EEOS 381 - Spatial Databases and GIS Applications

Lecture 1
Course Overview
Introduction to GIS Applications
Principles of Project Design
Syllabus

Topics
Prerequisites
Instructor
Class hours, format
Credits
Textbook, readings, lab materials

Class web site
Labs
Project
Policies
Grading
Schedule
Lab Basics

Student Accounts

- Each student will receive an account (username/password) to log into the network
  - Use for PCs
  - Don’t change password
  - Previous accounts still active
- Additional Oracle account will be issued for use with ArcSDE
Lab Basics

Logging On
- Windows 7 PCs -- At the login textbox be sure that the domain is set to COMPSERVDOM

Logging Off
- Start button > Shut Down, and then choose Log off <username>
  - Or, hit keys CTRL-ALT-DEL and click on the Logoff... button
**Lab Basics**

❗It is extremely important that you log off! Otherwise whoever uses the computer next will have complete access to your files!

You don’t need to shut down the PCs, just log off
File storage:

- Save work in your home directory on the server (H:) and on at least one memory stick and/or portable hard drive; PCs have CD/DVD writers.

THE LAB IS NOT RESPONSIBLE FOR BACKING UP YOUR FILES!

*** Keep at least two copies of any files that are important to you. ***

*** Keep at least two copies of any files that are important to you. ***
Lab Basics: The Computers

PCs
- Microsoft Windows XP Professional

Network drives (on st-helens.geogsvr.umb.edu)
- **H:** “USER NAME” – your home directory
- **S:** “classes”
- **T:** temp area/lab submission
- **X:** database (images, tutorial data)
- **LASSEN-PEA** (ArcSDE Windows server, with Oracle 11g and ArcSDE 10)
Lab Basics: The Computers

A user is limited to **2GB** of files, owned by that user across all shares.

- Once a quota has been reached, the user will not be able to save or update files, including ESRI documents and maps (save to USB stick and clean out network share).
Lab Basics: Printing

- There are two laser printers in entry room (Rm. 22)
- There are two laser printers in Room 34

See note on printing quotas when you log in

But assignments will be turned in as digital files
Components of GIS

- Hardware
- Software
- Data
- People
- Network
- Procedures
Definitions of GIS

An integrated collection of computer **hardware** and **software**, **people**, and **data** used to **collect**, **store**, **manage** and **analyze** objects and phenomena where **geographic location** is an important characteristic of or critical to analysis or problem-solving.
Definitions of GIS (cont.)

From Table 1.3 (p. 16) in GIS&S:
- **Maps** in digital form (*general public*)
- Computerized **tool** for solving geographic problems (*decision-makers, planners*)
- Spatial **decision support system** (*management scientists, operations researchers*)
Definitions of GIS (cont.)

- Mechanized **inventory** of geographically distributed features and facilities (*utility managers, transportation officials, resource managers*)
- Tool for **revealing what is otherwise invisible** in geographic information (*scientists, investigators*)
- Tool for **performing operations** (and analysis) on geographic data (*resources managers, planners, cartographers, GIS Analysts and technicians*)
Definitions of GIS (cont.)

Bottom line - there are many definitions, depending on whom you ask, and depending on their application

*What is your definition of GIS?*
Overview of Applications of GIS

GIS is used in MANY fields, disciplines, industries, in both the public (government) and private sectors:

- Business
- Environment
- Natural Resources
- Transportation/logistics
- Education
- Science
- Health
- Military/Defense
- Utilities
- Others…
Who uses GIS?

GIS Professionals - GIS is their main job

- Managers
- Administrators
- Analysts
- Technicians
- Programmers

GIS Users - GIS is part of their job

GIS is often behind the scenes, but “the word has spread” and is spreading
Why GIS?

- Solving real-world problems, many of which fundamentally have a spatial component or geographic dimension
- Easier to use, more powerful “off-the-shelf” / “out of the box” software
- Better, cheaper data (lots for free)
- Cheaper hardware (including GPS)
Why GIS?

- Networks (and Internet) now in place to support GIS
- Linkage to non-GIS software (RDBMS)
- Ability of maps to tell the story
- Greater awareness of real applications and proven cost/benefit cases
How is GIS Used?

No matter the application, GIS needs to be grounded in science, sound concepts and theory (of how the real world works), and geography.

Then you have to represent the real world in a GIS:
- get proper, useful data
- knowledge of software
  - also automation, programming

The focus of EEOS 381
In general, used for “The 5 M’s”:

- mapping
- measurement
- monitoring
- modeling
- management
How is GIS Used? (cont.)

To answer questions:
- What is at ...? (location)
- Where is ...? (condition)
- What has changed since ...? (trends)
- What spatial patterns exist? (patterns)
- What if ...? (modeling)

To solve problems
How is GIS Used? (cont.)

To find coincidence of factors:
- soil type and vegetation
- high crime areas and income level ...
Principles of GIS

Representing geography in digital form

Tobler’s First Law of Geography -

*Everything is related to everything else, but near things are more related than those far apart.* (p. 65 in GIS&S)

- patterns
- interpolation

The pattern of volcanoes are related to the pattern and orientation of fault lines.
Principles of GIS

★ What to represent?
★ How to represent it?
  – Scale (real world vs. map)
Principles of GIS

Geographic data link place, attributes, and time

- Reference systems (Chapter 5 in GIS&S)
  - coordinate systems (geographic, projected)
  - zones
  - georeferencing
Application Areas

There are many - See Table 2.1 in book (pgs. 48-49) and http://www.esri.com/industries

- Government
- Business
- Health
- Environment
- Transportation/Logistics ...
Government

Categories

- Inventory applications
- Policy Analysis applications
- Management/Policy-Making applications (which may affect allocation of funds)
Government

Tax assessment
- from analysis of revenues vs. land use to identifying abutters for zoning variance hearings; citizen information kiosks
Government

- Land and capital asset management
- Emergency management
- Law enforcement, public safety

Crime mapping and analysis
Government

Law enforcement, public safety

Violent Crimes by Neighborhood

- Per 100,000 Residents in the year 2005

<table>
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<th>Crime</th>
<th>Count</th>
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<td>Offense</td>
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<td>500 - 750</td>
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</tbody>
</table>
**Government**

- Transportation planning
- Economic development
- Public health delivery
- Redistricting (schools, legislative)
- Military

Create rings for target analysis

Maptitude for Redistricting State Edition software

Cross-discipline usage, local to national
**Government**

🌟 Recovery and reinvestment

- $100 million for broadband infrastructure in western Massachusetts and $5 million for statewide broadband mapping

Business

- Siting new locations
- Market research and analysis
- Job training and search services
- Efficient routing and scheduling delivery trucks

Business

- Modeling natural disaster risk to determine insurance premiums
- Production of tourist/trail maps
Business

Weekday Business Opening Hours

Weekday Opening Hours
- 7:00 AM or Earlier
- 7:01 AM to 9:00 AM
- 9:01 AM to 11:00 AM
- 11:01 AM or Later
- Vacant/No Data

Area of Interest

Maps showing various data analyses to support business decision-making.
Business

Software Example: ESRI Business Analyst
- Customer Market Analysis
- Customer Profiling and Prospecting
- Target Marketing & Campaign Planning
- Store Market Analysis
- Territory Design

See http://www.esri.com/software/arcgis/extensions/businessanalyst/key-features
Health

Analyzing the patterns and spread of disease outbreaks West Nile virus, SARS, AIDS, etc.
Health

- Finding the source of infectious diseases due to drinking water pollution
- Assessment of health care needs of elderly and children
- Studying incidence of breast cancer on Cape Cod
Environment

- Sustainable development
- Environmental impact analysis
- Gap analysis
- DEP: Wetlands development violations
**Environment**

- Marine and coast, fisheries

Bayesian Belief Network (BBN) and GIS Integration:
  - Single Species Mapping
  - Arrowtooth Flounder

Shoreline Change

Essential Fish Habitat GIS

EEOS 381 - Spring 2015: Lecture 1
Environment

- Insect infestation patterns
Environment

- Managing natural resources

Parks, recreation and open space/conservation facilities, etc. ...)
Environment

Natural resource inventory
Environment

Natural resource inventory

Timber Dependent Communities

County Timber Dependency Ratio
- Low (0 - 1.0)
- Medium (1.01 - 2.50)
- High (> 2.50)

Community Distress Index
- 1 - 1.2
- 1.2 - 1.5
- 1.5 - 2.0
- > 2.0

NOTE: See text on INDICATOR #46 for a complete description and listing of community names.
Environment

Natural resource inventory

Satellite imagery may be used for agricultural inventories, crop forecasts, and monitoring crop health and soil moisture.

“False color” image using a non-visible band of the ER spectrum
Environment

Archeology

3-D below ground site model
Environment

Natural hazard mitigation

Figure 11: Tornado activity in the United States

Summary per 1,000 square miles

* Based on NOAA, Storm Prediction Center Statistics
Environment

- Natural hazard mitigation
Environment

Natural hazard mitigation

How FEMA uses GIS in Disaster Response:
http://gis.fema.gov/
Environment

Natural hazard mitigation

From NOAA Coastal Services Center: Map of major hurricanes (category-3, -4 and -5) that struck Mexico and the U.S. Gulf Coast in August between 1851 and 2006.
Environment

Natural hazard mitigation

Also see http://joemaller.com/california_wildfires2003.shtml
(animated maps of California wildfires)
Environment

Agriculture
Environment

Precision Agriculture

- Differential Action
- Spatial
- Decision Support Systems
- Referencing
- Crop, Soil & Climate Monitoring
- Attribute Mapping

Images of precision agriculture equipment and practices.
Environment

Precision Agriculture

Mapping and analyzing variability in field conditions, and linking such spatial relationships to management action, places production agriculture at the cutting edge of GIS applications.

From http://www.innovativegis.com/basis/present/GW98_PrecisionAg/GW98_PrecisionAg.htm
Transportation/Logistics

Infrastructure maintenance: Inventory and management of road and rail networks, bridges, dams, bike paths, utility networks (water, sewer, gas, electric)
Transportation/Logistics

- Planning flight paths and airports, noise abatement
Transportation/Logistics

- Driving directions, emergency vehicle and delivery truck routing, traffic patterns and congestion abatement, travel planning, vehicle tracking
- Carpool/vanpool rider match services
- Two components
  - Static - infrastructure
  - Dynamic - vehicles
Transportation/Logistics

Tracking traffic patterns over time
Application Areas

Planning for Emergency Evacuation

- Major natural and human-induced events may necessitate area evacuations
- GIS can be used to create effective evacuation vulnerability maps based on:
  - Distribution of population
  - Street map
- Model demand and impact of bottlenecks on evacuation speed using standard GIS network tools
  - Adjacency, connectivity, shortest path network calculation
Application Areas
Application Areas

Mass. Towns with online web apps:

See this web site for more examples:
The Business of GIS

Industries that support those who use GIS and applications (and where GIS students may find jobs!):

- Software
- Data
- GIS Services
- Publishing
- Education
GIS Project Design

1. Identify objectives
2. Create and design the database
3. Perform analysis
4. Present results
GIS Project Design

Identify objectives:

- What is the problem to solve? How is it solved now?
- What question needs to be answered or addressed?
- Are there alternate ways to solve it using a GIS?

- Plan for project implementation
  - Needs assessment, pilot project?
GIS Project Design

**Identify objectives (cont.):**

- What are the **final products** of the project—reports, working maps, presentation-quality maps?
- Who is the **intended audience** of these products—the public, technicians, planners, officials?
- Will the data be used for **other purposes**? What are the requirements for these?
- What **software** will I use?
- In real world - consider **co$t** !!
Create the database:

- Designing the database:
  - identifying the spatial data you will need
  - identifying sources of data
  - collecting/creating the data
  - determining the required feature attributes
  - setting the study area boundary
  - choosing the coordinate system to use
  - Formal design methodology: Conceptual / Logical / Physical (see next slide)
GIS Project Design

**Conceptual model**
- identify data content and describe data at an abstract, or conceptual, level
- describe what the GIS must do
- Entity-Relationship (E-R) diagram

**Logical model**
- translation of the conceptual database model into the data model of a specific software system

**Physical model**
- representation of the logical data model in the schema of the software
- how the GIS will be implemented
GIS Project Design

Create the database (cont.):

- **Automating** the data:
  - digitizing or converting data from other systems and formats into a usable format
  - verifying the data and correcting errors (QA/QC)

- **Managing** the database:
  - joining adjacent layers
  - updates
  - system integration
    - work with system administrator for disk space, backups
    - staff training
    - data distribution
Create the database (cont.):

- Creating the project database is a critical and time-consuming part of the project. The completeness and accuracy of the data you use in your analysis determines the accuracy of the results.
GIS Project Design

**Perform analysis:**
- simple mapping
- measuring
- calculating
- complex modeling
  - coincidence
  - overlays
  - buffering
  - adjacency
  - routing
  - redistricting

Possible use of software extensions, multiple software products
GIS Project Design

Present results:
- Maps
- Charts, tables, graphics
- Reports
- Hardcopy, softcopy, written, oral, online?
- Metadata
- Specialized applications?
Past Student Project Topics

- Finding a location for a new commuter train station to relieve traffic in northern MA/southern NH
- Determining the shortest and most accessible routes in downtown Boston for persons with disabilities
- Analyzing Logan Airport noise
- Recommending which parcels of open space to purchase with CPA funds
Past Student Project Topics

- Studying impervious surface and potential for “green roofs” in the Muddy River watershed in Boston
- Mapping and analyzing patterns of tornados in Texas
- Determining which Brownfield in New Bedford to redevelop
Past Student Project Topics

- Locating new or extending existing bike trails in Boston
- Where to place vaccine distribution centers in Boston
- Finding the best place to live in Davis, CA
- Finding the best site for an IKEA store in eastern Mass.
- Calculating rainfall runoff
Past Student Project Topics

- Locating a new cemetery in a small town
- Deciding which land to protect as open space in a small town
- Finding the best site for a new Dunkin Donuts; a new thrift shop; an ethnic farmers market; wind turbines
- Locating a new skate park in Boston
Past Student Project Topics

- Analyzing distribution of fire hydrants in a town in Massachusetts
- Analyzing the correlation of invasive species and human development
- Analyzing pedestrian accidents in Boston
- Apartment hunting in the city of Boston (if you don’t have a car and are a recent college graduate)
Past Student Project Topics

- Evacuation routes during coastal storms
- Crime analysis
- UFO’s – analyze locations of sightings and Air Force bases, and demographics
- Assessing potential earthquake damage
- Siting a hydroelectricity generating plant
- Expanding the MBTA subway system
- Smart growth
- Inventory of New England’s 100 highest mountain peaks
### Past Student Project Topics

- Potential wildlife crossings
- Drowning frequency in Eastern Massachusetts
- Bird sightings across Mass.
- Minimizing the Cost of Commuting & Living Outside Boston
- Creating an network of trails in Wompatuck State Park
- Assessing commuting in metropolitan Atlanta
Past Student Project Topics

Which town in Mass. has the best weather?

Analyzing the Blizzard of ’78 to predict risk of large storm impact on the New England coast

Analyzing spatial trends in black bear-human conflict data in Colorado, in order to predict areas of risk and spread awareness

Determining sites to install solar panels in Boston
Past Student Project Topics

- Environmental Justice and waste disposal facilities
- Enabling elevation in a road network
- UMass Boston community programs and partnerships
- Locating a new senior center in Marlborough
Past Student Project Topics

- Tracking offshore bird sightings
- Ham radio use at the Boston Marathon
- Neponset Watershed sampling stations
- Where was Wheeler’s Surprise?
- Gym and recreation opportunities in Boston