EnvSci 360 Computer and Analytical Cartography

Lecture 4

Level of Data Measurement

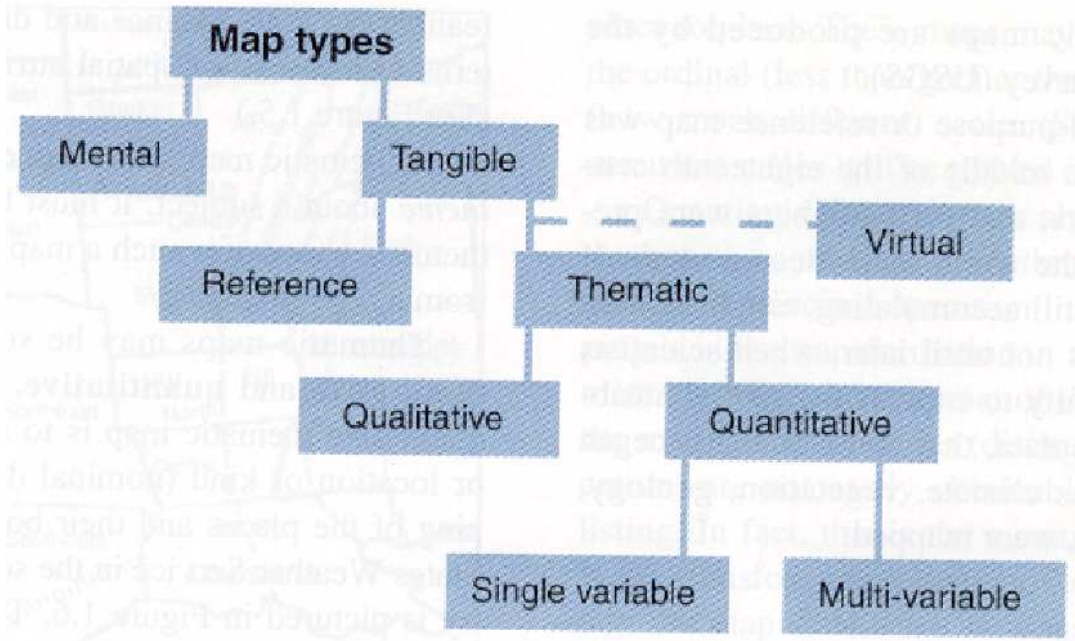
Thematic Mapping

Data Classification

Types of Maps

- Data always plays a role
- Maps – no matter what type -- are used to visualize measurements of:
  - Spatial Data
    - Entities
  - Aspatial Data
    - Attributes

Link together



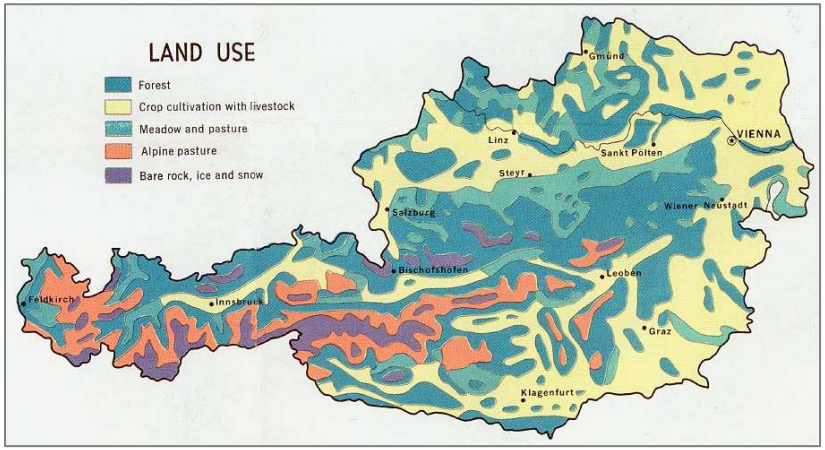
Level of Measurement

Nominal	*Qualitative*
Ordinal	
Interval	*Quantitative*
Ratio	

Ways to organize data -- Affects analysis and symbolization

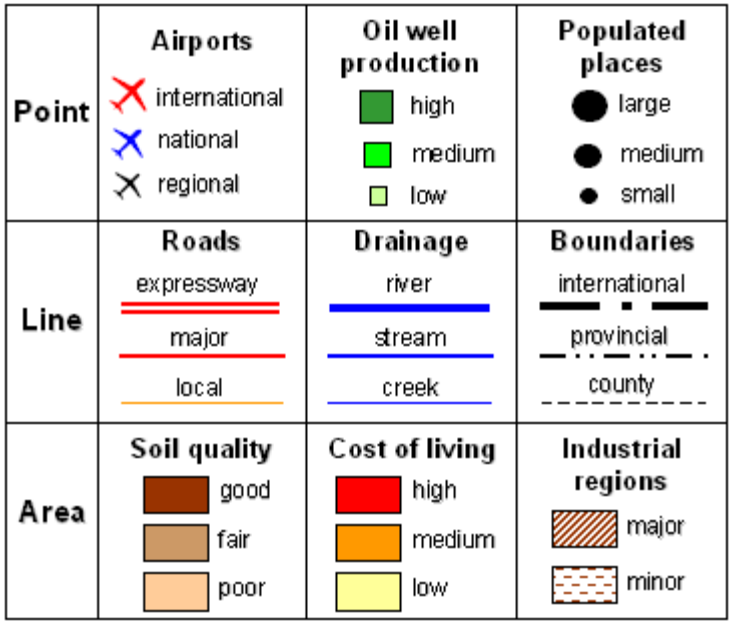
Level of Measurement: Nominal

- Distinguish features based on ***qualitative*** considerations, i.e. differences in kind
  - Establish identity of features
  - Assign items to groups or categories based on type (not on ordered value – no ranking)
  - *Examples: hospital ER status, land use*



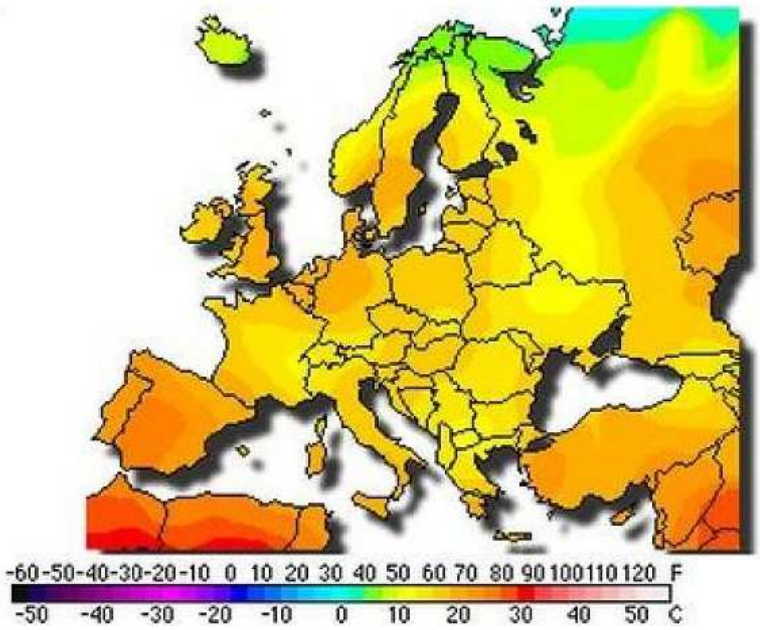
Level of Measurement: Ordinal

- Implies value by sequence or rank (good, better, best; low, medium, high) – order by some ***quantitative*** measure
  - Intervals between the numbers are not necessarily equal
  - No magnitude of difference; not measurable
  - Symbology must reflect the quantitative hierarchy



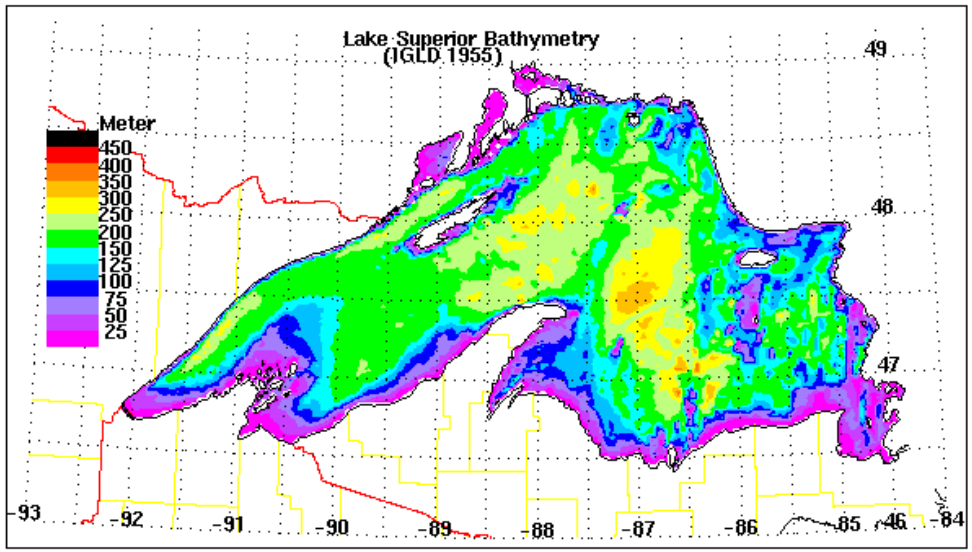
Level of Measurement: Interval

- Differences between values is measurable but no absolute zero (may be based on a standard "starting point")
  - Can't say how many times higher one value is than another
  - *Example: F or C temperature scale*
    - 30 degrees F is 15 degrees higher than 15 degrees F, but not twice as warm



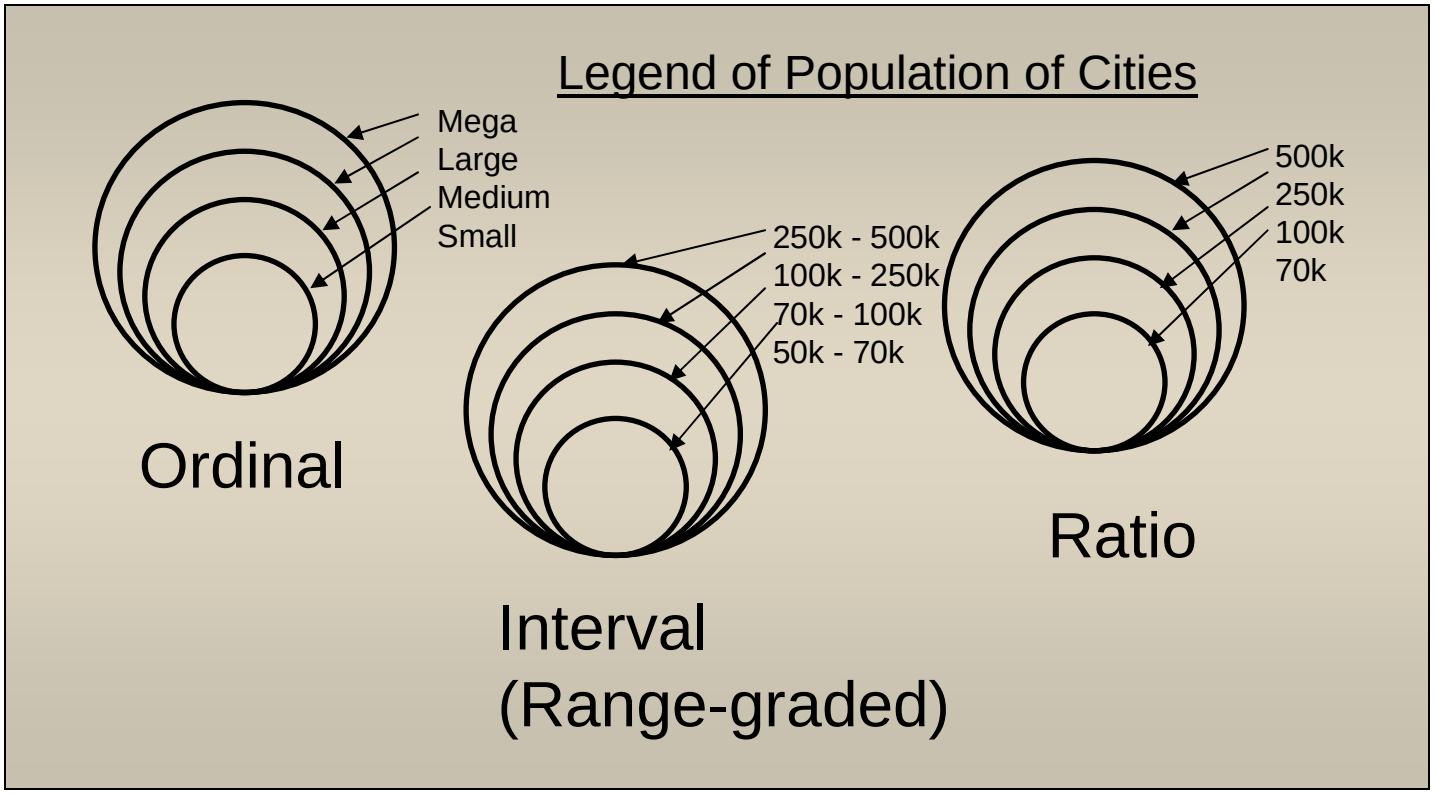
Level of Measurement: Ratio

- Differences between values is measurable (based on weight, length and area)
- Has a true zero (no features or sea level, e,g.)
  - *Examples: bathymetry, population (totals or density)*



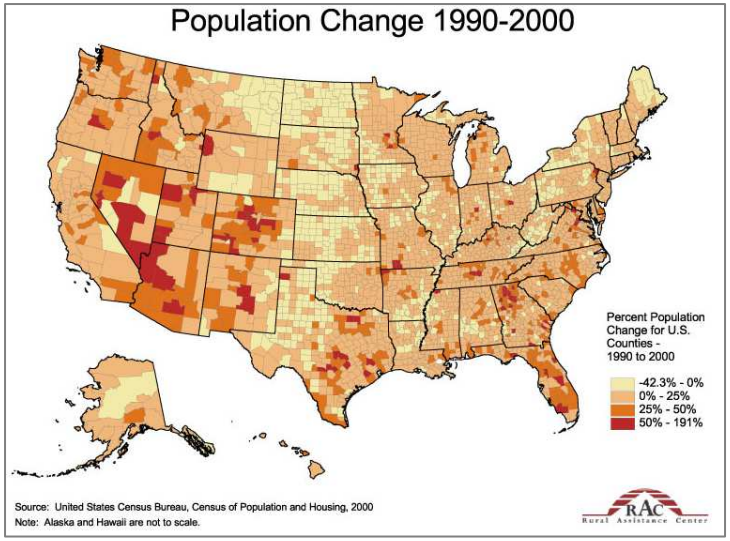
Level of Measurement

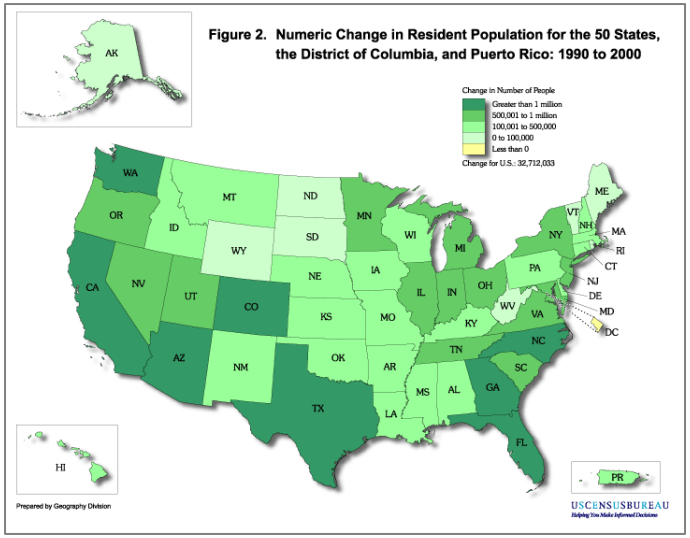
- Comparison using same symbols, but different levels of measurement



Level of Measurement

- NOTE: Nested in one direction only
  - data at higher levels can be reduced or generalized to lower levels, but not vice versa
  - on maps, data can be displayed below, but not above, their measurement level



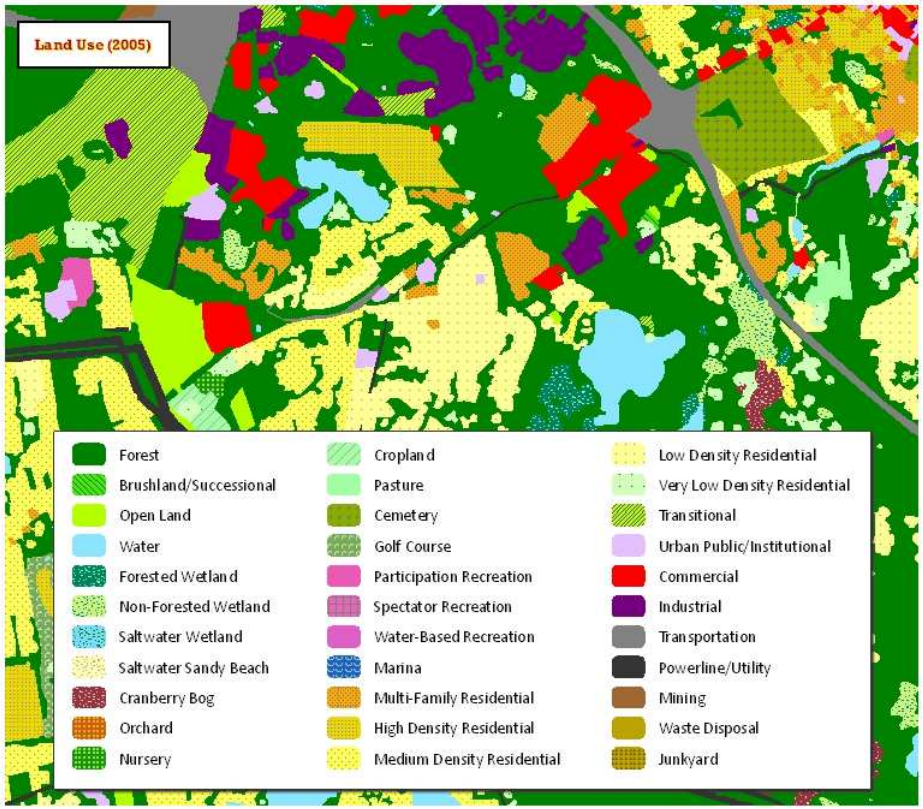


Nature of Geographic Phenomena

- Discrete
  - Individual items at particular locations
  - Empty intervening areas or zero value
  - *Examples - houses, monitoring stations, roads, calderas*
- Continuous
  - No location is empty
  - Surfaces may be smoothed or stepped
  - *Examples - land use, temperature, elevation*

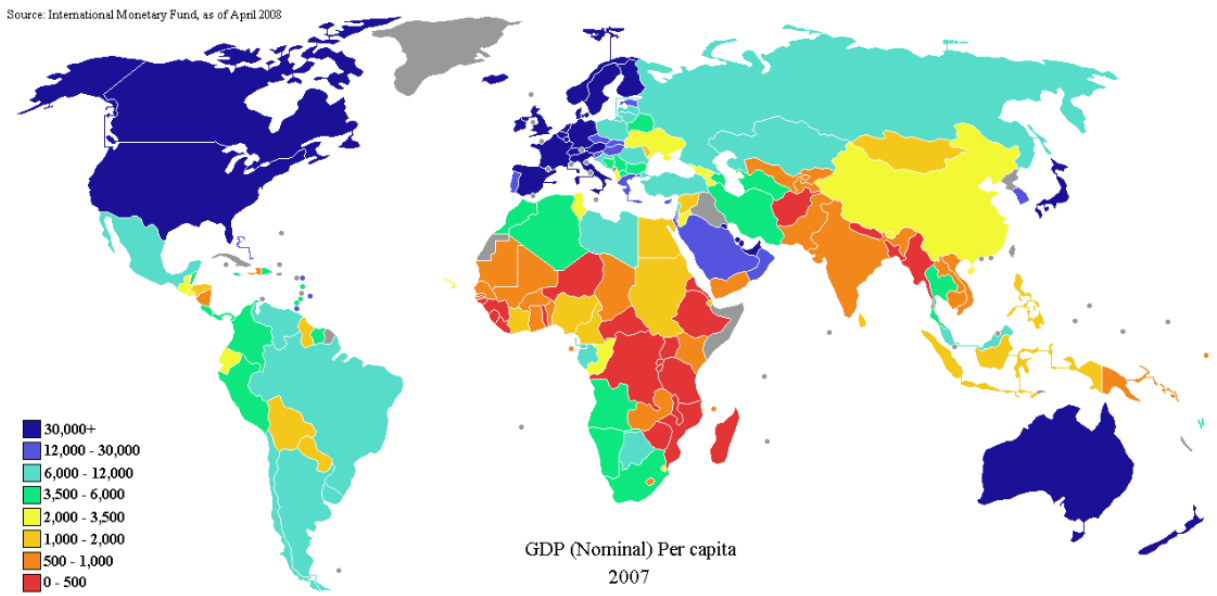
Absolute vs. Derived Data

- **Absolute** - "raw" data values
  - Single class of features
  - Uses appropriate measurement scale
  - Examples:
    - *land use*
    - *temperature*
    - *soil types*
    - *elevation*



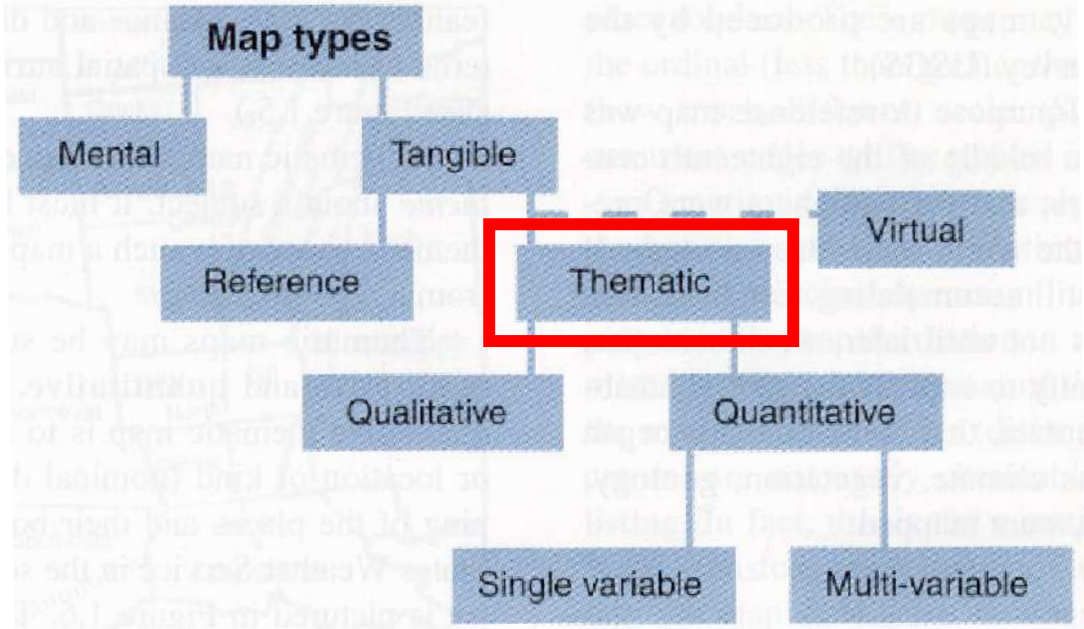
Absolute vs. Derived Data

- **Derived**
  - Obtained from raw data
  - Summarization or relationship between features (averages, ratios, densities, and potentials).
    - *population density, average temperature, per capita income, etc.*



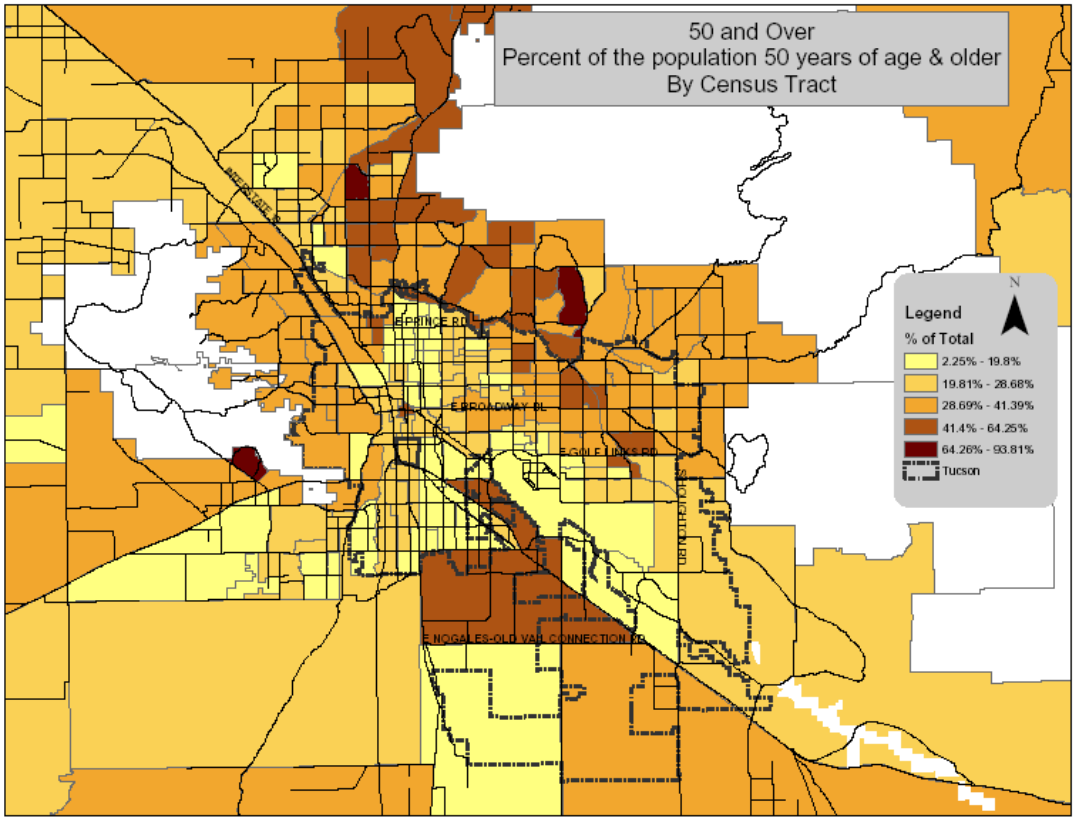
Thematic Maps

- Let's take a look at how levels of measurement, discrete and continuous data, and absolute and derived data come in to play when designing thematic maps



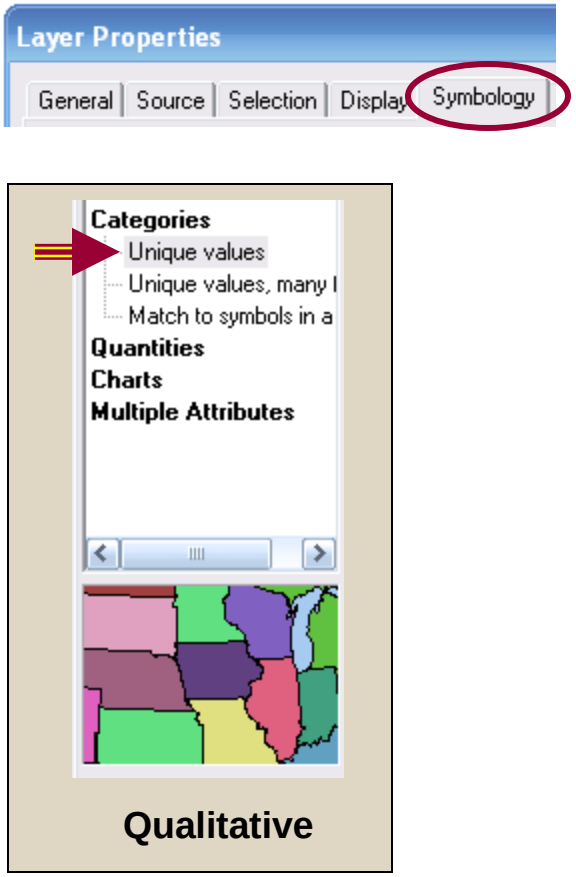
Thematic Maps

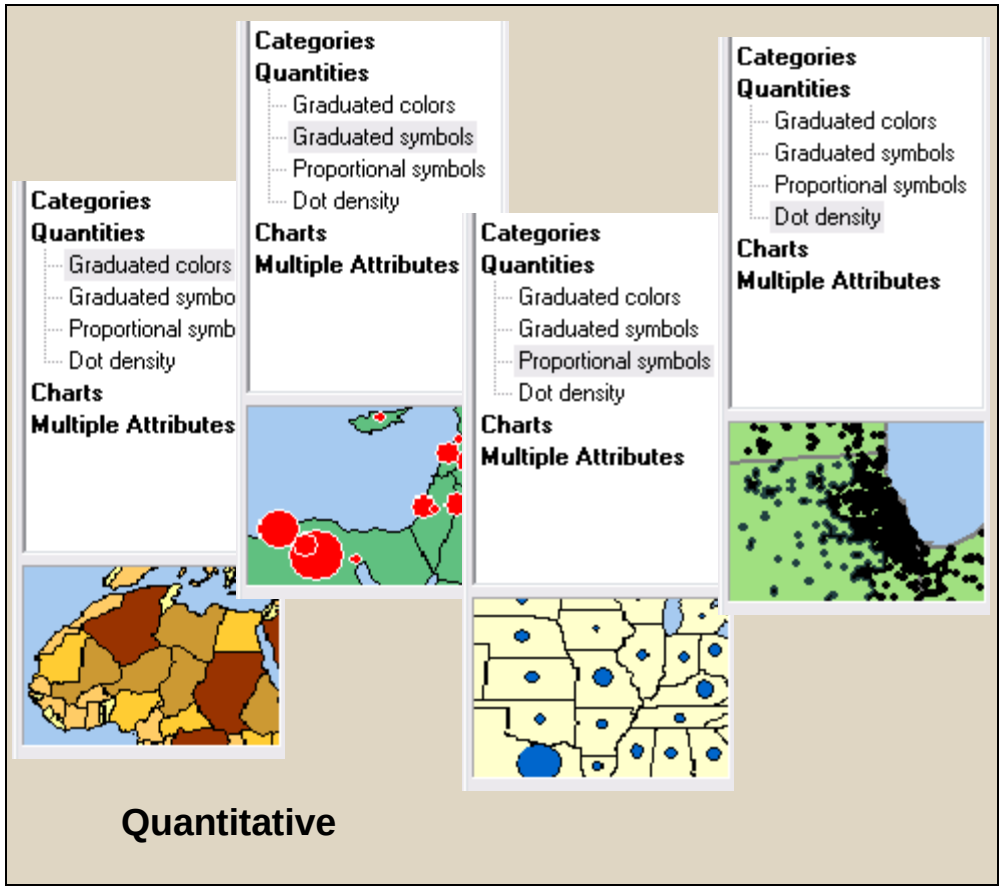
- Known as "special purpose" maps
- Display aspatial data spatially (by linking them together)
- Focus on a feature and display its spatial pattern
- There are a number of mapping techniques for displaying thematic information



Thematic Maps

- Consider whether data are **Qualitative** or **Quantitative**

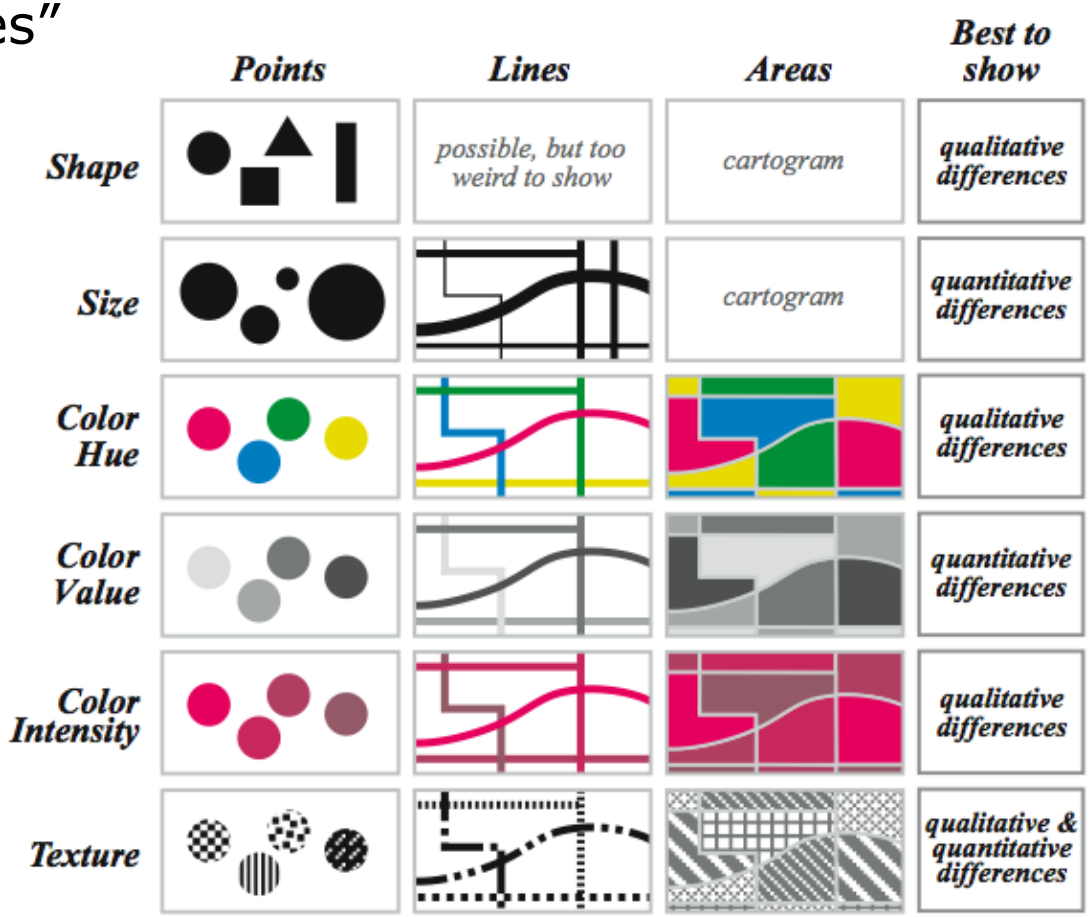




Qualitative vs. Quantitative Data

- Distinguish differences in data with cartographic "visual variables"

The graphic language used to represent information about the world, whether reference or thematic, qualitative or quantitative, consists of point, line, and area symbols.

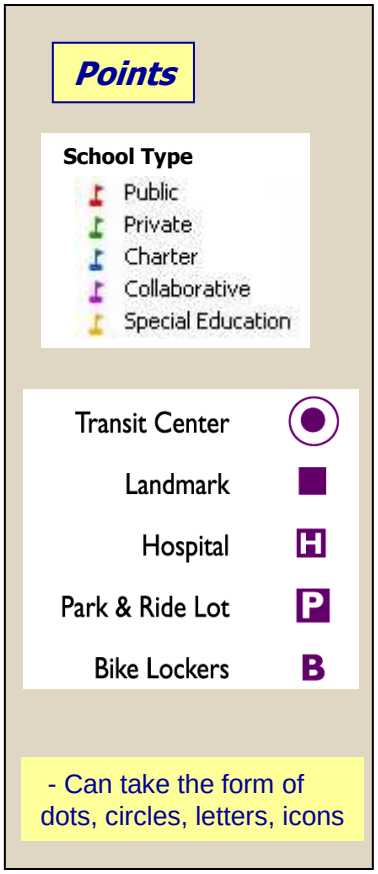


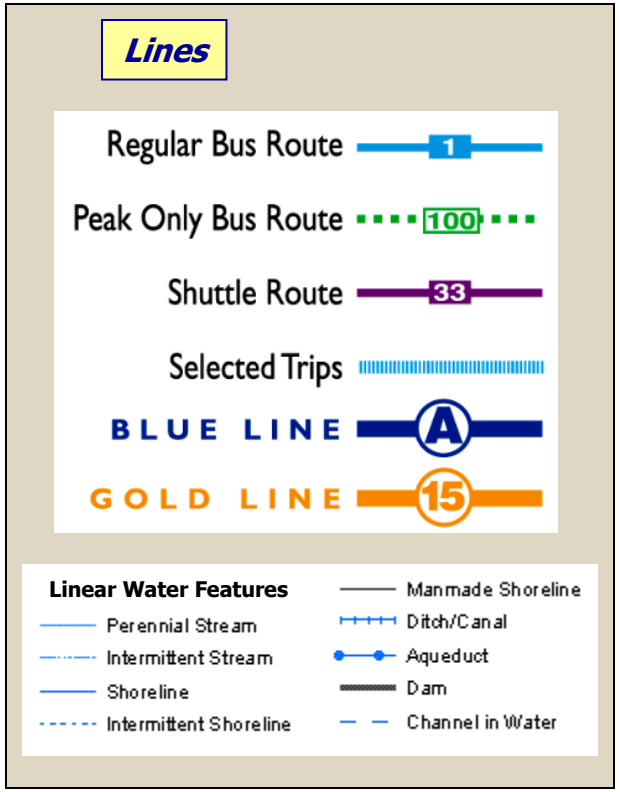
Qualitative Data Maps

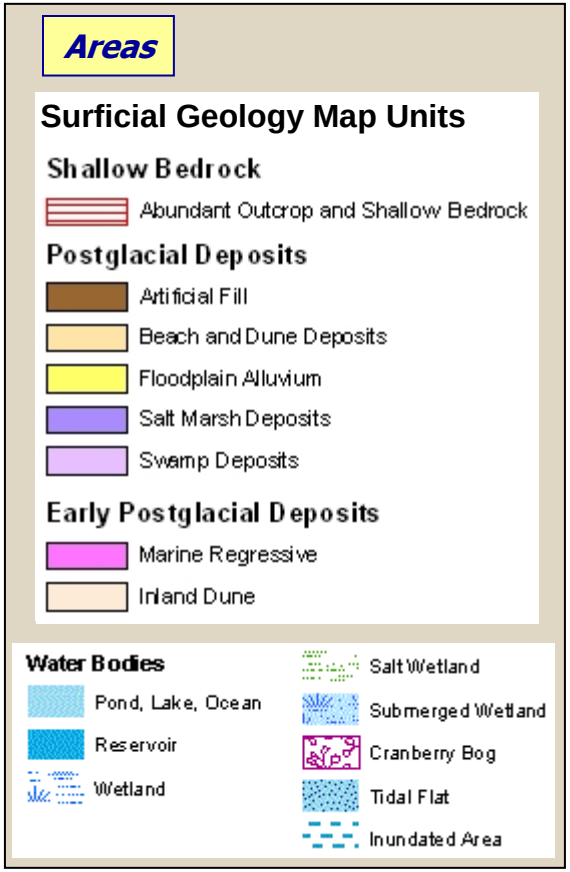
- Based on unique **numeric or character** fields in attribute table

Qualitative Data Maps

- Classification method using color hue and shape and texture to symbolize different categories of data

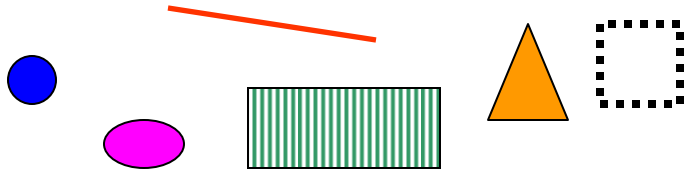


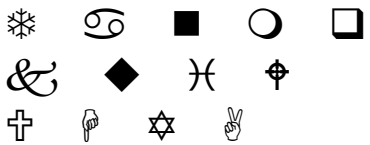


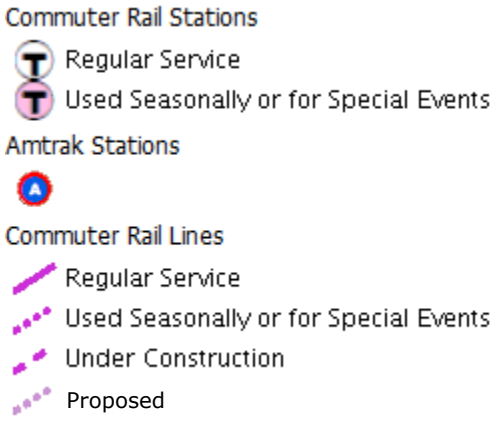


Qualitative Data Maps

- Types of symbols
  - Geometric Symbols
    - Dot
    - Line
    - Solid- or line-filled area
  - Mimetic Symbols
    - Pictorial, look like the feature
    - Must be unambiguous
    - Not too much detail if small
    - Don't be too whimsical – may lose detail
    - You can create your own and combine existing symbols together

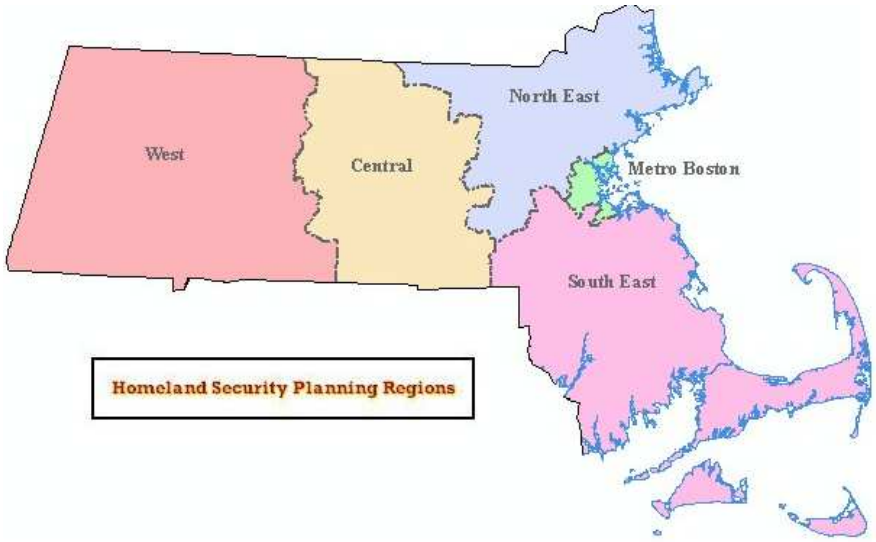




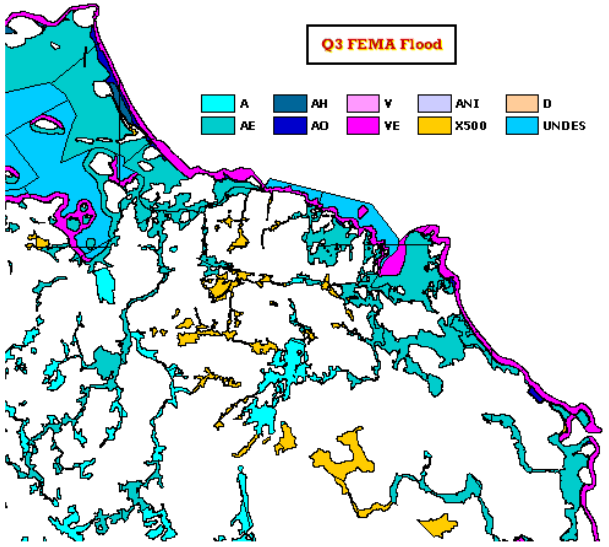


Qualitative Data Maps

- Qualitative thematic maps are also known as descriptive maps. Some examples:
  - Region Maps
  - Resource Maps



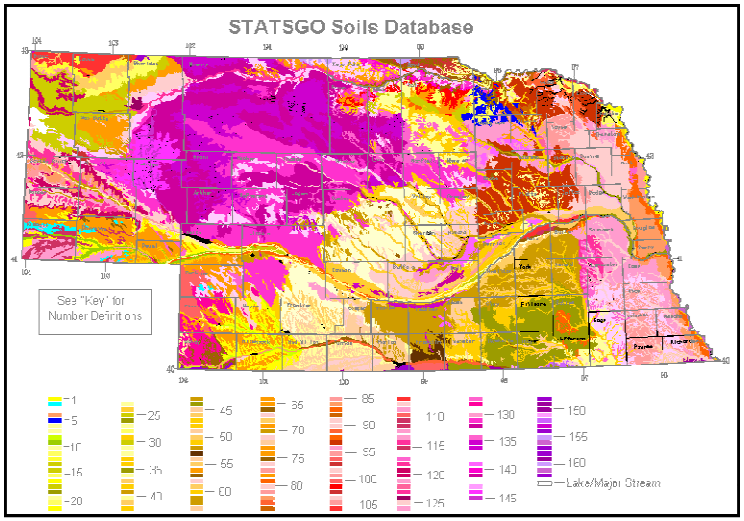
Boundaries based on pre-defined areas (e.g., states, Census Blocks)

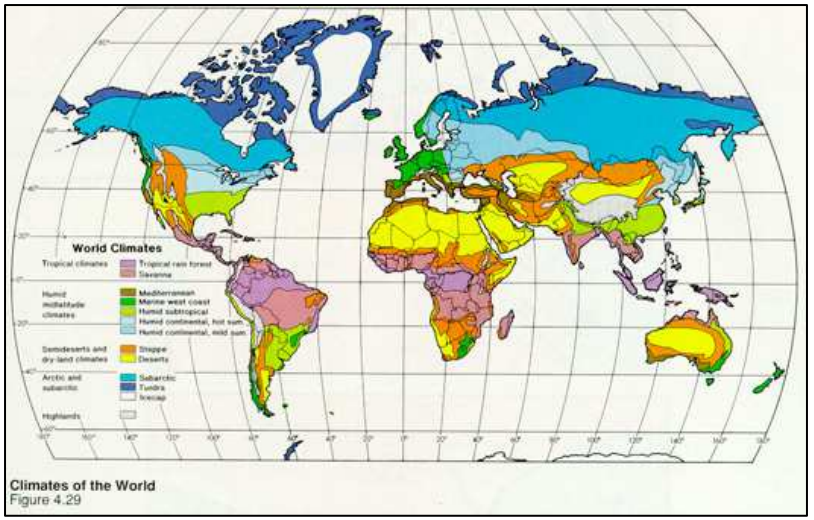


Boundaries defined by spatial distribution of data

Qualitative Data Maps

- More resource-based thematic maps

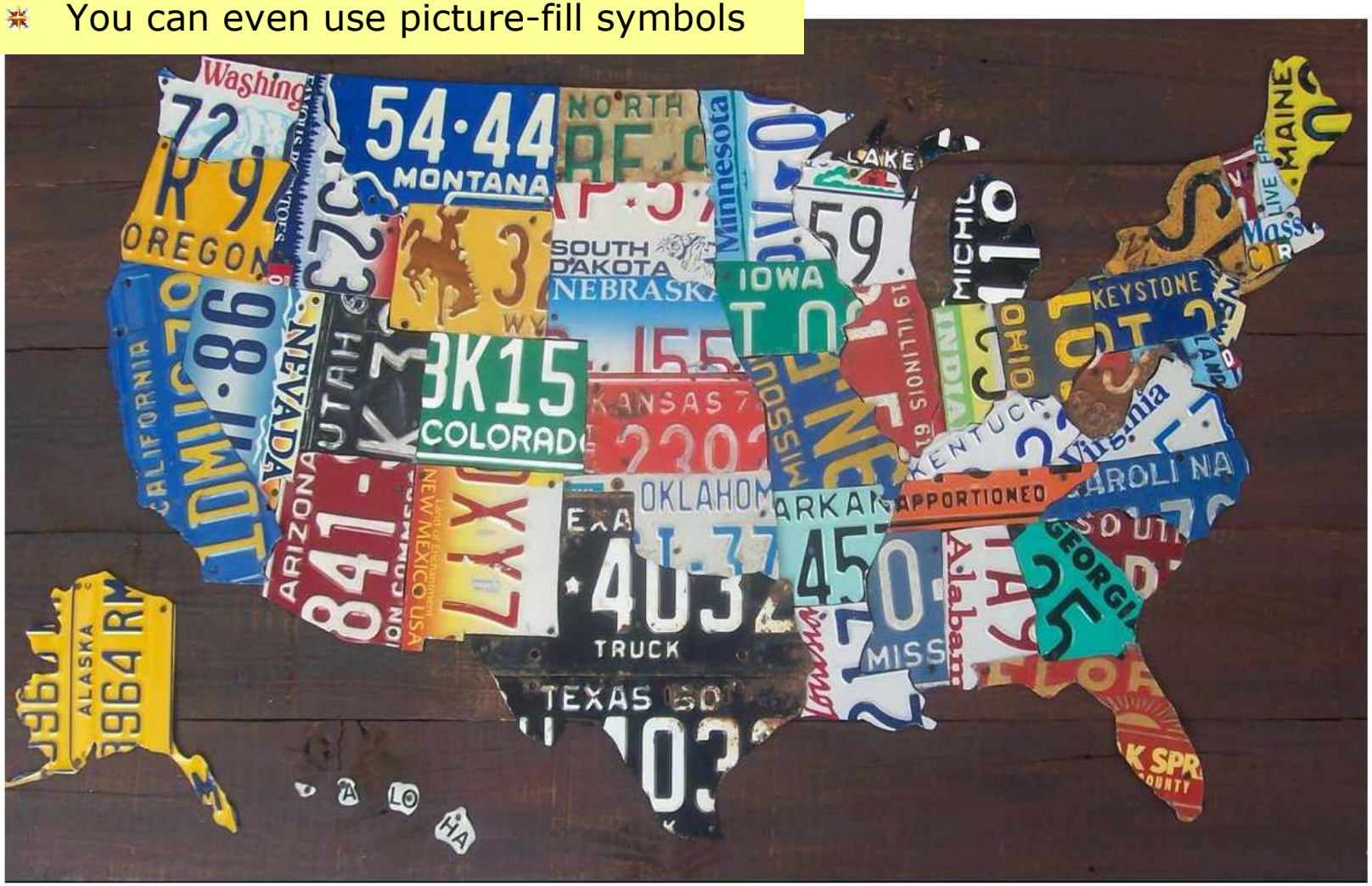




Two more examples where the boundaries between categories are defined by the spatial distribution of the data, independent of political or other administrative areas.

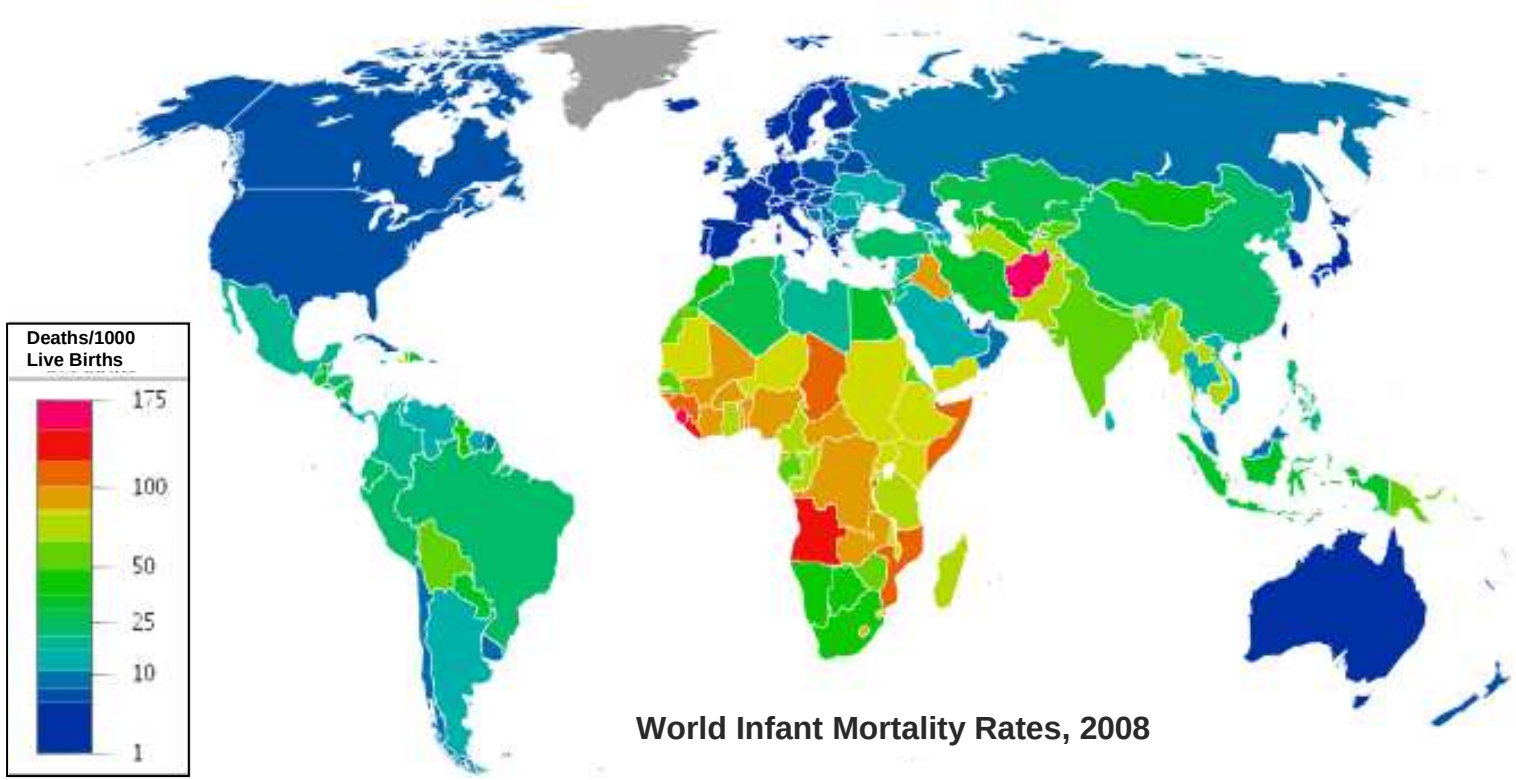
Qualitative Data Maps

- You can even use picture-fill symbols



Quantitative Data Maps

- Based on **numeric** attribute data, grouped into statistical categories (classes)
  - Not every unique value is mapped



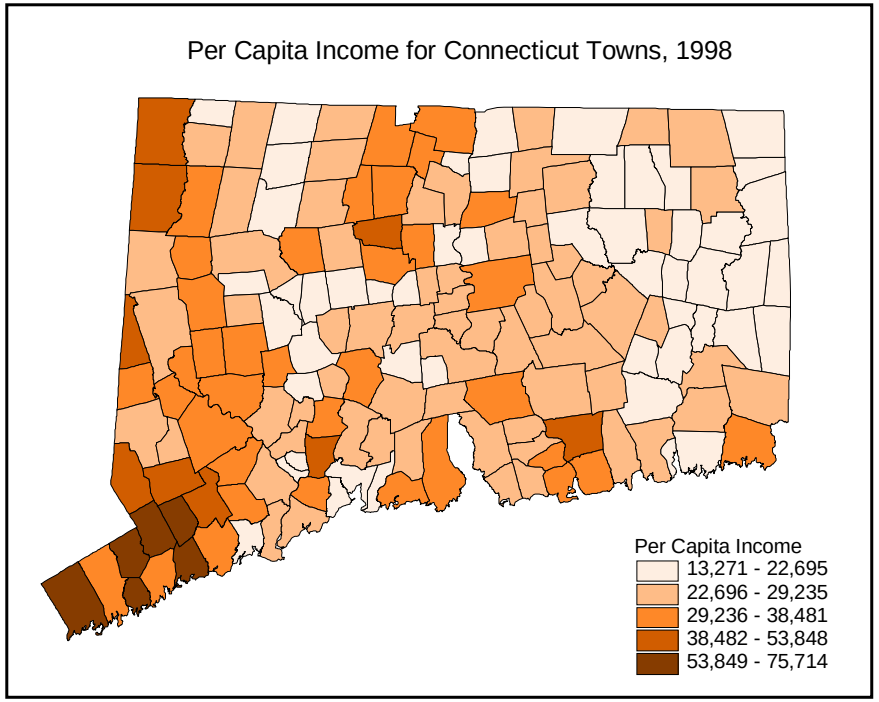
World Infant Mortality Rates, 2008

Types of Quantitative Data Maps

- **Choropleth**
  - Use a uniform color or pattern to fill an area based on pre-defined zones (e.g., states, counties, Census boundaries)
- **Isopleth**
  - Use color to fill areas defined by isolines (lines representing equal values)
- **Graduated symbol, Proportional symbol**
  - Use scaled symbols (points or lines) in order to indicate the relative quantity of a particular data attribute
- **Chart/Graphs**
  - Use pie charts or bar graphs to represent values of a pre-defined zone
    - May also be proportionally sized
- **Dot (dot density)**
  - Use a fixed size dot symbol to represent a fixed quantity of data

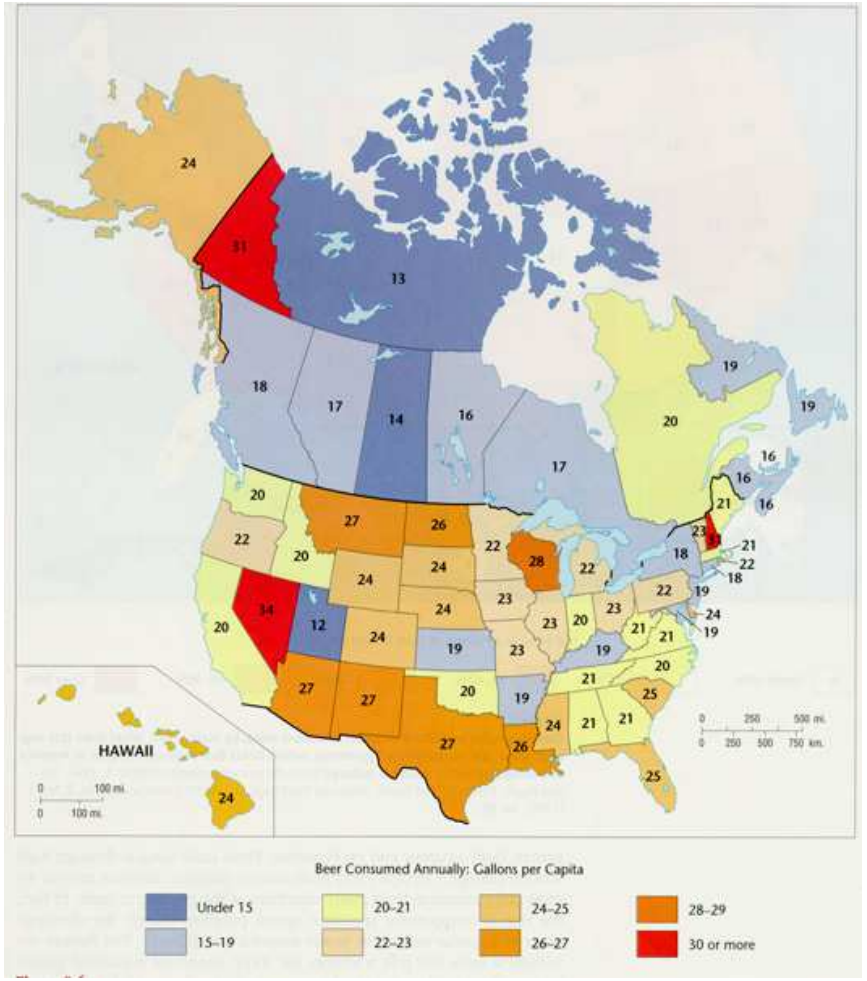
Choropleth Maps

- Use of reporting zones (areal units) to symbolize volume
  - Zones are independent of (not defined by) data
  - Types of attributes:
    - population density
    - mortality rates
    - average income
    - Etc., etc., etc.
  - **Use normalized, not raw data values (divide one field by another), or group values**



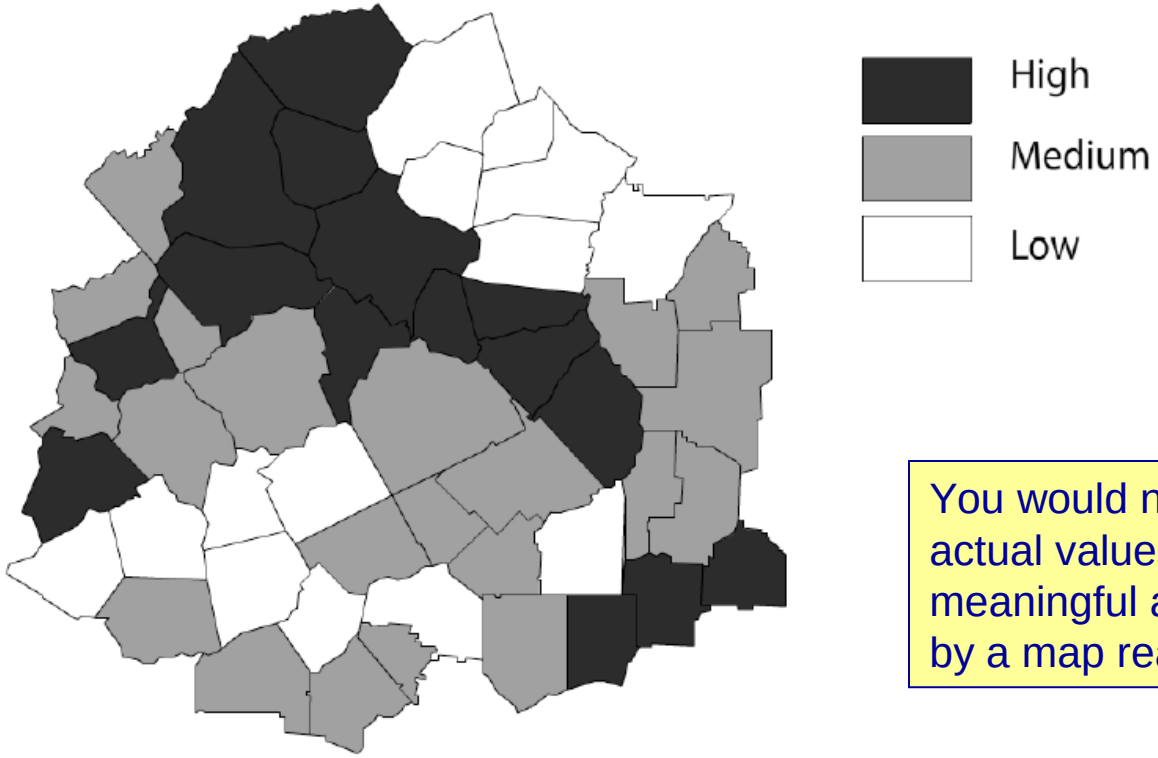
Choropleth Maps

- As long as you can link data (aspatial numeric attributes) to your area of interest (spatial component) using common fields (like State abbrev., Town ID, etc.) you can group and map them
- From *Choros - place, Pleth - value*



Choropleth Maps

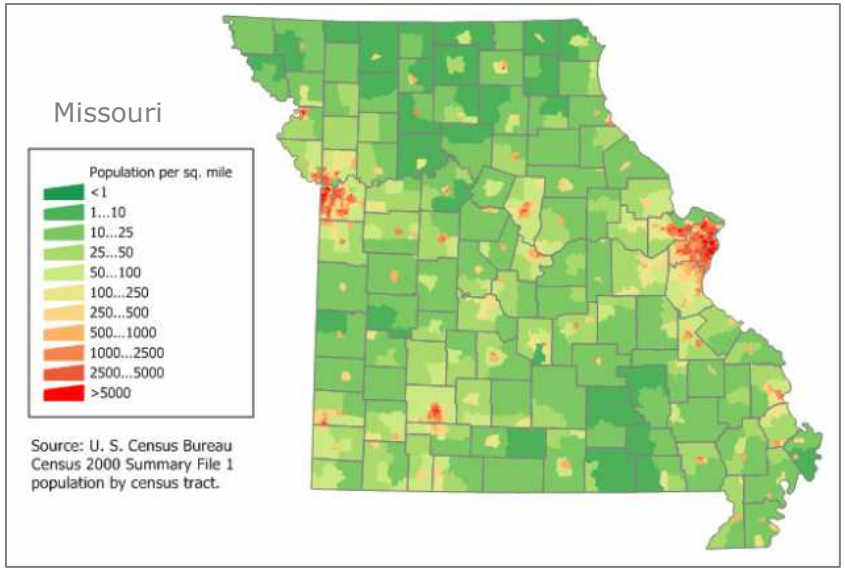
- Values usually follow the convention of darker meaning more and lighter meaning less



You would normally use actual values unless text is meaningful and understood by a map reader.

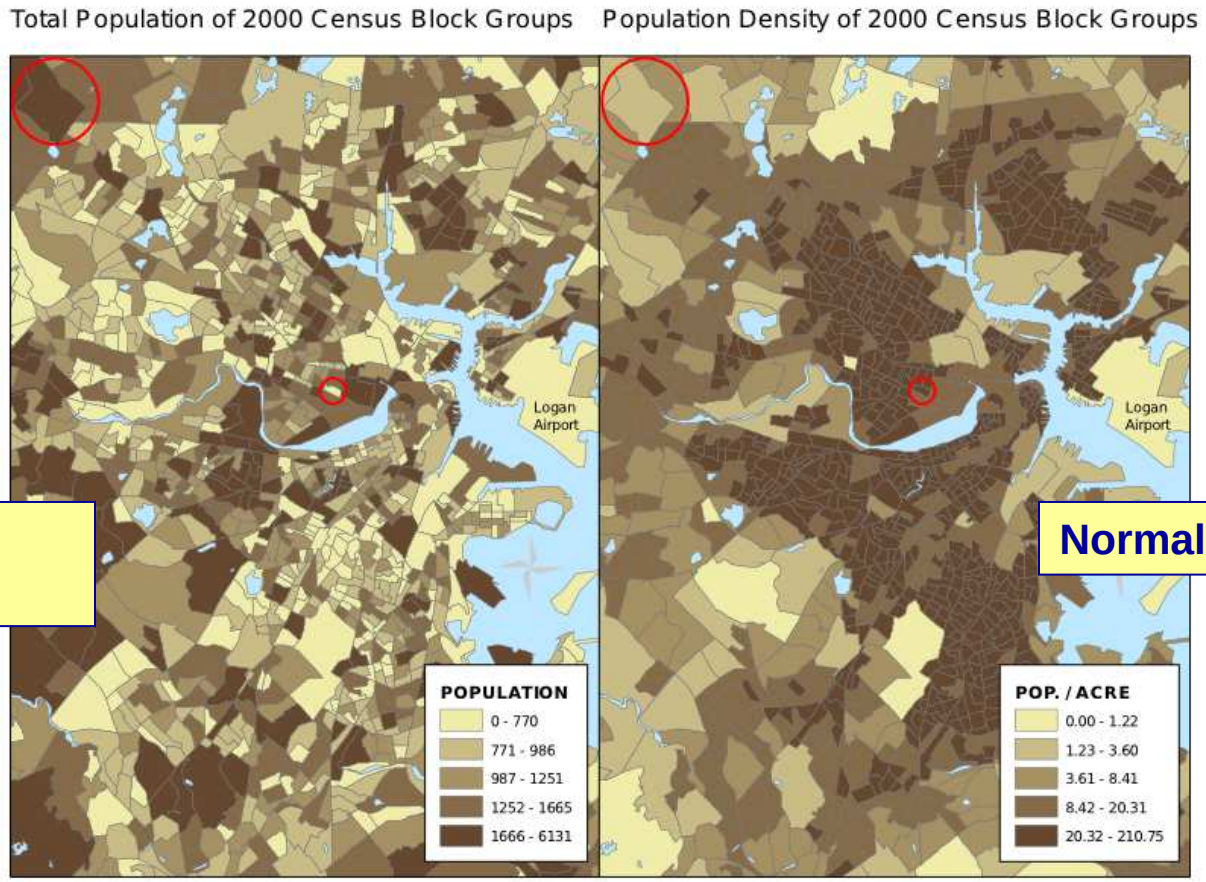
Choropleth Maps

- Considerations of classed choropleth mapping
  - Size and shape of unit areas
    - Better if small
    - Better if equal size
  - Number of classes
    - Consider maximum that can be easily read
    - Depends on monochromatic or color
  - Determining class limits
    - Should highlight critical values
    - Beware of biased views



Choropleth Maps

- Comparison of raw vs. normalized data (ratio mapping, derived data)



Raw values

Normalized

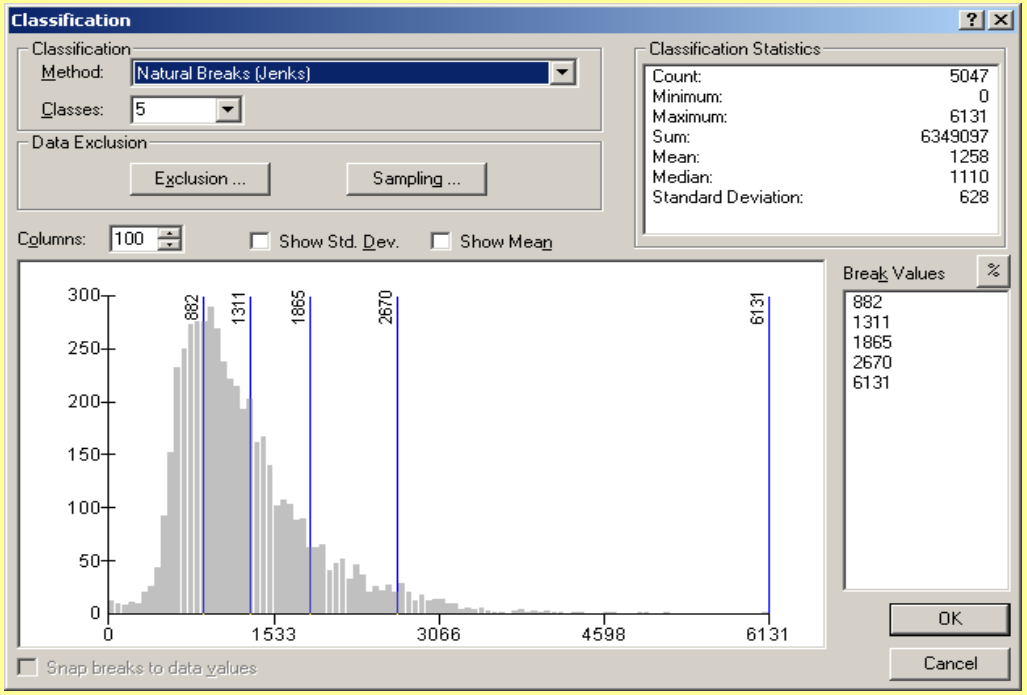
Provides a truer picture of actual phenomena

Classification Schemes

- **Ways to form the classes:**
  - **Natural Breaks** – based on natural groupings inherent in the data
  - **Equal Interval** – data divided into equal-sized ranges, based on set number of classes
  - **Defined Interval** – user defines the interval, which determines number of classes
  - **Quantile** – each class contains an equal number of features
  - **Standard Deviation** – shows how much an attribute value varies from the mean
  - **Manual** – user defines class breaks manually

Classification Schemes

- Base the scheme on the data you're using
- **Look at the distribution of values (view the histogram in ArcMap) – unique to each dataset**
- It's often difficult to distinguish more than 7 classes

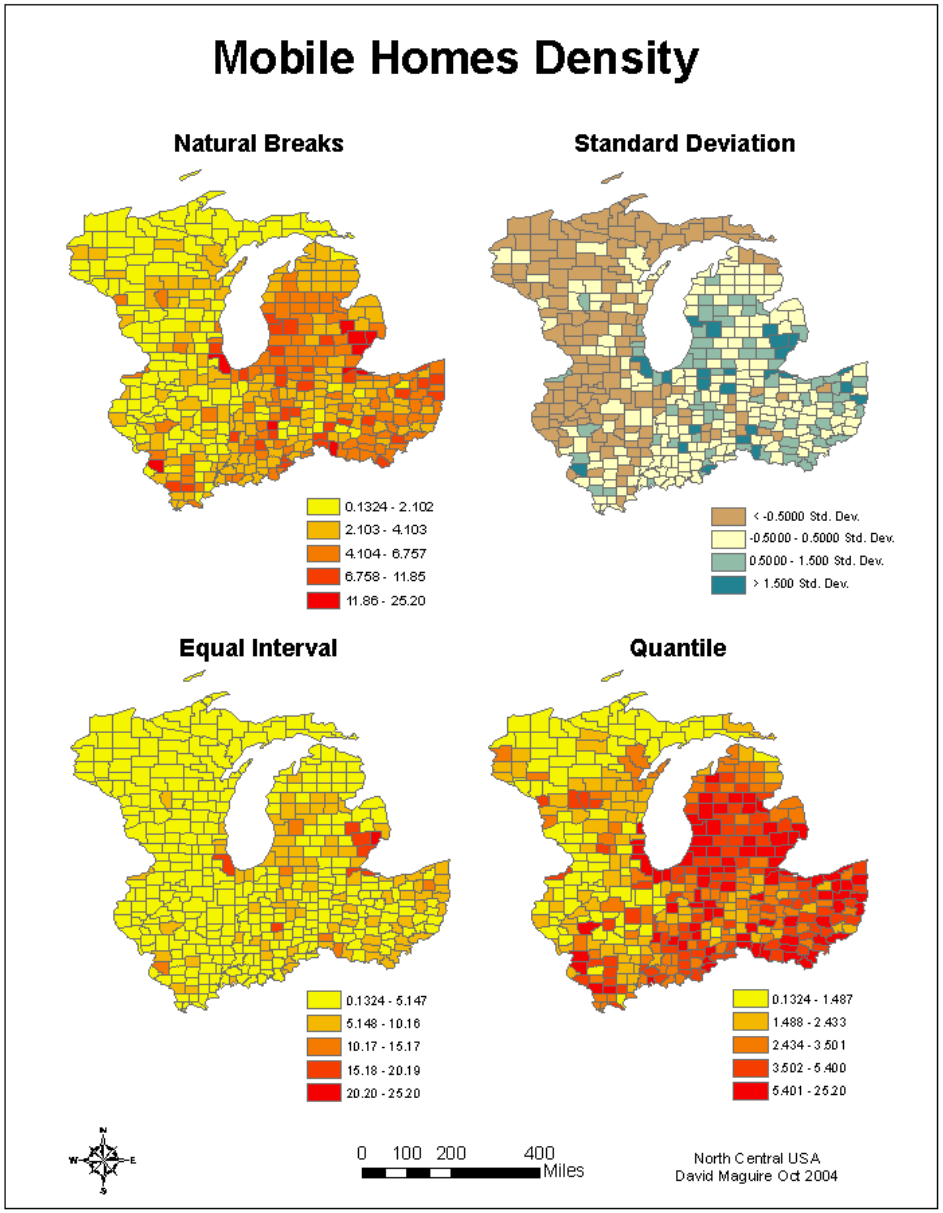


Histogram view in ArcMap

Classification Schemes

- Comparison of four choropleth classification schemes to map the same data

The method you choose can greatly affect the appearance of the map.



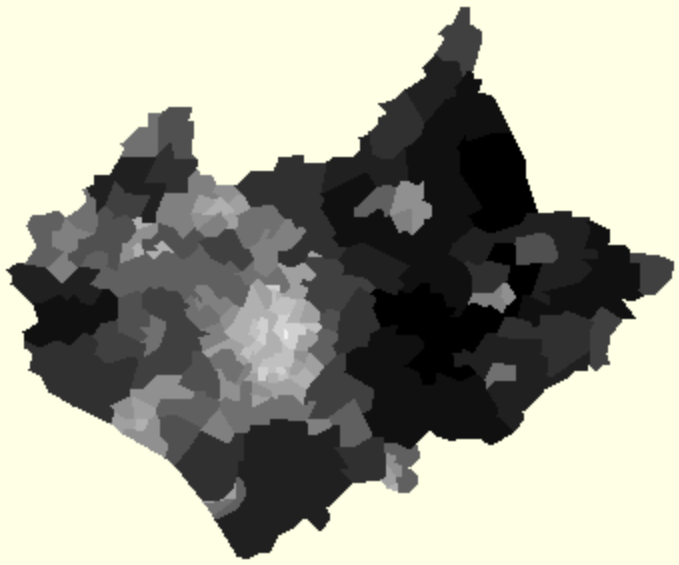
Classification Rules

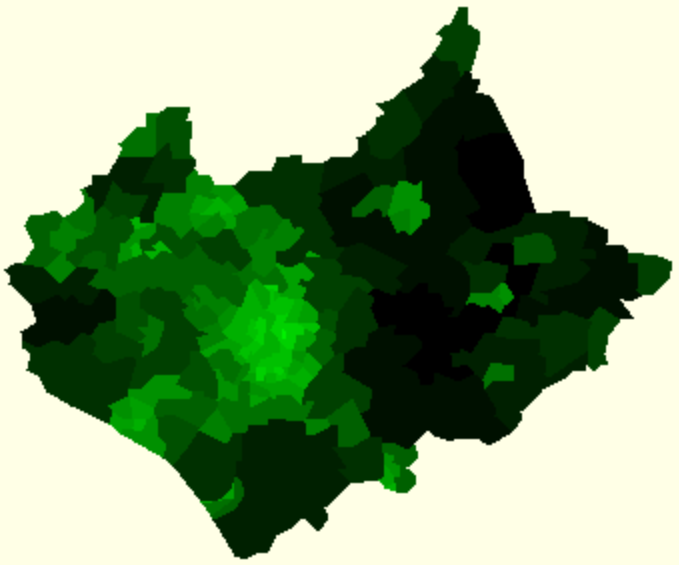
- Each class interval is unique
  - No data value can be in more than 1 category
  - Use 1-2, 3-4 or 1-2.9, 3-3.9 (not 1-2, 2-3, etc.)
- No gaps should exist between class intervals
  - Even if values don't exist (but may be overridden with ArcMap's "Use data values" checkbox)
- The number 0 (zero) is often a valid value
  - The absence of something can be as meaningful as its presence
- The classification scheme should make sense
  - Should be consistent and use understandable categories and intervals

Choropleth Maps

- Visual effects

Choropleth maps with gray and color shading

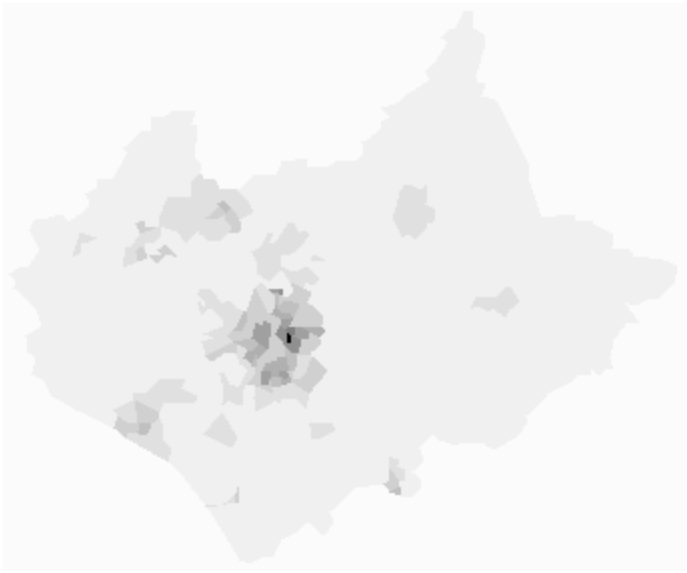




Choropleth Maps

- Visual effects

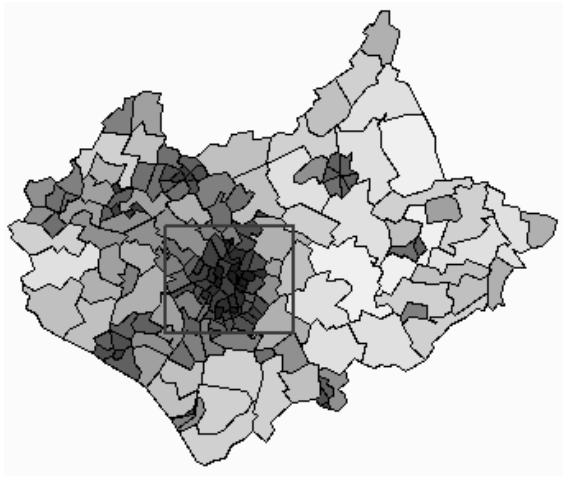
Choropleth maps with and without boundaries



Choropleth Maps

- Visual effects

Choropleth maps at different scales

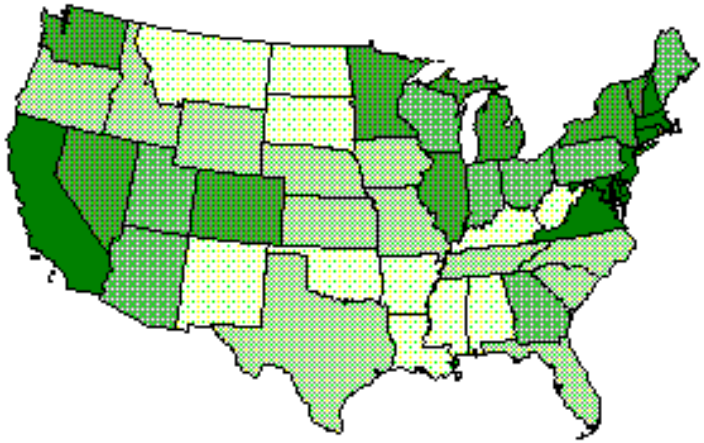


Small scale

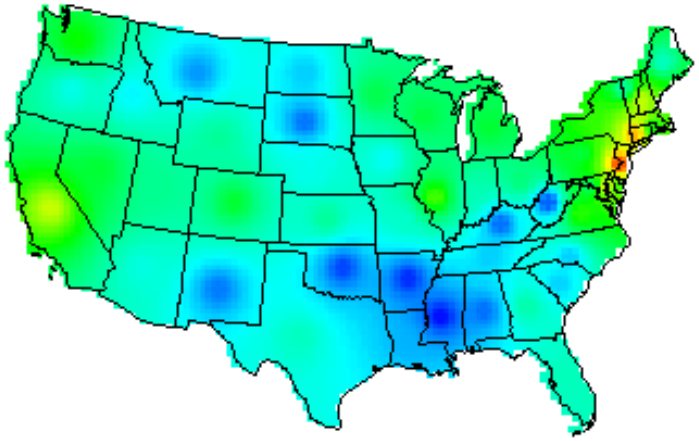
Large scale - easier to see shading differences when using outlines

Choropleth Maps

- Visual effects



Simple - stick to the boundary

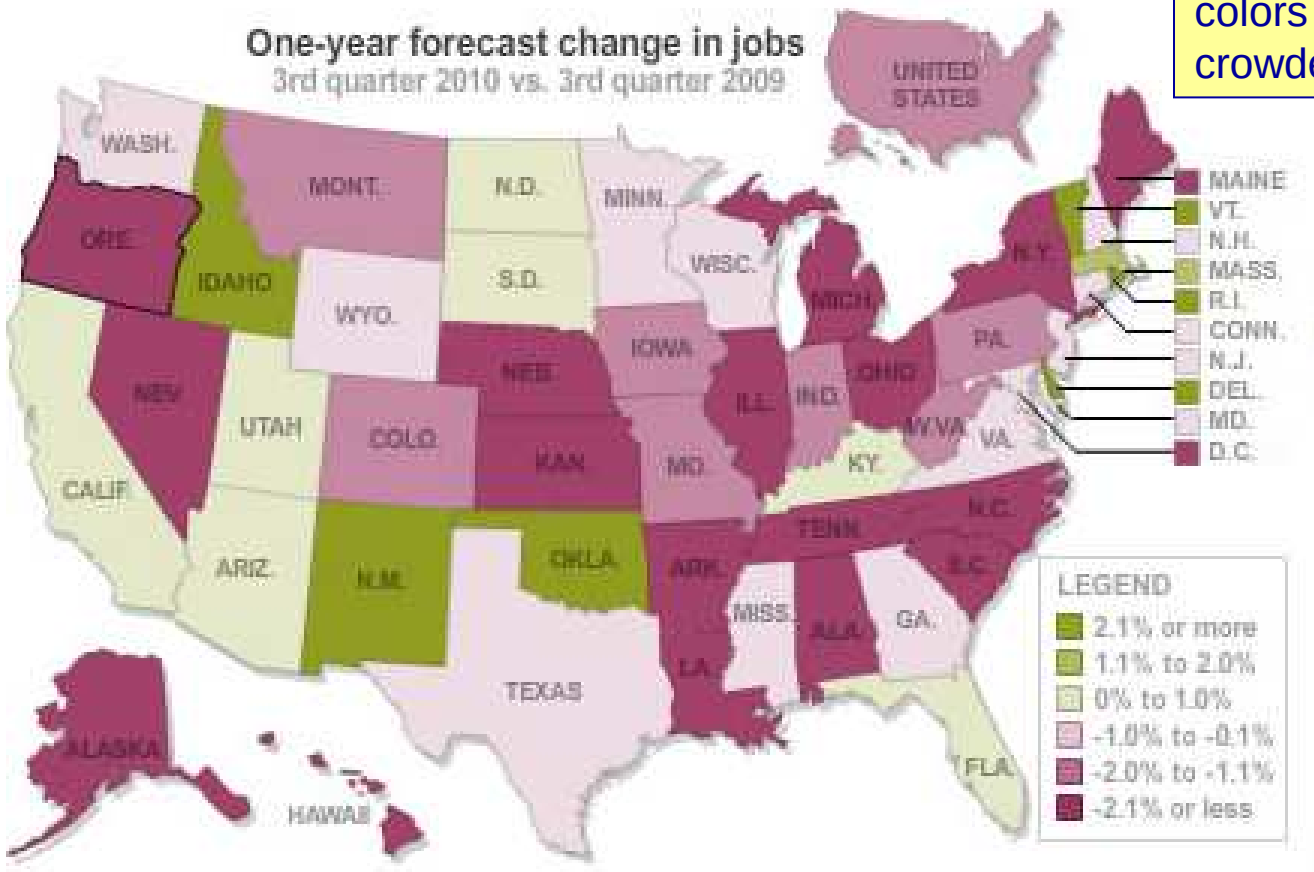


Classless - show gradual changes

Choropleth Maps

- Dealing with small polygons

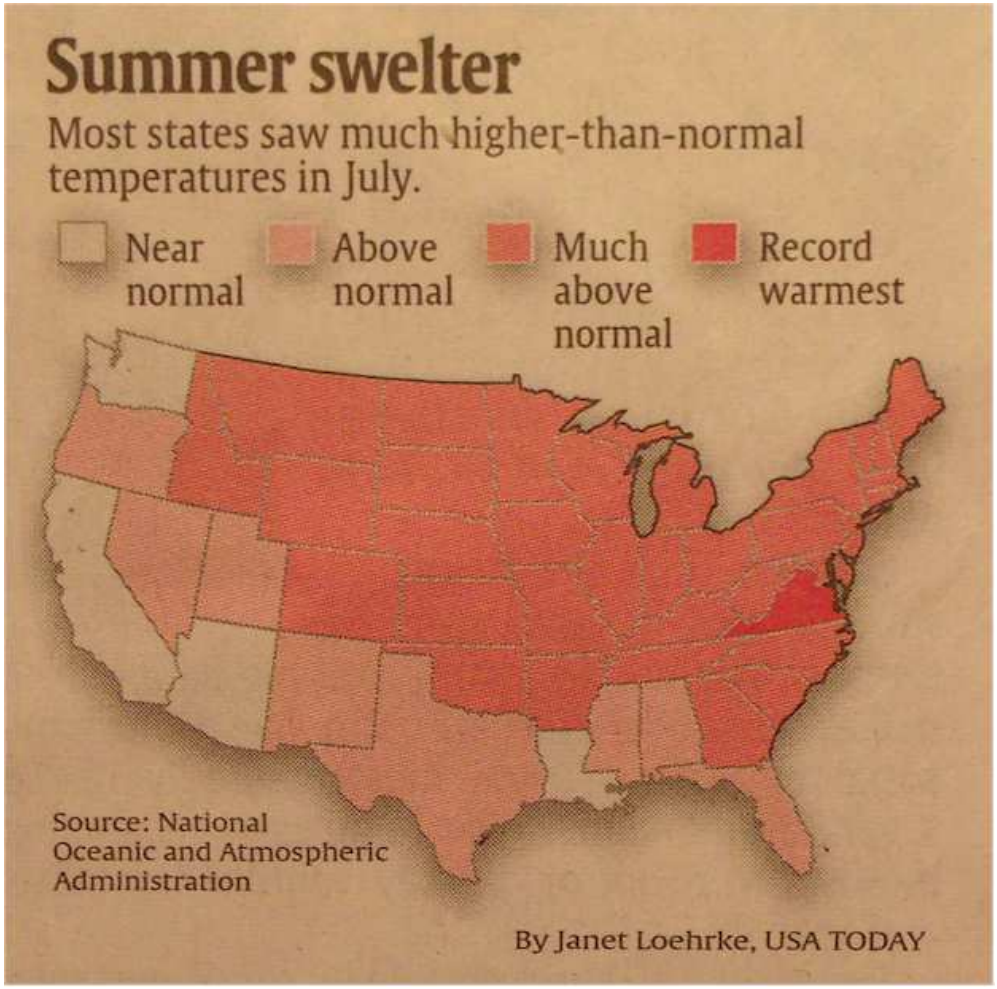
Nice use of labels – with representative colors – for small, crowded states



Choropleth Maps

OK for a quick graphic

- Legend that does not show actual values
  - Just shows general pattern
  - Nor does the map give any indication as to what "normal" is

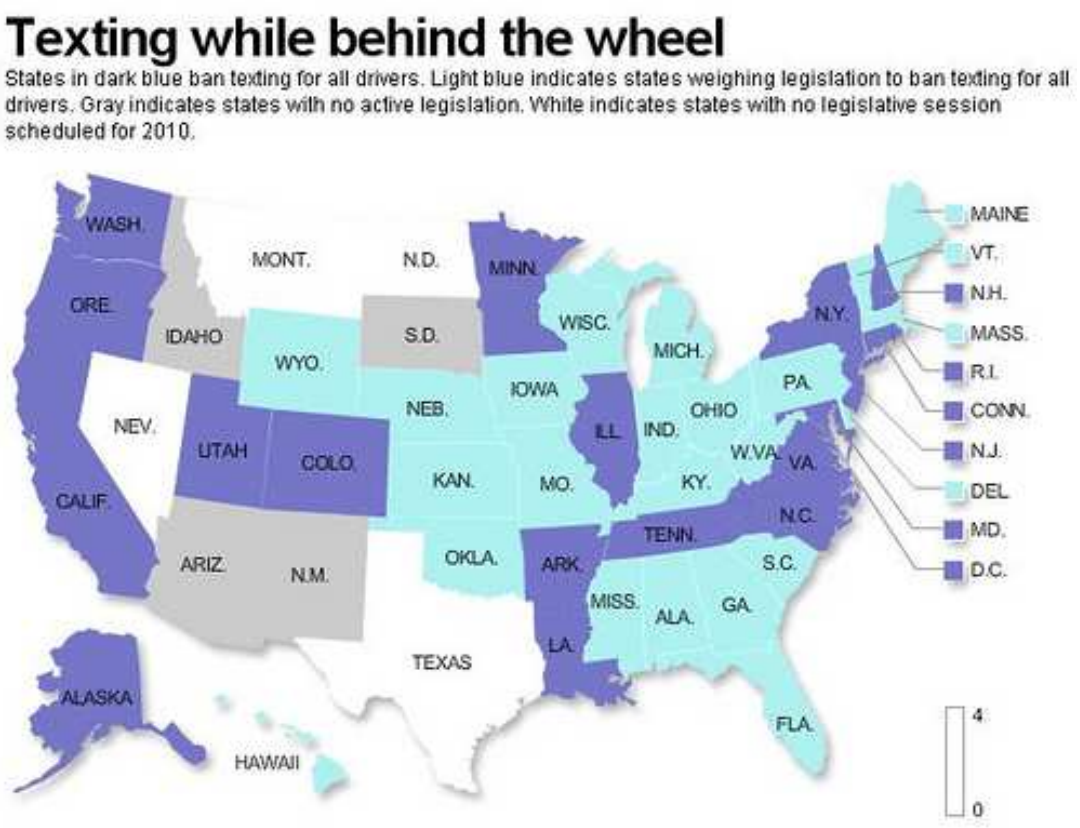


August 2012

Choropleth Maps

Don't do this!

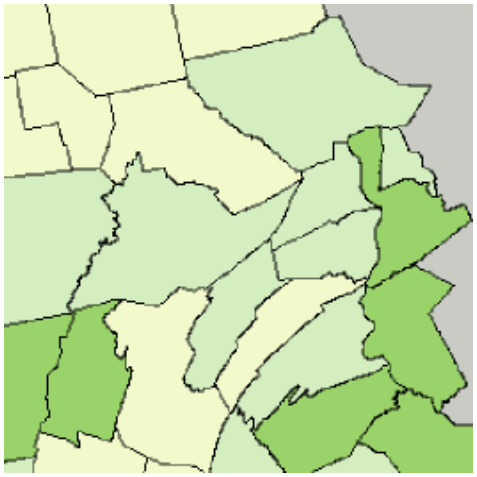
- No legend at all!
  - User must read text under the title
  - Also, no units on scale bar

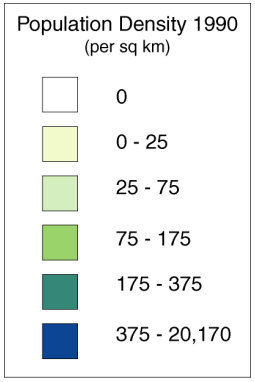


Choropleth vs Dasymetric Maps

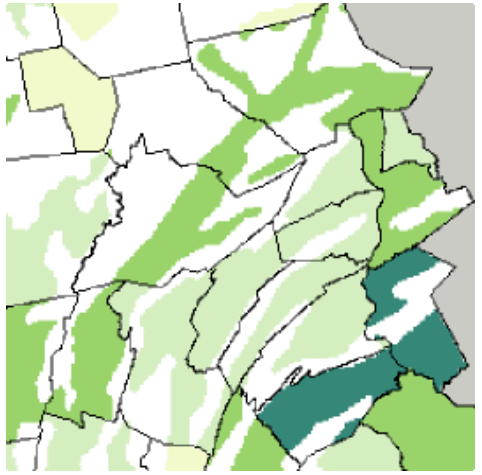
- *Dasymetric* - mapping unit boundaries are different from collection units
  - "Density measuring", still with homogeneous areas
  - Use other information, sources to realistically place symbols
  - Very useful in showing spatial trends

Choropleth map





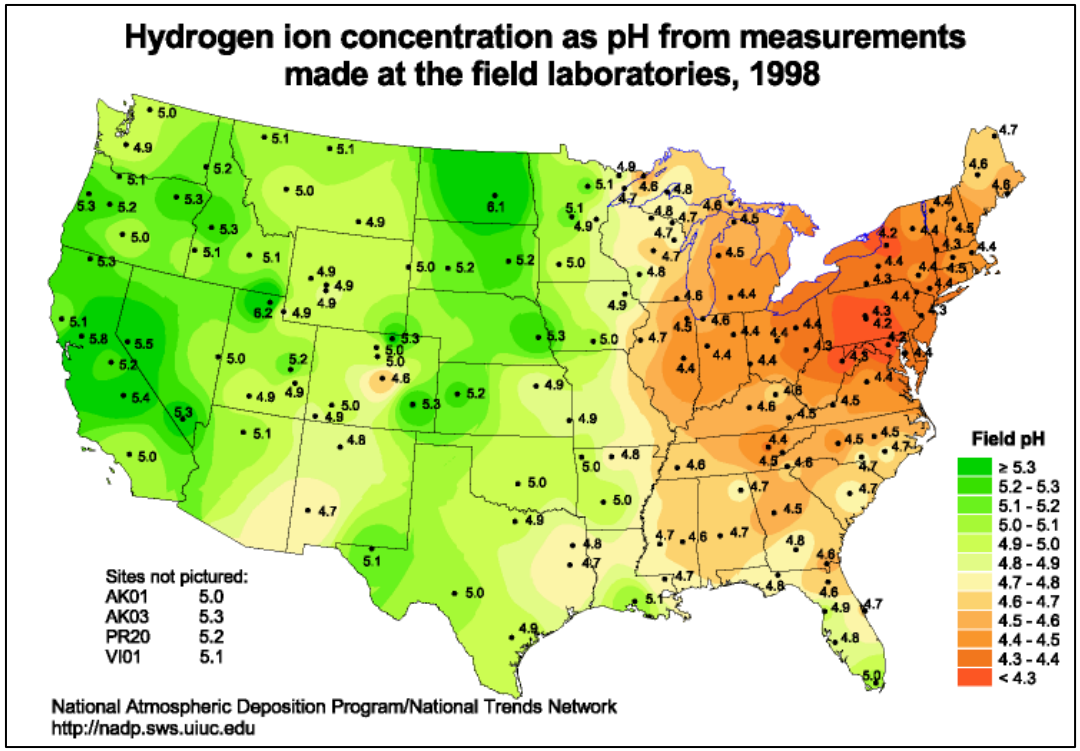
Dasymetric map



Same population data, different mapping methods

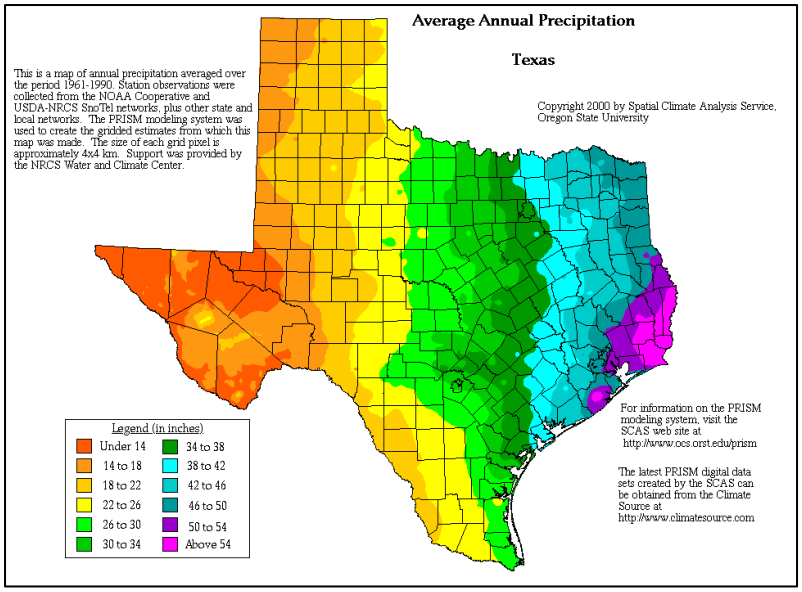
Isopleth Maps

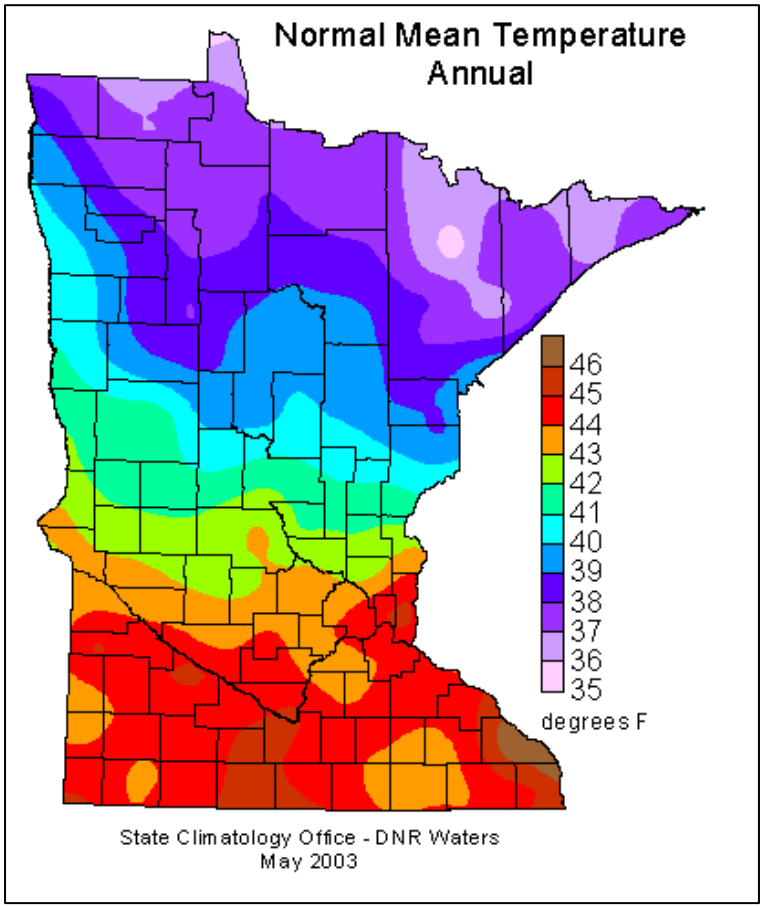
- Ideal when your data values vary continuously and smoothly over space
  - Temperature, Rainfall, Elevation, etc.
- Boundaries not based on pre-defined zones
- Aka "isarithmic mapping"



Isopleth Maps

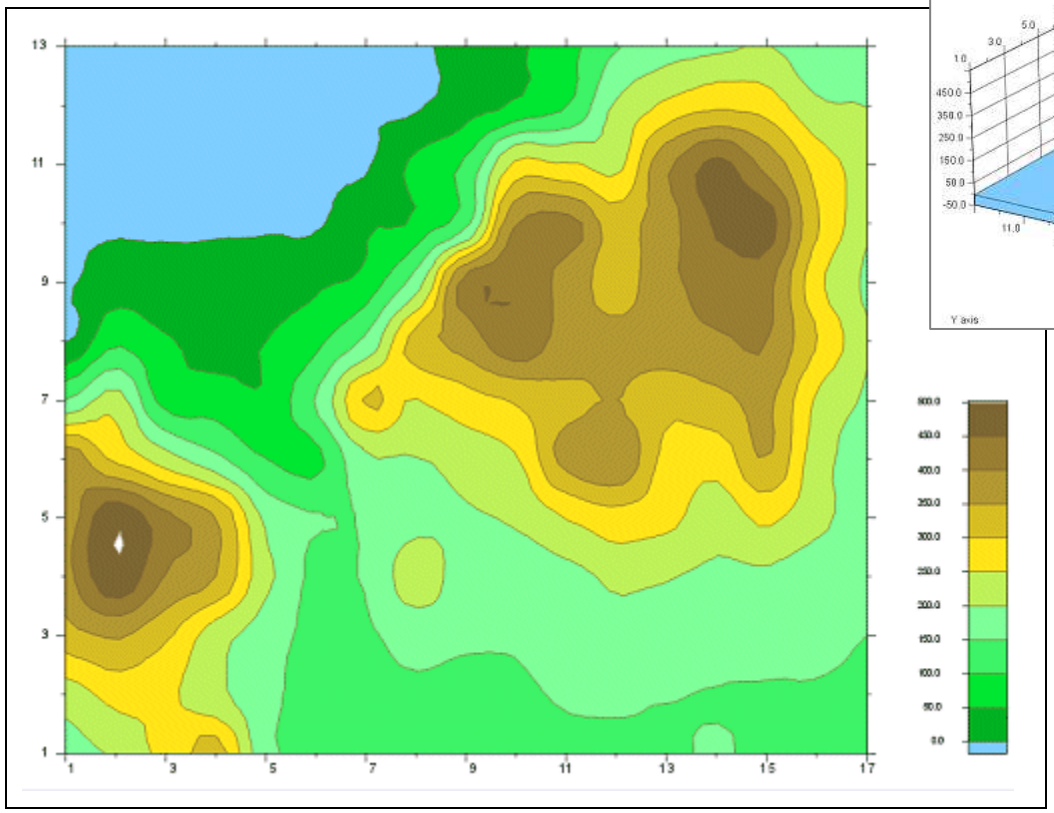
- Based on interpolated values of known point data locations with X,Y,Z values
- Results in a generalized view of the data (the more known points the better)

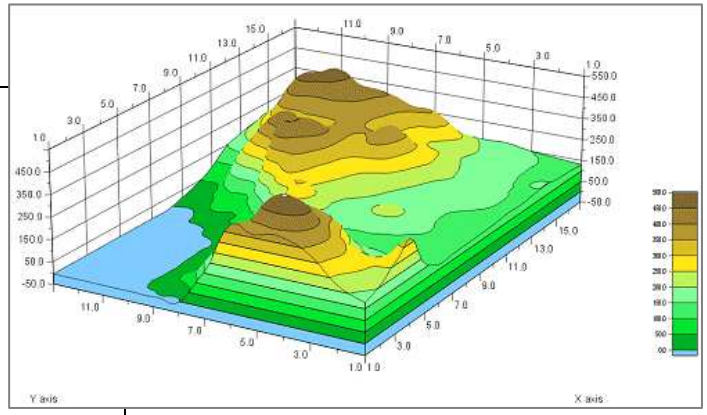




Isopleth Maps

- Example shown with isolines displayed





Same area shown in 3D

Isopleth Maps

- Kinds of isarithmic mapping
  - Values that can occur at points - *isometric lines*
    - Actual - temperatures, spot heights
    - Derived - averages, medians, ratios => referenced to actual values at points
  - Values that cannot occur at points - *isopleths*
    - Actual - "grouped-together" values (people in a city)
    - Derived - only for an area as a whole (people per sq. mi.)
    - A point is assigned to a location (random, or specific, like centroid)

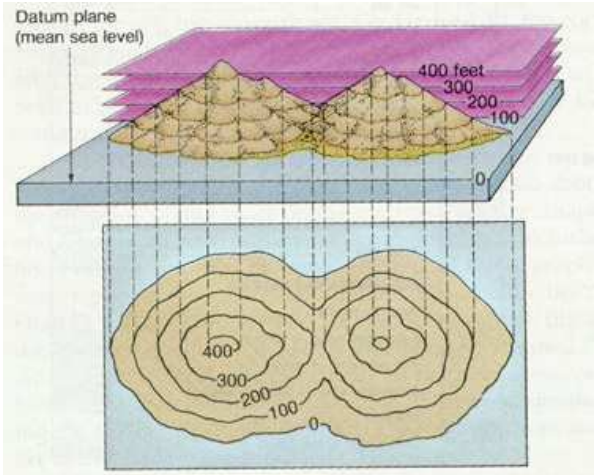
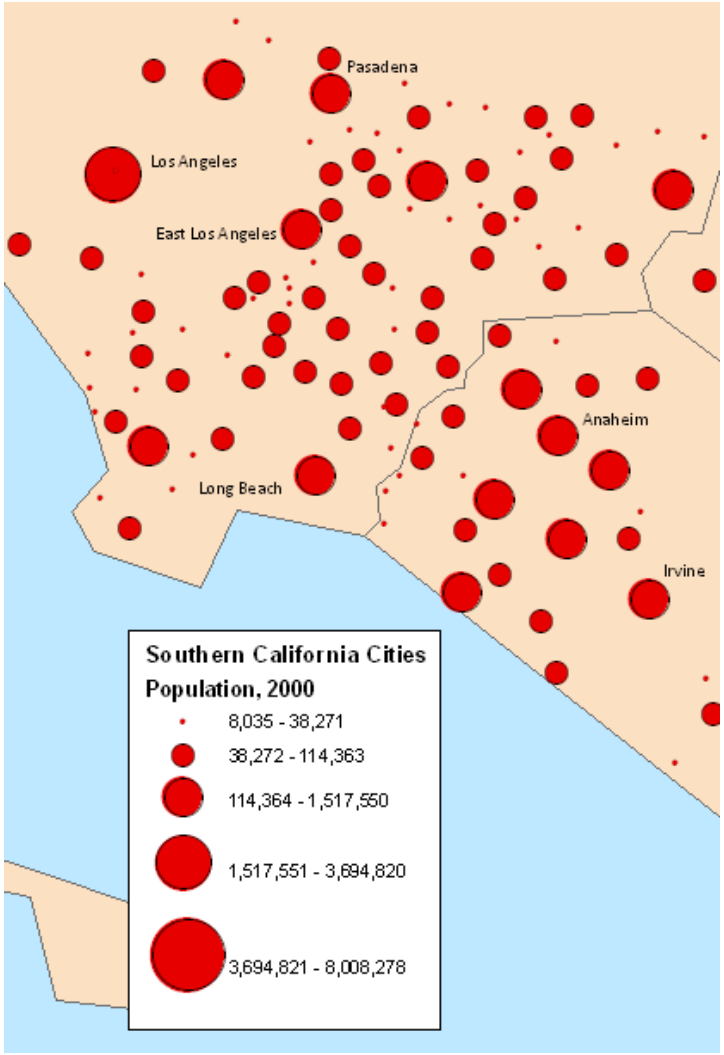


FIGURE 2.16 **Contours drawn for an imaginary island.** The intersection of the landform by a plane held parallel to sea level is a contour representing the height of the plane above sea level.

Graduated Symbol Maps

- Symbols on map match fixed sizes in legend

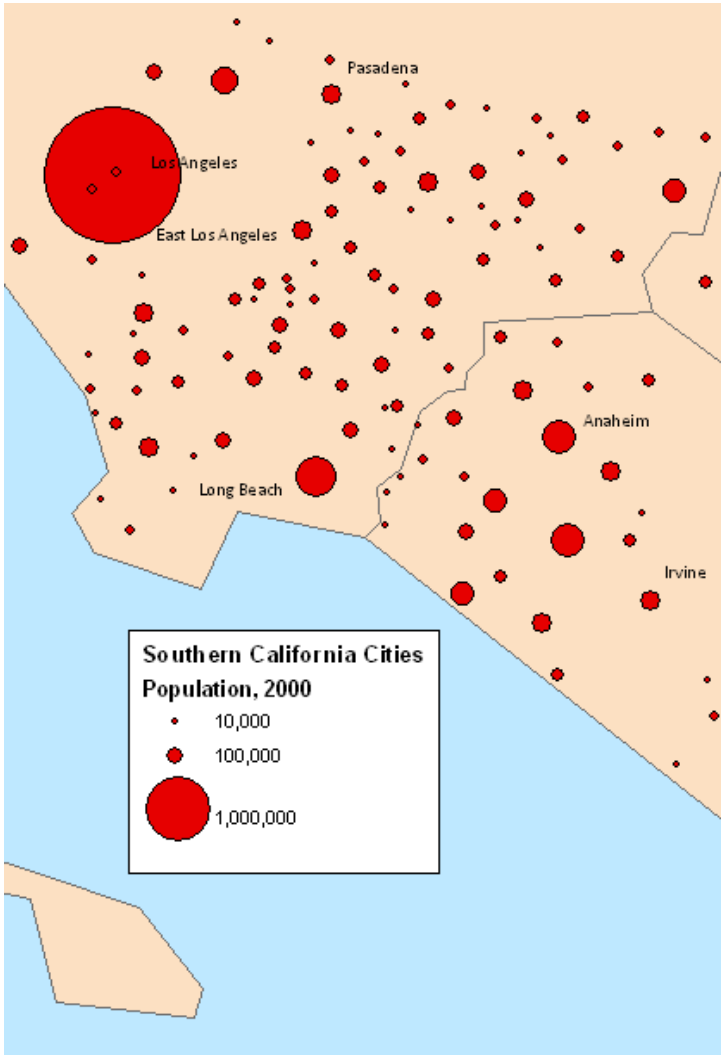


The sizes of the circles on this map are the same as the five in the legend

Proportional Symbol Maps

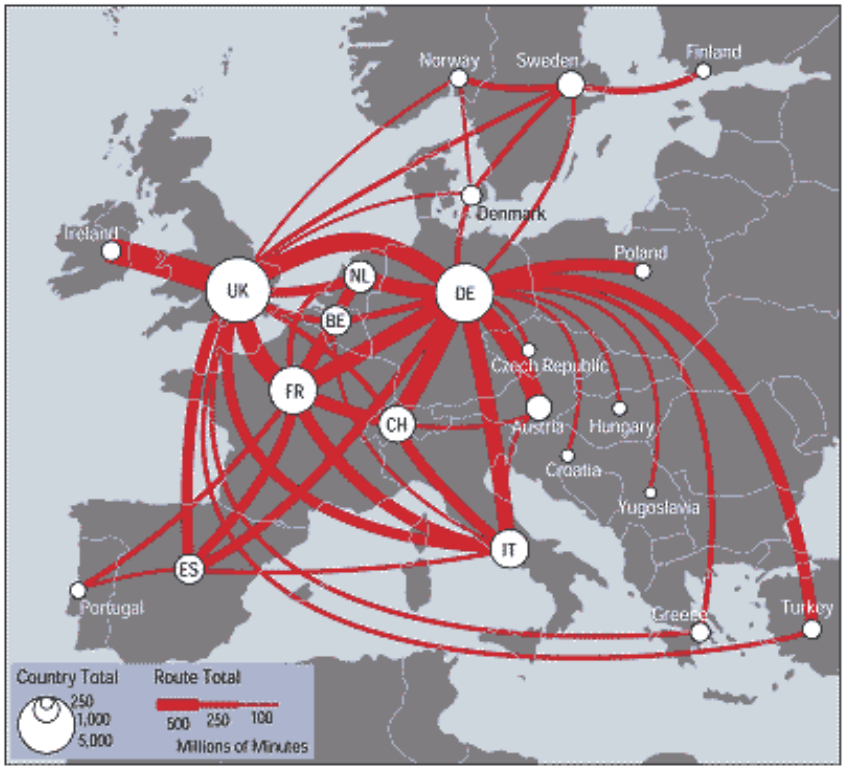
- Symbols in legend are representative of sizes of symbols on the map. Shown here are point symbols.

The sizes of the circles on this map can be any size, based on the range in the legend



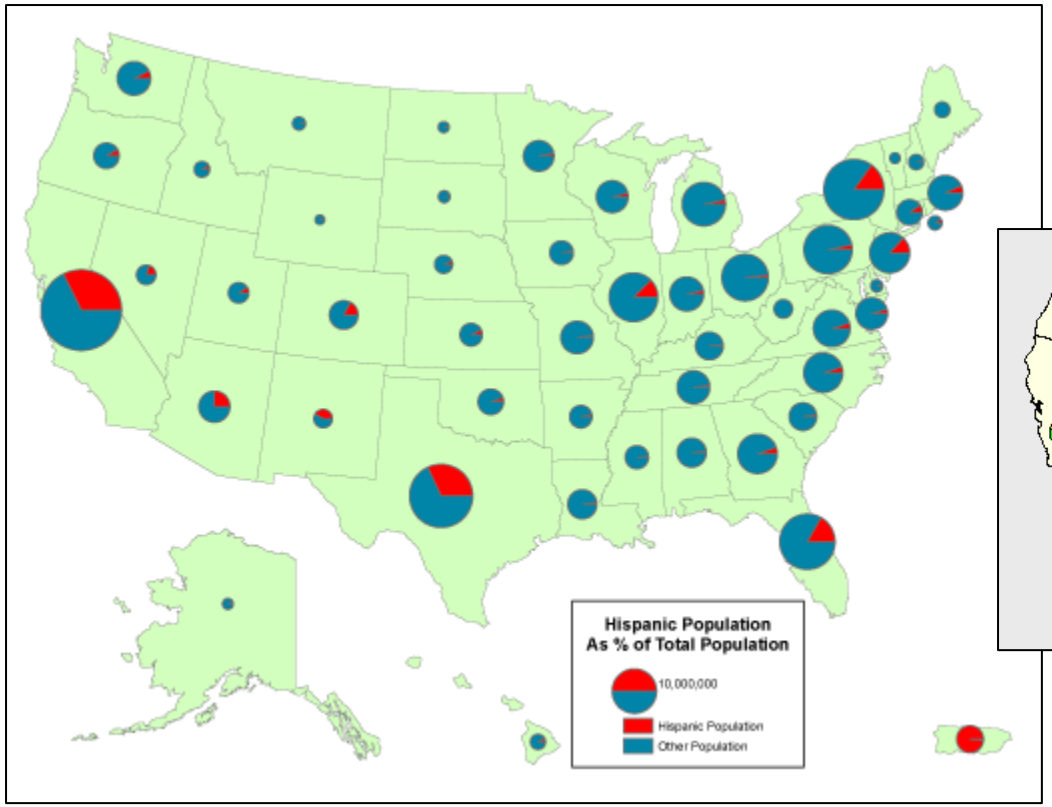
Proportional Symbol Maps

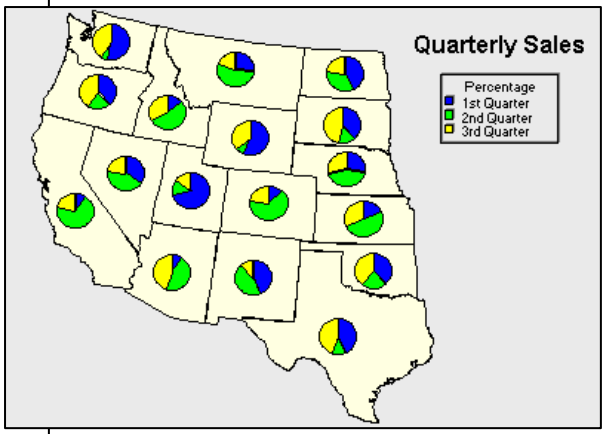
- Symbols in legend are representative of sizes of symbols on the map. Show here are line and point symbols.



Chart/Graph Maps

- Pie Charts





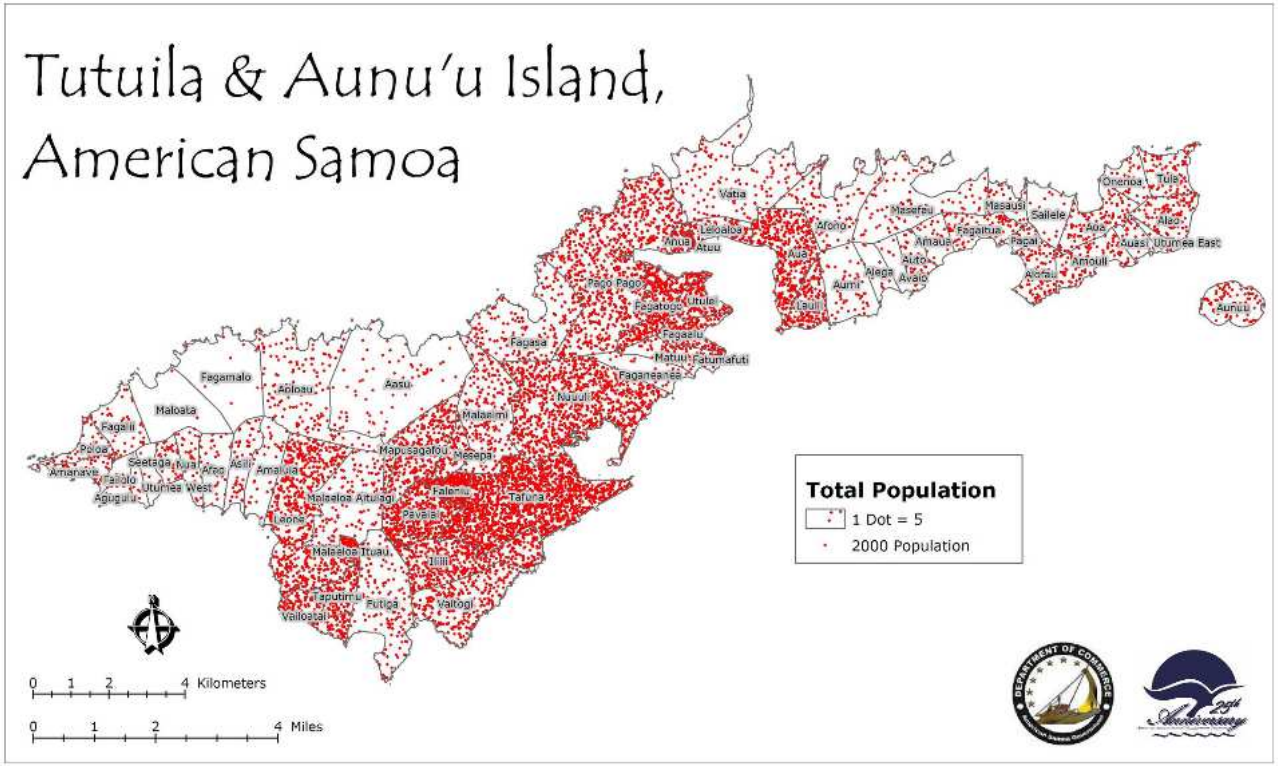
Chart/Graph Maps

- Bar Graphs

  Can be tricky to display if the charts are big and the polygons are small

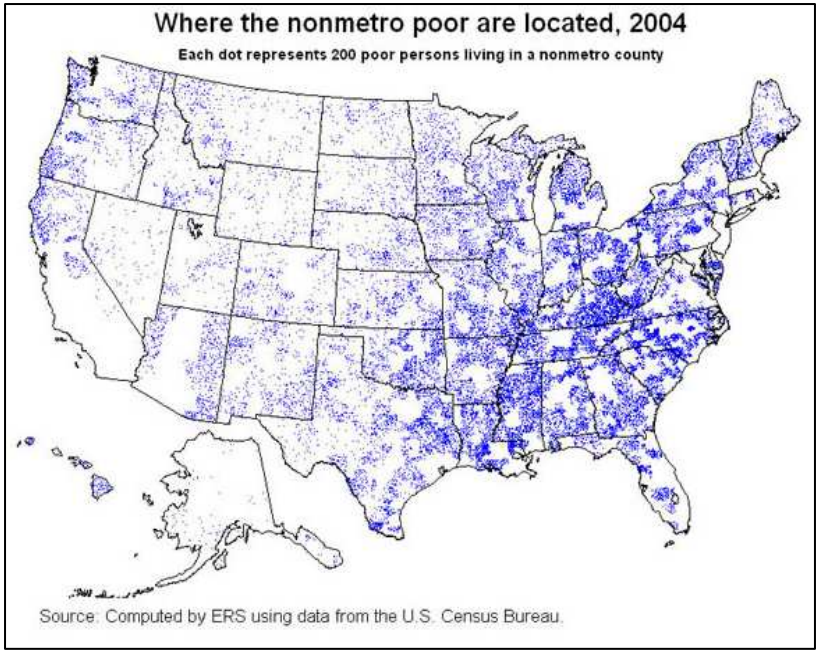
Dot Density Maps

- Concerned with the relative geographical crowding/clustering or sparseness of discrete phenomena
  - People, animal or plant species, crimes, business locations, etc...



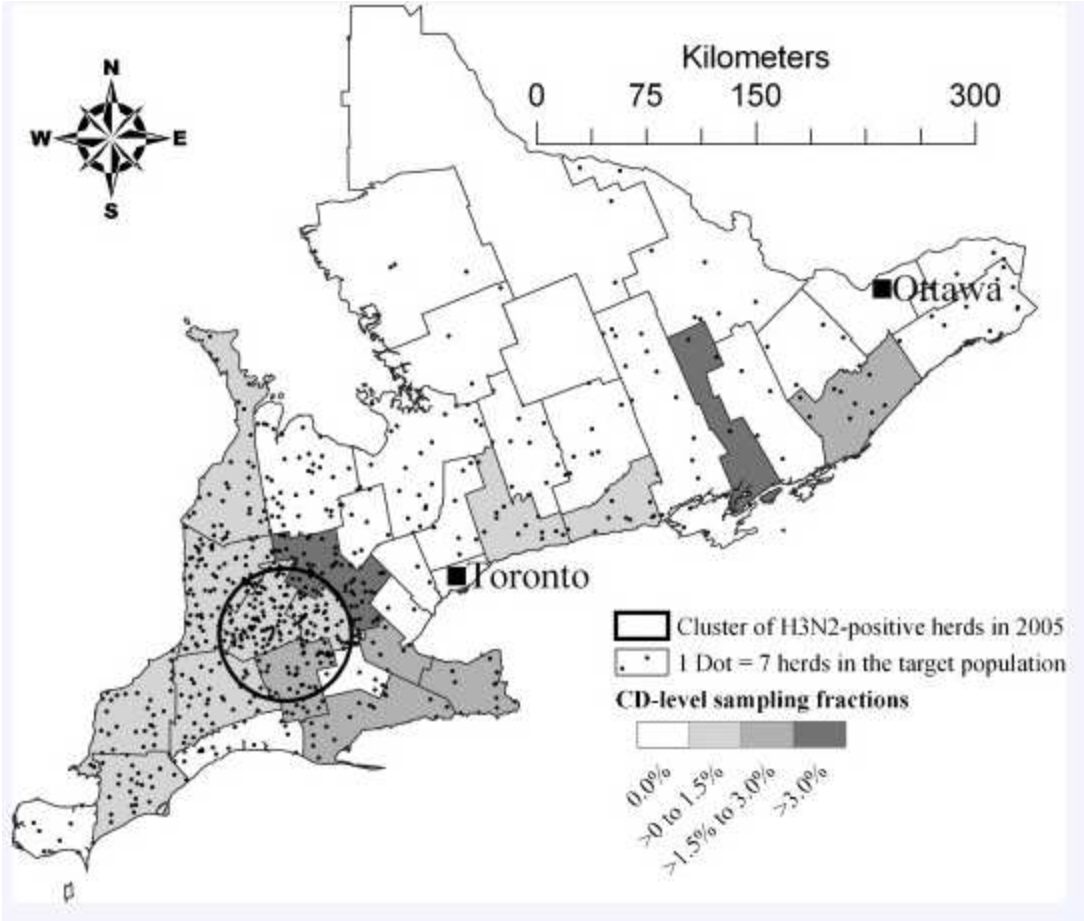
Dot Density Maps

- Success of a dot map
  - Size of dots - not too small, not too big
  - Unit value of a dot
    - not too low, not too high
    - usually > 1
  - Location of the dots
    - center of gravity?
    - equal distribution?
    - use other references
  - You can mask areas where phenomena don't occur (e.g. water bodies)



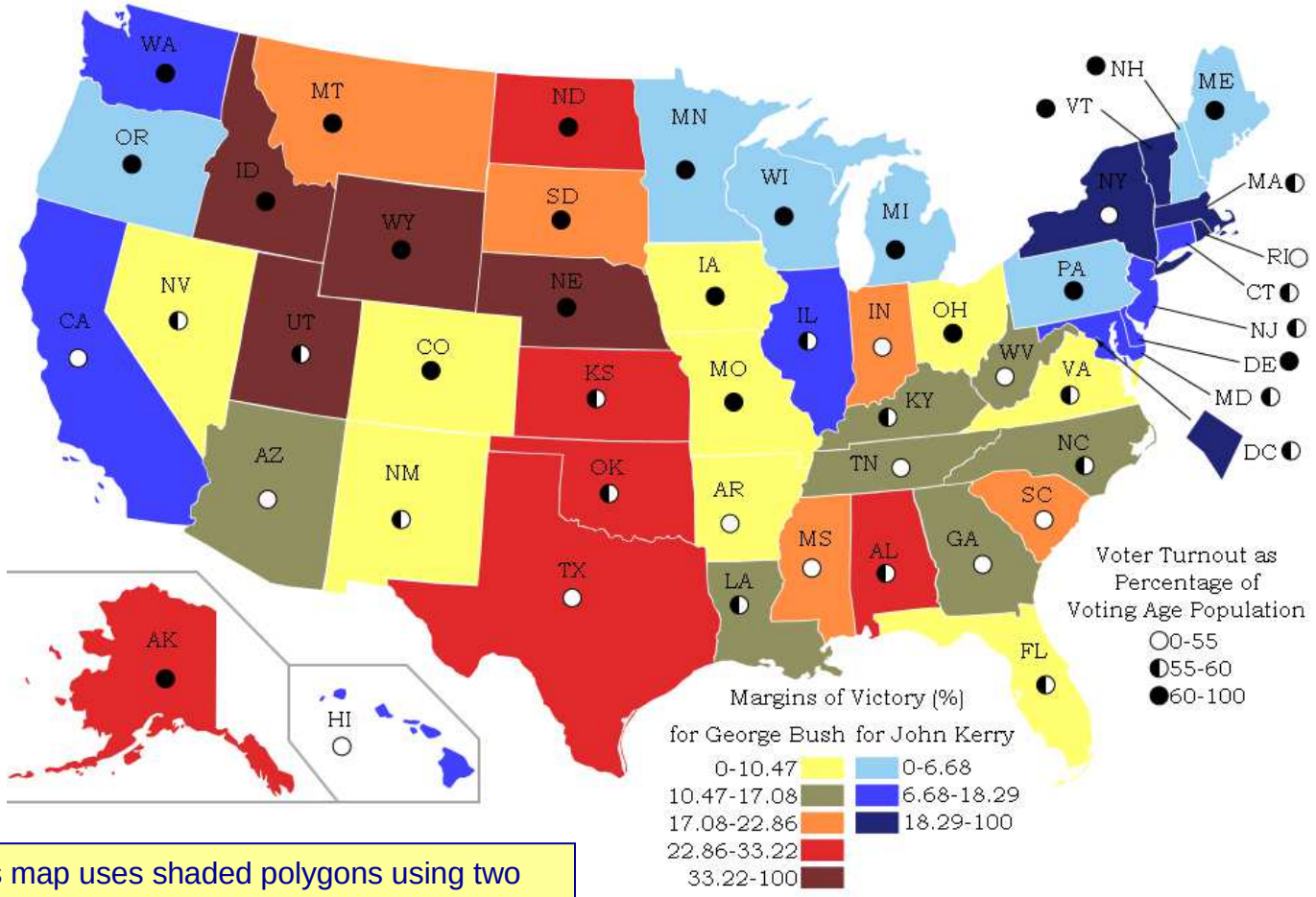
Multi-variable Mapping

- Different quantitative variables are shown on one map, with different symbolization



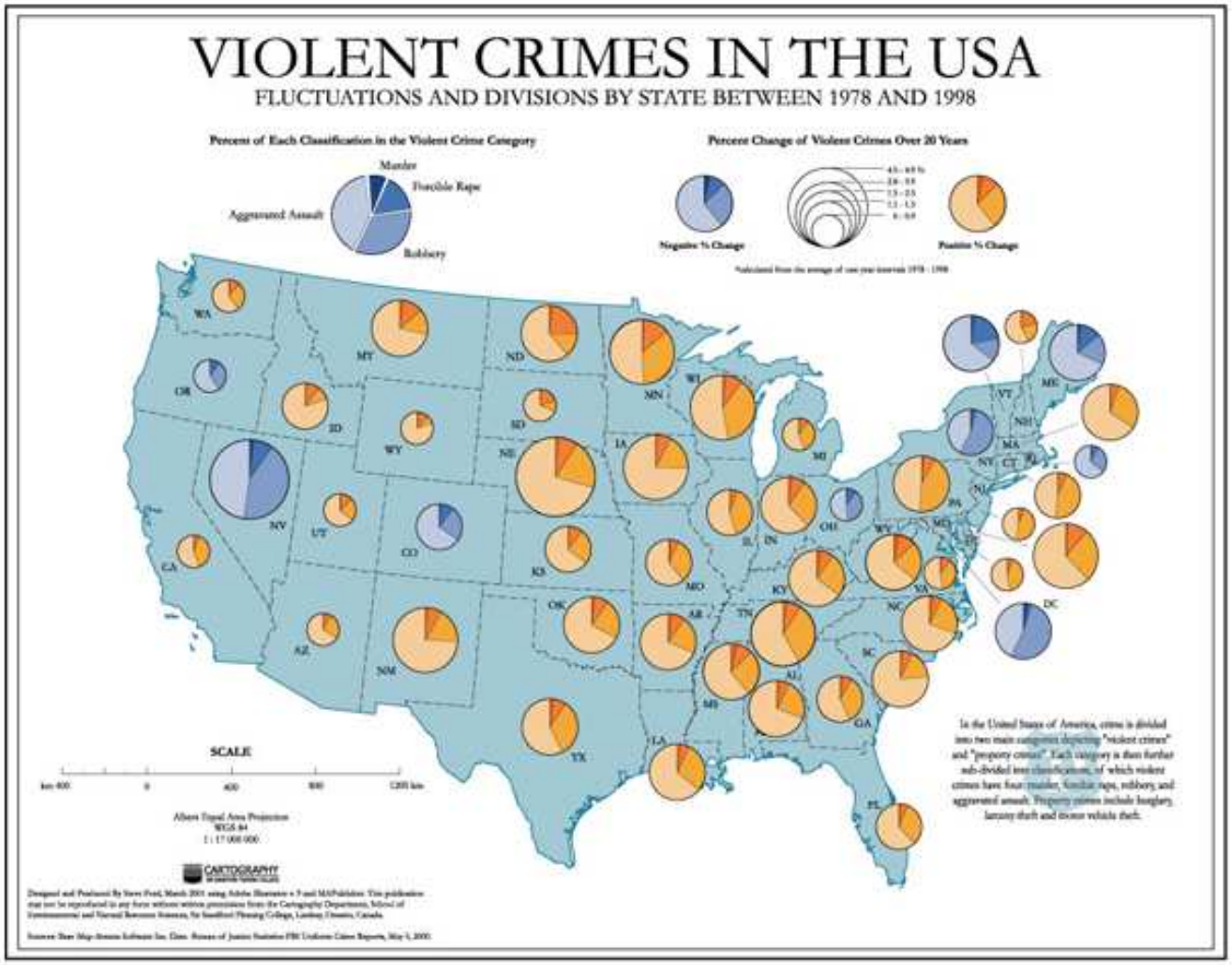
This map uses choropleth and dot density mapping techniques to portray the H3N2 swine epidemic situation in Ontario in 2005.

Multi-variable Mapping



This map uses shaded polygons using two color gradients, one for each candidate, plus symbols indicating percent of voter turnout.

Multi-variable Mapping



This map uses pie chart colors to represent increases and decreases in violent crime.

Further, the pies are broken into pieces, one for each crime category - murder, forcible rape, armed robbery, and aggravated assault.