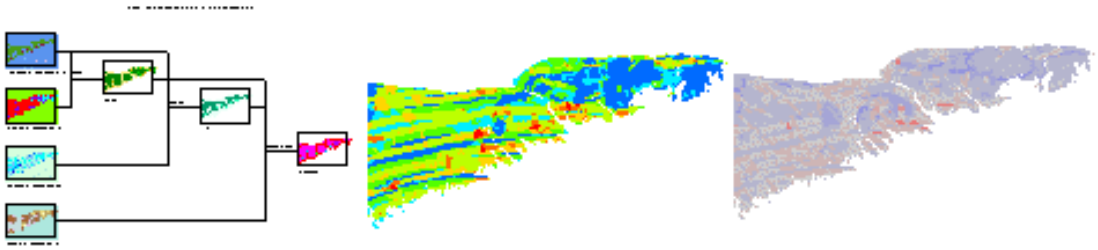

Arc-SDM and DataXplore User Guide

Spatial Data Modeller Extension for
ArcView and Spatial Analyst

[Table of Contents]

Barrick Gold Corporation
Cominco Ltd.
INCO Limited
Noranda Inc.
Placer Dome Inc.
Alaska Division of Geological and Geophysical Surveys
Western Mining Corp.
U.S. Geological Survey
Geological Survey of Canada

Arc-SDM was developed by Laura Kemp at the GSC under the direction of Graeme Bonham-Carter (GSC) and Gary Raines (USGS)

DataXplore was developed by Carl Looney and Han Yu at the University of Nevada, Reno

Spatial Data Modeller for ArcView and Spatial Analyst:

Arc-SDM and DataXplore User Guide

[View Front Cover]

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Add Bearings

Help

Symbolization Tools

File created by Arc-SDM

Installation of Arc-SDM

- Program files
- On-line Help

Unzipping files

Files provided on the web site have been compressed into zip files. A directory structure has been written to the zip file for the documentation files and the sample data sets that needs to be reconstructed by your unzip utility. If you are using WinZip, ensure that you have selected the option to 'Use folder names'. It's can also be useful to NOT have the 'Overwite existing files' selected because a prompt asking you if you want to overwrite an existing file will usually signal a problem with the reconstruction of the directory structure.

Installation of program files

Apart from unzipping the files, installation is the same from CD-ROM or the Arc-SDM web site.

Copy all of the following files into the ArcView extension directory. For the default installation of ArcView, the path is **c:\Esri\Av_gis30\ArcView\Ext32.**

Filename	Description
sdm.avx	Arc-SDM ArcView Extension
sdmlr.exe	Executable file that runs logistic regression functions.
DataXplore.exe	Executable file that runs neural network module.
mfc42.dll	Application extension required by DataXplore.exe.
msvcrt.dll	Application extension required by DataXplore.exe.

To load the extension

1. If you haven't already, start ArcView.
2. Make the project window or, in versions 3.1 or 3.2, a view window active.
3. Select 'Extensions...' from the 'File' menu.
4. In the dialog box, check the box beside 'Spatial Data Modeller (14-Mar-00).
5. Click 'OK'.

When the SDM extension loads:

	The following items are loaded to the project file:	... is /are added to...
	ArcView's Spatial Analyst extension (if it is not already loaded). The SDM extension uses classes and functionality provided by the Spatial Analyst extension and cannot be loaded if SA is not installed.	(When installed, Spatial Analyst is fully documented in the ArcView on-line help.)
	a menu labelled 'Spatial Data Modeller'	the menu bar to the right of Spatial Analyst's Surface menu in the View document GUI

User Interface	a tool menu	the farthest position to the right in the View document tool bar
	a menu item labelled 'Export With Names...'	to the 'File' menu of the Table document GUI
	a Bar/Line style toggle button	button bar of the Chart document GUI
	a button that invokes the document comment reporter	the Project GUI button bar
"Behind the scenes"	scripts used by Arc-SDM	the ArcView system scripts
	custom dialog used by Arc-SDM	the ArcView system dialogs

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Installation of On-line Documentation

Options:

Using documentation on CD:

1. The first time you invoke the on-line help from ArcView you will be prompted to specify the location of sdmhelp.htm.
2. Put the CD in the CD-ROM drive (if it is not already).
3. Navigate to <CD-ROM drive letter>:\documentation\sdmhelp.htm, select and click OK.

Using documentation on your hard drive:

1. Either
   copy the contents of the Documentation directory on the CD to a directory of your choice on your hard drive
   or
   download one of the zip files that contains the documentation files from the SDM web site. Unzip these files in a directory on your hard drive.
2. The first time you invoke the on-line help from ArcView you will be prompted to specify the location of sdmhelp.htm.
3. Navigate to the file, select and click OK.

How to change the location of the on-line documentation.

1. With your ArcView project file open, open the table named 'Data Types of Weights Themes'.
2. Start editing the table by selecting 'Start editing' from the Table menu.
3. Select the cell edit tool.
4. Click in the cell that contains the path to sdmhelp.htm and change to the new path.
5. Press the Tab key or click in another cell.
6. Stop editing the table by selecting 'Stop editing...' from the Table menu. Specify that edits be saved when prompted.

If there is no table named 'Data Types of Weights Themes' in the project, or the path to sdmhelp.htm is not found in the table:

Select Help from the Spatial Data Modeller menu to be prompted for the location of sdmhelp.htm.

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Methods

Arc-SDM provides tools for performing four methods of quantitative mineral potential mapping in ArcView and Spatial Analyst. This section provides description of each method as well as key terms used in the implementation of these methods. (Please refer to the Glossary for additional definition of terms used in Arc-SDM.)

Key Terms

Exploration data set. Here we refer to digital data sets, such as digitized geological maps, geophysical images, geochemical survey data and remotely sensed images, frequently employed by exploration geologists in the mineral exploration process. There is always a process of extracting evidence from the raw data set to be used in prediction. This process depends strongly on the exploration model being used.

Exploration model. There are a large number of deposit models that have been defined for the various mineral deposit types, based on deposit characteristics. Deposit models help to classify and identify new occurrences, lead to an improved understanding of how the deposits formed, and act as an aid to exploration. However, they are usually based on characteristics of the deposit and its immediate surroundings, and many of the characteristic diagnostics of a mineral deposit type cannot be used with regional exploration data sets. The exploration model, on the other hand, refers to the characteristics of a deposit type identifiable in regional data sets, as used in the exploration process. It is important to note that the absence of evidence can be equally important as the presence of evidence and data on negative associations between deposit and particular types of data are often poorly documented.

Evidential Theme. This is a map or area layer (in either vector or raster format) used for prediction of point objects (mineral occurrences). The polygons or grid cells of the evidential themes have two or more values (class values). For example, a geological map may have two or more values representing the classes (map units) present. **Weights of evidence** and **logistic regression** were originally defined for binary evidential themes (also named binary patterns in several publications) but they can also be applied to themes with more than two classes. Usually for these two methods multi-class evidential themes will be generalized, or simplified, by combining classes to a small number of values, facilitating interpretation. Evidential themes used for **neural network** analysis, however, should retain their detail, allowing the neural network algorithms as much information as possible to classify the data. For **fuzzy logic**, the classes in each evidential theme are assigned a fuzzy membership in the range [0,1]. The degree of generalization of the theme in this process is based on the user's expert opinion. In multivariate statistical terminology, an evidential theme is the same as an 'explanatory' variable.

Data Type of Evidential Themes. For **weights of evidence** and **logistic regression**, the user is asked to specify whether an evidential theme contains 'ordered' or 'free' data. 'Ordered' describes data that use an ordered measurement scale while 'free' describes data that have a categorical or nominal measurement scale. **Weights of evidence** will allow the calculation of cumulative weights tables for ordered data sets only. The **logistic regression** method requires that multi-class 'free' data sets, for example, a geology map with more than two rock type classifications, be expanded to a series of binary maps. This expansion is carried out automatically in Arc-SDM.

Training points. A point layer consisting of the locations at which the point objects are known to be either present. **Weights of evidence (normal option)** and **logistic regression** require a training point theme defining known point occurrences. In mineral exploration, the points are the mineral deposits (showings, occurrences, etc.) previously discovered by prospectors, mappers and exploration companies. But in other studies, the point objects may consist of locations of seismic events, intersections of faults, locations of springs, and other point types. The **neural network RBFLN (supervised)** method requires training point themes defining both presence and absence of the point objects. The terminology in Arc-SDM has been kept as generic as possible; however, the theme indicating the presence of point objects is referred to as a 'deposit training point theme', and a theme indicating absence is referred to as a 'non-deposit training point theme'. Databases of locations where mineral deposits are definitely not present are not often kept by exploration geologists so Arc-SDM includes a utility to generate a set of points at locations of low probability. See 'Generate Random Points...'. **Expert weights of evidence**, **the fuzzy clustering - unsupervised supervised option,** and **fuzzy logic** do not use training points.

Study area theme. In Arc-SDM, the study area is an integer grid theme that defines the region of interest. It acts as a mask on areas of evidential themes and, if they are being used, training points outside the study area are ignored during processing. The study area theme is used by all 4 Arc-SDM methods. It is sometimes referred to as the 'base map'.

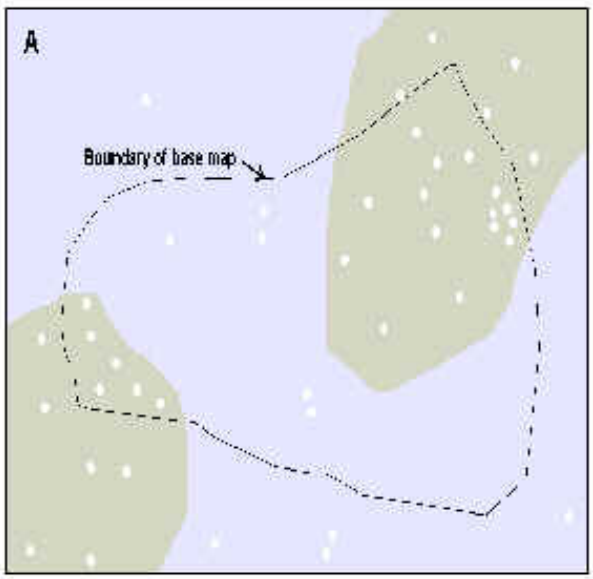
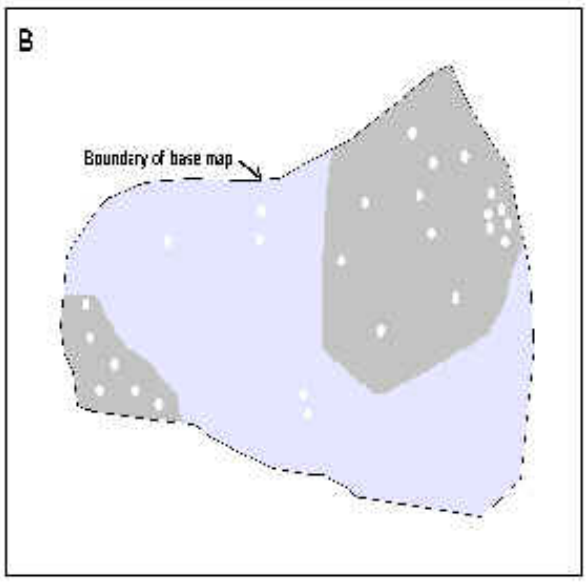


Figure1. A. Rectangular area showing binary evidential theme and training points.



B. Same area trimmed back to study area base map, excluding both points and areas outside study area.

Missing Data Integer. An integer is required to define areas of missing data for each evidential theme. Each method handles missing data differently (refer to the sections that follow, describing each method). The missing data integer is required even if missing data is defined by 'No Data' or the evidential theme does not contain any missing data within the study area. Missing data is different from the concept of 'No Data'. (See What is the difference between 'Missing Data' and 'No Data'.)

Unit cell area. In **weights of evidence** and **logistic regression**, each training point is assumed to occupy a small unit area, named the unit cell. In order to calculate the probability of a point occurrence, a unit of area must be selected. The output from **weights of evidence** and **logistic regression** is a map showing the probability that a unit area contains a point. Thus the values of probability will change with the choice of unit cell area. The unit cell is a constant set at the beginning of a particular computer run, and is the same for all training point and evidential themes. The area of the unit cell is unrelated to physical size or influence of points, and is *independent of the grid cell size used in raster data sets*. The values of the weights in weights of evidence are relatively independent of unit cell area, if the unit area is small. **Fuzzy logic** and **neural network methods** do not use a unit cell.

Unique Conditions Grid/Table. An important concept used in the Arc-SDM implementation of **weights of evidence**, **logistic regression** and **neural network analysis** is the idea of a "unique conditions" table and associated "unique conditions" map. This step is carried out in grid format in Spatial Analyst, regardless of whether the evidential themes were input as vector or raster, but the concept applies equally in vector mode. The unique conditions table and map are produced by an overlay of the evidential themes selected for prediction.

A unique condition is the collection of polygons or grid cells in which the same combination of the evidential themes occurs in the overlay map. Each row of the unique conditions table corresponds to a unique set of class values, with the same characteristics as indicated by the row vector of class values, one column for each evidential theme. If the evidential themes are all binary, then the maximum number of unique conditions equals 2^n, where n is the number of themes. However, the number of unique conditions rises sharply if some of the evidential themes are multi-class. The following table illustrates the concept for a combination of 3 binary themes, producing a map with 8 unique conditions.

Table 3. Unique condition table for three binary themes, in which class values are 2=present, 1=absent.

UC Number	Area, km2	Theme 1	Theme 2	Theme 3
1	101.7	2	2	2
2	56.2	2	2	1
3	142.1	2	1	1
4	17.0	1	2	2
5	29.8	1	1	2
6	229.3	1	2	1
7	171.2	2	1	2

8	3.8	1	1	1

In the corresponding unique conditions map, the values are the unique conditions number. The unique conditions grid is the basis of the response theme.

Response theme. This is an output map that expresses the probability that a unit area contains a point, estimated by combining the weights of the explanatory variables (evidential themes). The response map is usually classified into a small number of values and depicted as relative favourability. If the training points are mineral deposits of a particular type, then the response map show an estimate of mineral potential (also know as mineral prospectivity or mineral favourability).

Quantitative Mineral Potential Mapping in GIS

Although this computer package has been designed specifically for mineral potential mapping, it can also be used for other types of spatial prediction in which the goal is to predict the probability of occurrence of point objects. The remarks in this section are in the language of mineral exploration, but the same general principles guide other applications.

The GIS-based mineral potential mapping process can be broken down into four main steps: (1) building a spatial digital database, (2) extracting predictive evidence for a particular deposit type, based on an exploration model, (3) exploring each evidential theme individually in order to generalize or classify it, (4) combining the evidential themes to predict mineral potential.

This computer package assumes that step 1 has already been completed. This may have been carried out in totally different GIS or image processing environments, not necessarily ARC/INFO or ArcView. Step 2 may have at least partially been done prior to doing any processing using Arc-SDM. However, parts of step 2 and all of step 3 are done within Arc-SDM and its associated modules, and comprise in many ways the most useful part of a mineral potential study. This is because the examination of the evidential themes, particularly the spatial relationships between the training point and evidential themes, is exploratory, yielding measurements of spatial associations that are often unexpected. The process of generalization, grouping classes of evidential themes together, identifying breaks in continuous variables that maximize spatial associations, or determining the fuzzy membership of classes often leads to a better understanding of the data. Finally, in step 4, combining the evidential themes by one or more methods is valuable for identifying areas for exploration follow-up. The four methods provided in Arc-SDM provide a variety of measures that facilitate the interpretation of results.

Reference Papers

Copies of the following papers have been provided in order to provide a background to each of the methods included in Arc-SDM. The full references for these papers is included in the list of references appearing at the end of this section.

Method:

Weights of Evidence

Weights of evidence modelling: a new approach to mapping mineral potential
G.F. Bonham-Carter, F.P. Agterberg and D.F. Wright
wofe1.pdf

Statistical Pattern Integeration for Mineral Exploration
F.P. Agterberg, G.F. Bonham-Carter and D.F. Wright
wofe2.pdf

Integration of Geological Datasets for Gold Exploration in Nova Scotia
G.F. Bonham-Carter, F.P. Agterberg and D.F. Wright
wofe3.pdf

Weights of Evidence and Logistic Regression

Weights of Evidence Modeling and Weighted Logistic Regression for Mineral Potential Mapping
F.P. Agterberg, G.F. Bonham-Carter, Q. Cheng and D.F. Wright
wlr.pdf

Logistic Regression

Fuzzy Logic

Fuzzy Logic Method
pp. 291-302, Geographic Information Systems for Geoscientists: Modelling with GIS
Graeme Bonham-Carter
fl1.pdf

Application of fuzzy set theory for integeration of geological, geophysical and remote sensing data
P. An, W. Moon and A. Rencz

fl2.pdf

Neural Network Analysis

Lecture notes from neural network session during the Arc-SDM training workshop, October 29, 1999, held at the Geological Survey of Canada.
Carl Looney
neuralnet.htm

References

References for which a copy of the text is included are identified with an asterisk.

*Agterberg, F.P., Bonham-Carter, G.F., Cheng, Q. and Wright, D.F., 1993, Weights of Evidence Modeling and Weighted Logistic Regression for Mineral Potential Mapping: In *Computers in Geology -- 25 Years of Progress,* Editors: Davis, J.C. and Herzfeld, U.C., Oxford University Press, New York, p. 13-32.

*Agterberg, F.P., Bonham-Carter, G.F., and Wright, D.F., 1990, Statistical Pattern Integration for Mineral Exploration: In *Computer Applications in Resource Estimation: Prediction and Assessment for Metals and Petroleum,* Editors: Gaal, G. and Merriam, D.F., Pergamon Press, Toronto, p. 1-21.

*An, P., Moon, W.M., and Rencz, A., 1991, Application of fuzzy set theory for integration of geological, geophysical and remote sensing data; *Canadian Journal of Exploration Geophysics,* v. 27, p. 1-11.

*Bonham-Carter, Graeme F., 1994, *Geographic Information Systems for Geoscientists: Modelling with GIS*, Pergamon Press, Tarrytown, N.Y., 398p.

*Bonham-Carter, G.F., Agterberg, F.P. and Wright, D.F., 1988, Integration of geological datasets for gold exploration in Nova Scotia: In *Photogrammetric Engineering and Remote Sensing*, v. 54(11), p. 1585-1592.

*Bonham-Carter, G.F., Agterberg, F.P. and Wright, D.F., 1989, Weights of evidence modelling: a new approach to mapping mineral potential: In *Statistical Applications in the Earth Sciences,* Editors: Agterberg, F.P. and Bonham-Carter, G.F., Geological Survey of Canada Paper 89-9, p. 171-183.

Burrough, P.A., R. McDonnell. Principles of GIS. Oxford University Press, Oxford, 336p. (Contains a chapter on fuzzy logic.)

Griffiths, C.M., 1987, An example of the use of fuzzy-set based pattern recognition approach to the problem of strata recognition from drilling response: In *Handbook of Geophysical Exploration, Section I: Seismic Prospecting, Volume 20: Pattern Recognition and Image Processing,* Editor: Aminzadeh, F., Geophysical Press, London-Amsterdam, p. 504-538.

Hesmer, D.W., Lemeshaw, S. 1989, *Applied Logistic Regression*. Wiley, New York, 307p.

Looney, C.G., 1997, *Pattern recognition using neural networks: theory and algorithms for engineers and scientists*, Oxford University Press, New York, 458p.

Menard, S., 1995, Applied Logisitc Regression Analysis: In *Quantitative Applications in the Social Sciences*, No. 106, Sage Publications, London, 98p.

Zimmermann, H.J., 1985, *Fuzzy Set Theory - and Its Applications,* Kluwer-Nijhoff Publishing, Boston-Dordrecht-Lancaster, 363 p.

Zimmermann, H.J. and Zysno, P., 1980, Latent connectives in human decision making: In *Fuzzy Sets and Systems*, v. 4, p. 37-51.

ArcView: What you need to know about ArcView and Spatial Analyst to use Arc-SDM...

- How to load an extension
- How to manage Grid data sets
- How to organize your data sets as Themes in a View
- How to convert your data sets to formats with which ArcView and Spatial analyst can work
- How to use the Query Builder Dialog
- How to edit the name of a Theme or Document
- How to export a table from ArcView

Loading an Extension

1. If not currently active, make the project window active:

Select the window item '1. <*project file name*>.apr' from the Window menu.

2. Select Extensions... from the File menu. A dialog box will appear that lists all of the extensions available to load.

3. Check the box beside the extension title you want to use.

4. Click 'OK' to load the extension.

About Extensions

Extensions are new to ArcView starting with version 3.0. ESRI uses extensions to deliver modules that supplement ArcView's basic functionality. ESRI also allow ArcView users to write their own extensions using ArcView's scripting language, Avenue.

An extension is a particular type of Object Database. The objects in an extension may include Avenue scripts, new interface controls or customized document interfaces (DocGUI's). When you load the Arc-SDM extension, the Avenue scripts that run the Arc-SDM functions are added to ArcView's system script. The SDM menu and tool menu are added to the View interface.

When you save a project, references to any extensions currently loaded are written to the project file. When you open that project file at a later time, ArcView will look for the references extension file (*.avx) and load it if found. If ArcView cannot find the extension file, it will ask you to specify a path to the file.

ArcView On-line Help Topic: What is an extension?

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How to manage Grid data sets

A grid data set is stored in a directory called a workspace. Each grid data set is stored as a separate directory with associated tables and files that contain specific information about the grid. Each grid data set also stores some files in an INFO directory found in the workspace.

Do not use your computer's file system commands with grid data sets

Because each grid data set stores files in the INFO directory, you cannot rename, copy, or delete them with the computer's file management system. Rename, copy, or delete grid data sets with the Data Source Manager supplied with Spatial Analyst (or the Grid Manager in version 1.0). You can access the Manage Data Sources (or Grid Manager) dialog from the File menu when a view is active.

Note: The Data Source Manager loaded by Spatial Analyst 1.1 and later also allows the management of Shapefiles, so you do not have to worry about deleting all the files associated with a Shapefile, i.e., .shp, .dbf, .shx and any other index files.

ArcView On-line Help Topic: grid data sets, frequently asked questions and grid data sets, described (above text was taken directly from these help topics)

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How to organize your data sets as Themes in a View document

Theme Inputs to Arc-SDM and their source data types:

Arc-SDM Input	Training Point Theme	Study Area Grid Theme	Evidential Theme
Spatial Data Type	Vector	Raster	Vector or Raster
ArcView Theme Type	Point Feature Theme	Integer Grid Theme	Polygon Feature Theme Integer Grid Theme
File Source Formats	ArcView shapefile ARC/INFO coverage event theme based on table	Integer Grid	ArcView shapefile ARC/INFO coverage Integer Grid
Notes:	Place at top of Table of Contents	Place at bottom of Table of Contents, or alternatively make the cells defining the study transparent, and the No Data cells a colour, and place at the top of the table of contents.	Theme's extents do not need to be the same as the extents of the study area

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How to add a data set as a Theme to a View document

1. Open or create a View document.

2. Click the ‘Add Theme’ button

OR

Select Add Theme... from the View menu.

3. In the dialog box that appears:

Select the theme type you want to add from the combo box in the bottom left corner of the dialog. If you want to add a Grid Theme and Grid Theme does not appear in the list, most likely the Spatial Analyst extension has not been loaded. Close the dialog, load Spatial Analyst, then resume adding your themes.

Navigate to the location of your data set(s). Select the data set(s) you want to load and click ‘OK’. You can load more than one data set at a time by holding down the shift key and clicking the names of the data sets you want to add to the selection set, then click ‘OK’

Note: If have added Grid Themes to the view but Arc-SDM does not seem to be recognizing them and Spatial Analyst’s menu items are, or mostly are, disabled, you have probably added a grid data set as an Image theme. You can check this by making the theme active, then selecting Properties... from the Theme menu.

ArcView On-Line Help Topic: themes, adding

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How to convert your data sets to formats that ArcView and Spatial Analyst can use

Image Theme to Grid Theme conversion

This method can be used to convert raster data sets in formats other than ESRI’s grid format to grids. ArcView supports the following formats as Image Themes:

TIFF; TIFF/LZW compressed; ERDAS; IMAGINE (if ArcView’s IMAGINE image extension is loaded); BSQ, BIL and BIP; Sun rasterfiles; BMP; Run-length compressed files; JPEG (if ArcView’s JPEG image extension is loaded); Image catalogs;

The following is a sample contents of a header file that ArcView requires in order to read a BIL file:

```
NROWS 813
NCOLS 1302
NBANDS 1
NBITS 8
BYTEORDER M
ULXMAP 537529.48752835
ULYMAP 5031945.62548415
XDIM 94.9999865
YDIM 94.9999865
```

To load a raster format as an Image Theme:

Load a Theme to the View, as described in the preceding section, selecting ‘Image Theme’ from the Data Source Types: combo-box.

To convert your Image Theme to a Grid Theme:

1. Make the image theme active.

2. Set ‘Convert to Grid’ from the Theme menu.

Once you have converted the Image theme to a Grid Theme, you can delete the Image Theme from the View.

Analysis à **Reclassify...**

Use the reclassify function to reclassify a Grid Theme. Reclassify operates on the active Grid Theme(s) and creates new grids which you can add to the current View as themes.

You could use Reclassify to:

Map grid cell values to new values.

Map ‘No Data’ to a value or map one or more values to ‘No Data’. ‘No Data’ can be thought of as Null and corresponds to -9999 in ARC/INFO.

Reclassify can be useful to create a Study Area Grid Theme.

ArcView On-Line Help Topic: Reclassifying

Selecting a subset of features or classes to create a new data set

For both a Feature Theme and an integer Grid Theme, you can select features or cells with defined values by querying the theme’s attribute table.

1. Make the theme you want to subset active by clicking on its legend in the table of contents.

2. Click the Query Builder button  .

3. Build your query by selecting fields, operators and values from the lists on the dialog. Then click ‘OK’.

4. You can create a new data set from your selection selecting either:

a. Convert to Shapefile...

OR

b. Convert to grid...

from the Theme menu.

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Query Builder Dialog

The Query Builder Dialog, an ArcView Dialog accessible by Avenue, is used several times by Arc-SDM to allow you to define subsets of features or cells. It can be run from the following dialog boxes/functions:

Set Parameters Dialog: Select a subset of training points by attributes

Generalizing an Evidential Theme, Grouping Dialog: Select a group of records in the evidential theme's attribute table to map to a new class.

Extract Contacts: Define two sets of polygons from which you want to extract contacts.

Also, prior to using the Buffer Features... function, you may want to select a subset of features or classes to buffer.

ArcView On-Line Help Topic: Query Builder (Dialog Box)

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Document Names

Arc-SDM uses ArcView document and theme names almost exclusively in processing. If more than one document or theme name are identical, ArcView won't be able to distinguish them and may try to use the wrong one. Please refer to 'What you need to know about ArcView and Spatial Analyst'.

How to change the name of a Theme or Document

To change the name of a document:

1. Open the document.
2. Select the Properties... item from the menu with the document name.
3. Edit the document name in the Properties dialog and click 'OK'.

To change the name of a theme:

1. Activate the View that contains the theme.
2. Select the Properties... item from the Theme menu.
3. Edit the theme name in the Properties dialog and click 'OK'.

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You can export an ArcView table document or a selection set of a table document to one of the three data base formats that ArcView supports: dBase, INFO and comma-delimited text.

To export a table:

Open the document you want to export.

Select Export... from the File menu in the Table GUI.

Select the file format you want to export to, provide a file name and click 'OK'.

What happens to the field names when I export part or all of a table document?

The Table.Export script that ArcView runs from the File–>Export... item, exports the field name aliases. If you are exporting to dBase format, the field name for the W+ field will be W_ and the field name for the #Points field will be ZPoints. This appears to be a problem only with the dBase format: the INFO and delimited text formats handles the aliases well.

Arc-SDM adds a function in the Table GUI File menu labeled 'Export With Names...'. Use this function if you want to preserve the dBase compatible names used in tables created by the extension.

ArcView on-line Help Topic: Exporting, a table

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Set Analysis Parameters…

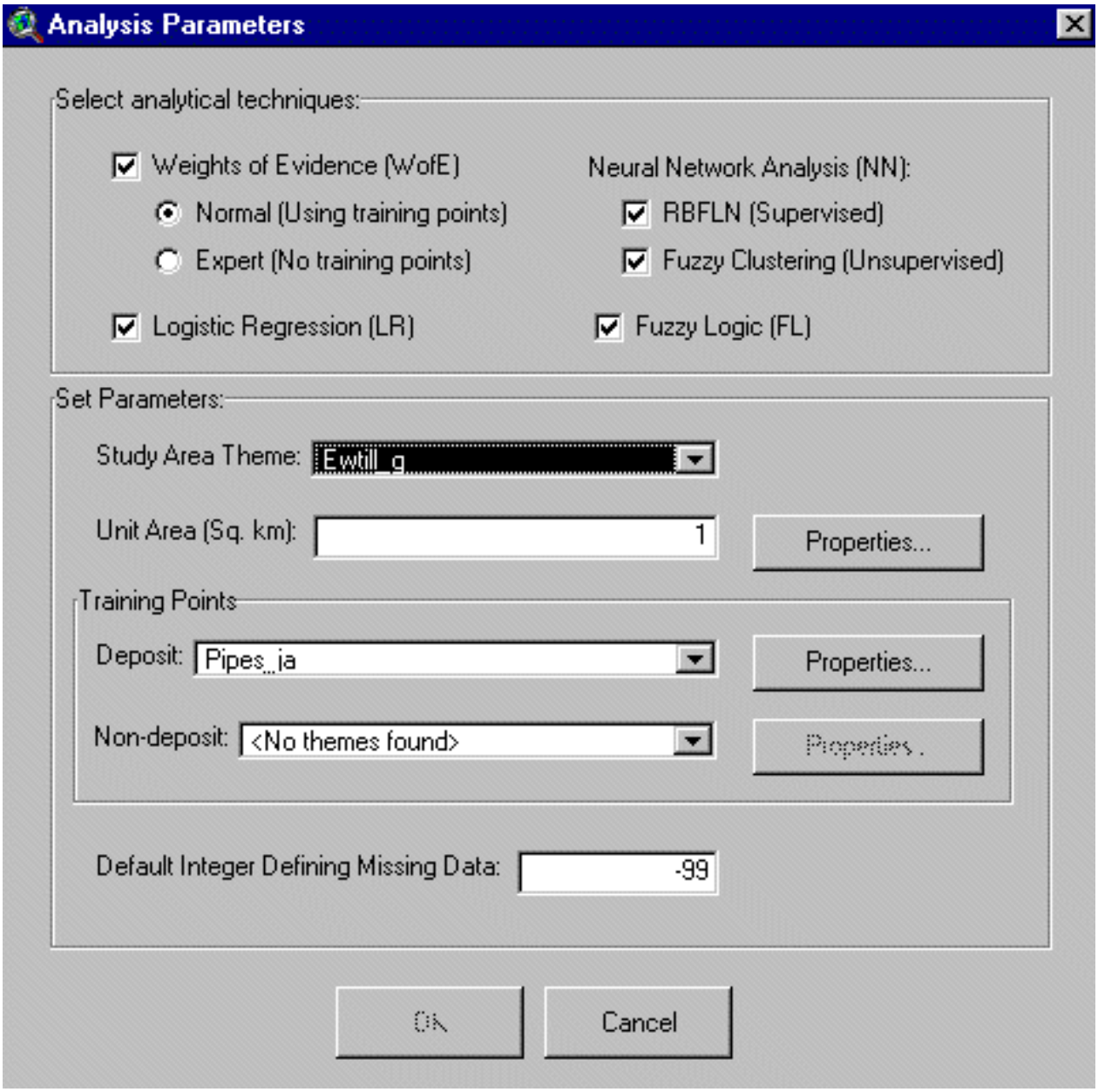
- Parameters dialog
- Study Area Grid Theme
- Unit Area
- Training Point Themes
- Missing Data
- Analysis Cell Size

Method:	Weights of Evidence		Logistic Regression	Neural Network		Fuzzy Logic
Parameter	Normal	Expert		RBFLN (Supervised)	Fuzzy Clustering (Unsupervised)	
Study Area Grid Theme	✔	✔	✔	✔	✔	✔
Unit Area	✔	✔	✔	✔	✔	
Deposit Training Point Theme	✔		✔	✔		
Non-deposit Training Point Theme				✔		
Default Missing Data Integer	✔	✔	✔	✔	✔	✔
Missing Data	Defined individually for each input theme.					
	✔	✔	✔	✔	✔	✔
Grid Cell Size	Defined by selecting Analysis --> Parameters... and specifying cell size, else defaults to the minimum cell size of inputs.					
	✔	✔	✔	✔	✔	✔
Method uses Unique Conditions Grid/Table	✔	✔	✔	✔	✔	

This menu item opens the Analysis Parameters dialog box. Select this option to set and edit parameters. Each parameter is described below. Once the parameters are set they remain in effect until changed for any analysis done in the active View with the following exception:

The extension sets the theme you select for the Study Area Theme as the Mask in the current view's Analysis Environment. This parameter can be changed via the Analysis à Properties… dialog. Check your analysis parameters before resuming any analysis to ensure that parameters are set as you expect.

Analysis Parameters Dialog



What happens to the parameters you have set when you change views or reopen a project file

If you activate a View to which your analysis parameters do not apply, most of the SDM menu items will be disabled and you will need to specify your parameters again before performing any analysis.

If you reopen a project file, the parameters are saved with the dialog, and should not have to be reset if you resume working with themes in the same View document.

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Study Area Grid Theme

Arc-SDM requires that an integer grid theme be specified as a Study Area Theme for all methods. The Study Area Theme is a theme based on a grid data set that defines the geographic extent of the analysis study area. It is set as the Analysis Extents and Mask in the current View's Analysis Environment.

Select Study Area Theme from Combo Box

The combo-box labeled 'Study Area Theme' contains a list of all integer grid themes in the current view. Select the theme you want to use as the study area theme. The current Analysis Mask, if any, is displayed by default.

Selecting a new study area theme will cause the controls in the Unit Area Properties dialog to be recalculated.

How the Study Area Grid Theme defines your study area

- all cells containing a value define the study area
- all cells containing ‘No Data’ are considered outside of the study area

'No Data' represents a Null cell value. (It corresponds to -9999 in ARC/INFO.)

Study Area Grid Theme

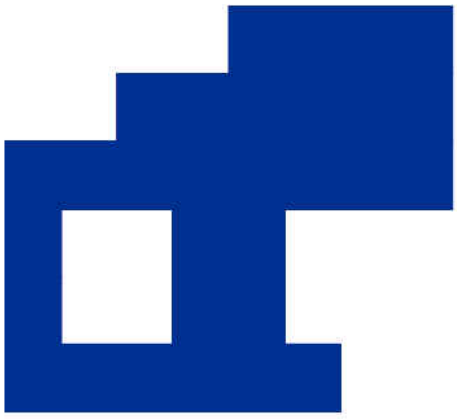
0	0	0	0	1	1	1	1
0	0	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	0	0	0
1	1	1	1	1	0	0	0
1	1	1	1	1	1	0	0

Defined Study Area

Study Area Grid Theme

ND	ND	ND	ND	2	2	2	2
ND	ND	1	1	1	1	2	2
1	1	1	3	3	1	1	1
1	ND	ND	3	3	ND	ND	ND
1	ND	ND	3	3	ND	ND	ND
1	1	1	3	3	1	ND	ND

Defined Study Area



ND = No Data

What you can use as a Study Area Grid Theme

If you want to use a data set as both your Study Area Theme and as an Evidential Theme:

ArcView on-line Help Topic: Cutting, copying and pasting themes

Make a copy of the Grid Theme:

1. Make your grid theme active by clicking on its legend in the View's Table of Contents
2. Select 'Copy Themes' from the 'Edit' menu.
3. Select 'Paste Themes' from the 'Edit' menu, or, press Ctrl-V to paste a copy of the Grid Theme into the View.

Ensure that the copy has a different name from the 'original' theme by renaming one or both themes:

To rename a theme:

1. Make the Grid Theme active by clicking on its legend in the View's Table of Contents
2. Select 'Properties' from the 'Theme' menu
3. Edit the Theme Name: and click 'OK'

You can also copy themes to other views.

How you can create or prepare a Study Area Grid Theme:

ArcView on-line Help Topic: Reclassifying the cell values of a grid theme

Analysis-->Reclassify...

Reclassify one or more classes that define areas outside the study area to 'No Data'

1. Set the Analysis Extent, Cell Size and Mask under the 'Properties' item in the Analysis menu.
2. Make the Grid Theme you want to reclassify active by clicking on its legend in the View's Table of Contents.
3. Select 'Reclassify...' from the 'Analysis' Menu
4. Type 'No Data' in the 'New Value' column for any of the rows that you want to reclassify to Null (areas outside the study area). 'Tab' out of the cell you are modifying to ensure that your edits register.
5. Click 'OK'

This will calculate the reclassified grid and add it to the top of the Table of Contents of the current

View, with the name 'Reclass of' <Input Theme Name>.

Creating a "rectangular" Study Area Grid Theme

You can create a grid with cells containing a single value from scratch.

1. Define the extents and cell size of the study area in the Analysis Properties dialog
2. Select 'Map Calculator...' from the Analysis menu.
3. Build the definition of the new grid using the controls in the dialog:

   Click one or more digits in the number keypad to define the value you want to fill the grid's cells.

   Click 'As Grid' to add the .AsGrid request to the grid definition.

   Click 'Evaluate'.

You can also type the expression in the display window, although ArcView is finicky about format including spaces.

Convert a set of polygons whose extent defines the study area to a Grid

1. Define the extents and cell size of the study area in the Analysis Properties dialog
2. Make your polygon feature theme active.
3. If only a subset of the polygons define your study area:

   Click the Query Builder  button to open the query dialog; define a query to select the polygon subset.
4. Select Convert to Grid... from the Theme menu to make a new grid and add it as a Grid Theme to the current view.

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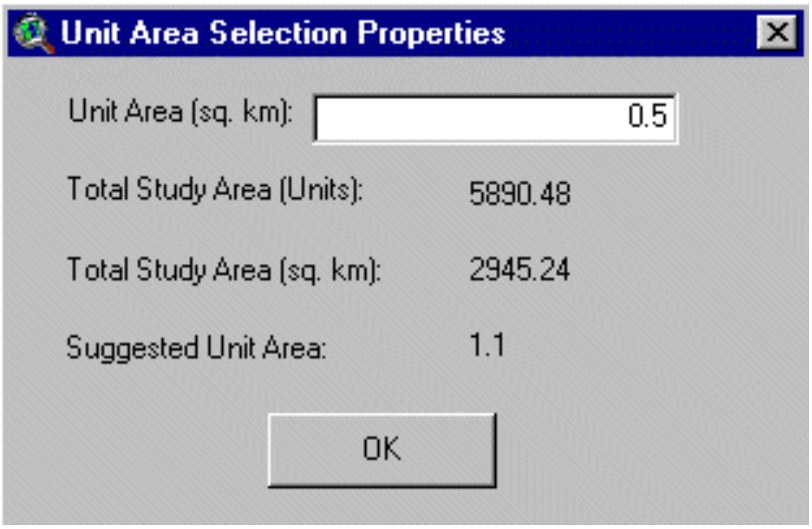
Defining Area Units

You need to define a unit area that Arc-SDM will use as the area unit of measurement during calculations for weights of evidence, logistic regression and neural network analysis. Input a unit area in km^2 in the text input line labeled 'Unit Area (Sq. km):' When you change the unit area, the total study area measured in units area will be updated.

Click the 'Properties' button to display a dialog with more information to assist in the selection of the unit area.



The unit area Properties dialog reports the following information:

- Total Study Area (Sq. km)
- Total Study Area (Units)
- Suggested Unit Area (Sq.km)

The total study area reported in km^2 and in unit cell area in the Study Area/Unit Area of the Analysis Parameters dialog box are based on the area of Study Area Theme pixels containing values. The area reported in the weights area, for example the cumulative area of all classes in an evidential theme, may vary from this area because the output cell size differs from the cell or pixel size of the study area theme, or because the area of all classes in the evidential theme is less than the study area defined by the study area theme. The study area theme area is used as the total area in the weights formulas in these cases.

The **Suggested Unit Area** is calculated using the following equation:

suggestedValue = (totalStudyArea / total TrainingPoints) / 40

This suggested value is a guideline. Typically your unit area should be about the same or smaller than the suggested unit area.

The Expert Weights of Evidence option

This option does not rely on a user specified unit area. Instead, a limiting value of unit area is assumed.

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Training Point Themes

The Training Point Theme(s) are point data sets. Arc-SDM deals with two types of training points, one that defines the occurence of a point object, and the other defining the absence of a point object. For mineral exploration, each "deposit" training point is a known mineral occurrence or deposit. Each "non-deposit" training point is the location where there is known to be no mineral occurrence.

Weights of evidence normal option, logistic regression and the neural network RBFLN option require a deposit training point theme. Only the neural network RBFLN option requires a

'non-deposit' training point theme.

Usable file formats

- ArcView shape files
- ARC/INFO point coverages
- an event theme created from a data set containing (x,y) coordinates

ArcView on-line Help Topic: Add Event Theme (Dialog box)

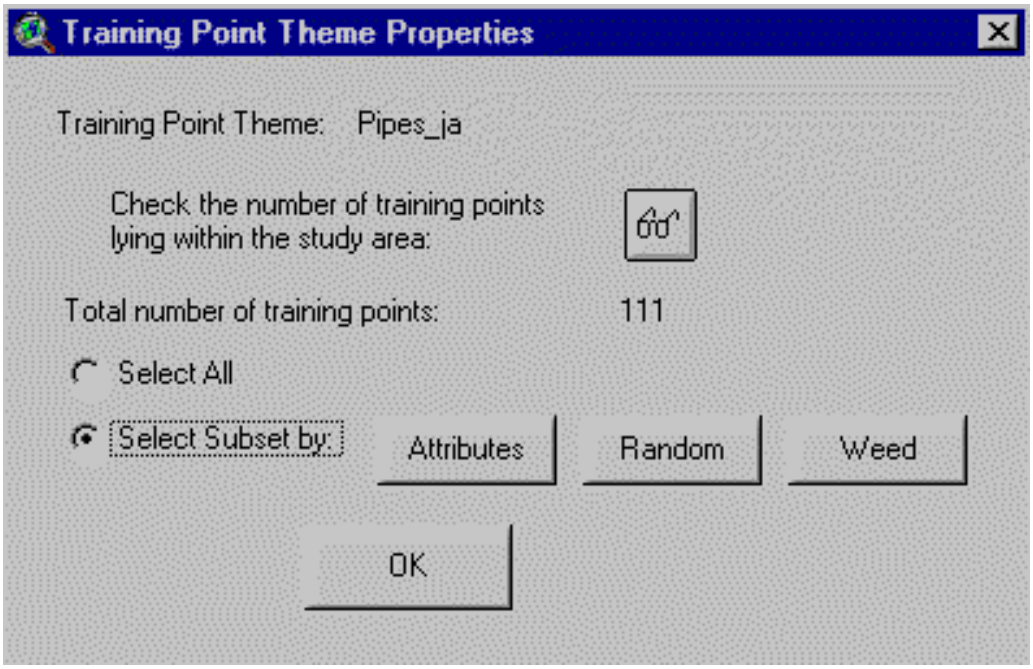
NOTE: Arc-SDM will not work with a multi-point feature type, one of the feature types available in ArcView.

A subset of this point data set can also be used for analysis without creating a new data set.

To use a subset of your theme:

Select a training point theme from the drop-down list.

Click the 'Properties' button beside the drop-down list. The training points properties dialog:



Total Number of Training Points

The total number of points in the specified training point theme is displayed. If you have selected a subset of your training points, the total number of points in the subset is displayed. This number may be more than the total number of deposits used in weights calculations if one or more of the points fall outside the study area as defined by the study area theme.

You can determine how many of your selected points fall in the study area by clicking on the 'Inspect Training Points' button,  .

Use all of your training points or a subset

You can toggle between 'All' of the points in your training point theme, or a 'Subset' of them by clicking the radio buttons labeled 'Select All' and 'Select Subset by:'. Clicking the 'Select Subset by:' applies the last defined subset if it is applicable to the currently selected training point theme.

The buttons labeled 'Attributes', 'Random' and 'Weed' are also enabled with the 'Select Subset by:' button is selected.

Clearing a subset

To clear a subset, click the 'Attributes' button, and then click 'OK' in the dialog box that appears. You can use any of these options to reduce or select a subset of your training point set.

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Select a Subset by:

- Attributes
- Random Selection
- Weeding
- Location

Attributes

You can define or change a subset of the training points based on its attributes by clicking the button labeled 'Attributes'. This displays ArcView's Query Builder dialog.

Build your query and click 'OK'.

ArcView on-line Help Topic: Query Builder (Dialog box)

The total number of training points will now display the number of points identified by your query and the suggested unit area will also be updated below.

How Arc-SDM subsets the training point data set

The query will be applied to the training point theme as a 'definition'. All of the features, and their attribute records, not included in the definition will be hidden from your view. The definition query string is also set as an attribute of the theme's attribute table. You can see this query string by making your training point theme active and then selecting the 'Properties...' item from the 'Theme' menu. Click the 'Definition' option in the left column in the dialog box that appears. This definition is persistent, meaning that it will be reapplied to the point theme each time you reopen your project file.

Random

To make a random subset of training points, click the button labeled 'Random'. A dialog box is displayed which allows you specify either the number of records or the percentage of records you would like to include in the subset. If the you specify a percentage, you can see how many records this will include. Click 'OK' to make the random selection. The random selection of a subset of training points is done in two steps:

- a randomly generated number is appended to each record in the training point theme's attribute table
- a subset records is selected based on values in the random number field

Generating Random Numbers

Arc-SDM will first look for a field called 'Random' in the attribute table of the specified training point theme. If not found, an integer field with this name will be appended to the data set. A random number between 1 and 1000 (ArcView's random number generator returns integers) will be generated for each record in the attribute table and then written to the new field.

If a field called 'Random' already exists in the attribute table, you will be asked if you want to overwrite the files contained in that field. Two things to consider when deciding to overwrite previously generated numbers are:

- the numbers written to the attribute table are a means of re-establishing a randomly generated subset, or simply knowing which points were included in the subset used previously for analysis. This source of information will be lost if the numbers are overwritten, not just for this theme but also any copies of the theme that are based on these numbers.
- if any records/features were added to the data set after the random numbers were generated, they will not be included in the subset selection. If you want to include them, you should regenerate a set of random numbers and overwrite the current ones.

If you choose 'Yes', a new set of random numbers will be generated and written to the 'Random' field. If 'No', the selection will be made on existing values.

Weeding

Arc-SDM will automatically remove some points from the training point theme (not permanently!) so that there is no more than one training point per unit area. The algorithm starts with the point defined in the first record of the point theme attribute table, calculates the distance to the other points "below" it in the attribute table and removes any that are less than the distance defined by:

$$(\text{Unit Area} * 1000000 / 3.14)^{0.5}$$

Selecting the Records

Starting at the lowest random number, the next highest random number is added to the subset until the number of records in the subset is what you specified. The subset is applied to the training point theme as a theme definition. Only the randomly selected features and their attribute records can be seen in the View and Table documents. The definition query string can be looked at by selecting 'Properties...' from the 'Theme' menu in the View document's interface.

Actually selecting the subset is like selecting a subset based on attributes. In fact, once the random numbers have been written to the theme's attribute table, you can re-establish the selection at a later time by clicking the Subset by: 'Attribute' button and querying the 'Random' field using the Query Builder (see above).

Location

You can also interactively select a subset of your training point theme using the 'Select Points By Location...' item in the SDM menu. A subset definition made this way will persist only for your current ArcView session.

To subset a point theme by location:

1. Make the point theme you want to subset active.
2. Make any themes you want to use as visual guides during selection visible.
3. Choose 'Select Points By Location...' from the SDM menu. The point theme will be be made active and visible, if not already. All other themes will be made inactive. The feature selection tool is activated and a small dialog box is positioned near the top of the View's Table of Contents.
4. Manually select the points you want to include in the subset. Hold down the Shift key while selecting to add to the current selection set.
5. When you are finished selecting, click the 'Apply Selection' button on the dialog box.

To remove a selection set (select all the points in the theme):

Click 'Clear Selection'

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Maintaining a complete training point theme, as well as one or more subsets

You may want to have your complete training point theme available, as well as one or more subsets in your Views at the same time. For example, say you would like to maintain the complete set of training points, a randomly generated subset of the training points, and a second set of the points not included in the random subset. You could make these three themes as follows:

Make two copies of your training point theme by making the training point theme active and selecting 'Copy' from the 'Edit' menu. Select 'Paste' from the 'Edit' menu to paste a copy of the theme, or press Ctrl-V. Rename the copies of the training point theme.

Open the Arc-SDM parameters dialog box by selecting 'Analysis Parameters...' from the SDM menu. Make your randomly selected subset using the steps described above and click 'OK'.

Open the Theme Properties dialog for the theme you just subsetted to see the definition query string. You can make an attribute query on the Random field to subset the remaining points. For example, if the query defining your random subset is ([Random] < 498) then to select the points excluded from this subset you could apply the query ([Random] >= 498).

Default Missing Data Value

Arc-SDM handles areas of missing data in your evidential themes in different ways, depending on the method being used. How missing data is handled is discussed in the sections explaining each method.

Generally:

Method	Handling of Missing Data
Weights of Evidence	● calculation of weights for each evidential themeexcludes areas with missing data and any training points that lie in these areas ● after combining evidential themes, an uncertainty due to missing data is calculated for each unique condition that contains missing data, and this is reported in the attribute table of the response theme
Logistic Regression	areas with missing data are assigned a value that is the area-weighted mean of the known values in the study area for each evidential theme
Neural Network	● for each evidential theme, areas with missing data are assigned a value that is the area-weighted mean of the known values in the study area ● input data to the neural network module is normalized from 0 to 1, so the mean is based on these values
Fuzzy Logic	areas of missing data are assigned a fuzzy membership value that is an area-weighted mean of the fuzzy membership values defined for the areas of known data

Arc-SDM requires that an integer value defining areas of missing data be specified for every evidential theme, whether or not there is any missing data in the study area. If areas with missing data are defined in the evidential theme by 'No Data' or the absence of a polygon within the study area, Arc-SDM will fill them in 'on-the-fly' with the missing data integer. In most cases, this so that the areas can be captured in the unique conditions grid and attribute table.

You can specify any integer to define areas of missing data and this can be done at two levels: a default value is specified in the Analysis Parameters dialog by entering it in the text input line labelled 'Default Integer Defining Missing Data:' In the processing for each method, the user is prompted to specify or confirm the missing data integer for each evidential theme. Once specified for an evidential theme, the value is recorded in an ArcView table, 'SDM Theme Properties' (sdmthms.dbf). Users can change this value at any time.

TIP: While you are able to specify a different missing data value for each evidential theme, it is recommended that the same value be used for all evidential themes for the sake of consistency and data organization.

What is the difference between 'Missing Data' and 'No Data'

In an Arc-SDM FAQ, this question would be at the top of the list!

'No Data' is a concept used by Spatial Analyst to specify that there is no data value associated

with one or more cells in a grid. (It corresponds to -9999 in Arc/INFO.) Cells with No Data can be symbolized, reclassified, displayed in a legend and handled in different ways during However, they are not included in the attribute table of an integer grid theme. In the context of Arc-SDM, cells with 'No Data' perform different functions and are handled in different ways:

For the study area grid theme, cells containing 'No Data' define areas that lie within the extent of the study area grid theme but which lie outside the study area. This allows a non-rectangular study area to be used.

Default symbolizations of new themes generated by Arc-SDM, the 'No Data' class is set to a transparent fill.

Cells with 'No Data' in a grid evidential theme (or areas with no polygon, for a feature evidential theme) fall within the study area are assumed to define areas where data is missing. In this case the concepts of 'No Data' and 'Missing Data' refer to the same areas of an evidential theme. The term 'Missing Data' is specific to Arc-SDM. Each method in Arc-SDM handles missing data in an explicit way but cannot apply their techniques to 'No Data' cells. In order that 'No Data' areas be handled as missing data, they are replaced on-the-fly with a user specified integer value.

Analysis Cell Size

The analysis, or output, cell size is not set using the 'Set Analysis Parameters' function. If the Analysis Cell Size has not been set to a specific value, Arc-SDM will set it to the minimum of inputs to a function. This is reported to the user at the time that the setting is changed. (The Spatial Analyst default is the maximum of inputs.)

You can set or change the Analysis Cell Size by selecting the Properties... item from the Analysis menu in the View interface. For more information about the Analysis Properties and the Analysis Environment, please refer to 'What you need to know about ArcView and Spatial Analyst' or to the **ArcView on-line Help Topic: Setting the analysis properties for a view**

Note that the analysis cell size and the unit area are unrelated.

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Calculate Theme Weights…

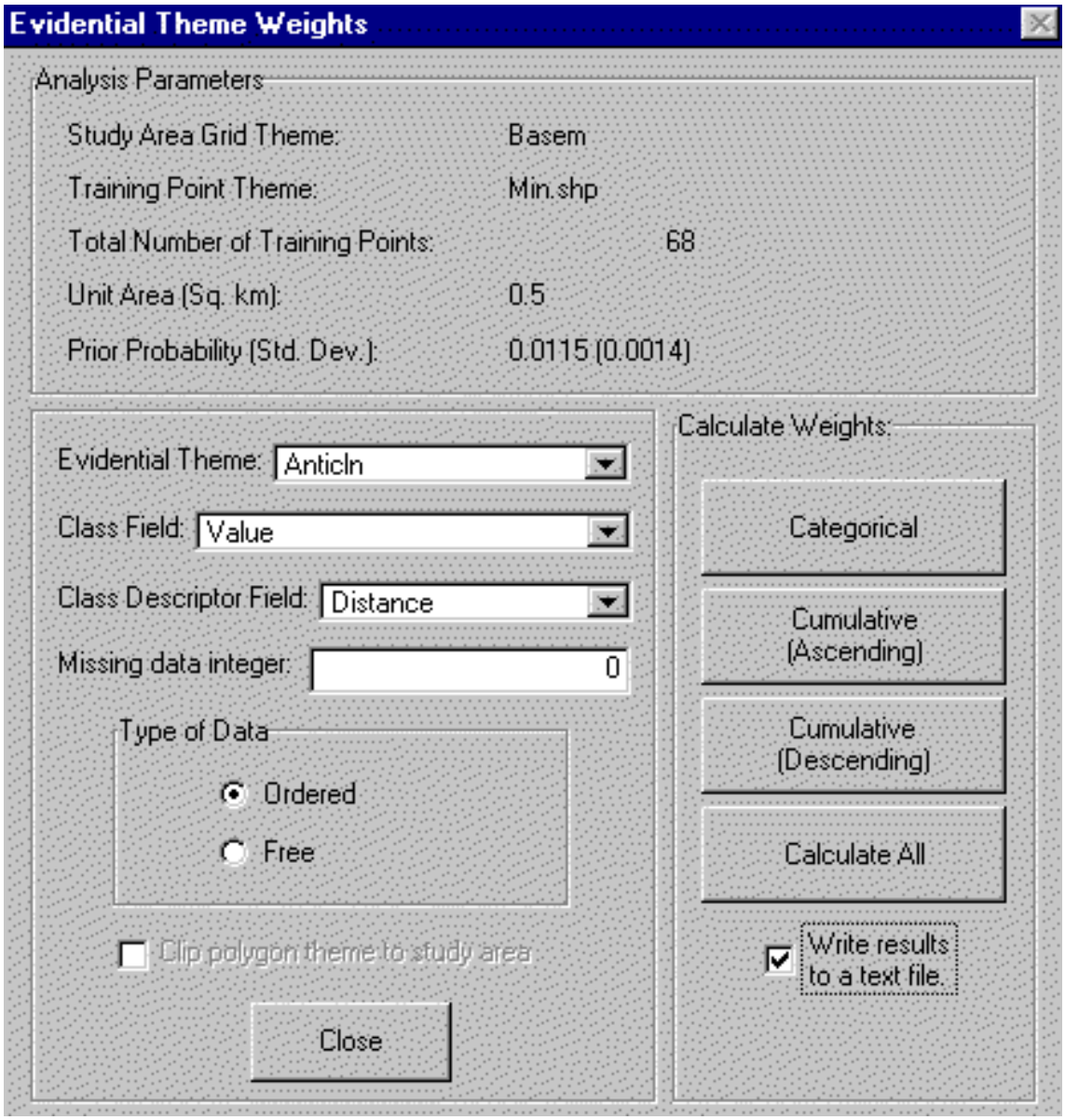
- Evidential Theme Weights dialog and its components
- Output weights tables

Select this option to calculate weights for a single evidential theme. A set of statistics, including the area, number of training points, W+, W-, Contrast and their standard deviations, as well as the studentized Contrast are calculated for each class in the specified class field and written to a *.dbf file and added as a Table document to the project. For ordered data, these statistics can also be calculated for cumulatively from lowest to highest class (ascending) and highest to lowest class (descending).

The resulting tables can be reviewed and used to determine appropriate generalizations or grouping of classes for input to calculations of the posterior probability map.

Charts can also be created based on these tables as additional aid to interpretation.

Evidential Theme Weights dialog and its components



Parameter Display

The following items, displayed at the top of the dialog, are either set by selecting the Set Analysis Parameters... menu item, or calculated from these parameters.

- Study Area Grid Theme
- Training Point Theme
- Total Number of Training Points
- Unit Area (Sq. km)
- Prior Probability (with its standard deviation following in brackets)

Only the number of points that fall in the study area is reported as the Total Number of Training Points. This number may be less than the total number reported in the Analysis Parameters dialog because the total number of points in the training point theme is reported there. (To see how many training points fall within the study area while setting parameters, click the Inspect Training Points button  .)

To change one or more of these parameters, close the Evidential Theme Weights dialog box and choose Analysis Parameters…from the SDM menu.

Parameter	Description
Evidential Theme	Select the Evidential Theme you want to calculate weights for, from the combo box. All of the integer grid and polygon feature themes, other than the study area grid, are available for selection.
Class Field	Select the field from the Evidential Theme attribute table that contains the classes for which you want to calculate a weights table. You are able to use string and real number type fields, in addition to integer fields. String fields are recommended only for free or categorical data. If you would like to include or preserve descriptive strings contained in the attribute table (or a table joined to it), you can select a Class Description Field below.
Class Description Field	Select a field from the Evidential Theme attribute table that contains the text descriptions of the classes you would like to use. Select <None> if you don't have or don't want to use a description field. If you select a class description field, and there are missing data in the evidential theme represented by No Data, the string "Missing Data".
Missing Data Integer	Specify an integer used to define areas of missing data. This value is persistent with the project file. The default value is one specified in 'Set Analysis Parameters'. Refer to Missing Data Integer for more information.

Type of Data	Specify whether the data should be treated as Free or Ordered. This choice affects whether cumulative weights can be calculated for the data. This characteristic is also written to a Table named 'Data Type of Weights Themes' so that Arc-SDM functions 'remember' later and the data type does not have to be re-specified. Once the evidential theme and its data type is written to the 'Data Type of Weights Themes' table, you can change its type by editing the table. Open the table document, from the Table menu, choose 'Start Editing'. Edit the data type, or delete the record. To finish editing and commit your changes, choose 'Stop Editing' from the Table menu.
Clip polygon theme to study area	For polygon feature evidential themes only. If the extent of the evidential theme is larger than the study area, check this box to automatically clip it during processing. Note: This process is very slow. It is recommended that clipping evidential themes be performed as a pre-processing step.
Calculate Weights Tables	
Categorical	calculates the weights for each class and writes these value to a table based on a dBase file. The default table name is ***<evidential theme name>*-CT** (dBase file name is the same as the table name with a .dbf extension).
Cumulative (Ascending)	calculates the cumulative weights from the first class to the last and writes these values to a table based on a dBase file. The default table name is ***<evidential theme name>*-CA** (dBase file name is ***<evidential theme name>*-CA.dbf**).
Cumulative (Descending)	calculates the cumulative weights from the last class to the first class and writes these values to a table based on a dBase file. The default table name is ***<evidential theme name>*-CD** (dBase file name is ***<evidential theme name>*-CD.dbf**).
Calculate All	Calculates and writes all of the above three tables.

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The Output Weights Table

To view the Weights Table, switch to the project window, click the Tables icon, select the name of the table you specified and then click the Open button.

The Weights Table(s) contain the following fields:		
Alias	**Name**	**Description**
Class	**Class**	the numbers or text identifying the classes or values in the attribute field you specified.

<source field alias>	<source field name>	this field will have the same name as the source field in the evidential theme's attribute table
Area (sq. km)	Area_sq_km	the area of each class given in km^2.
Area (Units)	Area_unit	the area of each class given in unit cells.
#Points	No_points	the number of training points that fell in the area of the class.
W+	Wplus	the value of W+
s(W-)	S_wplus	the standard deviation of W+
W-	Wminus	the value of W- (the weight for all other classes combined)
s(W-)	S_wminus	the standard deviation of W-
Contrast	Contrast	the difference between W+ and W-
s(C)	S_contrast	the standard deviation of the Contrast
stud(C)	Stud_cnt	the studentized Contrast: the contrast divided by its standard deviation

Equations used to calculate Weights

dBase field names vs ArcView table field names

The field names in ArcView table documents can be long and can incorporate special characters while field names in the underlying or source file format, dBase, cannot contain special characters and are limited to 10 characters. The ArcView names, as listed above, are only maintained with the ArcView table document. (A Table document can also use INFO and tab or comma delimited text files as its source.)

If the source dBase file is opened in another software, such as Excel, or added to another ArcView project as a new table document, the table names won't be available. To be able to take advantage of ArcView's naming capabilities, yet maintain legibility at the dBase level, both a name and an alias for that name have been set for each field.

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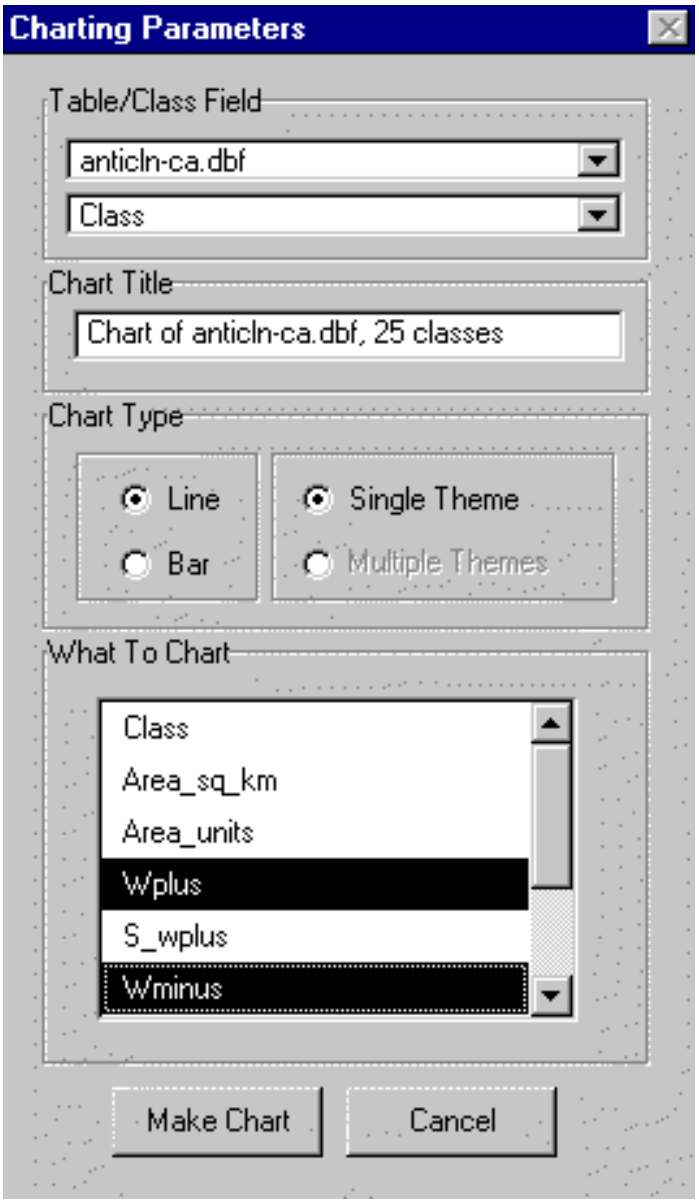
Create Charts…

- The charting dialog and its components
- The Line/Bar Toggle button

The Create Charts... function is designed to let you chart results of your weights calculations quickly. You can also use it to chart values in any table in your project. To create a chart choose Create Charts… from the SDM Menu. This displays the Charting Parameters dialog box.

Charting Parameters



Set the following parameters:

Table	Select the table on which you want to base the chart. All of the tables currently available in your project are listed. NOTE: If the table you select does not have a unique name, the incorrect table may be selected for charting.

Class	Select the field containing the classes for which you want to chart variables. All of the string and numeric fields are available for selection.
Title	Type in a title for the chart. A default title will be generated if you leave this line blank. To change the title once the chart has been created, refer to **ArcView on-line Help Topic: Changing the title in a chart**
Chart Type	1. Specify either a line chart or bar chart. Once your chart has been generated, you can easily toggle to the other chart type using a button in the chart document interface. 2. If both the 'Single Theme' or 'Multiple Themes' radio buttons are active, select the one you prefer. The 'Multiple Themes' option was designed to create a specific style of bar chart based on a weights of evidence table (default name: woe<#>.dbf) created using the 'Calculate Response Theme...' function, so this radio button will often be disabled.
What to Chart	The names of all the table's numeric fields are displayed in a list. Select the fields that contain the values you want to chart. To select more than one field, hold down the Shift-key while you click on each of the fields you want to use.

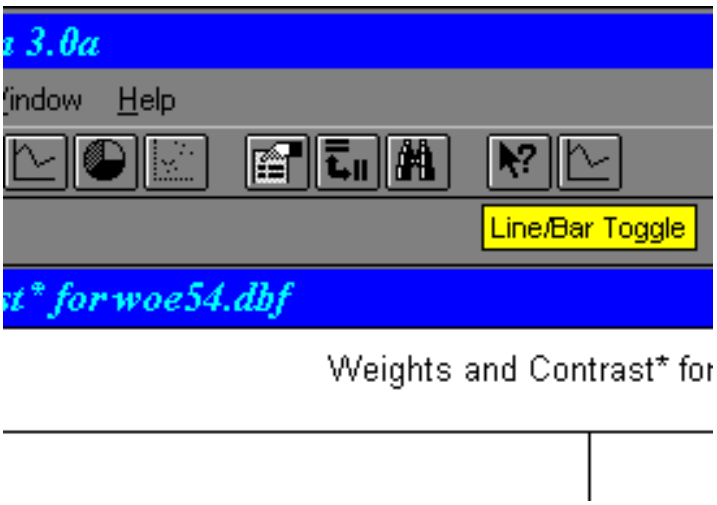
Click the '**Make Chart**' button to create the chart. The chart will be automatically displayed when complete.

The Chart

Charts are a document type in ArcView. Unlike themes and table, which depend on external data sources, the chart document is internal to ArcView and is saved entirely in your project file.

ArcView on-line Help Topic: What is a chart?

The chart toggle button (Line/Bar Toggle)



Arc-SDM adds a chart 'toggle' button to ArcView's Chart document GUI. The button is located at the far right of the button menu and allows you to toggle the displayed chart between line and bar type. Click the button to change the chart style. Depending on your chart, one style may be easier to interpret than the other.

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Generalize Evidential Themes

- the Generalize Evidential Theme dialog and its components
- common components of the generalization tool dialogs
- Reclassification Tools – Class to Class Mapping Tool
- Reclassification Tools – Grouping Tool
- Threshold Selection Tools – common components
- Threshold Selection Tools – Class-Cutoff Tool
- Threshold Selection Tools – Chart Tool
- Threshold Selection Tools – Table Tool

A set of tools have been developed to facilitate the generalization of data sets. Generalization in Arc-SDM refers to the 'reclassification' of evidential themes. The tools developed for Arc-SDM all use a similar method: the user selects the evidential theme and the field containing the classes to be generalized. Using one of the generalization tools, the user interactively specifies how the current classes are to be generalized and what the new classes will be. Once specified, the new classes are automatically appended to the evidential theme's attribute table.

A new data set is not created. Instead, the new classifications are appended to the attribute table. New descriptive text labels can also be appended during the generalization process. Because the generalization tools work with the attribute table, they work the same way with either polygon or grid themes.

Frequently an evidential theme has been generalized to two classes, creating a binary map in which each cell is either on or off a pattern. In some cases,reducing an evidential theme to a binary pattern may not be the most appropriate way of handling the data. A geological map, for example, might be more suitably treated as a three or four class map. Any table or chart created with the two previous functions can be examined to determine the optimum way of generalizing each of your evidential themes.

In the evidential theme's attribute table, the fields added by reclassification record the reduction of classes from initial exploration up to the stage of input for calculating a response theme. And in conjunction with weights tables and charts based on them, you can see the rationale for the generalization, which may be in several stages.

Spatial Analyst's Reclassification Function

Spatial Analyst has a reclassification tool for grids which is necessary for some conversion or reclassification of data and which you may prefer for generalizing grid evidential themes. To use this function:

Make the theme you want to reclassify active.

Select Reclassify... from the Analysis menu.

ArcView on-line Help Topic: Reclassifying the cell values of a grid theme

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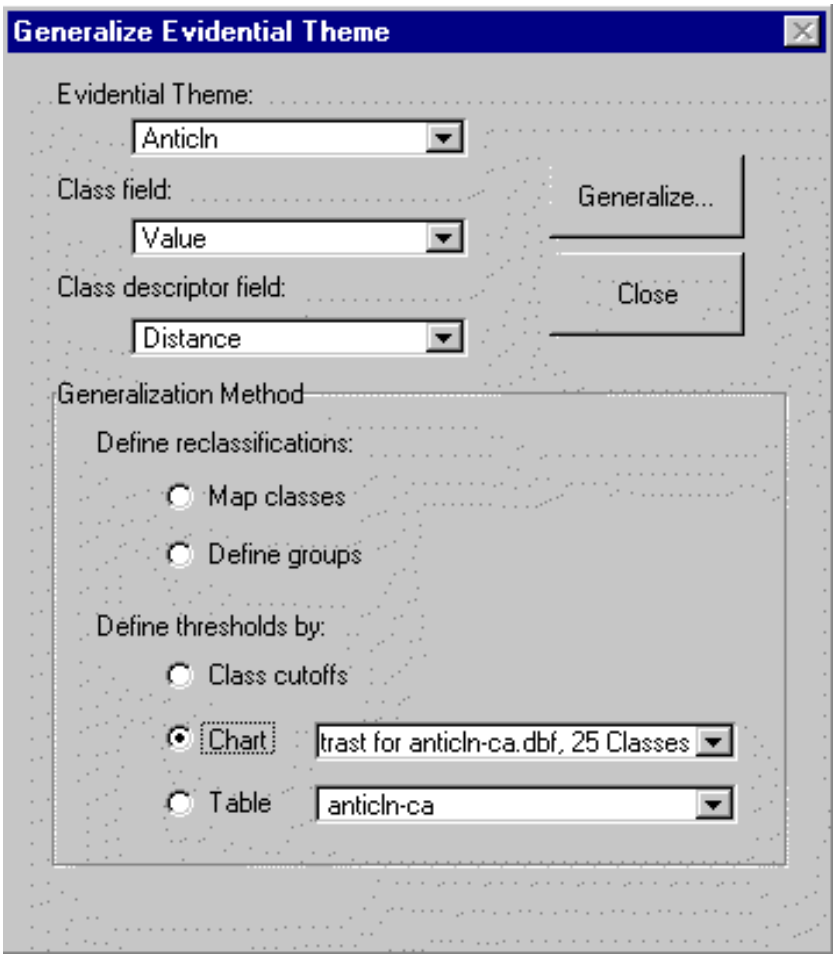
What you need to specify in the Generalize Evidential Theme dialog box



Evidential Theme – All evidential themes in the current view are displayed in the combo box. Select the evidential theme theme you want to generalize.

Class Field – All of the numeric fields found in the attribute table of the evidential theme selected above are displayed in the combo box. Select the field in the evidential theme's attribute table that contains the classes you want to generalize.

Class Descriptor Field – All of the string fields found in the attribute table of the evidential theme selected above are displayed in the combo box. If you are going to use one of the threshold selection tools (see descriptions below), the tool will try automatically to parse strings that define continuous ranges of numbers. You will edit any descriptive text that is automatically generated. Select the field containing descriptions of the classes. If there is none, select '<None>'. Whether you specify a class description field or not, you will be able to specify class descriptions for your new generalized classes and a name for the field to which they will be written.

Generalization Method – Select one of the following generalization methods or tools. The tools are each described in more detail below.

Define Reclassifications: Map Classes; Define Groups. These two tools were designed to generalize free or nominal type data. The grouping tool can be used for any data to base your new classes on queries of the data attributes.

Define Thresholds by using: Class cut-offs (slider bar/text input); Chart; Table. These tools were designed to generalize continuous or ordinal data, based on cumulative ascending or descending tables.

Generalize... – Clicking the 'Generalize...' button will display the dialog specific to the generalization tool you have specified, along with any ArcView documents, that is a chart or table, to be used in the generalization.

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Common components of the Generalization Tool dialogs:

Each of these dialogs have the following controls or elements in common:

The **name of the evidential theme** you are generalizing is displayed near the top of the dialog. For the reclassification tools, class field and class description field, if any, will also be displayed. Typically the class field and class description field are described as the 'current' fields.

Default names for new class and new class descriptions fields are displayed on all dialogs. The default class field name is the current class field with an integer appended or incremented to the end of the field name. For example, if you are generalizing classes in a field called 'Value', the default field name for the new class field will be 'Value2'. If the attribute table already contains a field names 'Value2', the default will be 'Value3', etc. The controls work with field names, rather than aliases. The default class description field name is created in the same way, unless no current field was specified (<None>): then the default name is 'Descrip'. You are able to edit the default field names.

Define Reclassifications:

Map Classes – allows you to explicitly map each class to a new one, as well as provide descriptive text for each label.

Define Groups – allows you to assign a group of records/classes to a new class. The group(s) of records/classes are defined by applying an attribute query.

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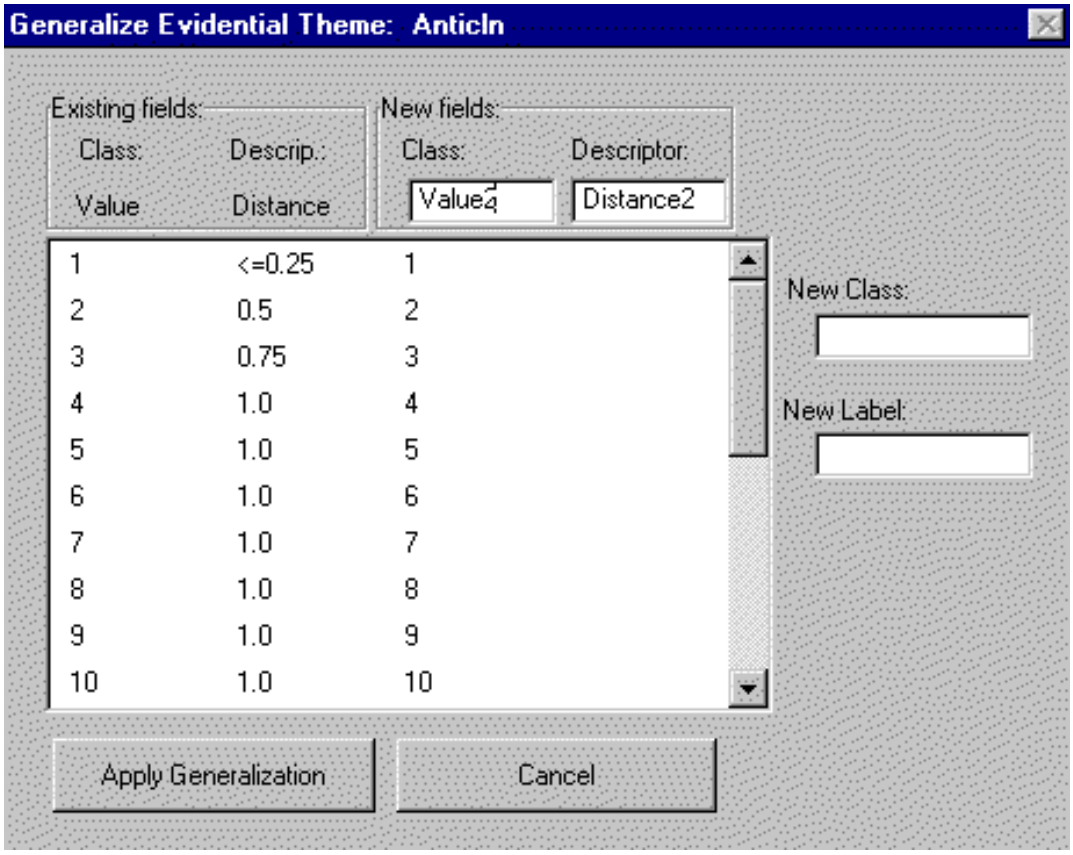
Class to Class Mapping Tool for generalizing Evidential Themes with Categorical Data

To use the Class to Class Mapping Tool, select Generalize Evidential Theme from the SDM menu. Select the Evidential Theme, the Class Field (field containing classes you want to generalize) and a Class Descriptor Field (field containing strings that describe the classes in the class field). Select the 'Map Classes' Generalization method (under 'Define Reclassifications'). Then click the 'Generalize' button. The following dialog box will be displayed. A description of each of the elements in the dialog is described below.



The contents of the list box display:

Column 1: the classes found in the Class field specified in the previous dialog box are listed.

Column 2: the text strings found in the Class Descriptor Field specified in the previous dialog box. If <None> was specified, this column will be blank.

Column 3: will contain the new generalized class values after you edit them. It initially contains the same values as column 1.

Column 4: is initially empty but will contain descriptive text of the new classes if you add it. (If no text labels are added to this column, no new label field will be added to the evidential theme attribute table.)

Editing the values in the list box display to define your new classes

There are two ways to edit values in the list box:

1. a) Double-click any value in columns 3 or 4 (the new class values or their descriptions) to open an edit box.

b) Enter new values and click 'OK'.

To edit more than one row at once, hold down the Shift-key while selecting adjacent rows. Double-click on the last row to select. The values entered in the edit dialog will be written to all of the selected cells.

2. a) Select the cells to edit. Enter the new class value in the text entry box to the right of the listbox, labelled 'New Class:'.
b) Press Enter.
c) Enter a text description in the text entry box labelled 'New Label:'.
d) Press Enter.

Pressing Enter repeatedly will write the same values to successive cells in the list box.

Applying the generalization

When editing is complete, click the 'Apply Generalization' button. The new fields will be added to the evidential theme's attribute table.

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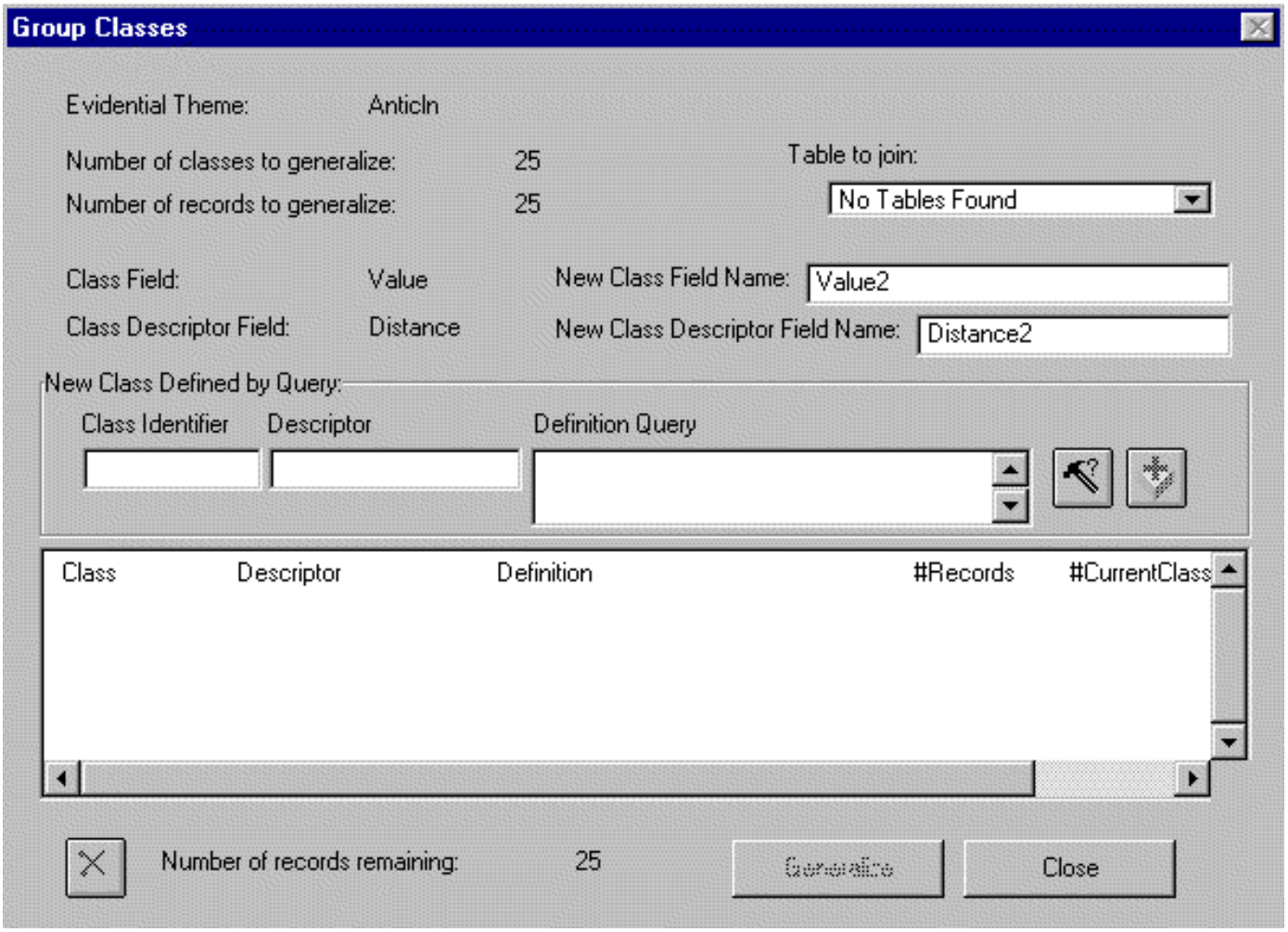
Grouping Tool for generalizing Evidential Themes with Categorical Data

To use the Grouping Tool, select Generalize Evidential Theme from the SDM menu. Select the Evidential Theme, the Class Field (field containing classes you want to generalize) and a Class Descriptor Field (field containing strings that describe the classes in the class field). Select the 'Define Groups' Generalization method (under 'Define Reclassifications'). Then click the 'Generalize' button. The following dialog box will be displayed. A description of each of the elements in the dialog is described below. Click on any of the elements to jump to its description.

While using the Grouping tool, it may be helpful to view the table containing the attributes that you are using to define some or all of the groups. Once the dialog is opened, you can switch to the project window and open a table.



Parameter Display

In addition to the items you selected in the previous dialog, and described previously, the following are also reported:

Number of records to generalize – This reports the number of records in the evidential theme's attribute table. You can use this as reference in conjunction with the 'Remaining number of records:' reported at the bottom of the dialog. You will only be able to apply your generalization after all of the records have been grouped.

Number of classes to generalize – This reports the number of classes contained in the class field, which will be the same or fewer than the number of records.

Associated table to join to attributes for queries – This combo-box lists any weights tables that you have calculated for an evidential theme (it looks for a field named "Class"). If you want to group your attribute records based on weights, contrast, etc., you can calculate the associated table. Once you select a table, it will be joined to the attribute table based on matching values between the "Class" field and the class field you specified previously.

Defining a generalization group

New Class Field Name – Type in a field name for a new field to which your generalized classes will be written. You need to type in a name before specifying any new class values.

New Descriptor Field Name – If you would like to add text strings that describe your generalized classes to the evidential theme's attribute table, type in a name for a new descriptor field here. You need to type in a field name before specifying descriptive text for the generalizations. If no name is entered, no label field will be created, even if descriptive text has been included in generalization definitions (this could happen if you entered a field name here and subsequently deleted it).

New Class – This is the first control to enter information about a new generalization. The field only accepts

integers. You cannot enter anything to this line if you have not specified a class field name above.

New Descriptor – Type in a string to describe your class integer, if you want. Data in this line are not required to create a generalization.

Group Definition and Query Builder  **–** The Group Definition text box and the query builder work in tandem. You can type the query that defines your group directly in the text box but most of the time it will be much easier to use the query builder to create your query. Click the query button to open the query builder. The fields in your attribute table, as well as the fields in an associated table, if you specified one, will appear in the left column. As you click on a field name, the values, in addition to zero, will appear for selection in the right hand column.

Unfortunately, there is not a way to define a group of records based on the occurrence of null values in the weights table (cells are blank). This would be a problem if no training points fall within a class, or if all training points fall within a class. To include these classes, you can query on the #Points field (e.g. ([#Points] = 0)).

Once you have specified a class integer and a query to define the group of records/classes to generalize, the 'Add Generalization' button will be enabled.

Add Generalization  **–** Click this button to add your group definition to the list of definitions in the display window. The values you entered in the input controls will be appended to the display of group definitions below, and they will be cleared from the input controls. The 'Add Generalization' button is enabled only when an integer has been specified as a new class value and valid query has been defined to group a set of records for generalization.

Generalization Display Window – Displays the generalization 'groupings' that will be applied to the evidential theme attribute table. A group definition or generalization will not be applied to an attribute table until it has been moved from the input controls to the display window.

To select one or more rows in the display, drag your mouse over the rows you want to select. Only contiguous rows can be selected at one time.

If you would like to edit one of the displayed rows, select it and click the 'Remove' button located below the display on the left side of the dialog. This will remove the generalization from the display window and display its components in their respective input boxes. You can edit any of the parts and re-add it to the display.

The Class, Description, and Definition that you specified before are written to a new row in the generalization display window. In addition, the number of records and the number of current classes selected by the query are displayed:

#Records – The number of records in the evidential theme attribute table that are selected when the query string/group definition is applied. When the generalization is added to the display, this number is subtracted from the number of records remaining to be processed that is reported at the bottom of the dialog.

#CurrentClasses – The number of unique classes contained in the class field that are represented by the records selected by the specified query.

Remove Generalization  **–** The 'Remove generalization' button is enabled when one or more of the rows in the generalization display window are selected. Clicking the button removes the selected rows from the display. The last row only will be displayed in the input controls, so if you are removing rows to edit them, remove them one at a time, edit them and re-add before removing the next.

Reporting the Number of records remaining – The initial 'Number of records remaining:' is the total number of records in the evidential theme attribute table. As you define queries to select groups of records for assignment to a new generalized class, and add them to the display window, the number of records is subtracted from the number of records remaining. When all of the records in the attribute table have been assigned to a group, the number of records remaining will be zero and the 'Generalize' button will be enabled.

Generalize – Applies the generalization as defined by the new classes, new class descriptors and queries of existing classes to the attribute table. Each row in the generalization display window is processed in sequence: the query is applied to the attribute table and the specified class and class descriptor are written to new fields for

the records selected by the query. The selection is removed and the next query is applied, until all of the rows have been processed.

Close – Clicking the close button closes the dialog and unjoins any tables joined to the evidential theme attribute table.

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Define Thresholds:

Common components

Three variations of a thresholding tool have been developed. Because these tools are so similar, the following description applies to all three. The differences among the three are described briefly following this section.

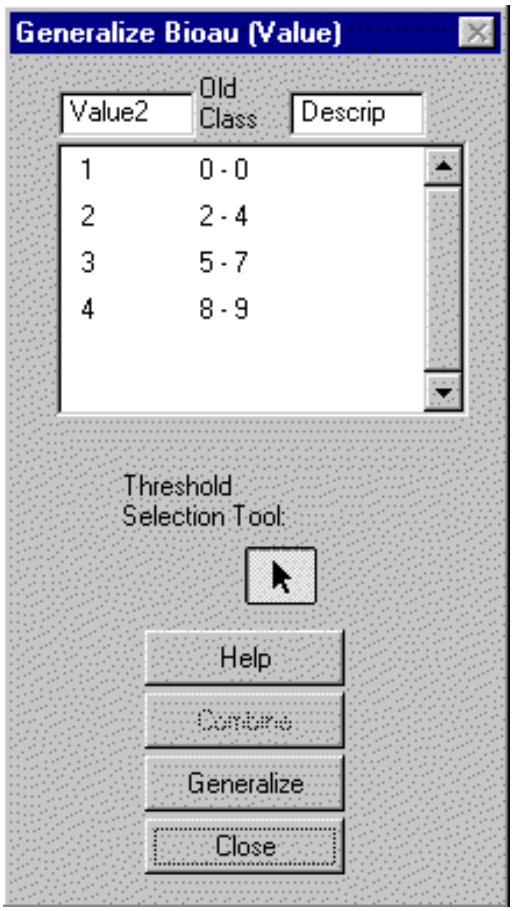
The threshold select tools are designed to define the breakpoints or thresholds between groups of existing classes in continuous or ordered data.

When you select thresholds you are defining the upper limit of a classification. For example, if you have a data set with values that range from 1 - 10 and you specify two thresholds, 4 and 7, the following class grouping will result:

1 - 4; 5 - 7; and 8 - 10.

If you assigned these grouping to new classes identified by 1, 2 and 3 respectively your attribute table might look like the following when the generalization is complete:

Value	Count	Value2
0		1
2		2
3		2
4		2
5		3
6		3
7		3
8		4
9		4



Default names for the new fields are provided the same way that they are in the other generalization tools. You can edit them by clicking on the text line they are displayed in and typing a more suitable name.

The display window – The display window works the same way for all three threshold selection tools. When

the dialog box is first displayed, the window will contain one row with the following elements:

Column 1: By default '1' will be displayed. Unedited, this will be the new class value.

Column 2: The initial class is the entire range of values found in the class field you specified.

Column 3: This column will be blank initially.

The threshold selection tool – This tool is a selection arrow for the generalization tools that let you interactively select thresholds using a table or chart and a slider bar/text input line combination in the Class-Cutoff tool dialog. How these tools are used is described in the section that follows.

Combining groups (or deleting a classification) – If you have defined a class and would like to remove it, you need to add it to the class above or below it. Select one or more 'adjacent' classes by clicking on one of the rows in the display window and dragging the mouse across all of the rows you want to include. The selected rows will be highlighted. When one or more rows are selected, the button labeled 'Combine' will become enabled. To combine the selected rows into a single class, click this button.

Editing the Class and Class Descriptor Values – The threshold selection tools automatically provide default classes, and class descriptors if an existing class description field was specified. You can edit values in either of these columns in the following way:

Select the row whose values you want to edit by clicking on it.

Type a new class in the text input line labeled 'Edit <*New Class Field Name*>:'. Press Enter to apply the change to the value in the display window. If you try to change the class value to the number you have specified as defining areas of missing data (during the setting of your analysis parameters) you will be asked whether you intend to assign this class the missing data value.

Type a new class descriptor in the text input line labeled 'Edit <*New Class Descriptor Field*>:'. Press Enter to apply the change to the value in the display window.

Apply Generalization – When you have finished defining the generalization, click the button labeled 'Generalize' to apply it to you evidential theme attribute table.

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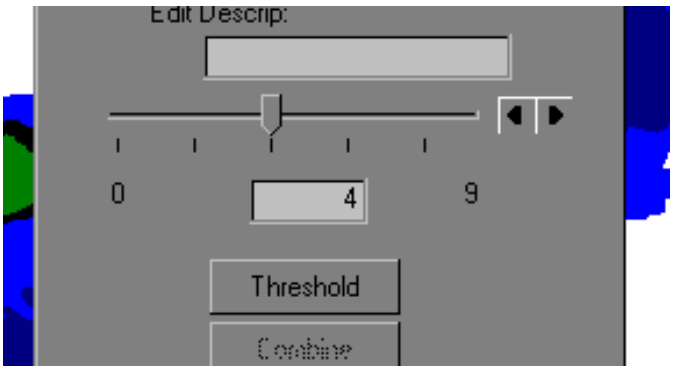
Threshold Selection using the Class-Cutoff tool

How to specify a threshold using the slider bar



When the dialog is opened, the value at the left and right ends of the slider bar indicate the minimum and maximum values respectively of the range of classes.

There are three ways that you can specify the threshold using the slider bar on the Class Cut-off dialog box, pictured above:

1. move the marker by clicking and dragging it. As you move the marker, the current value will display in the text input line below the slider.
2. click the arrow symbols at the right end of the slider. As you click the arrows, the marker will move and the current value will display in the text input line below the slider.

3. click on the text input line and type the value you want.

In all three cases,. the value that is displayed in the text input line is the threshold value. (When you type a value in this line, the slider bar does not respond properly. The marker will move, but not to the correct position. This is a limitation of the Dialog Designer's slider control.)

When the correct threshold is displayed, click the button labeled 'Threshold'. This applies the threshold to the range of classes and displays the new class ranges in the display window. The slider bar is now disabled until one of the rows in the display is selected. When you select a row in the display, the minimum and maximum of the class range are updated and the slider bar is enabled again. Repeat the selection procedure until you have arrived at the classes you want to apply.

Removal of a classification from the generalization, and editing of class and descriptor values are discussed under the previous general thresholding discussion.

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Selecting Thresholds using a Chart document

To select thresholds using a chart:

1. Select Generalize Evidential Themes... from the SDM menu.
2. Specify the evidential theme, class field and class descriptor field, if any, that you want to generalize.
3. Click the radio button labeled 'Chart'.
4. Select the chart you want to use from the combo-box to the right of the radio button.
5. Click the 'Generalize' button.

How to select thresholds using a chart

The chart document you selected will be displayed. If the wrong chart displayed, ensure that your chart has a unique name so that ArcView can differentiate between documents. The threshold generalization tool will be displayed in the upper right corner of your screen.

Please see the Common Components section for a description of the controls that the threshold selection dialogs have in common.

To select a threshold from the chart, activate the Threshold Selection Tool 

on the dialog by clicking on it.

To select a threshold, click on a point or bar in your chart document. You need to click on the chart bar or line graphic in the chart display in order for your selection to register. You may find it is easier to select accurately from a bar style chart. Click the Line/Bar Toggle button to switch from a line chart to a bar chart.

As you select points on the chart, the class definitions or ranges in the dialog display window will be updated.

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Selecting Thresholds using a Table document

To select thresholds using a table:

1. Select Generalize Evidential Themes... from the SDM menu
2. Specify the evidential theme, class field and class descriptor field, if any, that you want to generalize.
3. Click the radio button labeled 'Table'.
4. Select the table you want to use from the combo-box to the right of the radio button.

5. Click the 'Generalize' button.

How to select thresholds using a table

Selection of thresholds from a table document is very similar to selection using a chart.

When you click 'Generalize', the table document you selected will be displayed with the same threshold selection dialog placed in the upper right corner of the ArcView display.

To select a threshold:

Activate the Threshold Selection Tool on the dialog by clicking on it.

Select the record that corresponds to the class you want to choose as your threshold level. This record will be highlighted and the dialog's display window updated to reflect the new class range.

You may encounter problems because the table document is not scaled to fit in ArcView's display window the way a chart document is. For example, if you are selecting your thresholds based on the Contrast values they may be hidden under the dialog, or off the screen.

A few ways to alleviate this problem are:

- Repositioning the dialog on the screen by dragging it with your mouse. (You are not able to minimize the dialog.)
- selecting Table–>Properties... to display the list of fields in the table. Hide some of the fields you are less interested in by unchecking them in the left hand column of the properties dialog.
- move one or more fields (columns) in the table to a position where they are visible. Click on the field name and, holding down the mouse button, drag the column to a new position.

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Calculate Response Theme

This option is used to:

- combine a set of evidential themes into a unique conditions grid

For weights of evidence:

- calculate weights, variances, a contrast value, and a studentized contrast for a set of evidential themes
- calculate the posterior probability, normalized posterior probability, posterior logit, sum of weights, uncertainty due to weights, uncertainty due to missing data and the total uncertainty and join these statistics to the attribute table of the unique conditions grid

For logistic regression:

- calculate the posterior probability, student T-value and standard deviation and join these statistics to the attribute table of the unique conditions grid
- report the coefficients associated with each evidential theme

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This option performs the same weights calculations as those for individual evidential themes when you choose Calculate Theme Weights… but outputs only the W+, Contrast and Variance to tables with a format. Values in these summary tables are used to generate and append the output fields to the unique conditions attribute table. The output response themes are then produced by visualizing the unique conditions gird, symbolized according to attribute fields, such as posterior probability, posterior probability normalized by total uncertainty, and so on.

How the response theme is calculated

Each of the components is described in more detail following this section.

1. The user selects the evidential themes and attribute fields that contain the classes to analyze.

2. The evidential themes are combined by generating a unique conditions grid and attribute table.

3a. If **weights of evidence** is being calculated, weights, variances and contrast are calculated for each evidential theme and written to two tables, a weights table and a variances table.

Using the previously calculated weights and variances, statistics, including the sum of weights, the posterior logit, posterior probability, uncertainty due to weights, uncertainty due to missing data and the total uncertainty are calculated for each unique condition and appended to the unique conditions grid attribute table.

The evidential theme names (field names in the unique conditions grid attribute table) and classes occurring in each unique condition (record) are used to reference the weights and variances found in the weights and variances tables.

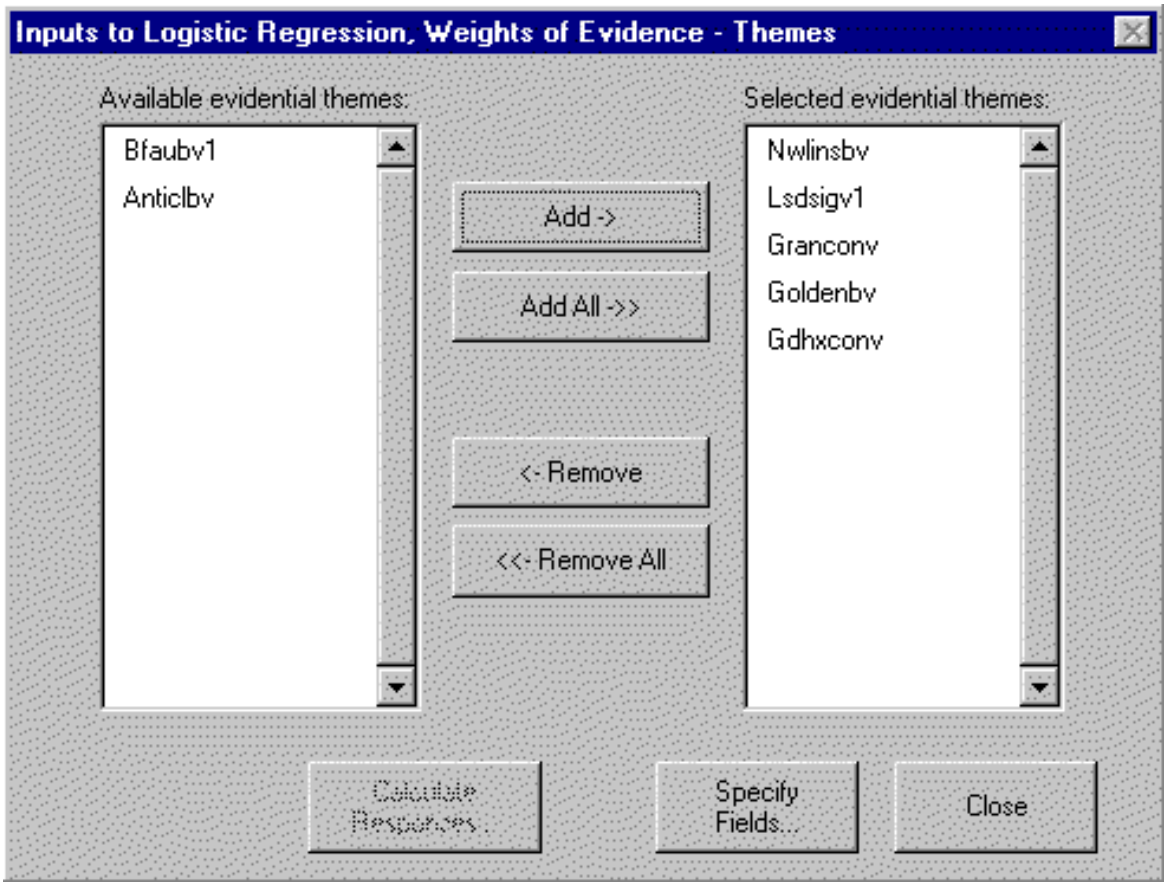
3b. If **logistic regression** is being performed, the unique conditions grid is modified for processing by:

- "expanding" any multi-class free evidential themes to a series of binary themes

- substituting the integer that defines missing data with an area weighted mean of the known data

4. The unique conditions grid is symbolized on one of the attributes to create a response theme.

Inputs... - Themes



This dialog box is also used by the '[Check Conditional Independence...]' and '[Generate Neural Network Input Files...]' functions.

When you choose the Calculate Response Theme… option, the Inputs... - Themes dialog box is displayed. The title of the dialog will indicate the process for which inputs are being selected, for example, 'Logistic Regression, Weights of Evidence' is displayed in the screen capture, preceding. The names of all of the evidential themes found in the current View are displayed in the left hand column with the exception of the theme specified as the study area theme. Weights will be calculated for all of the evidential themes appearing in the right hand column after the ‘Calculate Responses’ button is clicked.

Note: For the Calculate Response Theme... option, evidential theme names should be kept to 13 characters, or to 10 characters if the pair-wise conditional independence test is run. Grids can have names containing up to thirteen characters. If this totals more than 13 characters, the name will be truncated. The pair-wise conditional independence test produces a set of dBase tables. The maximum number of characters a dBase field name can have is 10. While the aliases will appear correctly, the underlying field names will be truncated to conform with this standard.

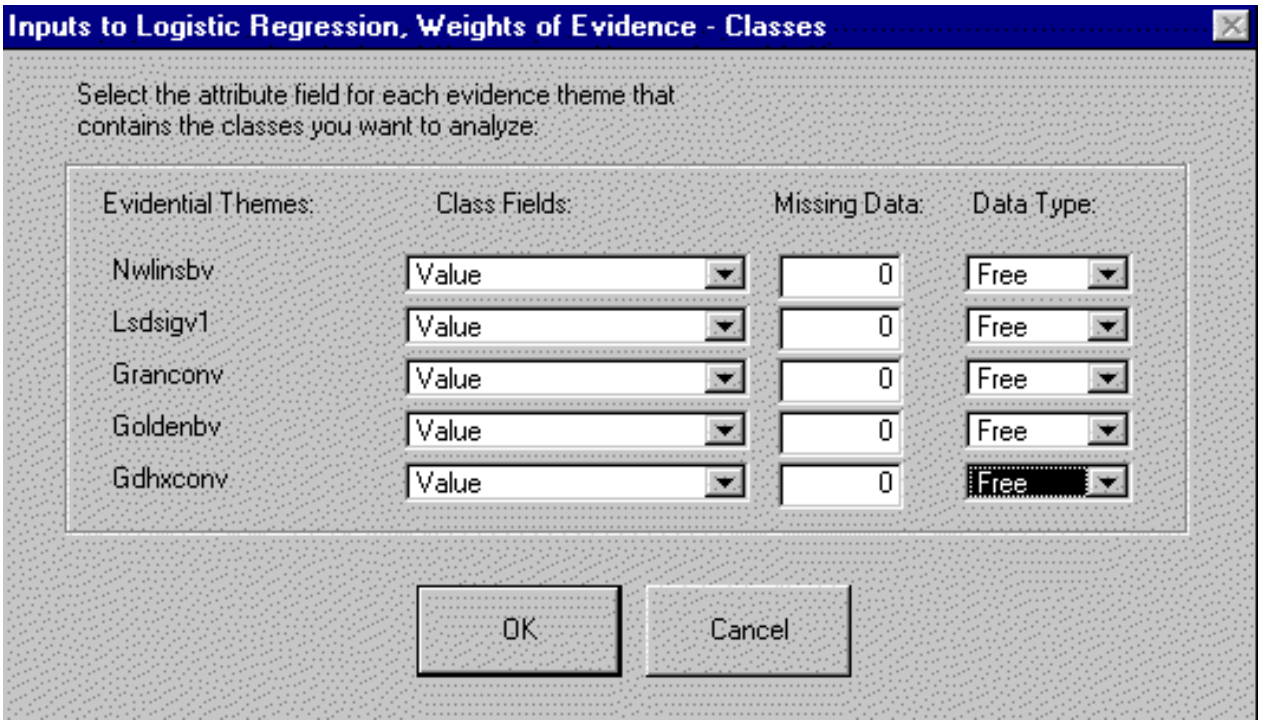
Select a theme by clicking on its name. Add to the selection set by holding down the Shift-key while clicking on other theme names.

Click...	will move	from	to
Add ->	any selected themes, or the first one if none are selected	Available	Selected

Add All ->>	**all themes**	Available	Selected
<- Remove	any selected themes, or the first one in the list if none are selected	Selected	Available
<<- Remove All	all themes	Selected	Available

Inputs... – Classes

When at least one evidential theme appears in the Selected… column, the **Specify Fields...** button is enabled. Clicking it displays the Inputs... – Classes dialog.



This dialog box is also used by the '[Check Conditional Independence...]' function and '[Generate Neural Network Input Files...]'.

Parameter	Description	How to specify
Evidential Themes	The names of the evidential themes selected in the previous dialog.	N/A

Class Fields	The list of fields in the evidential theme attribute table containing only integer values. That is, any fields potentially defining the classes you want to analyse. Default is the valid field farthest right in the attribute table.	Select the field from the drop-down box.
Missing Data	The integer defining areas of missing data. Defaults to the value specified in the Analysis Parameters dialog, if no other value has been set for the evidential theme.	• If the initial value is incorrect, enter a new value. • If the initial value was stored previously, you will be prompted to specify to verify the change.
Data Type	Either Free or Ordered. Initial default is 'Ordered'.	• Select the correct value from the drop-down box. • This parameter has no effect on binary evidential themes. • If the initial value was stored previously, you will be prompted to verify the change.

Generation of a Unique Conditions Grid and Table

Weights of evidence and logistic regression, as well as other functions in Arc-SDM described in their respective sections, use a unique conditions table. Within ArcView and Spatial Analyst, this table is also the attribute table of a grid, that can be described as a unique conditions grid. Its cell values range from 1 to n, each integer identifying a unique condition or combination of cells values found in the input evidential themes. The grid and its attribute table are created by a single Avenue request, Combine.

The table created by the Combine request automatically has a Value and Count field, plus one field for each input evidential theme. The field name for each of these fields corresponds to the name of the evidential theme:

Attributes Of Sdmuc9

Value	Count	Nwlinsby	Lsdsgv1	Goldenby	Gdhmconv	Bfs
1	6661	2	99	2	2	
2	9584	1	99	2	2	
3	4335	2	99	1	1	
4	2010	2	99	1	1	
5	1733	2	99	2	2	
6	7899	1	99	1	1	
7	20572	1	99	1	1	
8	2924	2	1	1	1	
9	28011	1	99	2	2	
10	11531	1	1	1	1	
11	6591	1	1	2	2	
12	26782	1	1	1	1	
13	6522	1	99	2	1	

Because of the way in which the Combine request works, a temporary grid is created from each evidential theme actually input to the process. The characteristics of this temporary theme are compared to those source evidential theme in the following table:

	Source Evidential Theme	Temporary Evidential Theme
If the source evidential theme is a polygon feature theme, it is converted to a grid theme.	polygon feature theme or integer grid theme	integer grid theme
Grid cell values are the...	values contained in field 'Value'	values contained in the class field of the source evidential theme, specified by the user
Grid cells containing 'No Data' that lie within the study area have the value:	'No Data'	Missing Data Integer
Grid cell values lying outside the study area have the value:	any value	'No Data'

Arc-SDM also calculates the following for each unique conditions and appends them as attributes to the unique conditions table:

Field Alias	Field Name	Description
Training Points	Trngpoints	number of training points occurring in that condition
Area (sq. m)	Area_sqm	area, measured in square metres

The unique conditions table is used 'as is' by the weights of evidence scripts. The logistic regression code method requires some modifications. These are described in the **Logistic Regression** section, following:

Weights Table

The default name for the weights table is woe#.dbf. It has the following structure:

Field Alias	Field Name	Description
Evidential Theme	Evidence_t	name of the evidential theme
Class Field	Class_fiel	this records the name (not the alias) of the field that contains the classes for which the weights were calculated
W<#>	W<#>	this is the template name for each of the fields containing the calculated weights, one for each class that occurs in any of the input evidential themes. If a class of the particular number does not occur in an evidential theme, its cell in that field will be blank Although it can be easier to read the table if a convention, such as 2 = presence and 1 = absence, any integer values can be used to identify classes. The number of classes that this table format can accommodate is very large, however it is recommended that multi-class evidential themes be limited to small number (typically not more than 5) to facilitate interpretation.
Contrast*	Contrast_	the difference between the highest weight and the smallest weight. Note that the 'true' contrast is defined only for binary themes
Confidence	Confidence	This is the studentized contrast*, which is the contrast divided by its standard deviation

The last row:

Several parameters are written to the last row of the weights table, as a convenient place to reference them. The name of the training point theme is written to the Evidential Theme field; the total number of training points is written to the first weight field; the total study area in units is written to the second weight field; and the prior probability (the total number of training points divided by the total study area) is written to the third weight field, or contrast* field. Note that these totals are not the values used in weights calculations for an evidential theme that contains areas with missing data.

Variances Table

The default name for the variances table is woevar#.dbf. It has the same structure as the weights table with the following exceptions:

1. The names of fields containing variances have a V<#> template.
2. Contrast* and Confidence are not reported.
3. The training point theme and study area are not reported in the final row.

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The Weights of Evidence Table

Arc-SDM calculates the following statistics for each unique condition and writes them to an ArcView table.

The table is based on a dBase file with a default name of wofe<#>.dbf. The table name defaults to 'Weights of Evidence <#>'. The table is automatically joined to the unique conditions table.

Field Alias	Field Name	Description
ID	ID	Unique condition ID
Posterior Probability	Post_prob	the posterior logit converted to a probability
Normalized Probability	Pstprbnrm	the posterior probability rescaled so that the overall measure of conditional independence is satisfied *
Posterior Logit	Post_logit	the sum of weights added to the prior logit
Sum of Weights	Sum_weights	the sum of the weights for each evidential theme class occurring in the unique condition
Uncertainty	Uncertainty	the uncertainty due to the calculation of weights (standard deviation)
Missing Data	Msng_data	uncertainty due to missing data (standard deviation)
Total Uncertainty	Tot_uncrty	the combined uncertainty due to weights and due to missing data (standard deviation)
***** re-scaled probablity by multiplying by Training Points / Sum of (area * probaiblity), where the summation is over all unique conditions. This normalization is not applied to the response theme in logit units.		

How the weights table is used to calculate posterior probabilities

One unique condition, or record, in the unique conditions table is processed at a time. For each evidential theme included in the response theme, determined by reading the field names, the class occurring in that unique condition is read. The evidential theme name is then located in the weights table, and the weights calculated for that class is read and added to the sum of weights. The correct weight is identified by the field name in the weights table, i.e. the weight for class 4 in Theme 3 is found in the cell located at the intersection of the record where 'Theme 3' is written in the Evidential Theme field, and the field named W4.

Missing Data

If any of the data input data sets have areas where data are missing, this should be identified during the setting of weights of evidence analysis parameters. Any integer, including zero and negative numbers, may be used to identify areas of missing data. The same number, however, must be used for all data sets when creating a response theme or testing conditional independence (i.e., multiple data sets are being input). Refer to Integer that defines Missing Data.

If areas with missing data are defined using 'No Data' in a grid evidential theme, these areas will be filled in "on-the-fly" with the specified integer.

Weights of evidence handles missing data in the following way:

During the calculations of weights for an evidential theme, the total area is calculated as the total study area less any area where data are missing. The total number of training points is calculated as the total number of points in the study area less any points located in areas where data are missing.

If at least one input evidential theme contains missing data, a field named W<missing data integer> will be included in the weights table. If an evidential theme contains areas of missing data, the cell in the missing data class column will contain zero. If a theme has no missing data, the cell will be blank.

Uncertainty due to missing data

The extension requires that missing data be identified by a value (rather than 'No Data', for example) so that these areas can be captured in the unique conditions grid and attribute table. With the areas of missing data identified in each unique condition, a measure of uncertainty in the posterior probability can be calculated.

Depending on the number of classes and evidential themes, and therefore number of unique conditions, and the number of themes in which data are missing, calculating uncertainty due to missing data may be time consuming. An estimation of the length of time it will take to calculate the uncertainty is made, and reported to the user if it is longer than one minute.

At the time of reporting, the user can choose to skip over the calculation of uncertainty due to missing data. The missing data and total uncertainty fields will be omitted from the unique conditions table. (Without the missing data component, total uncertainty will be equal to uncertainty due to weights.) The time estimate is based on processing times for a Pentium 133 notebook computer with 48 Mb of RAM. A more powerful computer, or a desk-top computer with the same parameters, will usually perform these calculations much faster. In some situations, such as processing data located across a network, may be considerably slower. The time required in most cases, however, is an over-estimate.

Expert Weights Option

This option allows the user to manipulate the weights that are generated for one or more of the evidential themes input to the model. Instead of using a set of training points to determine weights, the user specifies the model weights, either directly or by allocating the proportion of training points that fall in each class, or by specifying likelihood ratios for each class. This technique can be useful if the study area has not been previously explored, and a set of training points is small or not available. The "points" in this case are purely notional. It is often convenient to use 100 points, then estimate the % points occurring on the class of a theme as a way of subjectively defining importance. As each evidential theme is processed, the user is prompted by the following dialog:

You can set expert weights for up to 10 classes. If there are more than 10 classes in the class field you specified, you will be asked if you want to cancel the weights calculations or if you want to omit the evidential theme from your model.

On initial display, the dialog has the following settings:

1. The evidential theme name appears at the far left of the dialog box title.
2. The initial number of hypothetical "training points" is set to 100, and displayed in a text line in the upper right corner. You can type in any number of points, and can control the value of the prior probability in this way. Note that these points are not given any actual location.
3. Data about the evidential theme is displayed in the following columns:

   Class – The classes found in the specified class field in the theme's attribute table.

   % Points – The percentage of points allocated to each class. Initially this is set to be equal to the percentage of the total study area occupied by each class, resulting in weight values of zero.

   Area – The percentage of the total study area occupied by each class.

   Likelihood Ratio – The likelihood ratio calculated based on the specified percentage of points and percentage area for the class, as well as the total number of points, and total area. Initially this value is set to 1. The W+ value is the natural log of the likelihood ratio.

   Weights – The W+ calculated for the current class, based on the specified percentage of points and percentage area for the class, as well as the total number of points, and total area. Initially this value is set to 0.

Inputting values

You can edit the % Points, Likelihood Ratios or Weights columns by clicking on the associated radio button, found in the upper left corner of the dialog and editing the values in the text lines. As you change any of these three values, the calculated values for the other two will be updated.

Note: Weights are always calculated based on the % Points displayed in the dialog.

When you close the dialog, the total percentage of points must sum to 100%. You can automatically adjust your percentages so they total 100 by clicking the 'Normalize' button.

Reading Weights from an Existing Table

You can read weights that have been previously calculated and written to a weights table. To do this:

1. Select a weights table from the combo-box located above the display area on the right side of the dialog.
2. Click the 'Read Weights' button.
3. Arc-SDM will look for the current theme name and field name in the specified weights table and, if found, will update the text lines in the Weights column with the values from the table.

You can then modify the weights, and when you are done, click 'OK' to continue with calculations.

Except for the user interaction with this dialog, all of the calculations and output are the same as for the 'regular' weights option.

NOTE: It is not possible to check for conditional independence in expert weights because the actual locations of points is notional.

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Logistic Regression

Evidential Themes and the Unique Conditions Table

Logistic regression handles multi-class evidential themes of ordered data but not multi-class free data. This problem is dealt with after the unique conditions grid has been created. Arc-SDM determines if there are any multi-class free evidential themes and expands them to a series of binary themes in preparation for running logistic regression. In this way, the same evidential themes can be input to both weights of evidence and logistic regression at the same time.

Actual data sets are not created. A unique conditions table is written. For example, if one of the evidential themes was a geology map with three classes, identified by 1, 2 and 3, three binary "themes" would be generated with the values mapped in the following way:

Theme	Initial Class	New Class	Initial Classes	New Class
1	1	1	2 and 3	0
2	2	1	1 and 3	0
3	3	1	1 and 2	0

Missing Data

Logistic regression does not process missing data directly. Instead an area weighted mean of the known class values within the study area is calculated for each evidential theme that contains missing data and substituted for the missing data class. For binary themes that have been generated by the expansion of multi-class free data, the area weighted mean is between 0 and 1.

Temporary Files

During logistic regression processing, several temporary files are written to a directory created by Arc-SDM, ~sdmtemp. (NOTE: Please do not use this directory for any other files.) These files are not deleted by Arc-SDM but are overwritten the next time that logistic regression is run.

File Name	Description
case.dat	unique conditions table, processed for input to logistic regression
cumfre.tba	cumulative frequencies of probabilties calculated by logistic regression
logco.dat*	summary of the coefficients for each evidential theme and their standard deviations
logpol.dat	data showing the convergence of the logistic regression coefficients through each iteration on the calculations

logpol.tba*	the posterior probability as well as a Student-t, standard deviation, chi-square coefficient, and deviance coefficient for each probability

* Values from logco.dat and logpol.tba are read to ArcView tables.

Logistic Regression Table

The posterior probability for each unique condition, along with its studen-T value and standard deviation are written to an ArcView table. The table is based on a dBase file, default name logpol<#>.dbf and the default name of the table is 'Logistic Regression <#>'. The table is automatically joined to the unique conditions table.

Field Alias	Field Name	Description
ID	ID	unique condition ID
(LR) Posterior Probability	Lrpostprob	the posterior probability
(LR) TValue	Lrtvalue	student-T value
(LR) Std. Dev.	Lr_std_dev	standard deviation

Table of Coefficients

Arc-SDM automatically creates a table of the final coeffcients generated by logistic regression. In the example of the following table, the evidential theme 'Geolm' is a multi-class free data type evidential theme so it was expanded to three binary theme, each corresponding to the class value reported in brackets in the 'Evidential Theme' field. The coeffcient for a theme indicates its relative importance in determining the posterior probabilities. In this case, class 1 of the Geolm theme is most important.

lrcoef5.dbf

Theme ID	Evidential Theme	Coefficient	Standard Deviation
1		-4.548237	0.80687100
2	Geolm, Value (1)	2.220082	0.72401900
3	Geolm, Value (2)	0.596523	0.91593900
4	Geolm, Value (3)	0.000000	0.00000000
5	Bioau, Value	-0.165591	0.06954200

Field Alias	Field Name	Description
Theme ID	Theme_id	Unique identifier for the evidential themes
Evidential Theme	Theme	Theme name, field name (class value (if expanded))
Coefficient	Coefficien	the coefficient
Standard Deviation	Std_dev	the standard deviation of the coefficient

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Options to run CI test and Associate probabilities with point theme functions

Once the response theme has been calculated, an option is given to run the pair-wise conditional independence test. Running the test at this point is slightly faster than running it from the menu option because the unique conditions table has already been created for the response theme and is used as the basis for the test.

Overall Test of Conditional Independence

Once the response theme is complete, Arc-SDM reports a ratio that can be used as an overall assessment of conditional independence among your data sets. This ratio is calculated as follows:

The product of area and posterior probability summed over each unique condition is the number of points predicted by the model. A ratio is calculated by dividing the actual number of training points input to the model by this predicted number of points. This ratio will always be between 0 and 1. A value of 1 (never occurs in practice) indicates conditional independence among the evidential themes used in the model. Values much smaller than 1 indicate a conditional independence problem.

If you choose to run the pair-wise test of conditional independence when prompted, the overall test result will be written to the last row of the probability table.

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Symbolization of the Response Theme

The Response (Grid) Theme (actually the unique conditions grid) is automatically added to the current View and symbolized based on the Posterior Probability attribute, using 7 classifications defined by ArcView's natural breaks method. (Fewer classifications are applied if there are fewer than 7 records or values in the response theme attribute table.)

The following is the RGB colour palette used:

Classification	RGB Code
1	0,106,255
2	0,233,255
3	85,255,0
4	191,255,0
5	255,212,0
6	255,106,0
7	255,0,0

For options on symbolizing the reponse theme, see the section describing symbolization tools.

Making a Confidence Map: Normalizing the Posterior Probability by the Total Uncertainty

You can also normalize the probability values by Uncertainty (due to weights) if, for example, you did not elect to calculate uncertainty due to missing data.

1. Make the Response Theme you want to normalize active.
2. Double-click the theme's legend to open the legend editor dialog.
3. From the 'Normalize by:' combo box, select 'Total Uncertainty'.
4. Click 'Apply'.
5. Click the 'X' button to close the dialog.

You can change the Theme's name to reflect the legend by selection Properties from the Theme menu.

Dividing the posterior probability (not the normalized posterior probability) by the total uncertainty provides a map of the informatl "studentized" posterior probability. If enough training points are being used, then regions with values > about 2 have a high degree of "certainty" (with regard to variances of weights and variance due to missing data). This map is useful in a relative sense for highlighting regions with low or high confidence.

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Check Conditional Independence

- Pairwise test for conditional independence
- How to create a table of probabilities to assess conditional independence
- Table of Chi-squared statistics
- Table of degrees of freedom

The calculation of weights of evidence assumes conditional independence among the evidential themes input to the model. One technique to assess the conditional independence between pairs of binary evidential themes is to calculate a Chi-squared statistic to assess the variation between the expected and observed occurrences on and off the patterns in the two themes.

Pairwise test for conditional independence

The pairwise test between two evidential themes involves a contingency table calculation, applicable only to locations at which training points occur. The rows of the contingency table are the classes of one theme, and the columns of the contingency table are the classes of the second theme. Each cell *(i,j)* of the table records the number of training points occurring for a specific overlap of the *i*-th class of theme 1 and the *j*-th class of theme 2. Note that these numbers are independent of the unit cell area, because they are counts of points.

The calculation of chi-squared involves estimating the expected number of training points in each cell, under an assumption that theme *i* is independent of theme *j.* The expected value in a cell is calculated as the product of the marginal point totals divided by the grand total number of points. Chi-squared is a measure of the differences between the observed and expected frequencies, summed over all the cells of the table.

The null hypothesis of conditional independence is tested by determining if the measured chi-squared value exceeds a theoretical chi-squared value, given the number of degrees of freedom (ndf) and the level of significance. The ndf is the number of rows - 1 times the number of columns - 1. So for binary themes, the ndf=1. The level of significance for most tests is taken as 95%, equal to (1-probability)or p=0.05.

In Arc-SDM, three triangular matrices are produced as tables, one containing chi-squared values, one with number of degrees of freedom and the third with the corresponding probability value. The probability values are produced first, and the chi-squared and degrees of freedom tables are options.

Probability values <.05 indicates some conditional probability, or the failure of the conditional independence test at the 95% level. Low values of probability indicate conditional independence--and the lower the value the greater the indication of conditional independence.

Note that Yates' correction for small expected frequencies is applied automatically.

Warning: The chi-squared distribution becomes a poor test in tables where the expected frequencies are less than 5 in any cell (even with Yates' correction). In practice, this implies that if evidential themes with many classes are used in the test, particularly in datasets with a small total number of training points, the resulting probability values may be in error, and should be interpreted accordingly.

See Bonham-Carter (1994, p.313-315) for a full discussion and example.

Arc-SDM's conditional independence test produces a table of probabilities.

prb-3.dbf

Evidential Theme	Lsdsigv1	Granconv	Goldenbv	Antisibv
Nwlinsbv	0.7732	0.5334	0.0911	0.4886
Lsdsigv1		0.5925	0.3442	0.4837
Granconv			0.8094	0.5684
Goldenbv				0.7885
Values < .05 indicate some conditional dependence.				

In the example of prb-3.dbf, above, each pair of evidential themes was tested. The table is written like a spreadsheet with the first to second from last evidential themes written column headings and the second to the last evidential themes written to rows in the first column. A chi-squared statistic was calculated for the observed number of training points falling in each class compared to the expected number of training points. Null hypothesis of CI is not rejected (i.e. CI is accepted) at the (probability) level of significance.

The number of degrees of freedom depends on the number of classes, excluding missing data, that occur in both evidential themes being tested.

degrees of freedom = (# classes in theme1 - 1) * (# classes in theme2 - 1)

Optionally, two tables with the same structure as the probability table can be optionally produced: one contains the chi-squared statistics and the other, the degrees of freedom.

Note: The algorithm used for calculating the probabilities iterates a maximum number of times. If a probability is not determined before this maximum is reached, a Null value is returned and the cell in the probability table is set to 0, suggesting a problem with

conditional independence.

How to create a table of probabilities to assess conditional independence

Select 'Check Conditional Independence...' from the SDM menu.

From the dialog box titled 'Inputs to Conditional Independence Test - Themes', select the evidential themes you would like to test and add them to the list of selected themes. This dialog is the same as the one used to select themes in the Calculate Response Theme function. For more information, refer to the description of the dialog.

Click the 'Specify Fields...' button. For each of the evidential themes you selected in the previous step, specify the field that contains the classes for you would like to test conditional independence. Then click 'OK'. (For more information about this dialog, refer to the Calculate Response Theme function.)

Click the 'Conditional Independence' button.

You will be prompted for names for the output dBase file/Table document names in the following sequence:

Table of Probabilities – This table is always produced. The default name is Prb-<#>.dbf.

Table of Chi-squared Statistics and table of Degrees of Freedom

x2-3.dbf

Evidential Theme	Lsdsigv1	Granconv	Goldenbv	Anticlbv
Nwlinsbv	0.51	0.39	2.86	0.48
Lsdsigv1		1.05	2.13	1.45
Granconv			0.06	0.33
Goldenbv				0.07
Probability values depend on chi-squared values and number of degrees of freedom.				

df-3.dbf

Evidential Theme	Lsdsigv1	Granconv	Goldenbv	Anticlbv
Nwlinsbv	2	1	1	1
Lsdsigv1		2	2	2
Granconv			1	1
Goldenbv				1
Probability values depend on chi-squared values and number of degrees of freedom.				

These two tables go together since one is meaningless without the other. They are optional. To skip over them, click 'Cancel' when prompted for a file name for the chi-squared table. If you skip the chi-squared table, the degrees of freedom table will also be skipped. (If you specify a name for the chi-squared table, but then 'Cancel' the degrees of freedom table, the chi-squared table will not be produced.) The default name for the chi-squared table is X2-<#>.dbf and the default name for the degrees of freedom table is Df-<#>.dbf.

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Use Existing Weights/Variances Tables..

This option allows some flexibility in the application of the weights of evidence model. Once a set of weights and variances tables have been calculated by running the Calculate Response Theme... function, these tables can be ‘reused’ as a source of weights for application to a different area (which may or may not include the original study area.)

This menu item will be enabled if there is at least one weights table and one variances table in the format output by Arc-SDM.

The general idea

After calculating a response theme, the study area my be changed (in Set Analysis Parameters). If a new Response Theme is then calculated by running the ‘Use Existing Weights/Variances Tables...’, it must take as its inputs the same evidential themes in order to compute a the unique conditions grid and set of weights and variances calculated based on a previous study area.

An example

This example is a general description of a user’s application of this Arc-SDM option.

Suppose that the evidential themes available to the user had a much greater geographic extent than the set of known mineral occurrences or training points. An assumption was made that the same geological model applies to the entire area. Two study area grids were created: one that defined the extent of the evidential themes and a second that defined an area roughly encompassing the extents of the training points, about 25% of the area of the first study area. After calculating weights and then generalizing individual evidential themes, one response theme was calculated using the smaller study area. (Using the 'Calculate Response Theme...' menu item.)

The study area theme was then changed (in the parameters) to the larger geographic area and a second response theme was calculated using the weights and variances tables calculated for the smaller extent. (Using the 'Use Existing Weight/Variances Tables...' menu item.) In this way, weights were calculated for a relatively confined area that contained many known occurrences, but then those weights were applied to adjacent areas with no training points.

Note that the **prior probability** calculated for the first study area is used in the calculations for the second study area.

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Fuzzy Logic

- Set Analysis Parameters
- Define Fuzzy Membership
- Fuzzy Logic
- Process Existing Model

Set Analysis Parameters

1. Select 'Set Analysis Pararameter...' from the SDM menu.
2. Check the Fuzzy Logic option.
3. Select:
   - a study area grid theme
   - default value for defining missing data
4. Click OK.

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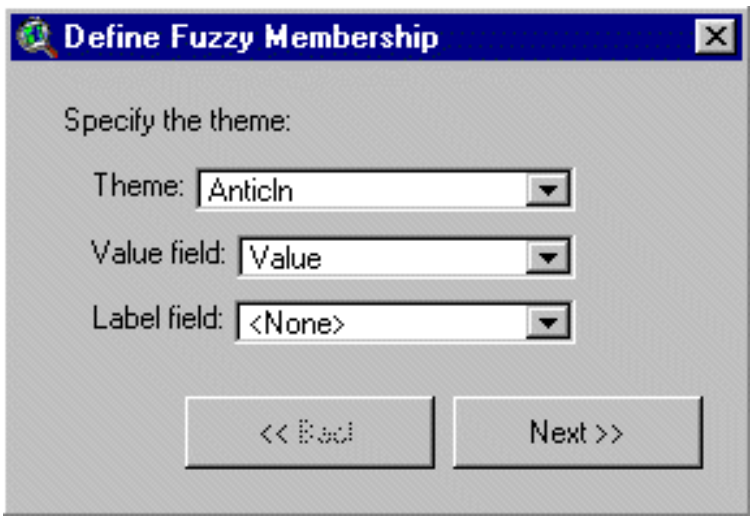
Define Fuzzy Membership

Membership of data in a fuzzy set is defined using values in the range [0,1]. A value of 1 indicates full membership in the set. In Arc-SDM, fuzzy membership values are written to the attribute table of the data set they are defining.

1. If you want to use data contained in other tables to guide the process of defining membership values, join the table(s) to the grid attribute theme.
2. Select 'Define Fuzzy Membership...' from the SDM menu. This displays a wizard dialog box. You can return to previous panels of the dialog at any time to verify and/or revise entries.



1. Select the integer grid theme for which you want to define fuzzy membership values. The first active grid theme will be selected by default.
2. Select the field that contains the (class) values for which you want to define fuzzy membership.
3. Optionally, select a field to label numeric values in the field selected in the previous step.
4. Click 'Next'.
5. Specify a name for the new field that the fuzzy membership values will be written to. The default name is **FMemshp#**.
6. Click 'Next'.
7. Specify an integer value that defines areas of missing data. You need to define this value even if there is no missing data within the study area. Any areas of missing data will not be determined and handled until the fuzzy membership values are written to the attribute table. The fuzzy membership value for areas where data is missing is determined by taking an area weighted average of the fuzzy membership values assigned to areas of known data within the study area.

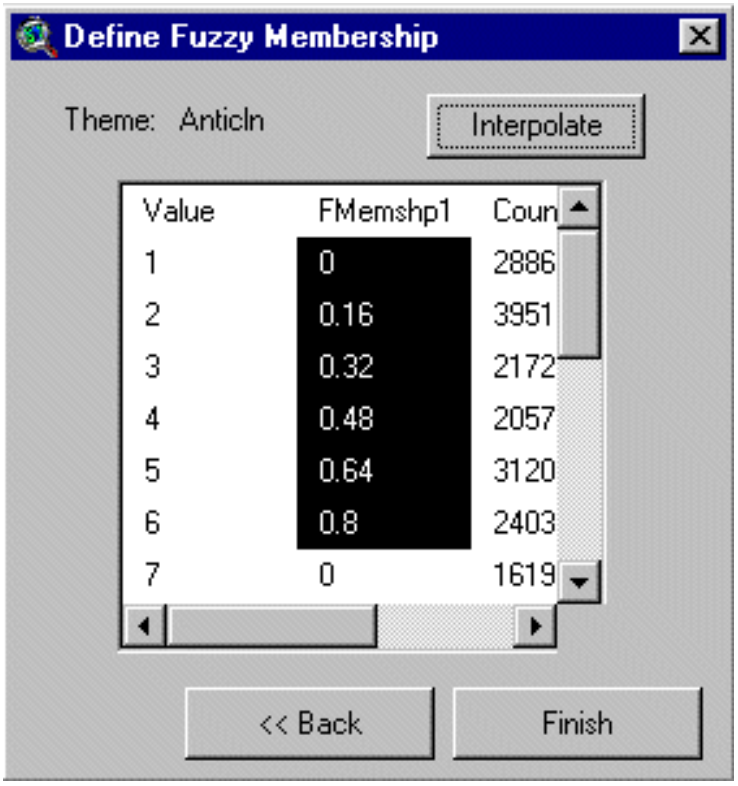
If you want to explicitly define the fuzzy membership value for areas of missing data yourself, you can edit the calculated value in the theme attribute table once the fuzzy memberships have been applied. An alternate technique is to specify a dummy value for the missing data class, that is some value that does not occur in the evidential theme. In this case, the missing data value will be available for the assignment of a fuzzy membership value.

1. Click 'Next'.
2. Select any additional fields containing data that may be useful as a guide to determining fuzzy membership values. Select a field by clicking on its name in the list. Select additional field by holding down the shift-key while clicking on their names. Clear the selection by clicking 'Unselect'. The values in these fields will be displayed in the interface used to

define fuzzy membership.

3. Click 'Next'.
4. Select either 'Define values by table' or 'Define values by graph and table'. If there are more than 64 values for which you need to define fuzzy membership, the 'Define values by graph and table' option will be disabled.
5. Click 'Next'.

Define values by table



What's in the table:

Column	Heading	Description
1	**Value**	The values for which you want to define a fuzzy membership.
2	**FMemshp<#>**	The column where fuzzy membership values are entered.
3 - n		Remaining columns are user specified, to guide the selection of fuzzy memberships.

To...	
...edit a single membership value:	1. Double-click the value in the column that you want to edit. This displays an edit dialog. 2. Enter the new value. 3. Click 'OK'.

...make a linear interpolation between two fuzzy membership values:	1. Select the first value by clicking on it. 2. Hold down the shift-key and drag the mouse to select the cells contiguous to the first value until the second value defining the interpolation is selected. 3. Click the 'Interpolate' button.

When definition of fuzzy membership values is complete, click 'Finish'.

The values will be written to the grid theme attribute table.

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Define values by graph and table

This option allows all of the same functionality as the "table only" option, but also allows users to graphically define a relationship between the values and their fuzzy memberships.

1. Optionally, select a field containing values to be displayed in the graph interface as a guide to defining fuzzy membership values.
2. Click 'Next' to display the interface.

To...	
...edit a single fuzzy membership value in the table:	1. Double-click on the value to display an edit dialog. 2. Enter the new value in the text entry line of the dialog. 3. Click 'OK'. Both the table and chart will be updated.
...edit a single fuzzy membership value in the chart:	1. Select the point to edit by: Clicking on or near it. **OR** Right-clicking on or near the point and selecting 'Select Point' from the pop-up menu. 2. Right-click and select 'Edit point position' from the pop-up menu. The point will turn green to indicate that it is in edit mode. 3. Left-click at the new position for the point. The point will move to the new position and the value displayed in the table will be updated. **NOTE: The points can only vary along the y-axis so even if you select a position to the right or left of the point it will maintain its position along the x-axis.** 1. Right-click and select 'Stop editing'.

...unselect one selected point:	*If there is only one point selected:* Right-click and select 'Unselect point' from the pop-up menu. **OR** Click on another point. This will select this point and unselect the one previously selected. *If there are two points selected:* Selecting 'Unselect point' from the pop-up menu will unselect the first of the two points that was selected.
...unselect two selected points:	Right-click and select 'Unselect all' from the pop-up menu. **OR** Click on a third point. This will select that points and unselect the two previously selected points.
...select a second point:	Right-click near the second point and select 'Select second point' from the pop-up menu. **OR** Hold down the shift-key and click the second point.
...apply a linear interpolation of values between two selected values:	Select the points defining the minimum and maximum values of the interpolation function. Right-click and select 'Align points between selected' from the pop-up menu. This will adjust the graph and update the values in the table.

When the definition of fuzzy memberships is complete, click 'Finish'. The values will be written to the theme's attribute table.

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Fuzzy Logic

Arc-SDM uses a fuzzy logic "calculator" to combine evidential themes using the fuzzy operators described in the section discussing the fuzzy logic method (fl1.pdf). Each of the "calculations" or operations is recorded in a dBase file that then can be viewed, rerun and/or plotted at any point in time.

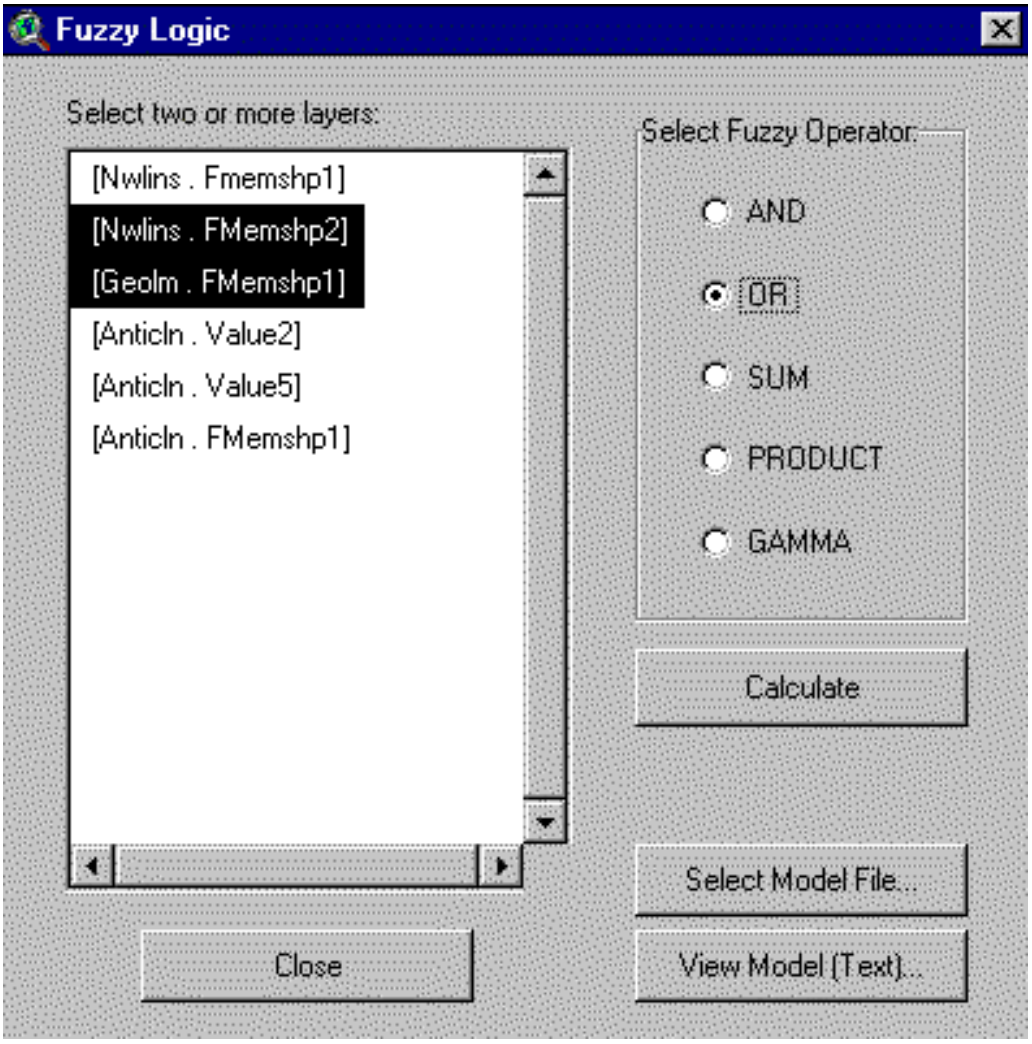
To combine two or more themes using a fuzzy operator:

Select 'Fuzzy Logic...' from the SDM menu.

You are first prompted to select an existing fuzzy logic model file (.dbf).

To...	
...append a record of the operations to be done in this session to an existintg file (created during a previous session):	select the file and click 'OK'.
...create a new file:	1. Click 'Cancel'. 2. When prompted, specify a name and location for the new fuzzy logic model file. The default name is **flmdl<#>.dbf**.

Then the "fuzzy logic calculator" dialog is displayed:



The listbox contains all of the theme-field pairs from the active view for which the values in the field or grid cells falls in the range [0,1]. In the case of a floating point grid theme, the "field" is identified as 'Value'.

1. Select two or more evidential themes to combine:

   Select a theme-field pair by clicking it in the listbox display.
   Select one or more additional theme-field pairs by holding down the shift-key and clicking them. **NOTE:** Two fields from the same theme attribute table cannot be selected at the same time.
   When two or more theme-field pairs are selected, the 'Calculate' button becomes active.
2. Select a fuzzy operator to use to combine the themes.
3. Click 'Calculate'.
4. If the GAMMA operator is selected, you will be prompted to specify a fuzzy gamma operator after you click 'Calculate'.
5. When prompted, specify a name and location for the output theme. The default names are as follows:

The default filename for the output grid from a fuzzy ...	... operation is ...
AND	And<#>

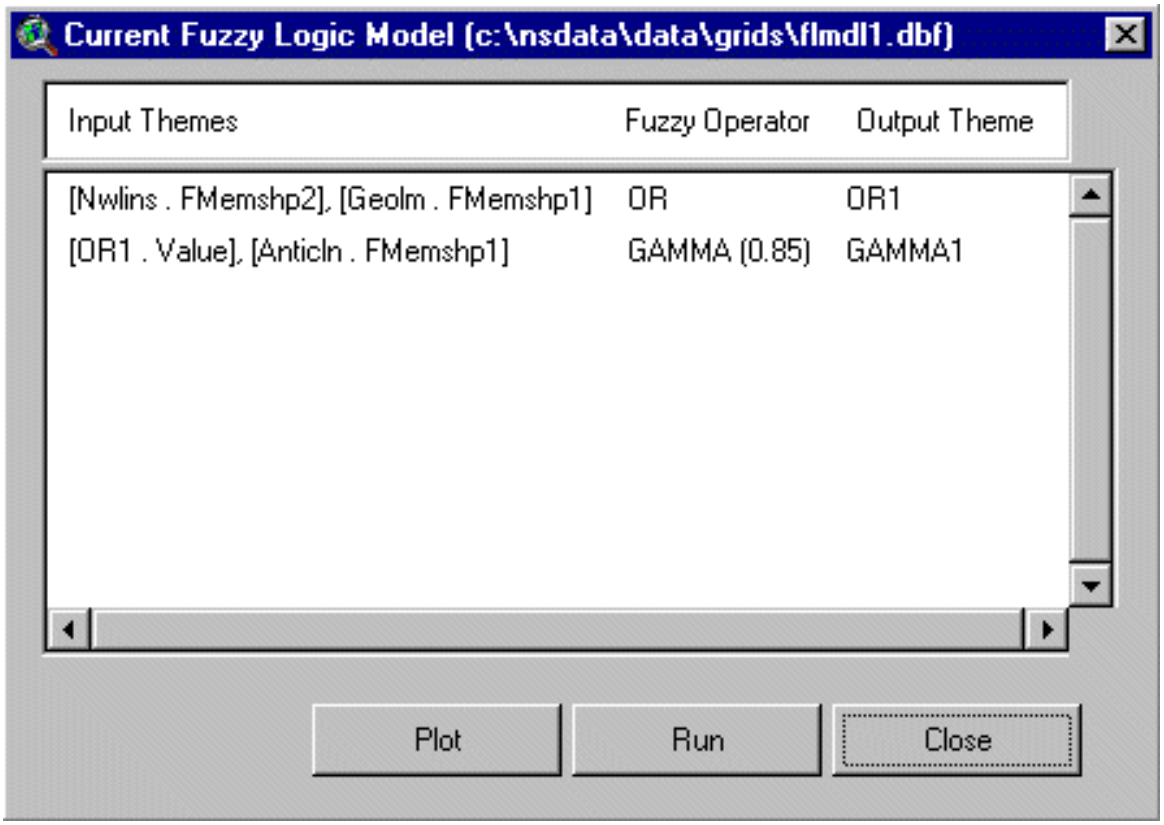
OR	Or<#>
SUM	Sum<#>
PRODUCT	Prd<#>
GAMMA	Gamma<#>

The new theme will be added to the active view and to the top of the theme-field list in the dialog box for input to a subsequent operation.

To view the contents of the fuzzy logic model

1. Click 'View Model (Text)'.

This displays the contents of the file as in the following example:



NOTE: The functions run from the 'Plot' and 'Run' buttons are described in the next section, 'Process Existing Model'.

To Select another model file

At any point you can click the button labelled 'Select Model File...' to select another file. Subsequent operations will be appended to the newly selected file until the dialog is closed or another file is selected.

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Process Existing Model

Two functions are available for processing fuzzy logic model files:

- "running" a model based on the contents of the file
- creating a flow chart of the contents of the file that graphically documents the inference network of the model

---

Re-running a model file

This function automatically executes fuzzy logic operations performed at some earlier point and recorded in a dBase file, referred to as a model file.

1. Select 'Process Existing Model...' from the SDM menu
   OR
   Click the 'View Model (Text)' button if the fuzzy logic calculator is open.
2. Select the steps to be run. Each row in the file represents a fuzzy operation or processing step.

- To select a row, click on it.
- To add to the selection, hold down the shift-key and click on additional rows.
- If no selection is made from the steps in the model, all steps will be processed.

1. To run, click 'Run'.
2. When prompted, specify whether the output grids are to be added to the active view or a new view.
3. When prompted, specify a name and location for each of the output grids as they are processed.

NOTE: If any of the initial evidential themes cannot be found in the active theme, processing will stop. If you want to apply the operations recorded in a model to themes with different names, you can:

- temporarily change the theme names to match those in the file
- edit the file so that the theme and field names match the themes in the view. NOTE: processing will fail if it Arc-SDM cannot interpret the file syntax

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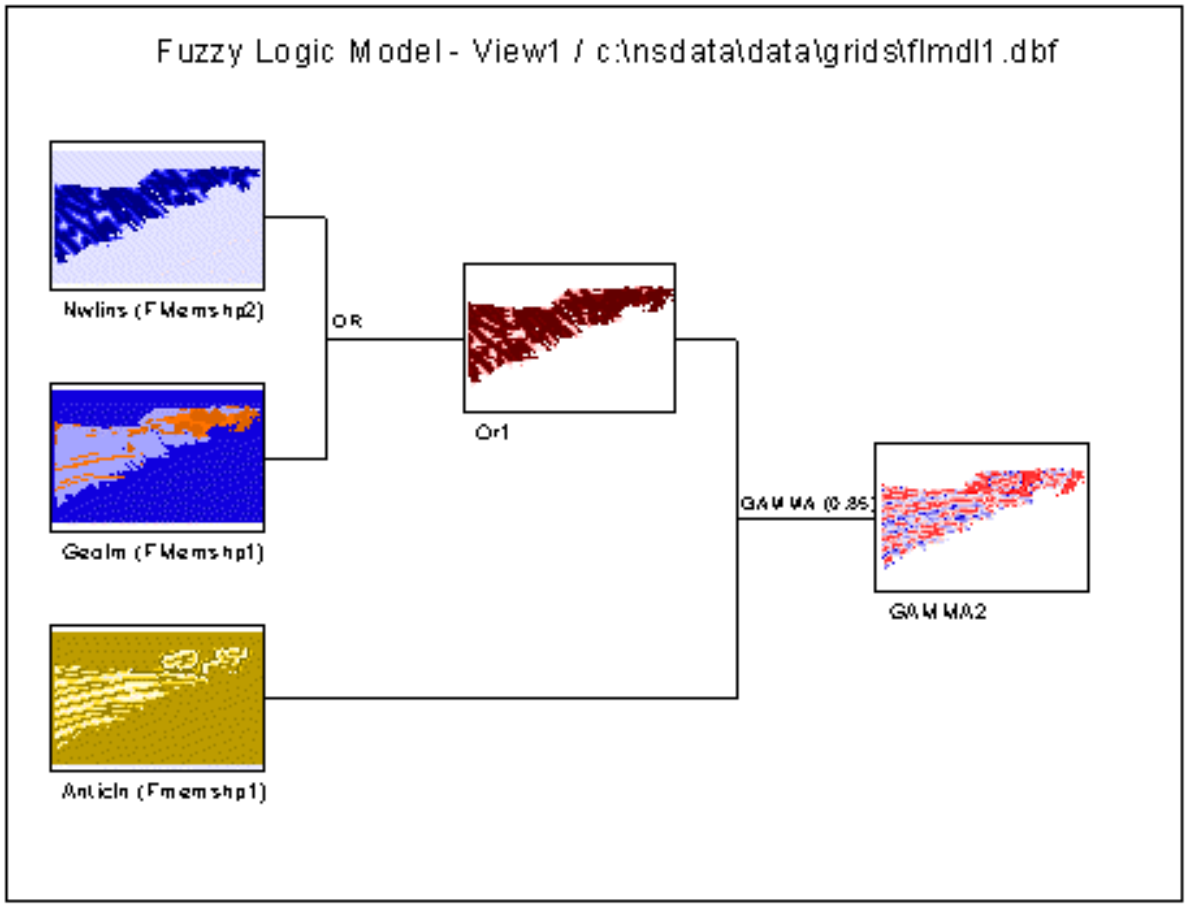
Plotting the contents of a model file as a flow chart

This function creates an ArcView layout document and draws a flow chart of the contents of the file. For example, the contents of the file shown in the section 'To view the contents of the fuzzy logic model' looks like this:



1. Follow steps 1 and 2 for re-running a model file, from the previous section.
2. To plot the flow chart, click 'Plot'.

When plotting is complete, the name of a new layout document will be reported where the flow chart has been plotted.

Editing the layout document

The graphic elements that are used to draw each theme, including the image of the theme, the surrounding frame and the caption, have been grouped so that they are easily moved or resized as a single element. To Ungroup:

1. Select the theme image.
2. Select 'Ungroup' from the Graphics menu.

The grain of the drawing grid has been set to a fine spacing (0.01" in both the x and y dimensions) to enable small adjustments.

ArcView On-line Help Topic: See 'Laying out and printing maps' in the help Contents

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Neural Network

- Setting Analysis Parameters
- Generate Random Training Points
- Generate Neural Network Input Files
- Run Neural Network Module
- Read Results from Neural Network Module

Note: Neural Network Analysis is performed in a Visual C++ program called "DataXplore".

RBFLN stands for radial basis functional link network. This method uses a training dataset of "deposit" and "non-deposits" combined.
The fuzzy clustering method finds clusters of unqiue conditiosn in the evidential themes and does not use training data (unsupervised).

Setting Analysis Parameters

1. Select 'Set Analysis Pararameters...' from the SDM menu.
2. Check the RBFLN (Supervised) and/or Fuzzy Clustering (Unsupervised) options listed under 'Neural Network Analysis'.
3. Select:
    - a study area grid theme
    - unit area
    - "deposit" training point theme (RBFLN option)
    - "non-deposit" training point theme (RBFLN option)
    - default value for defining missing data
4. Click OK.

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Generate Random Training Points

The RBFLN neural network object requires two sets of training points:

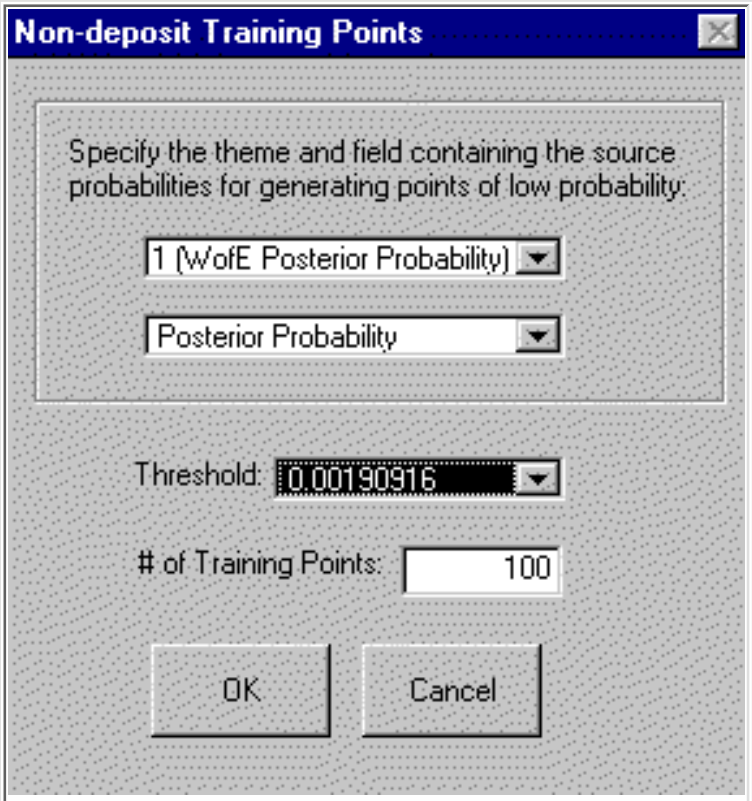
- one that defines the presence of the objects or conditions to be predicted (i.e., mineral occurrences)
- a second that defines the absence of these objects (i.e., locations where mineral occurrences are known not to occur).

The two sets of points (locations) are combined as training data.

This second type of data set is often not readily available so this function offers one way of approximating such a data set. The idea is to generate a set of points in parts of the study area where there is a very low probability of the object occurring.

One possibility for applying the function is to generate a probability map (response theme) using the weights of evidence or logistic regression methods and then generate a set of random points in areas of very low probability. This can be done as follows:

1. Generate a response theme using weights of evidence or logistic regression following the steps described in **Calculate Response Theme**.
2. Select 'Generate Random Training Points' from the SDM menu.



1. In the 'Non-deposit Training Points' dialog, specify:
   - the name of the response theme generated in step 1
   - the field containing the probability values (in this example, either (WofE Posterior Probability or LR Posterior Probability)
   - a threshold value: all of the points generated will fall in areas that have values less than this value.

In this example, the threshold should be lower than the prior probability. The prior probability can be found in the third column of the last row of the weights table associated with the response theme, or can be reported by clicking the  button in the deposit training point theme properties dialog. This dialog is displayed by clicking the 'Properties' button in the 'Analysis Parameters' dialog.

   - enter the number of points to be generated. The default is the number of points in the deposit training point set.

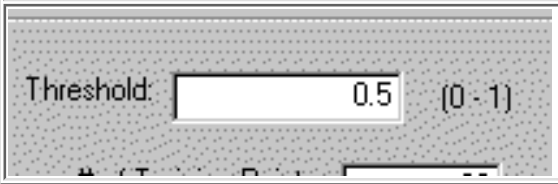
1. Click OK.
2. When prompted, specify the file

	name and location for the new point shapefile. A point theme is created and added to the top of the table of contents of the active view.

General Application

The 'Generate Random Training Points' function can use any grid theme in the active view. If a floating point grid theme is selected, the threshold value must be entered by the user. The minimum and maximum values in the grid theme are reported as guidance and the default value is the midpoint between these two.

For example, in this portion of the 'Non-deposit Training Points' dialog, for the selected theme (not shown) the minimum value is 0, the maximum is 1 and the default value is 0.5.



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Generate Neural Network Input Files

The first part of this process is the same as Calculating a Response Theme for the weights of evidence and logistic regression methods.

1. Select 'Generate Neural Network Input Files...' from the SDM menu. This displays the 'Input to Neural Network - Themes' dialog.
2. Select the evidential themes to include in the analysis.
3. Click 'Specify Fields'. This opens the 'Inputs to Neural Network - Fields' dialog.
4. For each evidential theme, specify the field containing the class values to analyse, the integer that defines areas of missing data and the theme data type, either free or ordered.
5. Click OK.
6. Click 'Generate Input Files...'.
7. When prompted, specify the following file names and locations:

filename and location of the...	**Description**	**Default Name**
unique conditions theme grid	Jump to definition.	sdmuc#
training file	• only generated if the RBFLN option is selected • text file containing information from unique conditions in which training points are located • 1 row = 1 unique condition • in DataXplore, 1 row = 1 training vector • each unique condition is written once, even though it may contain more than one training point • if a training point indicating presence of an object and another indicating absence occur in the same unique condition, the training point indicating presence takes priority	train#.dta
data file	• text file containing complete unique conditions • 1 row = 1 unique condition • in DataXplore, 1 row = 1 feature vector	class#.dta

After the files have been created, the unique conditions grid theme will be added to the active view with a default name of 'Neural Network #'.

Sample input files.

Unique conditions table in ArcView

Attributes of Neural Network 1

Value	Count	Nwlins	Lsdsigh	Geoln	Bloau	Antich	Tmgpoints	Area_sqm
1	28	1	0	1	5	16	0	252700.00
2	22	1	0	1	5	15	0	198550.00
3	15	1	0	1	5	14	0	135375.00
4	29	2	0	1	5	18	0	261725.00
5	9	2	0	1	5	17	0	81225.00
6	67	1	0	2	5	15	0	604675.00
7	77	1	0	2	5	14	0	694925.00
8	6	2	0	1	5	16	0	54150.00
9	57	1	0	2	5	13	0	514425.00

Neural network input Files

A. Unique conditions table written to neural network input file, delimited text format

```
5
151
1
3462
1, 0, 0.252700, 0.200000, 0.547131, 0.000000, 0.555556, 0.625000, 0
2, 0, 0.198550, 0.200000, 0.547131, 0.000000, 0.555556, 0.583333, 0
3, 0, 0.135375, 0.200000, 0.547131, 0.000000, 0.555556, 0.541667, 0
4, 0, 0.261725, 0.400000, 0.547131, 0.000000, 0.555556, 0.708333, 0
5, 0, 0.081225, 0.400000, 0.547131, 0.000000, 0.555556, 0.666667, 0
6, 0, 0.604675, 0.200000, 0.547131, 0.500000, 0.555556, 0.583333, 0
7, 0, 0.694925, 0.200000, 0.547131, 0.500000, 0.555556, 0.541667, 0
8, 0, 0.054150, 0.400000, 0.547131, 0.000000, 0.555556, 0.625000, 0
9, 0, 0.514425, 0.200000, 0.547131, 0.500000, 0.555556, 0.500000, 0
10, 0, 0.018050, 0.800000, 0.547131, 0.000000, 0.444444, 0.750000, 0
```

A. Unique conditions table written to neural network input file, delimited text format

```
5
151
1
3462
1, 0, 0.252700, 0.200000, 0.547131, 0.000000, 0.555556, 0.625000, 0
2, 0, 0.198550, 0.200000, 0.547131, 0.000000, 0.555556, 0.583333, 0
3, 0, 0.135375, 0.200000, 0.547131, 0.000000, 0.555556, 0.541667, 0
4, 0, 0.261725, 0.400000, 0.547131, 0.000000, 0.555556, 0.708333, 0
5, 0, 0.081225, 0.400000, 0.547131, 0.000000, 0.555556, 0.666667, 0
6, 0, 0.604675, 0.200000, 0.547131, 0.500000, 0.555556, 0.583333, 0
7, 0, 0.694925, 0.200000, 0.547131, 0.500000, 0.555556, 0.541667, 0
8, 0, 0.054150, 0.400000, 0.547131, 0.000000, 0.555556, 0.625000, 0
9, 0, 0.514425, 0.200000, 0.547131, 0.500000, 0.555556, 0.500000, 0
10, 0, 0.018050, 0.800000, 0.547131, 0.000000, 0.444444, 0.750000, 0
```

Description of file header:

Line 1 (5): Number of evidential themes.
Also called components or features, in the context of neural networks and DataXplore.

Line 2 (151): Number of training points.
In the context of neural networks, "the number of centres (for clustering) or the number of radial basis functions (each with a centre) when our neural networks are used. But the number is not fixed, and may be changed by the program or by the user in either the unsupervised (fuzzy) clustering or in the supervised training of radial basis function neural networks.

Line 3 (1): Number of output components, or values to be mapped as response themes.
This is always set to one in the Arc-SDM application.

Line 4 (A: 3462) (B: 151): Number of unique conditions.
In the context of neural networks, the number of target vectors.

Description of data columns:

Column 1: Unique condition number.

Column 2: Number of training points in unique condition (not currently used).

Column 3: Area of unique condition (not currently used).

Columns 4 - 8: Unique condition values or contents of target vectors.
Values are transformed from the ArcView unique conditions table in two ways:

1. the range of an evidential theme's values is normalized between 0 and 1
2. the missing data integer is replaced with an area weighted mean

Column 9: The output component

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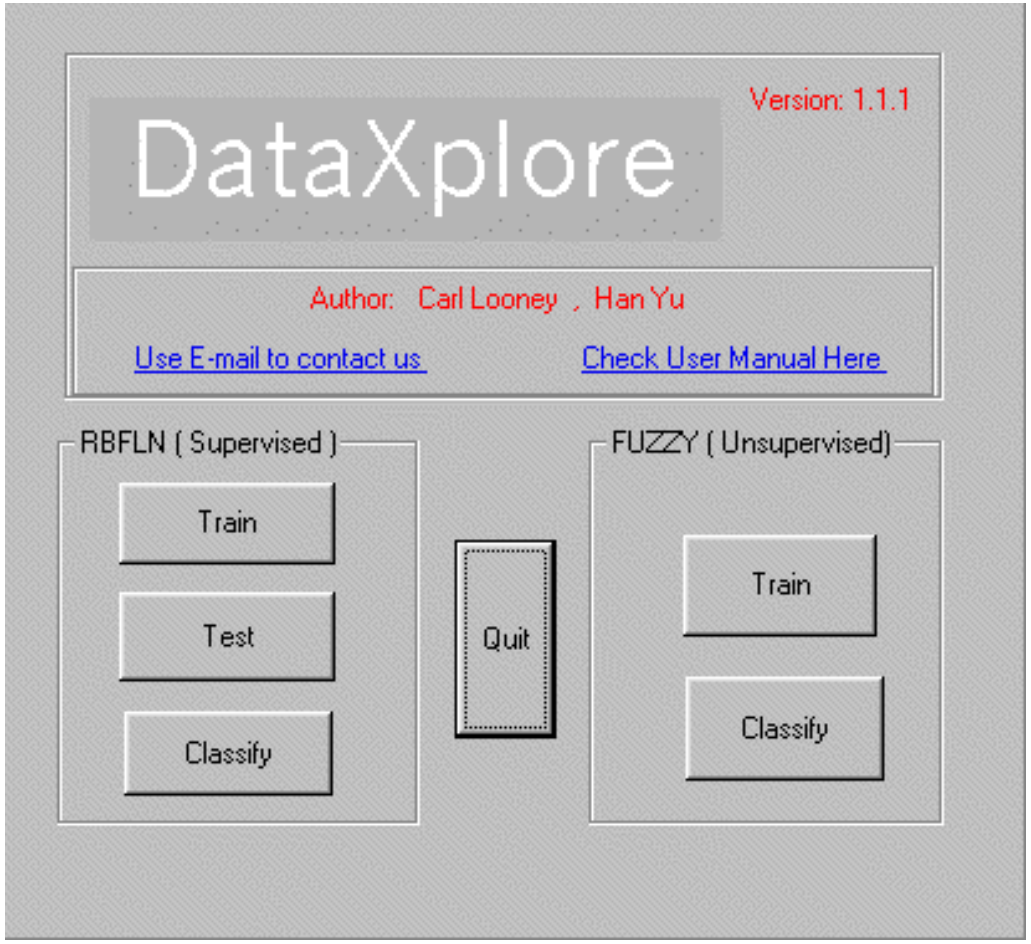
Run Neural Network Module

Much of the documentation found in this section is also available from readme.txt, the guide to DataXplore.exe

To run DataXplore

Select 'Run Neural Network Module...' from the SDM menu.

This will launch DataXplore, which is a separate MS Windows program from ArcView.



While DataXplore is running, ArcView is fully accessible.

The remainder of this section describes how to use DataXplore with reference to Arc-SDM and the input files generated in the previous step.

- Radial Basis Functional Link Network
- Fuzzy Clustering

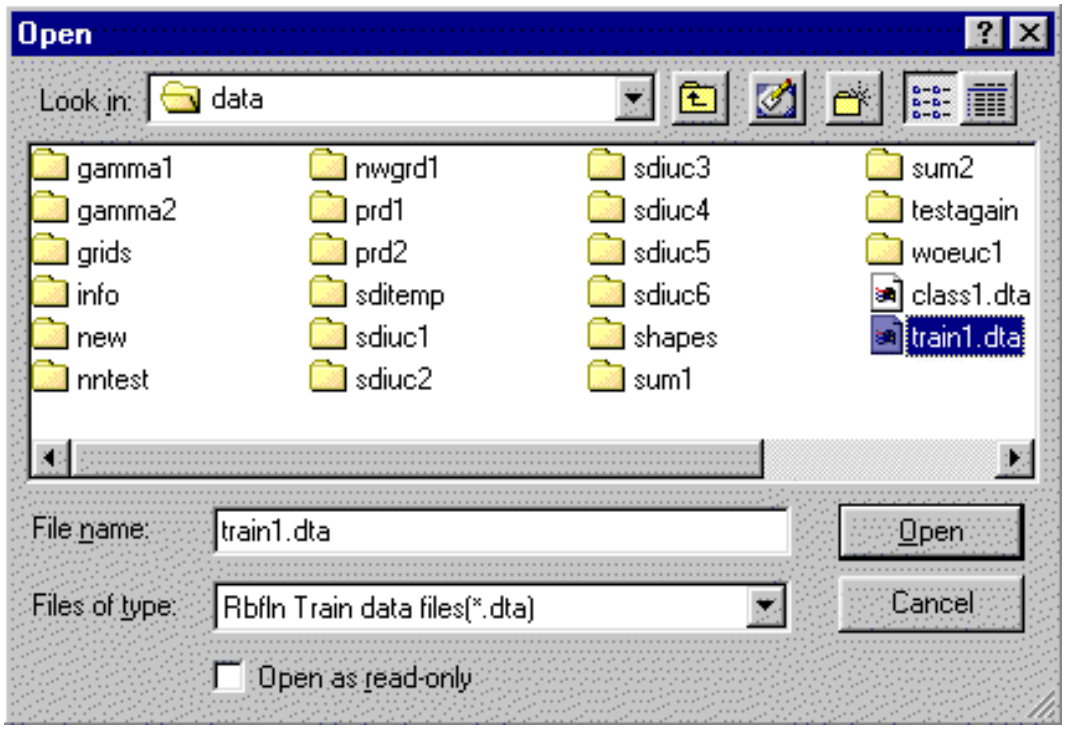
To perform Radial Basis Functional Link Network analysis (RBFLN)

there are three steps:

- training
- testing
- classification

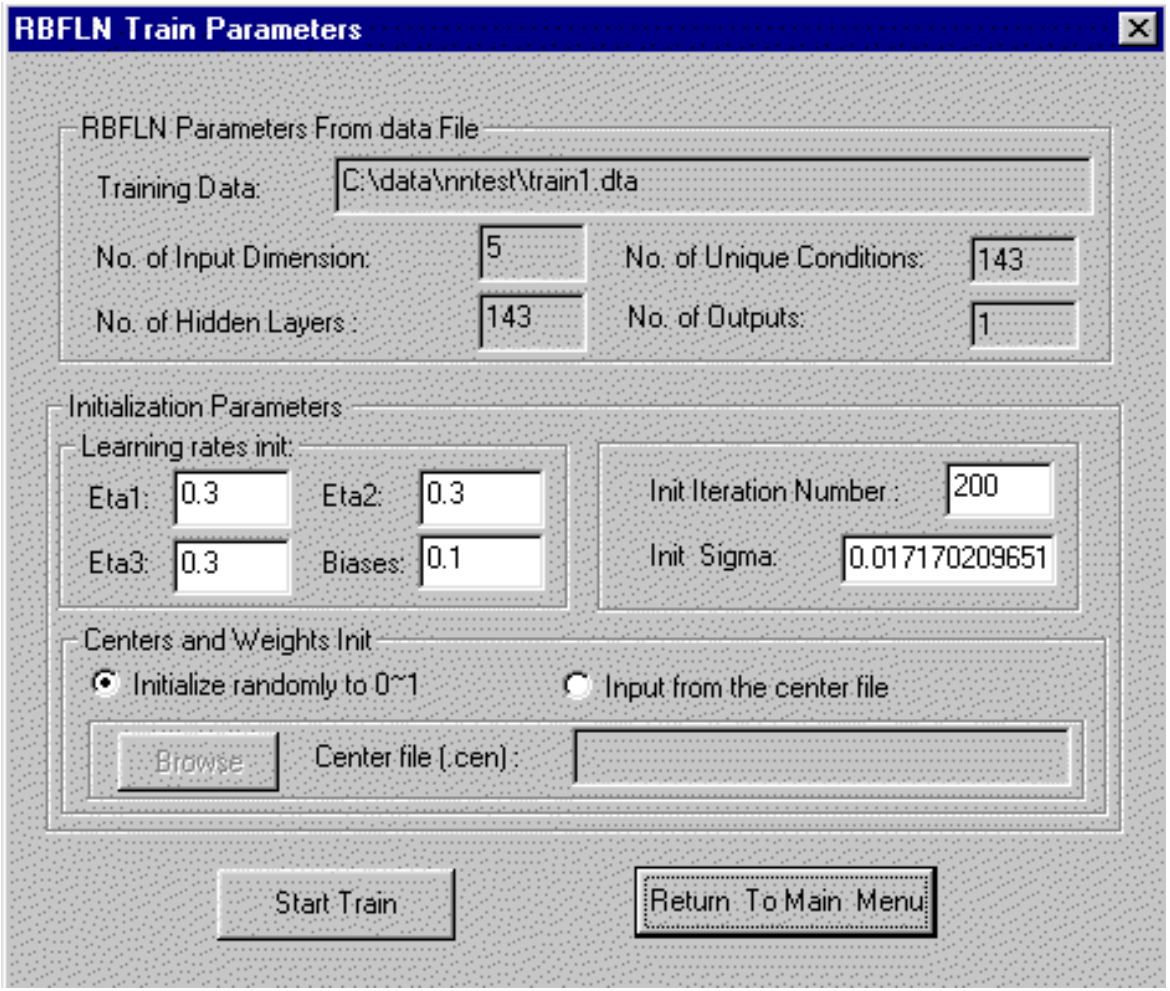
Training

Click the 'Train' button to display the following dialog:



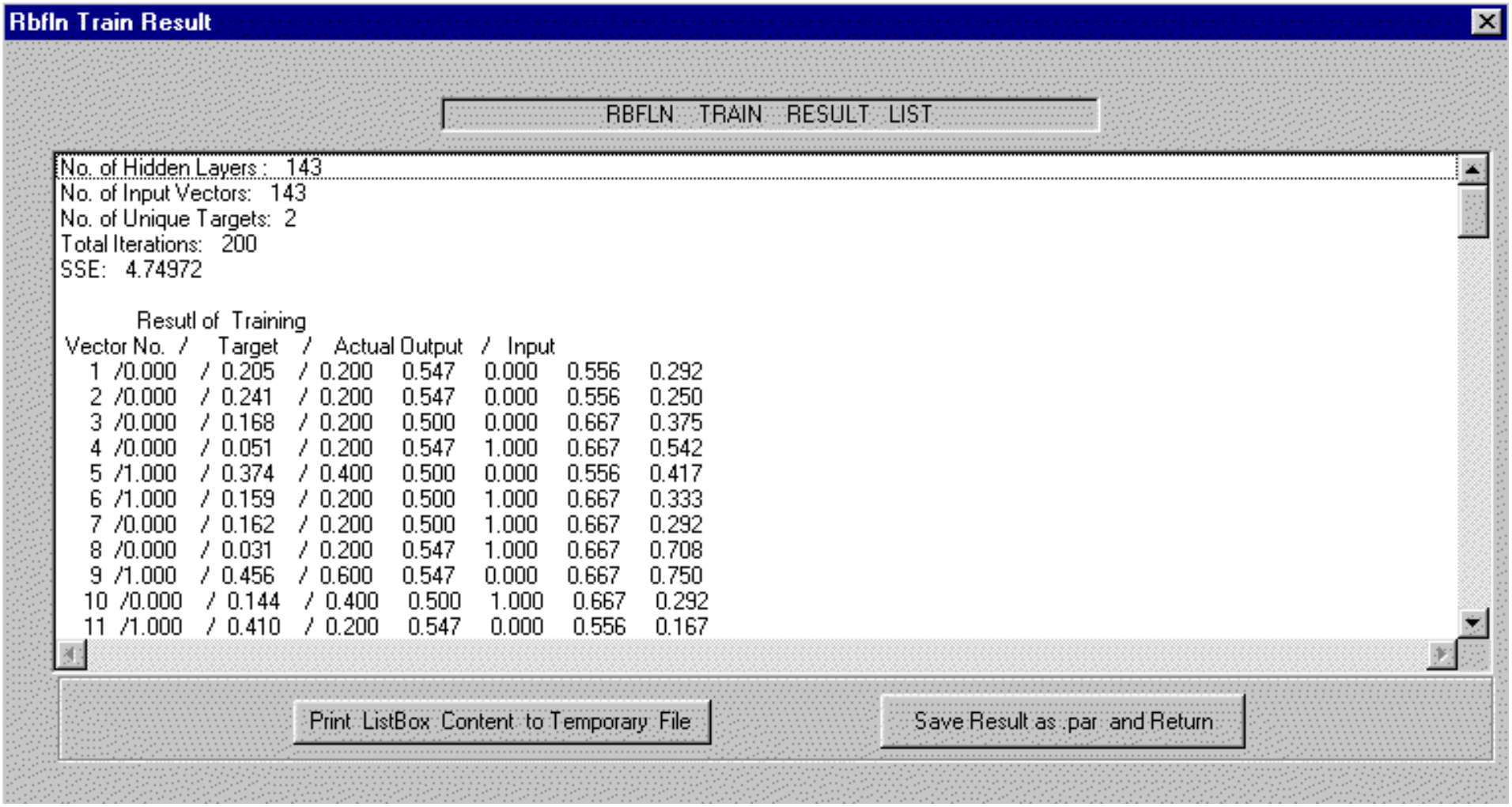
Select the file that contains your training data and click OK. The default name for neural network training data files generated from Arc-SDM is **train#.dta**.

The RBFLN parameter dialog is then displayed:



The parameters in the box 'RBFLN Parameters From data File' are read from the training data file specified in the previous step.

Click 'Start Train'. A report in the following format is displayed:



Contents of the report

No. of Hidden Layers -
No. of Input Vectors - the number of training vectors (unique conditions at the location of training points) in the training data file
No. of Unique Targets - this will always be 2, either 0 or 1, representing the presence or absence of a mineral occurrence
Total iterations - DataXplore parameter set in the parameter dialog. 200 is the default.
SSE - Sum Squared Error

Result of Training

Column 1: **Vector No.** - an integer uniquely identifying each vector
Column 2: **Target** - contains values of either 0 or 1. 0 indicates the absence of a mineral occurrence, 1 indicates presence.
Column 3: **Actual Output** - The actual value that was calculated for each training vector. The range of values is 0 to 1.
Column 4 - n: **The input data**. These are the actual values read from the training data file. If the file was generated by Arc-SDM, these values were derived from a unique conditions attribute table. The values for each evidential theme have been normalized or scaled between 0 and 1, and an area weighted average of known values has been calculated and used to define areas where data has been identified as missing.

To save this report to a file

You can optionally save the contents of this report to a text file for later inspection or reporting purposes. To do this,

1. Click 'Print ListBox Content to Temporary File'.
2. Specify a filename and location when prompted.

Save the results of the training session

1. Click 'Save Result as .par and Return'.
2. Specify a filename and location when prompted.

This file must created for input into the testing and classifying steps that follow.

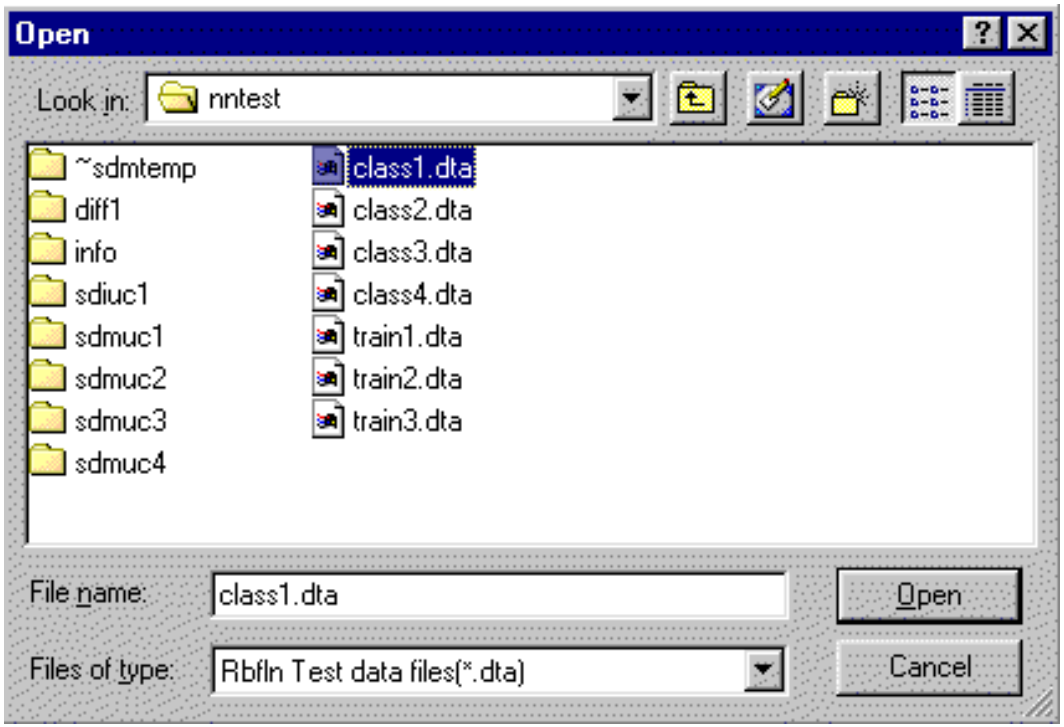
You will be returned to the RBFLN parameter dialog.

Click 'Return to Main Menu'.

Testing

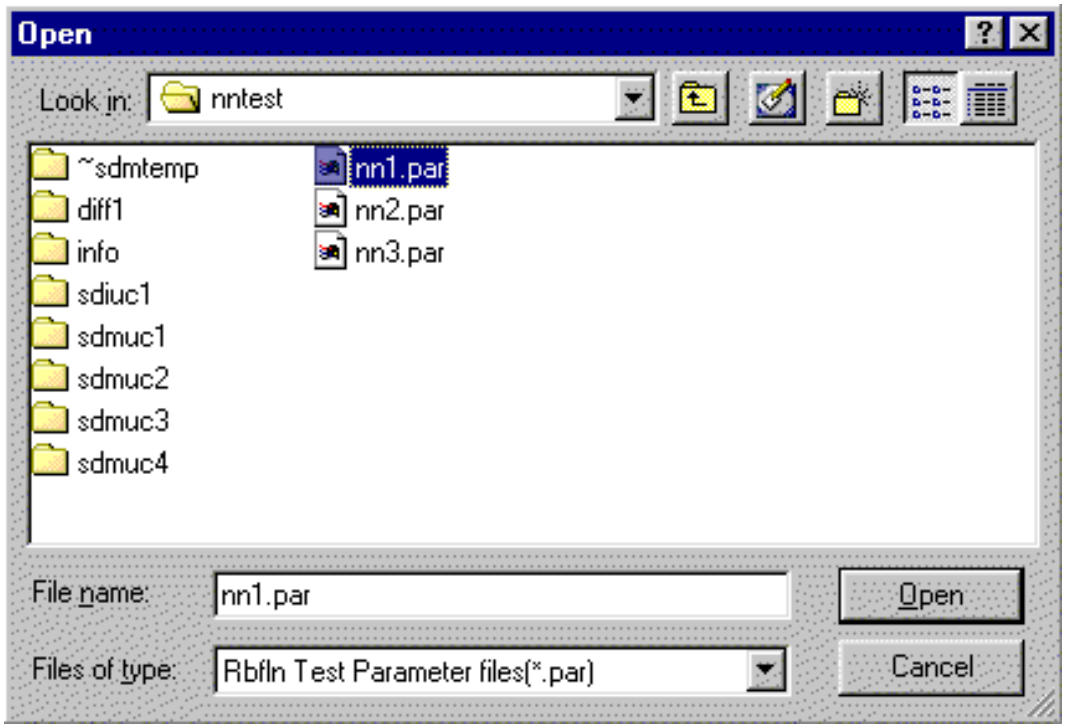
Click the 'Test' button.

Select the file that contains the data to be classified and click OK. The default name for neural network training data files generated from Arc-SDM is **class#.dta**.

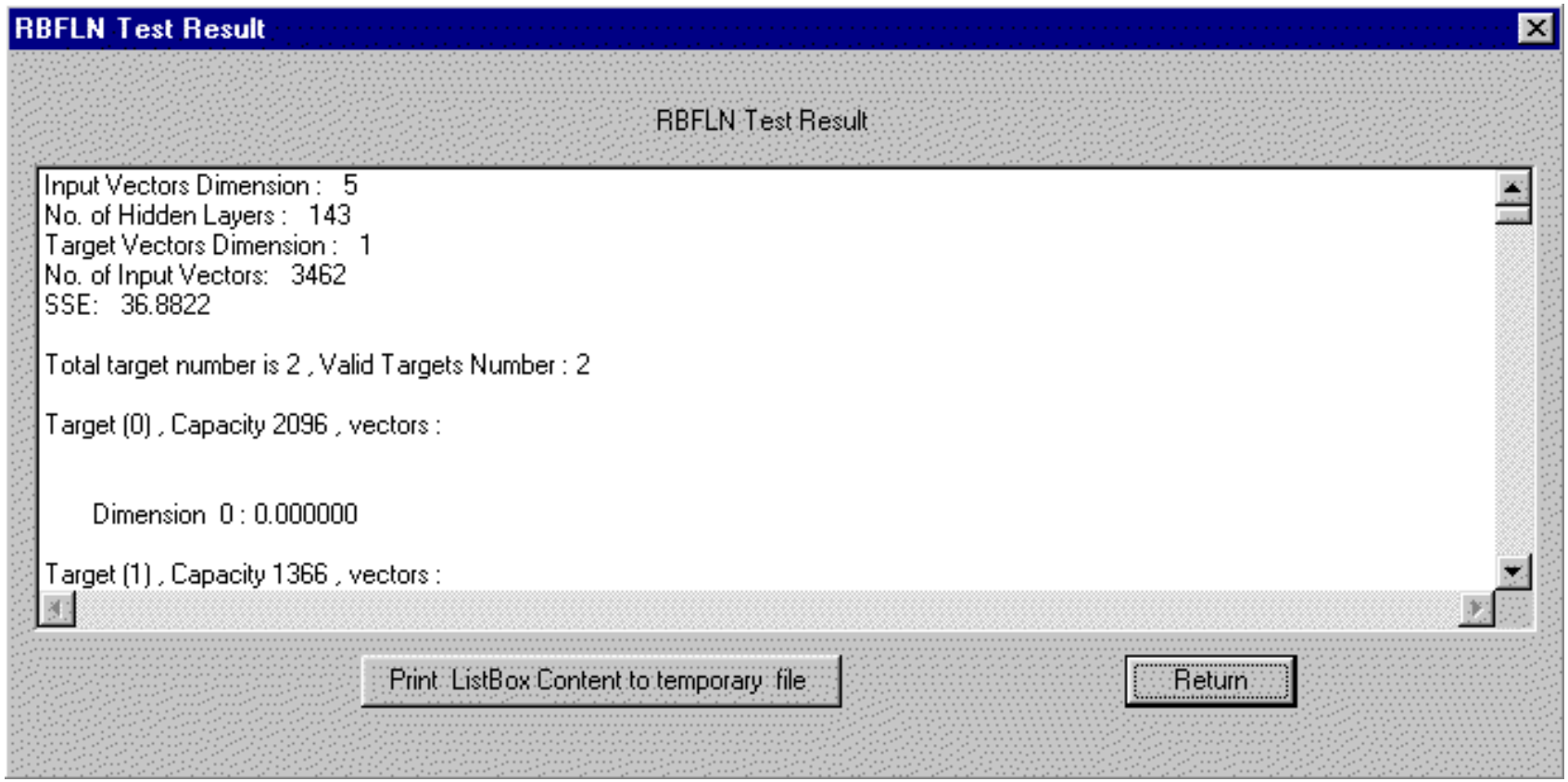


You will then be prompted to select an RBFLN Test Parameter (*.par) file

1. Select the that you just generated in the training step.
2. Click 'Open'.



The test is performed and the following report is displayed:



Report Contents

Input Vectors Dimension - the number of components in an input vector. If the data file was generated by Arc-SDM, this is the number of evidential themes.
No. of Hidden Layers - number of training vectors
Target Vectors Dimension - this is always 1
No. of Input Vectors - this is the number of unique conditions written to the data file
SSE - Sum Squared Error

There are two targets, 0 and 1. In the example of the screen-captured reported above, 2096 vectors (or unique conditions) were classified as 0 and 1366 were classified as 1. The assignment of vectors to either class 0 or 1 is done by rounding the value calculated by the RBFLN. Arc-SDM will read the calculated values rather than the classified (rounded) value.

Result of RBFLN Test

Column 1: **Vector No.** - an integer uniquely identifying each vector (or unique condition)

Column 2: **Class No.** - the class to which the vector has been classified

To save this report to a file

You can optionally save the contents of this report to a text file for later inspection or reporting purposes. To do this,

1. Click 'Print ListBox Content to temporary file'.
2. Specify a filename and location when prompted.
3. Click 'Save'.
4. Click 'Return' to return to the main DataXplore dialog.

Classify

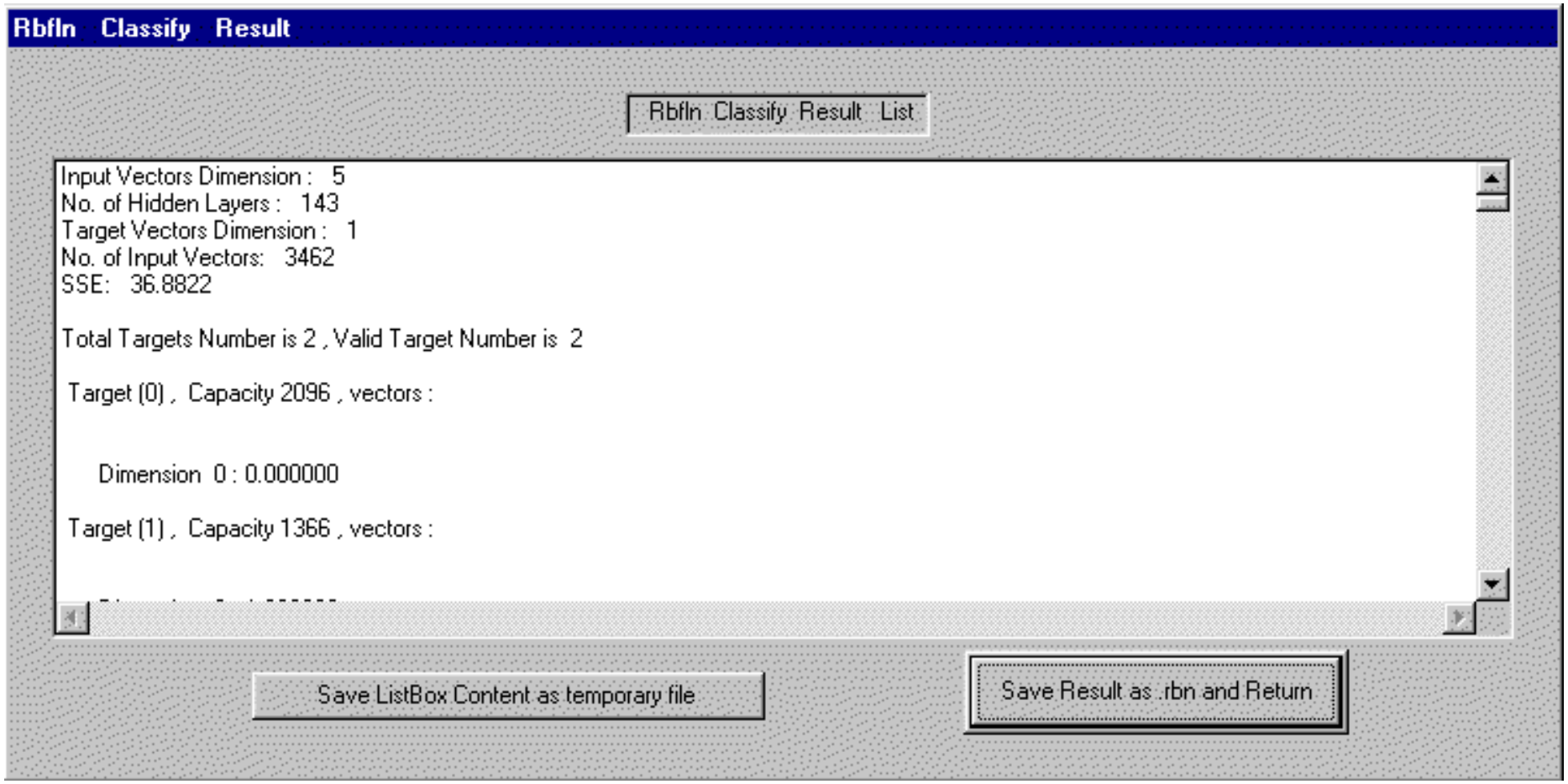
The steps for classifying data are the same as those taken for testing the classification in the preceding section, with the exception that results are saved to a permanent file that can be subsequently read by Arc-SDM.

Click the 'Classify' button.

When prompted, select the file containing the data to classify. If generated by Arc-SDM, the default name is **class#.dta** and click 'Open'.

When prompted, select the file containing the parameter file that was the result of the training step. Its extension is .par. Click 'Open'.'

When processing is complete, a report will be displayed with the following format:



The information reported in the report header is the same as shown an described in the preceding section about the testing process. The values reported should be identical.

Additional information is reported in the results section, as follows:

Result of RBFLN Classify

Column 0:	**Vector No.**	an integer uniquely identifying each input vector (unique condition). This number corresponds to the values in the unique conditions grid and attribute table. The values will be used to join the RBFLN results to the unique conditions grid theme when they are read by Arc-SDM in order to create a response theme.

Column 1:	**Classified Class No.**	the target class that the vector is classified as. The value is either 0 or 1 and is derived by rounding the actual output value.
Column 2:	**Target Output**	The contents of the target output from the data file (all 0's).
Column 3:	**Actual Output**	The value calculated by the RBFLN. This value can be read by Arc-SDM for mapping.

To save this report to a file

You can optionally save the contents of this report to a text file for later inspection or reporting purposes. To do this,

1. Click 'Print ListBox Content to temporary file'.
2. Specify a filename and location when prompted.
3. Click 'Save'.

Save the results of the RBFLN classification session

1. Click 'Save Results as .rbn and Return'.
2. Specify a filename and location when prompted.

This file must be saved if you want to read the results back into ArcView via Arc-SDM.

You will be returned to the main DataXplore dialog.

Fuzzy Clustering: Fuzzy (Unsupervised)

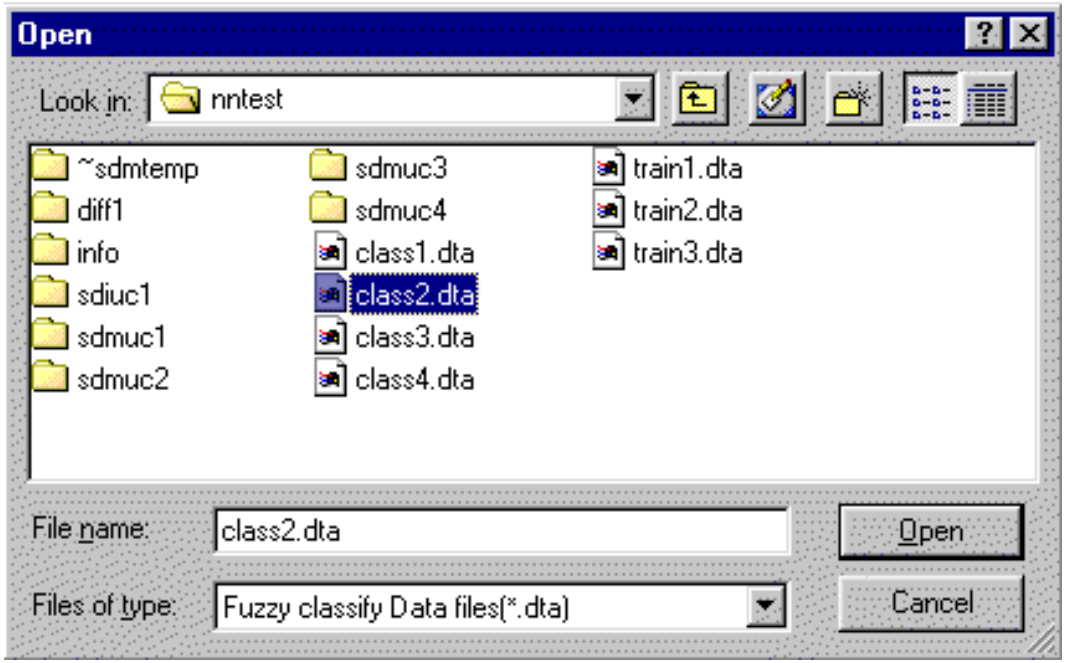
There are two steps in doing a classification by fuzzy clustering:

- Training 
- Classification 

Training

Click the 'Train' button located in the box labelled 'Fuzzy (Unsupervised)' on the main DataXplore dialog.

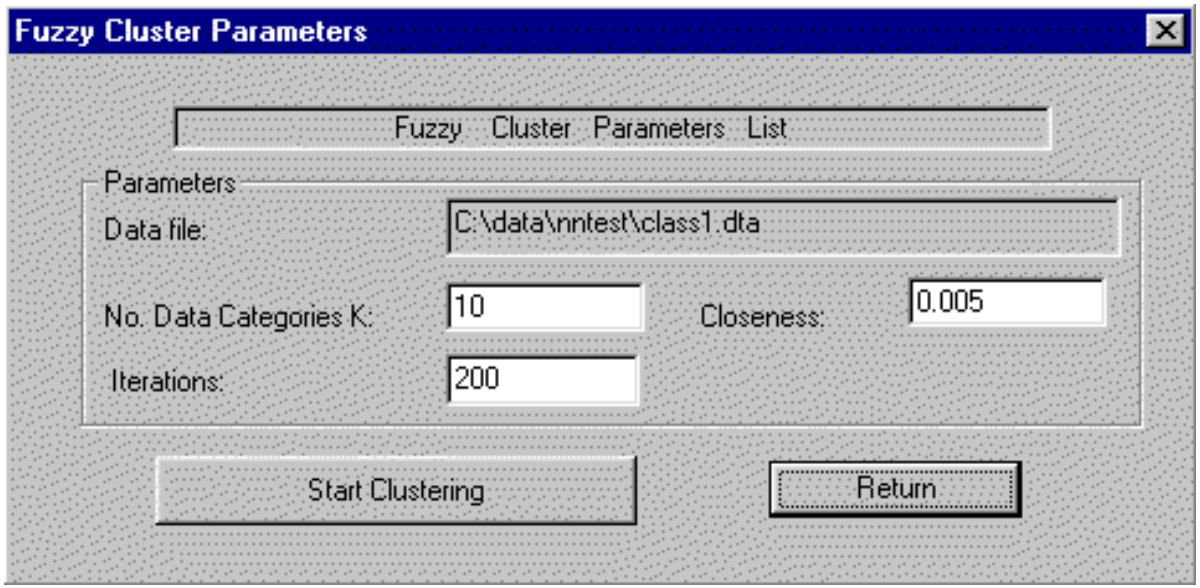
This will a dialog prompting you to select a 'Fuzzy Train Data File'. The fuzzy clustering algorithm trains using the complete data set that is to be classified. If your input files were generated by Arc-SDM, this file is the one that contains the entire unique conditions table information. The default name was **class#.dta**.



Select the file to use.

Click 'Open'.

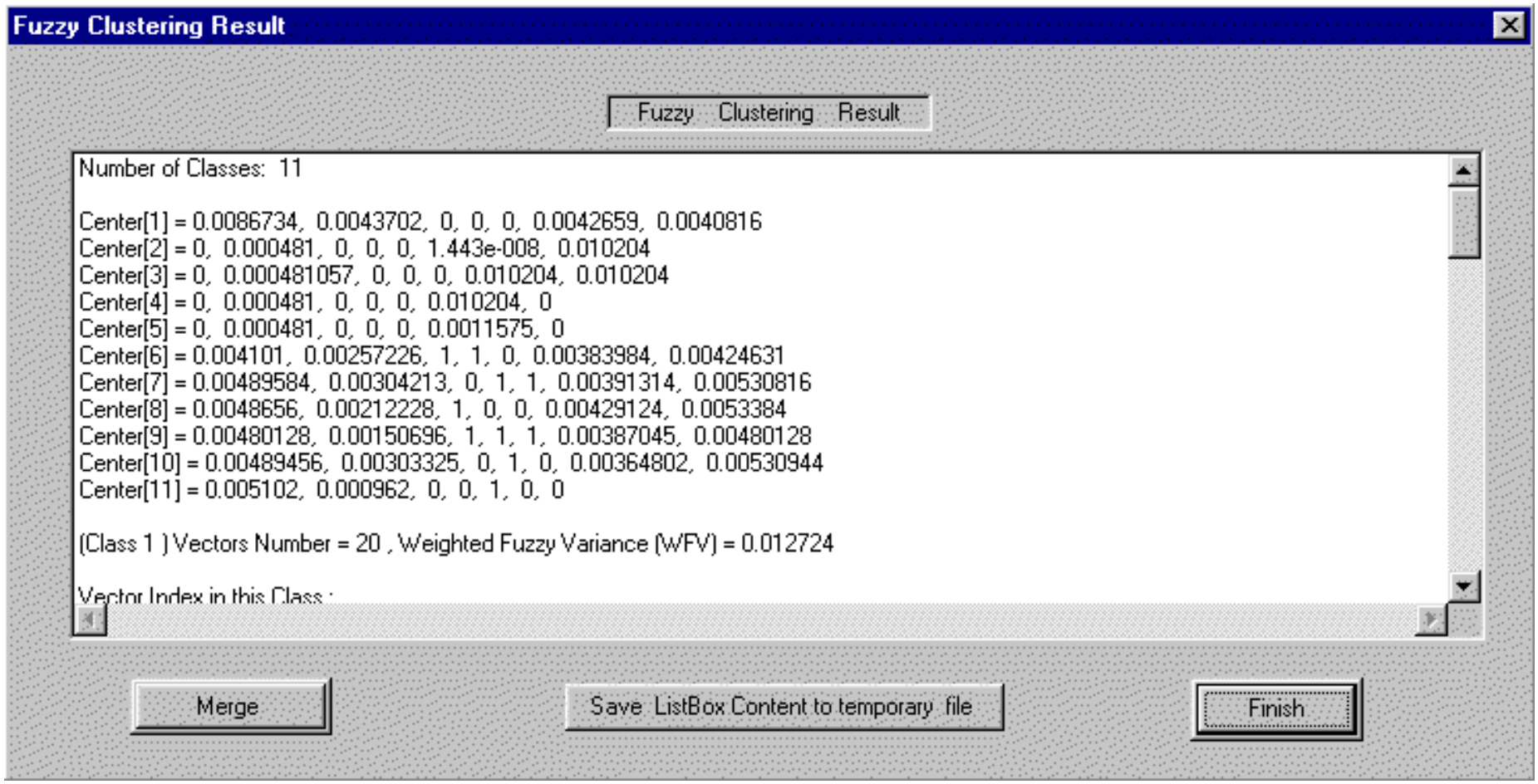
The following dialog will be displayed:



Accept the default parameters as displayed.

Click 'Start Clustering'.

When the clustering processes are complete, a report is displayed in the following format:



Fuzzy Clustering Result

Number of Classes - This is the number of classifications that DataXplore defined from the data.

Center[***i***] - the values that define the center of each cluster. The number of dimensions equals the number of input evidential themes.

For each Class, the following information is reported:

Vectors Number - the number of vectors (unique conditions) belonging to the class
Weighted Fuzzy Variance (WFV) - the value for the weighted variance of the class
Vector Index in this Class - a list o1f integers identifying the vectors (unique conditions) that belong to the class
Clustering Validity (1/XieBeni) - a measure of the validity of the clustering results. A value !!!!

Merge

You can merge classes by clicking the 'Merge' button.

You may want to do this if:

- you want to deal with fewer classes in your results
- the value of the clustering validity measure is too low

When the merge process is complete, the message 'Merge finished' will be displayed at the top of an updated report. There may be a point at which the algorithm cannot merge the data into fewer classes than currently exist.

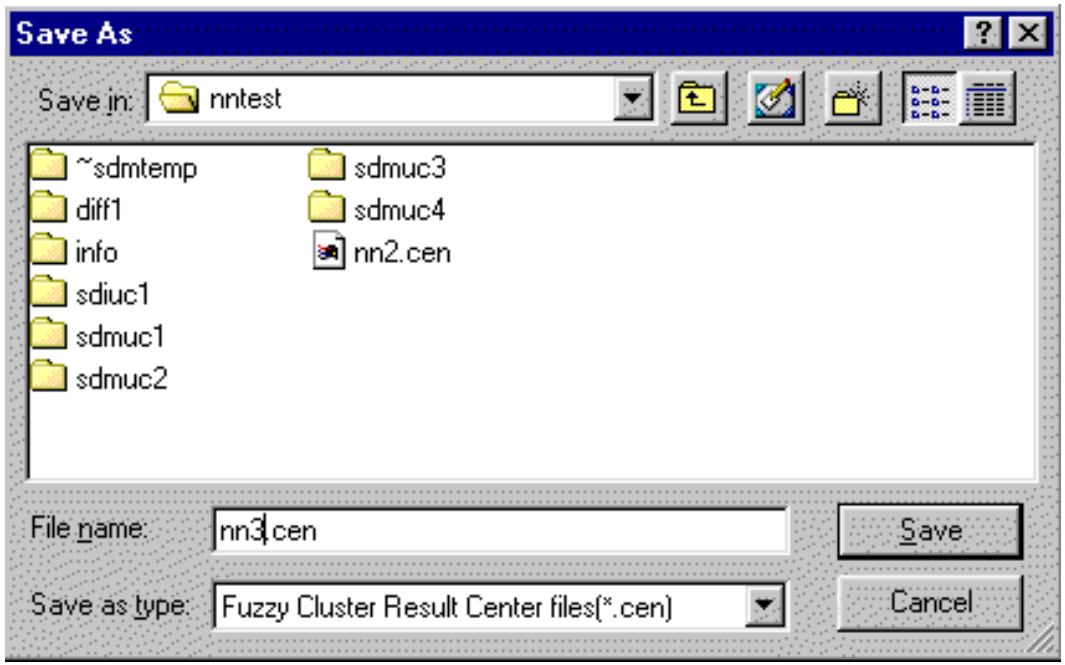
To save this report to a file

You can optionally save the contents of this report to a text file for later inspection or reporting purposes. To do this,

1. Click 'Save ListBox Content to temporary file'.
2. Specify a filename and location when prompted.
3. Click 'Save'.

When you are satisfied with the number of classes, click 'Finish'. This will prompt you to save the results of the clustering to a Fuzzy Cluster Result Center file (*.cen).

You must save the results of the clustering step for input into the Classify step that follows.

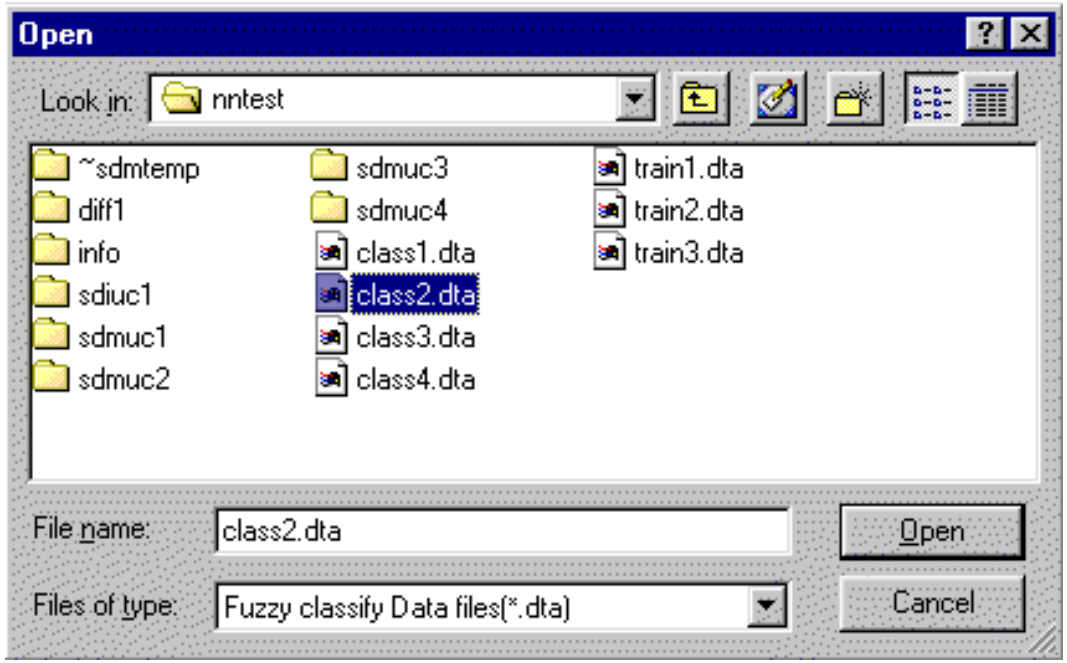


After you have saved the .cen file, click 'Return'.

Classify

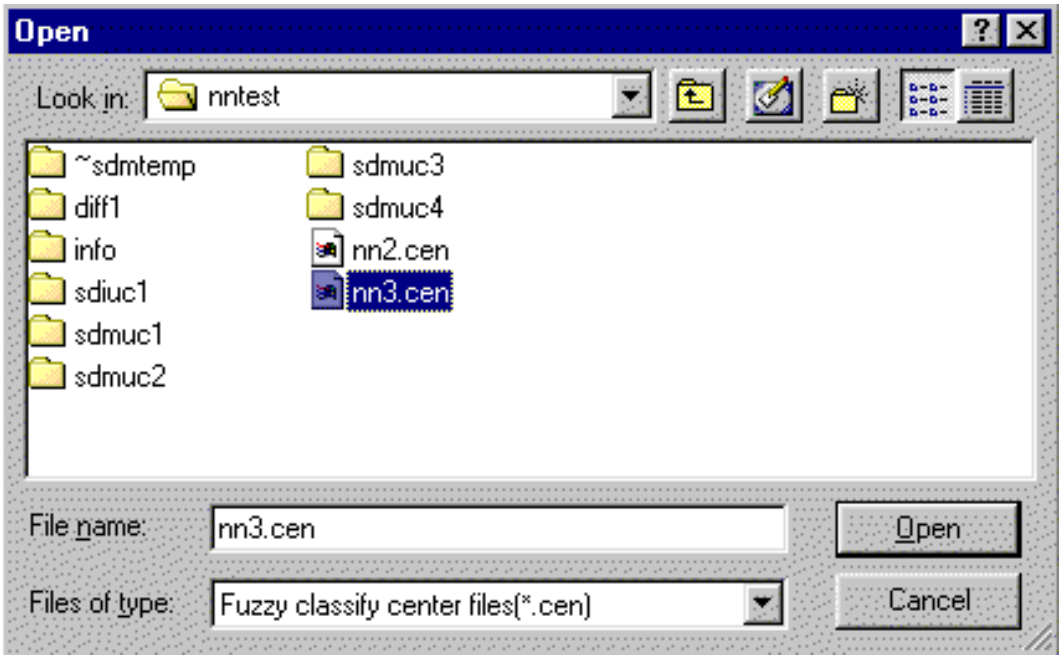
Click the 'Classify' button.

Select the 'Fuzzy Classify Data file'. This is the same file that was selected as the 'Fuzzy Train Data File' in the preceding step. If generated by Arc-SDM, it contains the complete unique conditions table information and a name of **class#.dta** was proposed by default.



Click 'Open'.

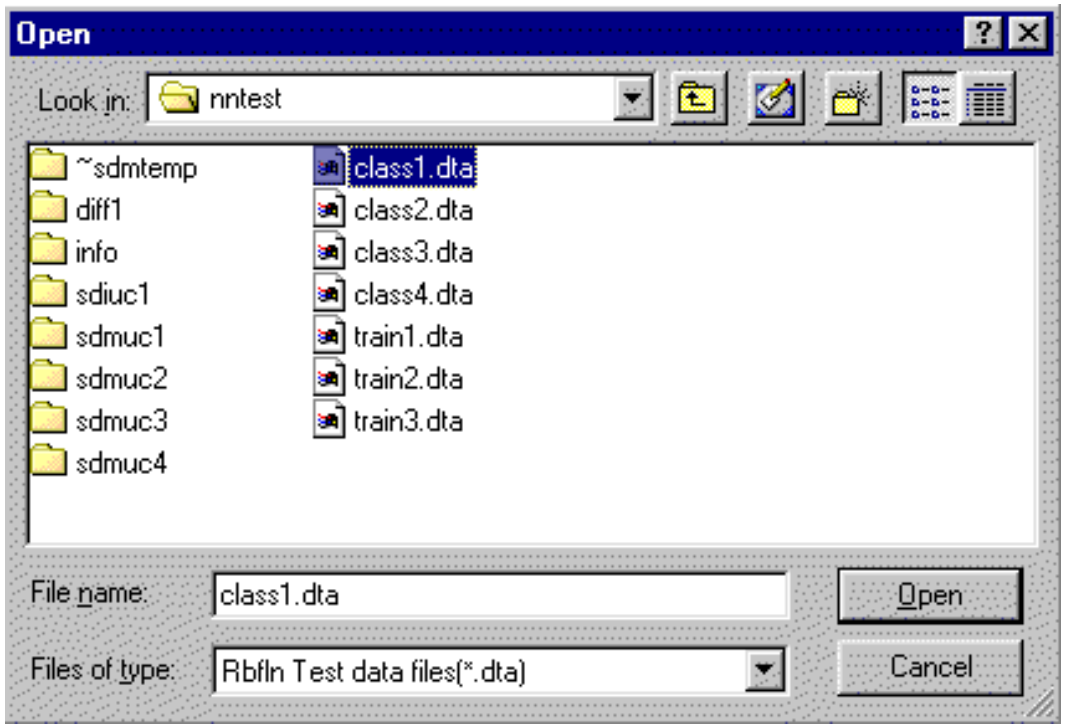
When prompted, select the Fuzzy Classify Center file generated in the training step:



The results of the classification are reported in a similar report to the one created during the training step. It can be saved by clicking 'Save ListBox Content to temporary file' and specifying a name and location for the file.

Click 'Finish'.

You will be prompted to save a Fuzzy Classify Result file (.fuz). Specify the file name and click 'Save'. This file is required to read the results of fuzzy clustering back into ArcView via Arc-SDM.



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Read Results from Neural Network Module

Select 'Read Results from Neural Network Module...' from the SDM menu.

Select the unique conditions grid theme with which you want to associate the results from the neural network analysis. This is the same unique conditions grid theme that was used to generate the neural network input files.

Click OK.

You will be prompted to do the following:

1. select the RBFLN Result File (.rbn) to read. If the RBFLN analysis was not done, click 'Cancel' to bypass this dialog.
2. select the Fuzzy Classify Result file (*.fuz) to read. If a fuzzy classification was not performed, click 'Cancel' to bypass this dialog.
3. specify the name and location to create a dBase file to write the results from the neural network analysis. The default name is **nnrslt#.dbf**.
4. the result field on which to symbolize the response theme. The possible fields are those of the neural network result file (nnrslt#.dbf). Descriptions of each are provided in the description of the table that follows.

The Neural Network Result file					
Field Name	**Field Alias**	**Data Type**	**Size (Precision)**	**Description**	**Symbolization**
ID	ID	Long Integer	6	Unique condition identifier. Used to join the results to the unique conditions attribute table.	N/A
PtrnMemshp	Pattern Membership	Decimal	10 (6)	The result from the Radial Basis Function Link Network (RBFLN). Values fall in the range 0 to 1. 1 indicates a mineral occurrence and 0 indicates the absence of a mineral occurrence. The higher the value the more closely the unique condition resembles a pattern in which	Graduated colour

				mineralization is known to occur.	
FuzzyClstr	Fuzzy Cluster			The result from the Fuzzy Classification. The class to which the unique condition was assigned.	"Unique" colour scheme
Pat#	Pattern <#>			A series of fields, one for each class defined during the fuzzy clustering. The value is a measure of the closeness of the unique condition to that particular pattern or class.	Graduated colour

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Compare Results

Two tools are provided in the Spatial Data Modeller as aids to comparing results obtained from the different analytical methods. They are:

- the calculation of an Area Weighted Spearman's Rank Correlation Coefficient
- the generation of a Map of Rank Differences

How to use the Compare Results tool

Comparison of Ranks

The ranks of values are compared rather than the raw values because the results from different methods may be scaled over a different range. For example, weights of evidence will typically generate higher probabilities than logistic regression, particularly for the areas predicted to be most favourable. When results are compared relatively, eg. using ranks, the results are very similar. So, for example, in the prediction of mineral favourability, the 5% of are study area predicted to be most favourable by one method is compared with the 5% predicted to be most favourable by the other method rather than the absolute probabilities generated by either method.

Ranks are generated by sorting the data in ascending order and assigns integer values R = 1, 2, ..., n. Spatial Data Modeller defines 20 ranks, or the maximum possible if the data set is too small to generate 20. The area weighting is built in to the equations for the Spearman's Rank Correlation, while an equal area classification is used to rank the data for the Map of Rank Differences.

Area Weighted Spearman's Rank Correlation Coeffiecient

If data in one data set are being compared to data in another data set, the two data sets are combined to create a unique conditions grid so that ranks can be compared for the same areas or "polygons". (If data from two fields in the attribute table of the same data set (grid them) are being compared this step is not necessary.) The data is transformed to ranks. The mean rank is calculated and the area associated with unique condition or polygon determined. An algorithm to calculate the following equation is used to calculate the coefficient:

$$r_s = \frac{\sum_{i=1}^{n} T_i (R_x - \bar{R}_x)(R_y - \bar{R}_y)}{\sqrt{\sum_{i=1}^{n} T_i (R_x - \bar{R}_x)^2 \sum_{i=1}^{n} T_i (R_y - \bar{R}_y)^2}}$$

r_s is reported in a table based on a dBase file.

r_s varies from 1 (perfect correlation) through 0 (no correlation or independence) to -1 (perfect negative correlation).

Map of Rank Differences

Ranks are generated using an equal area classification. The grid themes being compared are reclassified by rank and a unique conditions grid is generated that is the basis of the map of rank differences. For each unique condition, the difference between the source ranks is calculated and appended to the attribute table. It is this difference that is mapped. The map is primarily a visual tool: areas where the input maps match are coloured grey; the greater the first ranked data is than the second, the greater the saturation of blue; and the greater the rank of the second map is than the first, the greater the saturation of red.

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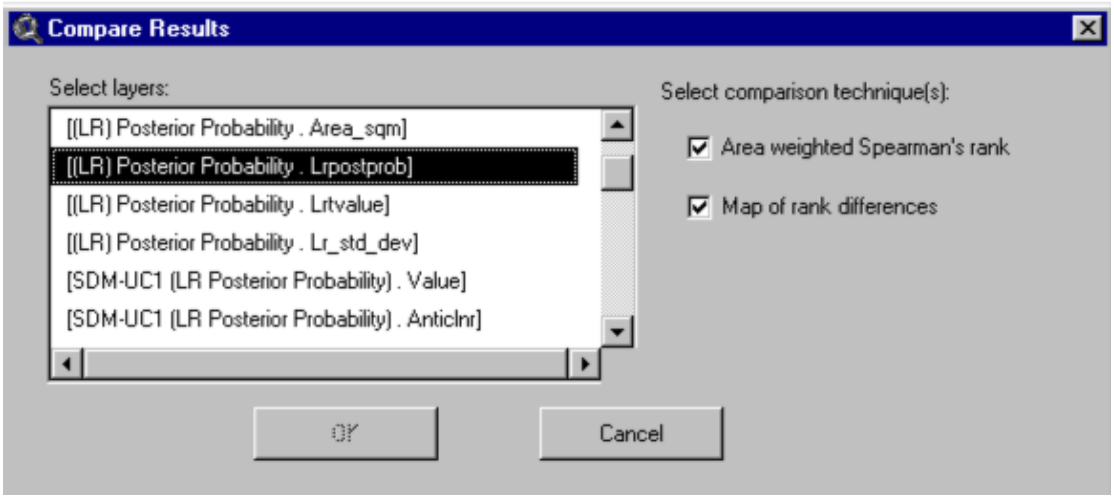
How to use the Compare Results tool

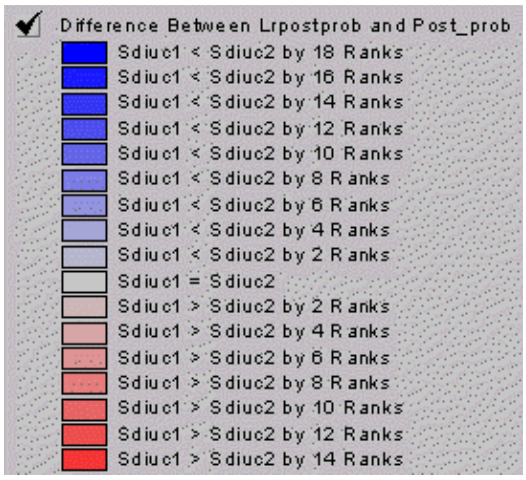
1. Select 'Compare Results...' from the SDM menu. The following dialog box is displayed:

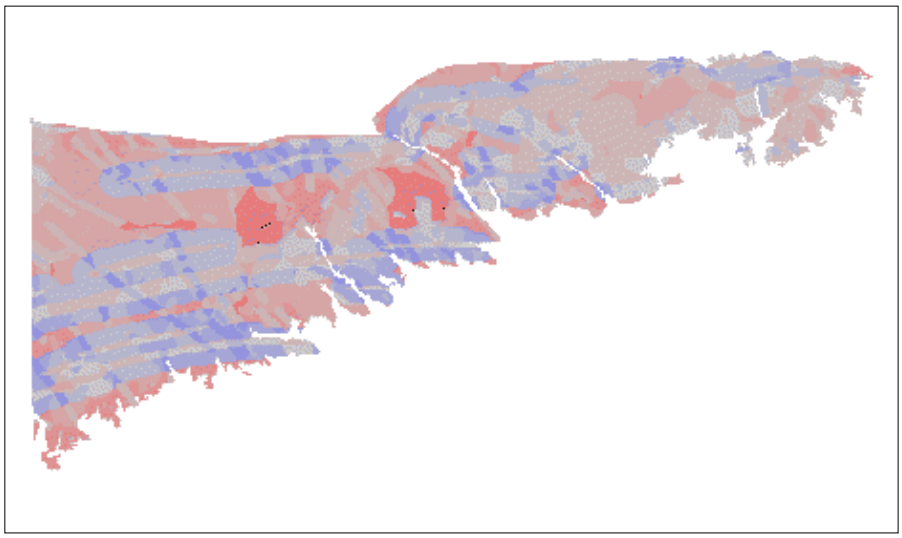


The box labelled 'Select layers:' lists all of the "theme-field" combinations available for comparison. The format for each item is [*theme name*

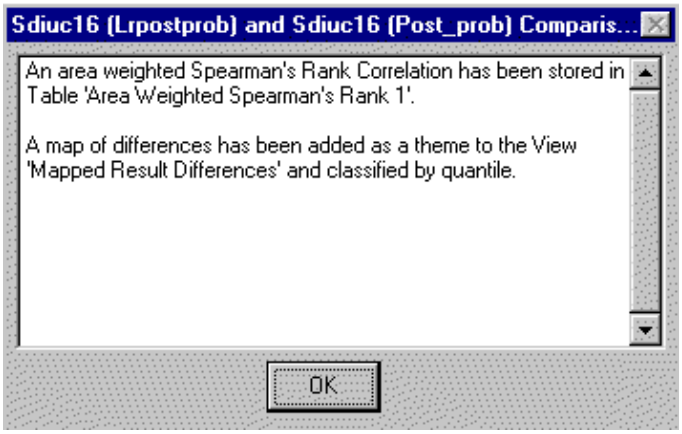
. *field name*]. Valid inputs for comparison are all the grid themes in the active view and the numeric fields in any integer grid theme attribute tables. If a grid theme is based on a floating point grid, the field name is specified as 'Value' (although technically there is no field).

1. Select two theme-field combinations to compare by clicking on one and holding down the shift-key and clicking on a second.
2. Check the comparison techniques(s) you want to use.
3. Click OK.
4. If the area weighted Spearman's rank correlation is calculated, specify the filename and location of the dBase file when prompted. The default name is **wsr#.dbf**
5. If the map of rank differences is generated, specify the name and location of the source grid when prompted. The default name is **diff#**.





When processing is complete, the location of the table containing the Spearman's rank correlation coefficient and the name of the view containing the map of rank differences is reported:



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Associate Responses With Point Theme...

This function allows you to determine the final probabilities at the locations of the training points you input to any of the models. Or, at some other set of points in the study area. This function creates a table that contains information about the locations of a set of points and the probabilities calculated at those points.

When you select this item from the SDM menu, a dialog appears, prompting you to select a point theme and a response theme.

Arc-SDM first appends a new field, RecordID, to your point theme's attribute table and writes the number of each record to that field. This ensures that each point has a unique identifier. A new .dbf file is created with one record for each point. In each record, the unique record number, as well as the x and y coordinates for each point, are written.

Arc-SDM then determines in which unique condition (record) in the response theme each point is located and copies the posterior probability, posterior logit, sum of weights, etc. from the response theme's attribute table to the new table. The final .dbf table contains in one place, the location of each of the points and the responses measured at those locations.

Pntrsp2.dbf

RecordID	X	Y	Posterior Probability	Posterior Logit	Sum of Weights	Uncertainty
94	246174.30909	237636.38533	0.00005653	-9.78073406	-4.55639982	0.00003916
95	255168.85094	243257.93478	0.00005653	-9.78073406	-4.55639982	0.00003916
96	220354.01092	256557.05367	0.00042609	-7.76043367	-2.53609991	0.00022875
97	217461.86112	263297.18486	0.00042609	-7.76043367	-2.53609991	0.00022875
98	219526.14634	261654.71817	0.00042609	-7.76043367	-2.53609991	0.00022875
99	216362.67079	264811.99107	0.00042609	-7.76043367	-2.53609991	0.00022875
100	215259.98701	266326.86090	0.00042609	-7.76043367	-2.53609991	0.00022875
101	253594.79049	261471.91384	0.00042609	-7.76043367	-2.53609991	0.00022875
102	121515.03294	384752.26337	0.24022728	-1.15143383	4.07289982	0.06894110
103	126483.12054	375244.78976	0.24022728	-1.15143383	4.07289982	0.06894110
104	200952.24579	369630.27768	0.00381636	-5.56463385	-0.34029999	0.00228416
105	121618.27168	386687.08445	0.04024339	-3.17173386	2.05259991	0.02232759
106	121324.15431	387410.61834	0.24022728	-1.15143383	4.07289982	0.06894110
107	124388.37739	386653.90046	0.24022728	-1.15143383	4.07289982	0.06894110

How can I symbolize or display the probability information at each point

You can either join the new table to your point theme using the RecordID in both tables as the 'to' and 'from' join fields, or you can add the new table to a View document as an X,Y event theme.

To join the associated .dbf table to your point theme:

Open the new table, Pntresp<#>.dbf, and select the field 'RecordID'.

Open the point theme attribute table and select the field 'RecordID'.

With the point theme attribute table active, click the 'Join' button, or select Join from the Table menu in the Table document interface.

Now, if you double click on the point theme's legend to edit it, the fields in the joined table are available for symbolization.

Arc-View on-line Help Topic: joining tables

To create an XY event theme

In a View document, from the View menu, select 'Add Event Theme...'.

In the dialog box that displays, select the table, the X field and the Y field, and click 'OK'.

Arc-View on-line Help Topic: themes, adding

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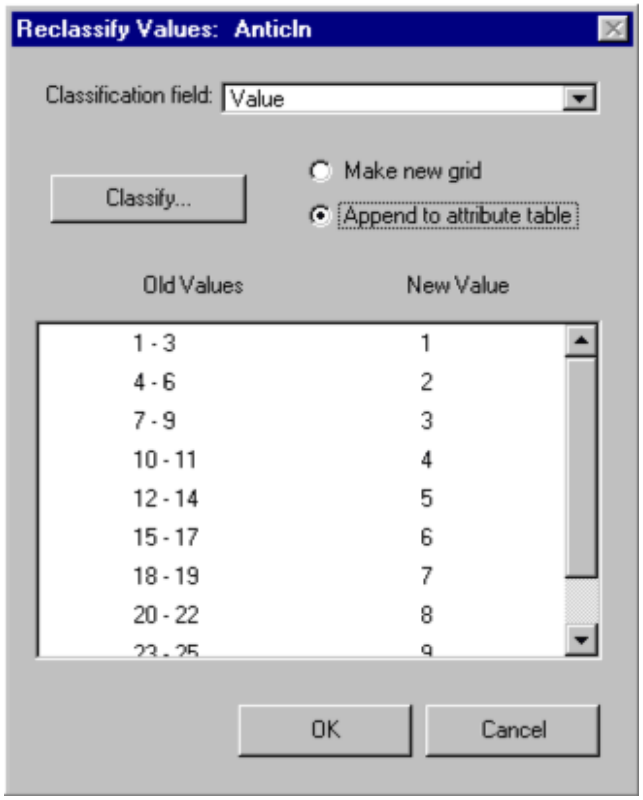
Reclassify Tool

This tool was developed for those who would like to reclassify a grid theme and keep a record of the input classifications (minimum and maximum of the range of values for each output class). NOTE: The resolution of the output grid cannot be coarser than that of the input because the tool cannot record how Spatial Analyst handles a reduction in classes.

This function is based on the Reclassify function found in the Spatial Analyst's Analysis menu, but differs in three ways:

- if the input grid theme is integer, the user has the option of appending the reclassification information to the attribute table of that theme rather than creating a new grid
- the values that define each new classification are written to the output grid theme attribute table
- the dialog box used to define the reclassification is a "stripped-down" version of the Spatial Analyst tool



To Reclassify the values in a grid theme:

Make the grid theme you want to reclassify active.

Select 'Reclassify Tool...' from the SDM menu.

If the theme is an integer grid theme, there will be a pair of radio buttons on the dialog labelled 'Make new grid' and 'Append to attribute table'. Select one of these options. If neither is selected, the reclassification defaults to appending the reclassification information to the input grid theme attribute table.

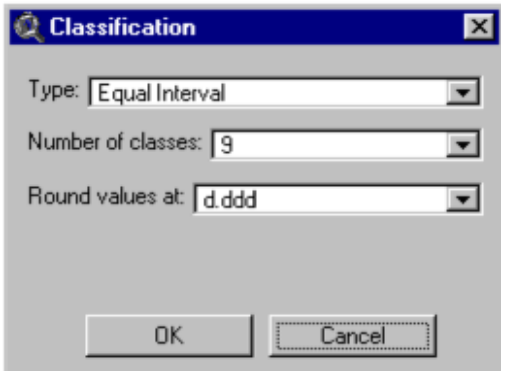
Option	Description
Make new grid	● Generates a new grid whose cell values are the new classes. ● The source values that define each class are appended to the attribute table of the new grid.

Append to attribute table	Both ● the class values generated by the reclassification ● the source values that define each new class are appended to the input grid theme attribute table.

To define a classification:

Click the 'Classify' button.

The dialog that is displayed works the same way as the classification dialog used with the ArcView legend editor and the Spatial Analyst reclassify tool.



The following steps are copied from ArcView On-Line Help.

1. Click the Classify button in ArcView's legend editor.
2. Choose a type of classification.
3. Set the number of classifications. You may use the drop-down method or click on the value box and directly type in your number of classes.
   If you chose the Standard Deviations classification, set the Interval that will determine the class breaks.
4. Choose the place at which your data values will be rounded.
5. Click OK.

For more information about defining a classification, refer to the **ArcView On-line Help Topics:**

legends, classification -> Set a classification
legends, classification, Classifying

To edit any of the 'Old Values' or the 'New Value' for an individual classification:

1. Double-click on the value(s) displayed in the Reclassify dialog. This will display an edit dialog.
2. Edit the values.
3. Click OK.

To apply the classification:

1. Click OK.
2. If a new grid is being generated, specify the name and location when prompted.

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Normalize Grid

This function creates a grid that contains the normalized values of the input grid, that is the values of the input grid scaled between 0 and 1. The input grid may be either integer or floating point. In the case of an integer grid, the only the cell values (appearing in the 'Value' field) can be normalized.

The equation to perform the normalization is:

output grid = (input grid - grid of minimum input value) / grid of maximum input value

To normalize a grid:

- Select 'Normalize Grid...' from the SDM menu.
- Select the grid theme to process when prompted. (The first active grid theme, if any, will be the default selection.
- Specify a name and location for the new theme when prompted. The default name is 'Nwgrd#' in the current working directory.
- The new theme will be added to the active view symbolized with a default classification and random graduated colour scheme.

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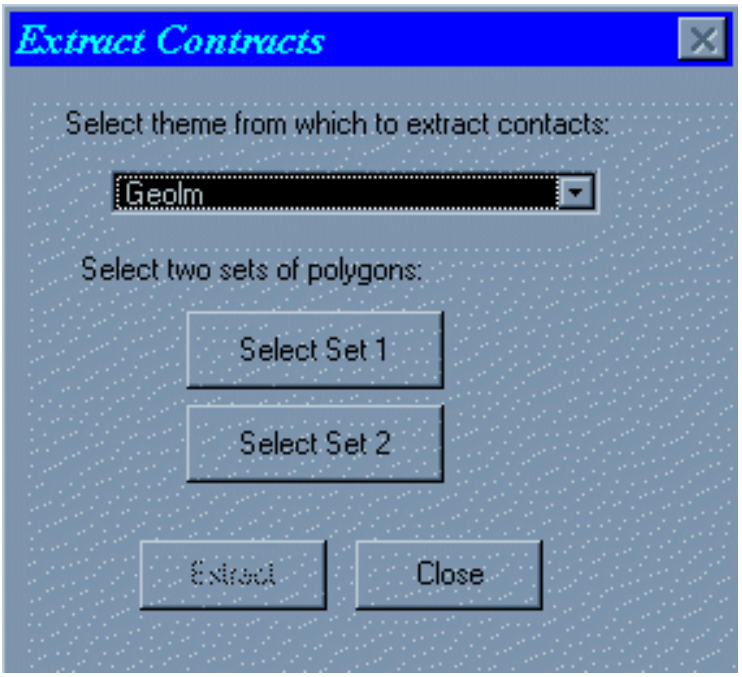
Extract Contacts...

The Extract Contacts function allows you to locate the contacts between two sets of polygons and write them to a new data set. If your input data is a polygon feature theme, the output will be a line feature theme, based on a shape file. If you input data set is a Grid Theme, your output data set will be a Grid Theme, based on a Grid, in which the cells defining the contacts contain 1 and all other cells contain 'No Data'.

The Extract Contacts... dialog box.



Input Theme – Select the theme of polygons

Select Set 1 – Click this button to display the Query Builder dialog. Build or type a query to define one set of polygons. Click 'OK' to accept.

Select Set 2 – Repeat the steps for 'Select Set 1' to define a second set of polygons.

Extract – This button becomes enabled once two selection sets have been made.

How to extract contacts

You can use the Geolm Grid Theme and/or the Geolm.shp Feature Theme, both in the d:/ns/novascot.apr, to test the extract contact function:

1. Make the View containing the theme you want to use active.

2. Select Extract Contacts... from the SDM menu.

3. Select Geolm or Geolm.shp from the combo box.

4. Click 'Select Set 1'.

5. In the Query Builder, build a query as follows:

Double-click 'Value' or 'Gridcode' in the field column.

Click the ‘=‘ button.

Double-click ‘3’ in the value column.

Click ‘OK’.

6. Click ‘Select Set 2’.

7. This time from the Query Builder dialog, build the following query:

[Value] = 1 OR [Gridcode] = 1

Click ‘OK’.

8. Click extract contacts.

Spatial Analyst: Version 1.0 vs 1.1

A new Avenue request is included in SA1.1 (aGrid.AsPolyLineFTab) that enables raster "lines" to be converted to vector lines.

Output contact theme

If your input theme is a feature theme (vector), then the contacts will be lines written to a new shape file. The default name for the shape file will be Ctact<#>.shp.

If your input theme is a grid theme (raster), then the contacts will be cells of value 1 in a new GRID. Cells not defining contacts will have ‘No Data’. In order to define contacts that are the approximate width of the cell size of the input Grid Theme and centred on the contact between the defined areas, the output cell size is half that of the input cell size.

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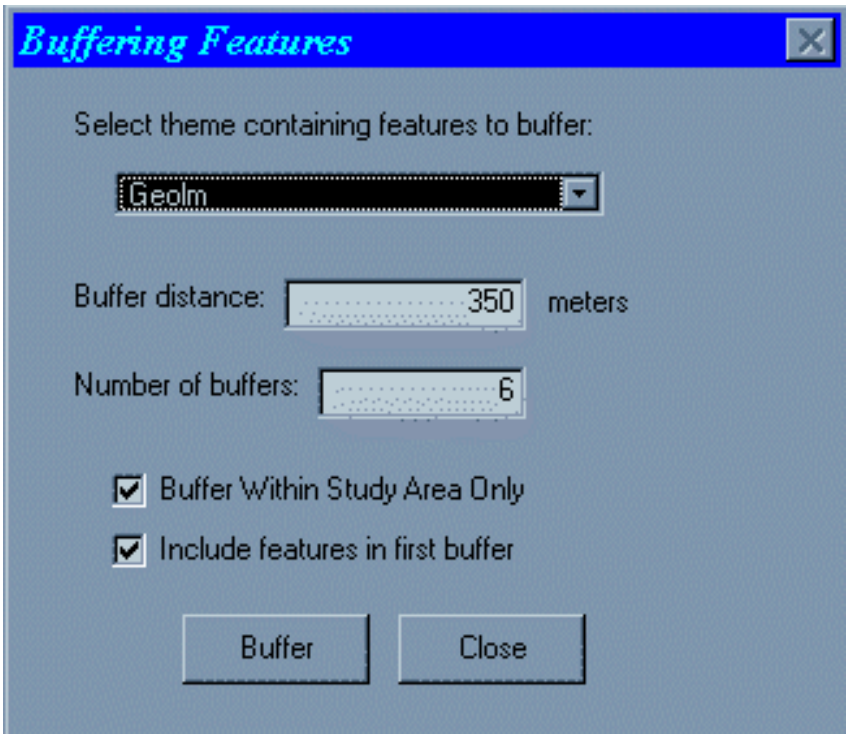
Buffer Features...

This function allows you to create a set of one or more buffers around point, line or polygon features. The input may be a Feature Theme or a Grid Theme. The output is always a Grid Theme.

Buffer Features Dialog



Input Theme – If your input theme is a Grid Theme, you may need to select your features before buffering.

Buffer distance – Type in the size of the buffer interval. You may get unexpected results if your buffer interval is smaller than your Analysis Cell Size. To check or edit the Analysis Cell Size, select Properties from the Analysis menu.

Number of Buffers – Type in the number of buffers you would like to create. All cells outside the distance equal to the interval size times the number of intervals will be grouped in a single class.

Confine buffering to study area – If this box is checked, the output grid will only contain buffer values within the study area. All cells outside of the study area will contain 'No Data'.

Include features in first buffer – Check this box if you want to include your features in the first buffer interval. By default the box is checked. If checked, the cells that define the feature will be assigned the value of the first buffer interval. This is the preferred option in most cases, usually for buffering point and line features. Sometimes you may want to retain the buffered features separately in the output grid. If unchecked, the cells that define the buffered features will be assigned a value of 1. This is usually done for polygon features.

How to buffer a set of features

1. Set the analysis cell size by selecting Properties from the Analysis menu. If you select a cell size larger than your desired buffer interval, you may get unexpected results. If you do not select

a cell size prior to buffering, and your input theme is a Feature (vector) theme, you will be prompted during buffering to specify a cell size.

2. If you want to confine buffering to your study area, ensure that the Study Area Grid Theme is selected by choosing Set Parameters from the SDM menu.

3. The buffering function buffers all selected features (Feature Theme) or cells (Grid Theme), or, if none are selected, all features or cells. If you want to buffer a subset, select it before running the buffering function.

4. Select Buffer Features... from the SDM menu to display the Buffer Features dialog.

5. Select the theme with the features you want to buffer from the combo box.

6. Type in an interval width.

7. Type in the number of buffer intervals you want to generate.

8. Specify whether you want to confine buffering to your study area. If you have a Study Area Theme specified, but do not want to apply it, the buffering function will ignore the study area boundaries.

9. Specify whether you want the buffered features to be included in the first buffer interval.

10. Click the ‘Buffer’ button.

The output buffer grid theme

If you have specified that the buffered features not be included in the first buffer interval, the cells defining them will have a value of 1.

The cells in each buffer interval will have a value of the upper limit/distance of the buffer interval.

Cells outside your last buffer have a value of the last buffer interval plus 1.

Spatial Analyst: Version 1.0 vs 1.1

A problem occurs periodically with Spatial Analyst 1.0 in which it is unable to create a temporary GRID during the calculation of a GRID of Euclidean distances. If this is happening the same type of error message will occur while running the Find Distance function in the Analysis menu, or when running the Buffer Feature... function from the SDMmenu.

This problem has been corrected in version 1.1.

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Add Bearings...

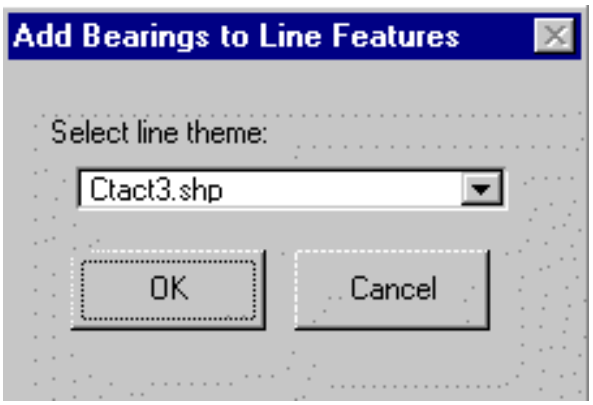
The Add Bearings... option allows you to add the bearing of each line in a line feature theme to its record in the attribute table. You can subsequently subset the line features by querying the attribute table and defining a range of suitable orientations. In order to create a new theme from the selected subset, make the theme active, then select 'Convert to Shapefile...' from the Theme menu.

This is a simple calculation involving the first and last vertext in each line only.

To calculate bearings for a line theme:

1. Select Add Bearings... from the SDM menu.

2. Select the line theme you want to process from the dialog:



3. Click 'OK'.

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Help on Help

This section should probably be unecessary but here are the main components of the help facilities in Arc-SDM.-

- Installation
- Help in the ArcView interface
- Arc-SDM On-line Help
- ArcView Comments
- The Comment Viewer
- PDF document

Installation

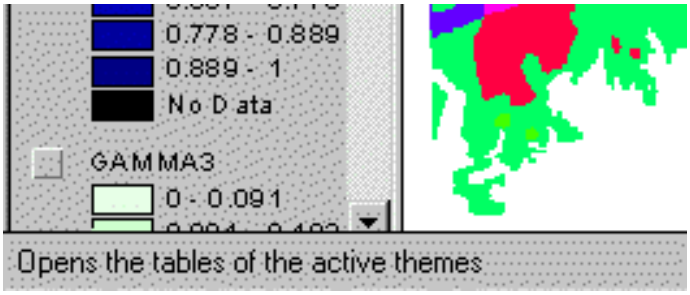
The instructions for installing the on-line help documentation are provided in the section for general installation instructions. There are a few options but essentially you need to:

Decide where you want to put the help files and copy or unzip them at this location. (You can also use them from CD-ROM.)

The first time you invoke the on-line help, tell Arc-SDM where the sdmhelp.htm file is and whether you prefer to use Netscape or Internet Explorer.

Help in the ArcView interface

ArcView provides help messages in the application status bar located in the lower left corner of its main menu frame. Information is provided about currently running processes or about controls (menu chocies, buttons and tools) in the user interface. Rest the mouse on a control to view the help message, for example the message shown in the following screen capture appears when the mouse passes over the 'Open Theme Table' button in the view interface.



Help has been supplied for all of Arc-SDM's interface controls (menu choices, buttons and tools), as well as many dialog controls. If further information in the on-line documentation (see next item), the message contains a reminder that this help can be displayed by holding down the shift key while clicking or selecting the control.

On-line Help

A set of HTML files provide on-line documentation that is integrated with Arc-SDM. Access this help by holding down the Shift key while selecting a control in the Arc-SDM interface. There are several access points from the interface as follows:

the Spatial Data Modeller menu items: select the menu item while holding down the Shift key

button and tool controls: click while holding down the Shift key

selected dialog controls: click or make a selection in the dialog control while holding down the Shift key

ArcView Comments

Arc-SDM generates many different ArcView documents and themes, as well as source files for these. To assist in the management of these outputs, all of the Arc-SDM functions writes comments for each document or theme that it generates. These comments include:

- the Arc-SDM function that created the document or theme
- the path and name of the source file of the document or theme, if there is any
- any associated documents or themes and the paths and names of their source files

These comments can be viewed and edited through the standard ArcView interface as follows:

For documents:

Open the document.

Select 'Properties...' from the 'document' menu, i.e. the 'Table' menu for a Table document.

For example: **ArcView On-line Help Topic: documenting a view**

For themes:

Make a theme active.

Select 'Properties...' from the 'Theme' menu.

ArcView On-line Help Topic: properties --> Setting a theme's properties

The Comment Viewer

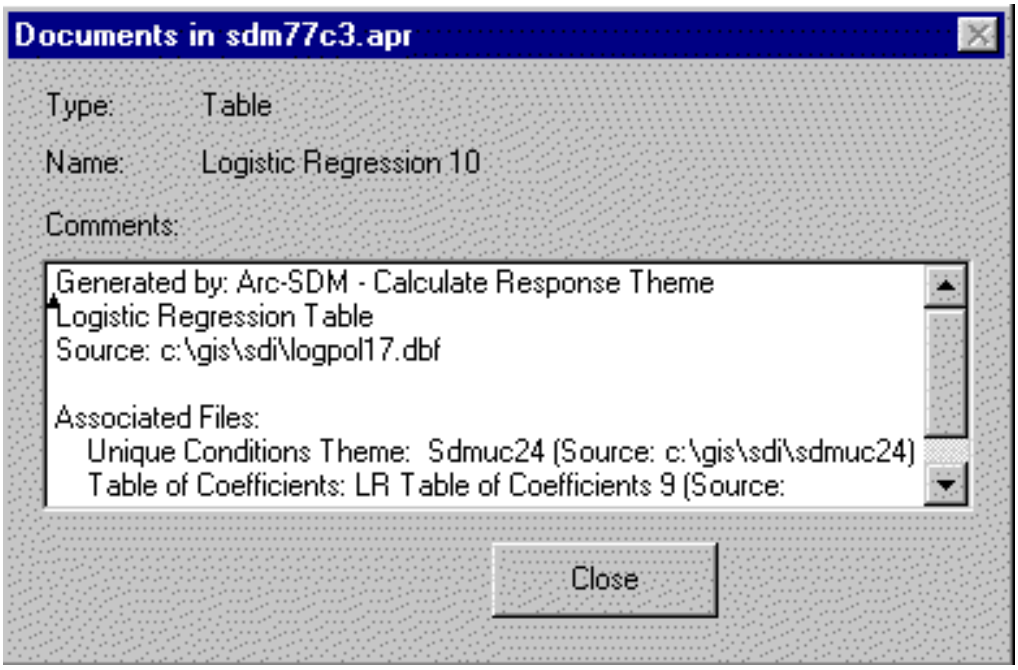
Arc-SDM includes a comment viewer dialog that can be opened from the project window or a view window. It allows you to review any comments about documents listed in the projet window without first opening them.

To use the comment viewer:

1. Click the  button located farthest right in the button bar in either the project window or a view window.

   If the project window is active, the document type, name and comments will be displayed for the first selected document in the current list of documents.

   If a view is active, the theme type, name and comments will be displayed for the first active theme in the active view.



You can resize the view dialog to display text without wrapping.

Arc-SDM Documentation in PDF format

The Arc-SDM HTML documentation is also provided in PDF format both to facilitate easier printing and the convenience of having all the documentation in one file.

An Acrobat reader is required to read PDF files. You can download the Acrobat reader for free from

Click to open sdmhelp.pdf.

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Symbolization Tool Menu

- Symbolize Response Theme
- Graduated Colour Tool
- Load RBF File
- Cumulative Area vs. Probability
- Shade Confidence
- Apply Mask

Arc-SDM includes a set of symbolization tools. They are attached to tools organized in a tool menu that is loaded to the far right position in the View document tool bar.

General instructions for using the symbolization tools.

1. Make the theme that you want to process active. The tools will only be applied to the first active theme, if there is more than one.

2. Select the tool you want to use from the tool menu. If the tool cannot be applied to the active theme, it will be disabled (grayed out).

3. After selecting the tool, click the display area of the View interface to execute the script.

The Tools

 **Symbolize Response Theme** – enabled when a response theme is active.

Description: Symbolizes the response theme based on one values in one of the following fields using a natural breaks classification and a default colour scheme: WofE Posterior Probability, WofE Normalized Probability, WofE Posterior Logit, WofE Sum of Weights, WofE Uncertainty, WofE Missing Data, WofE Total Uncertainty, LR Posterior Probability, LR T-Value, LR Standard Deviation, RBFLN Pattern Membership.

How to use:

1. Follow the general instructions, preceding.
2. When prompted:
    - select the field on which to base the symbolization
    - specify the number of classifications

 **Graduated Colour Tool** – enabled when a grid or polygon theme is active.

Description: Applies a graduated colour palette to a theme, one colour for each class value in the specified field.

How to use:

1. Follow the general instructions in the first section.

2. If prompted:
    - select a field containing values to symbolize
    - select a field with text to use as legend labels.

 **Load RGB File** – enabled when a grid or polygon theme is active.

Description: Reads RGB values from a comma delimited text file and applies them to classifications in the active theme.

How to use:

1. Set the number and type of classifications for a theme.
2. Make the theme active, select the Load RGB File tool and click the display area.
3. Select your RGB file from the file dialog and click 'OK'.

RGB file format: text file with one set of RGB values on each line, separated by commas.

 **Cumulative Area vs. Probablity** – enabled when a response theme is active.

Description: Reads the areas and posterior probabilities from the attribute table of a response theme. Creates a new table (default name is freq<#>.dbf) and writes the cumulative areas and corresponding probabilities. Then creates an XY chart of the table values. The table can be opened in software other than ArcView, that reads the dBase file format, to create a more complex chart.

How to use: Follow the general symbolization tool instructions. The chart will displayed when processing is complete.

 **Shade Confidence** – enabled when a response theme is active.

Description: Creates a polygon confidence theme, i.e. a theme symbolizes the posterior probability normalized, or divided, by the total uncertainty. The theme is classified using five natural breaks classifications. Each classification is shaded using a dot stipple and transparent background. The theme is meant to be displayed over the response theme from which it was derived. The lower the confidence, the more grayed out or shaded the underlying probability will appear.

The shaded theme is based on a new shape file named Conf<#>.shp.

How to use: follow the general symbolization tool instructions.

 **Apply Mask** – enabled when a response theme is active.

Description: Makes a copy of an active response theme and symbolizes the copy so that all areas with posterior probability values less than or equal to the prior probability are set to a flat gray, and all areas with posterior probability values greater than the prior are made transparent. The theme is intended to be displayed over the response theme from which it was derived, revealing only areas of interest.

How to use: Follow the general symbolization tool instructions.

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Files created by Arc-SDM

This is a reference to the files created by various functions in Arc-SDM. In most cases you will be prompted for a file name, so you can specify a name other than the default. Several files, including temporary files, are created behind the scenes. Text in brackets <> indicates a variable part of the default file name. If the Created when box is empty, the file is always generated when the specified function is run.

Default Name	Format	Source Function	Created when...
Permanent			
sdmthms.dbf	dBase	Calculate Theme Weights... / Calculate Response Theme.../ DefineFuzzy Membership.../ Check Conditional Indepedence.../ Generate Neural Network Input Files.../ Help...	the file does not already exist and a function is run during which the user provides information about the data type (ordered or free), or the missing data integer for an evidential theme
<*evidential theme*>.txt	ASCII text	Calculate Theme Weights...	the box labeled 'Write results to a text file.' is checked
<*evidential theme*>-CT.dbf	dBase	Calculate Theme Weights...	the calculate Categorical or All buttons are clicked.
<*evidential theme*>-CA.dbf	dBase	Calculate Theme Weights...	the calculate Cumulative (Descending) or All buttons are clicked.
<*evidential theme*>-CD.dbf	dBase	Calculate Theme Weights...	the calculate Cumulative (Ascending) or All buttons are clicked.
sdmuc<#>	GRID/INFO	Calculate Response Theme... / Generate Neural Network Input Files...	
woe<#>.dbf	dBase	Calculate Response Theme...	when the Weights of Evidence option is selected
woevar<#>.dbf	dBase	Calculate Response Theme...	when the Weights of Evidence option is selected

wofe<#>.dbf	dBase	Calculate Response Theme...	when the Weights of Evidence option is selected
logpol<#>.dbf	dBase	Calculate Response Theme...	the Logistic Regression option is selected
lrcoef<#>.dbf	dBase	Calculate Response Theme...	the Logistic Regression option is selected
prb-<#>.dbf	dBase	Check Conditional Independence...	
x2-<#>.dbf	dBase	Check Conditional Independence...	you provide a file name (otherwise is not generated)
df-<#>.dbf	dBase	Check Conditional Independence...	you provide a file name (otherwise is not generated)
flmdl<#>.dbf	dBase	Fuzzy Logic...	
and<#>	GRID	Fuzzy Logic.../ Process Existing Model...	
or<#>	GRID	Fuzzy Logic.../ Process Existing Model...	
sum<#>	GRID	Fuzzy Logic.../ Process Existing Model...	
prd<#>	GRID	Fuzzy Logic.../ Process Existing Model...	
gamma<#>	GRID	Fuzzy Logic.../ Process Existing Model...	
ndtp<#>.shp	Shapefile	Generate Random Training Points...	
class<#>.dta	Text	Generate Neural Network Input Files...	Either the RBFLN or Fuzzy Clustering neural network options are selected
train<#>.dta	Text	Generate Neural Network Input Files...	The RBFLN neural network option is selected
*.par	Text	DataXplore: RBFLN - Train	
*.rbn	Text	DataXplore: RBFLN - Classify	

*.cen	Text	DataXplore: Fuzzy Clustering - Train	
*.fuz	Text	DataXplore: Fuzzy Clustering - Classify	
nnrslt<#>.dbf	dBase	Read Results from Neural Network Module...	
wsr<#>.dbf	dBase	Compare Results...	the Area Weighted Spearman's Rank option is selected
diff<#>	GRID/INFO	Compare Results...	the Map of Rank Differences option is selected
Pntrsp<#>.dbf	dBase	Associate Probabilities with Points...	
Nwgrd<#>	GRID/INFO	Reclassify Tool... / Normalize Grid...	
Grid#	GRID	Buffer Features...	
Ctact#	GRID	Extract Contacts...	extract contacts from a Grid Theme
Ctact#.shp (.dbf/.shx)	Shapefile	Extract Contacts...	extract contacts from a Feature Theme
Freq#.dbf	dBase	Chart Cumulative Area vs Posterior Probability tool	
Conf#.shp (.dbf/.shx)	Shapefile	Shade Confidence tool	
Temporary			
~sdmtemp\<evidential theme>	GRID	Calculate Response Theme... / Check Conditional Independence... / Generate Neural Network Input Files...	
xxstyar<#>.shp(.dbf/.shx)	Shapefile	Calculate Theme Weights.../ Calculate Response Theme...	evidential theme is a Feature Theme
xxtempet<#>.shp(.dbf/shx)	Shapefile	Calculate Theme Weights.../ Calculate Response Theme...	evidential theme is a Feature Theme

~sdmtemp\case.dat	Text	Calculate Response Theme...	the Logistic Regression parameter is selected
~sdmtemp\cumfre.tba	Text	Calculate Response Theme...	the Logistic Regression parameter is selected
~sdmtemp\logco.dat	Text	Calculate Response Theme...	the Logistic Regression parameter is selected
~sdmtemp\logpol.out	Text	Calculate Response Theme...	the Logistic Regression parameter is selected
~sdmtemp\logpol.tba	Text	Calculate Response Theme...	the Logistic Regression parameter is selected
~sdmtemp\sdmlr.bat	Text	Calculate Response Theme...	the Logistic Regression parameter is selected
$AVEXT\param.dat	Text	Calculate Response Theme...	the Logistic Regression parameter is selected

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