

CIS 4930/6930-002

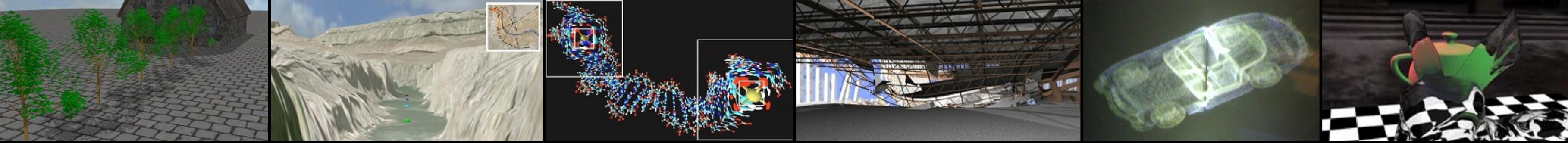
DATA VISUALIZATION



MAPS

Paul Rosen
Assistant Professor
University of South Florida

slides credits Miriah Meyer (U of Utah)



MAPS!

landmarks

discrete data

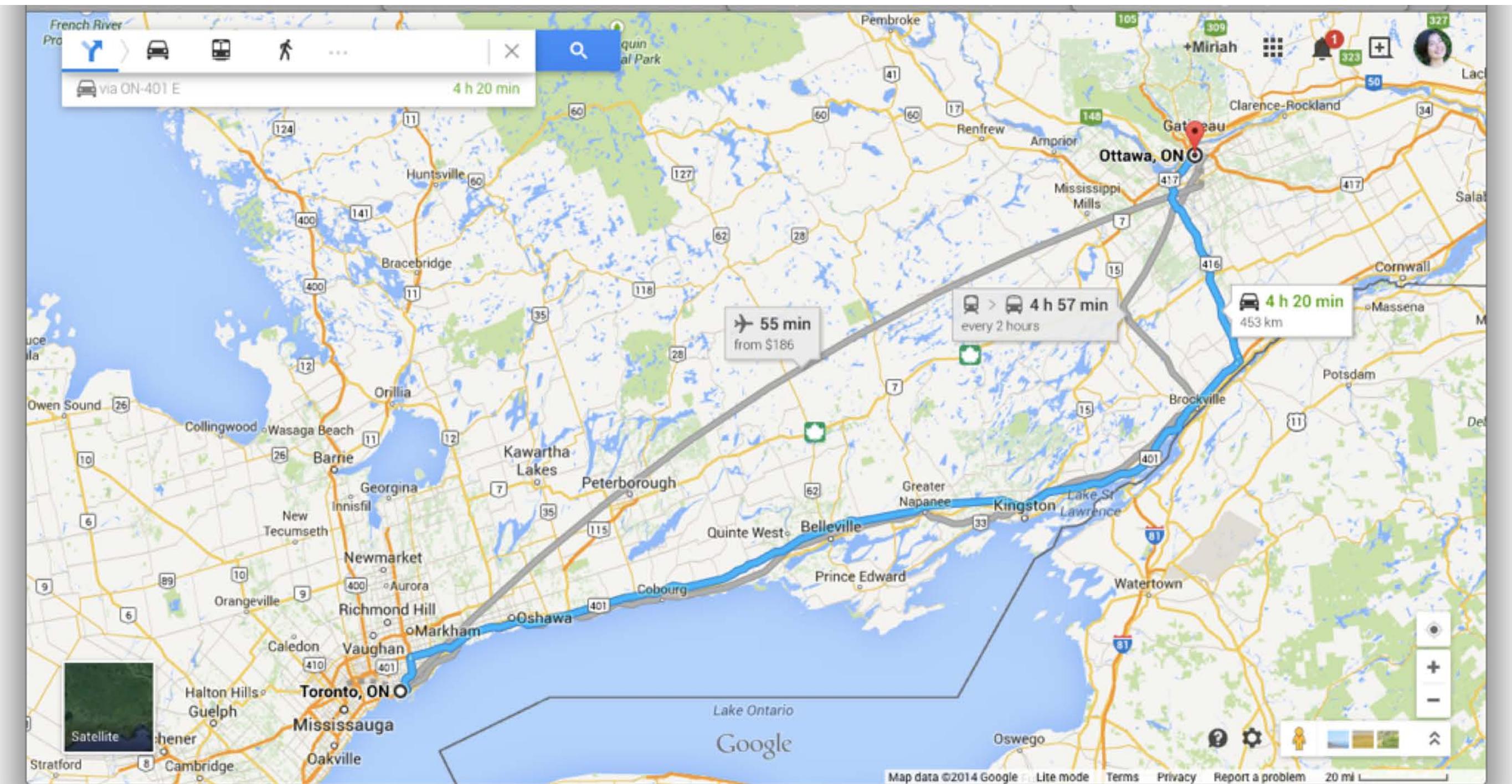
continuous data

choropleths

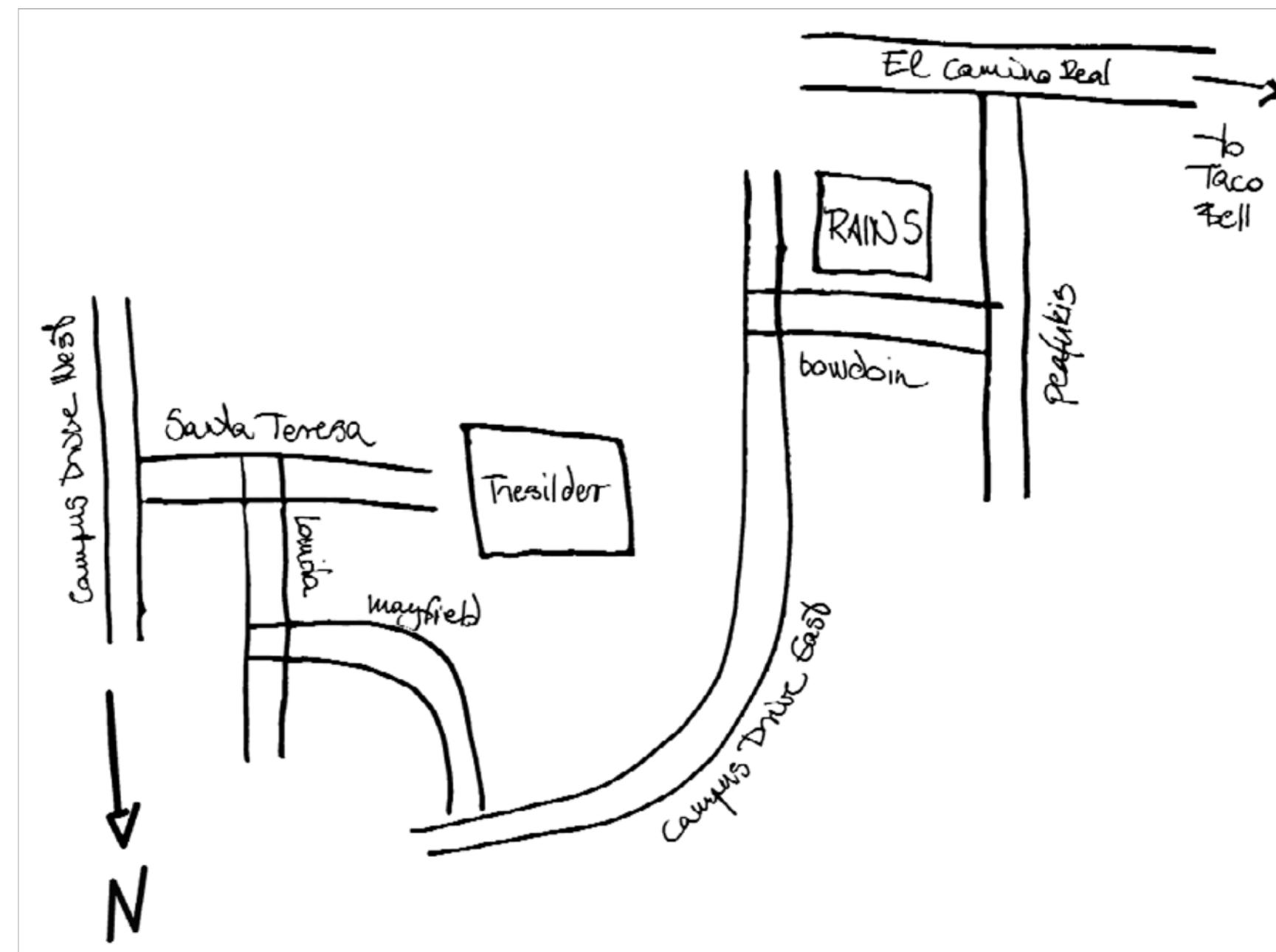
cartograms

projections

LANDMARKS



LANDMARKS



Rendering Effective Route Maps: Improving Usability Through Generalization

Maneesh Agrawala Chris Stolte
Stanford University*

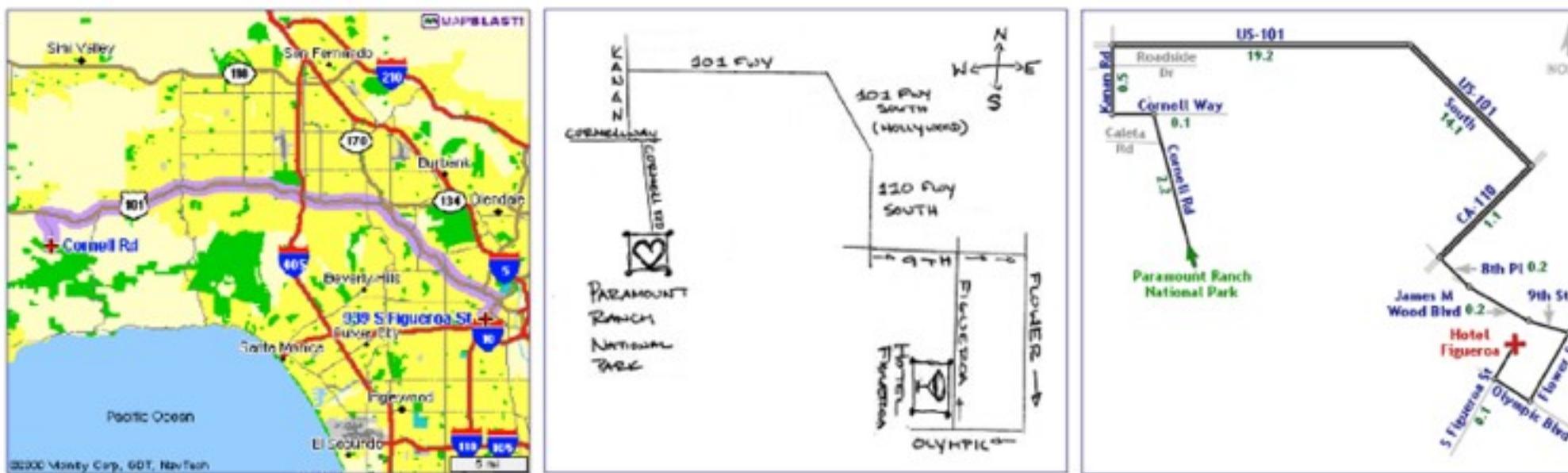


Figure 1: Three route maps for the same route rendered by (left) a standard computer-mapping system, (middle) a person, and (right) LineDrive, our route map rendering system. The standard computer-generated map is difficult to use because its large, constant scale factor causes the short roads to vanish 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 maintaining 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

clarity of the map and to emphasize the most important informa-

RECOMMENDED READING

cut 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.

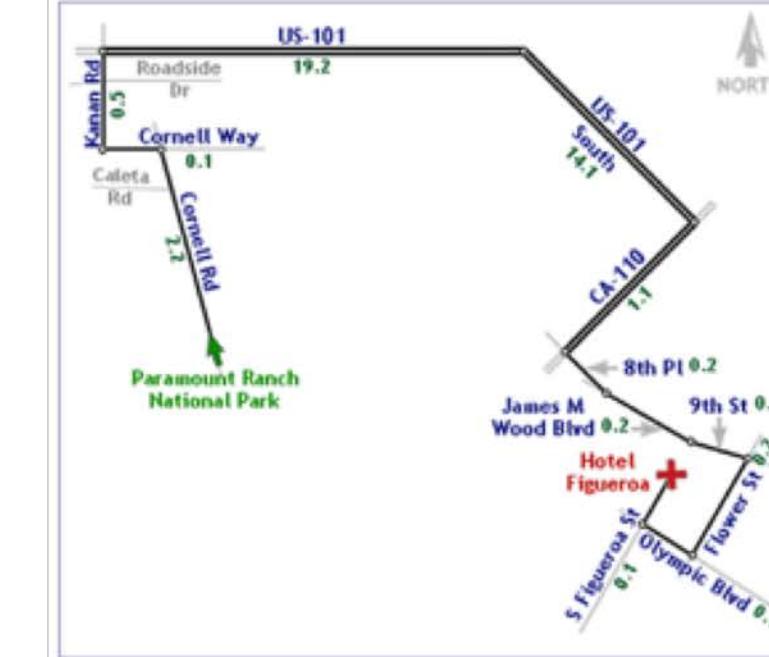
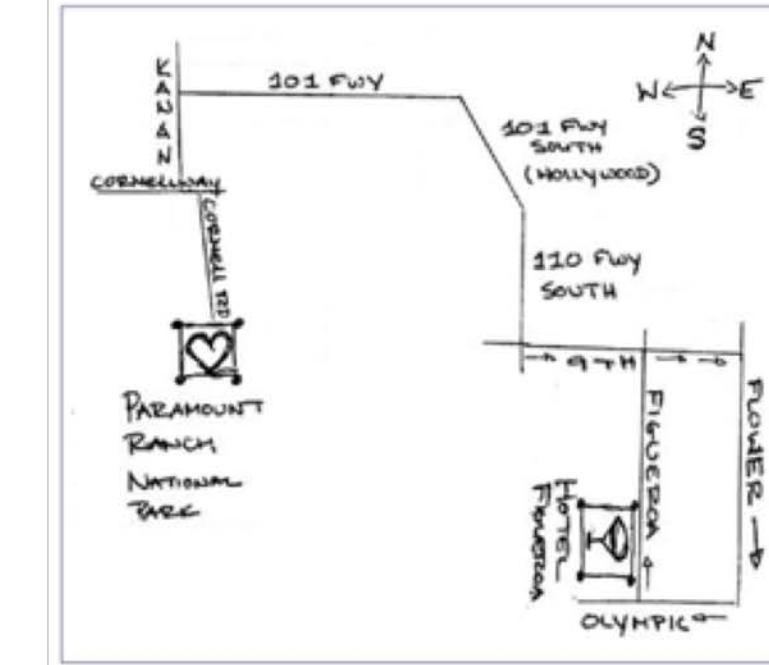
Keywords: Information Visualization, Non-Realistic Rendering, WWW Applications, Human Factors

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

RECOMMENDATIONS

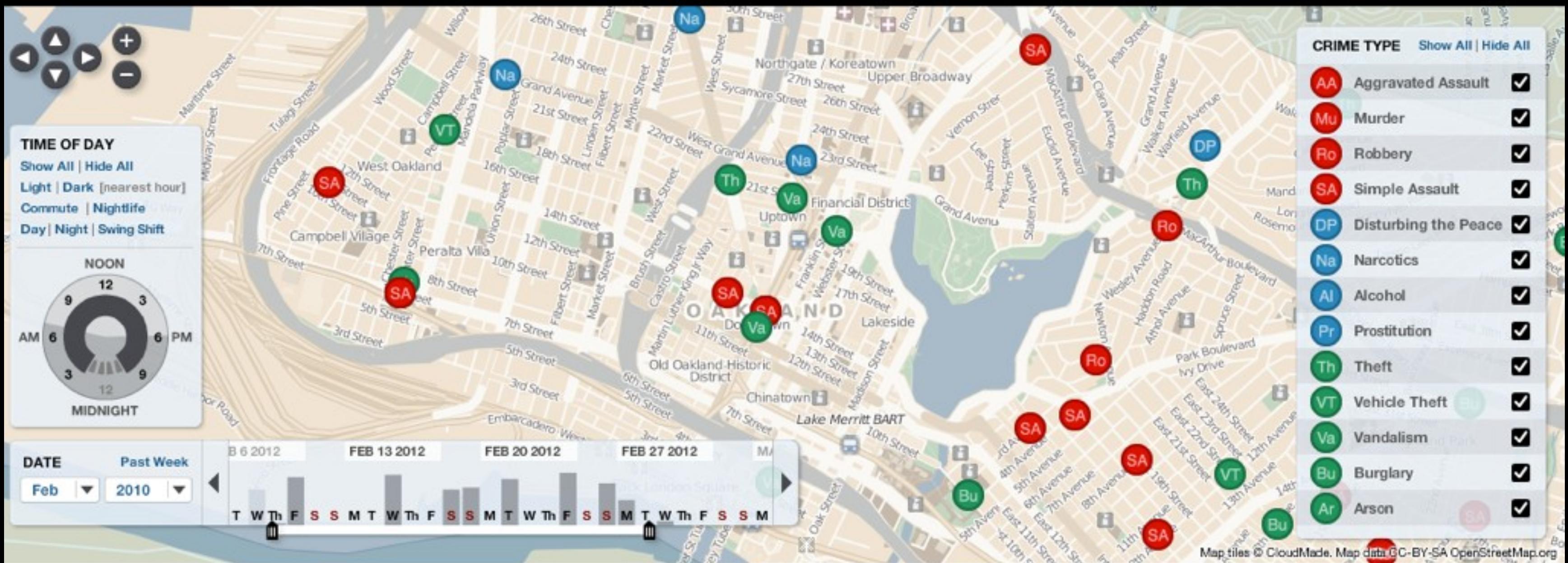
straighten wiggly lines
snap turns to right angles
expand regions with turns
contract long straight roads
label carefully
maintain overall orientation



DISCRETE DATA

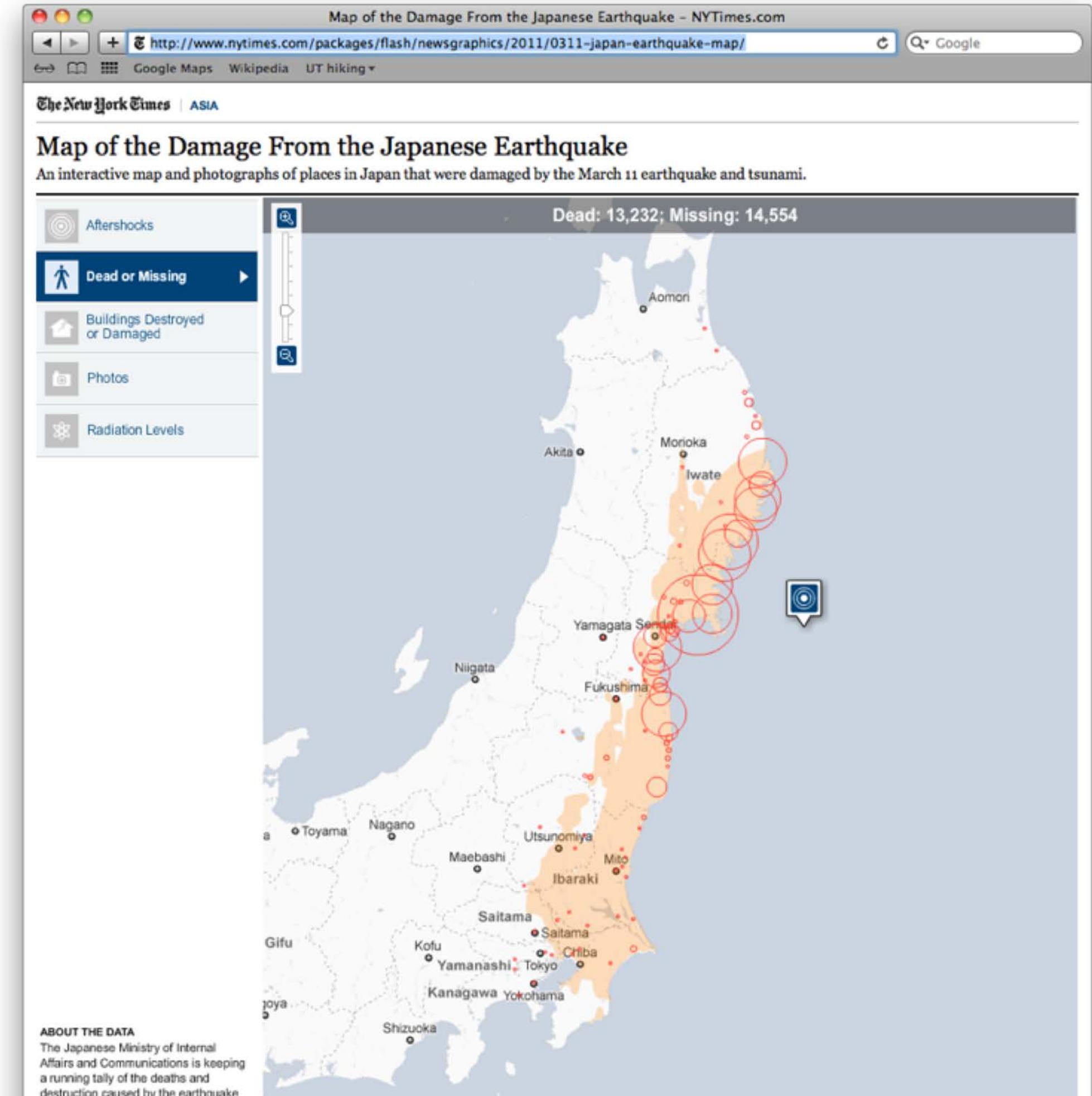
DATA AS ICONS/GLYPHS



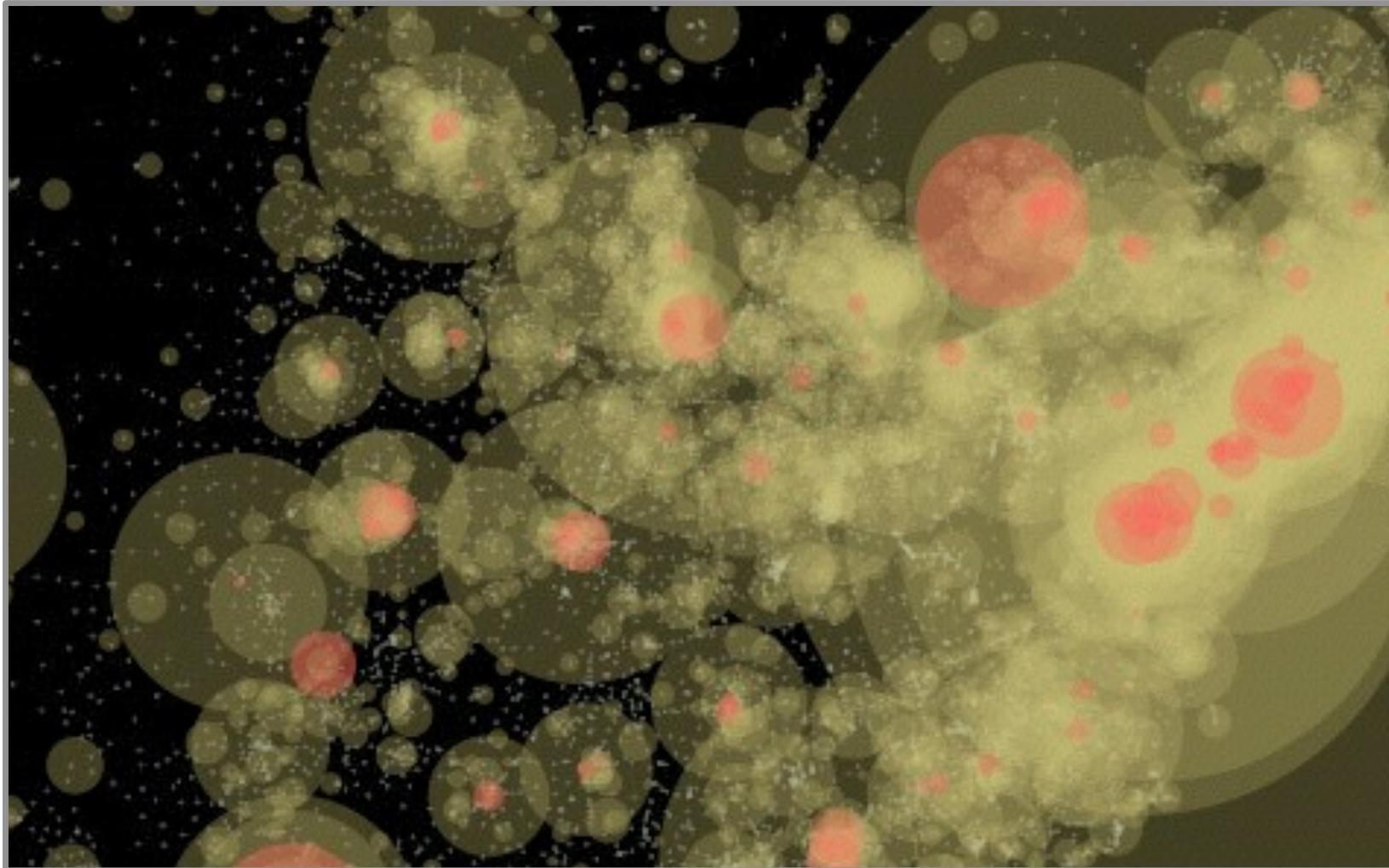


DATA AS POINTS

data : ordered/ quantitative
encoding : size

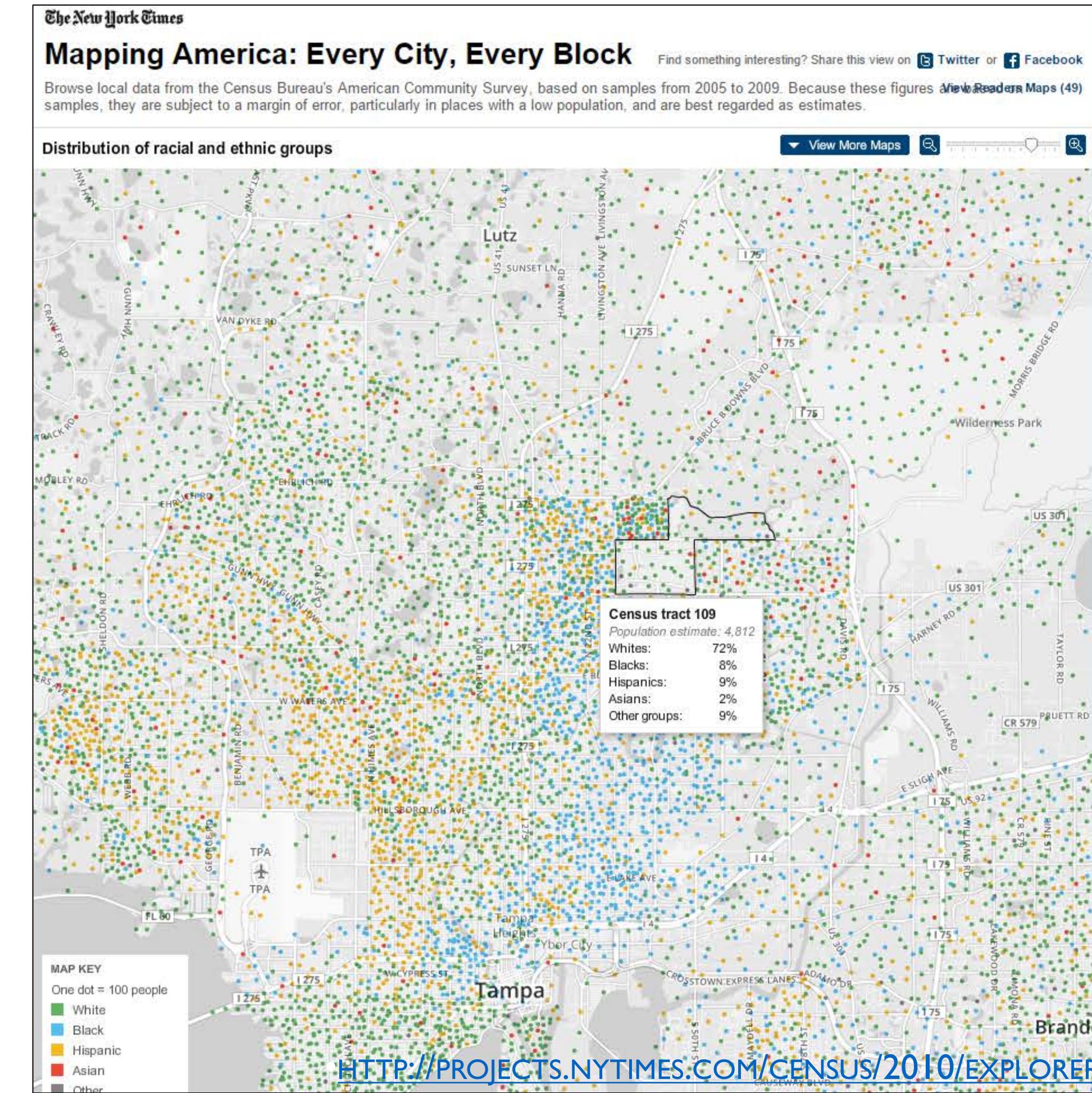


TRAFFIC



DATA AS POINTS

data : categorical
encoding : hue

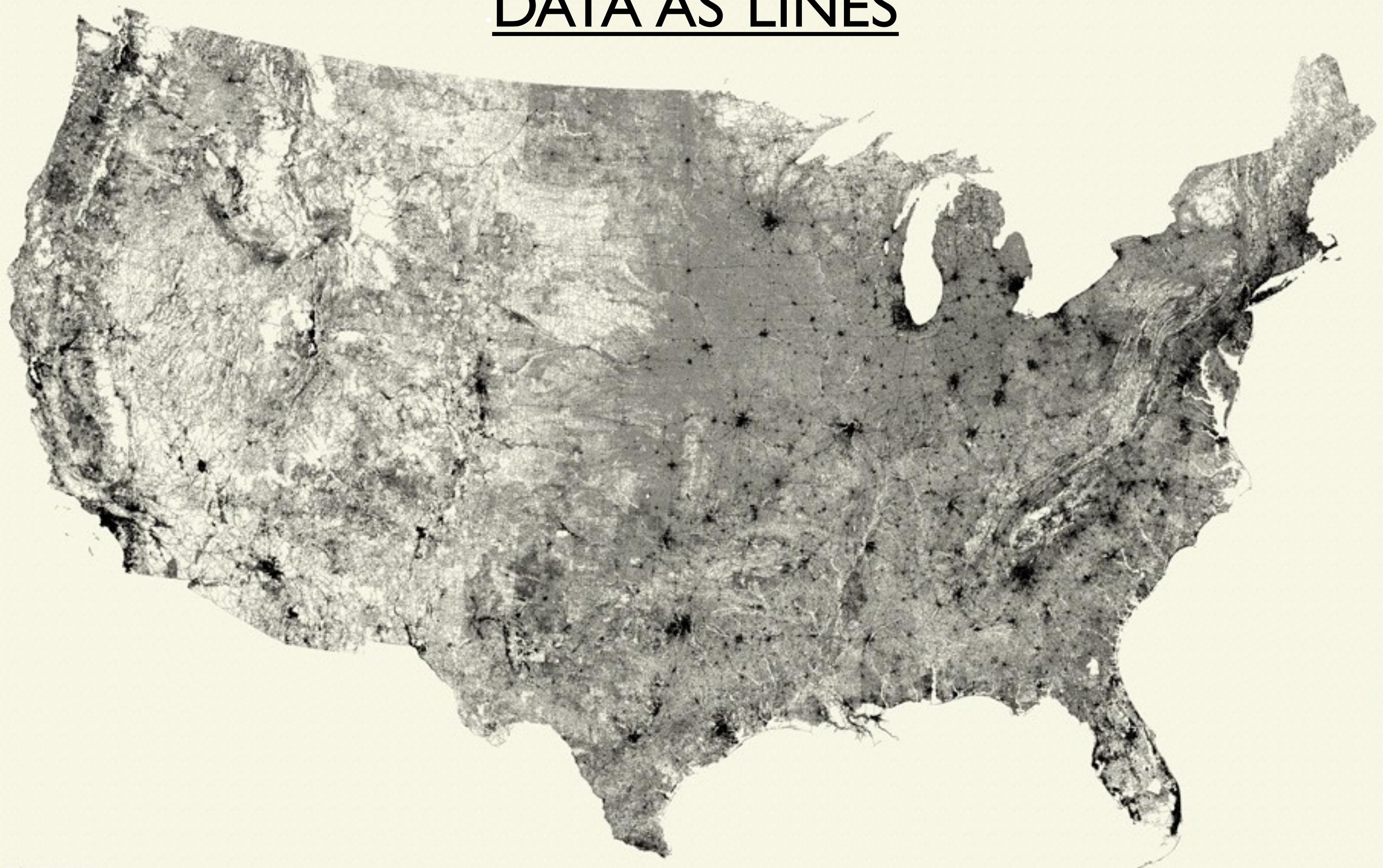


DATA AS POINTS

data : categorical
encoding : hue



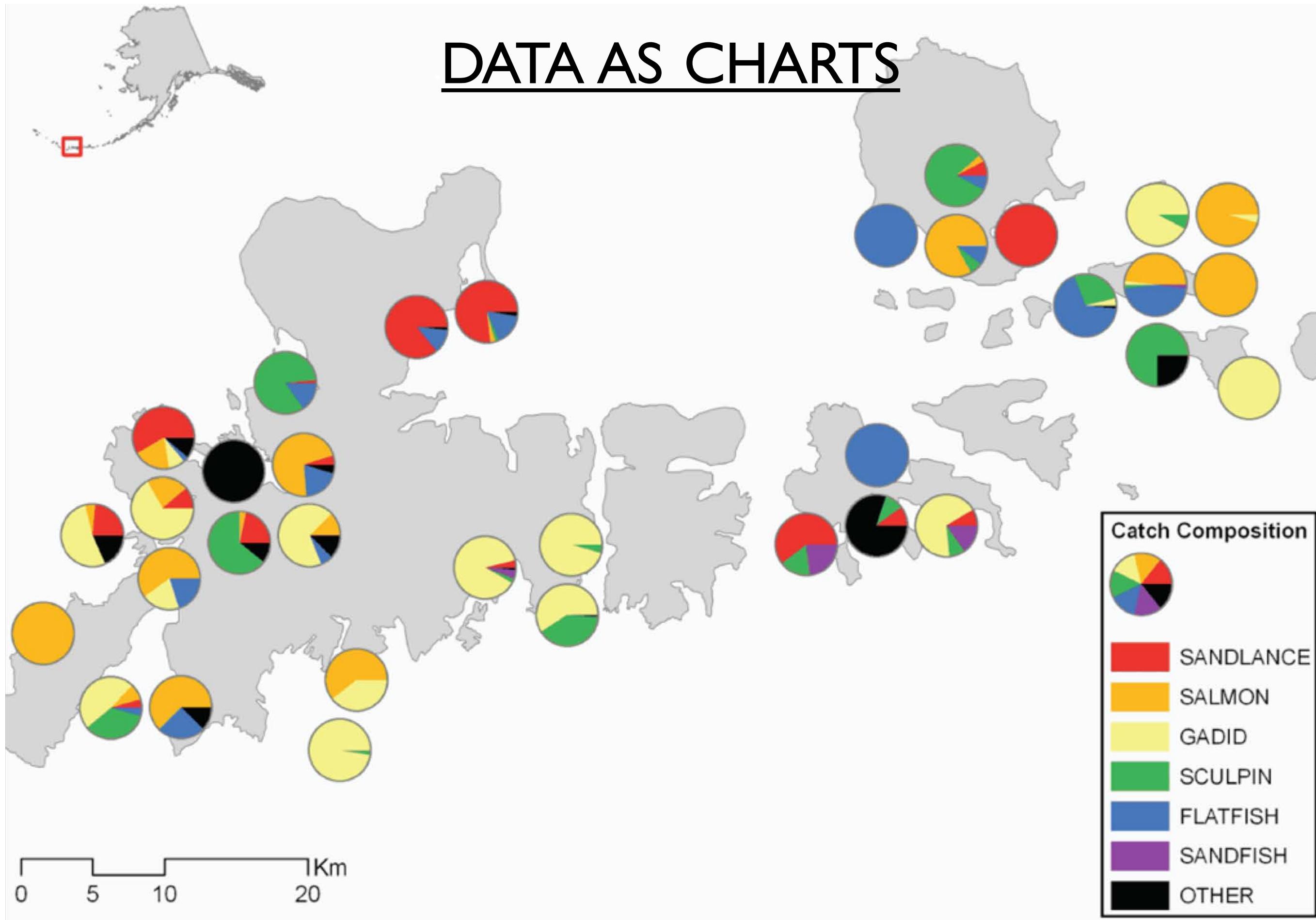
DATA AS LINES



F | DATA AS LINES

[HTTP://FATHOM.INFO/ALLSTREETS/](http://fathom.info/allstreets/)

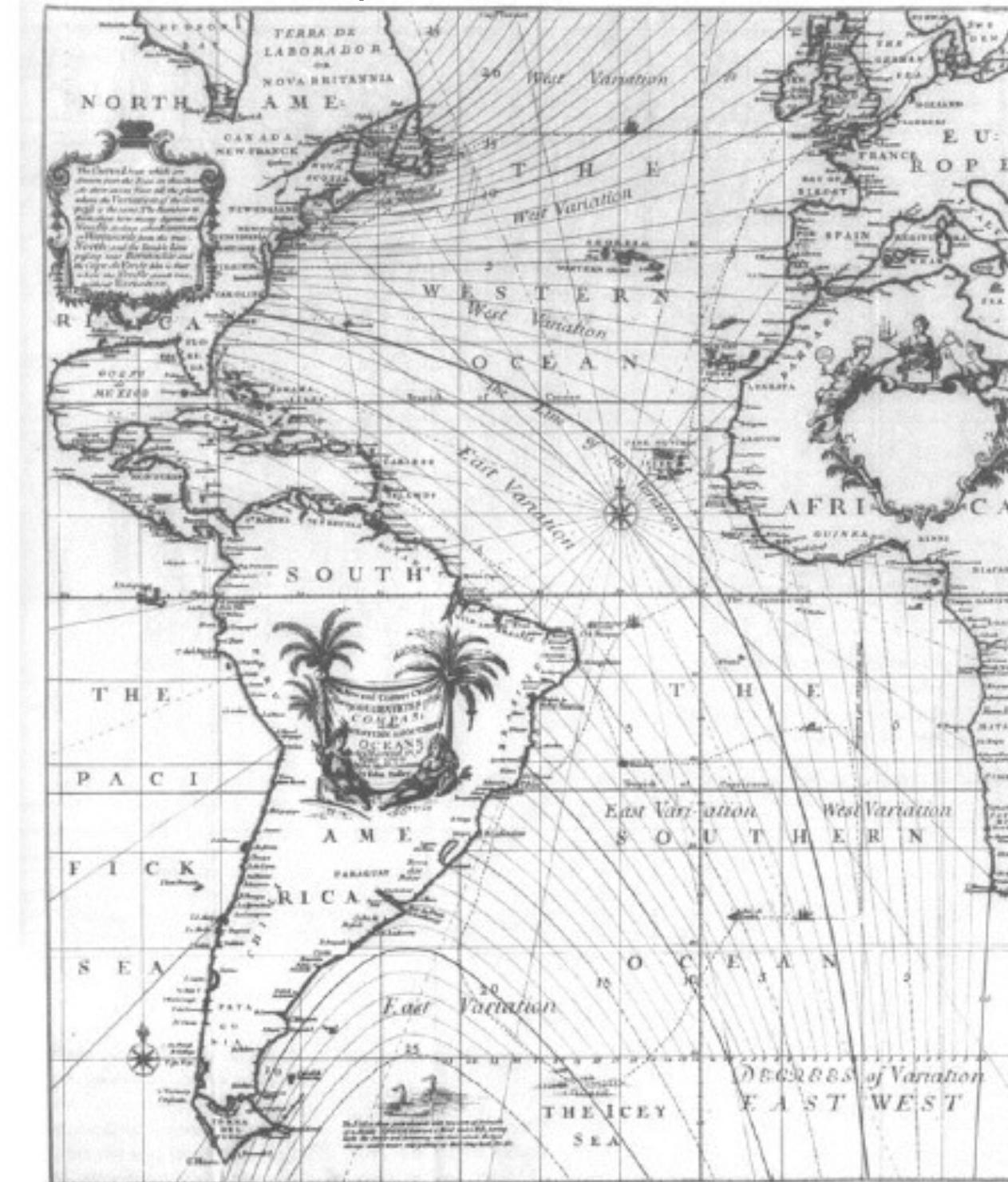
DATA AS CHARTS



CONTINUOUS DATA

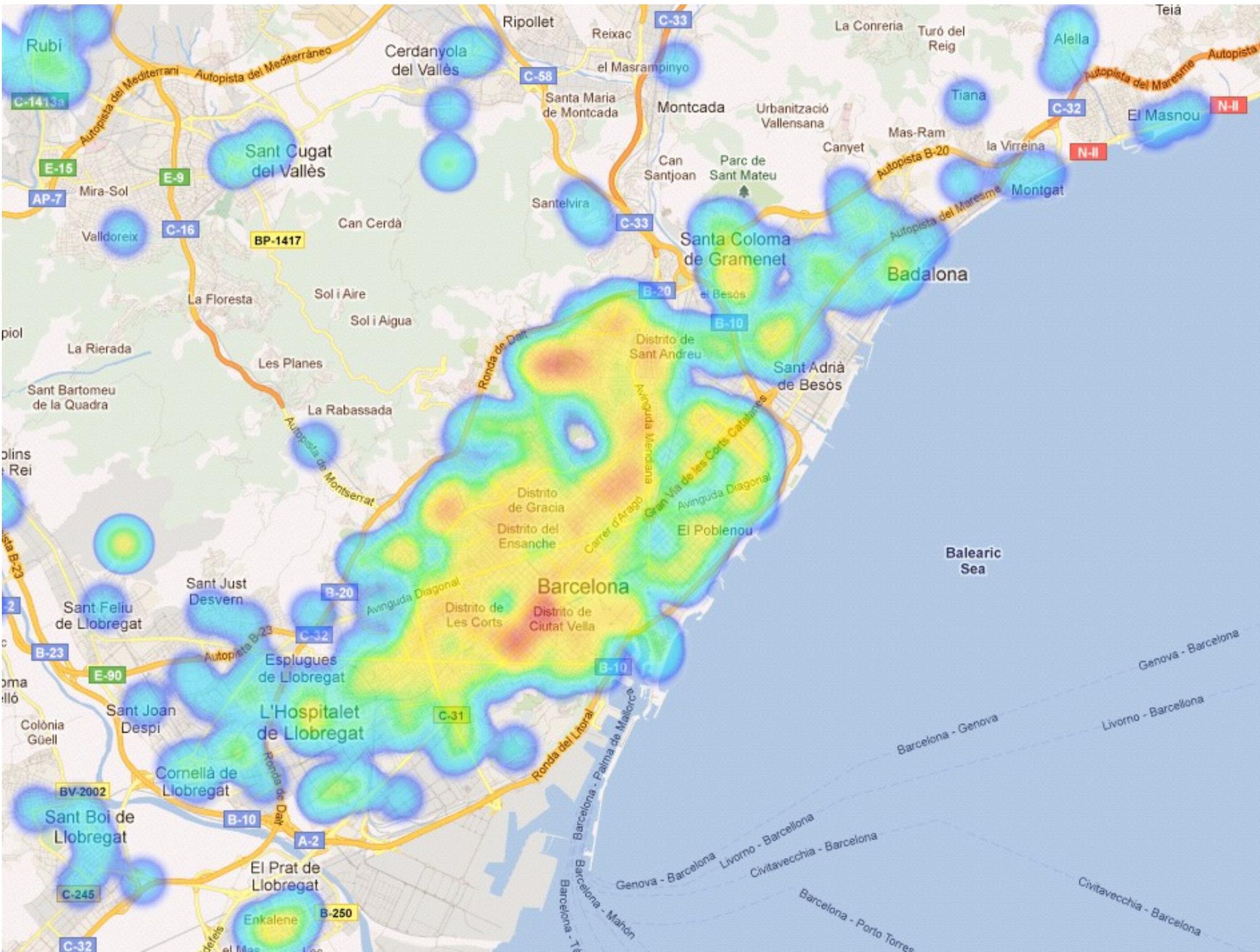
ISOPLETH
map which overlays
continuous data using a
third encoding channel

Lines of Equal Magnetic Declination
first contour map

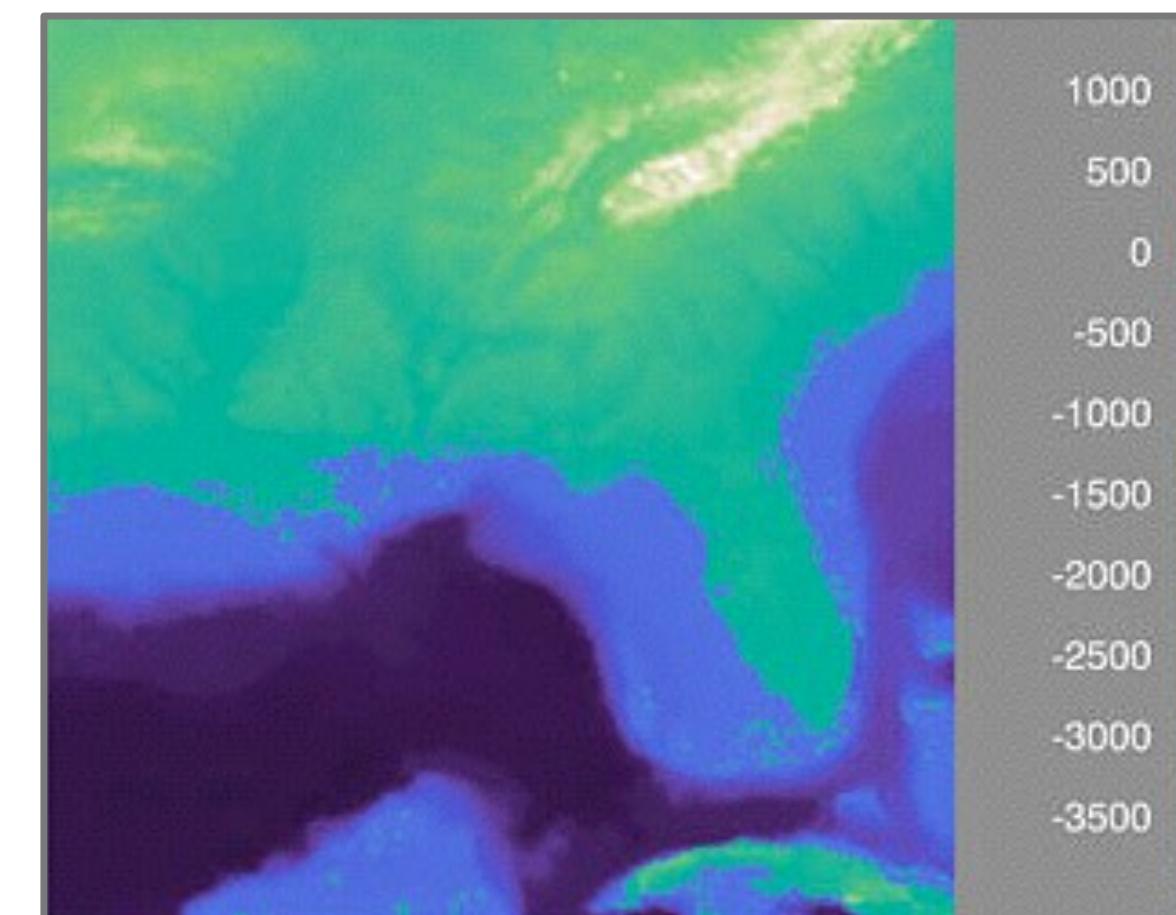
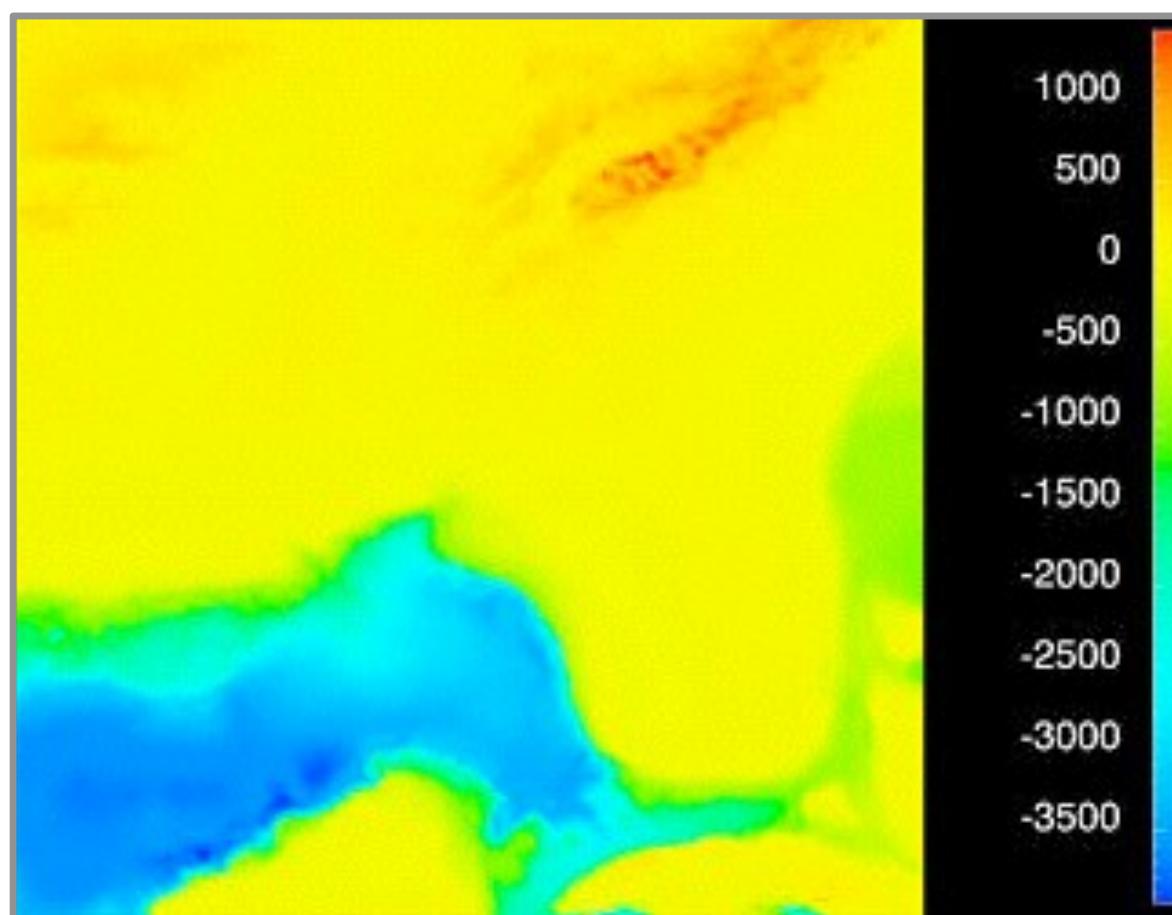


HEATMAPS

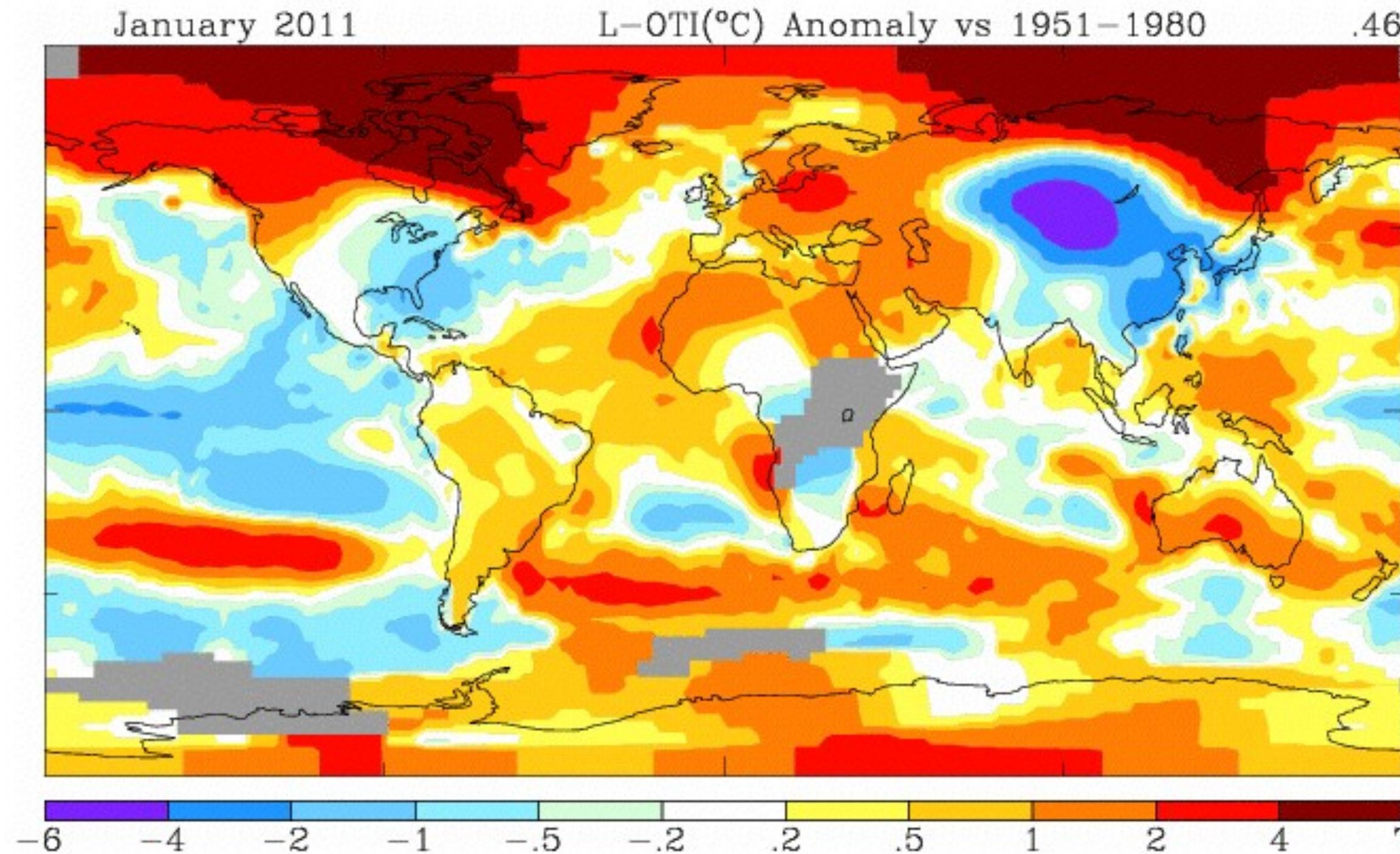
HEATMAP



CHOOSE THE APPROPRIATE COLORMAP



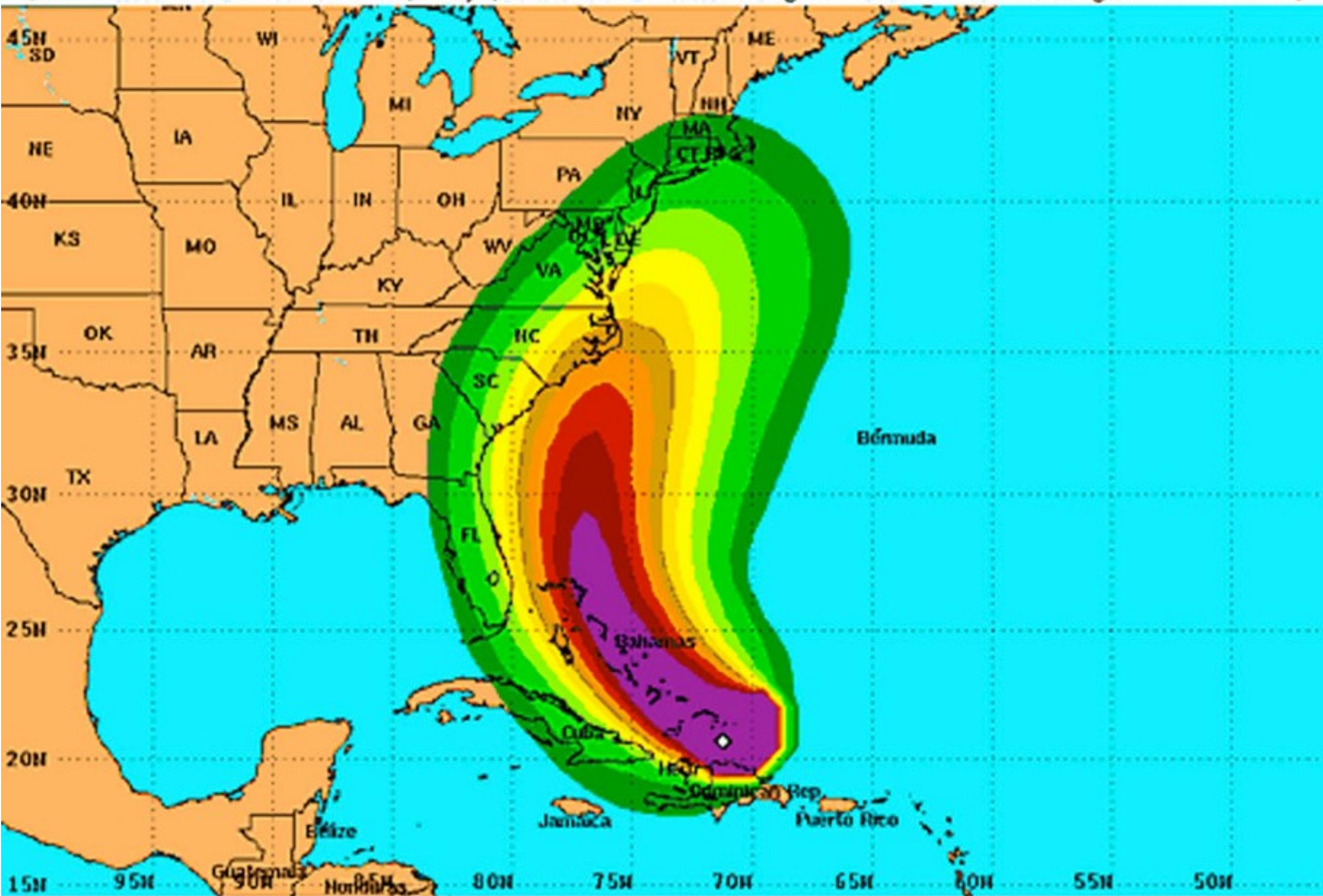
BIN THE DATA





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

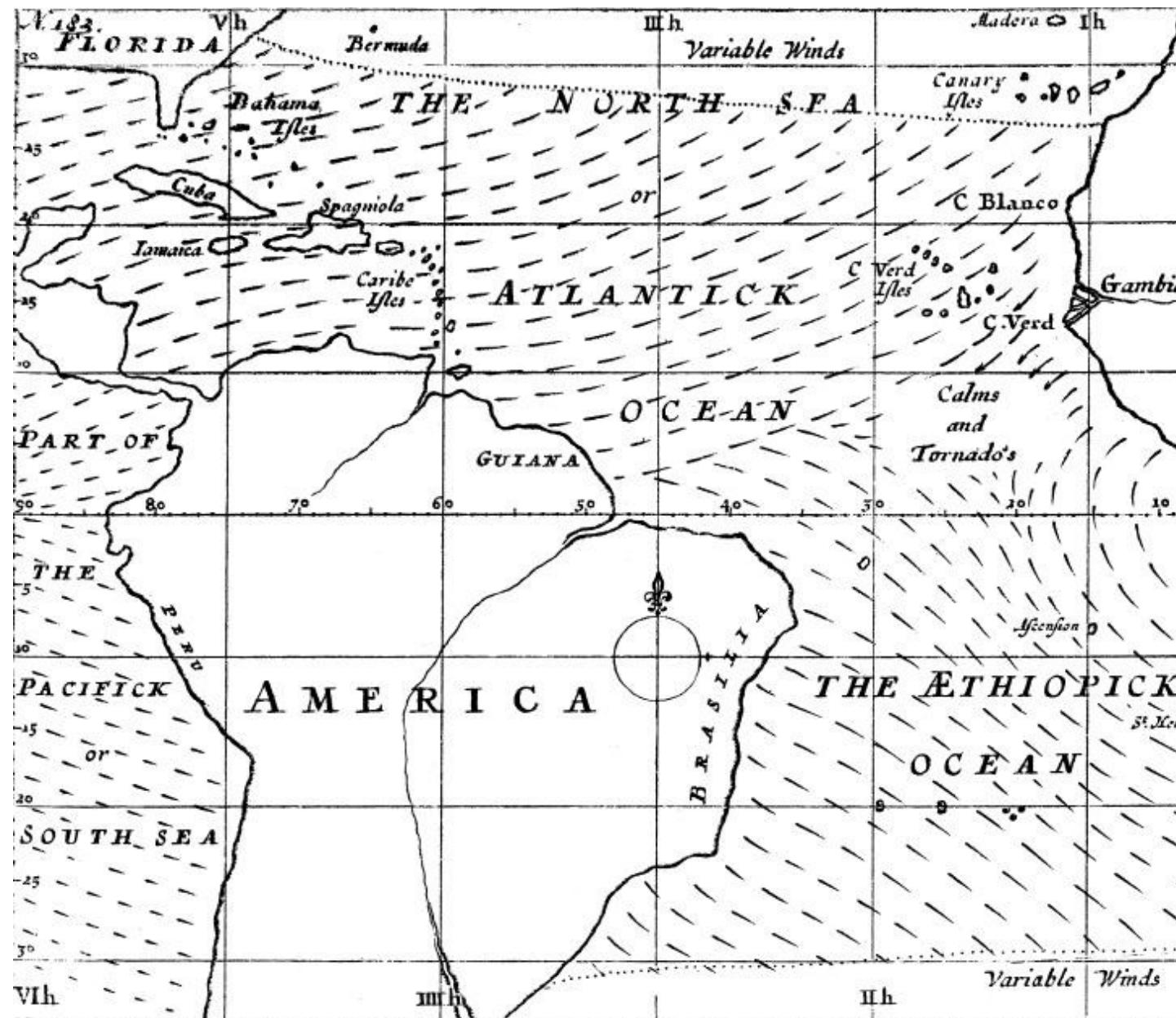
◆ indicates HURRICANE IRENE center location at 2 PM EDT Tue Aug 23 2011 (Forecast/Advisory #14)



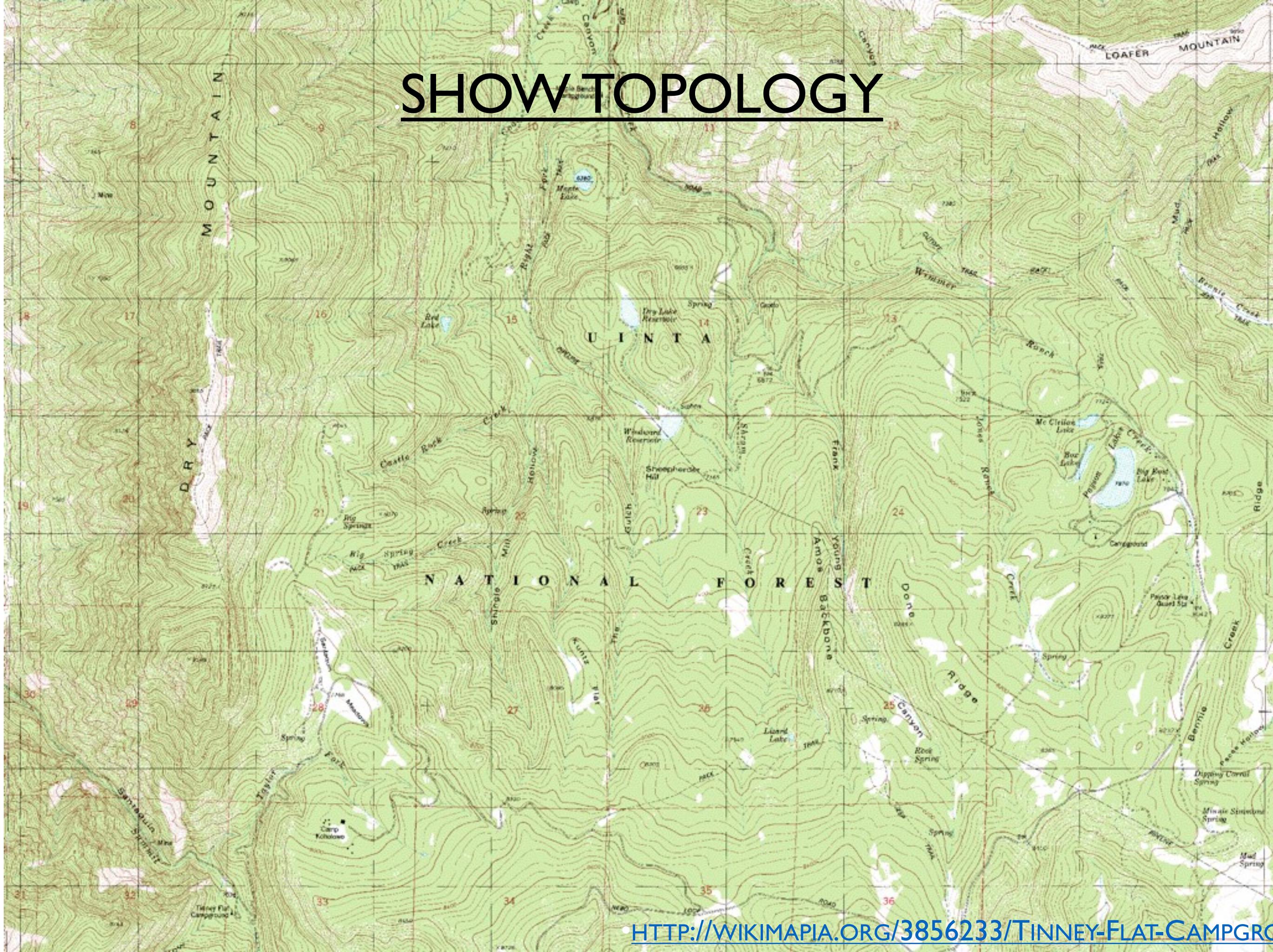
ISOCURVES

WIND MAP

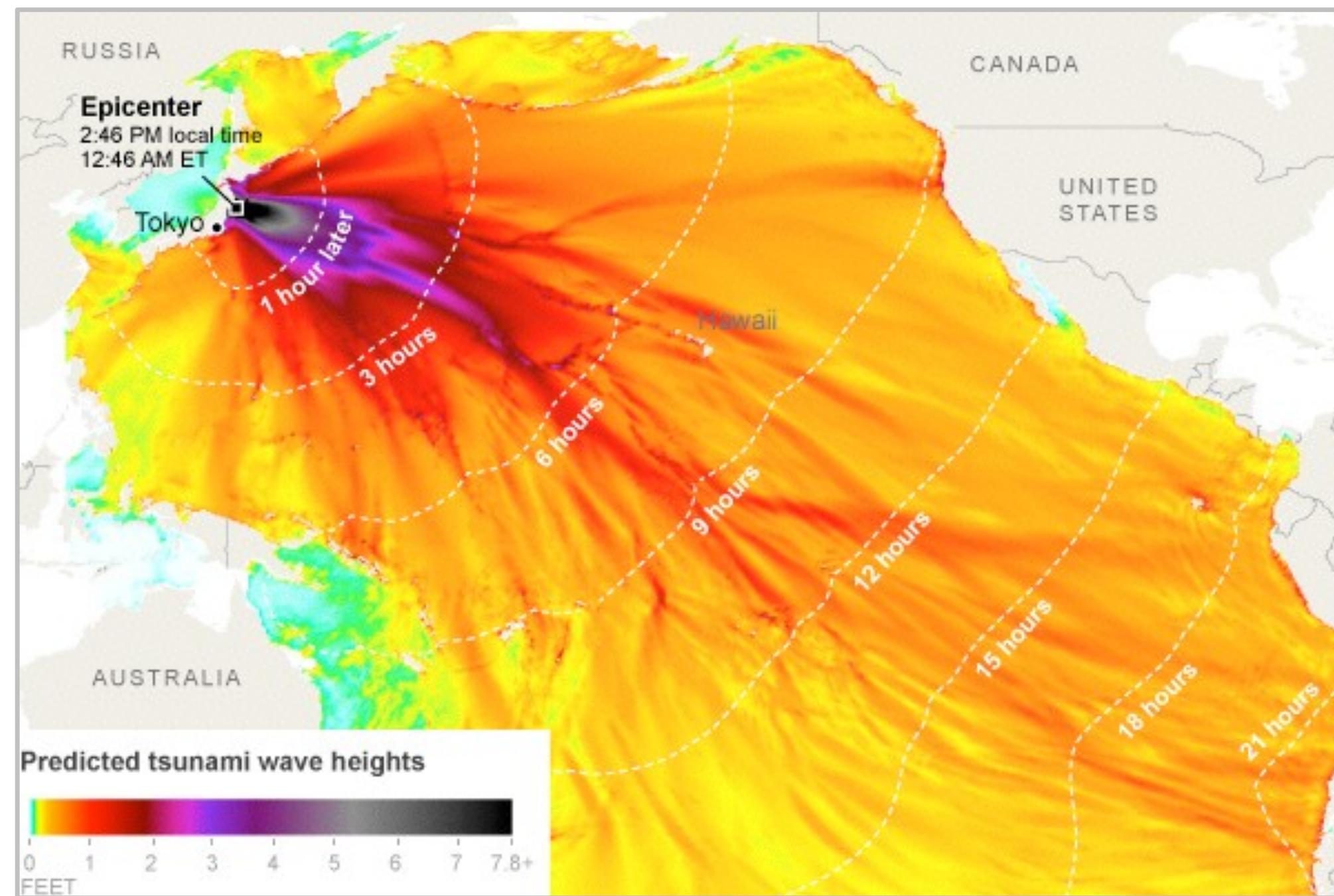
first weather map



SHOW TOPOLOGY



SHOW TIME



CHOROPLETHS

How Americans Think About Climate Change, in Six Maps

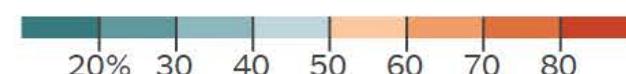
By NADJA POPOVICH, JOHN SCHWARTZ and TATIANA SCHLOSSBERG MARCH 21, 2017

Americans overwhelmingly believe that global warming is happening, and that carbon emissions should be scaled back. But fewer are sure that the changes will harm them personally. New data released by Yale researchers gives the most detailed view yet of public opinion on global warming.

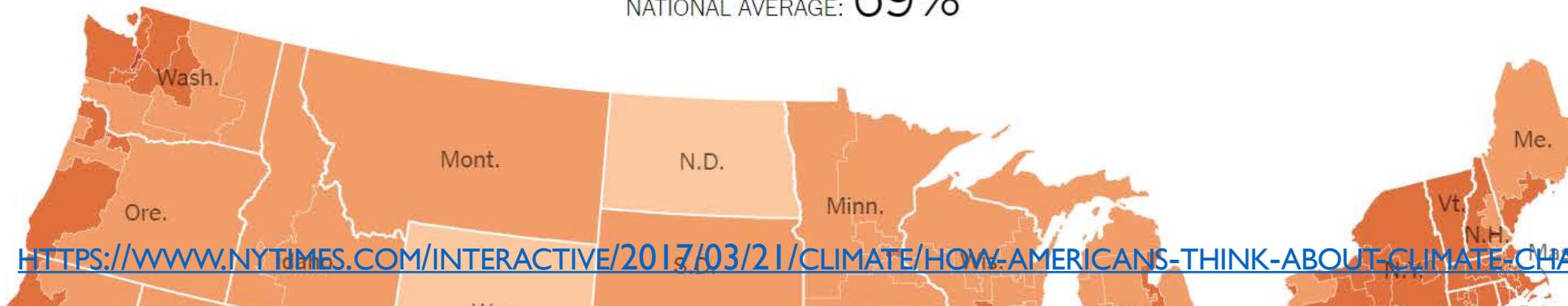
Americans want to restrict carbon emissions from coal power plants.

The White House and Congress may do the opposite.

Percentage of adults per congressional district who support strict CO₂ limits on existing coal-fired power plants



NATIONAL AVERAGE: 69%



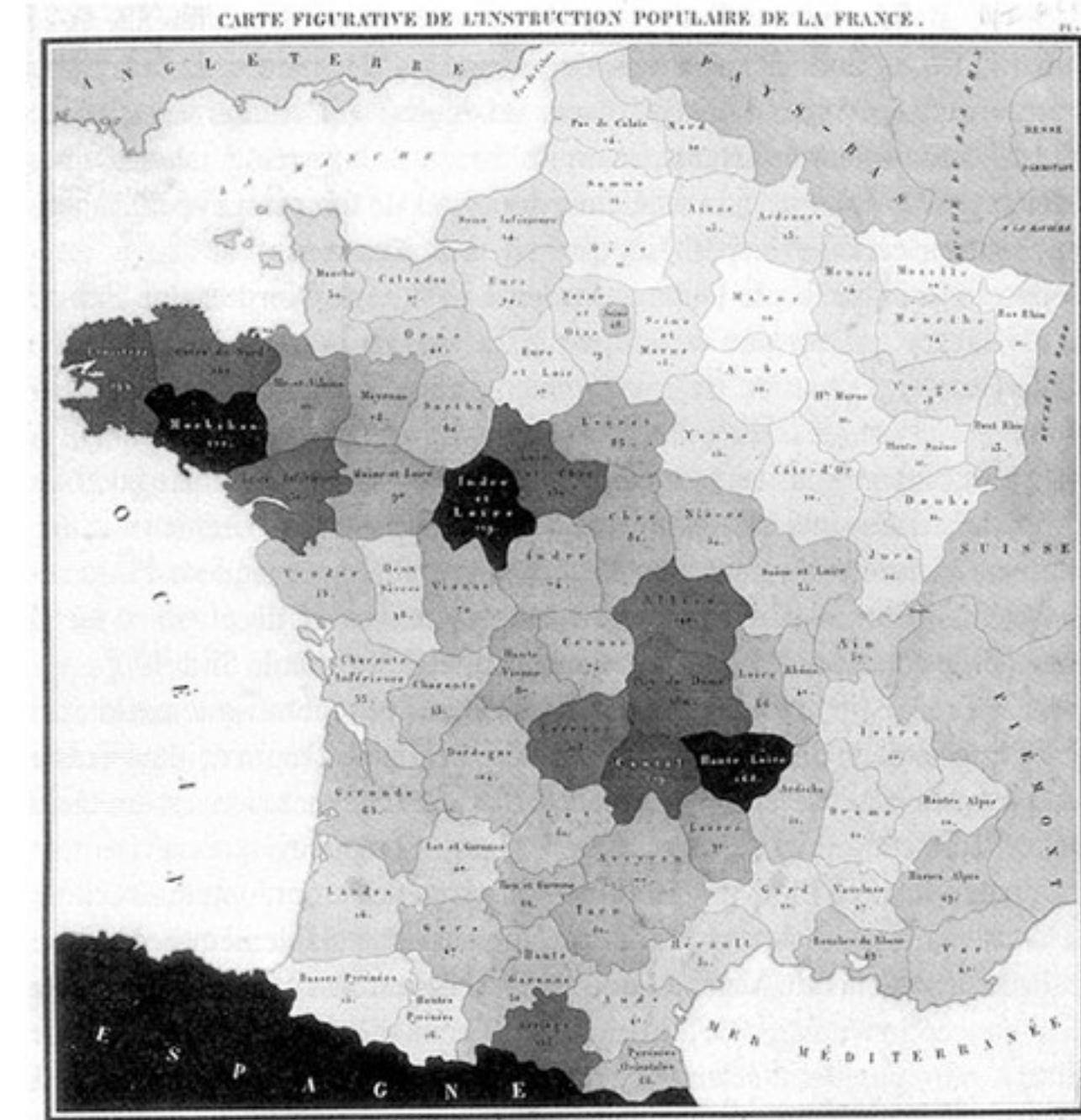
[HTTPS://WWW.NYTIMES.COM/INTERACTIVE/2017/03/21/CLIMATE/HOW-AMERICANS-THINK-ABOUT-CLIMATE-CHANGE-IN-SIX-MAPS.HTML?_R=0](https://www.nytimes.com/interactive/2017/03/21/climate/how-americans-think-about-climate-change-in-six-maps.html?_r=0)



CHOROPLETH

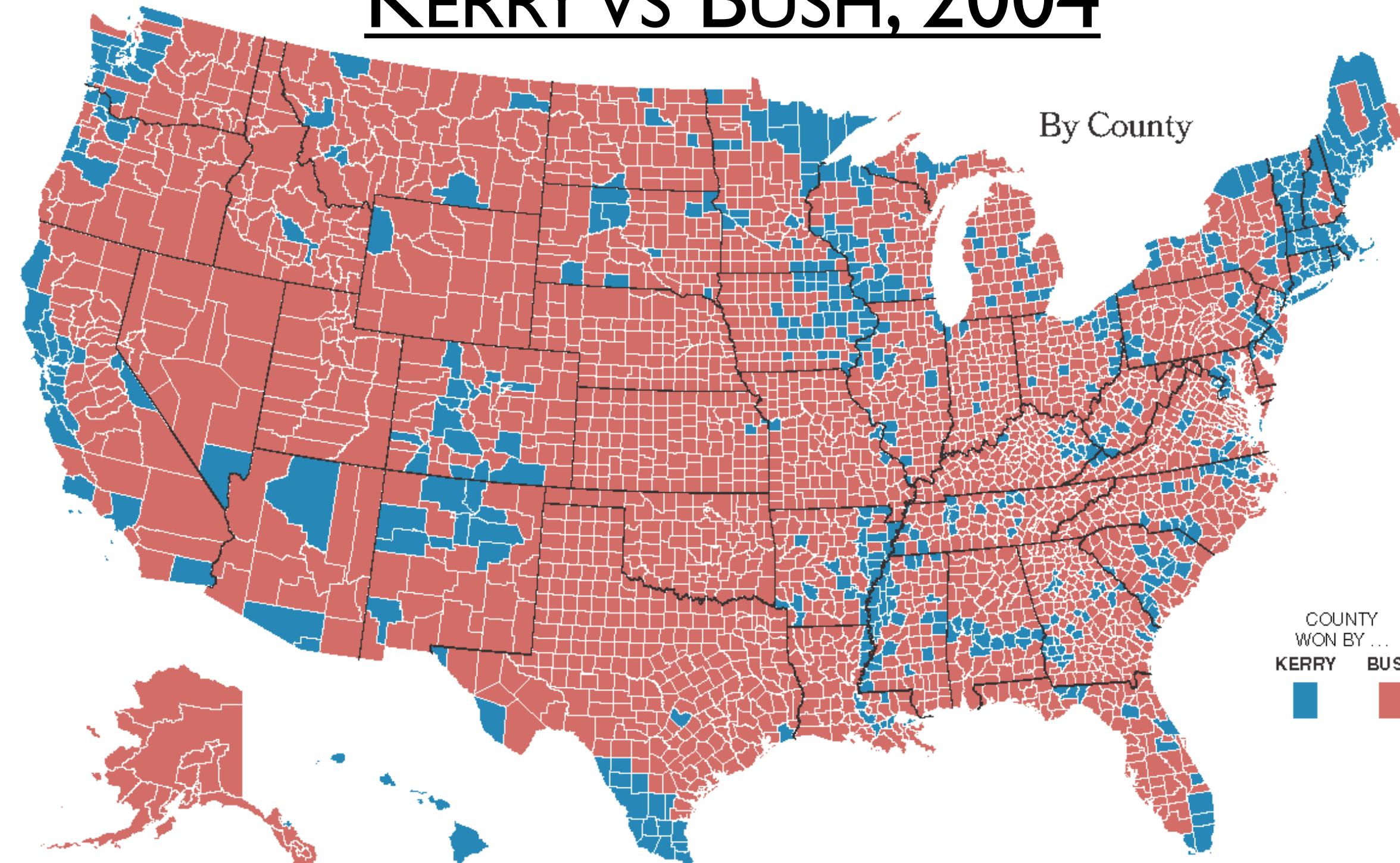
map in which areas are shaded, colored, or patterned relative to a data attribute value

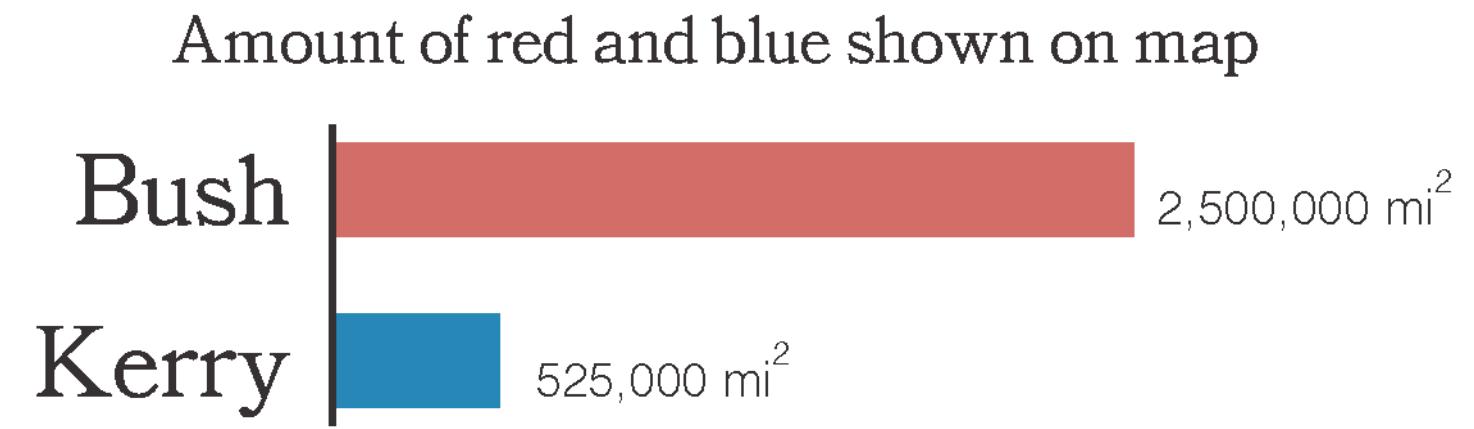
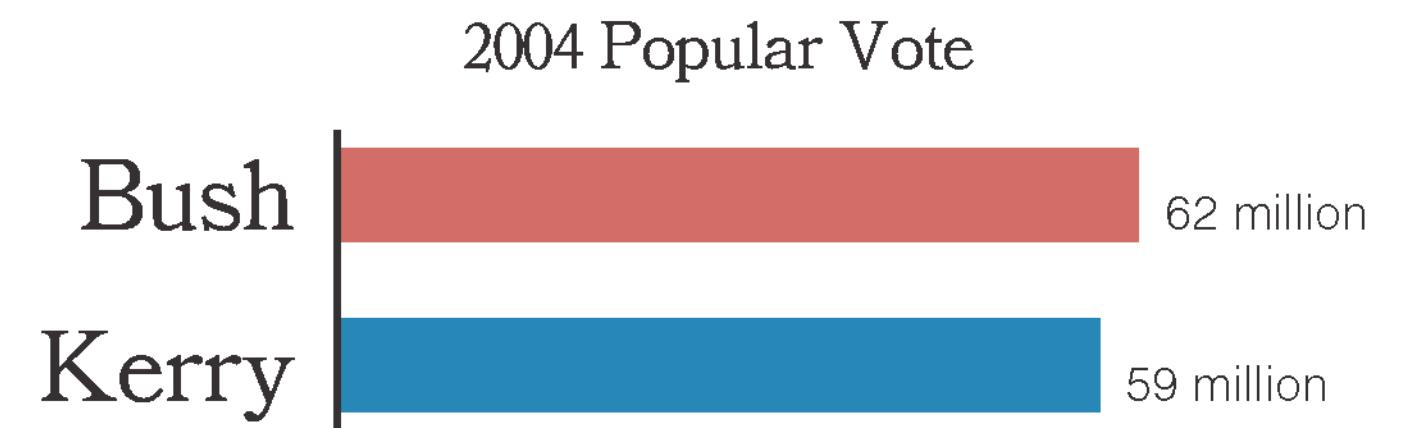
Illiteracy in France
first choropleth map

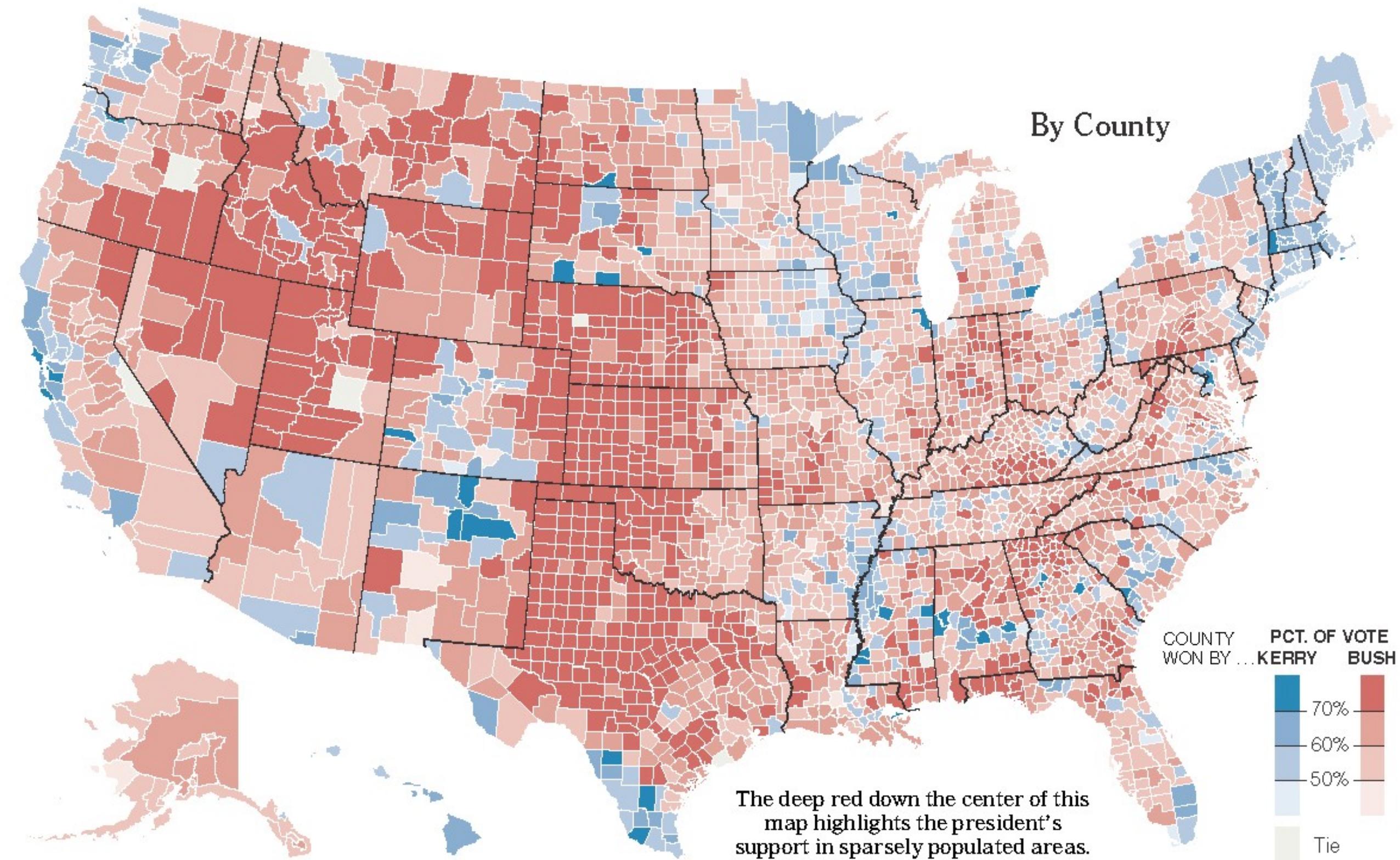


Charles Dupin, 1826

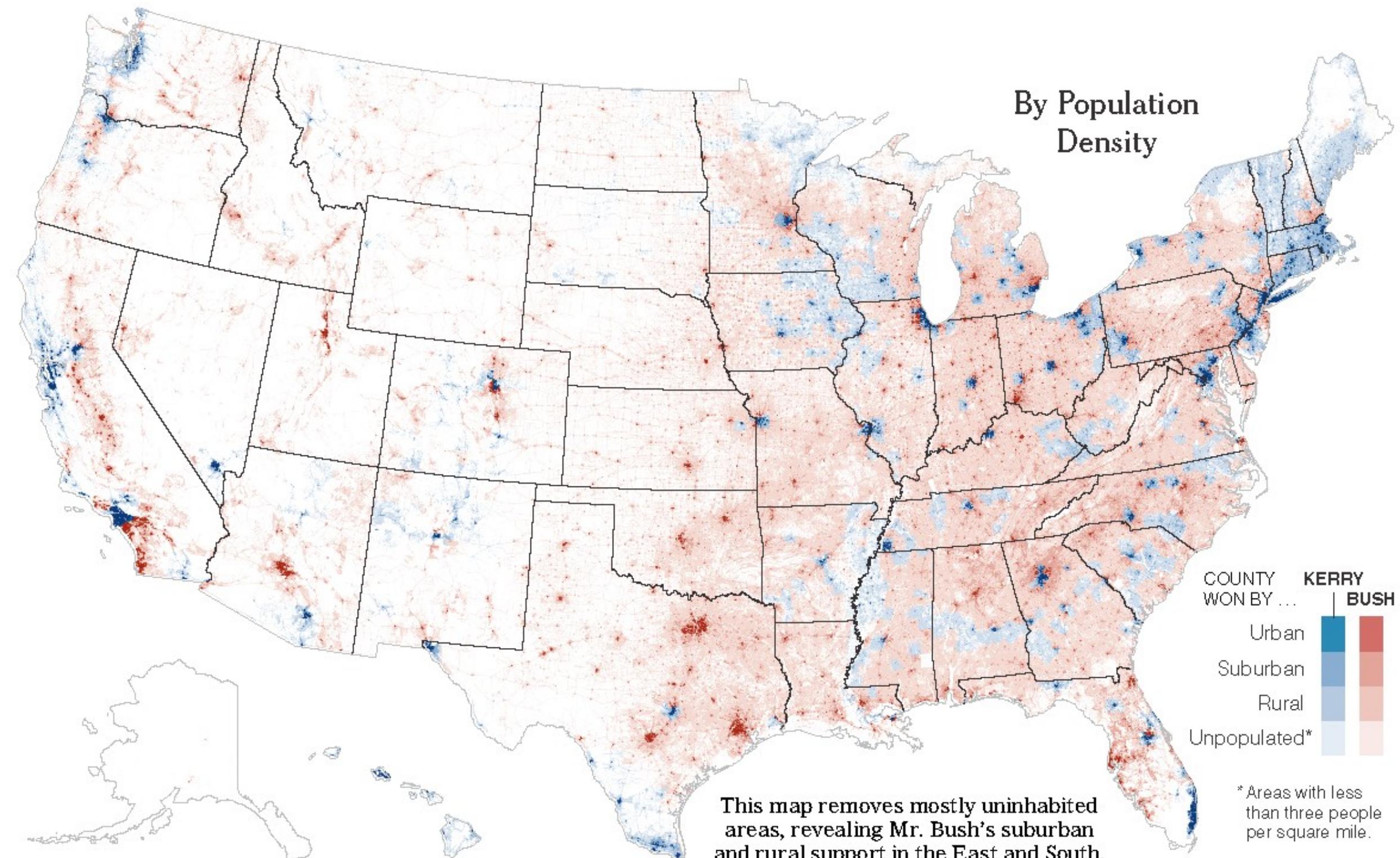
KERRY VS BUSH, 2004





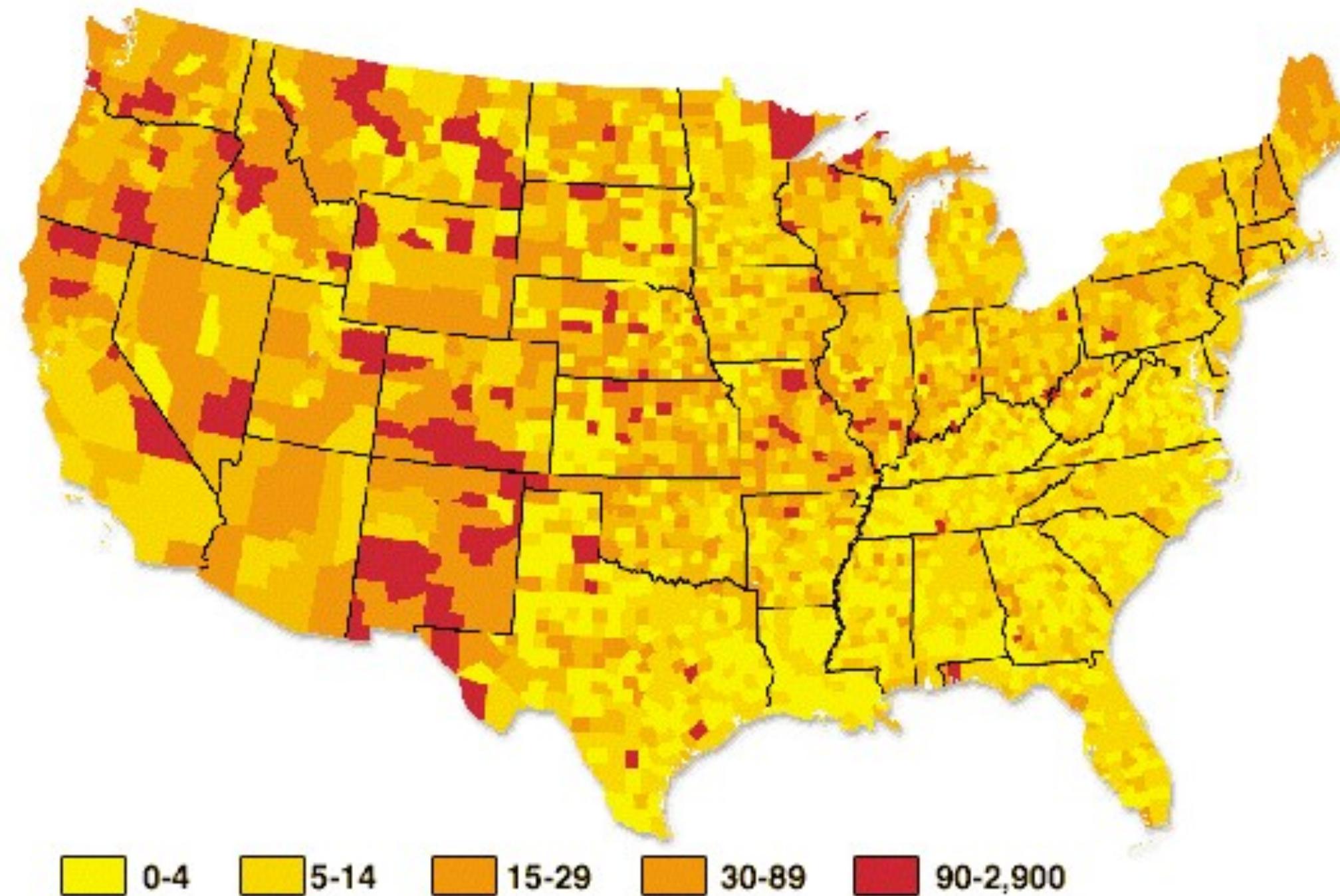


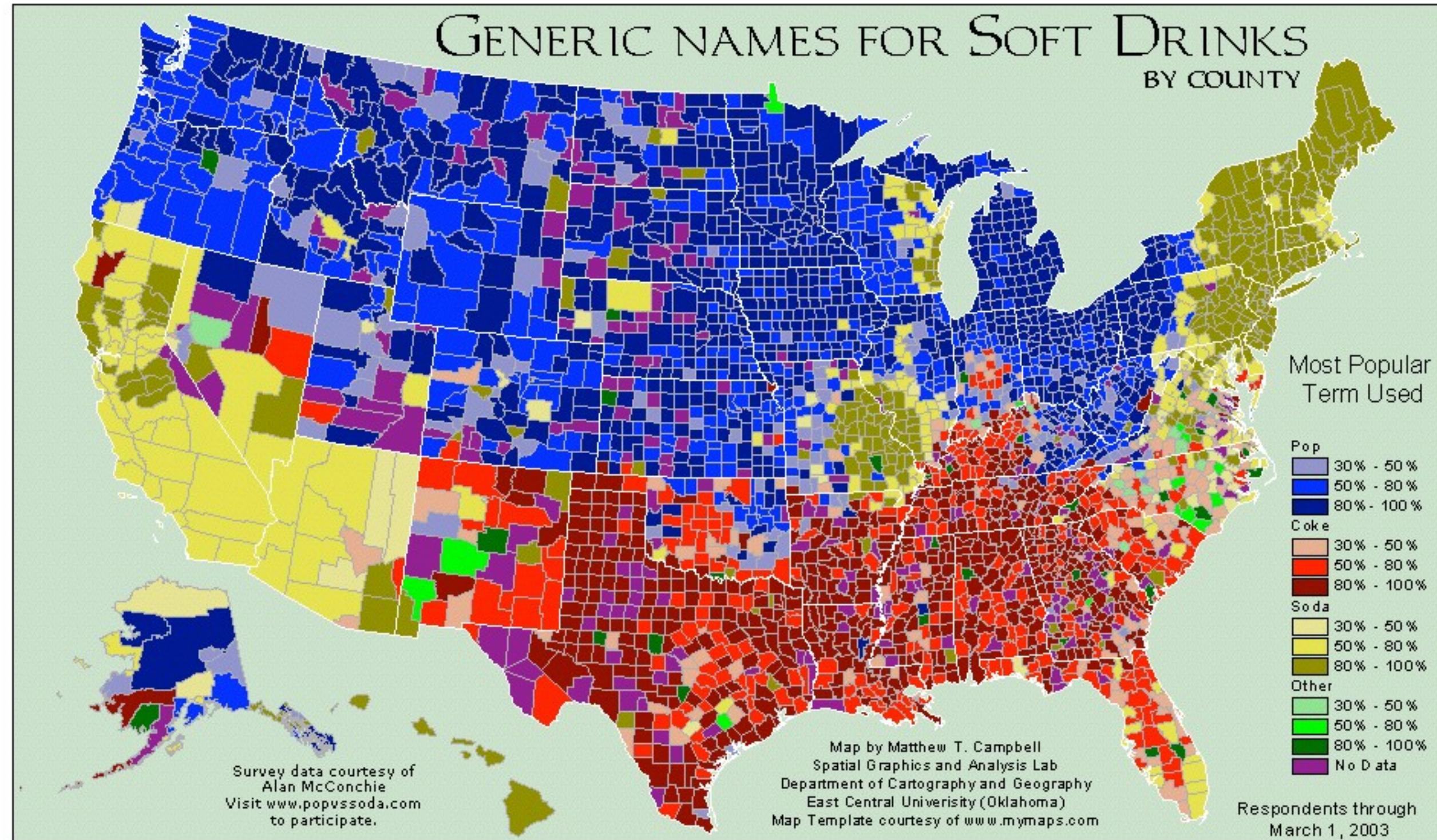
MATTHEW ERICSON, NY TIMES



MATTHEW ERICSON, NY TIMES

UFO HOTSPOTS

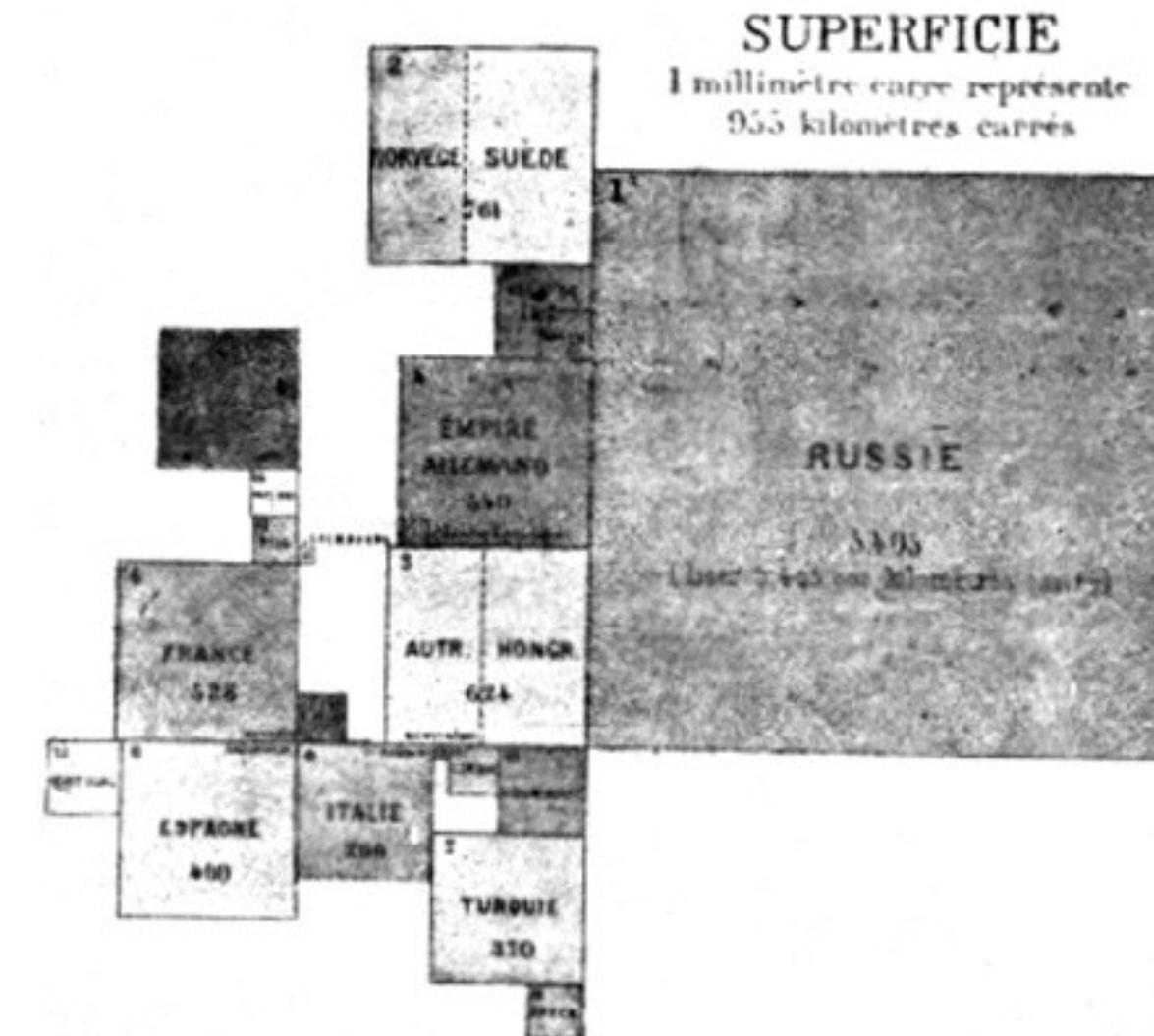




CARTOGRAM

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

Land Area
first cartogram
STATISTIQUE FIGURATIVE



Emile Levasseur, 1868

RECTANGULAR CARTOGRAM

2006 ELECTION GUIDE

SENATE RACES

HOUSE RACES

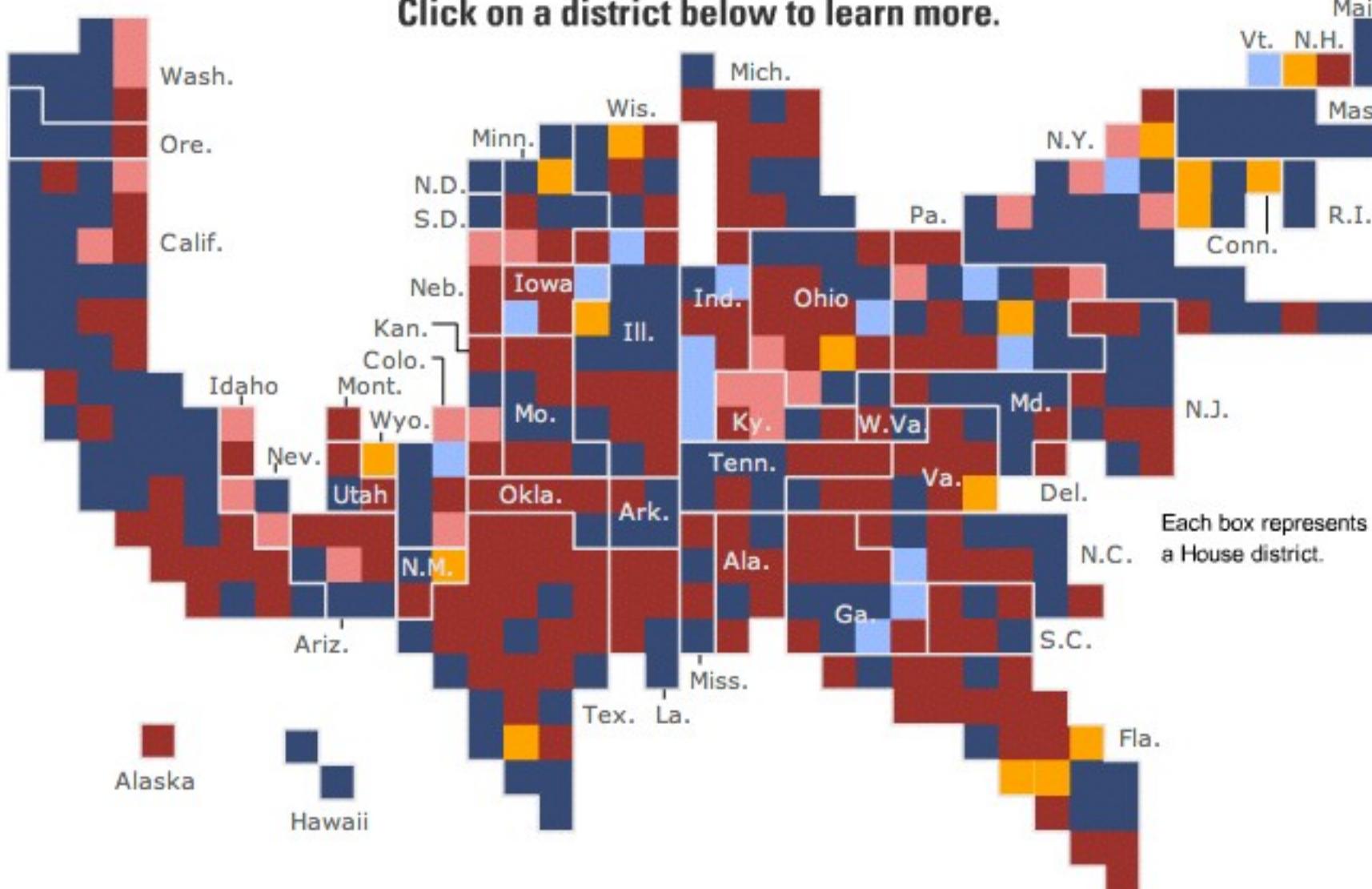
GOVERNORS' RACES

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.



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

Races to watch ?

Open races

Switch districts ?

Urbanization

Urban Suburban Rural Mixed

Race/Ethnicity

White Black Hispanic

Median income

<\$30K \$30-50K >\$50K

RESET

[WORLD](#) [U.S.](#) [N.Y. / REGION](#) [BUSINESS](#) [TECHNOLOGY](#) [SCIENCE](#) [HEALTH](#) [SPORTS](#) [OPINION](#) [ARTS](#) [STYLE](#) [TRAVEL](#) [JOBS](#) [REAL ESTATE](#) [AUTOS](#)[Search Business](#)[Financial Tools](#)

Select a Financial Tool

[More in Business »](#)[World Business](#)[Markets](#)[Economy](#)[DealBook](#)[Media & Advertising](#)[Small Business](#)[Your Money](#)

THE MOST REWARDS IN BUSINESS



LEARN MORE >

MORE INFO

September 4, 2008

[E-MAIL](#) | [FEEDBACK](#)

What Your Global Neighbors Are Buying

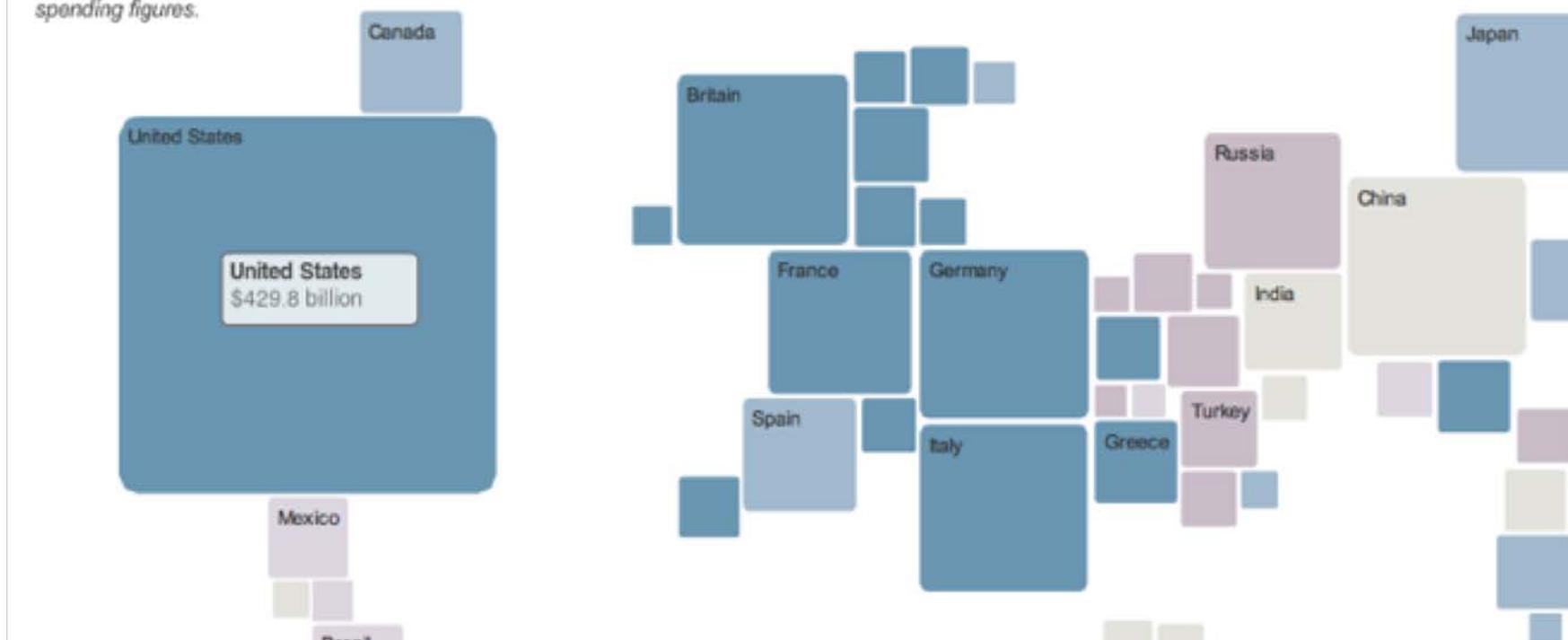
How people spend their discretionary income – the cash that goes to clothing, electronics, recreation, household goods, alcohol – depends a lot on where they live. People in Greece spend almost 13 times more money on clothing as they do on electronics. People living in Japan spend more on recreation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

PER CAPITA SPENDING
0 \$100 200 400 1,000

Roll over countries to see spending figures.



Population

first nonrectangular cartogram

Apportionment Map of the United States

BY WILLIAM B. BAILEY, PH.D.

ASSISTANT PROFESSOR OF POLITICAL ECONOMY IN YALE UNIVERSITY.



William Bailey, 1910

Population and Federal Taxes

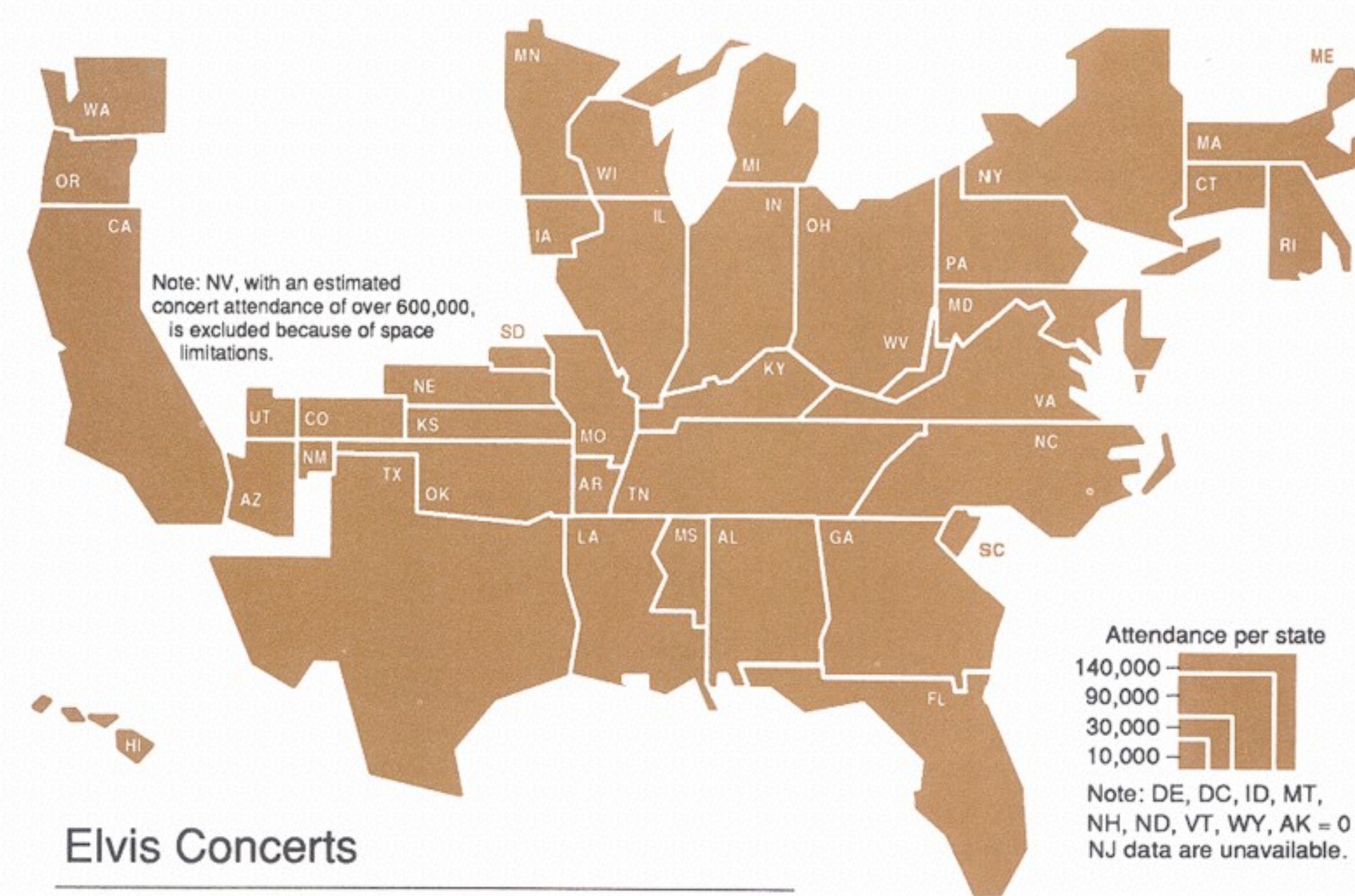
first modern cartogram

GRUNDY'S MAP OF THE UNITED STATES



Joseph Grundy, 1929

AREA SCALED BY DATA



Attendance per State, 1970 - 1977

Source: Stanley, David E., with Frank Coffey. *The Elvis Encyclopedia*.
Santa Monica, CA.: General Publishing Group, Inc , 1994.

© 1995 Andrew Dent and Linda Turnbull

KERRY VS. BUSH, 2004

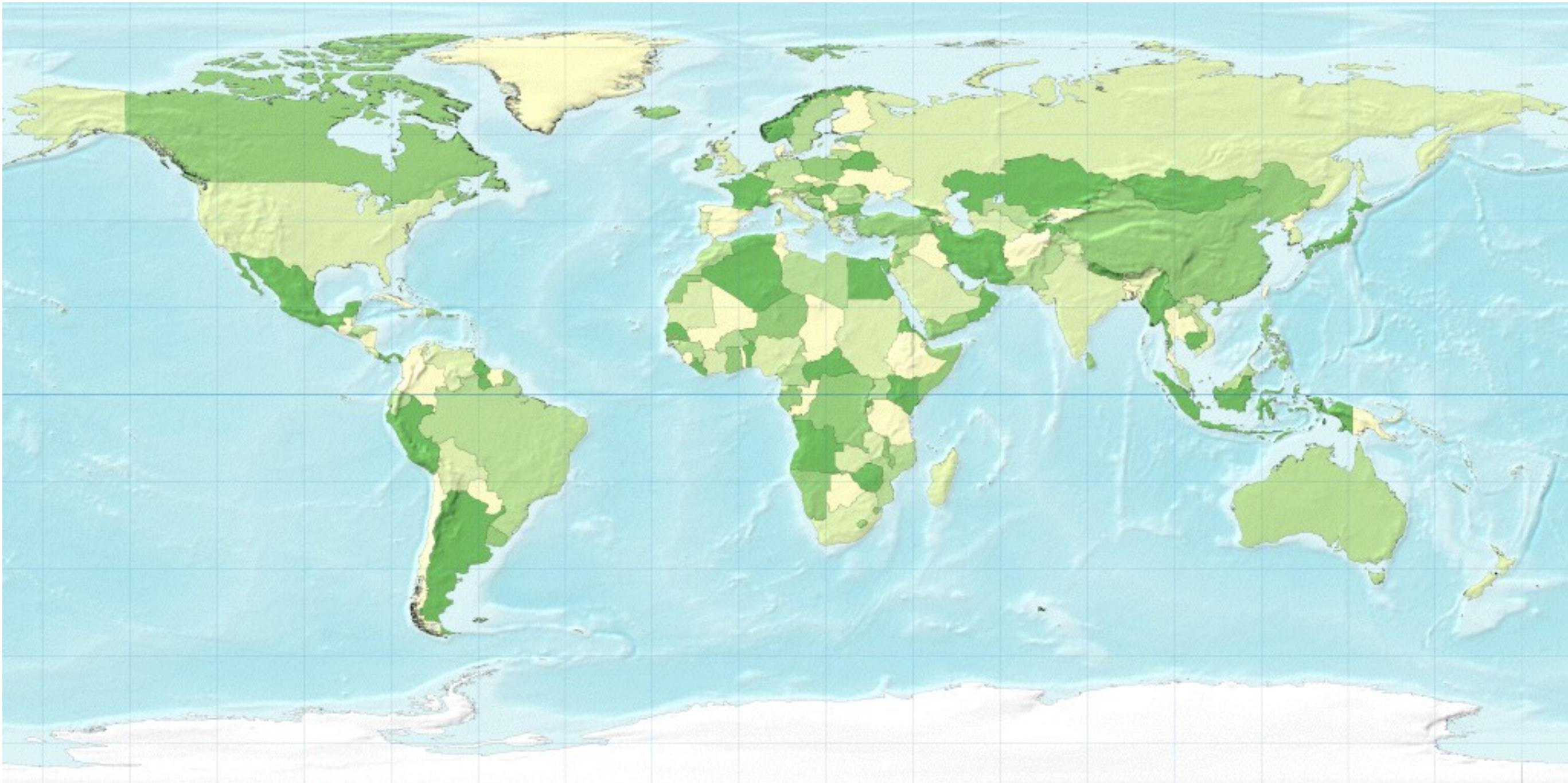


Michael Gastner,
Cosma Shalizi, and
Mark Newman

University of Michigan

distortion via diffusion

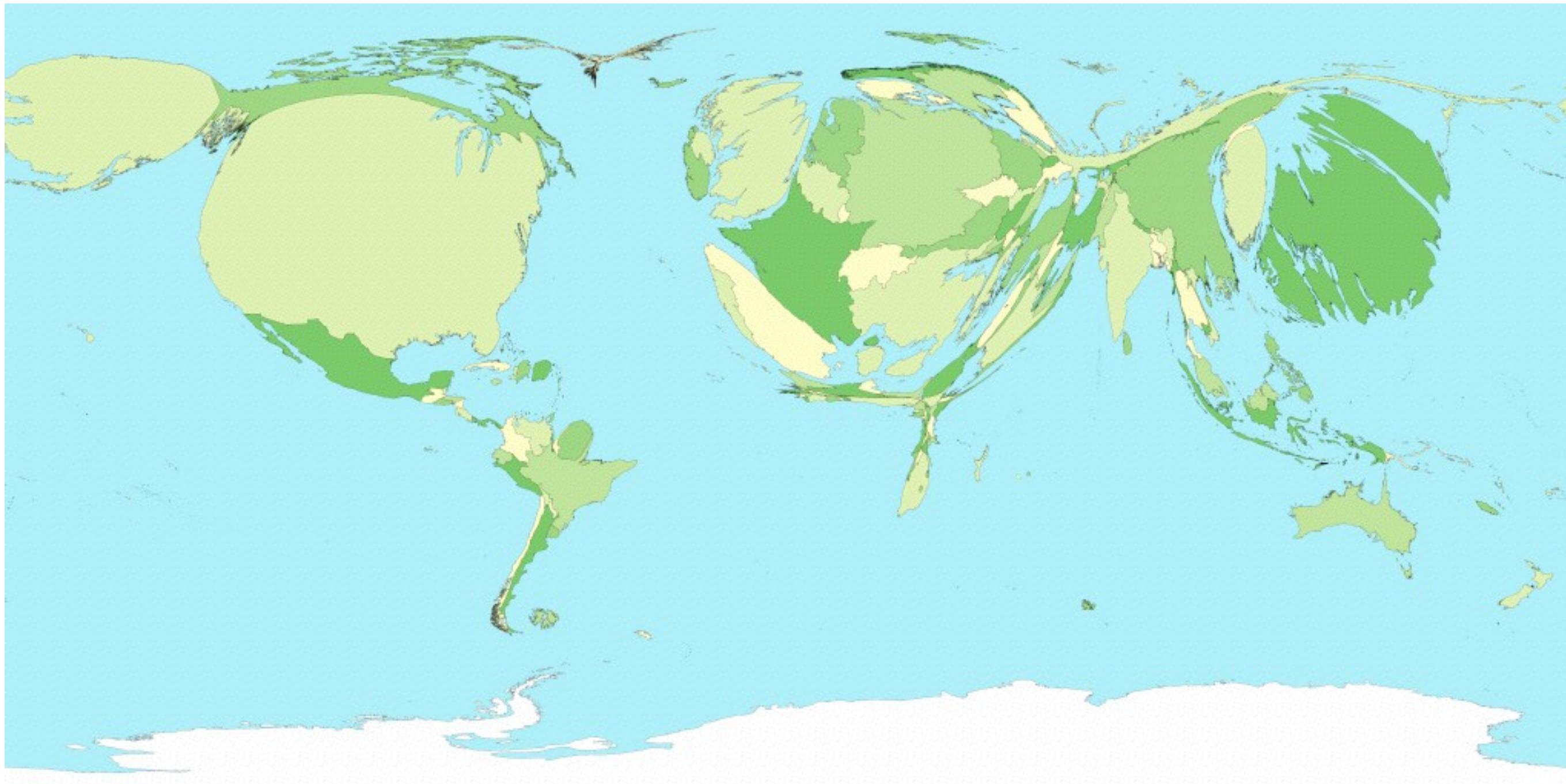
THE WORLD



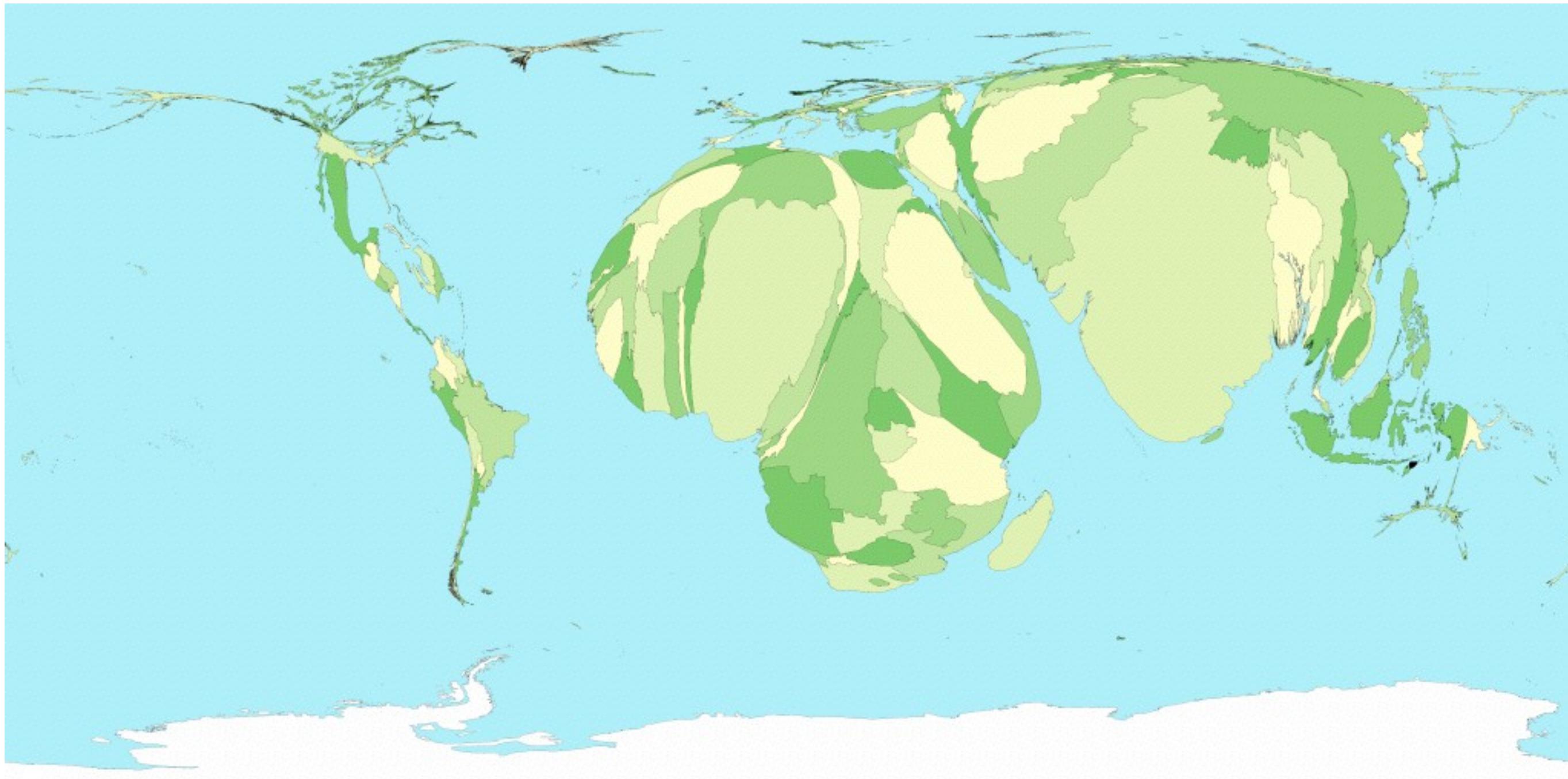
POPULATION



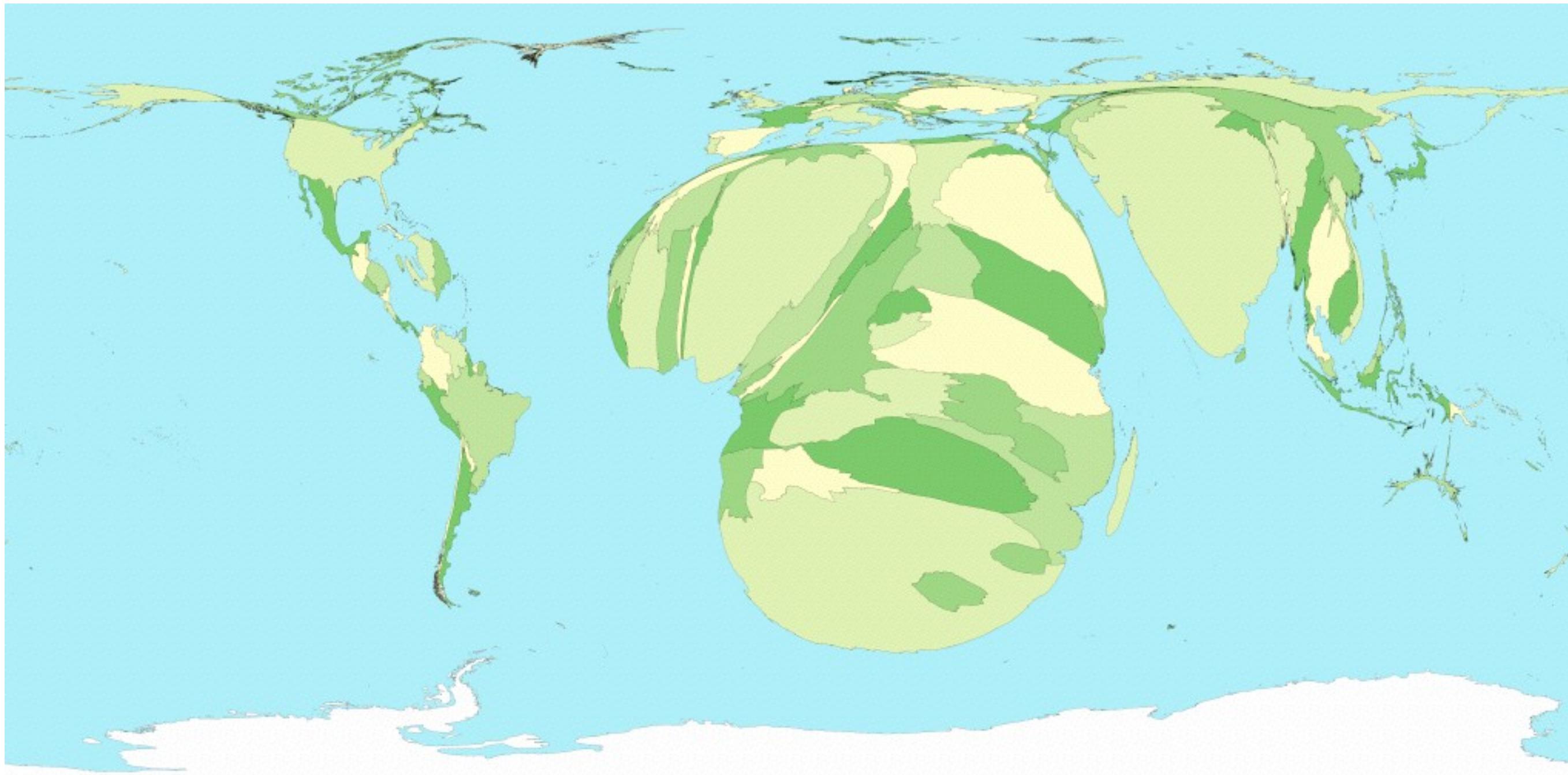
GDP



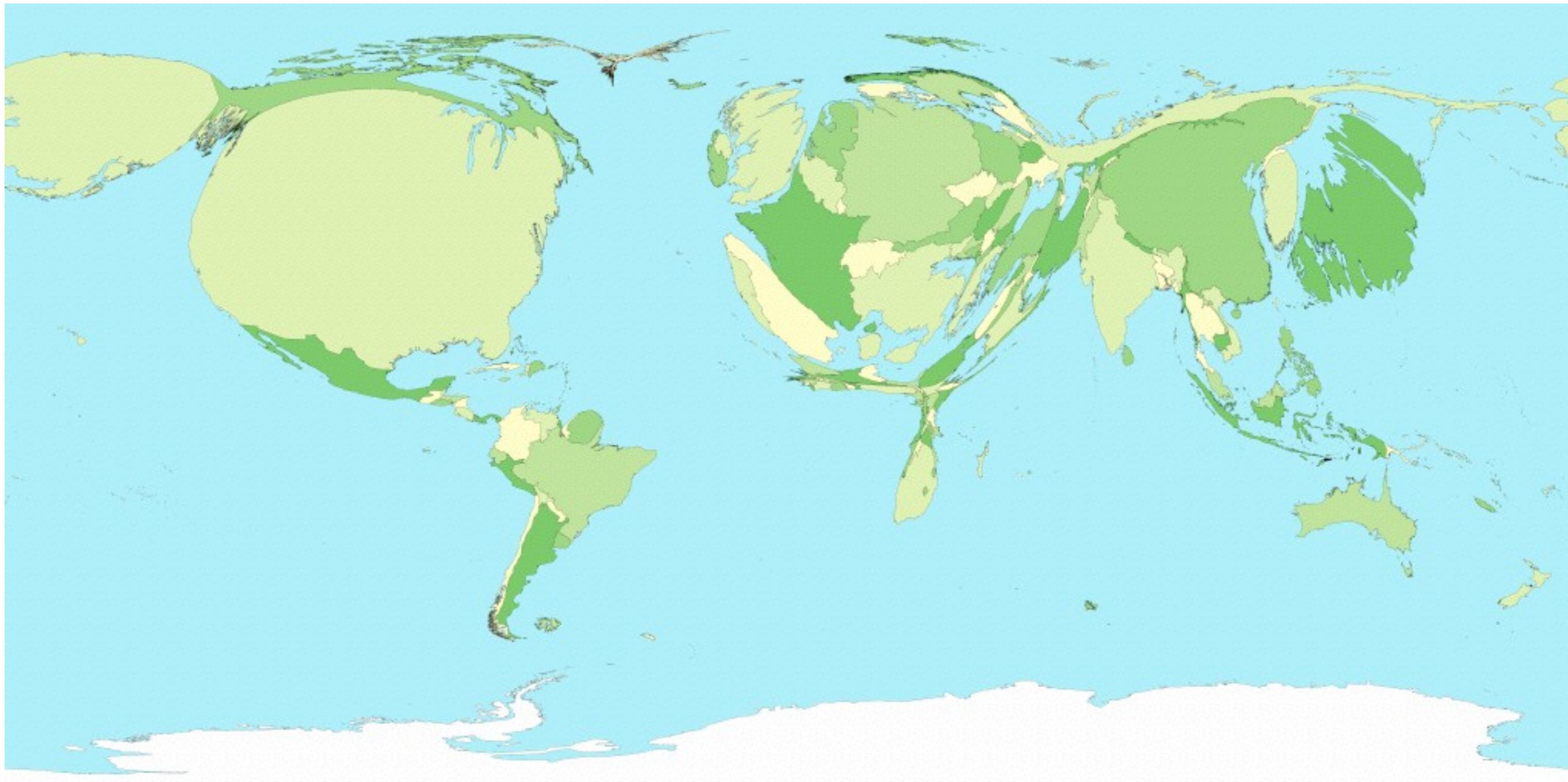
CHILD MORTALITY



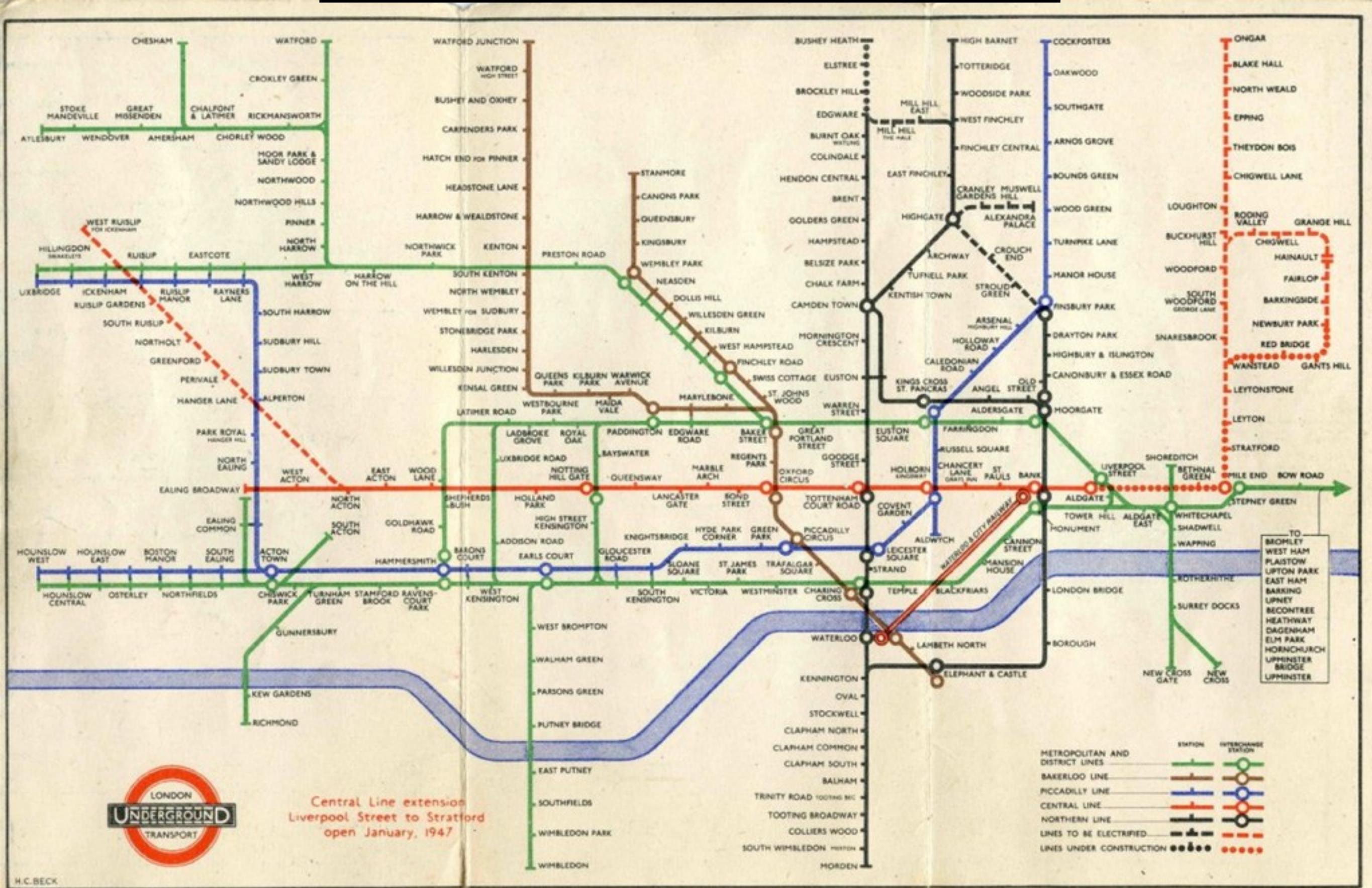
PEOPLE LIVING WITH HIV/AIDS



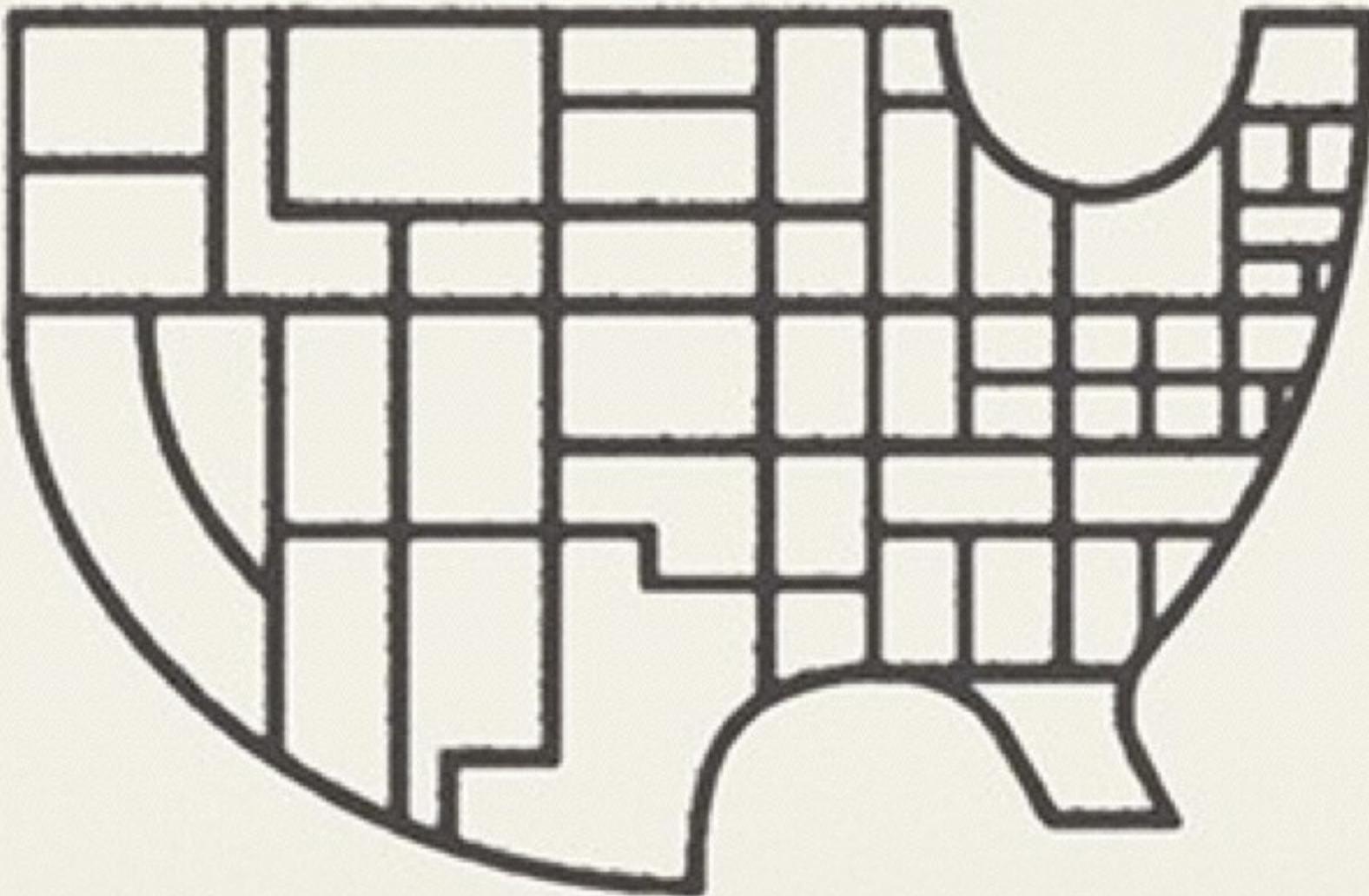
TOTAL SPENDING ON HEALTHCARE



HARRY BECK'S TUBE MAP



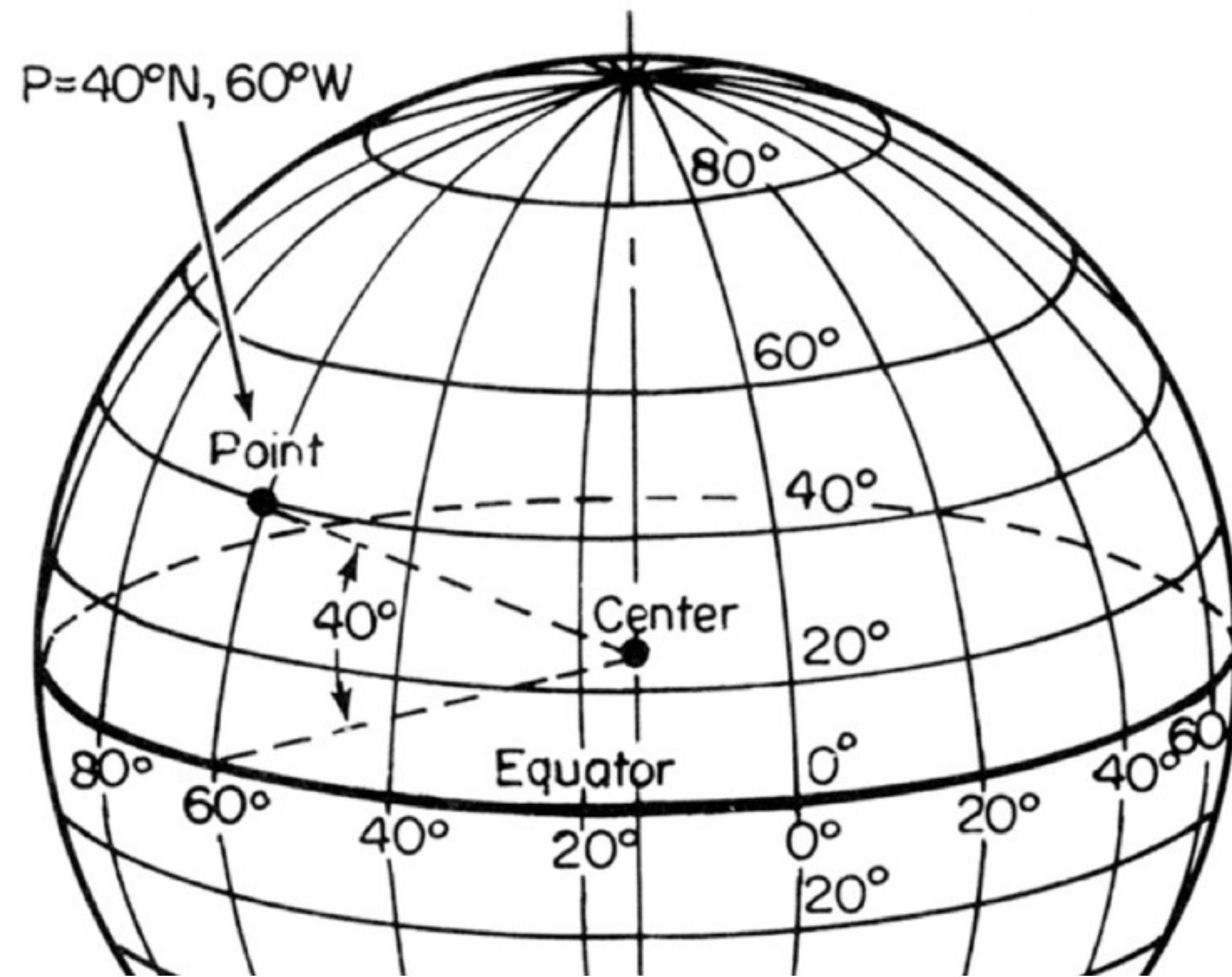
DO THEY WORK?



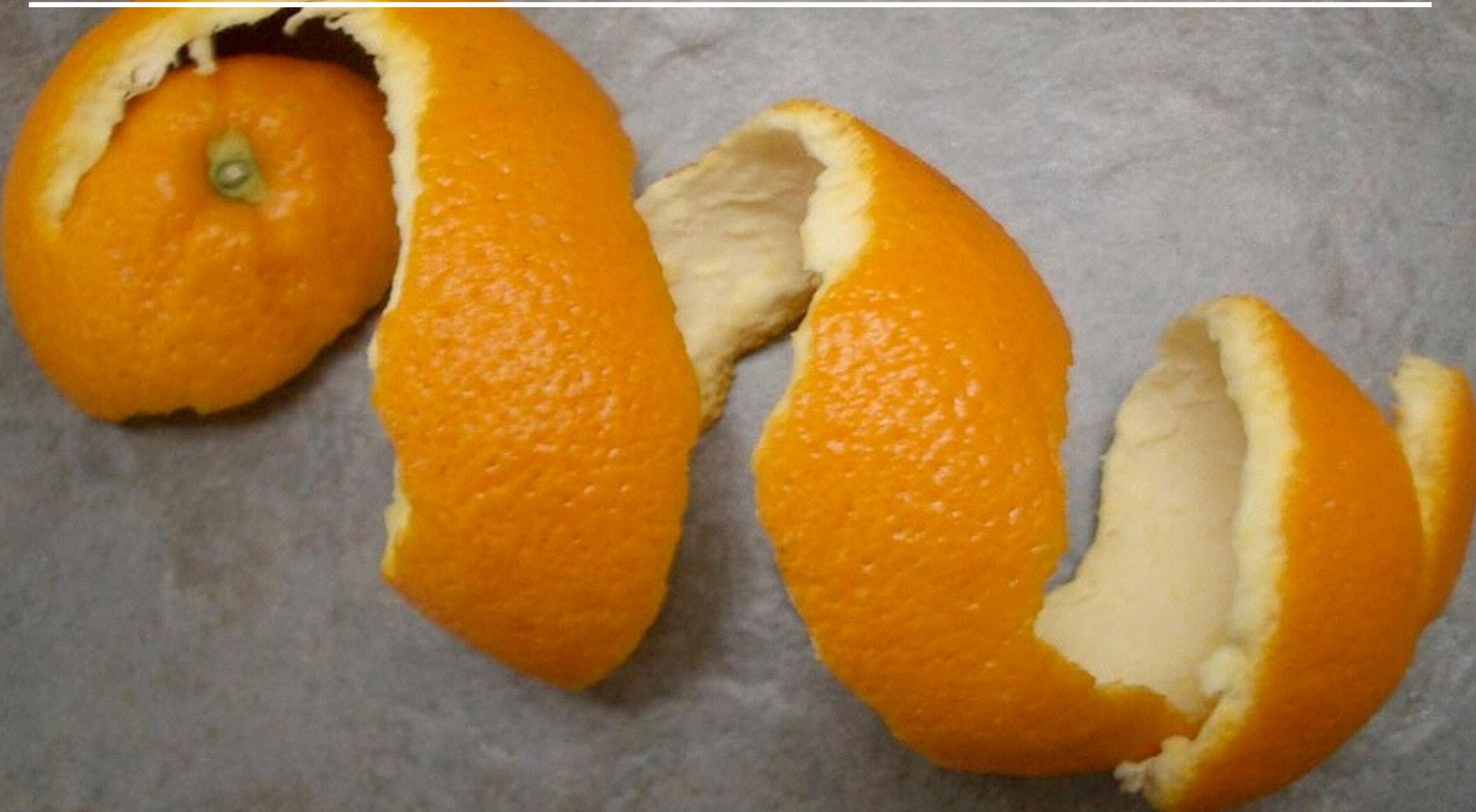
PROJECTIONS

flattening the globe

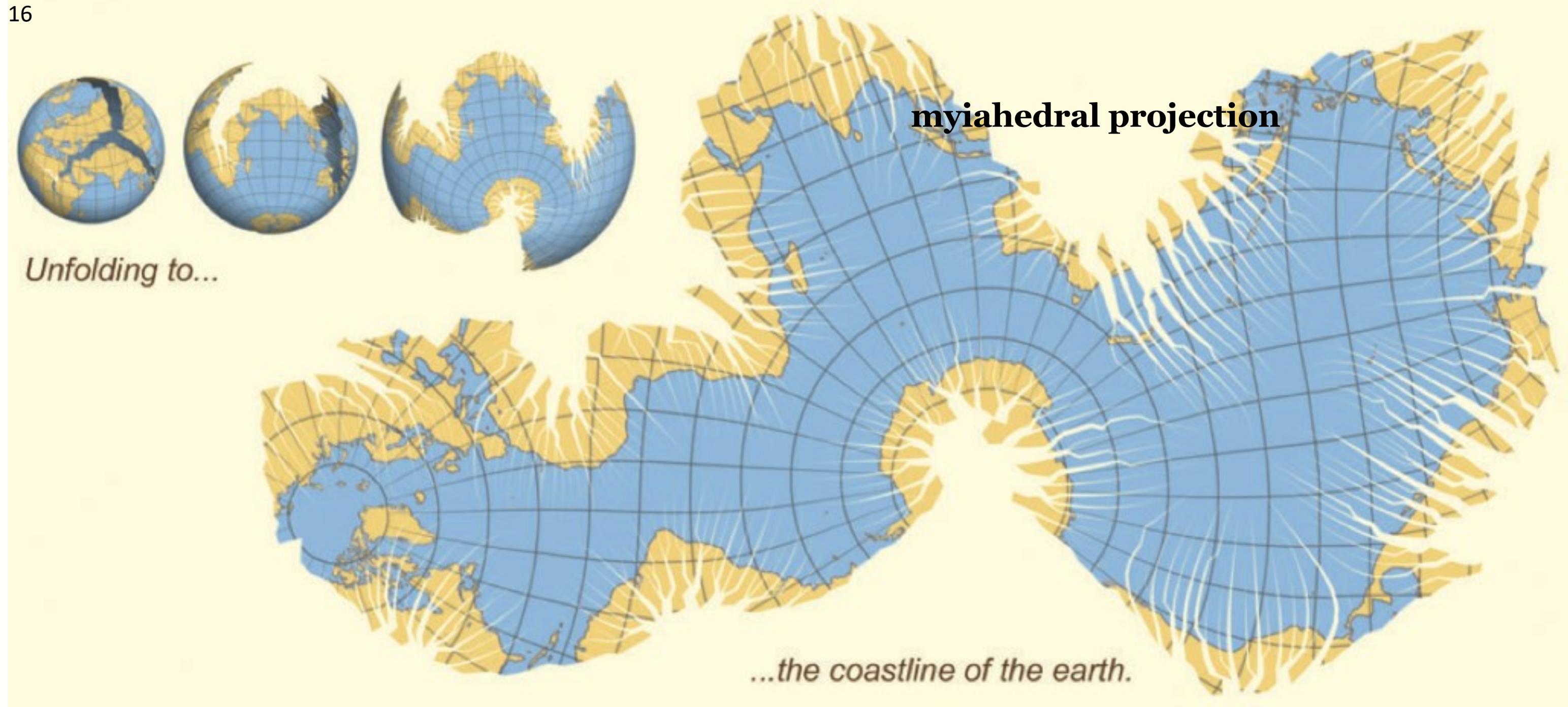
LATITUDE, LONGITUDE



A SPHERE TEARS WHEN YOU FLATTEN IT



MANY WAYS TO TEAR...



WHAT YOUR FAVORITE
MAP PROJECTION
SAYS ABOUT YOU

MERCATOR



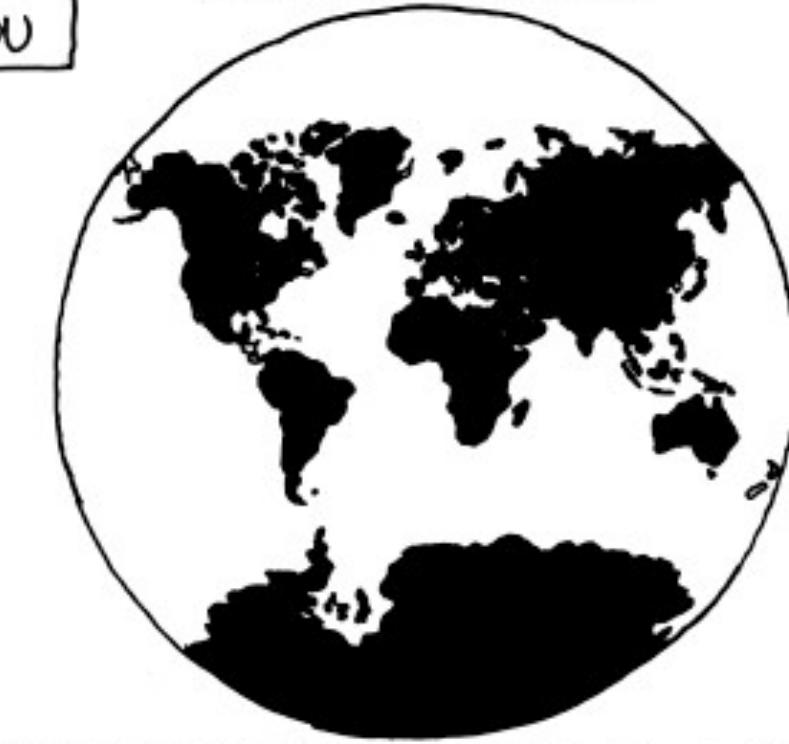
YOU'RE NOT REALLY INTO MAPS.

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.

VAN DER GRIJNEN



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!

Dymaxion



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

WINKEL-TRIPEL



NATIONAL GEOGRAPHIC ADOPTED THE WINKEL-TRIPEL IN 1998, BUT YOU'VE BEEN A WT FAN SINCE LONG BEFORE "NAT GEO" SHOWED UP. YOU'RE WORRIED IT'S GETTING PLAYED OUT, AND ARE THINKING OF SWITCHING TO THE KAVRAYSKY. YOU ONCE LEFT A PARTY IN DISGUST WHEN A GUEST SHOWED UP WEARING SHOES WITH TOES. YOUR FAVORITE MUSICAL GENRE IS "POST-".

HOB-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.

A GLOBE!

GOODE HOMOLOSONE



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.

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.

WATERMAN BUTTERFLY



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.

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.

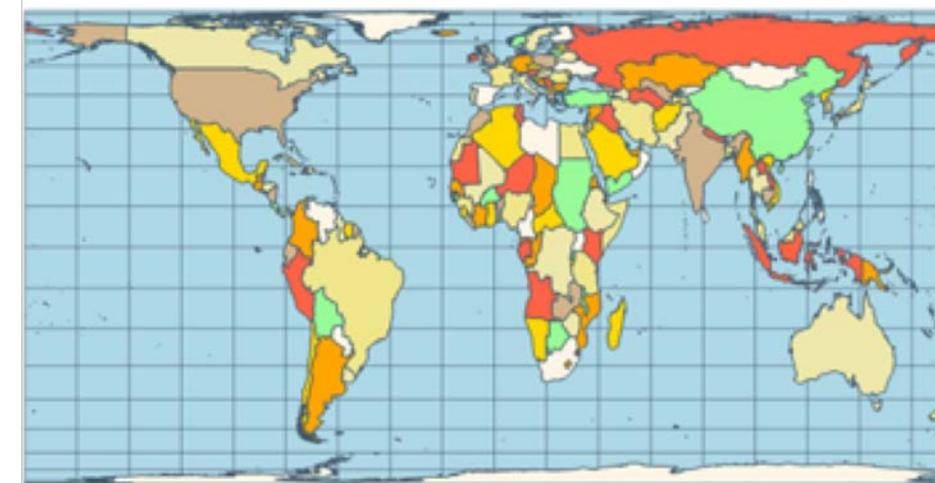
CLASSES OF PROJECTION

What map features would you like to maintain?

AZIMUTHAL
preserves direction



EQUAL-AREA
preserves area



CONFORMAL
preserves local shapes

