Suitability Analysis
With Raster Data—Part 2

By Chris Wayne, ESRI–Olympia

The tutorial "Suitability Analysis With Raster Data" that appeared in the April–June 2003 issue of *ArcUser* magazine showed how to create and convert grid layers and set up a model for landfill site suitability analysis for a fictional county. In this next installment, you will use the same data to perform the analysis and make a map showing the analysis process.

The sample data for this exercise came from the Montana Natural Resources Information System (NRIS) and is public access data. However, this data has been modified for purposes of this exercise, and you should not use it for anything other than this exercise. To acquire real data, go to the NRIS Web Site (nris.state.mt.us).

In this exercise, a continuation of the tutorial in the previous issue of *ArcUser*, you will reclassify the data for several layers that represent relevant factors to the landfill analysis and use the Raster Calculator in ArcGIS Spatial Analyst to run the model. The sample dataset, which can be downloaded from the *ArcUser Online* Web site, contains a ready-to-go map document (.mxd file) and data for the tutorial.

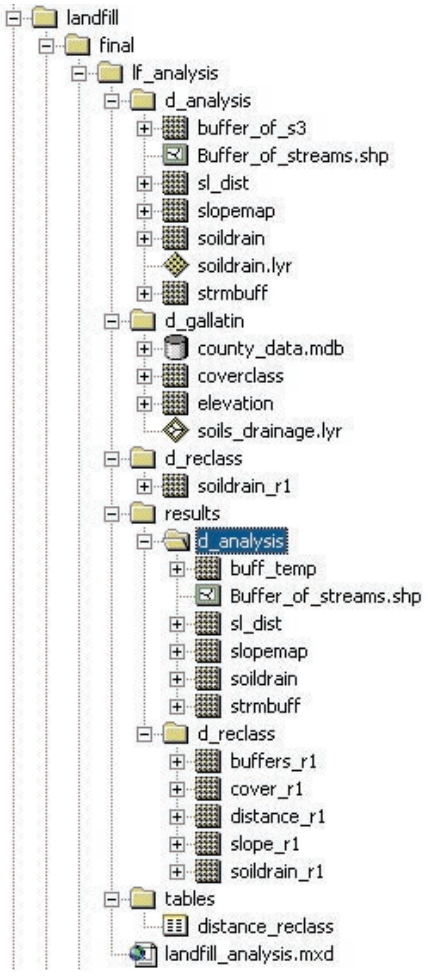


Figure 1: The file structure for this exercise

Measuring Suitability

You will reclassify each data layer on a scale of 1 to 5, with 5 being the most suitable for the new landfill and 1 being least suitable. In the real world, ranking these factors could be influenced by public input, scientific data, economic impacts, and other criteria. For the purpose of this exercise, the subjective values for most factors have been decided, but you could change them to reflect your own criteria. You can also exclude a category from analysis by reclassifying it as NoData.

Reclassifying Values

You will use different methods to reclassify each layer. It will be easier to examine each new grid that is generated during the reclassification process if you change each legend to graduated color and with 5 classifications based on value. Use a different color ramp for each reclassified layer. When reclassifying each layer, enter the new values manually.

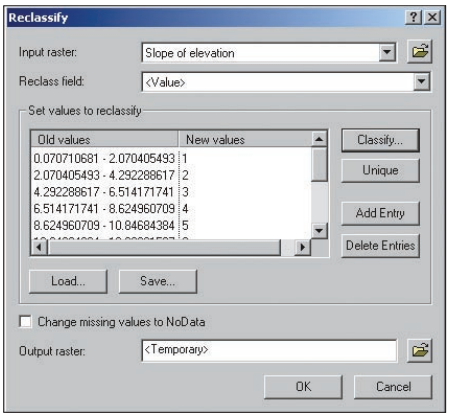
1. Download the sample data from the *ArcUser Online* Web site. Use WinZip or a similar utility to unpack the file. The directory structure shown in Figure 1 will be created.

2. Open landfill_analysis.mxd, the map document. Make sure the ArcGIS Spatial Analyst extension is activated. Choose Tools > Extensions and check Spatial Analyst. If the Spatial Analyst toolbar is not visible, choose View from the main menu and toggle it on.

3. Choose Spatial Analyst > Reclassify from the Spatial Analyst toolbar. Choose Slope of elevation as the input raster. In the Reclassify dialog box, click on the Classify button and change the Classification Method to Equal Interval and specify 5 classes. Click OK.

4. In the Reclassify dialog box, change the values as shown in Figure 2. This is most easily done by changing the values in the Old values column first, then changing the New values column. *Note: Leave a space between each value and the dash between them in the Old values column.* When the dialog box looks like the illustration, click OK. A new grid called Reclass of Slope of elevation is created.

5. Right-click on the new layer. Choose Properties, click on the Symbology tab and change the legend to Classified, specify 5 classes, and select a color ramp. Click Apply and OK.



In the Reclassify dialog box, click on the Classify button and in the Classification dialog box, change the Classification Method to Equal Interval and specify 5 classes. Click OK.

6. Right-click on the layer and choose Make Permanent from the context menu. Save the map in <YourDirectory>/lf_analysis/d_reclass/ as slope_r1. Notice that areas with high slope values are classified as unsuitable because of the problems associated with excavating on steep slopes.

Old values	New values
0 – 1	2
1 – 2	5
2 – 5	4
5 – 12	3
12 – 30	1
No Data	No Data

Figure 2: Reclassification values for Slope of Elevation

Using a Saved Classification

The least suitable sites are those closest to currently operating landfills. However, landfills too far away could cause management and maintenance headaches. In the first tutorial, the locations of open landfills were reclassified to measure the distance (in meters) of every cell from all open landfills. The output grid was saved as sl_dist.

1. In the Spatial Analyst toolbar, choose Spatial Analyst > Reclassify. In the Reclassify dialog box, make sl_dist the input raster.

2. Click the Load button and choose distance_reclass from <YourDirectory>\lf_analysis\tables\. Back in the Reclassify dialog box, click OK. A new grid called Reclass of sl_dist is created.

What You Will Need
- ArcGIS 8.*x* (ArcInfo, ArcEditor, or ArcView license)
- ArcGIS Spatial Analyst extension
- Sample data and map document from the *ArcUser Online* Web site (www.esri.com/arcuser)
- An unzipping utility such as WinZip

3. Right-click on the new layer and choose Properties to change the legend to Graduated Color with 5 classes as previously described. Right-click on the layer and choose Make Permanent from the context menu and save the layer as distance_r1 in <YourDirectory>\lf_analysis\d_reclass\.

Add a Reclassification Grid for Soil Drainage

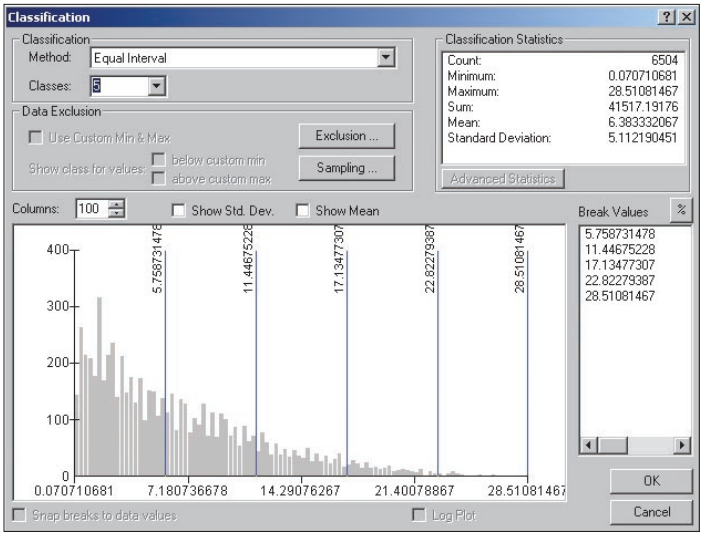
In this scenario, the soil drainage has already been reclassified for you by the geologist for our fictional county. Click on the Add Data button and add the soildrain_rl layer from <YourDirectory>\lf_analysis\d_reclass\. Right-click on this layer, choose Properties. Click on the General tab and change the layer name to Reclass of soildrain. If you open the attribute tables for these layers and inspect them, you will notice that the reclassified layer prohibits landfills on water and rock by reclassifying these areas as NoData.

Reclassify Stream Buffers by Unique Value

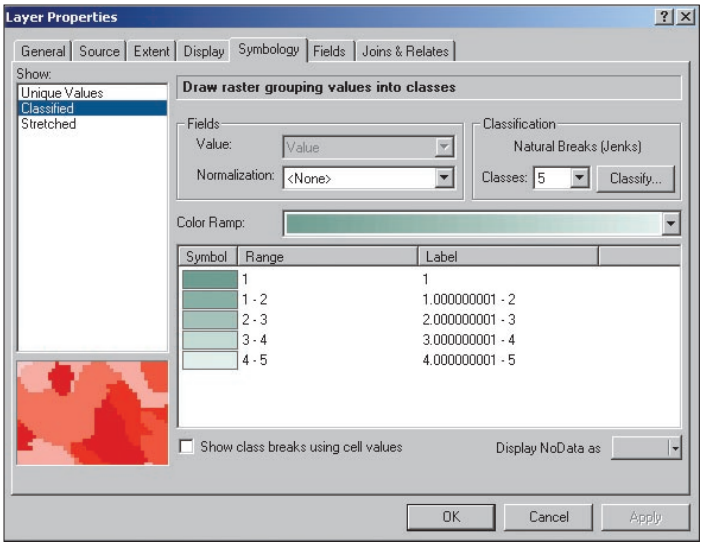
1. In the Spatial Analyst toolbar, choose Spatial Analyst > Reclassify. In the Reclassify dialog box, make Stream Buffers the input raster.

2. Click the Unique button in the Reclassify dialog box. Accept all default values except the NoData value. Change the New Value for NoData to 5. Areas more than four kilometers away from any stream are the most suitable for landfills. Areas close to streams are less suitable. Substituting 5 for the NoData value will eliminate areas too close to streams. Click OK. A new grid called Reclass of Stream Buffers is created.

3. Right-click on the new grid, choose Properties, reclassify the legend to 5 classes, assign a color ramp, and make it permanent. Save the file as buffers_r1 in …<YourDirectory>\lf_analysis\d_reclass\.



Right-click on Reclass of sl_dist and choose Properties to change the legend to graduated color with 5 classes as previously described.



Devise your own land cover classification scheme using the worksheet in Figure 3. Consider the cultural or financial value of the existing land types, the expense of altering a land type, and the relative abundance or scarcity of a land type by looking at the COUNT field.

Reclassify Land Cover

The land cover class is the final suitability factor that will be considered in this analysis. The old value for each cover class was a code that identified each S_VALUE (i.e., Grassland, Cropland). You will supply new values that reclassify Coverclass based on the suitability scale used elsewhere in the exercise (i.e., 5 is the most suitable and 1 is the least suitable).

1. Make the Coverclass layer visible in the Table of Contents (TOC). Drag it to the top of the TOC or turn off the layers above it so that it is visible.

2. Use the worksheet in Figure 3 to figure out the classification scheme you will use before entering it in ArcMap. Consider the cultural or financial value of the existing land types, the expense of altering a land type, and the relative abundance or scarcity of a land type (see the COUNT field). Remember that the final scheme will have 5 classes. Some land cover classes may be completely unsuitable

Continued on page 44

Old Value	New Value	S_VALUE	COUNT	Reason
1		Deciduous/Mixed Forest	3739	
2		Coniferous Forest	11904	
3		Cropland	2974	
4		Grassland	4880	
5		Desert Shrub and Savanna	2157	
6		Water	27	
7		Alpine, Tundra, Barren	169	

Figure 3: Reclassification worksheet

Suitability Analysis With Raster Data—Part 2

Continued from page 43

for landfills and should be excluded using NoData rather than ranked.

3. After determining the classifications, choose Spatial Analyst. Reclassify from the Spatial Analyst toolbar. In the Reclassify dialog box, make Coverclass the input raster. Click the Unique button. Enter your classification scheme. Click OK. A new grid called Reclass of Coverclass is created.

4. Change the legend to graduated color with 5 classes, make the layer permanent, and save it as cover_r1 in <YourDirectory>\lf_analysis\d_reclass\.

Running the Model

Before running the model, use Notepad or WordPad to create a new text file called landfillmodel.txt and save it in <YourDirectory>\lf_analysis. In this model as it is currently configured, each grid has equal weight in the decision making process.

Using the Raster Calculator

1. In the Spatial Analyst toolbar, choose Spatial Analyst > Raster Calculator. In the left pane of the Raster Calculator is a list of all the grids. The pane is too narrow to show the complete name, so you'll need to scroll down and to the left to see the entire list of grids and the full name of each grid.

2. Double-click on the grid names and the operators to build the statement exactly as it is shown in Figure 4. The spacing, location of parentheses, and the operators must match Figure 4. Copy the statement and paste it into landfillmodel.txt. Annotate it with "First arithmetic model."

3. In the Raster Calculator, click Evaluate. A new temporary grid called Calculation will be created. Notice that the range of values is between 7 and 23.

4. Right-click on the new layer and choose Properties. Click on the Symbology tab to change the new grid's legend to Classified with a single class for each value. Save the map document and then save again as model_a23.

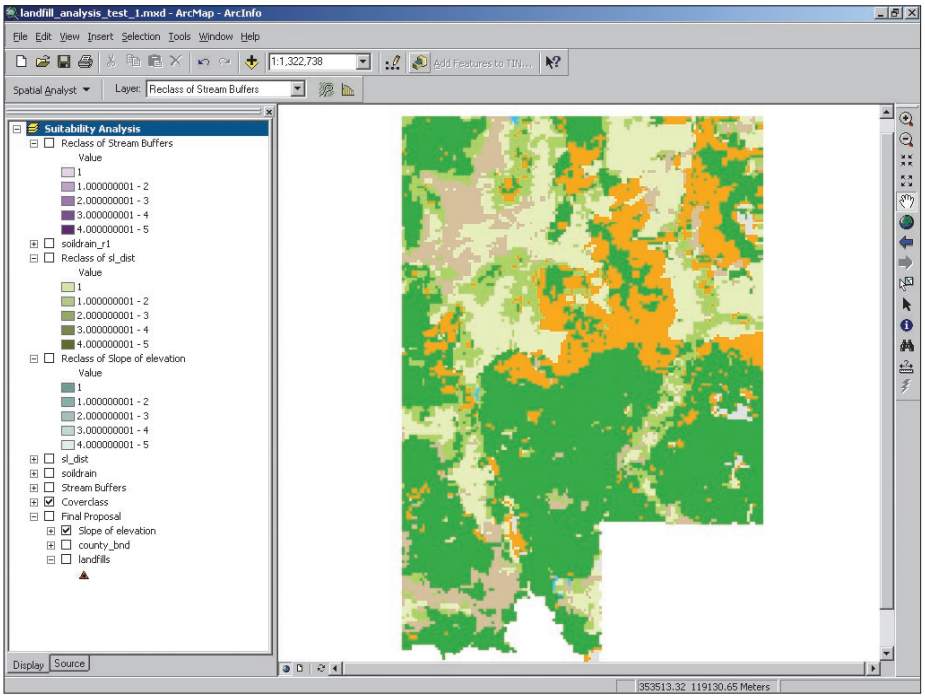
5. In landfillmodel.txt, write some information about this model. Note what data went into it, the purpose of the analysis, the cell size and measurement units used, the geographic extent of the model (i.e., Gallatin County, Montana), when you ran the model, and the name of the organization for which the model was developed.

An Optional Activity

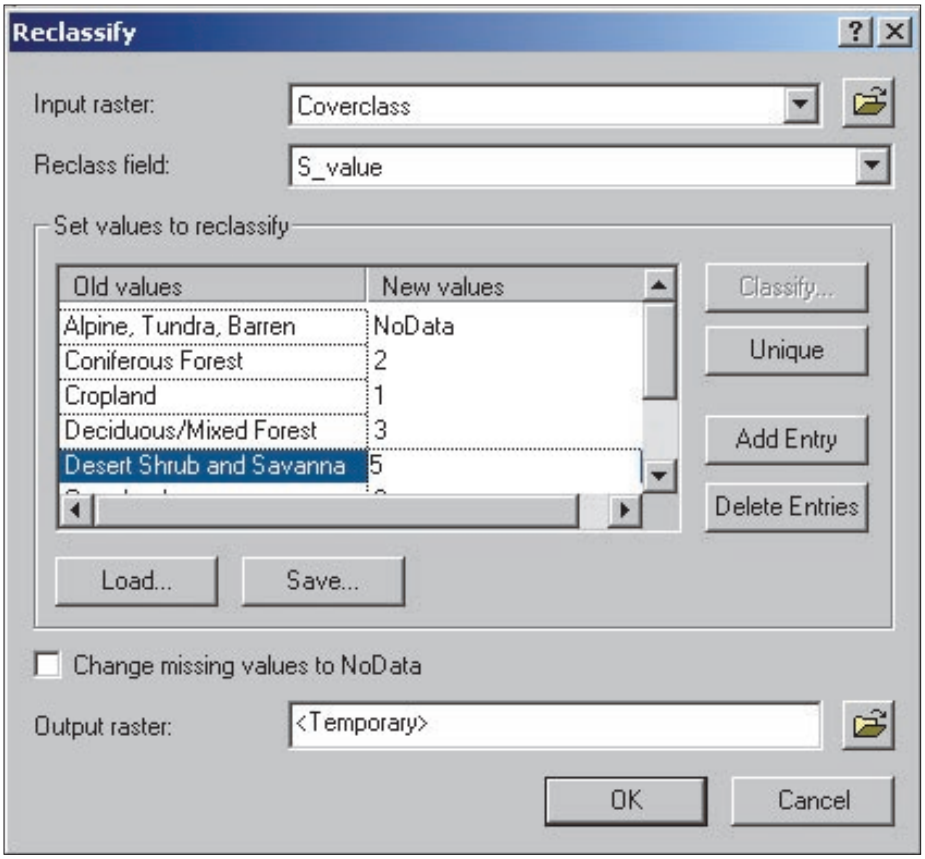
In the real world, certain features are more relevant than others in a suitability model. This can be reflected in the model by rerunning it using weighted values for slope and soils so that these factors will have the most influence. The syntax will differ slightly from the arithmetic

Figure 4: First arithmetic model

```
[reclass of Coverclass] + [reclass of sl_dist] + [Reclass of Slope of
elevation] + [Reclass of soildrain] + [reclass of Stream Buffers]
```



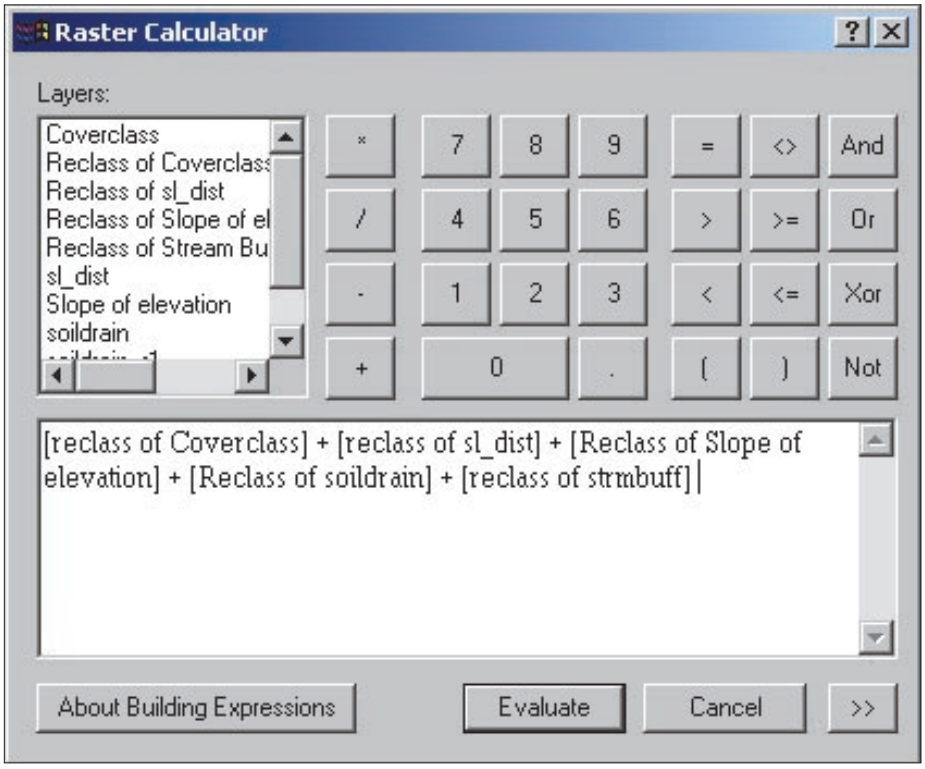
Use the Raster Calculator to perform a simple analysis of the data on the suitability factors.



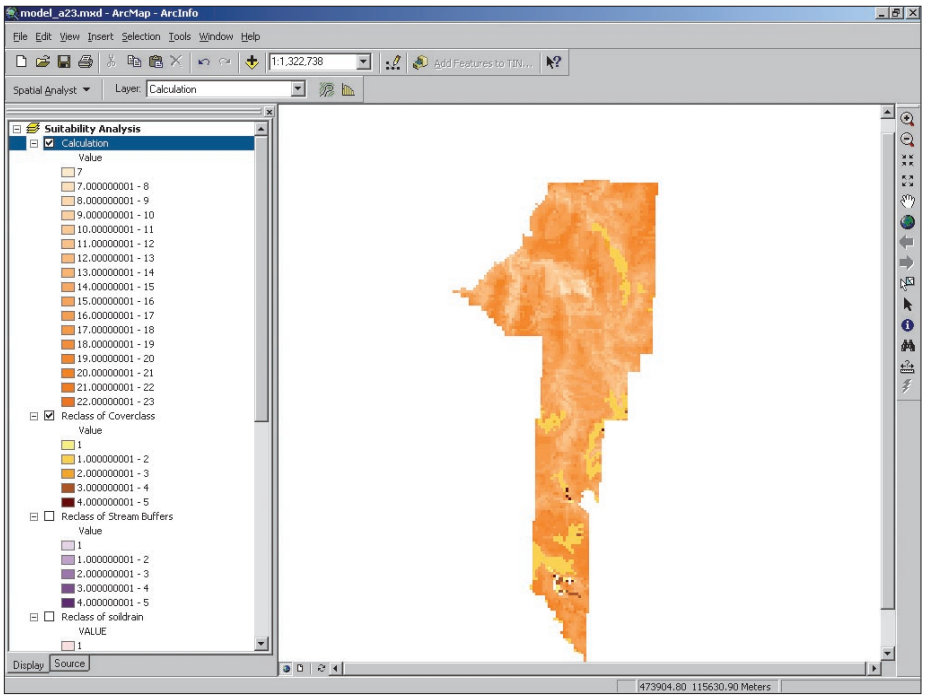
Devise your own land cover classification scheme using the worksheet in Figure 3. Consider the cultural or financial value of the existing land types, the expense of altering a land type, and the relative abundance or scarcity of a land type by looking at the COUNT field.

Figure 5: Using weighted values

```
(([Reclass of soildrain] * .3) + ([Reclass of Slope of elevation] * .3)
+ ([Reclass of Stream Buffers] * .2) + ([Reclass of Coverclass] * .1) +
([Reclass of sl_dist] * .1)) * 5
```



In the real world, certain features are more relevant than others in a suitability model. They can be reflected in the model by rerunning it using weighted values for slope and soils so that these factors will have the most influence.



The Layout toolbar has many of the same zoom and pan tools as the standard toolbar, but these tools work in layout view and allow you to move around the layout.

model. Each grid will have a decimal weight associated with it, and the sum of the decimal weights must be 1. Note that there are extra parentheses in the new statement. Create the weighting scheme shown in Figure 5 by building this statement in the Raster Calculator, or use a scheme of your own design.

Because the total number of factors in the equation is 5, the sum of all the individual calculated weights is multiplied by 5. Copy this text and paste it in landfillmodel.txt, and annotate it with something such as: "First weighted model." Click the Evaluate button and a new Calculation layer is created. Color ramp the legend and save the map as weighted.mxd.

Make an Analysis Process Map

A process map will show the factors that were involved in the analysis. Currently the map document has only one data frame called Suitability Analysis that contains all the reclassification grids and the final analysis grid. To present each of the grids side-by-side on a single map sheet will require placing each reclassification grid in its own data frame.

Organizing Data With Data Frames

1. From the main menu, choose Insert > Data Frame. A new data frame is created at the bottom of the Table of Contents. Right-click on the new data frame and choose Properties to rename it Landcover Reclass.

2. Left-click the Reclass of Coverclass layer and drag it to the Landcover Reclass data frame.

3. Right-click on the Landcover Reclass data frame and choose Properties. In the Data Frame Properties dialog box, click on the Source tab. Notice that the coordinate system has already been defined by the Reclass of Coverclass layer's coordinate system.

4. Create new data frames for each reclassification grid and the arithmetic or weighted grids using the same process. You should have seven data frames—the six new data frames and the original Suitability Analysis data frame.

5. Save the map document now.

Creating a Layout

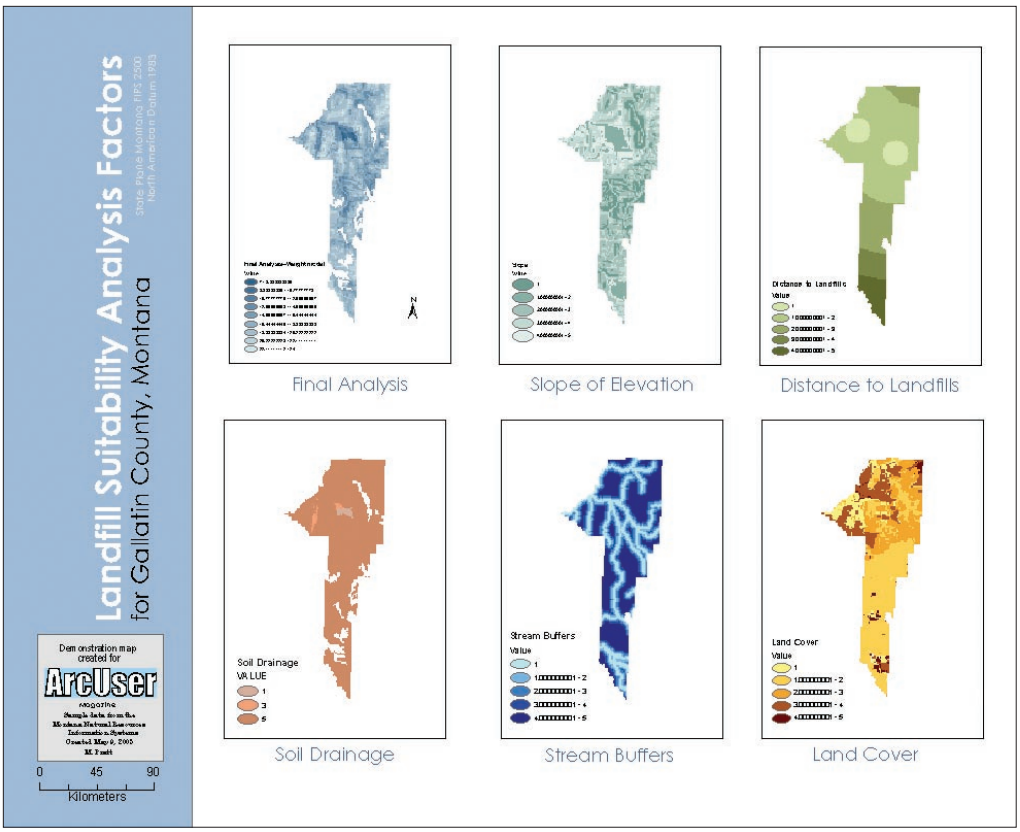
The next step is to arrange the data frames in a layout map that will show these factors and the final reclassification. When a map has multiple data frames, only one data frame is active at a time. To activate a data frame, right-click on it and choose Activate from the context menu. Save your work often during the layout process because layout elements are only stored in the map document.

1. From the main menu, choose View > Layout view. You now are switching from

Continued on page 46

Suitability Analysis With Raster Data—Part 2

Continued from page 45



The final step is to display the data frames in a layout map that will show these factors and the final reclassification.

map space to paper space, and the layout toolbar appears. It has many of the same zoom and pan tools as the standard toolbar, but these tools work in layout view and allow you to move around the layout.

2. In the layout, notice that the data frames are stacked on top of each other. To fix this, use the Zoom Out tool in the Layout toolbar to zoom out several times until there is some white space around the map sheet.

3. In the Table of Contents, right-click on the Final Proposal Data Frame and choose Activate from the context menu. A blue dashed line and handles appear around this data frame indicating that it is active.

4. Use the Select Elements tool on the standard toolbar (i.e., the black arrowhead) to grab this data frame and move it off the map page. Right-click the data frame and choose Properties. Click on the Size and Position tab in the Data Frame Properties dialog box. Change the size to 2 inches wide and 3 inches high. Click OK. On the main toolbar, change the scale to 3,000,000.

5. Repeat this procedure for each of the data frames. Arrange all six data frames neatly on the layout page. Make sure each data frame is the same scale and same size. Arrange the data frames so that the maps take up most of the space on the page and the Final Analysis data frame is in the upper left corner.

Making a Presentable Map

After arranging the data frames, modify the data frames and add standard map elements.

1. Make each data frame active by right-clicking on the data frame in the Table of Contents and choosing Activate. For each data frame, include a legend by choosing Insert > Legend from the main menu and following the steps in the Legend Wizard. Keep these legends simple because they will be small. Modify the legend for each data frame by right-clicking on it and choosing Properties to access the Legend Properties dialog box and set the display characteristics.

2. Include a title for each data frame by choosing Insert > Title from the main menu. Type in the name of the data frame and move it near the data frame with the pointer tool. Double-click on the title to set the font and style and other properties.

3. Repeat this process for each data frame, saving the map document after each data frame is modified. Add elements for the entire map layout.

- A title for the map such as "Landfill Suitability Analysis Factors."
- A scale bar. Only one is needed because all the data frames should be the same scale.
- A north arrow.
- Your name and the date the map was printed.

4. Inspect the entire map and make any necessary adjustments in the placement, size, or other properties of the map elements. Save the map before printing it.

Conclusion

Over the course of these two tutorials, you have assembled, converted, and modified data and created a model for determining the best location for a landfill. The first tutorial covered defining the study area, making slope and buffer maps, and calculating the distance from existing landfills. In the second tutorial, you reclassified a variety of grid layers based on suitability factors and created a new integer grid for each factor. Using the Raster Calculator, you combined these grids to generate a ranking for each cell for landfill suitability. The combined grid, reclassified on the same 1 to 5 scale, takes the three factors deemed important to the new landfill site into consideration. Finally, you created a map showing both the process and the results.

The ESRI Virtual Campus (campus.esri.com) provides additional information on spatial analysis. See *Getting Started with Surface Analysis using ArcGIS Spatial Analyst,* a workshop, and *Spatial Analysis in Agriculture: A GIS Approach* and *Spatial Analysis of Geohazards using ArcGIS,* two online courses.