GIS and Remote Sensing

Introduction to Mapping and GIS

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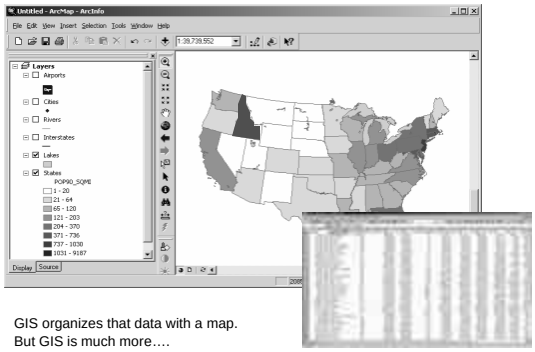
Think about all the activity occurring though out a landscape.
How can we map, manage and analyze all that is going on? GIS!

Break in to groups of 4-5
and Give Best Definition of GIS

US Census Data in Excel

Think about keeping information about phenomenon on a landscape.
How could you do it?

US Census Data in GIS



GIS organizes that data with a map.
But GIS is much more….

What is GIS?

1. Data Management
   - Manages various kinds of GIS data including vector, raster, images, tables, other data files
   - Data models and architectures
   - Conversion between formats
   - Import/export utilities
   - Interacts with RDBMS (SQL Server, Oracle, etc…)

What is GIS?

2. Analysis
   - Spatially aware data
   - Attribute and spatial query
   - Proximity and Overlay
   - Advanced geoprocessing techniques
   - Decision support
   - Flexible, customization
     - Programming, scripting (to perform analysis)

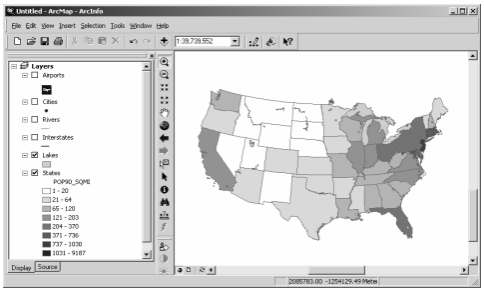
What is GIS?

3. Visualization
   - Maps! Maps! Maps!
     - If a picture is worth a 1000 words…
   - Professional cartographic tool
   - Charts, graphs, tables, etc…
   - Various coordinate systems
   - 2D and 3D
   - Web, desktop, handheld, etc…

What is GIS?

- Data Management – Database View
- Analysis – Model View
- Visualization – Map View

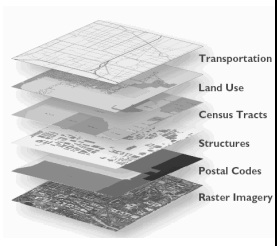
Core of GIS = "Layers"



Importance of Layers in GIS

- Geographic data = Representation of reality

- Reality is complex.
- GIS utilizes a layer approach
- Each layer only includes information about one type of phenomenon.
- Data layers must be aligned with one another



Importance of Layers

- **Proximity**
  - Finding what is near or within a distance from a certain location or feature

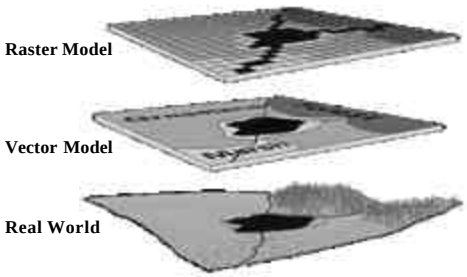
  e.g., all houses within 100 yards of a stream
- **Overlay**
  - Combining two layers to create new information

  e.g., habitat based on veg, elevation, and temp

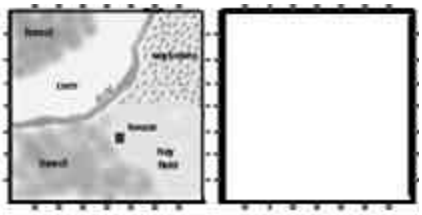
Families of G.I.S Data

- **Vector** mode or coordinate based
- **Raster** mode or grid cell

Modeling Geospatial Reality

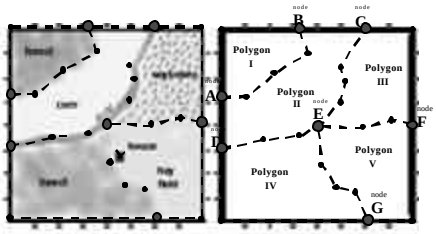


Coding Vector GIS



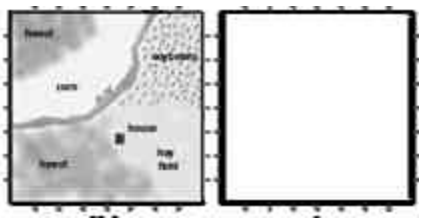
Reality Vector Mode Model of Reality

Coding Vector GIS



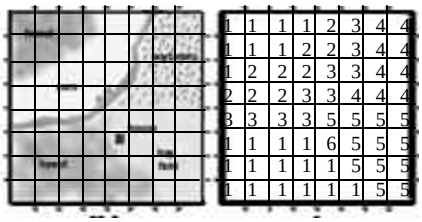
Reality Vector Mode Model of Reality

Coding Raster GIS Data



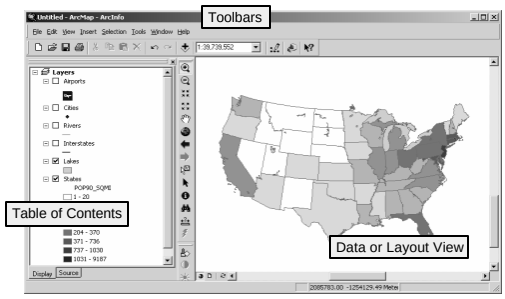
Reality Raster Mode Model of Reality

Coding Raster GIS Data



Reality Raster Mode Model of Reality

Arcmap window



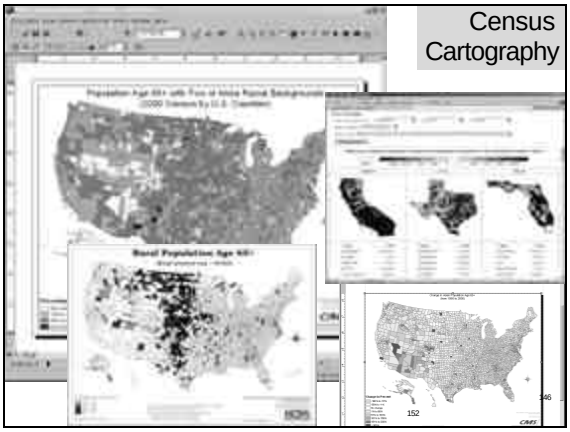
Demonstration

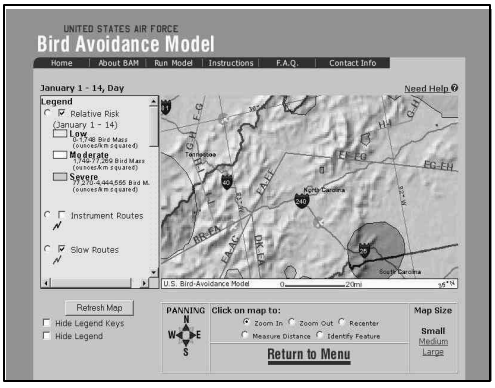
Desktop GIS: ArcMap

New Jersey

How is GIS used?

- Sometimes, the best way to learn about GIS is to see how it's being used.
- Let's take a look…

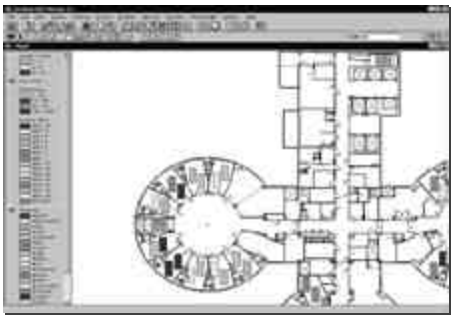




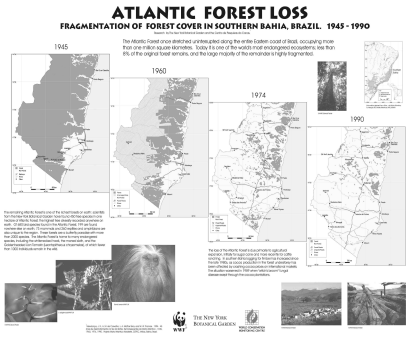
Network Solutions

Environmental Monitoring
Toxic Plume

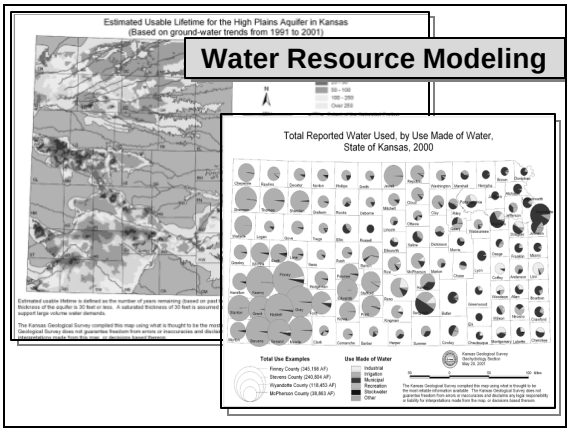
Loma Linda Hospital Facilities



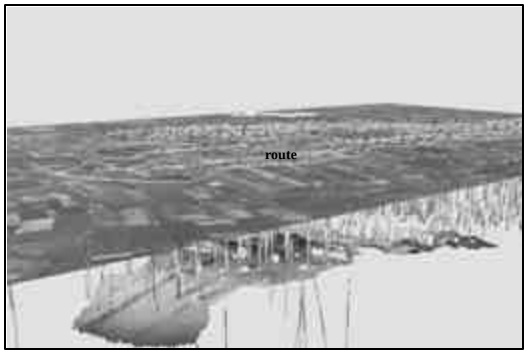
Vegetation Change



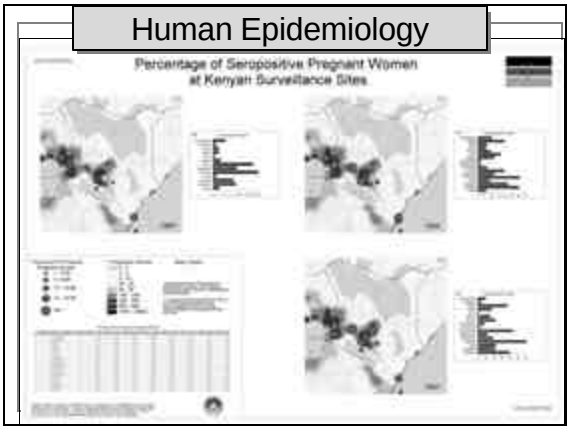
Water Resource Modeling



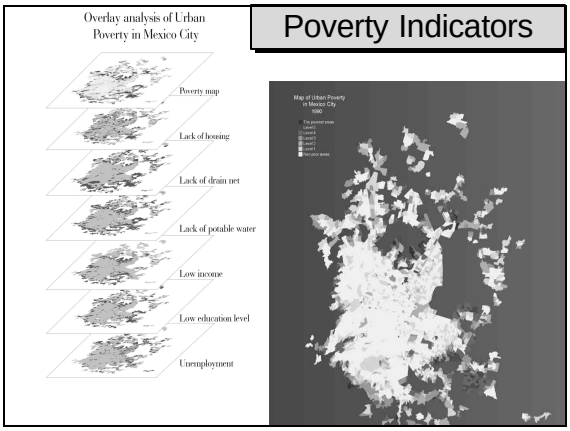
Geologic Understanding



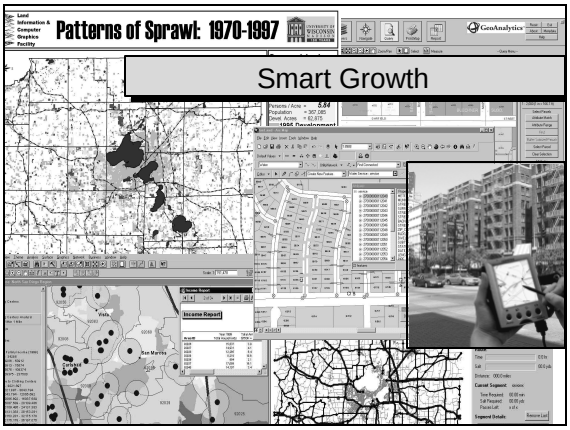
Human Epidemiology



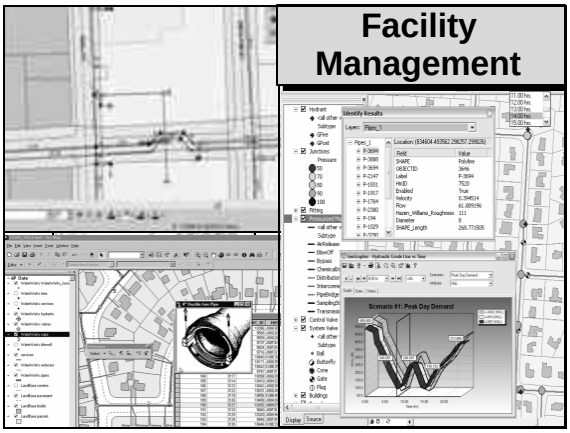
Poverty Indicators



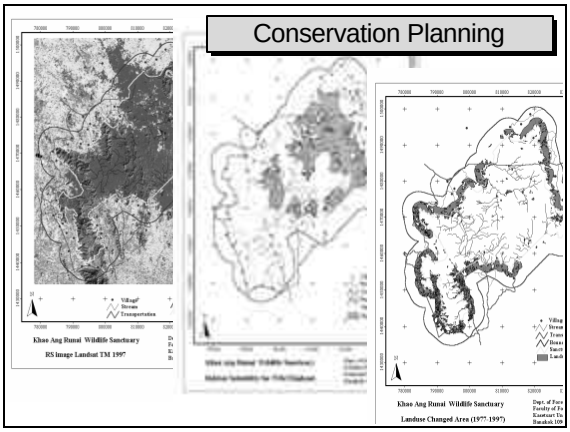
Smart Growth



Facility Management

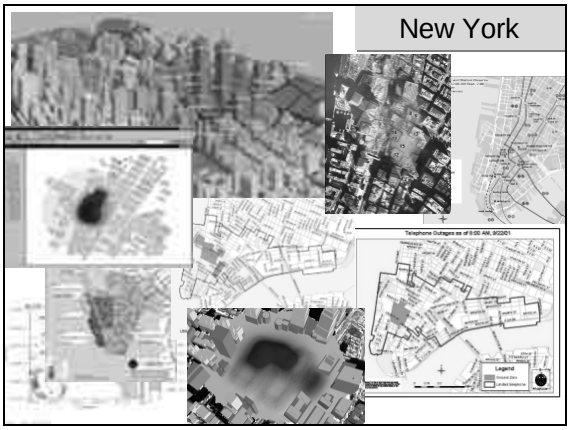


Conservation Planning



Business Location and Marketing

New York



What is GIS?

- Now that we've learned the essential elements that make up a GIS…
- …and have seen examples of how GIS is being used…
- …let's take a look at the big picture.

"G" vs. "IS"

- GIS uses maps to spatially analyze and search for patterns in the data that would otherwise not be found. (***Content***)
- GIS stores, manipulates, and displays data files and relationships in a information system using standard computing practices. (***IT***)
- With advances in technology, GIS users must now deal with both aspects!

The "G"

- "G" = Geographic
  - Denotes the concept of spatial location on Earth's surface
  - Importance of relative location (not just where you are but where you are in relation to everything else)
  - Theories and techniques in Geography form the basis of GIS

The "I"

- "I" = Information
  - Substance (knowledge) about location
  - Factual and interpretative
  - Tables + Maps + Analysis
  - Transformation of table information into spatial context for analysis
  - Technology and computer systems

What about just "GI"?

- Yes, it is used quite often.
- Commonly used as a replacement for or broadening of the term "GIS data"
- But…

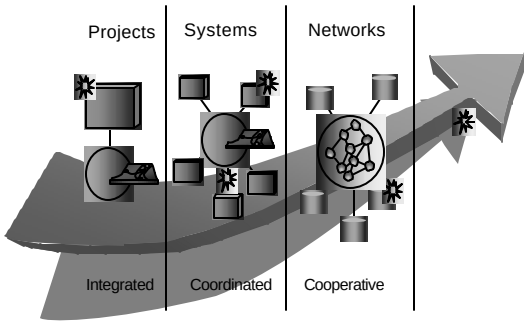
What About the "S" in GIS?

- Systems
- Science
- Studies
- Services

Geospatial?

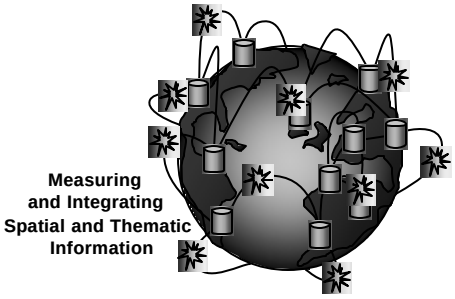
- Geographic + GIS = "Geospatial"
- Move in recent years to better define the industry and to focus on data (business) over geographic principles (academic)
- Geospatial includes all subcomponents of GIS embedded in other areas (remote sensing, GPS etc.)

GIS Is Evolving



. . . Moving to the Internet and Web Services

Creating a Digital Earth

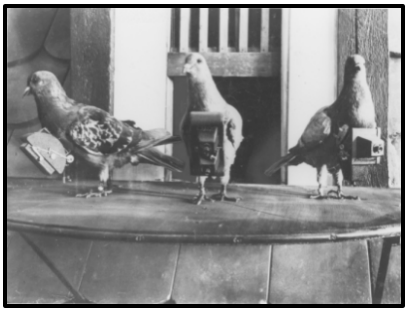


. . . A Nervous System for Spaceship Earth

Remote Sensing

- Acquiring data from a distance
- Usually uses electromagnetic energy
  - sunlight, radar, laser
- Originally captured on photographic film
- Recent platforms utilize digital sensors

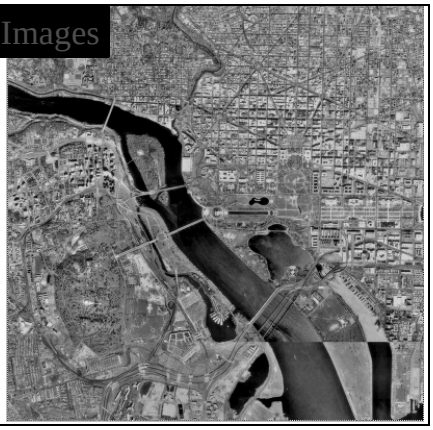
Early Remote Sensing Platforms



What kinds of devices collect the data?

- Aircraft
  - High altitude
  - Low altitude
- Spacecraft:
  - Landsat
  - Spot
  - Weather satellites
  - Hubble Telescope….

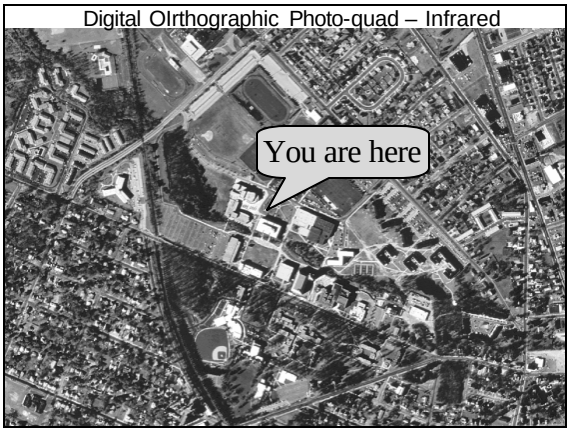
Aircraft Images



Black and White
or
"Panchromatic"

Sensitive to
visible light

Digital OIrthographic Photo-quad – Infrared

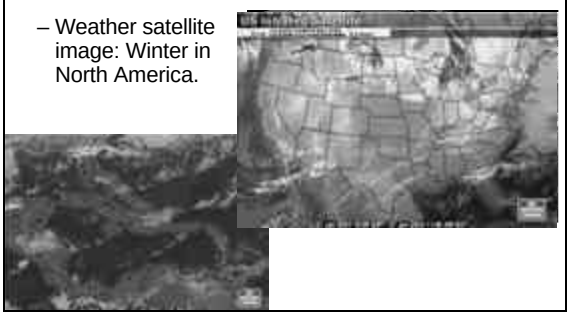


Remote Sensing Mediums

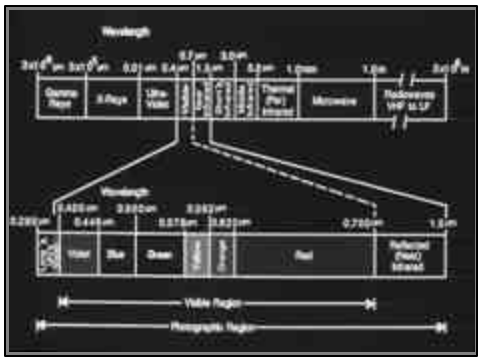
- Black and White or "Panchromatic"
  - Sensitive to visible light
- Infrared
  - sensitive to infrared frequencies
  - Good for vegetation and water
- False-color adjusted
  - When frequencies of received data are shifted to allow or enhance human viewing
- Multi spectral
  - When more than a single "band" of energy is captured
  - Color is multi-spectral (3 bands)

Satellite Images

– Weather satellite image: Winter in North America.

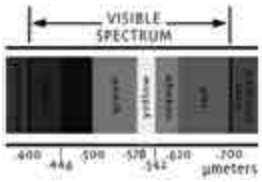


The Electromagnetic Spectrum

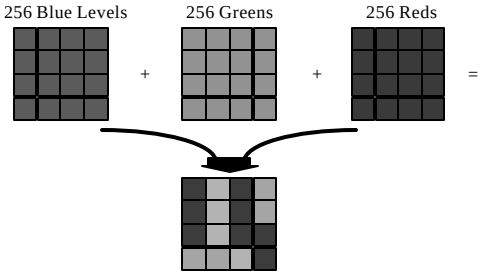


The Visible Spectrum

- The visible spectrum is only a tiny window
- We are blind to 99.99% of the energy in the universe
- We have created devices that allow us to see beyond the range of human vision



Multispectral
How can numbers create a picture?



True Visible Color

Satellite Platforms

- LANDSAT TM
- AVHRR
- GEOS
- IKONOS
- SPOT
- IRC
- Many Others ….

Geosynchronous Orbit

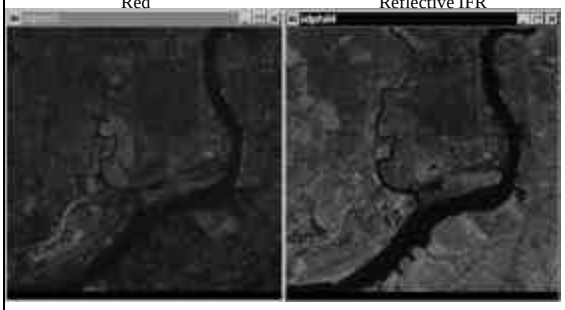
when the satellite moves at the same speed as the spinning earth

LANDSAT TM Image of Philadelphia
Bands 1 & 2

Blue Green

Philadelphia TM Bands 3 & 4

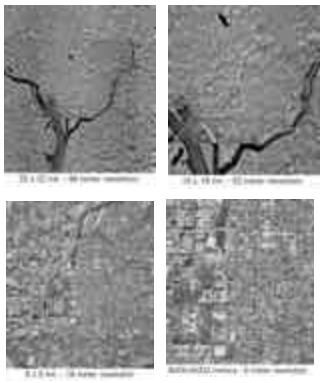
Red Reflective IFR



What are the spatial units for which data are collected?

- Pixel or Picture Element
  - Data collected for each pixel in the scene.
  - For each of several portions [bands] of the EMS
- Pixel Sizes
  - Landsat MSS = 79 meters
  - Landsat TM = 30 meters
  - SPOT = 10 meters
  - IRSC = 5 meters
  - IKONOS = 1 meter

Spatial resolution keeps getting better...



Spatial resolution keeps getting better...

1, 3, and 10 meters

Why is remote sensing important?

- Provides detailed data for large areas on a regular time schedule.
- These data can be used to determine:
  - Color
  - Surface configuration
  - Biomass
  - Temperature
  - Elevation
  - Land use / land cover
  - Soil moisture
  - Mineral characteristics

  These are all important GIS data sources.
- Remote Sensing is a very useful GIS layer

Using The Software

Desktop GIS: ArcMap

ArcGIS

- ESRI's Premiere GIS software
- A scalable GIS system which includes
  - ArcView, ArcEditor, and ArcInfo = level of capabilities
  - Extensions = added functions
- Provides a wide range of GIS tools for needs which range from Desktop mapping to Geostatistical Analysis

ArcGIS has a three part interface:

- **ArcCatalog** – for navigating spatial data

- **ArcMap** – for creating presentation graphics

- **ArcToolbox** – powerful geoprocessing tools

Data for ArcGIS

- Vector Data
  - ArcView Shapefiles
  - ArcInfo Coverages
  - Geodatabase
  - CAD drawings

- Raster Data
  - Most common imagery formats can be rea
  - ArcInfo GRIDs, MRSID

ArcCatalog

- ArcCatalog is similar to the Windows "explorer", or the "My Computer" icon on your windows desktop. It is a tool for navigating through your GIS datasets. The benefit of using ArcCatalog is that it has been specially designed for use with spatial data.

ArcCatalog: Previews

- Using ArcCatalog you can easily preview both your spatial datasets, and the attribute data associated with them

ArcCatalog: Data Management

- ArcCatalog is provides an environment where it is safe to cut and paste spatial data into new directories, and even into the newest ESRI spatial data structure, the geodatabase. Additionally, several common conversion routines are available from ArcCatalog

ArcCatalog: Metadata

ArcCatalog includes tools for viewing and editing Metadata. It even has an option to automatically update some items in the metadata whenever a dataset is edited

ArcMap

- ArcMap is like a virtual drafting table. It contains a **canvas** where GIS data layers are drawn, and a **Table of Contents** (TOC) which helps keep track of the data in the canvas. For desktop mapping, this is the interface which you will spend most of your time in. Almost any interactive analysis and visualization takes place in ArcMap. The canvas can be viewed in two states, Data view is where most of the analysis is done. When you are ready to create a presentation, switch to layout view and you gain access to cartographic tools.
- There are several toolbars available in ArcMap. The **standard** toolbar contains basic file management tools (new, open, save, cut/paste, etc). The **tools** toolbar contains simple navigation, identification, and selection tools. The **draw** toolbar is a basic windows style drawing toolbar (like you would find in word or PowerPoint). There are several other special need toolbars available from the View menu. Among other things, there is an edit toolbar and there are special toolbars for extensions available.
- In addition to the toolbars, there are several menus available in ArcMap. The menus contain some of the commonly used items from the toolbars as well as a few common functions from ArcCatalog and ArcToolbox.

ArcMap: Map View

Saving your work in ArcGIS

- **Map Documents (.mxd)** – Saves a snapshot of all the layers that are loaded into the map canvas BUT does NOT save the data layers themselves.
- **GIS Data File (many possible types)** – ArcGIS can utilize many different types of GIS and image data. Each data file is treated as a "layer" of information in the table of contents.
- **Layer Files (.lyr)** – Saves the way a data file is rendered on screen. Again, the data source itself is not copied, but instead referenced by the layer file

ArcToolbox

- For heavy duty processing, ArcToolbox contains analysis, conversion, and data management tools. Additionally, there is an option to construct your own custom tools. You may set up most tools using wizards which help take the guess work out of some of the otherwise complicated options