ArcGIS® Desktop II: Tools and Functionality
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Introduction

You may not realize it, but you benefit from the use of geographic information system (GIS) software every day. Whether it's the synchronization of traffic lights on your way to work or the convenient location of your favorite park, GIS probably had a hand in making these things happen. All over the world, organizations are using GIS to manage the environment, integrate emergency response systems, provide better customer service, and save money.

This course introduces you to the tools and functionality of ArcGIS and how to use layers, symbology, and map elements to create maps and visualize geographic information. You will look at the data behind the maps and explore the kinds of data you can use in ArcGIS. You will learn how to add new data, update existing data, and align data from a variety of sources.

Once you've worked with maps and the data behind them, you will use this knowledge, along with additional tools, to analyze geographic data, derive new data, and solve geographic problems.

This course is designed for those with an educational or workplace background in GIS. The completion of ArcGIS Desktop I: Getting Started with GIS or equivalent knowledge is required.
Course goals

After completing this course, you will be able to:

▪ Visualize geographic data in ArcMap.
▪ Manage layers in a map document.
▪ Symbolize, classify, and label geographic data.
▪ Create map layouts to share with others.
▪ Recognize different types of geographic data.
▪ Apply coordinate systems and map projections to geographic data.
▪ Integrate spatial and nonspatial tabular data.
▪ Edit geographic data using a workflow.
▪ Create a GIS database and new geographic data.
▪ Generate spatial data from x,y coordinates and addresses.
▪ Use query and analysis tools to solve geographic problems.

Using the course workbook

The course workbook is an integral part of your learning experience. During class, you will use the workbook to complete activities and exercises that reinforce specific tasks and skills. After class, the workbook is your personal reference to review activities or work through exercises again to reinforce what you've learned.

Essential elements include:

▪ Lessons—learning objectives at the beginning of each lesson to help you find the information you're looking for.
▪ Guided activities—interactive activities to reinforce key topics.
▪ Exercises—step-by-step instructions for accomplishing essential tasks and building skills.
▪ Review—questions and answers that reinforce key concepts.
▪ Appendixes—your guide to additional resources.
▪ CD—data necessary for completing the course exercises.

Additional resources

Refer to the following resources to learn more about ArcGIS Desktop:

ArcGIS Resource Centers
http://resources.arcgis.com/
This site provides unified access to Web-based help, online content, and technical support as well as access to the GIS community.
Esri GIS Dictionary

http://resources.arcgis.com/glossary

This online GIS dictionary includes terms related to GIS as well as Esri software-specific terminology.

Installing the course data

To use the workbook exercises, you will need to install the data that will be used throughout this course. The data is stored on a CD and will be copied to your hard disk drive by an automated install program.

- Remove the training data CD from the back of your workbook and place it in the disk drive.
- Click Yes to accept the Esri license agreement.
- Click Next on the welcome panel.

By default, the course data will be installed to the C:\Student folder.

```
Note: If you need to install the course data to a different location, browse to that location. Select the folder in which you want to store the course data, then click OK. Be sure to note the location of the folder you've selected so that you can easily access the data in the upcoming exercises.
```

- Click Next.
- Click Finish when the data installation is complete.
- Remove the training data CD from your disk drive and return it to its sleeve in your workbook.

```
Note: This course is designed to work with ArcGIS 10 at the ArcEditor or ArcInfo license level.
```
Introduction

In this lesson, you will examine the importance of maps and visualization in GIS. Using ArcMap, the mapping application for ArcGIS, you will explore GIS maps, including the ArcMap interface, and the layers that make up a map. You will learn about the relationship between map layers and the data they point to. You will also explore the relationship between features that you see on a map and the information about those features we call attributes.

Topics covered

- GIS and maps
- ArcMap: mapping application
- Maps and layers
- Feature classes and layers
- Features class organization
- Displaying and adding layers

Learning objectives

After completing this lesson, you will be able to:

- Describe what maps are used for.
- Visualize layers in ArcMap.
- Add layers to ArcMap.
GIS and maps

What do you use maps for?

What do you use GIS maps for?
ArcMap: mapping application

- **Table of Contents**
- **Name of the data frame.** "Layers" is the default name.
- **List of map layers, their symbols, and drawing order**
- **Tools toolbar**
- **Data frame**
- **Catalog window**

Toggle between Data view and Layout view.
Maps and layers
Feature classes and layers

**Feature class**
- Collection of similar features and their attributes
  - Same geometry type
  - Same attributes
  - Common geographic extent
  - Unique ID, shape, and other attributes stored in attribute table
  - Features correspond to records

**Layer**
- Map representation of feature class
  - Points to data but is not the data
  - Defines the name, appearance, and other properties of the data
  - Will not draw in ArcMap if path to data changes
Feature class organization

What feature classes do you use in your work?
Displaying and adding layers (demo)

Notes
Exercise 1: Explore data in ArcMap

Estimated time: 25 minutes

In this exercise, you will use ArcMap to organize layers and explore spatial and attribute properties of the Canada data.

In this exercise, you will:
  ▪ Change layer visibility, order, and symbology.
  ▪ Add layers to ArcMap.
  ▪ Identify, find, and measure map features.
  ▪ Select subsets of features for analysis.

Step 1: Start ArcMap

In this step, you will use ArcMap to open a particular map document.

☐ Start ArcMap by double-clicking the ArcMap icon on your desktop (or click the Start menu, point to All Programs, click ArcGIS, and click ArcMap).

☐ In the ArcMap – Getting Started dialog box, under Existing Maps, click Browse for more.

☐ In the Open ArcMap Document dialog box, browse to ..\Student\DESK2\ExploreArcMap and double-click it.

☐ Click CanadaMap.mxd and then click Open.

☐ Maximize the ArcMap application window.

ArcMap is divided into two windows: the table of contents on the left and the map display on the right.
From the Bookmarks menu, choose Canada to zoom to the Canada bookmark so that your map resembles the following graphic.

Some toolbars are turned on by default. Toolbars have no "correct" position. You can dock or float them, horizontally or vertically, as you like.

If you want, take a moment to dock or reposition any toolbars. Your configuration does not need to match the workbook graphics.

- On the right side of the ArcMap application window, click the Catalog tab to open the Catalog window.

- Click the Connect To Folder button.
In the Connect to Folder dialog box, expand Computer and browse to your ..\Student\DESK2 folder.

Click the DESK2 folder and then click OK.

This folder connection will make it easier for you to navigate to your data throughout the course.

Step 2: Work with layers

In this step, you will manage the map display, turning layer visibility on and off, reordering layers, and removing layers from the map.

The table of contents lists the layers in the map. At the top of the table of contents, just below the title, notice that the List By Source button is selected.

The List By Source button lists layers organized by the database or databases in which the sources for the data are found. Your data resides in the same database.

Click each button and notice how the table of contents changes.

1. How can you determine the name of a button?

Click the List By Drawing Order button.
Uncheck the box next to Mjcities.

The cities no longer display in the map.

In the table of contents, click the List By Visibility button.

Notice that Mjcities is placed below a collapsible heading called Not Visible.

Click the light gray icon to the left of Mjcities to turn the cities back on.

In the table of contents, click the List By Drawing Order button.

Notice that the check box next to Mjcities is checked and the layer is visible in your map.

Turn the Provinces layer off and on and do the same for any other layers you want to try.

Click the Mjcities layer to select it.

Click and slowly drag the layer downward through the table of contents. As you drag the layer, its position is indicated by a horizontal black bar.

Drop the layer at the bottom of the table of contents.

The cities can no longer be seen because they are covered by other layers. On the map, layers draw in order from bottom to top.

Drag the Mjcities layer back to the top of the table of contents.

Drag the Rivers layer and drop it just below the Provinces layer.

Now the rivers are visible in the United States but not in Canada. (They are covered by the Provinces layer but not by the Cntry07 layer.)

Right-click the Mjrroads layer and choose Remove.

The roads no longer display in the map because the layer is gone.

Note: Removing a layer in ArcMap does not delete the feature class that the layer references on disk.

Click the Mjcities layer. Click it again to make the layer name editable.

Change the name to Major Cities. Press Enter on your keyboard.
Change the name of the Cntry07 layer to **Countries** and the name of the World30 layer to **Ocean**.

**Step 3: Change symbology**

In this step, you will make some basic changes to layer symbology by changing the colors and markers that represent features in a map.

- In the table of contents, right-click the Provinces symbol (the color patch under the layer name).
- Move your mouse pointer around the palette and pause over a few different color squares.

When you hold your mouse pointer over a square, its name is displayed as a ToolTip.

- On the color palette, click the Yucca Yellow color square (row 1, column 5) to change the symbol.

Right-clicking a symbol enables you to change the symbol color but not its outline, pattern, marker, or other properties.

- In the table of contents, click (do not right-click) the symbol for the Water layer.
In the Symbol Selector, change the outline width to 0, then click OK.

In the table of contents, click the symbol for the Major Cities layer.

In the Symbol Selector, the list of available symbols changes according to whether you are symbolizing a point, a line, or a polygon layer.

Scroll down through the list of available symbols and notice the naming convention when there are several symbols with the same shape. You can interactively choose a symbol from the list or search for a particular symbol.

In the window at the top of the box, type Star 3 and click the Search button.

The indexing process executes and several formats for Star 3 display.
Scroll through the symbol list.

- Click the symbol below the ESRI heading.
- On the right, click the Color square.
- On the color palette, choose Mars Red (row 3, column 2).
- Change the symbol size to 16 points.
- Click OK.

Why use a star to symbolize major cities? In this case, the only major cities that actually appear on the map are capitals. Some of Canada's largest cities, such as Montreal and Vancouver, are not displayed.

**Step 4: Add layers to ArcMap**

In this step, you will see how to add layers to a map.
On the right, click the Catalog window tab to open it.

Because you will be working with the Catalog window during this step, you might want to set it to stay open.

*Hint:* Click the Pin button so that it is pointing downward. To set the window to auto hide, click the Pin control again.

One of the key workspaces in ArcMap is the Home folder for your map document.

In the Catalog window, below Home – DESK2\ExploreArcMap, expand Canada.

Click Natlpark to select it.

Drag the feature class from the Catalog window and drop it directly below the Water layer in the table of contents.

The layer is added to the table of contents and drawn on the map.

*Note:* You can also add layers using the Add Data button on the Standard toolbar in ArcMap, but dragging from the Catalog window is often easier.

In the ArcMap table of contents, click on some empty space to deselect the new layer.

Change the new layer's name to **National Parks**.
When a layer is added in ArcMap, the layer's symbol color is randomly assigned. Your National Parks layer might be green, but more likely it is another color.

- Right-click the symbol for the National Parks layer. Change the fill color to Leaf Green (row 5, column 7).
- In the Catalog window, click Elevation. Make sure you are selecting the yellow diamond-shaped layer file.
- Drag and drop Elevation onto the ArcMap display (the map).

The Elevation layer is added to the bottom of the table of contents. Note that not only are its colors predefined, but so are the labels that tell you which elevation range corresponds to which color. These and other properties can be set as part of the layer file.

2. Why doesn't the Elevation layer display on the map?

- Drag the Elevation layer directly below the Rivers layer.

3. What is the name of the raster dataset referenced by the Elevation layer?

- Confirm that the top-to-bottom order of layers is as follows:
  - Major Cities
  - Water
  - National Parks
  - Provinces
  - Rivers
  - Elevation
  - Countries
  - Ocean

- Click the symbol for the Provinces layer.

- In the Symbol Selector, click the Fill Color square and change it to No Color. Click OK on the Symbol Selector.

You can still see the province boundaries, but the Elevation layer now shows through.
You no longer need the Catalog window to remain open while you work.

- Set the Catalog window to auto hide.

**Note:** Whenever you click or hover your mouse pointer over the Catalog window tab, it will open.

**Step 5: Explore the Tools toolbar**

In this step, you will use several tools on the Tools toolbar. These tools for navigating map display and getting information about features are the most commonly used tools in ArcMap.

- Hold your mouse pointer over any major city on the map.

The name of the city appears as a MapTip. MapTips are a layer property you can turn on or off and set to any attribute in a layer's attribute table.

- Continue moving your mouse pointer over various cities until you locate Winnipeg, the capital of the province of Manitoba.

- On the Tools toolbar, click the Zoom In tool.


Drag a rectangle around the southern half of the province of Manitoba to zoom in on it.

It doesn't matter exactly how close you zoom. If your ArcMap window is maximized, you might want to make your scale somewhere between 1:3,000,000 and 1:7,000,000. The map scale is shown in the Map Scale box on the Standard toolbar.

**Note:** You can type directly into this box to change the scale.

Click the Identify tool and click the map.

The Identify window is a dockable window like the table of contents and the Catalog window. You will move it to a fixed location.

Click the title bar of the Identify window and drag the window toward the right side of the interface until you see the blue docking control (in the shape of a diamond) in the center of the interface.
4. Continue dragging the Identify window until your mouse pointer is over the diamond on the right.

The diamond turns a dark blue and a shadow appears, showing where the window will be docked.

- Release the mouse pointer.

This docks the Identify window along with the Catalog and Search windows. You should see a tab for each.

If you like, you can set the Identify window to auto hide. It will open each time you click a new feature.

- If necessary, from the drop-down list at the top of the Identify window, choose to identify features from the top-most layer.

If several layers overlap at an identified location, this setting identifies the one nearest the top in the table of contents.

4. Winnipeg lies to the south of two large lakes. What are their names?

- Click the Bookmarks menu and choose Canada to zoom to the Canada bookmark.

- On the Tools toolbar, click the Find tool.

- On the Find dialog box, click the Features tab, if necessary.

- In the Find box, type **Prince Edward Island**.

Leave the other settings in their default states, but note that you can restrict the text search to particular layers and to particular fields within layers. You can also find partial text strings.

- Click Find.

The bottom of the Find dialog box expands to show you the results. One occurrence of the text was found. Prince Edward Island is the name of a feature in the Provinces layer.

- Move the Find dialog box out of the way of the map display, if necessary.
At the bottom of the dialog box, right-click the value Prince Edward Island and choose Flash.

The small eastern province flashes in green on the map.

Right-click the value again and choose Zoom To.

5. What is the capital city of Prince Edward Island?

Close the Find dialog box.

The Identify window will auto hide.

From the Bookmarks menu, zoom to the Canada bookmark.

On the Tools toolbar, click the Measure tool 🟢.

At the top of the Measure window is a row of tools.

Hold your mouse pointer over the tools to see what they do.

If necessary, move the Measure window away from the map.

Make sure the Measure Line button 🟢 is selected.

Click the Choose Units button, point to Distance, and choose Kilometers.

Move your mouse pointer over the map and use MapTips to locate the cities of Whitehorse and St. John's (the westernmost and easternmost major cities).

Click Whitehorse.

Move your mouse pointer to St. John's and double-click to complete the measurement.

The distance between the two cities is shown in the Measure window. The value should be close to 5,140 kilometers, although the exact result will depend on where you click.

On the Measure window, click the Clear and Reset Results button ✗.

Close the Measure window.
Step 6: Make selections on features and records

In this step, you will see how to get information about subsets of features by making selections on the map and in the layer attribute table.

- On the Tools toolbar, from the Select Features menu, choose Select By Rectangle.
- Drag a box around any major city to select it.

The selected city is highlighted on the map, but so are features from other layers, such as Provinces, Countries, and Ocean.

By default, all layers are selectable.

- On the Tools toolbar, click the Clear Selected Features button.
- Right-click Major Cities, point to Selection, and choose Make this the only selectable layer.
- With the Select Features tool still active, drag a box around any major city.

In the map display, only the city within the box is selected.

- In the table of contents, click the List by Selection button.

The selected city is highlighted on the map and no other features are selected. In the table of contents, the List By Selection view shows you that one feature is highlighted in the Major Cities layer.
Introducing map layers

Note: The count of selected features also appears in the lower left of your ArcMap application on the status bar.

☐ Click the Clear Selected Features button \( \checkmark \) next to Major Cities.

When you view the table of contents on this tab, you can easily control which layers are selectable by toggling visibility on or off.

☐ List the layers by drawing order, right-click Major Cities, and zoom to the layer.

☐ Hold down the Shift key on your keyboard and click Whitehorse, Yellowknife, and Iqaluit, the three northernmost capital cities (north of the 60th parallel). Release the Shift key.

All three cities are selected.

☐ Now drag a selection box (or draw a polygon) that includes all the capital cities south of the 60th parallel and excludes the northern cities.

When you make a new selection, existing selections are cleared by default.
Note: You can change this default behavior with the Interactive Selection Method setting on the Selection menu.

- In the table of contents, right-click the Major Cities layer and choose Open Attribute Table.

The records corresponding to the selected features are highlighted in the table.

- Click the title bar of the Table window and drag the table until you see the blue docking control (in the shape of a diamond).

- Drag the table until it docks at the bottom of the map window.

- If you'd like, resize the table to make it shorter.

- In the attribute table, right-click the CSD_POP01 field heading and choose Statistics.

The Selection Statistics window gives you statistics for the selected features.

6. What is the mean (average) population of the capital cities that lie south of the 60th parallel?

______________________________________________________________________________

- Close the Selection Statistics window.

- On the Table window, click Switch Selection.

Now only the previously unselected records (representing the northern cities) are selected.

- Again, right-click the CSD_POP01 field heading and choose Statistics.

7. What is the mean population of the capital cities north of the 60th parallel?

______________________________________________________________________________

- Close the Selection Statistics window.

- Right-click the small gray box next to any of the selected records and choose Zoom To Selected.

The map has zoomed to the smallest extent (slightly buffered) that includes the selected features.
Close the Table window.

Clear the selected features.

Zoom to the Canada bookmark.

**Step 7: Save the map**

Now you will save the map document with a new name.

From the File menu, choose Save As.

Navigate to your ..\Student\DESK2\ExploreArcMap folder.

In the Save As dialog box, change the map document name to **CanadaElevation** and click Save.

Close ArcMap.
Lesson review

1. What is the difference between a layer and a feature class?

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______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

2. What are GIS maps used for?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
Answers to Lesson 1 questions

Exercise 1: Explore data in ArcMap

1. How can you determine the name of a button?
   
   **Hover your mouse pointer over the button.**

2. Why doesn't the Elevation layer display on the map?
   
   **It is covered by the Provinces layer, the Countries layer, and the Ocean layer.**

3. What is the name of the raster dataset referenced by the Elevation layer?
   
   Elev

4. Winnipeg lies to the south of two large lakes. What are their names?
   
   **Lake Manitoba and Lake Winnipeg**

5. What is the capital city of Prince Edward Island?
   
   **Charlottetown**

6. What is the mean (average) population of the capital cities that lie south of the 60th parallel?
   
   **500,067**

7. What is the mean population of the capital cities north of the 60th parallel?
   
   **13,611**

Lesson review

1. What is the difference between a layer and a feature class?

   **A layer is a representation of a feature class. It is not data, but points to data. It defines the way data is displayed on a map.**

   **A feature class is a collection of similar features and their attributes. The features have the same theme and the same geometry. Each individual feature corresponds to a record (row) in the attribute table.**
2. What are GIS maps used for?

GIS maps are used for visualizing geographic data, compiling data, analyzing data, communicating a message, and collaborating with others.
Introduction

In this lesson, you will apply different techniques to view subsets of data instead of viewing all the layers and all the features in each layer. You will also work with different types of layer files and create layer packages and layer files for sharing. A layer file lets you save properties that you can share with others who have access to the data.

Learning objectives

After completing this lesson, you will be able to:

- Control the display of map layers and their features.
- Save data in ways that can be shared with others.
### Zooming using commands and tools

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoom To Layer</td>
<td>A quick and easy way to zoom in to a study area</td>
</tr>
<tr>
<td>Zoom To Selected Features</td>
<td>Zoom to the extent of a subset of features</td>
</tr>
<tr>
<td>Zoom To Spatial Bookmark</td>
<td>Zoom to a particular geographic location that you saved as a bookmark</td>
</tr>
<tr>
<td>Zoom To Full Extent</td>
<td>Zoom out to show all the data in your map (using the Full Extent button); full extent can be set to individual preferences</td>
</tr>
</tbody>
</table>
Controlling which features display

Definition query

- Query statement defines which features draw

Query statement: "SQKM" > 500

- Attribute field: "SQKM"
- Operator: >
- Value: 500

All lakes are displayed

Only lakes larger than 500 square kilometers are displayed
Controlling when layers display

❉ Scale range

❉ Layer turns on or off when scale threshold is crossed

Railroads don’t display when zoomed out

Railroads display when zoomed in to a specified scale
Grouping layers

Thematically related layers grouped in the table of contents

When Transportation is unchecked, member layers do not draw
Creating basemap layers

Basemap characteristics

- Behave much like group layers
- Made up of relatively static layers that do not change frequently
- Provide a framework for displaying dynamic layers
- Provide locational reference
- Provide a way to improve display performance

Basemap examples

- Imagery is often used as a general base onto which dynamic layers are overlaid
- In utilities applications, parcel boundaries, buildings, and other built features are used as a basemap
- In many city maps, a street network is used as a basemap on top of which layers such as incidents and events are displayed
Making new map layers

Create selection layer

*Left:* Parks with lakes are selected  
*Right:* Selected parks are saved as new layer

- Parks
- Parks selection
- Parks
Saving layers

Layer file (.lyr)
- Saves a layer so it can exist outside your map
- Draws exactly as it was saved
- Requires access to data referenced by the layer

Layer package (.lpk)
- Saves a layer with its data
- Includes both the layer properties (symbology, labeling, table properties) and the data referenced by the layer
Exercise 2: Manage map layers

Estimated time: 45 minutes

In this exercise, you will learn different ways to navigate to a specific map extent. You can zoom to a feature, to the extent of selected features, or to the extent of a layer. You can save and return to a map extent by creating a bookmark.

You will also learn various techniques for controlling the display of map layers and their features. You will set scale ranges to turn layers on and off at specified map scales. You will write query expressions to display only the features you want. You will select features in one layer and create a new layer containing just those features. Finally, you will learn how to reuse symbology by importing one map layer's symbology into a different layer. In addition, you will use a layer file to share properties of a layer, such as a definition query or symbology, with anyone else who uses the same data.

In this exercise, you will:

▪ Create definition queries for layers.
▪ Set a scale range for a layer.
▪ Create a selection layer and examine its properties.
▪ Create a basemap layer.
▪ Work with layer files.
▪ Create a layer package.

Step 1: Open a map document

In this step, you will start ArcMap and open an existing map document.

☐ Double-click the ArcMap icon on your desktop to start ArcMap.

☐ In the ArcMap – Getting Started dialog box, under Existing maps, click Browse for more.

☐ Navigate to your ..\Student\DESK2\Layers folder, choose CanadaLayers.mxd, then click Open.

☐ If necessary, maximize the ArcMap window.
- If your display does not match the following graphic, zoom to the Canada bookmark.

![Map of Canada](image)

**Note:** Full extent has been set to a custom extent that applies to the data frame.

- Right-click Reference Map and click Properties.

Reference Map is the name of a data frame—a way to organize the data for your map. You will learn more about data frames in a later lesson.

- If necessary, right-click Reference Map, click Properties, click the Data Frame tab, then click Specify Extent.

The custom extent closely approximates the extent of the Provinces layer that was already set for you.

- Click Cancel to close the Full Extent dialog box, then click Cancel again to close Data Frame Properties.
Step 2: Zoom to features and layers

You have become familiar with many of the navigation tools on the Tools toolbar. In this step, you will use menu commands for zooming to the extent of specified features and layers.

- Click the Identify tool.
- Click any feature on the map to open the Identify window.
- If necessary, dock the window to the right side of the ArcMap interface.
- In the Identify window, choose to identify features from the Provinces layer.
- Click the province of Saskatchewan (labeled SK) to identify it.
- In the top panel of the Identify window, right-click Saskatchewan.

- From the context menu, choose Zoom To.

Saskatchewan flashes green and the map zooms to it. You can use this technique to zoom to any identified feature in any layer. You will learn more about the fields and values listed here in later lessons.
If necessary, hide the Identify window.

On the Tools toolbar, click the Go Back To Previous Extent button.

What if you want to zoom to the combined extent of several features? To do this, you must first select the features of interest.

In the table of contents, right-click the Lakes layer, point to Selection, and choose Make This The Only Selectable Layer.

On the Tools toolbar, click the Select Features by Rectangle tool.

Drag a box around the five Great Lakes that lie between Canada and the United States. (It is acceptable to include any smaller lakes in the vicinity.)

From the Selection menu, choose Zoom To Selected Features.

The map zooms to the extent of the selected features.
1. Why are the lakes labeled now when they were not labeled before?

- On the Tools toolbar, click the Clear Selected Features button.
- On the Tools toolbar, click the Go back to Previous extent button.

If you want to zoom to the extent of all features in a layer, you do not need to make a selection.

- In the table of contents, right-click the Nova Scotia Water Bodies layer and choose Zoom To Layer.

ArcMap zooms to the smallest extent that shows all features in the layer.

- Using the skills you just learned, zoom to the Provinces layer.

**Step 3: Create a bookmark**

You can set a bookmark for any map extent you want to save and return to. Bookmarks are created in a particular data frame, but they can be saved to a file and added to other map documents.
Click the Zoom In tool and drag a box around a city or any other map location of your choice. The size of the box does not matter.

From the Bookmarks menu, choose Create.

In the Spatial Bookmark dialog box, give your bookmark a meaningful name, like the name shown in the following example.

Click OK.

On the Tools toolbar, click the Full Extent button to zoom to the full extent of the map.

Click the Bookmarks menu and choose your new bookmark to zoom to it.
Step 4: Create a definition query

In this step, you will turn on the Airports layer, and then write a definition query to filter out small local airports.

- Zoom to the full extent.
- Turn on the Airports layer.

The map is cluttered with airports.

- Right-click the Airports layer and choose Open Attribute Table.

There are 356 features in the layer, as shown in the status bar at the bottom of the table.

- Sort the records in the DESCRIPT field in ascending order.

*Hint:* Right-click the field name and choose Sort Ascending.

- Scroll through the table.

2. How many unique values are there in the DESCRIPT field?

Your definition query will tell ArcMap to display only the international and municipal airports. Local airports will not be displayed.

- Close or hide the table window.
- Right-click the Airports layer and choose Properties.
- On the Layer Properties dialog box, click the Definition Query tab.
- Click Query Builder.

In this dialog box, you will create a query expression, using field names, logical operators, and attribute values, to filter out the airports you do not want to see.

- In the upper box of field names, double-click "DESCRIPT".

The name is added to the expression box at the bottom.

- Click the Not Equal To operator.
Click Get Unique Values.

**Note:** The values displayed represent the attribute fields in the table for the Airports layer.

Double-click 'Other airport'.

Confirm that your expression matches the following graphic. If not, click Clear and start again.

```
SELECT * FROM Airports WHERE:
"DESCRIPT" <> 'Other airport'
```

Click OK on the Query Builder.

Click Apply on Layer Properties and, if necessary, move the Layer Properties dialog box out of the way.

Only the international and municipal airports are shown.

**Step 5: Set a scale range for the Airports layer**

Perhaps it is not necessary to see airports at all map scales. In this step, you will set a scale range so that airports display only when the map is zoomed in.

On the Layer Properties dialog box, click the General tab.

In the Scale Range area, choose the option Don't show layer when zoomed.
In the Out beyond box, type **5,000,000**.

- Click OK.

The airports no longer display on the map. In the table of contents, there is a gray check mark next to the Airports layer. This tells you that the layer is turned on but not visible because of a scale range setting.

- In the table of contents, click the List By Visibility button 📊.

Notice that the Airports layer is listed below the heading Out of Scale Range.

3. Which other layer in the map has a scale range setting applied to it? At what scale will this layer's features display? **Hint:** Right-click Railroads.

- Zoom in 🔍 on an area of the map where there is sure to be an airport (such as the area around Ottawa). Make sure the map scale is larger than 1:5,000,000.

The airports display.

- Zoom to the full extent 🕵️.

- Change the table of contents view to List By Drawing Order 🚩.

**Step 6: Add a layer and write another definition query**

In this step, you will add a new layer to the map and write a definition query that uses a numeric attribute rather than a text attribute.
In the Catalog window, if necessary, expand Home – DESK2\Layers.

Expand Canada.

Drag and drop Water onto the map display.

The layer is added to the table of contents.

The Water layer is too detailed for a national map, although that detail may be useful at larger scales.

In addition, the default symbol color for the Water layer might not be appropriate. If you are looking at pink lakes, don't worry—you will fix the symbology soon.

Right-click the Water layer and choose Properties.

Click the Definition Query tab and click Query Builder.
Create the expression shown in the following graphic. Type the numeric value manually (do not try to obtain it from the Unique Values list).

```
SELECT * FROM Water WHERE:
"SQKM" > 1000
```

Click OK on both open dialog boxes.

The smaller water bodies do not display in the map.

**Step 7: Compare the Water layer to the Lakes layer**

In this step, you will visually compare features in the Water layer with features in the Lakes layer.

- Zoom to the Great Bear Lake bookmark.
- Make sure the Water layer is above the Lakes layer in the table of contents.
- Turn the Water layer off and on a few times.

The Water layer shows many of the same features as the Lakes layer, but in more detail. It also shows many of the same features as the Rivers layer—as polygons rather than lines.

You do not want the Water layer and the Lakes layer to draw different representations of the same features at the same time. What should you do? One solution is to set complementary scale ranges to make the Lakes layer display only at small scales and the Water layer display only at large scales.

A simpler solution is to choose one layer or the other as more appropriate for your map. In this case, you will choose the Water layer. Before removing the Lakes layer, you will apply its symbology to the Water layer.
Step 8: Import the Lakes layer symbology

You want to give the Water layer the same symbology you have been using for the Lakes layer. One way to do this is to open the Lakes layer properties, write down its symbology settings on some paper, and then apply these settings to the Water layer. Fortunately, there is a faster way.

- Zoom to the full extent.
- Right-click the Water layer and choose Properties.
- Click the Symbology tab.
- Click Import in the upper-right corner of the tab to open the Import Symbology dialog box.
- From the Layer drop-down list, choose Lakes to import symbology from this layer.

- Click OK, then click OK on the Layer Properties dialog box.
- If necessary, turn on the Water layer.

The Water layer is symbolized with the same symbol as that of the Lakes layer.

Step 9: Create a selection layer

It should be fine to remove the Lakes layer from the map, but first you will conduct a small test.

- Turn off the Lakes layer.
Do you notice anything missing in the Great Lakes area? When the Lakes layer is off, Lake Michigan disappears. The Water layer does not include any features that lie wholly outside Canada.

You do not want Lake Michigan to be absent from your map.

- Turn on the Lakes layer.
- Right-click the Lakes layer, point to Selection, and choose Make This The Only Selectable Layer.
- Using the Select by Rectangle tool, select Lake Michigan. *Hint:* Click and drag a rectangle large enough to include some of Lake Michigan.

- Right-click the Lakes layer, point to Selection, and choose Create Layer From Selected Features.

A new layer called Lakes selection is added to the top of the table of contents.

- Clear the selected features.

**Step 10: Examine the Lakes selection layer**

A selection layer is no different from any other layer. It is independent of the layer from which it is created. In this step, you will examine the properties of the Lakes selection layer.

- Right-click the Lakes selection layer and open its attribute table.

It shows a single record for Lake Michigan.
- Hide the Table window. *Hint:* On the Table window, if the pushpin is in its vertical position, click it to auto hide the window.

The Table window now displays as a tab in the application window. Depending on the size of your window, the tab might display on the right of the application window or possibly below the table of contents.

- Right-click the Lakes selection layer and open its properties.

- Click the Source tab.

The Lakes selection layer references the WorldLakes feature class in the Canada geodatabase. This is the same feature class referenced by the Lakes layer.

- Click the General tab.

- Change the layer name from Lakes selection to **Lake Michigan**.

- Click the Symbology tab.

- Import symbology from the Lakes layer.

- Click OK on the Import Symbology dialog box.

- Click OK on the Layer Properties dialog box.

- Right-click the Lakes layer and choose Remove.

You have created the illusion of a single layer of lakes in the map. You will move the Lake Michigan layer in the next step.

**Step 11: Create a group layer**

In this step, you will create a group layer from the Water, Lake Michigan, and Nova Scotia Water Bodies layers.

The layers participating in a group layer usually have a common theme, such as water or transportation. But layers should not be grouped just because they are thematically related. More important is whether it will be useful to control their visibility and scale range properties together.

- Holding down the Ctrl key on your keyboard, click the Lake Michigan, Water, and Nova Scotia Water Bodies layers so that all three layers are selected.
Right-click any one of the selected layers and choose Group.

A new group layer called New Group Layer appears in the table of contents.

In the table of contents, drag your new group layer directly below Rivers and make sure your water layers display in the sequence shown in the following graphic.

The three layers do not lose their individual identities or properties, but they have acquired some group properties that affect them all.

Rename New Group Layer Water Bodies.
Turn off the Water Bodies group layer.

**Note:** It looks as though you were still seeing parts of lakes, but this is actually the Ocean layer showing through from underneath.

The features in the participating layers do not display, even though their layers are individually turned on.

- When group layer visibility is unchecked, member layers do not draw.
- When group layer visibility is checked, member layers draw or do not draw according to whether their own visibility boxes are checked.

In the table of contents, drag the Rivers layer into the Water Bodies group layer, above the Water layer.

The rivers disappear. The Rivers layer is now part of the group layer and subject to its properties.

- Turn on the Water Bodies group layer.
- Turn off the Rivers layer.
- Turn on the Rivers layer again.
- Collapse the Water Bodies group layer.

From the View menu, click Refresh. (*Tip:* You can also click the Refresh button at the lower left of the map display.)

**Step 12: Create a basemap layer**

In this step, you will create a better viewing experience by creating a basemap layer.

- Click the Pan tool.
Pan the map along the west coast of North America and notice the large areas of white space that appear before the map finishes displaying.

- In the table of contents, right-click Reference Map, then choose New Basemap layer.
- Rename the new basemap layer **Basemap World**.
- Drag your Basemap World layer directly below Provinces.
- Drag the Countries layer into Basemap World. **Tip:** Watch the black insertion line and make sure that the left end aligns with the $B$ in Basemap World.

![Diagram of basemap layers]

**Note:** If the black line stretches too far to the left, the Countries layer will remain in place in the table of contents when you release the mouse and will not be moved into the basemap layer.

- When your Countries layer has been added to the Basemap World layer, two triangular warnings appear as shown in the following graphic.

![Diagram of basemap layers with warnings]

Next, you will resolve the warning on your Countries layer.
Right-click Basemap World, then click Analyze Basemap Layer.

The warning you see is one you can fix easily. The Description indicates that there is a problem with the projection or coordinate system. For now, you can be confident that this map is correct. You will learn more about projections (and their errors and warnings) in a later lesson.

Right-click the High warning in the table, then click Mark As Exception.

In the table of contents, drag the Ocean layer directly below Countries in your basemap.

Now, both the Countries layer and the Ocean layer reside in your Basemap World layer.

Analyze the Basemap World layer as you did earlier.

Resolve the projection warning for the Ocean layer by marking it as an exception.

Close the Prepare window.

Pan around the perimeter of North America and notice that the Countries and Ocean layers draw more quickly than previously.

Zoom to the Canada bookmark.

Step 13: Set layer properties

In this step, you will set some properties for a layer of provincial parks.

In the Catalog window, in your ..\Student\DESK2\Layers folder, make sure Canada is expanded, and drag and drop Provpark to the table of contents, directly below the National Parks layer.

This layer contains parks that are managed at the provincial level, as opposed to the national parks that are already in the map.

Change the layer name from Provpark to Provincial Parks.

Open the Provincial Parks layer properties, then click the Selection tab.
Below Show selected features, choose with this symbol.

- In the Symbol Selector, click the Outline Color box and choose Solar Yellow (row 3, column 5).
- Click OK.

You can also change the properties for the default symbology that is currently assigned to the layer. You will learn more about symbology in later lessons.

- Click the Symbology tab.
- Click the symbol to open the Symbol Selector.
- In the Symbol Selector, click the Fill Color square.
- On the color palette, change the fill color to Medium Key Lime (row 8, column 7).
- Click the Outline Color square.
- Change the outline color to Leaf Green (row 5, column 7).
- Click OK on the Symbol Selector.
- Click OK on the Layer Properties dialog box.

Step 14: Save a layer as a layer file

In this step, you will save the Provincial Parks layer as a layer file. A layer file lets you share properties of a layer with anyone else who uses the same data.

- In the table of contents, right-click the Provincial Parks layer and choose Save As Layer File.
In the Save Layer dialog box, navigate to your Home – DESK2\Layers folder.

Accept the default file name of Provincial Parks.lyr and click Save.

Remove the Provincial Parks layer from the table of contents (Hint: Right-click > Remove).

Turn off all layers.

From the Catalog window, right-click Home – \DESK2\Layers, then click Refresh.

Your layer file displays in the Catalog window.

From the Catalog window, drag Provincial Parks to the table of contents, directly below National Parks.

After you add a layer file to ArcMap, it displays the way other layers do.

Turn on all layers.
The layer file that you created can be shared with anyone who is using the data. In the next step, you will create another layer format that you can share.

**Step 15: Create a layer package**

Another layer format that you can share is the layer package. To begin, you will create an empty layer package, and then provide a brief description for each of the layers you will include.

- In the table of contents, right-click Provincial Parks, open its properties, and click the General tab.

The layer already contains a description.

- Close layer properties.
- Open the properties for National Parks.
- Make sure the General tab is selected.
- For Description, type **Canada National Parks**.

A description is required for a layer package.

- Click OK.
- Holding down the Shift key on your keyboard, click National Parks and Provincial Parks so that both parks layers are selected.
- Right-click the selected layers, then click Create Layer Package.

You have two options for sharing your layer package.
Choose the option to save the package to file.

Click Validate to confirm that your configuration is correct and to enable the Share button.

Click Share.

When the packaging process has completed and your layer package has been created, click OK.

To test your work, remove the National Parks and Provincial Parks layers from the table of contents.

From the Catalog window, right click Home – DESK2\Layers, then click Refresh.

In the Catalog window, right-click your layer package, then click Unpack.

The layers are added to the table of contents.
- Save your map document as MyCanadaLayers.mxd in your ..\Student\DESK2\Layers folder.

- Close ArcMap.
Lesson review

1. You have set the following properties on a layer: scale range, data description, and a definition query. How can you share these properties with a colleague who uses the same data?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
2. In a layer of city features, how can you display only the cities with a population greater than 1 million?
   a. Create a bookmark of the high-population cities.
   b. Drag a rectangle to select the high-population cities.
   c. Create a definition query (e.g., "POPULATION" > 1,000,000).
   d. Move the Cities layer to the Group layer.

3. Compare a layer file with a layer package. Why would you use one rather than the other?

   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
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4. What are some advantages to using a basemap layer?

   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
Answers to Lesson 2 questions

Exercise 2: Manage map layers

1. Why are the lakes labeled now when they were not labeled before?
   
   There is a scale range set for the labels.

2. How many unique values are there in the DESCRIPT field?
   
   Three: International, Municipal, and Other Airport

3. Which other layer in the map has a scale range setting applied to it? At what scale will this layer's features display? Hint: Right-click Railroads.
   
   The Railroads layer has a scale range. Its features will be displayed at scales larger than 1:3,000,000.

Lesson review

1. You have set the following properties on a layer: scale range, data description, and a definition query. How can you share these properties with a colleague who uses the same data?
   
   Create a layer (.lyr) file.
   Create a layer package.

2. In a layer of city features, how can you display only the cities with a population greater than 1 million?
   
   c. Create a definition query (e.g., "POPULATION" > 1,000,000).

3. Compare a layer file with a layer package. Why would you use one rather than the other?

   Both a layer file and a layer package allow one user to share layer properties with another user who is using the same data.

   Layer file
   A layer can exist outside your map as a layer file (.lyr). You can share layers over the network and through e-mail. When a user adds a layer file to a map, it will draw exactly
(with the same layer properties) as it was saved—as long as the user has access to the data referenced by the layer.

**Layer package**
A layer can also be saved with its data as a layer package (.lpk). A layer package includes both the layer properties and the dataset referenced by the layer. With a layer package, you can save and share both the layer's properties and its data. Other users will be able to add layer packages directly into their maps without needing to know how to access the database.

If you already have access to the data that is referenced by the layer file, you can use a layer file.

If you do not have access to the data, you need to use a layer package because it includes the data as well as the layer properties for the data.

4. What are some advantages to using a basemap layer?

   - Drawing static layers more efficiently
   - Providing a consistent locational reference for different dynamic layers
   - Using an image as a background layer and drawing it quickly
Introduction

This lesson focuses on how to symbolize features based on their attributes. You will explore the difference between categories and quantities, and then further examine different categorical attributes. You will see and apply different methods for symbolizing categorical attributes and creating informative maps.

Topics covered

▪ Symbolizing categorical and quantitative attributes
▪ Symbolizing categorical data

Learning objectives

After completing this lesson, you will be able to:

▪ Identify the relationship between symbology and attributes.
▪ Symbolize features using categorical attributes.
What is symbology?

Notes
Symbology based on attributes

1. Look at the attribute table. Which attributes are categories? Which attributes are quantities?
Categorical data describes or names features

- Usually text, but may be numeric codes
- Also called *nominal* or *qualitative* data

Examples of categorical data

- Names
- Zoning type (e.g., residential, commercial)
- Stream type (e.g., perennial, intermittent)

1. Can you think of other real-world examples of categorical data?
Exercise 3: Symbolize categorical data

Estimated time: 35 minutes

Feature symbology is assigned on the basis of a chosen attribute. In this exercise, you will symbolize provinces and cities according to different categorical attributes.

In this exercise, you will:
- Symbolize features by name.
- Explore color schemes.
- Symbolize features by type.
- Remove features from the symbology.
- (Optionally) Symbolize on more than one attribute.

Step 1: Open a map document

In the previous exercises, a geodatabase was associated with each of the map documents. In this step, you will associate a default geodatabase with your map document.

- Double-click the ArcMap icon on your desktop to open ArcMap.

- On the ArcMap – Getting Started dialog box, in the lower left, click Do not show this dialog in the future to check it.

- In the navigation tree, below Existing Maps, click Browse for more.

- In the Open ArcMap Document window, navigate to your ..\Student\DESK2\CategoricalData folder and double-click it.

- Double-click Canada.mxd to open the map document.

- Open the Catalog window.

- In the Catalog window, confirm that the Home directory now contains the map document and geodatabase that you will use in this exercise.

- Right-click the Canada geodatabase and click Make Default Geodatabase.
The default geodatabase is the location for storing the data needed for your map. You will learn more about the geodatabase in later lessons.

- If necessary, maximize the ArcMap window and auto hide any open windows.
- If your display does not match the following graphic, zoom to the Canada bookmark.

Step 2: Symbolize provinces by name

In this step, you will use the name attribute to assign each Canadian province and territory a unique color.

By default, ArcMap assigns a single symbol to all features in a layer. If the provinces and territories are a background layer for other features, this is probably useful in many situations. But if the goal is to draw attention to the provinces and territories, you might want each one to have its own color.

Symbology is based on attributes. Therefore, to give each province and territory its own color, you need an attribute that has unique values for each feature. This is commonly a name or ID attribute.
In the table of contents, right-click the Provinces layer and open its attribute table. *Tip:* Remember, if the Table window is closed and you want to reopen the Provinces table, click the Table tab.

There are a few different attributes that would work well for symbolizing. The NAME attribute is one such attribute.

- In the table of contents, double-click the Provinces layer to open the Layer Properties dialog box.
- Click the Symbology tab.

On the left under Show, you see the different symbology methods in ArcMap.

- Click Categories.

By default, the Unique values option is selected.

- Set the Value Field drop-down list to NAME.

In the drop-down list, you specify the attribute you will use for symbolizing.
Click Add All Values.

The name of each province and territory is added to the box and assigned a unique color. Note that their names appear twice. Under the Value heading, the names always match the attribute table. Under the Label heading, the names can be edited for display in the table of contents.

The colors are taken from the current Color Ramp setting (probably a pastel palette). There are many ramps from which to choose. For the moment, you will use the Basic Random ramp.

Right-click the Color Ramp bar. (Right-click the bar itself, not the drop-down arrow.)
On the context menu, click Graphic View to uncheck it.

The color ramp displays by name. (Yours may be different.)

- Click the drop-down arrow, scroll to the top, and choose Basic Random.
- Right-click the ramp name and again click Graphic View (this time to check it).
- In the Symbol column, uncheck the box for <all other values>.

You added all the values from the table when you clicked Add All Values, so there are no other values to symbolize.

- Click Apply and move the Layer Properties dialog box away from the map display.

In the table of contents, each province and territory is listed by name with its color patch. On the map, they are drawn in their assigned colors.

**Step 3: Change color ramps**

In this step, you will try some other color ramps and see how to use different color ramps in the same layer.

- Click the Color Ramp drop-down arrow and choose a different color ramp.
- Click Apply to update the map and table of contents.

**Note:** You can even choose the Basic Random ramp again. When you reapply it, it will produce a different set of colors in a different order.
Try a few other color ramps.

Suppose you would like to distinguish the 10 provinces from the three territories and still have every province symbolized uniquely.

Choose and apply the Yellows color ramp (the last one in the list).

In the Symbol column, click the color symbol for Northwest Territories to select the row.

Hold down the Ctrl key and click the color symbols for Nunavut and Yukon Territory.

Three rows should be selected.

Choose another color ramp, such as Reds.

A set of colors from the other ramp is applied to the selected rows (the territories), whereas the colors from the Yellows ramp remain assigned to the 10 provinces.

Click Apply to see the results on the map.

The provinces and territories are distinguished by color groups on the map and table of contents, although the table of contents is not organized to reflect the sorting.

To learn more about symbols and how they are organized, search the Help for symbols and styles.

Step 4: Add headings to the table of contents

In this step, you will add headings to the Provinces layer to reflect the grouping of provinces and territories. You will also save the map with a new name to preserve your work in its current state.

In the Layer Properties dialog box, the three territories should still be selected.

Right-click any one of the selected rows.

On the context menu, point to Move to Heading and choose New Heading.
In the New Heading dialog box, type **Territories**, as shown in the following graphic, and click OK.

![New Heading dialog box](image)

Scroll to the top of the box.

In the Label column, click the existing heading NAME to make it editable and type **Provinces** in its place.

Click OK twice in the Layer Properties dialog box.

The table of contents is now organized to reflect your color scheme.

![Table of contents](image)

From the File menu, choose Save As.

Choose to save the map document in the ..\Student\DESK2\CategoricalData folder with the name **CanadaProvinces**.

Click Save.
Step 5: Add a layer of major cities

In this step, you will add a layer of major cities to the map.

☐ From the Catalog window, from your Home folder, expand the Canada geodatabase.

☐ Drag Mjcities onto your map.

The Mjcities layer is added to the top of the table of contents with default symbology. The default symbol is always the same for point features, but the color varies.

Note: When you add a layer to a map, its position in the table of contents is determined by the feature class type. Layers are added in the following top-to-bottom order: points, lines, polygons, rasters.

☐ Rename the Mjcities layer to Major Cities.

Because the rest of the exercise focuses on symbolizing cities, you will now symbolize the provinces with a single symbol and save the map document with another name.

☐ Save the map document as CanadaMajorCities. (Hint: Refer to the end of the previous step if you need instructions.)

☐ In the table of contents, double-click the Provinces layer to open its properties. If necessary, click the Symbology tab.
In the Show box, click the Features method.

Click the symbol (the color rectangle) to open the Symbol Selector.

In the Symbol Selector, click the Fill Color square and click Yucca Yellow (row 1, column 5).

Click OK on the Symbol Selector and on the Layer Properties dialog box.

Step 6: Symbolize cities by type

In this step, you will symbolize the major cities according to whether or not they are capitals.

Open the attribute table for the Major Cities layer.

The Capital field has values of Y or N to indicate whether the city is a capital. The values do not distinguish provincial and territorial capitals from the federal capital of Ottawa, but for now that does not matter.

Hide the Table window to make more of the map display visible.

Double-click the Major Cities layer to open its properties. If necessary, click the Symbology tab.

In the Show box, click Categories to expand it.

Set the Value Field to CAPITAL and click Add All Values.
Two values are added: N for No and Y for Yes. The two values have the same marker symbol, but different colors. The colors are taken from the current color ramp.

To the right of the Label column is a Count column, which tells you how many features have each value.

- All values in the field have been added, so uncheck the box for <all other values>.
- Click Apply and move the Layer Properties dialog box away from the map.

The symbology is updated in the map and table of contents, but it is not very suitable symbology.

**Step 7: Change the symbology of the cities**

In this step, you will choose more appropriate symbols for the cities.

- In the Layer Properties dialog box, double-click the symbol next to the N value.
- In the Symbol Selector, click the Circle 2 symbol.
- Change its color to Seville Orange (row 4, column 4).

Underneath the color is a box that lets you set the symbol size.
- Change the size from 18 points to 8.

- Click OK on the Symbol Selector.

- Double-click the symbol next to the Y value.

- In the Symbol Selector, scroll through the symbols and notice the various types.

- Use the following table as a guide for setting symbol properties or, if you’d like, search for a symbol on your own.

<table>
<thead>
<tr>
<th>Symbol property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Style</td>
<td>Star 5</td>
</tr>
<tr>
<td>Color</td>
<td>Tuscan Red (row 5, column 2)</td>
</tr>
<tr>
<td>Size</td>
<td>14</td>
</tr>
</tbody>
</table>
If you chose a different symbol, write your values here in case you want to use your symbol later.

<table>
<thead>
<tr>
<th>Symbol property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Style</td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td></td>
</tr>
</tbody>
</table>

When you have chosen your symbol and set its properties, click OK.

Click Apply.

This symbology allows you to distinguish capitals from non-capitals readily.

The labels in the table of contents can be improved. For one thing, the values N and Y might not be clear to everyone. Also, listing the capitals first might be better.

**Step 8: Reorder values and edit labels**

In this step, you will move capitals above non-capitals in the table of contents. You will also edit the value labels to make them more descriptive.

In the Layer Properties dialog box, the Y value should still be selected. On the right side of the dialog box are two arrow buttons. The up arrow should be black (or enabled), indicating that you can move the value up.
In the Layer Properties dialog box, click the black up arrow, as shown in the following graphic.

The Y value moves above the N value.

- In the Label column (not the Value column), click the Y to make it editable.
- Replace the label with **Capital** and press Enter.

Now the N label should automatically be editable.

- Replace the N label with **Non-Capital**, then click the white space below the label.

The new labels make the heading redundant.

- In the Label column, click the heading CAPITAL and press Delete on your keyboard to delete it.
Click the white space underneath the labels.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
<th>Label</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;all other values&gt;</td>
<td>&lt;all other values&gt;</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>&lt;Heading&gt;</td>
<td></td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Capital</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>Non-Capital</td>
<td>30</td>
</tr>
</tbody>
</table>

Click Apply.

The changes are reflected in the table of contents. Note that the map display does not change—capitals do not necessarily draw above non-capitals. At this map scale, at least two capitals, Ottawa and Toronto, are covered by other cities.

Note: The order in which features within a layer are drawn is determined by the order of the records in the table. This order can be changed by manipulating what is referred to as the symbol level, but that is not part of this course.

Step 9: Remove values from the symbology

In this step, you will see how to change the symbology by removing values.

- In the Layer Properties dialog box, click the symbol for the N value to select the row.

- Click Remove.

The value no longer displays.
Click Apply.

On the map, only the capital cities draw. The non-capitals have not been deleted from the feature class—they are just not being displayed.

In the Symbol column, check the box for <all other values> and click Apply.

Now the major cities draw again, in the default symbol assigned to all other values. (This default symbol can be changed on the Symbol Selector like any other.)

If you would like to symbolize the Major Cities layer based on multiple attributes, go on to the optional next step.

Otherwise, close the Layer Properties dialog box, save your map, and close ArcMap.

**Step 10: (Optional) Symbolize on more than one attribute**

In this step, you will see how to assign symbology using more than one attribute. How might this be useful? Suppose, for example, that you want to distinguish capitals from non-capitals and then further distinguish the non-capitals by population rank. Or suppose that after distinguishing capitals from non-capitals, you want to symbolize provincial and territorial capitals differently from the federal capital.

That will be your task here. As mentioned earlier, there is no specific attribute value on which to base this distinction, but because you know the federal capital of Ottawa by name, you can use the NAME attribute.
In the Show box, under Categories, change the symbology option from Unique values to Unique values, many fields.

- Set the first Value Fields drop-down list to CAPITAL.
- Set the second Value Fields drop-down list to NAME.
- Click Add Values (not Add All Values).

In the Add Values dialog box, every combination of the two selected value fields displays. Each record is listed first by its CAPITAL value, and then by its NAME value.

In this case, you are interested in symbolizing capitals only.

- In the scrolling box, scroll past the N’s until you come to the Y’s.
Click Y, Charlottetown to select it.

Scroll to the bottom of the list.

Hold down the Shift key and click Y, Yellowknife.

Scroll up slowly to confirm that all the capitals, and only the capitals, are selected.

Click OK.

Only the values you selected are symbolized.

Each value pair is assigned a unique color according to the current color ramp. You are on the right track, but this is not yet the desired result. You want all the provincial and territorial capitals to be grouped with one symbol, and Ottawa to have a symbol of its own.

In the Value column, click Y, Ottawa to select it.

Click the up arrow on the right side of the dialog box to move Ottawa to the top of the list. (The arrow becomes disabled when you reach the top.)

Now you will group the provincial and territorial capitals and give them a symbol.

In the Value column, click Y, Charlottetown to select it.

Scroll to the bottom of the box. Hold down the Shift key and click Y, Yellowknife.
- Scroll up and confirm that all values except Y, Ottawa are selected.

- Right-click any selected value and choose Group Values.

<table>
<thead>
<tr>
<th>Symbol property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Style</td>
<td>Star 5</td>
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<tr>
<td>Color</td>
<td>Tuscan Red (row 5, column 2)</td>
</tr>
<tr>
<td>Size</td>
<td>14</td>
</tr>
</tbody>
</table>

- Double-click the symbol for the Y, Charlottetown; etc. value.

- On the Symbol Selector, assign the following properties or use the properties you chose in the *Change the symbology of cities* step earlier.

<table>
<thead>
<tr>
<th>Symbol property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Style</td>
<td>Star 3</td>
</tr>
<tr>
<td>Color</td>
<td>Lapis Lazuli (row 4, column 10)</td>
</tr>
<tr>
<td>Size</td>
<td>18</td>
</tr>
</tbody>
</table>

- Click OK.

- Double-click the symbol for the Y, Ottawa value and assign the following symbol properties or choose others.

<table>
<thead>
<tr>
<th>Symbol property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Style</td>
<td>Star 3</td>
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<tr>
<td>Color</td>
<td>Lapis Lazuli (row 4, column 10)</td>
</tr>
<tr>
<td>Size</td>
<td>18</td>
</tr>
</tbody>
</table>

- Click OK.

- In the Label column, change the Y, Ottawa label to **Federal Capital**, and press Enter.

The next label is selected.

- Change the Y, Charlottetown; etc., label to **Provincial Capital**.
Delete the CAPITAL, NAME heading.

In the Symbol column, uncheck the box for <all other values>.

1. If the <all other values> box were to remain checked, which additional cities would be displayed in the map?

Click OK on the Layer Properties dialog box.

The map and table of contents reflect the symbology you have assigned.

- On the Standard toolbar, click the Save button.
- Close ArcMap.
**Lesson review**

1. Describe the relationship between symbology and attributes.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

2. Which of the following is an example of categorical data?
   a. A lake feature class that contains the attribute DEPTH, populated with values in meters
   b. A land parcel feature class that contains the attribute ASSESSMENT, populated with the annual assessed valuation of each parcel, for example, $50,123, $60,432, and $100,075
   c. A railroad feature class that contains the attribute SERVICE, populated with the values FREIGHT and PASSENGER
   d. A school district feature class that contains the attribute NUMBER_of_STUDENTS, populated with the attendance for each day
Answers to Lesson 3 questions

Symbology based on attributes

1. Look at the attribute table. Which attributes are categories? Which attributes are quantities?

- STATE_NAME = category
- STATE_FIPS = category
- SUB_REGION = category
- STATE_ABB = category
- POP2000 = quantity
- POP2005 = quantity
- POP00_SQMI = quantity (density/ratio)
- POP05_SQMI = quantity (density/ratio)

Categorical data

1. Can you think of other real-world examples of categorical data?

- Vegetation types, codes, and descriptions
- Land use codes, descriptions

Exercise 3: Symbolize categorical data

1. If the <all other values> box were to remain checked, which additional cities would be displayed in the map?

The non-capitals

Lesson review

1. Describe the relationship between symbology and attributes.

Symbology may be associated with an attribute in the attribute table. A symbol may be associated with each unique attribute value or with a group of attribute values.
2. Which of the following is an example of categorical data?

   c. A railroad feature class that contains the attribute SERVICE, populated with the values FREIGHT and PASSENGER
Symbolizing quantitative data

Introduction

In this lesson, you will identify different types of quantitative data and apply classification methods to group numeric values into classes. Next, you will assign a symbol to the features in each class. Classifying and symbolizing groups of features will enable you to identify patterns in your data.

Topics covered

▪ Quantitative data (and quantitative data examples)
▪ Symbolizing quantitative data
▪ Classification methods (including natural breaks, equal interval, quantile, and manual)
▪ Normalization
▪ Classification method selection

Learning objectives

After completing this lesson, you will be able to

▪ Define quantitative data and classification methods.
▪ Symbolize features using quantitative attributes.
What is quantitative data?

List real-world examples of quantitative data.

Count

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Measurement

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Average

Ratio

Density

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<td>857</td>
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<td>1,254,237</td>
<td>768</td>
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<td>Polygon</td>
<td>1,986,965</td>
<td>3,063,316</td>
<td>649</td>
</tr>
<tr>
<td>119</td>
<td>Polygon</td>
<td>130,514</td>
<td>211,081</td>
<td>618</td>
</tr>
<tr>
<td>127</td>
<td>Polygon</td>
<td>226,696</td>
<td>382,636</td>
<td>592</td>
</tr>
<tr>
<td>164</td>
<td>Polygon</td>
<td>490,268</td>
<td>1,125,587</td>
<td>436</td>
</tr>
<tr>
<td>110</td>
<td>Polygon</td>
<td>110,087</td>
<td>265,913</td>
<td>414</td>
</tr>
<tr>
<td>163</td>
<td>Polygon</td>
<td>375,223</td>
<td>972,939</td>
<td>396</td>
</tr>
<tr>
<td>166</td>
<td>Polygon</td>
<td>103,977</td>
<td>283,638</td>
<td>367</td>
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</table>
Symbolizing quantitative data

Colors associated with elevation values

Symbol size associated with population values

<table>
<thead>
<tr>
<th>OBJECTID</th>
<th>Shape</th>
<th>NAME</th>
<th>PROV</th>
<th>POP2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>Point</td>
<td>Toronto</td>
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<td>2,481,494</td>
</tr>
<tr>
<td>31</td>
<td>Point</td>
<td>Mississauga</td>
<td>ON</td>
<td>612,925</td>
</tr>
<tr>
<td>30</td>
<td>Point</td>
<td>Hamilton</td>
<td>ON</td>
<td>490,268</td>
</tr>
<tr>
<td>27</td>
<td>Point</td>
<td>Brampton</td>
<td>ON</td>
<td>325,429</td>
</tr>
<tr>
<td>20</td>
<td>Point</td>
<td>Kitchener</td>
<td>ON</td>
<td>190,399</td>
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<td>129,170</td>
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<tr>
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<td></td>
<td>182,022</td>
</tr>
</tbody>
</table>

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Classification methods

Different classification methods create very different-looking maps.

**Natural breaks**
- Classes conform to cluster patterns in the data

![Natural Breaks](image1)

**Equal interval**
- Classes have equal value ranges

![Equal Interval](image2)
Quantile
- Classes contain equal numbers of features

Manual
- Classes are divided however you want
Test your knowledge

**Note:** In the following tables, the value of "0" means that there is fewer than one person per square kilometer.

1. Draw lines to divide the values below into 4 classes based on the **Natural Breaks** method.

<table>
<thead>
<tr>
<th>Provinces</th>
<th>NAME</th>
<th>PersonsPerSQKM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nunavut</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Northwest Territories</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Yukon Territory</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Newfoundland and Labrador</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Saskatchewan</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Manitoba</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>British Columbia</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Alberta</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Québec</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>New Brunswick</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Ontario</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Nova Scotia</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Prince Edward Island</td>
<td>24</td>
</tr>
</tbody>
</table>

2. Draw lines to divide the values below into 4 classes based on the **Equal Interval** method. What is the value range for each class?

<table>
<thead>
<tr>
<th>Provinces</th>
<th>NAME</th>
<th>PersonsPerSQKM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nunavut</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Northwest Territories</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Yukon Territory</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Newfoundland and Labrador</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Saskatchewan</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Manitoba</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>British Columbia</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Alberta</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Québec</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>New Brunswick</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Ontario</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Nova Scotia</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Prince Edward Island</td>
<td>24</td>
</tr>
</tbody>
</table>
3. Draw lines to divide the values below into 4 classes based on the **Quantile** method. How many provinces will be in each class?

<table>
<thead>
<tr>
<th>Provinces</th>
<th>NAME</th>
<th>PersonsPerSQKM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nunavut</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Northwest Territories</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Yukon Territory</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Newfoundland and Labrador</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Saskatchewan</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Manitoba</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>British Columbia</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Alberta</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Québec</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>New Brunswick</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Ontario</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Nova Scotia</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Prince Edward Island</td>
<td>24</td>
</tr>
</tbody>
</table>

4. Draw lines to divide the values into classes based on the **Manual** method. You decide on the number of classes and what you want to show.

<table>
<thead>
<tr>
<th>Provinces</th>
<th>NAME</th>
<th>PersonsPerSQKM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nunavut</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Northwest Territories</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Yukon Territory</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Newfoundland and Labrador</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Saskatchewan</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Manitoba</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>British Columbia</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Alberta</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Québec</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>New Brunswick</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Ontario</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Nova Scotia</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Prince Edward Island</td>
<td>24</td>
</tr>
</tbody>
</table>
What is normalization?

On the Label Properties Symbology tab, you have the option to normalize the values in an attribute field. Normalization is the process of dividing one numeric attribute by another. In this way, you can minimize differences in values based on the following:

- The size of areas
- The number of features in each area

For example:

- Dividing a value by the area of the feature yields a value per unit area, or density. For example, normalizing (dividing) total population by total area yields population per unit area, or density.
- Dividing the 18–30-year-old population by the total population yields the percentage of people ages 18–30.

By normalizing or adjusting the values in your classification field, you can show how your data relates to the values of another field.
Choosing a classification method

When you perform a classification, you group similar features into classes by assigning the same symbol to each member of the class. Classification allows you to spot patterns in the data more easily. How you define a class range determines which features fall into that class and affect the appearance of the map.

How do you choose a classification method?
There is no simple answer.

Ask:
- How is the data distributed?
- What is the map's message?
- What is aesthetically pleasing?

A few observations
- **Natural Breaks**—suitable in most situations; the default method
- **Equal Interval**—emphasizes differences at low and high ends of value range; legend is easy to interpret; best applied to familiar data ranges such as percentages or temperature
- **Quantile**—emphasizes differences in middle of value range
- **Manual**—emphasizes a particular range of values, such as those above or below a threshold (e.g., areas below a certain elevation level that are susceptible to flooding); useful for isolating and emphasizing ranges of data
Exercise 4: Symbolize quantitative data

Estimated time: 40 minutes

Thematic maps show the geographic distribution of a variable. Examples of variables are demographic or economic data, such as population, income, life expectancy, or greenhouse gas emissions. Thematic maps stand in contrast to location maps, which show the positions of geographic features.

In this exercise, you will make thematic maps of population and population density in Canada. The population data will be the same in each case; the symbology methods and the units of aggregation are what will vary. You will start at the province level and see how population patterns change as you switch to the smaller units of census divisions and subdivisions.

In this exercise, you will:
- Symbolize population data with graduated colors and graduated symbols.
- Map population density at different levels of detail.
- Classify population data by different methods.
- Optionally, exclude data from a classification.

Step 1: Open a map document and examine population data

In this step, you will open the map document for this exercise and familiarize yourself with the population data in the Provinces layer.

- Start ArcMap and from your ..\Student\DESK2\QuantitativeData folder, open CanadaPopulation.mxd.
- In the Catalog window, make sure that your Location is set to your Home – DESK2\QuantitativeData folder.
- Right-click Canada and make it your default geodatabase.
If necessary, maximize ArcMap and zoom to the Canada bookmark so your display matches the following graphic.

Open the attribute table for the Provinces layer.

The POP2001 field shows the population of each province and territory as of the 2001 census. You will base your symbology on this attribute.

Sort the POP2001 field in ascending order. *Hint:* Right-click the field name and choose Sort Ascending.

The values range from 26,745 in Nunavut to 11,410,046 in Ontario.

Close or hide the Table window.

**Step 2: Symbolize provinces by population using graduated colors**

In this step, you will use color ramps to distinguish provinces and territories that are relatively populous (like Ontario) from those that are not (like Nunavut).

Open the layer properties for the Provinces layer and click the Symbology tab.
For the Show method, click Quantities.

There are four options. The default is Graduated colors.

Set the Value drop-down list to POP2001 to base your symbology on the values for this attribute.

The range of values for the chosen attribute is divided into five classes. Each class is assigned a color on a graduated (progressive) scale. The classes are not equally broad; their ranges are decided by an algorithm that identifies clusters and gaps in the attribute values.

Set the color ramp to Brown Light to Dark. *Hint:* To see the names instead of the colors of the color ramps in the drop-down list, right-click inside the Color Ramp field and uncheck Graphic View.
1. Click OK on the layer properties.

Each province and territory is shaded with the color of the class in which its population value lies.

1. Which two provinces fall in the highest population class? *Hint:* If you do not know the name of a province, hover your mouse pointer over it to display the name in a MapTip.

2. Which four provinces or territories fall into the lowest population class? (You might need to look carefully to see all four.)

1. Open the layer properties for the Provinces layer.

2. In the Classes drop-down list, change the number of classes to 3.
Click Apply and move the dialog box away from the map.

The table of contents and the map reflect the new classification. Ontario and Quebec are still by themselves in the highest class. The middle class contains British Columbia and Alberta. The other provinces and territories fall into the lowest class.

The graduated color technique is not ideal for count data, such as population. The use of fill colors invites misleading comparisons because the map reader tends to compare only the colors and not the relative sizes of the features.

Step 3: Symbolize provinces by population using graduated symbols

In this step, you will use symbols of various sizes to represent population.

Move the Layer Properties dialog box back to a convenient location.

Under Show, change the Quantities option to Graduated symbols.

Confirm that the Value field is POP2001. If necessary, change the number of classes to 5.

Change the minimum symbol size to 6 and the maximum symbol size to 32.

Click the Background button.

On the Symbol Selector, click the Fill Color square and click Yucca Yellow (row 1, column 5) on the color palette.

Click OK on the Symbol Selector.

Click the Template button.

In the Symbol Selector, click the Circle 2 symbol. Change its color to Fire Red (row 3, column 3).
- Click OK on the Symbol Selector.

- Click Apply on the Layer Properties dialog box.
Graduated symbols help you remember that a small population means one thing in a small province (like Prince Edward Island) and something else in a large territory (like the Northwest Territories). A danger is that the map reader may think that the symbol size directly reflects the population values. In fact, a larger symbol simply means a larger population class.

**Best practice:** Use graduated symbols for counts.

**Note:** When you use graduated or proportional symbols with polygon features, the symbol is placed at the feature centroid—a calculated center of geographic mass that sometimes lies outside irregularly shaped or multipart features. (Nunavut's centroid is in the ocean.)

**Step 4: Normalize population by area**

In this step, you will normalize, or divide, the population value of each province by the province's area. The resulting values will reflect population density: the number of inhabitants per square unit of area.

- Move the Layer Properties dialog box back to a convenient place.
- Set the Quantities option back to Graduated colors.
- Confirm that the Value field is set to POP2001.
- Set the number of classes to 5.
- Set the Normalization field to SQKM (the area of each province in square kilometers).
- Set the color ramp, if necessary, to Brown Light to Dark.
Click Apply and move the Layer Properties dialog box away from the map.

When the data is normalized by area, some of the provinces fall into different classes. For example, Quebec was in the highest population class, but it is in the middle class of population density. Nova Scotia was in the middle population class, but it is the most densely populated province.

Graduated colors are appropriate for normalized data because the values have been standardized by units of area.

On the Layer Properties dialog box on the Symbology tab, click the Label heading and choose Format Labels.

On the Number Format dialog box, keep the category setting of Numeric.

In the Rounding area, choose the Number of decimal places option and change the value to 1.
- Near the bottom of the dialog box, uncheck the box for Pad with zeros.

- Click OK, then click OK on the layer properties.

- In the table of contents, click the heading POP2001/SQKM to select it, then click it again to make it editable.

- Change the heading to People per square km.

- The map is now easier to interpret.

**Best practice:** Use graduated colors for measurements and statistics.
Step 5: Symbolize population density by census division

In this step, you will symbolize population density by a smaller unit of aggregation, the census division. There is nothing wrong with your map of density by province, but it shows only very general patterns. You know that Ontario is one of the more densely populated provinces, but you don't know anything about how population is distributed within Ontario.

- Turn on the Census Divisions layer.
- Open the Census Divisions layer properties. If necessary, click the Symbology tab.
- Change the Show method to Quantities (Graduated colors).
- Set the Value field to POP2001 and the Normalization field to SQKM.
- Click the Label heading and click Format Labels.
- On the Number Format dialog box, choose the Number of decimal places option and change the number to 0.
- Check the Show thousands separators box. Click OK.
- Change the color ramp to Yellow to Green to Dark Blue.
- Click OK on the layer properties.

The map looks very homogeneous. Almost every census division falls into the lowest class. If you look carefully, you will see some patches of green along the northern shores of Lake Erie and Lake Ontario.
Zoom to the Toronto and Montreal bookmark.

At the census division level, you can see that population is concentrated in a few metropolitan areas. (The small, dark areas are Toronto to the southwest and Montreal to the northeast.) Ontario's apparent density at the province level is deceptive. Most of Ontario is like the rest of Canada—sparsely populated.

Zoom to the Canada bookmark.

Step 6: Change the classification method

So far, your classifications have used the default Natural Breaks method. In this step, you will explore some other methods.

Open the layer properties for the Census Divisions layer.
Next to the number of classes, click Classify to open the Classification dialog box.

On the upper left of the dialog box is the current classification method and number of classes.

On the upper right are summary statistics. For example, there are 288 census divisions. The mean population density is 82 (people per square kilometer), but the median value is only 8. In other words, half the census divisions have fewer than eight people per square kilometer.

Below the statistics are the class breaks.

The large box is the histogram, which you will use more in the next step. The x-axis shows you the range of values and the vertical blue lines mark the positions of class breaks.

From the Method drop-down list, choose Equal Interval.

There are still five classes, but the class breaks are different. On the histogram, they are now spaced evenly along the value range.

In the Equal Interval method, each class is equally broad. What might vary from one class to another?
Click OK on the Classification dialog box.

Click Apply on the Layer Properties dialog box and move it away from the map.

The map is more homogeneous than before.

Click Classify.

Change the classification method to Quantile.

On the histogram, most of the class breaks are grouped at the low end.

Look at the numbers in the Break Values box.

4. In the Quantile method, each class contains approximately the same number of features. What might vary from one class to another?

Click OK on the Classification dialog box.

Click Apply on the Layer Properties dialog box.

Now the map is usefully differentiated, but it might be too much of a good thing. The map reader might suppose that light green areas (second-lowest class) are much denser than yellow areas (lowest class). In fact, the difference is just one or two people per square kilometer. Dark blue areas (highest class) might be assumed to be very dense, when they might have as few as 43 people per square kilometer. With this data, at least, the Quantile method exaggerates the density of the populated areas.

Open the Classification dialog box and change the method to Geometrical Interval.

On the histogram, the class breaks are set at proportionally larger intervals. Each class is roughly six times broader than the class below it.

Change the number of classes to 4.

Each class is now about ten times broader than the class below it. The Geometrical Interval method applies a constant multiplier to class size; the multiplier used depends on the data and the number of classes.

Click OK on the Classification dialog box.

Click Apply on the Layer Properties dialog box.
This map is still well differentiated, but only a few features fall into the highest density class. For this data, the Geometrical Interval method strikes a good balance between the homogeneous results of the Equal Interval method and the exaggerated effect of the Quantile method.

Classification is a powerful tool. With the same data, you can make maps that give very different impressions—depending on where you set the class breaks.

**Step 7: Use the classification histogram**

In this step, you will work with the classification histogram in more depth.

- Open the Classification dialog box.
- Set the method to Natural Breaks.

On the histogram, the x-axis shows the range of population density values (0 to 3,922). The y-axis shows the count of census divisions (probably up to 250). The gray columns represent the number of features falling in a particular value range.

The width of the gray columns is arbitrary. When data is evenly distributed across the value range, many thin columns give a better picture. When the data is bunched up like this, thicker columns are more useful.

- Change the number of columns from 100 to 25.

The histogram tells you that more than 250 features in this feature class have a population density value smaller than 172 people per square kilometer. The number of features with larger
values drops off very rapidly after that. (You can manipulate the histogram appearance in many ways: by changing the classification method, the number of classes, the break values, and the column width.)

**Note:** You can also right-click a gray column and click Zoom In to examine the histogram at a finer level of detail.

Examining the histogram is not an academic exercise. You have already seen that, with this data, several classification methods lead to maps that are less than ideal. Knowing the value distribution can help you decide where to set class breaks to make an informative map.

- Click Cancel on the Classification dialog box and on the Layer Properties dialog box.

**Step 8: Symbolize population density by census subdivision**

In this step, you will symbolize population density by a smaller unit of aggregation, the census subdivision. You will classify the data manually.

- Turn on the Census Subdivisions layer.
- Open its layer properties and click the Symbology tab, if necessary.
- Change the Show method to Quantities (Graduated colors).
- Set the Value field to POP2001 and the Normalization field to SQKM.
- Format the labels to show zero decimal places and to show thousands separators, then click OK.
- Open the Classification dialog box.
- Change the number of classes to **10**.
- Change the classification method to Manual.
- In the Break Values box, click the top value (currently 59) to make it editable. Type **5** and press Enter to advance to the next break value.
Replace the second break value (currently 178) with 10 and press Enter to advance.

Continue replacing values up to, but not including, the last value. Use the values shown in the following graphic.

With the cursor in the last break value box, notice the message, below the histogram, in the lower-right corner of the dialog box: "4 Elements in Class."

When you click a value in the Break Values box, you can see how many features fall in that class. This is another tool to help you set class breaks.

In the Break Values box, click back through the breaks you set to see how the features are distributed.

When you are finished, click OK on the Classification dialog box.

In the Layer Properties dialog box, change the color ramp to Cyan to Purple.

The bright purple will help the very densely populated areas stand out in the map.

Click Apply and move the Layer Properties dialog box away from the map display.

On the map, the gray outlines of the census subdivisions overwhelm the symbology.
On the Layer Properties dialog box, click the Symbol column heading. From the context menu, choose Properties for All Symbols.

On the Symbol Selector, change the outline width to 0 and click OK.

You can also improve how your map looks by making the first bright blue symbol less bright.

In the Symbol column, double-click the first symbol (for the 0 to 5 density range).

On the Symbol Selector, change the fill color to Sodalite Blue (row 1, column 9). Click OK.

Click OK on the Layer Properties dialog box.

A large portion of the map looks speckled. It is not an attractive effect, but it makes the point that throughout much of the country, population is concentrated in small, isolated areas.

**Note:** Regardless of how your data displays in the attribute table, for any classification, the software organizes the data sequentially before it begins to classify.

Values are sorted into classes, five classes by default. However, any number of classes from 1 to 32 is allowed. Classes are sequential and have non-overlapping value ranges and each value range has a corresponding symbol. The general rule is to not show more than about 12 different colors hues, or about 5 or 6 color values.

**Step 9: Compare the population maps**

In this step, you will compare the three population maps you have made.

Turn the Census Subdivisions and Census Divisions layers on and off so you can compare all three maps. When you are finished, leave the Census Subdivisions layer turned on.

A drawback of the Census Subdivisions map is that it does not show the boundaries of the provinces and territories. You can fix that by making a copy of the Provinces layer, moving it above the Census Subdivisions layer, and symbolizing it with a transparent fill color.

In the table of contents, right-click the Provinces layer and choose Copy.

At the top of the table of contents, right-click the name of the data frame (Layers) and choose Paste Layer(s).

The layer, with its current symbology, is pasted just below the Major Cities layer.
- Rename the pasted layer to **Province Boundaries**.

- Make sure your layers are listed by drawing order, then drag the Province Boundaries layer directly below the GreatLakes layer.

- Open the layer properties for the Province Boundaries layer and click the Symbology tab, if necessary.

- In the Show box, click the Features (Single symbol) option, then click the symbol to open the Symbol Selector.

- Change the fill color to No Color at the top of the color palette. Click OK on the Symbol Selector and on the layer properties.

The Census Subdivisions data is given context by the provincial and territorial boundaries.

**Note:** You can have multiple copies of a layer in a map document—in the same data frame or in different data frames.

- Save the map in your ..\Student\DESK2\QuantitativeData folder as **MyCanadaPopulation**.

- From the Customize menu, choose ArcMap Options.

- Make sure the General tab is selected and click Show splash screen to uncheck it.

- Click OK.

The next time you start ArcMap, the splash screen will no longer appear prior to opening the application window.

- Close ArcMap.
Lesson review

1. Define quantitative data.

______________________________________________________________________________

______________________________________________________________________________

2. What is classification?

______________________________________________________________________________

______________________________________________________________________________

3. Describe the Natural Breaks, Equal Interval, and Quantile classification methods.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
Answers to Lesson 4 questions

Exercise 4: Symbolize quantitative data

1. Which two provinces fall in the highest population class? *Hint:* If you do not know the name of a province, hover your mouse pointer over it to display the name in a MapTip.
   
   **Ontario and Quebec**

2. Which four provinces or territories fall into the lowest population class? (You might need to look carefully to see all four.)
   
   **Yukon Territory, Northwest Territories, Nunavut, and Prince Edward Island**

3. In the Equal Interval method, each class is equally broad. What might vary from one class to another?
   
   **The number of features in the class.**

4. In the Quantile method, each class contains approximately the same number of features. What might vary from one class to another?
   
   **The value ranges of the classes.**

Lesson review

1. Define quantitative data.
   
   **Data consisting of a numeric count, measurement, or statistic (average, ratio, density)**

2. What is classification?
   
   **The sorting of values into sequential, non-overlapping groups**

3. Describe the Natural Breaks, Equal Interval, and Quantile classification methods.
   
   - **Natural Breaks: data clusters**
   - **Equal Interval: equal value ranges**
   - **Quantile: same number of features in each class**
Introduction

In this lesson, you will enhance your maps with labels and annotation. You will learn the differences between labels and annotation, and different ways to store annotation (in the geodatabase and in the map). You will also learn how to adjust the appearance and placement of annotation.

Topics covered

What are labels?
  ▪ Label placement, symbology, query, scale, classes, expressions, ranking, weighting

What is annotation?
  ▪ Geodatabase annotation
  ▪ Map annotation

Workflow for creating annotation from labels
Choosing the right type of map text
Learning objectives

After completing this lesson, you will be able to:

- Differentiate between labels and annotation.
- Determine when to use labels or annotation.
- Create annotation from labels.
- Differentiate between geodatabase annotation and map document annotation.
- Identify two ways of sharing annotation.
Where does map text come from?
What are labels?

- Software-generated map text based on attribute values
Dynamic label placement

Preferred label position is top right

Positions vary, but all labels fit

Mississauga and St. Catharines suppressed to avoid conflict
Placement rules for different feature types

- Points
- Lines
- Polygons

Ottawa

2 2 1
3 2
3 3 2

Prefer Top Right, all allowed

Curved and Above Line

St. Lawrence River

Horizontal

Pukaskwa National Park
Label symbology

◆ Font, size, color, more

Arial, 14-point, Bold, Purple Heart
Character spacing 25.00
White 2-point halo

More symbology options

Formatted text
◆ Case, character width, character spacing, more

Advanced text
◆ Text fill, background, more

Mask
◆ Halo

Predefined label symbols
SQL query

- Draw labels only for specified attribute values
- Example: Label only international airports

"DESCRIPT" = 'International'
Scale range

- Draw labels at specified scales
- Example: Label airports only at large scales
Label classes

- Additional sets of labels for a layer
- Typically use different symbology

Two label classes based on population
Label expressions

- Use scripting functions to format labels

![Image of map with label expressions]

Label expression:

```
[NAME]
&vbnewline &"<FNT size='8'>" &
"Population" &"</FNT>"
&vbnewline &"<CLR red='168'
green='0' blue='0'>" &
[CSD_POP01] &"</CLR>"
```

Concatenate attribute values
  - Example: [NAME] & [TYPE]

Add text to label
  - Example: "Pop:" & [POP2001]

Control format with VBScript or JScript functions
  - Examples: line breaks, round numbers

Save and load expressions
Ranks and weights

- **Ordered label classes by priority**
- **Assign weight to features and labels (in case of conflict)**

### Priority ranking
- In conflicts, higher-ranking labels are placed

### Label weight
- Controls likelihood of labels drawing on top of features
Exercise 5A: Work with labels

Estimated time: 30 minutes

Labeling is a complex process that encompasses a great deal of functionality. The display of any particular set of labels is a function of many interacting settings. Labeling also tends to be an iterative process. As you label new layers, you often go back and change symbology and placement properties set for other layers to get better results.

The placement of labels is affected not only by property settings but also by conditions of your display window—including monitor size, screen resolution, ArcMap window size, and even the number of toolbars you have open and where they are docked. If your results do not exactly match those shown or described, ask your instructor for help.

In this exercise, you will:

▪ Add labels to layers in a map.
▪ Change the label symbology.
▪ Set label placement preferences.
▪ Define the map scales at which labels display.
▪ Construct a logical expression to label only features with specific attribute values.
▪ Optionally, label line features.

Step 1: Open a map document

- Start ArcMap and open CanadaLabels.mxd from your ..\Student\DESK2\LabelsAnnotation folder.
If necessary, maximize ArcMap and zoom to the Canada bookmark so your display matches the following graphic.

The provinces are symbolized in shades of light yellow and tan.

- In the Catalog window, set Canada as your default geodatabase.
- Make sure your windows (including Catalog, Identify, and Search) are set to auto hide.

Step 2: Label the provinces

In this step, you will turn on labels for the Provinces layer. You will also see how ArcMap repositions labels on the fly as you navigate the map.

- In the table of contents, right-click the Provinces layer and choose Label Features.

Each province and territory is labeled with its name. Several are labeled multiple times because the feature consists of separate parts.

Note the positions of the labels for the eastern provinces of New Brunswick, Prince Edward Island (which may not display), and Nova Scotia (which is probably labeled twice).
Zoom to the Prince Edward Island bookmark.

The labels fit better at this scale. The New Brunswick label fits inside the province boundary (it did not before).

**Note:** The label size is 8 points. (A point is 1/72 of an inch or 1/28 of a centimeter.) As you zoom in and out, label size doesn't change.

- Click the Pan tool.
- While watching the Quebec label, pan eastward to show more of the Atlantic Ocean. Release the mouse button.
- Pan a bit farther east.

As the province pans out of view, the label keeps jumping eastward to remain visible. At times you might see more than one label.
Step 3: Remove duplicate labels

In this step, you will set your first label placement rule by telling ArcMap not to show duplicate labels.

- Zoom to the Canada bookmark.
- Open the layer properties for the Provinces layer and click the Labels tab.

Opening the Layer Properties dialog box is one way to access labeling functionality.

- On the lower left of the dialog box, click Placement Properties.
- On the Placement Properties dialog box, click the Placement tab, if necessary.
- Near the bottom of the dialog box, choose the option to remove duplicate labels.
- Click OK on both open dialog boxes.

Each province and territory displays a single label, regardless of how many parts it has.

Step 4: Change the attribute used for labels

Some of the province names are too long to fit within the province at the national extent. In this step, you will change the attribute on which the labels are based.

- Open the attribute table for the Provinces layer.
The PROV attribute contains unique two-letter designations. This is the attribute to which you will switch.

- Close the table window.
- Open the layer properties for the Provinces layer and make sure the Labels tab is still selected.
- From the Label Field drop-down list, choose PROV and click OK.

The province and territory names are replaced by two-letter codes.

**Step 5: Change label symbology**

In this step, you will begin using the Labeling toolbar. The toolbar is a more efficient interface for labeling functionality than the Layer Properties dialog box, especially when you are labeling several layers in a map.

- Click the Customize menu, point to Toolbars, and choose Labeling.

The Labeling toolbar displays.

- If you like, dock the toolbar to the ArcMap window.
- Click the Label Manager button.

![Label Manager dialog box image]
When you set labeling properties from the Layer Properties dialog box, you can only work with one layer at a time. In the Label Manager, you have access to all the layers in the map in one dialog box.

The Label Classes box on the left shows each layer in the map. Layers with check marks are labeled. Indented underneath are the layer's label classes. Each layer starts with a single label class, called Default, but you can add more. Label classes allow you to differentiate labels within the same layer. For example, if you wanted large cities to have bigger labels than small cities, you would need two label classes for the Cities layer.

- Click Options, then choose Collapse All.

You have options for managing the visibility of layers and label classes.

- Expand all the label classes.

- In the Label Classes box, click the Default label class under Provinces to select it.

This is how you specify which label class you want to work with.

- Click the Bold button. 

- Change the font size from 8 to 6 points.

- Change the color to Dark Umber (row 6, column 2).

- Click Apply and move the Label Manager away from the map display.
The labels display with their new symbology. The 6-point size might be a little too small, depending on how many other layers you plan to display and label in the map.

**Step 6: Explore placement properties for polygons**

Labels for polygon features have limited placement options. Basically, the label displays inside the polygon and ArcMap positions it as best as it can. You can choose to have the label placed horizontally or straight. ("Straight" means "at an angle corresponding to the longest axis of the polygon feature.")

- On the Label Manager, in the Placement Properties area, check the box to only place the label inside the polygon. Click OK to close the Label Manager.

The labels PE (Prince Edward Island) and NS (Nova Scotia) disappear. There is not enough room to place these labels without crossing the polygon outline.

In a heavily labeled map, it might be hard to know which labels have been suppressed. The Labeling toolbar has a tool that shows suppressed labels.

**Note:** If your labels do display, don't worry. Label placement may vary with monitor size and resolution.

- On the Labeling toolbar, click the View Unplaced Labels button.

- Look carefully to the east of New Brunswick (NB).

The suppressed labels display in red.

- Click the button again to turn off the suppressed labels.

- Open the Label Manager and uncheck the box to only place the label inside the polygon. Click OK.

**Step 7: Explore label weight ranking**

In this step, you will turn on additional layers. Then you will learn how to change weighting in order to influence labels so they do not cross features.

- Turn on the Major Cities, Rivers, Lakes, and National Parks layers.
For the exercise, you want some province labels to draw on top of features. For example, the PE label might cover the capital of Charlottetown, and the SK label might partially obscure Prince Albert National Park.

It is sometimes acceptable to have labels on top of features. Usually, however, you do not want labels from one layer to obscure features in another layer.

On the Labeling toolbar, click the Label Weight Ranking button.

Weights let you control which labels will be placed when there are potential conflicts (overlaps) between features and labels.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Feature Weight</th>
<th>Label Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;Default&gt;</td>
<td>High</td>
<td>N/A</td>
</tr>
<tr>
<td>Major Cities - Default</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>Rivers - Default</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>Lakes - Default</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>National Parks - Default</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>Provinces - Default</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>Countries - Default</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>Ocean - Default</td>
<td>None</td>
<td>High</td>
</tr>
</tbody>
</table>

In the Layer column, the layers in the map are listed. Feature weights and label weights are adjustable. As a rule, a label is not placed over a feature that has an equal or higher weight. By default, all feature weights are None and all label weights are High. This means that any layer's labels can cross any layer's features with no constraint.

For the Major Cities – Default layer, click the value in the Feature Weight column and change it from None to High.
Do the same for the following layers:

- Rivers – Default
- Lakes – Default
- National Parks – Default

<table>
<thead>
<tr>
<th>Layer</th>
<th>Feature Weight</th>
<th>Label Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;Default&gt;</td>
<td>High</td>
<td>N/A</td>
</tr>
<tr>
<td>Major Cities - Default</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Rivers - Default</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Lakes - Default</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>National Parks - Default</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Provinces - Default</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>Countries - Default</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>Ocean - Default</td>
<td>None</td>
<td>High</td>
</tr>
</tbody>
</table>

Click OK.

Some of the labels change position based on the feature weight settings.

Step 8: Add and symbolize a symbol class

In this step, you will add a second label class to the Provinces layer. This second label class will be used at larger map scales. (For now, you are creating the class; you will set the scale range in the next step.)

Open the Label Manager.
In the Label Classes box, click the Provinces layer. (Click the layer name above the label class name.)

In the Add label class area on the right, type **Large Scale** as the class name.

Click Add.

The new label class appears under the Provinces layer.

Under Provinces, right-click the Default label class and choose Rename Class.

In the Rename Label Class dialog box, type **Small Scale** and click OK.
In the Label Classes box, click the Large Scale label class.

For the moment, its properties are the same as those of the Small Scale class—it simply inherited the properties of the existing label class.

In the Text String area, change the attribute from PROV to NAME.

At small map scales, you will show the two-letter abbreviation from the PROV field. At large map scales, you will show the full province name.

In the Text Symbol area, change the size from 6 to 10 points.

Click the Bold button to undo bold text.

Click Symbol. In the Symbol Selector, click Edit Symbol.

In the Editor dialog box, click the Formatted Text tab.

Change the character spacing to 48.

Click OK on the Editor and Symbol Selector dialog boxes.
Click Apply and move the Label Manager out of the way.

Both sets of province labels display on the map. This is not yet what you want—you want the label classes to display at different scales.

**Step 9: Set scale ranges**

In this step, you will set scale ranges for the Provinces layer. When you are zoomed out, you want to see the two-letter abbreviation. When you are zoomed in, you want to see the full name.

- In the Label Manager, in the Label Classes box, click the Small Scale label class to select it. *(Hint: The label class is under Provinces.)*

- Below the Placement Properties area, click Scale Range.

- In the Scale Range dialog box, choose the Don't show labels when zoomed option.
In the In beyond box, type 15,000,000.

---

You can specify the range of scales at which labels will be shown.
- Use the same scale range as the feature layer.
- Don't show labels when zoomed:
  - Out beyond: <None> (minimum scale)
  - In beyond: 15,000,000 (maximum scale)

---

Click OK.

Click Scale Range.

In the Scale Range dialog box, click the Don't show labels when zoomed option.

In the Out beyond box, type 14,999,999. Click OK.

Click OK on the Label Manager.

This is the same way you set a scale range for the Airports layer earlier in the course.

Click OK.

The Small Scale labels (the two-letter abbreviations) will display as long as the map scale is smaller than 1:15,000,000. When the scale crosses this threshold, the labels will turn off. Now you need to set a reciprocal value for the Large Scale labels.

In the Label Classes box, click the Large Scale label class.

Click Scale Range.

In the Scale Range dialog box, click the Don't show labels when zoomed option.

In the Out beyond box, type 14,999,999. Click OK.

Click OK on the Label Manager.

Your current map scale should be somewhere around 1:20,000,000 to 1:30,000,000. Consequently, the Large Scale labels should not be displayed.

On the Standard toolbar, in the Map Scale box, type 10,000,000 and press Enter.

The map zooms in and you see the full province names, not the abbreviations.

Zoom in and out in the map to cross back and forth across your scale threshold until you're satisfied that it really works.

When you're finished, zoom to the Canada bookmark.
Step 10: Label major cities using a query

In this step, you will label the Major Cities layer using a query to filter which labels are drawn.

- Open the Label Manager.
- In the Label Classes box, check the box next to the Major Cities layer to turn on its labels.
- Click the Default label class under Major Cities to select it.

In the Placement Properties area, notice the placement diagram.

```
2 2 1
3 2
3 3 2
```

ArcMap tries to place labels above and to the right of point features (position 1). If this position is ruled out, it will try positions marked 2. As a last resort, it will try positions marked 3.

- In the Text String area, make sure the label field is set to NAME.
Click OK on the Label Manager.

Your results might be slightly different, but you should see a number of labeled cities, as well as some cities without labels.

Click the View Unplaced Labels button.

The Toronto and Vancouver areas are crowded with unplaced labels. There are so many that you might decide to have only capital cities labeled on the map. You can accomplish this with a query, like the one you used on the Airports layer earlier in the course.

Click the View Unplaced Labels button again to hide the unplaced labels.

Open the Label Manager.

Below the Placement Properties area, click SQL Query to open the SQL Query dialog box.

In the box at the top, double-click "CAPITAL".

The field name is added to the expression box at the bottom.
In the middle of the dialog box, click the Equals operator \[=\].

Click Get Unique Values, then double-click 'Y'.

Confirm that your expression matches the following graphic. If it doesn't, highlight the expression, delete it, and build the expression again.

```
SELECT * FROM Mcties WHERE:
"CAPITAL" = 'Y'
```

Click OK. Click Apply in the Label Manager and move the Label Manager out of the way.

Only the capital cities are labeled.

It is possible that not all the capital labels are displayed. For example, the Toronto label might not be displayed. This is a result of the label placement rules, not your query. You will adjust the rules so that all capitals display. First, however, you will set the desired label symbology.

**Step 11: Choose label symbology for major cities**

- In the Label Manager, in the Text Symbol area, change the text color to Gray 60% (row 7, column 1).

- Change the font size to 8.25.

- Make the text bold.

- Click Symbol.

- On the Symbol Selector, click Edit Symbol.

- On the Editor dialog box, click the Mask tab.

- Change the mask style to Halo.

- Change the halo size to 1.

- Click OK on all open dialog boxes, including the Label Manager.
Click the View Unplaced Labels button.

It is possible that you have no unplaced labels. However, it is likely that your Toronto label is suppressed, and perhaps the labels for Edmonton and Fredericton, as well.

1. What is the probable reason why some of the city labels are suppressed?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Click the View Unplaced Labels button again to hide unplaced labels.

If you have unplaced labels, continue to the next step. If you do not have any unplaced labels, skip the next step.

Step 12: Adjust label weight ranking

In this step, you will change the label weight rankings to make sure that labels for all the capitals display.

- On the Labeling toolbar, click the Label Weight Ranking button.
- Change the feature weight for Lakes – Default from High to Medium.
- Click Apply and move the dialog box out of the way.

If the Toronto label still does not display, change the feature weight to Low, or even to None, if necessary.

- Make similar adjustments to feature weights in any other layers that might be causing labels not to display.

It may be hard to get all the labels to display. If so, you can move to the next step—the point is to see that you can adjust label display by altering feature weights.

- When you are finished, click OK on the Label Weight Ranking dialog box.
Step 13: Explore placement properties for points

In this step, you will experiment with changing the preferred positions for placing labels next to point features.

- Open the Label Manager.
- In the Label Classes box, make sure the Default label class under Major Cities is highlighted.
- In the Placement Properties area, click Location.

The Initial point placement dialog box opens, showing different placement priority diagrams. The default is Prefer Top Right, all allowed.

- Scroll up and click Right Only, Prefer Bottom.
- Click OK on the Initial point placement dialog box.
- Click Apply on the Label Manager and move it away from the map.

The placement of several labels changes. Some labels might no longer display now that several positions are prohibited.

- Click Location again and change the placement properties back to Prefer Top Right, all allowed.
- Click OK on both open dialog boxes.
Click the Customize menu, point to Toolbars, and click Labeling to close the Labeling toolbar. (Tip: Another option is to right-click the Labeling toolbar, then click Labeling.)

If you would like to label line features, go on to the optional next step. Otherwise, save the map document in your ..\Student\DESK2\LabelsAnnotation folder as MyCanadaLabels and close ArcMap.

Step 14: (Optional) Experiment with labeling line features

Labeling lines, especially curved or irregular ones like rivers, can be trickier than labeling points or polygons. Should you use duplicate labels along the length of the line? If not, where should the label be placed? Should the label follow the curve of the line, or does that make the text hard to read? In this step, you will explore some of the label properties for line features. You will also use the third way of accessing labeling functionality—through the data frame context menu.

In the table of contents, right-click the Rivers layer and choose Label Features. (Tip: You can right-click and label features in the table of contents when you have chosen to list your layers by Drawing Order, by Source, or by Visibility.)

The river labels display with default properties. Not all the rivers are labeled.

At the top of the table of contents, right-click the data frame name (Layers), point to Labeling, and choose Label Manager.

The context menu tools access the same functionality as the Labeling toolbar.

In the Label Classes box, click the Default label class under Rivers to select it.

In the Text Symbol area, click Symbol to open the Symbol Selector.

In the Symbol Selector, click Referenced Styles and search for River.

Click River, then click OK on the Symbol Selector.
Click Apply on the Label Manager and move it away from the map.

On the Label Manager, in the Placement Properties area, under Position, the check box for Above is checked. This constrains labels to be placed "above" the river feature. (You will see what this means in a moment.)

In the Placement Properties area, under Position, check the boxes for the On the line and Below positions, so that all three check boxes are checked.

Click Apply and move the Label Manager out of the way.

Now that labels can be placed on either side of the line (or directly on it), you should see some labels appear that were not placed before. Some other labels should move to better positions.

On the Label Manager, click Properties. In the Placement Properties dialog box, click the Placement tab, if necessary.

In the Position area, notice that the Orientation System drop-down list is set to Page. The settings Above and Below mean that the label appears above or below the line relative to the top of the page. (The graphic on the dialog box illustrates the meaning.)

Change the orientation system to Line.

This setting orients labels according to the digitized direction of the line rather than according to the page.

Click Cancel on the Placement Properties dialog box.

On the Label Manager, in the Placement Properties area, change the orientation from Parallel to Curved.

Uncheck the boxes for the On the line and Below positions, so that only the Above box is checked.

Click OK on the Label Manager.
Now the label text follows the shape of the feature.

- If you would like to add a label expression, go on to the optional next step. Otherwise, save the map document in your ..\Student\DESK2\LabelsAnnotation folder as MyCanadaLabels and close ArcMap.

**Step 15: (Optional) Add a label expression**

What if you want to use the same label expression for several layers, even layers that reside in other maps? One way to do that is to use a label expression that has been saved to a file.

- Open the Label Manager.

- Make sure that labeling for Major Cities is turned on and that the Major Cities Default class is selected.

- Click Expression.

- Place your cursor in the Expression area, select [NAME], then press the Delete key on your keyboard.

- Click Load and navigate to your ..\Student\DESK2\LabelsAnnotation folder and expand the folder.

- Select Expression.lxp then click Open.

Prewritten VBScript code is added to the expression. The code will set the font to Arial, make the color blue, and make the font bold for the NAME attribute. In addition the code will place the Province name on a separate line.

- Click Verify to view a sample label. *(Tip: Place your cursor in the Expression window to activate the Verify button.)*

- Click OK on the Expression Verification dialog box and again on the Label Expression dialog box.

- Click OK on the Label Manager.

Labels display using the formatting in the label expression.

- Close the labeling toolbar.

- Save your map document.
Close ArcMap.
What is annotation?

- **User-generated map text**
- **Placement controlled by user**

- Behaves differently from labels
- May not be directly related to features (e.g., in the above graphic, Hudson Bay is not a feature in a layer—its shape is created by the surrounding provinces)
- May be converted from labels
- Can be selected, moved, and edited
- Two types:
  - Geodatabase annotation
  - Map annotation
Geodatabase annotation

- Stored in geodatabase
- Edited with editing tools

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>AdminBnd</td>
<td>File Geodatabase Feature Class</td>
</tr>
<tr>
<td>CanadaMuni</td>
<td>File Geodatabase Feature Class</td>
</tr>
<tr>
<td>Cntry07</td>
<td>File Geodatabase Feature Class</td>
</tr>
<tr>
<td>GreatLakes</td>
<td>File Geodatabase Feature Class</td>
</tr>
<tr>
<td>Mjcities</td>
<td>File Geodatabase Feature Class</td>
</tr>
<tr>
<td>A:ProvincesAnno</td>
<td>File Geodatabase Feature Class</td>
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<td>RegionalMuni</td>
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<td>File Geodatabase Feature Class</td>
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</table>

<table>
<thead>
<tr>
<th>OBJECTID</th>
<th>SHAPE</th>
<th>Status</th>
<th>TextString</th>
<th>FontName</th>
<th>FontSize</th>
<th>Bold</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Polygon</td>
<td>Placed</td>
<td>Québec</td>
<td>Arial</td>
<td>7</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Polygon</td>
<td>Placed</td>
<td>Ontario</td>
<td>Arial</td>
<td>7</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Polygon</td>
<td>Placed</td>
<td>Alberta</td>
<td>Arial</td>
<td>7</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Polygon</td>
<td>Placed</td>
<td>Nunavut</td>
<td>Arial</td>
<td>7</td>
<td>No</td>
</tr>
</tbody>
</table>
Map annotation

◆ Stored in map
◆ Managed through data frame properties

- Graphic elements, not features
- Created and edited with Draw toolbar tools
Creating annotation from labels

Labels

Annotation

Map document
Use in one map

Geodatabase
Use in many maps
Choosing the right type of map text

Best practice: Choose labels or annotation based on your needs

Labels
- Fast results, fairly customizable
- Best for interactive maps and work in progress

Annotation
- Maximum control over text placement and appearance
- Best for final map output
- Often converted from labels
- Geodatabase annotation
  - Best for reusability or many text pieces
- Map annotation
  - Best for once-only maps or fewer text pieces

Test for understanding

For each situation, circle the most appropriate type of map text.

1. You want to quickly add all the city names to your map.
   (Labels) (Geodatabase annotation) (Map annotation)

2. You want to describe particular features, like a mountain range, or add general information to your map.
   (Labels) (Geodatabase annotation) (Map annotation)

3. You want to add a few pieces of text manually to describe an area on your map.
   (Labels) (Geodatabase annotation) (Map annotation)
4. You want to derive text from attributes, then control the appearance and placement of individual pieces of text.
   (Labels) (Geodatabase annotation) (Map annotation)

5. You want to reuse text in more than one map.
   (Labels) (Geodatabase annotation) (Map annotation)
Exercise 5B: Work with annotation

Estimated time: 30 minutes

In this exercise, you will create geodatabase and map document annotation. The main difference between annotation and labeling is that annotation placement is controlled by the user and does not update with changes to the scale or extent of the map.

Geodatabase annotation is essentially a feature class of text. It is stored on disk and can be added to any map document. Map document annotation, on the other hand, is essentially a collection of graphics stored in the map. Both geodatabase and map document annotation can store graphic shapes, such as rectangles or circles, as well as text.

As in the previous exercise, it is possible that your results will not exactly match those shown or described. If necessary, ask your instructor for help.

In this exercise, you will:

▪ Convert labels into annotation in a geodatabase.
▪ Examine geodatabase annotation.
▪ Explore the reference scale of geodatabase annotation.
  Create and manage annotation in the map.

Step 1: Open a map document

☐ Start ArcMap and open CanadaAnno.mxd from your ..\Student\DESK2\LabelsAnnotation folder.
If necessary, maximize ArcMap and zoom to the Canada bookmark so your display matches the following graphic.

You see a map of Canada with cities, parks, lakes, and rivers. Provinces and cities are labeled.

Make Canada your default geodatabase.

**Step 2: Convert labels to geodatabase annotation**

In this step, you will convert the Major Cities labels to annotation in a geodatabase. It is a common practice to start working with labels (because labels are convenient), then later convert them to annotation.
In the table of contents, right-click the Major Cities layer and choose Convert Labels to Annotation.

You will accept all the default settings.

**Note:** You can also create annotation that is saved in the map. You will learn how to do that later.

Note the reference scale setting in the upper-right of the dialog box and write it down.

Reference scale setting: ________________________

Your value might be different from that shown in the preceding graphic. You will explore the meaning of this parameter later in the exercise.

Click Convert.

When the conversion is finished, the map looks the same, but a change has occurred—the city labels have been replaced by annotation. A new layer called Major_CitiesAnno has been added at the top of the table of contents.

In the table of contents, turn the Major_CitiesAnno layer off and on.

The visibility of geodatabase annotation is controlled in the same way as other layers.
Step 3: Examine an annotation feature class

In this step, you will view the annotation feature class in the Catalog window.

- In the Catalog window, from your Home – DESK2\LabelsAnnotation directory, expand the Canada geodatabase.

Major_CitiesAnno displays in its alphabetical position.

- In the table of contents, turn off all layers. (*Hint: Right-click the Layers data frame.)
- Turn on Major_CitiesAnno.

The layer displays like any other feature class, except that the "features" are pieces of text.

- Open the Major_CitiesAnno attributes table and scroll through the attributes.

Geodatabase annotation has a Shape field and is a polygon feature class. Most of the other attributes store text properties—similar to the kinds of properties you set in the Label Manager for labels.

- Hide the Table and Catalog windows.
- Turn on all layers.

**Note:** Like other feature classes, geodatabase annotation can be edited. You will learn more about editing in a later lesson.

Step 4: View the effect of reference scale

Unlike other feature classes or layers, geodatabase annotation has a built-in reference scale. The defined font size and spacing properties hold true at the reference scale but change proportionally as you zoom in or out.
The annotation for the cities is now very large. The province labels are not correspondingly enlarged. Annotation has a reference scale because it is designed for use at an exact scale, unlike labels, which are meant to be serviceable at all scales.

- Zoom to the Canada bookmark.

**Step 5: Create map document annotation**

In this step, you will create map annotation for the Great Lakes region between Canada and the United States. The Great Lakes region is not a feature in any of the layers in your map, so there is no way to generate a label for it.

- Turn on the Draw toolbar (*Hint: from the Customize menu*).

- If you'd like, dock the Draw toolbar.
On the Draw toolbar, click the New Text tool \textbullet{}. 

\textbf{Note:} There are several tools that allow you to create map annotation. You can click the drop-down arrow to view them all.

- Place your mouse pointer anywhere over the Great Lakes area and click to open a text box.
- In the text box, type \textbf{Great Lakes} and press Enter.

The map annotation is created with the default properties on the Drawing toolbar (probably Arial, 10-point, black).

- On the Draw toolbar, make sure the Select Elements tool \textbullet{} is selected.
- Click the Great Lakes text (or drag a box around it) to select it.

The text is surrounded by a light blue, dashed line.

- Right-click the selected text and choose Properties.
- On the Properties dialog box, click the Text tab, if necessary.
In the lower right of the dialog box, click Change Symbol to open the Symbol Selector.

Next, you will search for a suitable symbol.

In the Symbol Selector, search for Lake. (Hint: In the text box near the top of the Symbol Selector, type Lake and then click Search.

No symbols match the search criteria. However, in a previous lesson, you found a symbol for river, so there must be other symbols for water features.

Search for Sea.

Below the ESRI label, select Sea, then click OK.

Click the Center button to center the text.

The centering effect is not visible in the text box, but you will see it on the map.

Click OK.

Drag the selected text to a position that looks good to you.

Click anywhere off the text to deselect it.

Step 6: Manage map document annotation

Map document annotation can be placed in groups to make it easier to manage. Annotation groups can be turned on and off as a unit, made to turn on and off in concert with particular layers, or assigned scale ranges and reference scales. By default, all map annotation goes into a single group, called <Default>. However, you might decide to put annotation for water bodies into one group, for example, and annotation for mountain ranges into another.

Hold down the Ctrl key on your keyboard and turn off any layer in the table of contents.

All layers turn off. Nothing is visible in the map except the Great Lakes map annotation. By default, map annotation is not associated with any layer.

Hold down the Ctrl key on your keyboard again and turn on any layer.

All the layers are turned on.

In the table of contents, right-click the Layers data frame and choose Properties.

In the Data Frame Properties dialog box, click the Annotation Groups tab.
All annotation groups are listed. In this case, there is only the <Default> annotation group.

- Uncheck the box next to <Default> to turn off this annotation group.
- Click Apply and move the Data Frame Properties dialog box out of the way.

The Great Lakes annotation is no longer visible.

- Check the <Default> box and click Apply to turn on the annotation again.
- Click OK on the Data Frame Properties dialog box.
- Turn off the Draw toolbar.
- Save the map document as MyCanadaAnno in your ..\Student\DESK2\LabelsAnnotation folder.
- If you would like to work the following optional step that converts labels into map document annotation, you may do so now.
- Otherwise, close ArcMap.

**Step 7: (Optional) Convert labels to map document annotation**

In this step, you will convert your two-character province labels to map annotation so that you can adjust their positions.

- Make sure your reference scale setting is set to the value in an earlier step in this exercise.
- In the table of contents, right-click the Provinces layer and choose Convert Labels to Annotation.
On the Convert Labels to Annotation dialog box, choose the option to store annotation in the map.

Accept all other defaults.

Click Convert.

The Overflow Annotation window may appear.

If an Overflow Annotation window appears, right-click the first entry and choose Add Annotation.

The annotation is placed in its appropriate location, though it may overlap other annotation.
If there are other entries in the Overflow Annotation window, add them in the same way, then close the window.

- Open the data frame properties and click the Annotation Groups tab.

<table>
<thead>
<tr>
<th>Group Name</th>
<th>Associated Layer</th>
<th>Reference Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Default)</td>
<td>(n/a)</td>
<td>(None)</td>
</tr>
<tr>
<td>Provinces Anno Provincial</td>
<td>1:30,160,147</td>
<td></td>
</tr>
</tbody>
</table>

There are two annotation groups in the map:
- A default annotation group, which is empty
- The annotation group you just converted, which has an associated layer and reference scale

A reference scale links the specified text size (for example, 9 points) to a map scale. If the map scale changes, the text gets bigger or smaller. Geodatabase annotation has a reference scale that cannot be changed—it is meant to be used with maps whose output scale has already been decided. Map annotation may not have a reference scale.

**Note:** You can assign or remove reference scales for annotation groups on the data frame properties.

- Click next to ProvincesAnno to uncheck it, then click Apply.

- Move the Data Frame Properties dialog box to the side.

Your annotation is turned off but you can manage the visibility of map annotation in the data frame properties.

- Turn on ProvincesAnno, then click OK on the data frame properties.

Your map document annotation displays, which you can place wherever you want.

- Select annotation for one or more of the provinces, and move it where you’d like.
- Save your work.
- Close ArcMap.
Lesson review

1. Fill in the table below with the appropriate answers.

<table>
<thead>
<tr>
<th></th>
<th>Labels</th>
<th>Geodatabase annotation</th>
<th>Map annotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where is text managed?</td>
<td>-Layer properties</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Attribute table</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How is text placement managed?</td>
<td>By the user, in an edit session</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How is text position defined?</td>
<td>Position is fixed; determined by the user</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can text be shared or reused?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Answers to Lesson 5 questions

Exercise 5A: Work with labels

1. What is the probable reason why some of the city labels are suppressed?

   Because their placement is constrained by label weight rankings. Earlier, you set the weights for the Lakes layer and the Rivers layer too high. Toronto is more or less surrounded by the Great Lakes, and Edmonton lies on the Saskatchewan River. These labels cannot be placed if it means covering a feature.

Choosing the right type of map text

1. You want to quickly add all the city names to your map.
   (Labels) (Geodatabase annotation) (Map annotation)

   **Labels**

2. You want to describe particular features, like a mountain range, or add general information to your map.
   (Labels) (Geodatabase annotation) (Map annotation)

   **Map annotation**

3. You want to add a few pieces of text manually to describe an area on your map.
   (Labels) (Geodatabase annotation) (Map annotation)

   **Map annotation**

4. You want to derive text from attributes, then control the appearance and placement of individual pieces of text.
   (Labels) (Geodatabase annotation) (Map annotation)

   **Geodatabase annotation**

5. You want to reuse text in more than one map.
   (Labels) (Geodatabase annotation) (Map annotation)

   **Geodatabase annotation**
Lesson review

1. Fill in the table below with the appropriate answers.

<table>
<thead>
<tr>
<th>Where is text managed?</th>
<th>Labels</th>
<th>Geodatabase annotation</th>
<th>Map annotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Layer properties</td>
<td>Annotation feature class inside geodatabase</td>
<td>Map document</td>
<td></td>
</tr>
<tr>
<td>-Attribute table</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How is text placement managed?</td>
<td>By software</td>
<td>By the user, in an edit session</td>
<td>By the user, manually</td>
</tr>
<tr>
<td>How is text position defined?</td>
<td>Dynamically, by the software</td>
<td>Position is fixed; determined by the user</td>
<td>Position is fixed; determined by the user</td>
</tr>
<tr>
<td>Can text be shared or reused?</td>
<td>Yes, as layer file</td>
<td>Yes, as annotation feature class</td>
<td>No; part of map document</td>
</tr>
</tbody>
</table>
Making a map layout

Introduction

In this lesson, you will learn how to create map layouts. So far, you have only worked in data view. In this lesson, you will work in layout view, where you create page layouts and work with layout tools. You'll discuss issues you should consider before creating a map layout. You'll review the common elements used in map layouts, and learn to use some of the tools for creating and arranging map elements.

Topics covered

- Map content considerations
  - (P) Purpose,(S) Situation,(A) Audience
- Map elements
  - Arranging map elements
- Layout view versus data view
- Data frame properties
- Exporting maps
Learning objectives

After completing this lesson, you will be able to:

▪ Discuss the basic elements needed for a map layout.
▪ Add map elements to a layout.
▪ Modify the properties of map elements.
▪ Add graphic text to the layout.
Map content considerations

Purpose
- Design should support map's purpose

Situation
- Design should support viewing situation
  - Map medium (paper, computer screen, other)
  - Map size

Audience
- More complexity and detail for expert audience
What is the purpose, situation, and audience?

Look at the map below. Can you describe the purpose, situation, and audience?
Data view vs. layout view

Data view

- Used to add, organize, symbolize, and prepare data

Layout view

- Used to design complete map
- Arrange data frames on a virtual page
- Add map elements (e.g., title, legend, scale bar)
- Adjust map scale and extent
Legend and scale bar

- **Legend based on map layers**
- **Scale bar based on map scale**

Legend

- Linked to table of contents
- Includes layers as needed
- Updates with changes to table of contents
- Uses predefined styles or is customizable

Scale bar

- Updates with changes to map scale
- Uses predefined styles or is customizable
Other map elements

- Text, graphics
- North arrows
- Pictures
- Graphs, reports
Arranging map elements

- Rulers, guides, grid, margins

- Resize
- Arrange:
  - Group, align, order (front-to-back), and more
Data frame properties for layouts

- **Border, background, shadow**
- **Grid or graticule**

Data frames clipped to custom shapes.
Exporting maps

- Export to common formats
- Add to other documents

Note: Supported formats—for a complete list of map export formats, search for this topic in ArcGIS 10 Help: Exporting your map
What if you want to update or reuse a map?

Workflow for reusing a map

1. Save your map as another map document (*.mxd).
2. Give your new map a unique name.
3. Make the map read-only.
4. Create a directory with higher read-only privileges for storing templates for your organization or working group.

Depending on the number of maps you need to manage, the last step may be optional.
Exercise 6: Making a map layout

Estimated time: 40 minutes

Most of your work in ArcMap is performed in data view. This is where you add layers, symbolize them, label them, set layer properties, and choose a coordinate system. This work is usually preparation for an eventual output: a printed map, an online map, or an image of a map embedded in a report or document. Besides the data itself, a map needs supplemental information to give it context: a legend, a scale bar, a title, text, and perhaps pictures, graphs, or tables. These elements are added in layout view.

In this exercise, you will:

▪ Switch between data view and layout view.
▪ Set properties to structure your layout space.
▪ Set data frame size and position.
▪ Freeze the map scale.
▪ Insert title, legend, scale bar, and text elements.
▪ Adjust map annotation placement.
▪ Export your map to a file.

Step 1: Open a map document

☐ Start ArcMap and open CanadaMap.mxd from your ..\Student\DESK2\MapLayout folder.
If necessary, maximize your window and zoom to the Canada bookmark.

The map shows capital cities, other major cities, large bodies of water, and national parks. Provinces and cities are labeled. There is also map annotation for seas and bays (Beaufort Sea and so on) that is not associated with any map layer.

Save the map document in your ..\Student\DESK2\MapLayout folder as MyCanadaMapLayout.

Now that you have saved your map document, you can save your work as you go along.

Step 2: Switch to layout view

In this step, you will switch from data view to layout view and compare layout view navigation tools with data view navigation tools.
- From the View menu, choose Layout View.

When you switch to layout view, the Layout toolbar displays automatically.

- If you like, dock the Layout toolbar.

In layout view, you see the data frame placed against a representation of the output page, called the virtual page. The extent and scale of the map have changed. The default portrait orientation of the page is probably not ideal for Canada.
Step 3: Set page properties

In this step, you will change the map orientation from portrait to landscape.

- From the File menu, choose Page and Print Setup.
- In the Page area toward the bottom of the dialog box, change the orientation from Portrait to Landscape.

- Accept the other default settings and click OK.

The virtual page now has a landscape orientation.

Step 4: Set rulers and guides

You need to adjust the size of the data frame as well as the extent of the map. First, you will set some page layout properties to help you position map elements exactly where you want.

- In the lower-left of the display area, make sure Layout View is enabled.

- From the Customize menu, choose ArcMap Options.
- On the ArcMap Options dialog box, click the Layout View tab and change the units from inches to centimeters.
- In the Snap elements to area, check the box for Guides.
Confirm that your dialog box matches the following graphic.

Click OK.

In the map layout, the rulers now show centimeters rather than inches. The page dimensions are about 21.5 centimeters high (shown on the left vertical ruler) by 28 centimeters wide (shown on the top horizontal ruler).

Place your mouse pointer anywhere over the left vertical ruler, then right-click and choose Set Guide.

A light blue line appears running horizontally across the page. This guide can be used to align map elements. It does not print.

Hold your mouse pointer over the white arrow that marks the guide position.

When the mouse pointer changes to a two-headed arrow, click and drag the guide to the 19-centimeters position. Hint: As you drag, pay attention to the tip in the upper-left corner of the display area showing the guide's position.
Set another guide at the 1-centimeter position on the vertical ruler.

On the top horizontal ruler, set guides at the 1- and 26-centimeter positions.

Step 5: Resize the data frame

In this step, you will resize the data frame using the guides.

If necessary, on the Tools toolbar, click the Select Elements tool.

Click the data frame on the virtual page to select it. (Hint: The data frame contains the map.)

The data frame is surrounded by a dashed blue line and has selection handles at its corners and midpoints.

Click and drag the data frame so that its upper-left corner aligns with the intersection of the guides (19, 1) in the upper-left corner of the virtual page.

The data frame snaps to the guides when it gets close to them.
Place your mouse pointer over the selection handle in the lower-right corner of the data frame. When it changes to a two-headed arrow, click and drag the handle to the intersection of the guides (1, 26) in the lower-right corner of the virtual page.

Click anywhere outside the virtual page to deselect the data frame.

**Step 6: Zoom in on the data and freeze the map scale**

In this step, you will adjust the scale and extent of the map and lock them to prevent accidental changes. Your map is probably already zoomed to the right location, but you should still make sure.

- Zoom to the Canada bookmark.
- On the Standard toolbar, change the map scale value up or down to the nearest even million.
- Confirm that all of Canada is still included in the map extent. If necessary, pan using the Pan tool on the Standard toolbar to hide the white space at the north pole.
- Click outside the data frame to deselect it.
Open the data frame properties and click the Data Frame tab.

In the Extent area, click the drop-down list and choose the Fixed Scale option.

**Note:** Your scale may differ.

Click OK.

On the Tools toolbar, the zoom tools have been disabled. Your map scale is locked and cannot be changed accidentally.

**Note:** Bookmarks are not disabled.

The navigation tools on the Layout toolbar are not disabled. This is because they change the page magnification, not the map scale.

On the Layout toolbar, click the Zoom to 100% button.

The map now displays at its actual output size. This is useful for evaluating the size of text and features, although it prevents you from seeing the entire map at once.

On the Layout toolbar, click the Zoom Whole Page button.

You now see the entire map, but at a reduced size. The ratio of the display size to the output size is shown in the Zoom Control box on the Layout toolbar.

**Step 7: Move map annotation**

Most of your map text is well placed, but you may be able to find better positions for some text. In this step, you will adjust the placement of annotation as needed.

Look at the map annotation for the water areas.
You should see the text for Hudson Bay approximately in the middle of your display. The text for Hudson Bay should probably be moved down toward the middle of the bay.

- Look at the map annotation for the province and territory abbreviations.

Are there any you would like to center or move to less crowded positions?

**Note:** The city names are labels, not annotation, and therefore cannot be moved.

In layout view, you are not able to select annotation until you focus the data frame. Data frame focus is a state in which ArcMap allows you to move annotation or add new annotation to the map. By default, the data frame is not in focus, which safeguards you against moving text by mistake.

- On the Tools toolbar, confirm that the Select Elements tool is selected.

You will first confirm that, by default, you cannot select annotation in layout view.

- Try to select the Hudson Bay text.

You are unable to select the text.

- On the Layout toolbar, click the Focus Data Frame button.
- Select the Hudson Bay text.

The selected annotation is surrounded by a dashed blue line.

- Drag the selected annotation slightly to the south. (The exact position doesn't matter.)
- On the Layout toolbar (not the Tools toolbar), click the Fixed Zoom In button twice.
- On the Layout toolbar, click the Pan tool.
- Pan to any province or territory whose two-letter abbreviation you would like to move.
- On the Tools toolbar, click the Select Elements tool. Select and move the annotation to the place you want.
- Continue this process until you are satisfied with the annotation placement.
When you are finished, on the Layout toolbar, click the Zoom Whole Page button.

When the data frame is in focus, it is surrounded by a diagonal hashed black line.

Click the Focus Data Frame button to take the data frame out of focus.

Using the Select Elements tool, click outside the virtual page to deselect any selected annotation.

In the next few steps, you will add some standard map elements to your map. These elements will give the map reader a better understanding of the data that displays in your map.

Save your map.

**Step 8: Insert a title**

Next, you will add elements to your map.

From the Insert menu, choose Title.

A text box with highlighted text is added to the top of the map.
Double-click the text to open the Properties dialog box.

On the Text tab, replace the text with **Capitals and Major Cities of Canada**.

Click Change Symbol.

On the Symbol Selector, choose a color, font, size, and style that you like.

There are no constraints except your own taste, but you should probably use most of the available space above the data frame and avoid eccentric fonts and clashing colors. For reference, in the next graphic, the font is Arial, 40 point, bold. Your font size and depth or shade of color may differ from the text shown here.

Click OK on the Symbol Selector and on the Properties dialog box.

Drag the title to an appropriate position, such as approximately centered above the data frame.

Right-click the title, point to Align, and choose Align to Margins.

Nothing has happened yet. Align to Margins is a state that you toggle on or off.

Right-click the title again, point to Align, and choose Align Center.
Deselect the title.

Save your map.

**Step 9: Insert a legend**

Adding a legend is a multistep process completed through a wizard. A legend explains the map symbology and may include an item for every layer in the map. In this step, you will create a simple legend.

From the Insert menu, choose Legend.

The Legend Wizard opens. In the Map Layers box on the left, you see all the layers in the map (group layers are shown in gray). In the Legend Items box on the right, you choose the layers you want to include in the legend. By default, all layers are present.
In the Legend Items box, click Rivers to select it. Hold down the Ctrl key and click Lakes, Provinces, Countries, and Ocean to select them as well.

Click the left arrow button to remove the selected items from the legend.

The map reader should be able to interpret these features without a key.

Click Next to advance to the next panel.

Some maps require a title that can be displayed with a specific font or color. You map is relatively simple and will not need a title, so you can skip this panel of the legend wizard.

In the Legend Title area, select and delete the default legend title, Legend.

Click Next.

Click Next to skip past the legend frame panel.

Legends display a symbol patch to represent line and polygon features in the map. You have the option to modify the color of the patch for your National Parks layer but you will accept the default green that displays in the table of contents.

Click Next again to skip past the legend symbol patch panel.

On the final panel, click Finish to add the legend to the map.

It may seem that you did not spend enough time designing the legend. It often works better, however, to add the legend quickly and then modify it after you see it on the map.
Drag the selected legend to the lower-right corner of the map.

Note: The legend can overlap Canada for now. You will resize it in the next step.

Often, the legend and other important map elements are placed outside the data frame, not inside it. In this case, however, the shape of Canada leaves usable space in the geographic corners of the map.

Save the map.

Step 10: Modify the legend

In this step, you will modify legend properties. You will also make changes to the table of contents and see that they are updated automatically in the legend.

Right-click the legend to select it and choose Properties.

On the Legend Properties dialog box, if necessary, click the Legend tab.
You will make the legend patch (the green rectangle) used for National Parks features smaller.

- In the Patch area, change the width to 15 pt and the height to 10 pt.
- Click OK.
- In the table of contents, under the Major Cities layer, click the label "Over 500,000" to select it, then click again to make it editable.

![Major Cities Layer]

- Replace the text with **Cities over 500,000** and press Enter.

In the legend, the text is updated to match.

**Note:** Changes made to a symbol in the table of contents are also reflected in the legend.

- Change the label "325,000 to 500,000" to **Cities over 325,000**.
- If necessary, select the legend.
- Place your mouse pointer over a selection handle, then click and drag to shrink the legend to about two-thirds its current size.
- Right-click the legend and open its properties.
- Click the Frame tab.
- In the Border area, choose 1.0 Point from the main drop-down list.
- Click the color square and change the color to Larkspur Blue (row 10, column 9).

This matches the color of the seas annotation.
To put space between the legend text and the border, change the X gap to 5 and the Y gap to 5.

Click OK.

If you like, reposition the legend in the corner.

Click outside the virtual page to deselect the legend.

Save the map.
Step 11: Insert a scale bar

Next, you will add a scale bar to your map. Some maps may not need a scale bar if distance is not important. However, scale bars provide a visual indication of the size of features and distance between features on the map. A scale bar is a line or bar divided into parts and labeled with its ground length. If the map is enlarged or reduced, the scale bar remains correct.

- From the Insert menu, choose Scale Bar.
- On the Scale Bar Selector, click Alternating Scale Bar 1.
- Click Properties.
- On the Scale Bar dialog box, make sure the Scale and Units tab is selected.
- In the Scale area, below When resizing, click the drop-down list and change the setting to Adjust number of divisions.

At the top of the dialog box, the Division value becomes enabled and displays a default value based on the units, meters by default.

- In the Units area, click the Division Units drop-down list and change the division units to kilometers.

**Note:** Scale bars update automatically in response to changes in map scale; they also update if they are manually resized. The resizing options give you different ways to control how the updating is managed. You can have the width of the bar change, or the number of divisions within the bar, or the ground unit distance represented by each division.

- Change the division value to 2000 km.
- Make sure the Gap is set to 3 pt.

- Click Apply.

- Click the Format tab.

- In the Bar area, click the color square and change the color to Larkspur Blue (row 10, column 9).

- Click OK, then click OK on the Scale Bar Selector.

- Drag the scale bar down toward the bottom of the map and place it over some of the gray space of the United States.

One way to resize the scale bar manually is to drag a selection handle. You can also specify dimensions or percentages of the current size.
Right-click the scale bar and choose Properties.

On the Alternating Scale Bar Properties dialog box, click the Size and Position tab.

In the Size area, check the As Percentage check box.

Change the height from 100% to 75%.

Confirm that your dialog box matches the following graphic.

- Click OK.

The scale bar is resized.

Adjust the position of the scale bar if you want, then deselect it.

**Step 12: Insert text**

In this step, you will add text to identify the map scale.

- From the Insert menu, choose Text.

A small text box with highlighted text is added to the middle of the map.
Replace the text with **Scale 1:30,000,000** (or whatever your map scale is) and press Enter.

**Note:** If the text is too small:
- On the Layout toolbar, click the Fixed Zoom In button, or
- Click away from the text to show it with the surround dashed line, then double-click the text to open the Properties dialog box.

From the Customize menu, point to Toolbars, then choose Draw.

On the Draw toolbar, click the Font Size drop-down arrow and change the size to 8.

Drag the text element to a position slightly above the scale bar.

Hold down the Shift key on your keyboard and select the scale bar.

Right-click the scale bar, point to Align, and click Align to Margins to toggle it off.

You want to align the two elements to each other but not to the margin of the page.

Right-click the scale bar again, point to Align, and choose Align Left.

The two elements are aligned.

**Note:** The last selected element defines the alignment position.

Deselect the selected elements.

If necessary, zoom to whole page.

**Step 13: Insert text for the map projection and current date**

In this step, you will add text to identify the map projection. You will also add your name and the date to the map.

From the Insert menu, choose Text.

Deselect the text, then double-click Text to open its properties.

Type **Albers Equal Area Conic projection** and then click OK.

On the Draw toolbar, change the font size to 8.
The text is long, so you will put it on two lines.

- Right-click the text element and choose Properties.
- On the Properties dialog box, on the Text tab, place the cursor just before the word "Conic."
- Press Backspace to remove the space.
- Press Enter.
- Click the Align Text Right button \( \text{align text right} \) to right-justify the text. (It does not justify in the dialog box, but it will in the map.)
- Click OK.
- Move the selected text to the right side of the map.
- Right-click the selected text and choose Copy.
- Right-click anywhere on the map and choose Paste.

A copy of the text element is created and selected.

- Drag the new text element slightly below the one that you copied.
- Open its properties.
- Delete the existing text.
- Type Map by, press Enter, and then type your name.
- Click OK.

Next, you will add today's date as dynamic text.

- From the Insert menu, point to Dynamic Text, then click Current Date.
- If you like, adjust the text position of the date. (You can do this visually or with an alignment command, as you did in a previous step.)
- Deselect any selected elements.

This essentially completes the map layout.
When you are finished, zoom to the whole page and take the data frame out of focus.

Turn off the Draw toolbar and the Layout toolbar.

In the next step, you will save your map to a file that you can share with others.

**Step 14: Export and save the map**

In this step, you will export the map to a file.

- From the File menu, choose Export Map.
- In the Export Map dialog box, navigate to your ..\Student\DESK2\MapLayout folder.
Set the Save as type to PDF.

Accept the other defaults and click Save.

If you have Internet access, you can this file to yourself by e-mail and print it when you get home.

Save your changes.

Step 15: View your map in data view

Switch to Data view.

Notice that the elements you added in Layout view from the Insert menu do not appear on the map in Data view. Because the projection information, dynamic date, and other text elements were added in Layout view, they are visible only on the map layout.

Why are the Zoom In, Zoom Out, and other tools on the Tools toolbar disabled?

Remember, earlier in the exercise, you explicitly set a fixed map scale. Whenever you set a fixed map scale or fixed map extent, the tools that let you manage the map extent become disabled. In
order to be able to use all the navigation tools, you would need to open data frame properties and turn off the fixed map scale.

- Close ArcMap and do not save changes.
Lesson review

1. Name some of the elements that can be added to your map layout.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. What kinds of nongeographic information are appropriate to add as text to your map layout?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. Text that is added from the Draw toolbar to the layout will be visible in Data view.
   a. True
   b. False
Answers to Lesson 6 questions

Lesson review

1. Name some of the elements that can be added to your map layout.
   
   Title
   Legend
   Scale bar
   Map
   North arrow
   Text
   Other elements?

2. What kinds of nongeographic information are appropriate to add as text to your map layout?

   Nongeographic text includes author name, corporation name, or an explanatory paragraph that describes how the data was collected.

3. Text that is added from the Draw toolbar to the layout will be visible in Data view.
   
   b. False
Introduction

In this lesson, you will learn about different models for representing and storing geographic data. You will use ArcCatalog to explore geographic data stored in a geodatabase.

Topics covered

- Geographic data
  - Two types: vector, raster
  - Vector data organization: point, line, polygon
  - Examples of vector data
  - Raster data organization
  - Examples of raster data
  - Geodatabase

Learning objectives

After completing this lesson, you will be able to:

- Describe geographic data and how it is stored.
- Manage GIS data in ArcCatalog.
What types of geographic data do you work with?

Notes
Vector model

- Geographic features are most commonly represented as:
  - points
  - lines
  - polygons

Coordinates define feature shape and location
◆ **Point**: A pair of $x,y$ coordinates

    $x,y$

◆ **Line**: A series of $x,y$ coordinate pairs

![Line diagram](image)

◆ **Polygon**: A closed shape defined by connected $x,y$ coordinate pairs

![Polygon diagram](image)
List examples of real-world vector features

<table>
<thead>
<tr>
<th>Point</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>Polygon</td>
<td></td>
</tr>
</tbody>
</table>
Vector data organization

◆ Stored as feature classes
  ◆ Same geometry
  ◆ Same attributes

- A feature class is a collection of similar features and attributes.
- All the features in a feature class have the same geometry type and the same attribute fields.
- The attribute values for each feature may be different.
- The attribute table stores a unique identifier that links each feature with its attributes.
Raster data model

- Used to represent
  - imagery
  - digital elevation models
  - other thematic data
Raster data organization

- **Matrix of cells**
- **Cell values**
  - measurements
  - counts
  - statistical values
  - codes

- Raster data is stored as raster datasets.
- A raster dataset is a matrix of equal-sized cells.
- The size of each cell (e.g., 10 meters wide by 10 meters high) defines the size of the area on the ground covered by each cell.
- Each cell has a value that represents a measurement, a count, a statistical value, or a code.
- Cell values are either integers (whole numbers) or floating points (have a specified number of decimal places).
- Each cell location can be determined using a reference coordinate for the origin, the cell size, and the number of rows and columns.
How is geographic data stored?

- **Geodatabase**

  - The geodatabase is the Esri standard.

  ![Diagram of geodatabase components including Table, Feature class, Raster dataset, Canada, Elev, Mjcities, Mjroads, Natpark, PopStats, Province, Water]

  Primary storage mechanism in ArcGIS

  Geodatabase with feature classes, a raster dataset, and a stand-alone table
ArcCatalog: data management application

Catalog Tree View

Contents Panel

Right-click an item to view its shortcut menu
Exercise 7: Explore data in ArcCatalog

Estimated time: 25 minutes

In this exercise, you will use some of the most common and important ArcCatalog functions as you prepare data for a map. You will further explore the relationship between data and a map.

In this exercise, you will:
- Modify ArcCatalog display settings.
- Preview feature class geometry and attributes in ArcCatalog.
- View and modify feature class properties and metadata.

Step 1: Start ArcCatalog

In this step, you will explore how data is displayed and learn how to navigate to the data in ArcCatalog.

- Start ArcCatalog by double-clicking the ArcCatalog icon on your desktop (or click the Start menu, point to All Programs, click ArcGIS, and click ArcCatalog).

- Maximize the ArcCatalog window.

On the left of the ArcCatalog window is the Catalog Tree. In the Catalog Tree, you navigate to data, ArcGIS tools, and services. You can customize the information ArcCatalog displays here.

- From the Customize menu, choose ArcCatalog Options.

- Click the General tab, if necessary.

- In the upper box, which sets top-level entries, uncheck all the boxes except for Folder Connections (always shown) and Toolboxes.
Near the bottom of the dialog box, uncheck the Hide File Extensions box.

By default, ArcCatalog does not show the file name extensions of geographic data files, but as you have seen in previous lessons it is convenient to see the file name extensions.

Click OK.

Even though you currently have no data to view, the contents of the Catalog Tree have changed to correspond with the options you chose.

Next, you will create a folder connection. You learned in an earlier lesson how to create a folder connection in ArcMap. You can also create a folder connection in ArcCatalog.

In the Catalog Tree, right-click Folder Connections and choose Connect Folder.
In the Connect to Folder dialog box, browse to ..\Student\DESK2\ExploreArcCatalog, and click the ExploreArcCatalog folder to select it.

Click OK.

Now you can access this folder in ArcCatalog with a single click.

In previous lessons, you learned how to access data from the ArcMap Catalog window. Why would you want to use ArcCatalog? You might prefer to use ArcCatalog to create and manage data when you do not need to make a map.

Step 2: Use different views to display data

In the display area (the pane on the right), you see that the ..\Student\DESK2\ExploreArcCatalog folder contains many files.

On the Standard toolbar, you see buttons that let you change the way files are displayed when the Contents tab is selected.

Make sure that the Contents tab is selected in the display area.
Click each of the buttons and notice how the view changes.

When you are finished, click the Details button.

In the Catalog Tree, click the plus sign (+) next to the ExploreArcCatalog folder to expand it.

The ExploreArcCatalog folder contains geodatabases and other files. You have been working with file geodatabases in the previous lessons. Now, you can see that a file geodatabase is associated with the GDB (.gdb) file name extension.

Expand the Canada.gdb geodatabase.

The geodatabase contains point, line, and polygon feature classes, a raster dataset, and a table. These data sources are visible in the display area.

**Step 3: Preview data**

In this step, you will see how to access spatial and attribute information about data in ArcCatalog.

In the Catalog Tree, in the Canada geodatabase, click the Province feature class.

The display on the Contents tab shows a thumbnail image of the data and information about the data.

In the display area, click the Preview tab.

In Preview mode, you can explore the map and the Geography toolbar becomes enabled.

On the Geography toolbar, click the Identify tool.

Click British Columbia (the southwesternmost province) to identify it.

The Identify Results window displays the geodatabase data for British Columbia. For example, the area is 946,089 square kilometers.

Move the Identify Results window away from the display area, if necessary.

Identify some other provinces and territories. When you are finished, close the Identify Results window.

On the Geography toolbar, click the Zoom In tool.
Zoom in on a part of the coast of British Columbia by dragging a rectangle around the area you want to see.

Zoom in further until you can see coastal detail.

On the Geography toolbar, click the Full Extent button to return to the original view.

At the bottom of the Preview tab, click the drop-down arrow and change the preview type from Geography to Table.

You see the records (or rows) in the Province attribute table. Each record corresponds to a feature in the map. The information in the table is the same as that in the Identify Results window.

Scroll across the table to see all the attribute fields.

Right-click the heading of the SQKM field and click Sort Ascending on the context menu.

1. What is the area (rounded to integer) of the largest province or territory in Canada?

Right-click the heading of the POP2001 field and click Statistics on the context menu.

2. What was the total 2001 population of Canada?

Close the Statistics of Province window.

In the Catalog Tree, click the Elev raster dataset.

Preview its geography, then preview its table.

In the table, the VALUE field contains elevation measurements, sorted in numeric order. The COUNT field tells you how many raster cells store each elevation value.
Click the Move to end of table button at the bottom of the table to find the highest elevation in Canada. The values are in meters.

**Note:** You could have scrolled to the end of the table, but this way is faster. Another quick way to get the information would have been to sort the VALUE field in descending order.

**Step 4: View metadata**

In this step, you will view metadata. Earlier you learned that metadata is information about data. The information clarifies its origin, meaning, appropriate use, and so on.

- In the Catalog Tree, click the Mjcities feature class.
- In the display area, click the Description tab to view the Item Description for this feature class.

All items in ArcGIS have a standardized description called Item Description. The Item Description includes a title, thumbnail, summary, a brief description of the data, and credits. It is a small subset of the complete formal metadata that you can create to describe an item.

---

**Canada Major Cities**

File Geodatabase Feature Class

**Tags**
- point, major cities, cities, ville, populated places, location, Canada

**Summary**
Canada Major Cities provides a database of names and locations for the major cities across Canada.

**Description**
Canada Major Cities represents the locations of major cities within Canada. A major city is defined as: a populated place that has been designated as a provincial or federal capital by Statistics Canada, or a populated place that has been designated as a city by Natural Resources Canada and has a population greater than 100,000.

**Credits**
Access granted to Licensee only.
Read the Summary of the data and then answer the following question.

3. What data is included in the database for major cities?

If metadata that is based on a standard style has been created for an item, you can choose whether to display the metadata with the Item Description.

- From the Customize menu, click ArcCatalog Options and choose the Metadata tab.
- In the Metadata Style drop-down list, choose ISO 19139 Metadata Implementation Specification.
- Make sure the option to automatically update when metadata is viewed is checked.
- Click OK.
- From the View menu, choose Refresh.
- In the Item Description, scroll to the end.

Two styles appear. Metadata styles let you set all your preferences for working with metadata at once. They control how you view, edit, export, and validate an item's description. Additional metadata styles provided with ArcGIS let you create formal metadata that complies with a metadata standard.

- Click ArcGIS Metadata to expand it and then click Resource Identification.

This metadata displays with more detail than the Item Description alone. You will learn how to edit the Item Description in a later lesson.

**Best practice:** Whenever you add or update data, remember to add or update the associated metadata.

**Step 5: Search for data**

In this step, you will use ArcCatalog to search for data.
Metadata provides valuable information about your data that may not be reflected in the title. In addition, this information is searchable so that you can easily find the data you need. You will create a search index to optimize your searches.

☐ If necessary, click the Search window button

The Search window opens and is docked to the right side of the ArcCatalog interface. It is set to auto hide.

☐ In the Search window, click the Index/Search Options button, then click Add.

☐ In the Browse Folders to be Indexed dialog box, navigate to your ..\Student\DESK2 folder and select it.

☐ Click Select, then click Apply.
It will take a few moments to build the search index.

![Warning: When the Indexing Status has changed to Active, you can proceed.]

- Click OK on the Index/Search Options dialog box.

After you have indexed your folder, you can search for maps, data, and tools. You can choose one of the options to refine the search to focus on just the items you want.

If you do not know the value of specific keywords in the description you are searching, you might need to guess. For now, you want to locate a feature class that contains data for national parks in Canada.

- In the empty text box near the top of the Search window, type **national parks**, then click the Data link just above the text box. *(Tip: You can also click the Search button .)*

Your best guess returned a list of feature classes that contain the phrase national parks in their descriptions.

- In the list of returned items, hover your mouse over the paths to the data.

- Click the path to the feature class named natlpark that resides in the Canada geodatabase in your ..\Student\DESK2\ExploreArcCatalog folder.

- In the Catalog Tree, the feature class Natlpark is selected and its Item Description displays on the Description tab.

A description followed by a thumbnail of the data appears at the top of the Item Description.

The tags below the thumbnail are keywords that you can use if you want to search for this dataset again at a later time.

- Click the Preview tab to view the map.

- If necessary, set the Search window to auto hide by clicking the pin—that is, so that the pin is pointing sideways.

- Click in the Catalog Tree to move away from and hide the Search window.

In the next step, you will make a change to the Natlpark feature class.
Step 6: Explore feature class properties

In this step, you will learn how to access the properties that define data. Some of these properties can be changed at any time; others are fixed once they are set.

- In the Catalog Tree, preview the table for the Natlpark feature class and scroll all the way to the right.

Notice the field named Country with values of Canada for every record. This information is not very useful; you already know you are working with Canada data. At the end of this step, you will learn one way to delete attributes you do not need.

- In the Catalog Tree, right-click the Natlpark feature class and choose Properties from the context menu.

The Feature Class Properties dialog box contains several tabs. You will explore the information on some of these tabs.

- If necessary, click the General tab.

- Select the existing alias of Natlpark, which matches the feature class name.

- Type National Parks, as shown in the following graphic.

<table>
<thead>
<tr>
<th>Indexes</th>
<th>Subtypes</th>
<th>Relationships</th>
<th>Representations</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Name: Natlpark

Alias: National Parks

- Click Apply.

Whenever you add this data to ArcMap, the layer name will automatically be set to National Parks.

- Click the Fields tab.

You see the name of each attribute and its data type. (You will learn more about field data types later in the course.)

- In the Field Name column, click any field name and try to type over it. Do the same for any value in the Data Type column.
Once defined, a field name and its data type cannot be changed.

To the left of each field name is a small gray box.

- Click the box next to the Country field to select it.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBJECTID</td>
<td>Object ID</td>
</tr>
<tr>
<td>Shape</td>
<td>Geometry</td>
</tr>
<tr>
<td>NAME</td>
<td>Text</td>
</tr>
<tr>
<td>TYPE</td>
<td>Text</td>
</tr>
<tr>
<td>S OkM</td>
<td>Double</td>
</tr>
<tr>
<td>Country</td>
<td>Text</td>
</tr>
<tr>
<td>Shape_Length</td>
<td>Double</td>
</tr>
<tr>
<td>Shape_Area</td>
<td>Double</td>
</tr>
</tbody>
</table>

- Press Delete to delete the field from the list.
- Click OK on the Feature Class Properties dialog box.
- Preview the table.

The Country field and its values are gone.

Step 7: Preview data outside the geodatabase

In this step, you will preview non-geodatabase data, including shapefiles, layer files, and map documents. Shapefiles are feature classes—like geodatabase feature classes, they store geographic objects as points, lines, or polygons. Layer files do not store geographic data; rather, they store the display properties of geographic data. A map document is an ArcMap file consisting of a collection of layers.

- In the Catalog Tree, click the Areacode shapefile, which represents the boundaries of Canadian telephone area codes.
Click the Contents tab to view its thumbnail.

Preview its geography and table.

In the Catalog Tree, right-click Areacode and choose Properties from the context menu.

The Shapefile Properties dialog box shows four tabs that contain information about the shapefile. Shapefiles are a popular and easily managed data format.

Click Cancel to close the dialog box.

In the Catalog Tree, click the Elevation layer file and then click the Contents tab to view its thumbnail.

Preview its table. If you like, preview the Elev raster dataset again for comparison. (Hint: The raster dataset resides in the Canada geodatabase.)

A layer file does not actually store spatial or attribute data; it stores only the symbology and display properties associated with a specific feature class or raster dataset. Layer files, unlike feature classes, preview exactly as they will look in a map.

In the Catalog Tree, right-click Elevation.lyr and choose Properties from the context menu.

The properties of a layer file are exactly the same as the properties of a layer in ArcMap. The only difference is that a layer file is not stored in a map document. It can be added to any map document to save you the trouble of re-creating properties of the layer, including symbology.

Click Cancel on the Layer Properties dialog box.

In the Catalog Tree, click CanadaMap.mxd once. (Double-clicking will start ArcMap.)

The only available Preview mode for a map document is Geography. A map document lets you organize many different layers into a complete map.

In the Catalog Tree, right-click CanadaMap.mxd and choose Set Data Source(s) to open the Set Data Sources dialog box.

If necessary, resize the Set Data Sources dialog box to show all the layers.

This map document contains one data frame, called Layers. The data frame contains seven layers (Mjcities, Rivers, etc.). The layers reference data sources on disk.
The Set Data Sources dialog box can be used to redefine which data source a layer references. In this case, you are using it simply to see which data sources are referenced.

- If necessary, in the Set Data Sources dialog box, widen the Current data source column until you can see the full path. (To widen the column, drag the vertical bar that separates the column headings.)

4. The layers in CanadaMap.mxd reference data from which geodatabases?

It is acceptable for a map document to reference data in different geodatabases, different folders, or even different computers. You may, however, find it convenient to consolidate your data for a project into one geodatabase. In the next step, you will copy feature classes from the World geodatabase into the Canada geodatabase.

- Click Cancel on the Set Data Sources dialog box.

**Step 8: Manage data**

In this step, you will rename and copy feature classes.

- In the Catalog tree, from your ..\Student\DESK2\ExploreArcCatalog folder connection, click the World geodatabase to select it, and then expand World.

- Click the Contents tab in the display.
In the display, click the Lakes feature class to select it. Click it again (click the name) to make it editable.

<table>
<thead>
<tr>
<th>Contents</th>
<th>Preview</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td></td>
<td>Type</td>
</tr>
<tr>
<td>Cntry07</td>
<td></td>
<td>File Geodatabase Feature Class</td>
</tr>
<tr>
<td>Lakes</td>
<td></td>
<td>File Geodatabase Feature Class</td>
</tr>
<tr>
<td>Rivers</td>
<td></td>
<td>File Geodatabase Feature Class</td>
</tr>
<tr>
<td>World30</td>
<td></td>
<td>File Geodatabase Feature Class</td>
</tr>
</tbody>
</table>

Type **WorldLakes** and press Enter.

When you copy this feature class into the Canada geodatabase, the new name will make it clear that the features cover the entire world, not just Canada.

**Note**: Feature class names may not contain spaces.

If necessary, right-click the World geodatabase to refresh the Contents.

In the same way, rename Rivers to **WorldRivers**.

Make sure WorldRivers is still selected. Hold down the Shift key on your keyboard and click Cntry07.

All four feature classes in the World geodatabase should be selected.
- Drag and drop the feature classes into the Canada geodatabase.

![Catalog tree and Contents tab diagram]

- Click OK on the Data Transfer dialog box.

The feature classes have been copied into the Canada geodatabase and should be listed there in alphabetical order. (If you do not see them, right-click the Canada geodatabase and choose Refresh.)

**Note:** The drag-and-drop method is a convenient way to copy and paste feature classes from one geodatabase to another, but you can also use the Copy and Paste commands from the feature class context menu.
In the Catalog Tree, click the Areacode shapefile and slowly drag it over the Canada geodatabase.

A prohibition symbol appears, indicating that you cannot directly drag or copy a shapefile into a geodatabase.

Release the mouse button.

The shapefile stays in its original location. Although you cannot drag and drop a shapefile into a geodatabase, shapefiles can be converted to geodatabase format. This topic is covered in the *ArcGIS Desktop III: GIS Workflows and Analysis* course. Moreover, you might not find it necessary to convert all your data. A single map document can reference geodatabase feature classes, shapefiles, and other data formats.

**Step 9: Update layer paths to data**

In this step, you will explore the relationship between layers in a map and their data sources on disk. You will see how to repair a broken link between a layer and its data source, and you will see how to change the data source that a layer references.
5. In the Catalog Tree, double-click CanadaMap.mxd to open it.

5. Maximize the ArcMap window and then zoom to the Canada bookmark.

Does this map look familiar to you? This map is based on the same data that you used in a previous exercise. The table of contents lists the layers in the map.

The Rivers feature class does not display in either of the geodatabases. The red exclamation mark next to the Rivers layer means that the layer can no longer find the feature class it originally referenced.

5. What action of yours in the previous step could have changed the path from the Rivers layer to its feature class?

______________________________________________________________________________
______________________________________________________________________________

5. In the table of contents, right-click the Rivers layer, point to Data, and choose Repair Data Source.

5. In the Data Source dialog box, navigate to ..\Student\DESK2\ExploreArcCatalog\Canada.gdb.

5. In the Canada geodatabase, click WorldRivers to select it.

**Note:** You could also repair the data source by clicking the WorldRivers feature class in the World geodatabase, but your goal is to have all the map layers sourced to the same geodatabase (Canada.gdb).

5. Click Add.

The path is repaired and the rivers draw on the map.

5. In the table of contents, double-click the Cntry07 layer to open its properties.

5. On the Layer Properties dialog box, click the Source tab.

There is no need to repair the data source, but you can see from the Location line that the layer is referencing a feature class in the World geodatabase. Again, you will change the path.

5. On the Source tab, click Set Data Source.
If necessary, navigate to the ..\Student\DESK2\ExploreArcCatalog\Canada.gdb geodatabase.

Click Cntry07 to select it and click Add.

Confirm that the path is updated on the Location line.

Click OK.

Follow the same steps to point the World30 layer to the Canada geodatabase.

All of the data in your map now resides in the same geodatabase. Although ArcMap does not require all the data to come from the same geodatabase, it is sometimes more convenient when the data does reside in the same geodatabase.

Save your map document as MyRepairedCanadaMap.mxd in your ..\Student\DESK2\ExploreArcCatalog folder and close ArcMap.

In ArcCatalog, in the Catalog Tree, right-click your ..\Student\DESK2\ExploreArcCatalog folder and click Disconnect Folder.

Close ArcCatalog.
Lesson review

1. Why might you choose to use ArcCatalog rather than ArcMap?

______________________________________________________________________________
______________________________________________________________________________

2. What types of data can be stored in a geodatabase?

______________________________________________________________________________
______________________________________________________________________________
Answers to Lesson 7 questions

Exercise 7: Explore data in ArcCatalog

1. What is the area (rounded to integer) of the largest province or territory in Canada?
   1,925,460

2. What was the total 2001 population of Canada?
   30,007,094

3. What data is included in the database for major cities?
   Names and location

4. The layers in CanadaMap.mxd reference data from which geodatabases?
   Canada.gdb and World.gdb

5. What action of yours in the previous step could have changed the path from the Rivers layer to its feature class?
   Renaming the Rivers feature class to WorldRivers. Moving, deleting, or renaming a feature class can break the link between a layer in ArcMap and the feature class it references.

Lesson review

1. Why might you choose to use ArcCatalog rather than ArcMap?
   You might choose to use ArcCatalog instead of ArcMap to create and manage data when you do not need to make a map.

2. What types of data can be stored in a geodatabase?
   Feature classes, attribute raster datasets, and more
Introduction

In this lesson, you will review coordinate systems—what they are and how they work. You will compare geographic and projected coordinate systems, and learn some of the properties of each. In ArcMap, you will learn how to identify, define, and change the coordinate systems used to display map layers.

Topics covered

- What is a coordinate system?
- Two types of coordinate systems
- Spatial reference lines
- Latitude and longitude
- Shape of the earth
- Datum
- Map projection
- Projected coordinate system
- Spatial distortion
Learning objectives

After completing this lesson, you will be able to

▪ Differentiate between geographic and projected coordinate systems.
▪ Define the coordinate system for a feature class.
▪ Change the coordinate system of a data frame.
What is a coordinate system?

Notes
Two types of coordinate systems

- **Geographic coordinate systems (GCS)**
- **Projected coordinate systems (PCS)**

**Geographic coordinate system**

- Defines locations on a spherical (or spheroidal) model of the earth

**Projected coordinate system**

- Defines locations on a flat model of the earth (map)
Spatial reference lines

- **Spatial reference lines**
  - Equator
  - Prime meridian
  - Parallels
  - Meridians
Latitude and longitude

Latitude
90°N
0° north or south of the equator
90°S

Longitude
180°W ← 0° → 180°E

Angle east or west of the prime meridian
Shape of the earth

- **True earth shape is too complex**
- **Different spheroids have been defined**

**Why do we need different spheroids?**

The shape of the earth is a spheroid (or ellipsoid). However, it is not a perfect spheroid. The earth's surface is not perfectly symmetrical, so the semi-major (blue lines) and semi-minor (red lines) axes that fit one geographical region do not necessarily fit another one.

Satellite technology has revealed several elliptical deviations. For example, the South Pole is closer to the equator than the North Pole. In addition, the earth's spheroid deviates slightly for different regions of the earth.

Many different spheroids are used throughout the world to account for these deviations. Ignoring deviations and using the same spheroid for all locations on the earth could lead to errors of several meters, or in extreme cases hundreds of meters, in measurements on a regional scale.

Until recently, the *Clarke 1866* spheroid was the most commonly used spheroid for North America. Today, the *GRS80* spheroid is replacing Clarke 1866 in most geographic databases.

Spheroids created using satellite information, such as GRS80, are starting to replace traditional ground-measured spheroids, such as Clarke 1866. In this example, measurements for both spheroids have been rounded to the nearest meter.
Datum

- Fit earth measurements to a spheroid

- A datum defines the fit for a particular spheroid
- A point's coordinate values vary with the spheroid and the datum
Map projection

- Flattens the earth
- Converts geographic to projected coordinates

- Geographic coordinates are converted from angular units (degrees) to distance units on a map (feet or meters).
- A map projection defines a formula for this conversion.
Projected coordinate system

- Defines X and Y locations
  - X – measure east or west from 0
  - Y – measure north or south from 0
- Constant distance units
Spatial distortion

◆ Every map projection causes spatial distortion
  ◆ Shape, area, distance, and direction

- Each map projection handles distortion in a different way.
- To learn more about map projections, search for supported map projections in ArcGIS 10 Help. The supported map projections table includes short descriptions and links to more information.
Three key concepts

On-the-fly projection

▪ Every feature class has a native coordinate system.
▪ Every data frame also has a coordinate system.
  ▪ Defined by the first layer added
  ▪ Can be changed by the user
▪ Every subsequent layer that is added is projected to match the coordinate system of the data frame.
  ▪ Known as on-the-fly projection
  ▪ The native coordinate system of the data is not changed.

Geographic transformation

▪ On-the-fly projection works when all the layers added to a data frame have the same underlying geographic coordinate system.
▪ When you add a layer with a different geographic coordinate system, ArcMap may generate a warning message.
▪ ArcMap will try to project the data, but the alignment may be imperfect.
▪ You can fix this problem using geographic transformation.
▪ To perform geographic transformation, use the Project tool to convert one geographic coordinate system into another.
  ▪ Creates a new feature class with a new native coordinate system (the original feature class and coordinate system are preserved)

Unknown coordinate system

▪ On-the-fly projection works when a layer's coordinate system is known.
▪ When you add a layer with an unknown coordinate system, ArcMap cannot project it.
▪ The result may be gross misalignment.
▪ You can fix this problem by defining the coordinate system.
  ▪ First, determine the correct coordinate system.
  ▪ Second, use the Define Projection tool to identify the coordinate system.
    ▪ Adds information identifying the coordinate system to the existing feature class (does not create a new feature class)
    ▪ Used to update missing or incorrect coordinate system information
Exercise 8A: Project data on the fly

Estimated time: 20 minutes

In this exercise, you will work with data that has different coordinate systems and see how ArcMap can reconcile those differences automatically through on-the-fly projection.

In this exercise, you will:

▪ Find coordinate system information in ArcCatalog and ArcMap.
▪ Explore on-the-fly projection.
▪ Change the coordinate system of a data frame.
▪ Find information on map projections and coordinate systems in the ArcGIS Desktop Help.
▪ Optionally, project existing data to create new data.

Step 1: Examine a feature class coordinate system

In this step, you will explore a feature class in the Catalog window.

☐ Start ArcMap.

An empty map opens.

☐ Maximize the application window.

☐ Save the empty map in your ..\Student\DESK2\CoordinateSystems folder as MyCoordinateSystems.

☐ In the Catalog window, make sure your ..\Student\DESK2\CoordinateSystems folder is expanded and then expand the World geodatabase.

☐ Right-click the Countries feature class and click Item Description.
Click the Preview tab.

It may not be completely obvious, but the geography is stretched from east to west. Canada, for example, is wider and more compressed from north to south than you usually see it.

On the Item Description window, click the Identify tool.

Click the eastern border of Russia.

Resize the Item Description window and move it so you can see both the Identify Results window and the map.
In the following table, write the east longitude value that displays in the Identify Results window.

<table>
<thead>
<tr>
<th>East longitude</th>
<th>West longitude</th>
<th>North latitude</th>
<th>South latitude</th>
</tr>
</thead>
</table>

Click the westernmost border of North America (Alaska) and write the west longitude value in the table.

Click the northernmost border of North America, somewhere in Canada or Greenland, and write the north latitude value in the table.

Click the southernmost area of Antarctica and write the south latitude value in the table.

Within the extent of the data, the values range from –90 to 90 in the north-south direction and 180 to –180 in the east-west direction. This is the latitude-longitude value range.

Close the Identify Results window.

In the Item Description window, click the Description tab and resize the Item Description window to enlarge it.

Expand ArcGIS Metadata and then expand ESRI Spatial Information and view the extent information.

<table>
<thead>
<tr>
<th>Extent in the Item’s Coordinate Reference</th>
<th>Bounding rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>* West longitude</td>
<td>-180.000000</td>
</tr>
<tr>
<td>* East longitude</td>
<td>180.000000</td>
</tr>
<tr>
<td>* North latitude</td>
<td>83.623600</td>
</tr>
<tr>
<td>* South latitude</td>
<td>-90.000000</td>
</tr>
<tr>
<td>* Extent contains the resource</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The coordinate values are decimal degrees. The values you discovered with the Identify tool should closely approximate these values. These are latitude-longitude values expressed in decimal form rather than in degrees, minutes, and seconds.

If necessary, scroll to the coordinate reference.
The geographic coordinate reference is GCS_WGS_1984. There is no projected coordinate system.

**Note:** The World Geodetic System of 1984, abbreviated WGS84, is a common geographic coordinate system.

- Close the Item Description – Countries window.

**Step 2: Examine the coordinate system of another feature class**

- Preview the Continents feature class. *(Hint: Right-click Continents and click Item Description.)*

The geography looks different. Here, features are stretched from north to south, and are bent or sheared at the east and west edges of the map.

- Identify a location in the southernmost area of Antarctica.

- Identify a location in the easternmost area of Asia.

- The coordinate values range from the millions in the north-south direction to the tens of millions in the east-west direction.

- In the Item Description, click the Description tab and expand ArcGIS Metadata.

- Expand ESRI Spatial Information.
This feature class has the same WGS84 geographic coordinate system as the Countries feature class.

But it also has a projected coordinate system, World_Eckert_VI. The coordinate units are meters.

- Close the Item Description window and Identify Results.
- Close the Identify window.
- In the Catalog window, right-click the CanadaProvinces feature class.
- In Feature Class Properties, click the XY Coordinate System tab and view the coordinate system properties.

The geographic coordinate system for this feature class is based on the North American Datum of 1983 (NAD83). The projected coordinate system is an Albers Equal Area projection optimized for Canada.

- Close the feature class properties window.

You have explored the coordinate system properties for three feature classes and will now explore the data in ArcMap as you prepare to create your map.

**Step 3: Examine coordinate systems in ArcMap**

In this step, you will see how to check the coordinate system of a layer in ArcMap, as well as the coordinate system applied to the data frame.
Drag Countries to the map.

From the table of contents, open the Countries layer properties and click the Source tab.

The coordinate system information of the layer (actually, of its underlying feature class) is displayed in the Data Source area.

Click Cancel on the Layer Properties dialog box.

Open the properties of the Layers data frame and click the Coordinate System tab.

The data frame also has a coordinate system, independent of its layers. It is shown at the top of the dialog box and also in the contents of the <custom> folder. In this case, the coordinate system is the same as that of the Countries layer. That is because the data frame automatically adopts the coordinate system of the first layer that is added to it.

Click Cancel on the Data Frame Properties dialog box.

Step 4: Add another layer to the data frame

In this step, you will see how ArcMap is able to reconcile data in different coordinate systems through on-the-fly projection.
Drag Continents to the map from the World geodatabase.

The continents align perfectly with the countries. This might be surprising, because the continents looked different when you previewed them in ArcCatalog.

Open the data frame properties.

If necessary, click the Coordinate System tab.

In the lower window, expand the Layers folder. Expand the Continents folder and the Countries folder.

In the Layers folder, you see the native coordinate system of each layer in the data frame. Although the Continents layer is in a projected coordinate system, it aligns with the unprojected Countries layer. The Continents layer has been "unprojected on the fly."

**Note:** Data is called unprojected when it has only a geographic coordinate system.
Click Cancel on the Data Frame Properties dialog box.

**Step 5: Insert a new data frame with a different coordinate system**

- From the Insert menu, choose Data Frame.

A new, empty data frame (called New Data Frame) is added to the map and activated.

- Copy and paste the Continents layer from the Layers data frame to the new data frame. *Hint:* Right-click the layer in the table of contents, choose Copy, then right-click the new data frame and paste.

You can see that in the new data frame, the data looks the way it did in ArcCatalog.

- Open the properties of the new data frame and click the Coordinate System tab.

This data frame has assumed the projected coordinate system of the Continents layer, which is based on the Eckert VI projection.

- Click Cancel on the Data Frame Properties dialog box.

- Copy and paste the Countries layer from the Layers data frame to the new data frame.

Again the data aligns, but this time in the Eckert VI coordinate system. The Countries layer has been projected on the fly.

**Step 6: Add more layers to the data frame**

- From the World geodatabase, drag MajorCities and WorldBackground to the new data frame.

- Click inside some white space in the table of contents to deselect the layers you just added.

- Arrange the layers in New Data Frame in the following top-to-bottom order in the table of contents (*Hint:* You need to list the layers by drawing order.):
  - MajorCities
  - Countries
  - Continents
  - WorldBackground
If you like, symbolize the map to your liking.

1. What is the native *projected* coordinate system of the MajorCities layer?

______________________________________________________________________________

2. What is the native *geographic* coordinate system of the MajorCities layer? *Hint:* Look in the layer properties, not in the data frame properties.

______________________________________________________________________________

The MajorCities layer has been reprojected on the fly from one projected coordinate system to another.

- If you have any dialog boxes open, close them now.

**Step 7: Change the coordinate system of the data frame**

The data frame assumes the coordinate system of the first layer added. You can change the data frame's coordinate system to any one you want and all layers will be projected on the fly to match it.

- Open the properties for the new data frame. If necessary, click the Coordinate System tab.
In the Select a coordinate system area, expand the Predefined folder and then the Projected Coordinate Systems folder.

Coordinate systems are organized geographically for the most part. To find an appropriate coordinate system for world data, you look in the World folder; to find one for a continent, you look in the Continental folder; and so on.

Expand the World folder and scroll through the list of projected coordinate systems.

Move the Data Frame Properties dialog box to a corner of the screen so it does not block the map display.

Click any one of the coordinate systems listed in the World folder and click Apply.

The map redraws in the new coordinate system. All layers in the data frame have been projected (or reprojected) on the fly. The name of the selected coordinate system appears in the Current coordinate system area of the Data Frame Properties dialog box.

In the Data Frame Properties dialog box, click the Robinson (world) coordinate system and click Apply.

Click Cancel on Data Frame properties.
Step 8: Get help on map projections and coordinate systems

A basic understanding of coordinate systems will serve you well. The best place to start is with the ArcGIS Desktop Help, which has a complete section on map projections and coordinate systems.

- From the Help menu, choose ArcGIS Desktop Help.
- In the navigation pane on the left of the help window, if necessary, click the Contents tab.
- Expand Professional Library, then:
  - Expand Guide books.
  - Expand Map projections.
  - Expand Supported map projections.
  - Scroll down and click Robinson.
You can get information about how a chosen projection is constructed, how it manages distortion, and what its appropriate uses are. Under the same general heading, you can learn more about geographic and projected coordinate systems.

- Close the help window.

**Step 9: Add the CanadaProvinces layer**

In this step, you will see what happens when you add a layer that has a geographic coordinate system different from the data frame's geographic coordinate system.
For the following action, do not drag CanadaProvinces to your map.

On the Standard toolbar, click the Add Data button \[+\], then add CanadaProvinces from your ..\Student\DESK2\CoordinateSystems\World geodatabase.

A warning message appears.

The following data sources use a geographic coordinate system that is different from the one used by the data frame you are adding the data into:

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Geographic Coordinate System</th>
</tr>
</thead>
<tbody>
<tr>
<td>CanadaProvinces</td>
<td>GCS_North_American_1983</td>
</tr>
</tbody>
</table>

Alignment and accuracy problems may arise unless there is a correct transformation between geographic coordinate systems.

You can use this button to specify or modify the transformation(s) used by this data frame: Transformations...

The Transformations dialog can also be accessed from the Data Frame Properties dialog's Coordinate Systems tab after you have added the data.

Don't warn me again in this session
Don't warn me again ever

Click Close.

You get this warning when you mix geographic coordinate systems in a data frame. On-the-fly projection does not automatically fix differences between geographic coordinate systems. To fix them, an operation called a geographic transformation is needed.

Note: To learn more about performing a geographic transformation, take the ArcGIS Desktop III: GIS Workflows and Analysis instructor-led course.

Click Close.

The CanadaProvinces layer is added to the map and the geography looks fine. So just how important is a geographic transformation? The differences between two or more geographic coordinate systems are usually not noticeable at small scales. Often, it is a difference of a few
meters, or tens of meters, for a given point. Whether that is significant or not depends on your purposes.

- Save the map.

- If you would like to project data on disk, go on to the optional next step. Otherwise, close ArcMap.

### Step 10: (Optional) Project data on disk

Because ArcMap projects data on the fly, your feature classes do not need to be in the same coordinate system. However, it is a good data management practice, and it may help you avoid complications in data editing. Also, some advanced geodatabase behaviors, like topologies (which you will learn about in the course *ArcGIS Desktop III: GIS Workflows and Analysis*), do require that participating datasets be in the same coordinate system. You can change the native coordinate system of a feature class with the Project tool.

- From the Geoprocessing menu, click Geoprocessing Options, make sure that Enable is unchecked, and close the dialog box.

You will be running a tool in this step and you want to monitor its progress.

- If necessary, from the Standard toolbar, click the Search window button to open the Search window.

- In the Search window, click Tools.

- Type **Project** and then press Enter.

Several options are listed. The hammer icon 🛠 represents a tool.

- Hover your mouse pointer over the Project (Data Management) tool and read the description.

- If necessary, scroll down and then click Item Description.

The help for the Project (Data Management) tool opens.

- Read the Summary for the tool.
3. What is the output from the Project tool?

- Close the Item Description.
- Open the Search window again. (*Tip: If your Search window is set to auto hide, you can click the Search tab to open the window.*)
- Click the Project (Data Management) tool to open its dialog box.
- Click the Browse button next to the Input Dataset or Feature Class box and navigate to the World geodatabase in your ..\Student\DESK2\CoordinateSystems folder.
- Add the Countries feature class.

Now, you will change the output location.

- For Output Dataset or Feature Class, click the Browse button and navigate to the World geodatabase in your ..\Student\DESK2\CoordinateSystems folder and double-click it.
- For the output name, enter **Countries_Project** and then click Save.
- Click the Spatial Reference Properties button next to the Output Coordinate System box.

In the Spatial Reference Properties dialog box, you can choose a coordinate system or import the system of another feature class. In this case, assume you want to put the Countries feature class—which is in a geographic coordinate system—into the same system as the Continents feature class.

- Click Import and navigate, if necessary, to the World geodatabase in your ..\Student\DESK2\CoordinateSystems folder.
- Click Continents, then click Add.

The dialog box is populated with the details of the coordinate system.
Click OK on the Spatial Reference Properties dialog box.

Compare your Project dialog box with the following graphic to verify that it is filled out correctly. (Your paths may differ but your input and output feature classes and output coordinate system should match.)

Click OK to run the tool.

When the process has completed, close the Project tool window.
The World geodatabase in the Catalog Tree contains a new feature class called Countries_Project. If you do not see it, click the World geodatabase in the Catalog Tree, click the View menu, and choose Refresh.

- Open the Countries_Project Item Description and click the Preview tab.

Its geography resembles the Continents feature class that you previewed earlier—as it should.
Preview the geography for the Countries feature class.

It is the same as before. When you project a feature class, a new feature class is always created. The original data does not change.

- Close Item Description.

- Save your changes.
Exercise 8B: Work with an unknown coordinate system

Estimated time: 15 minutes

Every spatial dataset has a coordinate system. ArcMap is able to align datasets that have different coordinate systems by projecting one system on the fly to match the other. Occasionally, ArcMap cannot identify the coordinate system of a dataset. It is able to add such unknown data to a map document but cannot project it on the fly to align it with other data. In this exercise, you will see what happens when you add data with an unknown coordinate system to a map. You will also take measures to identify the coordinate system for ArcMap so that it can project the data on the fly.

In this exercise, you will:
- Add data with an unknown coordinate system to ArcMap.
- Investigate the data.
- Define a coordinate system for the data.

Step 1: Open a map document

- From the ArcMap File menu, open Canada.mxd from your ..\Student\DESK2\CoordinateSystems folder.
- If prompted, save your changes.
If necessary, maximize ArcMap and zoom to the Canada bookmark.

1. What is the coordinate system of the data frame—both geographic and projected systems?

______________________________________________________________________________

2. What is the linear unit of measure of the projected coordinate system?

______________________________________________________________________________

- Close data frame properties.
- Save your map in your ..\Student\DESK2\CoordinateSystems folder as MyCanadaCoordSys.mxd.
Step 2: Add data to the map

- On the Standard toolbar, click the Add Data button ☰ and navigate to your ..\Student\DESK2\CoordinateSystems folder. Add the feature class called CanadaMountains.shp.

**Note:** Feature classes represented by green icons are shapefiles, a spatial data format that is different from the geodatabase but compatible with it.

You receive a warning that the spatial reference is unknown. The CanadaMountains data has a coordinate system (every feature class does) but the information that identifies the system is missing. Without this information, ArcMap does not know how to project the feature coordinates on the fly into the Canada Albers Equal Area Conic system.

- Click OK on the Unknown Spatial Reference warning.

The CanadaMountains layer is added to the table of contents, but the features themselves are not evident on the map.
In the table of contents, right-click the CanadaMountains layer and click Zoom To Layer.

You can see that the mountains have been added somewhere to the map display—but where?

Step 3: Investigate the CanadaMountains layer

In this step, you will try to figure out where ArcMap has put the CanadaMountains data and why it has put it there.

- Measure the east-west distance of the mountain features in meters. *Hint:* On the Tools toolbar, click the Measure tool.

3. What is the distance?

---

- Close the Measure tool.
It is obviously impossible for so many mountains to be located within a few meters of one another.

The values must represent some other kind of coordinates, but ArcMap doesn't know what. It simply locates the features as if the coordinates belonged to the coordinate system of the data frame.

- In the scale box, replace the current value with **15,000,000**.
- If necessary, adjust the scale to get a result similar to the following graphic.

The features are grouped together somewhere in the middle of the United States—probably in Nebraska or Kansas.

- On the Tools toolbar, click the Go To XY tool.

The tool is probably set to work with latitude-longitude values, which is not what you want. The current units that are set display in parentheses in the title bar of the dialog box.

- On the Go to XY dialog box, click the Units button and choose Meters.
Type 0 as the X value and 0 as the Y value.

| X: 0 | Y: 0 |

The 0, 0 point will show you the origin of the data frame's coordinate system—the point relative to which all coordinate values are measured.

**Note:** The origin of a coordinate system is arbitrary. It is simply a reference point for making measurements within the system.

On the Go To XY dialog box, click the Add Labeled Point button.

The origin of the coordinate system is marked with a black dot and labeled.

Change the map scale to 5,000.

You should be able to see the origin and the CanadaMountains features.

If necessary, change your map scale so that you can see both.

Close the Go To XY dialog box.

ArcMap has read the feature coordinates as if they were meters (the units of the data frame's coordinate system) and placed each feature the corresponding number of meters from the origin. The x-coordinates are negative, so the features lie west of the origin. The y-coordinates are positive, so the features lie north of the origin.

As you know, the data is in the wrong place. This tells you that the native coordinate system of the CanadaMountains layer is not Canada Albers Equal Area Conic. (If it were, the data would
display correctly without any need for on-the-fly projection.) In fact, it is pretty certain that the x,y coordinates do not represent linear units in any projected coordinate system.

4. What is your best guess as to the type of units the CanadaMountains x,y coordinates represent?

- From the Edit menu, choose Select All Elements.
- Press Delete.

The graphic marking the coordinate system origin is deleted.

- Zoom to the Canada bookmark.

**Step 4: Define the CanadaMountains coordinate system**

In order to display the CanadaMountains data properly, you need to figure out its native coordinate system and then define it for ArcMap. Once it is defined, ArcMap can project the data on the fly.

At the end of the previous step, you may have correctly guessed what the CanadaMountains x,y coordinates probably represent—longitude (x) and latitude (y). How do you know this?

- The values lie within the general range of latitude-longitude values (360 degrees of longitude, 180 degrees of latitude).
- More specifically, they fall within the appropriate latitude-longitude range for Canada.
- Interpreting them as almost any kind of linear unit would place the features impossibly close together.

Knowing that the values represent latitude and longitude tells you that the data is in a geographic coordinate system and not in a projected coordinate system. However, there is no way to infer from the values alone which geographic coordinate system is the right one.

In this step you will use a tool to define a plausible coordinate system for your data.

- In the Search window, search for Define Projection.
5. Click the Define Projection tool to open it.

5. Click the Show Help button.

5. What is the use for this tool?

5. Click the Input Dataset or Feature Class drop-down arrow and click CanadaMountains.
Click the Spatial Reference Properties button next to the Coordinate System box.

On the Spatial Reference Properties dialog box, the name of the coordinate system is Unknown and the Details box is blank.

Click Select.

In the Browse for Coordinate System dialog box, double-click the Geographic Coordinate Systems folder, then double-click the North America folder.
- Scroll to the right until you see North American Datum 1983.prj. Click it to select it.

- Click Add.

- The name and parameters of the coordinate system are filled in.

- Click OK on the Spatial Reference Properties dialog box.

- Click OK on the Define Projection tool.

The process runs and, when finished, a progress window reports that the operation was successful.

- Close the progress window.
Now that the coordinate system has been defined, the layer can be projected on the fly. The mountain features should display on the map in their correct (or very nearly correct) positions.

- Close the Define Projection dialog box.
- If you like, symbolize the mountains. (You might try an 8-point Triangle 2 symbol.) (Hint: Remember you can search for symbols.)

Defining a projection, as you have done here, is not the same thing as projecting data. When you project a feature class, you change a known coordinate system into another known coordinate system and create a new feature class in the process. When you define a projection for a feature class, you are saying that a previously unknown coordinate system is now known. No new data is created.

- Save your work and close ArcMap.

**Note:** The coordinate system for CanadaMountains remains defined whether you save the map or not.
Lesson review

1. What are the differences between a geographic and a projected coordinate system? Write your answers in the space provided.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. You receive some data with an unknown coordinate system. You are able to identify the coordinate system by contacting the person who gave you the data. Which action would you take?
   a. Write it down somewhere.
   b. Use the Project tool to change the coordinate system.
   c. Use the Define Projection tool to define the coordinate system.
   d. Modify the coordinate system of the data frame.
Answers to Lesson 8 questions

Exercise 8A: Project data on the fly

1. What is the native *projected* coordinate system of the MajorCities layer?
   - *World_Winkel_Tripel_NGS*

2. What is the native *geographic* coordinate system of the MajorCities layer? *Hint:* Look in the layer properties, not in the data frame properties.
   - *GCS_WGS_1984*

3. What is the output from the Project tool?
   - *A new feature class with a specified coordinate system*

Exercise 8B: Work with an unknown coordinate system

1. What is the coordinate system of the data frame—both geographic and projected systems?
   - The geographic coordinate system is *GCS_North_American_1983*. The projected coordinate system is *Canada_Albers_Equal_Area_Conic*.

2. What is the linear unit of measure of the projected coordinate system?
   - *Meter*

3. What is the distance?
   - *About 80 meters*

4. What is your best guess as to the type of units the CanadaMountains x,y coordinates represent?
   - *Latitude-longitude*

5. What is the use for this tool?
   - *For datasets that have an unknown or incorrect coordinate system defined, you can specify the correct coordinate system.*
Lesson review

1. What are the differences between a geographic and a projected coordinate system? Write your answers in the space provided.

<table>
<thead>
<tr>
<th>Coordinate systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geographic</strong></td>
</tr>
<tr>
<td>Defines locations on a spherical model of the earth</td>
</tr>
<tr>
<td>Difficult to measure distances</td>
</tr>
<tr>
<td>Shape is defined as a sphere</td>
</tr>
</tbody>
</table>

2. You receive some data with an unknown coordinate system. You are able to identify the coordinate system by contacting the person who gave you the data. Which action would you take?
   c. Use the Define Projection tool to define the coordinate system.
Managing tables

Introduction

The information stored in tables is essential to GIS operations. You can use tabular information to symbolize, label, identify, and find features. You can also use it to query, analyze, edit, and create data. In this lesson, you will take a closer look at tables and their properties, and learn how to connect tables through joins and relates.

Topics covered

- Table anatomy
- Spatial tables
- Nonspatial tables
- Compare fields in spatial and nonspatial tables
- Table joins
- Table relates

Learning objectives

After completing this lesson, you will be able to:

- Describe the difference between spatial and nonspatial tables.
- Sort an attribute table on multiple fields.
- Manage visual properties of fields.
- Join a nonspatial table to a layer attribute table.
- Relate a nonspatial table to a layer attribute table.
Getting information from tables

Finding records in a table
   • Use the Find command to search for specific values in a table

Viewing statistics for a table
   • Get statistics describing the values in numeric columns (fields)

You see how many values the field has (count), as well as the sum, minimum, mean, maximum, and standard deviation of those values.

Selecting records in tables
There are various ways to select records in a table.
   • Interactively select records by pointing at them
   • Select all the records in a table at once
   • Select records that meet certain criteria through an attribute query (Select By Attribute).
   For example, you can select all the cities with a population greater than 1 million.
   You will learn more about attribute query in Lesson 12.
Sorting records in tables

Sorting the rows in a table lets you more easily derive information from it. For example, you can determine which county had the highest growth last year.

- Sorting a column's values in ascending order displays the values from A to Z or from 1 to 10.
- Sorting a column's values in descending order displays the values from Z to A or from 10 to 1.

**Note:** When a table's rows are sorted, only the table's display is modified.

Sometimes it's helpful to sort a table by more than one column. For example, it might be helpful to sort counties first by state, then by population and age.

The easiest way to sort by more than one column is to right-click a field name and click Advanced Sorting. This opens a dialog box (shown below) that allows you to choose up to four fields to sort by and set each field's sorting order.
Field properties, aliases, and table display options

Field properties
Each field, or column, in an attribute table has properties that describe its contents and how the data in it should be displayed.

Following are some properties you can set.

Visibility: define which fields are displayed (the visible fields)
Alias: define an alias for a field name so the field appears in the table with a name that is easy to understand (helpful because you cannot change the names of fields in your data once they are created)
Number format: define the formatting for numeric data, such as currency values, or to display a relevant number of decimal places
Primary display field: determine the display field, which is used by the Identify window, Attributes window, and other functionality in ArcMap

Table appearance
When you open a table, you can customize its appearance in a variety of ways. For example, if you don’t like the default table font, you can change it and set the font size as well. You can make changes for all tables or just one—each table can have its own individual settings.

- You can resize columns to better see their values.
- You can reposition columns to compare the values in one field with the values in another.
- You can freeze columns. Frozen columns are locked in position at the left of the table and are separated from the other columns by a heavy black line. When scrolling horizontally, all other columns move normally but the frozen columns remain fixed.

Following are some appearance options you can set.

- Changing the color for selected records
- Changing the table font, font size, and color
- Setting column header and cell heights
Exercise 9A: Set table properties

Estimated time: 25 minutes

In this exercise, you will return information from attribute tables by sorting and selecting records. You will learn how to change the display of fields by setting visibility and alias properties. You will have a chance to customize an attribute table's appearance by changing its font properties, and you will also have a chance to create a bar graph from an attribute table.

In this exercise, you will:

▪ Sort a field and create statistics.
▪ Sort an attribute table on multiple fields.
▪ Set visibility and alias properties.
▪ Optionally, create a graph from an attribute table.

Step 1: Open a map document

☐ Start ArcMap and open USA 1.mxd from your ..\Student\DESK2\ManageTables folder.

☐ Maximize the application, if necessary, and zoom to the Continental US bookmark.

You see a map of the United States with viewer windows showing the states of Alaska and Hawaii.
Drag the viewer windows, if necessary, to convenient positions and resize them.

Viewer windows let you zoom and pan to a different part of the map, for example, to compare another area of the map with what is shown in the map display.

**Step 2: Open the States layer attribute table**

- Open the attribute table for the States layer.

The table name appears as a tab below the table.

- Dock the table window at the bottom of the application window and move the Viewer window away from the table window.

- Scroll down through the records and then back to the top.

There are 51 records in the attribute table (50 states plus the District of Columbia).

Each record has an automatically generated unique identifier stored in the OBJECTID field.

- Scroll to the end of the attributes and back.
The attributes include a variety of demographic data from the national census in 2000.

**Step 3: Sort a field and select records**

- Right-click the gray column heading of the `STATE_NAME` field and choose Sort Ascending.

The states are ordered alphabetically, with Alabama at the top.

- Click the gray box to the left of the Alaska record.

The record is selected in the attribute table and the corresponding feature is selected on the map and in the top Viewer window.

- Hold down the Ctrl key on your keyboard and select the District of Columbia record (OBJECTID 28).

The record is selected. The Alaska record remains selected, as well. (Both features are selected on the map, but the District of Columbia is small—it lies about midway down the eastern coast.)

At the bottom of the attribute table, the Show all records button is selected. This means all records are displayed.

- Click the Show selected records button. 


Now only the selected records are shown.


2. Which had a greater population density in 2000? *Hint:* Use the POP00_SQMI field.

- Click Show all records.
- At the top of the table window, click Clear Selection.

The selection is removed from the table and from the Alaska viewer window.

**Step 4: Format a field**

Notice the values in the POP2000 field (4447100, 626932, etc.). Numeric values are easier to read when commas separate the thousands.

- Right-click the POP2000 field heading and choose Properties.
- On the right of the Field Properties dialog box, click the Numeric button.
- On the Number Format dialog box, check the Show thousands separators box.

Notice that there are options to format numbers by category (in the Category list), by number of decimal places shown (in the Rounding area), and by alignment (in the Alignment area).

- Click OK on the Number Format dialog box.
- Click OK on the Field Properties dialog box.

The values in the POP2000 field are now formatted with commas.
Step 5: Return statistics on a field

- Right-click the POP2000 field heading and choose Statistics.

3. What was the total population of the United States in 2000?

- From the Field drop-down list, choose POP2005 (the 2005 estimated population).

4. Did the population exceed 300,000,000 in 2005?

- Close the Statistics of States1 window.

Step 6: Sort on multiple fields

- Right-click the SUB_REGION field heading and choose Advanced Sorting.

The Advanced Table Sorting dialog box lets you sort on multiple fields.

- Set the first drop-down list (Sort by) to SUB_REGION. Leave the option on the right set to Ascending.
Set the second drop-down list (Then sort by) to POP2000. Leave the option set to Ascending.

<table>
<thead>
<tr>
<th>Sort by</th>
<th>Then sort by</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUB_REGION</td>
<td>POP2000</td>
</tr>
<tr>
<td>Ascending</td>
<td>Ascending</td>
</tr>
</tbody>
</table>

Click OK.

In the attribute table, the states are now ordered by subregion. Within each subregion, they are ordered by population.

- Scroll down until you see the states in the Mountain subregion.
- Select the record for Wyoming, the least populous mountain state.
- Hold down the Shift key on your keyboard and select Arizona, the most populous mountain state.

All eight mountain states are selected.

- Right-click the POP2000 field heading and choose Statistics.

5. What was the total population of the mountain states in 2000?

______________________________________________________________________________

Close the Selection Statistics of States window.

- Click the Clear Selected Features button on the Tools toolbar.

This is another way to clear selected records.

**Step 7: Set visibility and alias properties**

- Leave the attribute table open and open the layer properties for the States layer. (The windows can overlap.)
On the Layer Properties dialog box, click the Fields tab.

The Layer Properties dialog box gives you access to the same field properties that you set by right-clicking a field heading and choosing Properties. The difference is that the Layer Properties dialog box presents all the fields at once.

- In the upper-left, click the Turn all fields off button.
- Click Apply.

The visibility check boxes next to the field names are unchecked on the dialog box and all the fields disappear from the attribute table.

- Check the visibility check boxes for the first 10 fields in the list (the ones up to and including POP05_SQMI).
- Scroll to the bottom of the list of fields and check the visibility check box for the SQMI field.
- Click Apply.

The checked fields are visible in the attribute table. You can see some of them but you cannot scroll through the attribute table while the Layer Properties dialog box is open.

Apart from visibility, most field properties (e.g., name, data type, length) cannot be changed after the field is created. A property you can change is the Alias property. An alias is a name that is displayed in the attribute table instead of the true name. Aliases can be longer than field names and can include special characters not allowed by names (spaces, for example). By default, the alias is the same as the name.

- On the left, in the field's visibility list, click STATE_NAME to make it editable.
The `STATE_NAME` field is selected and editable properties display on the right.

- Under Appearance, replace `STATE_NAME` with `NAME`.
- Change the alias for `STATE_FIPS` to `FIPS`.
- Change the alias for `STATE_ABBR` to `ABBREVIATION`.

- Click OK.

The field names are replaced by the aliases in the attribute table.

You can turn aliases on or off at any time.

- On the Table toolbar, click Table Options.
- Click Show Field Aliases to uncheck it.

In the attribute table, you see the true field names.

- From the Table Options menu, click Show Field Aliases to show the aliases again.
Step 8: Adjust field widths

In this step, you will make additional adjustments to your table to make it easier to read. For example, you will adjust the ABBREVIATION alias that is too long for its field width.

- From the Table Options menu, choose Restore Default Column Widths.

The field widths are adjusted so that all field headings can be read.

You can also widen or narrow fields individually. This can be useful when the values in a field are too long for the field width.

- Place your mouse pointer over the divider between the ABBREVIATION and POP2000 field headings.

- Click and drag slowly to the right.

As you drag, the ABBREVIATION field becomes wider. A vertical red line marks the original column boundary and a vertical black line marks the new column boundary.

- When you have widened the field slightly, release the mouse button.

- Drag the mouse pointer again to make the ABBREVIATION as narrow as possible and still display the entire field header.

- To learn how to modify the default appearance of an attribute table, go on to optional step 9.

- To create a graph of population data in the attribute table, go on to optional step 10.

- Otherwise, close the attribute table, save the map document in your ..\Student\DESK2\ManageTables folder as MyUSA 1 and close ArcMap.
Step 9: (Optional) Change the appearance of an attribute table

- From the Table Options menu, choose Appearance.

**Note:** There is no command to revert to default appearance settings, so you may want to write down your property settings before you experiment.

**Default Table properties**

<table>
<thead>
<tr>
<th>Color for selected records</th>
<th>R=176 G=255 B=255</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color for highlighted records</td>
<td>R=255 G=255 B=0 (Solar Yellow)</td>
</tr>
<tr>
<td>Table Font</td>
<td>MS Sans Serif</td>
</tr>
<tr>
<td>Table Font Size and Color</td>
<td>8 Black R=0 G=0 B=0</td>
</tr>
<tr>
<td>Column Header Height</td>
<td>125</td>
</tr>
<tr>
<td>Cell Height</td>
<td>115</td>
</tr>
</tbody>
</table>

The Table Appearance dialog box opens.

- In the Table Font drop-down list, change the font from MS Sans Serif to another font of your choice.

- In the Table Font Size and Color drop-down list, change the font size from 8 to 9.

- Click Apply.

The changes are applied to the attribute table.

- On the Table Appearance dialog box, click the light blue color square used to highlight selected records.

- On the color palette, choose a new color of your choice. *Hint:* Use any light color, such as Rhodolite Rose (row 1, column 12).
Click OK.

Select a record in the attribute table to highlight it in the new color.

Clear the selection.

Appearance changes apply only to one layer in one map document. When you need to make global changes, you can open the Options dialog box from the Tools menu and select the Tables tab. Changes you make on the Options dialog box will be applied to all new attribute tables that are opened (though not to attribute tables in saved map documents).

To create a graph of population data in the attribute table, go on to the optional next step. Otherwise, close the table window, save the map document in your ..\Student\DESK2\ManageTables folder as **MyUSA 1**, and close ArcMap.

### Step 10: (Optional) Create a graph

Graphs are an effective tool for visual comparisons. In ArcMap, you can create several types of graphs from table data and add these to map layouts or export them to common image file formats.

Scroll down in the attribute table until you see the states in the New England subregion.

Select the record for Vermont.

Hold down the Shift key on your keyboard and select the record for Massachusetts.

The six New England states are selected.

From the Table Options menu, choose Create Graph.

On the Create Graph Wizard, make sure the graph type is Vertical Bar and the layer/table is States.

Set the value field to POP2000.

Set the X label field to ABBREVIATION.
- Confirm that your wizard panel matches the following graphic.

- Click Next.

- On the second panel, choose the option to show only selected features/records on the graph.

- In the General graph properties area, change the title from Graph of States to **New England Population by State in 2000**.

- Uncheck the Graph legend box.

- In the Axis properties area, click the Bottom tab.

- Delete the ABBREVIATION title.
Confirm that your panel matches the following graphic.

Click Finish.

The graph is added to the map in a window that can be moved and resized. The graph is also linked to the data. If you select different records in the attribute table, the graph will update.

Right-click the graph's title bar and choose Save.
In the Save As dialog box, navigate to your ..\Student\DESK2\ManageTables folder. Accept the default file name and click Save.

The graph can now be loaded into other map documents.

- Right-click the graph's title bar again and choose Export.
- On the dialog box, make sure the Picture tab is selected.
- Click the "as Bitmap" format.
- Click Save.
- In the Save As dialog box, save the file in your ..\Student\DESK2\ManageTables folder with the name NewEnglandPopulation2000.

The graph is now a static image that can be added to another document, such as a word processing document.

- Close the Export Dialog dialog box.
- Click the View menu, point to Graphs, and choose Manage.

The Graph Manager opens as a dockable window.
Drag the Graph Manager and resize it so you can view more of the window.

On the Graph Manager, you can create new graphs, load saved graphs, delete graphs, and access graph properties.

- Make sure the Delete button is enabled. If it is not, click the graph name in the Graph Manager to select it.
- Click the Delete button to delete the graph.

Because you saved the graph, you can always load it again.

- Close the Graph Manager.
- Close the Table window and save the map document in your ..\Student\DESK2\ManageTables folder as **MyUSA 1**.
- Close ArcMap.
Spatial tables

- Records correspond to features
- ObjectID and Shape fields
Nonspatial tables

- No record-feature correspondence
- No Shape field
- May have OID field

For a list of supported tabular data formats, search for *Tabular data sources* in ArcGIS 10 Help.
Compare fields in spatial and nonspatial tables

1. In the table below, identify which fields are part of spatial and/or nonspatial tables by marking true or false accordingly.

<table>
<thead>
<tr>
<th>Field Description</th>
<th>Spatial table</th>
<th>Nonspatial table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corresponds to a feature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contains Shape field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contains OBJECTID field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contains numeric fields</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contains text fields</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contains date fields</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What if...

- You want to symbolize countries based on UN data

<table>
<thead>
<tr>
<th>OBJECTID</th>
<th>Shape</th>
<th>CNTRY NAME</th>
<th>POP2006</th>
<th>SQKM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Polygon</td>
<td>Belarus</td>
<td>10293011</td>
<td>205986.55</td>
</tr>
<tr>
<td>2</td>
<td>Polygon</td>
<td>Belize</td>
<td>287730</td>
<td>22867.9</td>
</tr>
<tr>
<td>3</td>
<td>Polygon</td>
<td>Benin</td>
<td>7862944</td>
<td>118508.73</td>
</tr>
<tr>
<td>4</td>
<td>Polygon</td>
<td>Bhutan</td>
<td>2279723</td>
<td>39458.2</td>
</tr>
<tr>
<td>5</td>
<td>Polygon</td>
<td>Bolivia</td>
<td>8669046</td>
<td>109058.4</td>
</tr>
<tr>
<td>6</td>
<td>Polygon</td>
<td>Bosnia &amp; Herzegovina</td>
<td>4488976</td>
<td>51366.25</td>
</tr>
</tbody>
</table>

Spatial table has no UN data

<table>
<thead>
<tr>
<th>OID</th>
<th>NAME</th>
<th>UN YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>152</td>
<td>Belarus</td>
<td>1945</td>
</tr>
<tr>
<td>145</td>
<td>Belgium</td>
<td>1944</td>
</tr>
<tr>
<td>49</td>
<td>Belize</td>
<td>1981</td>
</tr>
<tr>
<td>113</td>
<td>Benin</td>
<td>1960</td>
</tr>
<tr>
<td>162</td>
<td>Bhutan</td>
<td>1971</td>
</tr>
<tr>
<td>19</td>
<td>Bolivia</td>
<td>1945</td>
</tr>
<tr>
<td>122</td>
<td>Bosnia &amp; Herzegovina</td>
<td>1992</td>
</tr>
</tbody>
</table>

Nonspatial table has UN data
Table joins

- Append fields from one table to another table
- Support one-to-one and many-to-one relationships between records

### Spatial table

<table>
<thead>
<tr>
<th>OBJECTID</th>
<th>Shape</th>
<th>ENTRY_NAME</th>
<th>SQLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>176</td>
<td>Polygon</td>
<td>Afghanistan</td>
<td>641358.44</td>
</tr>
<tr>
<td>121</td>
<td>Polygon</td>
<td>Albania</td>
<td>26796</td>
</tr>
<tr>
<td>107</td>
<td>Polygon</td>
<td>Algeria</td>
<td>2327910.25</td>
</tr>
<tr>
<td>10</td>
<td>Polygon</td>
<td>American Samoa</td>
<td>84.2</td>
</tr>
<tr>
<td>108</td>
<td>Polygon</td>
<td>Andorra</td>
<td>336.24</td>
</tr>
<tr>
<td>218</td>
<td>Polygon</td>
<td>Angola</td>
<td>1252934.88</td>
</tr>
</tbody>
</table>

### Nonspatial table

<table>
<thead>
<tr>
<th>ID</th>
<th>NAME</th>
<th>UN_YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Afghanistan</td>
<td>1946</td>
</tr>
<tr>
<td>6</td>
<td>Albania</td>
<td>1995</td>
</tr>
<tr>
<td>4</td>
<td>Algeria</td>
<td>1962</td>
</tr>
<tr>
<td>10</td>
<td>American Samoa</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>Andorra</td>
<td>1993</td>
</tr>
<tr>
<td>9</td>
<td>Angola</td>
<td>1976</td>
</tr>
</tbody>
</table>

### Table after join

Each record in spatial table has one matching record in nonspatial table

More about joining tables

- ArcGIS allows you to associate records in one table with records in another table through a common field, known as a key.
  - When you join two tables, you append the attributes from one onto the other based on a field common to both.
  - When you join tables in ArcMap, you establish a one-to-one or many-to-one relationship between the layer’s attribute table and the table containing the information you want to join.

The following example illustrates a one-to-one relationship.
Here's an example of a many-to-one relationship:

In the above example, a Landuse layer stores a land-use code (ZONE_CODE); a separate table stores the full description of each code. Joining these two tables together establishes a many-to-one relationship.
Table relates

- Select records in one table to find matches in another table
- Support one-to-many and many-to-many relationships between records
- Tables remain separate

More about relating tables

- Relating tables defines a relationship between two tables—also based on a common field—but doesn't append the attributes of one to the other; instead, you can access the related data when necessary through selection.
  - For example, if you select a building, you can find all the tenants that occupy that building. This is a one-to-many relationship.
  - Similarly, if you select a tenant, you can find what building the tenant resides in (or several buildings, in the case of a chain of stores in multiple shopping centers—a many-to-many relationship).
What type of association is needed?

For each of the following scenarios, indicate whether you would join or relate the tables.

Suppose you want to determine the percentage of population by gender.

```
<table>
<thead>
<tr>
<th>OBJECTID</th>
<th>Shape</th>
<th>City</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>Point</td>
<td>Anderson</td>
<td>57,282</td>
</tr>
<tr>
<td>002</td>
<td>Point</td>
<td>Bedford</td>
<td>13,846</td>
</tr>
<tr>
<td>003</td>
<td>Point</td>
<td>Carmel</td>
<td>53,111</td>
</tr>
</tbody>
</table>
```

Suppose you want to determine the mailing addresses for parcel owners.

```
<table>
<thead>
<tr>
<th>OBJECTID</th>
<th>Shape</th>
<th>ParcelID</th>
<th>Land use</th>
</tr>
</thead>
<tbody>
<tr>
<td>010</td>
<td>Polygon</td>
<td>49</td>
<td>Agricultural</td>
</tr>
<tr>
<td>020</td>
<td>Polygon</td>
<td>152</td>
<td>Residential</td>
</tr>
<tr>
<td>030</td>
<td>Polygon</td>
<td>23</td>
<td>Commercial</td>
</tr>
<tr>
<td>040</td>
<td>Polygon</td>
<td>278</td>
<td>Residential</td>
</tr>
</tbody>
</table>
```

Determine the number of hotels in several cities in California.

```
<table>
<thead>
<tr>
<th>OID</th>
<th>Name</th>
<th>Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Los Angeles</td>
<td>No</td>
</tr>
<tr>
<td>200</td>
<td>Sacramento</td>
<td>Yes</td>
</tr>
<tr>
<td>300</td>
<td>Redlands</td>
<td>No</td>
</tr>
<tr>
<td>400</td>
<td>Palm Springs</td>
<td>No</td>
</tr>
</tbody>
</table>
```

```
<table>
<thead>
<tr>
<th>OID</th>
<th>Capital</th>
<th>Hotels</th>
<th>Golf courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>No</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>200</td>
<td>Yes</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>300</td>
<td>No</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>400</td>
<td>No</td>
<td>40</td>
<td>25</td>
</tr>
</tbody>
</table>
```
Exercise 9B: Join and relate tables

Estimated time: 30 minutes

By linking nonspatial attribute data to spatial data, you greatly increase the amount of information you can map and analyze. Tables formatted as dBASE (.dbf), Excel (.xls), or text (.csv) files are rich sources of existing data you can use. These kinds of tables often need some preparation before they can be successfully joined or related to a layer attribute table.

In this exercise, you will:

▪ Add a spreadsheet of data to ArcMap.
▪ Join the table to a layer attribute table.
▪ Symbolize a layer on a joined attribute.
▪ Add a text file of data to ArcMap.
▪ Relate the table to a layer attribute table.
▪ View records in the related table.

Step 1: Start ArcMap and review the data

☐ Start ArcMap and open USA 2.mxd from your \Student\DESK2\ManageTables folder.

☐ In the Catalog window, from your Home – DESK2\ManageTables directory, expand the Tables folder.

The folder contains two tables.

CrimeData2005.csv is a table of crime statistics for 2005, prepared by the U.S. Department of Justice and downloaded from its Web site. The table is a text file in CSV (comma-separated values) format.

StatePopEst2007.xls is a table of population estimates for the years 2001 to 2007, prepared by the Population Division of the U.S. Census Bureau and downloaded from its Web site. The table is a spreadsheet in Microsoft Excel format.

You will work with both of these tables in the exercise.
Maximize the application, if necessary, and zoom to the Continental US bookmark.

Open the attribute table for the States layer.

This is the same attribute table you worked with in the previous exercise. Most of the fields have been turned off for this exercise.
Step 2: Add a nonspatial table

- From the Catalog window, expand StatePopEst2007.xls to expose its sub entries.

Excel spreadsheets have sub entries because one file may include multiple worksheets and named ranges of data. In this case, there is one subentry: a worksheet named POPEST$.

- Drag POPEST$ to your table of contents.

When a nonspatial table is added to ArcMap, the table of contents automatically switches to List By Source.

If you switch to List By Drawing Order, you will not see the table. (List By Drawing Order shows only layers.)

- In the table of contents, right-click the POPEST$ table and choose Open.
The POPTEST$ table is added as a second tab to your Table window.

Scroll through the attributes.

Notice that the table has neither an ObjectID field nor a Shape field. These fields are defining characteristics of spatial tables.

The attributes include state names, midyear population estimates for the years 2000 to 2007, and the April 1, 2000, estimate (called Census2000).

In the POPEST$ table, select the Arizona record.

The record is selected in the table but the feature is not selected on the map. There is no association between the attributes in this table and the map features.

From the Table window, click Clear Selection.

Step 3: Compare the two tables

To associate the new census data with the map, you need to join or relate the POPEST$ table to the States layer attribute table. A join is appropriate when each record in the spatial table has no more than one possible match in the nonspatial table.

To view both tables at the same time, you will arrange them in a side-by-side configuration.

Click Table Options, point to Arrange Tables and then choose New Vertical Tab Group.
1. What is the common field you can use to associate these two tables?

Step 4: Join tables

- In the table of contents, right-click the States layer, point to Joins and Relates, and choose Join.

- In the Join Data dialog box, make sure the first (unnumbered) drop-down list is set to Join attributes from a table.

- In drop-down list 1, choose STATE_NAME. This is the common field from the layer attribute table.

- In drop-down list 2, make sure that POPEST$ is selected as the table to join.

- In drop-down list 3, make sure that State is selected. This is the common field from the nonspatial table.
Make sure your dialog box matches the following graphic.

- Click OK.
- In the Table window, close the POPEST$ table.

**Step 5: Examine the joined table**

- Scroll through the States attribute table.

To the right of the SQMI field, all the fields from the POPEST$ table have been appended. Some of the appended fields are not needed.

- Right-click the STATE_NAME field heading and choose Freeze/Unfreeze Column.
The state name will remain in view as you scroll.

☐ Right-click the POP2005 field heading and choose Turn Field Off.

The values in this field were projections made in 2000. It is confusing to display them in the table with the July05 values, which are different and more accurate.

☐ Scroll to the end of the table.

The values in the Census2000 field are identical to those in the POP2000 field.

☐ Turn off the Census2000 field.

☐ Hide the Table window.

**Step 6: Symbolize on joined data**

In this step, you will make a U.S. population density map based on the Census Bureau's July 2007 data. You will symbolize using the data that you joined from the POPTEST$ table.

☐ Open the layer properties for the States layer and click the Symbology tab.

☐ In the Show box, click Quantities. Accept the Graduated colors option.

☐ Set the Value field to July07 and the Normalization field to SQMI.

You learned about normalization in a previous lesson. Remember, normalization is the process of dividing one numeric attribute value by another to minimize differences in values based on the size of areas or the number of features in each area.
Set the color ramp to Yellow to Dark Red.

- Click Classify.
- On the Classification dialog box, change the classification method to Geometrical Interval and click OK.
- Click OK on the Layer Properties dialog box.

Geometric intervals are used to delineate classes based on natural groupings of data values. Break points are identified by looking for patterns in the data. The states are now symbolized based on the Census Bureau's July 2007 population estimate values from the nonspatial POPEST$ table.

2. Identify one of the states with the highest population density. Which state did you choose?

- Close the Identify window.

**Step 7: Remove the join**

The table join exists only in this map document and will remain until you remove it (or close the map document without saving changes).
Note: If you want to permanently append the joined data to the layer attribute table, you can export the layer to a new feature class. To do so, right-click the layer in the table of contents, point to Data, and choose Export Data.

- In the table of contents, right-click the States layer, point to Joins and Relates, point to Remove Join(s), and choose POPEST$.

When you remove the join, you lose the symbology on which the join was based. The symbology reverts to single symbol.

- Open the attribute table for the States layer to confirm that the joined fields are gone.
- In the States table, right-click STATE_NAME and then unfreeze the field.
- Remove the StatePopEst2007 spreadsheet from the table of contents.
- Close the POPEST$ table.

Step 8: Add another nonspatial table to the map

In this step, you will explore the crime data table and add it to your map.

- In the Catalog window, right-click the CrimeData2005.csv table and open its Item Description.
- Click the Preview tab.
If you like, resize the table and adjust the field widths. (*Hint:* Place your mouse pointer over the divider between the headings for two fields. Click and drag slowly.)

The data was compiled from metropolitan police and county sheriff departments. Only areas with populations over 100,000 were included.

Scroll through the attribute columns and rows.

The table displays totals for violent crimes and property crimes.

---

**Note:** This table and the Excel POPTEST$ worksheet have been processed to meet ArcGIS formatting requirements. For example, nondata rows have been deleted from the top of the population spreadsheet because ArcGIS interprets the contents of the first row as field names. Underscores have been added to the crime table field names because ArcGIS does not allow spaces in field names.

---

Close the crime data table Item Description window.

From the ..\Student\DESK2\ManageTables\Tables folder, add the CrimeData2005.csv table to the ArcMap table of contents.

Open the table.

Like the previous table, this table is added as a new tab in the Table window.
Arrange your tables side-by-side in the Table window.

Again, notice that the crime data table has neither an ObjectID field nor a Shape field. The records in the table have no connection to any features in the map.

**Step 9: Compare the tables**

3. Is there a field in each table that you can use to associate these two tables? If so, what are the fields?

---

In the crime table, sort the State field in ascending order.

For many states, there are multiple records. For example, Alabama has crime data from Birmingham, Huntsville, Jefferson County, Mobile, and Montgomery. If you joined the crime table to the States table, only one of these records could be matched—the others would be ignored. This would not be a desirable result.

The relationship between the States table with respect to the crime table is one-to-many (one record in the States table may have many matches in the crime table). Therefore, the tables should be related, not joined.

**Step 10: Export the crime table to dBASE format**

Unlike a join, a relate requires that both tables have ObjectID fields. The crime table does not have this field. If you export the crime table to an ArcGIS-managed format, however, an ObjectID field will be added to it automatically.

- Make sure the crime table tab is selected, and from the Table Options menu, choose Export.

- In the Export Data dialog box, accept the default setting to export all records.

- In the Export Data dialog box, click the Browse button next to the Output table box and navigate to the ..\Student\DESK2\ManageTables\Tables folder.
Change the output table name to **CrimeData2005** and make sure the Save as type is dBASE Table.

- Click Save.
- On the Export Data dialog box, confirm that the output table path is ..\Student\DESK2\ManageTables\Tables\CrimeData2005. *Hint:* If you need to change the path or file name, you can type directly into the Output table box.
- Click OK on the Export Data dialog box.
- Click Yes when prompted to add the new table to the current map.
- Close the CrimeData2005.csv table and remove the table from the map document.

**Step 11: Examine the new table**

- Open the new CrimeData2005 table.
- Arrange the States and crime data tables side by side.
Resize the CrimeData2005 table to view more of its fields.

The table contains the same data as CrimeData2005.csv, but a new OID field has been added. Also, field names have been truncated to 10 characters.

Right-click the OID field heading and choose Properties.

Although the field name is OID (not OBJECTID), it has an Object ID field type. The name of an Object ID field may vary with the file format (e.g., dBASE versus geodatabase format), but the function is the same.

Click Cancel on the Field Properties dialog box.

Step 12: Relate tables

There are two ways you can create a join or a relate. Earlier you learned that you can right-click a layer and then choose Joins and Relates from the context menu that opens. In this step, you will use another option.

Make sure the States table is selected. (Hint: Click the States tab.)

Click Table Options, point to Joins and Relates, and choose Relate.

In the Relate dialog box, set drop-down list 1 to STATE_ABBR.

This is the common field from the layer attribute table.

Set drop-down list 2 to CrimeData2005.
- Set drop-down list 3 to State.

This is the common field from the nonspatial table.

- Accept the default name for the relate and click OK.

Nothing visible happens, but the records in the two tables are now linked.

**Step 13: Explore the relate and remove it**

- In the States table, sort the STATE_NAME field in ascending order.
- Select the Florida record.
- Click Table Options, point to Related Tables, and choose Relate1 : CrimeData2005.

The crime table opens with all Florida records selected.
4. If necessary, for the crime table, click Show selected to see only the selected records.

<table>
<thead>
<tr>
<th>OID</th>
<th>Agency</th>
<th>State</th>
<th>Months</th>
<th>Population</th>
<th>Violent_cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Alachua County Sheriff Dept</td>
<td>FL</td>
<td>12</td>
<td>104831</td>
<td>1027</td>
</tr>
<tr>
<td>39</td>
<td>Brevard County Sheriff Dept</td>
<td>FL</td>
<td>12</td>
<td>226867</td>
<td>1064</td>
</tr>
<tr>
<td>41</td>
<td>Broward County Sheriff Dept</td>
<td>FL</td>
<td>12</td>
<td>110239</td>
<td>691</td>
</tr>
<tr>
<td>47</td>
<td>Cape Coral Police Dept</td>
<td>FL</td>
<td>12</td>
<td>130874</td>
<td>361</td>
</tr>
<tr>
<td>54</td>
<td>Charlotte County Sheriff Dept</td>
<td>FL</td>
<td>12</td>
<td>143077</td>
<td>650</td>
</tr>
<tr>
<td>52</td>
<td>Citrus County Sheriff Dept</td>
<td>FL</td>
<td>12</td>
<td>129725</td>
<td>325</td>
</tr>
<tr>
<td>56</td>
<td>Clay County Sheriff Dept</td>
<td>FL</td>
<td>12</td>
<td>152523</td>
<td>703</td>
</tr>
<tr>
<td>68</td>
<td>Clearwater Police Dept</td>
<td>FL</td>
<td>12</td>
<td>111058</td>
<td>983</td>
</tr>
<tr>
<td>71</td>
<td>Collier County Sheriff Dept</td>
<td>FL</td>
<td>12</td>
<td>135928</td>
<td>1279</td>
</tr>
</tbody>
</table>

4. What was the total number of violent crimes (Violent_cr) for Florida in 2005? (Hint: Create statistics on the attribute.)

______________________________________________________________________________

- In the States attribute table, select the California record.

The records in the related table do not update automatically. You have to update them manually.

- With the States tab selected, from the Table Options menu, point to Related Tables, and choose Relate1 : CrimeData2005.

5. What was the total number of violent crimes for California in 2005?

______________________________________________________________________________

Why didn't you symbolize features based on the relate? Unlike joining tables, relating tables simply defines a relationship between two tables. The associated data isn't appended to the layer's attribute table as it is with a join. Thus, there are no attributes that can be used for symbolizing. Instead, you can access the related data when you work with the layer's attributes.

- Close the Table window.

- In the table of contents, right-click the States layer, point to Joins and Relates, point to Remove Relate(s), and choose Relate1.
☐ Close ArcMap and do not save changes.
Lesson review

1. The Shape field and ObjectID field essentially define a layer attribute table. Why are these fields so important?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. Compare a join and a relate.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. You have two tables. One table contains the names and mailing addresses of land owners who each own at least one parcel. The other table contains the parcel features. What kind of relationship exists between records in these tables?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

4. Suppose you have a cities layer with population information in the attribute table. You want to find the locations of the five cities with the largest populations. How would you do it?

______________________________________________________________________________
______________________________________________________________________________
Answers to Lesson 9 questions

Exercise 9A: Set table properties

   - Alaska

2. Which had a greater population density in 2000? *Hint:* Use the POP00_SQMI field.
   - The District of Columbia

3. What was the total population of the United States in 2000?
   - 281,421,906

4. Did the population exceed 300,000,000 in 2005?
   - No

5. What was the total population of the mountain states in 2000?
   - 18,172,295
Compare fields in spatial and nonspatial tables

1. In the table below, identify which fields are part of spatial and/or nonspatial tables by marking true or false accordingly.

<table>
<thead>
<tr>
<th></th>
<th>Spatial table</th>
<th>Nonspatial table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corresponds to a feature</td>
<td>True</td>
<td>False</td>
</tr>
<tr>
<td>Contains Shape field</td>
<td>True</td>
<td>False</td>
</tr>
<tr>
<td>Contains OBJECTID field</td>
<td>True</td>
<td>False</td>
</tr>
<tr>
<td>Contains numeric fields</td>
<td>True</td>
<td>True</td>
</tr>
<tr>
<td>Contains text fields</td>
<td>True</td>
<td>True</td>
</tr>
<tr>
<td>Contains date fields</td>
<td>True</td>
<td>True</td>
</tr>
</tbody>
</table>

Exercise 9B: Join and relate tables

1. What is the common field you can use to associate these two tables?

   The STATE_NAME field in the layer attribute table and the State field in the nonspatial table.

2. Identify one of the states with the highest population density. Which state did you choose?

   Massachusetts, Rhode Island, or New Jersey

3. Is there a field in each table that you can use to associate these two tables? If so, what are the fields?

   Yes. The STATE_ABBR field in the layer attribute table and the State field in the nonspatial table.

4. What was the total number of violent crimes (Violent_cr) for Florida in 2005? (Hint: Create statistics on the attribute.)

   81,995
5. What was the total number of violent crimes for California in 2005?

133,014

Lesson review

1. The Shape field and ObjectID field essentially define a layer attribute table. Why are these fields so important?

   ArcGIS creates and maintains both of these fields. Users should not modify these values outside the ArcGIS environment.
   Shape stores the geometry for the feature.
   In ArcGIS, the ObjectID is a system-managed value that uniquely identifies a record or feature.

2. Compare a join and a relate.

   A join appends fields from one table (usually nonspatial) to another table (usually spatial).
   A relate establishes a bidirectional lookup of matching records in two tables.

3. You have two tables. One table contains the names and mailing addresses of land owners who each own at least one parcel. The other table contains the parcel features. What kind of relationship exists between records in these tables?

   One-to-many (one land owner to many parcels)

4. Suppose you have a cities layer with population information in the attribute table. You want to find the locations of the five cities with the largest populations. How would you do it?

   You could sort the records in the table in descending order based on population, then select the top five records in the table.
Introduction

Editing GIS data is a key component of managing your data. You may need to modify existing data to reflect changes in the real world or add new features. Following a standard editing workflow makes editing more efficient.

Topics covered

▪ What is editing? What kinds of edits do you make?
▪ Types of data you can edit
▪ Ways to edit
▪ Preparing to edit
▪ Feature templates
▪ Snapping
▪ Editing workflow
▪ Editing and calculating attributes

Learning objectives

After completing this lesson, you will be able to:
▪ Apply a workflow for creating and editing features.
▪ Digitize new point, line, and polygon features.
▪ Update attributes for the features.
What is editing?

Types of data you can edit

- Feature data (stored in shapefiles and geodatabases)
- Tabular data
- Points, lines, polygons, text (annotation)
Ways to create and edit data

- Digitizing
  - “On-screen” or “heads up”
  - Digitizing board
- Scanning (automated digitization)
Preparing a map for editing

1. Confirm that layers are in same workspace (geodatabase or folder)
2. Confirm that coordinate systems of all layers match
3. Symbolize layers
4. Simplify attribute fields
Feature templates

- Define all the information required to create a feature
- Created automatically or create your own

Information required to create a feature:

- The layer to which the feature will be added
- The attributes associated with the new feature
- The tool that will be used to create the feature

Templates also have a name, description, and tags that will help you find and organize them.

The availability of feature creation tools, or construction tools, depends on the type of template you select. For example, when you select a point template, you see a set of tools for creating point features.

If templates are not present when you start editing, they are automatically created for each layer in the current editing workspace.

Templates are saved in the map document (.mxd) and the layer file (.lyr).
Snapping

◆ Create features that connect to other features
  ◆ Mouse pointer snaps to points, endpoints, vertices, and edges

The snapping tolerance is the distance within which the mouse pointer (or a feature) snaps to another element, such as a vertex or edge.
You set the default snapping tolerance value in pixels.
All the settings you need to work with snapping are located on the Snapping toolbar.
Additional ones are available on the Snapping menu.
Editing workflow

1. Start an edit session
2. Choose a feature template and construction tool
3. Set additional editing options, like snapping
4. Create new or edit existing features
5. Edit attributes
Editing attributes

- Enter new values
- Edit existing values

You enter new attribute values when you create features.
You can also edit existing attribute values.
When you create a new feature, it starts with only the default attribute values specified in the feature template.
The Attributes window shows the layer (at the top), and the attribute values of the selected feature or features.
Alternatively, you can open the Table window to add or change a value.
The Table window allows you to use the Field Calculator.
Calculating attribute values

- **Field Calculator**
- **Calculate Geometry**

**Editing tips**

- Edit in one data frame at a time.
- Edit in one workspace (geodatabase or folder) at a time.
- Although you can edit data in different coordinate systems, it is generally best if all the data you plan to edit has the same coordinate system as the data frame.
- You can undo edits back to the previous save.
- Although you don't have to be in an edit session to calculate field values, an edit session is recommended because it allows you to undo your edits.
- You can redo edits after undoing.
- Saving edits changes the data source.
- Saving the map document is not the same as saving edits.
- You can end an edit session without saving.
Exercise 10: Edit features and attributes in ArcMap

Estimated time: 50 minutes

Editing GIS data is a key component to mapping, visualization, and analysis. Sometimes, you may need to modify your existing data to reflect changes in the real world. Other times, you may need to capture existing features and add them to your data for a project.

In this exercise, you will:

▪ Use ArcMap editing tools.
▪ Create new point, line, and polygon features.
▪ Update attributes.
▪ Optionally, calculate attribute values.

Step 1: Open a map document and prepare a background layer

☑ Start ArcMap.

☑ From the Catalog window, navigate to your ..\Student\DESK2\Edit folder and expand it.

☑ Double-click Editing.mxd.

You will perform your editing in the Editing geodatabase.

☑ Right-click the Editing geodatabase, then choose Make Default Geodatabase.

The default geodatabase is the home location for the spatial content of your map document. This geodatabase is used for adding datasets and for saving datasets created by editing.

You will use a raster dataset as a basemap to use as a guide when you create new features. Before you begin, you will optimize this dataset to run faster.

Pyramids are representations of your dataset used to improve performance so the image will draw faster.
In the Catalog window, drag Louisiana_Landsat.jpg to the map.

In the Create pyramids dialog box that appears, click Yes to create pyramids.

Please be patient while the process takes several moments to complete.

**Note:** Pyramids are representations of your dataset used to improve performance. Pyramids can speed up the display of raster data by retrieving only the data at a specified resolution that is required for the display. Pyramids only need to be built once per raster dataset; after that, they are accessed each time the raster dataset is viewed.

When the process finishes, the image draws in the table of contents.

Maximize your application window and zoom to full extent.
The map contains a satellite image of southeastern Louisiana and several vector layers. You will be creating new features and modifying existing features in these layers.

- Save your map as MyFeatureEditing.mxd in your ..\Student\DESK2\Edit folder.

**Step 2: Prepare for editing**

First, you will determine whether the layers to be edited reside in the same geodatabase.

You will edit the Lakes, Places, and Rivers feature classes.

- From the table of contents, click List By Source.
  1. Do all three layers reside in the same geodatabase?
  
  Write the name of the geodatabase in the appropriate box in the following table and also write whether the layers reside in the same geodatabase.

<table>
<thead>
<tr>
<th>Preparing to edit</th>
<th>Name</th>
<th>Same for all layers? (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geodatabase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projection</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The geodatabase was easy to determine. But what about the projection? Next, you will determine the projection for each of the layers.

- Open the layer properties for Places, click the Source tab, and locate the projection.
- For the Places layer, write the projection name in the table.
- Close the layer properties window.
- On your own, determine the projection for the Lakes and Rivers layers.
  2. Are their projections identical to the projection for the Places layer?
Write this additional answer in your table.

You have now completed part of your pre-edit checklist.

Before you begin editing, you want to be certain that the symbology is appropriate for new features that you will add. You will accept the current symbology.

Finally, you will look at the attributes to determine whether any fields are not essential. You can turn off these fields to avoid inadvertently editing them.

One at a time, open the attribute table for each layer.

None of the tables is large and there are no unnecessary fields, so you do not need to turn off any fields. You have completed your pre-edit checklist and are now ready to begin editing.

Close the Rivers and Lakes attribute tables.

Step 3: Digitize a new point feature and update attributes

In this step, you will locate places of interest on the satellite image that you will use as the background for creating new point features.

View the attribute table for the Places layer.

Although the Places feature class has been created and attributes have been added to it, it does not yet contain any features.

Dock the Table window and set it to auto hide so you will have more space for editing.
On the Standard toolbar, click the Editor Toolbar button to display the Editor toolbar.

**Note:** If the Editor toolbar is already displayed, clicking this button will close it.

Most of the functionality on the Editor toolbar will be disabled while you prepare for editing.

In order to begin editing, you need to start an edit session.

**Start an edit session**

- On the Editor toolbar, from the Editor menu, choose Start Editing.

On the right, the Create Features window opens and displays templates for the layers in your map. You can control which templates you want to display.

- Set the Create Features window to Auto Hide.

**Filter templates**

- Click the Arrange templates by Grouping and Filtering button, point to Filter By, then choose Point.

Only the Places template displays; the Rivers template no longer displays.

**Best practice:** Feature templates are especially useful when there are many layers in the table of contents. Feature templates define all the information required to create a feature: the layer where a feature will be stored, the attributes a feature is created with, and the default tool used to create that feature. Templates also have a name, description, and tags that help you find and organize them.

- Click the Filter button again and choose Show All Templates.
Zoom to the Louisiana Superdome bookmark.

The large white circular structure to the west of the river is the Louisiana Superdome, an indoor sports stadium. This is the first place of interest you will digitize.

Before you begin digitizing the new feature, you need to choose the layer to edit.

In the Create Features window, click Places to select the template.

This is the layer to which new features will be added. The list of layers available includes all editable layers in the current data frame.
3. Why wasn't the Louisiana satellite image listed in the Create Features window?

Choose a construction tool

In the Construction Tools area, click the Point tool.

Add a new feature

- Click the Superdome.

A new point feature is added and selected. New features are always selected automatically so you can quickly access their attributes.

Best practice: When you create new features, edit their attributes.

Edit the attributes for your new feature

- On the right of the Editor toolbar, click the Attributes button.

The Attributes window opens with attribute information about the selected feature.
The layer name is listed, along with the selected feature’s value in the primary display field (in this case, OBJECTID). Below the OBJECTID attribute, other feature attributes are listed.

4. How many attributes are in the Places table?

- Click the <Null> value for the Name property to make it editable.
- Type Louisiana Superdome and press Enter.
Open or restore the attribute table for the Places layer.

<table>
<thead>
<tr>
<th>OBJECTID</th>
<th>SHAPE</th>
<th>Name</th>
<th>XCoord</th>
<th>YCoord</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Point</td>
<td>Louisiana Superdome</td>
<td>&lt;Null&gt;</td>
<td>&lt;Null&gt;</td>
</tr>
</tbody>
</table>

The Name value you just entered on the Attributes window is displayed in the attribute table.

**Note:** Look closely and notice that some of the field headings are shaded and some are white. The color indicates whether you can edit the field's values: white fields are user-managed and editable; shaded fields are software-managed and noneditable. The names of the shaded fields also display an asterisk.

From the Editor menu, choose Save Edits.

Saving edits is a key step to updating features and attributes. All edits are temporary until you save them. When you save edits, they are applied permanently to the feature class on disk—not just to the layer in ArcMap.

**Step 4: Create a new point feature from coordinate values and update attributes**

There is almost always more than one way to solve a problem or create a new feature. In the previous step, you digitized to create a new point feature. In this step, you will use known X and Y coordinate values to create a new point feature.

Zoom to the Big Branch Marsh National Wildlife Refuge bookmark.

You will create a point feature, based on the address of the park headquarters, for the Big Branch Marsh National Wildlife Refuge. You could create the point by clicking the Point construction tool as you did for your first feature, but you will use a different method this time. You will create the point using known x,y coordinates.

The address of the park headquarters is 16389 Highway 434, Lacombe, Louisiana 70445.

In the units of the current coordinate system, UTM Zone 15, this address is located at 794998, 3358326.
Open the Create Features window and make sure that the Places template and the Point construction tool are selected.

Right-click anywhere in the map and choose Absolute X, Y from the context menu.

The Absolute X, Y box opens.

- Click the small arrow and make sure that Meters is checked.
- In the X box, type 794998.
- This is the x-coordinate.

- In the Y box, type 3358326.

Press Enter.

A new point is added at the coordinates you specified.
You just generalized a large area on the image into a point feature. Feature geometry is often scale-dependent. For example, you have probably seen maps on which a city is represented by a point at a smaller scale and by a polygon at a larger scale.

- Open the Attributes window to view the attributes for the new feature. (*Hint:* You can click the Attributes tab or the Attributes button.)

- Change the Name value to **Big Branch Marsh NWR** and press Enter.

5. Why do the attributes for XCoord and YCoord show the value Null?

______________________________________________________________________________
______________________________________________________________________________

- From the Editor menu, choose Save Edits.
Step 5: Update an attribute for multiple features

You updated the Name attribute in the Attributes window for both of your new features individually. For unique values such as these names, that is suitable. What if you wanted to give them the same name (e.g., one that is more general)? When a single attribute value is applicable to more than one feature in a layer, you can update it for all of those features at the same time.

- Zoom to the full extent.

- In the table of contents, right-click the Places layer, point to Selection, and choose Select All.

Both features in the Places layer are selected.

- If necessary, open the Attributes window.

The names of both selected features display under Places.

- One at a time, click each feature name and view its attributes.

- In the Attributes window, click Places.

- Change its Name value to **Louisiana Places** and press Enter.
Click each feature again, then click Places.

The value you entered at the layer level has filtered down to all selected features. However, the specific names are probably more useful than "Louisiana Places."

Click the Undo button.

The Name values resort to Louisiana Superdome and Big Branch Marsh NWR. The ability to undo edits can save you a lot of trouble. When you make mistakes, you can always undo back to the point when you last saved edits.

Clear the selected features.

Save your edits.

Step 6: Digitize a new line feature and update an attribute

Notice the light blue squiggly line in the northwestern section of the map. This is a feature in the Rivers layer representing the Mississippi River. The feature ends over land. In actuality, however, the Mississippi River empties into the surrounding waters of the Gulf of Mexico. (You can see this in the underlying satellite image.) To fix this problem, you will digitize the rest of the river.
6. In the Create Features window, what change do you need to make in order to digitize the river?

- Make the necessary change in the Create Features window.

7. Which Construction Tool is selected?

- Click the selected construction tool.

  - Tip: Remember to set the Create Features, Attributes, and Table windows to auto hide while you edit.

- Pan so there is some white space to the right of the map. (You will use this space when editing.)

When you were creating new point features, the new points did not have to connect to any other features, so you did not need to set the snapping environment. Now, however, you need to make sure that when you continue the river, the new part will connect to the part that already exists.

- From the Editor menu, choose Snapping, then Snapping Toolbar.

The Snapping toolbar opens. In this case, your goal is to continue digitizing the partially digitized river from its end point.

- On the Snapping toolbar, make sure that Use Snapping is checked.

Snapping is enabled as soon as you turn on the Snapping window. By default, all the snapping tools are turned on.
One at a time, hover your mouse pointer over the four snapping tools at the top of the Snapping toolbar. You will be using End Snapping to extend an existing river feature.

To make it easier for you to see where you digitize and snap, you will turn on the background for your snapping tool.

- Click Snapping, then click Options. In the Snap Tips area, click Background to check it.
- Click OK.
- Dock the Snapping toolbar to move it away from the map.

To better see the area you are digitizing, you will use a magnifier window.

- From the Windows menu, choose Magnifier.
- In the scale box at the top of the magnifier window, set the magnification level to 300%, if necessary.
Position the magnifier window so that it is centered above the southern end of the existing river feature.

In the magnifier window, move your mouse pointer toward the end of the Rivers feature. When your mouse pointer gets close to the end point, it snaps to it.
While you are snapped to the feature, click to place the first vertex of your segment.

Look in the status bar in the lower left corner of your ArcMap application window.

The status bar at the bottom of your ArcMap window indicates that you have snapped to the end of a feature in the Rivers layer.

Move your mouse pointer away from the vertex (it does not matter where).

Your starting point is marked by a red square. As you drag, a colored line extends from the starting point.

Following the river in the satellite image, click to add vertices. Your segment can be rough; it does not need to be perfect.

When you reach the end of the magnifier window, use your mouse to move the window to the east to see more of the river.

Continue digitizing until you reach the end of the window again.
☐ When you reach the end of the magnifier window again, click the right arrow button under the X in the upper-right corner of the window.

☐ Choose Update While Dragging from the context menu.

☐ Move the magnifier window to see more of the river.

Now the contents of the map below the magnifier window automatically display as you drag the window, making the display easier to manage.

**Note:** You can also enlarge the Magnifier window by dragging one of its corners.

☐ Continue to add vertices until you reach the end of the river, as approximately shown in the following graphic (the location does not need to be exact).

☐ Double-click to finish.

Your new river feature is complete.

☐ Close the magnifier window.

☐ Open the River attributes window and enter a Name value of *Mississippi*.

☐ Save your edits.
Step 7: Explore snapping properties

You used end snapping in the previous step. Next, you will take a quick look at vertex snapping.

- In the Create Features window, make sure Rivers is selected.
- In the Construction Tools, click Line.

Hold your mouse pointer over the end point of the river feature you just digitized.

Your mouse pointer snaps to the Rivers end point.

Move your mouse pointer over other parts of the river feature.

Your mouse pointer snaps to each vertex.

8. Why does your mouse pointer snap to each vertex as well as to the end point?
**Best practice:** When you edit, turn on snapping. Snapping allows you to edit features that connect to each other so your edits are more accurate, with fewer errors.

- Close the Snapping Toolbar. (*Hint:* From the Editor menu > Snapping or from the Customize menu > toolbars.)

### Step 8: Modify feature vertices

In this step, you will fix a poorly digitized section of the river feature by moving vertices.

- Zoom to the Modify River bookmark.

This is not part of your digitization; it is part of the river feature that was already present when you opened the map.

The digitized feature should be located completely over the river it represents in the satellite image. However, portions of it are over land, not water. You will move vertices to fix these digitizing errors.

- In the Create Features window, make sure Rivers is selected.

- In the Construction Tools, click Line.

- On the Editor toolbar, click the Edit tool.
Double-click the river feature.

The feature's vertices are exposed. The Edit Vertices mini-toolbar displays with the Modify Sketch Vertices tool selected. The toolbar provides an easy way to select, add, and delete vertices.

Position your mouse pointer over a vertex that is located over land.

When it is over the vertex, the mouse pointer changes to a four-headed arrow.

Click the vertex, drag it to the center of the river in the image, and release your mouse button.

It may be difficult to distinguish the green vertex and lines of the sketch from the blue river below them. Finishing the sketch will help you see the results of your vertex move more clearly.

On the Edit Vertices toolbar, click the Finish Sketch button.

The river feature is reshaped based on where you moved the vertex.

Double-click the river feature to expose its vertices again.

From the Edit Vertices toolbar, click the Add Vertex button and click the segment where you want to insert the vertex.

A new vertex is placed where you clicked.

Click and drag the new vertex to a different location over the river.

If necessary, expose the river feature's vertices again.

Continue moving vertices in the current extent until they are all located over the river in the satellite image.

When you are finished, click Finish Sketch.

Save your edits.

Clear the selected feature.

**Step 9: Digitize a new polygon feature and update an attribute**

Next, you will digitize a new polygon feature.
There are many lakes in this part of Louisiana. From the satellite image, it would be difficult to get a sense of the area of each lake. If you create vector features, however, the area will be stored in the attribute table.

Turn on the Lakes layer.

A feature for Lake Pontchartrain has already been created. You will digitize neighboring Lake Maurepas.

Zoom to the Lake Maurepas bookmark.

Zoom in on the northern half of the lake.

In the Create Features window, change the template to Lakes.

Make sure the Polygon Construction tool is selected.
Click the location shown in the following graphic to place the first vertex of your edit sketch.

Begin digitizing counterclockwise, adding vertices until you reach the bottom of the current map extent. Like your river sketch, this sketch can be rough.

When you reach the bottom of the current map extent, hold down the C key on your keyboard.

Your mouse pointer switches to the Pan tool. The C key is a shortcut key to bring up the Pan tool while editing. Using a shortcut key allows you to temporarily switch between tools while you are sketching.

Note: Other shortcut keys include the Z key for the Zoom In tool and the X key for the Zoom Out tool.

While holding down the C key on your keyboard, pan to the southwest to see more of the lake, then release your mouse button and the C key.

Your mouse pointer switches back to the Sketch tool.

Continue adding vertices along the boundary of Lake Maurepas. If you like, use shortcut keys and/or the magnifier window as you digitize.
When you have digitized the whole lake, finish the sketch. (Hint: On the Edit Vertices toolbar, click the Finish Sketch button.)

Zoom to the Lake Maurepas bookmark.

Make sure the lake feature is selected.

From the Editor toolbar, open the Attributes window and enter a Name value of Lake Maurepas.

Examine the other attributes.

There is an attribute called Acres, which you will populate if you perform the optional next step. There are also attributes called Shape_Length and Shape_Area, which ArcGIS automatically adds to polygon feature classes when they are created. Their values are shown in the data's storage unit (in this case, meters). Now, by referring to the Shape_Area attribute, you can learn the area of any lake features that you digitize.

Save your edits.

From the Editor menu, choose Stop Editing to stop the edit session.

To learn how to calculate attribute values in an attribute table, go on to the optional step Calculate attribute values. Otherwise, save your map and close ArcMap.

**Step 10: (Optional) Calculate attribute values**

Up to this point, you have edited attribute values by entering them manually on the Attributes window. There are some types of attribute values that ArcMap can calculate and populate for you. In this step, you will edit attribute values using a command called Calculate Geometry.

Open the attribute table for the Places layer. (Remember: You open the attributes window from the Editor toolbar; you open the attribute table from the layer in the table of contents.)

The Places layer contains XCoord and YCoord attribute fields, both of which contain null values. You will calculate the x,y coordinates of both records in the attribute table.

Right-click the XCoord field heading and choose Calculate Geometry.

If a Calculate Geometry message box appears, click Yes.
On the Calculate Geometry dialog box, confirm that the Property drop-down list is set to X Coordinate of Point.

In the Coordinate System area, confirm that the option to use the coordinate system of the data source is chosen.

In this case, it does not really matter, because the data source and the data frame coordinate systems are the same.

Confirm that the Units drop-down list is set to Meters.

Click OK.

If necessary, widen the field to see the full values.

The x-coordinates of the features are calculated in meters. The XCoord attribute field is populated accordingly. Your XCoord value for the Louisiana Superdome may differ because you may have placed your point in a slightly different location.

Right-click the YCoord field heading and choose Calculate Geometry.

Click Yes on the warning.

From the Property drop-down list, choose Y Coordinate of Point.

Confirm that the option to use the coordinate system of the data source is chosen.
Confirm that the Units drop-down list is set to Meters.

Click OK.

<table>
<thead>
<tr>
<th>YCoord</th>
</tr>
</thead>
<tbody>
<tr>
<td>3316926.2756</td>
</tr>
<tr>
<td>3358326</td>
</tr>
</tbody>
</table>

Again, your values may differ slightly. Next, you will calculate the area of the Lakes features in acres.

Open the Lakes layer attribute table.

Right-click the Acres field heading and choose Calculate Geometry.

Click Yes on the warning.

If necessary, choose Area from the Property drop-down list.

From the Units drop-down list, choose Acres US [ac].

Click OK. (Your results may vary.)

<table>
<thead>
<tr>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>408094.09185</td>
</tr>
<tr>
<td>57807.954184</td>
</tr>
</tbody>
</table>

Now you have the acreage for each lake feature. The ability to calculate geometry is powerful because you may need to store area in a unit other than the coordinate system of the data.

Close the Table window.

Save your map and close ArcMap.
Lesson review

1. In the editing workflow, the first task is to choose the feature template.
   a. True
   b. False

2. Which attributes are calculated automatically when you digitize a polygon feature?

   ___________________________________________________________
   ___________________________________________________________

3. When ____________ is turned on, your mouse pointer will jump to an edge or vertex when your mouse pointer is near it and within a certain tolerance, or distance.
Answers to Lesson 10 questions

Exercise 10: Edit features and attributes in ArcMap

1. Do all three layers reside in the same geodatabase?
   Yes

2. Are their projections identical to the projection for the Places layer?
   Yes

3. Why wasn't the Louisiana satellite image listed in the Create Features window?
   Raster data is not editable in ArcMap.

4. How many attributes are in the Places table?
   Four attributes: OBJECTID, Name, XCoord, and YCoord

5. Why do the attributes for XCoord and YCoord show the value Null?
   When you created the point, you assigned X and Y values to its geometry, or Shape. The table contains the attributes XCoord and YCoord but these values are not associated with the Shape field.

6. In the Create Features window, what change do you need to make in order to digitize the river?
   You need to choose the Rivers template.

7. Which Construction Tool is selected?
   Line

8. Why does your mouse pointer snap to each vertex as well as to the end point?
   Because, by default, in addition to end snapping, vertex snapping is also turned on.
Lesson review

1. In the editing workflow, the first task is to choose the feature template.
   b. False

2. Which attributes are calculated automatically when you digitize a polygon feature?
   Shape_Length and Shape_Area

3. When snapping is turned on, your mouse pointer will jump to an edge or vertex when your mouse pointer is near it and within a certain tolerance, or distance.
Introduction

In this lesson, you will create a new geodatabase and a new feature class. When you create a new feature class, you have to define its properties and attributes, collectively referred to as feature class schema. Once you have created the feature class schema, you are ready to add features and attribute values. You will use construction tools to create a new feature, then add attribute values and metadata for the feature.

Topics covered

- How do you organize your data?
- How do you document your data?
- Organizing a geodatabase
- Organizing feature classes
- Defining feature class properties
- Defining attributes
- Workflow for creating new data
- Documenting your data
Learning objectives

After completing this lesson, you will be able to:

▪ Describe what a geodatabase schema is.
▪ Create the schema for a new feature class.
▪ Create a geodatabase and an empty feature class.
▪ Add a feature to the new feature class.
▪ Document the new feature class.
How do you organize your data?

Notes

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How do you document your data?

Notes
Organizing data in a geodatabase

**Examples:**
- Geography
- Scale
- Source
- Theme
- Project
Organizing data into feature classes

Features organized as three feature classes...

Features organized as one feature class...
Features organized as several feature classes…
Workflow for creating new data

1. Create new geodatabase
2. Create new feature class
3. Set feature class properties
4. Define attributes
5. Add features
6. Add attribute values
7. Document your data
Defining feature class properties (schema)

- **Name and alias**: Parcels, Lots
- **Type of geometry**: Polygon Features
- **Coordinate system**: NAD_1927_StatePlane_Oregon_North_FIPS_3601
- **XY tolerance**: 0.002 Foot_US

**Attributes**

- **System**
- **User-defined**

---

**Defining feature class properties**

When creating a new feature class, you must specify several feature class properties that will define its structure.

- In most scenarios, the best option is to accept the default values for these properties provided by the Create Feature Class wizard.
- To understand when and why you would need to use values other than the defaults, search for this ArcGIS 10 Help document: *Defining feature class properties.*
Defining attributes

◆ Field data types

◆ Numbers, text, dates, BLOBs, raster

<table>
<thead>
<tr>
<th>ADDRESS</th>
<th>STORIES</th>
<th>ACRES</th>
<th>SOLD</th>
<th>PRICE</th>
<th>IMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 Oleander Street</td>
<td>2</td>
<td>1.25</td>
<td>12/15/1995</td>
<td>350,000</td>
<td>&lt;Raster&gt;</td>
</tr>
</tbody>
</table>

**Geodatabase field data types**

You can store numbers in one of four data types:

- Short integers
- Long integers
- Single-precision floating-point numbers, often referred to as *floats*
- Double-precision floating-point numbers, commonly called *doubles*

In choosing the numeric data type, consider the following:

- Do you need to store whole numbers or fractional numbers?
  - If you just need whole numbers, such as 12 or 12,345,678, specify a *short* or *long integer*.
  - If you need to store fractional numbers that have decimal places, such as 0.23 or 1234.5678, specify a *float* or a *double*.
  - When choosing between a short or long integer, or between a float or double, choose the data type that takes up the least storage space required.

For more information on all field data types, search for this ArcGIS 10 Help document: *Geodatabase field data types*. 
Why document your data?

- Make data reliable, shareable, and searchable

What are these features? Where are they? Who made them? How were they made?

What are these fields? What do the values mean?

<table>
<thead>
<tr>
<th>NAME</th>
<th>IOTB</th>
<th>FTPRNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weniger Hall</td>
<td>N</td>
<td>Aerial</td>
</tr>
<tr>
<td>Gilbert Hall</td>
<td>N</td>
<td>Aerial</td>
</tr>
<tr>
<td>Gleeson Hall</td>
<td>N</td>
<td>Plan</td>
</tr>
</tbody>
</table>

To learn more about documenting your data, search ArcGIS 10 Help for this document: *A quick tour of metadata.*
Exercise 11: Create and document data

Estimated time: 45 minutes

In this exercise, you will work with data from the city of Corvallis, Oregon. Corvallis, located in northwestern Oregon, is the home of Oregon State University (OSU). You will create a feature to represent the new site for the football field.
The exercise will include the following workflow.

**Workflow for creating new data**

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create a geodatabase</td>
<td>For storing OSU data</td>
</tr>
<tr>
<td>Create a new feature class</td>
<td>For OSU geodatabase</td>
</tr>
<tr>
<td>Set feature class properties</td>
<td>In new feature class</td>
</tr>
<tr>
<td>Define attributes</td>
<td>In new feature class</td>
</tr>
<tr>
<td>Add a new feature</td>
<td>To your new feature class</td>
</tr>
<tr>
<td>Add attribute values</td>
<td>To your new feature</td>
</tr>
<tr>
<td>Create and edit metadata</td>
<td>For new feature</td>
</tr>
</tbody>
</table>

In this exercise, you will:
- Create a new geodatabase.
- Add and delete fields in a table.
- Calculate attribute values using the Field Calculator.
- Create a new feature class.
- Create a new feature in the feature class.
- Document the new feature class.

**Step 1: Create a new geodatabase**

Until now, you have worked with data in geodatabases that had already been created for you. In this exercise, you will create a new geodatabase and will add some feature classes to it from another geodatabase.

- Start ArcMap with an empty map and save the map document as Corvallis.mxd in your ..\Student\DESK2\CreateData folder.
- Maximize the application window.

In the Catalog window, the Home directory contains the geodatabase named Corvallis.gdb.
Expand the Corvallis geodatabase.

In the Catalog window, right-click your Home – DESK2\CreateData folder, point to New, and choose File Geodatabase.

The geodatabase contains data that a city typically manages. There are several feature classes of Oregon State University data; these feature classes have names starting with OSU.

You will create a new geodatabase to store and manage the university's data separately from the city's data.

In the Catalog window, right-click your Home – DESK2\CreateData folder, point to New, and choose File Geodatabase.

The geodatabase is created with the default name New File Geodatabase. In the display area, this name is selected and editable.

Replace the default name with OSU and press Enter.

You have created a new, empty geodatabase.

Next, you want to copy the feature classes that have OSU in their names to the OSU geodatabase.
In the Search window, click Tools, then type **feature class to geodatabase** and press Enter.

Hover your mouse pointer over the names of the items that are returned.

Click the item that converts one or more feature classes to the geodatabase.

**Note:** Why does the icon for this tool look like a scroll and other icons are hammers? This tool is a Python script.

In the dialog box that opens, for Input Features, click the Browse button.

Browse to the Corvallis geodatabase in your ..\Student\DESK2\CreateData folder.

Click the OSU_Bldgs feature class to select it.

Hold down the Shift key on your keyboard and click OSU_PavedWalks. (Tip: If you want to select feature classes that are not contiguous, use the Ctrl key.)

All five OSU feature classes (and no others) should be selected.

Click Add.
For Output Geodatabase, click the Home button and click OSU.gdb to select it. (A double-click will open the geodatabase in this dialog.)

Click Add and click OK.

When the process has finished, close the window.

Note: Remember to take advantage of auto hide to manage your windows.

In the Catalog window, expand OSU.gdb (collapse the Corvallis geodatabase, if necessary).

Make OSU.gdb the default geodatabase. (Hint: Right-click OSU.gdb and then click Make Default Geodatabase.)
The OSU geodatabase now contains copies of the five OSU feature classes. The original feature classes still reside in the Corvallis geodatabase.

**Workflow for creating new data**

<table>
<thead>
<tr>
<th>Status</th>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed</td>
<td>Create a geodatabase</td>
<td>For storing OSU data</td>
</tr>
<tr>
<td></td>
<td>Create a new feature class</td>
<td>For OSU geodatabase</td>
</tr>
<tr>
<td></td>
<td>Set feature class properties</td>
<td>In new feature class</td>
</tr>
<tr>
<td></td>
<td>Define attributes</td>
<td>In new feature class</td>
</tr>
<tr>
<td></td>
<td>Add a new feature</td>
<td>To your new feature class</td>
</tr>
<tr>
<td></td>
<td>Add attribute values</td>
<td>To the new feature</td>
</tr>
<tr>
<td></td>
<td>Create and edit metadata</td>
<td>For new feature</td>
</tr>
</tbody>
</table>

In the next step, you will delete redundant data from your geodatabase.

**Step 2: Explore the OSU data**

Now you will begin the second part of the exercise—adding and deleting fields in a feature class. You will also create attribute values for a new field and define the attribute in the metadata. This part of the exercise spans four steps. In this step, you will explore the data.

- In the Catalog window, from the OSU geodatabase, right-click the OSU_Bldgs feature class and then click Properties.

- Click the Fields tab.

- Notice the field names, especially BLDGNAME and BName_Full.

You will refer to this information later.

- Close the Feature Class Properties window.

- One by one, from the OSU geodatabase, drag the five OSU feature classes to the map.
  *(Tip: If the Catalog window closes after you drag a feature class, pin it open.)*

Next, you will explore the OSU_Bldgs feature class that contains building on the OSU campus.
In the table of contents, open the OSU_Bldgs attribute table and scroll through the attributes.

Do you see the attributes BLDGNAME and BName_Full? The field names that you see are aliases.

Right-click NAME, then click Properties.

You see that NAME is an alias for BLDGNAME.

Close the Field Properties dialog box.

1. FULL NAME is also an alias. What is the actual field name?

In the next step, you will change the table structure based on the following observations:

- The FULL NAME field contains the same attribute values as the NAME field, except that the names are in mixed case instead of uppercase. The FULL NAME field is perhaps a labeling convenience, but for your purposes it is redundant and can be deleted.

- Many values in the BLDG NUM field are blank. Unnumbered buildings are structures like kiosks, shelters, covered walkways, and bleachers. To show that these features belong to their own category—and are not simply incomplete records—you will add a field to identify them as improvements other than buildings (or IOTB, for short).

You are not finished exploring your data until you know its coordinate system.

Open the OSU_Bldgs layer properties.
Click the Source tab and scroll through the Data Source.

The projected coordinate system is NAD_1927_StatePlane_Oregon_North_FIPS_3601, which is part of the State Plane Coordinate System. The geographic coordinate system is GCS_North_American_1927 (NAD27). All the feature classes in the OSU geodatabase are in this coordinate system.

2. Does a geodatabase require that all of its feature classes be in the same coordinate system?

Close the Layer Properties window.

Step 3: Add and delete fields

In this step, you will use the Catalog window to add and delete fields in the OSU_Bldgs feature class. (Fields can also be added or deleted in ArcMap.)

In the Catalog window, in the OSU geodatabase, right-click the OSU_Bldgs feature class and choose Properties.
On the Feature Class Properties dialog box, if necessary, click the Fields tab.

Click any field to see its properties.

To add a new field, type the name into an empty row in the Field Name column, click in the Data Type column to choose the data type, then edit the Field Properties.

You see the name and data type of each field in the table, as well as other properties that can be set (for example, an alias).
Click the gray box next to the BName_Full field name to select this field.

<table>
<thead>
<tr>
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<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBJECTID</td>
<td>Object ID</td>
</tr>
<tr>
<td>Shape</td>
<td>Geometry</td>
</tr>
<tr>
<td>Sector_ID</td>
<td>Text</td>
</tr>
<tr>
<td>av_Bld_ID</td>
<td>Text</td>
</tr>
<tr>
<td>BNUM</td>
<td>Text</td>
</tr>
<tr>
<td>BLDGNAME</td>
<td>Text</td>
</tr>
<tr>
<td>BName_Full</td>
<td>Text</td>
</tr>
<tr>
<td>BName_Abbr</td>
<td>Text</td>
</tr>
<tr>
<td>FPrint_Def</td>
<td>Text</td>
</tr>
<tr>
<td>Shape_Length</td>
<td>Double</td>
</tr>
<tr>
<td>Shape_Area</td>
<td>Double</td>
</tr>
</tbody>
</table>

Confirm that the BName_Full field is selected.

Press Delete on your keyboard.

The field is removed from the list.

Click inside the first blank Field Name box (under Shape_Area).

Type **IOTB** in the box.

IOTB stands for Improvement Other Than Building.

Press Tab on your keyboard.

Accept the default data type of Text. (To choose a different data type, you would click the drop-down arrow.)

In the Field Properties area, change the Length value from 50 to 1.

An improvement to the property, such as a new sports field or walkway, will be attributed with a Y (for Yes) because these improvements are not classified as structures or buildings. However, if a new sports stadium is built, it would be attributed with an N (for No).

When a new building is constructed on campus, it is assigned a Building ID number. Its IOTB value will be N (for No). A grass sports field, however, will not be assigned a number and will be designated as an Improvement Other Than Building. Its IOTB value will be Y (for Yes).
Note: The Length property will accept a value that is one character long, for example, "Y" or "N". The field length cannot be changed after the field is created, so it is important to anticipate all possible values before creating the field.

Step 4: Add values to the new field

In this step, you will add values to the IOTB field. It would be tedious to do this record by record. Using the Field Calculator, you can select records and assign them all the same value at once. Assigning or changing attribute values is an operation that can only be done in ArcMap.

- If necessary, open the attribute table for the OSU_Bldgs layer.
- Scroll to the last attribute in the table.

This is the IOTB field you added. Its values are currently set to <Null>.
Recall that unnumbered buildings are the ones to be designated IOTB. You will select these buildings with an attribute query, then assign them the value Y with the Field Calculator.

- From the Table Options menu, choose Select By Attributes.

By default, attributes are listed by name, but you can also list them by alias.
On the Select by Attributes dialog box, click the small drop-down arrow to the right of the list of attributes.

```
"OBJECTID"
"Sector_ID"
"av_Bld_ID"
"BNUM"
"BLDGNAME"
```

On the context menu, click Show Field Aliases to check it.

The list of attributes updates.

- Double-click BLDG NUM in the list to add it to the expression box at the bottom of the dialog box.
- Click the Equals operator $=\.$
- Click Get Unique Values.

Each unique value in the BLDG NUM field is displayed in single quotation marks. The first value is a pair of quotation marks with nothing inside. This represents blank values.

- Double-click the empty quotation marks.

In the expression box, you have created an expression that will select all records with blank values in the BLDG NUM field.
Notice that although the alias (BLDG NUM) appears in the list of field names, it is the true name (BNUM) that is added to the expression.
- Under the expression box, click Verify to check whether your expression is valid.

![Verifying expression](image)

The expression was successfully verified.

- Click OK on the verification message.

**Best practice:** Verify your expressions to confirm that there are no syntax errors in the expression that would cause it to fail during execution.

- Click Apply on the Select by Attributes dialog box.

- Close the Select by Attributes dialog box.

- Notice the status bar below the attributes table.

3. How many records are selected in the attribute table?

- In the table, right-click the IOTB field heading and choose Field Calculator.
In the expression box at the bottom of the Field Calculator, type "Y". (Text string values must be enclosed in double quotation marks.) Remember: You are selecting the records for improvements that are not buildings.

- Click OK.

All selected records are assigned the value Y.

- On the table window, click Switch Selection.
Now the previously unselected records—the ones with building numbers—are selected. You will assign these records the value N in the IOTB field.

- Right-click the IOTB field heading and choose Field Calculator.
- Replace the existing expression with "N".
- Click OK.
- On the Table menu bar, click Clear Selection.
- Scroll through the table.

Every record now has a Y or an N to indicate whether it is an improvement other than building.

In the next step, you will create the feature class that will store the new sports field.

**Step 5: Create a new feature class and set its properties**

You have come to the third part of the exercise, which is to create a new feature class for the OSU geodatabase. The new feature class will be used to store athletic sites, such as football and baseball fields, running tracks, and tennis courts. You will complete this part of the exercise in one step.

- From the Geoprocessing menu, click Geoprocessing Options.
- In the Background Processing area, make sure Enable is unchecked and click OK.

When Enable is not checked, tools run in the foreground. When a tool is executing in foreground mode, you must wait until the tool stops executing before you can continue with other work. When the tool runs in the background, you can continue to work in ArcMap.

- In the Catalog window, right-click the OSU geodatabase, point to New, and choose Feature Class.

The New Feature Class wizard opens. To create a feature class, you will proceed through a series of wizard panels.

- On the first panel, type **OSU_AthleticSites** in the Name box.
In the Type area, the feature type defaults to Polygon Features, which is what you want in order to create the location for the new football field mentioned in the Introduction.

Click Next.

On the second panel, you assign the feature class a coordinate system. You will use the same system as the other feature classes (State Plane, Oregon North, NAD 27). You can either browse to this system or import it from a feature class that has it.

Click Import.
- In the Browse for Coordinate System dialog box, navigate to your ..\Student\DESK2\CreateData folder, double-click the OSU geodatabase, and click OSU_Bldgs (or any other feature class) to select it.

- Click Add.

The coordinate system name is added to the Name box.

- Click Next.
The third panel lets you change the XY tolerance, which is rarely necessary.

- Click Next.

The fourth panel lets you change the configuration keyword, which manages technical details of data storage and retrieval. It is useful to database administrators in multiuser environments, but is not applicable here.

- Click Next.

The fifth panel should look familiar. It allows you to add fields to the attribute table. Every new feature class automatically has an OBJECTID and SHAPE field.

### Workflow for creating new data

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</table>
In the next step, you will define the attributes for your new feature class.

**Step 6: Define attributes for the new feature class**

- Click inside the first empty Field Name box (under SHAPE) and type **NAME**.
- Press Tab and accept the default data type of Text.
- In the Field Properties area, change the length from 50 to **35**.

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<thead>
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<tr>
<td>SHAPE</td>
<td>Geometry</td>
</tr>
<tr>
<td>NAME</td>
<td>Text</td>
</tr>
</tbody>
</table>

- Click Finish.

The new feature class is added to the OSU file geodatabase (OSU.gdb).
The layer also appears in the table of contents and displays by source and by drawing order.

- If necessary, open the OSU_AthleticSites attribute table.

It is empty. You have created a feature class but it does not yet have any features in it.

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Now that you have created your new feature class and defined its attributes, you are ready to add data to it.

### Step 7: Find the football stadium

If you had time, you would create features for a variety of sites, but in this exercise, you will do just one: a football field. In this step, you will prepare the data in ArcMap.

- Make sure that the Catalog, Search, and Table windows are hidden.

You want to make sure that the map display area is large. For example, if the Table and Catalog windows are not set to auto hide, when you zoom, your map display will be smaller.
Zoom to the OSU_PavedStreets layer. (Hint: Right-click OSU_PavedStreets.)

Make sure athletic sites layer is above the buildings layer in the table of contents.

At this point, the symbology does not matter as long as you can distinguish the athletic sites from building layers.

The football field you are going to create is located in Reser Stadium, one of the features in the OSU_Bldgs layer.

On the Tools toolbar, click the Find tool.
In the Find dialog box, make sure the Features tab is selected. In the Find box, type *Reser*. Note: You could restrict the search to specified layers and fields, if needed.

Click Find.

The bottom of the dialog box expands to show that two features are found. One feature is a parking lot and the other is the stadium.

Although two results are returned, only one is valid for your purposes.

Right-click **RESER STADIUM** and choose **Zoom To**.

Close the Find dialog box.
Step 8: Add a new feature to your feature class

In this step, you will have the chance to use several editing tools as you create the football field in Reser Stadium. The completed feature will look like the one shown in the following graphic.

- In the table of contents, right-click the OSU_AthleticSites layer, point to Selection, and choose Make This The Only Selectable Layer.

You will not be editing features in other layers and you do not want to select and possibly change them by accident.

- If necessary, display the Editor toolbar. Hint: Click the Editor Toolbar button.

- From the Editor menu, choose Start Editing.

The Create Features window opens and displays several templates.
Click OSU_AthleticSites to select the template.

The choice of Construction Tools displays in the lower panel in the Create Features window.

Make sure that Polygon is the selected Construction tool.

The Rectangle tool is also a Construction tool. Can you use it to create your football field? The selected tool determines which editing tools are enabled. The Rectangle tool does not enable all the tools that you need to create the football field.

If you knew the x,y coordinates of a corner of the field, you could start the sketch with the Absolute X, Y command that you used in the previous lesson. But suppose that all you know are the dimensions of the field and the relationships of its boundaries to some of the stadium boundaries. For example, one corner of the field is aligned with the imaginary intersection of the lines shown in the following graphic.

Close the Create Features window.
On the Editor toolbar, click the Segment tool palette drop-down arrow and click the Intersection tool.

Move your mouse pointer over the map display.
As you move over any line segment, a black line is drawn parallel to it. This is the tool you use to specify your imaginary point of intersection.

Move your mouse pointer over the building segment indicated in the following graphic so that you see a black line that looks like the one shown.

Click to set this black line as the first line of intersection.
Now move your mouse pointer over the building segment shown in the next graphic, so that you see a second black line.

A red vertex displays at the point of intersection. This is the corner of the football field that begins your sketch.

Did you notice the semitransparent toolbar that appears? The Feature Construction mini-toolbar provides quick access to some of the most commonly used commands when editing. It appears
near your pointer when you are digitizing segments once you have placed the first vertex in a sketch.

- On the Feature Construction toolbar, click the Straight Segment tool 🗒.

A dark line represents the first segment of the sketch. At the moment, you can move it however you like because its direction and length have not been set.

The field must have a precise orientation within the stadium. If you knew the angle of one side of the field relative to north, you could set this angle with a command. But suppose instead that all you know is that the length of the field runs parallel to the edge of the stadium shown in the following graphic.
Move your mouse pointer over the line segment of interest.

Right-click to open the context menu, then choose Parallel.

The sketch segment is now constrained to be parallel to the segment you clicked.

Right-click again and choose Length.

In the Length box, type 380.

Press the Enter key on your keyboard.

The length of the field is set to 380 feet. (This is longer than the playing area of a football field, but it includes the end zones and a little space beyond them.)
Move your mouse a short distance to the left to see that although you have created a straight line, you are still working with a multi-sided shape.

You have defined the first side of the rectangle. The starting vertex turns green, the vertex just added turns red, and the mouse pointer jumps in anticipation of the next segment. (It does not matter where it goes.) Because you are creating a polygon, the sketch is now a closed figure.

Throughout this step, if the results of any of your editing operations do not match what is supposed to happen, use the Undo button on the Standard toolbar, and try again.

The second side of the field must be at a right angle to the first side, and should measure 200 feet. (This includes the width of the playing field plus the sidelines.)

On the Feature Construction toolbar, click the Segment Palette pull-down list and click the Right Angle tool.

The current segment is constrained to form a 90-degree angle with the segment just drawn.

Right-click the map to the left of the last point and choose Direction/Length.
Accept the default value (on the left) for the Direction and type 200 in the Length box and press the Enter key on your keyboard.

The second side of the rectangle is defined and the mouse pointer jumps again.

Right-click in the map and choose Square and Finish.
After you define two sides of a rectangle, ArcMap can complete it for you. Your completed sketch is outlined in blue to show that it is selected.

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**Step 9: Add attribute values to your feature**

- On the Editor toolbar, click the Attributes button 
- In the Attributes window, add the attribute value **Reser Field** in the NAME field.
- Press Enter.

- Close the Attributes window.
If you like, change the symbol color of the football field.

- From the Editor toolbar, save your edits.
- Stop editing.
- Close the Editor toolbar.

### Workflow for creating new data

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Your data is not complete until you have documented it. In the next step, you will edit the Item Description for your feature class.

### Step 10: Document your new feature class

In this step, you will update the documentation for your new feature class. You will begin by creating a thumbnail graphic of the feature in your OSU_AthleticSites feature class. You will also edit the theme keywords.

- From the Catalog window, from the OSU geodatabase, right-click OSU_AthleticSites and click Item Description.

- When the Item Description opens, click the Preview tab.

The shape of your new feature appears. You will use that shape to create a thumbnail image for the Item Description.
4. If you create additional features and add them to your OSU_AthleticSites feature class, what will display in the Item Description Preview?

- On the Geography toolbar, click the Create Thumbnail button.

![Thumbnail Image](image)

The thumbnail image is updated.

- Click the drop-down list and change the preview mode to Table.

The table contains five attributes. You added and populated the NAME attribute. As you learned in a previous lesson, the remaining fields were created automatically by the software.

- Preview the Geography.

- Click the Identify tool, then click the rectangular shape.

The Identify Results window displays the layer's attributes.

- Close the Identify Results window.

Next, you will update the Item Description for your new feature. The Item Description is a small subset of the complete formal metadata you can create to describe an item.
Click the Description tab.

Your thumbnail displays at the top of the window. By default, the feature class name displays as the title, and the subtitle shows that the feature class resides in a file geodatabase.

**Note:** You can also access metadata in ArcCatalog from the Description tab for the dataset.

Click the Edit tool to enable editing.

For Title, type **OSU Athletic Sites**.

Next, you will enter values for the tags (or keywords) that can be used for searching.

- If necessary, scroll to the Tags window, below the thumbnail.
- In the Tags window, type **football, athletics, campus, sports, Corvallis**.

- If you'd like, add another tag of your own.
- For Summary, type **Reser Stadium football field. Preliminary drawings** followed by today's date.
- On the left, in the Metadata section, click Contacts.
Click the plus sign next to Add Contact.

Enter your name, organization, position, and choose a role.

**Note:** Before you can edit the metadata, you must select a metadata style. In an earlier lesson, you set the metadata style in ArcMap Options.

Click Save.

Close the dialog box.

Search for your new feature class. *(Tip: Use one or more of the tags you added.)*

Your results should be similar to the following graphic.
Creating geodatabases and feature classes

The keywords that you entered are updated in the metadata. In this lesson, you learned how to edit a few elements of the Item Description. For more information on metadata and the Item Description, refer to the ArcGIS Desktop Help.

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☐ Save your map document and close ArcMap.

Your football field has already been saved to the OSU_AthleticSites feature class.
Lesson review

1. What is a geodatabase?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. What is a feature class?
   a. A set of thematically related features with each of the geometry types: point, line, and polygon
   b. A set of thematically related features of the same geometry type with the same attributes but with different values
   c. A set of unrelated features of the same geometry type with the same attributes
   d. A set of thematically related features with different attributes for each of the geometry types: point, line, and polygon

3. __________________ allows you to document datasets, layers, and other ArcGIS items so you can find them when you need them.

4. Before you can add a feature to a feature class, you must first add the feature class to a geodatabase.
   a. True
   b. False
Answers to Lesson 11 questions

Exercise 11: Create and document data

1. FULL NAME is also an alias. What is the actual field name?
   BName_Full

2. Does a geodatabase require that all of its feature classes be in the same coordinate system?
   No. In an earlier lesson, you saw that a geodatabase can contain feature classes with different coordinate systems.

3. How many records are selected in the attribute table?
   Ninety-seven (97) records are selected.

4. If you create additional features and add them to your OSU_AthleticSites feature class, what will display in the Item Description Preview?
   All the features in the feature class will display in Preview mode.

Lesson review

1. What is a geodatabase?

   The geodatabase is a collection of geographic datasets of various types used in ArcGIS and managed in either a file folder or a relational database. The geodatabase defines the rules and properties of each dataset in the geodatabase.
2. What is a feature class?
   b. A set of thematically related features of the same geometry type with the same attributes but with different values

3. Item Description allows you to document datasets, layers, and other ArcGIS items so you can find them when you need them.

4. Before you can add a feature to a feature class, you must first add the feature class to a geodatabase.
   a. True
Introduction

In this lesson, you will learn how to create spatial data from nonspatial data. For example, you will see how to create points from x,y coordinates and, on your own, you will create a point feature class from a list of addresses. You will learn how address matching works, and about the components required to perform address matching. You will also learn how to evaluate address data and how to adjust it to ensure better matching results.

Topics covered

- What kinds of tabular data do you have?
- Can you get locations from this data?
- Adding X,Y coordinate data
- Finding addresses and places
- Geocoding
- What can geocoding be used for?
- Geocoding components
- Address matching
- How addresses are matched
- Geocoding output
- Building an address locator
- Rematching addresses
- Geocoding workflow
Learning objectives

After completing this lesson, you will be able to:

▪ Identify different types of location information.
▪ Create a point feature class from street addresses.
What kinds of tabular data do you have?

Can you get locations from this data?
Adding x,y data

◆ May exist in nonspatial tables
◆ ArcMap displays coordinates as points

- Points created from x,y data display as a map layer, but they are temporary—they exist only during the ArcMap session.
- You can save the layer by saving the map document it was created in, or by exporting it to a feature class.
Finding places and addresses

◦ Requires Internet connection

<table>
<thead>
<tr>
<th>Enter address…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street</td>
</tr>
<tr>
<td>City</td>
</tr>
<tr>
<td>State</td>
</tr>
<tr>
<td>ZIP</td>
</tr>
<tr>
<td>Country</td>
</tr>
</tbody>
</table>

Two ways to find places and addresses:

* Click the Find tool, click the Locations tab, choose an address locator service, enter an address (multiple text boxes or single line)
* Open the Geocoding toolbar, choose an address locator service, enter an address (single line)

If an address is not found, use the Find tool instead since it displays more information.
Geocoding

- Get locations from addresses
- Create point features

<table>
<thead>
<tr>
<th>NAME</th>
<th>ADDRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. Maloney</td>
<td>310 East Andreas Road</td>
</tr>
<tr>
<td>K. Hickman</td>
<td>105 Maple Street</td>
</tr>
<tr>
<td>E. Palmer</td>
<td>3109 Bell Square West</td>
</tr>
</tbody>
</table>
Geocoding components

- **Match addresses to reference data**

<table>
<thead>
<tr>
<th>NAME</th>
<th>ADDRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. Maloney</td>
<td>310 East Andreas Road</td>
</tr>
<tr>
<td>K. Hickman</td>
<td>106 Maple Street</td>
</tr>
<tr>
<td>E. Palmer</td>
<td>3109 Bell Square West</td>
</tr>
</tbody>
</table>

- **Address table**—contains street addresses, ZIP codes, area codes, or other location descriptions

- **Address locator**—interprets and matches addresses based on a chosen address style and a set of rules

- **Reference data**—spatial data containing address information used to locate addresses in a table

...think of it as a street guide or map book for looking up addresses
Address matching

- Records in address table compared to records in reference data

<table>
<thead>
<tr>
<th>Reference data attribute table</th>
</tr>
</thead>
<tbody>
<tr>
<td>OID</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>277</td>
</tr>
<tr>
<td>278</td>
</tr>
<tr>
<td>279</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Address table</th>
</tr>
</thead>
<tbody>
<tr>
<td>OID</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>
How addresses are matched

- Address locator parses and standardizes address, then matches components

<table>
<thead>
<tr>
<th>House number ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>L_F_ADD</td>
</tr>
<tr>
<td>3100</td>
</tr>
</tbody>
</table>

ADDRESS
3109 Bell Square West

Parsed and standardized

3109 | BELL | SQ | W
Geocoding output

Point feature class

Sample output fields

<table>
<thead>
<tr>
<th>Shape</th>
<th>Status</th>
<th>Score</th>
<th>Match.Addr</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point</td>
<td>M</td>
<td>100</td>
<td>1377 N VIA TOPO</td>
<td>1377 North Via Topo</td>
</tr>
<tr>
<td>Point</td>
<td>U</td>
<td>0</td>
<td>2339 San Gorgino</td>
<td></td>
</tr>
<tr>
<td>Point</td>
<td>M</td>
<td>82</td>
<td>700 E AMADO RD</td>
<td>700 Amedo Road</td>
</tr>
<tr>
<td>Point</td>
<td>M</td>
<td>60</td>
<td>3271 SPRING ST</td>
<td>3271 Sring Street</td>
</tr>
</tbody>
</table>

In the output feature class:

- There is one record for each address in the address table.
- There is one point feature for each matched address.
- New attributes are added containing match information.

Only some of the fields created in the output feature class are shown in the preceding graphic. Following is a complete list:

- Status—a code indicating whether the address was matched
- Score—the match score
- Match_type—a code showing how an address was matched
- Match_addr—the actual address that was matched
- Addr_type—the type of address that was geocoded
- Side—the side of the street to which the address was matched

Address fields from the address table are appended to the geocoding output feature class.

Additional optional fields may appear. For a complete list, see this topic in ArcGIS 10 Help: About geocoding a table of addresses.
Rematching addresses

◆ Adjust geocoding options
  ◆ Spelling sensitivity; minimum match score

◆ Fix address errors

<table>
<thead>
<tr>
<th>Shape</th>
<th>Status</th>
<th>Score</th>
<th>Match_Addr</th>
<th>Address</th>
</tr>
</thead>
</table>
| Point  | U      | 0     | 2339 SanGorgino | Misspelling of "San Gorgonio"

◆ Rematch

**Note:** You can rematch addresses automatically or interactively. When you rematch interactively, you manually select the best candidate from a list.
Geocoding workflow

1. Obtain reference data
2. Explore reference data and addresses
3. Determine address locator style
4. Build address locator
5. Geocode addresses
6. Rematch as needed
Exercise 12A: Build an address locator

Estimated time: 15 minutes

In this exercise, you will build an address locator to geocode addresses in the city of Palm Springs, California. The most important part of building an address locator is choosing its style. There are many address locator styles to choose from. The choice depends on the attributes in the reference data and address table (and on some regional variations in address formatting). Before creating the address locator, you must examine the reference data and address table.

The address table contains a list of houses for sale in Palm Springs. The address data does not represent the true addresses of homes for sale.

In this exercise, you will:

▪ Examine an address table and reference data attributes.
▪ Build an address locator.

Step 1: Examine data

In this step, you will examine the address table and the reference data table. The attributes in these two tables determine the address style you will choose for the address locator.

☐ Start ArcMap.

☐ From the Geoprocessing menu, click Geoprocessing Options.

☐ In the Background Processing area, make sure Enable is unchecked and click OK.

Tools will run in the foreground so you will be able to monitor their progress.

☐ From the Catalog window, expand the ..\Student\DESK2\XYLocations folder.

The folder contains a geodatabase, a table in dBASE format, and a map document.
Preview the ForSale.dbf table. (Hint: Right-click ForSale.dbf, open its Item Description, then Preview the table.)

<table>
<thead>
<tr>
<th>OID</th>
<th>ADDRESS</th>
<th>CITY</th>
<th>STATE</th>
<th>ZIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2150 S CAM Road</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>1</td>
<td>3609 Sunflower Loop North</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>2</td>
<td>510 West Sunview Avenue</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82262</td>
</tr>
<tr>
<td>3</td>
<td>2775 E Yelta Cir</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82262</td>
</tr>
<tr>
<td>4</td>
<td>5580 Fairview Circle</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>5</td>
<td>705 E Raminon Road #57</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>6</td>
<td>1545 Mira Loma Way</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>7</td>
<td>700 S El Calo Rd</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>8</td>
<td>85329 Palm Canyon Ave</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>9</td>
<td>236 South Pine Canyon Drive</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>10</td>
<td>2000 Sunshine Way</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>11</td>
<td>2277 E Paquel Club Rd</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>12</td>
<td>2304 East Anadale Road, Palm Springs</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>13</td>
<td>2339 San Drogno Road</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>14</td>
<td>1100 East Juliano Road</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>15</td>
<td>1237 East Mesquite Ave</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>16</td>
<td>146 E La Venta Way</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>17</td>
<td>2222 Carolino Avenue</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>18</td>
<td>2264 East Paseo Gorda</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>19</td>
<td>1389 Navajo Drive</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>20</td>
<td>2402 North Palermo</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>21</td>
<td>516 West Panorama Rd</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>22</td>
<td>752 Camino Sur</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
<tr>
<td>23</td>
<td>85 Ninguna Road</td>
<td>Palm Springs</td>
<td>CA</td>
<td>82294</td>
</tr>
</tbody>
</table>

Maximize your window and resize the table columns so you can view the data with a minimal scrolling.

In addition to the OID field, which is necessary for geocoding, there are fields for the address, city, state, and ZIP code. This is a typical address table.

Note: Most styles require the address table to store the street address in a single field. If it is stored in multiple fields (for example, if the house number is in a different field from the street name), you can concatenate values using the Field Calculator.

The ADDRESS field name is important. When you build the Address locator, you must make sure that the name of this field matches one of the default names listed in the address locator so it can match the proper field to the reference data. If the field is not listed in the address locator, it needs to be added. For example, are street names stored in a NAME field or in a STREET field or a field with a completely different name?

Scroll through the table and look for any anomalies, particularly the addresses for OIDs 0, 3, and 12.
1. What are the anomalies?

After your data has been geocoded, you will examine the results for these records.

- Close the Item Description window.
- In the RiversideCounty geodatabase, preview the table for the StreetsPalmSprings feature class.

This is a typical attribute table for street-level reference data and contains many fields.

- Scroll through the table from left to right and from top to bottom and observe the following attributes: (Tip: Sort some of the fields, such as PREFIX and PRETYPE.)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREFIX</td>
<td>Directions that precede the street name</td>
</tr>
<tr>
<td>PRETYPE</td>
<td>Qualifiers that precede the street name</td>
</tr>
<tr>
<td>TYPE</td>
<td>Qualifiers that follow the street name</td>
</tr>
<tr>
<td>SUFFIX</td>
<td>Directions that follow the street name</td>
</tr>
<tr>
<td>POSTAL_L and POSTAL_R</td>
<td>Left or Right of ZIP (or similar) boundary</td>
</tr>
<tr>
<td>GEONAME_L and GEONAME_R</td>
<td>Left or Right of geographic boundary</td>
</tr>
<tr>
<td>STATE_L and STATE_R</td>
<td>Left or Right of state boundary</td>
</tr>
</tbody>
</table>

- Close the Item Description window.

**Step 2: Create an address locator**

Now that you are familiar with the data, you will create the address locator.

- Make RiversideCounty your default geodatabase.
- In the Catalog window, right-click the RiversideCounty geodatabase, point to New, and choose Address Locator.
The address locator style should be appropriate to the attributes in the reference data. For example, the ZIP 5Digit style is used if the reference data has a five-digit ZIP code attribute and no other address attributes. The US Streets with Zone style is used if the reference data has street address and ZIP code attributes and no city or state name attributes.

The locator style also captures regional variations in address formatting. For example, there are several "hyphenated range" address styles, which are used specifically for the borough of Queens, New York, where street addresses are hyphenated with the cross street name.

The Create Address Locator geoprocessing tool dialog box opens.

- Click the Address Locator Style browse button.

The Select Address Locator Style dialog box opens.

- In the Select Address Locator Style dialog box, click US Address – Dual Ranges. This style will locate addresses on both sides of the street.

- Click OK.

- In the Create Address Locator tool dialog box, click the Browse button next to the Reference Data box.
In the Reference Data dialog box, navigate, if necessary, to the RiversideCounty geodatabase in your ..\Student\DESK2\XYLocations folder.

Double-click the RiversideCounty geodatabase to open it.

Click StreetsPalmSprings and click Add.

In the Field Map area, the field names are filled in automatically and correctly. The fields are the attributes required in the reference data for this address locator style.

ArcMap does not always know how to interpret the field names. For example, if the street name attribute is called NAME, as here, ArcMap will correctly infer that this is the field with street names in it. If the attribute is called something else—STRNAME, for example—you might need to use the drop-down list to specify that this is the street name field.

The dialog box interprets field names in the reference data and the field names in the address table. This address locator style requires that the address table store the street address (excluding city, state, and ZIP code) in a single field. If this field is called "Address," "Addr," or "Street," ArcMap will know it is the street address field. If it is called something else, you will need to add the field name to the list.

Note that although the address locator is tied to a reference dataset, it is not tied to a particular address table. Any number of tables can be geocoded using the same locator. You do not need to specify an address table until you are ready to geocode.

Click the Field Name column header.

If necessary, click the Show Help button and click a field name with an asterisk next to it.

The Field Map help topic displays in the Help panel.

2. Why do some fields display an asterisk next to their names?
Make sure that the Output Address Locator will be created in your `..\Student\DESK2\XYLocations\RiversideCounty geodatabase`

Click OK.

The process runs and the address locator is added to your geodatabase and is ready to use.

**Note:** An address locator can be stored either inside or outside a geodatabase.

Close the Create Address Locator window.

Rename your address locator **PalmSpringsLocator**.
Exercise 12B: Geocode addresses

Estimated time: 30 minutes

In this exercise, you will geocode addresses using the ForSale address table and the address locator you just built. Once geocoded, the locations of the houses might be interesting to analyze. Are there cluster patterns? Are they located mainly in new housing developments? If you had demographic data associated with census tracts or census block groups, you could investigate variables like income and age groups by neighborhood.

You will not be doing an analysis like that, but you could if you had the supporting data. Sometimes geocoding serves an immediate and practical end—for example, mapping customer locations to see where to increase advertising or expand a business. At other times, it may be a part of a larger analysis project.

In this exercise, you will:

▪ Geocode an address table.
▪ Interpret geocoding results.
▪ Rematch addresses interactively.

Step 1: Open a map document

❑ In ArcMap, from the Catalog window, from your ..\Student\DESK2\XYLocations folder, drag PalmSprings.mxd to the table of contents.
Do not save changes to Untitled.

The map contains a layer of streets and a layer of ZIP codes. The Streets layer is based on the StreetsPalmSprings feature class, the geocoding reference data.

Remember, the address locator contains a snapshot of the reference data. It is not necessary to add the reference data to ArcMap—or even to have ArcMap open—in order to geocode. To visualize results, however, it is helpful to have ArcMap open and the reference data added as a layer.

Zoom to the Palm Springs bookmark.

Previously, when you built the address locator, you were working in an untitled map document and you made RiversideCounty the default geodatabase in order to easily specify the location for saving the address locator. Now that you are working in a different map document, you need to specify its default geodatabase.

Make RiversideCounty the default geodatabase.

If necessary, click the List By Source tab.

The table of contents contains a Streets line layer and ZIP Codes polygon layer. In addition, the stand-alone ForSale table is also present in the table of contents.
Step 2: Geocode addresses

In this step, you will geocode the address table.

- From the table of contents, right-click ForSale and choose Geocode Addresses.

The dialog box that displays shows a list of geocoders. However, you need to use a geocoder that is not listed by default.

- On the Choose an Address Locator to use dialog box, click Add.

- In the Add Address Location dialog, navigate to the RiversideCounty geodatabase in the XYLocations folder and click Add.

- Click PalmSpringsLocator and click Add.

- Click OK.

The Geocode Addresses dialog box opens and the ForSale table appears in the Address table drop-down list.

- In the Output area, click the Browse button next to the Output shapefile or feature class box.
  - At the bottom of the Saving Data dialog box, set the Save as type to File and Personal Geodatabase feature classes.
  - Navigate, if necessary, to the RiversideCounty geodatabase in your ..\Student\DESK2\XYLocations folder.
  - Change the output Name to **HomesForSalePalmSprings**.
Click Save.
 confirm that your settings in the Geocode Addresses dialog box match those in the following graphic.

- Address table: ForSale
  - Address Input Fields:
    - Street or Intersection: ADDRESS
    - City or Placename: CITY
    - State: STATE
    - ZIP Code: ZIP
  - Output:
    - Create static snapshot of table inside new feature class
    - Create dynamic feature class related to table
    - Output shapefile or feature class: \K2XY\Locations\RiversideCounty.gdb\Homes\ForSale\PalmSprings
    - Config Keyword: DEFAULTS

- Click OK.

- Geocoding Addresses...
  - Matched: 21 (58%)
  - Tied: 0 (0%)
  - Unmatched: 3 (13%)
  - Completed
    - Average speed: 369,000 records/hour

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The process runs quickly on such a small table. (Your average speed may be different.) Of the 24 addresses in the table, 21 were matched and 3 were unmatched. You will rematch the unmatched addresses. First, though, you will look at the new feature class that has been created.

- Click Close.
- In the table of contents, rename the new geocoding results layer to **Homes For Sale**.

**Note:** The feature class itself is called HomesForSalePalmSprings.

- Change the Homes For Sale symbol to Circle 2, size 8, or to another symbol of your choice.
- Change the color to Dark Umber (row 6, column 2).
- Click OK.

**Note:** You will be opening and closing tables frequently, so make sure you take advantage of docking and auto hide.

### Step 3: Examine geocoding results

When you close the dialog box, a point layer of the geocoding results is added to the map. There is one point feature for each of the 21 matched addresses. (There are 24 records in the attribute table—one for each address—but a point is not drawn until the address is matched.)
Open the attribute table for the Homes For Sale layer.

![Attribute table image]

- ObjectID
- Shape
- Status M or U (matched or unmatched)
- Score 0–100 (a perfect score is 100)
- Match_type A indicates automatic match
- Match_addr Complete address for matched records
- Side L or R (address is on left or right side of street)

Scroll through the table and observe the following fields and their values:

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status</td>
<td>M or U (matched or unmatched)</td>
</tr>
<tr>
<td>Score</td>
<td>0–100 (a perfect score is 100)</td>
</tr>
<tr>
<td>Match_addr</td>
<td>Complete address for matched records</td>
</tr>
<tr>
<td>Side</td>
<td>L or R (address is on left or right side of street)</td>
</tr>
</tbody>
</table>

The Match_type field displays a code that shows how the address was matched. For example, an A indicates that the record was automatically matched. You will learn more later.
In the table, right-click the Status field heading and choose Advanced Sorting to sort your attribute table by multiple fields.

In the first drop-down list on the Advanced Table Sorting dialog box, choose to sort by the Status field in descending order.

In the second drop-down list, choose to sort by the Score field in ascending order.

Click OK.

At the top of the table are the three unmatched addresses (Status = U). The next rows display the matched records, with the lowest scores first. Scores below the value of 80 should be double-checked. Other than the unmatched addresses, you have no results with scores lower than 80.

In the Homes For Sale results table, locate the ADDRESS field and find the record with the value 2150 S CAM Real. (Hint: Scroll to the end.)

Click the gray box at the left to select the row.

Scroll to the left to the Match_addr field.

For the unmatched records, this field is empty. You will need to try to match this record.

This record was one of the anomalies you explored in a previous step. The geocoding algorithm was unable to match this address.
Locate the ADDRESS field value 2304 East Amado Road, Palm Springs, and select the row.

What is the value in the Status field for this record?

Clear the selection.

This record was another anomaly that you explored earlier. The geocoding algorithm successfully matched this record after determining that the duplicate reference to Palm Springs in the address was unnecessary.

Hide or close the attribute table.

**Step 4: Rematch addresses**

Now that you have explored your results, you will work on the unmatched addresses.

In this step, you will look at your nonmatches and improve their scores by fixing address errors.

In the table of contents, make sure that HomesForSalePalmSprings is selected.

Click the Customize menu, point to Toolbars, and point to Geocoding.

On the Geocoding toolbar, make sure the PalmSpringsLocator is selected and then click Review/Rematch Addresses.

Maximize the Interactive Rematch window.

The Interactive Rematch dialog box contains a lot of information.

1. Parsed and standardized record from the address table
2. All the possible matches (candidates) for this address in the reference data table; the top candidate has a score of 100 and is highlighted in light gray
3. Attribute values of the highlighted candidate
4. Records from the new geocoded table; the top candidate, 3775 E Vista Chino, is the address that was written to the geocoded table

At the top of the Interactive Rematch dialog box, change the Show results drop-down setting to Unmatched Addresses.

Make sure the first of the three unmatched records is selected.

Scroll to the right to the Match_addr field.
In the list of records at the top, the Match_addr values are blank because the records are not matched. There may be candidates for a particular record, but there will be no candidates with scores of 80 or higher (if there were, they would have been matched).

- Scroll to the left.
- In the list of addresses at the top of the dialog box, click the first record (with the ObjectID of 8).

This record has 10 candidates. The first record, with a match score of 79.93, is lightly shaded.

- Compare the address from the address table (on the left), the matched candidate with a score of 79.93, and the Candidate details. (Tip: You can hover your mouse over the line that divides one area from another and then modify the size of the panels.)

- Hover your mouse over the divider between the Address panel and the Candidates panel, then widen the Address panel.

- What do you notice about the street name?

The street name is misspelled in the address table ("Gorgino" should be "Gorgonio"). ArcMap has matched the record anyway, but without great confidence (the score is below 80). Since the
point feature has already been placed correctly, you could simply leave things as they are, but you will fix the misspelling to improve the match score.

1. In the Address area on the left of the dialog box, click inside the Street or Intersection box and change the street name spelling from GORGINO to GORGONIO.

<table>
<thead>
<tr>
<th>Address:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street or Intersection: 2339 SAN GORGONIO ROAD</td>
</tr>
<tr>
<td>City or Placename: PALM SPRINGS</td>
</tr>
<tr>
<td>State: CA</td>
</tr>
<tr>
<td>ZIP Code: 92252</td>
</tr>
</tbody>
</table>

1. Press Enter.

The top candidate's score changes from 79.93 to 93.64.

To update the geocoded table, you must manually rematch this candidate.

1. Click the Match button at the bottom of the Interactive Rematch window.

Now, on the right, in the Candidate details, the match score has changed from 79.93 to 93.6363. Under Show results (upper left), the match type has changed from "A" (automatic, meaning that no user interaction was needed) to "M" (manual). And the Match_addr field was updated to contain the correctly matched address.

The number of candidates is reduced to 4 and the top candidate now has a score of 93.64, a very high match score, but not perfect. You will explore further to determine whether you can make a perfect match for this address.

1. Minimize the Interactive Rematch window.

1. Open the Streets attribute table.

1. Scroll to the rows that contain San Gorgonio in the NAME field and Rd in the TYPE field and notice the Prefix field. (Tip: Sort ascending on the NAME field.)
2. In the Interactive Rematch window, compare the address in the Street or Intersection box with the top candidate address. Why is the score less than 100?

- In the Interactive Rematch dialog box, modify the address in the Street or Intersection box to include the prefix direction. (Tip: You can just type N rather than NORTH.)
- Match the address to the top candidate.

Now the score for this address is 100, a perfect match.

The next example is another case in which a record did not match but is very close to matching. Under Show results, select the next record (with ObjectID = 15).

This address has no candidates. Recall that this was one of the addresses you inspected earlier in the exercise.

- Compare the address as stored in the address table with the matched candidate from the reference data.

What is the reason for the failure to match? This is another spelling error. The correct street name spelling is "Camino," but in the address table, the street name is misspelled "CAM."
In the Address area on the left, correct the address in the Street or Intersection box and press Enter.

The top candidate score changes to a perfect 100.

Match with the candidate that has the highest score to populate the Match_addr field.

Zoom to the Homes For Sale layer.

Save the map document in your ..\Student\DESK2\XYLocations folder as GeocodedPalmSprings.

Matching the third unmatched address requires some investigation. To match it, go on to the optional next step.

Otherwise, close the Interactive Rematch dialog box, the Geocoding toolbar, and then close ArcMap.

Step 5: (Optional) Match the last unmatched address

In the table of contents, click the Homes For Sale layer to select it.

In the Geocoding toolbar drop-down list, make sure PalmSpringsLocator is selected, then click Review/Rematch Addresses.

From the Show Results drop-down list, choose Unmatched Addresses.

There is only one unmatched record left (88 Ninguna Road) and it has no candidates. By now you know that spelling errors are a common cause of matching problems. "Ninguna" is not an obvious misspelling, but it might be worth searching the Streets attribute table for similar names.

Select the row with OBJECTID equals 24.

Minimize the Interactive Rematch dialog box.

In ArcMap, from the Selection menu, choose Select by Attributes.

On the Select by Attributes dialog box, set the layer to Streets.

In the list of fields, double-click NAME.

Click the Like operator.
- Type a space, then type 'Ni%'. Be sure to type single quotation marks (not double quotation marks) and do not type the period.

"NAME" LIKE 'Ni%'

The percent sign is a wildcard. The expression will select all street names that begin with "Ni."

- Click OK.

- Open the Streets layer attribute table.

- Click Show selected records.

There are three different street names that begin with "Ni": Nile, Niblick, and Nicola. None of these seems to be a plausible version of "Ninguna."

- Show all records and then clear the selected features.

- Hide the attribute table.

When you encounter an address that is spelled sensibly and standardized correctly but has no candidates, the reason might be that there is no corresponding feature in the reference data. The reference data might have been clipped inappropriately. (Perhaps an area of Palm Springs was left out by the person who prepared the data.) It is also possible that the reference data is old. (Perhaps Ninguna Road is part of a recent housing development.)

Another possibility is that the street feature exists in the reference data but has no name attribute. There are many such features in the Palm Springs street data, including alleys, parking lot driveways, and dirt roads. There may also be ordinary streets that were never completely attributed for some reason.

To investigate further, you would need to acquire different reference data or check other sources, such as print or online maps.

For the purpose of this exercise, assume you have conducted some online research and discovered that Ninguna Road is a real street in Palm Springs. By comparing the names of nearby streets in the online map with those in your reference data, you have figured out which feature it is.

- Zoom to the Ninguna Road bookmark.

Ninguna Road is the short street running north-south that is circled in the following graphic.
Identify this feature using the Identify tool. *Hint:* Be sure to identify from the appropriate layer.

The feature has no address attributes. Its OBJECTID value is 1276.

- Close the Identify window.

- Restore the Interactive Rematch dialog box.

In the Street or Intersection box, the address is 88 Ninguna Road.

- If necessary, click the row that contains the Ninguna Road address.

Since you do not have To or From address ranges in the reference data, you will assume that the address range is from 0 to 100, because this fits your address number. You will further assume that 0 is the north end of the street.

- At the bottom of the dialog box, click Pick Address from Map.
Minimize or move the Interactive Rematch dialog box out of the way.

Right-click anywhere in the map to open a context menu and confirm that Match to Click Point is checked.

Press Esc on your keyboard to close the context menu.

Position the mouse pointer close to the southern end of Ninguna Road, then right-click and choose Pick Address.

A point is added at the location where you clicked.
In the Interactive Rematch dialog box, the record is matched with a score of 100. The match type is PP (Pick by Point). There is no Side or Match_Addr value because there are still no attributes for this feature in the reference data.

- Close the Interactive Rematch dialog box and the Geocoding toolbar.
- Zoom to the Homes for Sale layer.
- Save the map document and close ArcMap.
Lesson review

1. What types of location information can be added to a map?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. What are the three main components of the geocoding process?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
Answers to Lesson 12 questions

Exercise 12A: Build an address locator

1. What are the anomalies?
   
   For OID 0, the street name is rather short and is formatted in uppercase type. The ZIP value is missing for OID 3. The record in OID 12 shows the city name in the Address field.

2. Why do some fields display an asterisk next to their names?
   
   These fields are required in this address locator style.

Exercise 12B: Geocode addresses

1. What is the value in the Status field for this record?
   
   M

2. In the Interactive Rematch window, compare the address in the Street or Intersection box with the top candidate address. Why is the score less than 100?

   The reference data has a Prefix value of "N," which is missing from the address table. If the street address in the address table were changed to "2339 NORTH SAN GORGONIO ROAD," the candidate score would be 100.

Lesson review

1. What types of location information can be added to a map?

   - Latitude/longitude (x,y) coordinates
   - Street addresses
   - Street intersections
2. What are the three main components of the geocoding process?

- Address table
- Address locator
- Reference data
Introduction

The earlier lessons illustrated how to use the software. In this lesson, you will think about using ArcGIS to analyze data, solve geographic problems, or answer geographic questions.

Learning objectives

After completing this lesson, you will be able to:

- Apply a workflow for GIS analysis.
- Use query and analysis tools to solve spatial problems.
Analysis process

Analysis

*Analysis* is a systematic process used to solve a problem. The graphic illustrates the analysis process used to solve a problem using GIS.

In a GIS, you work with information that is associated with locations. Therefore, the type of analysis you perform is called *spatial analysis*—the process of examining locations, attributes, and relationships of features in spatial data.

Spatial analysis is performed using a variety of analytical operations.
Common analysis operations

Following are the analysis operations you will perform in this lesson:

- Selecting features based on attribute values
- Selecting features based on spatial relationships
- Extracting data from layers
- Buffering features (proximity analysis)
- Overlaying layers (union, intersect)

Geoprocessing

Some of the analysis operations you will perform result in the creation of new data, also referred to as geoprocessing operations.

- Geoprocessing refers to any GIS operation in which new data is derived from existing data.
- When geoprocessing operations are used for analysis, they create new data that you can use to answer geographic questions.
- Geoprocessing tools used for analysis typically fall into three categories:
  - Data extraction
  - Overlay
  - Proximity
Working with attribute queries

- **Scenario:** Acute care hospitals in flood-prone areas need evacuation plans
  - **Operation:** Use Select By Attributes to select acute hospitals

![Diagram showing attribute query]

- **Operator**
- **Field**
- **Value**

"TYPE" = 'Acute'

Acute hospitals are selected
Working with spatial (location) queries

- **Determine which acute hospitals are in flood-prone areas**

- **Operation: Use Select By Location to select features from current selected set that are inside flood areas**

- Select By Location lets you select features based on their location relative to features in another layer.
  - The Target layer is the layer in which features are selected.
  - The Source layer is the layer whose features are used to determine the selection (based on its spatial relationship to the target).
- You can use a variety of selection methods to select point, line, or polygon features in one layer that are near or overlap features in the same or another layer.

To learn more about these selection methods, search for this ArcGIS 10 Help topic: *Using Select By Location*
Extracting features using the Clip tool

- Extract highways that are in flood-prone areas
  - Operation: Use Clip tool to clip highways to flood areas

Use the Clip tool to cut out a piece of one feature class using one or more of the features in another feature class as a "cookie cutter."

This is particularly useful for creating a subset of the features in a large feature class.

For more information on Clip, look for this ArcGIS 10 Help topic: Clip (Analysis)
Buffering features

- **Scenario:** Highways within 2 miles of acute hospitals need evaluation as potential evacuation routes
  - **Operation:** Use Buffer tool to create 2 mile buffers around acute hospitals

  ![Buffering features diagram]

  - Use the Buffer tool to create buffer polygons around input features at a specified distance.

  For more information on Buffer, look for this ArcGIS 10 Help topic: *Buffer (Analysis)*
Overlay analysis

- Combines multiple layers into one
- Helps answer basic question: *What is on top of what?*

For a further description of overlay analysis and a comparison of overlay tools, look for this ArcGIS 10 Help topic: *Overlay Analysis*
Intersect

◆ Scenario: Highways inside 2-mile buffer zones need to be evaluated
◆ Operation: Use Intersect tool to overlay buffers and highways

- The Intersect tool calculates the geometric intersection of two or more feature classes or feature layers. The features, or portion of features, that are common to all the inputs (that is, they intersect) are written to the output feature class.
- The inputs can be any combination of geometry types (point, line, or polygon).
  - If the inputs are polygon and polygon, the output feature class is polygon.
  - If the inputs are polygon and line, the output feature class is line.
  - If the inputs are polygon and point, the output feature class is point.

For more information about how intersect works, including examples of different inputs and outputs, look for this ArcGIS 10 Help document: *How Intersect works*
Union

◆ **Scenario:** Ecoregions need to be categorized as inside or outside flood areas

◆ **Operation:** Use Union tool to overlay ecoregions and flood areas

- Union calculates the geometric union of two or more feature classes or feature layers.
- All input feature classes or feature layers must be polygons.
- The output feature class will contain polygons representing the geometric union of all inputs and all fields from all input feature classes.

To learn more about how Union works, and to see examples of how attribute values are assigned to the output features, search for this ArcGIS 10 Help document: *How Union works*
Exercise 13A: Analyze habitat data

Estimated time: 25 minutes

Querying and analyzing data are powerful methods of problem solving in a GIS. In this exercise, you will use queries and analysis tools to find solutions to real-world spatial problems.

For this exercise, assume you are a GIS analyst for the State Park Service. You will work with wildlife habitat areas in southern Louisiana. Your goal is to identify areas where habitats for multiple species exist within 1 mile of a scenic river. The state wants to prioritize habitats for conservation based on biodiversity—the greater the number of animals sustained, the higher the conservation priority.

In this exercise, you will:

▪ Use attribute and spatial queries to locate features in ArcMap.
▪ Use geoprocessing tools to extract data into new feature classes.
▪ Buffer and overlay layers using geoprocessing tools.
▪ Use the results for further analysis in ArcMap.

Step 1: Open a map document

☑ Start ArcMap and open Habitat.mxd from your ..\Student\DESK2\QueryAnalysis folder.

☑ If necessary, maximize ArcMap.

☑ Zoom to full extent.
The map contains a layer of scenic rivers and two layers of wildlife habitat areas in southern Louisiana.

☐ In the Catalog window, make SpatialAnalysis the default geodatabase.

☐ From the Geoprocessing Options on the Geoprocessing menu, make sure that Background Processing is disabled.

**Step 2: Explore habitat layers**

You are trying to locate areas where multiple habitats overlap. To begin your habitat analysis, you will add and calculate some attribute fields. You will add an attribute field containing a Y value (for Yes) to each habitat layer. Then, when you combine these layers in subsequent steps, it will be easy to locate each habitat.

☐ Open the attribute table for the Waterfowl layer and add a field. *(Hint: Click Table Options.)*

☐ On the Add Field dialog box, type **Waterfowl** in the Name box.

☐ For Type, choose Text.

☐ For Length, replace 50 with 5.

You know that the values in your new field will be a few letters long at most, so there is no need to have a field length of 50 (and having a shorter length will save you some storage space).

☐ Click OK.

Next, you will calculate values for the new field using a geoprocessing tool.

☐ In the Search window, search for the **Calculate Field** tool. *(Tip: Click Tools to reduce the size of the response.)*

☐ From the list that is returned, locate the tool that calculates the values for a field for a feature class.

☐ Hover your mouse pointer over the phrase, then click the phrase to open the Item Description for the tool.

Like data, geoprocessing tools also have an Item Description as documentation.

☐ Read through the Summary to learn what the tool does.
Close the Item description – Calculate Field window.

In the Search window, click the Calculate Field (Data Management) tool to open its dialog box.

Click the Browse button for Input Table and add Waterfowl from your ..\Student\DESK2\QueryAnalysis\SpatialAnalysis geodatabase.

For Field Name, choose Waterfowl.

For Expression, click the calculator button at the right side of the input field.

Under Waterfowl =, type "Y" (include the quotation marks).

Click OK.

Click OK in the Calculate Field dialog.

When the tool has completed, click Close.

Confirm that the Waterfowl field has been calculated.

Note: Remember that you can auto hide windows to make them accessible only when you need them.

Now you have a field to designate waterfowl habitats. Now you will add a similar field to the Gator attribute table.

In the Search window, search for the Add Field tool.

From the list that is returned, locate the tool that adds a new field to a table or the table of a feature class.

Open the Item Description for the tool.
Scroll through the Item Description to the Usage section.

Read the documentation for the first three bullets to answer the following question.

1. Where will the newly added field display in the table?

______________________________________________________________________________

Close the Item Description – Add Field window.

In the Search window, click the Add Field (Data Management) tool to open its dialog box.

For Input Table, choose Gator Habitat from the list.

Use the following table as a guide to enter or select the input values.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Name</td>
<td>Gator</td>
</tr>
<tr>
<td>Field Type</td>
<td>TEXT</td>
</tr>
<tr>
<td>Field Length</td>
<td>5</td>
</tr>
</tbody>
</table>

*Note:* The number 5 will display right-justified in the Field Length box.

Be sure FieldIsNullable is checked on and FieldIsRequired is checked off.

Click OK.

When the process has finished, close the Add Field window.

Next, you will calculate the Gator field.

Open the tool you used earlier that calculates the values of a field for a feature class. (*Hint:* Use the Search Window.)
Use the following table as a guide to enter or select the input values.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Table</td>
<td>Gator Habitat (browse)</td>
</tr>
<tr>
<td>Field Name</td>
<td>Gator</td>
</tr>
<tr>
<td>Expression</td>
<td>&quot;Y&quot;</td>
</tr>
</tbody>
</table>

Click OK and close the progress window when the process completes.

Open the Gator Habitat attribute table and locate the Gator field.

2. Where did the Add Field tool add the new field to the table?

Now you have a calculated attribute field that you can use later to locate alligator habitat areas.

You will combine these layers together and use these fields to locate areas where there are alligators, waterfowl, or both.

**Step 3: Clip rivers to the habitat area**

The Gator Habitat layer does not cover the entire state, but the Scenic Rivers layer does. Your study is taking place in southern Louisiana, so you don't need the rivers in the north. You will clip the rivers to the extent of the Gator Habitat layer to work with rivers only in the study area.

Clip is a frequently used geoprocessing tool. For convenience, you can access frequently used geoprocessing tools from a menu.

Click the Geoprocessing menu, then choose Clip.

Use the following table as a guide to complete the input values for the Clip tool.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Features</td>
<td>Scenic Rivers</td>
</tr>
<tr>
<td>Clip Features</td>
<td>Gator Habitat</td>
</tr>
</tbody>
</table>
- Store the output in ..\Student\DESK2\QueryAnalysis\SpatialAnalysis.gdb with the name ScenicRivers_ClipGator.

- Click OK to run the tool and close the Clip window when the process has completed.

- Zoom to the new layer and make it the only visible layer.

Now you are working with just the rivers in the habitat area.

- Change the symbol for the ScenicRivers_ClipGator layer to ESRI River, Navigable with a width of 2. (*Tip: Search the symbol selector.*)

- Open the attribute table for the ScenicRivers_ClipGator layer.

The attribute fields in this layer are from the original Scenic Rivers layer only. The Clip tool does not preserve attributes from both inputs the way that Intersect and Union do. However, the Clip tool is a useful way to extract only the data you need for further analysis.

- Close the ScenicRivers_ClipGator table.

**Step 4: Buffer rivers**

In order to identify habitats located within 1 mile of the scenic rivers, you will create a buffer feature class of the 1-mile zone. As you learned earlier, you could find out which habitats intersect the river by 1 mile by creating a spatial query. However, the habitat features would not be split at the 1-mile mark, so you would not get an accurate idea of how large the habitat is within 1 mile of the river. Buffering features is usually a preliminary step in analysis and is often followed by overlay operations.

- On your own, open the Buffer tool. (*Hint: Like the Clip tool, the Buffer tool is also a commonly used tool.*)

- Use the following table as a guide to fill in the parameters. (*Tip: As you enter the input values, read the associated help topic on the right side of the dialog box.*)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Features</td>
<td>ScenicRivers_ClipGator</td>
</tr>
<tr>
<td>Output Feature Class</td>
<td>..\SpatialAnalysis.gdb\ScenicRivers1MBuffer</td>
</tr>
</tbody>
</table>

- Under Distance, for Linear Unit, type 1 and change the unit to Miles.
Notice the Dissolve Type option midway down the dialog box. You can choose to dissolve the barriers around each buffer feature. This will result in a more seamless appearance, but it will not preserve attributes from the input. In this case, you will not preserve the river attributes, so you will dissolve the boundaries.

- For Dissolve Type, choose ALL.

- Click OK and close the tool window when the process has finished.
Zoom to the buffered rivers.

Turn the ScenicRivers_ClipGator layer on and off to see the underlying buffer polygons.

Next, you will overlay habitat layers in order to find areas of multiple habitats.

**Step 5: Union the habitat layers**

Because you are trying to find habitats within the 1-mile buffer of the river, you will create a union of the two habitat layers in preparation for further analysis using the buffer zone. The following graphic is a conceptual example of what happens to your data when you create a union of two polygon layers.
The output will contain all features from the inputs and all polygons will be split where their boundaries cross. A union often results in more features in the output than in the inputs.

- Open the Union tool. *(Hint: This tool is commonly used.)*
- For Input Features, choose Waterfowl, then choose Gator Habitat.
- Save the output feature class in SpatialAnalysis.gdb with the name WaterfowlGator_Union.
- Click OK.

Where waterfowl and alligators share a habitat, the feature will have attributes for both. Do you remember the fields you added and calculated with the Y values? You will use them to find habitat areas that are common to both layers. If you had additional habitat layers, you could union them with the WaterfowlGator_Union layer to combine all habitats.

- When the Union has finished, close the tool and make WaterfowlGator_Union the only visible layer.
This layer is a combination of the habitat layers. Next, you will compare the Gator Habitat table with the WaterfowlGator_Union table and determine which fields were copied from the Gator Habitat table to the WaterfowlGator_Union.

- Open the attribute table for the WaterfowlGator_Union layer.
- Open the Gator Habitat attribute table.
- Arrange the tables side-by-side. *(Hint: Click Table Options and point to Arrange Tables.)*
- In the fill-in-the-blank table that follows, for each field that was copied from the Gator Habitat table, write an X in the column titled *Fields from Gator Habitat.*
- In ArcMap, close the Gator Habitat attribute table.

Now you will compare the Waterfowl Habitat table with the WaterfowlGator_Union table and determine which fields were copied from Waterfowl Habitat table to the WaterfowlGator_Union.

- If necessary, open the Waterfowl attribute table.
- Make sure the WaterfowlGator_Union table is open.
- In the fill-in-the-blank table, for each field that was copied from the Waterfowl table, write an X in the *Fields from Waterfowl* column.
The WaterfowlGator_Union layer contains Gator and Waterfowl fields. There are some areas in the layer where there are no waterfowl and no alligators. The value for those fields will be null or blank.

- In ArcMap, in the WaterfowlGator_Union table, locate the Gator field.
- Sort the Gator field descending.
- Scroll past the cells that contain Y until you see cells that contain blank spaces.

The blank cells are features where there is no alligator habitat, and the Y value indicates features where alligators are present. The same will hold true for the Waterfowl field.

**Step 6: Intersect habitats and river buffer**

Now that you have all the habitat information in one layer, you will intersect that layer with the buffer of the scenic rivers. The output from this will be the habitat areas that are within 1 mile of the rivers.
4. Why are you using the Intersect tool instead of Union?

Intersecting these layers will limit the extent of the output and you will only be analyzing habitats within 1 mile of the scenic rivers. You could do a union, but the extent would be larger, the data would be more complex, and the size of the output would be larger. The following graphic is a conceptual example of what the Intersect tool does.

In this case, Layer 1 is WaterfowlGator_Union and Layer 2 is ScenicRivers1MBuffer. Notice that the extent of the output matches Layer 2.

- Open the Intersect tool.
- For Input Features, choose WaterfowlGator_Union, then choose ScenicRivers1MBuffer.
- Store the output feature class in SpatialAnalysis.gdb with the name **Habitats1MBuffer**.
- Click OK and close the Intersect tool when the process has finished.
- Make Habitats1MBuffer the only visible layer.
Zoom to the Habitats1MBuffer layer.

These polygons represent the places where habitats intersect the 1-mile buffer around the rivers. Now you can create a query to find out which habitats are located within 1 mile of the scenic rivers and determine whether they are home to multiple species.

Step 7: Query habitats within 1 mile of rivers

Next, you will create an attribute query to locate habitat areas. You want to find out which areas contain single-species habitats and which ones contain habitats for more than one species so that conservation efforts can be prioritized accordingly.

- From the Selection menu, choose Select By Attributes.
  - For Layer, choose Habitats1MBuffer.
  - In the fields list, double-click the Gator field to add it to the expression box.
  - Click the Equals operator.
  - Click Get Unique Values.
  - Double-click Y in the list of values.
- Click Apply.
- Open the attribute table for the Habitats1MBuffer layer.

Out of 241 features total, 239 are selected, indicating that alligator habitats are abundant near the scenic rivers.

- Clear the expression.
- Create the expression "Waterfowl" = 'Y' to find the waterfowl habitats.
- Click Apply.
- In the table of contents, click the List By Selection button.

Seventy-three of 241 features are home to waterfowl. Next, you will find out where alligator and waterfowl habitats overlap.

- On the Select By Attributes dialog box, add to your expression to find features that are both waterfowl and alligator habitats.

```
"Waterfowl" = 'Y' AND "Gator" = 'Y'
```

- Click OK.
Seventy-one of the polygons have mixed habitats. Next, you could create a selection layer of each habitat area within the buffer of the scenic rivers and modify their symbology to better show the habitat areas on a map.

- Clear the selection.
- Save your map as MyHabitat.mxd in your ..\Student\DESK2\QueryAnalysis folder.

**Step 8: Add the Louisiana image to your map (self-directed)**

In an earlier exercise, you used a Louisiana image as the background layer for your map.

- If you would like to see where the waterfowl and alligator habitats overlap, drag the ..\Student\DESK2\Edit\Louisiana_Landsat image to your map.
- Pan and zoom to explore the results.
- Close ArcMap without saving changes.
Exercise 13B: Analyze soils data

Estimated time: 25 minutes

For this exercise, assume you have been commissioned to do a soil study of the Jefferson and Orleans parishes in Louisiana. The study is sponsored by a developer wanting to build on nonexpansive soils (soils that do not expand when frozen). You need to figure out which soil types are located within each parish and the total area of each of those types. You will use queries and analysis tools in your analysis.

In this exercise, you will:

▪ Locate features using queries.
▪ Summarize attribute information.
▪ Use overlay tools for analysis.
Step 1: Open a map document

- Open Soils.mxd from your ..\Student\DESK2\QueryAnalysis folder.

The data frame contains a layer of soils data, symbolized in shades of green, and a layer of parishes (counties) for the state of Louisiana. The Parishes layer has a transparency set on it to make the underlying Soils layer visible.

- If necessary, make SpatialAnalysis the default geodatabase.

Step 2: Select features by attribute

First, you need to place the Jefferson and Orleans parishes into their own layer. You could use the Find tool or Select By Attributes to locate the parishes.
1. Which of these do you think would be more efficient in this situation? Why?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Assume that you only need these parishes for a temporary analysis. Therefore, you will create a selection layer rather than a new data source. To isolate the parishes, you will select them by their name attributes.

- From the Selection menu, choose Select By Attributes.
- From the Layer drop-down list, make sure that Parishes is selected.
- Begin a query by adding "PARISH" = to the expression box.
- Click Get Unique Values.
- In the Go To box under the list of unique values, type jeff to navigate to the value that starts with this text.
- In the list of unique values, double-click 'Jefferson' to add it to the expression.

```
SELECT * FROM Parishes WHERE:
  "PARISH" = 'Jefferson'
```

You have finished the first part of the query. Now you need to add to the expression to select the Orleans parish.

2. Will you use an OR or an AND operator for this query? Why?
3. Should you construct the query as "PARISH" = 'Jefferson' OR 'Orleans' or "PARISH" = 'Jefferson' OR "PARISH" = 'Orleans'?

- Finish constructing the expression.
- Click Verify to verify the expression's syntax. If necessary, fix any errors.

```
SELECT * FROM Parishes WHERE:
"PARISH" = 'Jefferson' OR "PARISH" = 'Orleans'
```

You can save expressions for future use. This will save you time if you ever need to use the same expression again.

- Click Save.
- Save the expression in your ..\Student\DESK2\QueryAnalysis folder with the name JeffOrleans.exp.
- Click OK on the Select By Attributes dialog box.

The Jefferson and Orleans parishes are selected in the map.
Zoom to the selected parishes and turn off the Soils layer to see the selection more clearly.

Create a selection layer from the selected features. Hint: Right-click the Parishes layer, point to Selection, and choose Create Layer From Selected Features.

The selection layer exists in the current map document only. What if you needed to provide the layer to someone else to use in another map document? You cannot share the selection layer. You would need to export the selected parishes into a new feature class, or skip the selection process in ArcMap by using the Select geoprocessing tool.

Clear the selected features.

Remove the Parishes selection layer.

Step 3: Create a shapefile from a selection

As part of your analysis, you will extract the two parishes and output them to a new feature class using the Select geoprocessing tool.

Search for analysis extract select.
Open the Select (Analysis) tool.

In the Select dialog box, for Input Features, choose Parishes.

All geoprocessing tools can output features to a geodatabase feature class or to a shapefile. The recipient of your data uses shapefiles, so you will output a shapefile.

For Output Feature Class, click the Browse button.

If you browse to a folder, a shapefile will be created. If you browse to a geodatabase, a geodatabase feature class will be created.

Navigate to your ..\Student\DESK2\QueryAnalysis folder.

Name the shapefile Jefferson_Orleans and click Save.

For Expression, click the SQL button.

The Query Builder opens. Here, you can construct a new query or load an existing one.

On the bottom of the Query Builder, click Load.

Navigate to your QueryAnalysis folder, click JeffOrleans.exp, and click Open.

The saved expression is loaded into the Query Builder. The expression can be used by the Select tool even though it was created in the Select By Attributes dialog box.

Click OK.

Click OK on the Select tool and close it when the process finishes.

A new layer named Jefferson_Orleans is added to the map. It contains the same features as the Parishes selection layer, but unlike the selection layer, it can be added to other maps because it references a shapefile on disk.

Next, you will use the new shapefile in a spatial query to find out which soil types are found in the parishes.

**Step 4: Select features spatially**

Spatial queries allow you to select features based on their spatial relationships with other features. For example, you can select the cities located within a county, the parcels intersected by a flood zone, or the customer locations located within 1 mile of a business. Like with an
attribute query, the result of a spatial query is a selected set of features in the map document, not a new data source.

- Turn on the Soils layer and turn off Parishes.

You see the boundaries of the two parishes over the Soils layer. Now, you will select the soils within these parishes (the study area).

- From the Selection menu, choose Select By Location.

You want to select features from the Soils layer that intersect features in the Jefferson_Orleans layer.

- In the first drop-down list, if necessary, choose "select features from."

- In the list of Target layers, check the box for the Soils layer.

- In the Source Layer drop-down list, if necessary, choose Jefferson_Orleans.
These are the spatial relationships you can choose from. There are a couple of relationship types that will select the soils in the study area. You will experiment with them to see which one you need.

- In the Spatial selection method drop-down list, if necessary, choose "Target layer(s) features intersect the Source layer feature" from the list.

4. Fill in the blanks to complete the following statement. Your query means "I want to select features from the __________ layer that intersect the features in the ______________ layer."

- Click Apply.
5. Why are some soils outside the study area selected?

The intersect relationship yields many selected soil features.

- Open the attribute table for the Soils layer.
- Click Show selected records to view the selected records.
Thirty-eight soil features were selected. Using this result, you can figure out which soil types are in the Jefferson and Orleans parishes, but can you accurately figure out the area of each soil polygon? You will answer that question shortly. For now, you will continue experimenting with your spatial query.

- Clear the selected features, show all records in the table and, if necessary, hide the attribute table.

- In the Select By Location dialog box, change the relationship type from "intersect" to "Target layer(s) features are completely within the Source layer feature."

- Click Apply.

- Zoom into the study area.

- Open the attribute table for the Soils layer.
Click Show selected records.

Based on this relationship, seven soil polygons were selected. If any portion of a soil feature is outside the parishes, it is not selected.

6. Of the relationship types you used, which one will select all Soils features in the study area?

Because the intersect relationship gives a more accurate representation of the soil polygons in the study area, you will use it.

In the Select By Location dialog box, change the relationship type back to "Target layer(s) features intersect the Source layer feature."

Click OK.

Next, you will summarize the attribute table to find out which soil types are present in the study area.

**Step 5: Summarize an attribute table**

Summary tables count the number of features that have the same value for a given attribute (for instance, how many features have the SOILTYPE value of "loamy"). They can also calculate statistics for other attributes (for instance, the average area of features with a SOILTYPE value of "loamy").

Open the attribute table for the Soils layer.

Because there is a selection in this layer, the selected features will be summarized.

Scroll to the SOILS_ON field.

Right-click the field heading and choose Summarize.

In the second box of the Summarize dialog box, locate the AREA_SQM field and expand it.

**Note:** This field stores area in square meters.

You need to tell ArcMap which statistics you want to see.
Check Sum.

- AREA_SQM
  - Minimum
  - Maximum
  - Average
  - Sum

Check Sum for the AREA_AC field also.

Note: This field stores acreage.

ArcMap will calculate the total area and acreage for each soil type in the output table.

- Click the Browse button next to the Specify output table box.
- For Save as type, choose File and Personal Geodatabase tables.
- Store the output table in your ..\Student\DESK2\QueryAnalysis\SpatialAnalysis.gdb with the name Soils_Statistics and click Save.
At the bottom of the dialog box, make sure the check box next to Summarize on the selected records only is checked.

- Click OK on the Summarize dialog box.
- Click Yes on the prompt to add the result table to the map.
- Open the Soils_Statistics table.

<table>
<thead>
<tr>
<th>SOILS_ON</th>
<th>Count_SOILS_ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brookish Organic and Mineral Deltaic Deposits</td>
<td>9</td>
</tr>
<tr>
<td>Fresh Organic and Mineral Deltaic Deposits</td>
<td>7</td>
</tr>
<tr>
<td>Loamy and Clayey Low Terraces and Floodplains</td>
<td>7</td>
</tr>
<tr>
<td>Saline Organic and Mineral Deltaic Deposits</td>
<td>7</td>
</tr>
<tr>
<td>Sandy and Loamy Alluvial Natural Levees and Low Terraces</td>
<td>2</td>
</tr>
<tr>
<td>Water</td>
<td>6</td>
</tr>
</tbody>
</table>
The result clearly states which types of soils are found within the two parishes. It also provides a count field of how many features of each type of soil exists. Next, you need to find the area of each soil type in the parishes.

- View the Sum AREA SQM and Sum AREA AC fields on the right.

<table>
<thead>
<tr>
<th>Sum AREA SQM</th>
<th>Sum AREA AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1278195581.66</td>
<td>315353.535</td>
</tr>
<tr>
<td>1260014282.26</td>
<td>311355.065</td>
</tr>
<tr>
<td>498500747.22</td>
<td>122707.205</td>
</tr>
<tr>
<td>963663924.47</td>
<td>238125.589</td>
</tr>
<tr>
<td>378840907.61</td>
<td>93119.044</td>
</tr>
<tr>
<td>16367628368.53</td>
<td>4044512.874</td>
</tr>
</tbody>
</table>

These values represent the areas of the soils that intersect the parishes. If you recall from the previous step, the extent of the selected soils extended beyond the study area, so these area and acreage values are not limited to the extent of the study area. You will split the Soils polygons at the parish boundaries and recalculate these fields.

- Hide the Table window.
- Clear the Soils selection.

**Step 6: Find the area of soil types in the study area**

Tools that combine features and attributes are sometimes referred to as "overlay" tools. Tools that split geometry where features cross are also called "overlay" tools. You will overlay the soils data and the study area and use the output to calculate area of soils in the study area.

Two tools can help you find the area of the soils: Intersect and Union.

- Refer to the workbook for this lesson and the topic Overlay analysis, or search for each of the tools and read its help. Think about the graphic illustrations.

7. If you use the Union tool on the Soils and Jefferson_Orleans layers, what will the spatial extent of the result be?
8. If you use the Intersect tool, what will the spatial extent of the result be?

______________________________________________________________________________
______________________________________________________________________________

9. Would the Union tool or Intersect tool be more efficient for your purposes? Why?

______________________________________________________________________________

- Open the appropriate tool.

The tool's dialog box opens. First, you need to set the input features—that is, the layers that you want to intersect.

- Click the Input Features drop-down arrow and choose Jefferson_Orleans.

- Click the Input Features drop-down arrow again and choose Soils.

- Store the output feature class in ..\Student\DESK2\QueryAnalysis\SpatialAnalysis.gdb with the name SoilsInStudyArea.

- Run the tool and close the progress window when finished.

- In the table of contents, make SoilsInStudyArea the only visible layer. (Hint: Make sure you choose the appropriate list view.)
The Soils polygons have been split at the parish boundaries. You can now calculate the area.

- Open the attribute table for the SoilsInStudyArea layer.

The Shape_Area field has been automatically recalculated because it is a software-managed field.

- Scroll to the AREA_SQM and AREA_AC fields.

These are user-added fields, so you need to recalculate them manually. First, you'll calculate the area of the soils in square meters.

- Right-click the AREA_SQM field heading and choose Calculate Geometry.

- If necessary, click Yes on the prompt to calculate outside of an edit session.
On the Calculate Geometry dialog box, confirm that the units are set to Square Meters [sq m].

If necessary, move the Calculate Geometry dialog box so you can see the AREA_SQM field in the attribute table.

Click OK.

The AREA_SQM values are updated.

Now you'll calculate the acreage of soils in the study area.

Right-click the AREA_AC field heading and choose Calculate Geometry.

If necessary, click Yes on the prompt.

Change the units to Acres US [ac].

Click OK.

The AREA_AC values are updated.

The attribute table also contains attributes from the Parishes layer.

Scroll to the Parish field.

Scroll down until the values change from Jefferson to Orleans.

This attribute was carried over from the Parishes layer. When using overlay tools (such as Intersect), all attributes from the inputs are preserved in the output layer. You can now query one layer to find features of a particular soil type and see which parish they are in. You could have used the Clip tool to get the soils within the parishes into their own layer, but the layer would only contain soils attributes, not parish attributes.

Now, you will summarize the attribute table and compare the area values to the values in your previous summary table.
Summarize the SOILS_ON field the way you did earlier:

- Choose to calculate Sum statistics for the AREA_SQM and AREA_AC fields.
- Store the output in ..\Student\DESK2\QueryAnalysis\SpatialAnalysis.gdb.
- Name the output IntersectSummary.

Click OK on the Summarize dialog box.

Click Yes on the message to add the result table to the map.

Open the IntersectSummary and Soils_Statistics tables and position them so that you can see the contents of both.

Close all other open tables.

Compare the area values in both tables. (Tip: Arrange the tables side by side.)

### Intersect_summary table:

<table>
<thead>
<tr>
<th>Sum_AREA_SQM</th>
<th>Sum_AREA_AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>592648175.448115</td>
<td>146445.967684</td>
</tr>
<tr>
<td>442523277.474263</td>
<td>109349.445889</td>
</tr>
<tr>
<td>90571113.320464</td>
<td>22306.717627</td>
</tr>
<tr>
<td>125611596.054039</td>
<td>31039.177203</td>
</tr>
<tr>
<td>252496781.773855</td>
<td>62393.064006</td>
</tr>
<tr>
<td>1086069755.76159</td>
<td>268372.507804</td>
</tr>
</tbody>
</table>

### Soils_statistics table:

<table>
<thead>
<tr>
<th>Sum_AREA_SQM</th>
<th>Sum_AREA_AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1275195581.66</td>
<td>315353.535</td>
</tr>
<tr>
<td>1263014282.26</td>
<td>311365.065</td>
</tr>
<tr>
<td>495580747.22</td>
<td>122737.285</td>
</tr>
<tr>
<td>96366924.47</td>
<td>238125.589</td>
</tr>
<tr>
<td>375840907.61</td>
<td>93119.044</td>
</tr>
<tr>
<td>16367628368.53</td>
<td>4044512.874</td>
</tr>
</tbody>
</table>

The area values for the layer created by the Intersect tool are much smaller than those of the selection layer from your spatial query because the intersect polygons were split at the study area boundary.

At this point, you could create a map, graph, or report illustrating the soil distribution in the study area, as well as the area of each soil type.
Remember, one benefit of an overlay analysis is that it preserves all attributes from the inputs in
the output feature class.

☑ Click the Identify tool, then click a soil polygon.

In the Identify window, you see that there are both parish and soil attributes associated with the
feature.

☑ Close the Identify window.

☑ Save your map as MySoils.mxd.

☑ If you would like to work the optional exercise, go there now, otherwise, close ArcMap.
Exercise 13C: (Optional) Symbolize your map and create a layout (Self-directed)

Estimated time: 10 minutes

In previous exercises, you learned how to symbolize your maps and how to create a layout. In this step, you will apply the skills you learned in those prior lessons.

In this exercise, you will:
  ▪ Symbolize a map.
  ▪ Create and export a map layout.

Step 1: Create and export a map layout

Here are some ideas to help you get started.

☐ If you want to use the MyHabitat map document:
  ▪ Create a selection layer of each habitat area within the buffer of the scenic rivers.
  ▪ Modify the symbology to better show the habitat areas on a map.
  ▪ Add the Louisiana image from the Edit exercise as a background layer.
  ▪ Alternatively, add Parishes as a background layer.

☐ If you want to use the MySoils map document:
  ▪ Modify the symbology to better show the habitat areas on a map.
  ▪ Add the Louisiana image from the Edit exercise as a background layer.

☐ Create a map layout. *(Tip: Remember to turn on the Layout toolbar.)*

☐ Export your layout to a PDF file.

☐ Save your work.

☐ Close ArcMap.
Lesson review

1. Why is the analysis workflow often circular rather than linear?

______________________________________________________________________________
______________________________________________________________________________

2. You have two layers—land parcels and forest. You want to calculate the land area that is covered by forest. Which overlay operation would you use? In this operation, what will the output feature class contain?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

3. Which overlay operation requires all the inputs to be polygons?

______________________________________________________________________________
______________________________________________________________________________
**Answers to Lesson 13 questions**

**Exercise 13A: Analyze habitat data**

1. Where will the newly added field display in the table?
   
   The newly added field will display at the end of the table, on the right.

2. Where did the Add Field tool add the new field to the table?
   
   At the end, or right, of the table—the same as the Table Options Add Field button.

3. | Fields in WaterfowlGator_Union table | Fields from Gator Habitat | Fields from Waterfowl Habitat |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>OBJECTID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shape</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FID_Waterfowl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W_FOWL_ID</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Waterfowl</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>FID_GatorHabitat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GATOR_ID</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Gator</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Shape_Length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shape_Area</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Why are you using the Intersect tool instead of Union?
   
   You are only concerned with the area within the buffer. The Intersect tool will limit the extent of the output to it, whereas the Union tool will produce an output with a much larger extent.
Exercise 13B: Analyze soils data

1. Which of these do you think would be more efficient in this situation? Why?

   Select By Attributes would be more efficient because it will create a selection of the features that you can use to create a selection layer or export to a new layer. The Find tool would be less efficient because it will not select the features; you would have to find and select each feature separately before creating a selection layer or exporting.

2. Will you use an OR or an AND operator for this query? Why?

   OR, because no parish will be named both Jefferson and Orleans.

3. Should you construct the query as "PARISH" = 'Jefferson' OR 'Orleans' or "PARISH" = 'Jefferson' OR "PARISH" = 'Orleans'?

   "PARISH" = 'Jefferson' OR "PARISH" = 'Orleans'

4. Fill in the blanks to complete the following statement. Your query means "I want to select features from the __________ layer that intersect the features in the _________________ layer."

   Your query means "I want to select features from the Soils layer that intersect the features in the Jefferson_Orleans layer."

5. Why are some soils outside the study area selected?

   With the intersect relationship, all features that touch the study area are selected. These polygons are very large, but they are selected in their entirety even if only a small portion of them is located within the study area.

6. Of the relationship types you used, which one will select all Soils features in the study area?

   Intersect

7. If you use the Union tool on the Soils and Jefferson_Orleans layers, what will the spatial extent of the result be?

   The spatial extent of the result will be that of the Soils layer. All features from both layers will be preserved in the output feature class.
8. If you use the Intersect tool, what will the spatial extent of the result be?
   
   The spatial extent of the result will be that of the Jefferson_Orleans layer. Features or portions of features located within the common area of both layers will be preserved in the output feature class.

9. Would the Union tool or Intersect tool be more efficient for your purposes? Why?
   
   The Intersect tool, because you are only concerned with the study area.

Lesson review

1. Why is the analysis workflow often circular rather than linear?
   
   Results from an initial analysis may lead the analyst to ask more geographic questions or discover new geographic problems.

2. You have two layers—land parcels and forest. You want to calculate the land area that is covered by forest. Which overlay operation would you use? In this operation, what will the output feature class contain?
   
   Intersect.
   Only the area(s) of overlap between the two layers plus attributes of both layers.

3. Which overlay operation requires all the inputs to be polygons?
   
   Union
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No Implied Waivers: No failure or delay by Esri or its licensor(s) in enforcing any right or remedy under this Agreement shall be construed as a waiver of any future or other exercise of such right or remedy by Esri or its licensor(s).

Order for Precedence: This Agreement shall take precedence over the terms and conditions of any purchase order or other document, except as required by law or regulation.

Export Regulation: Licensee acknowledges that the Training Course and all underlying information or technology may not be exported or re-exported into any country to which the U.S. has embargoed goods, or to anyone on the U.S. Treasury Department's list of Specially Designated Nationals, or to the U.S. Commerce Department's Table of Deny Orders. Licensee shall not export the Training Course or any underlying information or technology to any facility in violation of these or other applicable laws and regulations. Licensee represents and warrants that it is not a national or resident of, or located in or under the control of, any country subject to such U.S. export controls.

Severability: If any provision(s) of this Agreement shall be held to be invalid, illegal, or unenforceable by a court or other tribunal of competent jurisdiction, the validity, legality, and enforceability of the remaining provisions shall not in any way be affected or impaired thereby.

Governing Law: This Agreement, entered into in the County of San Bernardino, shall be construed and enforced in accordance with and be governed by the laws of the United States of America and the State of California without reference to conflict of laws principles.

Entire Agreement: The parties agree that this Agreement constitutes the sole and entire agreement of the parties as to the matter set forth herein and supersedes any previous agreements, understandings, and arrangements between the parties relating hereto.