NUS
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GE2215 Lecture 4
GIS Data Visualization and Spatial Representation

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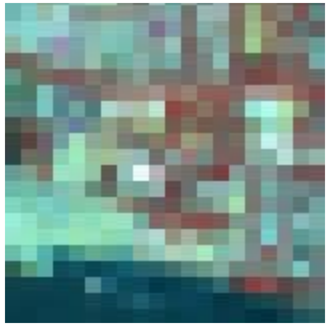
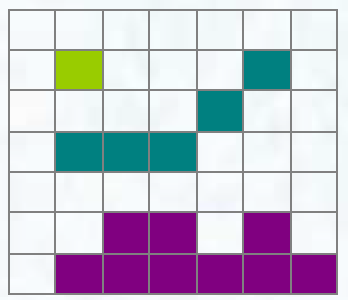
Recap: Concepts of Raster Data Model

A raster image



A raster image after zooming in

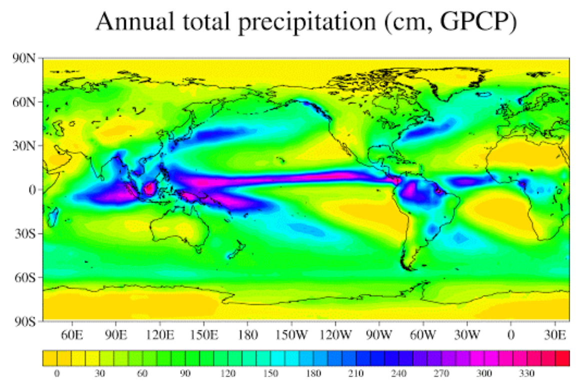


Digital representation of a raster image

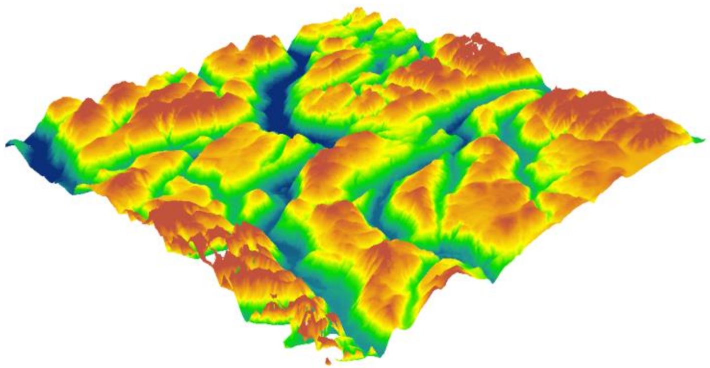
The basic unit in raster image data is **pixel** or **cell**.
The essence of raster image data is a **pixel array**

Recap: Why Raster Data Model

- A better option for representing continuous phenomenon is the raster data model



Precipitation distribution



Elevation model

Recap: Types of Raster Data

- Scanned paper maps
- Maps captured on computer screen
- **Satellite images**
- **DEM**

Scanned paper map

Screenshot OneMap

Satellite	Country	Bands	Resolution (m)	Spectral range (um)	First Launch time
Landsat	USA	~ 8	15 - 120	0.45 – 2.35	1972
Spot	France	4	1.5 - 20	0.50 – 0.89	1986
GeoEye	Digital Globe/USA	5	0.4 – 1.6	0.45 – 0.92	2008
MODIS	NASA/USA	36	250 - 1000	0.62 – 14.4	1999

Satellite image

Recap: Elements of Raster Data Model

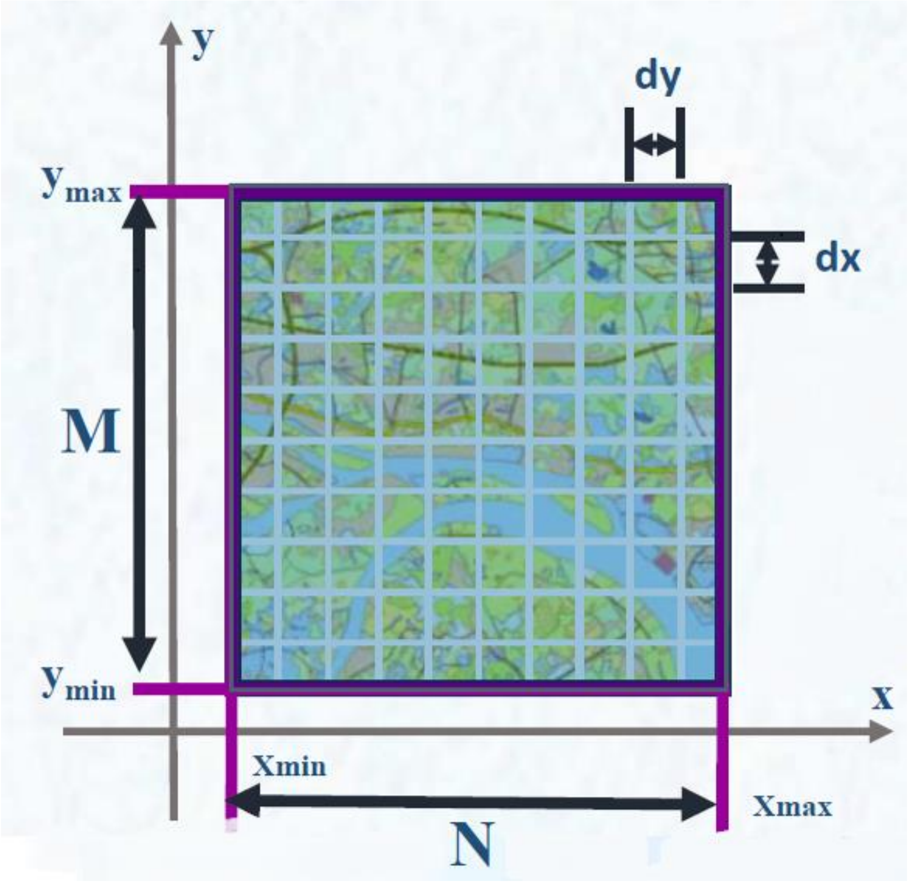
- Cell size
- Resolution (satellite image)
  - Spatial, temporal, spectral resolution
- Cell value
  - Categorical or numerical
- Cell depth
- Raster bands
- Spatial reference

Recap: Raster Data Structure

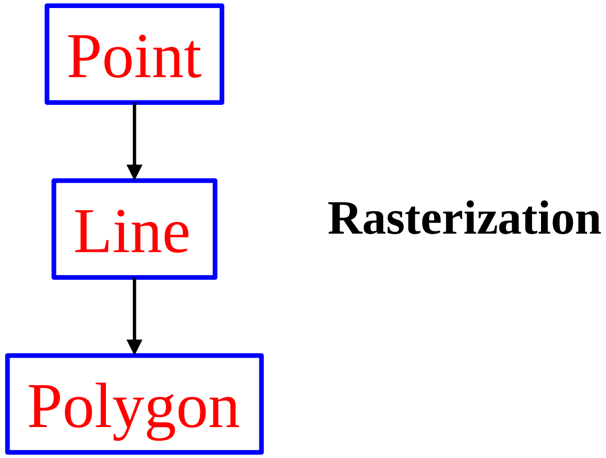
- Cell-by-cell encoding
- Run-length encoding
- Quadtree encoding

Recap: Rasterization

First step: Set up a raster with a specified **cell size**



Each point corresponds to one pixel in the raster data



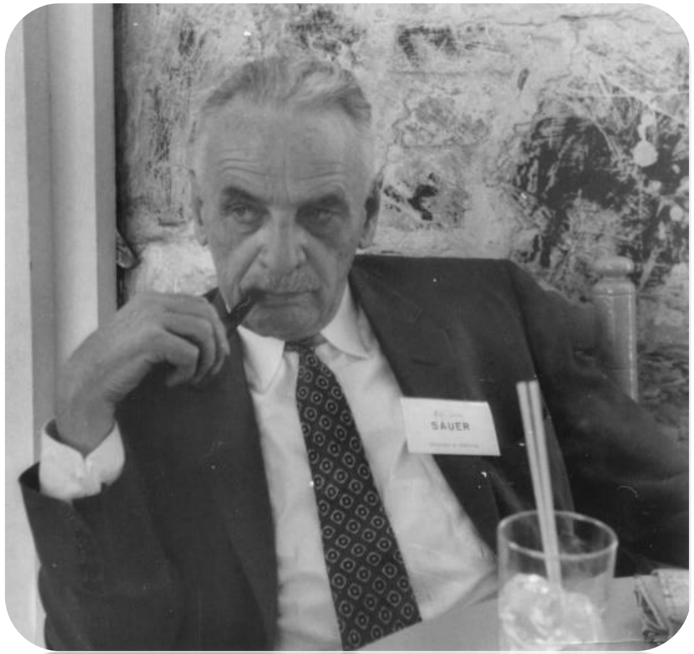
Outline of this lecture

- What is map?
- Types of maps
- Symbolization
- Classifying features
- Elements of cartographic design
- Principles of map design

What is map?

“The map speaks across the barriers of language. it is sometimes claimed as the language of geography.”

Sauer (1956)



Carl Ortwin Sauer (December 24, 1889 – July 18, 1975) was one of the most prominent geographers in America during the twentieth century.

What is map?

- Map VS GIS
  - Many professionals, for whatever reasons, often say they want to get into GIS, but what they really mean is that they want a way to display data, not a way to analyze data as can be done with most GIS (Dent, 1999).
  - Maps are an interface to a geographic information system (GIS) (Kraak and Ormeling, 1996)
  - As a visual tool, maps are most effective in communicating geospatial data.

Singapore Planning Area Boundaries 2018

Missing a legend

URA

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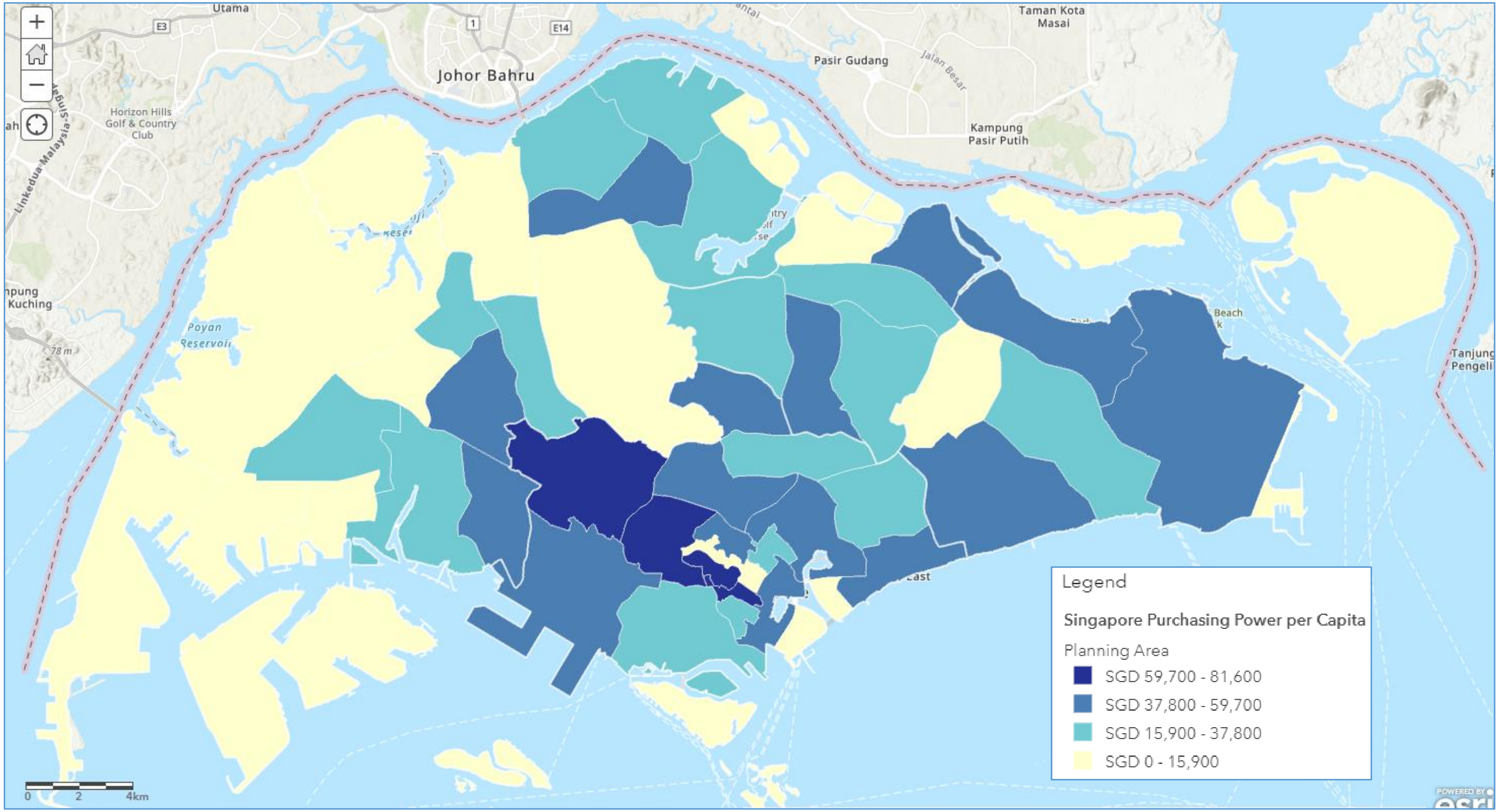
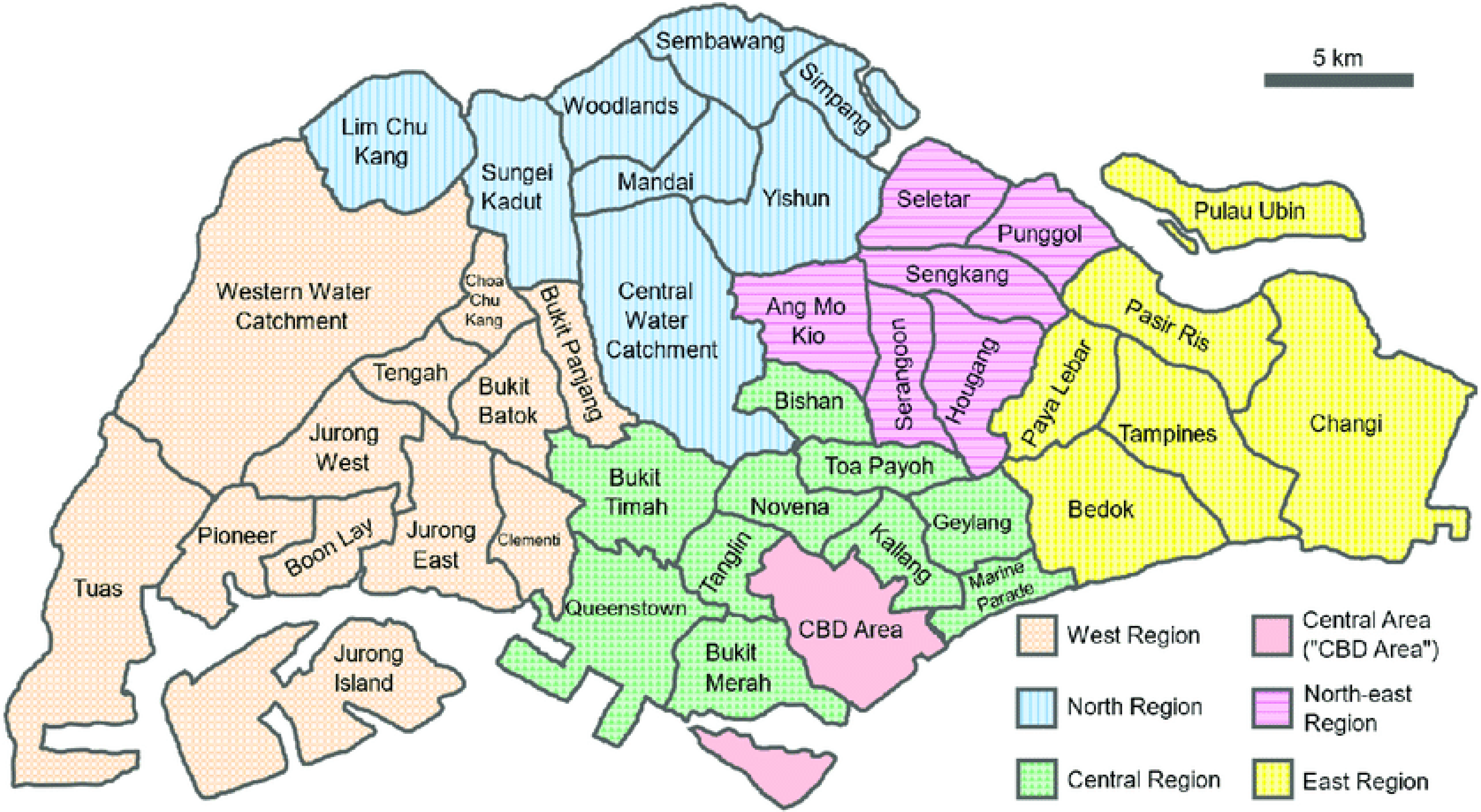
Singapore Purchasing Power Per Capita in 2018

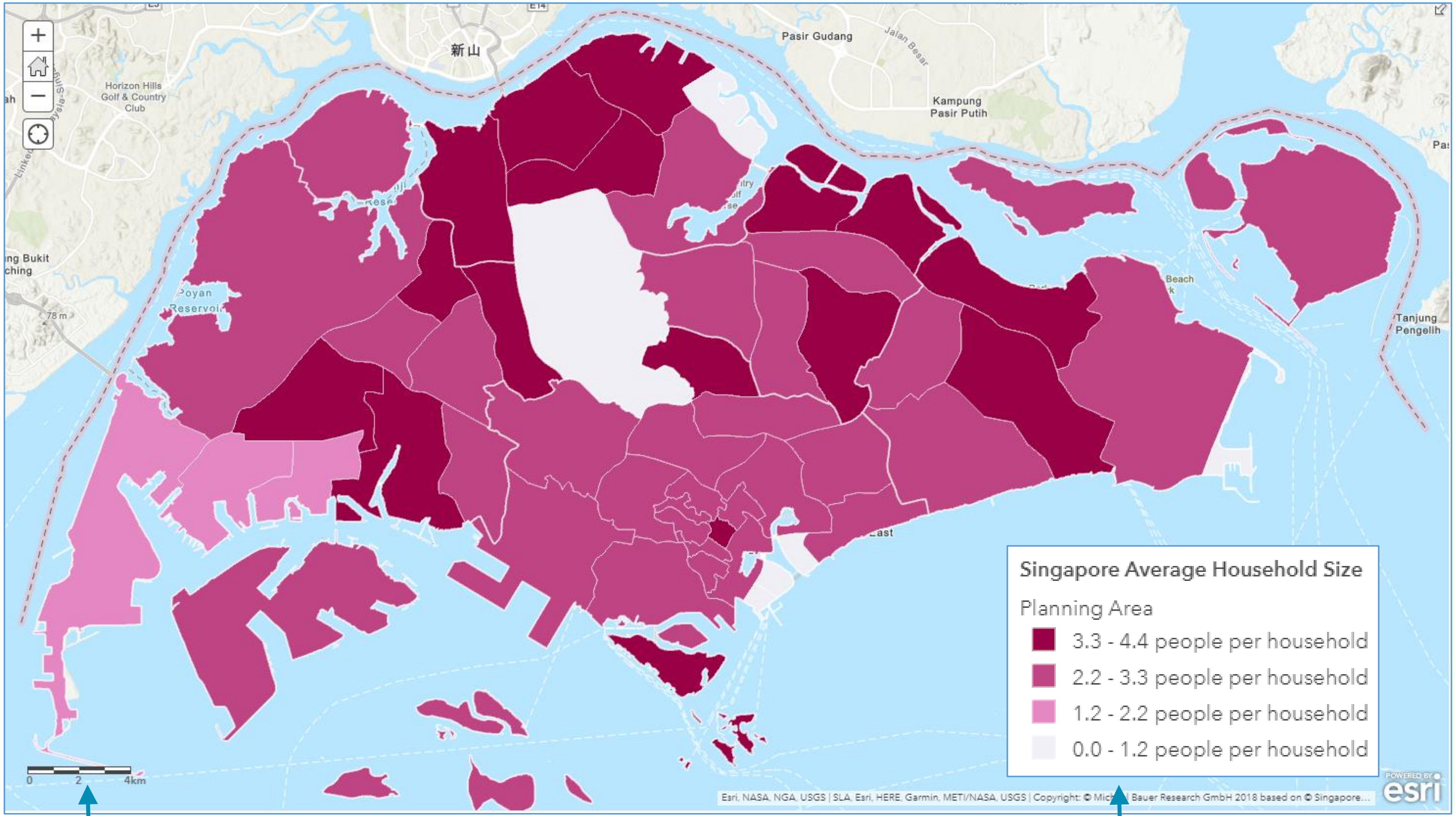


ESRI



https://www.researchgate.net/figure/Major-planning-regions-of-Singapore-as-defined-by-the-Urban-Redevelopment-Authority-URA_fig1_361419955

Singapore Average Household Size in 2018

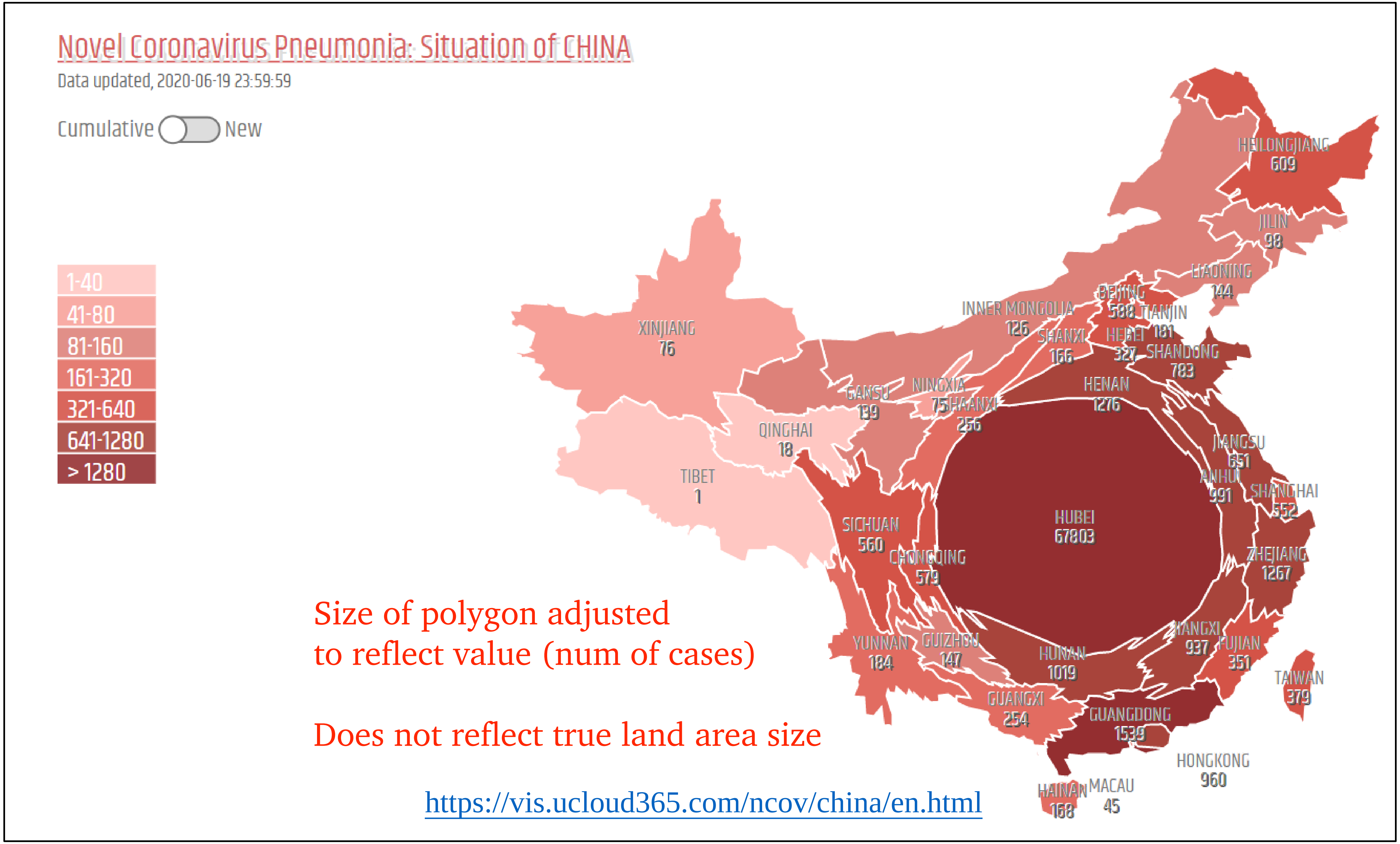


Scale bar

Legend

ESRI

Cartogram

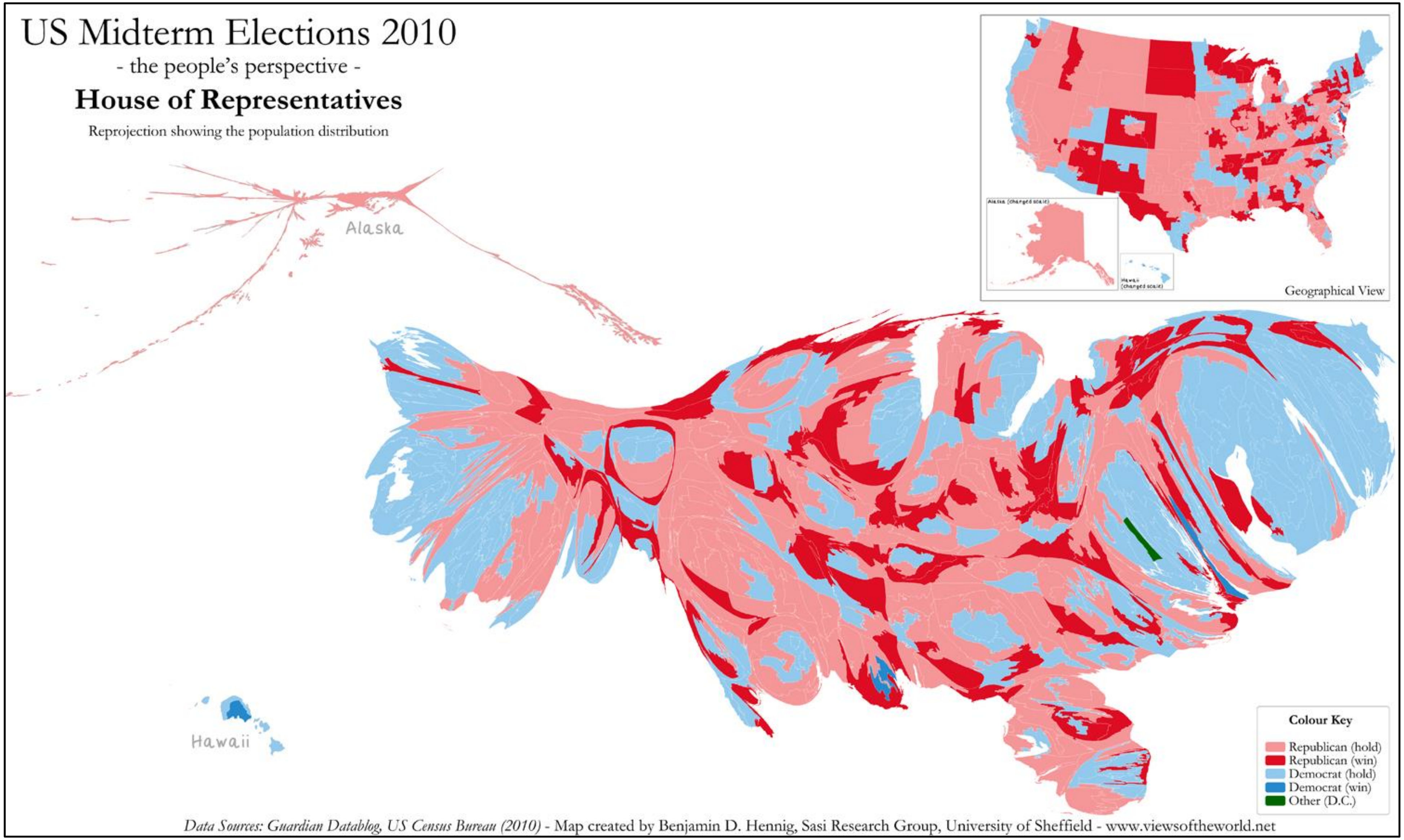


Size of polygon adjusted
to reflect value (num of cases)

Does not reflect true land area size

https://vis.ucloud365.com/ncov/china/en.html

Cartogram

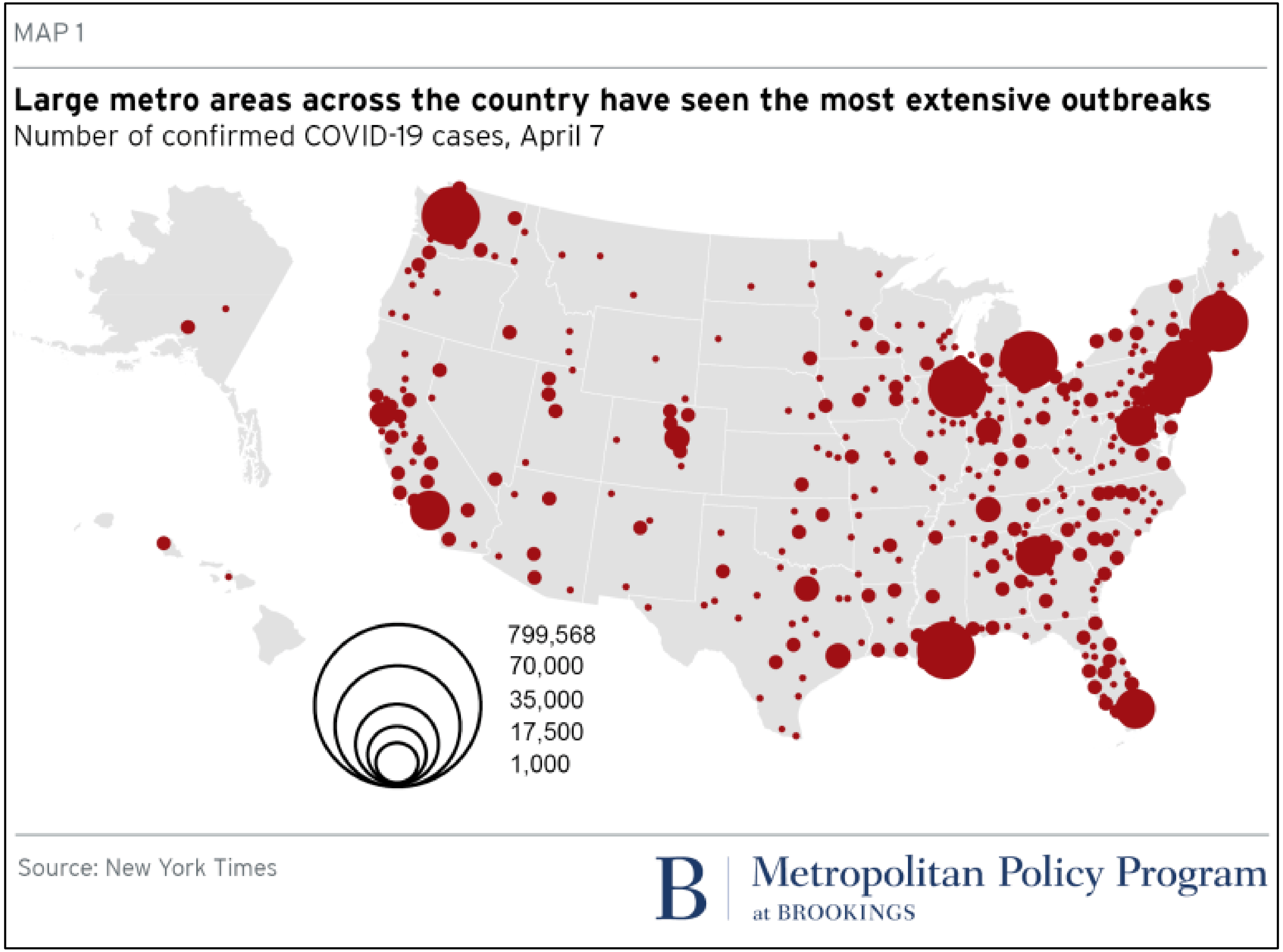


Adjusted based on population http://www.viewsoftheworld.net/?p=1011

Topological relations remain unchanged

Proportional map

Size of circle represents diff values



Missing scale bar is ok (big area)

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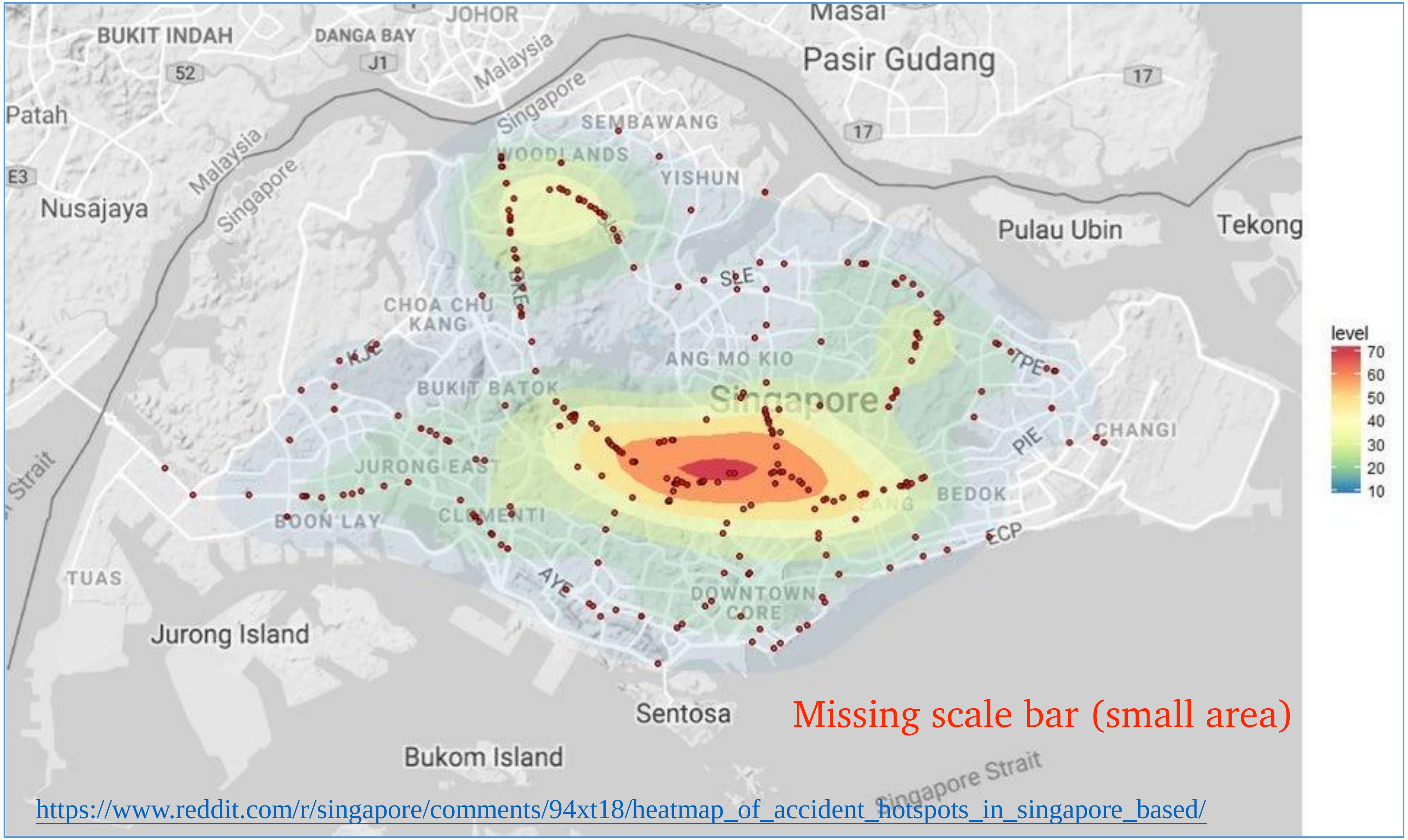
Heatmap of accident hotspots in Singapore based on around 15 days of accident data in June 2018



https://www.reddit.com/r/singapore/comments/94xt18/heatmap_of_accident_hotspots_in_singapore_based/

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- Types of maps
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- Classifying features
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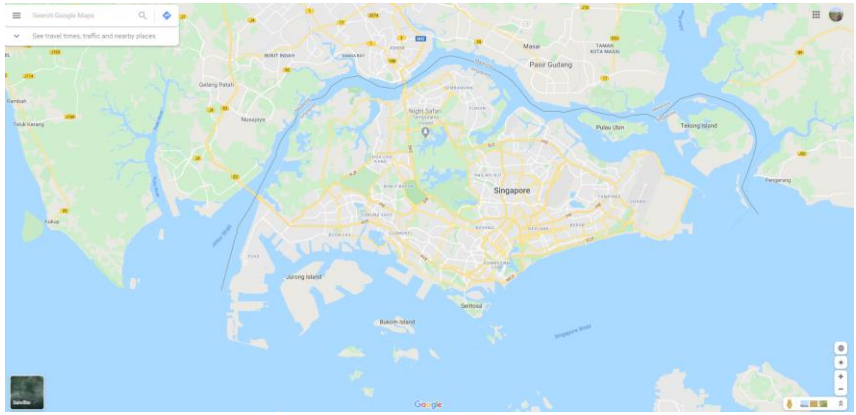
Types of maps

- Based on different classification strategies, cartographers classify maps into:
  - **General reference** or **thematic**
  - **Qualitative** or **quantitative**

General reference maps

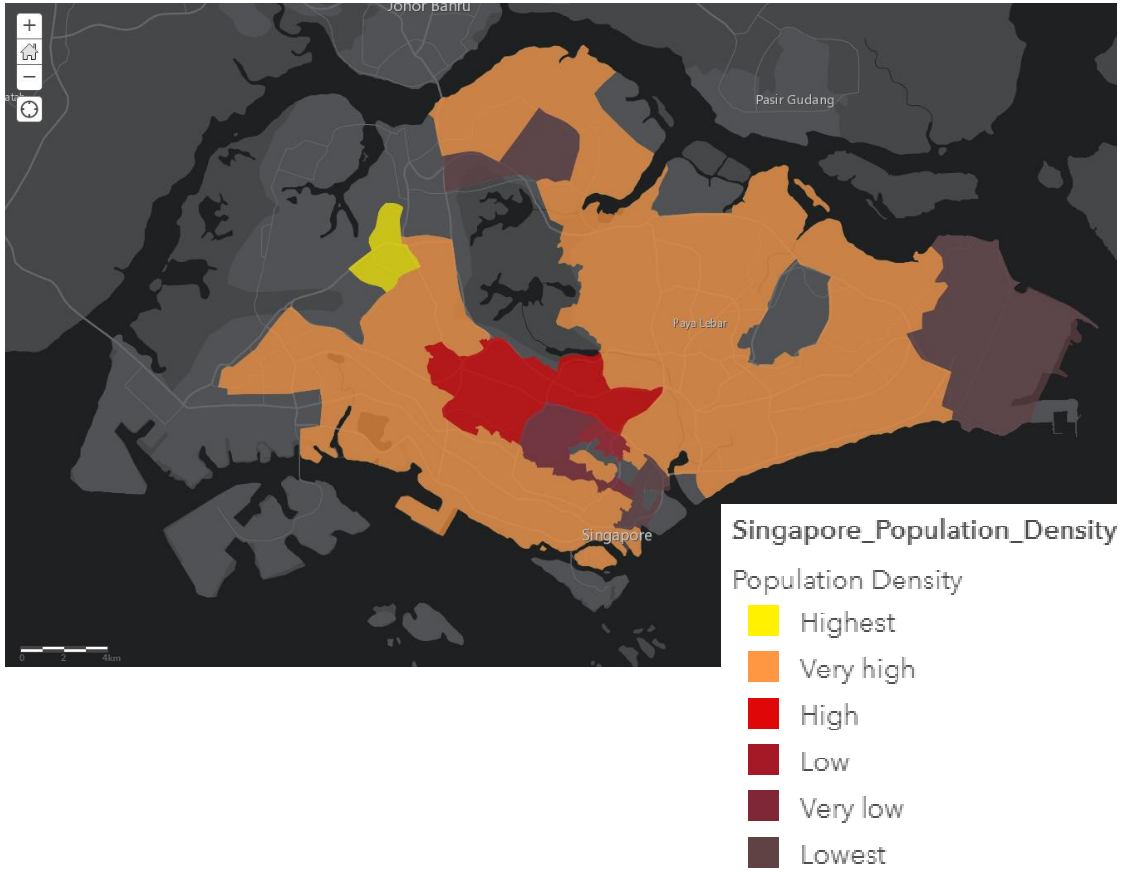
- Designed for general purposes, primarily used for navigation
- Often standardized symbolization and scales
- Displays a large variety of spatial features
- World map, OneMap, Google map, Bing map



Thematic maps

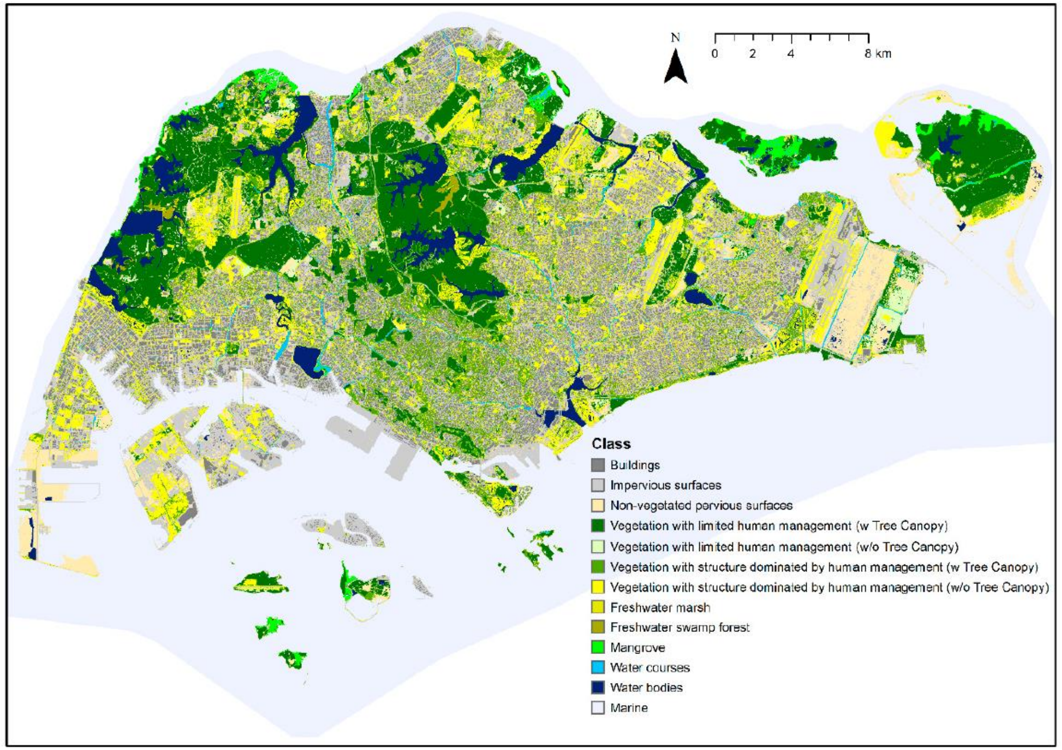
- Designed for special purposes
- Displays the spatial pattern of one or more select themes
- For example, distribution of population densities by planning area, or distribution of purchasing power per capita

Singapore Population Density



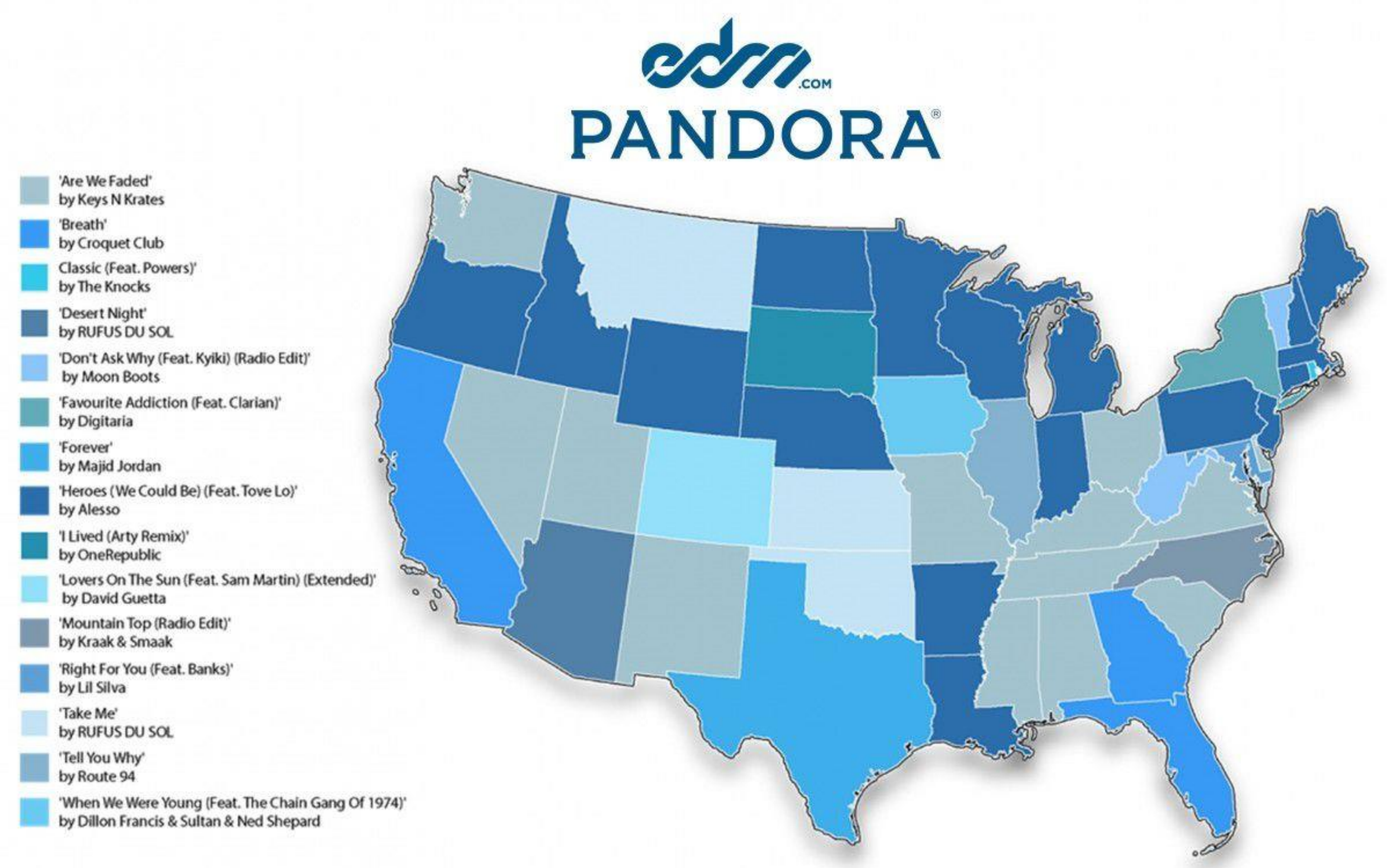
Qualitative maps

- A qualitative map portrays different types of data
  - Land use map displaying different categories of land use
  - Vegetation map showing different categories of vegetation



Cited from "A High-Resolution Map of Singapore's Terrestrial Ecosystems"

Is this a good map?



Colours are too close to each other, should be more differentiable

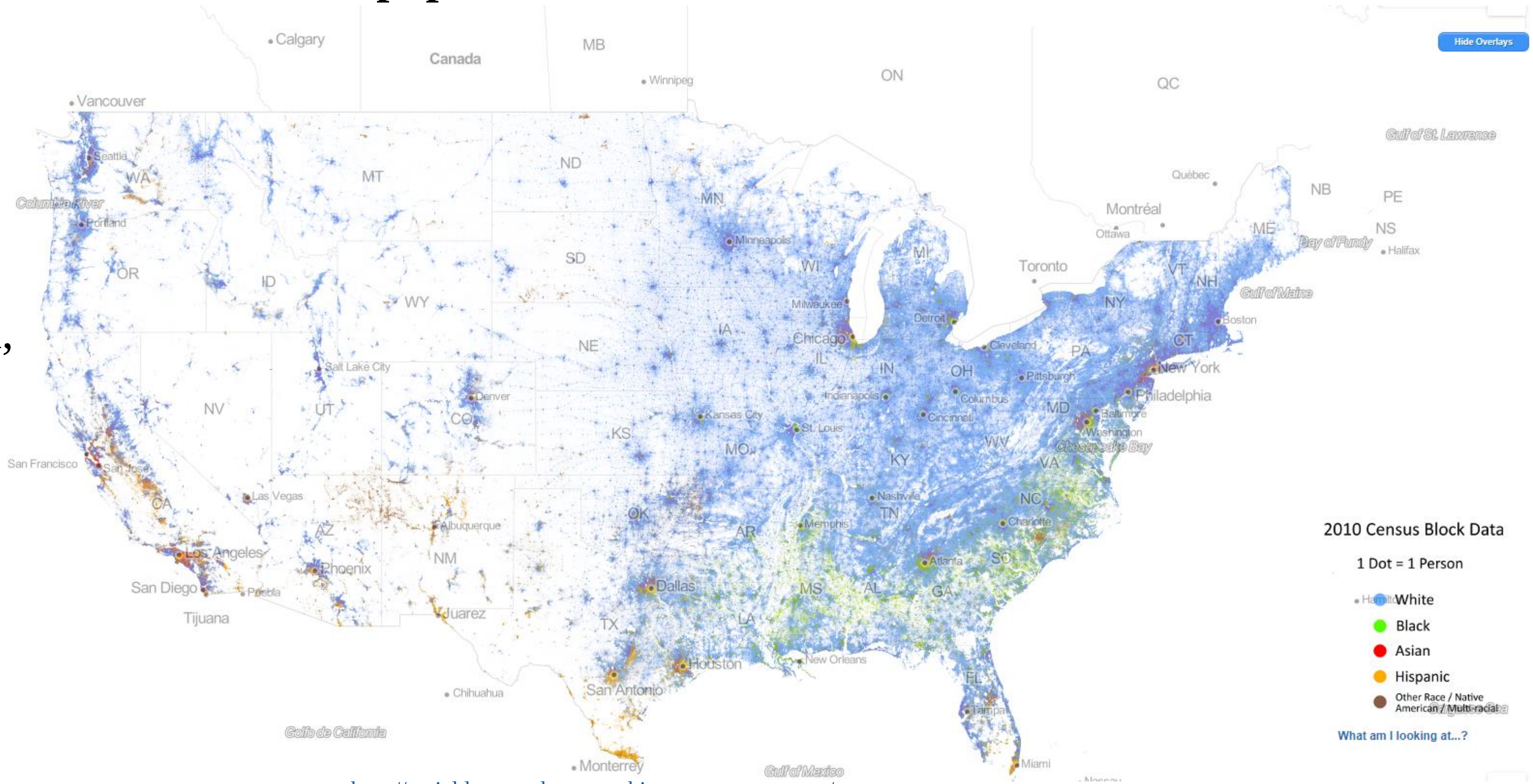
Quantitative maps

- A quantitative map communicates ranked or numeric data
- How can the quantity information be reflected?
  - Color
  - Size of symbol
  - Chart
- Common types of quantitative maps
  - Dot map
  - Choropleth map
  - Graduated symbol map
  - Pie chart map
  - Flow map
  - Isarithmic map

Dot map

The dot map uses **uniform** point symbols to show geospatial data, with each symbol representing a unit value

US population distribution in 2010



http://racialdotmap.demographics.coopercenter.org/

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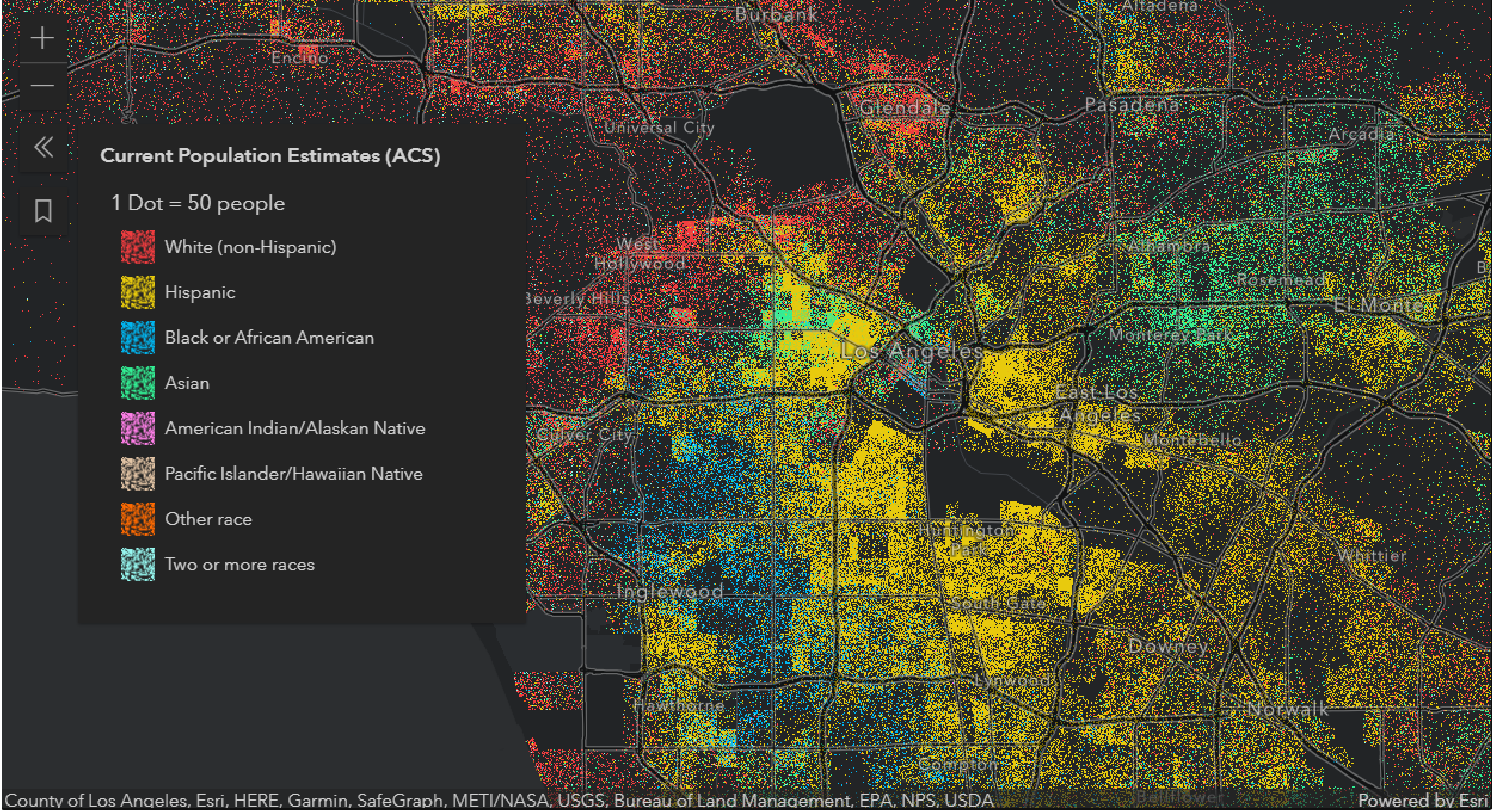
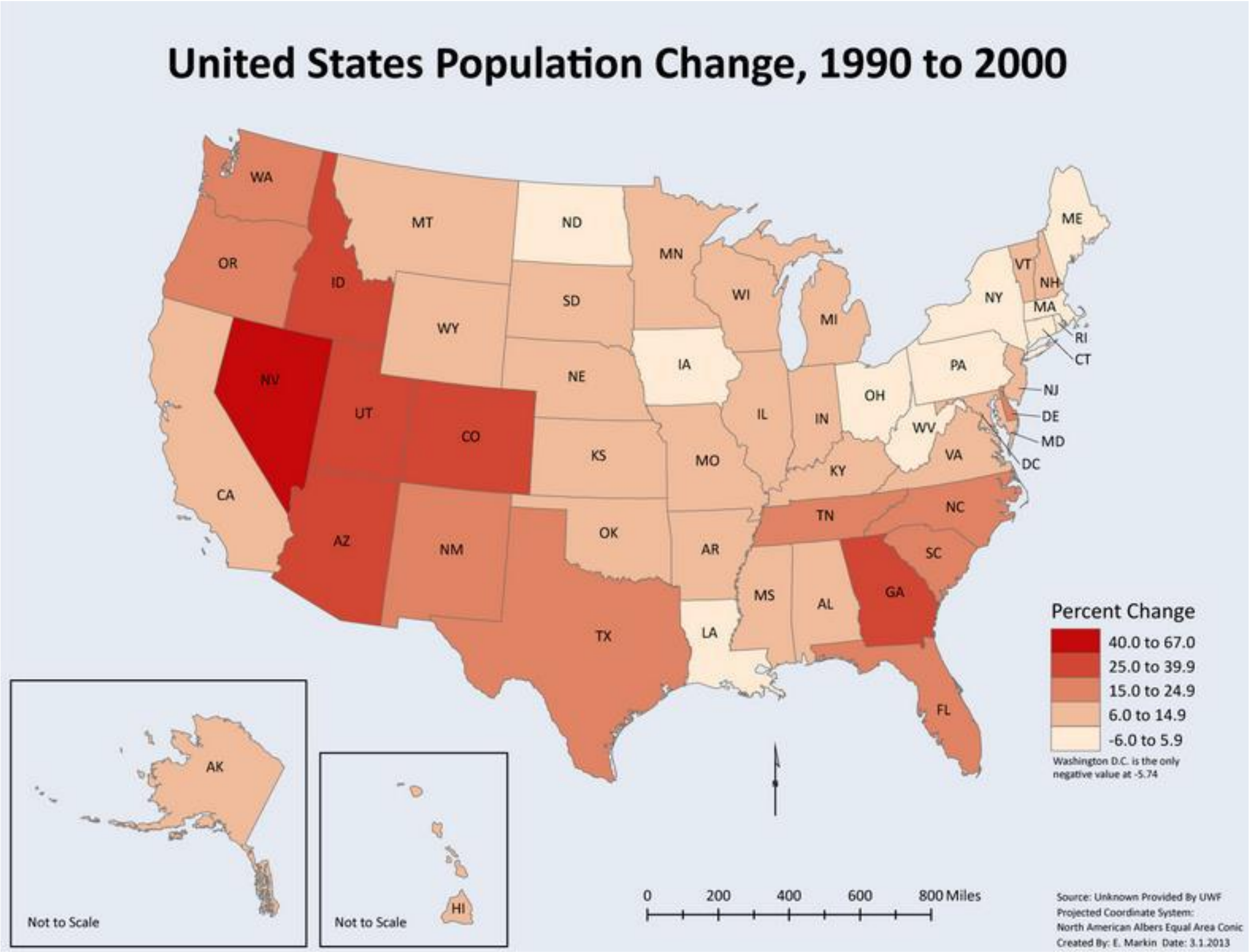


https://www.esri.com/arcgis-blog/products/js-api-arcgis/mapping/interactive-dot-density-maps-for-the-web/

Choropleth map

- The choropleth map symbolizes derived data based on administrative units using a color scheme
- The derived data are usually classified prior to mapping
- The appearance can be greatly affected by data classification

Need to consider best way to classify data. It affects the design of the choropleth map



Is this a good map?

1. The colours do not suggest an increase or decrease in magnitude

2. It would be nice to have some commas in the legend to help us read the numbers

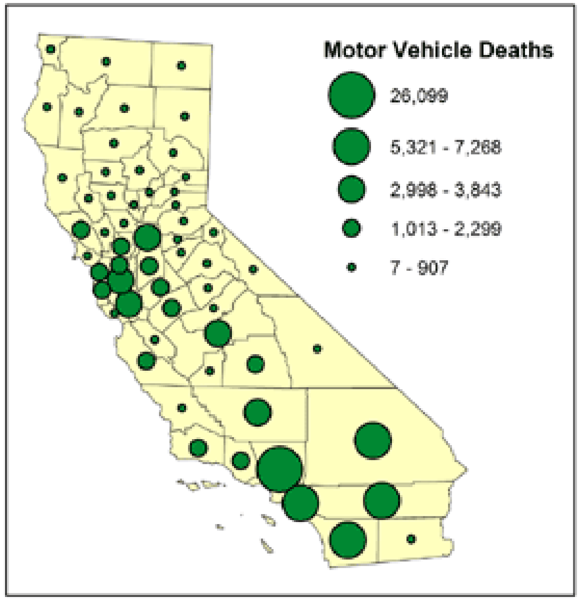
3. Absolute numbers used, instead of ratios or percentages

4. Bad projection (See Lecture 5)

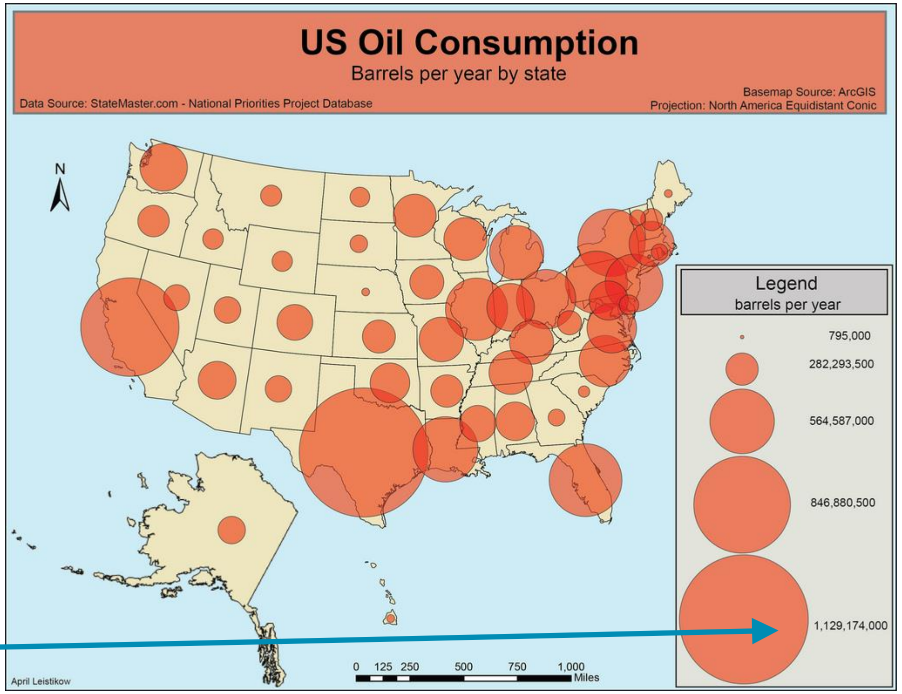
http://geographer-at-large.blogspot.com/2011/02/wtf-is-this-bad-maps.html

Graduated symbol map

- It uses different-sized symbols such as circles, squares, or triangles to represent different ranges of values
- Two issues:
  - Ranges of sizes
  - The discernible difference between sizes
- A variation is proportional map, which uses a specific symbol size for each numeric value rather than a range of values



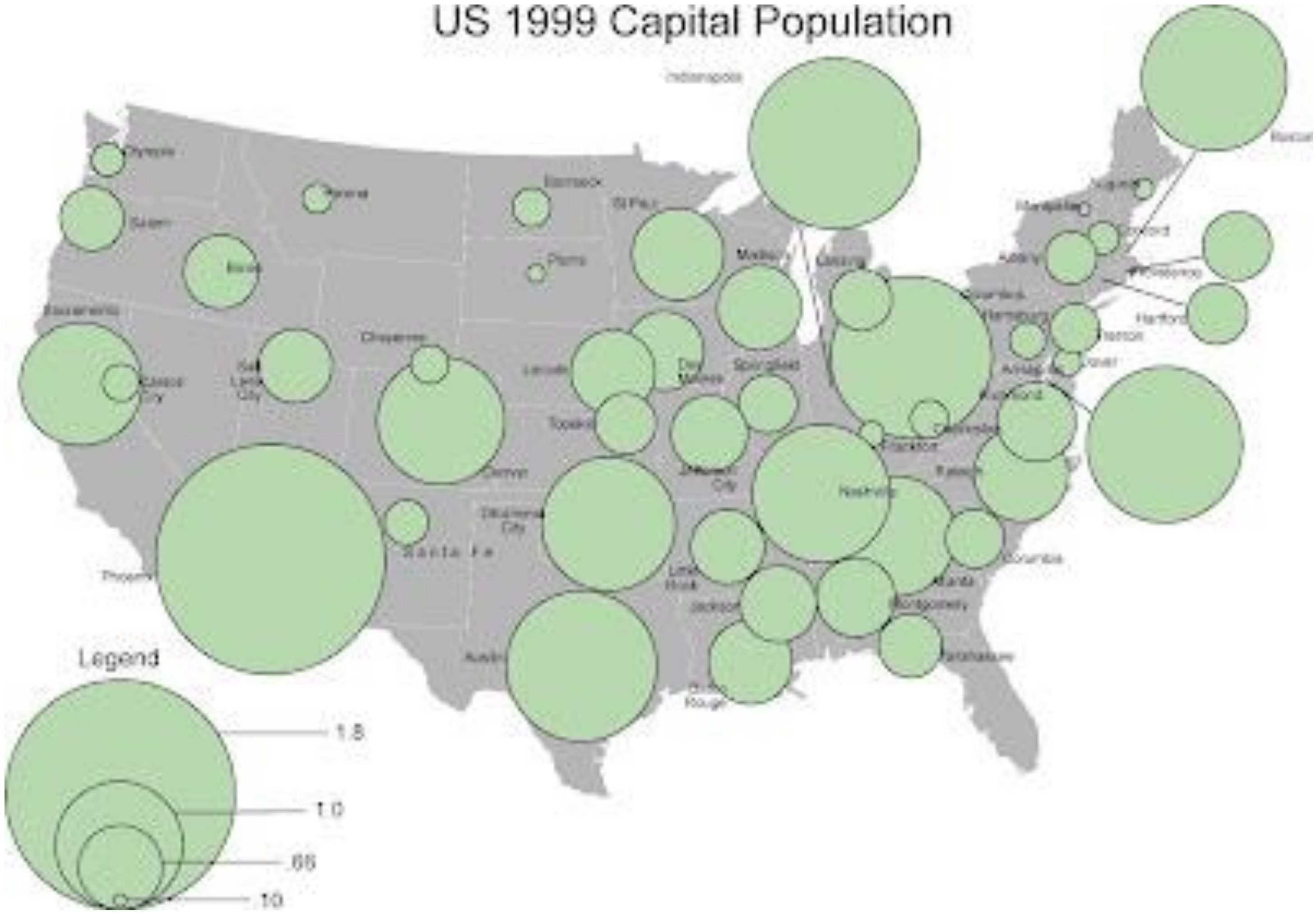
http://royrogersfsu.blogspot.com/2014/04/continuously-variable-proportional.html



Proportional symbol map:
No ranges in values

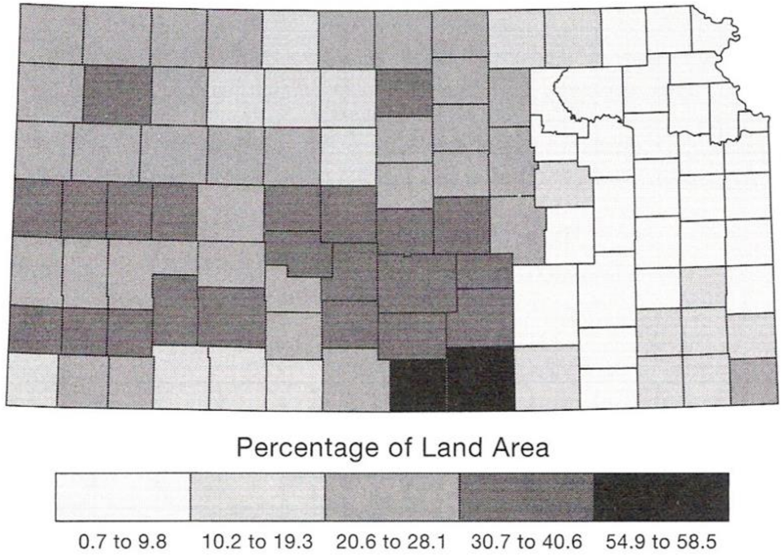
https://www.flickr.com/photos/89769525@N08/8242929652/

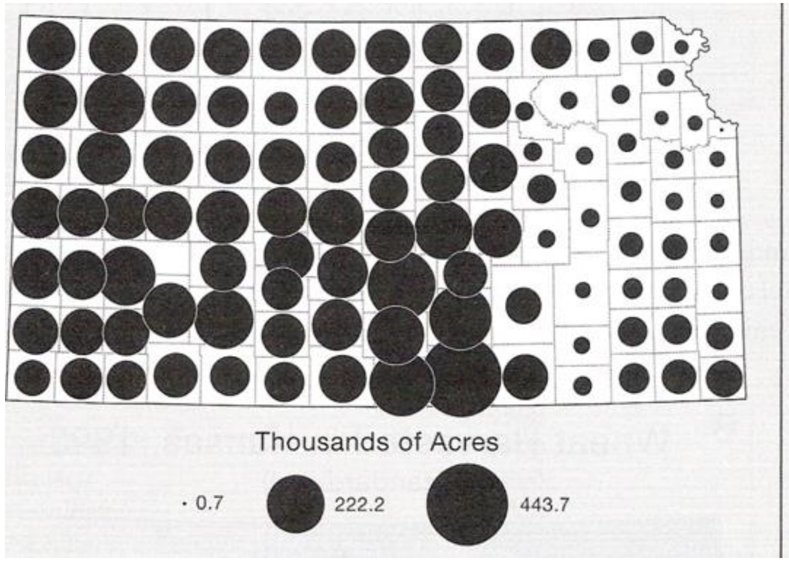
Is this a good map?



http://geographer-at-large.blogspot.com/2011/02/wtf-is-this-bad-maps.html

What are the differences?





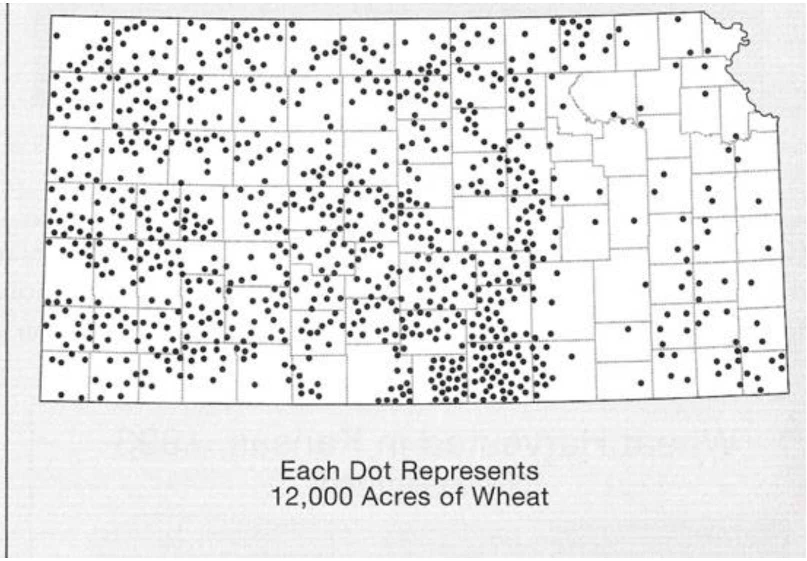
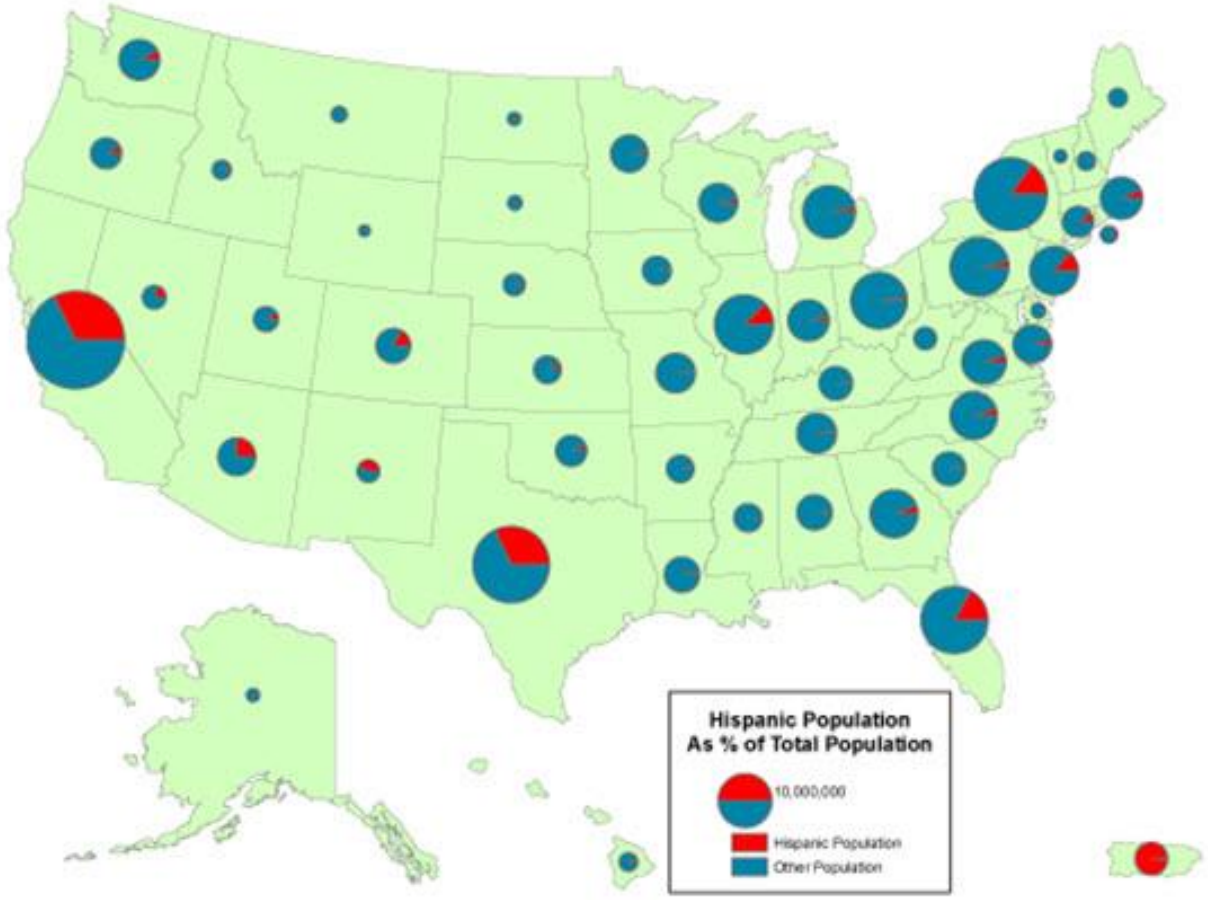


Chart map

- It uses either pie charts or bar charts.
- The pie chart can display two sets of quantitative data:
  - The circle size can be made proportional to a value of a state population
  - The subdivision can show the make of the value, e.g., the composition of Hispanic population

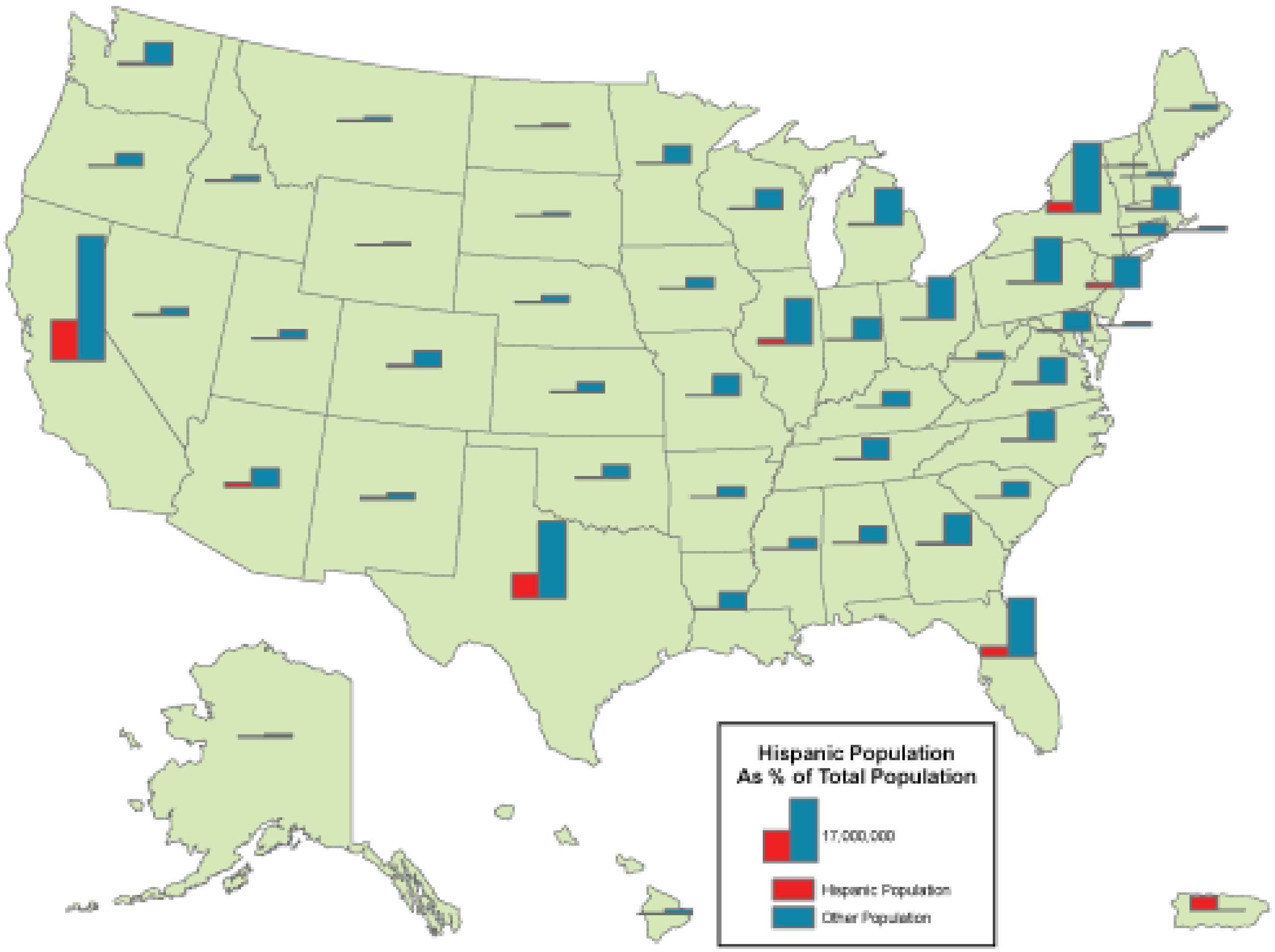


https://pro.arcgis.com/en/pro-app/latest/help/mapping/layer-properties/chart-symbology.htm

Credit: Cartography by Geoff Hatchard

Chart map

- It uses either pie charts or bar charts.
- Bar charts use vertical bars and their height to represent quantitative data



Credit: Cartography by Geoff Hatchard

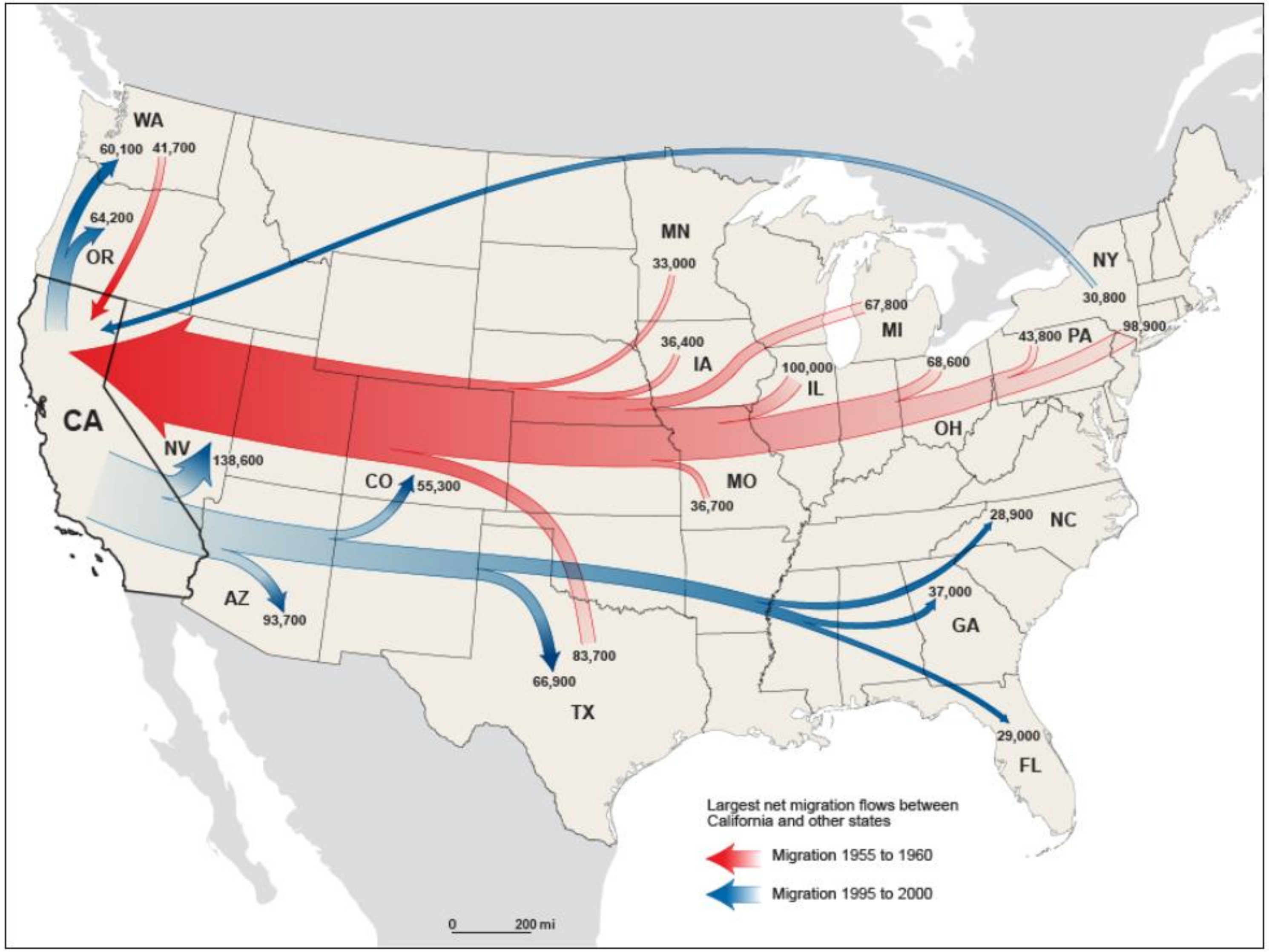
https://pro.arcgis.com/en/pro-app/latest/help/mapping/layer-properties/chart-symbology.htm

Flow map

- The flow map displays flow or spatial interaction data such as **stream flow**, **traffic**, and **migration data**.
- To represent different **range of values** by varying the line symbol width or color

Net Migration Between California and Other States: 1955-1960 and 1995-2000

March 7, 2013



Credit: Census.gov

Flow map

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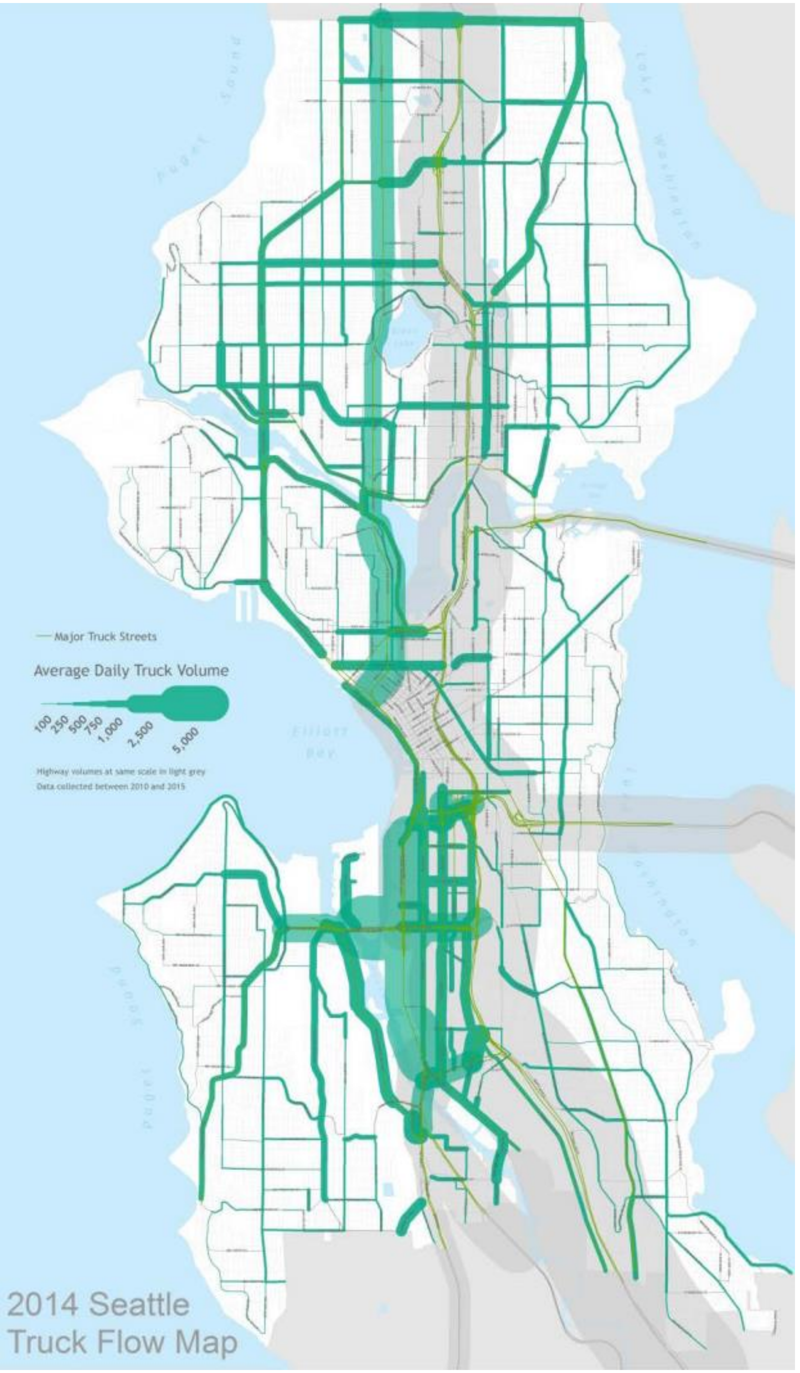
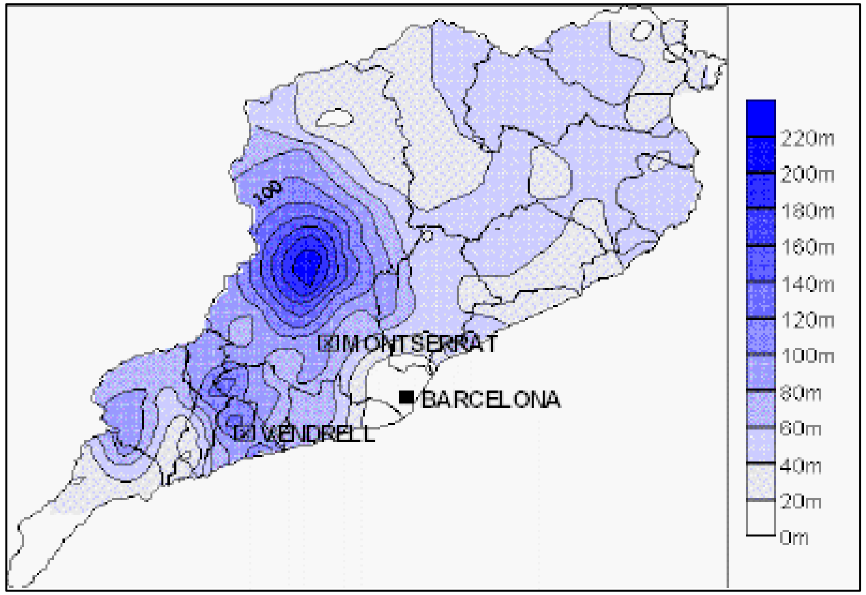


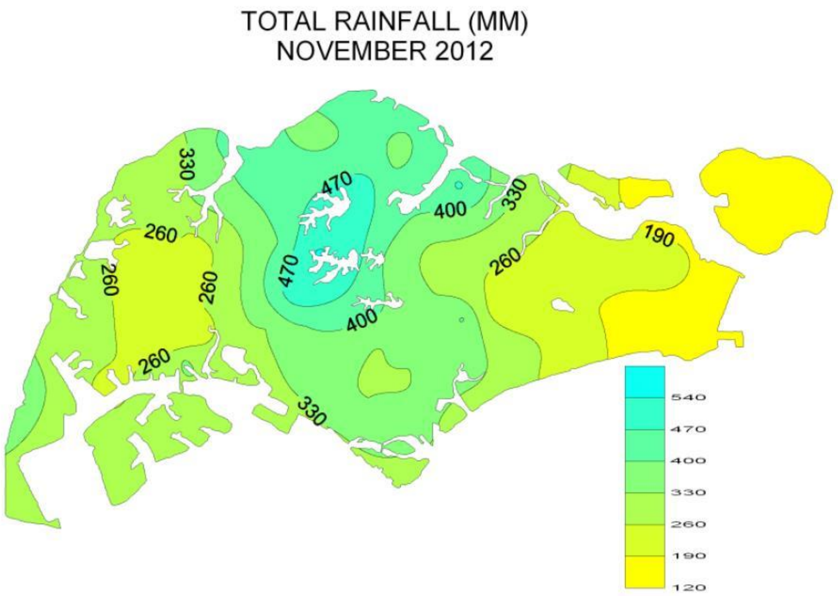
Credit: Seattle Department of Transportation, Urban Forestry Commission

Isarithmic map

- The isarithmic map uses a system of isolines to represent a surface. Each isoline connects points of equal value.
- They differ from choropleth map in that the data is not grouped to a pre-defined unit (administrative unit)
  - Lines of equal value are drawn such that all values on one side are greater than the "isoline" value and all values on the other side are lower, or
  - Ranges of similar value are filled with similar colours or patterns



Isopleth example: precipitation 10th June 2000 (mm)

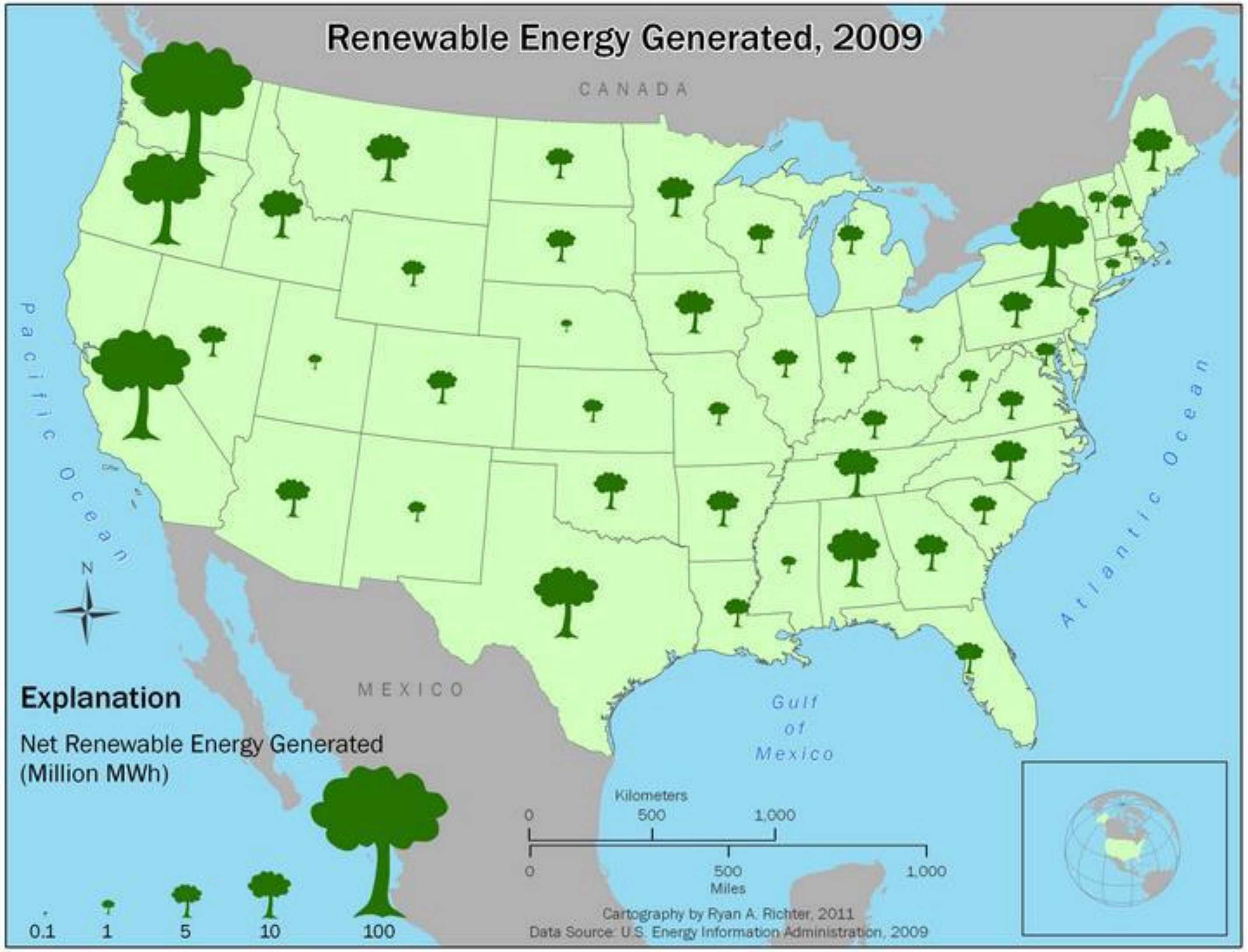


Outline of this lecture

- What is map?
- Types of maps
- Symbolization
- Classifying features
- Elements of cartographic design
- Principles of map design

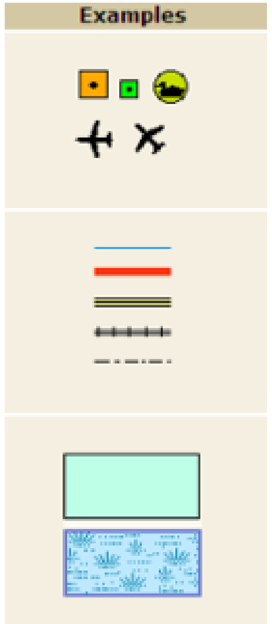
Symbolization

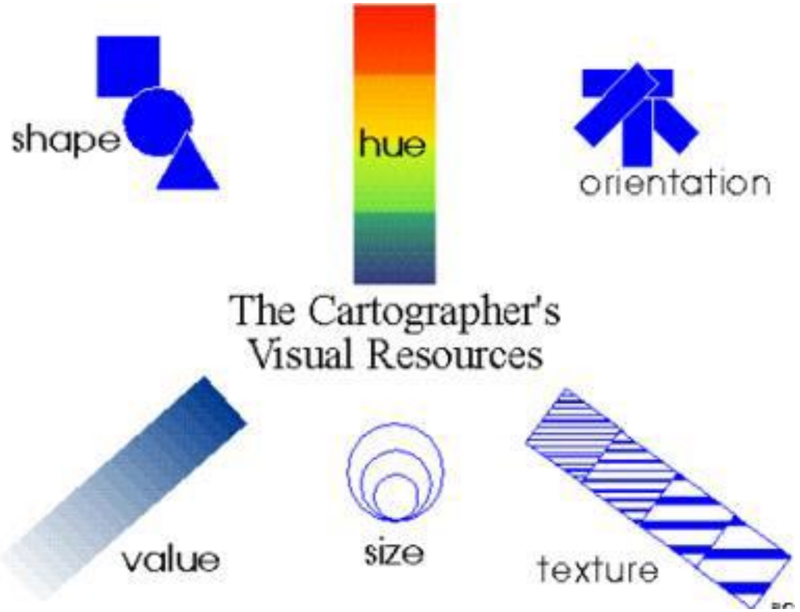
- Assign colors, markers, sizes, widths, angles, patterns, transparency, and other properties to make the feature recognizable on a map.
- Good: making the symbol look like the object it represents
  - Pictographic Symbols



Symbolization

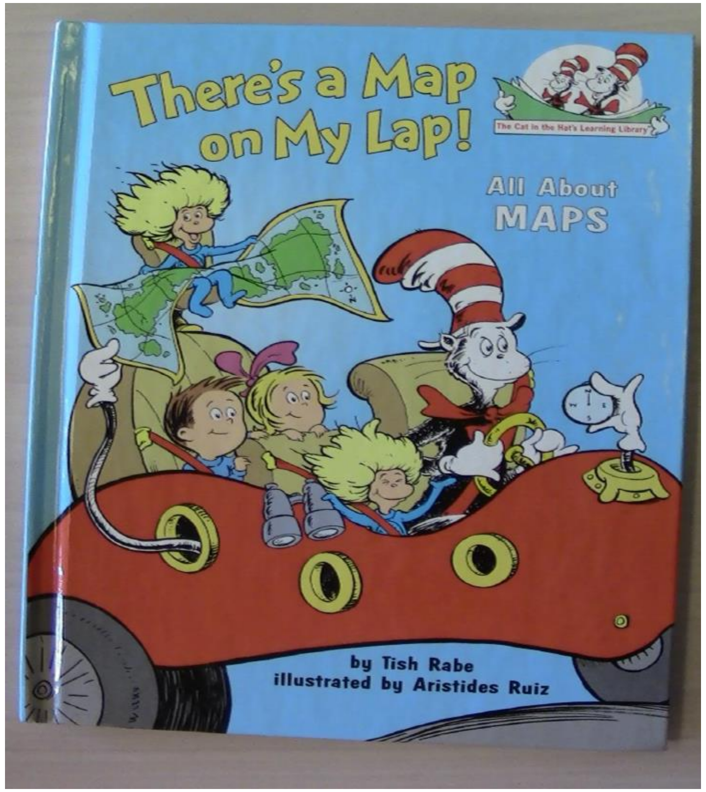
- Three types of symbols
  - Point
  - Line
  - Polygon
- Options for symbolization:
  - Shape
  - Hue
  - Orientation —> (wind direction)
  - Value —> (brightness of colour)
  - Size
  - Texture —> (land use categories)

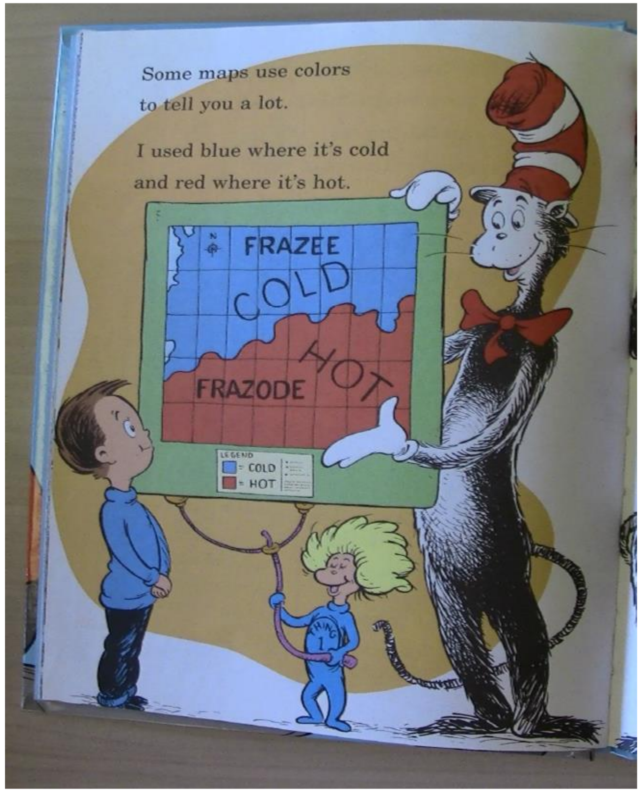




Symbolization – color

- The most powerful element in map symbolization
- It invokes unconscious, perceptual, and cognitive responses





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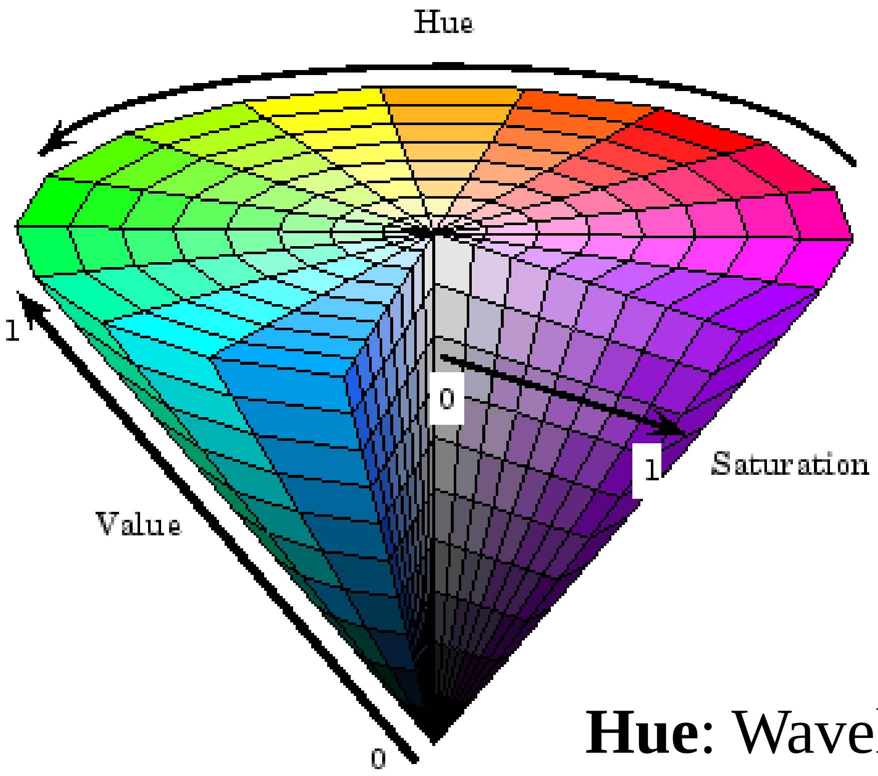
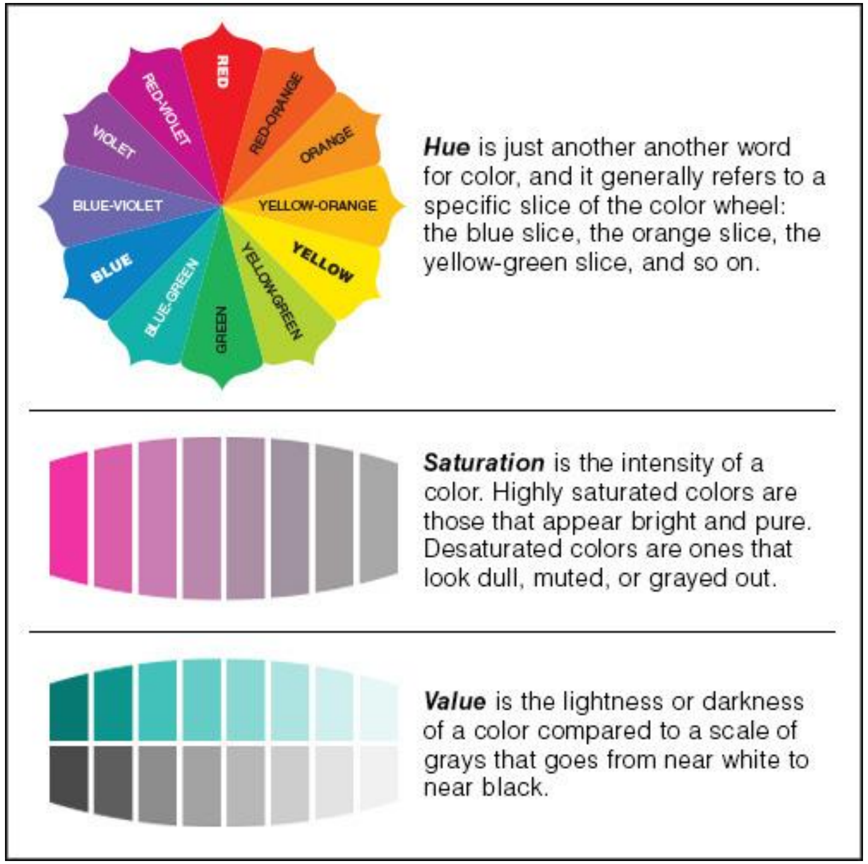
Symbolization – color

- Three dimensions of color: hue, lightness (value), and saturation



Hue: Wavelength
Saturation: Amount of pigment
Value: Intensity or brightness



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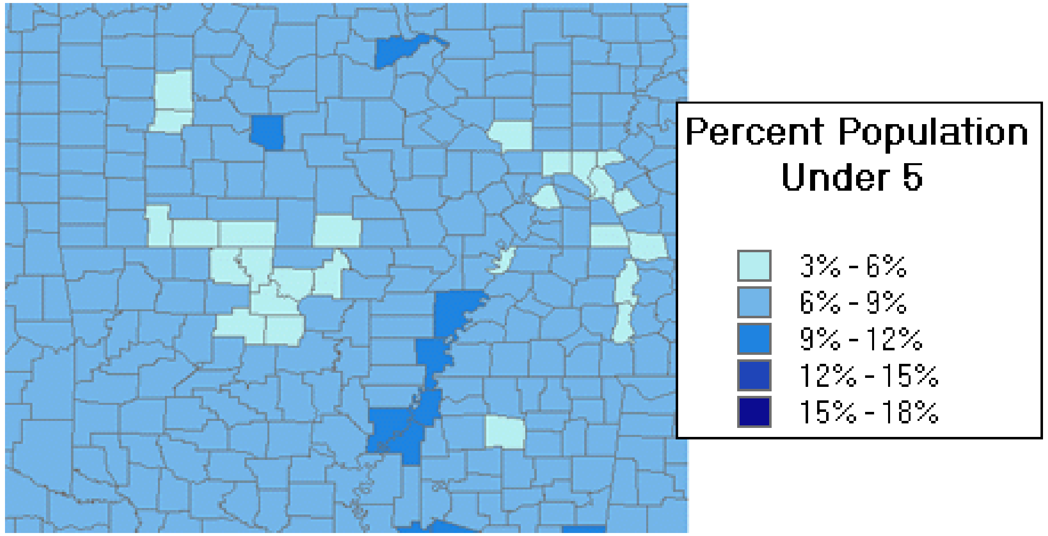
Classifying features

- The derived data are often required to be classified prior to mapping, e.g., the choropleth map, the graduated symbol map
- Two parameters for classifying features
  - Number of classes
  - Value ranges of those classes
- Six common methods for classification
  - Equal intervals
  - Natural breaks
  - Quantile
  - Mean standard deviation
  - Maximum breaks
  - Optimal
    - Jenks-Caspall
    - Fisher-Jenks

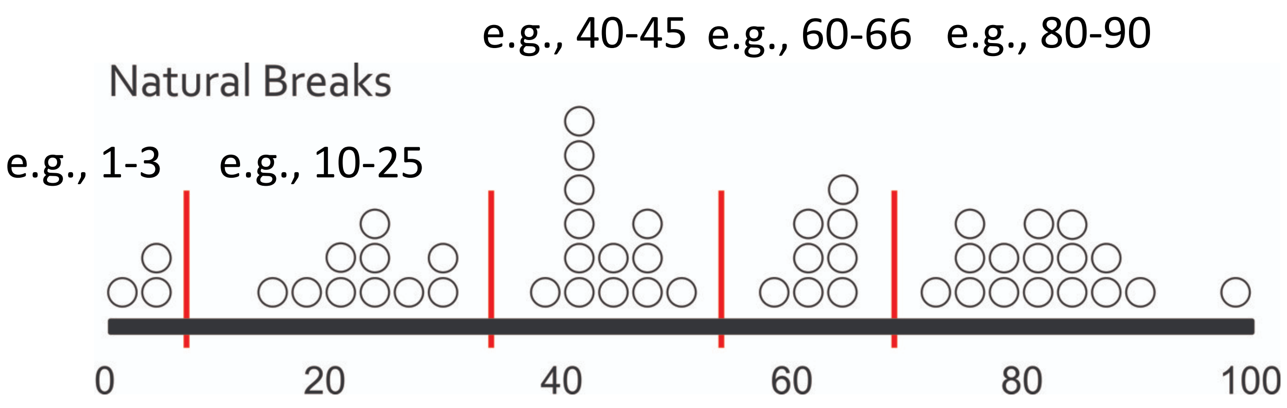
Equal interval

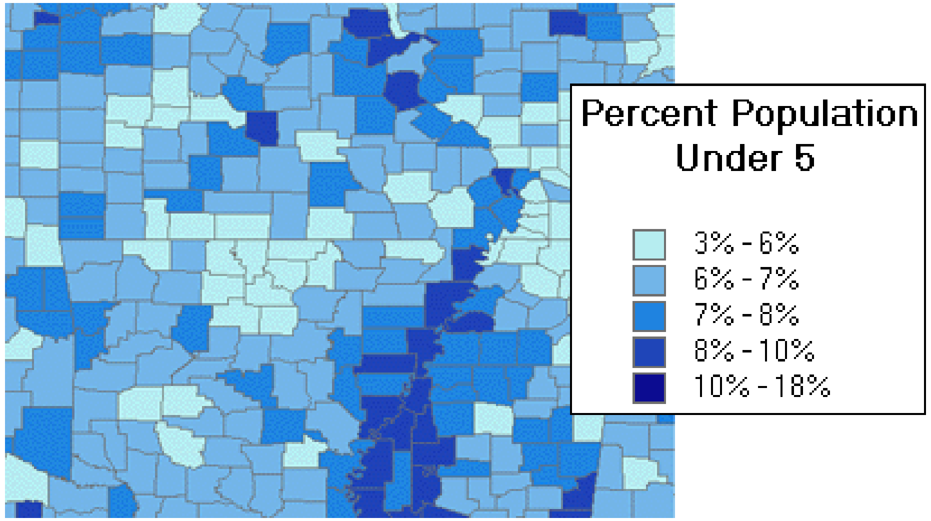
- This method is like a ruler: the interval between each class is the same
- It is the best applied to continuously distributed data, such as percentages or temperature.



Natural breaks (Jenks Optimization)

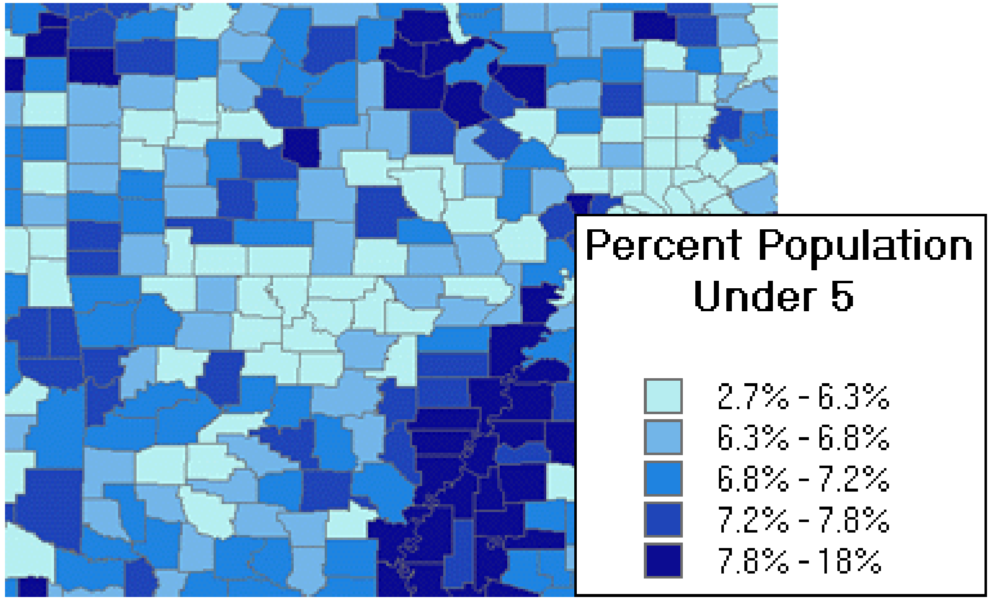
- Default method in ArcGIS (also called “Jenks Optimization”)
- Classes are based on natural groupings inherent in the data
- Group similar values together and maximizes the differences between classes
- The features are divided into classes whose boundary are set where there are relatively big jumps (differences) in the data values





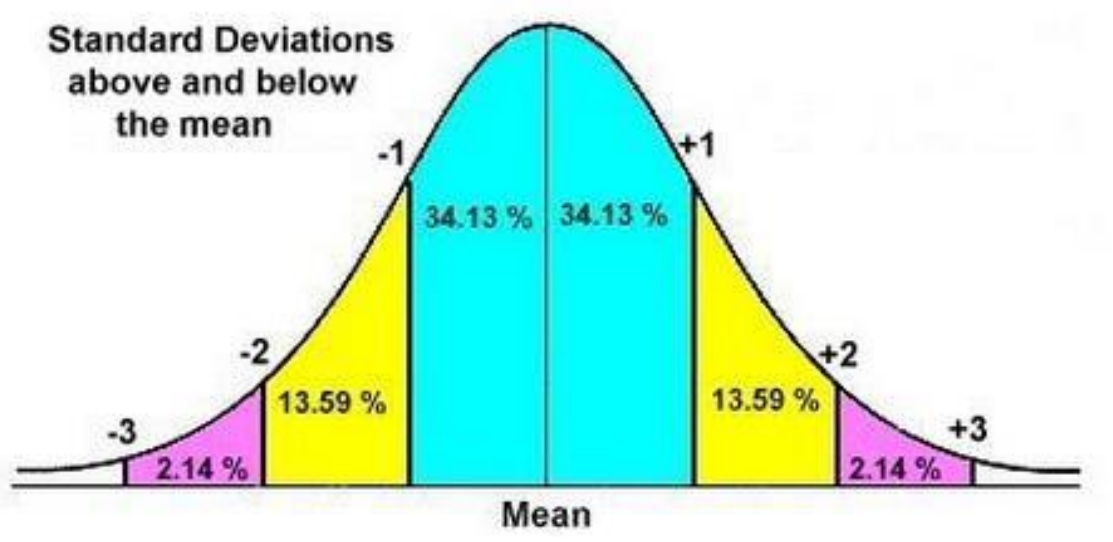
Quantiles

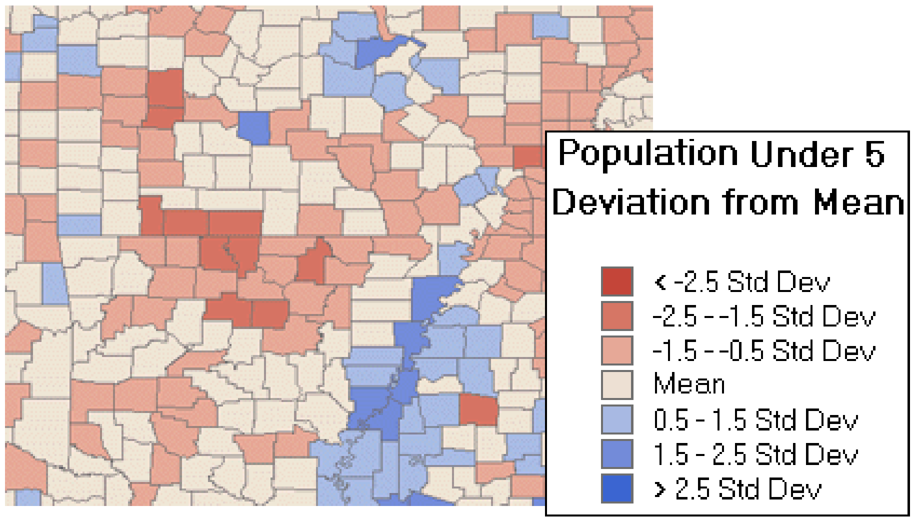
- Each class contains an equal number of values
- For example, you have 100 counties grouped into 5 classes – each would contain 20 counties regardless of the values of the attributes



Mean standard deviation

- Calculates the mean of the data distribution and then maps one or two standard deviations above or below the mean





Which method?

	Equal Interval	Quantiles	Mean SD	Maximum Breaks	Natural Breaks	Optimal
Considers distribution of data along a number line	P	P	G[a]	G	VG[b]	VG
Ease of understanding concept	VG	VG	VG	VG	G	G[c]
Ease of computation	VG	VG	VG	VG	VG	VG[d]
Ease of understanding legend	VG[e]	P[f]	G	P[f]	P[f]	P[f]
Legend values match range of data in a class	P	VG	P	VG	VG	VG
Acceptable for ordinal data	U	A	U	U	U	U
Assists in selecting number of classes	P	P	P	P	G	VG

P = Poor G = Good VG = Very Good A = Acceptable U = Unacceptable

[a] Rating would be poor if data are not normal.

[b] Although breaks are subjectively determined, the results are often similar to those obtained by the optimal method.

[c] Only a good rating is assigned because of the fairly complex nature of the algorithm.

[d] The optimal method does require the use of a computer.

[e] Only a good rating would be appropriate if round numbers are not used.

[f] Using rounded values may produce a good rating; some data distributions may mimic an equal interval map, thus producing a good or very good rating.

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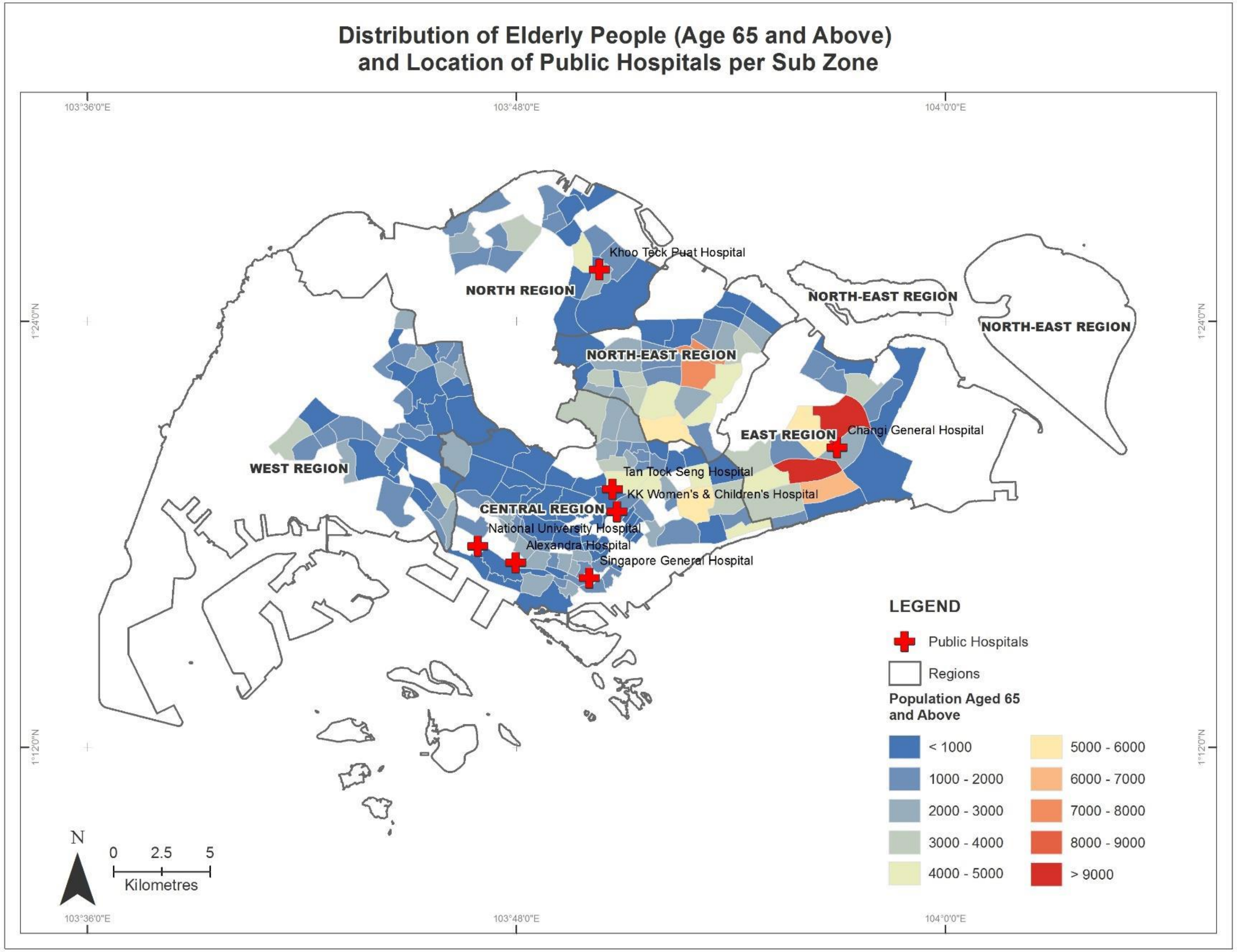
Map elements

- Title and subtitle
- Legend
- Mapped area
- Frame line and neat line
- Scale
- Orientation
- Graticule (grid)
- Inset
- Data source



(**Source**: ERICKSON CASILES LANUZA

Please read: https://storymaps.arcgis.com/stories/dd1cf50a17914df8a02146e3e5264923

Map elements

- Title and subtitle
- Legend
- Mapped area
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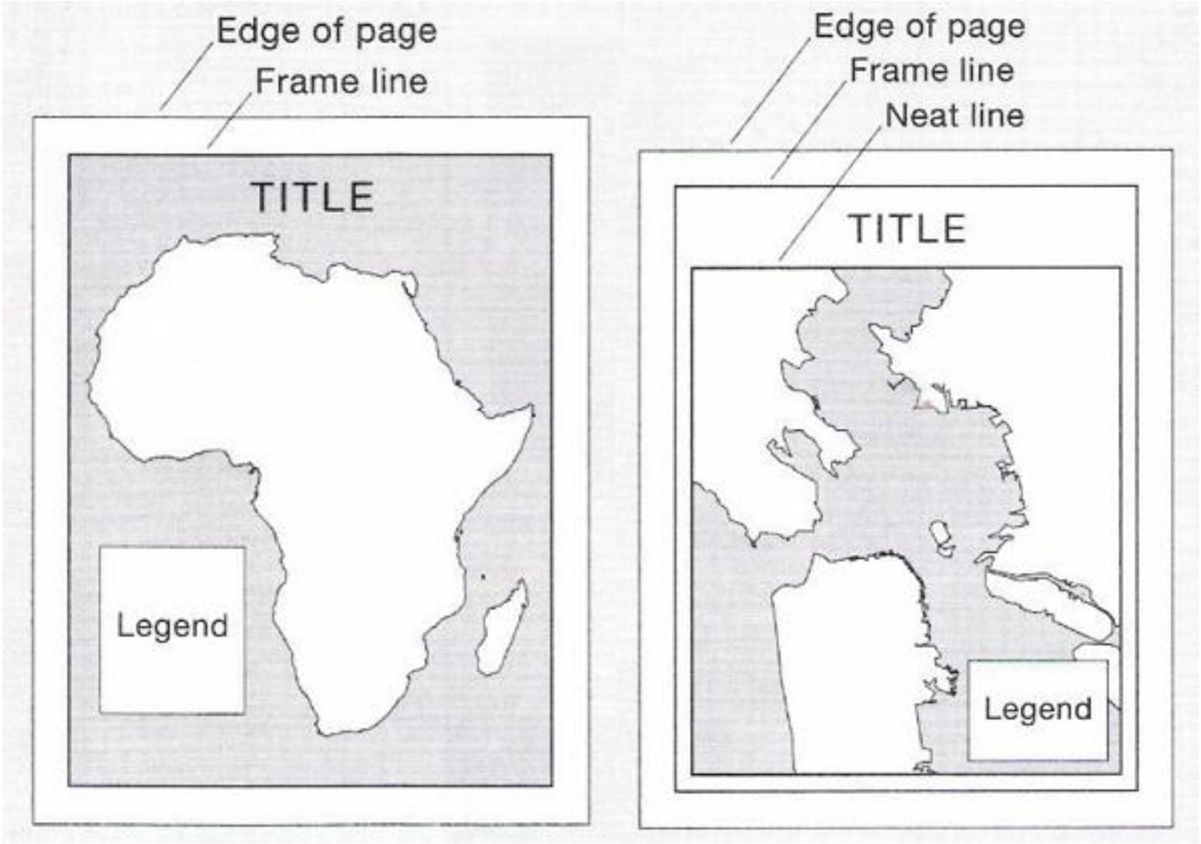

http://siera104.com/Geography/Cartography/chap11.html

Map elements

- Title and subtitle
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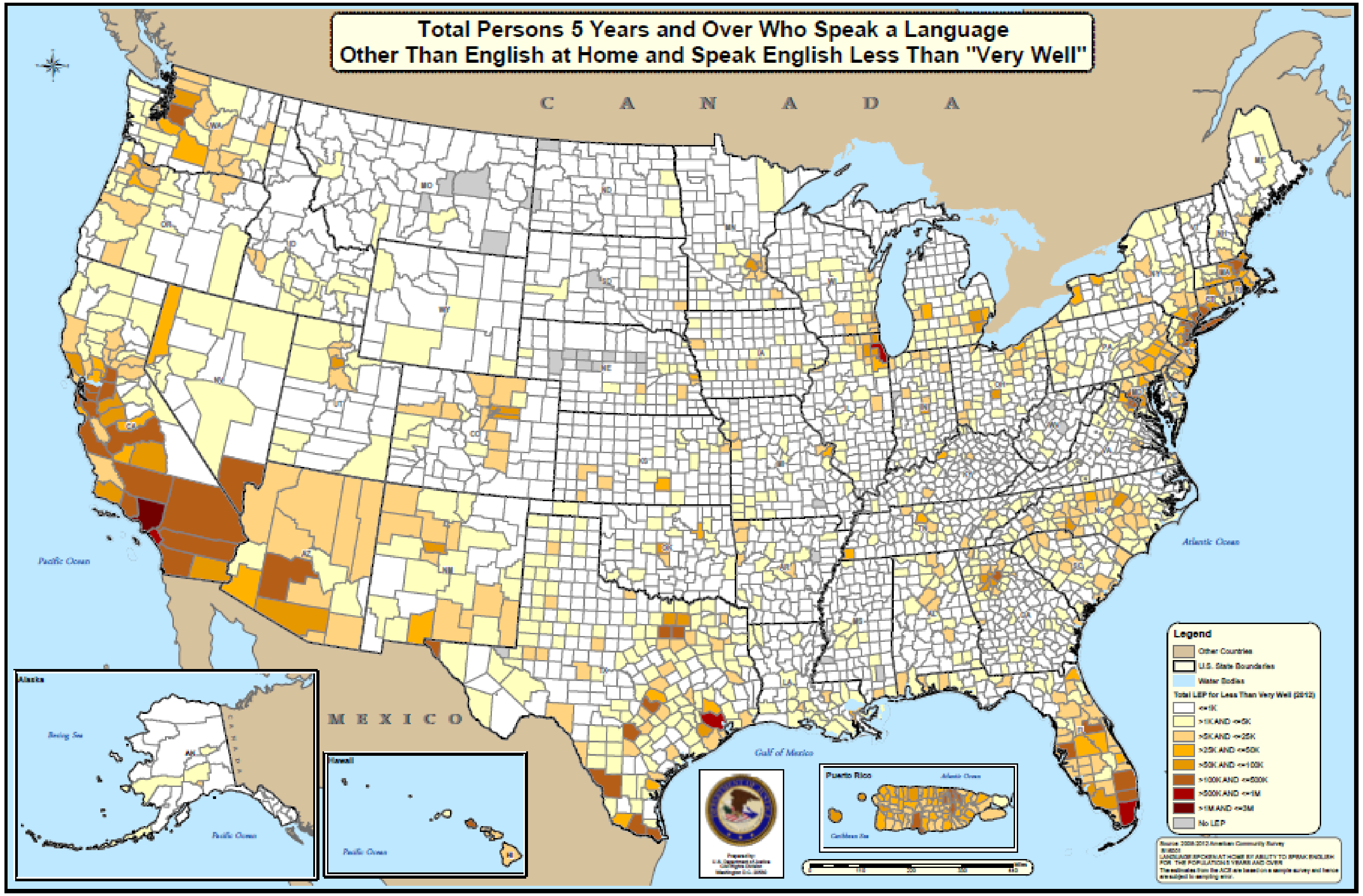


Map elements

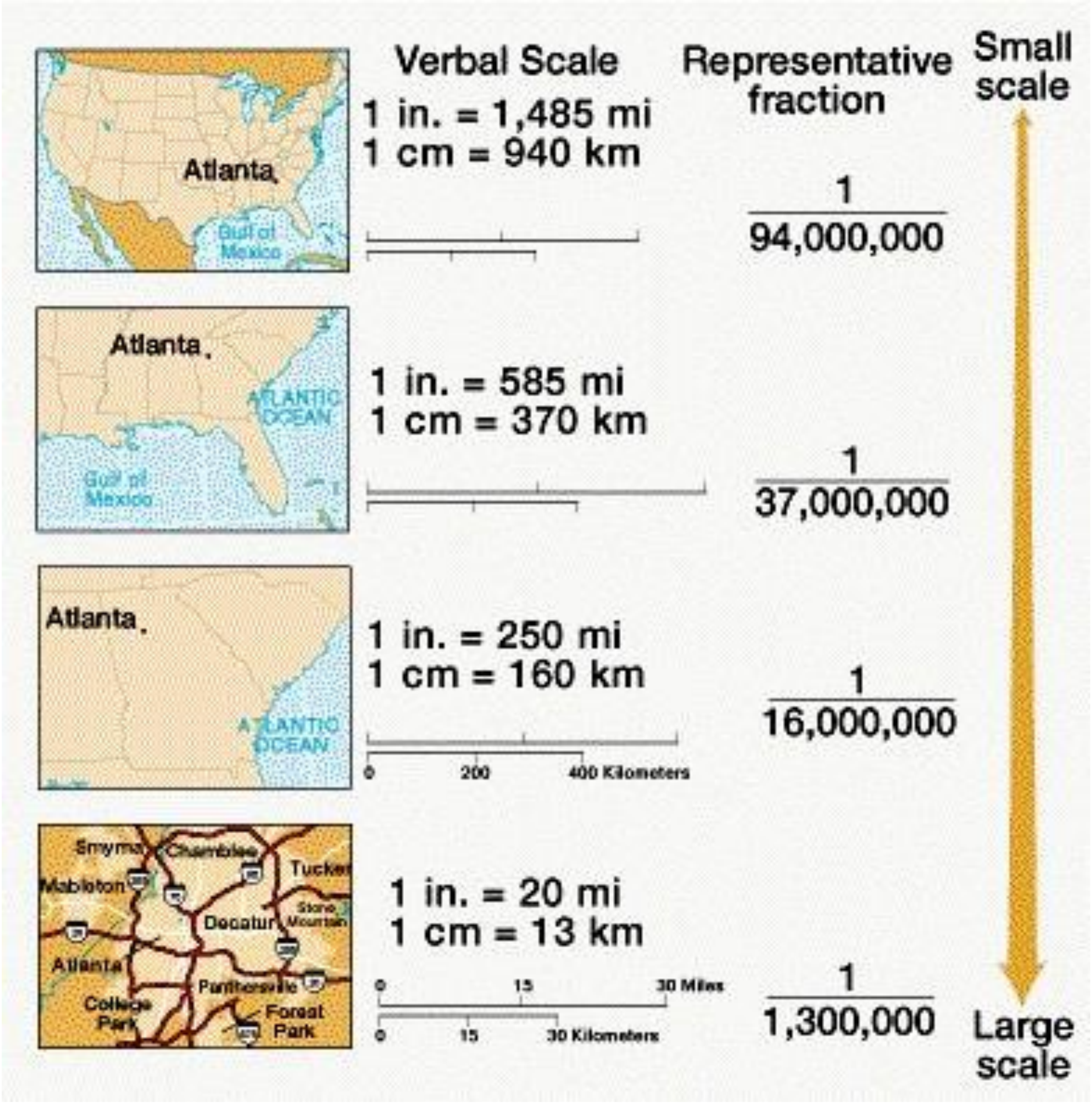
- Title and subtitle
- Legend
- Mapped area
- Frame line and neat line
- Scale
- Orientation
- Graticule (grid)
- Inset
- Data source

VS

Which one has a smaller scale?

Map elements

- Title and subtitle
- Legend
- Mapped area
- Frame line and neat line
- Scale
- Orientation
- Graticule (grid)
- Inset
- Data source



Outline of this lecture

- What is map?
- Types of maps
- Symbolization
- Classifying features
- Elements of cartographic design
- Principles of map design

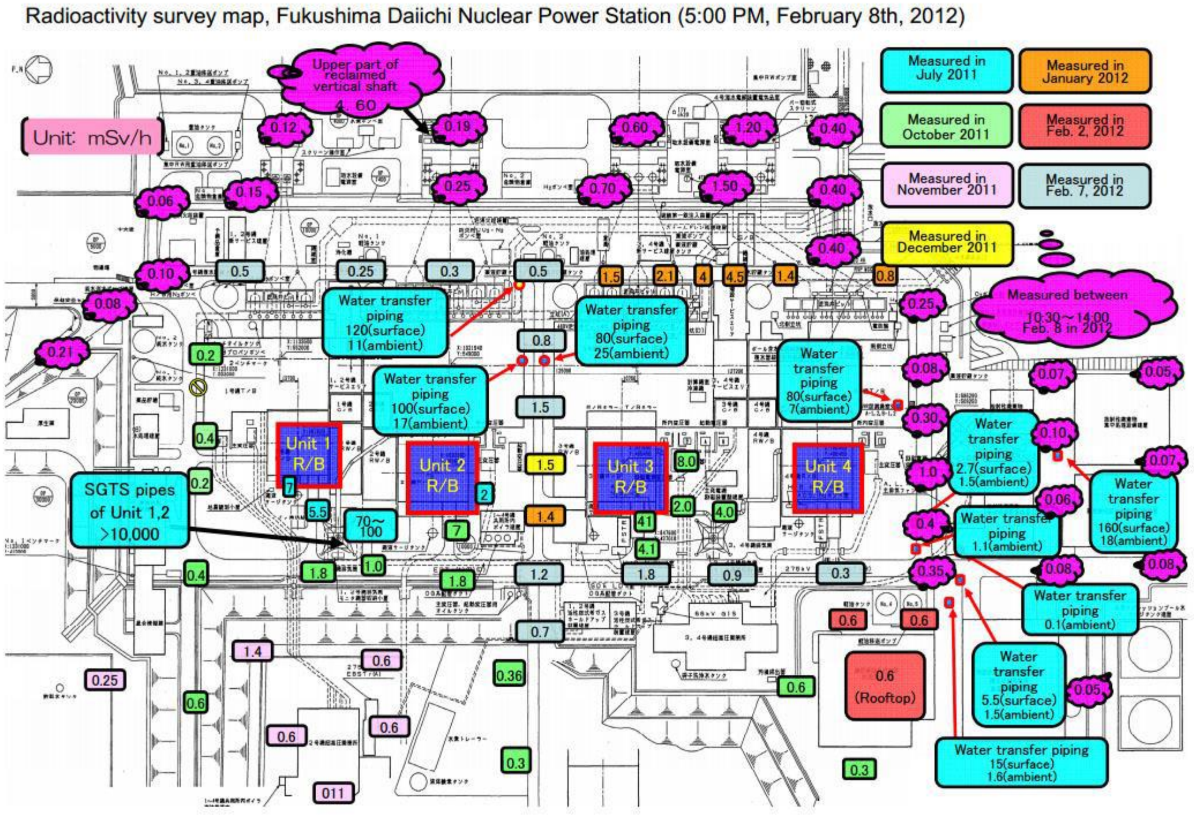
Rule No. 1: Don’t make wrong maps

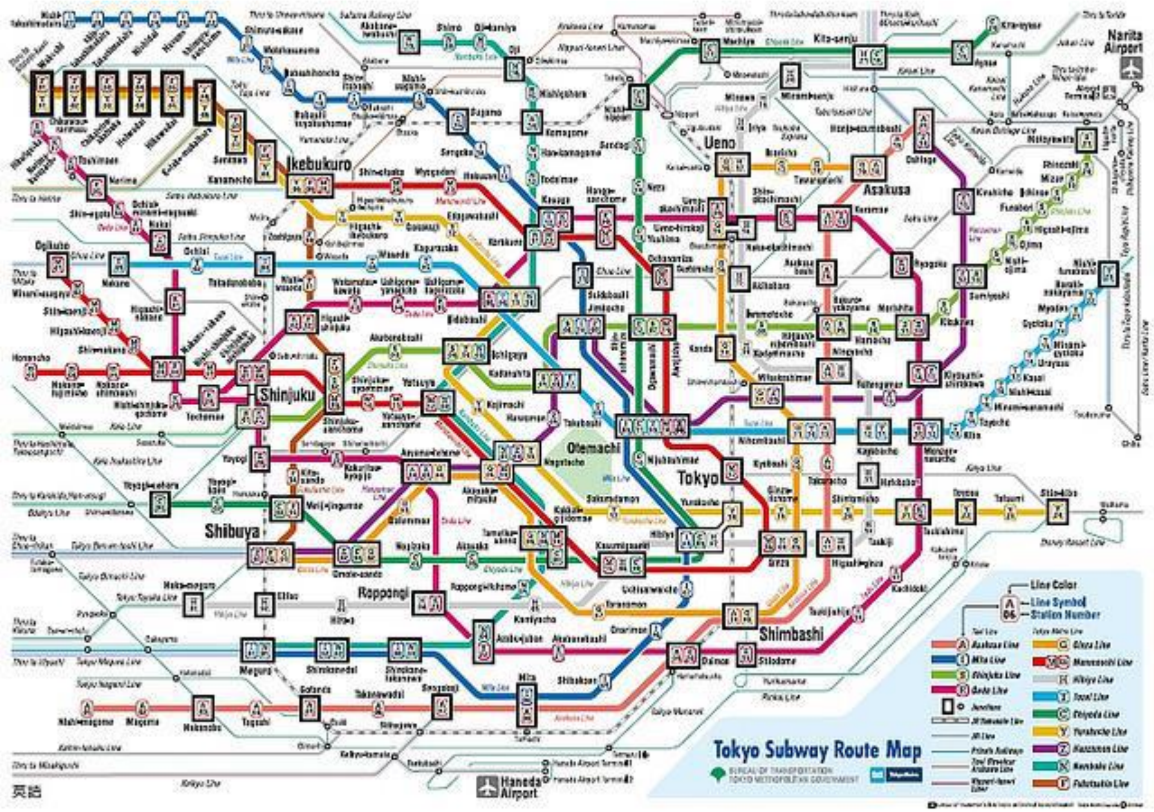
https://www.vox.com/2015/2/18/8056325/bad-maps

Principles of map design

- There are no right or wrong design, but there are better or worse maps.
- A good design makes map more effective, interpretable and understandable, and communicates the correct message.
- Characteristics of a good map:
  - Simplicity
  - Balance
  - Contrast

Simplicity– Remove unnecessary complexity



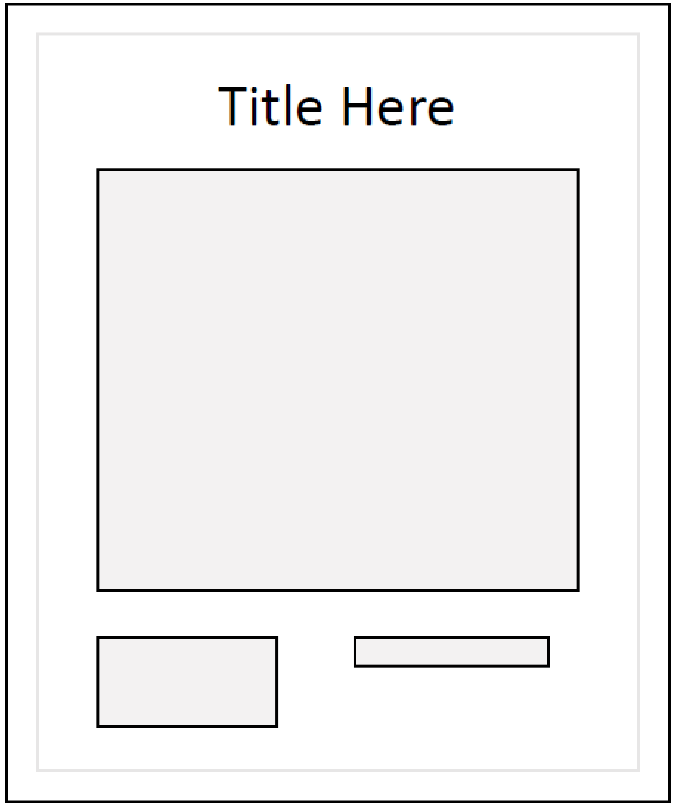


Eyes seek simplicity

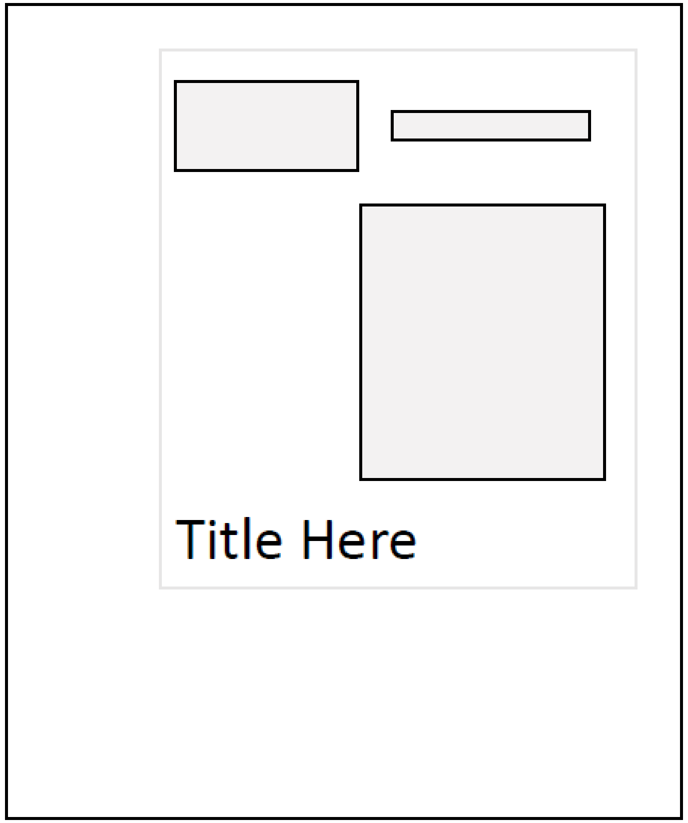
Slides for education purpose only

Balance – Layout balance

- A finished map should look balanced. It should not give the map reader an impression the map looks heavier on any side



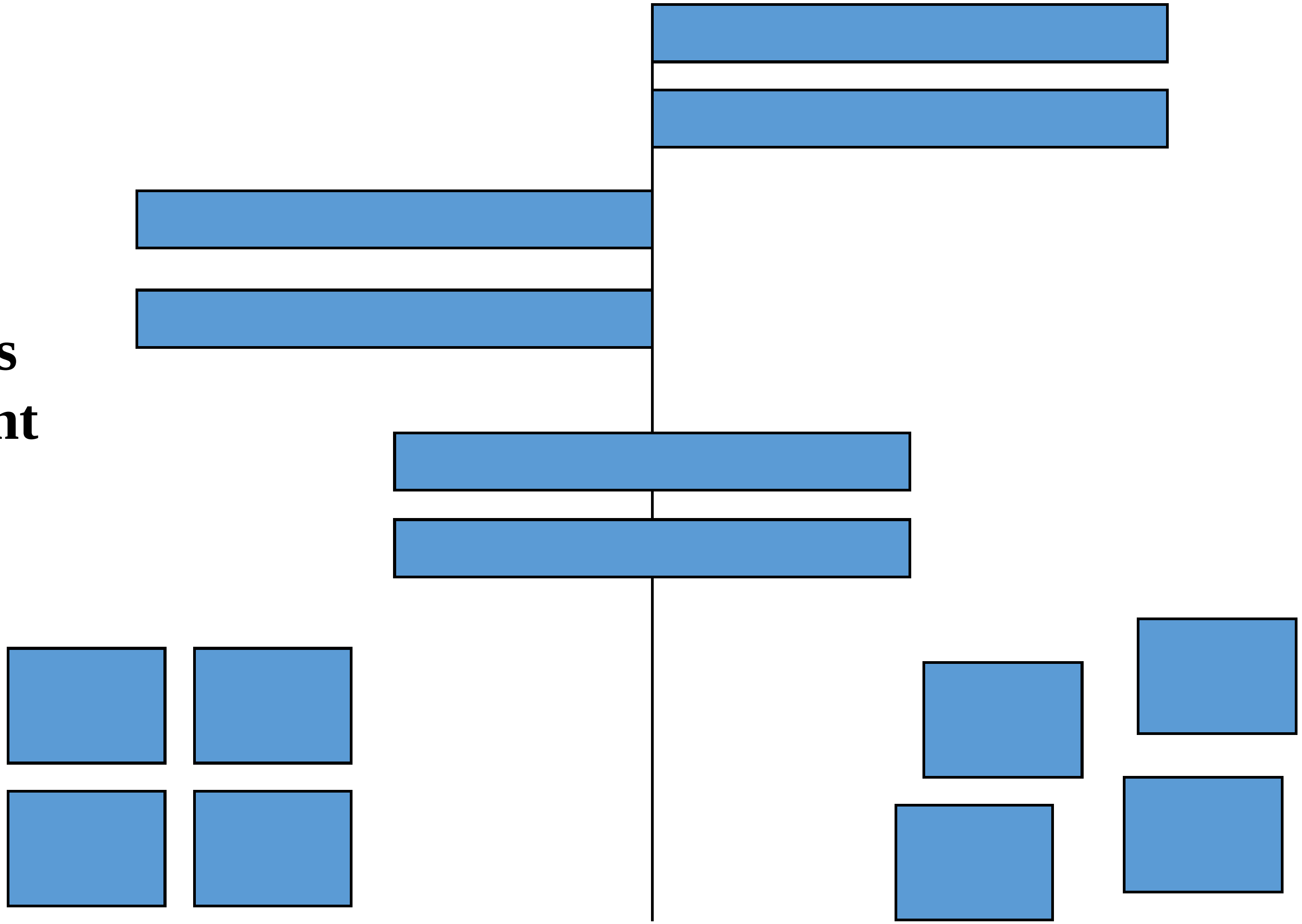
GOOD



Bad

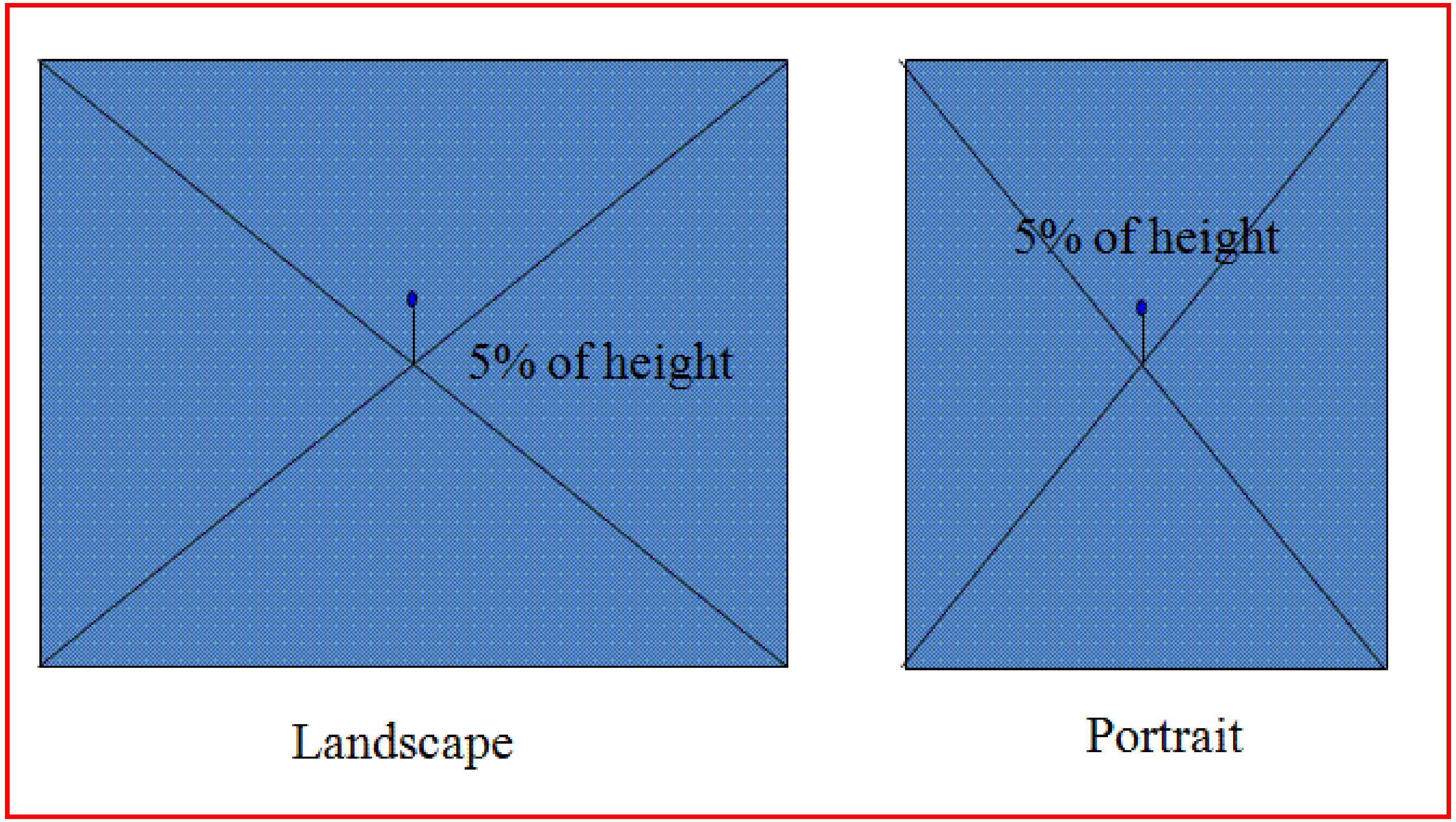
Balance – Alignment: precision matters

The visual balance is sensitive to alignment



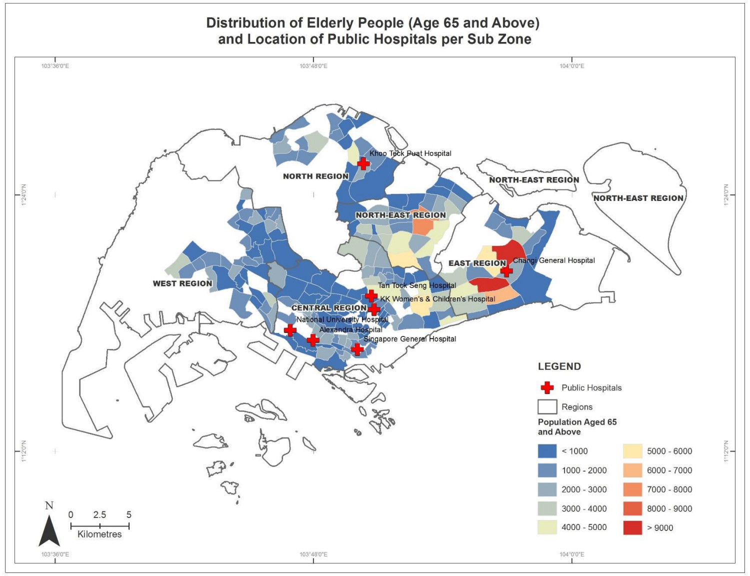
Balance – Visual center

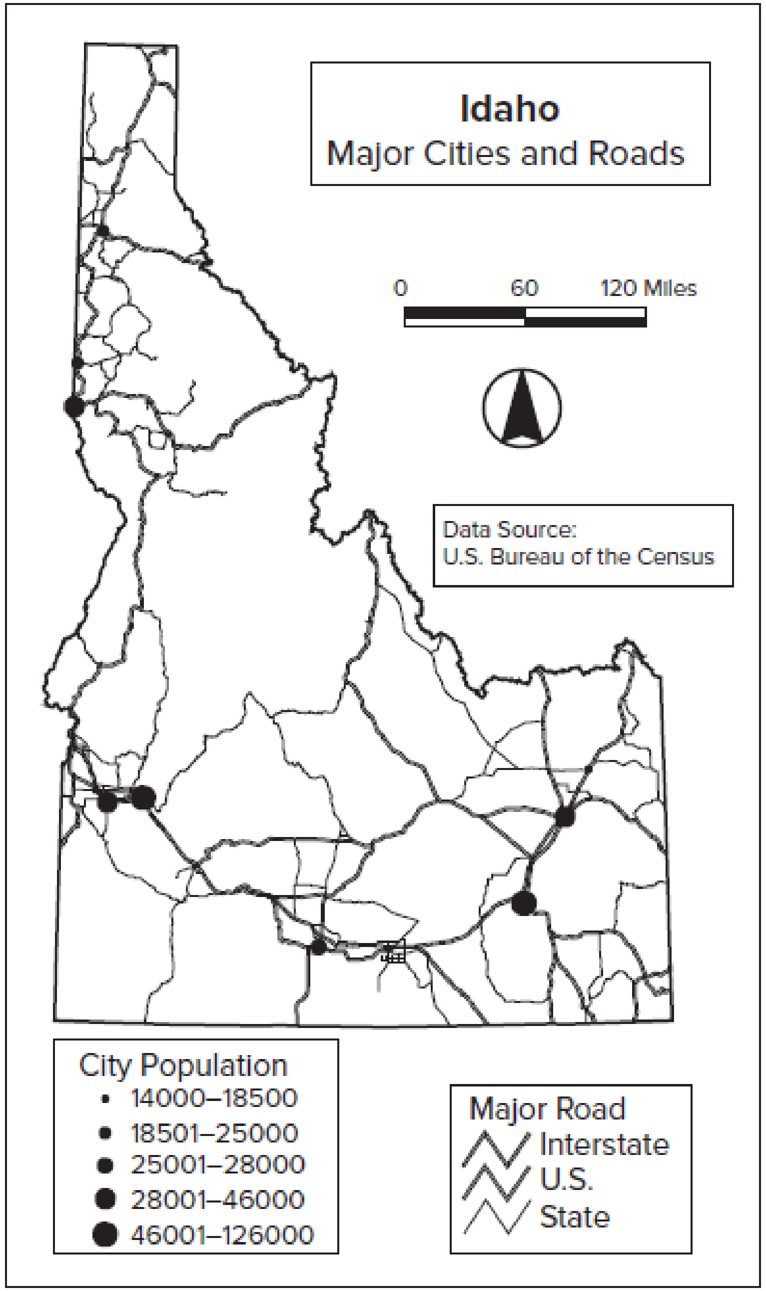
- The focal element should be placed near the visual (optical) center, which is a little above the map's geometric center



Balanced legend

- A balanced legend is also important
- If the legend is too long. One solution is to divide it into two or more columns



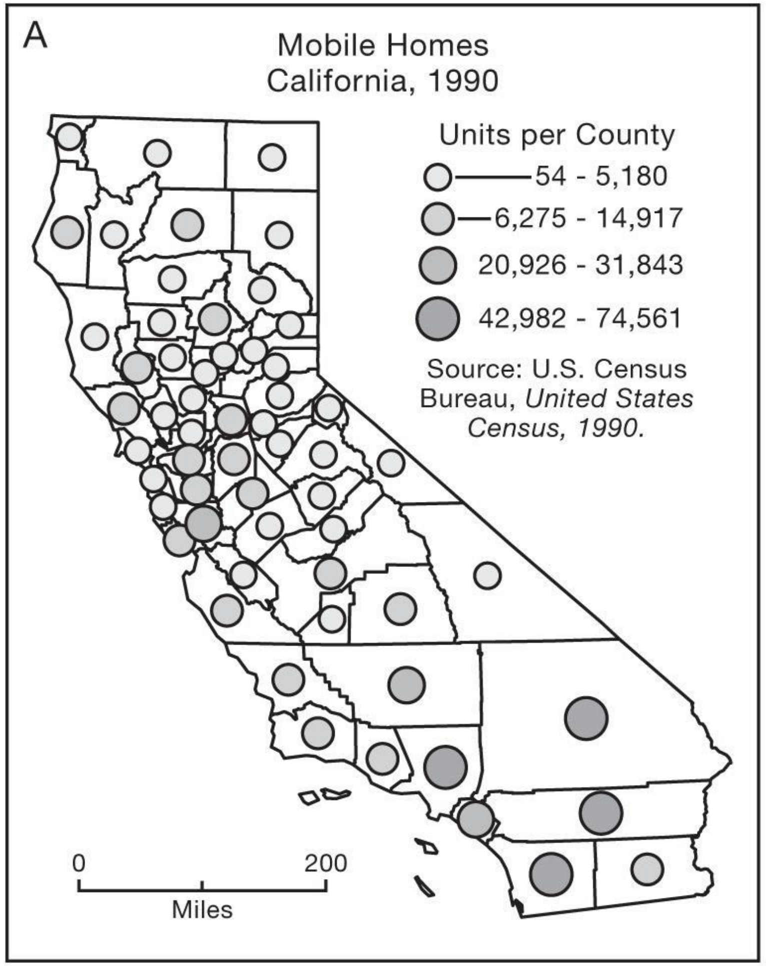


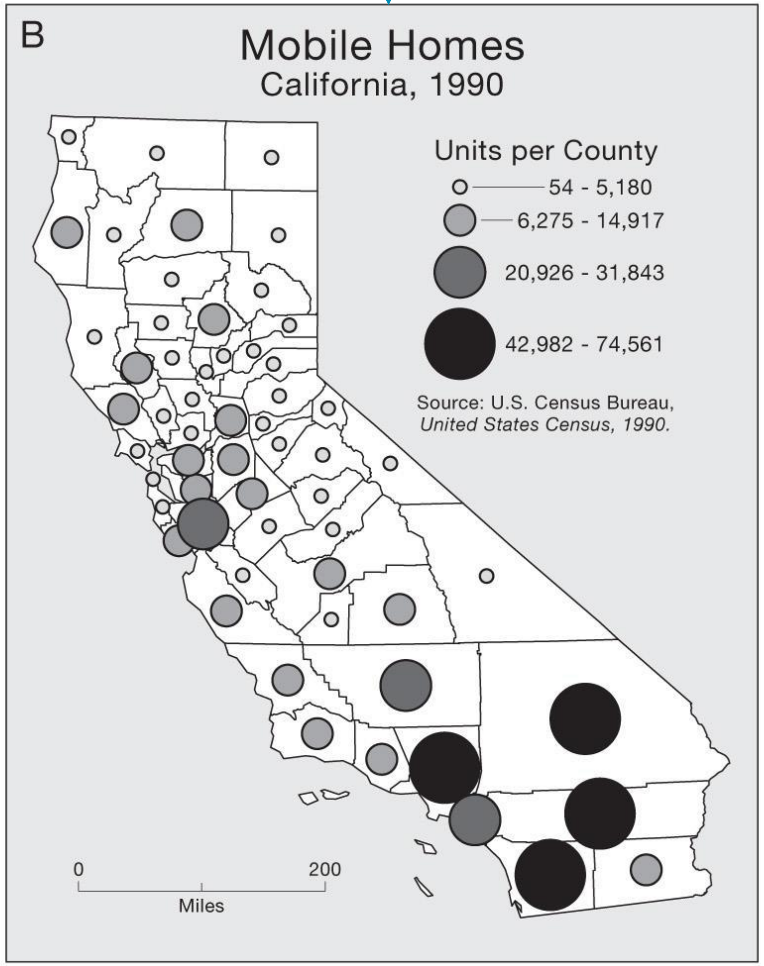
Contrast

- The focal element should be differentiated by contrast in **size**, **color**, **line width**, **texture** etc.
- The figure should be differentiated from the background by contrast in **color**

Which one is better?

Different font sizes
for title and subtitle





Good colour
contrast

Summary

- What is map?
  - A visual tool, geography language, effective in communicating geospatial data
- Type of maps
  - **General reference** and **thematic** map
  - **Qualitative** and **quantitative** map
  - Common quantitative maps
    - **Dot**, **choropleth**, **graduate symbol**, **pie char**, **flow**, and **isarithmic** map

Summary

- Symbolization
  - Assign **colors**, markers, sizes, widths, angles, patterns, transparency, and other properties to make the feature recognizable on a map
- Classifying features
  - Two parameters: **number** and **range**
  - Six common methods
    - **Equal intervals**, **natural breaks**, **quantile**, **mean standard deviation**, **maximum breaks** and **optimal methods**

Summary

- Map elements
  - **Title**, **legend**, mapped area, frame line and neat line, **scale**, **orientation**, inset and data source
- Principles of map design
  - Effective, interpretable, understandable and communicate correct information
  - Simplicity, balance, contrast

Homework before next class: Spatial Reference and Coordinate Systems

- Before next class, go to Canvas -> Modules ->Week 5 to complete the Spatial Reference and Coordinate Systems Pre-class Homework.
    - Spatial Reference and Coordinate Systems is an important but difficult/tedious part of this course. Make sure you have watched the videos in the homework assigned and understood the content.
    - The homework is worth 2 marks of your participation assessment.
    - Due: 11:59pm, 8 September, 2024

THANK YOU