbreviations

ASCII	American Standard Code for Information Interchange
AUC	Area Under the Curve
CSR	Completely Spatially Random
CSU	Colorado State University
CSV	Comma separated values
GIS	Geographic information system
HTML	Hypertext Markup Language
ICR	Information Collection Request
OMB	Office of Management and Budget
PRA	Paperwork Reduction Act
PSI	Pike and San Isabel National Forests
ROC	Receiver Operating Characteristic
SolVES	Social Values for Ecosystem Services
SQL	Structured Query Language
RMGSC	Rocky Mountain Geographic Science Center
USGS	U.S. Geological Survey

*Socia*l *V*alues for *E*cosystem *S*ervices, Version 2.0 (SolVES 2.0): Documentation and User Manual

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Abstract

In response to the need for incorporating quantified and spatially explicit measures of social values into ecosystem services assessments, the Rocky Mountain Geographic Science Center (RMGSC), in collaboration with Colorado State University, developed a geographic information system (GIS) application, *So*cia*l V*alues for *E*cosystem *S*ervices (SolVES). With version 2.0 (SolVES 2.0), RMGSC has improved and extended the functionality of SolVES, which was designed to assess, map, and quantify the perceived social values of ecosystem services. Social values such as aesthetics, biodiversity, and recreation can be evaluated for various stakeholder groups as distinguished by their attitudes and preferences regarding public uses, such as motorized recreation and logging. As with the previous version, SolVES 2.0 derives a quantitative, 10-point, social-values metric, the Value Index, from a combination of spatial and nonspatial responses to public attitude and preference surveys and calculates metrics characterizing the underlying environment, such as average distance to water and dominant landcover. Additionally, SolVES 2.0 integrates Maxent maximum entropy modeling software to generate more complete social value maps and to produce robust statistical models describing the relationship between the social values maps and explanatory environmental variables. The performance of these models can be evaluated for a primary study area, as well as for similar areas where primary survey data are not available but where social value mapping could potentially be completed using value-transfer methodology. SolVES 2.0 also introduces the flexibility for users to define their own social values and public uses, model any number and type of environmental variable, and modify the spatial resolution of analysis. With these enhancements, SolVES 2.0 provides an improved public domain tool for decisionmakers and researchers to evaluate the social values of ecosystem services and to facilitate discussions among diverse stakeholders regarding the tradeoffs among different ecosystem services in a variety of physical and social contexts ranging from forest and rangeland to coastal and marine.

Disclaimer

The SolVES 2.0 tool described in this manual is applied at the user's own risk. The U.S. Department of the Interior, or the system authors cannot assume responsibility for system operation, output, interpretation, or use.

SolVES 2.0 is a tool for mapping and analyzing social survey response data. It is not a tool designed for the collection of survey data, nor is any survey attached to SolVES 2.0. Any survey or survey response data referred to in the SolVES 2.0 documentation, sample data, or publications is the work and responsibility of the persons or groups who developed and conducted that survey. Please note that before a Federal agency may collect information or sponsor a collection of information, the Paperwork Reduction Act (PRA) requires approval from the Office of Management and Budget (OMB). Any Federal agency or sponsored program interested in developing and conducting a survey for use with SolVES 2.0 is wholly responsible for submitting an Information Collection Request (ICR) to OMB.

Introduction

*So*cia*l V*alues for *E*cosystem *S*ervices, Version 2.0 (SolVES 2.0) is a geographic information system (GIS) application for incorporating quantified and spatially explicit social values information into ecosystem services assessments. The initial version of SolVES (Sherrouse and others, 2010) was developed by the U.S. Geological Survey's (USGS) Rocky Mountain Geographic Science Center (RMGSC), in collaboration with Dr. Jessica Clement at Colorado State University (CSU), to address the need to account for differing values, attitudes, and preferences among diverse stakeholders in the analysis of tradeoffs among ecosystem services (Sherrouse and others, 2011). With SolVES 2.0, RMGSC has improved and expanded the functionality of SolVES.

Ecosystem services provide both tangible and intangible benefits to human life (Daily, 1997). Although sometimes these benefits can be quantified in monetary terms, often they exist as public goods that bypass the economy (Costanza and others, 1997). Further, monetary values, even if available, are not always desirable because they can distract decisionmakers and stakeholders from the primary purpose of ecosystem management (USDA, 2008). Decisionmakers require estimates of social values beyond those defined economically to assess the full range of ecosystem values. These social values include sociocultural perceptions of human well-being derived from nature, measured using social assessments and other non-utilitarian means of capturing their value (Millennium Ecosystem Assessment, 2003; Cowling and others, 2008; Kumar and Kumar, 2008; Nijkamp and others, 2008). SolVES uses previous social-values mapping research (Brown and Reed, 2000; Brown and others, 2002; Reed and Brown, 2003; Brown and others, 2004; Brown, 2005; Brown and Alessa, 2005; Alessa and others, 2008) to implement a methodology for incorporating social values into the ecosystem services assessment process by quantifying and mapping these values across a study area as a "Value Index," which provides a spatial, non-monetary metric statistically related to characteristics of the underlying physical environment.

SolVES 2.0 provides functionality to assess, map, and quantify social values such as aesthetics, biodiversity, and recreation by deriving social value maps of a 10-point Value Index from a combination of spatial and nonspatial responses to stakeholder attitude and preference surveys. SolVES 2.0 also calculates metrics characterizing the underlying environment, such as average distance to water and dominant landcover. SolVES 2.0 has been integrated with Maxent maximum entropy modeling software (Phillips and others, 2004; Phillips and others, 2006; Phillips and Dudík, 2007; Elith and others, 2010) to generate more complete social value maps and to produce statistical models describing the relationship between the social value maps and explanatory environmental variables. The performance of these models can be evaluated for a primary study area as well as for similar areas where primary survey data are not available but where social value mapping could potentially be completed using value-transfer methodology. Finally, SolVES 2.0 also introduces the flexibility for users to define their own social values and public uses, model any number and type of environmental variables, and modify the spatial resolution of analysis.

New in SolVES 2.0

Several new analysis options and enhanced functions are available in SolVES 2.0.

Value Comparison Type

Users may now choose to compare values represented by the Value Index either by survey subgroup across social value types or by social value type across survey subgroups. The first option, by survey subgroup across social value types, is the same option available in the first version of SolVES. The Value Index is calculated as the relative value among all social value types for a specified survey subgroup, such as those who oppose or strongly oppose oil and gas drilling. With this option, users may also choose to analyze results from all surveys. The new value comparison type option, by social value type across survey subgroups, allows users to compare values for a single social value type, such as recreation, across all potential survey subgroups by shifting the calculation of the Value Index to compare values among all survey subgroups. This new option lets the Value Index be compared quantitatively across multiple survey subgroups as well as within a single survey subgroup.

Output Cell Size and Search Radius

Users may now select the output cell size for their analysis. This option allows users to generate SolVES spatial output at the same spatial scale as their mapped survey data. The search radius of SolVES' kernel density calculations may also be adjusted as desired.

Environmental Layer Selection

There is no longer a limit to the number or type of environmental data layers that can be analyzed. Users may select environmental layers appropriate for their study area, and categorical data layers are now included in the modeling of relationships between social values and the environment.

Buffer Study Area

It is possible that points mapped by survey respondents fall just outside a formal study area boundary; however, there may be reasons for users to include these points in their analysis. The buffer study area option allows users to specify a desired study area buffer in order to include such points.

Multiple Value Surface Selection

Multiple model runs are no longer required in order to generate multiple Value Index surfaces. After selecting a survey subgroup or social value type for analysis, users may now select all desired Value Index surfaces in a single model run.

View Results

The creation of a composite Value Index map and environmental metric report is now accomplished through use of the View Results tool. After results have been generated, users may use the View Results tool to create these composite reports as desired. This also allows users to access results from previously completed projects and create composite reports at a later time.

Maxent Maximum Entropy Modeling Software

SolVES 2.0 has been designed to run in conjunction with Maxent maximum entropy modeling software. Maxent was developed to model the geographic distribution of species; however, its modeling structure provides a fitting analogy for its application to mapping the social values of ecosystem services. Maxent relies on point data representing observations of plant or animal species presence. In lieu of true absence data (points where species are actually observed to be absent), Maxent generates randomly selected background points. Using these point data along with environmental variables that are judged to influence the suitability of the environment for a selected species, Maxent applies a machine learning method to estimate a probability distribution of maximum entropy (closest to uniform) but satisfying constraints represented by the environmental variables. Most pertinent to its use with SolVES 2.0 are the logistic map outputs Maxent generates. Each cell contains a value from 0 to 1, representing the probability that a location is suitable habitat for a species given the environmental conditions and the known presence of that species. In a social values mapping context, the logistic output represents the relative intensity that survey respondents attribute to a social value type (analogous to a species) at a location given the underlying environmental characteristics and the respondents' identification of such locations as representing a particular social value type. Together with the kernel density method already used by SolVES, Maxent's logistic output provides more complete maps within a study area were survey attitude and preference survey data are available.

Maxent also enhances SolVES functionality by generating statistical model output describing the relationship between the points and the environmental variables (or features as operationalized by Maxent). Additionally, Maxent calculates Area Under the Curve (AUC) statistics for each model to evaluate its performance in the study area as well as its potential for use as a model to transfer values to similar study areas where primary survey data are not available. Maxent output includes jackknife statistics that can help SolVES 2.0 users improve each model by adjusting the environmental variables included in their analysis. Through an iterative process, SolVES 2.0 users have the ability to repeat their selected analyses as different projects to generate models best suited for their purposes. More information regarding Maxent's AUC statistics can be found in the section titled, "Interpreting and Adjusting Maxent's AUC Statistic".

This user manual does not attempt to provide an exhaustive description of Maxent. Its focus is instead on those items most pertinent to SolVES 2.0 users. For additional information regarding Maxent, please refer to the Maxent website *www.cs.princeton.edu/~schapire/maxent/* with links to journal articles, tutorials, user groups, and software.

SolVES 2.0 Overview

SolVES 2.0 is packaged as a custom toolbar for the Environmental Systems Research Institute's (ESRI's) ArcGIS 9.3 GIS software and was developed with VB.NET. SolVES 2.0 uses geospatial and tabular data to parameterize three separate models: the Ecosystem Services Social Values Model, the Value Mapping Model, and the Value Transfer Mapping Model. The general process flow of these models is shown below (fig. 1).

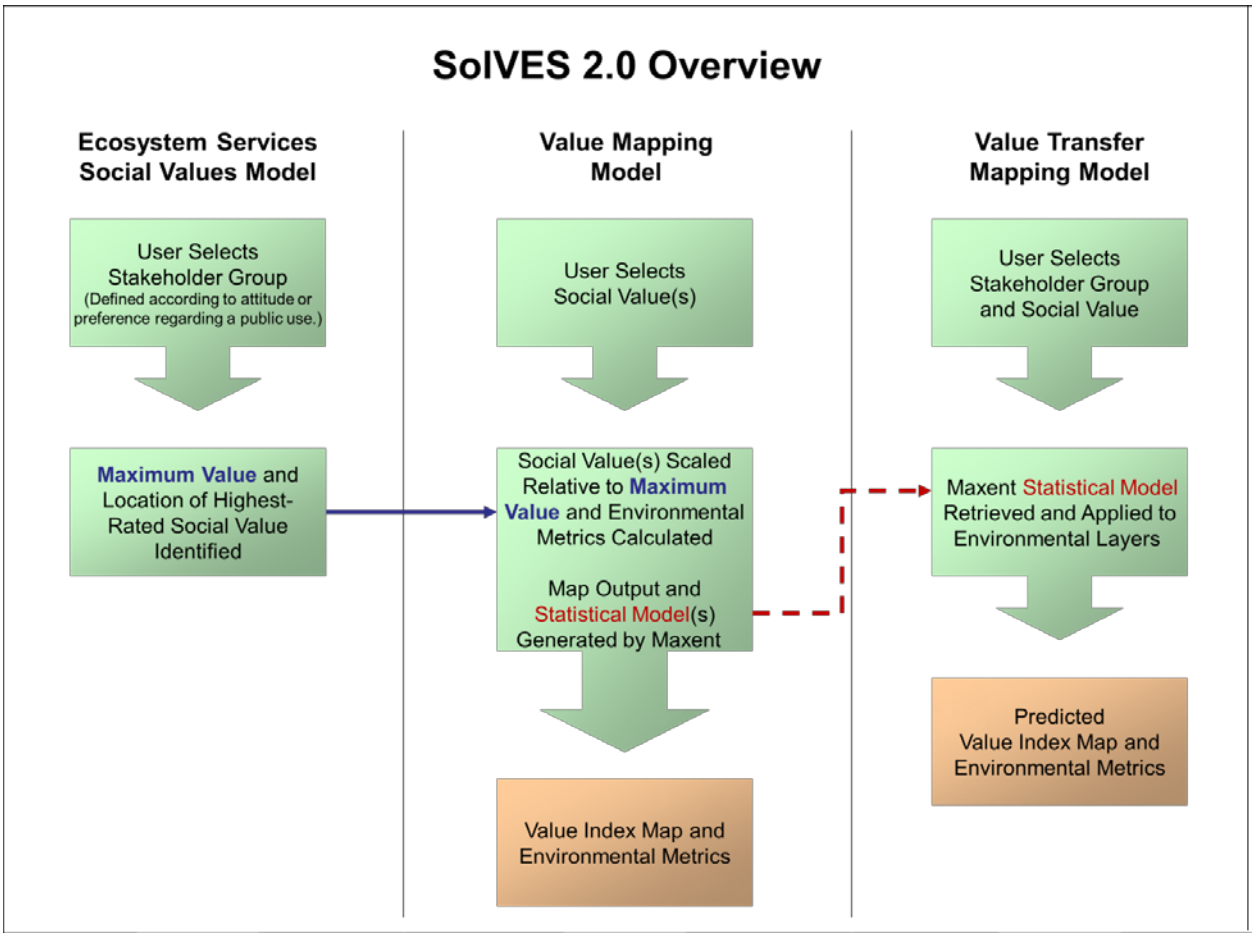

Figure 1. Generalized SolVES 2.0 process flow.

The Ecosystem Services Social Values Model and the Value Mapping Model operate together in a sequence as follows:

1. The user selects a public use and an attitude or preference regarding that use (for example, favor or strongly favor motorized recreation) to define a stakeholder group (survey subgroup).
2. Based on the user's selections, the Ecosystem Services Social Values Model retrieves mapped points and social value allocation amounts for the matching subgroup of survey respondents.
3. Using the amounts the survey subgroup allocated to each social value type as weights, the model calculates weighted kernel density surfaces and average nearest neighbor statistics for the mapped points associated with every social value type included in the survey.

4. The model identifies the most highly rated social value type as well as the location where it is most highly valued (Maximum Value in fig.1).
5. The user starts the Value Mapping Model by selecting one or more social values types (for example, aesthetics or recreation).
6. The model uses the Maximum Value to normalize the weighted kernel density surface(s) of the selected social value type(s) and then standardizes the calculated surface to produce a kernel density-based Value Index surface.
7. The model provides Maxent maximum entropy modeling software with the selected survey responses along with the environmental layers for the study area.
8. Maxent produces map output based on the relationship between the provided points and environmental layers, and generates statistical models describing the relationship.
9. The Value Mapping Model then derives a final Value Index surface from the Maxent map output in conjunction with data from the corresponding kernel density Value Index surfaces. Additionally, the Value Mapping Model calculates environmental metrics using the final Value Index surface.

A Value Index map and associated environmental metrics can then be compiled into a composite report.

The Value Transfer Mapping Model operates independently of the other models but relies on their statistical model output. It operates as follows:

1. The user starts the Value Transfer Mapping Model and selects a stakeholder group (survey subgroup) and social value type.
2. Based on the user's selections, the model retrieves the appropriate Statistical Model (see fig. 1) generated by Maxent.
3. Maxent applies the retrieved Statistical Model to the environmental layers for the receiving study area.
4. The model standardizes the Maxent output to generate a predicted Value Index surface.
5. The model calculates environmental metrics using the predicted Value Index surface.

A predicted Value Index map and associated environmental metrics can then be compiled into a composite report.

Hardware and Software Requirements

SolVES 2.0 requires the ESRI® ArcGIS 9.3 software and the Spatial Analyst Extension for working with grid-based data. The application is available as a custom toolbar that must be installed in ArcMap. SolVES 2.0 was developed and tested on systems running Microsoft® Windows 7 Enterprise Edition but should function with other operating systems supported by ArcGIS 9.3. SolVES 2.0 also requires the installation of Maxent maximum entropy modeling software, version 3.3.3e. Additionally, the user's computer must also run the .NET Framework and Java. Processing time will vary depending on factors such as the computer's processor speed, the spatial resolution and extent of the study area, and the number of variables selected for analysis.

Installation

Installation requires the user to have administrative privileges on their computer.

Special SolVES 2.0 Installation Instructions for Microsoft Windows Vista and Windows 7

If the installation is made on a computer running Windows Vista or Windows 7, the following steps may be necessary prior to completing the General Installation Instructions.

1. Open the Control Panel.
2. Search for "uac" (fig. 2).

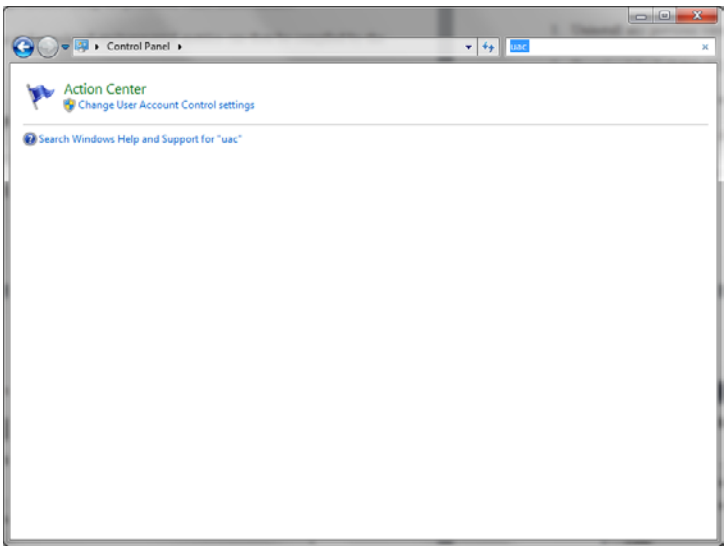

Figure 2. Searching for User Account Control in the Control Panel.

3. Select Change User Account Control settings from the search results.
4. Note the original position of the slide bar for restoring the setting later, and then move the slide bar down to "Never notify" (fig. 3).

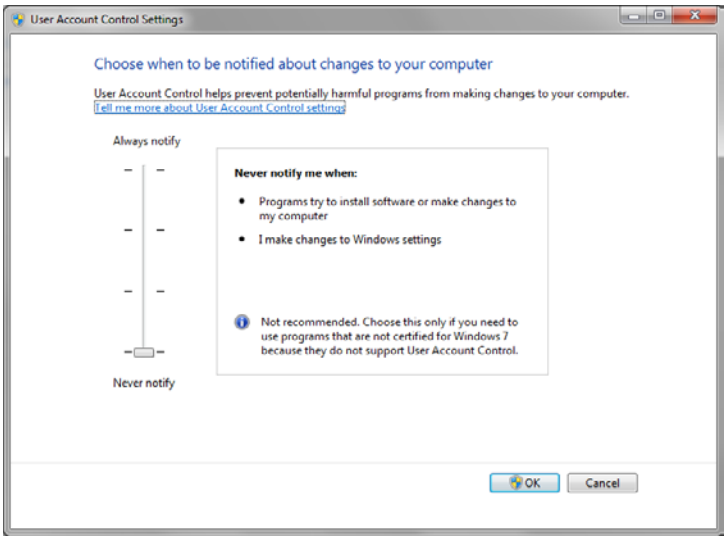

Figure 3. Changing User Account Control Settings.

5. Select OK.
6. Restart the computer.
7. Be sure to restore the original User Account Control settings after completing the SolVES 2.0 installation. (This may also require a computer restart.)

General SolVES 2.0 Installation Instructions

Complete the following steps to finish the SolVES 2.0 installation process.

1. Uninstall any previous version of SolVES.
2. Download the SolVES_V2.zip file from the SolVES website *http://solves.cr.usgs.gov* and place it in a temp directory on the computer.
3. Unzip the file to the temp directory.
4. Run the solvesV2_setup.msi installation file by double clicking on the file.
5. Click “Next” on the Welcome to the solvesV2_setup Setup Wizard screen (fig. 4).

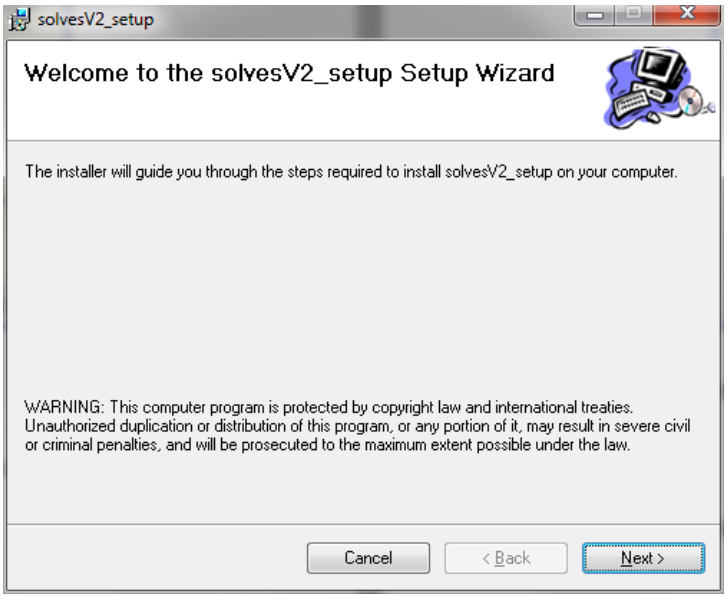

Figure 4. Welcome Setup Wizard screen.

6. On the Select Installation Folder screen, use the default folder or select another (fig. 5).

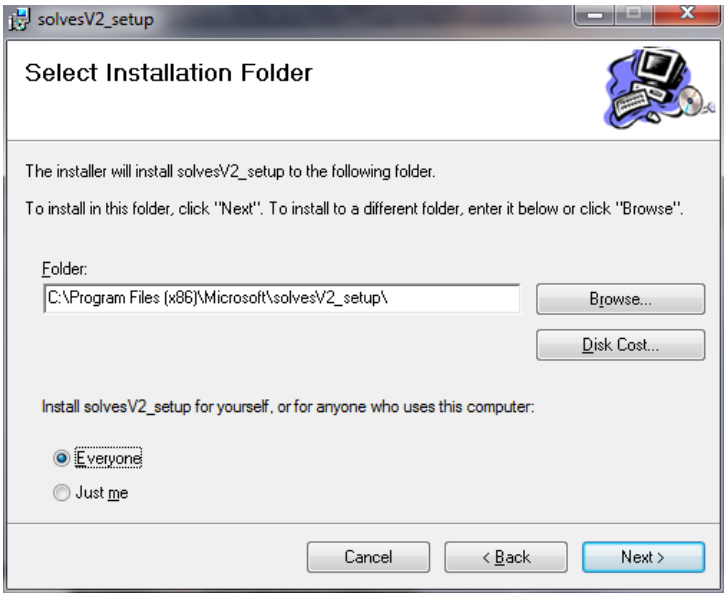

Figure 5. Select installation folder.

7. Select the radio button next to “Everyone”.
8. Click “Next” on the Select Installation Folder screen.
9. Click “Next” on the Confirm Installation screen (fig. 6).

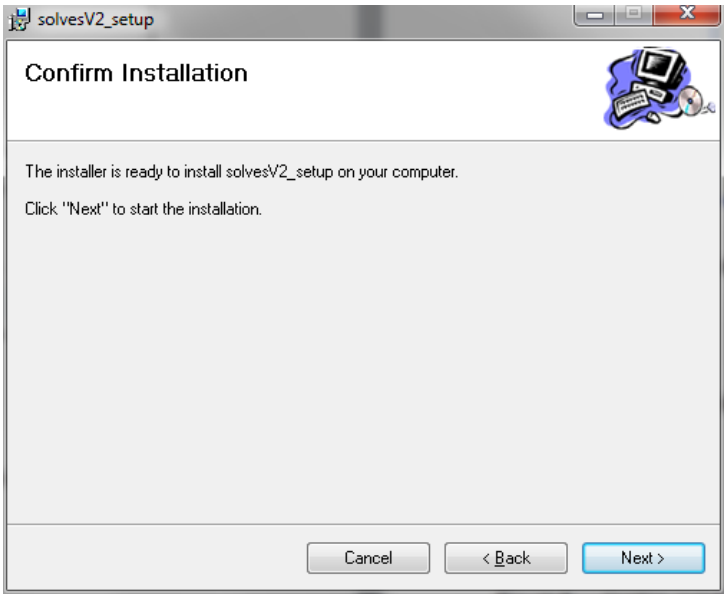

Figure 6. Confirm installation.

10. Wait while the tool is being installed (fig. 7).

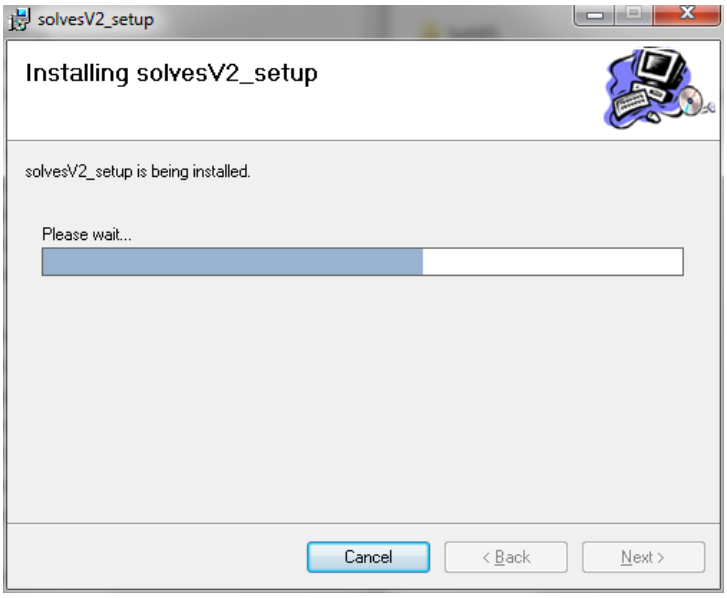

Figure 7. Installation in progress.

11. Click “Close” on the Installation Complete screen after the tool has been installed (fig. 8).

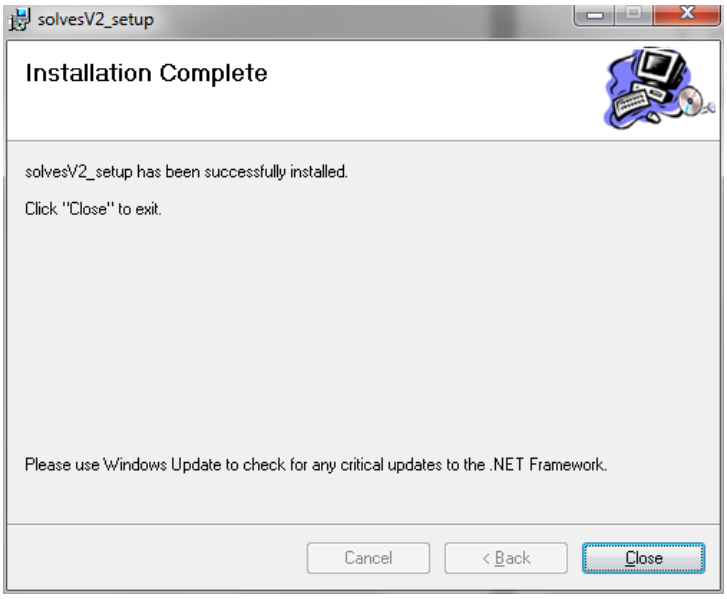

Figure 8. Installation complete.

Adding the SolVES 2.0 Toolbar to ArcMap

1. Open ArcMap.
2. Choose Tools -> Extensions from menu.
3. Click on “Spatial Analyst” (fig. 9).

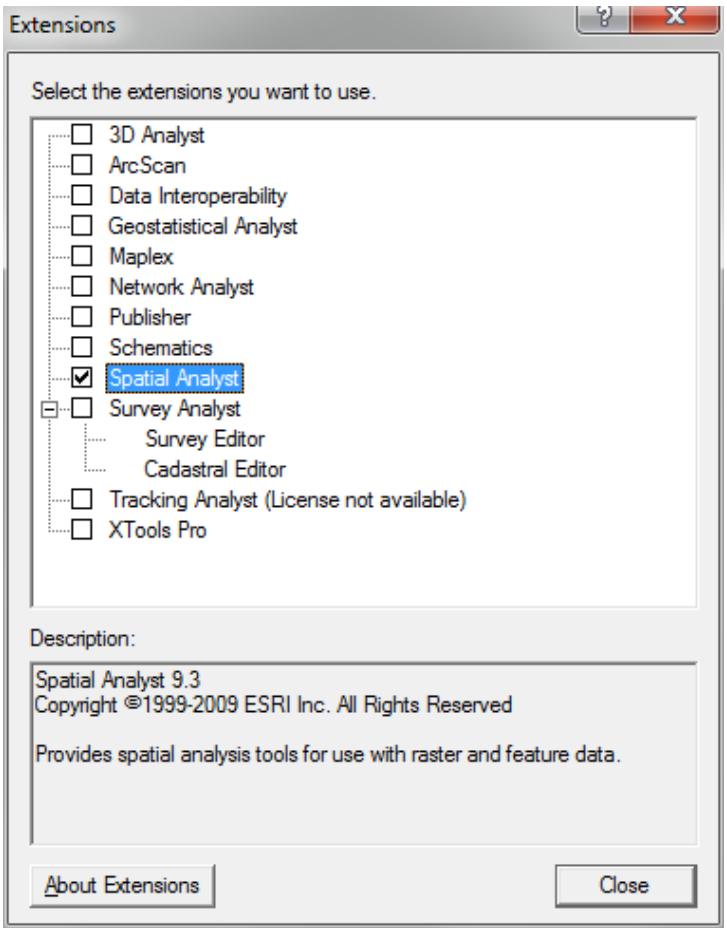

Figure 9. Selecting Spatial Analyst extension.

4. Close the Extensions form.
5. Choose Tools -> Options from menu.
6. Select the Geoprocessing tab.
7. Under General, be sure the checkbox next to “Overwrite the outputs of geoprocessing operations” has been checked (fig. 10).

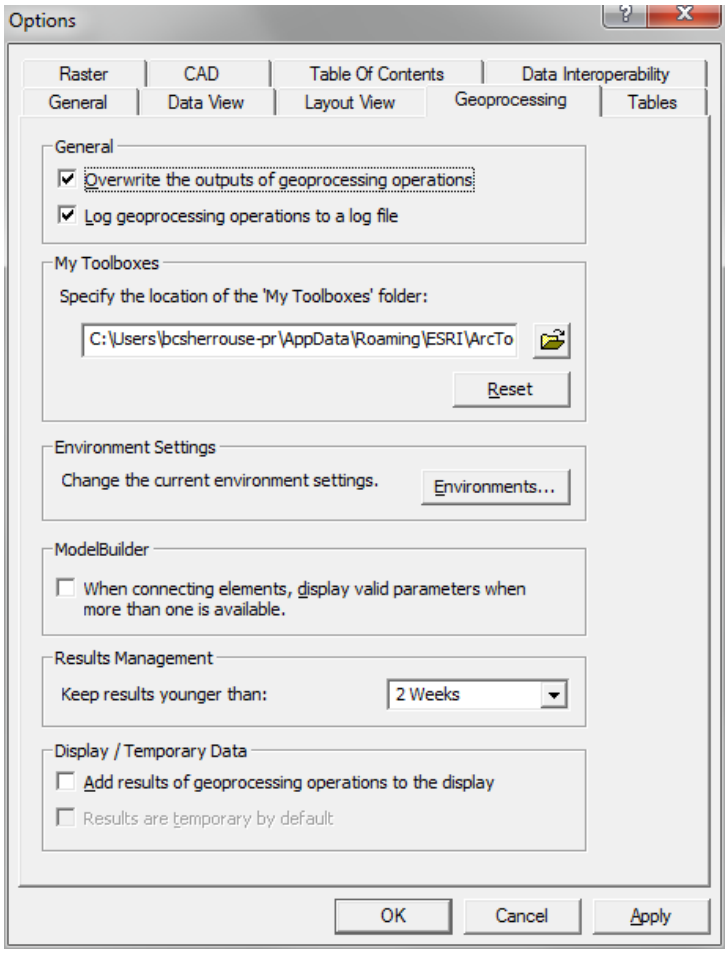

Figure 10. Select overwriting of geoprocessing outputs.

8. Choose Tools -> Customize from menu.
9. Click on SolVES Toolbar (fig. 11). The toolbar listing may be followed by a numeral 1 or 2 but this should not impact the installation.

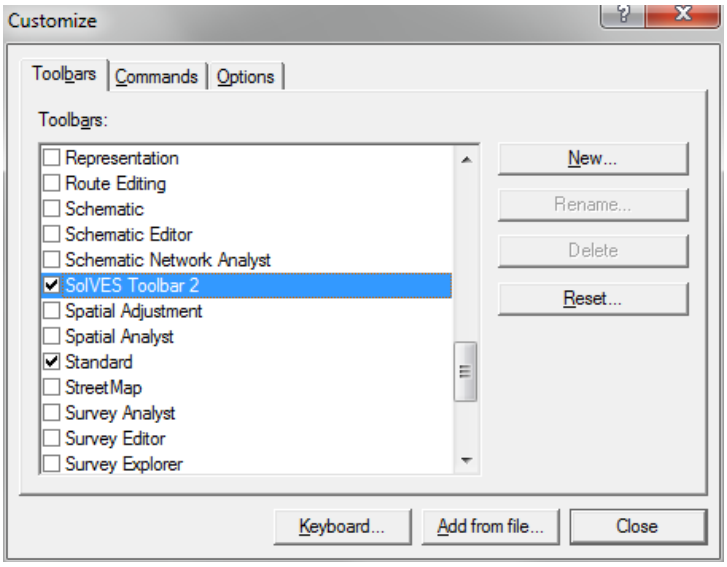

Figure 11. Customize form.

10. Close the Customize form.
11. The SolVES toolbar will be added to ArcMap.
12. Place the tool in the menu area of ArcMap (fig. 12).

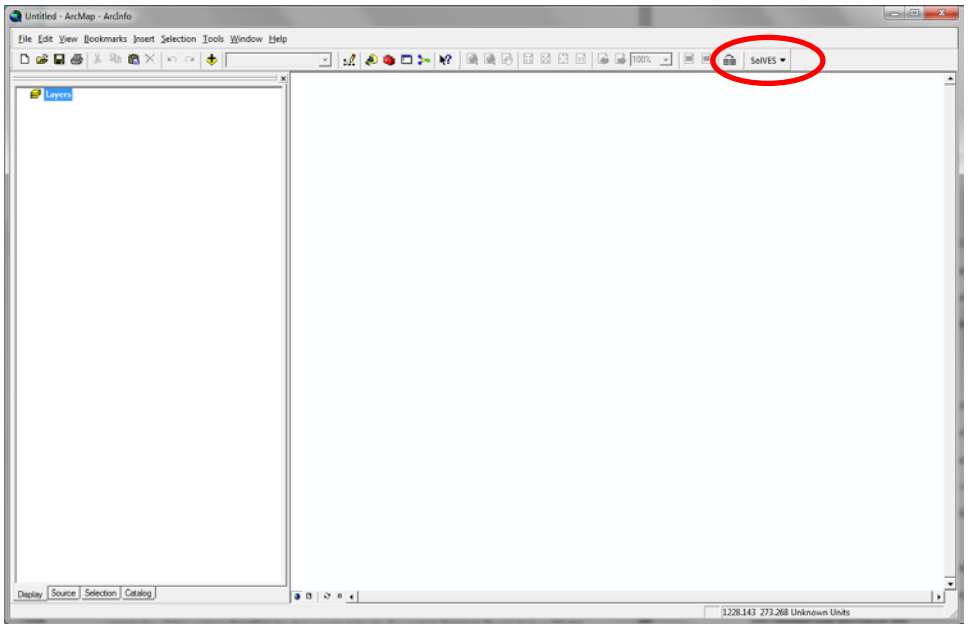

Figure 12. SolVES 2.0 toolbar visible in ArcMap.

Maxent Maximum Entropy Modeling Software Installation Instructions

Maxent maximum entropy modeling software is freely available for educational and research activities; however, it is not authorized for redistribution by its users. Maxent must be downloaded directly from the Maxent website *www.cs.princeton.edu/~schapire/maxent/*. The website also contains various links to additional information regarding Maxent. After navigating to the website, complete the following steps:

1. Follow the website instructions to download Maxent version 3.3.3e.

This is not the current version of Maxent, but an archived version.

2. Return to the location of the unzipped SolVES 2.0 download file and copy the three downloaded Maxent files (maxent.bat, maxent.jar, and readme.txt) into the Maxent folder contained within the SolVES root directory. (If needed, please see the File Management section, including fig. 13, for information regarding the SolVES 2.0 directory structure.)

Data Installation

1. Copy the SolVES root directory to a local directory that will serve as the SolVES 2.0 home directory.
2. If a properly loaded file geodatabase containing study area data is available, load it into the Data folder contained within the SolVES folder to make it accessible to SolVES 2.0. (If needed, please see the Data Requirements and File Management sections, including fig. 13, for information regarding data formatting requirements and the SolVES 2.0 directory structure.)

File geodatabases containing data for the Pike and San Isabel National Forests (for use with the Analyze Survey Data or Transfer Values tools) and Grand County, Colorado, (for use with the Transfer Values tool) can be downloaded from the SolVES website *http://solves.cr.usgs.gov*.

Data Requirements

SolVES 2.0 uses various geospatial and tabular data, which may be obtained in a variety of ArcGIS-supported formats, including coverages, shapefiles, grids, and spreadsheet files. For use with SolVES 2.0, these data must be imported into a file geodatabase format. Instructions on how to import to the file geodatabase format can be found in the Source File Geodatabase Structure and Contents section. The remainder of this section describes the required data.

Environmental Data

Unlike the first version of SolVES, the environmental data requirements for SolVES 2.0 are much less restrictive. Technically, SolVES 2.0 requires only one environmental data layer to run, but for practical application, users may include any number and type of environmental data in their analyses.

Survey Data

Specifically formatted attitude and preference survey response data are required in order to use the Ecosystem Services Social Values Model and Value Mapping Model. These data are not required, however, if only using the Value Transfer Mapping Model. The format of these data are based on attitude and preference survey results obtained by J.M. Clement (written commun., 2008) for the Pike and San Isabel National Forests (PSI) in Colorado that, in turn, are based on collection procedures described by Brown and others (2002).

SolVES was initially developed based on a random mail survey of 2,000 households located within 45 miles of the PSI conducted in late 2004 and early 2005 (J.M. Clement, written commun., 2008). The response rate was approximately 33 percent, with 684 surveys returned. The survey was divided into five sections. Section 1 requested information regarding each respondent's familiarity with the PSI, such as when and how often they visited, if they derived any income from the PSI, and their interest level in what happens to the PSI in the next 10 to 15 years. Section 2 requested respondents to indicate whether they favored or opposed each of 18 public uses of the PSI such as logging for wood products, motorized recreation, and wilderness. Section 3 allowed respondents to indicate their views regarding various issues impacting the PSI, such as the extent and purpose of road building and logging, reservoir development, and tradeoffs between recreational use and environmental quality. The first part of section 4 (4A) requested that respondents allocate or "spend" $100 among 12 different social value types associated with the PSI such as aesthetics, biodiversity, and recreation. Although dollar units were used for convenience to express value denominations (for example, points could have been used instead of dollars), it was explained in the survey instructions that this was not a reference to any actual money held by the respondent or Forest Service. Once the allocation exercise was completed, respondents were then instructed in the second part of section 4 (4B) to hand-mark points (later digitized into a geographic data layer) on a series of maps of the PSI corresponding to the social value types to which they had allocated dollars. If the respondent had allocated dollars to aesthetic value, for example, they were to place a mark or marks on the map at up to four locations indicating aesthetic, and label and number each mark accordingly. Of the 684 surveys returned, the mapping section was completed for 55 percent of them. Finally, section 5 of the survey requested various demographic and socioeconomic information from each respondent. Further details regarding the PSI survey are provided in Sherrouse and others (2011).

The only required survey data for SolVES 2.0 are based on survey sections 2, 4A, and 4B. To analyze user-supplied survey data with SolVES 2.0, the structural requirements set forth in the remainder of this section must be met. Surveys designed to collect data containing the specific elements described below, even if not otherwise designed as the PSI survey, can be used with SolVES 2.0. Again, survey data are not required if only using the Value Transfer Mapping Model.

Users providing their own survey data must assign a unique identifier (SURVEY_ID), an integer value, to each survey in order to distinguish each survey and to relate its separate sections. See the Source File Geodatabase Structure and Contents section for additional details regarding the location of SURVEY_ID within the geodatabase schema.

USE_ATTITUDE (based on survey section 2)—SolVES 2.0 supports public use data that include responses as to whether or not such uses are favored or opposed. These responses are structured as an integer range from 1 to 5 (table 1). If the survey responses are structured to only include Favor or Oppose options, coding Favor values as 2 and Oppose values as 4 will make the responses compatible

with SolVES 2.0, although the labeling of output will still include references to Strongly Favor and Strongly Oppose. For information regarding how parameters other than public uses might be used by SolVES 2.0, see the section, “Substituting the Public Use Parameter” under Advanced Options.

Table 1. Attitude or preference integer values supported by SolVES 2.0.

Attitude or preference	Integer value
Strongly Favor	1
Favor	2
Neutral	3
Oppose	4
Strongly Oppose	5

VALUE_ALLOCATION (based on survey section 4A)—SolVES 2.0 supports integer values ranging from 0 to 100, allocated among the survey’s social value types.

SURVEY_POINTS (based on survey section 4B)—SolVES 2.0 supports point layers representing the digitized points that survey respondents marked on a map or maps of a study area. Each point must be identified with one of the social value types included in the survey.

Other Spatial Data

The only other spatial data requirement for SolVES 2.0 is a STUDY_AREA polygon feature representing the study area boundary.

Data Management

Directory Structure

SolVES 2.0 uses the directory structure illustrated below (fig. 13).

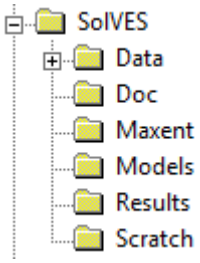

Figure 13. SolVES 2.0 directory structure.

SolVES is the root directory and contains the folders described below (table 2).

Table 2. Description of the SolVES 2.0 directory structure.

Folder name	Folder description
Data	This folder holds the required source file geodatabase, SolVES.gdb, necessary for SolVES 2.0 to function. All environmental and survey data will be loaded into this geodatabase. This folder also contains a layer defining the Value Index map color scheme.
Doc	SolVES 2.0 supporting documentation are stored here.
Maxent	The Maxent maximum entropy modeling software files (maxent.bat, maxent.jar, and readme.txt) are downloaded to this folder.
Models	Contains statistical models previously generated by Maxent in the form of lambdas files, which enable value-transfer functionality for SolVES 2.0.
Results	All final data SolVES 2.0 generates are written here.
Scratch	All intermediate data SolVES 2.0 generates are written here.

Source File Geodatabase Structure and Contents

A schematic of the SolVES.gdb source file geodatabase structure is shown below (fig. 14). The diagram summarizes the contents of a fully loaded geodatabase and the relationships between each survey data element. SURVEY_ID does not exist as a distinct element in the geodatabase; instead, it is a field included in the attribute table of each of the related elements. The field is included in the schematic to emphasize its role as a primary key for relating the data. The (1-M) symbology indicates a one-to-many relationship between elements. For example, one survey (SURVEY_ID) may be related to many SURVEY_POINTS. Additional descriptions of the geodatabase contents are included in the remainder of this section.

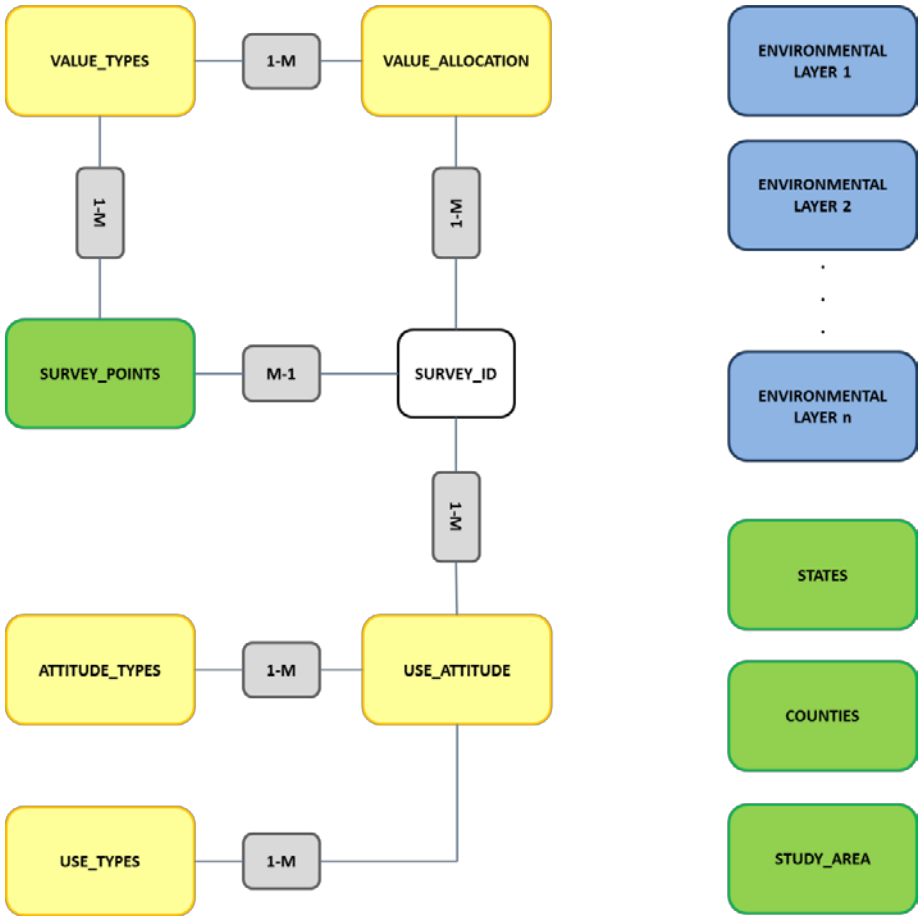

Figure 14. Schematic of the SolVES.gdb source file geodatabase.

Environmental Layers (blue, fig. 14)—These are supplied by the user and may range from one to any number of raster datasets. It is recommended that users also supply a raster dataset such as a hillshade to serve as a background for the Value Index maps; however, it is not required.

Tables (yellow, fig. 14)—These are present when SolVES 2.0 is downloaded. The contents of ATTITUDE_TYPES are already loaded, but users must load their own survey data into the remaining tables. Individual table structures are described next to serve as guide to users for preparation and proper formatting of their survey data (table 3). These data may be prepared for loading into SolVES.gdb by compiling them into database or spreadsheet file formats such as DBF or XLS.

Table 3. Source file geodatabase table formatting requirements.

Table name	Field names	Field data type	Field description
ATTITUDE_TYPES	ATTITUDE_ID	Short Integer	Unique attitude or preference identifier.
	ATTITUDE_NAME	Text	Name of the attitude or preference.
	ATTITUDE_CODE	Text	Code used for defining survey subgroups.
USE_ATTITUDE	SURVEY_ID	Long Integer	Unique survey identifier.
	USE_ID	Short Integer	Unique public use identifier.
	ATTITUDE_ID	Short Integer	Unique attitude or preference identifier.
	USE_NOTES	Text	Additional (optional) use notes.
USE_TYPES	USE_ID	Short Integer	Unique public use identifier.
	USE_NAME	Text	Name of public use. These values will be used to populate the Public Use dropdown.
	USE_DESCRIPTION	Text	Additional (optional) public use description.
VALUE_ALLOCATION	SURVEY_ID	Long Integer	Unique survey identifier.
	VALUE_ID	Short Integer	Unique social value type identifier.
	AMOUNT	Double	Amount allocated to social value type.
VALUE_TYPES	VALUE_ID	Short Integer	Unique social value type identifier.
	VALUE_NAME	Text	Name of social value type. These values will be used to populate the Social Value Type dropdown.
	VALUE_DESCRIPTION	Text	Additional (optional) social value type description.

Feature Classes (green, fig. 14)—These include the mapped points as well as polygon layers representing the study area and other boundaries as listed in table 4. Users must supply their own SURVEY_POINTS and STUDY_AREA layers. STATES and COUNTIES are included in the SolVES 2.0 download, and are only used for generating a locator map that assists in orienting the study area within a broader geographic area. For study areas located outside the contiguous 48 United States, it is recommended that users supply an appropriate polygon layer for generating the locator map; however, this is not required.

Table 4. Formatting requirements for feature classes.

Feature class name	Field names	Field data type	Field description
SURVEY_POINTS	SURVEY_ID	Long Integer	Unique survey identifier.
	VALUE_ID	Short Integer	Unique social value type identifier.
	PLACE_NAME	Text	Place name at location of point (optional).
STUDY_AREA	NAME	Text	Name of study area.
	Shape_Length	Double	ArcGIS adds when loaded to SolVES.gdb.
	Shape_Area	Double	ArcGIS adds when loaded to SolVES.gdb. The value is used as a parameter for calculation of average nearest neighbor statistics.

Importing and Loading Data to the Source File Geodatabase

As previously noted, the environmental and survey data used by SolVES 2.0 may come from numerous sources in a variety of formats. Because SolVES 2.0 was designed to work in conjunction with a file geodatabase, user-supplied data must be imported or loaded into SolVES.gdb. Open ArcCatalog and navigate to SolVES.gdb as shown in figure 15, and complete the following five steps.

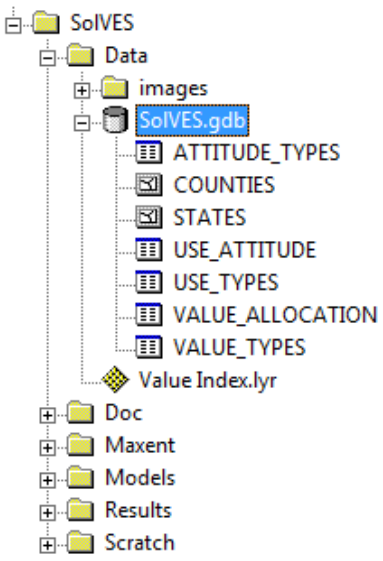

Figure 15. SolVES.gdb as seen in ArcCatalog.

1. Import each environmental layer into SolVES.gdb by right clicking on SolVES.gdb, selecting Import, and then selecting Raster Datasets as shown below (fig. 16).
2. Navigate to where the user-prepared raster data are stored, select them all, and complete the import in a single process.

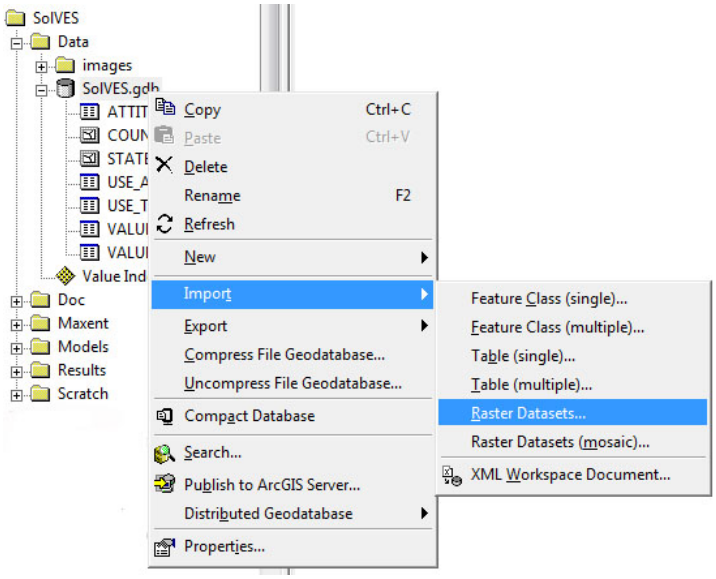

Figure 16. Importing rasters in ArcCatalog.

3. Import each feature class (SURVEY_POINTS, STUDY_AREA, and any feature class that will be used in replacement of STATES or COUNTIES) by right clicking on SolVES.gdb, selecting Import, and then selecting Feature Class (multiple).

4. Navigate to where the user-prepared feature classes are stored, select them all, and complete the import in a single process.
5. Load the user-prepared data to the USE_ATTITUDE, USE_TYPES, VALUE_ALLOCATION, and VALUE_TYPES by right clicking on each, selecting Load, selecting Load Data, and following the Simple Data Loader Wizard instructions as shown in figure 17. This process will need to be repeated separately for each table. After loading is complete, SolVES 2.0 is ready for use.

Any projected coordinate system suitable for the study area may be used; however, the projection should have linear units defined in meters. It is also *critical* that all of the spatial data share a common projection and extent before completing any analyses with SolVES 2.0. Failure to do so may result in SolVES 2.0 functioning improperly or not at all.

The STUDY_AREA layer must be supplied as a single polygon feature. This feature may exist as multiple parts, but it must be defined as a single feature. One way to confirm this is to view the value attribute table for the STUDY_AREA feature class to see if it contains only one record. This is a necessary to prevent the malfunction of the buffering option and average nearest-neighbor statistics calculations in SolVES 2.0.

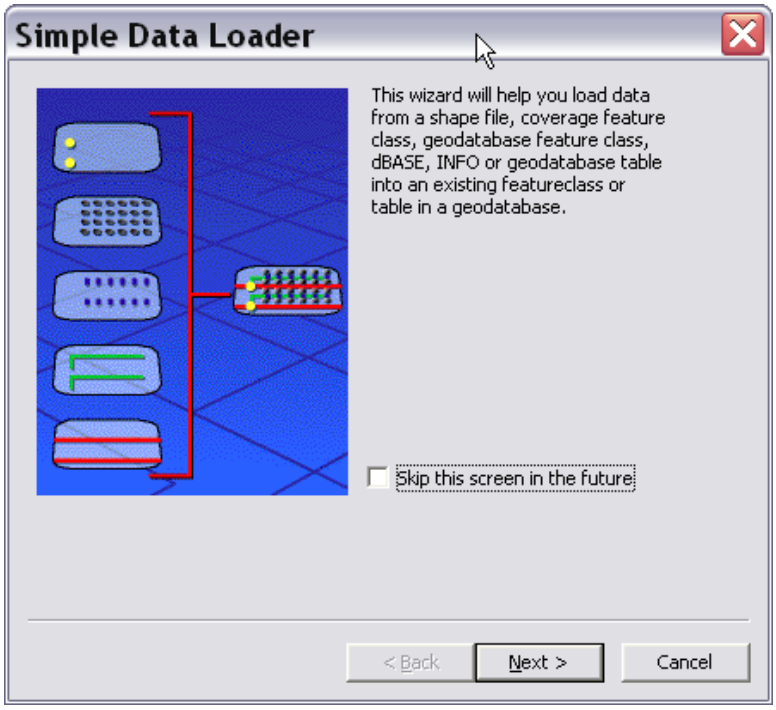

Figure 17. Simple Data Loader Wizard.

Final Results and Intermediate Data

Output Structure

As SolVES 2.0 is processing, project-level folders bearing the Project Name and analysis-level folders bearing the name of the selected survey subgroup or social value type within the project-level folder are created within both the Results and Scratch folders of the SolVES root directory (fig. 18).

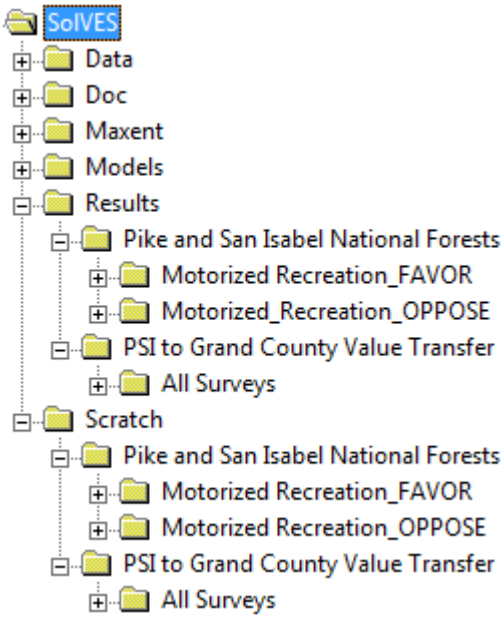

Figure 18. Project-level and analysis-level folders created under the Results and Scratch Folders.

As additional analyses are completed for the same project, separate analysis-level folders will be added within each corresponding project-level folder. File geodatabases named Results.gdb and Scratch.gdb containing final results and intermediate data, respectively are generated in the corresponding analysis-level folders (fig. 19).

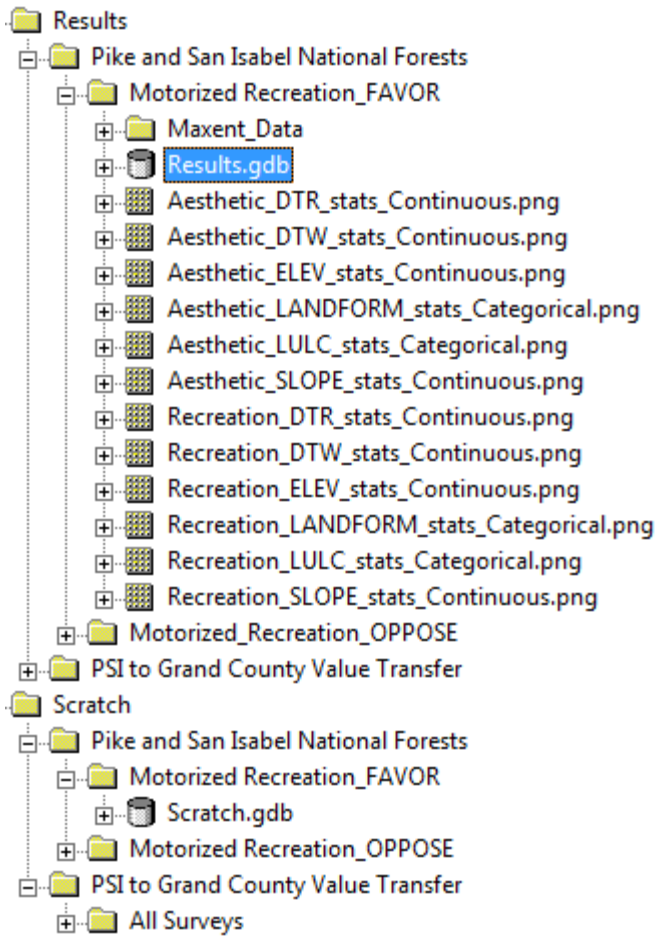

Figure 19. Results and Scratch file geodatabase locations.

Results Folder Contents

In addition to the Results file geodatabase, other SolVES 2.0 and Maxent output are written to the Results analysis-level folders. All environmental metric graphs generated for the final map layout, including those that will not fit on the map layout, are saved here as PNG files. Log files for each SolVES 2.0 run are written to each analysis-level folder. A Maxent_Data folder is also written here that contains output from Maxent as well as specially formatted survey point and environmental data inputs for Maxent (fig. 20). The Environmental folder contains resampled environmental layers from SolVES.gdb that have been converted to ASCII format, whereas the Samples folder contains the user-selected survey points converted to CSV format. The Output folder contains value grids generated by Maxent as ASCII files, along with other files describing Maxent results. (The Samples folder will remain empty and the Output folder will only contain the ASCII value grids when the Transfer Values tool is used.)

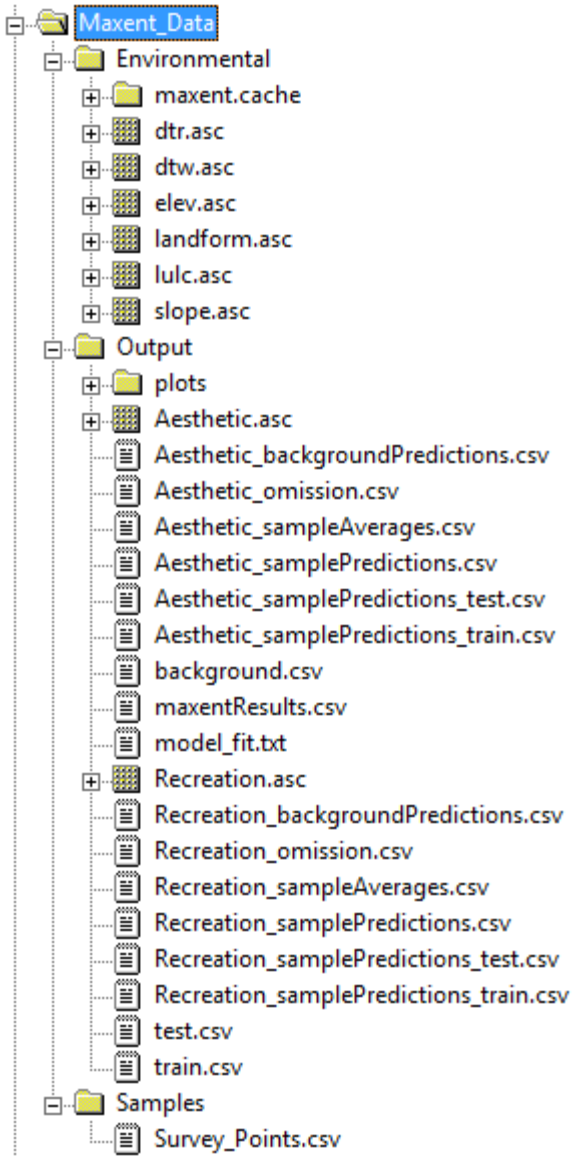

Figure 20. Maxent_Data folder contents as seen in ArcCatalog.

Accessing the Output folder through Windows, users will also see HTML files associated with each value grid generated by Maxent that provide additional information regarding the Maxent results (including AUC and jackknife graphs), along with links to the other files contained in the Output folder (fig. 21).

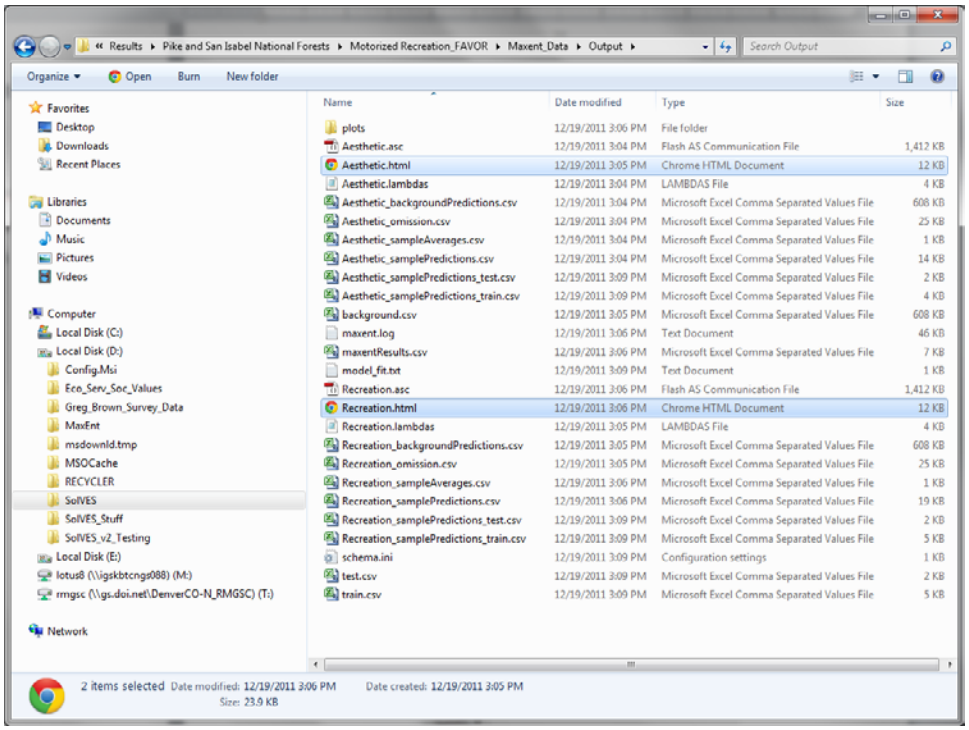

Figure 21. Maxent_Data\Output folder contents as seen in Windows.

The Results.gdb contains the final results generated by SolVES 2.0 (fig. 22). A general description of the contents is provided in table 5.

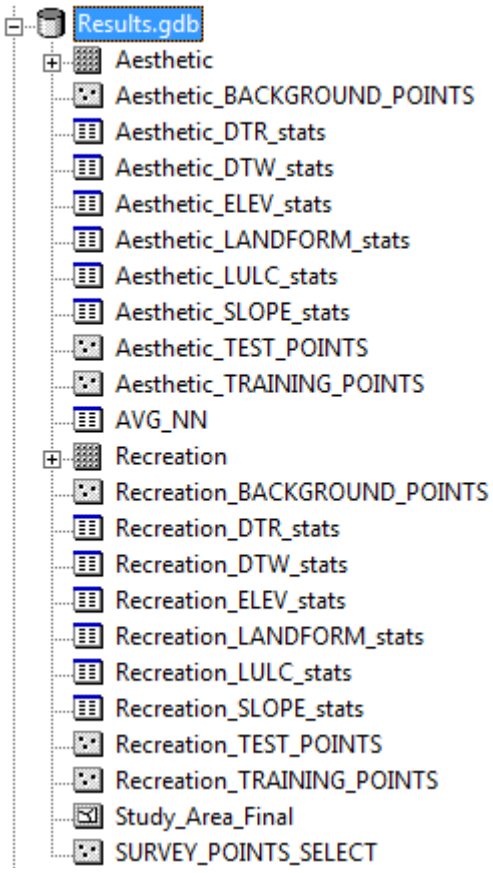

Figure 22. Example Results.gdb contents.

Table 5. Results.gdb contents description.

Table, feature, or grid name	Description
[Social Value Type or Survey Subgroup]	Final raster dataset containing the final Value Index surface generated from Maxent output for the social value type or survey subgroup for which it is named (for example, Aesthetic).
*_BACKGROUND_POINTS	Background points selected at random by Maxent for the user-selected social value type or survey subgroup (*). Not applicable for Transfer Values tool output.
*_stats	Environmental metrics (average or dominant) with * being the associated social value type or survey subgroup and the environmental layer.
*_TEST_POINTS	The 25 percent of survey points withheld by Maxent as test points for the user-selected social value type or survey subgroup (*). Not applicable for Transfer Values tool output.
*_TRAINING_POINTS	The 75 percent of survey points used by Maxent as training points for the primary study area for the user-selected social value type or survey subgroup (*). Not applicable for Transfer Values tool output.
AVG_NN	Table containing average nearest neighbor statistics. Not applicable for Transfer Values tool output.
Study_Area_Final	Study area boundary including any user-selected buffer.
SURVEY_POINTS_SELECT	Survey points for the user-selected social value types or survey subgroups. Not applicable for Transfer Values tool output.
*_clamping	Raster dataset indicating environmental layer values for a study area where the Value Transfer tool is applied falling outside the range of environmental layer values for the primary study area where a Maxent model was originally generated. (*) indicates the user-selected social value type or survey subgroup. Not applicable for Analyze Survey Data tool output.

Scratch Folder Contents

The Scratch.gdb contains intermediate data generated by SolVES 2.0. A general description of the contents is provided in table 6.

Table 6. Scratch.gdb contents description.

Table, feature, or grid name	Description
[Social Value Type or Survey Subgroup]	Maxent logistic output for the user-selected [Social Value Type or Survey Subgroup] for which it is named (for example, Aesthetic or Motorized Recreation_FAVOR).
*_100	The _plus grid converted to an integer grid for the user-selected social value type or survey subgroup (*).
*_KD	Initial kernel density surface generated for each social value type or survey subgroup (*).
*_KDnorm	Result of kernel density surface of user-selected social value type or survey subgroup (*) divided by MAX_GRID.
*_KDsqrt	The square root of the _KDnorm grid for the user-selected social value type or survey subgroup (*).
*_KDVI	The Value Index surface generated from the kernel density surface for the user-selected social value type or survey subgroup (*).
*_KDVIMax	The maximum attained value on the kernel density Value Index surface for the user-selected social value type or survey subgroup (*).
*_plus	Addition of 0.5 to the _times grid so values will properly round when converted to an integer grid for the user-selected social value type or survey subgroup (*).
*_times	Multiplication of Maxent logistic output by 10 to convert values to a 10-point scale for the user-selected social value type or survey subgroup (*).
*_timesTen	Multiplication of _times by 10 to convert values to a 100 point scale for use in calculating zonal statistics for the user-selected social value type or survey subgroup (*).
[Environmental Layer]	Environmental layer from SolVES.gdb resampled according to user-entered output cell size.
*_extract	Extract of environmental layer (*) within the study area boundary. This layer is only generated as a workaround for an issue involving SolVES 2.0 failing to consistently recognize a study area analysis mask.
MAX_ALL	The maximum value found in each grid cell after evaluating all _KD grids.
MAX_GRID	The single, maximum value found in the MAX_ALL grid.
MAXENT_POINTS	The user-selected survey points to be converted to CSV format.
Survey_Points_Clip	The SURVEY_POINTS layer from SolVES.gdb to include only points within the final study area boundary (including the buffer, if selected).
SurvPntSelect_#	Survey points selected for each individual social value type or survey subgroup (#) used for kernel density analysis.
UseAttSel	A summary of all public use and attitude or preference data for the user-selected social value type or survey subgroup.
VALUE_ALLOCATION_SUM	The total amount allocated to each social value type by each survey subgroup. Used as the weight parameter for kernel density analysis.

Project Setup

1. To begin using SolVES 2.0, a new project will need to be started by selecting Project Setup and New SolVES Project from the toolbar as shown in figure 23.

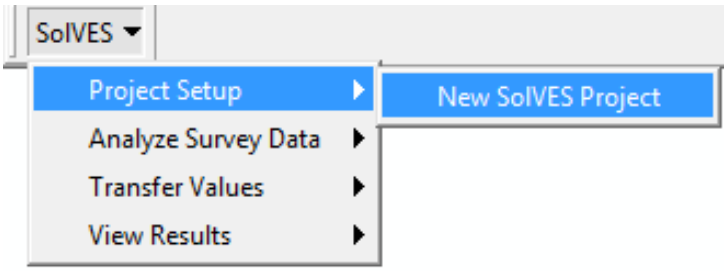

Figure 23. Starting a new project.

2. Once the Project Setup form is open (fig. 24), navigate to wherever the SolVES root directory is located to set the Home Directory (fig. 25).

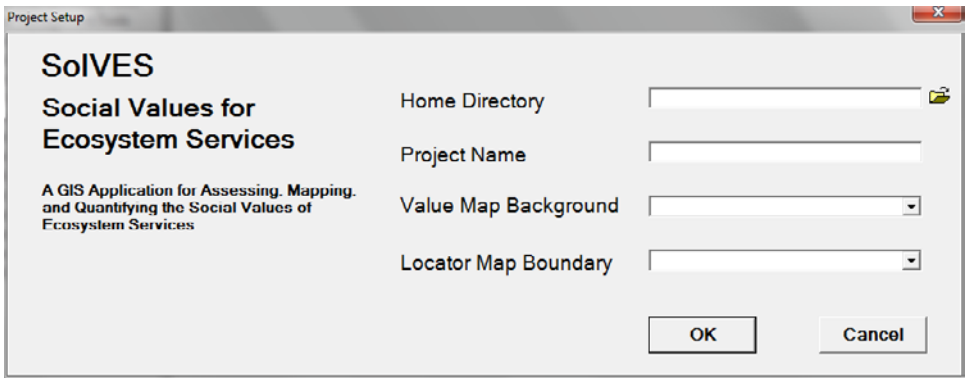

Figure 24. The Project Setup form.

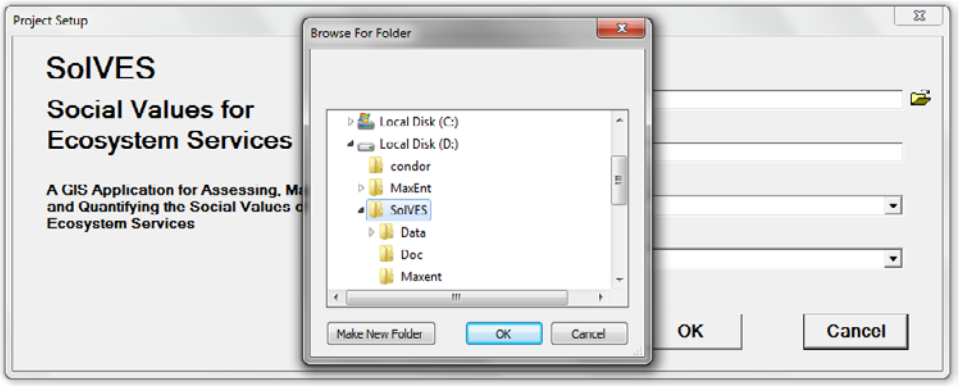

Figure 25. Navigating to the Home Directory from the Project Setup form.

3. Enter a Project Name. This can simply be the name of the study area or some other unique, descriptive name.
4. If a hillshade raster has been provided to serve as the Value Map Background, it will be selected by default. Otherwise, select the name of the provided Value Map Background or leave blank if none was provided.
5. STATES will be selected as the default Locator Map Boundary (fig. 26), but may be left blank or changed to COUNTIES or another polygon feature provided as the Locator Map Boundary.
6. Select OK.

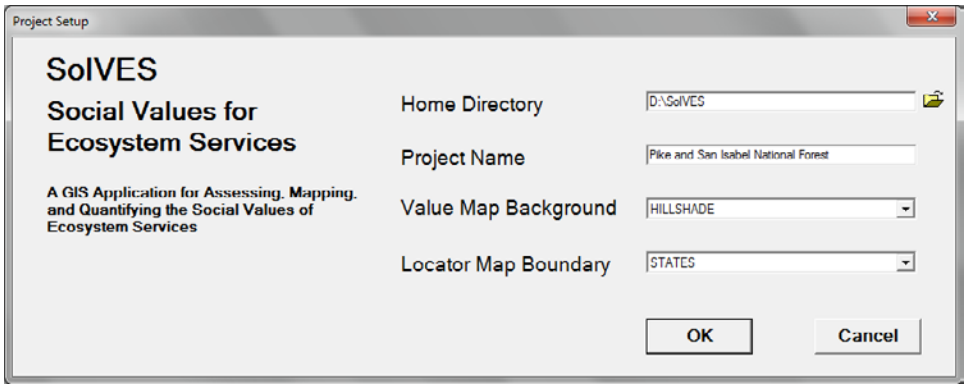

Figure 26. A completed Project Setup form.

Analyze Survey Data

1. Select the Analyze Survey Data tool from the toolbar (fig. 27).

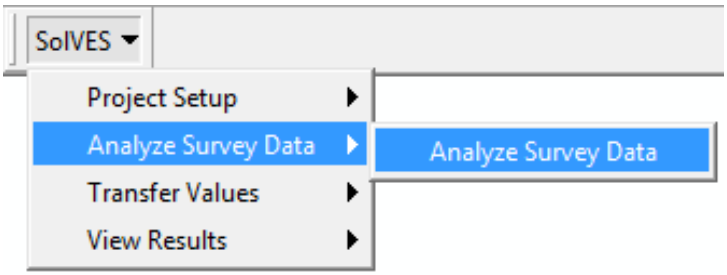

Figure 27. Selecting the Analyze Survey Data tool.

2. The Analyze Survey Data tool (fig. 28) provides access to the Ecosystem Services Social Values and Value Mapping Models.

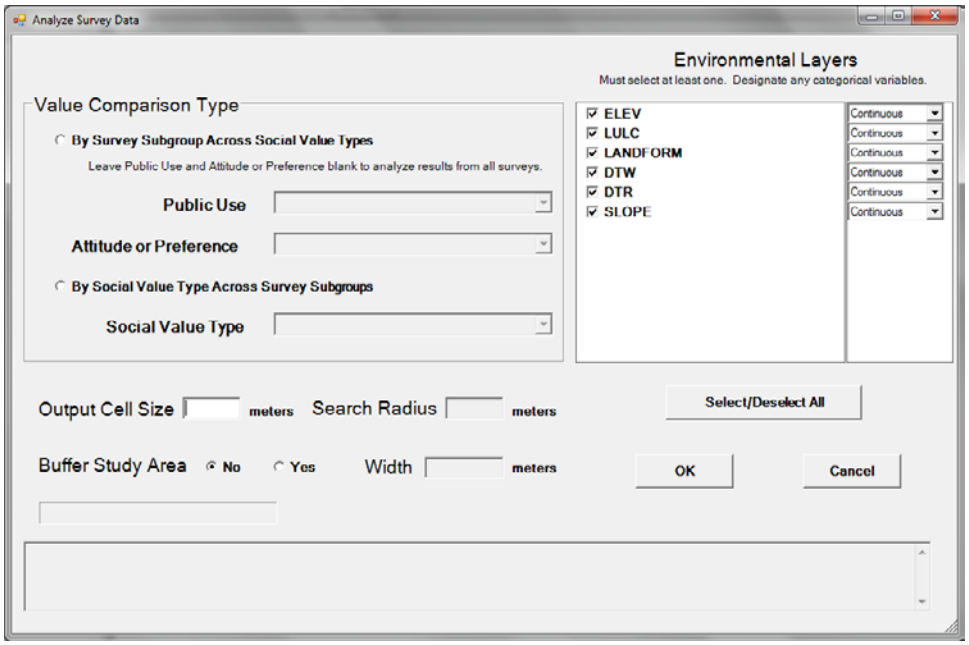

Figure 28. The Analyze Survey Data tool.

3. Begin by selecting the desired Value Comparison Type for analysis. Select "By Survey Subgroup Across Social Value Types" to select a specific survey subgroup or "By Social Value Type Across Survey Subgroups" to select a specific social value type for analysis.
4. If the selected Value Comparison Type is "By Survey Subgroup Across Social Value Types," then define the desired survey subgroup by selecting the desired Public Use and Attitude or Preference parameters. Leave these parameters blank to analyze results from all surveys. If the selected Value Comparison Type is "By Social Value Type Across Survey Subgroups," then select the desired Social Value Type.

The values available for the Public Use and Social Value Type parameters are determined by the values loaded into the USE_TYPES and VALUE_TYPES tables in SolVES.gdb.

5. Enter the desired Output Cell Size. This should be determined by the scale of the map or maps included in a survey. A general rule of thumb used during SolVES development is to apply a cell size that is one thousandth the scale of the survey map scale. For example, if the map scale is 1 to 450,000, then the output cell size is set to 450 meters (m). The assumption is that a hand-marked point on the map is approximately 1 millimeter (mm) in width.
6. The Search Radius parameter used by the kernel density function defaults to 10 times the Output Cell Size. Enter a new value into the Search Radius field if the default value is not adequate for a specific analysis.
7. The Buffer Study Area option defaults to No. If a buffer is desired, select Yes, and then enter a buffer size, in meters, into the Width field.

Remember to give careful consideration to the selected buffer width, because a buffer width that is too large could lead to meaningless analysis results. The purpose of the buffer option is to include points falling just outside the formal study area that may still be relevant to the analysis.

8. Select the environmental layers to be included in the analysis by confirming the appropriate checkboxes are marked under the Environmental Layers section. All layers are selected by default.
9. Use the dropdown box next to each selected environmental layer to indicate whether it is continuous or categorical data. All layers are continuous by default.
10. After all options and parameters have been set (see fig. 29 for an example), select OK, and the Ecosystem Services Social Values Model will process as described next (fig. 30). Processing may take several minutes. The main ArcMap application window will not be visible during processing.

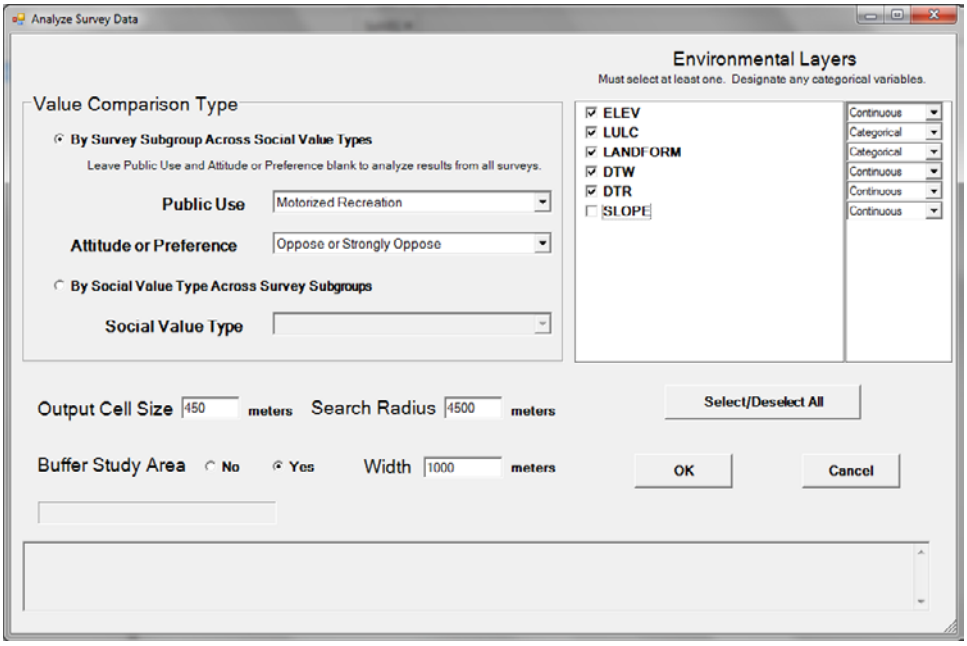

Figure 29. The Analyze Survey Data tool ready for processing the Ecosystem Services Social Values Model.

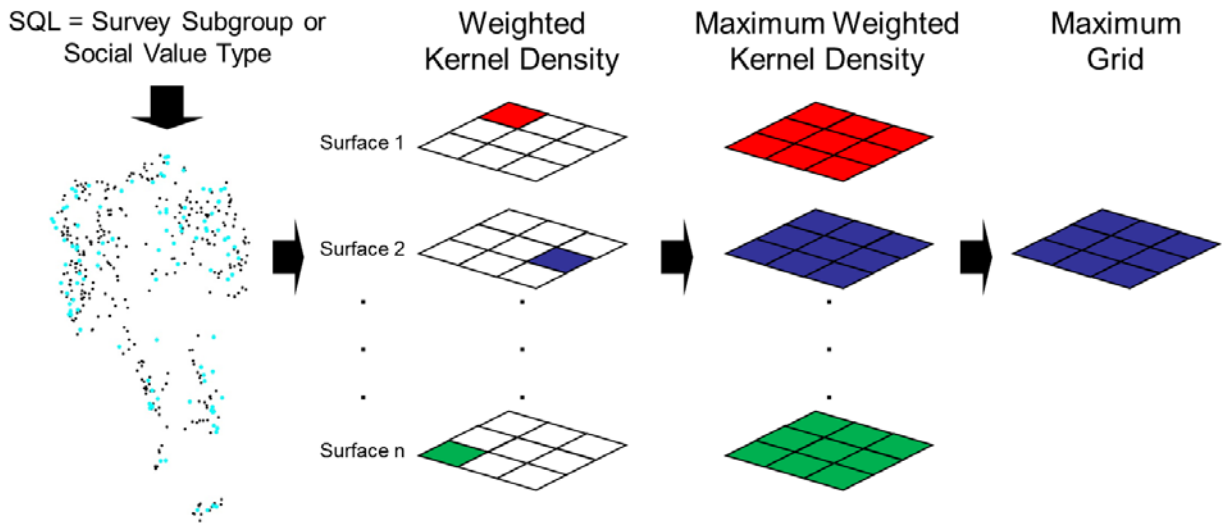

Figure 30. Ecosystem Services Social Values Model generalized process flow.

The survey subgroup (public use and attitude or preference) parameters (or the social value type parameter depending on the selected value comparison type) are converted to a Structured Query Language (SQL) statement, which is then used to select the appropriate mapped survey points. Kernel density surfaces weighted by the total amount of value allocated to each social value type are generated for each social value type (or each survey subgroup). The maximum value from each weighted kernel density surface (as indicated by colored grid cells in fig. 30) is identified and compared among all the weighted kernel density surfaces. A grid containing the overall maximum weighted kernel density value is generated (for example in fig. 30, this overall maximum value was located in the blue cell in Surface 2). This "Maximum Grid" will be used by the Value Mapping Model to normalize the kernel density surfaces and ultimately generate Value Index maps. In addition, during model processing, the selected mapped points are converted to a CSV file while the environmental layers are resampled to the user-provided output cell size and converted to ASCII format for use by Maxent.

Because a survey respondent can be a member of more than one survey subgroup (as opposed to each mapped point representing a single social value type), a single point mapped by survey respondent may be included in the calculation of more than one weighted kernel density surface if the By Social Value Type Across Survey Subgroups Value Comparison Type is selected.

The kernel density surfaces are generated following a methodology similar to that of Alessa and others (2008) in their mapping of social-ecological hotspots on Alaska's Kenai Peninsula. As opposed to simple point density, the basis of kernel density is a quadratic kernel function (Silverman, 1986). This function defines a smoothly curved surface fit over each point and extending out to a defined search radius. The volume below each surface is equal to the weight assigned to the point.

To assist with the selection of social value types of survey subgroups for further analysis by the Value Mapping Model, the Ecosystem Services Social Values Model generates average nearest neighbor statistics describing the relative dispersion, clustering, or randomness of the mapped points. Following the example of Clement (2006) and Brown and others (2002), the point data are subjected to

Completely Spatially Random (CSR) hypothesis testing through the calculation of average nearest neighbor statistics. The ratio of the observed distance between points to the expected distance between points is represented by an R value. Each R value, along with its number of standard deviations from the mean, or Z score, identifies point patterns for which statistically significant clustering is observed. Such clustering is indicated by R values of less than 1 and large negative Z scores. With SolVES 2.0, average nearest neighbor statistics are now calculated based on the total area within the study area boundary rather than the total area within the study area's rectangular extent. These statistics can be used to limit a user's focus to social value types occupying locations with specific levels of significance. Individual users may be less concerned about the relative spatial distribution of the mapped points, but the average nearest neighbor statistics do provide an initial indication of the Value Index maps that will likely display the most intensely valued hotspots.

Value Mapping Model

Once processing of the Ecosystem Services Social Values Model is complete, the second screen of the Analyze Survey Data tool is opened to provide access to the Value Mapping Model. A list of all social value types or survey subgroups available for analysis is presented, along with their associated average nearest neighbor statistics. An example showing user-selected social value types is shown below (fig. 31).

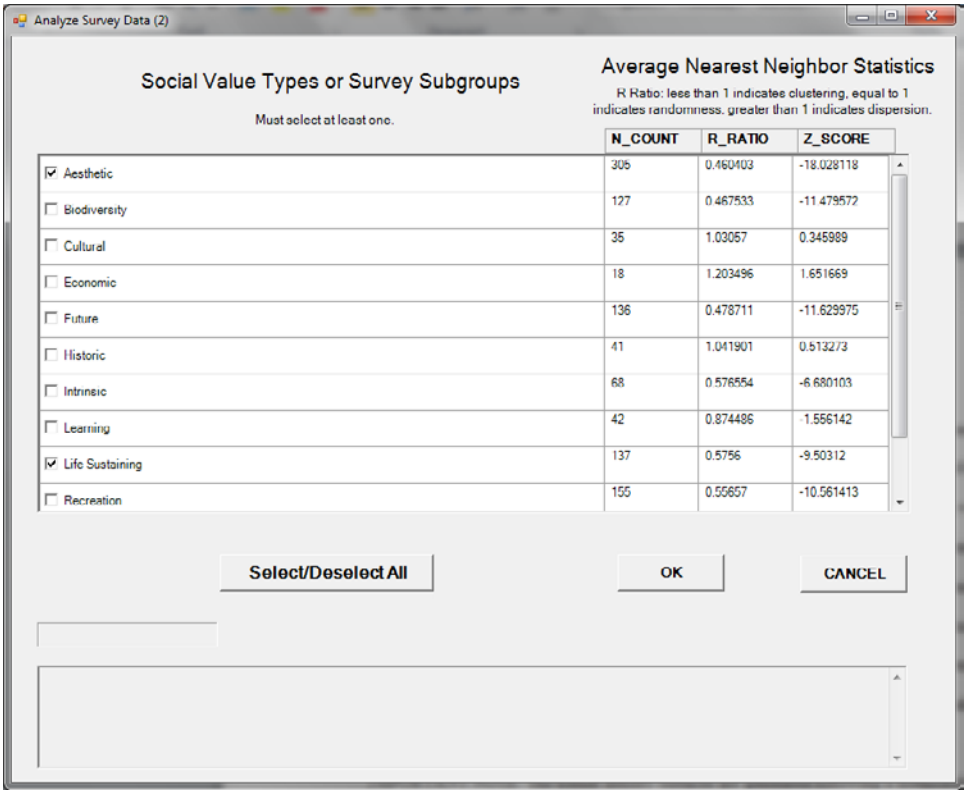

Figure 31. The Analyze Survey Data tool ready for processing the Value Mapping Model.

1. Based on average nearest neighbor statistics, or other user criteria, select the desired social value types or survey subgroups to include in the analysis. (All social value types or survey subgroups are selected by default.)
2. Select OK. Processing may take several minutes. The main ArcMap application window will not be visible during processing; however, while the Maxent maximum entropy modeling software is processing, its interface will be temporarily visible behind the Analyze Survey Data screen (fig. 32). The model will process as described below (fig. 33).

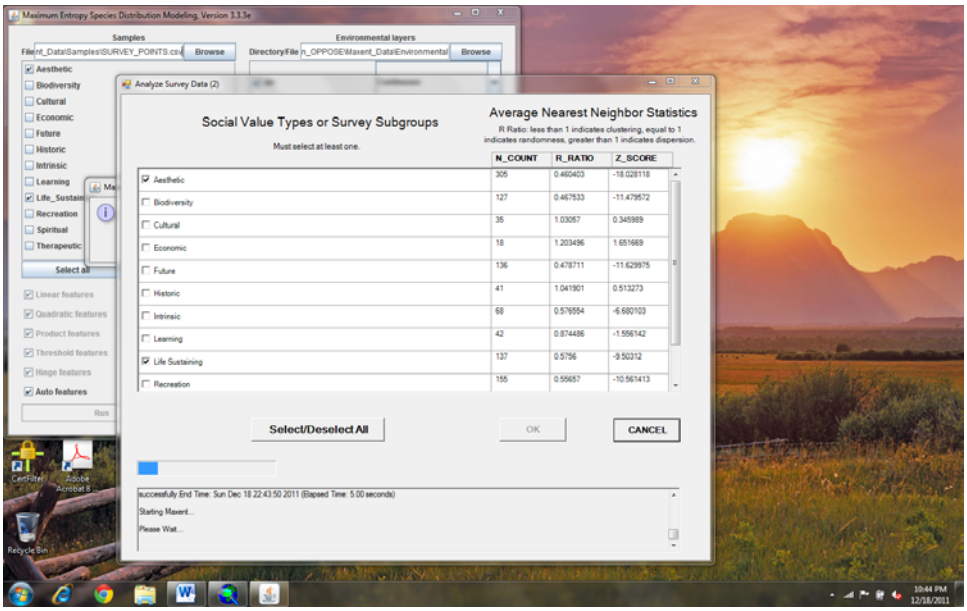

Figure 32. The Value Mapping Model during processing.

Programming limitations that existed during the development of SolVES 2.0 prevented the desired option of having the Maxent interface completely hidden from view during processing. It is *critical* that users do not attempt to adjust or otherwise interact with the Maxent user interface, because doing so may cause SolVES 2.0 to malfunction.

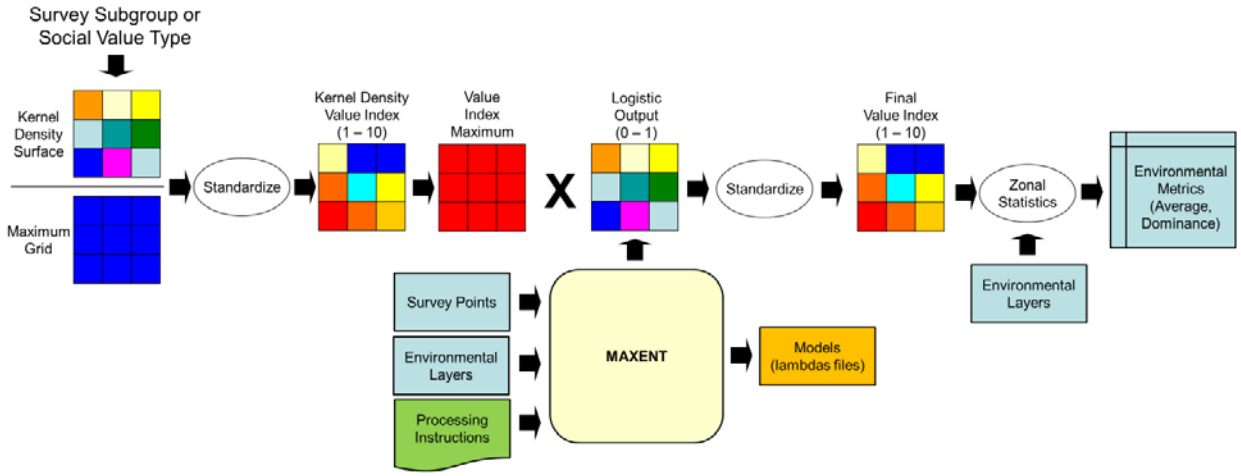

Figure 33. Value Mapping Model generalized process flow.

Given the selected social value types or survey subgroups, the Value Mapping Model identifies the matching kernel density surfaces that were generated by the Ecosystem Services Social Values Model. The selected kernel density surfaces are then divided by the "Maximum Grid" generated by the Ecosystem Services Social Values Model. The normalized grids are then standardized into the 10-point, kernel-density based Value Index integer grid. A constant grid of the maximum value in each Value Index grid is also generated. The Value Mapping Model then sends processing instructions to Maxent by means of a batch file. Maxent then uses the specially formatted point and environmental data converted by the Ecosystem Services Social Values Model to generate logistic value layers (ranging in value from 0 to 1) for each selected social value type or survey subgroup. Maxent also generates models as lambdas files for each selected social value type or survey subgroup based upon the relationship between the mapped points and the environmental layers. Included along with these models are AUC statistics indicating the performance of each model both for the study area and for potential use in transferring values to other study areas. The Value Mapping Model then converts Maxent's logistic output to final Value Index surfaces by multiplying each value layer with its corresponding maximum attained value and rounding the result to the nearest integer. Lastly, the Value Mapping Model uses the final Value Index surfaces generated from the Maxent output to calculate zonal statistics (that is, the environmental metrics) from each environmental layer.

Given the range of logistic values included in the Maxent output, it is possible that the process of multiplying the maximum attained value by the logistic output will result in the maximum attained value being reduced to the next lowest integer value. For example, if the maximum attained value for a particular social value type is 10 and the maximum value in the logistic output is less than 0.95, the resulting Value Index surface will have a maximum value of 9. It is also possible that the lowest value in the logistic output is significantly greater than 0, so that the resulting Value Index surface has a minimum value greater than 0.

Notes Regarding Calculation and Interpretation of the Value Index

As a result of normalizing to the Maximum Grid, the value of every cell on every weighted kernel density grid is scaled relative to the highest weighted density value among all social value types

or survey subgroups (values ranging from 0 to 1). This normalization, however, can frequently lead to grids with value distributions that are highly positively skewed, resulting in many Value Index maps with very low maximum values, minimal value range across the map, and very limited coverage of nonzero values across a study area. To counteract this effect, and thereby improve the utility of a greater number of Value Index maps produced during an analysis, the square root of each normalized grid is taken as part of the standardization process that converts the normalized grid to the Value Index.

The Value Index can be used to measure and compare the magnitude of value differences across social value types and survey subgroups as well as to produce social value maps and associated environmental metrics. The higher the value attained on the Value Index by a social value type, the more highly it is valued by a survey subgroup. A social value type that attains a 10 on the Value Index corresponds to one or more locations within the study area where that survey subgroup values that social value type more highly than at any other location and more highly than any of the other social value types, regardless of location. For social value types that attain less than a 10 on the Value Index, the maximum index value corresponds to locations where that social value type is valued more highly than at any other location. A similar explanation of the Value Index applies for analysis of a single social value type across survey subgroups. In that case, a Value Index of 10 will indicate the survey subgroup that most highly values the selected social value type.

The Analyze Survey Data tool can be repeatedly processed under the same project in order to complete analyses for multiple survey subgroups or social value types (depending on the value comparison type selected). However, if it is necessary to perform repeated analyses for the same survey subgroup or social value type (for example, when performing analyses for the same survey subgroup or social value type but with different environmental layers, output cell sizes, buffers) a new project should be created for each individual analysis. Failure to do so will cause results of the previous analysis under the same project to be overwritten.

Transfer Values

The Value Transfer Mapping Model, accessible through the Transfer Values tool, can be used when primary survey data are unavailable for a study area. It relies on statistical models generated by Maxent from previous SolVES' analyses in study areas having available survey data. Prior to running the Value Transfer Mapping Model, it will be necessary to review the individual model metadata to acquire the appropriate environmental data and to determine the necessary parameter values for the Transfer Values tool.

A limiting factor for using the Transfer Values tool will be the availability of environmental data for a study area that matches the content and format of the environmental data originally used to generate the models. It is recommended that users carefully examine the model metadata files of interest to determine whether they will be able to acquire the necessary environmental data for their study area. For categorical data, make sure to confirm that the data classification schemes match. Currently, these metadata files must be generated manually. For more information, see the Sharing Models section under Advanced Options.

Complete the following steps to apply the Transfer Values tool to a selected study area.

1. Use Windows to navigate to the Models folder contained within the SolVES root directory.
2. Navigate to the desired project and analysis-level folders (fig. 34).

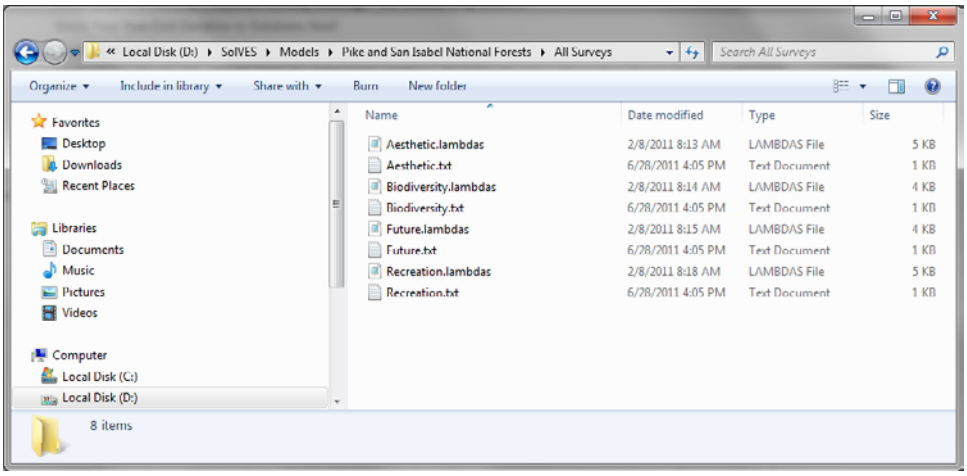

Figure 34. Navigating to the location of models and metadata for use with the Transfer Values tool.

3. Although the lambdas files contain the actual models, the matching text files include information regarding the environmental data used to generate the model as well as the output cell size and the maximum attained value on the Value Index. Open the text file for the desired model to examine the metadata (fig. 35).

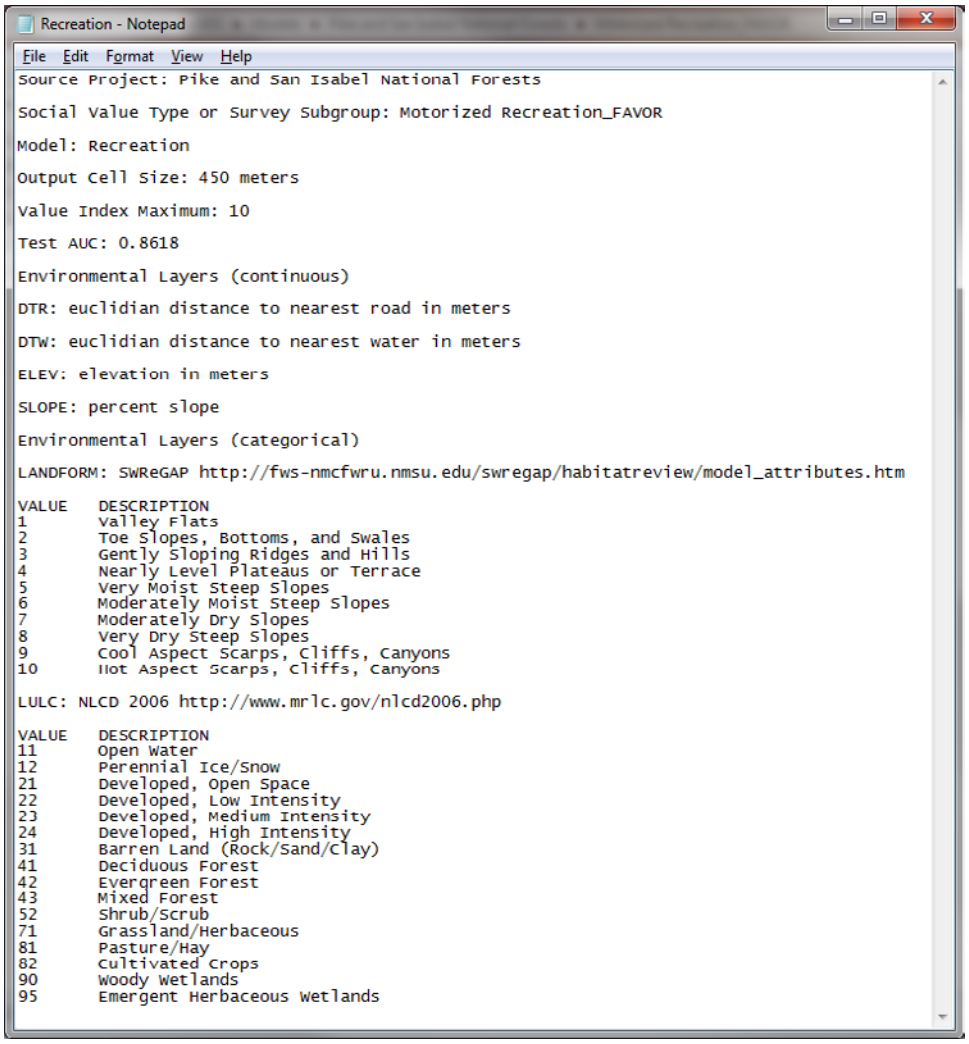

Figure 35. Contents of a value transfer model metadata file.

4. If not already completed, load the required environmental layers into SolVES.gdb using the same layer names as those used in the metadata.
5. Setup a new project as described in the Project Setup section.
6. Access the Value Transfer Mapping Model by selecting Transfer Values from the toolbar (figs. 36 and 37).

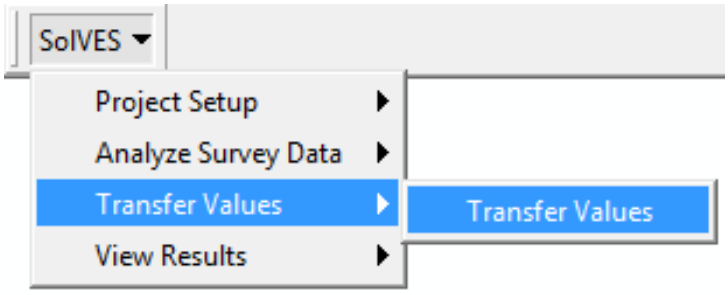

Figure 36. Selecting the Transfer Values tool.

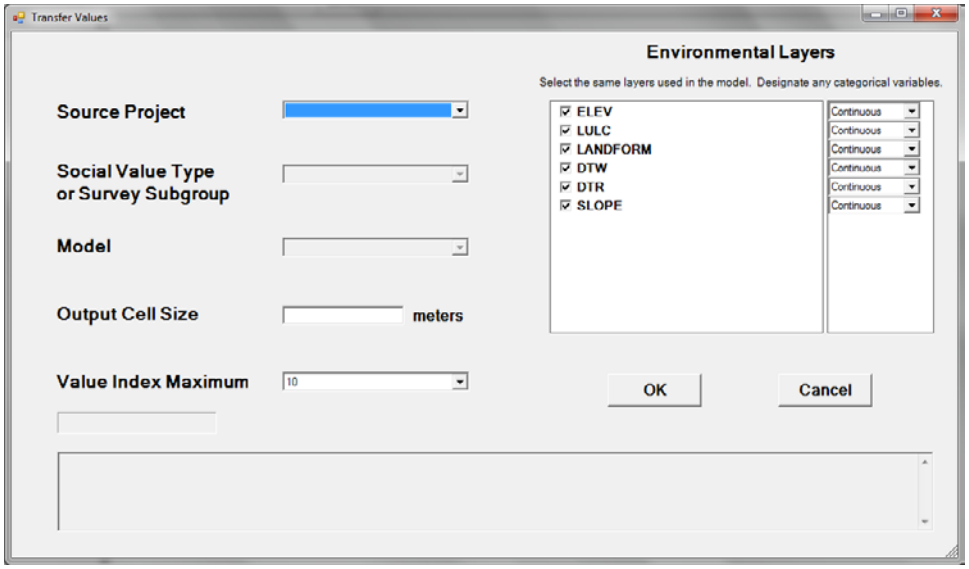

Figure 37. The Transfer Values tool.

7. Select the Source Project.
8. Select the Social Value Type or Survey Subgroup.
9. Select the Model.
10. Enter the Output Cell Size from the model metadata.
11. Enter the Value Index Maximum from the model metadata. (The default value is 10.)
12. Confirm that the checkboxes for all the environmental layers required for the model are checked (and those that are not required are unchecked) in the Environmental Layers section. (All are selected by default.)
13. Designate any categorical data using the dropdown for the appropriate environmental layers. (All are designated as continuous by default.)
14. After entering all parameters, the Transfer Values tool screen should look something like the example shown in figure 38. Select OK. The model will process as shown in figure 39. Processing may take several minutes. The main ArcMap application window will not be visible during processing.

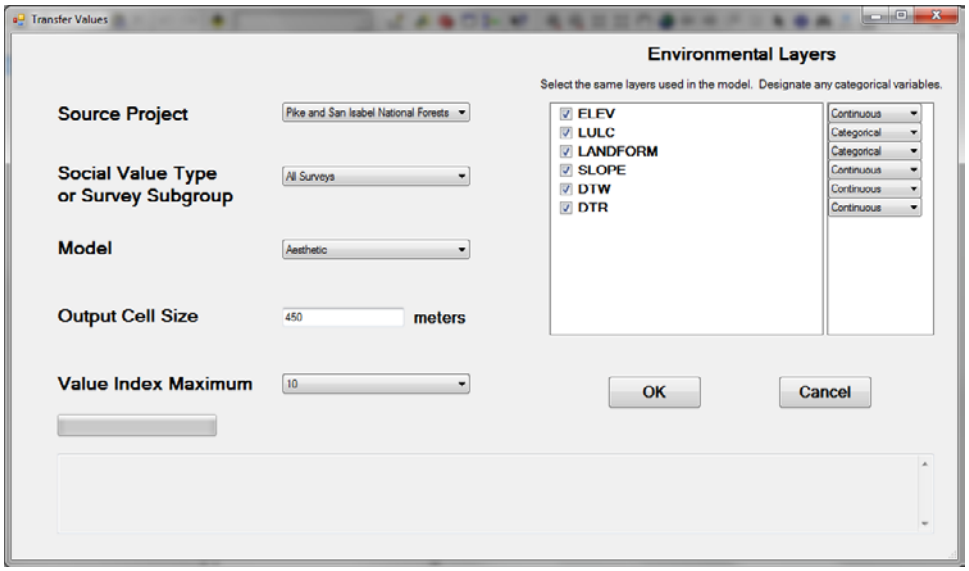

Figure 38. The Transfer Values tool screen after parameter selection.

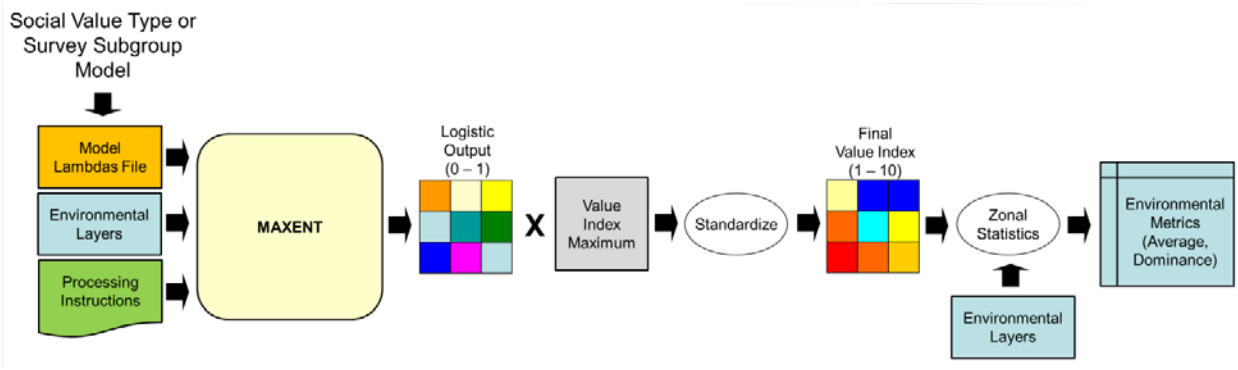

Figure 39. Value Transfer Mapping Model generalized process flow.

The Source Project and Social Value Type or Survey Subgroup selections navigate the user through the project-level and analysis-level folders contained in the Models folder to the selected Model. The selected Model informs the Transfer Values tool which lambdas file to select. The selected environmental layers are resampled to the designated Output Cell Size, and the Value Transfer Mapping Model sends processing instructions to Maxent as a batch file. Maxent applies the selected lambdas file to the resampled environmental layers to generate a logistic value layer for the selected model. The Value Transfer Mapping Model then multiplies the resulting logistic value layer by the selected Value Index Maximum and standardizes the result to a Value Index surface. Lastly, the Value Index surface is used to calculate metrics from each environmental layer.

Analyses conducted with the Transfer Values tool should be completed under a separate project from analyses conducted with the Analyze Survey Data tool.

View Results

The View Results tool allows users to produce composite reports of Value Index maps and associated environmental metrics from the results of a current project or from previously completed projects. Complete the following steps to view results generated by SolVES 2.0.

1. Select the View Results tool from the toolbar (fig. 40).

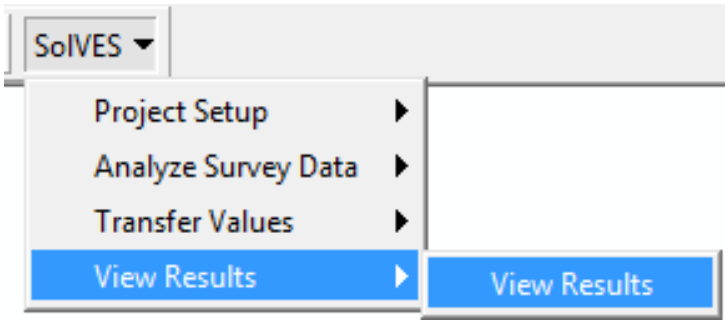

Figure 40. Selecting the View Results tool.

The View Results tool is the only SolVES 2.0 tool that can be accessed without first setting up a new project.

2. If a project is currently in progress, the Home Directory, Project Name, Value Map Background, and Locator Map Boundary parameters will already be set according to the values previously entered in the Project Setup screen (fig. 41). If a different value map background or locator map boundary or results from another project are desired, those parameters may be changed here. If the View Results tool is directly accessed without setting up a current project, all parameters will be blank, and the Home Directory must be set by navigating to the location of the SolVES root directory containing the desired existing results.

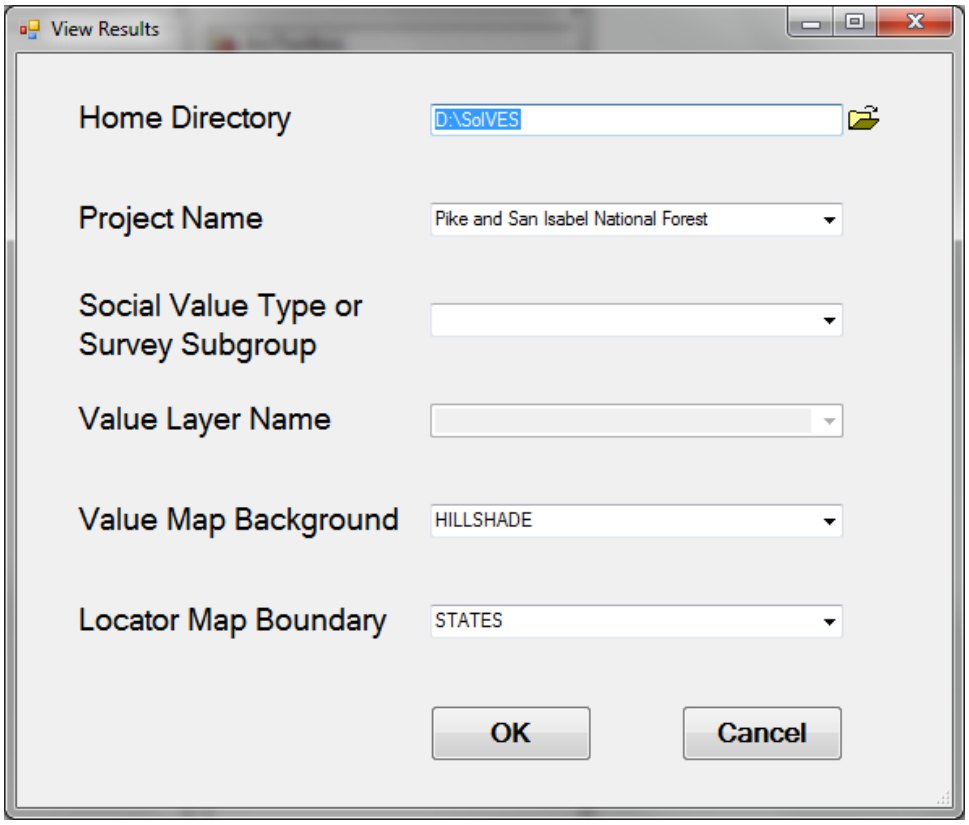

Figure 41. Accessing the View Results tool during a current project.

3. Select the Social Value Type or Survey Subgroup.
4. Select the Value Layer Name.
5. Select OK. Within a few seconds, a composite report should be generated in the map layout (figs. 42 and 43).

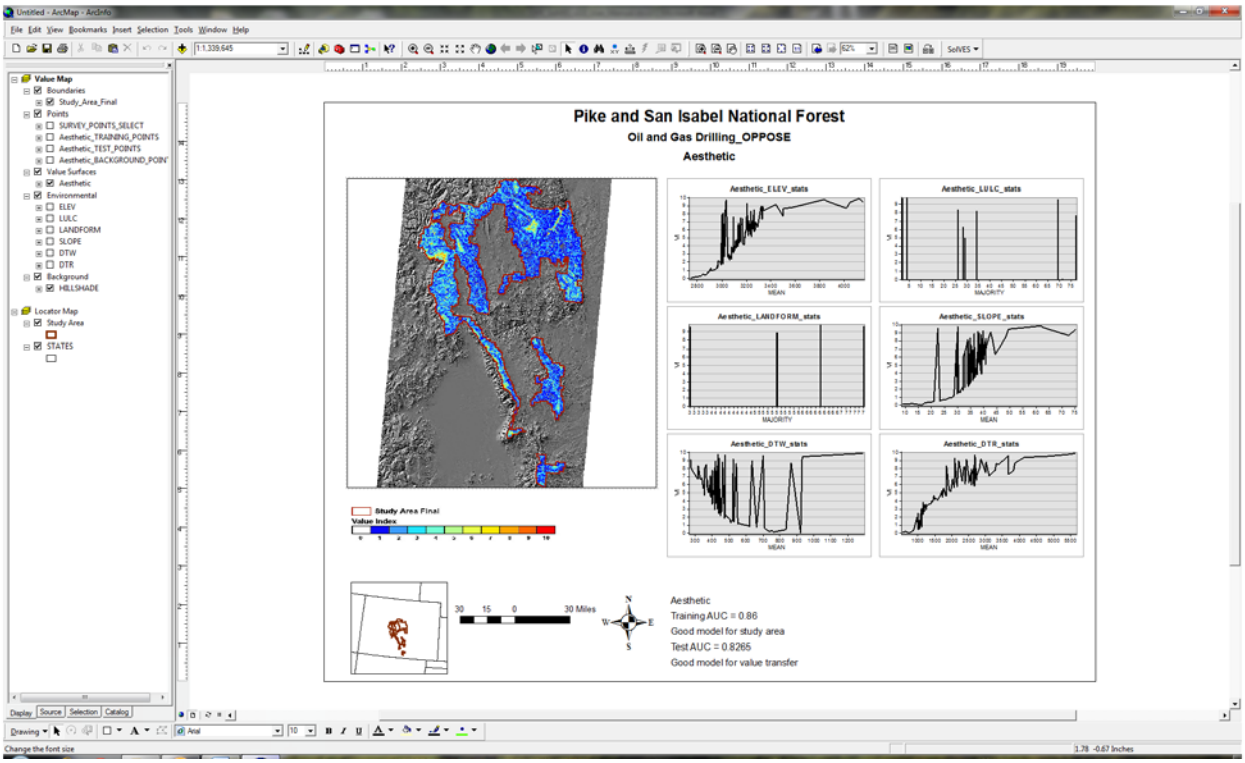

Figure 42. View Results from the Analyze Survey Data Tool.

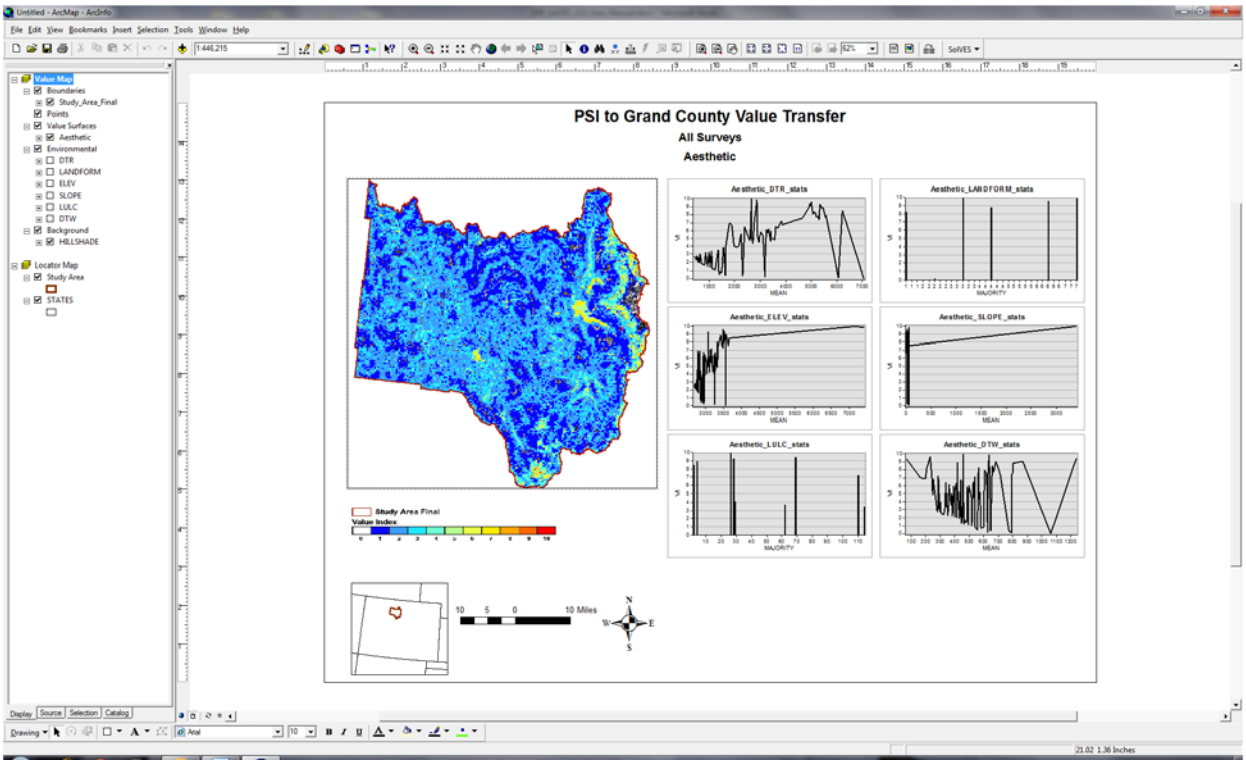

Figure 43. View Results from the Transfer Values Tool.

The map layout contains the selected Value Index map, including the study area boundary and selected background. The locator map in the lower left corner indicates the location of the study area within a larger geographic region. Graphs of environmental metrics are limited to a maximum of six on the map layout, but those, along with any additional graphs, are saved to the analysis-level folder of the project results. Continuous data are displayed as line graphs, whereas categorical data are displayed as bar graphs. The x-axis labels for the bar graphs consist only of the integer value designating each category. The DESCRIPTION field for each categorical data layer in SolVES.gdb should be consulted if the meaning of the integer value is not known. The notation below the environmental metrics graphs indicates the training AUC and test AUC for the displayed results along with a statement describing model performance for the current study area and for value transfer to other study areas. AUC notations are not included in the map layout for results generated by the Transfer Values tool.

Programming limitations that existed during the development of SolVES 2.0 resulted in the possible duplication of x-axis labels on the continuous-data bar graphs. Additionally, if a data category is dominant for multiple values on the Value Index, only the highest value is displayed on the bar graph.

The table of contents includes the final study area boundary (including a buffer if selected), the selected value surface, each environmental layer, the value map background, the selected survey points, the survey points designated as training points and test points by Maxent, and the background points selected by Maxent. Point layers are not included in the table of contents for results generated by the Transfer Values tool.

The map layout produced by the View Results can be manipulated to suit individual user's needs. Titles can be modified, map and graph elements can be moved and resized, and other data layers can be turned on or added to the table of contents. Map layouts can be exported using various formats including JPG and PDF. The entire ArcMap document (MXD) can also be saved for viewing at a later time.

Interpreting and Adjusting Maxent's AUC Statistics

When the SolVES 2.0 Analyze Survey Data tool is used, Maxent produces a model for each user-selected social value type or survey subgroup. Along with these models, Maxent produces additional statistics describing the performance of each model. Included in these is the AUC statistic. The AUC statistic represents the area under the Receiver Operating Characteristic (ROC) curve. This is a curve in which the false positive rate (specificity or commission error) of predicted class membership is plotted on the x-axis and the true positive rate (sensitivity or omission error) is plotted on the y-axis. Because Maxent does not rely on true absence points, the ROC curves it generates plot fractional predicted area on the x-axis, which considers the fact that Maxent is analyzing presence-random data rather than presence-absence data. An example of a ROC curve generated by Maxent and included in its HTML output is shown in figure 44.

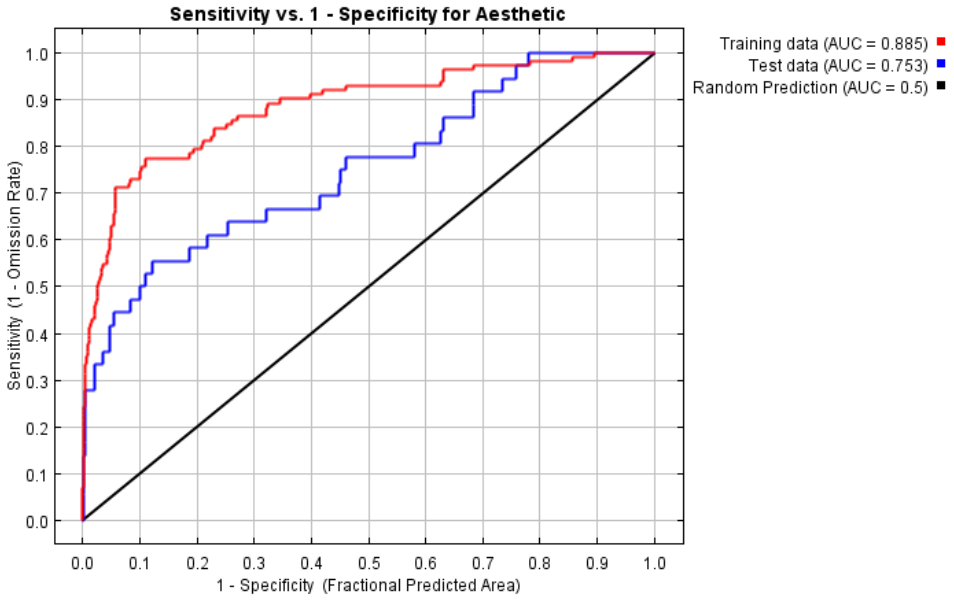

Figure 44. Receiver Operating Characteristic (ROC) curve generated by Maxent.

Models with AUC values of 0.5 or less perform at the level of random prediction (Phillips and others, 2006) or worse. Models with AUC values above 0.75 are considered potentially useful (Phillips and Dudík, 2007). SolVES 2.0 instructs Maxent to withhold 25 percent of the points from each user-selected social value type or survey subgroup as test points so that Maxent can calculate AUC statistics for both training points (the remaining 75 percent) and test points. AUC training point values provide a measure of performance of the model for the current study area while AUC test point values provide a measure of the potential performance of a model if used for another study area (in the context of SolVES 2.0, to evaluate its potential usefulness for value transfer to similar study areas lacking their own attitude and preference survey data). When the View Results tool is used to generate map layouts of output generated by the Analyze Survey Data tool, the training AUC and test AUC statistics are reported at the bottom of the map layout, along with a brief statement interpreting the reported values. Based on this information, users may wish to make adjustments to the model to improve the test AUC and make the model more generalized for application to other study areas. If necessary, users can modify the model by changing the environmental layers it includes. One way to identify environmental layers that may be good candidates for removal is to examine the jackknife graphs of test AUC included in Maxent's HTML output (fig. 45). In the example below, the test AUC of the model could potentially be improved by removing dtr or slope from the model. (The green bar indicating the test AUC of the model without the environmental variable extends beyond the red bar indicating the current test AUC.) Users can complete such changes by setting up a new SolVES 2.0 project and running the Analyze Survey Data tool, being sure to not include the indicated environmental layers.

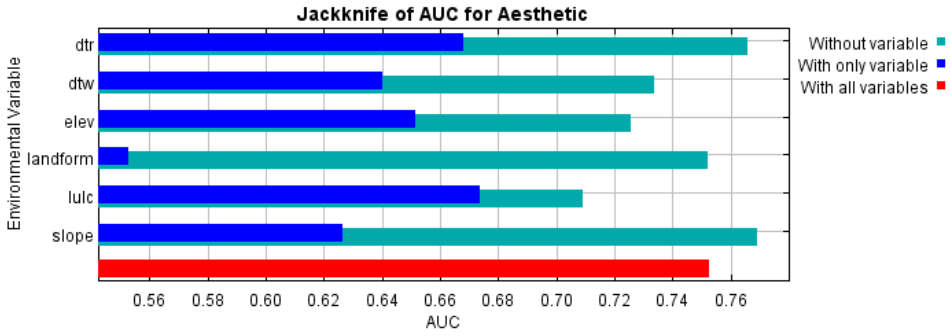

Figure 45. Example jackknife graph generated by Maxent.

Advanced Options

Substituting the Public Use Parameter

SolVES 2.0 is designed to accept a Public Use parameter for defining survey subgroups along with the Attitude or Preference parameter; however, if a user has survey results that would be useful for defining survey subgroups in a manner other than with public uses (for example, attitudes or preferences regarding particular issues impacting a study area), they may do so as long as the attitude or preference responses are structured in the same format as indicated in table 1. Note that with proper recoding of the attitude and preference responses (be sure not to overwrite the original responses) and careful tracking of any differences in response meanings, some minor variations in the response structure could be recognized by SolVES 2.0. Otherwise, assuming the response structure is suitable, users may simply load their data into the USE_TYPES table in SolVES.gdb as a substitute for Public Use. Be aware that the SolVES 2.0 interface will still refer to the parameter as Public Use although this will have no effect on the analysis.

Creating Survey Data Subsets Prior to Loading SolVES 2.0

The SolVES 2.0 Analyze Survey Data tool only accepts Public Use (or user-provided substitutes) and Attitude or Preference parameters to define subgroups; however, users may wish to subdivide their survey data in some manner, such as by certain demographic characteristics like age or income. This can be accomplished by creating separate datasets for each subset, loading them separately into SolVES.gdb for analysis, and leaving the Public Use and Attitude or Preference parameters blank to process all survey data. Users, of course, will need to track and manage the results because SolVES 2.0 will not be able to recognize or meaningfully label the results as belonging to a specific subset. Users should also be aware that overly restrictive criteria may result in data subsets that are too small for SolVES 2.0 to analyze for any meaningful results.

Sharing Models for Value Transfer

At some point, users may wish to share a model they have generated with others who would like to apply the model in another study area using the Transfer Values tool. Although the lambdas file generated by Maxent contains the actual model that other SolVES 2.0 users would apply to environmental layers for their own study area, additional metadata describing the content and format of the required environmental layers as well as other model parameters are necessary. To apply a model using the Transfer Values tool, users will need to know the model's output cell size and the maximum value the model attained on the Value Index (although results will otherwise default to 10). For continuous data, users will need a description of the values, units included. For categorical data, users will need the textual description of each value. The source of the environmental data used to generate the model may also assist other users in finding the environmental layers necessary to apply the model to their own study area. Finally, users should be provided with the model's test AUC as an indicator of its potential performance in transferring values to other study areas. As a guide, see figure 35 for an example of the metadata text files provided with the models included in the SolVES 2.0 download.

Troubleshooting Common Errors

Installation Errors

The following error messages (figs. 46 and 47) will appear during installation if the User Account Control settings have not been adjusted properly. Please see the Installation section for specific instructions on how to set the User Account Control.

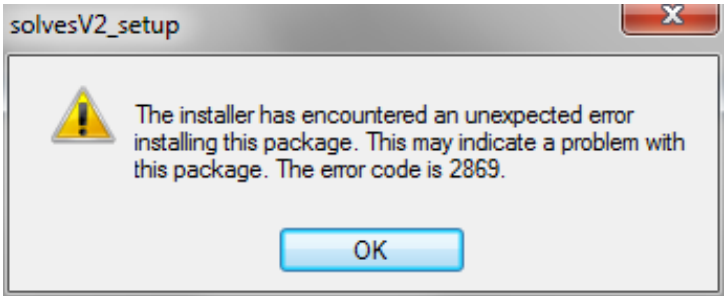

Figure 46. Installation error message 1.

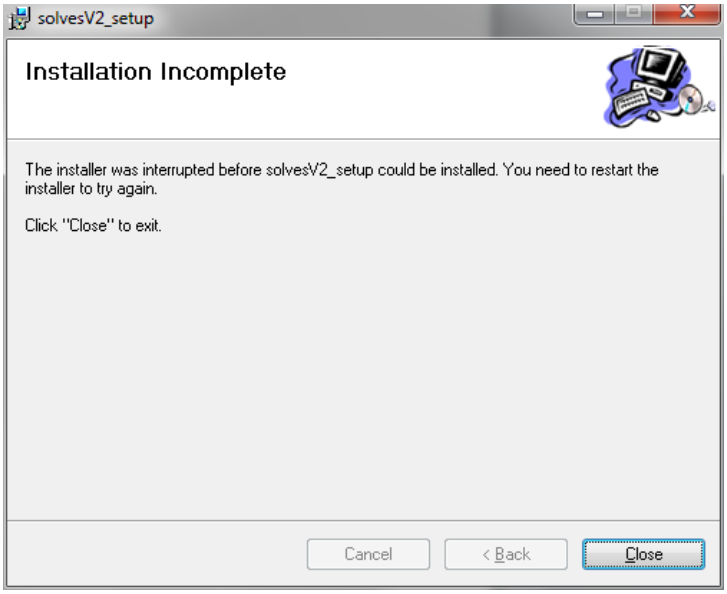

Figure 47. Installation error message 2.

SolVES 2.0 Toolbar Not Visible in the ArcMap Toolbar List After Installation

If the SolVES 2.0 toolbar is not visible in the ArcMap Tools Customize form as described in the Adding the SolVES 2.0 Toolbar to ArcMap section, then complete the following steps.

1. In ArcMap, select Tools > Customize > Add from file…
2. Navigate to the location of the file “Solves_V2.tlb”. (This will be C:\Program Files (x86)\Microsoft\solvesV2_setup if the default path was used during installation).
3. Select OK on the Added Objects… window.

4. SolVES toolbar should now be visible in the toolbar list.
5. Mark the checkbox next to SolVES toolbar to make it visible and ready for use in ArcMap.

Source File Geodatabase Not Present in Directory

The following error message will appear during project setup if SolVES.gdb is not present in the Data folder under the SolVES root directory or if the Home Directory is not properly set (fig. 48). Please see the Data Installation section to resolve the error.

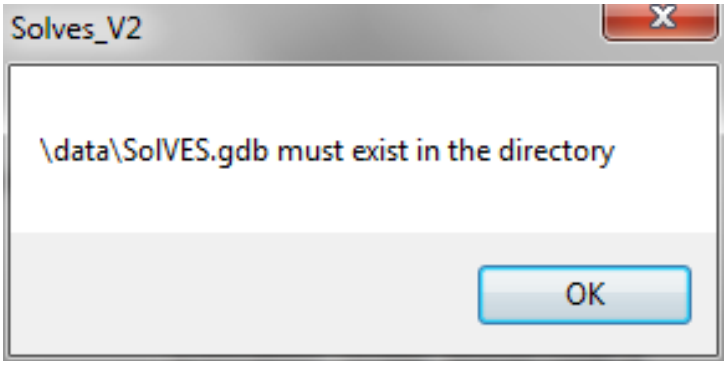

Figure 48. Missing SolVES.gdb error message.

Acknowledgments

SolVES was originally developed by the RMGSC in collaboration with Dr. Jessica M. Clement of the Department of Forest, Rangeland and Watershed Stewardship at Colorado State University. Dr. Clement made available to the RMGSC the Pike and San Isabel National Forests survey data (J.M. Clement, written commun., 2008) that served as the basis for the initial development of SolVES. Additionally, her continued contributions are invaluable to the success of SolVES 2.0 and subsequent versions.

Thanks are also extended to our colleagues at the RMGSC, Mike Stier and Lori Baer, who reviewed the SolVES 2.0 application and documentation. Finally, special thanks to Jodi Riegle for all her work programming SolVES 2.0.

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