

Section 1: Introduction to ArcGIS

Lecture Notes

Course Scenario

This course will effectively walk students through a GIS project, start-to-finish, including data discovery, incorporating data received from other organizations, performing basic analysis and editing, and finally presenting the findings in the form of a map. The project setting is in Montana, more specifically in Glacier National Park's Lake McDonald/Apgar area, near the park entrance in West Glacier. Students will use some of Glacier's base cartographic data and a subset of its Bear Information Management (BIMS) database to visualize and analyze in two separate analyses bear sightings/activity with respect to residences as well as a wastewater treatment facility. Students will explore the proximity of bear sightings to these features of interest, distinguishing between black bear and grizzly bear sightings, and will perhaps learn something about bear behavior through the analyses.

ArcGIS Desktop Software Suite

Licenses

Background of ESRI software preceding ArcGIS software suite:

- ArcInfo Workstation – command-line driven interface, robust GIS software package with large learning curve
- ArcView 3.x – menu driven interface, originally designed to be a spatial data “viewing” software package, but given its ease of use it evolved into a more robust program.

Combine the two preceding software packages, the robustness of ArcInfo and ease of use of ArcView, and you get ArcGIS Desktop. ArcGIS is accessed using one of three software licenses with varying levels of functionality:

- ArcView - provides comprehensive mapping and analysis tools with simple editing and geoprocessing capabilities
- ArcEditor - provides all ArcView functions plus advanced editing capabilities
- ArcInfo - provides all ArcEditor functions plus advanced geoprocessing and data management tools. This is the largest “toolbox” and is currently the only license distributed by the NPS and for which the NPS is licensed.

Note: This course was primarily written for use with ArcGIS 9.2 so its contents may not be compatible with other versions. It can also be used with version 9.1, but some of the steps vary and there are different instructions provided where needed. Version 9.2 was just being released as the course was completed so for more information on any differences in the newer version refer to the “What’s New in ArcGIS 9.2” resource on ESRI’s website:

<http://www.esri.com/software/arcgis/about/whats-new.html>

Applications

Regardless of license level – whether ArcView, ArcEditor, or ArcInfo – ArcGIS Desktop includes two main applications: ArcCatalog and ArcMap. More simply, ArcInfo is the product you install, while ArcCatalog and ArcMap are the applications that you run.

ArcCatalog

Application used to organize and manage your GIS data. Some of its functionality includes allowing you to preview datasets and viewing and managing metadata.

Because spatial data may be composed of complicated file structures or multiple related files, it is important to use ArcCatalog rather than Windows Explorer to manage your data. With ArcCatalog, these complicated relationships are simplified and you can move, copy, or delete all related files with one operation rather than many.

Launch ArcCatalog



ArcCatalog can be opened from a shortcut , such as **Start > Programs > ArcGIS > ArcCatalog** or from the **ArcCatalog** button in **ArcMap**:



Folder Connections

In ArcCatalog, folder connections enable you to access your file-based data such as coverages, shapefiles, images, etc. All of the folder connections that you make are listed in the Catalog tree. Once you have connected to a folder, you can browse its contents in the Catalog, including the contents of any of its subfolders.

ArcCatalog allows you to connect to any folder on your hard drive as well as to folders on network drives and GIS servers on the Internet (such as ArcIMS servers). You may connect to the top level of a drive or to any subfolder. To improve efficiency, it is usually better to connect to subfolders rather than to the top level of drives, e.g., c:.

Use the **Connect to Folder** button  on the **Standard** toolbar to create new folder connections.

Think of folder connections as being like “favorites.” Make a separate connection to each of your most frequently used GIS folders. In this way, you will have the most convenient access to your data because you will not have to click down through a series of subfolders to get to it. Folder connections are necessary to access spatial data.

Preview Spatial and Tabular Data

ArcCatalog is a great tool for browsing and becoming familiar with the available spatial data—basically the “Windows Explorer” for spatial data.

Use the **Contents** tab to view folder contents.

Use the **Preview** tab to view spatial and tabular data. To do select the dataset from the **Catalog tree** on the left of the ArcCatalog interface and then click on the **Preview** tab to view the selection. Use the **Preview** dropdown list to view **Geography** or **Table** of spatial datasets. To view a table not associated with a spatial dataset, such as one stored in an Access database, select it in the **Catalog tree** and then click on the **Preview** tab.

Geography Toolbar

Once the Preview tab is selected the **Geography** toolbar, shown below, becomes active:



You can use these tools for basic data exploration, including zooming, panning and identifying.

View Metadata

The **Metadata** tab in ArcCatalog is used for viewing the metadata of spatial data. Simply stated, metadata is often referred to as “data about data” and describes the content, quality, condition and other characteristics of a spatial dataset. Metadata will be covered in more detail in Section 3.

To view the metadata of a spatial dataset, select it in the **Catalog tree** and then select the **Metadata** tab. Use the **Stylesheet** dropdown list to select different metadata stylesheets or views, such as **FGDC**.

And Much More...

These are just some of the functions that can be performed in ArcCatalog. You can also define projections (which will be demonstrated in section 2), create new spatial data, manage tables including adding and deleting fields, create metadata, and much more!

ArcMap

Application used to view, edit, and analyze spatial data and create maps. It is the primary application used in this course.

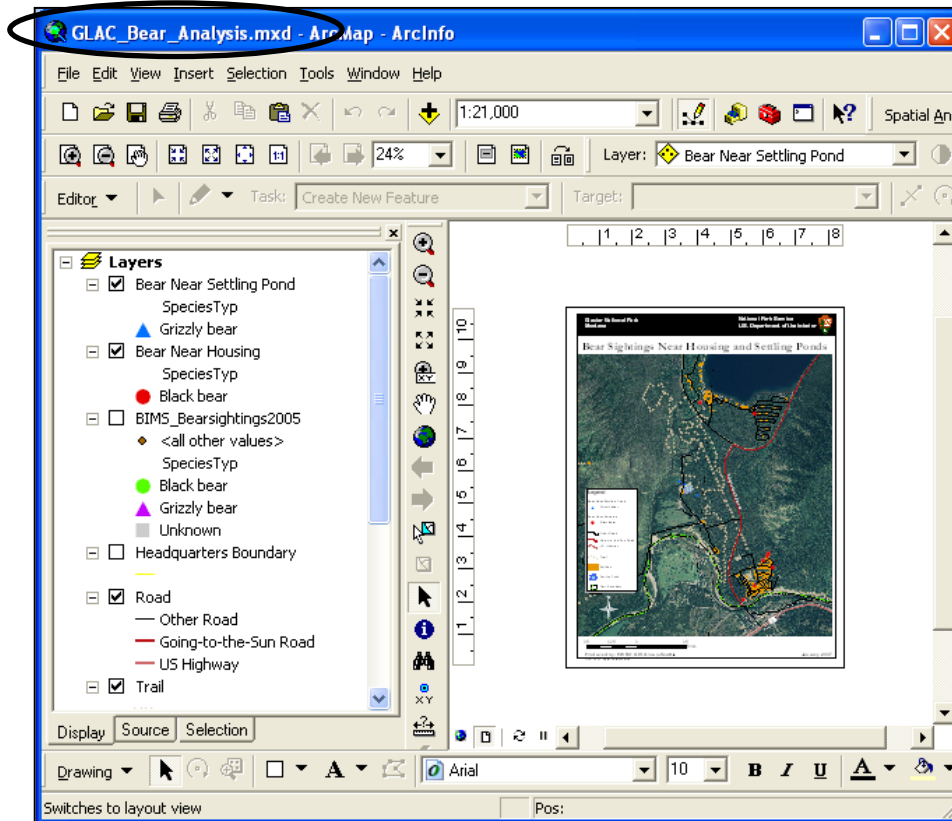
Launch ArcMap

ArcMap can be opened from a shortcut , such as **Start > Programs > ArcGIS > ArcMap** or from the **ArcMap** button in **ArcCatalog**:



The Map Document (*.mxd)

A map document is the fundamental component you work with in ArcMap. It is a collection of data layers and a cartographic layout. It is important to note that map documents store references to the locations of the data sources (e.g., shapefiles, coverages, image files, etc.) NOT the data themselves. This allows the layers on a map to reflect the most up-to-date information in a GIS database. The map document has an .mxd file extension which is displayed in the ArcMap title bar, circled below:



Notice the map document name shown above is *GLAC_Bear_Analysis.mxd*. By default, a new map document will be named *Untitled* until it is saved and given a name, and it will contain one **data frame** named *Layers*. Data frames will be discussed in more detail later in this section.

Add Spatial Data to a Data Frame

To access spatial data in ArcMap you will add layers to a map document data frame, which can be done in a variety of ways. You will work directly with data sources as well as layer files (.lyr) which have a few differences. For instance, layer files display with the symbology and properties (such as transparency) with which they were saved; whereas layers added directly from data sources are displayed with default, single symbol, symbology, which

means all of the features display with the same symbol. You can think of a layer file as a cartographic view of your spatial data. It is a separate file on disk and has a .lyr extension. It essentially stores all of the settings present in the Layer Properties when it is created.

Both layer files and data sources reference geographic data stored on disk and they can reference most data sources supported by ArcGIS. Layer files can have spaces in the filenames but data sources and map documents should not. To be safe it is best not to use spaces in any filenames—use an underscore character instead (e.g large_lake_map.mxd). Generally, it is a good idea to stick to characters, both lower and upper-case, and the underscore character—including pathnames, filenames, field names in tables, etc.

Creating layer files is a great way to “reorganize” spatial data in a way that works best for you. For example, many parks provide access to spatial data centrally on a GIS server, and the files are organized in a particular manner that isn’t intuitive to you. To get around this you could create layer files for the spatial data, customizing the symbology and other layer properties as desired, and save them to the location and file structure of your choice. You will practice creating a layer file in Section 2.

Add Layers to a Data Frame

One method is to use the **Add Data** button on the **Standard** toolbar . Then navigate to and select the desired layer file or data source. To add multiple layers at one time navigate to and select one layer file or data source and then hold down the **Ctrl** key and select the others. It is only possible to add multiple layers from a single folder.

After adding an image data source you may be prompted to **Create pyramids**. For more information on pyramids refer to the **Raster pyramids** (ArcGIS 9.2) **Creating raster pyramids** (ArcGIS 9.1) or topic in the **ArcGIS Desktop Help**.

Add Layers to a Data Frame from ArcCatalog

Another method for adding data to a data frame is to drag-and-drop from ArcCatalog. This requires having both ArcMap and ArcCatalog open at the same time and resizing them in such a way that layer files and/or data sources can be dragged and dropped into a data frame in ArcMap. A black line will appear so you can see where the layer will be placed.

Set Layer Data Source

If any layers in a data frame have a red exclamation mark (!) and are not displayed, you need to set the layer data source. This occurs when the source data of a layer file is in a different location than when it was created and can not be found, or really when the data source referenced by a layer in a data frame has moved from the original location from

which it was added. You can set the data source by either clicking on the red exclamation mark or in the Layer Properties on the Source tab. By using the method of clicking on the red exclamation mark, any other layers whose data source are also not found and are stored in a similar location will automatically have their data sources set, saving time. This is not the case when setting the data source in the Layer Properties; however, the Layer Properties is a great place to verify the original data source to ensure you choose the correct one when setting it.

Save a Map Document

When you are working in ArcMap it is important to save often in order to minimize the amount of work that would be lost in the event it crashes, that is ArcMap closing unexpectedly. There are a few ways to save a map document, first clicking on the **Save** button or selecting **Save** from the **File** menu will save changes to the current map document. Under the **File** menu there are also options to **Save As** and **Save A Copy**. **Save As** is useful for saving the current map document to a new map document in which you will then immediately be working. **Save A Copy** is similar to Save As but instead of immediately beginning to work in the new map document it saves it to the new name and to the designated location but you continue to work in the current map document. Both Save As and Save A Copy are useful for saving multiple versions of map documents that document incremental and important edits for projects.

ArcGIS versions prior to 9.1 are not “backward compatible,” meaning that map documents created in version 9.0 can NOT be used with earlier versions (e.g., version 8.x). As of version 9.1 this limitation was removed with the option to save a map document to an older version, e.g., from 9.1 to 9.0. As with most software, the versions ARE “forward compatible”, meaning that map documents created in an earlier version, such as 9.0, can be opened and manipulated in subsequent versions, such as 9.1 and 9.2.

Open and Close a Map Document

Opening and closing a map document is not to be confused with adding data, this is a common mix-up for new users. To open an existing map document, click on the **Open** button . There is no option to “close” a map document, to do so either open a new one or exit ArcMap.

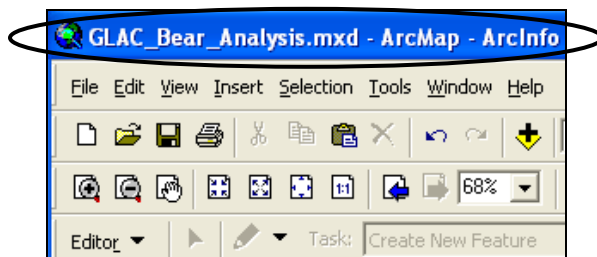
ArcMap Interface

Key components of the ArcMap interface are:

- The title bar, menu bar, toolbars and status bar;
- Two side-by-side windows: the Table of Contents and the Map Display window.

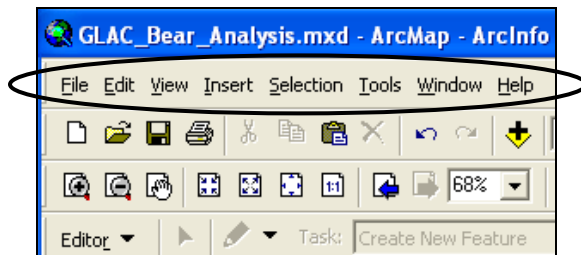
Title Bar

The **Title Bar** is located at the top of the ArcMap window and not only displays the name of the map document, *GLAC_Bear_Analysis.mxd* in the figure shown below, but also the application (ArcMap) and license being used (ArcInfo).



Menu Bar

The **Menu Bar** is located just below the Title Bar, and contains a series of **menus**, such as: **File**, **Edit**, **View**, **Insert**, **Selection**, **Tools**, **Window**, and **Help**.



Clicking on a menu opens a dropdown menu with numerous options. Click on a menu item to select it.

Toolbars

ArcMap includes a variety of **Toolbars**. To see all of the toolbars that are available to you click on the **View** menu and select **Toolbars**. A check mark next to the toolbar name indicates that it is visible. You can also access the toolbars list without using the View menu by right-clicking any toolbar or the status bar.

To quickly hide or turn off a toolbar, click its Close button. If it is docked, you would need to undock it to access the Close button.

Two of the most commonly used toolbars are **Standard** and **Tools**.

Standard Toolbar

The **Standard** toolbar contains buttons and tools that give you fast and easy access to many functions, some of which are also available from menus.



Buttons execute operations immediately after clicking on them, such as **Open**  and **Save** .

In addition to buttons, toolbars also have **tools** which are selected and then used to carry out operations, such as the **What's This?** tool . Typically, the pointer changes when a tool is used.

Tools Toolbar

The **Tools** toolbar includes buttons and tools that allow you to interact with the data displayed in the map display window to carry out specific tasks; such as zooming and panning to change the map extent as well as selecting spatial features and exploring their attributes, among other functions. You will learn how to use many of the buttons and tools throughout the course exercises.



ArcMap provides a number of other toolbars, such as:

- Draw** - for drawing graphics and adding text
- Editor** – for editing spatial data
- Layout** – for working with layouts
- Effects** – for altering the display of spatial data

Spend some time browsing through the list of available toolbars.

Status Bar

The **Status Bar** is located at the bottom of the ArcMap window. It provides information about the function of a button or a tool when you hold the pointer over it, as shown below on the left. It also displays the coordinate position of the mouse pointer in the display window, as shown below on the right, as well as information about the progress of particular operations, such as printing a layout.

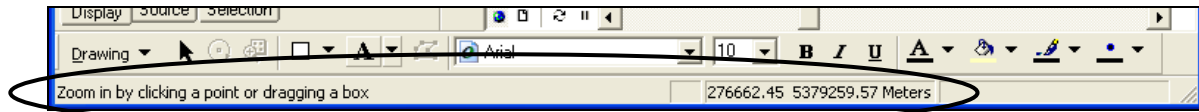
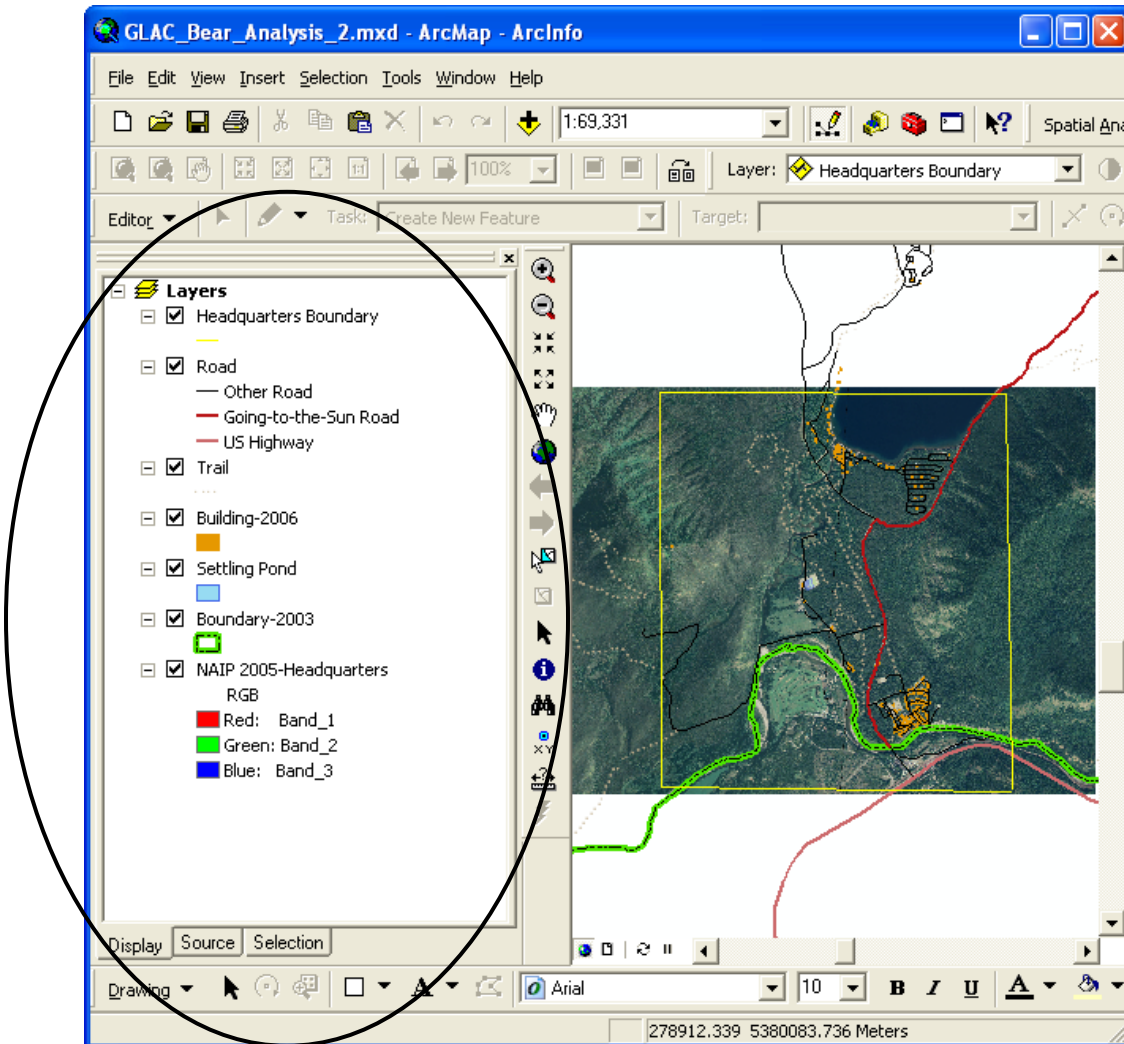


Table of Contents

The **Table of Contents**, shown below, is located on the left side of the ArcMap window and lists the data frames and layers that you have added to your map as well as displaying the symbols that are used to represent the features in each data layer.



Data Frame

A **data frame** is located within the Table of Contents and contains the data layers that you add to a map to display together. When you create a map or map document in ArcMap, it always contains at least one data frame, with the default name of *Layers*, listed at the top of the Table of Contents. However, a map document can contain more than one data frame, for instance if you wanted to include a locator map. You can change a data frame name to something more meaningful by click-pause-clicking on it, such as *Layers*, typing a new name, and hitting **Enter**.

Layers

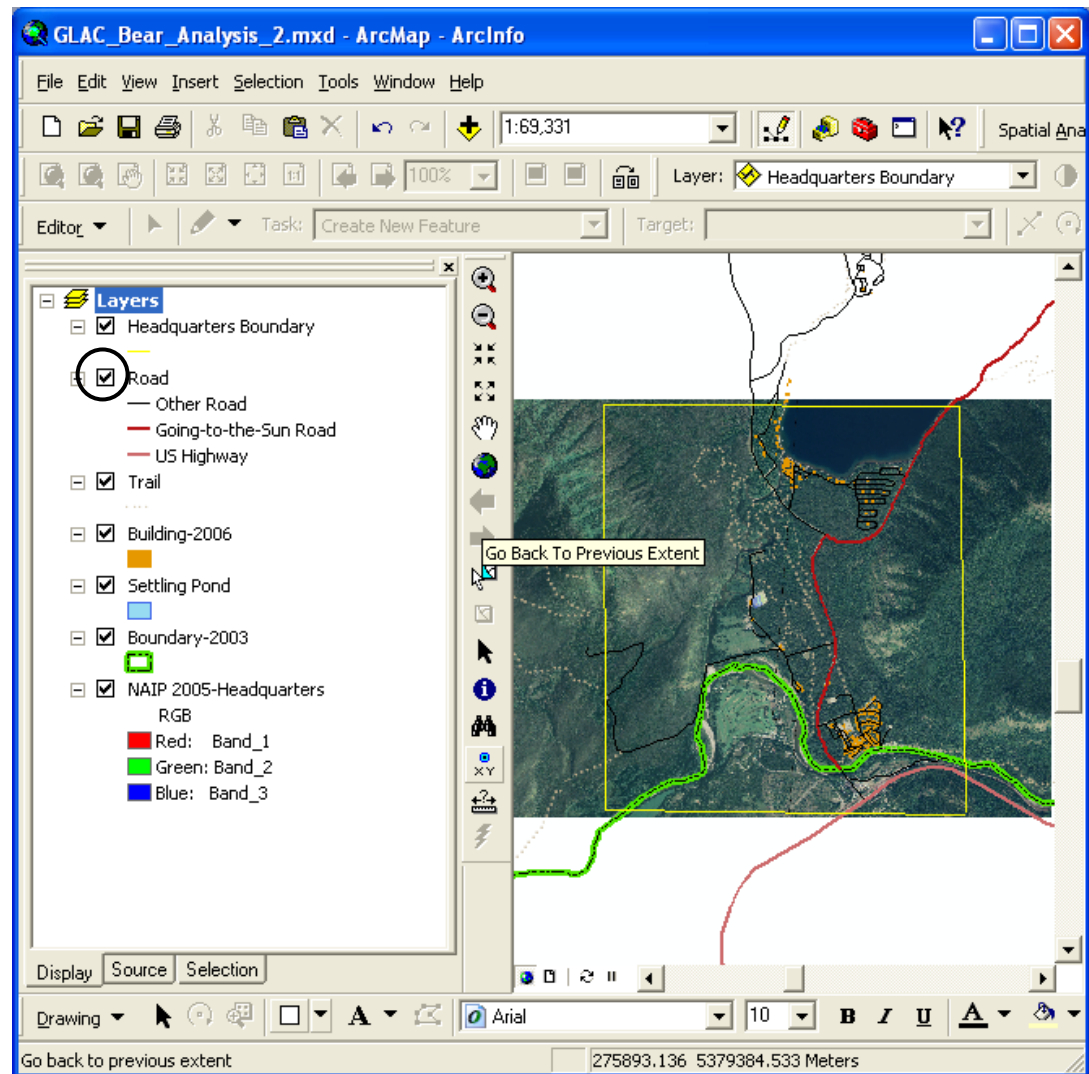
In ArcMap, geographic features are displayed on a map as **layers**. Each **data layer** represents a specific type of feature such as rivers, lakes, archaeological sites, political boundaries, etc. The layers displayed in the graphic on the previous page are:

Headquarters Boundary
Road
Trail
Building-2006
Settling Pond
Boundary-2003
NAIP 2005-Headquarters

It is important to know that a data layer does not store the actual geographic data; instead, it references the source data such as: coverages, shapefiles, geodatabases, images, grids, and so on. Referencing data in this way allows the layers on a map to automatically reflect the most up-to-date information in your GIS database.

Turn Layers On and Off

The check box next to each layer name indicates whether it is currently displayed in the **Map Display** window to the right of the Table of Contents, that is whether it is turned on or turned off. By default when a layer is added it is on. To turn it off click on the checkmark in the box to the left of the layer name, as shown below for the *Road* layer:



To turn a layer on click on the box to place a checkmark in it.

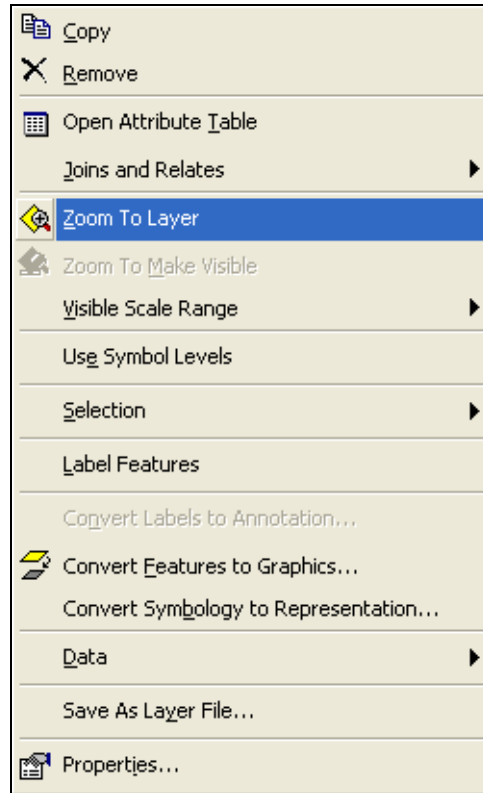
Change Layer Drawing Order

The order of layers within the Table of Contents is important because the layers at the top draw on top of those that are listed below them. To move a layer click and drag it to the desired location and drop it. A black line will appear so you can see where the layer will be placed as shown below:



Zoom to a Layer

Often you may want to zoom to the extent of a layer to display a particular area and/or to display all of the features within a layer. To do so right-click on a layer and select **Zoom To Layer**, as shown below. Notice there are many other options that are also available. When in doubt, right-click!



Change Layer Symbolology

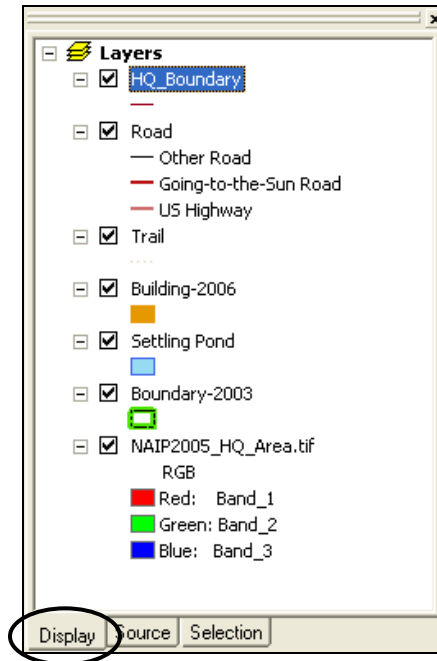
There are many ways to symbolize layers and many symbols and colors available in ArcMap. Often you will want to change layer symbology so it is intuitive and easy for the audience to understand. You can change the symbology of a layer both by clicking on the layer legend to open the Symbol Selector and by opening the Layer Properties and changing it on the Symbology tab.

You can also adjust a layer's transparency by right-clicking on a layer and selecting **Layer Properties** and changing the **Transparent** value on the **Display tab** as desired. This is particularly useful when there are features from one layer obscuring features in another, so making the top layer partially transparent allows the bottom features to display.

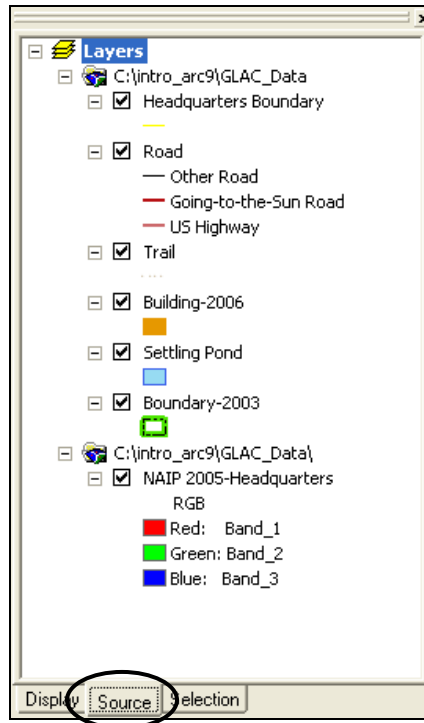
Table of Contents Tabs

At the bottom of the Table of Contents there are three tabs, **Display**, **Source**, and **Selection**.

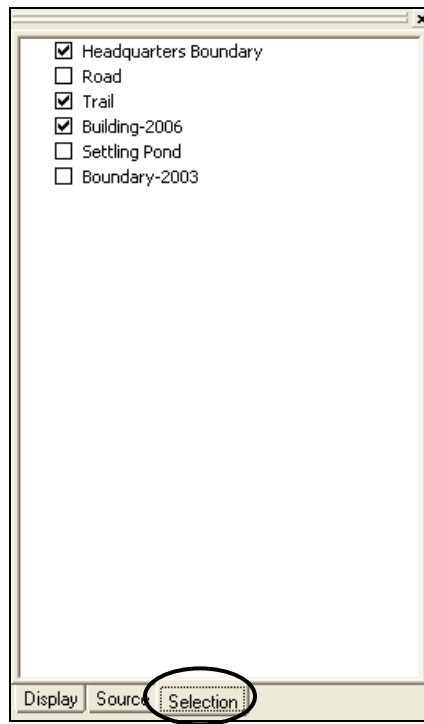
When you select the **Display** tab, shown below, you see the drawing order of the layers and you can move layers up or down in the Table of Contents by dragging and dropping them.



When you select the **Source** tab, shown below, layers are sorted by where they are stored on disk. This is useful during editing when you want to edit all layers in a given folder or database. You cannot change the drawing order of layers when the Source tab is selected. The Source tab is also where you would access standalone tables that are not associated with a layer, which will be covered in Section 2.



The **Selection** tab, shown below, allows you to choose the layers from which features can be selected and is very useful when editing spatial data, which will be covered in Section 3.



Data and Layout Views

In ArcMap there are two views with which you can work with spatial data, the **Data View** and **Layout View**. The Data View is for browsing, editing, and/or analyzing spatial data on your map, while the Layout View is for preparing finished maps for sharing, printing and publication. You will learn more about layouts in Section 5.

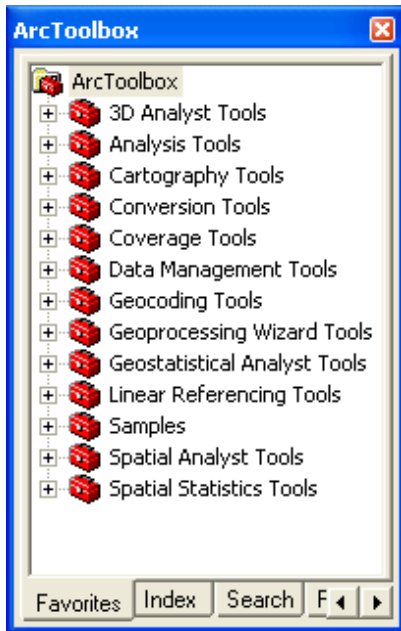
You can switch from the Data View to the Layout View by clicking on the Layout View  button, located in the lower left portion of the map display window. Use the Data View  button to switch back to the Data View. You can also switch from one view to another by clicking on the View menu and selecting either Data View or Layout View.

ArcToolbox

ArcToolbox, shown below, was a separate application in ArcGIS 8.x, but is now a component of both ArcCatalog and ArcMap. It contains tools for geoprocessing, data conversion, and defining map projections. To open ArcToolbox click on the **Show/Hide ArcToolbox Window** button



in either ArcCatalog or ArcMap. We will not be using ArcToolbox in this course, with the exception of demonstrating how to define projections in the Section 2 lecture.



ArcGIS Desktop Help

The help system in ArcGIS Desktop contains a wealth of information – it is well worth your time to learn how to access this information. Help can be accessed in a variety of ways from both ArcCatalog and ArcMap.

Context-sensitive help can be accessed with the **What's This?** tool , on the **Standard** toolbar. Select the **What's This?** tool then click on a menu item, button or tool, such as the **Hyperlink** tool  on the **Tools** toolbar in ArcMap, shown below, to see the definition or purpose of it.

Hyperlink tool

Click on a feature to trigger a hyperlink. This tool will be inactive if no hyperlinks have been defined for any of the feature layers in your map. If you want to use hyperlinks they have to be defined before you use this tool. This tool uses the selection tolerance specified in pixels in the Selection > Selection Options dialog.

When you click this tool, any visible features in the map that have hyperlinks defined for them are shown in blue or outlined in blue in the case of polygons. To specify that a different color be used or to prevent features with hyperlinks changing color, use the option in the Tools > Options dialog General tab. When you are over a feature for which a hyperlink exists, the cursor will turn into a pointing hand and you'll see a popup tip with the name of the target. If more than one hyperlink has been defined for the feature you clicked, a dialog will appear from which you can select the hyperlink you want to launch.

Hyperlinks can be of one of three types:

Document: when you click on a feature with the Hyperlink tool, a document or file will be launched using the application with which that file type is currently associated.

URL: when you click on a feature with the Hyperlink tool, a web page will be launched in the default web browser.

Macro: when you click on a feature with the Hyperlink tool, a value will be sent to a macro. This option enables you to create customized hyperlink behavior.

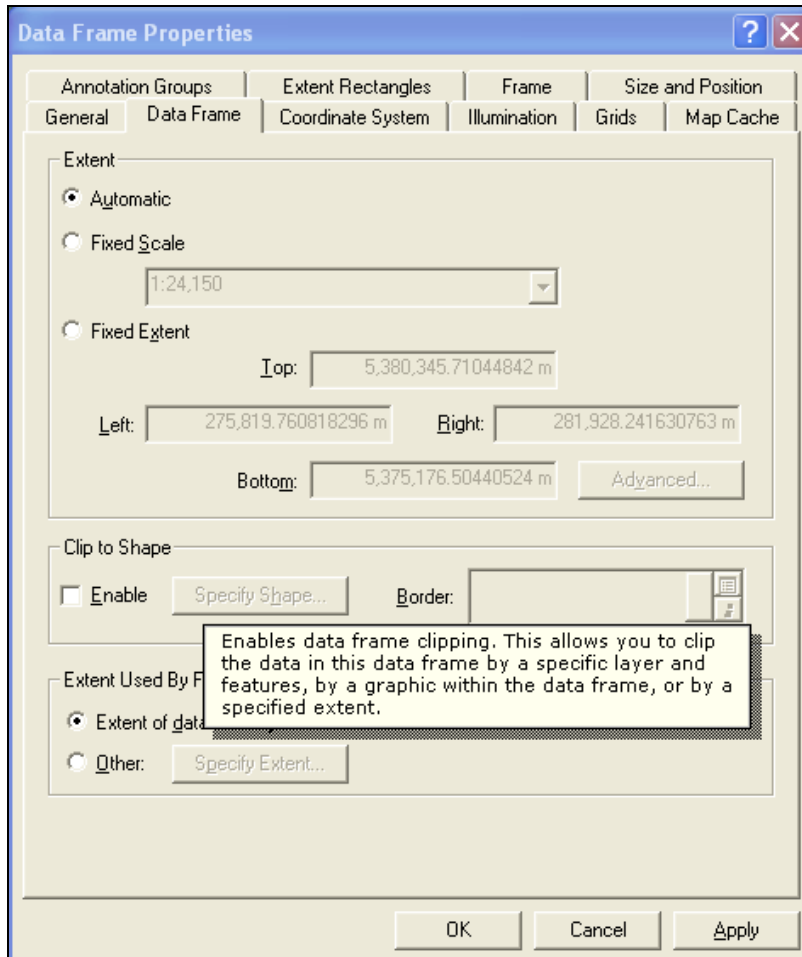
There are two ways to define a hyperlink for the features in a layer:

Field-based hyperlinks: The target document, URL, or macro value that will be launched is specified for each feature in a field in the layer's attribute table. To define field-based hyperlinks for a layer, double-click the layer in the Table Of Contents to get its Layer Properties dialog and in the Display tab check the Support Hyperlinks check box and choose the field that will supply the hyperlink targets.

The values of the field that you choose to provide document or URL hyperlinks can include the full path to the target document or the full URL of the target web page. Alternatively, the value may just contain the name of the target document or web page and you can use the **Hyperlink Base** property to specify the pathname or URL where the target can be found. The Hyperlink Base property is specified in Map Properties in the File menu. Using this property makes it easier to manage hyperlinks because if the location of the targets changes you can simply edit this one setting instead of having to edit each value of the field providing the hyperlink targets.

Dynamic hyperlinks: The target document or URL is specified for a particular feature in the Add Hyperlink dialog. (Dynamic hyperlinks don't support macro values as targets.) This enables you to specify hyperlinks directly without having to use a field to supply the targets. To access the Add Hyperlink dialog, first use the Identify tool to identify the feature you wish to define a hyperlink for, and then in the Identify Results dialog right-click the feature and choose the Add Hyperlink command. The Add Hyperlink dialog will let you specify either a file or a URL target. The names of targets you specify in this way are stored with the layer in your map. They are also stored with the layer if you save the layer to a file. You can define any number of dynamic hyperlinks for a feature. You can manage dynamic hyperlinks by choosing the Manage Hyperlinks command from the menu containing the Add Hyperlink command. The Hyperlink Base setting has no effect on dynamic hyperlinks.

Another method for accessing context-sensitive help is using the **F1** key, which is useful in popup windows and dialog boxes for accessing help about particular elements, such as **Clip to Shape** on the **Data Frame Properties** > **Data Frame** tab in ArcMap, shown below. Place the cursor over an item and hit the **F1** key.



Clicking on the **Help** menu gives you access to the complete **ArcGIS Desktop Help** system. There are four tabs in the ArcGIS Desktop Help window: **Contents**, **Index**, **Favorites**, and **Search**, shown on the left below. The help documents are organized by topic and often by application, that is ArcCatalog, ArcMap, etc. Locating information in the ArcGIS Desktop Help is much improved over versions prior to 9.2.

