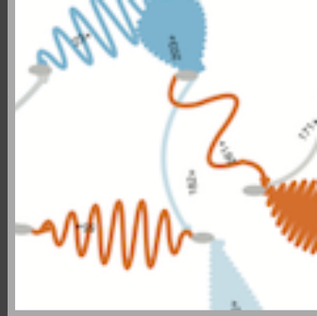
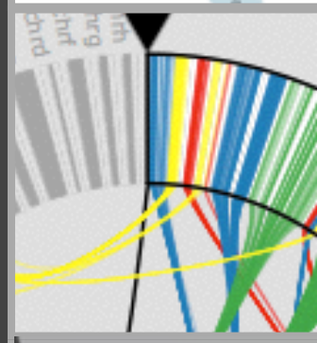
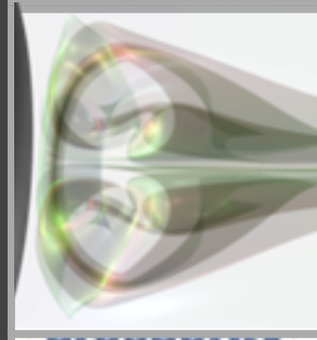
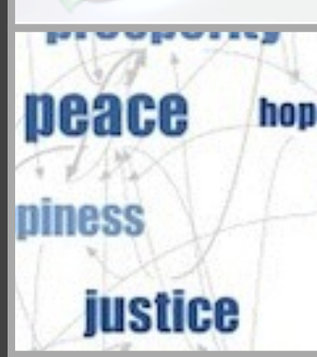
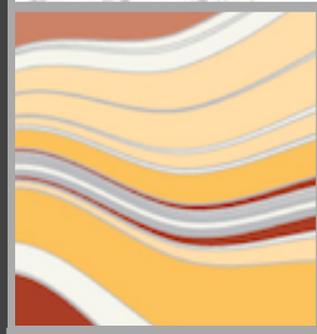
cs6630 | October 28 2014

# MAPS

**Miriah Meyer**
*University of Utah*




# administrivia . . .

- parallel coordinates assignment due Thursday

# last time . . .

| Tables | Networks & Trees | Fields | Geometry | Clusters, Sets, Lists |
| --- | --- | --- | --- | --- |
| Items | Items (nodes) | Grids | Items | Items |
| Attributes | Links | Positions | Positions | |
| | Attributes | Attributes | | |

| Tables | Networks & Trees | Fields | Geometry | Clusters, Sets, Lists | Text |
|---|---|---|---|---|---|
| Items | Items (nodes) | Grids | Items | Items | |
| Attributes | Links | Positions | Positions | | |
| | Attributes | Attributes | | | |

| Tables | Networks & Trees | Fields | Geometry | Clusters, Sets, Lists | Text |
|---|---|---|---|---|---|
| Items | Items (nodes) | Grids | Items | Items | ? |
| Attributes | Links | Positions | Positions | | |
| | Attributes | Attributes | | | |

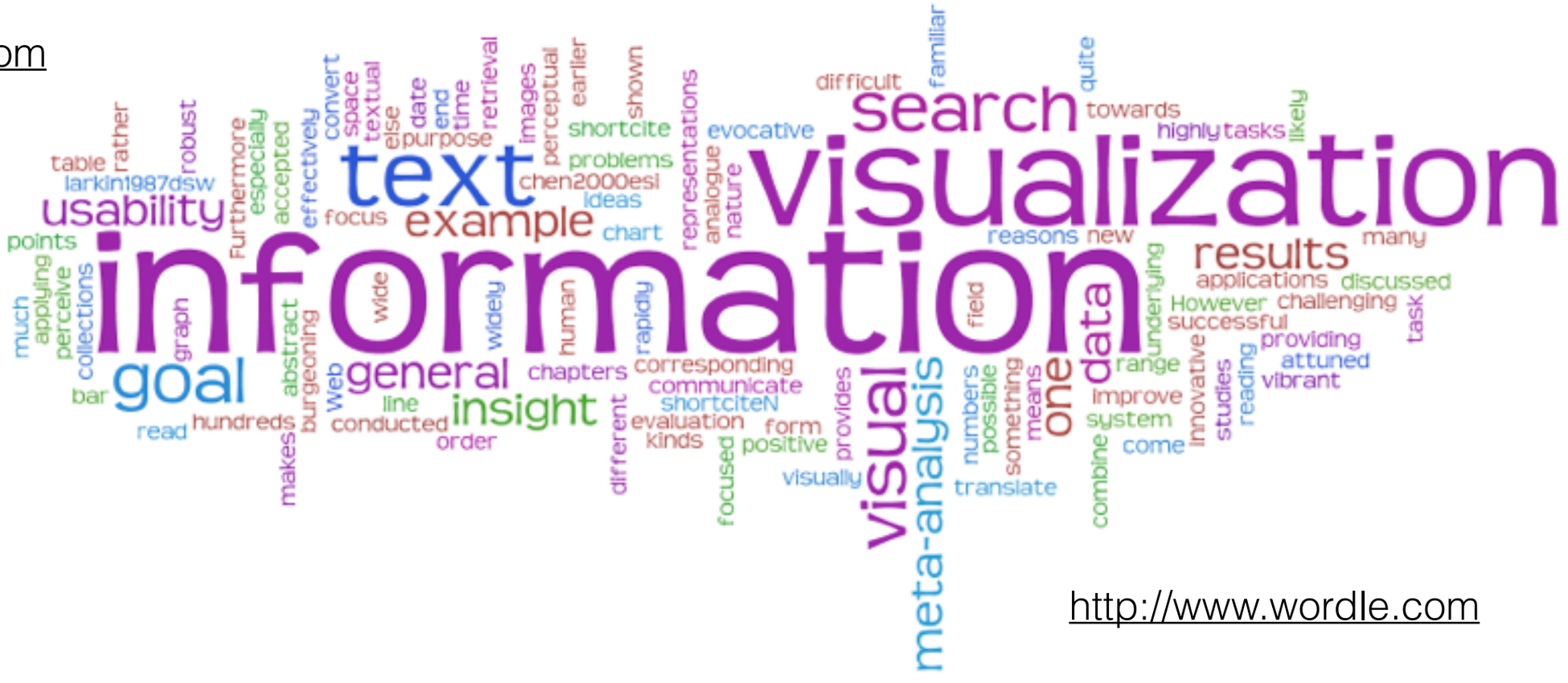
WHAT DOES IT MEAN TO BE AN "ITEM"?

single document

# Tag Clouds / Word Clouds

abstract accepted analogue applications applying attuned bar burgeoning challenging chapters chart collections combine communicate conducted convert data date difficult discussed earlier effectively end evaluation evocative familiar field focus focused form general goal graph highly human hundreds ideas images improve information innovative insight kinds line makes means meta-analysis nature new numbers order ost perceive perceptual points positive problems providing purpose range rapidly read reading reasons representations results retrieval robust search shortciten{chen2000esi} shortcite{larkin1987dsw} shown space studies successful system table task tasks text textual time translate underlying usability vibrant visual visualization visually web wide widely

http://www.tagcrowd.com



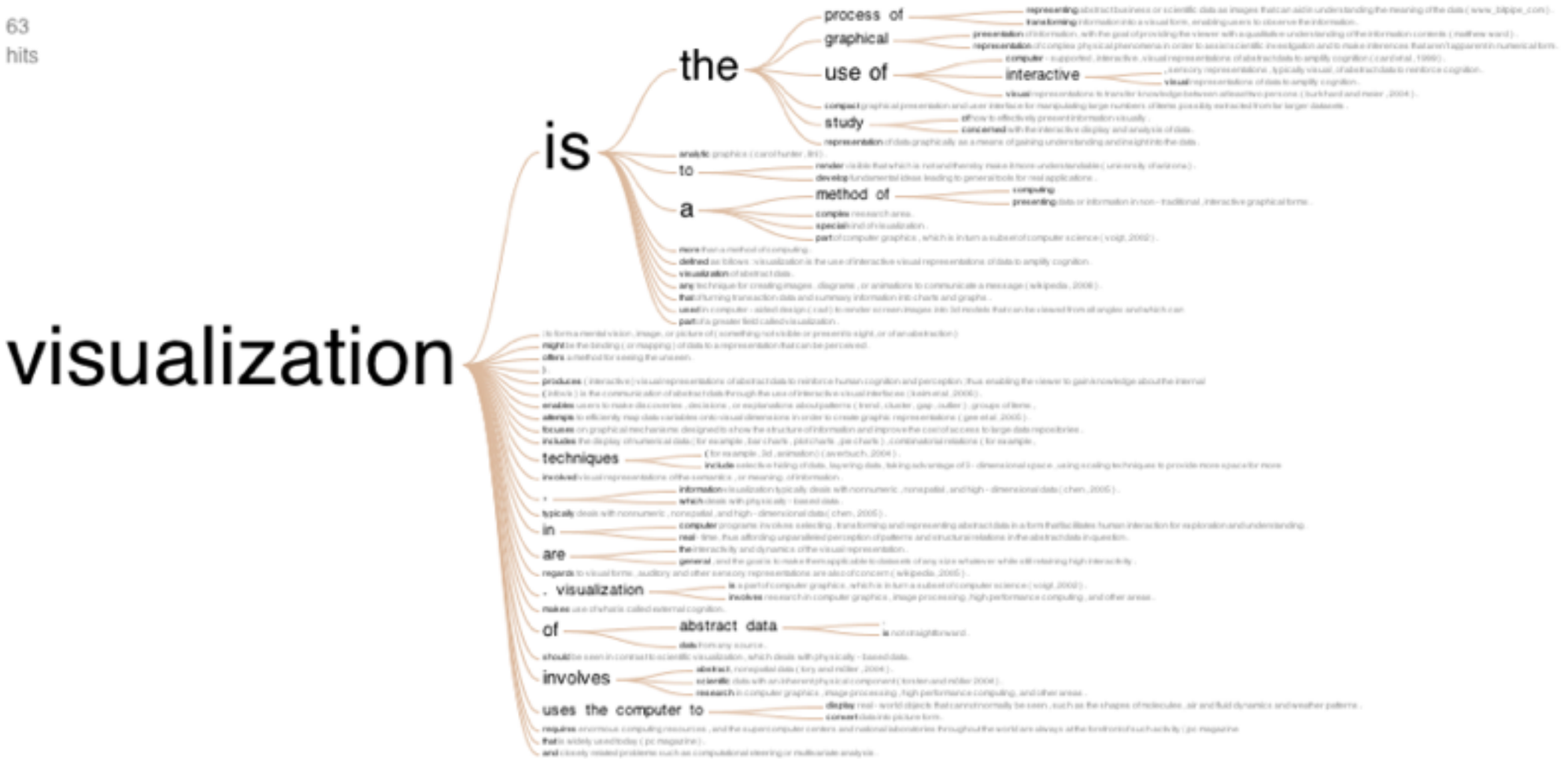

http://www.wordle.com

# Visualizations : definitions of visualization word tree

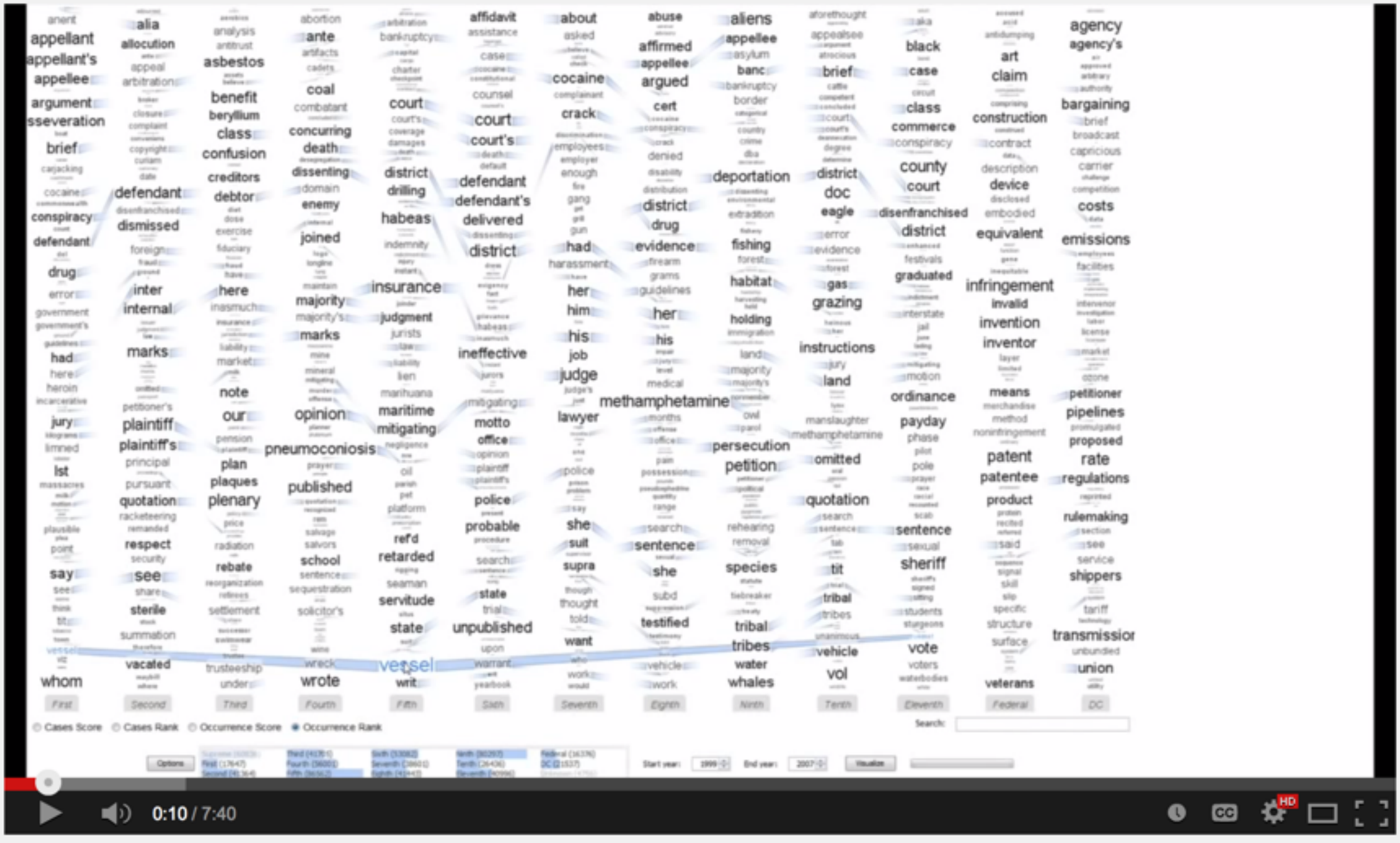
Uploaded by: mhalle
Created at: Wednesday May 21 2008, 11:37 PM
Tags: text

Search visualization | Back | Forward | Start | End | Occurrence Order | Clicks Will Zoom

63
hits



collection of documents



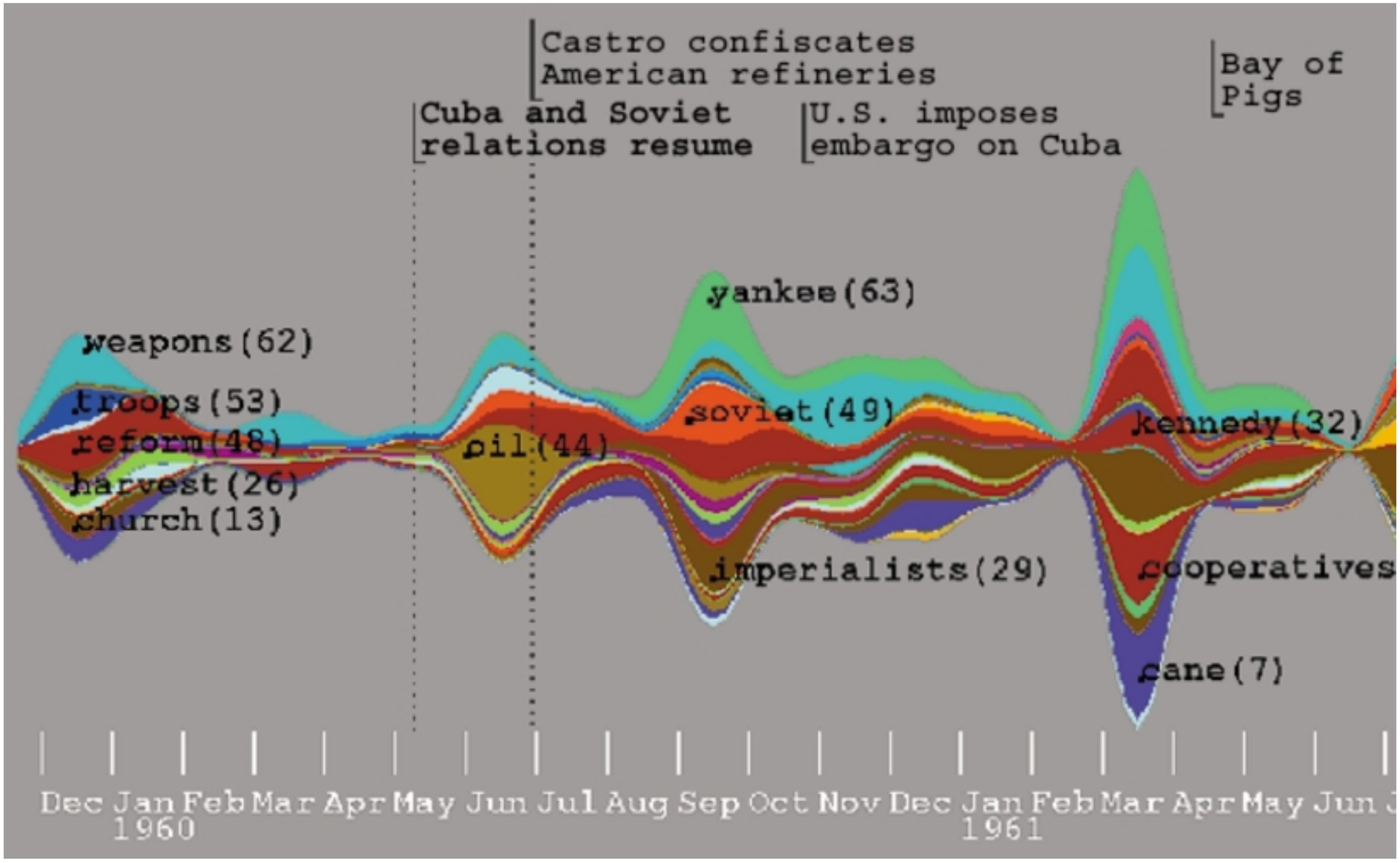

# Parallel Tag Clouds to Explore and Analyze Faceted Text Corpora

**Christopher Collins**

Subscribe 25

2,451

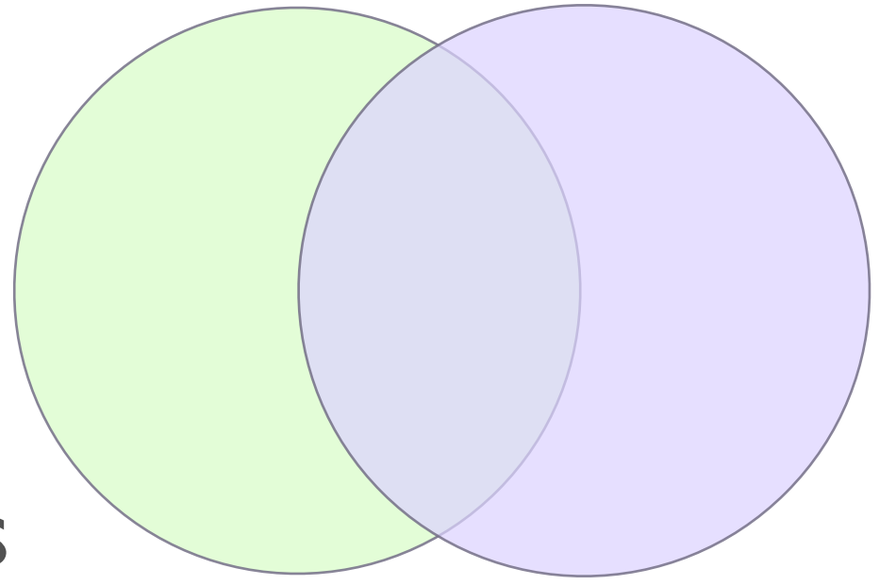
# Showing Temporal Relationships: ThemeRiver (Stream Graph)



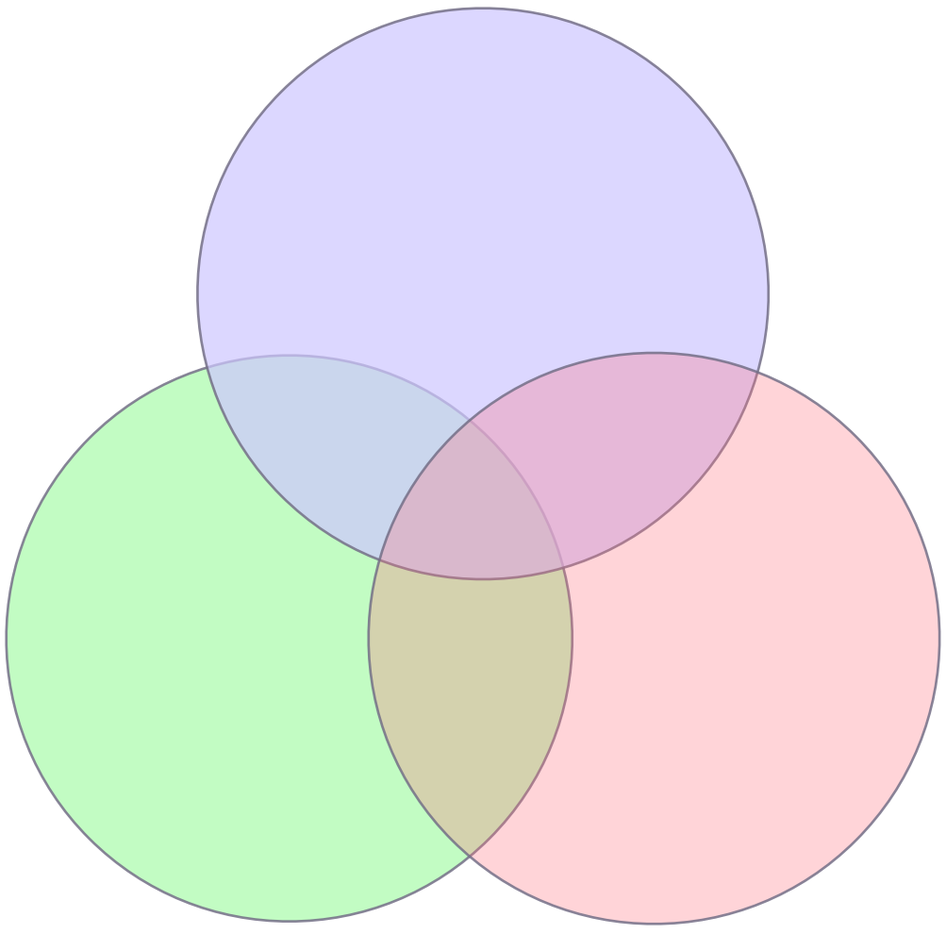

Havre, Hetzler, Nowell 2000

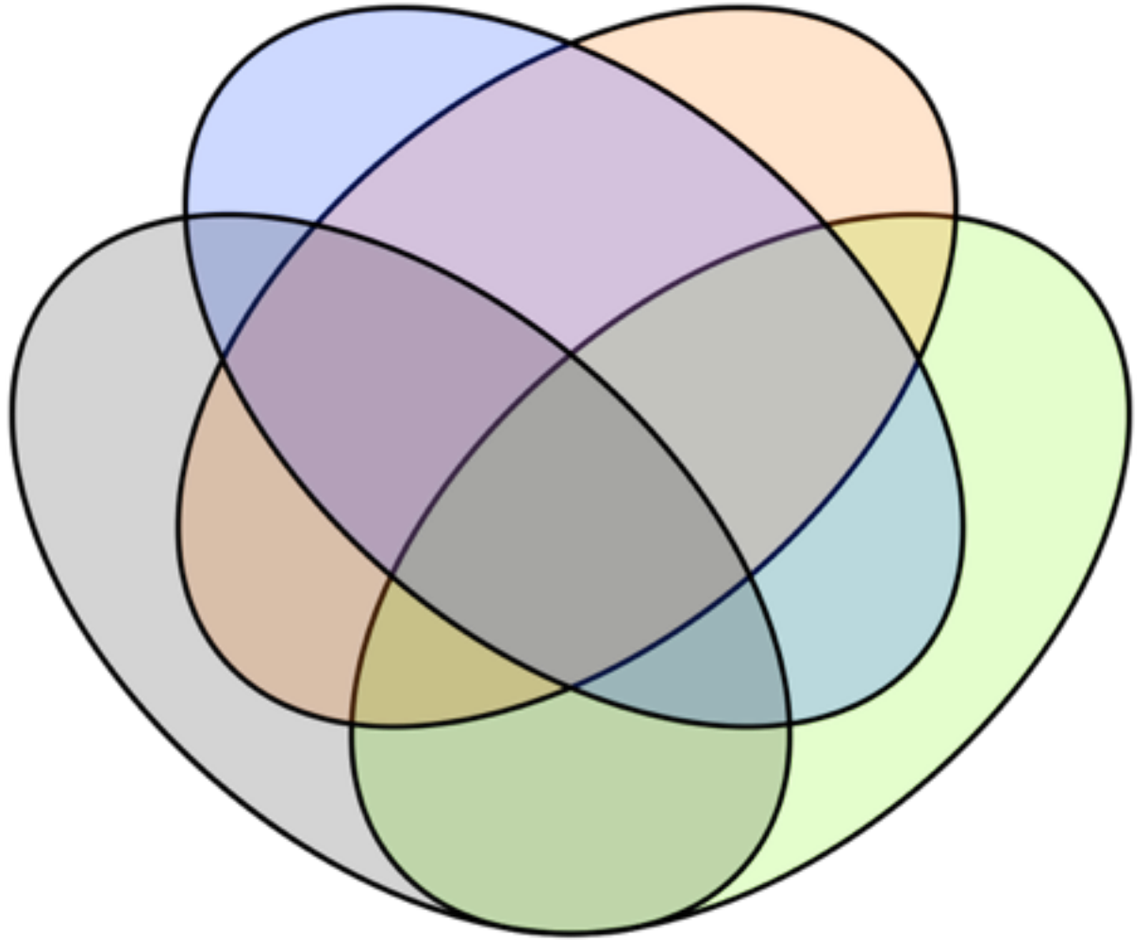
# SETS

# venn diagrams



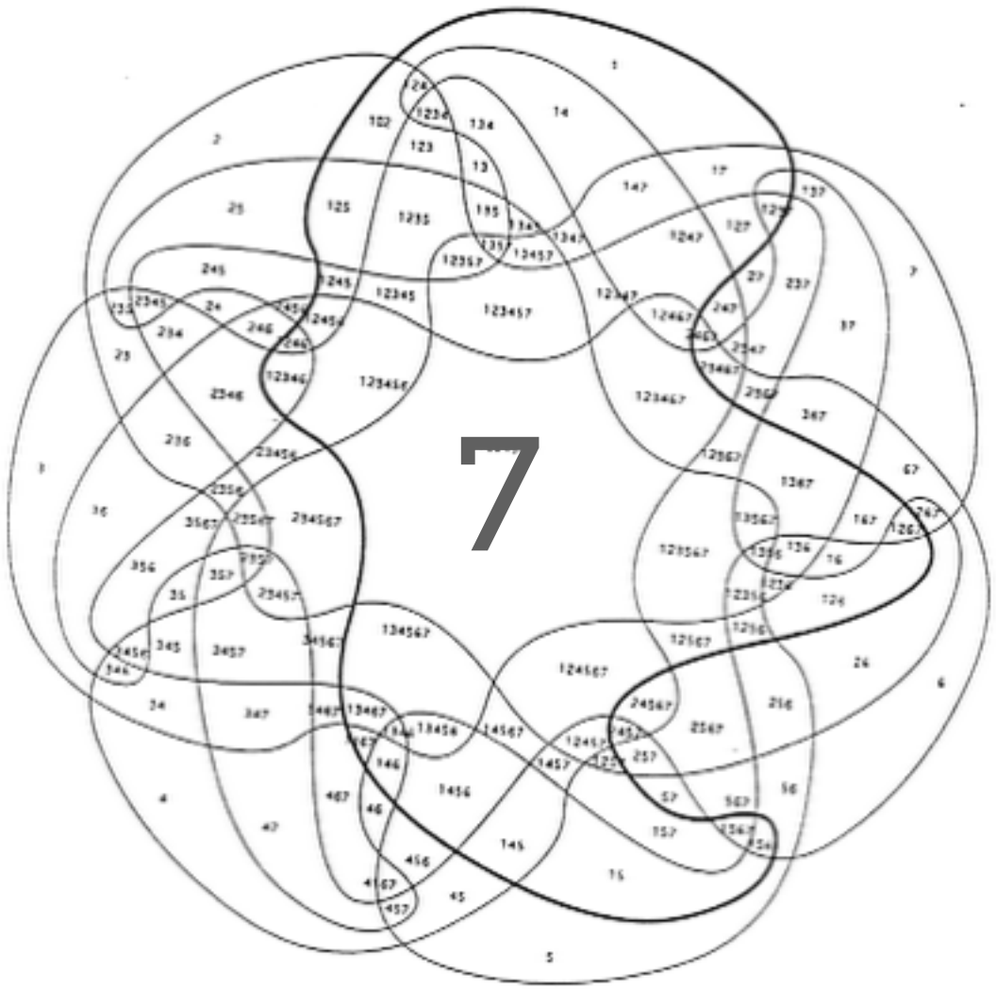
- show all possible relationships

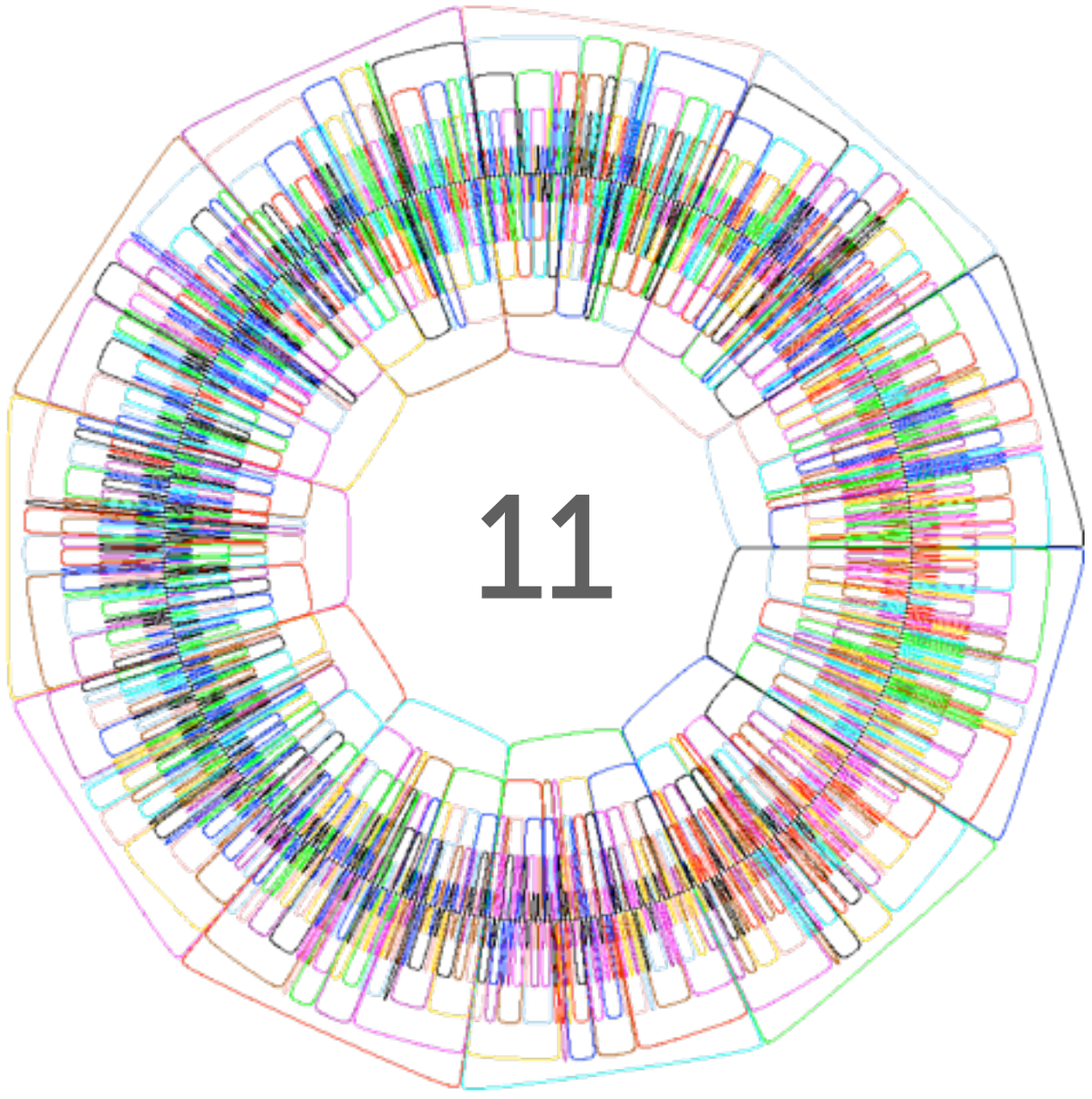




# venn diagrams

- get messy fast

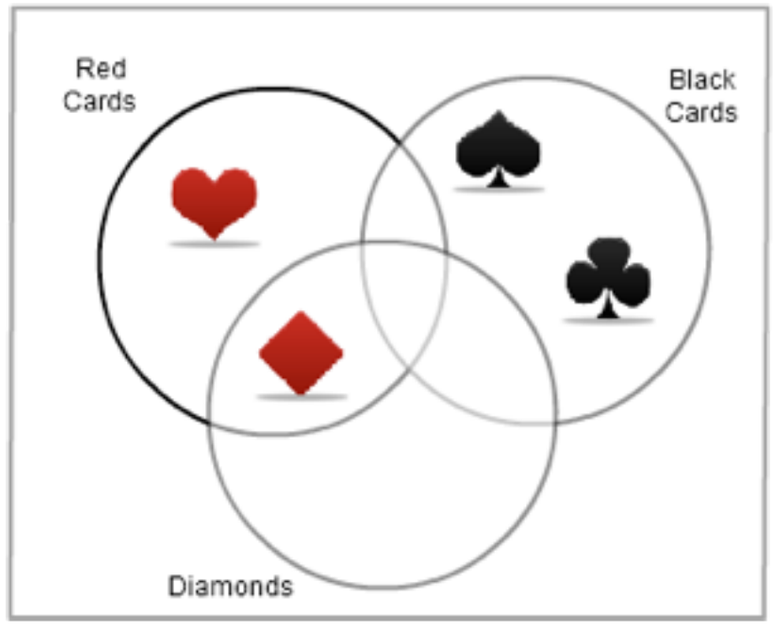


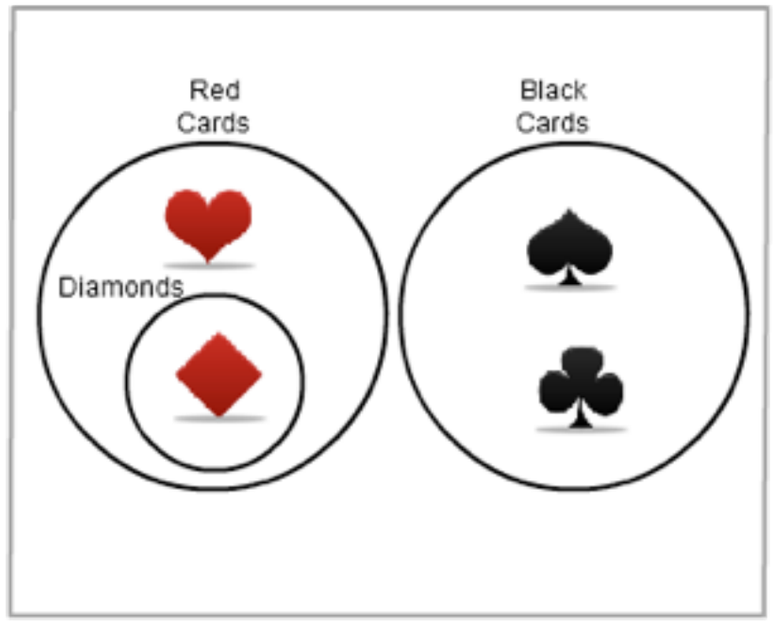
# euler diagrams

- show only existing relationships

**VENN**

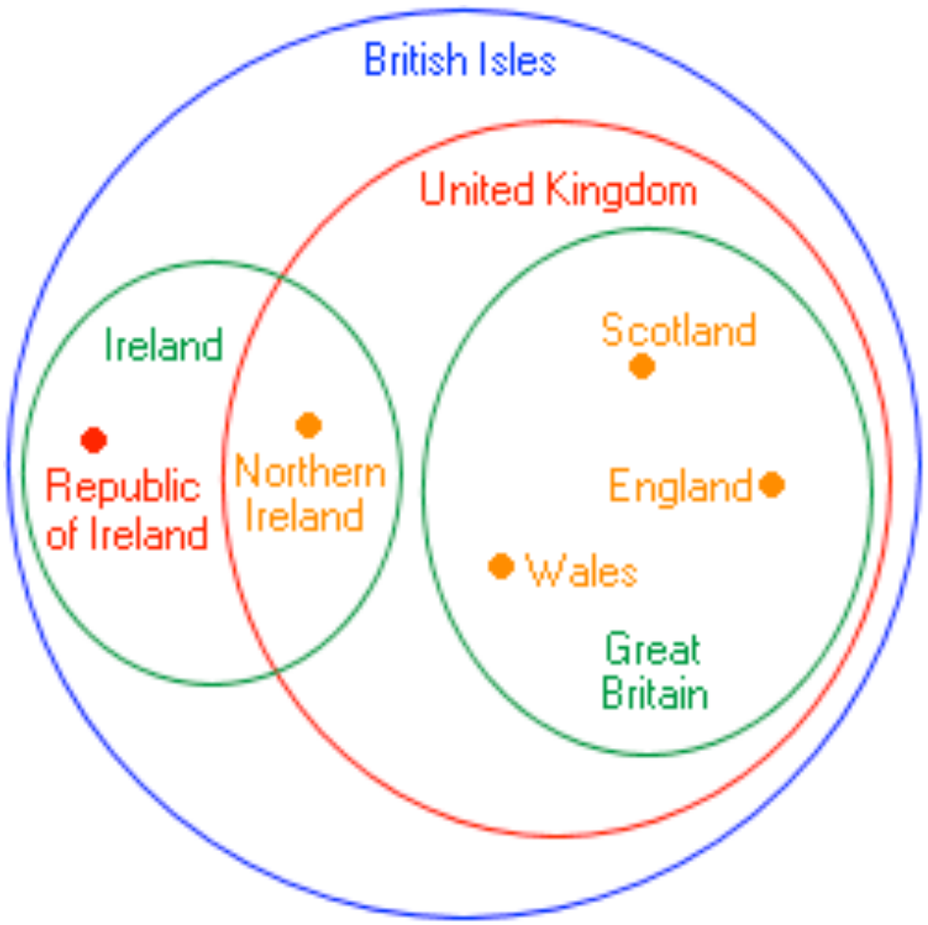



**EULER**

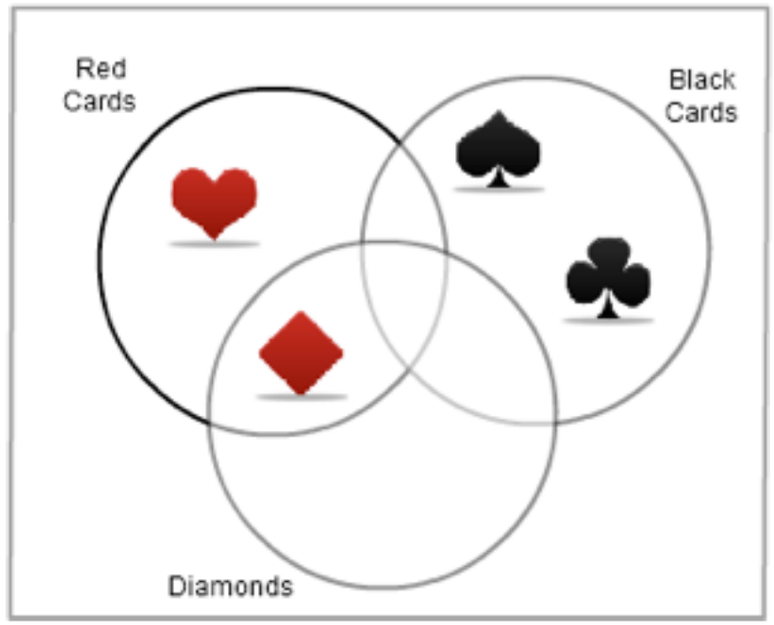


# euler diagrams

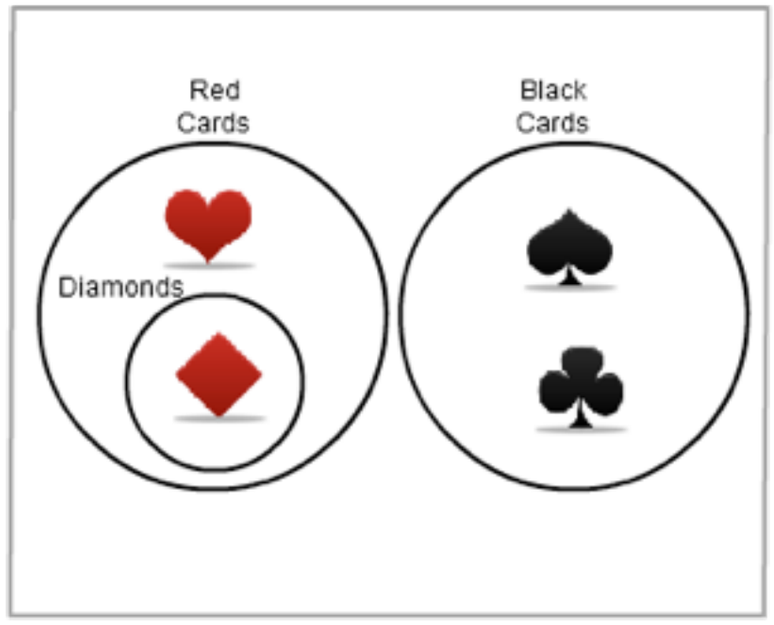
- show only existing relationships




**VENN**



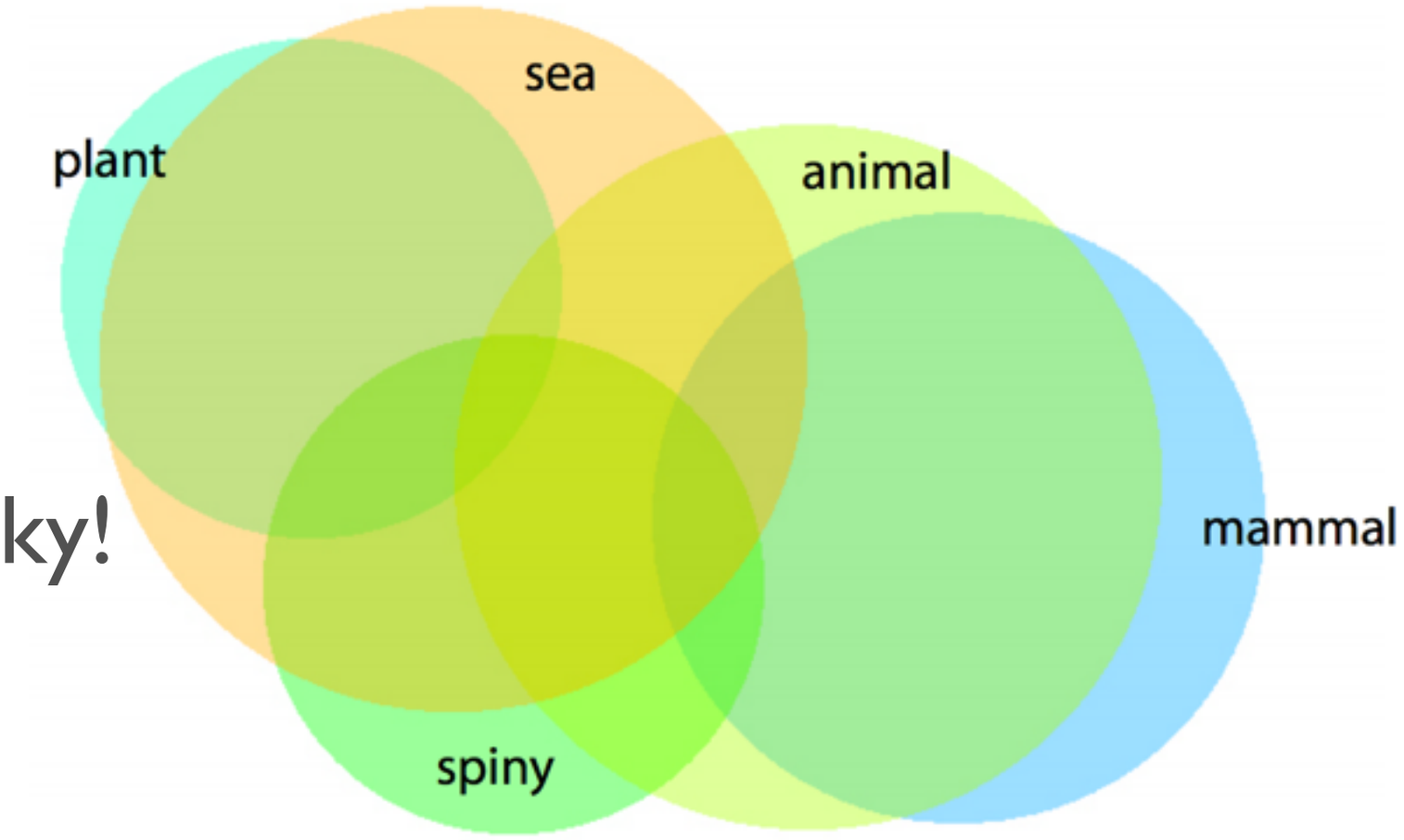

**EULER**



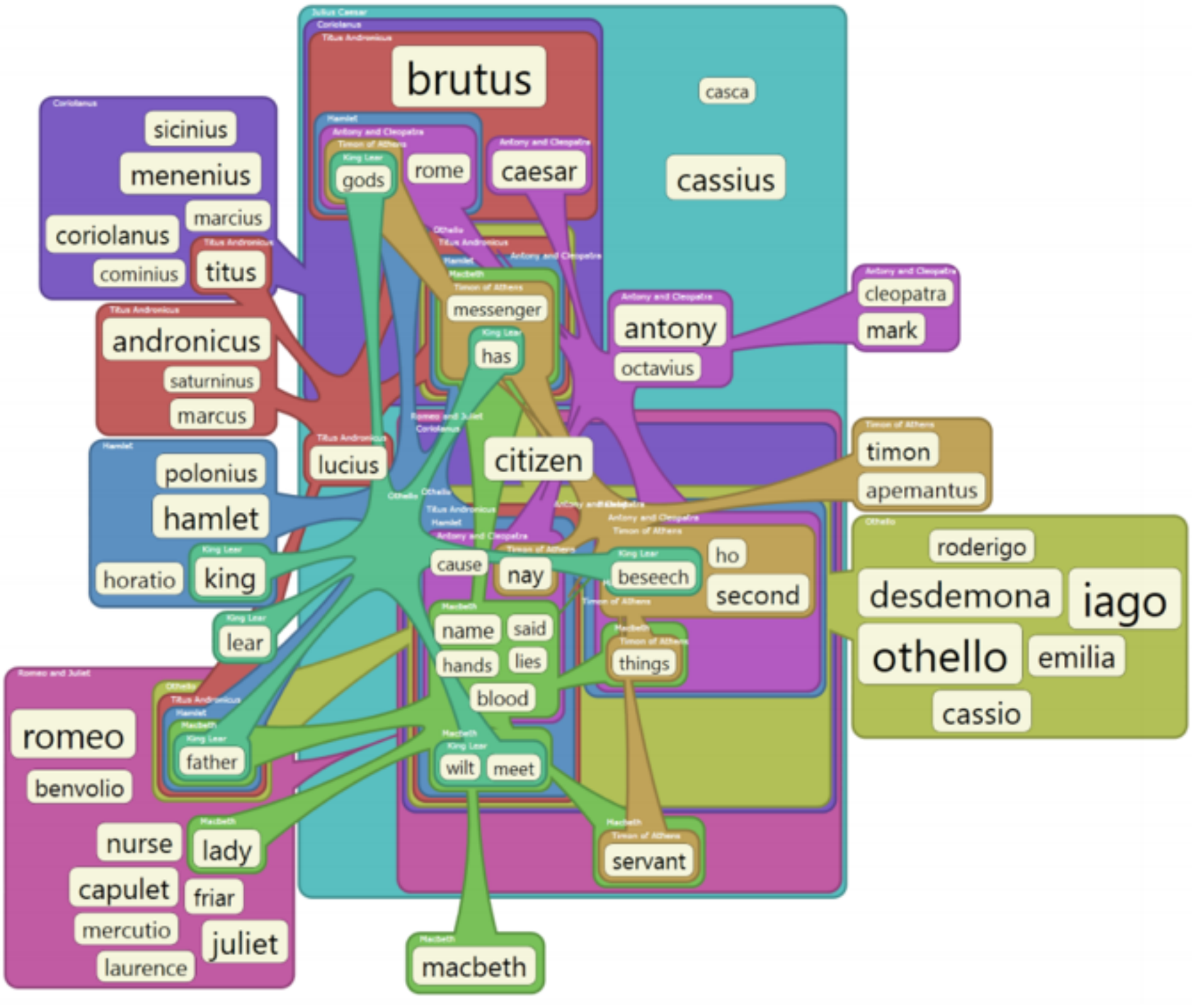
# venn & euler diagrams

- adjust for area

- starts getting tricky!



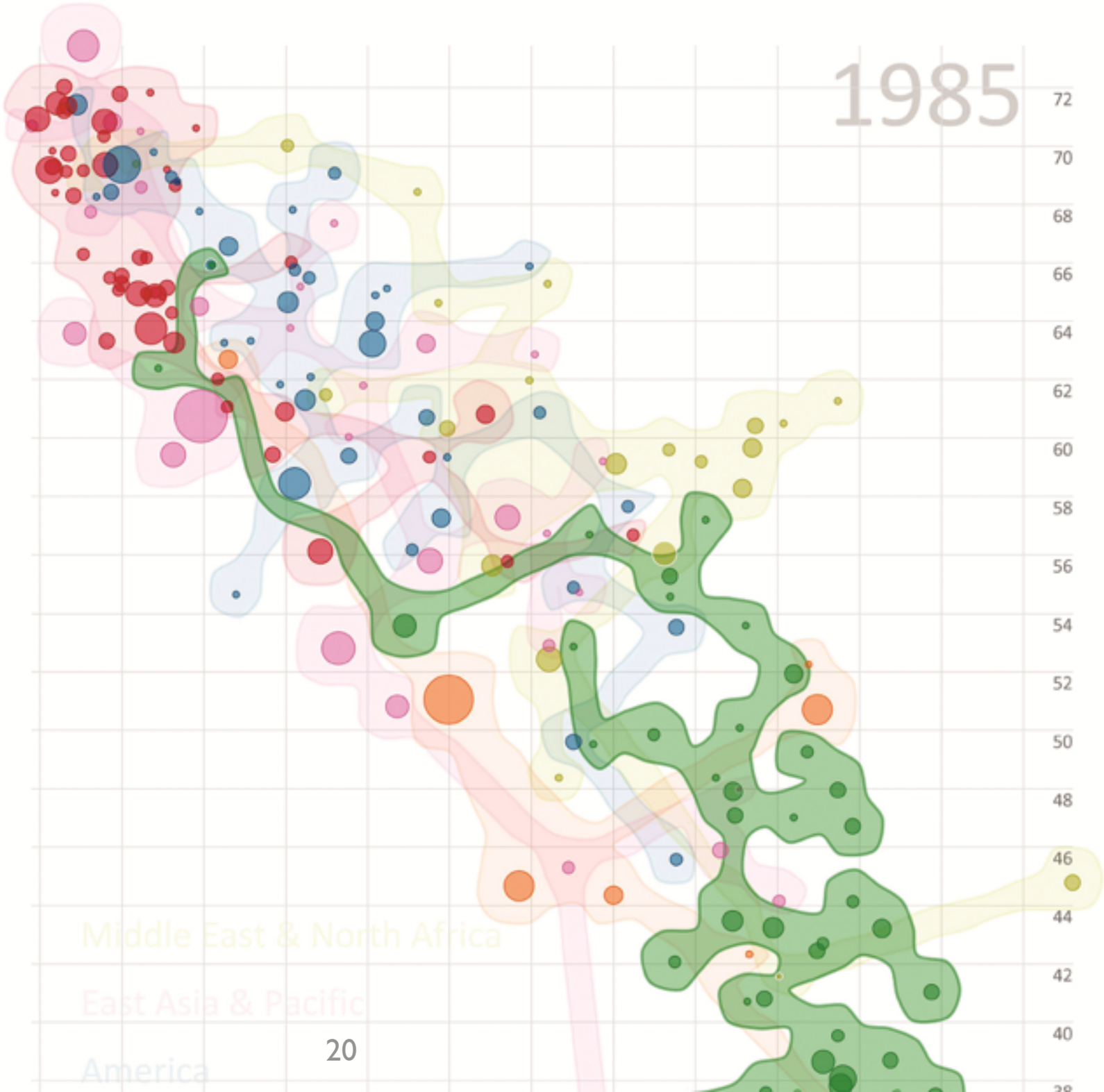
# compact euler diagrams



# visualizing sets with constraints

# bubble sets

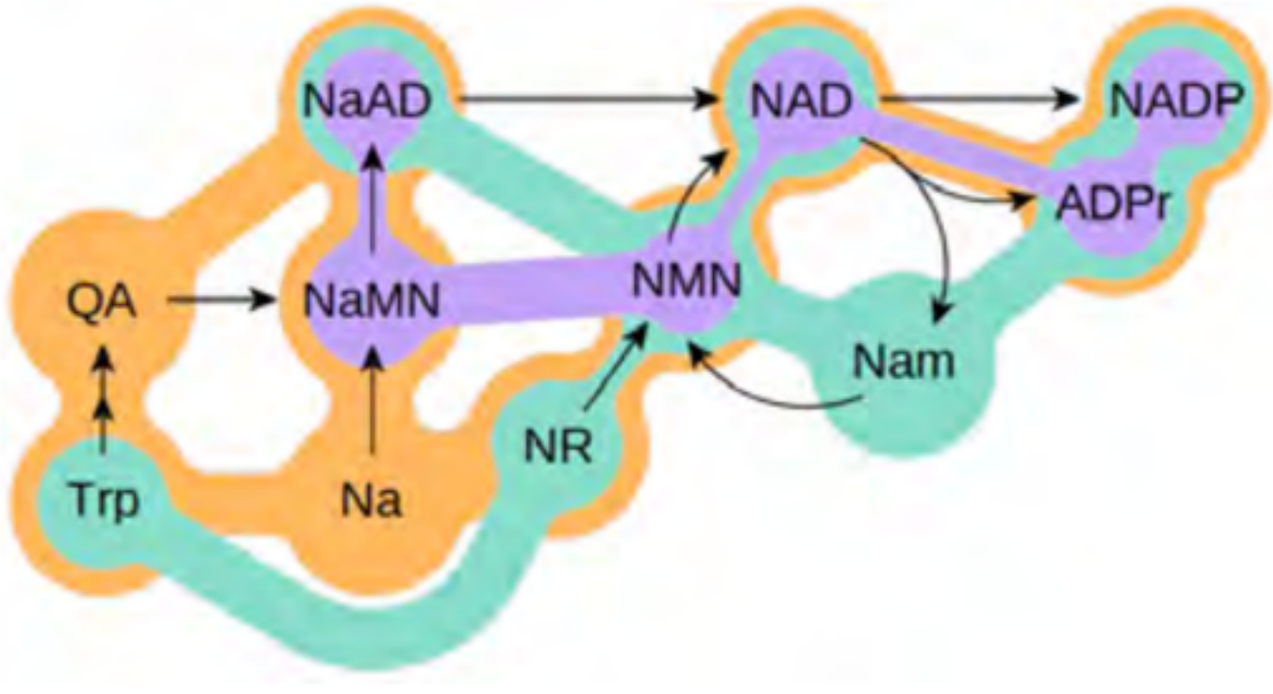
- connect points



# kelp diagrams


- cities on a map

- metabolic network



today . . .

# MAPS

- landmarks
- discrete data
- continuous data
- choropleths
- cartograms
- projections

- landmarks
- discrete data
- continuous data
- choropleths
- cartograms
- projections

Google Maps

Web Images Video News **Maps** more »

Toronto ⇄ Ottawa Get Directions

Search the map Find businesses **Get directions**

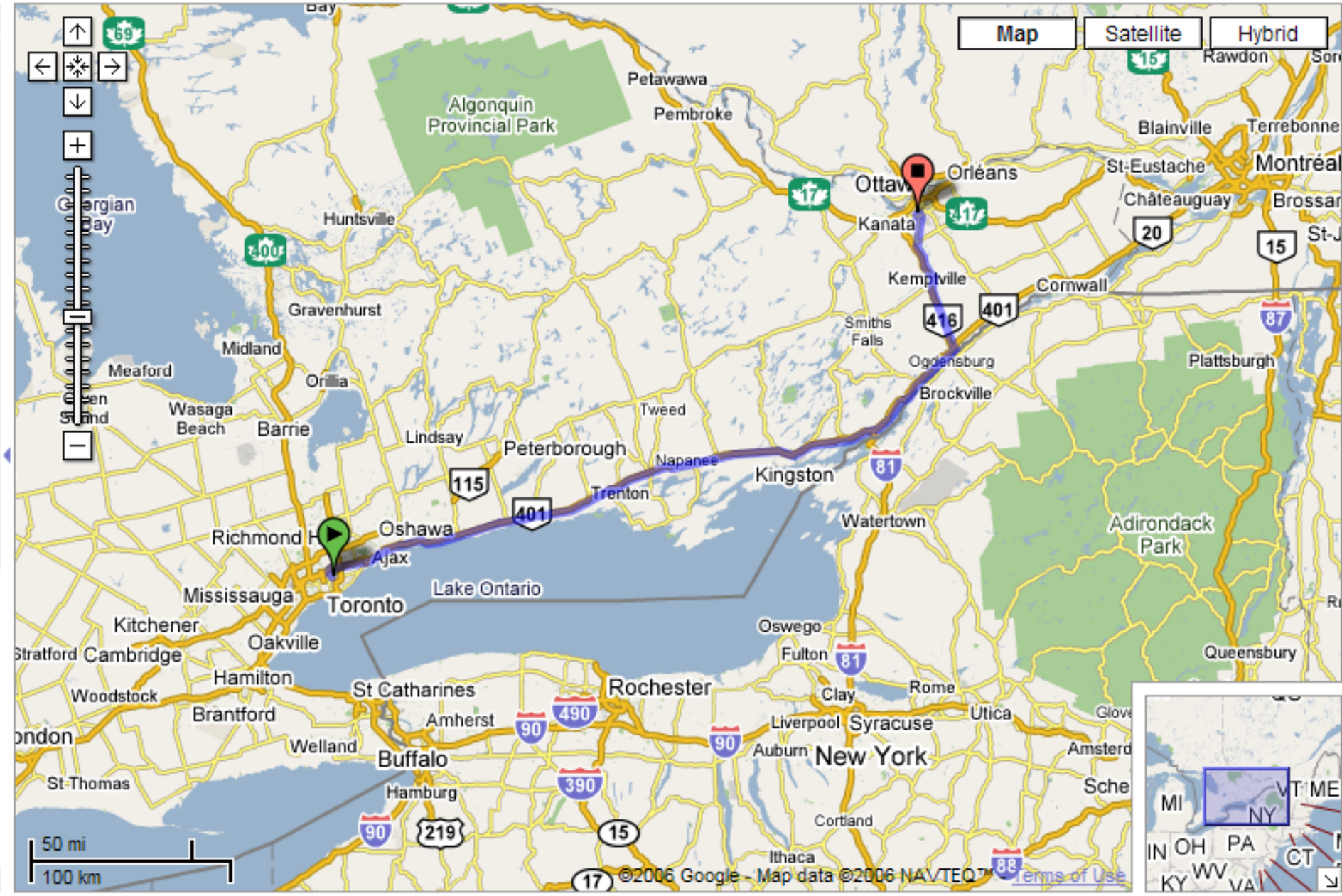
## Maps

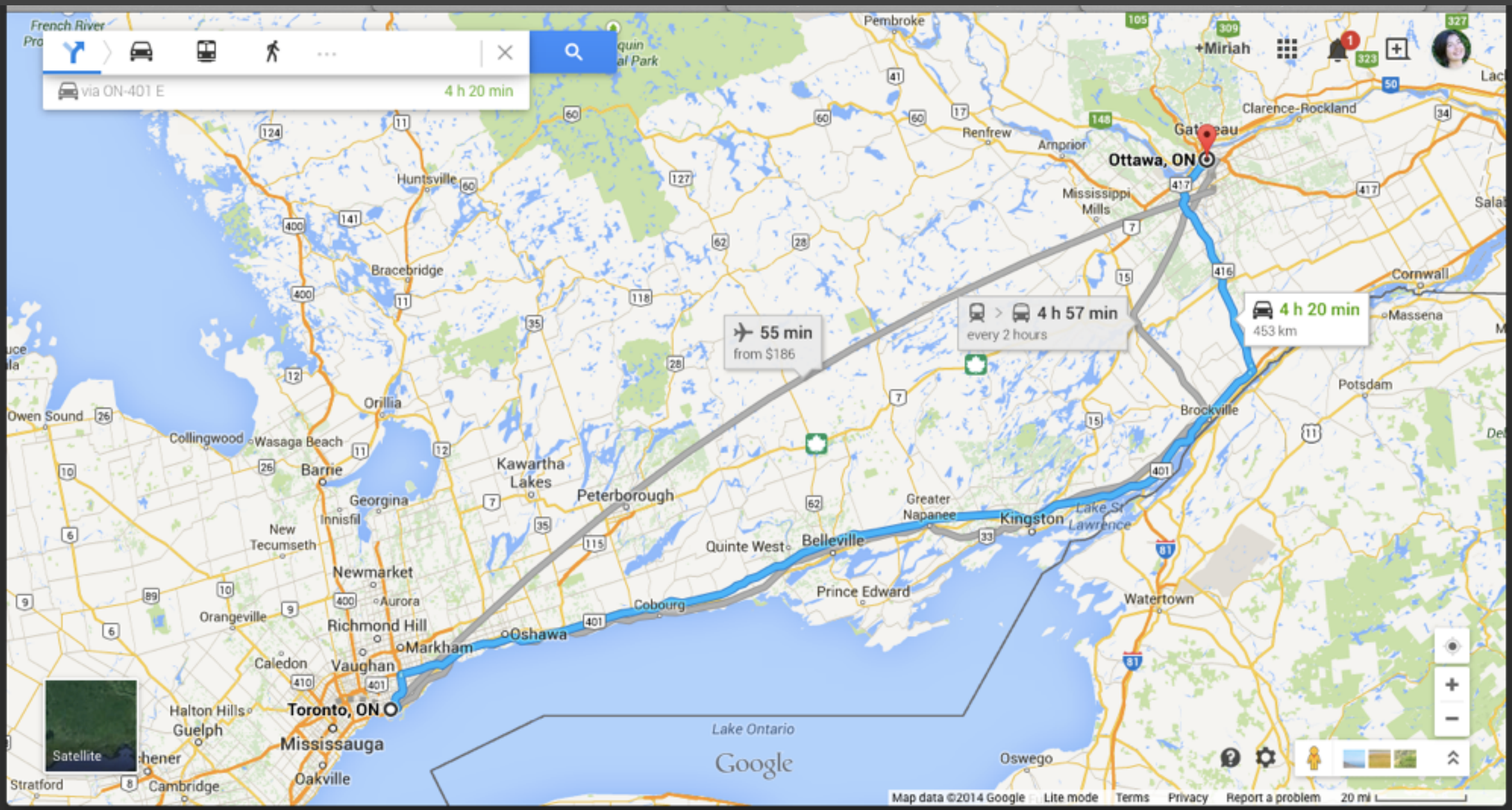
Print Email Link to this page

| | |
|---|---|
| Start address: | Toronto, ON<br>Canada |
| End address: | Ottawa, ON<br>Canada |
| Distance: | 431 km (about 6 hours 2 mins) |

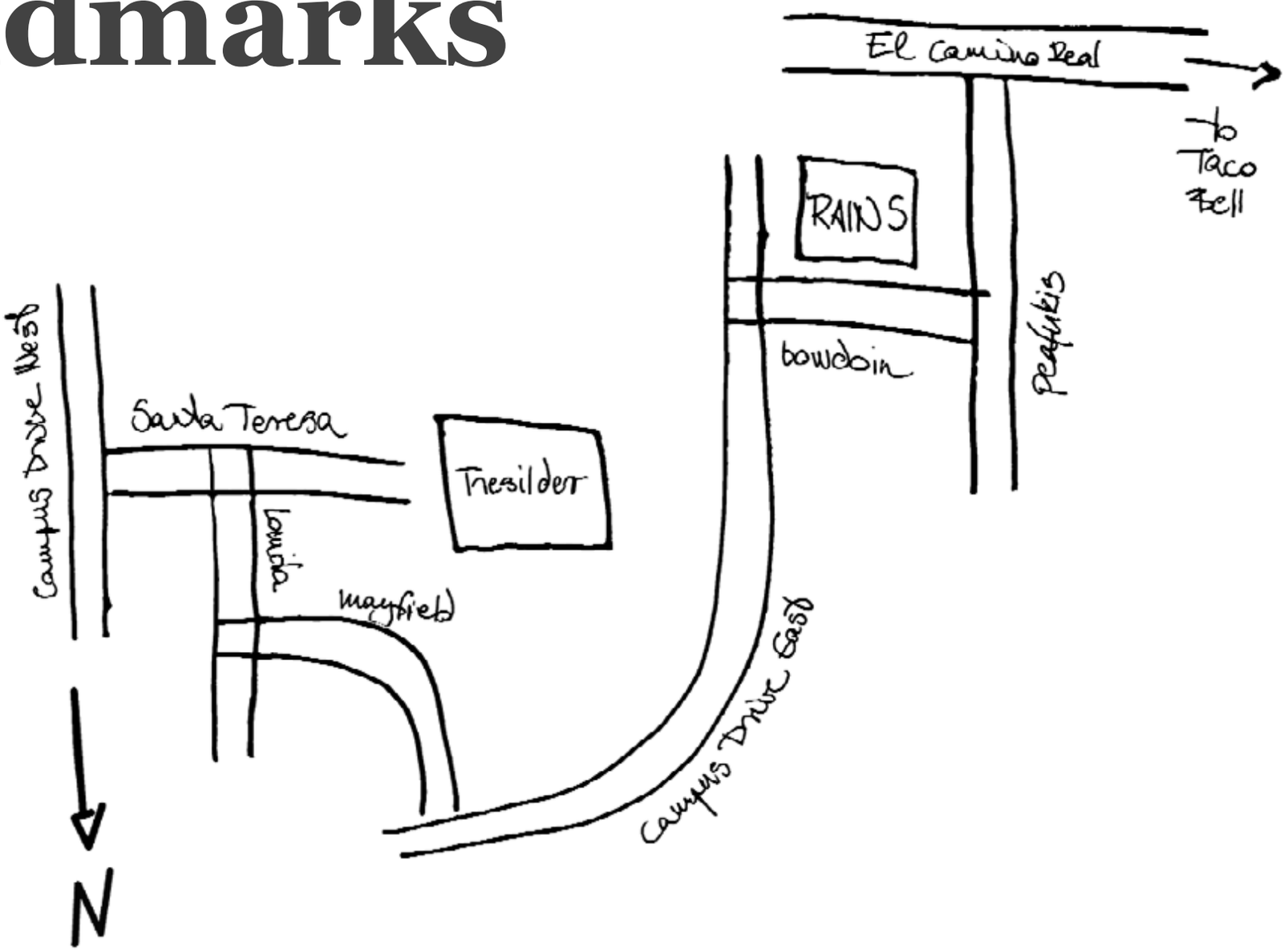
Get reverse directions

| | |
|---|---|
| 1. | Head **west** from **St Leonards Ave** - go **0.3 km** |
| 2. | Turn **right** at **Mt Pleasant Rd** - go **0.4 km** |
| 3. | Turn **left** at **Lawrence Ave E** - go **0.5 km** |
| 4. | Turn **right** at **Yonge St** - go **3.1 km** |
| 5. | Turn **right** at **Lord Seaton Rd** - go **83 m** |
| 6. | Bear **left** - go **54 m** |
| 7. | Bear **left** into the **HWY-401 E** entry ramp - go **0.3 km** |
| 8. | Merge into **HWY-401 Collectors E** - go **29.3 km** |
| ... | |
| 9. | Continue on **HWY-401 E** - go **319 km** |
| ... | |
| 10. | Take the **HWY-416 N** exit **721A** to **Kemptville/Ottawa** - go **57.7 km** |
| ... | |
| 11. | Take exit **57** to **(HWY-16)/Nepean/Manotick** - go **0.6 km** |
| 12. | Turn **right** at **Bankfield Rd** - go **1.7 km** |
| 13. | Turn **left** at **Prince of Wales Dr** - go **13.2 km** |




via ON-401 E
4 h 20 min
55 min
from $186
4 h 57 min
every 2 hours
4 h 20 min
453 km
Ottawa, ON
Toronto, ON
Pembroke
Renfrew
Arnprior
Mississippi Mills
Clarence-Rockland
Cornwall
Massena
Potsdam
Brockville
Kingston
Greater Napanee
Belleville
Quinte West
Prince Edward
Cobourg
Peterborough
Kawartha Lakes
Oshawa
Watertown
Oswego
Lake Ontario
Lake St Lawrence
Huntsville
Bracebridge
Orillia
Barrie
Georgina
Innisfil
New Tecumseth
Newmarket
Aurora
Richmond Hill
Markham
Vaughan
Caledon
Orangeville
Owen Sound
Collingwood
Wasaga Beach
Halton Hills
Guelph
Mississauga
Oakville
Cambridge
Stratford
Satellite
Google
Map data ©2014 Google
Lite mode
Terms
Privacy
Report a problem
20 mi

# landmarks


El Camino Real
to Taco Bell
RAINS
Peaslee's
Bowdoin
Campus Drive West
Santa Teresa
Lasuen
Mayfield
Tresidder
Campus Drive East
N

# Rendering Effective Route Maps: Improving Usability Through Generalization

Maneesh Agrawala Chris Stolte
Stanford University*

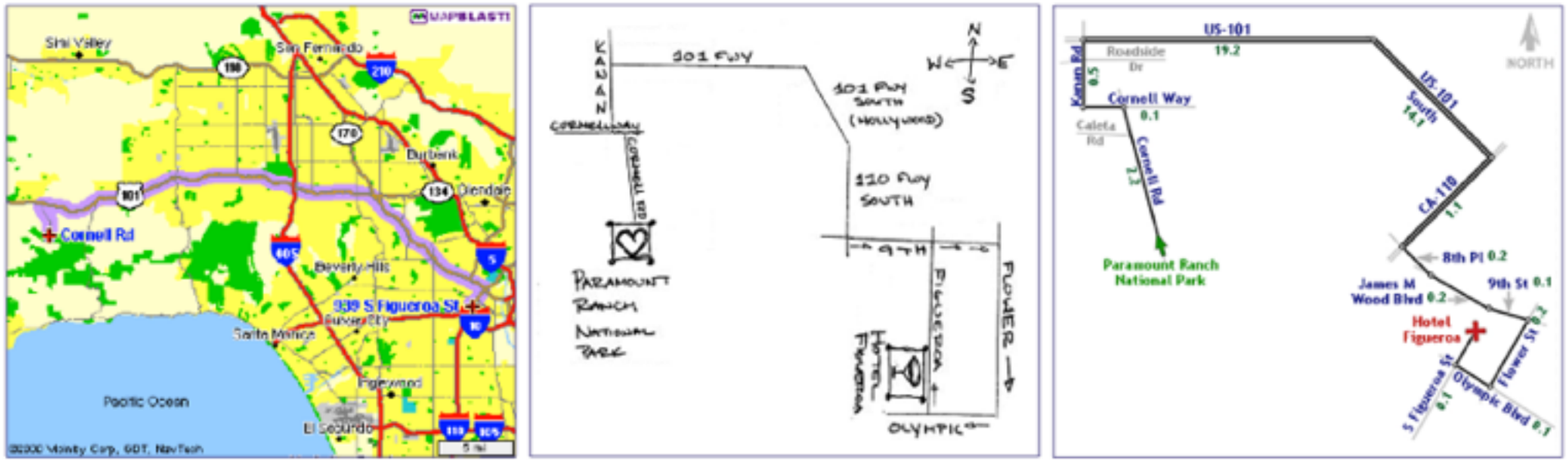



Figure 1: Three route maps for the same route rendered by (left) a standard computer-mapping system, (middle) a person, and (right) LineDrive, our route map rendering system. The standard computer-generated map is difficult to use because its large, constant scale factor causes the short roads to vanish and because it is cluttered with extraneous details such as city names, parks, and roads that are far away from the route. Both the handdrawn map and the LineDrive map exaggerate the lengths of the short roads to ensure their visibility while maintainaing a simple, clean design that emphasizes the most essential information for following the route. Note that the handdrawn map was created without seeing either the standard computer-generated map or the LineDrive map. *(Handdrawn map courtesy of Mia Trachinger.)*

## Abstract

Route maps, which display a path from one location to another, have emerged as one of the most popular applications on the Web. Current computer-generated route maps, however, are often very difficult to use. In this paper we present a set of cartographic generalization techniques specifically designed to improve the usability of route maps. Our generalization techniques are based both on cognitive psychology research studying how route maps are used and on an analysis of the generalizations commonly found in handdrawn route maps. We describe algorithmic implementations of these generalization techniques within LineDrive, a real-time system for automatically designing and rendering route maps. Feedback from over 2200 users indicates that almost all believe LineDrive maps are preferable to using standard computer-generated route maps alone.

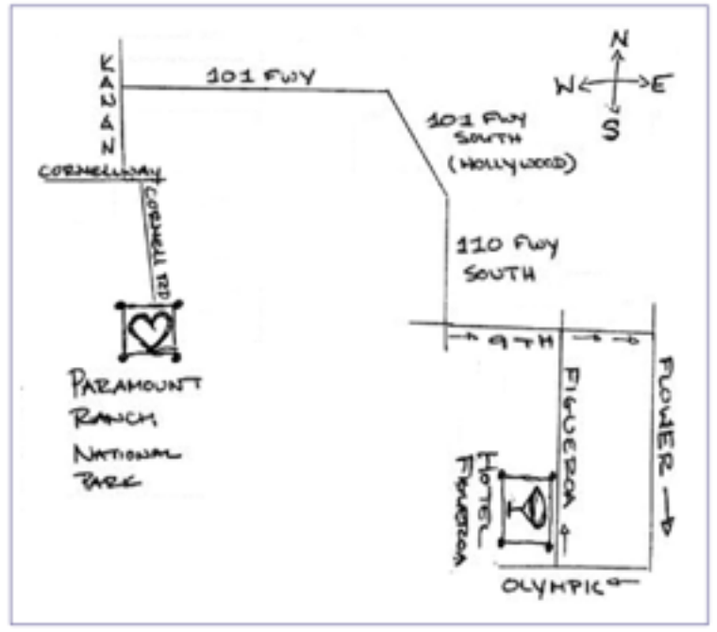
**Keywords:** Information Visualization, Non-Realistic Rendering, WWW Applications, Human Factors

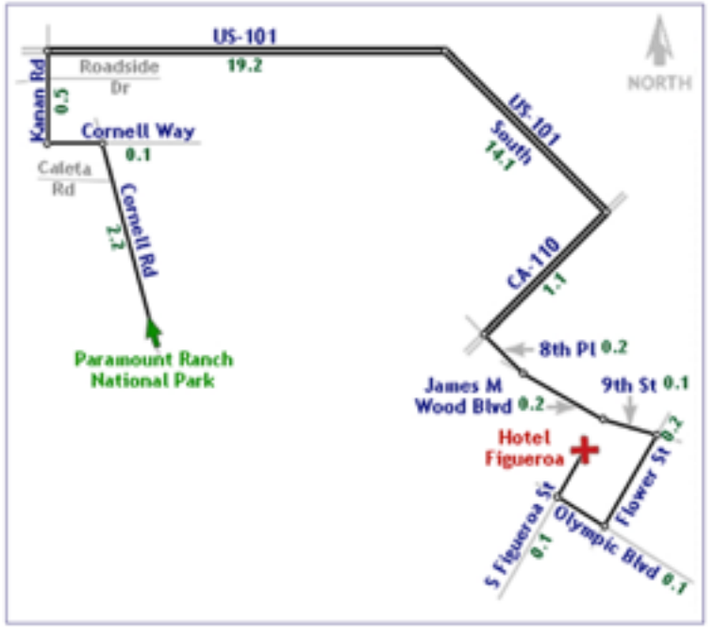
clarity of the map and to emphasize the most important information [16, 21]. This type of generalization, performed either consciously or unconsciously, is common both in quickly sketched maps and in professionally designed route maps that appear in print advertisements, invitations, and subway schedules [25, 13].

Recently, route maps in the form of driving directions have become widely available through the Web. In contrast to hand-designed route maps, these computer-generated route maps are often more precise and contain more information. Yet these maps are more difficult to use. The main shortcoming of current systems for automatically generating route maps is that they do not distinguish between essential and extraneous information, and as a result, cannot apply the generalizations used in hand-designed maps to emphasize the information needed to follow the route.

Figure 1 shows several problems arising from the lack of differentiation between necessary and unnecessary information. The primary problem is that current computer-mapping systems maintain a constant scale factor for the entire map. For many routes, the

- straighten wiggly lines
- snap turns to right angles
- expand regions with turns
- contract long straight roads
- label carefully
- maintain overall orientation

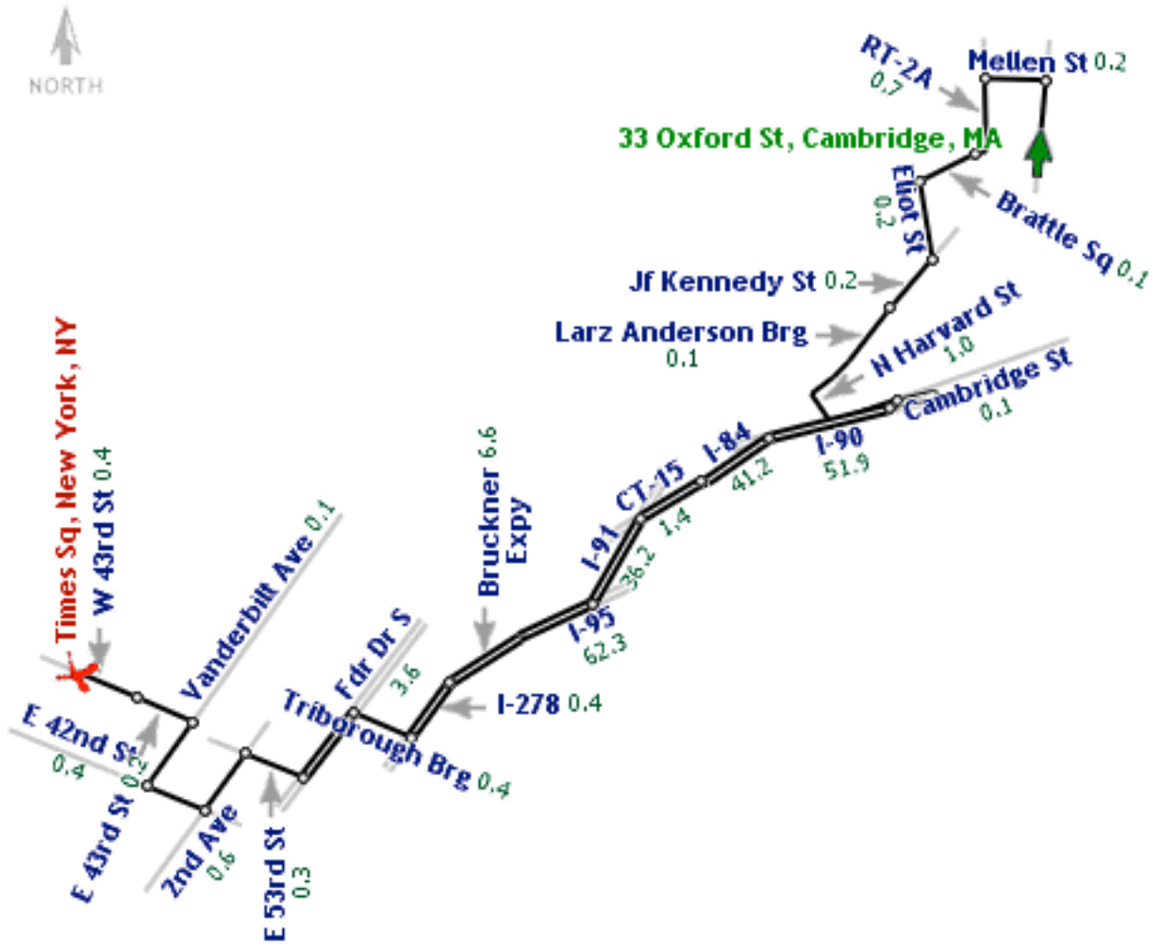

Agrawala 2001

Microsoft®

msn Maps & Directions

Home | Maps | Directions | Help

Map Size | Print | E-mail




**Start:** 33 Oxford St, Cambridge, MA 02138
**End:** Times Sq, New York, NY 10036
**Total Distance:** 211.2 Miles
**Estimated Total Time:** 3 hours, 29 minutes

Directions | Miles

**Route**
- Turn-by-Turn Directions
- Reverse Directions
- Change Start
- Change End
- Get New Directions

**Local Resources**
- Traffic Maps
- City Guide
- Yellow Pages
- Weather

advertisement

Microsoft

bing

Maps

Directions My places Map apps

A

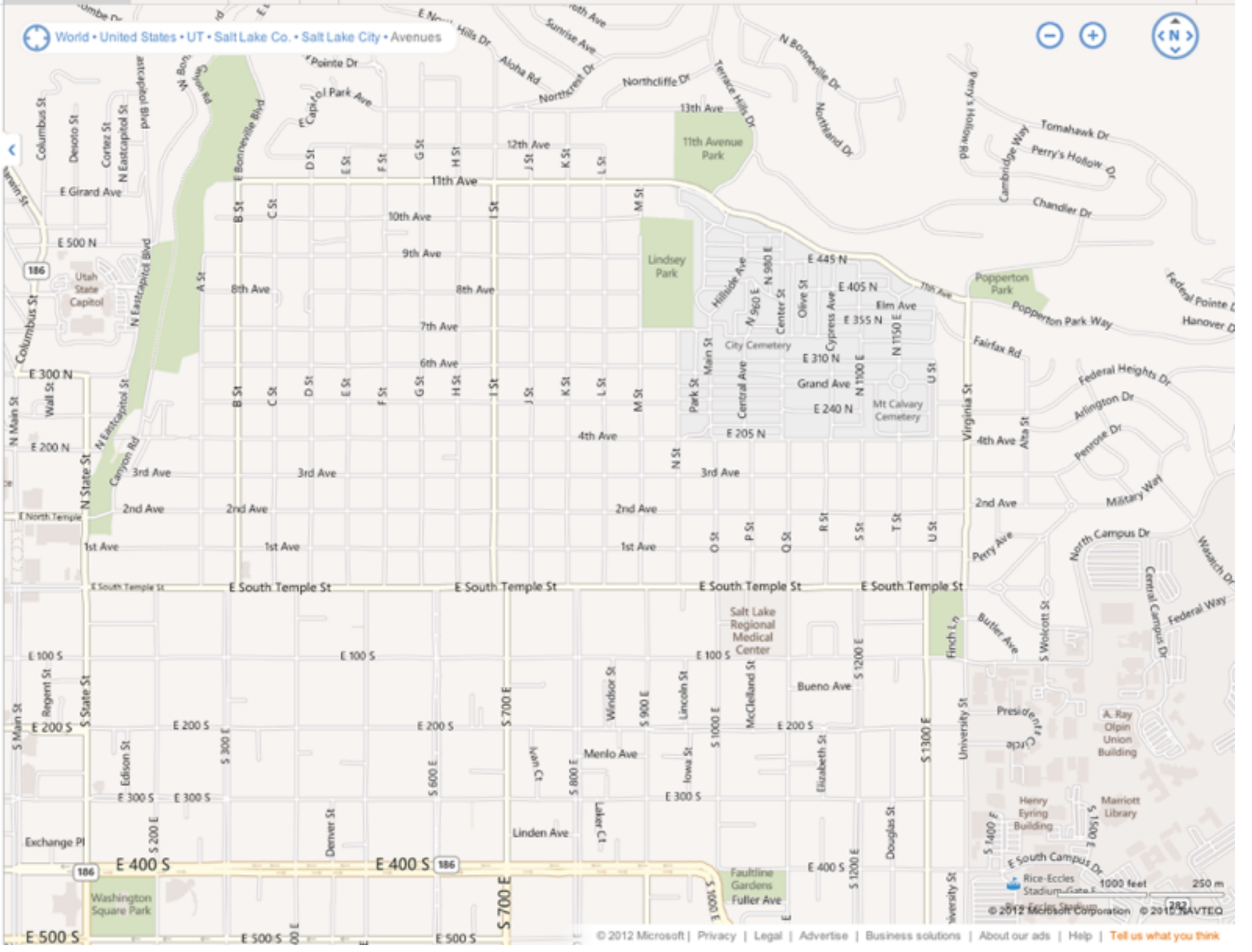
B Business, address, or landmark

add destination show options

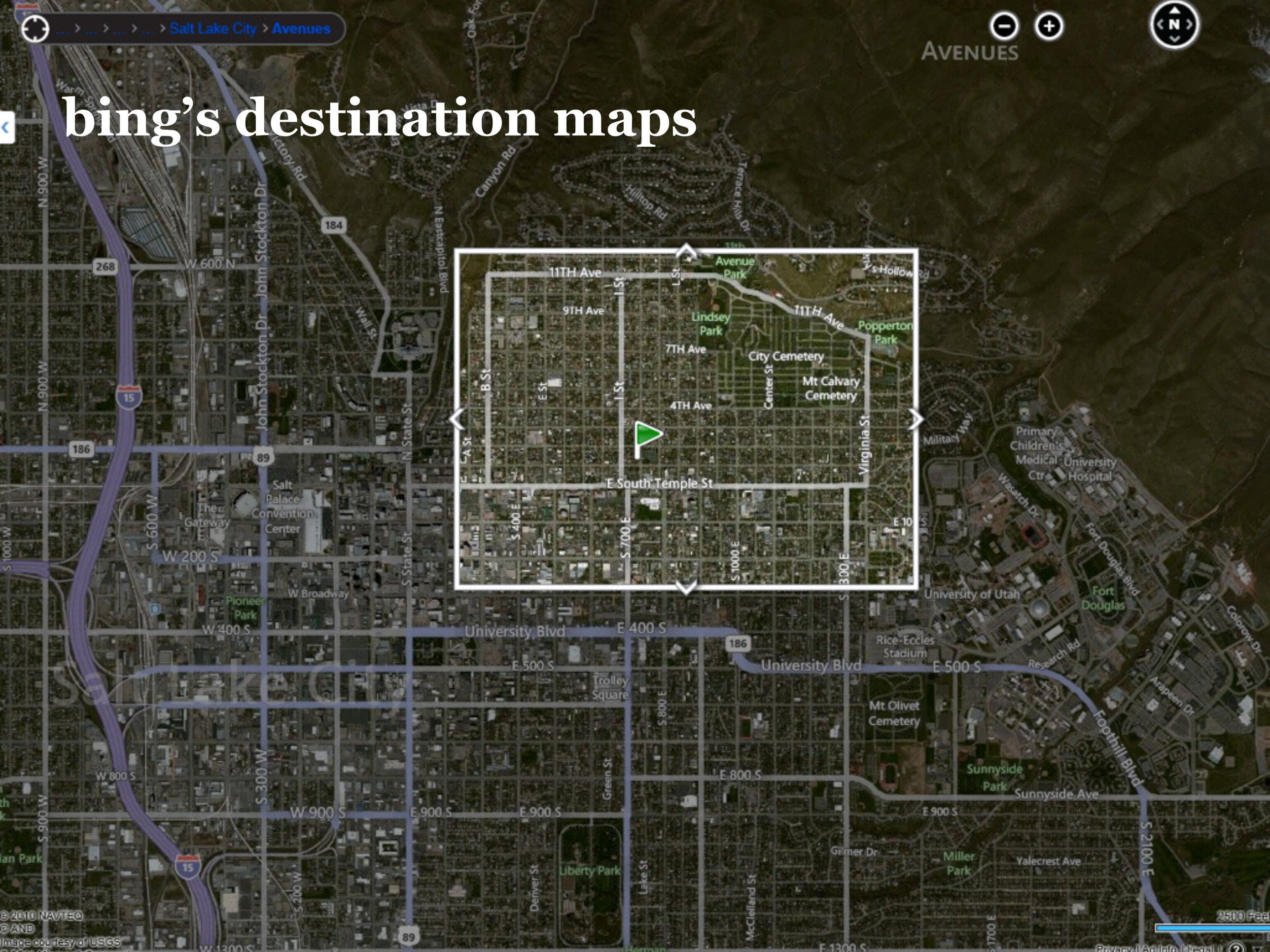
Clear Go

Automatic Aerial Traffic Print Share

World • United States • UT • Salt Lake Co. • Salt Lake City • Avenues

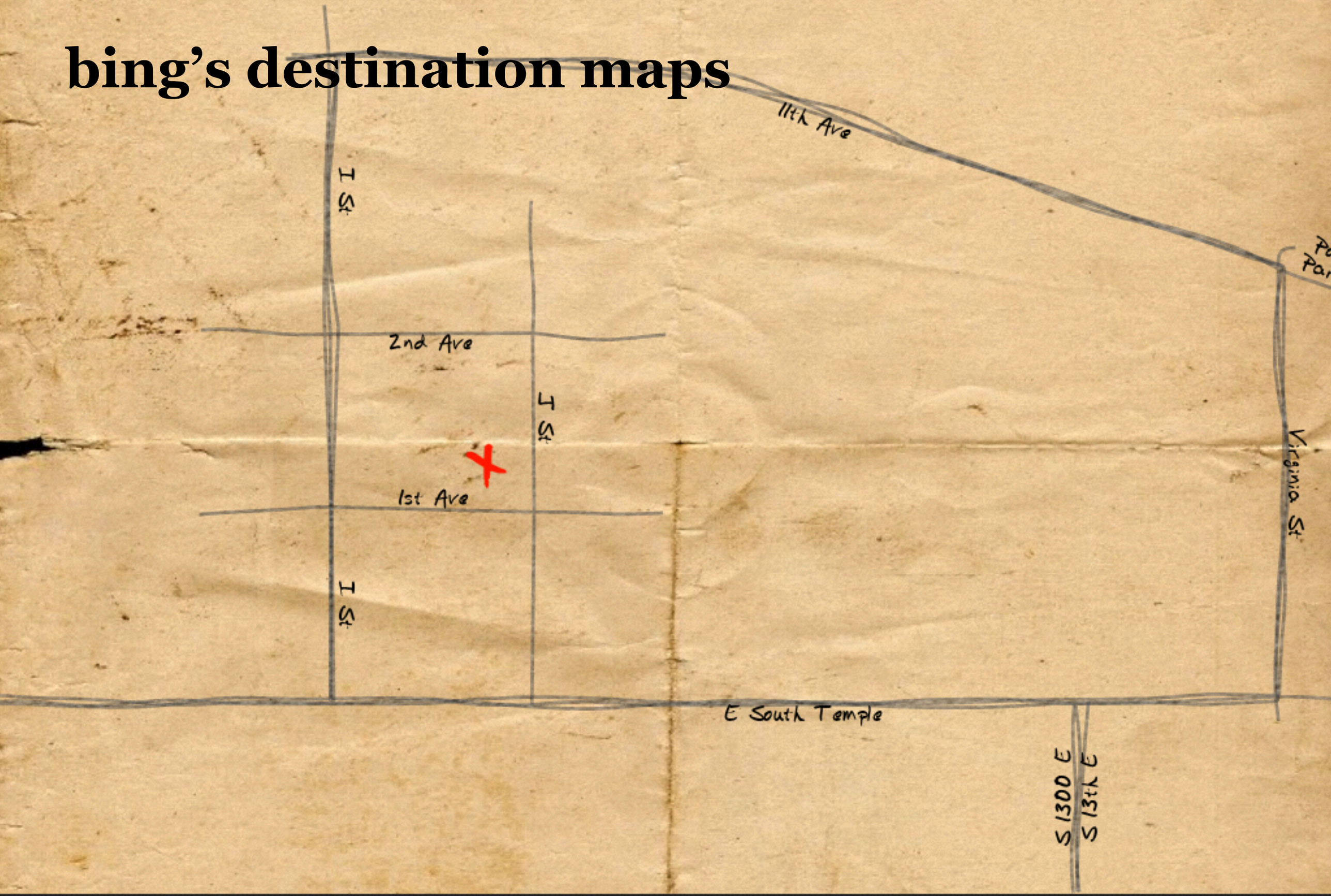


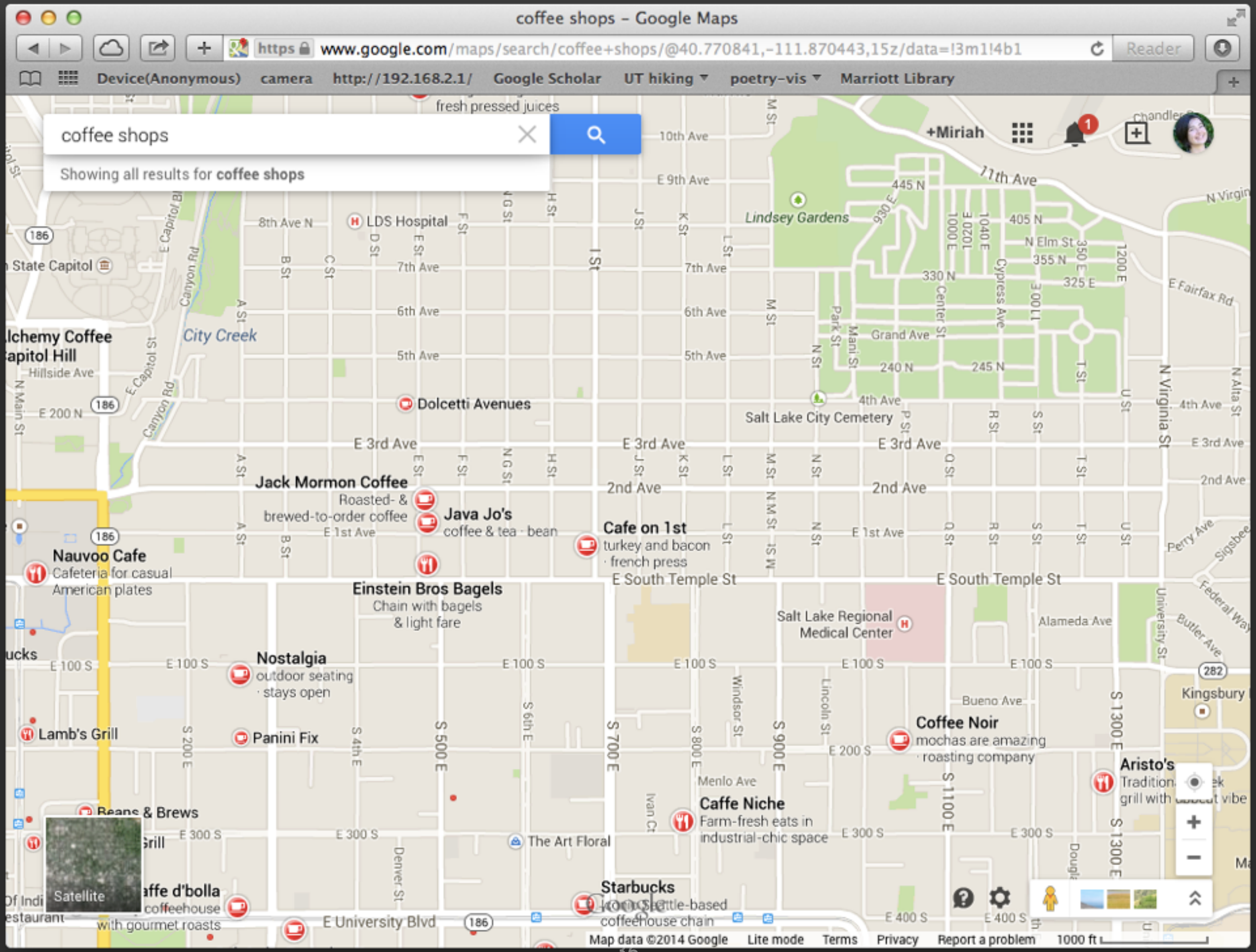
# bing's destination maps



# bing's destination maps

# bing's destination maps




coffee shops - Google Maps
https www.google.com/maps/search/coffee+shops/@40.770841,-111.870443,15z/data=!3m1!4b1
Reader
Device(Anonymous)
camera
http://192.168.2.1/
Google Scholar
UT hiking
poetry-vis
Marriott Library
coffee shops
Showing all results for coffee shops
+Miriah
fresh pressed juices
10th Ave
E 9th Ave
8th Ave N
LDS Hospital
Lindsey Gardens
11th Ave
445 N
405 N
N Elm St
355 N
330 N
325 E
State Capitol
E Capitol Blvd
Canyon Rd
7th Ave
6th Ave
5th Ave
City Creek
Alchemy Coffee
Capitol Hill
Hillside Ave
E 200 N
Dolcetti Avenues
Salt Lake City Cemetery
Grand Ave
240 N
245 N
4th Ave
E 3rd Ave
E Fairfax Rd
N Virginia St
Jack Mormon Coffee
Roasted- & brewed-to-order coffee
Java Jo's
coffee & tea · bean
E 1st Ave
Cafe on 1st
turkey and bacon · french press
Nauvoo Cafe
Cafeteria for casual American plates
Einstein Bros Bagels
Chain with bagels & light fare
E South Temple St
Salt Lake Regional Medical Center
Alameda Ave
2nd Ave
Nostalgia
outdoor seating · stays open
Lamb's Grill
Panini Fix
Coffee Noir
mochas are amazing · roasting company
Aristo's
Caffe Niche
Farm-fresh eats in industrial-chic space
The Art Floral
Starbucks
Seattle-based coffeehouse chain
Beans & Brews
Satellite
E University Blvd
Bueno Ave
Menlo Ave
E 100 S
E 200 S
E 300 S
E 400 S
Kingsbury
Map data ©2014 Google
Lite mode
Terms
Privacy
Report a problem
1000 ft

UPDATED March 15, 2011



# Satellite Photos of Japan, Before and After the Quake and Tsunami

Move the slider to compare satellite images, taken by GeoEye/EyeQ, from before and after the disaster.


## Fukushima Daiichi Nuclear Plant

Japan's largest ongoing threat is at this nuclear power plant. There have been explosions at four of its six reactors and all four have released some radioactive material.

- landmarks
- **discrete data**
- continuous data
- choropleths
- cartograms
- projections

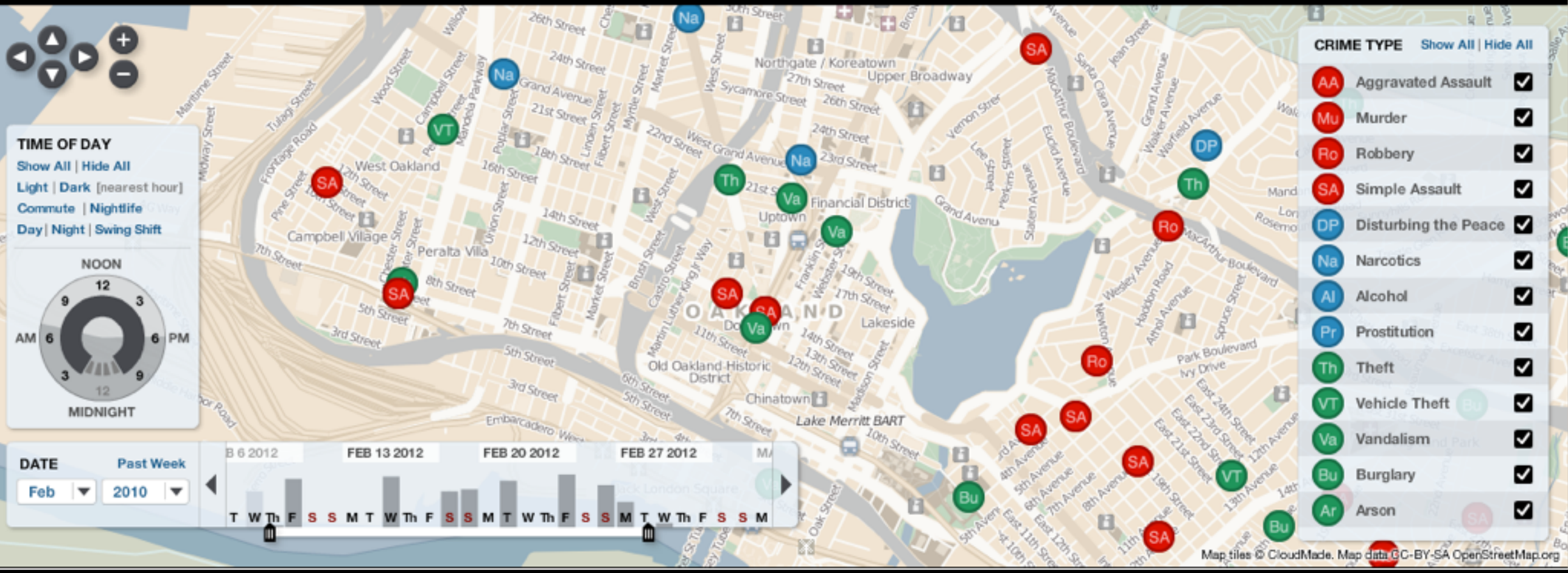

E PARK
980
TELEGRAPH AVE
94612
SNOW PARK
LAKESIDE
12TH ST
ING JR WY
H ST
BROADWAY
FRANKLIN ST
WEBSTER ST
LINCOLN SQUARE
OAK ST
11TH ST
data as icons

# what do they mean?

Oakland crimespotting

Report data last published by Oakland Police: **6 days ago**

Home | Map | Crime Reports | Police Beats | Alerts | API | About | Feedback



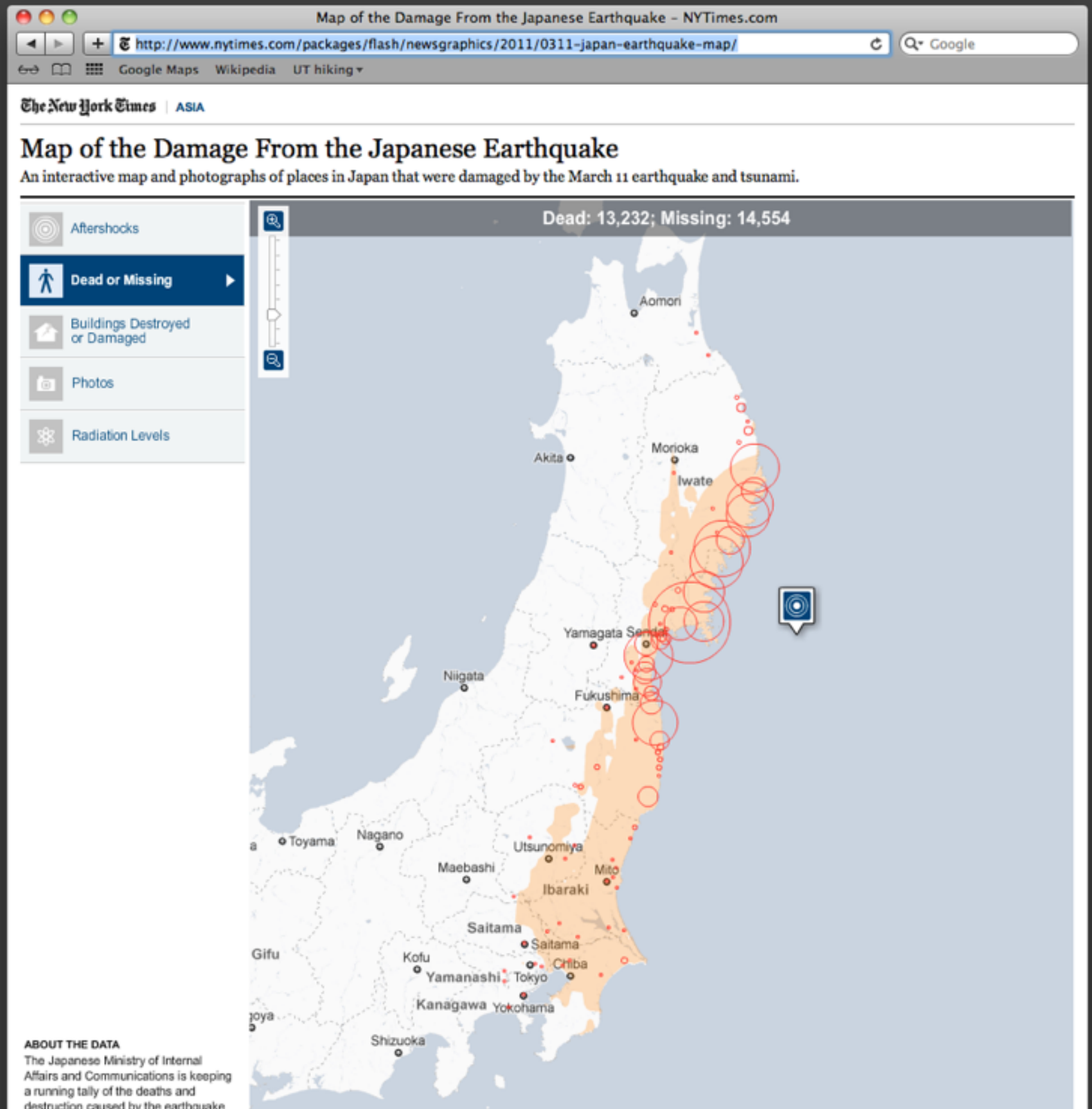



http://oakland.crimespotting.org/

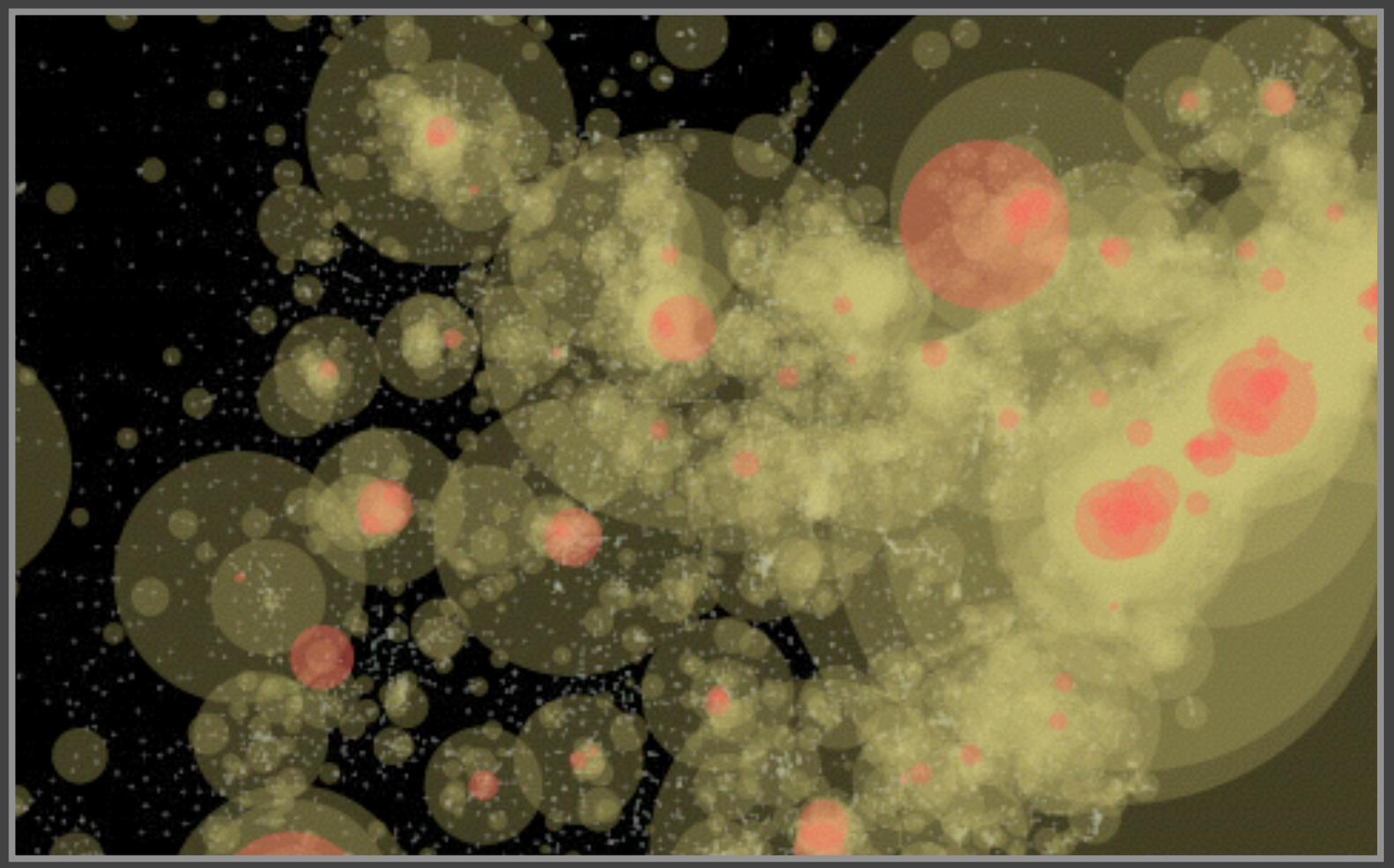
# data as points

data : ordered/ quantitative

encoding : size



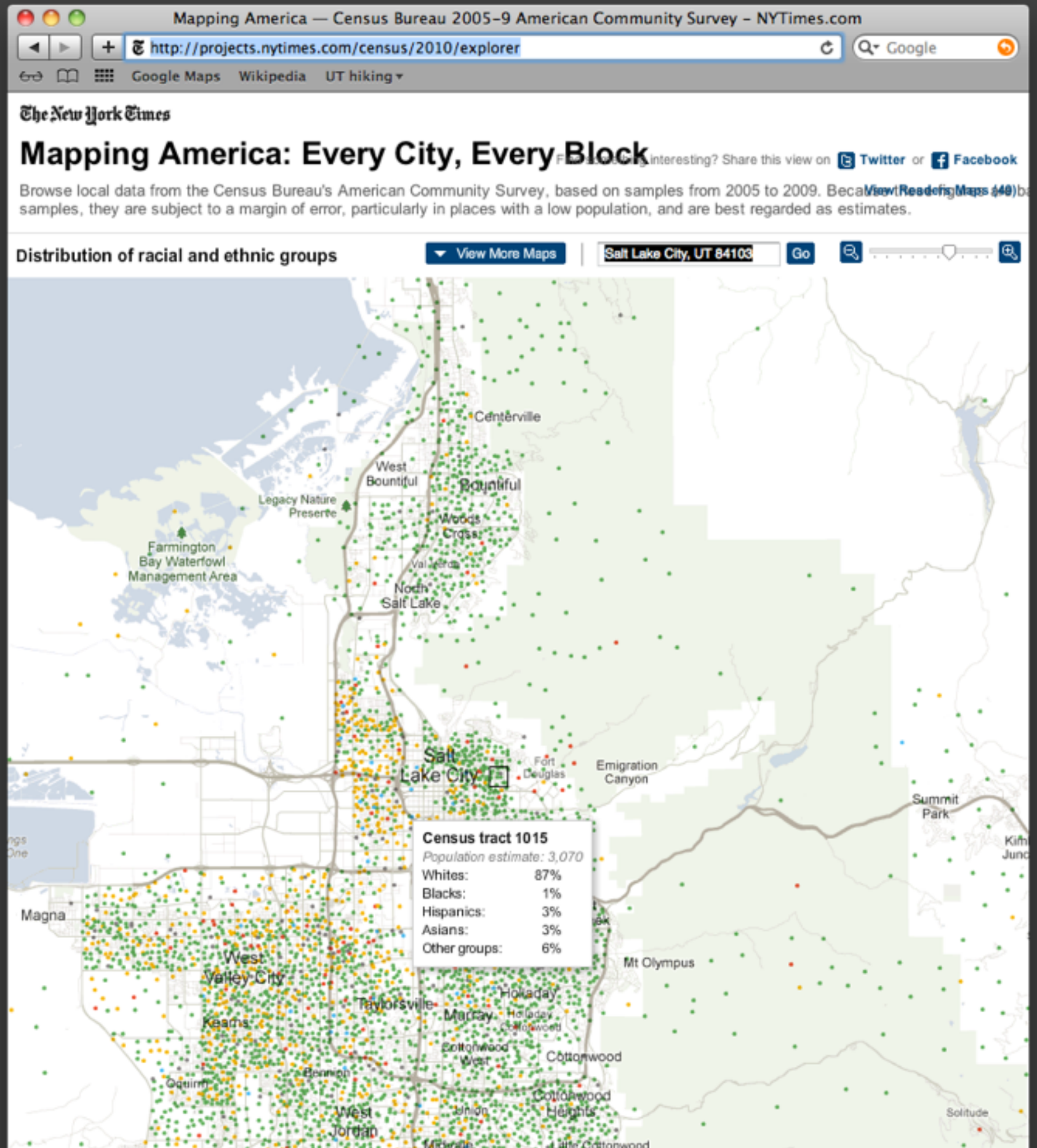
# traffic



# data as points

data : categorical

encoding : hue




data : categorical
encoding : hue

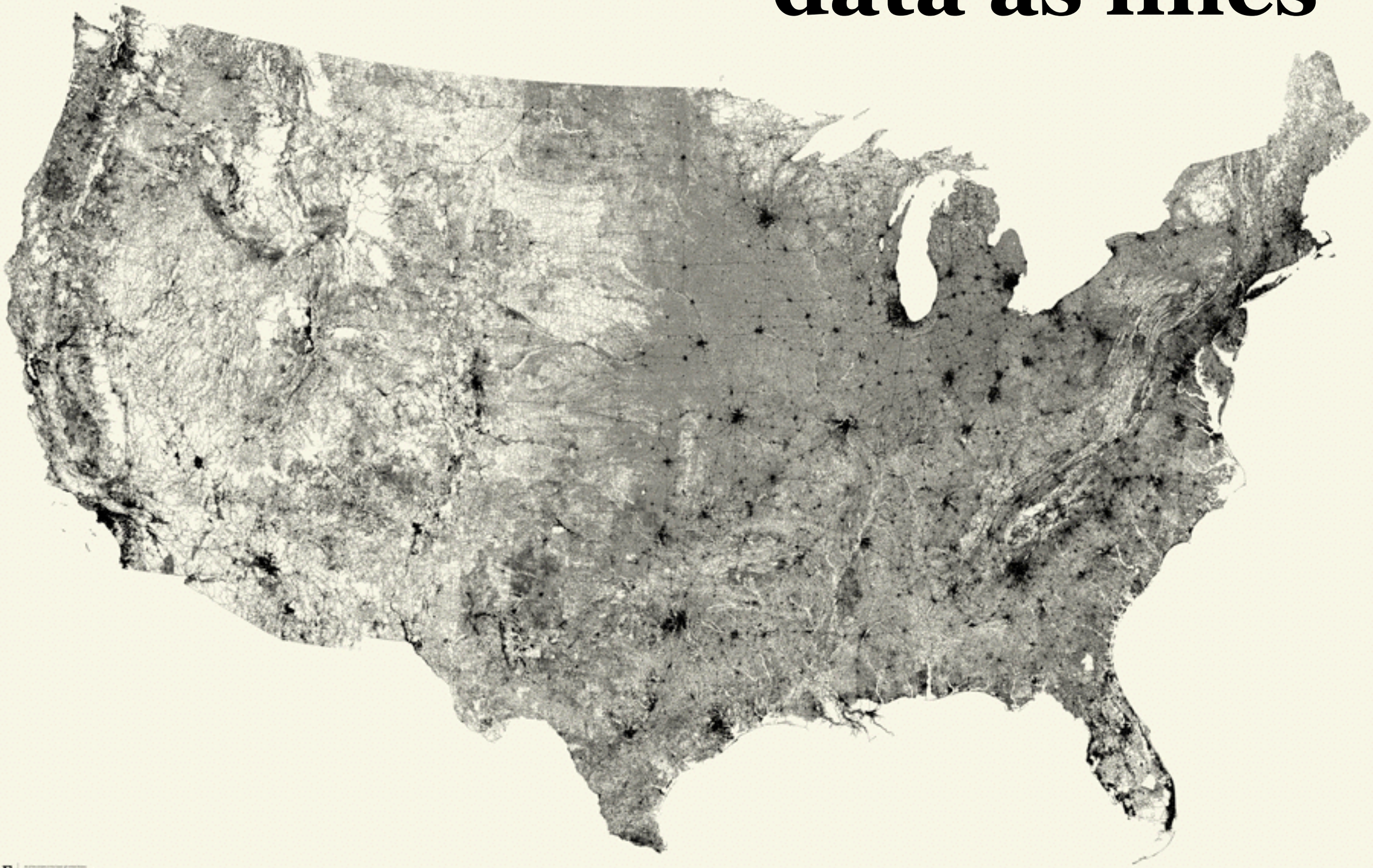
http://www.flickr.com/photos/shazbot/3282821808/in/set-72157614736071588/

# EBB & FLOW

*October 1, 2013*

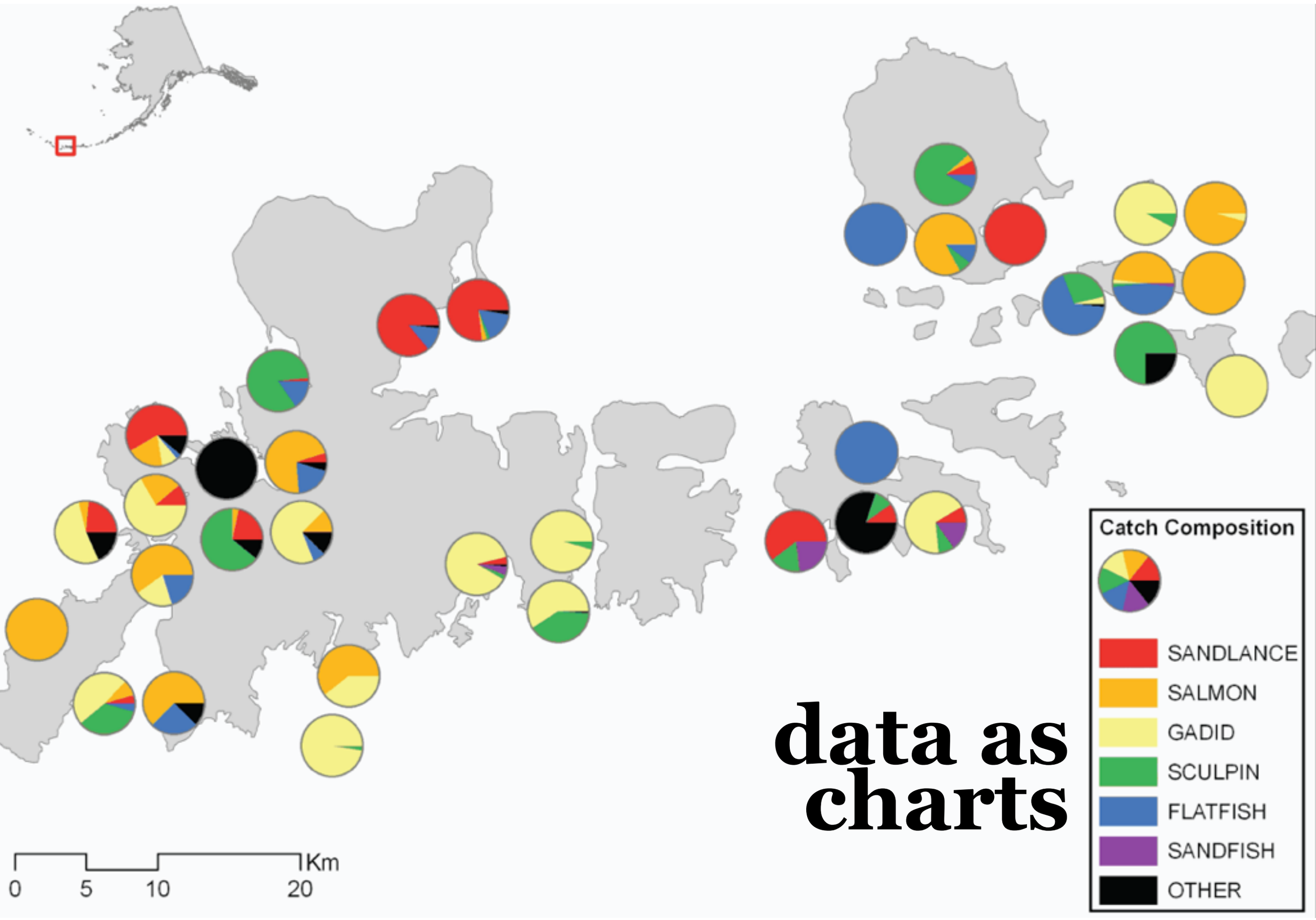
Some really neat data visualization from foursquare showing the ebb & flow of people in New York City and if you would like to see more they have it for San Francisco, London and Tokyo too. For more on how they did it read this article.

# data as lines



http://fathom.info/allstreets/

# data as charts




http://alaska.usgs.gov/science/biology/seabirds_foragefish/foragefish/Aleutian/results.php

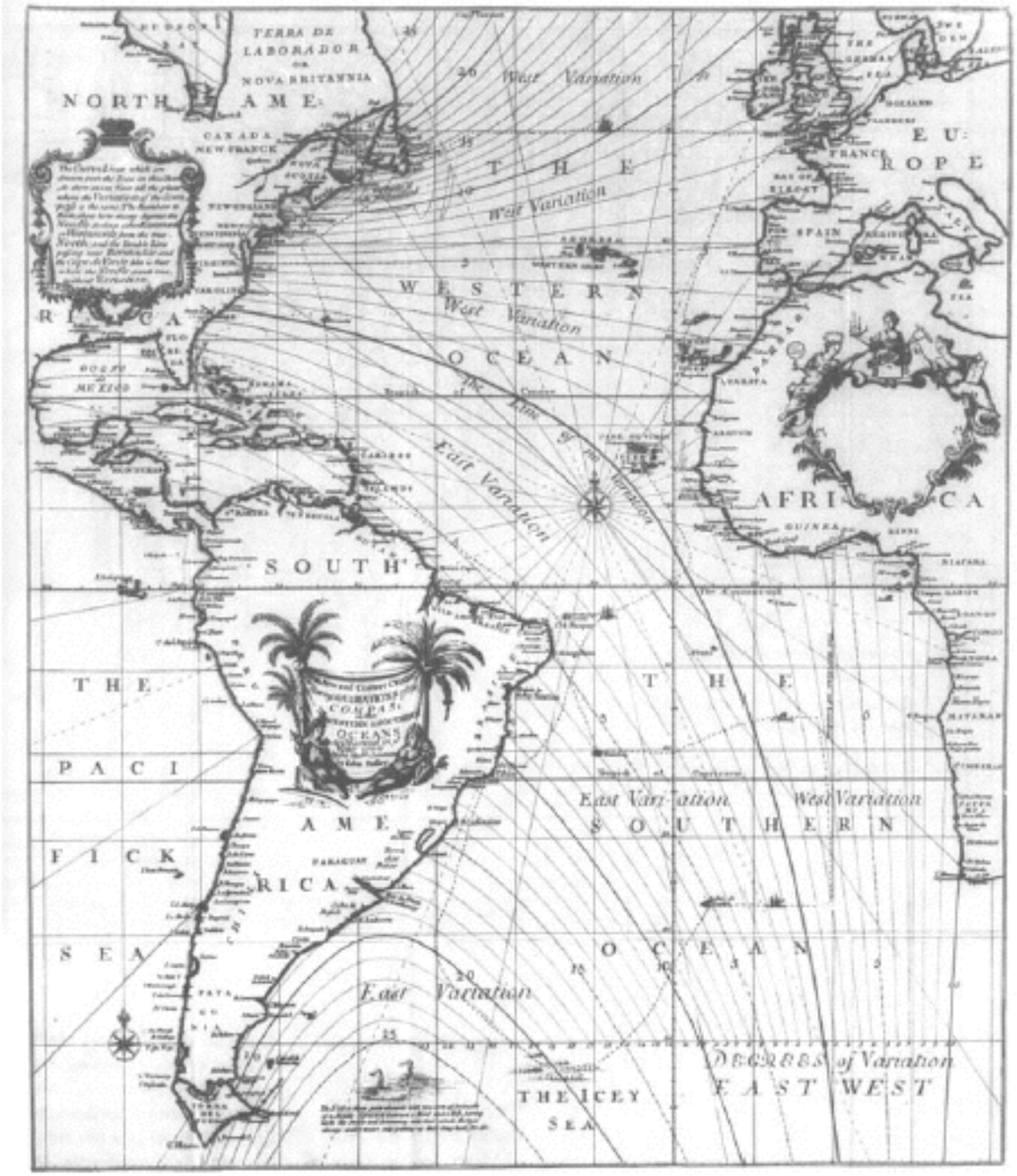
- landmarks
- discrete data
- **continuous data**
- choropleths
- cartograms
- projections

# isopleth

map which overlays continuous data using a third encoding channel

**Lines of Equal Magnetic Declination**

*first contour map*



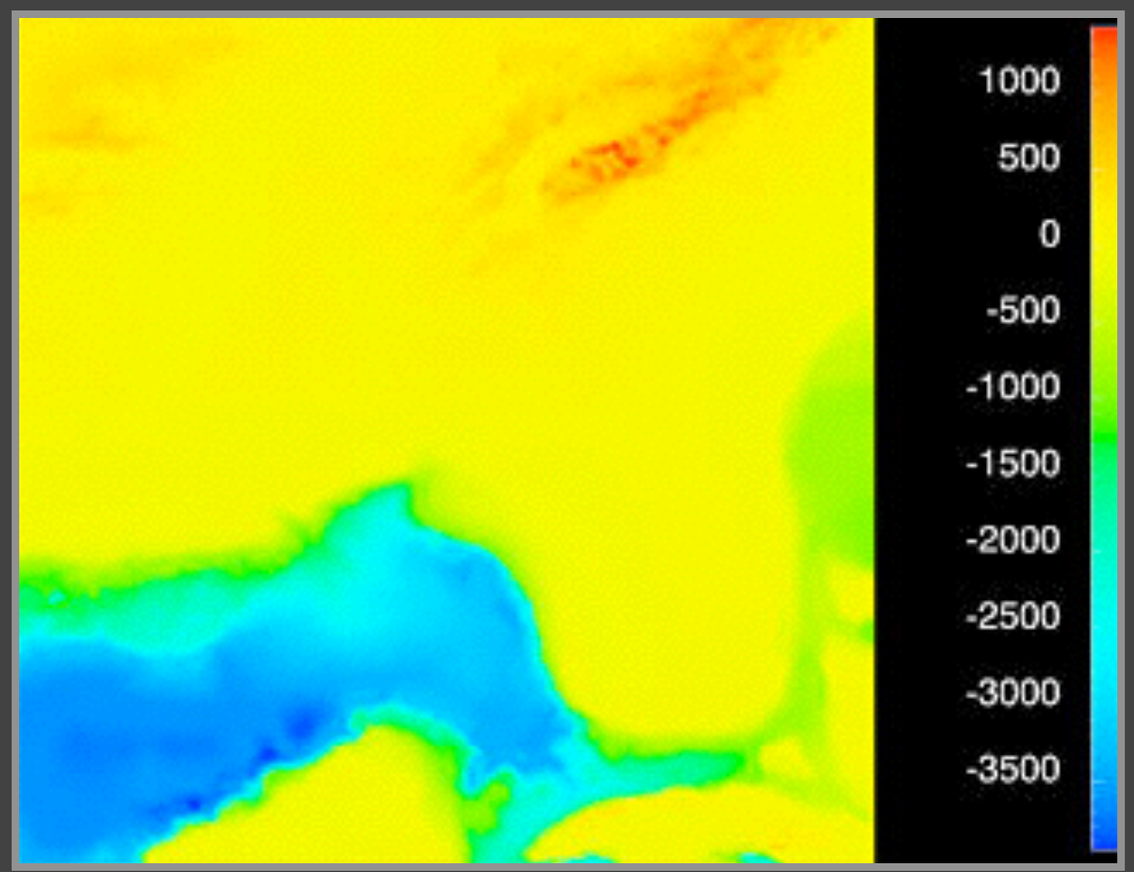

Edmond Halley, 1701

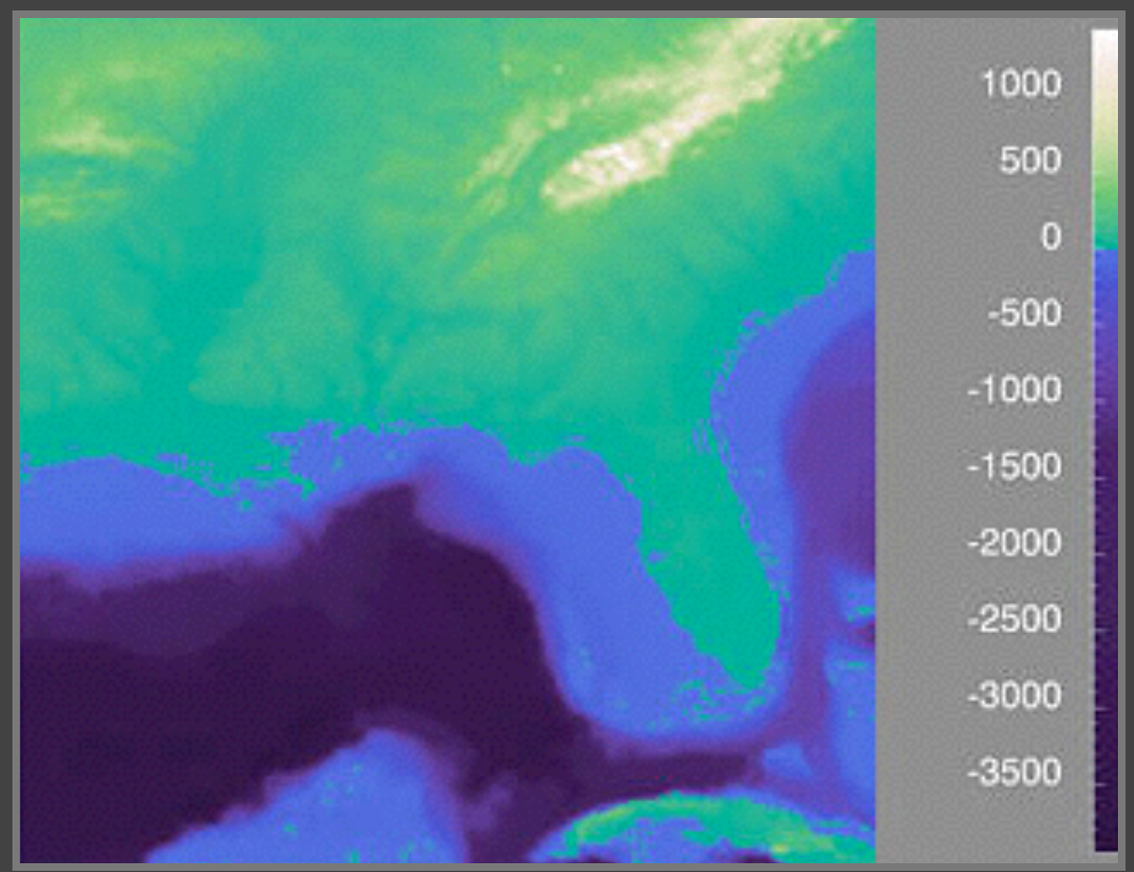
# HEATMAPS

# don’t hide the context

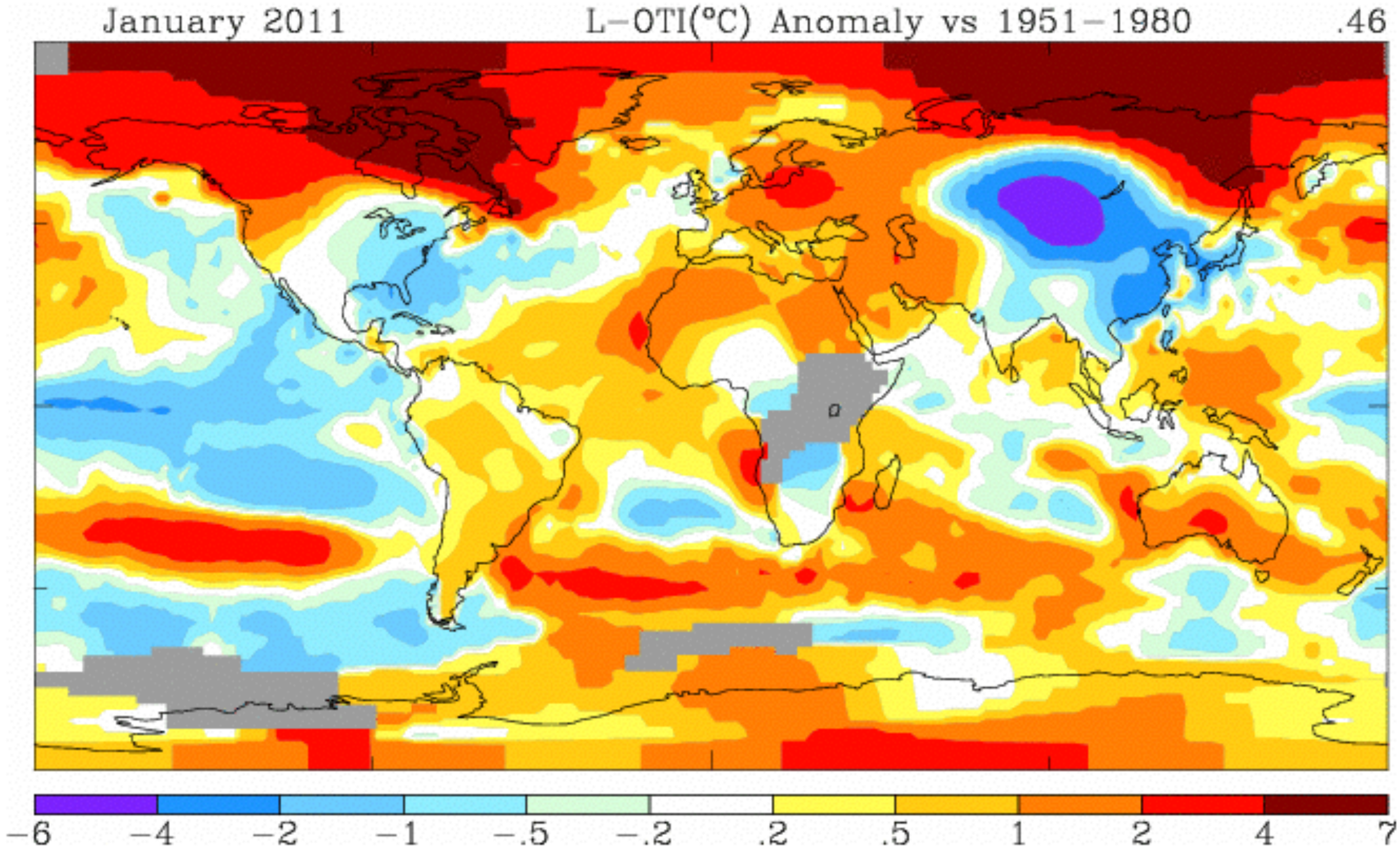

http://es.deister.net/es/solutions/ax-mobile/ax-mobile-components-maps/

# choose the appropriate colormap



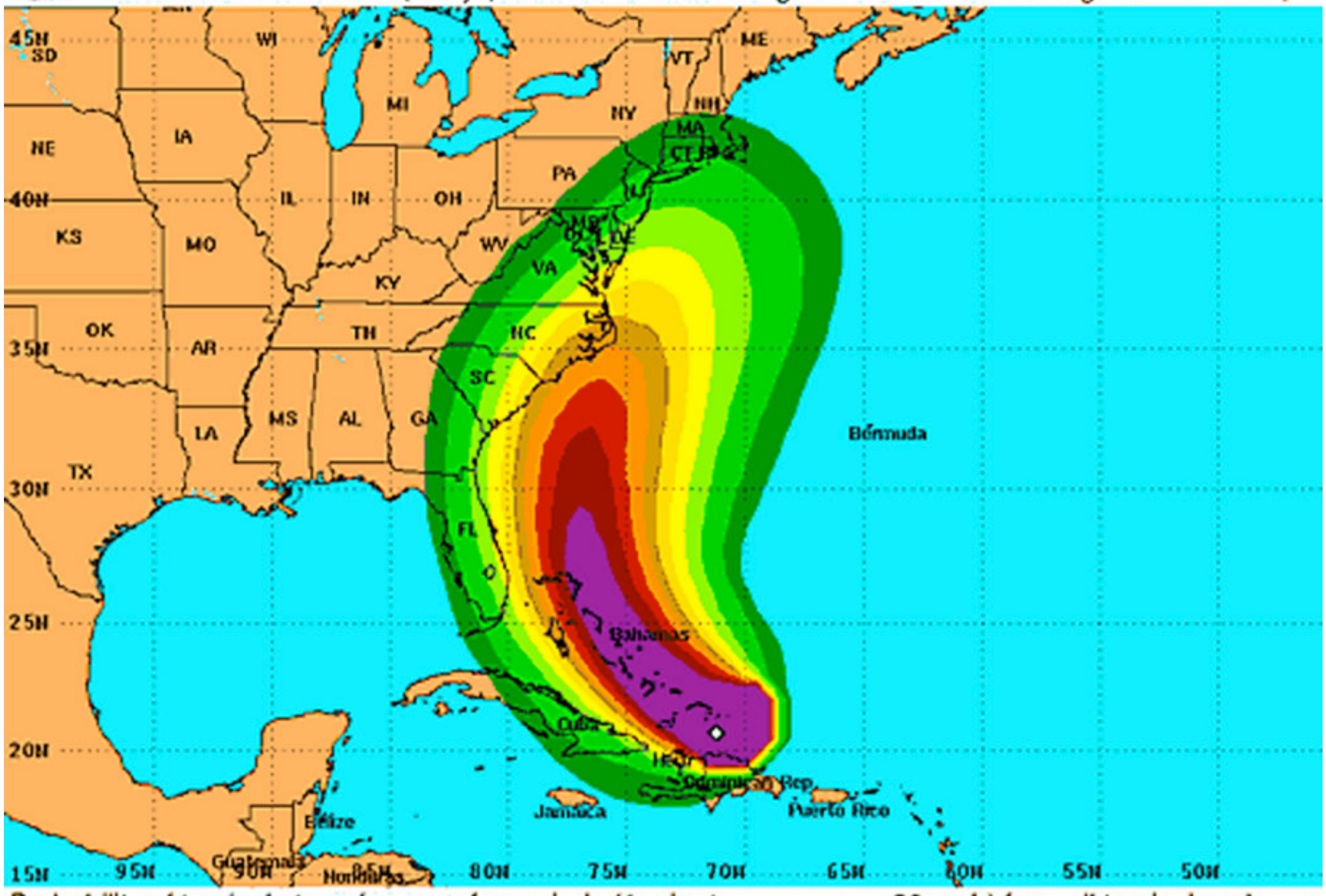



# bin the data



# Tropical Storm Force Wind Speed Probabilities

For the 120 hours (5 days) from 2 PM EDT Tue Aug 23 to 2 PM EDT Sun Aug 28




Probability of tropical storm force surface winds (1-minute average >= 39 mph) from all tropical cyclones

◇ indicates HURRICANE IRENE center location at 2 PM EDT Tue Aug 23 2011 (Forecast/Advisory #14)

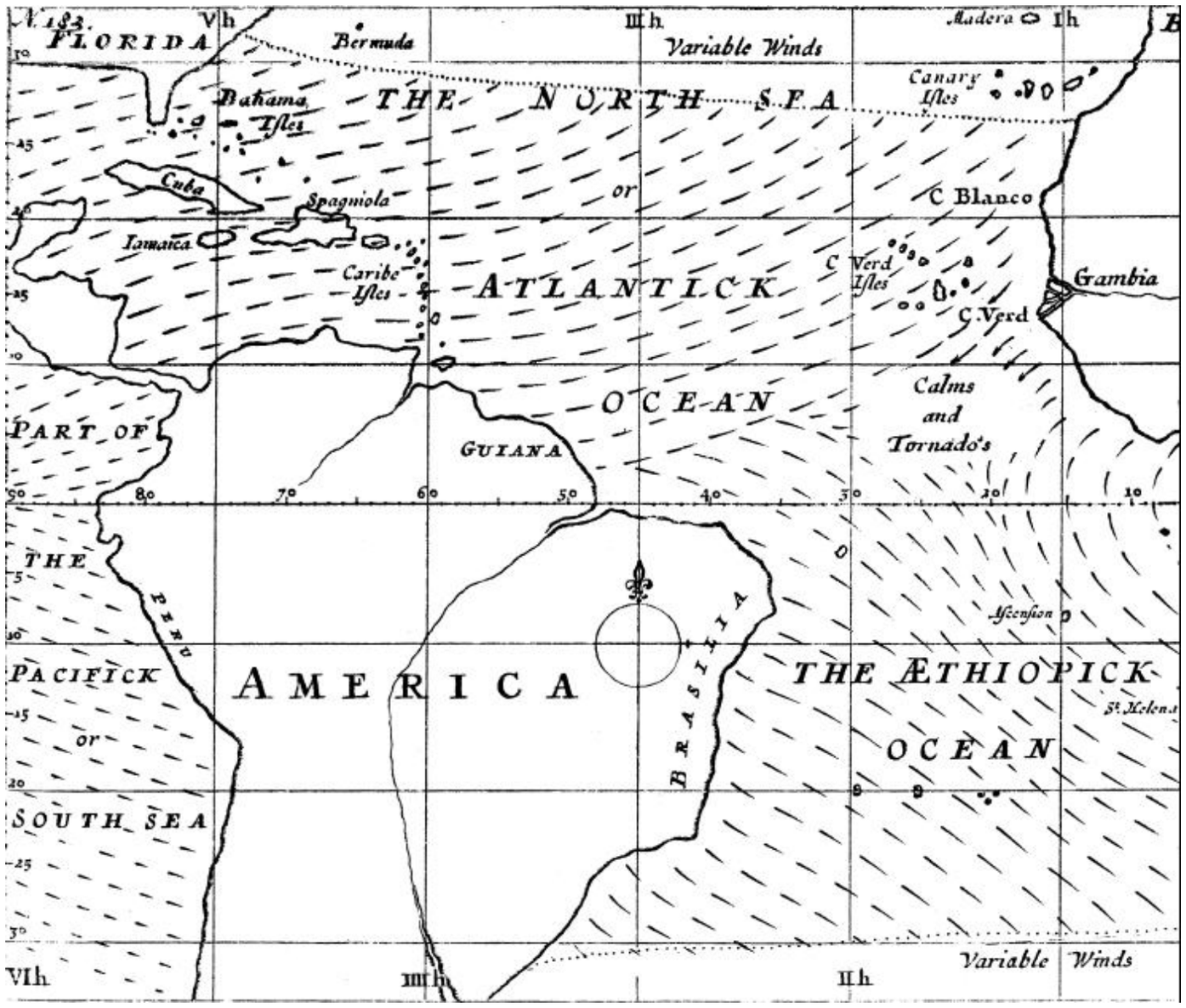
5% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

http://www.nola.com/hurricane/index.ssf/2011/08/hurricane_irene_lashes_the_tur.html

# ISOCURVES

# Wind Map

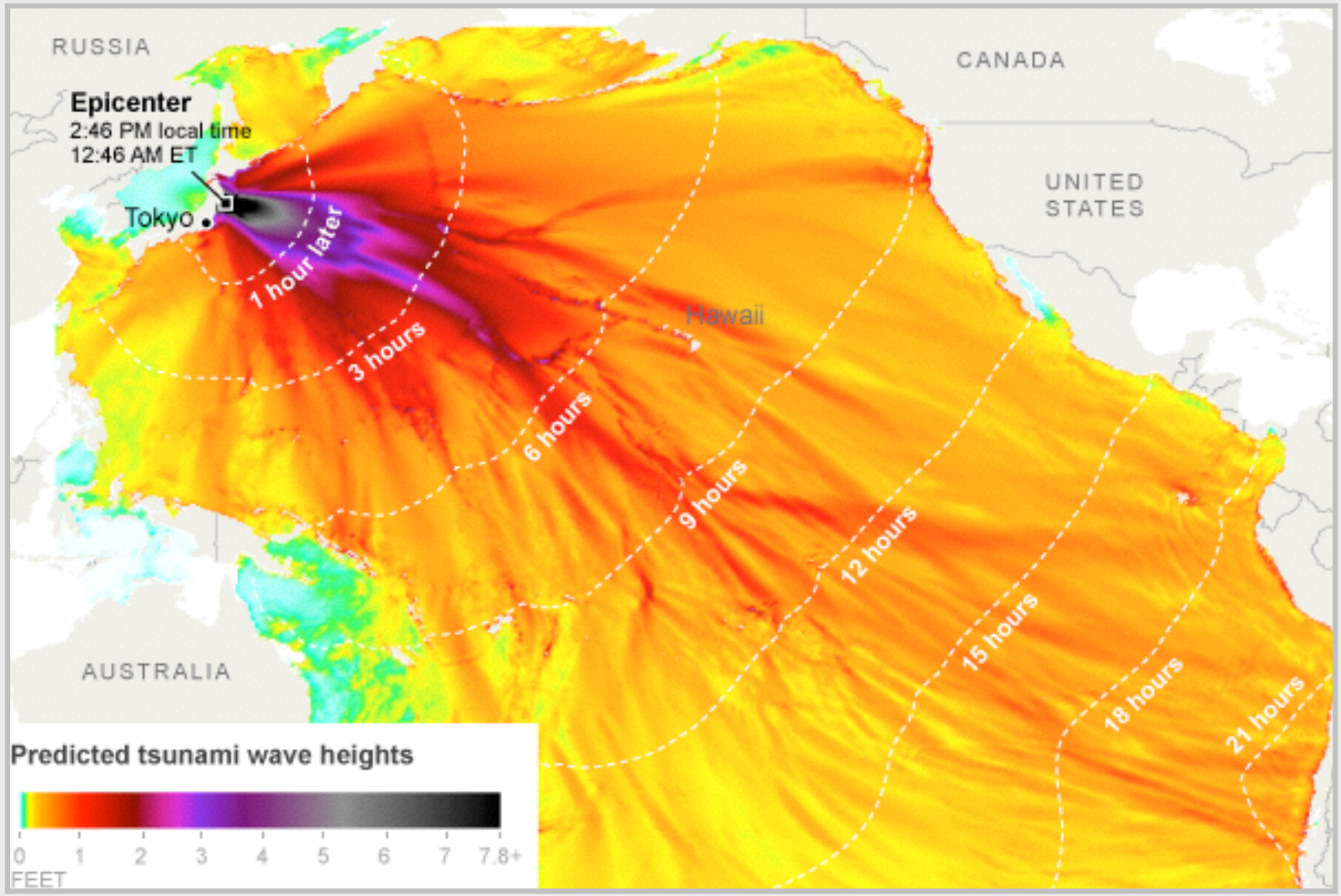
*first weather map*




Edmond Halley, 1686

# show topology

# show time



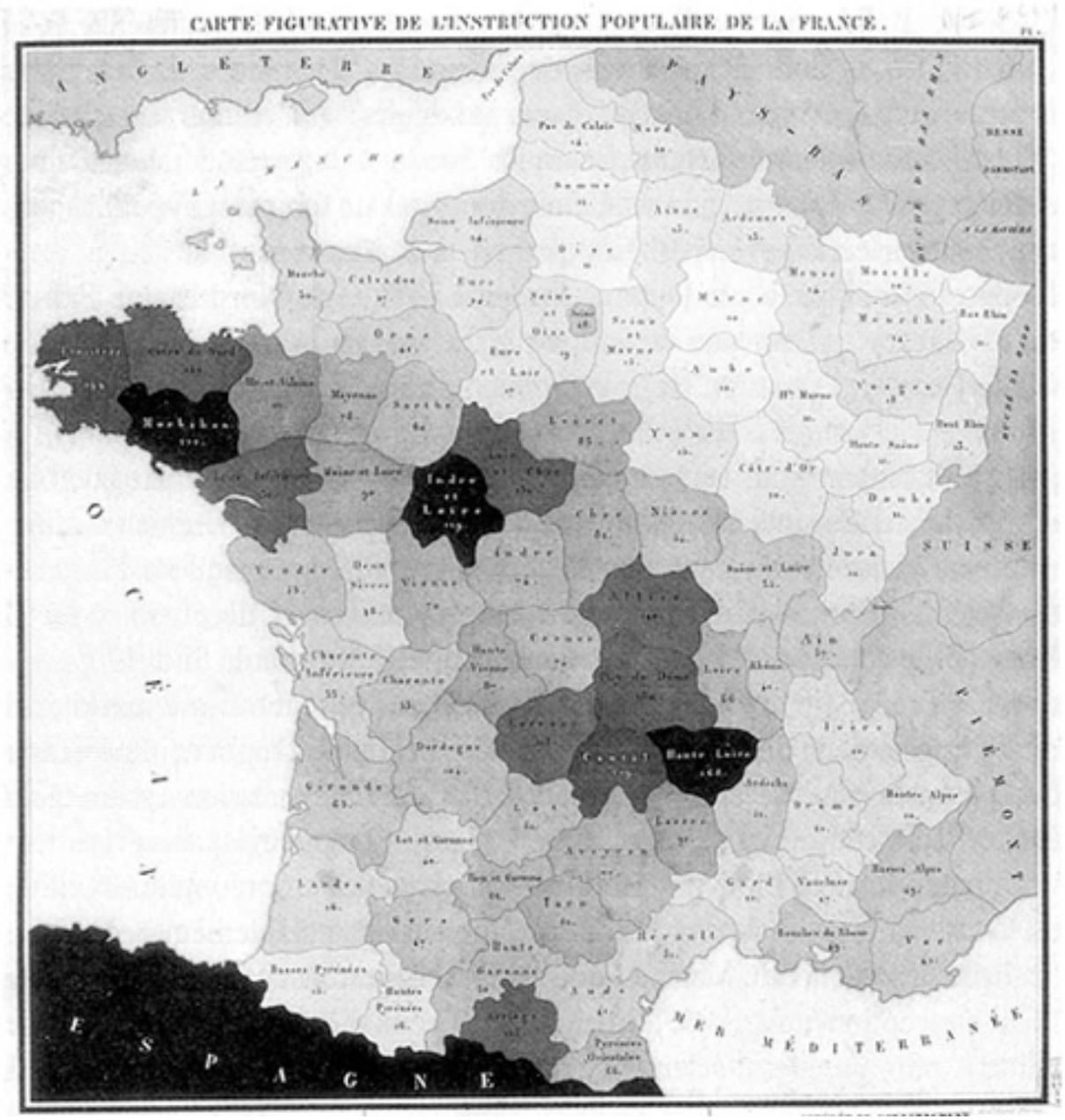

http://www.nytimes.com/interactive/2011/03/11/world/asia/maps-of-earthquake-and-tsunami-damage-in-japan.html

- landmarks
- discrete data
- continuous data
- choropleths
- cartograms
- projections

# choropleth

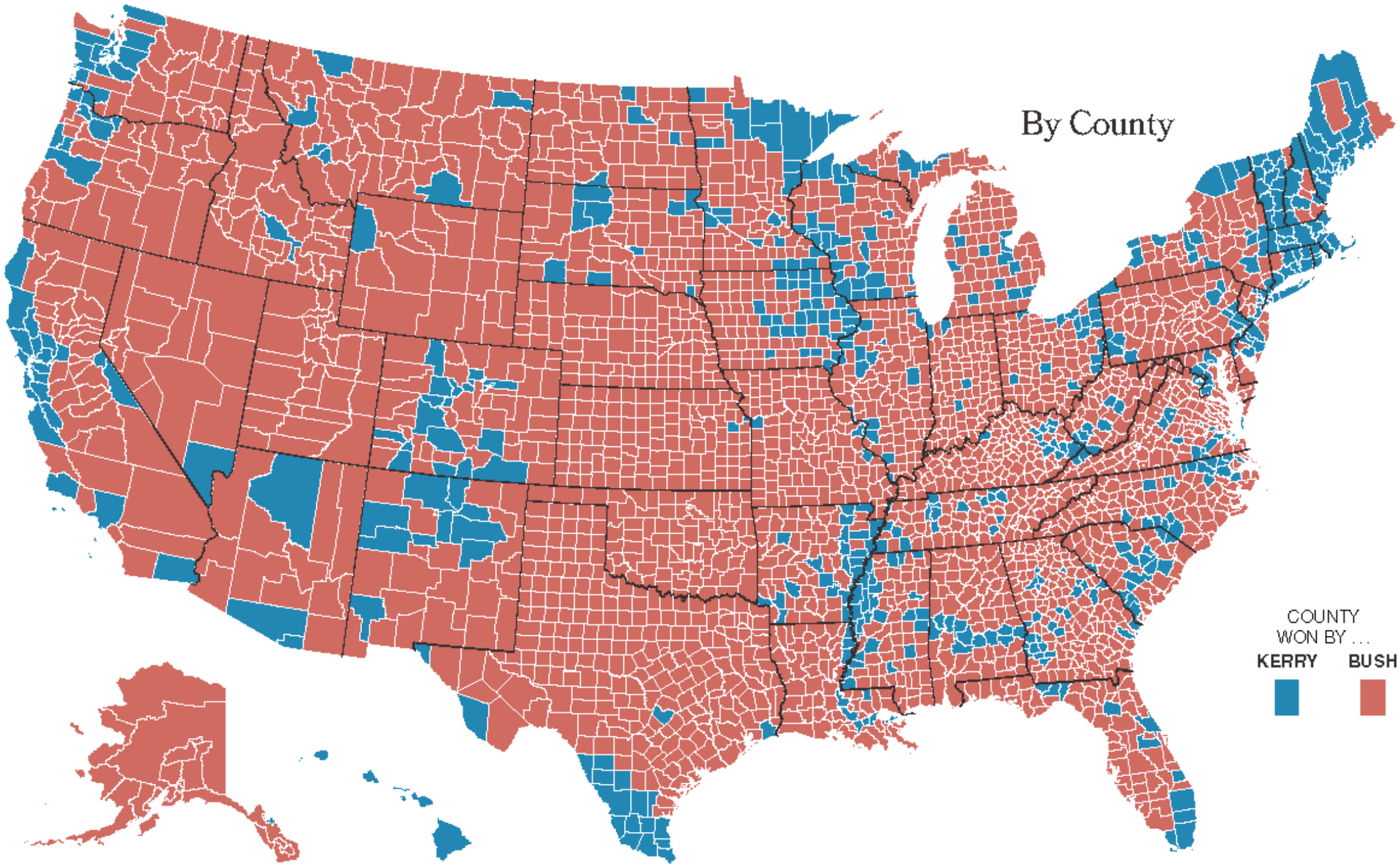
map in which areas are shaded, colored, or patterned relative to a data attribute value

**Illiteracy in France**
*first choropleth map*

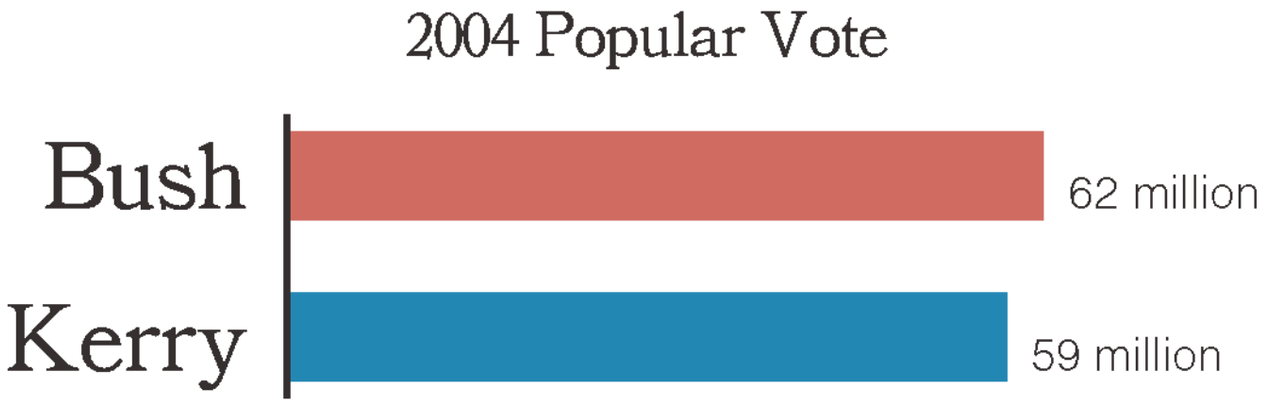


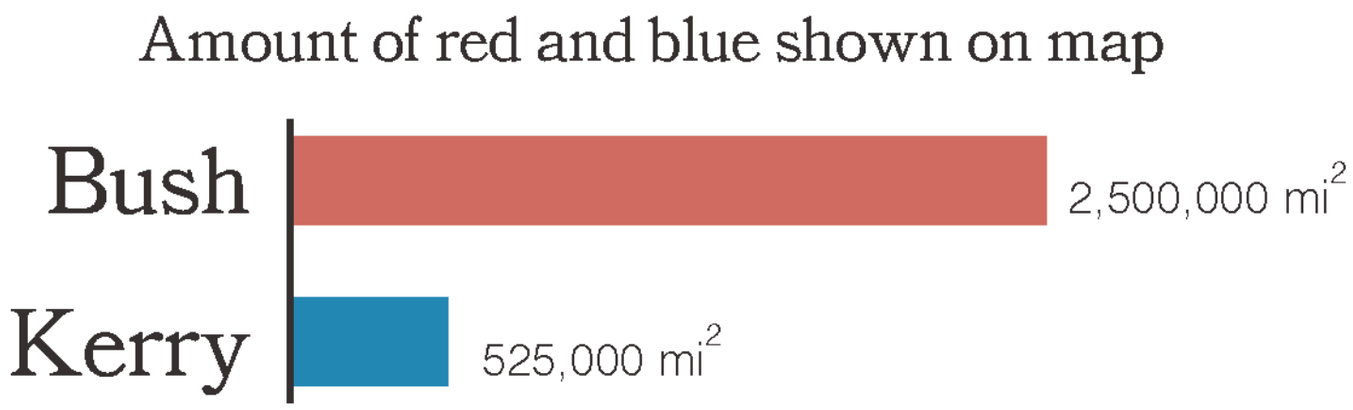

Charles Dupin, 1826

# Kerry vs Bush, 2004

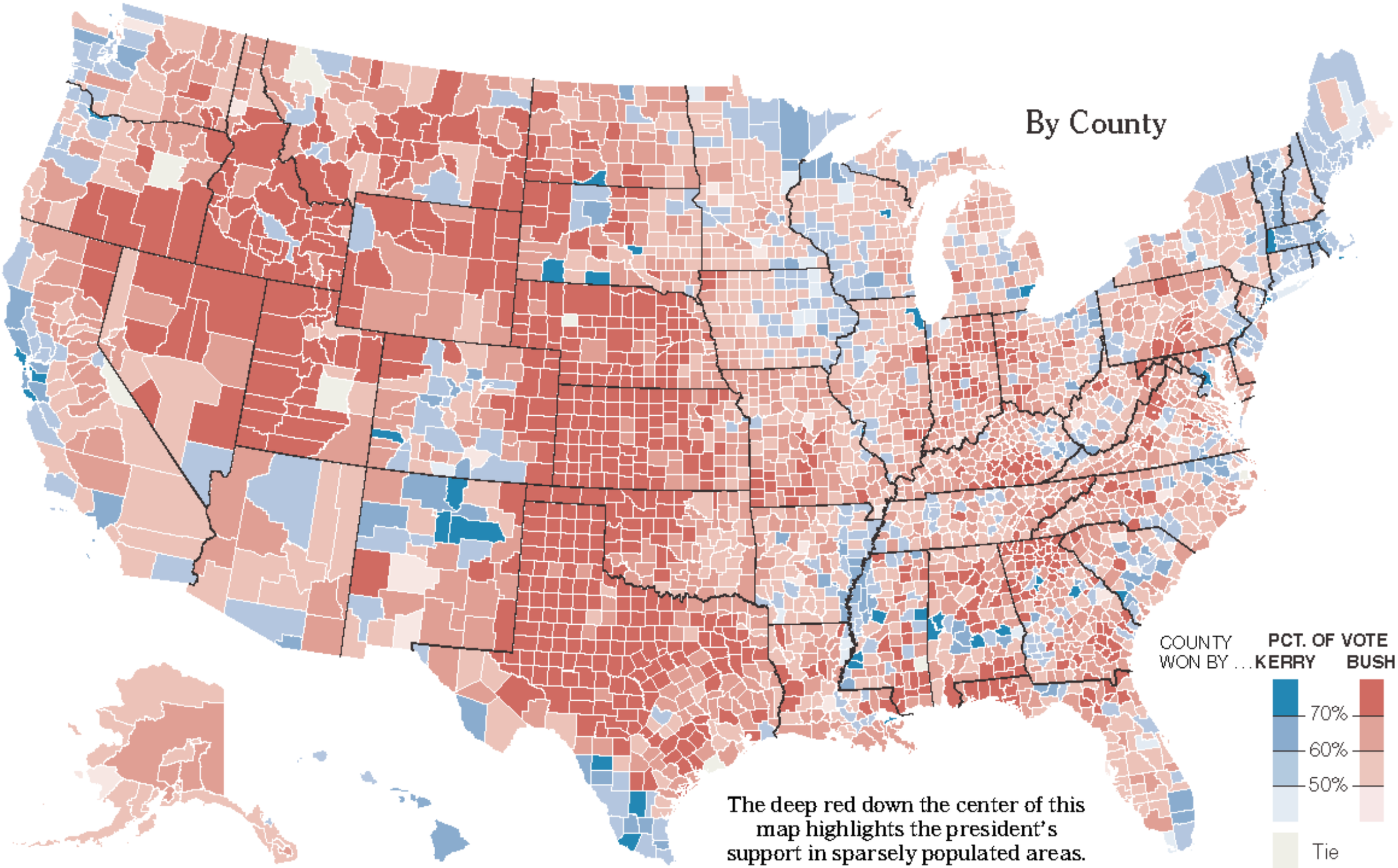



Matthew Ericson, NY Times




Matthew Ericson, NY Times




Matthew Ericson, NY Times

By Population Density

COUNTY WON BY . . . KERRY / BUSH

Urban

Suburban

Rural

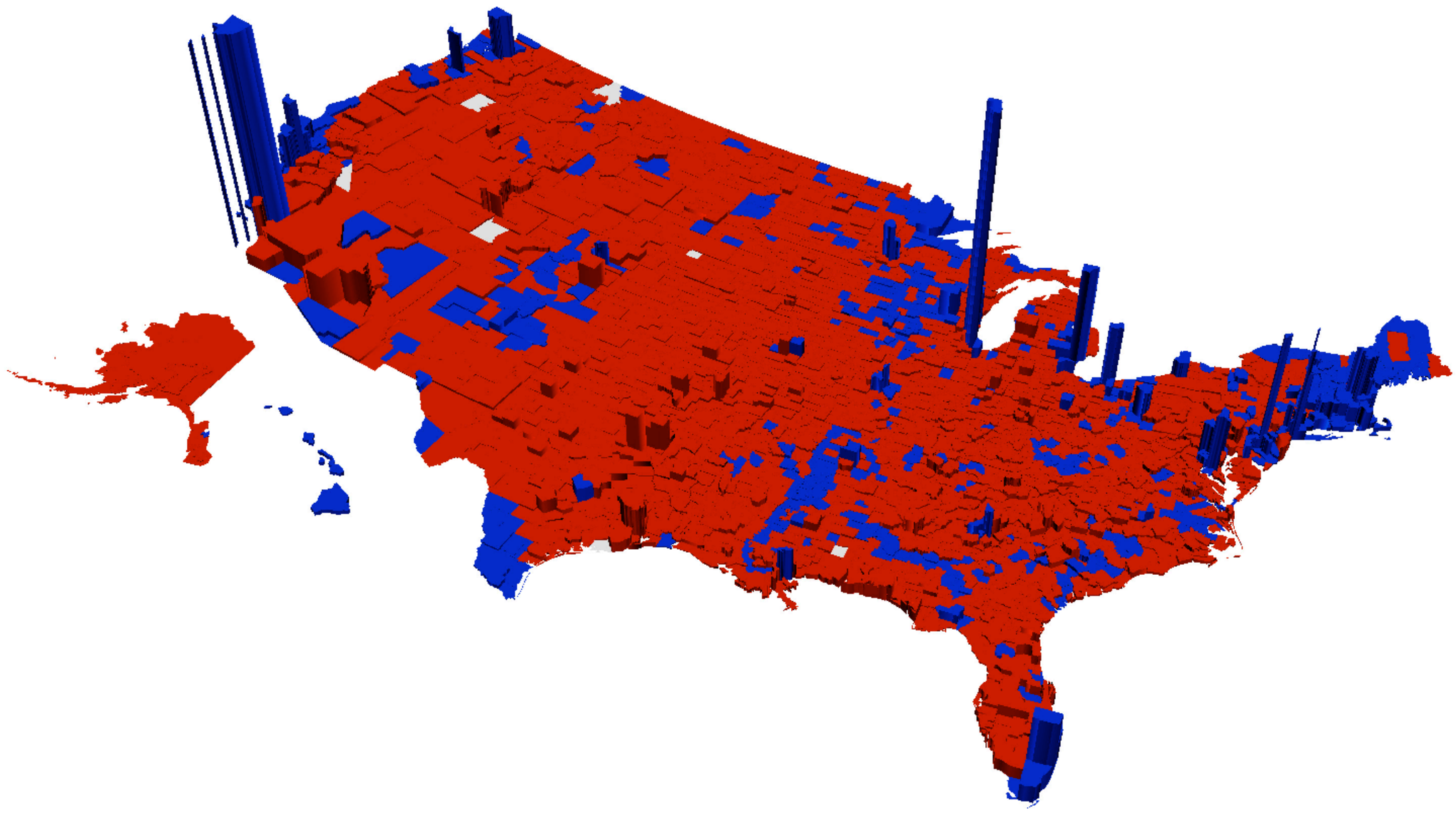
Unpopulated*

* Areas with less than three people per square mile.

This map removes mostly uninhabited areas, revealing Mr. Bush's suburban and rural support in the East and South.

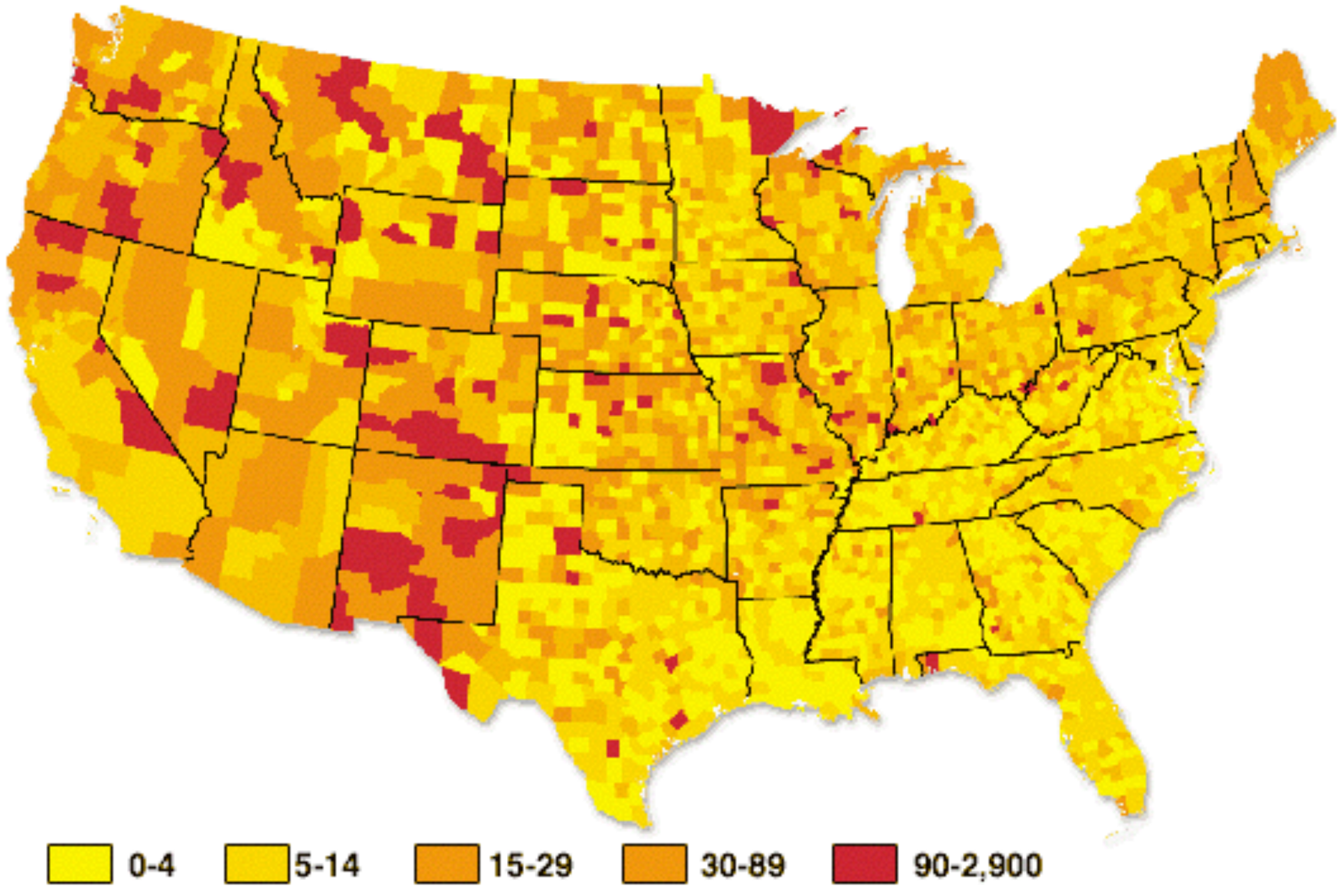
Matthew Ericson, NY Times

# in 3D!

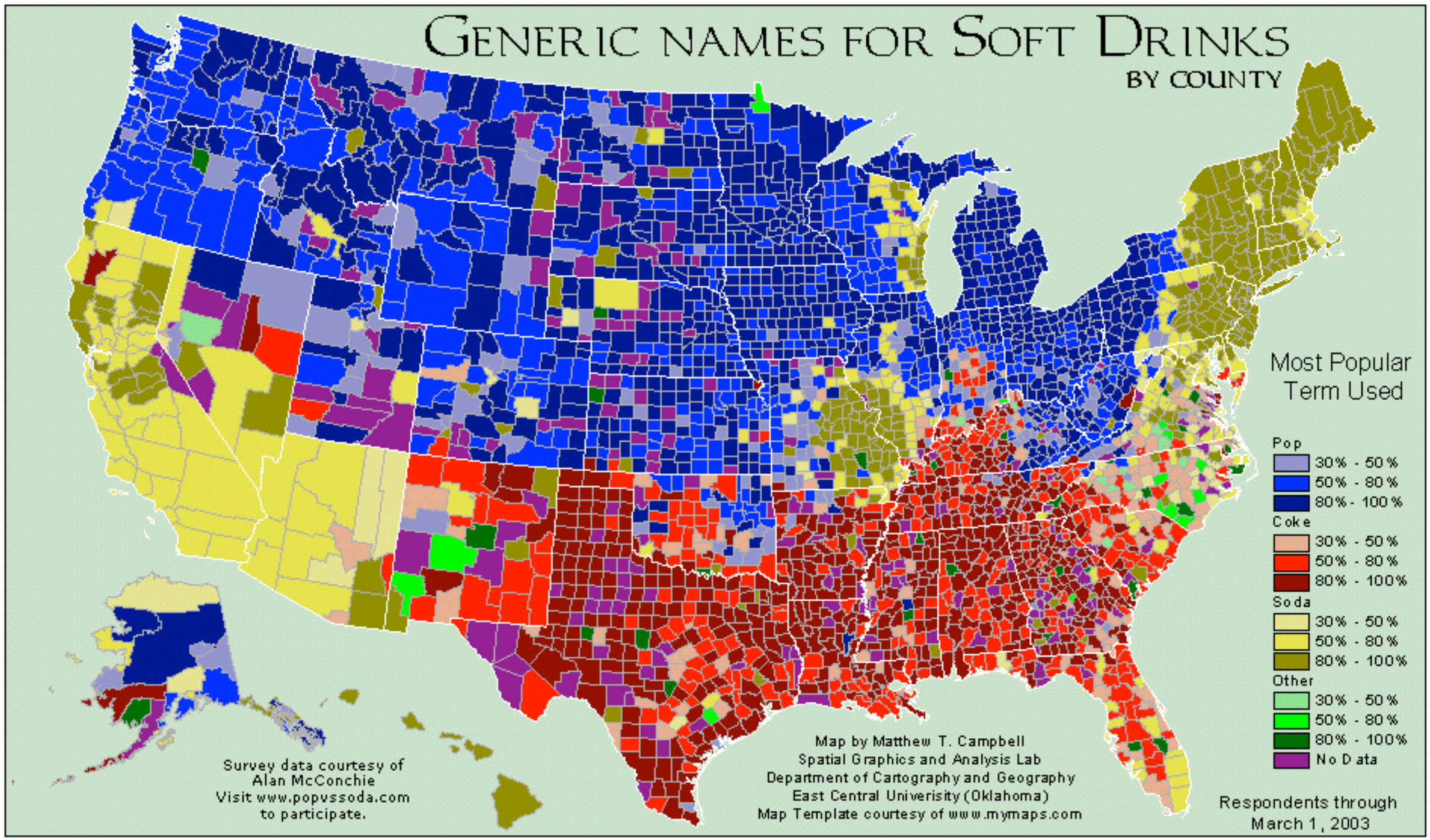


Matthew Ericson, NY Times

# UFO hotspots




http://www.ufoera.com/images/ufo/ufo-hotspots-map_117.png




http://popvssoda.com/

March 7, 2009

E-MAIL | FEEDBACK

# New Yorkers Assess Their City

How New Yorkers feel about everything from fire protection to rat control, taken from a survey of thousands of residents by the city last year.

Related Article

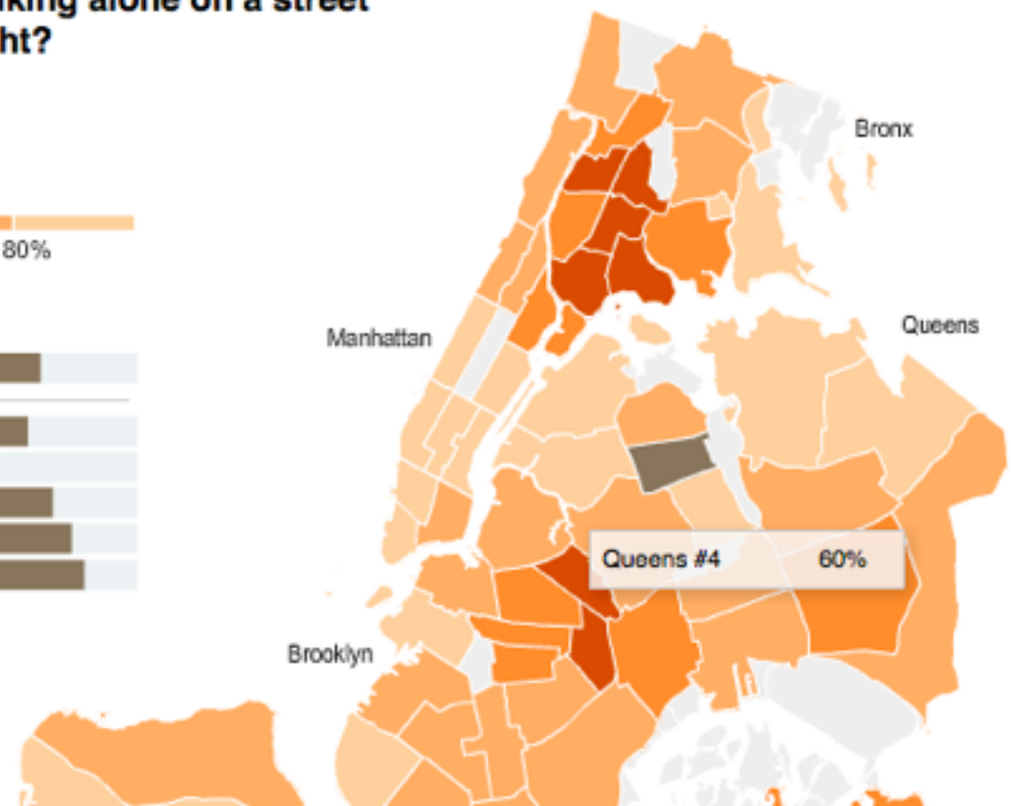


## How safe would you feel walking alone on a street in your neighborhood at night?

Percent saying very or somewhat safe

20 40 60 80%

| TOTALS | |
|---|---|
| **New York City** | **69%** |
| Brooklyn | 65% |
| Bronx | 55% |
| Queens | 73% |
| Manhattan | 79% |
| Staten Island | 83% |

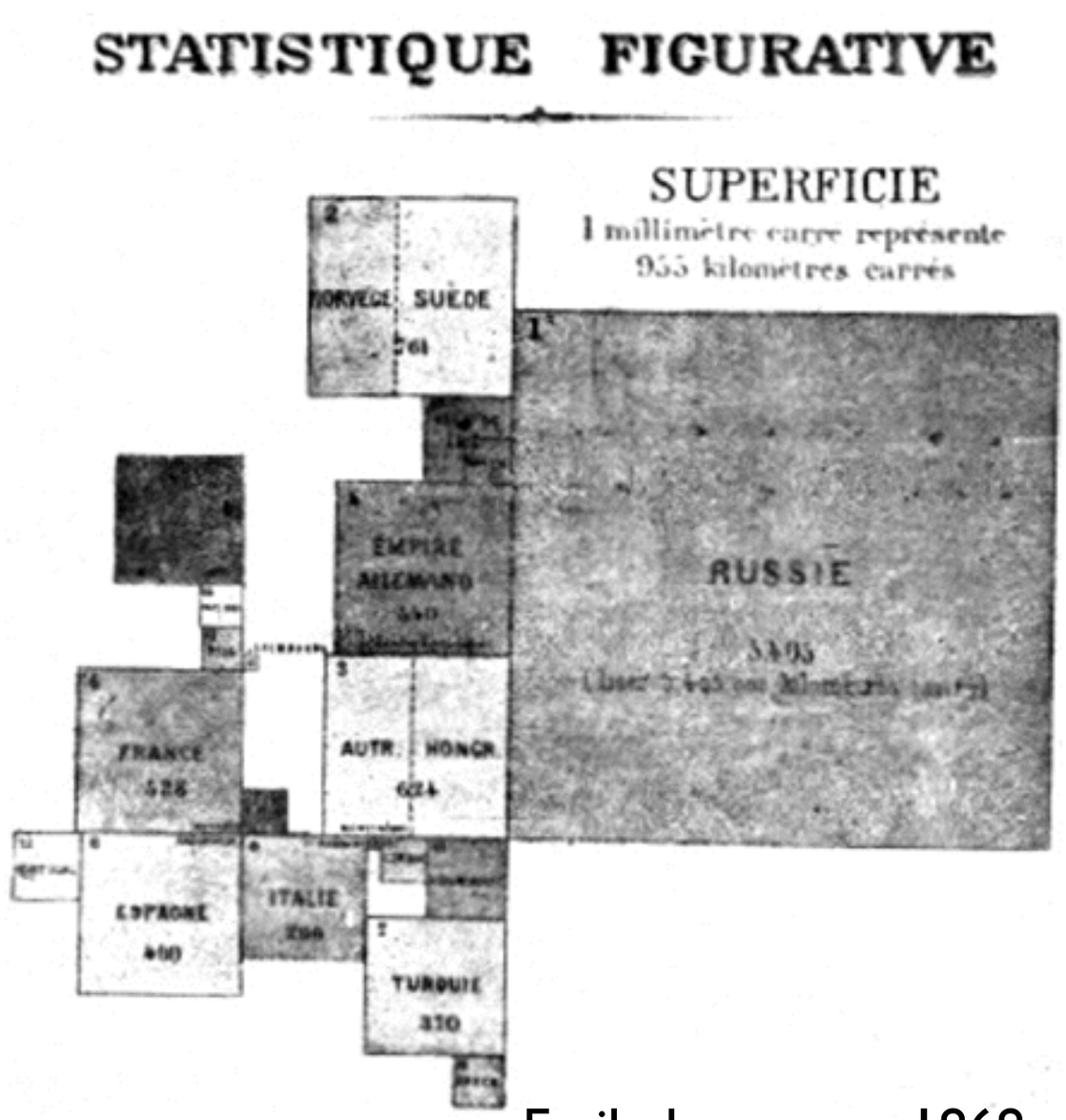


- landmarks
- discrete data
- continuous data
- choropleths
- **cartograms**
- projections

# cartogram

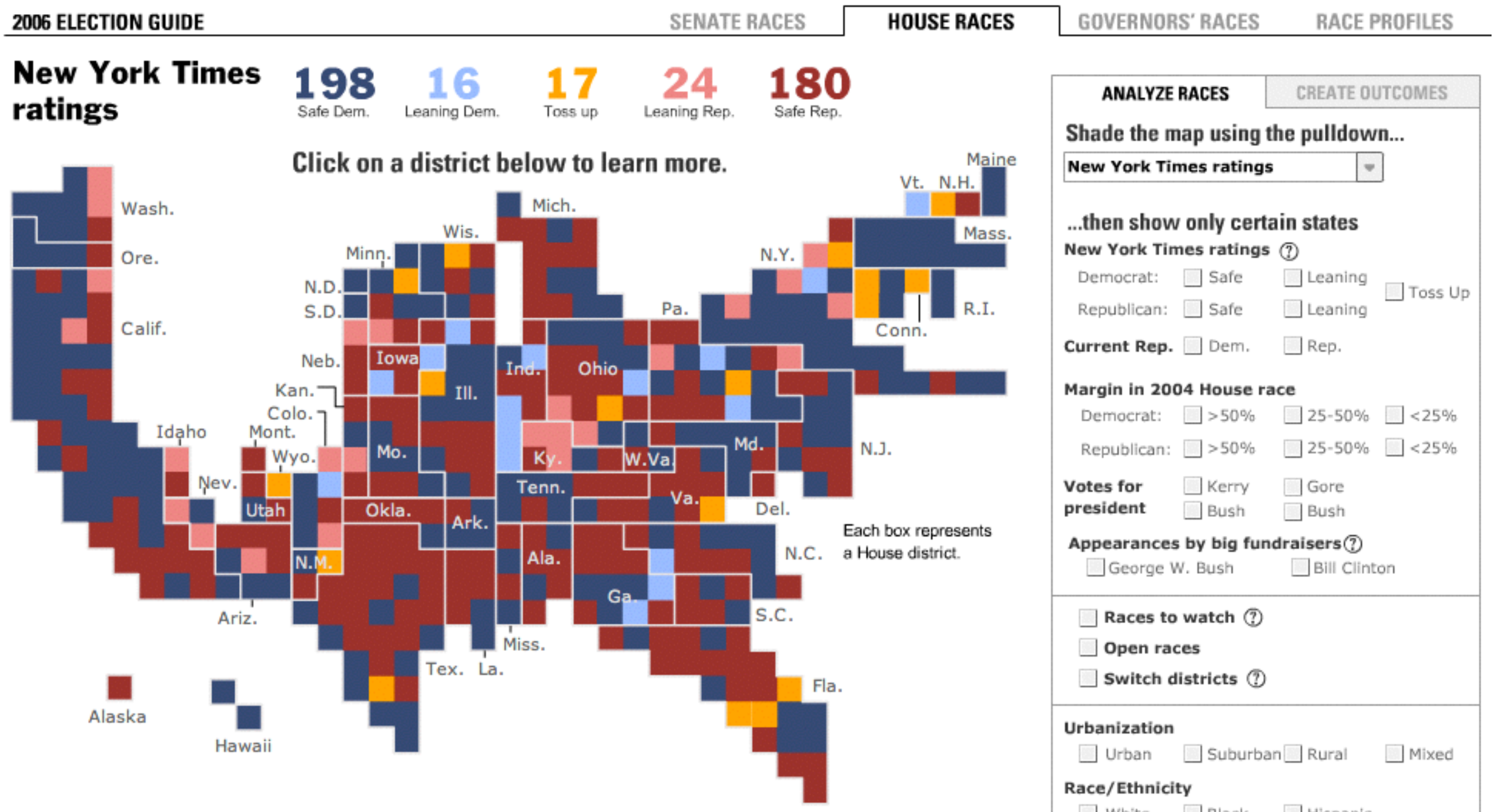
map in which areas are scaled and distorted relative to a data attribute value

**Land Area**
*first cartogram*




Emile Levasseur, 1868

# rectangular cartogram




http://www.nytimes.com/ref/washington/2006ELECTIONGUIDE.html

What Your Global Neighbors Are Buying - Interactive Graphic - NYTimes.com

http://www.nytimes.com/interactive/2008/09/04/business/20080907-metrics-graphic.html

Google

Apple Yahoo! Google Maps YouTube Wikipedia News (2,012) Popular Google Scholar



The New York Times

# Business









September 4, 2008



## What Your Global Neighbors Are Buying

How people spend their discretionary income – the cash that goes to clothing, electronics, recreation, household goods, alcohol – depends a lot on where they live. People in Greece spend almost 13 times more money on clothing as they do on electronics. People living in Japan spend more on recreation than they do on clothing, electronics and household goods combined. Americans spend a lot of money on everything.

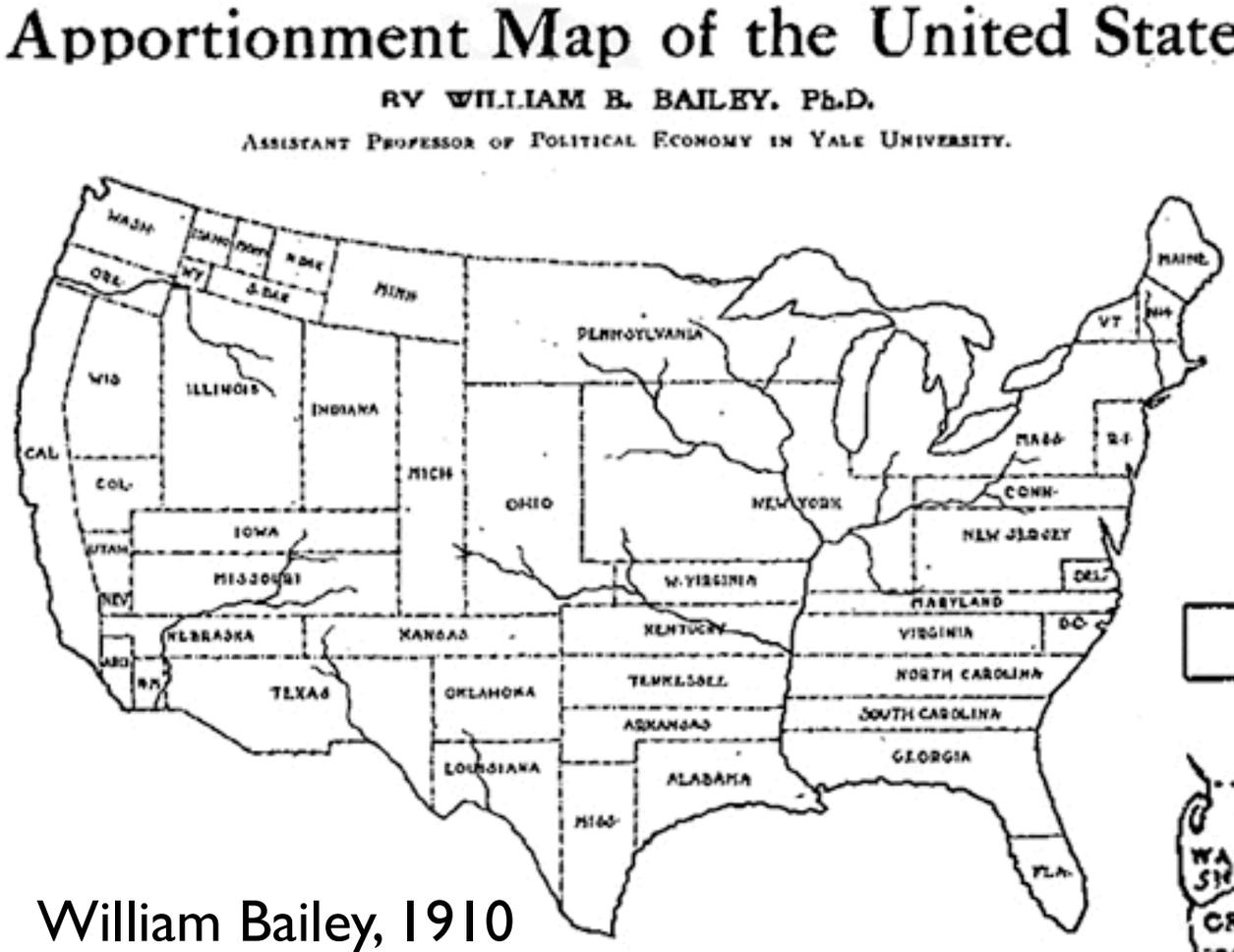
Related Article

CLOTHING & FOOTWEAR | ELECTRONICS | ALCOHOL & TOBACCO | HOUSEHOLD GOODS | RECREATION

Boxes represent selected countries and are scaled according to total spending in 2007.

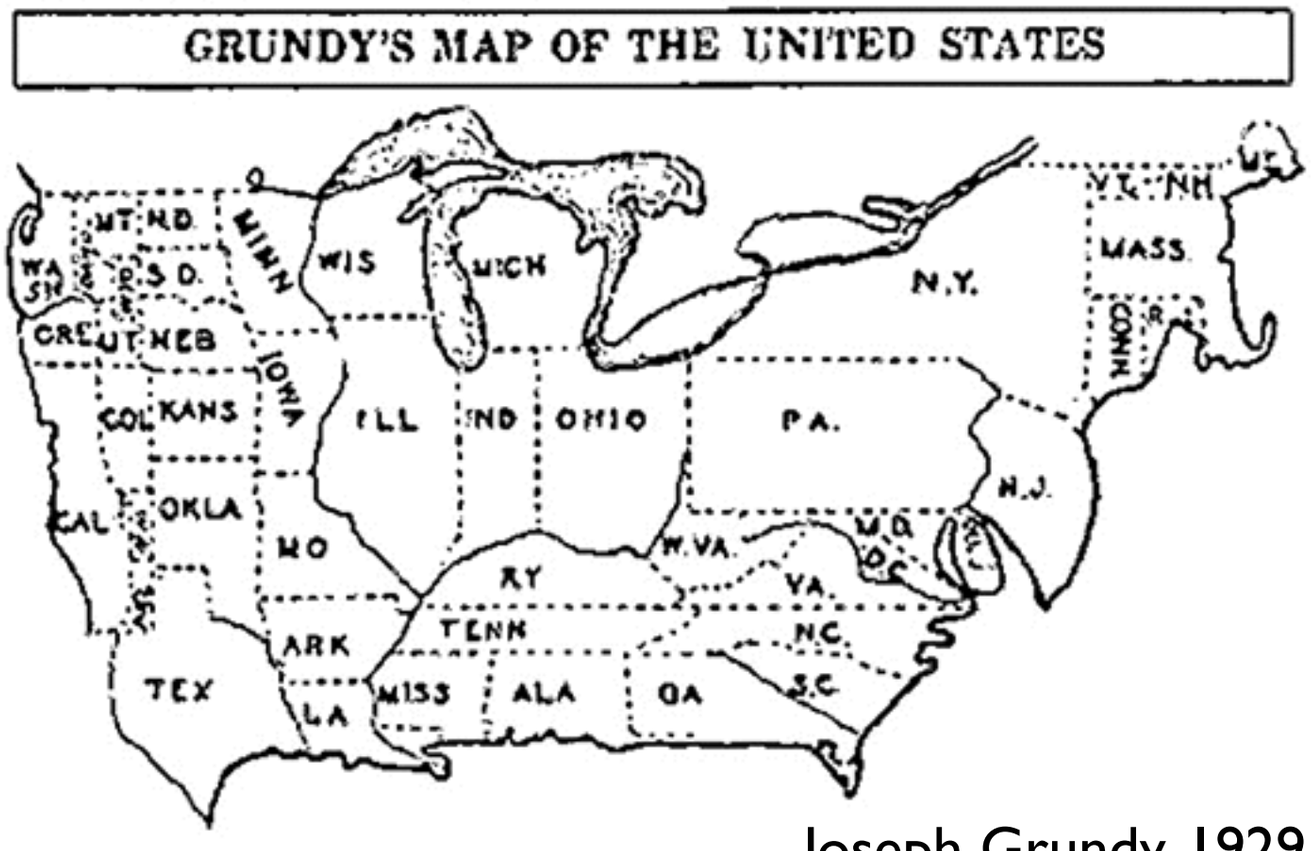
*Roll over countries to see spending figures.*


## Population
*first nonrectangular cartogram*



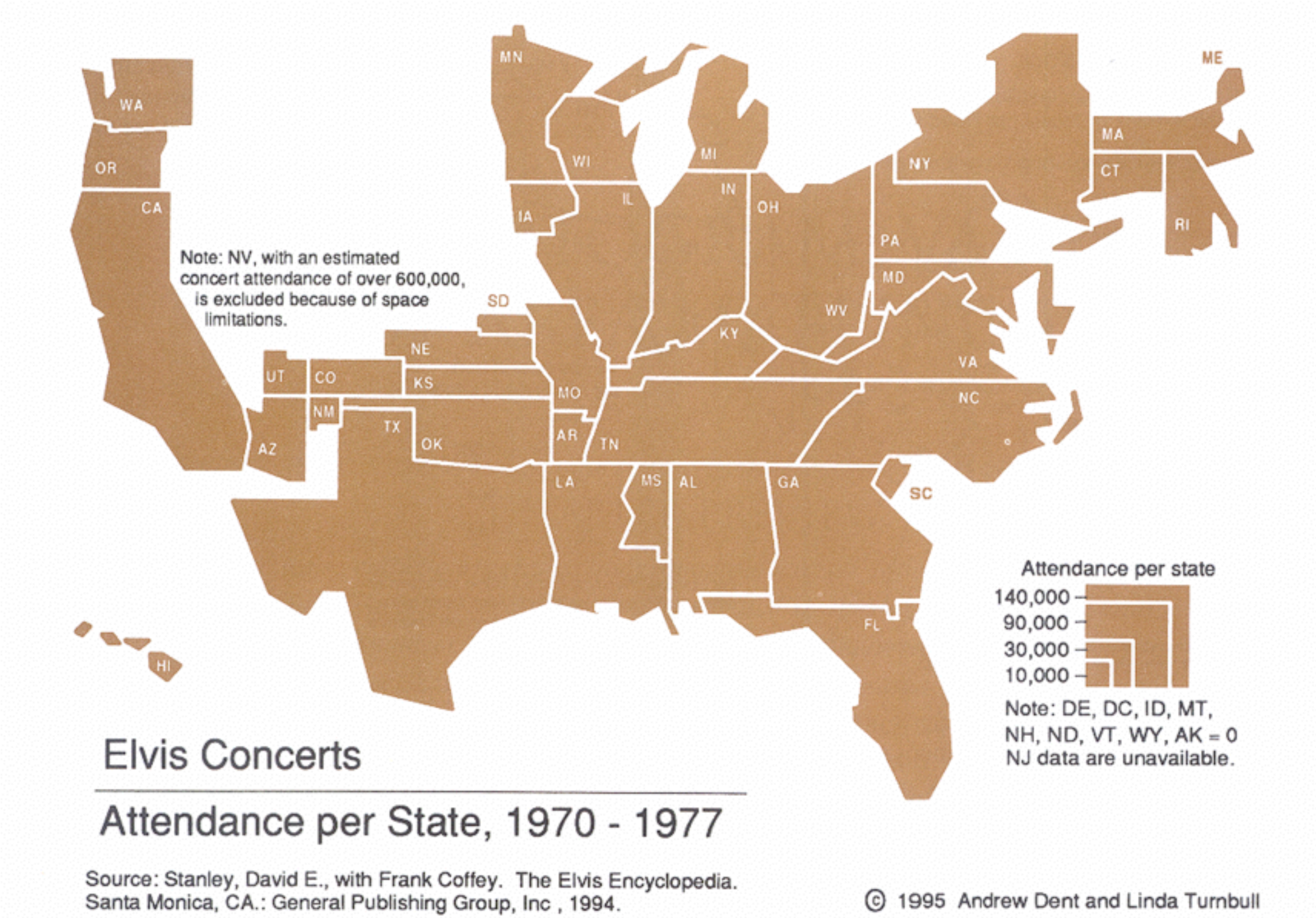

William Bailey, 1910

## Population and Federal Taxes
*first modern cartogram*




Joseph Grundy, 1929

# area scaled by data



# Kerry vs. Bush, 2004

Michael Gastner,
Cosma Shalizi, and
Mark Newman

*University of Michigan*

**distortion via diffusion**

Matthew Ericson, NY Times

# Diffusion-based method for producing density-equalizing maps

**Michael T. Gastner and M. E. J. Newman***

Center for the Study of Complex Systems and Department of Physics, University of Michigan, Ann Arbor, MI 48109

Edited by Michael F. Goodchild, University of California, Santa Barbara, CA, and approved April 2, 2004 (received for review January 13, 2004)

**Map makers have for many years searched for a way to construct cartograms, maps in which the sizes of geographic regions such as countries or provinces appear in proportion to their population or some other analogous property. Such maps are invaluable for the representation of census results, election returns, disease incidence, and many other kinds of human data. Unfortunately, to scale regions and still have them fit together, one is normally forced to distort the regions' shapes, potentially resulting in maps that are difficult to read. Many methods for making cartograms have been proposed, some of them are extremely complex, but all suffer either from this lack of readability or from other pathologies, like overlapping regions or strong dependence on the choice of coordinate axes. Here, we present a technique based on ideas borrowed from elementary physics that suffers none of these drawbacks. Our method is conceptually simple and produces useful, elegant, and easily readable maps. We illustrate the method with applications to the results of the 2000 U.S. presidential election, lung cancer cases in the State of New York, and the geographical distribution of the European population.**



Suppose we wish to represent on a map some data concerning, to take the most common example, the human population. For instance, we might wish to show votes in an election, incidence of a disease, number of cars, televisions, or phones in use, numbers of people falling in one group or another of the population, by age or income, or any of very many other variables of statistical, medical, or demographic interest. The typical course under such circumstances would be to choose one of the standard projections for the area of interest and plot the data on it with some color code or similar representation. Such maps, however, can be misleading. A plot of disease incidence, for example, will inevitably show high incidence in cities and low incidence in rural areas, solely because more people live in cities. Maps of this kind are known as value-by-area maps, density-equalizing maps, or cartograms.

The construction of cartograms is a challenging undertaking. A variety of methods have been put forward, but none is entirely satisfactory. In particular, many of these methods produce highly distorted maps that are difficult to read or projections that are badly behaved under some circumstances, with overlapping regions or strong dependence on coordinate axes. In many cases the methods proposed are also computationally demanding, sometimes taking hours to produce a single map. In this article we propose a method that is, we believe, intuitive, but also produces elegant, well behaved, and useful cartograms, whose calculation makes relatively low demands on our computational resources.

## Previous Methods for Constructing Cartograms

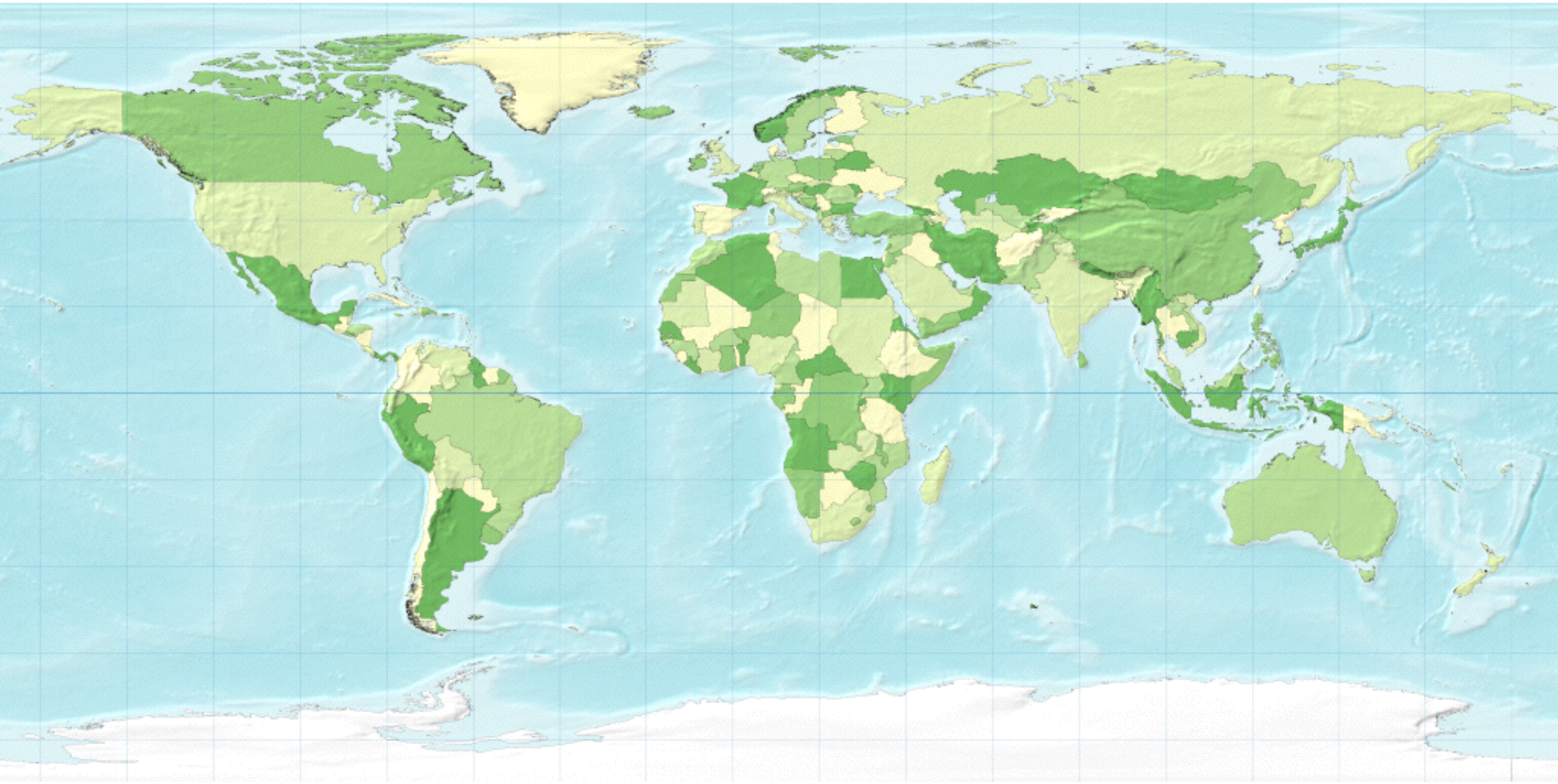
Mathematically, the construction of a (flat 2D) cartogram involves finding a transformation $\mathbf{r} \to \mathrm{T}(\mathbf{r})$ of a plane to another such that the Jacobian $\partial(x,y)/\partial(x,y)$ of the transformation is proportional to the (population) density $\rho(r)$, thus:

$$\frac{\partial(T_x, T_y)}{\partial(x, y)} \equiv \frac{\partial T_x}{\partial x}\frac{\partial T_y}{\partial y} - \frac{\partial T_x}{\partial y}\frac{\partial T_y}{\partial x} = \frac{\rho(\mathbf{r})}{\bar{\rho}}, \qquad [1]$$

where $\bar{\rho}$ is the mean population density averaged over the area to be mapped. (This choice of normalization for the Jacobian ensures that the total area before and after the transformation is the same.)

Eq. 1 does not determine the cartogram projection uniquely. To do that, we need one more constraint; two constraints are needed to fix the projection for a 2D cartogram. Different choices of the second constraint give different projections, and

# the world

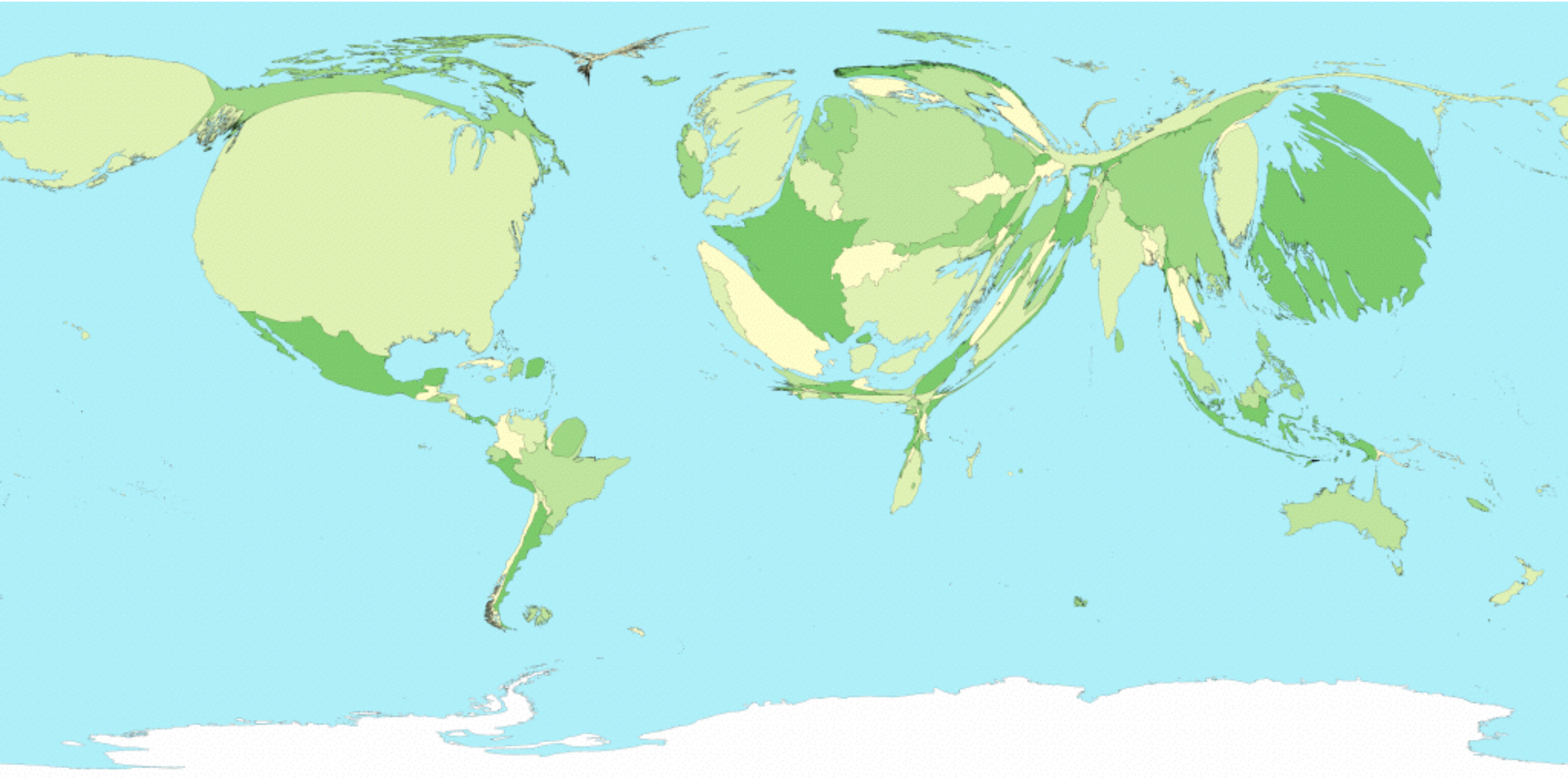


http://www-personal.umich.edu/~mejn/cartograms/

# population

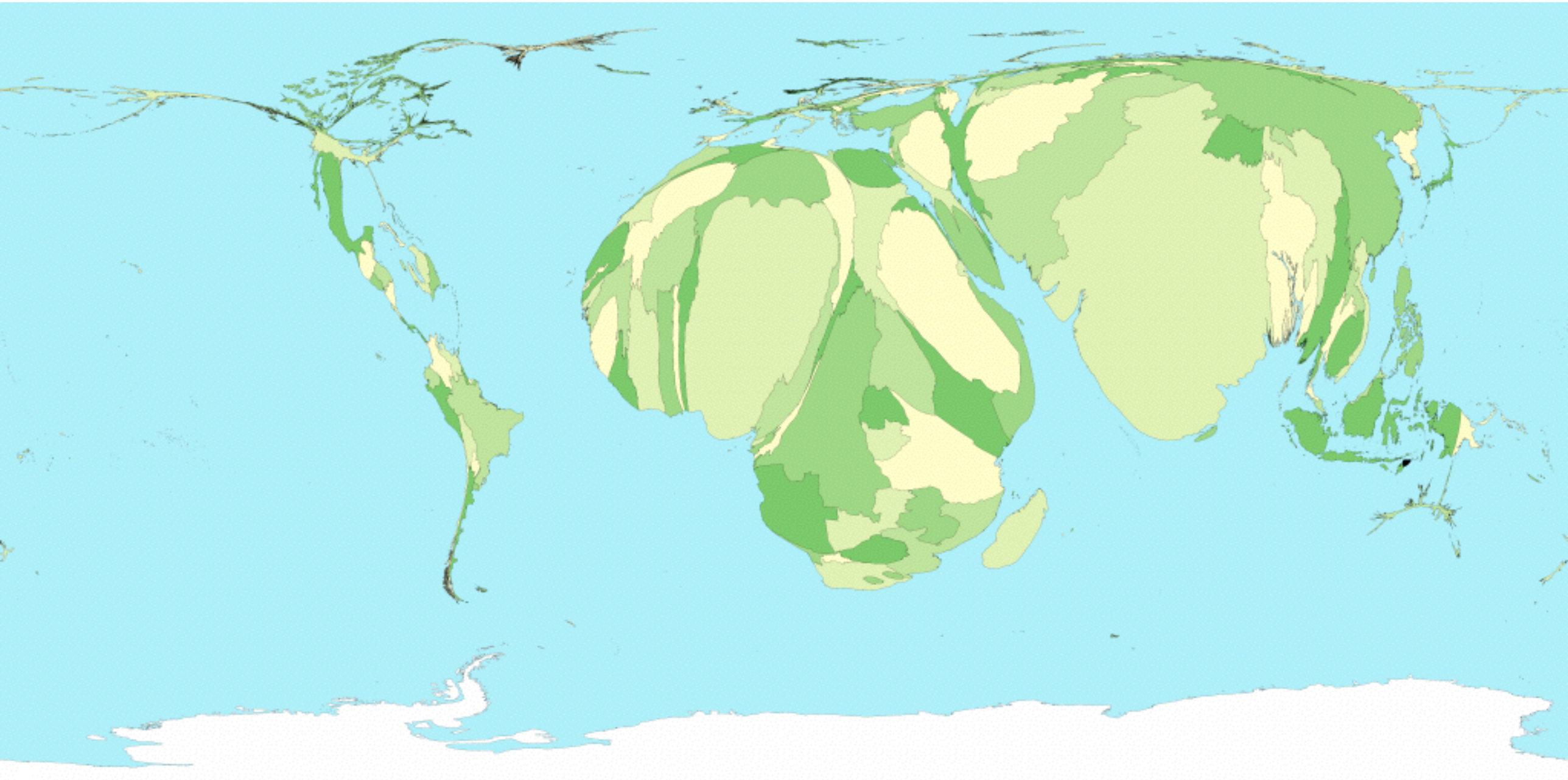

http://www-personal.umich.edu/~mejn/cartograms/

# GDP



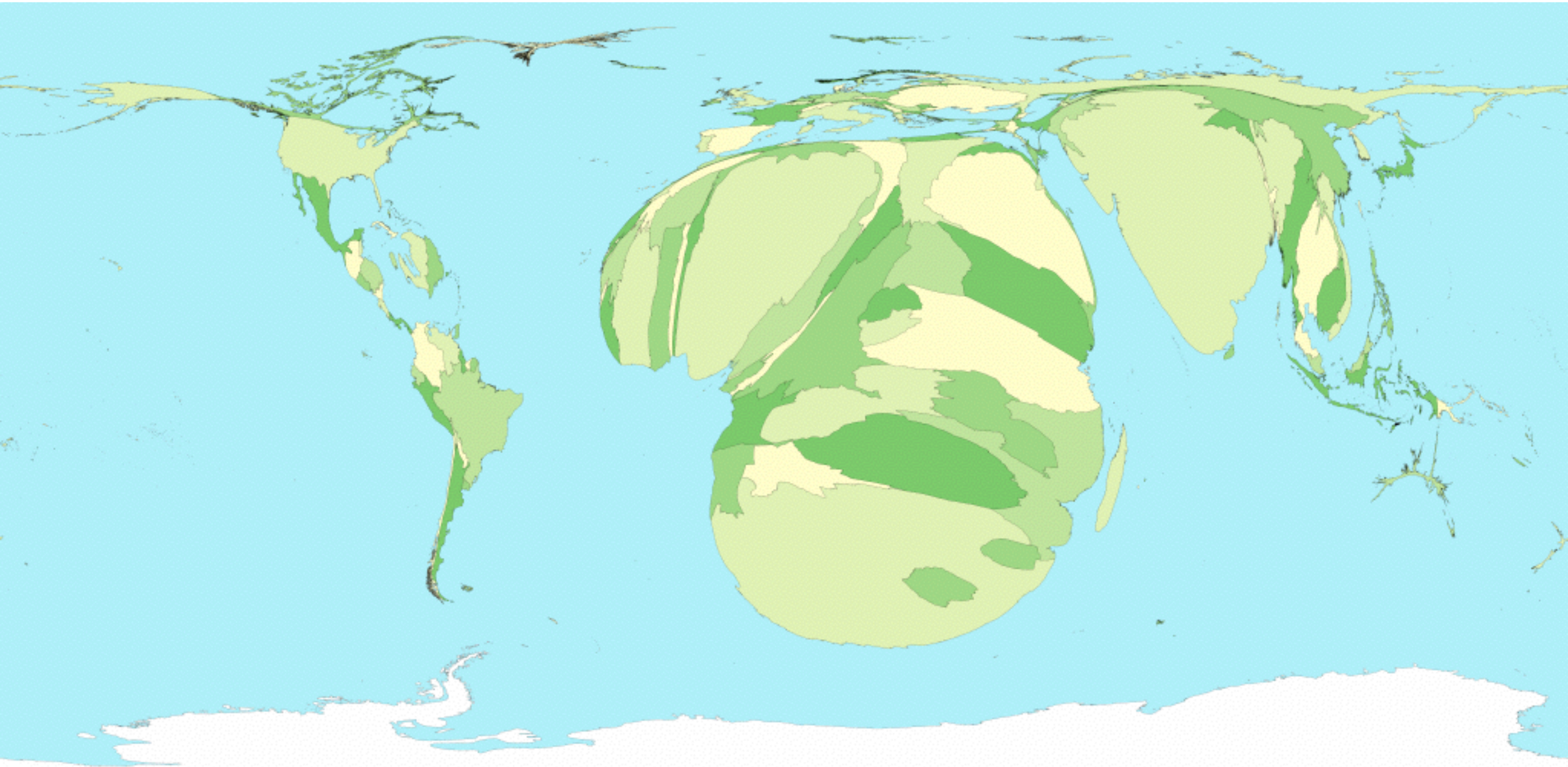
http://www-personal.umich.edu/~mejn/cartograms/

# child mortality



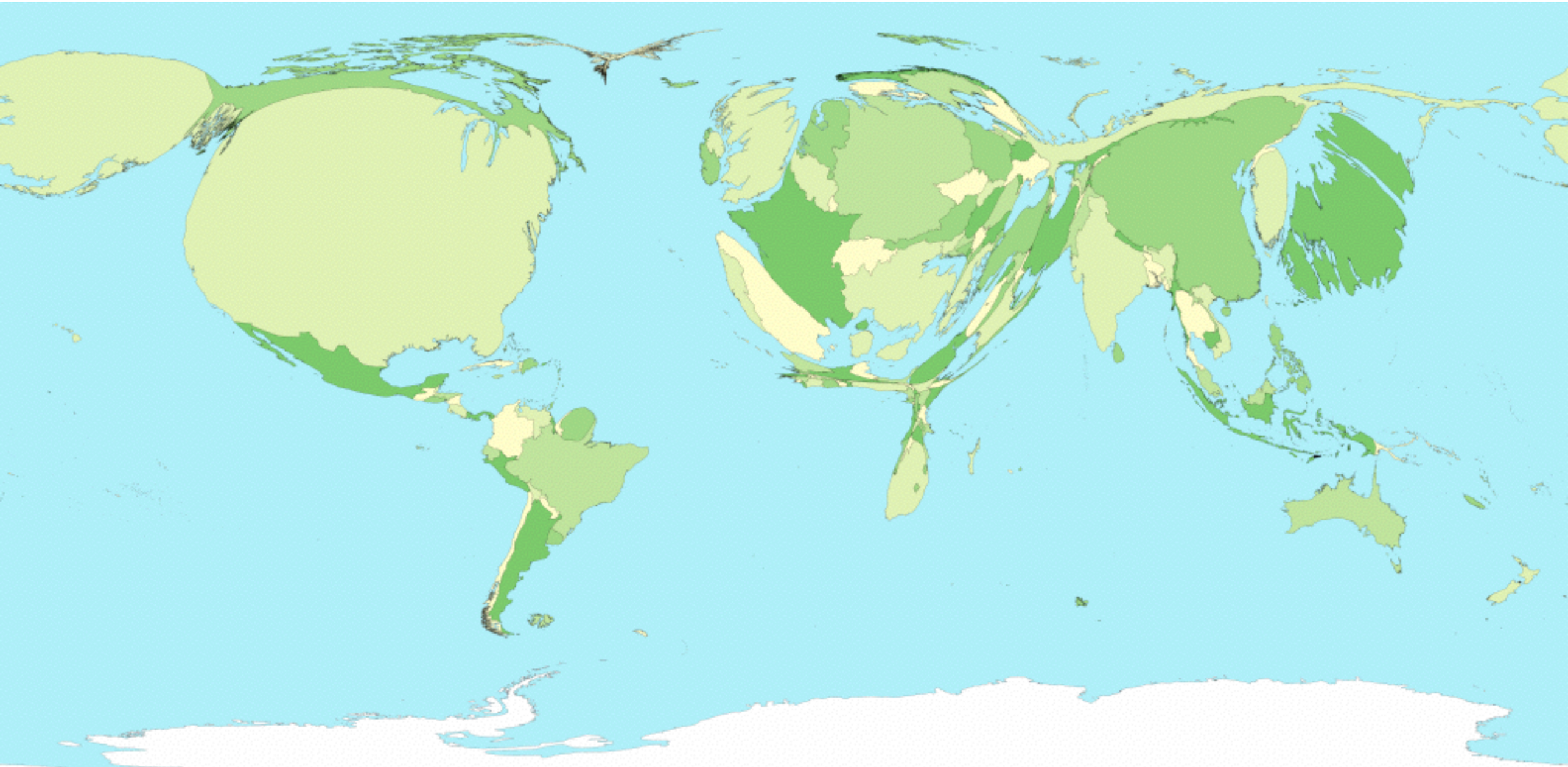
http://www-personal.umich.edu/~mejn/cartograms/

# people living with HIV/AIDS



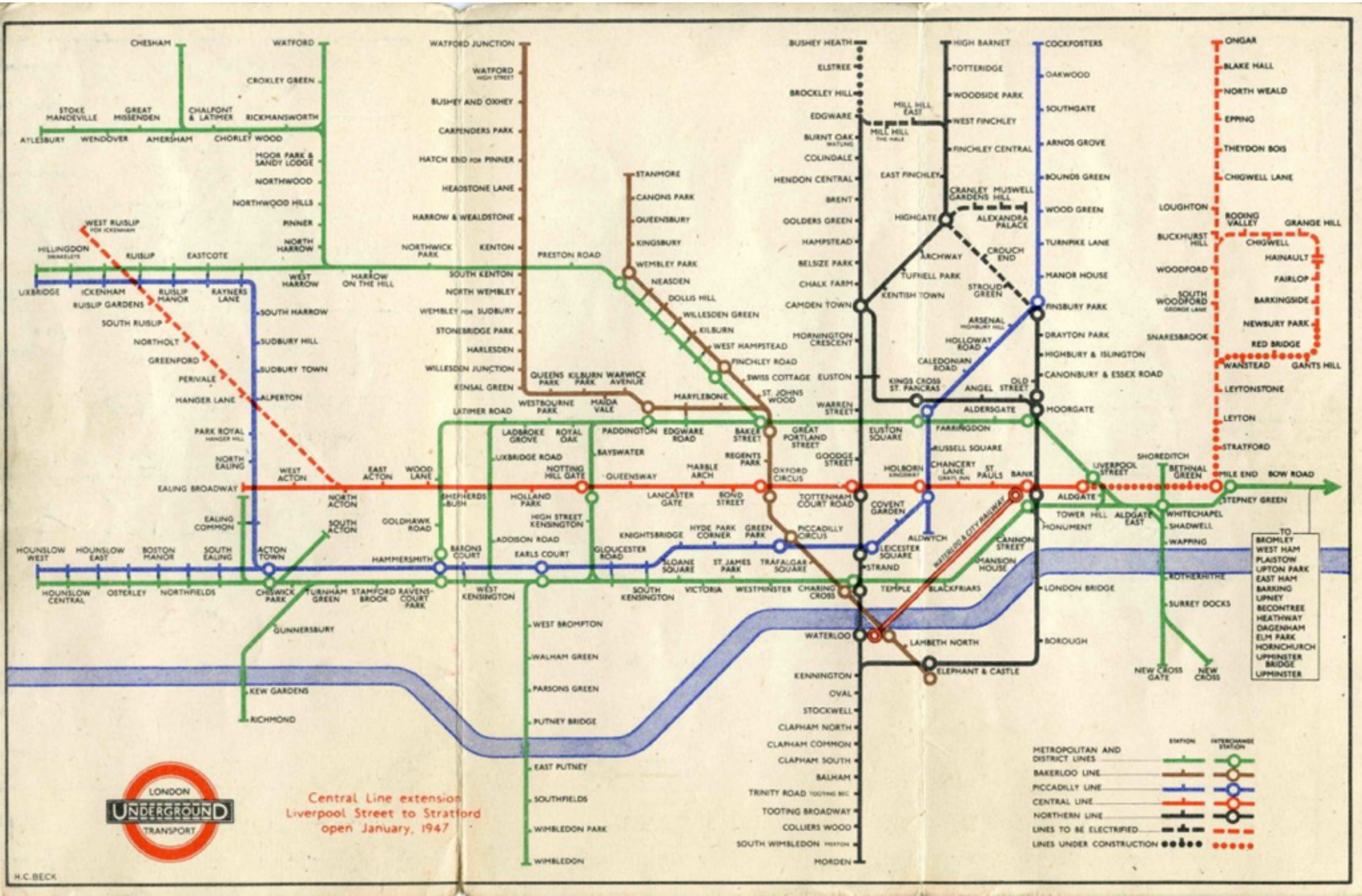
http://www-personal.umich.edu/~mejn/cartograms/

# total spending on healthcare



http://www-personal.umich.edu/~mejn/cartograms/

# Harry Beck's Tube Map

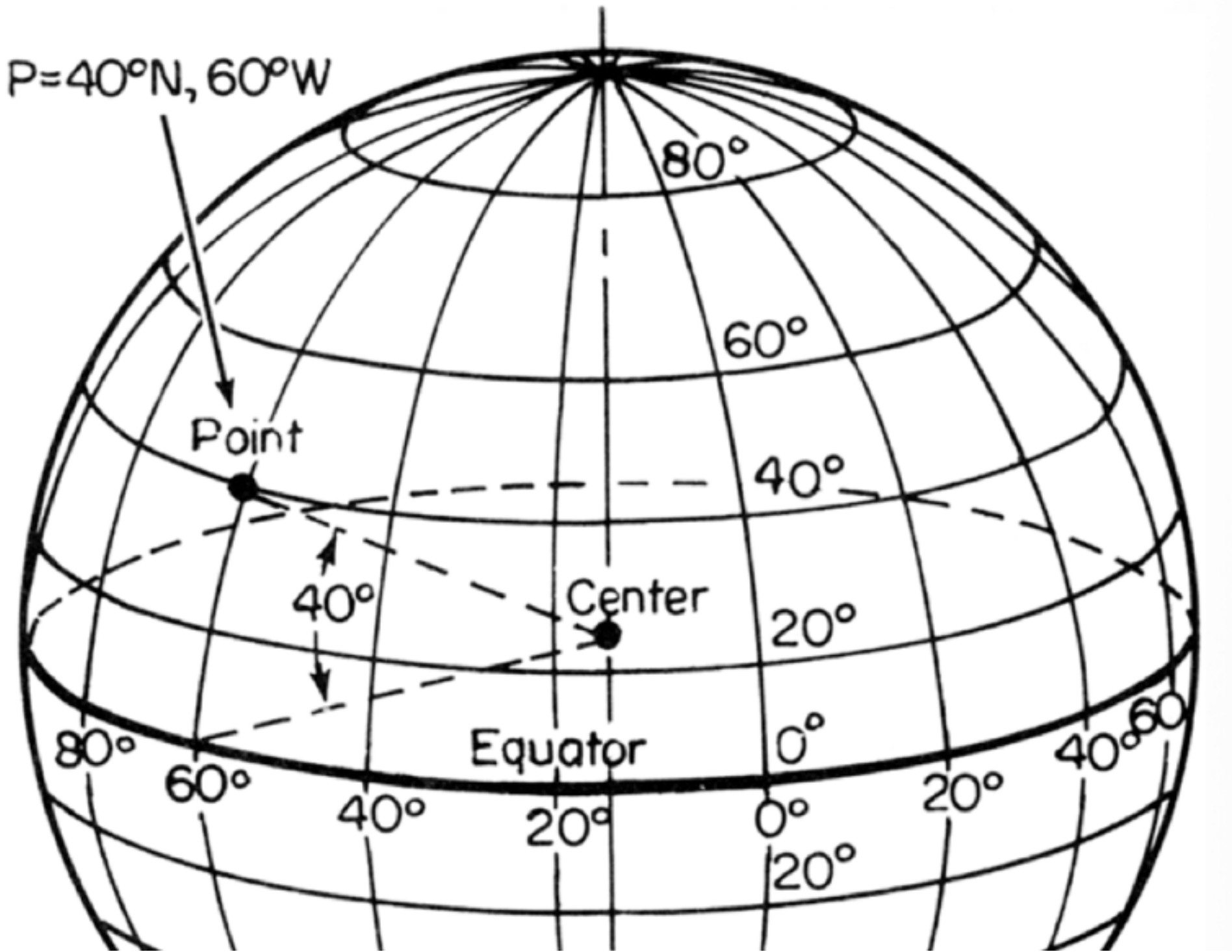


# do they work?

- landmarks
- discrete data
- continuous data
- choropleths
- cartograms
- projections

# FLATTENING THE GLOBE

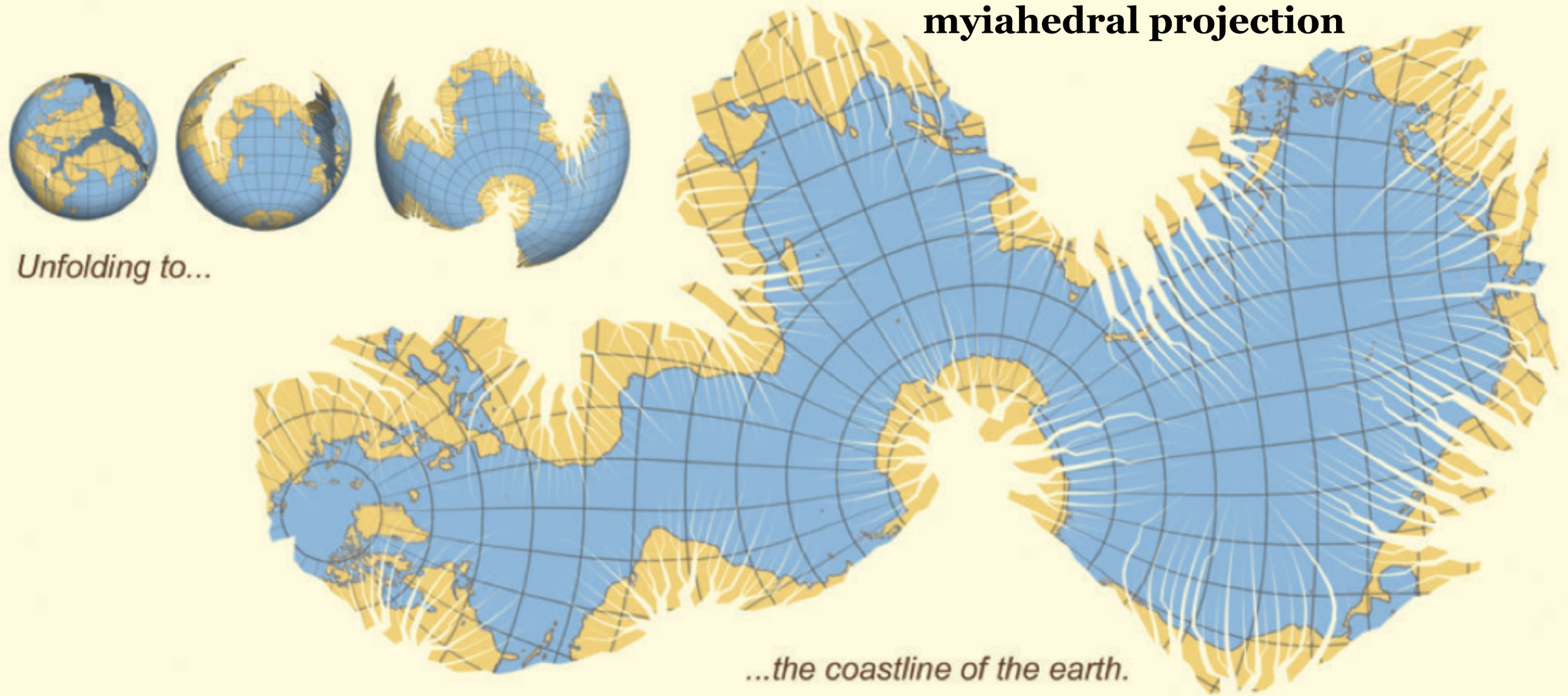
# latitude, longitude



# a sphere tears when you flatten it

http://www.oocities.org/suzy_gillece/

# many ways to tear…






van Wijk 2008

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!

## ROBINSON

YOU HAVE A COMFORTABLE PAIR OF RUNNING SHOES THAT YOU WEAR EVERYWHERE. YOU LIKE COFFEE AND ENJOY THE BEATLES. YOU THINK THE ROBINSON IS THE BEST-LOOKING PROJECTION, HANDS DOWN.

## DYMAXION

YOU LIKE ISAAC ASIMOV, XML, AND SHOES WITH TOES. YOU THINK THE SEGWAY GOT A BAD RAP. YOU OWN 3D GOGGLES, WHICH YOU USE TO VIEW ROTATING MODELS OF BETTER 3D GOGGLES. YOU TYPE IN DVORAK.

## WINKEL-TRIPEL

NATIONAL GEOGRAPHIC ADOPTED THE WINKEL-TRIPEL IN 1998, BUT YOU'VE BEEN A W-T FAN SINCE *LONG* BEFORE "NATGEO" SHOWED UP. YOU'RE WORRIED IT'S GETTING PLAYED OUT, AND ARE THINKING OF SWITCHING TO THE KAVRAYSKIY. YOU ONCE LEFT A PARTY IN DISGUST WHEN A GUEST SHOWED UP WEARING SHOES WITH TOES. YOUR FAVORITE MUSICAL GENRE IS "POST-".

## GOODE HOMOLOSINE

THEY SAY MAPPING THE EARTH ON A 2D SURFACE IS LIKE FLATTENING AN ORANGE PEEL, WHICH SEEMS EASY ENOUGH TO YOU. YOU LIKE EASY SOLUTIONS. YOU THINK WE WOULDN'T HAVE SO MANY PROBLEMS IF WE'D JUST ELECT *NORMAL* PEOPLE TO CONGRESS INSTEAD OF POLITICIANS. YOU THINK AIRLINES SHOULD JUST BUY FOOD FROM THE RESTAURANTS NEAR THE GATES AND SERVE *THAT* ON BOARD. YOU CHANGE YOUR CAR'S OIL, BUT SECRETLY WONDER IF YOU REALLY *NEED* TO.

## HOBO-DYER

YOU WANT TO AVOID CULTURAL IMPERIALISM, BUT YOU'VE HEARD BAD THINGS ABOUT GALL-PETERS. YOU'RE CONFLICT-AVERSE AND BUY ORGANIC. YOU USE A RECENTLY-INVENTED SET OF GENDER-NEUTRAL PRONOUNS AND THINK THAT WHAT THE WORLD NEEDS IS A REVOLUTION IN CONSCIOUSNESS.

## PLATE CARRÉE
(EQUIRECTANGULAR)

YOU THINK THIS ONE IS FINE. YOU LIKE HOW X AND Y MAP TO LATITUDE AND LONGITUDE. THE OTHER PROJECTIONS OVERCOMPLICATE THINGS. YOU WANT ME TO STOP ASKING ABOUT MAPS SO YOU CAN ENJOY DINNER.

## A GLOBE!

## WATERMAN BUTTERFLY

YOU'RE CONFLICT-AVERSE AND BUY ORGANIC. YOU USE A RECENTLY-INVENTED SET OF GENDER-NEUTRAL PRONOUNS AND THINK THAT WHAT THE WORLD NEEDS IS A REVOLUTION IN CONSCIOUSNESS.

A GLOBE!

YES, YOU'RE VERY CLEVER.

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.

MAP TO LATITUDE AND LONGITUDE. THE OTHER PROJECTIONS OVERCOMPLICATE THINGS. YOU WANT ME TO STOP ASKING ABOUT MAPS SO YOU CAN ENJOY DINNER.

WATERMAN BUTTERFLY

REALLY? YOU KNOW THE WATERMAN? HAVE YOU SEEN THE 1909 CAHILL MAP IT'S BASED— ...YOU HAVE A FRAMED REPRODUCTION AT HOME?! WHOA. ...LISTEN, FORGET THESE QUESTIONS. ARE YOU DOING ANYTHING TONIGHT?

GALL-PETERS

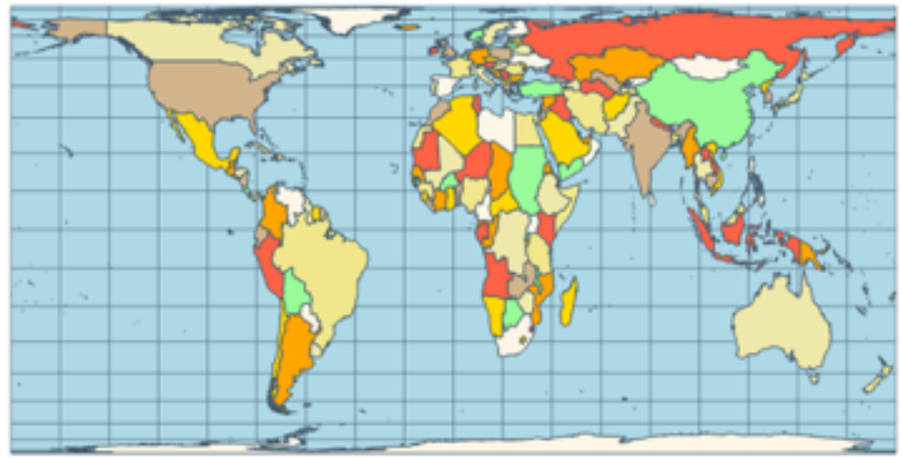
I *HATE* YOU.

http://xkcd.com/977/

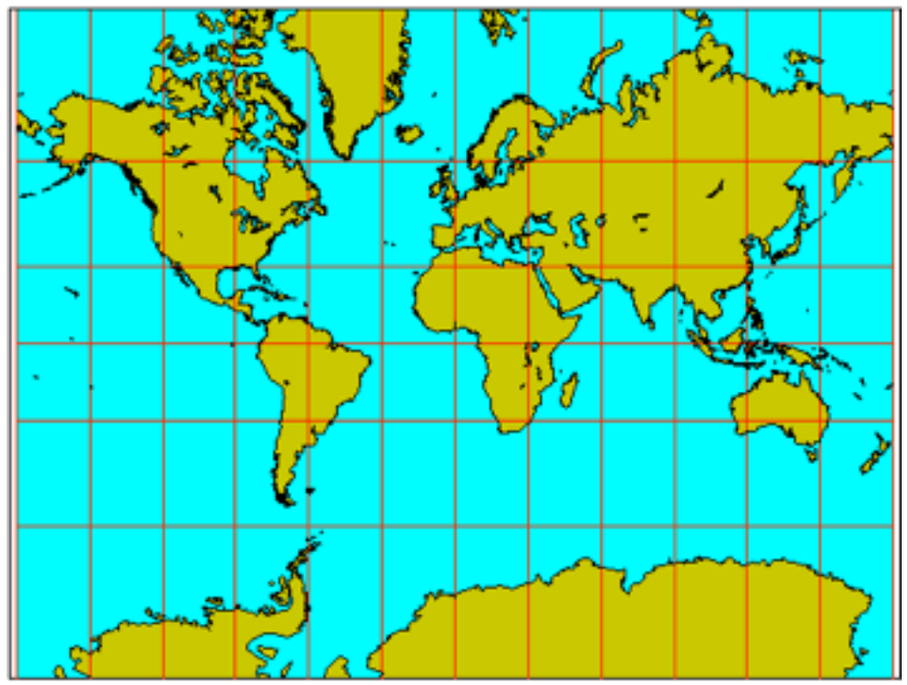
# CLASSES OF PROJECTION

**azimuthal**
preserves direction


**equal-area**
preserves area



**conformal**
preserves local shapes



# L16: Grids

# REQUIRED READING

# 13

# Facets

Increasingly, 3D data acquisition techniques, such as laser scanners, are used to bring the physical world into a digital form. Powerful computers that are equipped with large amounts of memory can be credited for this increase in use. Laser scanners produce *point clouds*—unorganized 3D points. Analysis and rendering of these point clouds are most efficiently done when the points are connected to form *facets*—planar entities.

## 13.1 Triangles

The subject of triangles as taught in high school constructed them from angles, edge lengths, and trigonometric functions. Typically, we dealt with *one* triangle. In computing and visualization, we also encounter triangles; however now they exist in rather large numbers. Some objects consist of up to 1,000,000,000 triangles.

We present a brief review of triangle facts. Everything in this review holds for both 2D and 3D triangles.

*Triangle.* A *triangle* is a 2D or 3D object defined by three vertices $\mathbf{v}_1, \mathbf{v}_2, \mathbf{v}_3$, where the $\mathbf{v}_i$ are points in 2D or 3D.