Geography 360: GIS & Mapping

Representing Geography

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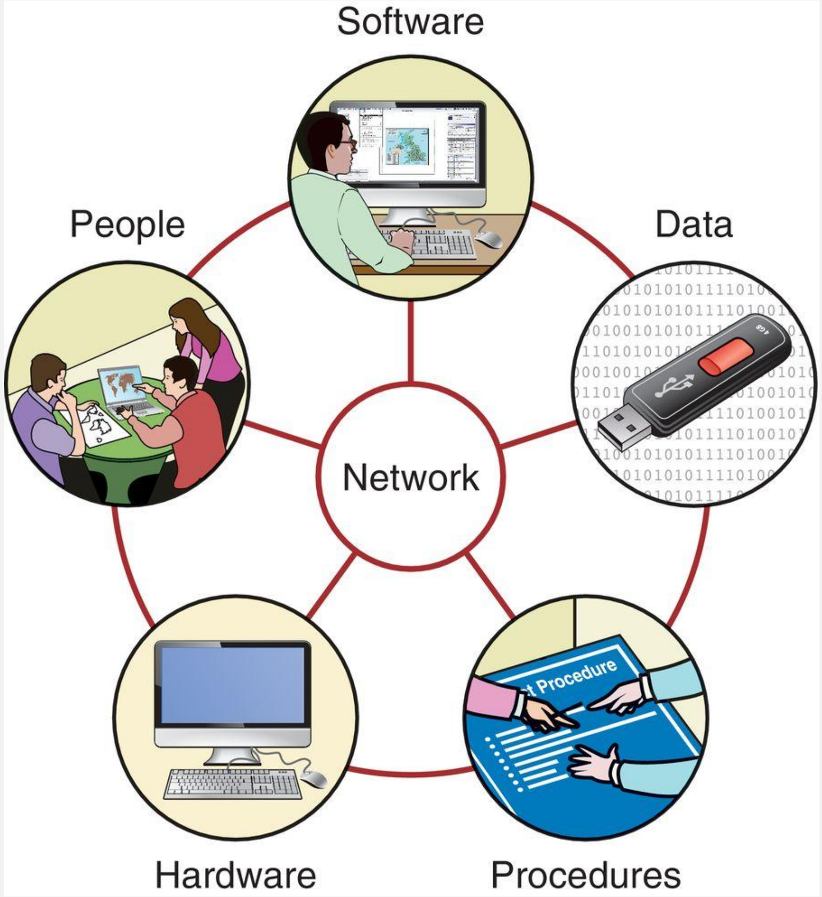
Review

- Know definitions of the terms used, including geographic information (GI) (What is GIS? Components of GIS?).
- Be familiar with a brief history of GI technology (History of GIS).
- Understand the significance of GI science, and how it relates to GI systems.

Review from Monday

Components of GIS?

- ◆Hardware
- ◆Software
- ◆Network
- ◆Data
- ◆People
- ◆Procedures



The **Internet** is core to most aspects of GIS use, and the days of standalone GISystems are mostly over.

Network – for rapid communication or sharing of digital information.

Review from Monday

Spatial Data?

Non –Spatial Data?

- **Spatial Data(where)**
  - Graphic spatial representation of real-world physical features
  - Have unique geographic coordinates

- **Non-spatial data (what, when, how)**

  - Attributes describing spatial data

STATE_NAME	DRAWSEQ	STATE_FIPS	SUB_REGION	STATE_AE
California	25	06	Pacific	CA
Ohio	26	39	East North Central	OH
Illinois	27	17	East North Central	IL
District of Columbia	28	11	South Atlantic	DC
Delaware	29	10	South Atlantic	DE
West Virginia	30	54	South Atlantic	WV
Maryland	31	24	South Atlantic	MD
Colorado	32	08	Mountain	CO
Kentucky	33	21	East South Central	KY
Kansas	34	20	West North Central	KS
Virginia	35	51	South Atlantic	VA
Missouri	36	29	West North Central	MO
Arizona	37	04	Mountain	AZ
Oklahoma	38	40	West South Central	OK
North Carolina	39	37	South Atlantic	NC
Tennessee	40	47	East South Central	TN
Texas	41	48	West South Central	TX
New Mexico	42	35	Mountain	NM
Alabama	43	01	East South Central	AL
Mississippi	44	28	East South Central	MS
Georgia	45	13	South Atlantic	GA
South Carolina	46	45	South Atlantic	SC
Arkansas	47	05	West South Central	AR
Louisiana	48	22	West South Central	LA
Florida	49	12	South Atlantic	FL
Michigan	50	26	East North Central	MI
Alaska	51	02	Pacific	AK

Learning Objectives

To understand:

- The importance of understanding representation in GI databases.
- The concepts of fields and objects and their fundamental significance.
- What raster and vector representation entails and how these data structures affect many principles, techniques, and applications of GI.
- The paper map and its role as a product and data source.
- The importance of generalization methods and the concept of representational scale.
- The art and science of representing real-world phenomena in GIS databases.

Outline

- **Introduction**
- **Digital representation**
- **The fundamental problem**
- **Discrete objects and continuous fields**
- **Rasters and vectors**
- **The paper map**
- **Generalization**
- **Key properties of spatial data**
- **Data Sources**
- **Conclusion**

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From Phenomena to Data

- **As Krygier and Wood (2014) put it:**
  - “**Phenomena**
    - Are all the stuff in the real world.”
  - “**Data**
    - Are records of observations of phenomena.”
    - Data are models of phenomena.
    - There are different approaches to measuring and modeling phenomena, and therefore different ways of making data.
  - “**Maps show us data, but not phenomena**.”
    - Always be thinking about the difference between phenomena and data in the particular context of your map.
    - This is, once again, a place where the real world is distorted by maps – they only ever give us a partial view of the world.

From Phenomena to Data

- **The world is too complex to put even a tiny fraction of it on a map.**
- **This probably does not mean merely showing a smaller portion of the world.**
- **Instead, it means only showing the information that serves the purposes of the map.**
- **In this way, we simplify the world.**
- **This often involves**
  - Choosing a geographic space (a particular place in the world)
  - Choosing a map scale (how zoomed in/zoomed out the map is)
  - Choosing a projection
  - Choosing data variables – what should be represented?
  - Choosing what to leave out

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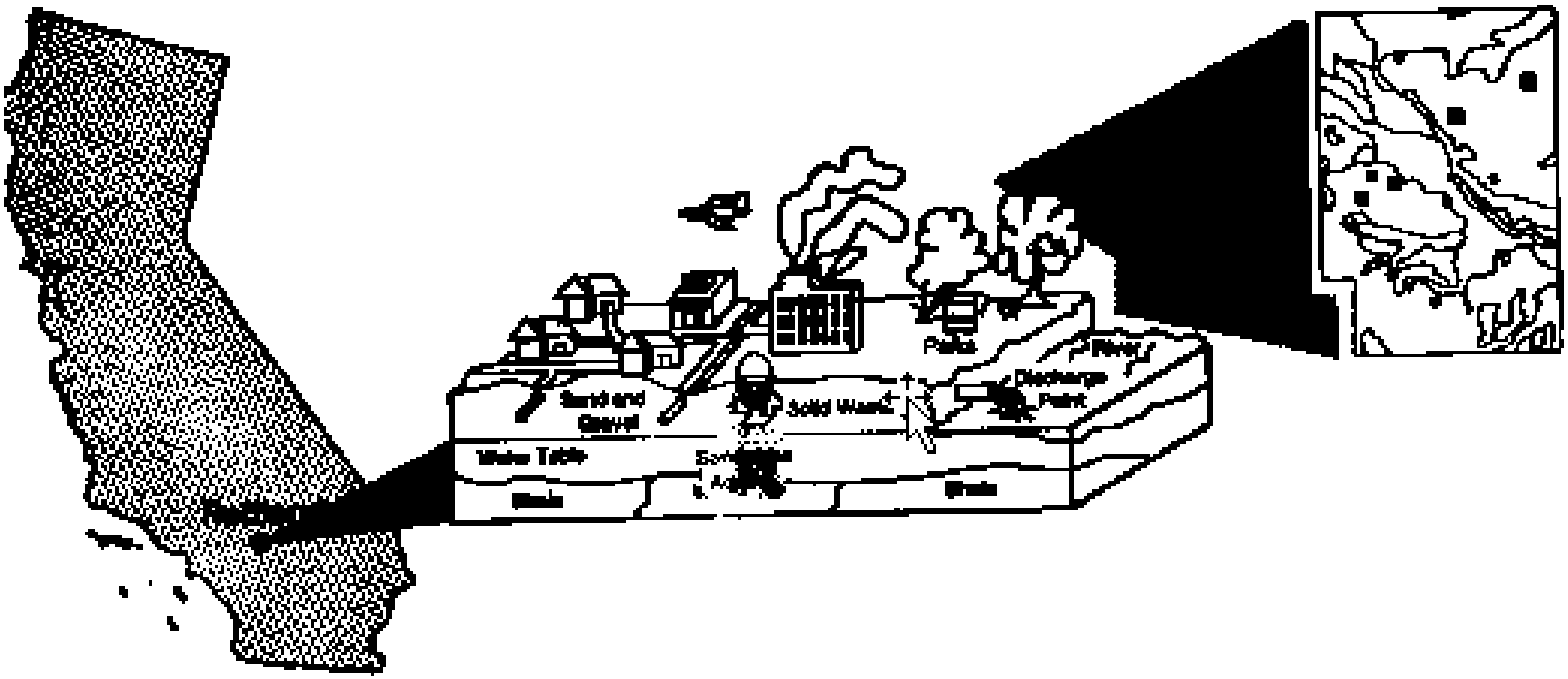
The GIS Data Model: Purpose

- **Allows the geographic features in real world locations to be digitally represented and stored in a database.**
- **Can be abstractly presented in map (analog) form.**
- **Can also be worked with and manipulated to address some problem.**

GIS Data Model

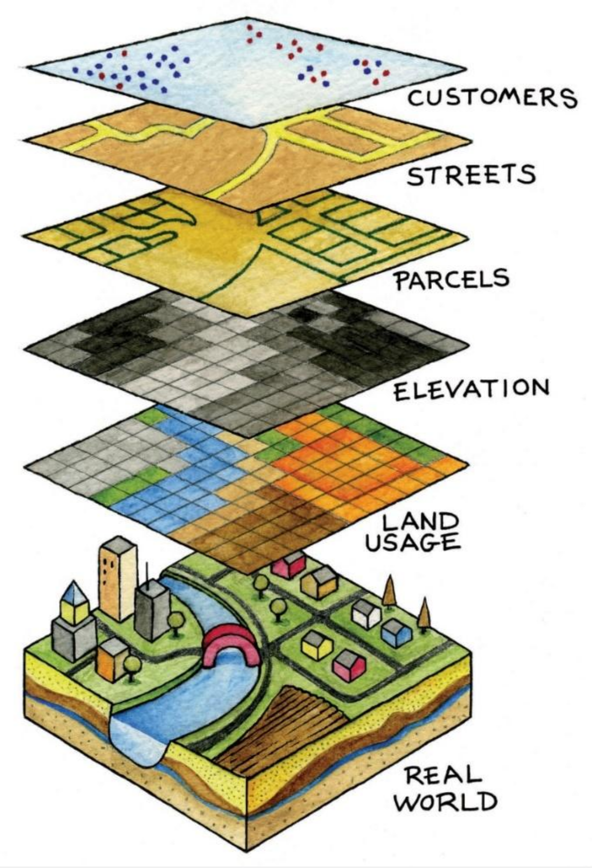


Real-world locations Geographic features Abstract representation

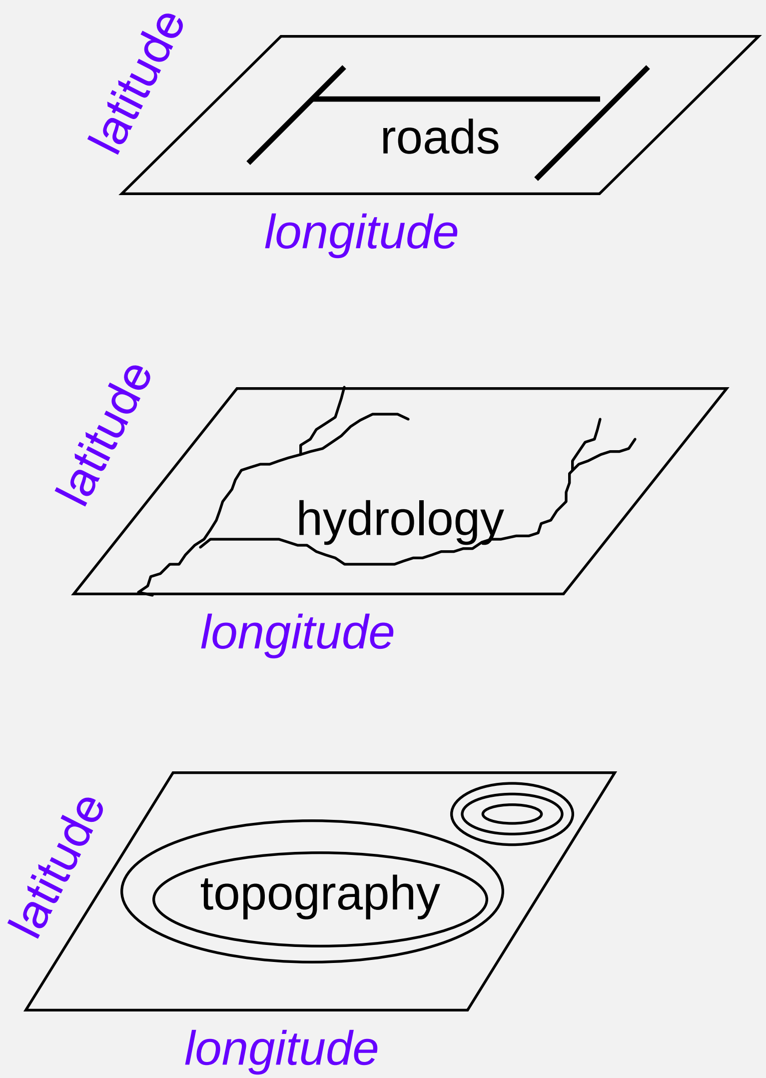
GIS Data Model

- **Data are organized by layers or themes, with each layer representing a common feature.**
- **Layers are integrated using explicit location on the earth's surface, thus geographic location is the organizing principal.**

A layer-cake of information



GIS Data Model



Here we have three **layers** or **themes:**
--roads,
--hydrology (water),
--topography (land elevation)

They **can be related because precise geographic coordinates** are recorded for each theme.

Layers are comprised of two data types
•***Spatial*** *data* which describes location (where)
•***Attribute*** *data* specifying what, how much, when

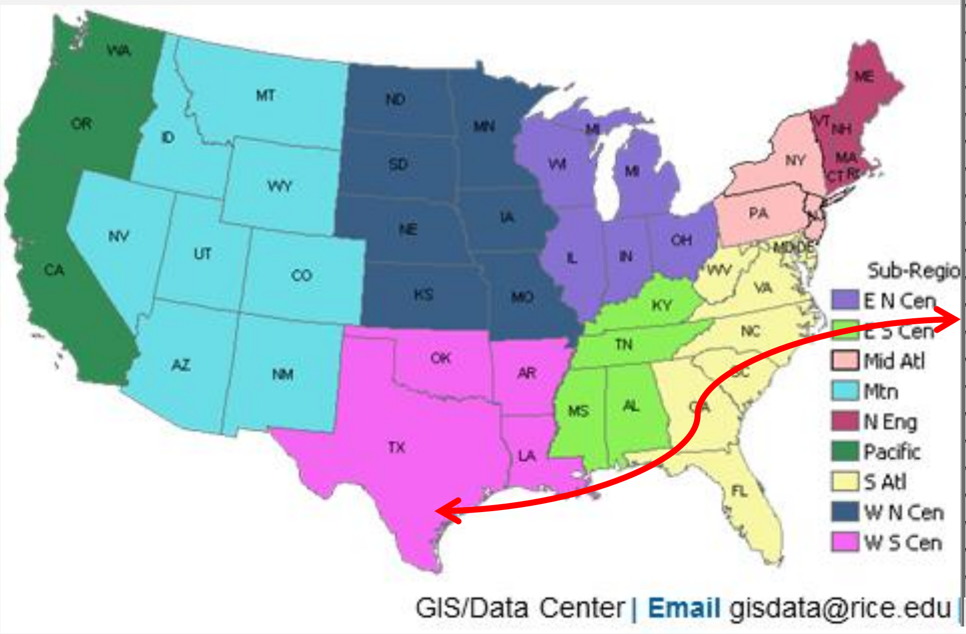
Layers may be represented in two ways:
•in *vector* format as points, lines and polygons
•in *raster(or image)* format as pixels

All geographic data has **4 properties**:
projection, scale, accuracy and resolution

Spatial and Attribute Data

- **Spatial data *(where)***
  - specifies location
  - stored in a *shape file, geodatabase* or similar geographic file
- **Attribute (descriptive) data *(what, how much, when)***
  - specifies characteristics at that location, natural or human-created
  - stored in a database *table*
- **GIS systems traditionally maintain spatial and attribute data separately**
  - "Join" them later for display or analysis
  - E.g. *Attribute* of a table is used to link a *shapefile* (spatial structure) with a *database table* to display the attribute data spatially on a map

Spatial and Attribute Data



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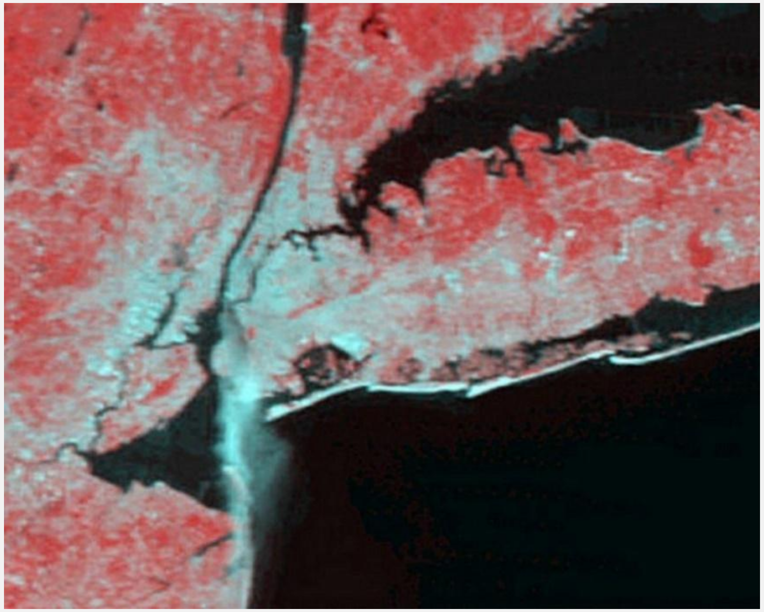
The Fundamental Problem Revisited

- Geographic data are built up from atomic elements, or facts about the geographic world.
- At its most primitive, an atom of geographic data (strictly, a datum) links a *place*, often a *time*, and some descriptive *property*.
- The *fundamental problem* is "the world is infinitely complex, but computer systems are finite".
- Representations must **somehow limit the amount of detail captured**.

Spatial Resolution



Courtesy: NOAA: Liam Gumley, MODIS Atmosphere Group, University of Wisconsin-Madison

This image shows Manhattan at a spatial resolution of 250 m, detailed enough to pick out the shape of the island and Central Park

The image is from NASA's Terra satellite showing a large plume of smoke streaming southward from the remnants of the burning World Trade Towers in downtown Manhattan on September 11, 2001.

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Discrete Objects and Continuous Fields

- In the *discrete object* view, the world is empty, except where it is occupied by objects with well-defined boundaries that are instances of generally recognized categories.
  - Objects can be counted
  - Objects have dimensionality:

    0-dimension (points),

    1-dimension (lines),

    2-dimensions (areas)

Discrete Objects and Continuous Fields

- The *continuous field view* represents the real world as a finite number of variables, each one defined at every possible position.
  - Continuous fields can be distinguished by

    what varies,

    and how smoothly.

Discrete Objects and Continuous Fields

Bears are easily conceived as discrete objects, maintaining their identity as objects through time and surrounded by empty space.

Discrete Objects and Continuous Fields

Lakes are difficult to conceptualize as discrete objects because it is often difficult to tell where a lake begins and ends, or to distinguish a wide river from a lake.

(Oliviero Olivieri/Getty Images, Inc.)

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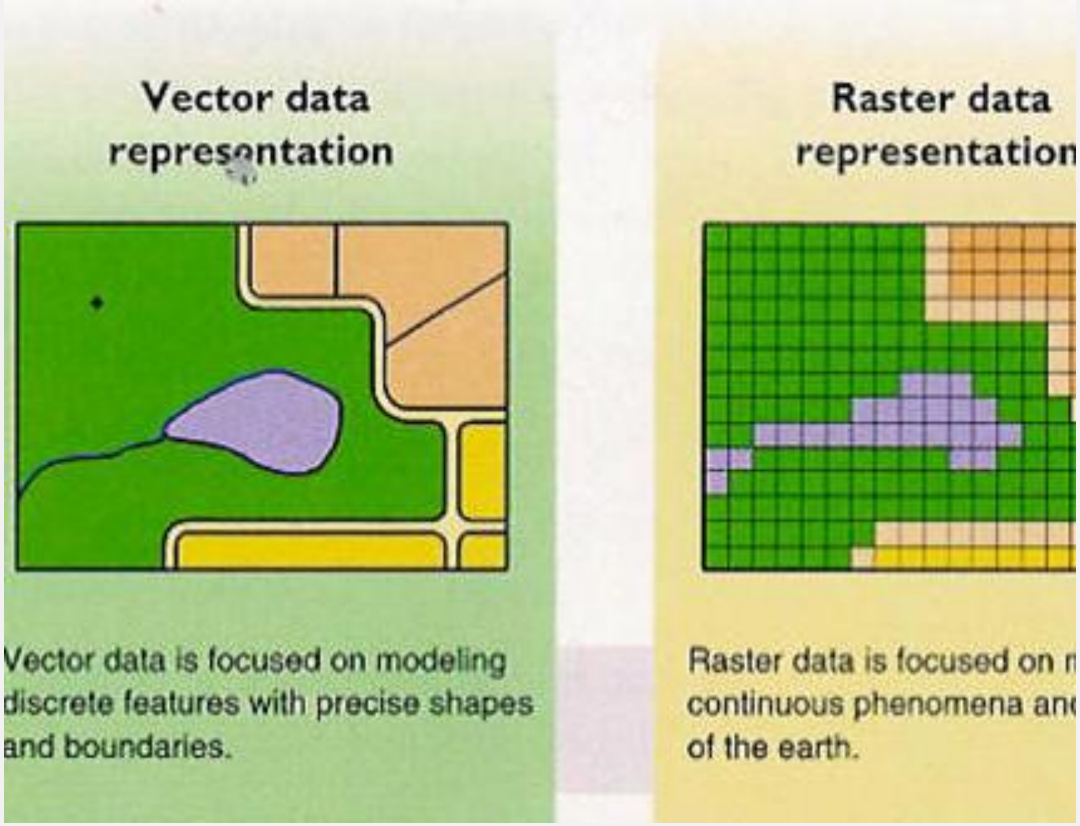
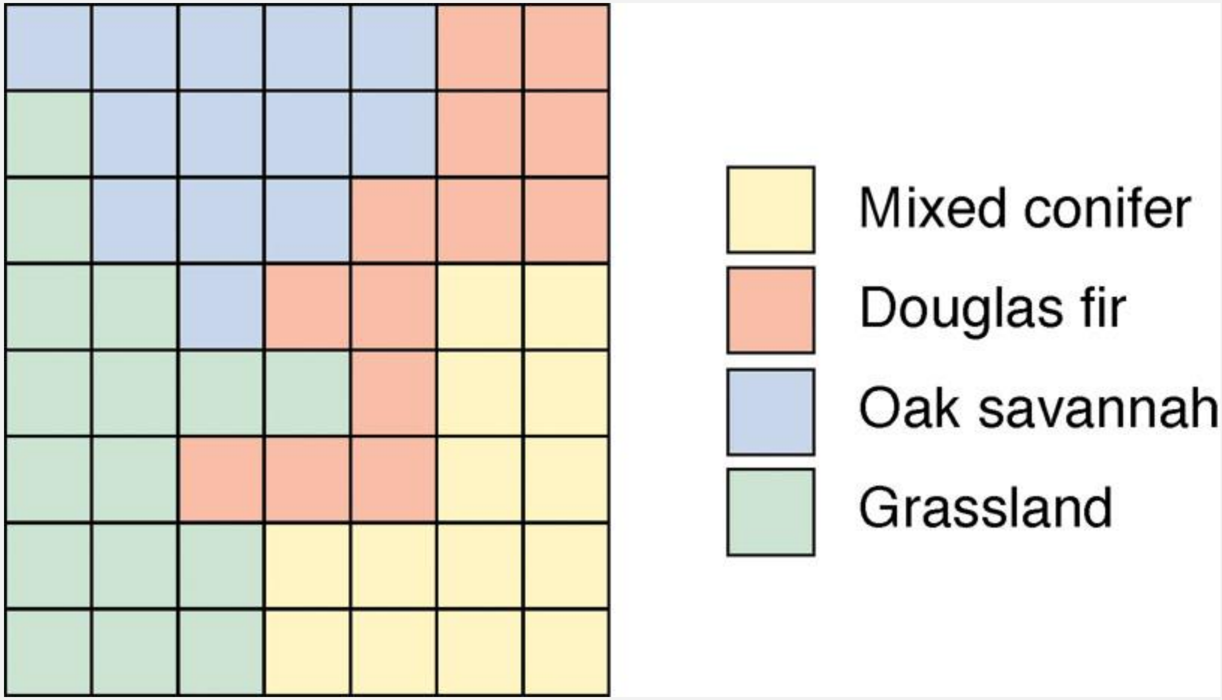
Rasters and Vectors

- Two methods that are used to reduce geographic phenomena to forms that can be coded in computer databases.
- In principle, each can be used to code both fields and discrete objects, but in practice there is a strong association between **raster and fields**, and between **vector and discrete objects**.



Raster Representation

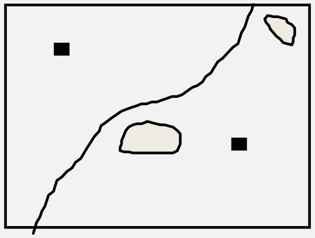
- In a raster representation geographic space is divided into an array of cells, each of which is usually square, but sometimes rectangular.
  - All geographic variation is then expressed by assigning properties or attributes to these cells.
  - The cells are sometimes called pixels (short for picture elements).



Each color represents a different value of a nominal-scale variable denoting land-cover class

Vector Representation

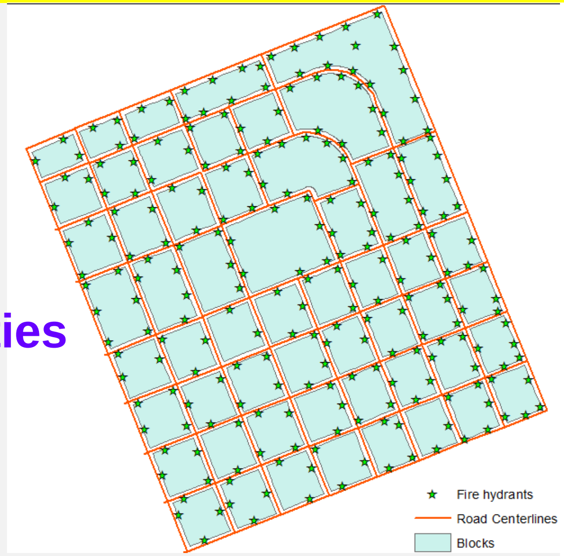
- In vector representation, objects/phenomena can be represented digitally either as points, line or polygons.
  - areas are often called polygons
  - lines are sometimes called polylines

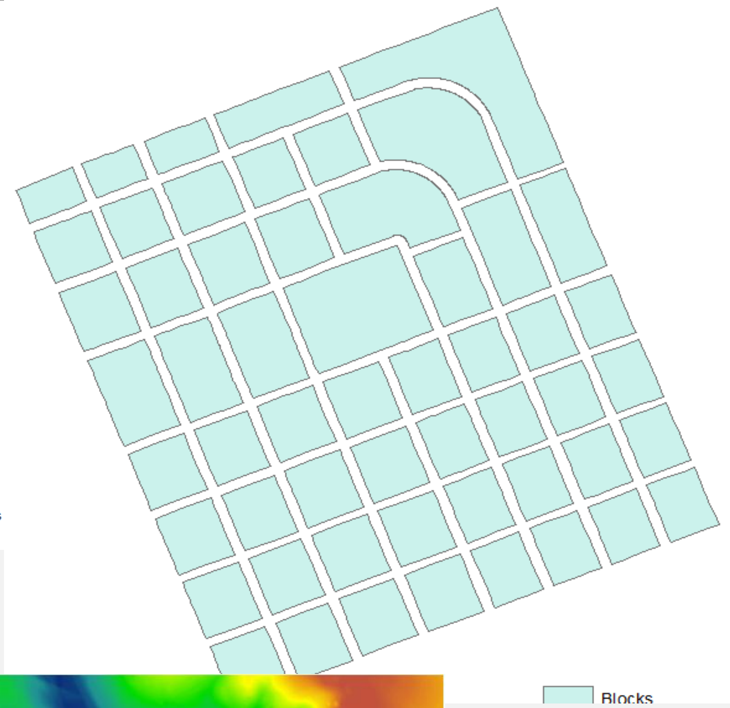


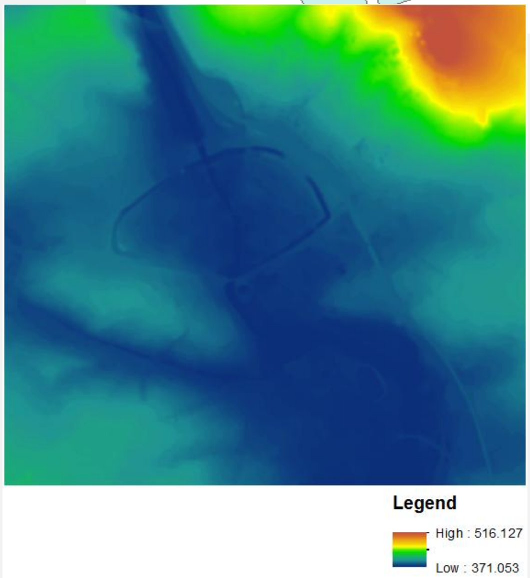
- Usually, in a vector representation, all lines are captured as points connected by precisely straight lines (some GI software also allows curves).
  - **the choice between raster and vector is often complex**

Representing Data with Vector and Raster Models

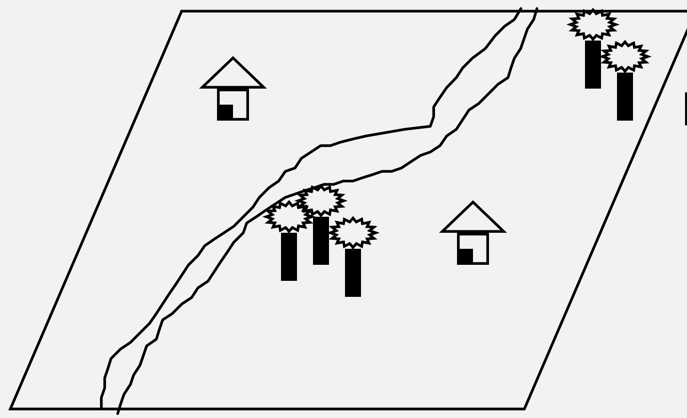
- Spatial data
  - Discrete (Vector)
    - Point
      - Trees, poles, cities
    - Line
      - Roads, streams
    - Polygon (area)
      - landparcels, cities, forest, rock type
  - Continuous(Raster)
    - Elevation, temperature, precipitation
    - Area is covered by grid
      - Usually equal-size square cells
    - Attributes are recorded by assigning each cell a single value







Concept of Vector and Raster

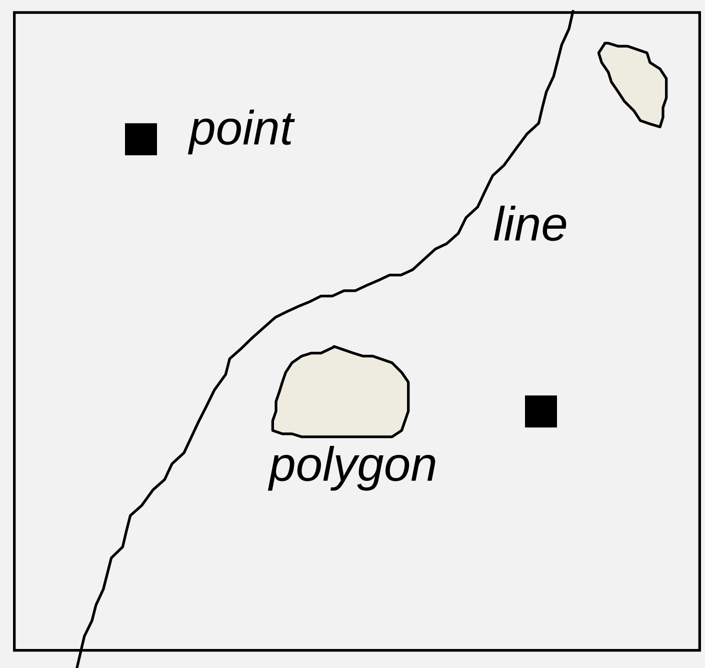


Real World

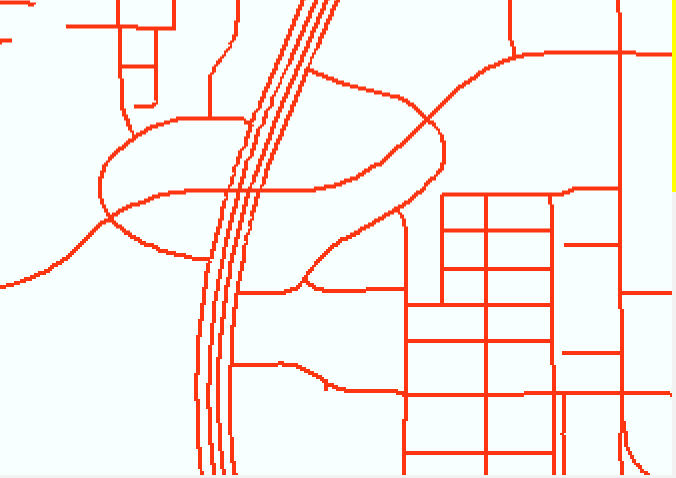
Raster Representation

	0	1	2	3	4	5	6	7	8	9
0								R	T	
1							R			T
2		H					R			
3							R			
4					R	R				
5				R						
6			R		T	T		H		
7			R		T	T				
8		R								
9		R								

Vector Representation



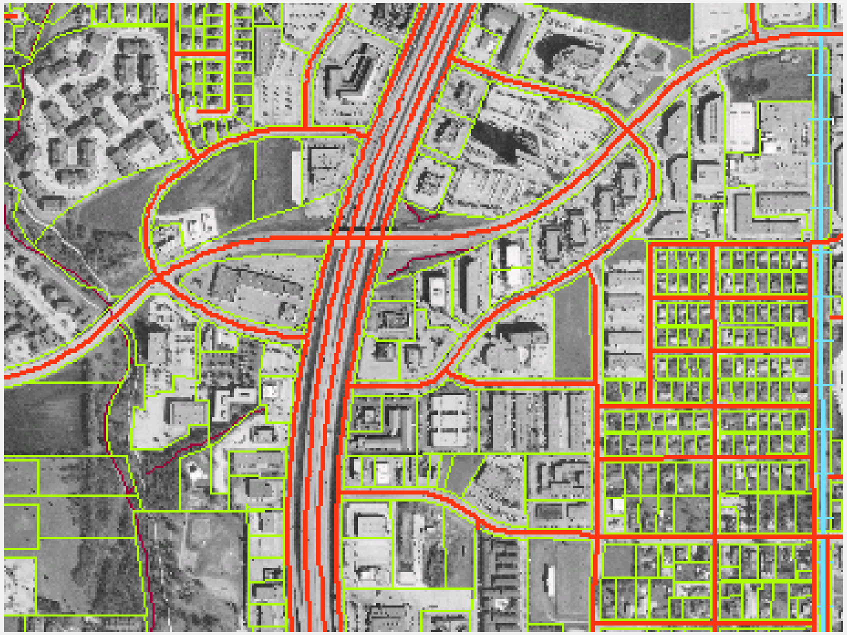
Vector Layers



Street layer: lines

Land Parcels layer: polygons

Raster (image) Layer



Overlay based on Common Geographic Location

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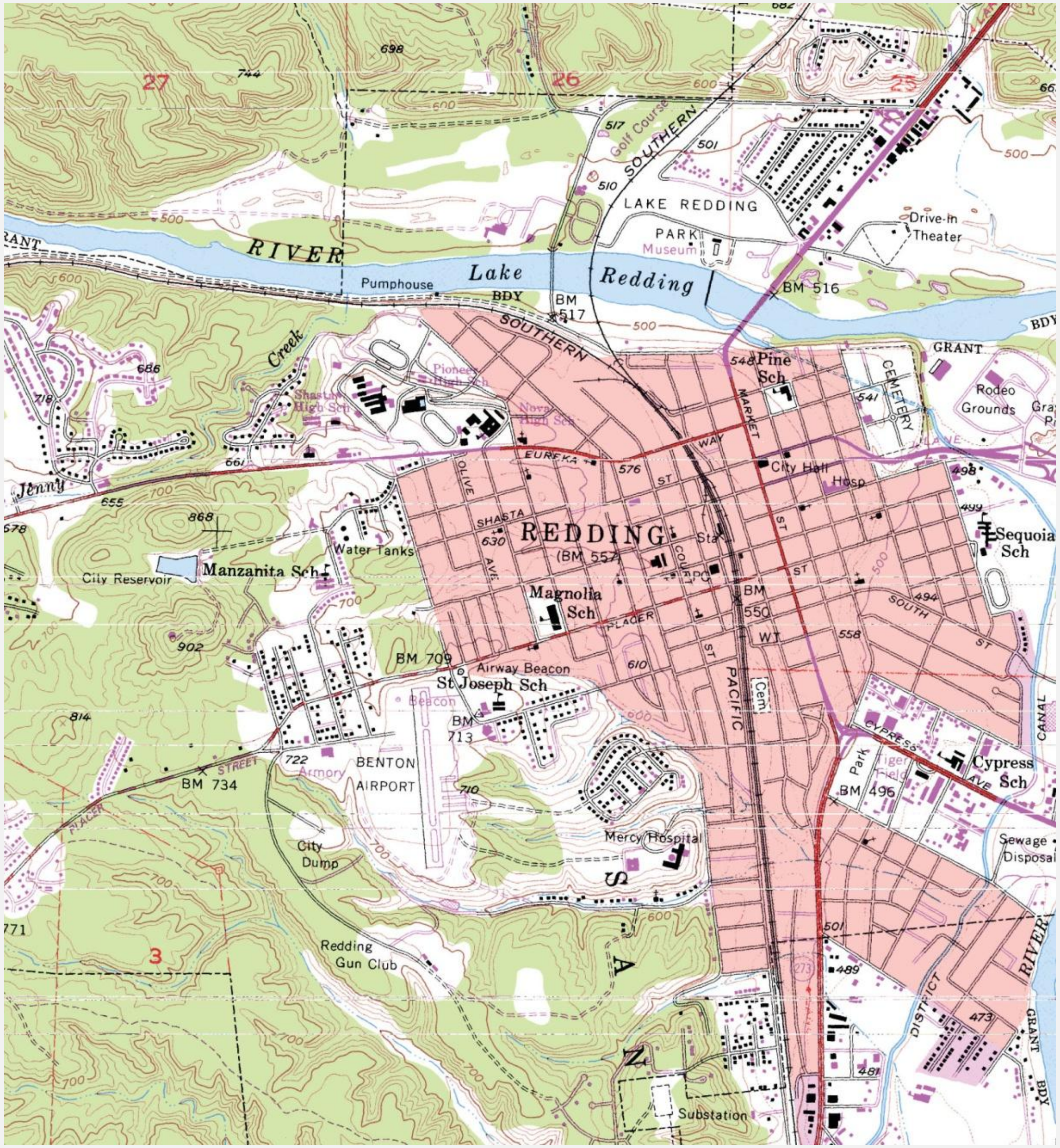

Part of a Digital Raster Graphic,
a scan of a U.S Geological Survey 1:24000 topographic map

(Courtesy USGS)

The Paper Map

- **Has a scale or representative fraction**
  - **The ratio of distance on the map to distance on the ground**
  - E.g. 1:24 000 – reduces everything on earth surface to 24,000th its real size
- **Is a major source of data for GI technologies**
  - Obtained by digitizing or scanning the map and registering it to the Earth’s surface
- **Digital representations are much more powerful than their paper equivalents**
- **But a GI database is much more than a container of conventional maps.**

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Generalization

- **Ways of simplifying the view of the world include:**
  - describe entire areas, attributing uniform characteristics to them, even when areas are not strictly uniform;
  - identify features on the ground and describe their characteristics, again assuming them to be uniform;
  - limit our descriptions to what exists at a finite number of sample points, hoping that these samples will be adequately representative of the whole.
  - some degree of generalization is almost inevitable in all geographic data.

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Projection, Scale, Accuracy and Resolution

the key properties of spatial data

- **Projection:**

  the method by which the curved 3-D surface of the earth is represented by X,Y coordinates on a 2-D flat map/screen (distortion is inevitable).

- **Scale (Small Scale and Large Scale, 1:1000 and 1: 50,000) ? :**

  the ratio of distance on a map to the equivalent distance on the ground

  - in theory ,GIS is scale independent but in practice there is an implicit range of scales for data output in any project.

- **Accuracy:**

  how well does the database information match the real world

  - ***Positional:*** how close are features to their real world location?
  - ***Consistency*:** do feature characteristics in database match those in real world
    - is a road in the database a road in the real world?
  - ***Completeness*:** are all real world instances of features present in the database?
    - Are all roads included.

- **Resolution:**
  - the size of the smallest feature able to be recognized; for raster data, it is the *pixel* size
  - *The tighter the specification, the higher the cost.*

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Data Sources

- **Federal geospatial data repositories**
  - **EarthExplore (USGS): http://earthexplorer.usgs.gov/**
  - **U.S. census bureau: http://www.census.gov/geography.html**
  - **The national map (USGS): http://nationalmap.gov/**
- **State GIS data clearinghouses**

Data Sources

TABLE A–6 State GIS Data Clearinghouses.

State	GIS Clearinghouse Website
Alabama	http://portal.gsa.state.al.us/Portal/index.jsp
Alaska	http://www.asgdc.state.ak.us/
Arizona	http://agic.az.gov/
Arkansas	http://www.geostor.arkansas.gov/G6/Home.html
California	http://atlas.ca.gov/
Colorado	http://coloradogis.nsm.du.edu/Portal/
Connecticut	http://magic.lib.uconn.edu/
Delaware	http://datamil.delaware.gov/geonetwork/srv/en/main.home
Florida	http://www.fgdl.org/
Georgia	http://gis.state.ga.us/
Hawaii	http://hawaii.gov/dbedt/gis/download.htm
Idaho	http://www.insideidaho.org/
Illinois	http://www.isgs.uiuc.edu/nsdihome/ISGSindex.html
Indiana	http://www.igic.org/
Iowa	http://www.igsb.uiowa.edu/nrgislibx/
Kansas	http://www.kansasgis.org/
Kentucky	http://technology.ky.gov/gis/Pages/default.aspx

TABLE A–6 (continued) State GIS Data Clearinghouses.

State	GIS Clearinghouse Website
Louisiana	http://lagic.lsu.edu/
Maine	http://www.maine.gov/megis/
Maryland	http://www.marylandgis.net/index.jsp
Massachusetts	http://www.mass.gov/mgis/
Michigan	http://www.michigan.gov/cgi
Minnesota	http://www.mngeo.state.mn.us/chouse/index.html
Mississippi	http://www.gis.ms.gov/portal/home.aspx
Missouri	http://www.msdis.missouri.edu/
Montana	http://nris.mt.gov/gis/
Nebraska	http://www.dnr.state.ne.us/databank/geospatial.html
Nevada	http://www.nbmg.unr.edu/DataDownloads/VirtualClearinghouse.html
New Hampshire	http://www.granit.unh.edu/
New Jersey	https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp
New Mexico	http://rgis.unm.edu/
New York	http://www.nysgis.state.ny.us/http://rgis.unm.edu/
North Carolina	http://www.nconemap.com/
North Dakota	http://www.nd.gov/gis/
Ohio	http://ogrip.oit.ohio.gov/Home.aspx
Oklahoma	http://www.seic.okstate.edu/
Oregon	http://gis.oregon.gov/
Pennsylvania	http://www.pasda.psu.edu/
Rhode Island	http://www.edc.uri.edu/RIGIS/
South Carolina	http://www.gis.sc.gov/data.html
South Dakota	http://www.sdgs.usd.edu/
Tennessee	http://www.tngis.org/
Texas	http://www.tnris.org/
Utah	http://gis.utah.gov/

Data Sources

Washington http://geo.wa.gov/

TABLE A–6 (continued) State GIS Data Clearinghouses.

State	GIS Clearinghouse Website
Vermont	http://www.vcgi.org/dataware/
Virginia	http://gisdata.virginia.gov/Portal/
Washington	http://metadata.gis.washington.edu/geoportal/catalog/main/home.page
West Virginia	http://wvgis.wvu.edu/
Wisconsin	http://www.sco.wisc.edu/wisclinc/
Wyoming	http://www.wyoming.gov/loc/04222011_1/statewideIT/gis/Pages/default.aspx

Conclusions

- **From paper maps to digital representation**
- **The fundamental problem** (infinitely complex world; finite computer systems; limit the amount of detail captured.)
- **Discrete objects and continuous fields**
  - **Two fundamental ways of representing geography**
- **Raster and vector**
  - **two methods of representing geographic data in digital computers**
- **Representation, or more broadly *ontology*, is a fundamental issue in GI**

Questions ?

https://www.google.com/url?sa=i&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwihuqvgkpjcAhU3IDQIHZbqB8QQjRx6BAgBEAU&url=http%3A%2F%2Fwww.cityofrockhill.com%2Fdepartments%2Finformation-technology-services%2Fmore%2Finformation-technology-services%2Fgeographic-information-systems-gis-%2Fgis-frequently-asked-questions&psig=AOvVaw2fEUXAIjbJY26W-bnjS0wY&ust=1531436220322311

Upcoming

- Wednesday (Lecture) : Georeferencing I
- Readings updated on canvas.
- Week 2, GIS Lab 01: Introduction to Web Mapping will be assigned (check your sections).
- Check canvas for updates on readings, due dates, etc.
- Submit Assignment 00 (Self Introduction) – 10 points