Week 1: Exercise 1 – Introduction to ArcMap and ArcCatalog

ArcGIS is a type of software used for GIS (Geographical Information Systems) that enables the user to work with spatial data. This lab will provide you with an overview of the different functions of ArcGIS and demonstrate the different types of applications for GIS.

ArcGIS is composed of three components:

ArcMap – This is the program that you will primarily be using for this exercise and other analyses. ArcMap is where you can display data, make maps, label features and query data.

ArcCatalog – This is basically a program like Windows Explorer, but built specifically for ArcGIS. Use ArcCatalog when you want to organize, copy or paste, or preview data.

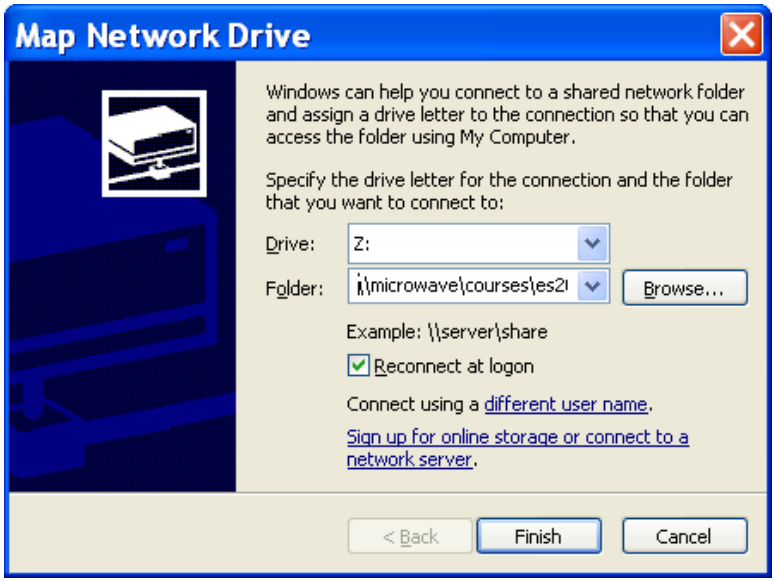
ArcToolbox – Includes tools that you will need for more advanced types of analyses such as combining data sets, or clipping data such as clipping county soil data to just the town boundaries of Brunswick.

Exercise 1 – Using **ArcMap** and **ArcCatalog** to display and preview data
Exercise 2 – Using **ArcMap** to display data
Exercise 3 – Using **ArcMap** and **ArcToolbox** to analyze data

In **Exercise 1**, you will start by exploring data for Brunswick and learn how to display data in ways that make it more understandable.

Step 0 – Map your student folder on the Microwave network drive

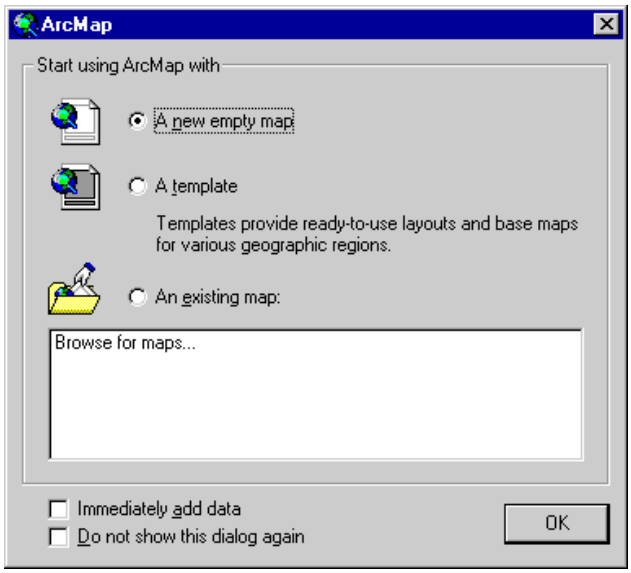
This is where all the files for this exercise are stored, and where you will store your work for Exercises 2 and 3.



- Open My Computer.
- From the Tools menu, choose **Map Network Drive.** The Map Network Drive window will appear.
- Next to "Drive:" select a drive letter. Any letter not already used is OK, but choose a letter that you will *remember* so that you can use this letter EVERY TIME you link to your student folder to work on the GIS projects; because the data in your ArcMap documents will be linked to this drive, if you use a different letter next time you map your folder, the ArcMap file won't "know" where the data is and *this will cause problems*. Write down which drive letter you used. _____
- Next to "Folder:", type: \\microwave\courses\es201
- Click on the **Finish** button. A new window for the course folder, through which you can access your student folder, will appear on your desktop. An icon for the course will also appear ("mount") in your list of drives in My Computer.

Step 1 – Start ArcMap

- Click on Start>Programs>ArcGIS>ArcMap.
- When the ArcMap dialog appears, click "A new empty map," then OK.



You will see the interface of the ArcMap application.

- From the File menu, choose Open.
- Navigate to the Exercise1 folder in your student folder on our Microwave Course Directory
- Click on **Merrymeeting_Bay.mxd**. Click Open.

When the map opens, you see a map of Merrymeeting Bay. Don't worry if your ArcMap interface looks different from the graphic below (see page 3). For example, your ArcMap window may be larger or smaller. The graphic shows toolbars at the top and bottom of the ArcMap window. Your ArcMap may have these toolbars in other locations, or some of the toolbars may not be displayed at all. These differences have no effect on the results of the exercise.

The ArcMap Window

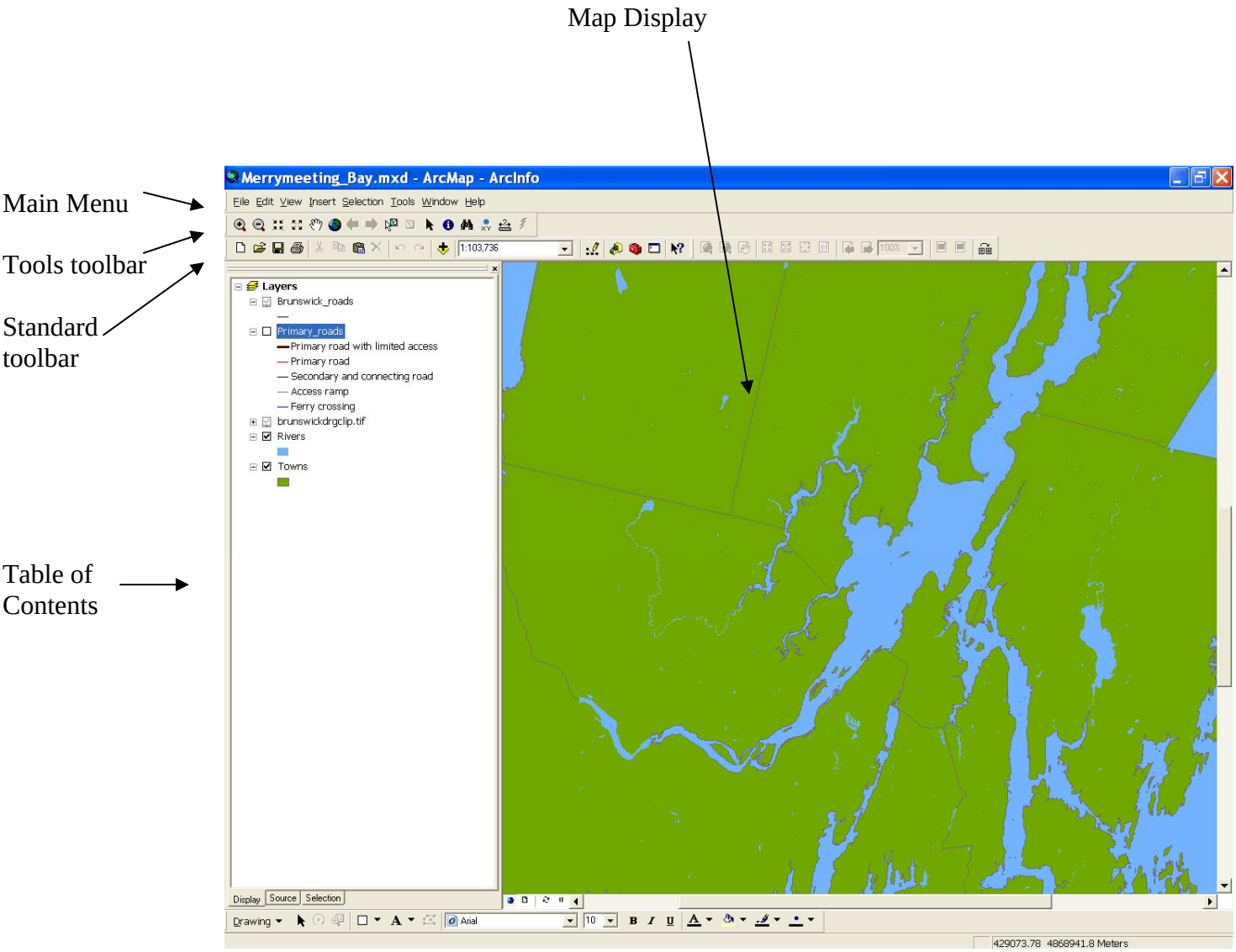
Whenever you work in ArcMap, you are working with a map document. A map document has the .mxd file extension.

The ArcMap window displays geographic features organized into layers. Each layer is a particular theme of information such as roads or rivers.

The area on the left side of the ArcMap application window contains the list of layers and is called the Table of Contents. The area on the right side of the application window contains Map Display for all of the active layers listed in the Table of Contents.

For instance, the roads layer is composed of line features (represented with lines) grouped into a layer called Primary_roads. The towns are contained in a layer called Towns, which is made up of polygon features.

The ArcMap window also contains drop down menus and toolbars such as the Standard Toolbar that allows you to work with the data.



Step 2 – Displaying layers

You can make any of the layers visible (active) or hidden by clicking on the box next to the layer name.

- Check the box next to the Primary_roads layer. The map will re-draw, and the roads will display as lines.

Note that you cannot turn on the Brunswick_roads layer. This is set so that it will only display when you are zoomed in closer to Brunswick.

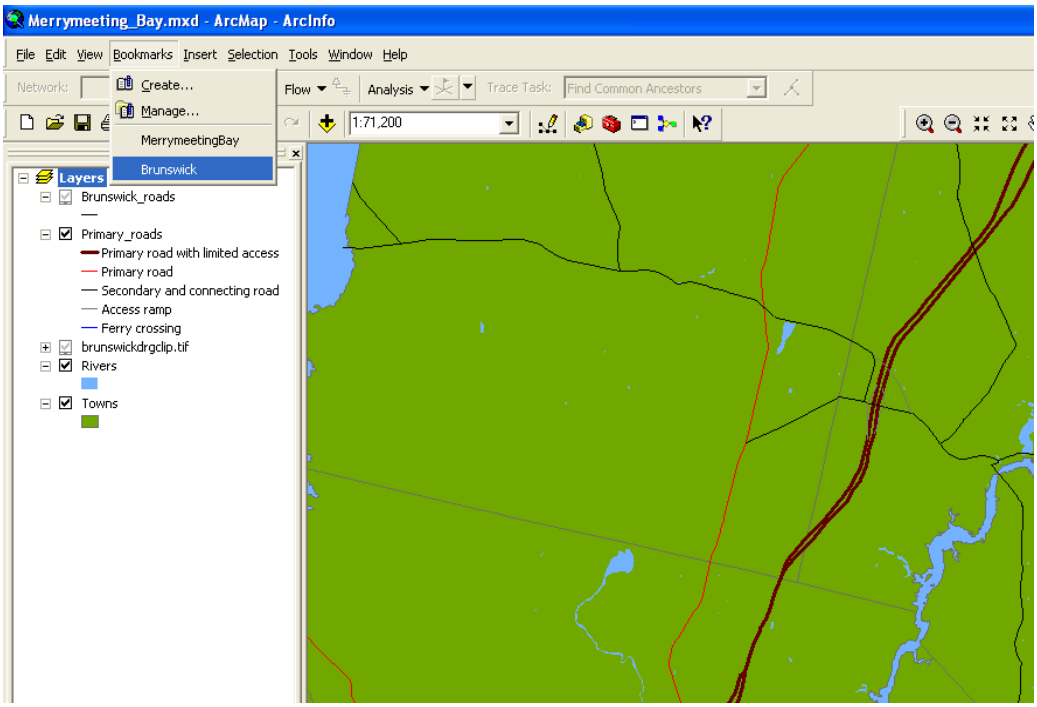
Many of the tools you use in ArcMap to look at features and identify features are similar to tools in programs such as MapQuest or Google Maps, such as Identify, Zoom, and Pan.

Step 3 – Identify geographic features

In ArcMap, you can find out what features are just by clicking on them in the map display area.

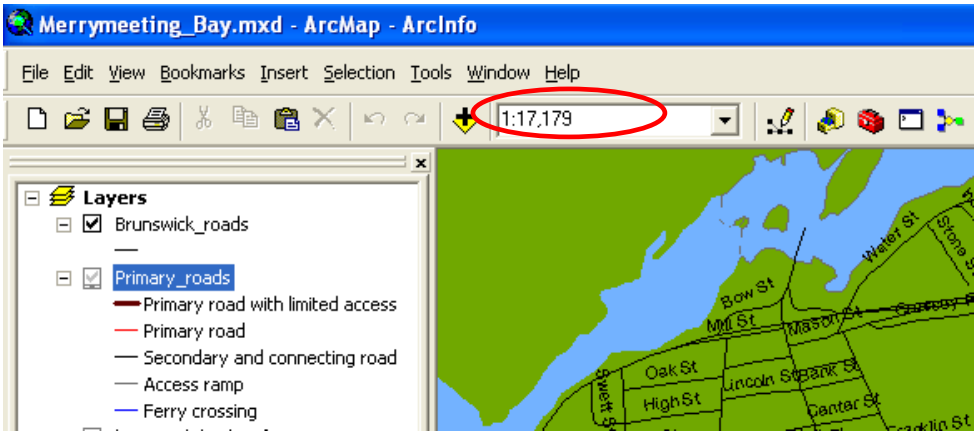
First, you'll zoom in so you can see individual features more clearly. To do this, you will access a previously created bookmark that stores a specific geographic region.

- At the top of the ArcMap Window, select Bookmarks,
- Select Brunswick.



The display zooms into Brunswick. Notice that the "Brunswick_roads" layer is visible and that you can see more streets in Brunswick. The "Primary_roads" layer is no longer visible. Labeling streets at this scale would make it difficult to read the names of the streets, so the Brunswick_roads labeling feature has been set to only display street names when you are zoomed in closer than 1:20,000.

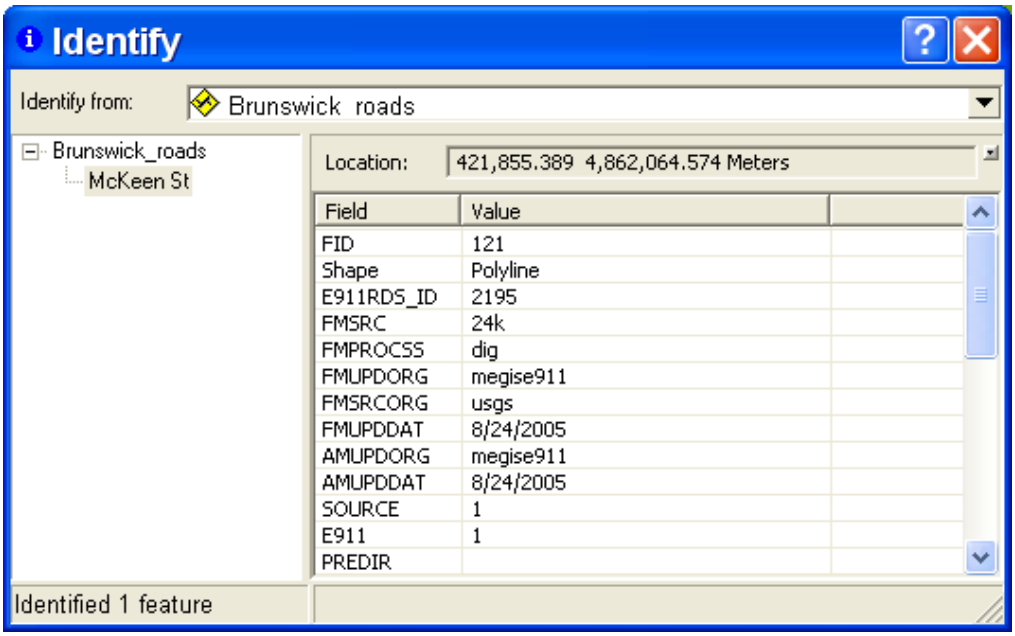
- Click on the zoom in button  until the scale reads greater than 1:20,000 (a number smaller than 20,000). The road names should now be visible. [If the Tools toolbar, which contains this button, is not visible, right-click the menu bar to the right of the Help menu and select Tools.]



Step 4 – Using the Identify button

- On the Tools toolbar, click the Identify button . The Identify window opens.
- In the Identify from drop-down menu, select **Brunswick_roads**.
- Click on a Brunswick road.

The Identify window resets; it displays all the attributes for the Brunswick road you selected.



- In the Identify window, from the Identify from dropdown list, choose <All layers>,
- Click any of the roads.

The Identify window now contains the attributes for the road you have clicked on and all the other layers that display in that area. You may have to enlarge the Identify window to see all attributes.

- Continue identifying other features in the display area by clicking on them with the Identify button. When you are finished, close the Identify window.

Step 5 – Using the Pan Tool

- Using the pan tool , move the map until downtown Brunswick is in the center of the map.

Step 6 – Use the Zoom In Button

- On the Tools toolbar, click the Zoom In button.
- Draw a box around where you think Bowdoin College is located. ArcMap zooms in to this area.

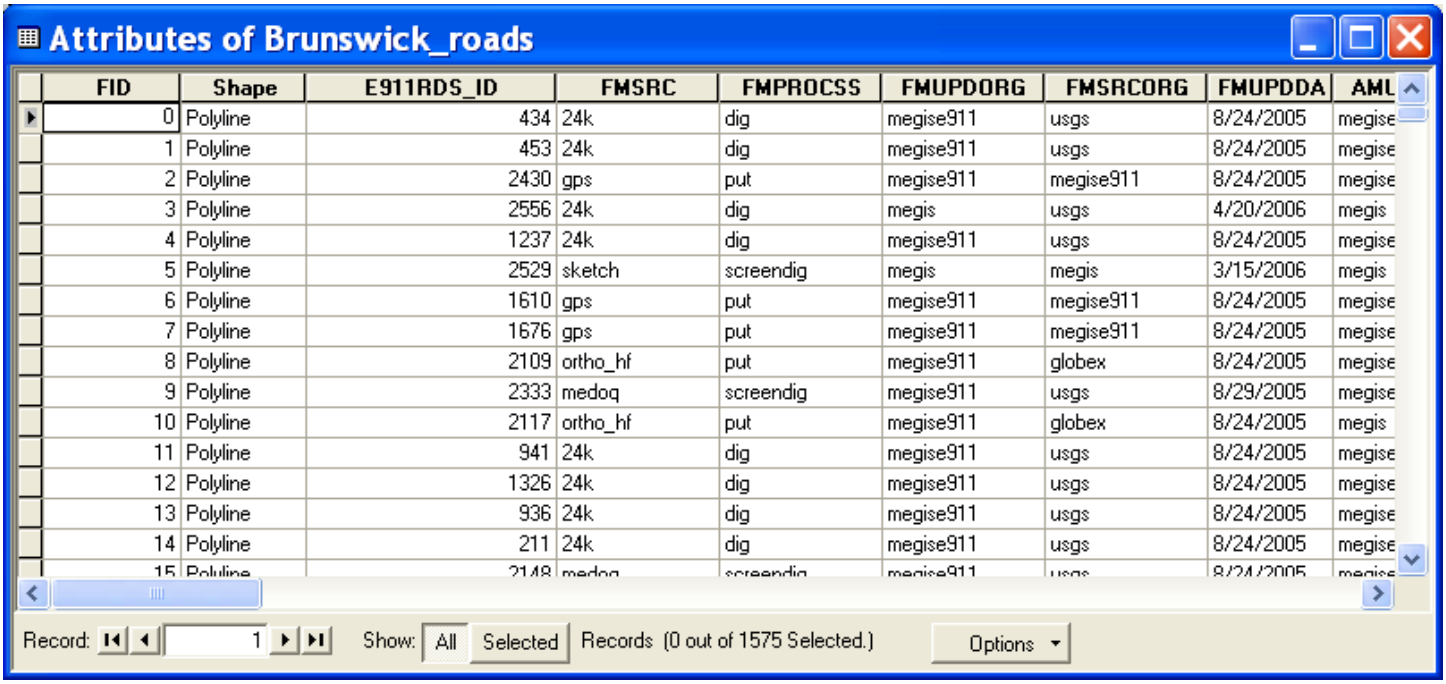
Once you have zoomed in to a scale larger than 1:5,000, the layer brunswickdrgclip.tif displays. This layer is a raster image, or a scanned image of a USGS topo map.

Use this to find Bowdoin College. Look at some of the details of this map.
Can you find Druckenmiller Hall? (this is a "trick" question)

Step 7 – Examine attribute information

Attribute data provides information about spatial data. For example – the location of a house is spatial data – the color or owner of the house is attribute information. ArcGIS allows the user to look at this attribute data – the "data behind the data." This is what makes GIS a powerful tool for applications like environmental analyses and land use planning.

- Turn off the layer "brunswickdrgclip.tif."
- In the Table of Contents, right-click on the Brunswick _roads layer (its name, not the symbol) and
- Click Open Attribute Table.



FID	Shape	E911RDS_ID	FMSRC	FMPROCSS	FMUPDORG	FMSRCORG	FMUPDDA	AML
0	Polyline	434	24k	dig	megise911	usgs	8/24/2005	megise
1	Polyline	453	24k	dig	megise911	usgs	8/24/2005	megise
2	Polyline	2430	gps	put	megise911	megise911	8/24/2005	megise
3	Polyline	2556	24k	dig	megis	usgs	4/20/2006	megis
4	Polyline	1237	24k	dig	megise911	usgs	8/24/2005	megise
5	Polyline	2529	sketch	screendig	megis	megis	3/15/2006	megis
6	Polyline	1610	gps	put	megise911	megise911	8/24/2005	megise
7	Polyline	1676	gps	put	megise911	megise911	8/24/2005	megise
8	Polyline	2109	ortho_hf	put	megise911	globex	8/24/2005	megise
9	Polyline	2333	medoq	screendig	megise911	usgs	8/29/2005	megise
10	Polyline	2117	ortho_hf	put	megise911	globex	8/24/2005	megis
11	Polyline	941	24k	dig	megise911	usgs	8/24/2005	megise
12	Polyline	1326	24k	dig	megise911	usgs	8/24/2005	megise
13	Polyline	936	24k	dig	megise911	usgs	8/24/2005	megise
14	Polyline	211	24k	dig	megise911	usgs	8/24/2005	megise
15	Polyline	2148	medoq	screendig	megise911	usgs	8/24/2005	megise

The attribute table associated with the Brunswick _roads layer displays. Each record represents an individual feature - in this case, a road.

- Scroll to the right to see all the attributes describing this layer.

This road layer was developed for the purposes of assisting emergency response. What are some of the attributes that would make responding to an emergency such as a house fire easier?

- Close the attribute table.

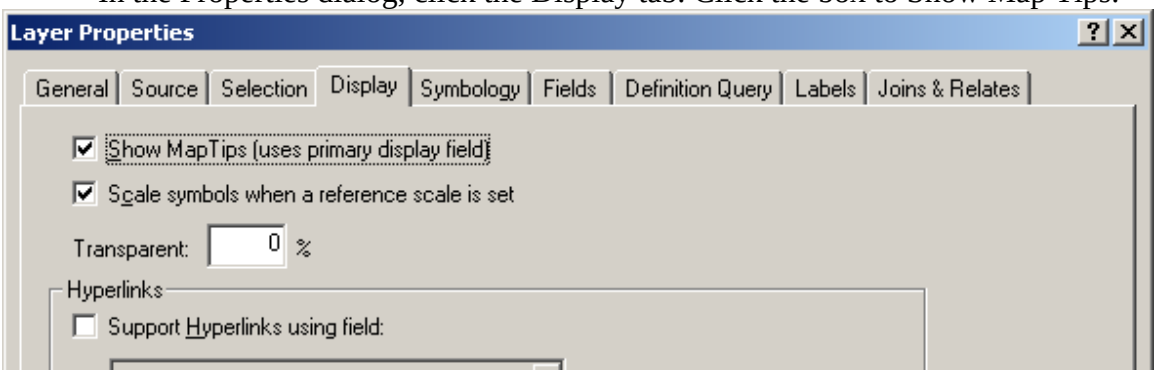
Step 8 – Add map tips to your display

- From the Bookmark menu select MerrymeetingBay. This zooms out to show a larger area.

Map tips are text that represents a single feature attribute; map tips display when you hold the mouse pointer over a feature. They are an easy way to get attribute information for a specific feature.

You can specify which field displays by setting it in the layer's Properties dialog.

- In the Table of Contents, right-click the Towns layer name and click Properties.
- In the Properties dialog, click the Display tab. Click the box to Show Map Tips.



You can choose the attribute that is used as the map tip field in the Fields tab of the Properties dialog box. The default that ArcGIS chooses (Name) is usually the most useful for a map tip.

- Click OK to close the Properties dialog.
- Hold your mouse pointer over anywhere on the map and the name of the town should appear.

Step 9 – Label features

In this step, you will label features on your map using labels stored in one of the layer's Attribute fields.

- In the Table of Contents, right-click Towns
- Select Label Features. Labels appear for the towns. If some of the towns are not labeled, enlarge the display area.

Step 10 – Add layers to the map document

- Click on the Add Data button  .

- Connect to your student folder in the Microwave Course Directory folder by clicking on the  connect to folder button.
- When the "Connect To" folder dialog box opens up, navigate to your student folder and click OK.
- When the Add Data dialog box opens your student folder, go into the Exercise1 folder and
- Select the layer **bald_eagle.shp** and add it to your project. This layer shows the location of bald eagle nests around Merrymeeting Bay.

- From the File menu, choose Exit to close ArcMap. Click No when you're prompted to save changes.

ArcCatalog is a partner program to **ArcMap**. It provides a way of managing the different types of data you work with in a GIS. Because spatial data can be more complicated than other types of data like spreadsheet files, you should always use ArcCatalog when looking at your data, copying or moving data, or doing minor edits, rather than using Windows Explorer. The next part of the exercise will walk you through how to use ArcCatalog to explore data.

Step 11 – Start ArcCatalog

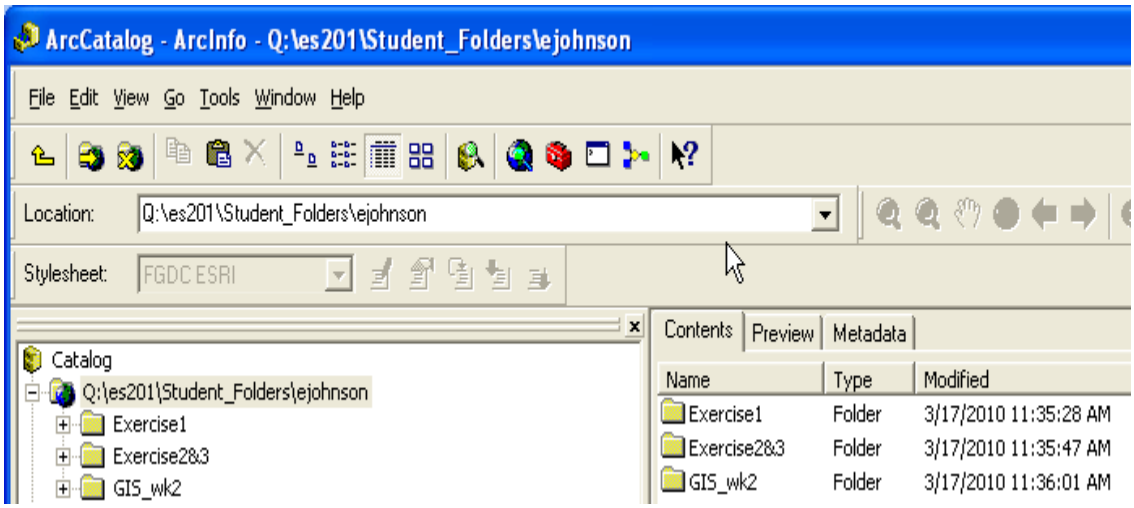
- Click the Start menu, then click Programs, ArcGIS, ArcCatalog
- When ArcCatalog opens, click the Connect to Folder button  .
- Navigate to your student folder within the ES201 Microwave Course Directory, where you will be saving data;
- Click OK.

The ArcCatalog Window

The ArcCatalog window has the Catalog Tree on the left where all of the data layers are listed. On the right are three different tabs which give you three ways to look at your data:

- The Contents Tab – shows a list of data within a folder.
- The Preview Tab – provides you with a way to look at your data before you add it to ArcMap.
- The Metadata Tab – is where you store important documentation about the spatial data such as who created the data, when and why.

Catalog Tree →

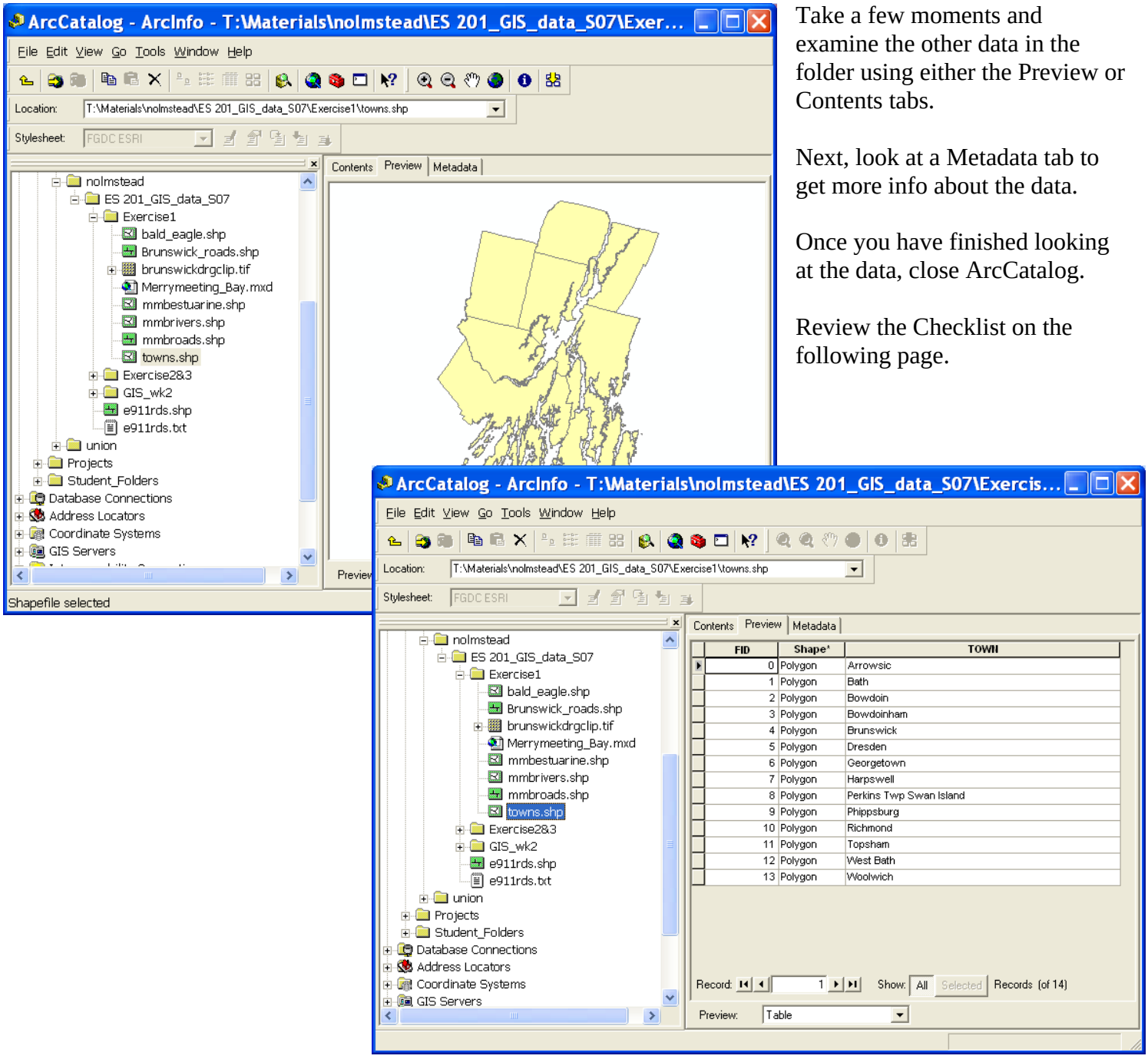


- In the Catalog Tree on the left side of the ArcCatalog window, click the plus sign (+) next to the folder connection you just set up. If you can't see the entire table of contents you can widen it by holding the arrow over the grey bar in the middle of the dialog box until it turns into a double sided arrow and moving this line to the left or right.
- Go into the Exercise 1 folder by clicking the (+) sign next to it in the catalog tree.

Step 12 - Preview features.

Now you will preview and display features.

- On the right side of the ArcCatalog window, click the Preview tab to make it active.
- In the Catalog Tree, click on **towns** to make it active (see graphic below).
- In the Preview dropdown menu at the bottom of the Preview window, choose Geography. You see the town polygons.
- Next, in the Preview dropdown menu (below the preview area at the bottom of the window), choose Table. Now you see the town attribute table. Examine its fields.



Take a few moments and examine the other data in the folder using either the Preview or Contents tabs.

Next, look at a Metadata tab to get more info about the data.

Once you have finished looking at the data, close ArcCatalog.

Review the Checklist on the following page.

Checklist of things learned in Exercise 1:

- ✓ How to **map the network drive**
- ✓ How to use the **Identify**, **Zoom**, and **Pan** tools
- ✓ How to use a **Bookmark**
- ✓ What is the **Attribute Table** and how to access it
- ✓ How to use **Map Tips**
- ✓ How to **label features**
- ✓ How to **add layers** to your map
- ✓ What is **ArcCatalog** and how to **Preview** features; where **Metadata** is stored

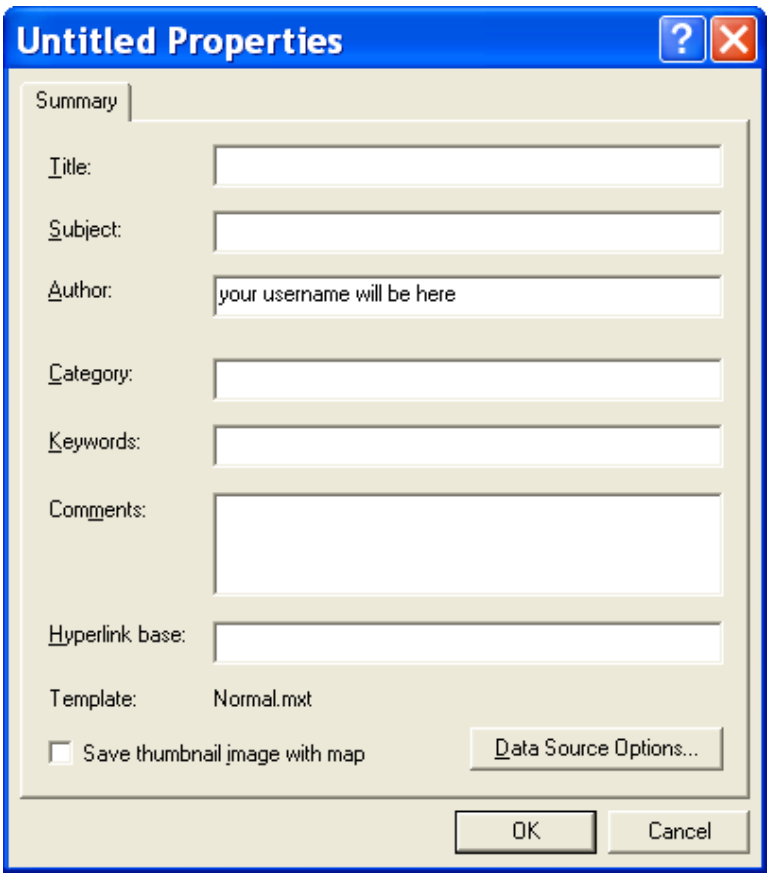
Week 1: Exercise 2 – Displaying data in ArcMap

In this exercise you will learn how to symbolize spatial as well as attribute data to make it meaningful and understandable. Display of data is just one of the tools available through ArcGIS and other GIS software packages.

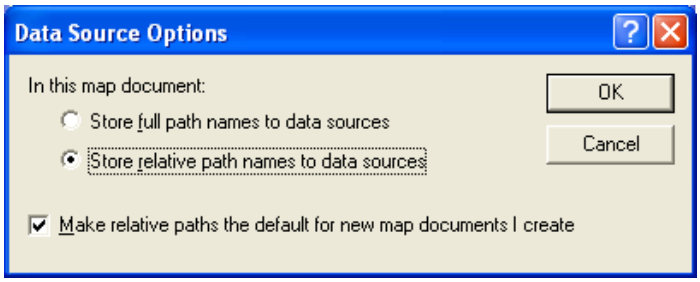
Step 1 – Start ArcMap

- Start ArcMap and click "A new empty map,"
- Click OK.
- If the Tools toolbar is floating separately on your desktop, drag it into the top, grey area so that it docks at the top of the screen.
- Under the file menu, click on Document Properties.

You should see this box (below left):



- Click on the Data Source Options button
- Select “Store relative path names.”
- Click OK, then click OK again.



This will allow you to more easily find all of the data that is associated with your project.

SAVE YOUR PROJECT INTO YOUR EXERCISE 2&3 FOLDER – use only letters, #s, and/or the underscore mark in the file name.

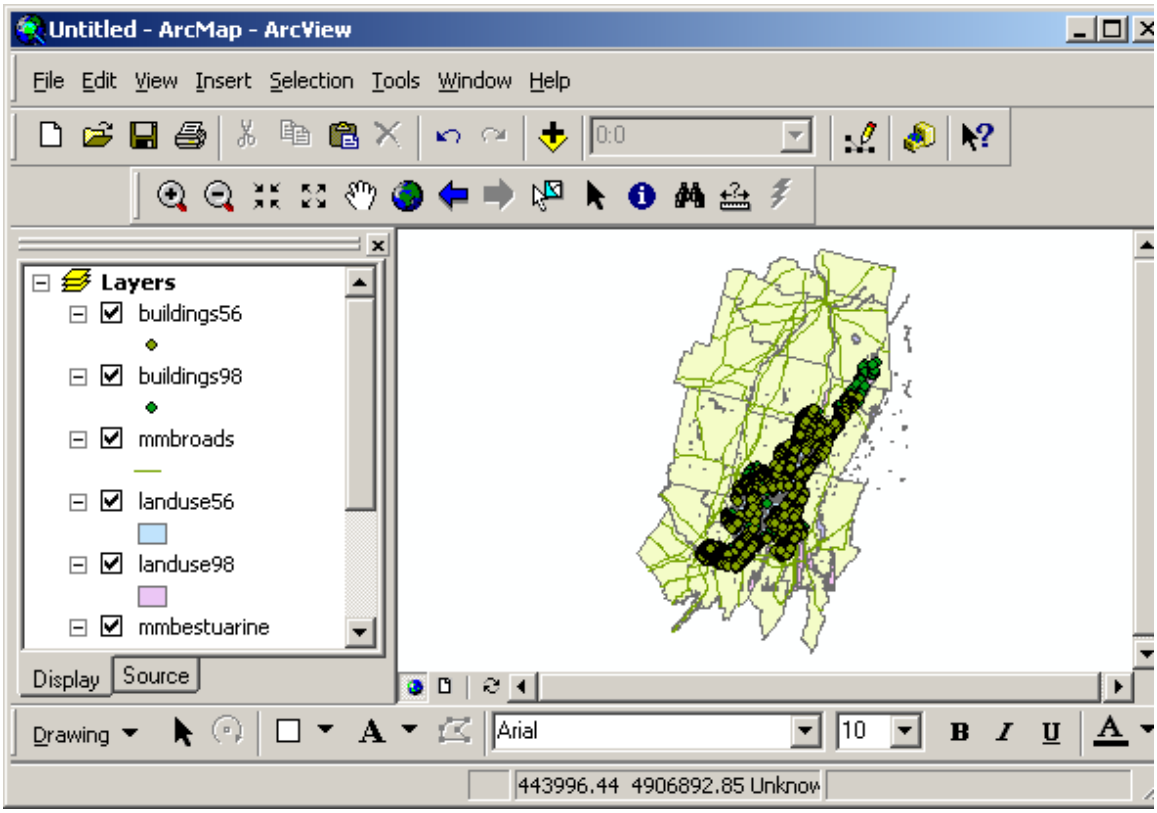
Step 2 – Adding data in ArcMap

In Exercise 1, you learned how to add data by using the Add Data button  .

- Click on the Add Data button and navigate to the Exercise2&3 folder (inside your student folder on our Microwave course directory),
- Click on the MerrymeetingBay.mdb file, 

- Add all the layers inside it (but not the red toolbox). There should be eight layers to add. You can add more than one layer at a time by holding down the Control key and selecting all the layers you wish to add.

Note that *the order of layers in the Table of Contents is the order of how the layers are displayed* – in the example below, the buildings56 layer is on top of the buildings98 layer. Rearrange your layers so that the map makes sense. (You can click and drag the layers to rearrange their order in the TOC.)



- **SAVE** your project!

Step 3 – Change the symbology for a layer

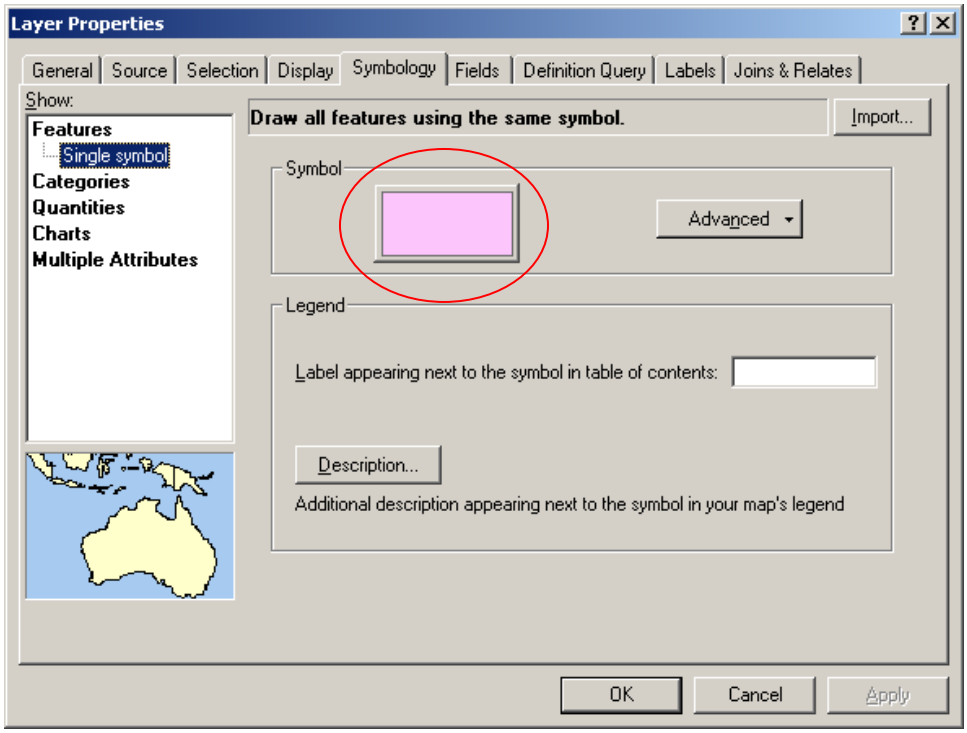
In ArcMap, you can symbolize layer features in a number of ways. Varying the color, shape, and fill patterns of different layer types can help your audience interpret your maps. When creating layer symbology, you should always choose colors, shapes, and patterns that enhance the map reader's ability to distinguish between different areas on the map display. A clear legend facilitates map interpretation. A map that is not understandable is one that is not useful.

In this step, you will change the color of the town polygons.

- In the Table of Contents, right-click on the **mmbtowns** polygon symbol (the colored square).The Color Picker displays. Experiment with changing the colors of the town polygons.

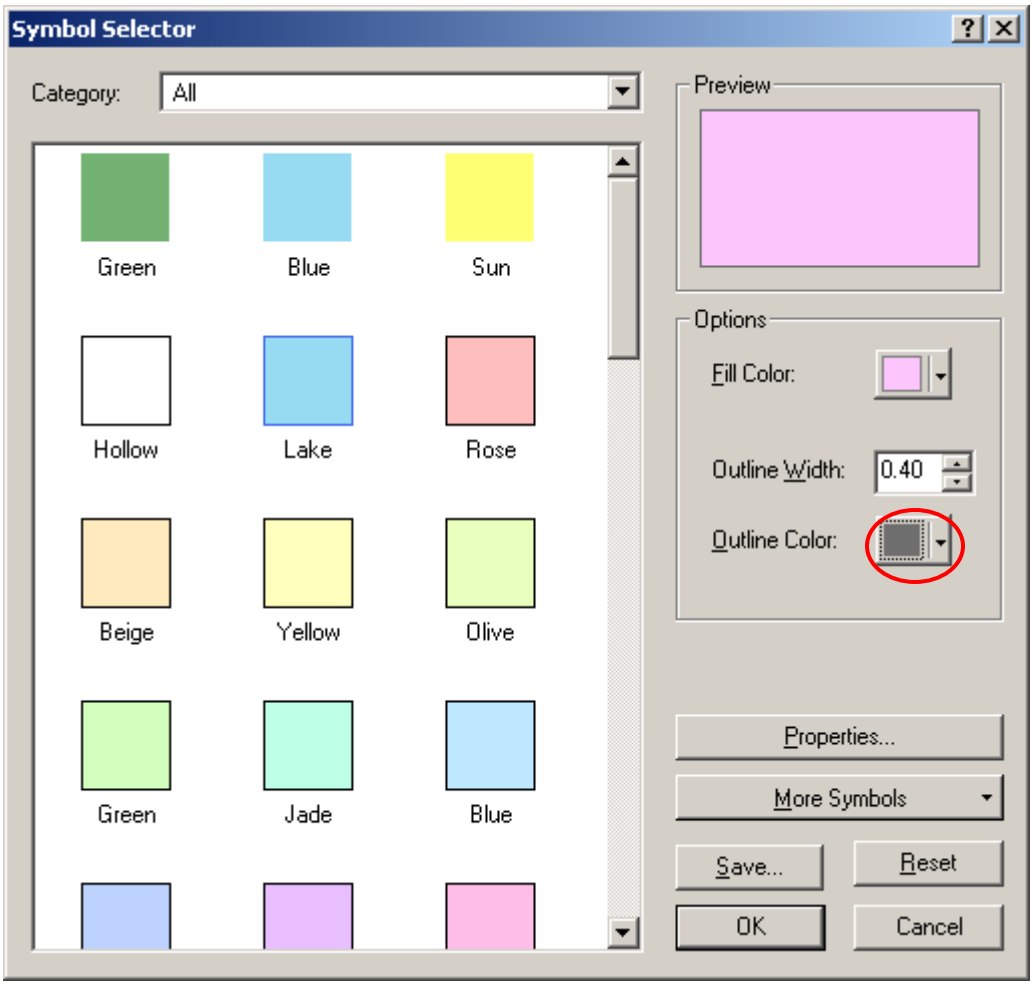
Another approach for changing symbology is to use the Layer Properties box.

- Right click on the word **mmbestuarine.**
- Select Properties. The Layer Properties box will open.



There are a number of different tabs on this box. Click on each of them and look at options that are available in each of these windows.

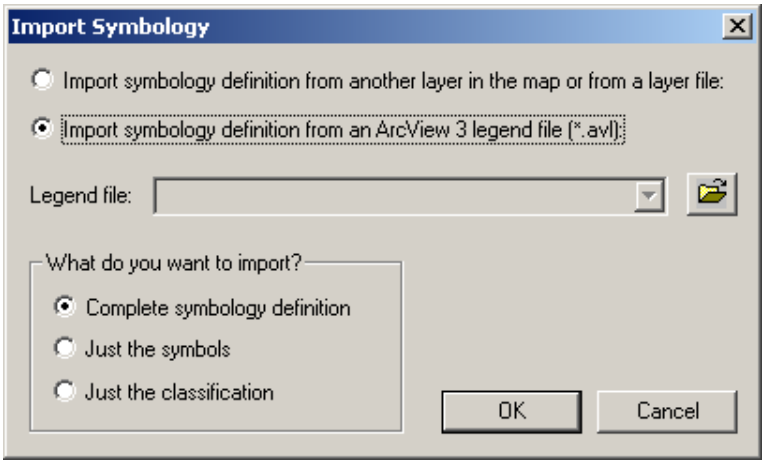
- Click on the Symbology tab in order to change the color of this layer.
- Click on the symbol box (circled). A symbol selector dialog box will open up (see next page).
- Change the fill color and the outline color so they are the same color.
- Click OK twice



- Use the same steps to change the color of the **mmbriver**, **buildings56**, and **buildings98** layers.

ArcMap allows you to import a legend (symbology) that was created in an earlier project. You will import the legend that was created for **mmbroads** in Exercise1.

- Right click on **mmbroads** and open the Layer Properties dialog.
- Click on the Symbology tab.
- Click on the Import button on the upper right hand corner of the symbology tab. A new dialog box opens up. Select "Import symbology definition from an ArcView 3 legend file (*.avl).



- Click on the folder button in order to navigate to your folder.
- **Click the Exercise 2&3 folder to select the Legend file.** Select **mmroads.avl**.
- Click Open, then click OK.
- In the next box, select FCC (a classification field for highways) as the value field, then click OK.
- Click OK again.

The **mmbroads** layer symbology should now resemble the roads layer from Exercise 1.

Step 4 – Examine attribute information

Examine the attribute table for landuse98. This layer is comprised of various attributes that were developed from aerial photos of land surrounding Merrymeeting Bay. We will be looking at land use patterns in 1956 and 1998. In the landuse98 attribute table, one of the column headings is LUCLASS (Land Use Class); this column lists different codes for each of the rows or records in the attribute table. Below is a table containing the attribute codes and categories:

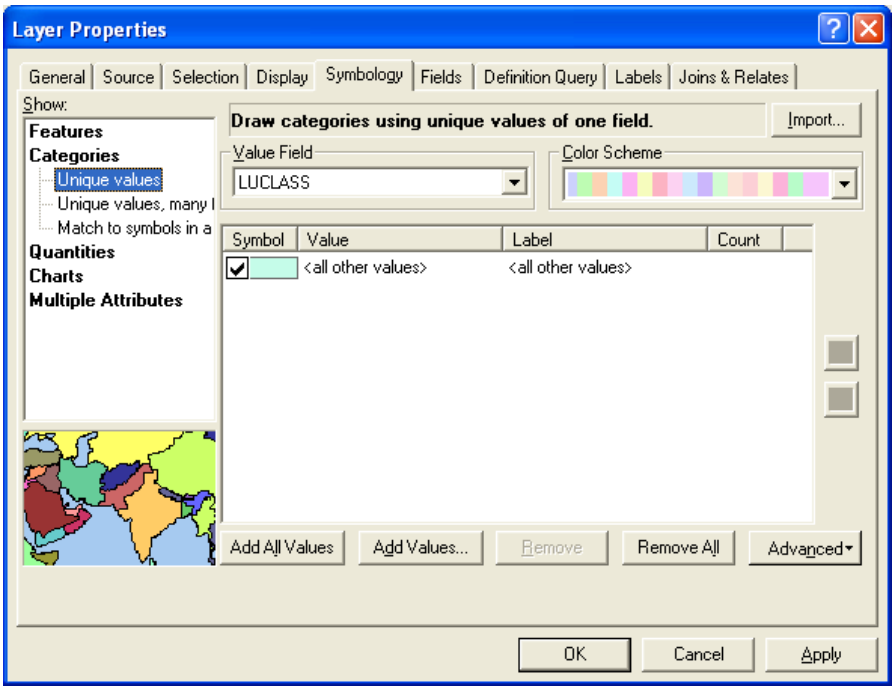
CODE	Category
AGR	Agriculture (cropland or pasture in current or recent use)
COM	Commercial (business or commercial predominant use)
FOR	Upland Forest (predominant land use = forest)
IND	Industrial (manufacturing facilities and associated lakes)
OW	Open Water (lake, river, or bay areas under water greater than a few inches deep at time of photography)
RES	Residential (homes and related neighborhoods)
USS	Upland Scrub-Shrub (usually abandoned agricultural field)
UHE	Upland Herbaceous (large expanses of lawn not obviously associated with residence)
WET	Wetland areas/intertidal zone

Close the Attribute Table.

Step 5 – Changing the symbology to reflect attribute information

A layer's display is meant to communicate a message. When defining a layer's display properties you must consider two issues: the message you are trying to communicate and who your audience is. Also, bear in mind the audience's ability to interpret the information presented. One way to effectively communicate your message is to assign every feature in a layer a unique color or group features by an attribute value.

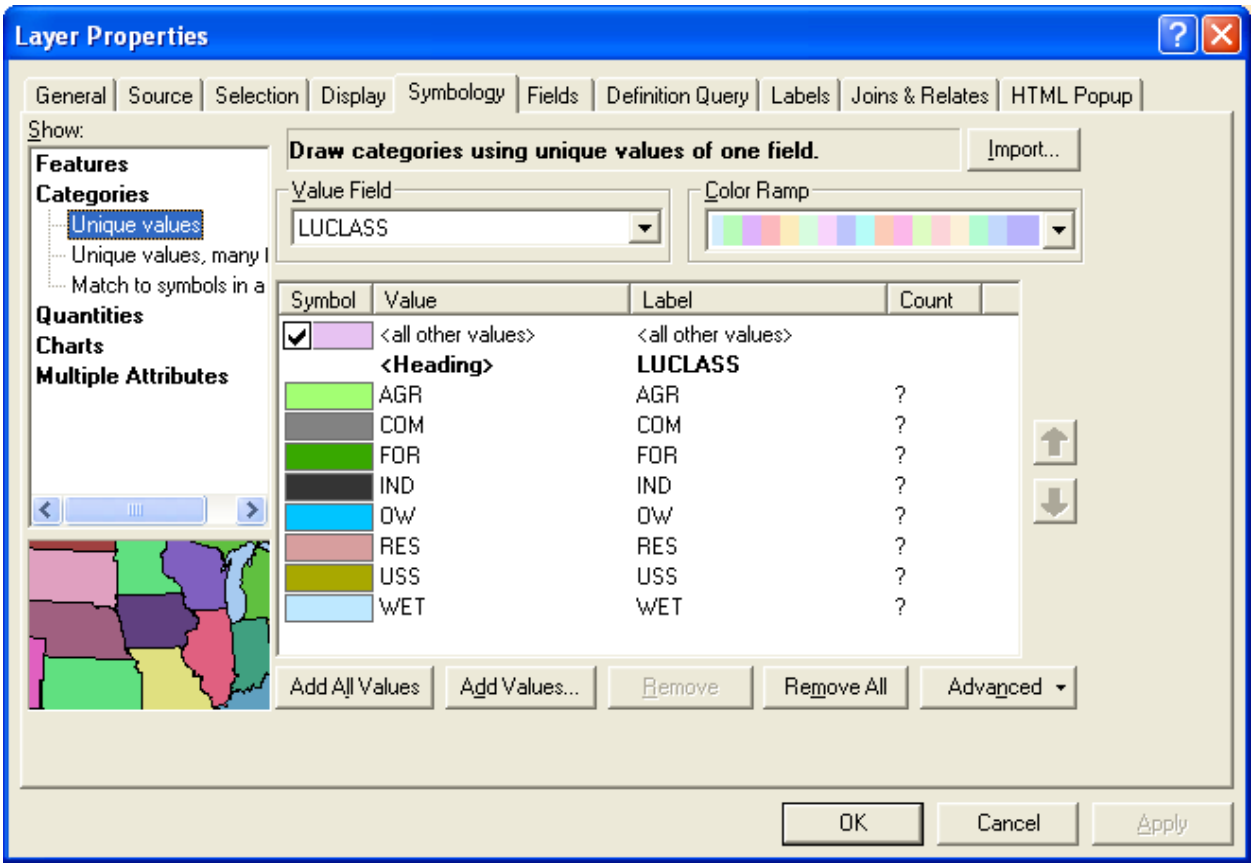
- Open the Layer Properties for landuse56.



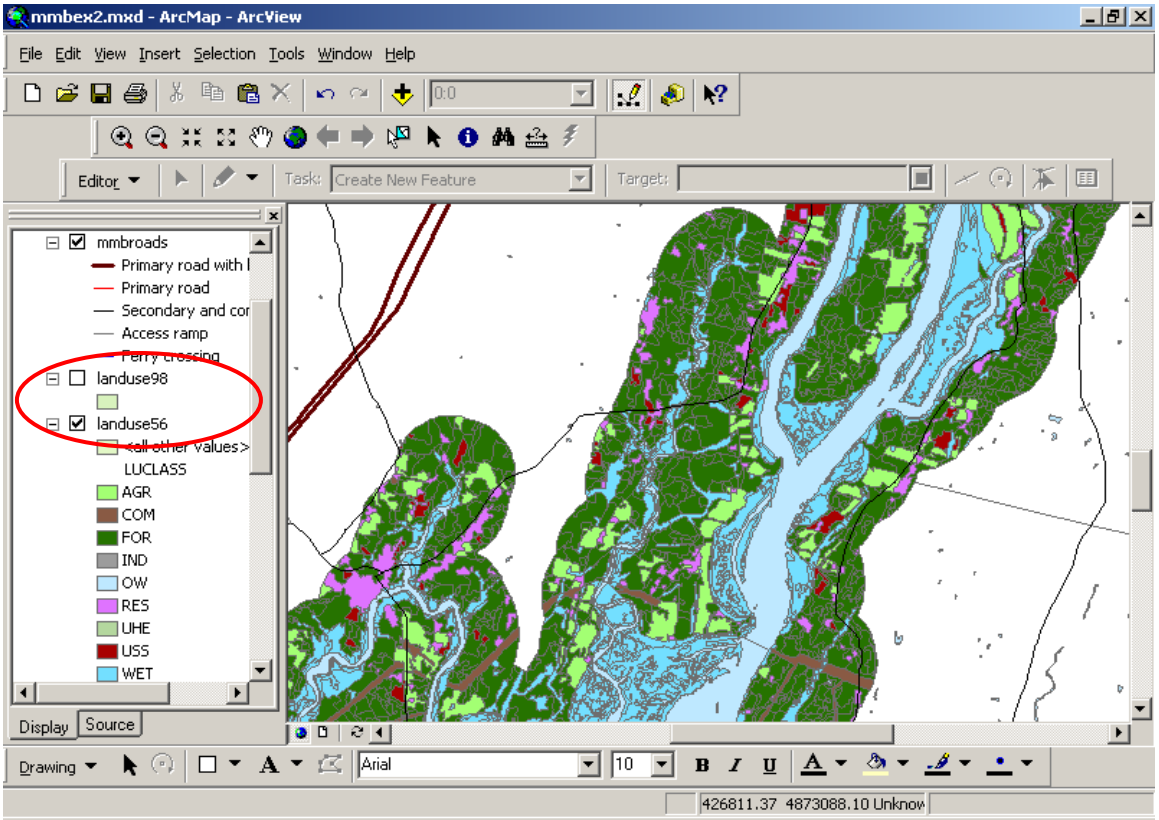
- Click on the symbology tab.

On the left of the box are options for displaying the different types of attribute information.

- Click on the word Categories. You should see different options for displaying unique values. Make sure Unique Values is highlighted.
- Make sure that the Value Field that has been selected is LUCLASS
- Click on the Add All Values button. Each of the categories will now have a unique color (see graphic below).
- Click Apply.



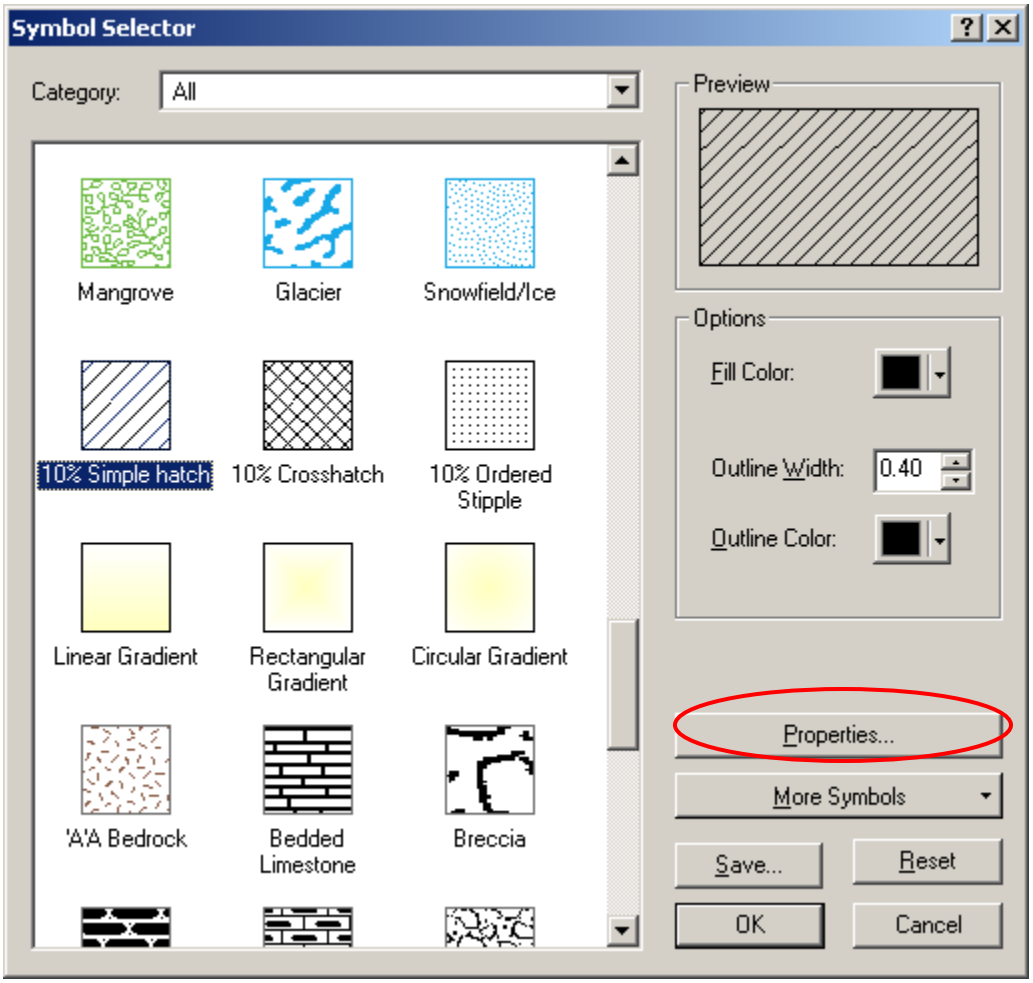
- Double click each of the color symbols to change the color of the different land use classifications, so that the color relates to the color of the category (e.g., forestry is green).
- Click Apply, then OK.



Step 6 – Use a fill pattern

You will be adding land use categories for more than one year. It will be helpful to differentiate between the years by using a transparent pattern for landuse98.

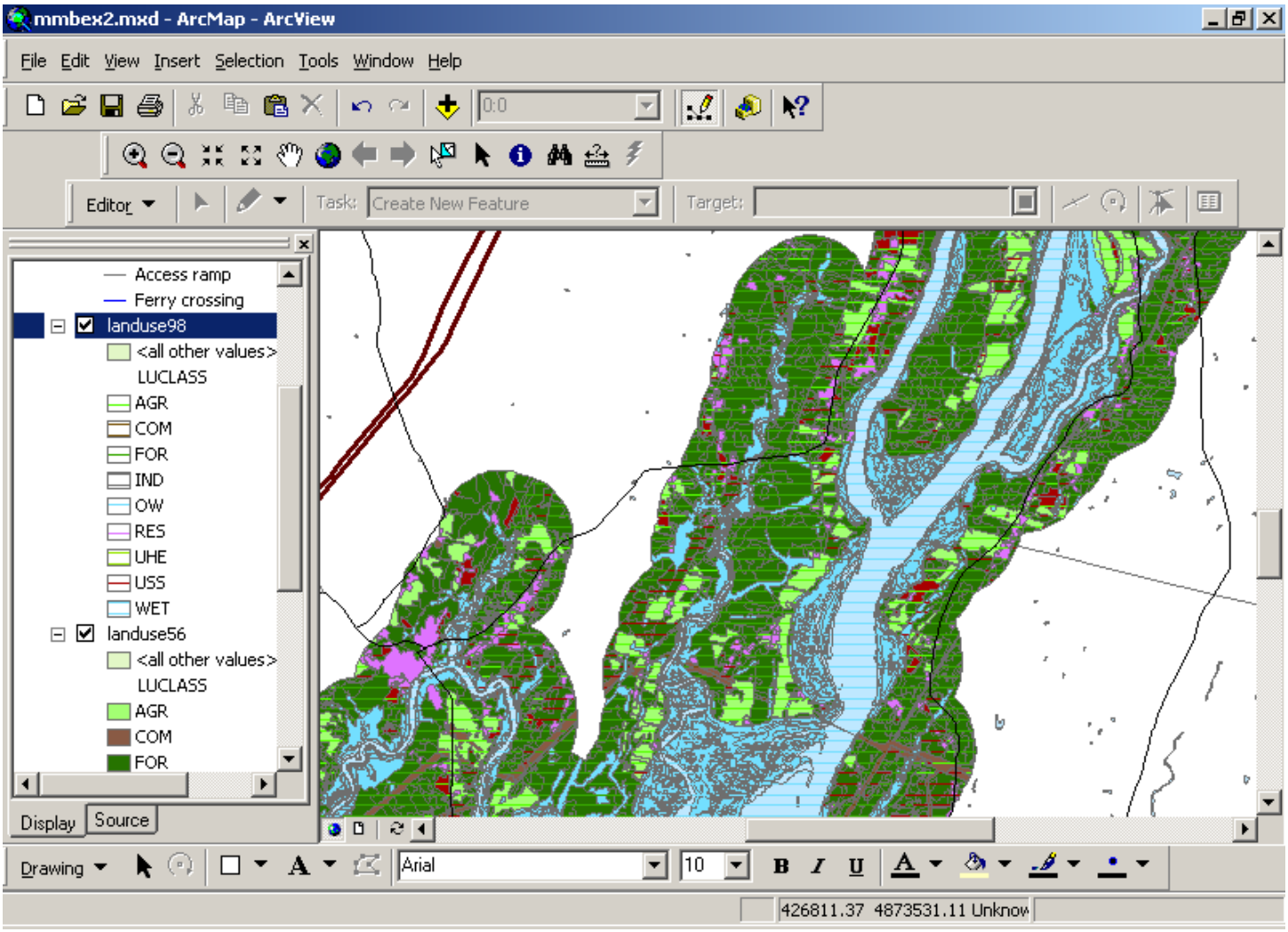
- Move the landuse98 layer so it is on top of the landuse 56 layer (see previous page)
- Turn on the landuse98 layer.
- In the Symbology tab (in the Layer Properties box), add all values for LUCLASS. In order to change the fill pattern, stay in the Symbology tab in the Layer Properties box.
- Double click on the first colored box next to the first land use attribute (AGR). This will open up the Symbol Selector box.
- Scroll down in the symbol box (displaying different colors) and examine the different fill patterns. You can look for more fill patterns by clicking the More Symbols button. Select a different fill pattern for each of the land use classifications. Change the outline color to No Color.



If you select a fill pattern with a white background, ***you will need to make the background transparent by selecting the Properties button (circled) and then selecting **No Color** for the Background Color.

Check to be sure the background is transparent by seeing if the gray background color shows through your symbol selector Preview (see Preview here, top right of box). If the fill background is not gray, you need to fix it.

This will allow you to differentiate areas that were in agriculture in 1956 and have been converted to a different land use by 1998.



Change the color and fill patterns until you can differentiate between the two layers. Find an area that was agricultural in 1956, but is now forested**.** What percentage of the overall study area do you think has been converted from agriculture?

Symbolizing data in ArcGIS allows users to see changes in the landscape visually, but does not allow for quantitative analyses. For example, you can pick out areas that have changed in land use (from forestry to agriculture) but it is impossible to determine the exact acreage of these changes visually. ArcGIS has a number of tools, which you will learn about in Exercise 3, which will allow you to quantitatively answer questions such as these.

Step 7 – Save your project!

Checklist of things learned in Exercise 2:

- ✓ **Save** your map document often!
- ✓ How to **store relative path names**
- ✓ How to **import symbology** from a legend file
- ✓ How to **add unique values** to symbolize categories based on attribute table fields
- ✓ How to use **transparent symbology** to see through a layer to the layer below

Week 1: Exercise 3 – Analyzing Data Using ArcGIS

In this exercise, you will analyze changes in land use patterns around Merrymeeting Bay. In the previous exercise, you used symbolization to get a sense as to changes that had occurred between 1956 and 1998. A more quantitative analysis can help us start to answer the following questions:

- Could changes in land use explain, in part, the degradation of Merrymeeting Bay?
- As land use continues to change, what are the implications for water quality in the bay?
- What is the impact of residential development upon the bay?

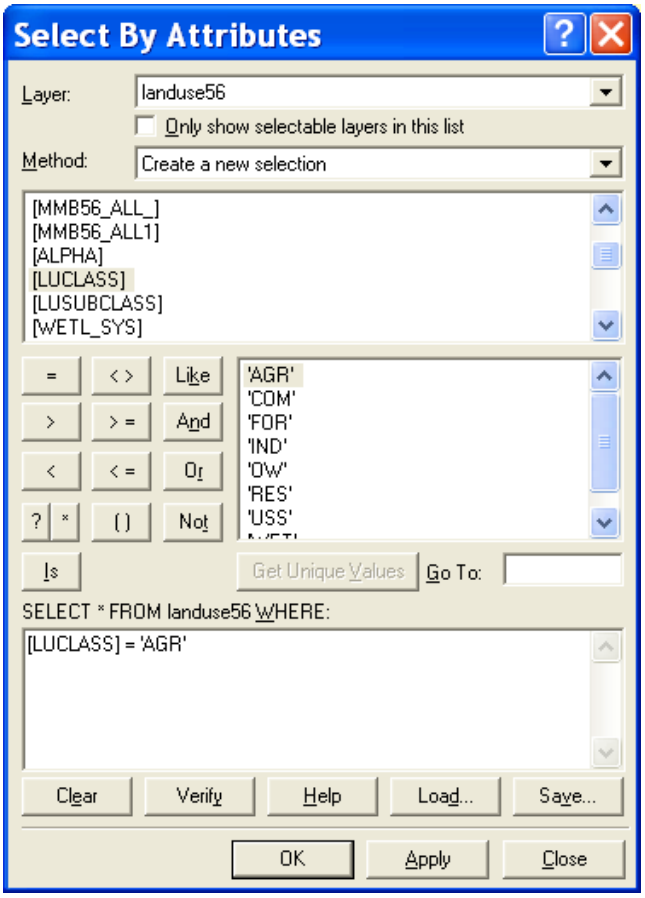
AGRICULTURAL LAND CONVERSION ANALYSIS

Step 1 – Select features by their attributes

We can symbolize spatial data based upon their attributes. In Exercise 2, you symbolized different types of land use. We can also choose to display data based upon their attributes – for example, in order to more clearly see changes in land use, we may only want to display one or two types of land use at a time. In this case, we will display those areas that were agricultural in 1956 and in 1998.

The tool that allows us to display data that meets a specific criterion is "Select by Attribute"

1a. In the Table of Contents, make sure that landuse56 is turned on.



1b. From the Selection menu, choose Select By Attributes.

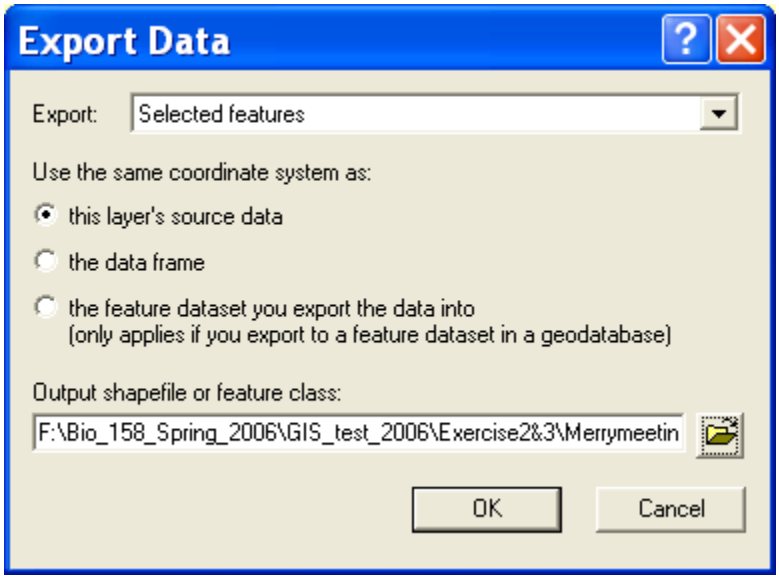
The Select By Attributes dialog allows you to select features by building a query. You will build a query by creating an expression for the landuse56 layer that selects polygons whose LUCLASS is equal to AGR (agricultural lands). Once selected, these features will be highlighted on the map and in the layer's attribute table.

--In the Layer dropdown list, click landuse56.
--For Method, choose "Create a new selection"
--In the list of attribute fields, scroll down and double-click on LUCLASS.
--Click the equals sign button (=) in the middle of the dialog.
--Next, click Get Unique Values button.
--Scroll down the list of unique values and double-click on 'AGR'.
--Notice the expression you have created in the lower window: Select From Landuse56 where LUCLASS = AGR

1c. Click Apply. Move the Select By Attributes dialog out of the way so you can see the map display. In the display area, notice that certain polygons are highlighted – these are all of the areas that were agricultural in 1956.

1d. Close the Select By Attributes dialog.

Next, you will create a new layer comprised of just those areas that you have selected.

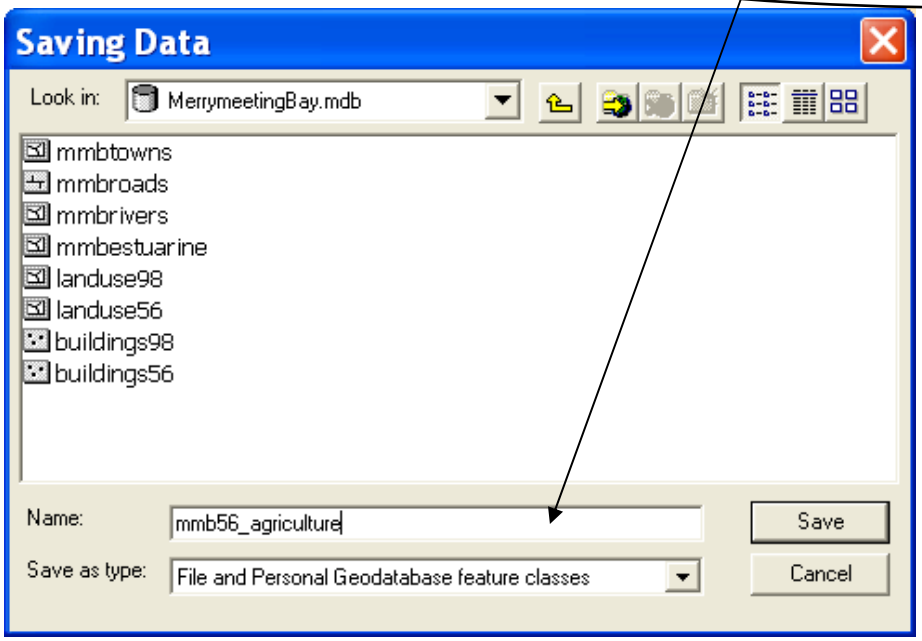


1e. Right click on the landuse56 layer name.

1f. Click Data, then Export Data.

1g. In the Export data window, choose Export: Selected features in the Export dropdown menu. (These are the polygons that have LUCLASS=AGR).
Choose "Use the same coordinate system as: this layer's source data"
Beside the "Output shapefile or feature class" bar, click the folder button.
The Saving Data window will open.

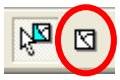
1h. From the Save as Type drop-down menu, select File and Personal Geodatabase feature classes.



-Navigate to your Exercise2&3 folder and then **double click** into your MerrymeetingBay.mdb file.
-Name the new feature class (layer) "mmb56_agriculture"
Click Save. You return to the Export Data window
Click OK.

1i. The program will ask you if you want to add the new layer to the map. Click YES.

1j. Unselect the selected features clicking on the **Clear Selected Features button on the top tool bar**



1k. Now make sure the landuse98 layer is turned on, and then repeat these same steps in order to create a layer showing agricultural areas in 1998 (mmb98_agriculture). (Steps 1a – 1i).

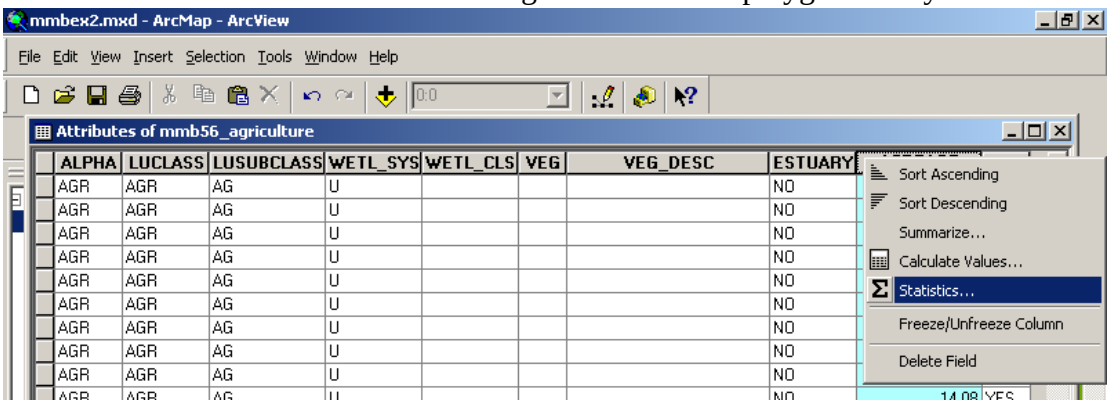
In order to better see which areas have been converted from agricultural lands, turn off the landuse and building layers so that you can see the agricultural lands from each of these two years. Change the fill pattern of the new mmb98_agriculture layer so that you can differentiate it from mmb56_agriculture. (Hint: a pattern, with a transparent background, would work well here.)

Turn off landuse 56 and landuse 98 and compare the two new agricultural layers.
This is an easier way to visualize the change in agricultural lands between 1956 and 1998.
Although it is possible to visually differentiate the changes, it is not possible to visually quantify these changes.

Step 2 – Calculating statistics using attribute values.

Next you will quantify how much land was agricultural in 1956.

2a. Open the attribute table for mmb56_agriculture. Scroll over until you find the column named ACREAGE. This column lists the acreage of each of the polygons that you selected from landuse56.



2b. Right click on the word ACREAGE. Select statistics. A box will pop up with statistics for this column. Note the various statistics that this tool gives you: the count of all records (here, polygons) in the table; acreage of the smallest and largest records (minimum and maximum); sum of all the acreage; mean acreage; the standard deviation from the mean; and a frequency distribution (how many records fell into each of several different acreage categories).

What was the total amount of farmland in 1956?
Answer **question #1** on the Exercise 3 questions (at the end of this handout).

Repeat these same steps in order to determine how many acres of agricultural land there were in 1998.

Record your answer on **question #2.**

By inspecting the map, estimate which of the towns has lost the most amount of agriculture.
At this point, one of the questions that we need to answer is what is happening to this agricultural land – is it being converted to new homes?

Another important capability of a GIS is the ability to analyze relationships between features. In this case, we want to find the answer to two questions:

- Is there a relationship between loss of agricultural land and increases in buildings in these same areas? (Step 3)
- If we are losing agricultural land, what other types of land use is this land converting into – residential, forest, industrial? (Step 4)

If we visually inspect the data, it is hard to pick out these trends; our minds just don't allow us to easily do this type of analysis. In ArcMap, like many other types of GIS software, we can compare two different types of spatial information to see if there is any correlation.

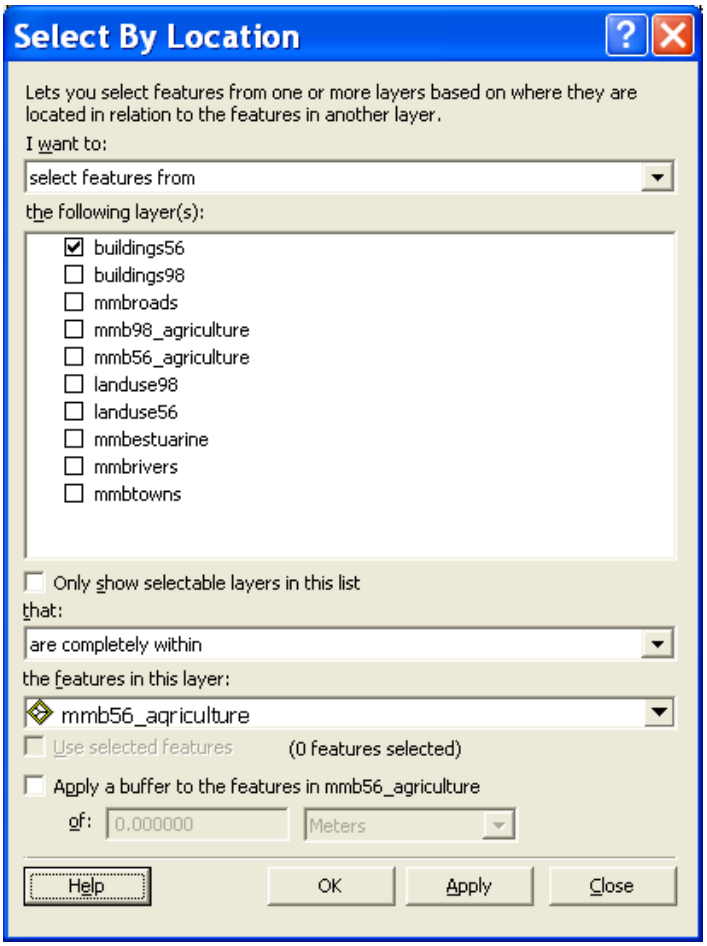
Step 3 – Select geographic features using spatial relationships

To answer the first question, we will need to determine how many buildings were located on agricultural land in 1956 and how many buildings are located on these same parcels in 1998. By comparing the number of buildings in 1956 with the number of buildings in 1998, you can get a sense as to whether agricultural land has been converted to residential development.

In order to do this, we will be using a tool called "Select by Location." The Select by Location tool allows us to select features which meet a specific spatial criteria based upon their location. In this case we want to find buildings (points) which fall within the boundaries of the agricultural parcels (polygons) from 1956.

3a. Turn on the buildings56 layer so that it is visible

3b. From the Selection menu, choose Select By Location.



3c. In the Select By Location dialog, select items in the dropdown lists so that the selection query reads, "I want to select features from the buildings56 layer that are completely within the features in this layer: mmb56_agriculture." Click Apply. Close the Select by Location window.

All 1956 buildings that are located on land that was agricultural in 1956 should be selected (display as blue). Zoom into one area of the map to find where the selected buildings are.

3d. Open the Attribute Table for the buildings56 layer. At the bottom of the table in parentheses, see how many records are selected. Each record corresponds to one building. How many buildings are located on formerly agriculture land?

Answer **question # 3**.

3e. Clear the buildings that were selected by clicking the Clear Selected Features button at the top.

3f. Turn off the buildings56 and turn on the buildings98. Now using Select by Location and these same steps, find out how many buildings were located on 1956 agricultural land in 1998. How many buildings existed in 1998 on land that was agricultural in 1956? Answer **question # 4**.

3f. **Go back to *Step 1* of this exercise (Exercise 3) and use the steps to figure out how to create a new layer that shows only those lands that are not agricultural in 1998.** (Hint, use this expression: "[LUCLASS] <> 'AGR'" to select the features, and then Export Data to make the new layer.) Save this new feature class as **mmb98_not_ag** into your MerrymeetingBay.mdb. Display this new layer in your map.

How many acres of non-agricultural land uses were there in 1998? Answer **question #5**.

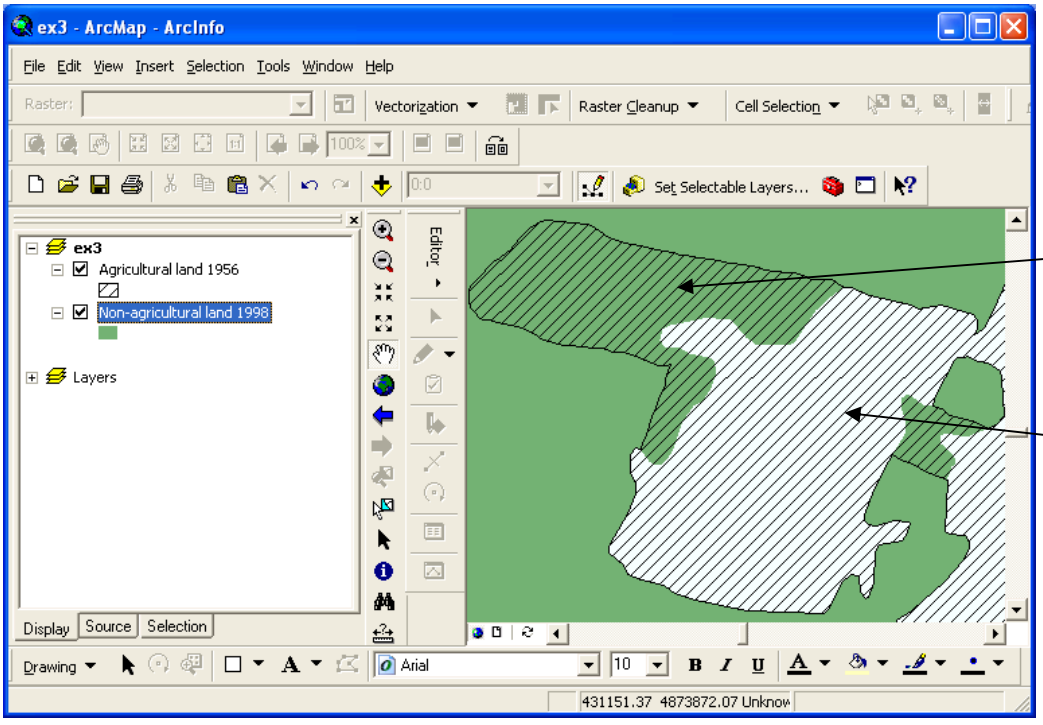
Step 4 – Using ArcToolbox to clip files

To answer our second question – what land use types exist on land that was formerly agricultural, we will need to use ArcToolbox. ArcToolbox is a component of ArcGIS with a number of different tools. In this exercise, you will be using the **Clip** tool.

You will identify areas that were agricultural in 1956 and were no longer agricultural in 1998. Then you will find out what the breakdown is for each of the parcels in terms of their 1998 land classifications. To do this, you will follow these steps:

- You have already created a layer showing areas (polygons) that were agricultural in 1956
- You have already created a layer showing areas (polygons) that are not agricultural in 1998 (i.e., they are one of the following categories: residential, commercial, forest, etc.)
- By overlaying this non-agricultural land from 1998 with areas that were agricultural in 1956, you will be able to see where agricultural land has been converted to other land use types (those areas that overlap both layers meet this criteria)
- Clip the 1998 polygons so that you have created a new layer that meets the criteria that it was agricultural in 1956 but is no longer agricultural in 1998.
- Analyze the new 1998 (non-agricultural) polygons to see what land use types they are composed of.

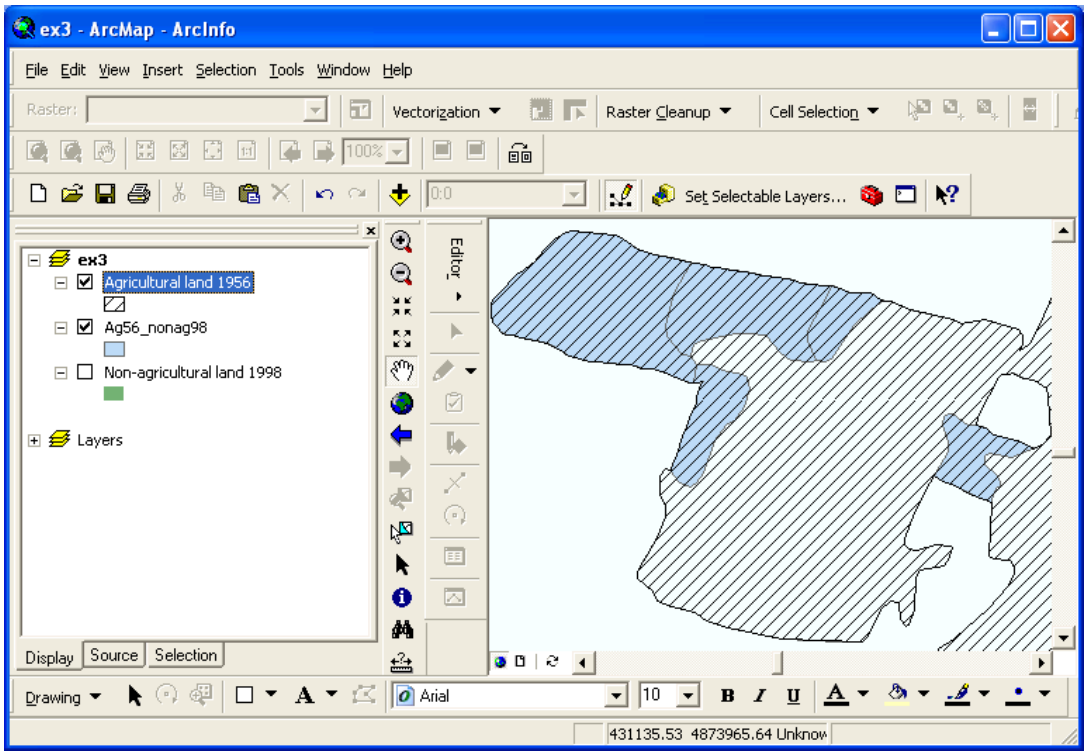
In the example below, the land that was agricultural in 1956 is indicated by cross-hatching. Land that is not agricultural in 1998 is indicated by the shaded areas. Those areas that have cross hatching over shaded areas are places that were once farms and were converted to another use by 1998.



This area was farmland in 1956 and is no longer farmland in 1998.

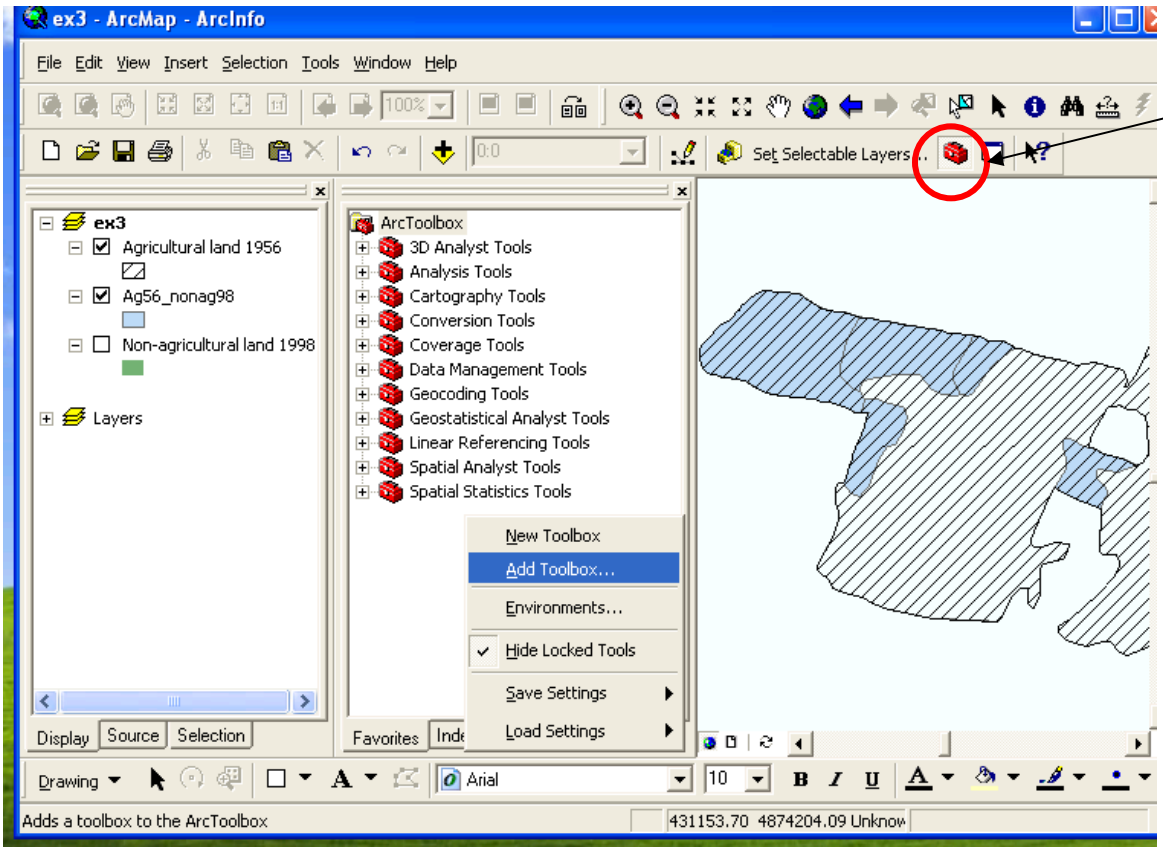
This area was farmland in 1956 and is still farmland in 1998.

The **Clip** tool is like a cookie cutter, it allows you to cut out those areas that were agriculture in 1956, but are no longer agricultural in 1998. Your result will look something like this:



Your map will only show shaded areas that were once farmland and are now no longer farmland.

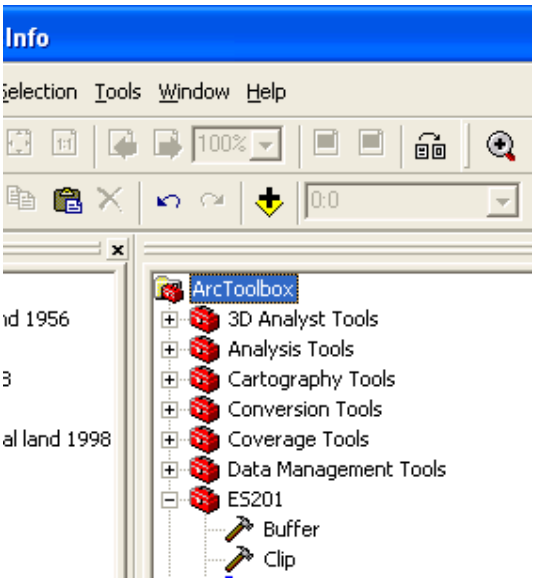
4a. Open ArcToolbox by clicking on the red toolbox in the top of the ArcMap Window.
When you click on this tool, a new window, the ArcToolbox window will open in your ArcMap window between the Table of Contents and Map View.



ArcToolbox

There are a lot of tools in ArcToolbox that we will not need in this exercise. Click on the boxes next to some of the toolboxes to see what types of tools are included. By double-clicking on a tool, you will bring up an individual tool window that explains what the tool will do and gives an example of how it works.

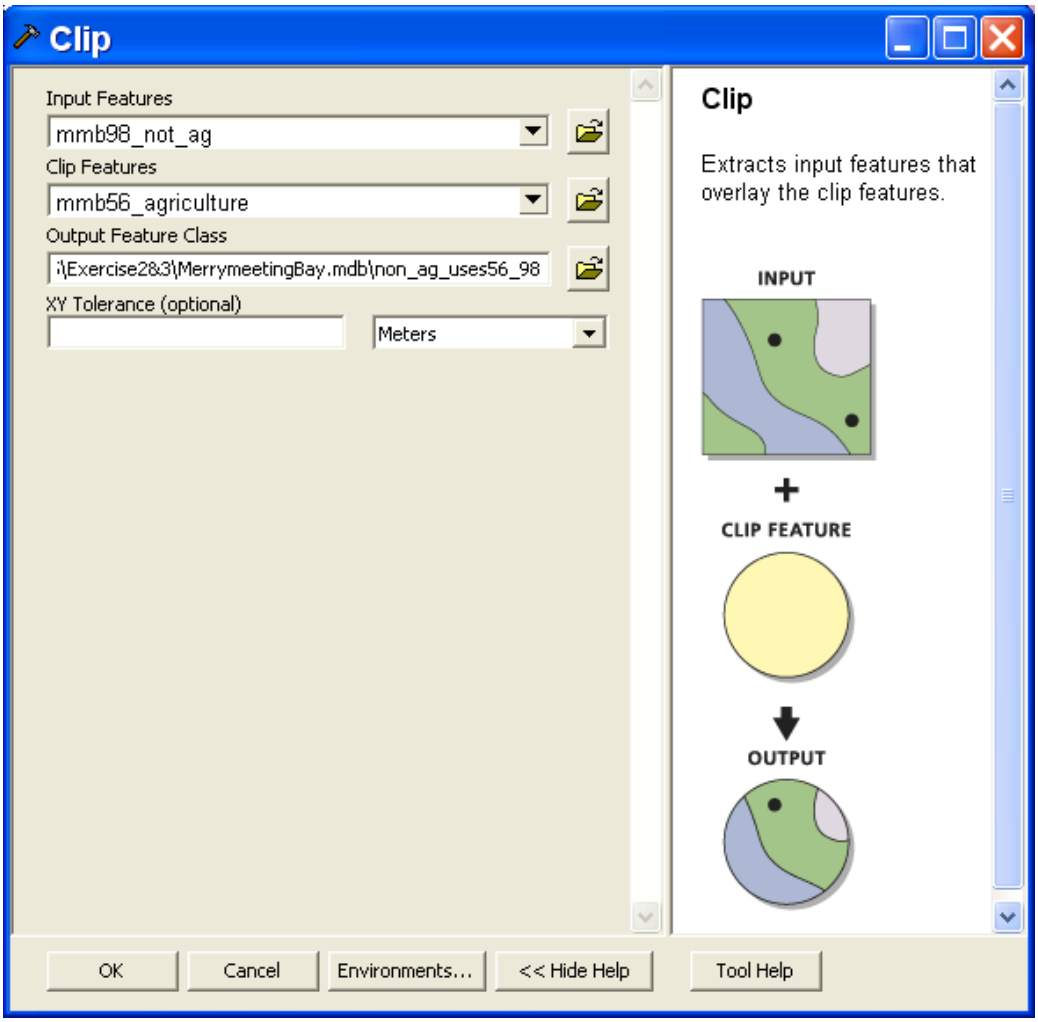
We've created a specialized "ES201 toolbox" with just the tools that you will be using in this exercise.



4b. Right click on the ArcToolbox Window (anywhere in the center white area). Select Add Toolbox. Navigate to Merrymeetingbay.mdb. Double-click it and select the red toolbox called "ES 201." Click open. A new red toolbox will show up in your ArcToolbox window.

4c. Open the toolbox by double clicking on it. You will see the following tools: Buffer and Clip. We will be using both of these in this part of the exercise.

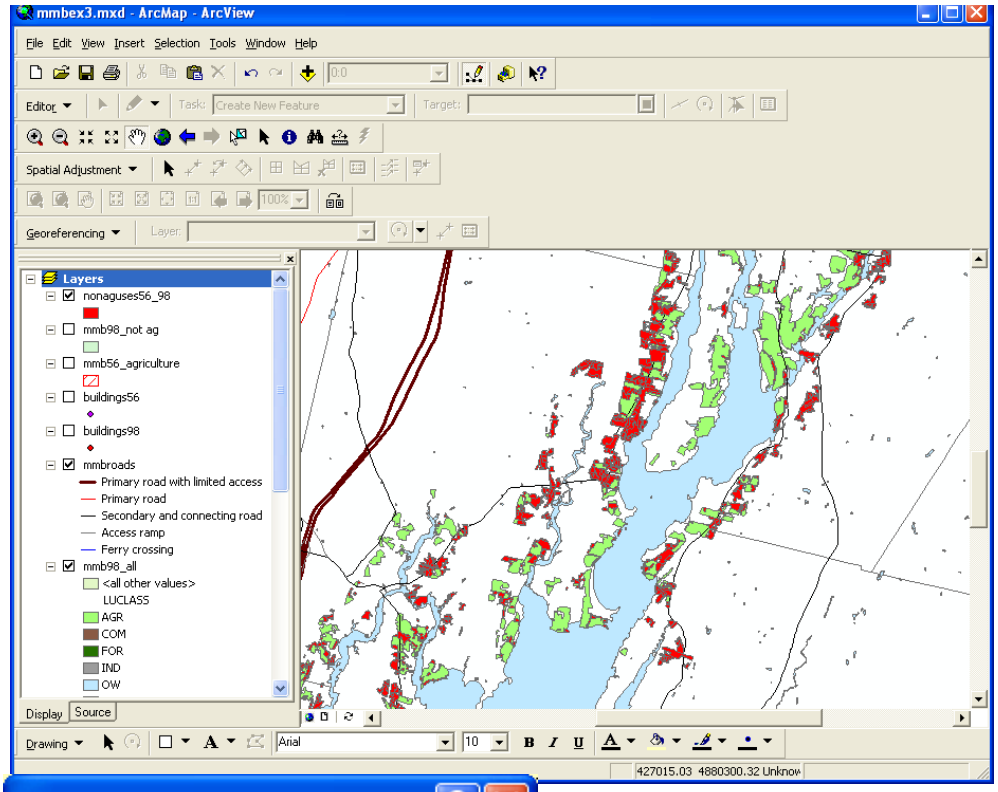
4d. Double click on the Clip tool.
In this step, you are going to clip the polygons or parts of polygons that were agricultural in 1956, but were not agricultural in 1998, and make a new layer out of them. Read the Help section to visualize what the Clip tool is doing. If you need more info about what a tool does, click the Help button at the top of the Help panel.



Make sure the two layers you want to use in the Clip are turned on in the Table of Contents.

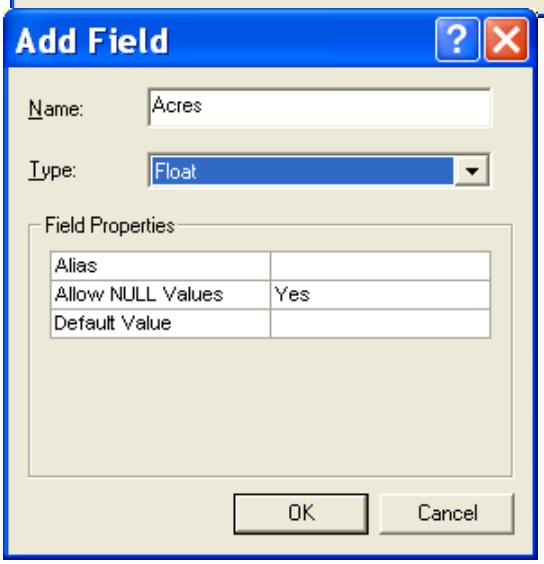
In the Clip window, you need to specify the Clip parameters. For the input layer to clip, choose **mmb98_not_ag** from the dropdown menu. For the clip features, choose **mmb56_agriculture**. Beside the Output Feature Class bar, click the Folder button and save the Output Feature Class (layer) as a feature class named **nonaguses56_98** in the MerrymeetingBay.mdb in your project folder.

Click OK. This may take a while – so take a break – get up and stretch!

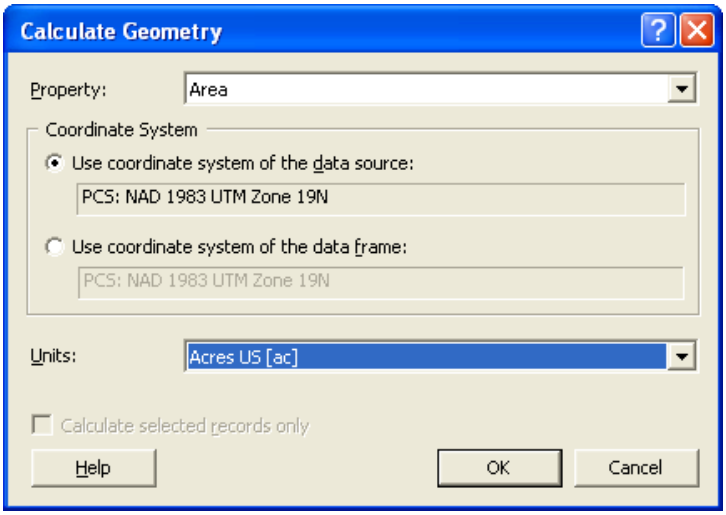


Click on the new layer and examine it to make sure that it does not overlap with any agricultural polygons in landuse98. This is a check to make sure you did it correctly.

The area of each of these polygons is calculated in square meters (m^2). In order to analyze the change in acres, you will need to add a new column to the attribute table that calculates the area value in acres.



4e. Check to be sure that **ArcCatalog is closed.** You may run into problems in this next step if ArcCatalog is open.
Open the nonaguses56_98 attribute table.
Click on the Options button and select Add Field. Name this new field **Acres** and select Float as the type. Click OK. The table will now have a new column at the end with <Null> in each of the rows.



4f. Right click on the Acres column heading and select Calculate Geometry. Click Yes when the pop-up box appears asking if you want to continue. In the Calculate Geometry dialog box, select **Area** in the Property dropdown menu. In the Units dropdown menu, select **Acres US [ac]**.
Click OK.

The new Acres column should now contain the acreage for each of the polygons in your table.
Click Save!

In addition to the spatial analysis tools that you have used (e.g, the Clip tool), the program includes other tools that allow you to analyze data quantitatively. You will use these tools in order to determine the number of acres that fall into each of the non-agricultural land use categories. For those areas (polygons) that are no longer agricultural, how many acres (or what percentage) are now residential or forest land? For the next part of the analysis, you will use two tools: the Summarize Tool and the Graphing Tool. The Summarize Tool is useful when you want to summarize information for many features or records. For example if you have 20 polygons that are classified as residential, it will add all of these polygons together and summarize the area.

Step 5 – Using the Summarize Tool

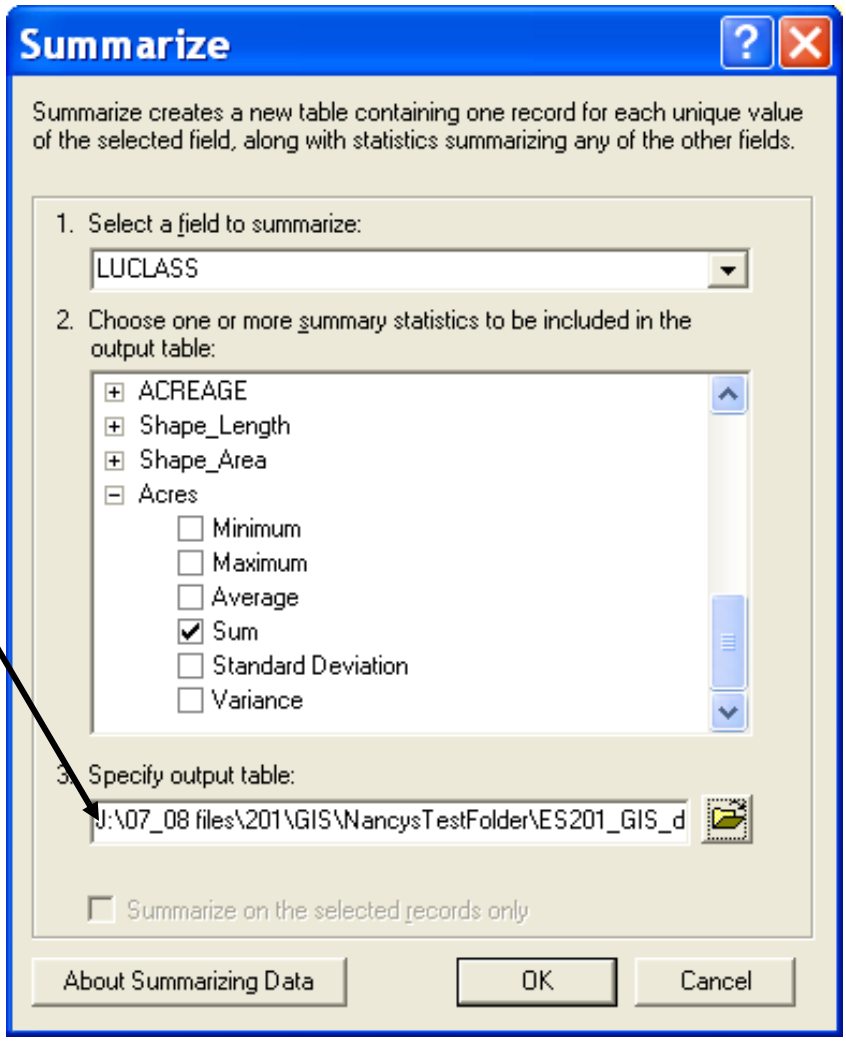
In order to find the number of acres of each of the different LUCLASS categories in the new nonaguses56_98 layer, you will use the summarize function. The result of using the summarize tool is a new database file that adds up area for each of the Land Use classes.

5a. Open the attribute table for nonaguses56_98. Right click on the LUCLASS field name. Choose Summarize.
In the Summarize window, select **Acres** (the field you created, not "ACREAGE") and then **Sum** as your choices.
This will calculate the total (sum) of the acreage of each of the LUCLASS classifications.
This new file will be a database file, or .dbf file.

5b. Name this file sum_ag_conversion and save it into your Exercise2&3 folder. (Use folder button to navigate there.) Click OK.

5c. You will be asked if you want to add this table to your project. Click Yes.
The sum_ag_conversion appears in the Table of Contents **Source** tab (see bottom of TOC). It is a database table, so it will look different from the other layers in your Table of Contents window.

Open the table for sum_ag_conversion by right clicking on it and selecting Open.

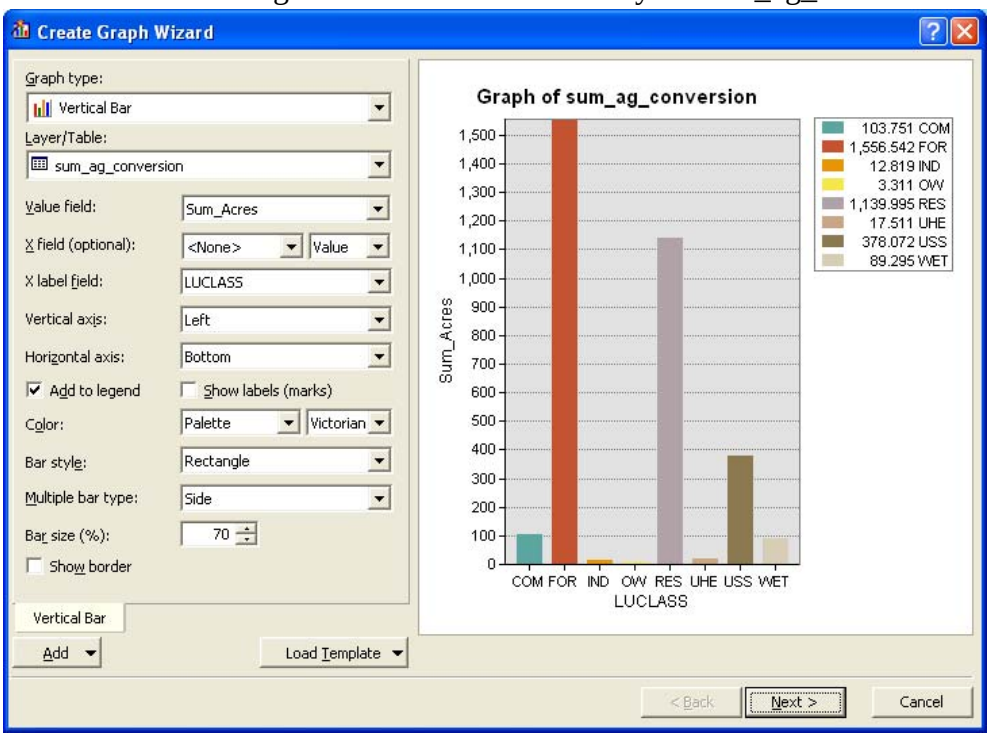


Answer **question # 6.**

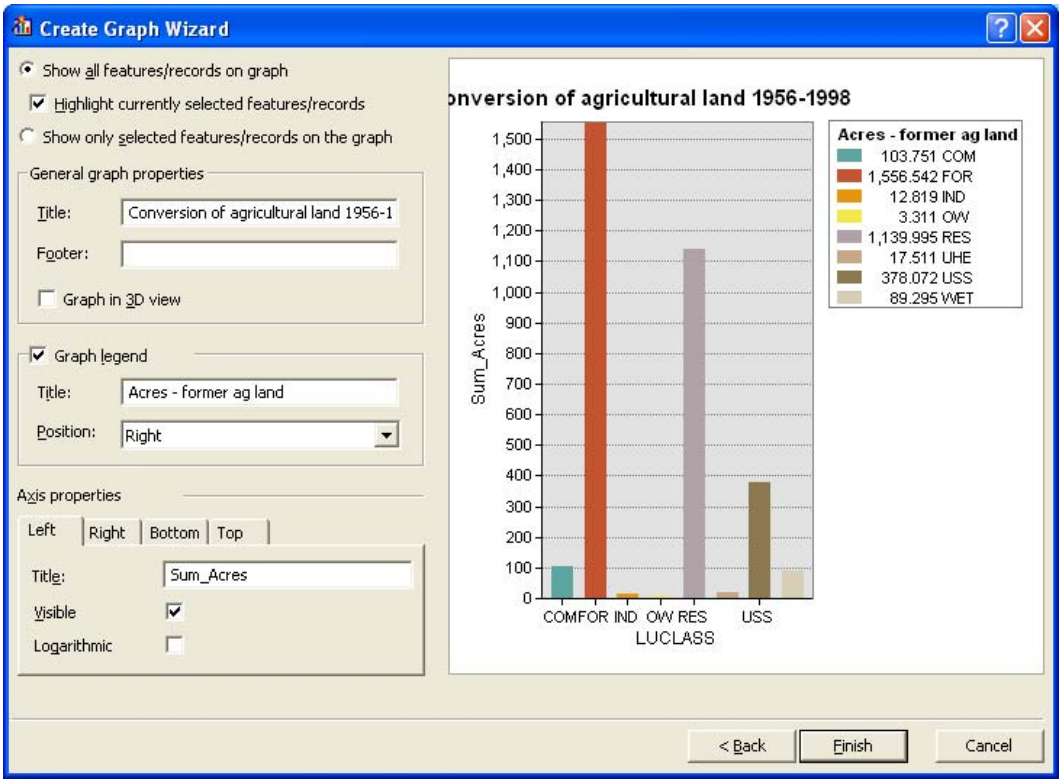
Step 6 – Making a graph

Next you will make a graph of this database table so you can visualize the 1998 land use classifications for these converted agricultural areas; in other words, what has the farm land around Merrymeeting Bay been converted into?

6a. Click on the Tools menu and select Graph and then Create
This will open the Graph Wizard. Select the following options on the screens that come up as part of the Graph Wizard. Set the dialog box to show the results of your sum_ag_conversion table.



6b. Examine and then close the graph. It will be saved and will remain part of your ArcMap file. To access it again, go to the Tools menu and select Graphs.



Be sure to save your project! Close both ArcMap and ArcCatalog.

Checklist of things learned in Exercise 3:

- ✓ How to **Select by Attribute**
- ✓ How to **Export selected features** to **create a new feature class** (layer)
- ✓ How to get **Statistics** for a column in the Attribute table
- ✓ How to **Select by Location**
- ✓ How to **Clear selected features**
- ✓ How to use the **Clip** tool
- ✓ How to **Add a Field** to the Attribute Table and **Calculate Geometry** for that field
- ✓ How to create a database table by using the **Summarize** tool in the Attribute table
- ✓ How to create a **Graph** from a database table

Exercise 3 questions

1. How many acres of agricultural land existed around Merrymeeting Bay in 1956?

2. How many acres of agricultural land existed around Merrymeeting Bay in 1998?

3. How many buildings were located on agricultural lands around Merrymeeting Bay in 1956?

4. In 1998, how many buildings were located on land that was used for agriculture in 1956?

5. How many acres of non-agricultural lands were there in 1998?

6. How many acres of agricultural land have been converted into:
    a. Commercial land?
    b. Forest land?
    c. Industrial land?
    d. Open Water?
    e. Residential land?
    f. Upland Herbaceous?
    g. Upland Scrub-Shrub (Abandoned Fields)?
    h. Wetlands?

Land Use Analysis within the Androscoggin River Watershed

Nancy Olmstead, Eileen Johnson

Perspectives in Environmental Studies GIS Lab – Week 2 Project

Introduction

Throughout the semester, we have been working on a project to investigate the Gulf Island Pond (GIP) section of the Androscoggin River. In this GIS project, you will continue to investigate GIP and our control system, Lake Auburn (LA), using the spatial tools available through the ArcGIS software. The goals of this project are twofold: first, you will create a map which illustrates the spatial data in a meaningful way; second, you will use some of the more quantitative tools of the ArcGIS program in order to compare the watersheds of GIP and LA.

First, you will make a map which visualizes the areas we are studying, including the Androscoggin River, GIP, and LA. You will symbolize our sampling stations according to the amount of turbidity and total phosphorus (P) found in the water column. You will visualize the water quality classifications (Class A, B, C, etc.) of the river and the streams in the areas that drain into GIP and LA. You will also have data on the land use within the watersheds that drain into GIP and LA. Land use data may be relevant to the GIP water quality problems due to non-point source pollution.

Non-point source (NPS) pollution is runoff that drains into a waterbody by sheet flow of water; this is distinguished from point source discharges, such as paper mills (PMs) and municipal wastewater treatment plants, which pipe effluent directly into the river. One of the arguments that the PMs made during the permit appeals process in 2007 was that regulators have underestimated the amount of NPS P pollution affecting the GIP system. The PMs argued that NPS pollution, e.g., from areas of agriculture in the GIP watershed, could be an important part of the P pollution problem.

Phosphorus inputs from NPS pollution are known to vary based on land use type (Reynolds and Davies, 2001). Runoff from forests, grasslands, and other non-cultivated land has been shown to be low in phosphorus (Bashkin, 2002). Even grazing land does not export much P in runoff (Reynolds and Davies, 2001). Cultivated lands may export P, though much of this P will be bound to particulates (soil particles) and therefore only somewhat bioavailable (Bashkin 2002). Agricultural lands that have been treated with manure may be a source of bioavailable P (Reynolds and Davies 2001). Previous studies of the entire Androscoggin River watershed have found that the watershed is mostly (85%) forested (Boyer et al., 2002), but we are aware of no study of the particular portion of the watershed that drains into GIP. You will use the land use data to graphically compare the amount of different land uses within the GIP and LA watersheds.

The degree of imperviousness of the land surface is also a factor in how much P may run off into waterbodies (Brabec et al., 2002). Impervious surfaces are those which do not allow precipitation to soak into the soil slowly. Higher volumes of water run off from these areas, and this runoff tends to carry more pollutants and sediment, which can both be detrimental to aquatic biota (Brabec et al., 2002). Different land use categories vary in their degree of imperviousness. Examples of very impervious surfaces include roads and buildings, while vegetated areas vary in their degree of imperviousness – golf courses and lawns, for example, are much more impervious than mature forests. You will have data on the extent of impervious surfaces in the Androscoggin watershed, and you will use those data to graphically compare the amount of imperviousness in the watersheds of GIP and LA.

Outcomes

There will be three outcomes for this assignment: a PDF map, a word document of graphs, and an extended abstract which summarizes your conclusions in writing. ***Print only the abstract.***
These are due at the end of lab on May 4, 5, or 6.

1. 11x17 PDF Map, *saved in your Student Folder, in the GIS folder* – to include:
   - Water quality classifications for streams and rivers
   - Sampling sites classified by amount of Turbidity and Total Phosphorus in the water
   - Land uses within the areas of interest
   - Impervious areas within the areas of interest
   - Focus in on the two small watersheds for the map – large one is too big for 11x17
   - All features detailed in the separate "Making a Layout" handout (legend, etc.)

2. Word document, *saved in your Student Folder, in the GIS folder*, composed of six pie charts:
   - % of impervious and pervious area of GIP entire watershed
   - % of impervious and pervious area of GIP subwatershed
   - % of impervious and pervious area of LA watershed
   - % of land in different land use categories for GIP entire watershed
   - % of land in different land use categories for GIP subwatershed
   - % of land in different land use categories for LA watershed

2. Abstract, double-spaced and double-sided, ***not to exceed 500 words*** – to include:
Written summary of your conclusions regarding the questions:
   - Overall, how does GIP compare to LA in terms of percent of the watershed in impervious area and the percents in different land use categories?
   - Is GIP likely to be receiving significant amounts of P from NPS pollution? Why or why not?
   - Knowing what we know about the varying amounts of sediment P in GIP compared to LA, do our data support the PM's contention that NPS P pollution is a major factor in the GIP water quality problems? Why or why not?

Data you will have

1. Waterbody data provided by the Maine DEP (Department of Environmental Protection). These data show all waterbodies within the Androscoggin watershed and their water quality classification.
   - andro_streams_water_quality
   - andro_ponds – no water quality info because *all* Maine ponds are Class A
   - andro_rivers_water_quality – *all* rivers in the Andro watershed
   - andro_streams_upstream_from_GIP – although these data do not include water quality info, they include just the streams that feed GIP

2. Watershed data is also available from the USGS (United States Geological Survey). For this exercise, four different watersheds have been provided.
   - andro_watershed – the entire Androscoggin River watershed showing all subwatersheds
   - andro_watershed_LA – the entire watershed of LA; all the land draining into LA
   - andro_watershed__GIP – the entire watershed of GIP; all the land draining into LA

- andro_subwatershed_GIP – the subwatershed for GIP; not the entire GIP watershed, just the immediately adjacent watershed

3. Land Use Data
   - andro_landuse – all land use types within the entire Androscoggin River watershed
   - andro_impervious_areas – all lands of the Androscoggin watershed classified as to whether they are impervious or pervious

4. androscoggin_river – shows you the course of just the *Androscoggin* River, in case you are not familiar with it. This may be useful just for orienting yourself (probably not for final map).

5. maine – the towns of the southwest portion of Maine.

Suggested steps

1. Create a project using data available in the "Androscoggin" folder in your GIS folder, inside your student folder
   a. Add all of the feature classes within the androscoggin geodatabase
   b. Look at the metadata for these layers in order to understand the data, their sources, and the attributes in the attribute tables
2. Symbolize the data in order to see what they can tell you about the water quality of GIP and LA
   a. Symbolize streams and rivers based upon water quality classification
   b. Symbolize the land use and impervious data.
      Note: Land_Use.lyr is a layer file that includes the symbology for the different land use types. Since you will eventually have multiple land use layers in your map, this will allow all of your various layers to have the same symbology for the different land use categories. Once you have added the "andro_landuse" layer, review last week's handout on importing a previously defined symbology. (Exercise 2 – page 4.) In the Import Symbology window, select the option to "Import symbology definition from another layer in the map or a layer file," then navigate to the Land_Use.lyr file in your folder.
   c. Note: features outside of Maine are not subject to Maine law and therefore are not included in these data sets
3. Using the separate instructions, add the excel spreadsheet with the locations of your sampling points and their water quality data. Display the locations of the sample points and symbolize the information based on the following parameters. Refer to last week's instructions on displaying data. You may want to use graduated symbols or graduated color depending upon which one you think displays better:
   a. Total_Water_Phosphorous_ppb_2009
   b. Turb_NTU (Turbidity in NTU)
4. You will analyze the relative percentages of impervious/pervious surfaces and different land use types within three different scales of watersheds:

a. The entire GIP watershed – the whole area within which NPS pollution potentially affects GIP

b. The entire LA watershed

c. The GIP subwatershed – this is a more similar size to the LA watershed and is also the most immediate source of potential NPS pollution, since runoff from this area flows directly into streams feeding GIP, rather than into streams feeding waterbodies farther upstream in the Androscoggin watershed.

To complete the analysis of land uses and impervious areas, refer to last week's handout and the notes below; you will need to use the following steps:

d. Symbolizing by unique value or importing a previously defined symbology

e. Clipping of data ("andro_impervious_areas" and "andro_landuse") to the watershed of interest

f. Add a field ("Acreage") and then calculate geometry (US Acres)

g. Add a field, then right-click on the new column and use the Field Calculator command to calculate the percent of total acreage that is represented by each land use category. [Hint: before you do the Field Calculator, you'll need the total (sum) of acreage, from the column you just made (f), in order to calculate the percentage. In the Field Calculator, use the formula = [Acreage]*100/ (the sum of acreage)] Once you calculate the column, you can adjust the # of decimal places shown by right clicking on the column heading and selecting Properties. In the Field Properties dialog box, click on the little box next to where it says "Numeric" and you can adjust how many decimal places display in the attribute table.

h. Graph results using pie charts. (Note: you should set the symbology of the pie chart to match the symbology of the land use categories as displayed in the map, by setting the Color to "Match with Layer.")

Literature Cited

Bashkin, V., 2002. *Modern Biogeochemistry* Kluwer Academic Publishers, Boston, USA.

Boyer, E., Goodale, C., Jaworski, N., and R. Howarth. 2002. Anthropogenic nitrogen sources and relationships to riverine nitrogen export in the northeastern U.S.A. *Biogeochemistry* 57: 137–169.

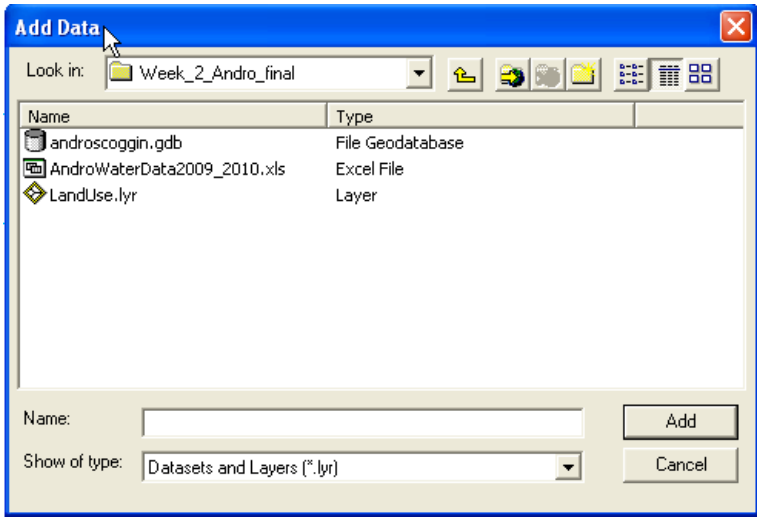
Brabec, E., Schulte, S, and P. Richards, 2002. Impervious surfaces and water quality: a review of current literature and its implications for watershed planning. *Journal of Planning Literature* 16 (4): 499-514.

Reynolds, C., and P. Davies, 2001. Sources and bioavailability of phosphorus fractions in freshwaters: a British perspective. *Biological Reviews* 76: 27-64.

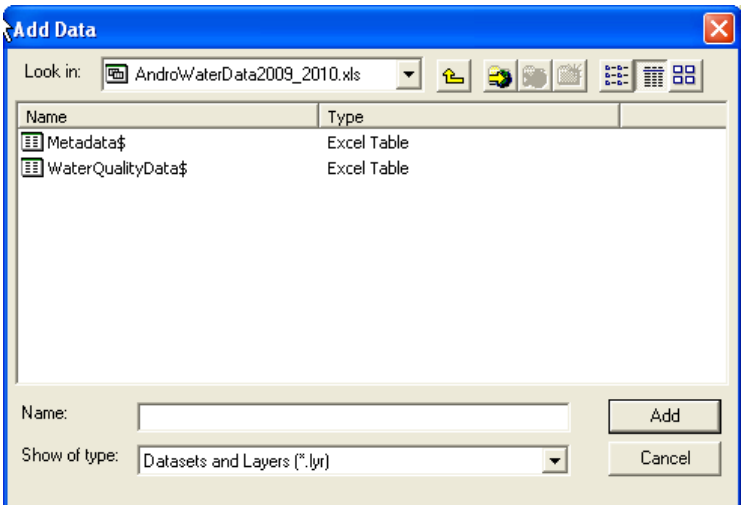
Adding Point Data to ArcMap.

Locations can be added to ArcMap from a variety of file types: word files, txt files, or excel spreadsheets. In this exercise, you will add the locations of core sites that you sampled earlier in the semester to your ArcMap project. The locations of the sample sites were collected with a GPS unit and then downloaded into an Excel spreadsheet. Locations were recorded in latitude and longitude.

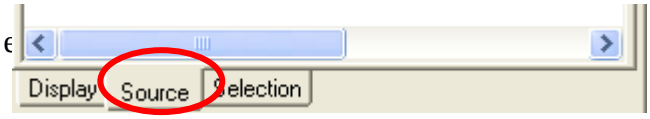
1. Add the excel file "AndroWaterQuality" to your project
    a. Click on Add Data
    b. Navigate to this spreadsheet "AndroWaterData2009_2010"



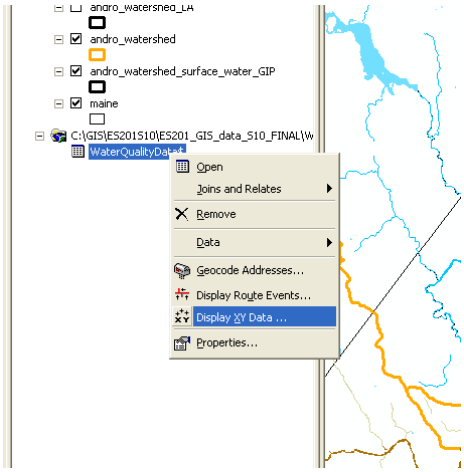
    c. You need to add individual worksheets when adding data in excel format, so click on the spreadsheet. There are two worksheets associated with this excel file. Select the worksheet titled "WaterQualityData"



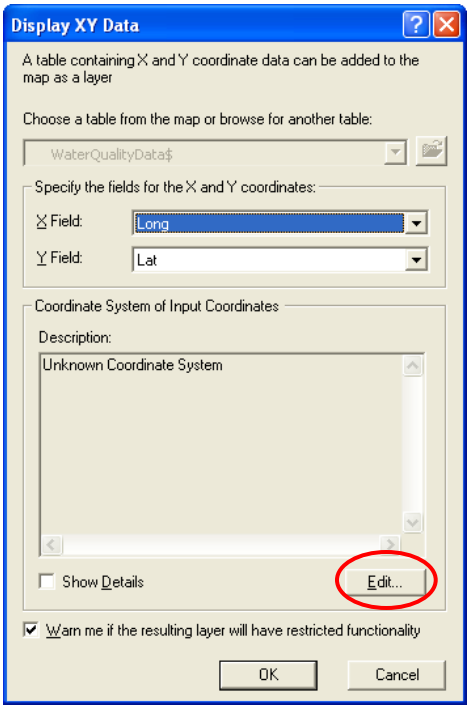
    d. If you cannot see the excel spreadsheet in your map document, click on the Source tab located at the bottom of the left hand Table of Contents (where all of your data layers are displayed).



2. Right click on “WaterQualityData” in the lefthand Table of Contents and select “Display XY Data”

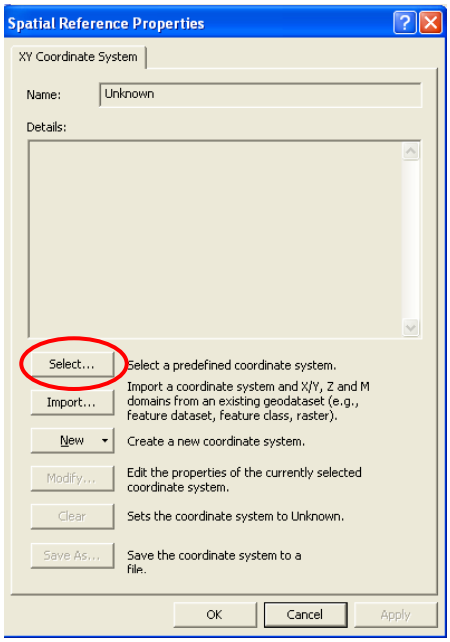


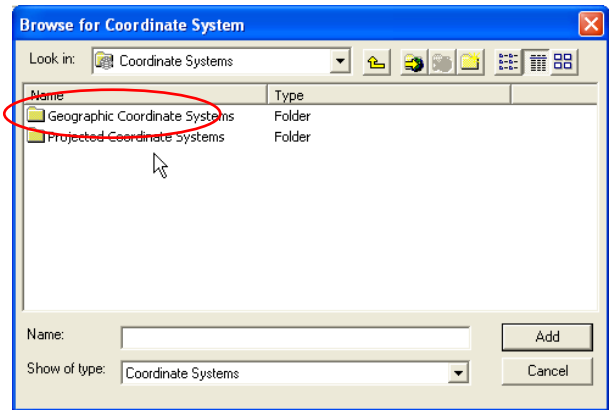
3. A Dialog box “Display XY Data” will display. Make sure that X Field is set to Long and the Y Field is set to Lat



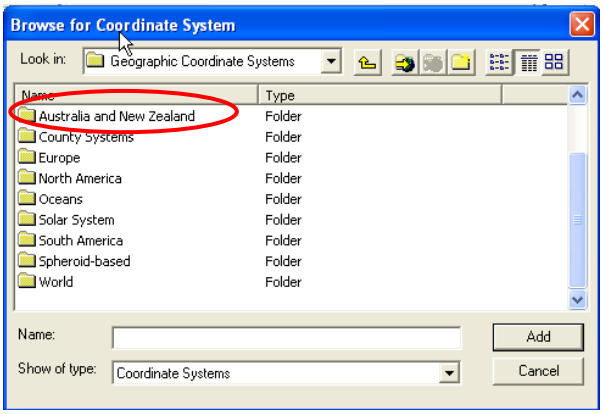
4. You will need to set the spatial reference for this data. It was collected in Latitude and Longitude which is a Geographic Coordinate System. Click on the Edit button under “Coordinate System of Input Coordinates”

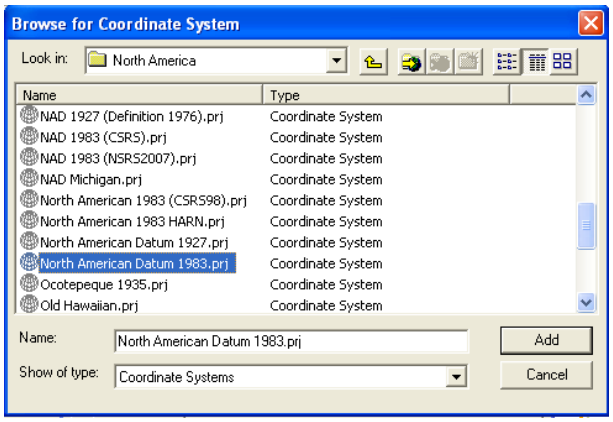
    a. At the next dialog box “Spatial Reference Properties” click on Select





b. Then click on Geographic Coordinate System
c. Next click on North America
d. Finally Click on the file “North American Datum 1983.prj” Click on Add
e. Back in the Display XY Data click on OK





5. If you get an error message “Table Does Not Have Object-ID Field,” Click OK
6. You should see your points displayed on your map.