

**11.520: A Workshop on Geographic Information Systems**

**11.188: Urban Planning and Social Science Laboratory**

## **Lab Exercise 2: Thematic Mapping in ArcMap**

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In this exercise, you will build on the basic ArcMap techniques you explored in Lab 1 to make more sophisticated thematic maps. You will make two different kinds of maps: exploratory and explanatory. To gain some experience with incorporating raster datasets into maps, you will access [orthophotos](#) using ArcMap. Finally, you will convert some of your finished maps into Portable Document Format (PDF) files, a format that facilitates electronic distribution of your work.

### **I. Setting Up a Work Environment**

Step 1. Attach 11.520 Locker. This is exactly the same step as in Lab1.

Step 2. Start ArcMap by follow the following steps.

1. Click the Start button in the left bottom corner.
2. Move the mouse over the item Programs.
3. Move the mouse over the item ArcGIS
4. Move the mouse over the item ArcMap and Click.

Please wait patiently for ArcMap to launch. The program takes awhile to come up.

### **II. Effective Mapmaking**

We will use 1990 U.S. Census data for Cambridge for this exercise. In ArcMap, add **cambbgrp** (in the **M:\data** directory). Open the **Data Frame Properties (View > Data Frame Properties** from the menu bar) window and set the "Map Units" to **meters** and the "Display Units" to **feet**.

## A. Exploratory Mapping

Exploratory mapping is the kind of mapping we do to get a feel for what the data "looks like." Before coming to any conclusions, you should make a number of maps that summarize what is in the database and raise questions that you would like to answer. We will go through a number of exploratory mapping techniques here.

### *The Effect of Normalization on Thematic Maps*

Use the *layer properties* to modify the characteristics of the `cambbgrp` theme to match these criteria:

- Legend Type: **Graduated Color**
- Classification Field: **Population**
- Normalize by: **<None>**
- Color Ramps: **Orange monochromatic**
- Null value: **0**
- Classification Type: **Quantile**
- Number of Classes: **5**

Use the *Layer Properties* window to change the name of this theme to `Population`. To change the number of decimal places, put the cursor on a label, click right mouse button. It will open a *Number Format* window. Since numbers represent population, choose **numeric** and set the number of decimal places you want. In this case, set 1 for number of decimal degree.

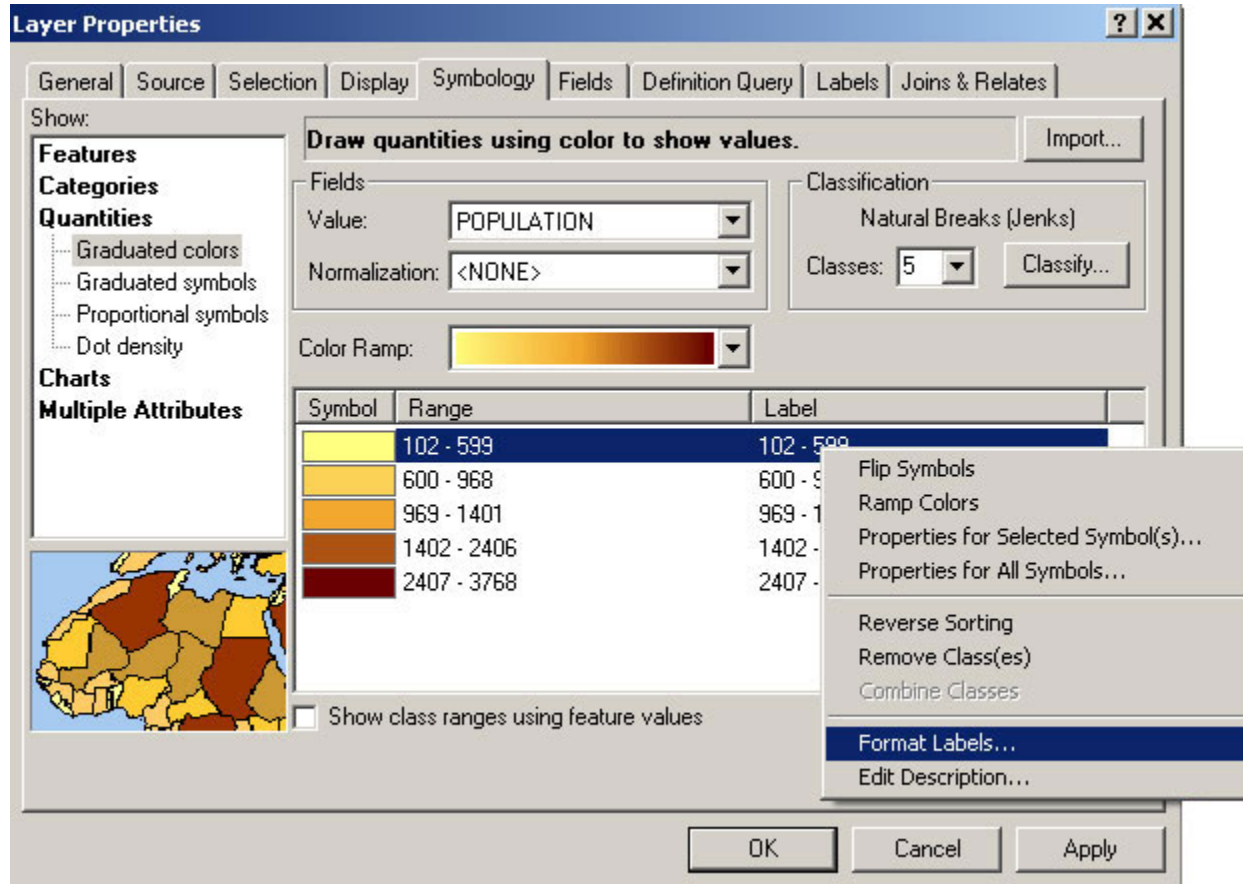
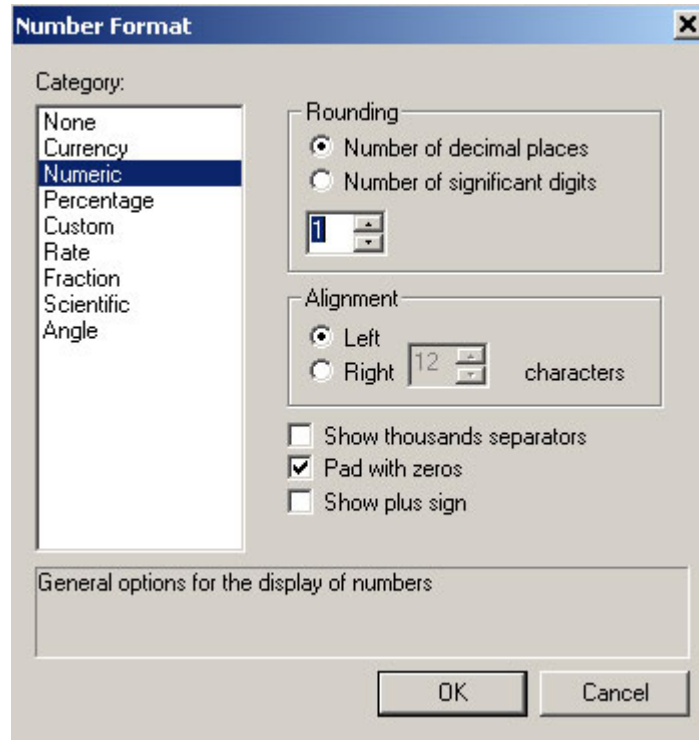



Fig. 5. Open a Number Format window



**Fig. 6. Set the number of decimal places**

You have created an *unnormalized* map of Cambridge population by block group. Your map isn't as meaningful as you might like since your thematic shading depends only on the raw number of people in each block group - regardless of whether a block group is itself large or small. In such cases where your raw data are not 'normalized' (i.e., adjusted to represent a compared-to-something-meaningful comparison), it is easy to generate a pretty looking map that is quite misleading. Shortly, we'll compare this thematic map with one that does normalize the population count. But, first, let's spruce up the map a bit.



Click on the Add layer button , and add **majmhda1.shp** from **M:\data** . This is a [MassGIS](#) (Massachusetts Geographic Information Systems) Major Roads Datalayer created in December 2000.

Now let's adjust the characteristics of the major roads theme. First, change the name of the layer to **Major Roads**. Next, open the **Layer Properties** window and click the symbology tab and set the properties as follows:

- Categories: **Unique Value**
- Values Field: **Class**
- Color Schemes: **(don't change)**
- Then click **Add All Values** button in the bottom of the symbology tab

This is the first time we have encountered a "Unique Value" legend type. This type of legend is often useful when a field takes on only a limited number of discrete values. In this case, the field **Class** assumes only four values: 1, 2, 3, and 4. Each value represents a different type of road. These numbers are not very descriptive, so we will want to include text labels for each value. But what do the numbers mean? For that, we must consult the [MassGIS metadata](#) for this dataset. Use the descriptions for the values of **Class** there for the labels in your legend.

By default, ArcMap does not choose a very attractive symbolization scheme for the roads. You will need to adjust the symbols manually. Set the symbols as described in Table 1.

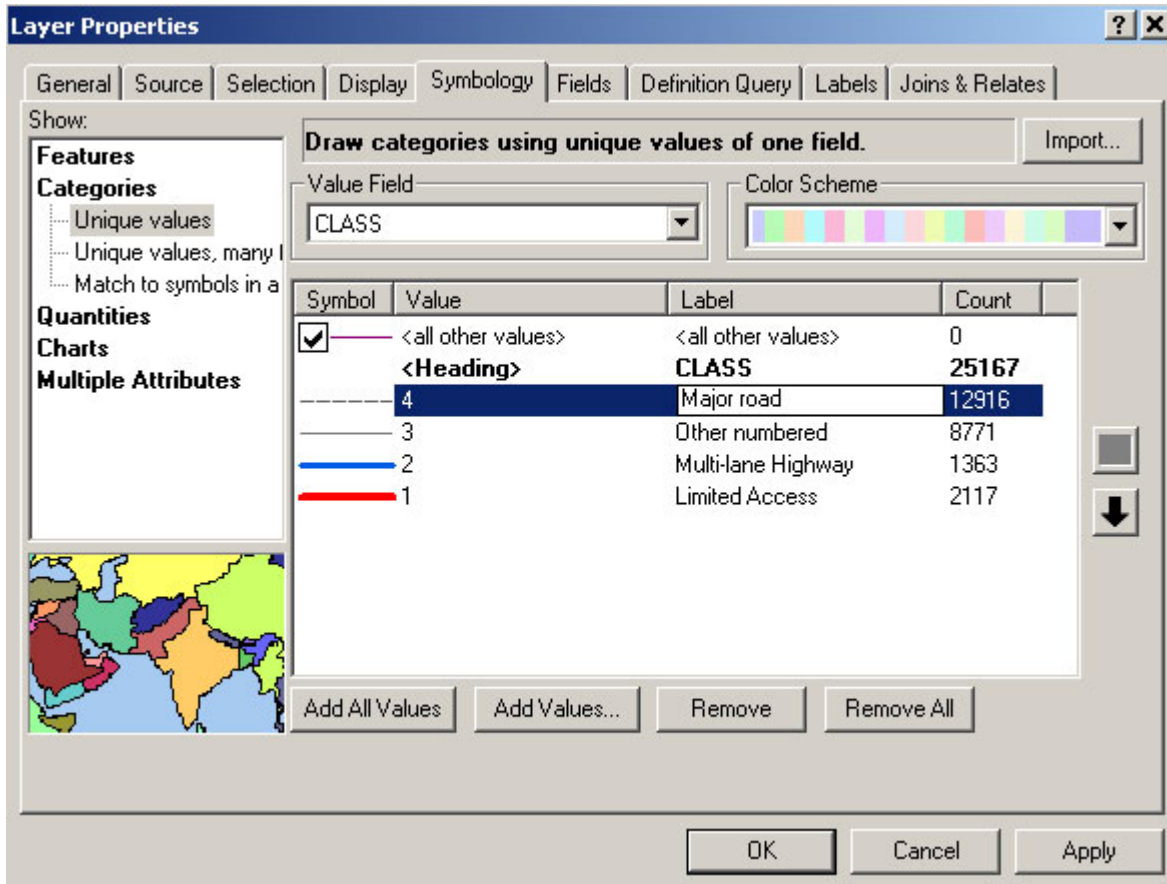
Value	Color	Size	Style
1	Red	3	Solid
2	Blue	2	Solid
3	Dark Gray	0.1	Solid
4	Dark Gray	0.1	Closely Dotted

**Table 1. Road Symbolization**

When you're done, your layer properties-symbology window should resemble Fig. 7. Note that the full text of the labels is cut off in Fig. 1; you should enter the full text of the description as documented in the dataset's [metadata](#). Don't forget to apply your changes!

Now you will create a *normalized* map of the population data. Normalizing means adjusting for effects that distort the way the data appears. Here, you will compensate for the effect of land area on population. Larger areas typically

have larger populations than smaller ones, but the actual *densities* of the areas may be quite different.



**Fig. 7. Unique Value Legend Window**

Create a new data frame by select insert "Data Frame" menu from the menu bar. You should now see the "New Data Frame" icon in the data frame window. Select the Major Roads layer under "Layers", click the right mouse button and select "copy". Then select the "New Data Frame", click the right mouse button and select "Paste Layer". Now paste the **population layer** into the "New Data Frame". Remember to set the Map and Display units for this new data frame.

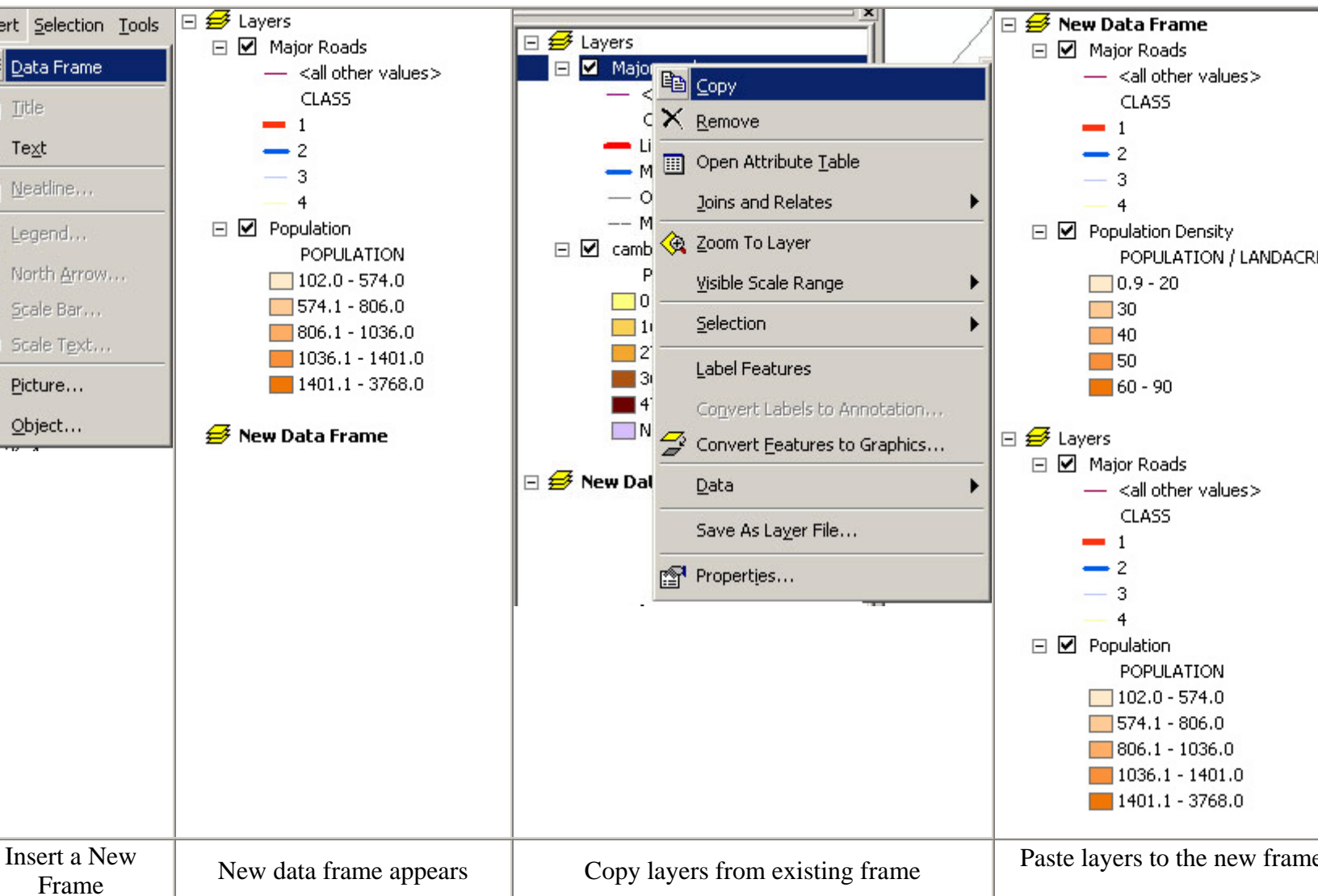
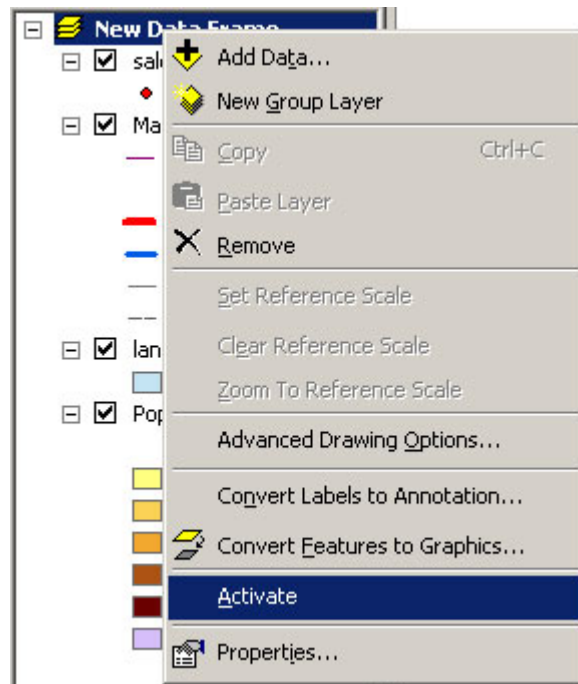


Fig. 8. Create a New Data Frame

Open the *layer properties* to modify the **Population** layer. Adjust the number of decimal places to "1" and set the "Normalize by:" field to "**Landacre.**" In ArcMap, the 'normalize by' option is used to pick an attribute that will be divided into the mapped attribute before doing the classification and shading. Hence, normalizing by landacre will create a **population per acre** measure. You should still be using the "Quantile" classification with 5 classes and "Orange Monochrome" color ramps. When you apply your changes, you will have a population density map. Change the layer's name to **Population Density**. Mathematically speaking, what did the setting the normalization field do to the population values? Is the population density map more consistent with your impression of the parts of Cambridge that are more crowded? Also, compare the result when you normalize by the 'Area' attribute rather than the 'Landacre' attribute. The

'Area' attribute is the area (in square meters) of each block group polygon whereas the 'landacre' measure excludes bodies of water (like the Charles River Basin).

Since you have two data frame and data view displays only one frame at a time (you can show two maps in one layout view though. We will cover that soon), you need to activate a frame to see it. For example, if you want to see "New Data Frame", select "New Data Frame", click right mouse button then select "Activate".




**Fig. 9. Activate a Frame**

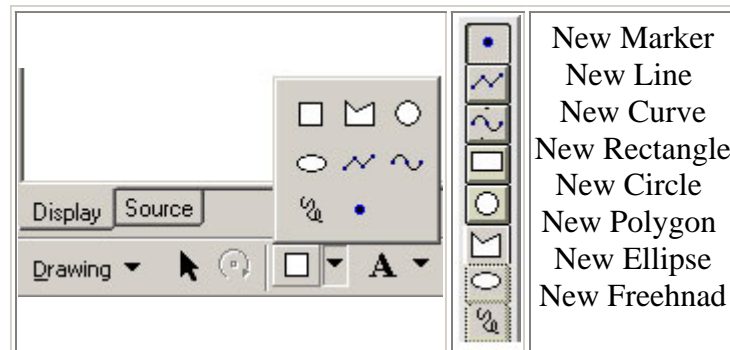
### ***Annotating Your Map***

While a map often can tell a convincing story on its own, you can often strengthen your case with well-chosen labels and annotation.


### **Highlighting an Area of Interest**

You should be able to spot one or more areas in your two maps of Cambridge where the discrepancy between them is especially apparent. In "Layers" frame (the unnormalized map), highlight one of these by drawing a circle around the area with the New Circle tool . To select the New Circle tool, you will first need to open the draw tool pop up menu as shown in table 2 and select the New Circle from the pop up list of icons that appears. The complete list of drawing tools is shown in Table 2.







**Table 2. Drawing Tools**

Once you've drawn the circle, you can use the Arrow Pointer tool  to move and resize it. You can change attributes such as the line thickness, outline color, fill pattern, and so on using the *Properties Window*. To open the *properties window*, either **double click** the circle you just created. You can also open the *properties window* by clicking right mouse button while putting the cursor on the circle, then select **properties** from the button of the drop down list that appears. Make your circle have an outline width of 3 and change the color to something that stands out, yet doesn't clash with the color scheme of the map.

### Adding Text Annotation

Now use the "A" Text tool  to add some text annotation near the circle explaining why you put it there (e.g., "Zone of High Discrepancy"). Use an economy of words. Choose font characteristics that will make the text visible but not overwhelming. Note that like the drawing tools, you can choose annotation style from a pop up list. You can experiment with these if you wish.



### Adding Labels

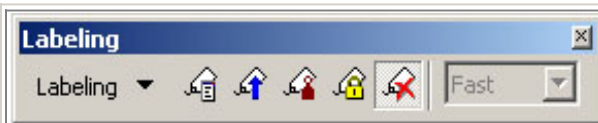
Labeling features on the map can help viewers orient themselves. Labeling too many features, however, clutters up the map and impedes readability. Let's put identifying markers on stretches of limited access highways, symbolized by thick red lines on your map. Use the "i" Info tool  to look at the attributes of the highways. Make sure that the **Major Roads** layer is selected first. You will probably find that at least two records show up for each click; that's because the two directions of the multilane highways have been encoded separately, as if they were two different routes very close to one another. If you watch closely as ArcMap flashes the matching links, you can actually see this.

Interstate 90 (a.k.a. the Mass. Pike) extends east-west near the bottom of the image. As you identify links along this stretch, you should see that the "Rt-number" field is "90" and that the "Admin\_type" is "1." From the [metadata](#), you can see that an Admin\_type of 1 indicates an Interstate highway. We want to label a few roads using this "Rt-number"

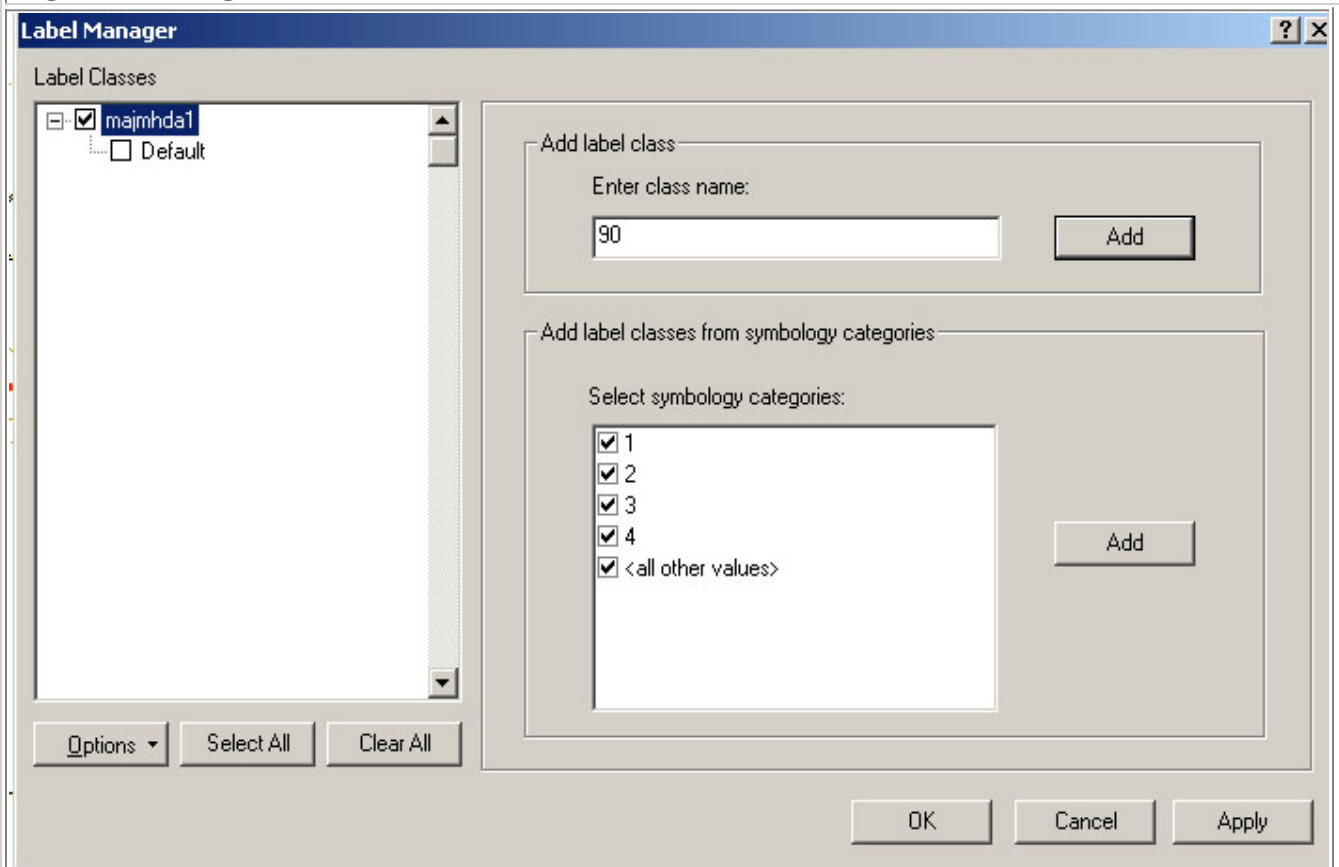
field. Open the *Theme Properties* window for this theme. Click on the "Text Labels" icon and confirm that the "Label Field" is set to "Rt-number."

ArcMap has some nice cartographic goodies that will let us put highway shields on the maps not unlike those you've seen in commercial road maps. Go to Menu View/Toolbars, select labeling tool box. The labeling tools like fig 10. will appear in ArcGIS software.

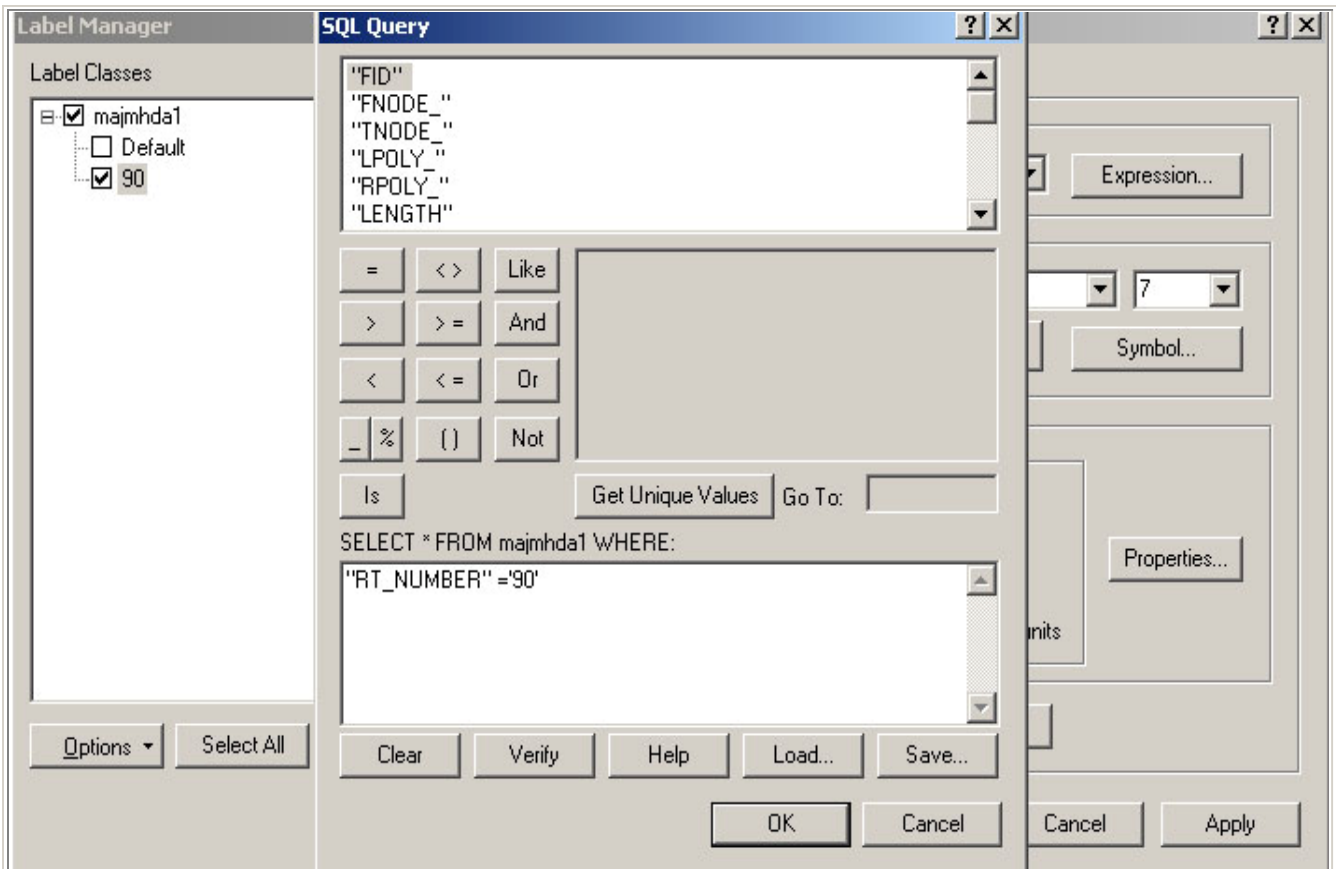
Click the second button  to bring up label manager dialog and input 90 as a new class name and click add (see table 3-1). A new class with name "90" will appear on the left side. Right click "90" to select it, and select SQL Query to select I-90 from the roads (see table 3-2). In the sql query input window, input as table 3-3, and click ok after input is done. Click "Symbol" button , then select the "U.S. Interstate HWY" shield among many label styles (see table 3-4). Now click **Apply** to see the shield to appear on I-90, and click **OK** to exit the labeling tool box.



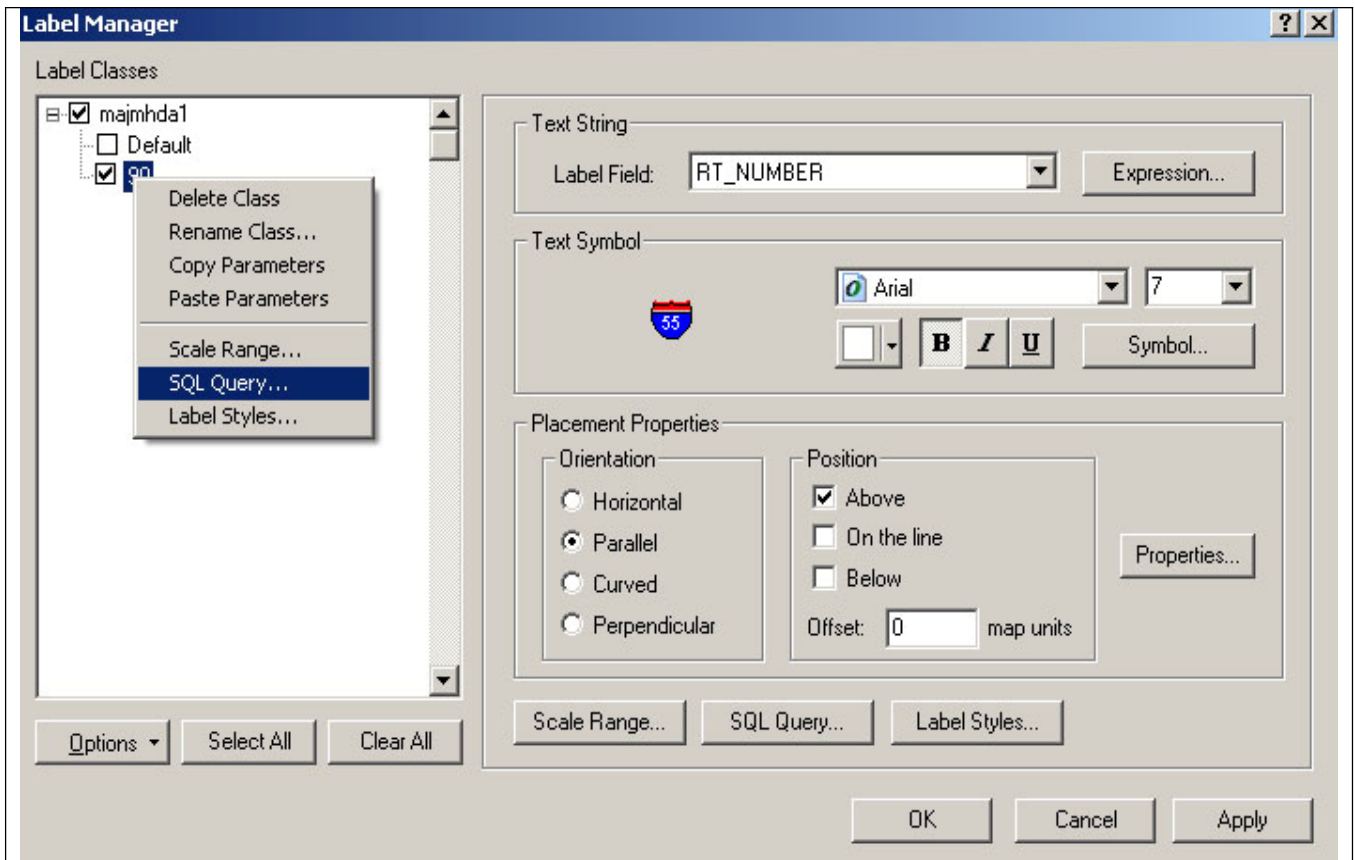
**Fig 10. Labeling Tool Bar**



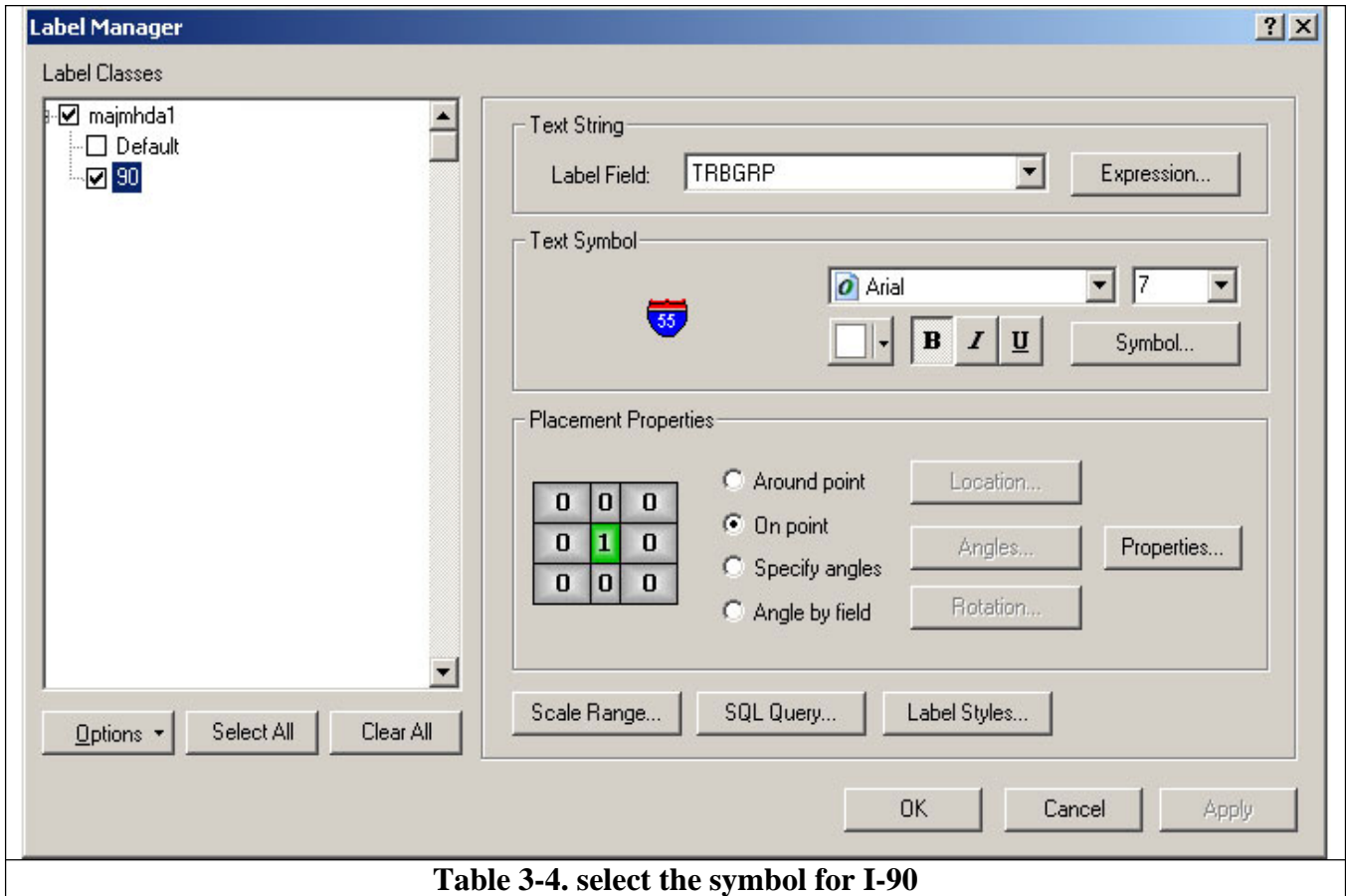
**Table 3-1. add a new class**



**Table 3-3. the sql query**



**Table 3-2. make a query to select I-90.**



**Table 3-4. select the symbol for I-90**

Other limited access highways visible in this view are Interstate 93, Mass. State Route 2, and a tiny stub of US 1. Place labels on I-93 and Mass. 2 and ignore US 1. Note that Mass. 2 should not get an Interstate shield since it is a state highway (Admin\_type = 3); instead use a round, square, or oval shield. The full set of label tools is shown in Table 3. ArcMap gives you some control over the fonts and colors that appear in the shield symbols. You may open *Layer Properties* window, select *Labels* tab and click *Symbol* button to open the *Symbol Selector* window, which gives you the chance to alter the settings. You can experiment with this if you wish, but it is *not* necessary for this exercise. Once you've placed a shield symbol on the map, you can open *Properties* window by double clicking the label you inserted, click the *Change Symbol* button and it brings up *Symbol Selector* window. Then you can change the characteristics of the shield.

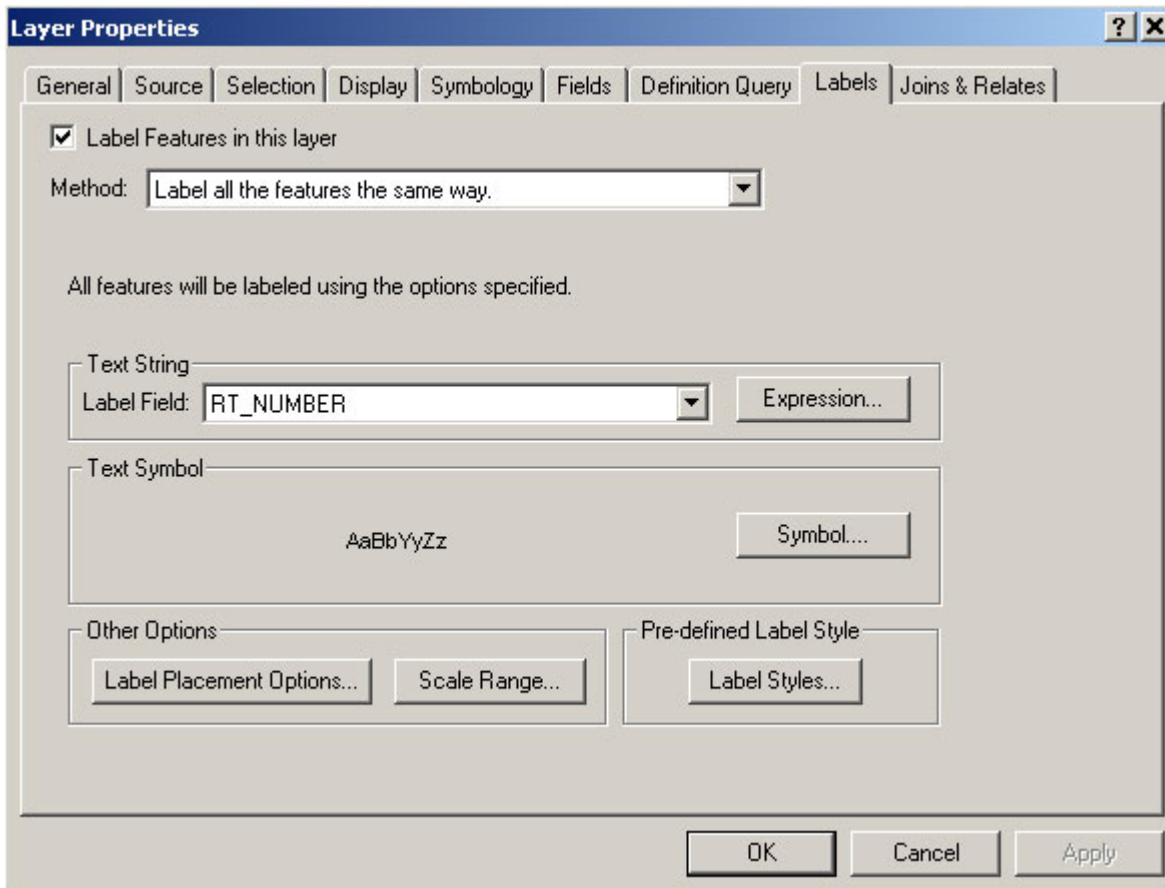



Fig. 11. Layer Properties - Lables Tap

### *Enhanced Layouts*

In Lab 1, you created a basic layout and made some simple customizations to it. Now, let's create a more elaborate layout that shows the comparison between the normalized and unnormalized population data. Since you have two data frames, if you create a layout view, Two data frames will be shown in the layout. Use **View > Layout view** to create a default layout using the "Portrait" template. Now you can see two frames in the layout. Adjust the size and location of each frames so they can be readable. Click right mouse button while putting the cursor on a data frame to check the properties of the frame.

In this layout we want the two view frames to be the same size and lined up vertically, with "Layer" frame higher on the page than "New Data Frame." Fortunately, ArcMap has tools to resize and align layout elements. Select the Arrow Pointer tool . Move "View1" near the top of the page and "View2" near the bottom, resizing them, if necessary, so that they both fit. You may also need to move the other layout elements. Now, hold down the **Shift** key, and click on both frames to select them. Click the right mouse button and choose **Align Center** from the **Align** menu.

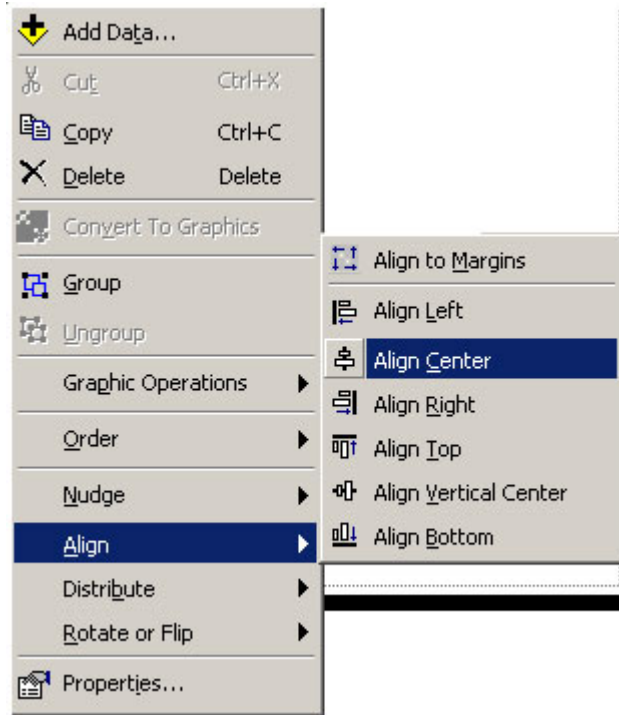
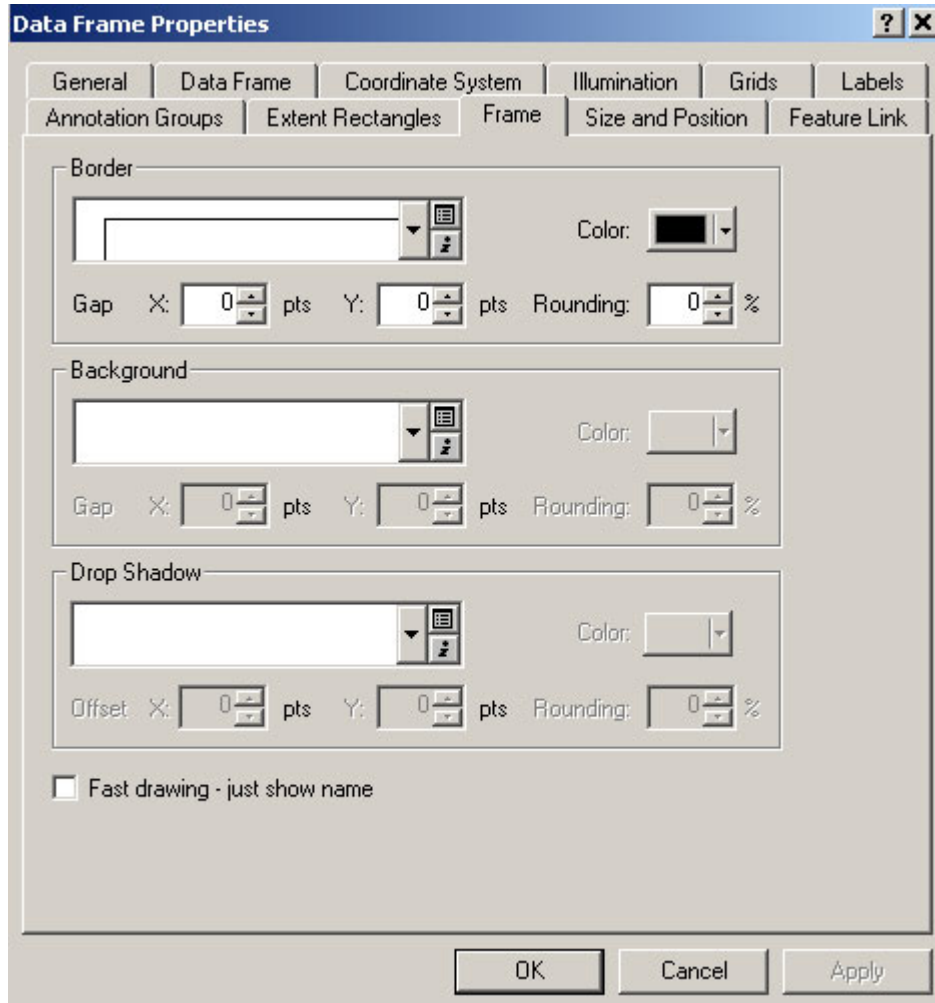


Fig. 12. Align Window

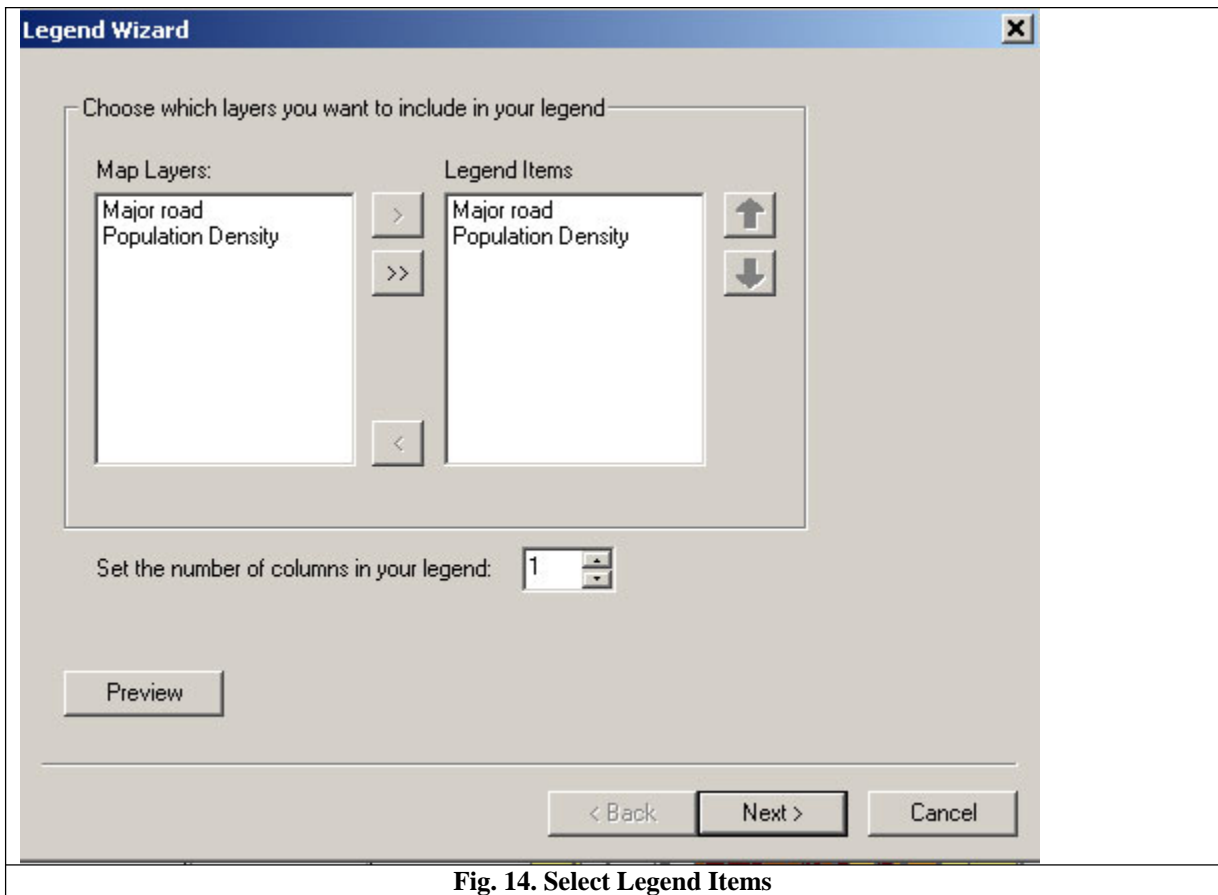
Now let's spiff up the frames by adding a **border line** around their edges. Select one of the view frames and click the right mouse button. Choose *properties* from the bottom of the drop down menu list. *Properties* window will come up. Select *Frame* tab then set the characteristics of border lines as you wish (we recommend keep default settings for this lab.) and click *OK*. You should see a black line forming a tight box around the view frame. Repeat this procedure for the other view frame.



**Fig. 13. Data Frame Properties - Border Line Setting**

Now, you need a legend, a scale bar, and a north arrow to make the layout view to a map. First, let's insert a legend for "Layers" frame, Activate the view frame either click it or click the name of data frame(Layers), click the right mouse button, and select activate from the drop down list. Then select the **Insert** menu from the menu bar, and select **legend**. Legend Wizard window will come up. Using the legend wizard, you can choose which layers to be shown in the legend. For this exercise, select all the name of layers shown in **Map Layers** space and click ">" button. Selected layers will be shown in the **Legend Items** space. Click **Next**. Change the legend title, set font, color and click **Next**. Now you can choose border line characteristics. Click **Next** and set spacing between the parts of your legend and click **Finish**. The legend will show up on the layout view. Follow the same steps, create legend for "New Data Frame". Also, insert scale bars and north arrow for both view frames.





**Fig. 14. Select Legend Items**

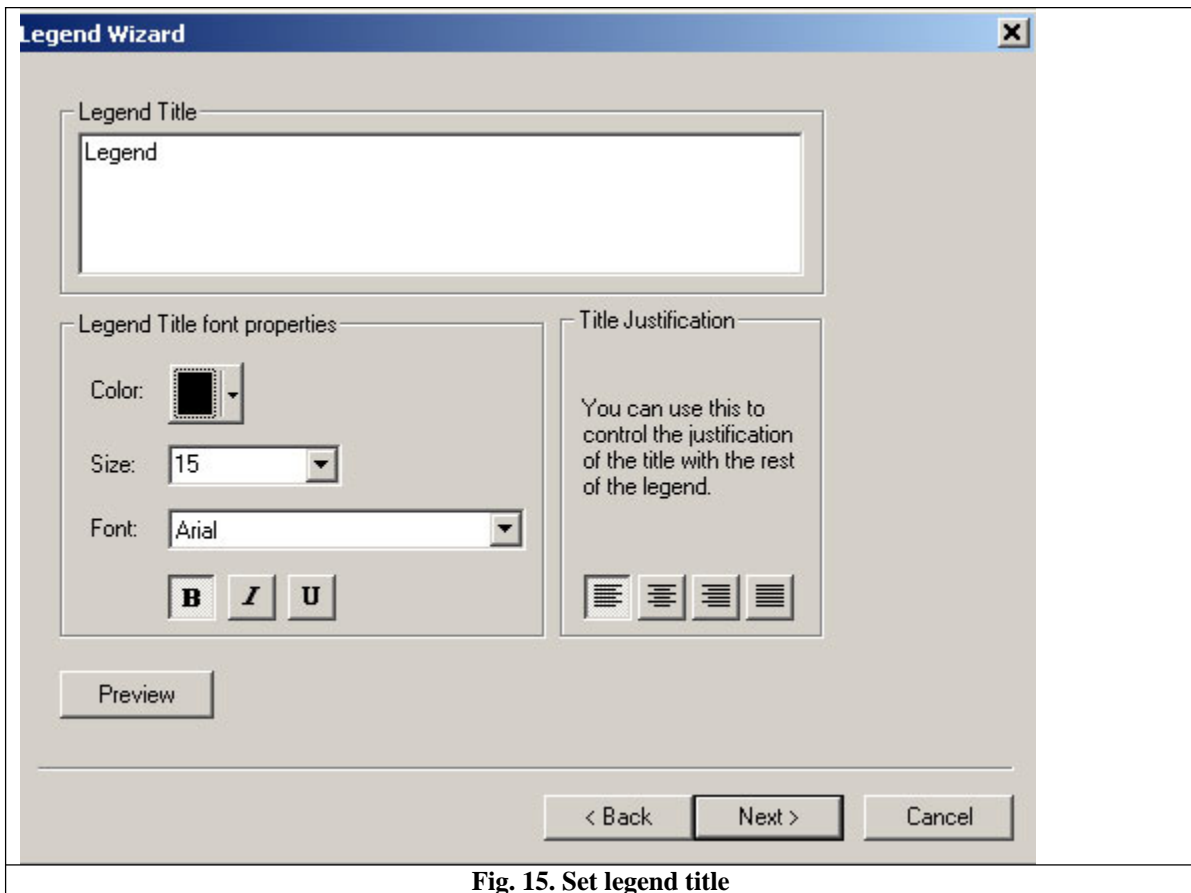
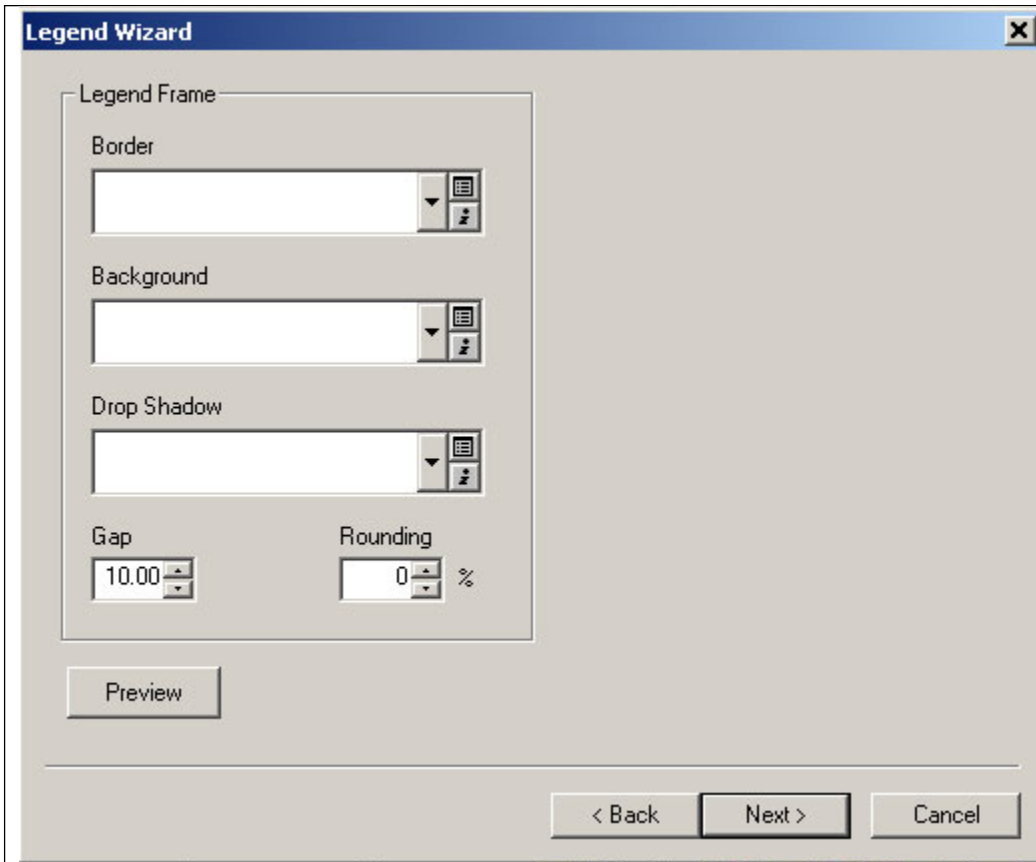


Fig. 15. Set legend title



**Fig. 16. Set Border Line**

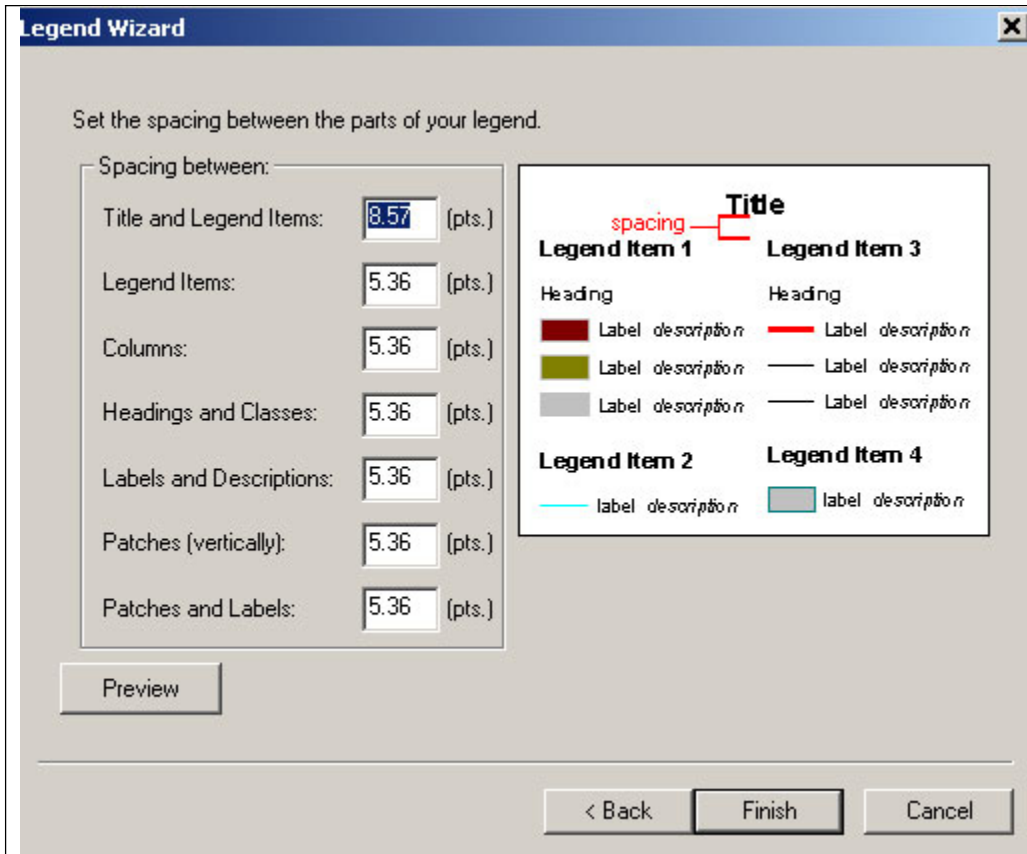


Fig. 17. Set Spacing between Parts

Finally, round off your map by setting the title of the layout to "Population of Cambridge, MA, 1990" and adding your name, today's date, and appropriate credit to the data source. When you're happy with the way that it looks, save your project, and print out your map.

## B. Explanatory Mapping

In this section of the lab we will create a map that makes a specific point. Explanatory maps try to zero in on more specific questions than exploratory maps. Hence, your choice of normalization, classification methods, and the like should be suited to the particular relationship or hypothesis that you postulate. Here we will ask -- and suggest an answer to -- the question, "What is the relationship between land use and home prices?"

### *Map Land Use and Sales Prices*

Open a new empty document and add these layers to it from the **M:\data** directory:

- Landuse85.shp
- Sales89\_shape.shp

Remember to set the map and Display units for the data frame. Rename this data frame "Land Use and Sales Prices."

Open the table for **Landuse85.shp** (click once on the layer to activate it and click right mouse button and select *Open Attribute Table*). The field called "Landuse" is the only one we're interested in.

### ***Refine the Symbolization***

Open the *layer properties* for **Landuse85.shp**. Change the "Symbology" to "Unique Value" and select "Landuse" as the "Values Field" then click "Add All Values." Your data is now classified by land use category. Notice that the colors the program automatically chooses are quite random. You can edit them manually, however. Notice in the top right-hand corner of the window are *Import* button. If you click the Import button, you can either using symbology definitions from other layer files or import ArcView (a previous version of ArcMap) legend file.

Fortunately for you, a legend was previously prepared for this layer using ArcView. Click the *Import* button, navigate to the usual **M:\data** directory and select the file **landuse.avl** (the **avl** stands for ArcView legend). Click *OK*. Your layer should pick up the saved symbolization choices. By default, ArcMap orders the categories (values) alphabetically, but we would rather group the residential categories together and have them at the top of the legend. Moving the categories helps us understand them better and will "read" much better on our final map. To move categories, simply click on a symbol and click the up and down arrow buttons in the right side of the window. Locate it where you would like it to be. Move the residential categories to the top:

- HIGH DENSITY RESIDENTIAL (R1)
- MED. DENSITY RESIDENTIAL (R2)
- MULTI-FAMILY RESIDENTIAL (RO)

When you are done click *Apply* to register your changes.

Open the *layer properties* for **sales89\_shape**. Using "Realprice" as your "Classification Field," try out the "Legend Types" "Graduated Color" and "Graduated Symbol." Also try the classification schemes "natural breaks," "quantile," and "equal interval." Remember the question we were interested in? Have these exploratory symbolization exercises shown you the relationship between sale price and land use? It's very difficult to see any type of pattern with so many data points, especially in a place like Cambridge, where high and low income neighborhoods are so close together. We'll now abandon the automatic classification settings and use some of our expertise to determine the classes. We'll look only at very high-priced properties and very low-priced properties. Change the number of classes to "3" in the *layer properties - Symbology tab* and click *Classify* button. Change the first number shown in "**Break Values**" from something like 474099 to 100000 and second number to 1000000. Now you have three categories, less than 100000, more than 1000000, and in between. Click O.K. and Change the color and size

of second category (realprice from 100000 to 1000000), so that two extreme values, lower than 100000 and higher than 1000000, stand out. Give the points bright colors that will show up on top of the land use layer. Notice that the high-priced properties are in the lowest density areas. We're on our way to making an explanatory map!

We do not have time to cover all of the symbolization possibilities in ArcMap. The built-in ArcMap help has some useful examples of thematic maps. To see them, select **Help Topics** from the **Help** menu. The Help system can take some time to launch. When the **ArcMap Help** window appears, click once on the "Contents" tab, double-click on the "Creating and Using Maps" book icon, double-click on the "Choosing colors and symbols" book icon, and double-click on "Types of thematic maps."

### ***Creating a Layout***

Using the same techniques outlined above in the Enhanced Layout section, create an attractive layout of the "Land Use and Sales Prices" view.

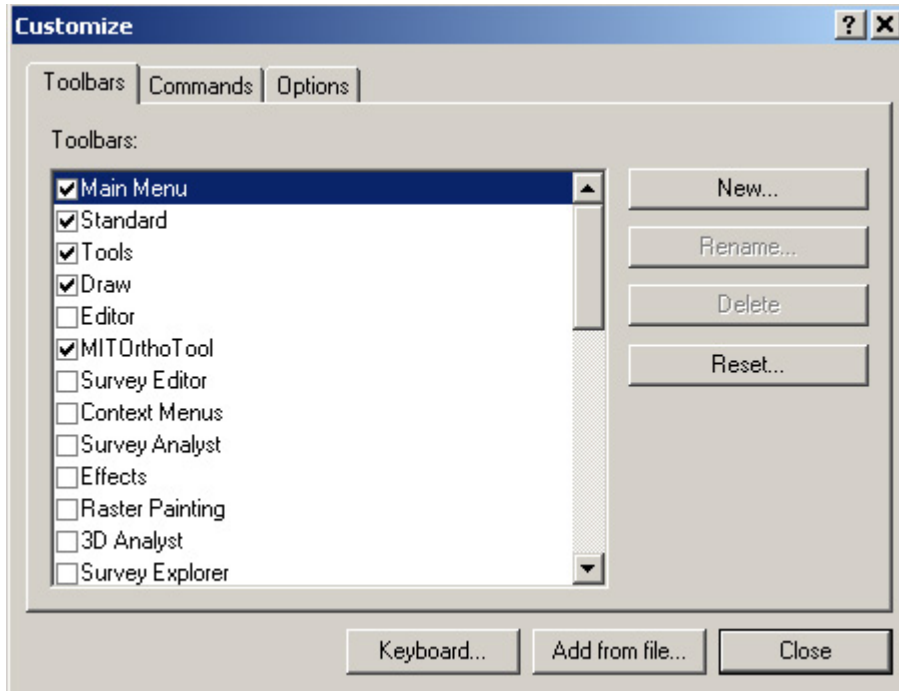
As an added refinement, add a "picture frame" to your layout that includes a CRN and a MIT logo. You will need to use Insert > Picture menu to insert following JPEG files in **M:\data**:

- **crnlogo.jpg** (CRN logo)
- **mitlogo.jpg**(small MIT logo)

Make sure to save your map document file before continuing with the next part of this exercise.

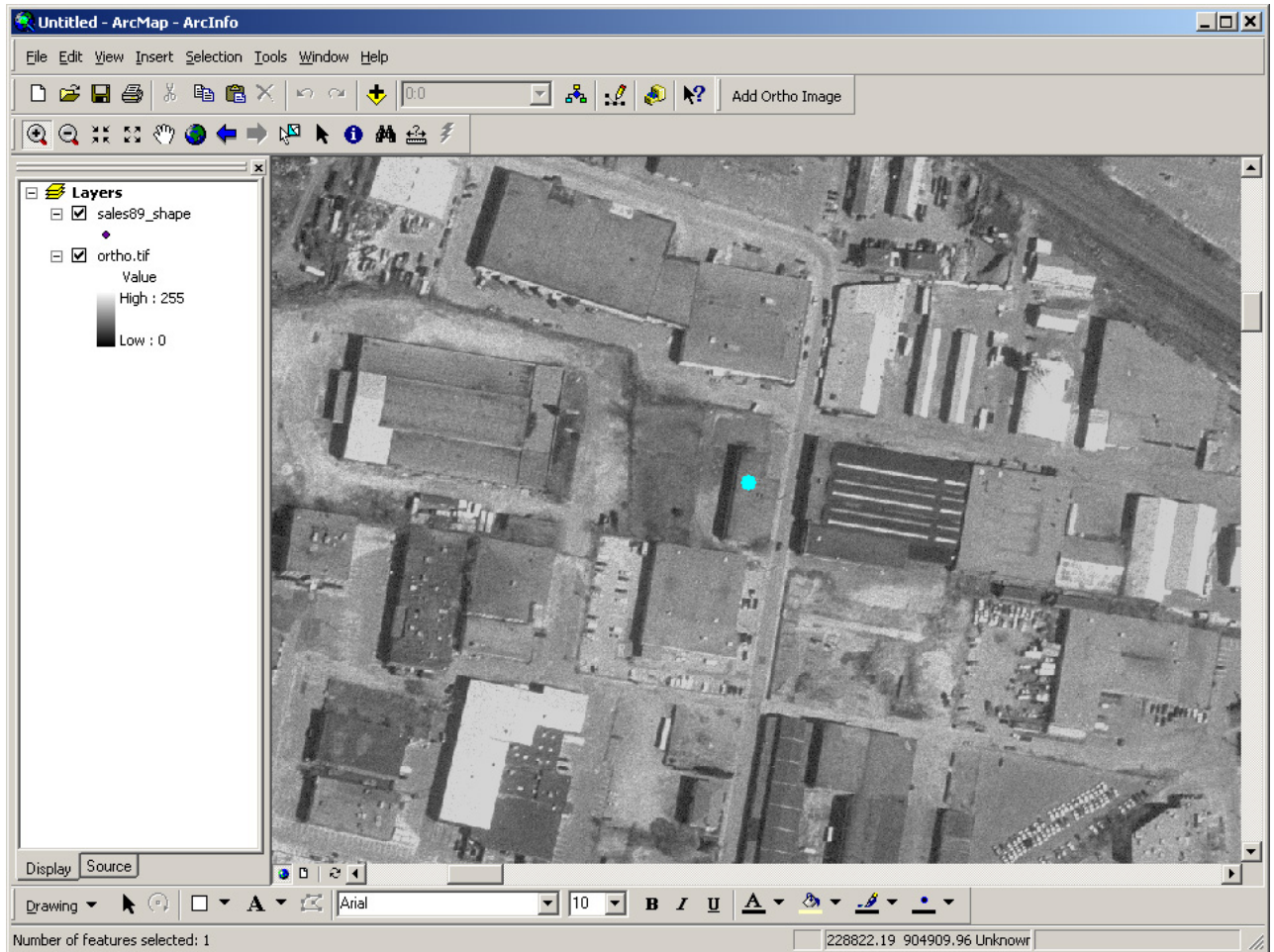
## **III. Using Digital Orthophotos in ArcMap**

We have developed the [MIT/MassGIS Digital Orthophoto web site](#) and now you will get the chance to experiment the MIT OrthoPhoto function. Before bringing orthophoto into ArcMap, we will add toolbar, which will activate the orthophoto function. First select **Tools > Customize** then **Customize** window will come up. Select **Toolbars** tab and scrolling down until you find "**MIT Ortho Tool**". Check it on. The toolbar will show in ArcMAP.



In your "Land Use and Sales Prices" view, turn off **Landuse85.shp** and leave **sales89\_shape** active. Now click on the **Add Ortho Image** button. It takes up to about one minute to load the photo from MIT Ortho server. Now, zoom in on one of the high priced sales in **sales89\_shape**. Notice how blocky the image became? That's because the ortho server gave you a low resolution image to cover all of Cambridge. Click on the **Add Ortho Image** button again to get a fresh, sharper image. Zoom out to see that the old image is gone, and now you have only a smaller, sharper one.

Now zoom in tightly on the sale point, so that the area contains only a few buildings. Click on the **Add Ortho Image** button again. If you're fortunate, you may see your point right on top of a fairly clear image of the building that was sold! Your view should resemble the following; the specific building may be different.



## IV. Exporting Maps from ArcMap

There are a number of reasons you might want to do something with your map other than print it from ArcMap. You may want to create a JPEG or PDF file for use on the web or just get the map into a graphics program to add some finishing touches. Here we consider these two popular formats.

**PDF format:** This is a format we will use often. Files in this format can be read using a free program called [Acrobat Reader](#). This program comes in a standalone version and as a web browser plugin. The benefit of this format over a JPEG and other bitmap formats is that it's resolution independent. You can zoom in and out of the map and print it at any scale. To create a PDF file from your layout in ArcMap, select **File > Export Map**. **Export** window will show up. From the Export window, select the file location, choose "PDF(\*.pdf)" option for Save as type, type the File name you want, then click **Export**.



**JPEG format:** Follow the same step describe above and choose "JPEG(\*.jpg)" as Save as type. Unfortunately, JPEG use "lossy" compression, meaning that a JPEG image is not fully faithful to the original. Artifacts caused by the lossy compression are often visible in JPEG versions of maps. Also, like any bitmap format, JPEGs have a fixed resolution, limiting the ability to zoom in effectively. JPEGs are useful for overview graphics on web pages, while PDFs can be used to supply the full detail.

## **V. Lab Assignment**

1. Create an exploratory map as described in II A and print it out in Black and White.
2. Create an explanatory map as described in II B and print it out in Color (There is a color printer "Echo" in room 37-312).

Note: All the maps you produce should contain your name, a title, legend, north arrow, scale bar, data source attribution, and, for the Question 2 map, a CRN and MIT logo.

3. Export the two above maps into .pdf format and make it available online.

**Lab 2 is due by the beginning of the class in Lab 3.**