

### What You Will Need

- ArcGIS 8.2 (ArcView, ArcEditor, or ArcInfo license)
- ArcGIS Spatial Analyst extension
- Sample data from the *ArcUser Online* Web site ([www.esri.com/arcuser](http://www.esri.com/arcuser))
- An unzipping utility such as WinZip

# Suitability Analysis With Raster Data

By Chris Wayne, ESRI-Olympia

This exercise, the first of a two-part series, will teach you how to work with raster layers using the ArcGIS Spatial Analyst extension. You will be creating and converting grid layers to prepare them for input into an analysis model. Then you will run a model to determine potential sites for a new landfill.

In this tutorial, you will prepare and model data that will help a fictional county use GIS to identify suitable sites for a new landfill. These sites will be chosen based on the characteristics of the land, water, and soils in the county. The tutorial sample data 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 ([nr.is.state.mt.us](http://nr.is.state.mt.us)). The site provides data so that additional factors, such as wilderness areas or population centers, can be considered in your analysis.

## Notes on Working With Grids

Grids are actually collections of files within several folders in a directory. *Never move, rename, copy, delete, or otherwise alter grids in Windows Explorer—always use ArcCatalog.* Grid names must be less than 11 characters,

and the name of any grid folder, shapefile, table, or other file should not contain spaces or any character other than a letter, number, or underscore.

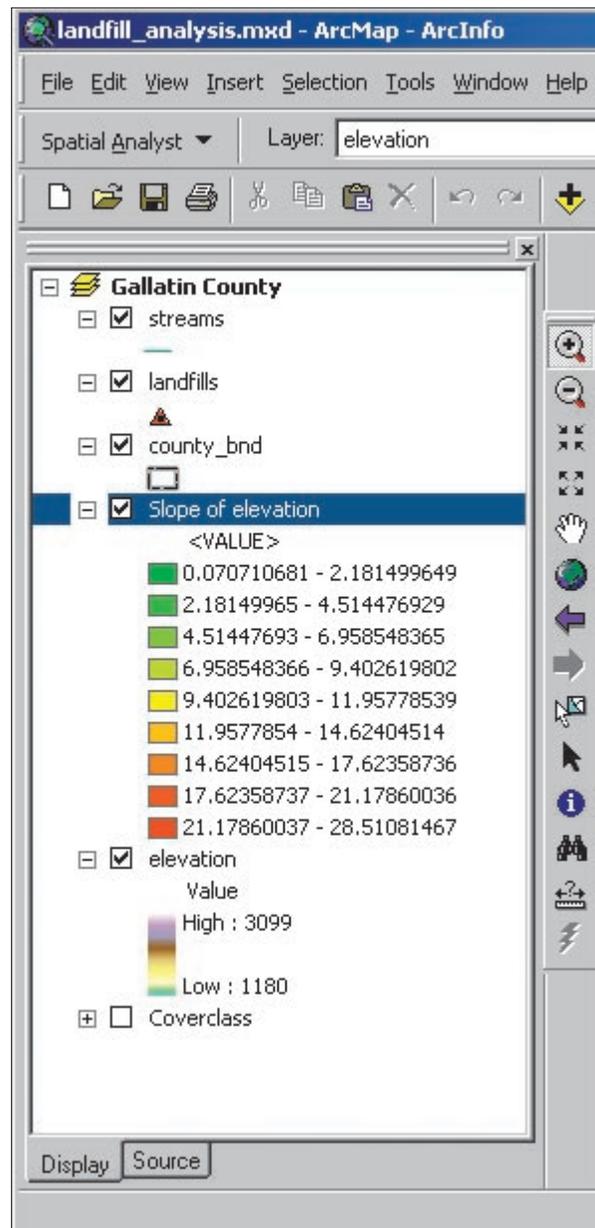
## Setting Up the Data

After downloading the sample dataset from *ArcUser Online* ([www.esri.com/arcuser](http://www.esri.com/arcuser)), create a folder on your computer called landfill and unzip the archive into it. The archive creates subfolders named *lf\_analysis* and *Results*. The *lf\_analysis* folder has several subfolders. The *Results* folder will be used to store the results of all the analysis steps. Inspect the contents of these folders in both ArcCatalog and Windows Explorer before starting the exercise.

## Define the Study Area

In this section you will use the Options dialog box in ArcGIS Spatial Analyst to save steps while processing data for the analysis. The raster data analysis generates a lot of new grids. The cell size and map extent must be specified for each new grid. Instead of doing this for each grid individually, you can set a default cell size and extent in the Options dialog box. This will also help maintain consistency in the data that you create.

1. Start an ArcMap session. Enable the Spatial Analyst extension. This is a two-step process. Choose **Tools > Extensions** from the menu and check the box next to Spatial Analyst. Next, choose **View > Toolbars** and check **Spatial Analyst** on. The Spatial Analyst toolbar will appear. You can leave it floating or dock it.
2. Open *landfill\_analysis.mxd* in the *landfill\analysis* subfolder. From the Spatial Analyst toolbar, choose **Options**. In the Options dialog box, click on the **General** tab and set the Working directory to *landfill\analysis\analysis*. Click **OK** but do not close the Options dialog box.
3. The analysis extent sets the *x,y* coordinates for all the grid operations. Although the extent can be specified by using another layer, the intersection or union of layers, or manually entering *x,y* coordinates, the analysis extent will

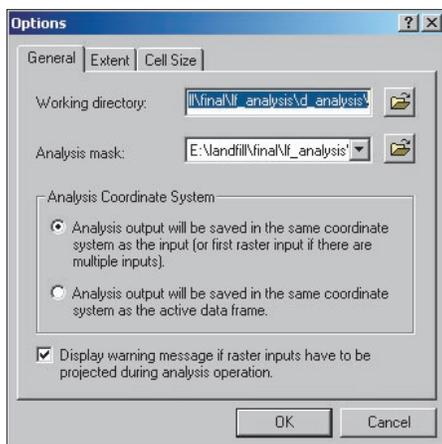


always be a rectangle. However, an analysis mask, which works in much the same way, can use only a layer as a mask but uses the actual shape of the layer instead of a rectangular envelope. This exercise will use an analysis mask. Still on the **General** tab of the Options dialog box, select *county\_bnd* from the drop-down box next to **Analysis mask**. Read the **Analysis Coordinate System** section of the dialog box but do not modify it.

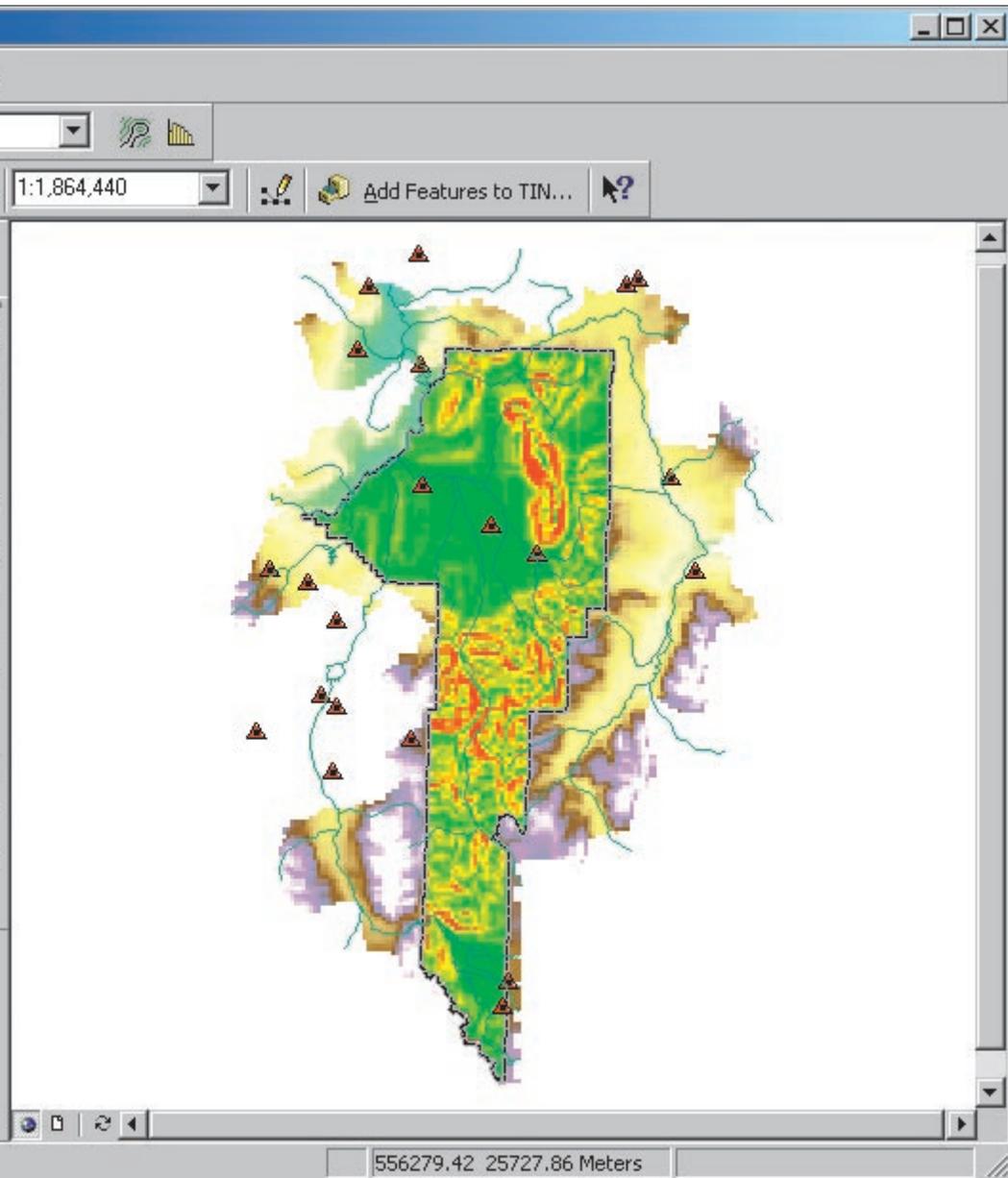
4. Click on the **Extent** tab. Select **Same as Layer** *county\_bnd* from the drop-down box. Click on the **Cell Size** tab and select **As Specified Below** from the drop-down box, and enter 1000 in the **Cell Size** box. Click **OK** and save the map document.

## Make a Slope Map

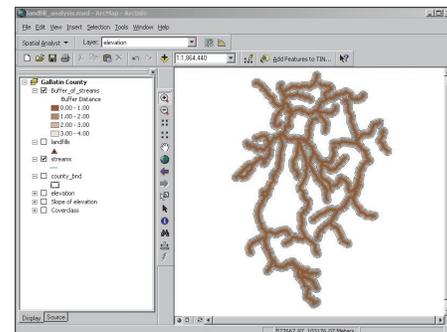
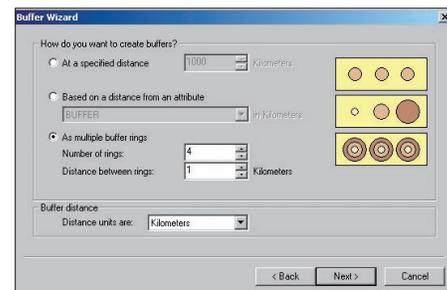
The elevation layer is a continuous surface of values. Information can be derived from this surface, such as hillshading, contour lines, and slope, which indicates the rate of change.



Use the Options dialog box in ArcGIS Spatial Analyst to save steps while processing data for the analysis by setting the working directory, extent, cell size, and analysis mask.



Use Surface Analysis > Slope from the Spatial Analyst toolbar to create a layer that depicts slope in percent.



Generate a multiringed buffer around the streams using the Buffer Wizard.

Slope will be a relevant factor in siting the landfill because the topography of an area is an important consideration for excavation.

1. Make the elevation layer visible. In the Spatial Analyst toolbar, choose Surface Analysis > Slope. Set Input surface as Elevation and Output measurement as Percent. Accept the rest of the defaults (i.e., Z Factor 1, Output Cell Size 1000, Output raster: <Temporary>). A new layer, with the same shape as the county outline, will be created. Its values (rounded) should range from 0.07 to 28.51.
2. Right-click on the Slope of Elevation layer and choose Properties. In the Properties dialog box, click on the Source tab. This grid layer is a continuous (i.e., floating point), temporary dataset. Click on the Extent, Display, and Symbology tabs to explore the grid's properties before closing the Properties dialog box.

3. Because this grid will be needed for future analysis, convert it from a temporary grid to a permanent one. Right-click on Slope of Elevation and choose Make Permanent. Save the file as `slopemap` in the `landfill \lf_analysis\ d_analysis\` subdirectory.

To demonstrate the effect of the analysis mask, choose Spatial Analyst > Options and click on the General tab. Change the Analysis mask to None. Running the slope and hillshade operations as previously described will produce an output grid that has the same extent as the county's bounding box but does not honor the actual shape of the county. Change the Analysis mask back to `county_bnd`, and delete the temporary rasters just created.

**Creating Buffers for Analysis**

Figure 1 shows all the layers needed for this analysis as they should appear in the Table of Contents. The distance from both

Layer	Visible	Legend
landfills	No	Show
streams	Yes	Show
county_bnd	No	Hide
elevation	No	Hide
Slope of elevation	No	Hide
Coverclass	No	Hide

Figure 1: Layers

streams and existing landfills will also be a factor for siting the new landfill. The core functionality in ArcGIS contains a Buffer Wizard that simplifies the process of creating buffers. Although many existing landfills have been built right on riverbanks, this is a less acceptable practice today so distance from a waterway will be one of the criteria used in selecting a site.

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Panel	Action
1	Buffer the streams layer.
2	Make sure distance units are set to kilometers. Choose As Multiple Buffer Rings, and make four rings with one kilometer between each ring.
3	Choose Yes to dissolve barriers between buffers. Save the buffer in a new layer as a new shapefile in landfill\analysis\d_analysis\ and accept the default name, Buffer_of_streams.shp.

Figure 2: Choices for Buffer Wizard

and Choose Tools > Buffer Wizard from the menu. Use the parameters for each panel in the wizard shown in Figure 2 to build the Stream buffer. Buffering may take a few minutes to perform so be patient. Click the Help button for additional information if necessary.

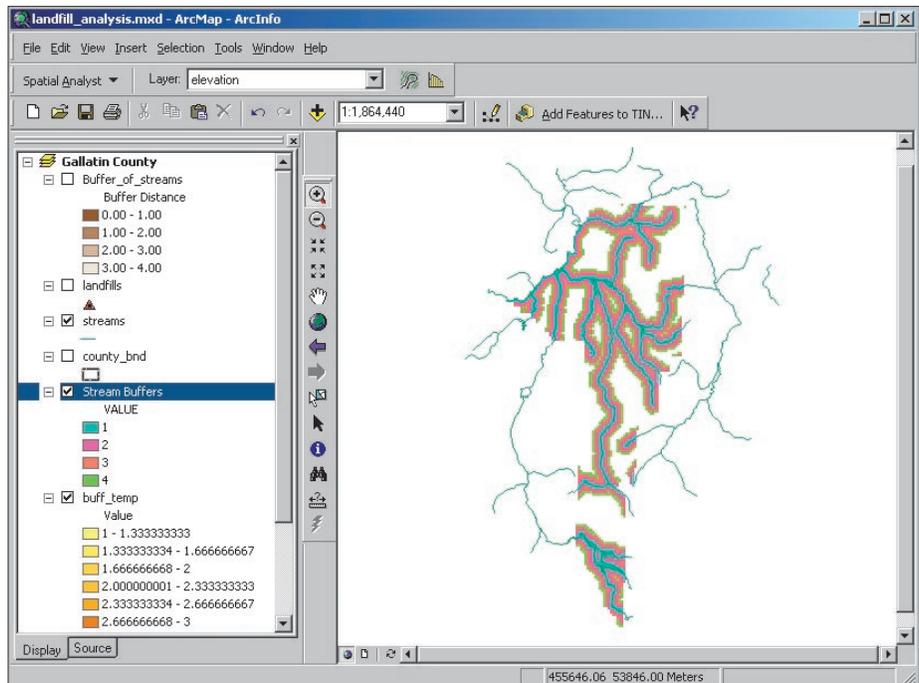
The stream buffer layer will be added to the map. Examine the layer's attribute table by right-clicking on the layer in the Table of Contents and choosing Open Attribute Table. What fields does the table have? How many records does it contain? Close the table, and make the layer invisible.

A feature class (whether stored in a geodatabase or as a shapefile) has different data structures than a grid. A feature class layer must be converted to a grid before Spatial Analyst can perform analysis on it. Choose Spatial Analyst > Convert > Features to Raster. Select Buffer\_of\_streams.shp as the input layer and ToBufDist as the field. Save this grid as landfill\analysis\d\_analysis\buff\_temp, and click OK.

A new floating point grid is added to the map. Confirm this by right-clicking on the layer, choosing Properties, and clicking on the Source tab. Because an analysis mask was applied to this layer, the county\_bnd layer defines the shape of this grid not the streams or the buffer shapefile.

There are two types of grid layers—floating and integer. Floating point grids represent continuous data, such as elevation, store numbers with decimal places, and don't have attribute tables because the possible number of unique cell values is too large. Buff\_temp is a floating point grid. To avoid problems later in the analysis, use the Raster Calculator to change buff\_temp to an integer grid.

1. From the Spatial Analyst toolbar, choose Raster Calculator. In the text box, type the following statement, making sure there is a space between int and the parentheses: `int ([Buff_temp])`
2. Click on Evaluate, and a new grid is created and added to the map. Right-click on this new layer, choose Make Permanent, and save it as strmbuff in the landfill\analysis\d\_analysis\



Change the floating point grid to an integer one using the Raster Calculator.

3. Right-click on the strmbuff layer and choose Properties. Click on the General tab to change the name to Stream Buffers. Make it invisible.
4. Delete buff\_temp and buffer\_of\_streams.shp from the Table of Contents, and save the map.

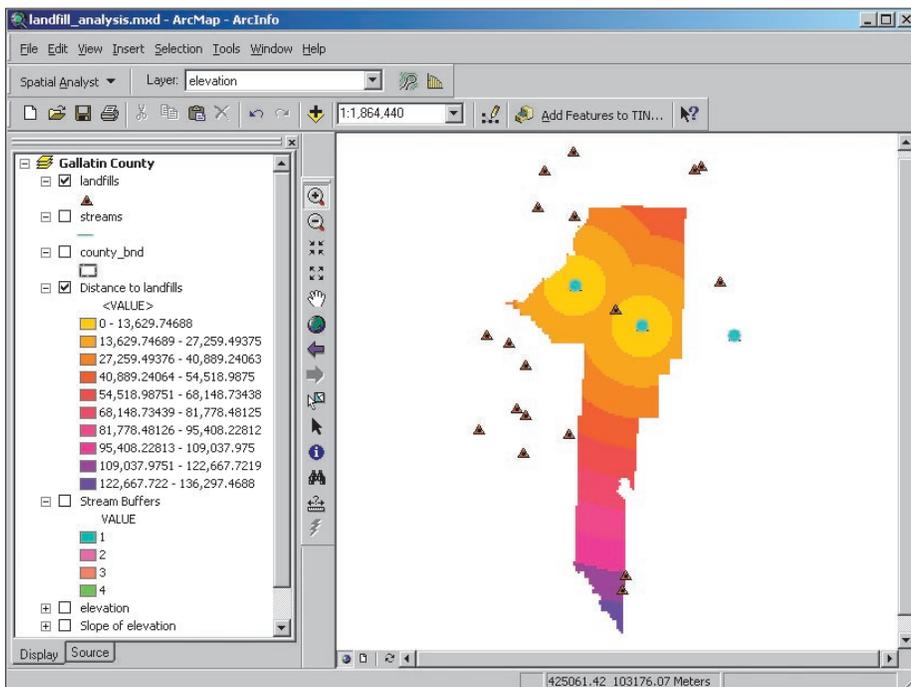
## Calculate Distance From Existing Landfills

Next, you will use Spatial Analyst to calculate the distance of every cell from the location of open landfills in the county.

1. Verify that the landfills layer is at the top of the Table of Contents, and make it visible.
2. To work only with open landfills, choose Selection > Select by Attributes from the menu, and in the Select by Attributes dialog box, set Landfills as the layer, choose to create a new selection, and use the query builder to create the expression

“STATUS” = ‘0’. Click Apply. Three landfills should be selected.

3. In the Spatial Analyst toolbar, choose Distance > Straight Line and set Landfills as the Distance To: layer. Accept the rest of the defaults. Click OK. Setting a maximum distance is not necessary because the analysis mask will define the search area.
4. A new raster layer is created. Move the new grid below the landfill layer so both layers are visible. The new layer should be the shape of the county. The values in this grid represent meters from any given point to the nearest open landfill.
5. Right-click on this layer and choose Make Permanent. Save it as sl\_dist (i.e., straight-line distance) in landfill\analysis\d\_analysis\. Right-click on the layer again, choose Properties, and rename the layer sl\_dist. Save the map.



Use ArcGIS Spatial Analyst to calculate the distance of every cell from the location of open landfills in the county.

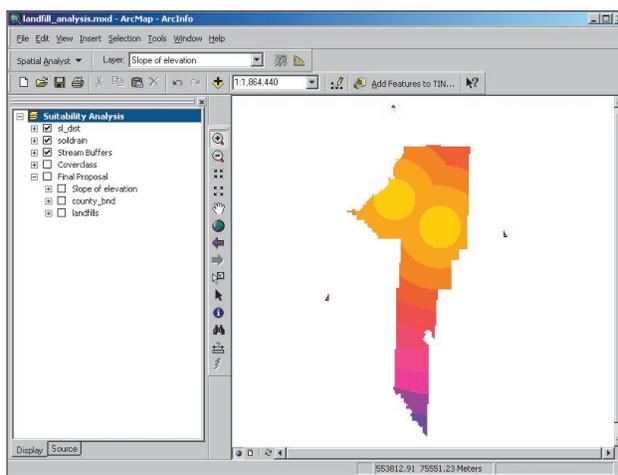
### Add a Soil Drainage Grid

Soils data is important to include in landfill siting analysis because this data often indicates wetlands, rock depth, and drainage. Click on the Add Data button, and navigate to `landfill\analysis\analysis\` and add the `soldrain.lyr` layer to the map. This grid has already been converted from a polygon feature class to a grid. The original polygon feature dataset was included in the sample dataset and can be found in `landfill\analysis\gallatin\county_data.mdb\soils`.

### Prepare for Analysis

The last phase in this tutorial will prepare the project data for the analysis that will be performed in the second part of this exercise.

1. Right-click on the Data Frame, choose Properties from the context menu, and click the General tab. Change the name of the Data Frame from Gallatin County to Suitability Analysis.
2. Right-click on the Suitability Analysis Data Frame and choose New Group Layer from the context menu. Right-click on the New Group Layer, choose Properties, click the General tab, and change the name to Final Proposal.
3. Drag the landfills, county\_bnd, and Slope of elevation layers into the Final Proposal group layer and make this group layer invisible.
4. Delete the streams and elevation layers.
5. Activate Suitability Analysis. This Data Frame should have the layers



Reorganize and rename the layers in preparation for the second part of this tutorial.

listed in Figure 3 and be listed in the Table of Contents in the order shown. Hide all the legends for these layers. The Final Proposal group layer provides background data. All other layers will be used for suitability analysis.

6. Save the map document now.

Layer	Visible
sl_dist	Yes
soldrain	Yes
Stream Buffers	Yes
Coverclass	No
Final Proposal	No

Figure 3: Table of Contents

### Overview of the Model

Most of the model design process—determining the relevant factors, getting data for these factors, and documenting the entire process in a flowchart—has been done for you. The procedures in this tutorial made the data usable for analysis. The second part of this tutorial, to be published in the July–September 2003 issue of *ArcUser*, will cover reclassifying each of the five suitability factors on a scale of one to five and creating a new integer grid for each factor. Combining all of these grids will generate a ranking for each cell for landfill suitability. The combined grid, reclassified on the same one to five scale, will take all three factors deemed important to the new landfill site into consideration.