LECTURE 3: MAP SCALES

Section I – Scale

A scale is a devise that can be used to convert map distance into real world distances. Maps have two types of scales (graphic and fractional).

GRAPHIC SCALE

A graphic map scale, normally located near the bottom of a map, is illustrated below in Figure 1 for the world map utilized in Assignment #1.

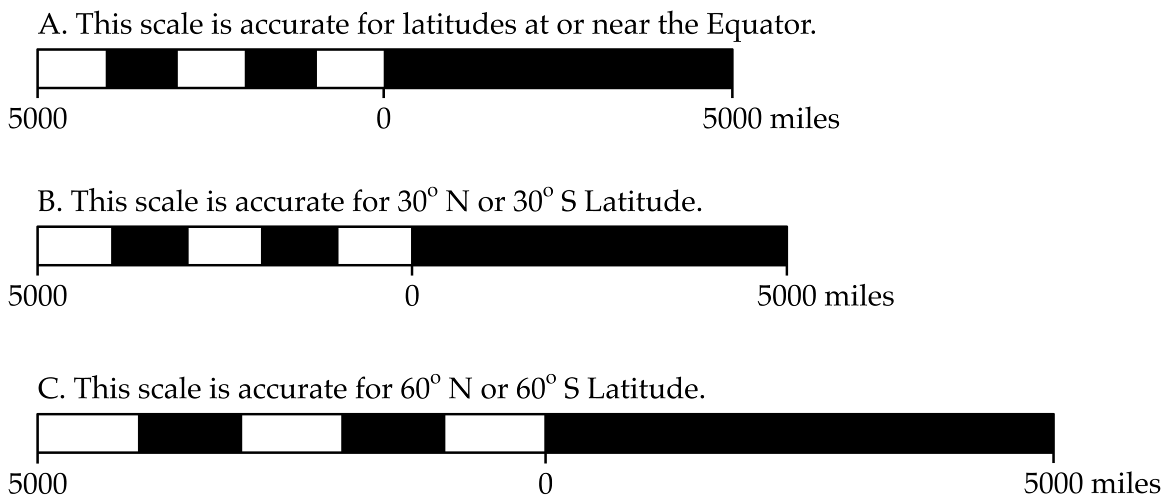

Figure 1. Graphic scales that correspond with the world map from Assignment #1.

Note that will dealing with the whole world, or even at the scale of a state, graphic scales can be latitude sensitive and therefore we include three graphic scale bars with the world map. The procedure for using the graphic scale is outlined below:

i. Select the correct graphic scale based on the latitude of the points whose distance you will be measuring.

ii. Lay a blank piece of paper between two points and mark the position of the points on the piece of paper.

iii. Take these points to the appropriate graphic scale to determine real ground distances. You may want to use a ruler for increased accuracy.

FRACTIONAL SCALE

The second type of scale is numeric based and is referred to as a fractional scale. The scale is a numeric ratio that relates distance on the map to distance in the real world. The United

States Geological Survey (USGS) publishes standards maps in the United States. Check out the USGS website were you can download these maps in a PDF format (http://store.usgs.gov/). These maps form a seamless, without gaps, coverage of the entire United States.

• Know the standard map scales used by the USGS

The most common base map published by the USGS is their 7.5' quadrangles, which represent 7.5' of latitude and longitude. A schematic representation of a 7.5' quadrangle is illustrated below (Figure 2). These 7.5' quadrangles have a fractional scale of 1:24,000, which is defined additional below:

1 (unit of map distance) = 24,000 (units of distance in the real world)

A typical unit of measurement on a map is inches so this fractional scale indicates that:

1 inch on the map = 24,000 inches in the real world (or 2,000 ft)

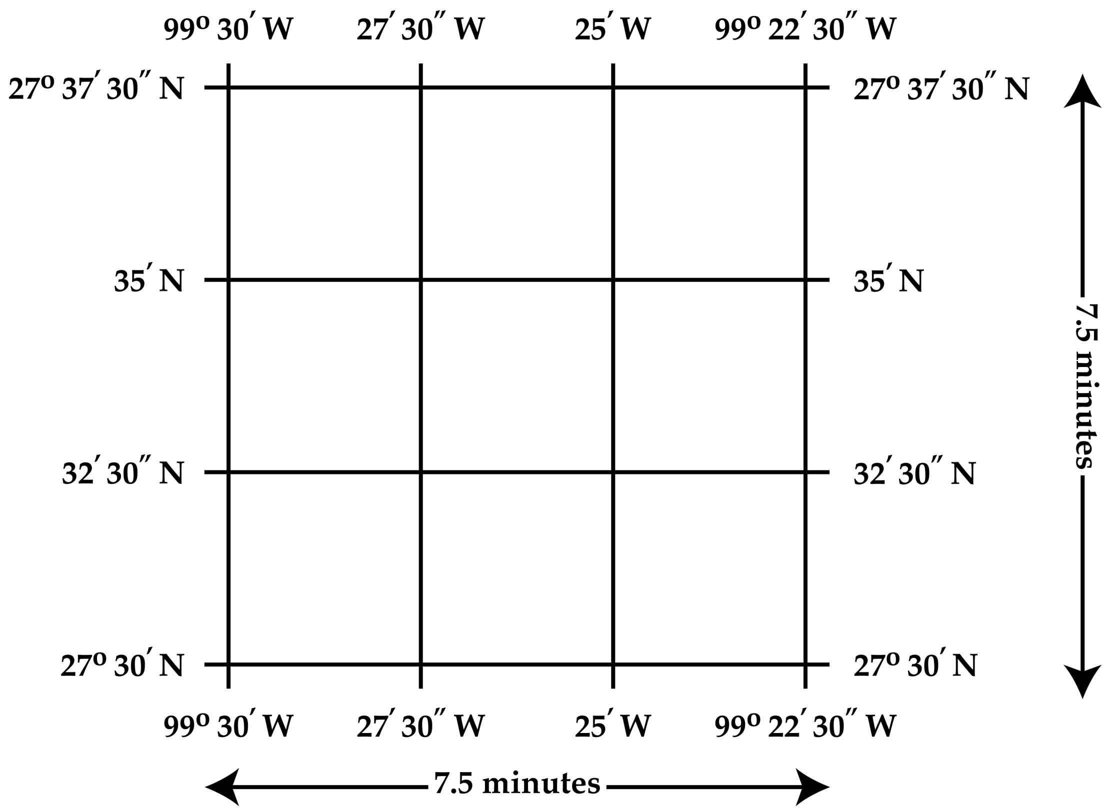

Figure 2. Simplified quadrangle map showing latitude and longitude.

Additionally common map series published by the USGS include 15' quadrangles and maps that spans 1º of latitude and 2º of longitude (pg. 128). The 15' quadrangles have a fractional scale of 1:62,500, which roughly translates into 1 inch on the map representing approximately one mile of real world distance. The 1º X 2º USGS maps have a fractional scale of 1:250,000, which indicate an equivalence of 1 map inch to approximately 4 miles in the real world. Additionally, the US military and other countries have developed maps based on different fractional scales, most common scales include 1:50,000 or 1:100,000.

• What is the difference between a small and large-scale map?

Some potentially confusing terminology associated with the fractional scale is when a geographer refers to a small scale versus large-scale map. Basically, a **small-scale** map covers a larger geographic region such as the world; whereas, a **large-scale** map covers a relatively small geographic area, such as a 7.5' quadrangle map. The confusing nature of this terminology can be explained by examining the precise meaning of two fractional scales.

• How to calculate a fractional scale

For a 7.5' quadrangle the scale is 1:24,000 and for a 1º X 2º map the scale is 1:250,000. Mathematical these scales can be defined as the following:

$$1 / 24{,}000 = 4.2 \times 10^{-5} \qquad \text{vs.} \qquad 1 / 250{,}0000 = 4.0 \times 10^{-6}$$

So you can see that the 7.5' quadrangle fractional scale is a larger number than the 1º X 2º map scale. Therefore, the 7.5' quadrangle has a relatively large scale compared to the 1º X 2º map.

• What is the National Map Accuracy Standard and how can it be translated into the allowable error of a geographic entity in the real world

Accuracy is also influenced by map scale. The USGS guarantees that the mapped positions of 90% of well-defined points on a quadrangle map; such as **benchmarks** (Google 'USGS Benchmarks') or road intersections that are locations that have been accurately surveyed, will be within 0.02 inches (0.5 mm) of their actual position on the map.

This level of accuracy is referred to as the National Map Accuracy Standard. Obviously, map accuracy is strongly connected with scale. For example, for the 1:24,000 quadrangles 90% of the points need to be within 40 ft of their actual location (the level of uncertainty typically associated with a low grade commercial GPS unit). This level of accuracy is generally sufficient to find geographic entities in the real world. However, applying the same accuracy standard to a 1:250,000 results in having 90% of the points mapped within 417 ft. Obviously small-scale maps are not well suited for highly detailed georeferencing applications.

Section II – Beware of Generalization

As a user of geographic data one must understand how various entities can be represented on a map or within a GIS. The classic example is that of a city whose boundaries can easily encompass an entire 7.5' quadrangle and yet on a small-scale map (*i.e.* state or country map) may be only represented as a point or dot. Therefore, smaller scale maps display less detail than larger scale maps (**see Figure 2.5.1 in reading**). The process that geographers use to simplify map detail in smaller scale maps is referred to as **generalization**. Users of geographic information need to understand the potential pitfalls associated with generalization because not all geographic data is equal. An example, within a city, streets may be represented by centerlines that run down the center of the road (Figure 3). This representation may be perfectly adequate at the relatively small scale of an entire city to support emergency response or traffic and utilities management. However, the centerline depiction of streets is a simplified representation of this entity. We know that a street is not a one but a two-dimensional object with both length and width. Problems can arise when applying generalized data developed for small-scale applications to large-scale mapping. Specifically, if you need to know exact location where streets are located within a subdivision to support the precise delineation of land parcels for property transactions street centerlines will not suffice and you will need to represent streets as discrete polygons (Figure 3).

Another method of generalizing involves not changing the geographic data present in a GIS but displaying geographic entities based on scale. For example, on a world map you would not want to display every town with a population over 10,000 people. This would make the map display overly cluttered. With GIS software you can set up thresholds so that at the scale of the world you show only cities with populations greater 1,000,000 but as you zoom down to larger scales - say South Texas you can then visualize the smaller urban centers. A common practice is to develop a scale-dependent database with the data of interest for your project. For example, if you have a large demographic database of the United States and you are only interested in South Texas it is common practice to extract the data of interest for your project - this practice has the practical impact of speeding up data access and refresh on a GIS computer system.

Figure 3. Streets depicted as both centerlines (red) and polygons (black). From ESRI Technical Topics website http://www.esri.com/technology-topics/cartography/graphics/centerlines_lg.gif

Readings

DiBiase, D., 2014, Nature of Geographic Information Systems. Sections 2.2, 2.3, 2.4, 2.5, 2.6, 2.7

Terms

Fractional Scale	Graphic Scale	1:24,000	1:62,500
1:100,000	1:250,000	Large Scale Map	Benchmarks
Small Scale Map	Generalization	National Map Accuracy Standard	

Concepts

Know how to calculate the national map accuracy standard for maps of different scales
What is generalization and how can it have a deleterious effect on the quality of GIS data
Know how to calculate the fractional scale of a map.

HOMEWORK

1. What is the national map accuracy standard for a 15' map with a fractional scale of 1:62,500.

__________________ ft __________________ miles

2. A map of the Lake Casa Blanca area is an example of a small-scale map compared with a map of the entire State of Texas?

True or False

3. Generalization is a process that intentionally degrades the quality of geographic data. Why would a geographer generalize data? Explain in detail.

4. Using any resource determine the following?

a. Map distance (in inches) of 4000 ft on a map with a fractional scale of 1:24,000

b. Real-world distance (in km) of 4 cm measured on a map with a fractional scale of 1:100,000