Bivariate Mapping

GEOG 5201 – Spring 2022

Outline

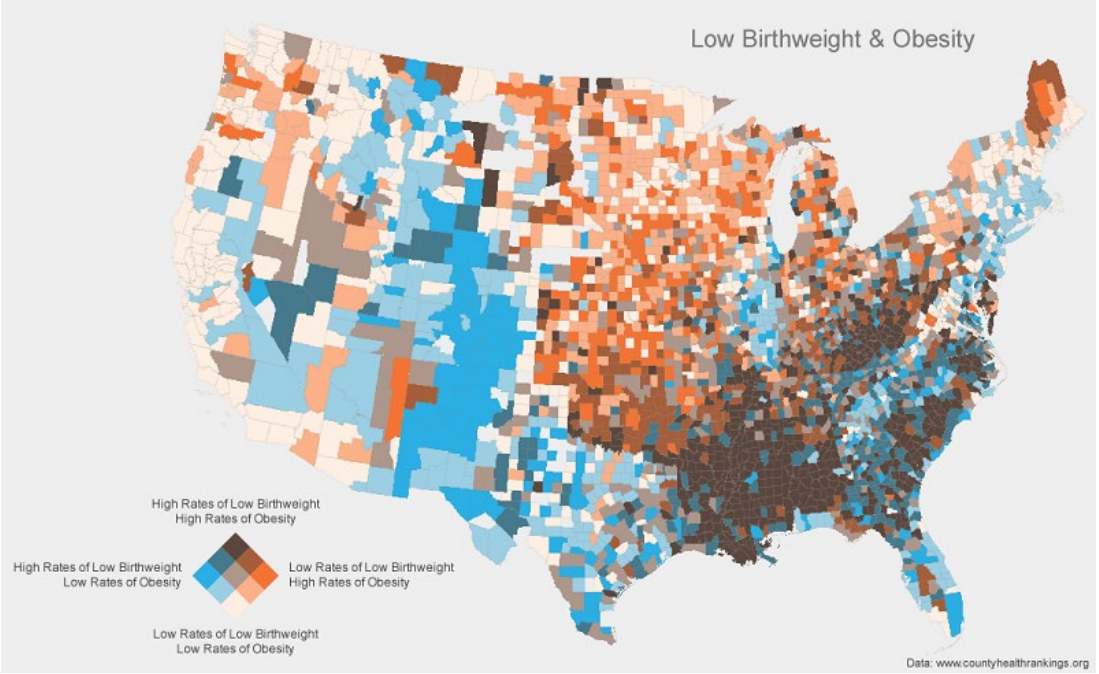
- Concepts of bivariate mapping
- Bivariate mapping techniques
  - Maps compared
    - Choropleth maps
    - Miscellaneous thematic maps
  - Maps combined
    - Bivariate choropleth maps
    - Bivariate point symbol maps
    - Combining two types of symbols

Recall Univariate Mapping

- The display of one single geographic attribute (or variable)

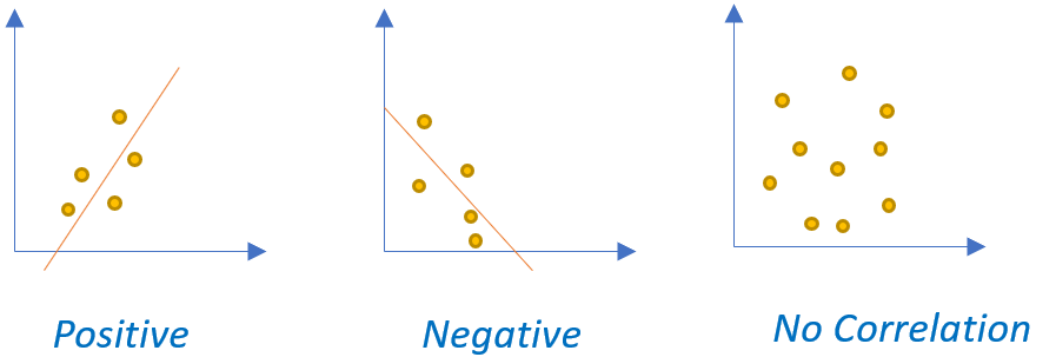
What is Bivariate Mapping?

- The cartographic display of two geographic attributes (or variables) for data exploration
  - The purpose is to reveal and communicate relationships between the variables that might not otherwise be apparent via a standard single-variable technique
- Two major layouts
  - Comparing
  - Combining



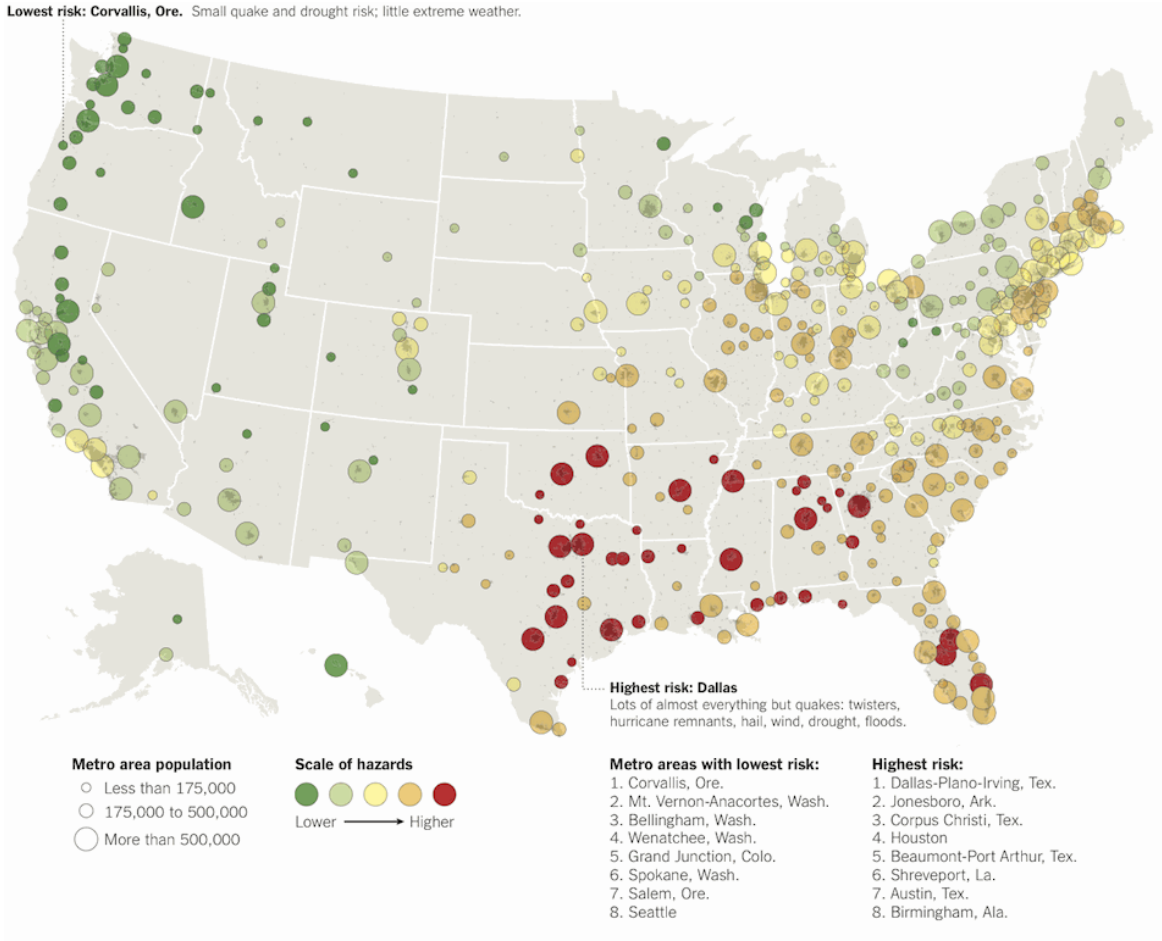
Correlation

- An important measure of the relationship between two variables is their correlation
  - Positive correlation: one variable increases as the other increases
  - Negative correlation: one variable decreases as the other increases



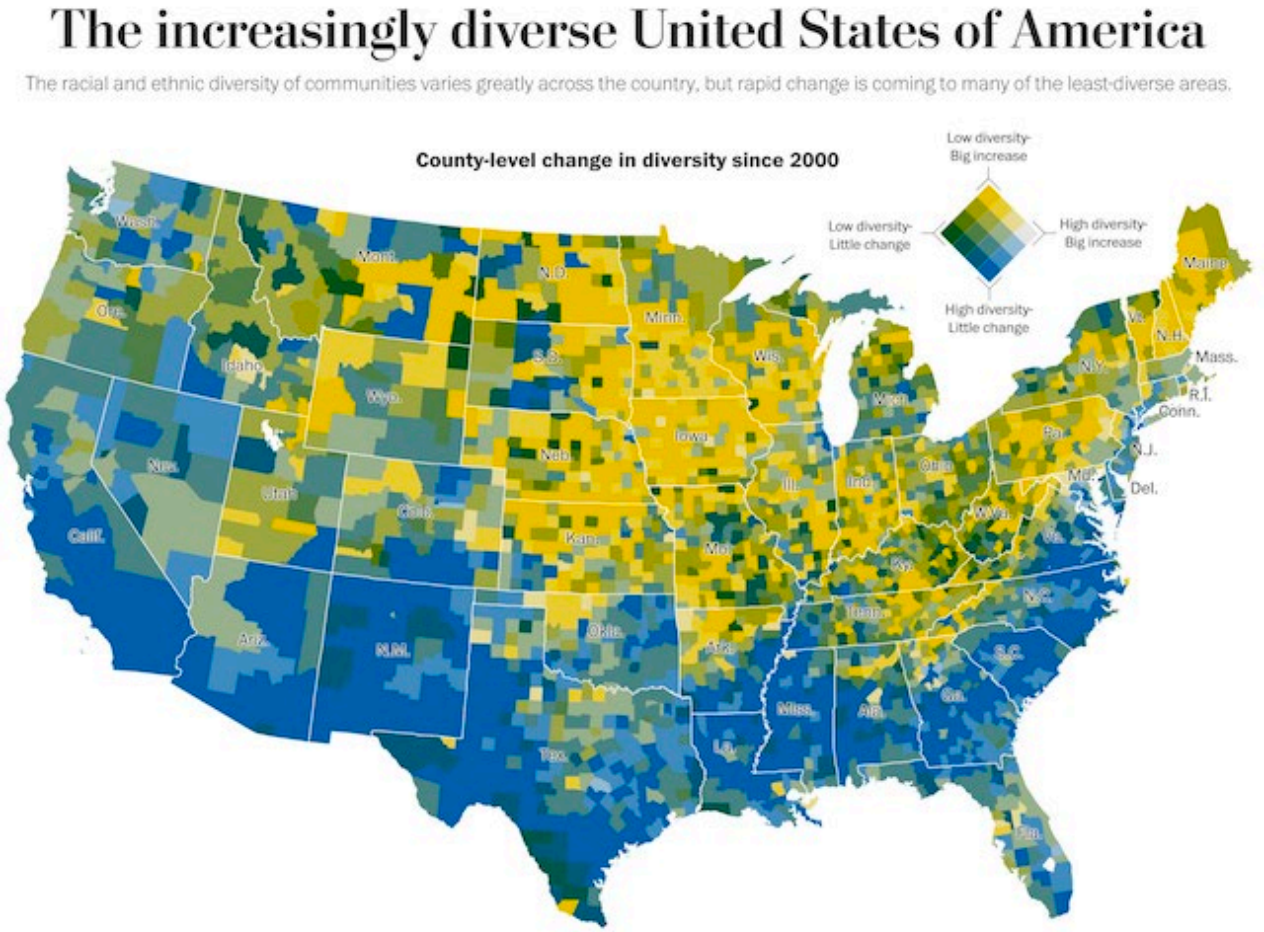
Question 2-1-1

Is this a bivariate map? What are the variables of interest?



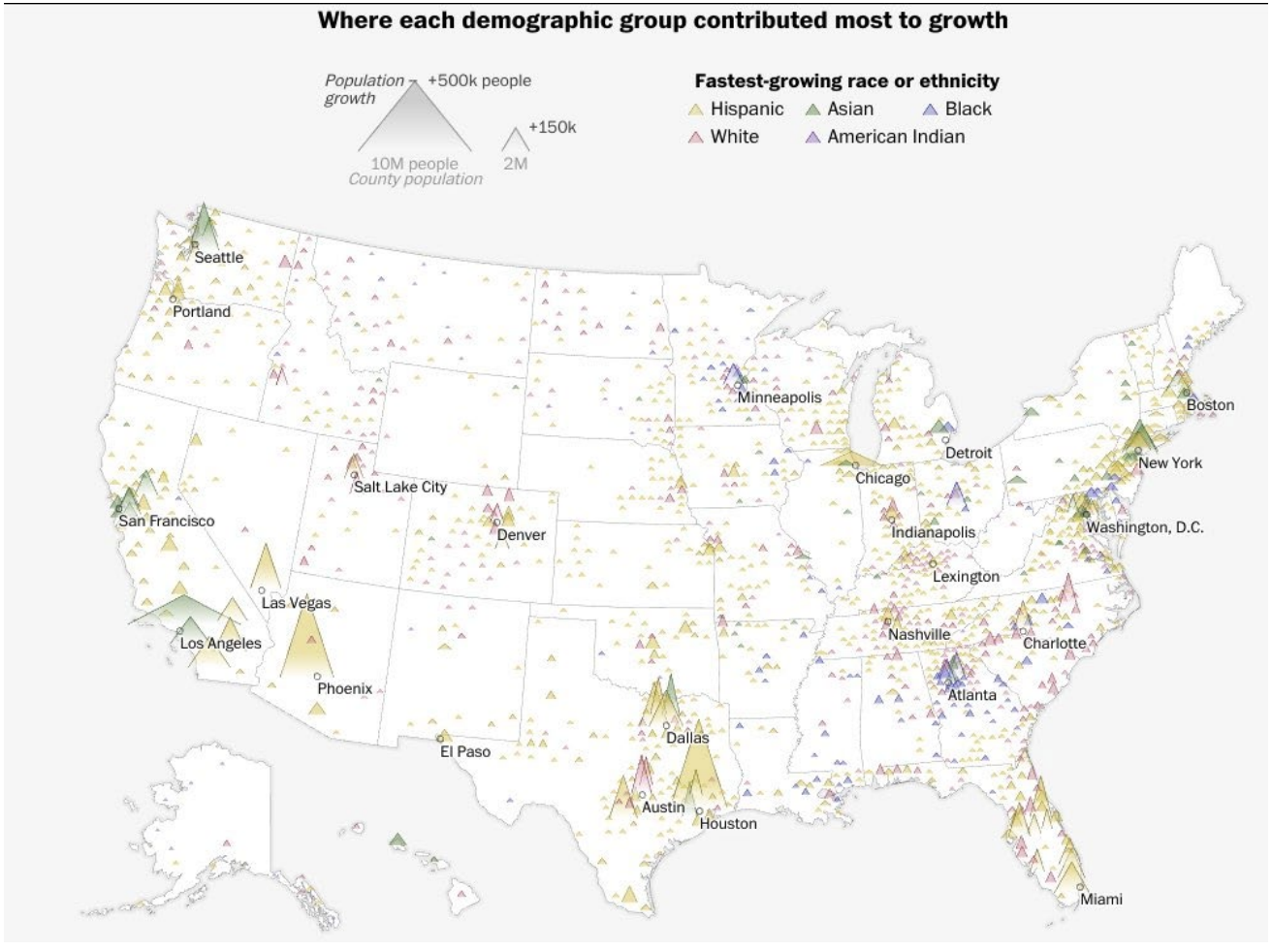
Question 2-1-2

Is this a bivariate map? What are the variables of interest?



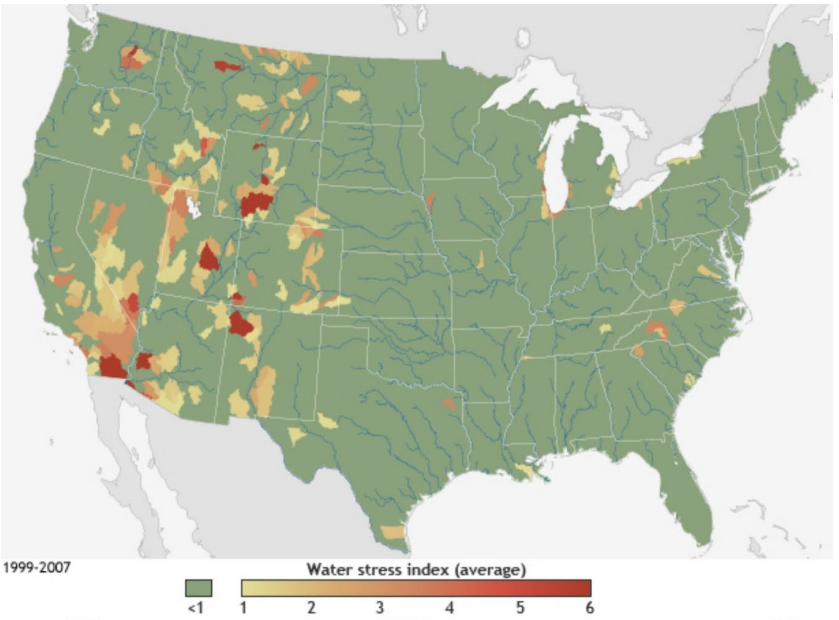
Question 2-1-3

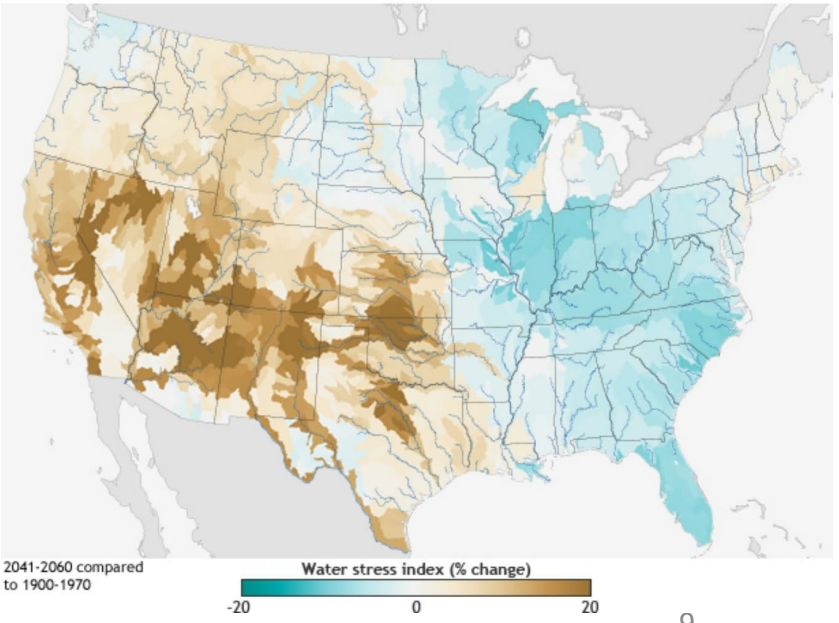
Is this a bivariate map? What are the variables of interest?

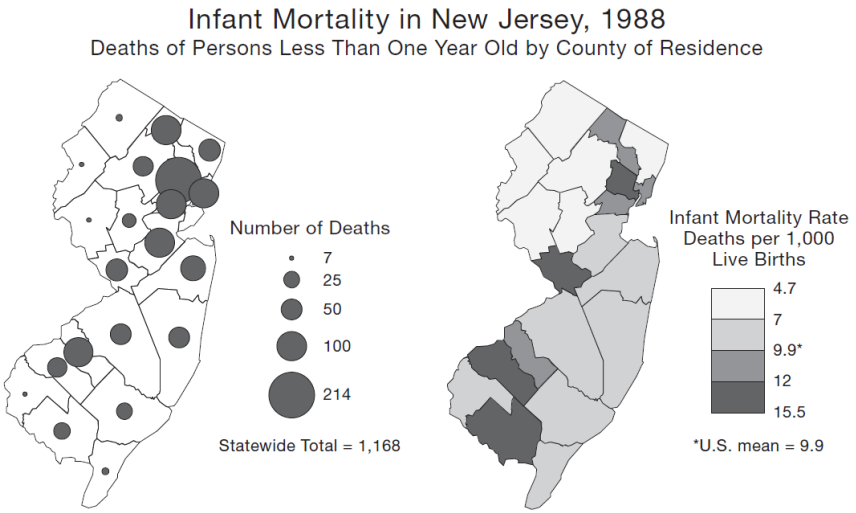


Maps Compared

- Individual (sub)maps to be shown for each variable (i.e., maps are compared)
  - Choropleth maps
  - Miscellaneous thematic maps

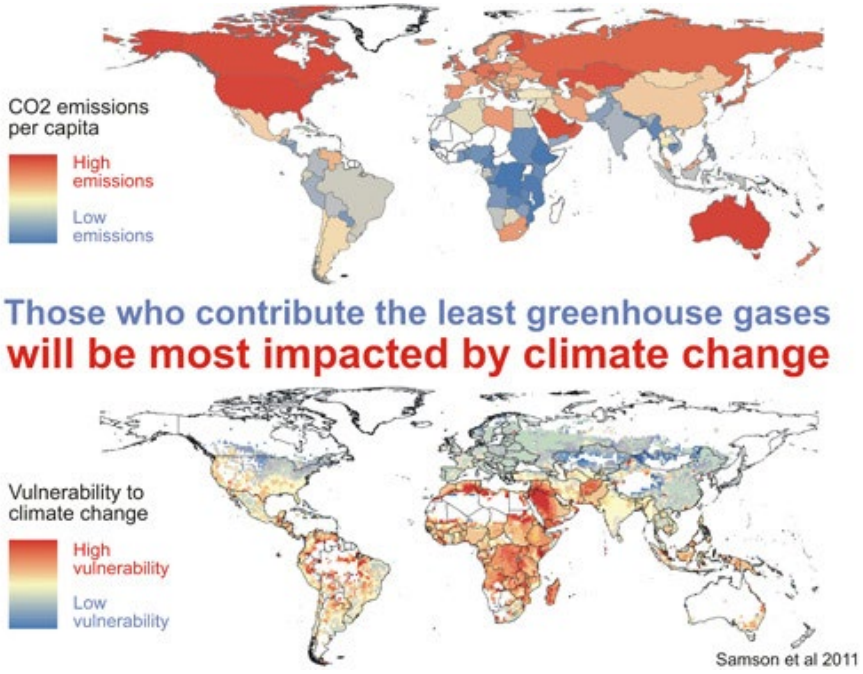


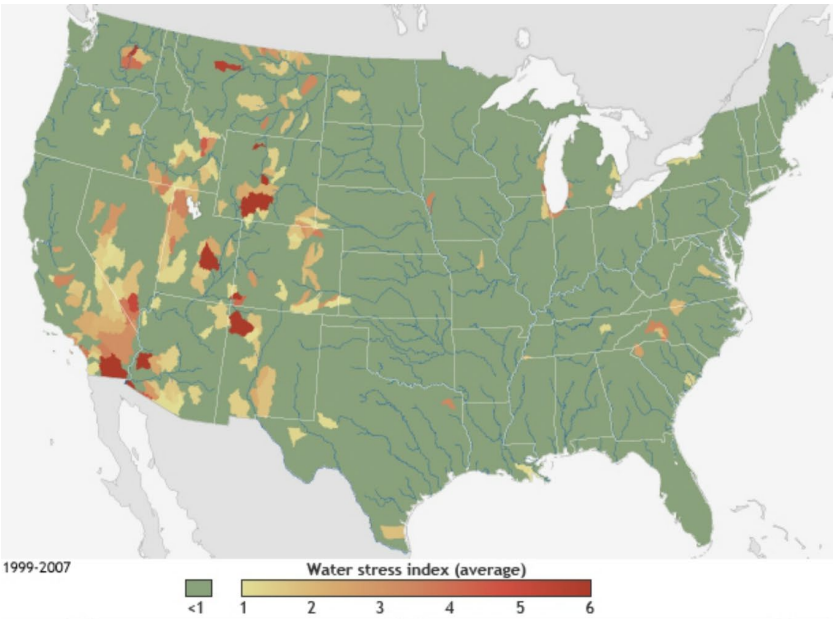


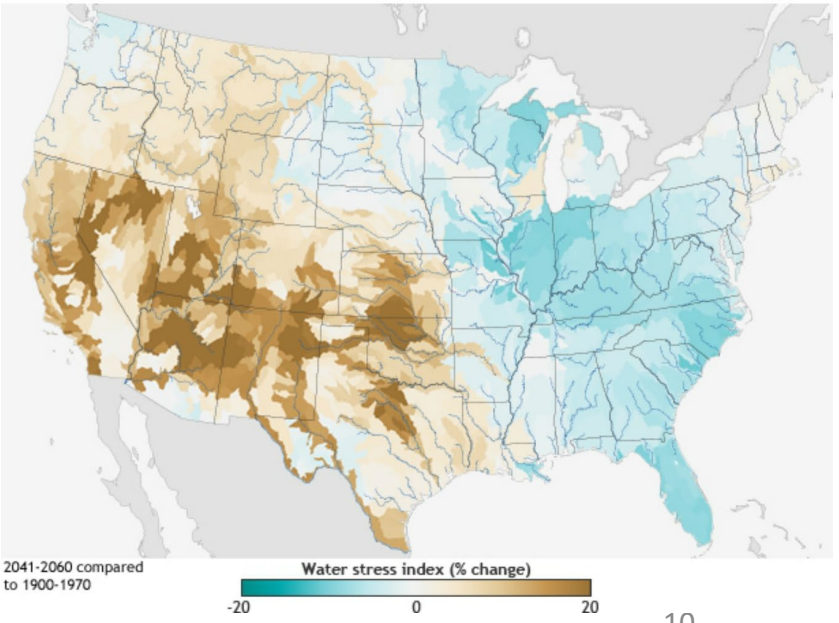


Maps Compared I: Choropleth Maps

- Two choropleth (sub)maps are compared

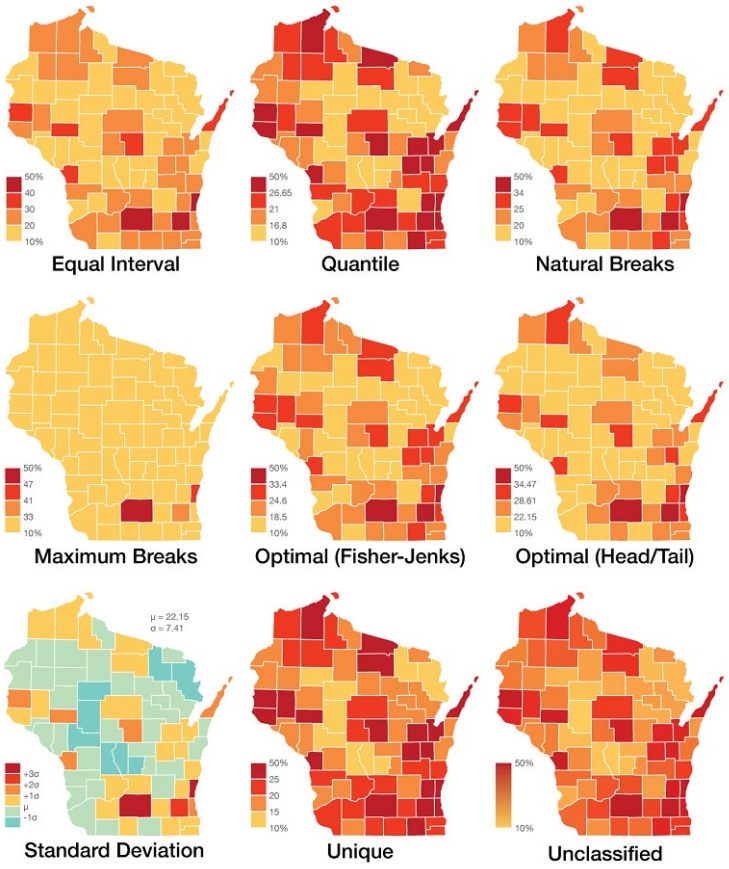






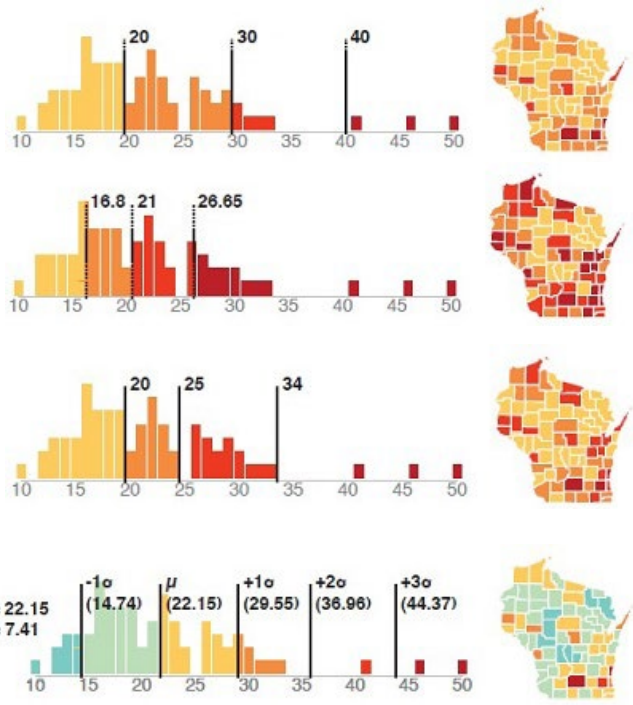
Maps Compared I: Choropleth Maps

- An important consideration is whether and how these variables should be classed



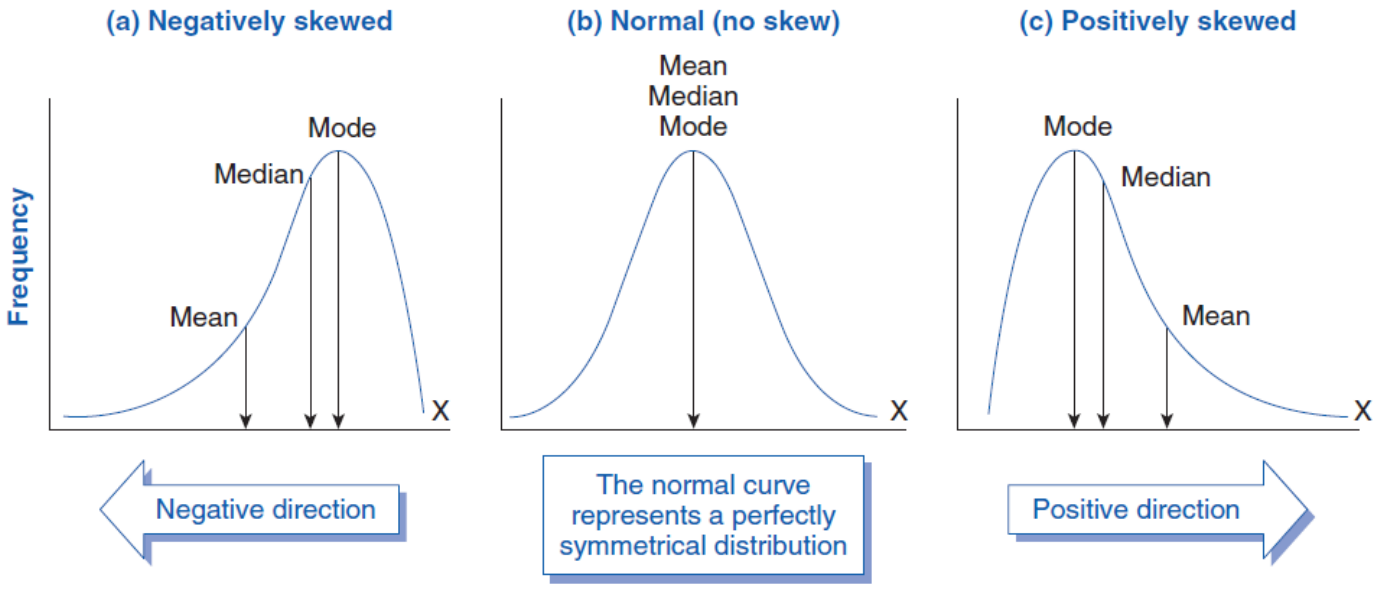
Maps Compared I: Choropleth Maps

- Recall classification methods
  - Equal interval: equivalent range of class breaks
  - Quantile: equal amount of data in each class
  - Natural breaks (Jenks): minimizing differences between data values in the same class and maximizing differences between different classes
  - Mean-standard deviation: groups according to the distance to the mean standard deviation of the dataset
  - Others (optimal, nested-means)



Maps Compared I: Choropleth Maps

- Recall normal distribution and skewness

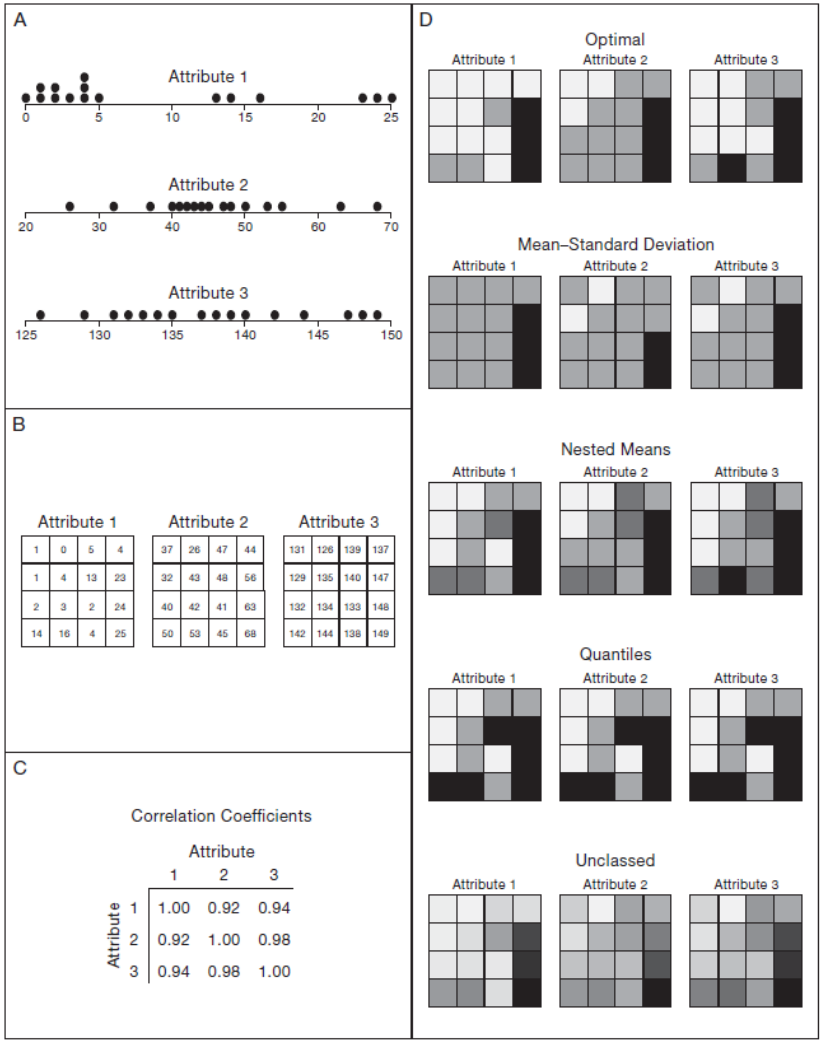


Maps Compared I: Choropleth Maps

- In selecting a method of classification, it is critical to consider the distribution of **each** variable along the number line (i.e., symmetric/normal, negatively skewed, positively skewed)
- If the variables have differing distributions (e.g., one is skewed and the other is normal), certain classification methods can lead to an inappropriate visual impression of correlation between the variables

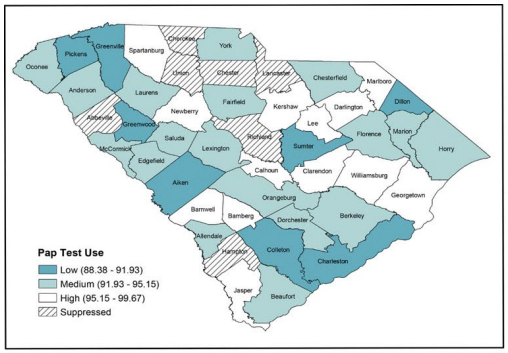
Maps Compared I: Choropleth Maps

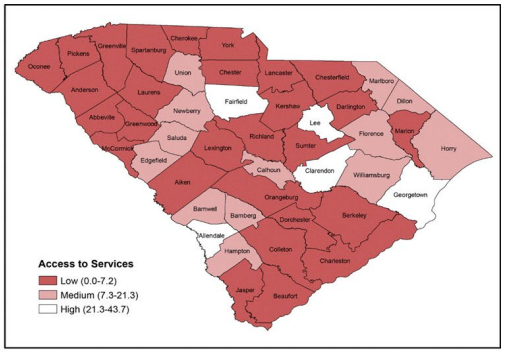
- Example: Attribute 1 is positively skewed, Attributes 2 and 3 are normal; three attributes are highly correlated
  - When is such a correlation most obvious?
    - Optimal
    - Mean-standard deviation
    - Nested means
    - **Quantiles**
    - Unclassed



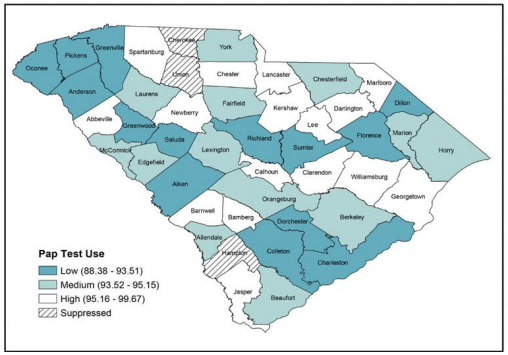
Question 2-1-4

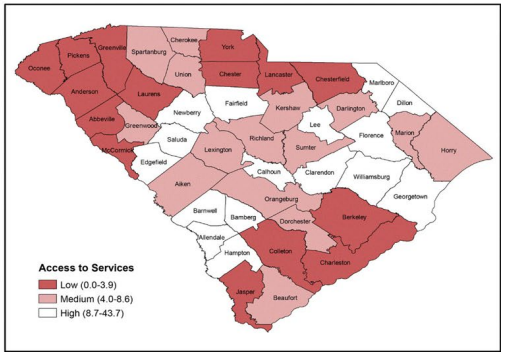
Suppose we know that the below two variables, “pap test use” and “access to services”, are strongly correlated. Which classification method would you prefer to produce the bivariate map comparison (natural breaks or quantiles)?





Natural Breaks

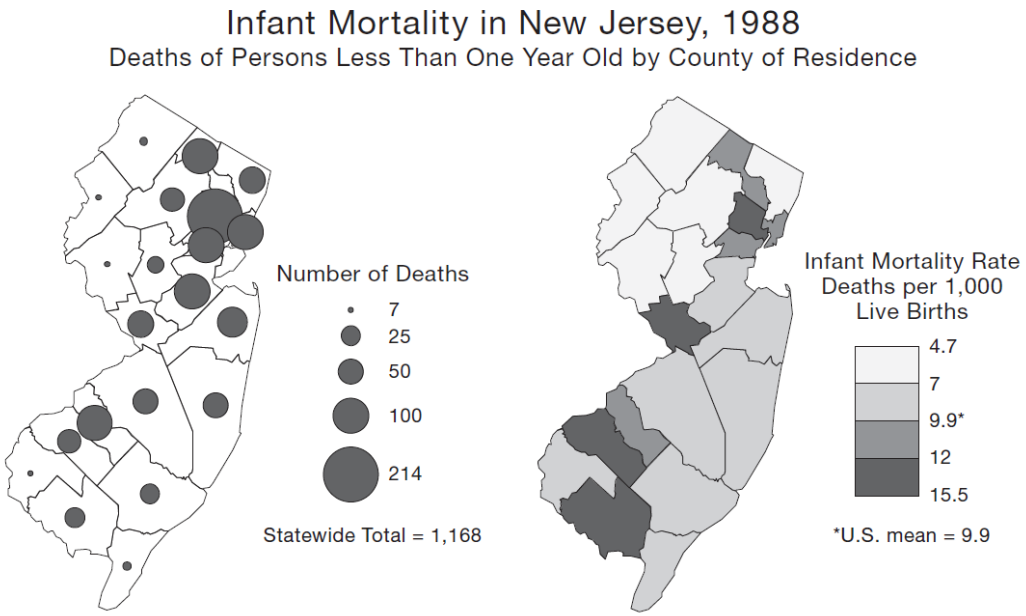




Quantiles

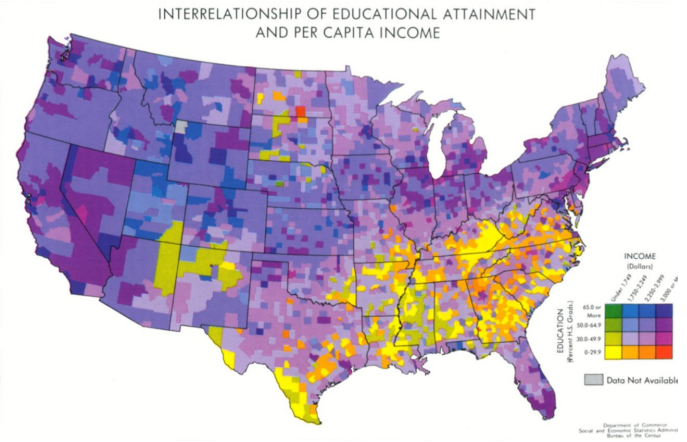
Maps Compared II: Miscellaneous Thematic Maps

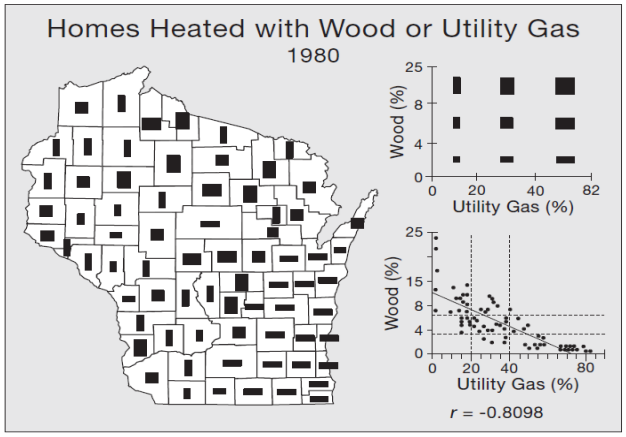
- Two different kinds of thematic (sub)maps are compared
  - Example: a proportional symbol map and a choropleth map

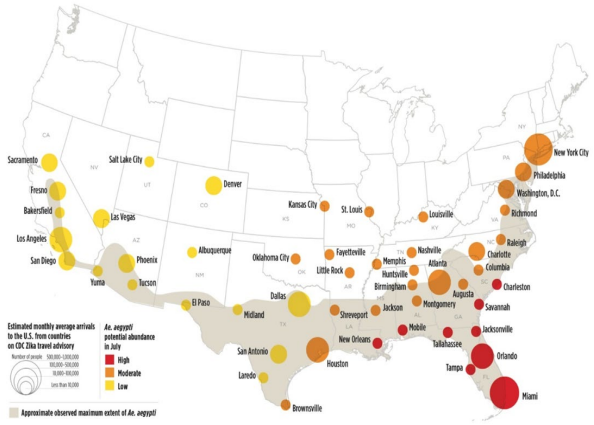


Maps Combined

- Two variables to be shown on the same map
  - Integral symbols
    - Bivariate choropleth maps
    - Bivariate point symbol maps
  - Separable symbols
    - Combining two types of symbols

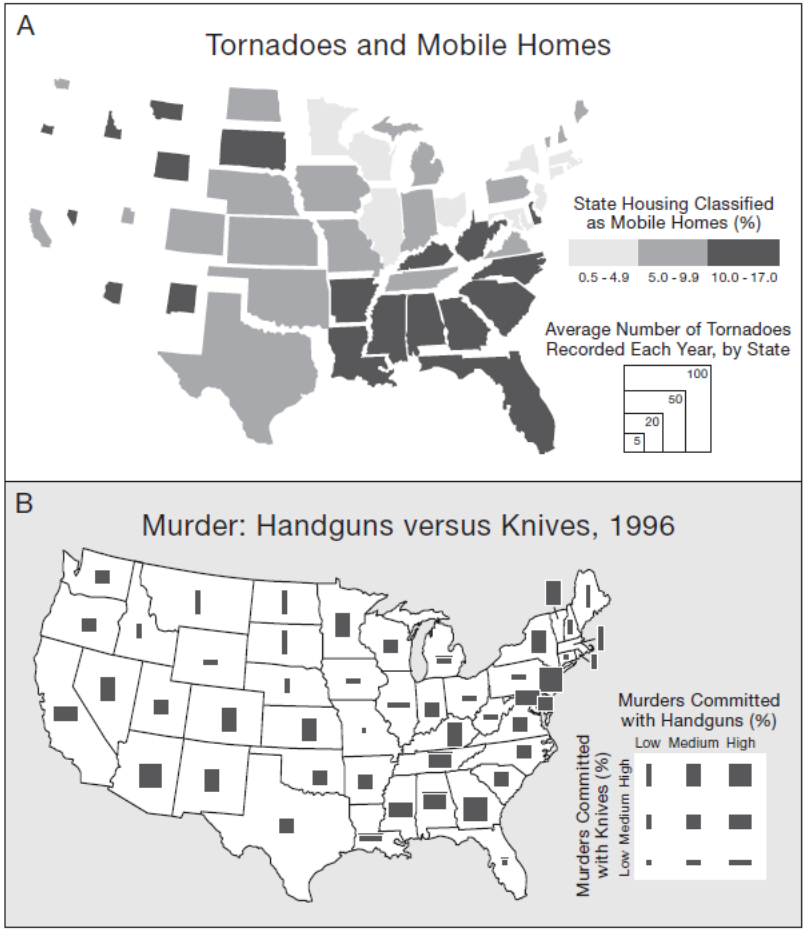






Separable versus Integral Symbols

- Separable symbols
  - Allow map readers to focus on individual attributes
- Integral symbols
  - Easier to examine correlation between attributes

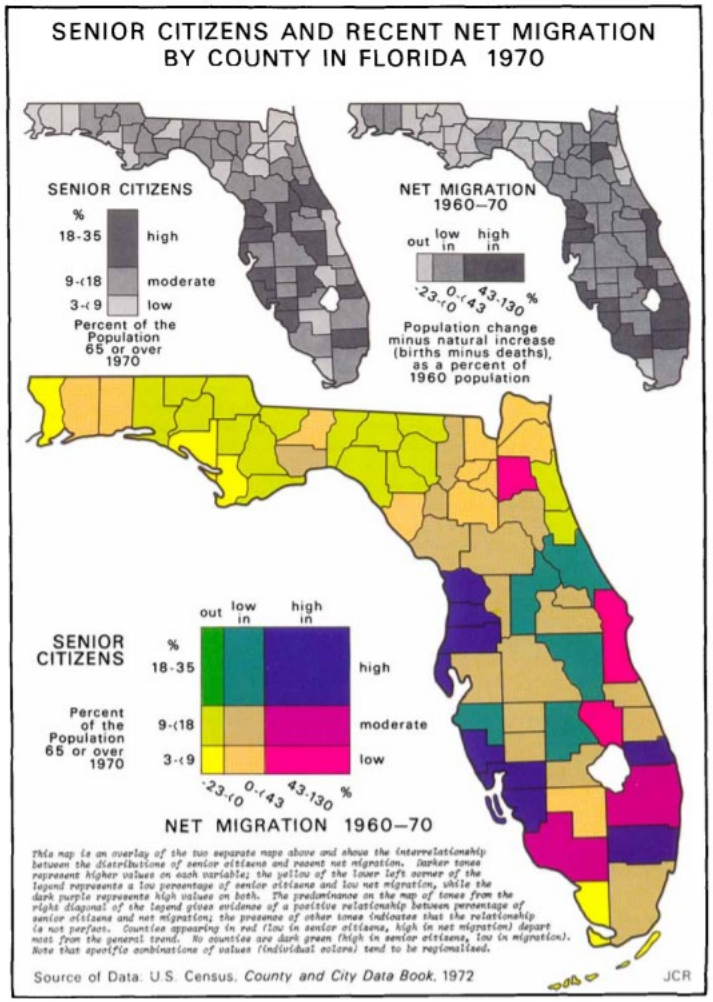


Maps Combined I: Bivariate Choropleth Maps

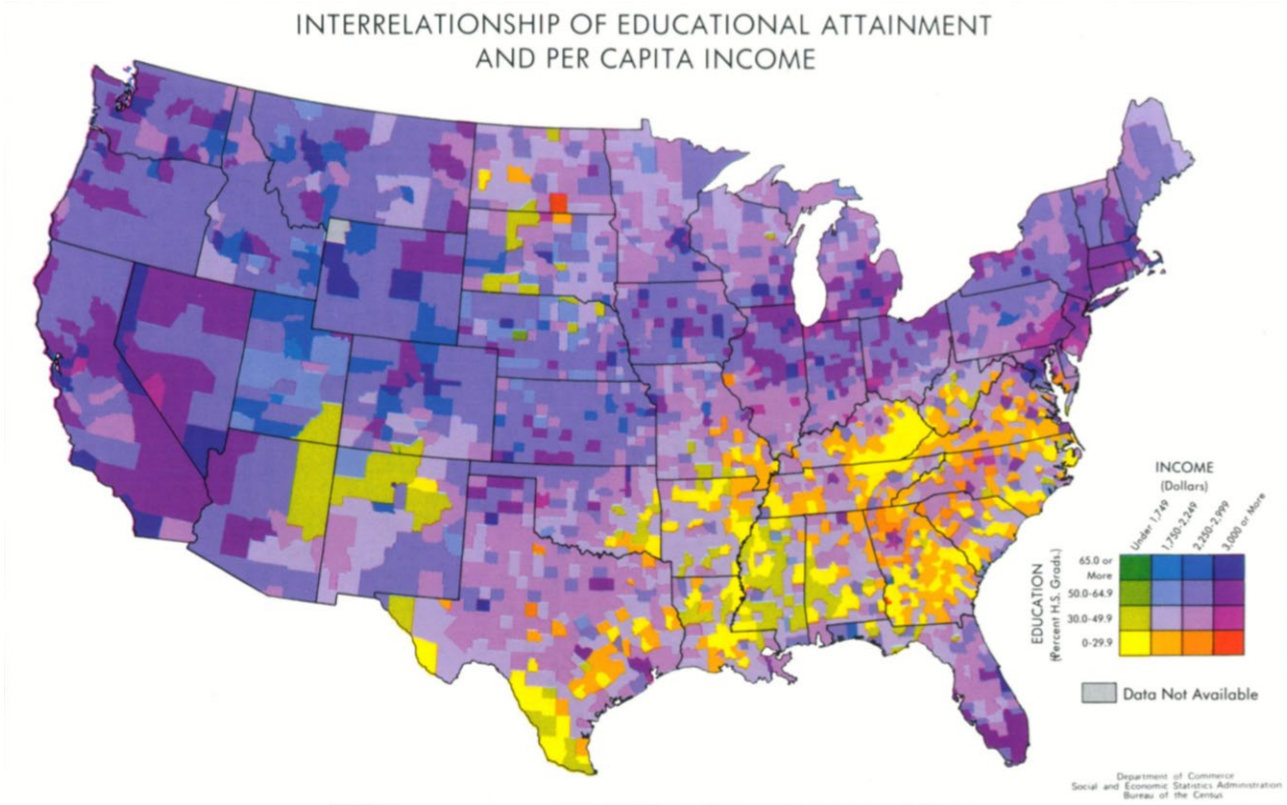
- Blending two colored choropleth maps into a single choropleth map
- How to design the color schemes?
  - United States Census Bureau's color schemes
  - Complementary colors by Eyton (1984)
  - Qualitative/sequential/diverging color schemes by Brewer (1994)
  - Cross-hatched shading by Carstensen (1986) and Lavin and Archer (1984)

Maps Combined I: Bivariate Choropleth Maps

- **U.S. Census Bureau's color schemes**
  - Distinguishability of colors
  - Smooth transition between colors
  - Individual categories visually distinguishable; two distributions as a whole separable from one another
  - Coherence in the triangle of cells above and below the main diagonals
  - Map relationship reflects as closely as possible the statistical relationship
  - Number of categories not exceed the number that can be dealt with by the reader



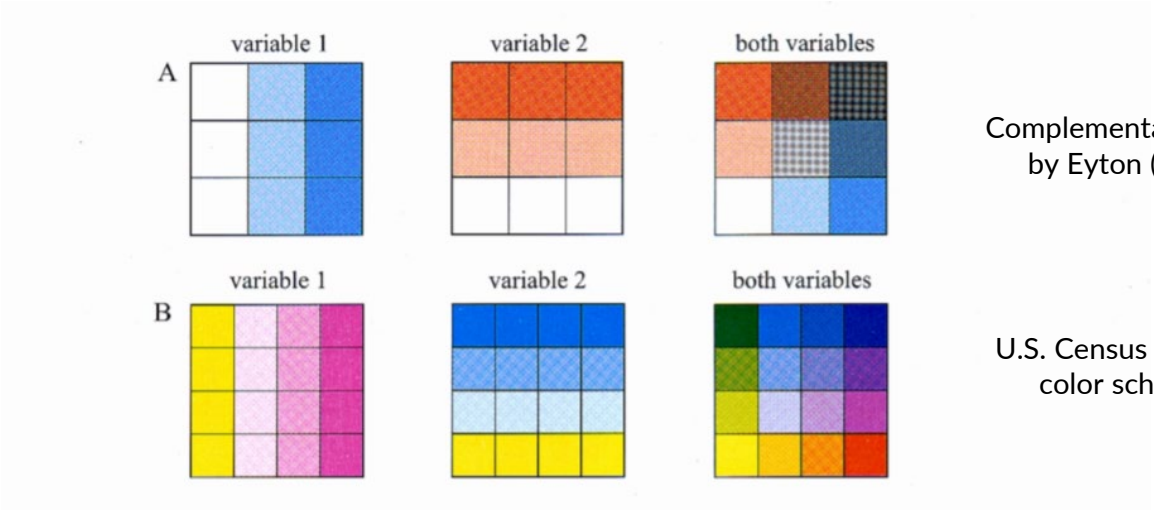
Olson, J. M. (1981). Spectrally encoded two-variable maps. *Annals of the Association of American Geographers*, 71(2), 259-276.



Bivariate choropleth map from the 1970s Urban Atlas from the U.S. Census Bureau

Maps Combined I: Bivariate Choropleth Maps

- **Complementary colors by Eyton (1984)**
  - Colors that combine to produce a shade of gray; also called “opposite colors” (strong contrast)
  - Compared to the census’s color schemes, such complementary colors are more logically ordered, and map patterns are discerned more easily



Complementary colors by Eyton (1984)

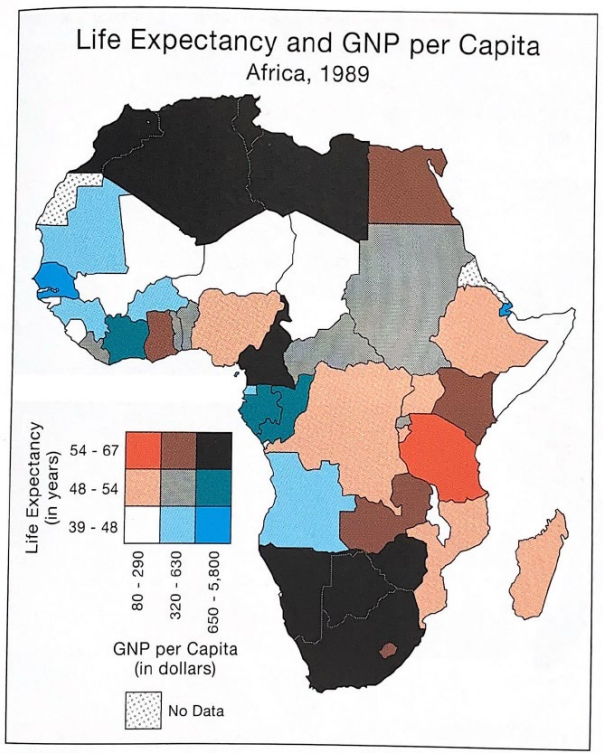
U.S. Census Bureau’s color schemes

Eyton, J. R. (1984). Complementary-color, two-variable maps. *Annals of the Association of American Geographers*, 74(3), 477-490.

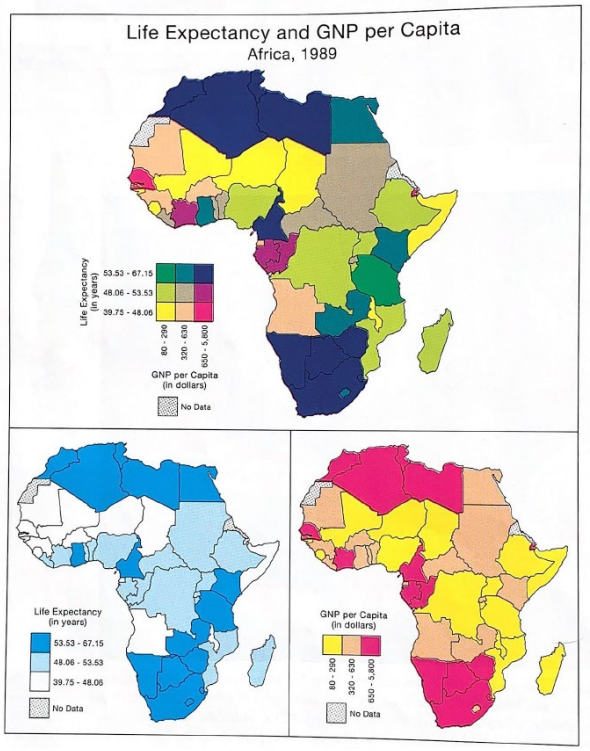
Question 2-1-5

Match the following two maps with their corresponding color schemes

- U.S. Census Bureau's color schemes, or complementary colors by Eyton (1984)



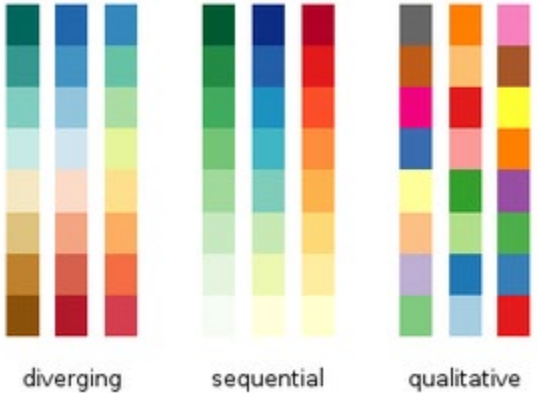
A



B

Maps Combined I: Bivariate Choropleth Maps

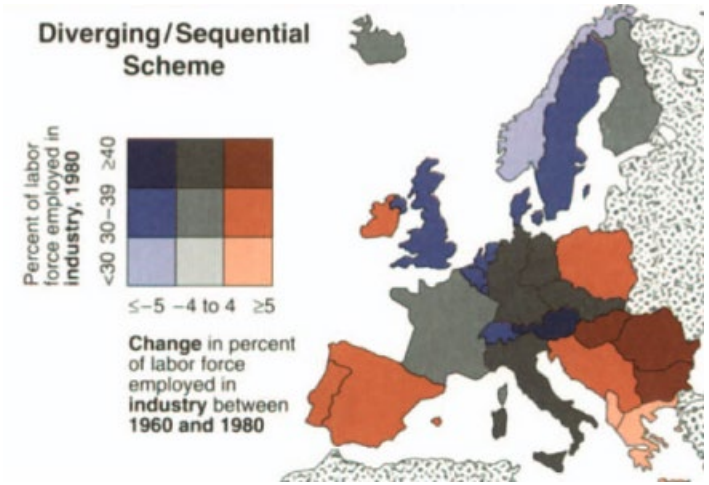
- **Qualitative/sequential/diverging color schemes by Brewer (1994)**
  - Recall color schemes for univariate mapping
    - Qualitative: for nominal data that has no inherent ordering, where color is used only to distinguish categories (e.g., dominant sectors)
    - Sequential: for unipolar data that progresses from low to high (e.g., population density)
    - Diverging: for bipolar data that emphasizes positive or negative deviations from a central value (e.g., population change: gain and loss, central value is 0)

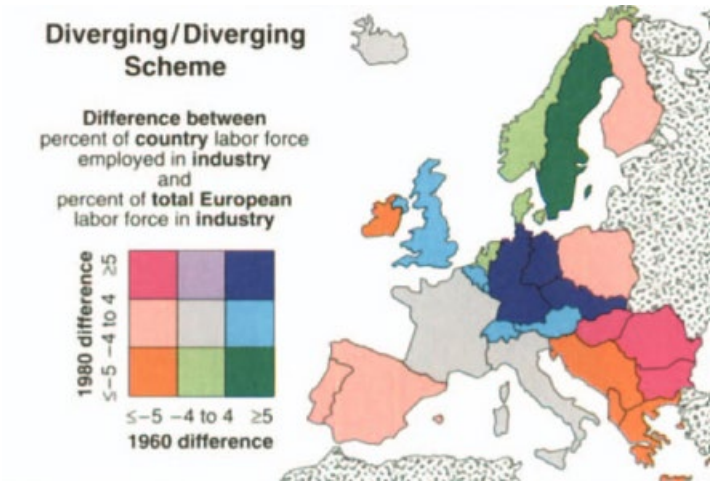


Brewer, C. A. (1994). Color use guidelines for mapping. *Visualization in Modern Cartography*, 1994, 123-148.

Maps Combined I: Bivariate Choropleth Maps

- **Qualitative/sequential/diverging color schemes by Brewer (1994)**
  - Combine color schemes for bivariate mapping
    - Qualitative/sequential: one nominal, the other unipolar
    - Qualitative/diverging: one nominal, the other bipolar
    - Sequential/sequential: two unipolar (complementary colors or subtractive primaries)
    - Sequential/diverging: one unipolar, the other bipolar
    - Diverging/diverging: two bipolar

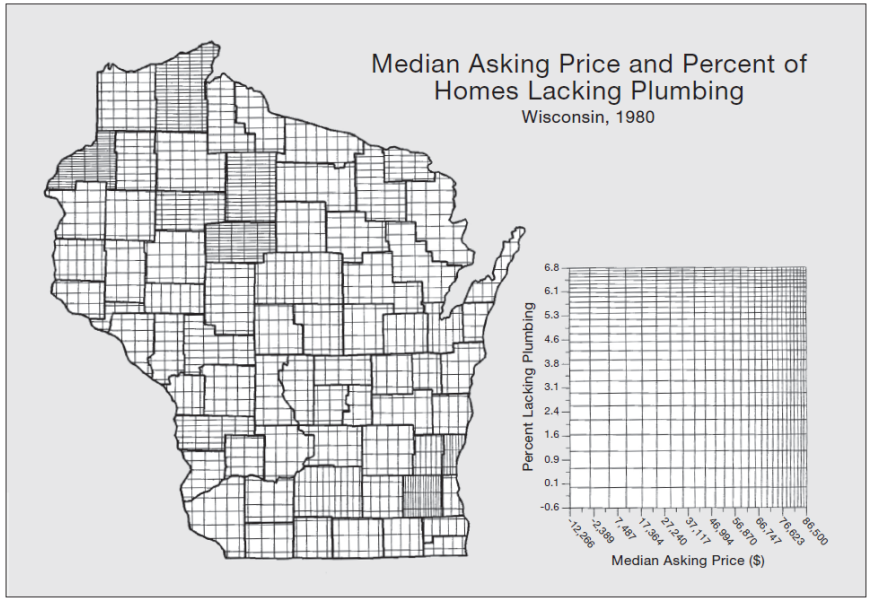




Brewer, C. A. (1994). Color use guidelines for mapping. *Visualization in Modern Cartography*, 1994, 123-148.

Maps Combined I: Bivariate Choropleth Maps

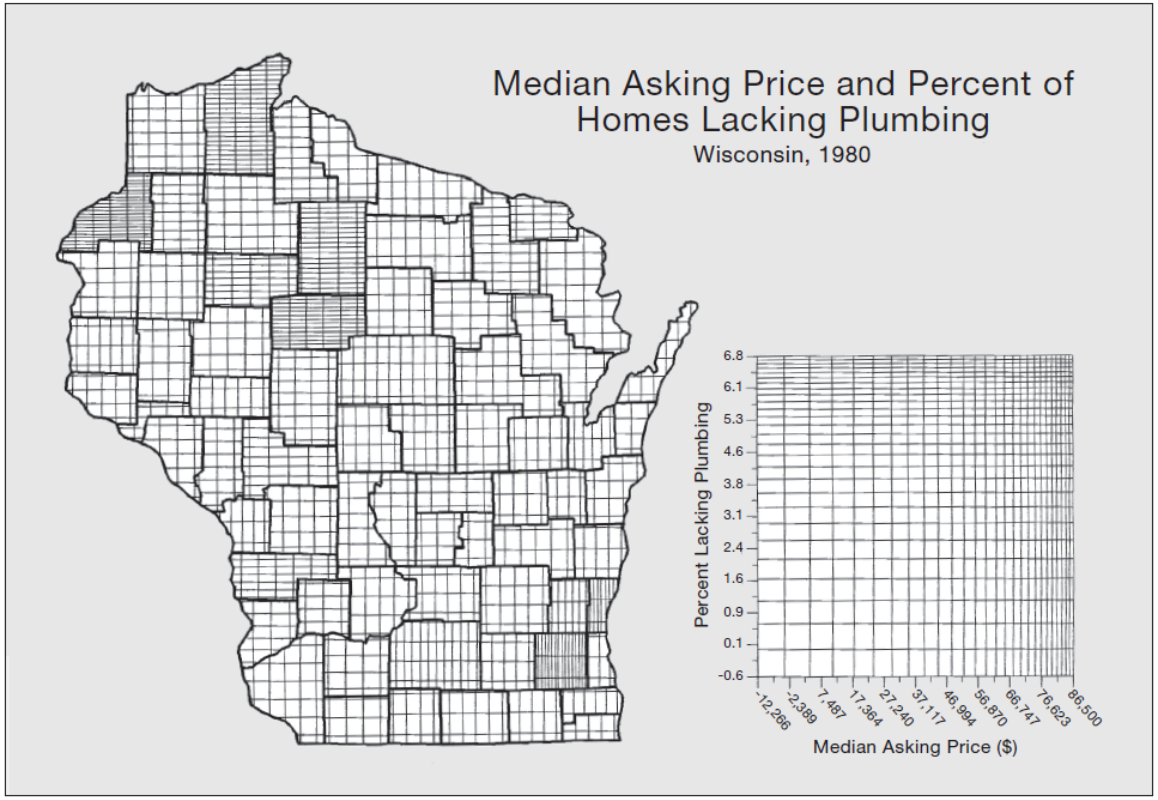
- **Cross-hatched shading**
  - Interpretation of such maps focuses on the size and shape of the boxes formed by the cross-hatched lines
    - Low values on both variables -> large squares, high values on both variables -> small squares
    - High positive correlation -> squares dominant, high negative correlation -> rectangles dominant



Bivariate choropleth mapping: The effects of axis scaling. *The American Cartographer*, 13(1), 27-42.

Question 2-1-6

What is your guess about the correlation between “median asking price” and “percent of homes lacking plumbing”?

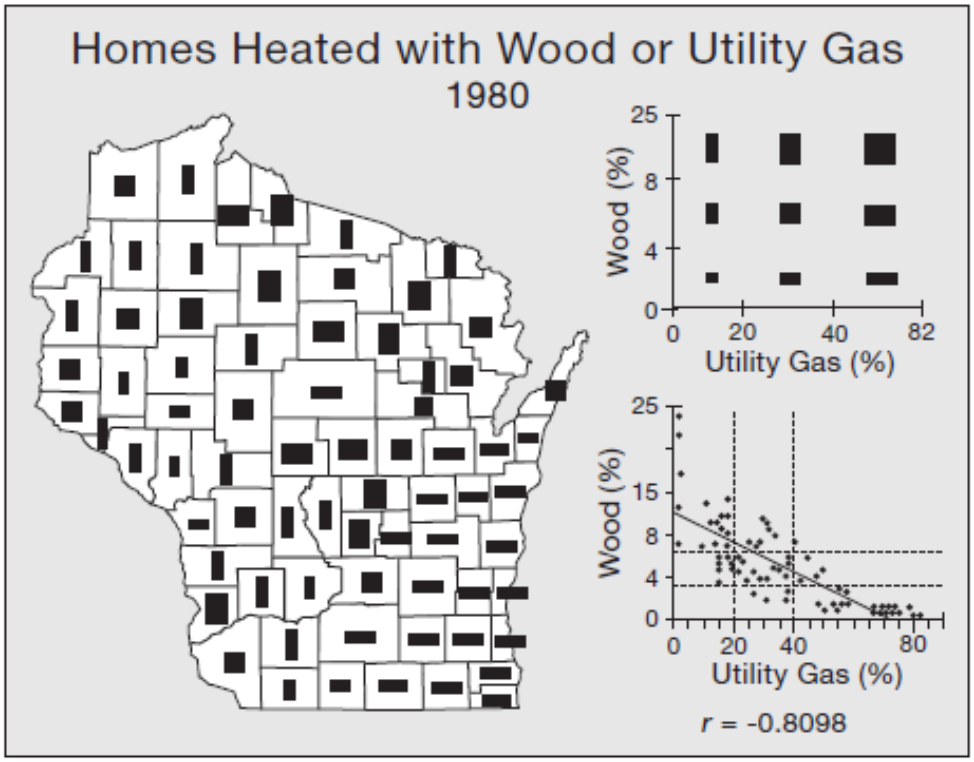


Maps Combined II: Bivariate Point Symbol

- Use one visual variable in the point symbol to represent two attributes
- Commonly used point symbols
  - Rectangular point symbol
  - Bivariate ray-glyph

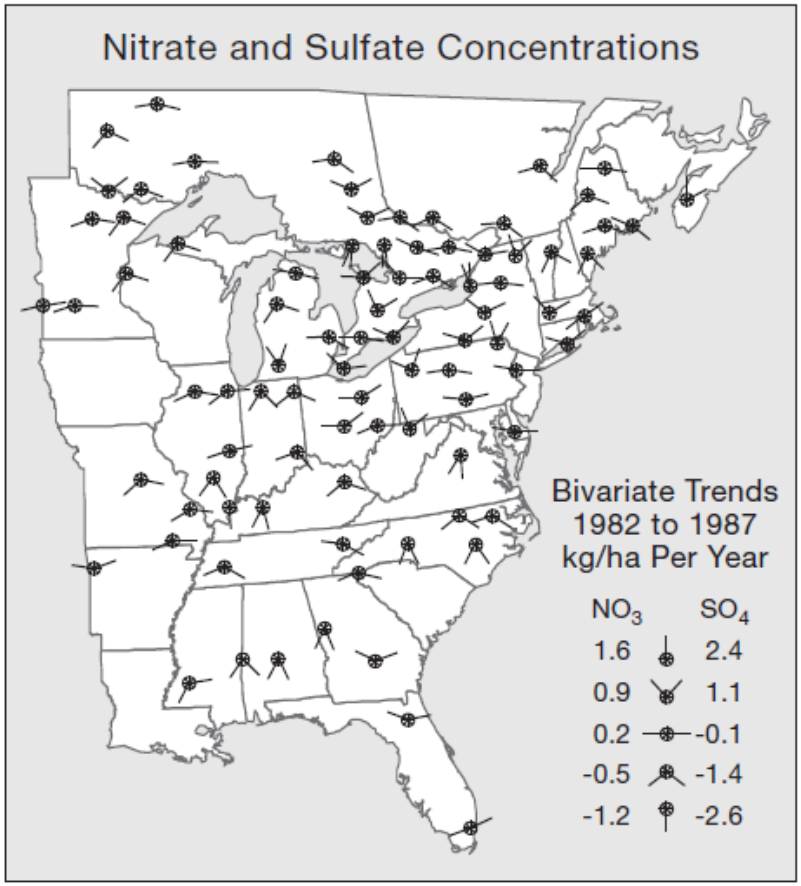
Maps Combined II: Bivariate Point Symbol

- **Rectangular point symbol**
  - Width and height of a rectangle are made proportional to each of the attributes being mapped



Maps Combined II: Bivariate Point Symbol

- **Bivariate ray-glyph**
  - Rays pointing to left and right represent two variables

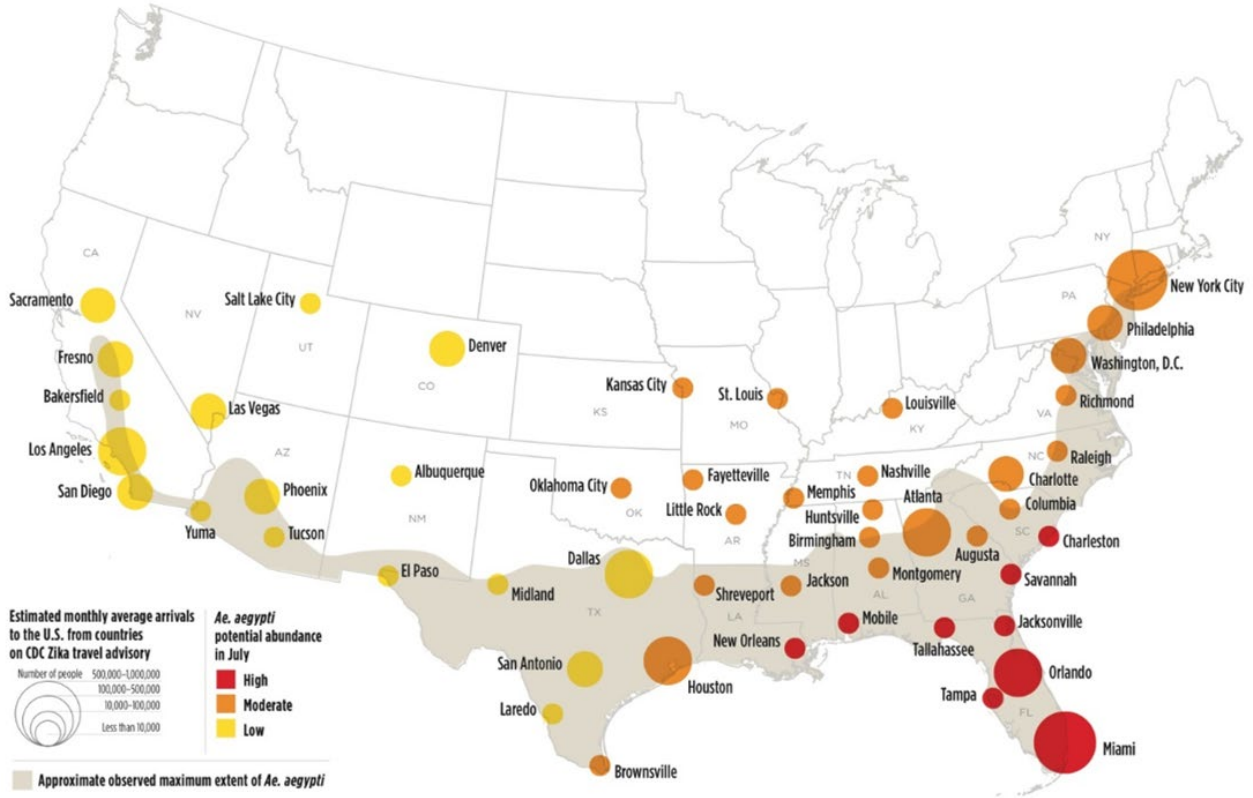


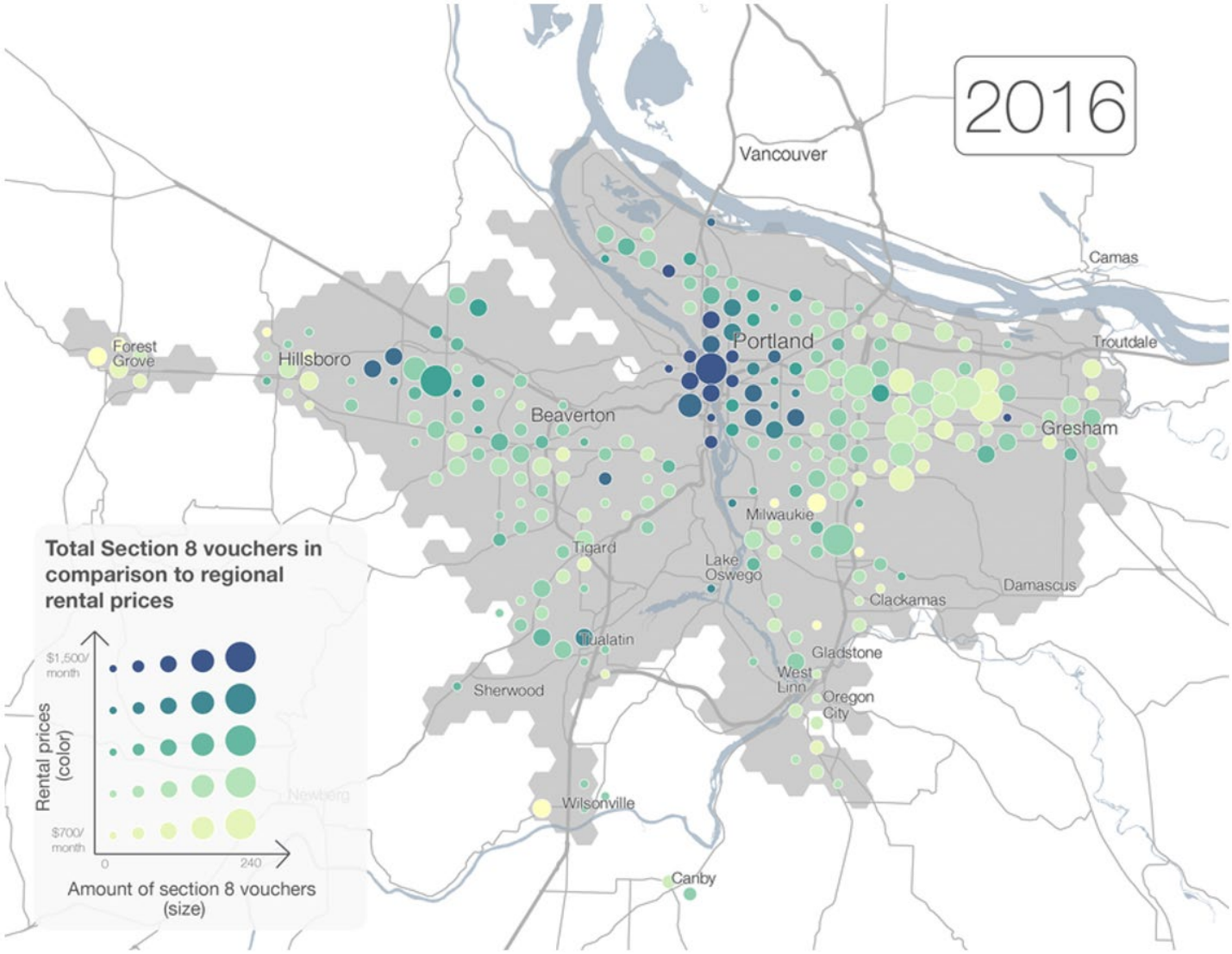
Maps Combined III: Combining Two Types of Symbols

- Use two visual variables to represent two attributes
- Commonly used methods
  - Combining proportional and choropleth symbols
  - Overlaying proportional symbols with a choropleth map

Maps Combined III: Combining Two Types of Symbols

- **Combining proportional and choropleth symbols**
  - The size of the proportional symbol used for one variable, and a choropleth shaded within the symbol used for the other





A map of Section 8 housing and rent prices in Portland, Oregon

Maps Combined III: Combining Two Types of Symbols

- **Overlaying proportional symbols with a choropleth map**
  - The size of the proportional symbol used for one variable, and the choropleth shade within the polygon used for the other