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This a big week! Choropleth maps, custom attribute scales, and definition queries – that’s a lot and all thrown together into Chapter 2 of the GIS Tutorial.

- On the plus side – those are the most important GIS concepts and mapping tools you will learn this semester.
- We will review and practice these topics extensively over the coming weeks.
1) Introducing Choropleth Maps

What are Choropleth Maps?
- A choropleth map is a map in which the feature polygons are colored according to their attribute values.
- Or, where the size or color of symbols used for features is a function of feature attributes.

For Example
- A map of the lower 48 states in different colors, depending on how many people lived in each state in 2003.
- A map showing the location of the state capitals as circles, with the diameter of each circle showing city population.

We see and use choropleth maps all the time...without knowing the fancy word for it! Just look around and I’m sure you see a choropleth map somewhere.

Compare the following map examples

Map 1
- Simple wireframe map of the USA.
- All states labeled with abbreviation.

This map is simple and ‘boring’ because it does not show any content or meaning.

But – this map is still useful – how else would you create a map to show the states and their abbreviations?

Map 2
- The 5 states with the highest number of vacant housing units are highlighted in red and labeled with their state abbreviation.

This map is more useful, since it shows content and thus conveys information to the map user – in this case which states have the highest number of vacant housing units

But, it’s still only a simple wireframe map.
Map 3
- This is a classic choropleth map.
- The colors show the different absolute numbers of vacant housing units in 5 classes.

This map conveys real content – you can compare the different states using the colors and visualize spatial patterns.

Now you can start interpreting these patterns – why do California and Texas have a lot of vacant housing units?

But: Is this a meaningful map? Is this a meaningful spatial pattern?

Map 4
- This is also a classic choropleth map.
- The colors here show the different relative numbers of vacant housing units in 5 classes.
- Here, we show the percentage of vacant housing units relative to total housing units.

This map has real meaning!

Map 3: of course Texas and California have a high number of vacant housing units...they also have a high number of people and housing units overall.

It makes much more sense to show the percentage of vacant housing units, relative to the total number of housing units as done in Map 4 – now Maine stands out.

Things to consider when creating colorful choropleth maps:

1. Are the colors meaningful?
2. Is the color scale appropriate? (dark colors suggest high, many, intense, etc.)
3. Printing color is expensive!
4. Color-blind people!

⇒ If in doubt...use grey scale in your map!
White/light grey representing low/small/little/weak and the black/dark grey representing high/many/intense. It may not look as cool as color, but has a lot of advantages.
2) Introducing Map Elements

The following are mandatory map elements that have to be always included on any map for legality, clarity, and beauty.

1. Map Title. Every map needs a title = a short and meaningful description of the map, usually located above the map.
2. Your name, affiliation, and date. Example: Map prepared by Carsten Braun, Westfield State University, 02/25/2013.
3. Data Credits = extremely important: You always have to cite the source(s) of the data you use in a map.
4. Scale Bar. Use meaningful units and meaningful ranges depending on the size and scale of your map. For example, the scale bar for a driving map is probably best shown in miles.
5. North Arrow. That’s your classic map element…you need to orient your map in space by providing a North Arrow.
6. Map Legend. Meaningful, comprehensive, and well-designed. Good legends are the key to a good map. Always use an appropriate classification system with reasonable break points.
7. Text. Every map needs helpful, well-written explanatory text = a description of map and the information it conveys.

Optional map elements that can be included on map:
- Neat Lines (= a frame around all map elements) to tie all map elements together.
- Logos of your company, business, or agency. For example, you could add the Westfield State College logo to your maps.

Finally:
- A map should be visually-appealing, aka beautiful.
- A map should be neat and error-free.
- A map should be well-organized.

Suggestions:
- Use simple fonts with appropriate font sizes (not too small, not too big).
- Use italics, bold, underline as appropriate.
- Align your map elements using guide lines.
- Your north arrow and scale bar should be readable, but not too large.
- Your legend should be readable, but not too large.

In ArcGIS, you can work on your map in two different views

Data View
- Click on View – Data View in ArcGIS
- This ‘view’ of your map is best for data analysis and map making.

Layout View
- Click on View – Layout View
- This ‘view’ of your map is best for defining the map/page size, map layout, adding map elements, and printing, but you can also perform the data analysis in the Layout View.
3) Hands-On Example #1

Let’s make a simple choropleth map of the United States in the Data View and then add the required map elements in the Layout View. This map you can print and have a professional map.

1. Start ArcMap – A new empty map and open the ArcCatalog window
2. Create a folder connection to C:\ESRIPress\GIS1\Data.
3. Expand the United States.gdb geodatabase and add the USStates feature class to your map.

You get a simple wireframe map of the lower 48 states (and DC), with all states shown in the same identical color (ArcGIS picks a random color for you).

**Mapping Task:** Change the map and show the states in different colors, depending on their Population in 2000. This turns the simple wireframe map into a simple choropleth map.

4. Double-click on the map layer USStates to open the Layer Properties.
5. Select the Symbology Tab.
   Here you control how the spatial features of the map layer (in this case States) are displayed on your map. You are **NOT** changing the underlying data! You are **ONLY** changing the way the data are displayed as a map layer on your map.

![Layer Properties dialog box](image)


8. Select a panchromatic Color Ramp – that is a color bar with different colors.  
   Is this a good color choice for your map?

9. Select a monochromatic Color Ramp – that is a color bar with different shades of the same color, for example red. Is this a good color choice for your map?

10. Select grey scale. Is this a good color choice for your map?

11. Reverse the grey scale by clicking on Range and selecting Reverse Sorting.  
   Is this a good color choice for your map?

**Your choice of Color Ramp and Sorting is a deliberate decision you make!**

Don’t just accept whatever ArcGIS gives you as a default. Think about (1) what you want to show with your map and (2) who will be the audience for your map. You can create very misleading maps by choosing an inappropriate color bar…in fact we will practice this in a few weeks with the *Lying with Maps* Project.

12. Add the USCities feature class from the United States.gdb.

Okay, now you have a simple choropleth map – nothing fancy, but let’s explore how we can turn this map into a professional map that we can print and publish.

13. Switch to the Layout View (View – Layout View).

14. Click on Insert, add the required map elements, and move to a suitable location on your map:  
   - Map Title  
   - Text: Enter your name, affiliation, and date  
   - North Arrow (many types to choose from)

15. Click on Insert – Scale Bar to add a scale bar. Adjust to meaningful units a range.

16. Click on Insert – Legend and add a simple map legend using the Legend Wizard (just click Next> until the wizard is finished and a legend is added to your map.

17. Arrange your Map Elements.  
   You can move the map elements around using the mouse. Double-clicking on a map element brings up the Properties dialog box. For example, double-click on a text box to edit the text, change the font size, alignment, etc.

18. Save the map to your USB flash drive, into the \garp0544spring2013\week6 folder, using the map name: week5example.mxd.
Let’s review the basic mapping sequence.

You start with a blank map and add feature classes which are displayed as map layers. Then you change the Symbology of each map layer to make them visualize the information you want to visualize, for example population in 2000. Then you switch to the Layout View and add the mandatory map elements. Then you print the map and export it as a PDF file or JPG image.

- The single most important map element is the legend – we will practice making good legends all throughout the semester. For now you can make decent legend simply by using the defaults of the Legend Wizard.

Your Turn

Change the symbology of your map layer USCities so that the diameter of the circle becomes a function of the city population in 2000 and change the color of the circles to green. We’ll use this map again on Thursday to explore Definition Queries.

4) Definition Queries

Definition Queries are the single most important concept and tool you will learn all semester.

- Also important (and very similar): Select by Attribute; Select by Location
- Also important (and complementary): Custom Attribute Scales

Definition Queries (and Select by Attribute) allow you to select sub-sets of spatial features, depending on their attributes. Select by Location allows you to do the same thing, but based on the location of your spatial features.

Example

You have a map layer, displaying a shape file that consists of 3533 circles, each showing the location of a city in the USA.

The associated attribute table contains demographic data for each city.

Arguably – this is an interesting map if you are interested in all 3533 cities in the USA.

How about if you are only interested in a certain sub-set of these cities? For example:

- Cities in Massachusetts?
- Cities in Connecticut?
- Cities in Massachusetts and in Connecticut?
- Cities in Massachusetts and in Connecticut, but only if they have more than 100,000 people?
5) **Hands-On Example #2**

Open the map you before, showing US States and US Cities. Or, create a new map as follows:

2. Open the ArcCatalog window, create a folder connection to C:\ESRIPress\GIST1\Data.
3. Add the feature classes USStates and USCities from the UnitedStates.gdb geodatabase.
4. Save your map to your USB flash drive, into the ‘garp0244spring2012\week4 folder, using a meaningful file name.

Now you have a map showing US States and 3533 cities.

*Now we are ready to explore Definition Queries.*

5. Double-click on the map layer USCities to open the Layer Properties, select the Definition Query tab, and click on Query Builder. Now you are ready to create a query.

6. Use the buttons and scroll windows to create the following expression:

   “ST” = ‘MA’  Here is how:

   Double-click on “ST”
   Single-click on the equal sign
   Click on Get Unique Values
   Double-click on ‘MA’ (you will need to scroll down a bit)
   Click the OK twice

   Do NOT even attempt to type this expression using the keyboard! ALWAYS use ONLY the buttons and scroll windows – trust me!
Your map layer USCities now only shows the cities located in MA. Open the attribute table to confirm – you should only see the cities located in MA listed in the attribute table.

7. Go back into the Query Builder, highlight and delete the old expression, and create the following new expression:

   “ST” = ‘CT’

Your map layer now only shows the cities located in CT. Open the attribute table to confirm – you should only see the cities located in CT listed in the attribute table.

8. Go back into the Query Builder, highlight and delete the old expression, and create the following new expression:

   ( “ST” = ‘MA’ AND “POP2000” > 100000 )

   Here, ONLY use the keyboard to enter the value 100000
   Make sure that you include the parentheses!
   Click the OK twice

Your map layer now shows the 5 cities in MA with more than 100,000 people in 2000 (Springfield, Worcester, Lowell, Cambridge, and Boston. Open the attribute table to confirm – you should only see five cities listed in the attribute table.

9. Go back into the Query Builder, delete the old expression and create a new expression to only show the cities in CT with more than 100,000 people in 2000.

Your map layer now shows the 5 cities in CT with more than 100,000 people in 2000. Open the attribute table to confirm – you should only see five cities listed in the attribute table.

10. Go back into the Query Builder, delete the old expression and create a new expression to only show the cities in CT and MA with more than 100,000 people in 2000.

   ( “ST” = ‘MA’ AND “POP2000” > 100000 ) OR
   ( “ST” = ‘CT’ AND “POP2000” > 100000 )

   Make sure that you include the parentheses!
   Click OK twice

Your map layer now shows the 5 cities in MA and the 5 cities in CT with more than 100,000 people in 2000. Open the attribute table to confirm – you should only see ten cities listed in the attribute table.

The possibilities for data analysis are endless!

- You can combine selection criteria using logical operators (Like, And, Or, Not) – which is classic Boolean Algebra.
- Be careful and use parentheses in your selection statement to combine or separate your logical expressions.
- Always check your Definition Query results by looking at the attribute table.
  Did your Definition Query produce the desired results?
SELECT * FROM USCities WHERE:
("ST" = 'MA' AND "POP2000" > 100000) OR ("ST" = 'CT' AND "POP2000" > 100000)
6) Your Turn: GIS Tutorial Chapter 2

Chapter 2 introduces many important concepts and skills, albeit rather briefly and not all that well organized in my opinion. The key here is to work slowly and methodically – many of the steps build on one another…thus skipping steps or making mistakes will cost you later!

- As always – whenever prompted to save a map, layer, or file – save to your USB flash drive, into the \garp0544spring2013\week6 folder.

Content

- Choropleth Maps and Group Layers. We have already covered choropleth maps. Group Layers are great to ‘bundle’ map layers and help with the map organization.
- Complete the important ‘Your Turn’ Box on Page 56.
- Save the layer file as described on Page 56, but to your USB flash drive, into the \garp0544spring2013\week6 folder.
- Add the layer file as described on Page 57, but from USB flash drive, from the \garp0544spring2013\week6 folder.

Page 63 to 61: Choropleth Maps with Custom Attribute Scales

- The single most important thing you will learn all semester!
- Save the layer file as described on Page 66, but to your USB flash drive, into the \garp0544spring2013\week6 folder.
- Complete the important ‘Your Turn’ Box on Page 67.

Page 69 to 76: Pin (point) Maps and Definition Queries

- Page 70 is critical! You have to change the actual break points using the “Classify” button and then change the legend labels.
- Pages 71 to 76 describe Definitions Queries. More about that later, but this is the second most important thing you will learn all semester.
- Complete the important ‘Your Turn’ Box on Page 75 and Page 76.

Page 77 to 81: Create Hyperlinks and MapTips

- Complete the ‘Your Turn’ boxes on Page 78 and Page 81.
- Save the map as described on Page 81, but to your USB flash drive, into the \garp0544spring2013\week6 folder.

This is a long and difficult chapter!

But, on the plus side, you will learn the two most important things this semester: Custom Attribute Scales and Definition Queries. We will repeat and practice both many times more this semester.
7) Additional Resources

Explore the ArcGIS Help Library for great, step-by-step help and answers!

- ArcGIS 10
  http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/Welcome_to_the_ArcGIS_Help_Library/00r90000001n000000/
- ArcGIS 10.1
  http://resources.arcgis.com/en/help/main/10.1/#/Welcome_to_the_ArcGIS_Professional_Help_Library/00qn0000001p000000/

About Symbolizing Data as Quantities

- ArcGIS 10
- ArcGIS 10.1

Using Graduated Colors

- ArcGIS 10
- ArcGIS 10.1
Using Graduated Symbols

- ArcGIS 10

- ArcGIS 10.1
About Classification for Choropleth Maps

- ArcGIS 10

- ArcGIS 10.1
About Classification Legends

- ArcGIS 10
  http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/Working_with_the_Classification_Legend/00s5000000280000000/

- ArcGIS 10.1
  http://resources.arcgis.com/en/help/main/10.1/index.html#/Working_with_the_Classification_Legend/00s50000002800000000/
Definition Query

- ArcGIS 10
- ArcGIS 10.1
Using Select by Attributes

- ArcGIS 10

- ArcGIS 10.1
Using Select by Location

- ArcGIS 10

- ArcGIS 10.1
Map and Page Layouts

- ArcGIS 10

- ArcGIS 10.1

Map Elements

- ArcGIS 10

- ArcGIS 10.1
Map Printing
- ArcGIS 10
- ArcGIS 10.1

Exporting Your Map
- ArcGIS 10

Exporting to PDF
- ArcGIS 10
- ArcGIS 10.1
8) Homework Assignment #3: Demographics of U.S. States

This assignment practices and expands the skills you have learned in Chapter 2 – everything you need to know to complete this assignment is covered in Chapter 2 of your GIS Tutorial. See Section 5 for additional great resources.

This exercise practices creating choropleth maps using absolute and relative values, creating custom attribute scales, and adding the mandatory map elements.

This assignment consists of three complementary parts:

1. GIS Mapping
2. GIS Analysis
3. Deliverables: Reporting and Documentation

Part 1: GIS Mapping

You will create four professional choropleth maps.

Data
- Polygon feature class USStates from the UnitedStates.gdb geodatabase located in C:\ESRIPress\GIST1\Data.
- Point feature class USCities from the UnitedStates.gdb geodatabase located in C:\ESRIPress\GIST1\Data.

Map 1
Show the U.S. States as a choropleth map colored as a function of the number of children less than 5 years of age in each state. Change the default classification to Manual with 5 classes and the following Break Values:

- 0-150,000 (less than 150,000)
- 150,001 – 300,000
- 300,001 – 600,000
- 600,001 – 1,200,000
- 1,200,000 – 2,486,981 (greater than 1,200,000)

- Use the AGE_UNDER5 attribute field as Value.
- Switch to layout view and add the required map elements.

Map 2
Show the U.S. States as a choropleth map colored as a function of the percentage of children less than 5 years of age in each state (= percentage of the total population in each state). Change the default classification to Manual with 5 classes and the following Break Values:

- 0 to 0.06 (less than 6 percent)
- 0.06 to 0.065 (6 to 6.5 percent)
- 0.065 to 0.07 (6.5 to 7 percent)
- 0.07 to 0.08 (7 to 8 percent)
- 0.08 to 0.09376 (8 percent and greater)
• Use the AGE_UNDER5 attribute field as Value.
• Use the POP_2000 attribute field as Normalization.
• Switch to layout view and add the required map elements.

Map 3
Show only the cities located in Massachusetts and Connecticut with more than 100,000 people as a choropleth map with their symbols as a function of population in 2000. Choose an appropriate classification method and break points. Add the required map elements.

Map 4: Your Turn!
Create a meaningful and professional map using the data provided in C:\ESRIPress\GIST1\Data.

Part 2: GIS Analysis

1. In your own words: What is a choropleth map?
2. Describe and interpret the spatial pattern you see in Map 1.
3. Describe and interpret the spatial pattern you see in Map 2.
4. Explain the differences and/or similarities between Map 1 and Map 2.
5. Explain the map you created as Map 4.

Note: Always separate your description of the spatial patterns from your interpretation/explanation – that’s in essence the hallmark of the scientific method: First we describe the results of our analysis or study, then we proceed to interpret, explain, and look for the bigger-picture context.

Part 3: Deliverables

Please submit professional report using proper English language and professional formatting and layout. Think in terms of using this report as a sample of your work for a job interview. Include:

• Include a starting paragraph describing your overall GIS Analysis.
• A step-by-step documentation of what you did to create the three maps in ArcGIS and how you selected/adjusted your classification system and break points. Think in terms of writing a cook book recipe that a similarly-trained GIS user can follow along to repeat your mapping and analysis. I need to be able to understand your methods to assess your work. Use a numbered list to organize your recipe.
• The answers to the five questions.
• Your printed maps as the last four pages.
• Include a cover page and page numbers in the page footer.
• Your report will have about 8 pages (cover page, ~3 pages for documentation and the five questions, 4 pages for the maps).
• Due Date: next class.

Please note: the maps, the analysis questions, and the documentation are all equally important in terms of your assignment grade. This is a difficult assignment, so get started as soon as possible!

📍 Contact me for help or clarification of this assignment or my expectations as needed.
‘Lying’ with Choropleth Maps: What’s Your Message?

Same data – different message: A small change in your classification system and break points changes the message of the map dramatically!