Quick-start tutorial

2

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With Spatial Analyst you can easily perform spatial analysis on your data. You can provide answers to simple spatial questions, such as "How steep is it at this location?" or "What direction is this location facing?", or you can find answers to more complex spatial questions such as "Where is the best location for a new facility?" or "What is the least-cost path from A to B?" When used in conjunction with ArcMap, Spatial Analyst provides a comprehensive set of tools for exploring and analyzing your spatial data, enabling you to find solutions to your spatial problems.

Tutorial scenario

The town of Stowe, Vermont, USA, has experienced a substantial increase in population. Demographic data suggests this increase has occurred due to families with children moving to the region, taking advantage of the many recreational facilities located nearby. It has been decided that a new school must be built to take the strain off the existing schools, and as a town planner you have been assigned the task of finding the potential sites.

Spatial Analyst provides the tools to find an answer to such spatial problems. This tutorial will show you how to use some of these tools and will give you a solid basis from which you can start to think about how to solve your own specific spatial problems.

It is assumed that you have installed the Spatial Analyst extension before you begin this tutorial. The data required is included on the Spatial Analyst installation disk (the default installation path is ArcGIS\ArcTutor\Spatial, on the drive where the tutorial data is installed). The datasets were provided courtesy of the State of Vermont for use in this tutorial. The tutorial scenario is fictitious, and the original data has been adapted for the purpose of the tutorial.

The datasets are:

Dataset	Description
Elevation	Raster dataset of the elevation of the area
Landuse	Raster dataset of the landuse types over the area
Roads	Feature dataset displaying linear road network
Rec_sites	Feature dataset displaying point locations of recreation sites
Schools	Feature dataset displaying point locations of existing schools
Destination	Feature dataset displaying the destination point for use in finding the shortest path

In this tutorial you will first explore your data to learn more about it and to understand its relationships. Then, you will find suitable locations for the new school, based on the fact that it is preferable to locate close to recreational facilities for ease of access to these places for the children, and it is also important to locate away from existing schools to spread their locations over the town. You also want to avoid steep slopes and certain landuse types.

Once you have found the best sites, you will examine these locations to see which is potentially the most suitable. You will then examine the data to see if any problems may arise from building the school in the chosen location.

This tutorial is divided into exercises and is designed to let you explore the functionality of Spatial Analyst at your own pace.

- Exercise 1 shows you how to display and explore your data using the functionality of ArcMap and Spatial Analyst. You will add and display your datasets, highlight values on the map, identify locations to obtain values, examine a histogram, and create a hillshade.
- Exercise 2 helps you to find the best location for a new school by creating a suitability map. You will derive datasets of distance and slope, reclassify datasets to a common scale, weight those that are more important to consider, then combine the datasets to find the most suitable locations.
- Exercise 3 shows you how to find an alternative route (the least-cost, or shortest path) for a road to the new school site.

Copies of the results obtained from each exercise are stored in the Results folder on your local drive where you installed the tutorial data (the default installation path is ArcGIS\ArcTutor\Spatial\Results).

You will need about one hour of focused time to complete the tutorial. However, you can perform the exercises one at a time if you wish, saving your results along the way when recommended.

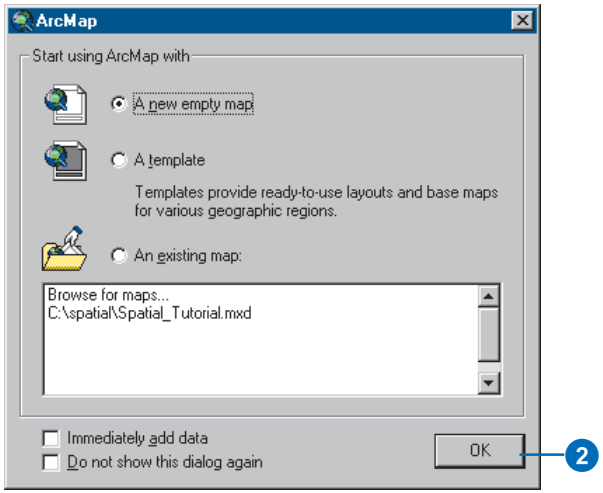
Exercise 1: Displaying and exploring your data

You should explore your data to understand it and to identify relationships. Understanding your data and recognizing relationships will enable you to more accurately prepare your data for analysis.

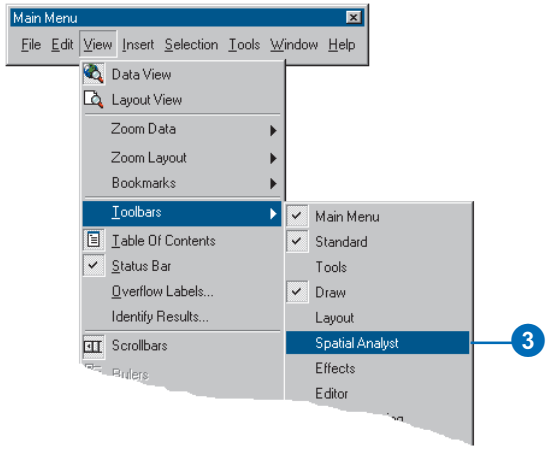
In this exercise, you will open ArcMap and add the Spatial Analyst toolbar to your ArcMap session. You will then explore your datasets using functionality within ArcMap and Spatial Analyst.

Starting ArcMap and Spatial Analyst

1. Start ArcMap by either double-clicking a shortcut installed on your desktop or using the Programs list in your Start menu.
2. Click OK to open a new empty map.



3. Click View, point to Toolbars, and click Spatial Analyst.



The Spatial Analyst toolbar is added to your ArcMap session.

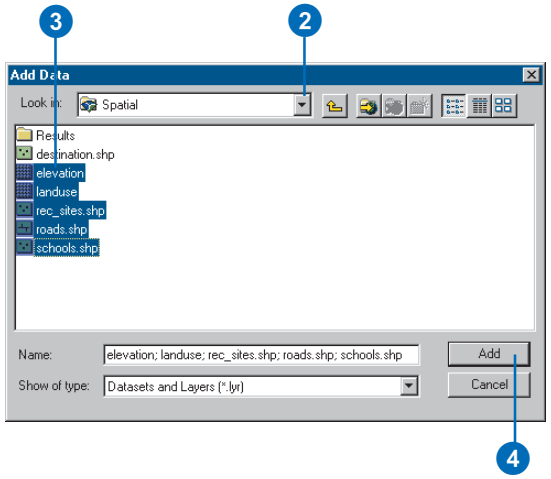
Enabling the Spatial Analyst toolbar

1. Click the Tools menu.
2. Click Extensions and check Spatial Analyst.
3. Click Close.

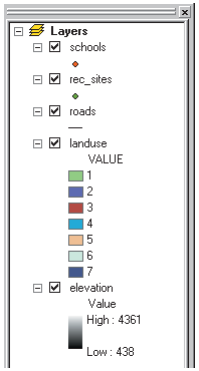
Adding data to your ArcMap session

1. Click the Add Data button on the Standard toolbar.

2. Navigate to the folder on your local drive where you installed the tutorial data (the default installation path is ArcGIS\ArcTutor\Spatial, on the drive where the tutorial data is installed).
3. Click elevation, press and hold down the Shift key, then click landuse, rec_sites, roads, and schools.
4. Click Add.



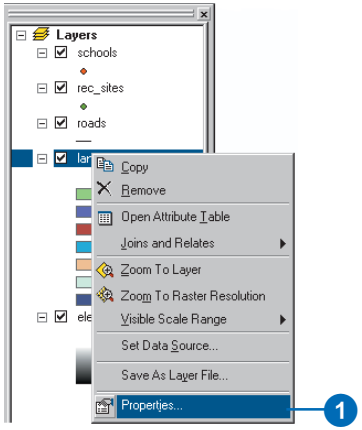
The datasets are added to the ArcMap *table of contents* as layers.



Displaying and exploring data

You will now explore the display capabilities of ArcMap by changing the *symbology* of some of the layers.

1. Right-click landuse in the table of contents and click Properties.



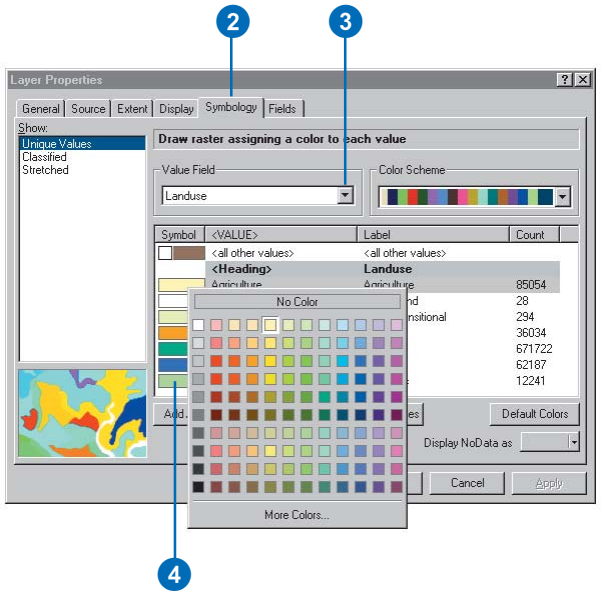
2. Click the Symbology tab.

   All landuse categories are currently drawn using *cell* values as the Value Field and in random colors. You will change the Value Field to be more meaningful and change the color of each *symbol* to show a more appropriate color for each landuse on the map.

3. Click the Value Field dropdown arrow and click Landuse.

4. Double-click each symbol and choose a suitable color to represent each landuse type.

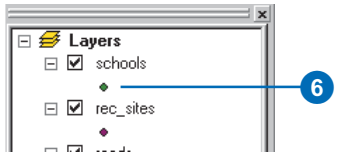
5. Click OK.



The changes you make are reflected in the table of contents and in the map.

You can also change the color and properties of symbols via the table of contents.

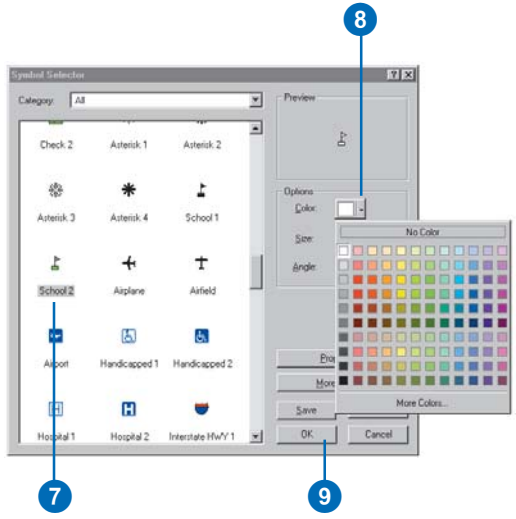
6. Click the point representing schools in the table of contents.



7. Scroll to the School 2 symbol and click it.

8. Click the color dropdown arrow and click a color.

9. Click OK.

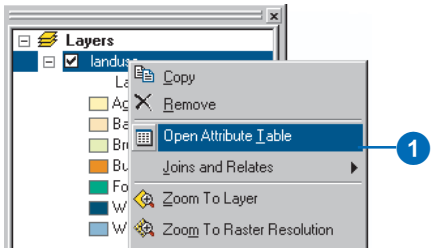


The changes you make are reflected in the table of contents and in the map.

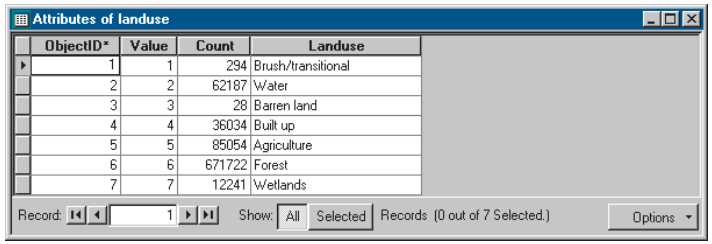
Highlighting a selection on the map

Examining the attribute table gives you an idea of the number of cells of each attribute in the dataset.

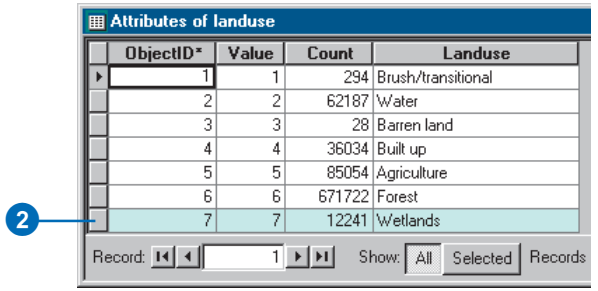
1. Right-click landuse in the table of contents and click Open Attribute Table.



Notice that Forest (value of 6) has the largest count, followed by Agriculture (value of 5), then Water (value of 2).

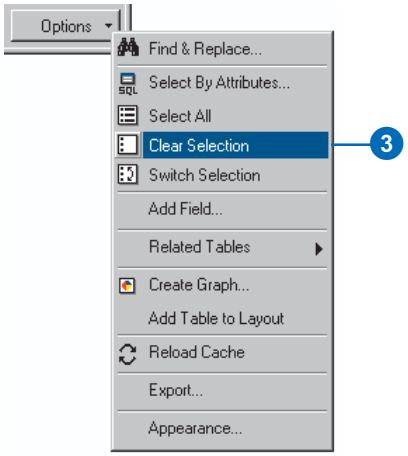


2. Click the row representing Wetlands (value of 7).



This *selected set,* all areas of Wetlands, is highlighted on the map.

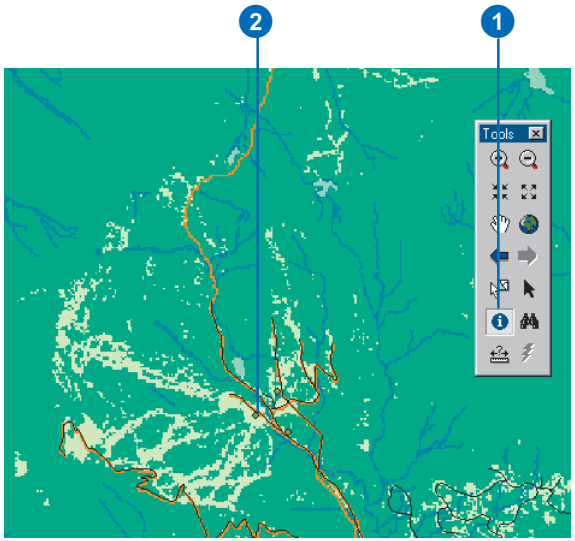
3. Click the Options button on the Open Attribute Table dialog, then click Clear Selection.



4. Click the Close button to close the Attributes of landuse table.

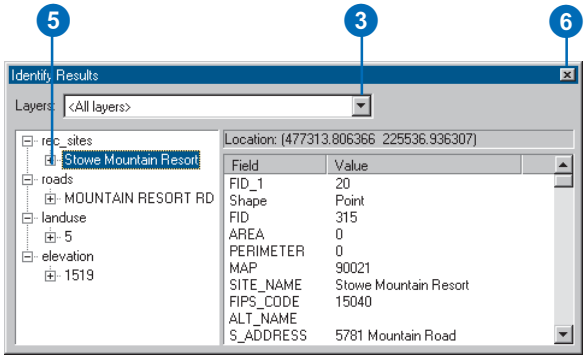
Identifying features on the map

1. Click the Identify tool on the Tools toolbar.
2. Click the Rec_site shown in the map below to identify the features in this particular location.



Note: Your display will not be zoomed in this much; this is only to show the location of the recreation site to click.

3. Click the Layers dropdown arrow on the Identify Results dialog box and click All layers.
4. Click the Rec_site again to identify the features in this particular location for all layers.
5. Expand the tree of each layer to obtain the value for each layer in this location.
6. Close the Identify Results dialog box.



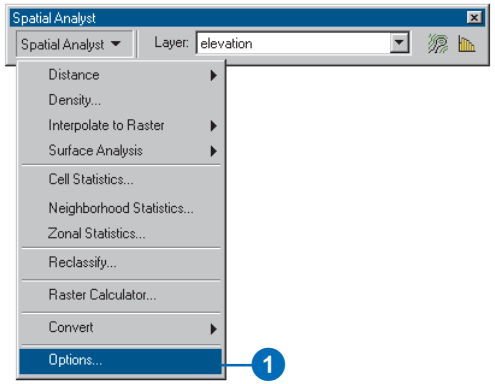
Using Spatial Analyst to explore your data

You will now create a *histogram* from the landuse layer and a *hillshade* from the Elevation layer to gain more of an understanding of the nature of the landscape.

Setting the analysis properties

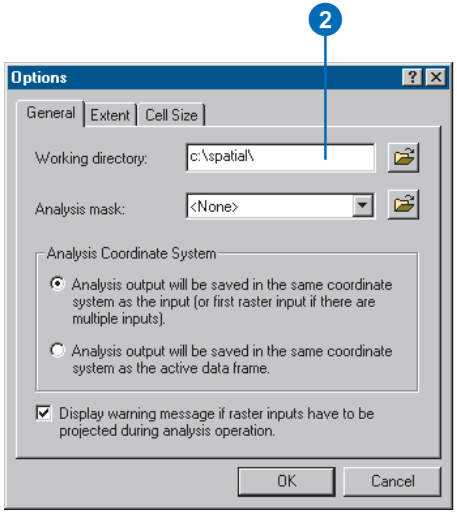
Before you use Spatial Analyst, you should set up the analysis options, stating the working directory, the extent, and the *cell size* for your analysis results. These settings are specified in the Options dialog box.

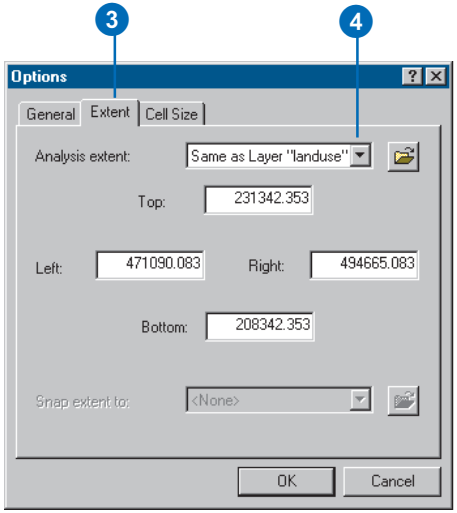
1. Click the Spatial Analyst dropdown arrow and click Options.



2. Specify a working directory on your local drive in which to place your analysis results. For example, type c:\spatial to create a folder called spatial on your C:\ drive for use throughout this tutorial.
3. Click the Extent tab.
4. Click the Analysis extent dropdown arrow and click Same as Layer “landuse”.

   The extent of all subsequent resulting datasets will be the same as the Landuse layer.



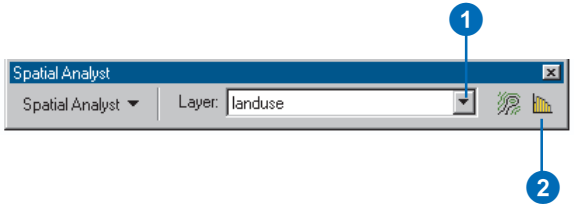


5. Click the Cell Size tab.
6. Click the Analysis Cell Size dropdown arrow and click Same as Layer “elevation”.
7. Click OK on the Options dialog box.

   This will set the cell size for your analysis results to be at a 30-meter resolution (the largest cell size of your datasets).

Examining a histogram

1. Click the Layer dropdown arrow and click landuse.
2. Click the Histogram button.

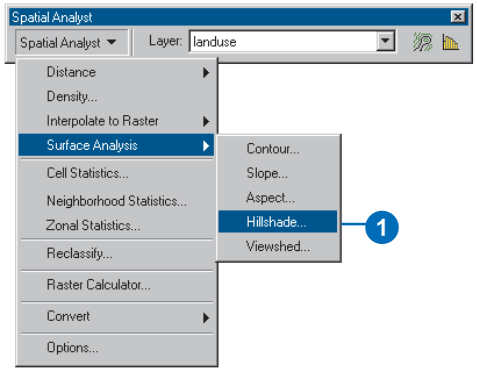


   The histogram displays the number of cells of each type of landuse.
3. Close the Histogram.

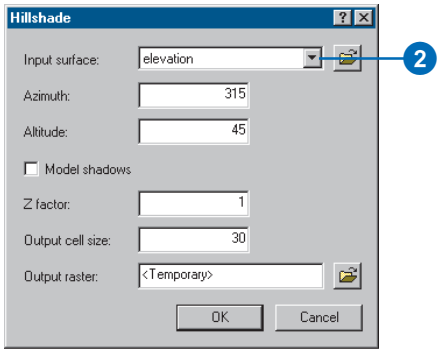
Creating a hillshade

Creating a hillshade from elevation data and adding transparency gives you a good visual impression of the terrain and can greatly enhance the display of your map.

1. Click the Spatial Analyst dropdown arrow, point to Surface Analysis, and click Hillshade.

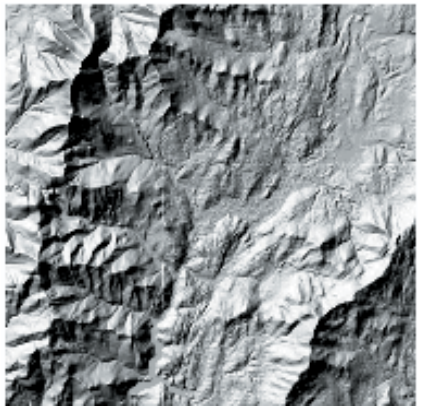


2. Click the Input surface dropdown arrow and click elevation. Leave the defaults for all other options.



3. Click OK on the Hillshade dialog box.

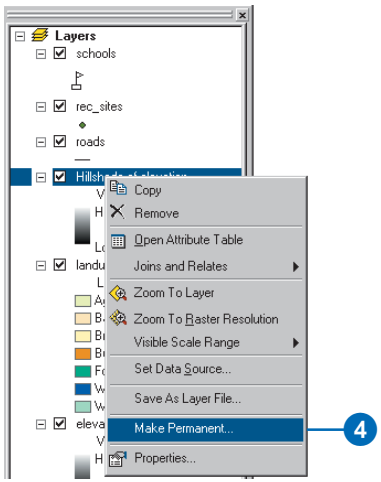
   The result of the Hillshade function is added to the map as a new layer.

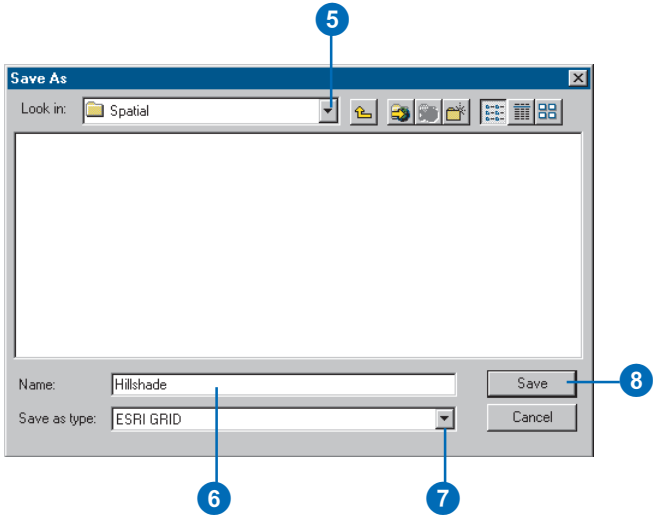


   All results from analysis functions are *temporary*. If you want to make any result available for future use, you should make the dataset *permanent*.

4. Right-click the created hillshade layer and click Make Permanent.
5. Navigate to the folder on your local drive where you set up your working directory (C:\Spatial).
6. Type “Hillshade” in the Name text box.
7. Click the Save as type dropdown arrow and click ESRI GRID.
8. Click Save.

   Note: A copy of Hillshade can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex1\Hillshade on the drive where the tutorial data is installed.

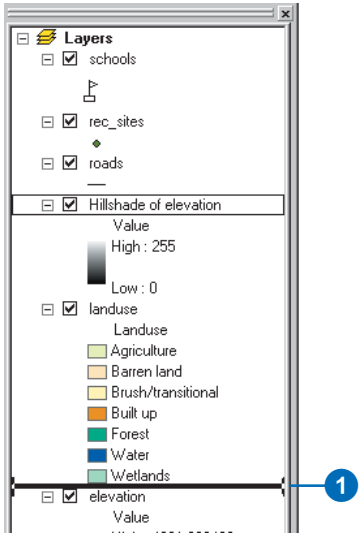




Applying transparency

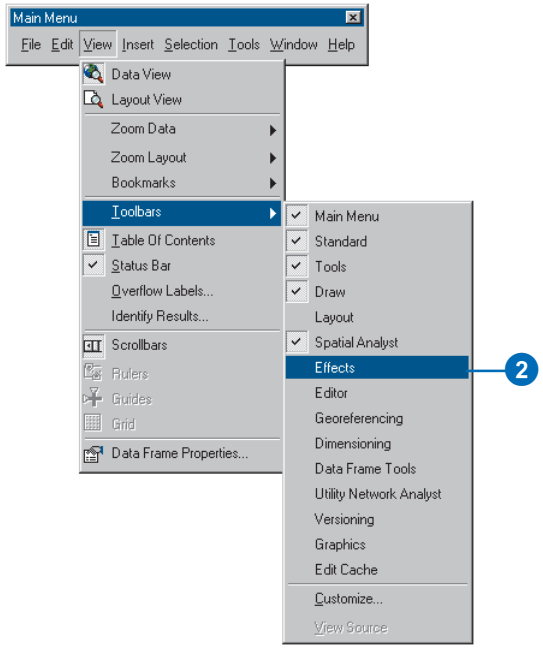
You will now make the Landuse layer transparent so the Hillshade can be seen through it.

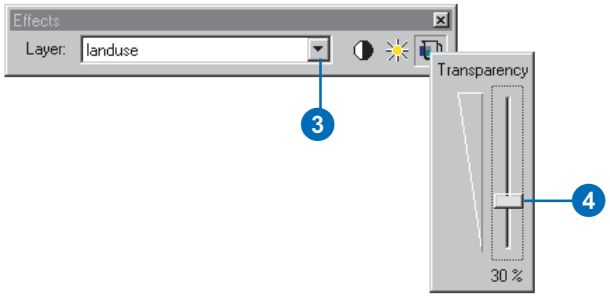
1. Click Hillshade of elevation in the table of contents and drag the layer below the landuse layer.

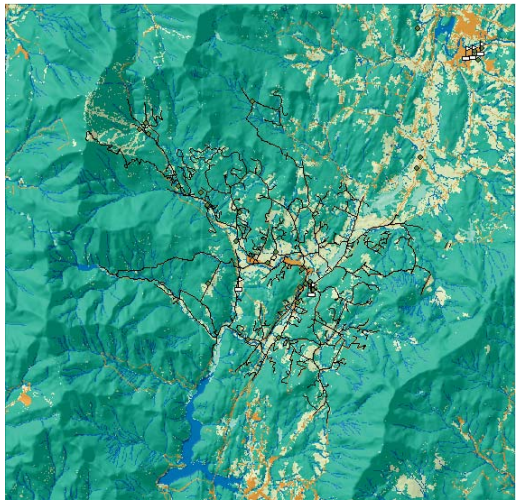


2. Click View on the Main menu, point to Toolbars, and click Effects.
3. Click the Layer dropdown arrow and click landuse.
4. Click the Adjust Transparency button and move the scroll bar up to 30 percent transparency.

   The Hillshade layer can now be seen underneath the landuse layer, giving a vivid impression of the terrain.





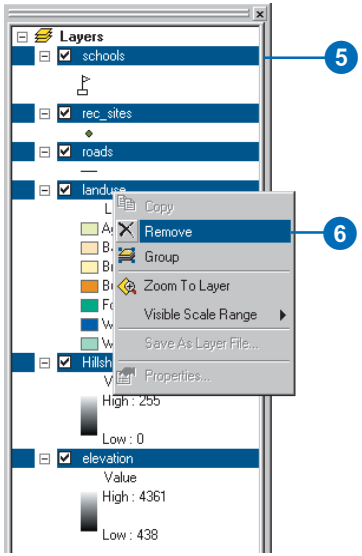


Exploring your data gives you a useful basis of information that will help you during your analysis. For example, you need to know the different landuse types and their distribution over an area, as well as their relative importance, in order to decide how much weight each should have in a *suitability model*. Alternatively, you need to know how rugged the terrain is so you know to include *slope* as a factor in determining the *least-cost path*.

Having explored your data, you are now in a position to begin to find suitable locations for the new school.

First, you will need to remove all the layers used in this exercise.

5. Click the top layer in the table of contents to highlight it. Press and hold the Shift key and click all other layers.
6. Right-click one of the layers in the table of contents and click Remove.



All layers will be removed from the ArcMap *data frame*.

This exercise showed you how to display and explore your data. In the next exercise you will use the Spatial Analyst functions to find a potential site for a new school. You can continue on with the tutorial or close ArcMap and continue at a later date. There is no need to save the map document at this point.

Note: To save your work at any time, click the File menu and click Save As. Navigate to the location where you set up your local working directory (C:\Spatial), specify a filename for the *map document* (Spatial_Tutorial), and click Save. Simply open Spatial_Tutorial.mxd when you wish to continue with the tutorial. You will, however, be prompted when it is appropriate to save the map document.

Exercise 2: Finding a site for a new school in Stowe, Vermont, USA

In this exercise you will find suitable locations for a new school. The four steps to produce such a suitability map are outlined below.

Step 1: Input Datasets

Step 2: Derive Datasets

Step 3: Reclassify Datasets

Step 4: Weight and Combine Datasets

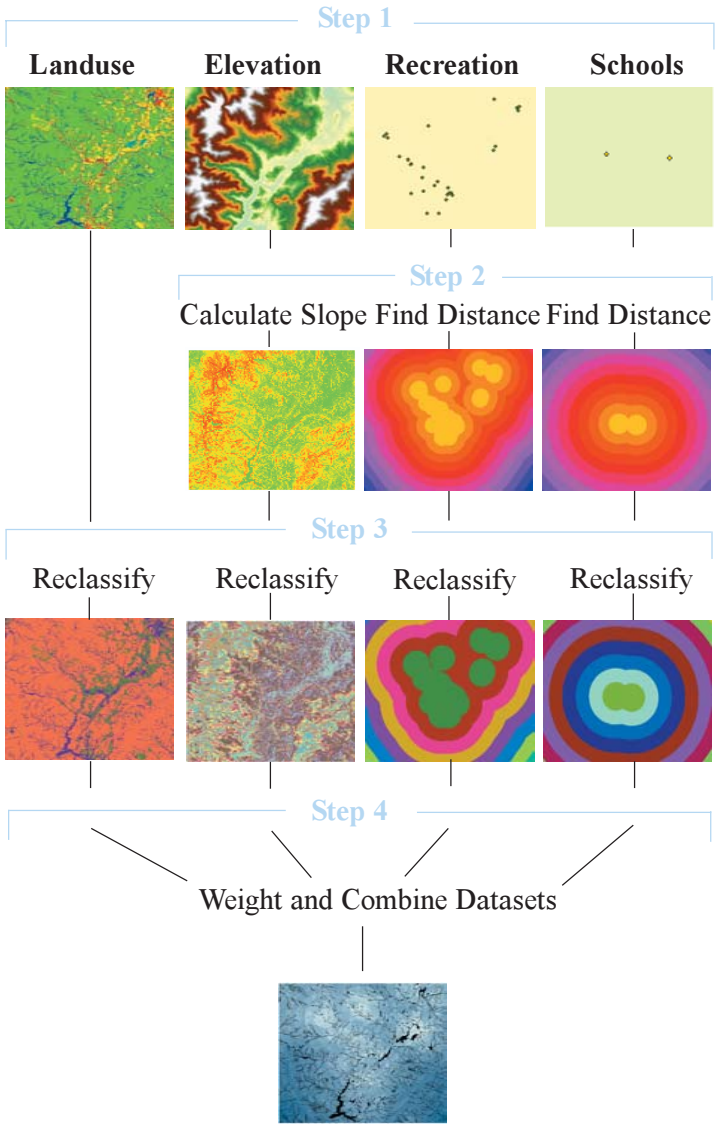
Decide which datasets you need as inputs. The datasets you will use in this exercise are displayed to the right.

Derive datasets. Create data from existing data to gain new information.

Reclassify each dataset to a common scale (for example, 1–10), giving higher values to more suitable attributes.

Weight datasets that should have more influence in the suitability model if necessary, then **combine** them to find the suitable locations.

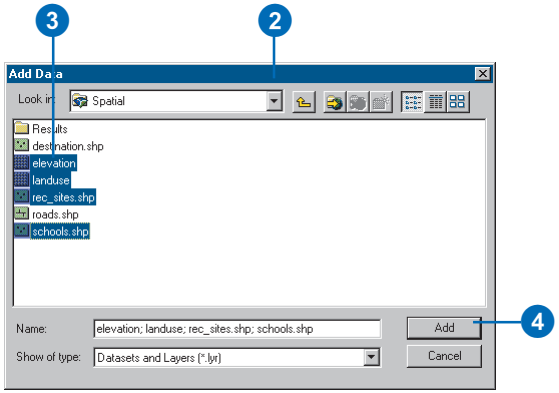
Your input datasets in this exercise are Landuse, Elevation, Recreation Sites, and Existing Schools. You will derive slope, distance to recreation sites, and distance to existing schools, then *reclassify* these derived datasets to a common scale from 1–10. You will then weight them according to a percentage influence and combine them to produce a map displaying suitable locations for the new school. The diagram to the right shows the process you will take.



Step 1: Inputting datasets

1. Click the Add Data button on the Standard toolbar.

2. Navigate to the folder on your local drive where you installed the tutorial data (the default installation path is ArcGIS\ArcTutor\Spatial, on the drive where the tutorial data is installed).
3. Click elevation, then click and hold down the Ctrl key and click landuse, rec_sites, and schools.
4. Click Add.



Each dataset is added to the ArcMap table of contents as a *layer*.

Setting the analysis properties

Set up the analysis options like you did in Exercise 1.

1. Click the Spatial Analyst dropdown arrow and click Options.
2. Specify a working directory on your local drive in which to place your analysis results. Type c:\spatial to create a folder called spatial on your C:\ drive.
3. Click the Extent tab.
4. Click the Analysis Extent dropdown arrow and click Same as Layer “landuse”.
5. Click the Cell Size tab.
6. Click the Analysis Cell Size dropdown arrow and click Same as Layer “elevation”.
7. Click OK on the Options dialog box.

Step 2: Deriving datasets

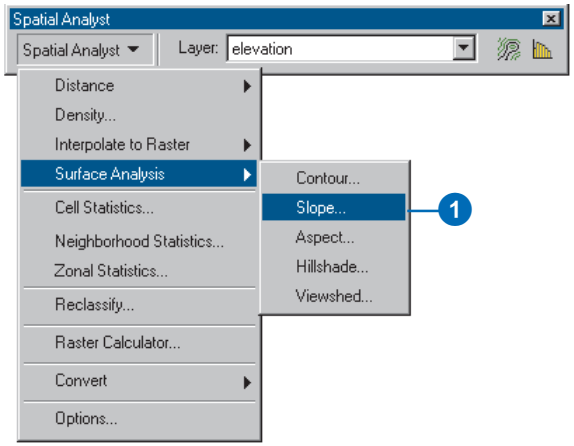
Deriving data from your input datasets is the next step in the suitability model. You will derive the following:

- Slope from elevation
- Distance from recreation sites
- Distance from existing schools

Deriving slope

Since the area is mountainous, you need to find areas of relatively flat land to build on, so you will take into consideration the slope of the land.

1. Click the Spatial Analyst dropdown arrow, point to Surface Analysis, and click Slope.



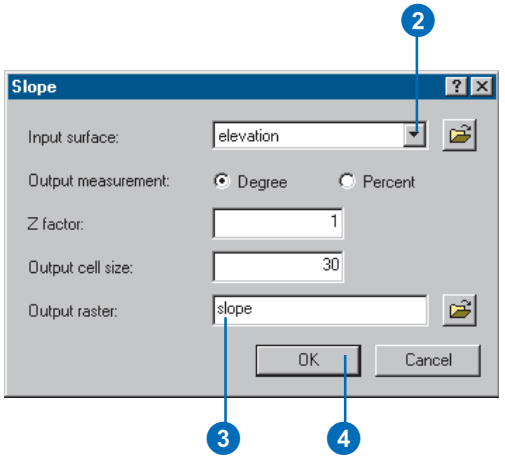
2. Click the Input surface dropdown arrow and click elevation.

3. Type slope in the Output raster text box to permanently save your output slope dataset to the location of your working directory (c:\spatial).

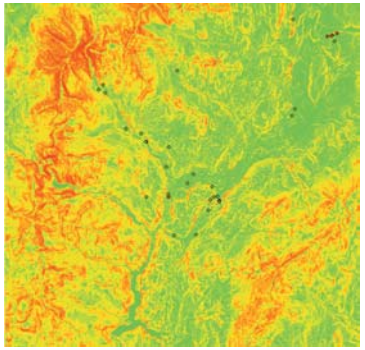
You will use this dataset again in Exercise 3.

Note: A copy of this slope dataset can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex2\Slope.

4. Click OK.



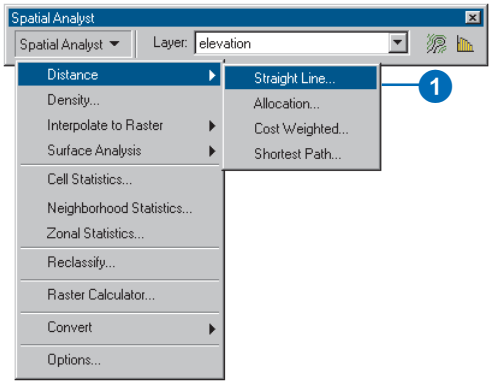
The output slope dataset will be added to your ArcMap session as a new layer. High values (red areas) indicate steeper slopes.



Deriving distance from recreation sites

In this model, it is preferable that the school be built near recreational facilities, so you will now calculate the straight-line distance from Recreation Sites.

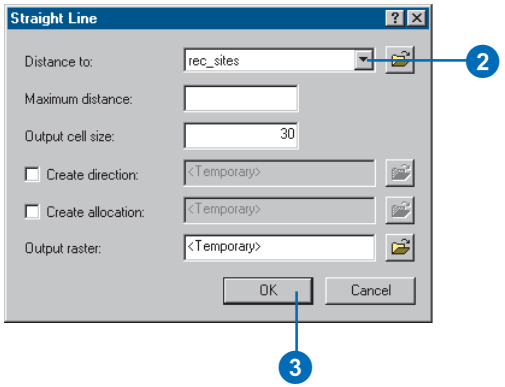
1. Click the Spatial Analyst dropdown arrow, point to Distance, and click Straight Line.



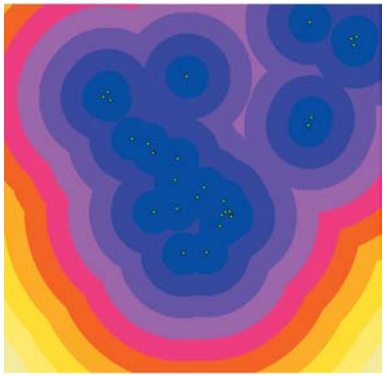
2. Click the Distance to dropdown arrow and click rec_sites.

   Leave the defaults for all other options.

3. Click OK.



The output distance to the rec_sites dataset will be added to your ArcMap session as a new layer. Values of zero indicate the location of a recreation site, with values (distances) increasing as you move away from each of these sites.



Note: A copy of this distance to rec_sites dataset can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex2\recD.

4. Uncheck the box next to Schools to turn off this layer so you only see the locations of the recreation sites and the distance to them.

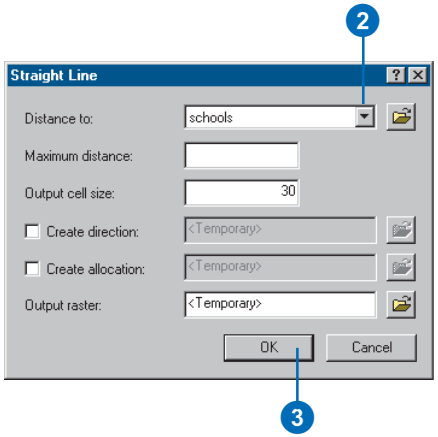
Deriving distance from schools

You will now derive a dataset of distance from existing schools. It is preferable to locate the new school away from existing schools to spread out their locations through the town.

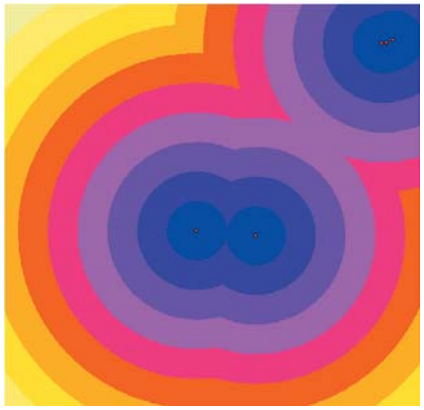
1. Click the Spatial Analyst dropdown arrow, point to Distance, and click Straight Line.
2. Click the Distance to dropdown arrow and click schools.

   Leave the defaults for all other options.

3. Click OK.



The output distance to schools dataset will be added to your ArcMap session as a new layer.



4. Check the box next to the schools layer to turn it back on and uncheck the box next to rec_sites to turn this layer off so you only see the locations of the schools and the distance to them.

Note: A copy of this distance to schools dataset can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex2\schD.

Step 3: Reclassifying datasets

You now have the required datasets to find the best location for the new school. The next step is to combine them to find out where the potential locations can be found.

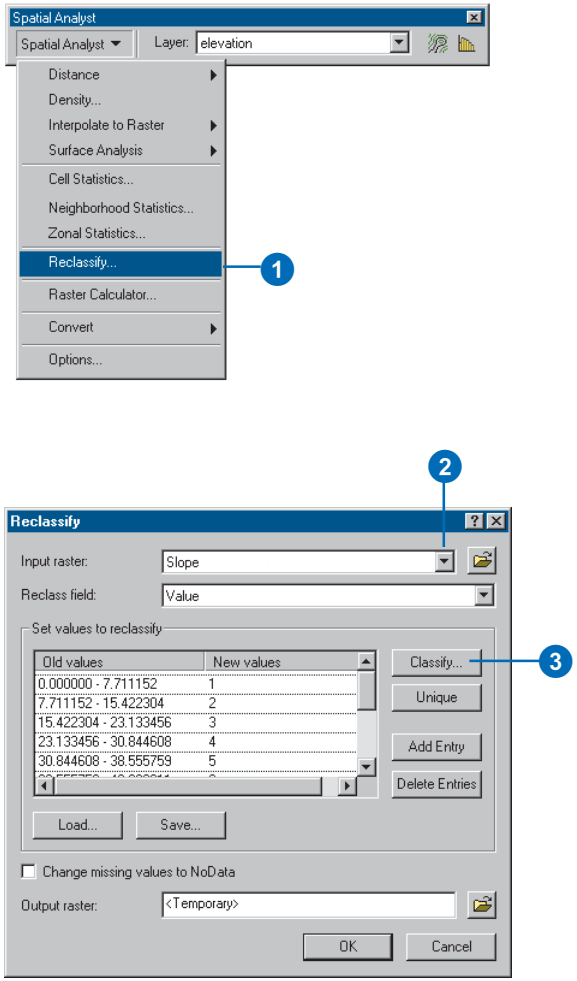
In order to combine the datasets, they must first be set to a common scale. That common scale is how suitable a particular location (each cell) is for building a new school. You will reclassify each dataset to a common scale, within the range 1–10, giving higher values to attributes within each dataset that are more suitable for locating the school:

- Reclassify slope
- Reclassify Distance to recreation sites
- Reclassify Distance to schools
- Reclassify landuse

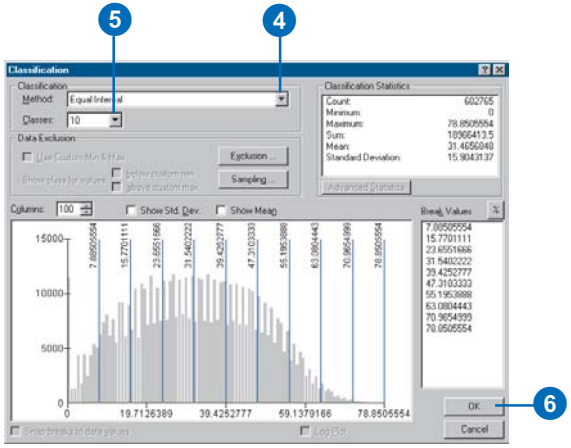
Reclassifying slope

It is preferable that the new school site be located on relatively flat ground. You will reclassify the Slope layer, giving a value of 10 to the most suitable slopes (those with the lowest angle of slope) and 1 to the least suitable slopes (those with the steepest angle of slope).

1. Click the Spatial Analyst dropdown arrow and click Reclassify.
2. Click the Input raster dropdown arrow and click Slope.
3. Click Classify.

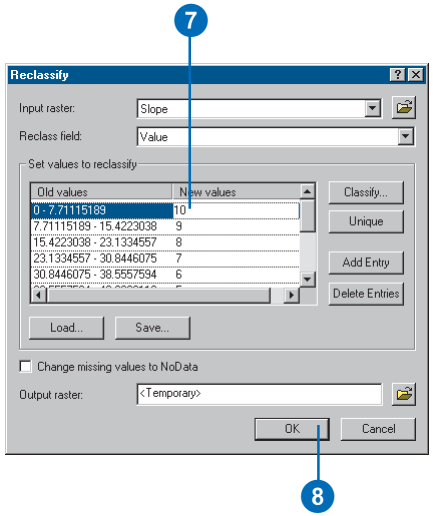


4. Click the Method dropdown arrow and click Equal Interval.
5. Click the Classes dropdown arrow and click 10.
6. Click OK.

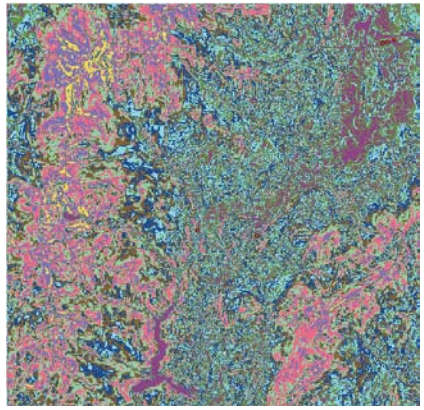


You want to reclassify the Slope layer so steep slopes are given low values, as these are least suitable for building on.

7. Click the first New value record in the Reclassify dialog box and change it to a value of 10. Give a value of 9 to the next New value, 8 to the next, and so on. Leave NoData as NoData.
8. Click OK.



The output reclassified slope dataset will be added to your ArcMap session as a new layer. Locations with higher values (less-steep slopes) are more suitable than locations with lower values (steeper slopes).

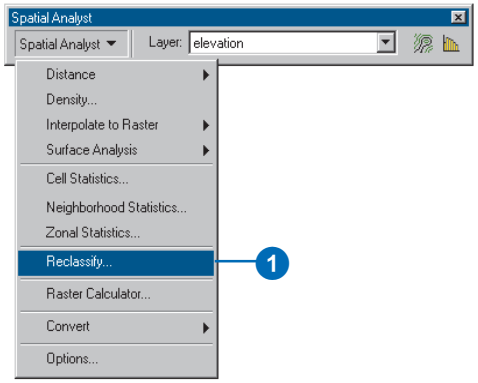


Note: A copy of this reclassified slope dataset can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex2\slopeR.

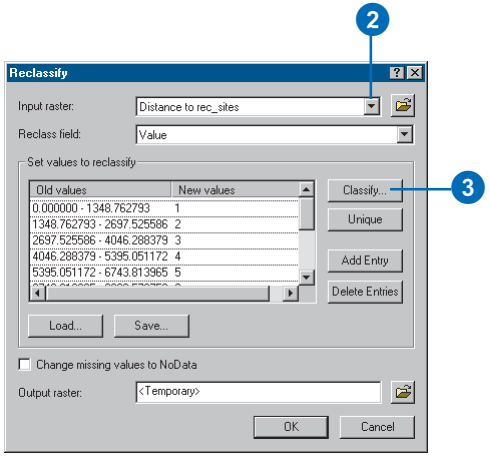
Reclassifying distance to recreation sites

The school should be located near recreational facilities. You will reclassify this dataset, giving a value of 10 to areas closest to recreation sites (the most suitable locations), giving a value of 1 to areas far from recreation sites (the least suitable locations), and ranking the values in between. By doing this you will find out which areas are near and which areas are far from recreation sites.

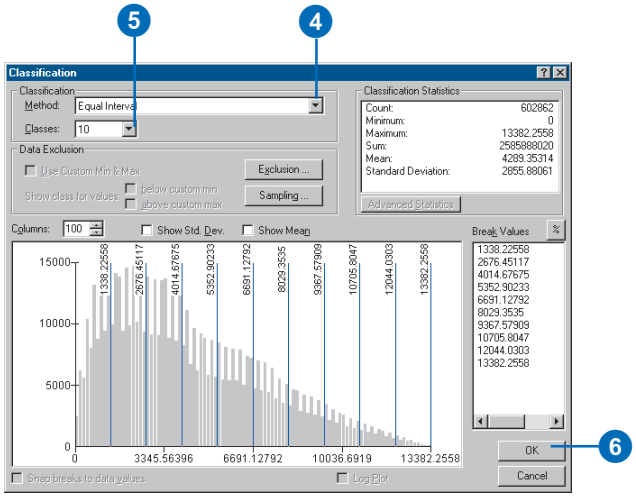
1. Click the Spatial Analyst dropdown arrow and click Reclassify.



2. Click the Input raster dropdown arrow and click Distance to rec_sites.
3. Click Classify.

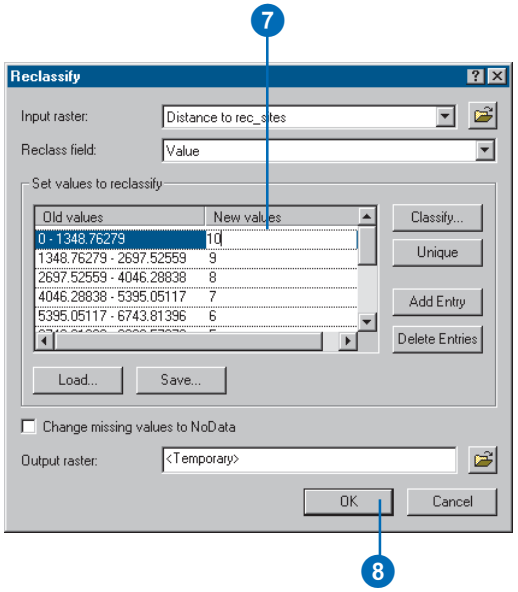


4. Click the Method dropdown arrow and click Equal Interval.
5. Click the Classes dropdown arrow and click 10.
6. Click OK.

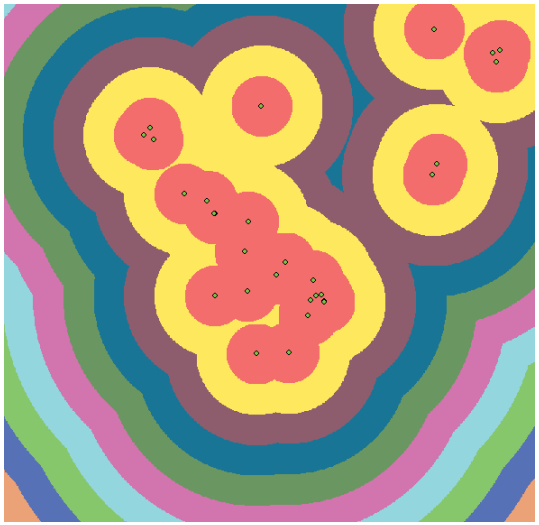


You want to locate the school near recreational facilities, so you will give higher values to locations close to recreational facilities, as these are the most desirable.

7. As you did when reclassifying the Slope layer, click the first New value record in the dialog box and change it to a value of 10. Give a value of 9 to the next New value, 8 to the next, and so on. Leave NoData as NoData.
8. Click OK.



The output reclassified distance to recreation sites dataset will be added to your ArcMap session as a new layer. It shows locations that are more suitable for locating another school. High values indicate more suitable locations.

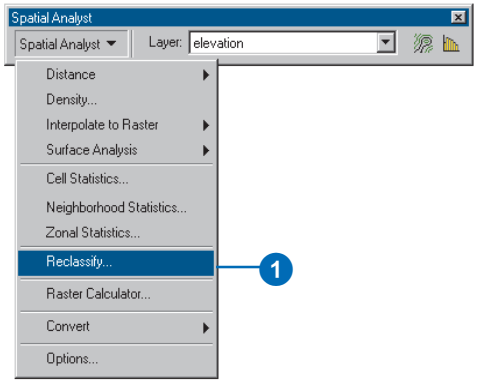


Note: A copy of this reclassified distance from recreation sites dataset can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex2\recR.

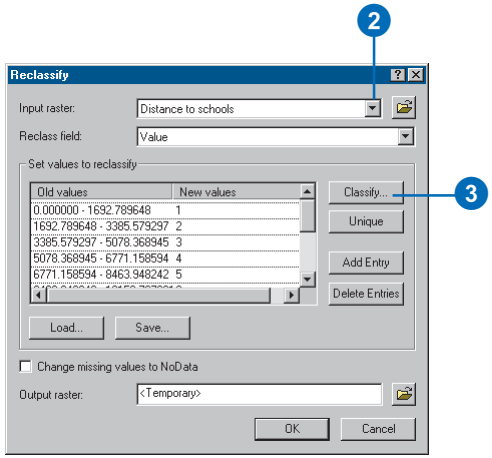
Reclassifying distance to schools

It is necessary to locate the new school away from existing schools in order to avoid encroaching on their catchment areas. You will reclassify the Distance to schools layer, giving a value of 10 to areas away from existing schools (the most suitable locations), giving a value of 1 to areas near existing schools (least suitable locations), and ranking the values in between. By doing this you will find out which areas are near and which areas are far from existing schools.

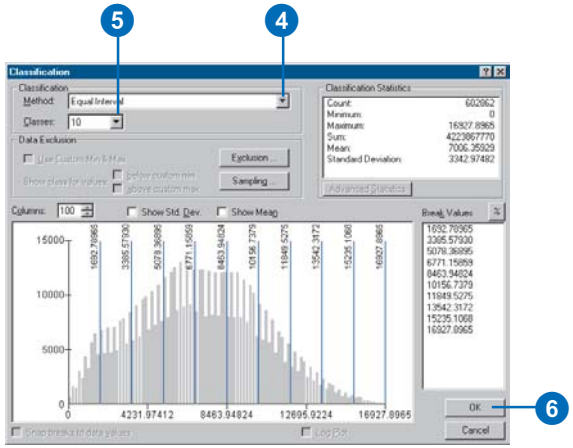
1. Click the Spatial Analyst dropdown arrow and click Reclassify.



2. Click the Input raster dropdown arrow and click Distance to schools.
3. Click Classify.



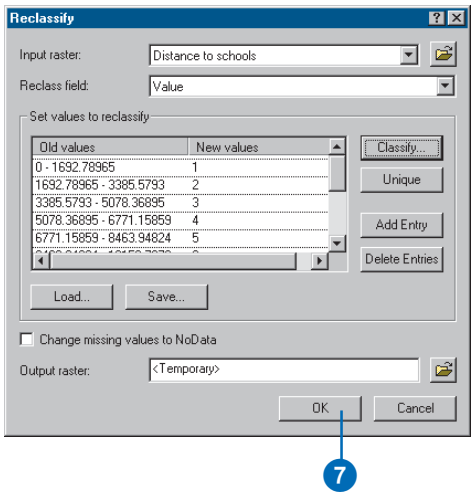
4. Click the Method dropdown arrow and click Equal Interval.
5. Click the Classes dropdown arrow and click 10.
6. Click OK.



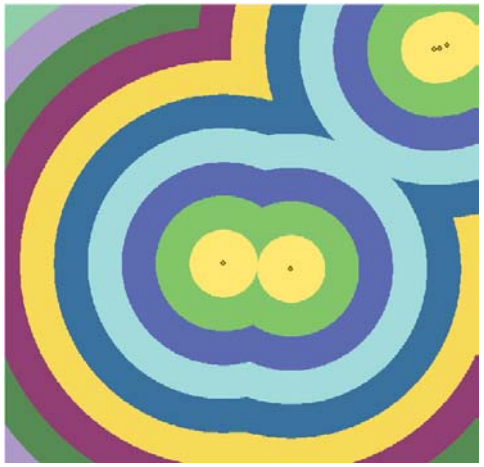
You want to locate the school away from existing schools, so you will give higher values to locations farther away, as these locations are most desirable.

As the default gives high New values (more suitable) to high Old values (locations farther away from existing schools), you do not need to change any values this time.

7. Click OK.



The output reclassified distance to schools dataset will be added to your ArcMap session as a new layer. It shows locations that are more suitable for locating another school. Higher values indicate more suitable locations.



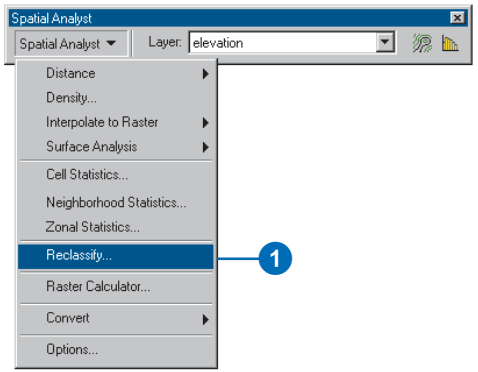
Note: A copy of this reclassified distance from schools dataset can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex2\schR.

Reclassifying landuse

At a town planners meeting it was decided that certain landuse types were better for building on than others, taking into consideration the costs involved in building on different landuse types.

You will now reclassify Landuse. A lower value indicates that a particular landuse type is less suitable for building on. Water and Wetlands will be given NoData as they cannot be built on and should be excluded.

1. Click the Spatial Analyst dropdown arrow and click Reclassify.



2. Click the Input raster dropdown arrow and click Landuse.
3. Click the Reclass field dropdown arrow and click Landuse.
4. Type the following values in the New values column:

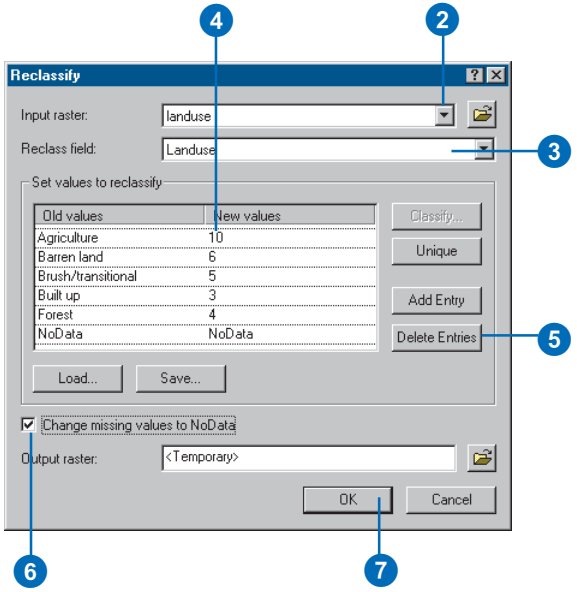
   Agriculture—10
   Barren land—6
   Brush/Transitional—5
   Built up—3
   Forest—4

   You will now remove the Water and Wetland attributes and change their values to NoData.

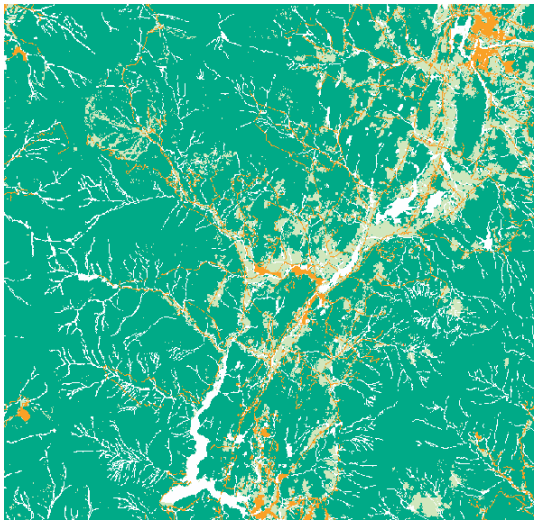
5. Click the row for Water, press the Shift key, click Wetlands, then click Delete Entries.
6. Check Change missing values to NoData.

   All values for Water and Wetlands will be changed to NoData.

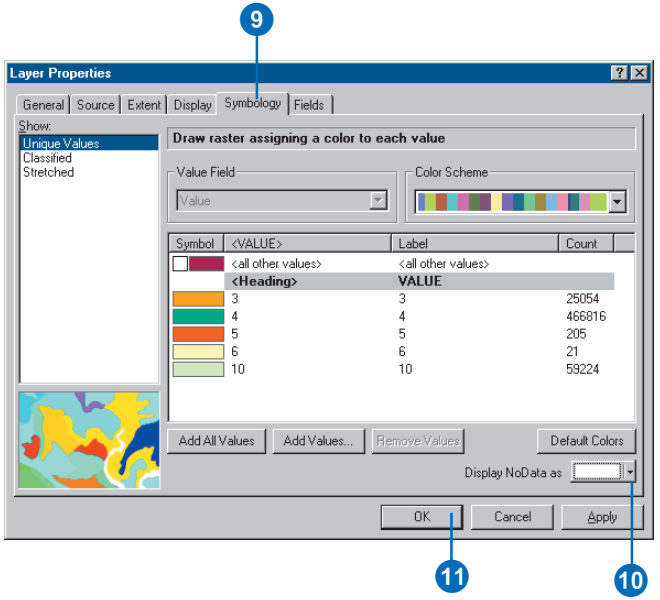
7. Click OK.



The output reclassified landuse dataset will be added to your ArcMap session as a new layer. It shows locations that have landuse types that are considered to be better than others for locating the school (higher values indicate more suitable locations).



8. Right-click Reclass of landuse in the table of contents and click Properties.
9. Click the Symbology tab.
10. Click the Display NoData as dropdown arrow and click Arctic White to show NoData values (Water and Wetlands) in this color.
11. Click OK.



Note: A copy of this reclassified landuse dataset can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex2\landuseR.

Step 4: Weighting and combining datasets

After applying a common scale to your datasets, where higher values are given to those attributes that are considered more suitable within each dataset, you are ready to combine them to find the most suitable locations.

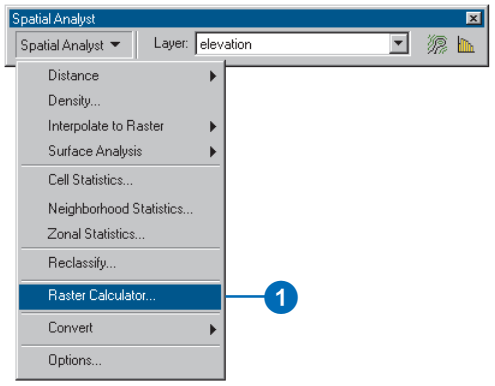
If all datasets were equally important, you could simply combine them at this point; however, you have been informed that it is preferable to locate the new school close to recreational facilities and away from other schools. You will weight all the datasets, giving each a percentage influence. The higher the percentage, the more influence a particular dataset will have in the suitability model.

You will give the layers the following percent influence:

(Each percentage is divided by 100 to *normalize* the values.)

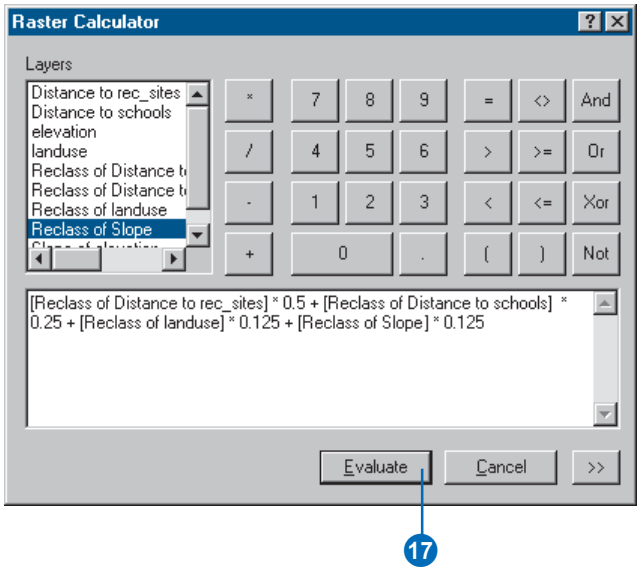
Reclass of Distance to rec_sites:	0.5	(50%)
Reclass of Distance to schools:	0.25	(25%)
Reclass of landuse:	0.125	(12.5%)
Reclass of slope:	0.125	(12.5%)

1. Click the Spatial Analyst dropdown arrow and click *Raster Calculator*.



2. Double-click Reclass of Distance to rec_sites from the Layers list to add it to the expression box.
3. Click Multiply.
4. Click 0.5.
5. Click Add.
6. Double-click Reclass of Distance to schools.
7. Click Multiply.
8. Click 0.25.
9. Click Add.
10. Double-click Reclass of landuse.
11. Click Multiply.
12. Click 0.125.
13. Click Add.
14. Double-click Reclass of slope.
15. Click Multiply.

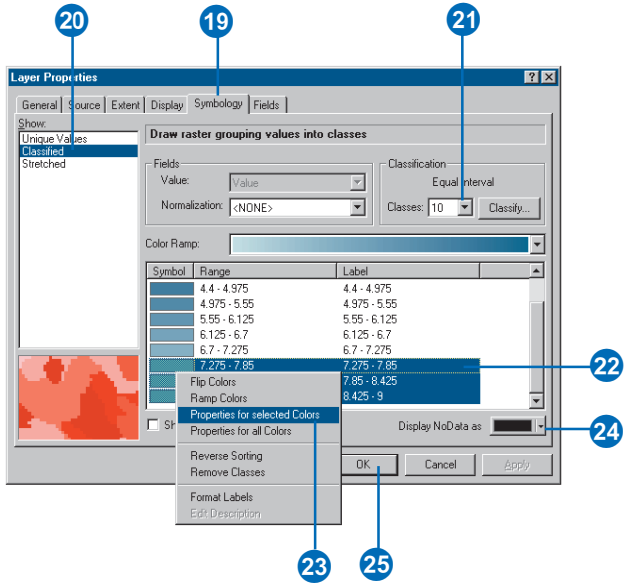
16. Click 0.125.
17. Click Evaluate to perform the weighting and combining of the datasets.



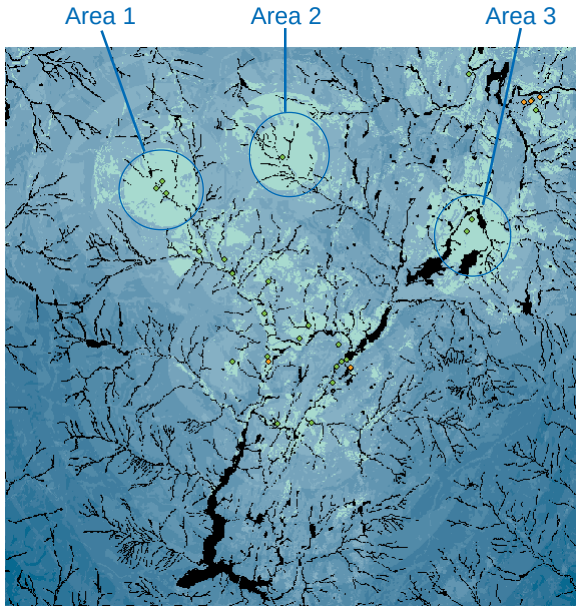
The output raster dataset shows you how suitable each location is for locating the new school, according to the criteria you set in the suitability model. Higher values indicate locations that are more suitable.

The suitable locations are those areas that are close to recreation sites, away from existing schools, on relatively flat land, and on certain types of landuse. The higher weightings set for Distance to schools and Distance to rec_sites have a powerful influence on deciding which areas are more suitable than others.

18. Right-click the newly created raster layer in the table of contents and click Properties.
19. Click the Symbology tab.
20. Click Classified from the Show list.
21. Click the Classes dropdown arrow and click 10.
22. Scroll to the last three classes, click one, then press and hold the Shift key and click the other two.
23. Right-click the highlighted classes, click Properties for selected Colors, and click a bright color.
24. Click the Display NoData as dropdown arrow and click the color black. This displays values of NoData (Water and Wetlands) in this color.
25. Click OK.



You decide that there are three main potential areas for locating the school. They are labeled in the diagram below.



You should now assess these locations to see which might be the best location. This should be done in the field, as well as by examining the data you have on each potential area.

26. Right-click the output layer in the table of contents and click Make Permanent.

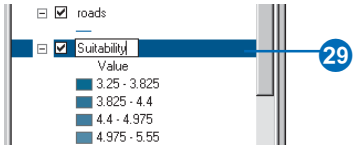
27. Navigate to the folder on your local drive where you set up your working directory (c:\spatial).

28. Type Suitability and click Save.

    The temporarily created dataset will now be permanently stored on disk.

    Note: A copy of this Suitability dataset can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex2\Suitability.

29. Click the output raster twice slowly. Rename the layer Suitability.



You decide that the best location is somewhere within Area 1, as there are three recreation sites in the neighboring area, the ski resort being one of them. Also, although you know that a considerable volume of traffic already uses the current access road to this potential site, you are involved in plans for constructing an alternative road to this area, which will help alleviate the volume of traffic on the current access road.

30. Click the Schools layer in the table of contents, press the Ctrl key, and click all other layers except Suitability (use the scroll bar to move down the table of contents).

31. Right-click one of the highlighted layers and click Remove.

You have now completed Exercise 2. You can continue on to Exercise 3, or you can stop and continue later. Whichever option you choose, save the map document at this point. Click the File menu and click Save As. Navigate to the location where you set up your local working directory (c:\spatial), specify a filename for the map document (Spatial_Tutorial), and click Save.

Exercise 3: Finding an alternative access road to the new school site

In this exercise you will find the best route for a new access road. The steps you might follow to produce such a path are outlined below, and the steps you will take in this exercise are diagrammed to the right.

Step 1: Create Source and Cost Datasets

Create the *source dataset* if necessary. The Source is the school site in this exercise.

Create the *cost dataset* by deciding which datasets are required, reclassifying them to a common scale, weighting, then combining them.

Step 2: Perform Cost Weighted Distance

Perform *cost weighted distance* using the Source and Cost datasets as inputs. The Distance dataset created from this function is a raster where the value of each cell is the accumulated cost of traveling from each cell back to the source.

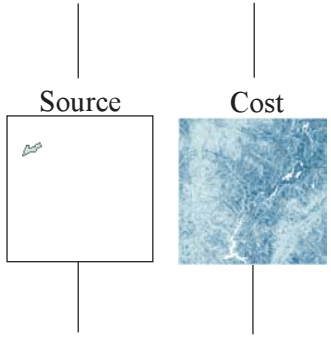
To find the *shortest path*, you need a Direction dataset, which can be created as an additional dataset from the cost weighted function. This gives you a raster of the direction of the least costly path from each cell back to the source (in this exercise, the school site).

Step 3: Perform Shortest Path

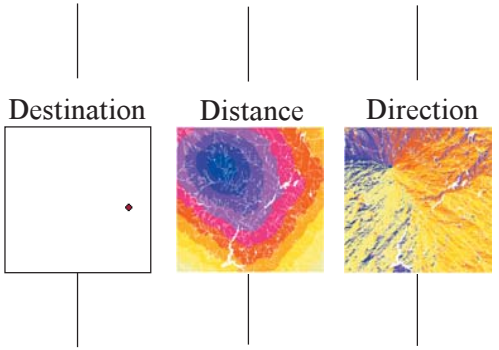
Create the *destination* dataset if necessary. In this exercise, the Destination is a point at a road junction.

Perform shortest path using the Distance and Direction datasets created from the cost weighted function.

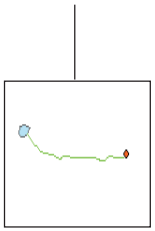
Step 1: Create Source and Cost Datasets



Step 2: Cost Weighted Distance



Step 3: Shortest Path



Step 1: Creating the source and cost datasets

To find the best route to the potential school site, you will first need to create the Source dataset (the school site) from the suitability map, and a Cost dataset, and use these as inputs into the cost weighted function.

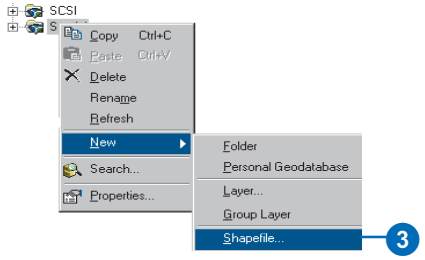
Creating the source dataset

If you want to know how to create the Source dataset, follow the next 29 steps. Alternatively, click the Add Data button and navigate to the location where you installed the tutorial data (ArcGIS\ArcTutor\Spatial). Click Roads, then click Add. Then, click the Add Data button again and navigate to ArcGIS\ArcTutor\Spatial\Results\Ex3. Click School_site, then click Add and skip the next 29 steps.

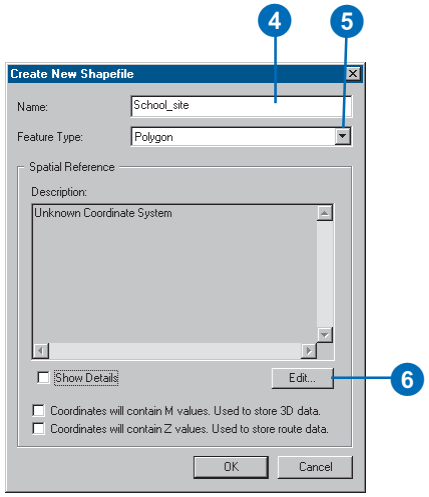
You will first create an empty shapefile in ArcCatalog, then digitize the location of the site using the editing tools in ArcMap.

1. Click the ArcCatalog button on the Standard toolbar.

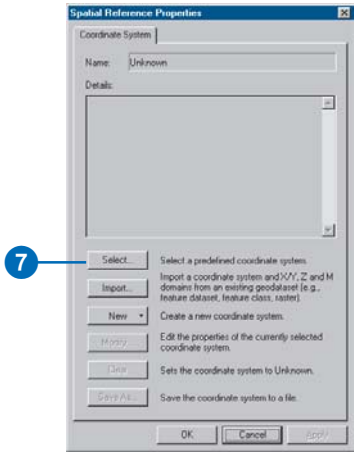
2. Navigate in the *Catalog tree* to the folder on your local drive where you set up your working directory (c:\spatial).
3. Right-click the Spatial folder, point to New, and click Shapefile.



4. Type “School_site” for the name of the new shapefile.
5. Click the *Feature* Type dropdown arrow and click Polygon to choose the type of feature that will be created.
6. Click Edit to add *spatial reference* information to the shapefile.

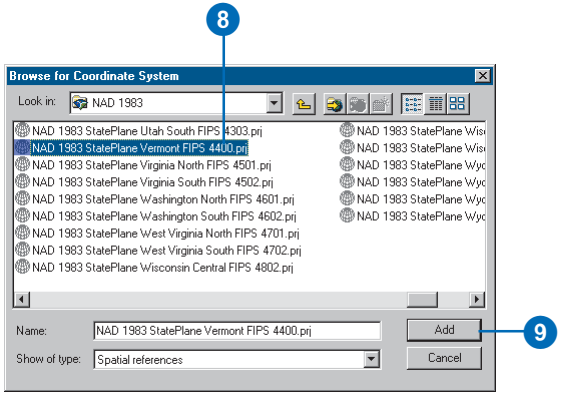


7. Click Select to use a predefined *coordinate system*.



8. Click the Projected Coordinate Systems folder, click State Plane, then click NAD 1983 and scroll to NAD 1983 StatePlane Vermont FIPS 4400.prj.

9. Click Add.



10. Click OK on the Spatial Reference Properties dialog box.

11. Click OK on the Create New Shapefile dialog box.

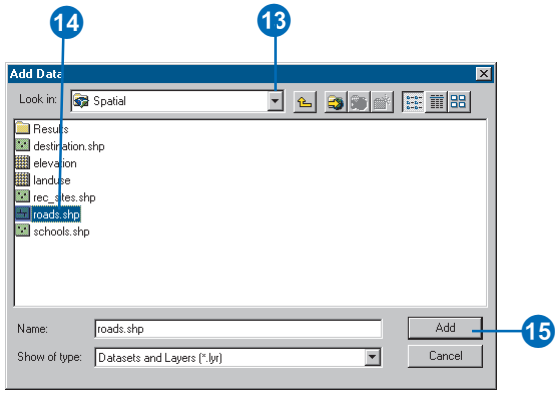
    A new shapefile called School_site will be created and added to the Catalog tree.

12. Click File, click Exit to close ArcCatalog, and return to ArcMap.

13. Click the Add Data button and navigate to the folder on your local drive where you installed the tutorial data (the default installation path is ArcGIS\ArcTutor\Spatial).

14. Click roads.shp.

15. Click Add.

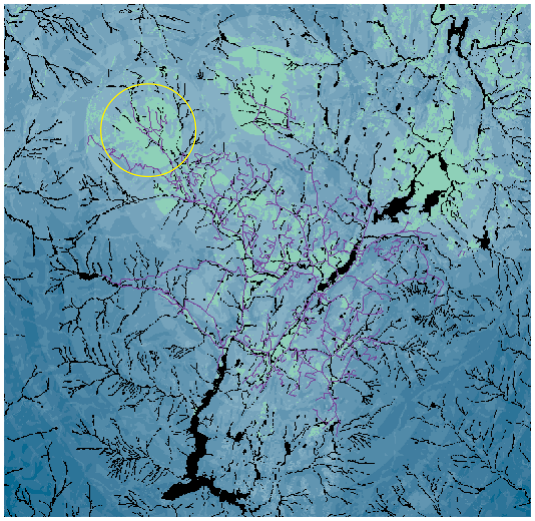


16. Click the Add Data button again and navigate to the folder on your local drive where you set up your working directory (c:\spatial).

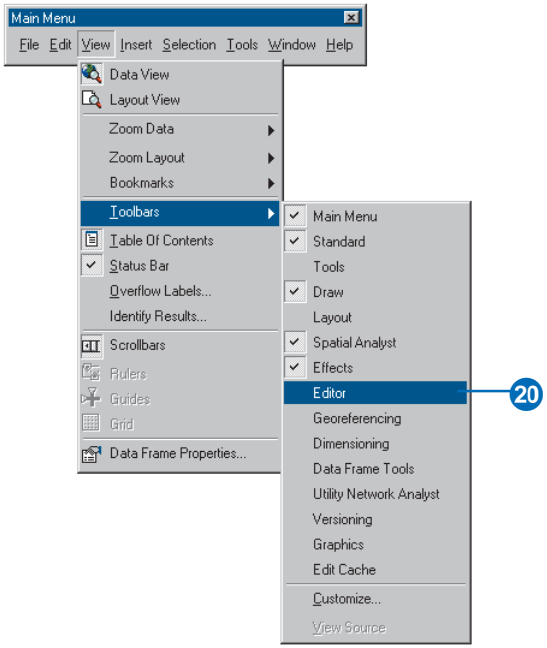
17. Click School_site.

18. Click Add.

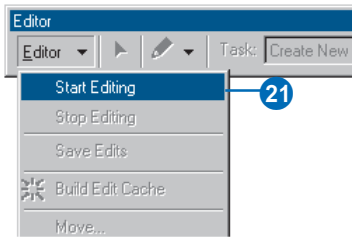
19. Click the Zoom In tool on the Tools toolbar and zoom in on the area that was deemed most suitable (area 1, circled in yellow below).



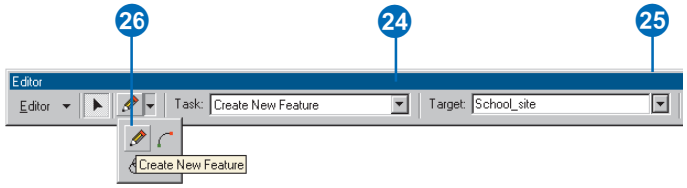
20. Click View, point to Toolbars, and click Editor.



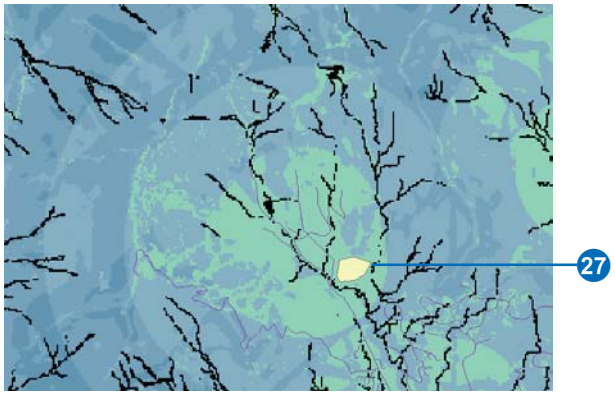
21. Click the Editor dropdown arrow and click Start Editing.



22. Click c:\spatial (or wherever you specified your working directory to be) for the folder from which to edit data.
23. Click OK.
24. Click the Task dropdown arrow and click Create New Feature.
25. Click the *Target* dropdown arrow and click School_site.
26. Click the Create New Feature dropdown arrow and click Create New Feature.



27. Draw a polygon on the screen in the location shown in the diagram. Click and hold to add a polygon vertex, drag the cursor, and add another polygon vertex. Continue until the polygon is complete. Double-click to close the polygon.



28. Click the Editor dropdown arrow and click Stop Editing.
29. Click Yes to save your edits.

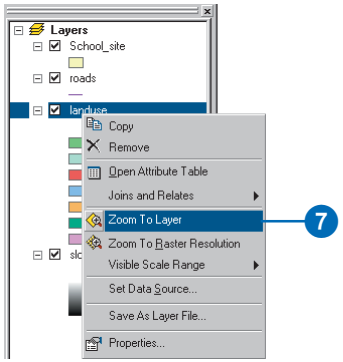
Note: A copy of this school_site dataset can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex3\source.shp.

Creating the cost dataset

You will now create a dataset of the cost of traveling over the landscape, based on the fact that it is more costly to traverse steep slopes and construct a road on certain landuse types.

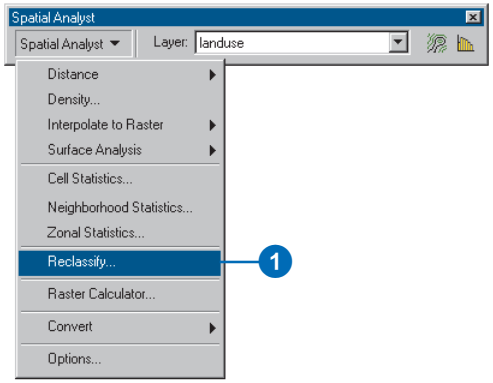
1. Right-click the Suitability layer and click Remove.
2. Click the Add Data button and navigate to the folder on your local drive where you set up your working directory (c:\spatial).
3. Click slope (the dataset created in exercise 2).
4. Click Add.
5. Click the Add Data button again and navigate to the folder on your local drive where you installed the tutorial data (the default installation path is ArcGIS\ArcTutor\Spatial).
6. Click Landuse and click Add.

7. Right-click Landuse and click Zoom To Layer.

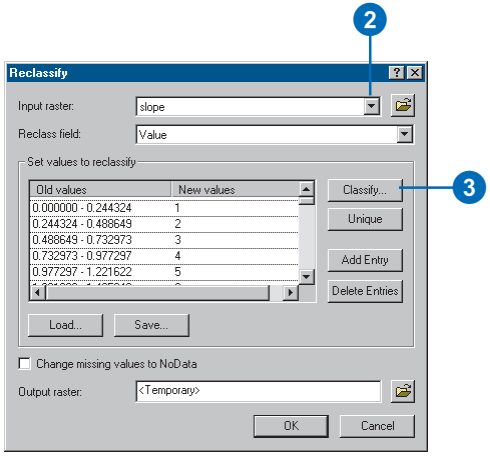


Reclassifying slope

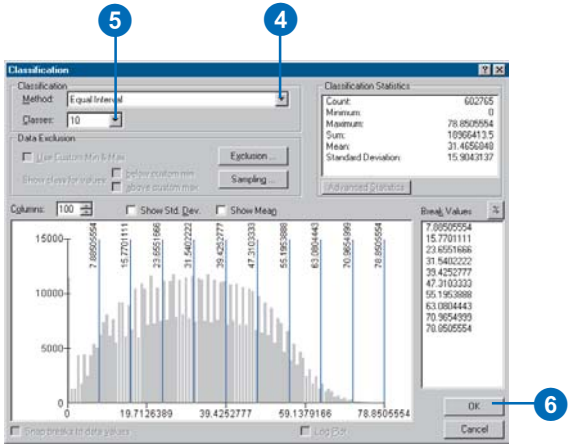
1. Click the Spatial Analyst dropdown arrow and click Reclassify.



2. Click the Input raster dropdown arrow and click slope.
3. Click Classify.



4. Click the Method dropdown arrow and click Equal Interval.
5. Click the Classes dropdown arrow and click 10.
6. Click OK.

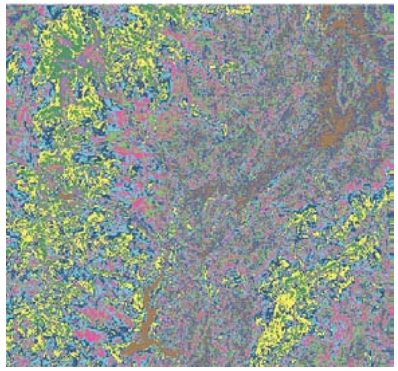


You want to avoid steep slopes when constructing the road, so steep slopes should be given higher values in the Cost dataset.

As the defaults give high values to steeper slopes, you do not need to change the default New Values.

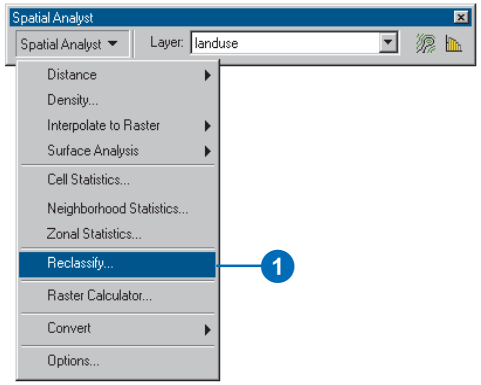
7. Click OK on the Reclassify dialog box.

   The Reclass of slope layer will be added to the table of contents. It shows locations that are more costly than others for constructing a road (higher values indicate the more costly areas that should be avoided).



Reclassifying landuse

1. Click the Spatial Analyst dropdown arrow and click Reclassify.

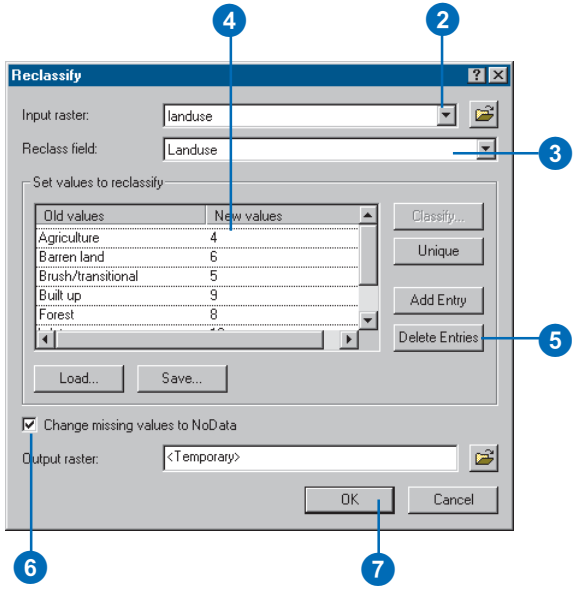


2. Click the Input raster dropdown arrow and click Landuse.
3 Click the Reclass field dropdown arrow and click Landuse.
4. Click the first New value to edit the values and type in the following values:

Agriculture—4	Built up—9
Barren land—6	Forest—8
Brush/Transitional—5	Water—10

Higher values indicate higher road-construction costs.

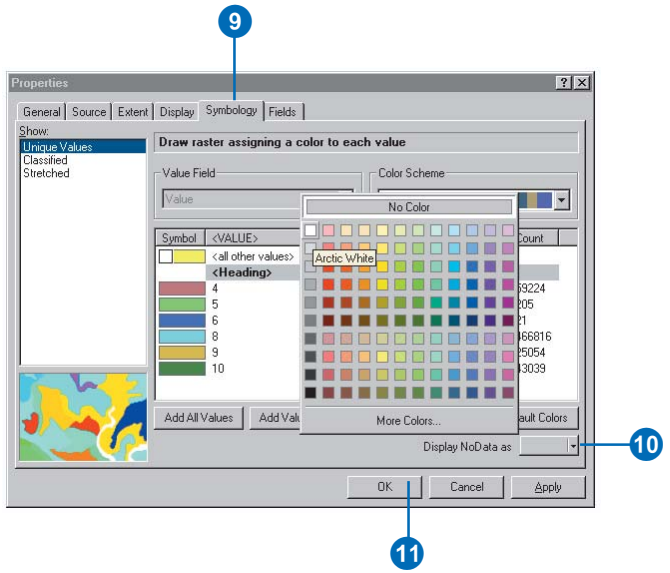
5. Click Wetlands, and click Delete Entries.
6. Click Change missing values to NoData.
7. Click OK.

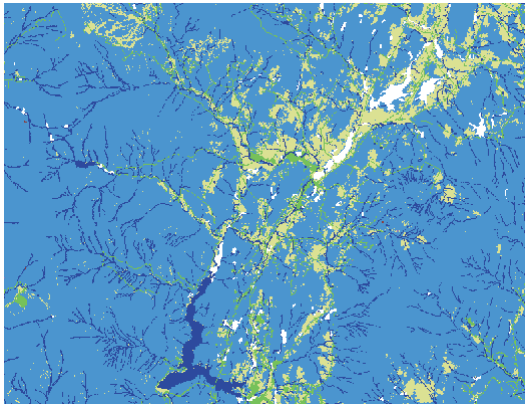


The Reclass of landuse layer will be added to the table of contents. It shows locations that are more costly than others for constructing a road, based on the type of landuse.

The NoData value (Wetlands) is currently displayed transparently so you can see the layers underneath. To make this value solid, change it to white.

8. Right-click Reclass of landuse and click Properties.
9. Click the Symbology tab.
10. Click the Display NoData as dropdown arrow and click Arctic White.
11. Click OK.

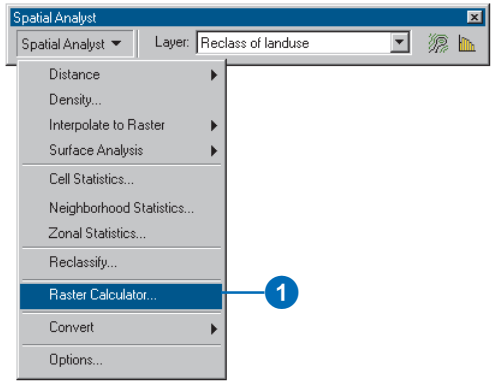


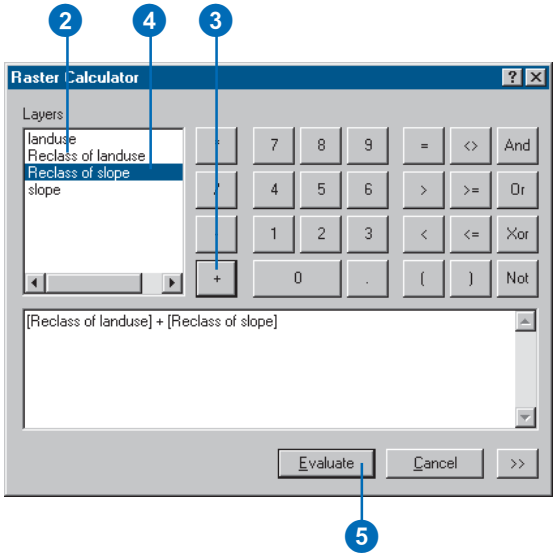


Combining datasets

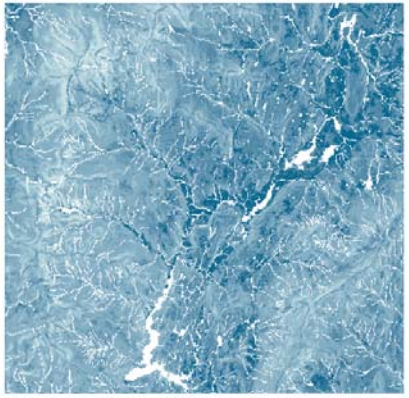
You will now combine Reclass of slope and Reclass of landuse in order to produce a dataset of the cost of building a road at each location in the landscape, in terms of steepness of slope and landuse type. In this model, each dataset has equal weighting, so it is not necessary to apply any weight as we did when finding the suitable location for the school.

1. Click the Spatial Analyst dropdown arrow and click Raster Calculator.
2. Double-click Reclass of landuse to add it to the expression box.
3. Click the Add button.
4. Double-click Reclass of slope to add it to the expression box.
5. Click Evaluate.





The result is added to your ArcMap session. Locations with low values identify the areas that will be the least costly to build a road through. They are displayed in dark blue in the graphic below.



6. Click the output layer in the table of contents to highlight it, click again, and rename it Cost.

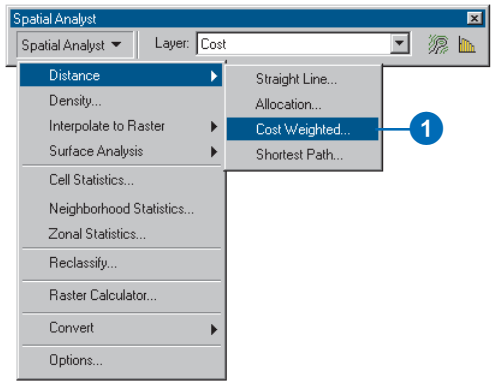
   You will now remove all layers except Cost, School_site, and Roads.

7. Click Reclass of landuse, press and hold down the Ctrl key, click Reclass of slope, slope, and landuse.
8. Right-click one of the layers and click Remove.

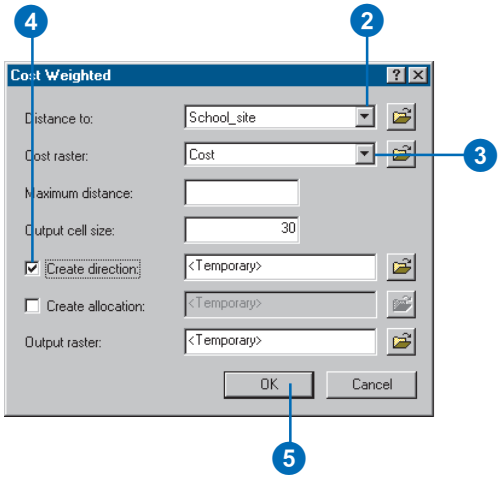
Step 2: Performing cost weighted distance

You will now perform cost weighted distance using the Cost dataset you just created and the School_site layer (the source). Using this function, you will create a Distance dataset where each cell contains a value representing the accumulated least cost of traveling from that cell to the school site, and a Direction dataset that gives the direction of the least-cost path from each cell back to the source. This conceptual process is explained in more detail in Chapter 7, 'Performing spatial analysis'.

1. Click the Spatial Analyst dropdown arrow, point to Distance, and click Cost Weighted.

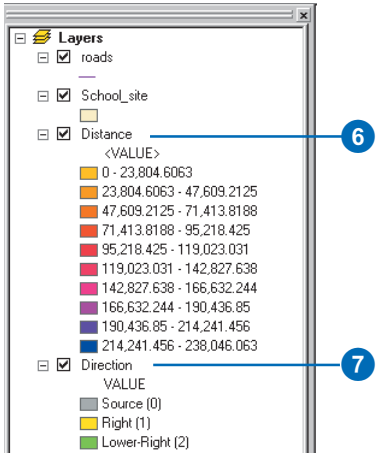


2. Click the Distance to dropdown arrow and click School_site.
3. Click the Cost raster dropdown arrow and click Cost.
4. Check Create direction.
5. Click OK.



The Distance and Direction datasets are added to your ArcMap session as layers.

6. Click the output Distance layer in the table of contents, click again, and rename it Distance.
7. Click the output Direction layer in the table of contents, click again, and rename it Direction.



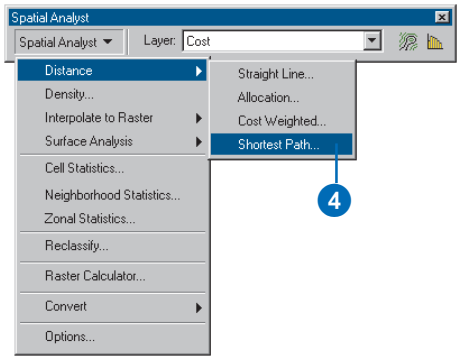
Step 3: Performing shortest path

You are now almost ready to find the shortest path from the school site. You have performed cost weighted distance, creating a Distance dataset and a Direction dataset, using the school site as the source. However, you will need to decide on, and then create, the destination point for the road. As you have already learned how to create a new shapefile, this destination point shapefile has been created for you.

1. Click the Add Data button.
2. Navigate to the folder on your local drive where you installed the tutorial data (the default installation path is ArcGIS\ArcTutor\Spatial).
3. Click Destination and click Add.

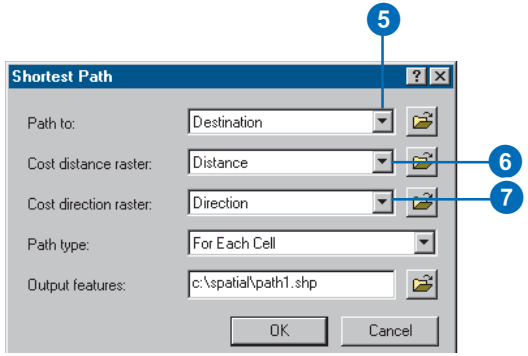
   Locating the destination point for the road in the position identified by the Destination shapefile will take much of the traffic away from the current road and provide a "back route" to the area for school buses and other vehicles.

4. Click the Spatial Analyst dropdown arrow, point to Distance, and click Shortest Path.

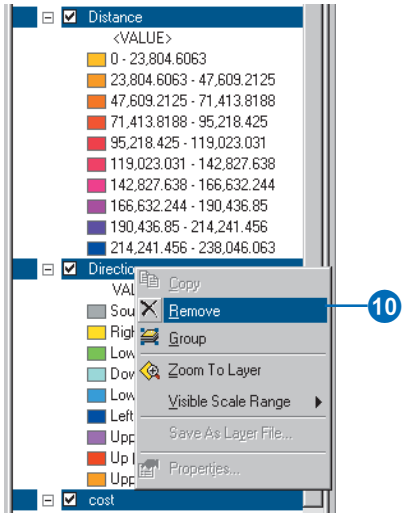


5. Click the Path to dropdown arrow and click Destination.
6. Click the Cost distance raster dropdown arrow and click Distance.
7. Click the Cost direction raster dropdown arrow and click Direction.

   Leave the defaults for the other options.
8. Click OK.



   The shortest path is calculated, and the resulting layer is added to your ArcMap session. It represents the least-cost path (least cost meaning avoiding steep slopes and on landuse types considered to be least costly for constructing the road) from the school site to the road junction.
9. Click Distance in the table of contents, press the Ctrl key, and click Direction and Cost.
10. Right-click Cost and click Remove to remove all three layers.



Displaying the results

To see exactly where this path should be constructed, you will now create a more detailed map.

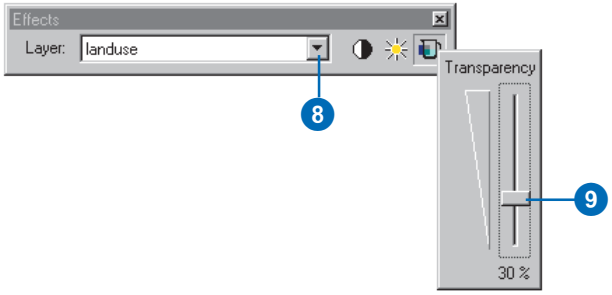
Adding the datasets

1. Click the Add Data button on the Standard toolbar.
2. Navigate to the folder on your local drive where you set up your working directory (c:\spatial).
3. Click Hillshade and click Add.

   Note: A copy of this hillshade dataset can be found in the location ArcGIS\ArcTutor\Spatial\Results\Ex1\Hillshade.
4. Click the Add Data button on the Standard toolbar.
5. Navigate to the folder on your local drive where you installed the tutorial data (the default installation path is ArcGIS\ArcTutor\Spatial).
6. Click Landuse and click Add.

Applying transparency

7. If the Effects toolbar is not already present, click View on the Main menu, point to Toolbars, and click Effects.
8. Click the Layer dropdown arrow on the Effects toolbar and click landuse.
9. Click the Adjust Transparency button and move the scroll bar up to a transparency of 30 percent.

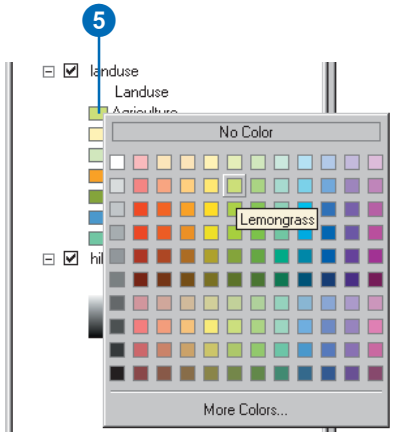


Changing the default field for Landuse

You will now change the value field for the Landuse layer so you can more easily distinguish each landuse type.

1. Right-click Landuse in the table of contents and click Properties.
2. Click the Symbology tab.
3. Click the Value Field dropdown arrow and click landuse.
4. Click OK.

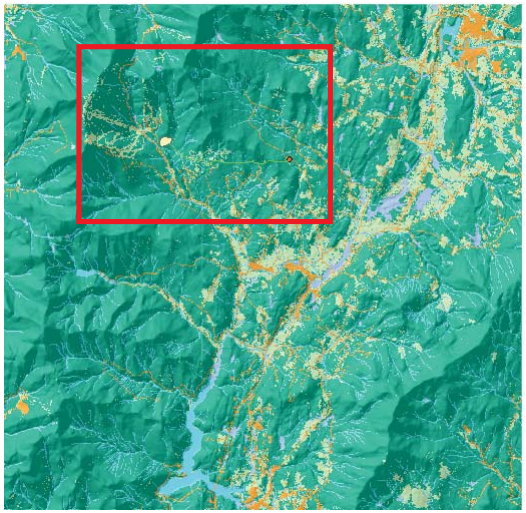
   Change the color of the symbols in the table of contents to more appropriate colors for each type of landuse.
5. Right-click the symbols representing landuse types in the table of contents and pick an appropriate color for each one.

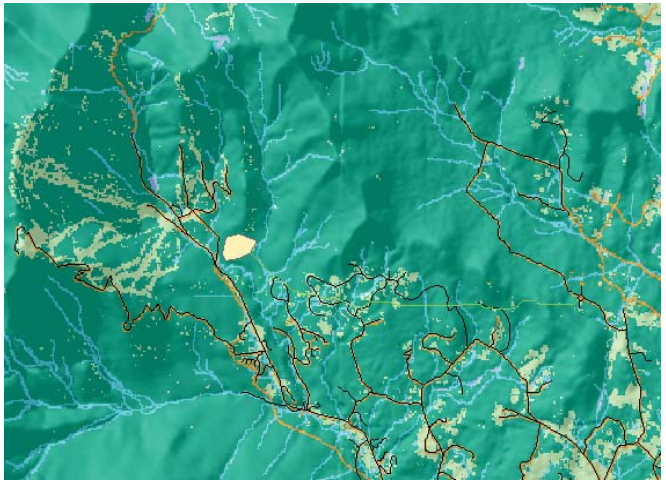


Zooming in on the area

1. Click the Zoom In tool on the Tools toolbar.

2. Click and drag a rectangle around the location of the new road to zoom in on this area (the area to zoom to is highlighted in red on the map below).

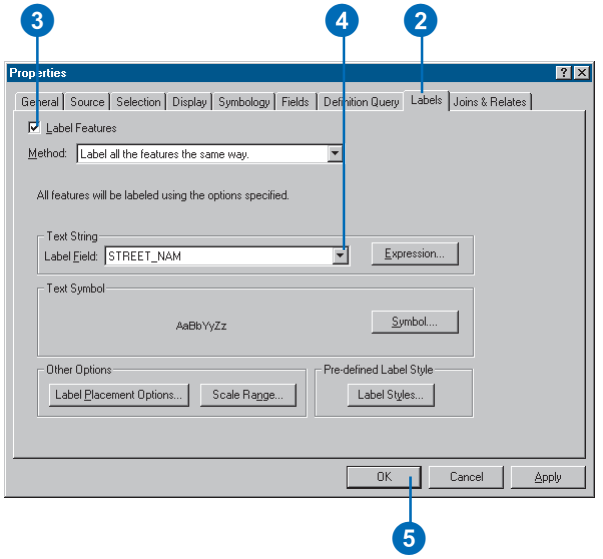




Labeling the roads

Label the road network to be able to identify which existing roads may be of use in constructing the new road.

1. Right-click Roads in the table of contents and click Properties.
2. Click the Labels tab.
3. Check Label Features.
4. Click the Label Field dropdown arrow and click STREET_NAM.
5. Click OK.



The road names are labeled on the map.

6. Click the File menu and click Save.

   If this is the first time you are saving the map document, navigate to the location where you set up your working directory (c:\spatial), specify a filename for the map document (Spatial_Tutorial), and click Save.

This brings you to the end of this tutorial. You have been introduced to some of the functions of Spatial Analyst, such as learning how to explore your data, producing a suitability map, and finding the least-cost path.

You have covered much ground, but there is a great deal more for you to explore. The rest of this book will provide you with a guide as you learn how to solve your own specific spatial problems.