Week 1: Introduction to GIS

GEOG 011

Dr. Evan Lue

Pasadena City College

Spring 2015

Course Introduction

- Tuesdays and Thursdays, 7:30-10:00pm
  (CRN 33527; https://canvas.pasadena.edu/courses/951434)

or

- Fridays, 8:00am-1:25pm
  (CRN 33526; https://canvas.pasadena.edu/courses/951435)

- Location: E220
- Prerequisites: None
- Credit hours: 3
- Contact e-mail: elue@pasadena.edu
- Office Hours: Tuesdays 4-5pm in E210G (please e-mail 24 hours in advance)

Student Learning Outcomes

1. Identify and evaluate a GIS, GIS data sources and the importance of metadata and the capabilities of various GIS software programs.

2. Demonstrate the process of converting analog data to digital data for use in a GIS and identify, compare and contrast vector and raster GIS.

3. Apply cartographic principles of scale, resolution, projection and data management to a problem of a geographic nature and apply spatial analysis functions on a GIS to solve a Geospatial problem.

Course Format

- Students will meet in class for 5 hours per week: approximately 2 hours for lecture and 3 hours for lab, though the ratio of lecture-to-lab time may vary as necessary.

Evaluation

Assignment	Qty.	Unit Contribution to Final Grade	Total Contribution to Final Grade
Lab Exercises	8	6%	48%
Midterm Exam	1	20%	20%
Final Project (10% for presentation, 17% for report)	1	27%	27%
In-Class Participation	1	5%	5%
TOTAL			100%

Evaluation (continued)

- **Lab Exercises (8 x 6% = 48%)**
- Lab exercises will be taken from the book *Understanding GIS*, which has 9 chapters. Students will submit lab worksheets (distributed at the start of each lab) for exercises 2 through 9. Lab worksheets are due after the lab exercise is complete; if a lab exercise topic is to be covered over two weeks, no worksheet is due at the end of the first week, but is instead due at the end of the second week.

- **Midterm Exam (20%)**
- This exam will be a mixture of multiple choice and short answer, with a practical computer component.

Evaluation (continued)

- **Final Project (27%)**
- Students will use their GIS knowledge to conduct a project from start to end. Examples of projects include doing a community analysis of their neighborhood, assessing site suitability, or exploring the hydrologic features of a landscape. These projects will be discussed shortly before the midterm and projects will be picked and instructor-approved after the midterm. The grade for this assignment will be split 10% for an oral presentation and 17% for a report to be published on a website.

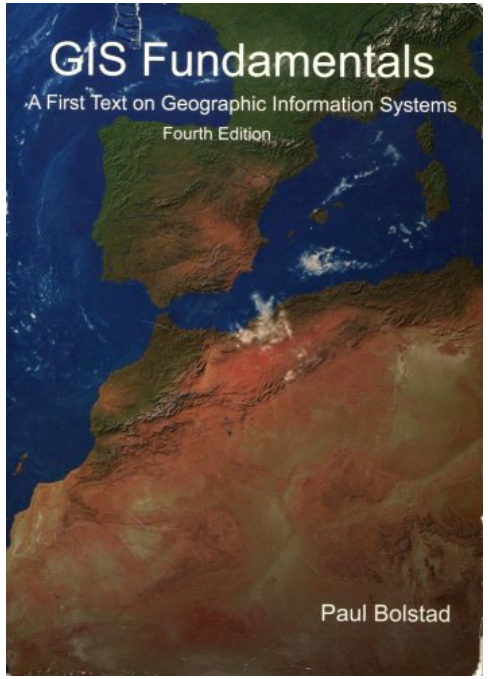
- **In-Class Participation (5%)**
- Participation is expected of every student via attendance, prompt arrival, and discussion.

Grading Metrics

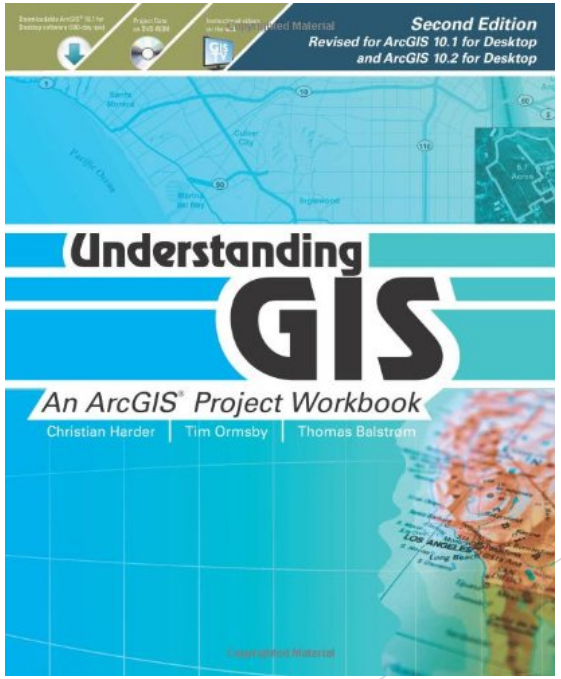
- Completeness of assignment specifications
- Demonstrated application competency (i.e. correctness where applicable)
- Clear communication, including aesthetics
- Demonstrated critical thinking and/or creativity
- Promptness; each day late results in 10% grade reduction with no late work after 5 days

Textbooks

- Bolstad, P. 2012. GIS Fundamentals: A First Text on Geographic Information Systems, 4th Edition.



- Harder, C., T. Ormsby, and T. Balstrom. 2013. Understanding GIS: An ArcGIS Project Workbook, Second Edition.



USB Flash Drive

- You must bring a USB flash drive with at least 1GB free space to every class session (2GB recommended)!
- Primarily used for lab exercise data, which is 836MB alone
- You will work off of this flash drive, as the lab computers wipe clean after you log off

Academic Conduct

- Academic conduct is taken very seriously, especially in regard to plagiarism. Any text that you submit in an assignment that is clearly copied from another source needs to be cited. Also, verbatim copied responses should be a small fraction of the word count of the text you submit to an assignment. For example, if an assignment asks you to describe what a GIS tool does, you cannot simply copy and paste the description of that tool from its website, even if you do cite it. Plagiarism in a portion of an assignment may result in no credit for the entire assignment.

TuTh Schedule

Semester Week	Tuesday/ Thursday	Lecture (GIS Fundamentals Chapters)	Lab (Understanding GIS chapters)
1	01/13 and 01/15	Ch 1: An Introduction to GIS (24 pp.)	1
2	01/20 and 01/22	Ch 2: Data Models (46 pp.)	2
3	01/27 and 01/29	Ch 3: Geodesy, Datums, Map Projections, and Coordinate Systems (60 pp.)	3
4	02/03 and 02/05	Ch 4: Maps, Data Entry and Editing (52 pp.)	4
5	02/10 and 02/12	Ch 5: Global Navigation Satellite Systems and Coordinate Surveying (40 pp.)	4 cont.
6	02/17 and 02/19	Ch 6: Aerial and Satellite Images (48 pp.)	5
7	02/24 and 02/26	Ch 7: Digital Data (36 pp.)	6
8; Mid	03/03 and 03/05	Ch 8: Attribute Data and Tables (40 pp.)	7 cont.
9	03/17 and 03/19	Ch 9: Basic Spatial Analysis (60 pp.)	7
10	03/24 and 03/26	Ch 10: Topics in Raster Analysis (36 pp.)	7 cont.
11	04/02	GUEST LECTURE	---
12	04/07 and 04/09	Ch 11: Terrain Analysis (30 pp.)	8
13	04/14 and 04/16	Ch 12: Spatial Estimation: Interpolation, Prediction, and Core Area Delineation (48 pp.)	8 cont.
14	04/21 and 04/23	Ch 13: Spatial Models and Modelling (40 pp.)	9
15	04/28 and 04/30	Ch 14: Data Standards and Quality (24 pp.) and Ch 15: New Developments in GIS (17 pp.)	9 cont.
16; Final	05/05 and 05/07	Present final projects	---

Due to campus holidays, TuTh and Friday classes will be out of sync for 7 weeks, indicated by *italics*.

Friday Schedule

Semester Week	Friday	Lecture (GIS Fundamentals Chapters)	Lab (Understanding GIS chapters)
1	01/18	Chapter 1: An Introduction to GIS (24 pp.)	1
2	01/23	Chapter 2: Data Models (46 pp.)	2
3	01/30	Chapter 3: Geodesy, Datums, Map Projections, and Coordinate Systems (60 pp.)	3
4	02/06	Chapter 4: Maps, Data Entry and Editing (52 pp.)	4
5	02/13	HOLIDAY	---
6	02/20	Chapter 5: Global Navigation Satellite Systems and Coordinate Surveying (40 pp.)	4 cont.
7	02/27	Chapter 6: Aerial and Satellite Images (48 pp.)	5
8; Mid	03/06	Chapter 7: Digital Data (36 pp.)	6
9	03/20	Chapter 8: Attribute Data and Tables (40 pp.)	7 cont.
10	03/27	Chapter 9: Basic Spatial Analysis (60 pp.)	7
11	04/03	Chapter 10: Topics in Raster Analysis (36 pp.)	7 cont.
12	04/10	Chapter 11: Terrain Analysis (30 pp.)	8
13	04/17	Chapter 12: Spatial Estimation: Interpolation, Prediction, and Core Area Delineation (48 pp.)	8 cont.
14	04/24	Chapter 13: Spatial Models and Modelling (40 pp.)	9
15	05/01	Chapter 14: Data Standards and Quality (24 pp.) and Chapter 15: New Developments in GIS (17 pp.)	9 cont.
16; Final	05/08	Present final projects	---

Due to campus holidays, TuTh and Friday classes will be out of sync for 7 weeks, indicated by *italics*. Students are invited to the Thursday, 4/2 guest lecture.

Time to Learn Something

A GIS is an information system

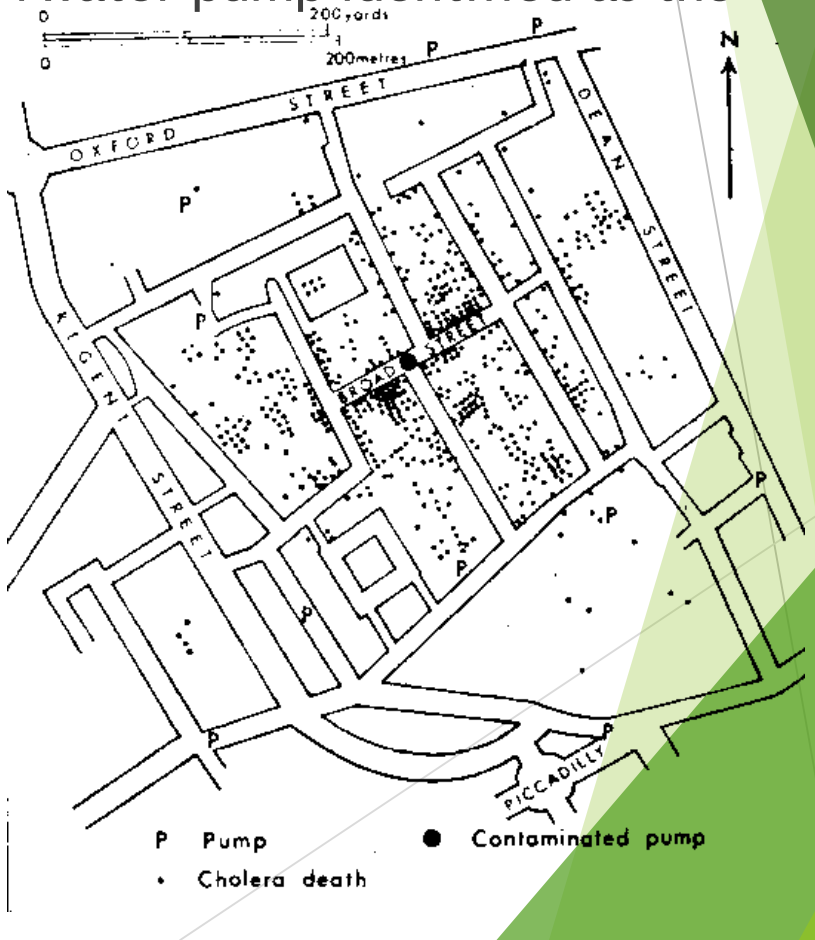
"*An information system that is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially-referenced data, as well as a set of operations for working with the data*" (Star and Estes, 1990, p. 2).

Historic Examples - Spatial Patterns

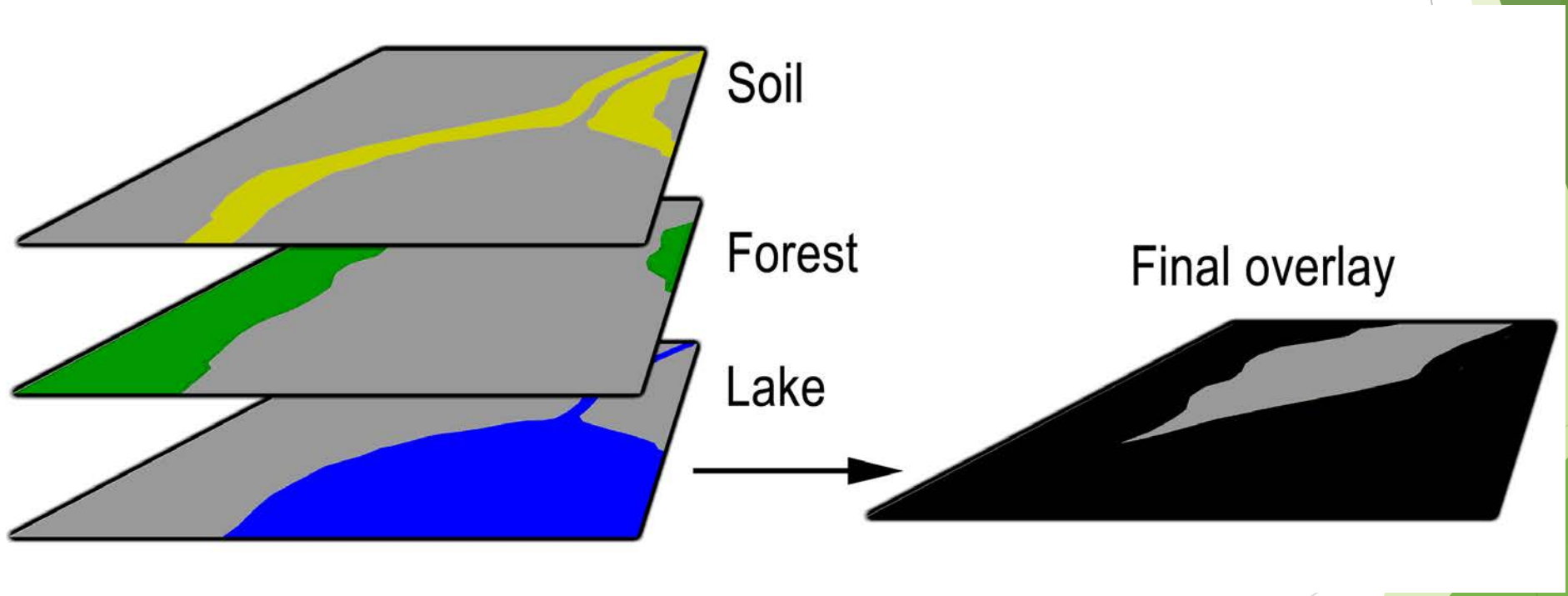
- Historic Examples
  - 1855 Asiatic Cholera in London : A water pump identified as the source

On proceeding to the spot, I found that nearly all the deaths had taken place within a short distance of the [Broad Street] pump. There were only ten deaths in houses situated decidedly nearer to another street-pump. In five of these cases the families of the deceased persons informed me that they always sent to the pump in Broad Street, as they preferred the water to that of the pumps which were nearer. In three other cases, the deceased were children who went to school near the pump in Broad Street…

—John Snow, letter to the editor of the Medical Times and Gazette



Map Overlay



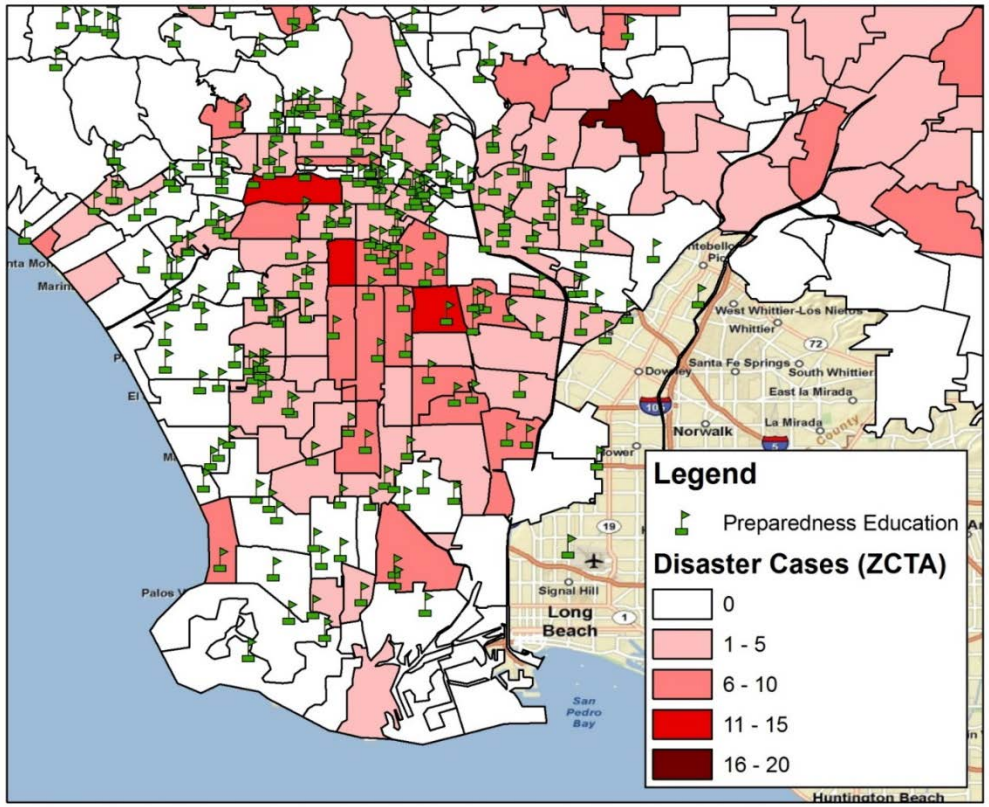
Why GIS? To Solve Problems

- Geography has always been important
  - Where to hunt?
  - Where is safe?
  - Where are resources?
  - Where can we go and how do we get there?

Modern GIS Problem Solving

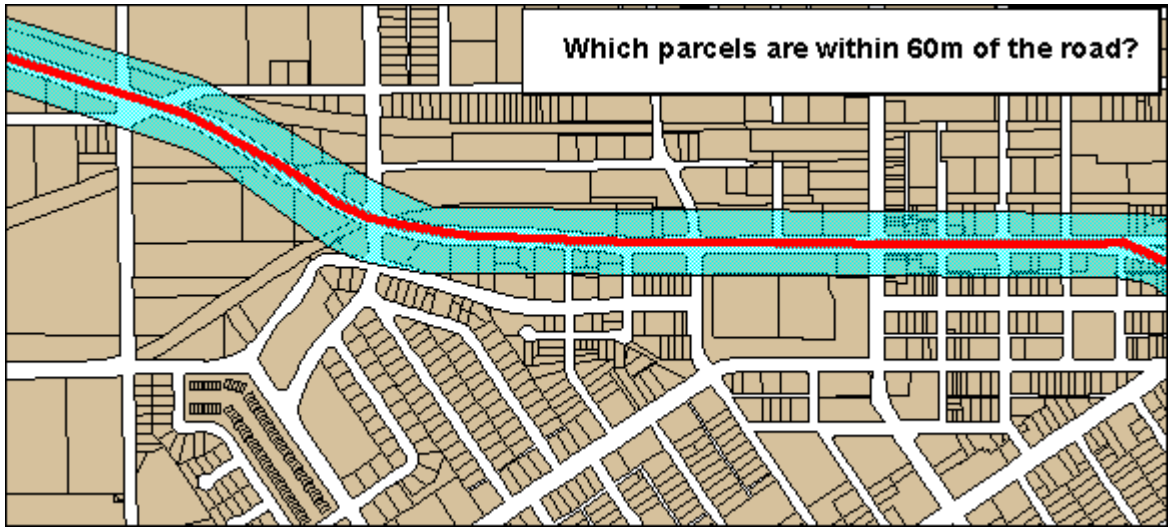
- Water management (rivers, watersheds)
- Natural resources (timber, minerals, wildlife)
- Emergency response
- Military
- Public services (police, fire)
- Utilities (electricity, gas, water, waste)
- Real estate
- Health and community services (resource accessibility, proximity to danger)
- Business (location-based intelligence)

Thematic Maps and Overlays



Created by Evan Lue

Impact Analysis



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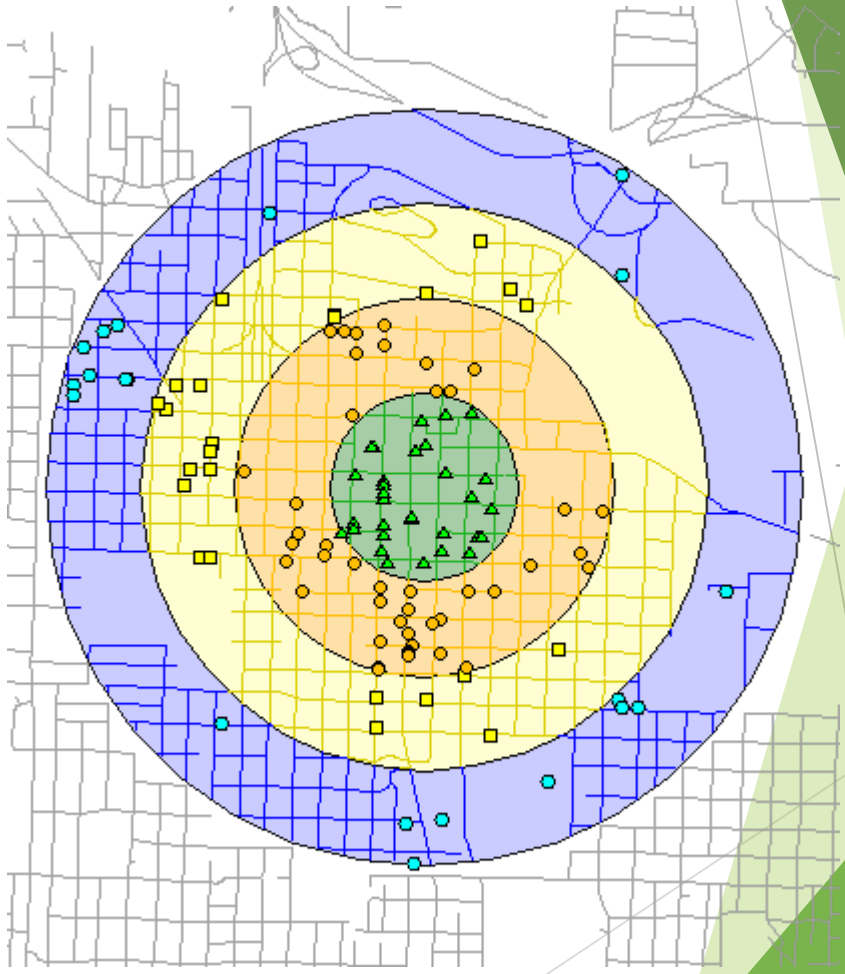
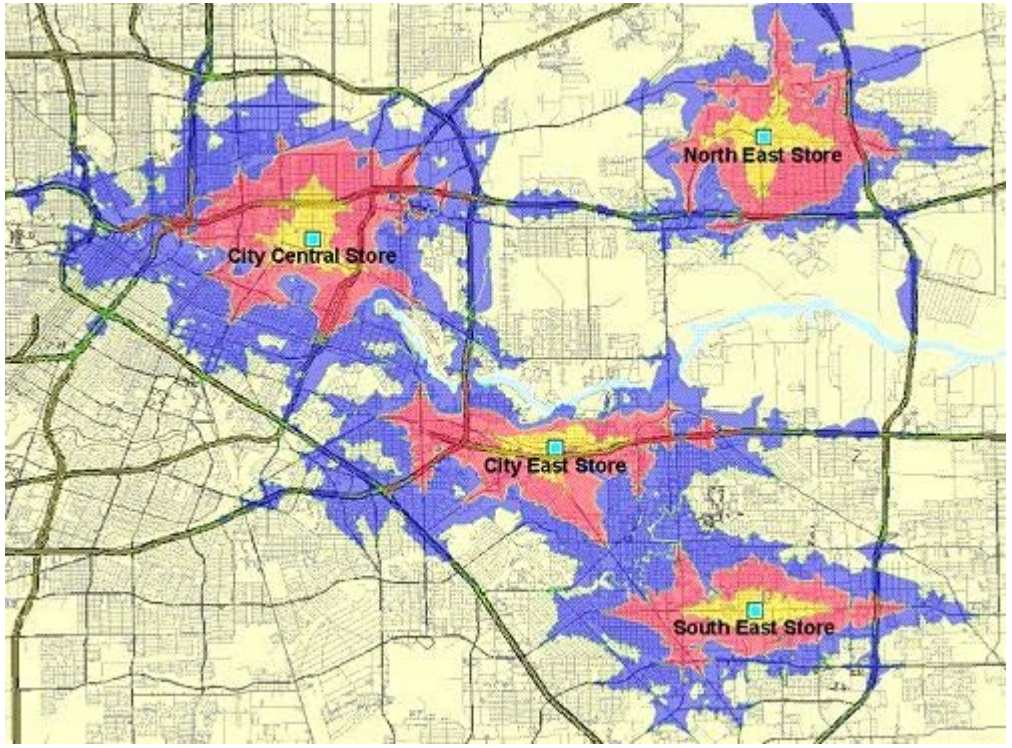


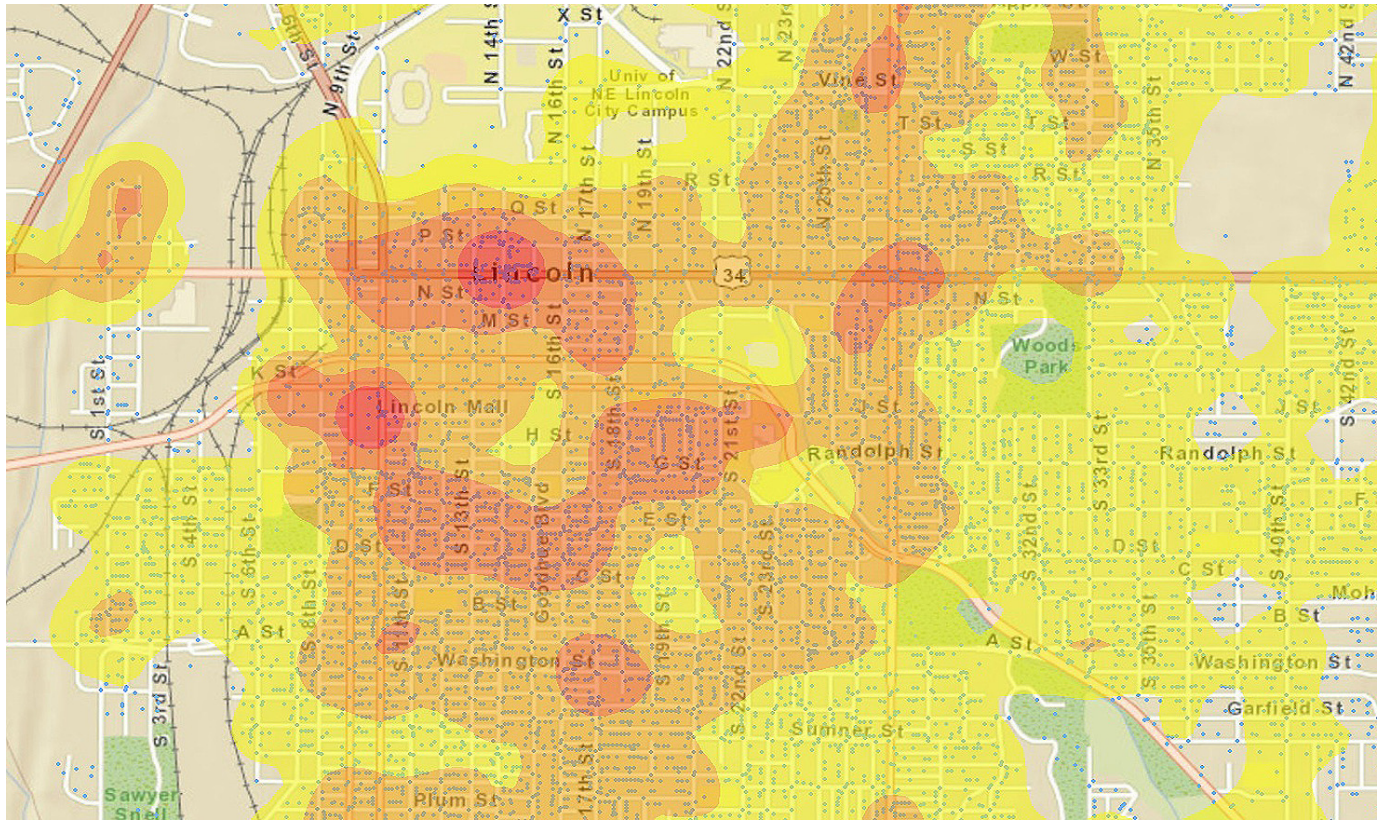
http://www-personal.umich.edu/

Drive Times



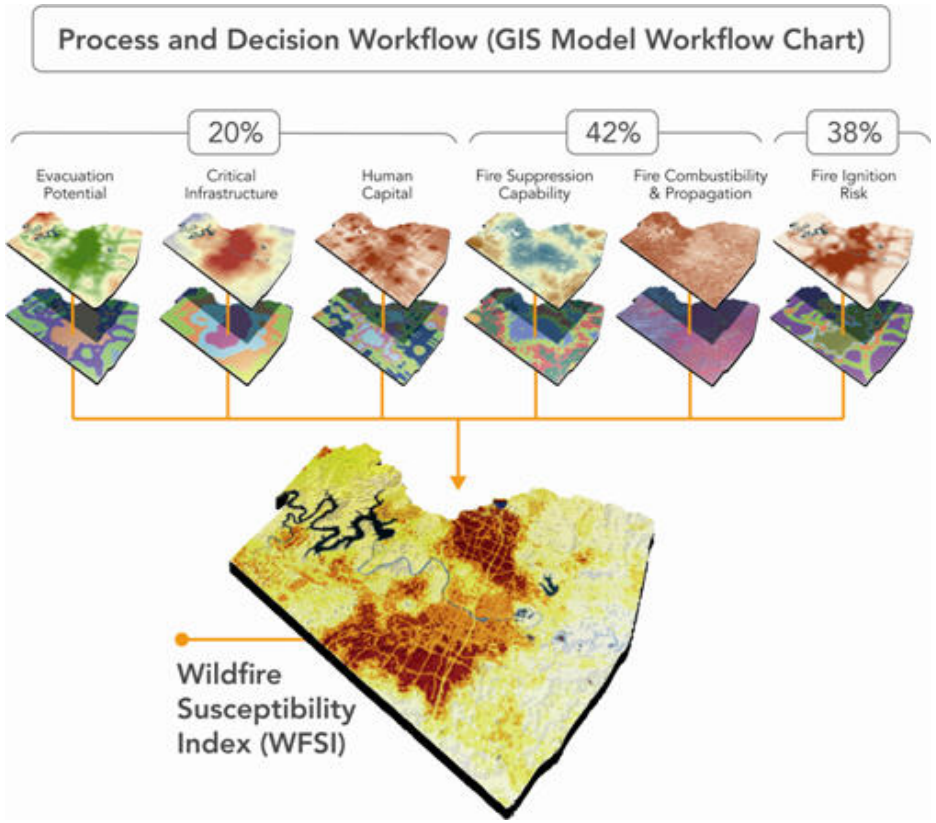
http://resources.arcgis.com

Heat maps



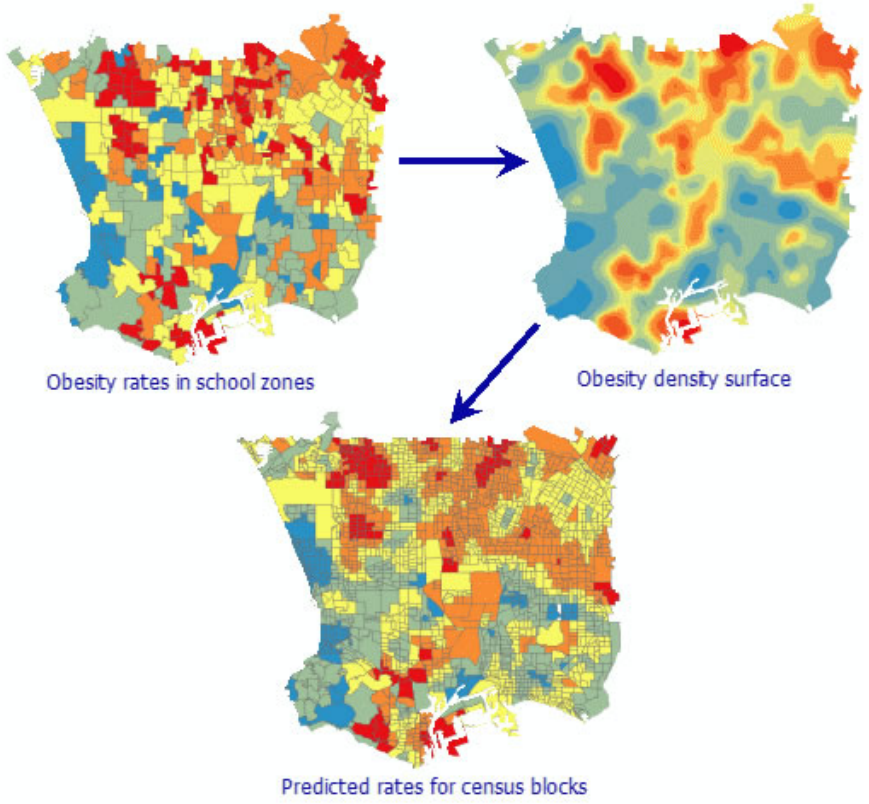
http://www.theomegagroup.com

Multi-Criteria Analysis



http://www.directionsmagazine.com

Predictive Modeling



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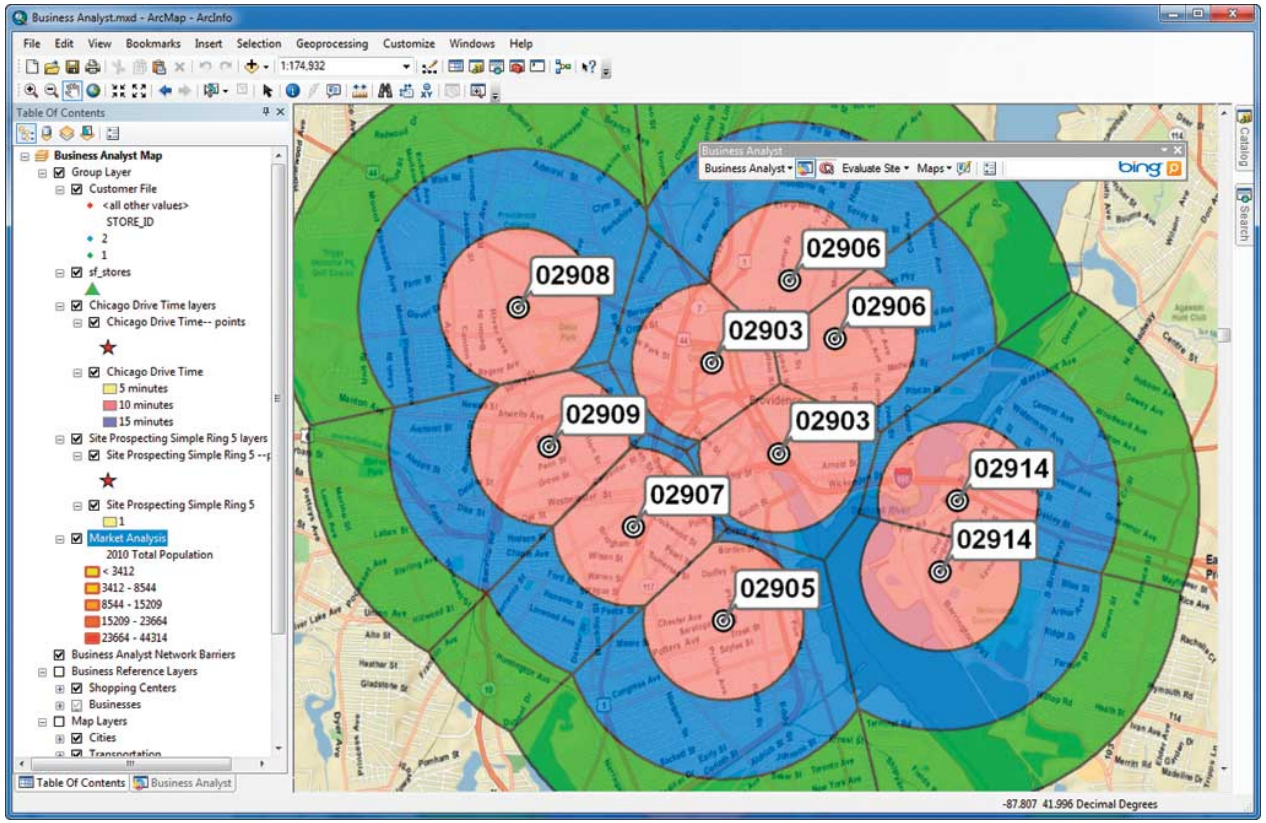
Designing Boundaries



http://www.esri.com/

GIS vs GIScience

- GIS stands for Geographic Information Systems
- GIScience (sometimes GISci) stands for Geographic Information Science
- There is overlap and some people (sloppily) use the terms interchangeably, but think of it as the difference between computer systems and computer science
  - What does a computer user do?
  - What does a computer scientist do?

Questions Asked by Those Interested in…

GIS

- What is the average distance a household in my community will travel to get to a supermarket?
- Which homes receive the most solar radiation?
- Which homes are within our river's 100-year flood zone?

GIScience

- How can we utilize/develop technology to improve our geographic information delivery?
- How do people perceive space and spatial patterns?
- How does psychology and our experiences impact our spatial reasoning?

GIS Hardware (in this graphic, pretty much a computer)

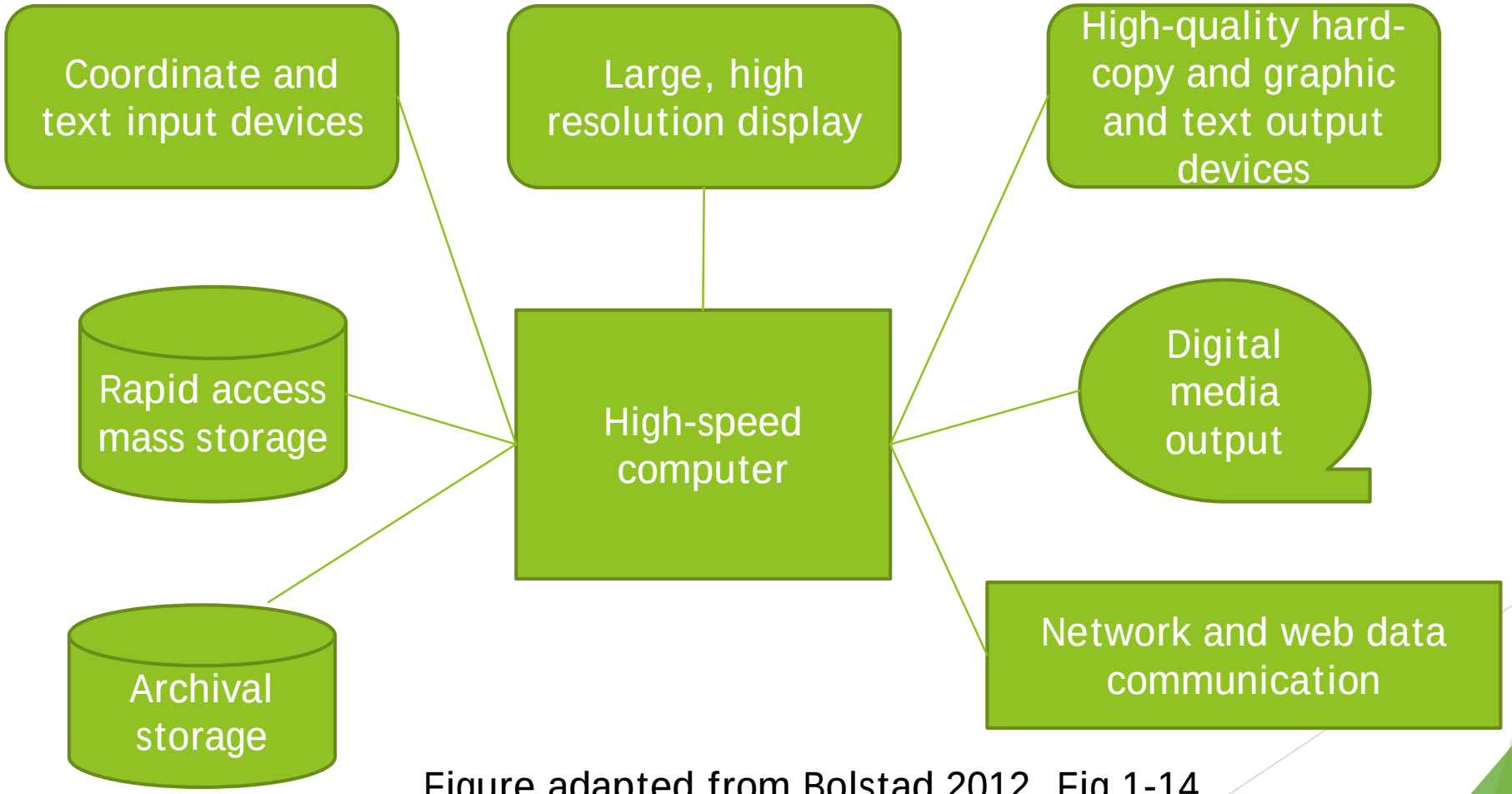


Figure adapted from Bolstad 2012, Fig 1-14

GIS Software

- Data entry
  - Manual coordinate capture
  - Attribute capture
  - Digital coordinate capture
  - Data import
- Editing
  - Manual point, line and area feature editing
  - Manual attribute editing
  - Automated error detection
- Data management
  - Copy, subset, merge data
  - Versioning
  - Data registration and projection
  - Summarization, data reduction
  - Documentation
  - Compression
  - indexing

List adapted from Bolstad 2012, Fig 1-15

GIS Software (continued)

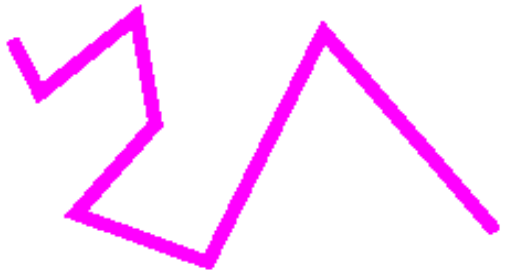
- Analysis
  - Spatial query
  - Attribute query
  - Interpolation
  - Connectivity
  - Proximity and adjacency
  - Buffering
  - Terrain analyses
  - Boundary dissolve
  - Spatial data overlay
  - Moving window analyses
  - Map algebra
- Output
  - Map design and layout
  - Hardcopy map printing
  - Digital graphic production
  - Export format generation
  - Metadata output
  - Digital map serving

List adapted from Bolstad 2012, Fig 1-15

GIS Data Models

- A logical data model is how data are organized for use by the GIS
- GIS have traditionally used either
  - raster
  - vector

Rasters and vectors can be flat files … if they are simple

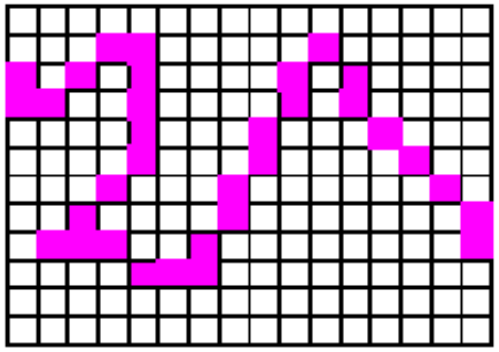


Vector-based line

e

```
4753456 623412
4753436 623424
4753462 623478
4753432 623482
4753405 623429
4753401 623508
4753462 623555
4753398 623634
```

Flat file



Raster-based line

```
0000000000000000
0001100000100000
1010100001010000
1100100001010000
0000100010001000
0000100010000100
0001000100000010
0010000100000001
0111001000000001
0000111000000000
0000000000000000
0000000000000
```

A raster data model uses a grid.

- One grid cell is one unit or holds one attribute
- Every cell has a value, even if it is “missing”
- A cell can hold a number or an index value standing for an attribute
- A cell has a resolution, given as the cell size in ground units

Features and Maps

- A GIS map is a scaled-down digital representation of point, line, area, and volume features
- While most GIS systems can handle raster and vector, only one is used for the internal organization of spatial data
- Only one can be used in combined operations across layers

Rasters are faster…

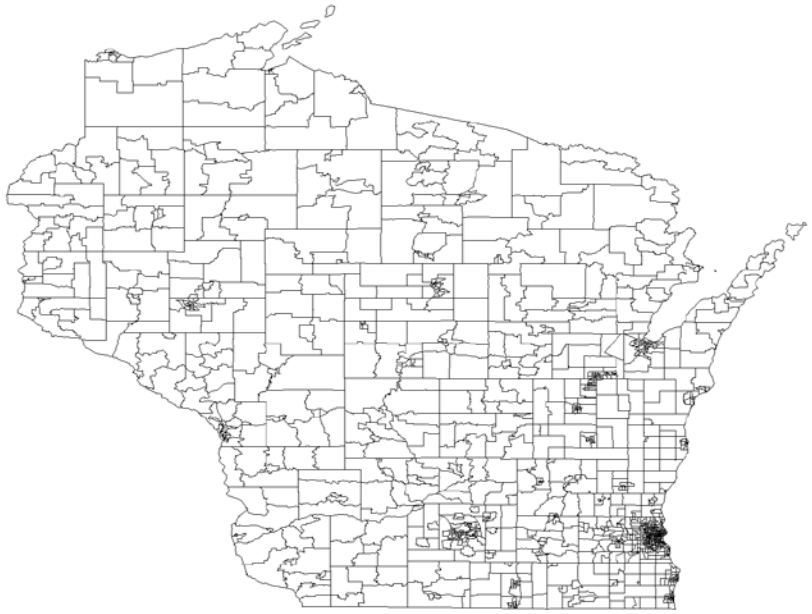
- Points and lines in raster format have to move to a cell center
- Lines can become fat
- Areas may need separately coded edges
- Each cell can be owned by only one feature
- As data, all cells must be able to hold the maximum cell value
- Rasters are easy to understand, easy to read and write, and easy to draw on the screen

RASTER

- A grid or raster maps directly onto a programming computer memory structure called an array
- Grids are poor at representing points, lines and areas, but good at surfaces
- Grids are good only at very localized topology, and weak otherwise
- Grids are a natural for scanned or remotely sensed data
- Grids suffer from the mixed pixel problem
- Grids must often include redundant or missing data
- Grid compression techniques used in GIS are run-length encoding, R-trees and quad trees

Vectors

Wisconsin
Top: transportation and urban places from VMAP0
Bottom: Census tracts



The Vector Model

- A vector data model uses points stored by their real (earth) coordinates
- Lines and areas are built from sequences of points in order
- Lines have a direction to the ordering of the points.
- Polygons can be built from points or lines
- Vectors can store information about topology

VECTOR

- At first, GISs used vector data and cartographic spaghetti structures
- Vector data evolved the arc/node model in the 1960s
- In the arc/node model, an area consist of lines and a line consists of points
- Points, lines, and areas can each be stored in their own files, with links between them
- The topological vector model uses the line (arc) as a basic unit. Areas (polygons) are built up from arcs
- The endpoint of a line (arc) is called a node. Arc junctions are only at nodes
- Stored with the arc is the topology (i.e. the connecting arcs and left and right polygons)

Vectors are more accurate and efficient

- Vector can represent point, line, and area features very accurately
- Vectors are far more efficient than grids
- Vectors work well with pens and digitizers
- Vectors are not good at continuous coverages

The Feature Model

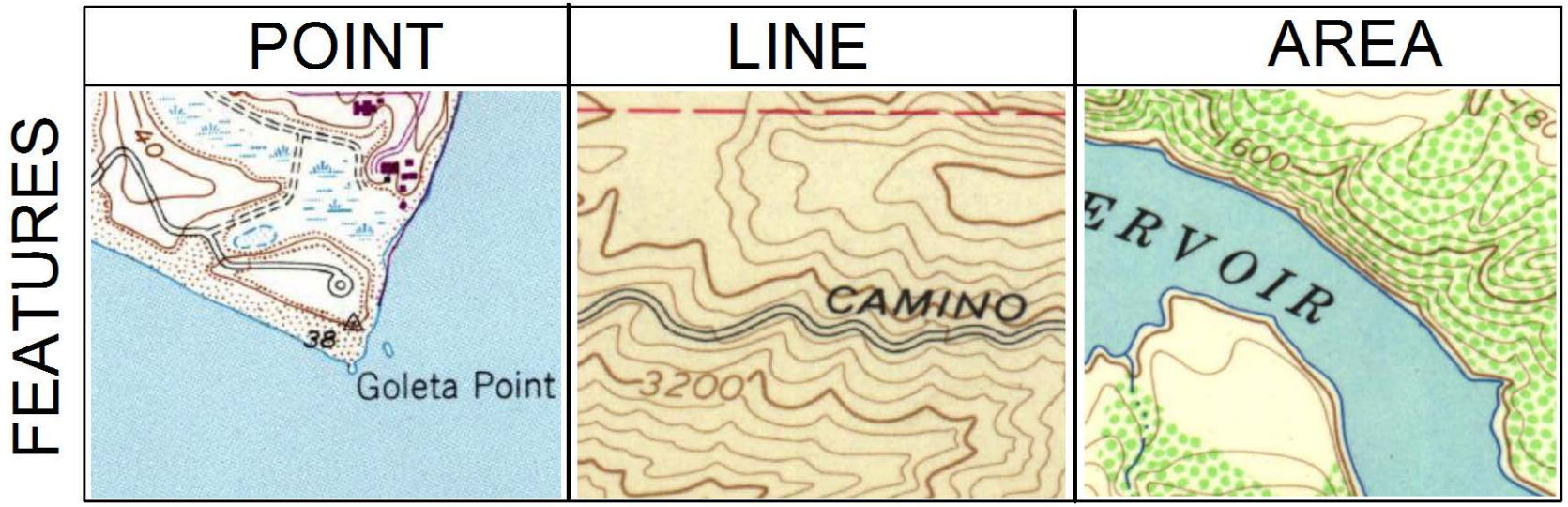
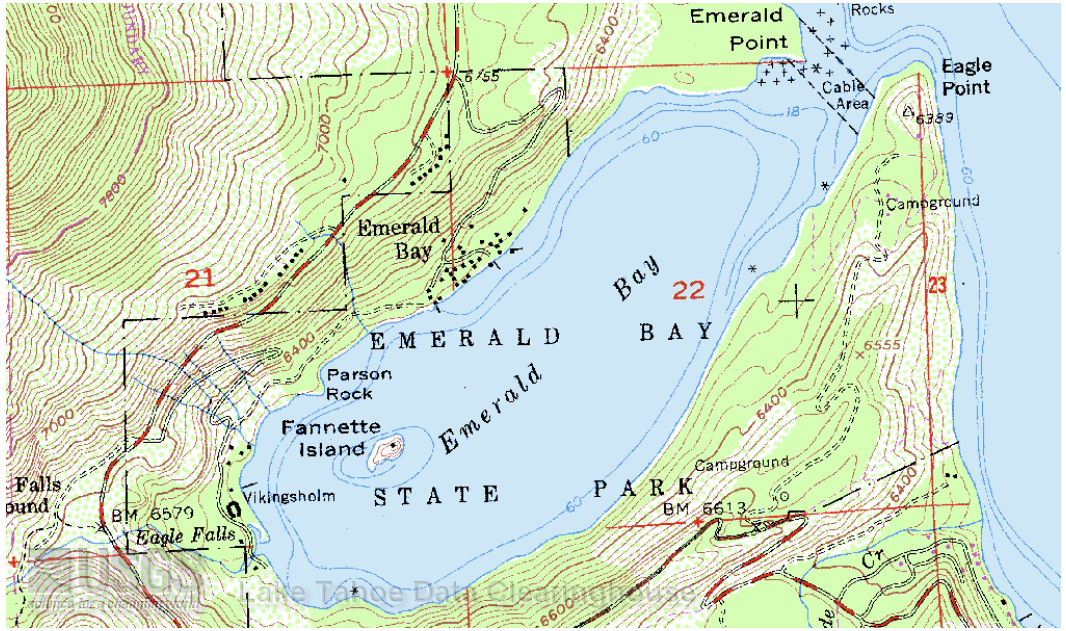


Figure 1.2 The Feature Model: Examples of a point feature (38 foot elevation bench mark), a line feature (road, contours) and area features (reservoir, vegetation).

Spot the data structure

- A. RASTER
- B. VECTOR



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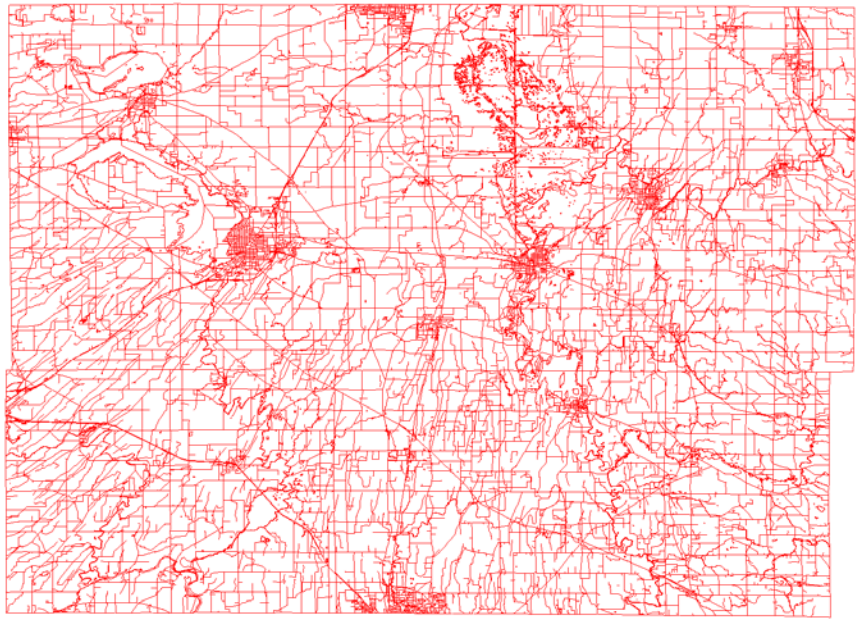

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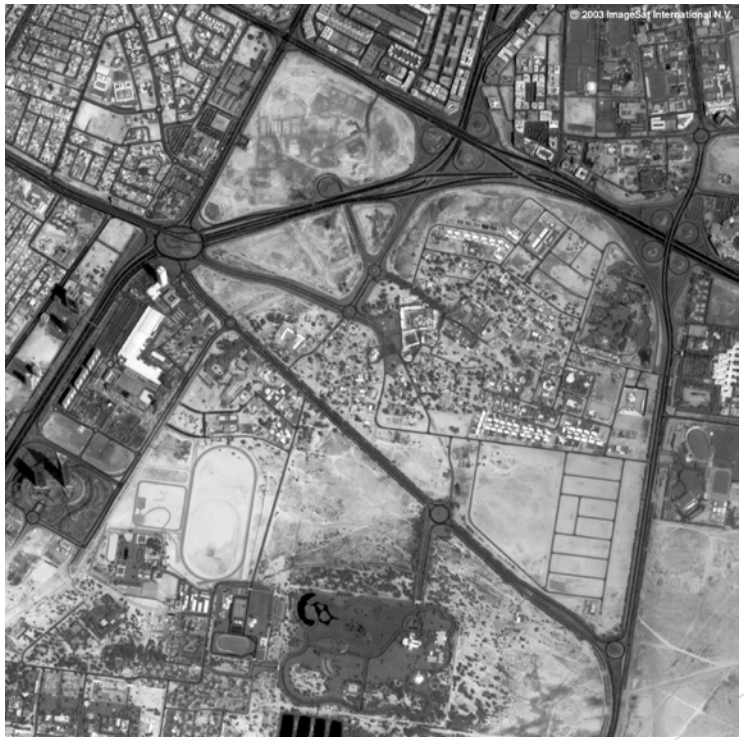


Student Performance Objectives

1. The student will describe the fundamental concepts of Geographic Information Science and Technology.
2. The student will demonstrate proficiency in the basic functions of geospatial software and hardware.
3. The student will demonstrate awareness of fundamental remote sensing and spatial analysis techniques.
4. The student will demonstrate proficiency in the creation and acquisition of spatial data including the use of the Global Position System.
5. The student will demonstrate how to access different sources of data, demonstrate the process of creating data, and discuss the fundamental concepts of data quality.
6. The student will demonstrate basic proficiency in map creation and design principles, including thematic map display, employment of map projections and cartographic design.

Lab 1: Frame the Problem and Explore the Study Area

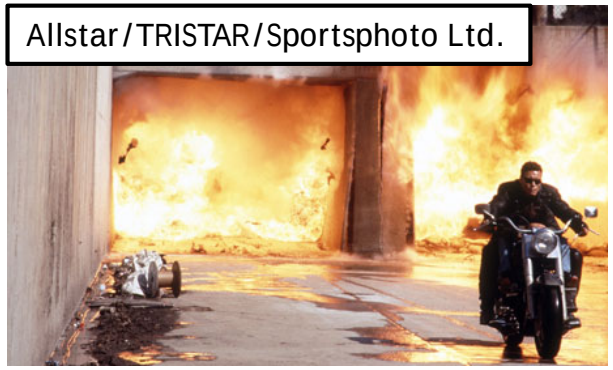
History of the River

- The river is why this city was founded here by Spaniards in 1781!
- Of course, Gabrielino/Tongva Native Americans had lived here prior
- River flooded every few decades; 1938 flood killed 100+
- 1941, Army Corps reshaped the river
- Now, it's not so pretty

Check Out the River

- If you've never been on a river tour, try it! Visit FOLAR (www.folar.org).

Allstar/TRISTAR/Sportsphoto Ltd.



http://www.wmanthony.com

http://ravepad.com

www.flickr.com
Luis Lopez

http://www.canoekayak.com

www.youtube.com
CBS Los Angeles

Los Angeles River Revitalization Master Plan (launched 2005)

"The Plan provides a 25- to 50-year blueprint for transforming the City's 32-mile stretch of the river into an 'emerald necklace' of parks, walkways, and bike paths as well as providing better connections to the neighboring communities, protecting wildlife, promoting the health of the river, and leveraging economic reinvestment."

-Mayor Antonio Villaraigosa

http://www.twitter.com
Antonio Villaraigosa

Time to Role-Play

GIS Roles	
Editors (aka Technicians)	People who create, update, and correct spatial data and attributes (i.e. statistical and descriptive information)
Cartographers	People who make and publish maps and solve information design problems.
Analysts	People who query and process geographic data to solve analytical problems.
Programmers	People who implement custom GIS functionality by developing scripts and applications for specific procedures.
Managers	People who oversee staffing and equipment, database design, workflow, new technology, and data acquistion

Adapted from Harder et al. 2013

“We want to find a suitable site for a park near the Los Angeles River”

Here’s what we want:

- On a vacant parcel of land at least one acre in size
- Within the Los Angeles city limit
- As close as possible to the Los Angeles River
- Not in the vicinity of an existing park
- In a densely populated neighborhood with lots of children
- In a lower-income neighborhood
- Where as many people as possible can be served

Can you do it?

- Easy!
- Most definitely!
- Okay… what’s too far away?
- How big is this vicinity?
- How dense is “dense”? What does “lots” mean?
- So… how low is “low”?
- How far away do I have to live before I’m not “served” by the park?

Lesson Roadmap