

LECTURE 1 - INTRODUCTION TO GIS

Section I - GIS versus GPS

- What is a geographic information system (GIS)?

GIS can be defined as a computerized application that combines an interactive map with a database of related information. Data is the raw material upon which GIS operates (*e.g.* maps; related data). You can think of GIS is analogous to a system that transforms the data into something useful. There is no universally accepted definition for what a GIS is (read Chp. 1 on the GIS Commons webpage)

- What are the five components of a GIS?

A typically GIS consists of five elements:

- Hardware, Software, Data, People and Procedures (Work Flows)

Hardware - Most modern computers can support a GIS system. Since GIS software is computationally intensive the faster your computer's CPU and the more RAM memory the better. Additionally, some types of GIS data can be very large (GB's) so the bigger your hard drive the better

Software - Most prevalent GIS software comes from Environmental Systems Research Institute (ESRI) including ArcView 3.x and ArcMap 9.x and 10.x. However, there is some non-ESRI GIS software (MapInfo, Idrisi Kilimanjaro) and MapWindow, which is freeware. Significantly, MapWindow is open source software.

Data - Back during the 1990's there was a limited amount of data available for GIS. However, over the last two decades that has been a proliferation of data. In essence, we have moved from a data poor to data rich environment.

People - Obviously the experience of the people using GIS will determine the utility of this tool to address geographic problems. Also, in terms of people the GIS user needs to think of the end consumer of their work. Maps need to be understandable to the end user.

Procedures - The S in GIS can also represent science. Like any science the work you do with a GIS needs to be reproducible by other scientists. This can only happen by following consistent and well-defined procedures.

- Describe how the Global Positioning System (GPS) can provide a user with geographic coordinates?

A global positioning system (GPS) bounces radio signals between a hand-held GPS receiver and a number of earth-orbiting satellites to precisely determine positions on the earth's surface. The distance that the receiver is from a satellite is determined by the time it takes a radio signal to travel from the satellite to the GPS receiver (Figure 1). If a receiver can lock onto a minimum of three satellites then the position of the receiver, in terms of latitude and longitude can be determined. If the receiver can lock on to four satellites then elevation can also be determined. We will discuss GPS technology in much more detail in a later lecture.

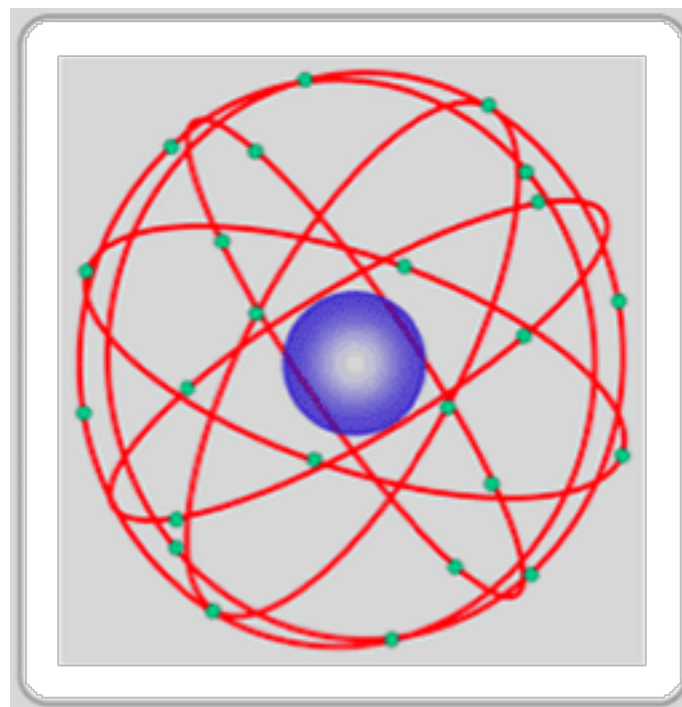


Figure 1. NAVSTAR GPS constellation of satellites operated by the US Department of Defense.

Section II - Conceptualizing Geographic Objects

- Introduce the concept of a **geographic entity**.

As GIS operates on the premise that **features** in the real world, or geographic entities, can be represented in a digital format.

- Introduce the concept of vector versus raster **data models** for representing geographic entities.

At the level of an individual geographic entity there are two possible ways of encoding geospatial data into a GIS, which are referred to as data models.

- **Vector Data Models** - Where an entity is represented as discrete objects
- **Raster Data Models** - Where an entity is represented as a continuous surface

- **The nature of the vector data model**

Vector data models are best suited to geographic entities that have discrete and sharp boundaries. Additionally, vector data is free to define geographic entity at any spacing in a non-uniform manner.

- **When representing objects using the vector approach there are three possible representations:**

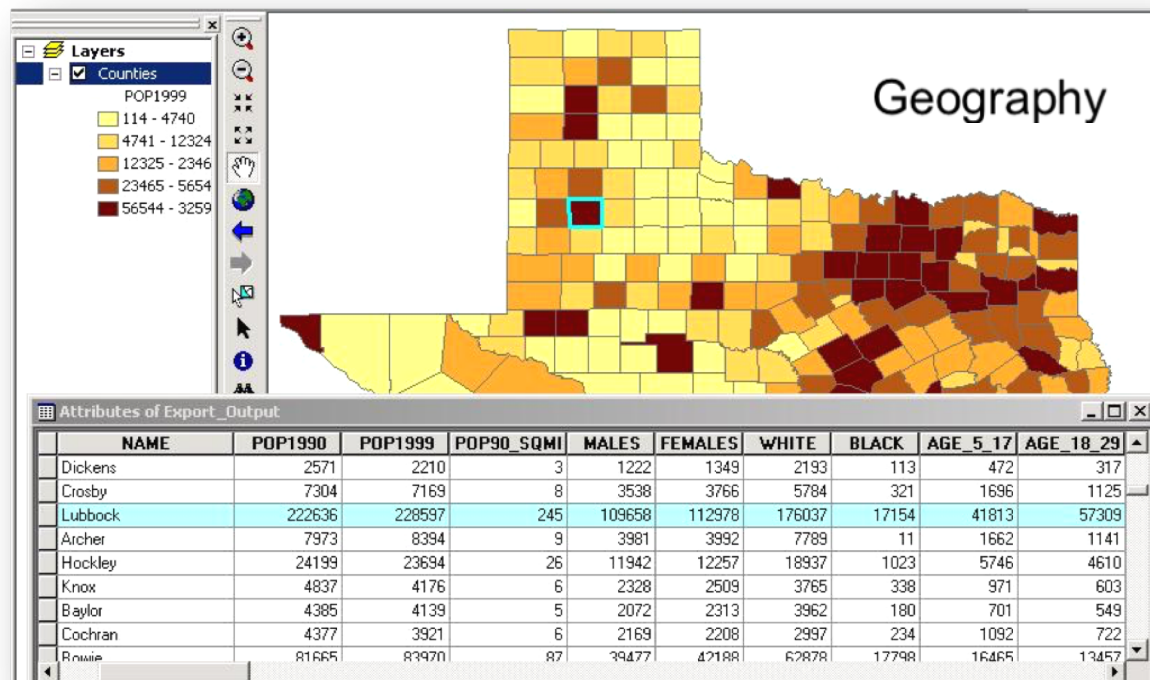
Points reflect specific locations on a map. Some examples of point features include wells in a county, landmarks, cities on a world map. Two points (vertices) connected by a line segment define a **line**. Examples of lines include: roads, streams, pipelines, transmission lines. Multiple line segments can be connected to form **polylines**. Polylines that close on themselves form **polygons** and include features such as counties, tax parcels, land use, soil types (Figure 2).

- **Raster data is generally represents continuous entities as surfaces**

Raster data models define objects in a fixed manner through varying the color values of individual **pixels** that make up the geographic entity. Each grid cell has fixed size or spatial resolution. The raster approach is better for delineating continuous geographic fields of data, which can be thought of as surfaces. Some examples of raster geographic data include elevation, temperature, atmospheric pressure, airborne or satellite imagery.

- **Beyond how entities are represented how does the vector data model differ from the raster data model?**

GIS data layers have an advantage in that they can be linked to database management system (DBMS). Digital data is stored as files (called tables). A database is a collection of tables and each table in a GIS system is referred to as an **attribute table**. Tables are generally in tabular form. Rows are known as records corresponding to individual geographic entities or **features**, typically geographic objects represented in only a vector format. Each record in the **attribute table** is associated with a particular map feature. See blue selected feature in Figure 2. Columns reflect attributes (or **fields**) associated with each entity. Typically, each vector entity (point, line, polygon) can have spatial attributes that define the geographic location of the entity (LAT, LONG, x, y). Additionally, any number of non-geographic attributes can be included.



Attribute Table

Figure 2. Texas counties layer should geographic and attribute information.

Raster data tends to be more limited in terms of attribute information. Geographic objects are depicted by pixel intensity. If grayscale image (black and white) pixel intensities can vary between 0 (black) and 255 (white). With a color image there are several options; a common format is RGB (red, green, blue) where millions of colors can be shown by 0 to 255 intensities of R, G, and B (Figure 3).

An ages old argument is what type of data model is better, vector or raster. The answer is it depends. Chp. 1 on the GIS Commons webpage highlights the advantages and disadvantages of each data model. We will get into a much more detailed discussion of data models later in the course.

Section III - What you can do with a GIS?

- GIS supports basic functions such as measure distances, lengths, and determine areas.
- The most powerful function of GIS is its ability to **overlay** different data layers allowing the user to **visualize** spatial relationships between different types of geographic data.

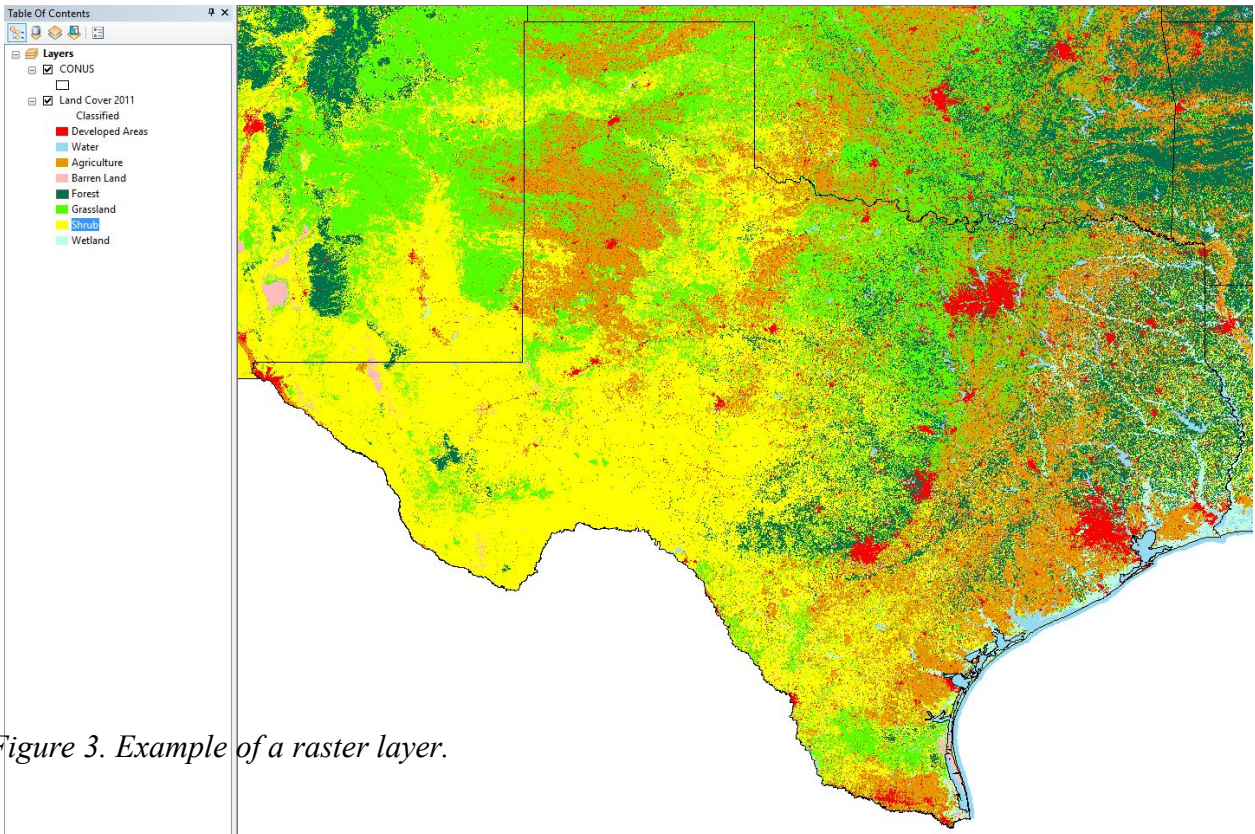


Figure 3. Example of a raster layer.

Point, line, polygon, and surface features can be organized into logical data layers. One of the core functions of GIS is the ability to **overlay** multiple layers allowing the user to understand complex spatial relationships between different features on the landscape. This overlay process is the essence of digital cartography and was the motivation to develop GIS several decades ago.

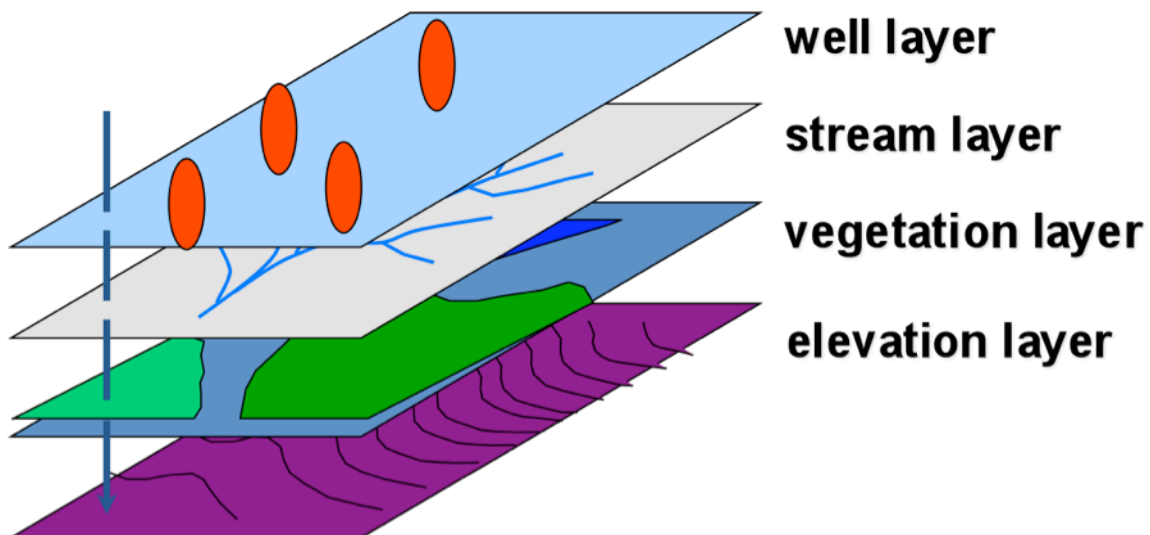


Figure 4. Overlay of several different layers.

However, today GIS is much more than computer mapping. The true power of GIS is its ability not only to display geographic entities but its ability to facilitate geographic analysis. Analysis transforms geographic data into information that is created in response to a question (or hypothesis) - Remember the S in GIS can also stand for science.

- GIS systems are powerful because users can select specific entities for visualization. For example,

You can select by clicking on the map (Location) or clicking on a feature in the attribute table (Attribute). Again, see Figure 2.

- Additionally, GIS can be used to answer spatial questions, map and analyze change, and support advanced spatial models

- Basic spatial questions

Example: Determine which ecological regions are adjacent to South Texas

- Map and Analysis Change

Example: Model changes in plant phenology associated with climate change.

- Support Advanced Spatial Models

Example: Disease outbreaks and vectors.

Section IV - Why is GIS important?

- What type of activities are supported by GIS?

See if you can think of ten different types of GIS data that could help you with either your work or research. Check out the web and see what you can come up with. You will be asked about this later.

Readings

GIS Commons webpage; Chapter 1

Terms

GIS	GPS	Vector Data Model	Raster Data Model
Feature	Attribute Table	Point	Line
Polygon	Pixel	RGB	Overlay Function

Concepts

Be able to explain the difference between a vector and raster data model.

From your readings determine when a vector data model is more appropriate than raster data.
From your readings determine when a raster data model is more appropriate than vector data.
Compare and contrast the advantages and disadvantages of the vector and raster data models.
What type of data model is best able to handle numerous attributes. Explain.

HOMEWORK – DO NOT BLOW OFF!!!

Some of these questions may show up on the quiz a week from Tuesday so make you should complete the questions below.

1. What is GIS? Define the following components of the GIS system you will use this semester.
Hardware (System, Hard drive Space, RAM Memory, Other Devices)

Software (Name and Version of GIS Software)

People

Describe your level of experience with GIS software.

Describe your background in general regarding operation of computers.

2. In your own word explain the difference between a vector and raster data model.

3. Examine Figure 4 and describe the data model associated with each layer.

Layer Name	Data Model (Vector, Raster)	Vector Type (Pt, Line, Polygon)

4. Check out the Geographic Names Information Systems (GNIS; <http://geonames.usgs.gov/pls/gnispublic>)

Find your hometown in the GNIS and see what other features share this name across the country.

5. At the end of the semester you will have to complete a final project. Start thinking about what you might be interested in working on and the type of GIS data that you will need to complete this work. How can these data be overlaid to promote a more meaningful analysis.