Geographic Information Systems

Acknowledgements to Ted Sickley

Principles of Landscape Ecology

Definition (academic)

The organized activity by which people

- ***measure*** aspects of geographic phenomena and processes;
- ***represent*** these measurements, usually in the form of a computer database, to emphasize spatial themes, entities, and relationships;
- ***operate*** upon these representations to produce more measurements and to discover new relationships by integrating disparate sources; and
- ***transform*** these representations to conform to other frameworks of entities and relationships.

These activities reflect the larger context (institutions and cultures) in which these people carry out their work. In turn, the GIS may influence these structures.

GIS course notes, University of Washington

Definition (GIS software vendor)

A geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on earth.

ESRI

GIS stands for Geographic Information Systems. A Geographic Information System is a combination of elements designed to store, retrieve, manipulate, and display geographic data - information about places. It is a package consisting of four basic parts: hardware, software, data and a thinking operator.

ESRI Canada

Hardware
- Computer
- Network connection
- Input: scanner, digitizing table; PDA, data logger; Global positioning system (GPS)
- Output: printer or plotter; export data or digital image

Software

Data

the Thinking Operator

Hardware

Software
- GIS software
- image processing
- analysis packages
  - spreadsheets
  - relational databases
  - statistical (SAS, S-Plus, Oracle have GIS and spatial statistics modules)

Data

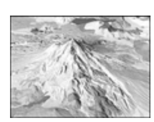
the Thinking Operator

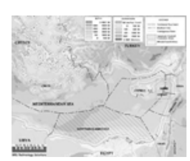
Hardware

Software

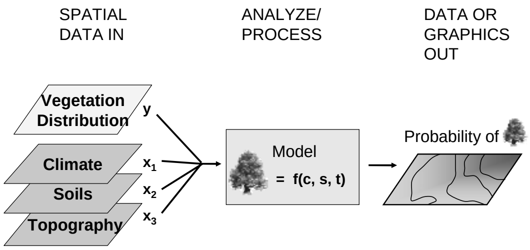
Data
- spatially referenced information
  - land cover, elevation, census data,
  - utility networks, rare species locations, etc., etc.

the Thinking Operator





Images from www.esri.com

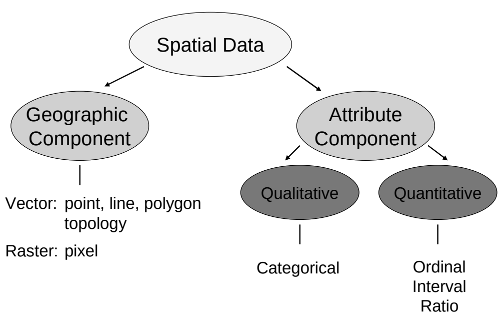


Data – how the world is represented digitally

Geographic features
- streams
- census blocks
- bird nesting sites
- pixel, cell, polygon

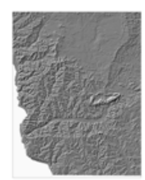
Database containing attribute information
- width, order, invertebrate fauna, flow
- age, income, number of bathrooms
- species, success, habitat
- reflectance value > land cover class

Spatial Data Components

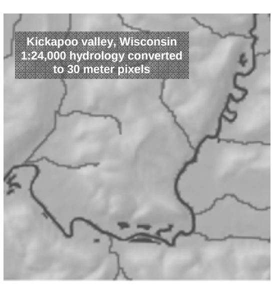


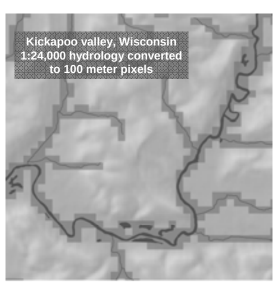
Vector vs. Raster

Advantages of vector:
- Good representation of discrete features
- Space efficient storage of categorical data, linear or point features
- Topology can be described explicitly and be easily manipulated



Advantages of raster:
- Simple data structure
- Efficient representation of highly variable data
- Mathematical modeling easier because all entities have simple, regular shape





Data sources

Project/field generated

Historic maps/documents

Government agencies
- Dane County
- MN Data Deli
- USGS

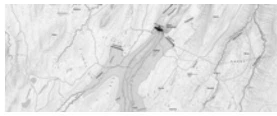
Internet
- Geography Network
- Spatial data clearinghouses

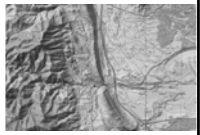
Private vendors

Cartographic and analytical tools

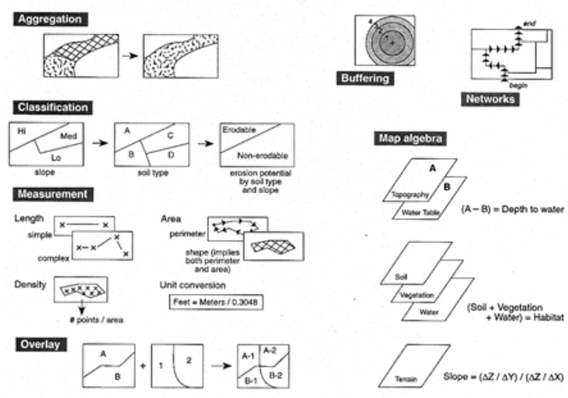
- Mapping
- Visualization

- Spatial overlay
- Spatial modeling
- Pattern analysis
- Interpolation
- Statistical analysis
- Network analysis





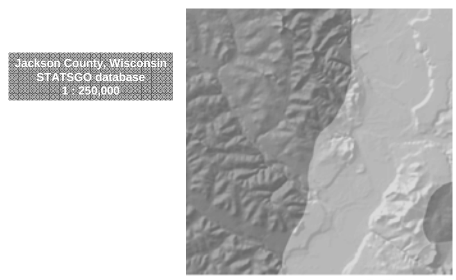
Images from www.esri.com



Issues, concerns

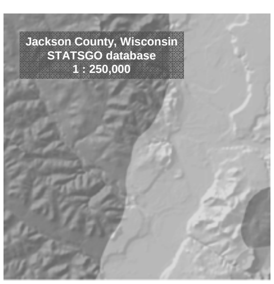
Scale, resolution
Generalization, simplification
Accuracy, precision
Metadata

Scale / resolution:

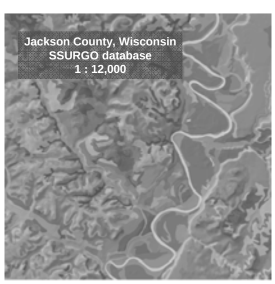


Minimum mapping unit ~100 ha

Scale / resolution:

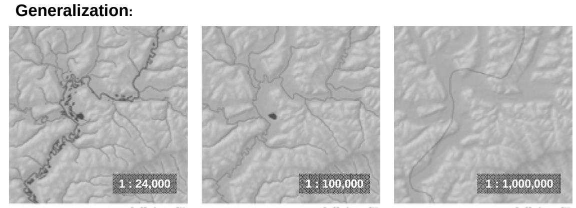


Minimum mapping unit ~100 ha



Minimum mapping unit ~1 ha

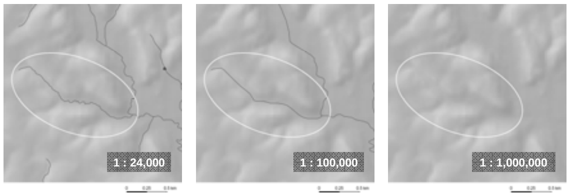
Generalization:



Kilometers of hydrologic features by scale

	1:24,000	1:100,000	1:1,000,000
Center line	19	19	12
Side streams	85	49	0
Other features	33	1	0
Total	137	69	12

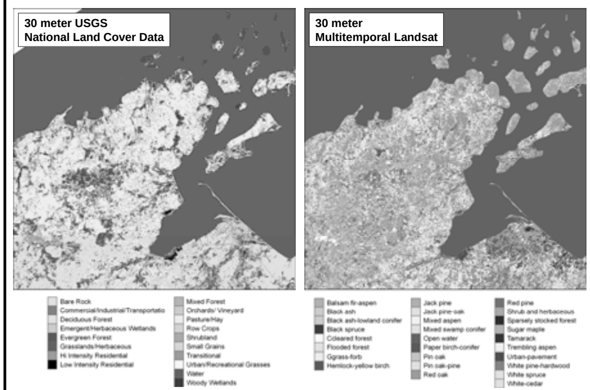
Generalization:



Kilometers of hydrologic features by scale

	1:24,000	1:100,000	1:1,000,000
Side stream	1.8	1.6	0

Attribute resolution:



http://landcover.usgs.gov/index.asp

Wolter, P.T. et al. 1995. Photogrammetric Engineering and Remote Sensing 61, 1129-1143

Accuracy / precision

1. The feature of interest
   - a. Area vs. site location
   - b. Fuzzy vs. firm boundary
   - c. Age of data; mobility of feature

2. Equipment, techniques
   - a. Field conditions
   - b. GPS
   - c. Thinking operator error

Accuracy / precision

3. Scale / generalization
   - a. Base map
     1:24,000 topographic map, 1:12,000 air photo, sub-meter orthophotographs
   - b. Variability within mapped features

"The difference in positional accuracy between the soil boundaries … in the field and their digitized locations is unknown." SSURGO metadata

Metadata:

Documentation, or data about your data

Overview of data

Coordinate system, spatial accuracy

Process steps

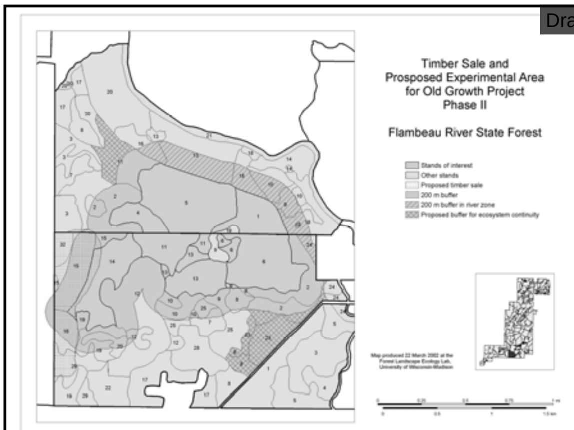
Dates

Attribute definitions, codes

Access to data

Disclaimers

Draft



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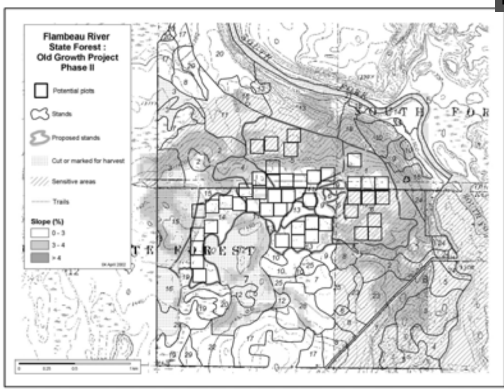

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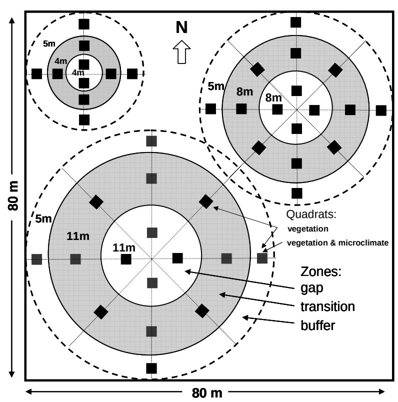


Hall, M.H.P. and D.B. Fagre. 2003. Modeling climate-induced glacier change in Glacier National Park, 1850-2100. BioScience 53, 131-140

1850-1993, 73% reduction in glacial cover in Glacier NP
Important as evidence of changing climate

Figure 3. Historic and recent photos of Grinnell Glacier. Taken from the same point, the photographs clearly demonstrate the retreat of Grinnell Glacier over 88 years. Photographs: 1910, Fred Kiser, courtesy of Glacier National Park archives; and 1998, Karen Holzer, US Geological Survey.

Digitized terminal moraine positions 1850-1979
Related glacial extents to physiographic factors and climatic drivers

Hall, M.H.P. and D.B. Fagre. 2003. Modeling climate-induced glacier change in Glacier National Park, 1850-2100. BioScience 53, 131-140

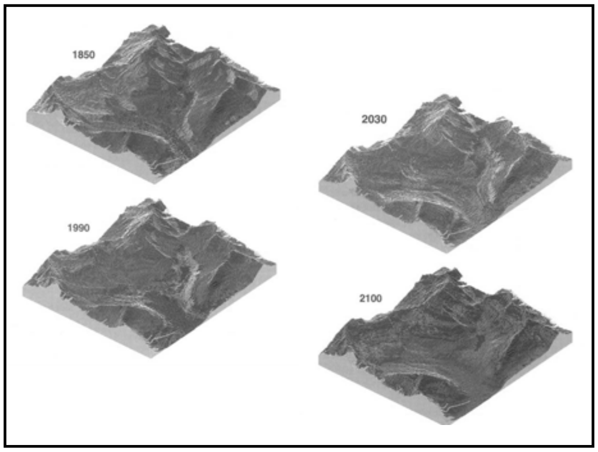
Assigned a probability of melt factor to each cell in their study area
Modeled glacial distribution into the future under 2 warming scenarios

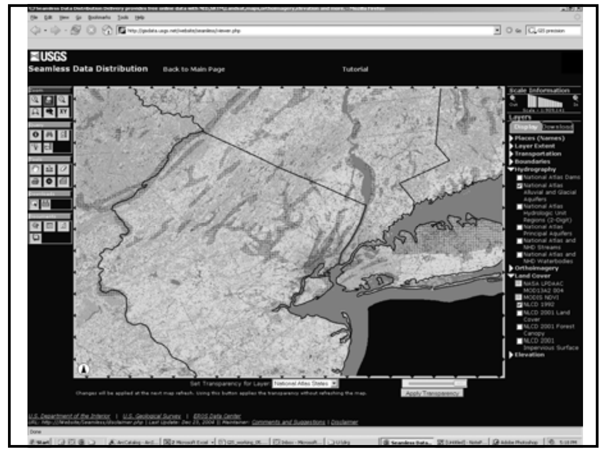
Figure 5. Boulder Glacier: 1932 (left), 1988 (right). These two views of Boulder Glacier demonstrate the dramatic reduction in ice in Glacier National Park and its ecological consequences. Vegetation has moved in where the ice cave used to be. Photographs: 1932, George Grant, courtesy of Glacier National Park archives; 1988, Jerry DeSanto, National Park Service.

Also ran companion vegetation distribution model to assess reaction of vegetation to changes in soil moisture and increasing temperature

Glacier Distribution y
Climate x_1
Topography x_2
Model
= f(c, t)
Probability of

Vegetation Distribution y
Climate x_1
Soils x_2
Topography x_3
Glaciers x_4
Model
= f(c, s, t, g)
Probability of


1850
2030
1990
2100


USGS
Seamless Data Distribution
Back to Main Page
Tutorial
Scale Information
Layers
Places (Names)
Layer Extent
Transportation
Boundaries
Hydrography
Orthoimagery
Land Cover
Elevation
Apply Transparency