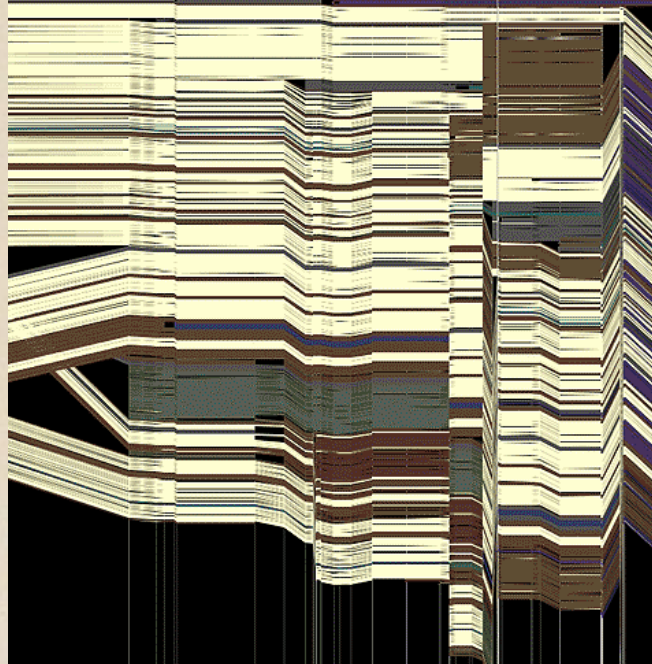
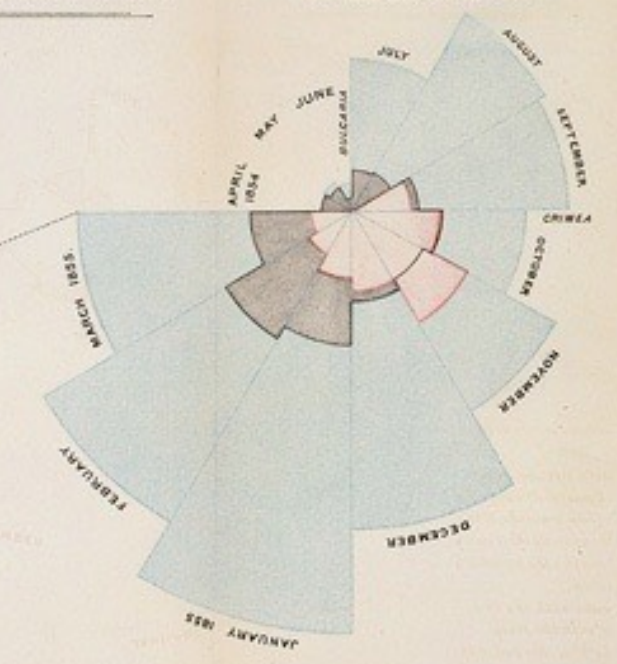
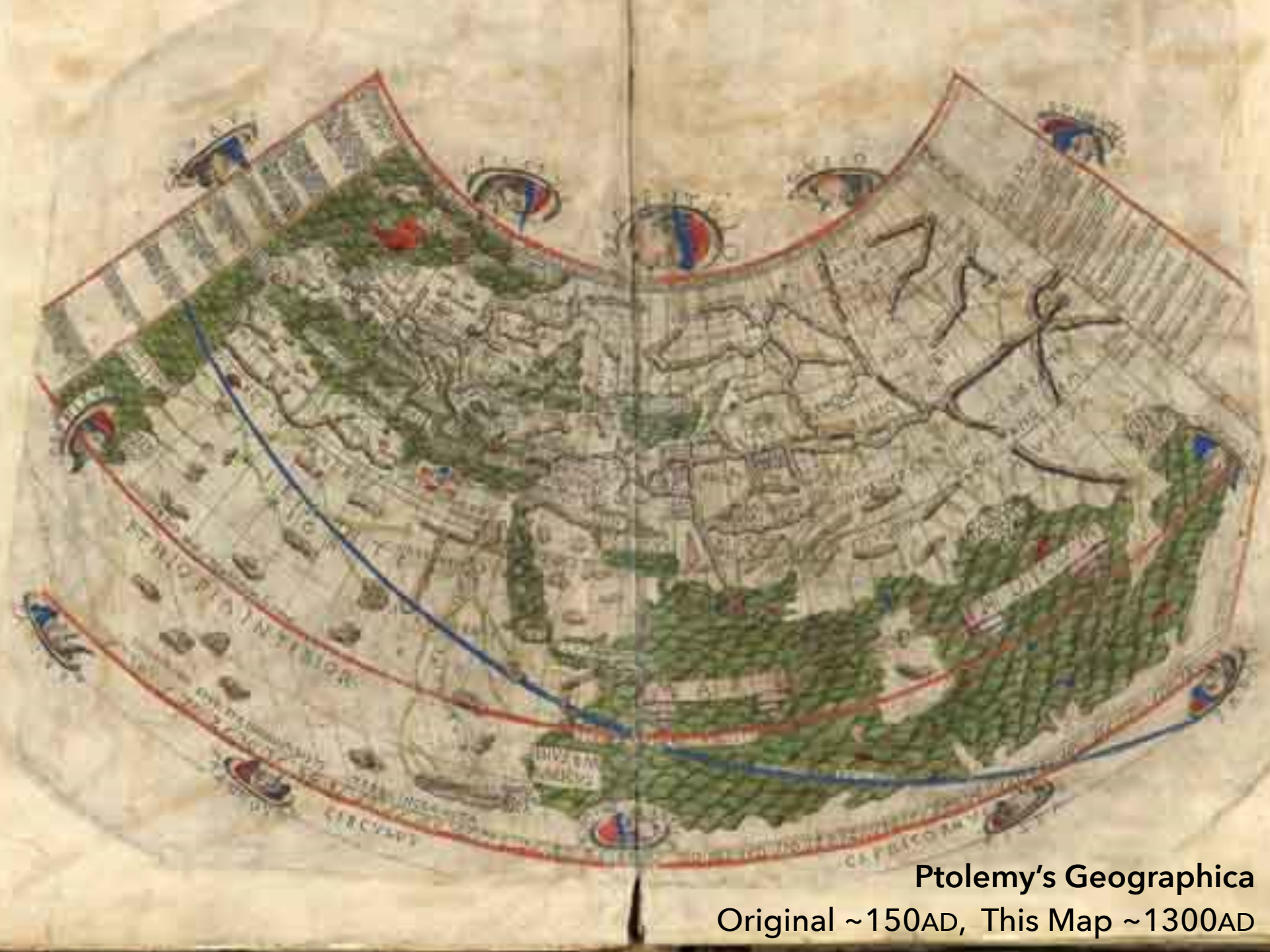


CSE 442 - Data Visualization

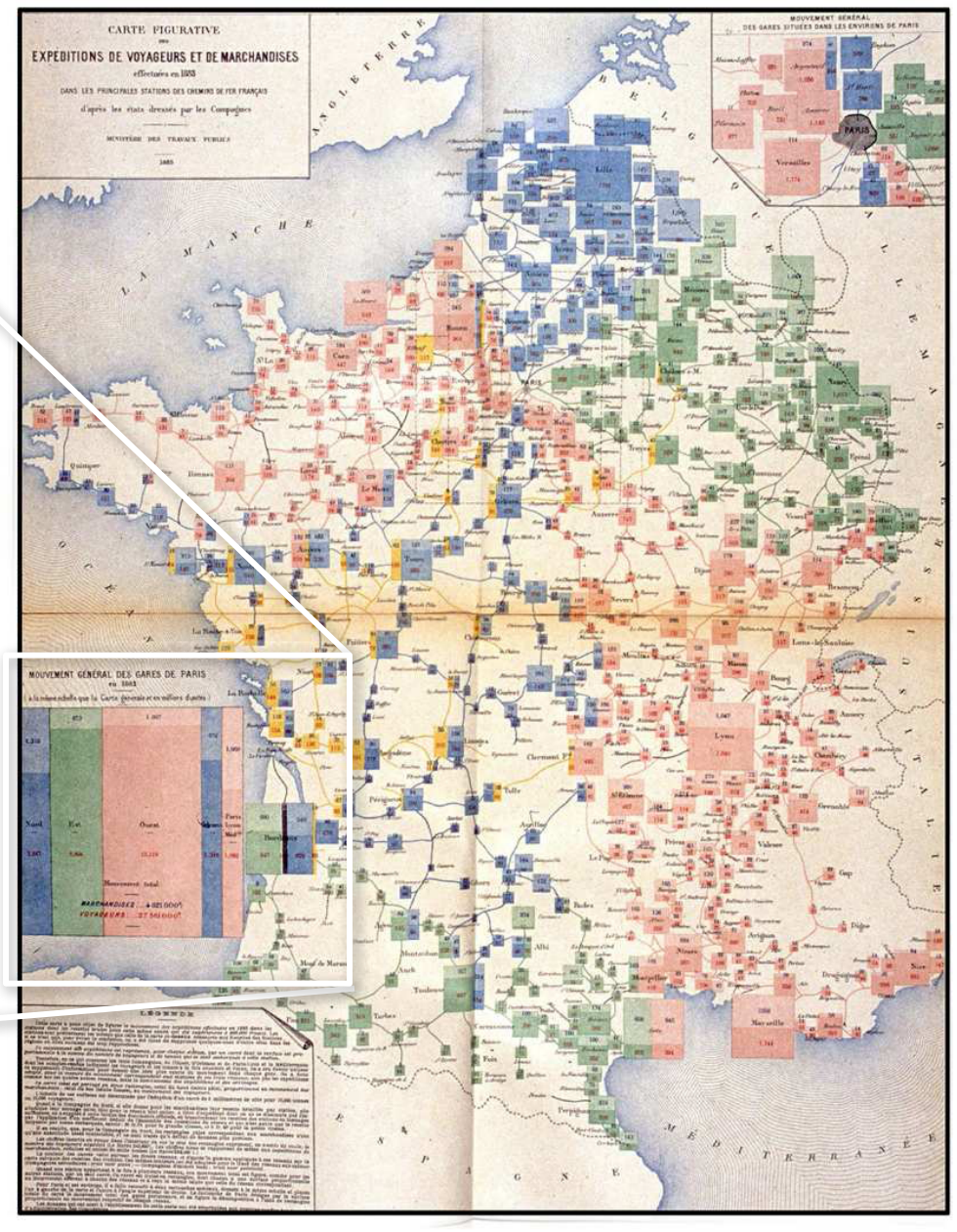
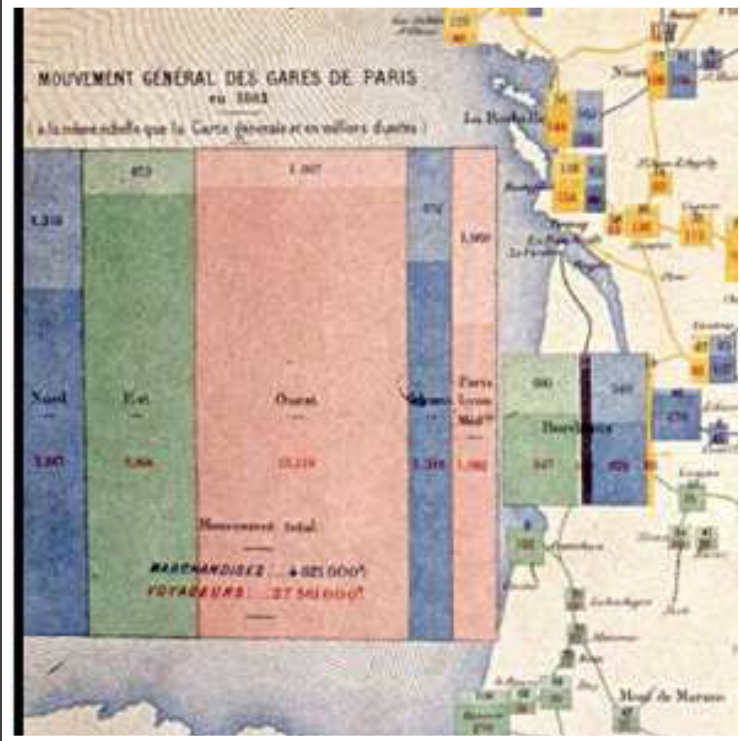
# Mapping & Cartography



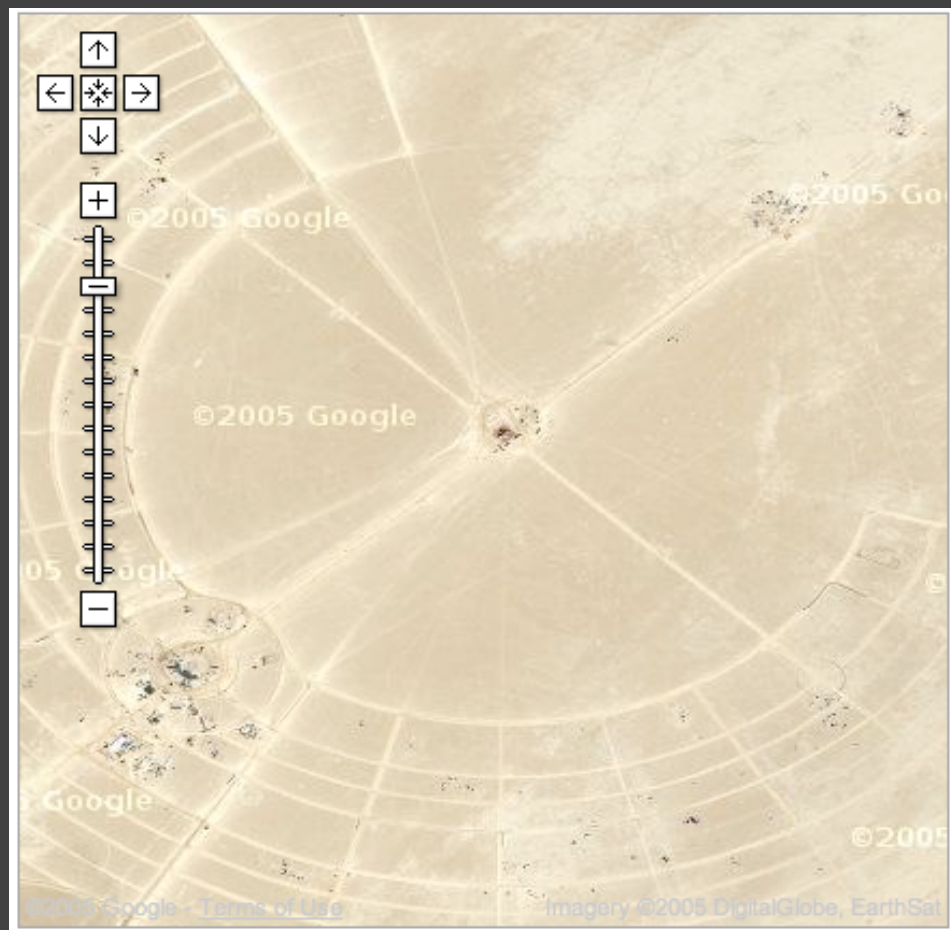
Jeffrey Heer University of Washington  
(with significant material from Michal Migurski)



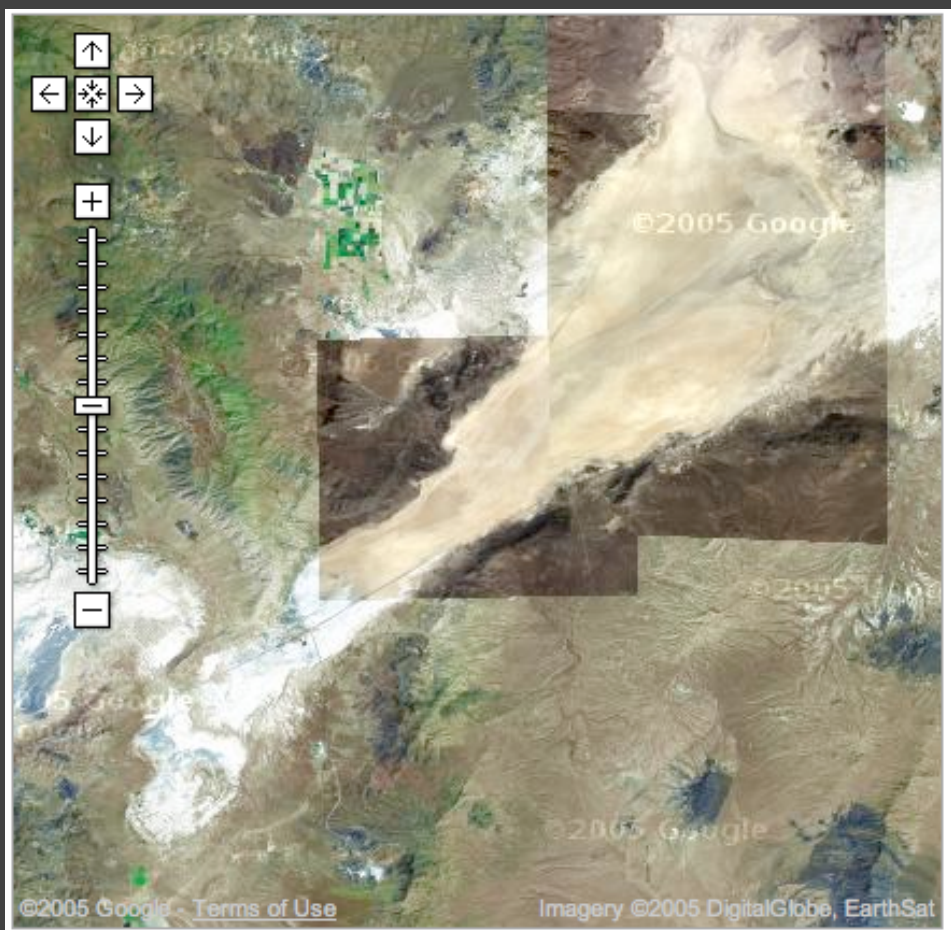
Ptolemy's Geographica  
Original ~150AD, This Map ~1300AD



Rail Passengers and Freight from Paris 1884



Black Rock City, Nevada  
(Burning Man)



Google Maps 2005

# Casualties of War

FACES | ANALYSIS | THEIR STORIES

E-MAIL | FEEDBACK

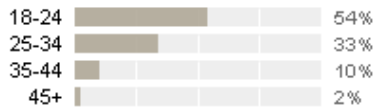
Use the slider below to investigate the demographics and military status of U.S. service members who died during the war in Iraq.

MARCH 16, 2003 JULY 5, 2008 (277 WEEKS)

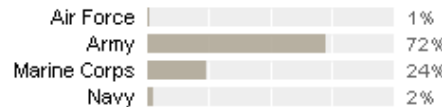
Show all | Initial invasion | First invasion of Falluja | Second invasion of Falluja | Since troop buildup began

4,097 deaths

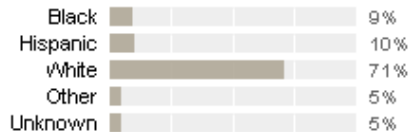
### Age



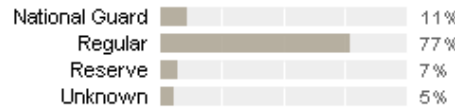
### Branch of Military



### Race



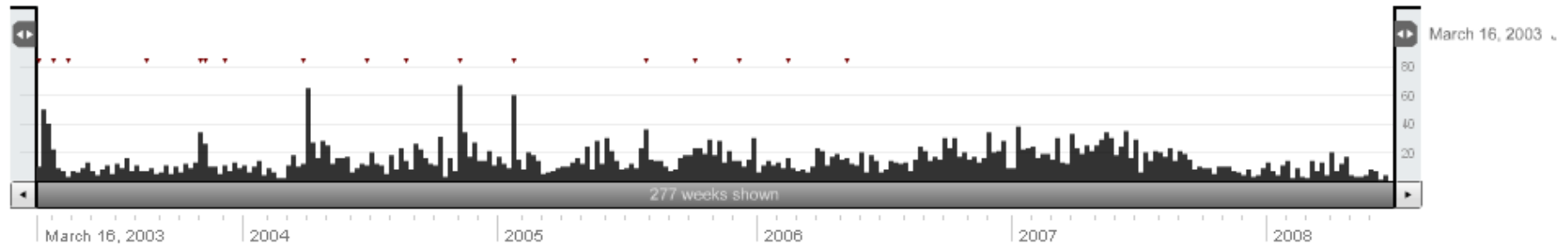
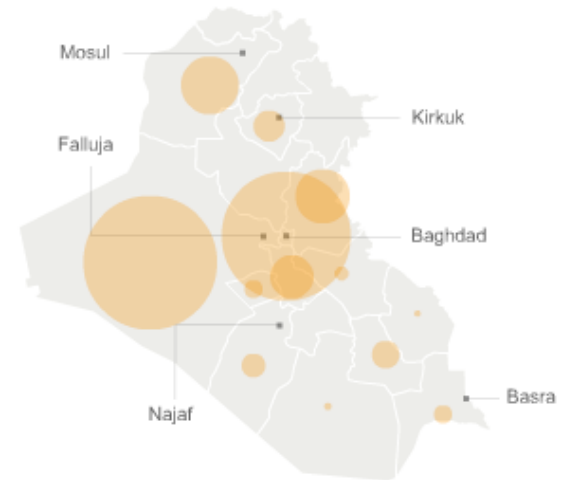
### Type of Duty



### Location of death

Circles sized according to percentage of deaths in each Iraqi province.

Show home



### Ramadi: The Government Provides an Opening for ISIS ISIS Control

Tensions between this city's residents, who are mostly Sunni, and the central government had been brewing here for at least a year. Then in December, Iraq's prime minister, Nuri Kamal al-Maliki, ordered security forces to dismantle a protest camp — an outlet for disenchanting Sunnis angered at their treatment by the Shiite-dominated government. The action ignited days of violence and created the opening ISIS needed to seize parts of the city, the provincial capital.

Lake Tharthar

### Falluja: A Symbolic Fall ISIS Control

Just days after the raid on the camp in Ramadi, ISIS fighters destroyed the Police Headquarters and mayor's office here, planted their flag on government buildings and decreed the city to be theirs. Ten years earlier, American forces had captured this city from Qaeda-style insurgents at a considerable cost of American lives.

Lake Habbaniya

Balad



17 MILES TO BAGHDAD

237

Joseph R. Biden Jr.

70,098,068 votes (50.2%)

87

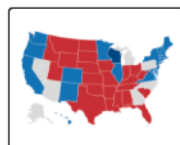
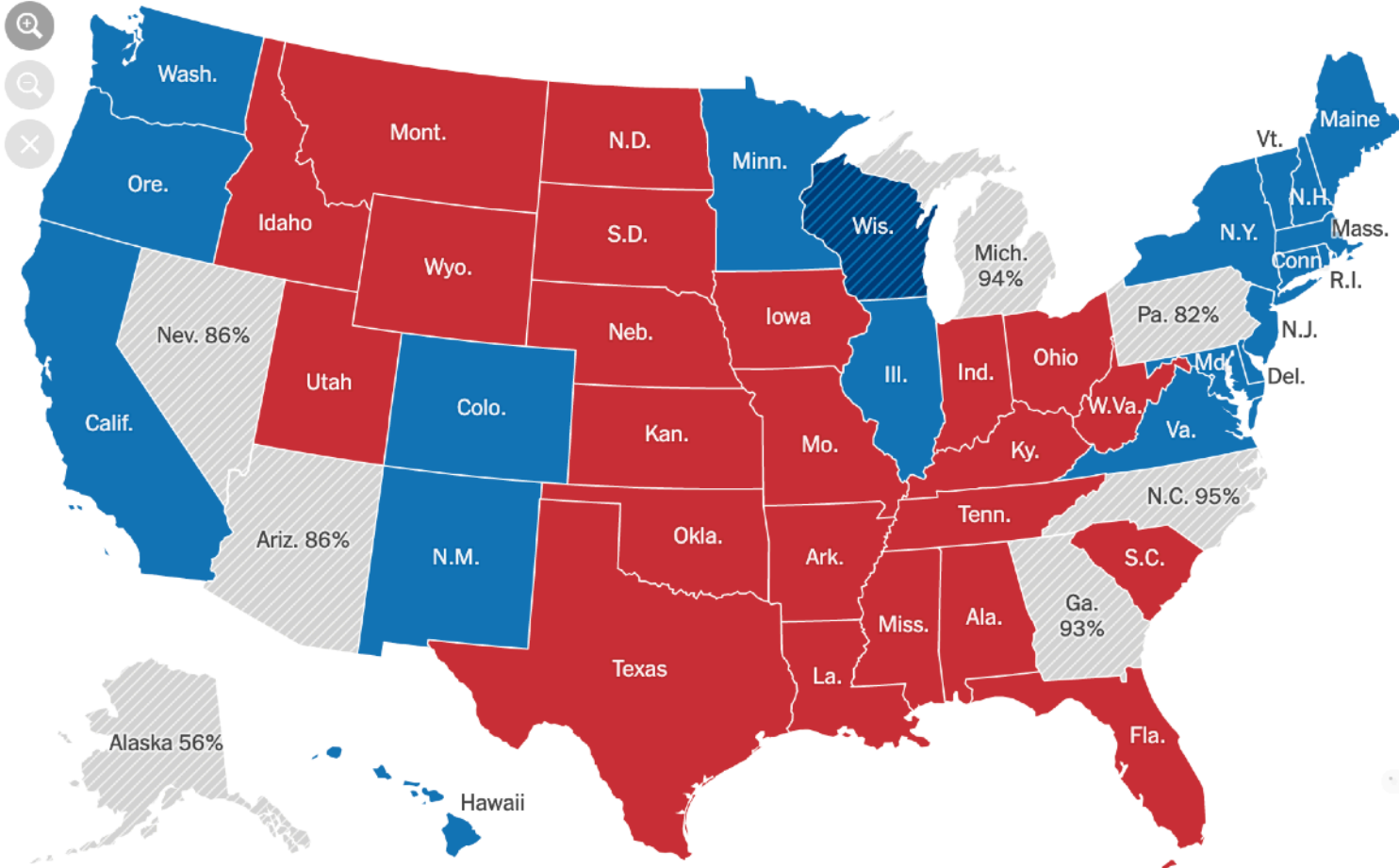
remaining

270  
TO WIN

214

Donald J. Trump

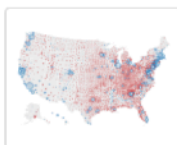
67,072,823 votes (48.1%)



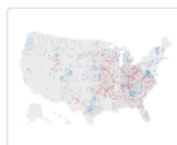
By winner



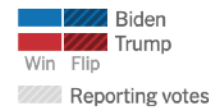
Electoral votes



Size of lead



Shift from 2016



Percentages are estimates of how much vote has been counted.

Choropleth Map  
[NY Times]

# 237

Joseph R. Biden Jr.

70,122,063 votes (50.2%)

# 87

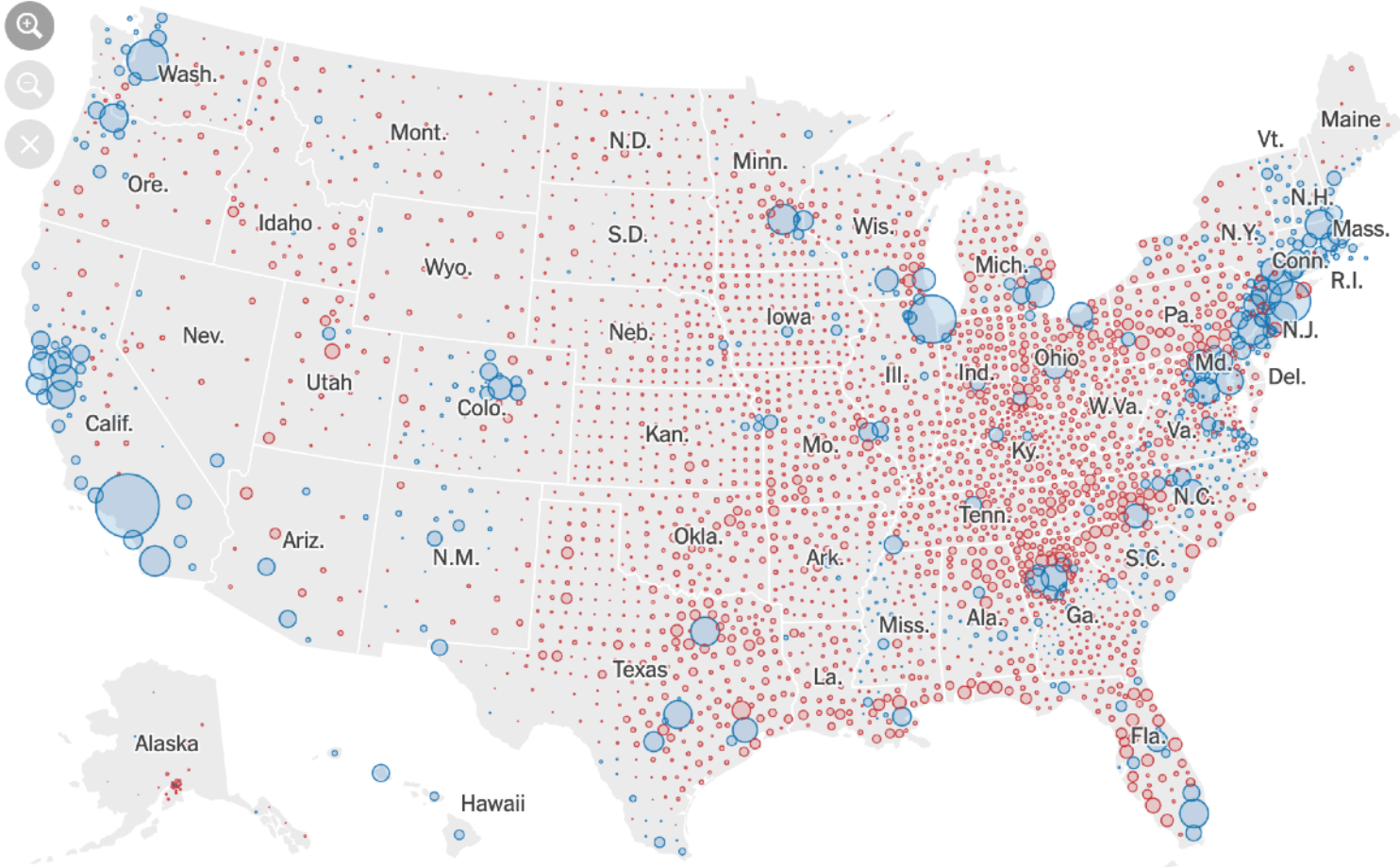
remaining

270  
TO WIN

# 214

Donald J. Trump

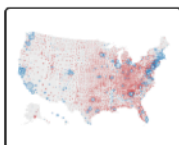
67,075,300 votes (48.0%)



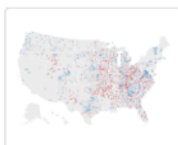
By winner



Electoral votes



Size of lead



Shift from 2016

**LEADER:** ● Biden ● Trump  
 Circle size is proportional to the amount each county's leading candidate is ahead.

Symbol Map  
 [NY Times]



# 237

Joseph R. Biden Jr.

70,122,064 votes (50.2%)

# 87

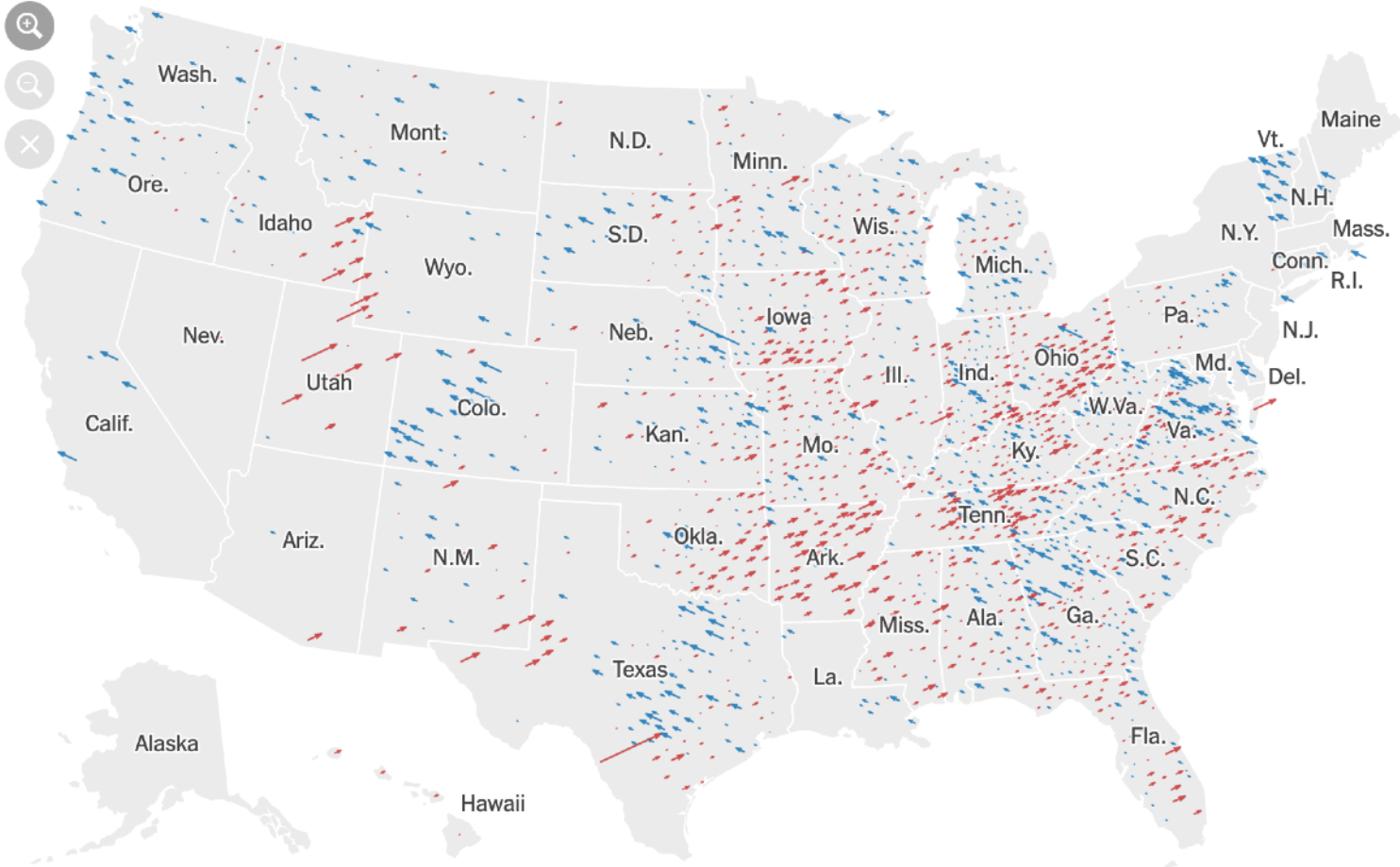
remaining

270  
TO WIN

# 214

Donald J. Trump

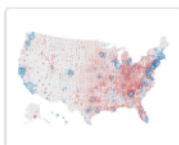
67,075,309 votes (48.0%)



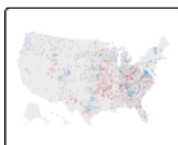
By winner



Electoral votes



Size of lead



Shift from 2016

**SHIFT IN MARGIN**  
 In counties that have reported almost all of their votes


  
 More Democratic    More Republican

Symbol Map  
 [NY Times]

237

Joseph R. Biden Jr.

70,122,063 votes (50.2%)

87

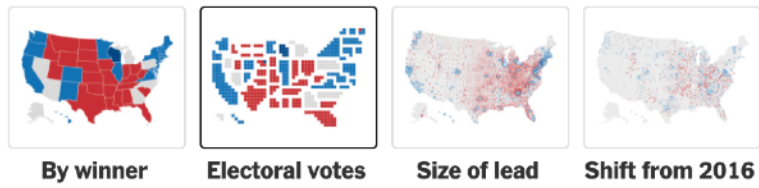
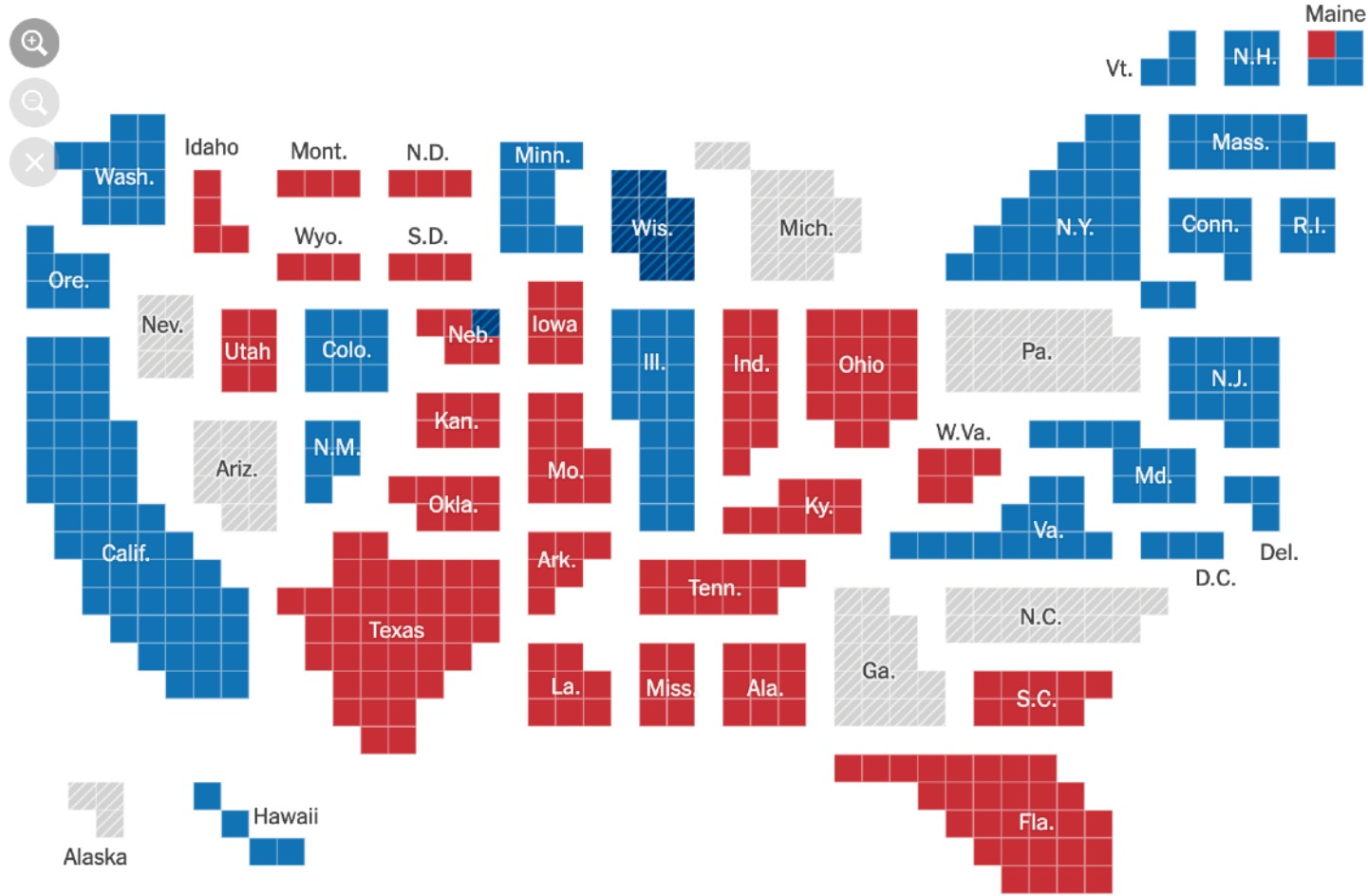
remaining

270  
TO WIN

214

Donald J. Trump

67,075,300 votes (48.0%)



■ Biden  
■ Trump  
 Win Flip  
  Reporting votes

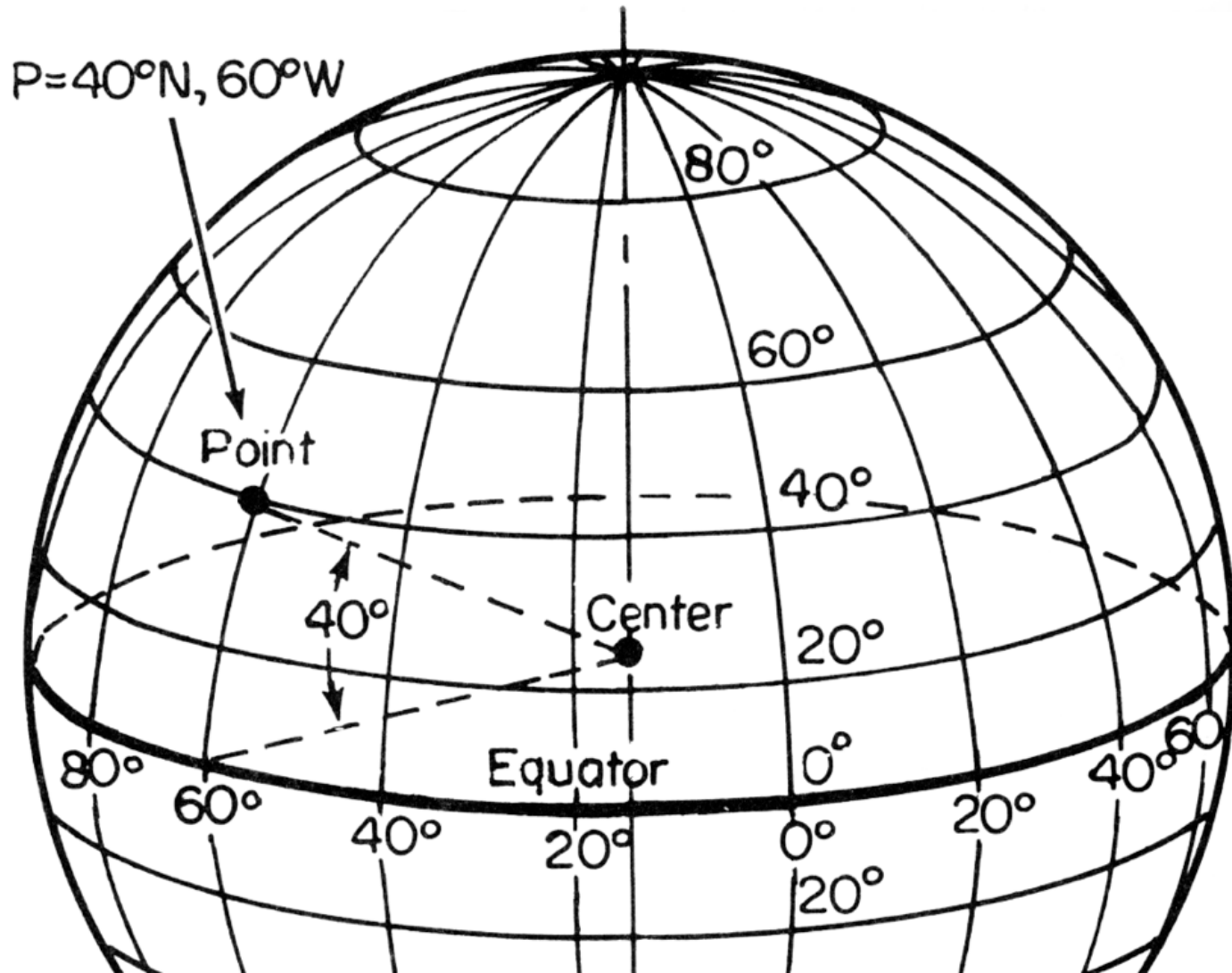
Cartogram  
[NY Times]

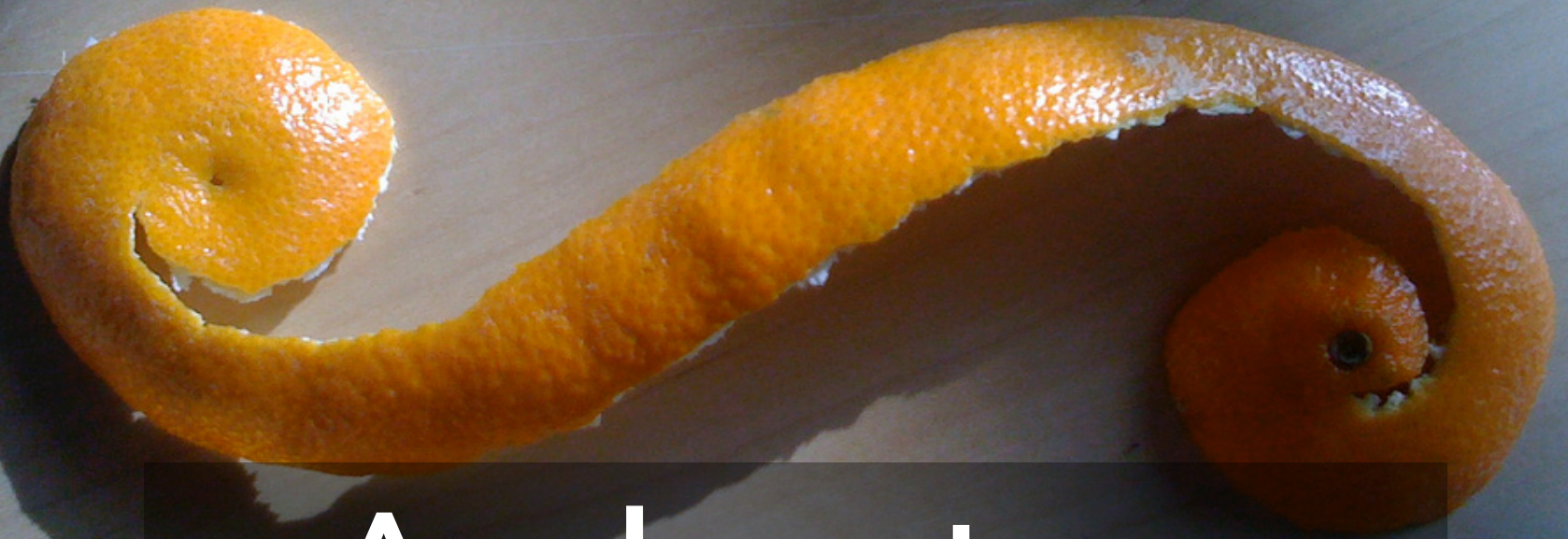
# Cartography

The Making of Maps

# Projections

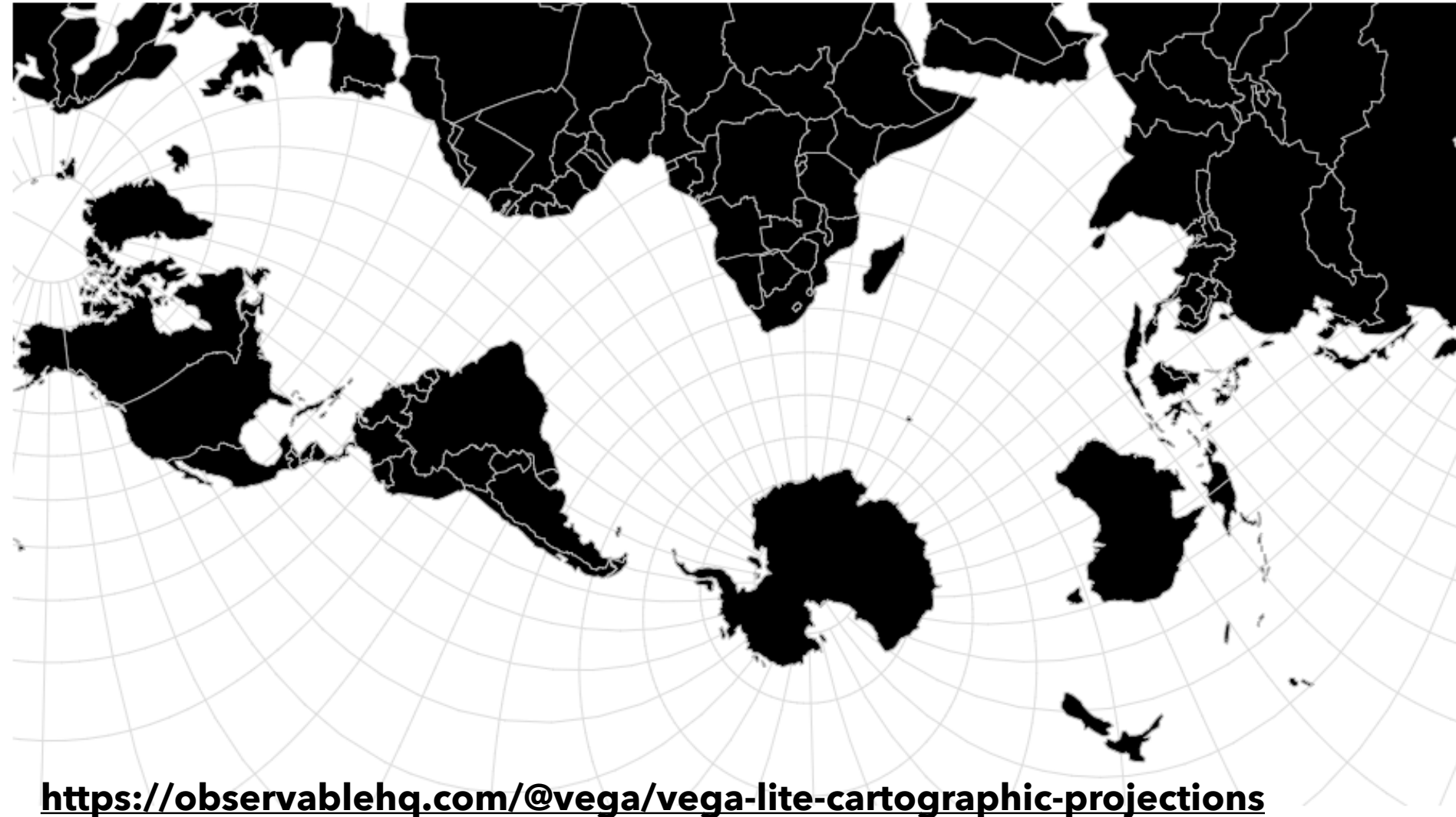
# Latitude, Longitude





**A sphere tears  
when you flatten it**

# Exploring Projections...



<https://observablehq.com/@vega/vega-lite-cartographic-projections>

**We can categorize  
projections by what  
they preserve...**

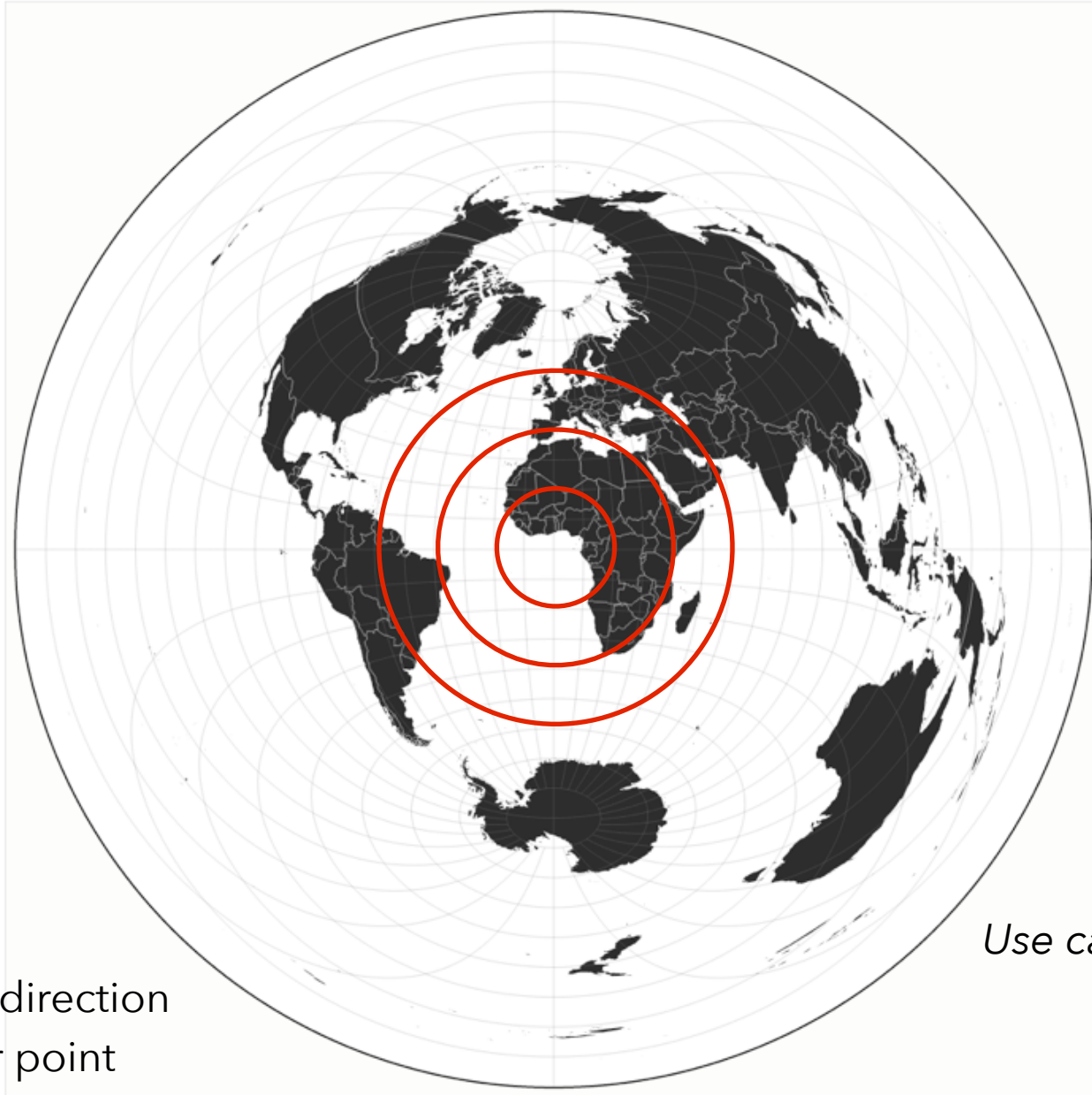




# Distance

Preserve distance / direction from center

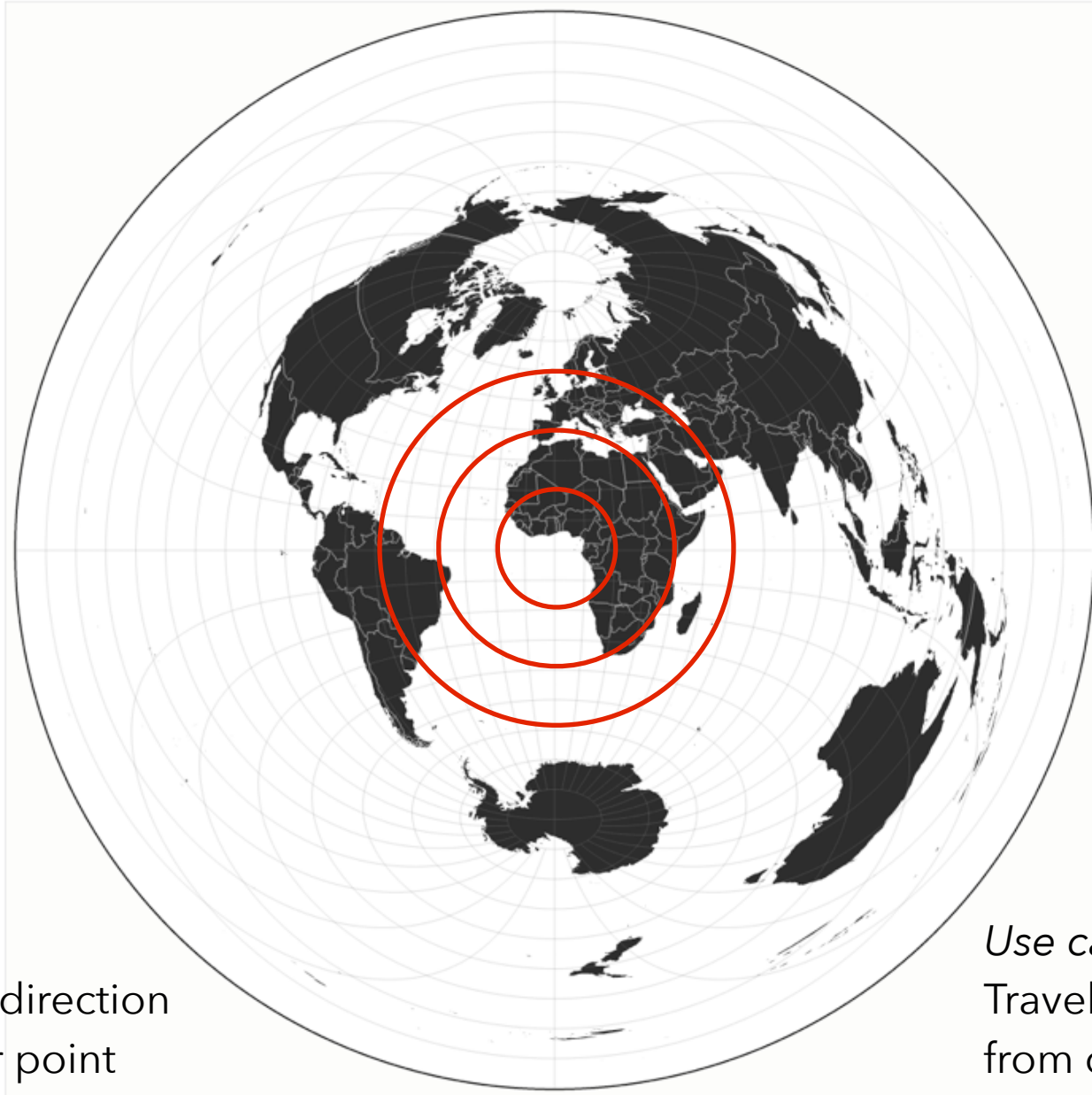
# Azimuthal Equidistant



*Preserves:*  
Distance & direction  
from center point

*Use cases?*

# Azimuthal Equidistant



*Preserves:*  
Distance & direction  
from center point

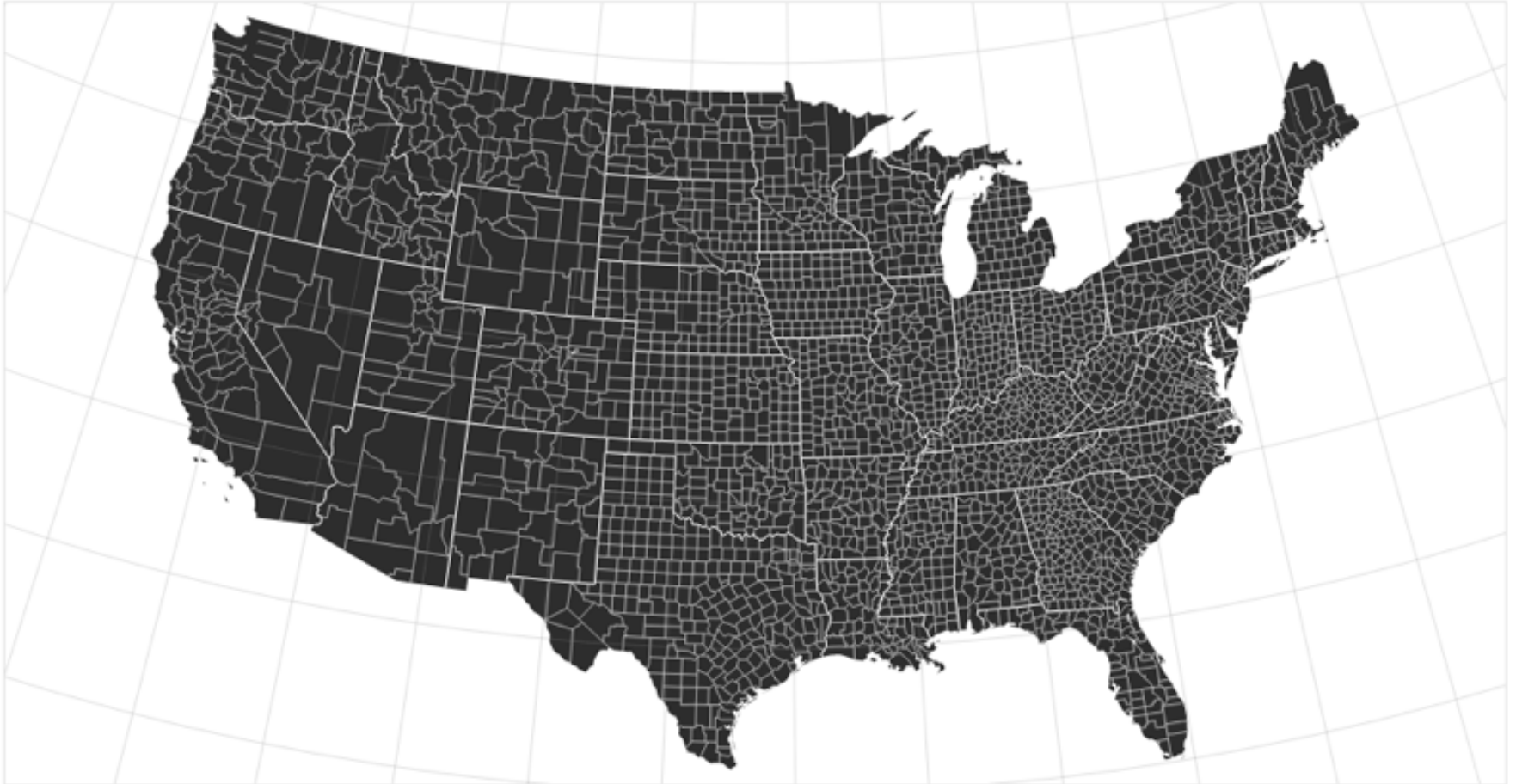
*Use cases:*  
Travel / propagation  
from center point

A world map where landmasses are colored yellow and oceans are dark gray. A semi-transparent dark gray rectangular box is centered over the map, containing white text. The text is arranged in two lines: a large title and a smaller subtitle.

# Equal-Area

Preserve proportional areas

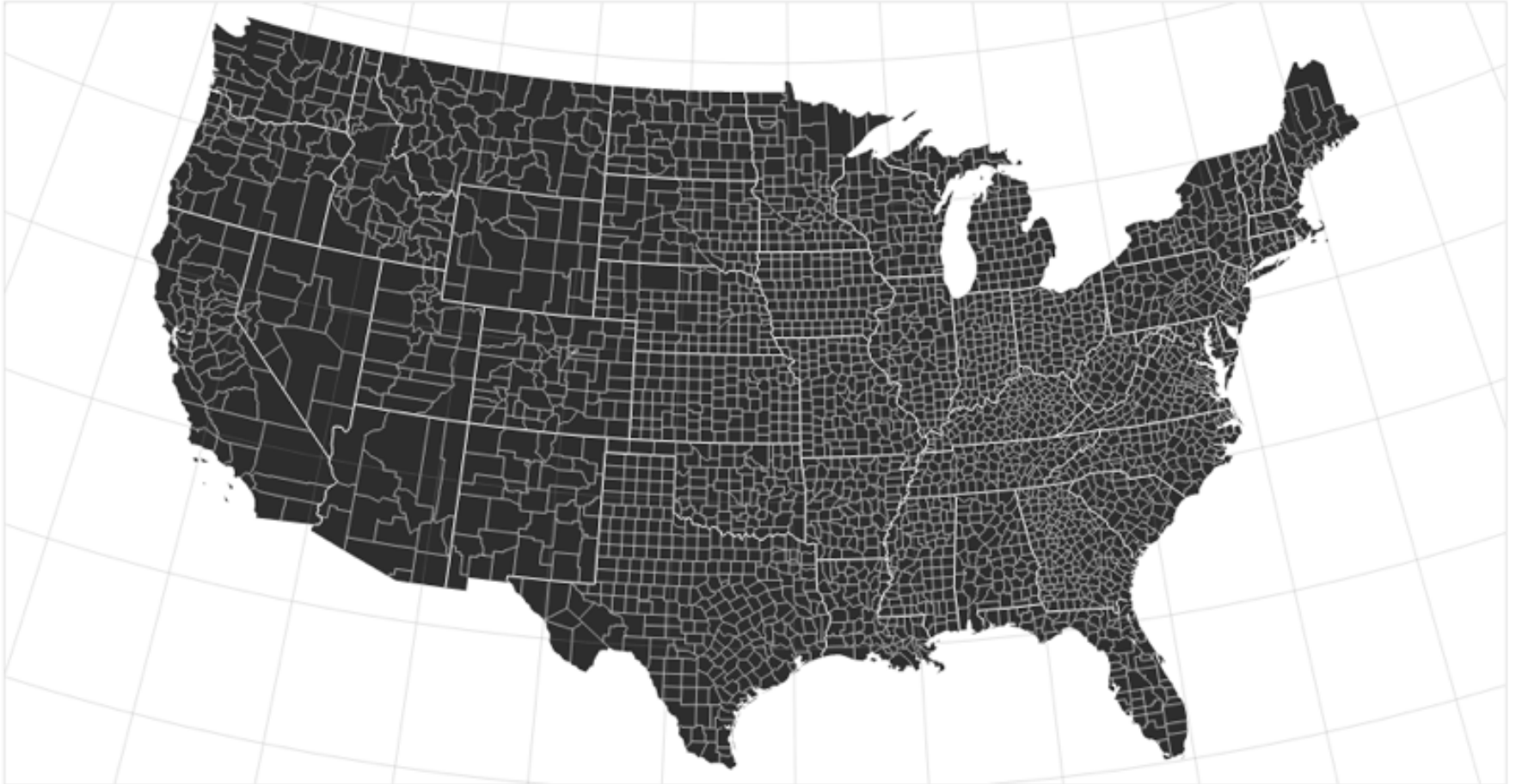
# Albers Equal-Area Conic



*Preserves:* Proportional area of geographic regions

*Use cases?*

# Albers Equal-Area Conic



*Preserves:* Proportional area of geographic regions

*Use cases:* Land surveys, choropleth (shaded) maps

A world map with a yellow background and black outlines for continents and countries. A semi-transparent grey rectangular box is centered over the map, containing text. The text is white and reads "Conformal" in a large font, and "Preserve local angles ('shape')" in a smaller font below it.

# Conformal

Preserve local angles ("shape")

# Spherical Mercator



*Preserves:*  
Compass bearing  
as straight line

*Use cases?*



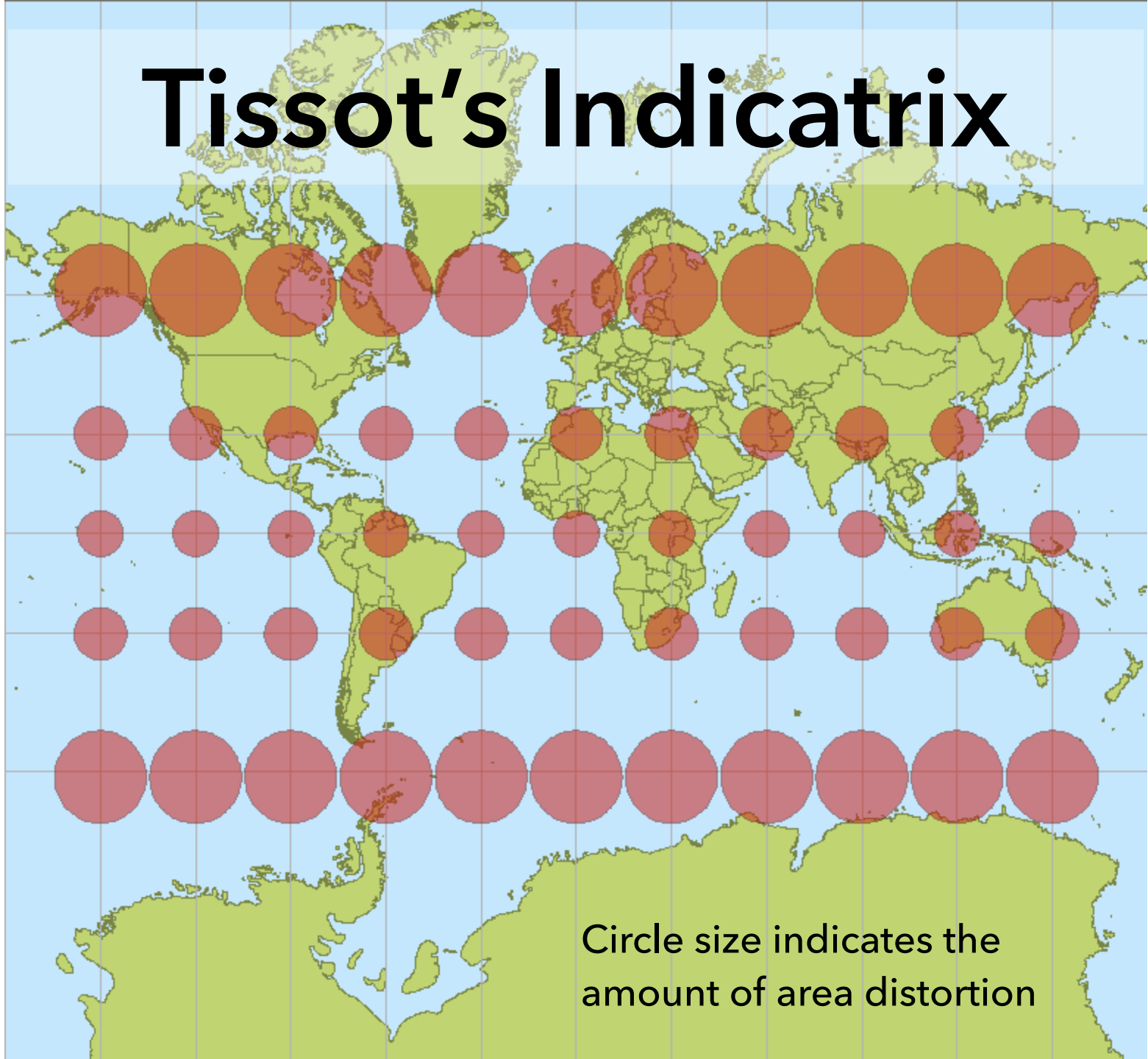
# Spherical Mercator



*Preserves:*  
Compass bearing  
as straight line

*Use cases:*  
Navigation

# Tissot's Indicatrix



Circle size indicates the amount of area distortion



Spherical Mercator  
is ubiquitous on  
the web. Why?

# The Earth as a Square



# Web Mercator

$$x = \frac{128}{\pi} 2^{\text{zoom level}} (\lambda + \pi) \text{ pixels}$$

$$y = \frac{128}{\pi} 2^{\text{zoom level}} \left( \pi - \ln \left[ \tan \left( \frac{\pi}{4} + \frac{\varphi}{2} \right) \right] \right) \text{ pixels}$$

World coordinates adjusted to map to 256 x 256 pixels.

**Latitude cut-offs** at 85.051129 degrees: the exact point at which the projection frames the world in a square.

# Peirce Quincuncial



But there are other ways to fit the Earth into a square...

A map of the Americas, including North and South America, is shown in yellow. A vertical orange rectangular box highlights the western coast of North America, from the Pacific Northwest down to the Gulf of California. The text "Projections usually have a home" is overlaid in white on a semi-transparent grey background at the bottom of the map.

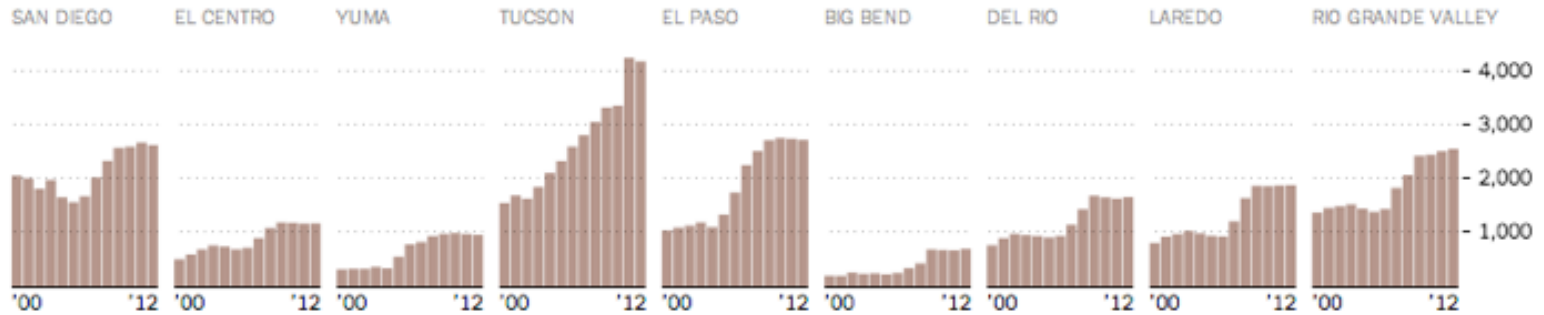
Projections usually  
have a home

# Increased Border Enforcement, With Varying Results



**There are now more agents along the 1,954 mile-long border than ever before...**

Border agents per sector.



Satellite Projection, NY Times

Not appropriate for the whole Earth, but fits the chosen focus region!



WHAT YOUR FAVORITE  
**MAP PROJECTION**  
SAYS ABOUT YOU

MERCATOR



YOU'RE NOT REALLY INTO MAPS.

VAN DER GRINTEN



YOU'RE NOT A COMPLICATED PERSON. YOU LOVE THE MERCATOR PROJECTION; YOU JUST WISH IT WEREN'T SQUARE. THE EARTH'S NOT A SQUARE, IT'S A CIRCLE. YOU LIKE CIRCLES. TODAY IS GONNA BE A GOOD DAY!

## PEIRCE QUINCUNCIAL



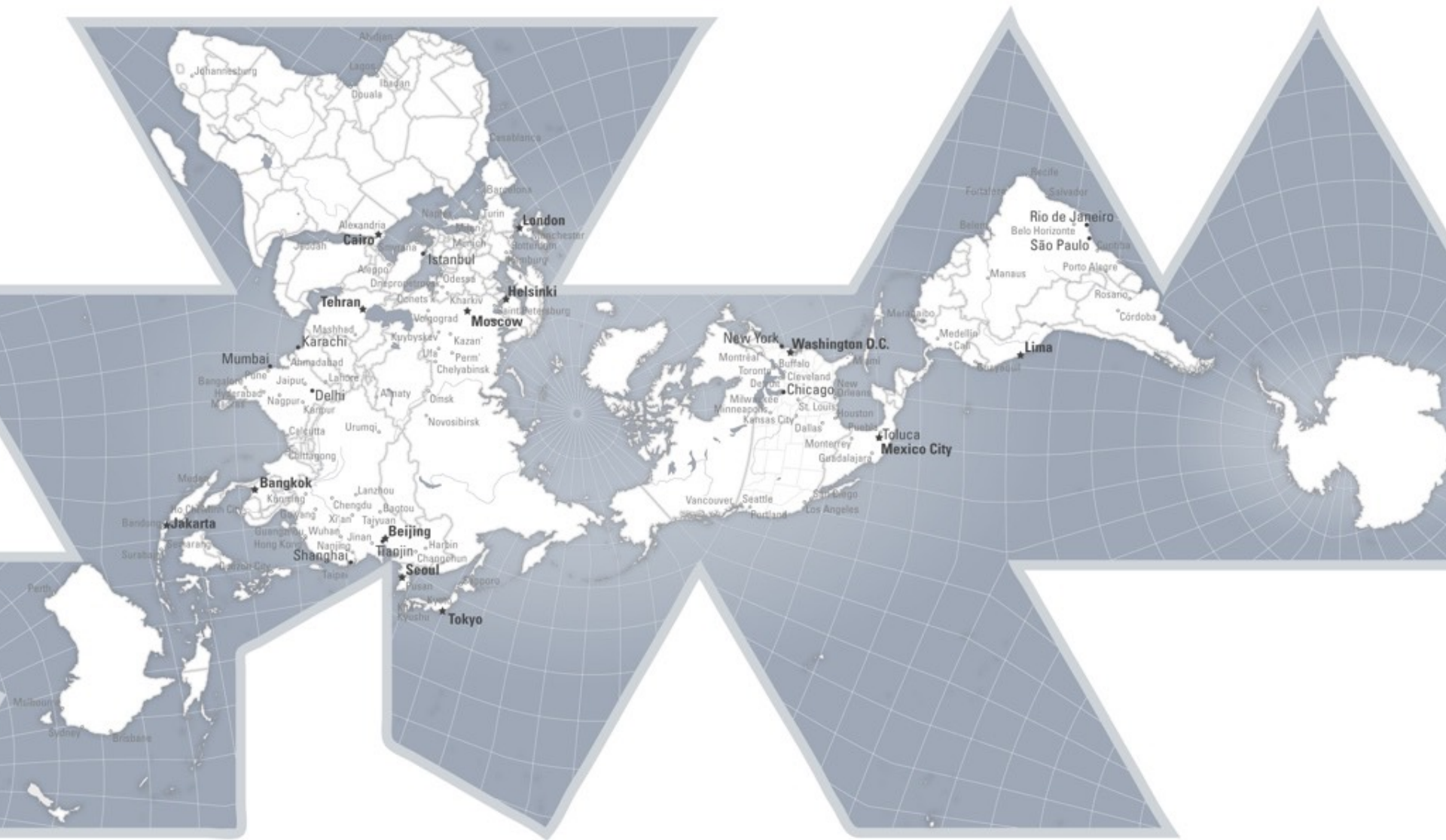
YOU THINK THAT WHEN WE LOOK AT A MAP, WHAT WE REALLY SEE IS OURSELVES. AFTER YOU FIRST SAW *INCEPTION*, YOU SAT SILENT IN THE THEATER FOR SIX HOURS. IT FREAKS YOU OUT TO REALIZE THAT EVERYONE AROUND YOU HAS A SKELETON INSIDE THEM. YOU *HAVE* REALLY LOOKED AT YOUR HANDS.



**There are interesting  
ways to tear spheres**

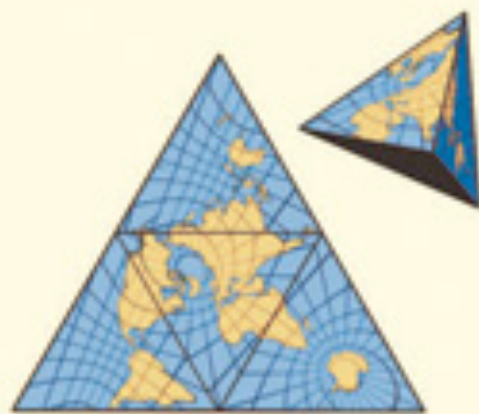
One notable interesting  
way to tear a sphere



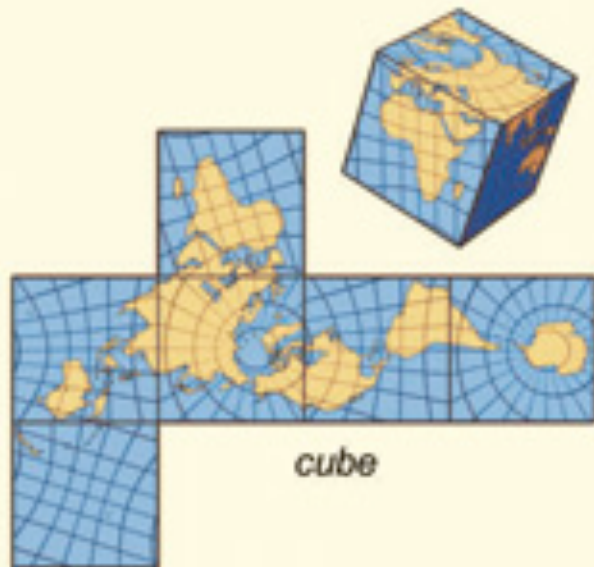


Balances preservation of area and shape.

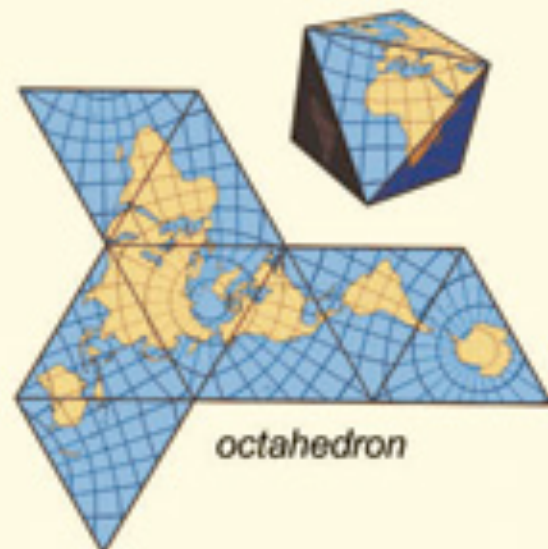
*Provides different ways of thinking about the world!*



*tetrahedron*



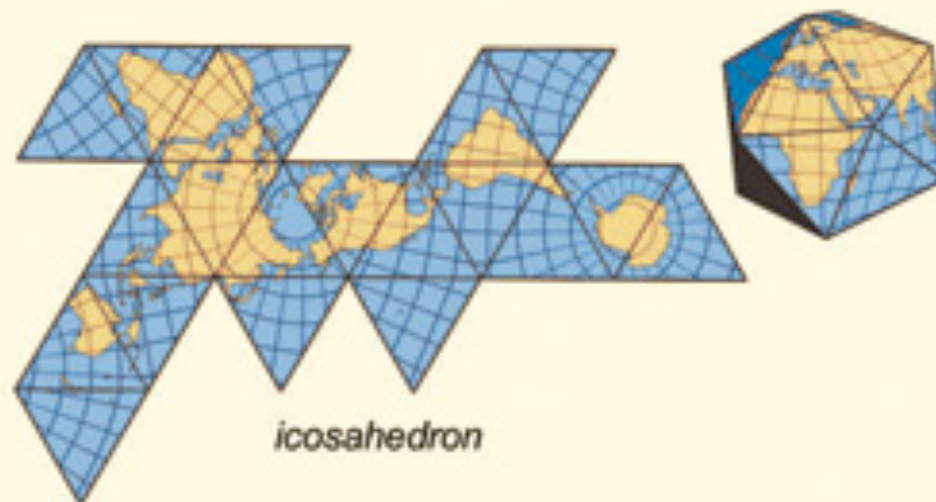
*cube*



*octahedron*



*dodecahedron*



*icosahedron*



## ADAPTIVE COMPOSITE MAP PROJECTIONS

---

Idea: switch *between* projections by location and zoom level

**Scale**



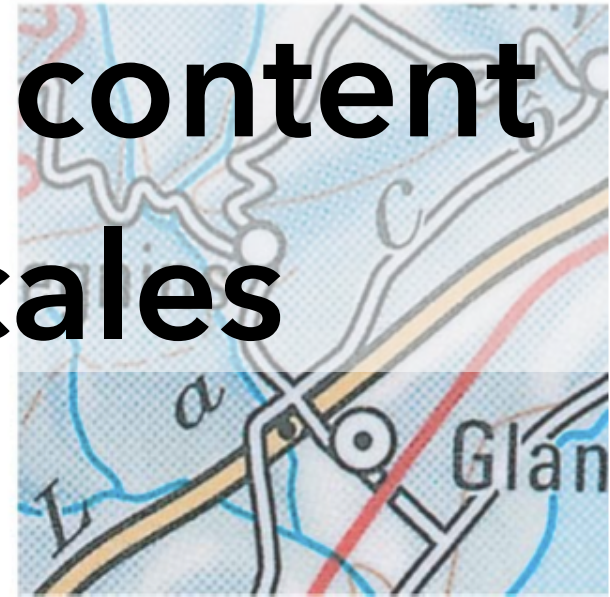
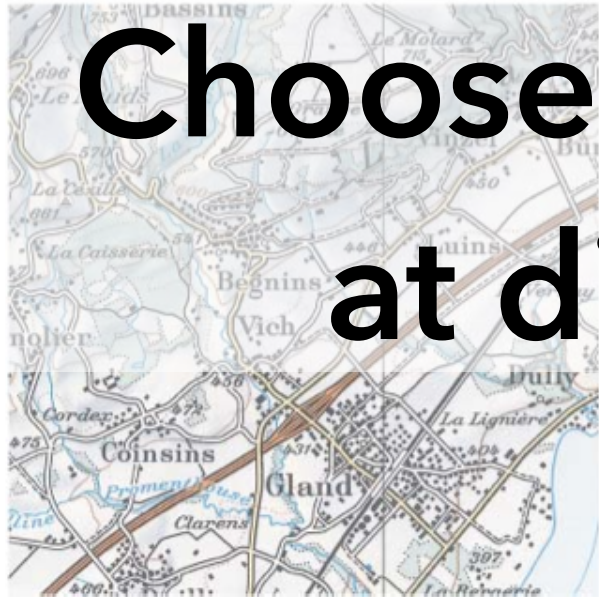
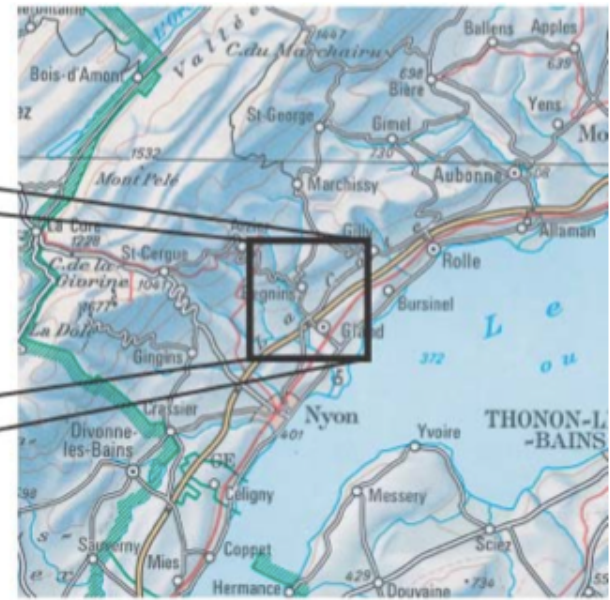
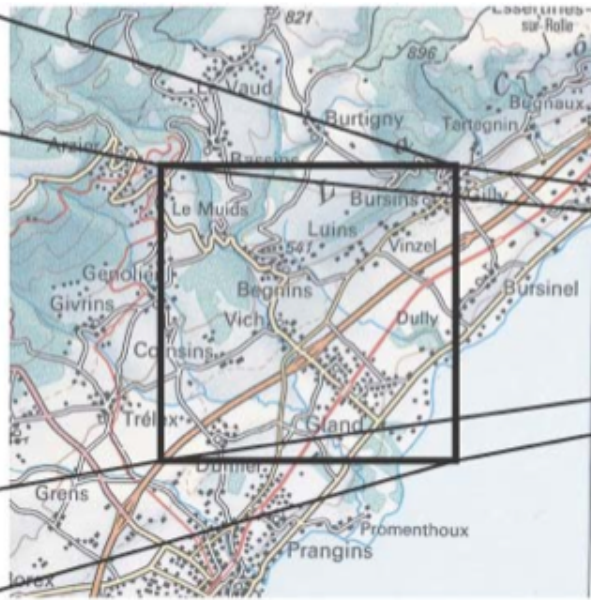


**This is not "scale"**

*Texas-Europe Size Comparison*

# Scale is an idea imported from print





**Choose the right content  
at different scales**

**Four maps, same area**



# What shows at different scales?





Pittsburgh

Harrisburg

Reading

NEW JERSEY

Camden

Cumberland

MARYLAND

Millville

Washington

DELAWARE

Harrisonburg

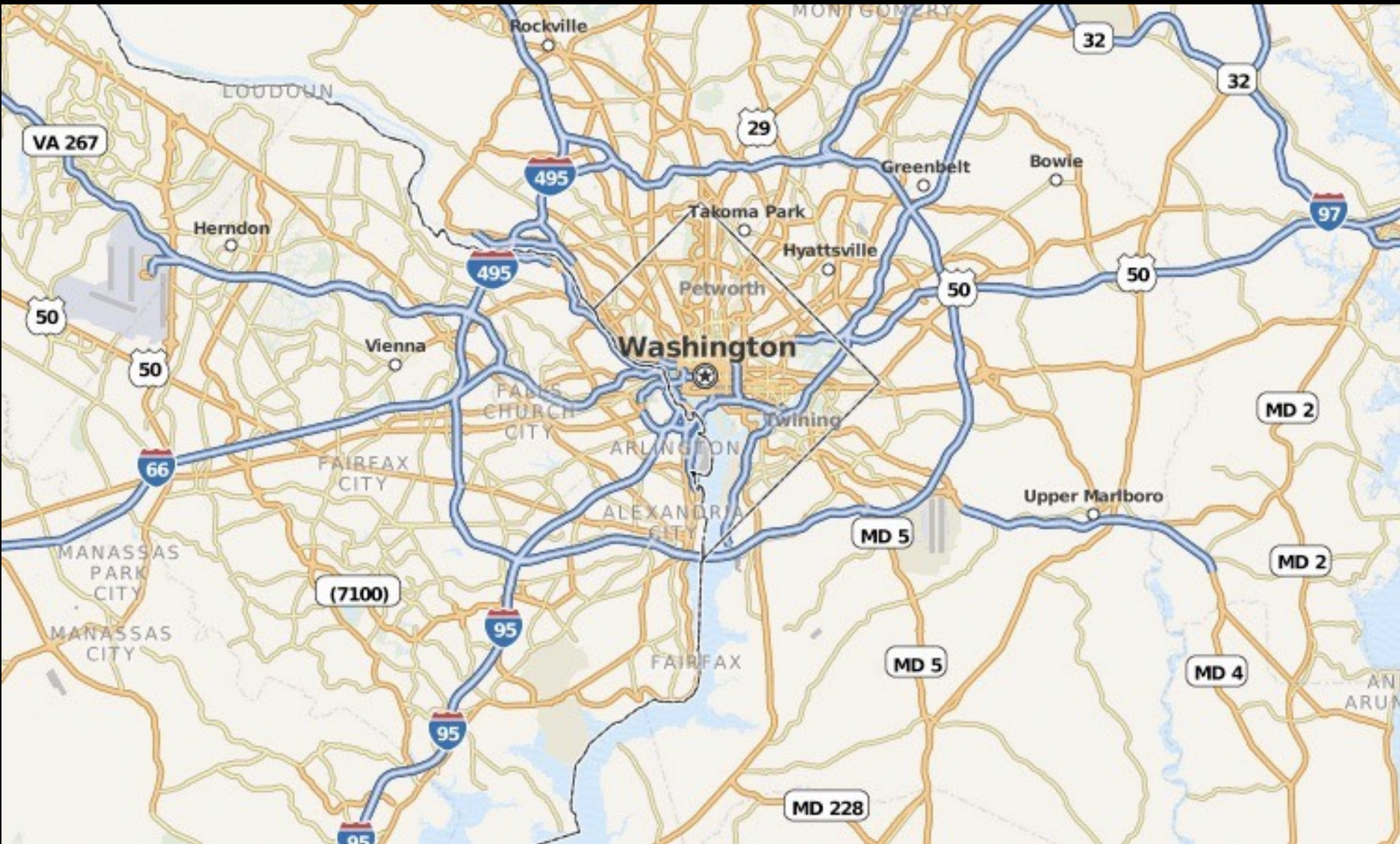
WEST VIRGINIA

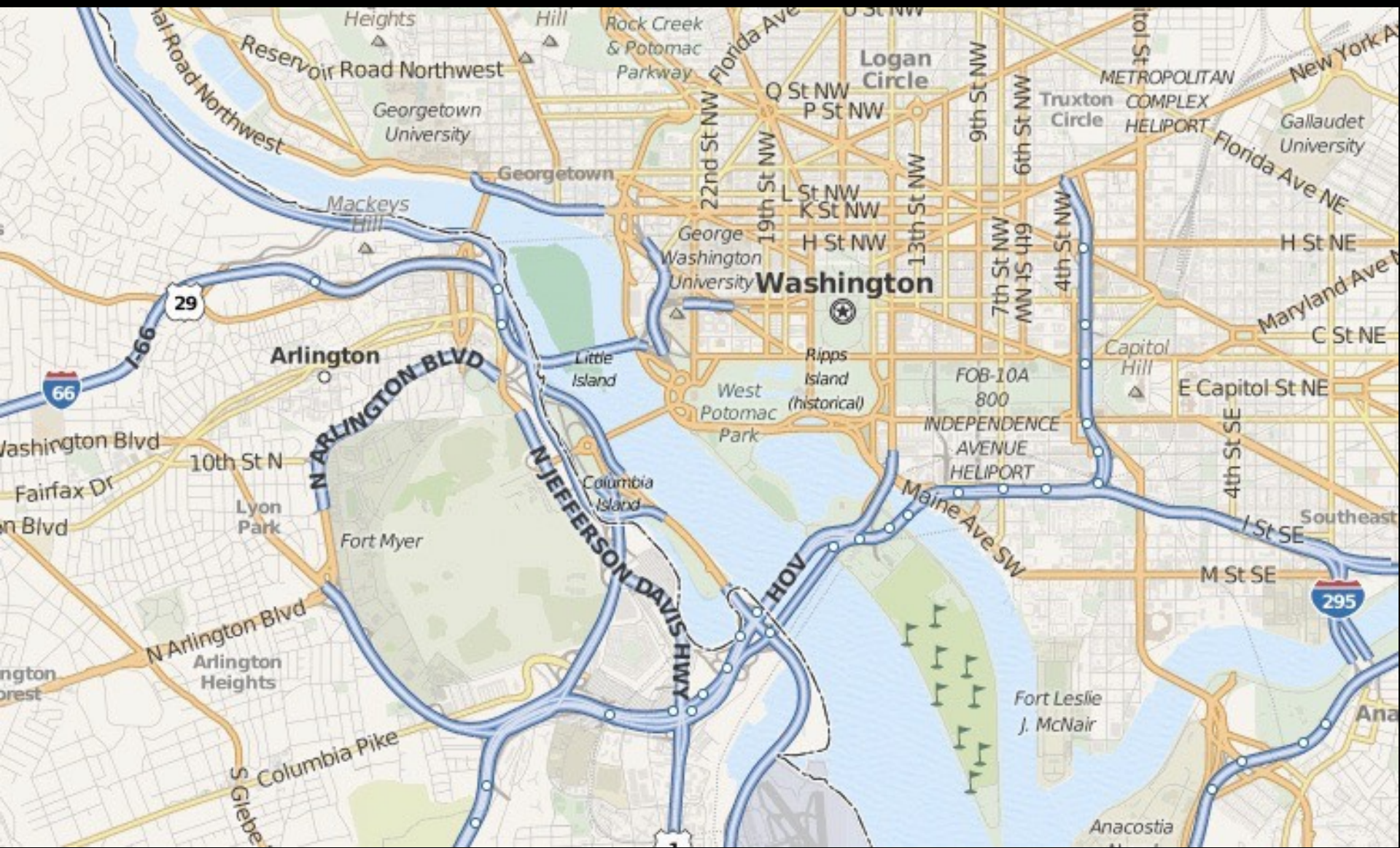
Richmond

Roanoke

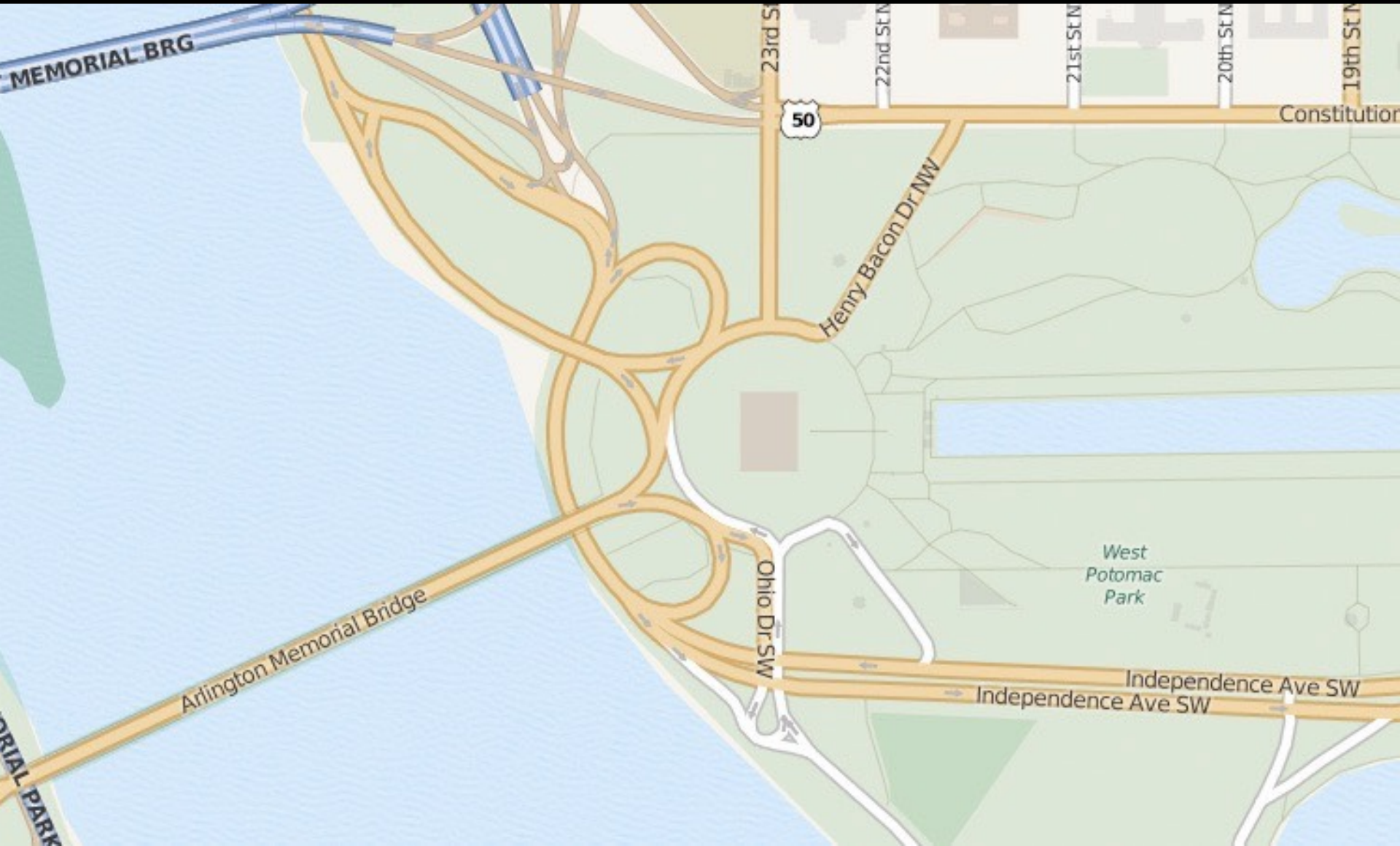
VIRGINIA

Suffolk









MEMORIAL BRG

50

Constitution

Henry Bacon Dr NW

West Potomac Park

Arlington Memorial Bridge

Ohio Dr SW

Independence Ave SW

MEMORIAL PARK

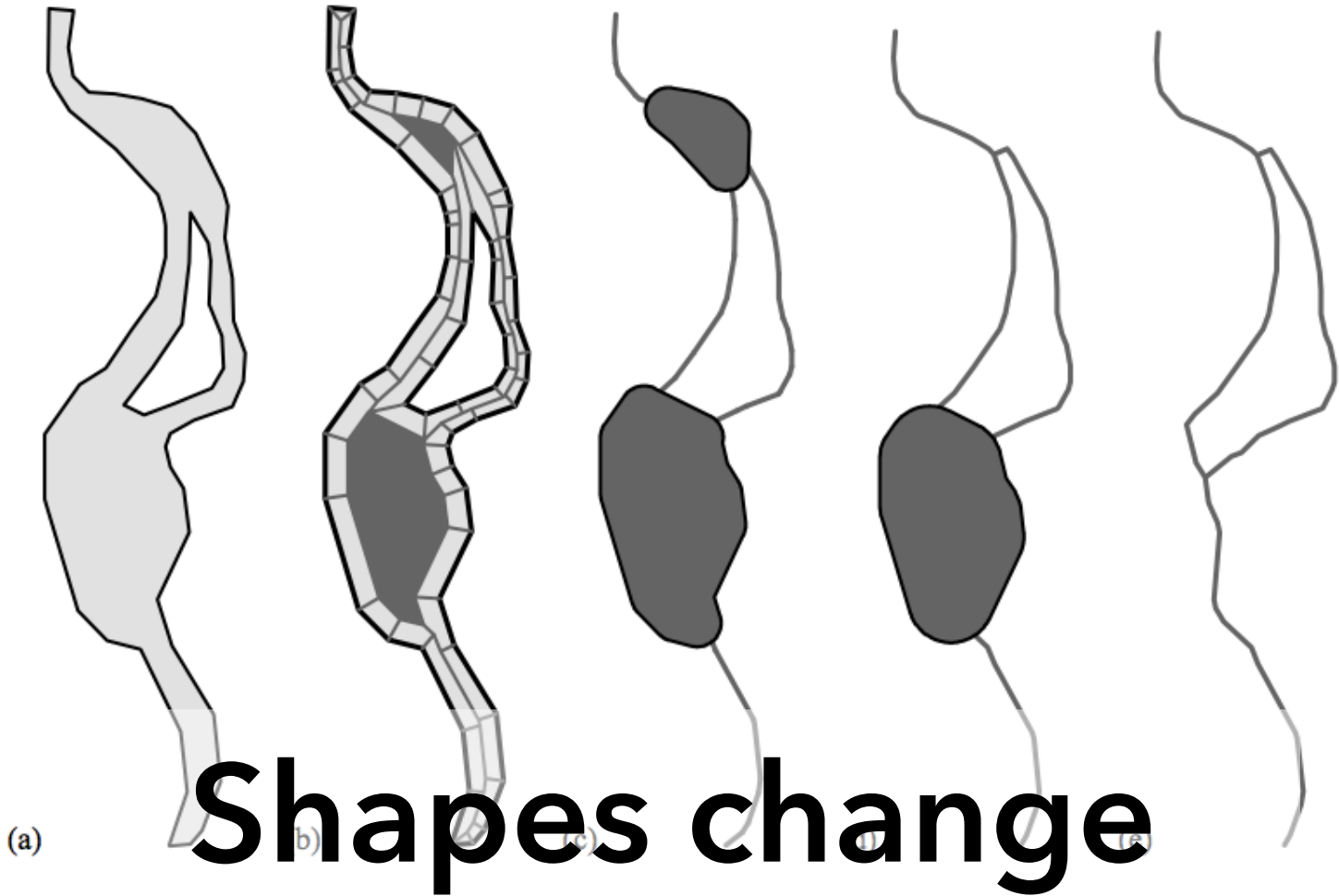


Figure 11. Fragmentation of a river into polygons and lines with different thresholds leading to different results (c, d, e).

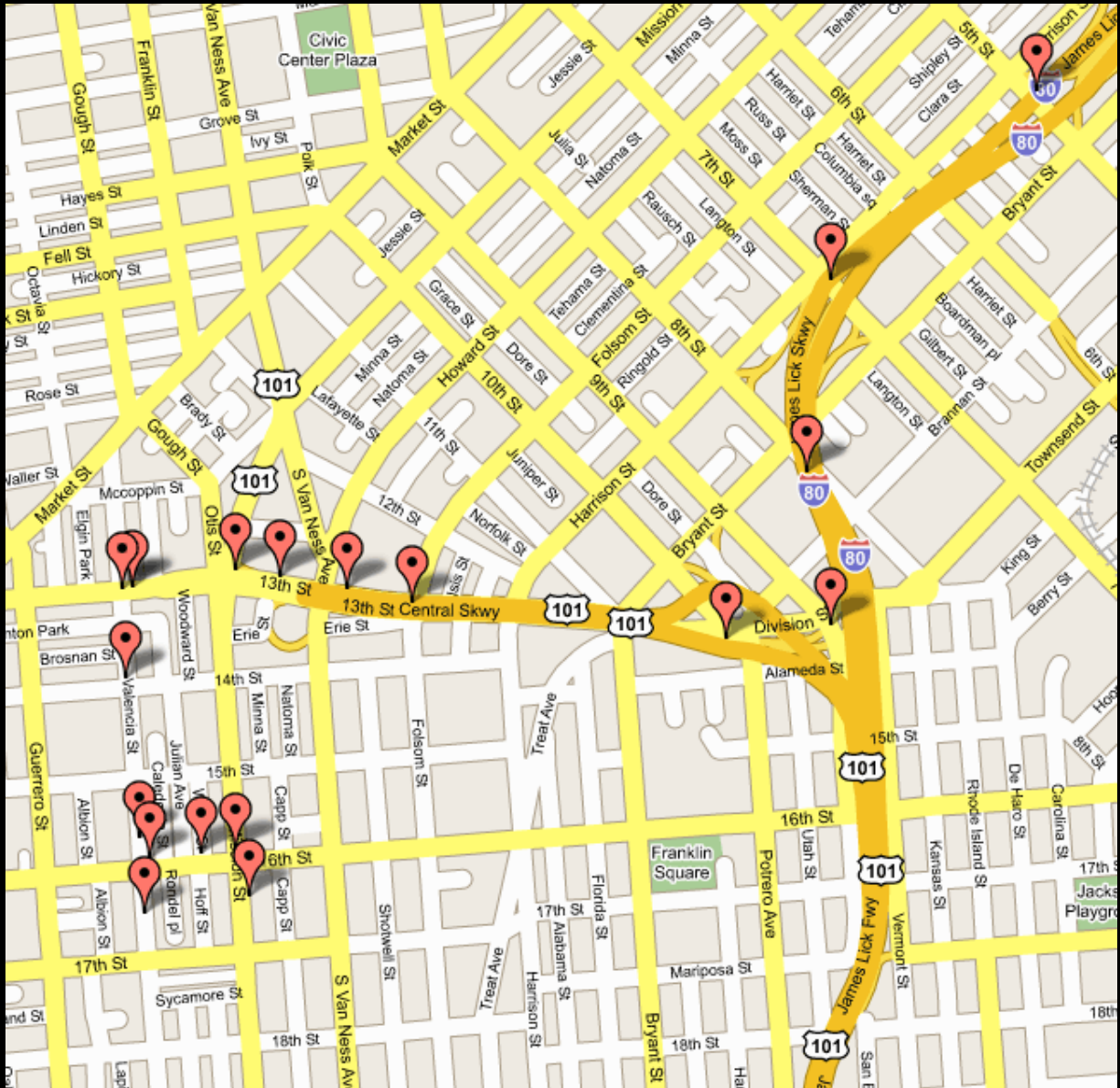
# Shapes change at different scales

# Mapping

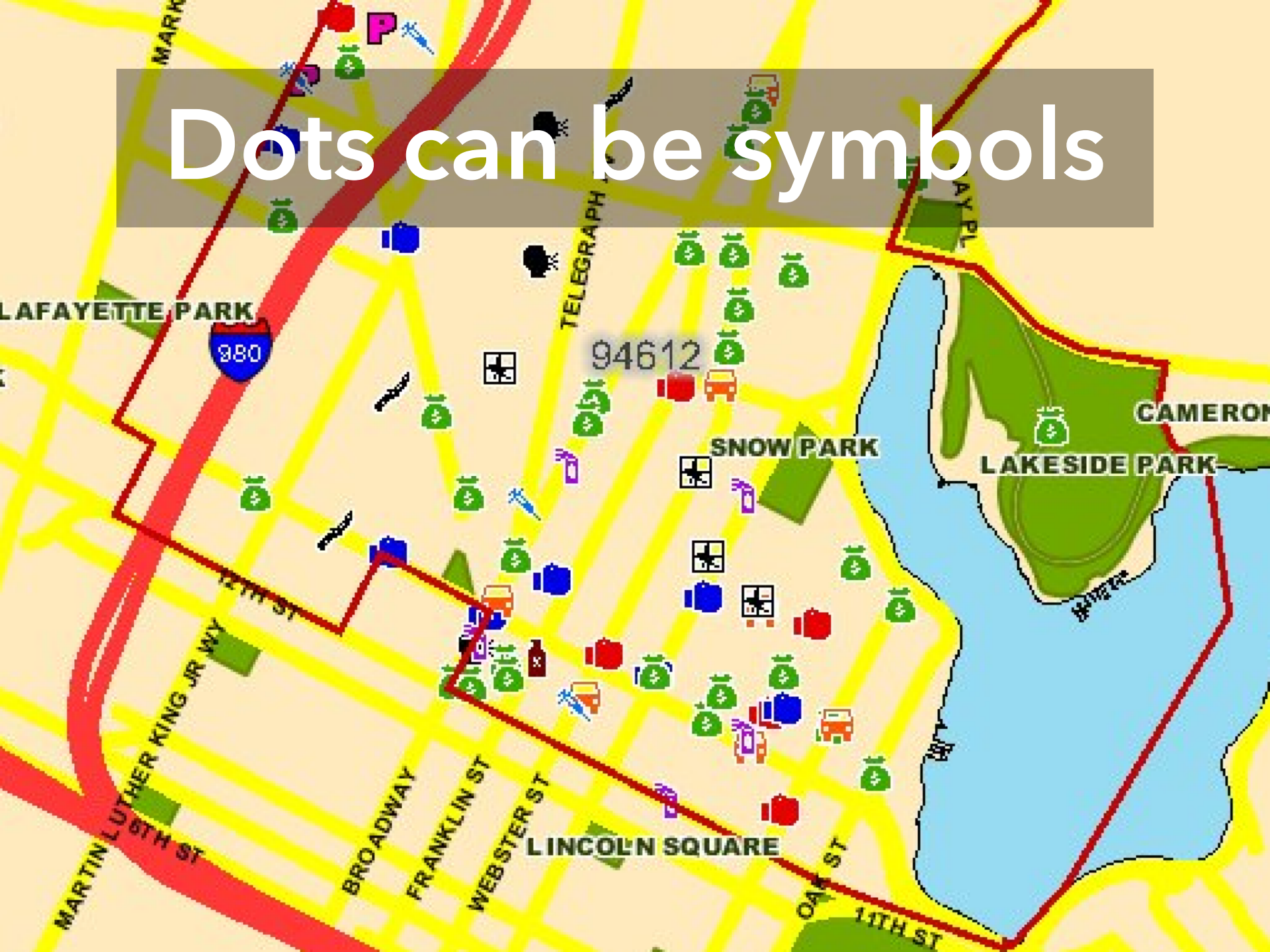
Visualizing Geospatial Data

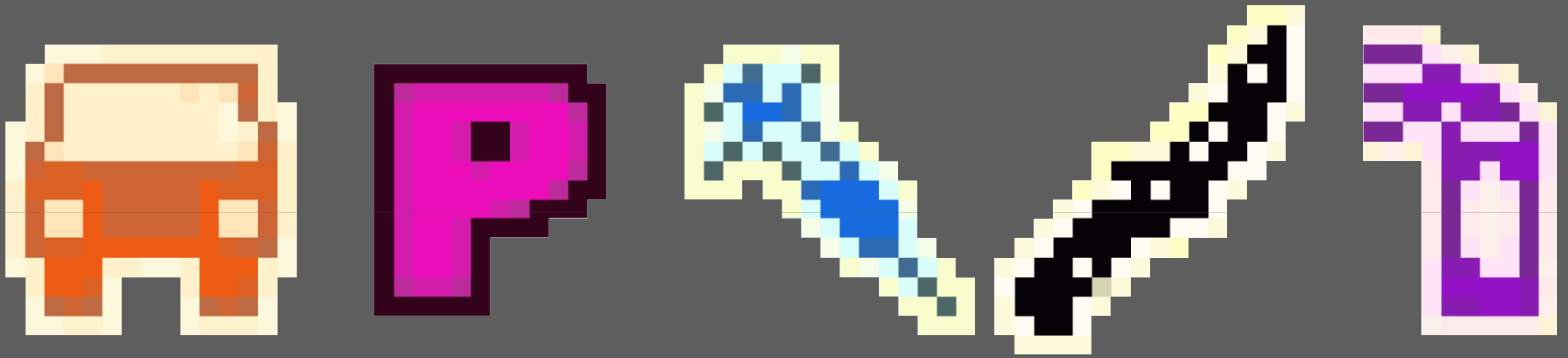
# Symbol Maps

Convey Locations & Magnitudes



# Dots can be symbols





Guess the crime

# Dots can can be good symbols



**TIME OF DAY**  
Show All | Hide All  
Light | Dark [nearest hour]  
Commute | Nightlife  
Day | Night | Swing Shift

NOON  
12 3 6 PM  
9 6 AM  
3 12  
MIDNIGHT

**DATE** Past Week  
Sep 2009  
AUG 17 2009 AUG 24 2009 AUG 31 2009 SEP 7 2009

T W Th F S S M T W Th F S S M T W Th F S S M

**CRIME TYPE** Show All | Hide All

AA	Aggravated Assault
Mu	Murder
Ro	Robbery
SA	Simple Assault
DP	Disturbing the Peace
Na	Narcotics
Al	Alcohol
Pr	Prostitution
Th	Theft
VT	Vehicle Theft
Va	Vandalism
Bu	Burglary
Ar	Arson



Dots are ubiquitous



# 237

Joseph R. Biden Jr.

70,122,063 votes (50.2%)

# 87

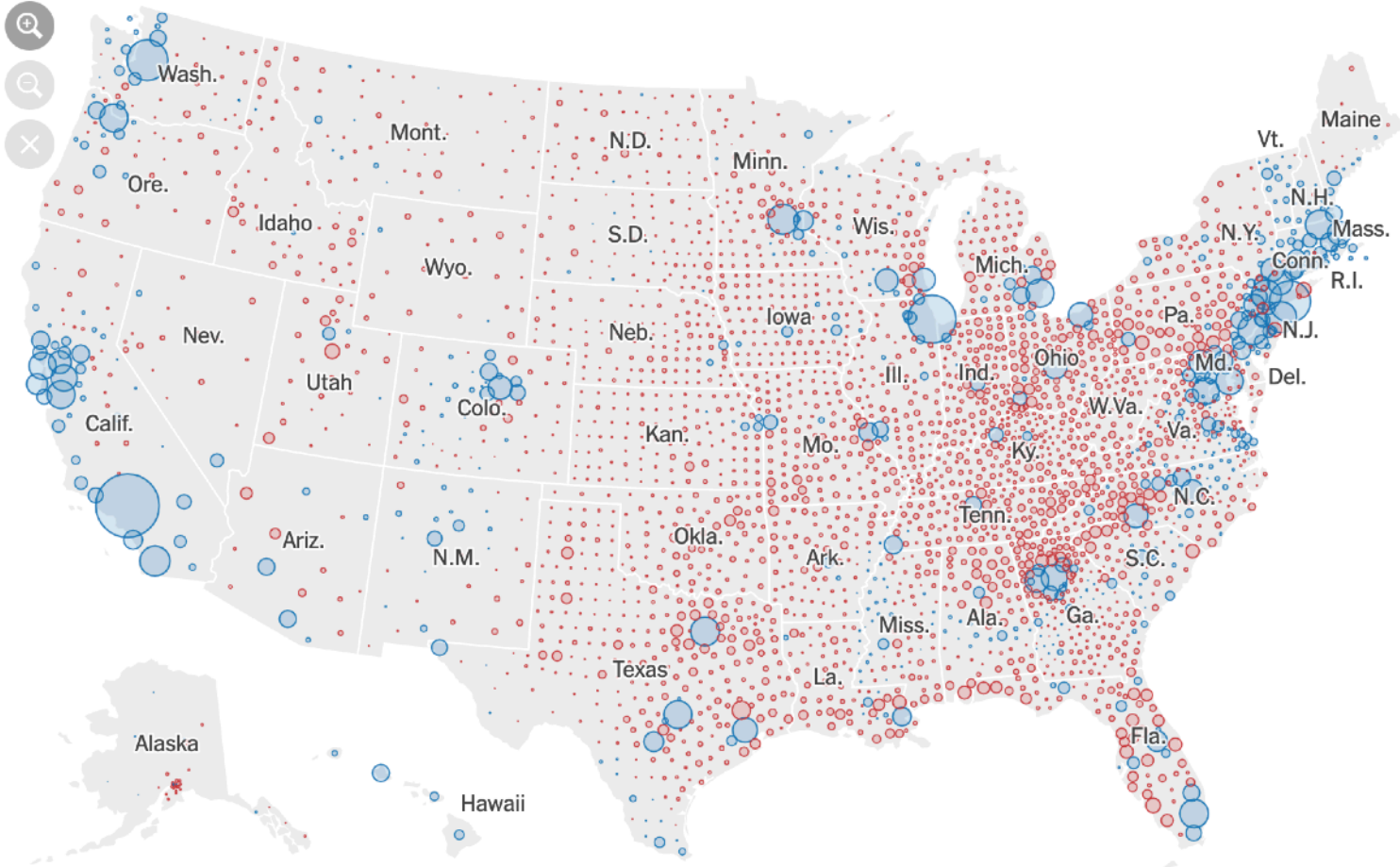
remaining

270  
TO WIN

# 214

Donald J. Trump

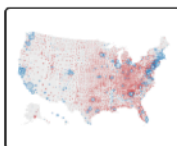
67,075,300 votes (48.0%)



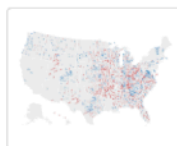
By winner



Electoral votes



Size of lead



Shift from 2016

**LEADER:** ● Biden ● Trump  
 Circle size is proportional to the amount each county's leading candidate is ahead.

Symbol Map  
 [NY Times]

# “Red Dot Fever”





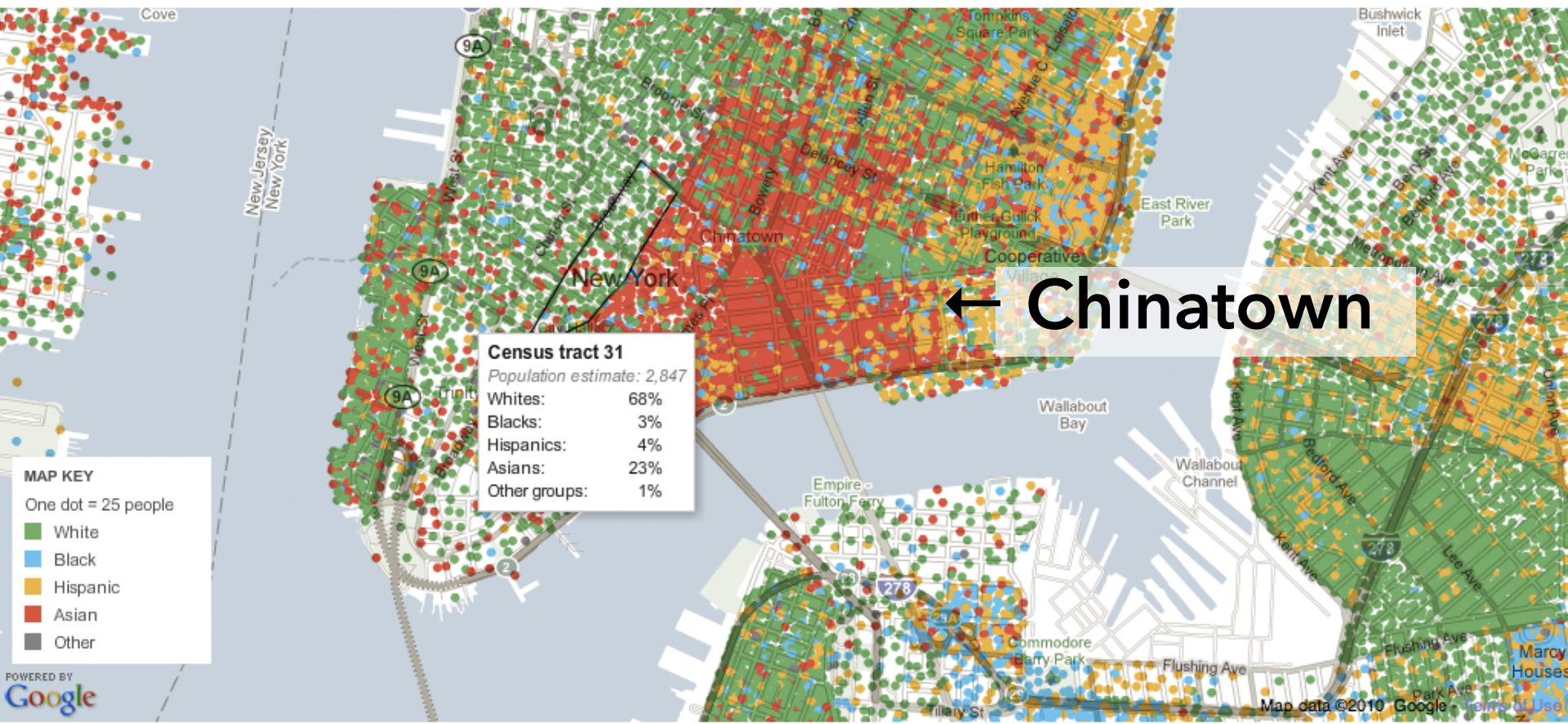
# Mapping America: Every City, Every Block

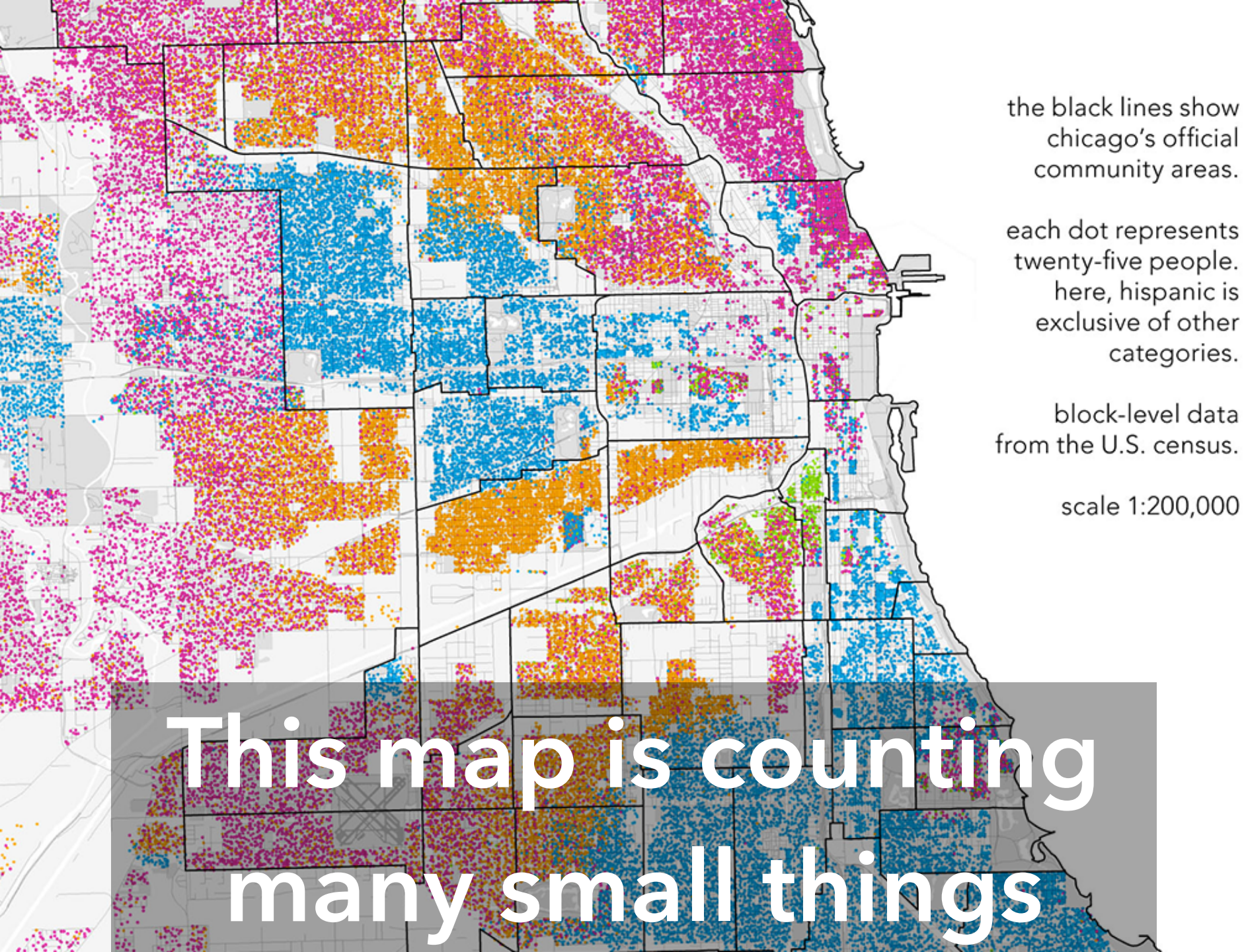
Find something interesting? Share this view on [Twitter](#) or [Facebook](#)

Browse local data from the Census Bureau's American Community Survey, based on samples from 2005 to 2009. Because these figures are based on [View Readers Maps \(49\)](#) samples, they are subject to a margin of error, particularly in places with a low population, and are best regarded as estimates.

## Distribution of racial and ethnic groups

[View More Maps](#) |  [Go](#)  





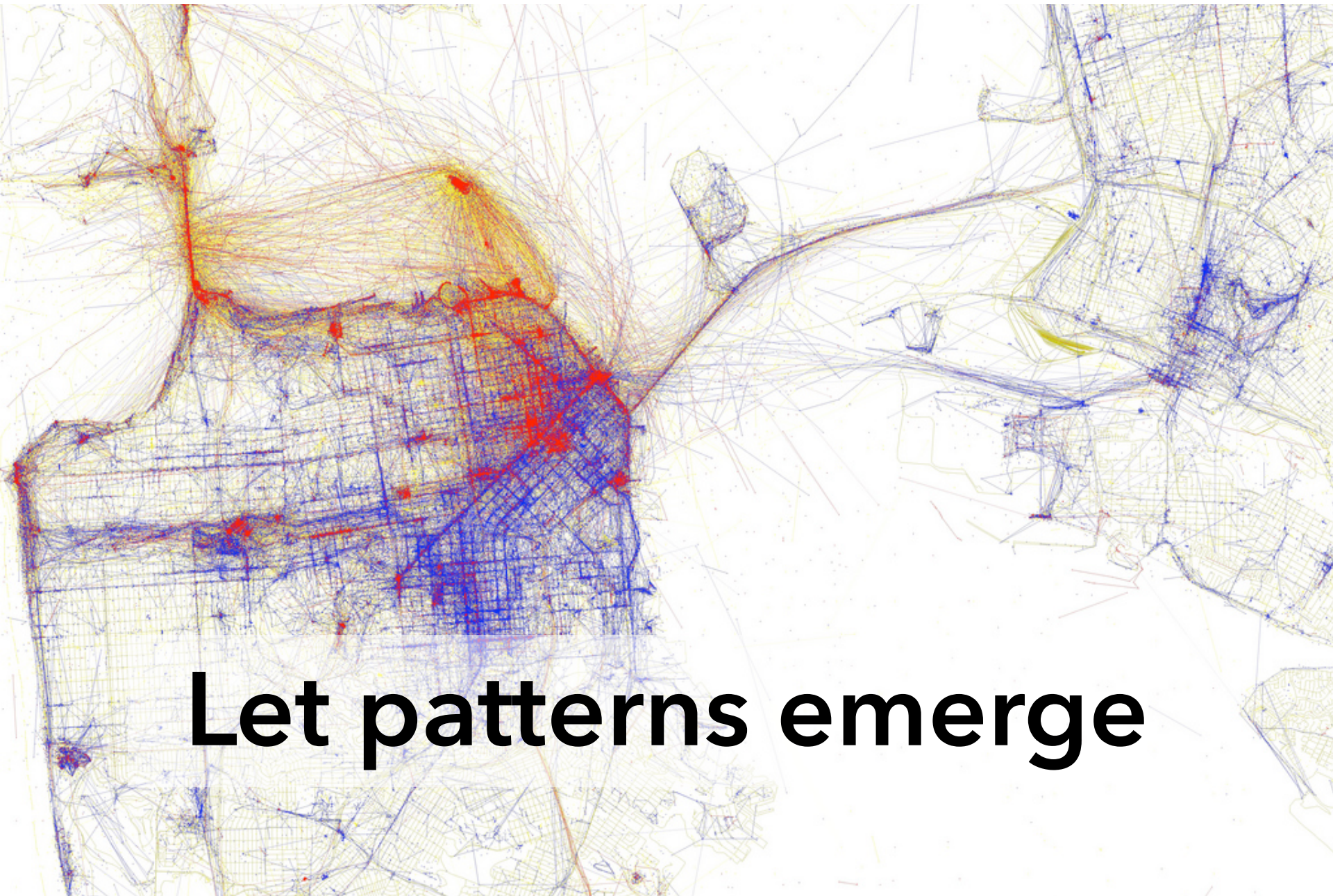
the black lines show  
chicago's official  
community areas.

each dot represents  
twenty-five people.  
here, hispanic is  
exclusive of other  
categories.

block-level data  
from the U.S. census.

scale 1:200,000

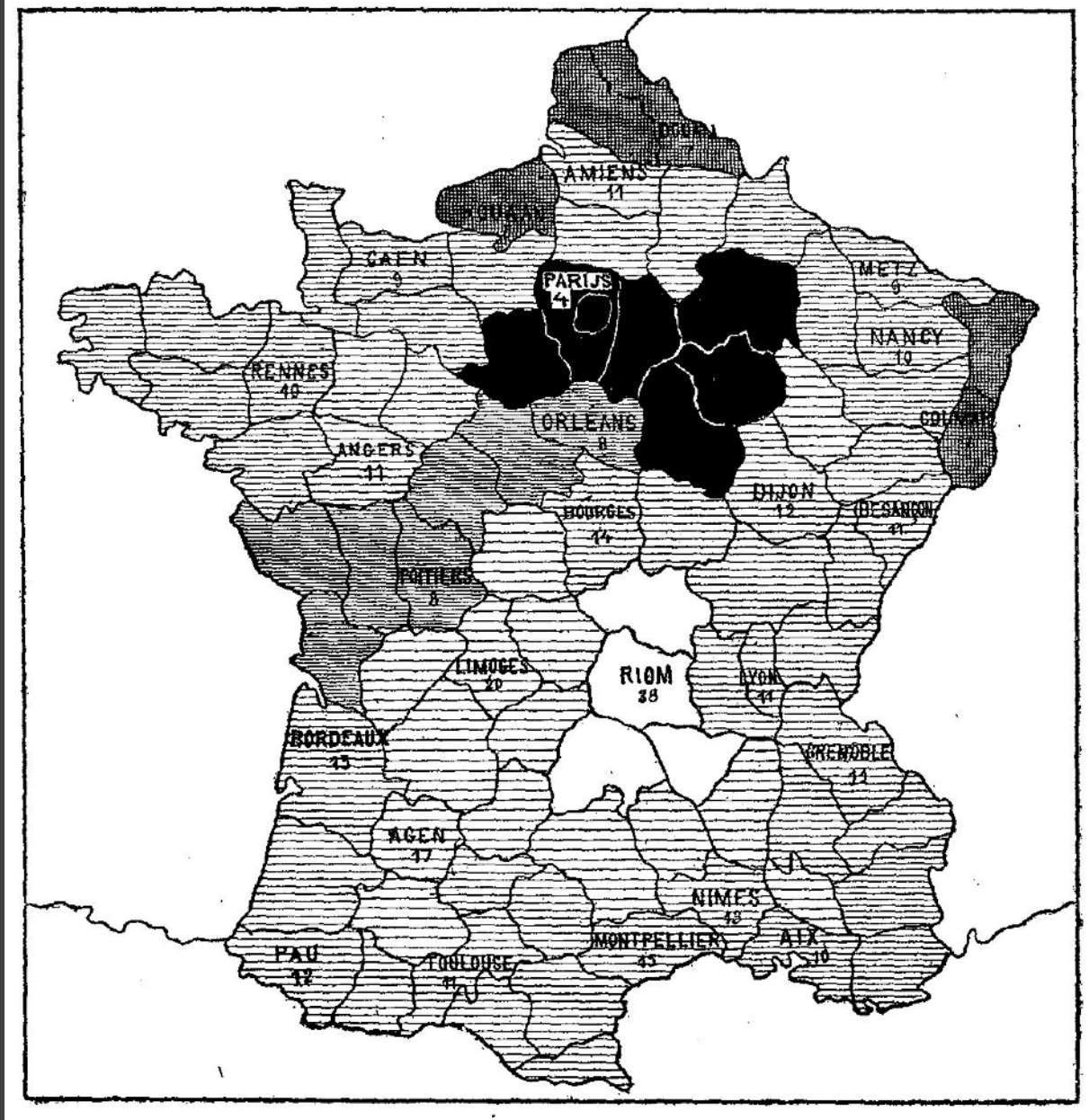
**This map is counting  
many small things**



**Let patterns emerge**

# Choropleth Maps

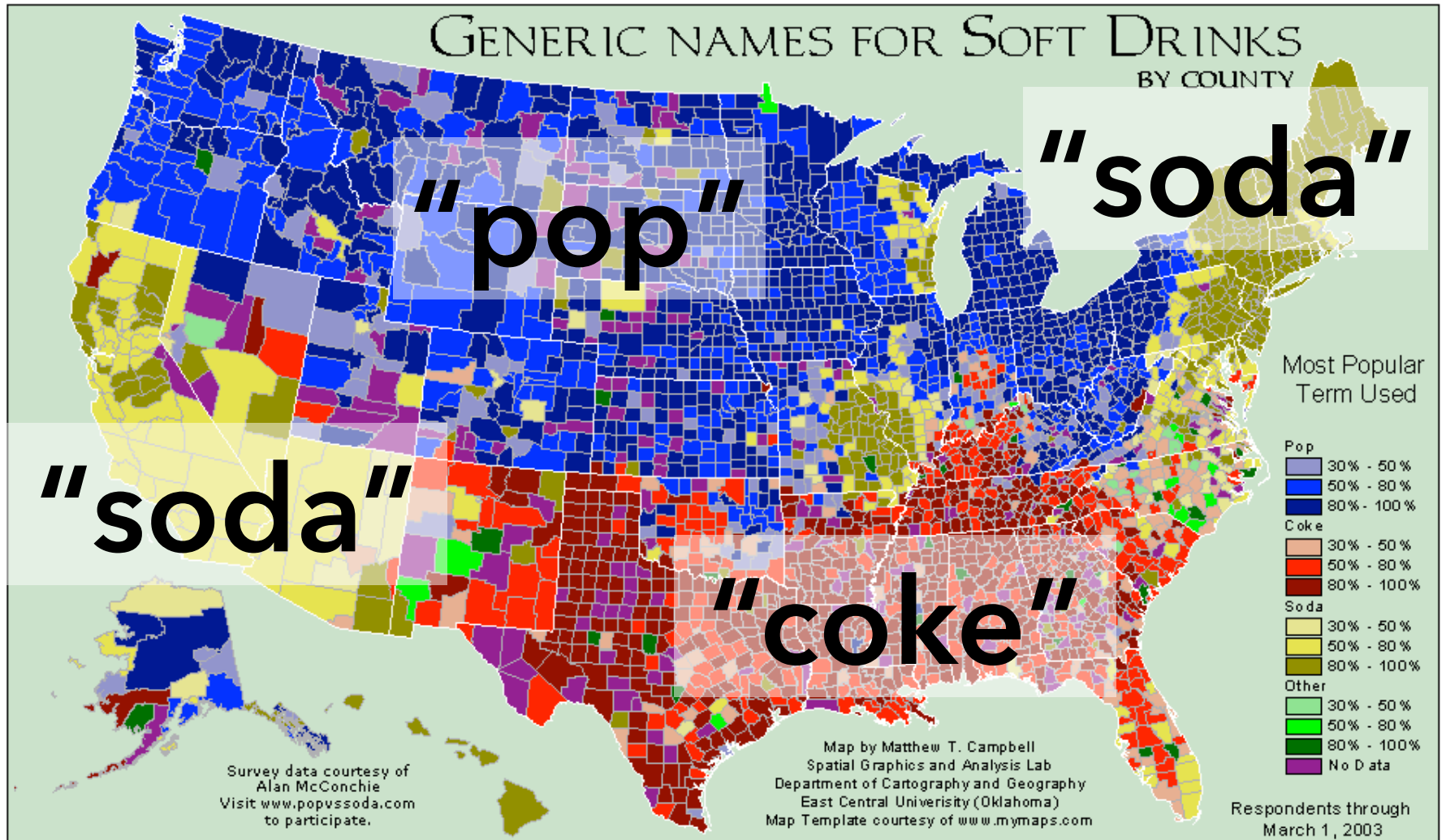
Convey Rates Across Regions



1826(?) Illiteracy in France, Pierre Charles Dupin

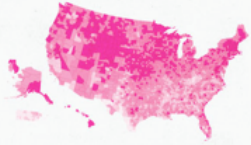


# GENERIC NAMES FOR SOFT DRINKS BY COUNTY



# READING, WRITING, AND EARNING MONEY

The latest data from the U.S. Census's American Community Survey paints a fascinating picture of the United States at the county level. We've looked at the educational achievement and the median income of the entire nation, to see where people are going to school, where they're earning money, and if there is any correlation.



**A** HIGH SCHOOL GRADUATES 65% 75% 82% 85%



**B** COLLEGE GRADUATES 15% 22% 30% 40%

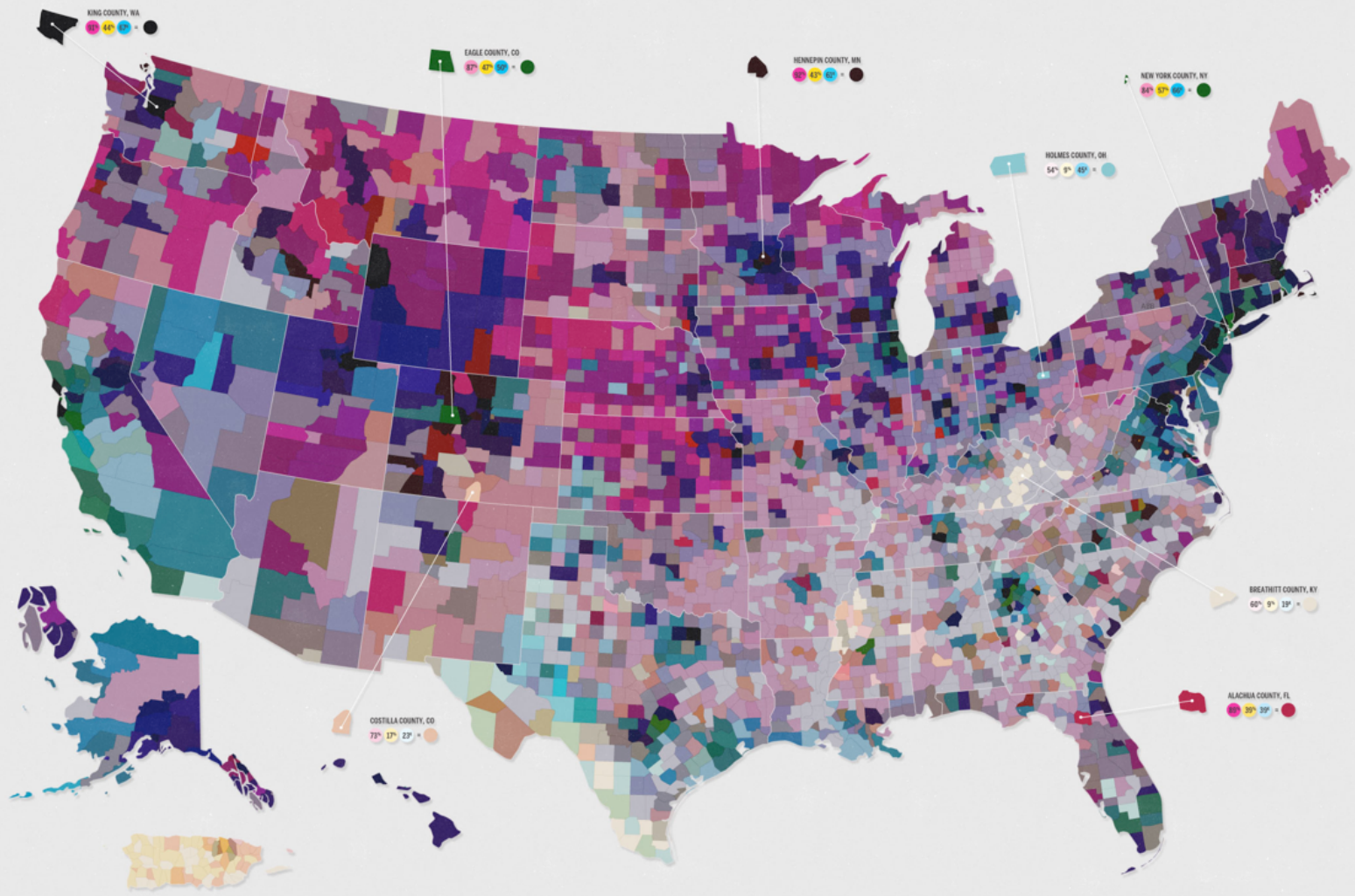


**C** MEDIAN HOUSEHOLD INCOME 25K 40K 50K 60K

The map at right is a product of overlaying the three sets of data. The variation in hue and value has been produced from the data shown above. In general, darker counties represent a more educated, better paid population while lighter areas represent communities with fewer graduates and lower incomes.

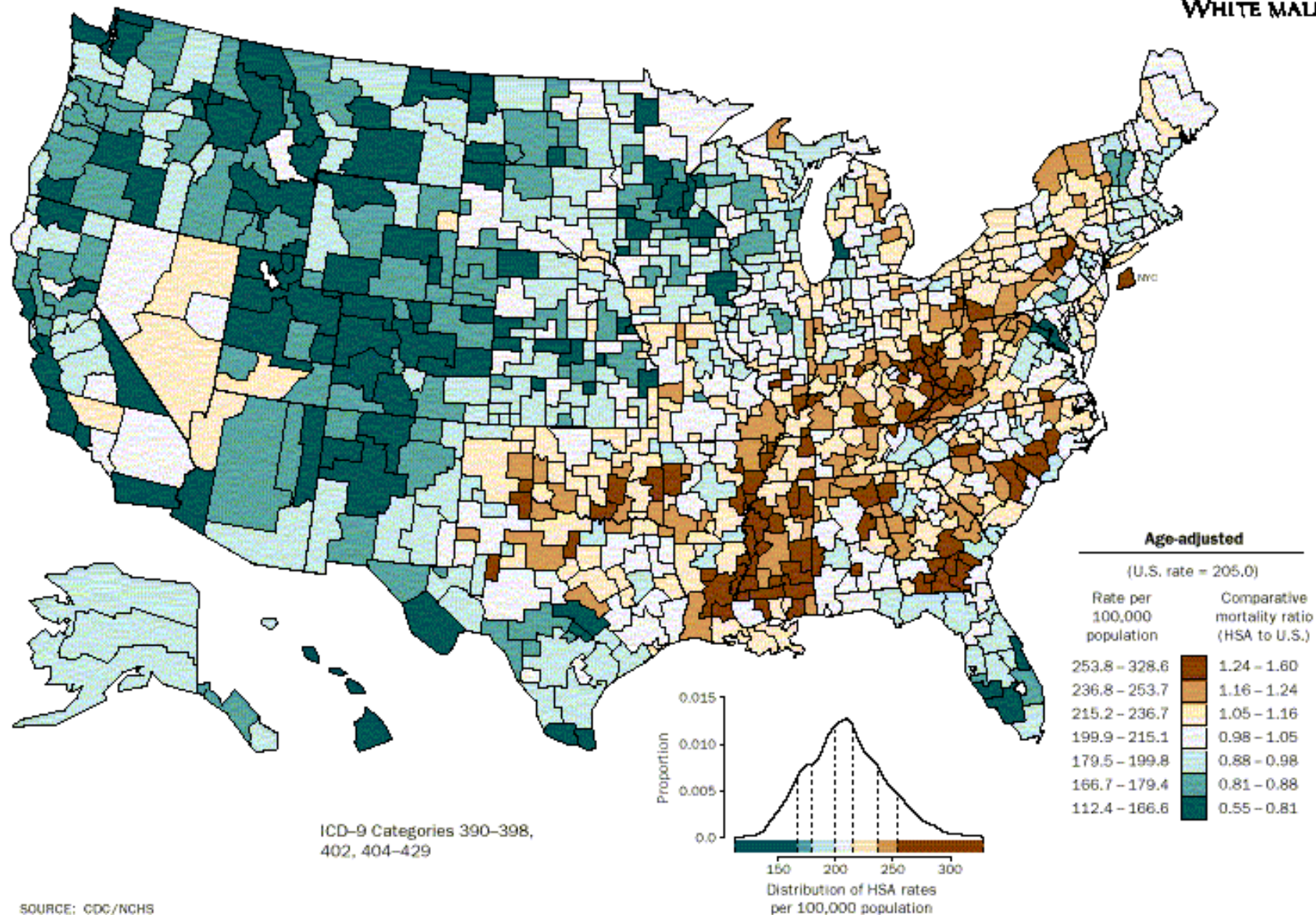


A collaboration between GOOD and Gregory Huback  
SOURCE: US Census



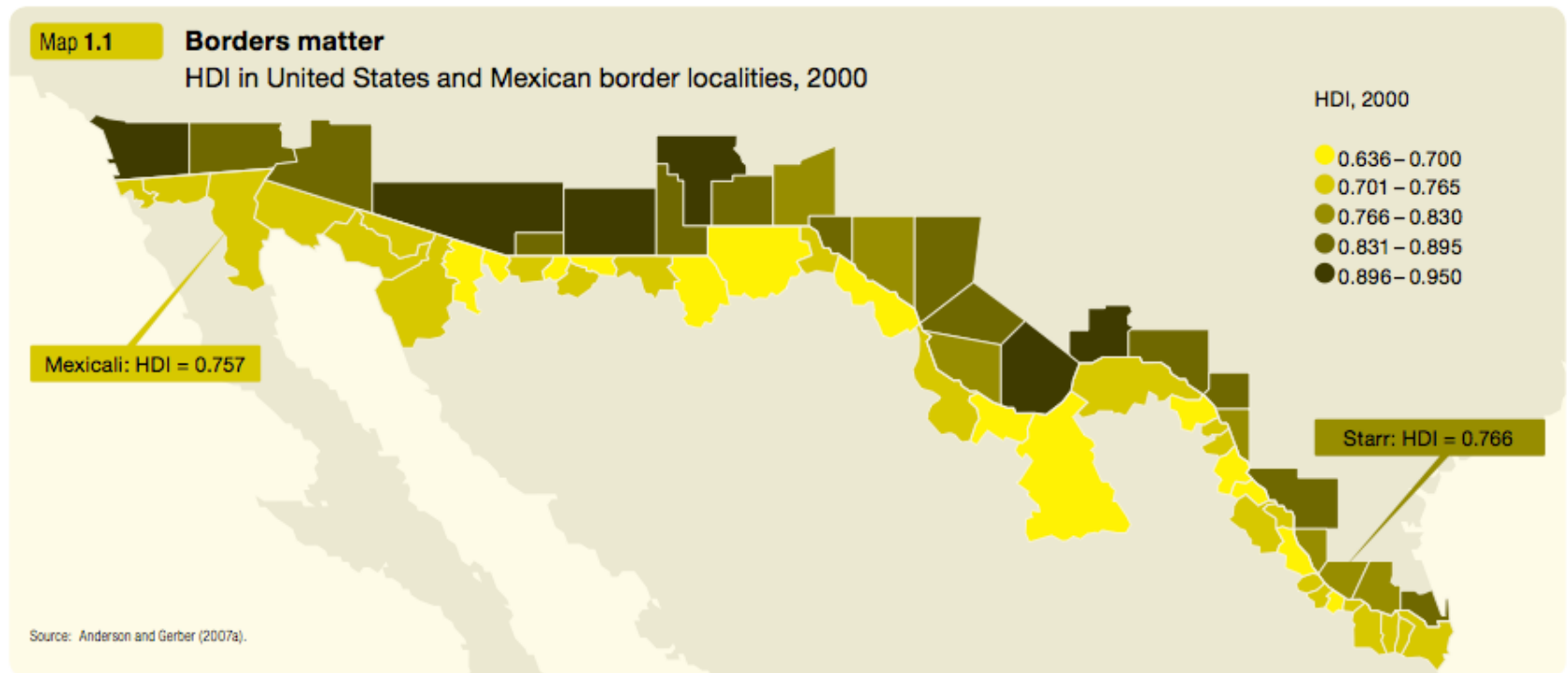
# Choose colors with care

## AGE-ADJUSTED DEATH RATES BY HSA, 1988-92

HEART DISEASE  
WHITE MALE

SOURCE: CDC/NCHS

# Seven quantiles

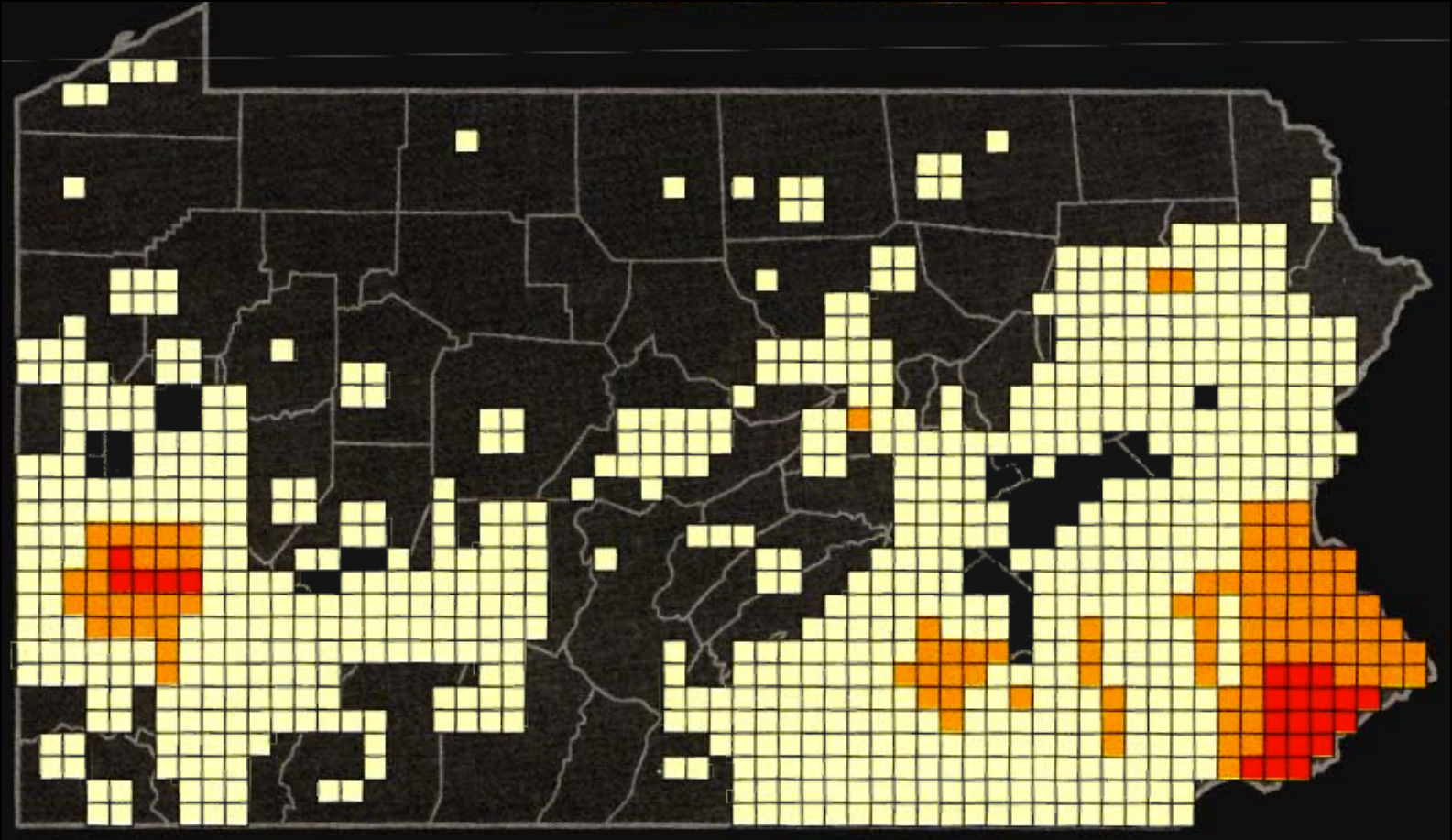


# Focus on the foreground

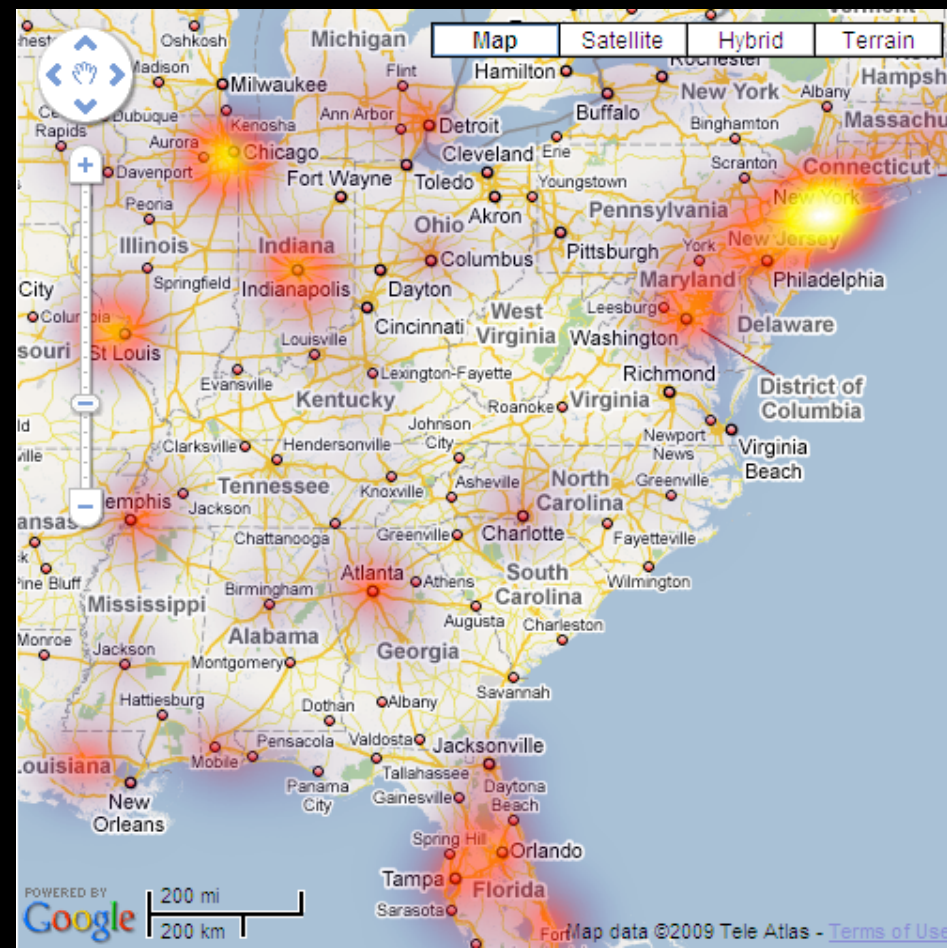
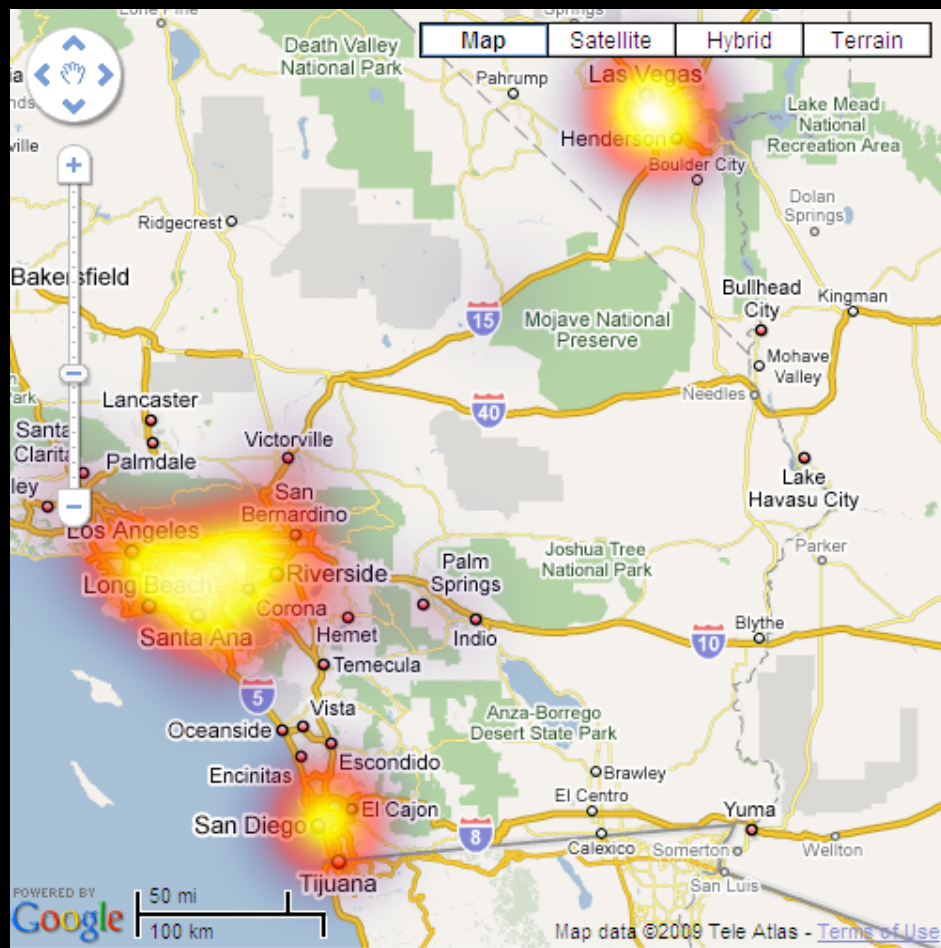
# Heatmaps / Contour Maps

Convey Continuous Data

# Binning

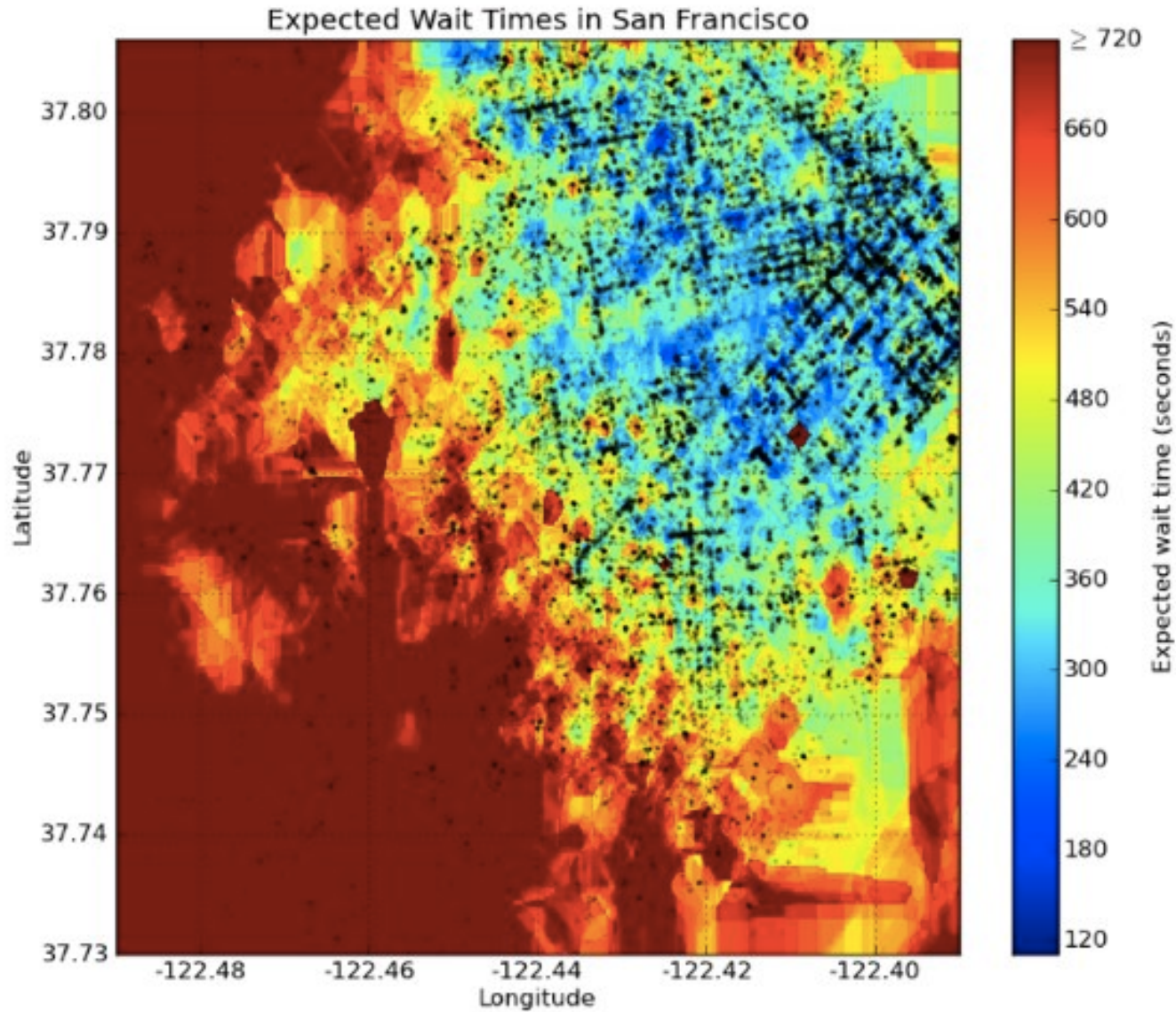


Chorodot Maps: Alan MacEachren and David DiBiase, 1991



**Don't hide the context**

# Uber Wait Times, 2011





# Break data into buckets

## CRIMESPOTTING

The brazen 2007 murder of journalist Chauncey Bailey in Oakland, California, led Stamen partner Mike Migurski to

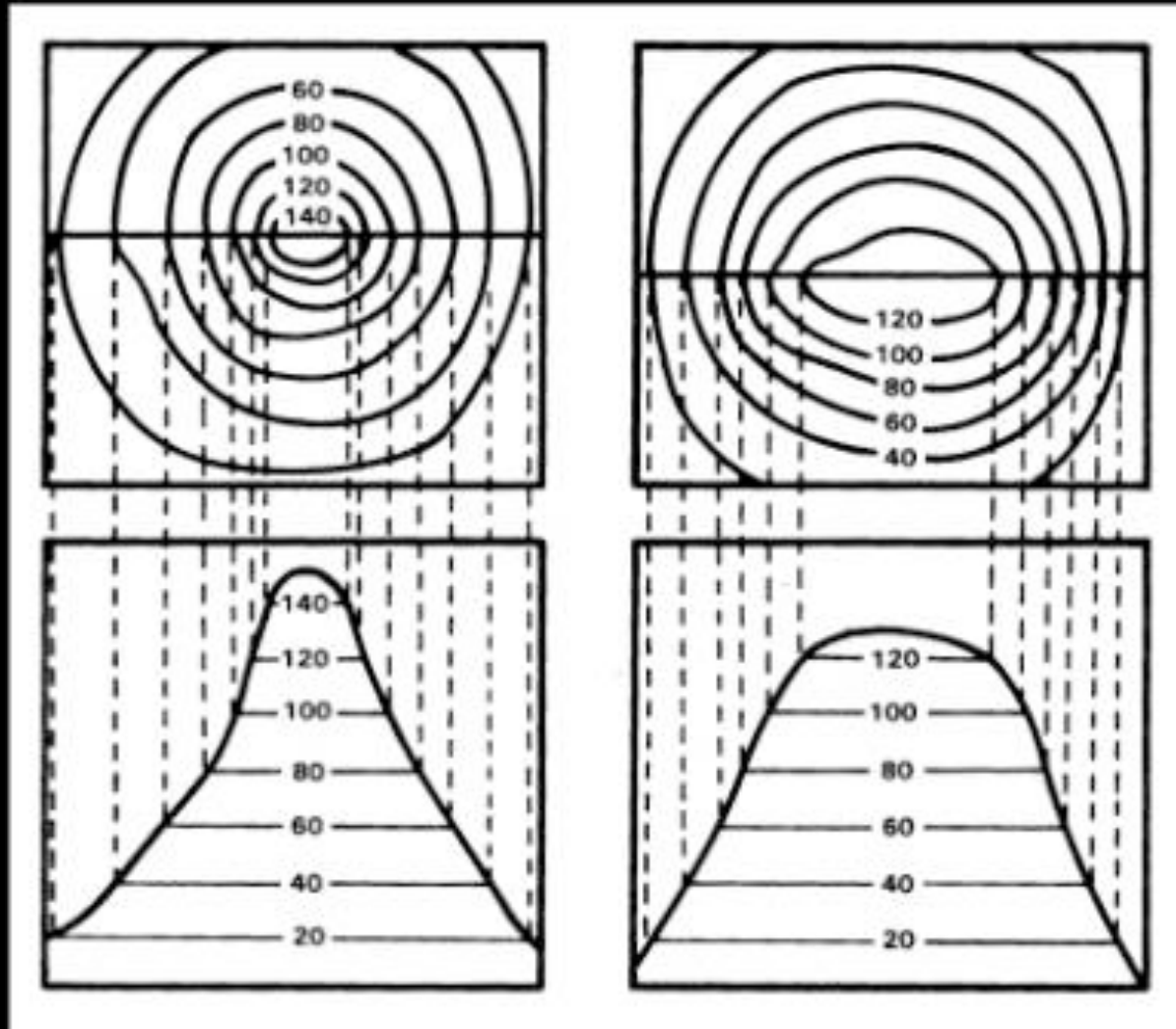
make the city's crime data more accessible. This heat map of downtown uses data from CrimeWatch, a community website,

to show the gaps between crimes at a given intersection: white is high-crime; darker areas are safe. [stamen.com](http://stamen.com)

**KEY**  
Colours show how recently a crime was reported in a given part of Oakland

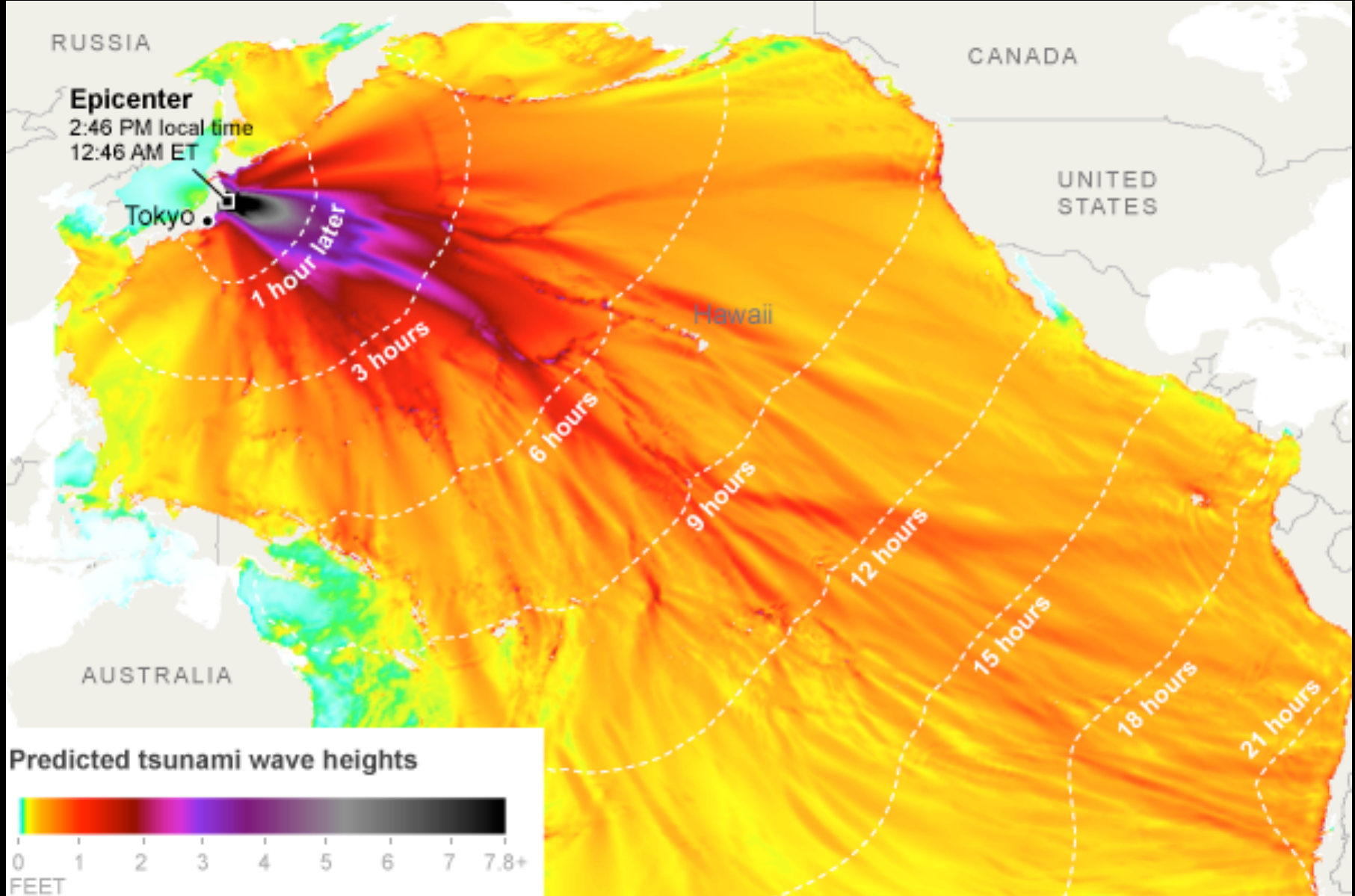
- A week ago
- Two weeks ago
- A month ago
- Two months ago
- Three months ago
- Four months ago
- Five months ago

# Meaningful buckets, isolines





**“Iso” means “same”**  
**Isolines for elevation**

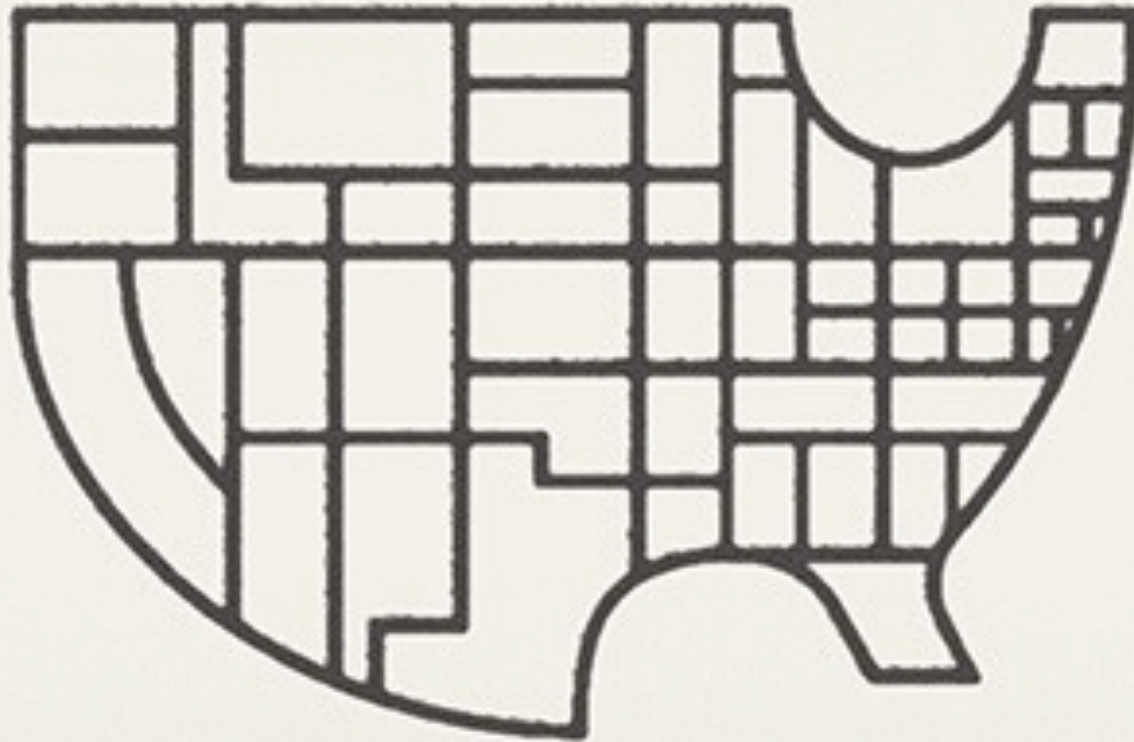


**Isochrones are isolines for time**

# Cartograms

Distort Shape to Convey Quantities

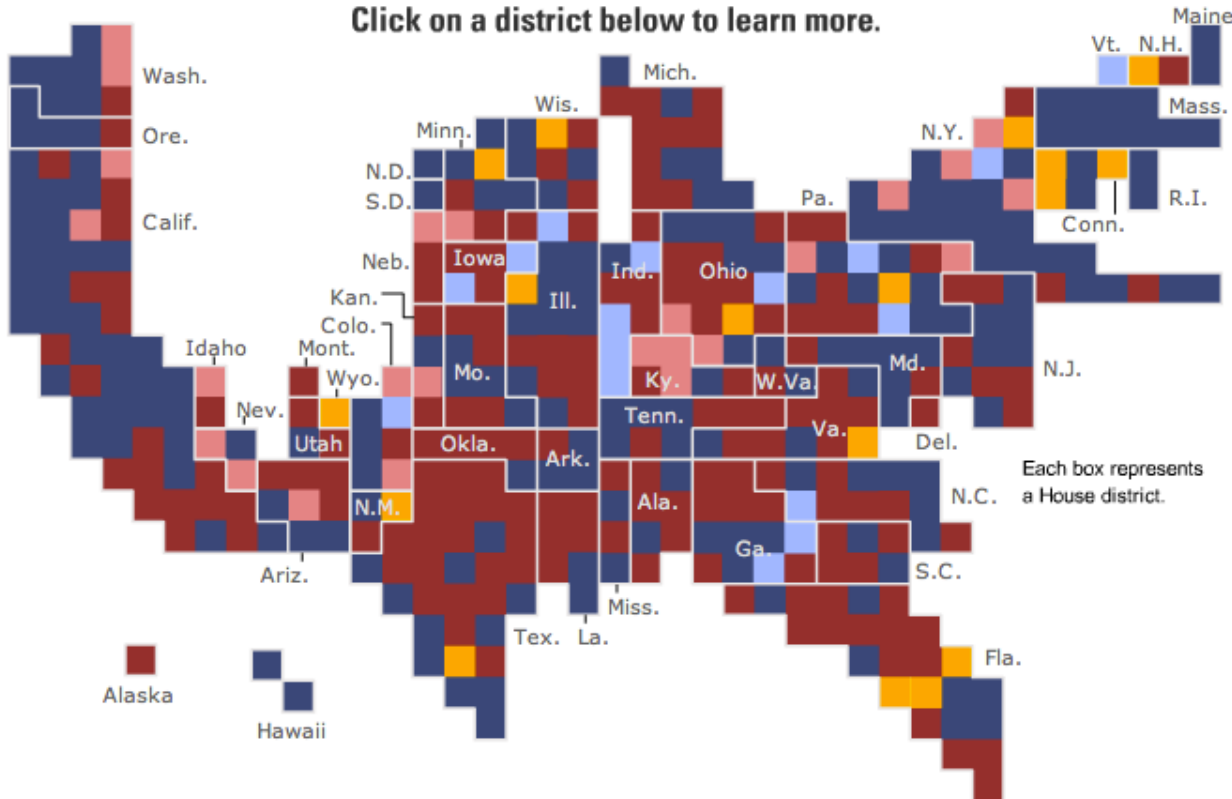
**Major distortions  
can stay recognizable**



# 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.



**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     Gore  
 Bush     Bush

**Appearances by big fundraisers** ?

George W. Bush     Bill Clinton

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**Races to watch** ?  
 **Open races**  
 **Switch districts** ?

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**Urbanization**

Urban     Suburban     Rural     Mixed

**Race/Ethnicity**

White     Black     Hispanic

**Median income**

<\$30K     \$30-50K     >\$50K

**RESET**

## Block Cartogram: Discrete Units

# China Still Dominates, but Some Manufacturers Look Elsewhere

While China maintains its overwhelming dominance in manufacturing, multinational companies are looking for ways to limit their reliance on factories there. [Related Article »](#)

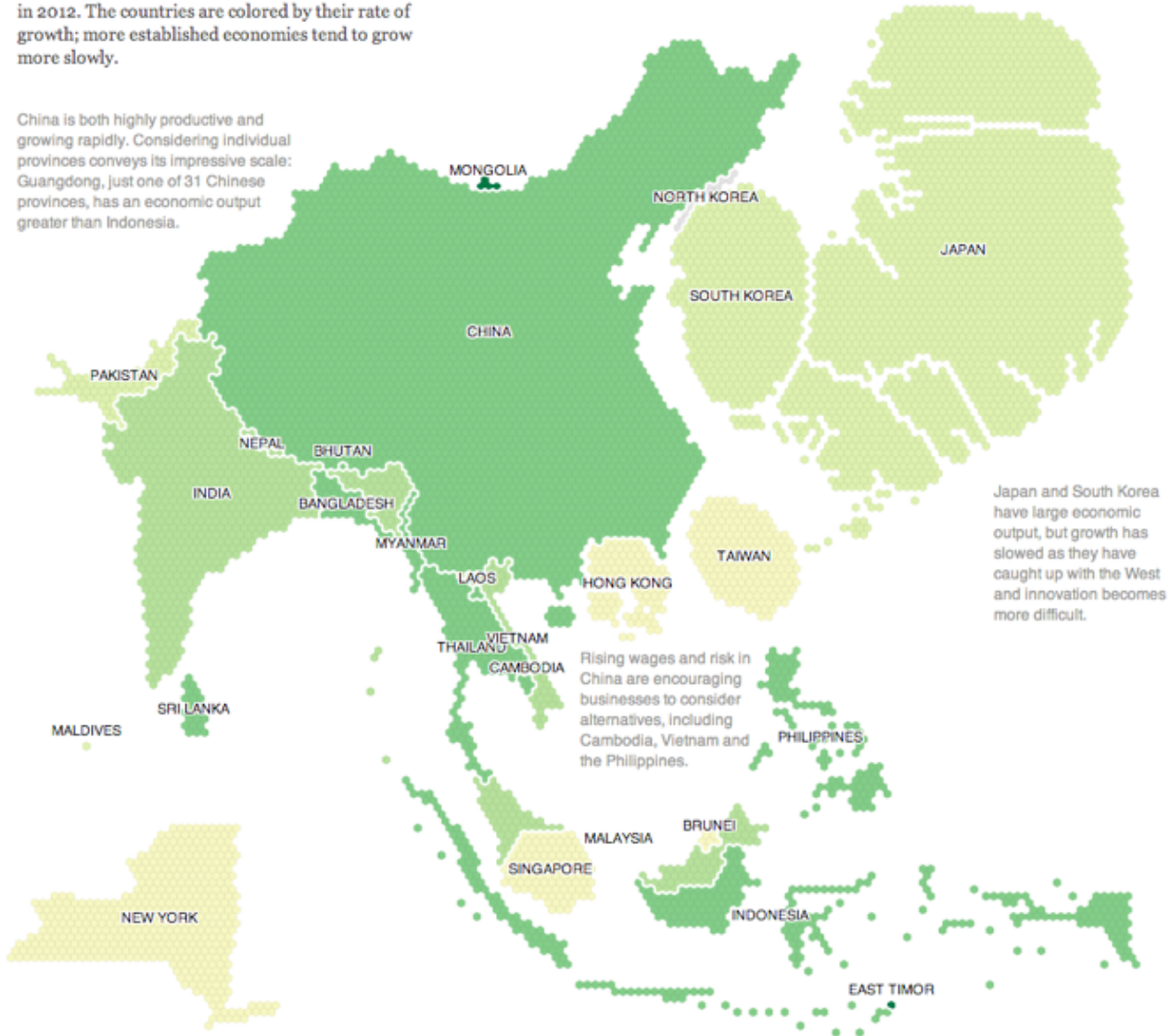
## Economic Output

In this map, geography is distorted so that each country is **sized according to its economic output in 2012**. The countries are colored by their rate of growth; more established economies tend to grow more slowly.

China is both highly productive and growing rapidly. Considering individual provinces conveys its impressive scale: Guangdong, just one of 31 Chinese provinces, has an economic output greater than Indonesia.

Each hexagon represents \$2.7 billion in G.D.P.

G.D.P. growth, 2011 to 2012

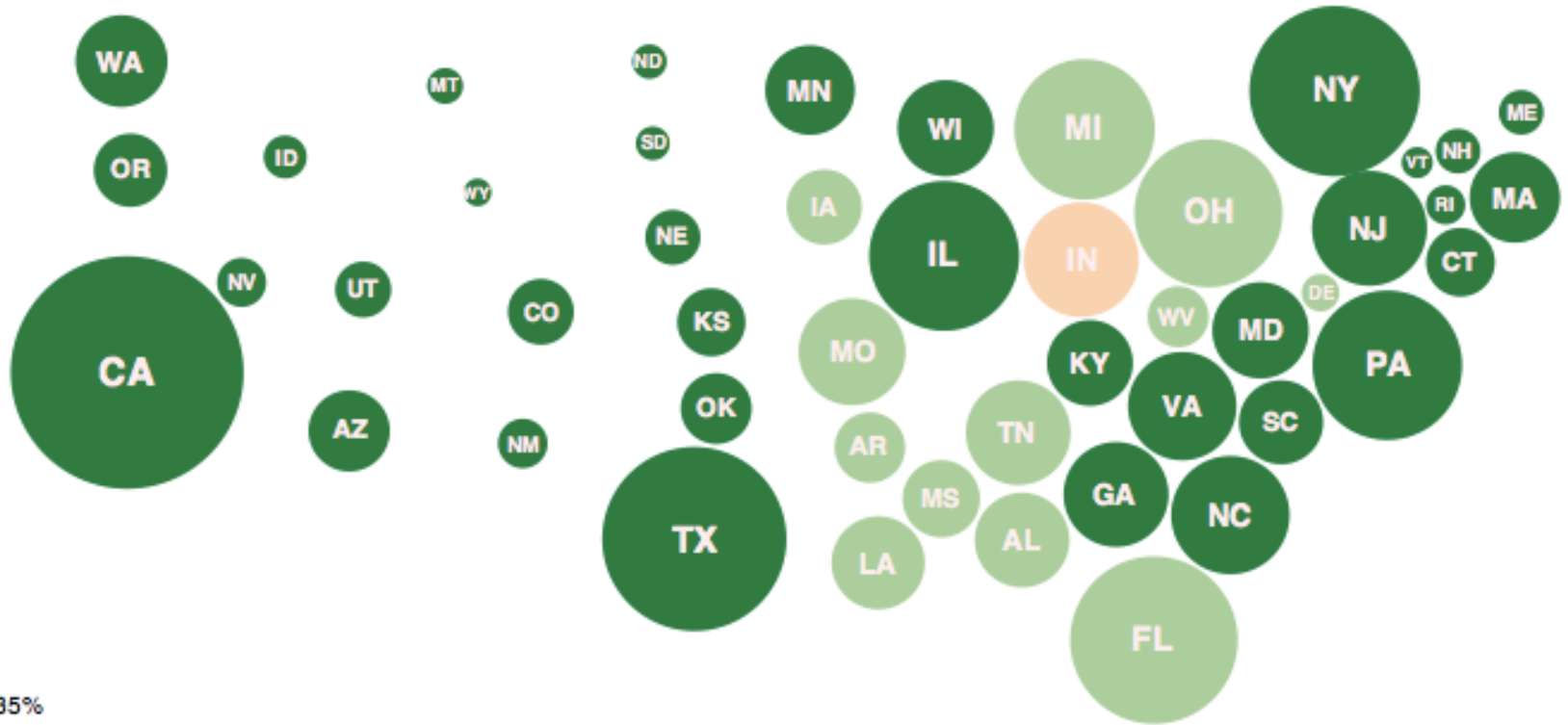


Japan and South Korea have large economic output, but growth has slowed as they have caught up with the West and innovation becomes more difficult.

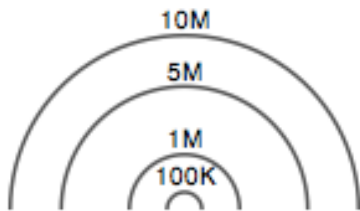
Rising wages and risk in China are encouraging businesses to consider alternatives, including Cambodia, Vietnam and the Philippines.

New York shown for comparison.

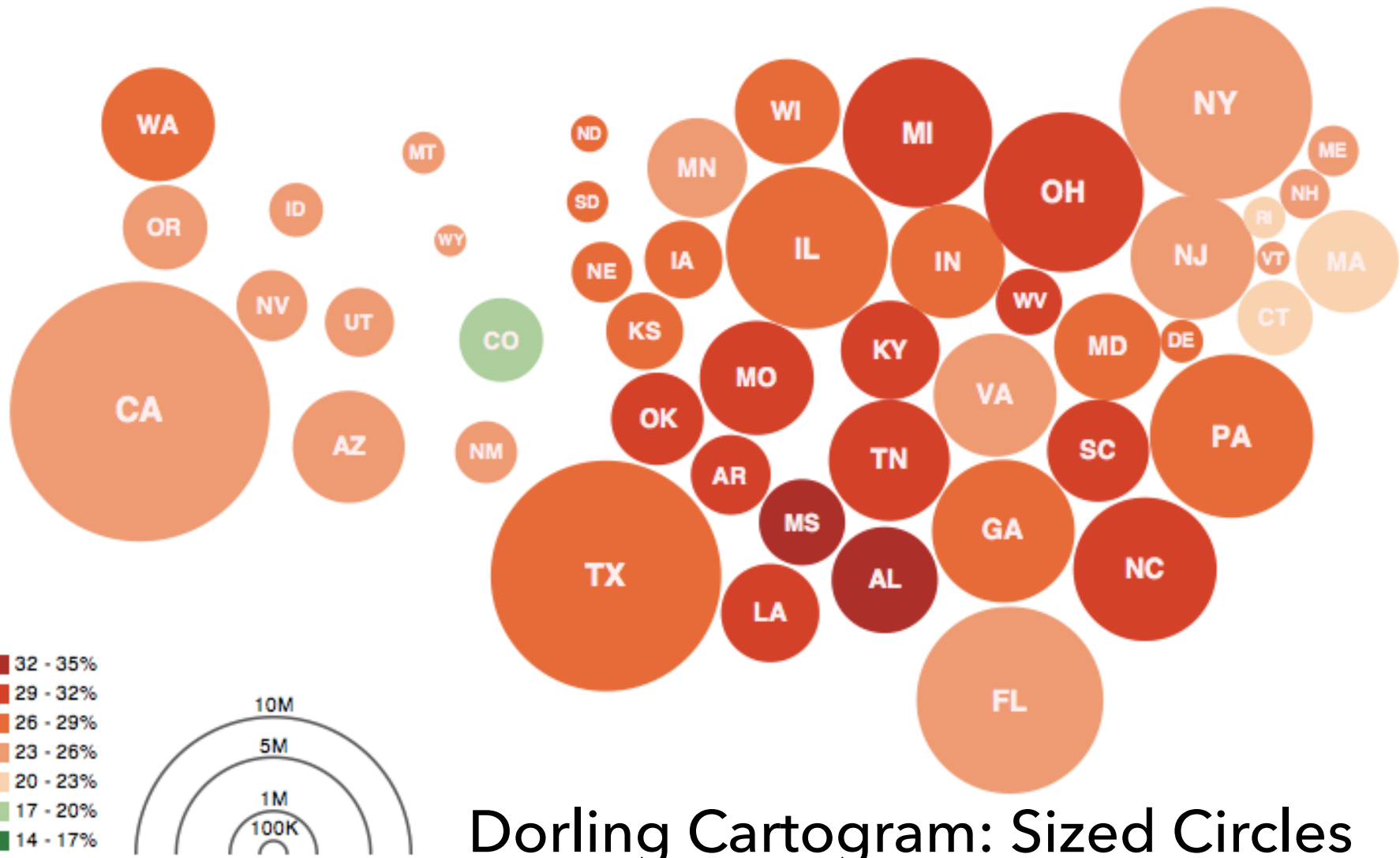




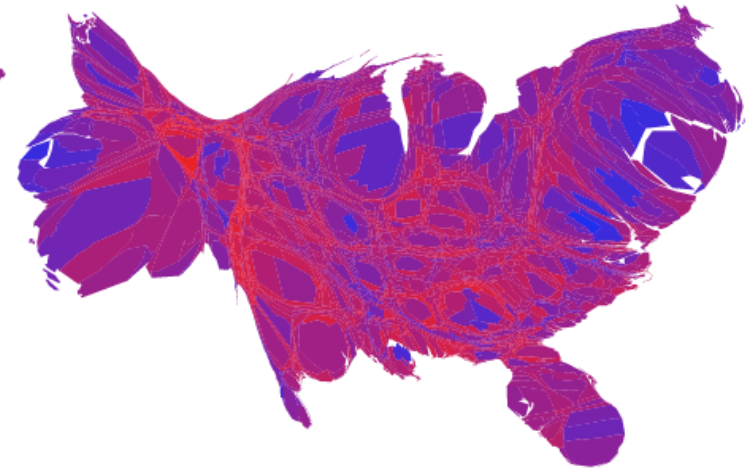
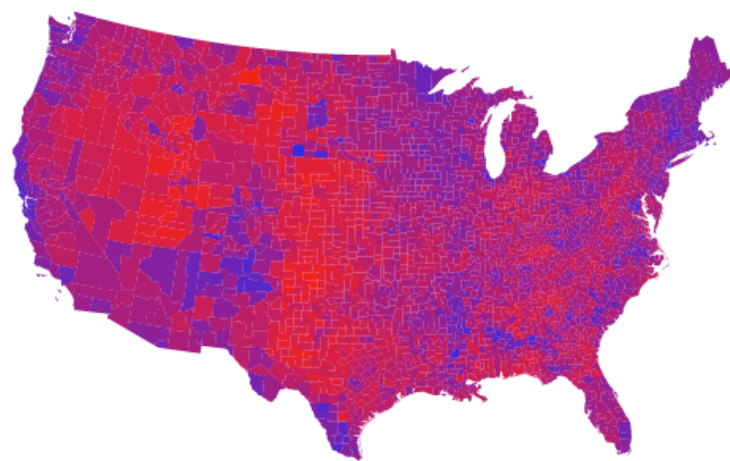
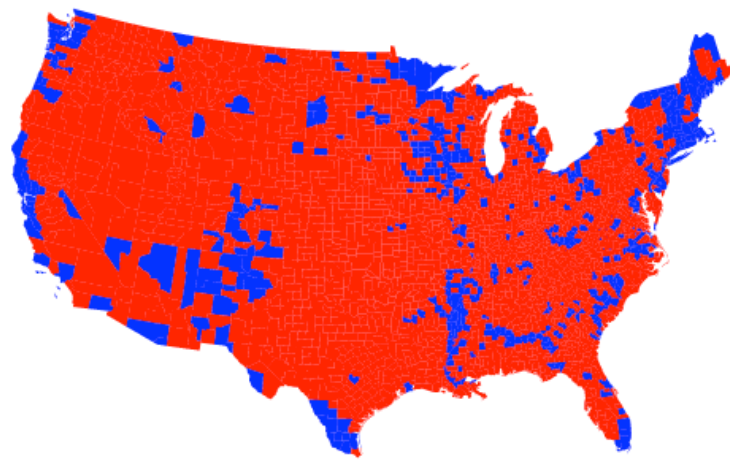
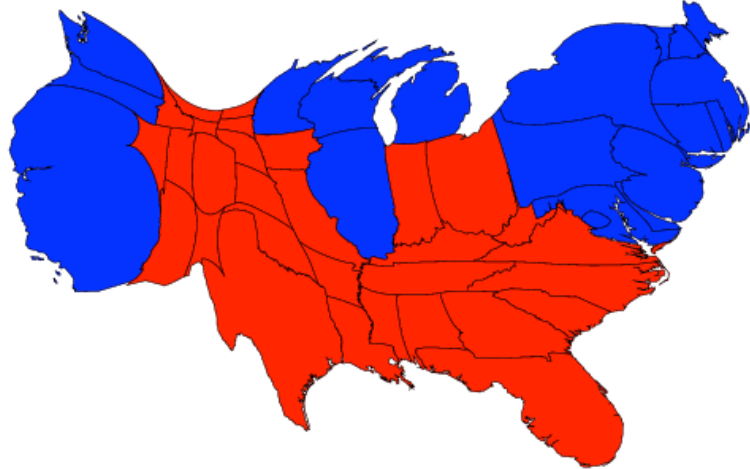
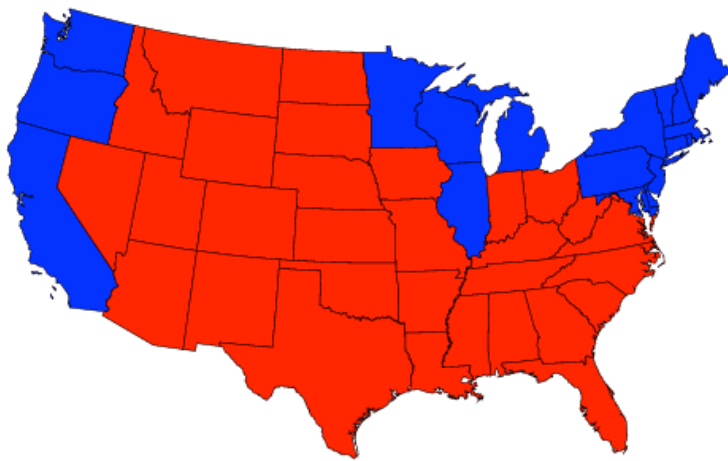
- 32 - 35%
- 29 - 32%
- 26 - 29%
- 23 - 26%
- 20 - 23%
- 17 - 20%
- 14 - 17%



## Dorling Cartogram: Sized Circles



Dorling Cartogram: Sized Circles



# Physical Diffusion Model

[Newman 2004]

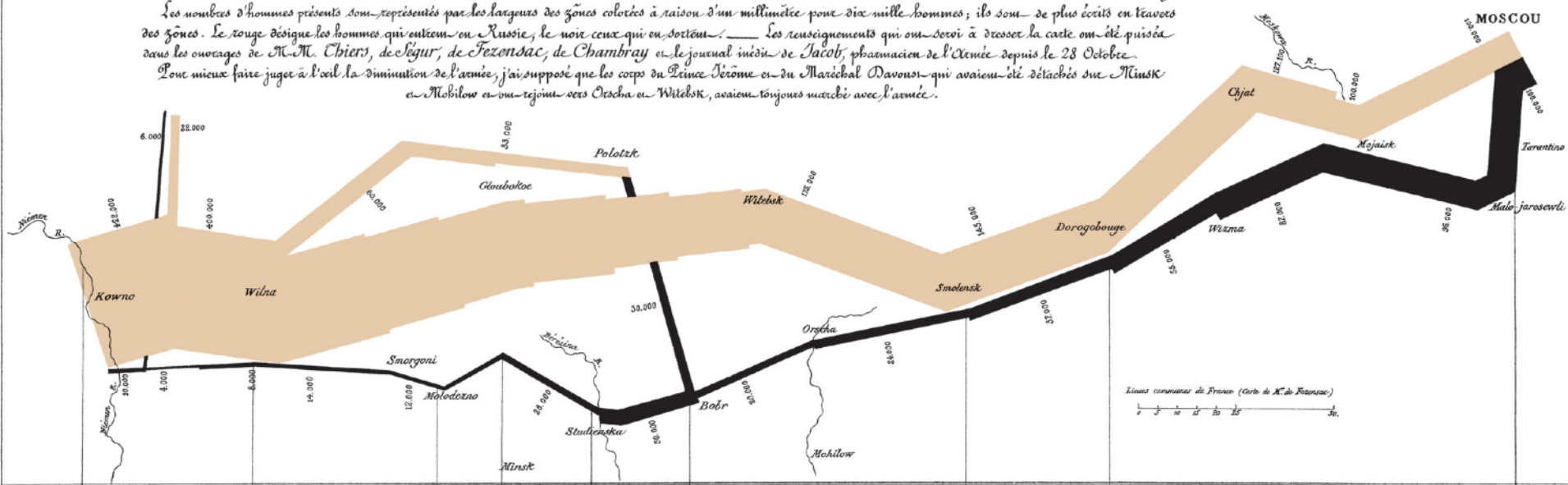
# Flow Maps

Convey Flux Between Locations

# Minard 1869: Napoleon's march

*Carte Figurative* des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.  
Dressée par M. Minard, Inspection Générale des Ponts et Chaussées en retraite Paris, le 20 Novembre 1869.

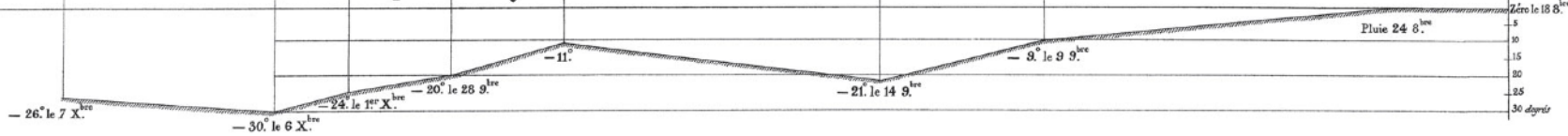
Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont plus écrits en travers des zones. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. M. Chier, de Légar, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre. Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davout qui avoient été détachés sur Minsk et Mohilow et qui rejoindrent Orscha et Witebsk, avoient toujours marché avec l'armée.



Liens communs de France (Carte de M. de Rossier)  
0 5 10 15 20 25 30

TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.

Les Cosaques passent au galop le Niémen gelé.



**CARTE** figurative et approximative de la **Houille Anglaise** exportée en 1864 dessinée par M<sup>r</sup> MINARD, Ingénieur Civil des Ponts et Chaussées en France.

Les tracés sont basés sur les chiffres de M<sup>r</sup> Robert Bost pour l'année 1864 (page 18 & 19) en ce qui concerne l'Amérique du Nord et l'Amérique du Sud.

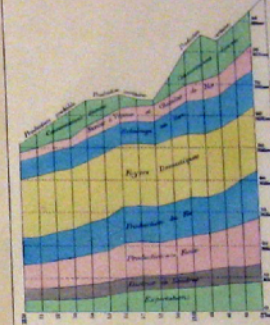
**Observation.** — Les tracés des autres continents de cette figure approximative et purement graphique de la houille anglaise et de son trafic sont basés sur les données les plus récentes et les plus exactes que l'on possède à l'heure actuelle. Les tracés des autres continents de cette figure approximative et purement graphique de la houille anglaise et de son trafic sont basés sur les données les plus récentes et les plus exactes que l'on possède à l'heure actuelle.

Paris, le 27 Septembre 1864.

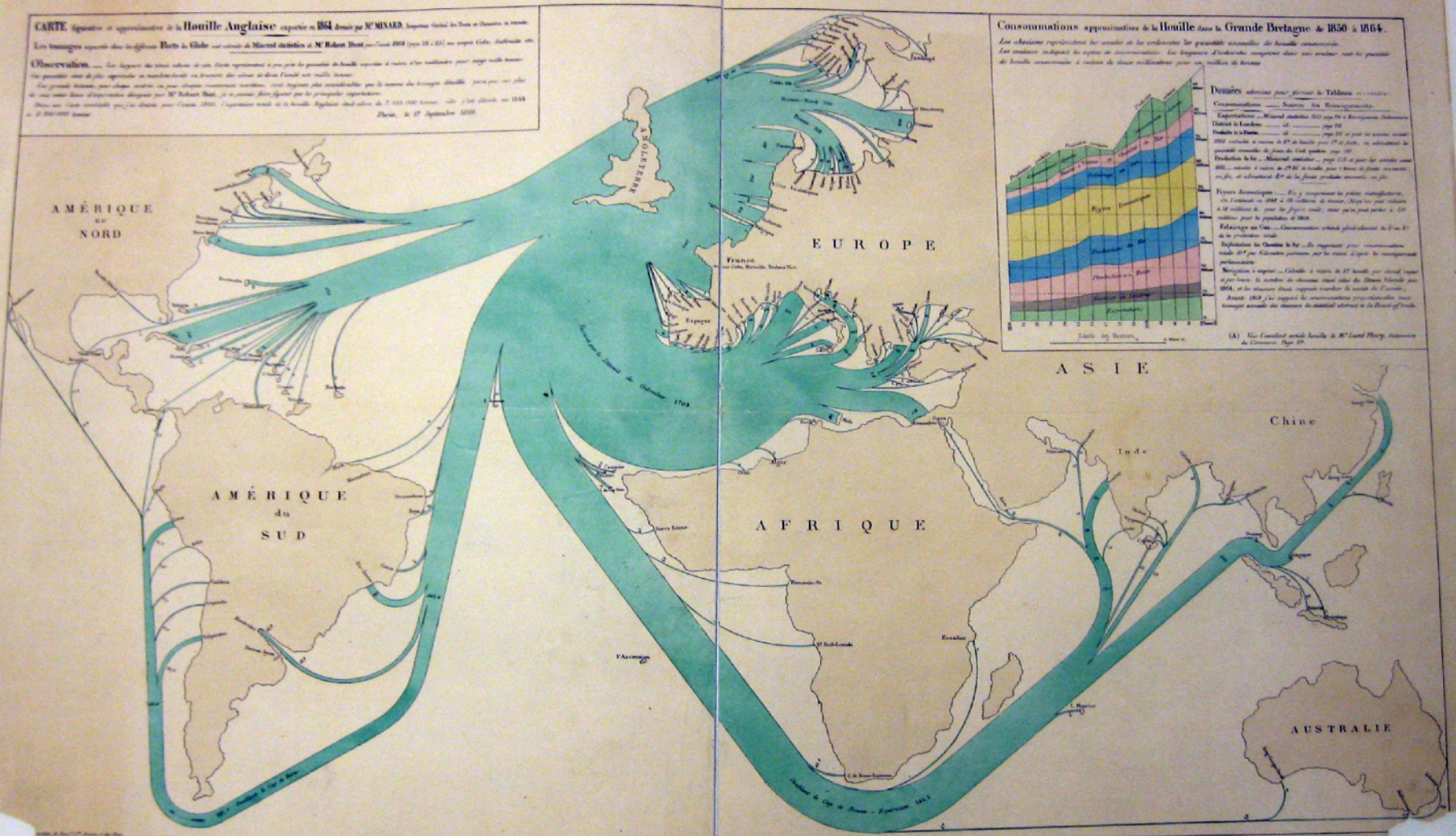
**Consommations approximatives de la Houille dans la Grande Bretagne & 1850 à 1864.**

Les chiffres expriment les années et les volumes les plus exactes de houille consommée.

Les volumes indiqués les années de consommation. Les figures d'indicateur expriment dans une échelle, sur le plan de la houille consommée à raison de deux millions par un million de tonnes.



**Données relatives pour former le Tableau ci-dessus.**  
 Consommations approximatives de la Houille dans la Grande Bretagne.  
 Exportations — M<sup>r</sup> Robert Bost page 18 & 19.  
 Industrie de la laine — M<sup>r</sup> Robert Bost page 18 & 19.  
 Industrie de la soie — M<sup>r</sup> Robert Bost page 18 & 19.  
 Industrie de la houille — M<sup>r</sup> Robert Bost page 18 & 19.  
 Industrie de la houille — M<sup>r</sup> Robert Bost page 18 & 19.  
 Industrie de la houille — M<sup>r</sup> Robert Bost page 18 & 19.



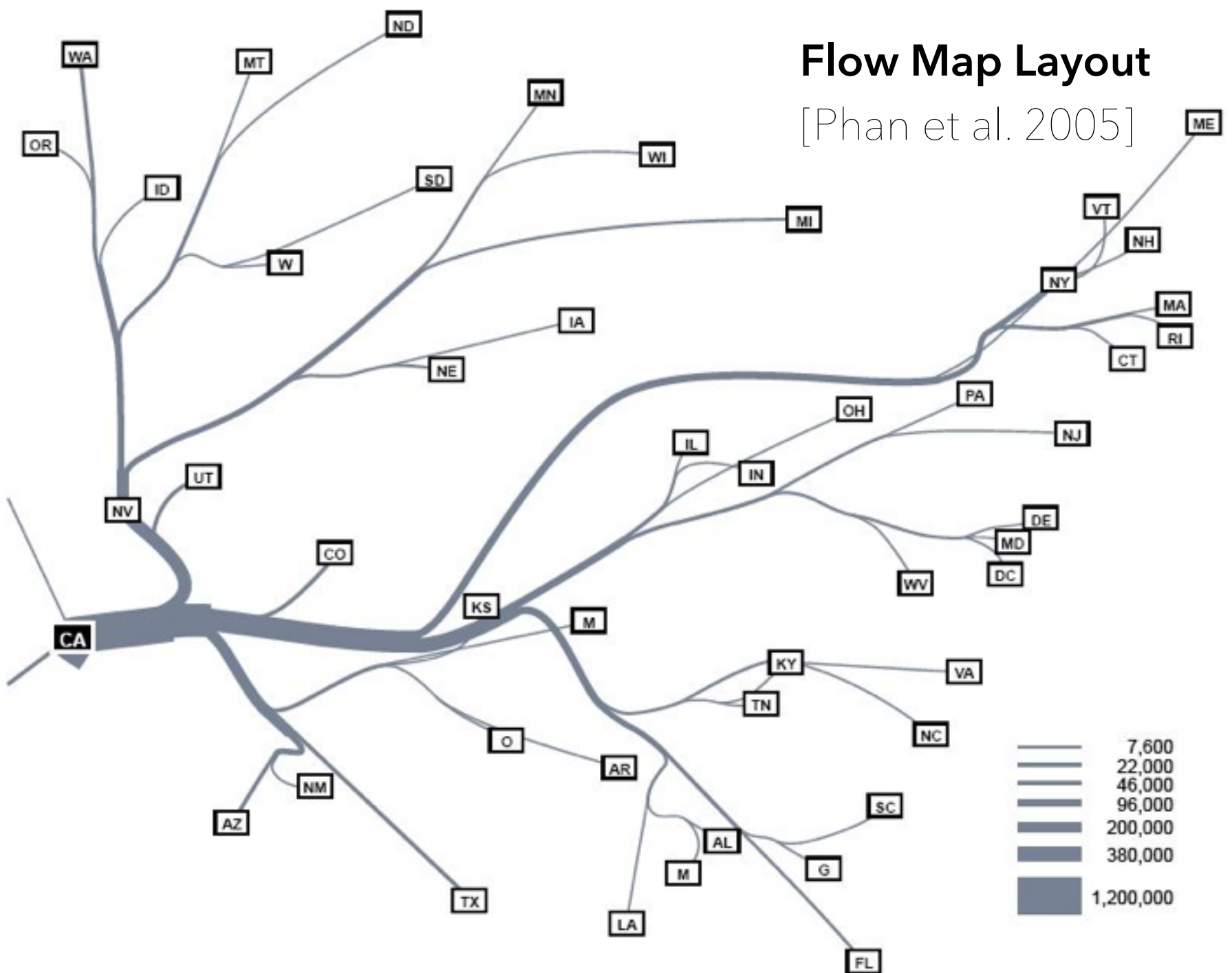
2204-62628

G2201 My 1864 Ms

1864 British Coal Exports, Charles Minard

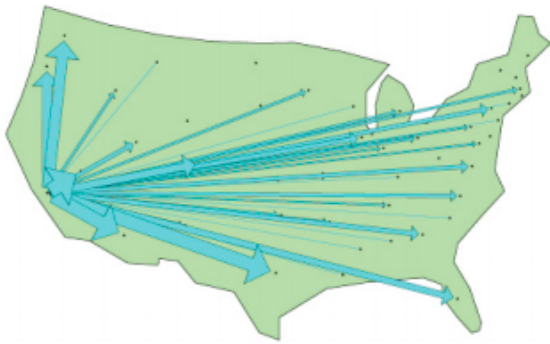
# Flow Map Layout

[Phan et al. 2005]

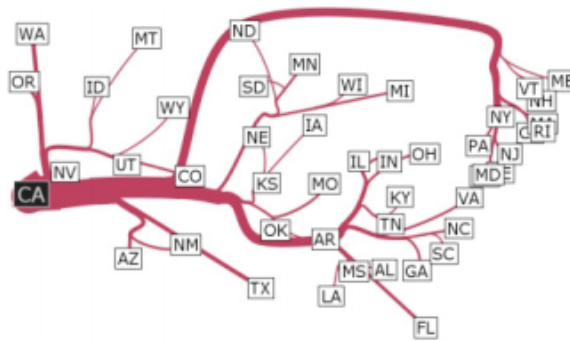


# Migration from California, '95-'00

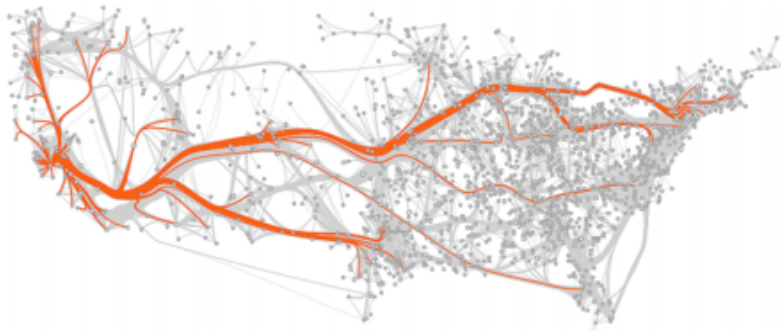
Tobler 1987



Phan et al. 2005



Verbeek et al. 2011



Cui et al. 2008



Holten & van Wijk 2009



# wind map

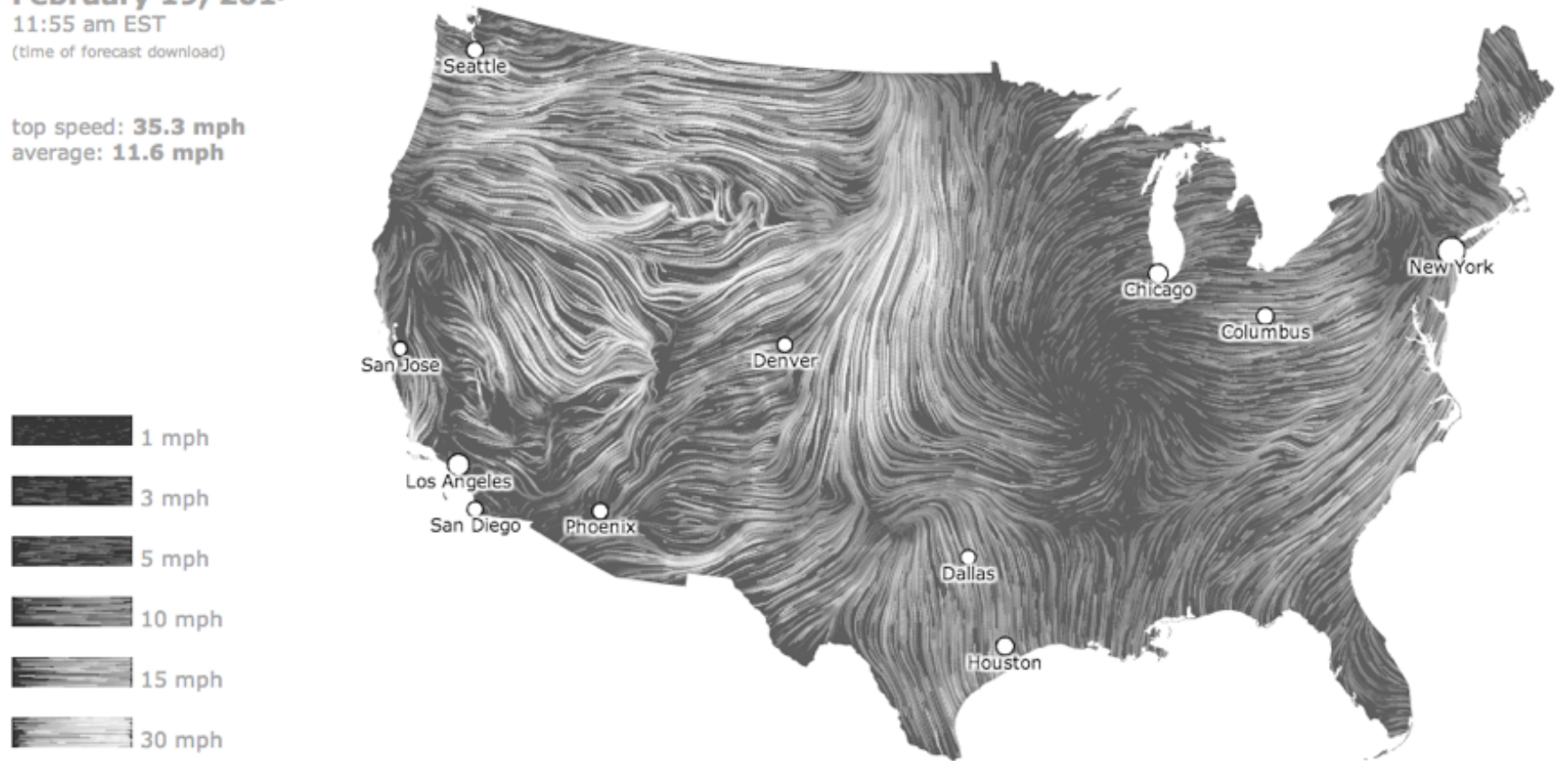
**February 19, 2014**

11:55 am EST

(time of forecast download)

top speed: **35.3 mph**

average: **11.6 mph**



# How Obama Won Re-election

Whites Were Outvoted

Women

Hispanics

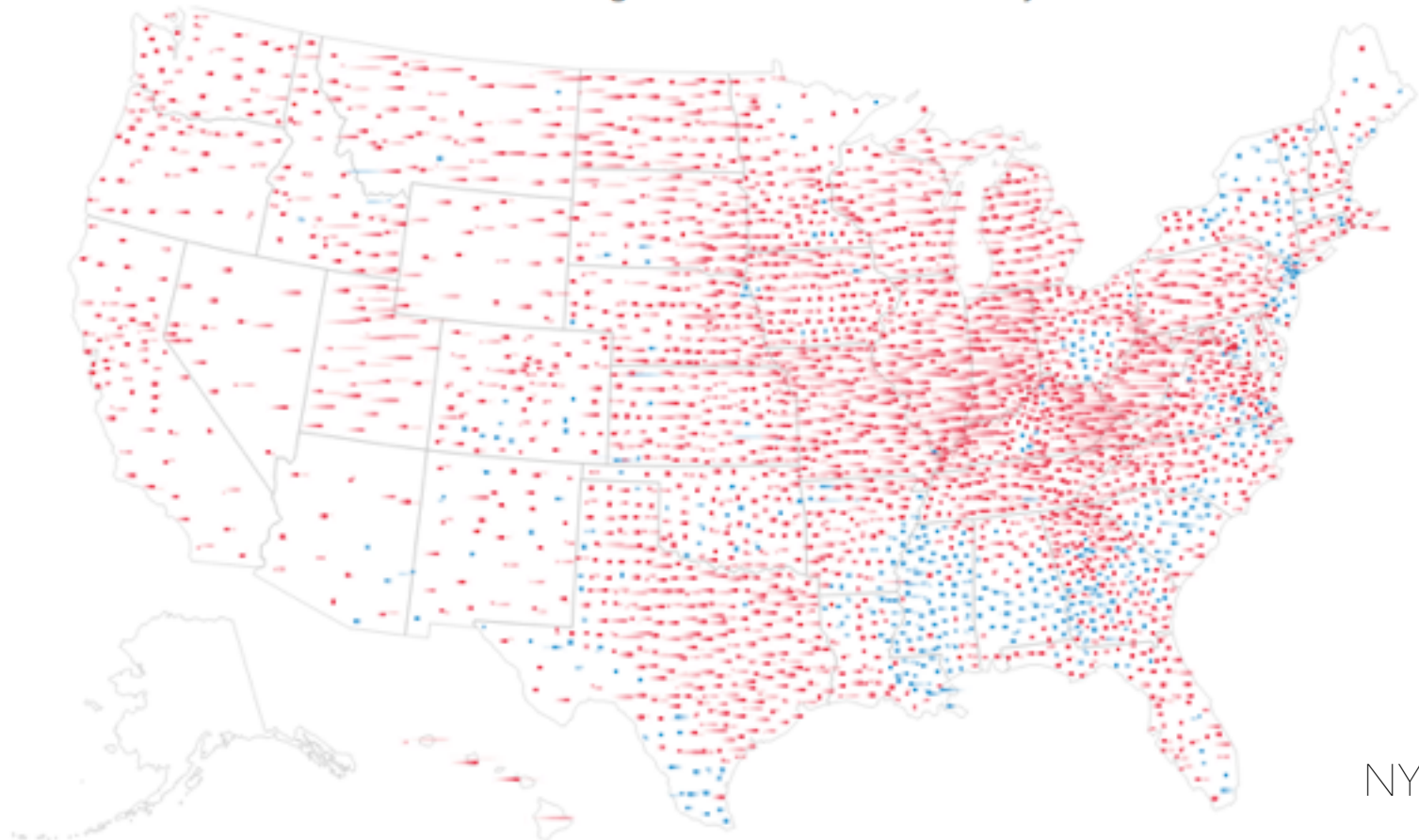
Youth

## Romney's Shift Wasn't Enough

2008

2012

Most of the nation shifted to the right in Tuesday's vote, but not far enough to secure a win for Mitt Romney.



# Generalization

Abstraction to Convey Topology

**CARTE** figurative et approximative de la Houille Anglaise exportée en 1864 dessinée par M. MINARD. Impression tirée de Paris et Chaux-de-Fonds.

Les données sont tirées des différents Bureaux et Gênes sur les ventes de M. Robert Hunt, par l'année 1864 (pages 18 & 19) un rapport Gênes, daté du 10 Mars 1864.

**Observation.** Les lignes de même couleur de cette Carte représentent à peu près la provenance de houille exportée à l'étranger, et les courbes de même couleur les quantités de houille exportées.

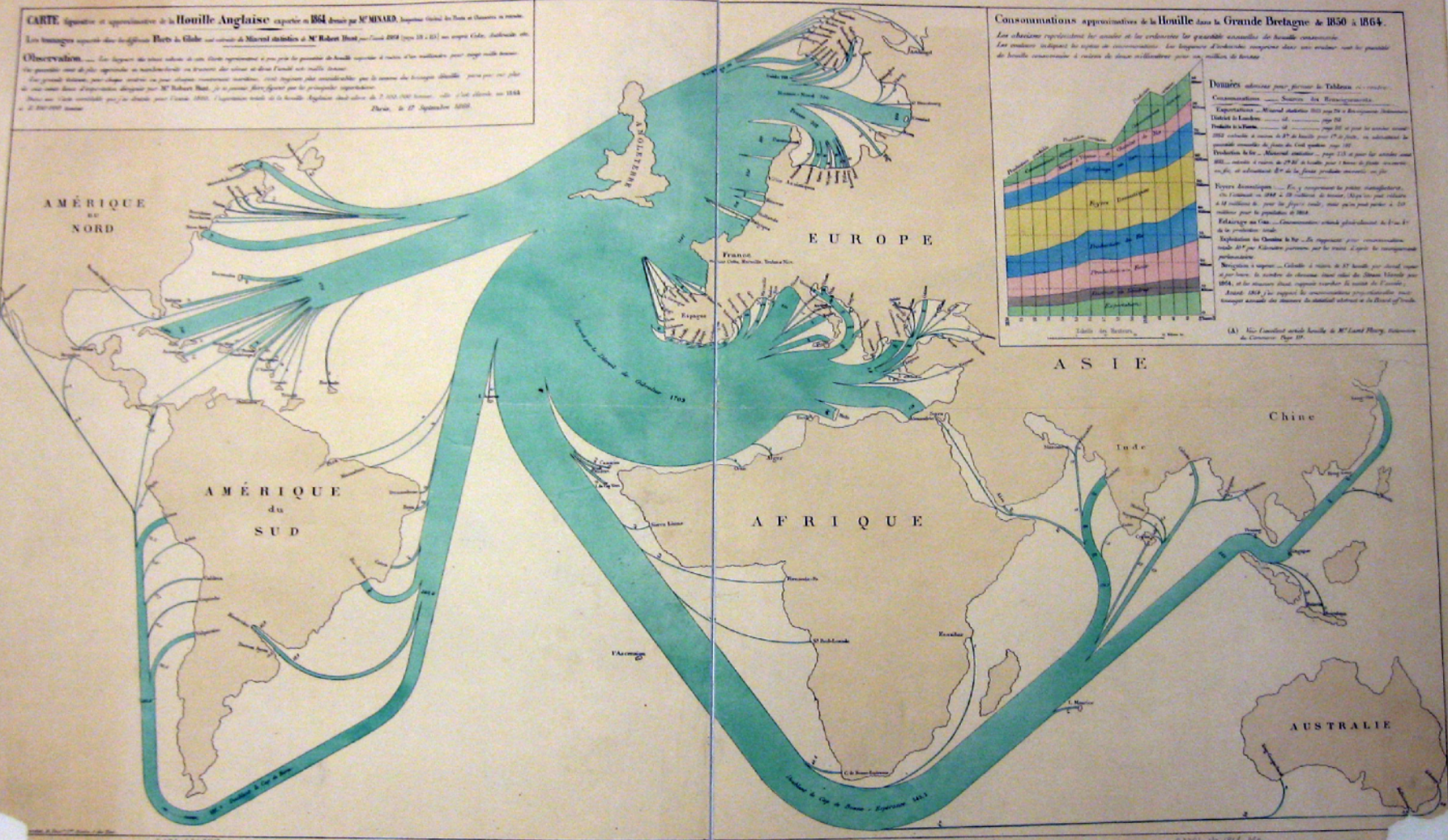
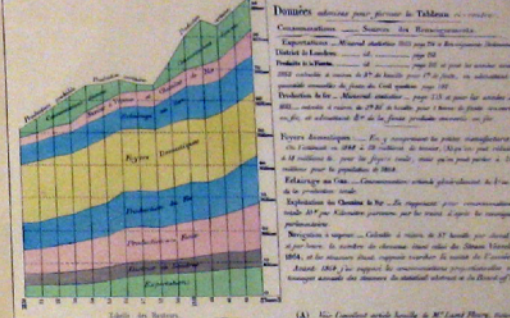
Les courbes de même couleur de cette Carte représentent à peu près la provenance de houille exportée à l'étranger, et les courbes de même couleur les quantités de houille exportées.

Paris le 27 Septembre 1864.

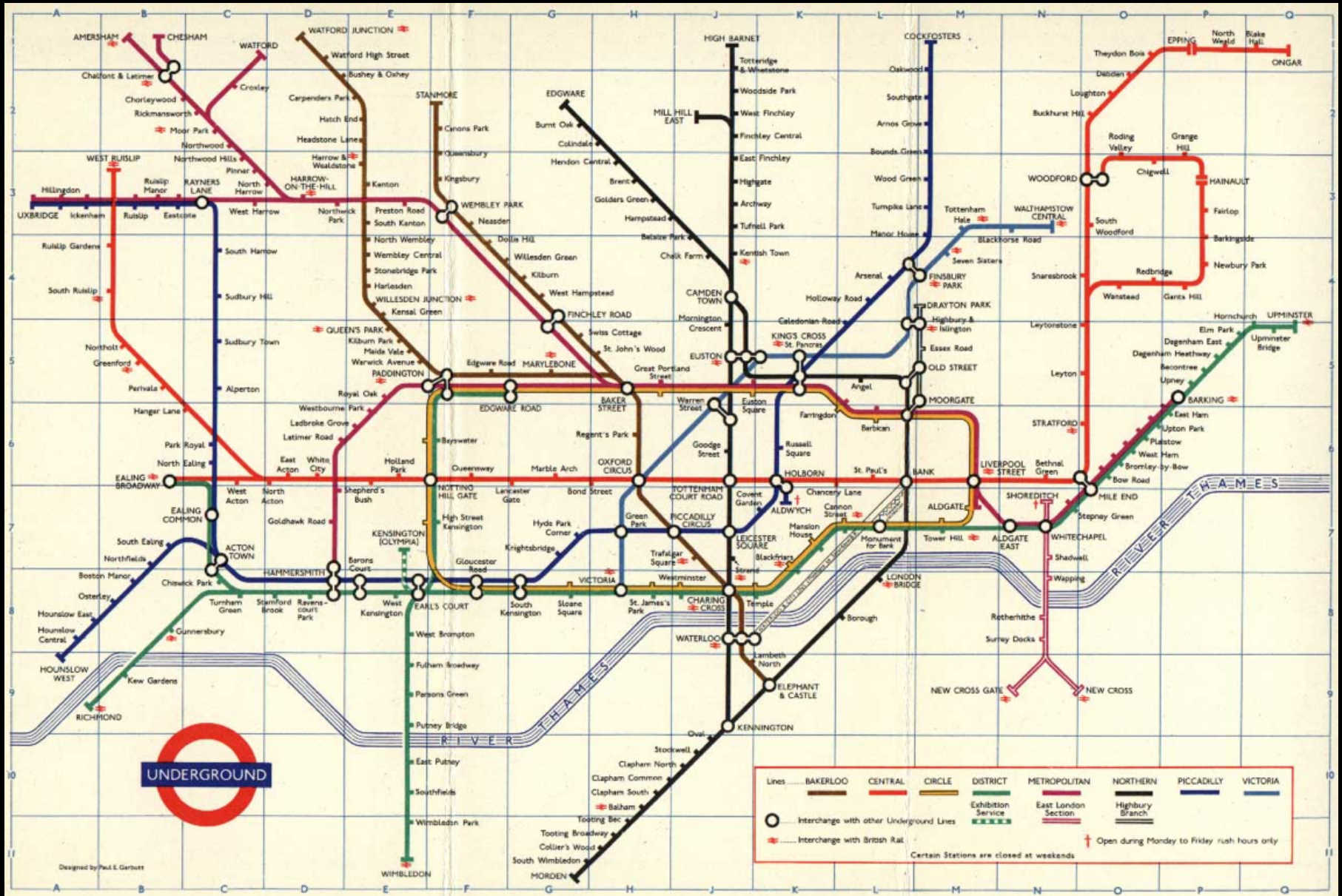
**Consommations approximatives de la Houille dans la Grande Bretagne & 1850 à 1864.**

Les courbes représentent les années et les courbes les quantités annuelles de houille consommée.

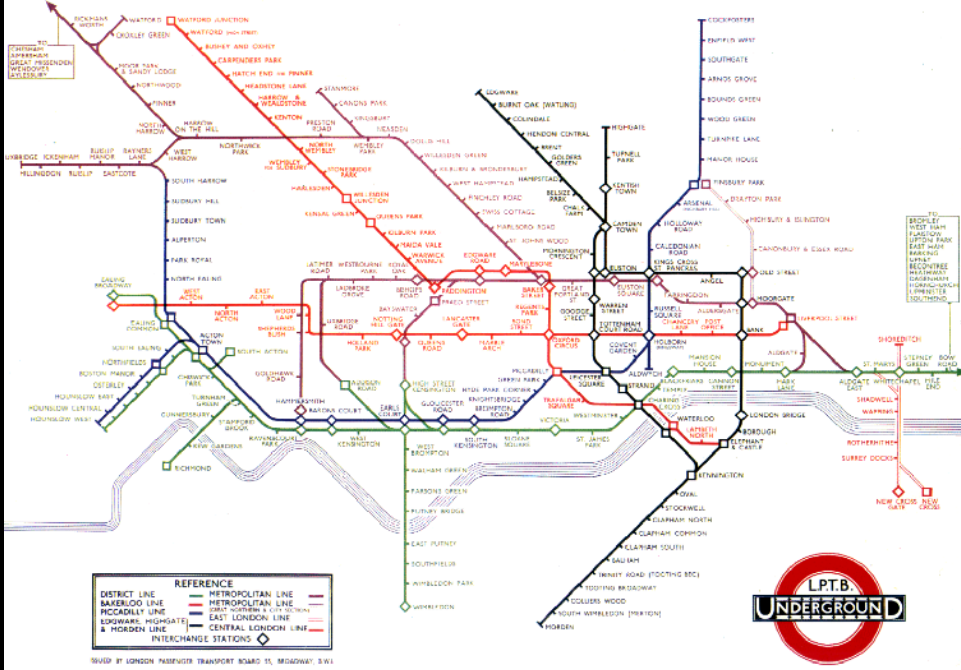
Les courbes indiquent les années de consommation. Les courbes d'ordonnée comptent dans une année, non le poids de houille consommée à l'étranger, mais le poids de houille consommée en France.



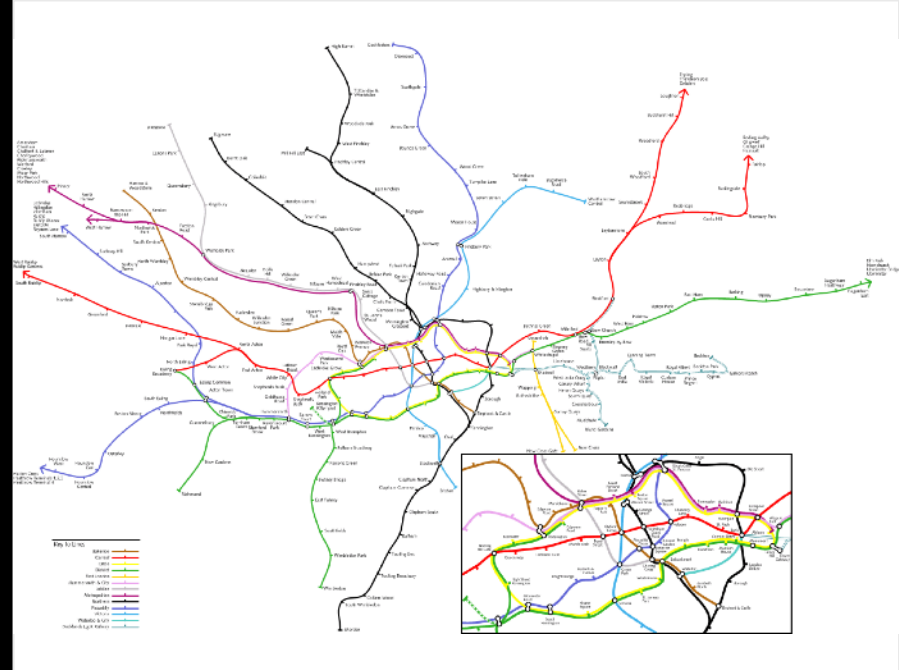
1864 British Coal Exports, Charles Minard



Beck's London tube diagram



London Underground [Beck 33]



Geographic version of map

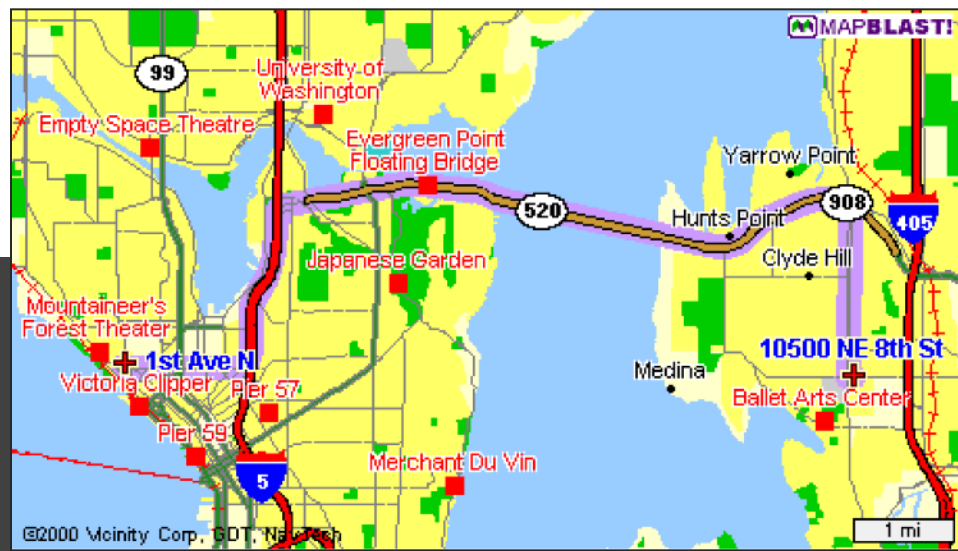
**Principle:** Straighten lines to emphasize stop sequence  
**Technique used to emphasize/de-emphasize information**



People *love* tube maps...

[Huffman]

# Route Maps: Bellevue to Seattle





# Map Design via Optimization [Agrawala '01]

## Set of graphic elements

Roads, labels, cross-streets, ...

## Choose visual attributes

Position, orientation, size, ...

Distortions increase flexibility

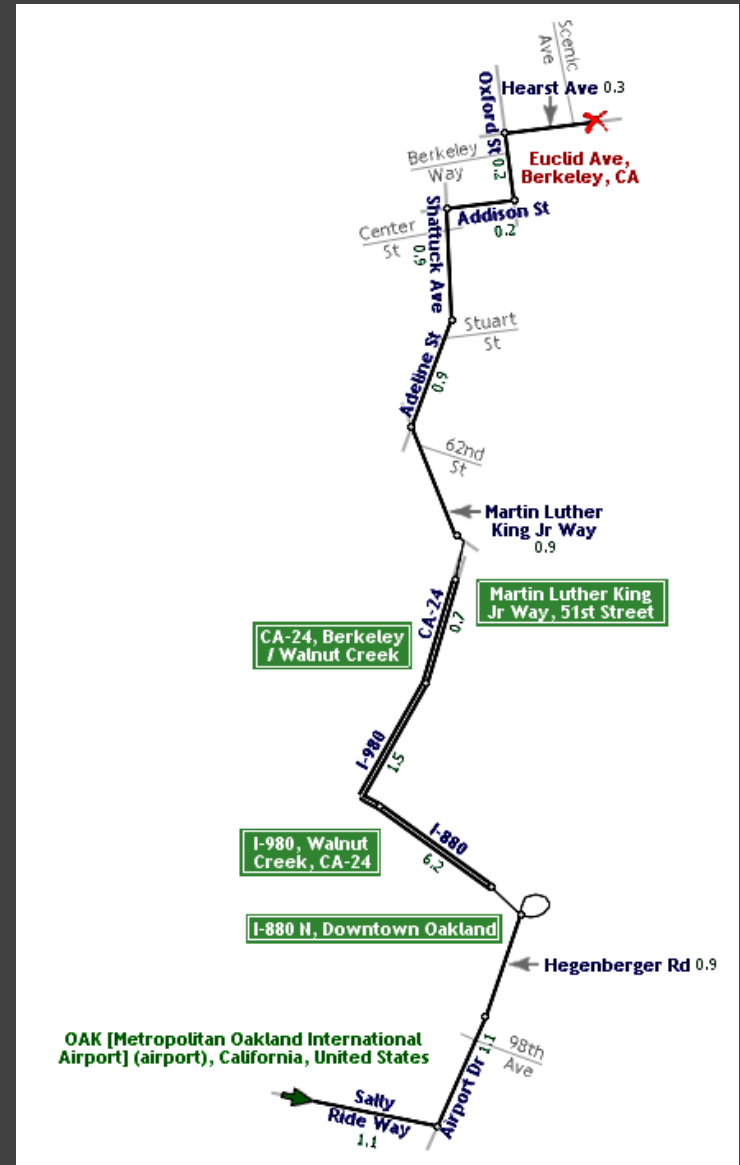
## Develop constraints based on design principles

## Simulated annealing

Perturb: Form a layout

Score: Evaluate quality

Minimize score



# Road Layout Constraints [Agrawala '01]

## Length

Ensure all roads visible

$$((L_{\min} - l(r_i)) / L_{\min})^2 * W_{\text{small}}$$

Maintain ordering by length

$$W_{\text{shuffle}}$$

## Orientation

Maintain original orientation

$$|\alpha_{\text{curr}}(r_i) - \alpha_{\text{orig}}(r_i)| * W_{\text{orient}}$$

## Topological errors

Prevent false

$$\min(d_{\text{origin}}, d_{\text{dest}}) * W_{\text{false}}$$

Prevent missing

$$d * W_{\text{missing}}$$

Ensure separation

$$\min(d_{\text{ext}}, E) * \text{Ext}$$

## Overall route shape

Maintain endpoint direction

$$|\alpha_{\text{curr}}(v) - \alpha_{\text{orig}}(v)| * W_{\text{enddir}}$$

Maintain endpoint distance

$$|d_{\text{curr}}(v) - d_{\text{orig}}(v)| * W_{\text{enddist}}$$

**Tools**

# Software Tools

## Web Tools

**d3-geo**: projections, paths and more

**GeoJSON**: JSON format for geo data

**TopoJSON**: topology -> compressed GeoJSON

**MapShaper**: online editor for map data

**Leaflet**: open-source, customizable map tile system

## Other

**PostGIS**: Postgres DB extensions for geo data

**Mapnik**: Render your own map tiles!

# Data Resources

## Natural Earth Data

[naturalearthdata.com](https://naturalearthdata.com)

## OpenStreetMap

[openstreetmap.org](https://openstreetmap.org)

## U.S. Government

[nationalatlas.gov](https://nationalatlas.gov), [census.gov](https://census.gov), [usgs.gov](https://usgs.gov)

# Tutorials

## Cartographic Visualization in Vega-Lite

<https://observablehq.com/@uwdata/cartographic-visualization>

## Command-Line Cartography

<https://medium.com/@mbostock/command-line-cartography-part-1-897aa8f8ca2c>

## How to Infer Topology

<http://bost.ocks.org/mike/topology/>