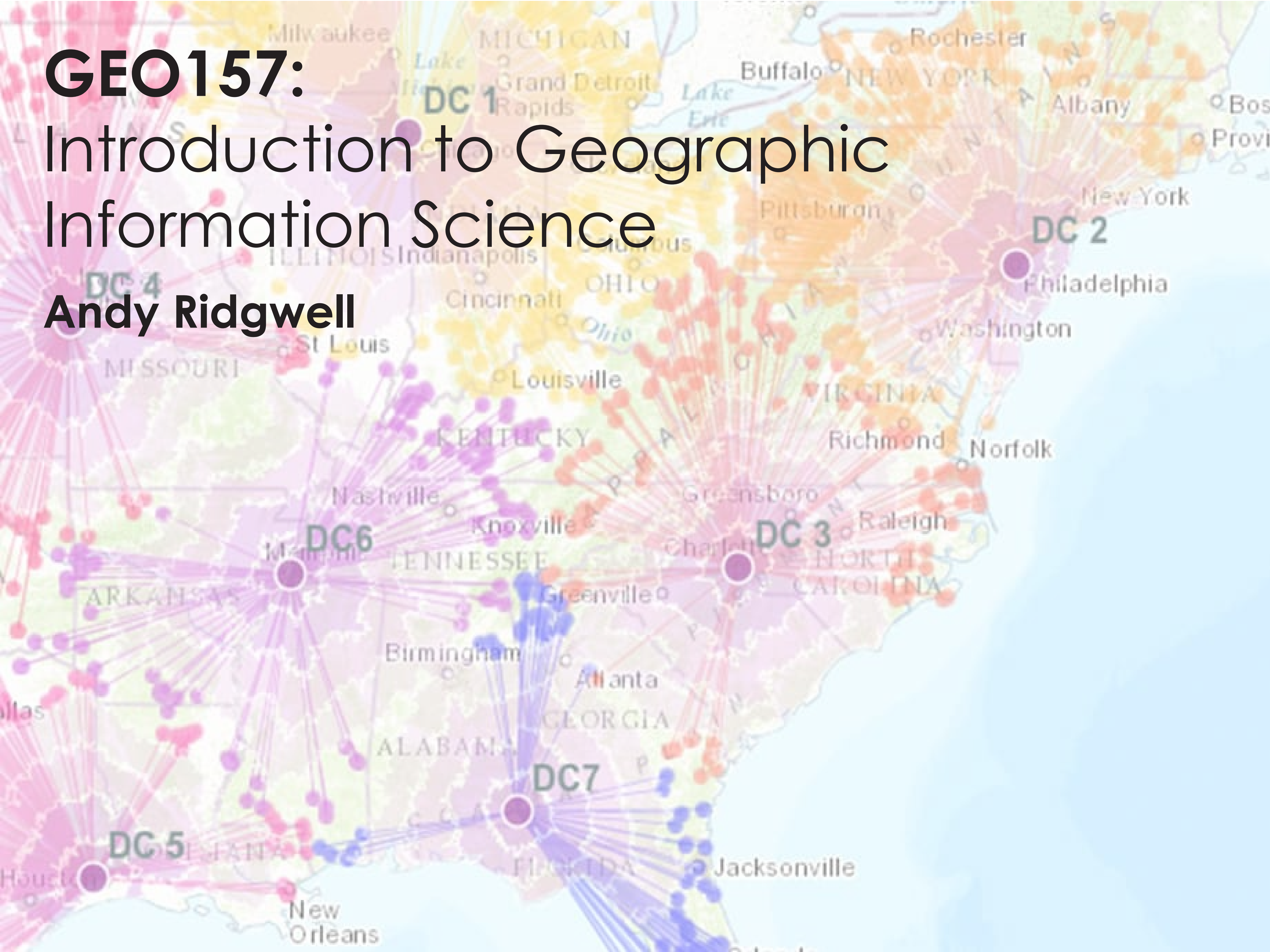
GEO157:
Introduction to Geographic Information Science

Andy Ridgwell



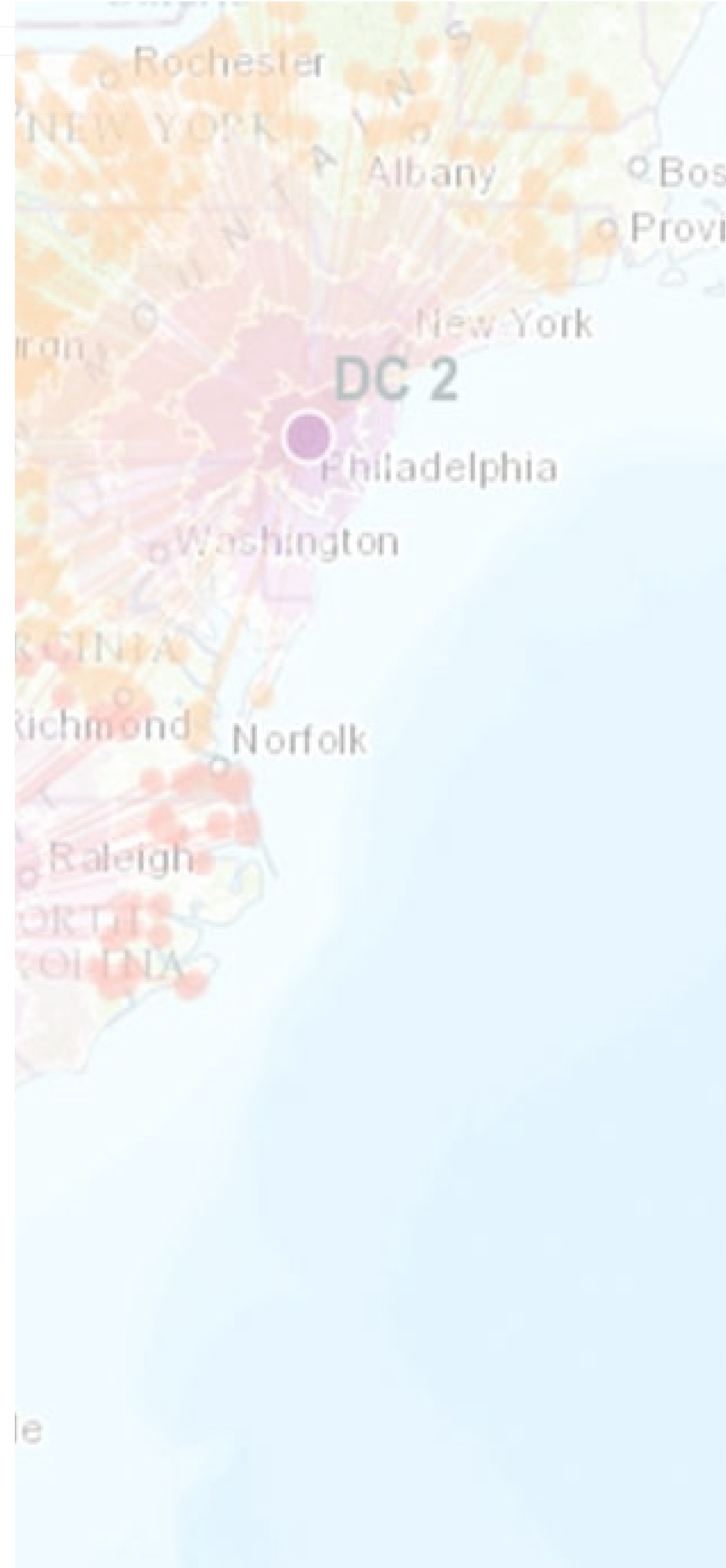
GEO157

WEEK	Monday am (1) *Lecture A* *09:10-10:30* *Sproul 2225*	Monday am (2) *Lecture B* *10:40-12:00* *Sproul 2225*	Monday *Office Hours:* *12-2 pm*	Friday am *LAB* *09:10-12:00* *Sproul 2225*	Friday *Exrta lab hours:* *12-2 pm*
(#1) 2nd / 6th April	**Course introduction** Course introduction and logistics. Laptop software installation.			**fake 'fieldwork' fun** Paper-based and web-based GIS-like problems.	
(#2) 9th / 13th April	**Lecture 1, Discussion** Chapter 1: What is GIS? **Problem Set 0 due**	**Lecture 2** Chapter 2: Spatial data **Problem Set 1 (Ch. 1)**		**Lab 1** Digitizing	
(#3) 16th / 20th April	**Worked problems** **Problem Set 1 due**	**Lecture 3** Chapter 3: Spatial data modelling **Problem Set 2 (Ch. 2+3)**		**Lab 2** GPS, Georeferencing, and Geocoding **Lab 1 due**	
(#4) 23rd / 27th April	**Worked problems** **Problem Set 2 due**	**Lecture 4** Chapter 4: Database management		**Lab 3** Interpolating weather **Lab 2 due**	
(#5) 30th / 4th May	**Worked problems** **Oral presentations set**	**Lecture 5** Chapter 5: Data input and editing **Problem Set 3 (Ch. 4+5)**		**Lab 4** Vector analysis using earthquake data **Lab 3 due**	

3 short exercises to ease you into GIS thinking.

May be completed today in class, or after class, or over the weekend ... as long as handed in on Monday.

BONUS % (3) will be awarded.



Alphabetical Legend

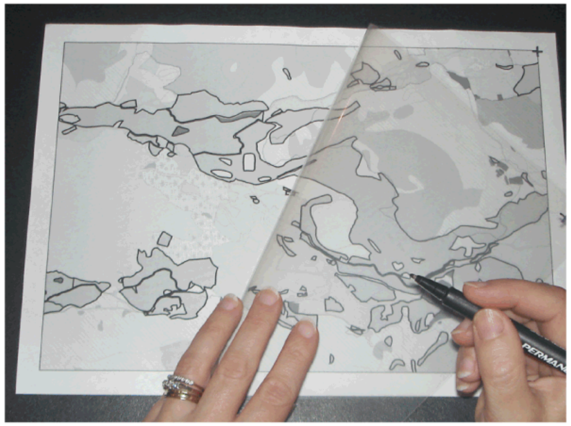
Building Name	Grid
Aberdeen-Inverness Residence Hall	E4
Administration (Hinderaker Hall)	C6
Agricultural Operations	B8
Alumni & Visitors Center	C5
Anderson Hall (SoBA, AGSM) 1 & 2	E7-8
Arts Building	C5-6
Arts 113-Studio Theatre	C, D5
Arts 166-Performance Lab	C5
Athletics & Dance Bldg (PE Bldg)	D5-6
Bannockburn Village	C4-5
Barn Group/University Club	D6
Batchelor Hall	E6
Bell Tower	E6
Biological Sciences	E6-7
Biomedical Teaching Complex	F6
Bookstore (Campus Store)	D, E5
Botanic Gardens	G, H7-9
Bourns Hall (Engineering)	E5
Boyce Hall	F6
Boyden Laboratories	E7
Campus Surge	D5
Campus Tours (Student Services Building)	D6
Canyon Crest Family Student Housing	D, F 2-4
Capital Planning	A5
Career Center (Health Services)	E, F5
Chapman Hall	E7
CHASS Interdisciplinary North and South	D,5-6
Chemical Sciences	F6
Child Development Center	E, F3
College Building North	E8
College Building South	E8
Computing & Communications	F, G7
Corporation Yard	F3-4
Costo Hall	D6
Cottage	D7
East I & Q (Insectary)	F7
Entomology	E7
Entomology Museum	E7
Environmental Health and Safety	E8
Falkirk Apts	C3-4
Fawcett Laboratory	F7
Fleet Services Dept.	F3
Geology Building	E6
Glen Mor 1	G4
Genomics	E7
Greenhouses	F6-7
Headhouse (greenhouses)	F8
Health Services	E, F5
Herbarium	F7
Highlander Hall	B5-6
Highlander Union Bldg/Plaza (HUB)	D6
Hinderaker Hall (Administration)	C6
Housing Administration	C, D4
HUB (Highlander Union Building)	D6
Humanities	D6
Humanities 400/University Theatre	D7
Humanities & Social Sciences Building	D6
Humanities 1500	D6
Human Resources	B5
International Village Housing	B6
Keen Hall	E, F6
KUCR Radio	E, F4
Library, Orbach	F6
Library, Rivera	E6-7
Life Science Building	E6
Life Sciences 1500	E6
Lothian Residence Hall	F, G5
Material Sciences & Engineering Building	D, E5
Oban Apts	C4
Olmsted Hall	D, E7
Orbach Library (Science Library)	F6
Parking Services	F, G4
Pentland Hills	F, G 4-5
Physical Plant Office	F3
Physics Building	E, F 5-6
Physics 2000	F6
Pierce Hall	E6
Plaza Apts (The Plaza)	C4
Police Facility	D4
Printing and Reprographics	E6
Psychology Building	E7
Purchasing Dept.	F3
Rivera Library	E6-7
School of Medicine Education Bldg	E7
School of Medicine Research Bldg	F6
Schools First Credit Union	A4
Science Laboratories 1	E6
Spieth Hall	E6
Sproul Hall	D6
Stonehaven Apts	C2-3
Student Recreation Center	D, E4
Student Services	D6
UCR Baseball Complex	C2-3
UCR Extension Center	A, B 5-6
University Laboratory Building	E7
University Lecture Hall	D, E5
University Office Building	F7
University Theatre	D7
University Village	A, B4-5
University Village Theater	A, B5
USDA Salinity Laboratory	G6
Watkins Hall	D6
Watkins 1000	D6
Webber Hall	E6
Winston Chung Hall (EBU2)	E5

Performance/Lecture Halls/Libraries

Arts 113 Studio Theatre (P1)	C, D5
Arts 166 Performance Lab (P1)	C5
Humanities 1500 (P1)	D6
Life Science 1500 (P6)	E6
Orbach Library (P10)	F6
Physics 2000 (P10)	F6
Rivera Library (P6)	E6-7
University Lecture Hall (P24)	D, E5
University Theatre/Humanities 400 (P6)	D7
University Village Theater (Parking structure)	A, B5
Watkins 1000 (P1)	D6

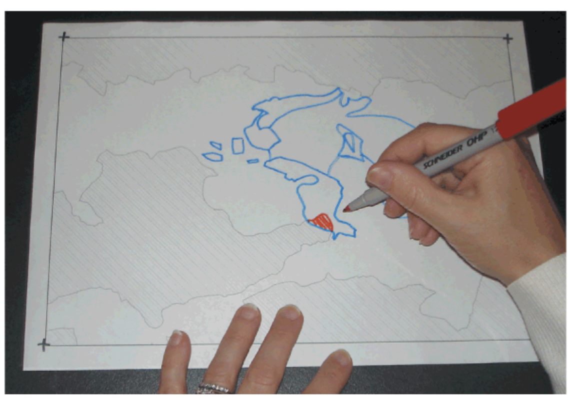
'Old-school' (low-tech) spatial analysis

- Pen & paper approach.
- Use paper maps to create overlays.
- Problems?

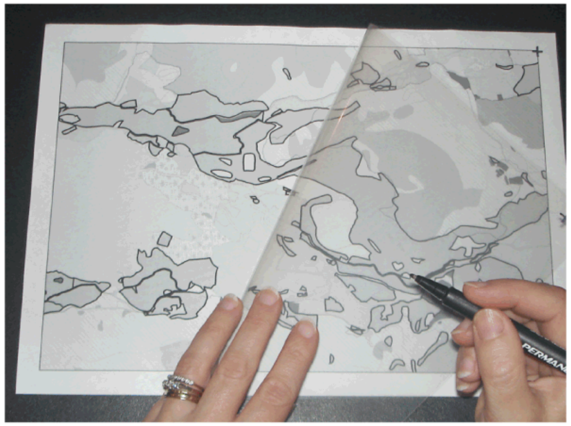


(a) Step one

(b) Step two

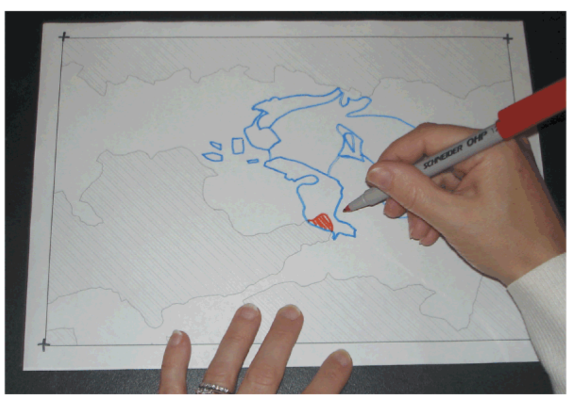


(c) Step three



(a) Step one

(b) Step two

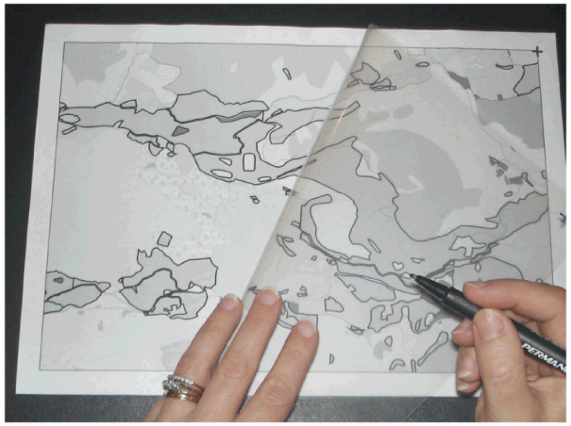


(c) Step three

‘Old-school’ (low-tech) spatial analysis

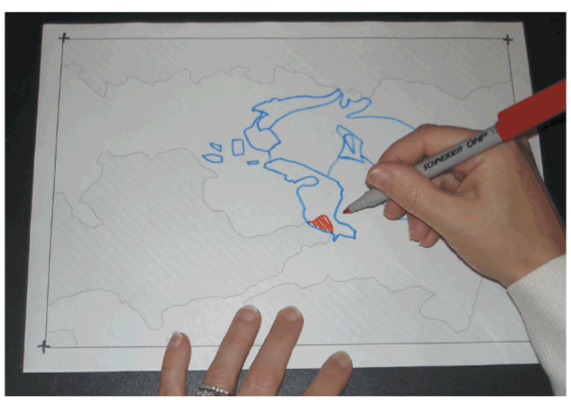
- Pen & paper approach.
- Use paper maps to create overlays.
- Problems?
  - ♦ slow (e.g. compared to loading electronic data)
  - ♦ less precise (only as accurate as the sketch / tracing)
  - ♦ fixed co-ordinate system
  - ♦ ’layers’ (data-sets) can be added, but not removed or hidden (a problem when dealing with a large number of different sorts of data)
  - ♦ can be difficult to revise (e.g. if road layout changes)
  - ♦ likely to be ’poor’(?) presentation
  - ♦ quantitative analysis difficult, e.g. or length of uneven shapes and curves

‘Old-school’ (low-tech) spatial analysis



(a) Step one

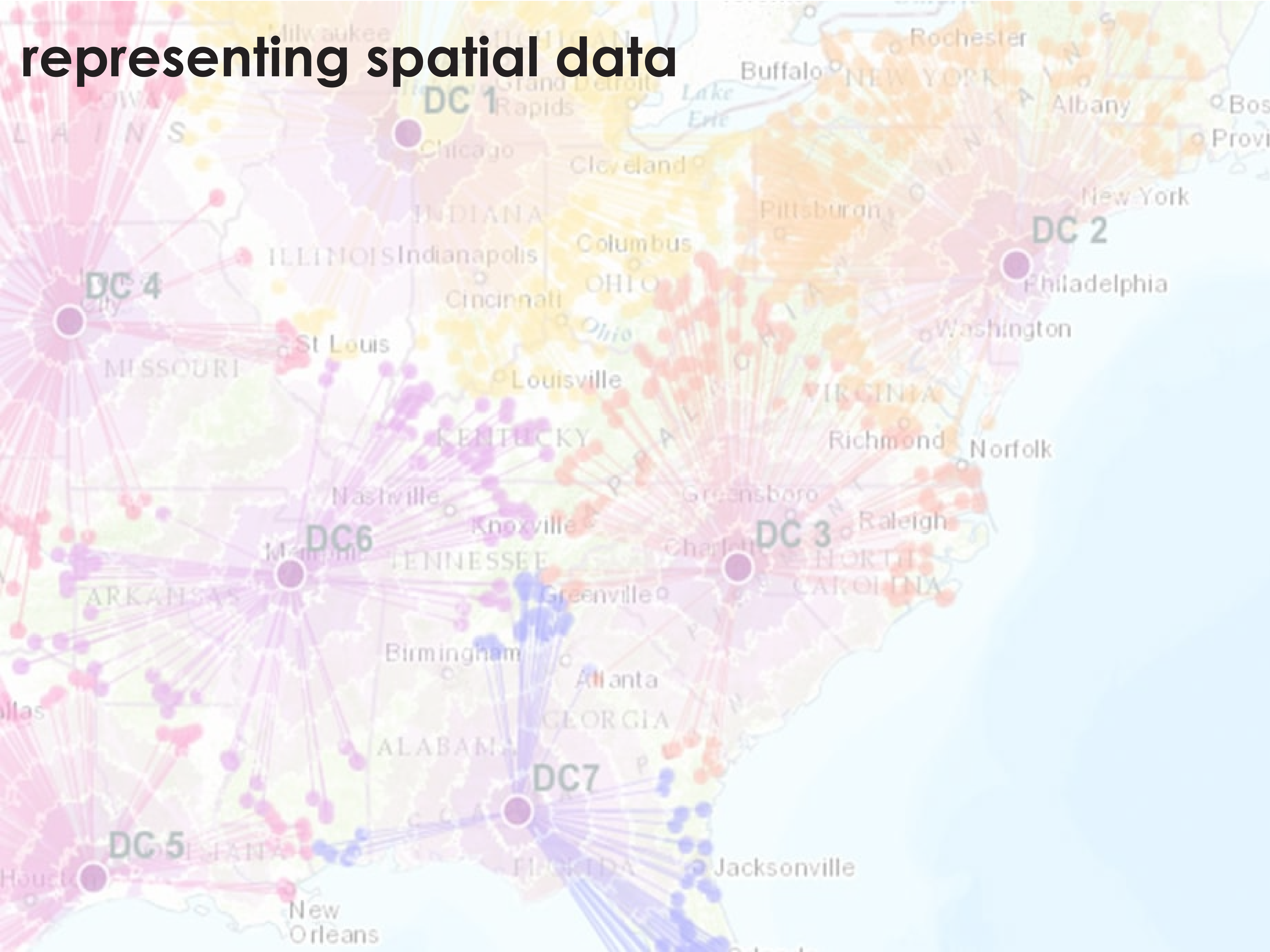
(b) Step two



(c) Step three

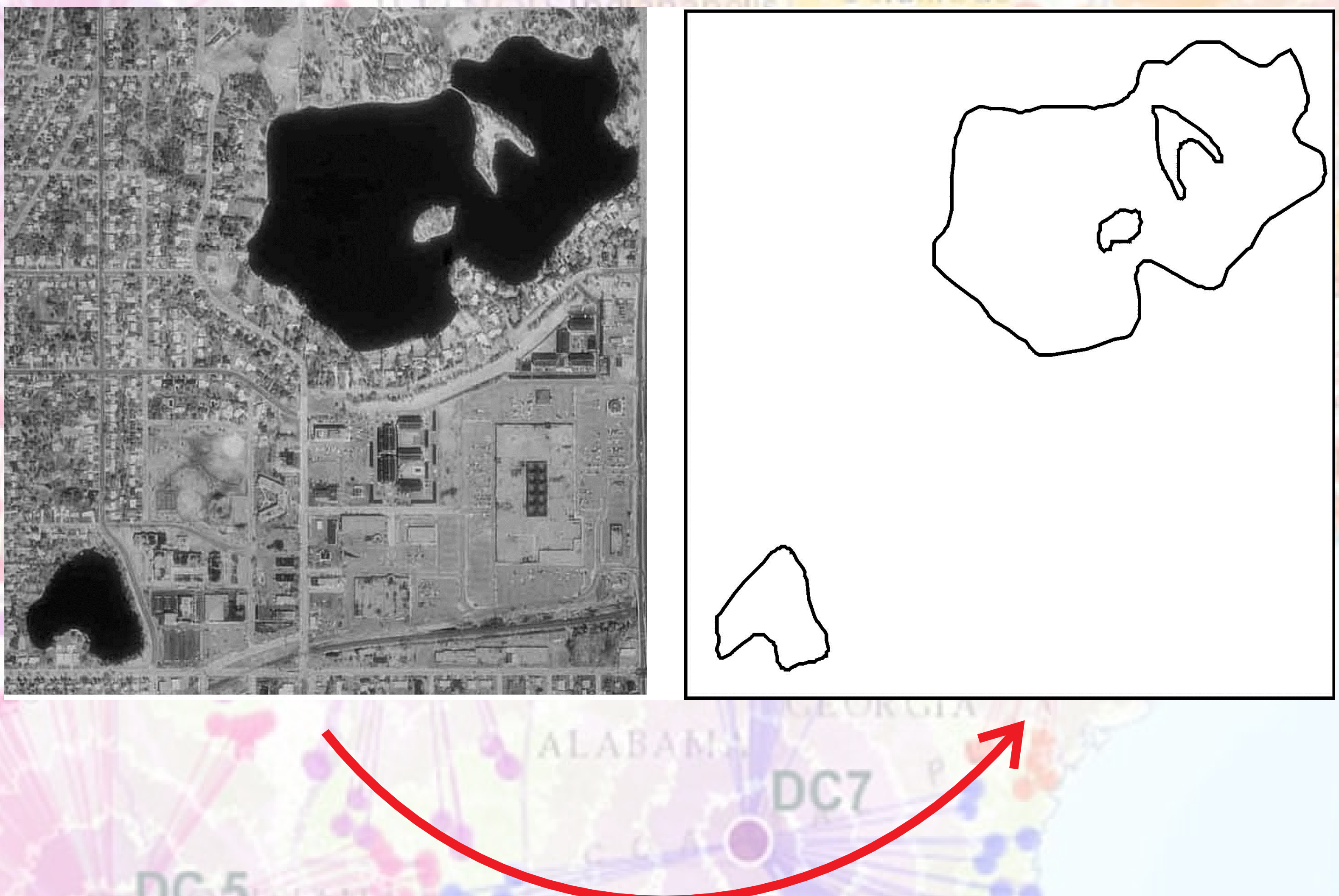
- Pen & paper approach
- Use paper maps to create overlays
- Problems?
  - ♦ slow (e.g. compared to loading electronic data)
  - ♦ less precise (only as accurate as the sketch / tracing)
  - ♦ fixed co-ordinate system
  - ♦ ’layers’ (data-sets) can be added, but not removed or hidden (a problem when dealing with a large number of different sorts of data)
  - ♦ can be difficult to revise (e.g. if road layout changes)
  - ♦ likely to be ’poor’(?) presentation
  - ♦ quantitative analysis difficult, e.g. or length of uneven shapes and curves
- Advantages?

representing spatial data

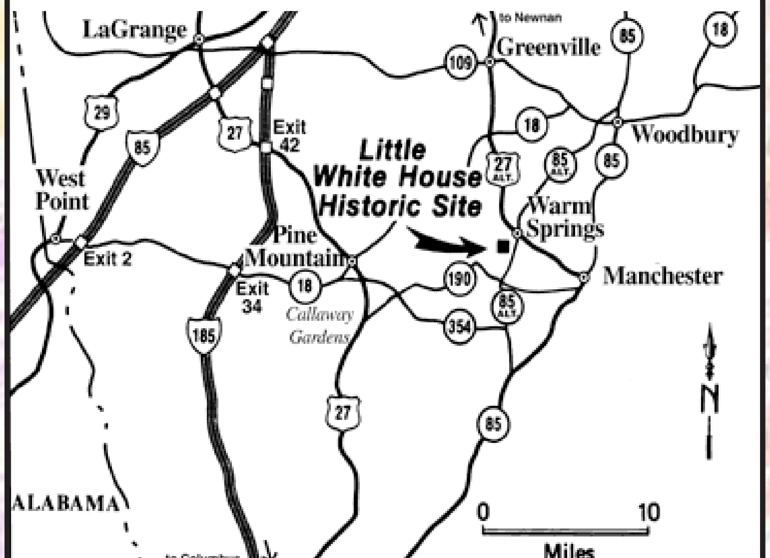


Data/entities are simplified view of real-world features or phenomena.

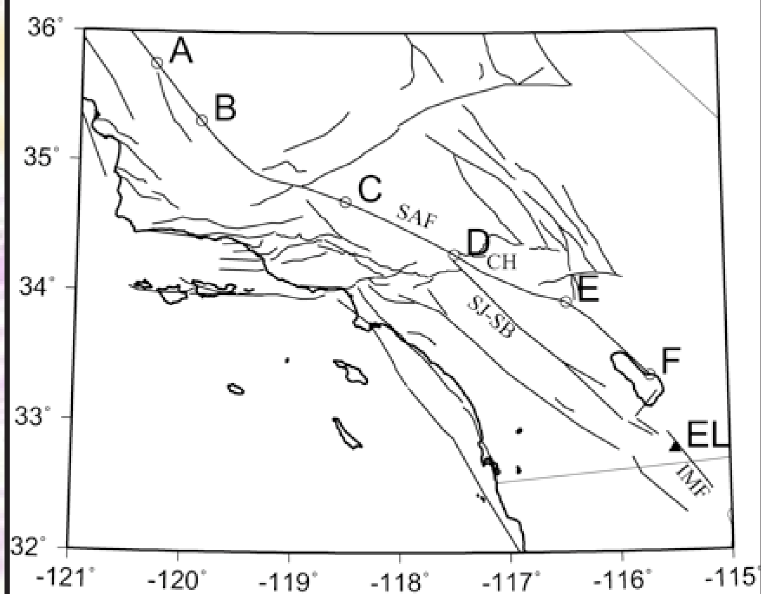
- We can take only the information we are interested in.
- What we are interested in depends on the purpose of the GIS.



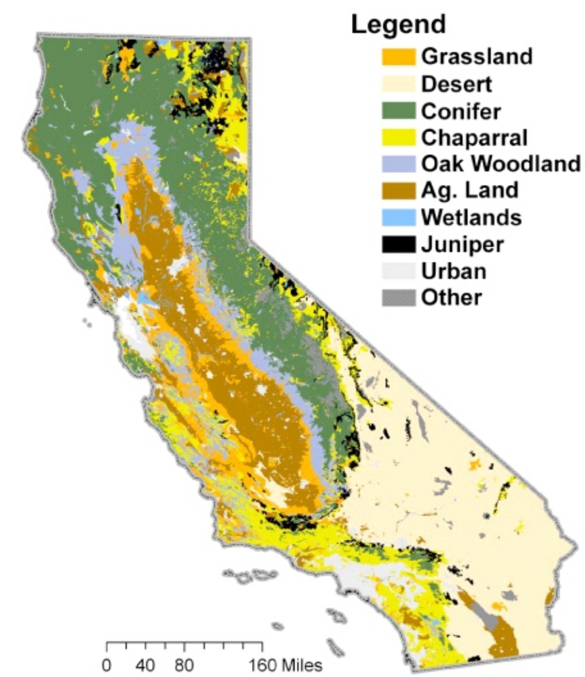
Real Geographic Features to Spatial Entities



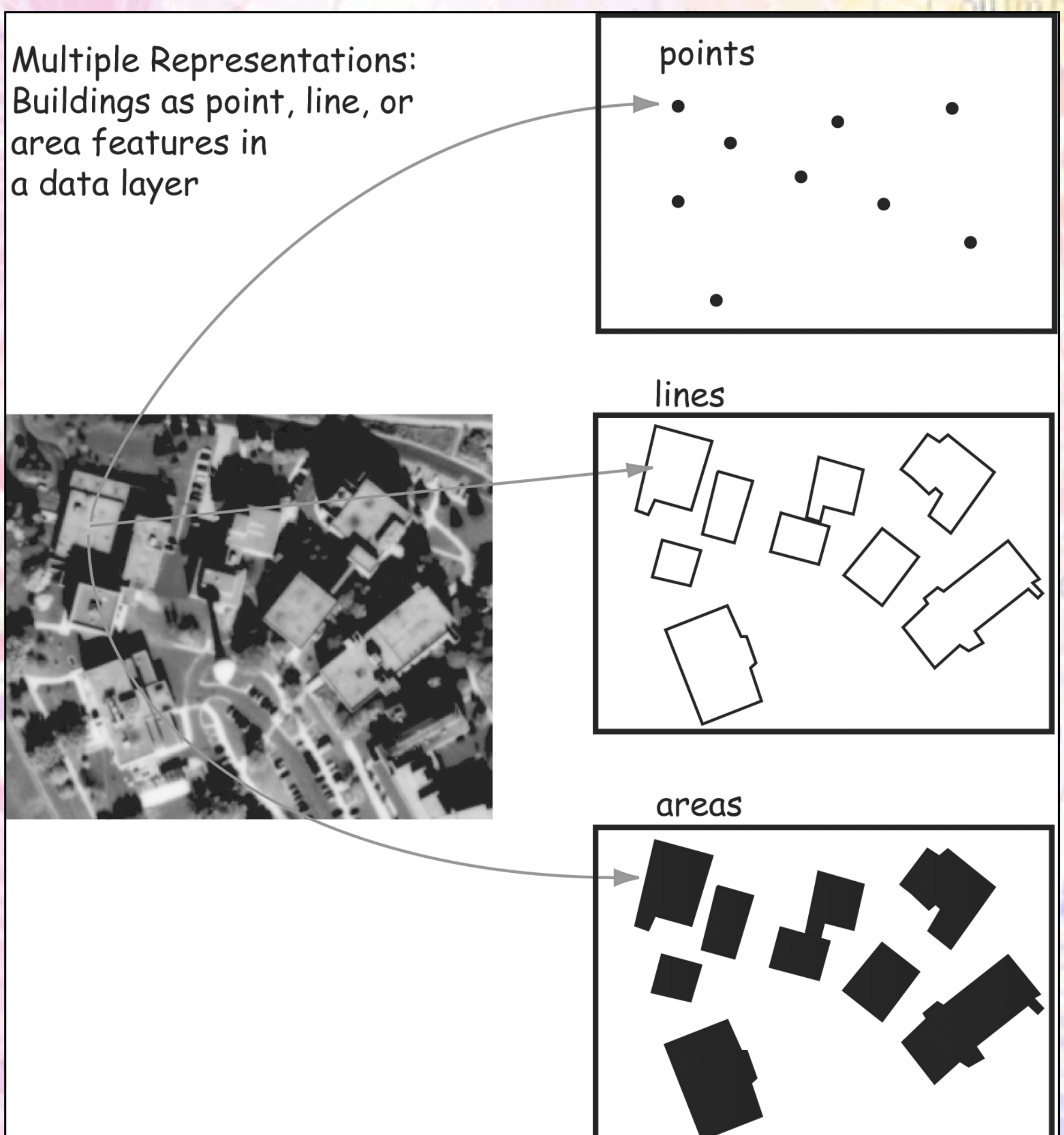
Real Geographic Features to Spatial Entities



Real Geographic Features to Spatial Entities



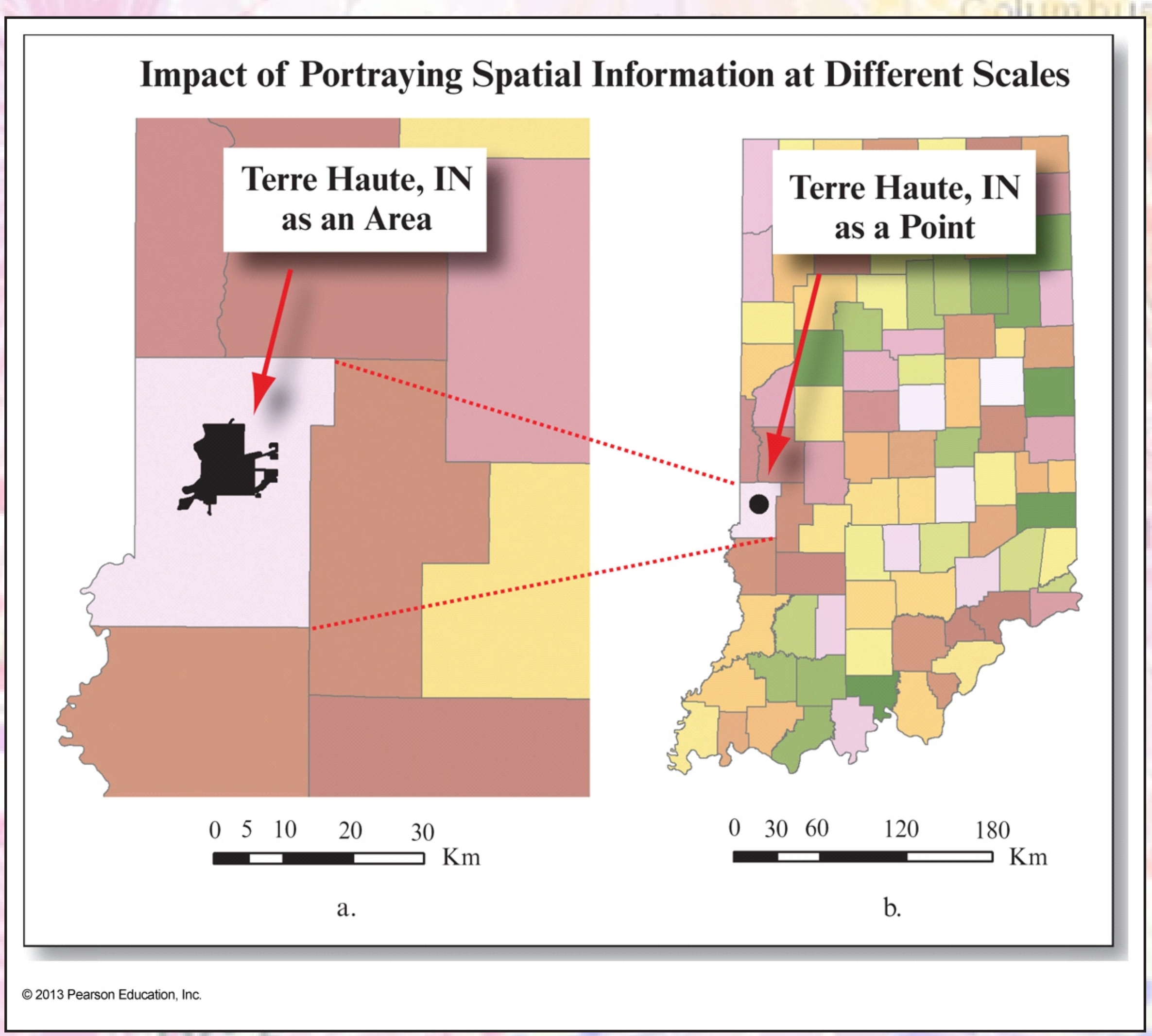
Multiple Representations of an Entity



Spatial entities may move, change, be represented in multiple ways.

- People & things move so any spatial reference represents one location in time.
- New roads are built, rivers meander.
- A house can be both a point and area depending on map scale.

Multiple Representations of an Entity



Spatial entities may move, change, be represented in multiple ways

- People & things move so any spatial reference represents one location in time.
- New roads are built, rivers meander.
- A house can be both a point and area depending on map scale.

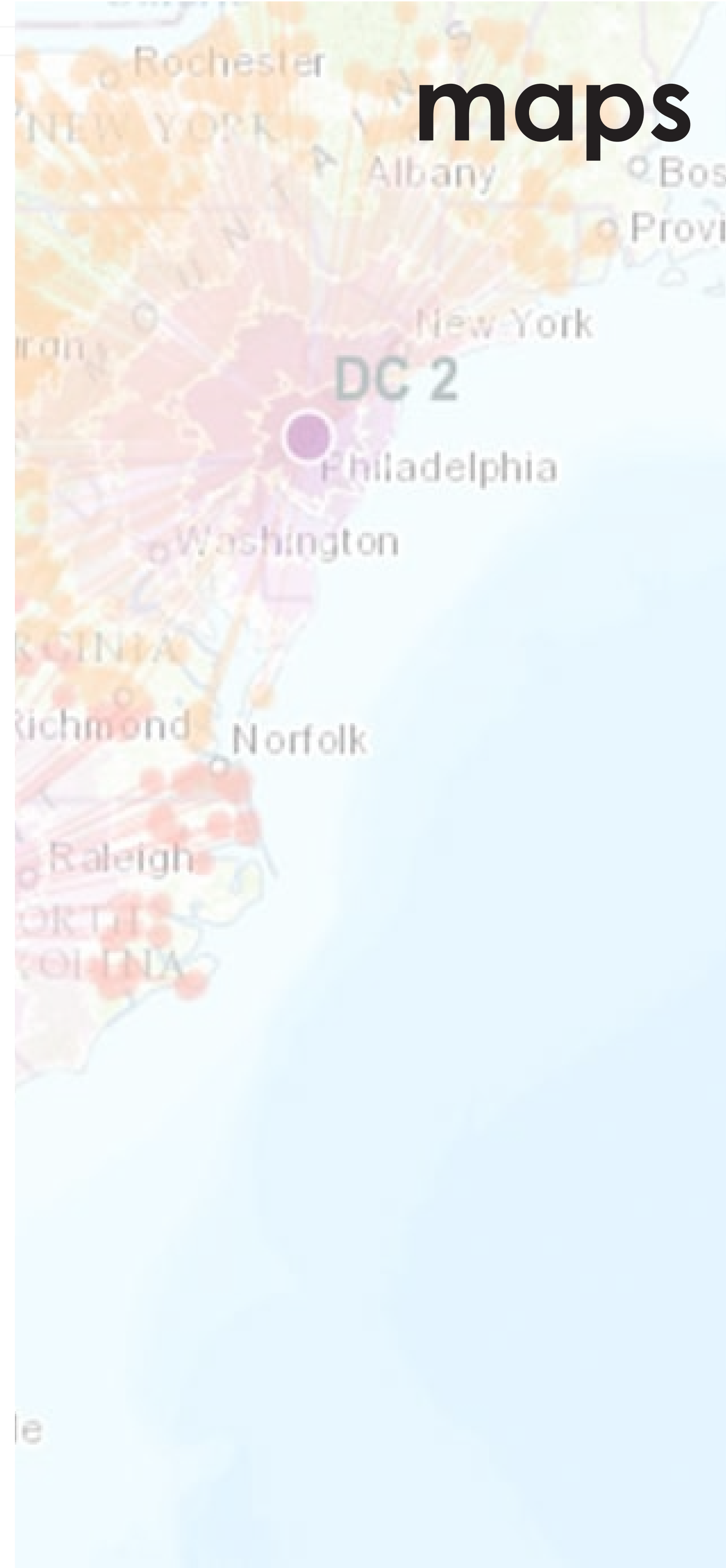
maps

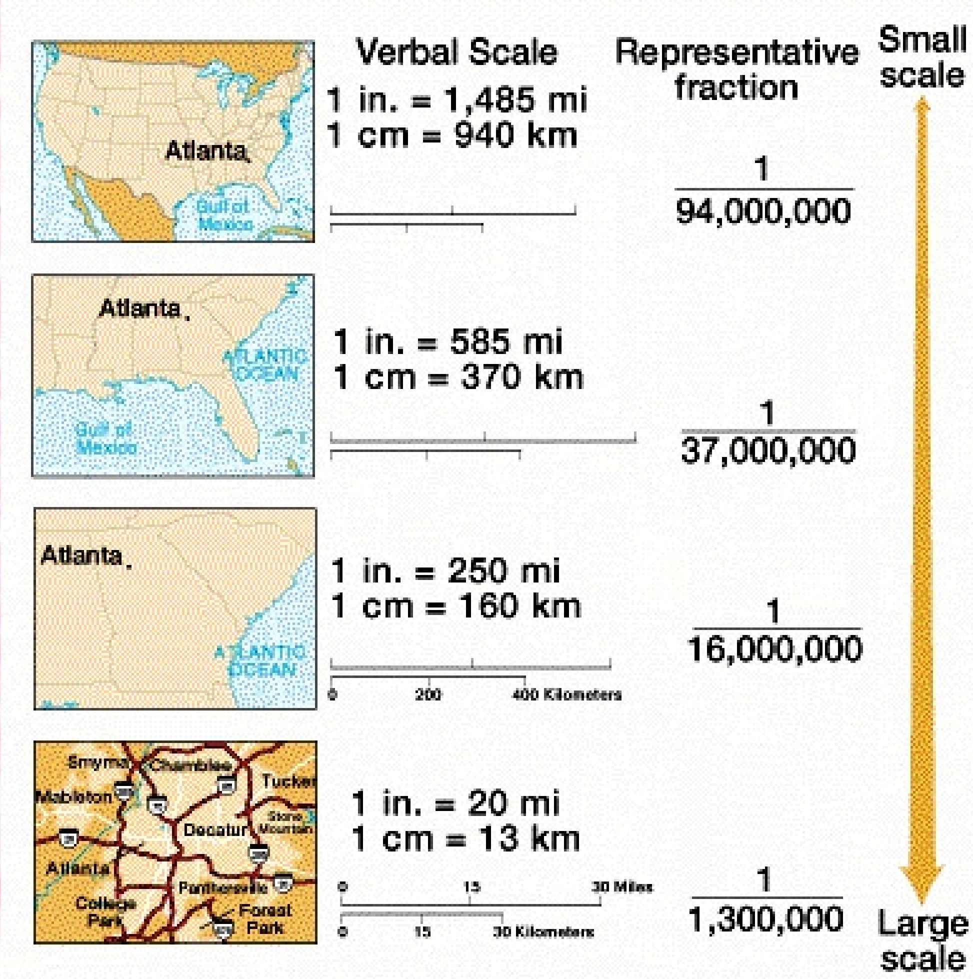
Alphabetical Legend

Building Name	Grid
Aberdeen-Inverness Residence Hall	E4
Administration (Hinderaker Hall)	C6
Agricultural Operations	B8
Alumni & Visitors Center	C5
Anderson Hall (SoBA, AGSM) 1 & 2	E7-8
Arts Building	C5-6
Arts 113-Studio Theatre	C, D5
Arts 166-Performance Lab	C5
Athletics & Dance Bldg (PE Bldg)	D5-6
Bannockburn Village	C4-5
Barn Group/University Club	D6
Batchelor Hall	E6
Bell Tower	E6
Biological Sciences	E6-7
Biomedical Teaching Complex	F6
Bookstore (Campus Store)	D, E5
Botanic Gardens	G, H7-9
Bourns Hall (Engineering)	E5
Boyce Hall	F6
Boyden Laboratories	E7
Campus Surge	D5
Campus Tours (Student Services Building)	D6
Canyon Crest Family Student Housing	D, F 2-4
Capital Planning	A5
Career Center (Health Services)	E, F5
Chapman Hall	E7
CHASS Interdisciplinary North and South	D,5-6
Chemical Sciences	F6
Child Development Center	E, F3
College Building North	E8
College Building South	E8
Computing & Communications	F, G7
Corporation Yard	F3-4
Costo Hall	D6
Cottage	D7
East I & Q (Insectary)	F7
Entomology	E7
Entomology Museum	E7
Environmental Health and Safety	E8
Falkirk Apts	C3-4
Fawcett Laboratory	F7
Fleet Services Dept.	F3
Geology Building	E6
Glen Mor 1	G4
Genomics	E7
Greenhouses	F6-7
Headhouse (greenhouses)	F8
Health Services	E, F5
Herbarium	F7
Highlander Hall	B5-6
Highlander Union Bldg/Plaza (HUB)	D6
Hinderaker Hall (Administration)	C6
Housing Administration	C, D4
HUB (Highlander Union Building)	D6
Humanities	D6
Humanities 400/University Theatre	D7
Humanities & Social Sciences Building	D6
Humanities 1500	D6
Human Resources	B5
International Village Housing	B6
Keen Hall	E, F6
KUCR Radio	E, F4
Library, Orbach	F6
Library, Rivera	E6-7
Life Science Building	E6
Life Sciences 1500	E6
Lothian Residence Hall	F, G5
Material Sciences & Engineering Building	D, E5
Oban Apts	C4
Olmsted Hall	D, E7
Orbach Library (Science Library)	F6
Parking Services	F, G4
Pentland Hills	F, G 4-5
Physical Plant Office	F3
Physics Building	E, F 5-6
Physics 2000	F6
Pierce Hall	E6
Plaza Apts (The Plaza)	C4
Police Facility	D4
Printing and Reprographics	E6
Psychology Building	E7
Purchasing Dept.	F3
Rivera Library	E6-7
School of Medicine Education Bldg	E7
School of Medicine Research Bldg	F6
Schools First Credit Union	A4
Science Laboratories 1	E6
Spieth Hall	E6
Sproul Hall	D6
Stonehaven Apts	C2-3
Student Recreation Center	D, E4
Student Services	D6
UCR Baseball Complex	C2-3
UCR Extension Center	A, B 5-6
University Laboratory Building	E7
University Lecture Hall	D, E5
University Office Building	F7
University Theatre	D7
University Village	A, B4-5
University Village Theater	A, B5
USDA Salinity Laboratory	G6
Watkins Hall	D6
Watkins 1000	D6
Webber Hall	E6
Winston Chung Hall (EBU2)	E5

Performance/Lecture Halls/Libraries

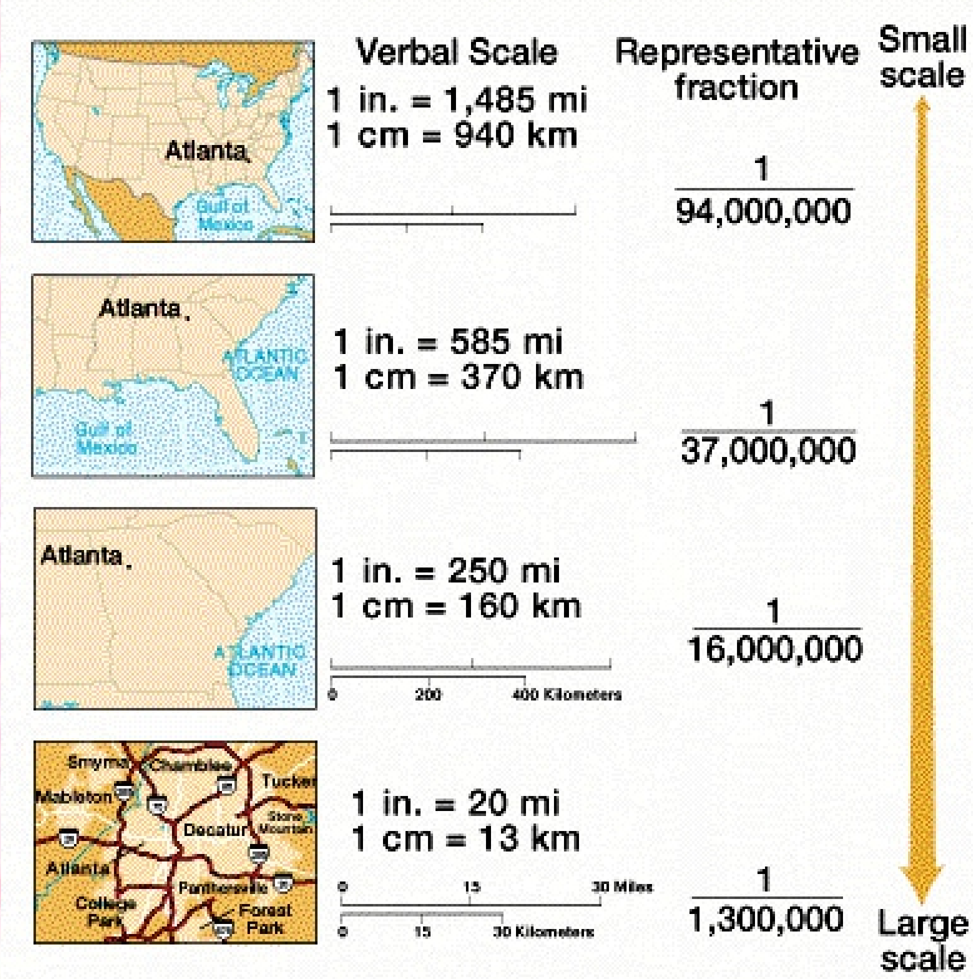
Arts 113 Studio Theatre (P1)	C, D5
Arts 166 Performance Lab (P1)	C5
Humanities 1500 (P1)	D6
Life Science 1500 (P6)	E6
Orbach Library (P10)	F6
Physics 2000 (P10)	F6
Rivera Library (P6)	E6-7
University Lecture Hall (P24)	D, E5
University Theatre/Humanities 400 (P6)	D7
University Village Theater (Parking structure)	A, B5
Watkins 1000 (P1)	D6





Purpose of Maps

- Maps are used to present spatial data.
- Important information:
  - ♦ Purpose.
  - ♦ Scale and referencing.
  - ♦ Features including representation and generalization (Legend).
  - ♦ Projection.



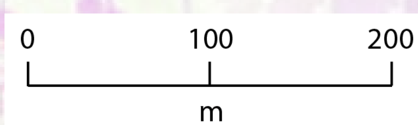
Purpose of Maps

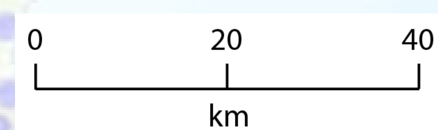
- Maps are used to present spatial data.
- Important information:
  - ♦ Purpose.
  - ♦ Scale and referencing.
  - ♦ Features including representation and generalization (Legend).
  - ♦ Projection.
- Scale can be expressed 3 ways:

RATIO: **1:5000** **1:1,000,000**

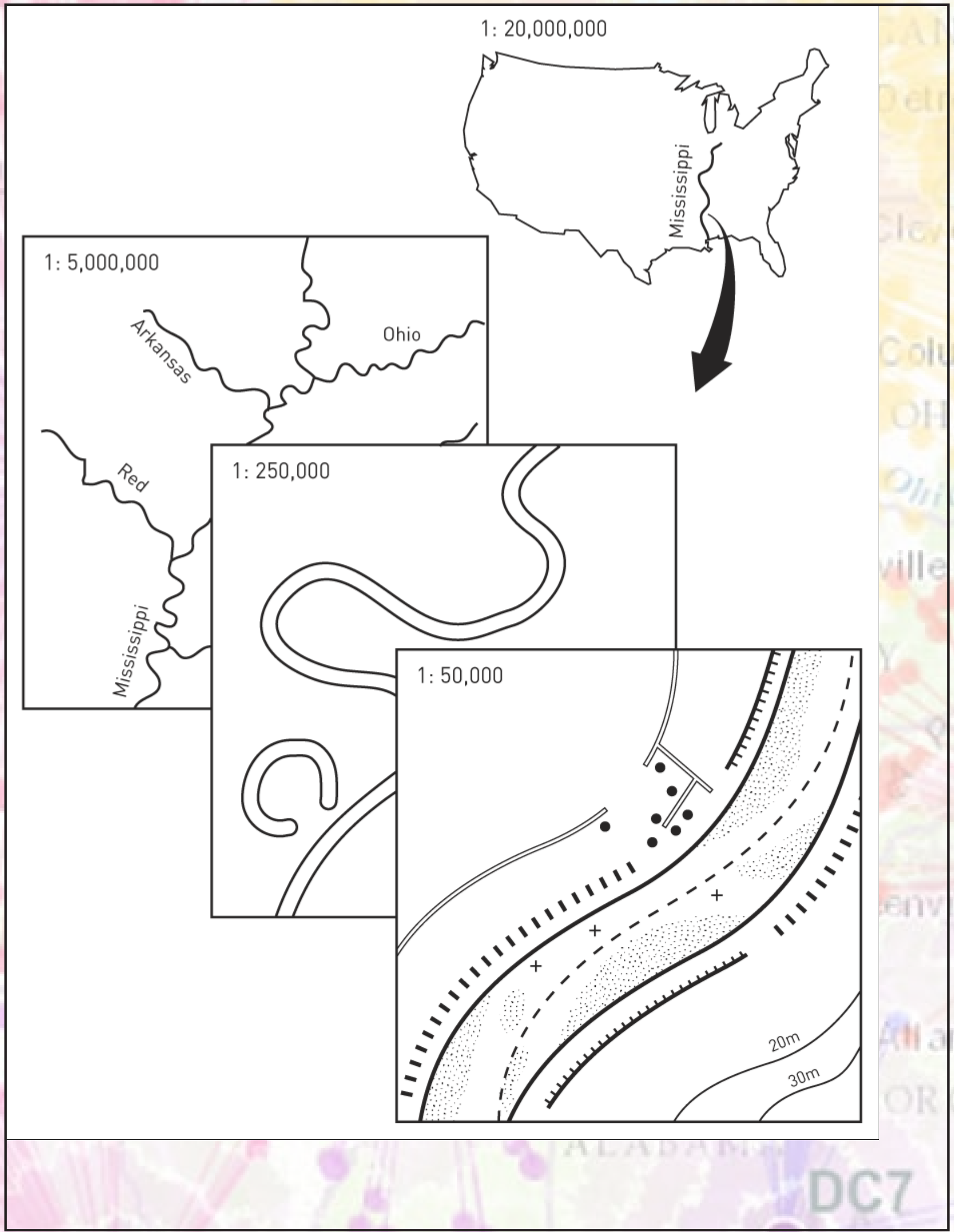
VERBAL: 1 cm represents 50 m 1 cm represents 10 km

GRAPHICAL:



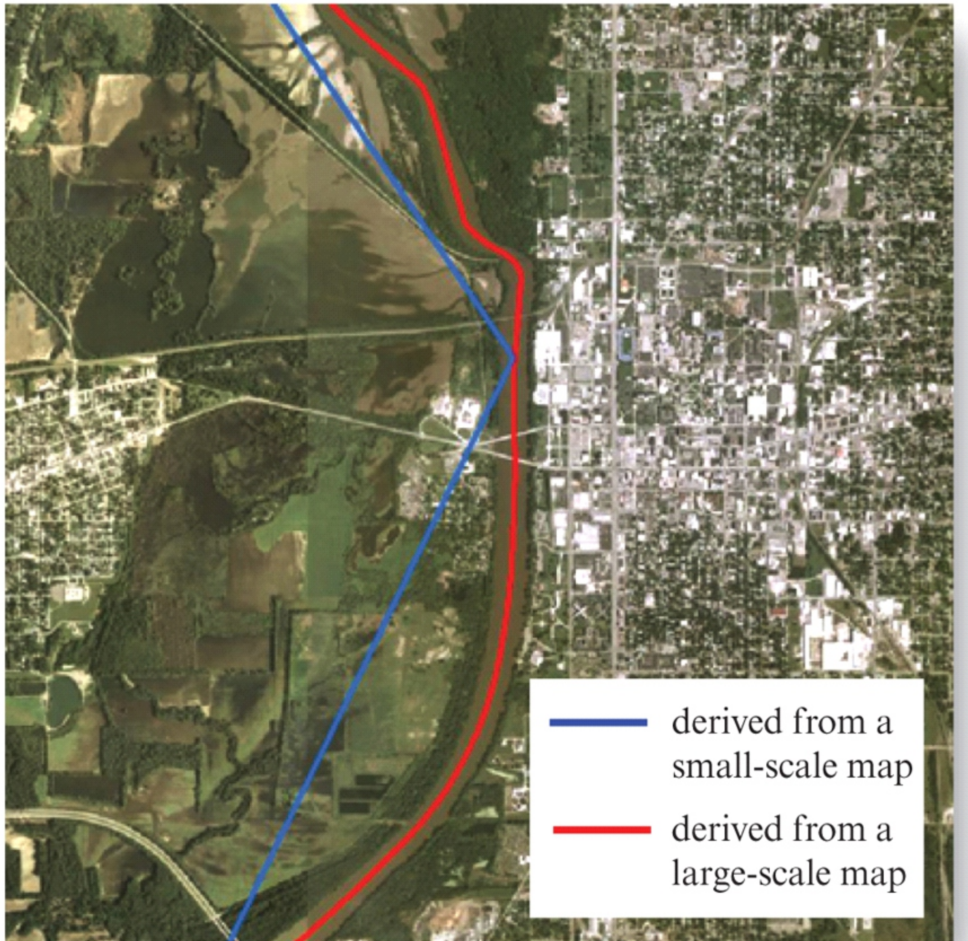


Purpose of Maps – scales



- All spatial data are a generalization of real-world features.
- Generalization may be needed due to scaling.
- Generalization decided by cartographer depending on map purpose:
  - ♦ Selection – map feature?
  - ♦ Simplification – how to simplify feature?

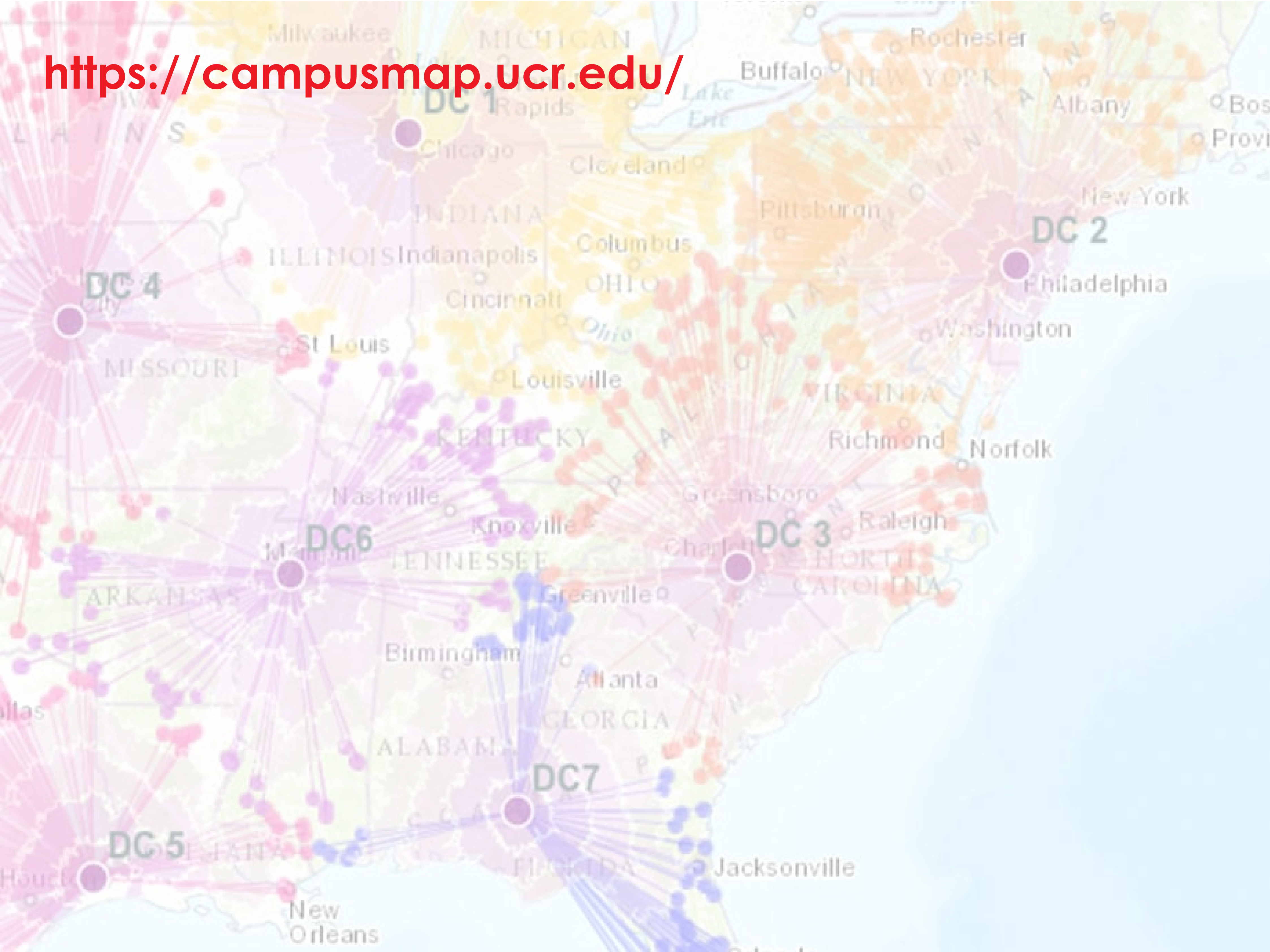
The Impact of Scale when Representing the Wabash River in Indiana



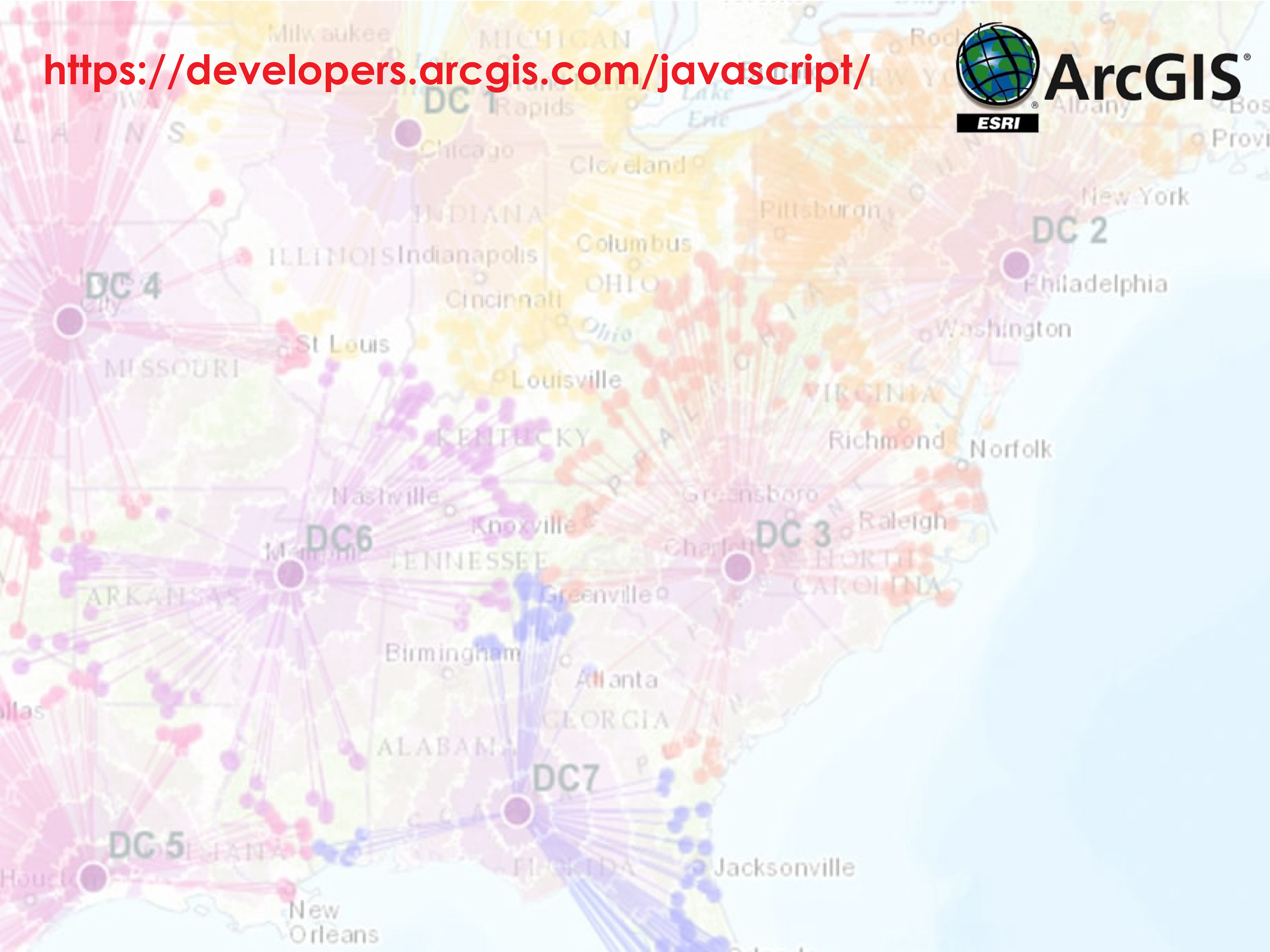
Purpose of Maps – scales

- All spatial data are a generalization of real-world features.
- Generalization may be needed due to scaling.
- Generalization decided by cartographer depending on map purpose:
  - ♦ Selection – map feature?
  - ♦ Simplification – how to simplify feature?

https://campusmap.ucr.edu/



https://developers.arcgis.com/javascript/



What is a GIS?

- A computer-based system to aid in the:
  - collection,
  - manipulation,
  - storage,
  - analysis,
  - output, and
  - distribution

of spatial data and information.

What is a GIS?

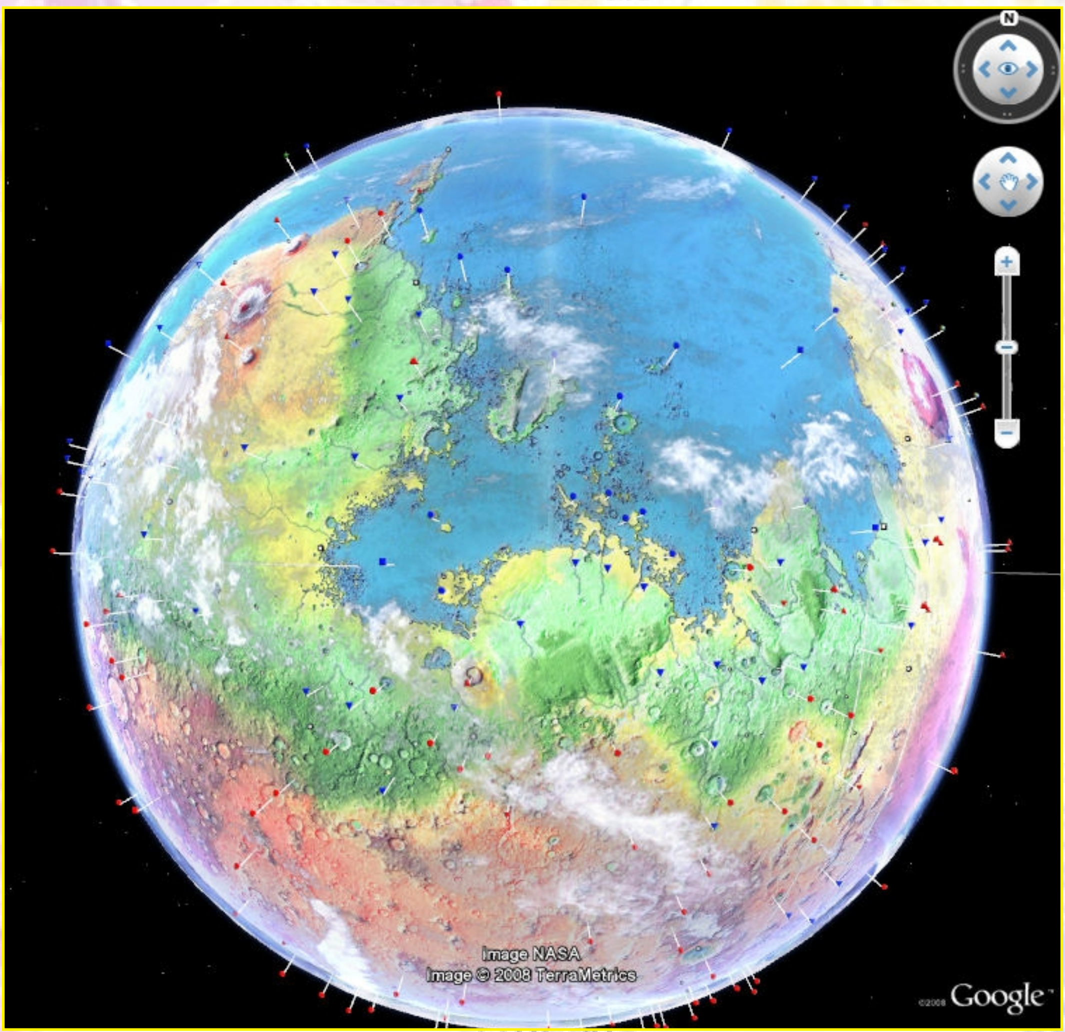
- A computer-based system to aid in the:
  - collection,
  - manipulation,
  - storage,
  - analysis,
  - output, and
  - distribution

of spatial data and information.

What is a GIS?

- A computer-based system to aid in the:
  - ♦ collection,
  - ♦ manipulation,
  - ♦ storage,
  - ♦ analysis,
  - ♦ output, and
  - ♦ distribution

of spatial data and information ... *data "spatially referenced to Earth".*

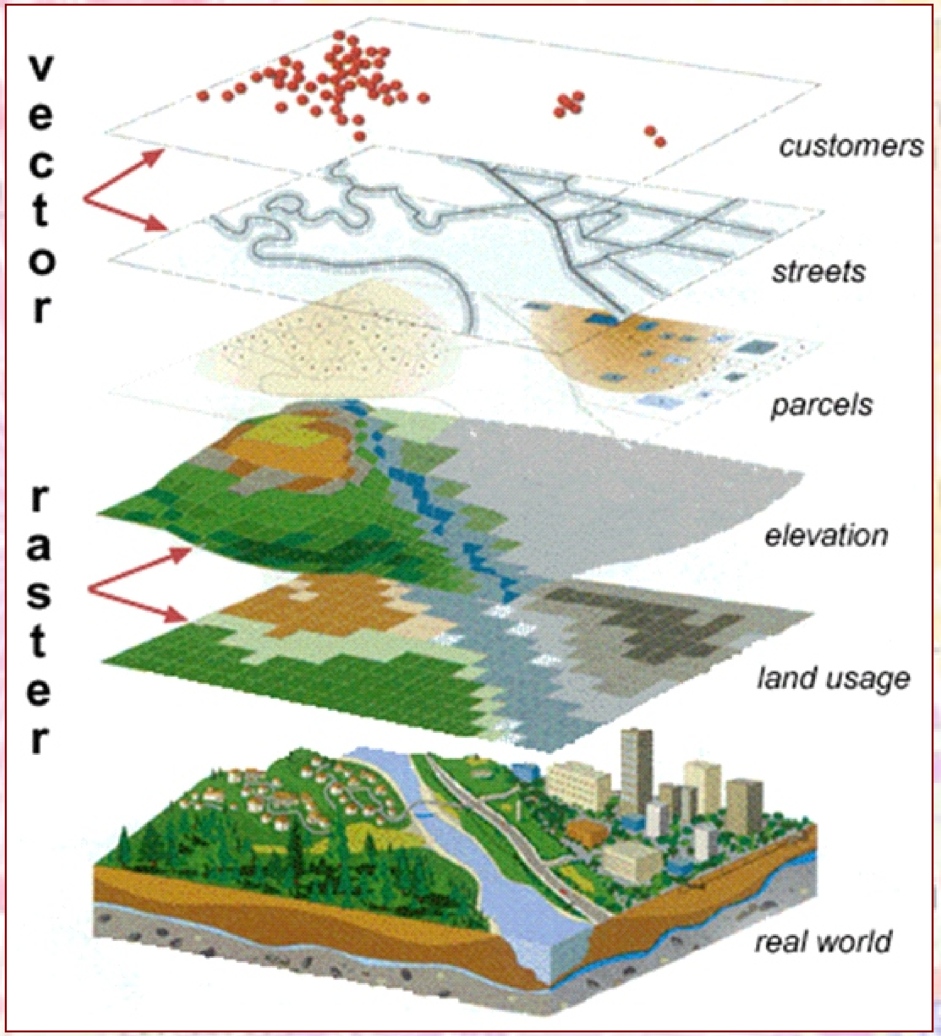


What is a GIS?

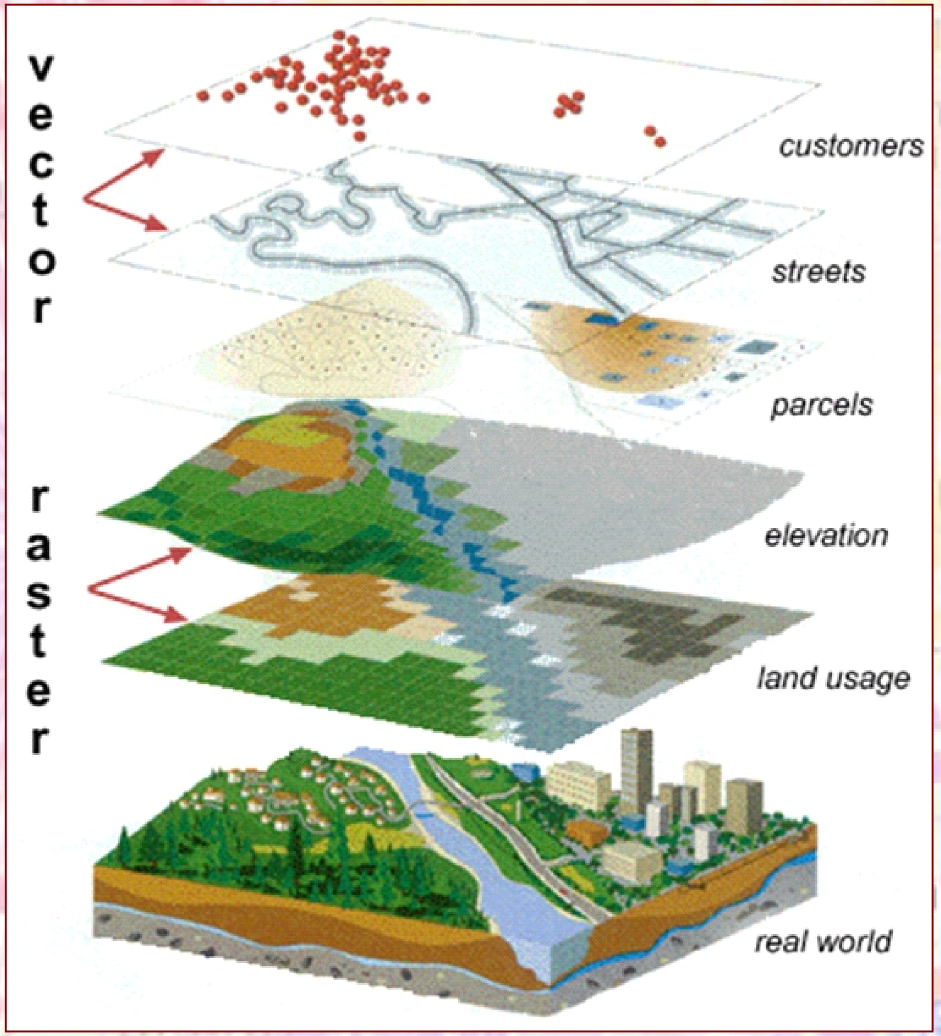
- A computer-based system to aid in the:
  - ♦ collection,
  - ♦ manipulation,
  - ♦ storage,
  - ♦ analysis,
  - ♦ output, and
  - ♦ distribution

of spatial data and information ... *data "spatially referenced to Earth"*.

GIS applications



- Answer spatial questions:
  - Where are features?
  - What geographical patterns exist?
  - Where have changes occurred in an area?
  - Where do certain conditions apply?
  - What would be the implications to certain actions?
- Create maps / present spatial data.



GIS applications

- Socio-economic/ Government:

Health, disease outbreak, local government, urban management, radioactive waste management, transportation, …

- Commerce and Business:

Insurance, fleet management, marketing, consumer interest gathering, fleet management, transportation of merchandise, …

- Utilities:

Telecommunications, emergency repairs, service boundaries, network management, marketing, …

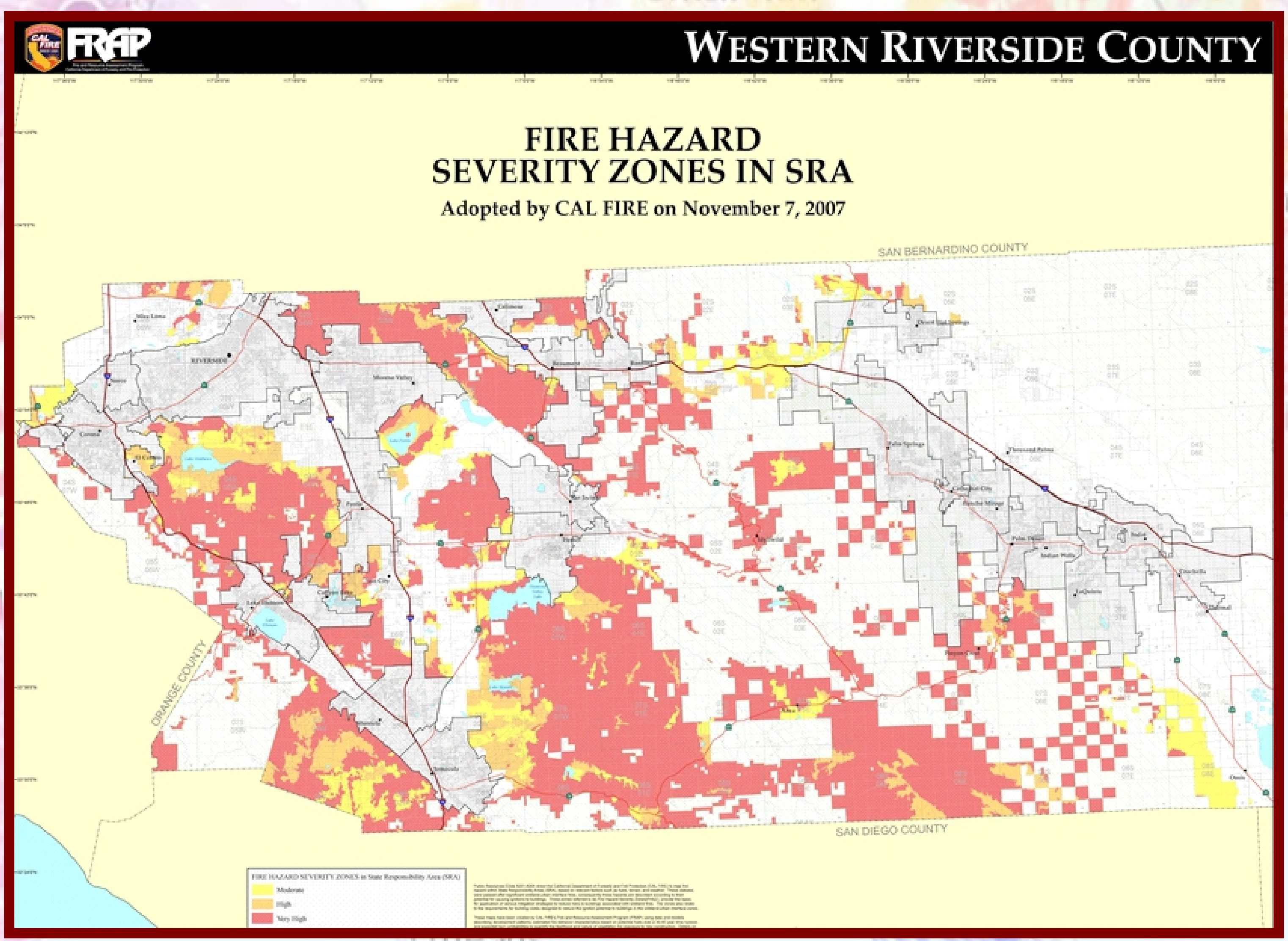
- Environmental Management:

Geologic and mineralogic mapping, pollution monitoring, natural hazard assessment, disaster management and relief, landfill site selection, …

GIS examples:

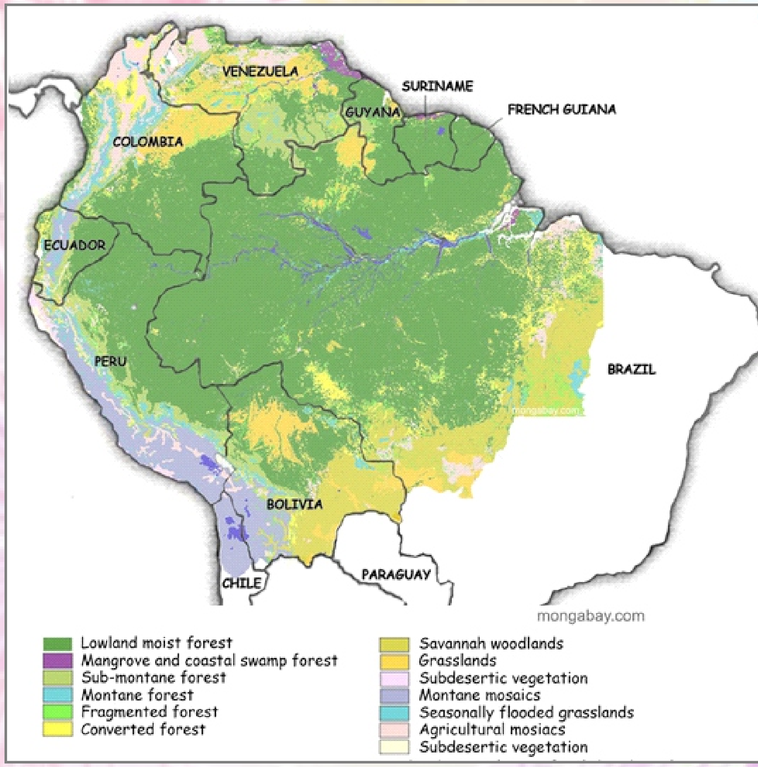
- Mapping fire risk areas and the spread of wildfires.

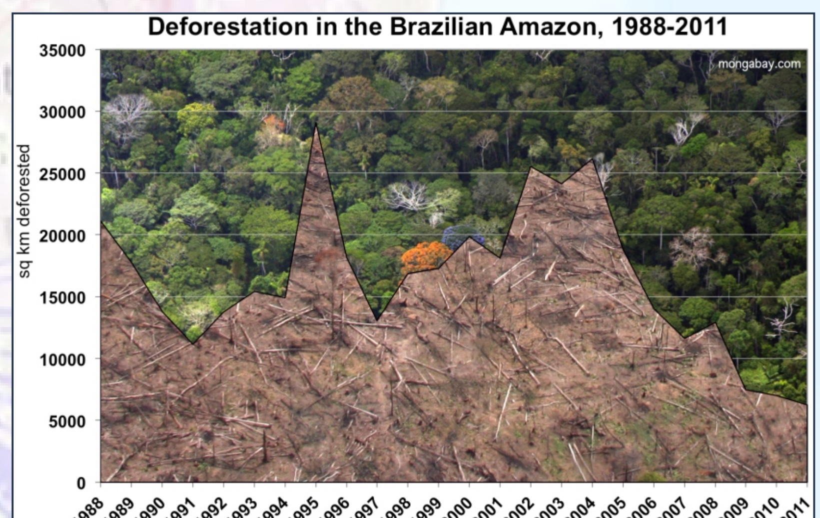
http://frap.fire.ca.gov/data/frapgisdata-subset

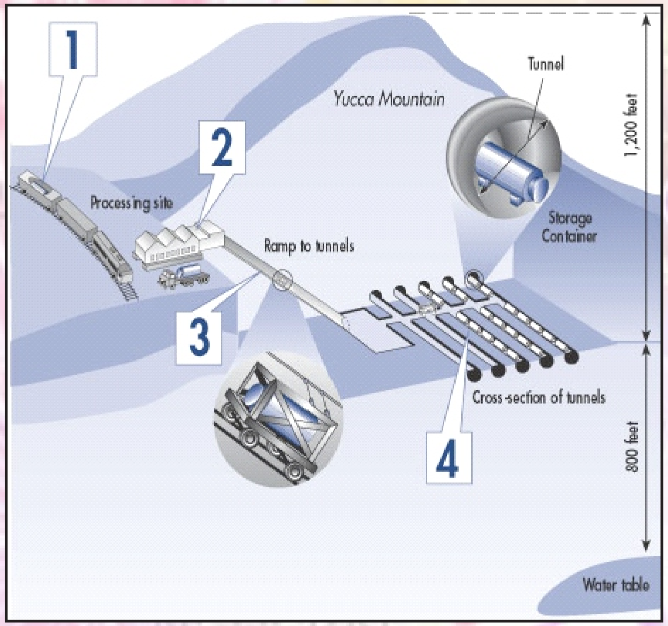


GIS examples

- Deforestation in the Amazon – potentially useful GIS information/data layers:
  - Roads, Rivers.
  - Cleared areas vs. pristine forest.
  - Endangered species habitat and migration patterns
  - Carbon storage density.
  - Biodiversity / biodiversity hotspots.



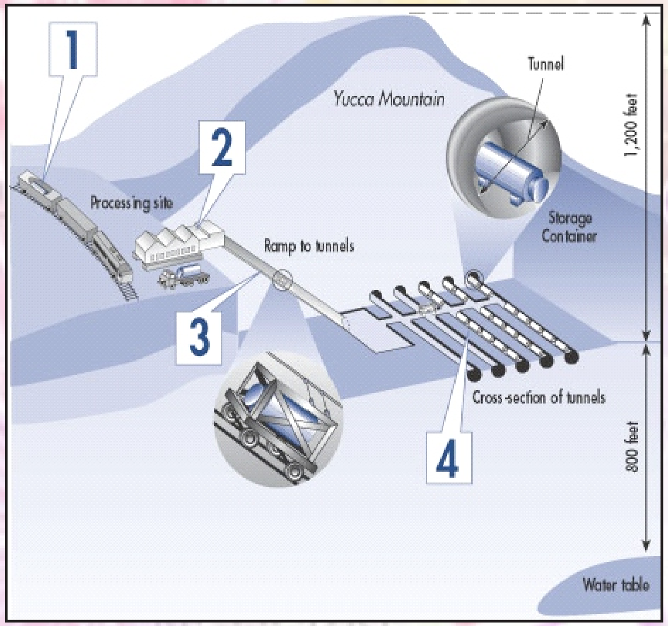




GIS examples

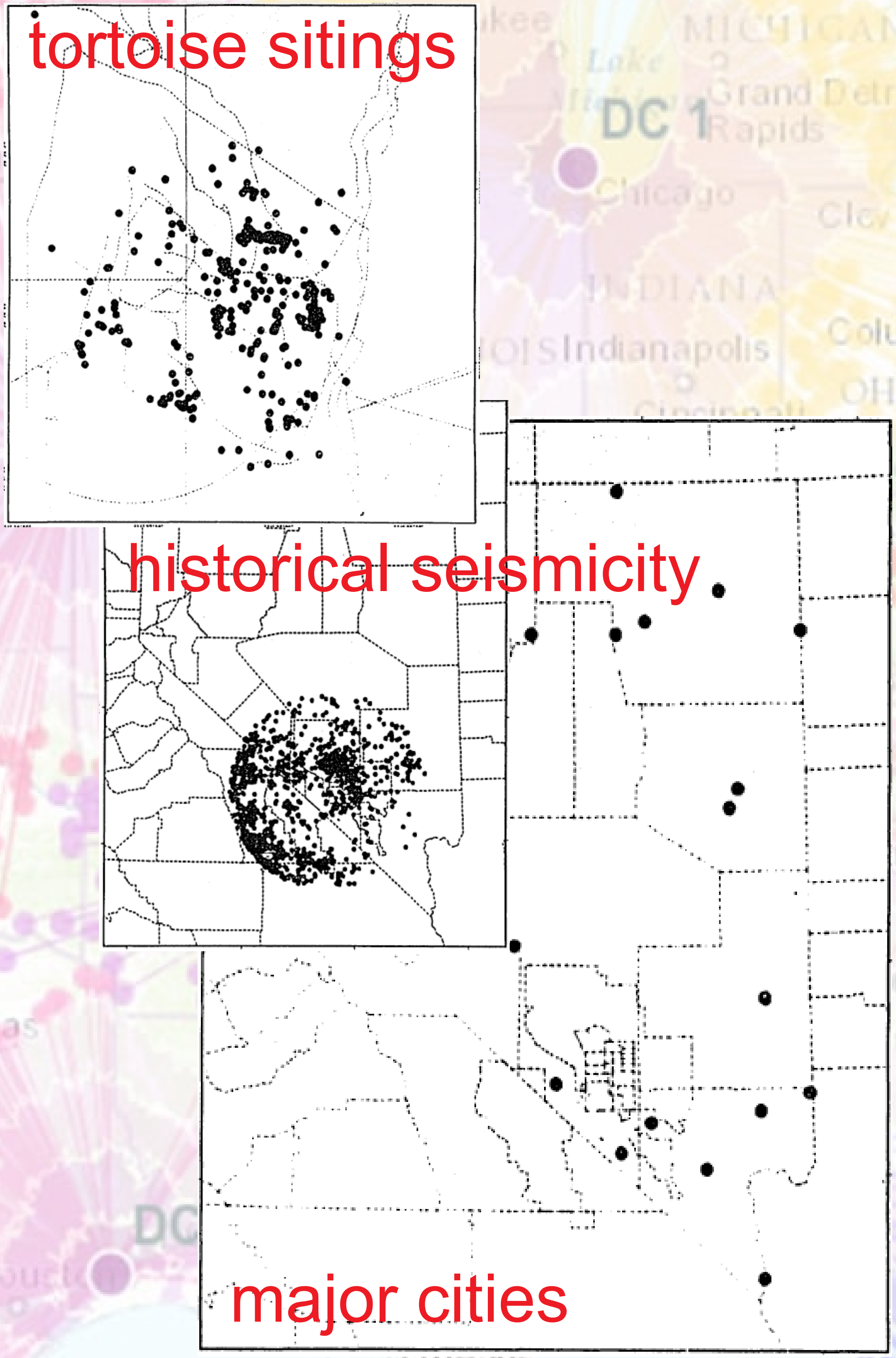
- Yucca Mountain, NV Nuclear Waste Repository
  - U.S. needs locations to store all spent radioactive waste from the country's 100-plus nuclear power plants.
  - Estimated that it takes over 100,000 years for nuclear waste to decay.
  - National Academy of Sciences recommended (1957) that the best way to dispose of nuclear waste was to place deep underground.
  - Waste to be stored 1,000 feet under the surface and also be 1,000 feet above the water table.

where?



1
2
3
4
Yucca Mountain
Tunnel
Processing site
Ramp to tunnels
Storage Container
Cross-section of tunnels
1,200 feet
800 feet
Water table

where?



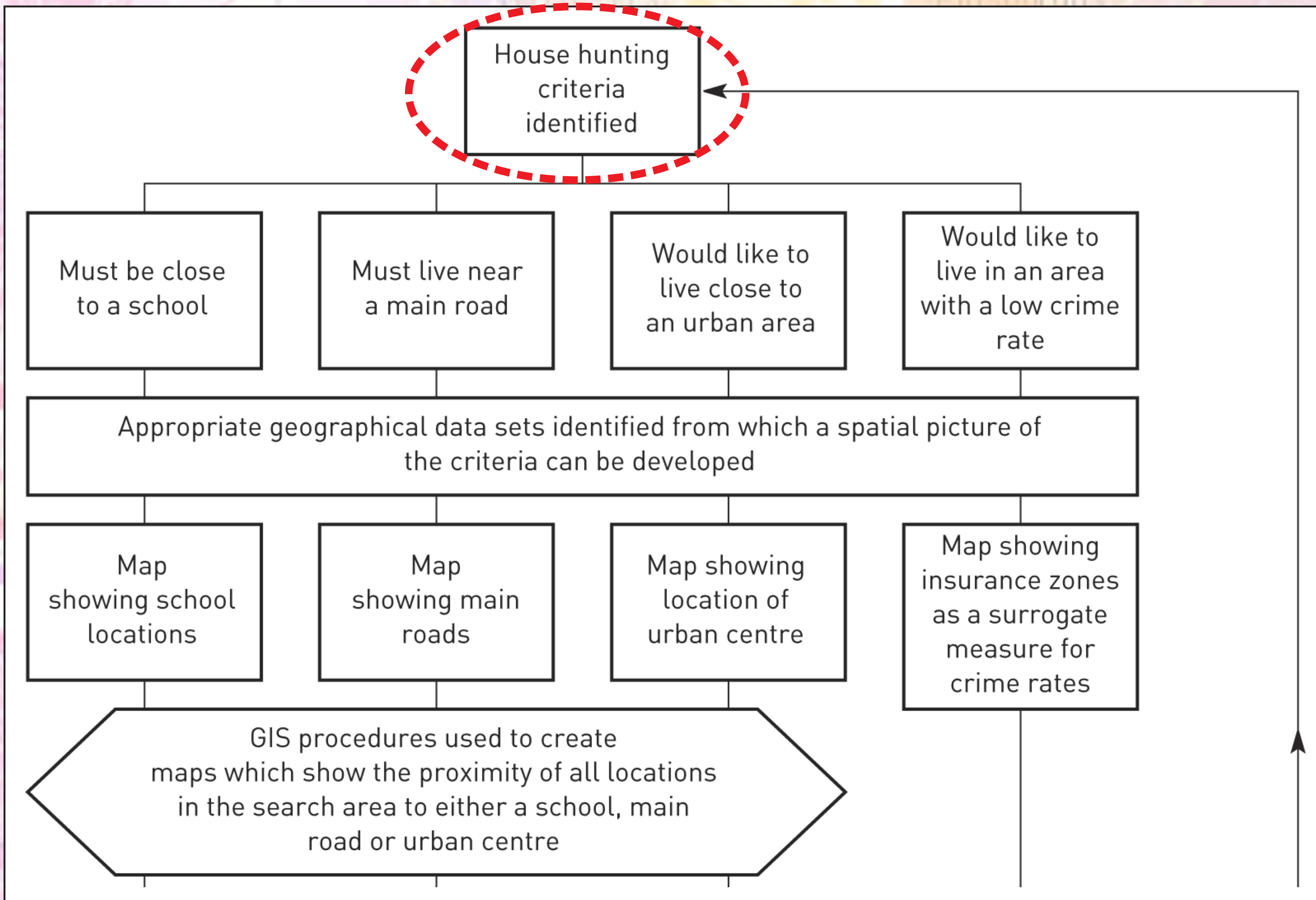
GIS examples

- Considerations:
  - Population centers, infrastructure, emergency services.
  - Accessibility.
  - Geology.
  - Climate and hydrology.
  - Seismicity.
  - 1973 Endangered Species Act requires mapping of available habitat of endangered species as well as migration patterns and species rangeplants.

GIS examples

- Decision Support: Buying a Home

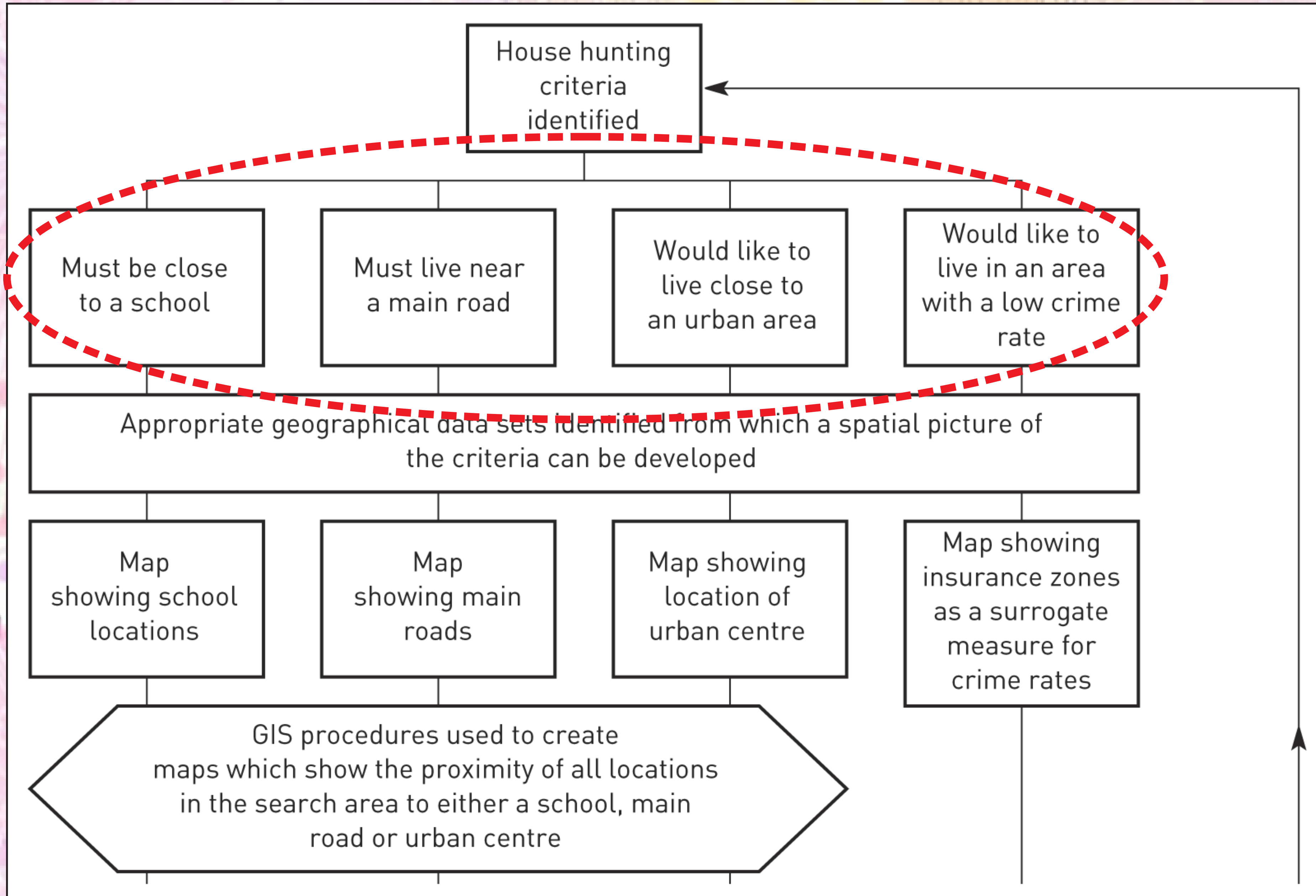
Start by identifying the problem you want to answer



GIS examples

- Decision Support: Buying a Home

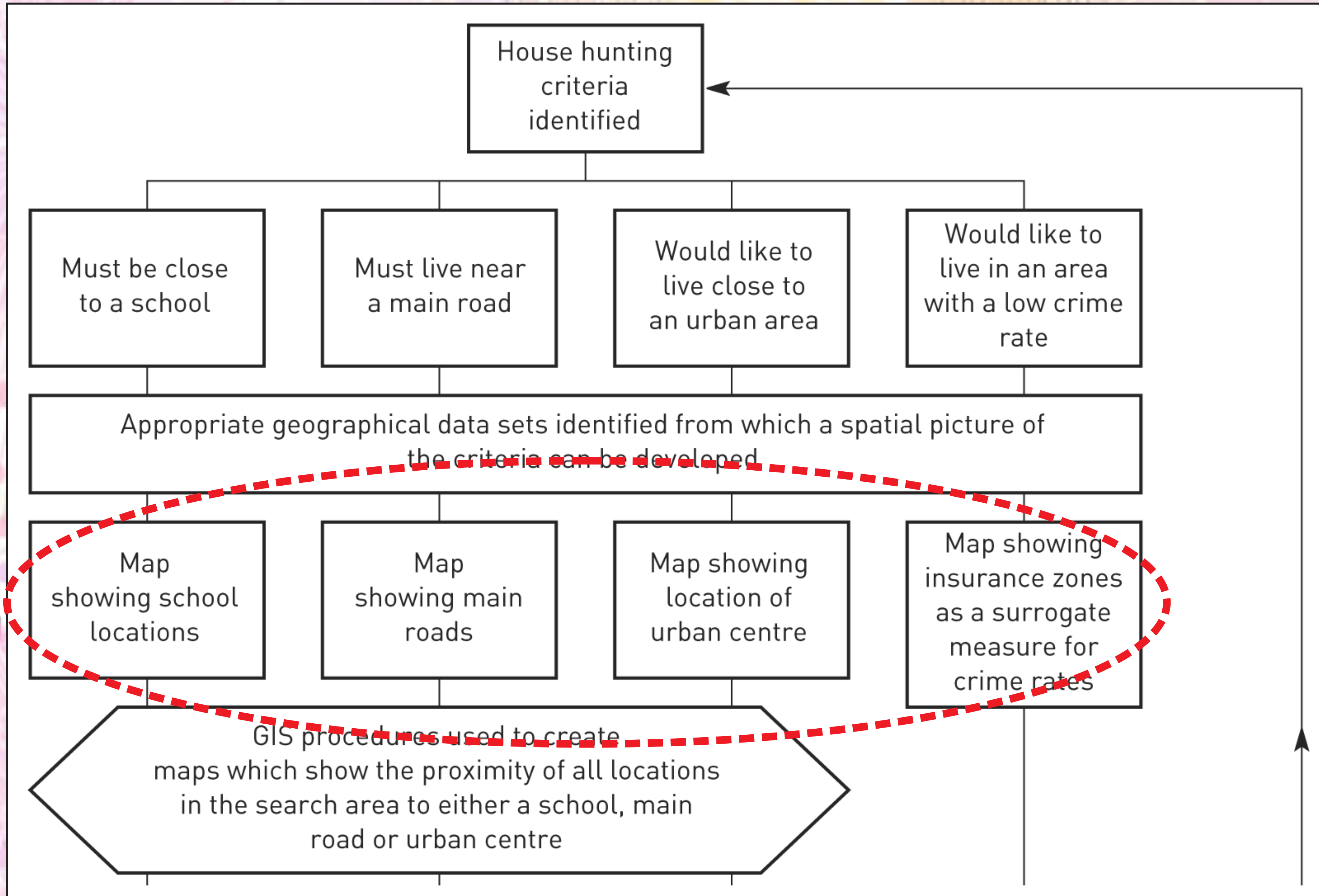
Determine constraints,
what factors are important to answer the question?



GIS examples

- Decision Support: Buying a Home

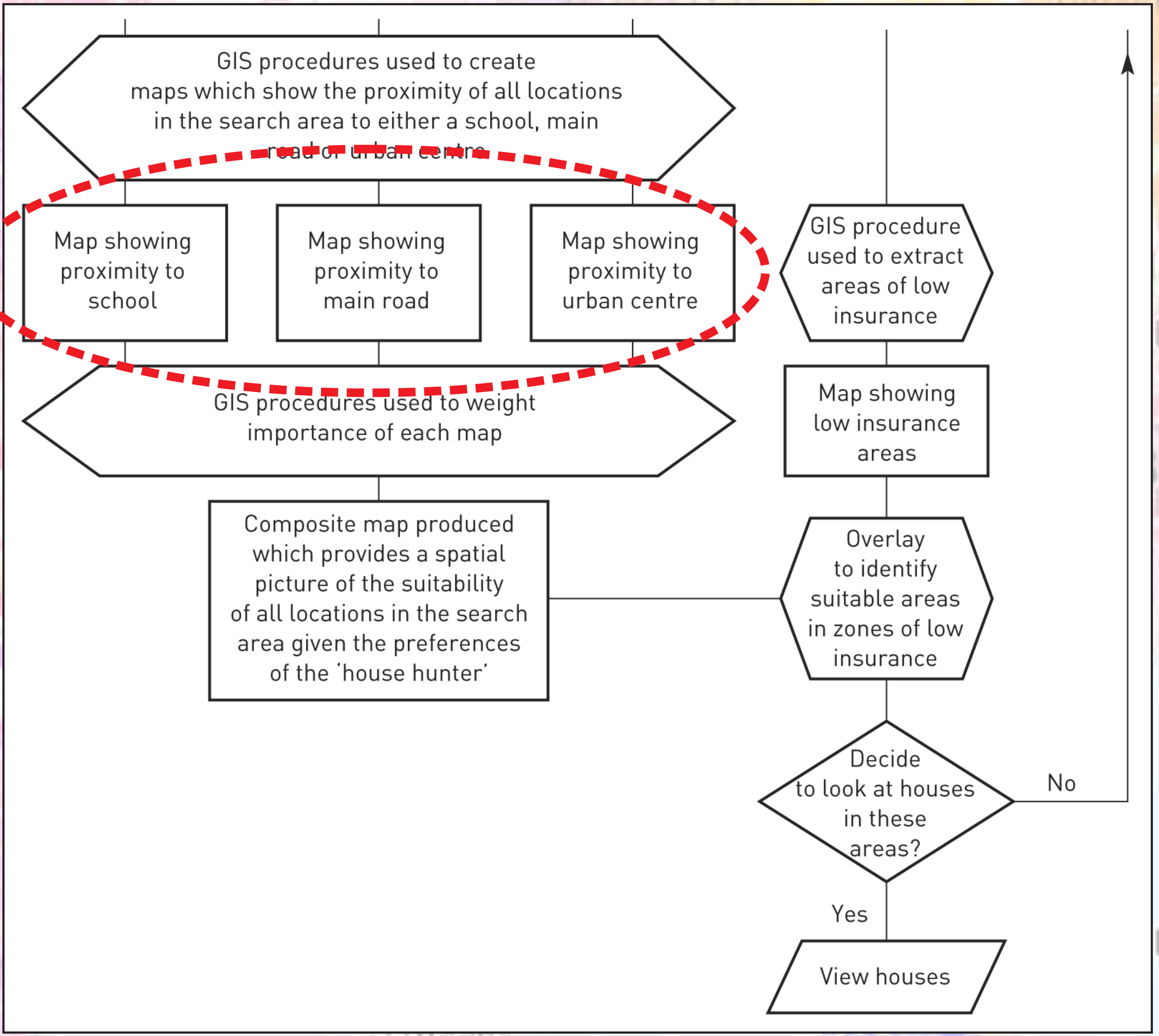
Gather identified data to create map overlay for analysis



GIS examples

- Decision Support: Buying a Home

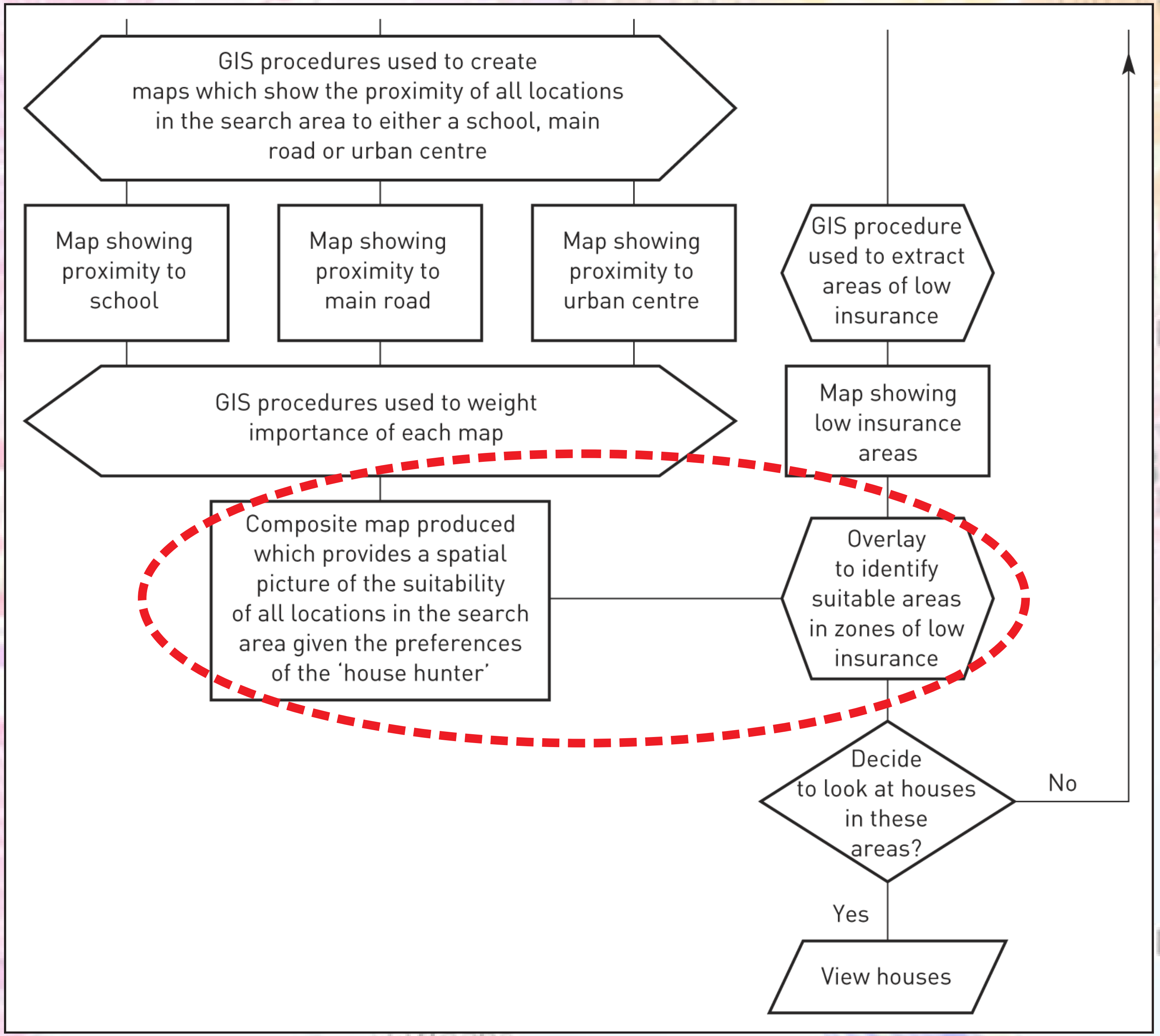
Do proximity analysis between criteria data to identify potential home sites

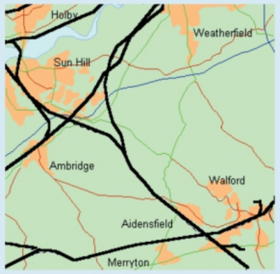


GIS examples

- Decision Support: Buying a Home

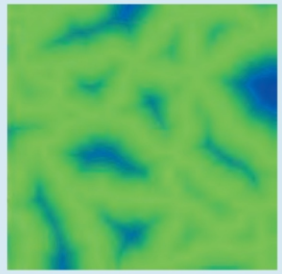
Create map overlay showing areas that meet all criteria for home site



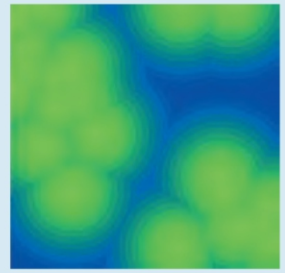


(a) Railway constraint

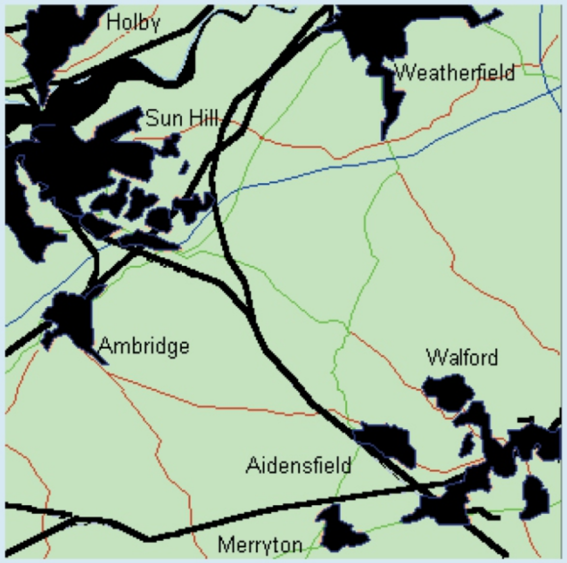
(b) Countryside constraint



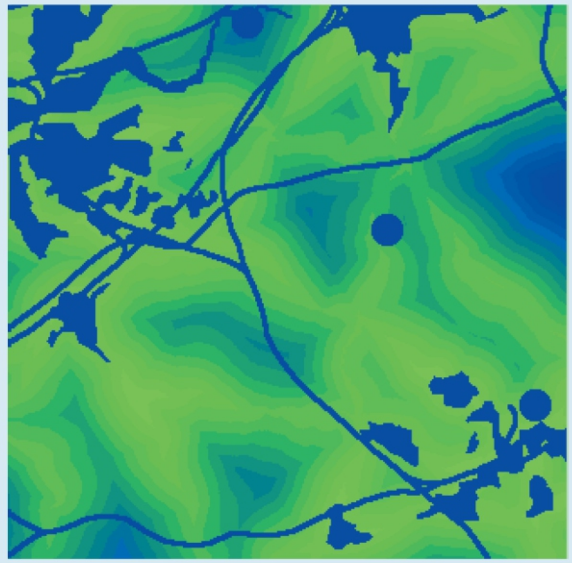
(c) Proximity to roads



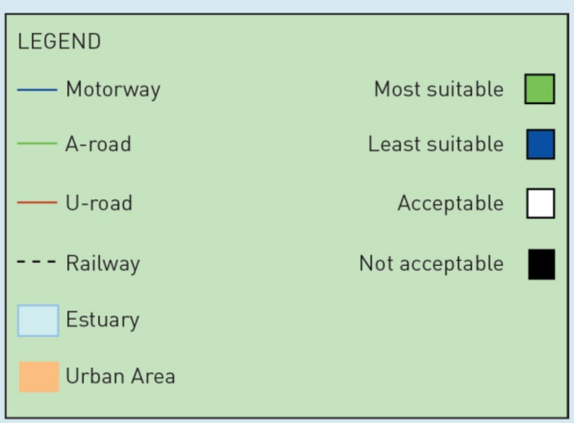
(d) Proximity to school



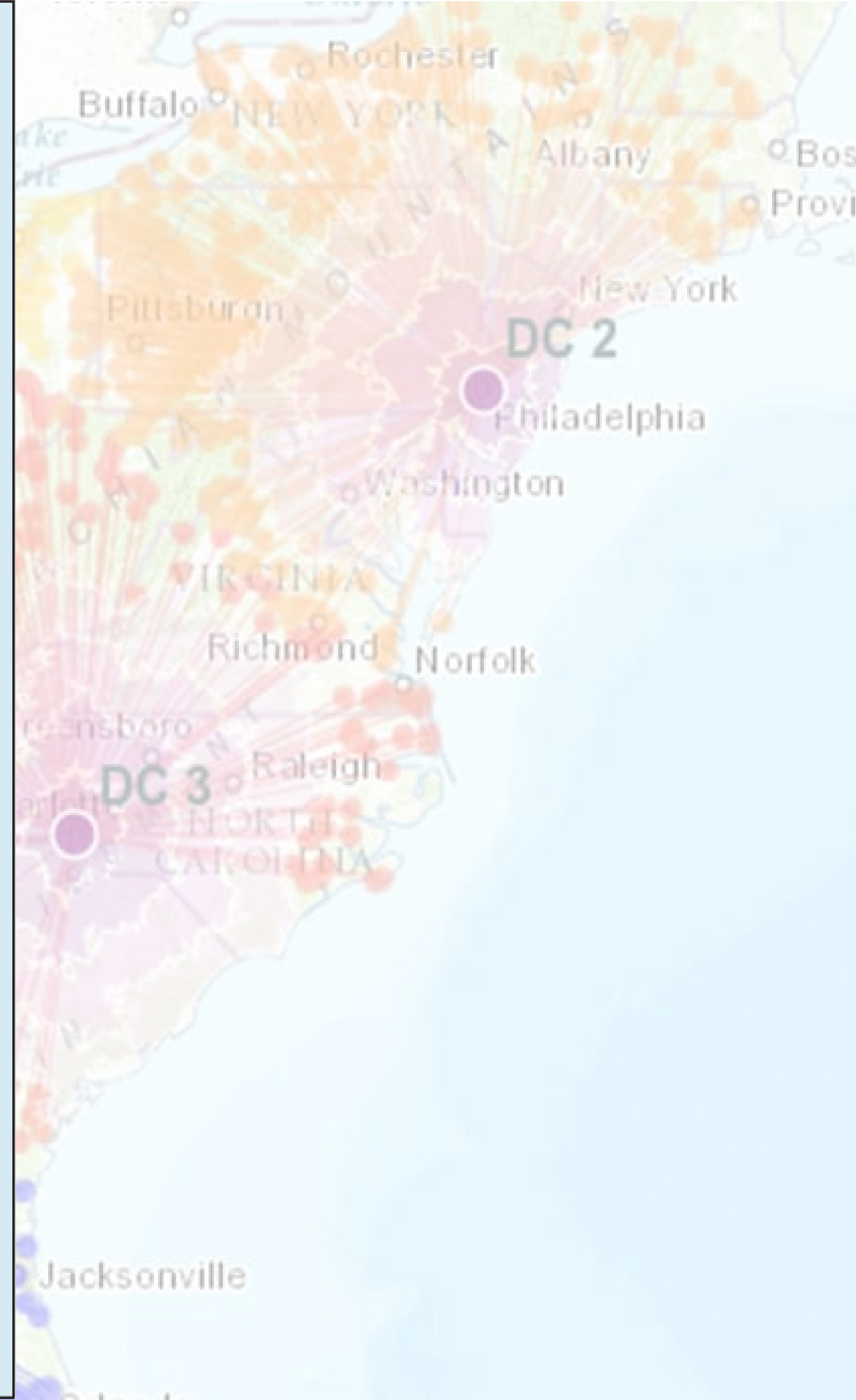
(e) Combination of railway constraint and countryside constraint



(f) Combination of proximity and constraint maps [(c), (d) and (e)] with proximity to road used as the most important factor



(g) optimal sites [reclassified from (f)]

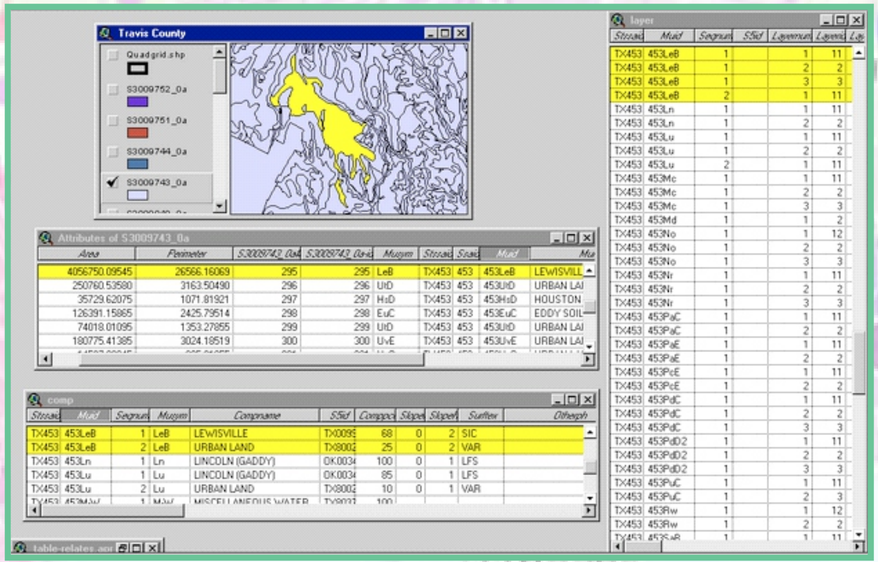


Three key components of a GIS

- Computer system.
  - Hardware (computer, printer, scanner).
  - Software.
- Spatially referenced or geographical data.
  - Maps in a known coordinate system.
  - One or more spatial layers (i.e. political boundaries, rivers, population density).
- Methodology for management and analysis.
  - Input and output of data and results.

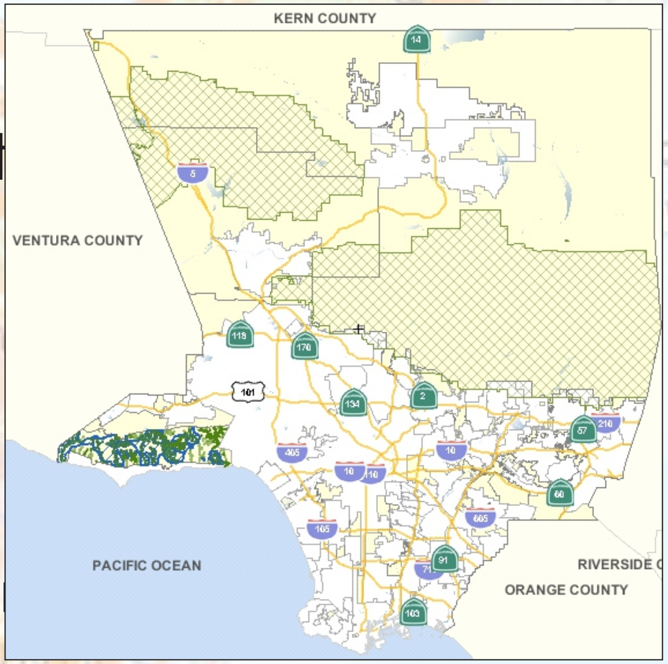
A well-designed GIS should provide:

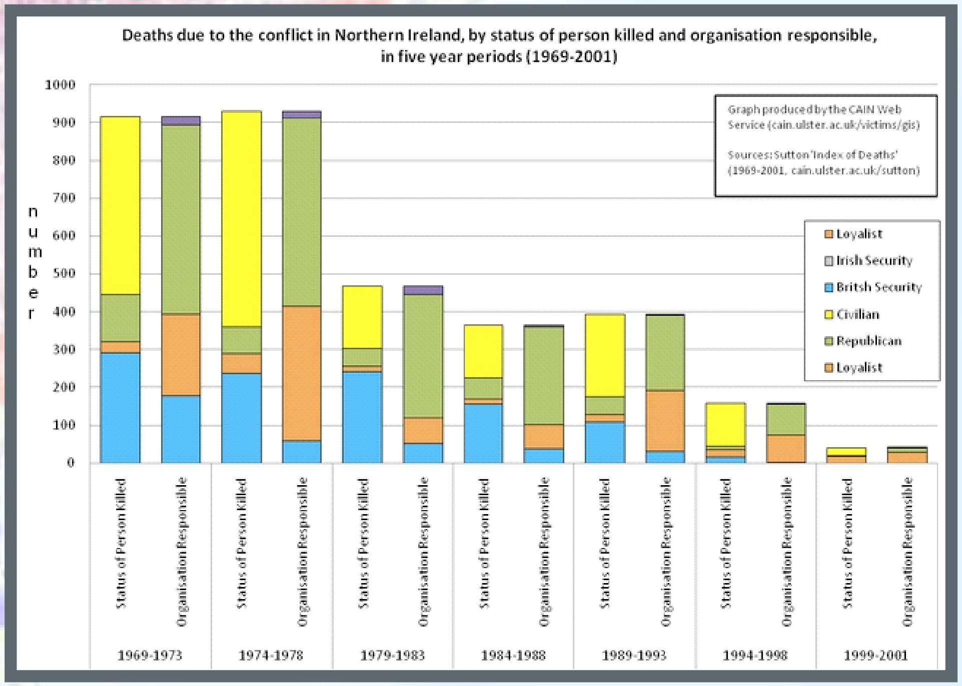
- Quick and easy access to large volumes of data.
- The ability to:
  - ♦ Select detail by area or theme.
  - ♦ Link or merge one data set with another.
  - ♦ Analyze spatial characteristics of data.
  - ♦ Search for particular characteristics or features in an area.
  - ♦ Update data quickly and cheaply.
  - ♦ Model data and assess alternatives.



A well-designed GIS should provide:

- Quick and easy access to large volumes of dat
- The ability to:
  - ♦ Select detail by area or theme.
  - ♦ Link or merge one data set with another.
  - ♦ Analyze spatial characteristics of data.
  - ♦ Search for particular characteristics or features in a
  - ♦ Update data quickly and cheaply.
  - ♦ Model data and assess alternatives.
- Output capabilities tailored to meet particular needs:
  - ♦ Maps.
  - ♦ Graphs.
  - ♦ (Address) lists.
  - ♦ Summary statistics.





A well-designed GIS should provide:

- GIS Software Functions

Data entry
- manual coordinate capture
- attribute capture
- digital coordinate capture
- data import

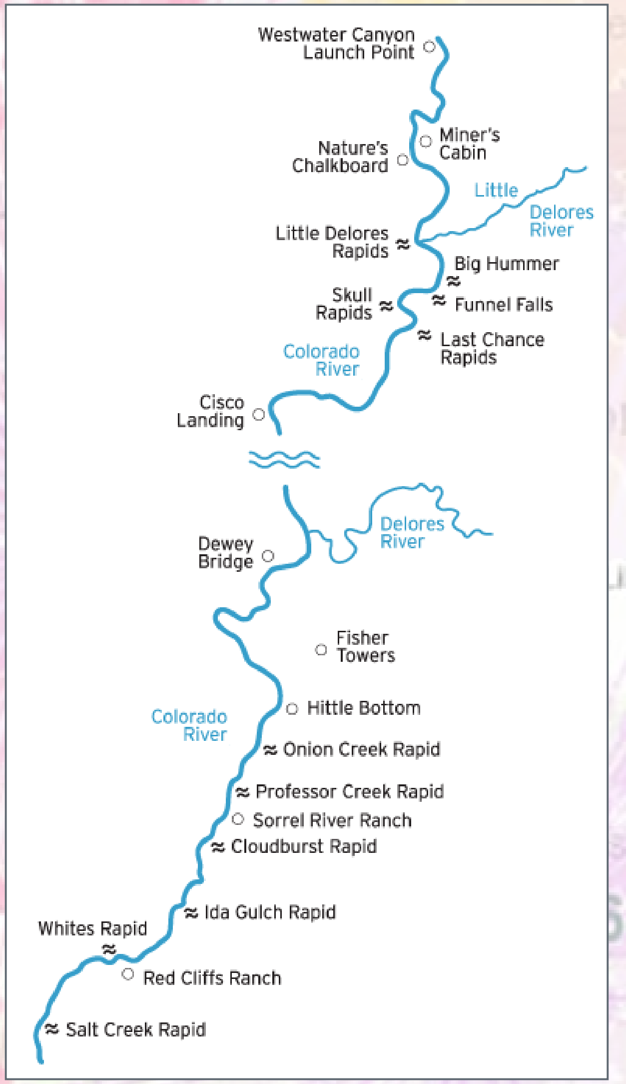
Editing
- manual point, line and area feature editing
- manual attribute editing
- automated error detection and editing

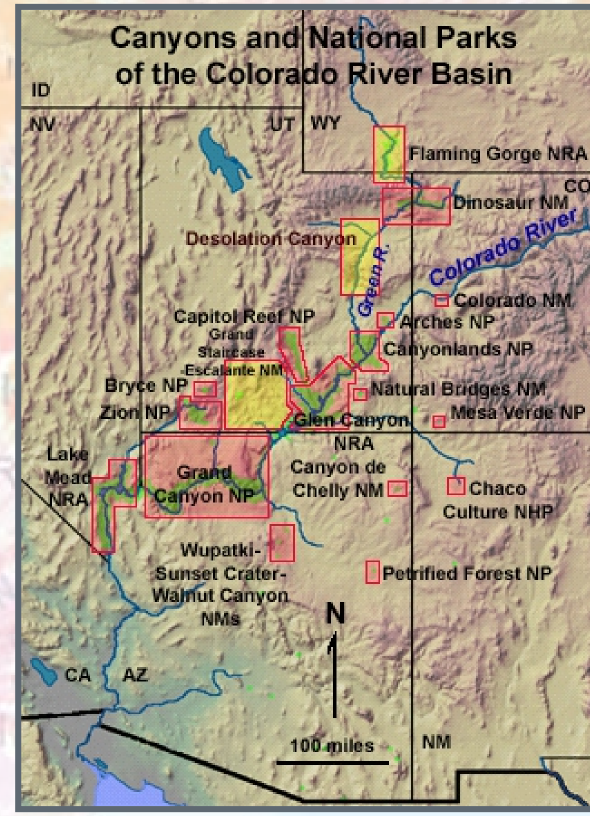
Data management
- copy, subset, merge data
- versioning
- data registration and projection
- summarization, data reduction
- documentation

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

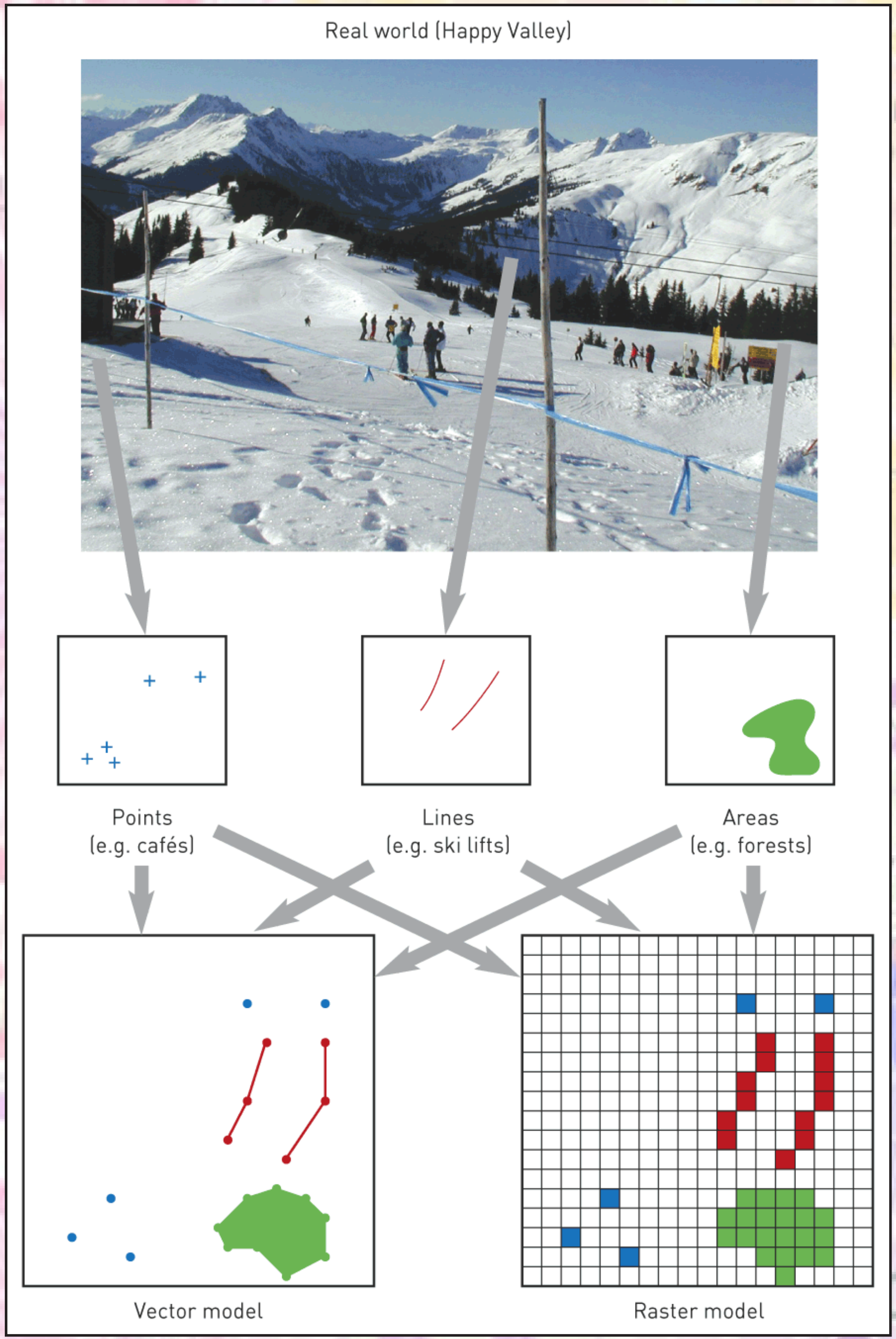
Key to GIS Definitions





- Spatial Data:
  - Lat/Lon
  - Relative Locations
- Attribute Data:
  - River Flow Rate
  - Fish Populations
  - Number of River Rafters
- Combined in a GIS
  - River location flow
  - Where the best fishing is

"a piece of information that determines the properties of a field or tag in a database"

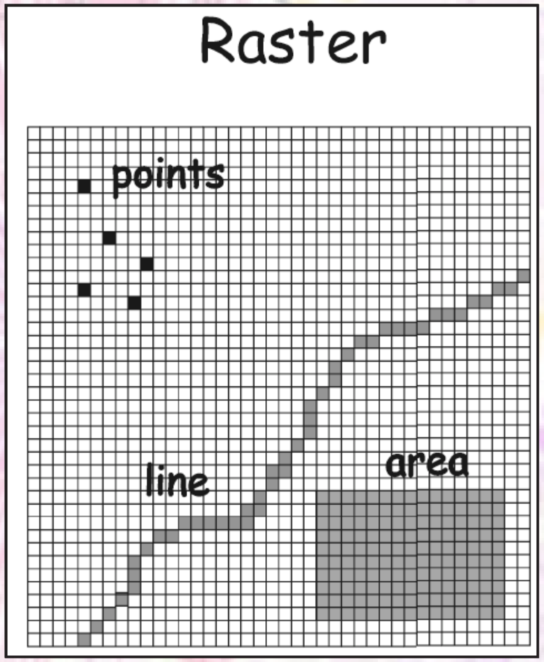


Key to GIS Definitions

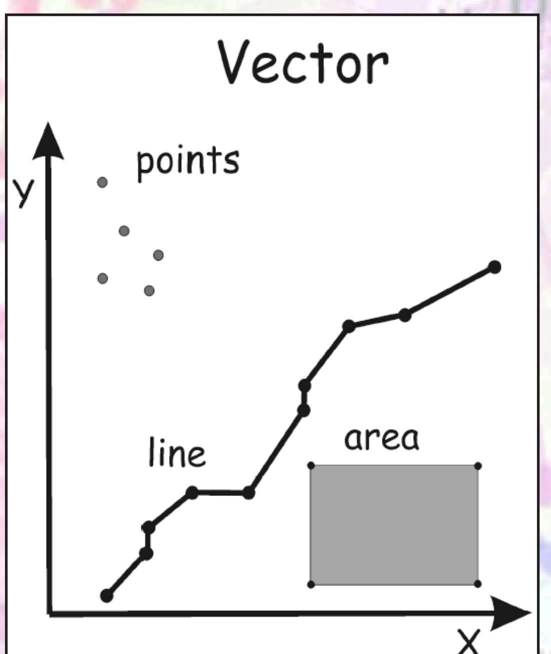
Three key components of a GIS

- Real-world spatial data must be simplified for computer models.
- Break down geographic features into 3 basic entities – points, lines, areas/polygons:
  - <u>Points:</u> locations of small objects
  - <u>Lines:</u> represent linear objects
  - <u>Area/Polygons:</u> defined by closed connected set of lines

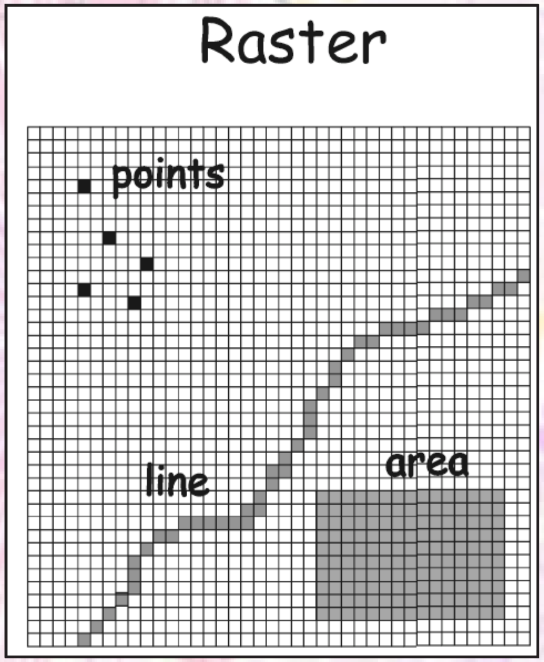
Key to GIS Definitions

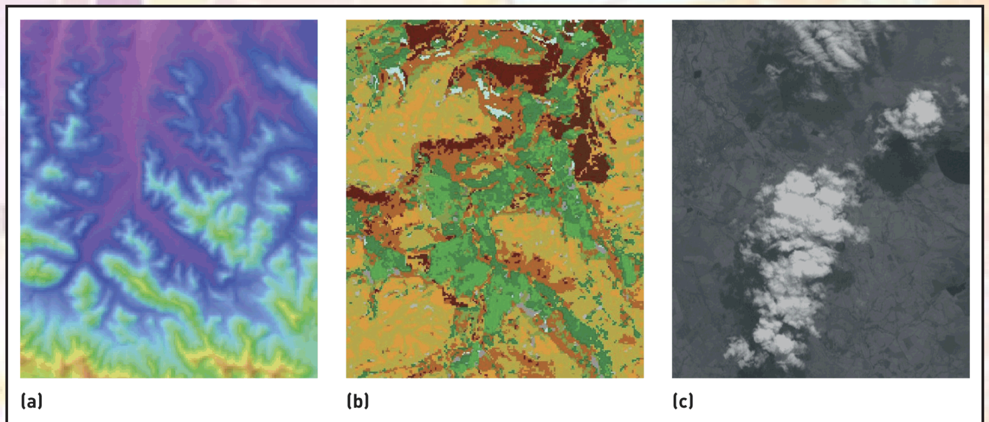


- Data can be modeled as *discrete objects (vector)* or *continuous feature (raster)*.

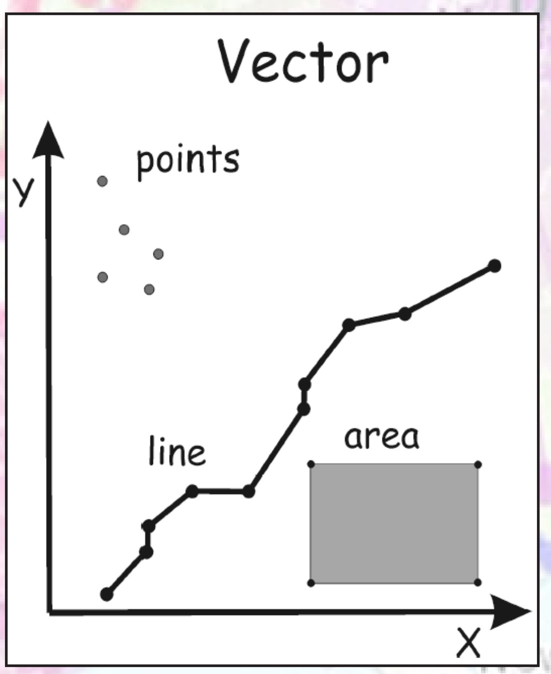


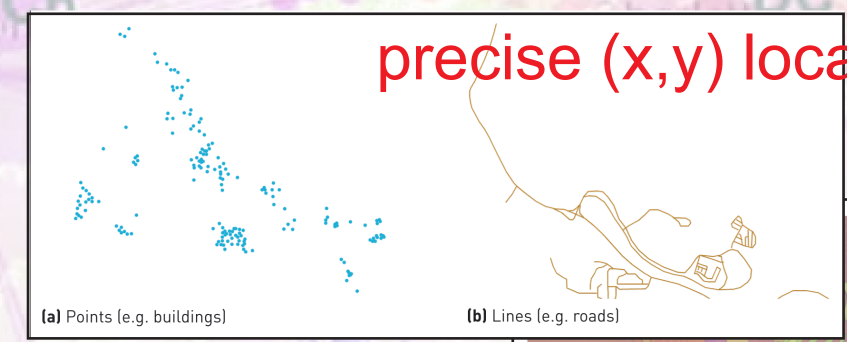
Key to GIS Definitions



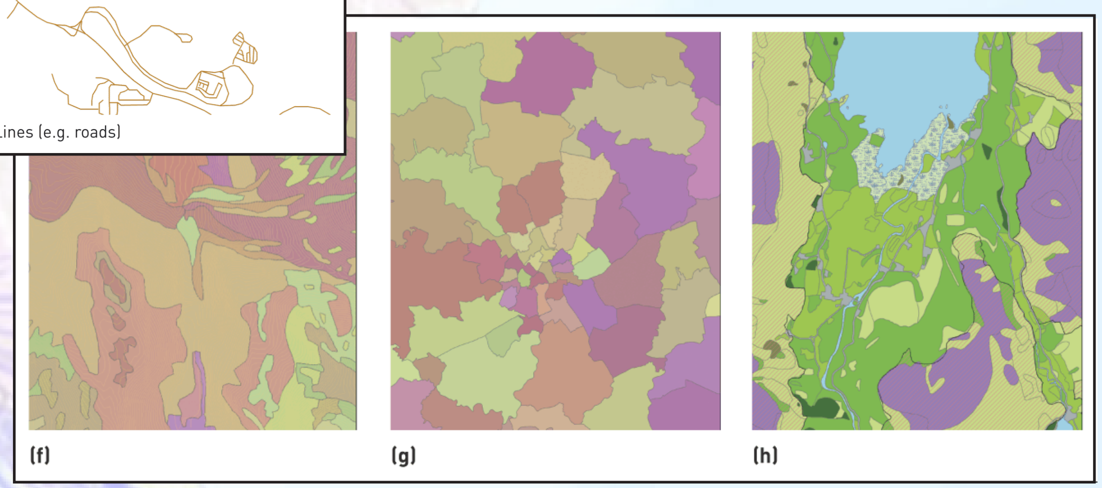


location recorded as ‘nearest’ cell

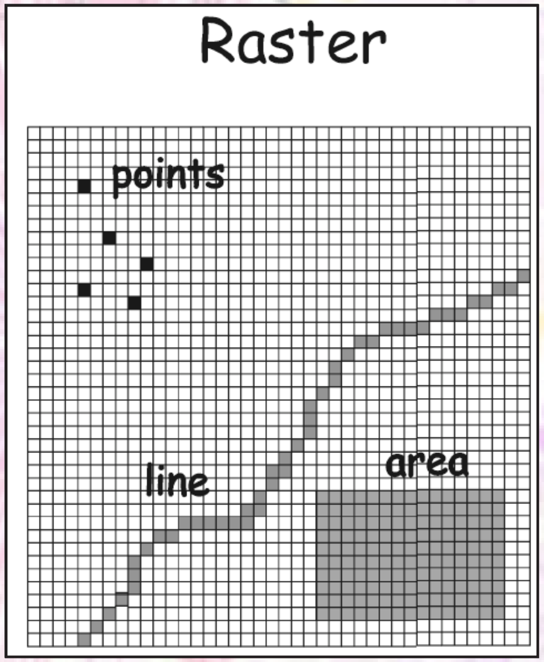


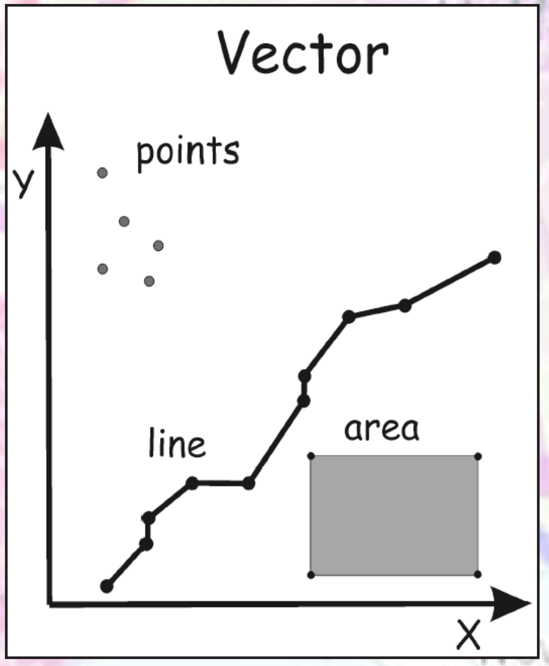


precise (x,y) location of points and vertices

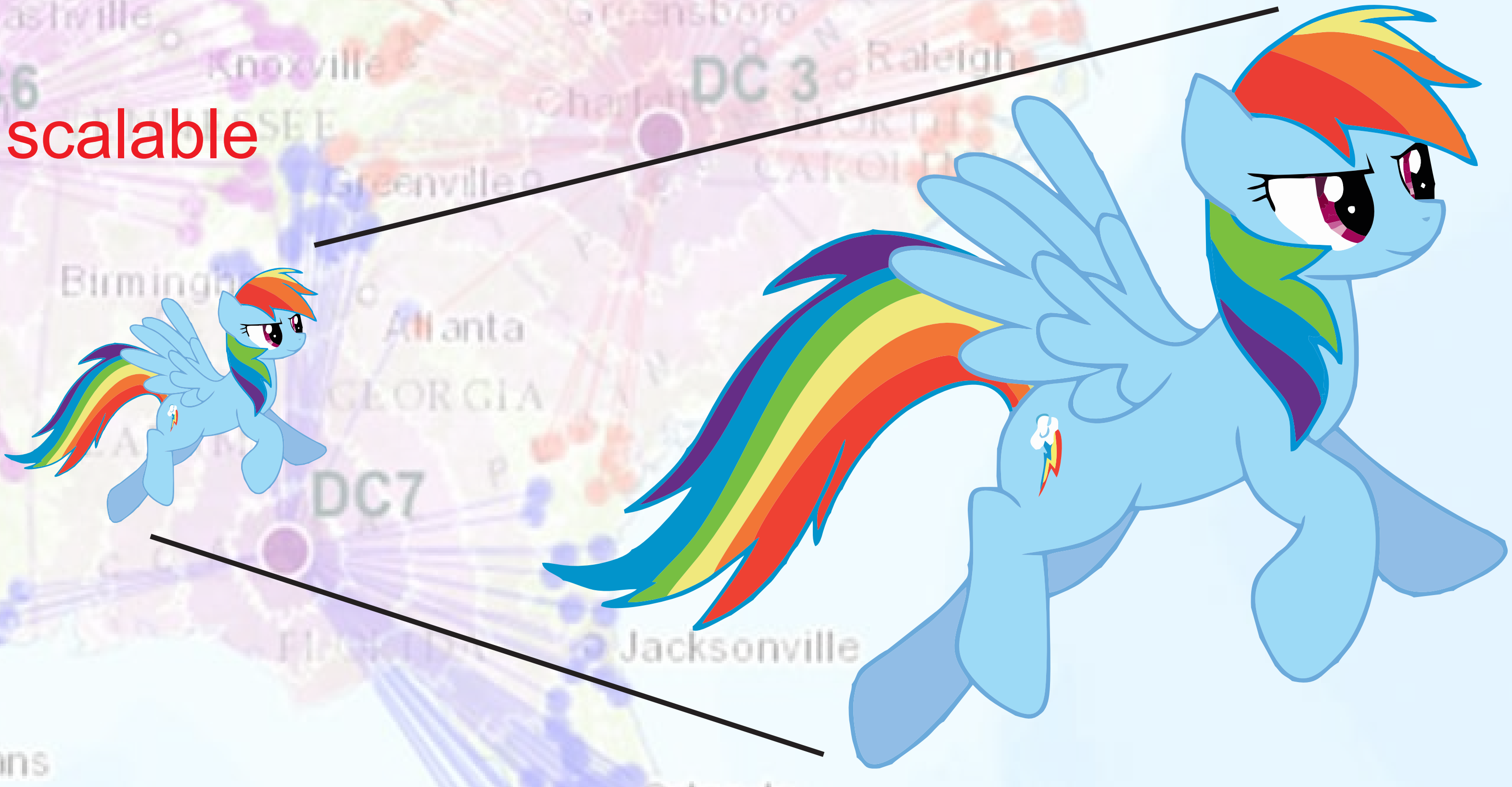


Key to GIS Definitions

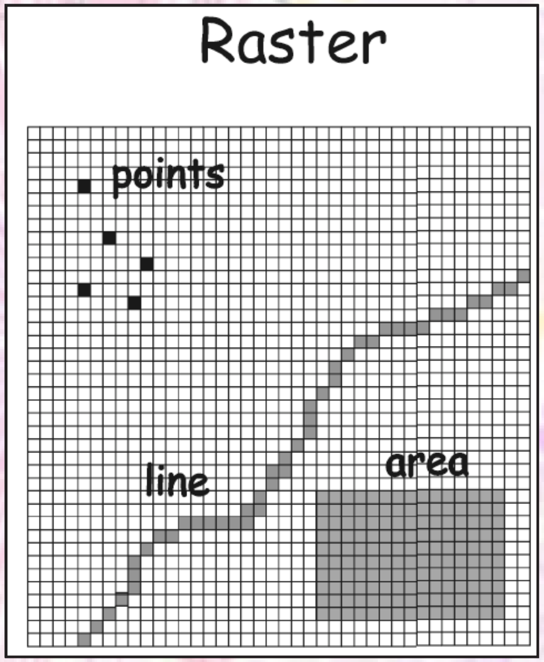


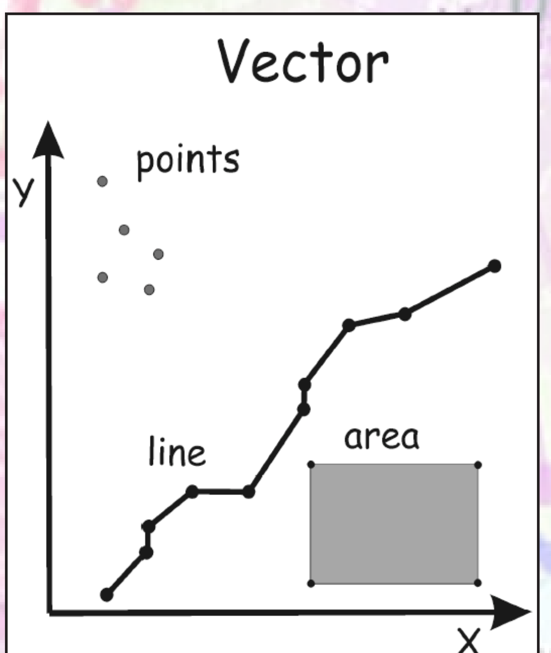


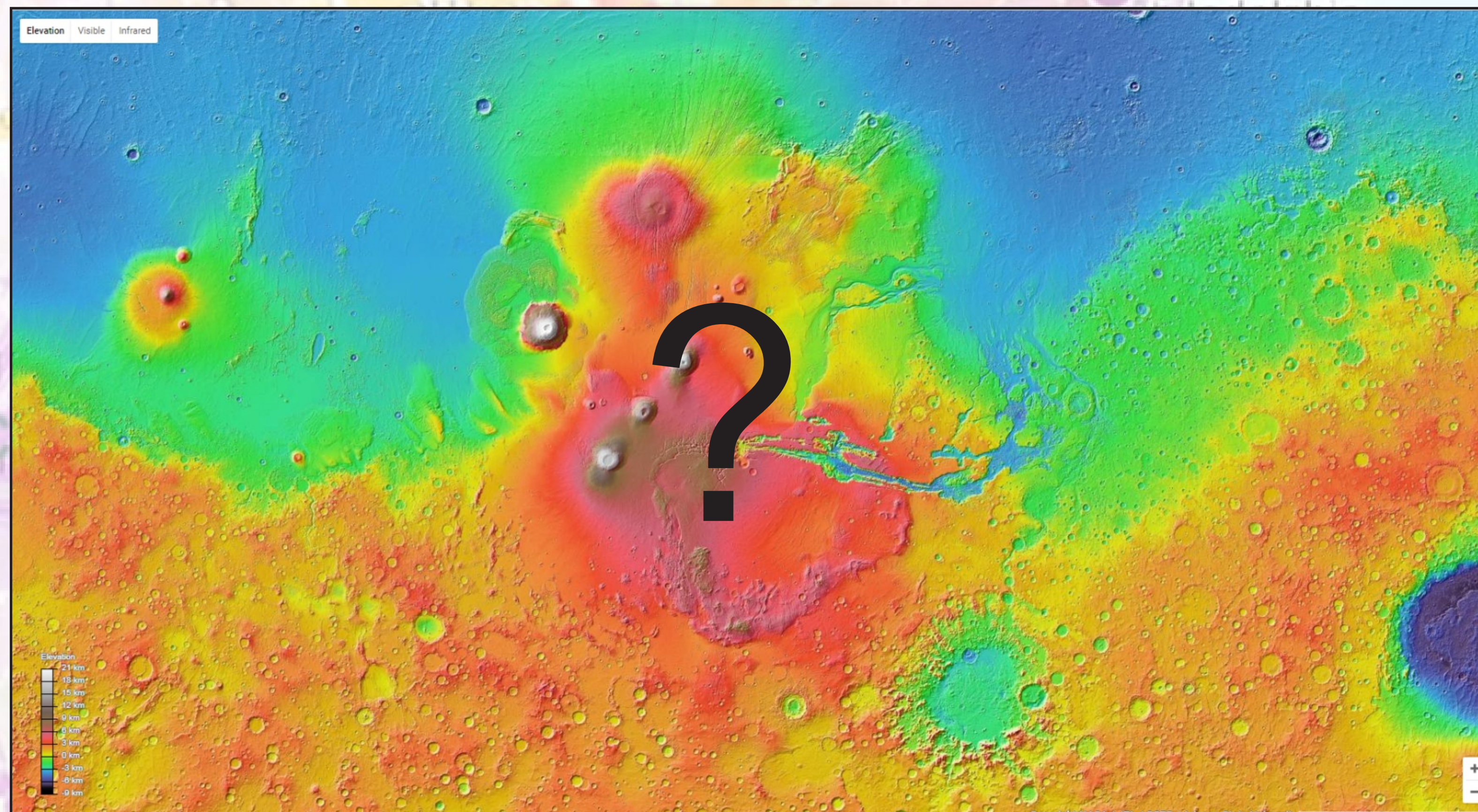
scalable



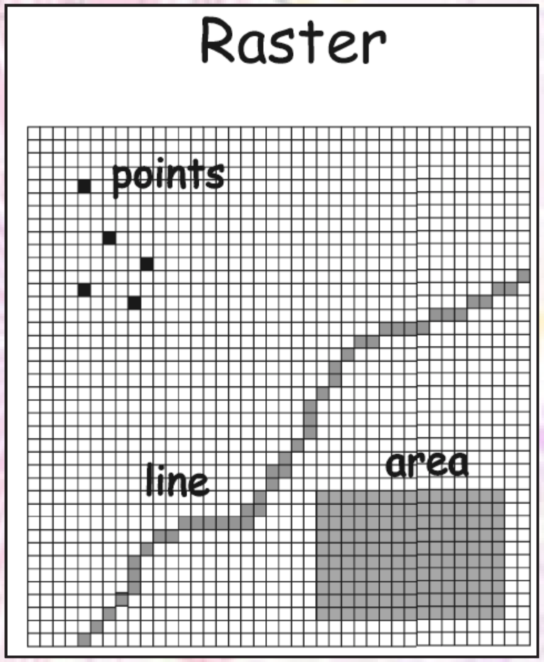
Key to GIS Definitions

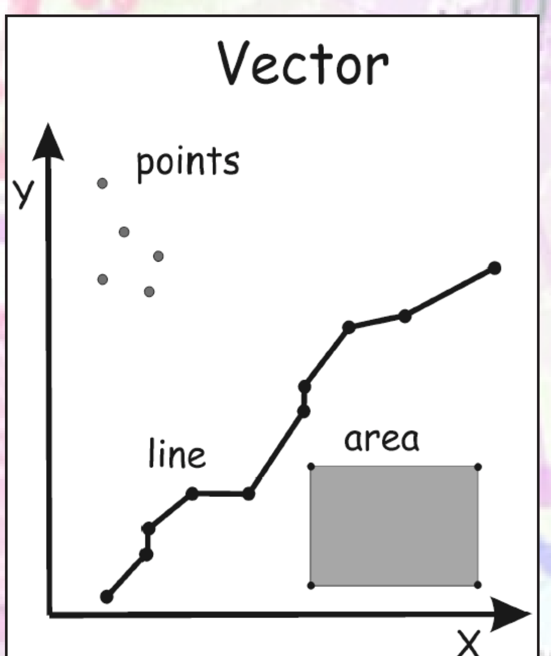


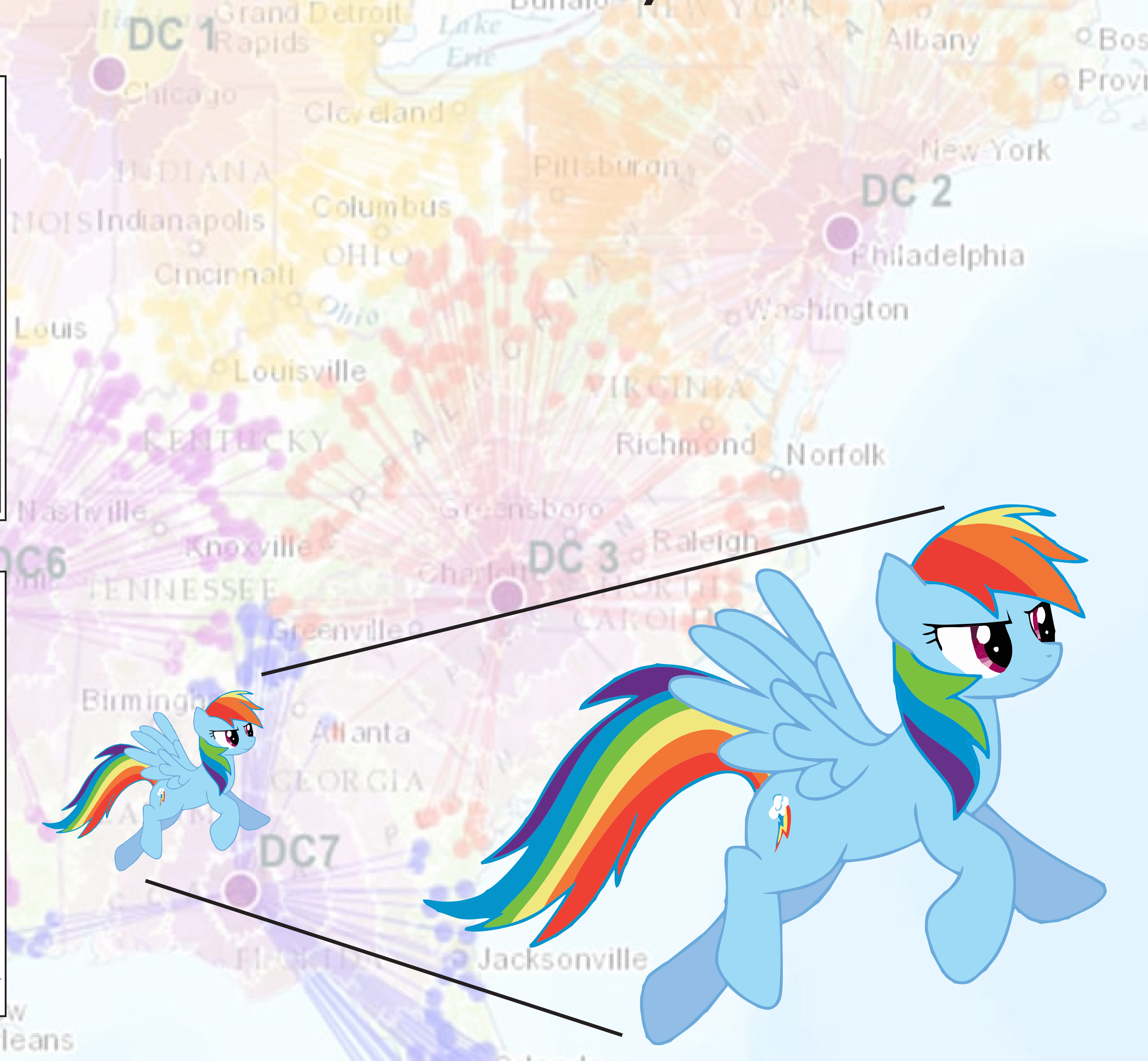




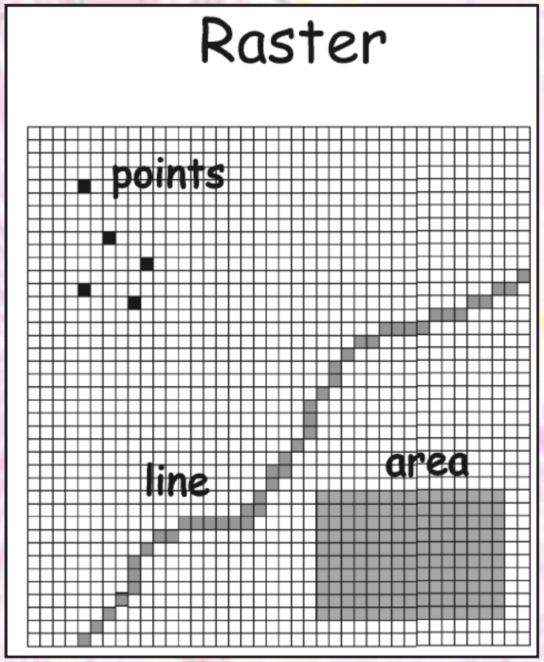
Key to GIS Definitions





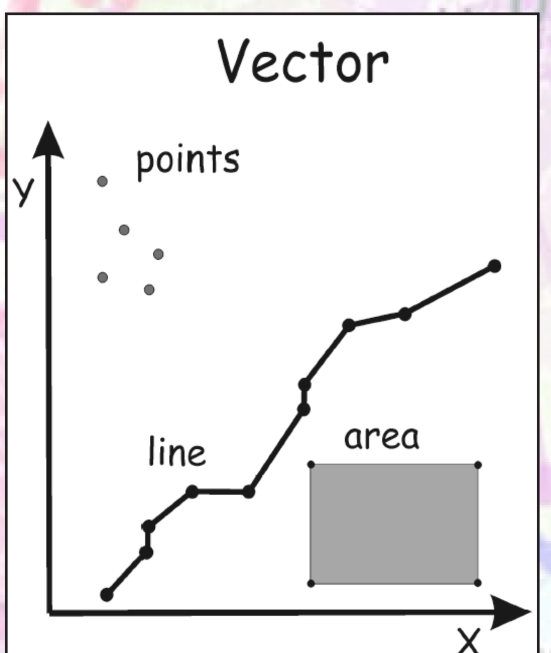


Key to GIS Definitions

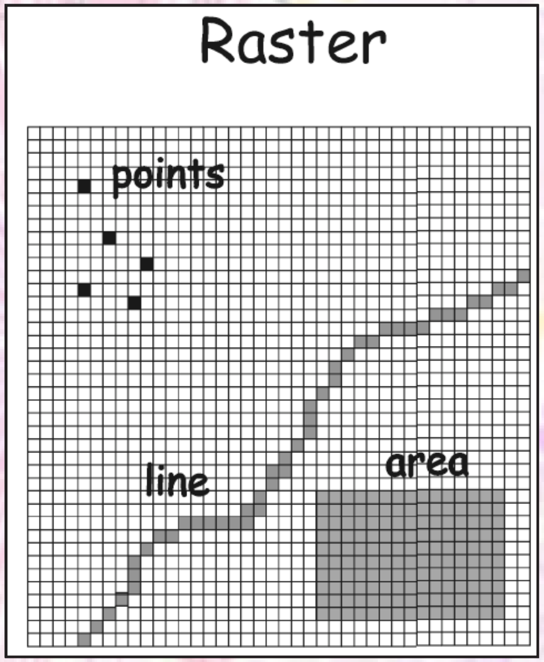


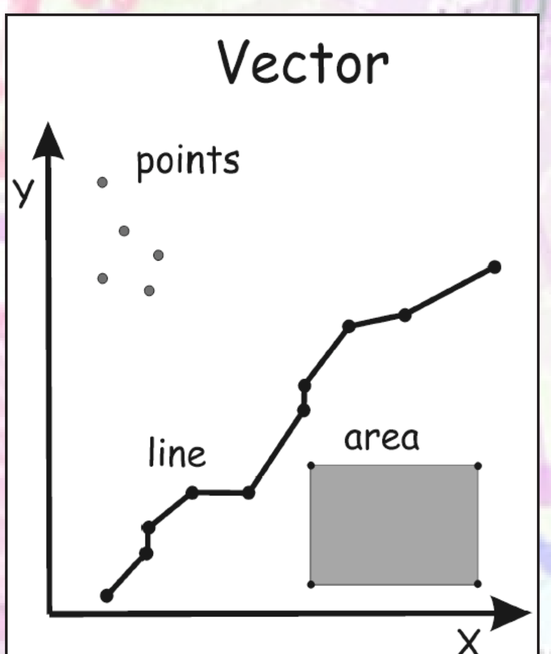
300 dpi 60 dpi 30 dpi

progressive loss of information and resolution



Key to GIS Definitions



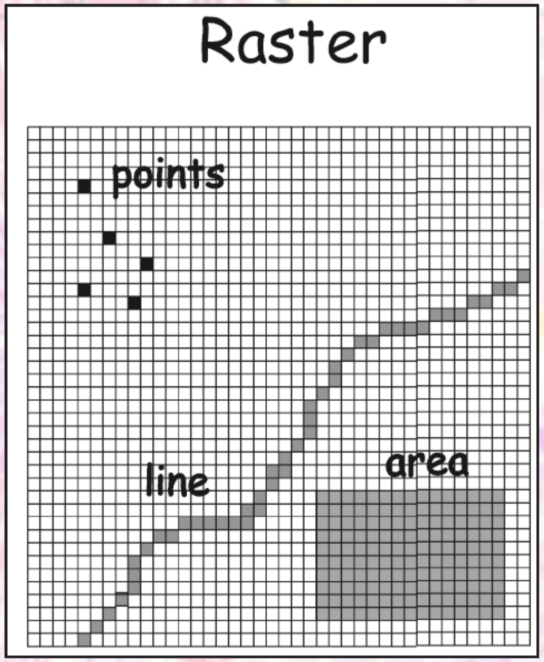


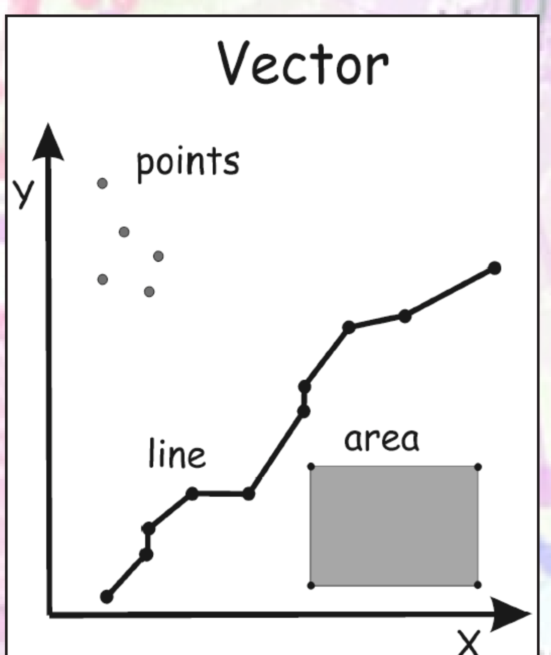
300 dpi 60 dpi 30 dpi

progressive loss of information and resolution

progressively larger file size

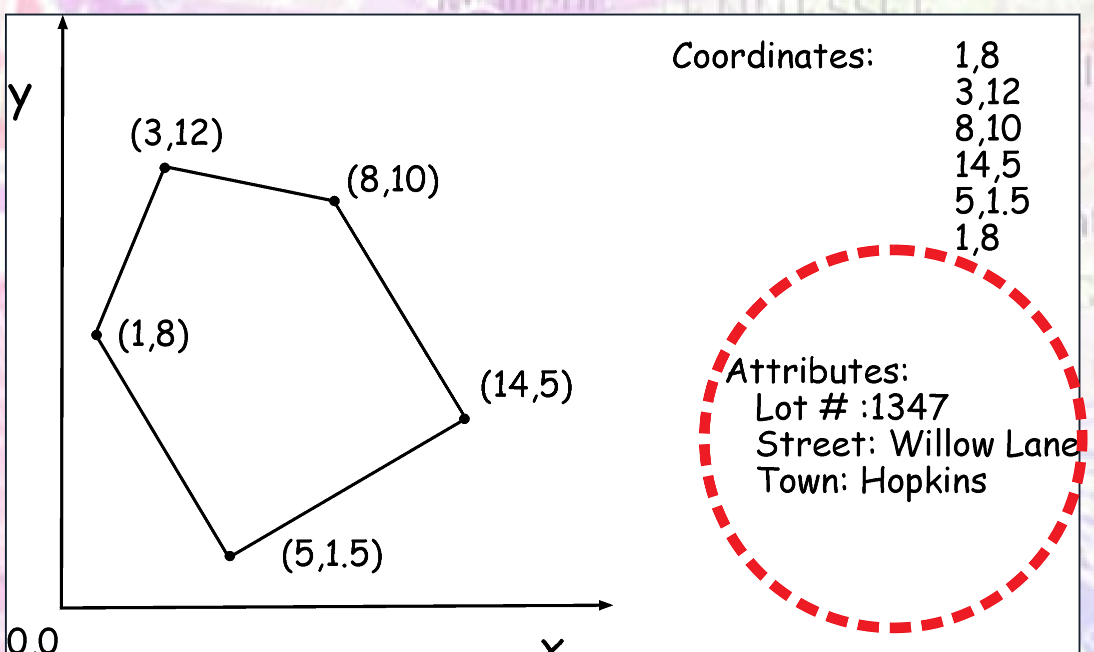
Key to GIS Definitions





Spatial referencing

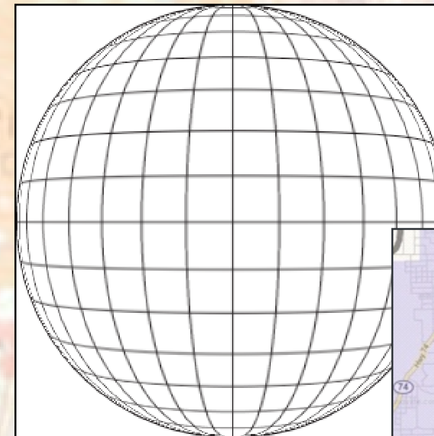
- Define the spatial location and extent of geographic objects.
- Typically, a pair of numbers that specify location in relation to an origin.

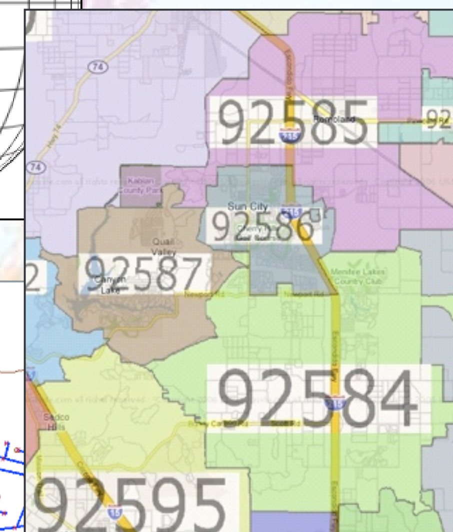


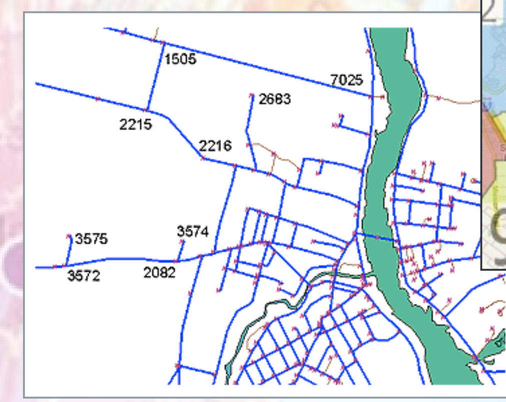
Attribute data connected to coordinates help define objects in the GIS

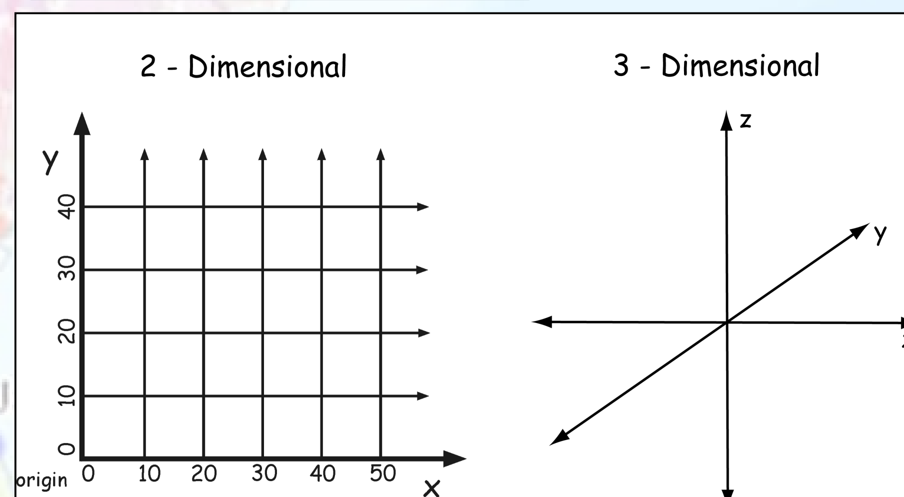
Spatial referencing

- Referencing systems are used to locate a feature on the Earth's surface or a map
- Characteristics of a referencing system
  - Show points, lines, areas
  - Measure length, size, shape
- Methods of spatial referencing
  - Geographic coordinates
  - Rectangular coordinates
  - Non-coordinate systems



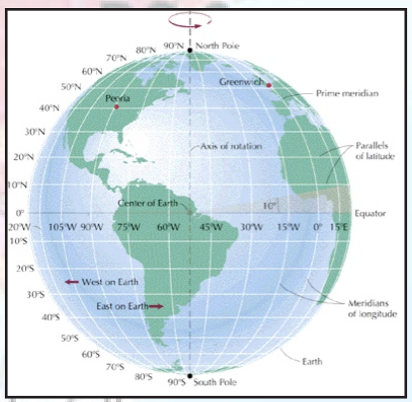


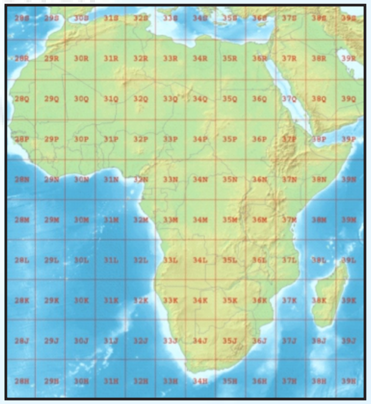


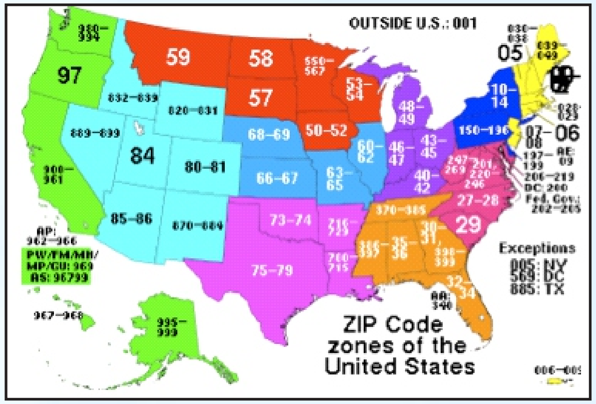


Spatial referencing

- Referencing systems are used to locate a feature on the Earth's surface or a map
- Characteristics of a referencing system
  - Show points, lines, areas
  - Measure length, size, shape
- Methods of spatial referencing
  - Geographic coordinates
  - Rectangular coordinates
  - Non-coordinate systems

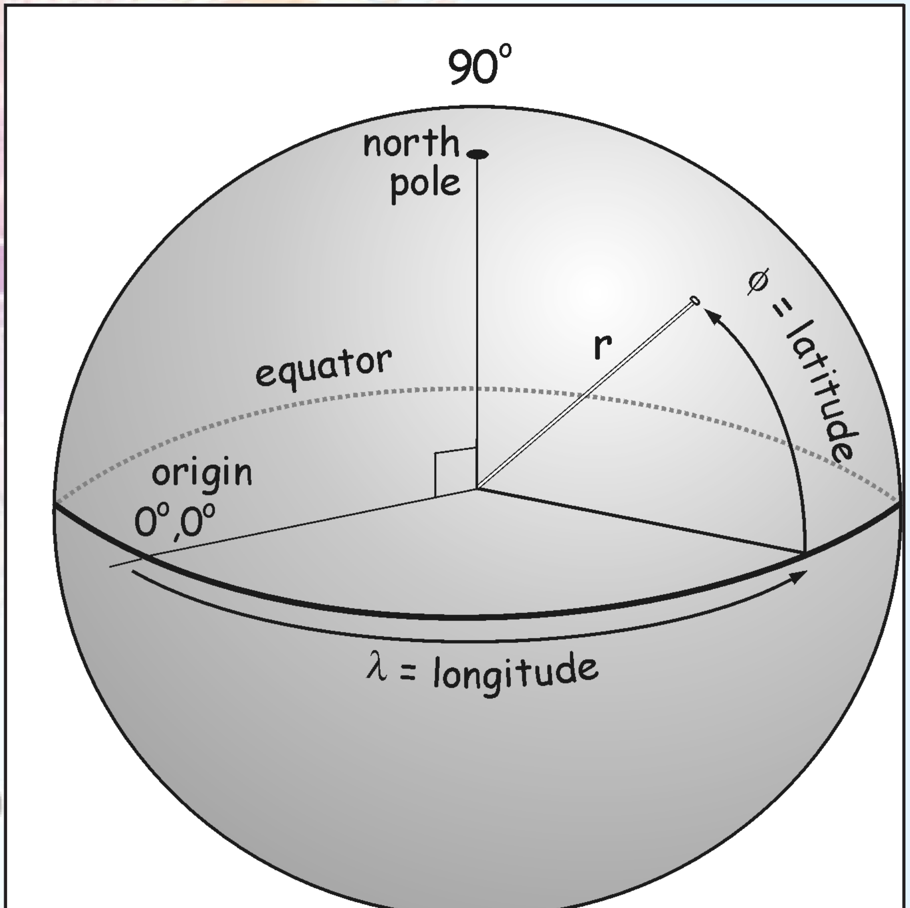






Spatial referencing – geographic coordinates

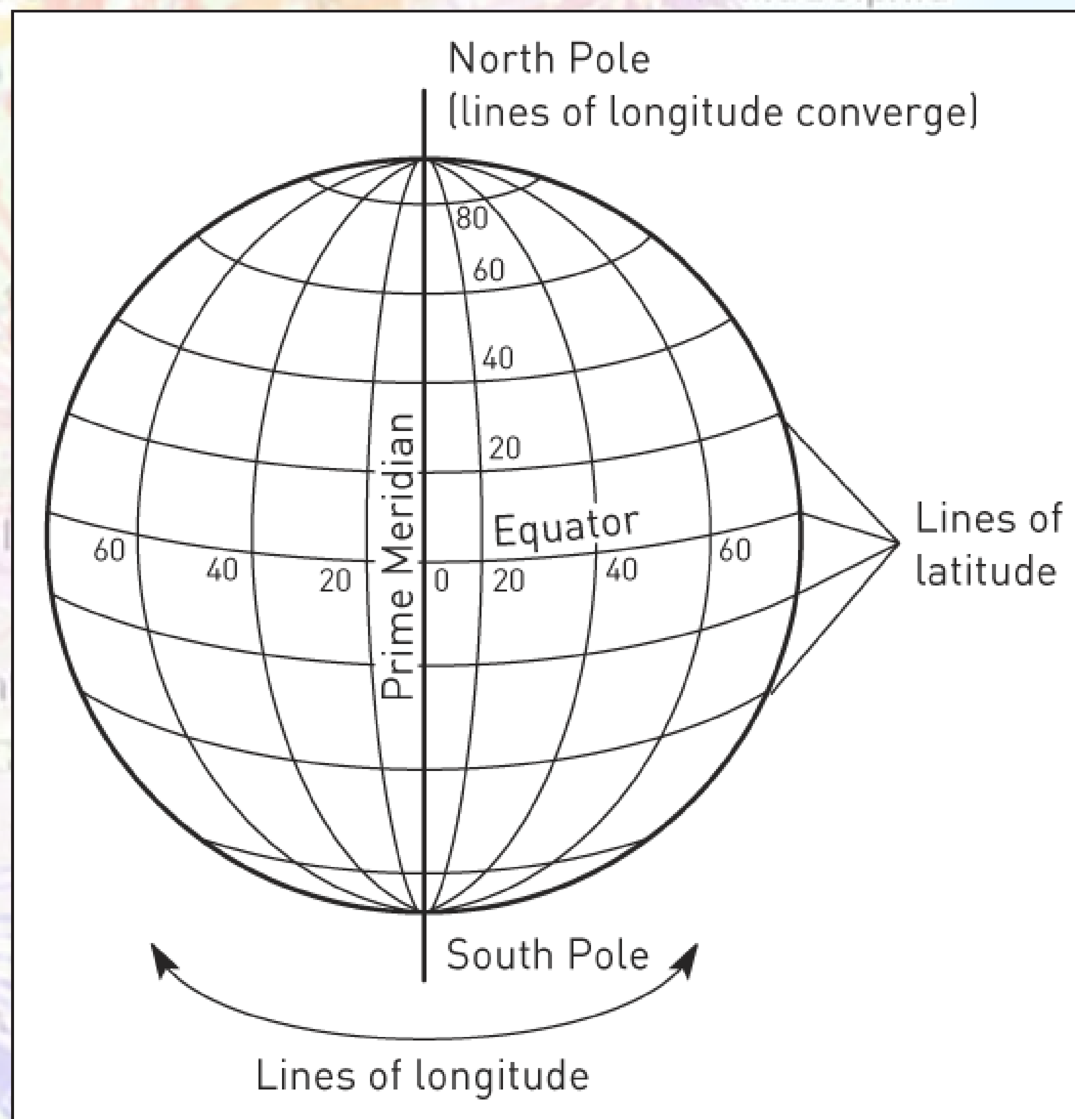
- Uses 2 angles of rotation and a radius to specify locations.
- Latitude and longitude are the only true geographic coordinates.



Spatial referencing – geographic coordinates

- Lines of longitude (meridians) converge at the poles.
  - Zero is at the Greenwich meridian (aka Prime Meridian).

- Lines of latitude are perpendicular to lines of longitude and are parallel to each other



Spatial referencing – geographic coordinates

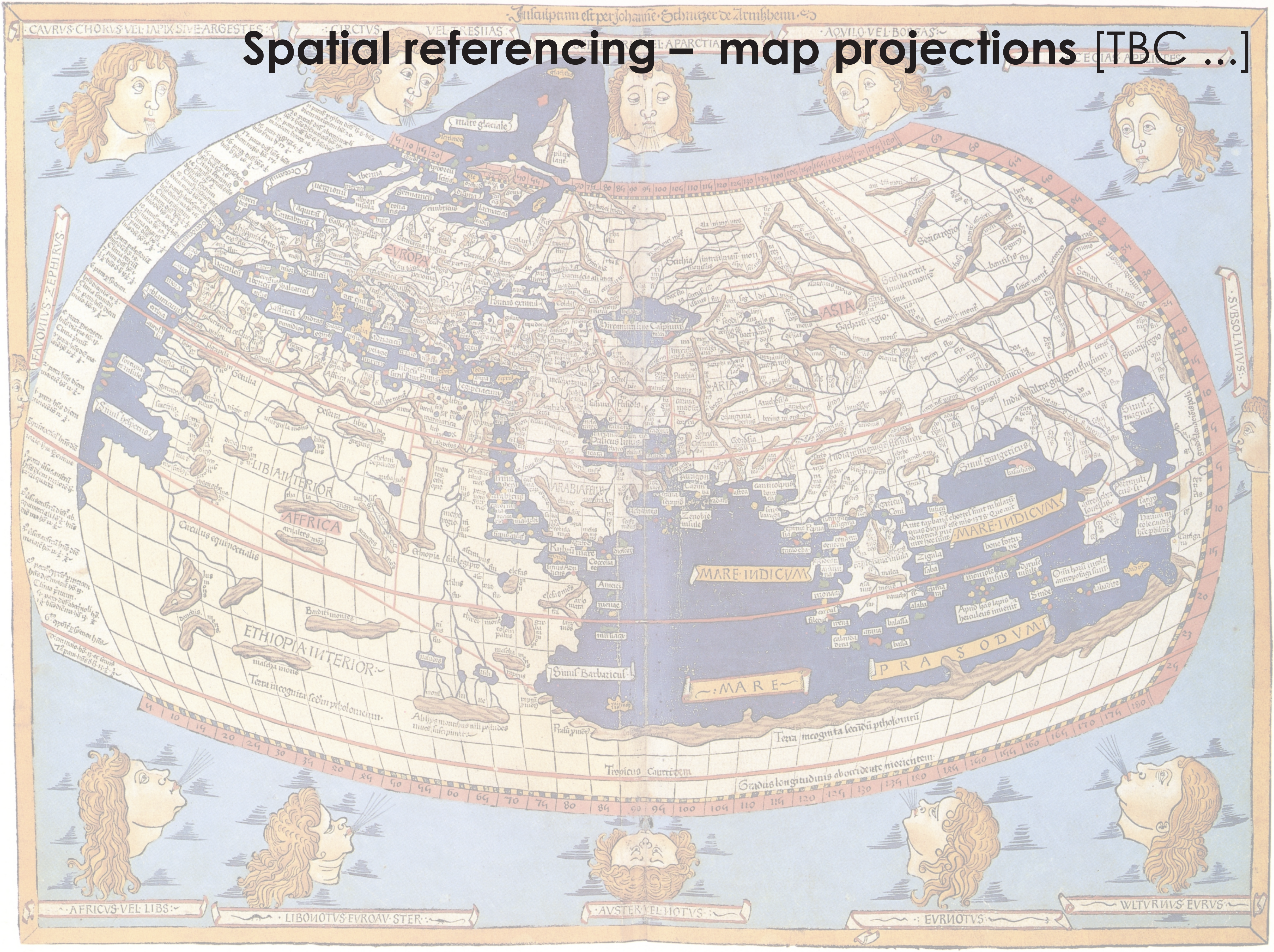
- Can be expressed as decimal degrees (DD), but …
- Coordinates are most often recorded in degrees-minutes-seconds (DMS) notation:
  - Expressed in degrees, minutes (1/60th of a degree) and seconds (1/60th of a minute).

DD from DMS
DD = D + M/60 + S/3600
e.g.
DMS = 32° 45' 28"

DD = 32 + 45/60 + 28/3600
= 32 + 0.75 + 0.0077778
= 32.7577778

DMS from DD
D = integer part
M = integer of decimal part x 60
S = 2nd decimal x 60
e.g.
DD = 24.93547
D = 24
M = integer of 0.93547 x 60
= integer of 56.1282
= 56
S = 2nd decimal x 60
= 0.1282 * 60 = 7.692
so DMS is
24° 56' 7.692"

Spatial referencing – map projections [TBC …]

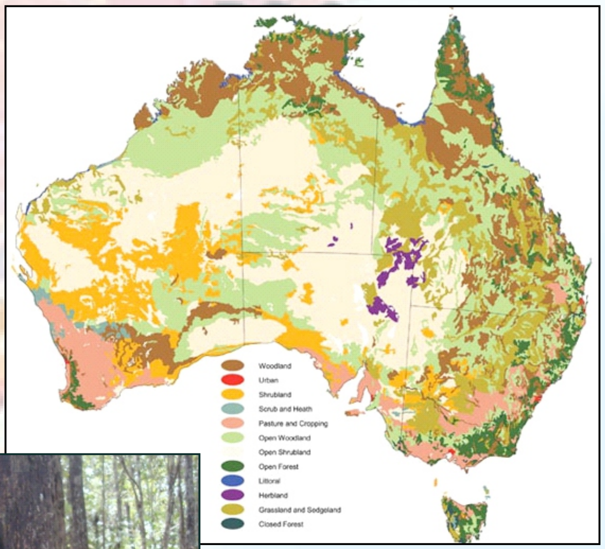


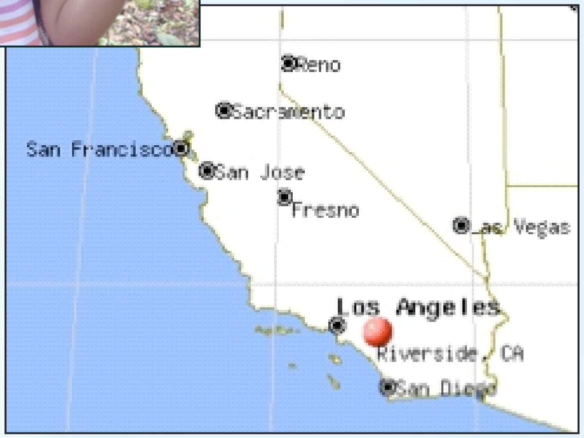
Non-Spatial Data: Attribute Data

- Record the non-spatial characteristics of a spatial entity (point, line, area)

1) *Nominal Attributes*:
- Descriptive information about an object
- Establish identity
- No implied order, size or quantitative information
- Can't add or subtract to get useful information

Examples:
- Place names (Riverside, Los Angeles, San Diego)
- Vegetation types (Grass, Forest, Tundra)
- Telephone numbers





Non-Spatial Data: Attribute Data

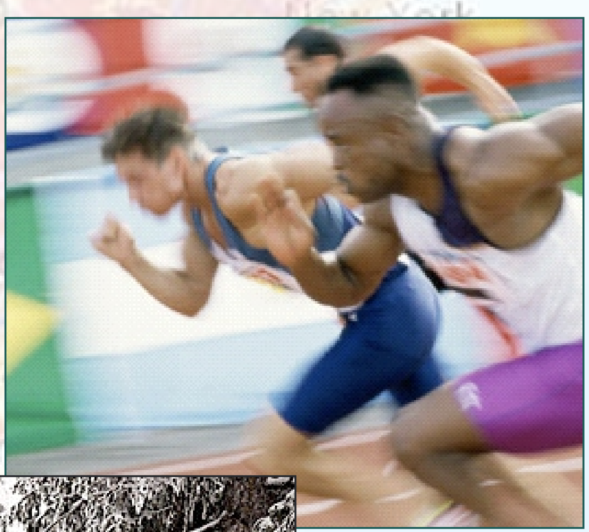
- Record the non-spatial characteristics of a spatial entity (point, line, area)

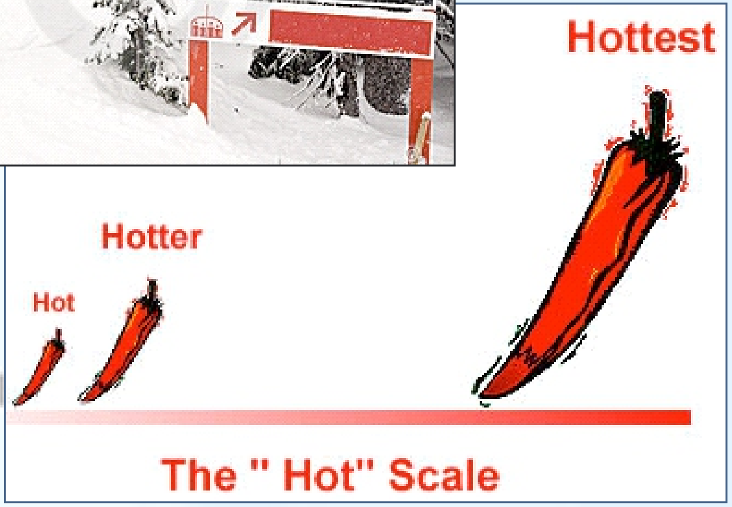
2) *Ordinal Attributes:*

- Imply a rank order or scale, but not relative size
- Descriptive: small, medium, large
- Numeric: scale 1-10
- Similar to nominal, cannot use arithmetic to get meaningful information about the difference between two objects.

Examples:

- Dividing possible housing locations by classes where Class 1 implies a better building site than Class 2 or Class 3, etc.
- Amount of rainfall, e.g. high, moderate, low
- Ski run difficulty, e.g. black diamond, blue, green





Non-Spatial Data: Attribute Data

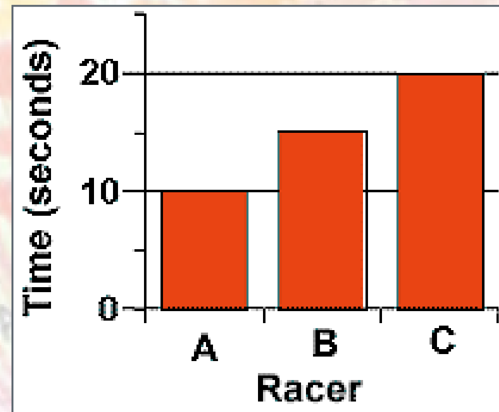
- Record the non-spatial characteristics of a spatial entity (point, line, area)

3) *Interval/Ratio Attributes:*

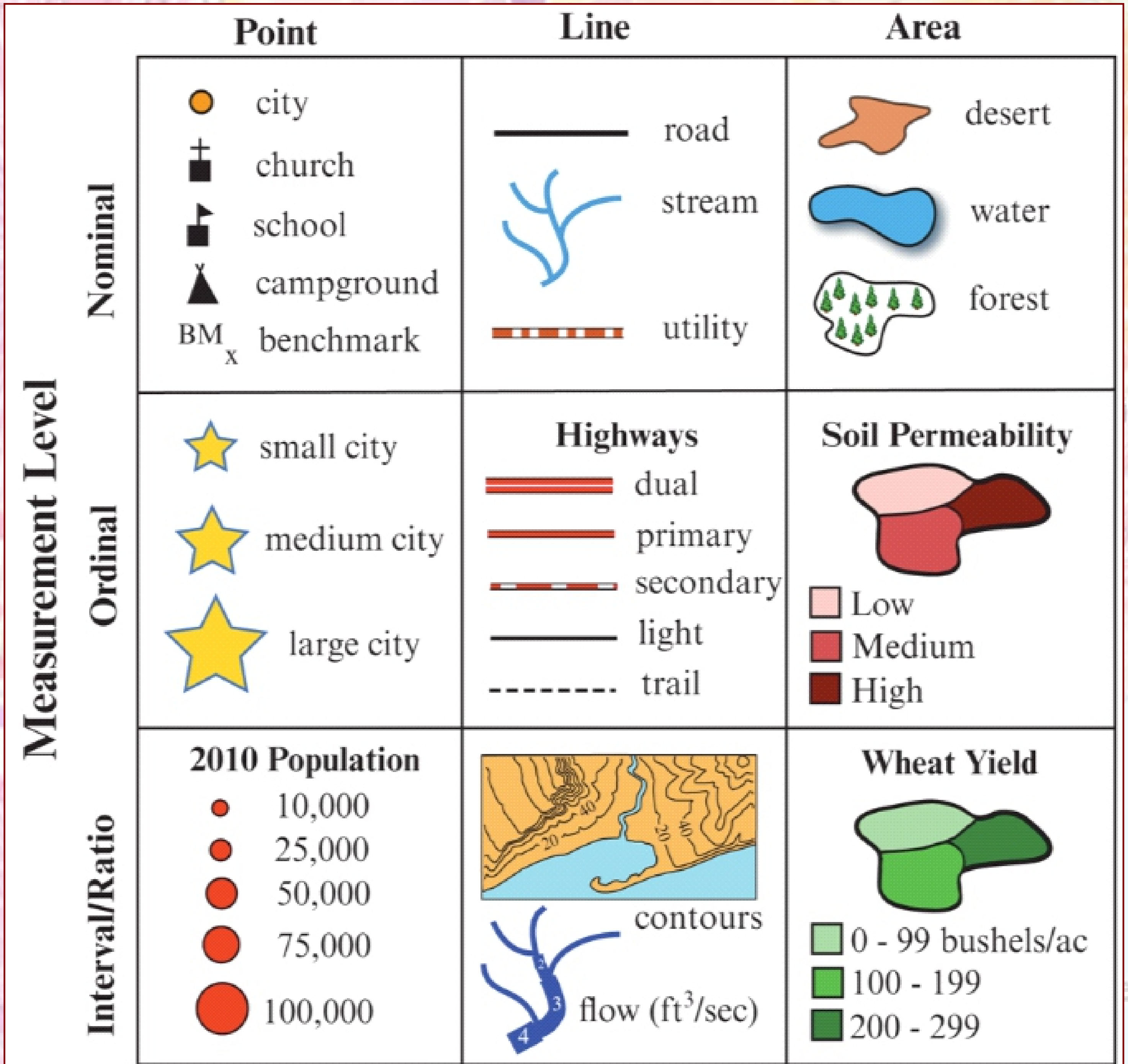
- Numeric items that reflect both order and absolute difference in magnitude.
- Often real numbers on a linear scale
- i.e. area, length, width, weight, etc.

Example:

- Housing parcel area, e.g. Area1 = 5000 sq ft, Area2 = 10000 sq ft
- Length of railway track, e.g. Track1= 50 mi, Track2=100mi

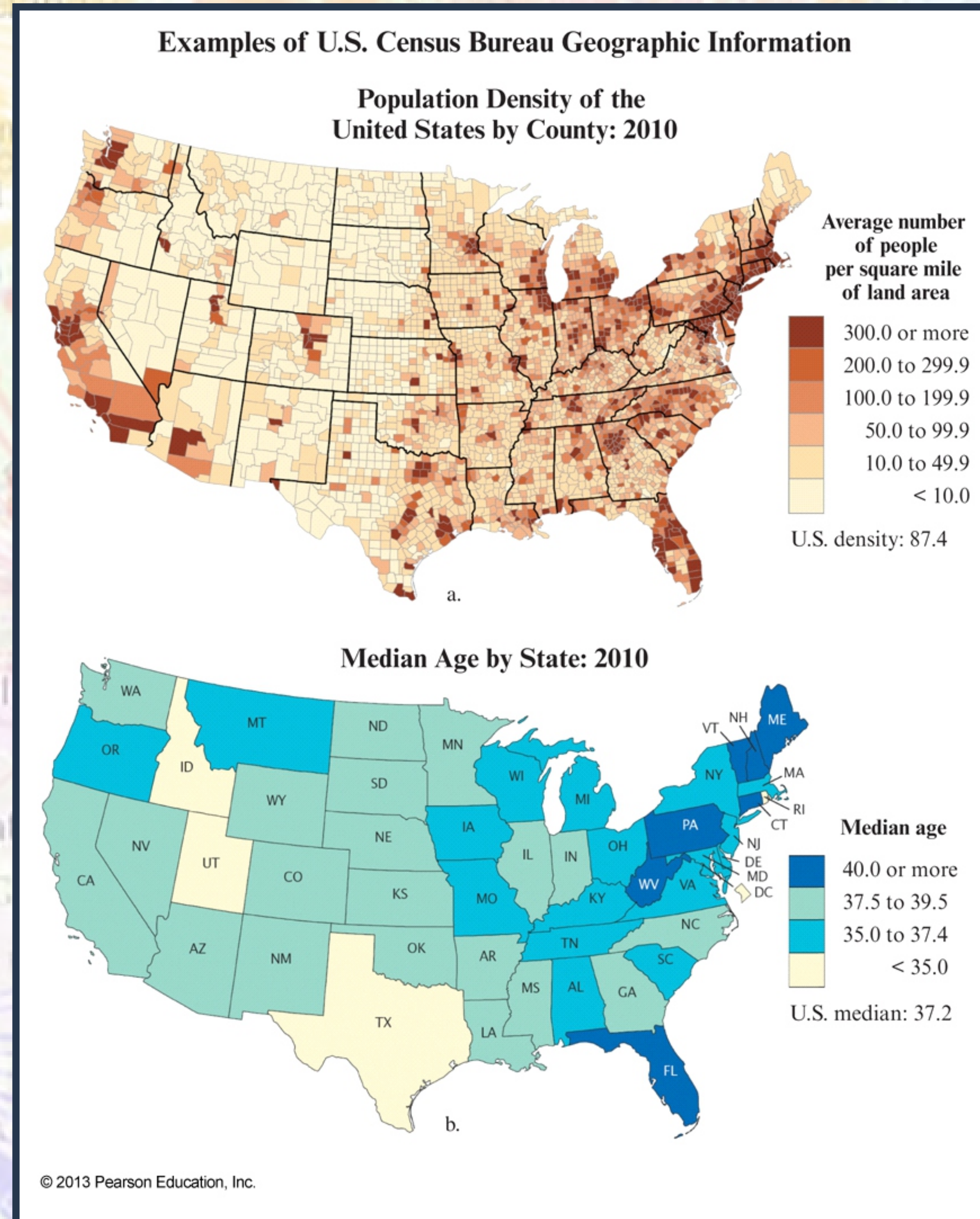


Non-Spatial Data: Attribute Data



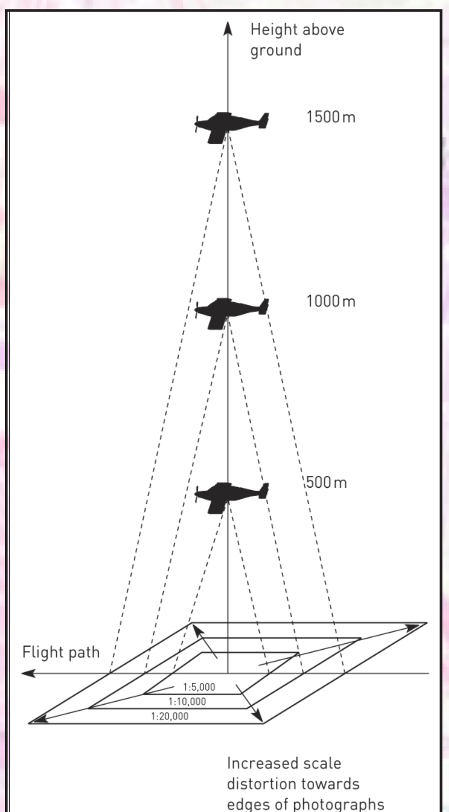
Sources of Spatial Data

- Census is systematic collection of information about all members of a population
- U.S. collects data every 10 years



Sources of Spatial Data

- Images taken above the Earth's surface typically by plane, info about land use, vegetation type, and land change, etc.



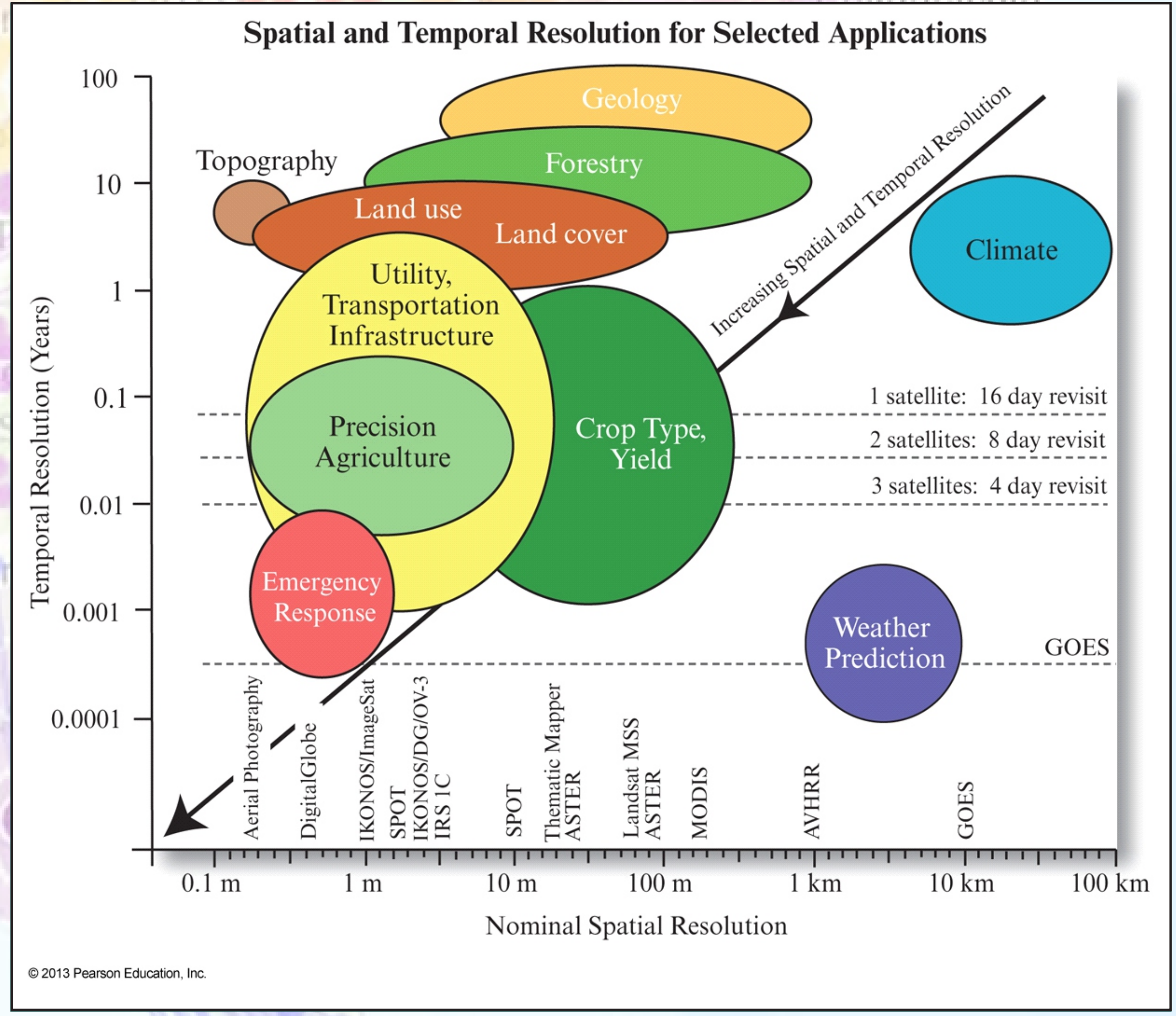
(a) Infrared vertical aerial photograph

(b) Vertical colour aerial photographs showing archaeological remains

(c) Vertical black and white aerial photograph

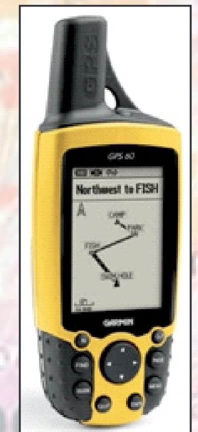
Sources of Spatial Data

- Spatial and temporal resolution trade-offs must be made when collecting data
- For example:
  - Land-use mapping require high spatial resolution (1-5 m) imagery (1-10 yrs)
  - Weather applications can use lower resolution (5 km) but be collected more frequently (subhour to hour).



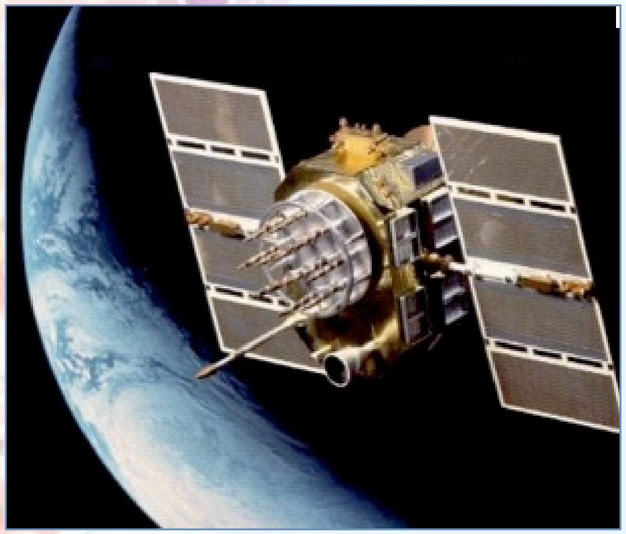
Sources of Spatial Data

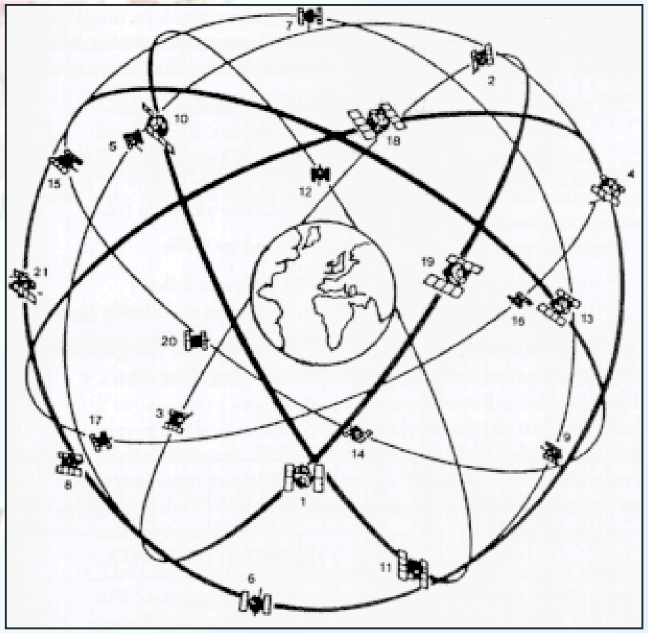
- One way to collect data in the field to import into GIS
- Hand-held devices that use signals from GPS satellites to work out the exact location of the user on the Earth's surface
- Maintained by the U.S. Govt
- Accuracy varies from 100 m to mm's!




Sources of Spatial Data

- First GPS satellite launched in 1978
- Full constellation achieved in 1994
- 24+ satellites in constellation
  - 6 planes with 55° inclination
  - Each plane has 4-5 satellites
  - Broadcasting position and time info on 2 frequencies
  - 1 revolution in approximately 12 hrs





Sources of Spatial Data

- Over $19 billion invested by Department of Defense
- Dual Use System Since 1985

(civilian & military)

- Civilian community was quick to take advantage of the system

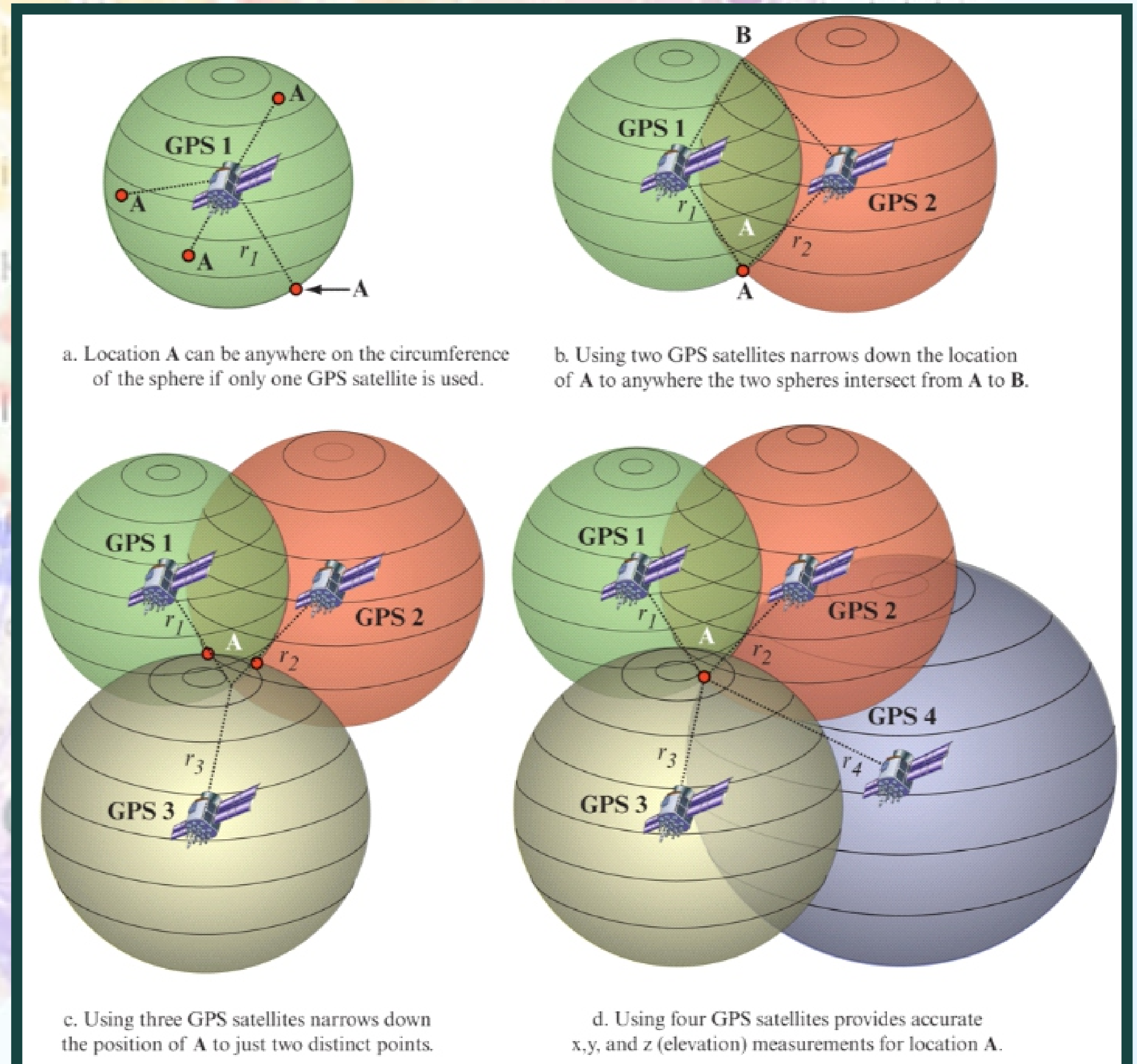
Sources of Spatial Data

How it works:

- Know time (distance) to one satellite

- With distances to 2 other satellites, we can pinpoint location using trigonometry

- Fourth satellite is used to check timing issues



a. Location **A** can be anywhere on the circumference of the sphere if only one GPS satellite is used.

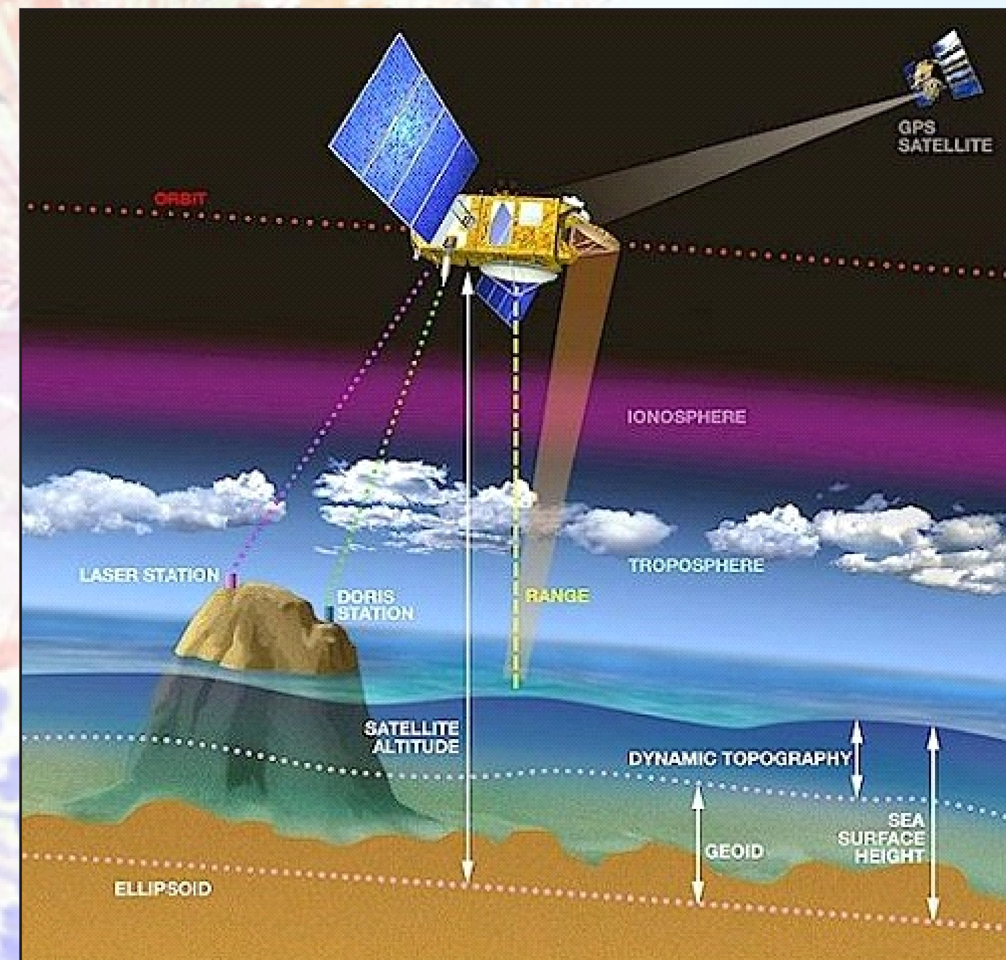
b. Using two GPS satellites narrows down the location of **A** to anywhere the two spheres intersect from **A** to **B**.

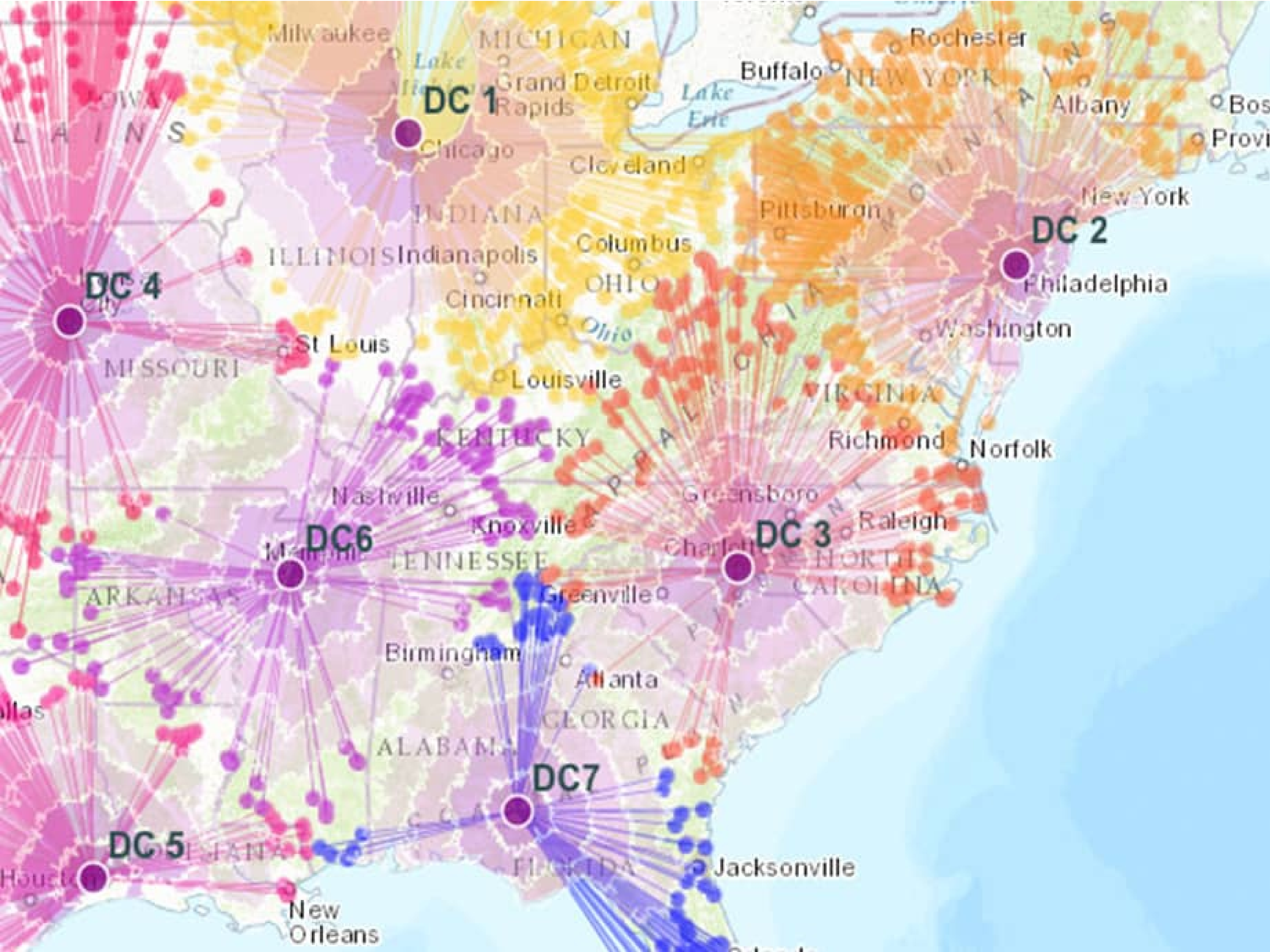
c. Using three GPS satellites narrows down the position of **A** to just two distinct points.

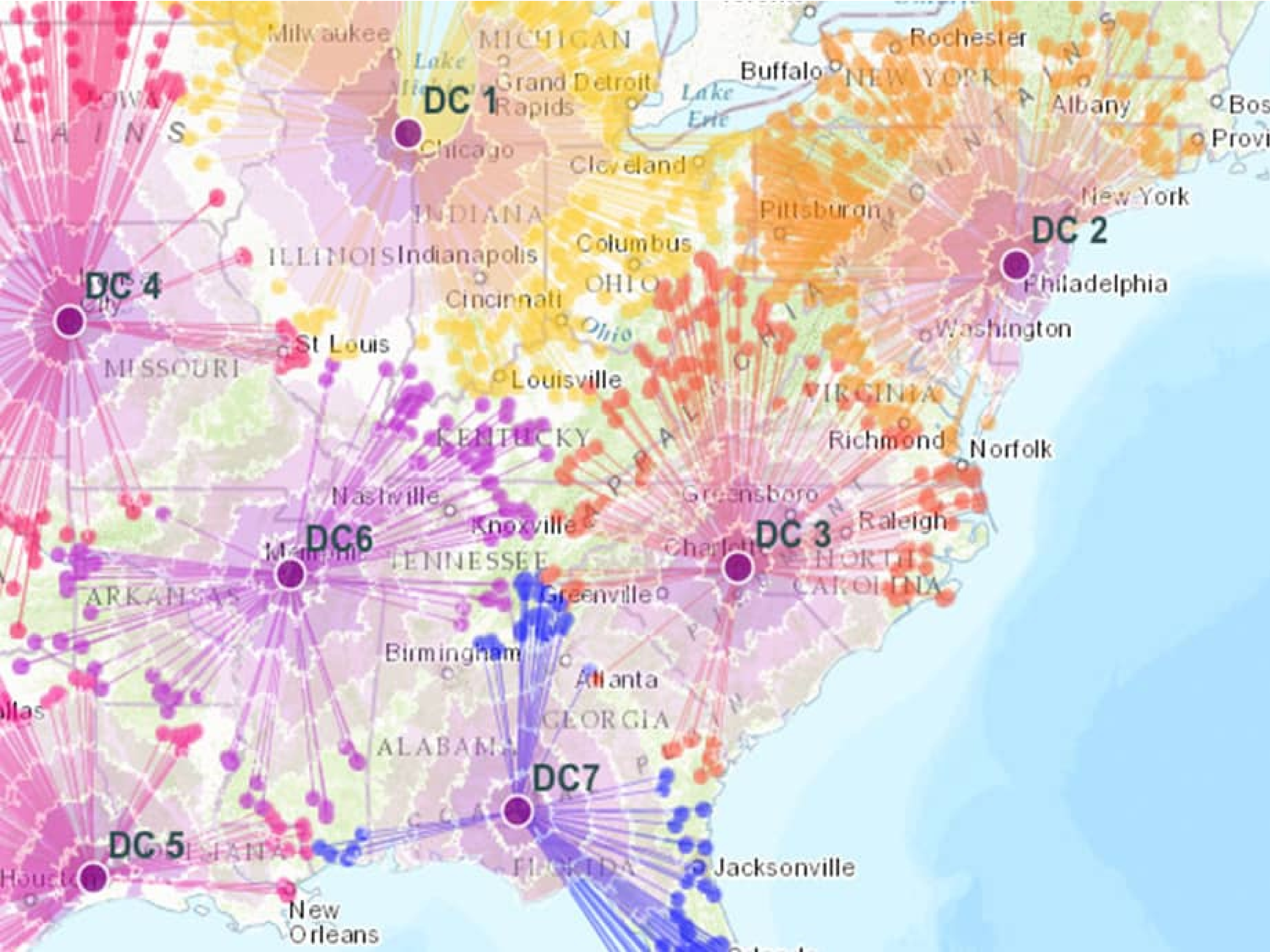
d. Using four GPS satellites provides accurate x,y, and z (elevation) measurements for location **A**.

Sources of Spatial Data

- **Sources of Error:**
- Clock Error
  - Differences between satellite clock and receiver clock
- Ionosphere Delays
  - Delay of GPS signals as they pass through the layer of charged ions and free electrons known as the ionosphere.
- Multipath Error
  - Caused by local reflections of the GPS signal that mix with the desired signal




DC 1
DC 2
DC 3
DC 4
DC 5
DC6
DC7
Milwaukee
MICHIGAN
Lake Michigan
Grand Rapids
Detroit
Chicago
Rochester
Buffalo
NEW YORK
Lake Erie
Albany
Bos
Provi
Cleveland
New York
Pittsburgh
INDIANA
Columbus
Philadelphia
ILLINOIS
Indianapolis
OHIO
Cincinnati
Ohio
Washington
St Louis
MISSOURI
Louisville
VIRGINIA
KENTUCKY
Richmond
Norfolk
Nashville
Greensboro
Knoxville
Raleigh
TENNESSEE
Charlotte
NORTH CAROLINA
ARKANSAS
Greenville
Birmingham
Atlanta
GEORGIA
ALABAMA
Jacksonville
FLORIDA
New Orleans
Houston
IOWA
PLAINS
APPALACHIAN MOUNTAINS

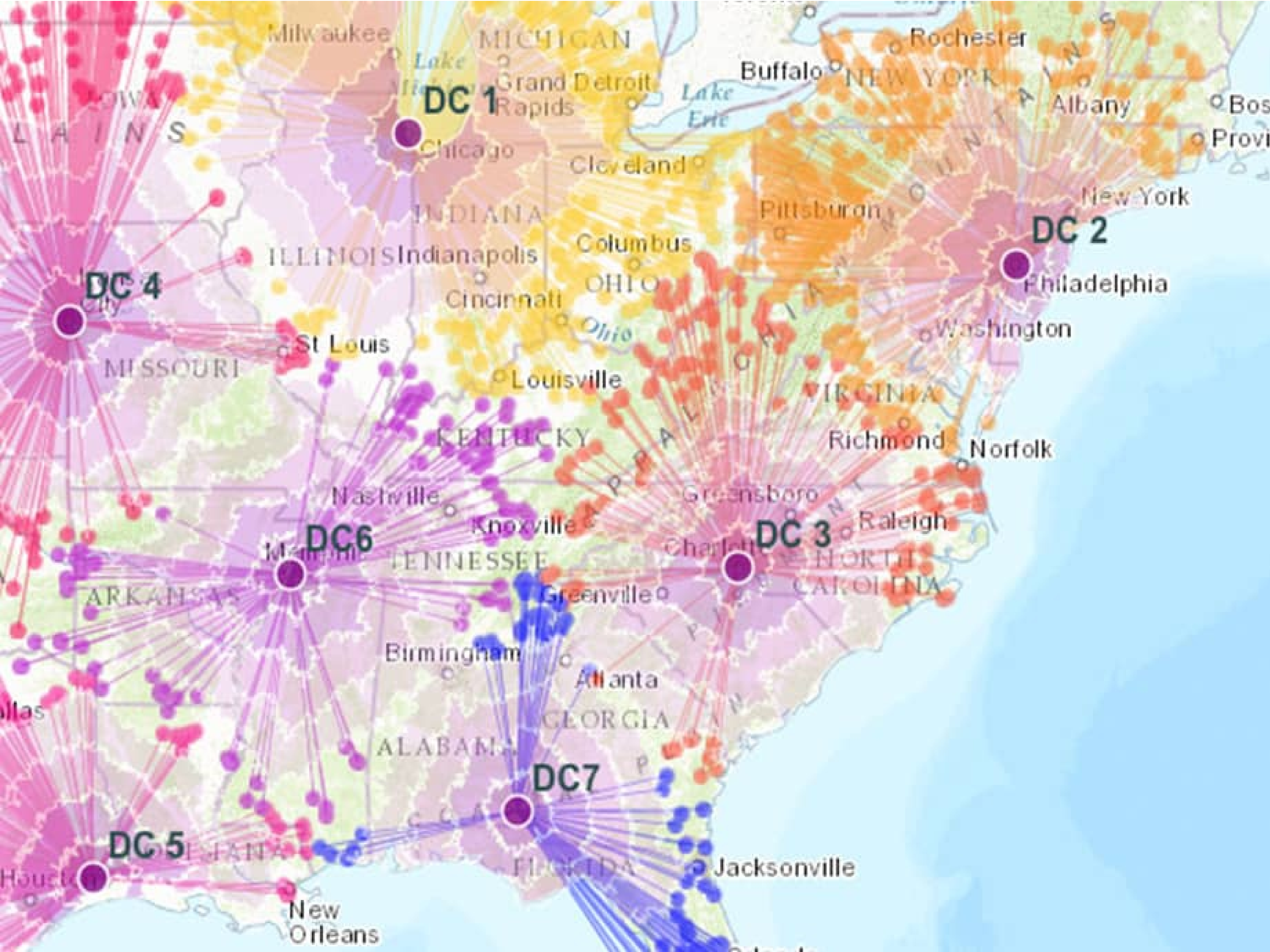

DC 1
DC 2
DC 3
DC 4
DC 5
DC6
DC7
Milwaukee
MICHIGAN
Grand Rapids
Detroit
Chicago
Cleveland
Rochester
Buffalo
NEW YORK
Albany
New York
Pittsburgh
Philadelphia
Washington
INDIANA
ILLINOIS
Indianapolis
Columbus
OHIO
Cincinnati
St Louis
MISSOURI
Louisville
VIRGINIA
Richmond
Norfolk
KENTUCKY
Nashville
Knoxville
Greensboro
Raleigh
TENNESSEE
NORTH CAROLINA
ARKANSAS
Greenville
Birmingham
Atlanta
GEORGIA
ALABAMA
Jacksonville
New Orleans

GEO157

WEEK	Monday am (1) *Lecture A* *09:10-10:30* *Sproul 2225*	Monday am (2) *Lecture B* *10:40-12:00* *Sproul 2225*	Monday *Office Hours:* *1-3 pm*	Friday am *LAB* *09:10-12:00* *Sproul 2225*	Friday *Exrta lab hours:* *12-2 pm*
(#1) 2nd / 6th April	**Course introduction** Course introduction and logistics. Laptop software installation.			**fake 'fieldwork' fun** Paper-based and web-based GIS-like problems.	
(#2) 9th / 13th April	**Lecture 1, Discussion** Chapter 1: What is GIS? **Problem Set 0 due**	**Lecture 2** Chapter 2: Spatial data **Problem Set 1 (Ch. 1)**		**Lab 1** Digitizing	
(#3) 16th / 20th April	**Worked problems** **Problem Set 1 due**	**Lecture 3** Chapter 3: Spatial data modelling **Problem Set 2 (Ch. 2+3)**		**Lab 2** GPS, Georeferencing, and Geocoding **Lab 1 due**	
(#4) 23rd / 27th April	**Worked problems** **Problem Set 2 due**	**Lecture 4** Chapter 4: Database management		**Lab 3** Interpolating weather **Lab 2 due**	
(#5) 30th / 4th May	**Worked problems** **Oral presentations set**	**Lecture 5** Chapter 5: Data input and editing **Problem Set 3 (Ch. 4+5)**		**Lab 4** Vector analysis using earthquake data **Lab 3 due**	

GEO157

WEEK	Monday am (1) *Lecture A* *09:10-10:30* *Sproul 2225*	Monday am (2) *Lecture B* *10:40-12:00* *Sproul 2225*	Monday *Office Hours:* *1-3 pm*	Friday am *LAB* *09:10-12:00* *Sproul 2225*	Friday *Exrta lab hours:* *12-2 pm*
(#1) 2nd / 6th April	**Course introduction** Course introduction and logistics. Laptop software installation.			**fake 'fieldwork' fun** Paper-based and web-based GIS-like problems.	
(#2) 9th / 13th April	**Lecture 1, Discussion** Chapter 1: What is GIS? **Problem Set 0 due**	**Lecture 2** Chapter 2: Spatial data **Problem Set 1 (Ch. 1)**		**Lab 1** Digitizing	
(#3) 16th / 20th April	**Worked problems** **Problem Set 1 due**	**Lecture 3** Chapter 3: Spatial data modelling **Problem Set 2 (Ch. 2+3)**		**Lab 2** GPS, Georeferencing, and Geocoding **Lab 1 due**	
(#4) 23rd / 27th April	**Worked problems** **Problem Set 2 due**	**Lecture 4** Chapter 4: Database management		**Lab 3** Interpolating weather **Lab 2 due**	
(#5) 30th / 4th May	**Worked problems** **Oral presentations set**	**Lecture 5** Chapter 5: Data input and editing **Problem Set 3 (Ch. 4+5)**		**Lab 4** Vector analysis using earthquake data **Lab 3 due**	


DC 1
DC 2
DC 3
DC 4
DC 5
DC6
DC7
Milwaukee
MICHIGAN
Grand Rapids
Detroit
Chicago
Cleveland
Buffalo
Rochester
NEW YORK
Albany
New York
Pittsburgh
Philadelphia
Washington
INDIANA
ILLINOIS
Indianapolis
Columbus
OHIO
Cincinnati
St Louis
MISSOURI
Louisville
KENTUCKY
VIRGINIA
Richmond
Norfolk
Nashville
Knoxville
Greensboro
Raleigh
TENNESSEE
NORTH CAROLINA
Greenville
ARKANSAS
Birmingham
Atlanta
GEORGIA
ALABAMA
Jacksonville
New Orleans
FLORIDA