

Geographic Information Systems (GIS 101) Workshop

Sponsored by U-Spatial

Section 1	Welcome	8:30 - 8:45
Welcome		
Introductions		
Outline of day		
Accessing data		
Section 2	Introduction to GIS and ArcGIS	8:45 - 10:45
Exercise 1		
Intro to GIS		
Functions		
Software		
Data		
Exercise 2		
Esri ArcGIS		
ArcMap		
Exercise 3		
ArcCatalog		
Search		
ArcToolbox		
Section 3	Preparing Data for Use in GIS	10:45 - 12:00
Data sources		
NHGIS		
Natural resources		
Public health		
Design		
Joining data a feature class (shapefile)		
Attribute tables		
Primary key		
Joining		
Exercise 4		
Section 4	Thematic mapping	
Standardizing data		
By population		
By area		
Classification		
Jenks		
Quintile		
Equal interval based on range		
Equal interval manual		
Exercise 5		
Lunch	12:00 - 1:00	

Section 5	Map elements	1:00 - 2:30
	Title	
	Legend	
	Scale bar	
	Source information	
	Projection	
	Color	
	Color ramps	
	Diverging	
	Qualitative data	
	ColorBrewer.org	
	Geographic context	
	Visual hierarchy	
	<i>Exercise 5 continued</i>	
Section 6	Geocoding	2:30 - 3:15
	Theory of geocoding	
	Address locator	
	Creating tabular data	
	Using the geocoding tool	
	Rematching addresses	
	<i>Exercise 6</i>	
Section 7	Selection and Spatial Analysis	3:15 - 4:15
	Select by location	
	Select by attribute	
	Spatial analysis examples	
	Proximity	
	Overlay	
	Dissolve	
	<i>Exercise 7 or Exercise 8</i>	
Closing		4:15 - 4:30
	Questions	
	Other resources	
	uspatial.umn.edu	

ACCESSING COURSE DATA

Download Course Data

Step 1. Navigate to the U-Spatial homepage, <http://uspatial.umn.edu>

Step 2. Click *Training* in the navigation menu at top of the page

Step 3. Under *Workshops*, *Desktop GIS 101*, click *Workshop Materials* to download the data

Fall 2015 Workshops

Mapping 101: Introduction to Spatial Analysis using ArcGIS Online

This five-hour workshop introduces participants to web-based mapping and spatial analysis using Esri's ArcGIS Online. Through a combination of lectures and hands-on activities, participants will learn the fundamentals of designing and sharing online maps. Topics covered include preparing data for use, online data sources, map design, and spatial analysis.

- [UMN Employees: Registration Information](#)
- [Non-Employees: Registration Information](#)
- [Download Workshop Materials](#)

Desktop GIS 101: Analyzing Data and Creating Maps

This seven-hour workshop introduces participants to using a geographic information system (GIS) to analyze data and create maps. Through a combination of presentations and hands-on exercises, participants will learn basic GIS concepts and the fundamentals of spatial analysis. While this workshop is taught using Esri ArcMap software, the concepts apply to geographic information systems in general.

- [UMN Employees: Registration Information](#)
- [Non-Employees: Registration Information](#)
- [Download Workshop Materials](#)

Extract Data to Local Storage

Step 4. Navigate to the location where you downloaded the data (likely the *Downloads* folder)

Step 5. Right-click on the GIS101 zip file and select *Extract All...*

Step 6. Extract the contents to the C drive by deleting everything after *C:* and clicking *Extract*

Select a Destination and Extract Files

Files will be extracted to this folder:

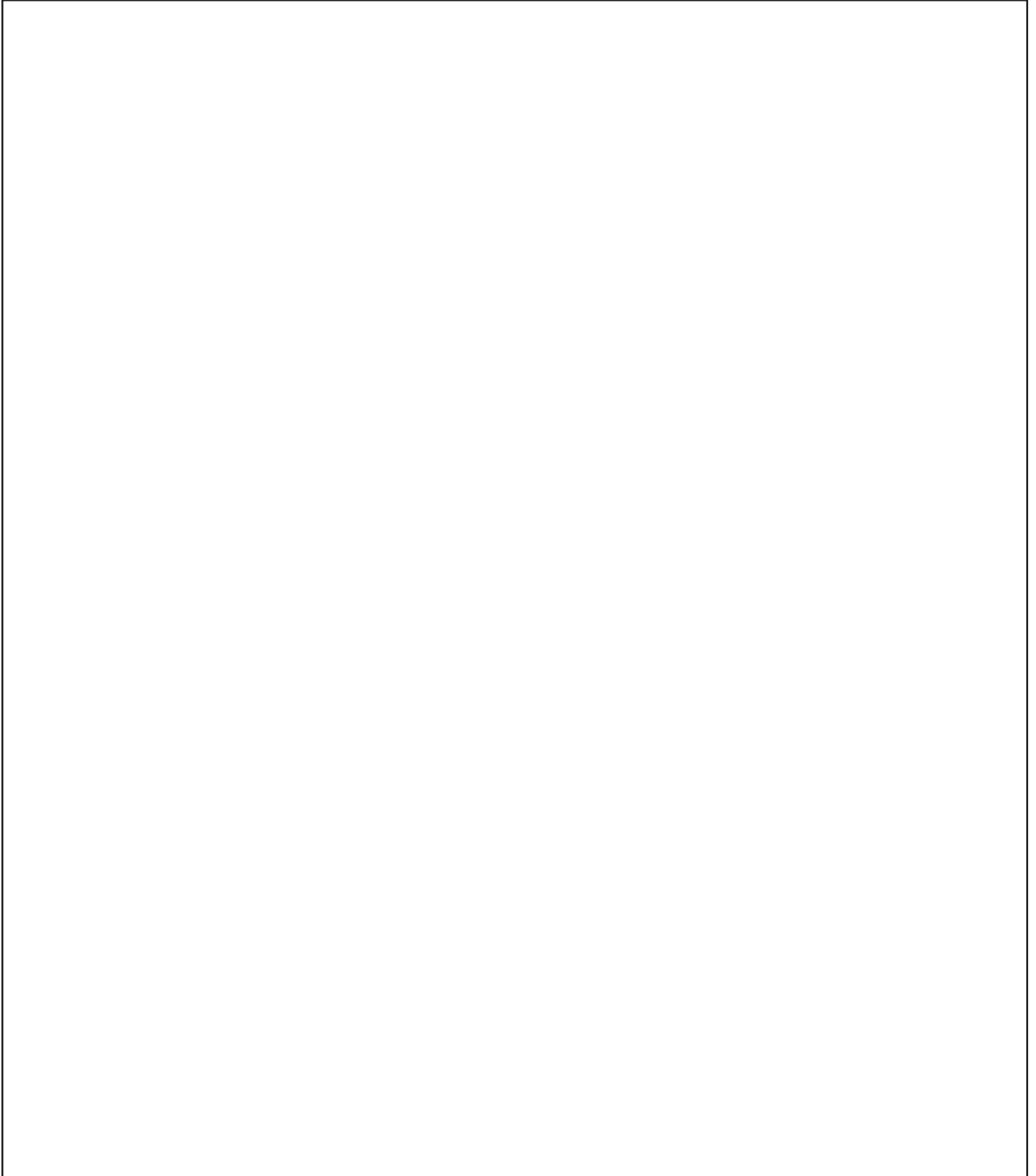
☒ Show extracted files when complete

Note: For the remainder of the course, you'll be able to access your data and maps by navigating to *C:\GIS101*

EXERCISE 1

Creating a Map

In this exercise, we'll start by drawing a simple map from memory. Choose a location and try to represent it in map form. You might include streets and paths, trees and houses, or areas and borders.

A large, empty rectangular box with a thin black border, intended for drawing a map from memory. The box occupies the majority of the page below the instructions.

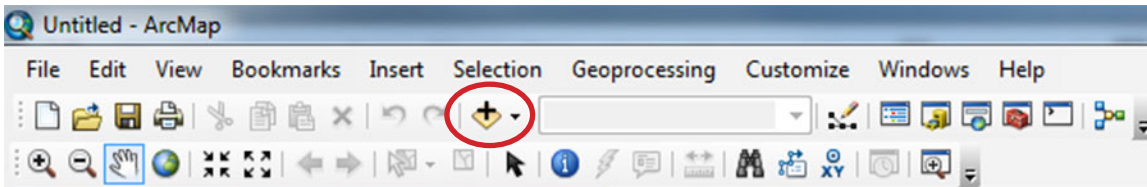
EXERCISE 4

Opening ArcMap and Adding Data to Your Map

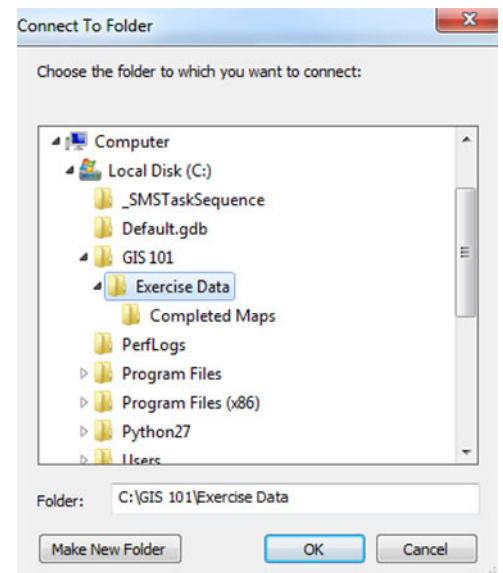
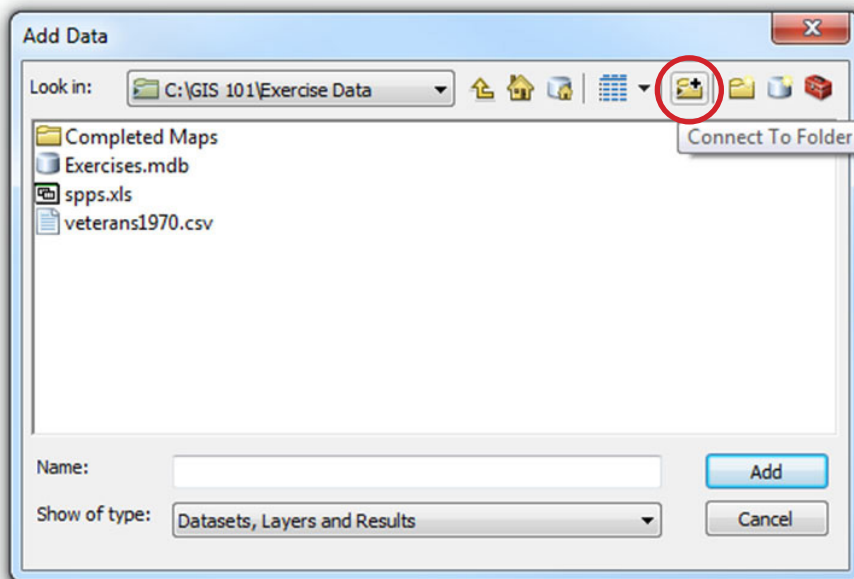
Step 1. Close any instances of ArcMap you may have already opened

Step 2. Navigate to C:\GIS101\Exercise Data\ and open *Exercise 4.mxd*

Step 3. Click the *Add Data* button in the toolbar



Step 4. In the *Add Data* window, click on the *Connect To Folder* button and connect to C:\GIS101\Exercise Data\



Step 5. Examine the contents of *Exercise Data*. It looks different in ArcMap than it does in Windows Explorer.

Completed Maps – finished versions of the maps you'll create in each exercise
Exercises.mdb – a geodatabase containing all of the geographic data for today's exercises
spps.xls, *veterans1970.csv* – two spreadsheets that we'll use later in the course

Step 6. Double-click on *Exercises.mdb* to look inside. You'll see a series of sub-folders, these are referred to as *feature datasets* in ArcMap. The different feature datasets contain the data for each of the upcoming exercises.

Step 7. Within *Exercises.mdb*, double-click on the *Exercise 4* feature dataset and add ***MinnesotaCntys*** to your map.

Step 8. Retracing your steps from before, click the *Add Data* button again, click the *Up One Level*  button twice, and add the spreadsheet ***veterans1970.csv*** from the *Exercise Data* folder.

Step 1. Right click on *MinnesotaCntys* in ArcMap's Table of Contents and select *Open Attribute Table*. The table will display as either a stand-alone window or docked at the bottom of the screen. It will look something like this:

OBJECTID	Shape	DECADE	NHGISNAM	NHGISST	NHGISCTY	ICPSRST	ICPSRCTY	ICPSRNM	STATENAM	ICPSRSTI	ICPSRCTYI
1	Polygon	2000	Dakota	270	0370	33	370	DAKOTA	Minnesota	33	370
2	Polygon	2000	Winona	270	1690	33	1690	WINONA	Minnesota	33	1690
3	Polygon	2000	Itasca	270	0610	33	610	ITASCA	Minnesota	33	610
4	Polygon	2000	Todd	270	1530	33	1530	TODD	Minnesota	33	1530
5	Polygon	2000	Kittson	270	0690	33	690	KITTSO/PEMBINA	Minnesota	33	690
6	Polygon	2000	Wright	270	1710	33	1710	WRIGHT	Minnesota	33	1710
7	Polygon	2000	Rock	270	1330	33	1330	ROCK	Minnesota	33	1330
8	Polygon	2000	Redwood	270	1270	33	1270	REDWOOD	Minnesota	33	1270
9	Polygon	2000	Sibley	270	1430	33	1430	SIBLEY	Minnesota	33	1430

Step 2. Right click on *veterans1970* in the Table of Contents and select *Open*. You should now see two tabs at the bottom of the table, one for *veterans1970* and one for *MinnesotaCntys*:

YEAR	GISJOIN	GISJOIN_X	GISJOIN_Y	STATE	STATEA	COUNTY	COUNTYA	GEOCOMP	GEOCOMPA	CHARITER	CHARITEA	Vietnam
1970	G2700010	-44.788428	9.743506e+015	Minnesota	270	Atkin	10	Total area	0	All races	0	135
1970	G2700030	123.786364	1.044454e+016	Minnesota	270	Anoka	30	Total area	0	All races	0	4440
1970	G2700050	25.883459	1.120381e+016	Minnesota	270	Becker	50	Total area	0	All races	0	398
1970	G2700070	-114.443481	1.202682e+016	Minnesota	270	Beltrami	70	Total area	0	All races	0	611
1970	G2700090	-22.355584	1.291965e+016	Minnesota	270	Benton	90	Total area	0	All races	0	673
1970	G2700110	-148.665322	1.388903e+016	Minnesota	270	Big Stone	110	Total area	0	All races	0	105
1970	G2700130	-80.13936	1.494244e+016	Minnesota	270	Blue Earth	130	Total area	0	All races	0	1985
1970	G2700150	-97.147933	1.608815e+016	Minnesota	270	Brown	150	Total area	0	All races	0	566
1970	G2700170	112.53884	1.733537e+016	Minnesota	270	Carlton	170	Total area	0	All races	0	174

To view both tables at once, click on the *Table Options* button in the upper-left corner of the current table and choose *Arrange Tables* and *New Horizontal Tab Group*. You may need to resize the table window.

Let's examine both tables. In order to join these two tables we must first find a common field. A common field is a column that has the same information in both attribute tables and allows us to identify a unique row. In this case, *GISJOIN* is our common field. Try to find it in both tables.

Step 3. Close the attribute tables.

Step 4. In the table of contents, right-click on *MinnesotaCntys* and select *Joins and Relates* and then *Join...* from the menu.

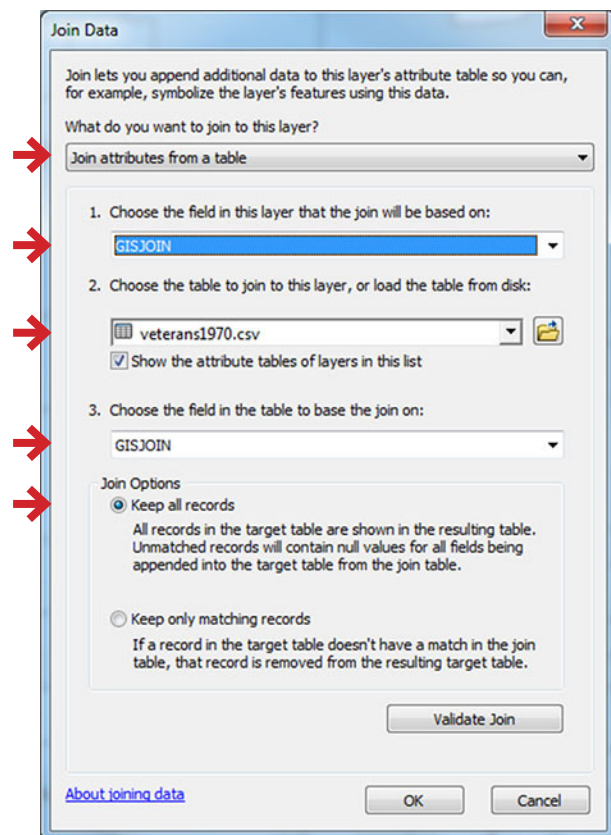
In this process, we are going to join attributes from the *veterans1970* spreadsheet to the features (counties) in the *MinnesotaCntys* file based on their common field, *GISJOIN*.

Step 5. Using the drop-down boxes, enter the following settings into the Join Data menu:

1. Field in this layer: **GISJOIN**
2. Table to join: **veterans1970.csv**
3. Field in the table: **GISJOIN**
4. Join options: **Keep all records**

Click *OK* to join the two files.

Note: In general, it's best to click on *Validate Join* to check for any potential joining errors before clicking *OK* to complete the join.




Step 6. Open the attribute table for *MinnesotaCntys* and use the slider bar at the bottom of the table to scroll all the way to the right. If your join was successful, you should see the tabular data from *veterans1970* appended to the far-right of the *MinnesotaCntys* table:

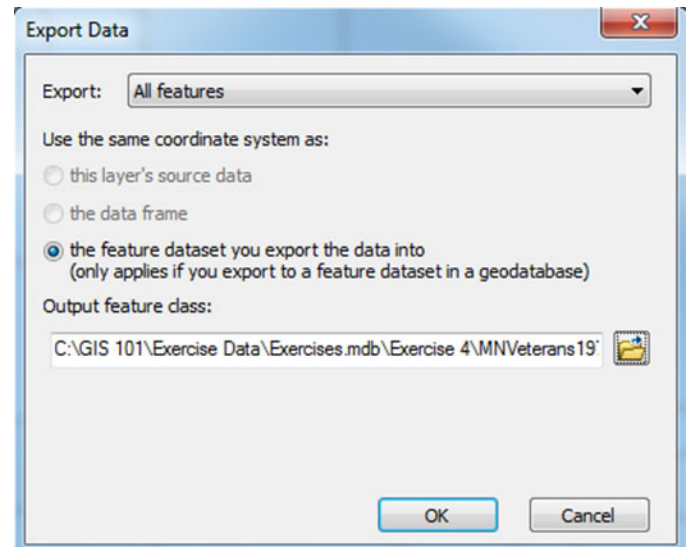
MinnesotaCntys												
COUNTYA	GEOCOMP	GEOCOMPA	CHARITER	CHARITEA	Vietnam	Korean	KoreanWWII	WWII	WWI	OtherSrv	Nonveteran	Pop1970
370	Total area	0	All races	0	4065	4307	577	7420	636	4465	19369	139808
1690	Total area	0	All races	0	1072	773	97	2260	319	764	10027	44409
610	Total area	0	All races	0	693	688	142	2557	408	674	6790	35530
1530	Total area	0	All races	0	279	539	25	929	314	284	4930	22114
690	Total area	0	All races	0	92	142	0	457	51	150	1525	6853
1710	Total area	0	All races	0	836	922	64	1722	383	931	7467	38933
1330	Total area	0	All races	0	289	218	28	600	114	203	2217	11346
1270	Total area	0	All races	0	168	453	47	993	197	358	4375	20024
1430	Total area	0	All races	0	322	364	30	613	133	351	3609	220693
1510	Total area	0	All races	0	257	198	22	753	120	218	2884	13177

MinnesotaCntys (0 out of 87 Selected)

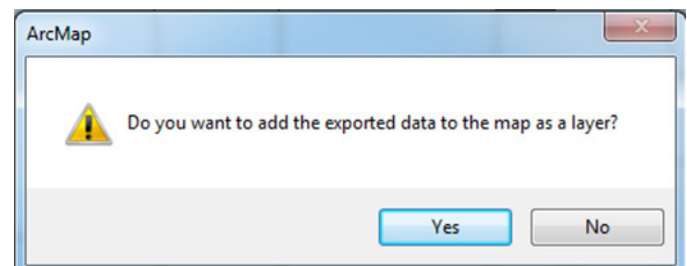
Step 7. These two tables appear to be joined, but the join is only temporary. If we were to close ArcMap now, we would lose this joined data. In order to make the join permanent, we must export the data as a new feature class. Do this by right-clicking on *MinnesotaCntys* in the table of contents and selecting *Data > Export Data*.

From the Export Data window, use the *Browse*  button to navigate to the *Exercise 4* feature dataset. Note that you might have to change the setting under *Save as type*: from *shapefile* to *File and Personal Geodatabase feature classes* in order to see the *Exercise 4* feature dataset.

Once you've found the correct folder, enter *MNVeterans1970* as the name for your file and click *Save*.



When prompted, click *Yes* to add the exported data to the map as a layer.



Step 8. Remove *MinnesotaCntys* and *veterans1970.csv* from your table of contents by right-clicking on them and selecting *Remove*.

Step 9. Save your map (you can keep the same name) and close ArcMap.

This is the end of Exercise 4.

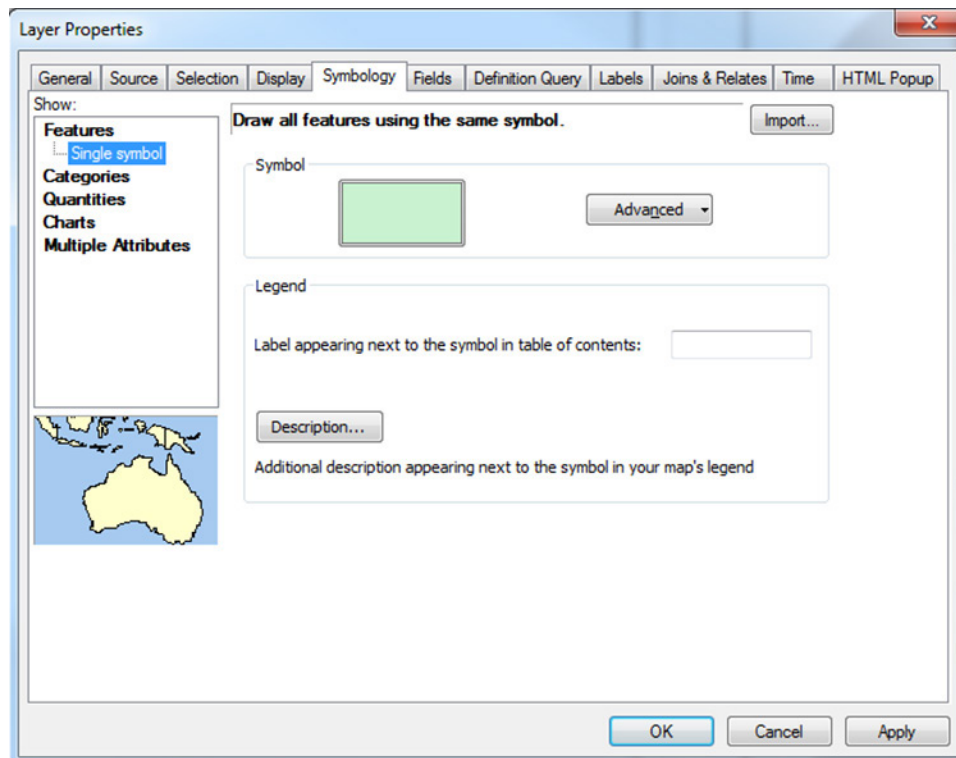
EXERCISE 5

Opening The Exercise Document

Step 1. Navigate to C:\GIS101\Exercise Data\ and open *Exercise 5.mxd*

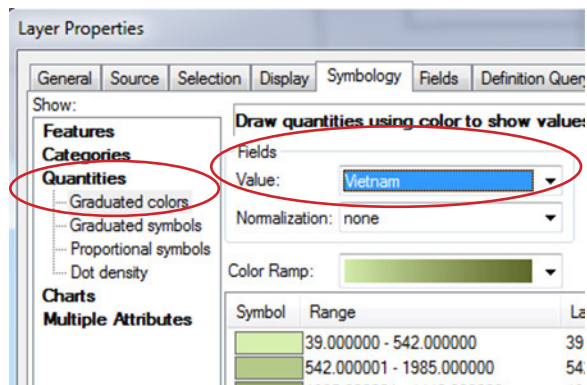
Displaying Spatial Data

Step 1. The options for displaying spatial data are located in the *Properties* menu. Let's look at the properties for ***MNVets1970***. To do so, right click on ***MNVets1970*** in the table of contents and select *Properties*. Then, click on the *Symbology* tab. Your screen should now look like this:



Step 2. At left, click on *Quantities*, then *Graduated colors*.

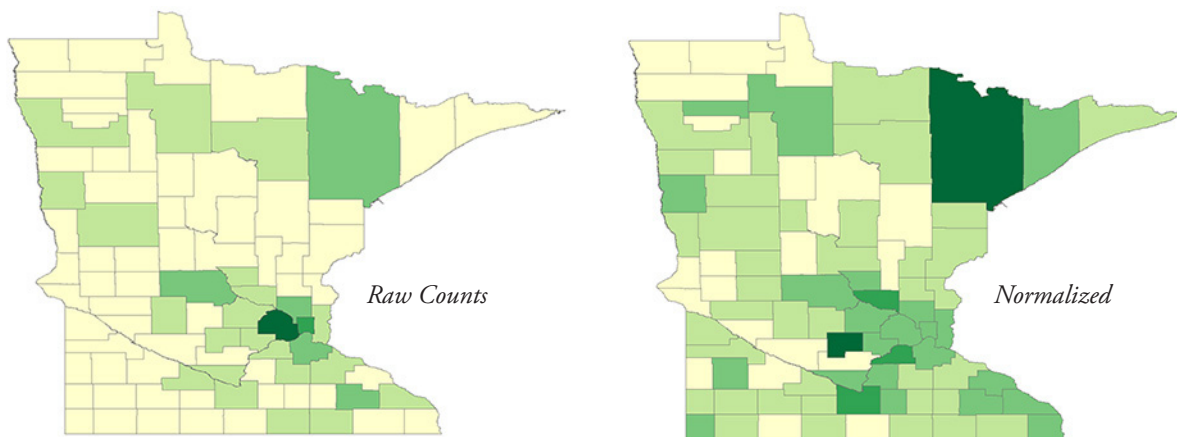
Step 3. Next to *Value* under the *Fields* menu (***NOT the Fields tab***), select *Vietnam* from the drop-down menu. Recall that *Vietnam* is a field from our original spreadsheet that was joined to the shapefile of Minnesota counties. See the image below for reference. Select any color palette you'd like. If your other settings match, click *OK*.



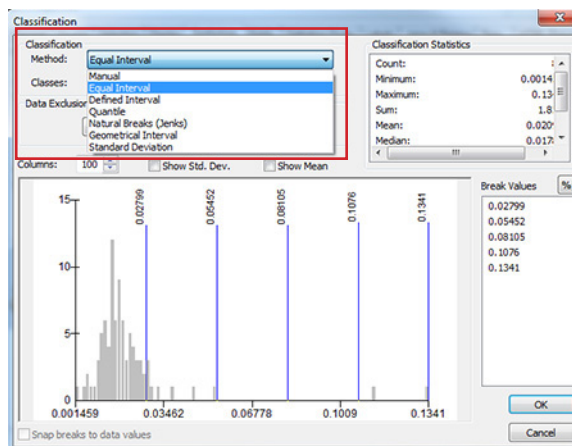
Step 4. You now have a map showing raw counts of Vietnam veterans by county in Minnesota. This map shows a distinct spatial pattern: Hennepin County has the highest number of Vietnam veterans. However, we have not *normalized* (divided) the data by population, thus the veteran counts are not comparable across counties. We can figure out the percentage of Vietnam veterans by normalizing the number of veterans by the total population in each county.

Step 5. Return to the *Symbology* tab under the *Properties* menu for *MNVets1970*. This time, keeping *Vietnam* as the value under *Fields*, select *Pop1970* from the drop-down menu next to *Normalization*. Click *OK* to apply the changes.

The two maps below show Vietnam veteran data by county for Minnesota. The map at left shows raw counts, while the map at right shows Vietnam veteran counts normalized by total population. Take a moment to visually compare the two maps:

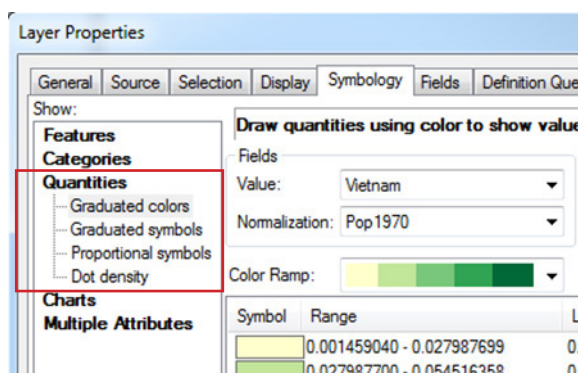


Step 6. Once again, return to the *Symbology* tab. At right, under *Classification*, click *Classify...* and spend some time testing out the different classification schemes and class numbers. After selecting a classification scheme, click *OK* in the *Classification* menu and then click *Apply* in the *Layer Properties* menu. Your map will update to display the data with the new classification scheme. **Note:** You may have to move the window to see your map.



Step 7. Back in the *Symbology* tab, test out the other methods for displaying quantities: *Graduated symbols*, *Proportional symbols*, and *Dot density*. Do this by clicking *Apply* for each classification method to view it on your map.

When you've finished exploring classification and symbology, return to a graduated color map showing Vietnam Veterans normalized by Total 1970 population.



Step 8. Click *File*, then *Save* to save your map. **Stop here, Exercise 5 will continue after the next lecture.**

EXERCISE 5 CONTINUED

Important Map Elements

- **Title**
- **Legend**
- **Scale Bar**
- **Sources**
- **Projection**
- **Color**
- **Geographical Context**
- **Visual Hierarchy**

Working with Layout View

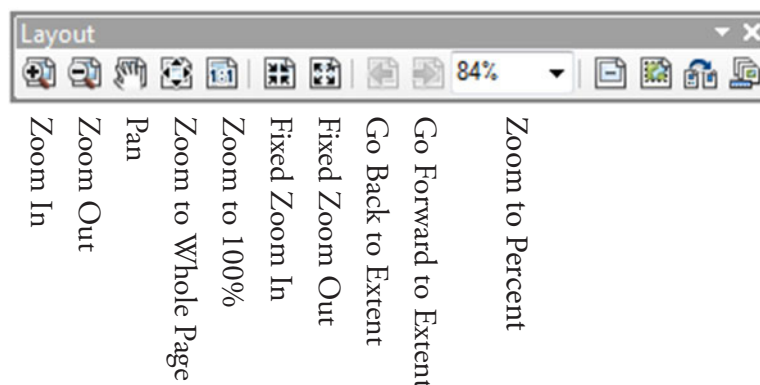
Step 1. Put your display in *Layout View*. To accomplish this, click on the small button located in the lower left hand corner of the display panel, immediately to the right of the table of contents. **Hint:** the button looks like a sheet of paper.



You can think of layout view as a virtual page. We use layout view to add finishing touches to our map, such as the legend, scale bar, and title.

After switching to layout view, the layout toolbar becomes active.

Take a moment to explore its tools:

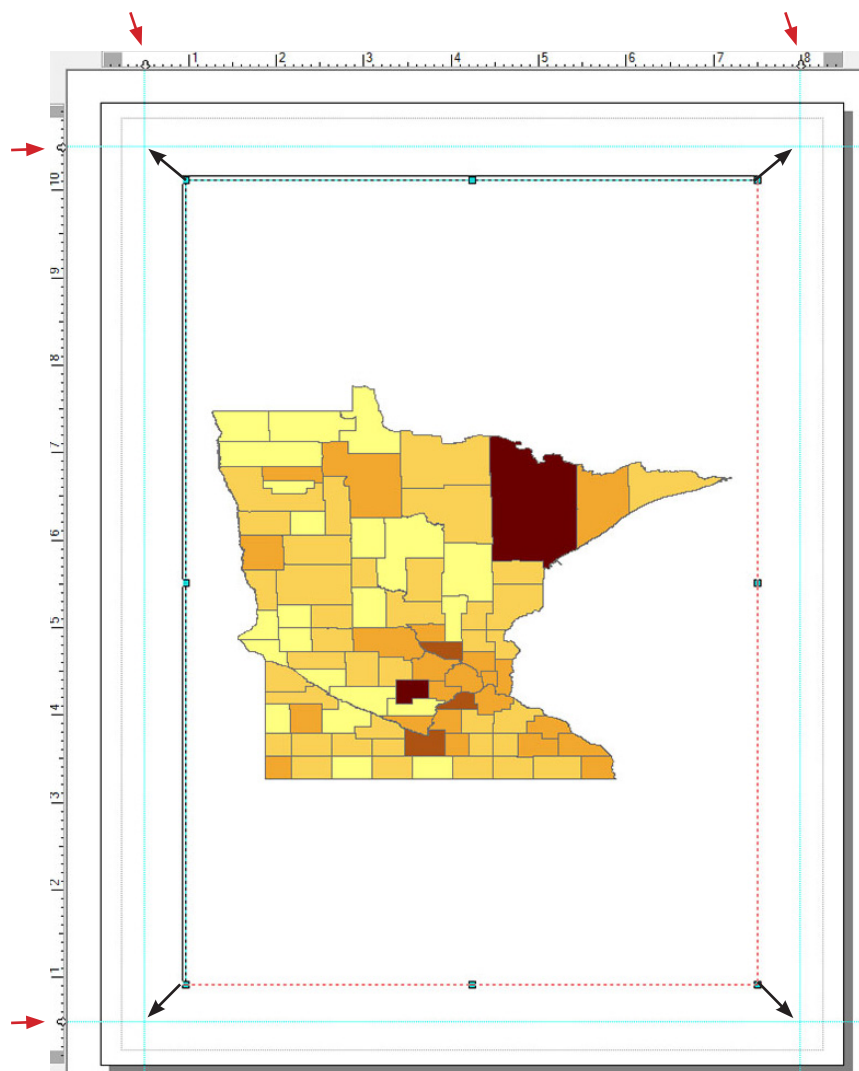




Step 2. Place 1/2 inch guides around the edge of your document to frame the workspace. Do this by single-clicking on the rulers at .5" and 8" on the horizontal axis and .5" and 10.5" on the vertical axis. You can adjust the guides by clicking and dragging.

When your guides are appropriately placed, click and drag your map frame to meet the guides. It should snap into place. Take a look at the image at right for reference.

Alternatively, the data frame size can be adjusted by right-clicking on the data frame and specifying width and height values under *size* in the *Size and Position* tab.

Use this method when specifying a precise data frame size is important.



Step 3. Back on the data frame toolbar (*not the layout toolbar*), use the Zoom In  and Zoom Out  tools to fit the map comfortably in the center of the display area. Your goal is use the space as effectively as possible, limiting white space, while being careful to avoid cutting off any part of the map.

Add a Title

Note: A good title includes the theme, place, and time for the data being mapped.

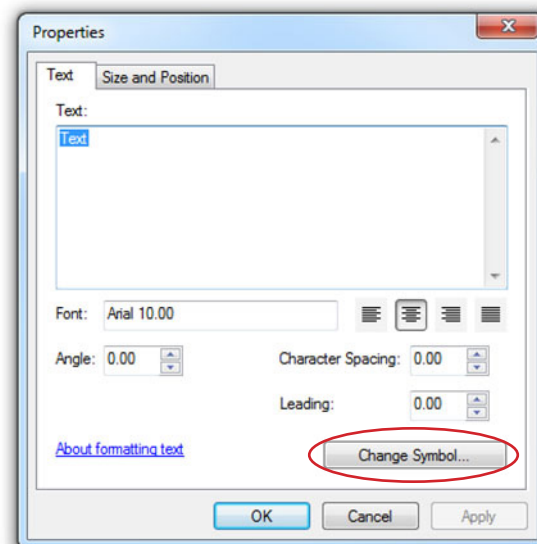
Step 1. Select *Text* from the *Insert* menu. A tiny box containing the word *Text* should appear near the center of your map.

Step 2. Double-click on the text box to open its properties menu.

Step 3. Give your map a meaningful title, for example, “Vietnam Veterans in Minnesota by County, Census 1970.” It’s okay if your title takes up more than one line.

Step 4. Click on *Change Symbol...* to change the title font. Change the typeface, size, and style to your liking (at least 20 pt).

Step 5. Click *OK* twice and drag your title to the top of the map.



Add a Legend

Step 1. Select *Legend* from the *Insert* menu.

Step 2. In the *Legend Wizard*, make sure that *MNVets1970* is included under *Legend Items*. If so, click *Next*.

Step 3. Erase the word *Legend* under *Legend Title* and click *Next*.

Step 4. If desired, select a border for your legend.

Note: *Gap* refers to the amount of space between the legend items and the border. A gap of 10.00 is common. *Rounding* is specified as a percentage, referring to the rounding of the border's corners. It is not necessary to change the default settings.

Step 5. Click *Next*, *Next*, and *Finish* to exit the Legend Wizard.

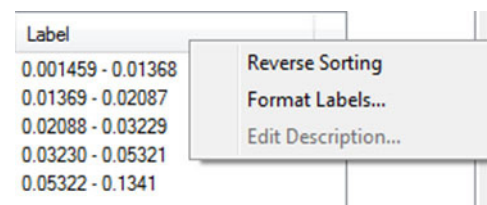
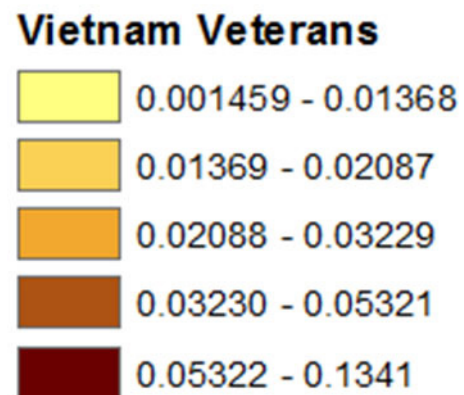
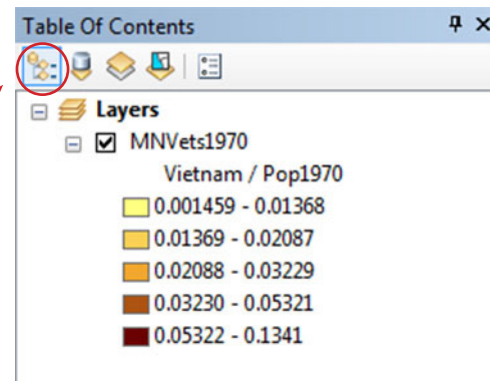
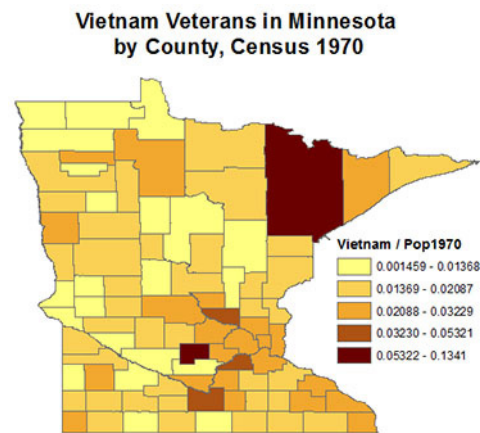
Step 6. Move your legend to an appropriate place on your map.

Step 7. In the table of contents, click the *List by Drawing Order* button in the upper left-hand corner. This allows for a simplified view of the legend and will let us rearrange our layers as we add them in the following steps.

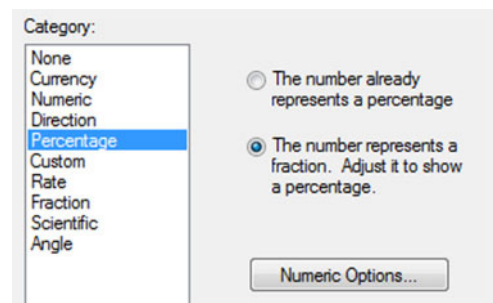
Step 8. Still working in the table of contents, re-label the legend by clicking on *MNVets1970*, pressing F2, and then entering a more appropriate title, such as “*Vietnam Veterans*.” Press the *Enter* key to update the title. Notice the change reflected in your map's legend. See the example at right.

Step 9. Click on *Vietnam / Pop1970*, press F2, remove the label by pressing *Backspace* or *Delete*.

Step 10. Next, let's format the numbers in the legend to make them easier to read. Since these numbers represent percentages of veteran population, we'll change them accordingly. To do so, right click on *MNVets1970* in the table of contents, select *properties*, and open the *symbology* tab. Click on ***Label*** and select ***Format Labels...***



Step 11. Select *Percentage* from the *Category* menu. Then, click the radio button next to “*The number represents a fraction. Adjust it to show a percentage.*” Click on *Numeric Options...* and reduce the number of decimal places to 2. Click *OK* on all of the proceeding windows until you’re back to your map. Take a look at your legend to verify that it’s displaying as a percentage.



Add a Scale Bar

Step 1. Select *Scale Bar* from the *Insert* menu

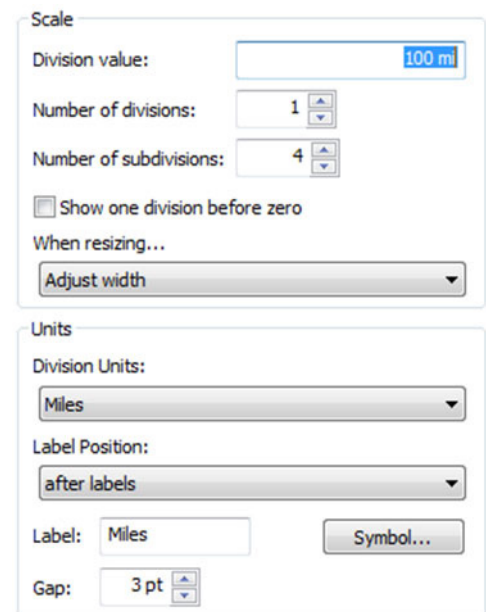
Step 2. Select an appropriate scale bar, such as *Scale Line 1*

Step 3. Click on the Properties button to examine the scale bar options. Make sure that Miles is listed under Division Units. Click *OK* twice to place the scale bar on your map.

Note: Be sure to select an appropriate division unit for your maps. In this case, miles are a logical choice for division units, but that wouldn’t necessarily be the case at a different scale or geographic location.

Step 4. Let’s make a few edits. Double-click on the scale bar to open its properties menu. In the dropdown below *When resizing...*, choose *Adjust width*. Then, change the *Division value* to 100 mi and the *Number of divisions* to 1.

Step 5. Lastly, place your scale bar in an appropriate place on your map.

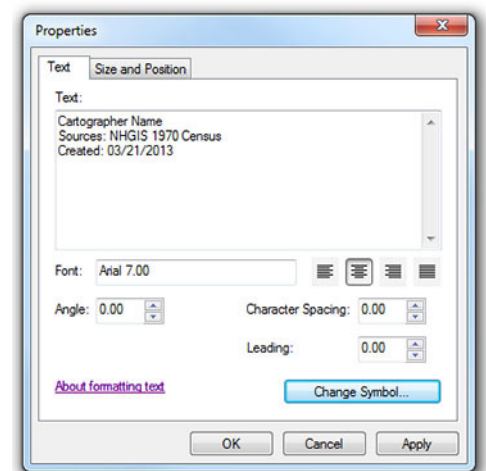


Add Sources and Text

Step 1. We’ll use the same steps we used to insert a title to insert our source information. (**Hint:** Insert > Text). Be sure to reduce the font size using the options under *Change Symbol...*

Step 2. Enter your name, the data source(s), and the date the map was created.

Step 3. Place your sources somewhere out of the way, such as the bottom corner or under the legend.



Projections

Note: Thousands of projections exist! We will not cover them in detail in this course. We'll be using a *State Plane* projection designed for central Minnesota in this exercise, though we have a number of other options.

Step 1. Right-click on *Layers* in the table of contents and select *Properties*. Navigate to the *Coordinate System* tab.

Step 2. Type "State Plane" in the projection search box.

Step 3. Click through the file tree in the following order to find the desired projection: Projected Coordinate Systems > State Plane > NAD 1983 (US Feet) > **NAD 1983 StatePlane Minnesota Central FIPS 2202 (US Feet)**. When you've found it, select it and click *OK*.

Note: After projecting, you may need to adjust your map using the zoom and pan tools. Do so now.

Color

Note: ColorBrewer (colorbrewer2.org) is a fantastic resource for color options for cartography. In addition to offering a wide range of color ideas for different types of data, ColorBrewer also allows you to select colors that are colorblind safe, printer friendly, or photocopy-able. Remember to follow best practices from lecture when selecting your colors!

To download the ColorBrewer styles:

Step 1. Navigate to <http://tinyurl.com/lhcx52>

Step 2. Click on the yellow "download" button

Step 3. Click the radio button to agree to the license agreement and click the yellow "download" button again

Step 4. If prompted, save the file to your *downloads* folder. Otherwise, it will save there by default.

Step 5. Navigate to your downloads folder

Step 6. Right-click on the folder you downloaded, *ASI4403*, and select *Extract All...*

Step 7. Extract the file, *ColorBrewer.style*, to a meaningful location (e.g. a flash drive, your current workspace, etc.)

To load the ColorBrewer styles into ArcMap:

Step 1. In ArcMap, click *Customize* on the main menu bar and select *Style Manager...*

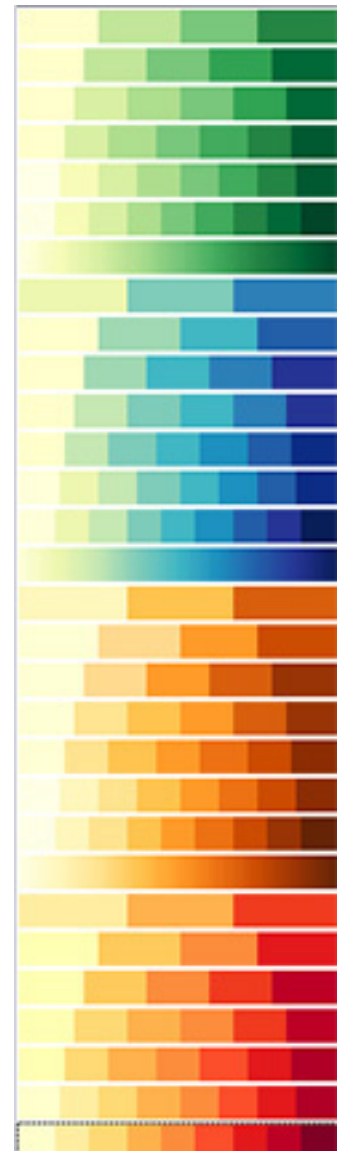
Step 2. Click *Styles...* on the right side of the Style Manager window

Step 3. Click *Add Style to List...*

Step 4. Navigate to the location where you extracted the *ColorBrewer.style* file, select it, and click *Open*

Step 5. Click *OK* and then *Close*

You will now see the ColorBrewer styles when you examine the color ramps drop-down in the symbology menu. Take a few minutes to browse through the color ramps and select one for your MN Veterans data.



Step 1. Click the *Add Data* button

Step 2. Navigate to C:\GIS101\Exercise Data\Exercises.mdb\Exercise5 and add **LakeSuperior** and **BorderStates** to your map.

Note: You can add multiple datasets at once by holding down *Ctrl* or *Shift* while selecting the data.

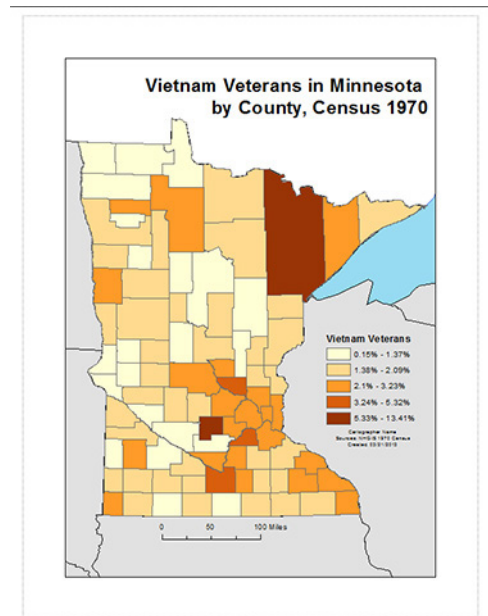
Step 3. Reorder the files so that *Vietnam Veterans* is the topmost layer in the table of contents.

Step 4. Remove *BorderStates* and *LakeSuperior* from the legend. Do this by double-clicking on the legend and opening the *General* tab. Click on the unwanted items under *Legend Items* and use the “<” button to remove them from the box.

Step 5. Change the fill colors for *BorderStates* and *LakeSuperior* to something more appropriate.

Step 6. Change the data frame's background color to make it look as though we have a data layer for Canada. Right-click in the white space above Minnesota and select *Properties...* Next, click on the *Frame* tab and select a light gray fill for the background. Click OK.

Step 7. Save your map and close ArcMap. Congratulations, you've just completed a basic thematic map!



Optional Challenge: Geographical Context

Finished early and feeling up for an additional challenge?

In the exercise above, we simply changed our map's background color to imitate a shapefile for Canada. Now, let's see if we can find an actual shapefile to put in its place.

Step 1. Using a web search, locate a shapefile of Canada's provincial boundaries.

Step 2. Download and unzip the file.

Step 3. Connect to the folder in which you unzipped the shapefile and add it to your map.

Step 4. Symbolize the layer appropriately and remove it from the legend.

Which step was the most time-consuming?

EXERCISE 6

A Definition of Geocoding

Geocoding is the process of assigning geographic coordinates to an address. In other words, it's the process we use to transform a table of addresses into a series of corresponding points on a map.

Prepare Data for Geocoding

Step 1. Open *Exercise 6.mxd* from the *Exercise Data* folder

Step 2. Click the Add Data button and add the following layers:

GIS101\Exercise Data\Exercises.mdb\Exercise 6**Stpaul** - A polygon shapefile of St. Paul
GIS101\Exercise Data\Exercises.mdb\Exercise 6**Stpaulrds** - A line shapefile of St. Paul roads
GIS101\Exercise Data\spps.xls**Sheet1\$** - An Excel table of St. Paul Public Schools

Step 3. Make *Stpaul* a light gray color and *Stpaulrds* two shades darker.

Step 4. Change the data frame's projection to **Ramsey County** (NAD 1983 HARN Adj, US Feet)

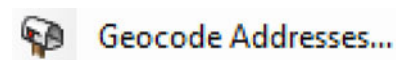
We'll use this simple map as a background to help us visualize the school location data we're about to geocode.

About Address Locators

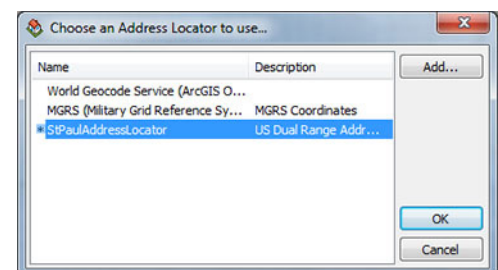
An **Address Locator** is a dataset that includes important information for matching addresses, including address attributes. There are a number of different styles of address locators for various address formats around the world. In this activity, we are using an address locator that was created based on St. Paul's road network.

Geocoding Addresses

Step 1. Right-click on **Sheet1\$** in the table of contents and select *Geocode Addresses...*

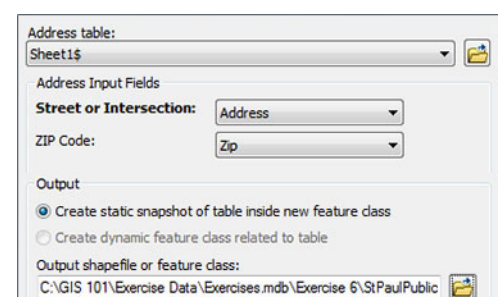


Step 2. Choose StPaulAddressLocator from the pop-up when prompted to choose an address locator. **Note:** You will need to click *Add...* and then navigate up to *Exercises.mdb* to locate StPaulAddressLocator.

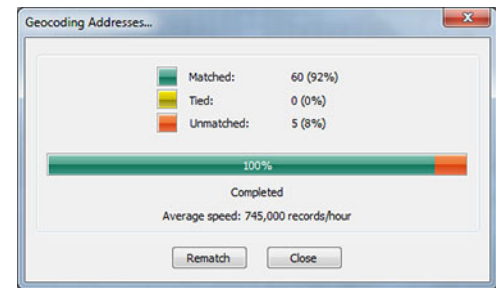


Step 3. Make sure **Address** is selected as the field next to *Street or Intersection* and **Zip** is selected for *ZIP Code*. The geocoder will use these fields to locate addresses.

Step 4. Change the Output Feature Class so your output file is called **StPaulPublicSchools** and it is located in the *Exercise 6* feature dataset within the *Exercises* Database. Click **OK** to geocode the addresses.



Step 5. This brings up the Geocoding Results Menu. Your results may differ, but in the example at right we see that 60 schools were matched, 0 were tied, and 5 were unmatched. We'll look at rematching addresses in a moment. For now, click *Close*.

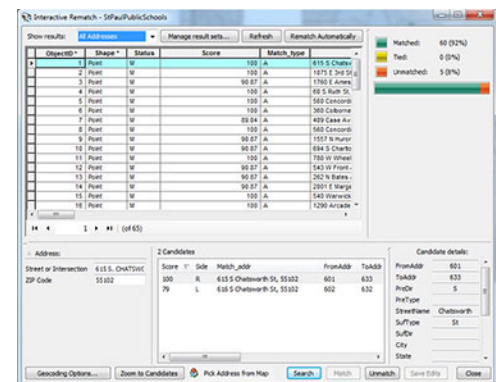


You should see something like this on your screen. Each dot on the map represents one of the 60 successfully-geocoded addresses. Your table of contents likely says “*Geocoding Result: StPaulPublicSchools.*” Change the layer name to ***St. Paul Public Schools***.



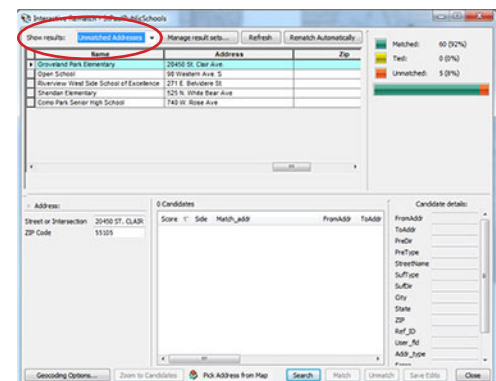
Step 6. Right-click on *St. Paul Public Schools* in the table of contents and select *Data > Review/Rematch Addresses...* to bring up the *Interactive Rematching* window.

We'll be using this interface to correct the addresses that weren't matched when we geocoded our table of St. Paul public schools.

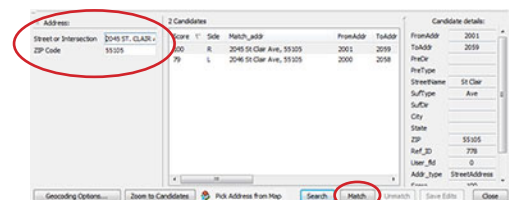


Step 7. Select ***Unmatched Addresses*** from the drop-down in the upper-left hand corner of the Interactive Rematching window, next to *Show Results*. This simplifies things by only showing us the unmatched results.

Note: You'll need to scroll over to the right to find the important information in the table (e.g. school name, address, etc.).



Step 8. Use the web to find the problems with your unmatched addresses. There may be errors in the address or zip code. When you've found the correct address, enter it into the *Address* box in the lower-left corner and hit the Enter key to update the list of candidates. When you have a match above 80%, select it and click *Match* in the lower-right corner and continue on until all addresses are matched.



Optional Challenge: Symbolize Schools by Type

Our dataset includes elementary, middle, and high schools. As such, it might be useful to use a unique symbol for each school type on our map.

Step 1. Right-click on *St. Paul Public Schools* in the table of contents and open its layer properties window

Step 2. Click on the Symbology tab if it is not already selected

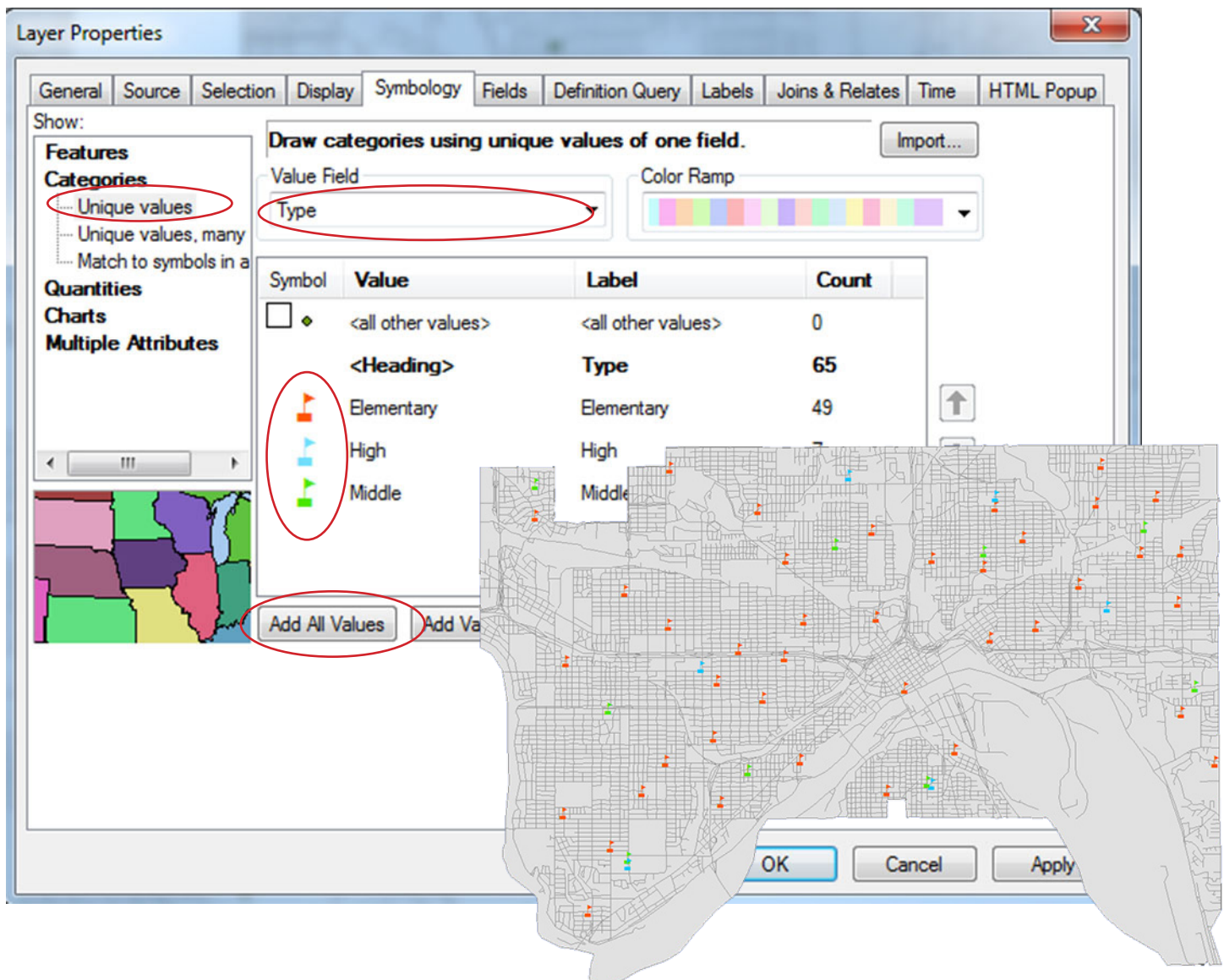
Step 3. In the left pane, under *Show:*, select *Categories* and then *Unique values*

Step 4. Select *Type* from the *Value Field* drop-down

Step 5. Click on *Add All Values*

Step 6. Double-click on the symbol for each school type and change it to something appropriate

Step 7. Save your map and close ArcMap



EXERCISE 7

Exercise Objectives

In this exercise, we'll employ three techniques from lecture:

1. Selecting by Attributes
2. Selecting by Location
3. Spatial Join

Getting Started

Step 1. Open the *Exercise 7.mxd* map document from the *Exercise Data* folder.

Step 2. Verify that there are three layers on your map — schools, roads, and the city boundary for Saint Paul.

Step 3. Add *convstores* to your map from the *Exercise 7* feature dataset. These points represent convenience stores. They have already been geocoded for you. Change the layer symbol to something that contrasts with the schools layer.

Selecting by Attributes

Before we start asking questions about our data, (such as, “How many convenience stores are within ¼ mile of a school?”) let's focus our analysis by extracting out only the high schools in St. Paul. To do so, we'll select them from the schools layer and export them as a new layer.

Step 1. On the main menu, click on *Selection* and choose *Select by Attributes...* from the drop-down menu.

Now, using the Select By Attributes window, we're going to build a selection query to select only the high schools.

Step 2. For *Layer:*, select *StPaul_Schools*. For *Method:*, choose *Create a new selection*.

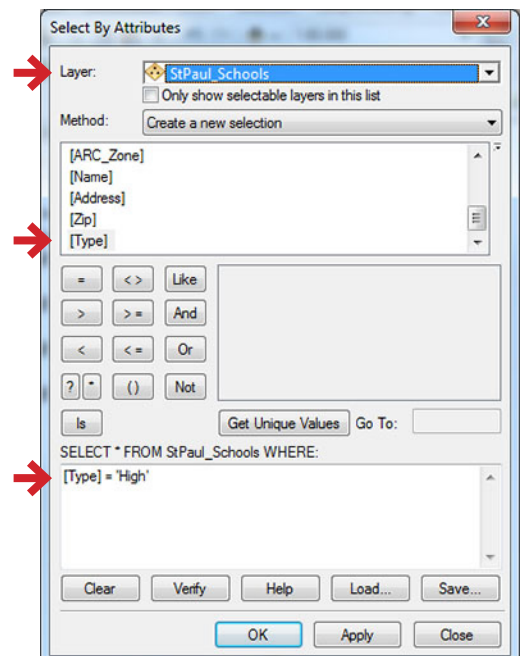
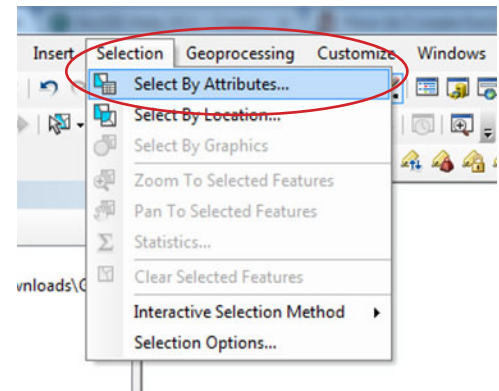
Step 3. Scroll down and double-click on *[Type]* from the menu. Once clicked, it should appear in the text box at the bottom of the window.

Step 4. Click on the “=” button from the menu at center.

Step 5. Click on *Get Unique Values* to bring up a list of all the values in the Type field. Double-click on *'High'* from the menu.

Your selection query should read: `[Type] = 'High'`

Step 6. Click *OK* to run the selection query.

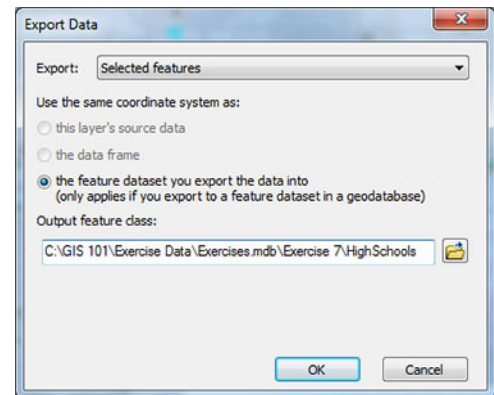


Notice that some of the schools turned blue. These are the selected features. In this case, they are the high schools.

Next, let's export them as a new layer.

Step 7. Right-click on *StPaul_Schools* in the table of contents and select *Data > Export Data*.

Step 8. Save the new layer as ***HighSchools*** in your *Exercise 7* feature class. When prompted, click Yes to add the layer to the map.



Selecting by Location: A Case Study

Let's use our new layer of high schools for a little case study. Suppose we're working in the public health field and we want to find out which convenience stores are located within walking distance of a high school in St. Paul. Information like this might be useful in targeting obesity among high school students — convenience stores are stocked with candy, soda, and other unhealthy products at relatively inexpensive prices.

Our goal is to reach out to convenience stores owners whose stores are located within one mile of a high school.

Selecting by Location: Procedures

Step 1. In the Selection drop-down, select Clear Selected Features to remove your previous selection.

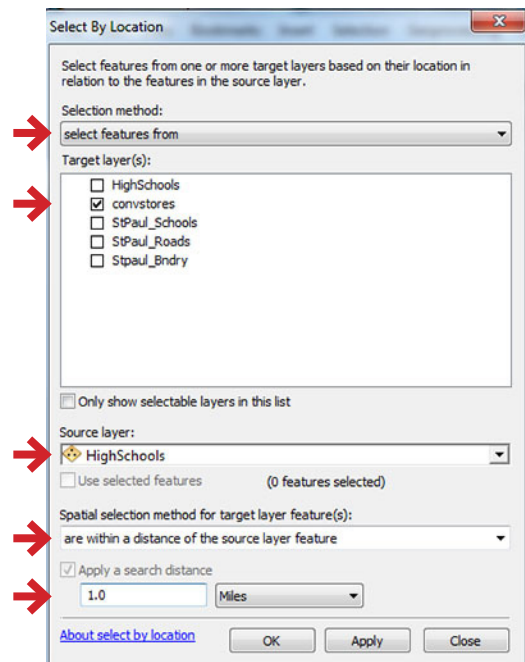
Step 2. Back in the selection drop-down, choose *Select By Location...*

Step 3. Modify the Select By Location settings as follows:

1. Selection method: ***Select features from***
2. Target layer(s): ***convstores***
3. Source layer: ***HighSchools***
4. Spatial selection method: Target layer feature(s) are ***within a distance of the source layer feature***
5. Apply a search distance: ***1.0 Miles***

Step 4. Click OK to view the convenience stores that are within one mile of a high school.

Step 5. Export the selected features from the *convstores* layer as a new layer and change their symbology to distinguish them as a feature of interest. **Hint:** Right-click on convstores, data > export data.



Buffering

Using the Select by Location tool allowed us to see which convenience stores are within a certain distance of high schools, but what if we want to know *how many* convenience stores are within a certain of *all schools*?

In this section, we'll create a 0.5 mile buffer zone around each school. In the following section, we'll spatially join the buffered layer and the convenience stores layer to get a count of the convenience stores within half a mile of each school.

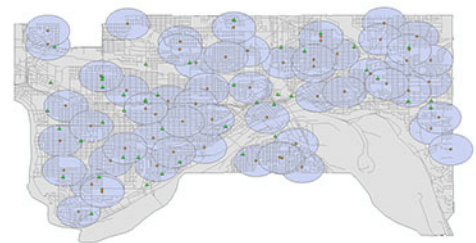
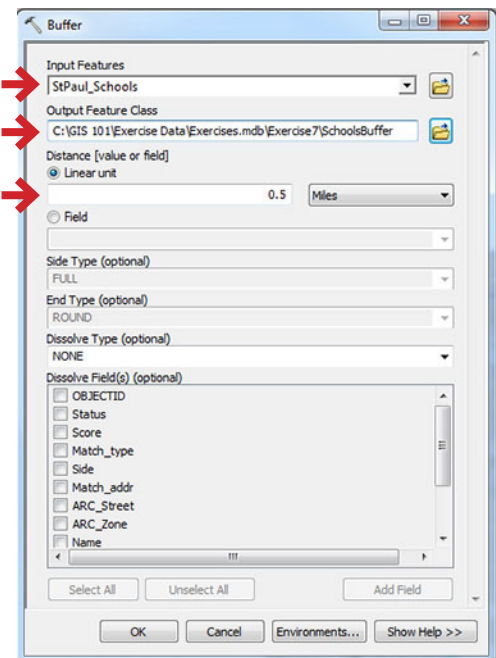
Step 1. Make sure your table of contents contains *convstores*, *StPaul_Schools*, *StPaul_Roads*, and *Stpaul_Bndry*. You can remove the other layers.

Step 2. Locate the **Buffer** tool from the Geoprocessing drop-down menu. **Note:** Alternately, you can access it through *ArcToolbox* > *Analysis* > *Proximity* > *Buffer*.

Step 3. With the Buffer window open, enter the following settings:

Input Features: ***StPaul_Schools***
Output Feature Class: ...***Exercise 7\SchoolsBuffer***
Linear unit: ***0.5 Miles***

Step 4. Click **OK**. You should see a half-mile buffer around each school in a new layer called *SchoolsBuffer*.



Spatial Join

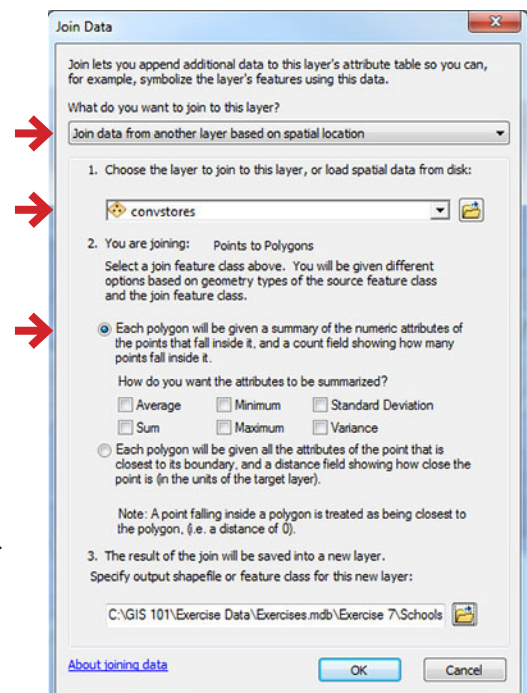
Step 1. Right-click on *SchoolsBuffer* in the table of contents and select *Joins and Relates* > *Join...* to open the Join Data menu.

Step 2. Enter the following settings in the Join Data menu:

What do you want to do to join this layer? **Join data from another layer based on spatial location**
Choose the layer to join to this layer...: **convstores**
Click the button for **“Each polygon will be given a summary of the numeric attributes...”**
Save the new file as: ...**Exercise 7\SchoolsBuff_Stores**
Press **OK**

Step 3. Open the attribute table for *SchoolsBuff_Stores*. Scroll to the right and find the field called *Count_*. It contains the number of convenience stores within a half mile from each school. Sort this column by right-clicking on the field name and selecting *Sort Descending...* Which school is surrounded by the most convenience stores?

Step 4. Congratulations, you're done! Save and close ArcMap.



EXERCISE 8

Exercise Objectives

In this exercise, we'll employ the following techniques from lecture:

1. Selection using the select tool
2. Selecting by location
3. Selection by attributes
4. Buffer
5. Intersect
6. Dissolve

Our goal is to determine the best place for a nature lover to live in Minnesota, based on the following criteria:

1. In a town with a population greater than 1,000 people
2. Within two miles of a boat trailer launch
3. In a state forest
4. In an area of mixed deciduous and coniferous forest

Getting Started

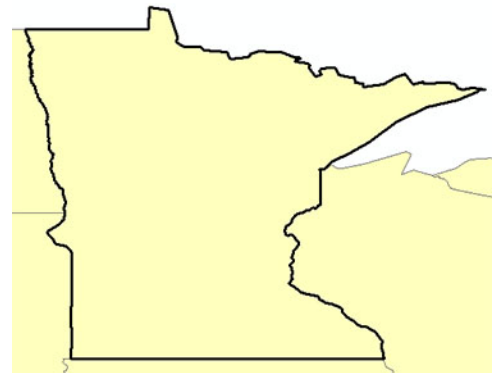
Step 1. Open *Exercise 8.mxd* from the *Exercise Data* folder. You should see a map document with a layer called *States* (turned on) and a layer called *Cities* (turned off).

Using the Select Tool

Firstly, we need to select Minnesota from the *States* layer and export it as a new layer for focused analysis. We aren't concerned with the rest of the country in this activity.

Step 1. Click on the *Select Features* tool in the toolbar 

Step 2. Click on Minnesota to select it. When selected, the border should turn cyan blue.



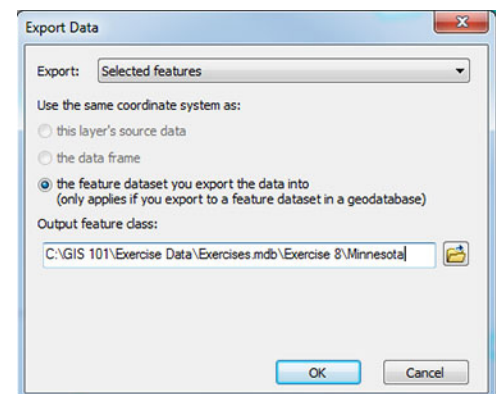
Export Minnesota

Step 1. Right-click on the *States* layer in the table of contents and choose *Data > Export Data*.

Step 2. Browse to the *Exercise 8* feature dataset and save your new layer as *Minnesota*.

Step 3. When prompted, click *Yes* to add the layer to the map.

Step 4. Remove the *States* layer from your map.



Select by Location

Using the Select by Location tool, we're now going to select all of the cities that are within Minnesota.

Step 1. Turn on the *Cities* layer by checking the box next to its name in the table of contents. You should see cities for the entire country.

Step 2. From the *Selection* menu in the topmost toolbar, choose *Select By Location...* Here, we're going to select features from the *Cities* layer that intersect the *Minnesota* layer.

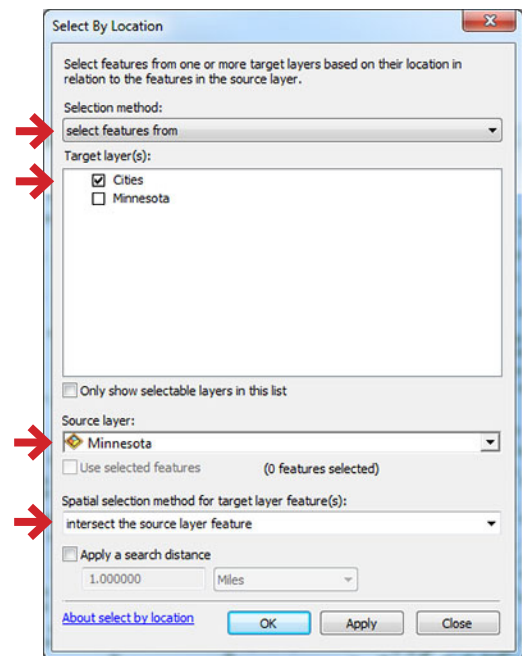
Step 3. Enter the following settings to select the desired features:

Selection method: **select features from**

Target layer(s): **Cities**

Source layer: **Minnesota**

Spatial selection method: **Target layer(s) features intersect the Source layer feature**



Step 4. Click **OK**. All Minnesota cities should now be selected.


Export Minnesota Cities

Step 1. Like we did earlier in the exercise, right-click on *Cities* in the table of contents and select *Data > Export Data*.

Step 2. Browse to the *Exercise 8* feature dataset and save the new layer as **MNCities**.

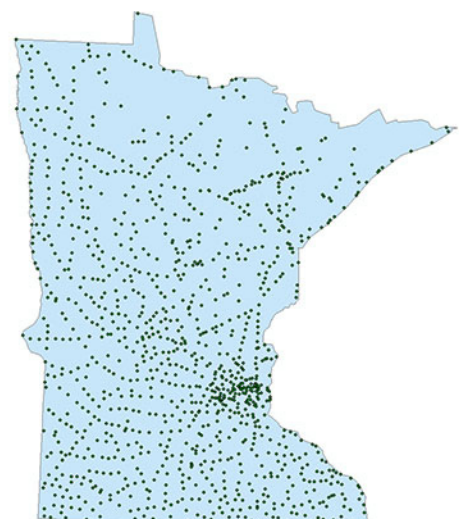
Step 3. Add the new layer to the map and remove the *Cities* layer (right-click, *Remove*).

Data Management

Before we move on, let's take a moment to get our bearings and clean up any extraneous data. At this point you should only have two layers on your map: *MNCities* and *Minnesota*. Remove any other layers. Then, click the Full Extent button  in the toolbar.

Minnesota and its cities should fill your data frame. Getting rid of layers once they're no longer necessary will help us keep our data organized throughout the activity. Repeat this process for each successive step in this activity.

Note: In the image at right, Minnesota has been projected into WGS 1984 UTM Zone 15N, another commonly used projection for Minnesota. You might consider projecting your data frame (**Hint:** Layers > Data Frame Properties > Coordinate System) before proceeding with this exercise.



Select by Attributes

Because we know we're only looking for towns with more than 1,000 people, we can remove any cities with fewer than 1,000 inhabitants. To do so, we'll use the Select by Attributes tool.

Step 1. From the *Selection* menu in the topmost toolbar, choose *Select By Attributes...*

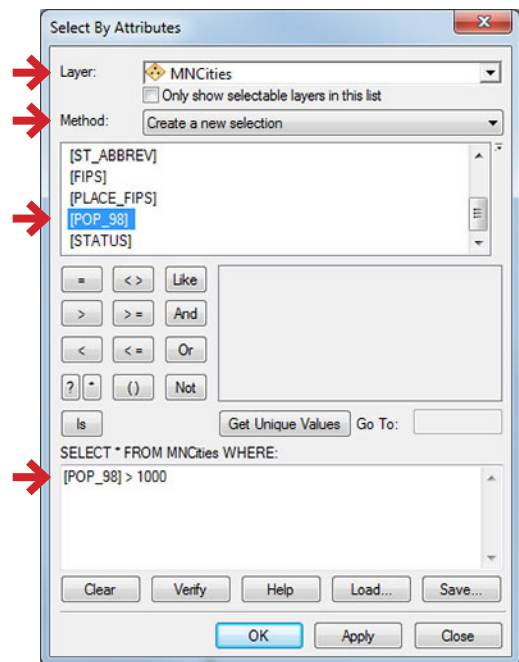
Step 2. Do the following to build the appropriate selection query:

1. Layer: ***MNCities***
2. Method: ***Create a new selection***
3. Double-click on ***[POP_98]*** in the attribute box
4. Click on the > (greater than) button
5. Type ***1000*** in the box below to complete the query

Your statement should read: `[POP_98] > 1000`

Click **OK** to run the selection query. All of the cities in Minnesota with a population greater than 1,000 are now selected.

Step 3. Export the selected cities as a new layer called ***MNCities1000***. Add it as a new layer and delete the *MNCities* layer.



Buffer

Our next step is to figure out which areas are within two miles of a boat trailer launch site. We'll do this by creating a 2-mile buffer around each launch site.

Step 1. Click the *Add Data* button and choose ***TrailerLaunchSites*** from the *Exercise 8* feature dataset.

Step 2. Locate the ***Buffer*** tool from the *Geoprocessing* drop-down menu (or via *ArcToolbox > Analysis Tools > Proximity > Buffer*).

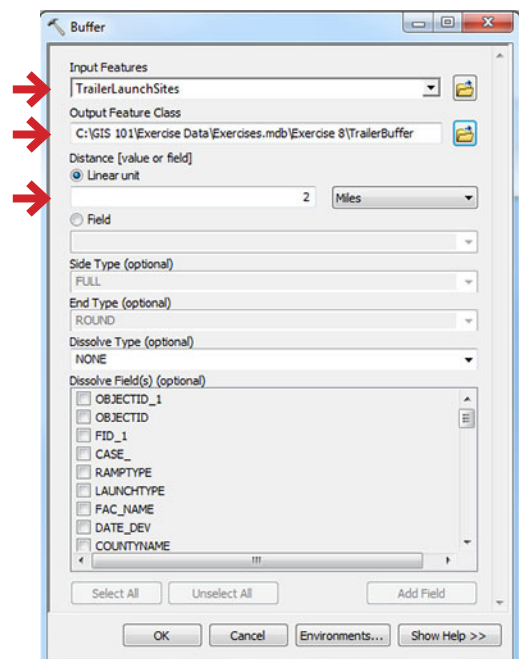
Step 3. Enter the following settings in the Buffer tool window:

Input Features: ***TrailerLaunchSites***

Output Feature Class: ...\\Exercise 8***TrailerBuffer***

Linear unit: ***2 Miles***

Accept defaults for the rest and click **OK**.



Step 4. Once your new *TrailerBuffer* layer is added, remove *TrailerLaunchSites* from your map.

Intersect

Although we can now see which cities have 1,000+ residents and are within two miles of a boat trailer launch site, we still need to figure out which towns are within a state forest AND in a mixed forest.

Step 1. Add *StateForest* and *MixedForest* from the *Exercise 8* feature dataset.

Step 2. Create a layer containing the intersection of these two layers. Do this by selecting the **Intersect** tool from the *Geoprocessing* drop-down (or via *ArcToolbox > Analysis Tools > Overlay > Intersect*).

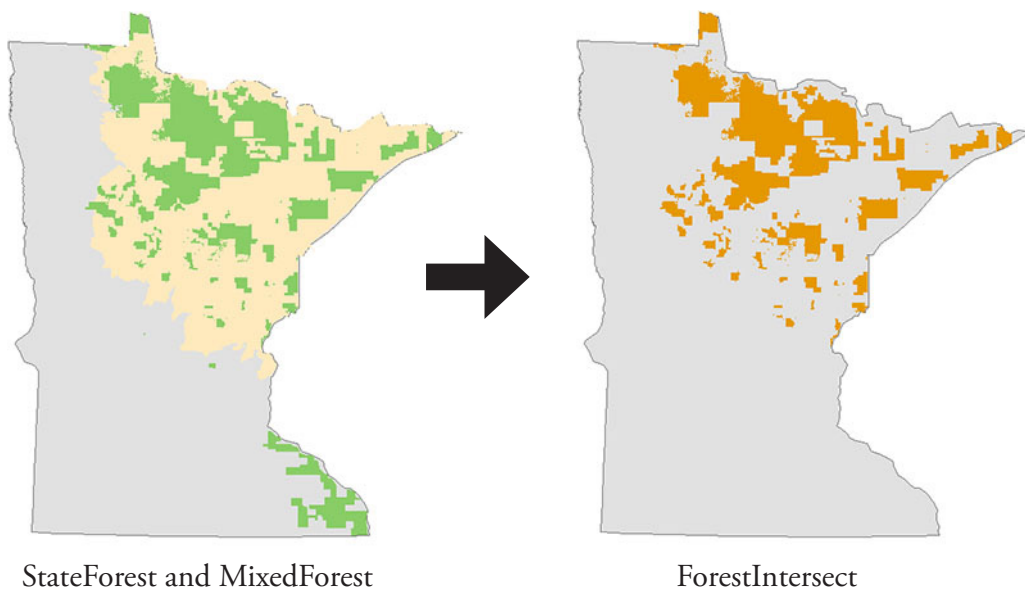
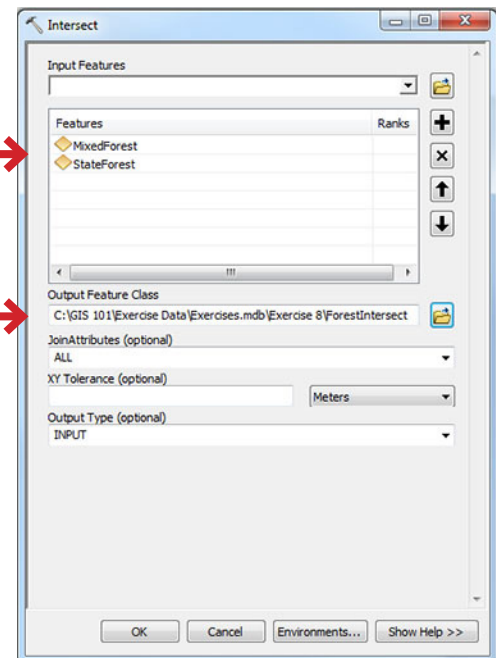
Step 3. In the Intersect window, enter the following:

Input Features: *StateForest*, *MixedForest*

Output Feature Class: ...Exercise 8\ForestIntersect

Step 4. Click **OK**. In this step, we've created a new, simplified layer containing only the areas in which state forests and mixed forests overlap.

Step 5. Remove *StateForest* and *MixedForest*



Intersect, Again

Next, we'll intersect the *ForestIntersect* and *TrailerBuffer* layers to find areas that are in a state and mixed forest AND are within two miles of a boat trailer launch.

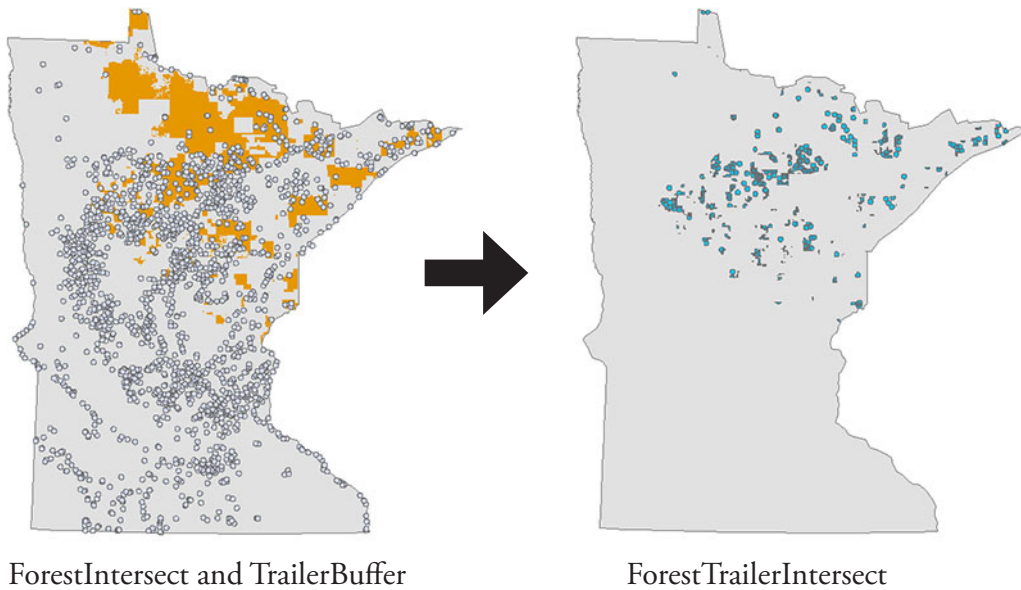
Step 1. Run the **Intersect** tool again, this time with the following settings:

Input Features: *ForestIntersect* and *TrailerBuffer*

Output Feature Class: ...Exercise 8\ForestTrailerIntersect

Click **OK**.

A new layer containing the intersection of the two layers should be visible. Remove *ForestIntersect* and *TrailerBuffer*.



Dissolve

We can dissolve the new layer in order to make its boundaries easier to see.

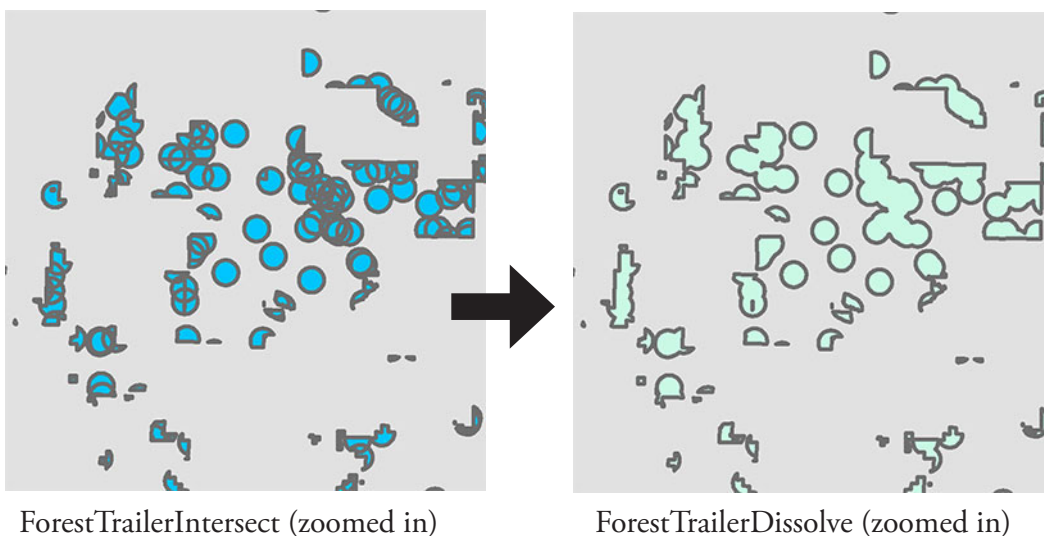
Step 1. Select the **Dissolve** tool from the Geoprocessing drop-down (or via *ArcToolbox* > *Data Management Tools* > *Generalization* > *Dissolve*).

Step 2. Enter the following settings:

Input Features: **ForestTrailerIntersect**
Output Feature Class: ...\\Exercise 8**ForestTrailerDissolve**

Accept the defaults for the other settings and click **OK**.

Step 3. Remove *ForestTrailerIntersect*.



Determine the most desirable place to live!

Finally, determine which city from *MNCities1000* meets all of the criteria. **Note:** You may need to add *MNCities1000* to your map if you deleted it earlier.

Use the **Select by Location** tool to find out which city from *MNCities1000* falls within the *ForestTrailerDissolve* layer. There should only be one!

Hint: Refer to page 24 if you need a refresher on how this tool works.

Once you have a city selected, right-click on *MNCities1000* and open its attribute table to view the name of the city. Alternately, you can select **Zoom To Selected Features** from the *Selection* drop-down and use the **Identify** tool to click on the city for more information.

Found the answer? Congratulations! You can verify the name of the city below.

Save your map and close ArcMap.