

Introduction to Geographic Information Systems

This introductory module will address concepts needed to begin using Geographic Information Systems (GIS) software to explore and analyze spatial data. ArcGIS is the GIS software used for this course. The most recent version, ArcGIS 10.1, is available in all open labs at Michigan Tech. We also have Student licenses available to all enrolled Michigan Tech students, as well as faculty and staff for installation on personally-owned computers. DVDs to install the Student edition of ArcGIS 10.1 are available from the Help Desk in the Library. ArcGIS only runs on the Windows operating system. Mac or Linux users can run ArcGIS on a Windows VM.

GIS resources at Michigan Tech

<http://gis.mtu.edu/> - this is the Michigan Tech GIS support web page. Here you may find information about GIS software available on Campus, training options, and user guides, tips, and tricks.

Download and extract data

Download the data for this course from <http://emml.mtu.edu/courses/training1.zip> and save to c:\temp: **Right-click** the link above and choose **save to** or **save target as**. Browse to c:\temp and save.

Extract the course data to c:\temp

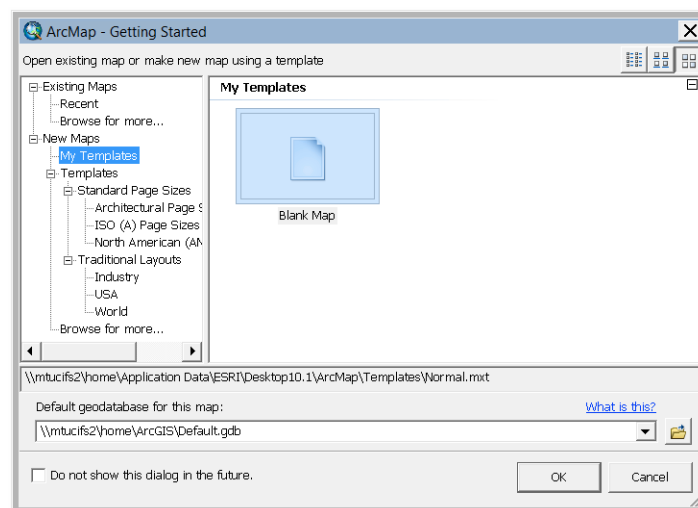
Open a Computer window and browse to c:\temp

Right-click on training1.zip and choose **Extract All...** Save to c:\temp\training1 (should be the default)

Start ArcMap

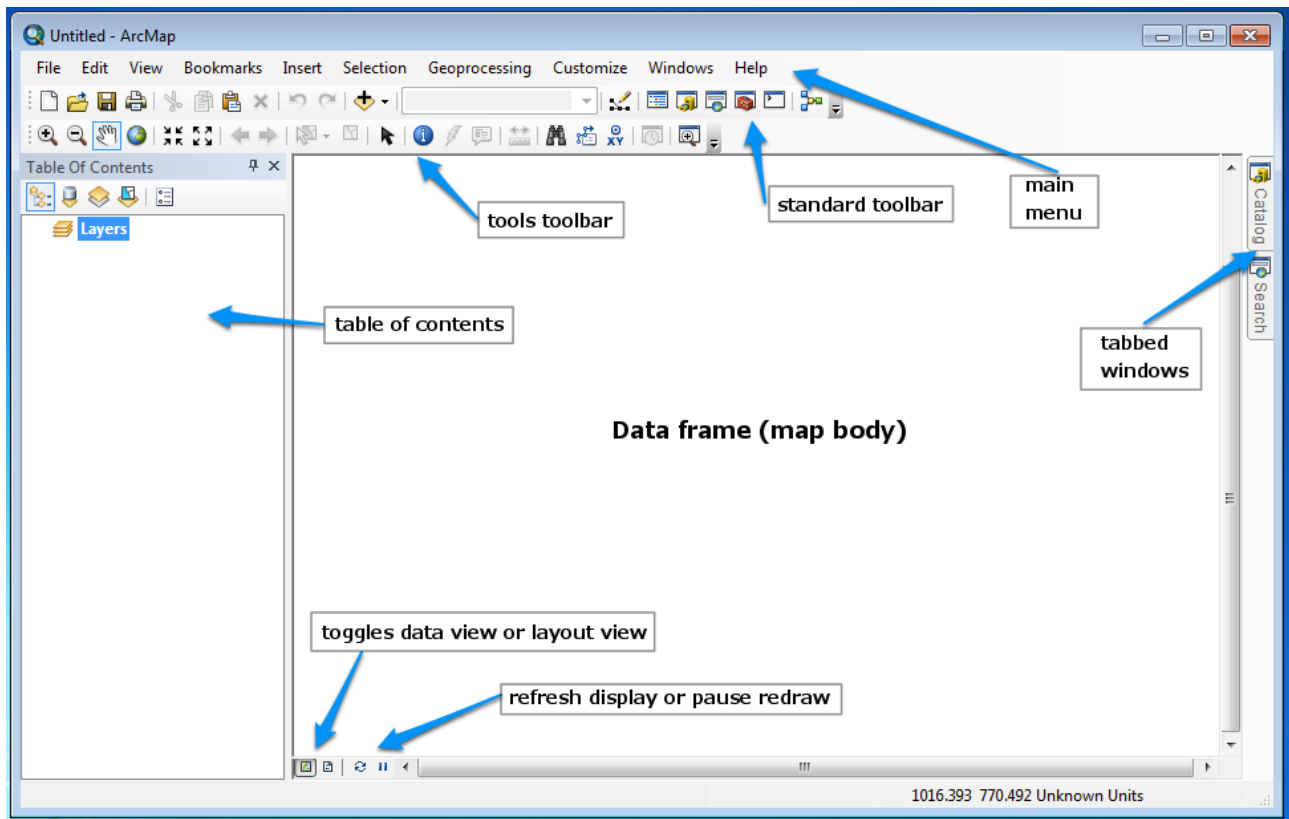
ArcMap is a component of ArcGIS, and is the application where most visualization and mapping is done. From the Windows (Start) menu, either search for **ArcMap**, or choose **All Programs**, then the **ArcGIS** folder, and then **ArcMap**.

The **ArcMap - Getting Started** window will open. From the list on the left hand side, choose New Maps > My Templates, click Blank Map, and click OK.



Introduction to Geographic Information Systems

A new, empty map document will open:



The ArcGIS user interface is customizable, so your window may appear different from the example above.

The **data frame**: this is where your map layers will appear and where you interact with them. You can select features on the map, click on them to get more information about the feature, or zoom in or out on the map.

The **table of contents**: any layers available to your map are listed here. You can turn layers on or off, change the order in which they appear, or alter how they are symbolized (color, line style, fill pattern).

Toolbars: there are several dozen toolbars available in ArcMap. Some are used often; others infrequently. You can leave the ones you don't use turned off to minimize interface clutter. Tools that are "grayed out" on a toolbar are unavailable for some reason, e.g., the "cut" or "delete" tool is unavailable because you don't have any features selected.

Tabbed windows: there are a number of ArcMap windows that may be minimized to a tab to keep your map visible. **Search**, **Catalog**, and **ArcToolbox** are used frequently and are available on the Standard toolbar.

Data or Layout View: most interaction with data in ArcMap is done in "data view", where your

Introduction to Geographic Information Systems

data are displayed at the largest possible size in the data frame. When your work session is complete, you can switch to “layout view”, which displays your map data on a virtual sheet of paper. Here you can add elements such as a map title, legend, scale bar, north arrow, and other graphic elements that will help your audience better understand your map.

Standard toolbar:



1. New map document
2. Open... an existing map document
3. Save the map document you currently have open
4. Print the data frame or layout you have open
5. Undo last operation (s). Unlimited back to last time you saved.
6. Redo last operation (s) Unlimited back to last time you saved.
7. Add data to your map.
8. Displays the current map scale as a ratio. In the example, an inch on the map is equivalent to 78,512 inches on the ground, or a little more than 1 inch to the mile (1:63,360 is 1 inch to the mile).
9. Opens the Catalog window
10. Opens the Search window
11. Opens the ArcToolbox window.

Tools toolbar:




1. Zoom in on the map. Click and drag to identify an area you want to zoom in on.
2. Zoom out on the map. Click and drag.
3. Pan across the map while keeping the same scale. Click and drag to move the map right, left, up, or down.
4. Zoom to extent of all layers present in the map. The behavior of this tool will vary depending on the data you are working with.
5. Zoom in a fixed amount.
6. Zoom out a fixed amount.
7. Select features from data layers present in the map.
8. Select graphic elements from the map (different from features).

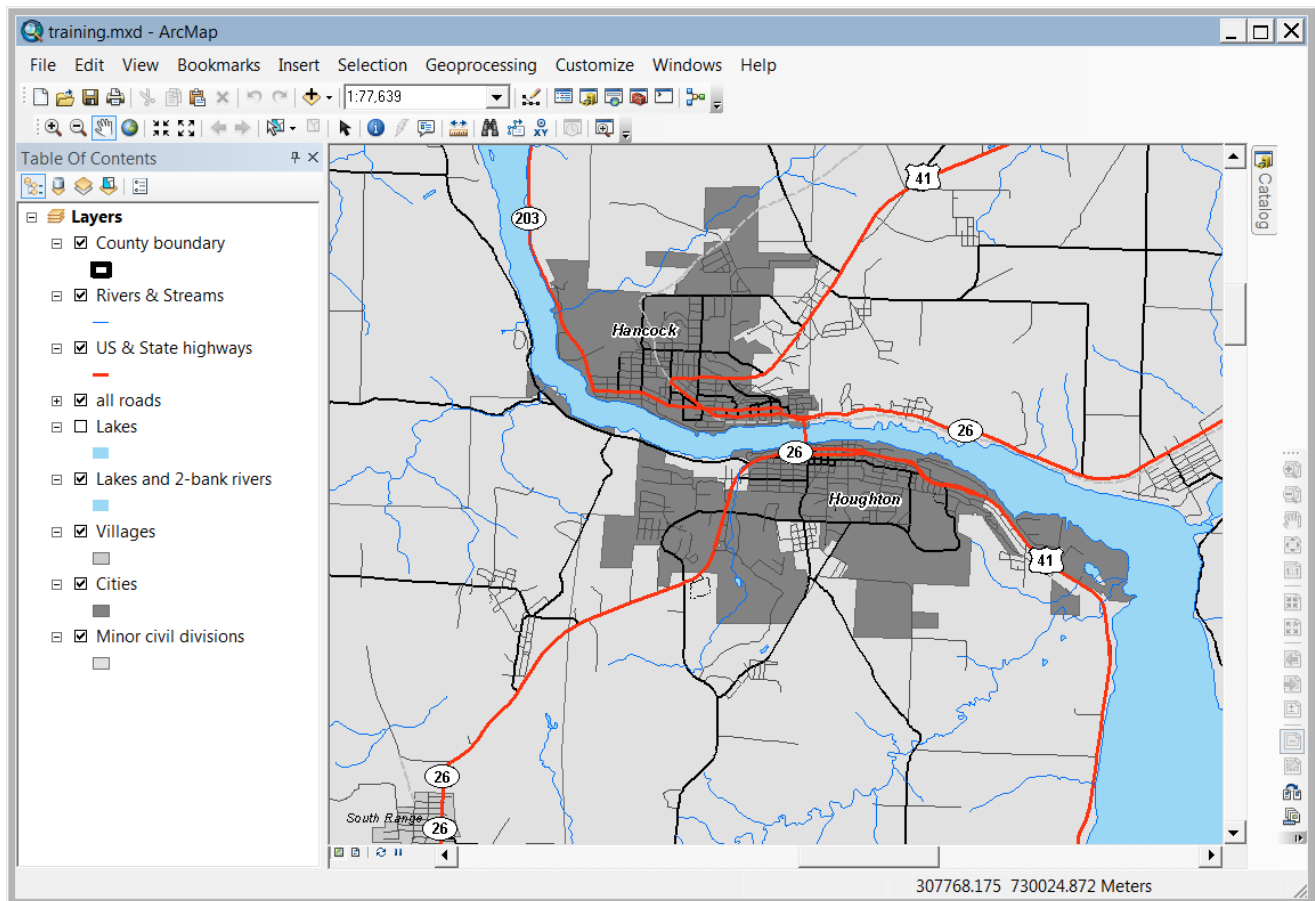
Introduction to Geographic Information Systems



9. Identify tool - used to get more information about map features.
10. Measure tool - measure distances between map features. By default, distance is reported in map units (often meters or feet depending on the map projection) but the units can be configured in the tool.

Open an existing Map document

From ArcMap's **File** menu, choose **Open...** You can also select the "Open" icon  from the Standard toolbar. You will find as you work with ArcMap more that there are usually two (or more) ways to accomplish any task. Many of the icons available on toolbars are shortcuts to often-used features.

Browse to **c:\temp\training1** and select **training.mxd**. Click **Open**. A map document with some data for Houghton County should open and look similar to the following graphic:




Your open toolbars and map scale may be different, but the same layers should be present in your map. Explore the user interface and tools. Click the "**Full Extent**" tool  and observe the results. What is the extent of the data layers in this map? You can either click the "**Previous extent**" tool  to return to viewing the Houghton-Hancock area, or open the **Bookmarks** menu and choose "**Houghton / Hancock**" from the list. Choose the "Keweenaw" bookmark and examine the area shown on the map and the map scale.

Introduction to Geographic Information Systems


Tip: tools that are used for interacting with the map (magnifying glass zoom, pan, select, identify) stay selected until you choose another tool. Others simply operate on the map (full extent, previous extent, fixed zoom in and out) but don't change the selected tool. You will get two visual clues to remind you which tool is in use: its icon will change when you move the tool over the data frame (map window), and the selected tool will be highlighted in the toolbar with a box around it.

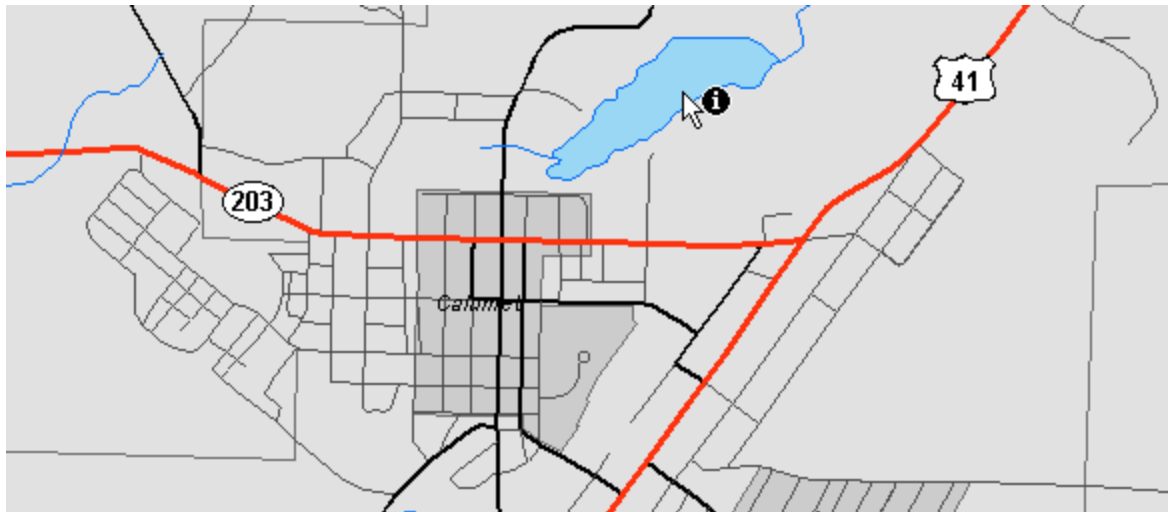
Create your own bookmark

Select the **Zoom in** tool  and click and drag a box around Calumet and Laurium in the northern part of Houghton County. Choose "**Create Bookmark...**" from the **Bookmarks** menu. Change the bookmark name from the default, **Bookmark 1**, to **Calumet**. Click **OK** to save the bookmark. Bookmarks are a handy way to return the map view to show to often-visited areas. They can be renamed or deleted under the **Bookmarks > Manage Bookmarks...** menu option.

Tip: any menu item that ends with an ellipsis (...) opens an additional window where you need to choose options, enter a new file name, or make other decisions.

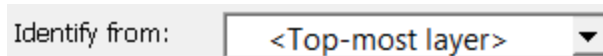
Use the identify tool to get information about map features

If you have changed your map view, return to the **Calumet** bookmark you created above. Select the Identify tool  from the toolbar and click on Calumet Lake (the large lake just to the northeast of the Village of Calumet).



After you click on the lake, the Identify window should open. It will display information about the Houghton County layer. If you clicked on a lake, why?

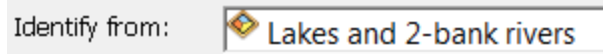
The default operation of the tool is to identify from the "<Top-most layer>".



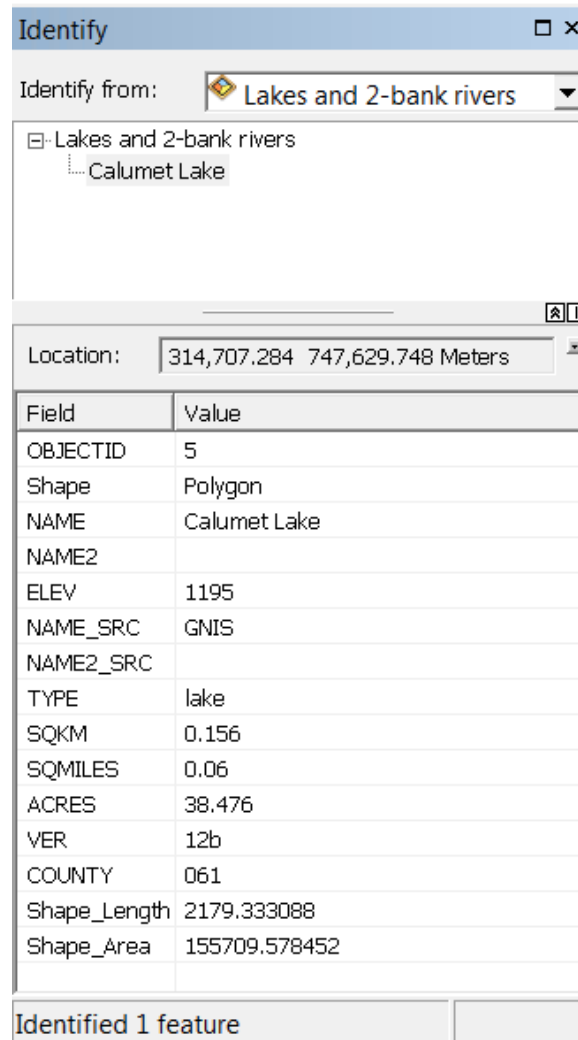
This is an important lesson about how ArcGIS functions: many operations work only on selected features or selected layers. You often need to be aware of what the default behavior is and what you are asking the software to do.

Introduction to Geographic Information Systems

If you look at the list of layers in the **Table of Contents**, you will see that “County Boundary” is the topmost layer, which is why its information was shown in the Identify window. Fortunately, the default behavior is easy to change. Click the arrow to the right of **Top-most layer** and select **Lakes and 2-bank rivers**. Next, ensure you still have the **Identify** tool selected and click on Calumet Lake again.



Now, the information associated with Calumet lake is shown in the Identify window, including some feature metrics (area in square meters and shoreline length in meters, plus its size in square kilometers, square miles, and acres).

A screenshot of the 'Identify' window in a GIS application. The window title is 'Identify'. The 'Identify from:' dropdown is set to 'Lakes and 2-bank rivers'. Below the dropdown, a tree view shows 'Lakes and 2-bank rivers' expanded to show 'Calumet Lake'. The 'Location:' field displays '314,707.284 747,629.748 Meters'. Below this is a table with two columns: 'Field' and 'Value'. The table contains the following data:

Field	Value
OBJECTID	5
Shape	Polygon
NAME	Calumet Lake
NAME2	
ELEV	1195
NAME_SRC	GNIS
NAME2_SRC	
TYPE	lake
SQKM	0.156
SQMI	0.06
ACRES	38.476
VER	12b
COUNTY	061
Shape_Length	2179.333088
Shape_Area	155709.578452

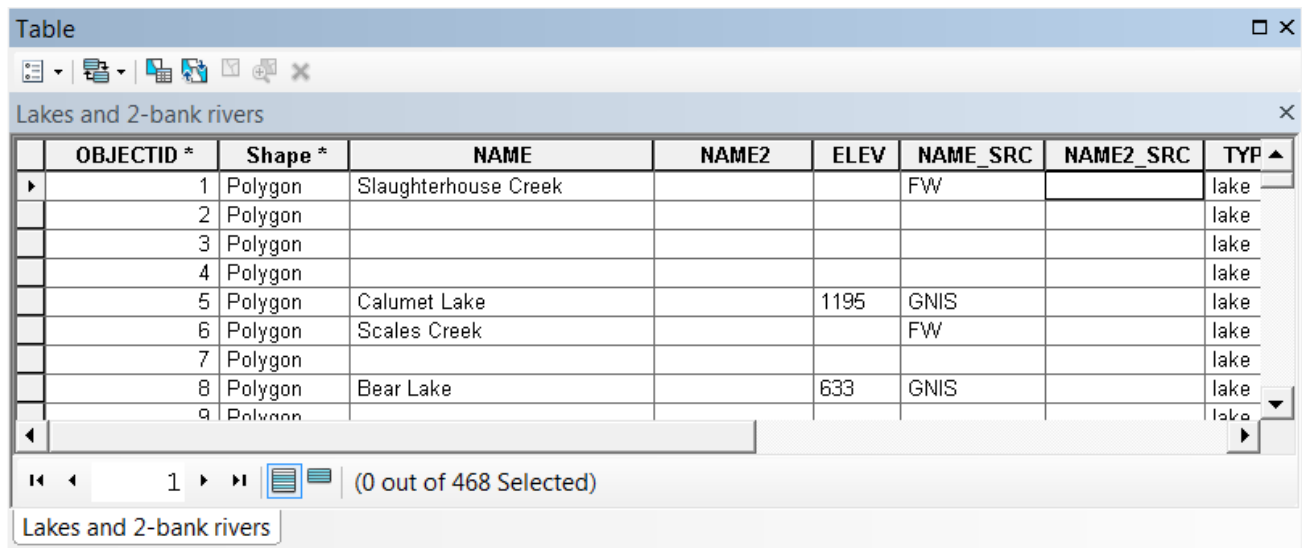
At the bottom of the window, it says 'Identified 1 feature'.

Experiment with the **Identify** tool. Explore other features in the Lakes layer and those in other map layers (don't forget to change the **Identify from:** option when looking at other layers).

The values shown in the **Identify** window are read from the attribute table for whatever layer you are exploring. Each feature (object) in a layer has an associated record in a database. To view the attribute table (database) for the lakes and 2-bank rivers layer, right-click on the layer name and choose Open Attribute Table. Each row is a record (corresponds to each feature in the layer) and each column is a field (attribute). Neither all fields nor all records are populated in every layer - their

Introduction to Geographic Information Systems

completeness will vary. You can sort each field by right-clicking on the column heading and choosing **Sort Ascending** (or **Descending**), and some quick metrics are given at the bottom of the window: number of selected records and total number of records (features) in the layer.



OBJECTID *	Shape *	NAME	NAME2	ELEV	NAME_SRC	NAME2_SRC	TYP ▲
1	Polygon	Slaughterhouse Creek			FW		lake
2	Polygon						lake
3	Polygon						lake
4	Polygon						lake
5	Polygon	Calumet Lake		1195	GNIS		lake
6	Polygon	Scales Creek			FW		lake
7	Polygon						lake
8	Polygon	Bear Lake		633	GNIS		lake
9	Polygon						lake

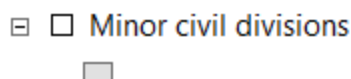
We will explore working with tables in greater detail in a later exercise.

Modify layer display

You as the user have (nearly) unlimited control over how your layers are displayed. You can change the drawing order, which layers are shown (and at what scales), and how layers are symbolized, including polygon fill pattern and color, line color, style, and weight, and point symbols.

Change drawing order: layers draw from the bottom up. This means that polygon layers, particularly those with a larger areal extent, should be at the bottom of your list of layers. Point layers should be at the top, with lines next, and smaller polygon features below those. As an example: the **'minor civil divisions'** layer covers all of Houghton County. The lakes polygon layer encompasses a much smaller area spatially, so the lakes should be above the minor civil division layer in the list, otherwise the lake features will be obscured by the MCD polygons. To change the drawing order, just click on the layer and drag it up or down in the list.

Try it out: click the layer name **"lakes and 2 bank rivers"** and drag it to the bottom of the list. Release the mouse and the layer should stay at the bottom of the list. The filled lakes will disappear from the map (they are still present, just obscured by the **MCD** layer. To verify this, turn off the MCD layer by clicking the check box next to its name. The **MCD** layer will no longer be displayed, and the lake polygons will reappear.



Restore the 'order' of layers. Re-enable the **MCD** layer's visibility, and drag the **lakes and 2-bank**

Introduction to Geographic Information Systems

rivers layer above the **Villages** layer. You should again be able to see both the lake polygons and the MCD features.

Minor civil divisions

















Layer display can be controlled by map scale, and these settings can be customized for each layer in a map.. Choose the **Keweenaw** bookmark and examine the roads layer. Highways are still displayed (those in the US & State highways layer) but **all roads** no longer display. This is evident for two reasons: the features disappear, and the check box indicating layer visibility is grayed out.

all roads


This behavior is controlled in the Layer Properties dialog box. To see how it's set, right-click on **all roads** and choose **Properties...** Select the General tab and examine the settings under Scale Range. You can set both minimum and maximum scales for layer display. Click OK or Cancel to close the layer properties dialog box.

All roads has a second difference from the others in the map: its legend is collapsed. To expand, click the "+" to the left of the layer name and the legend will be displayed. You will need to zoom in to a scale larger than 1:125,000 to have the roads display on the map. Choose the Houghton / Hancock or Calumet bookmark, or use the zoom tool to change the scale. You can also type a value directly in the map scale box.

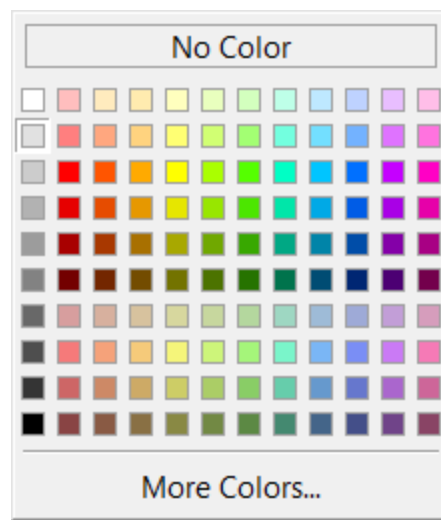
- all roads**
 - road class
 -  Highways
 -  County roads
 -  Minor roads
 -  Residential roads
 -  non-certified road
 -  Forest roads
 -  Campground roads
 -  unnamed residential
 -  Boat access
 -  unclassified
 -  Trail; Rail to trail
 -  Pedestrian overpass
 -  structure
 -  right-of-way

To hide again, click the "-" to the left of **all roads** to re-collapse the legend. Hiding legend values is a handy way to keep your Table of Contents less cluttered.

Change layer symbology


To change how a layer is displayed, you can either click on the layer's symbol box in the Table of Contents  or open the layer's Properties... and choose the Symbology tab. Clicking the symbol box is OK for quick changes; selecting the Symbology tab from the layer's properties gives you more options.

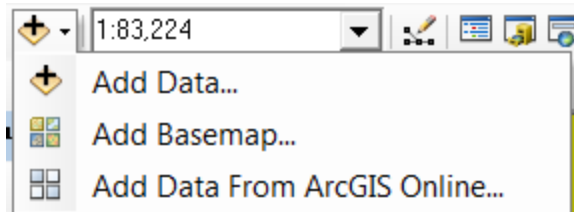
Click the grey box beneath the Minor civil divisions layer and the **Symbol Selector** will open. Choose one of the pre-defined symbols from the left side of the window, or click the drop-down menus for the fill color and / or the outline color on the right. If you hover over a color box its name will appear, and choosing the **More Colors...** option at the bottom of the window will allow you to enter colors as RGB, CMYK, or HSV values.



Change the fill and outline colors for the MCD layer. If you like, experiment with changing other symbols in your map. Different controls are available depending on the layer type. (Example: lines have color, weight, and pattern options. You can choose from pre-defined styles or access more control by choosing the Edit Symbol... button).

Add data from the Internet

Esri has enabled "GIS in the cloud" with the last few releases of ArcGIS. Click the arrow to the right of the Add Data button  and choose Add Basemap...



Select Imagery and click Add. Turn off the MCD, Cities, and Villages layers. Zoom in to an area of interest, to a scale larger than 1:10,000. The resolution of the imagery will change as you zoom in. Note that these basemap layers are background only (you cannot edit or query them), but they can add a nice touch to a map project. Quit ArcMap without saving your map (or save with a new name).