Lecture Notes, Module 5

GEOG 319/658 **Cartographic Foundation** **FALL 2014**

Slide 1: Cartographic Foundation…

- Since, several students in our class did not have solid cartographic foundation, we needed to get everyone at the same level. We felt that a number of the topics covered in Chapter 7 of Peterson's text were appropriate here.

Slide 2: Cartographic Foundation Topics

- Those of you with a solid cartography background will have had much of this, but remember that we have a broad group of folks enrolled in this course; I suspect that a fair number of students have only touched on some of these issues
  - Most of you have done some work with scale, but a few have not
  - A discussion of Map Projections is critical because of the use of the Web Mercator in Web Mapping
  - Data Classification is necessary because we will be working with classed and unclassed maps and need to understand the impact of choosing various methods of classification or possibly choosing no classification (the unclassed map)
  - Linear Simplification – When working with large datasets, it is often useful to simplify lines

Slide 3: Map Scale Issues

Slide 4: Three ways of depicting map scale; the first of these is the Representative Fraction (RF)

- This simply says that one unit on the map = 24,000 units on the Earth or ground
- Or we could say that one inch on the map = 24,000 inches on the ground
- Or if we are not in the U.S. one centimeter = 24,000 centimeters on the ground
  - Peterson notes that there are only three countries where English units are used; although according to a Wikipedia article on Metrication in the United States, the U.S. is now the only country using the English system
- We can argue that the RF is a bit abstract because what does 24,000 centimeters or inches represent?

Slide 5: Three ways of depicting map scale; the second of these is the Verbal Scale

- This clearly tells us what one inch represents

Slide 6: Three ways of depicting map scale; the third of these is the Bar Scale…

Slide 7: Examples of Bar Scales

- Note that this image comes from Chapter 11 of my co-authored book. Hugh Howard, one of my co-authors wrote this chapter, and I happen to think it is quite well done. As you use various software to create scales, read Hugh's chapter to see what should and should not be done.
  - Hugh indicates those in D are good examples, describing them as "slender, simple, and well-designed"
  - C is also a possibility – it uses an extension to the left of zero, but Hugh argues that the extension is confusing to map readers and probably should not be used on thematic maps

Slide 8: Bad Examples of Bar Scales

- I suspect that you probably won't be designing bar scales in this class, but as you work with maps in other classes and use various software, think about the design of your scales

Slide 9: Bar scales can be used as map scale changes

- Think about the size of map on this screen; does the distance from here to here represent 800 miles? If I show this map in another room, say 412, will the same hold true?
  - Yes to both
  - In contrast the representative fraction and verbal scales will not generally be meaningful.
  - In our world of Web mapping, we should be using bar scales!

Slide 10: Large scale vs. small scale maps.

- Have them define these
- Is there a particular scale that separates large and small scale maps?

  - 1/50,000 and larger are often considered large scale
  - 1/250,000 and smaller are often considered small scale
  - Between 1/50,000 and 1/250,000 intermediate scale

Slide 11: Distance Measurements

- Although map service providers often provide automated procedures for measuring distance, we also should be able to compute distance by hand
- Let's consider a typical problem…
- What do we know?
  - 1 cm on map = 24,000 cm on the Earth (this is the RF)
- Thus, 5 cm on the map = 24,000 * 5 = 120,000 cm on the Earth
- Converting to kilometers, we divide cm by 100,000, we get 1.2 km

Slide 12: Distance Measurements (in English units)

- What do we know?
  - 1 inch = 30,000 inches
- Thus, 2.2 inches = 2.2 * 30,000 = 66,000 inches
- Converting to miles, we divide by 63,360 to get 1.04 miles

Slide 13: Computing an RF for a Bar Scale

- What do we know?
  - 3.3 inches on the map = 5 miles on the Earth
- Thus, 3.3 inches on map = 5 * 63,360 inches = 316800 inches on Earth
- Dividing through by 3.3, we have
  - One inch on map = 96000 inches on Earth
  - So this is a 1:96,000 map

Slide 14: Map Projections

Slide 15: Definition

- Stress that we are going from a curved 3D surface to a 2D surface and thus we must lose something
  - We cannot maintain correct areal relations, angles, distances, and directions at the same time
  - We can maintain these on a globe, but globes are cumbersome
- These ideas are easiest to see if we exam maps that do preserve certain characteristics…

Slide 16: Equal-area or equivalent projection

- Maintains correct areal relationships
  - By this we mean that if two areas have a particular areal relationship on the 3D globe, they will have the same relationship on the 2D map (i.e. if one area is twice as large as another on the globe, it will be twice as large on the 2D map)
- This a map of literacy rates by country at a world scale; note that areal relations are correct (e.g., compare South America vs. Greenland)
- This is a thematic choropleth map in which countries are shaded with an intensity proportional to literacy; by using an equivalent projection, we weight each country correctly (based on its actual size on the globe)

Slide 17: Conformal projection

- Maintains angular relationships around points
  - One way of thinking about this is that lines of latitude and longitude intersect each other at right angles on the globe and they do that here
- BUT we can see that there is gross distortion of area
  - Greenland and Antartica are now huge. In this case they fall in the " no data" category, but it doesn't make sense that they should have this visual impact
  - Ignoring Greenland and Antarctica, much of the world seems to fall in the black because the northern latitudes are exaggerated
  - Rather than using the Mercator for thematic info like this, the Mercator should be used for navigation

Slide 18: Mollweide vs. Mercator

- Looking at both maps, we see that low literacy rates are a more apparent problem with the Mollweide projection

Slide 19: Areal vs conformal and dot mapping

- This is a fictitious data set. The left map is an equal-areal projection and the right map is a conformal projection. The true density is greatly distorted on the conformal. The density will appear less in areas where the areas are greatly exaggerated.

Slide 20: Equidistant projection

- Equidistant projections show distances correctly…
- The azimuthal equidistant is an example
  - In this case correct distances are maintained from the center of the projection (along the Kansas-Nebraska border) to surrounding areas of the world

Slide 21: Azimuthal projection

- Show directions correctly from a point
  - More specifically, these projections measure direction correctly from the center of the map to any other point on the map
- Note that the previous projection is both equidistant and azimuthal; in general , this is not necessarily true; here we see one (the orthographic) that is just azimuthal.
- Also note these last two categories (equidistant and azimuthal) generally are not as important in thematic cartography as the other two (equal-area and conformal).

Slide 22: Why the Mercator projection for the Web?

- Here we have combined the reasons provided by Peterson and Battersby et al. (Peterson is the textbook for the course; Battersby et al. is the article referred to in the course syllabus)
  - 1 and 2 (Peterson covers)
  - 2 and 3 (Battersby et al. cover)
  - One of the difficulties of fully understanding this is that we are not writing the code for tiling and panning and zooming
  - These all deal with speed of processing, which of course we want to be as fast as possible

Slide 23: Why Web Mercator?

- The justifications listed in the previous slide focus on why the Mercator projection is used on the Web. We now ask why a particular version of the Mercator known as Web Mercator is used?
- Stress that they should read Battersby et al.
- We have read Battersby, but also discussed this with Kessler, who is a specialist in projections
  - The key is that the approach used for Web Mercator is computationally faster than if Mercator were used
  - Ellipsoidal coordinates are the basic Earth coordinates that are normally used
    - For example, when you use a GPS device
    - When these coordinates are projected, one should use ellipsoidal equations, BUT Google and other use spherical equations (they assume the Earth is a perfect sphere, which of course it is not)
      - The spherical equations are simpler and more efficient, but they lead to error

Slide 24: Shows the error when overlaying the two systems (Mercator and Web Mercator are overlaid)

- At this scale, there appears to be no error

Slide 25: Shows the actual magnitude of error between Mercator and Web Mercator

- Note how the error is small near the equator and then increases as we move away from the equator
- Note that 30Km relative to 12,500 miles is not much; that's why we didn't see error clearly on the previous slide

Slide 26: Winkel Tripel: An Example of a compromise projection

- Equal area projections maintain correct area relations, but they distort angles. In contrast, conformal projections maintain correct angular relations, but distort area relations.
- Can we somehow compromise?
  - Yes, there are a number of projections that are neither equal area nor conformal. The Robinson projection is one that Peterson mentions and is a well known projection. The Winkel Tripel is a more recently developed compromise projection.
  - This image also shows the area and angular distortion using Tissot's indicatrix. If there is no areal or angular distortion, all of the ellipses shown would be circles of the same size. Obviously, this is not possible.

        - The greater the difference in area, the greater the areal distortion.
        - The greater the difference from a circle, the greater the angular distortion.

Slide 27: Data Classification

- We group our raw data into classes and then use separate symbols to represent each class…

Slide 28: Why do we class data?

- Normally, data classification is discussed in the context of choropleth maps. Here we see classed and unclassed maps of foreign-owned agricultural as a percentage of all privately owned land.
    - Classed is map on the left. We've divided the data into five classes
    - Unclassed is map on the right. Data are shaded with a gray directly proportional to the data.
    - Normally, we say that the right-hand map is too difficult to interpret because we can't easily differentiate the shades and it is difficult to match them up with shades in the legend.
    - However, note in the dispersion graph at the bottom that the data value for Maine is appreciably different from the rest of the data and that this is reflected in the map.
        - In this sense the unclassed map is a visual expression of what we see in the dispersion graph.
    - BUT most folks have chosen to class their data…

Slide 29: <u>Some</u> methods of classification

- There are lots of other methods; we cover some of the more commonly used methods…

Slide 30: Equal Interval Method

- Places an equal portion of the data range in each class
    - Imagine a dataset of % urban ranging from 0-100 and 5 classes; each class would span an interval of 20%.
- Many of you have learned this in your stats class and so this should seem straightforward.
- It is a five-step process

Slides 31-32: Step 1. Determine the class interval…

- Note the sample data set below

Slide 33: Step 2. Determine the upper limit of each class.

- Simply add the class interval to the smallest data value and then repeat… You should end up with the highest value in the data.

Slide 34: Step 3. Determine the lower limit of each class.

- Note that this is one unit higher than the upper limit of the preceding class.

Slide 35: Specify the class limits actually shown in the legend.

- These should be in the same precision as your original data. So for Exercise 3, report final classes to tenths.

Slide 36: Determine which observations fall in each class.

Slide 37: Advantages of equal interval

Slide 38: Key disadvantage of equal interval

- The key disadvantage is that class limits may not reflect how data are distributed along the number line
    - With the hypothetical data we have been working with (in the top graph), we seem to have picked up a couple of reasonable breaks, but we also seem to have missed one; this also seems to raise the issue of what an appropriate number of classes would be
    - For another hypothetical dataset (the bottom graph), our breaks don't seem to coincide with actual breaks in the data

Slides 39-45: Quantiles

- In slide 41, we compute that 3 observations should fall in each class, with two left over; if we assume the two left over are placed in the first and second class, we end up with the results shown in slide 42
- A key point is that again we find that the class limits may not reflect how data are distributed along the number line, as shown in slide 45; this disadvantage for both equal interval and quantiles leads us to the maximum breaks method

Slides 46-49: Maximum breaks

- Note how the maximum breaks method does seem to pay attention to the distribution of the data along the number line

Slide 50: Linear simplification

Slide 51: Linear simplification

- Could use the term “linear generalization”, but it is probably more appropriate to use the term “linear simplification” because there is a host of generalization operators.

Slide 52: Generalization operators

- Go through and touch briefly on a number of the operators
    - Simplification
        - Eliminating points to speed processing (we’ll see other reasons in a moment)
    - Smoothing
        - Smoothing (or reducing angularity) as in contour mapping
    - Amalgamation
        - Grouping points or areas
        - Why do we do this? Scale change…
    - Merging
        - Grouping linear features
        - Again, why do we do this? Scale change…
    - Exaggeration
        - Amplify a specific portion of an object
        - Maybe for shipping, we need to show that there is an entrance to this bay
        - We lie for good reason

Slide 53: Why simplify?

Slide 54: Local vs. Global

- To illustrate the difference between the two, draw a simple example on the board and ask students to think about how you would delete points

Slide 55: An example of a local method

Slide 56: The classic Douglas-Peucker <u>global</u> algorithm…