Lecture 14: Overview of Common GIS Data Products

Today, we will discuss a number of different types of GIS data that are useful in the biological and environmental sciences.

1. Elevation (DLG, TIN's, DEM's)

Remember from last week's lecture that USGS topographic maps can be represented in a vector format. This is the digital line graphic (DLG) product. One of the layers developed for DLG's is Hypsography or contour lines, which reflect lines of equal elevation. These lines are brown in color. Typically, contour lines are defined based on even elevations with a specified contour interval that separates each contour line. For example, the contour interval can be 10, 50, 100 ft, etc depending on the nature of the terrain.

The elevations that define the contour lines can be determined in two different ways. The most accurate method is to survey these elevations in the field by the process of leveling, a form of suryeying. The second method is to use a stereoplotter on an aerial photo to estimate elevation.

As lab two from EPSC 1170 Lab 2 (pgs. 4 to 6) indicates there are some rules associated with contour lines

- Contour lines connect points of equal elevation
- Contour lines never branch or cross
- Contour lines are widely spaced where the slope is gentle & closely spaced when the slope is steep
- Hills are represented by a series of concentric contour lines
- Topographic depressions are indicated by a series of concentric contour lines with hachure marks on the inside of the circle
- When contour lines cross rivers and streams the "V" formed by the contour line crossing the stream always points uphill

I really suggest that you read lab #2 for more details. To test your knowledge, I suggest that you label the contours associated with the example given in Figure 1. I will provide the answer to this example in CEES. You need to know this how to apply this concept as you will be given a contouring exercise on the final exam. The vertical distance between contours is the contour interval, which in the case of Figure 1 is 10 feet. See if you can fill in all the elevations for the contour lines on this map.

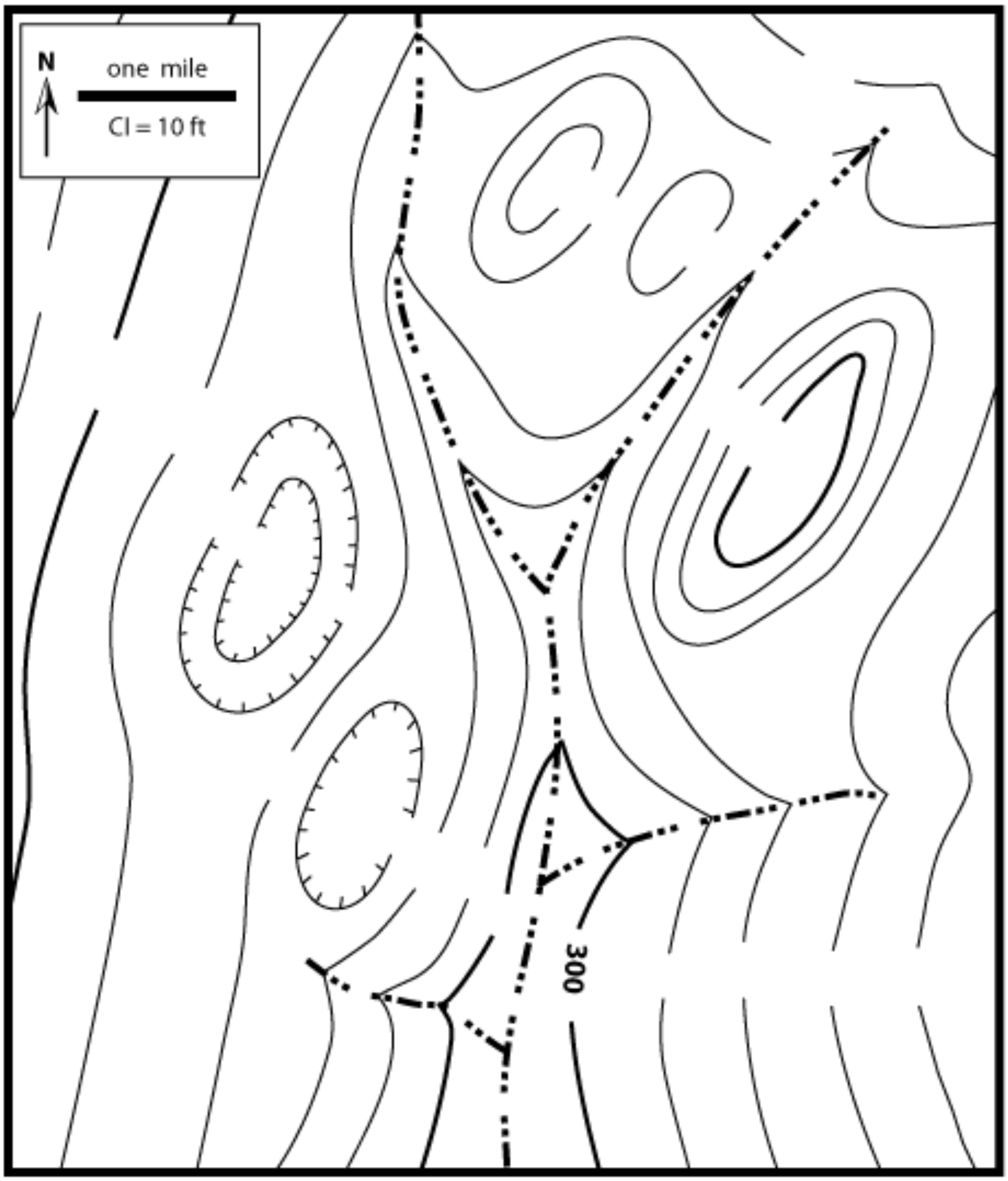

Figure 1. Contour map example.

In reality the contours will not be drawn and you will have to draw them on the map yourself. This is not so easy. Here are a couple of insights that may help with this activity. (1) As you are approaching a body of water your elevation decreases (elevations increase away from the waterbody). (2) You need to be logically consistent. For example, imagine you have drawn a 760

-contour line on a map (see Figure 2). This line separates elevations that are greater and less than 760 ft. At every point as you draw your contour the question of logical consistency must be addressed. For example, you would not draw the 760 ft contour to the right of the point that has an elevation of 759 ft. This would be a logical inconsistency and you would be indicating that there are points with elevations that are both less and greater than 760 ft to one side of this line. Additionally, it is always a good idea to first draw your contours in pencil. See a great example of this in section 7.5 of DiBiase.

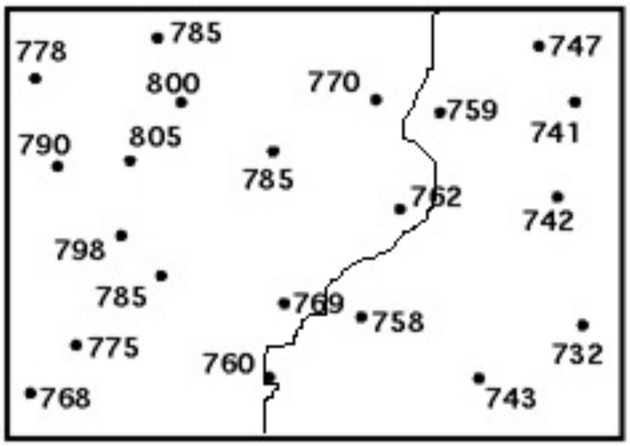

Figure 2. How to and not to draw a contour line.

The typical procedure to making contour lines is to obtain a number of elevations by the above methods. Next, a triangulated irregular network (TIN) is established, which is a representation of a continuous surface that consists of entirely triangular facets (Figure 3). A major assumption behind TIN's is that that elevation varies in a linear fashion along the TIN, which may not necessarily be true. TIN data is stored as a topological vector file with nodes (the vertexes of the triangles) and links or lines connecting the nodes. TIN files are memory intensive and are difficult to update and generally are not the preferred method for storing elevations in a GIS system. However, TIN’s are useful for helping to construct the contour lines as the example in Figure 3 demonstrates.

Digital products based on contouring are available. Besides the previously mentioned DLG's there are global products such as the National Imagery and Mapping Agency (NIMA) has developed a Vector Map Level 0 (VMAP-0). This product includes not just hypsography but nine other layers that map transportation, hydrography, and political boundaries. This product is developed at a small-scale (1:1,000,000 scale) and is suitable for continental scale applications. The nominal contour interval of this product is 1000 ft. You can find out more about the Vector Map Level 0 (VMAP-0) product at the following website.
http://www.mapability.com/index1.html?http&&&www.mapability.com/info/vmap0_index.html

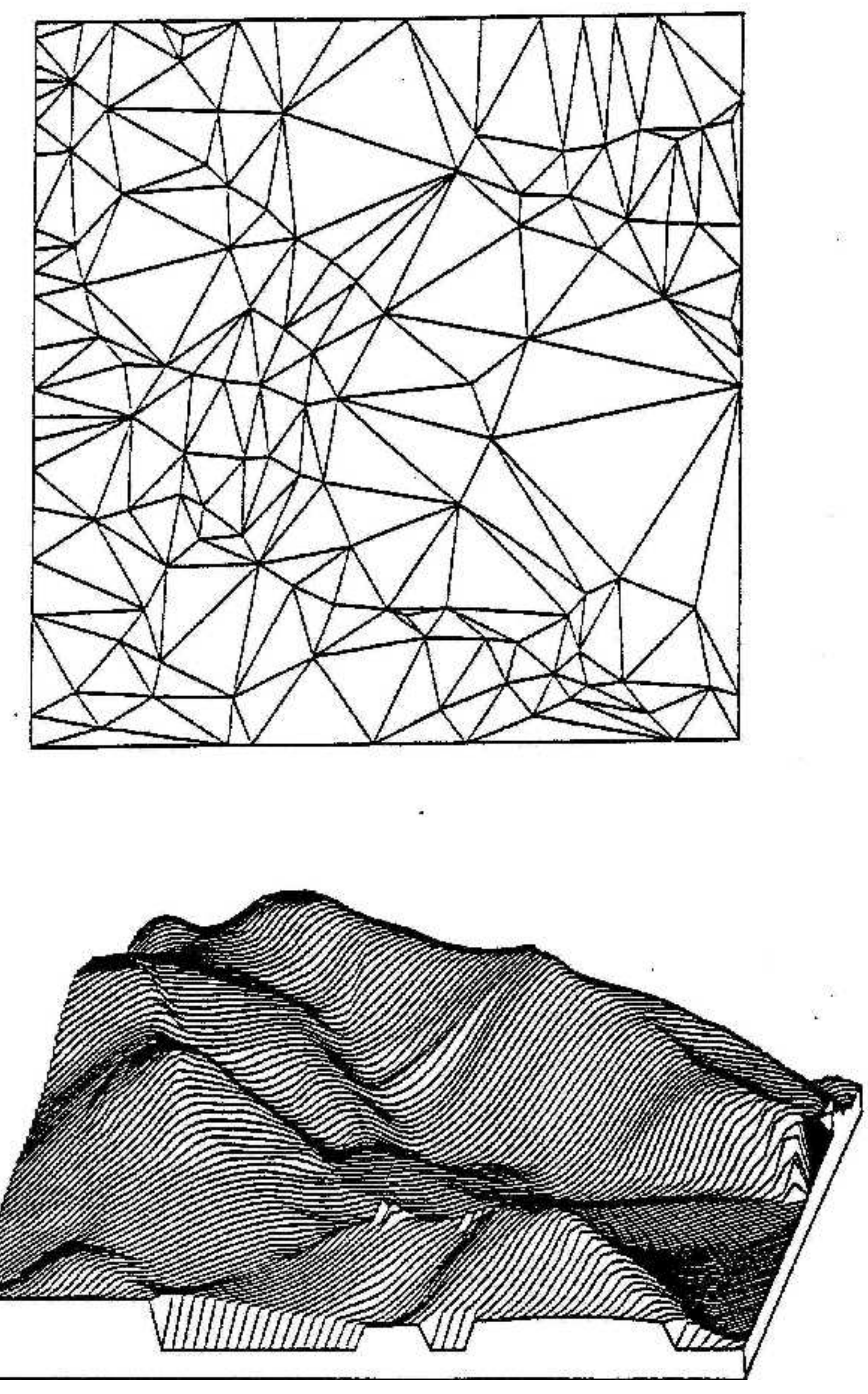

Figure 3. TIN Example. Upper figure shows the triangulated network and lower figure illustrates landscape generated based on the TIN.

Hypsography refers to elevations as lines of equal elevation. These lines represent discrete objects - *i.e.* vector data model (Figure 4)

vs.

The raster data model approach is completely different and involves measuring and encoding elevation as an attribute for a regular grid of locations (Figure 4). Therefore, elevation is treated as a continuous surface.

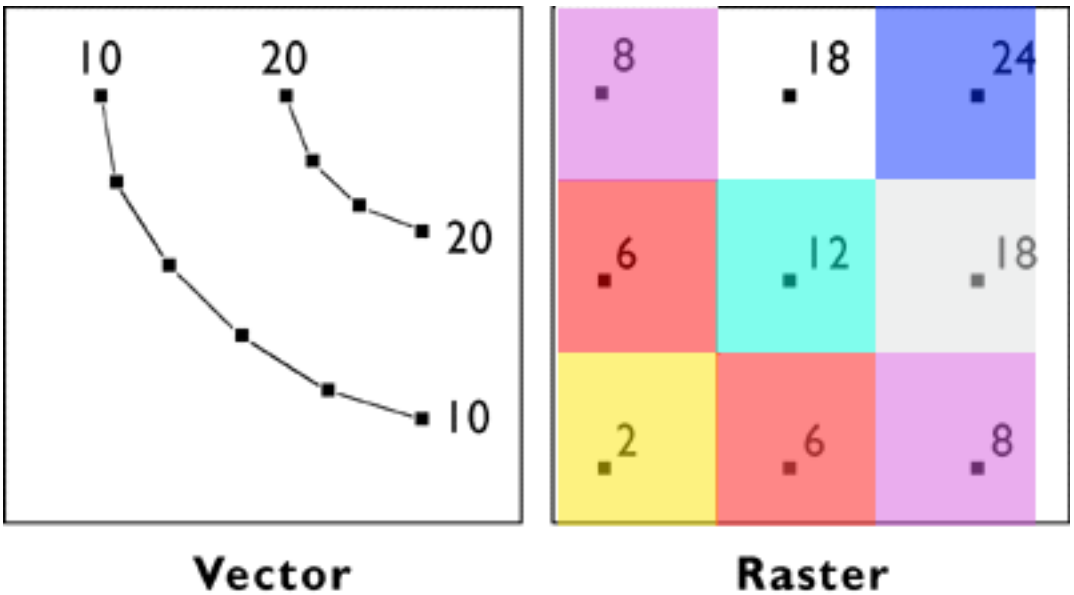

Figure 4. Vector versus raster depiction of elevation.

A raster representation of elevation is called a digital elevation model (DEM). DEM's are based on a regular grid of pixels (Figure 4). DEM's are particularly useful in that they allow you to calculate slope and gradient within drainage basins. Therefore, the raster approach is more useful in terms of analysis whereas vector elevation depictions are useful for only data visualization (looking at elevations on a map layer).

The USGS has developed a seamless coverage of DEM's for the US. There are several scales at which these DEM's have been developed. DEM's are available for large-scale and small-scale applications. The high resolution, large-scale DEM's available from the USGS have a resolution of 10 m and are mapped a scale of 1:24,00 scale and form the core product in the National Elevation Dataset (NED). Lower resolution, small-scale DEM's have a 90 m resolution (2 arc seconds) being mapped at a much smaller scale (1:250,000). More information about the various

USGS DEM products can be found at: http://catalog.data.gov/dataset/usgs-national-elevation-dataset-ned

At the scale of the world (very small scale) there are two major DEM products:

ETOPO2 http://www.ngdc.noaa.gov/mgg/global/etopo2.html

- Covers the whole world and has topography and bathymetry
- Consists of 58 million regularly spaced points at 2' of latitude and longitude; Each pixel is specified in geographic coordinates
- At the equator the resolution is 3.7 km
- Vertical resolution is in meters

GTOPO30 http://lta.cr.usgs.gov/GTOPO30

- Cover only the world's land surfaces
- Consists of 2.5 million regularly spaced points at 30" of latitude and longitude; Each pixel is specified in geographic coordinates
- At the equator the resolution is 0.925 km
- Vertical resolution is in meters

Another worldwide (small scale) DEM was obtained from the Space Shuttle Topography mission in 2000. The shuttle bounced radar signals off the earth and measured the speed at which these signals returned to the shuttle - basically a reverse GPS. This data is available at 30 m spatial resolution across the US and 90 m resolution worldwide.

GIS users can also develop customized DEM's for specific applications that require higher resolution data. For example, Light Detection And Ranging (LIDAR), in which a laser range finder on an overflight can produce DEM's with pixel resolution that are submeter.

An interesting secondary data set that you can develop with a DEM's is a 3-D terrain model. ESRI has developed a number of extensions that augment the functionality of ArcGIS Pro. These modules are plug-ins that add functionality beyond the basic ArcGIS program. 3-D terrain models can be developed using the ESRI 3-D Analyst module. Finally, GIS software can use a DEM to create a viewshed, which is the land area visible for any given vantage point (Figure 5).

Figure 5. Sample viewshed superimposed on a 3-D terrain model with green indicating landscape visible from the small + symbol in the center of the map. From http://freegeographytools.com/wp-content/uploads/2007/05/viewshed.jpg

2. Hydrography, Wetlands, and Floodplain Digital Data

The National Hydrologic Dataset (NHD) provides digital data about all surface water features mapped by the USGS, which include rivers, streams, canals, lakes, springs, wells, and the location of USGS streamflow monitoring stations. The base scale of the NHD is 1;100,000; although data at a smaller scale (1:250,000) is also available. The NHD represents a significant improvement over how hydrography data was previously available. Originally, hydrography data was basically scanned hydrography features from USGS topographic maps and features were not linked together with a consistent topology. An improvement on this situation was the development of reach files by the EPA, which represents segment of stream channels. The EPA developed several versions of reach files (RF1 to RF3). These reaches files were ultimately incorporated into the NHD. In the NHD flow directions and stream ordering are encoded as attributes allowing for the development of a connected river system within a watershed. As an environmental scientist it is well worth spending some time learning more about the NHD. The NHD is so important that frequently there are professional development classes offered on this topic at conferences around the country and by TNRIS in Austin.

The National Wetlands Inventory (NWI) determines whether an area is a wetland through fieldwork and interpretations of aerial photograph. Knowing the location of wetlands is important because many cities and town restrict development on areas defined as wetlands, which also tend to be highly ecologically sensitive areas. A problem with the definition of a wetland is that a segment of land many only be transitory. Therefore, mapping that occurs during dry years may miss significant areas that normally can be considered wetlands. Another issue that comes up when mapping wetlands is what is the smallest size of land that can be considered as a wetland. This is all in how you set up your minimum mapping unit (MMU). For the NWI the MMU is typically about 1 hectare (100 X 100 m). In any mapping project you have to decide what your MMU is? After all, you do not want to try to map puddles as wetlands.

A project that we were involved in a couple of years back was to develop a FEMA approved hazard mitigation plan for fourteen counties along the Texas-Mexico border. This project was called the CoverTheBorder project. As a part of this plan we were required to gather together all information about the major hazards that can potentially impact the border communities. The risk assessment developed in this plan determined that a major threat to life and property is the risk posed by flooding. The map we will discuss in this lecture is a low-resolution depiction of the FEMA approved 100-year floodplain for Webb County (Figure 6).

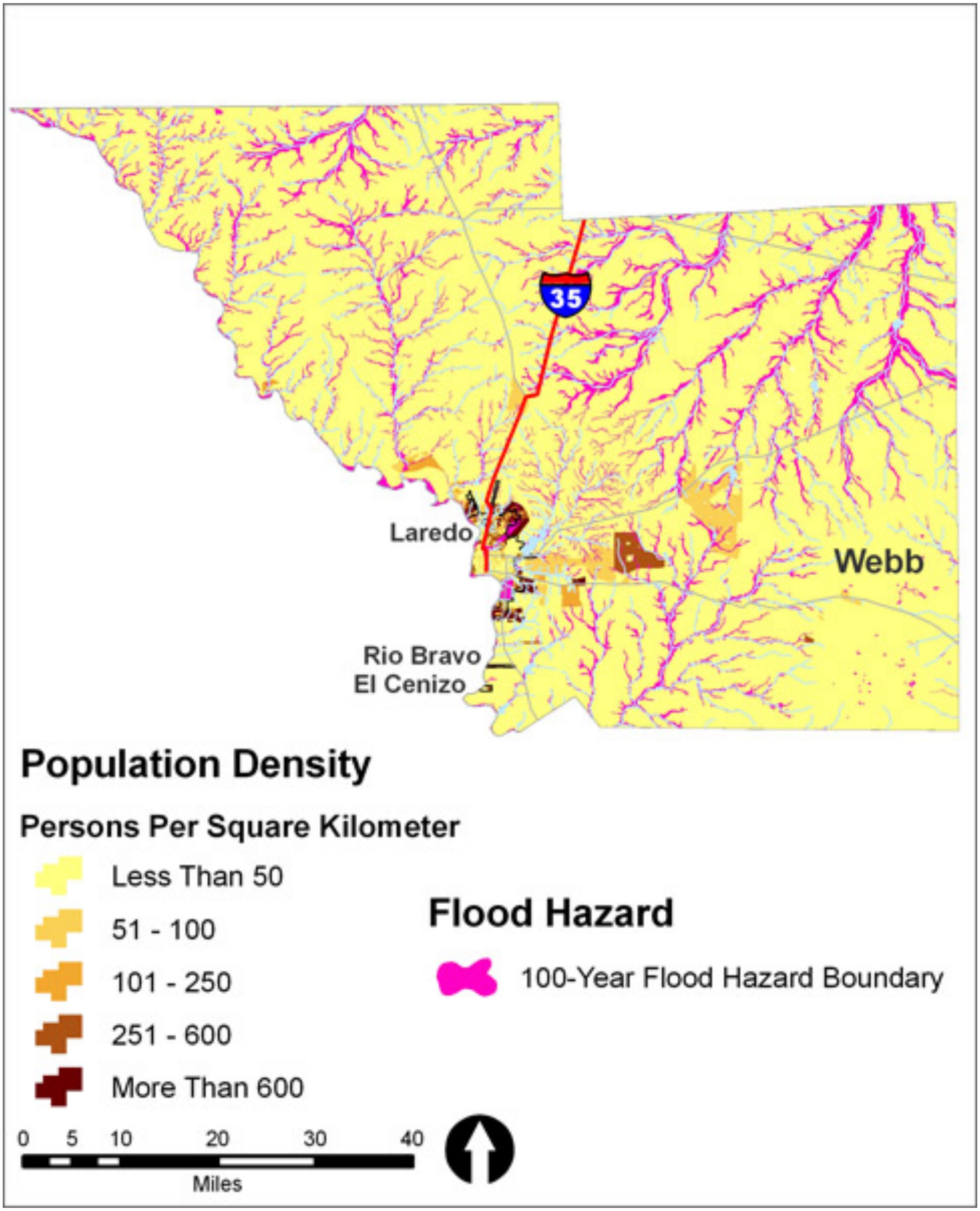

Figure 6. FEMA approved 100-year floodplain locations in Webb County.

A note about flood terminology - a 100-year flood is not a flood that happens every 100 years like clockwork. No, it is a severe flood that has a 1% change of occurrence on an annual basis. In this country most floodplain mapping was done back in the 1970's and 1980's and today only is infrequently updated as scare resources become available. You should realize that any map is out-of-date almost from the moment it was created. This is especially true in rapidly growing regions such as South Texas. Put another way - geospatial information has a finite shelf life. However, once something is created it is often difficult to modify or change it because financial interests are tied to the original product. This is what I mean when I say that geospatial data can take on a life of its own based not on technical but social considerations. In the case of floodplain delineation, it is a common practice to link insurance requirements and mortgage underwriting to the extent of the 100-year floodplain. Change the delineation and suddenly people's property are in the hazard zone impacting their property values and the ability to sell or refinance their home. This is why public meetings are required when floodplain modification occurs and the data must be of the highest quality, *i.e.* totally defensible, because likely someone will be so negatively impacted by the process that legal recourse will ensure.

3. Soils Digital Data

There are two type of digital soil data that are available in the US, SSURGO (1:24,000) and STATSGO (1:250,000). SSURGO is appropriate for large-scale applications such as a farmer planning how to plant crops on their farm. SSURGO map units are based on county soil surveys that where completed back in the 1960's to 1970's (show the class a **County Soil Survey book**). SSURGO files link GIS map units with an extensive database of information that is present for each soil type. This information includes physical soil properties such as available water capacity, permeability, pH, salinity, depth to bedrock, building suitability. Additionally, each soil type is divided into one to five layers. Remember that the boundaries of each soil unit may in general be correct but also realize that soils can commonly exhibit a gradually relationship where the characteristics of unit A blend into unit B (remember Figure 1 from Lecture 5).

STATSGO soil maps are smaller scale (1:250,000) and represent a generalization of SSURGO data. Typically, SSURGO is appropriate at the scale of a county, whereas, STATSGO represents statewide data sets. A STATSGO polygon may include up to 20 SSURGO map units.

4. Landcover Digital Data

Nationwide there are two land cover data sets. The earlier Land Use Land Cover (LULC) was developed back in the 1970 's to 1980's. The National Land Cover Database (NLCD) was developed in 1992 and a more recent update was made in 2001 and again in 2006 and 2012. The virtue of the NLCD is that it represents a consistent and continuous coverage of land uses across the entire US. As previously discussed land cover polygons are developed by examination and classification of aerial and satellite photograph including Landsat imagery. Figure 7 illustrates an example of a landcover map from one of my research watersheds.

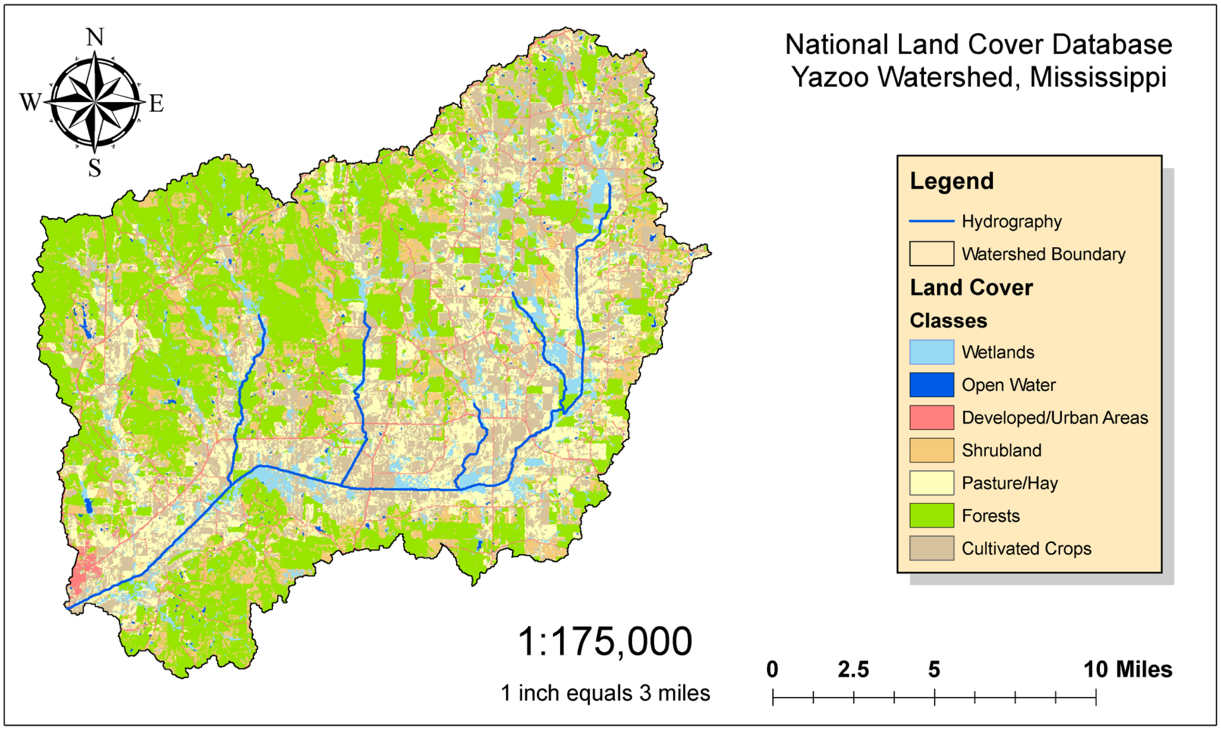

Figure 7. Example of NLCD data from a watershed in Mississippi.

5. Transportation Digital Data

The USGS and many partners including the Census Bureau has a mission to maintain the most up to date information regarding the countries transportation infrastructure. This is available in TIGER/Line data format. The advantage of this format is this data is topologically correct meaning that it can be used to support network applications such as routing. In fact, commercial services like Google Maps and MapQuest have TIGER/Line at their cores. Transportation reaches are represented as center-lines which makes them suited for small-scale applications.

Readings

DiBiase, D., 2014, Nature of Geographic Information Systems. Sections 7.2 to 7.13; 7.15 to 7.16.

Terms

DLG	TIN	DEM	Counter Line
Contour Interval	VMAP-0	NED	ETOPO2
GTOPO30	Viewshed	Space Shuttle Topography mission	
NHD	NWI	MMU	STATSGO
FEMA 100-year Floodplain		SSURGO	NLCD

Concepts

Know how contour lines are drawn from raw data

What are the advantages and disadvantages of representing elevation with a vector and raster data model

Know about the different products used to represent elevation

Know about the different data sets available for water related features

Know about the different data sets available for soils, land use and transportation

HOMEWORK

1. The following GIS product does not depict elevation.

(a) DEM (b) TIN (c) SSURGO (d) DLG (e) None of the above

2. The NED contains information about what type of features

(a) Rivers (b) Roads (c) Springs (d) Lakes (e) None of the above

3. Make sure you complete the contours for Figures 1 and 2. This is be a practicum question on the final.

4. Think about an application where you want to model water that flows in a watershed. Could you do this with stream segments that are saved in a shapefile format. Explain.

5. If you are looking at soils across the entire state of Texas what type of dataset would be more appropriate STATSGO or SSURGO. Explain.