# Spatial Analysis and Modeling

## 03 - Visualize

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@UNITO

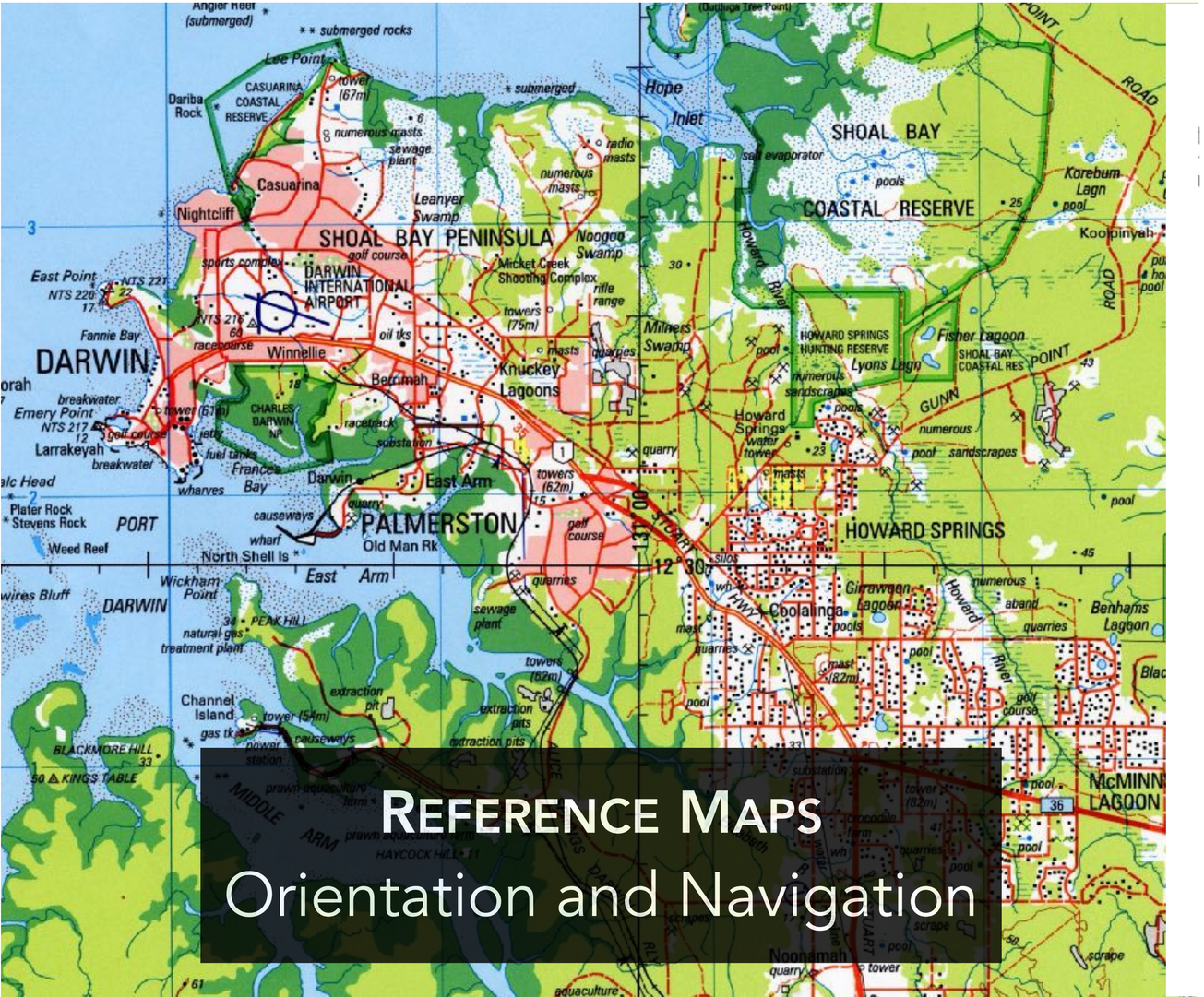
# Learning Objectives

Learn the basic steps to create an informative **thematic cartography**

Know the main thematic cartography **types**

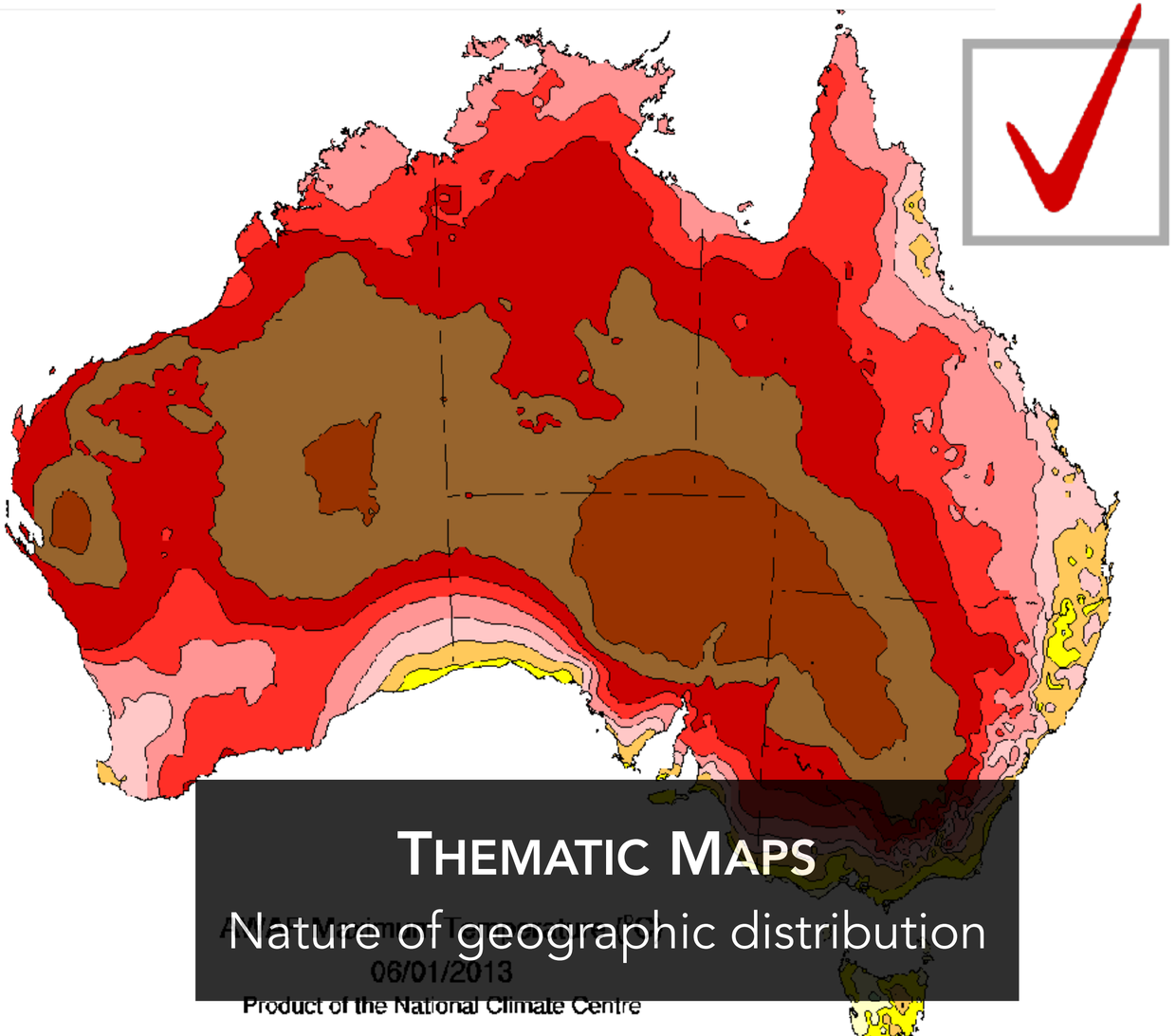
Know some basic thematic cartography **rules of thumb**

# The world of cartography can be split into two (overlapping) categories:




**Reference Maps**

Orientation and Navigation




**Thematic Maps**

Nature of geographic distribution

# Thematic maps

Visualize **spatial distributions of data**, e.g., population density

Thematic maps serve three primary purposes.

1. They provide specific information about particular locations.
2. They provide general information about spatial patterns.
3. They can be used to compare patterns on two or more maps.

# Design is driven by

- **Data**

**Categorical** mutual exclusive, not ordered, categories
e.g., five different genotypes, average no meaning

**Ordinal** order matters but not the difference
e.g., movie ratings

**Interval** difference between two values is meaningful
e.g., temperatures in Celsius, a temperature of 100 degrees C is not twice as hot as 50 degrees C

**Ratio** as interval but has a clear definition of 0.0
e.g., temperature in Kelvin,

| | Nominal | Ordinal | Interval |
|---|---|---|---|
| frequency distribution. | Yes | Yes | Yes |
| median and percentiles. | No | Yes | Yes |
| add or subtract. | No | No | Yes |
| mean, standard deviation, standard error of the mean. | No | No | Yes |
| ratio, or coefficient of variation. | No | No | No |

# Design is driven by

- Data
- **Spatial scale and granularity**

## Discrete

only found at fixed locations or when the data represent only specific values, e.g., # accidents at crossings

**Point Line Polygon**

## Continuous

seen throughout the mapped area and smoothly transitions from one value to another, e.g., air temperature.

**Surface Volume**

# Design is driven by

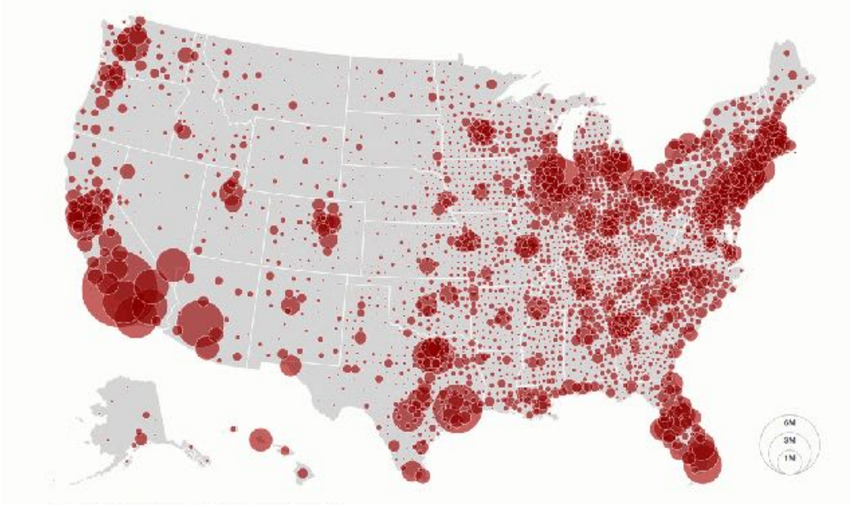
- Data
- Spatial scale and granularity
- **Human visual perception and aesthetics**
  - choosing the correct visual variables, e.g., symbols, colors

# Design is driven by

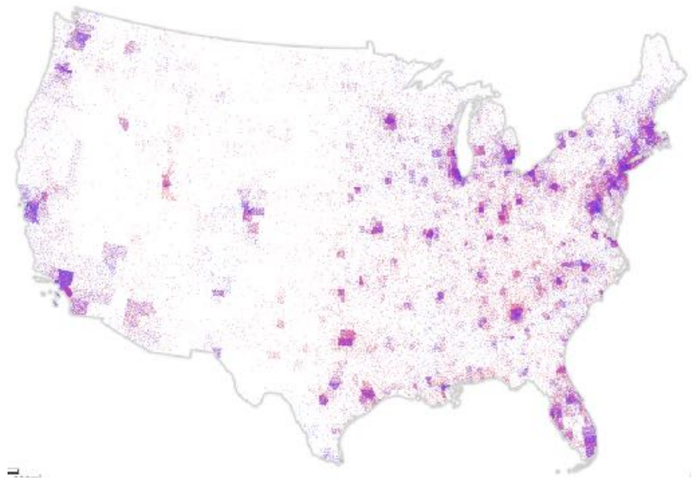
- Data
- Spatial scale and granularity
- Human visual perception and aesthetics
  - choosing the correct visual variables, e.g., symbols, colors
- **Audience**
  - knowing **who** will read the thematic map and for what **purpose** helps define how it should be designed
    - political scientist vs biologist

# Types of thematic maps

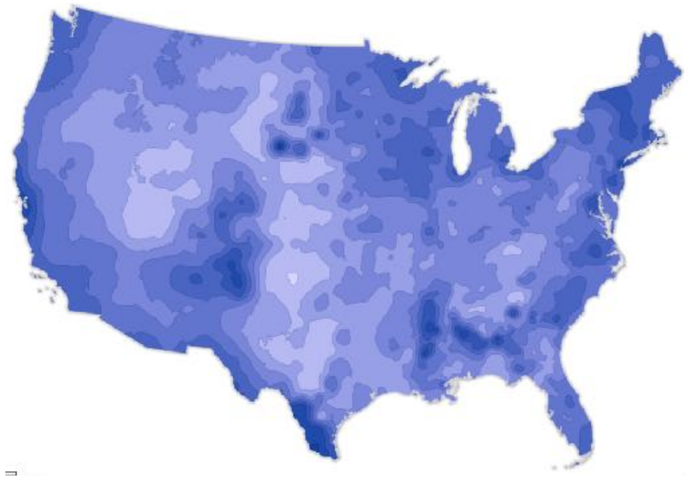
## Proportional symbols



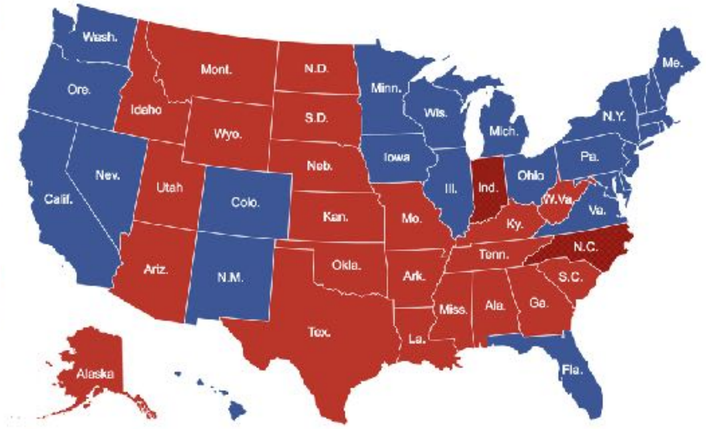
## Dot distribution



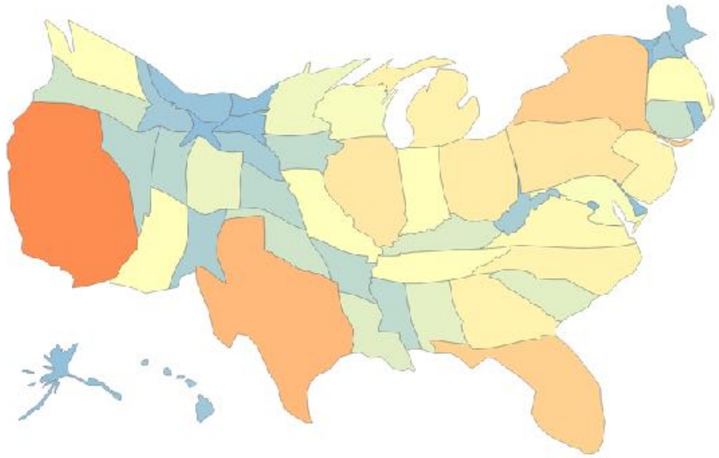
## Isopleth



## Choropleth




## Cartograms

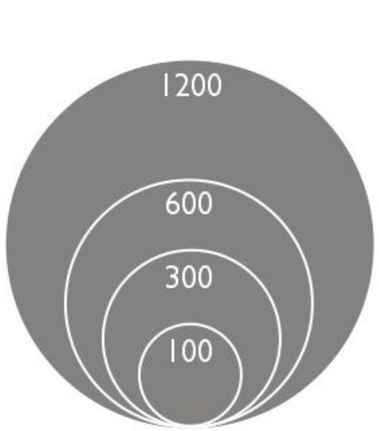


## Flow Maps

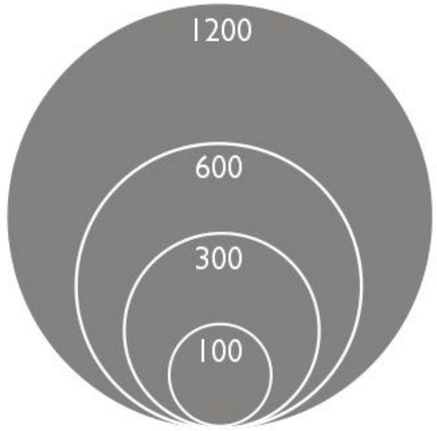
# Proportional Symbols

# Proportional symbol maps

- Represent data variables by **symbols** that are **sized**, **colored according to their amount or type**.
- Data is (or can be) aggregated at points within areas.
- Three methods for setting symbol size:
  - **absolute scaling** .
  - **apparent magnitude (perceptual) scaling**
    - psychophysical research revealed that while people tend to correctly estimate lengths, they tend to underestimate areas and volumes.
  - **range grading**




Absolute Scaling




Apparent Scaling
(Flannery's Compensation)

# Proportional Symbol

2012 US Presidential election results by County, by total votes

### Map type

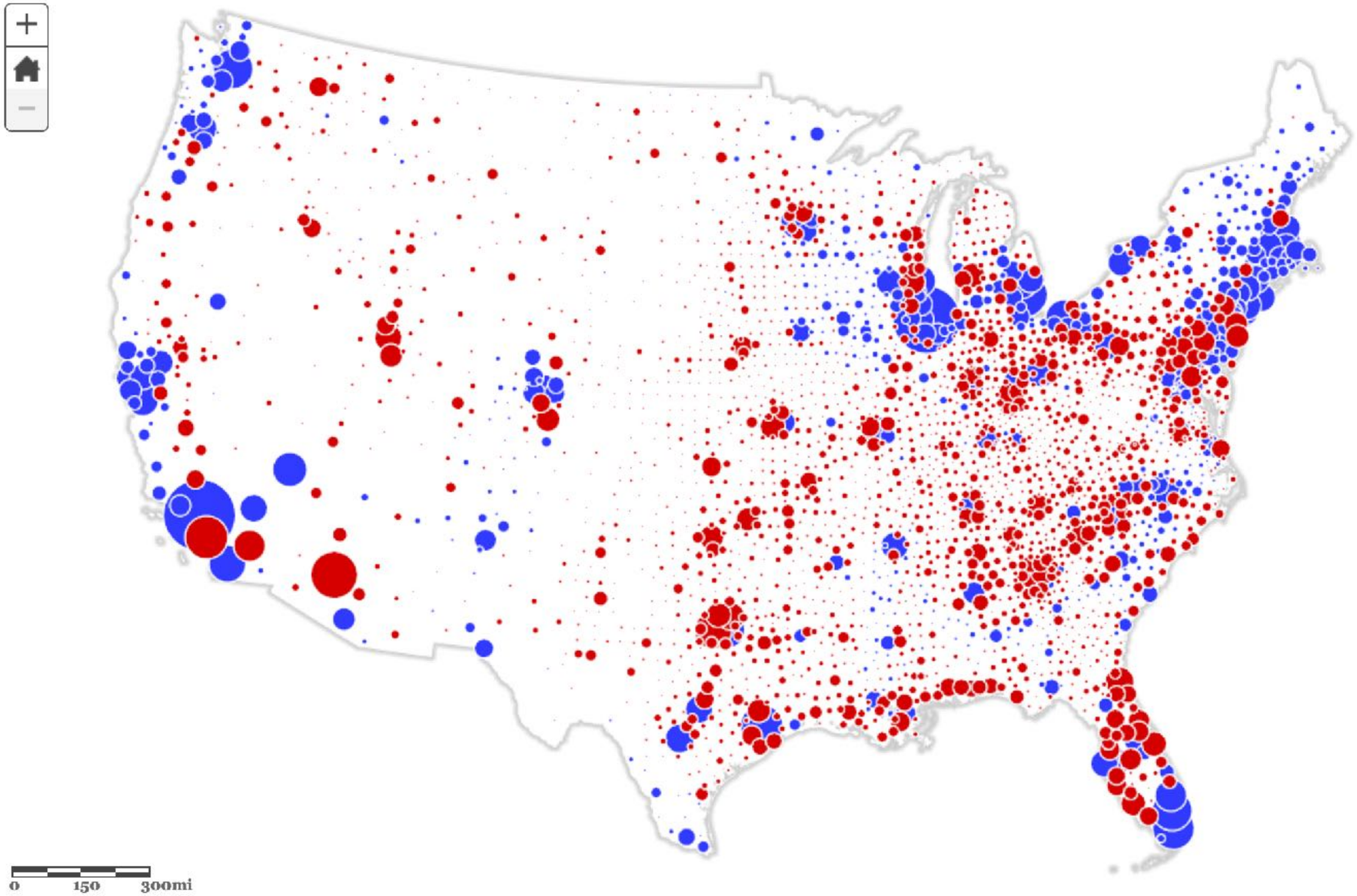
The purpose of a **proportional symbol** thematic map is to show how features differ in quantity for the theme being mapped. In this example of the 2012 Presidential election, the map is designed to show the number of votes cast for the predominant party in each County.

### Data

For the theme being mapped, the data should
be **numerical (quantitative)** and represent differences between features on an **interval or ratio** scale of measurement. The map type requires data to be absolute, as totals. Here, the vote totals are augmented by symbols that define a second **categorical** characteristic of the data, namely 'Republican' or 'Democrat'.

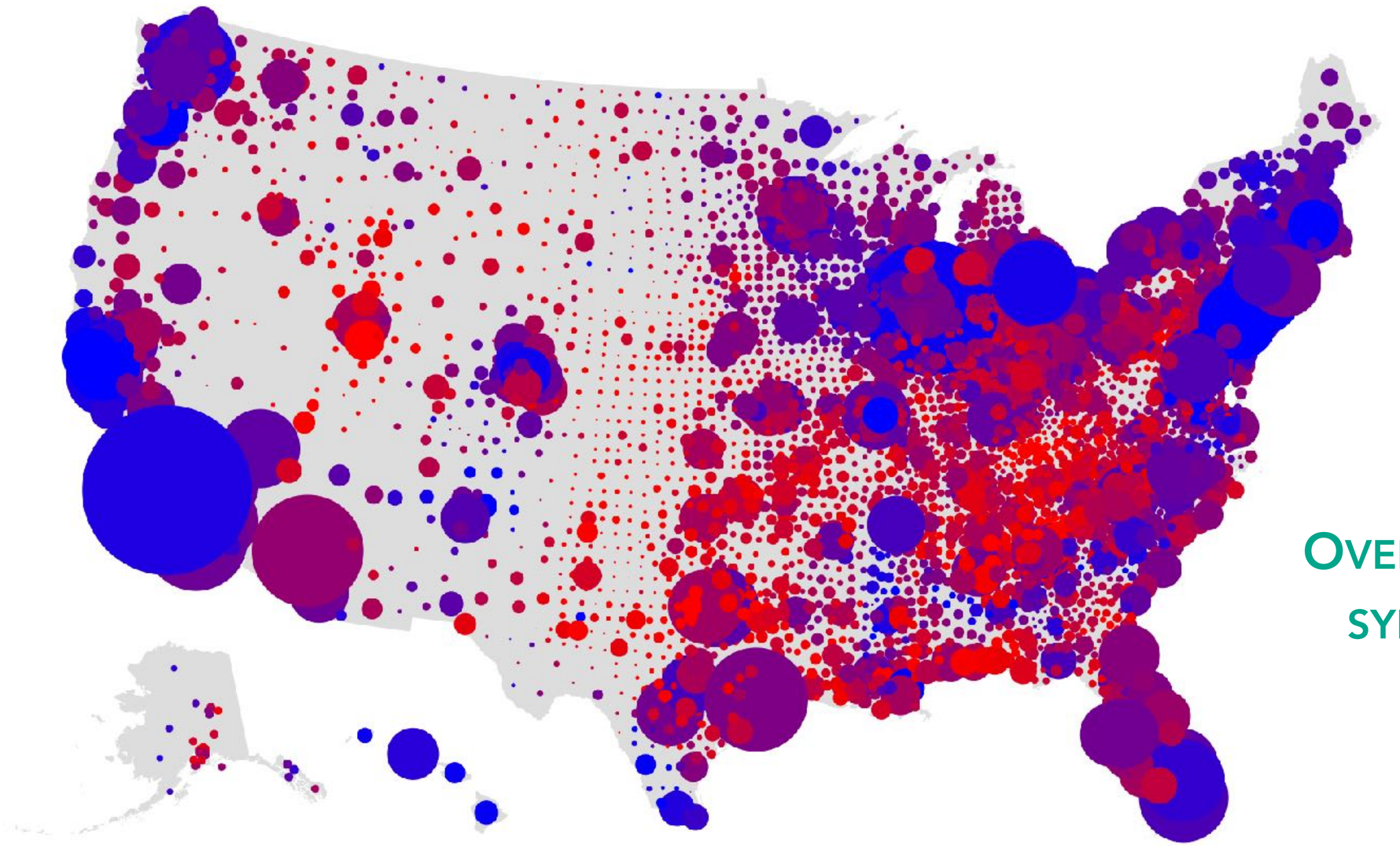
### Symbols

Symbols are scaled to the data values and should be designed so that different magnitudes of data can be easily distinguished from one another through variation in the **size** of the symbol, used as an **ordering visual variable**. Symbols should be scaled so that the smallest are visible and the largest do not overly smother the map

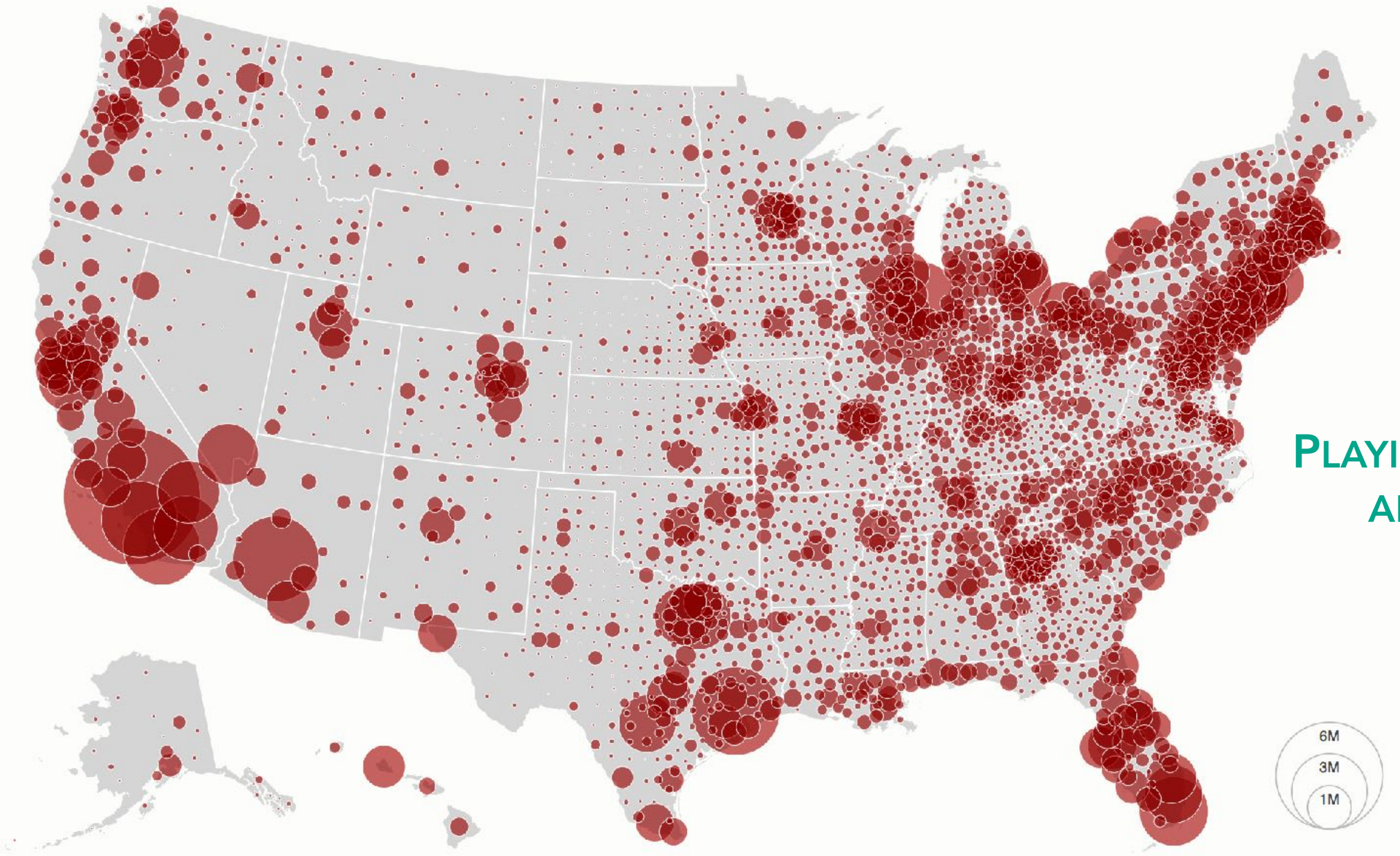



Kenneth Field, politico.com

# Presidential Elections 2012 per county



**OVERLAPPING SYMBOLS!**



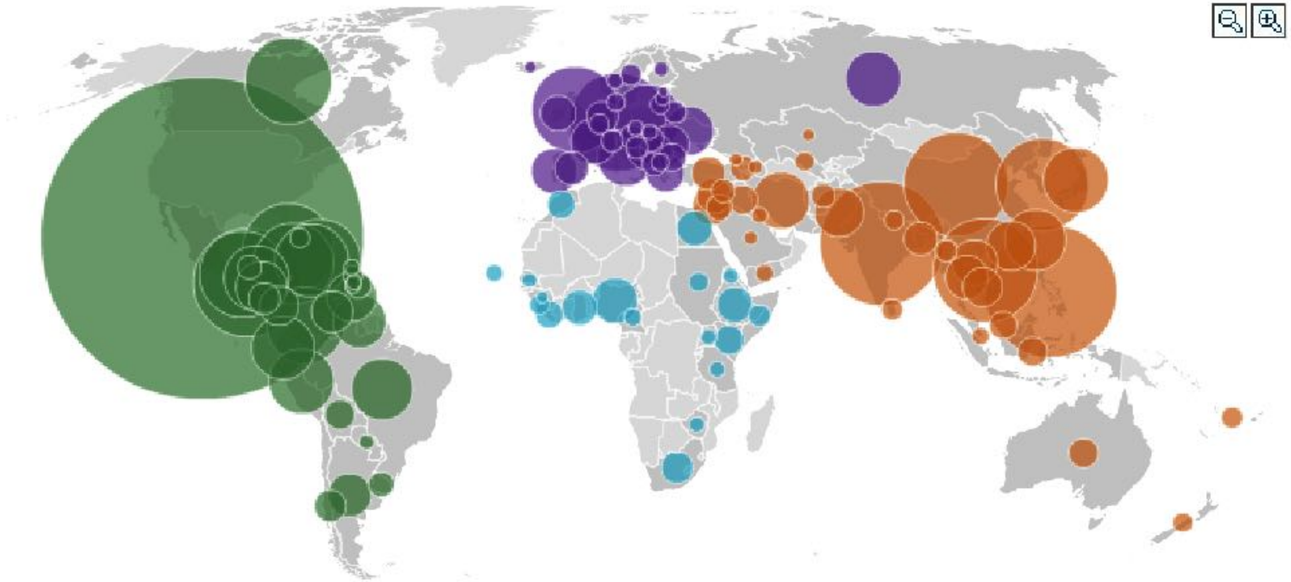

Source: American Community Survey, 2012 5-Year Estimate

# Playing with alpha

# ADDING COLORS

## All foreign-born workers

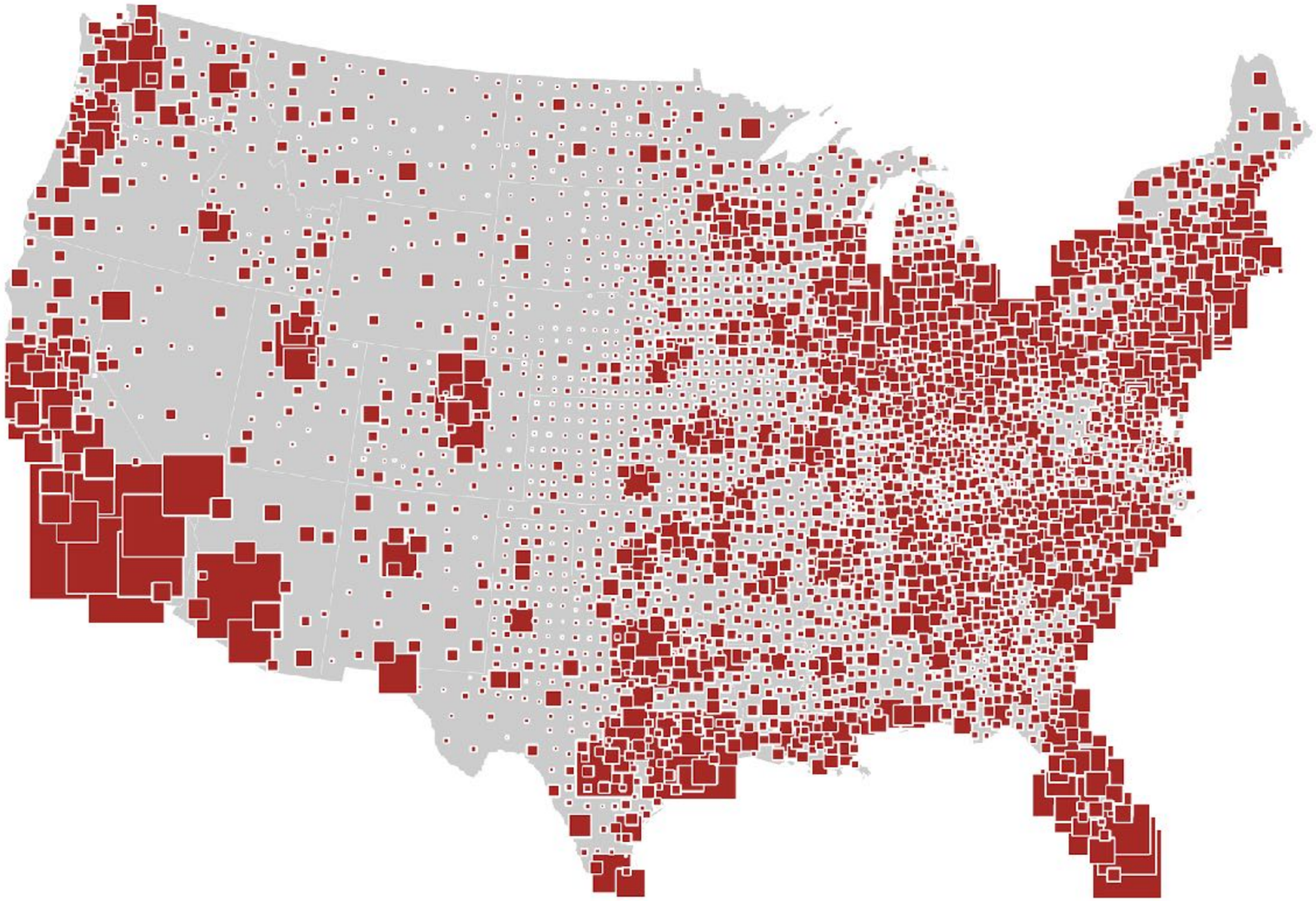
Number of workers: 17,553,000 As a percentage of all U.S. workers in this category: 17%



Map shows countries with more than 500 workers for the selected occupation.

| Top ten | Number of workers (+/- Margin of error) | |
|---|---|---|
| 1. Mexico | 5,286,400 | +/- 1% |
| 2. Philippines | 848,800 | +/- 2% |
| 3. India | 746,200 | +/- 2% |
| 4. China | 653,000 | +/- 2% |
| 5. El Salvador | 580,100 | +/- 2% |
| 6. Vietnam | 526,000 | +/- 2% |
| 7. Germany | 476,100 | +/- 2% |
| 8. South Korea | 408,400 | +/- 2% |
| 9. Cuba | 399,300 | +/- 2% |
| 10. Canada | 364,900 | +/- 2% |

# Different symbols, circles work better!



# Proportional text

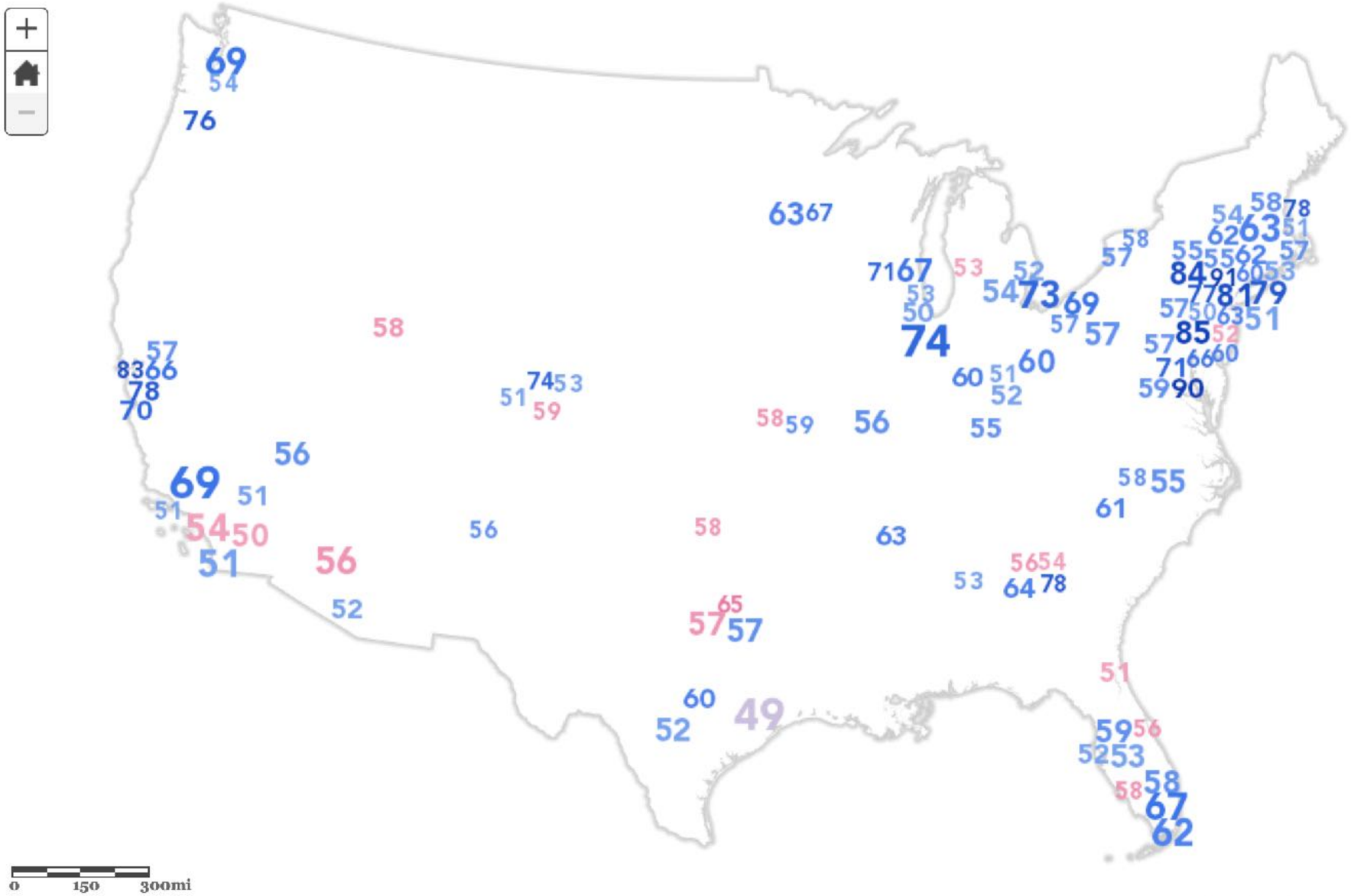
2012 US Presidential election results by County, labelled by share of vote

### Map type

The purpose of a **proportional text** thematic map is to show, using a literal symbol, how features differ in quantity for the theme being mapped. In this example of the 2012 Presidential election, the map is designed to show two variables at the county level. The share of the vote is shown by the text label itself. The total number of votes in the county is represented by the size of the label. Additionally, colour is used to accentuate the share of the vote by making the text increasingly blue for a stronger Democrat win and increasingly red for a strong Republican win.

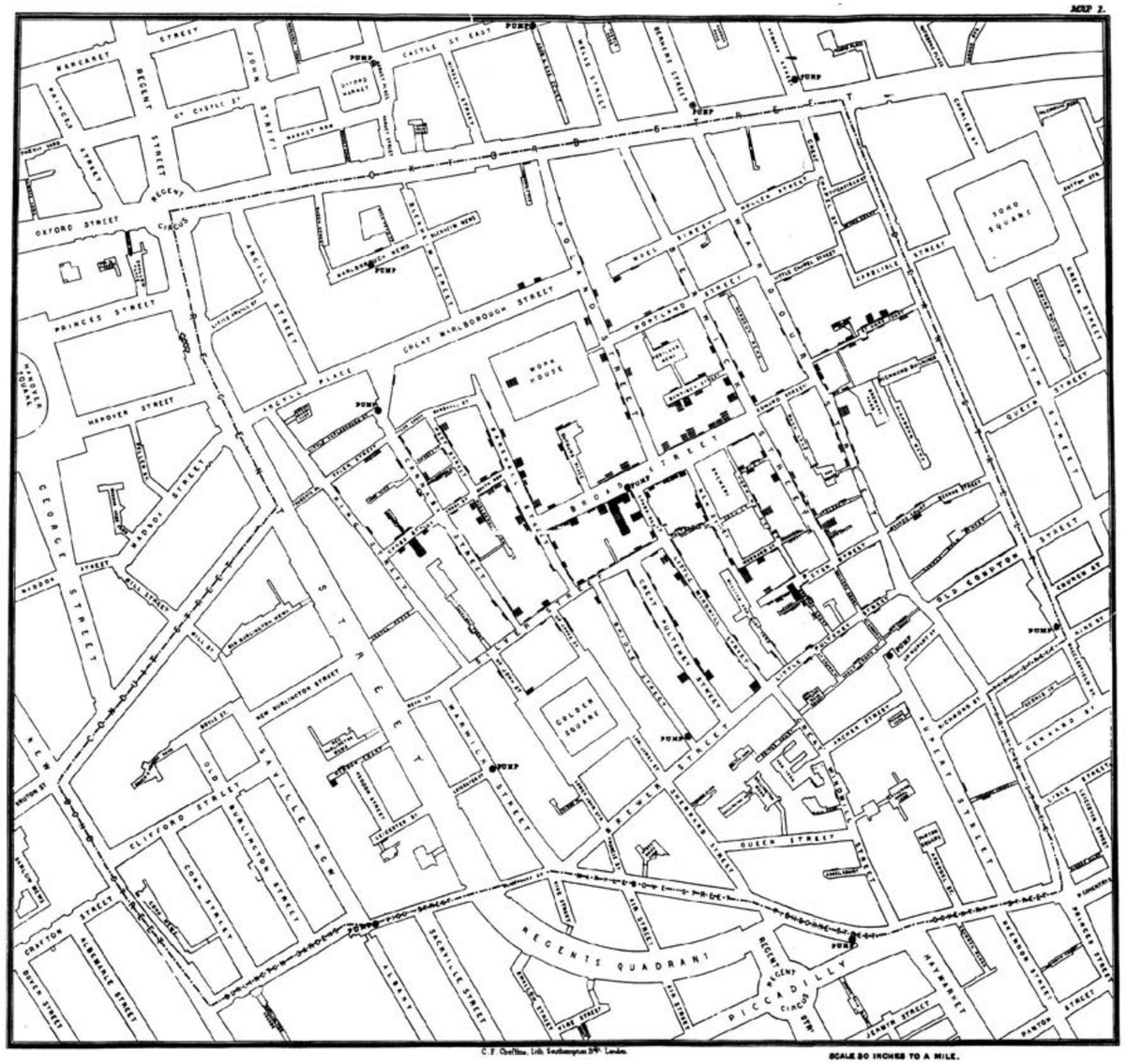
### Data

The label itself can be any combination in characters, in this case numeric (on a percentage scale). The data used to scale the symbols should be **numerical (quantitative)** and represent differences between features on an **interval or ratio** scale of measurement based on absolute values, or totals. The data represented by colour should be **numerical (quantitative)** and be expressed as a ratio or percentage. This is due to the need to normalize data represented by areas of unequal size.




Kenneth Field, politico.com

# Dot Distribution

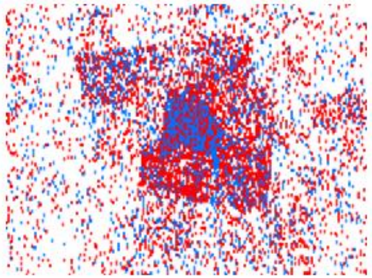



Original map by John Snow showing the clusters of cholera cases in the London epidemic of 1854.

# Dot density

2012 US Presidential election results by County: total votes

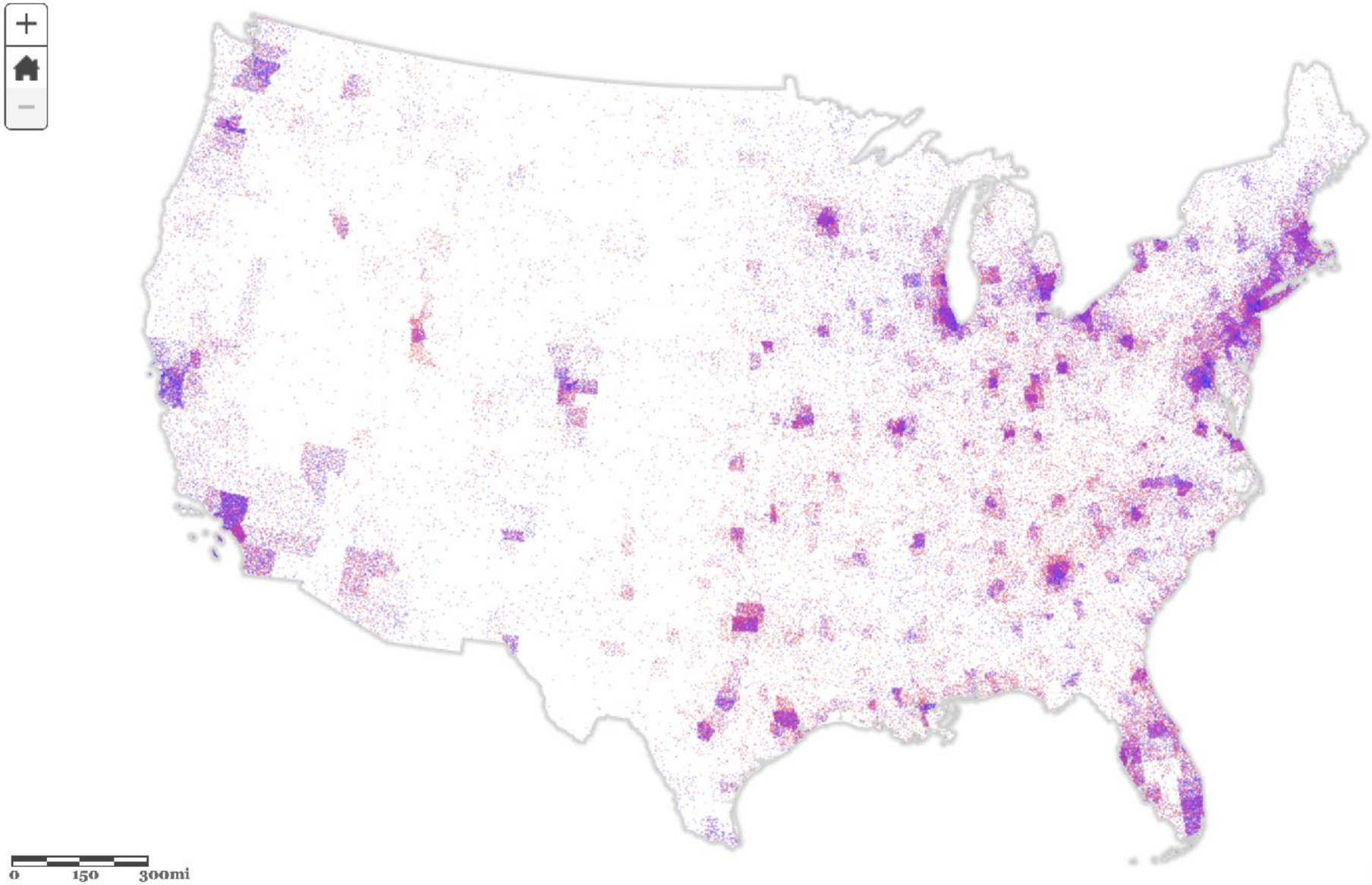
### Map type



**Dot density** (or dot-distribution) thematic maps use dots as shading symbols, usually in a random pattern across a statistical areal unit. The rationale is easily understood since more dots relates to larger data magnitudes of the mapped phenomena. It is an effective method to represent spatial density and has one advantage over the **choropleth** in that more than one variable can be mapped at the same time. In this example of the 2012 Presidential election, red dots represent Republican votes and Blue dots represent Democrat votes. Each dot represents 1000 votes at the smallest map scale. This value changes at larger scales..

### Data

Data represent values for areas units. For the theme being mapped, the data should
be **numerical (quantitative)** and represent differences between features

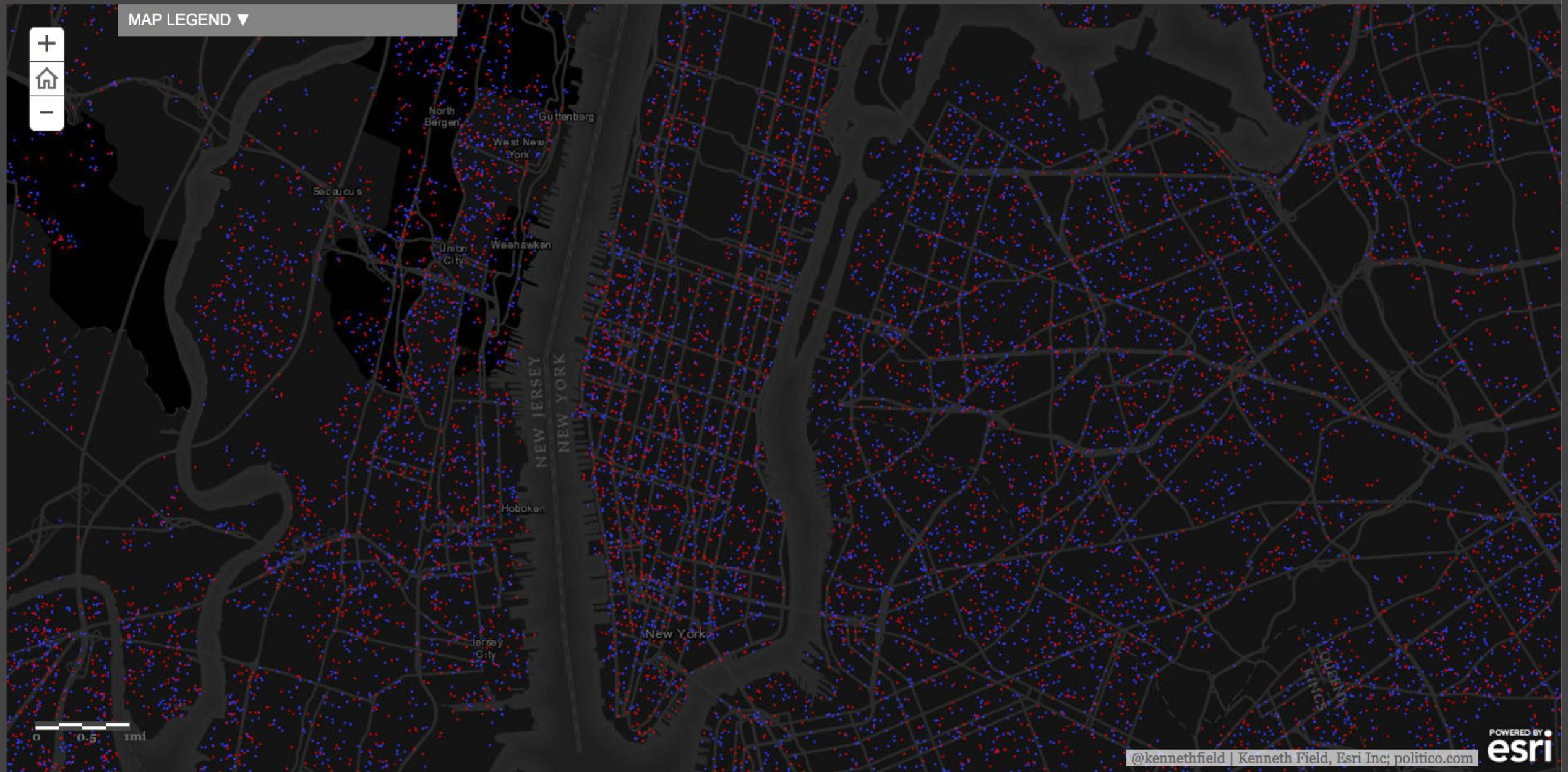



Kenneth Field, politico.com

# Dasymetric Dot Density

2012 US Presidential election results

1 dot = 50 votes
Republican Red (Romney)
Democrat Blue (Obama)



show labels link to this map

# Census Dotmap

Buy a print

### What's all this?

This is a map of every person counted by the 2010 US and 2011 Canadian censuses. The map has **341,817,095** dots - one for each person.

### Why?

I wanted an image of human settlement patterns unmediated by proxies like city boundaries, arterial roads, state lines, &c. Also, it was an interesting challenge.

### Who is responsible for this?

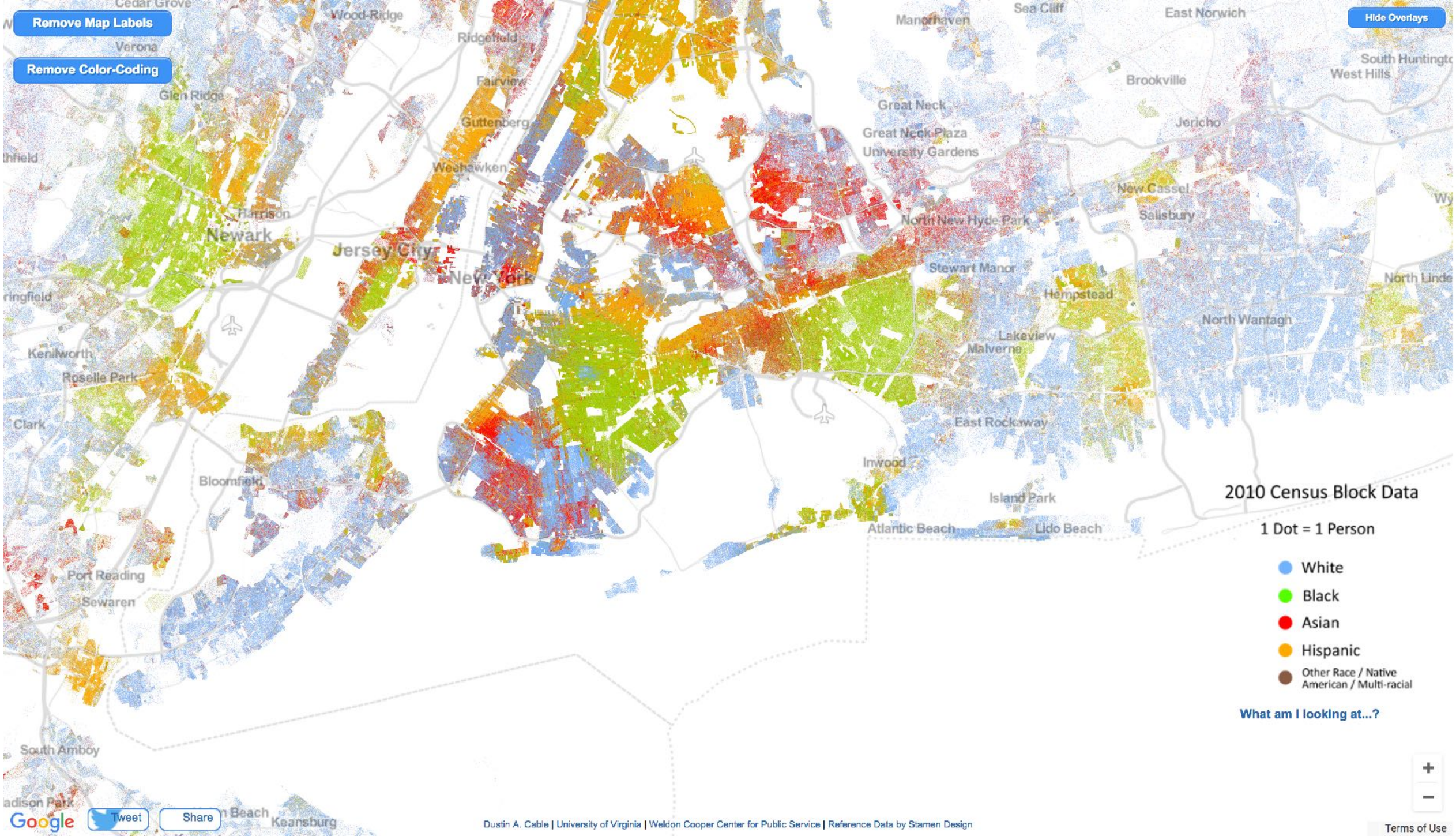
The US and Canadian censuses, mostly. I made the map. I'm Brandon Martin-Anderson. Kieran Huggins came to the rescue with spare server capacity and technical advice once this took off.

### How?

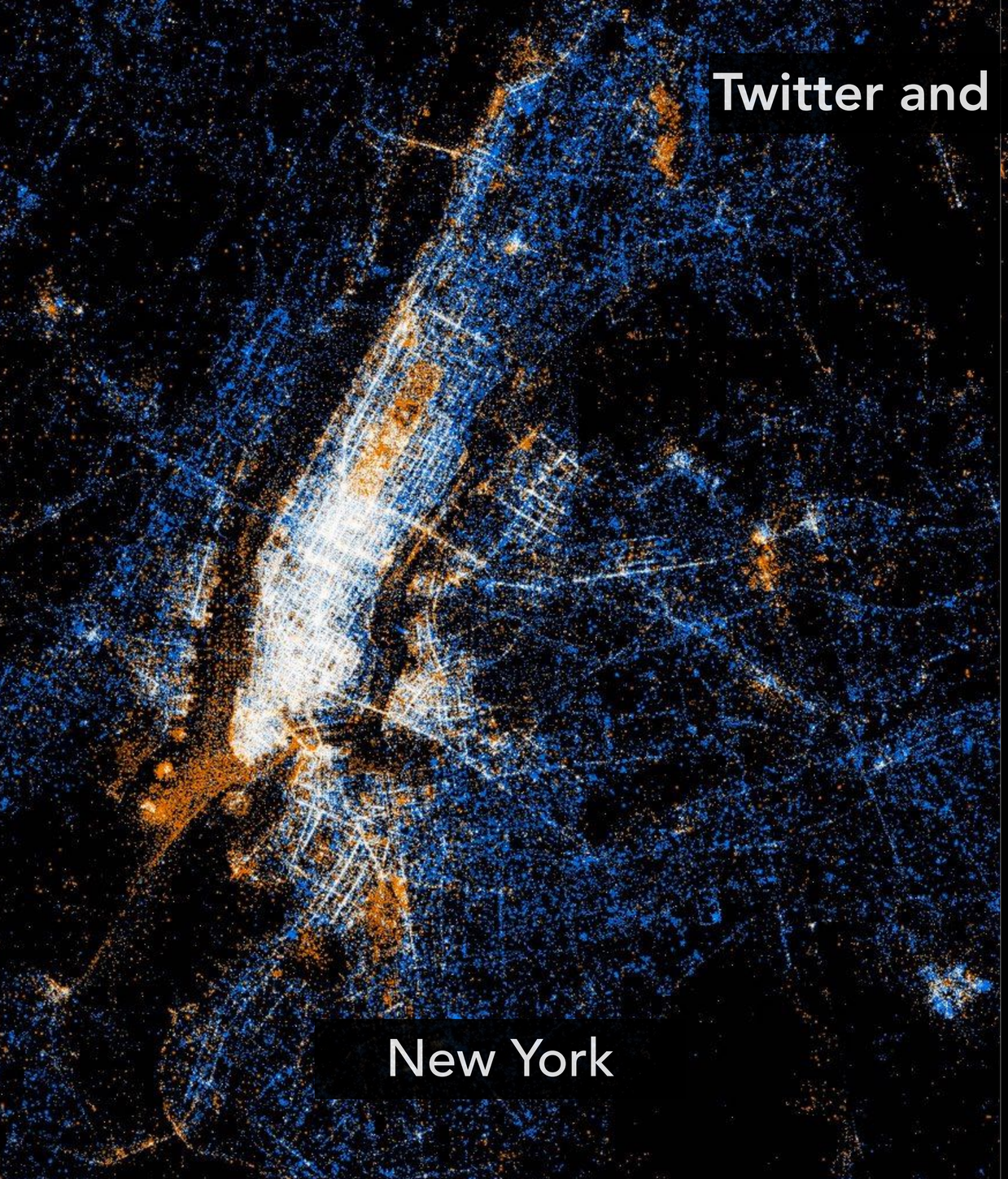
I wrote a Python script to generate points from US Census block-level counts, and then generated the tiles with Processing. Here's more detail for the interested.

### I don't see dots. I see

Terms of Use

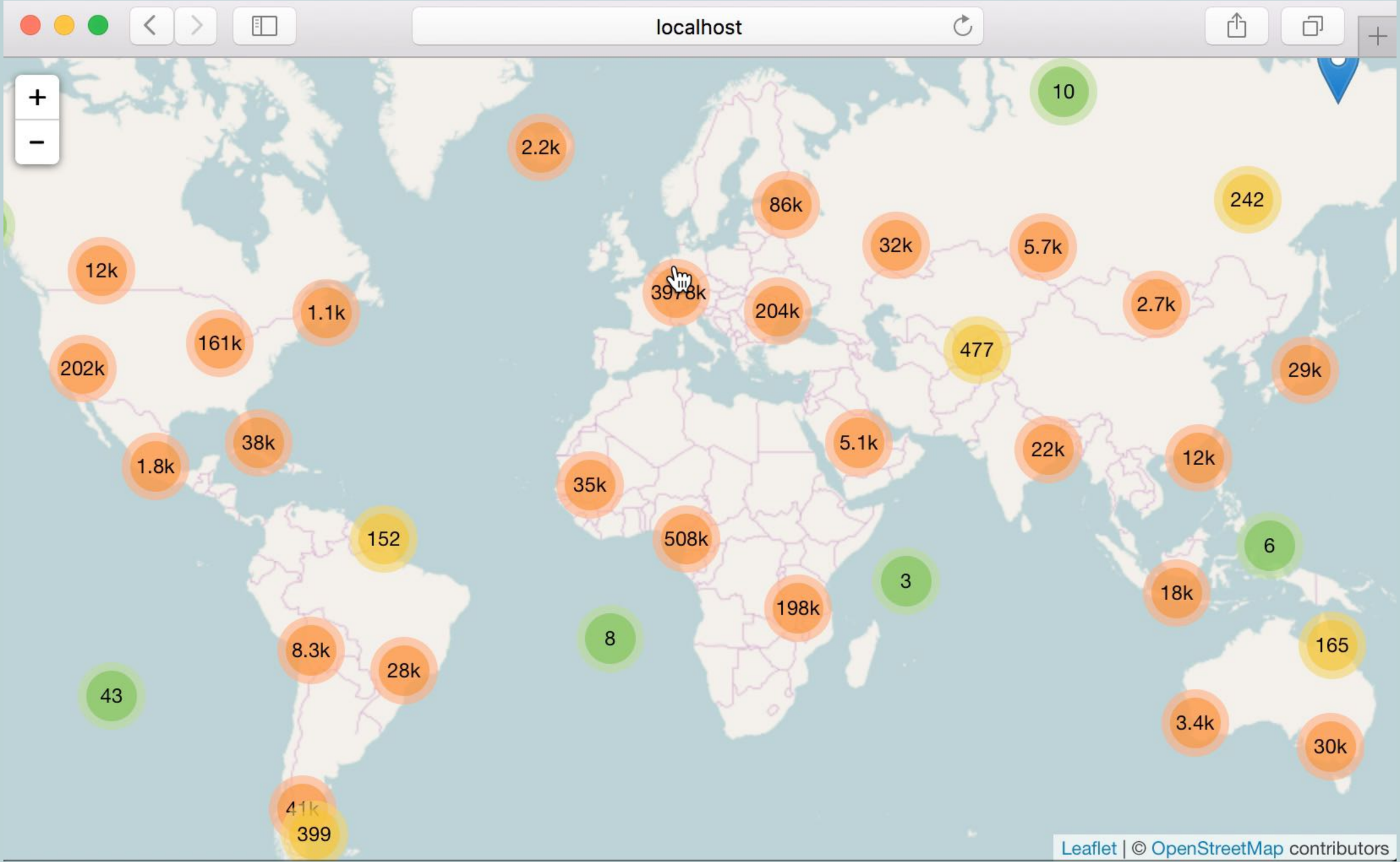

Remove Map Labels
Remove Color-Coding
Hide Overlays
Cedar Grove
Wood-Ridge
Verona
Ridgefield
Fairview
Glen Ridge
Guttenberg
Weehawken
Harrison
Newark
Jersey City
New York
Kenilworth
Roselle Park
Clark
Bloomfield
Port Reading
Sewaren
South Amboy
Keansburg
Manorhaven
Sea Cliff
East Norwich
Brookville
South Huntingto
West Hills
Great Neck
Great Neck Plaza
University Gardens
Jericho
New Cassel
Salisbury
North New Hyde Park
Stewart Manor
Hempstead
North Linde
North Wantagh
Lakeview
Malverne
East Rockaway
Inwood
Island Park
Atlantic Beach
Lido Beach
2010 Census Block Data
1 Dot = 1 Person
White
Black
Asian
Hispanic
Other Race / Native American / Multi-racial
What am I looking at...?
Google
Tweet
Share
Dustin A. Cable | University of Virginia | Weldon Cooper Center for Public Service | Reference Data by Stamen Design
Terms of Use

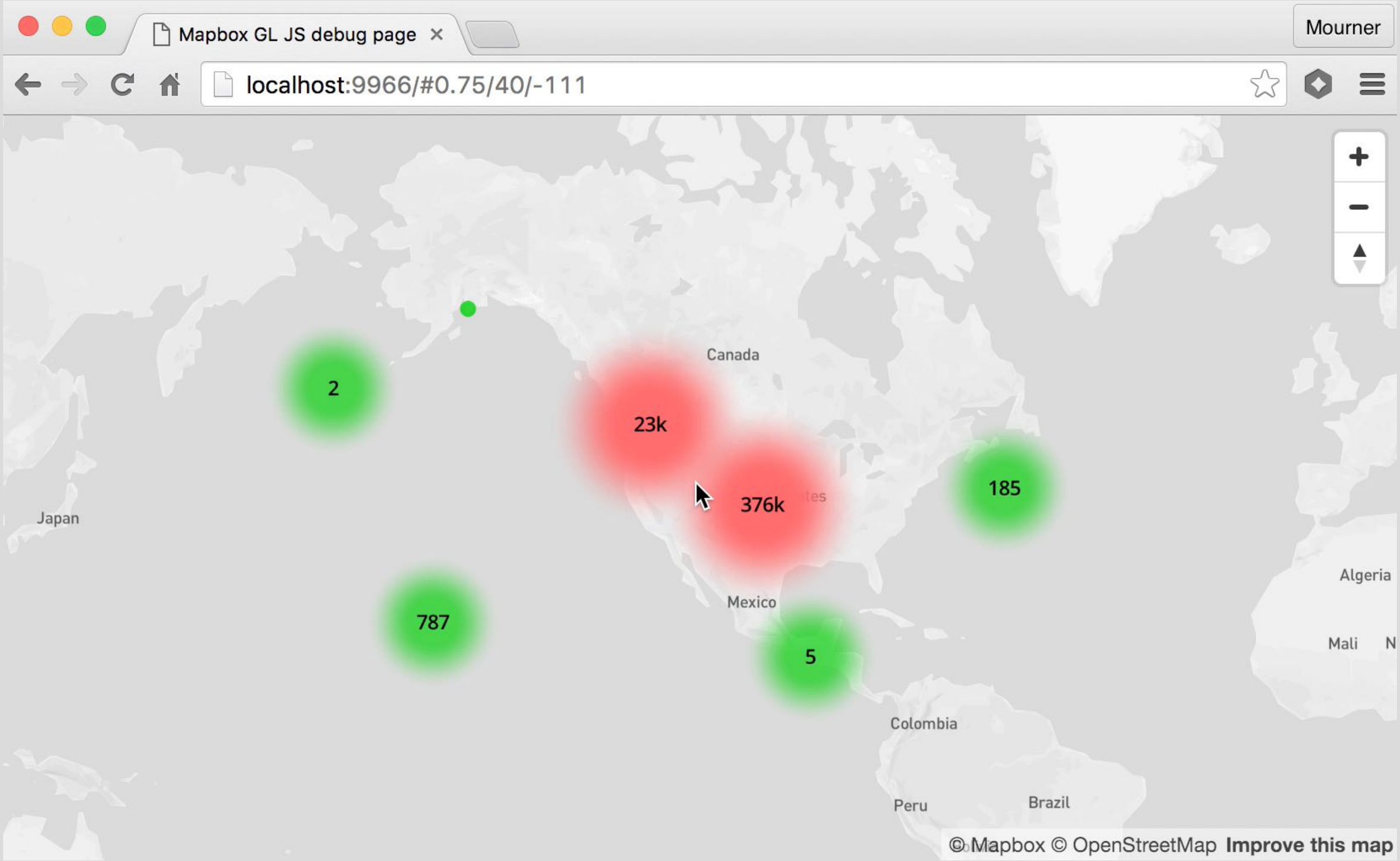
# Twitter and Flickr Activity



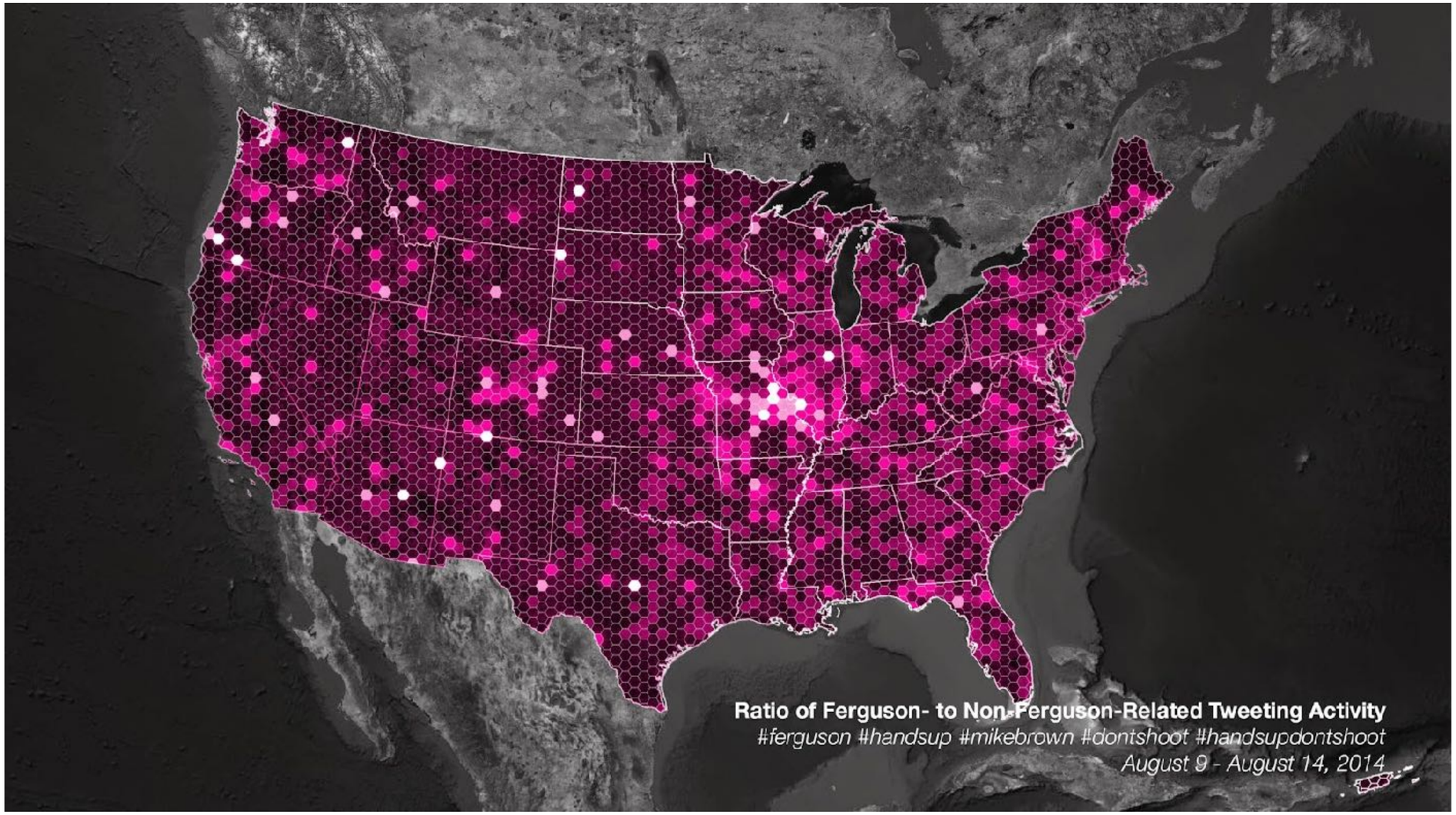
# Too many points or symbols?

- Clustering
- Hexbins
- Heatmaps


localhost
10
2.2k
86k
242
32k
5.7k
12k
3978k
204k
2.7k
1.1k
161k
477
202k
29k
38k
5.1k
22k
12k
1.8k
35k
152
508k
6
3
18k
198k
8
165
8.3k
28k
43
3.4k
30k
41k
399
Leaflet | © OpenStreetMap contributors


Mapbox GL JS debug page
Mourner
localhost:9966/#0.75/40/-111
Canada
2
23k
376k
185
Japan
Algeria
Mexico
787
5
Mali
Colombia
Peru
Brazil
© Mapbox © OpenStreetMap Improve this map

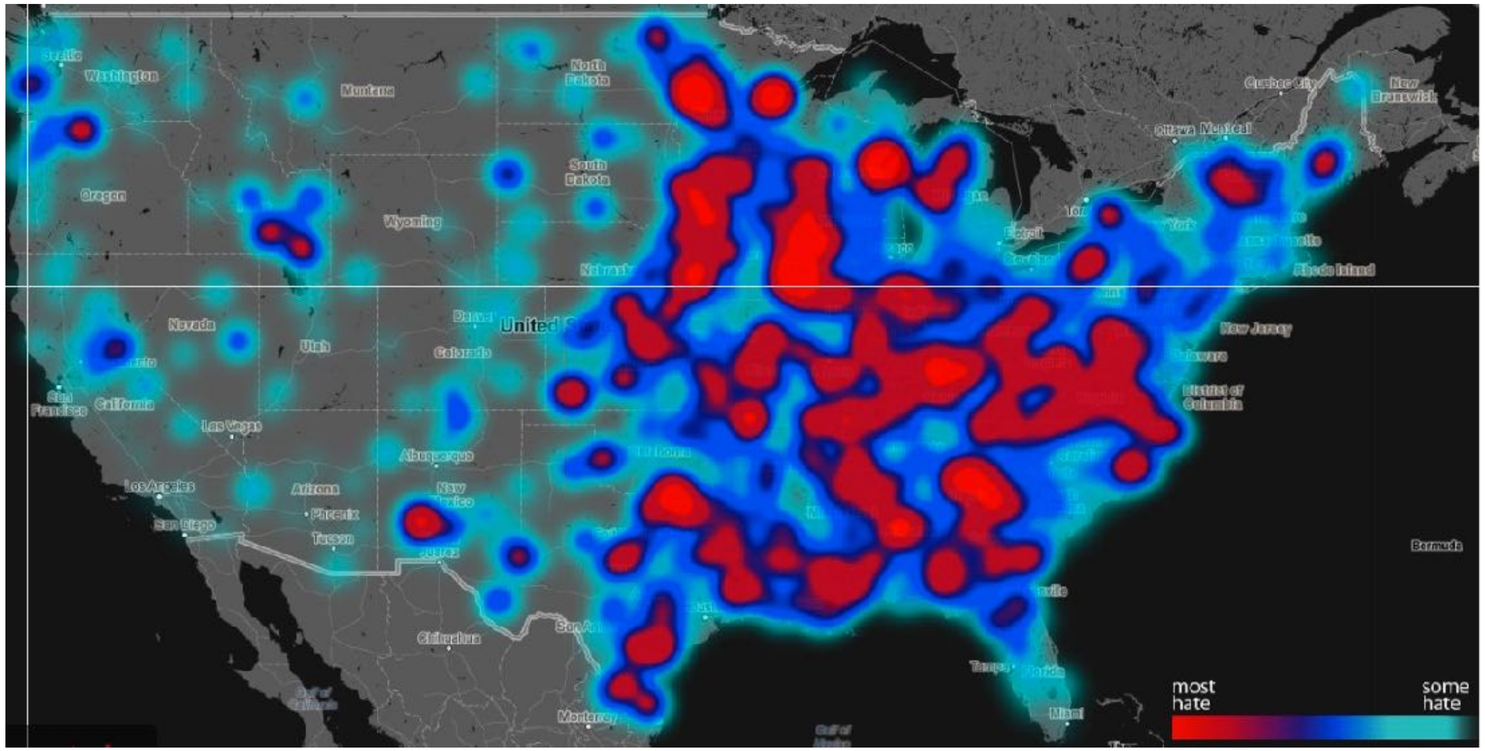
# Hexbins

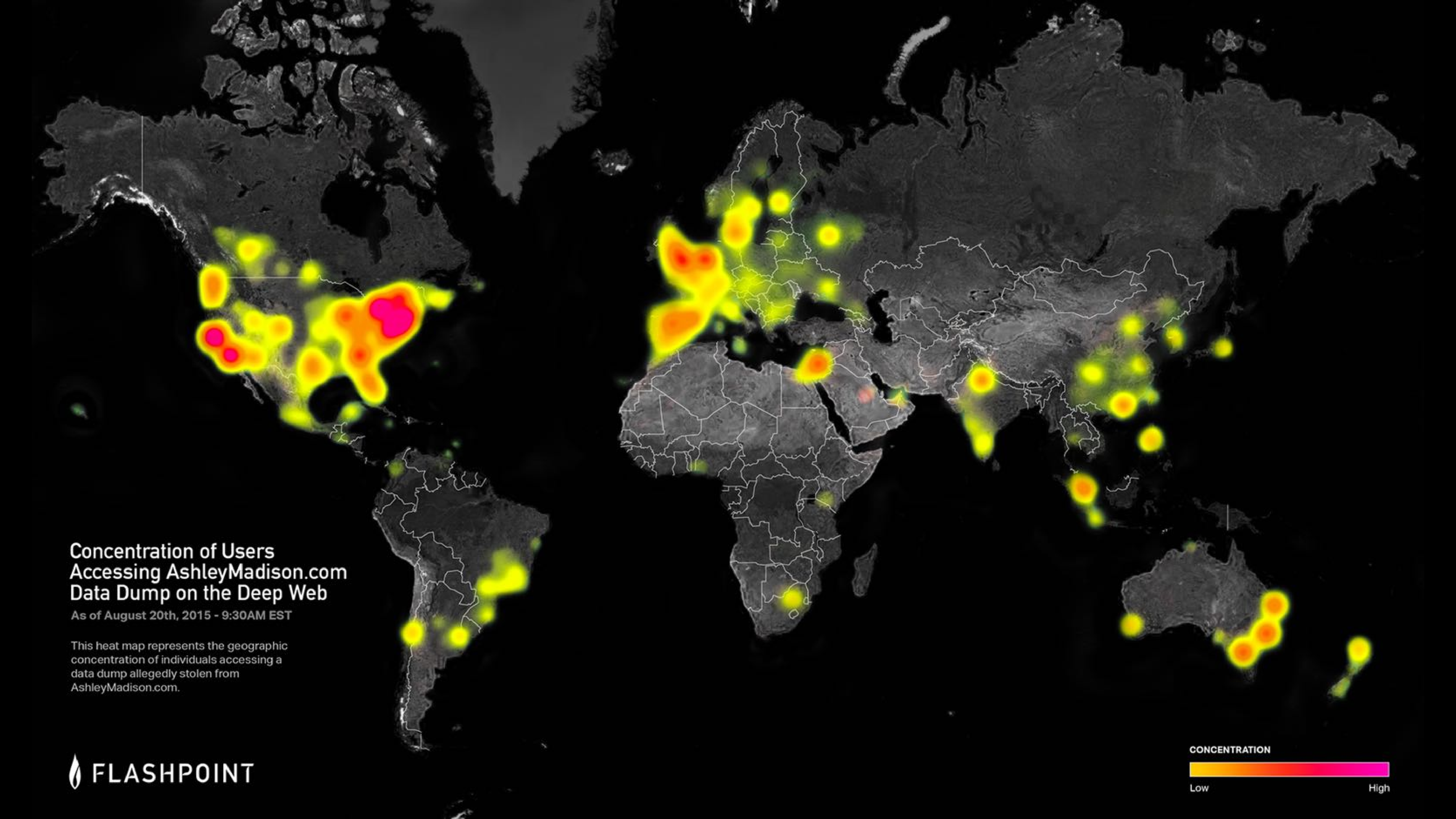

Ratio of Ferguson- to Non-Ferguson-Related Tweeting Activity
#ferguson #handsup #mikebrown #dontshoot #handsupdontshoot
August 9 - August 14, 2014

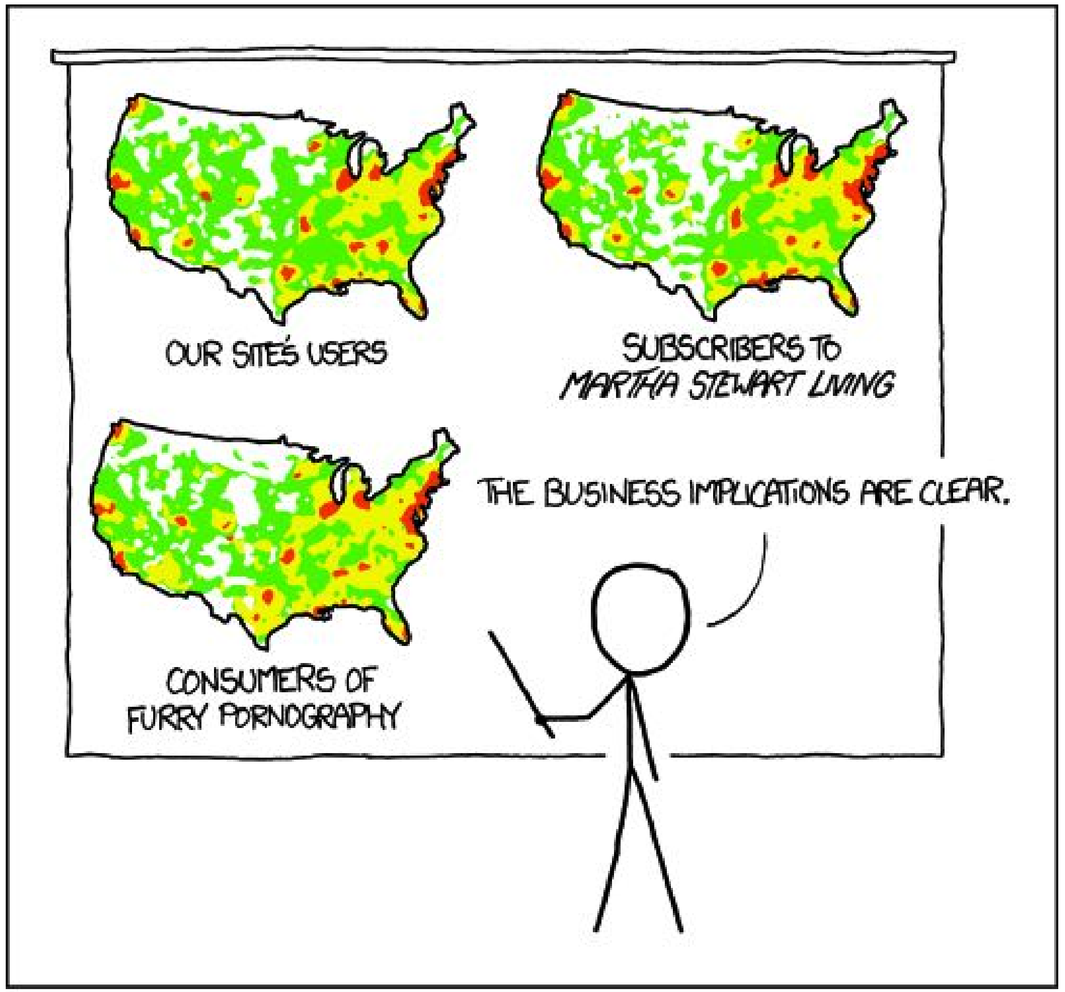
# Heatmaps

Used to identify clusters where there is a high concentration of activity (attribute under analysis)

They can ben also useful for doing hotspot analysis.




Concentration of Users Accessing AshleyMadison.com Data Dump on the Deep Web
As of August 20th, 2015 - 9:30AM EST
This heat map represents the geographic concentration of individuals accessing a data dump allegedly stolen from AshleyMadison.com.
FLASHPOINT
CONCENTRATION
Low
High




PET PEEVE #208:
GEOGRAPHIC PROFILE MAPS WHICH ARE BASICALLY JUST POPULATION MAPS

# Isopleth

# Isopleth: Filled Contours

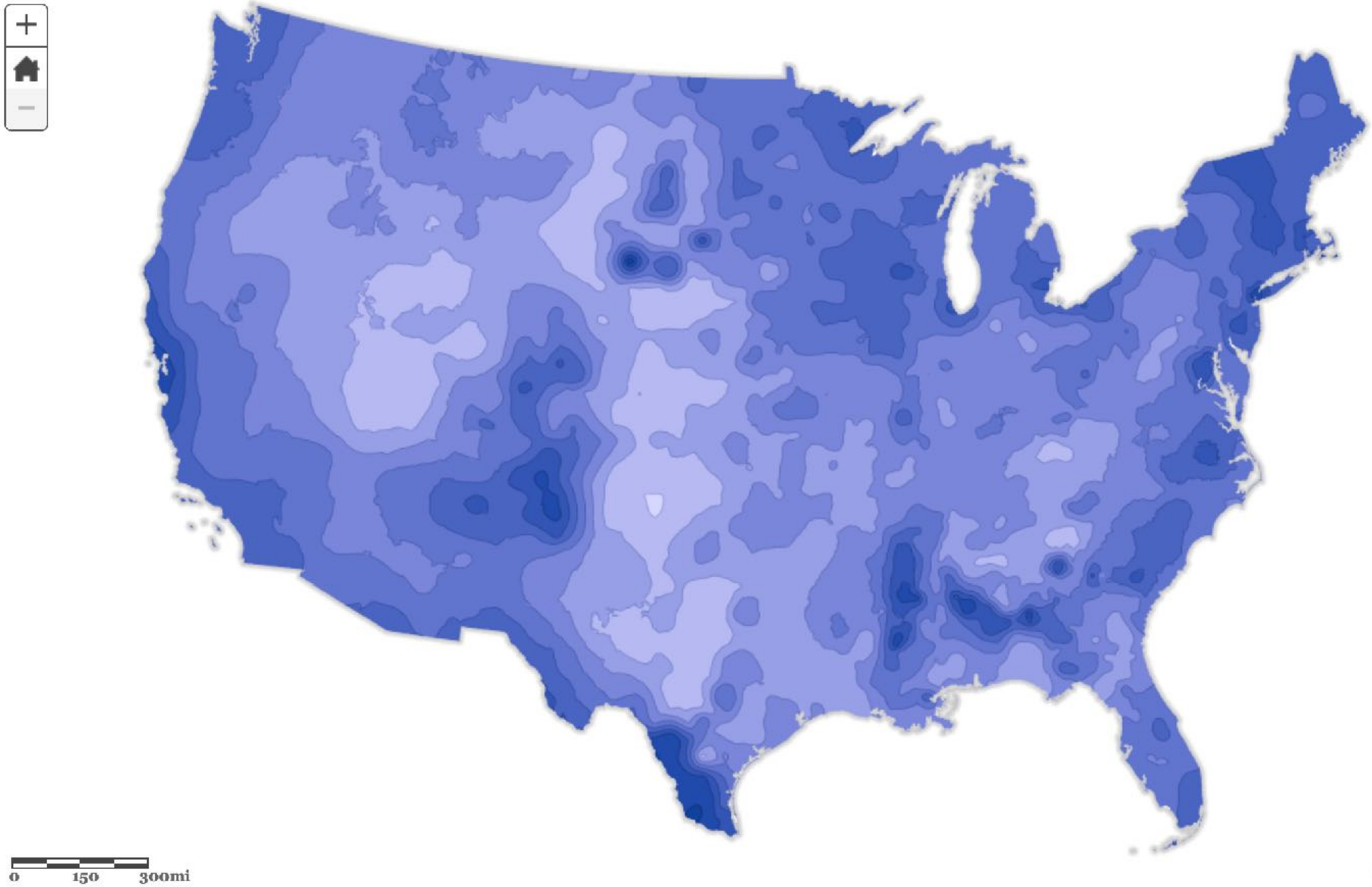
2012 US Presidential election results: Democrat share of vote

### Map type

An **isarithmic** map is a two-dimensional representation of a three-dimensional volume. Two types exist: an **isometric** form that is constructed from data at points and an **isoplethic** form constructed from data that occur over geographic areas. The purpose of an **isopleth** thematic map is to show how features differ in quantity as a surface. This can be achieved through representing the volume using **contour lines** or by using **filled contours** that are shaded according to the quantitative value being mapped. In this example of the 2012 Presidential election, the map is designed to show the share of the vote gained by the Democrat party based on County level data.

### Data

**Isopleth** maps are generated from data that occur over geographical areas and values represent **numerical (quantitative)** diffe between features on an **interval or ratio** scale of measurement. Absolute values cannot be illustrated isoplethically due to the inherent problems of using totals for areas that might vary in size or which contain an unequal denominator of the data being mapped. This is the issue that prevents **choropleths** from being used to map totals and the same occurs for




Kenneth Field, politico.com | Kenneth Field

# Isopleth: Contours

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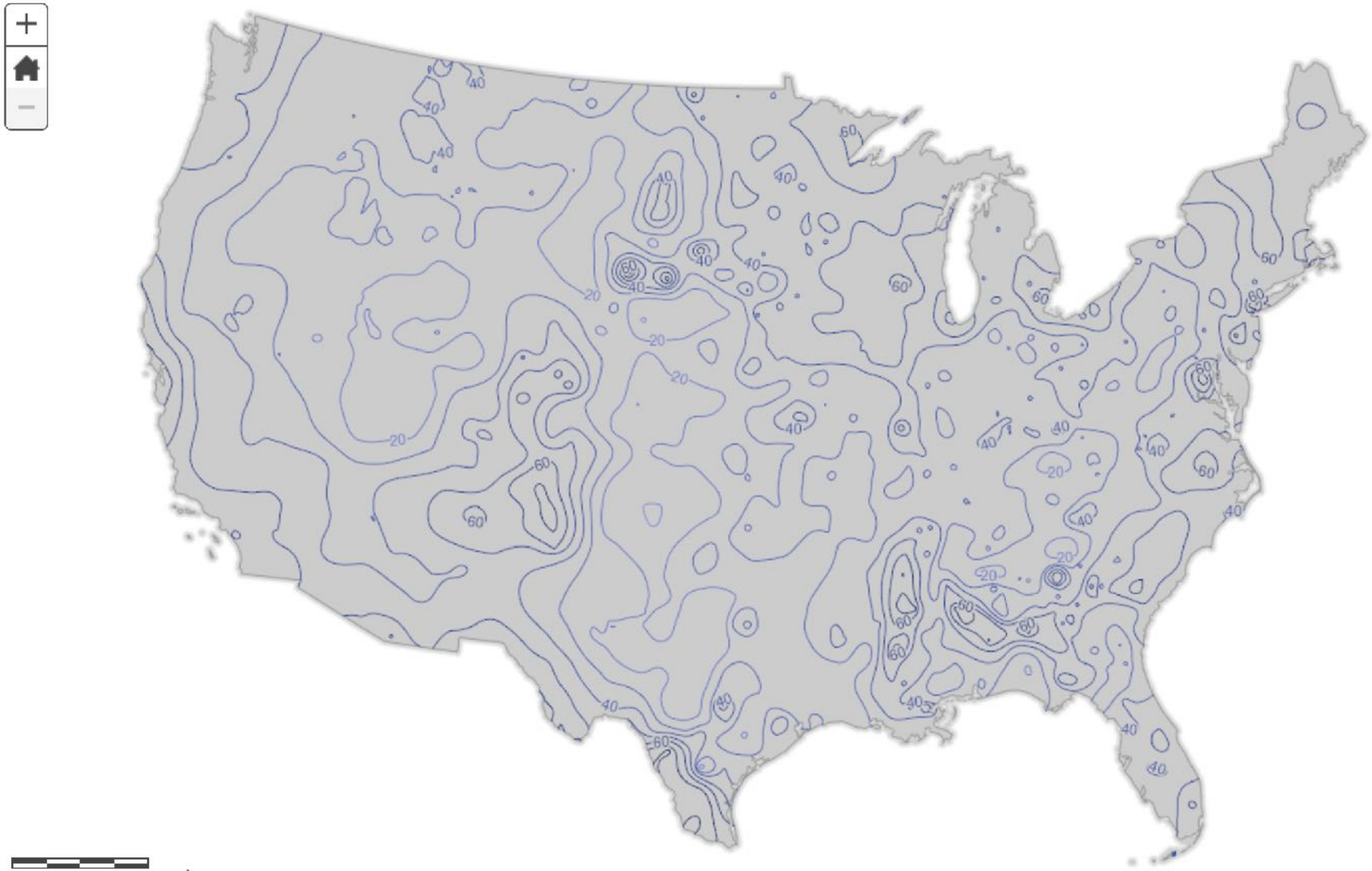
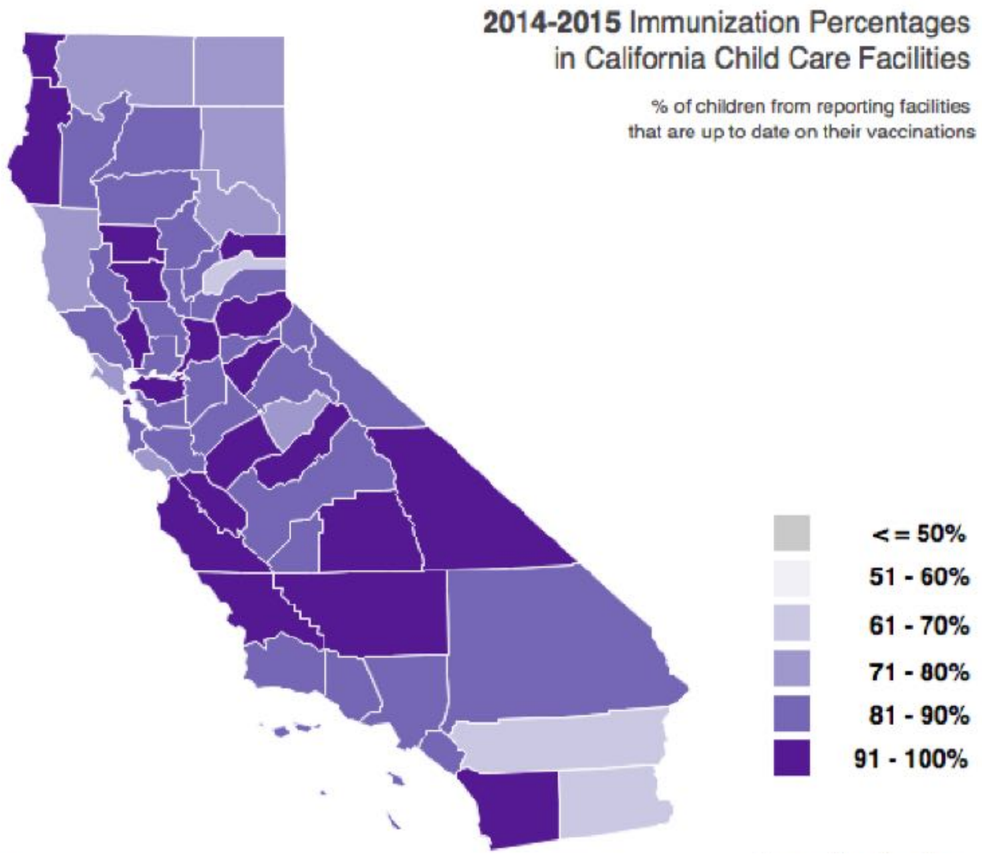



Kenneth Field, politico.com | Kenneth Field

# Choropleth

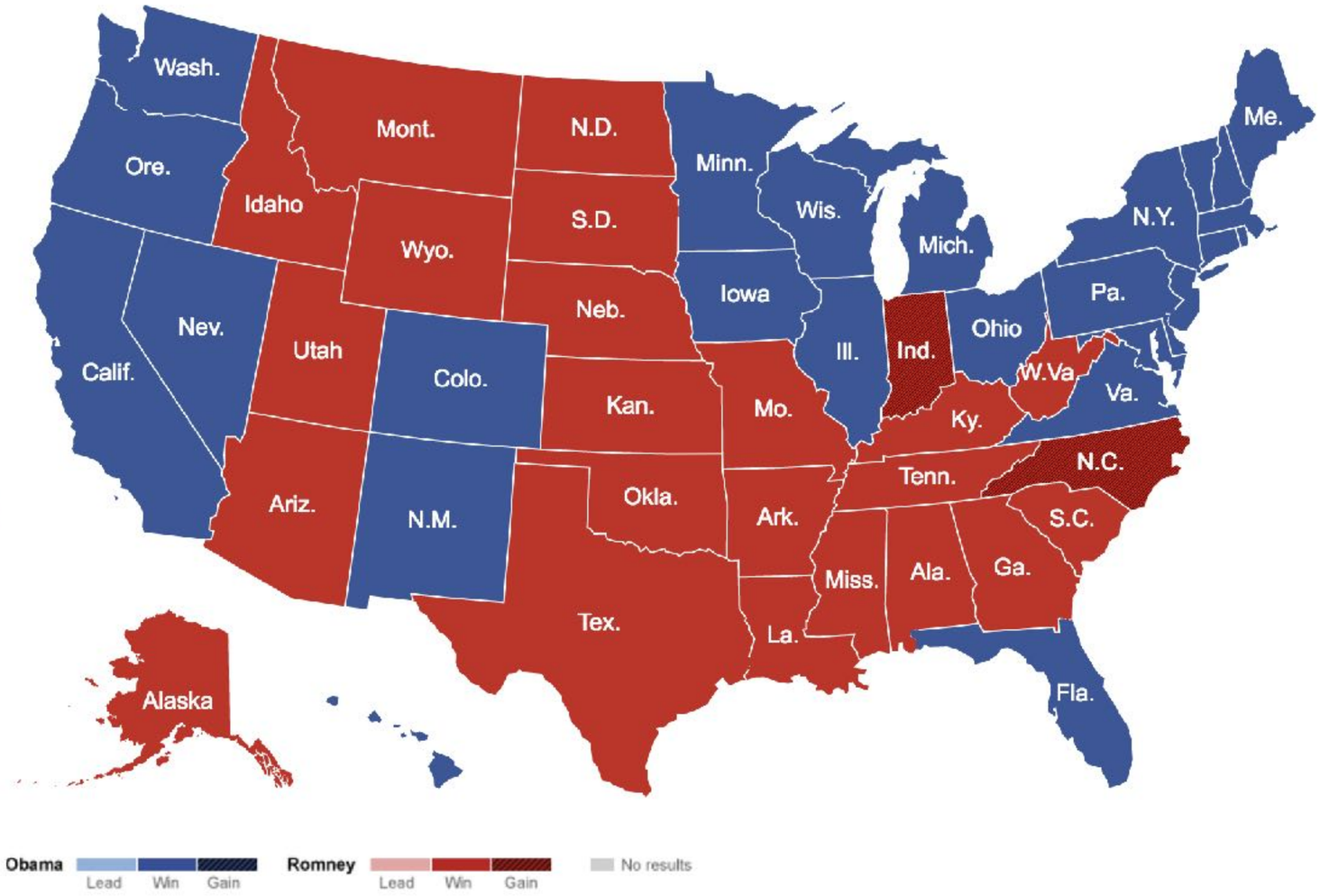
# Choropleth
(from Greek χῶρος ("area/region") + πλῆθος (“multitude"))

- Areas are **shaded** or **coloured** in proportion to the measurement of the **statistical variable** being displayed on the map.
- Key factors:
  - Resolution of the base map
  - Data
    - source and processing
    - classification
    - MAUP
    - legend
  - Symbolization



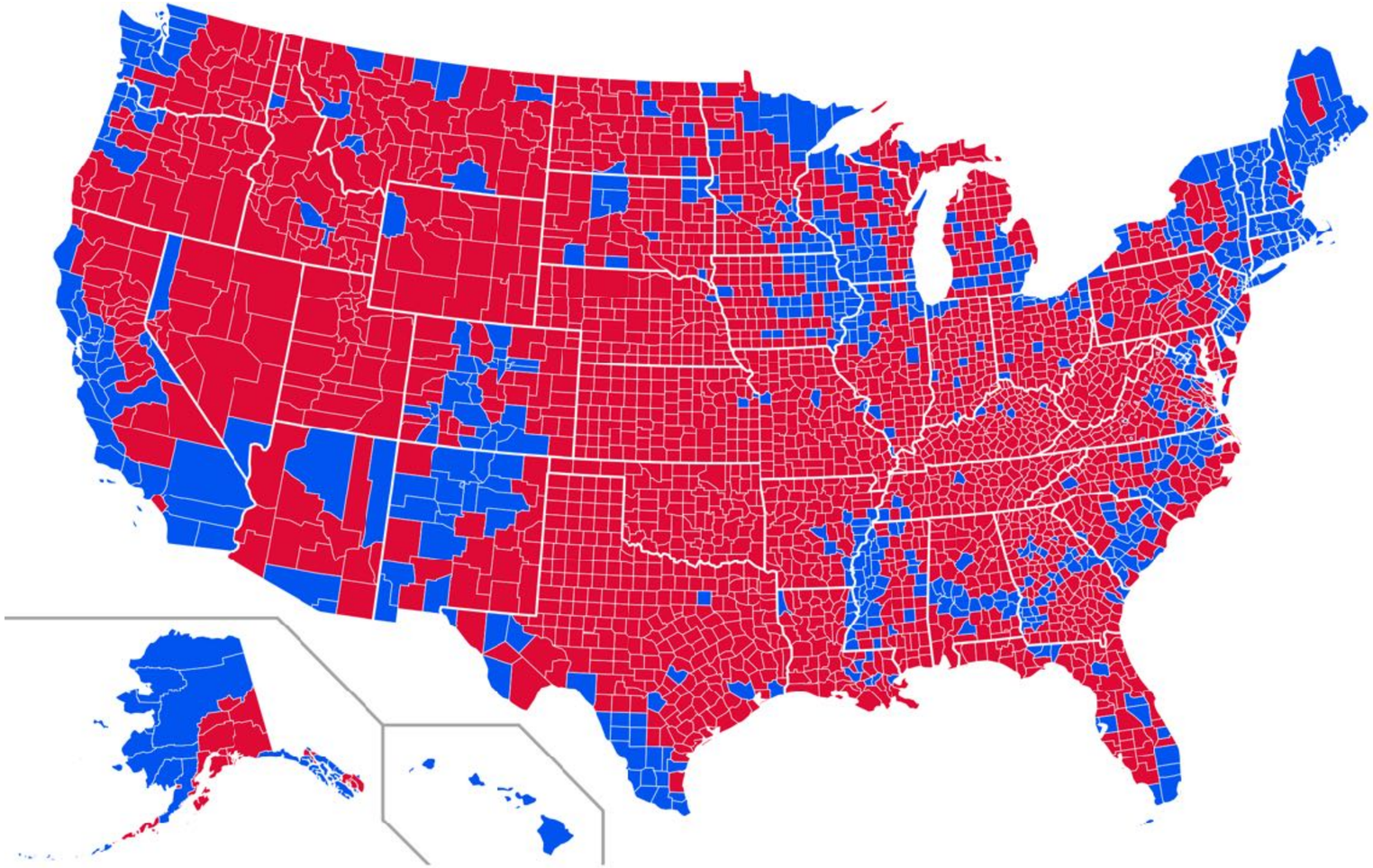
# Resolution of the base map

## Presidential election 2012 (by state)



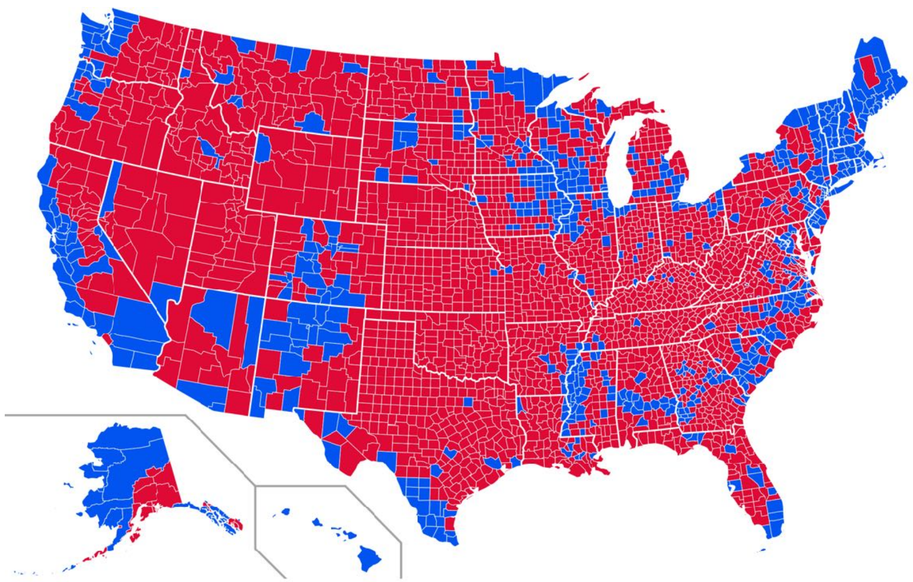
# Resolution of the base map

## Presidential election 2012 (by county)



# Data type

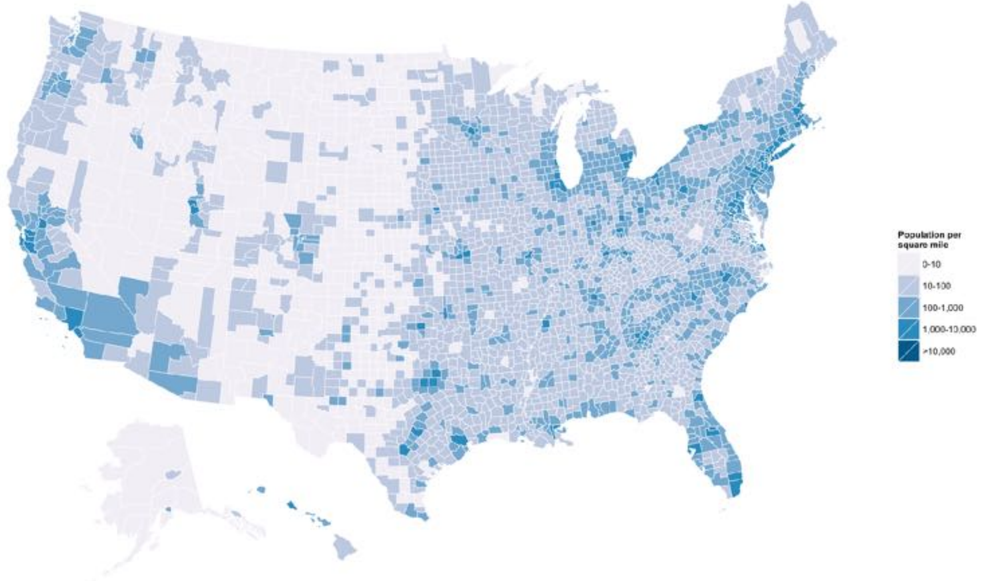
Presidential election 2008



**CATEGORICAL**

Obama or Romney

Population density 2014




**CONTINUOUS**

interval [0, 1]

Data Type

**Continuous**

(sequential)

≠!

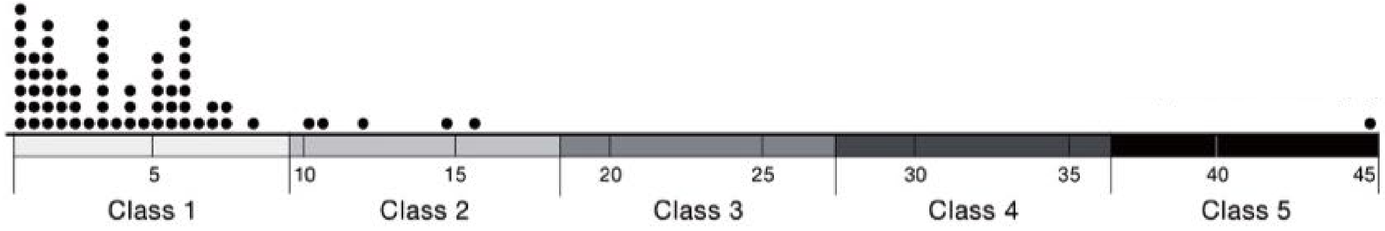
Color Scheme

**Categorical**

(qualitative)

# Classification

Take observations and group them into data ranges or classes




## How many classes?

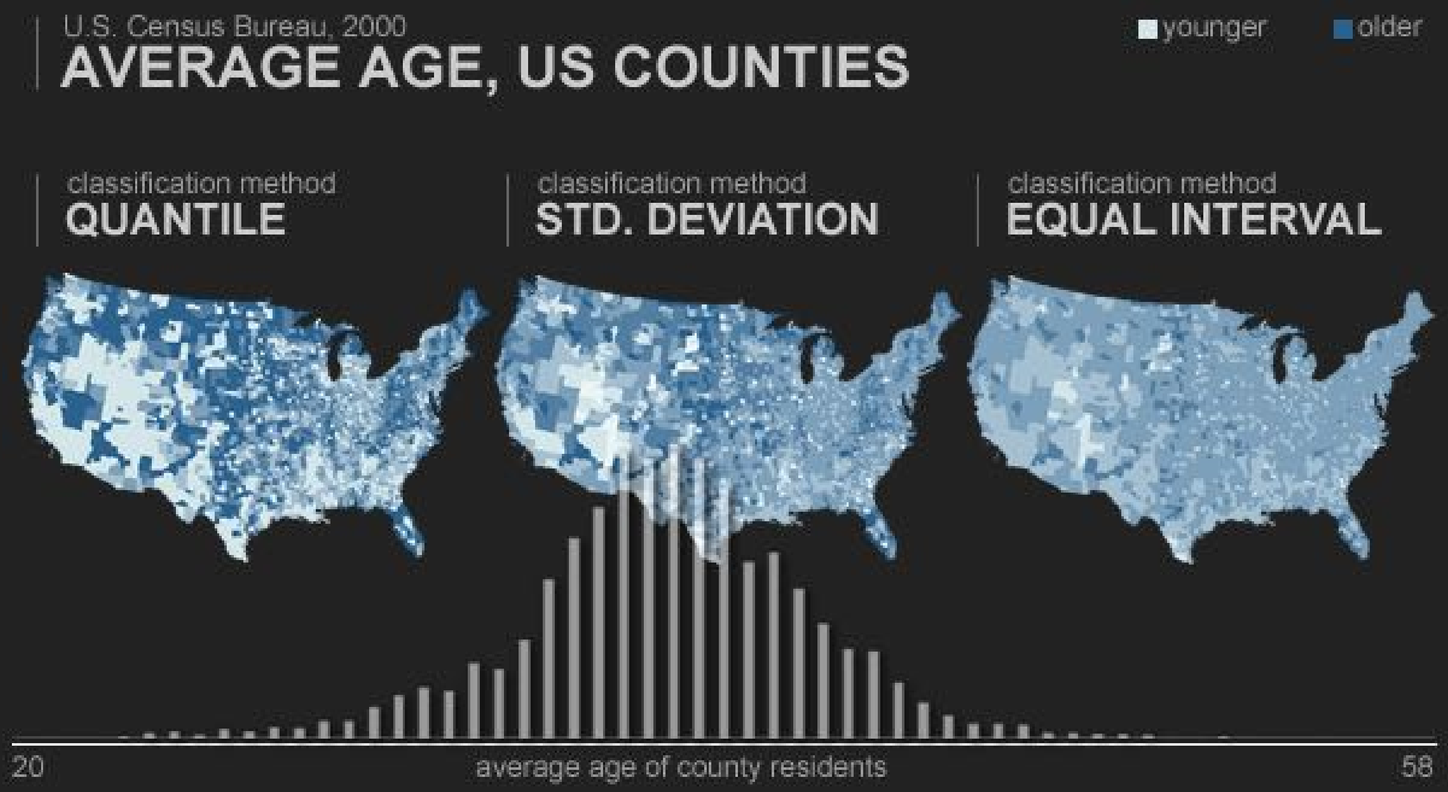
**5-7 ± 2**

George Miller (1956)
short term memory capacity

## Which method?

# Classification methods

- **Manual (eyeball, interactive)**
- **Natural breaks**
- **Equal intervals**
  - not valid if your data is skewed or in presence of outliers.
- **Unequal, i.e., non-linear, logarithmic**
- **Quantiles**
  - can position elements in a class even if being closer to the adjacent
- **Mean-standard deviation**
- **Jenks-Caspall:** reduce the variance within classes and maximize the variance between classes
  - unique classification, hard to compare between maps.



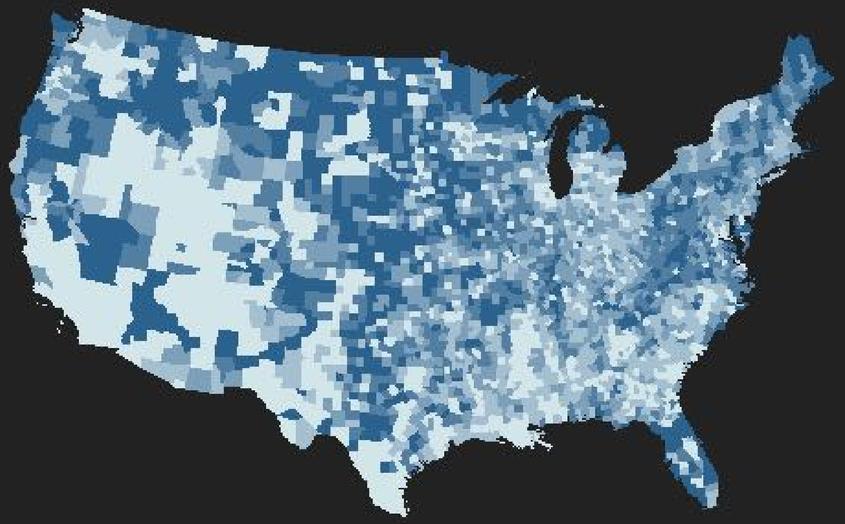

http://uxblog.idvsolutions.com/2011/10/telling-truth.html

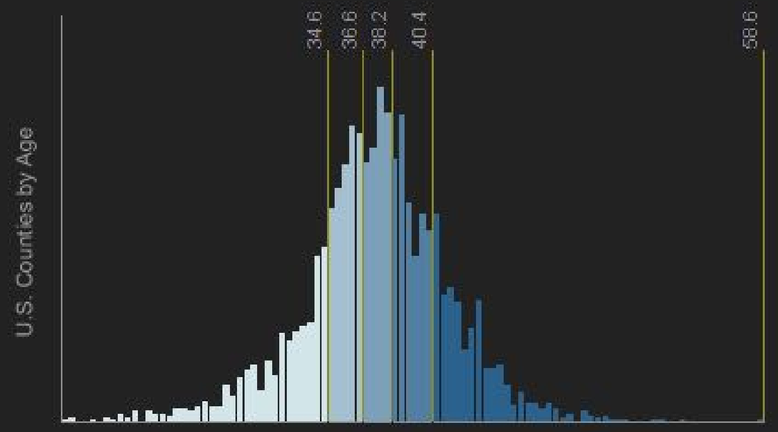
U.S. Census Bureau, 2000

# MEDIAN AGE

classification

# QUANTILE



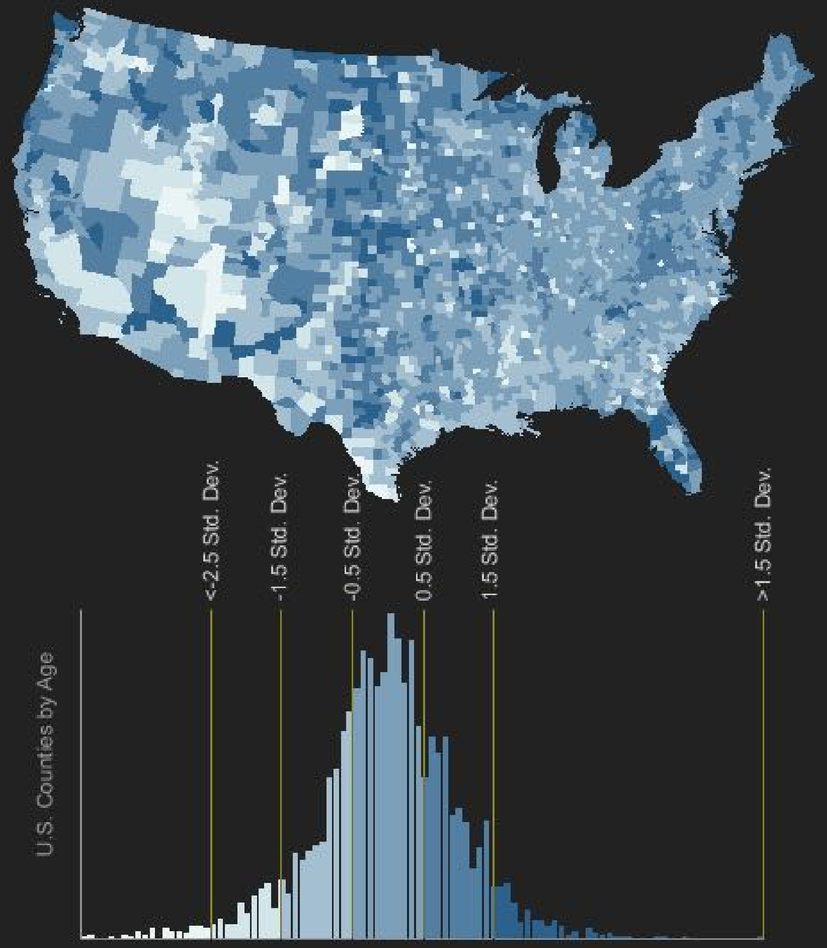


U.S. Census Bureau, 2000

# MEDIAN AGE

classification

# STD. DEVIATION

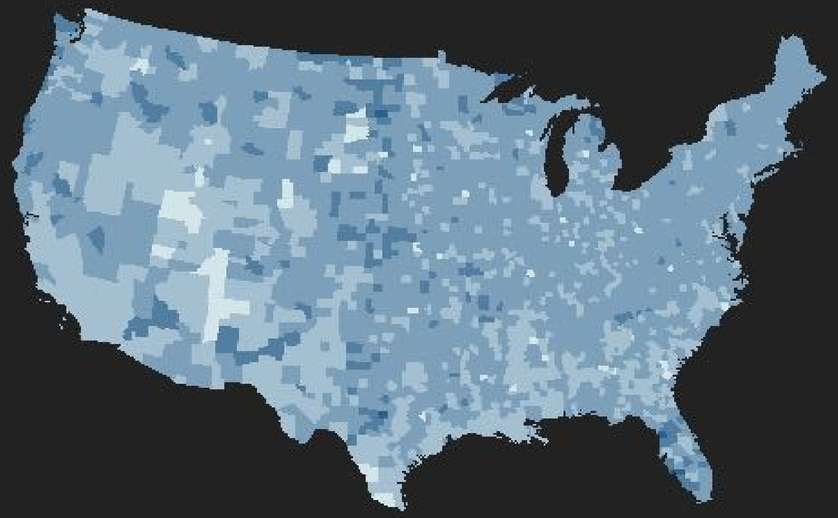


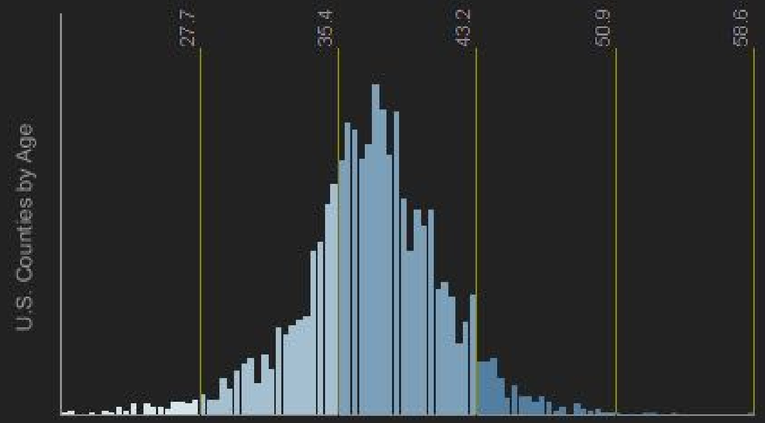
U.S. Census Bureau, 2000

# MEDIAN AGE

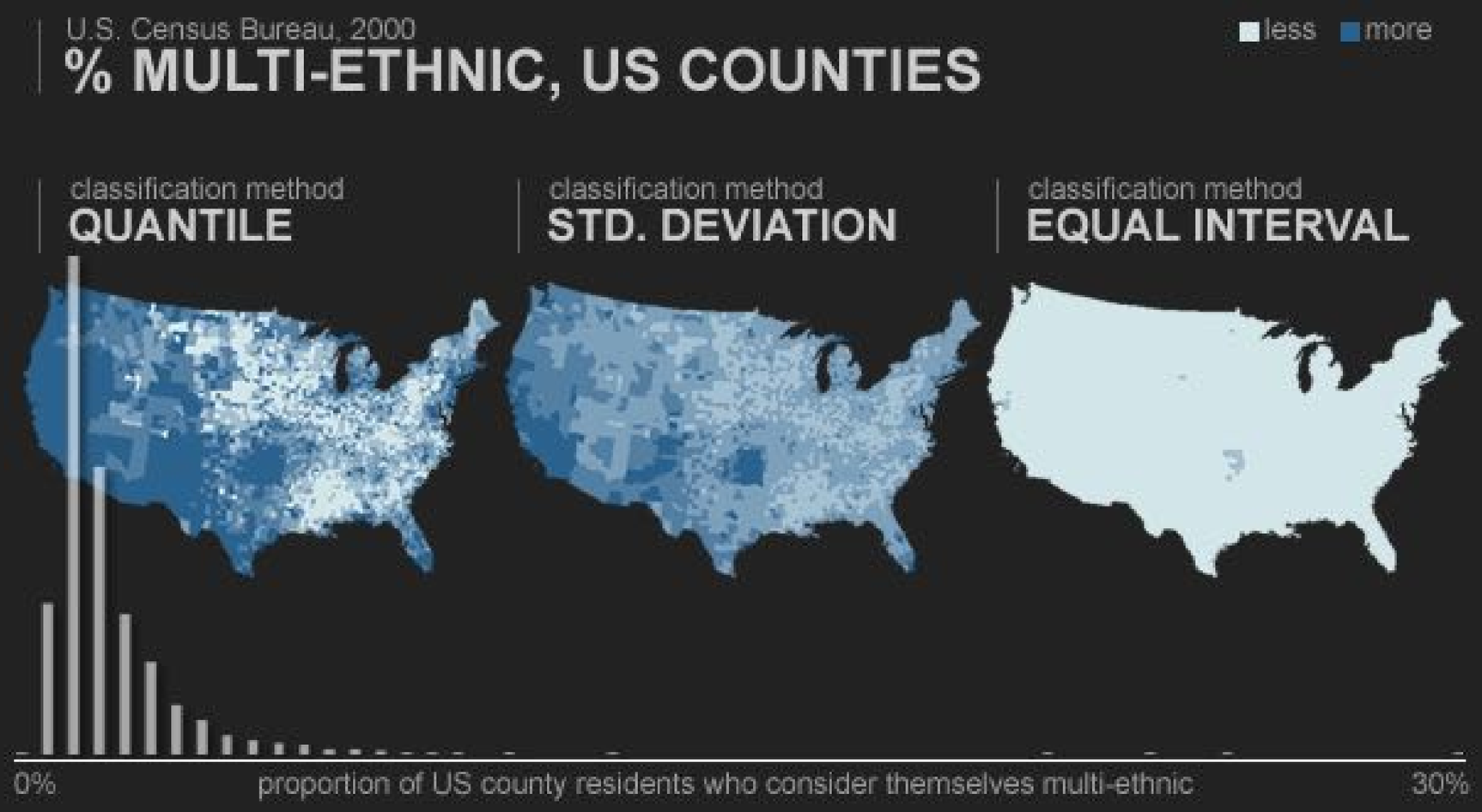
classification

# EQUAL INTERVAL





# Proportion of US county residents who consider themselves multiethnic

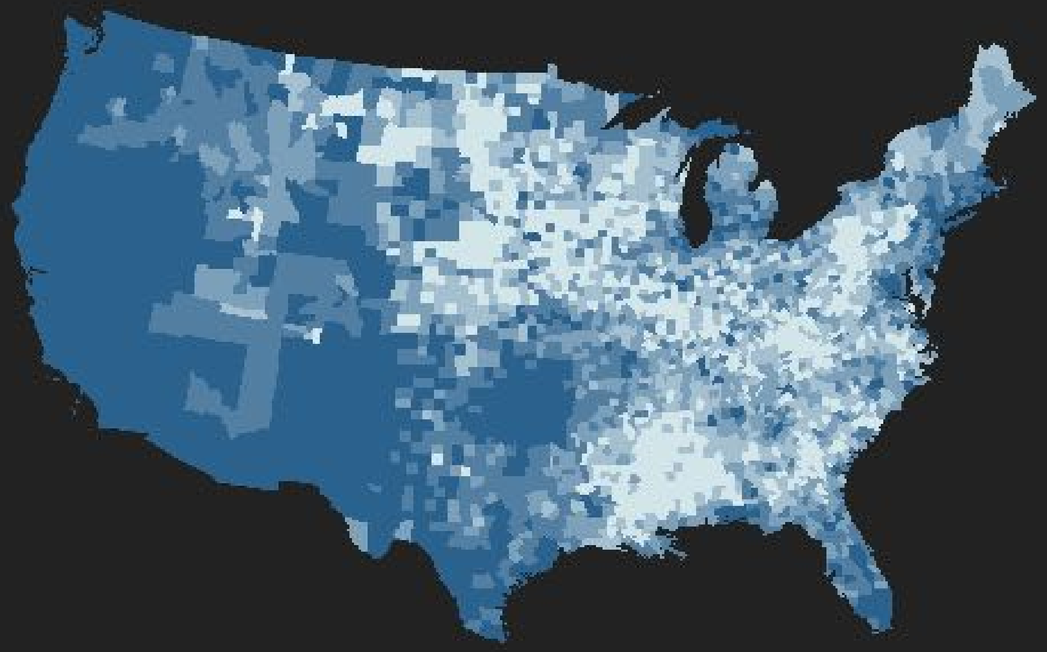


U.S. Census Bureau, 2000

# % MULTI-ETHNIC

classification

# QUANTILE

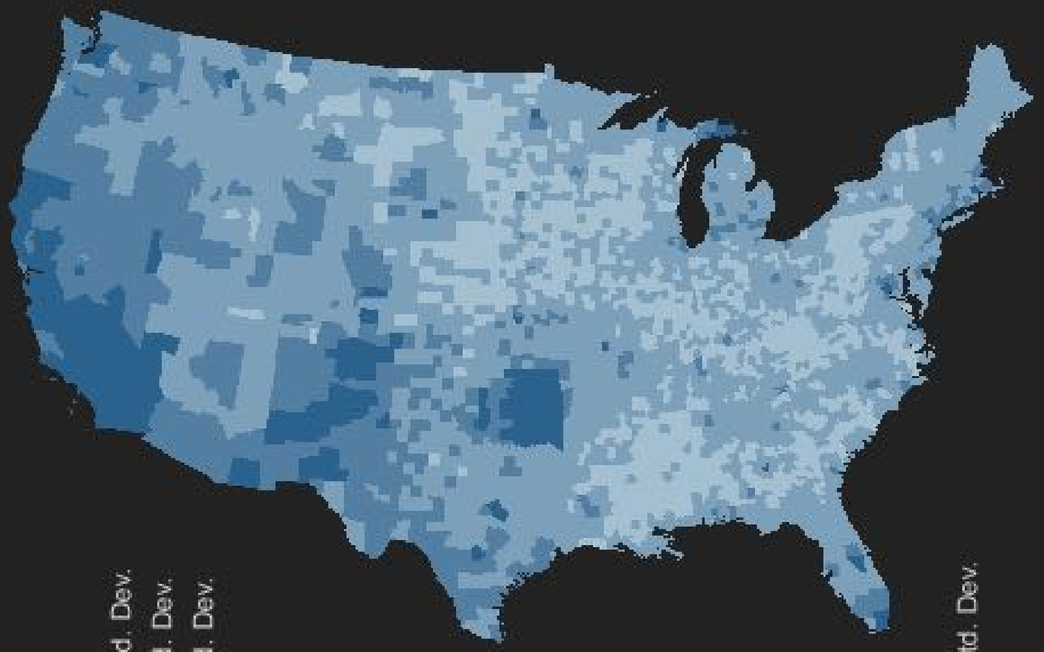


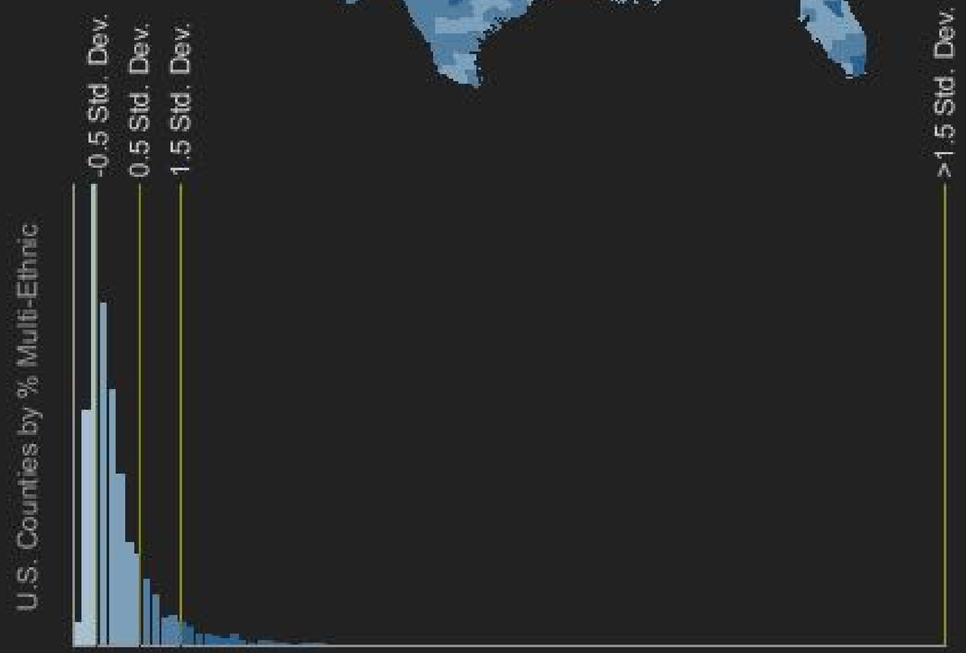
U.S. Census Bureau, 2000

# % MULTI-ETHNIC

classification

# STD. DEVIATION



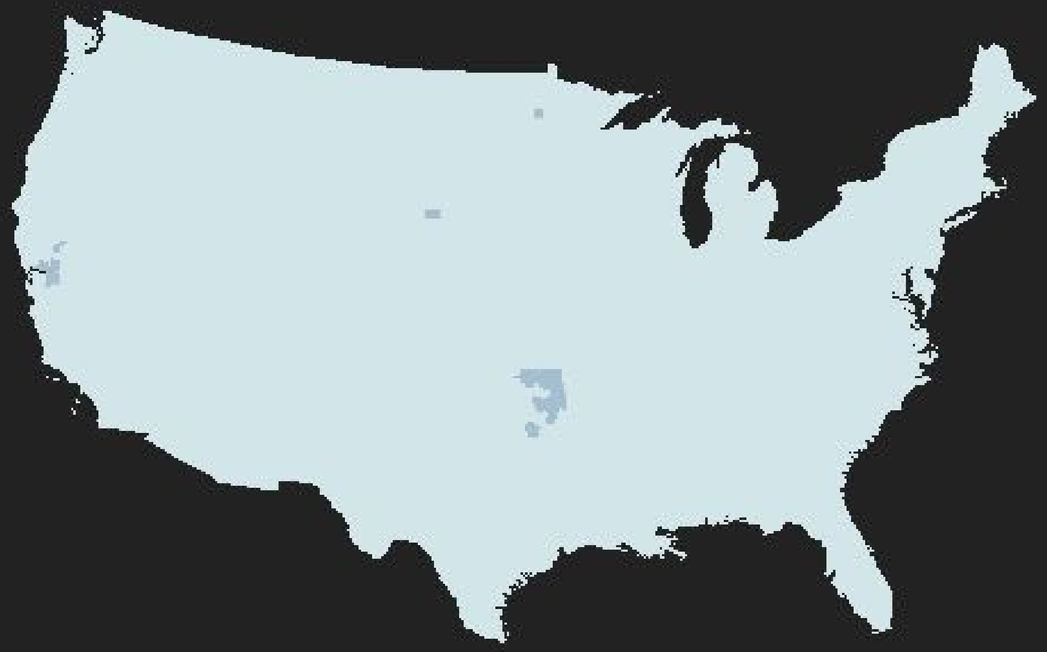


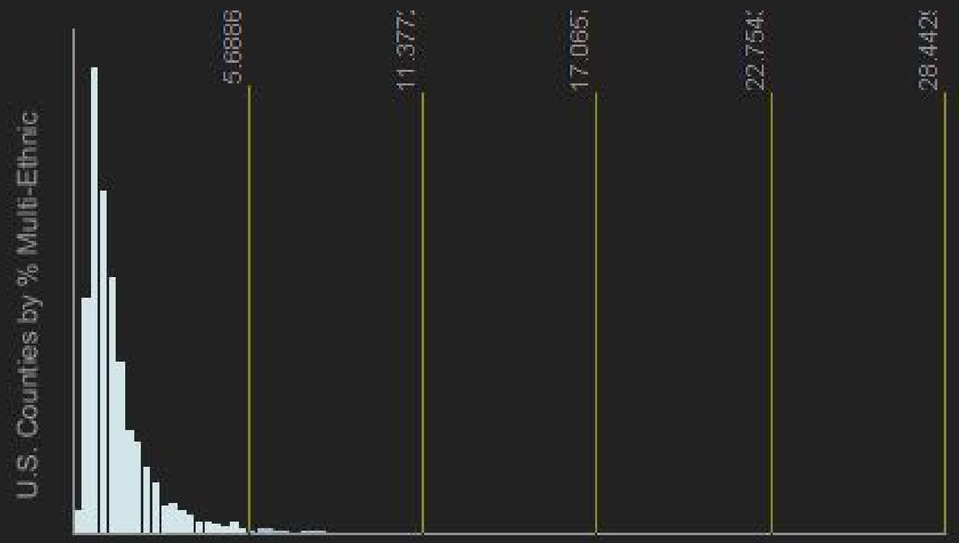
U.S. Census Bureau, 2000

# % MULTI-ETHNIC

classification

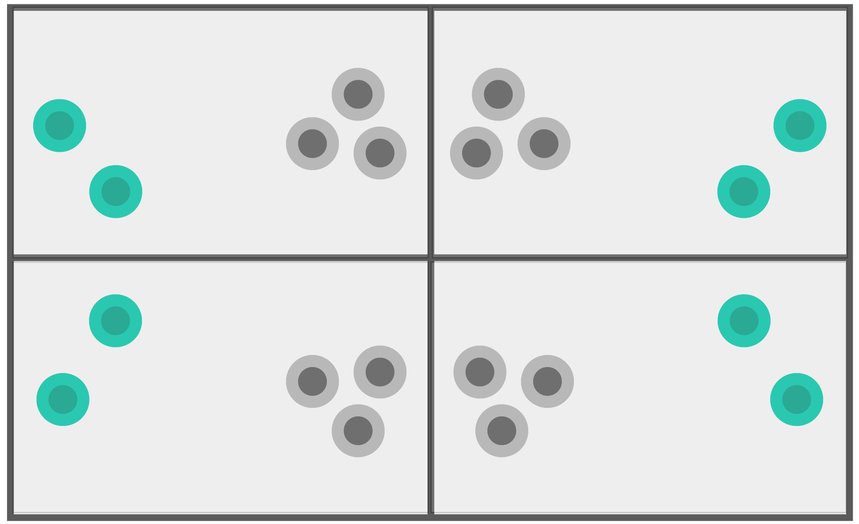
# EQUAL INTERVAL

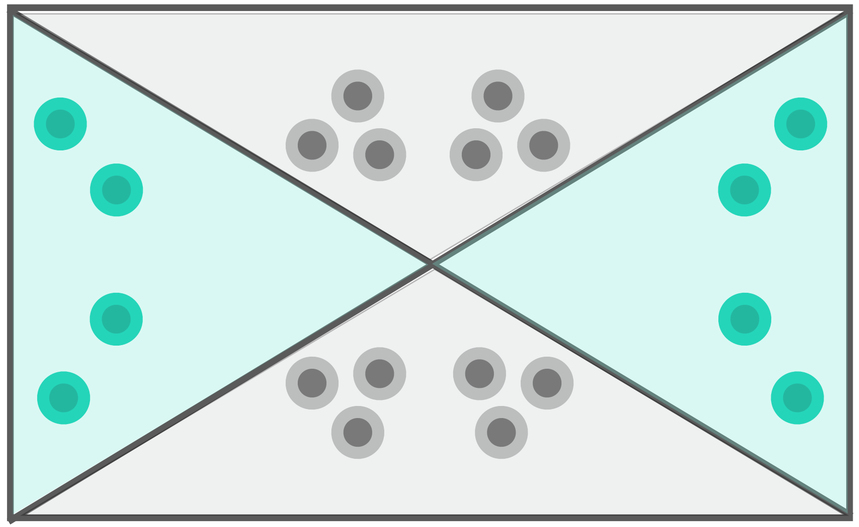




# Modifiable Area Unit Problem

- Also called ecological fallacy
- Source of statistical bias the can affect radically the results of statistical hypothesis tests
- Results when measures are aggregated into districts, usually for counting
- Openshaw (1983): “the areal units (zonal objects) used in many geographical studies are arbitrary, modifiable, and subject to the whims and fancies of whoever is doing, or did, the aggregating.”

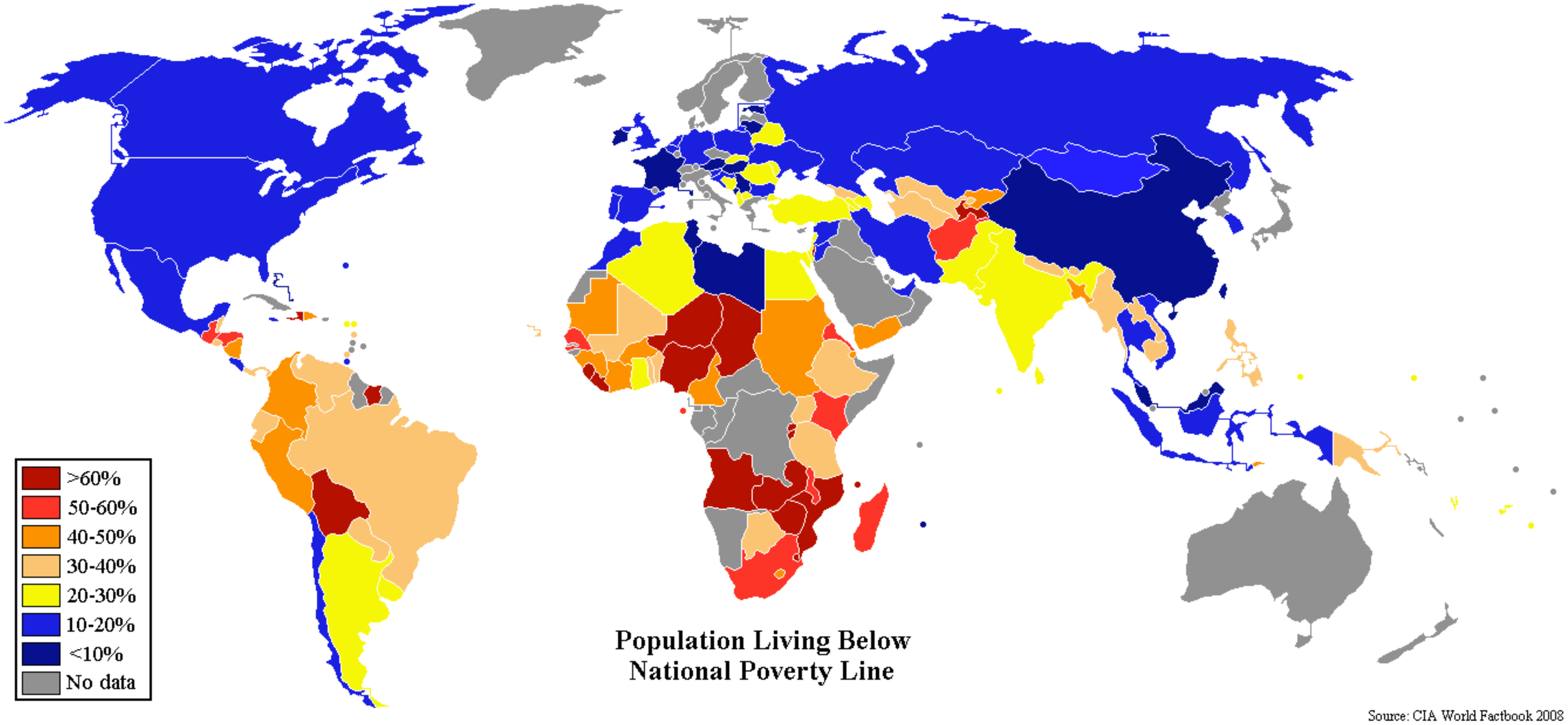


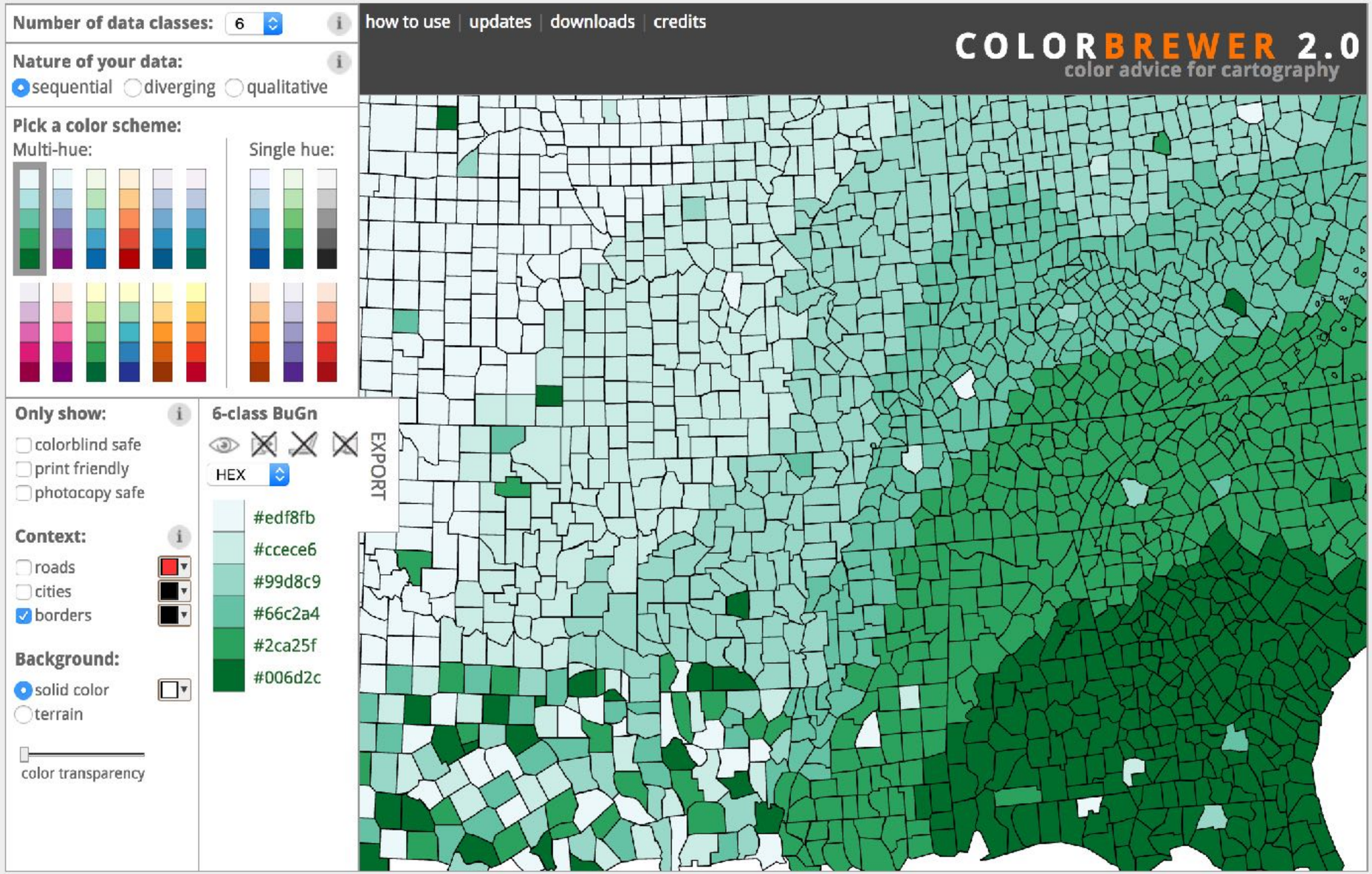


# Symbolizing the choropleths

- Select colors wisely!
- Monochrome shading
  - darker is more!
  - vary density
  - different schemas: Munsell vs Stevens
- Color shading
  - hue is not always a good variable, unless bipolar distribution
  - use saturation or intensity

# NOT A GOOD CHOICE!



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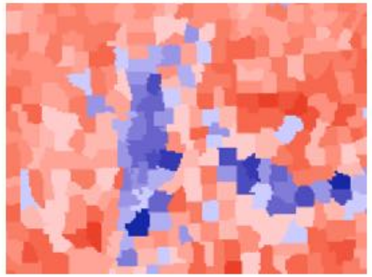
Source code and feedback
Back to Flash version
Back to ColorBrewer 1.0

axismaps

# Choropleth - Diverging Hue

2012 US Presidential election results by County: Democrat & Republican share of vote

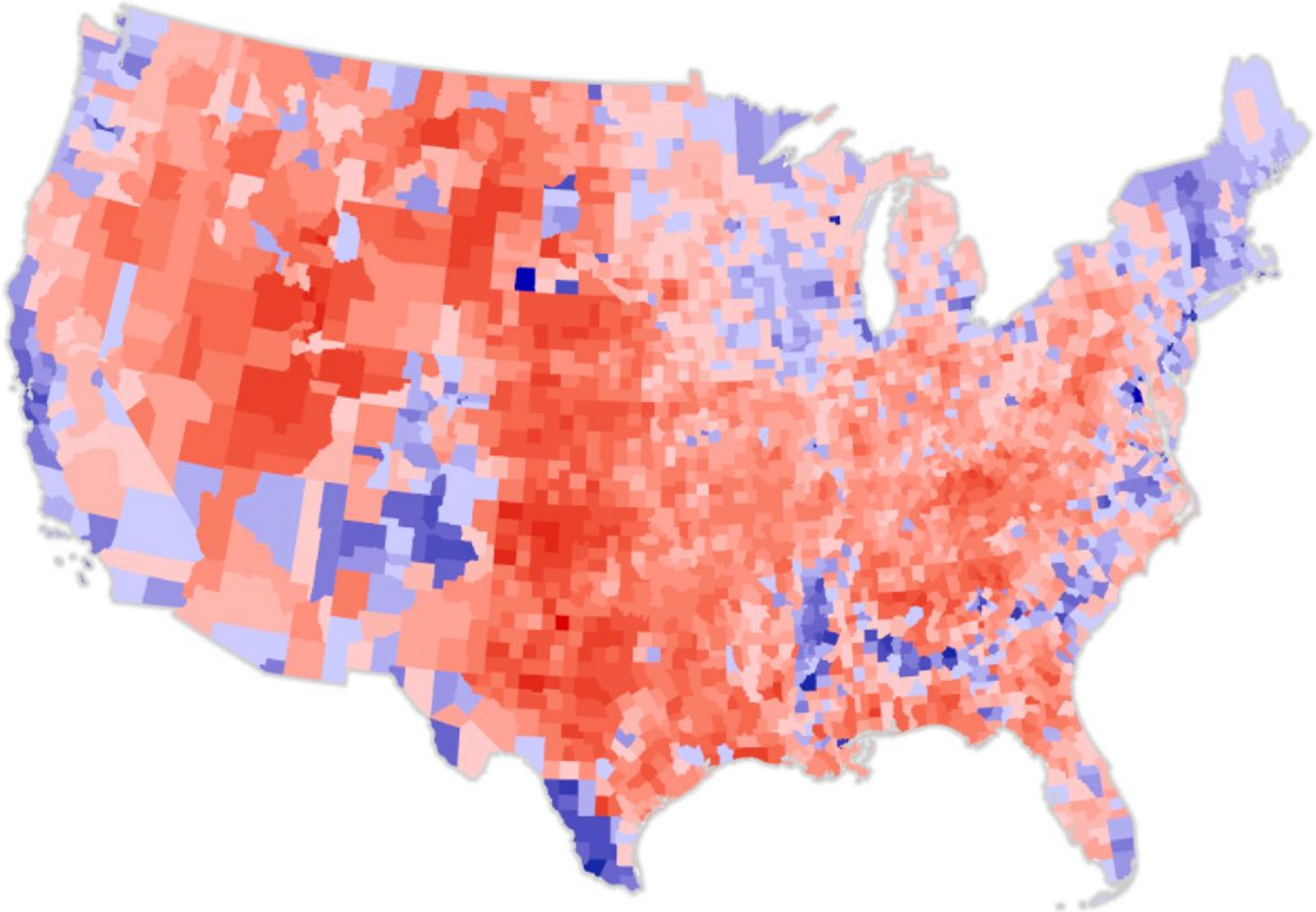
### Map type



The **choropleth** is a common technique for representing data for areas by variations in shading or pattern. The rationale is easily understood to map readers which is a large part of its success though it's often seen as somewhat boring by today's mapping fashions. That said, done well it can be a powerful technique for understanding the patterns in numerical area data. **Data classification** and **symbolization** are crucial to designing an effective choropleth and are based on what best serves the purpose of the map and the data array. In this example of the 2012 Presidential election, the map is designed to show the percentage share of the vote gained by the Democrat and Republican parties at county level by using a diverging hue technique.

### Data

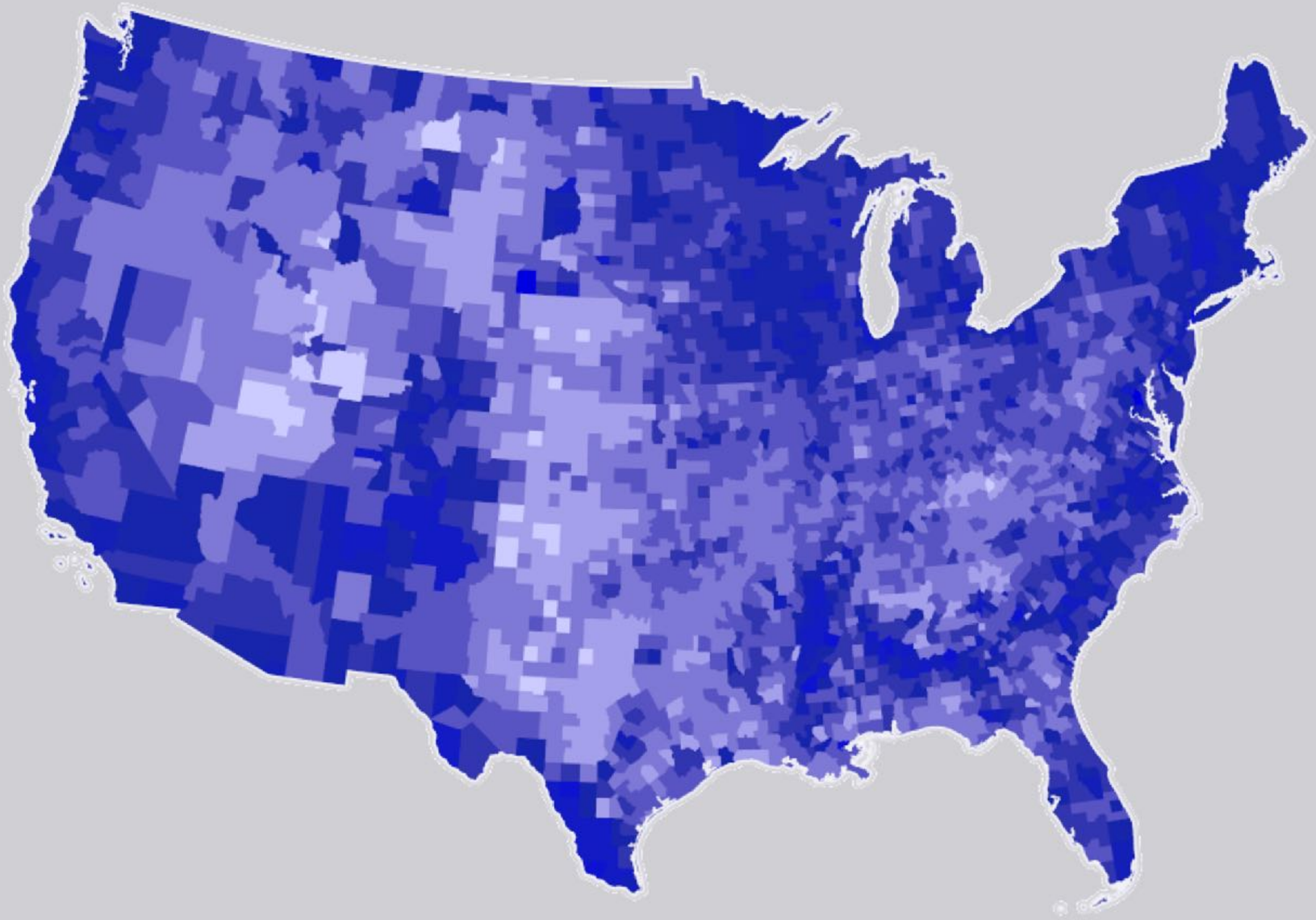
The **choropleth** technique is only useful when the form of data is




Kenneth Field | Kenneth Field, politico.com

# Choropleth - Single Hue

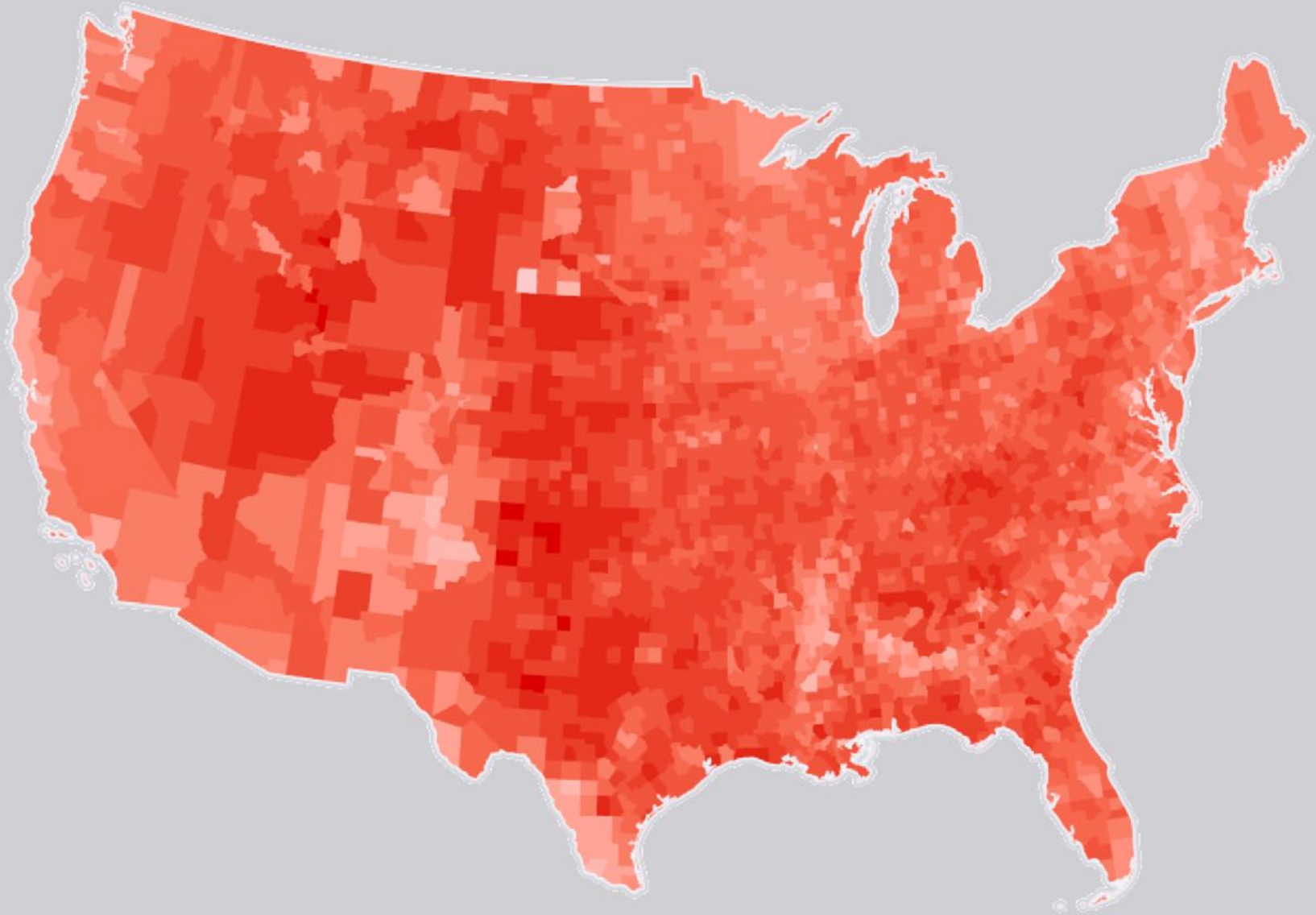
2012 US Presidential election results by County: Comparison of the Democrat and Republican share of vote



Kenneth Field | Kenneth Field, politico.com

# Choropleth - Single Hue

2012 US Presidential election results by County: Comparison of the Democrat and Republican share of vote

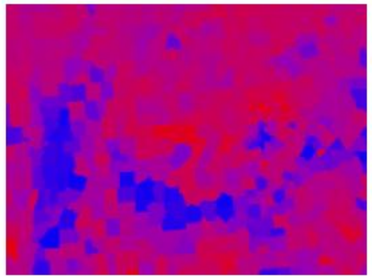


Kenneth Field | Kenneth Field, politico.com

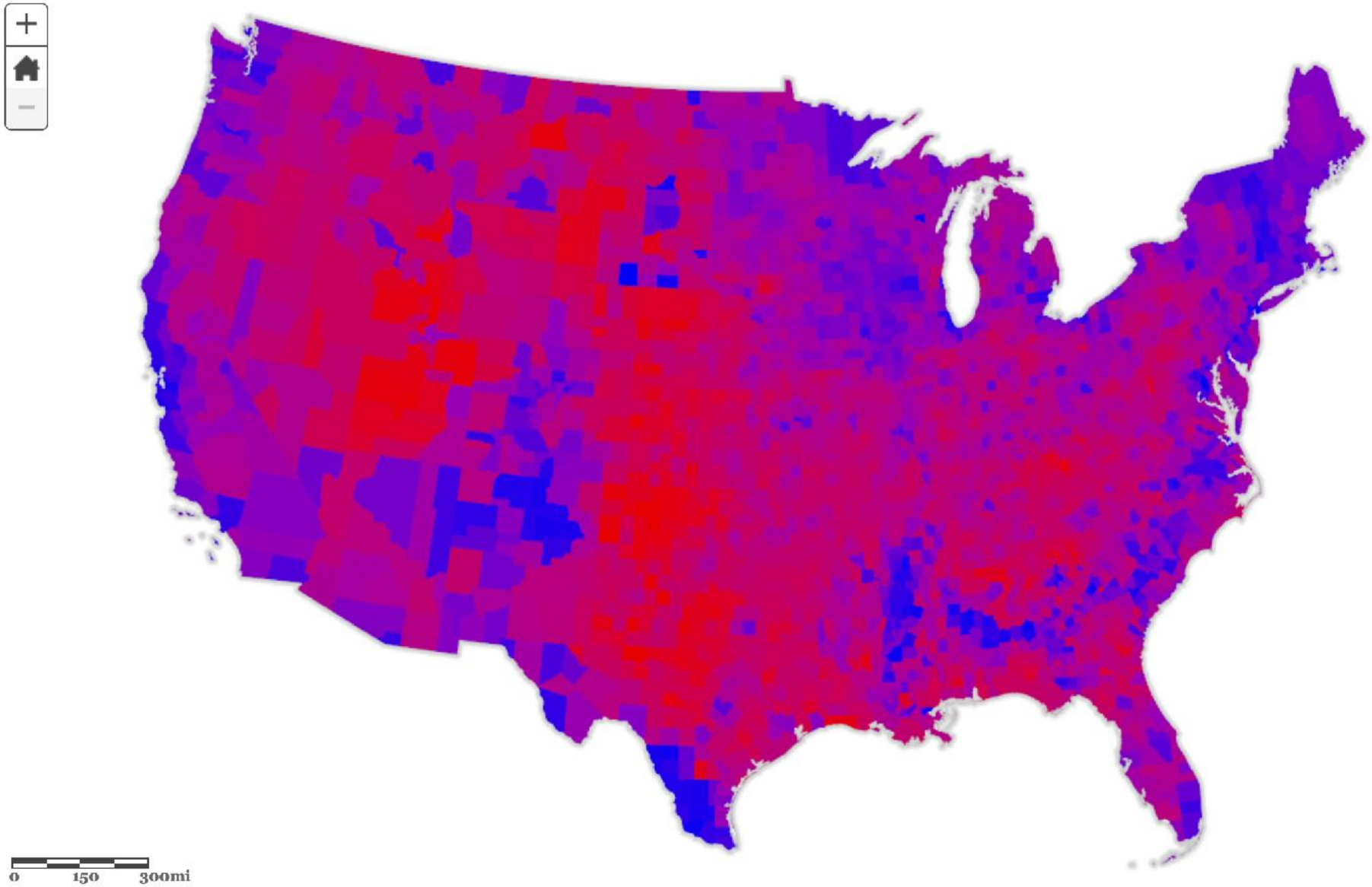
# Choropleth - Unclassed

2012 US Presidential election results by County: Democrat & Republican share of vote

**Map type**



The **choropleth** is a common technique for representing data for areas by variations in shading or pattern that represent classes of data. The **classed choropleth** is the norm because of the problems of the human eye being able to discriminate between too many shades on the same map. The **unclassed choropleth** is not as widely used because of this potential drawback yet it has its own merits, principally that it maintains numerical relationships among data values in a visual sense by assigning a unique shade to each data value. The result is a map with the potential for as many shades as there are data variables in the array that shows a more detailed pattern. In this example of the 2012 Presidential election, the map is designed to show the percentage share of the vote gained by the Democrat and Republican parties at county level.




**Data**

Kenneth Field, politico.com

# Election shades

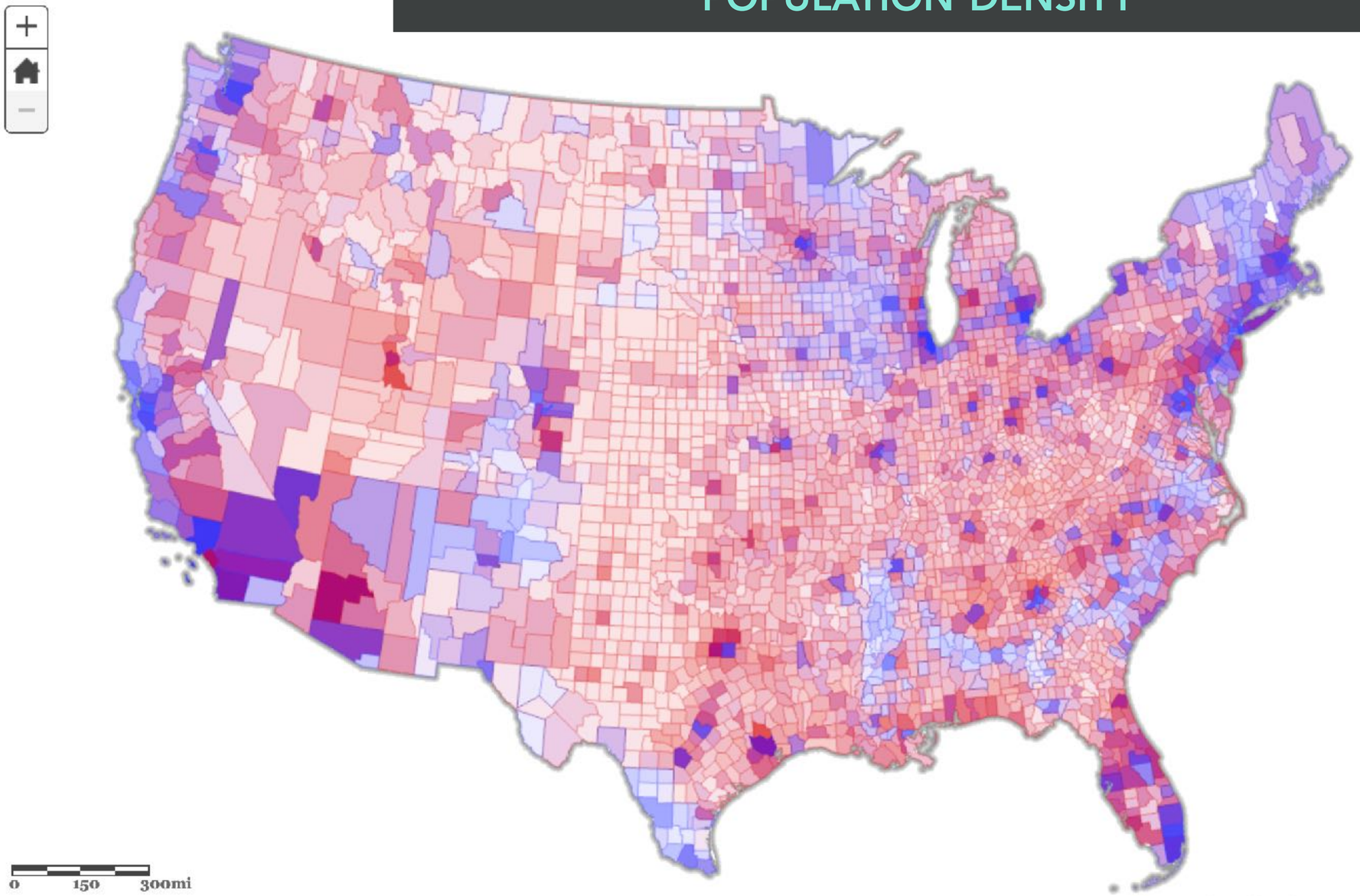
2012 US Presidential election results by County, equalized by total votes

SECOND LAYER WHICH VARIES TRANSPARENCY BY POPULATION DENSITY

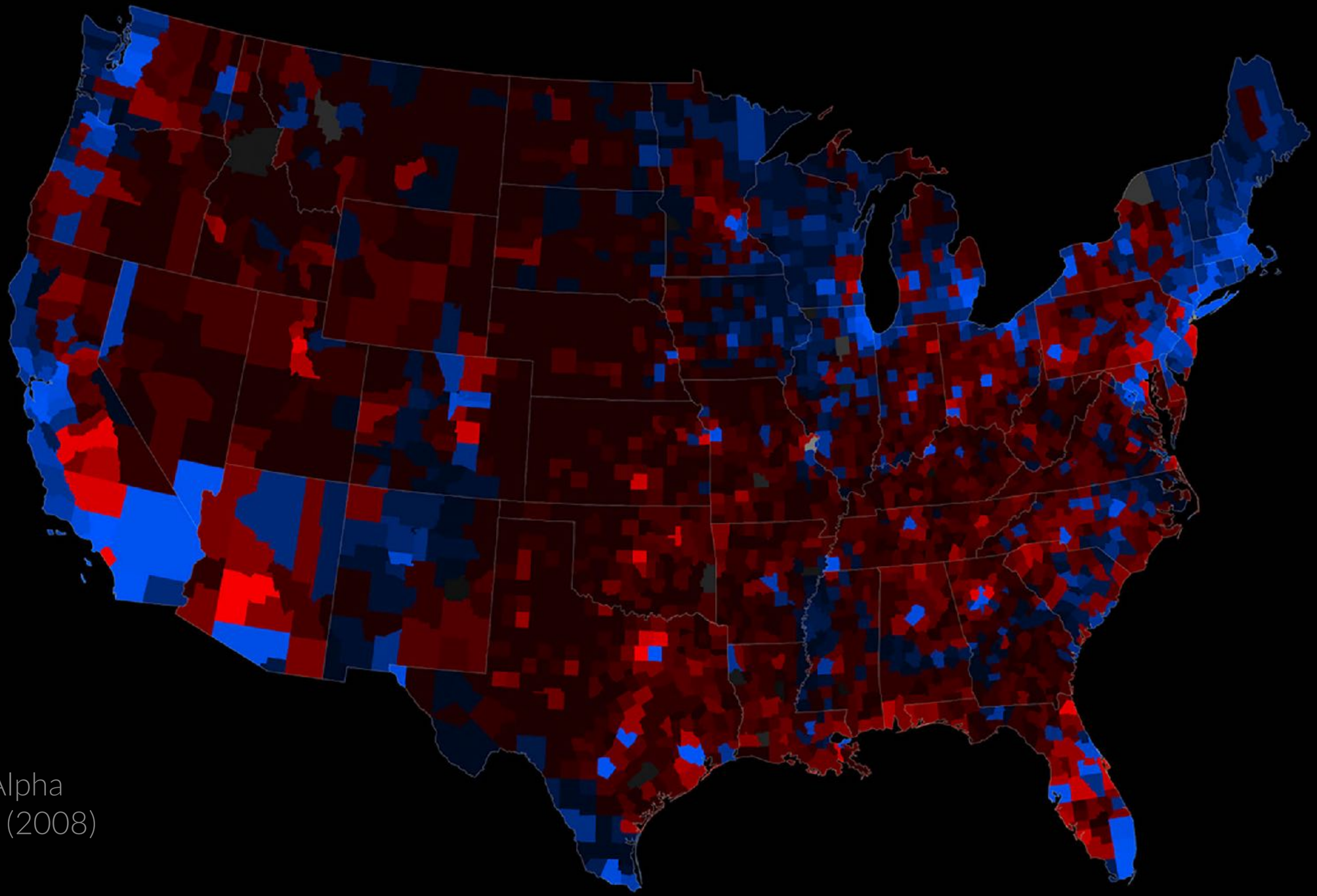
Traditional maps of election results tend to paint the US as red or blue which hides a number of important factors, most crucially the distribution of the population. They often create a visually skewed impression of reality and leave you wondering how come the Democrats won in 2012 when the map is mostly red! This map uses a technique called value-by-alpha to overlay a second layer which varies transparency by population density. It corrects the map's message by bringing the areas with more voters into focus and so we see not only how the vote went but where and to what magnitude.

**Map type**

The purpose of a **value-by-alpha** thematic map is to show how areas differ in type by using an equalizing variable to account for the problems of visual interpretation of areas of different sizes. The technique is explained in this paper by Robert Roth *et al.* In this example of the 2012 Presidential election, the map is designed to show the percentage vote by colour with strong blue representing increasing Democrat vote share, strong red representing increasing Republican share and colours tending towards purple for an equal share. Total votes are used as an equalizing value so counties with a low overall number of voters tend to dissolve into the background and disappear from the map (becoming increasingly white). The map is an alternative to the choropleth (which requires an equalizing variable to be used to normalize the data) or a cartogram (which modifies the shape of the enumeration areas



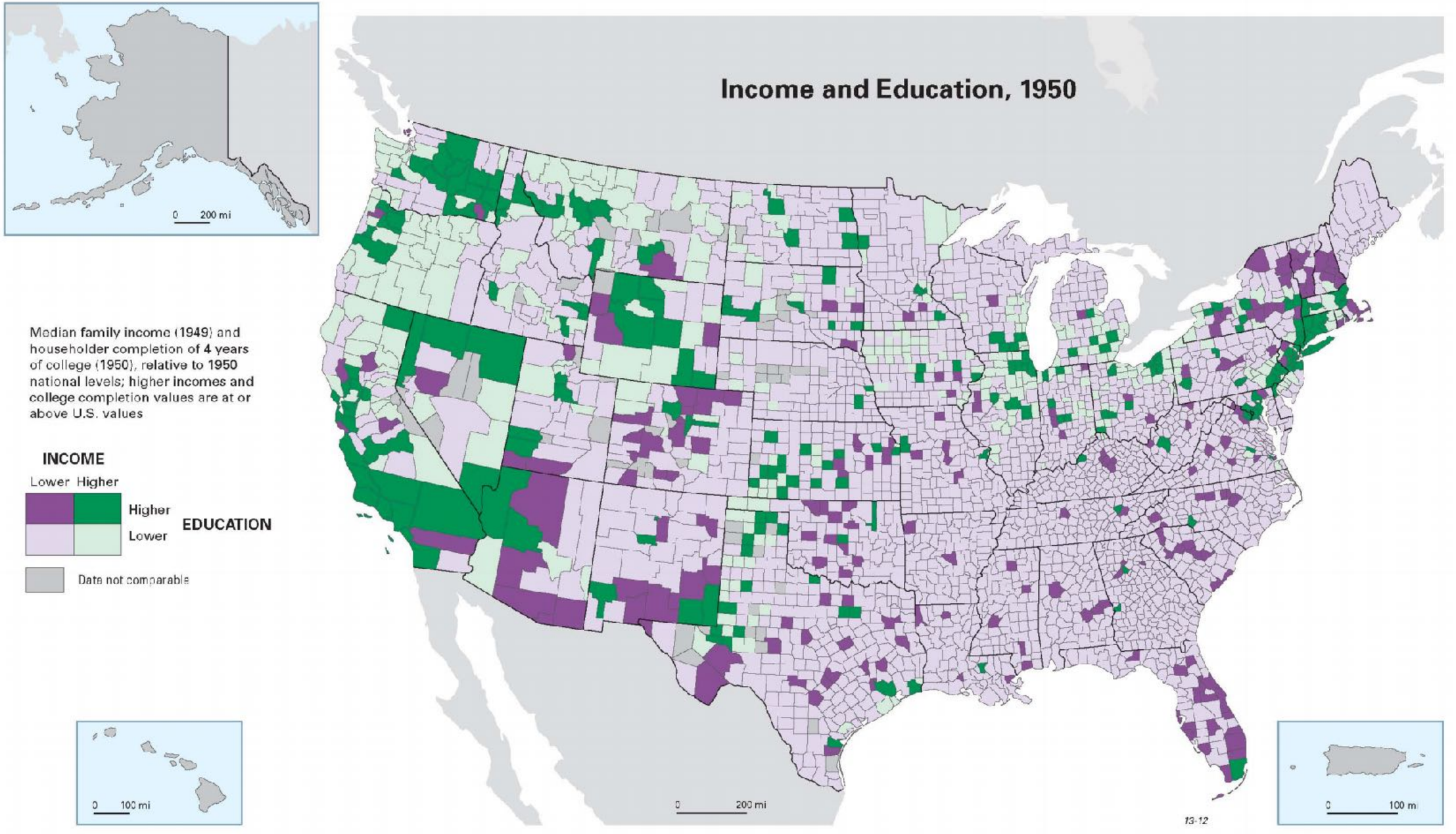

Kenneth Field, politico.com



Value by Alpha
Woodruff (2008)

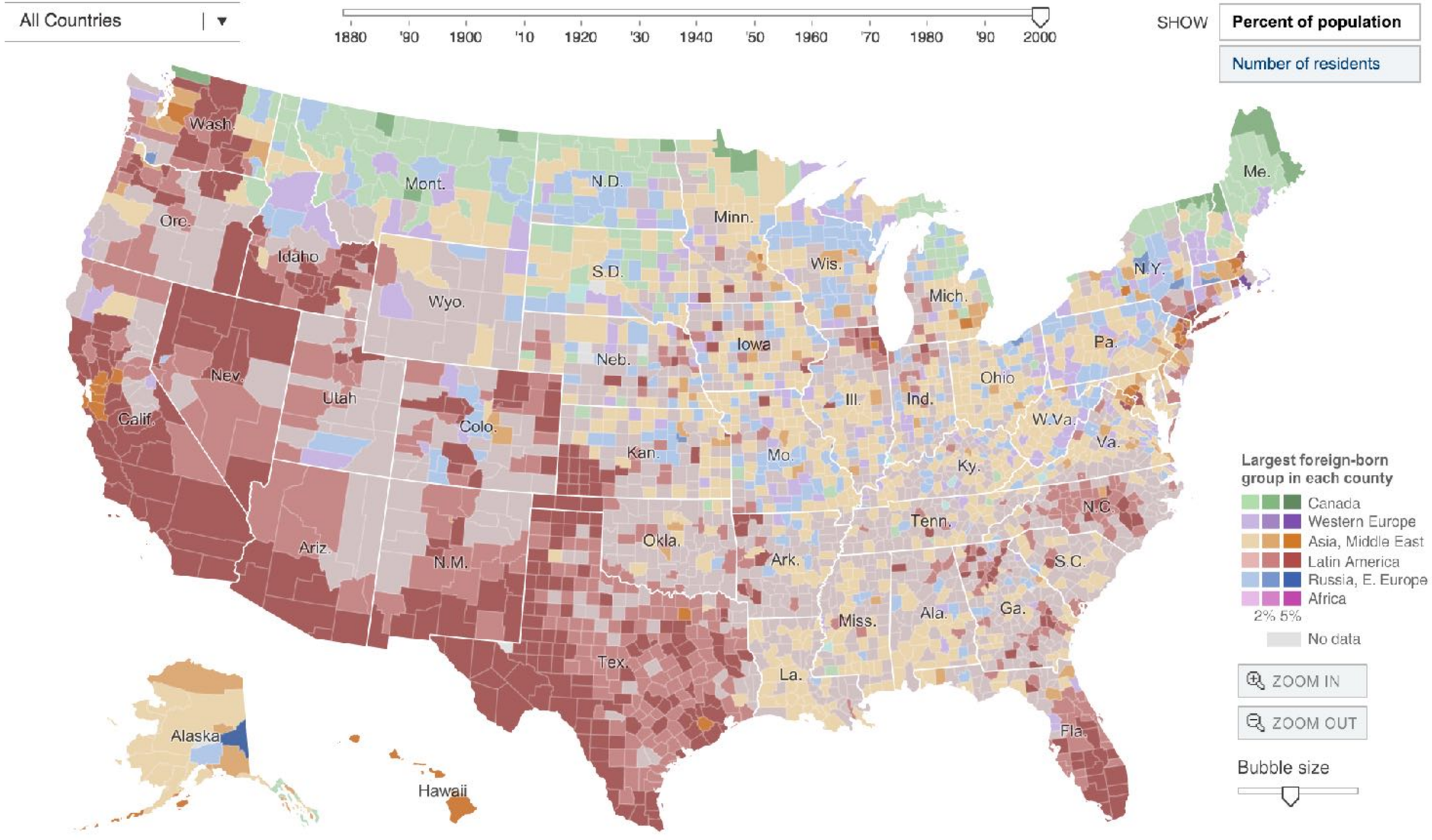
# Bivariate choropleth maps

- Method for comparing two dissimilar distributions on the same map
- Popularized in the Census Atlas
- For choropleth, best with few classes
- Uses overlay legend
- Need contrasting colors


Income and Education, 1950
Median family income (1949) and householder completion of 4 years of college (1950), relative to 1950 national levels; higher incomes and college completion values are at or above U.S. values
INCOME
Lower Higher
Higher
Lower
EDUCATION
Data not comparable
0 200 mi
0 100 mi
0 200 mi
0 100 mi
13-12

# Immigration Explorer

Select a foreign-born group to see how they settled across the United States.



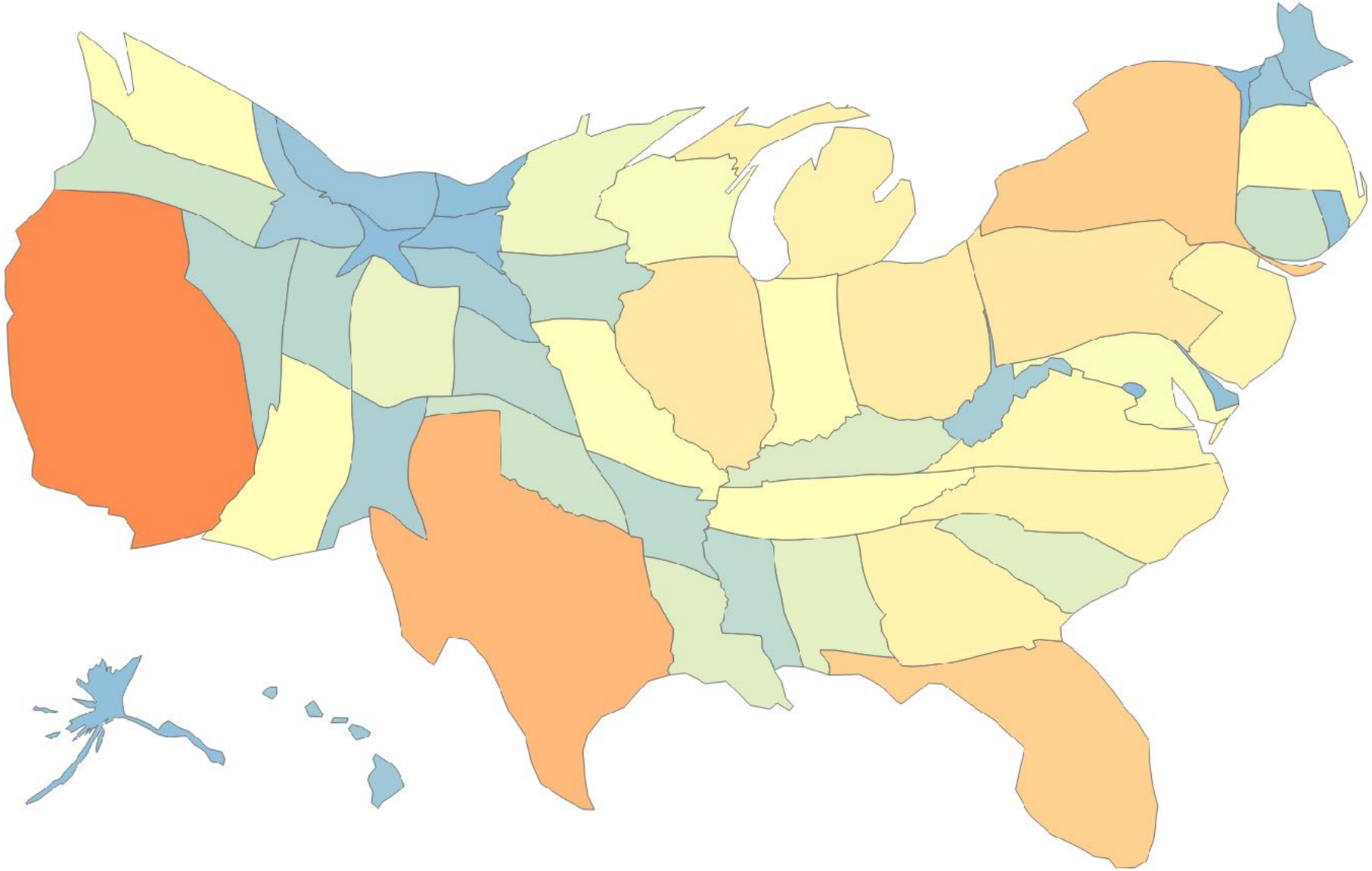

Note: Due to limitations in the Census data, foreign-born populations are not available in all areas for all years.

Sources: Social Explorer, www.socialexplorer.com; Minnesota Population Center; U.S. Census Bureau

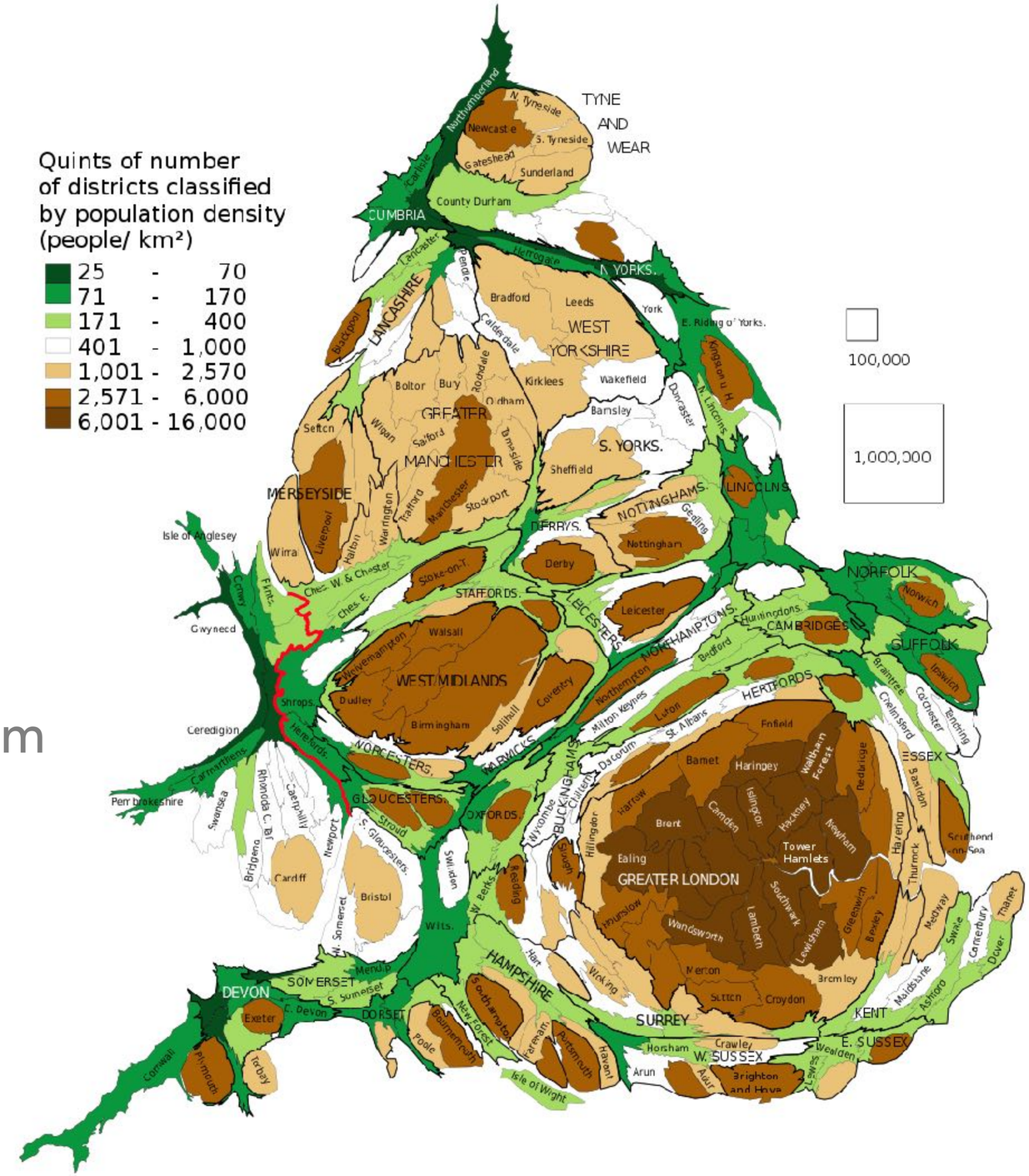
Matthew Bloch and Robert Gebeloff/The New York Times

# Cartograms

Scale by Population Estimate in 2010 calculated in 0.1 seconds



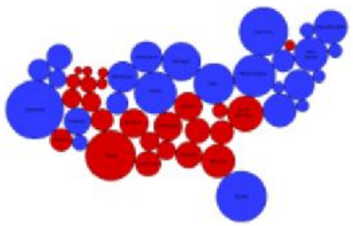
# England and Wales population cartogram



# Dorling Cartogram

2012 US Presidential election results by State

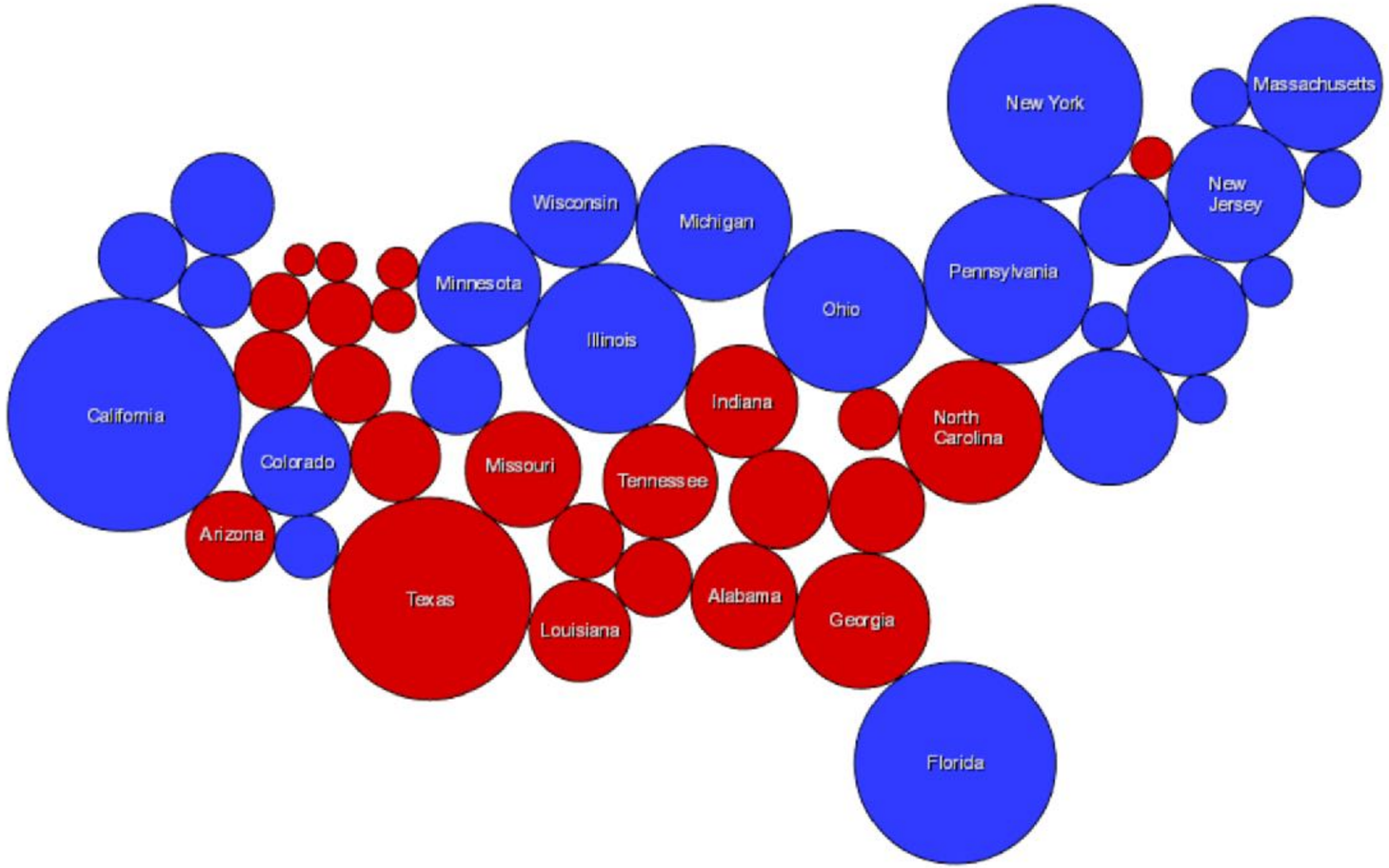
**Map type**



The **Dorling Cartogram** is a technique for representing data for areas that eschews geography in preference for (normally) a geometric shape that represents the unit areas. Circles are usually the shape of choice since they can be more neatly positioned. A Dorling cartogram maintains neither shape, topology or object centroids and is an abstract representation of the spatial pattern of the phenomena being mapped.

Named after Professor Danny Dorling (the inventor of the technique), it can be equated to a proportional symbol map where the symbols have been repositioned in a self-organising manner to overcome the problems of overlaps caused by some non-contiguous cartogram techniques. The positions of areas are moved to deal with the problem.

A variant of the Dorling cartogram is referred to as the Demers cartogram which uses squares instead of circles and thus reduces the gaps between




0 150 300mi

Kenneth Field, politico.com

# Non Contiguous Cartogram

2012 US Presidential election results by State

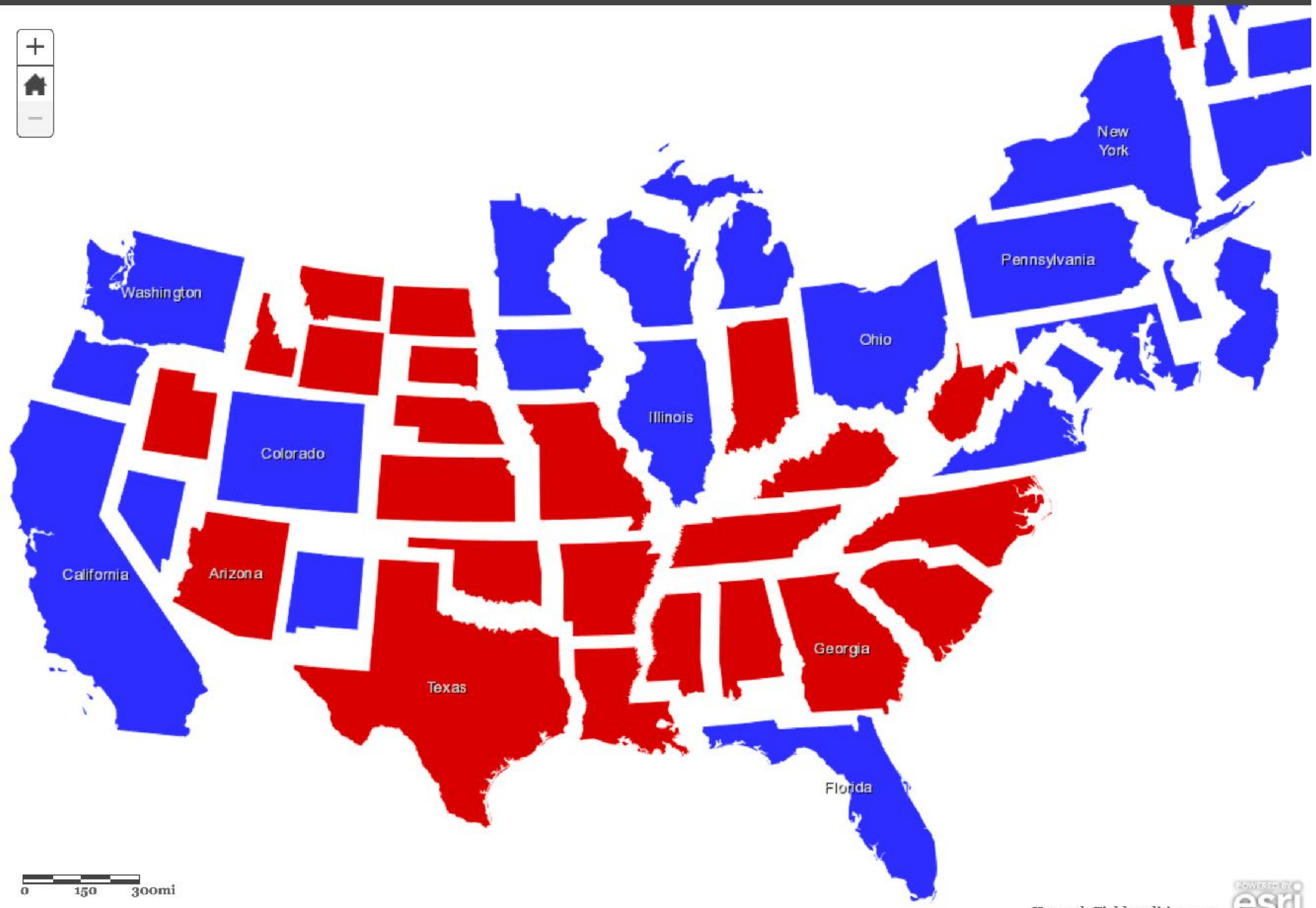
**Map type**

The **Non Contiguous Cartogram** is a technique for representing data for areas that uses re-sized geographical shapes to depict a quantifiable difference between values of data in the unit areas. While shape is preserved, topology and object centroids are not and the resulting map is an abstract representation of the spatial pattern of the phenomena being mapped.

Similar to the Dorling Cartogram, the symbols are repositioned to overcome the problems of overlaps caused by some non-contiguous cartogram techniques. On disadvantage of this technique compared to a Dorling cartogram is the irregularity of the shapes makes relative comparisons less easily assessed.

A cartogram can be a powerful approach to mapping population data since it provides a strong visual and does not require data to be normalised. The drawback is that the distortions can be a hurdle for some in their understanding. In this example of the 2012 Presidential election, the map is designed to show the size of the overall vote at State level with the addition of colour to represent the winning candidate.

**Data**

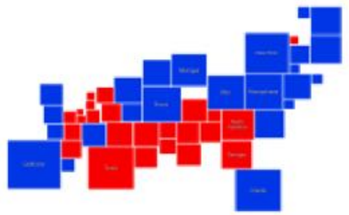



Kenneth Field, politico.com

# Demers Cartogram

2012 US Presidential election results by State

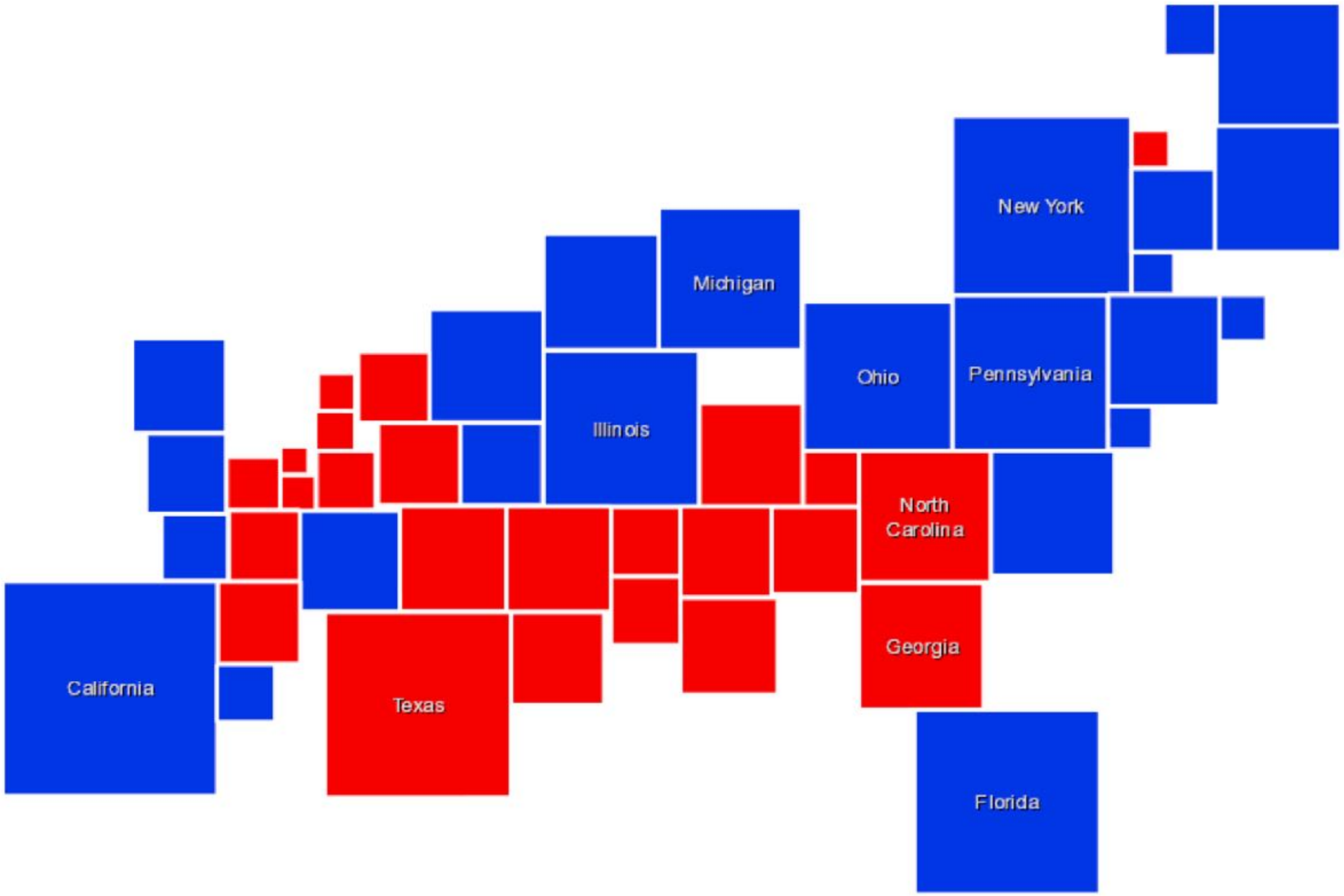
**Map type**



The **Demers Cartogram** is a technique for representing data for areas that eschews geography in preference for a geometric shape that represents the unit areas. It is ostensibly the same as a Dorling cartogram except it uses squares instead of circles to reduce the gaps between mapped objects.

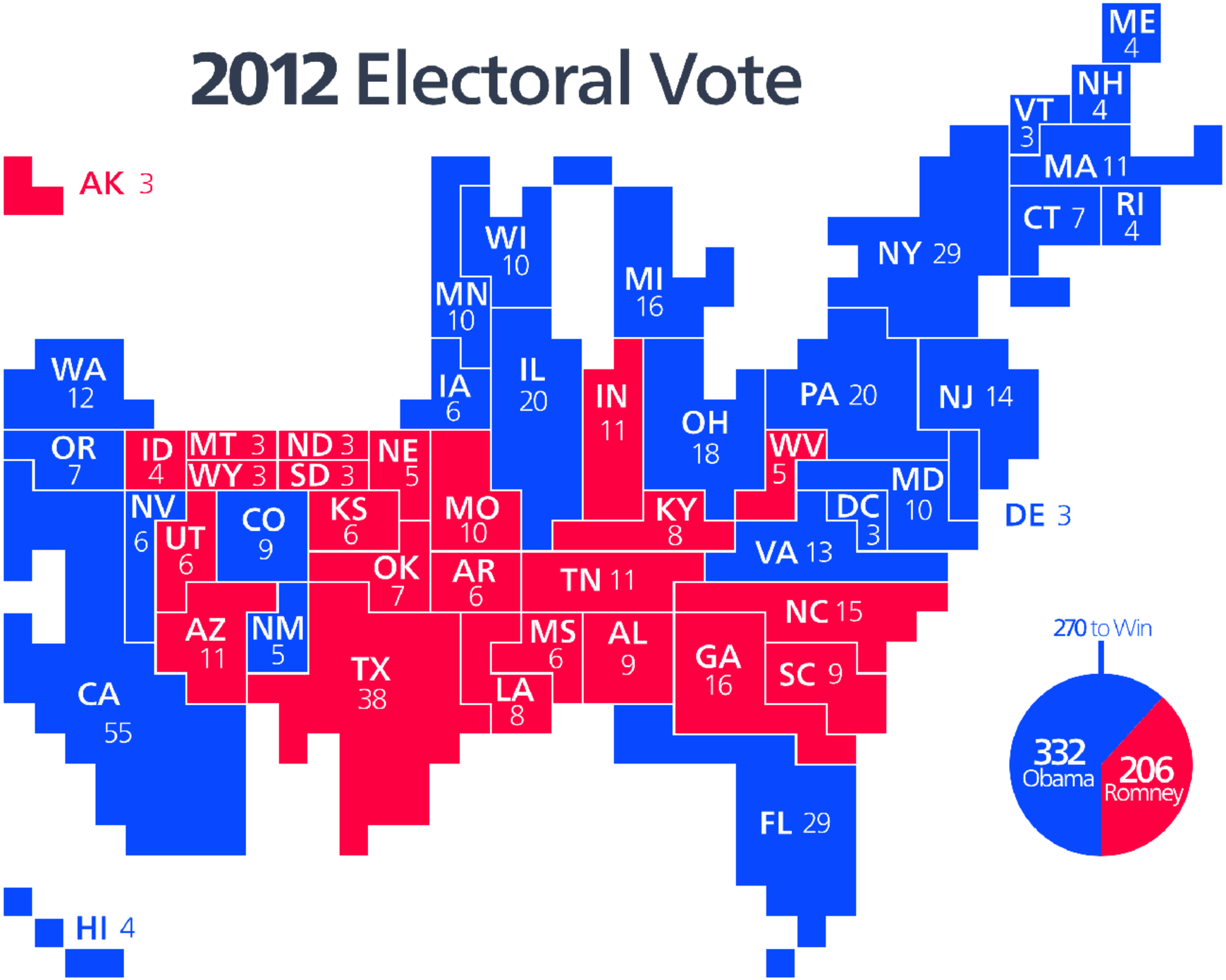
A Demers cartogram maintains neither shape, topology or object centroids and is an abstract representation of the spatial pattern of the phenomena being mapped. However, whereas the Dorling cartogram attempts to limit the distance of the eventual position of each object from its original position, the Demers sacrifices distance to maintain contiguity. The positions of areas are moved to deal with the problem of overlapping objects caused by some non contiguous cartograms.

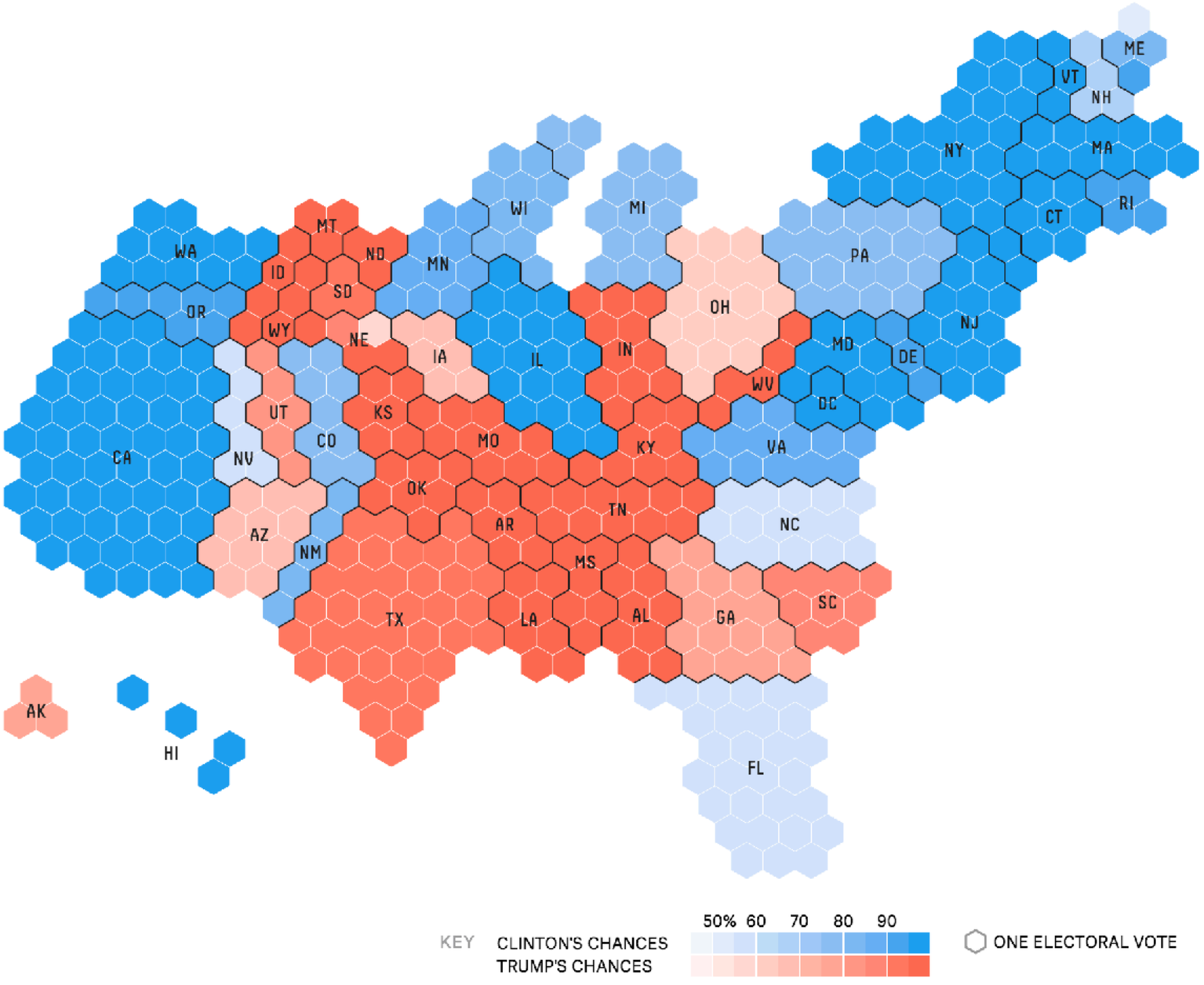
A cartogram can be a powerful approach to mapping population data since it provides a strong visual and does not require data to be



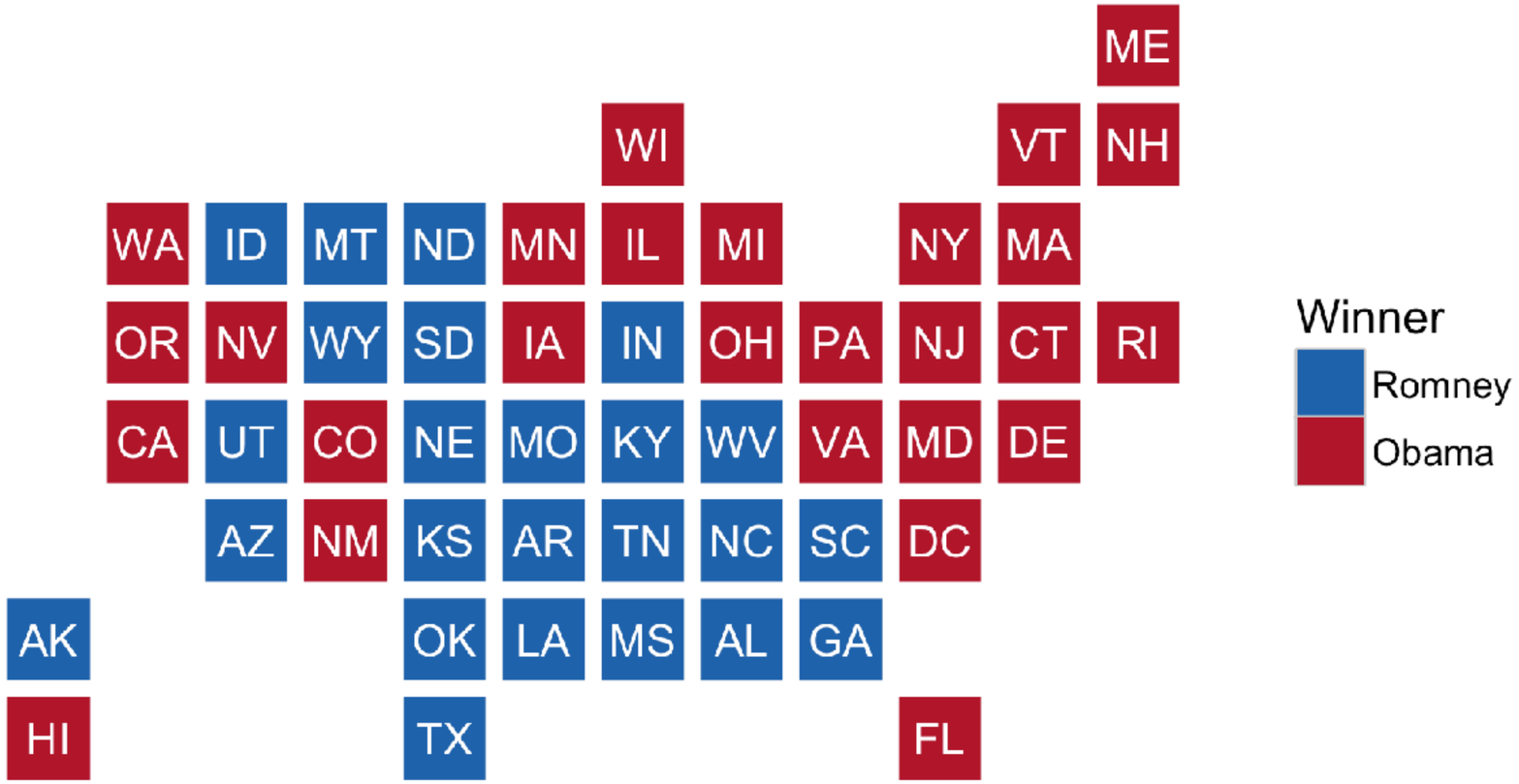

Kenneth Field, politico.com

# 2012 Electoral Vote




ME
VT
NH
NY
MA
RI
CT
WI
MI
PA
NJ
MT
ND
MN
WA
ID
SD
OR
OH
WY
NE
IA
IL
IN
MD
DE
WV
DC
UT
KS
CO
MO
KY
VA
CA
NV
OK
TN
NC
AR
AZ
NM
MS
SC
TX
LA
AL
GA
AK
HI
FL
KEY
CLINTON'S CHANCES
TRUMP'S CHANCES
50%
60
70
80
90
ONE ELECTORAL VOTE

# FOLLOW CONVENTIONS IN COLORS!

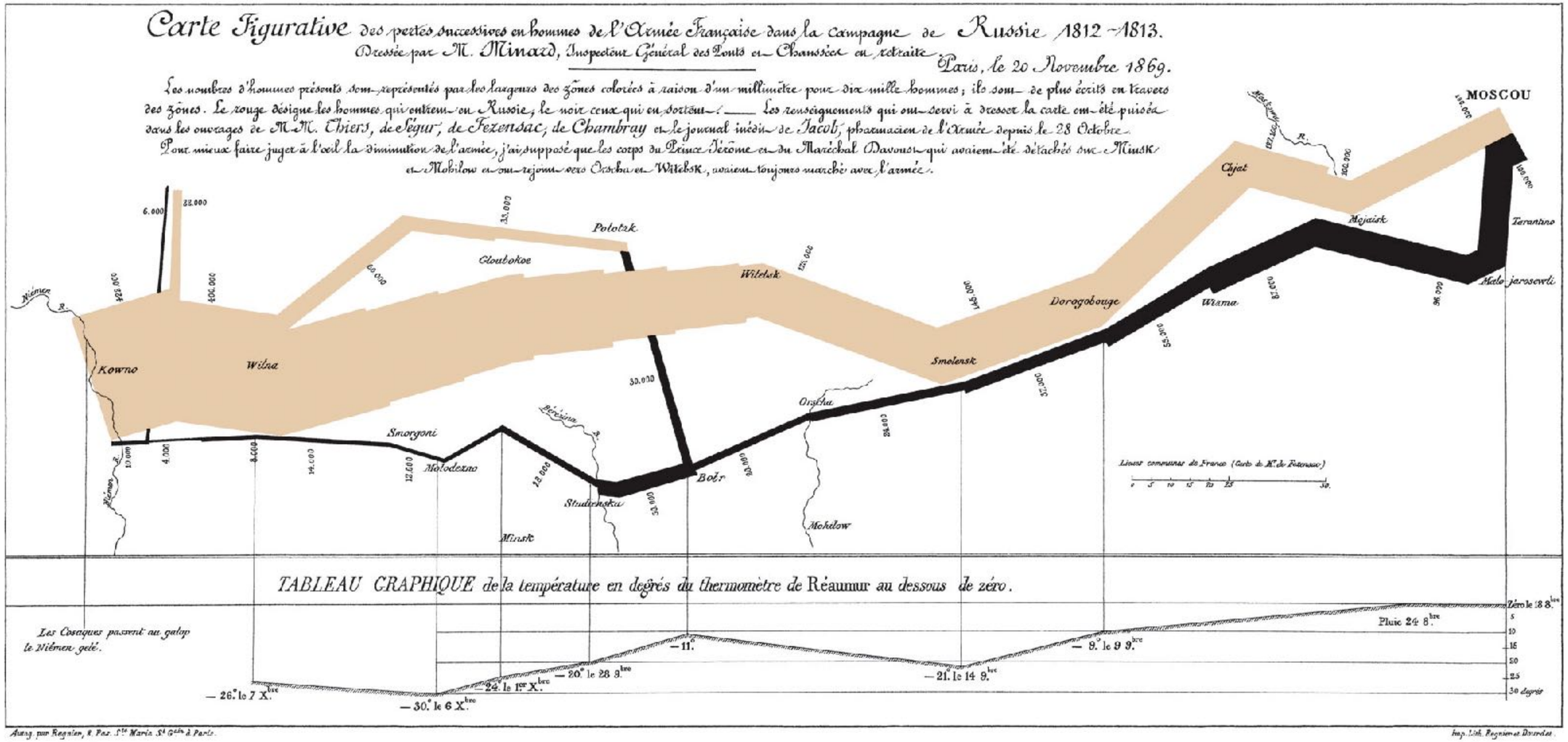


# Flow Maps

# Flow Maps

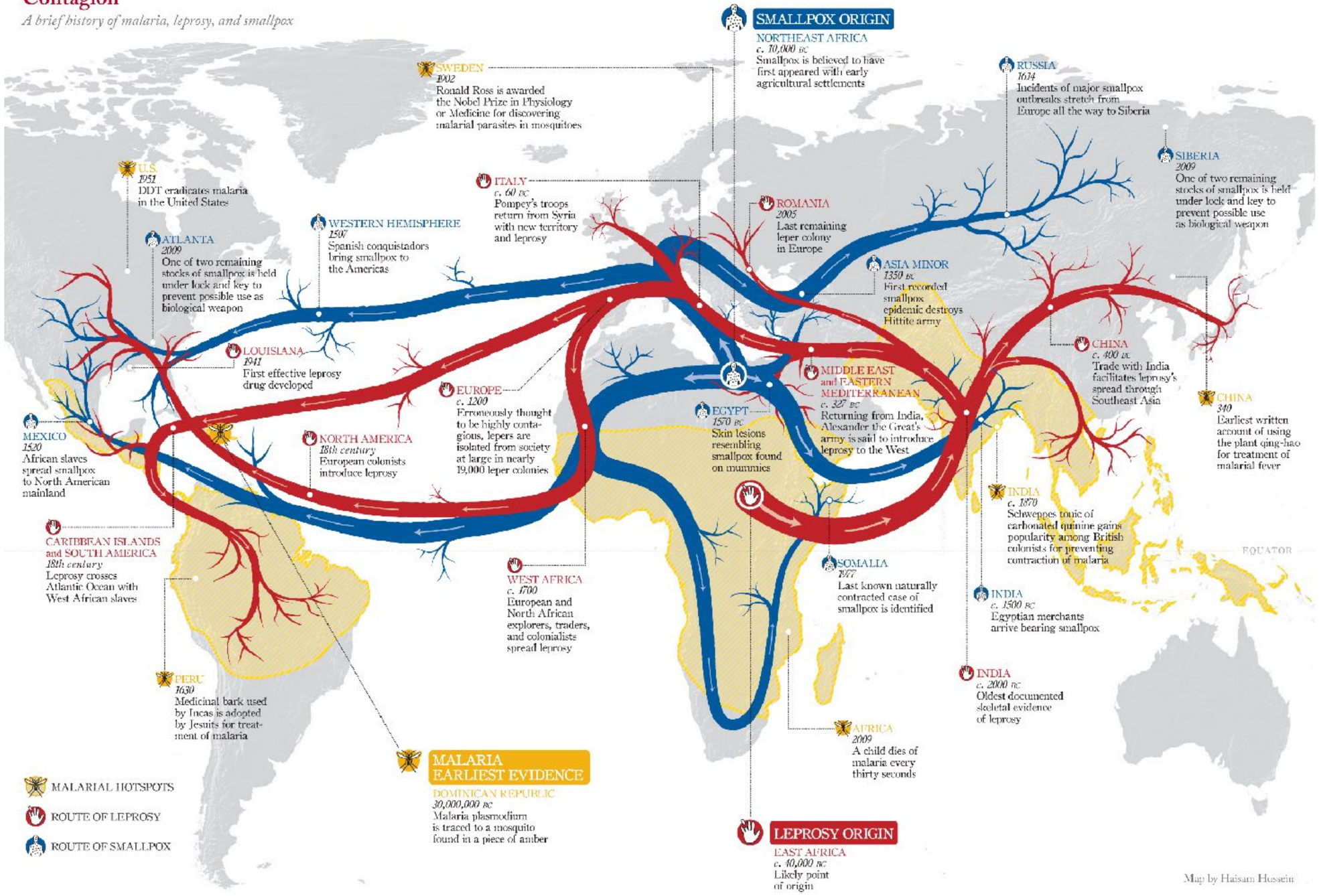
- Point pairs (one/two ways and symbol) trajectories
- Encoding
- Edge between two locations indicates flow between those locations
  - Width of edge proportional to flow
  - Usually wider end of edge is source of flow
- Limitations
  - Can get difficult to compare flows
  - Best flow maps are done by hand

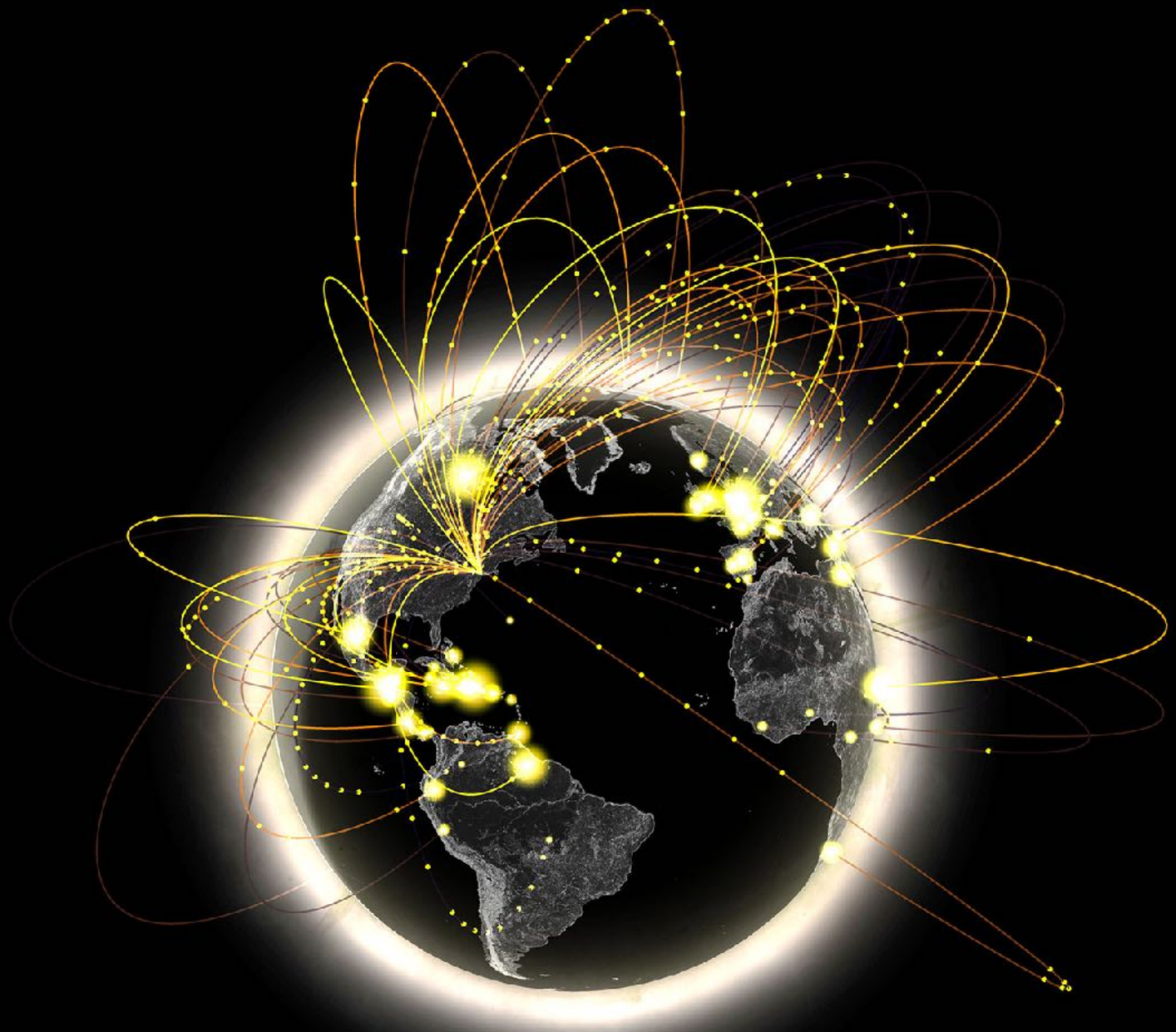
# Losses in men of the French Army in the Russian campaign 1812-1813



# Contagion

*A brief history of malaria, leprosy, and smallpox*





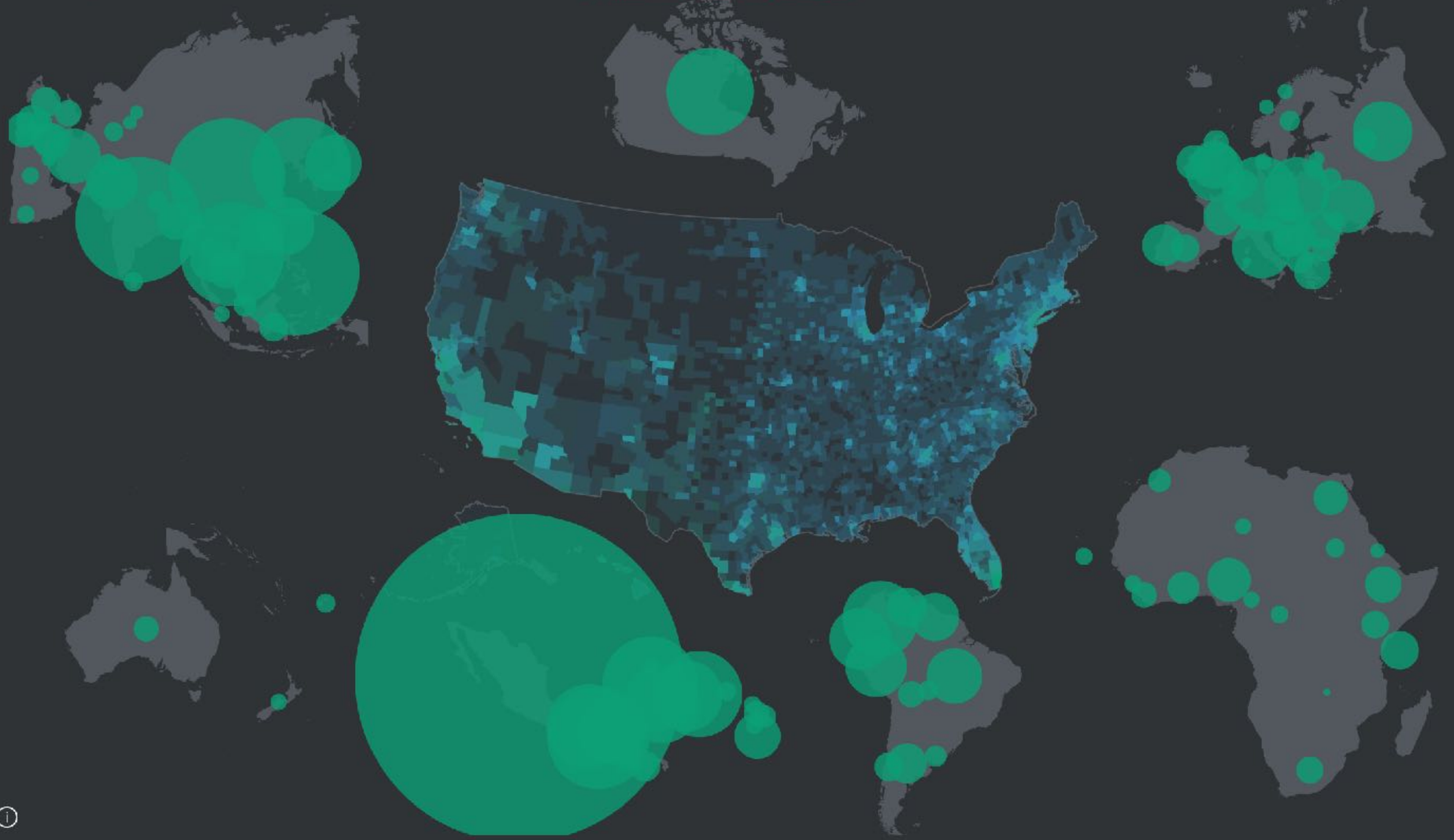
CARBON
$CO_2$ 149,826 t
FREIGHT
Containers 13,989,537
Dry 528,658 kt
Liquids 389,600 kt
Gas 59,619,496 $m^3$
Vehicles 10,017,126 kt
OPTIONS
Show
Colours
Filters
2 May 2012 03:00
MAP: Kiln RESEARCH: UCL EI
DATA: exactEarth & Clarksons
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

# MAPS FUSION

About this map

1850 **FOREIGN-BORN POPULATION** 2010

A Nation of Overlapping Diasporas



## 2010 Foreign Born

| | |
|---|---|
| Mexico | 11,566,960 |
| Philippines | 1,751,981 |
| India | 1,696,057 |
| China | 1,463,242 |
| Vietnam | 1,174,884 |
| El Salvador | 1,133,462 |
| Korea | 1,071,527 |
| Cuba | 1,003,052 |
| Canada | 826,000 |
| Dominican Republic | 802,001 |
| Guatemala | 777,073 |
| Jamaica | 641,849 |
| Germany | 627,569 |
| Colombia | 625,906 |
| Haiti | 542,091 |
| Honduras | 467,515 |
| Poland | 463,202 |
| Ecuador | 413,690 |
| Peru | 407,435 |
| Russian Federation | 385,620 |
| Italy | 384,655 |
| Taiwan | 364,625 |
| England | 363,128 |
| Japan | 348,399 |
| Brazil | 335,505 |

## TOTAL FOREIGN-BORN

2010 38,449,761 12.5%

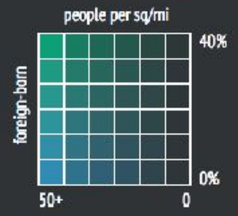
SEARCH BY COUNTY NAME

2 million people

1 million people

500 thousand people

100 thousand people




POPULATION OVER TIME

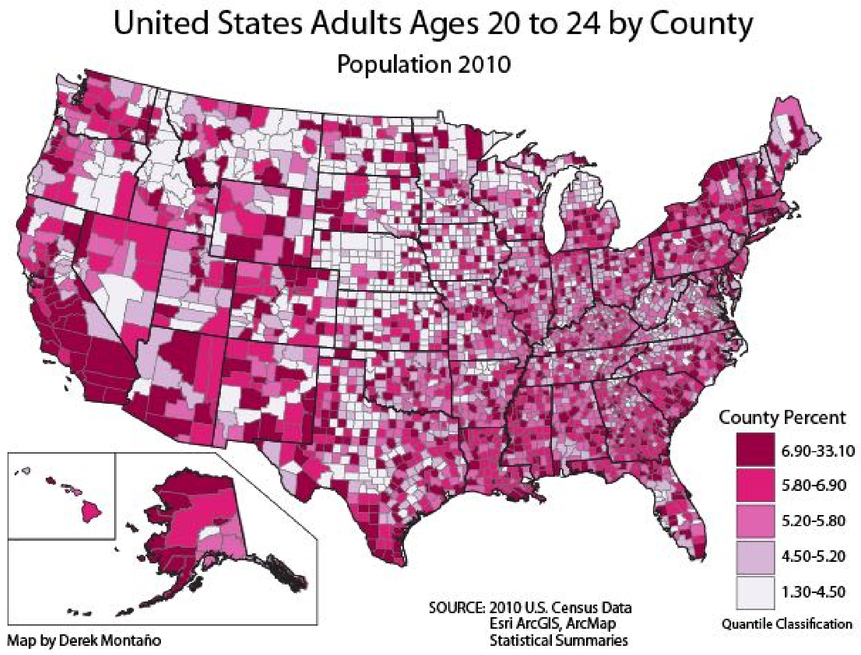
In 2010, the number of Americans born in India had risen substantially. Immigrants from India are often highly educated, many of them entering the US on H-1B visas for high-skilled workers.

# WEB

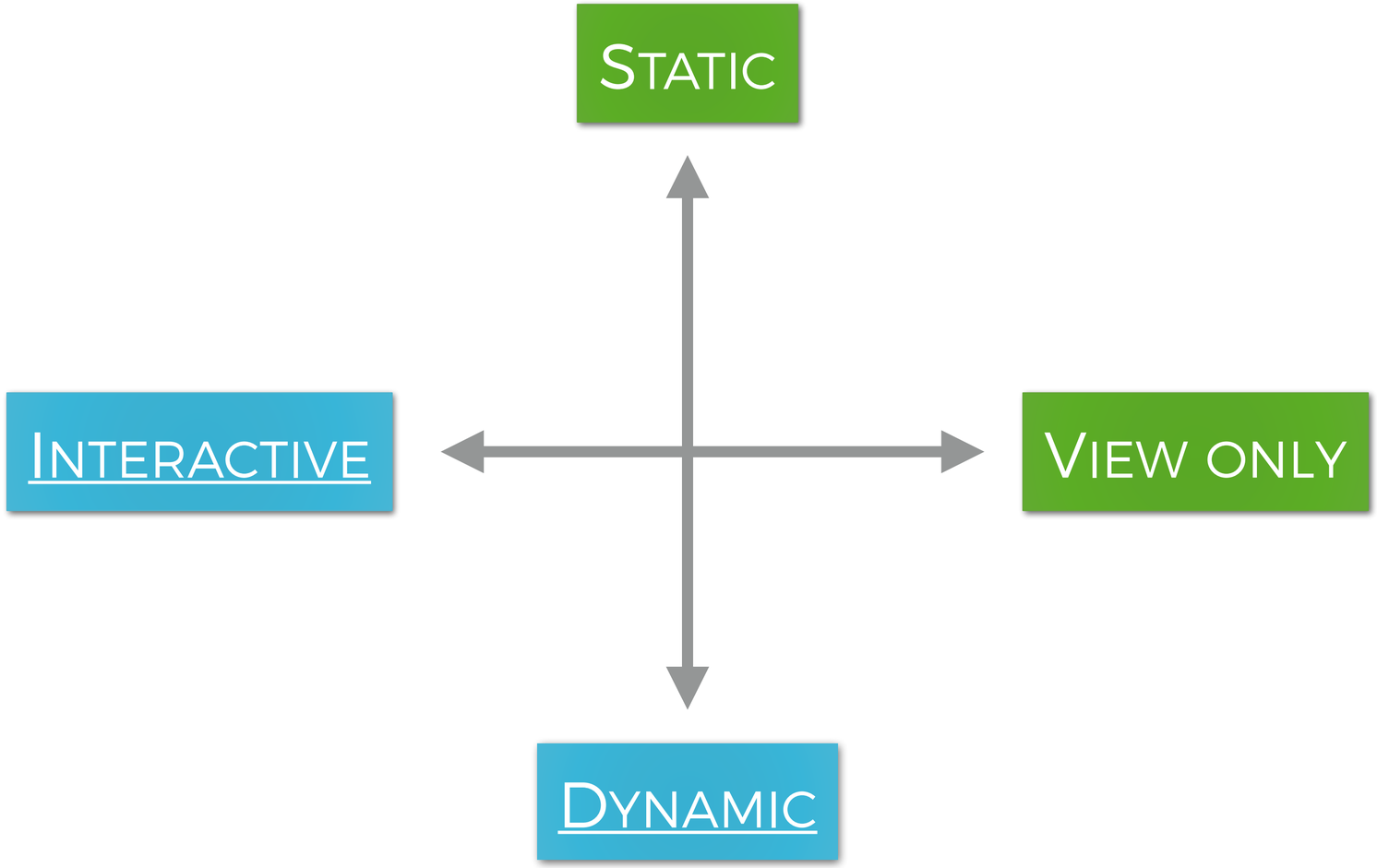
# First choice

## Interactive Web Map

## Typographic static map

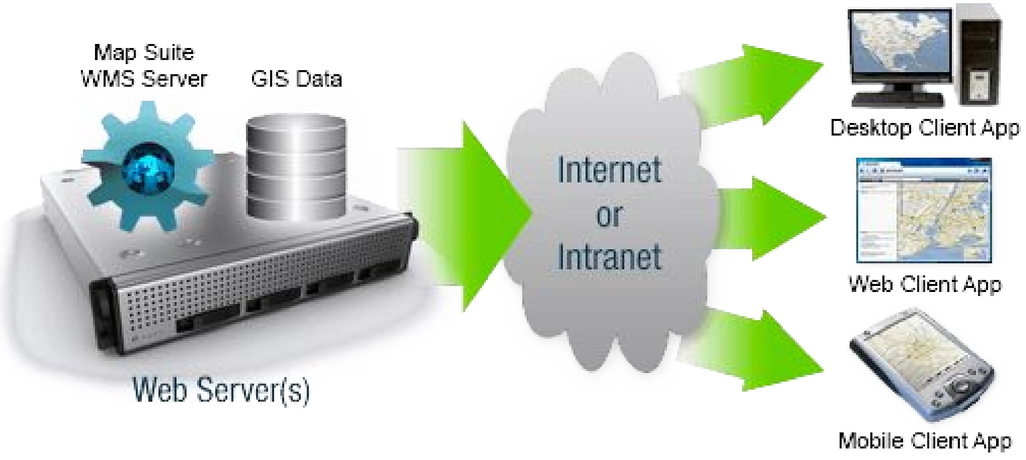


# Web Maps



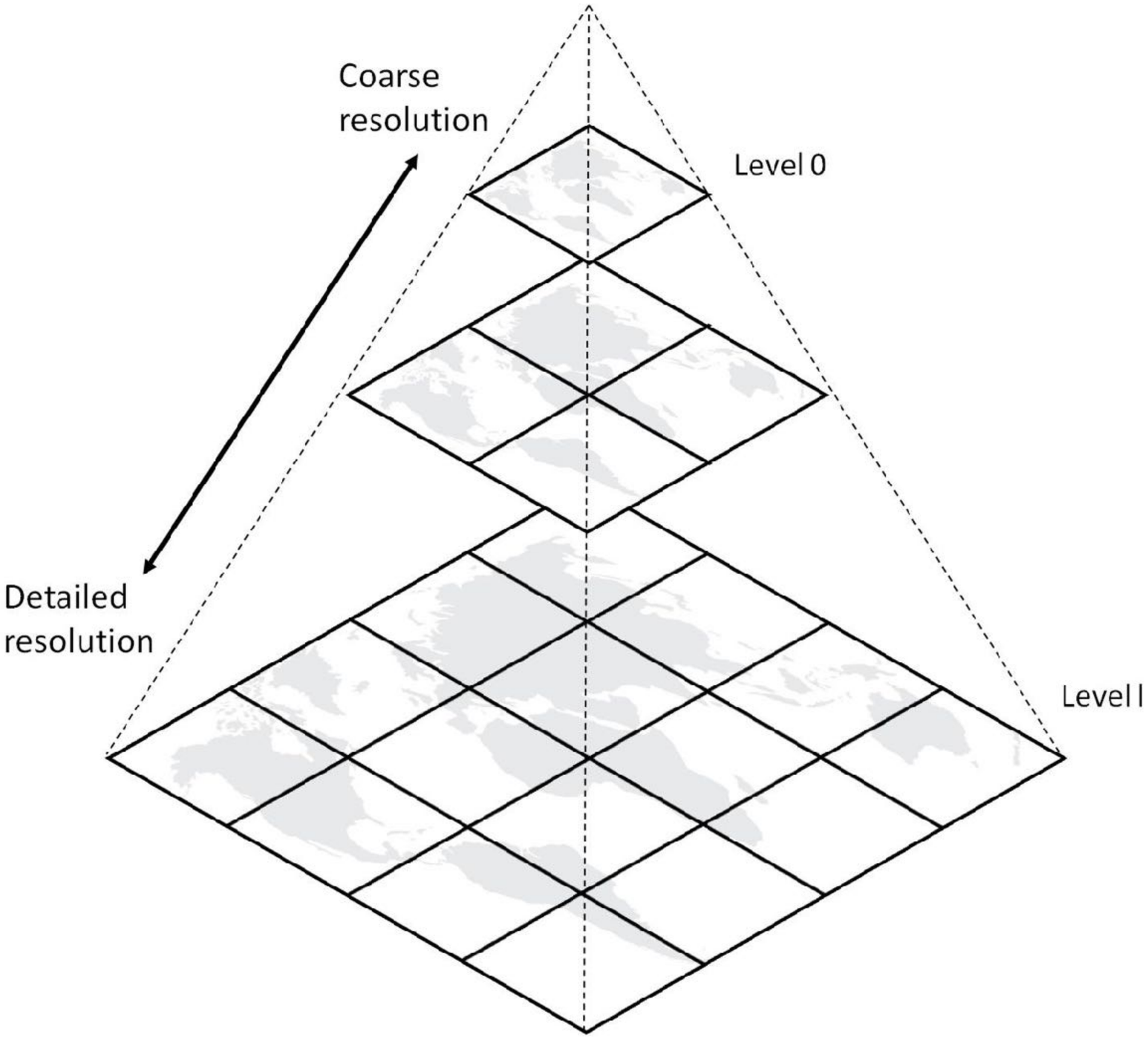
# Web Map Service (WMS)

- Developed by the OGC provides a simple HTTP interface for requesting geo-referenced map images
- Clients can specify
  - Bounding box
  - Multiple layers
  - Multiple CRS
  - Image size, style, background colors, etc.
- Server replies with an image
- Not suited for our scenario!

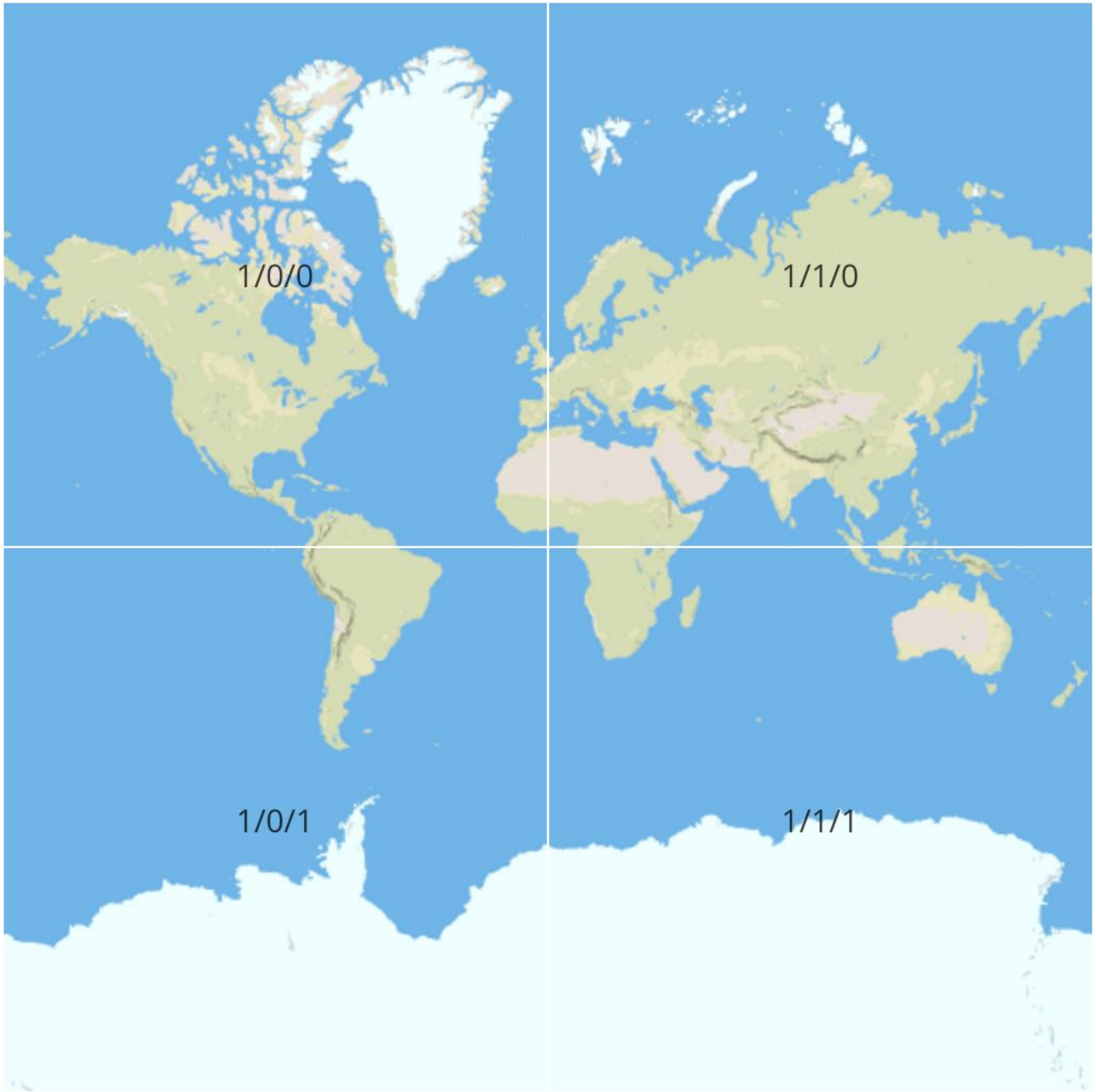


# Tiles Map

- Web maps are made up of many **small**, **square** images called **tiles**
- Tiles are placed side-by-side in order to create the illusion of a very large seamless image
- Each tile has a **z** coordinate describing its **zoom level** and x and y coordinates describing its position within a square grid for that zoom level
- URL system in the form z/x/y


Coarse
resolution
Level 0
Detailed
resolution
Level l

0/0/0


1/0/0
1/1/0
1/0/1
1/1/1

# Why Tiles?

Tiled maps **cache efficiently**.

- If you download tiles of Manhattan to view a map of Central Park your browser can make use of those same tiles from cache instead of downloading them again when showing a map of Jersey City.

Tiled maps **load progressively**.

- Central Park will load before the outer edges of Manhattan letting you pan or zoom into a particular spot even if tiles at the edges of your map view haven't finished loading.

Tiled maps are **simple to use**.

- The coordinate scheme describing map tiles is simple, making it easy to implement integrating technologies on the server, web, desktop, and mobile devices.

# Vector Tiles

**Vector data which has been clipped to the tile boundary and sent to the client**

Clipping performed in advance (no need of online GIS)

Advantages:

- **Data transfer is reduced** (only within the viewport and zoom level)
- **Separate data from design**
- Styling can be applied later in the process (even in the browser)
- **Easy to add interactivity** (vector representation already within the client)

VS

# Useful Links

https://github.com/mapbox/vector-tile-spec

https://github.com/mapbox/awesome-vector-tiles

https://en.wikipedia.org/wiki/Vector_tiles

# Javascript Libraries for Web Maps

- **Free**
  - Leaflet
  - OpenLayers 3
  - D3.js
- Not entirely free
  - CartoDB.js
  - MapBox
    - Mapbox.js (raster tile)
    - Mapbox GL JS (vector tile)
  - Google Maps API

Leaflet

D3

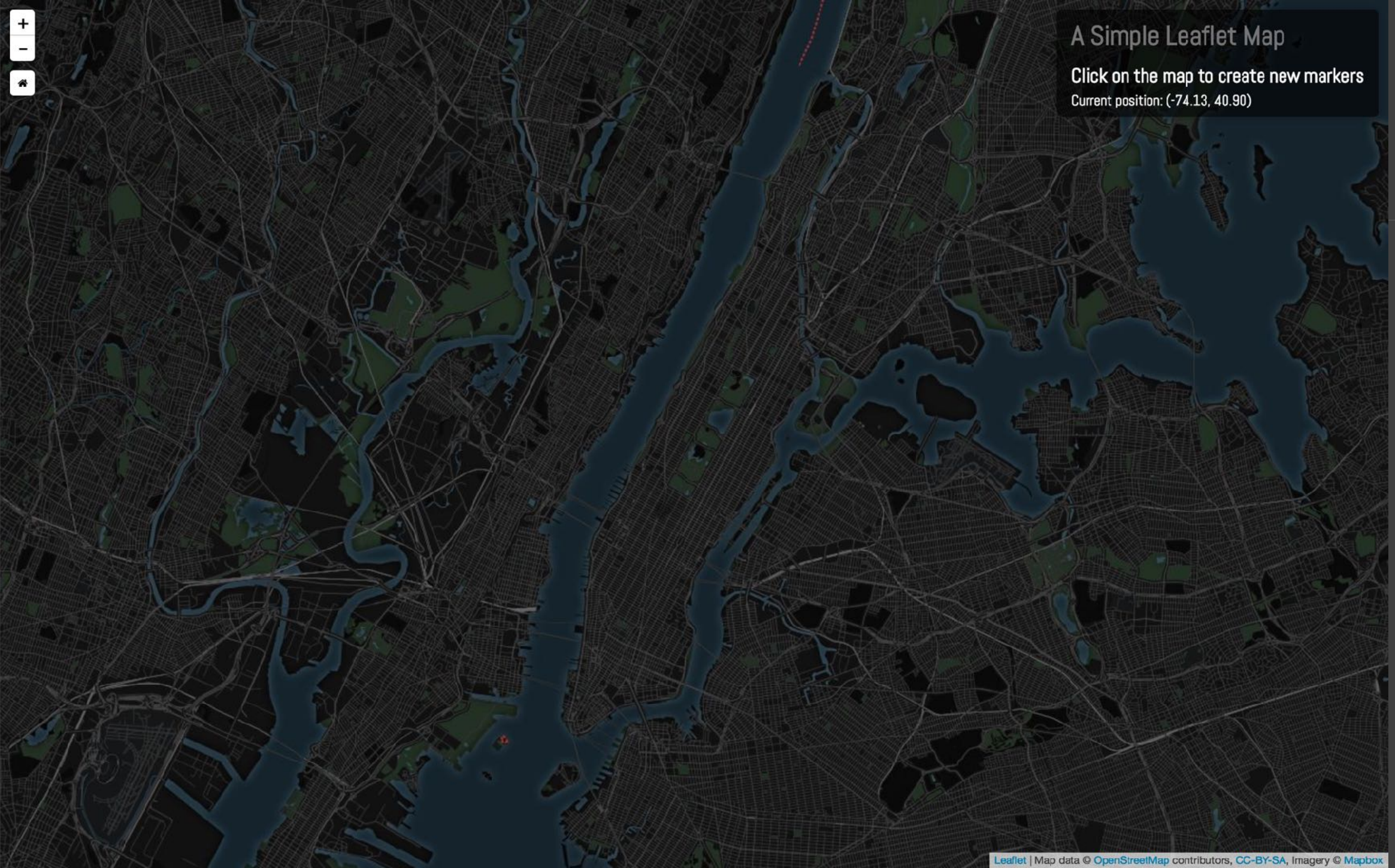
CARTO

Mapbox

MAPZEN

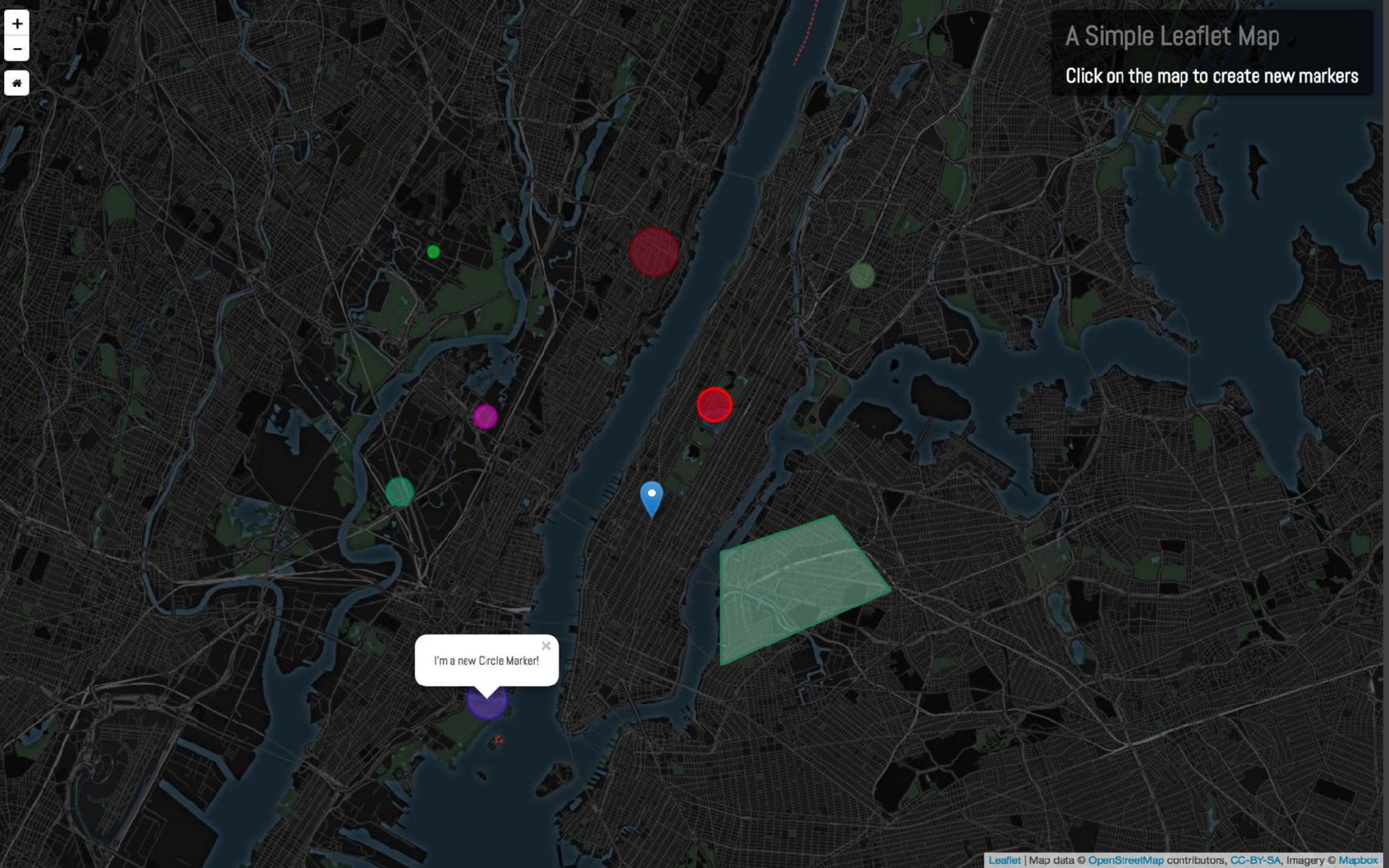
# Leaflet

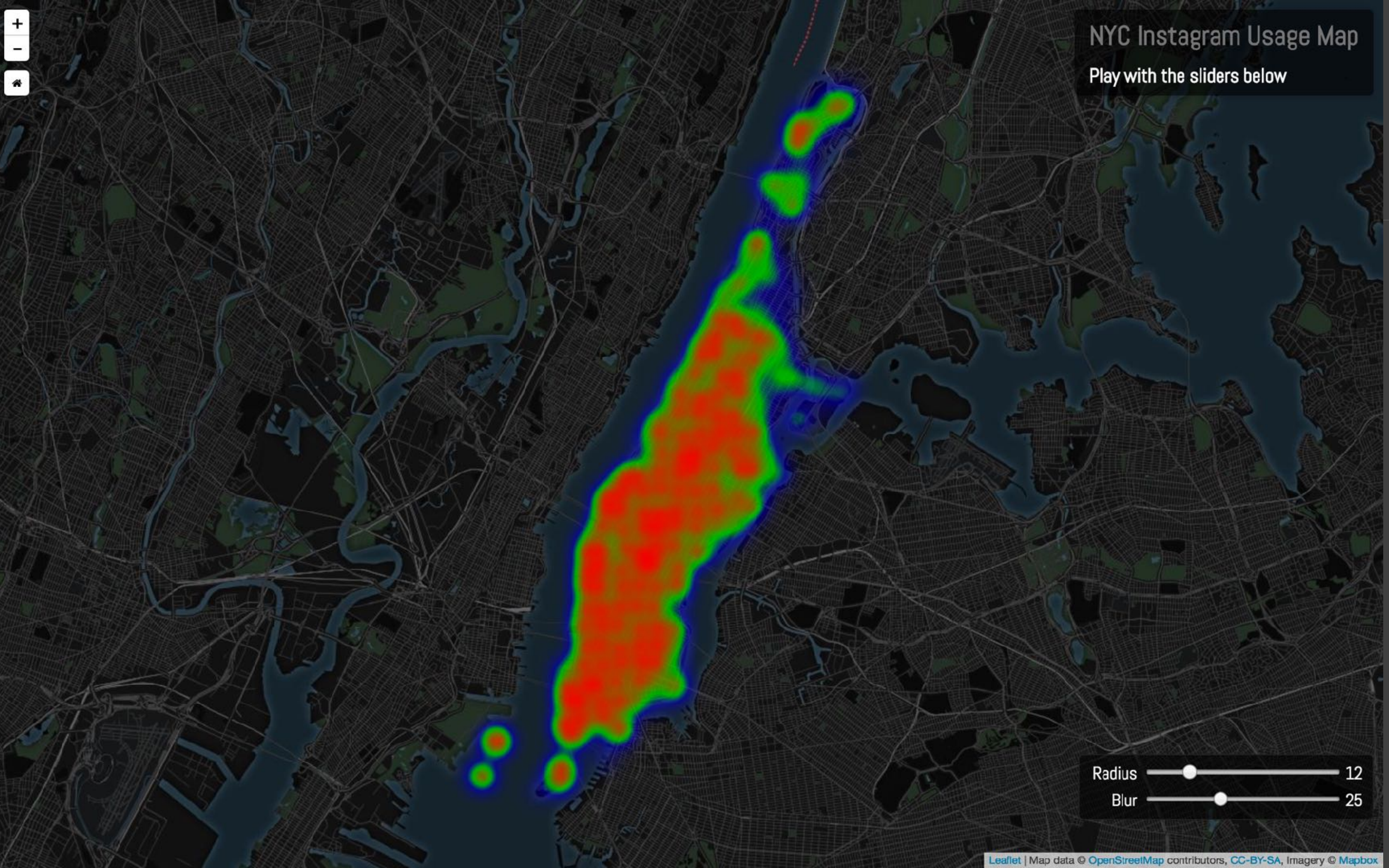
- **Create a simple map**
- **Load GeoJSON** data in Leaflet
- **Visualize Points**
  - **Heatmaps**
  - **Clustering**
- **Visualize Polygons**
  - **Choropleth Map**
- **Add interactivity**
- **Create data-driven custom style**
- **Visualize Linestrings**
- **Link D3.js to spatial visualizations**



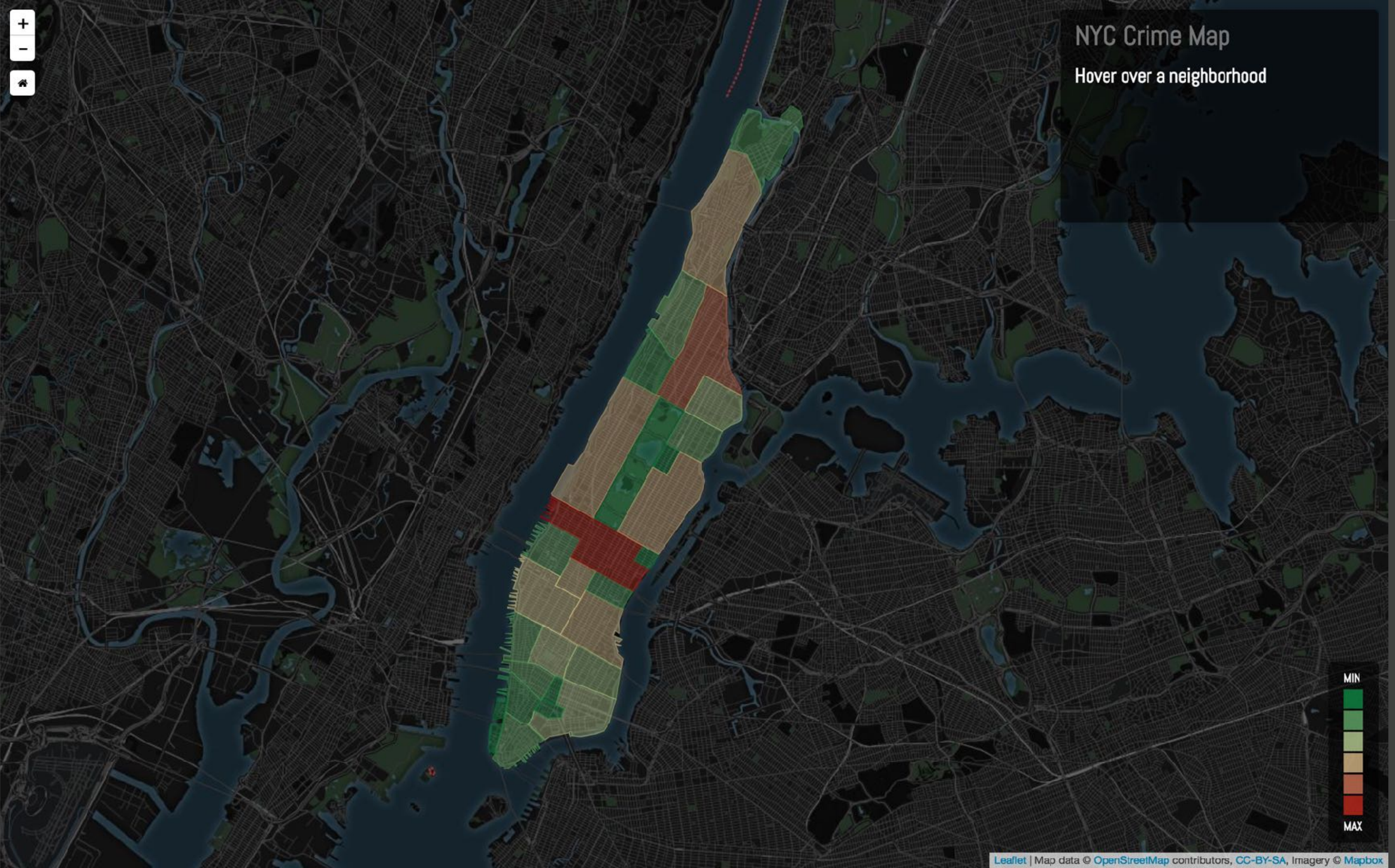

# CREATE A SIMPLE MAP

# ADD MARKERS, GEOMETRIES, POPUPS

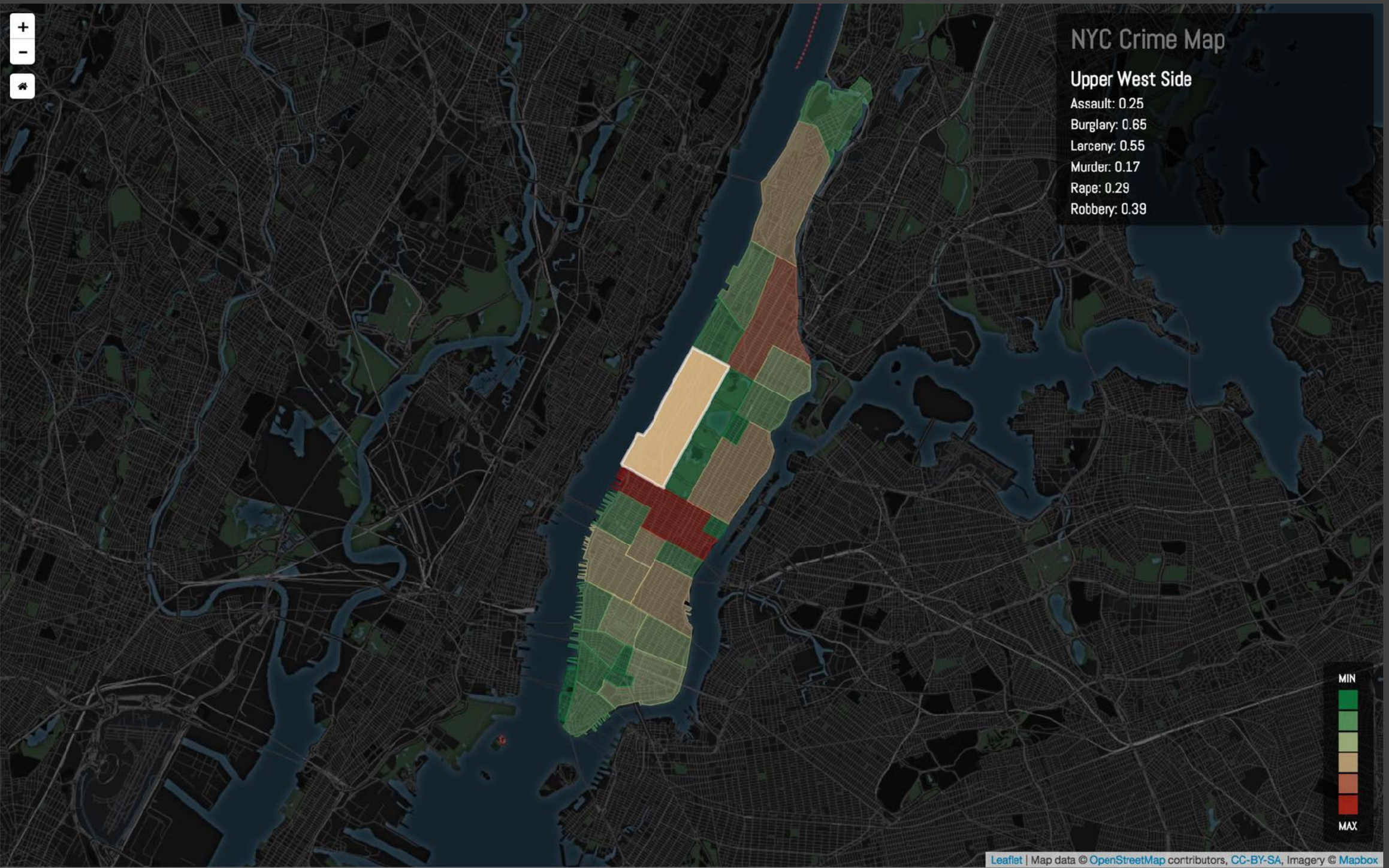



NYC Instagram Usage Map
Play with the sliders below
Radius
12
Blur
25
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

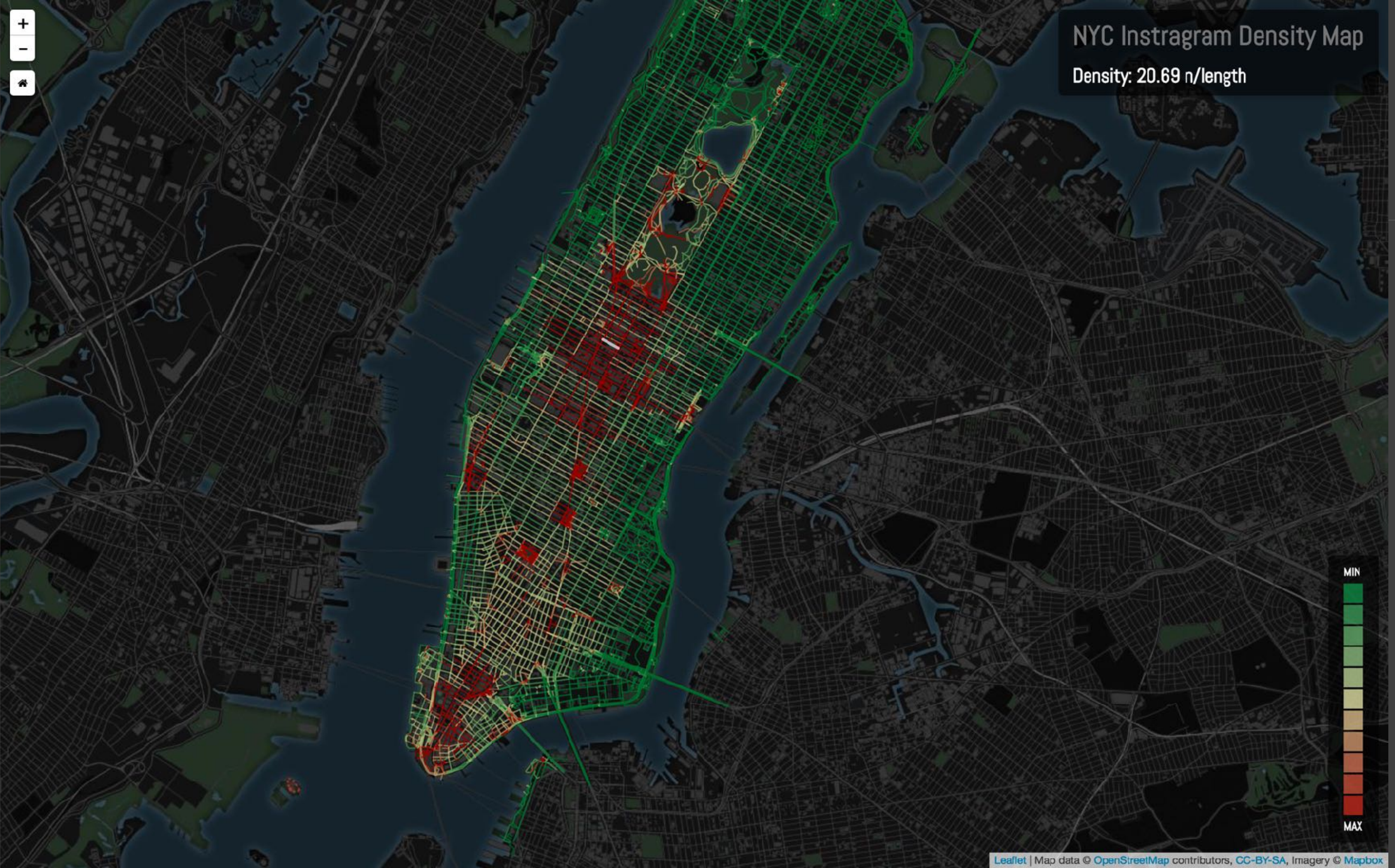
# HEATMAPS


NYC Crime Map
Hover over a neighborhood
MIN
MAX
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

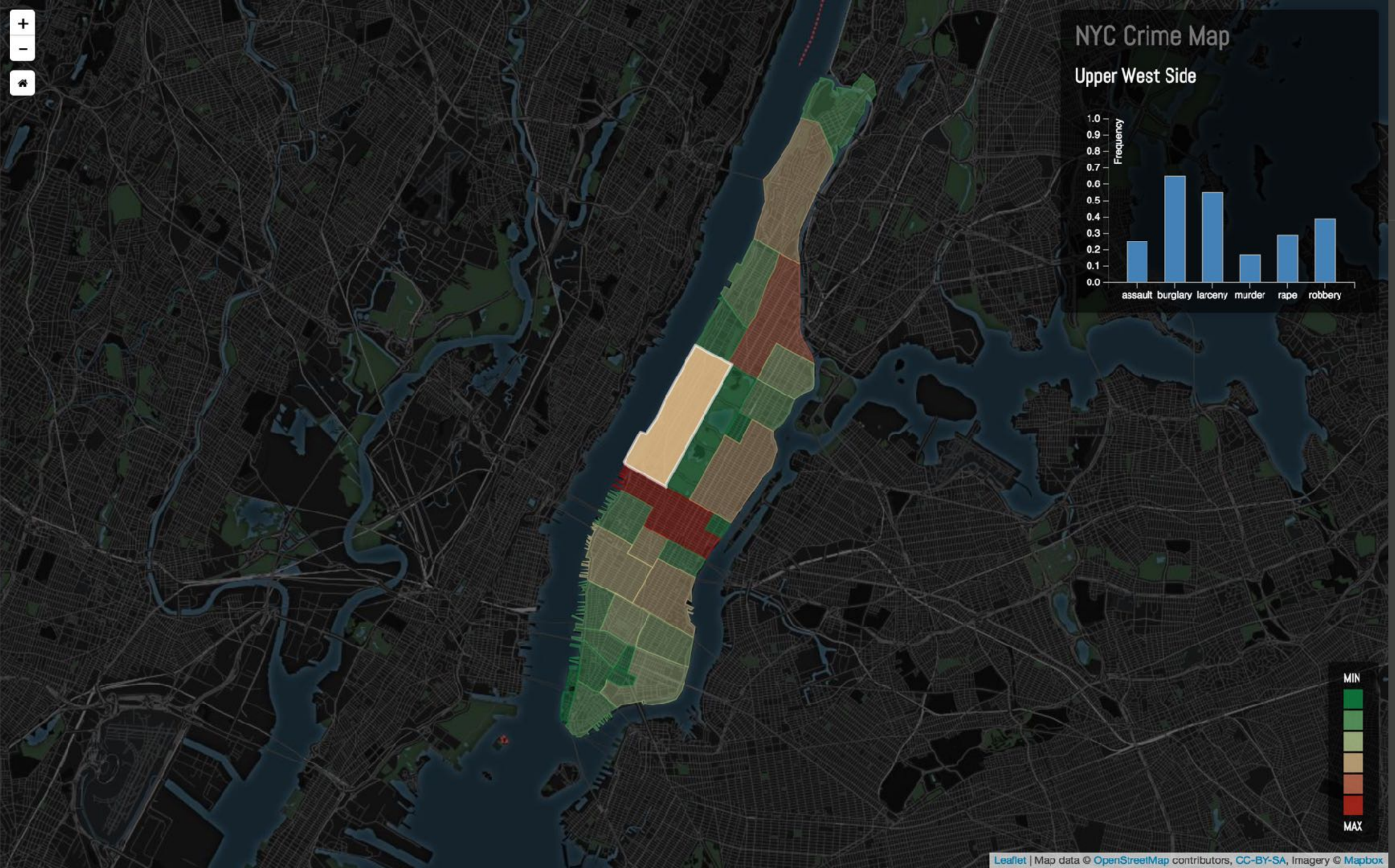
# CHOROPLETH




# ADD INTERACTIVITY




# LINESTRING DATA


NYC Crime Map
Upper West Side
Frequency
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
assault
burglary
larceny
murder
rape
robbery
MIN
MAX
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

# LINK D3.JS

# Typographic (static) Maps

How to use Python to produce static maps ready for publishing

Several other alternatives in other platforms

- **R has a nice support for spatial data** (next tutorial!)
  - **ggmap**: extends the plotting package ggplot2 for maps
  - **rgdal**: R's interface to the popular C/C++ spatial data processing library gdal
  - **rgeos**: R's interface to the powerful vector processing library geos
  - **maptools**: provides various mapping functions
  - **dplyr** and **tidyr**: fast and concise data manipulation packages
  - **tmap**: a new packages for rapidly creating beautiful maps
- Check out this tutorial:
  - **https://cran.r-project.org/doc/contrib/intro-spatial-rl.pdf**

# Python environment

We are going to use a bunch of packages:

- **Matplotlib**: matplotlib is a python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms
- **Basemap**: the matplotlib basemap toolkit is a library for plotting 2D data on maps in Python. Basemap does not do any plotting on it's own, but provides the facilities to transform coordinates to one of 25 different map projections (using the PROJ.4 C library).
- **Descartes**: use geometric objects as matplotlib paths and patches
- **Shapely**
- **Fiona**

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