9

How to Perform Geoprocessing in ArcGIS

Introduction

Many types of GIS analysis involve taking a layer, performing an action on it, and then getting a new output layer in return. **Geoprocessing** is the general term used for this type of task. For example, you could take a point layer representing culvert locations and create a new polygon layer that represents a one-mile area around each point, which you could then use for examining the land-cover characteristics in each of these one-mile areas. In ArcMap, geoprocessing covers a wide range of tasks that are used for multiple applications. In fact, the tools in ArcToolbox are referred to as *geoprocessing tools*. You already used some of these tools in Chapter 1; we'll examine more of them in this chapter.

Geoprocessing is often used to create zones of spatial proximity around features or to combine similar polygons. Another common form of geoprocessing is an **overlay**, which involves combining two (or more) layers that have some of the same spatial boundaries but different properties or attributes to create a new layer. Think of creating an overlay as the process of placing one layer on top of another layer, determining where these layers match up and combine, and then producing a new layer as a result (Figure 9.1). For instance, to determine what sites are available for developing new coastal properties, a polygon representing a buffer around a lake could be overlaid with a second polygon layer representing the parcel boundaries that are zoned for commercial use. The resultant overlay would show only those polygons within the buffer zone that are also available for commercial usage.

geoprocessing When an action is taken to a dataset that results in a new dataset being created.

overlay The combining of two or more layers together in GIS.

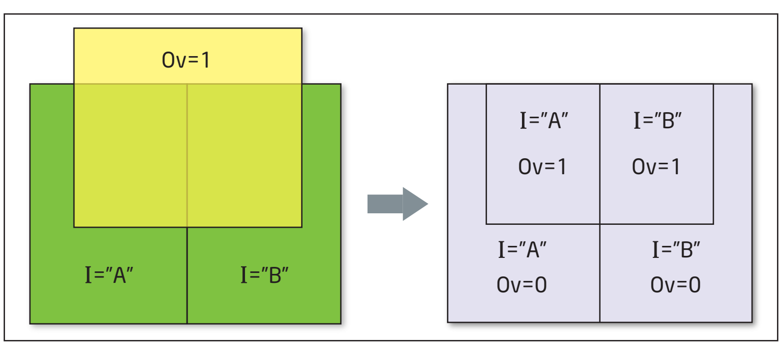

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FIGURE 9.1 An example of overlaying two layers and the resultant third layer that combines the spatial and attribute characteristics of the two inputs.

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Chapter Scenario and Applications

This chapter puts you in the role of an Ohio teacher examining the distribution of schools in one of Ohio's regions, as well as access to those schools. As part of your study, you will be trying to determine which schools are located within place boundaries (whether an incorporated or an unincorporated place), as well as which schools are near major roads. You want to figure out which schools are in which places, as well as which schools are not in a place and not near a major road.

The following are additional examples of other real-world applications of this chapter's theory and skills:

- An urban planner wants to determine the distribution of residential land parcels on a floodplain. He can use polygon overlay to find out which homes are in the floodplain.
- A county engineer needs to examine which areas of the county cannot hear tornado sirens. He can create a buffer around each siren's location to denote the extent of the siren, then determine which populated areas the sirens do not reach.
- A developer wants to see the potential effect of the placement of a new shopping center and its parking area. She can overlay the digitized footprint of the proposed development onto the existing land use to gauge the amount of wetlands and forested areas that would be removed by such a project.

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ArcGIS Skills

In this chapter, you will learn:

- How to merge multiple feature classes together into a single feature class.
- How to interactively select and extract objects to their own layer.
- How to choose which layers can have objects selected from them.
- How to dissolve the boundaries of a set of polygons and combine them.
- How to extract a subset of the features in a layer by using the shape of another layer.
- How to build a buffer around features.
- How to perform polygon overlay as well as point-in-polygon overlay.

Study Area

For this chapter, you will be starting with data for the entire state of Ohio, then working only with a subset of four counties representing Ohio Educational Regional Service System 5: Ashtabula, Trumbull, Mahoning, and Columbiana counties.

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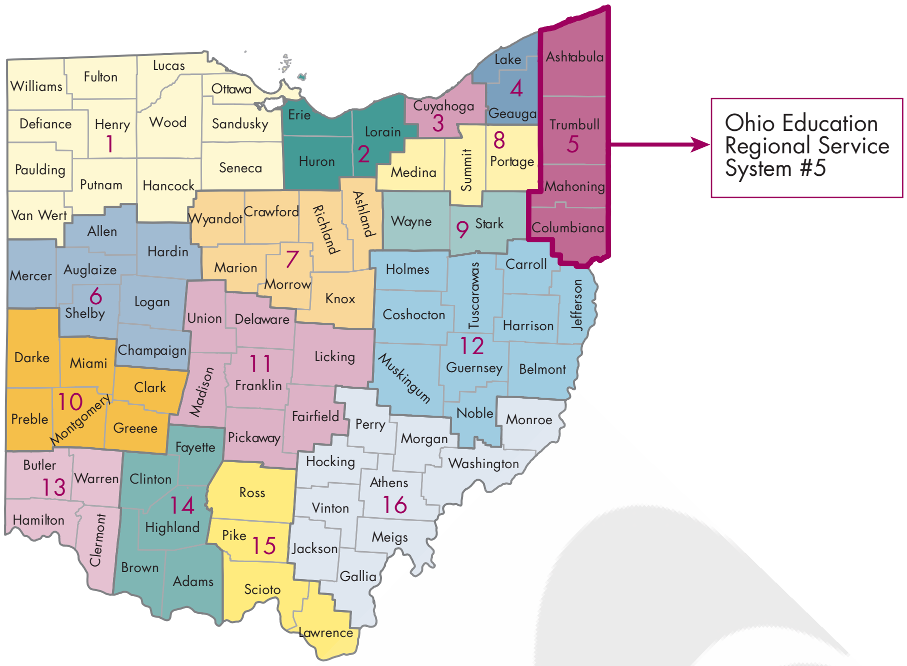

Data Sources and Localizing This Chapter

This chapter's data focus on datasets from within the state of Ohio. However, you can easily modify this lab to use data from your own state instead. For instance, if you were going to perform this lab's activities in Missouri, the same sets of data would be available. The Ohio counties' dataset was downloaded (free) and extracted from the USA Counties dataset available on ArcGIS Online (and also available for download here: **http://www.arcgis.com/home/item.html?id=a00d6b6149b34ed3b833e10fb72ef47b**). By querying the USA Counties layer for "STATE_NAME = 'Missouri'" you can select all Missouri counties and export them to a new feature class. From there, you can choose the counties within Missouri that correspond to the educational region you wish to examine.

The roads and places (incorporated and unincorporated) datasets were downloaded and extracted from The National Map and are available for all states. Use the Trans_RoadSegment feature class as the source for your state's roads, and the GU_IncorporatedPlace and GU_UnincorporatedPlace feature classes for your state's places. The schools data were also downloaded and extracted from The National Map (use the Struct_Point feature class and use Ftype = "730 - Education").

Step 9.1 Getting Started

- Start ArcMap and use the Catalog to copy the folder called **Chapter9** from the C:\GISBookdata\folder to your own D:\GIS\ drive. Be sure to copy the entire directory, not just the files within it.
- Chapter 9 contains a file geodatabase called **Ohiogeo** that contains the following feature classes:
  - **Ohiocountiesproj**: a polygon feature class of the 88 counties of Ohio
  - **Ohiomajrds**: a line feature class of the major roads in Ohio

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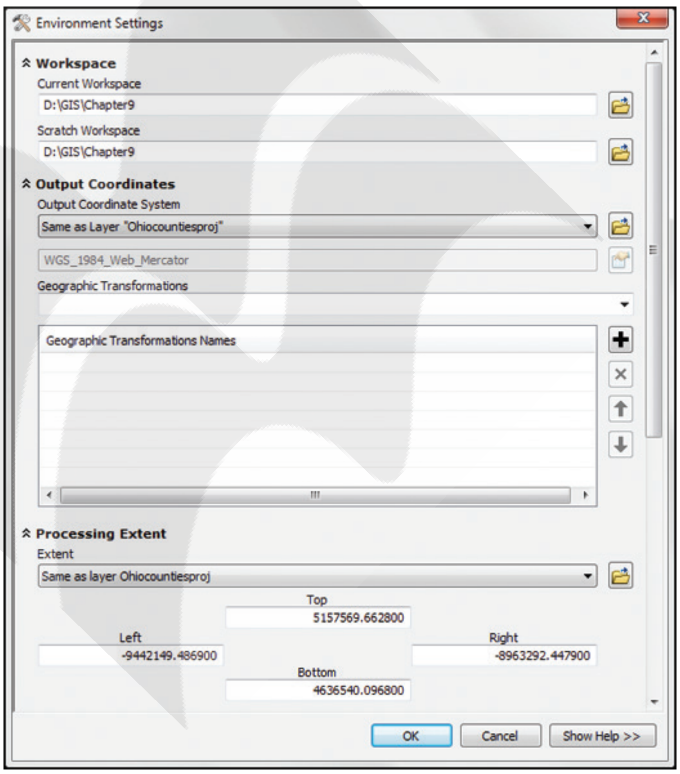
environment settings
Geoprocessing options that control activities in a map document, such as the extent of outputs, the coordinate system of outputs, or the cell size of outputs.

- **Ohioschools:** a point feature class of elementary and secondary schools in Ohio
- **Ohioincplaces:** a polygon feature class of Ohio's incorporated places
- **Ohiononincplaces:** a polygon feature class of Ohio's unincorporated places

- Add the **Ohiocountiesproj** layer to the TOC.
- Before proceeding, you'll want to make sure your Geoprocessing **environment settings** are correct for the work you'll be doing in this chapter. When performing geoprocessing in ArcGIS, several settings will affect all the actions that you take during a project. For example, you can specify the extent or coordinate system that all results should have. Several upcoming chapters will show you how to fix these settings in place before starting the chapter. To set up the environment settings for this chapter, from the **Geoprocessing** pull-down menu, select **Environments...** to open the Environment Settings dialog box.



SOURCE: ARCMAP/ESRI

- Under the **Workspace** options, for **Current Workspace**, use the browse button to navigate to: **D:\GIS\Chapter9**.
- Under the **Workspace** options, for **Scratch Workspace**, use the browse button to navigate to: **D:\GIS\Chapter9**.
- Under the **Output Coordinates** options, for **Output Coordinate System**, select **Same as Layer "Ohiocountiesproj"**. This selection tells ArcMap to use the same coordinate system as the Ohiocountiesproj layer for all of its output.
- Under the **Processing Extent** options, for **Extent**, select **Same as Layer Ohiocountiesproj**. This selection tells ArcMap to use the same extent as the Ohiocountiesproj layer for all output.

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- Click **OK** when all the environment settings are in place.
- The Ohiocountiesproj layer was projected from its initial coordinate system to another one for use in this chapter. The coordinate system being used in this chapter is **Web Mercator (WGS 84)**, using Map Units of **Meters**. Check the Data Frame to verify that this coordinate system is being used.

Step 9.2 Merging Multiple Layers

- Add the Ohioincplaces and Ohiononincplaces layers to the TOC and position them so that you can see both of them on top of the Ohiocountiesproj layer.
- The National Map separates areas into two categories: incorporated places and unincorporated places. For purposes of this chapter, we'll not be making a distinction between these two. Thus, we want to combine these two layers into a single layer, rather than work with two different layers. In ArcMap, we can do this by using the merge process (see **Smartbox 44** for more information).

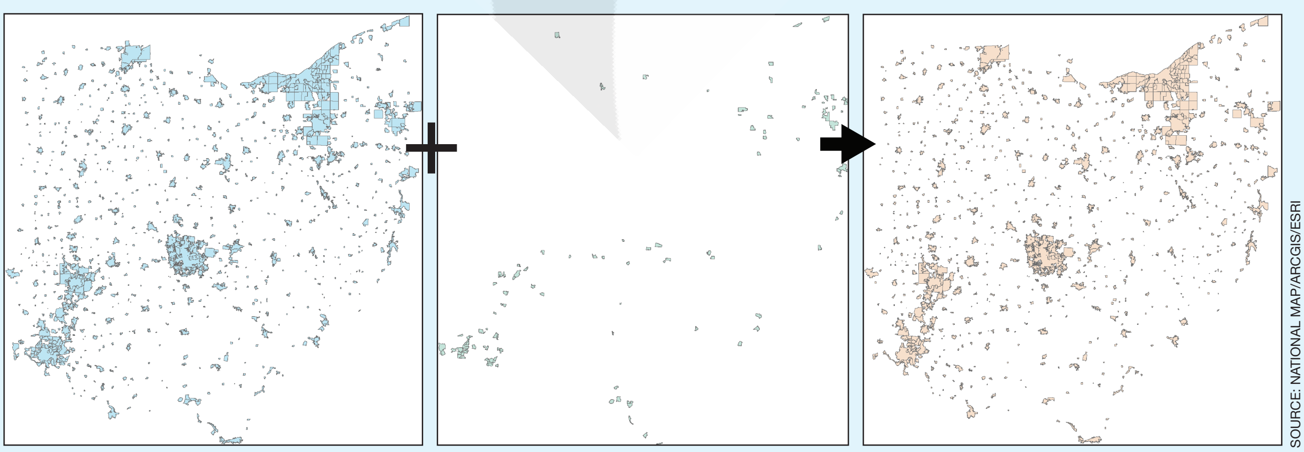
Smartbox 44

How can multiple layers be merged in ArcMap?

A common geoprocessing operation combines several different layers into a single layer. For instance, if a team of three people is mapping the trails of a large metropark, each person will be producing feature classes of a third of the park. Ultimately, you do not want three separate layers of trails but rather a single layer of trails that combines the geography of all three. You can accomplish this with the Merge tool in ArcMap. **Merge** combines the geospatial features and attributes of two or more vector layers into a single new vector layer.

See Figure 9.2 for an example of a merge. Two different polygon layers (with features in different locations) can be combined into a single polygon layer that will contain all features (and attributes) from both layers. If attributes

merge A geoprocessing operation that combines two or more layers of data into a single layer.



Incorporated Places

Non-incorporated Places

Merged All Places

FIGURE 9.2 Using the Merge tool to combine two layers into one.

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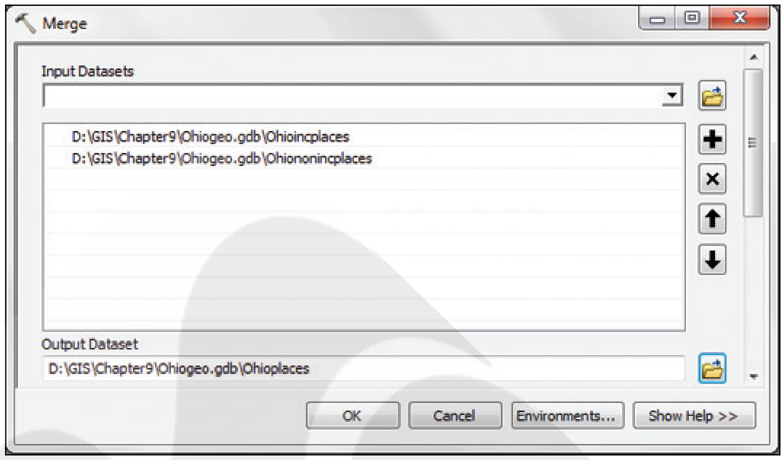
append A geoprocessing operation that combines one or more layers of data together with an already existing layer.

are present in one layer and not another, a value of "null" will be assigned to the missing values. Keep in mind that only features of the same type can be merged (for instance, two line feature classes can be merged into a single line feature class, but a point feature class and a line feature class cannot be merged into a single feature class). A related operation in ArcMap is **append**, which combines one or more layers with an already existing feature class.

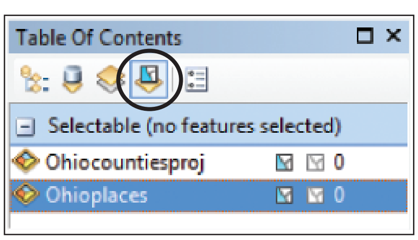


SOURCE: ARCMAP/ESRI

- From the **Geoprocessing** pull-down menu, select **Merge**.
- Press the **browse** button next to Input Datasets and navigate to your D:\GIS\Chapter9 folder and look inside the Ohiogeo geodatabase. Select the **Ohioincplaces** layer. Back in the Merge dialog box, you'll see it at the top of the list of Input Datasets (this is the list of layers to be merged).
- Press the **browse** button a second time and follow the same procedure to add the **Ohiononincplaces** layer to the Input Datasets list.
- For the Output Dataset, call it **Ohioplaces** and save it in your Ohiogeo geodatabase.
- Click **OK**. A new layer called Ohioplaces will be added to the TOC and will have both of the layers combined in it. At this point, you can remove both the Ohioincplaces and Ohiononincplaces layers from the TOC (since you now have a new merged layer to work with).

Step 9.3 Interactively Selecting and Extracting Data Layers

- The focus of this chapter is on the four counties in northeast Ohio that make up Educational Region 5: Mahoning, Trumbull, Columbiana, and Ashtabula. Thus, the first thing to do is to select and extract only those four counties to work with (instead of working with all 88 Ohio counties). For this chapter, what we'll do is select those counties and extract them to their own layer (see Chapter 2 for more about selection and selected features in ArcMap).
- Because we want to select features only from the Ohiocountiesproj layer (and not from the Ohioplaces layer), we want to communicate this to ArcMap. In the TOC, choose the option to display the layers



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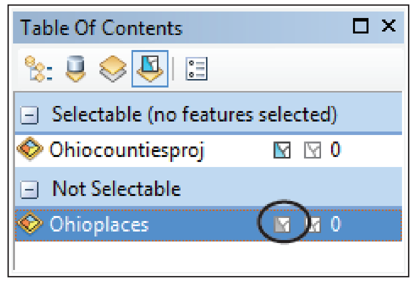
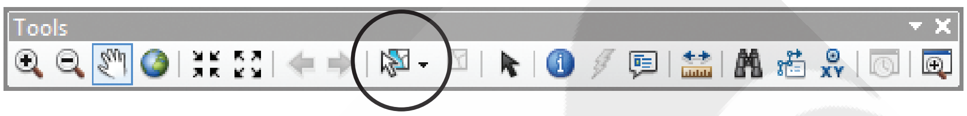
according to List By Selection (see Chapter 1 for more about TOC settings). This will show you the layers from which you can and cannot select.



SOURCE: ARCMAP/ESRI

- By default, all layers start off as being selectable (i.e., allowing you to select features from them). You want to change this setting so that only the Ohiocountiesproject layer is Selectable and the Ohioplaces layer is Not Selectable. Pressing the "select" button next to Ohioplaces will toggle it from Selectable to Not Selectable. (Note that pressing it again will toggle it back to being Selectable.)
- Now, only Ohiocountiesproj should be in the Selectable category. Next, from the **Tools toolbar**, choose the Select Features tool. This will allow you to draw shapes on the View and select features that fall within those shapes. From the pull-down menu of the Select Features tool, choose **Select By Rectangle**.

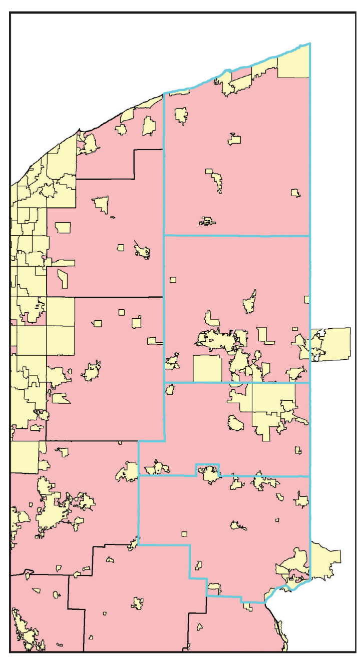


SOURCE: ARCMAP/ESRI

- The cursor will change to the selection cursor. Draw a rectangle within the boundaries of the four counties we'll be using in this chapter (see the graphic in the Study Area section for their locations). Because you indicated to ArcMap that only features within Ohiocountiesproj would be selected, none of the corresponding features in Ohioplaces that fell within the rectangle were selected.
- ***Important Note:*** Select only the four counties. If you find that you've selected other counties, you can de-select them by holding down the Shift key on the keyboard and clicking on the counties you want to de-select to remove them from the selection. If you want to clear all selected counties and start over, click on the Clear Selected Features button on the Tools toolbar:

SOURCE: ARCMAP/ESRI

- The next step is to create a new feature class containing just these four selected counties (see Chapters 2 and 8 for how to export data into a new feature class in a geodatabase). First, change how you're viewing items in the TOC to **List By Drawing Order**. Next, in the TOC, right-click on the Ohiocountiesproj layer, choose **Data**, then choose **Export Data**. Export your **selected features** to create a new feature class called **fourcounties** and place this in your **Ohiogeo** geodatabase. Add the new exported data to the map as a layer when prompted.
- At this point, turn off the Ohiocountiesproj layer and zoom in on the four counties that we will be using in this lab.
- Switch the fourcounties polygons color to hollow (see Chapter 1 for how to change the color or symbology of a layer) so that you can see through it (that is, make it transparent). Give it a thicker outline as well so that it stands out.



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Step 9.4 Dissolving Polygon Boundaries

- The next step to defining our four-county region is to dissolve the borders between the counties so that we can use the entire region as a boundary, not just four separate counties (see **Smartbox 45** for more about using dissolve for geoprocessing). We will use this new "region" in further analysis.

Smartbox 45

How does dissolve operate in ArcMap?

dissolve A geoprocessing operation that combines polygons with similar attributes.

The **dissolve** function in ArcMap combines multiple objects in a feature class into a single object when these objects have the same attributes. For example, a polygon feature class of U.S. counties may have an attribute indicating the state to which they belong (such as a FIPS code or state name). When dissolve is used, the boundaries of the counties' polygons are removed, and they are combined into a single polygon, as long as those polygons have the same attribute (for example, all counties that have the same state FIPS code or state name). Figure 9.3 shows how dissolve can be used to remove county boundaries and create a larger object of the geography of the combined area. By dissolving polygon boundaries, you can create "regions" of data that have the same attributes. For instance, a polygon feature of parcels may contain an attribute indicating how that parcel is zoned. You can dissolve the polygon boundaries according to their zoning type so that you can create larger polygons of areas zoned residential, commercial, or industrial.

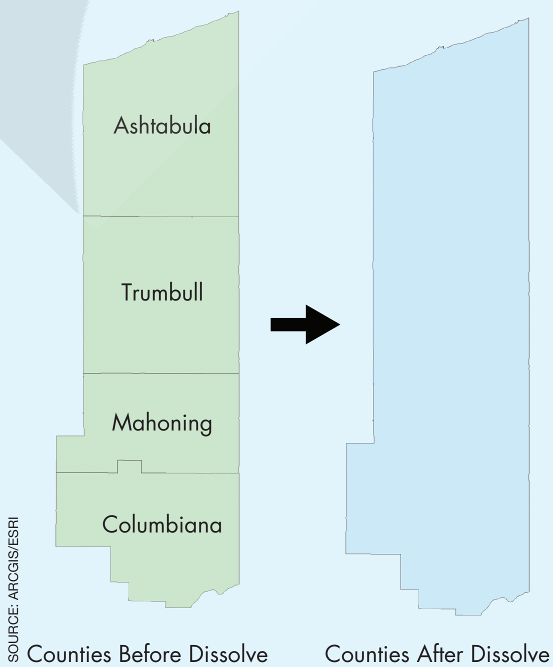

FIGURE 9.3 Using the Dissolve tool to combine several features in a single layer into one feature.

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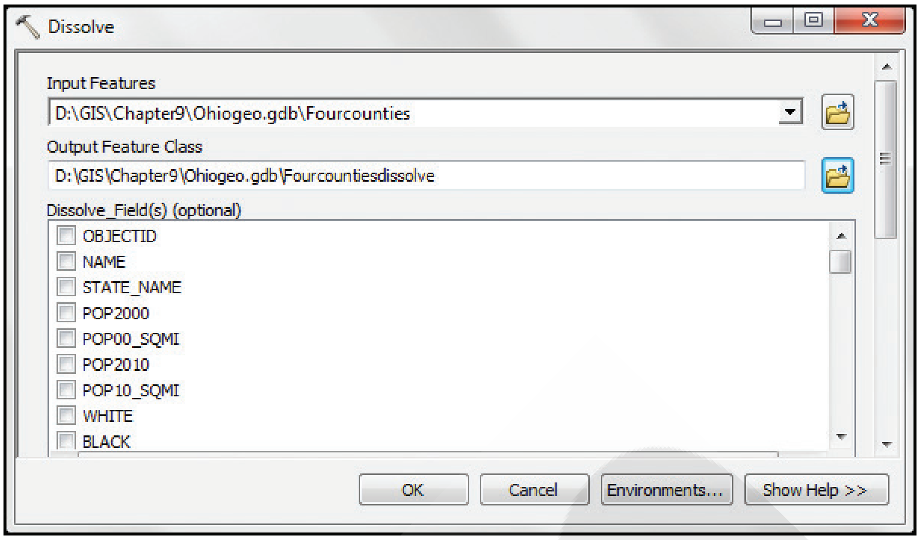
- From the **Geoprocessing** pull-down menu, select **Dissolve**.



SOURCE: ARCMAP/ESRI

- For the Input Features use **fourcounties** (from your Ohiogeo geodatabase). This is the feature class you wish to dissolve.
- For the Output Feature Class, use the browse button to save this newly dissolved feature class in your **Ohiogeo** geodatabase and name it **fourcountiesdissolve**.
- Don't choose a Dissolve Field. When all options are set, click **OK**.
- You will now have a "borderless" four-county region layer called fourcountiesdissolve added to your table of contents. Change its symbology to Hollow and turn off the fourcounties layer.

Step 9.5 Clipping Feature Classes

- Add the Ohioschools and Ohiomajrds layers to the TOC. Right now, these two layers and the Ohioplaces feature class contain information about all of Ohio. We want to focus only on those schools and major roads that are within the boundaries of the four-county region. To select only those areas, you can use the Clip operation in ArcMap. (For more information about Clip, see **Smartbox 46**.)

Smartbox 46

How does clip operate in ArcMap?

The **clip** operation in ArcMap uses the shape and geometry of one feature class to extract objects out of another feature class. In Figure 9.4, the roads layer covers the entire state, but we want to use only the roads that fall within the multi-county polygon boundaries. The roads can be clipped so that a new dataset consisting of only the roads within the geographic area of the polygon can be extracted for use. Using clip is like using a feature class (such as a polygon) as a "cookie cutter"; all features from another layer that fit within this cookie cutter are removed to a new layer for use. Polygons, lines, and points can all be clipped using this operation. For instance, if you have a land-cover map of

clip A geoprocessing operation that extracts objects from one layer based on the geometry of a second layer.

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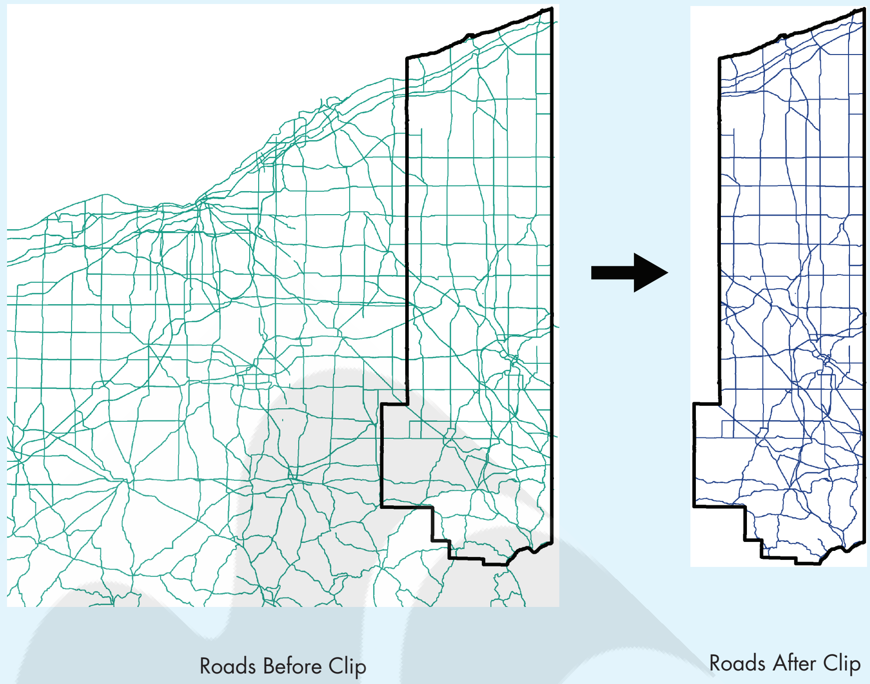
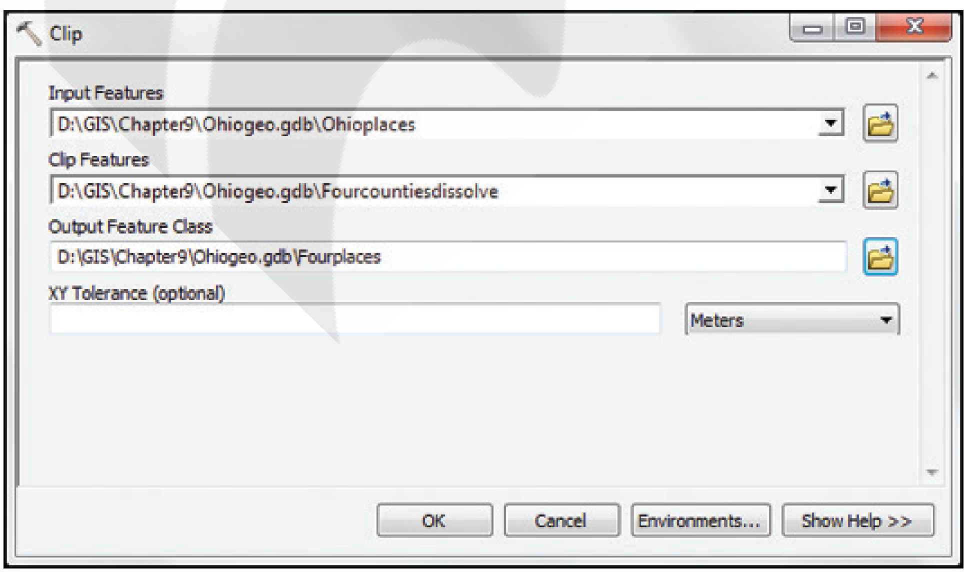
your entire state but will be focusing your environmental analysis on a single county, you could use the polygon boundaries of the county to clip out the land-cover polygons that are within that single county.



SOURCE: NATIONAL MAP/ARCGIS/ESRI

FIGURE 9.4 Using the Clip tool to create a new feature class.

- From the **Geoprocessing** pull-down menu, select **Clip**.



SOURCE: ARCMAP/ESRI

- For the Input Features, select **Ohioplaces** from the Ohiogeo geodatabase. This is the feature class that you want to clip.
- For the Clip Features, select **fourcountiesdissolve**. This is the feature class that will define the cookie cutter shape used for clipping.
- For Output Feature Class, call the layer **fourplaces** and save it in the Ohiogeo geodatabase.

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- Click **OK** when done.
- You will now have a new feature class called fourplaces added to the Table of Contents that shows only the places inside the four-county region.
- Use the Clip tool twice more to create the following feature classes in the Ohiogeo geodatabase:
  - **fourschools** from the Ohioschools layer
  - **fourmajrds** from the Ohiomajrds layer
- You now have a lot of layers in the TOC. Remove all layers from the Table of Contents except for the dissolved county boundaries (the fourcounties-dissolve layer) and the three clipped layers (fourplaces, fourschools, and fourmajrds). These are the ones we'll be using for the remainder of the lab. Zoom to the full extent of the View; it should center on only the four-county region.
- Open the attribute table for the fourschools layer. Answer Question 9.1. (Close the table when you're done.)

Question 9.1

How many schools are within the four-county region?

Step 9.6 Creating a Buffer Around Features

- Because we're examining access to schools, our next step is to examine information concerning areas that are near the region's major roads. To do this, we can create a buffer around all of the major roads in the region. See **Smartbox 47** for more information on buffers.

Smartbox 47

How do buffers operate in ArcMap?

A **buffer** is a region of spatial proximity created around a set of objects. In ArcMap, a buffer is a new feature class created by calculating a distance around a set of objects in another layer (whether points, lines, or polygons). See Figure 9.5 for an example: A feature class contains a set of lines representing roads, and a half-mile buffer is created around these roads and saved as a polygon feature class. Distances and polygons are calculated around each road, and in this example, the borders between those polygons have been dissolved in order to create a single new object that is the buffer. Creating buffers is a common geoprocessing operation. For instance, engineers may create a buffer around a road that needs widening to see which sections of neighboring properties will be affected, or emergency planners may create buffers around tornado sirens that represent the distance that the sirens' sound reaches.

Note that a buffer is different from a Select By Location query (see Chapter 8). In Select By Location, one of the options allows you to select how many objects are within a certain distance of other objects. The Buffer tool creates a new polygon object that represents this distance, allowing you to work with the actual dimensions of the buffer zone as a separate layer.

buffer A zone of spatial proximity around a feature or set of features.

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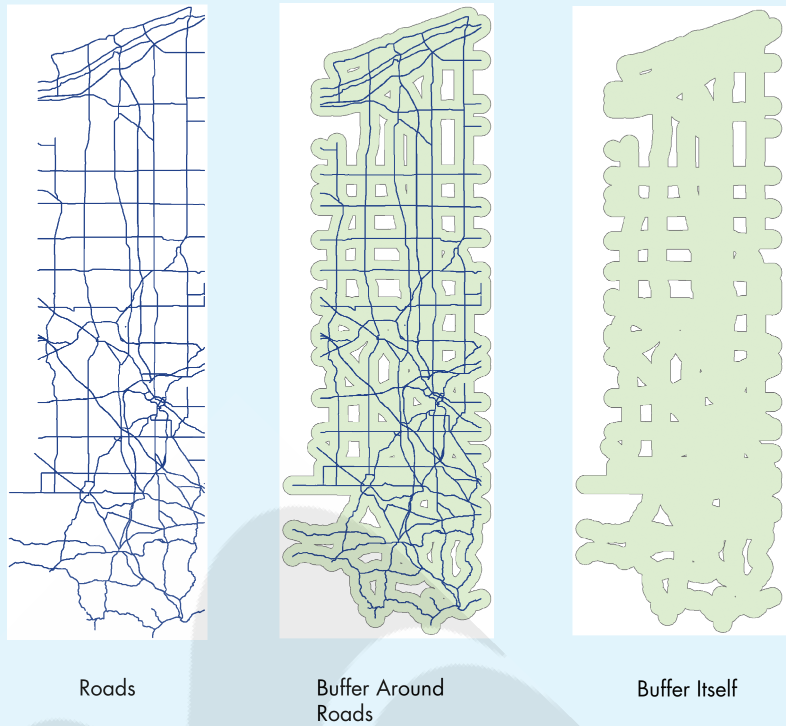
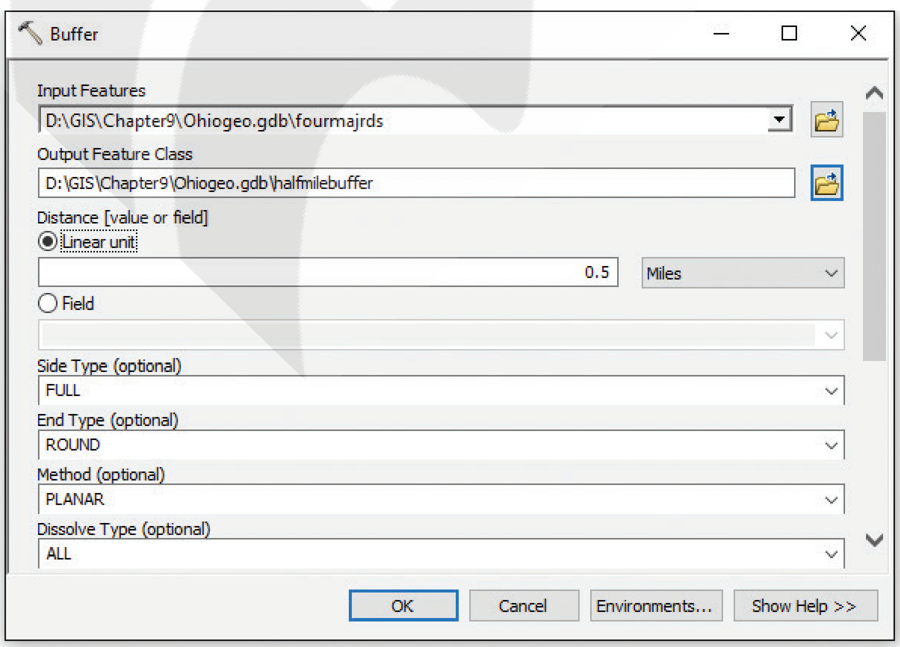
FIGURE 9.5 Creating a half-mile buffer around the roads of a feature class.



SOURCE: NATIONAL MAP/ARCGIS/ESRI

- We'll start by creating a half-mile buffer around the major roads. From the **Geoprocessing** pull-down menu, select **Buffer**.



SOURCE: ARCMAP/ESRI

- For Input Features, select **fourmajrds**. This is the layer whose features you want to create a buffer around.
- Call the Output Feature Class **halfmilebuffer** and save this in your Ohiogeo geodatabase.

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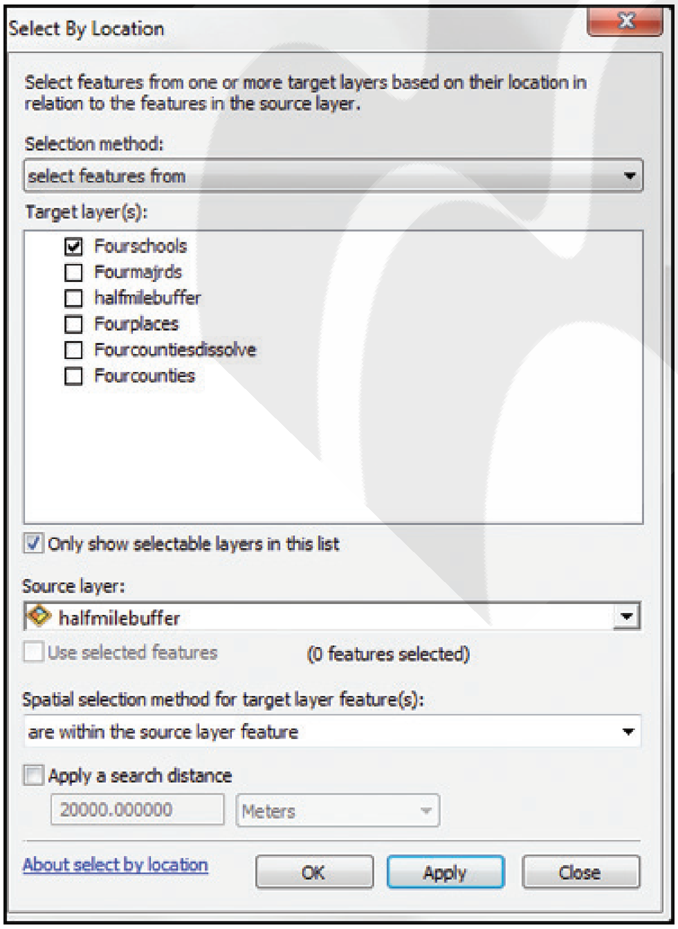
- For Distance, click on the **Linear unit** radio button. Type **0.5** for the Linear unit and select **Miles** from the pull-down menu. This will create a half-mile buffer around the road features.
- The next three options help define the shape of the buffer. For Side Type, select **FULL**. For End Type, select **ROUND**. For Method, select **PLANAR**. For Dissolve Type, select **ALL** (this will dissolve any boundaries between overlapping buffers).
- Click **OK** when all settings are correct.
- Place your fourschools layer on top of the half-mile buffer layer in the Table of Contents to eyeball just how many schools are (and are not) within a half mile of a major road. Zoom in and Pan around the map to see what the dimensions of the buffer are and how the schools fit in the buffer.
- Counting points in the buffer by hand will be inefficient and likely inaccurate. What you'll do next is a spatial query operation (as in Chapter 8) that will select only those schools within the buffer (and will thus not select schools that are not within the buffer).
- From the **Selection** pull-down menu, choose **Select By Location**.



SOURCE: ARCMAP/ESRI

- Build a Select By Location query (see Chapter 8 for instructions on how to use the Select By Location tool) to select features from the fourschools layer that are within the source layer (the halfmilebuffer layer). Answer Questions 9.2 and 9.3.

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Question 9.2 How many schools in the four-county region are within half a mile of a major road?

Question 9.3 How many schools in the four-county region are not within half a mile of a major road?

- Clear your selected features.

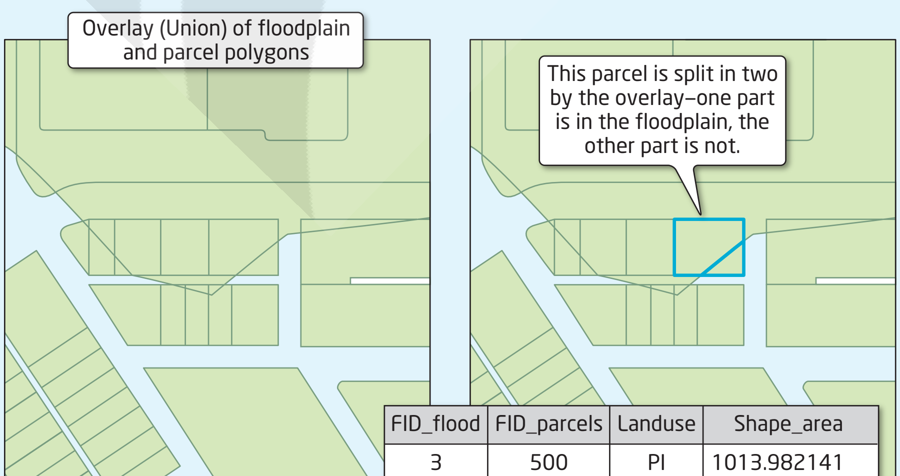
Step 9.7 Performing Polygon Overlay

- Knowing about the proximity of schools to roads is only part of our analysis. We also want to know which schools are within the boundaries of an incorporated or unincorporated place and also near a major road. We want to identify those areas on the ground that are in the place boundaries and also near a road, something that a spatial query could not do for us. What we can do is create a new feature class that shows us the boundaries of the buffer and the boundaries of the places together, but there are several different ways we can overlay these two types of polygons. See **Smartbox 48** for more information about overlaying polygons.

Smartbox 48

What are the different types of polygon overlays in ArcMap?

When two polygons are overlaid, the two layers are combined to create a new, third layer that has qualities retained from the two polygons used to create it. This new layer combines not only the geospatial qualities and geometry of the two polygons but also their attributes. For an example, see Figure 9.6—two



FID_flood	FID_parcels	Landuse	Shape_area
3	500	PI	1013.982141
3	501	PI	1093.839820
-1	502	PI	335.67675422
3	502	PI	1270.84552
-1	503	PI	389.410594

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FIGURE 9.6 An overlay of two polygon layers (land parcels and the floodplain) to create a new third layer and how the attribute table of the new layer combines both layers.

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polygon layers (a set of land parcels and the floodplain) are overlaid to create a new, third layer that has the geographic characteristics of both inputs. However, where a land parcel polygon is split into two polygons (with one on the floodplain and one not on the floodplain), the attribute table is updated to include two separate records: One polygon has the attributes of being on the floodplain (FID_flood = 3), and another polygon has the attributes of not being on the floodplain (FID_flood = −1).

Overlay operations are used for multiple types of applications. Figure 9.7 shows some of the overlay methods available in ArcMap:

- **Intersect**: In this type of overlay, only the features that both input layers have in common are retained in the output layer. If the land parcels and

Intersect A type of GIS overlay that retains the features that are common to both layers.

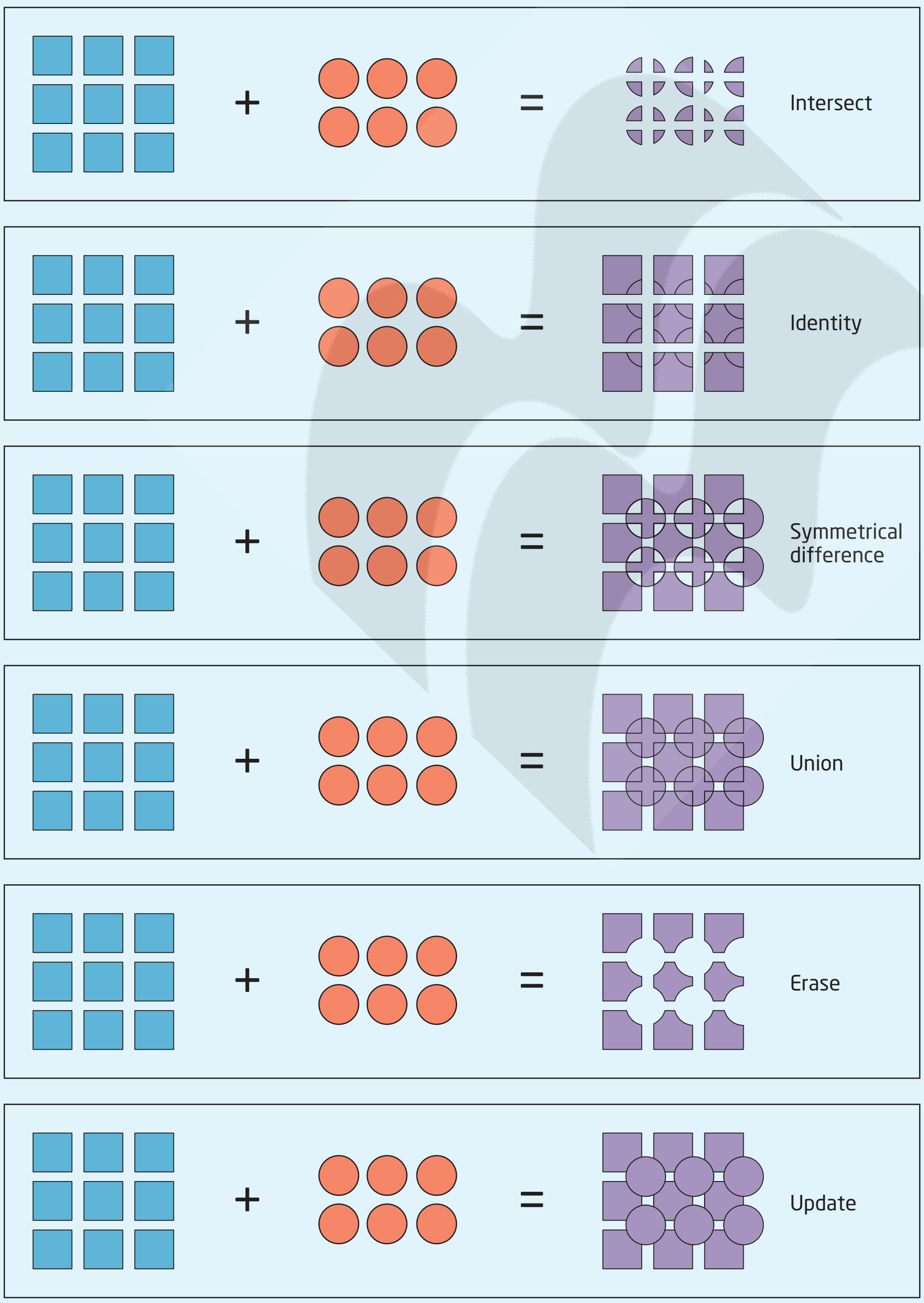

FIGURE 9.7 Six different types of polygon overlay operations: Intersect, Identity, Symmetrical Difference, Union, Erase, and Update.

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Identity A type of GIS overlay that retains all the features from the first layer along with the features it has in common from the second layer.

Symmetrical Difference A type of GIS overlay that retains all of the features from both layers except for the features that they have in common.

Union A type of GIS overlay that retains all of the features from both layers.

Erase A type of GIS overlay that retains all of the features from the first layer except for what they have in common with the second layer.

Update A type of GIS overlay that retains all features from the second layer as well as those features from the first layer that are not in common with the second.

the floodplain are overlaid using an Intersect operation, the new layer would show only areas that have land parcels on the floodplain, not any other parcels or any other sections of the floodplain.

- **Identity**: In this type of overlay, all of the features of the first input layer are retained in the output layer, along with all of the intersecting features of the second layer. If the land parcels and floodplain are overlaid using an Identity operation, the new layer would show all available land parcels plus the area of the floodplain covering these parcels (but no other parts of the floodplain).
- **Symmetrical Difference**: In this type of overlay, the output layer retains all features of the two input layers except for those areas they have in common. If the land parcels and floodplain are overlaid using a Symmetrical Difference operation, the new layer would show all land parcels and all areas of the floodplain except for those parcels or sections of parcels that were on the floodplain.
- **Union**: In this type of overlay, the output layer retains all features of the two layers. If the land parcels and floodplain are overlaid using a Union operation, the new layer would show all land parcels as well as all areas of the floodplain combined.
- **Erase**: In this type of overlay, the output layer retains all features of the first input layer except for those areas that the first layer has in common with the second input layer. If the land parcels and the floodplain are overlaid using an Erase operation, the new layer would show all land parcels except those on the floodplain.
- **Update**: In this type of overlay, the output layer retains all features of the first input layer with all features of the second input layer placed on top of them, sort of like a cut-and-paste operation. All of the features of the first layer that are in common with the second layer would be covered over by the second layer. If the land parcels and the floodplain are overlaid using an Update operation, the new layer would show all of the floodplain and any parts of the land parcels not covered by the floodplain.

- To show the areas that are both near a road and also within a place boundary, we'll use the Intersect option. Answer Questions 9.4 and 9.5.

Question 9.4 Why did we use the Intersect operation and not the Union operation? What would the resulting overlay have been if Union were used?

Question 9.5 Why did we use the Intersect operation and not the Symmetrical Difference operation? What would the resulting overlay have been if Symmetrical Difference were used?

- From the **Geoprocessing** pull-down menu, select **Intersect**.

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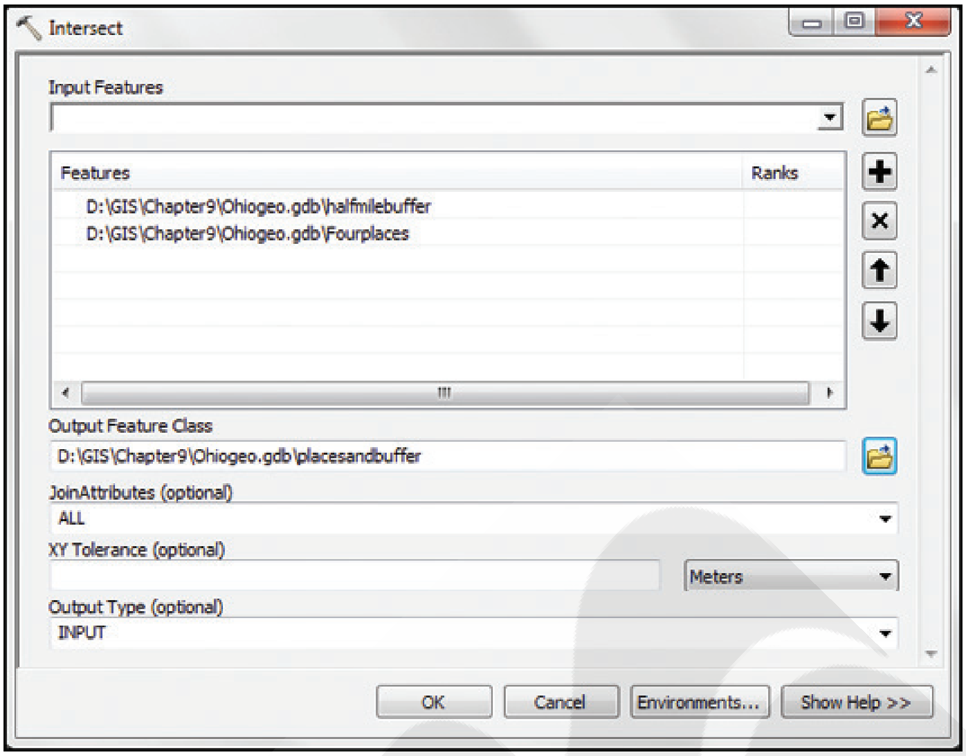

SOURCE: ARCMAP/ESRI

- For Input Features, add the **halfmilebuffer** and the **fourplaces** layers from the Ohiogeo geodatabase (either open both at the same time or open them one at a time). These are the features that you want to overlay using an Intersect operation.
- For Output Feature Class, call it **placesandbuffer** and save it in the Ohiogeo geodatabase. This is the name of the new layer created from the overlay.
- Use **ALL** for the JoinAttributes option.
- Click **OK** when you're done. The placesandbuffer layer will be added to the TOC. Turn off the fourplaces and halfmilebuffer layers to see only the new overlay.
- Use Select By Location to determine which of the schools in the fourschools layer are within the source layer feature (use placesandbuffer for the source layer). Answer Question 9.6.

Question 9.6

How many schools are within half a mile of a major road and also within the boundaries of a place?

- In the fourschools attribute table, you can switch the selection to select the records (see Chapter 2) that did not meet the selection criteria. Do so and answer Question 9.7.

Question 9.7

How many schools are not within half a mile of a major road and also not within the boundaries of a place?

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- Export these points (the schools that do not fall within the placesand-buffer layer) to a new feature class in your Ohiogeo geodatabase called **fourschoolsoutside**.
- Examine the attribute table of the fourschoolsoutside layer. Answer Question 9.8.

Question 9.8 Of the schools not near a road and not within a place, how many of them are considered to be affiliated with the city of Youngstown? How many of them are considered to be affiliated with the city of Warren? (*Hint:* You may want to use Select By Attributes queries on the fourschoolsoutside layer to help determine the answers to these questions.)

- Clear your selected features.

Step 9.8 Performing Point-in-Polygon Overlay

- For the last step of analysis, for those schools that are near a major road and within the boundary of a place, we want to identify which place they are in. We can do this by overlaying the points of the schools with the polygon boundaries of the placesandbuffer layer as a point-in-polygon overlay (see **Smartbox 49** for more information).

Smartbox 49

How is a point-in-polygon overlay performed?

Overlay operations can be performed with more than just polygons. As its name implies, a **point-in-polygon overlay** operation will overlay points onto polygons. The end result is a new point layer, in which each point will contain the attributes of the polygon that it was overlaid in (a process similar to a spatial join; see Chapter 8). Figure 9.8 shows an example of a point-in-polygon overlay. The figure shows a set of polygons representing land parcels in one layer and a set of points representing water wells in a second layer. You want to determine which wells are on which parcels of land. Because you want to see where these two layers intersect, you can perform the point-in-polygon overlay using the Intersect tool. Like the Intersect overlay operation, it will determine which points and which polygons are in common with one another.

The output layer will be a new point layer in which each point now also has the attributes of its corresponding polygon parcel. For instance, in Figure 9.8, point 2 was in polygon F. In the resultant new point layer, point 2 will have the attributes of polygon F (that is, the record for point 2 will now contain information that it is in a parcel owned by Young).

A similar operation is a **line-on-polygon overlay**, which overlays lines onto polygons. The result of this operation is a new line layer in which each line is assigned the attributes of the polygon through which it passes. If a single line were to pass through three polygons, that line would be split into three separate lines (and thus, the attribute table would have three records instead

point-in-polygon overlay A type of GIS overlay that results in a new point layer where the points have the attributes of the polygons within which they are located.

line-on-polygon overlay A type of GIS overlay that results in a new line layer where the lines have the attributes of the polygons within which they are located.

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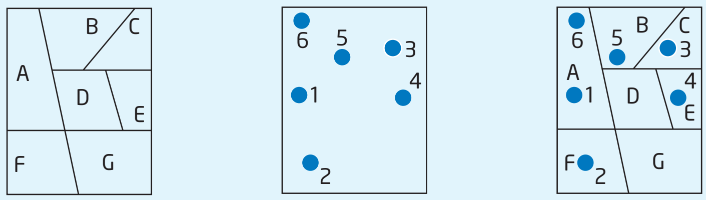
of one), and each of these segmented lines would have the attributes of the corresponding polygon through which it passed.



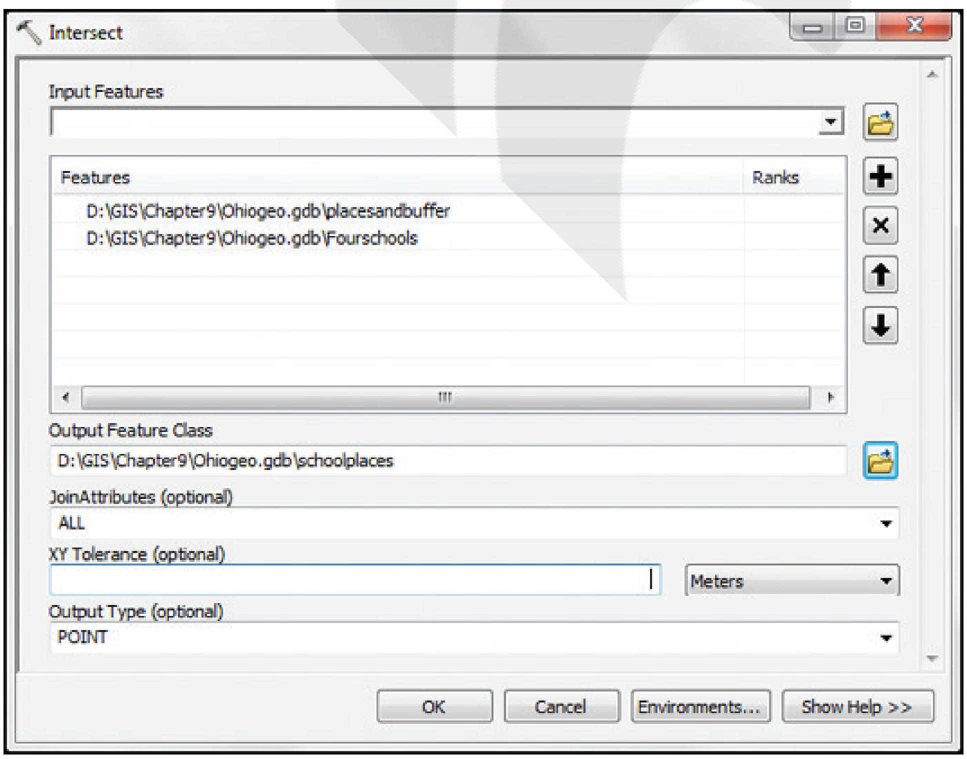
Land Parcel	Owner
A	Smith
B	Jones
C	Roberts
D	Hill
E	James
F	Young
G	Cross
Parcel polygons layer	

Wells
1
2
3
4
5
6
Wells points layer

Wells	Owner
1	Smith
2	Young
3	Roberts
4	James
5	Jones
6	Smith
Points with polygon attributes layer	

FIGURE 9.8 The layers and output of a point-in-polygon overlay operation.

- Out of our available geoprocessing operations, an Intersect operation will do the job, so from the **Geoprocessing** pull-down menu, select **Intersect**.



SOURCE: ARCMAP/ESRI

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- For Input Features, add the **fourschools** and the **placesandbuffer** layers from the Ohiogeo geodatabase (either open both at the same time or open them one at a time). These are the features that you want to overlay using an Intersect operation.
- For Output Feature Class, call it **schoolsplaces** and save it in the Ohiogeo geodatabase. This is the name of the new layer created from the overlay.
- For the JoinAttributes option select **ALL**.
- For Output Type, select **POINT** (because you are performing a point-in-polygon overlay, the output will be a point feature class with polygon attributes attached to it).
- Click **OK** when you're done. The schoolsplaces layer will be added to the TOC. Turn off the fourschools and fourschoolsoutside layers to see only the new overlay. Using the information from the schoolsplaces layer, answer Questions 9.9, 9.10, 9.11, and 9.12. (*Hint:* You may want to use Select By Attributes queries to help find the answers.)

Question 9.9 In which incorporated or unincorporated place is Cardinal Mooney High School located?

Question 9.10 In which incorporated or unincorporated place is John F. Kennedy High School located?

Question 9.11 In which incorporated or unincorporated place is Saints John and Paul Elementary located?

Question 9.12 Which three schools are considered to be in Edgewood?

Step 9.9 Printing or Sharing Your Results

- Save your work as a map document. Include the usual information in the Map Document Properties.
- Next, turn off all layers except the placesandbuffer and the schoolsplaces layers and change the symbology so that the overlaid areas and the points can be clearly seen.
- Finally, either print a layout (see Chapter 3) of your final version of your sites (including all of the usual map elements and design for a layout) or share your results as a map service through ArcGIS Online (see Chapter 4).

Closing Time

Geoprocessing operations are common and versatile methods for performing spatial analysis in GIS. Buffers, overlay operations, merge, and dissolve operations are all highly useful. In ArcGIS, geoprocessing tools can be incorporated into more

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complex projects such as chaining several commands together or executing iterative procedures. See the *Related Concepts for Chapter 9* for information on how scripts using the Python programming language can be used to work with geoprocessing within ArcGIS.

We'll continue using geoprocessing tools throughout future chapters. In the next chapter, we'll continue working with other GIS applications, such as taking a table of addresses and turning that information into a layer of geospatial data. Once we've created GIS data through this geocoding process, we can use spatial analysis techniques to examine the data.

Python An object-oriented, open-source programming language that is used for developing scripts for ArcGIS.

script A short section of computer code.

ArcPy The Python add-in that allows for ArcGIS tools and settings to be used in Python scripts.

RELATED CONCEPTS FOR CHAPTER 9

Geoprocessing and Python

The **Python** scripting language is used for programming in ArcGIS, especially for creating **scripts** (sections of computer code) to run tools, create apps, and perform geoprocessing operations. By using Python, you can execute command-line operations rather than using the tools from ArcToolbox; you can also create more in-depth operations. For instance, if you need to build ten different buffers of different sizes, you can write a Python script with a few lines of code to automate those tasks for you.

Python (created by Guido van Rossum and named for the Monty Python comedy team) is an object-oriented, open-source programming language that is very versatile and used in several different fields. In ArcGIS, the **ArcPy** add-in allows you to gain access to the tools of ArcGIS and use them when writing scripts or executing code. When using Python in ArcGIS, the first command you should execute is "import ArcPy," which gives you access to the ArcPy add-in (and thus, the ArcGIS tools and Environment Settings).

There are two ways to work with Python in ArcMap. The first of these is through the Python window accessible from the Standard toolbar (see Chapter 1). The Python window is a command line that allows you to type and execute Python code directly; it's best used for short statements, such as running a tool. See Figure 9.9 for an example of using the Python window to run the Merge tool as used in this chapter. The left-hand pane is where Python code is typed at the command line; the right-hand pane shows the results of the code's implementation. In the left pane, the first line ("import arcpy") gets the ArcPy add-in so that you can work with ArcGIS functions in Python. The second line sets one of the Geoprocessing Environment Settings for the workspace (i.e., the location of the data that you'll be working with). The third line runs the Merge tool by taking two layers in the Ohiogeo geodatabase (Ohioincplaces and Ohiononincplaces), merging them to become a third layer (Ohioallplaces), and writing that output to the Ohiogeo geodatabase.

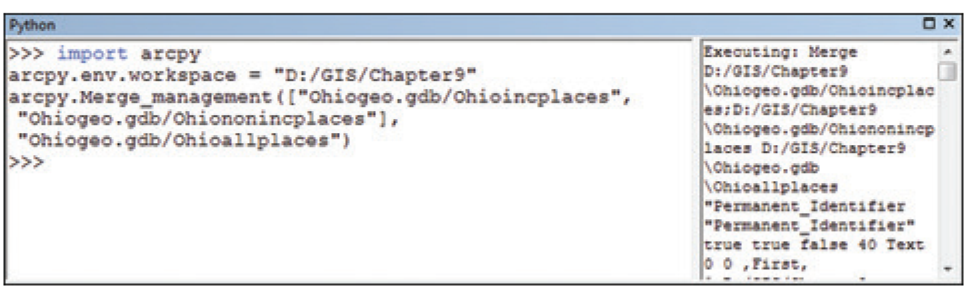

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FIGURE 9.9 An example of running the Merge tool using the Python window.

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A second way of working with Python in ArcGIS is to use a separate program to write lengthier or more complex scripts. Keep in mind that Python scripts are simply text files, so you could use a text-editing utility like Notepad to write the script. However, a more effective means of preparing scripts would be to use a program specifically designed to aid you in writing Python scripts, such as the PythonWin program (available for free download from **http://python.org**; note that you should use version 2.7.x as that's the version supported by ArcMap). Using a program like PythonWin as an environment for writing scripts will help you keep your coding, commenting, and syntax clearer when writing lengthy scripts. A Python script is saved with the extension .py and can be run through a program like PythonWin.

Python is commonly used with ArcGIS for writing scripts related to geoprocessing. In the ArcGIS Help utility (see Chapter 1), the help page for each tool also lists examples of Python code that can be used in the Python window and as a stand-alone script. For instance, if you want to use Python to overlay two layers through the Intersect operation, look up the Intersect tool in ArcGIS Help, and you'll see examples of Python code showing how Intersect can be implemented in Python scripting.

For in-depth information about the topics presented in this chapter, references and a list of items are available online for use with the ArcGIS Help feature on this book's website at: **http://www.macmillanlearning.com/Catalog/product/discoveringgisandarcgis-secondedition-shellito**

Go Pro! With Chapter 9

How do you set Geoprocessing Environments in ArcGIS Pro?

At the start of Chapter 9 you set a series of Geoprocessing Environments within ArcMap (see page 220). You'll continue to do so in many future chapters, but these same environments can also be set in ArcGIS Pro. Go to the **Analysis** tab, within the **Geoprocessing** group, and click on the **Environments** button. The Workspace, Output Coordinates, and Processing Extent environments used in Chapter 9 can be set here.

How do you interactively select features in ArcGIS Pro?

You can interactively select features (see page 222) in ArcGIS Pro similar to how you do so in ArcMap. Within the Contents pane, first choose the option to **List By Selection**, and you can choose (by placing a checkmark or removing a checkmark) which layers can have features selected from them. Next, choose the **Map** tab, go to the **Selection** group, and press the **arrow under the Select button**. A new set of options will appear that will allow you to interactively select features in different ways (rectangle, polygon, lasso, circle, or line).

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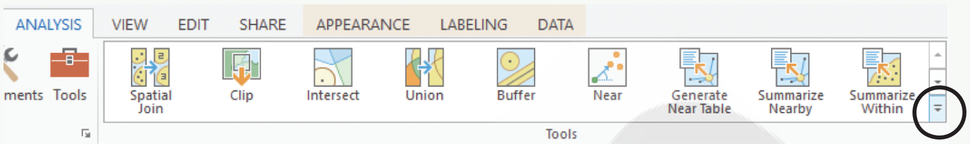
How do you use geoprocessing tools in ArcGIS Pro?

The various geoprocessing tools used in this chapter in ArcMap (plus many more) are all available in ArcGIS Pro. Go to the **Analysis** tab and in the **Tools** group, you'll see a variety of different geoprocessing tools. However, by clicking on the down arrow in the right-hand corner of the Tools group, the group will expand to give you access to many commonly used geoprocessing tools, organized by function. These include the Merge, Append, Dissolve, Clip, Buffer, Intersect, and Union tools referenced in Chapter 9. Clicking on the tool's button will open up that tool for use in the Geoprocessing pane.



SOURCE: ARCGIS PRO/ESRI

How do you work with Python in ArcGIS Pro?

As in ArcMap, Python scripts (see page 237) are an integrated part of ArcGIS Pro. To access the Python window to type in code, go to the **Analysis** tab, within the **Geoprocessing** group, and press the **Python** button. A Python window will open at the bottom of ArcGIS Pro for you to directly enter Python code.

However, ArcGIS Pro uses Python 3.4 rather than the version 2.7 used in ArcMap. Some scripts that work fine in Python 2.7 may not work in Python 3.4 and will need to be converted to the new version of Python to work in ArcGIS Pro. The 2to3 Python utility (see online here: **https://docs.python.org/2/library/2to3.html**) may be of help in converting Python scripts to version 3.4.

In addition, some tool functions that were available in ArcPy will not work in ArcGIS Pro. A new geoprocessing tool called **Analyze Tools For Pro** can help identify issues with previous Python scripts written for ArcGIS to determine compatibility with ArcGIS Pro. This tool is available in the Geoprocessing pane within the **Data Management** toolbox and inside the **General** toolset.

Key Terms

geoprocessing (p. 217)
overlay (p. 217)
environment settings (p. 220)
merge (p. 221)
append (p. 222)
dissolve (p. 224)
clip (p. 225)
buffer (p. 227)
Intersect (p. 231)
Identity (p. 232)
Symmetrical Difference (p. 232)
Union (p. 232)
Erase (p. 232)
Update (p. 232)
point-in-polygon overlay (p. 234)
line-on-polygon overlay (p. 234)
Python (p. 237)
script (p. 237)
ArcPy (p. 237)

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