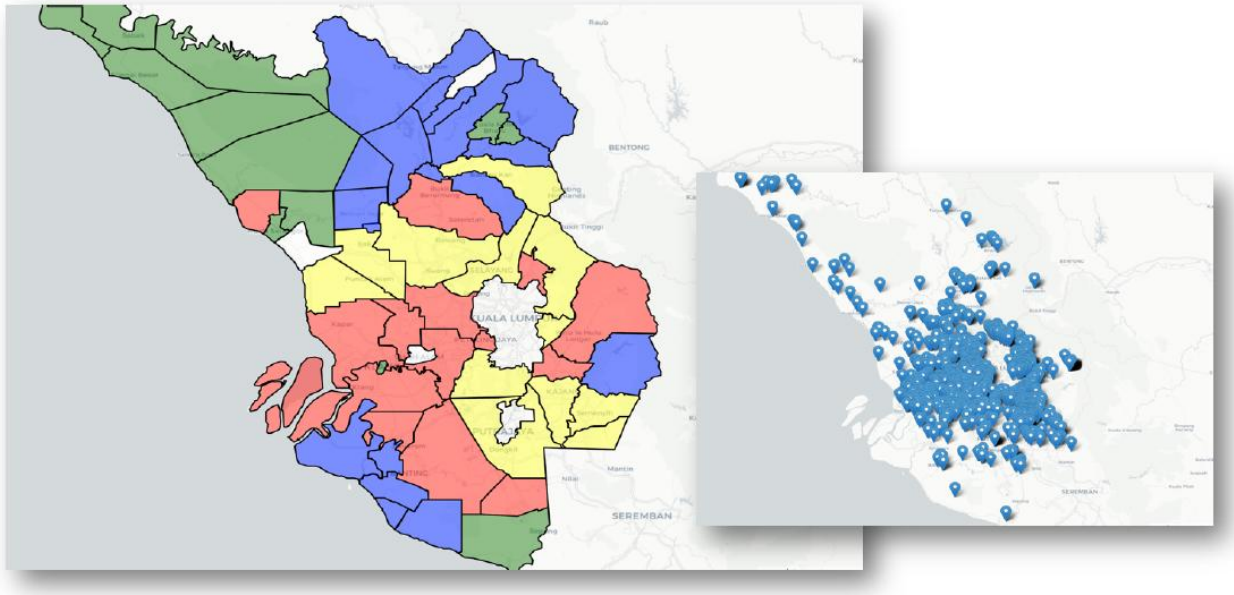
CDS 6324
DATA VISUALIZATION

Lecture 9: Geospatial Mapping

Mapping

If a picture is worth a thousand words, then **a map is worth a thousand cells**.

- Location can relate disparate data
- Easy to see problem areas
- By State, County, Zip, Block
- Even down to individual Address



Active Covid-19 cases in Selangor

Mapping

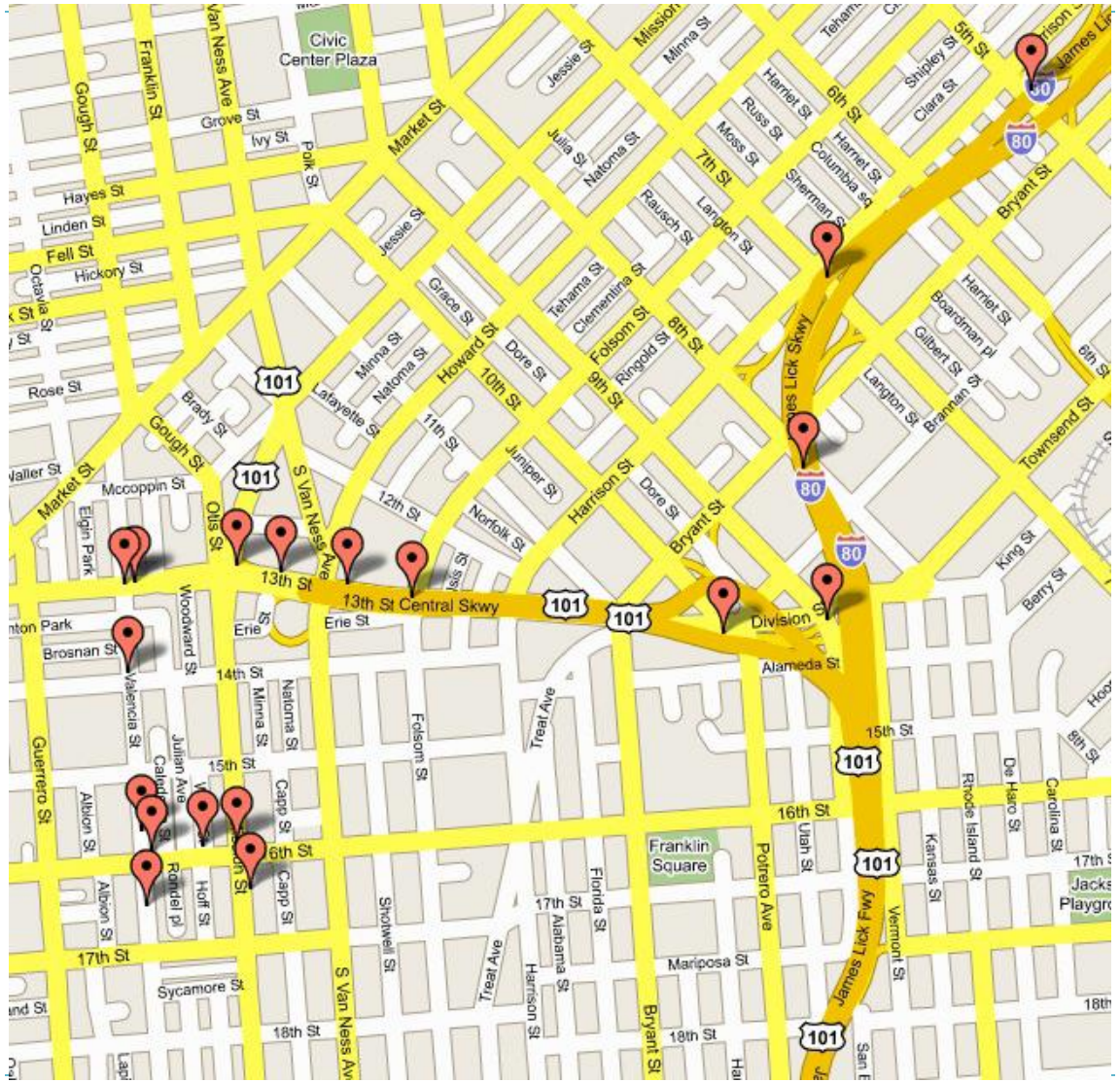
- Visualizing data on maps:
  - Dots, more dots, continuous data, choropleths and cartograms
- Cartography:
  - Projections, scale and data
- Effective use of color on maps:
  - Sequential, diverging, categorizing, highlight and alert
- Example
  - **Beautiful Trash**

    Winner of "Information of Beautiful Award"

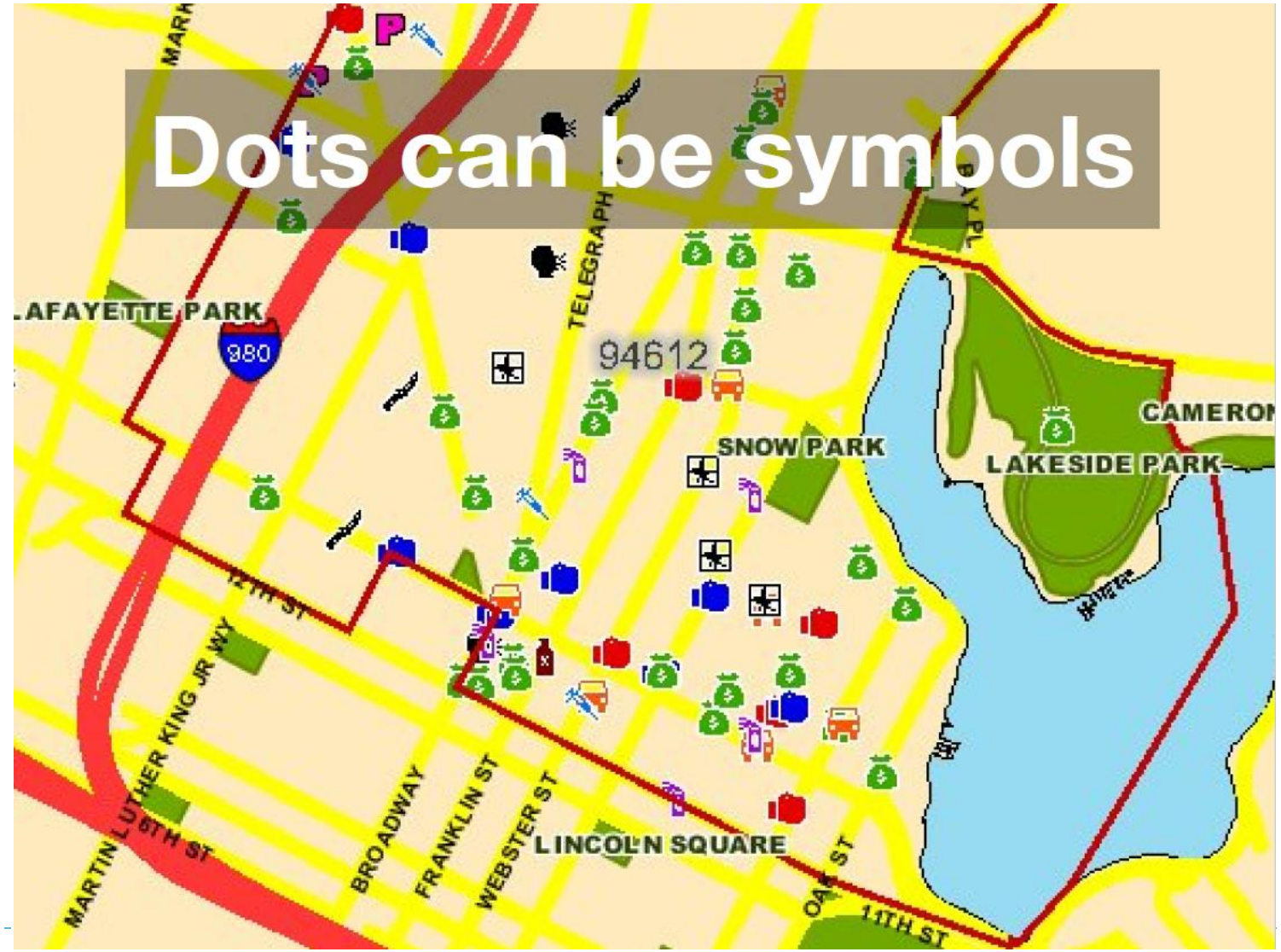
Visualizing Data on Maps

Dots

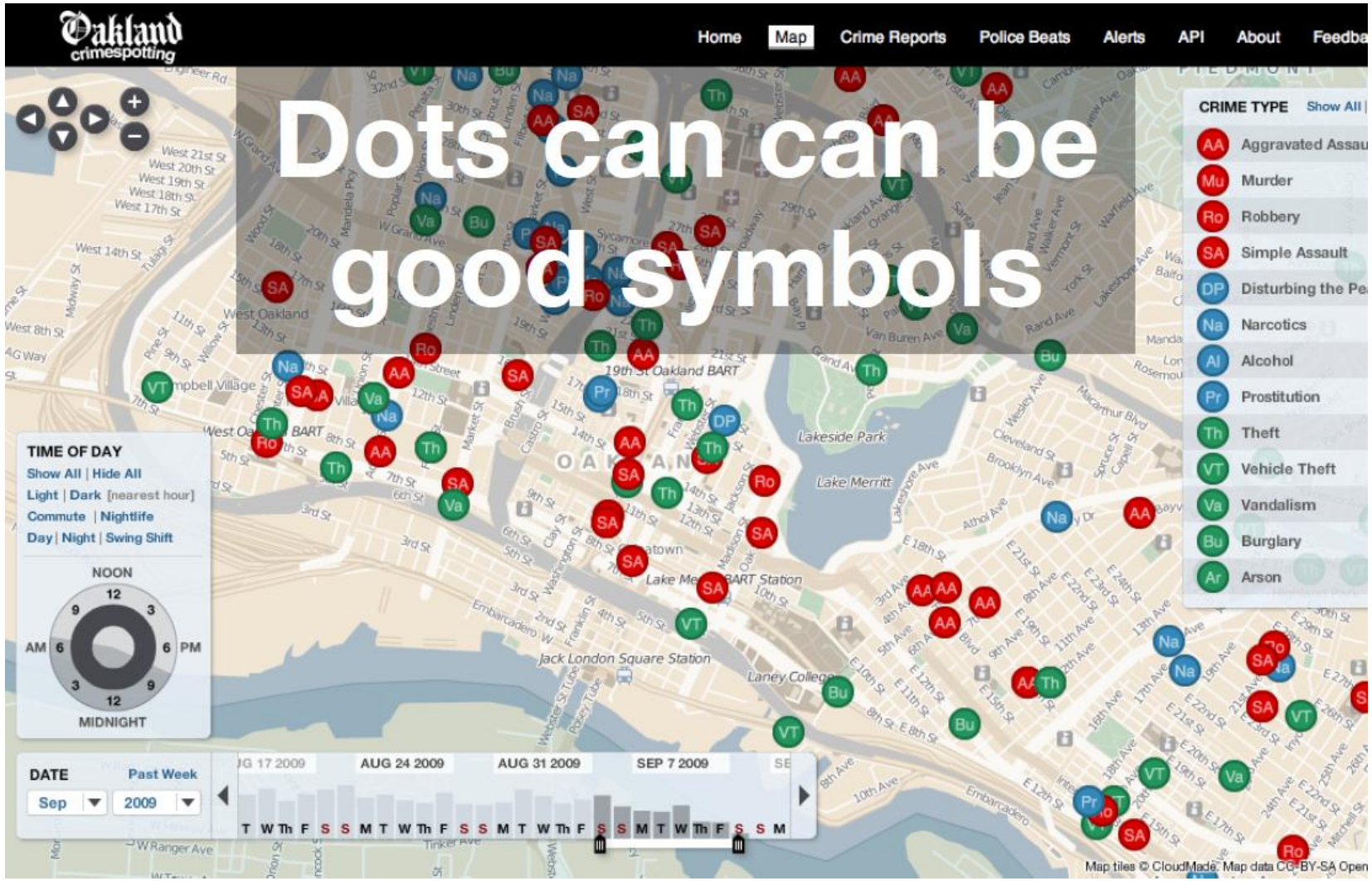
Dots


Civic Center Plaza
Franklin St
Van Ness Ave
Gough St
Grove St
Ivy St
Hayes St
Linden St
Fell St
Hickory St
Market St
Polk St
Jessie St
Mission
Minna St
Natoma St
Julia St
Russ St
Moss St
Harriet St
6th St
7th St
5th St
Shipley St
Clara St
Columbia sq
Sherman St
Rausch St
Langton St
Bryant St
Boardman pl
Gilbert St
Brannan St
Townsend St
Grace St
Howard St
Tehama St
Clementina St
Folsom St
Ringold St
8th St
9th St
10th St
11th St
Dore St
Juniper St
Lafayette St
Rose St
Brady St
Waller St
Mccoppin St
Elgin Park
Otis St
S Van Ness Ave
12th St
Norfolk St
Harrison St
13th St
13th St Central Skwy
Erie St
Woodward St
Brosnan St
Valencia St
14th St
15th St
16th St
17th St
Julian Ave
Albion St
Capp St
Guerrero St
Hoff St
Rondel pl
Sycamore St
18th St
Shotwell St
Treat Ave
Folsom St
Florida St
Alabama St
Harrison St
Bryant St
Potrero Ave
Franklin Square
Utah St
Mariposa St
James Lick Skwy
Division
Alameda St
King St
Berry St
De Haro St
Rhode Island St
Kansas St
Carolina St
Vermont St
Jacks Playgro
101
80
30

Dots


Dots can be symbols
LAFAYETTE PARK
980
TELEGRAPH
94612
SNOW PARK
LAKESIDE PARK
12TH ST
MARTIN LUTHER KING JR WY
61ST ST
BROADWAY
FRANKLIN ST
WEBSTER ST
LINCOLN SQUARE
OAK ST
11TH ST

Dots


Oakland crimespotting
Home
Map
Crime Reports
Police Beats
Alerts
API
About
Dots can can be good symbols
CRIME TYPE
Show All
Aggravated Assau
Murder
Robbery
Simple Assault
Disturbing the Pe
Narcotics
Alcohol
Prostitution
Theft
Vehicle Theft
Vandalism
Burglary
Arson
TIME OF DAY
Show All | Hide All
Light | Dark [nearest hour]
Commute | Nightlife
Day | Night | Swing Shift
NOON
AM
PM
MIDNIGHT
DATE
Past Week
Sep
2009
AUG 24 2009
AUG 31 2009
SEP 7 2009
Lakeside Park
Lake Merritt
19th St Oakland BART
Jack London Square Station
Laney College
West Oakland
Map tiles © CloudMade, Map data CC-BY-SA Open

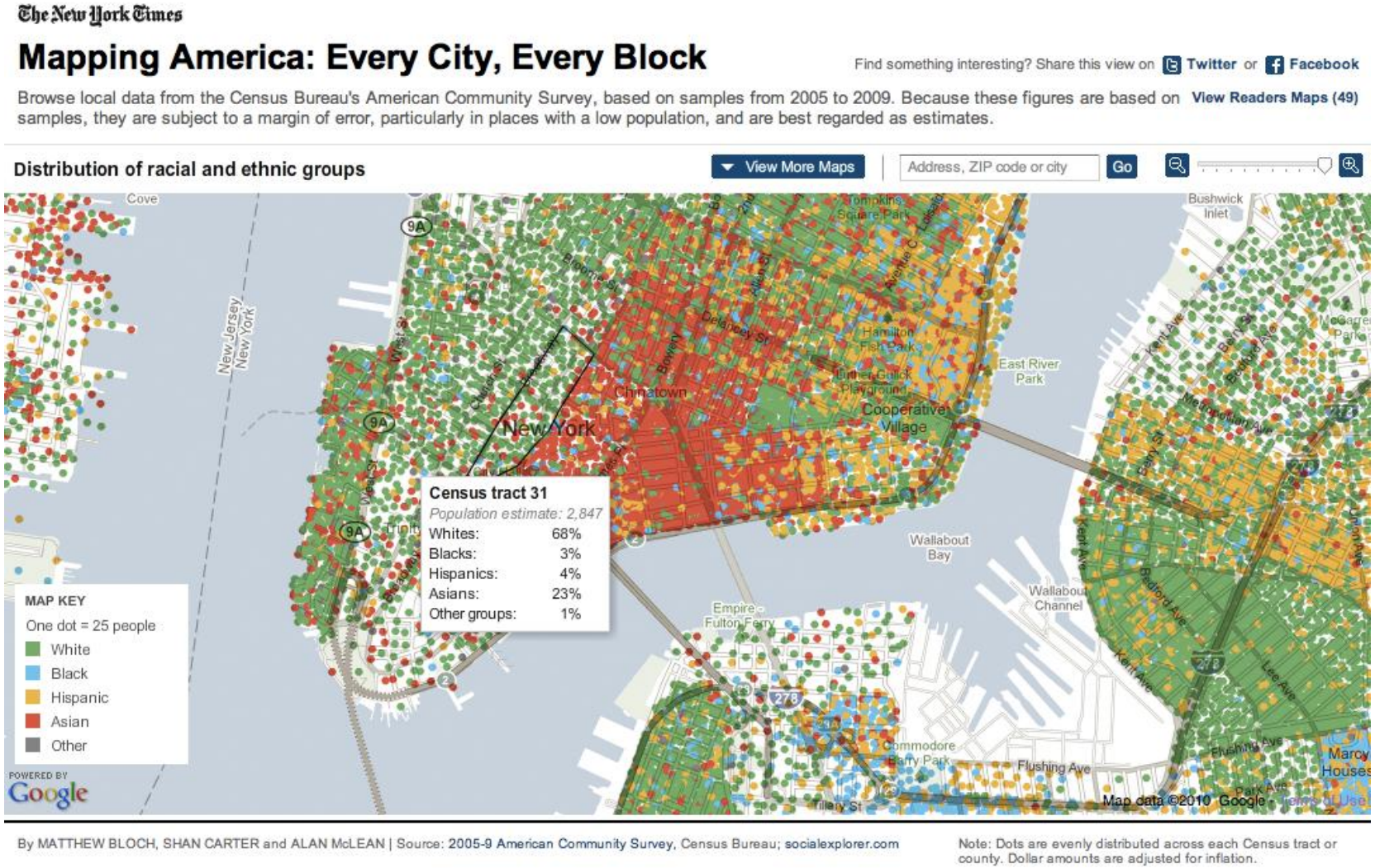
Dots

Dots

More, Smaller Dots

Clusters and point density maps

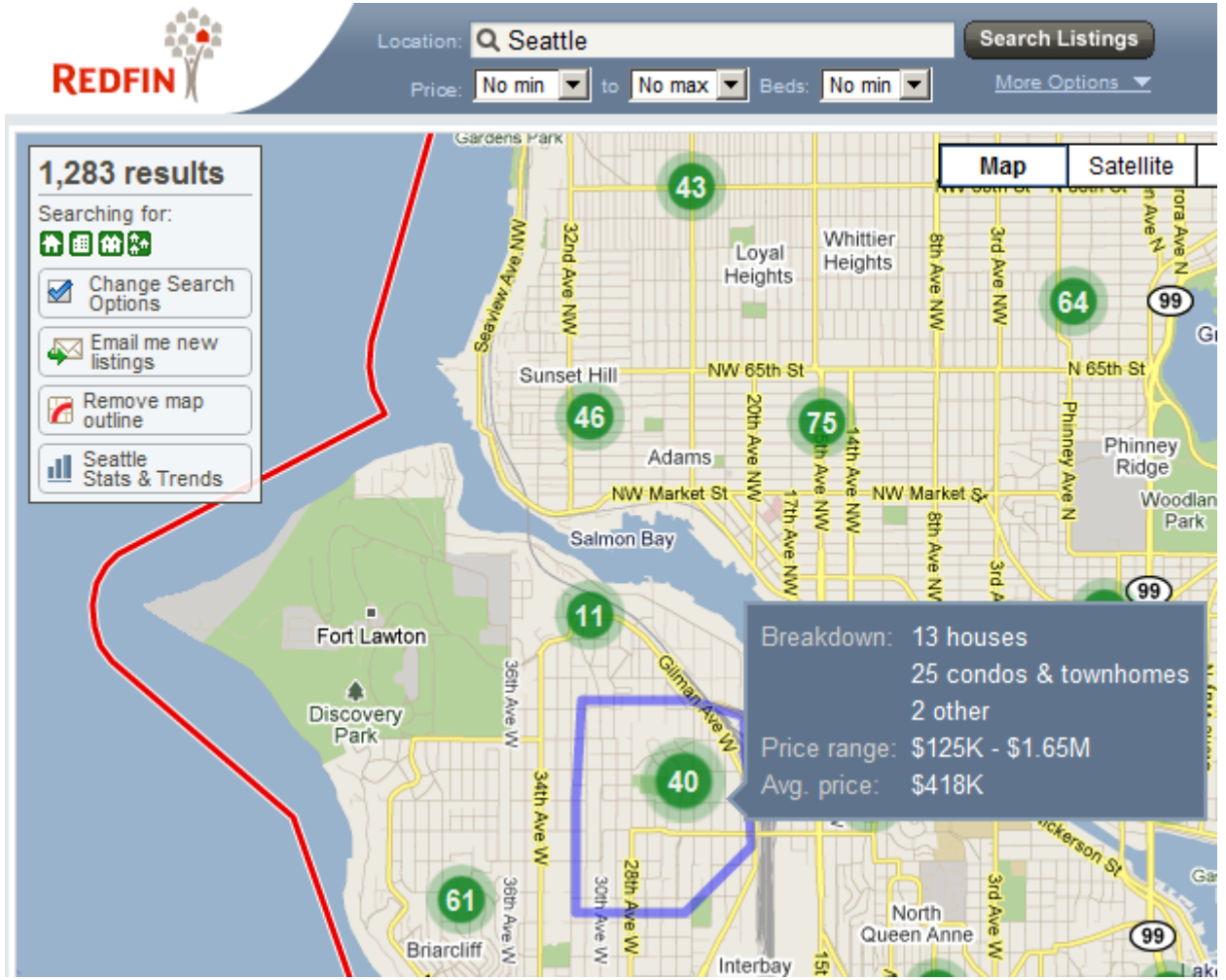
Dots – Point density map

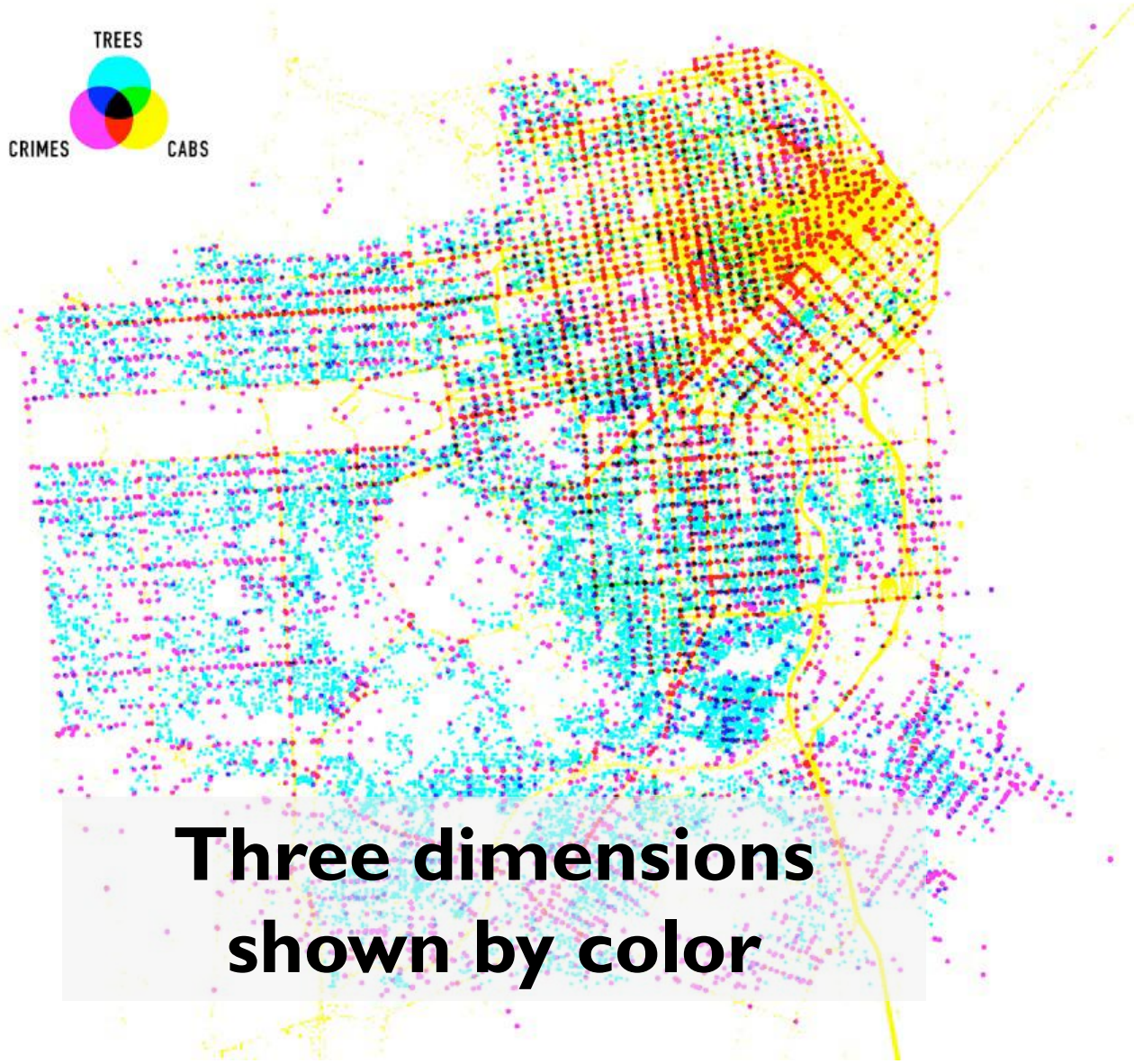


Clustering, Grouping

Clustering, Grouping

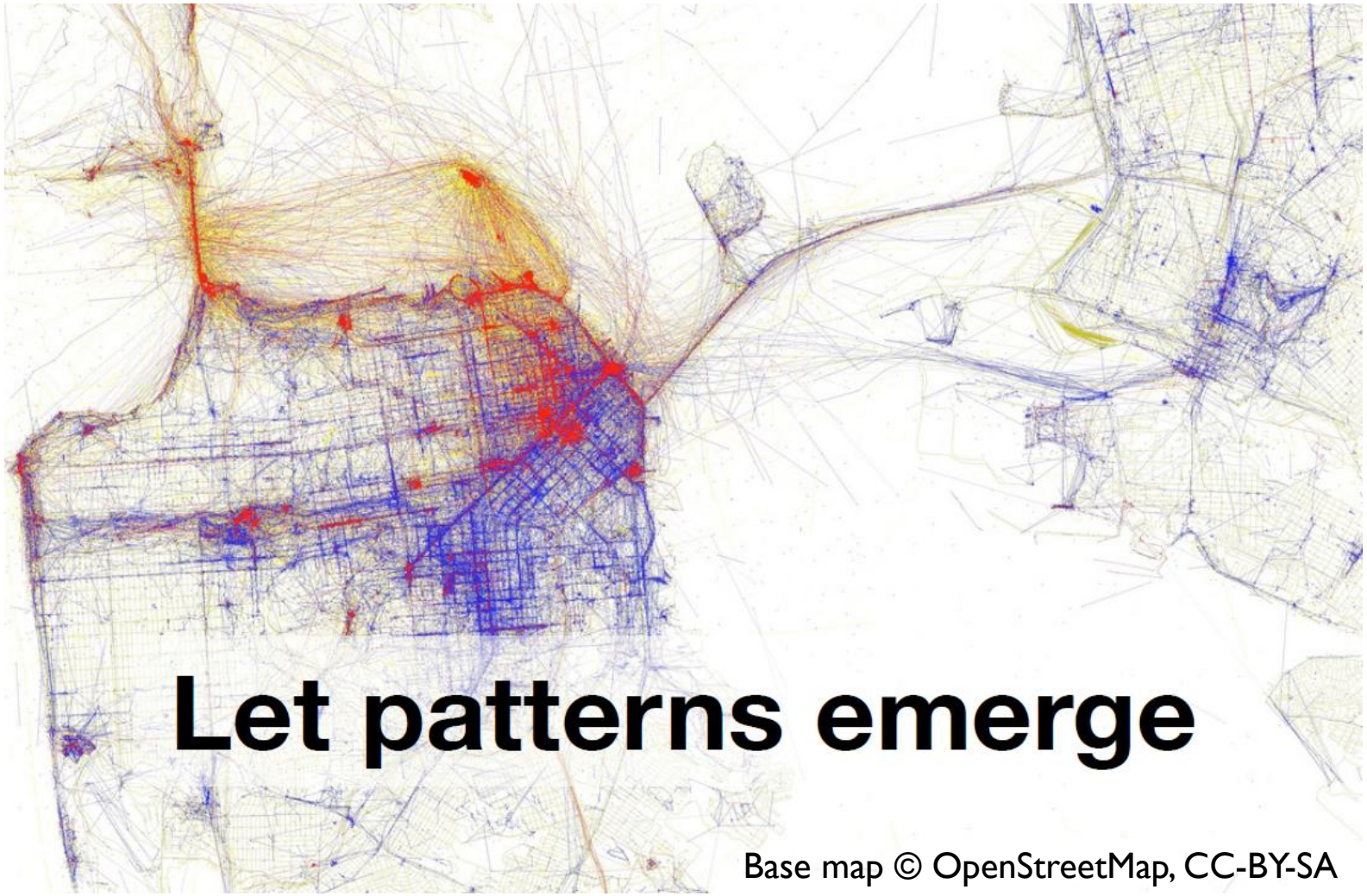
Clustering, Grouping





Three dimensions shown by color

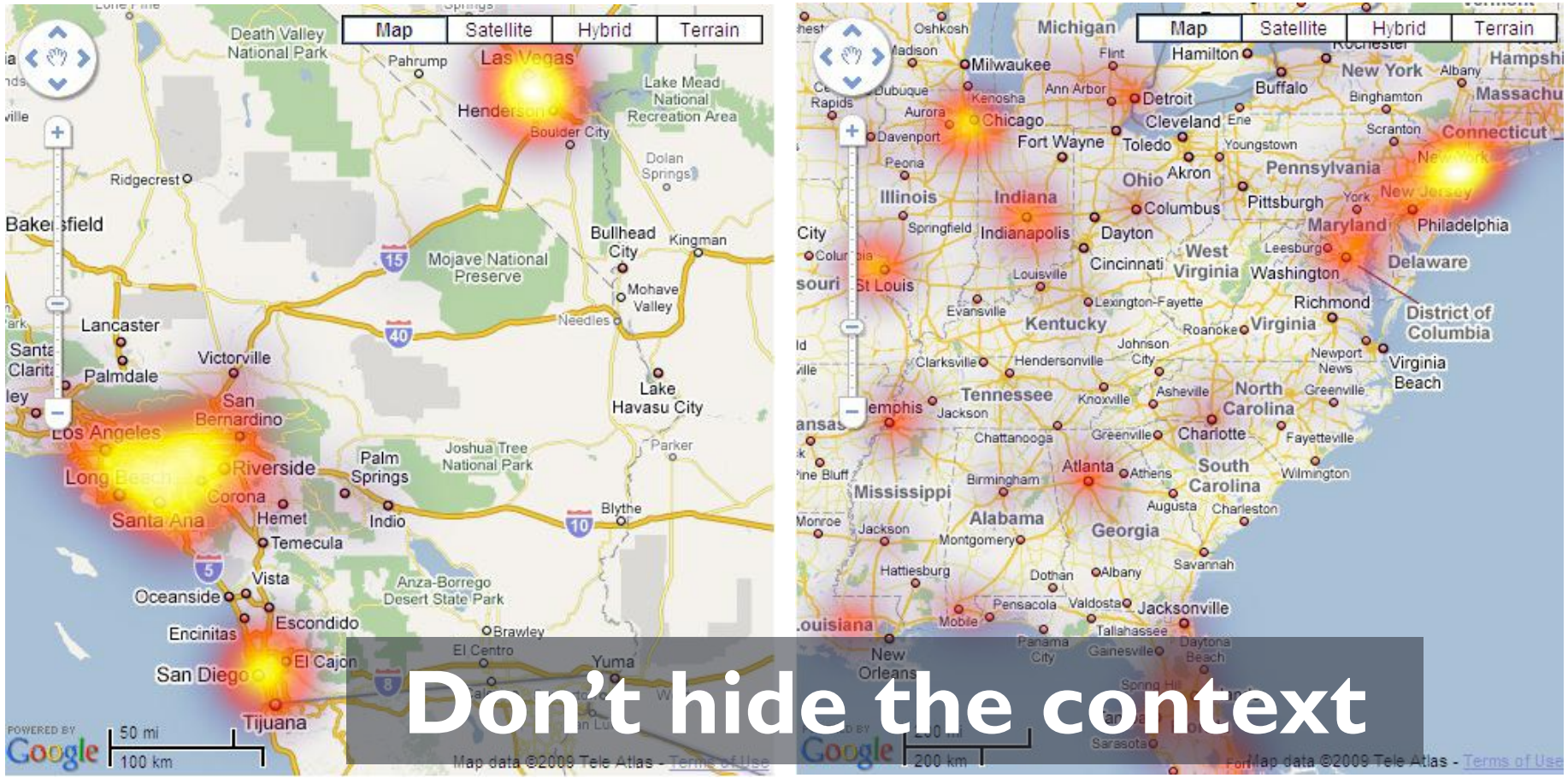
Dots – Point density map



Continuous Data

Heat maps and isolines

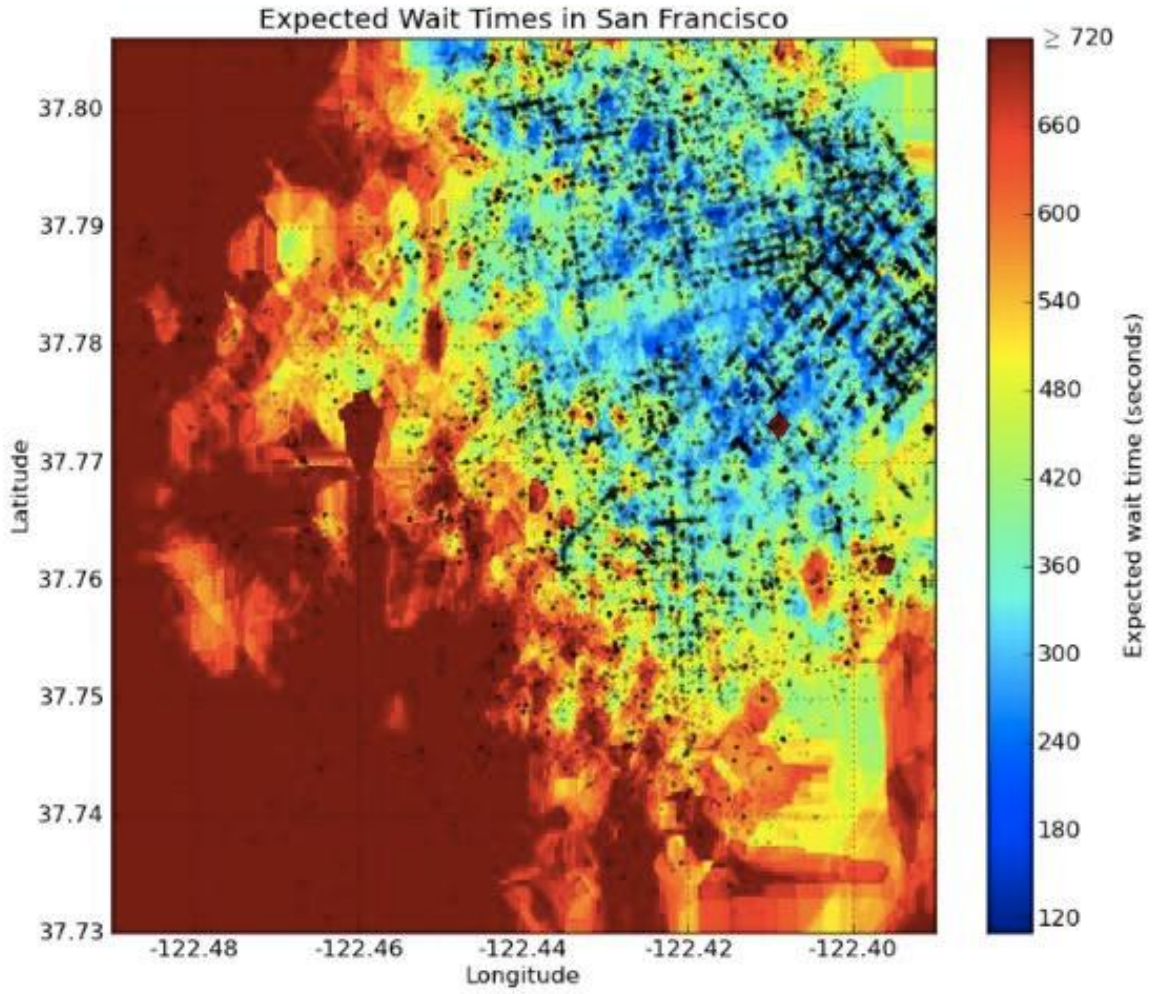
Continuous Data - Heat Maps



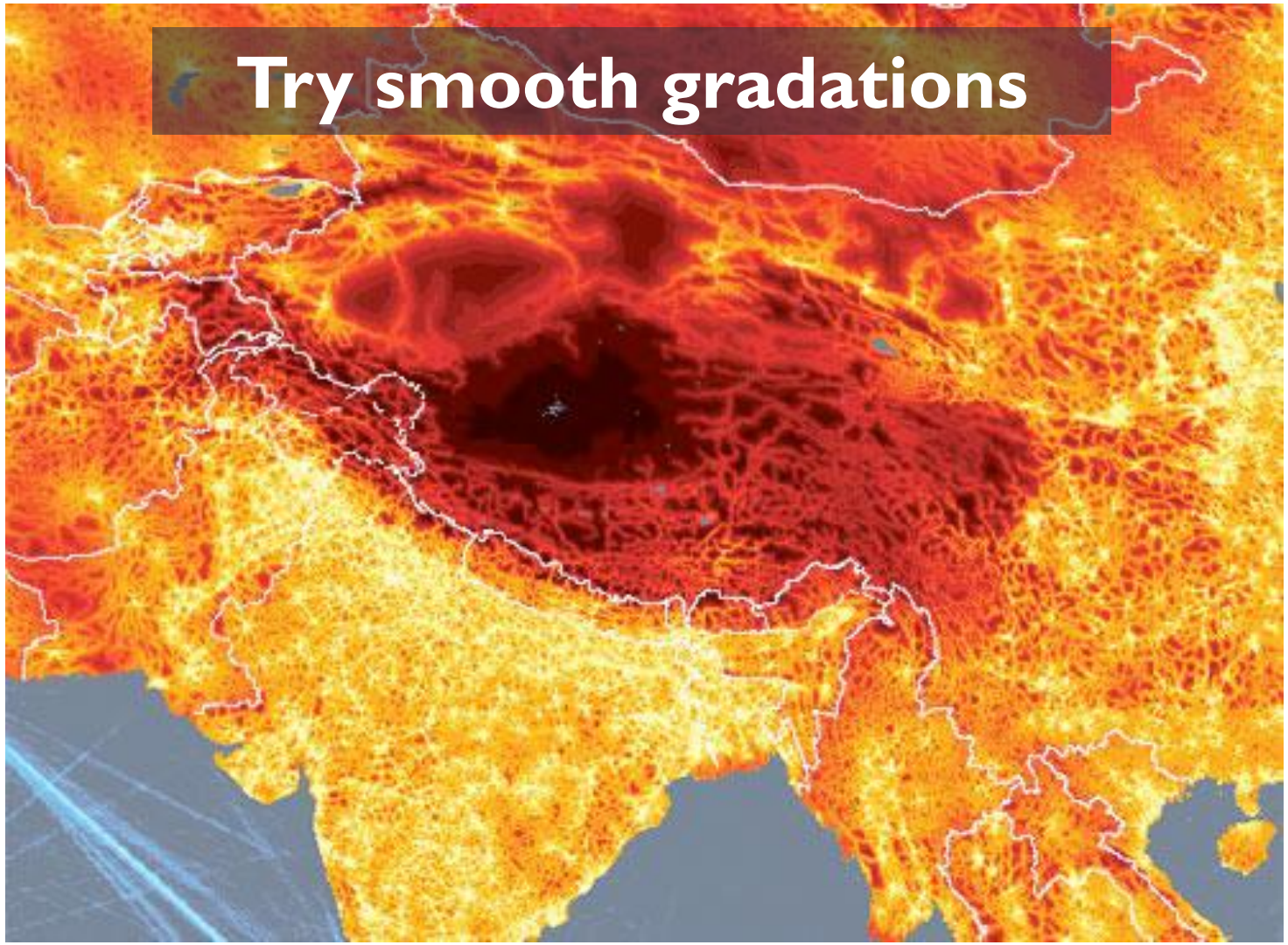
Don’t hide the context

https://geochalkboard.wordpress.com/2009/03/11/density-mapping-in-google-maps-with-heatmapapi/

Continuous Data - Heat Maps

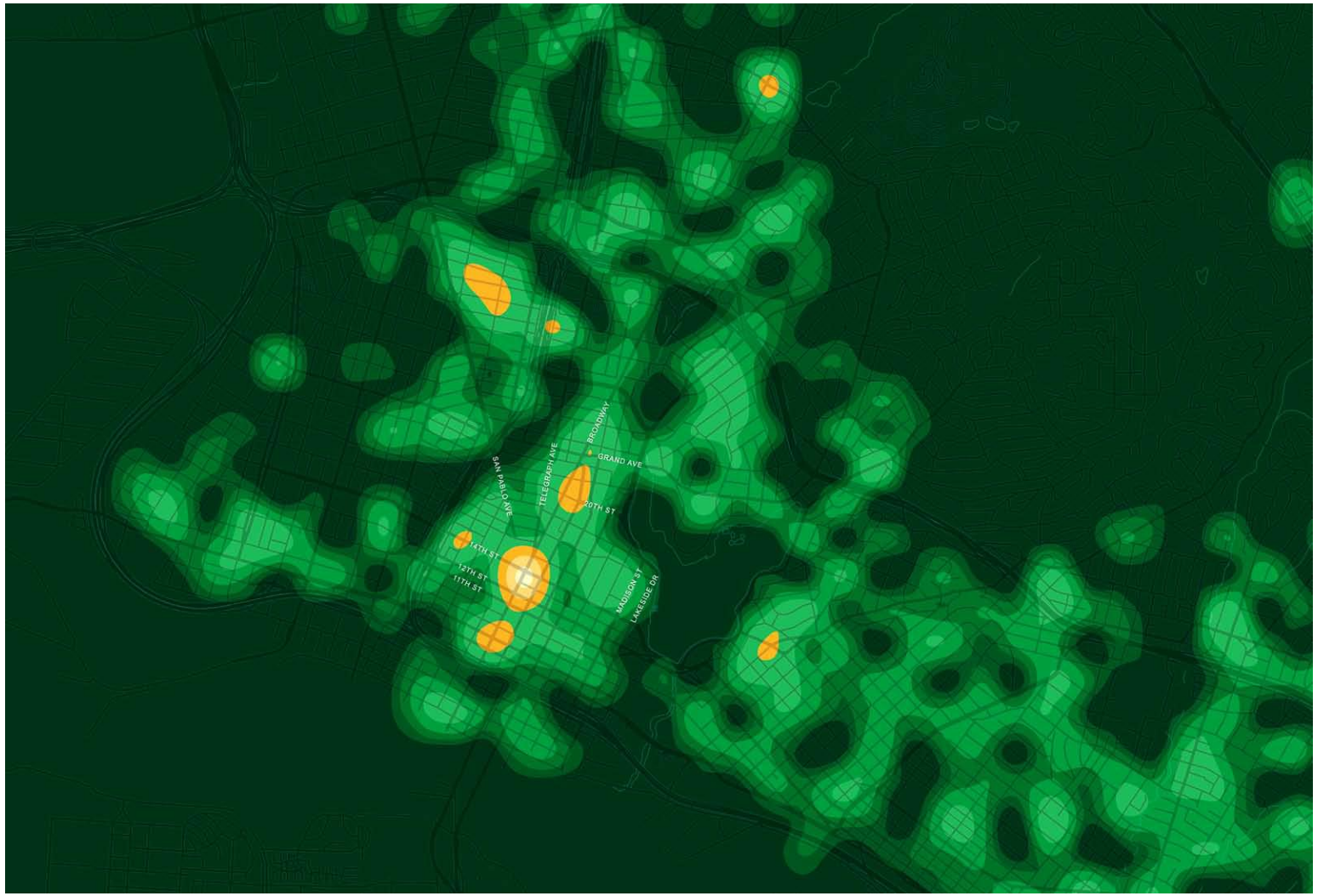


Continuous Data - Heat Maps

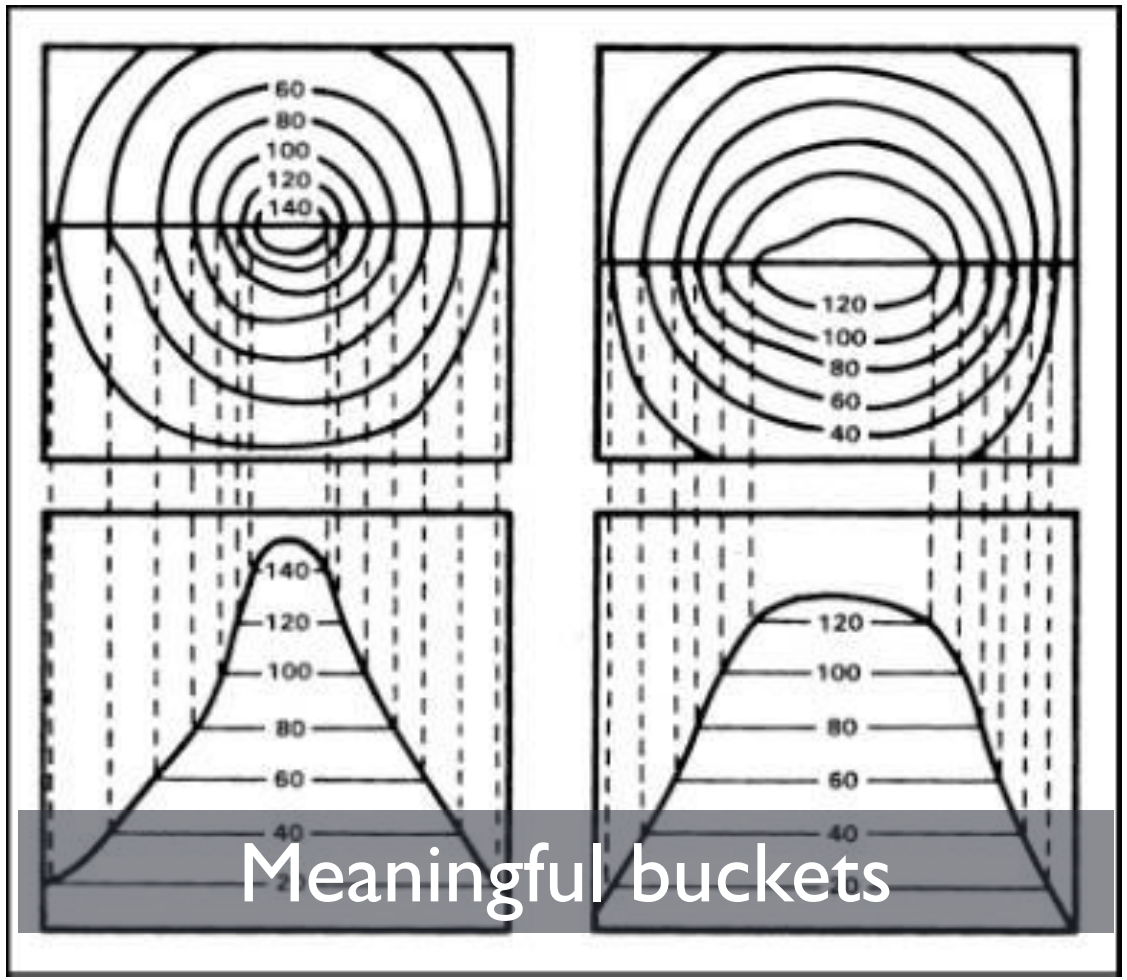


https://www.newscientist.com/gallery/small-world/

Continuous Data - Break data into buckets

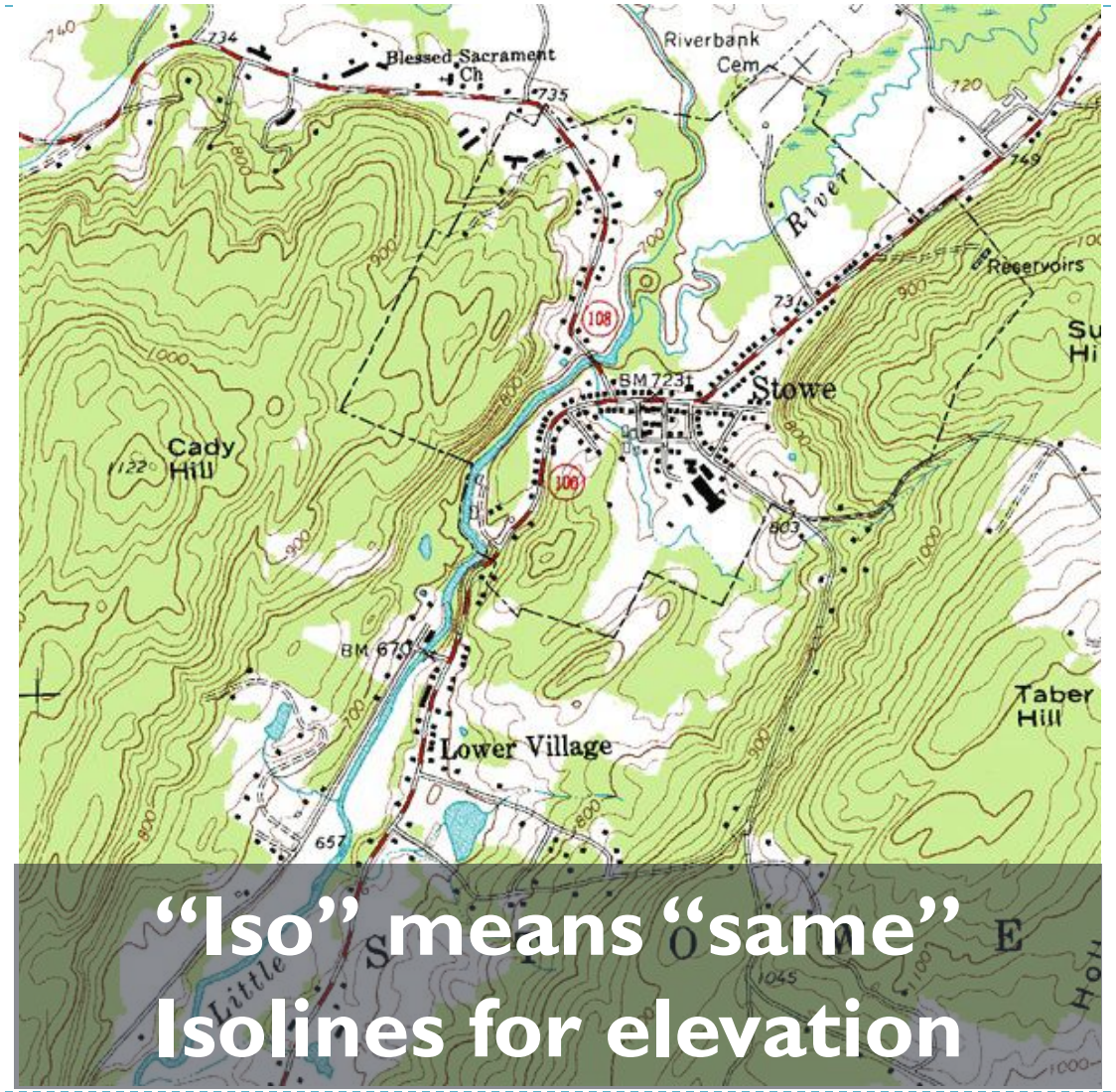


Continuous Data - Break data into buckets

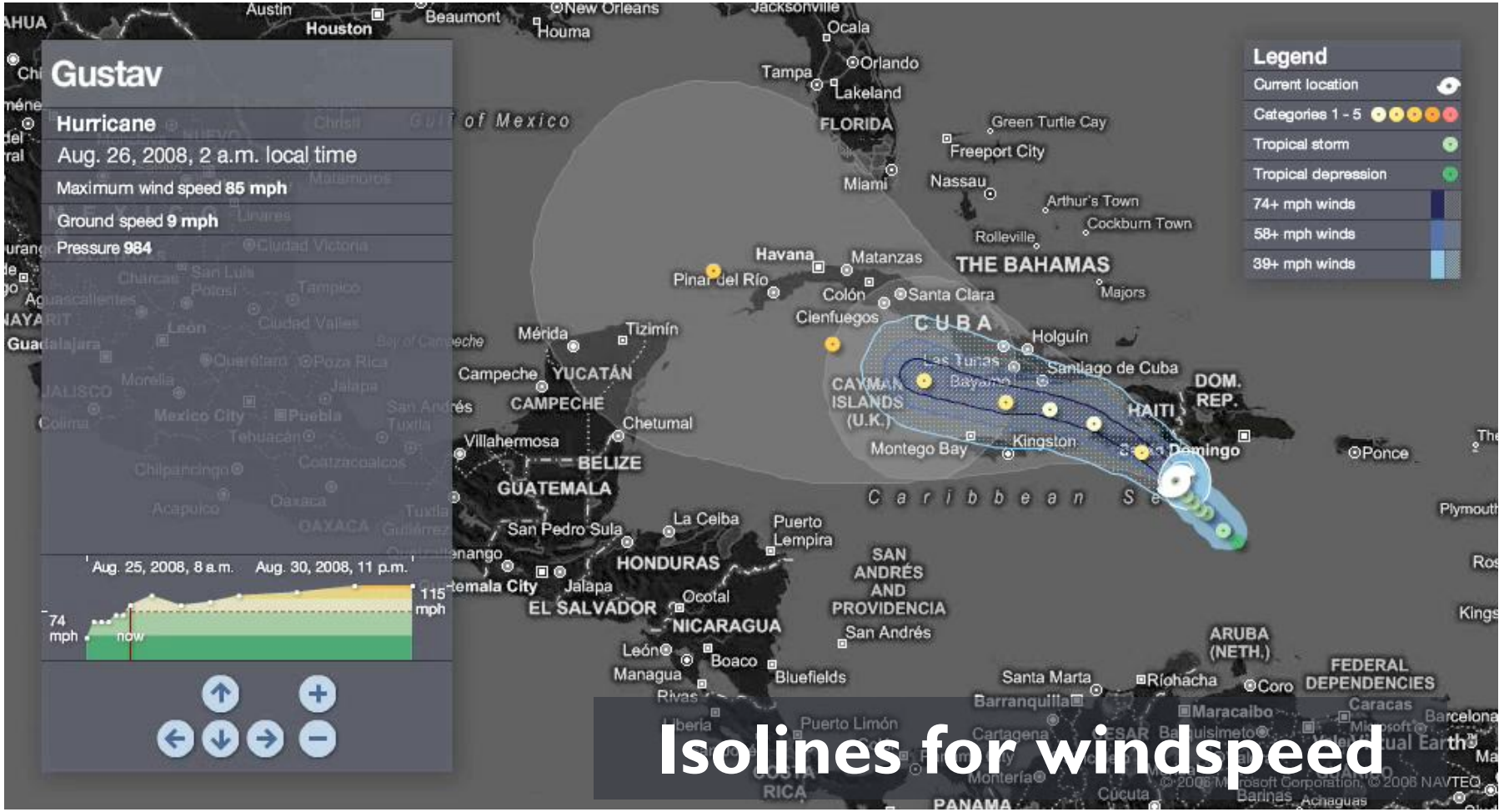


https://www.armystudyguide.com/content/SMCT_CTT_Tasks/Skill_Level_1/land-nav-task-6-determine.shtml

Continuous Data - Break data into buckets



Continuous Data - Break data into buckets



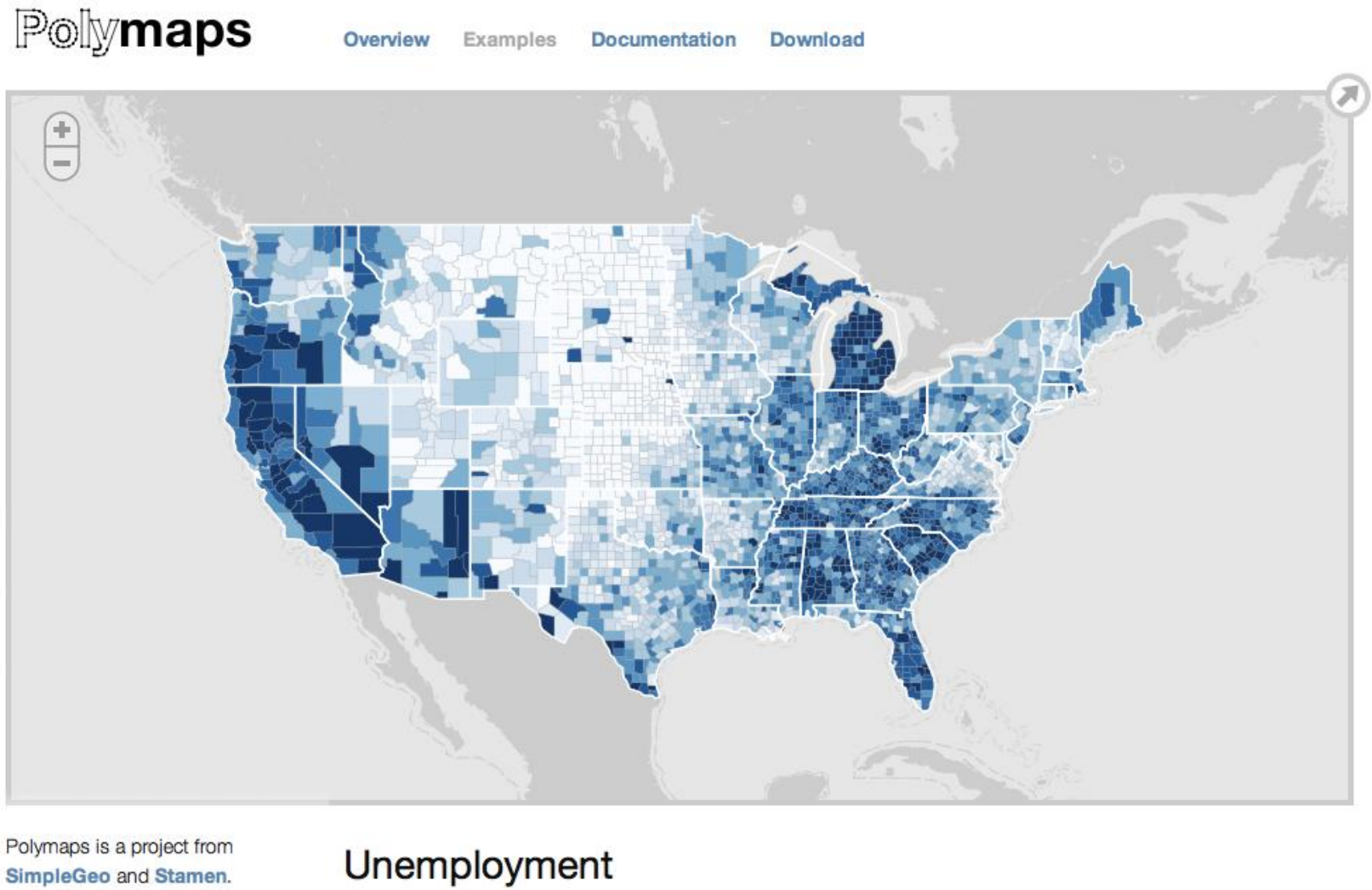
Choropleths

Choropleths

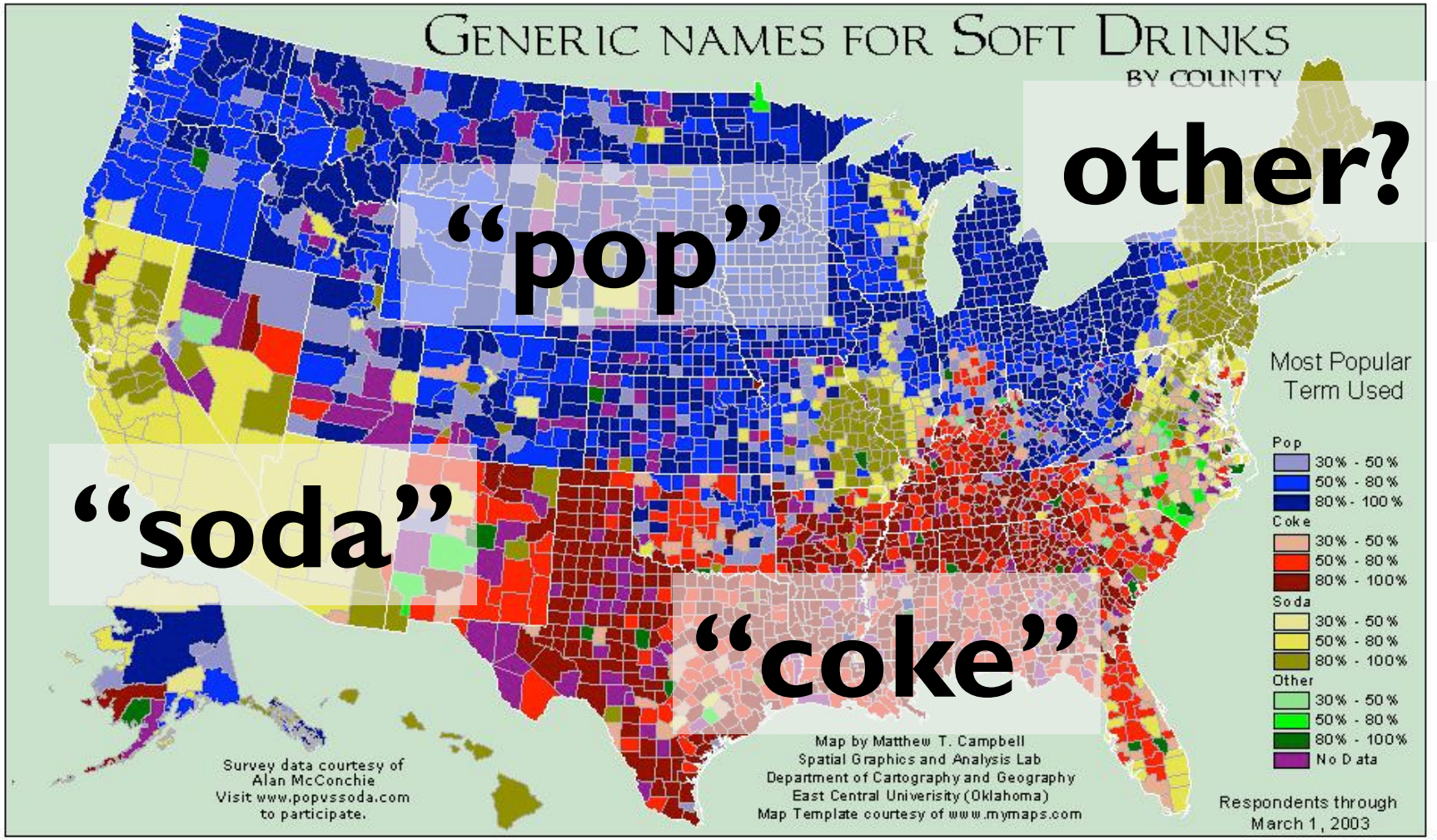
- The earliest known choropleth map was created in 1826 by Baron Pierre Charles Dupin.
- A thematic map in which areas are shaded or patterned in **proportion to the measurement of the statistical variable** being displayed on the map, such as population density or per-capita income.
- An easy way to visualize how a measurement varies across a geographic area or show the level of variability within a region.

- Ref: https://en.wikipedia.org/wiki/Choropleth_map

Choropleths



Choropleths



http://popvssoda.com/

Choropleths

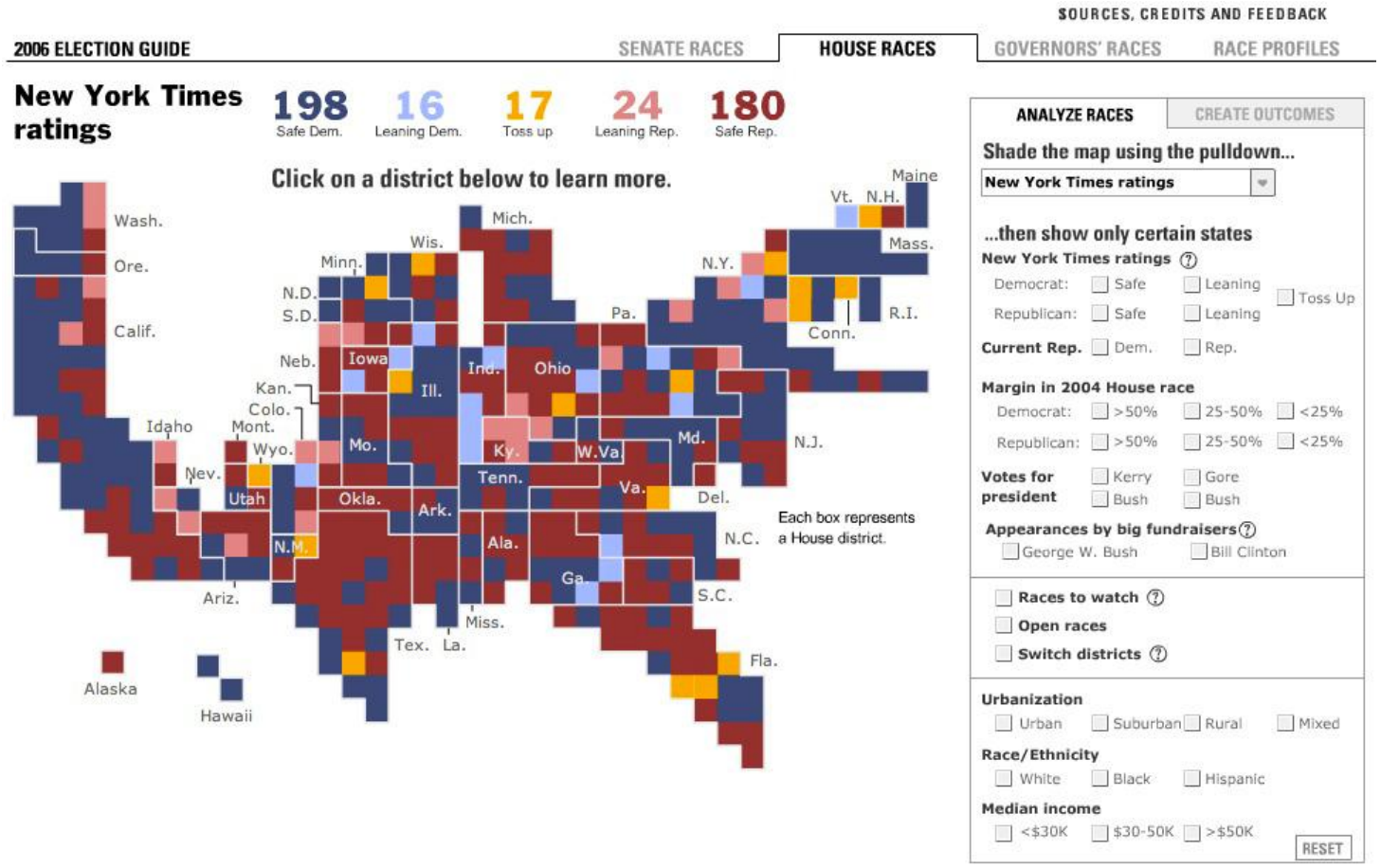
Cartograms

Cartograms

- A map in which some **thematic mapping variable** – such as travel time, or population – is substituted for land area or distance.
- The geometry or space of the map is distorted in order to convey the information of this alternate variable.
- Two common types of cartograms: **area** and **distance** cartograms.
- Cartograms have a fairly long history, with examples from the mid-1800s.

- Ref: https://en.wikipedia.org/wiki/Cartogram

Cartograms


SOURCES, CREDITS AND FEEDBACK
2006 ELECTION GUIDE
SENATE RACES
HOUSE RACES
GOVERNORS' RACES
RACE PROFILES
New York Times ratings
198 Safe Dem.
16 Leaning Dem.
17 Toss up
24 Leaning Rep.
180 Safe Rep.
Click on a district below to learn more.
Each box represents a House district.
ANALYZE RACES
CREATE OUTCOMES
Shade the map using the pulldown...
New York Times ratings
...then show only certain states
New York Times ratings
Democrat: Safe Leaning Toss Up
Republican: Safe Leaning
Current Rep. Dem. Rep.
Margin in 2004 House race
Democrat: >50% 25-50% <25%
Republican: >50% 25-50% <25%
Votes for president
Kerry Bush
Gore Bush
Appearances by big fundraisers
George W. Bush
Bill Clinton
Races to watch
Open races
Switch districts
Urbanization
Urban Suburban Rural Mixed
Race/Ethnicity
White Black Hispanic
Median income
<$30K $30-50K >$50K
RESET
Wash.
Ore.
Calif.
Idaho
Nev.
Mont.
Wyo.
Utah
Ariz.
Colo.
N.M.
Kan.
Neb.
S.D.
N.D.
Minn.
Iowa
Mo.
Okla.
Ark.
Tex.
La.
Miss.
Ala.
Ga.
Fla.
S.C.
N.C.
Va.
W.Va
Ky.
Tenn.
Ohio
Ind.
Ill.
Mich.
Wis.
Pa.
N.Y.
Md.
Del.
N.J.
Conn.
R.I.
Mass.
Vt.
N.H.
Maine
Alaska
Hawaii

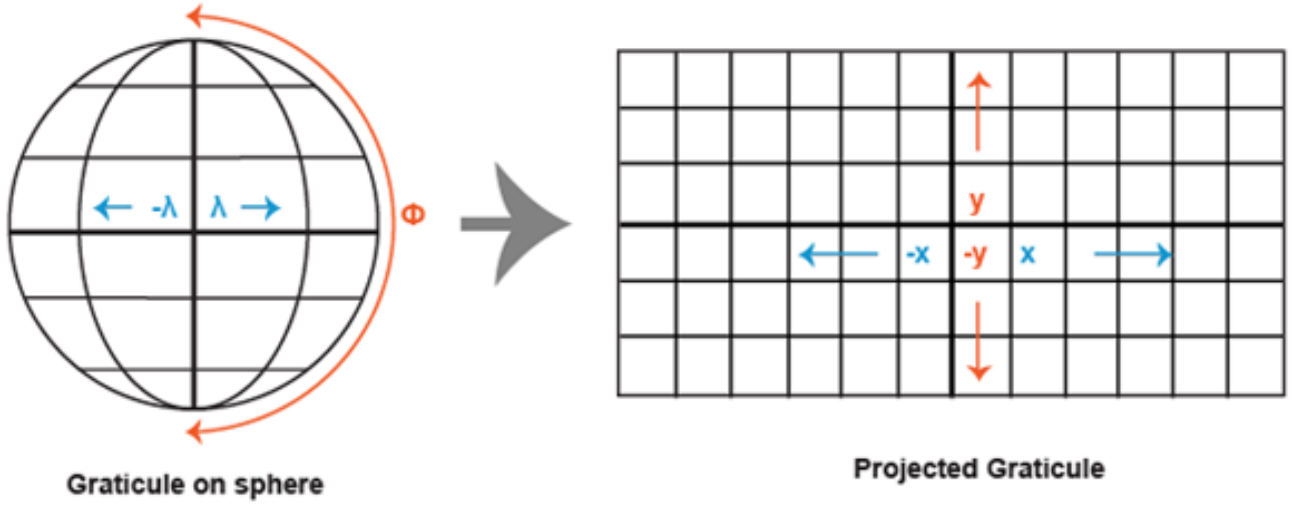
Cartography

Map Projection

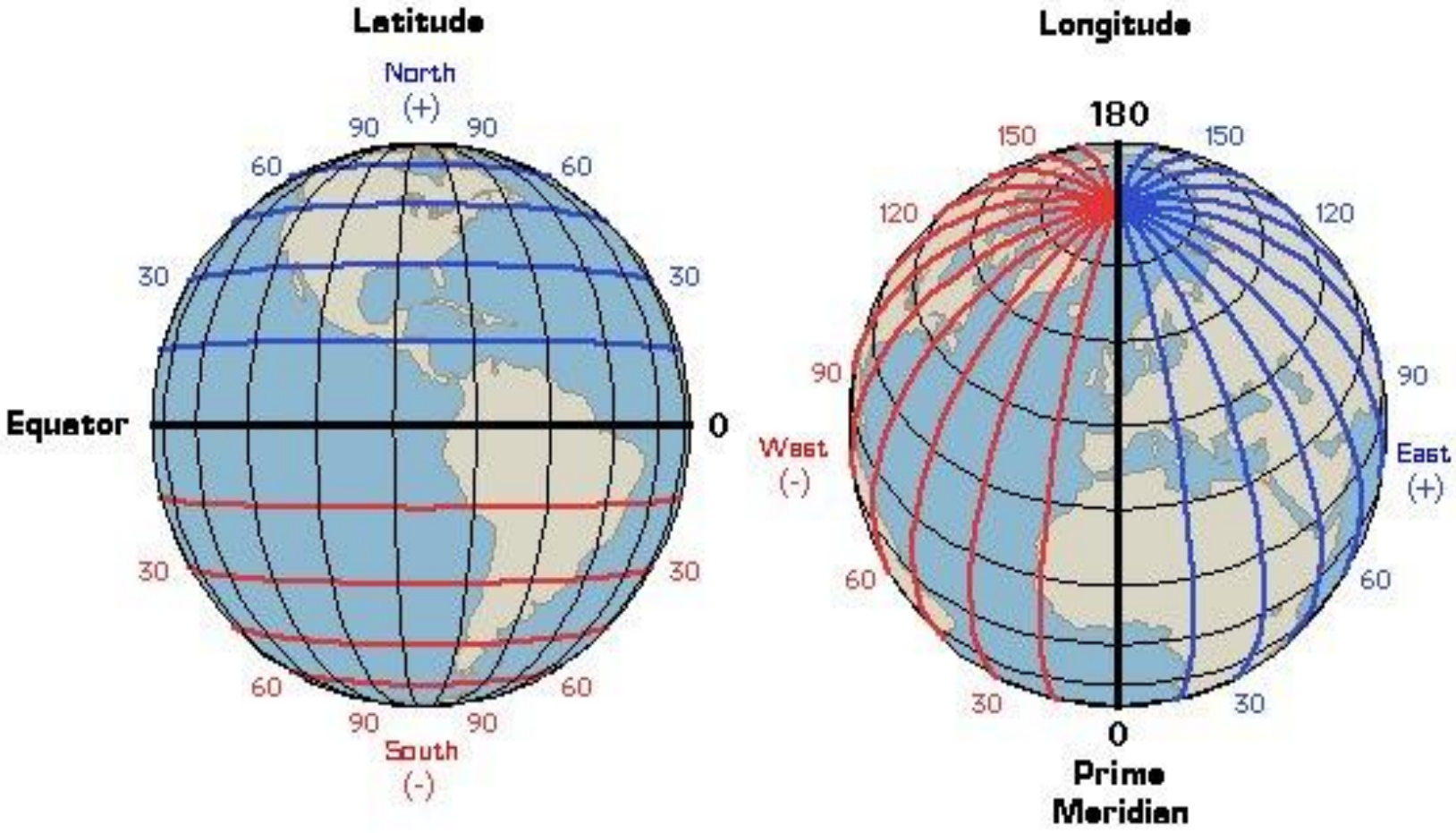
Flattening the globe onto a flat screen

Map Projection

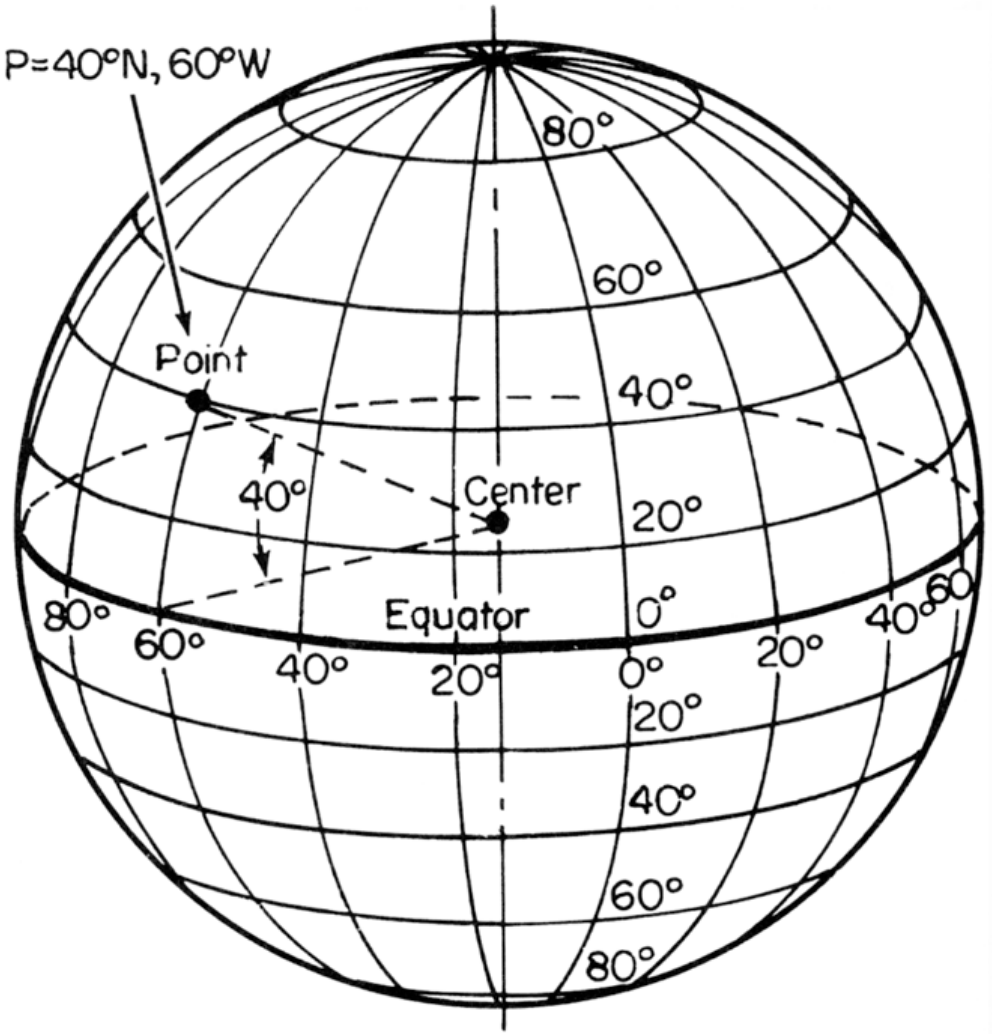
- A **map projection** is *a systematic transformation of the latitudes and longitudes of locations from the surface of a sphere or an ellipsoid into locations on a plane.*
- **Maps** cannot be created without **map projections**.
- All **map projections** necessarily distort the surface in some fashion.



Latitude and Longitude



Latitude and Longitude



Batch Geocoding

- Geocoding is the process of taking input text, such as an address or the name of a place, and returning a latitude/longitude location on the Earth's surface for that place.

- Most tools would require a Map API key: Bing, MapQuest, Google

- Some popular approaches for geocoding:
  - Cloud tool: http://www.gpsvisualizer.com/geocoder/
  - Python: https://www.geoapify.com/tutorial/geocoding-python
  - Google Sheet (Geocode plug-in): https://workspace.google.com/marketplace/app/geocode_by_awesome_table/904124517349

Distance between two lat/long points

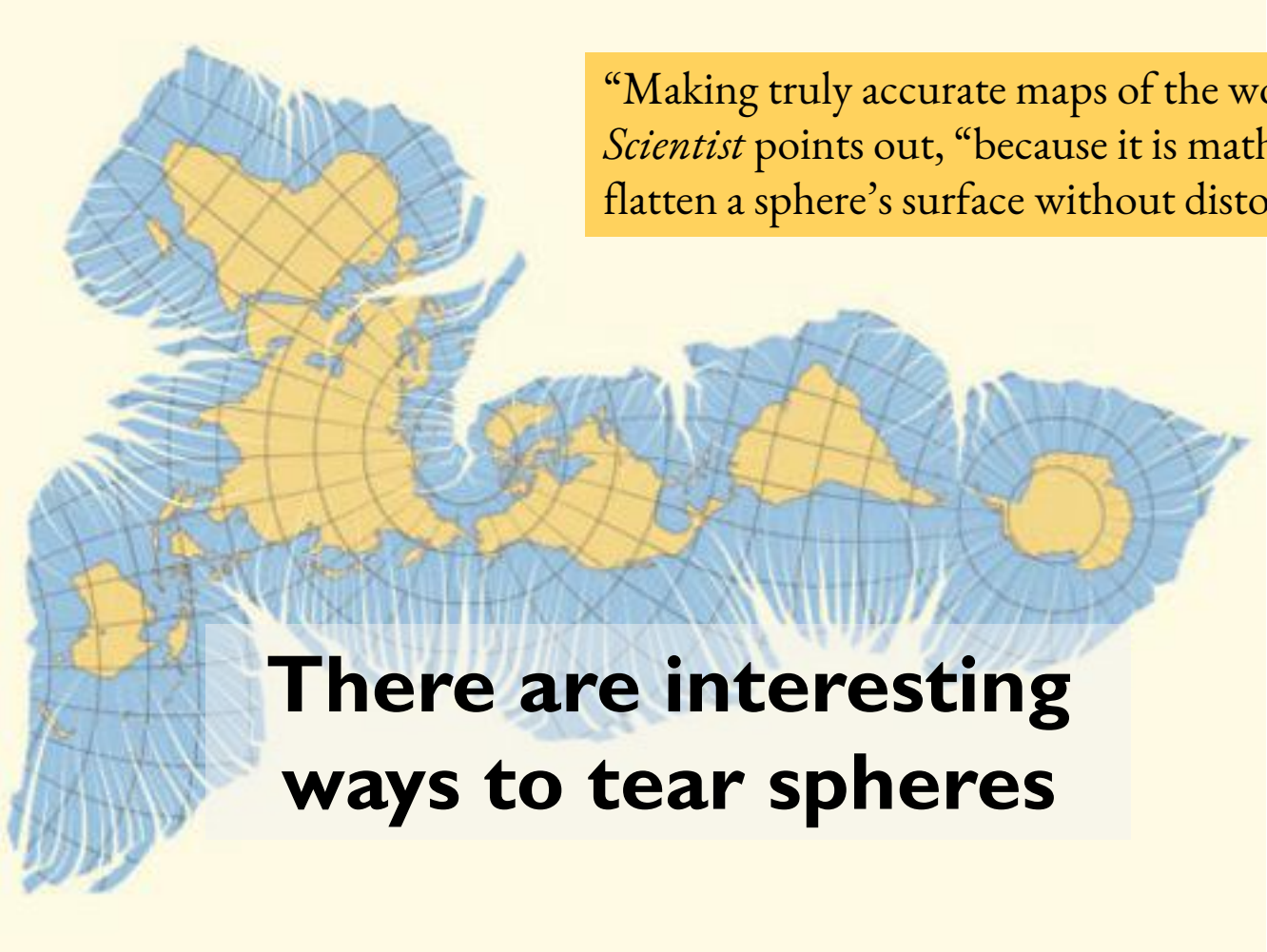
Calculate Distance between two lat/long points
(the problem - the world is not flat)

```
= acos(cos(radians(90-Lat1)) *cos(radians(90-Lat2))
     +SIN(radians(90-Lat1)) *SIN(radians(90-Lat2))
     *cos(radians(Long1-Long2))) *6371
```

To calculate distances in miles, substitute R (6371) with 3958.756 (and for nautical miles, use 3440.065)

Map Projection

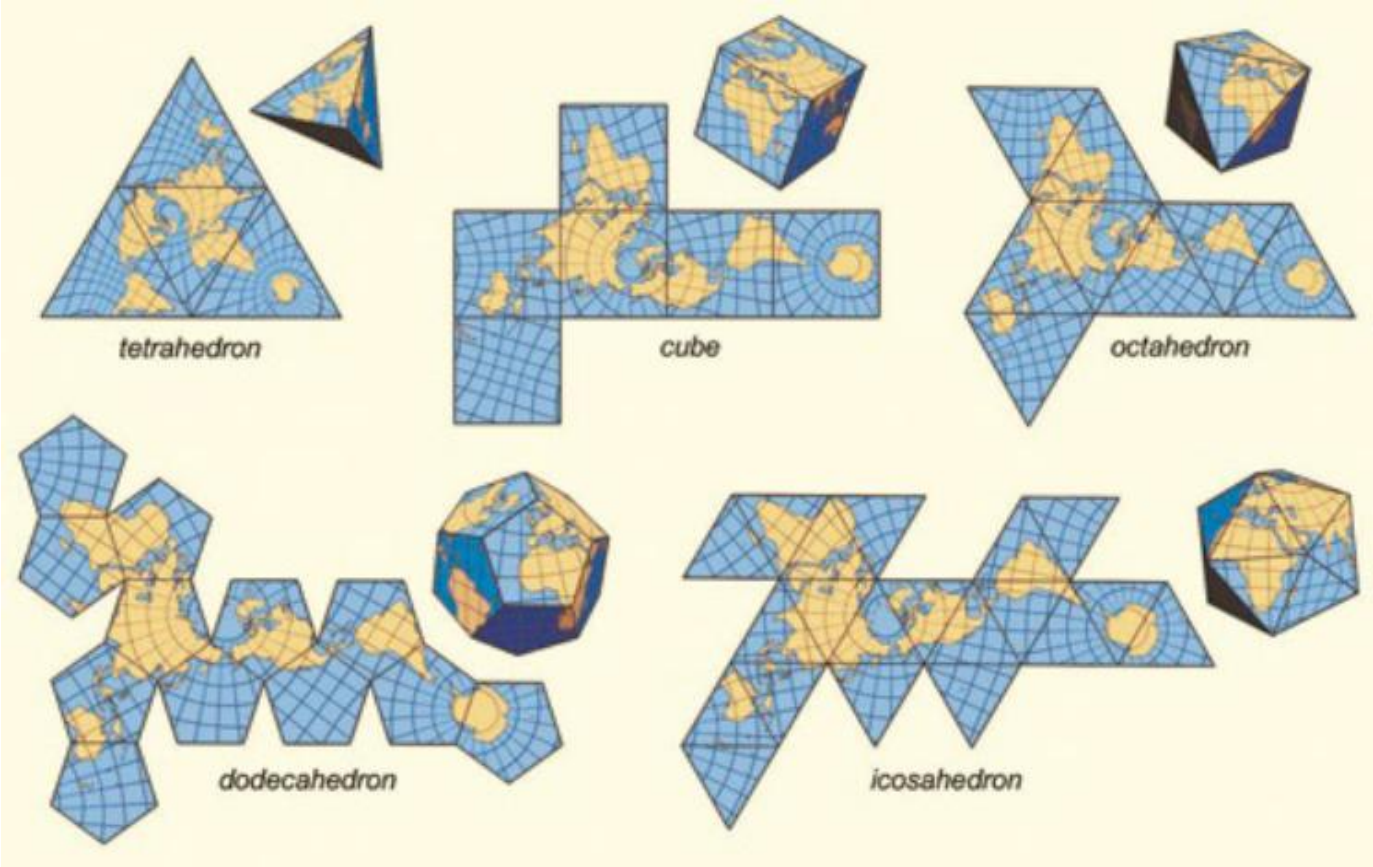
Map Projection



"Making truly accurate maps of the world is difficult," *New Scientist* points out, "because it is mathematically impossible to flatten a sphere's surface without distorting or cracking it.

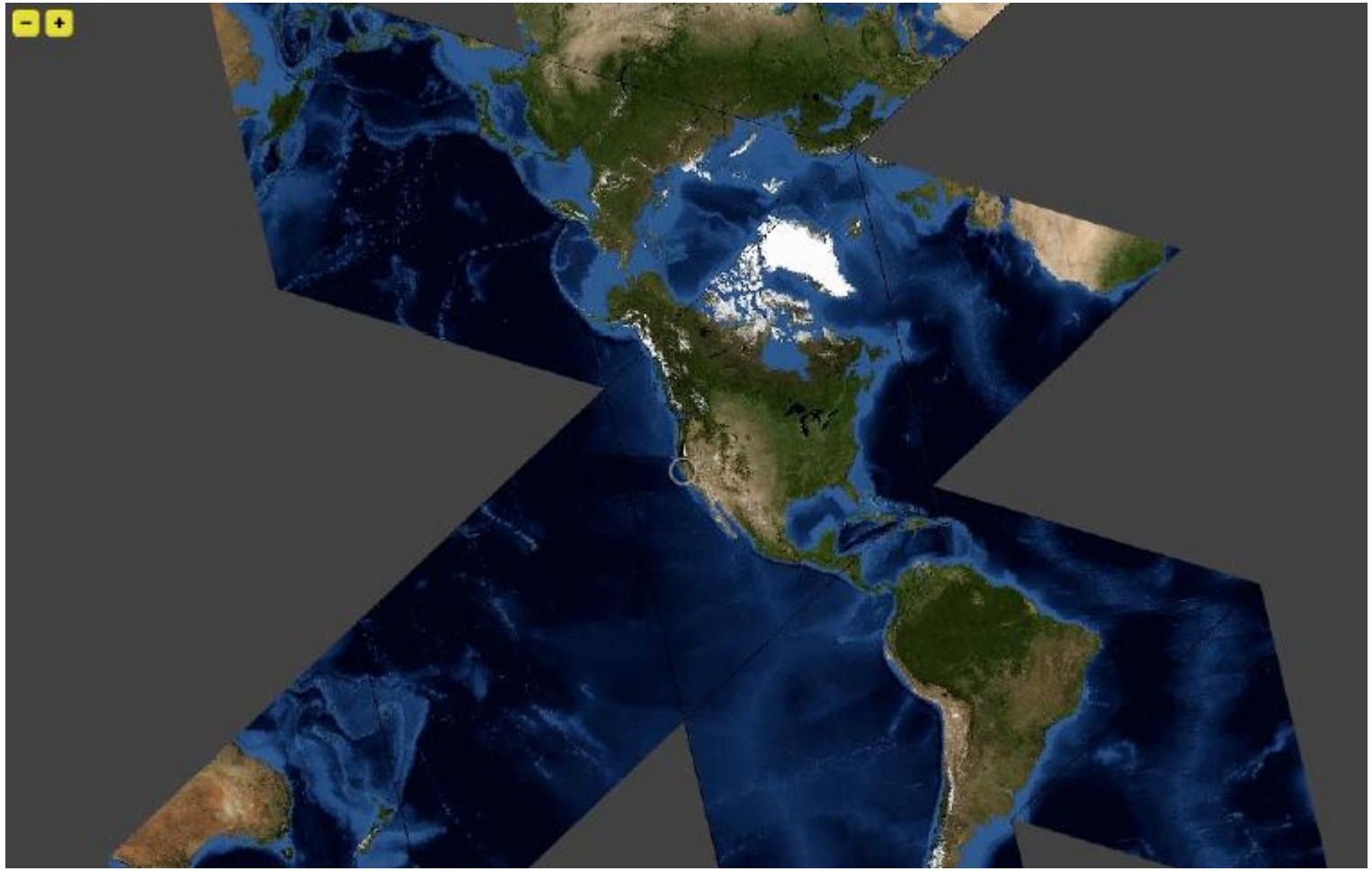
There are interesting ways to tear spheres

Map Projection

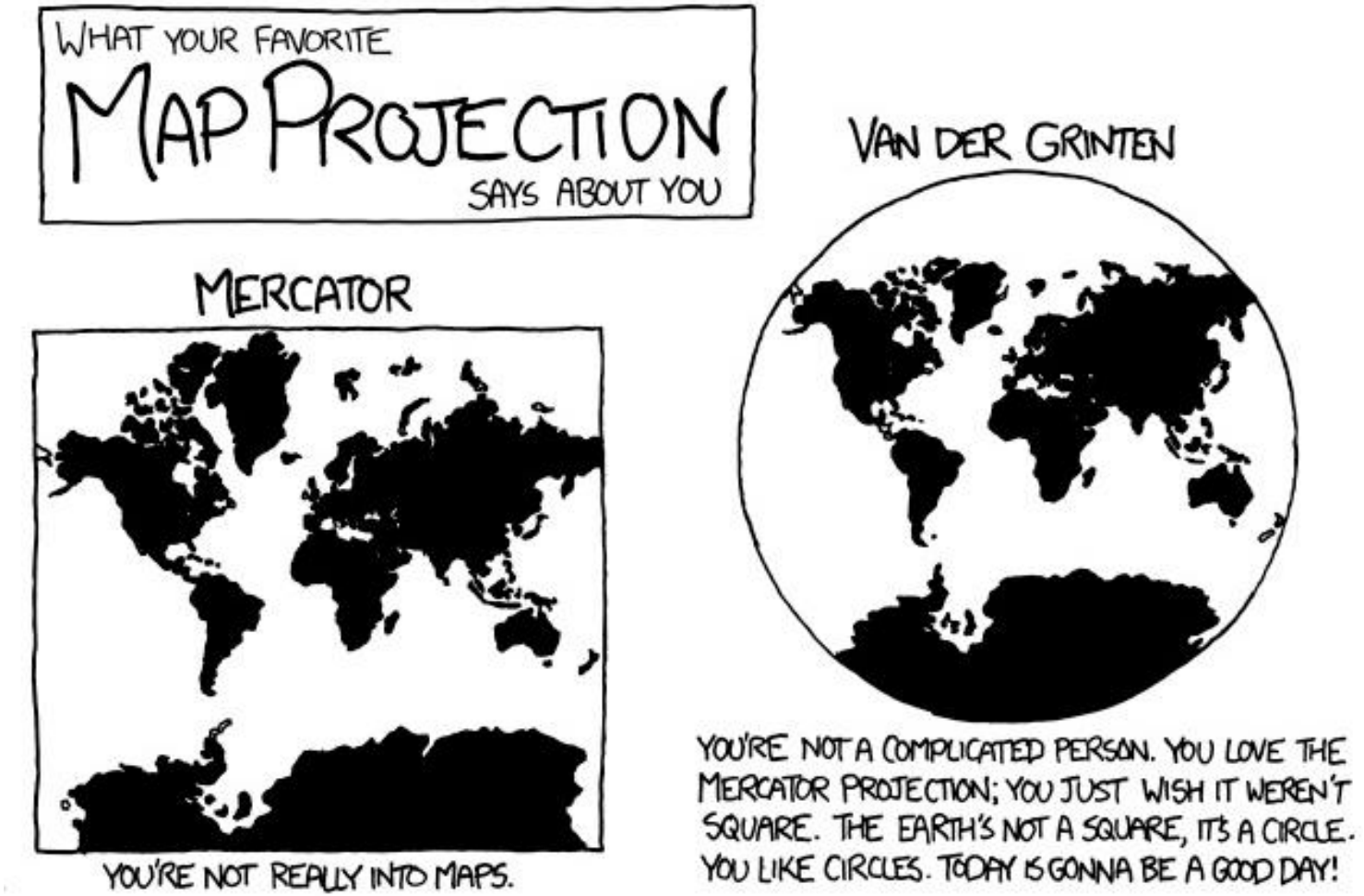


http://www.bldgblog.com/2009/12/cracking-the-planet/

Mapping Projection

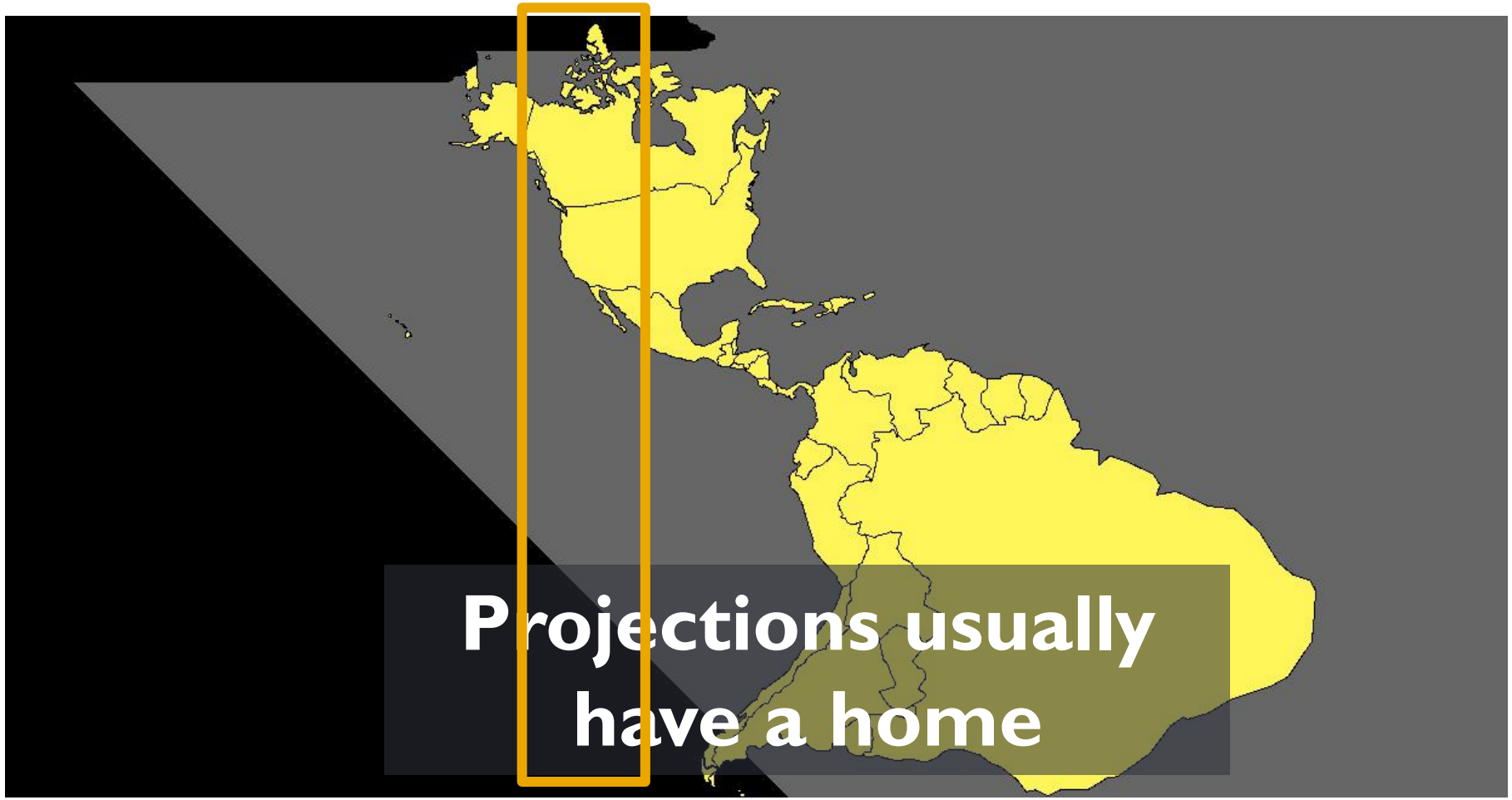


Map Projection

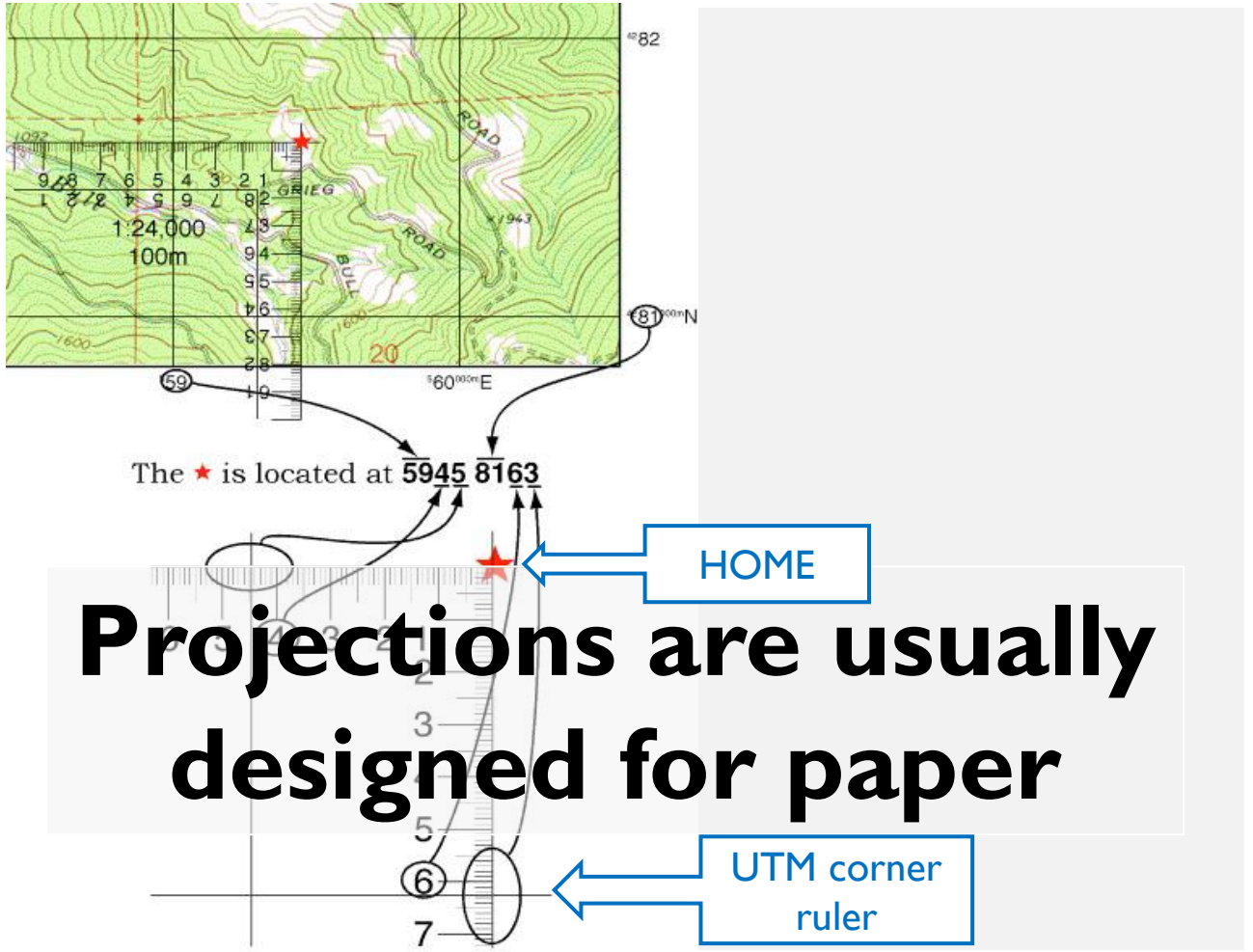


http://xkcd.com/977

Map Projection



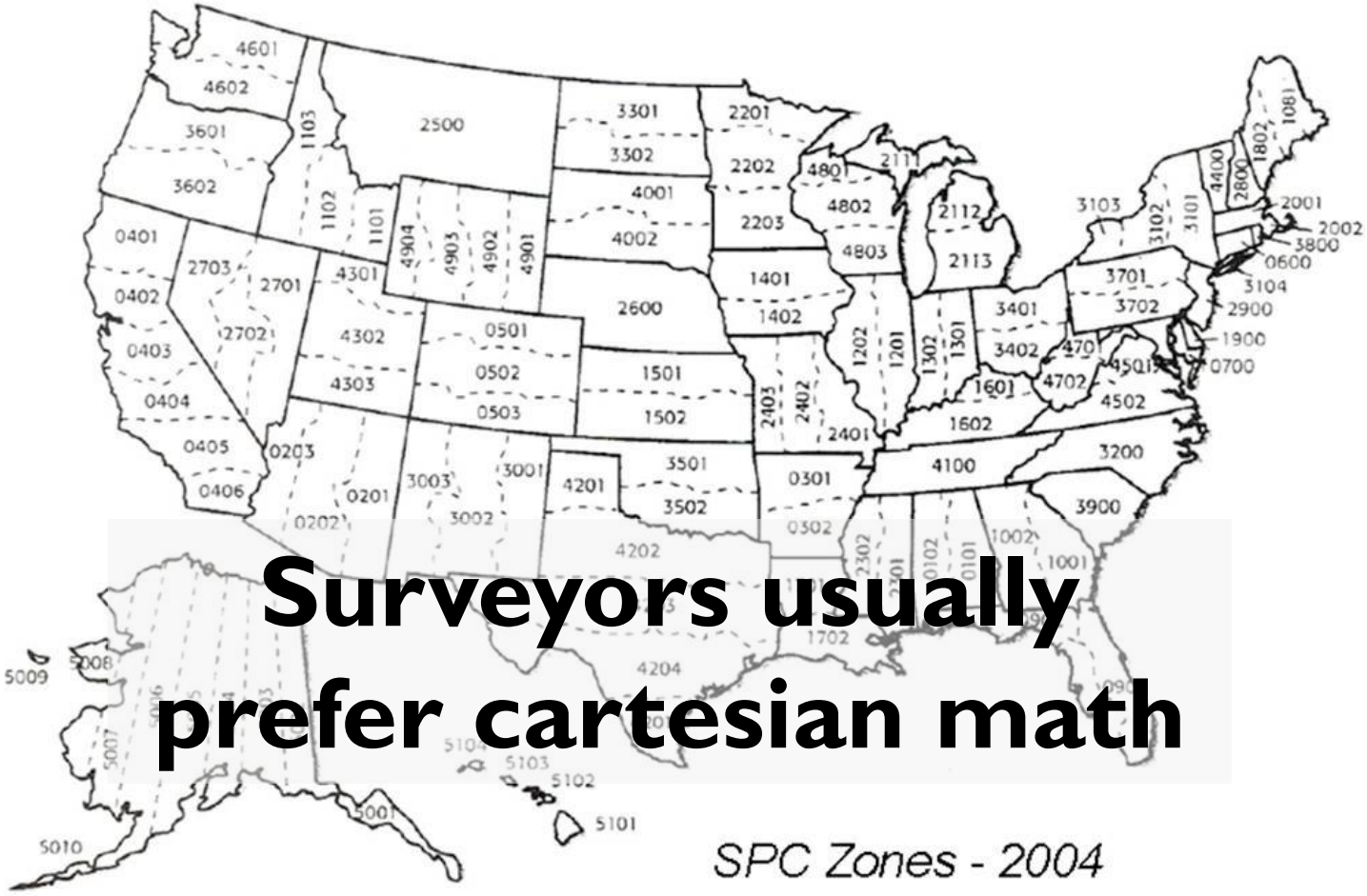
Map Projection



Projections are usually designed for paper

https://www.maptools.com/tutorials/utm/corner_tools

Map Projection



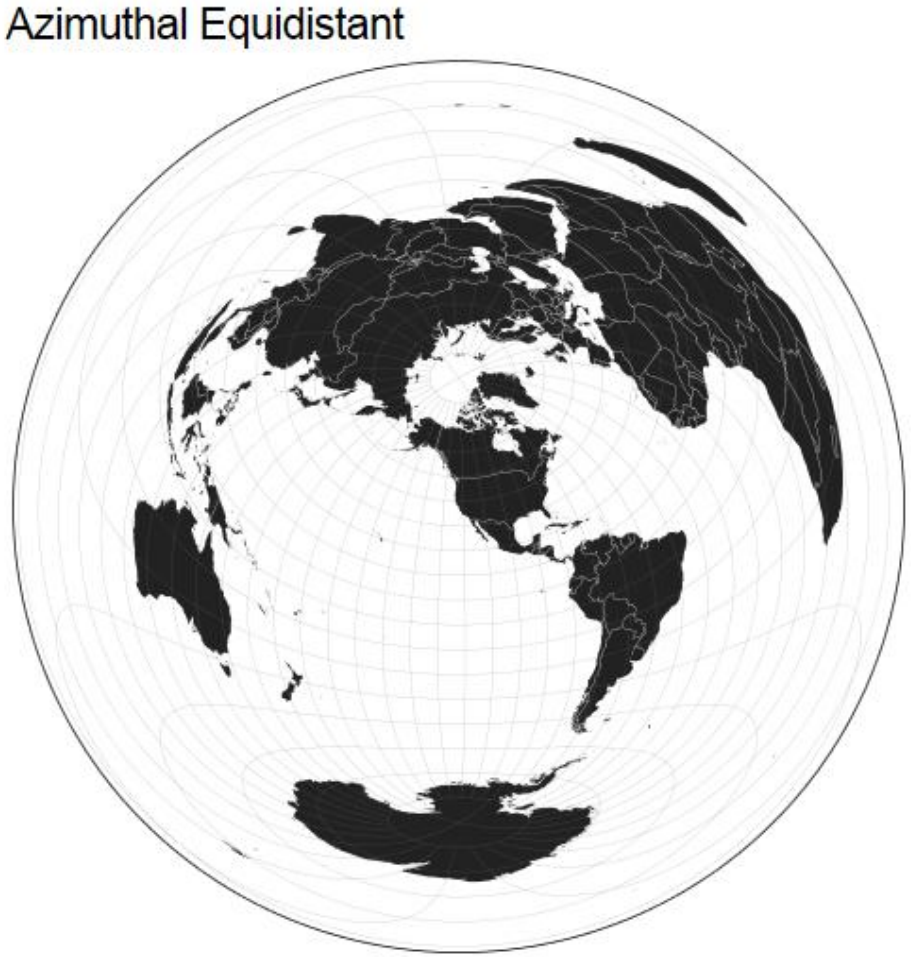
Surveyors usually prefer cartesian math

Map Projections: Distortion

- No projection allows us to flatten the globe without distorting it.
- When positions on the graticule are transformed to positions on a projected grid, four types of distortion can occur: distortion of **sizes**, **angles**, **distances**, and **directions**.
- Map projections that avoid one or more of these types of distortion are said to preserve certain properties of the globe:
  1. equivalence – preserves area
  2. conformality – preserves shape
  3. azimuthality – preserves direction
  4. equidistance – preserves distance
- Ref: https://www.e-education.psu.edu/geog160/node/1918
  https://en.wikipedia.org/wiki/List_of_map_projections

Categorizing Map Projection: Azimuthal

Categorizing Map Projection: Azimuthal

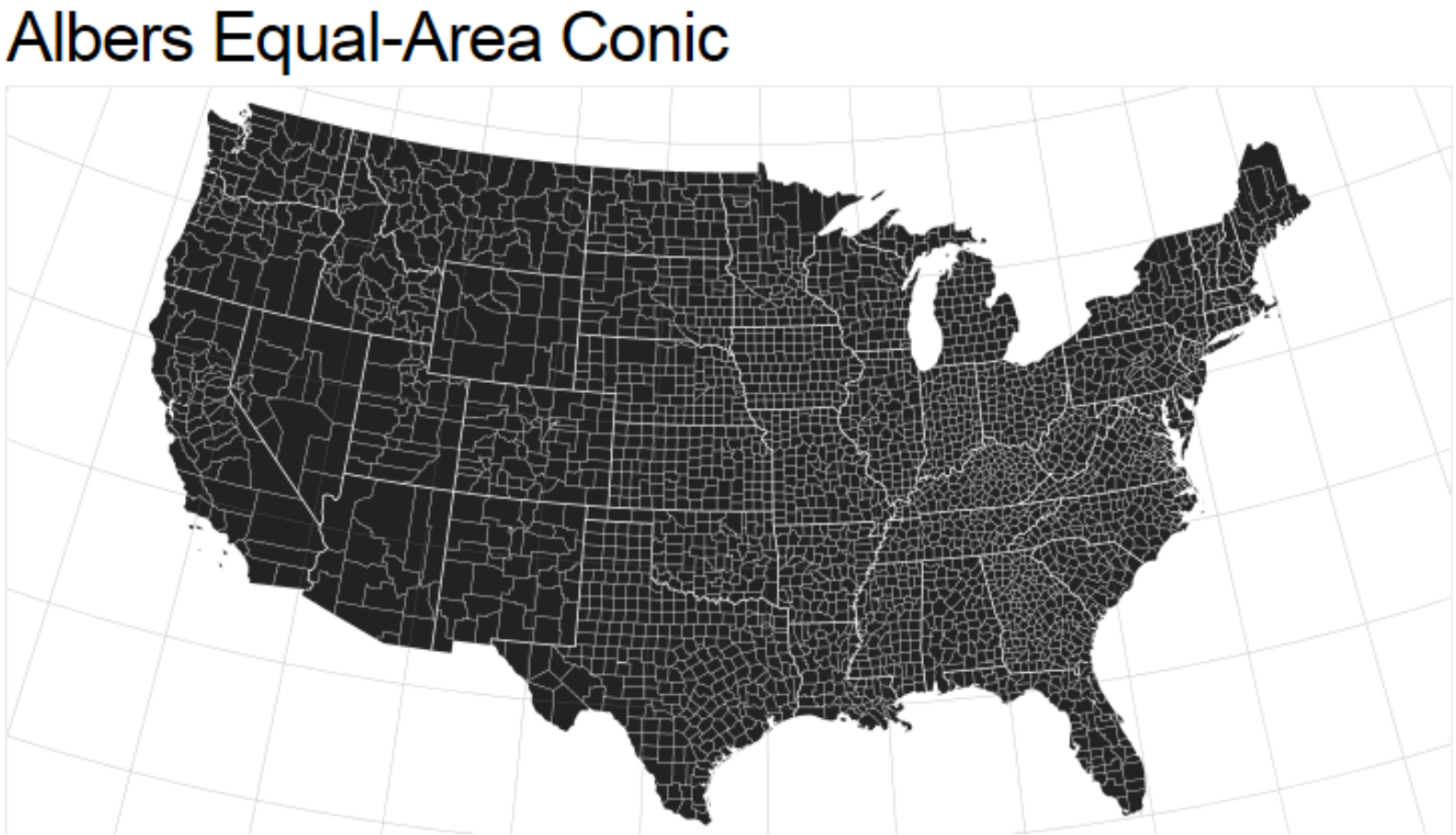


azimuthal equidistant projection

d3.geoAzimuthalEquidistant

Categorizing Map Projection: Equal-Area

Categorizing Map Projection: Equal-Area



Albers equal-area conic projection

d3.geoAlbers

Categorizing Map Projection: Conformal

Categorizing Map Projection: Conformal

Mercator projection

d3.geoMercator

Categorizing Map Projection: Conformal

Spherical Mercator

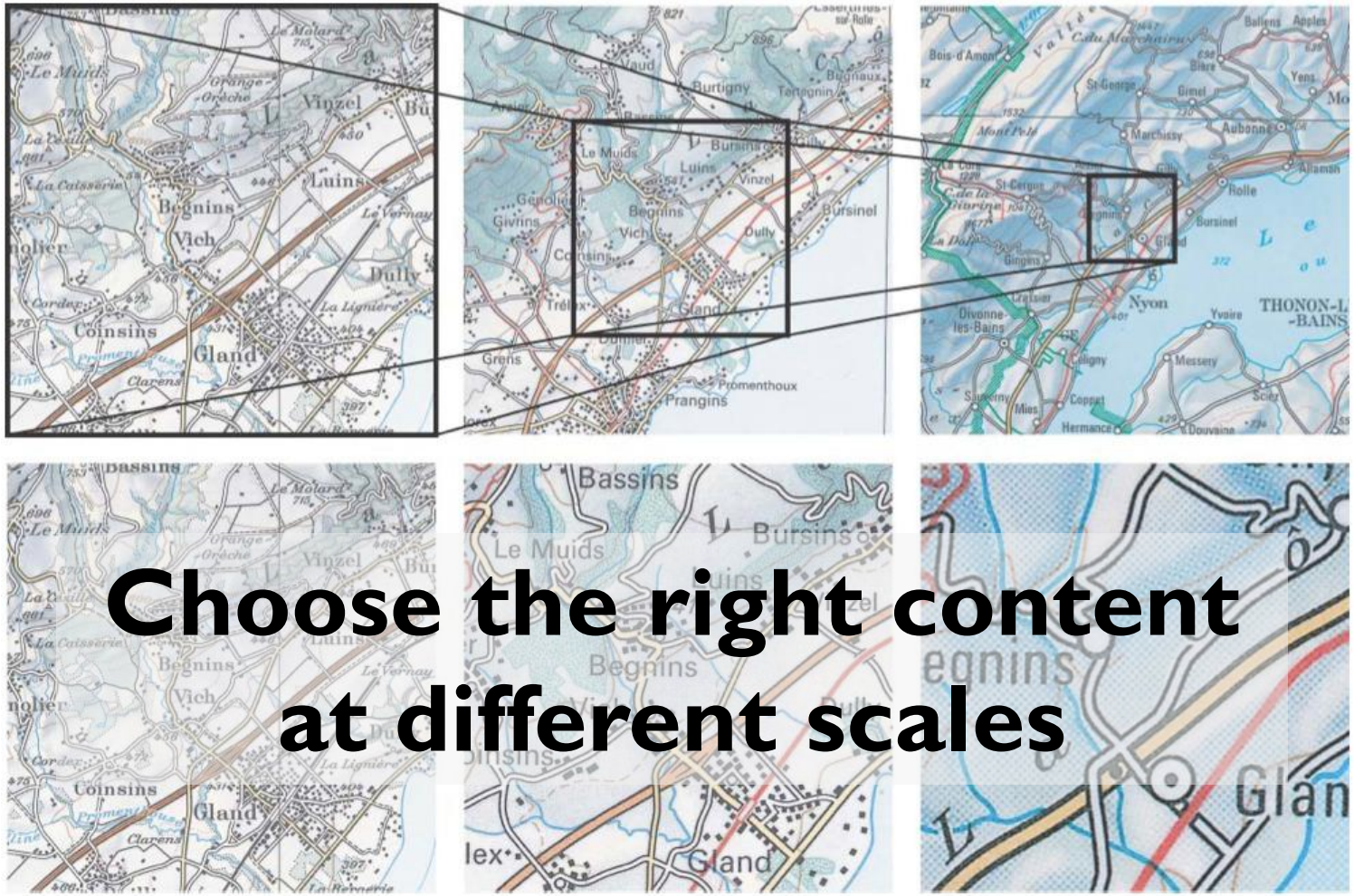
- A **cylindrical map projection** presented by the Flemish geographer and cartographer Gerardus Mercator in 1569.
- The standard map projection for nautical purposes.
- Being a **conformal projection**, angles are preserved around all locations.
- A de facto term used inside the OpenLayers community – and also the other existing Open Source GIS community.
- Describes the projection used by *Google Maps*, *Microsoft Bing Maps*, and other commercial API providers.

- Ref: https://en.wikipedia.org/wiki/Mercator_projection

Scale

How big is your map?

Scale



Scale

Four maps, same area

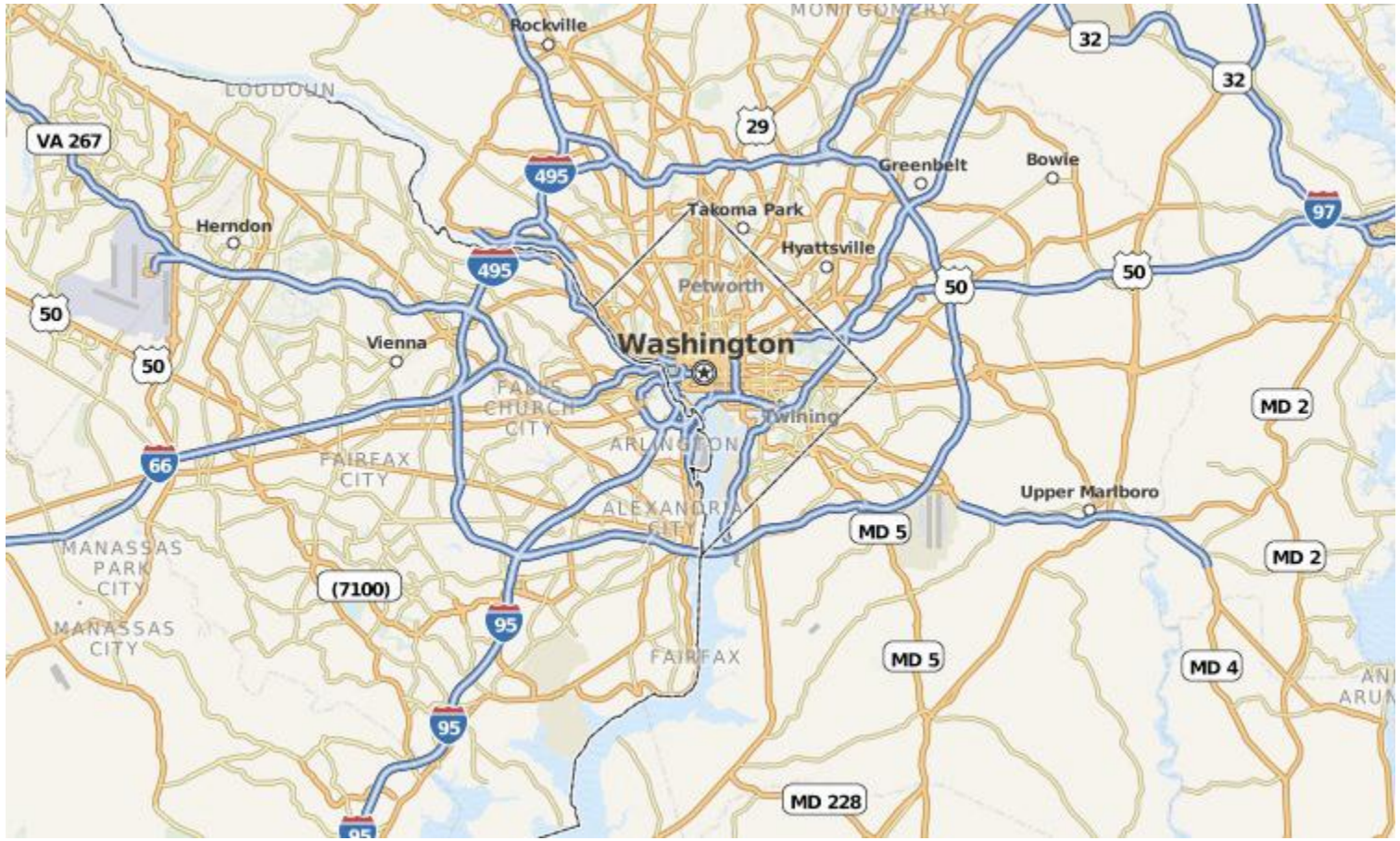
Scale

What is shown at deferent scales?

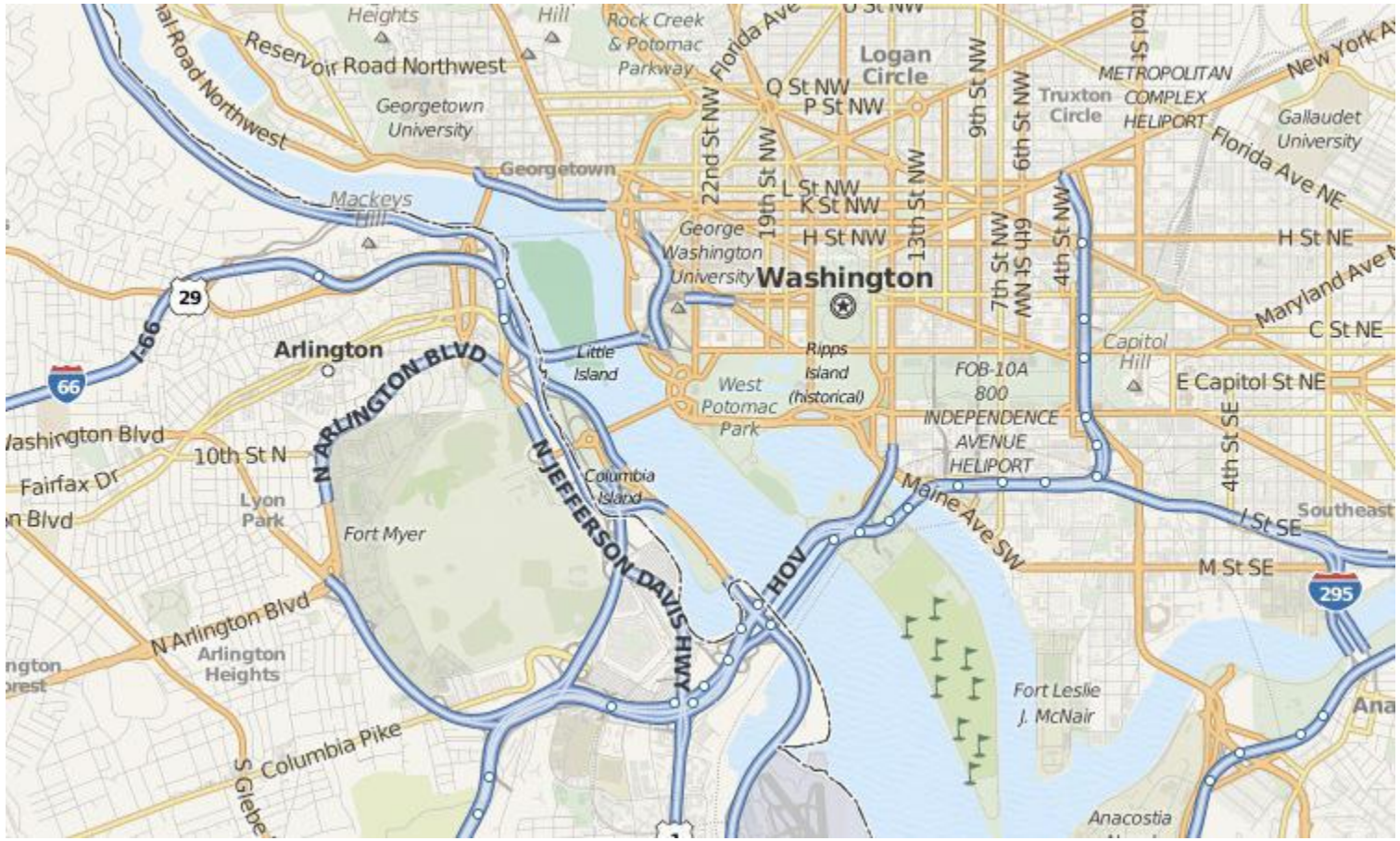
Scale


Pittsburgh
Harrisburg
Reading
Camden
NEW JERSEY
Cumberland
MARYLAND
Millville
Washington
DELAWARE
WEST VIRGINIA
Harrisonburg
Richmond
Roanoke
VIRGINIA
Suffolk
70
79
76
83
68
81
95
64
85

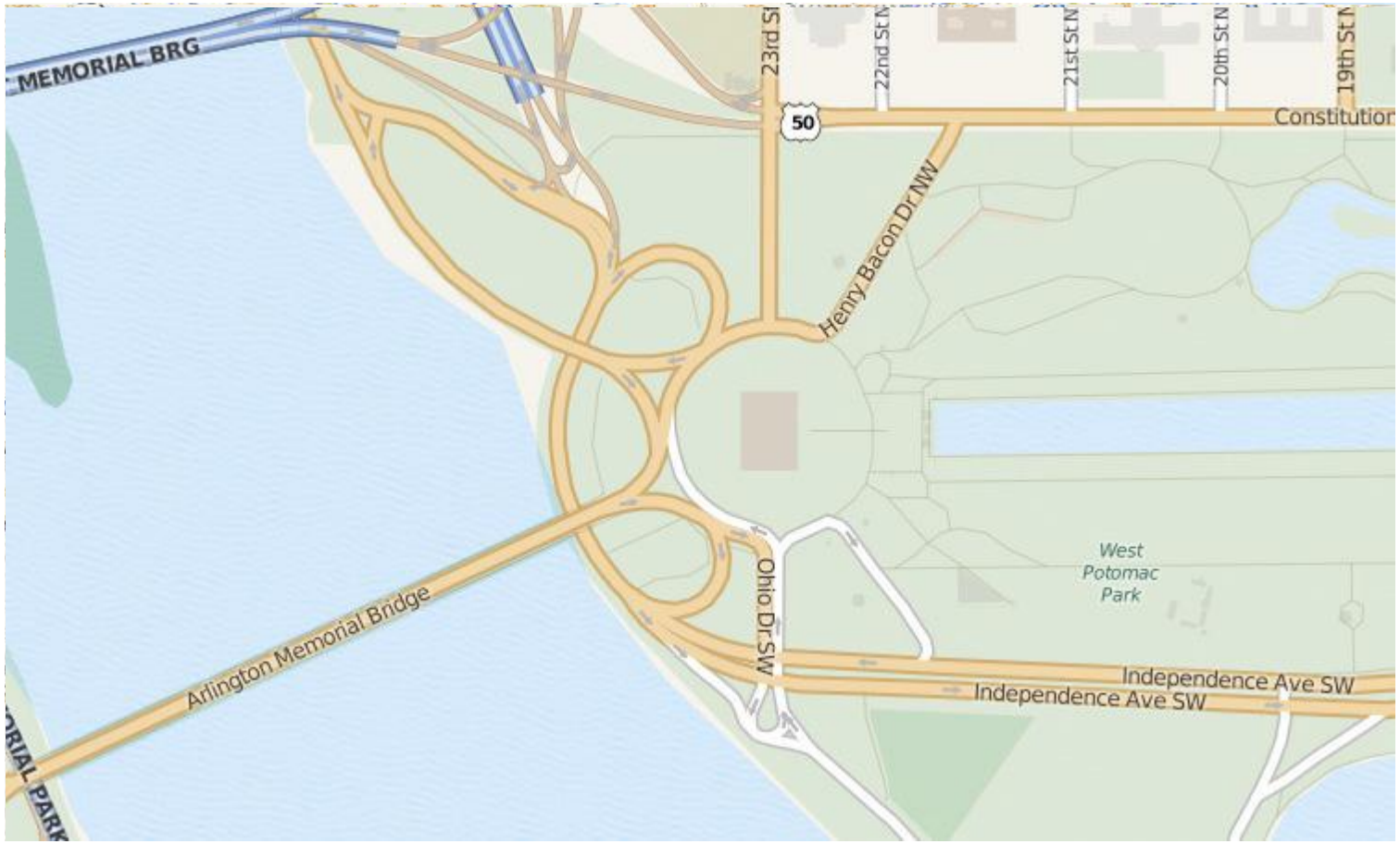
Scale


Rockville
LOUDOUN
VA 267
29
495
Greenbelt
Bowie
32
32
97
Takoma Park
Hyattsville
Herndon
495
50
50
Petworth
50
50
Vienna
Washington
MD 2
Falls Church City
Arlington
Twining
66
Fairfax City
Upper Marlboro
Alexandria City
MD 5
MD 2
Manassas Park City
(7100)
95
Manassas City
Fairfax
MD 5
MD 4
95
MD 228

Scale


Reservoir Road Northwest
Georgetown University
Georgetown
Mackeys Hill
Rock Creek & Potomac Parkway
Logan Circle
Q St NW
P St NW
L St NW
K St NW
H St NW
George Washington University
Washington
Truxton Circle
METROPOLITAN COMPLEX HELIPORT
Gallaudet University
Florida Ave NE
H St NE
Maryland Ave
C St NE
E Capitol St NE
Capitol Hill
Arlington
Little Island
Ripps Island (historical)
West Potomac Park
FOB-10A
800 INDEPENDENCE AVENUE HELIPORT
Washington Blvd
10th St N
Fairfax Dr
Lyon Park
Fort Myer
N ARLINGTON BLVD
N JEFFERSON DAVIS HWY
HOV
Columbia Island
Maine Ave SW
I St SE
M St SE
Southeast
N Arlington Blvd
Arlington Heights
Columbia Pike
Fort Leslie J. McNair
Anacostia
I-66
29
66
295
22nd St NW
19th St NW
13th St NW
9th St NW
7th St NW
6th St NW
4th St NW
4th St SE

Scale


MEMORIAL BRG
23rd St
22nd St N
21st St N
20th St N
19th St N
50
Constitution
Henry Bacon Dr NW
West
Potomac
Park
Ohio Dr SW
Arlington Memorial Bridge
Independence Ave SW
Independence Ave SW

Data

Where data for maps comes from?

Data

Large scale data, 1:10m

Cultural | Physical | Raster

The most detailed. Suitable for making zoomed-in maps of countries and regions. Show the world on a large wall poster.

1:10,000,000
1" = 158 miles
1 cm = 100 km

Medium scale data, 1:50m

Cultural | Physical | Raster

Suitable for making zoomed-out maps of countries and regions. Show the world on a tabloid size page.

1:50,000,000
1" = 790 miles
1 cm = 500 km

Small scale data, 1:110m

Cultural | Physical

Suitable for schematic maps of the world on a postcard or as a small locator globe.

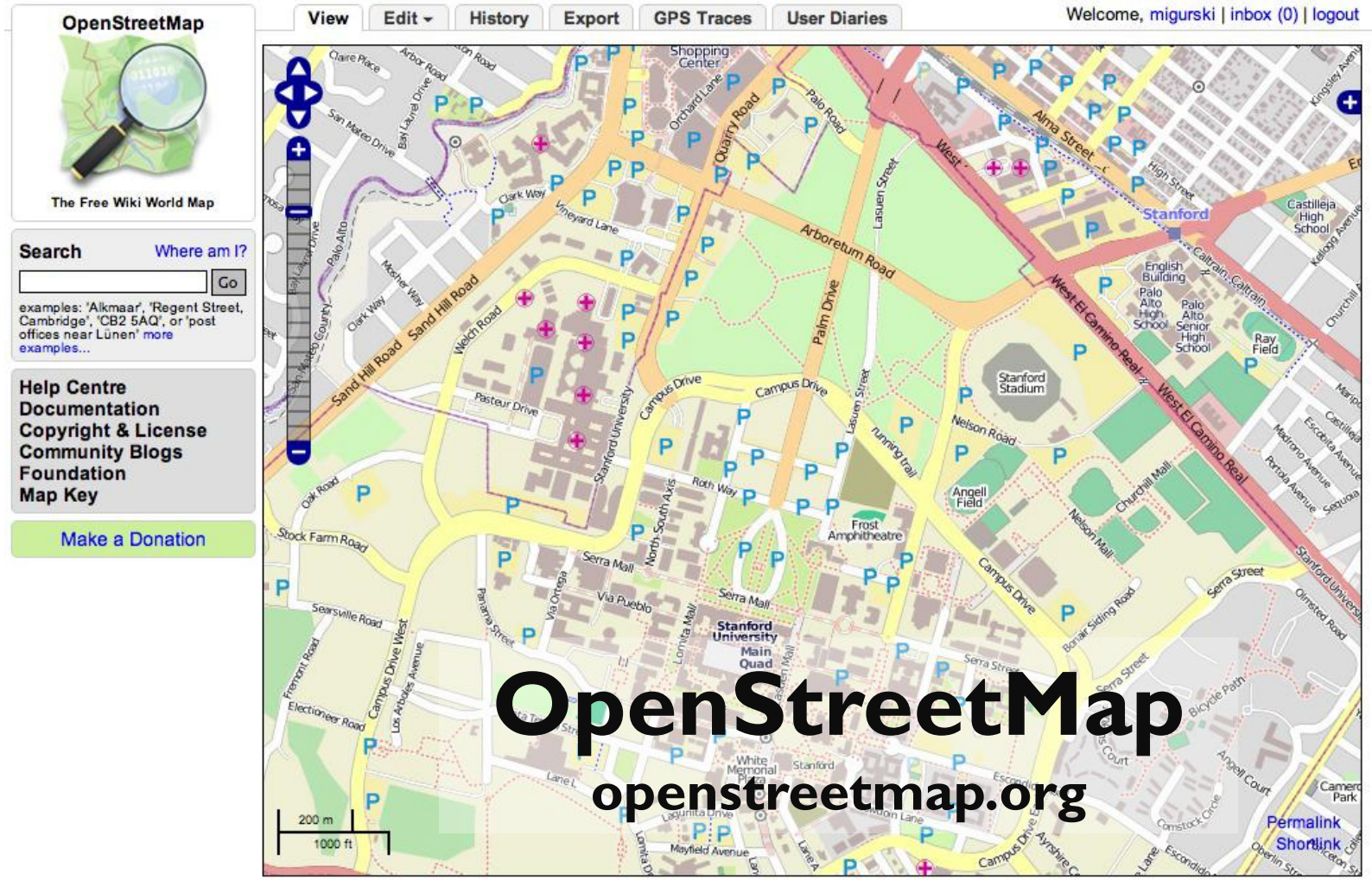
1:110,000,000
1" = 1,736 miles
1 cm = 1,100 km

Natural Earth Data

A public domain map dataset available at
1:10m, 1:50m, and 1:110 million scales.

naturalearthdata.com

Data

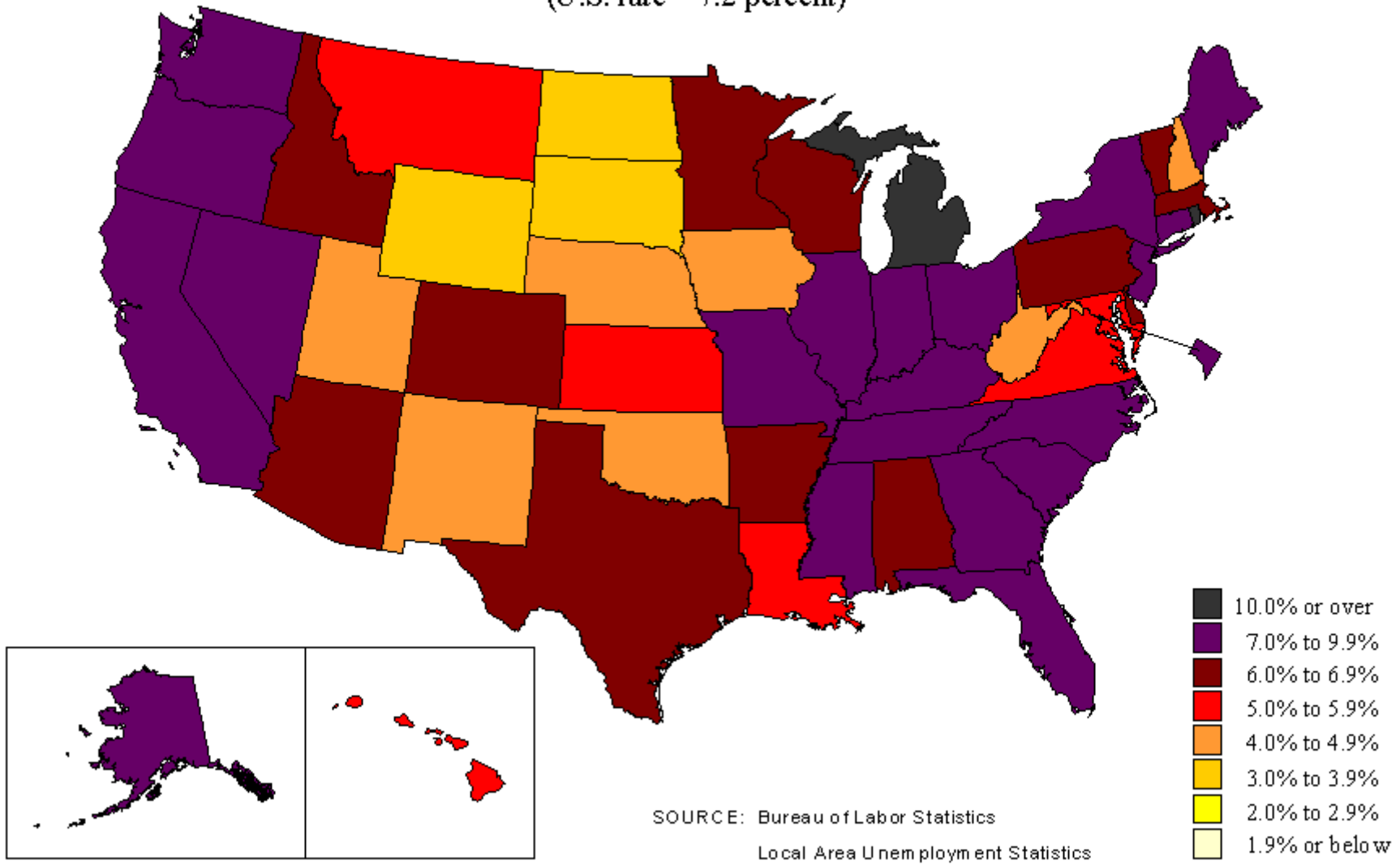

OpenStreetMap
The Free Wiki World Map
Search
Where am I?
Go
examples: 'Alkmaar', 'Regent Street, Cambridge', 'CB2 5AQ', or 'post offices near Lünen' more examples...
Help Centre
Documentation
Copyright & License
Community Blogs
Foundation
Map Key
Make a Donation
View
Edit
History
Export
GPS Traces
User Diaries
Welcome, migurski | inbox (0) | logout
OpenStreetMap
openstreetmap.org
Permalink
Shortlink
200 m
1000 ft

Effective Use of Color in Maps

Sequential, diverging, categorizing, highlight and alert

Unemployment rates by state, seasonally adjusted, December 2008

(U.S. rate = 7.2 percent)

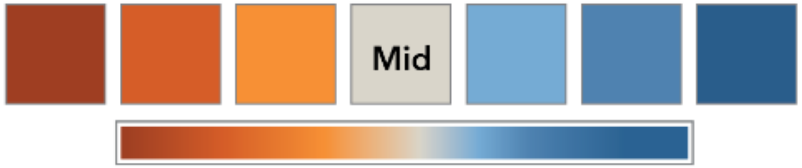


SOURCE: Bureau of Labor Statistics
Local Area Unemployment Statistics

The Use of Color in Data Visualization

Sequential
color is ordered from low to high

Diverging
two sequential colors with a neutral midpoint

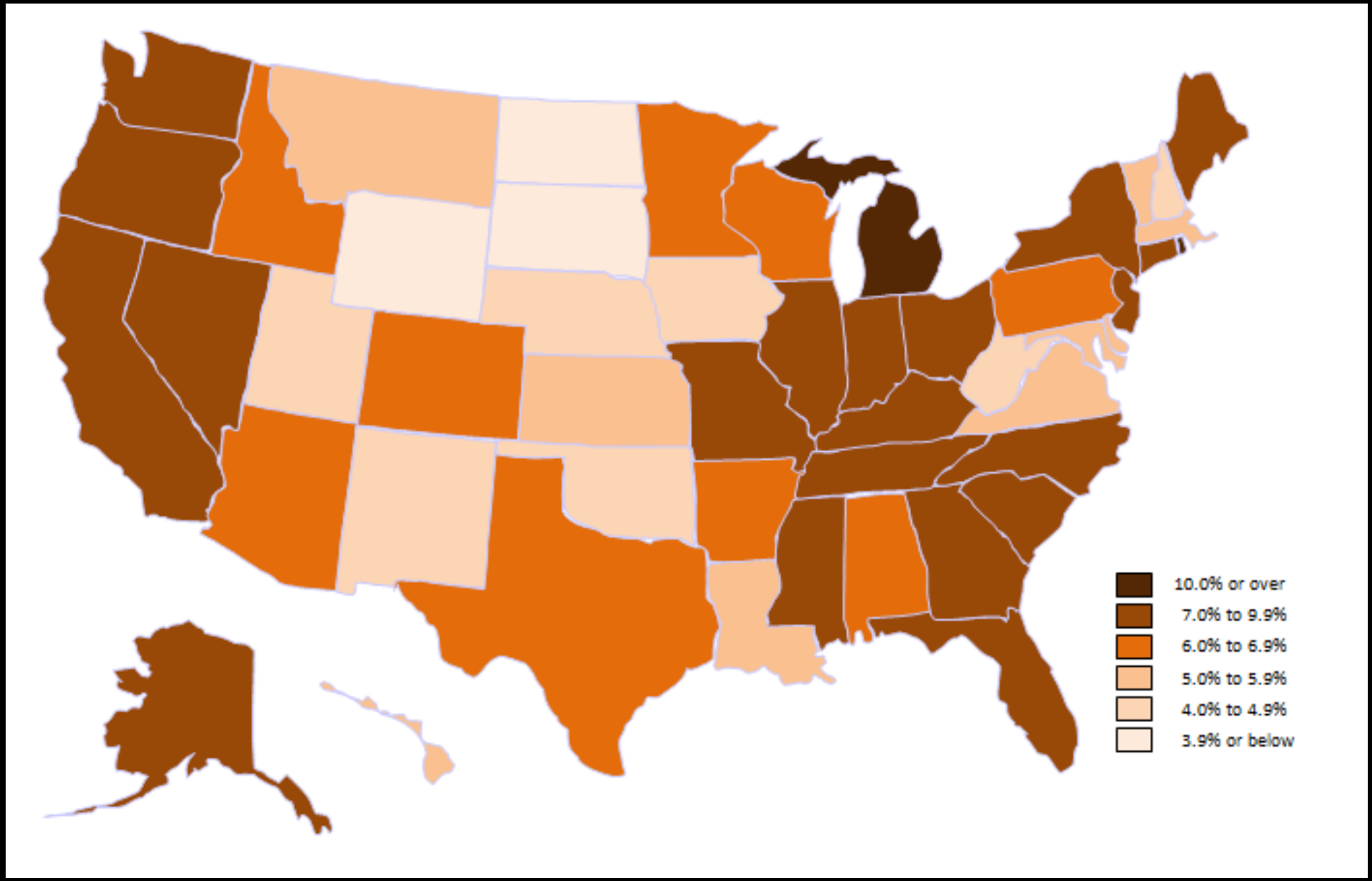


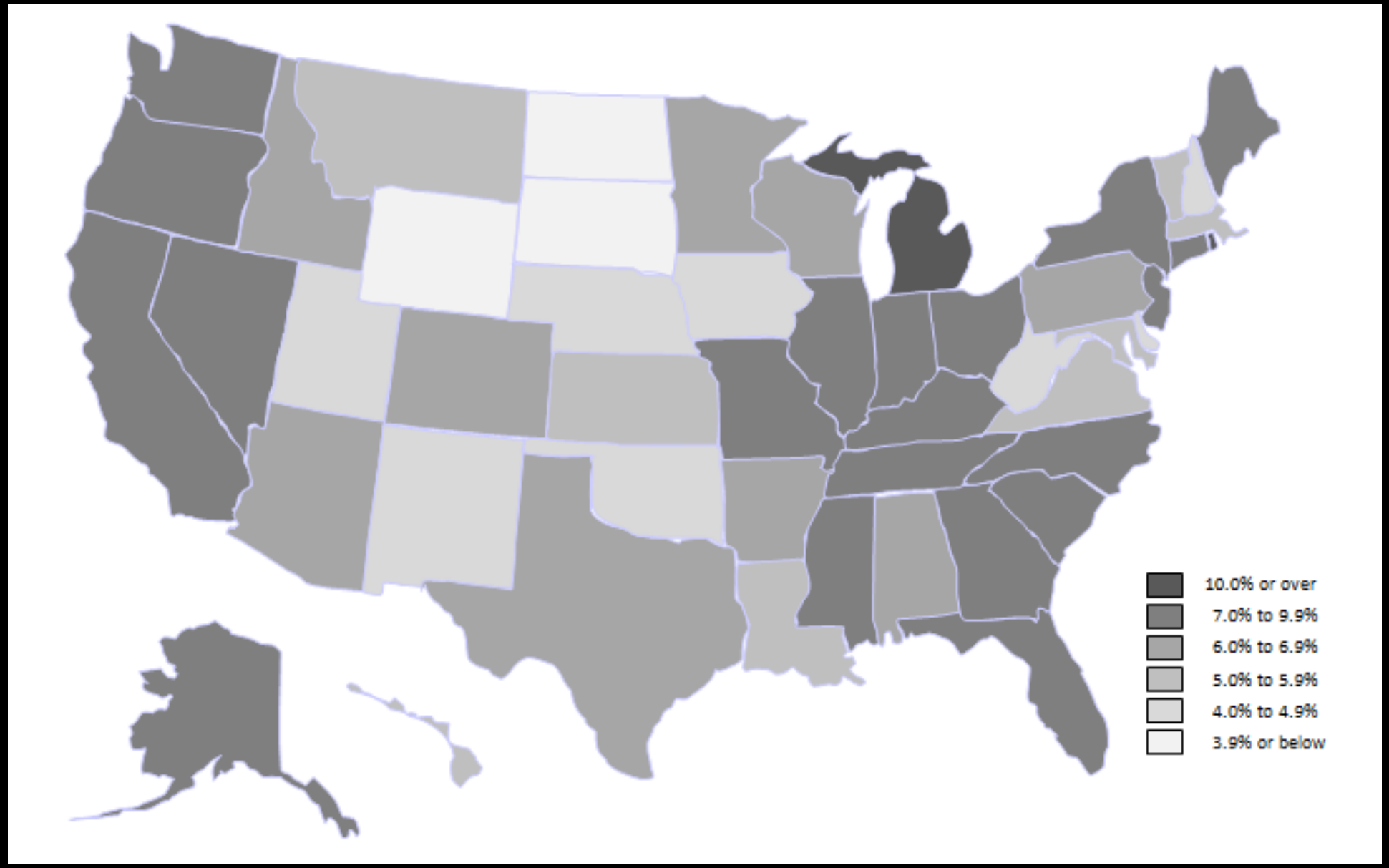
Categorical
contrasting colors for individual comparison

Highlight
color used to highlight something

Alert
color used to get reader's attention

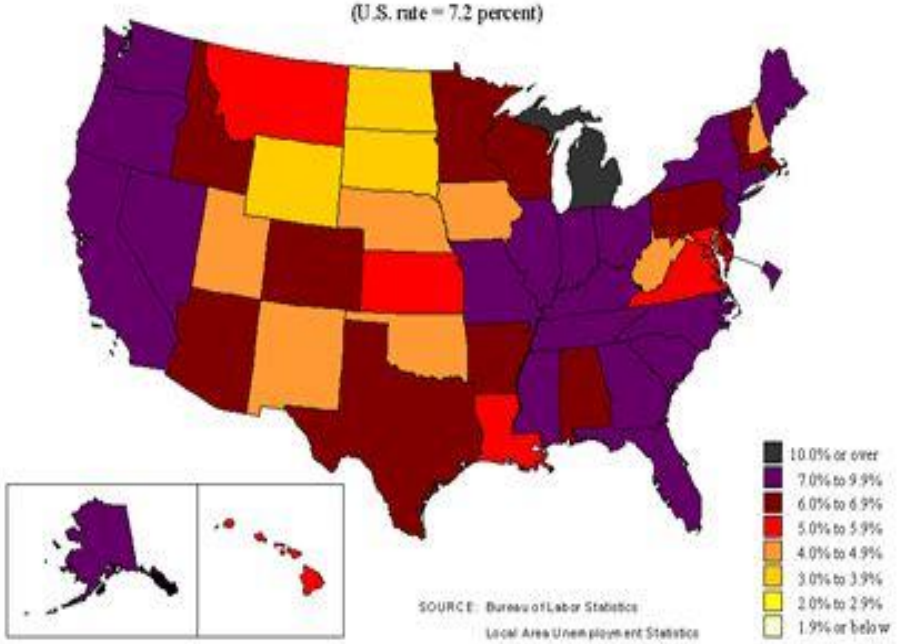
Source: *The Big Book of Dashboards* (page 15)


10.0% or over
7.0% to 9.9%
6.0% to 6.9%
5.0% to 5.9%
4.0% to 4.9%
3.9% or below


10.0% or over
7.0% to 9.9%
6.0% to 6.9%
5.0% to 5.9%
4.0% to 4.9%
3.9% or below

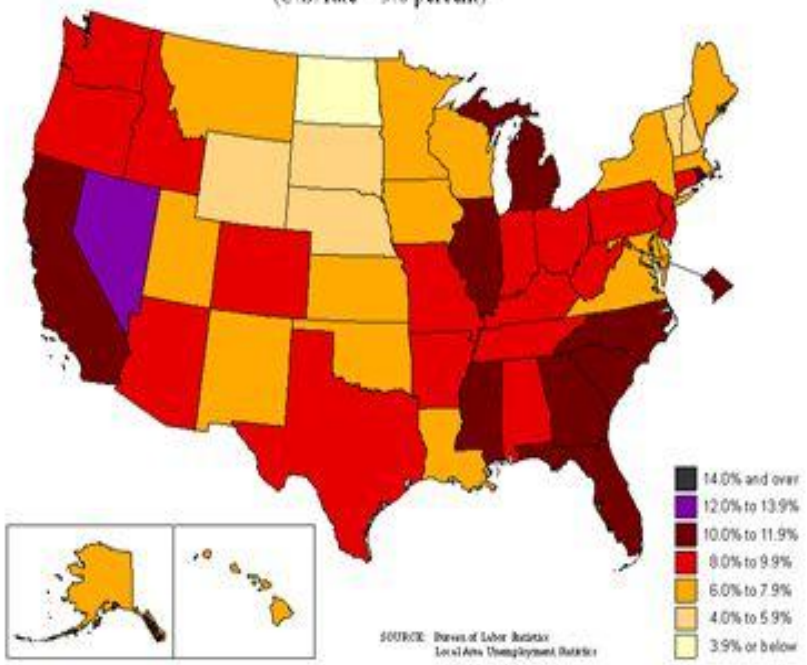
Unemployment rates by state, seasonally adjusted, December 2008

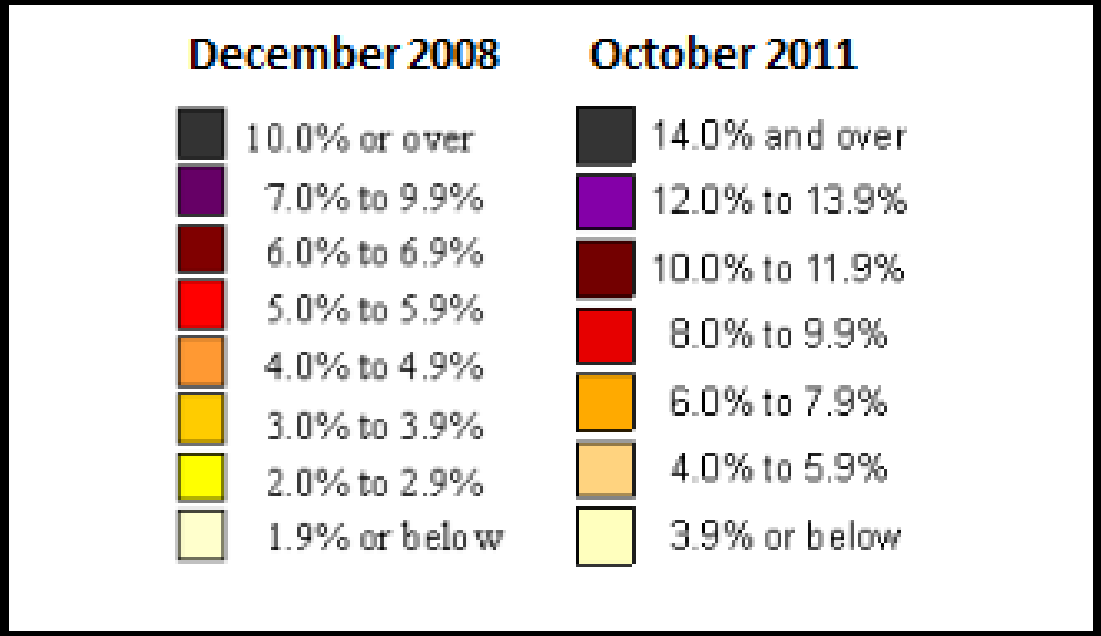
(U.S. rate = 7.2 percent)

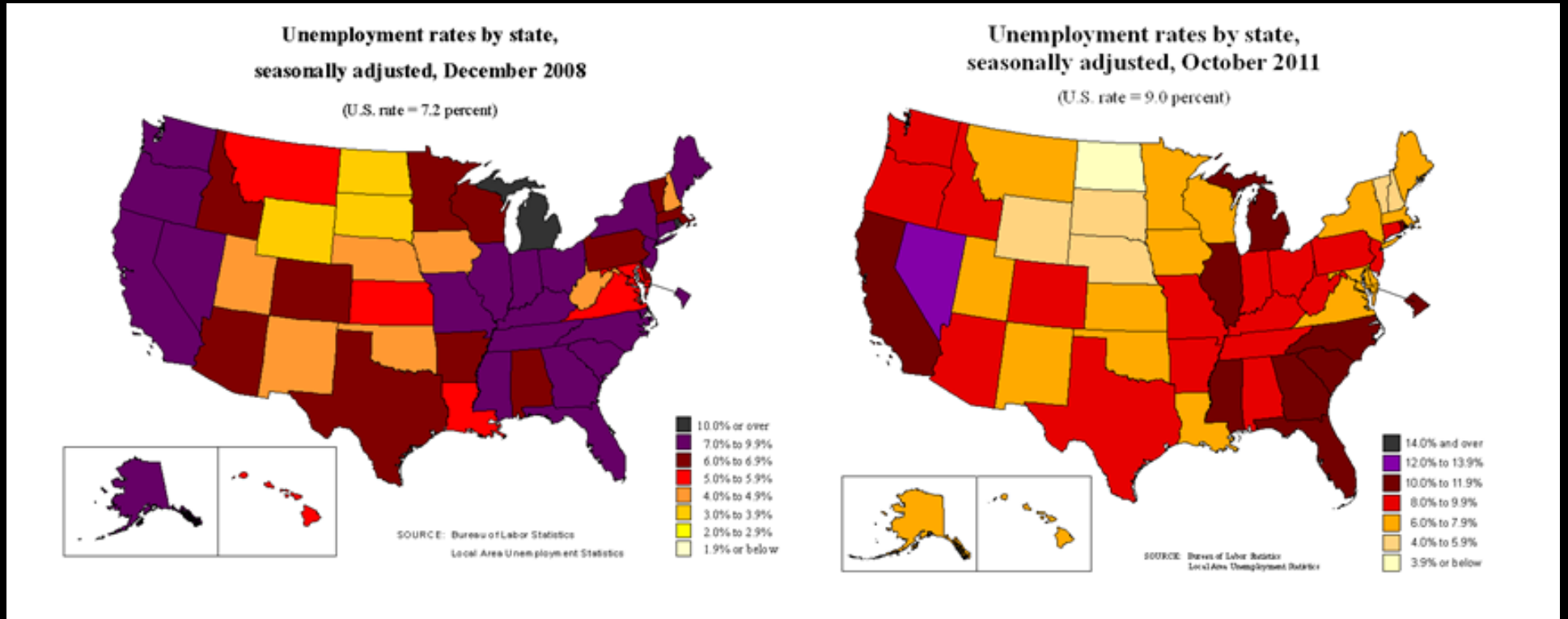


Unemployment rates by state, seasonally adjusted, October 2011

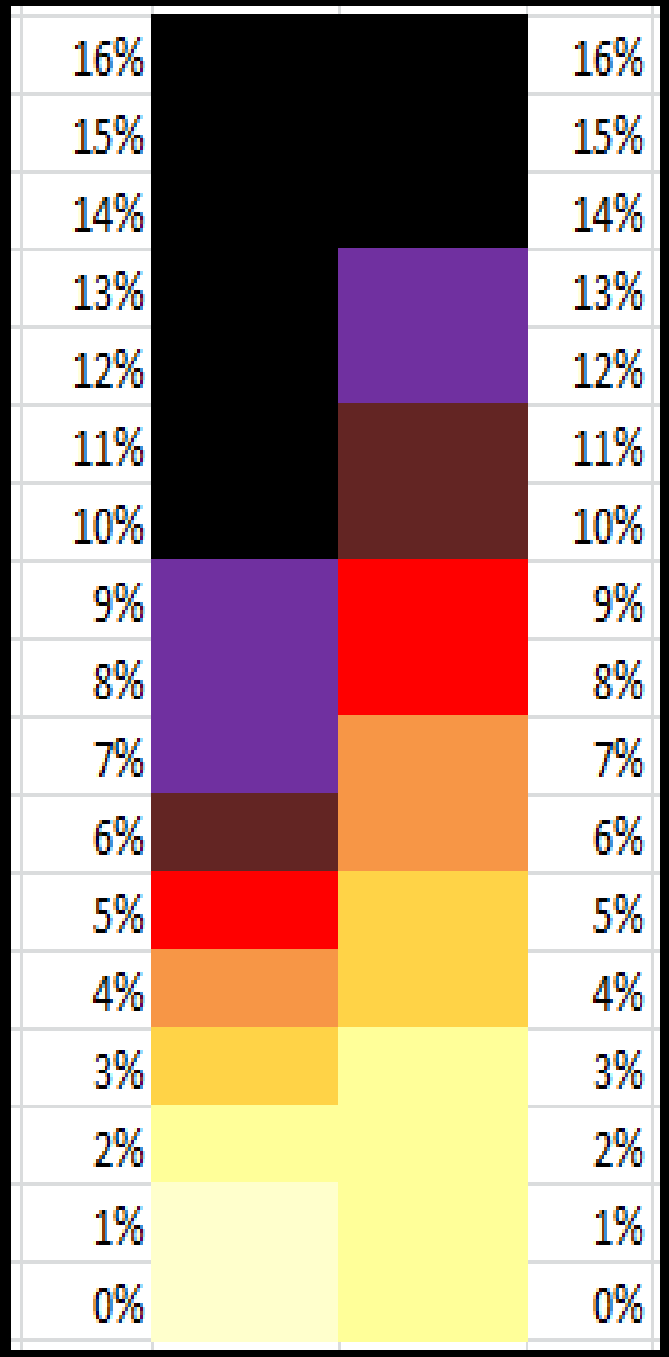
(U.S. rate = 9.0 percent)




December 2008
10.0% or over
7.0% to 9.9%
6.0% to 6.9%
5.0% to 5.9%
4.0% to 4.9%
3.0% to 3.9%
2.0% to 2.9%
1.9% or below
October 2011
14.0% and over
12.0% to 13.9%
10.0% to 11.9%
8.0% to 9.9%
6.0% to 7.9%
4.0% to 5.9%
3.9% or below


Unemployment rates by state,
seasonally adjusted, December 2008
(U.S. rate = 7.2 percent)
SOURCE: Bureau of Labor Statistics
Local Area Unemployment Statistics
10.0% or over
7.0% to 9.9%
6.0% to 6.9%
5.0% to 5.9%
4.0% to 4.9%
3.0% to 3.9%
2.0% to 2.9%
1.9% or below
Unemployment rates by state,
seasonally adjusted, October 2011
(U.S. rate = 9.0 percent)
14.0% and over
12.0% to 13.9%
10.0% to 11.9%
8.0% to 9.9%
6.0% to 7.9%
4.0% to 5.9%
3.9% or below

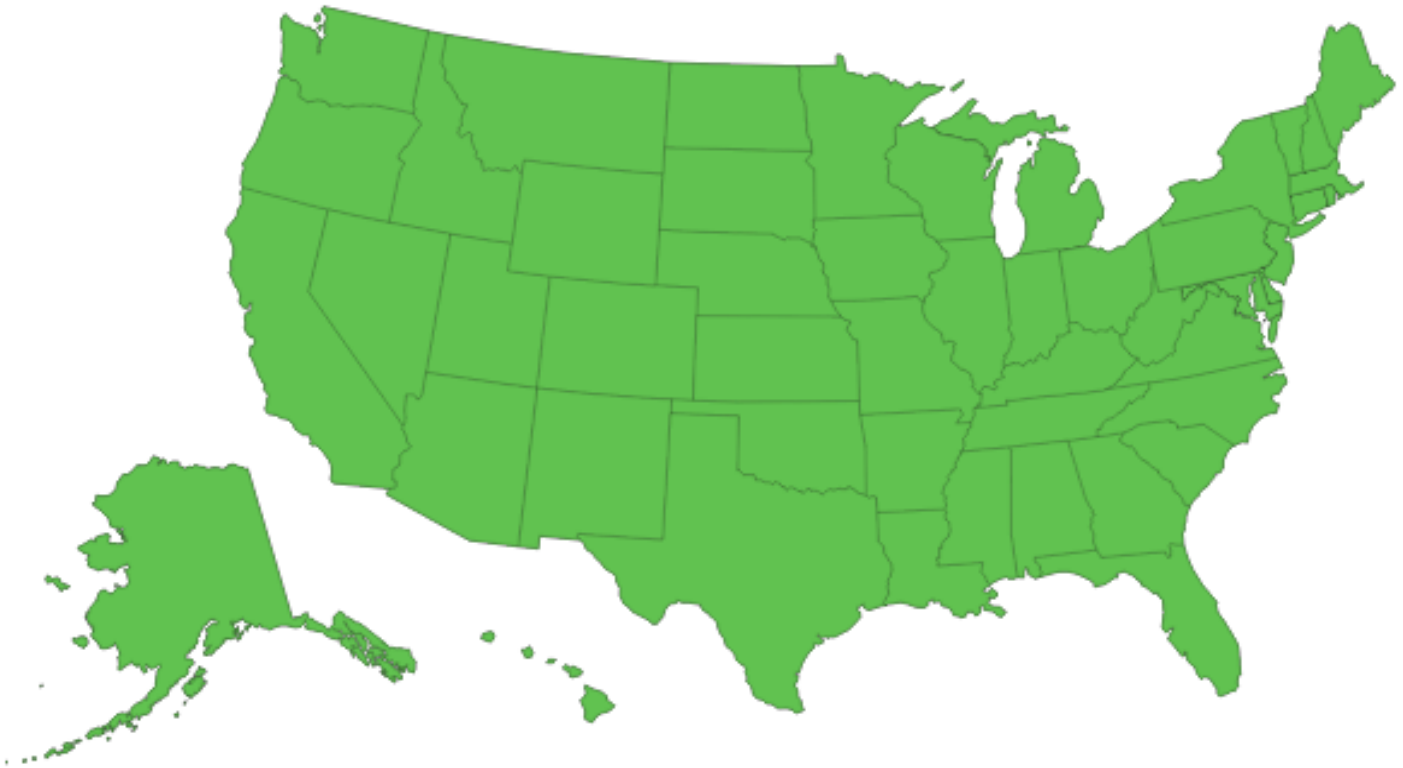
In 2008 it was purple at 7%, but in 2011 it takes 12% to reach purple. In 2011, 5% is a low-value colored in yellow, but was red in 2008.



LGBT, 2012

State: Nation

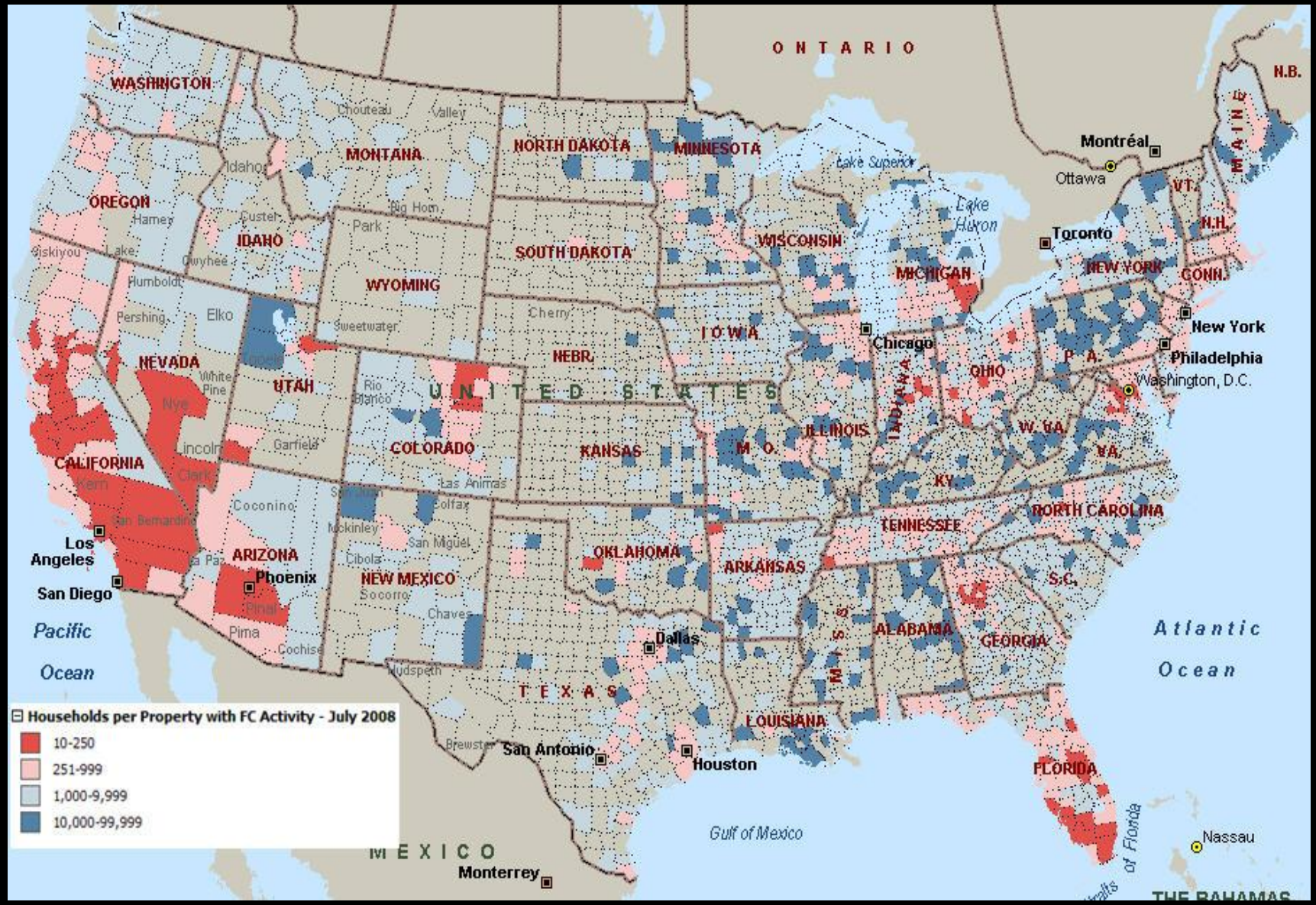
% LGBT: **3.5**



Share

This tool offers a Dropdown menu to choose the State, but when the entire nation is selected is simply colors everything at the average, which is not at all useful. Now we just h
ave a green image of the U.S.

Foreclosures (July 2008)

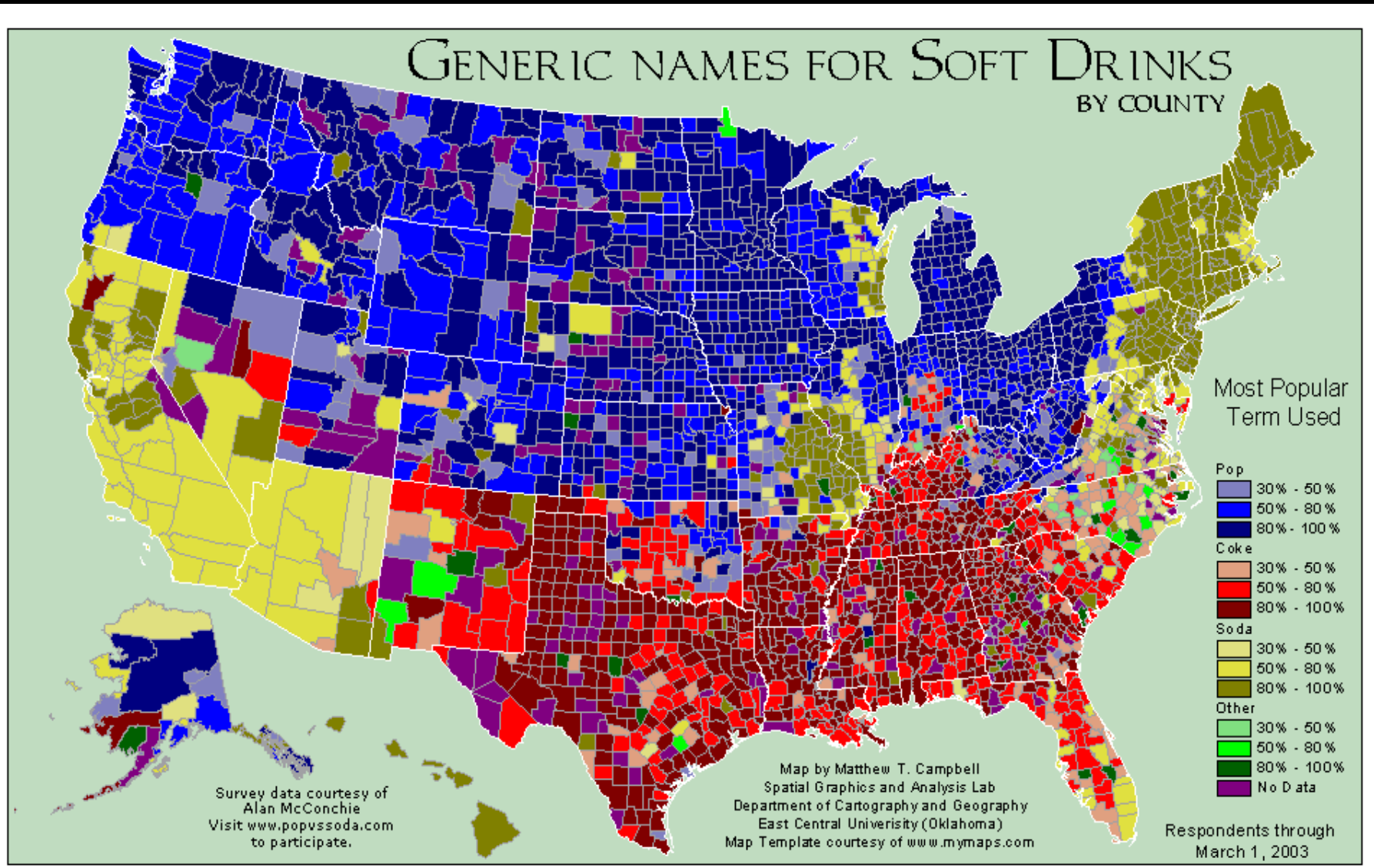


Source: RealtyTrac (www.RealtyTrac.com)

The Wall Street Journal – GDP Recovery by County

By Ben Leubsdorf

Source: National Association of Counties



Created by Matthew Campbell and Prof. Greg Plumb of East Central University in Oklahoma
Source: http://www.huffingtonpost.com/2012/11/12/soda-vs-pop_n_2103764.html

Courtesy of **darkhorseanalytics.com**

Beautiful Trash

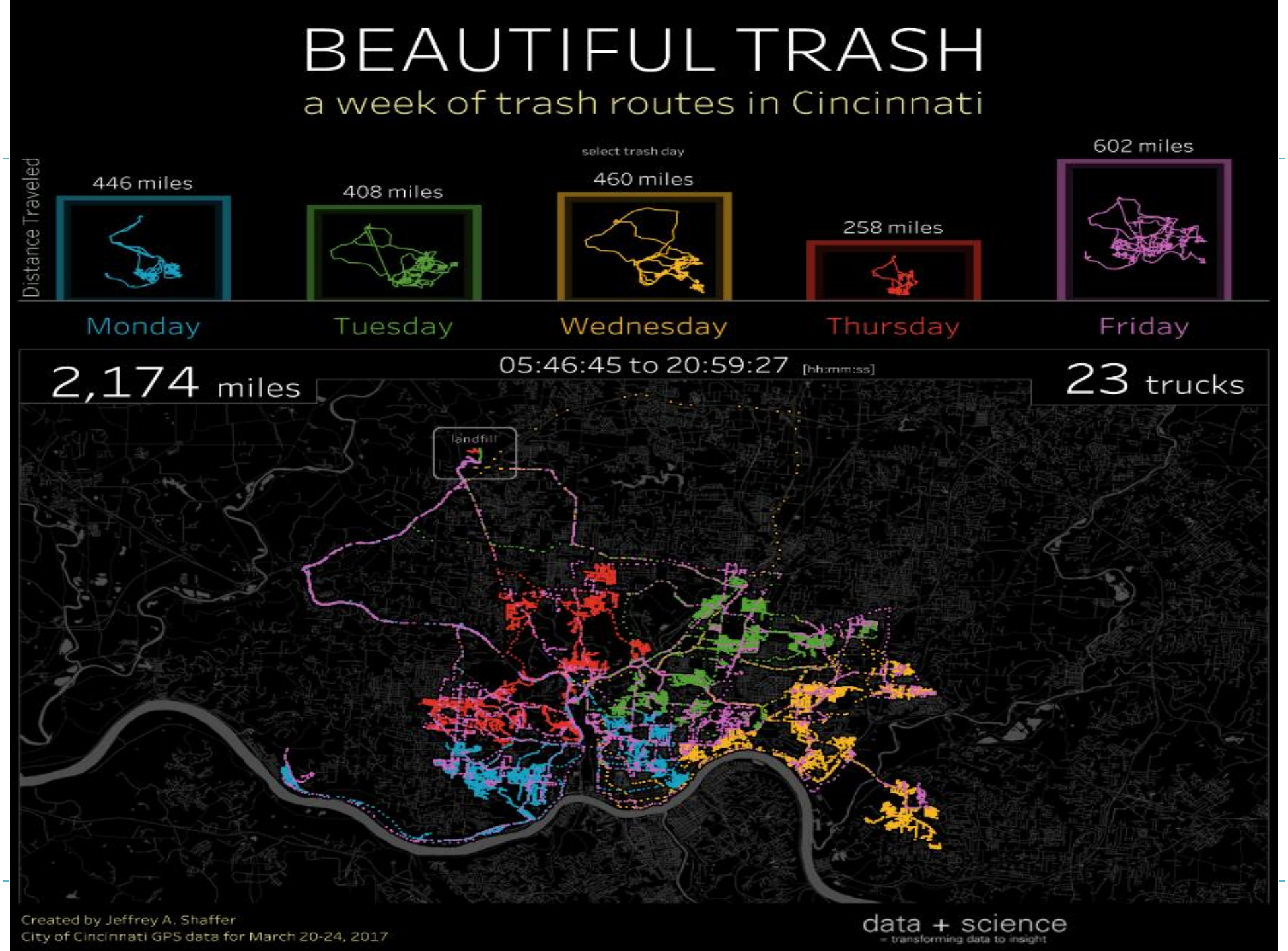
by Jeffrey Shaffe

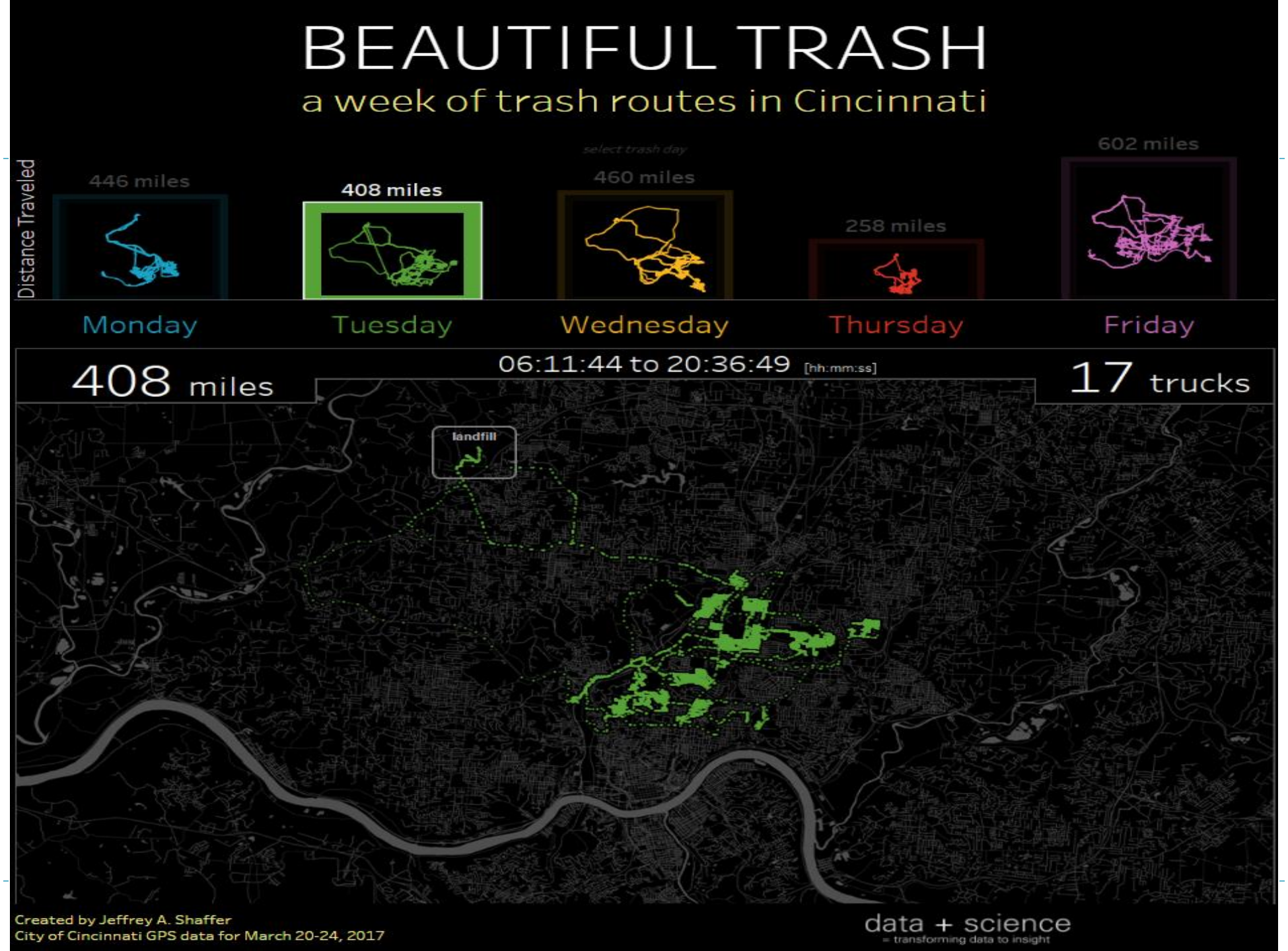
a week of trash routes in Cincinnati

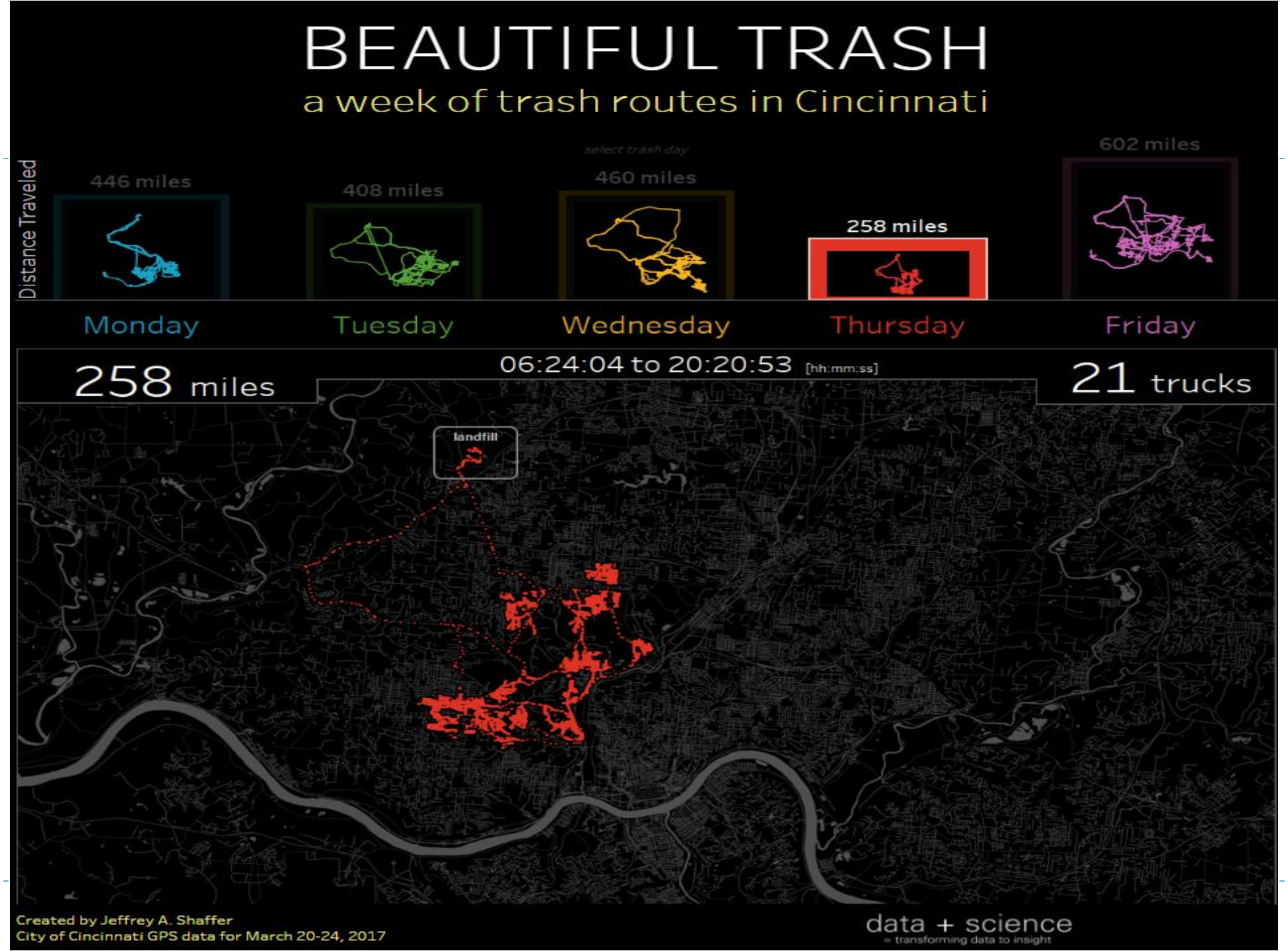
Kantar Information is Beautiful Awards 2017

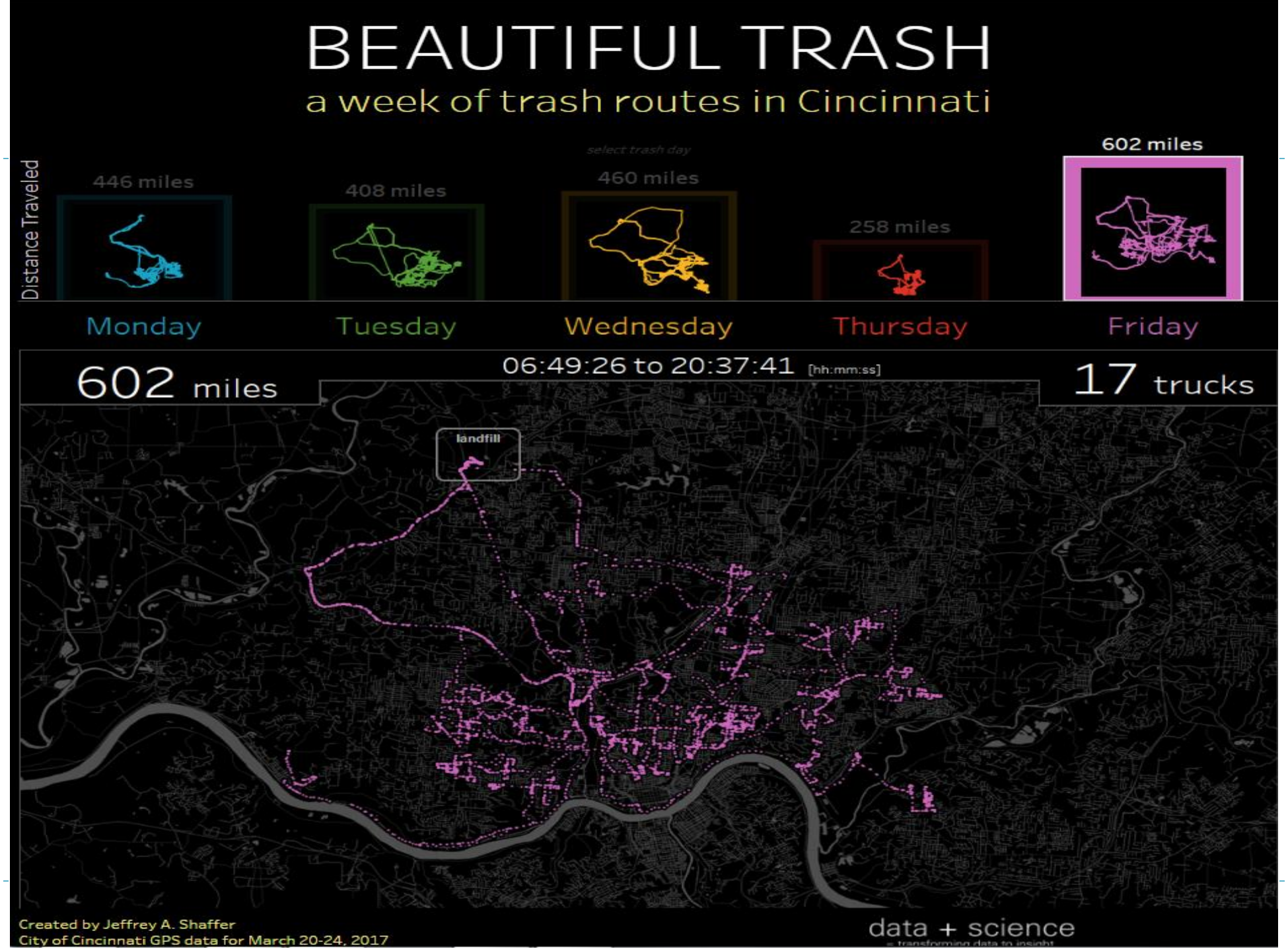
https://www.dataplusscience.com/BeautifulTrash.html


Cincinnati Trash Collection on March 15, 2017 10:38 AM


BEAUTIFUL TRASH
a week of trash routes in Cincinnati
Distance Traveled
446 miles
408 miles
select trash day
460 miles
258 miles
602 miles
Monday
Tuesday
Wednesday
Thursday
Friday
2,174 miles
05:46:45 to 20:59:27 [hh:mm:ss]
23 trucks
landfill
Created by Jeffrey A. Shaffer
City of Cincinnati GPS data for March 20-24, 2017
data + science
= transforming data to insight


BEAUTIFUL TRASH
a week of trash routes in Cincinnati
Distance Traveled
select trash day
446 miles
408 miles
460 miles
258 miles
602 miles
Monday
Tuesday
Wednesday
Thursday
Friday
408 miles
06:11:44 to 20:36:49 [hh:mm:ss]
17 trucks
landfill
Created by Jeffrey A. Shaffer
City of Cincinnati GPS data for March 20-24, 2017
data + science
= transforming data to insight


BEAUTIFUL TRASH
a week of trash routes in Cincinnati
Distance Traveled
select trash day
446 miles
408 miles
460 miles
258 miles
602 miles
Monday
Tuesday
Wednesday
Thursday
Friday
258 miles
06:24:04 to 20:20:53 [hh:mm:ss]
21 trucks
landfill
Created by Jeffrey A. Shaffer
City of Cincinnati GPS data for March 20-24, 2017
data + science
= transforming data to insight


BEAUTIFUL TRASH
a week of trash routes in Cincinnati
Distance Traveled
select trash day
446 miles
408 miles
460 miles
258 miles
602 miles
Monday
Tuesday
Wednesday
Thursday
Friday
602 miles
06:49:26 to 20:37:41 [hh:mm:ss]
17 trucks
landfill
Created by Jeffrey A. Shaffer
City of Cincinnati GPS data for March 20-24, 2017
data + science

Mapping

- Visualizing data on maps:
  - Dots, more dots, continuous data, choropleths and cartograms
- Cartography:
  - Projections, scale and data
- Effective use of color on maps:
  - Sequential, diverging, categorizing, highlight and alert
- Example
  - **Beautiful Trash**

    Winner of "Information of Beautiful Award"