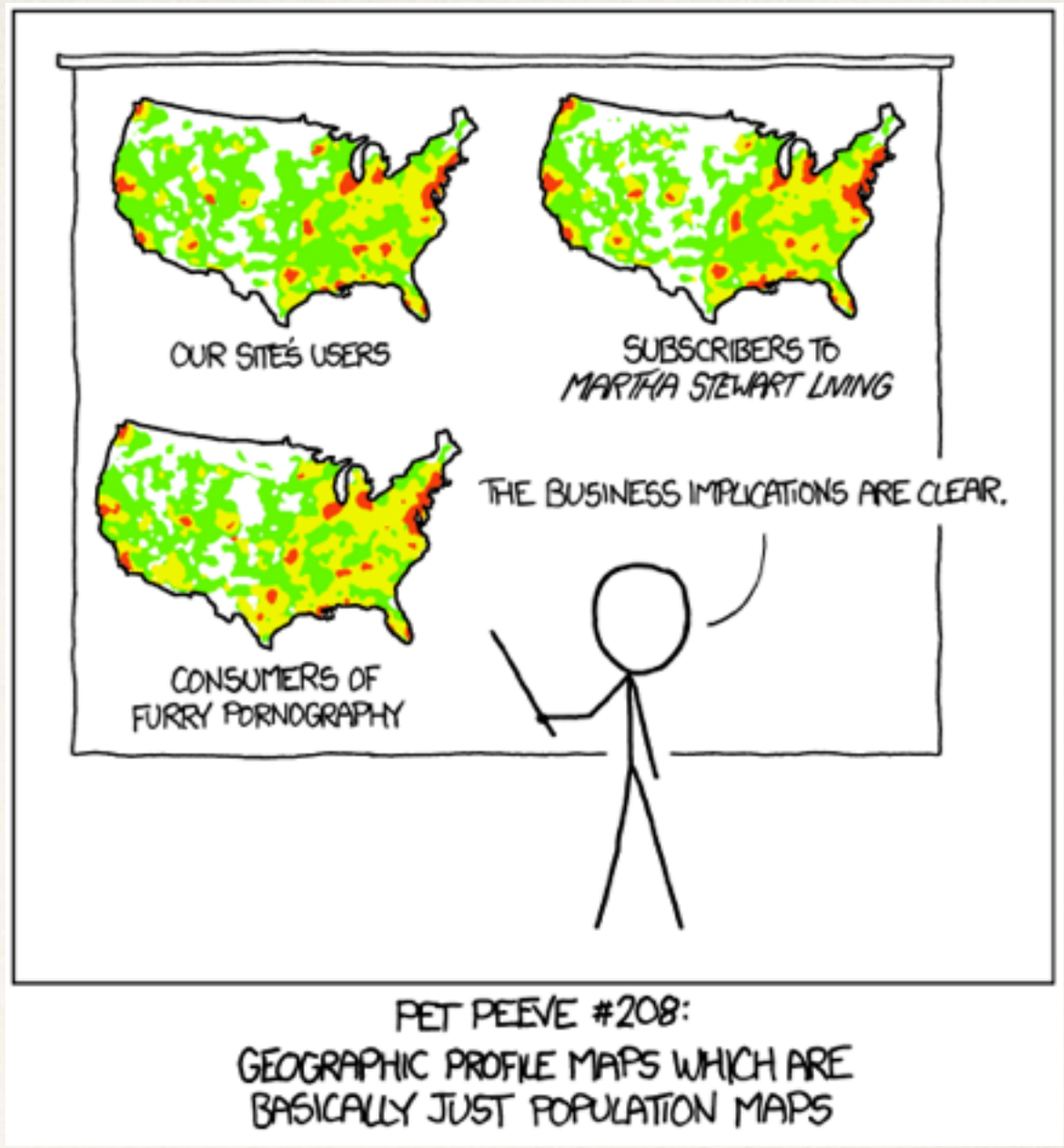


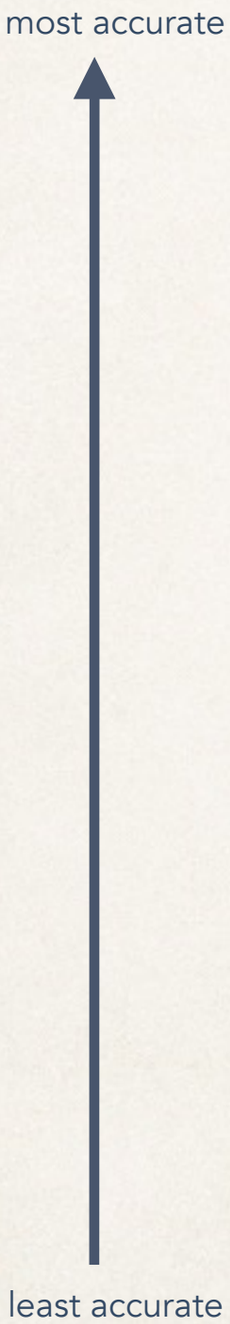
http://xkcd.com/1138/

Geospatial Visualization

C. Andrews

2016-04-26

Quantitative estimation ranking



position, aligned scale

position, identical nonaligned scales

length

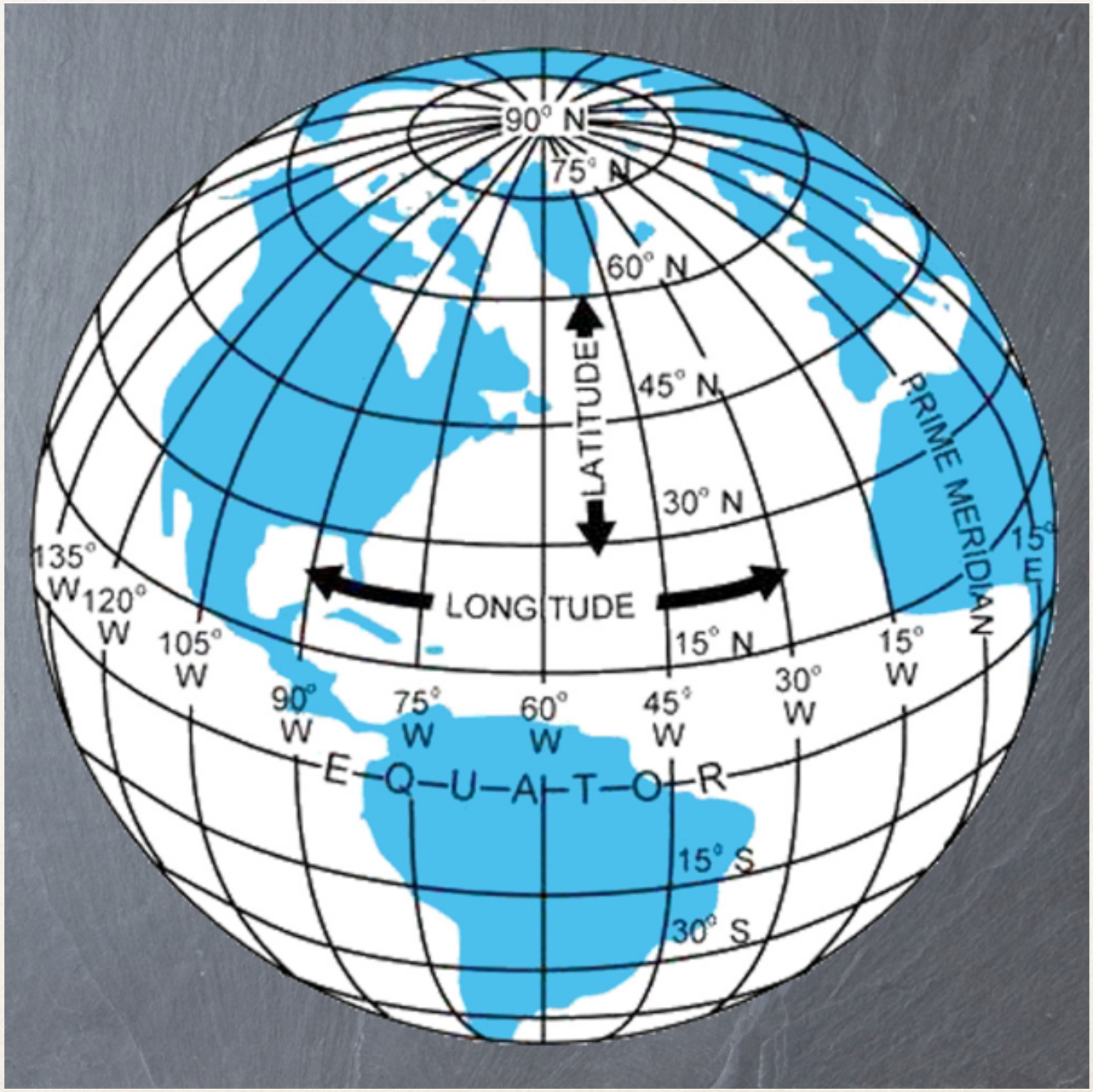
angle, slope

area, volume

color

Cleveland and McGill, 1984

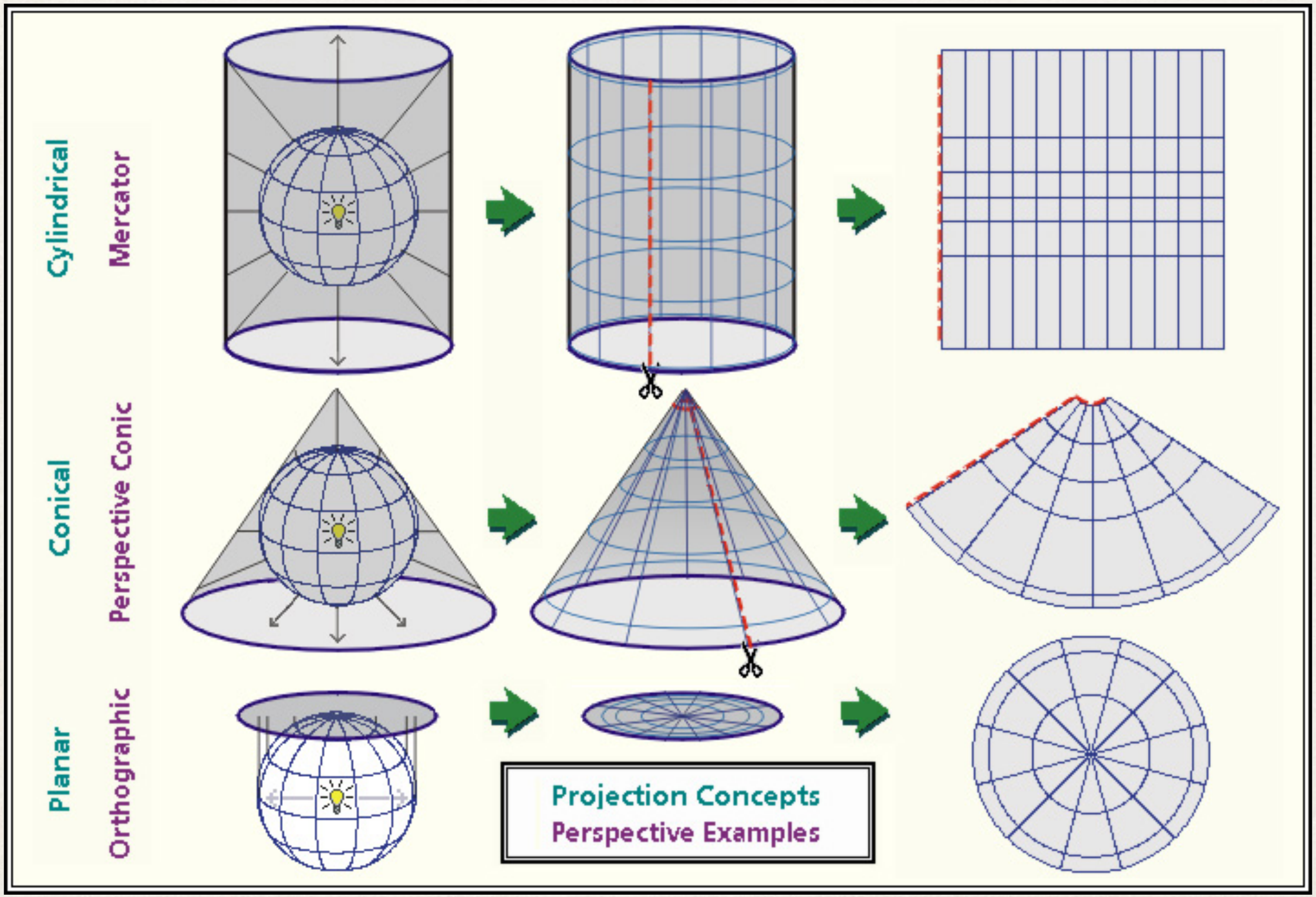
The Earth is not flat



http://sixboats.co.nz/category/tasman/

borrowed from J. Heer

Projecting a sphere



http://earth.rice.edu/mtpe/geo/geosphere/topics/mapprojections.html

Projection properties

conformal projection - preserve shape (but not area)

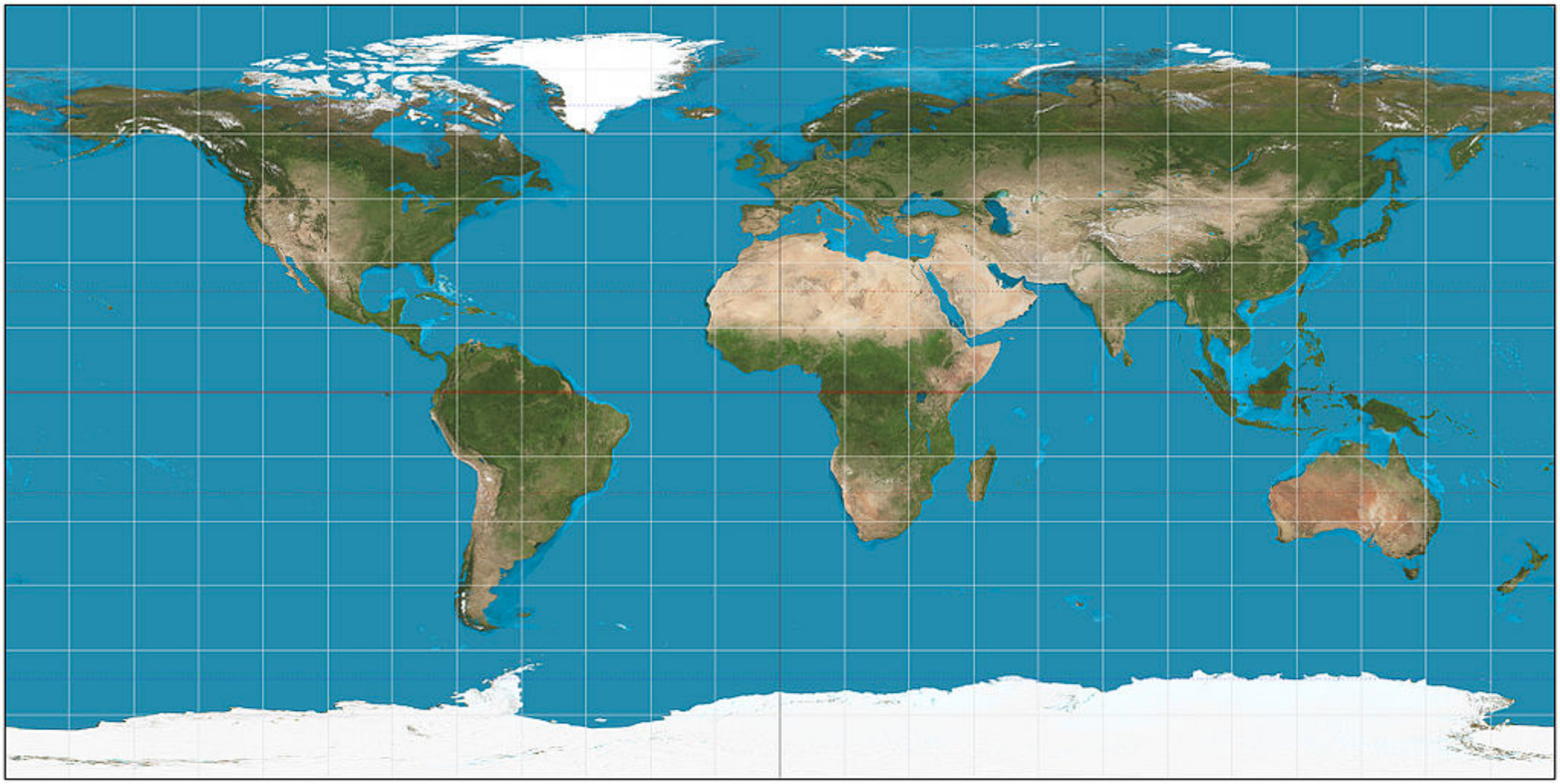
equal-area projection - preserve area (but not shape)

equidistant projection - preserve distance from some standard point

gnomic projection - preserve distance between two points

azimuthal projection - preserve direction from a central point

Equirectangular or Plate Carrée



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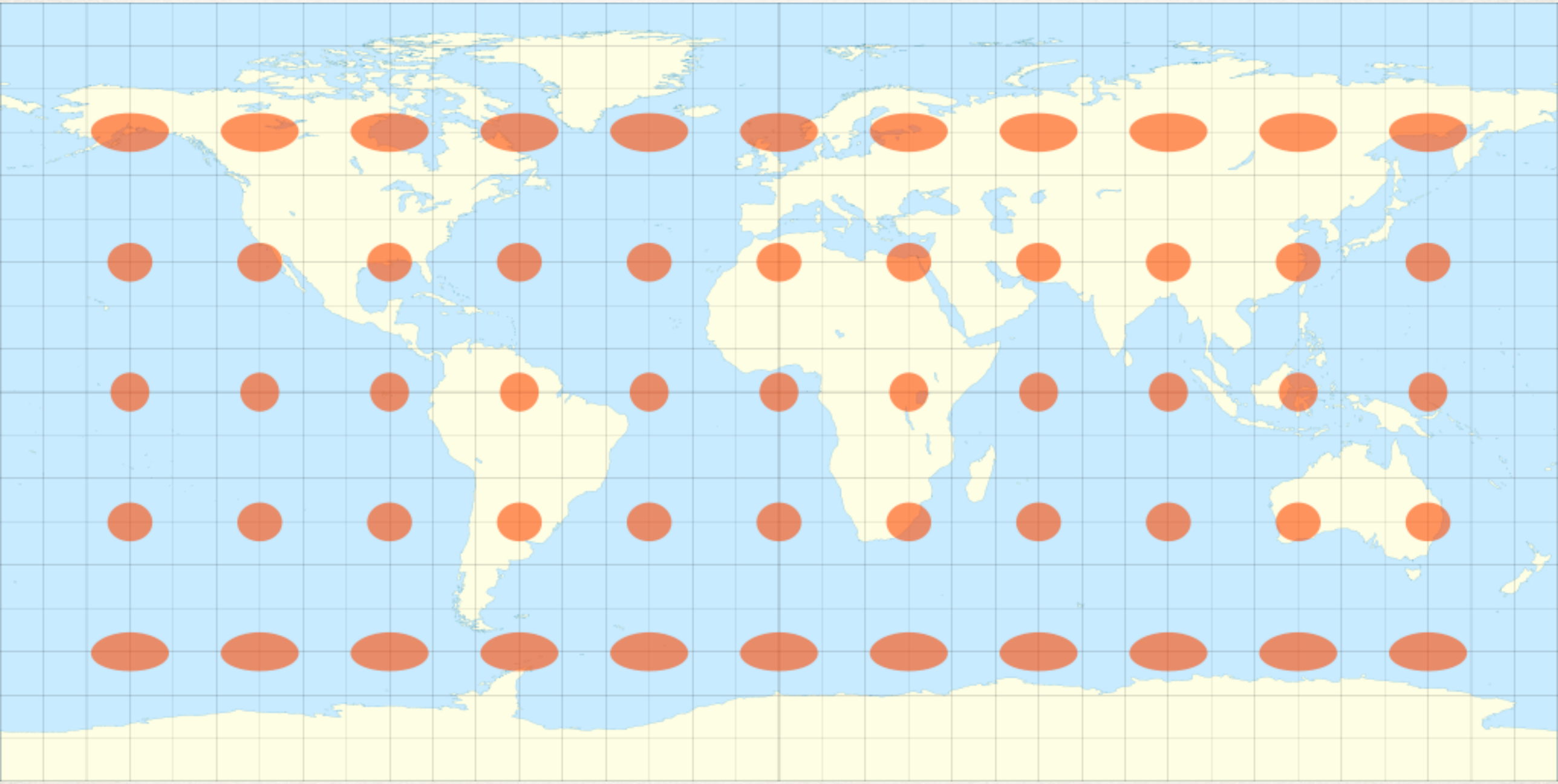
Equirectangular



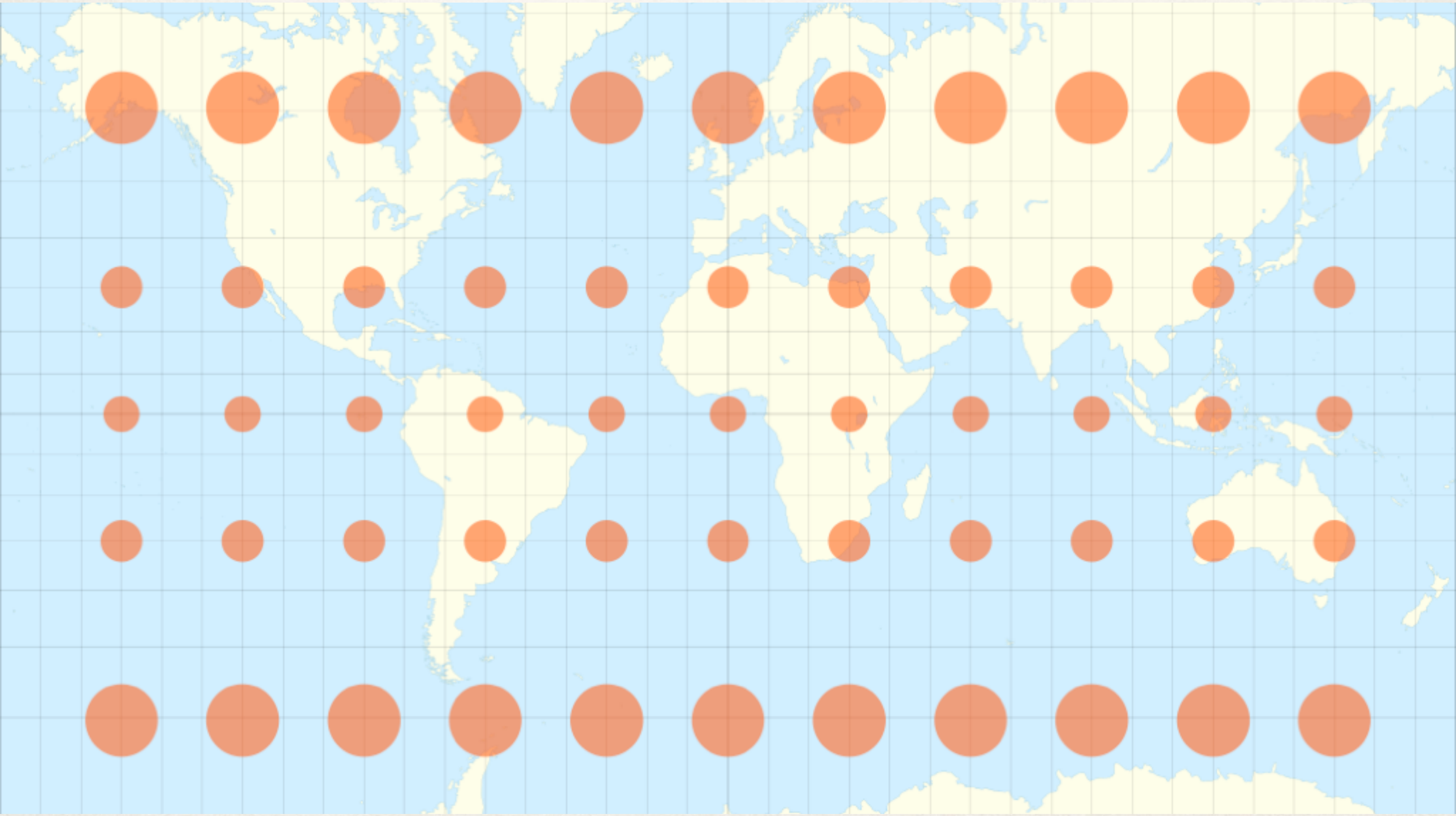
Wikimedia Commons

Mercator

Wikimedia Commons

Arctic Ocean
Arctic Ocean
Greenland
Iceland
Finland
Sweden
Norway
Russia
United Kingdom
Poland
Germany
Ukraine
France
Kazakhstan
Mongolia
Spain
Italy
Turkey
China
Japan
South Korea
Afghanistan
Iraq
Iran
Pakistan
Algeria
Libya
Egypt
Saudi Arabia
India
Thailand
Mali
Niger
Sudan
Chad
Nigeria
Ethiopia
Kenya
DR Congo
Tanzania
Angola
Namibia
Botswana
Madagascar
South Africa
Indonesia
Papua New Guinea
Australia
New Zealand
Canada
United States
Mexico
Venezuela
Colombia
Peru
Brazil
Bolivia
Chile
Argentina
North Pacific Ocean
North Atlantic Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean
Southern Ocean

Mercator distortion



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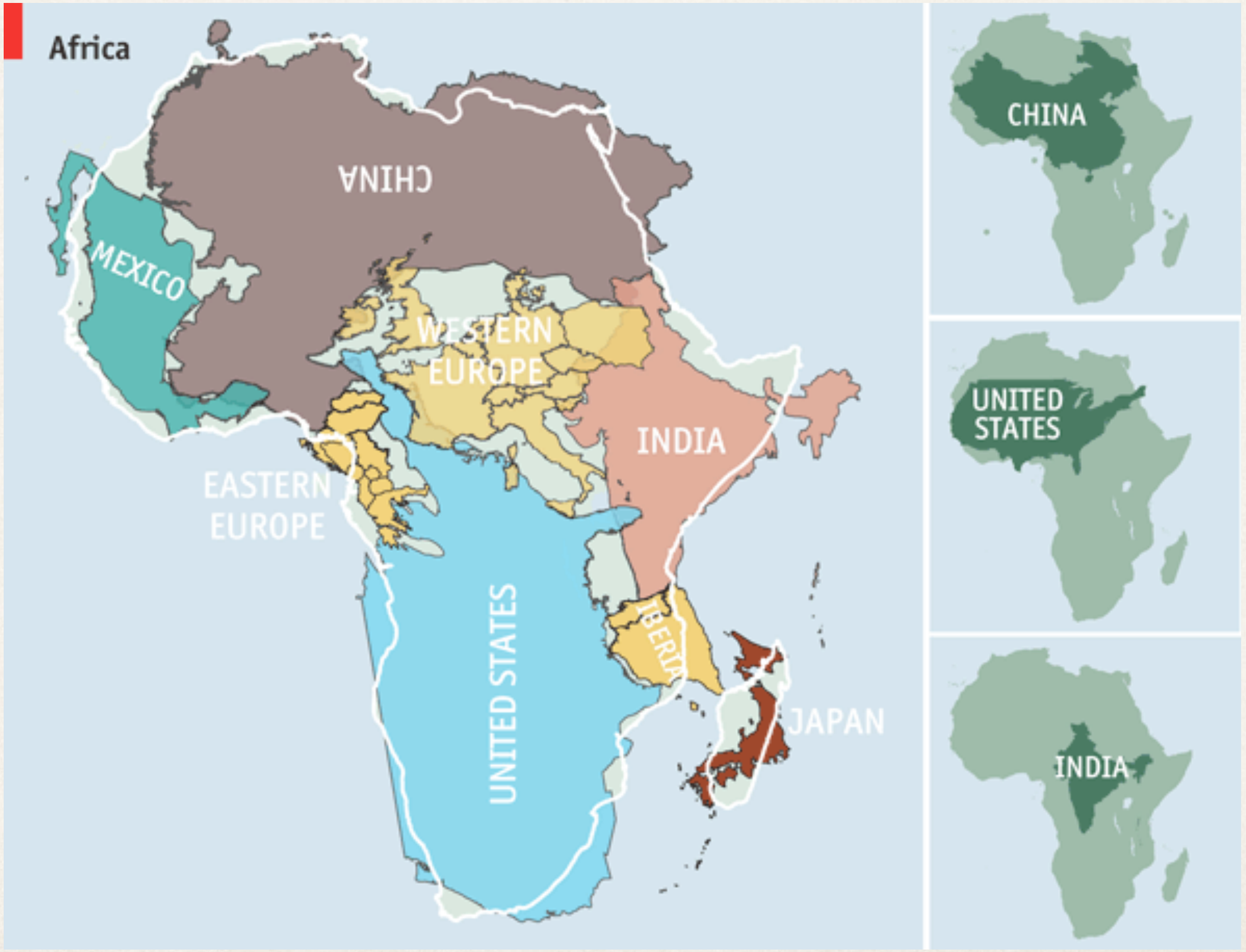
True size of Africa

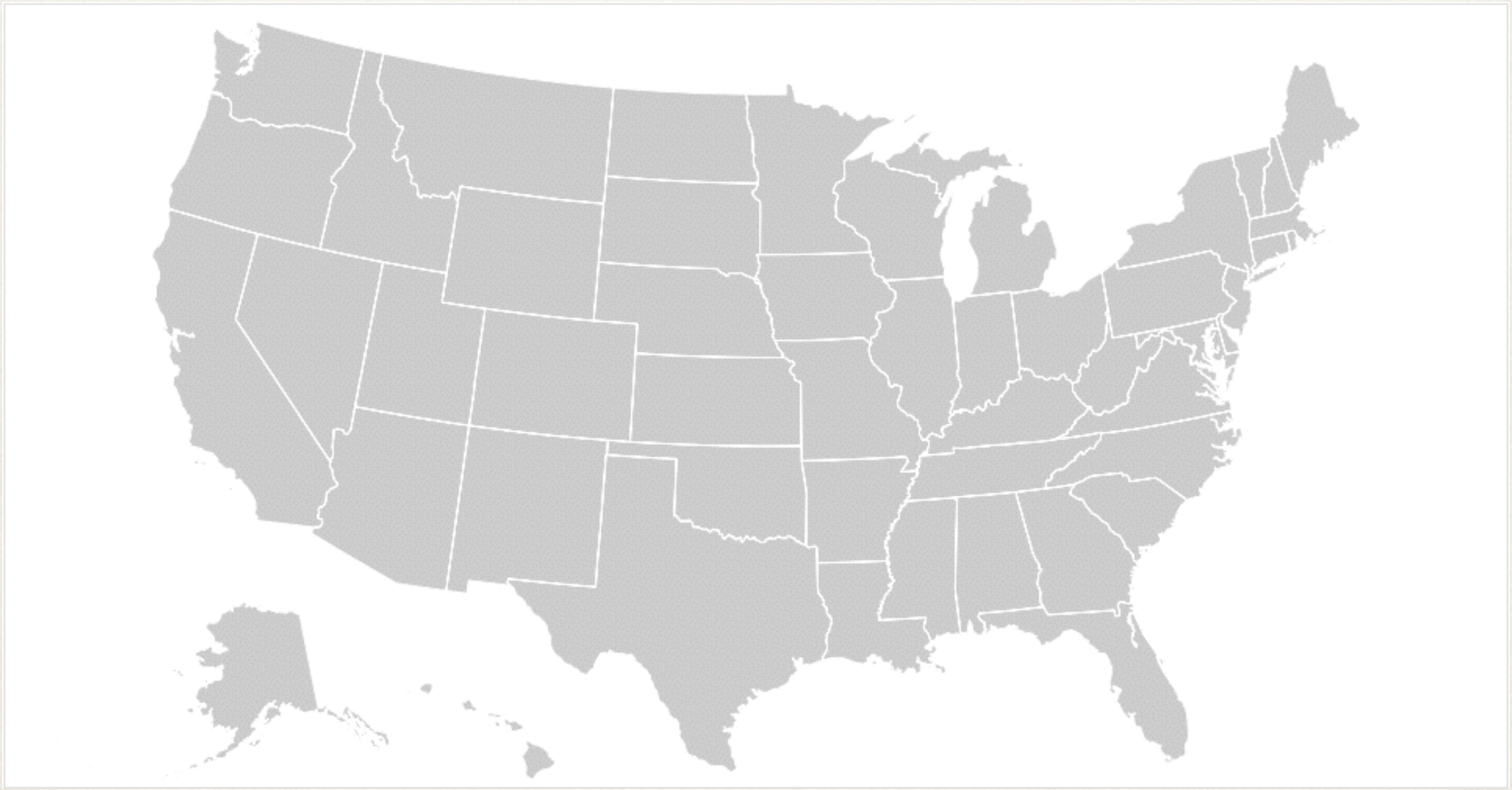


http://www.economist.com/blogs/dailychart/2010/11/cartography

True size of Greenland

Wikimedia Commons

Albers Equal-area Conic projection



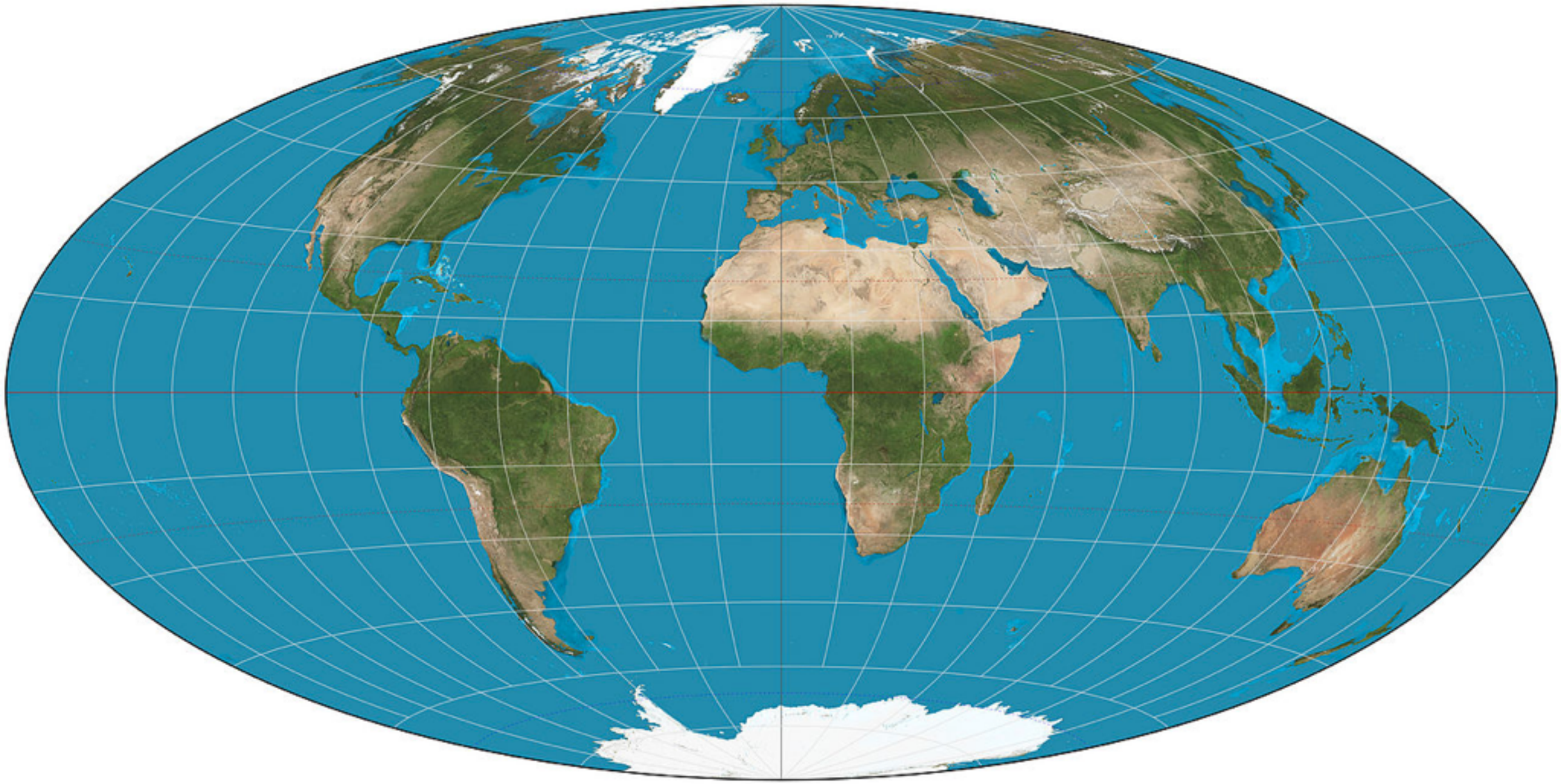
Albers vs. equirectangular

GEOGRAPHIC

ALBERS

Hammer projection

modified azimuthal equal-area projection



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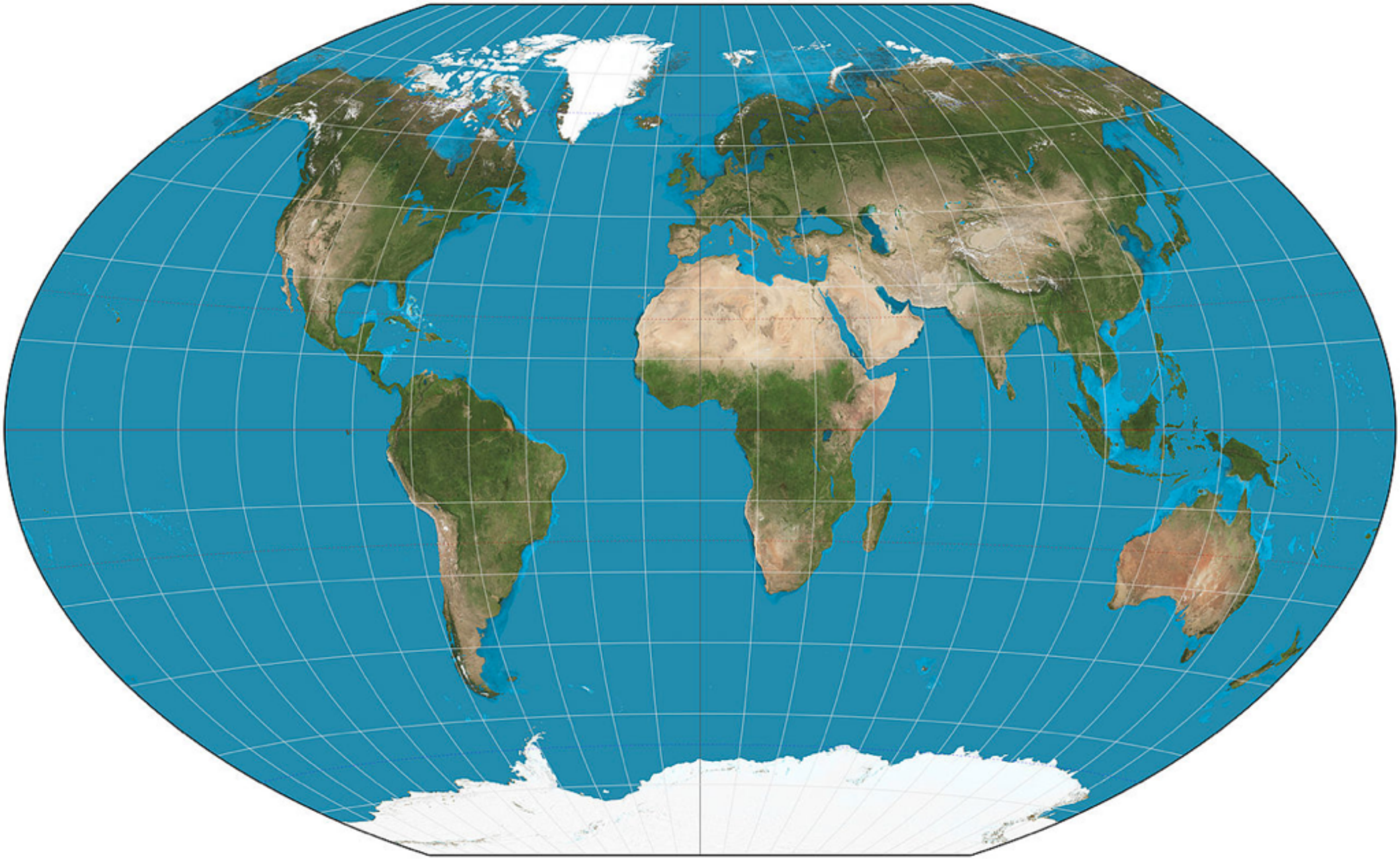
Winkel tripel projection

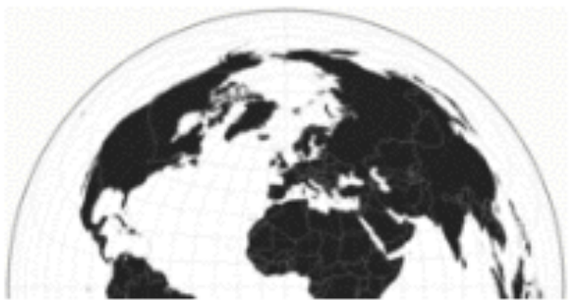


Wikimedia Commons

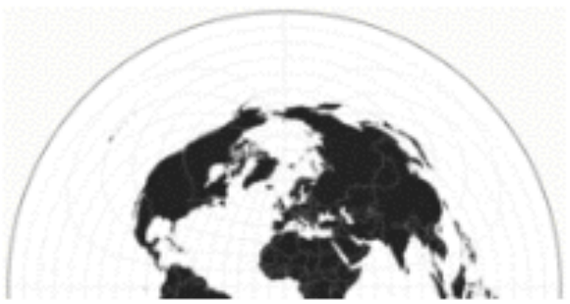
Projections in D3

d3.geo.albersUsa

d3.geo.azimuthalEqualArea



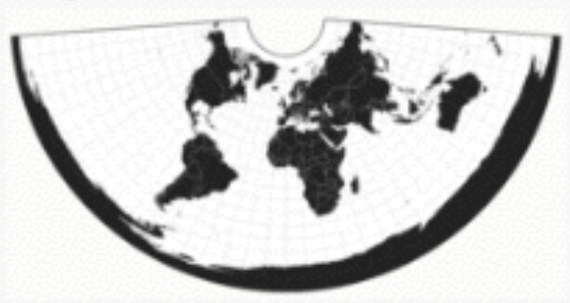
d3.geo.azimuthalEquidistant



d3.geo.conicEqualArea

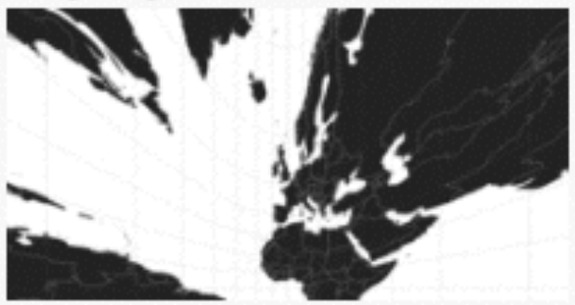
d3.geo.conicConformal

d3.geo.conicEquidistant



d3.geo.equirectangular

d3.geo.gnomonic



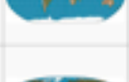
d3.geo.mercator

d3.geo.orthographic

d3.geo.stereographic

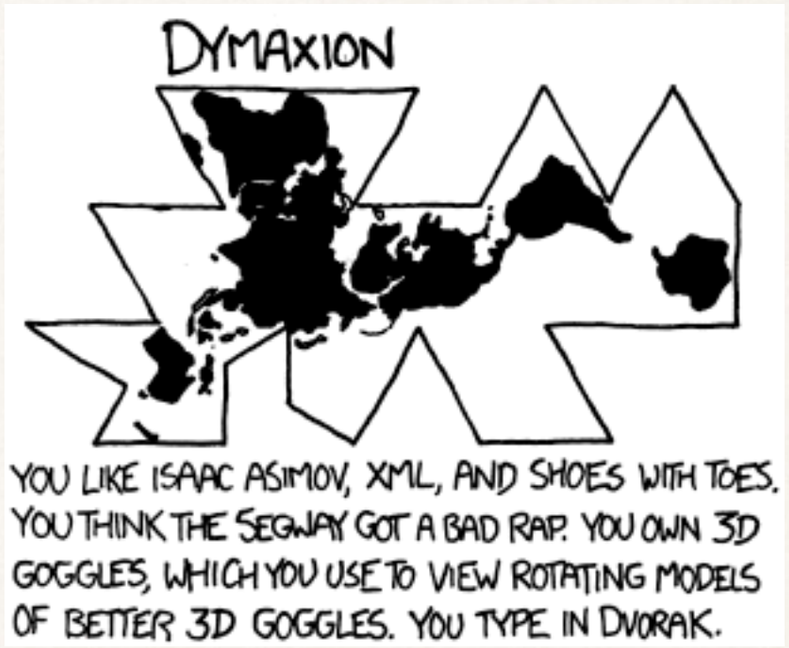
d3.geo.transverseMercator

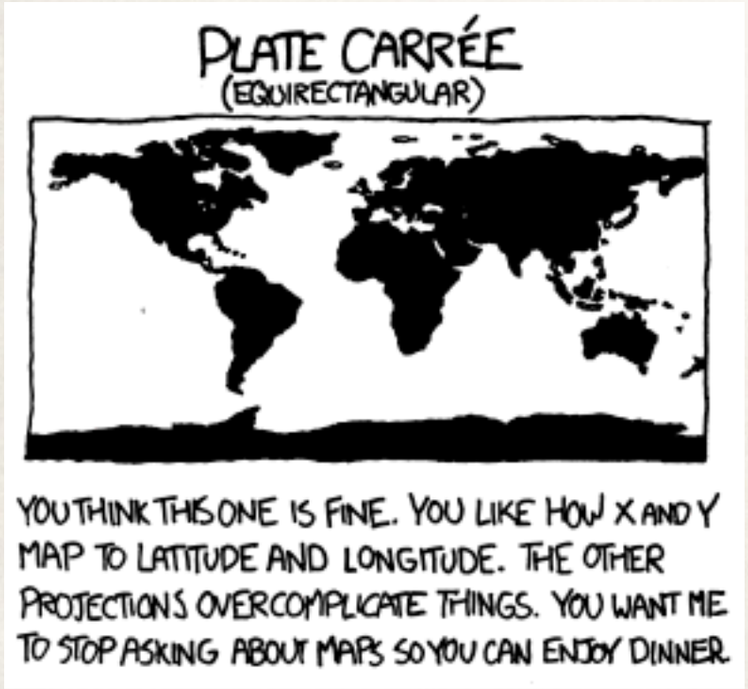
Wikipedia list of map projections

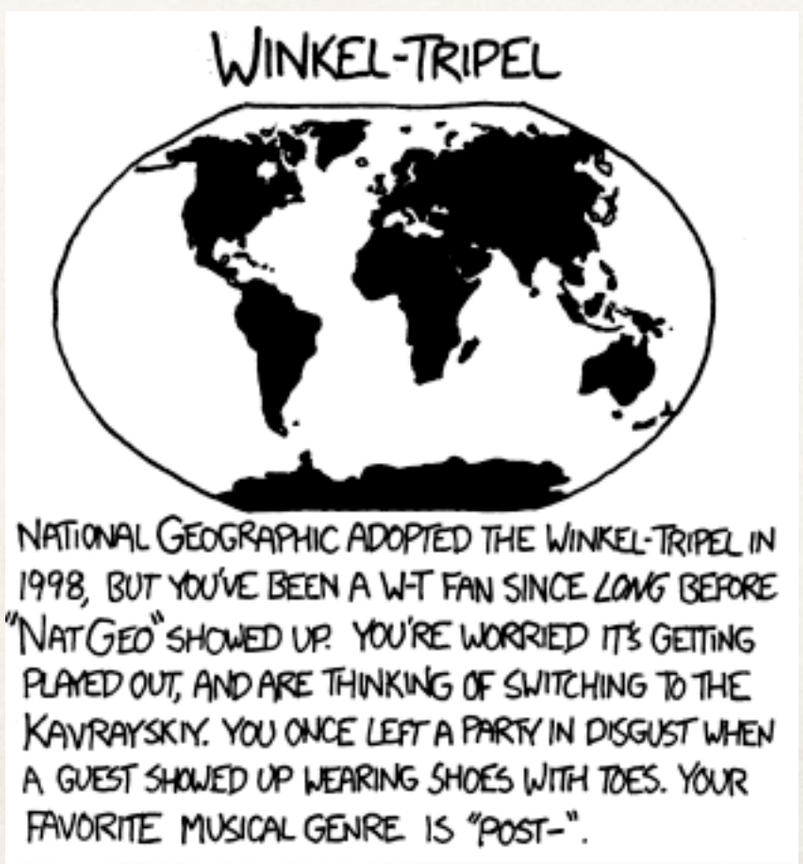
Equirectangular = equidistant cylindrical = rectangular = la carte parallélogrammatique		Cylindrical	Equidistant	Marinus of Tyre	120 (c.)	Simplest geometry; distances along meridians are conserved. Plate carrée: special case having the equator as the standard parallel.
Mercator = Wright		Cylindrical	Conformal	Gerardus Mercator	1569	Lines of constant bearing (rhumb lines) are straight, aiding navigation. Areas inflate with latitude, becoming so extreme that the map cannot show the poles.
Gauss–Krüger = Gauss conformal = (Elliptical) Transverse Mercator		Cylindrical	Conformal	Carl Friedrich Gauss Johann Heinrich Louis Krüger	1822	This transverse, ellipsoidal form of the Mercator is finite, unlike the equatorial Mercator. Forms the basis of the Universal Transverse Mercator system.
Gall stereographic similar to Braun		Cylindrical	Compromise	James Gall	1885	Intended to resemble the Mercator while also displaying the poles. Standard parallels at 45°N/S. Braun is horizontally stretched version with scale correct at equator.
Miller = Miller cylindrical		Cylindrical	Compromise	Oldborn Maitland Miller	1942	Intended to resemble the Mercator while also displaying the poles.
Lambert cylindrical equal-area		Cylindrical	Equal-area	Johann Heinrich Lambert	1772	Standard parallel at the equator. Aspect ratio of π (3.14). Base projection of the cylindrical equal-area family.
Behrmann		Cylindrical	Equal-area	Walter Behrmann	1910	Horizontally compressed version of the Lambert equal-area. Has standard parallels at 30°N/S and an aspect ratio of 2.36.
Hobo-Dyer		Cylindrical	Equal-area	Mick Dyer	2002	Horizontally compressed version of the Lambert equal-area. Very similar are Trystan Edwards and Smyth equal surface (= Craster rectangular) projections with standard parallels at around 37°N/S. Aspect ratio of ~2.0.
Orthographic		Azimuthal		Hipparchos (deployed)	200 BC (c.)	View from an infinite distance.
Vertical perspective		Azimuthal		Matthias Seutter (deployed)	1740	View from a finite distance. Can only display less than a hemisphere.
Two-point equidistant		Azimuthal	Equidistant	Hans Maurer	1919	Two "control points" can be arbitrarily chosen. The two straight-line distances from any point on the map to the two control points are correct.
Peirce quincuncial		Other	Conformal	Charles Sanders Peirce	1879	
Guyou hemisphere-in-a-square projection		Other	Conformal	Émile Guyou	1887	
Adams hemisphere-in-a-square projection		Other	Conformal	Oscar Sherman Adams	1925	
Gall–Peters = Gall orthographic = Peters		Cylindrical	Equal-area	James Gall (Arno Peters)	1855	Horizontally compressed version of the Lambert equal-area. Standard parallels at 45°N/S. Aspect ratio of ~1.6. Similar is Balthasart projection with standard parallels at 50°N/S.
Sinusoidal = Sanson-Flamsteed = Mercator equal-area		Pseudocylindrical	Equal-area	(Several; first is unknown)	1600 (c.)	Meridians are sinusoids; parallels are equally spaced. Aspect ratio of 2:1. Distances along parallels are conserved.
Mollweide = elliptical = Babinet = homolographic		Pseudocylindrical	Equal-area	Karl Brandan Mollweide	1805	Meridians are ellipses.
Eckert II		Pseudocylindrical	Equal-area	Max Eckert-Greifendorff	1906	
Eckert IV		Pseudocylindrical	Equal-area	Max Eckert-Greifendorff	1906	Parallels are unequal in spacing and scale; outer meridians are semicircles; other meridians are semiellipses.
Eckert VI		Pseudocylindrical	Equal-area	Max Eckert-Greifendorff	1906	Parallels are unequal in spacing and scale; meridians are half-period sinusoids.
Goode homolosine		Pseudocylindrical	Equal-area	John Paul Goode	1923	Hybrid of Sinusoidal and Mollweide projections. Usually used in interrupted form.
Kavrayskiy VII		Pseudocylindrical	Compromise	Vladimir V. Kavrayskiy	1939	Evenly spaced parallels. Equivalent to Wagner VI horizontally compressed by a factor of $\sqrt{3}/2$
Robinson		Pseudocylindrical	Compromise	Arthur H. Robinson	1963	Computed by interpolation of tabulated values. Used by Rand McNally since inception and used by NGS 1988–98.
Tobler hyperelliptical		Pseudocylindrical	Equal-area	Waldo R. Tobler	1973	A family of map projections that includes as special cases Mollweide projection, Collignon projection, and the various cylindrical equal-area projections.
American polyconic		Pseudoconical		Ferdinand Rudolph Hassler	1820 (c.)	Distances along the parallels are preserved as are distances along the central meridian.
Azimuthal equidistant = Postel zenithal equidistant		Azimuthal	Equidistant	Abū Rayḥān al-Bīrūnī	1000 (c.)	Used by the USGS in the National Atlas of the United States of America. Distances from centre are conserved. Used as the emblem of the United Nations, extending to 60° S.
Gnomonic		Azimuthal	Gnomonic	Thales (possibly)	580 BC (c.)	All great circles map to straight lines. Extreme distortion far from the center. Shows less than one hemisphere.
Lambert azimuthal equal-area		Azimuthal	Equal-Area	Johann Heinrich Lambert	1772	The straight-line distance between the central point on the map to any other point is the same as the straight-line 3D distance through the globe between the two points.
Stereographic		Azimuthal	Conformal	Hipparchos (deployed)	200 BC (c.)	Map is infinite in extent with outer hemisphere inflating severely, so it is often used as two hemispheres. Maps all small circles to circles, which is useful for planetary mapping to preserve the shapes of craters.
Wagner VI		Pseudocylindrical	Compromise	K.H. Wagner	1932	Equivalent to Kavrayskiy VII vertically compressed by a factor of $\sqrt{3}/2$
Collignon		Pseudocylindrical	Equal-Area	Édouard Collignon	1865 (c.)	Depending on configuration, the projection also may map the sphere to a single diamond or a pair of squares.
HEALPix		Pseudocylindrical	Equal-area	Krzysztof M. Górski	1997	Hybrid of Collignon + Lambert cylindrical equal-area
Craster parabolic = Reinhold Putnins P4		Pseudocylindrical	Equal-area	John Craster	1929	Meridians are parabolas. Standard parallels at 36°46'N/S; parallels are unequal in spacing and scale; 2:1 Aspect.
Flat-polar quartic = McBryde-Thomas #4		Pseudocylindrical	Equal-area	Felix W. McBryde, Paul Thomas	1949	Standard parallels at 33°45'N/S; parallels are unequal in spacing and scale; meridians are fourth-order curves. Distortion-free only where the standard parallels intersect the central meridian.
Quartic authalic		Pseudocylindrical	Equal-area	Karl Siemon Oscar Adams	1937 1944	Parallels are unequal in spacing and scale. No distortion along the equator. Meridians are fourth-order curves.
The Times		Pseudocylindrical	Compromise	John Muir	1965	Standard parallels 45°N/S. Parallels based on Gall orthographic, but with curved meridians. Developed for Bartholomew Ltd., The Times Atlas.
Loximuthal		Pseudocylindrical		Karl Siemon, Waldo Tobler	1935, 1966	From the designated centre, lines of constant bearing (rhumb lines/loxodromes) are straight and have the correct length. Generally asymmetric about the equator.
Aitoff		Pseudoazimuthal	Compromise	David A. Aitoff	1889	Stretching of modified equatorial azimuthal equidistant map. Boundary is 2:1 ellipse. Largely superseded by Hammer.
Waterman butterfly projection		Polyhedral	Compromise	Steve Waterman	1996	
Quadrilateralized spherical cube		Polyhedral	Equal-area	F. Kenneth Chan, E. M. O'Neill	1973	
Dymaxion map		Polyhedral	Compromise	Buckminster Fuller	1943	
Myriahedral projections		Polyhedral		Jarke J. van Wijk	2008	Projects the globe onto a myriahedron: a polyhedron with a very large number of faces.[23][24]
Craig retroazimuthal = Mecca		Retroazimuthal		James Ireland Craig	1909	
Hammer retroazimuthal, front hemisphere		Retroazimuthal		Ernst Hammer	1910	
Hammer retroazimuthal, back hemisphere		Retroazimuthal		Ernst Hammer	1910	
Littrow		Retroazimuthal		Joseph Johann Littrow	1833	
Hammer = Hammer-Aitoff variations: Briesemeister, Nordic		Pseudoazimuthal	Equal-area	Ernst Hammer	1892	Modified from azimuthal equal-area equatorial map. Boundary is 2:1 ellipse. Variants are oblique versions, centred on 45°N.
Winkel tripel		Pseudoazimuthal	Compromise	Oswald Winkel	1921	Arithmetic mean of the equirectangular projection and the Aitoff projection. Standard world projection for the NGS 1998–present.
Van der Grinten		Other	Compromise	Alphons J. van der Grinten	1904	Boundary is a circle. All parallels and meridians are circular arcs. Usually clipped near 80°N/S. Standard world projection of the NGS 1922–88.
Equidistant conic projection = simple conic		Conic	Equidistant	Based on Ptolemy's 1st Projection	100 (c.)	Distances along meridians are conserved, as is distance along one or two standard parallels[21]
Lambert conformal conic		Conic	Conformal	Johann Heinrich Lambert	1772	
Albers conic		Conic	Equal-Area	Heinrich C. Albers	1805	Two standard parallels with low distortion between them.
Werner		Pseudoconical	Equal-area	Johannes Stabius	1500 (c.)	Distances from the North Pole are correct as are the curved distances along parallels.
Bonne		Pseudoconical, cordiform	Equal-area	Bernardus Sylvanus	1511	Parallels are equally spaced circular arcs and standard lines. Appearance depends on reference parallel. General case of both Werner and sinusoidal
Bottomley		Pseudoconical	Equal-area	Henry Bottomley	2003	Alternative to the Bonne projection with simpler overall shape Parallels are elliptical arcs Appearance depends on reference parallel.
B.J.S. Cahill's Butterfly Map		Polyhedral	Compromise	Bernard Joseph Stanislaus Cahill	1909	
Cahill-Keyes projection		Polyhedral	Compromise	Gene Keyes	1975	

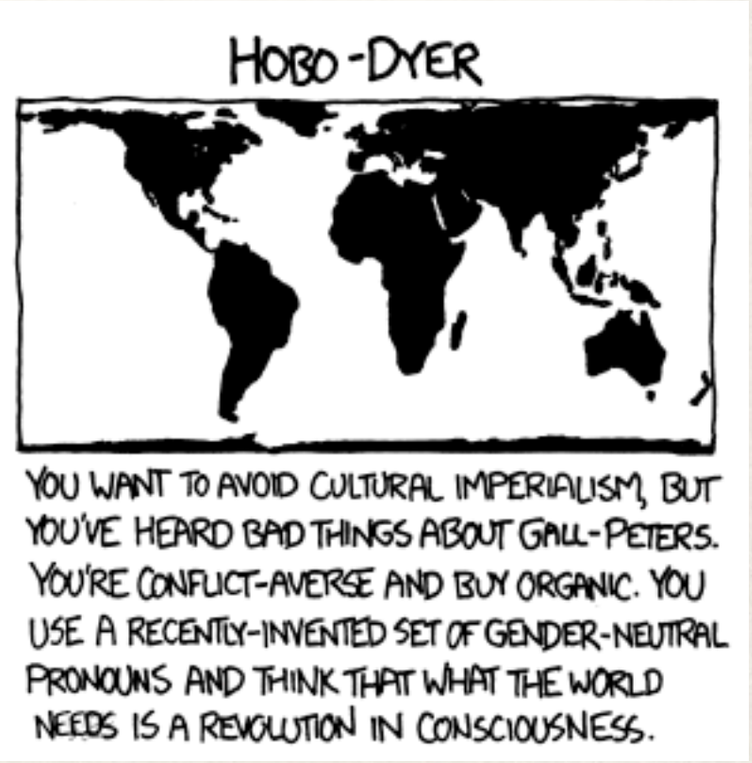
http://en.wikipedia.org/wiki/List_of_map_projections

XKCD - Map Projections



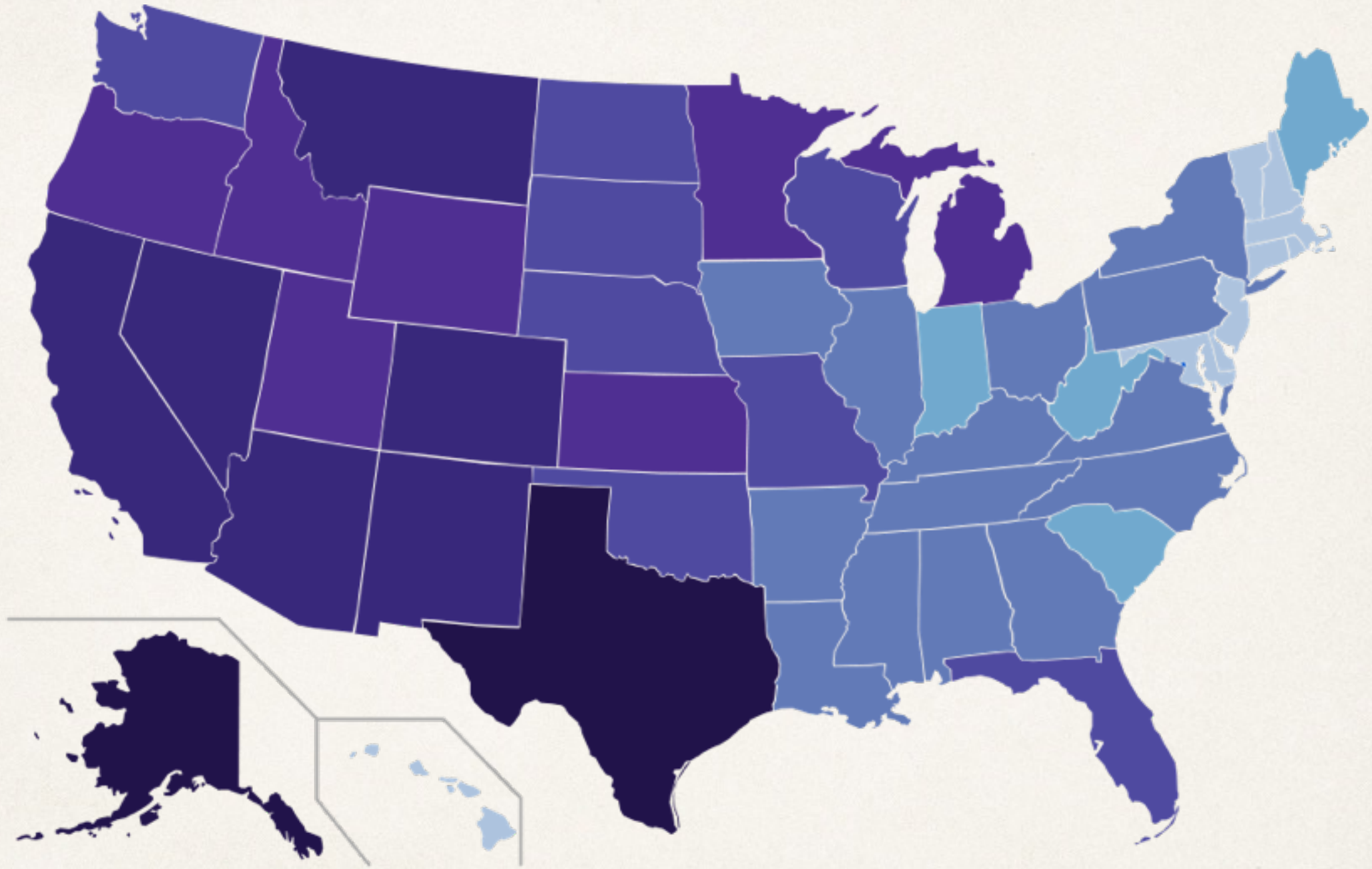




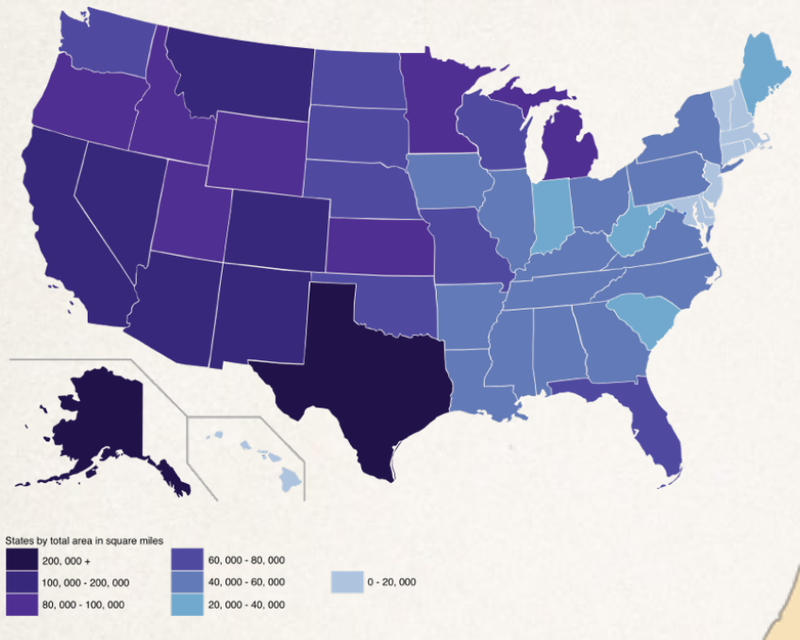


http://xkcd.com/977/

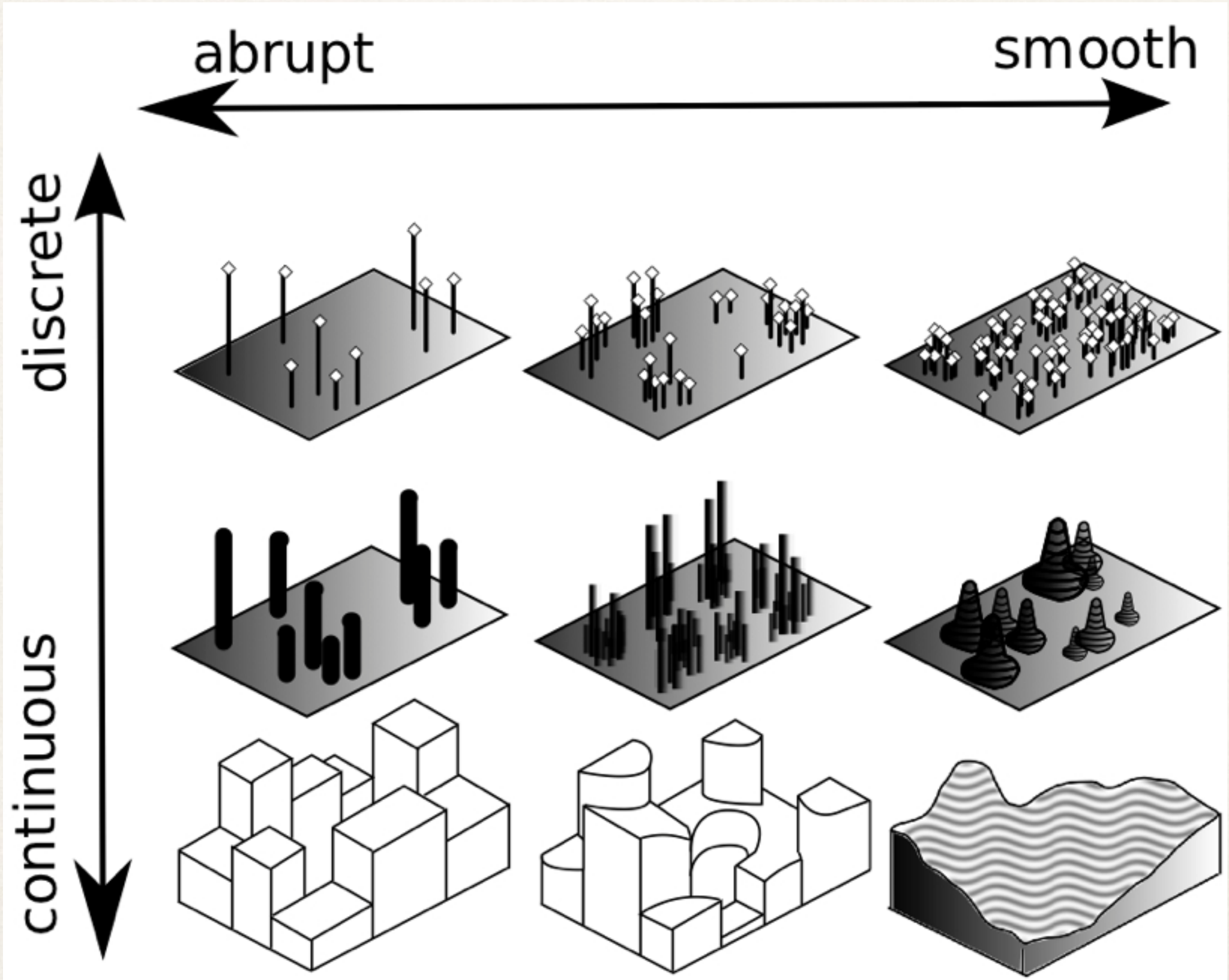
U.S. State by total area



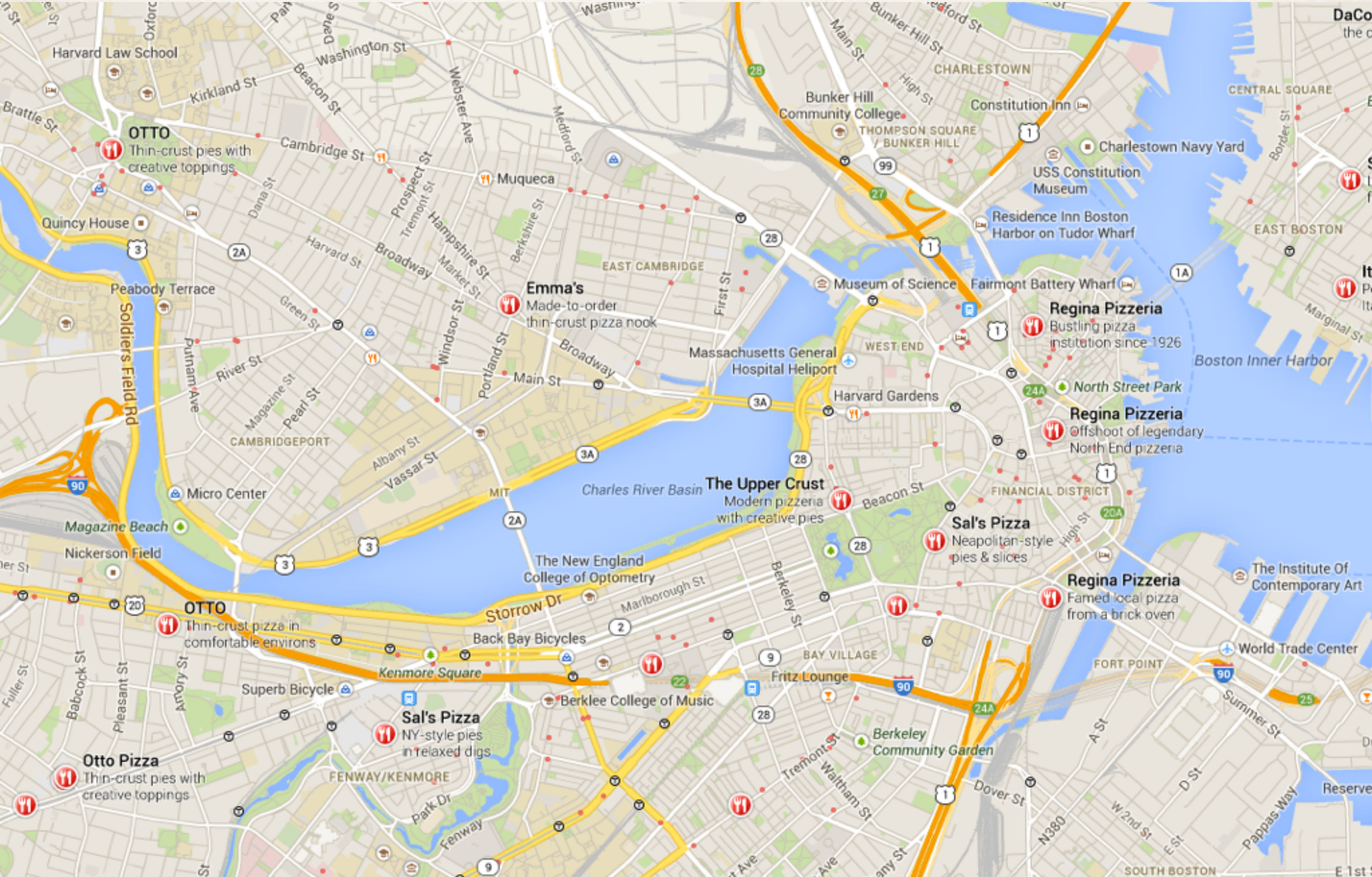
U.S. State by total area



Map style



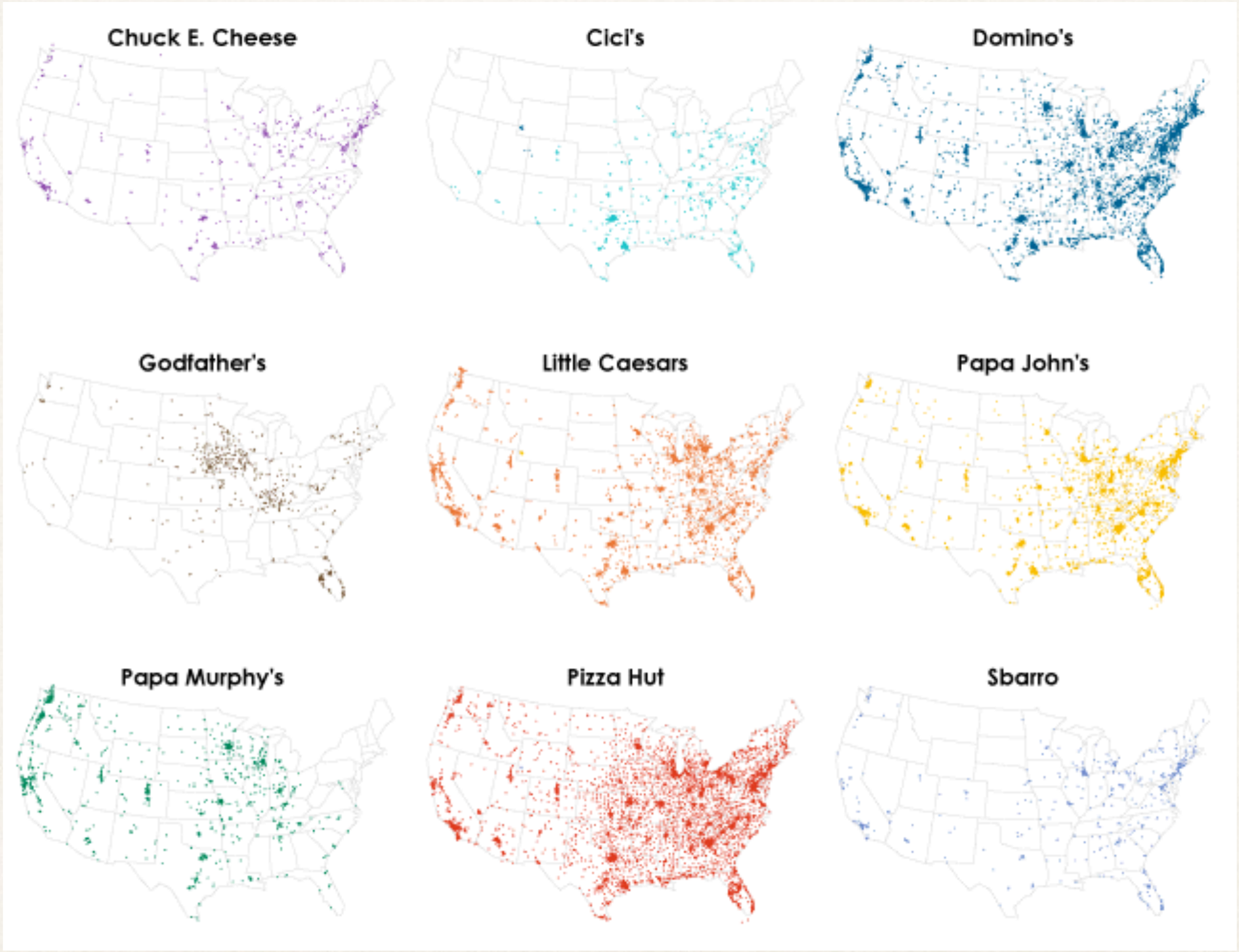
Dot maps



Harvard Law School
Kirkland St
Washington St
Beacon St
Webster Ave
Medford St
Brattle St
OTTO
Thin-crust pies with creative toppings
Cambridge St
Muqueca
Quincy House
Prospect St
Hampshire St
Berkshire St
Harvard St
Broadway
Market St
EAST CAMBRIDGE
Peabody Terrace
Soldiers Field Rd
Green St
Emma's
Made-to-order thin-crust pizza nook
First St
River St
Windsor St
Portland St
Main St
Putnam Ave
Magazine St
Pearl St
CAMBRIDGEPORT
Albany St
Vassar St
MIT
Micro Center
Charles River Basin
Magazine Beach
Nickerson Field
OTTO
Thin-crust pizza in comfortable environs
Storrow Dr
The New England College of Optometry
Marlborough St
Back Bay Bicycles
Kenmore Square
Superb Bicycle
Berklee College of Music
Sal's Pizza
NY-style pies in relaxed digs
FENWAY/KENMORE
Park Dr
Fenway
Babcock St
Pleasant St
Amory St
Otto Pizza
Thin-crust pies with creative toppings
Bunker Hill St
Main St
CHARLESTOWN
High St
Bunker Hill Community College
THOMPSON SQUARE / BUNKER HILL
Constitution Inn
Charlestown Navy Yard
USS Constitution Museum
Residence Inn Boston Harbor on Tudor Wharf
CENTRAL SQUARE
EAST BOSTON
Museum of Science
Fairmont Battery Wharf
Regina Pizzeria
Bustling pizza institution since 1926
Massachusetts General Hospital Heliport
WEST END
Harvard Gardens
North Street Park
Boston Inner Harbor
Regina Pizzeria
Offshoot of legendary North End pizzeria
The Upper Crust
Modern pizzeria with creative pies
Beacon St
FINANCIAL DISTRICT
Sal's Pizza
Neapolitan-style pies & slices
Regina Pizzeria
Famed local pizza from a brick oven
The Institute Of Contemporary Art
World Trade Center
FORT POINT
Summer St
Berkeley St
BAY VILLAGE
Fritz Lounge
Tremont St
Waltham St
Berkeley Community Garden
Dover St
A St
N380
W 2nd St
D St
E St
Pappas Way
SOUTH BOSTON
Marginal St

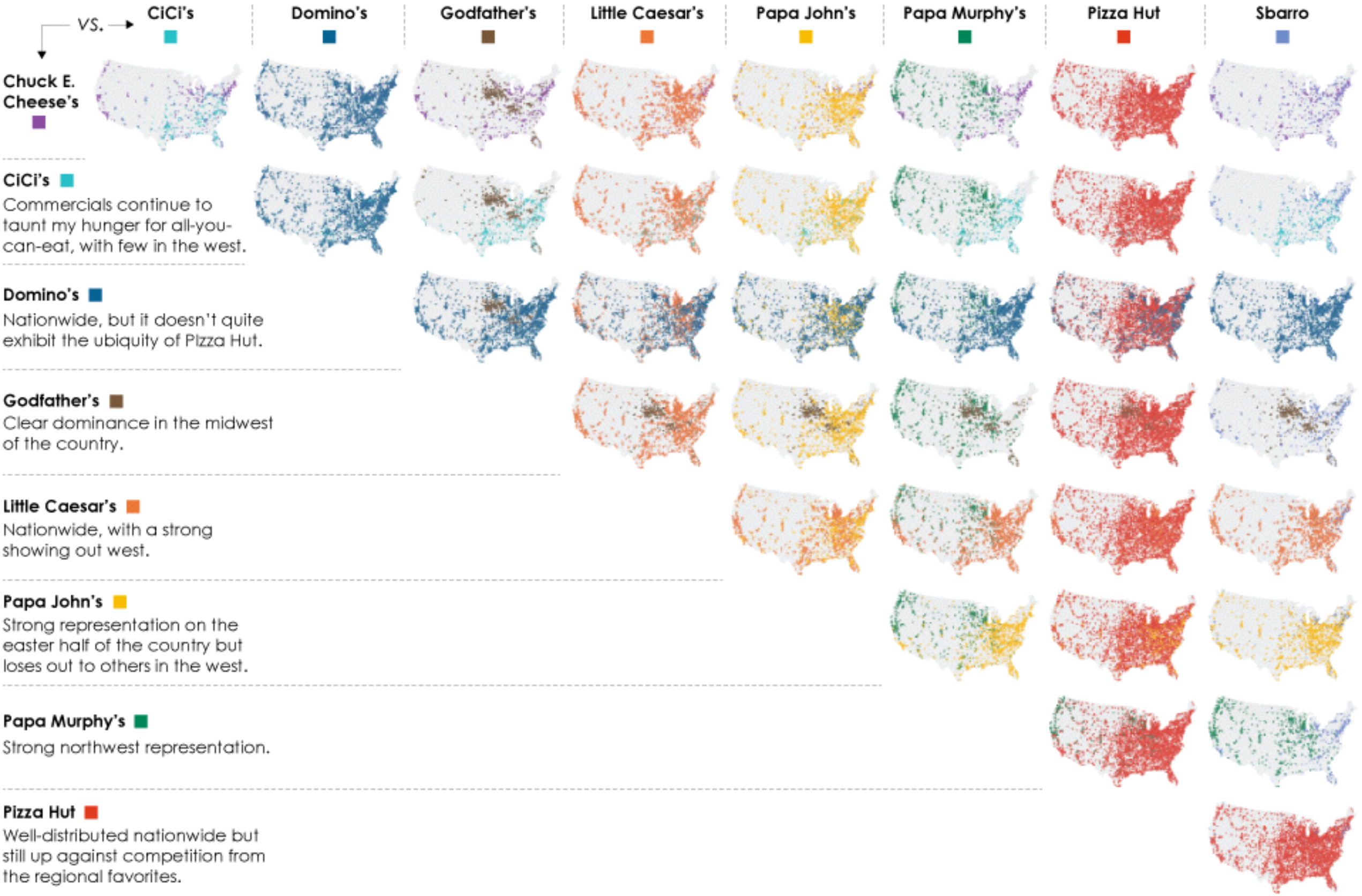
Dot map

Dot map



http://flowingdata.com/2013/10/14/pizza-place-geography/

Which pizza place is closer?



CiCi's
Commercials continue to taunt my hunger for all-you-can-eat, with few in the west.

Domino's
Nationwide, but it doesn't quite exhibit the ubiquity of Pizza Hut.

Godfather's
Clear dominance in the midwest of the country.

Little Caesar's
Nationwide, with a strong showing out west.

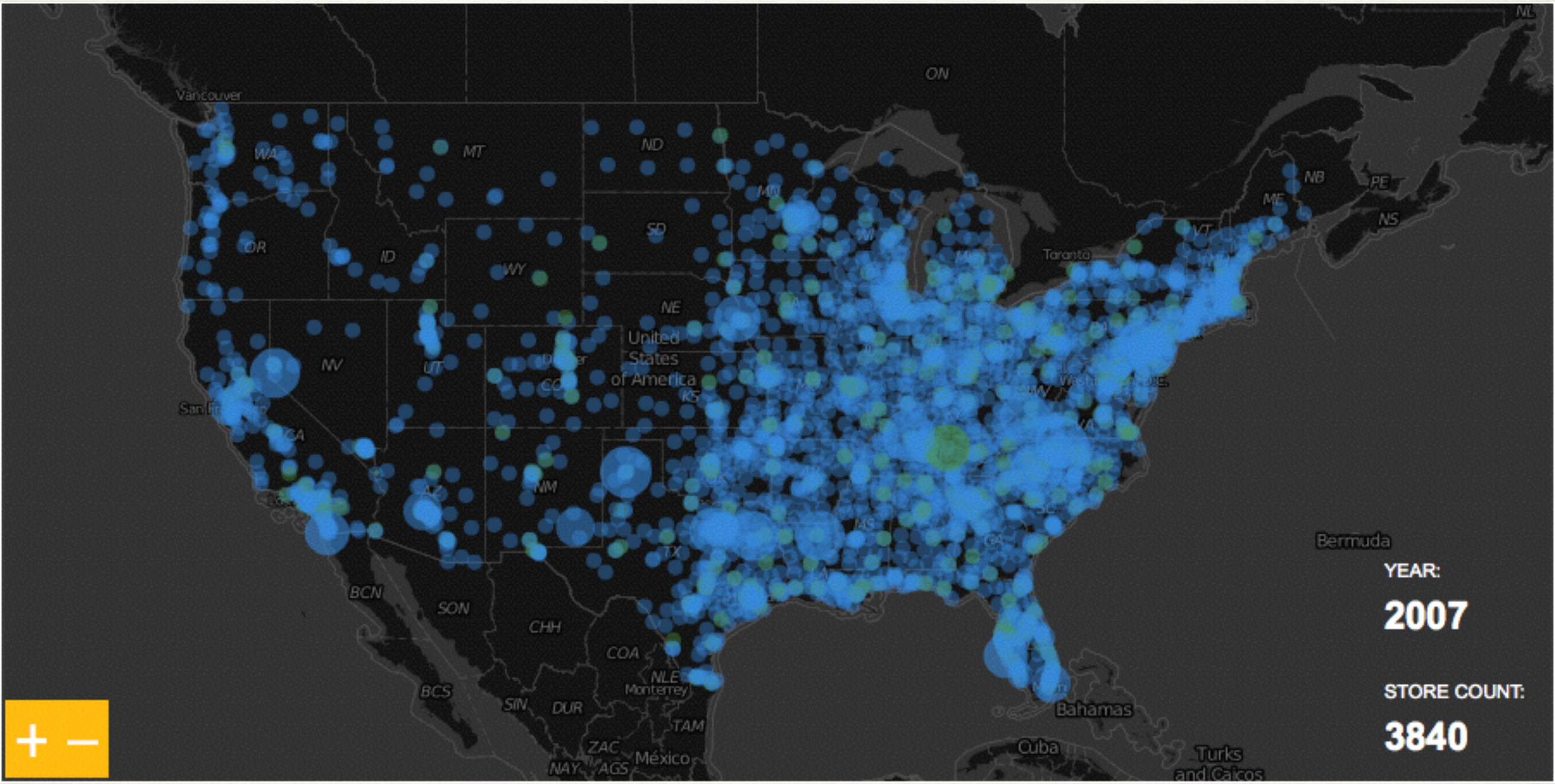
Papa John's
Strong representation on the easter half of the country but loses out to others in the west.

Papa Murphy's
Strong northwest representation.

Pizza Hut
Well-distributed nationwide but still up against competition from the regional favorites.

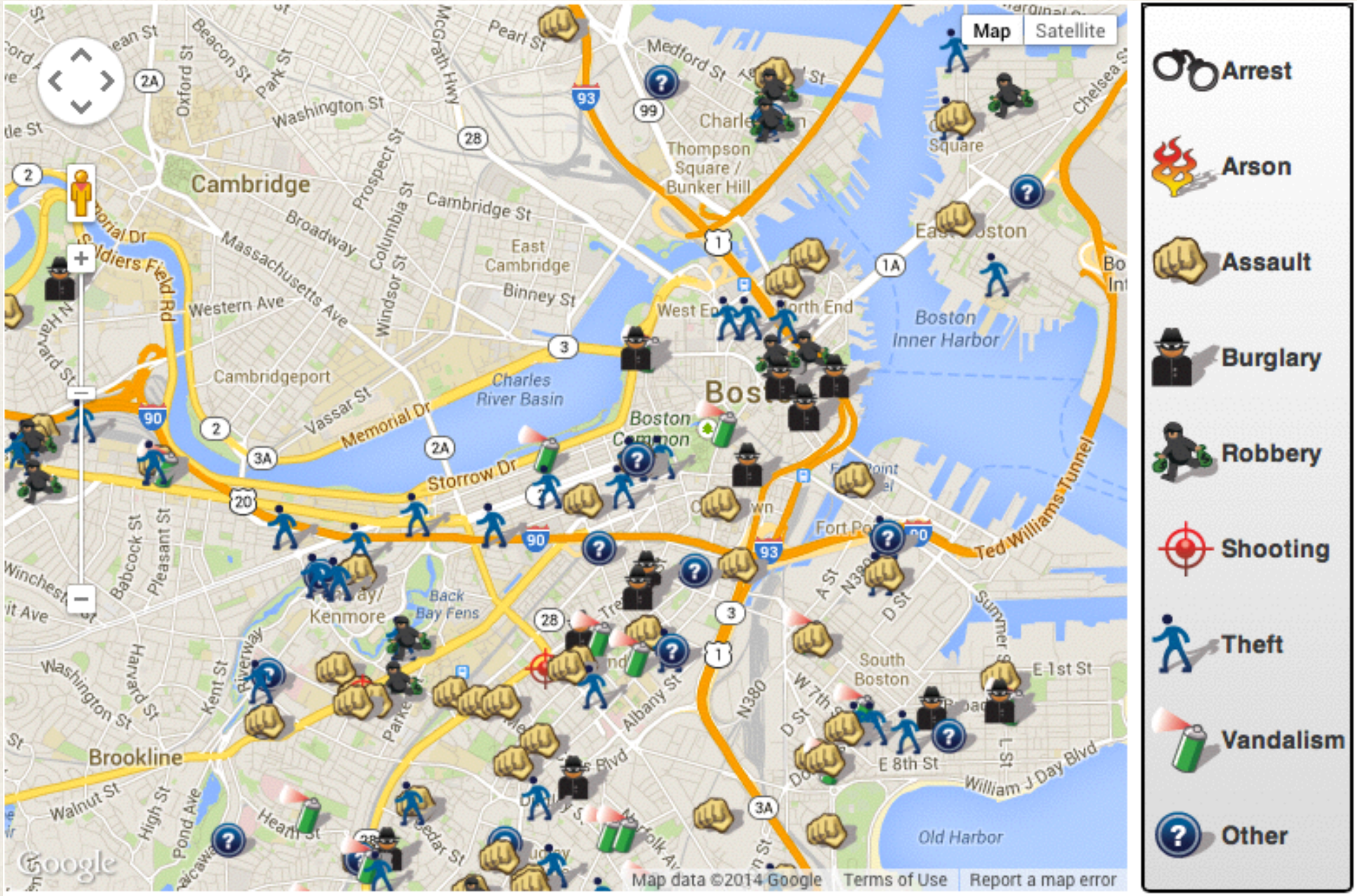
SOURCE: AggData, http://aggdata.com | BY: FlowingData, http://flowingdata.com

The Growth of Walmart



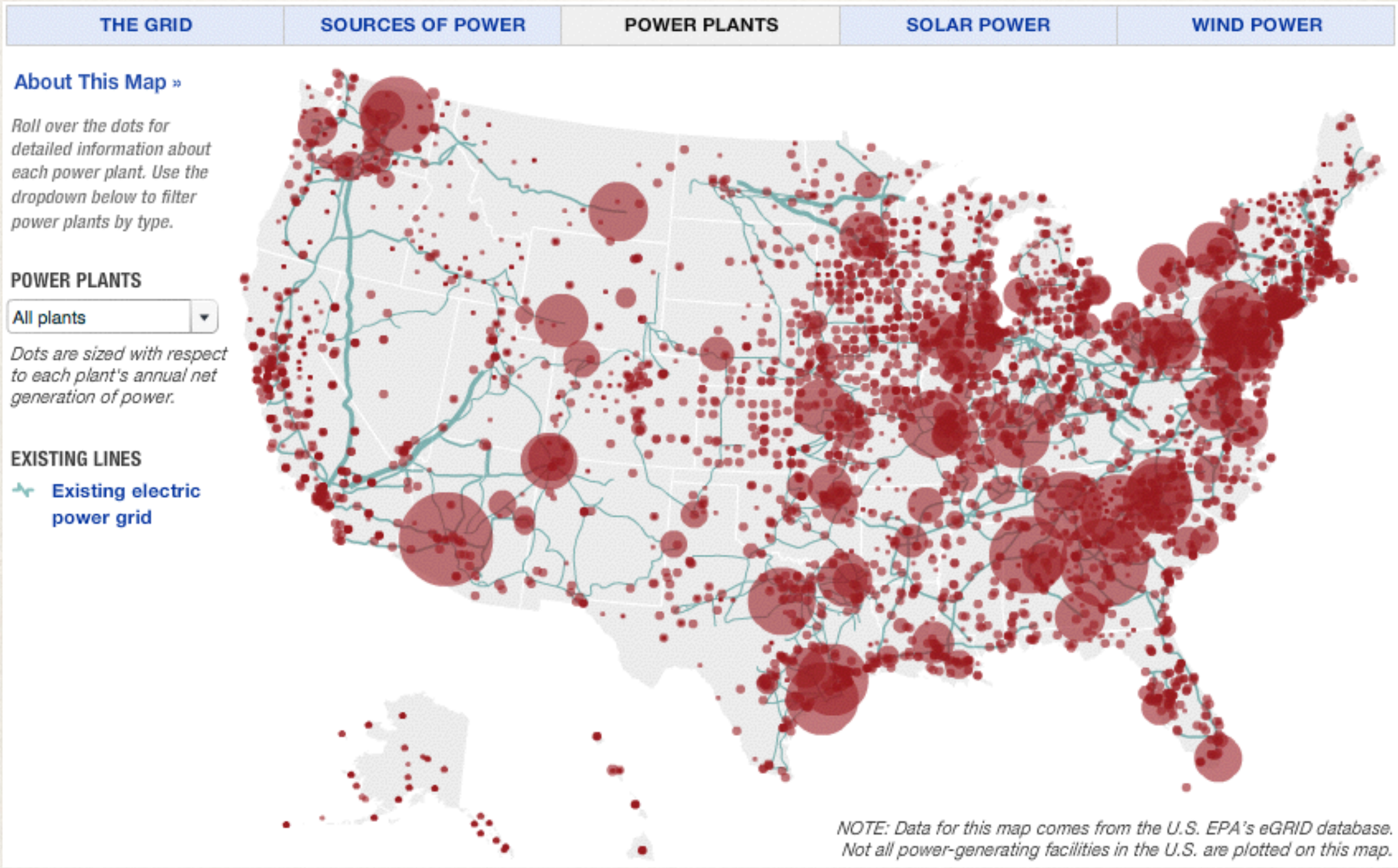
http://projects.flowingdata.com/walmart/

Dot maps with icons



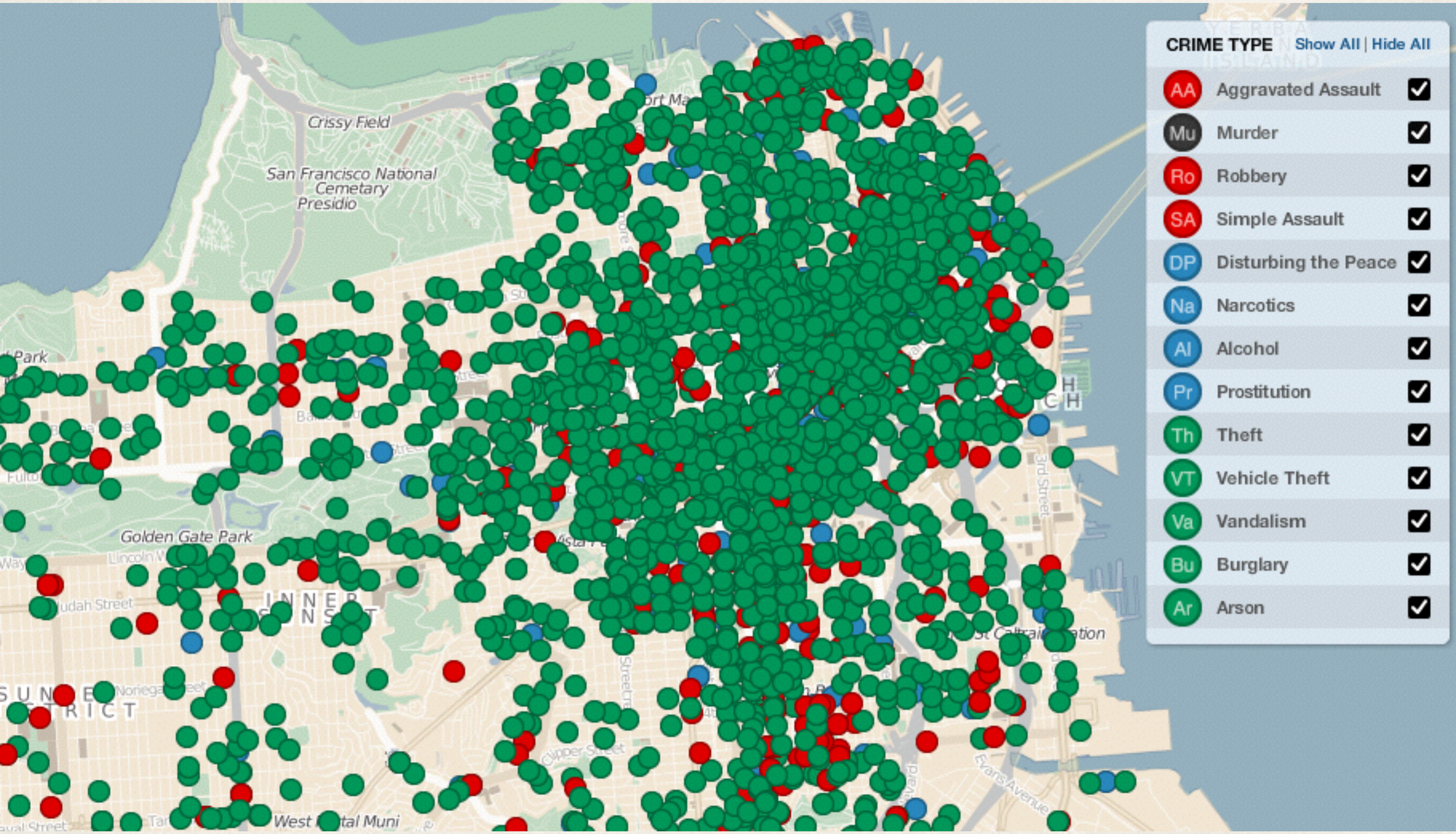
http://spotcrime.com/ma/boston

Dot map with size encoding



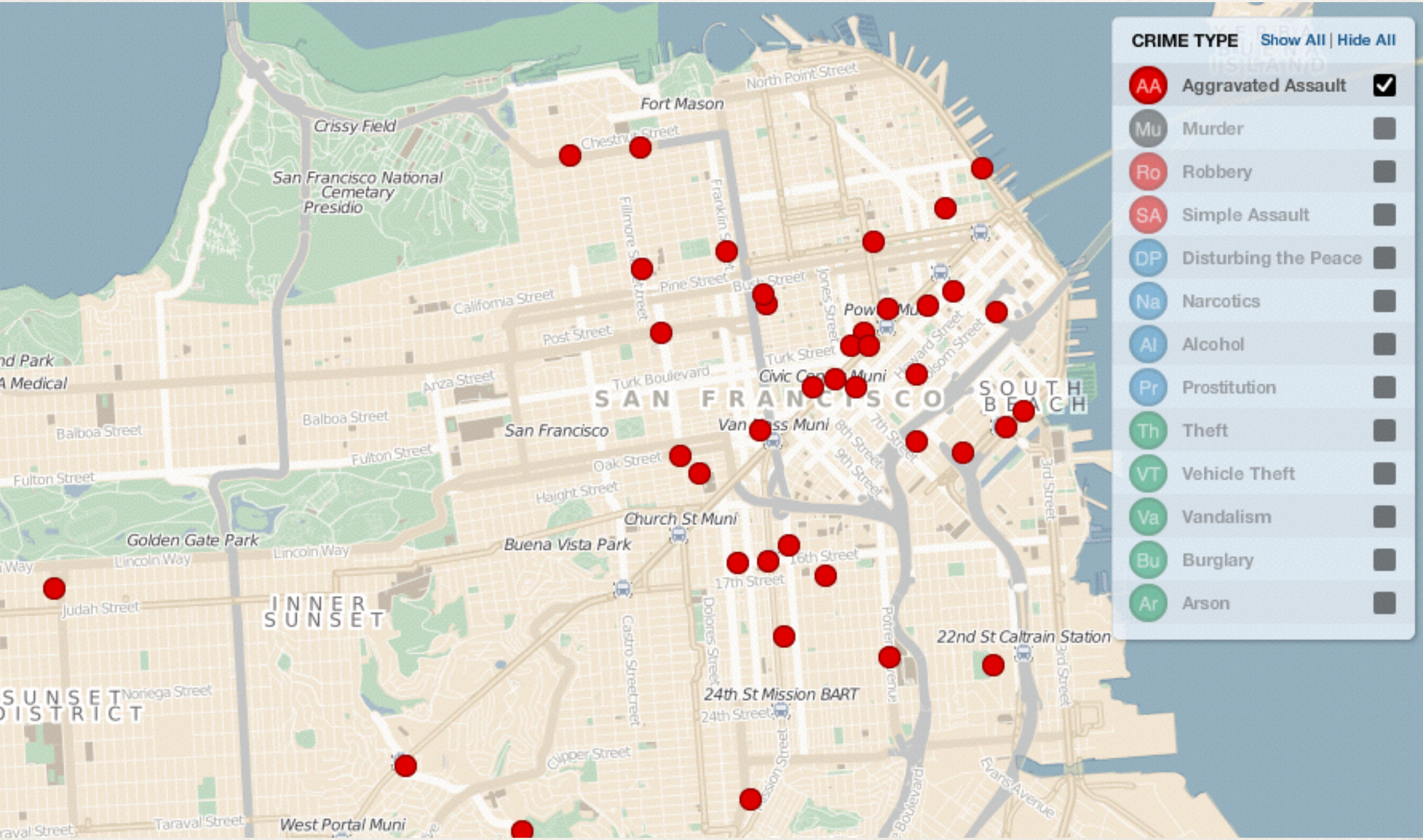
http://www.npr.org/templates/story/story.php?storyId=110997398

Dot map - What's the problem?

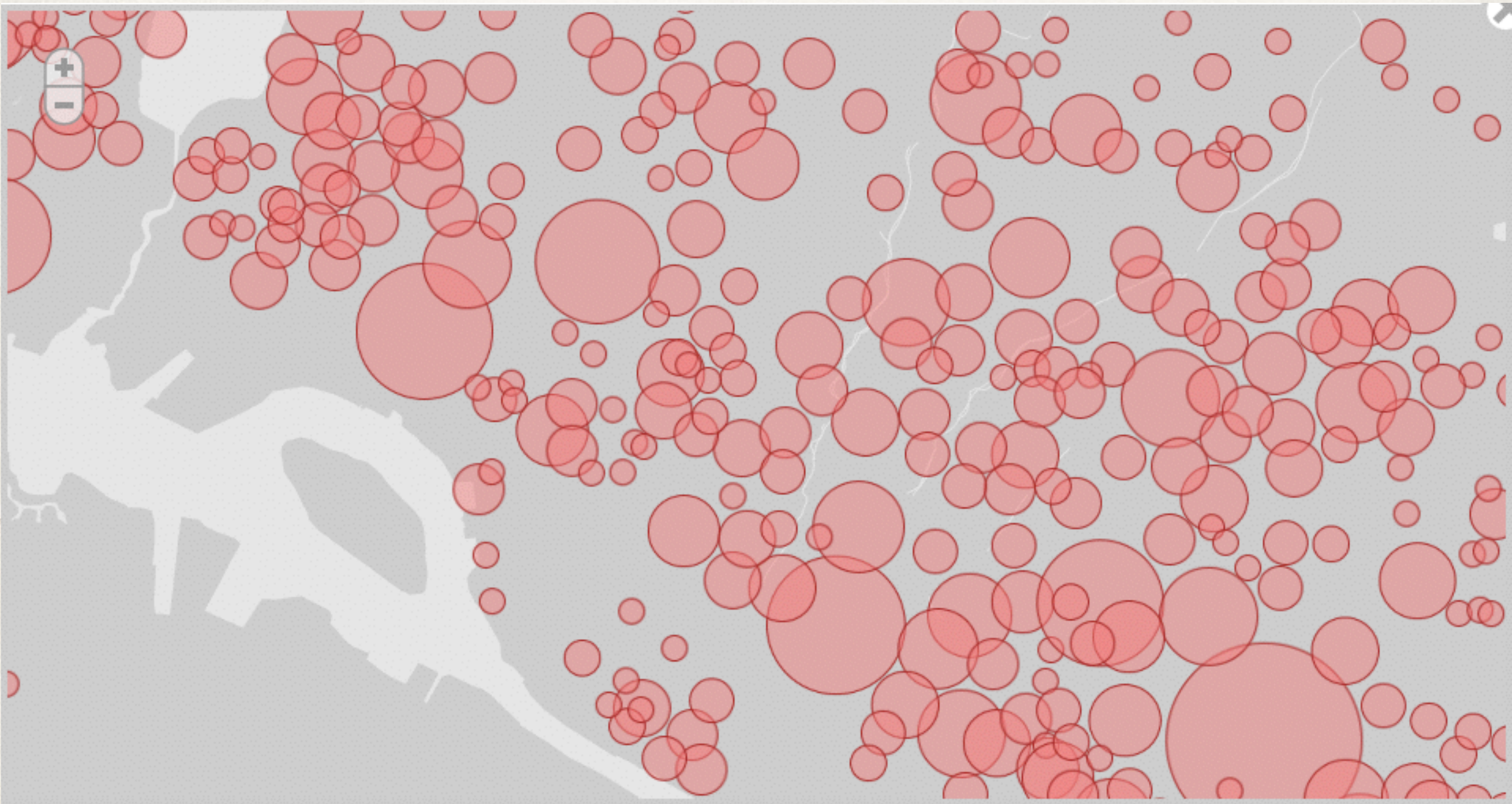


http://sanfrancisco.crimespotting.org

Dot map - What's the problem?

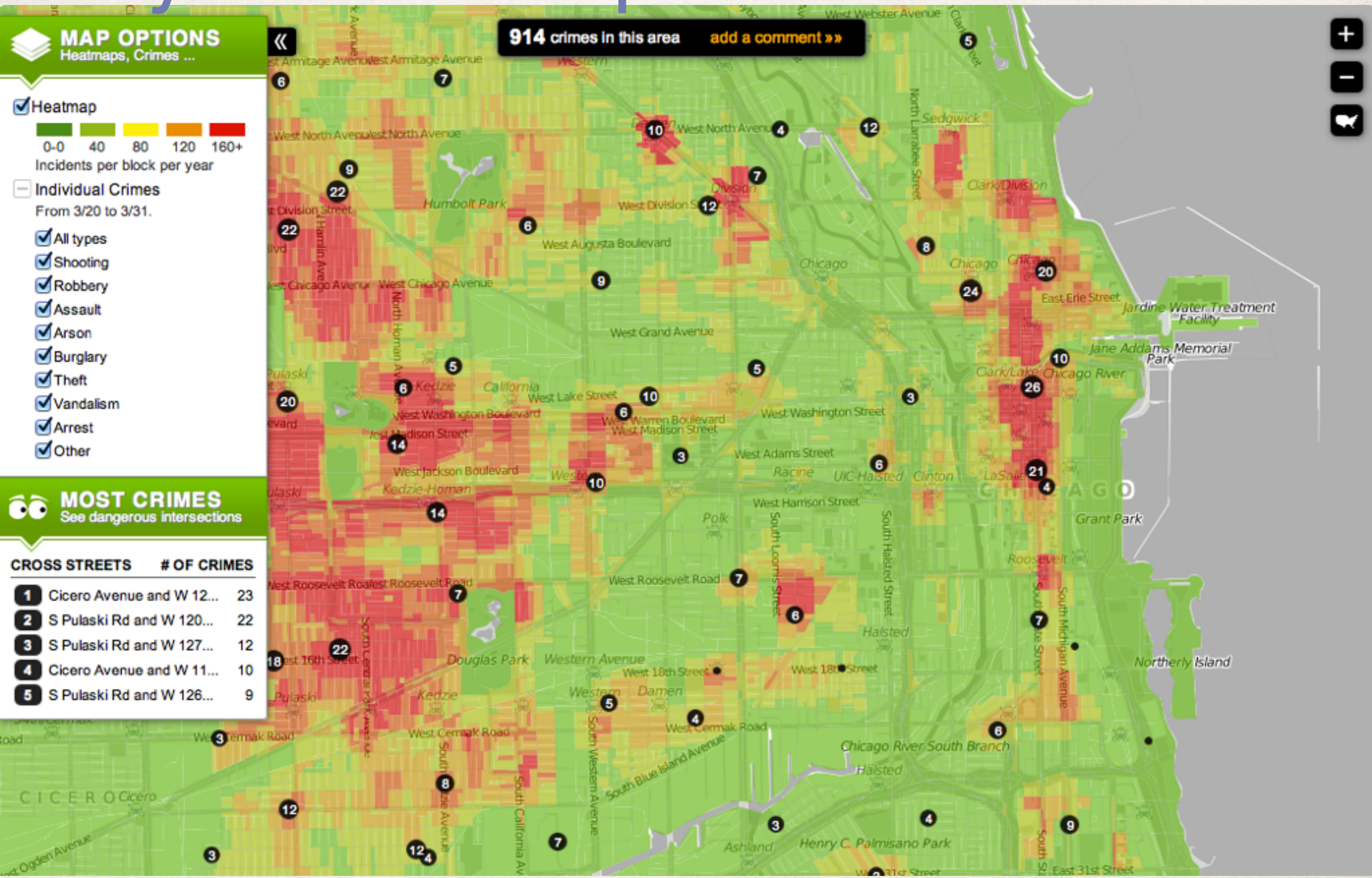


k-Means clustering



http://polymaps.org/ex/cluster.html

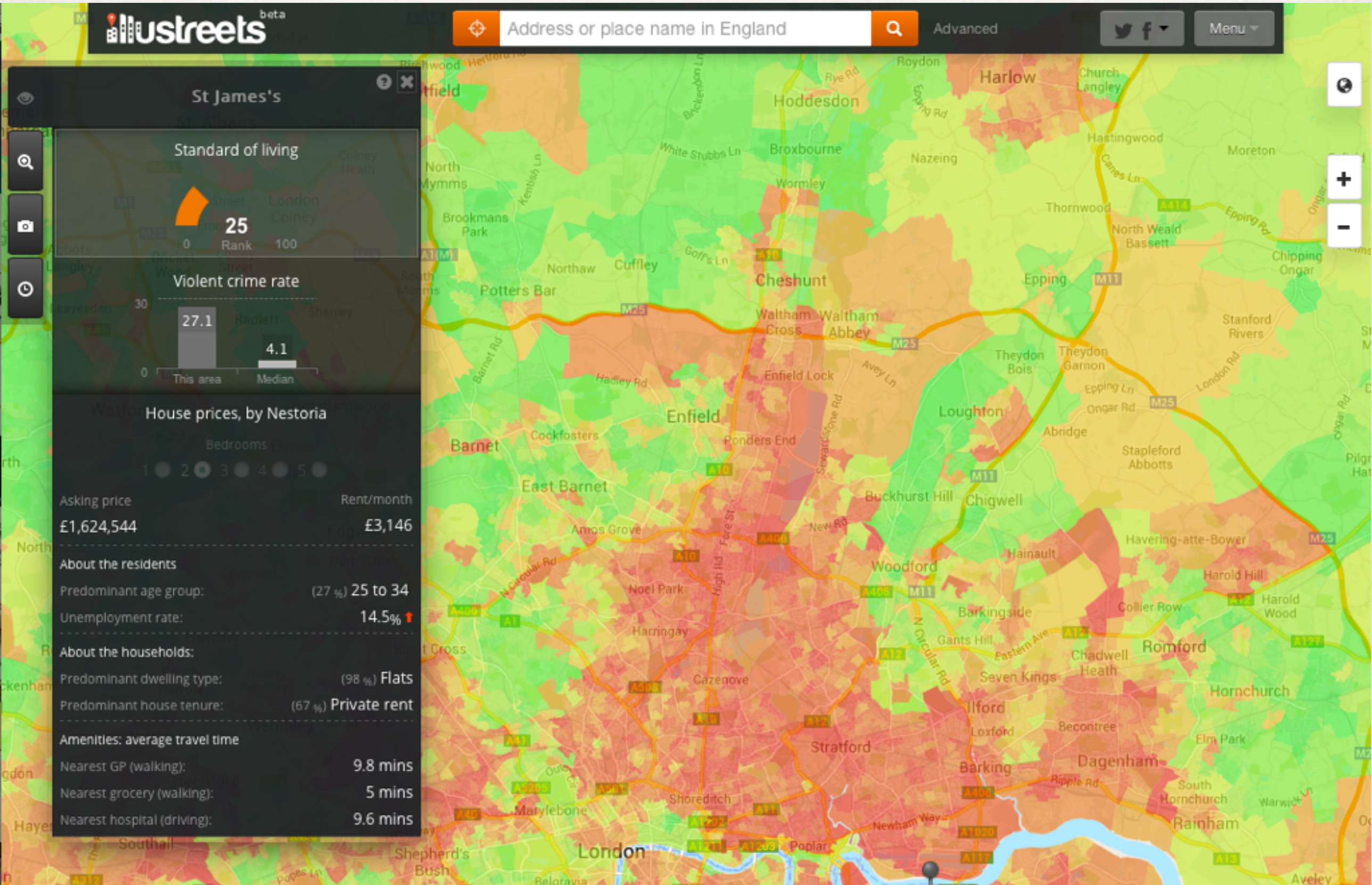
Dasymetric area map



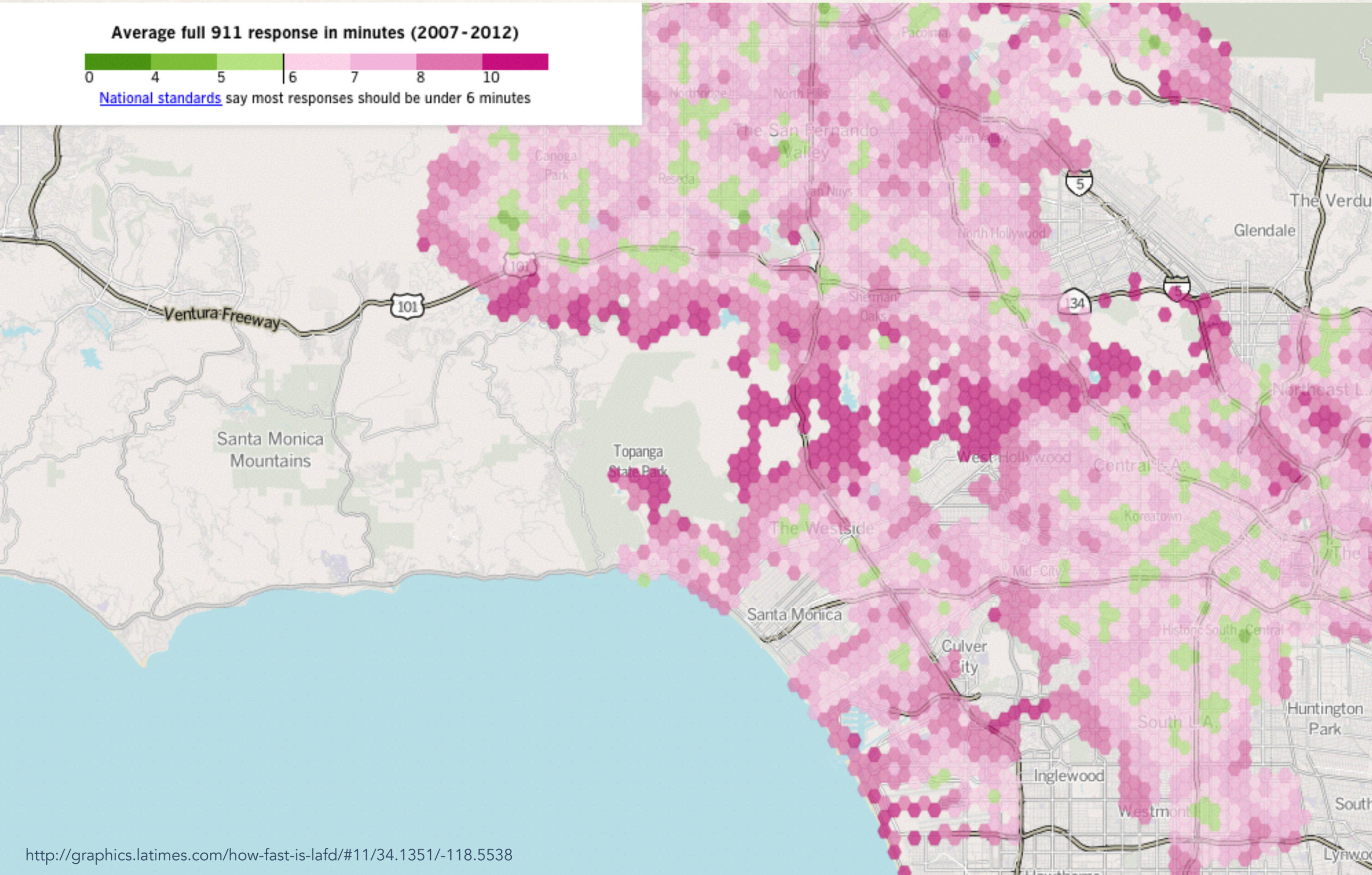
http://www.trulia.com/crime/

Illustreets

http://illustreets.co.uk/explore-england/

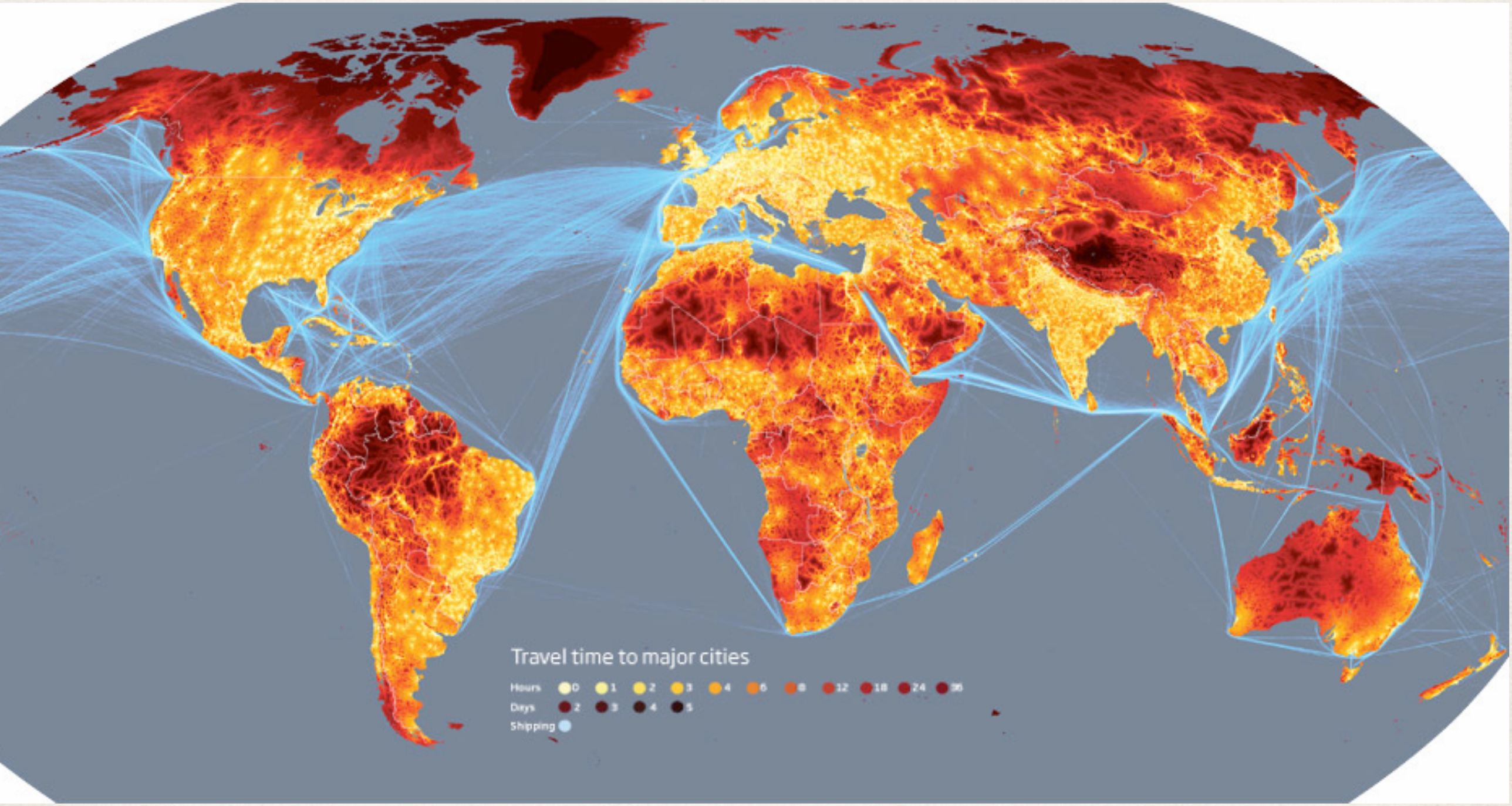


Binning



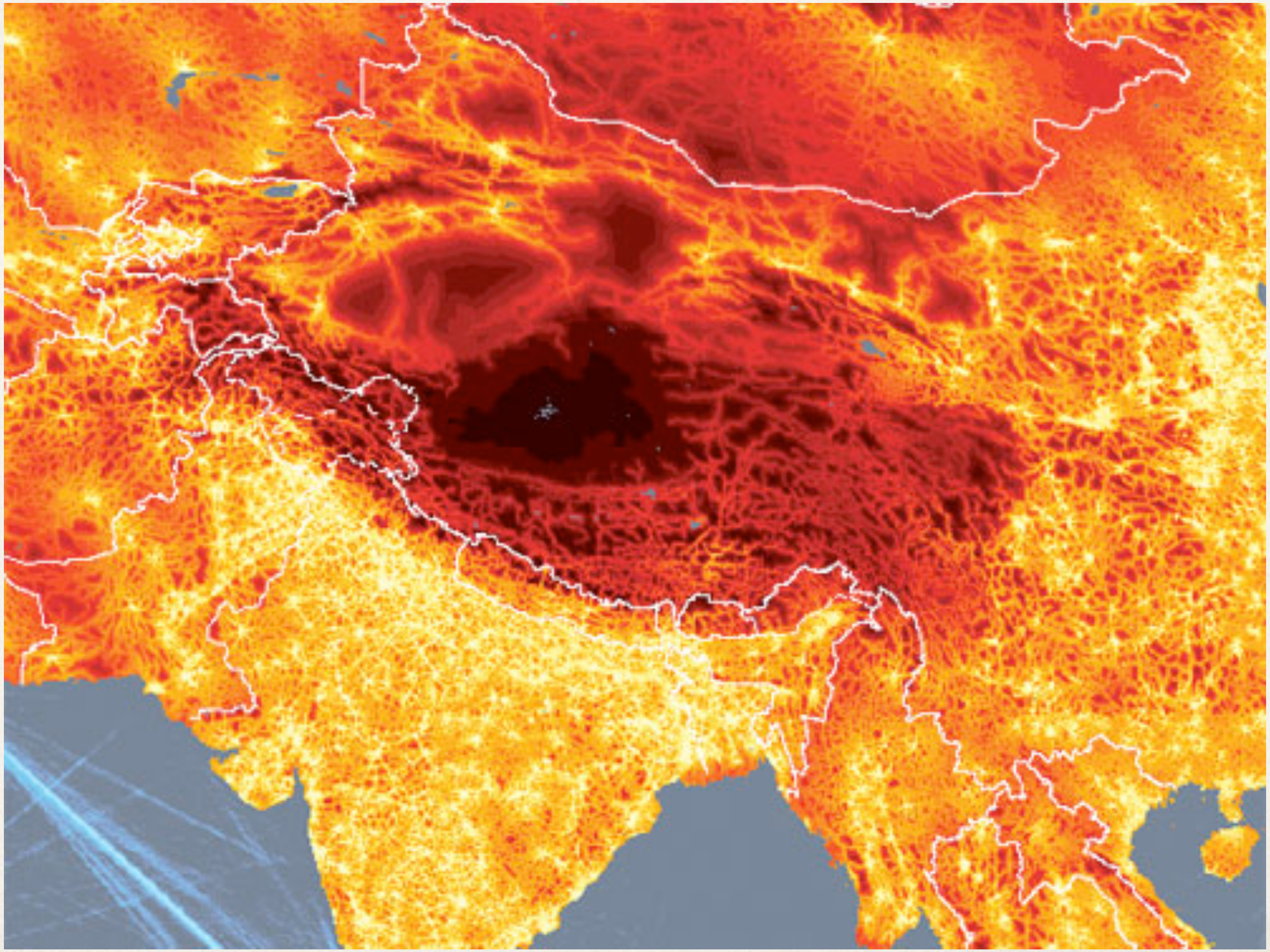
http://graphics.latimes.com/how-fast-is-lafd/#11/34.1351/-118.5538

Continuous mapping



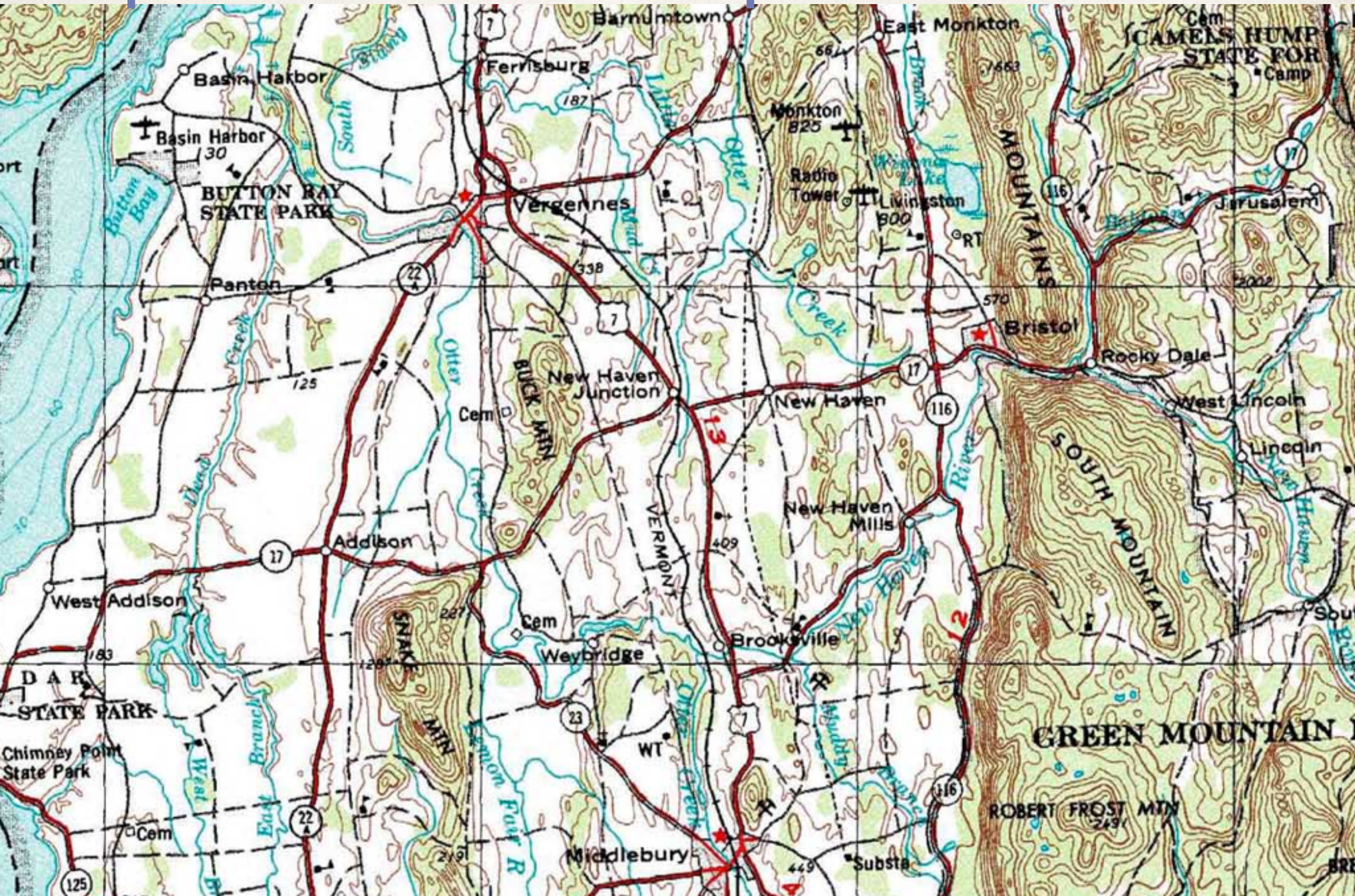
http://www.newscientist.com/gallery/small-world/1

Continuous mapping

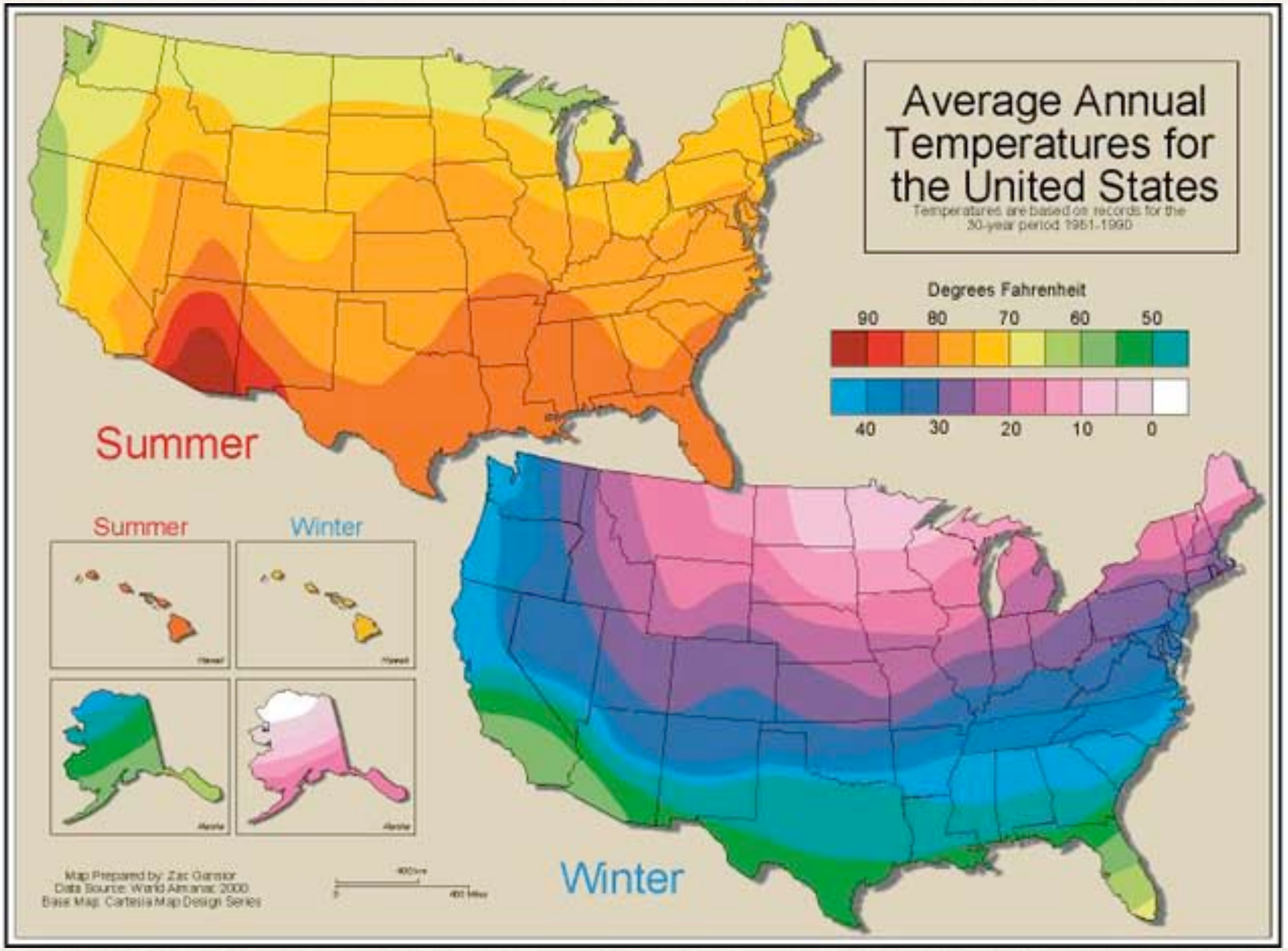


http://www.newscientist.com/gallery/small-world/1

Isopleth or isarithmic maps

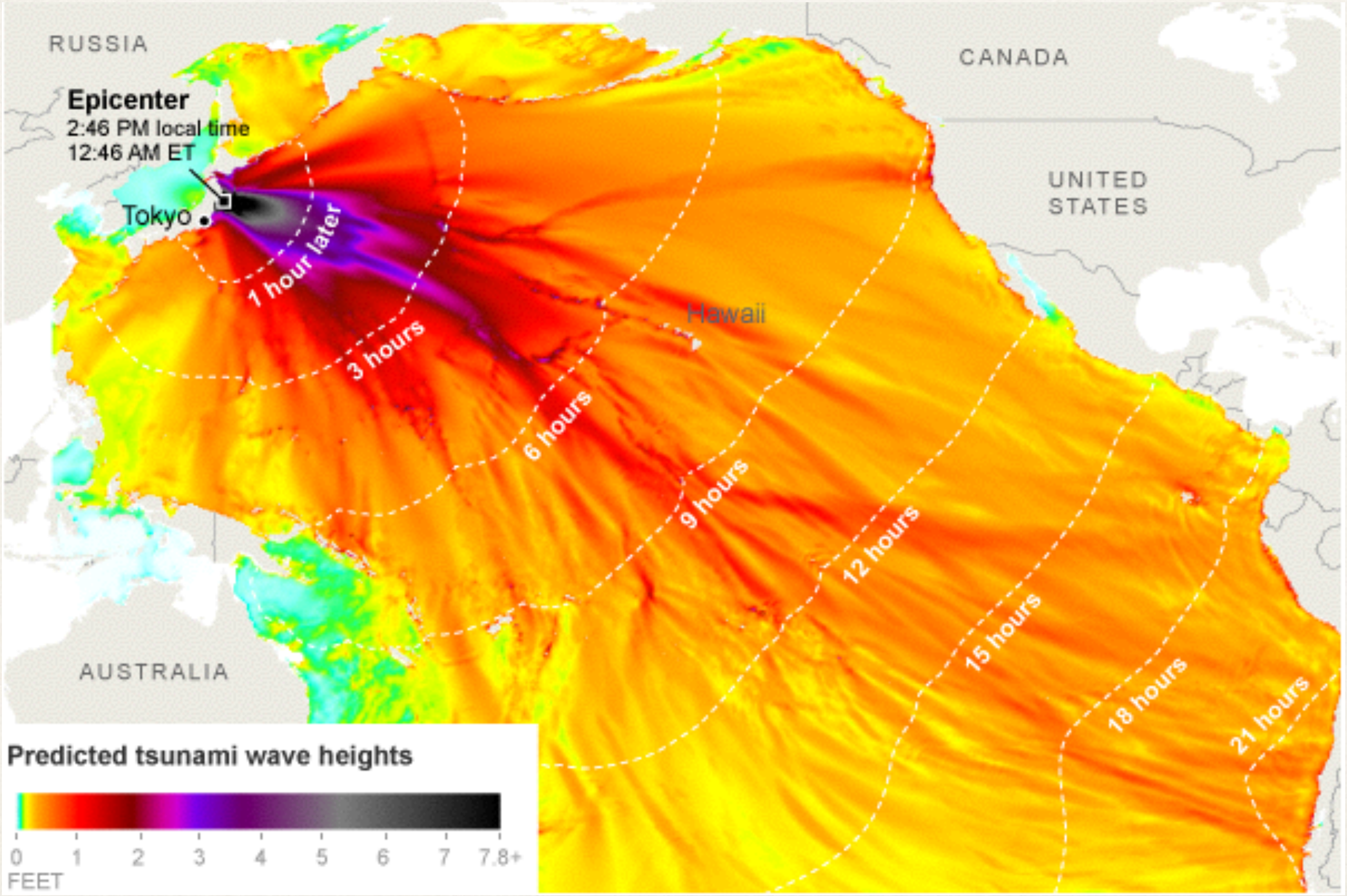


Isopleth or isarithmic maps



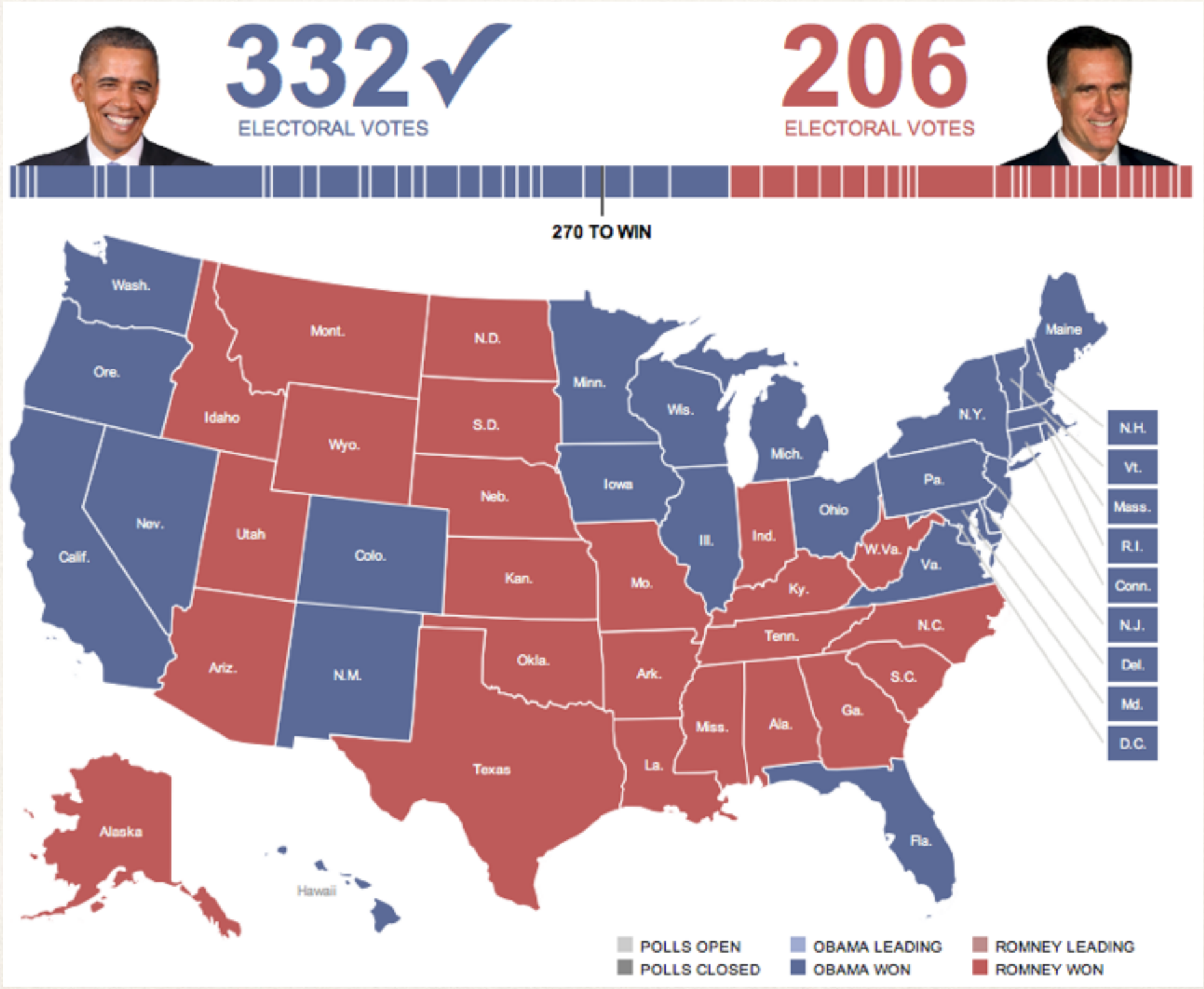
Heatmap + isochrones

iso == “same”, chrones” == time



http://www.nytimes.com/

Choropleth maps

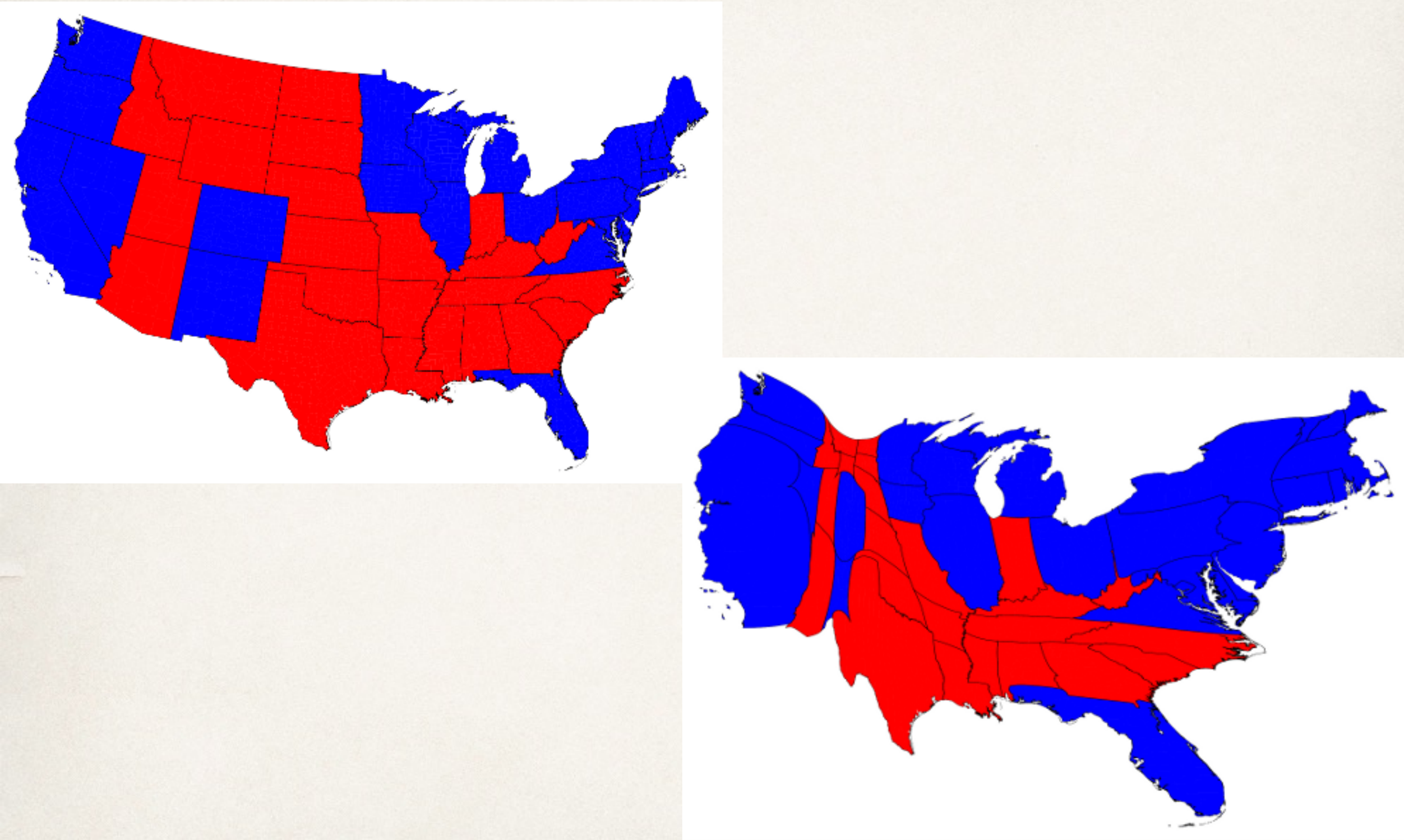


http://elections.huffingtonpost.com/2012/results

Building ages in Amsterdam

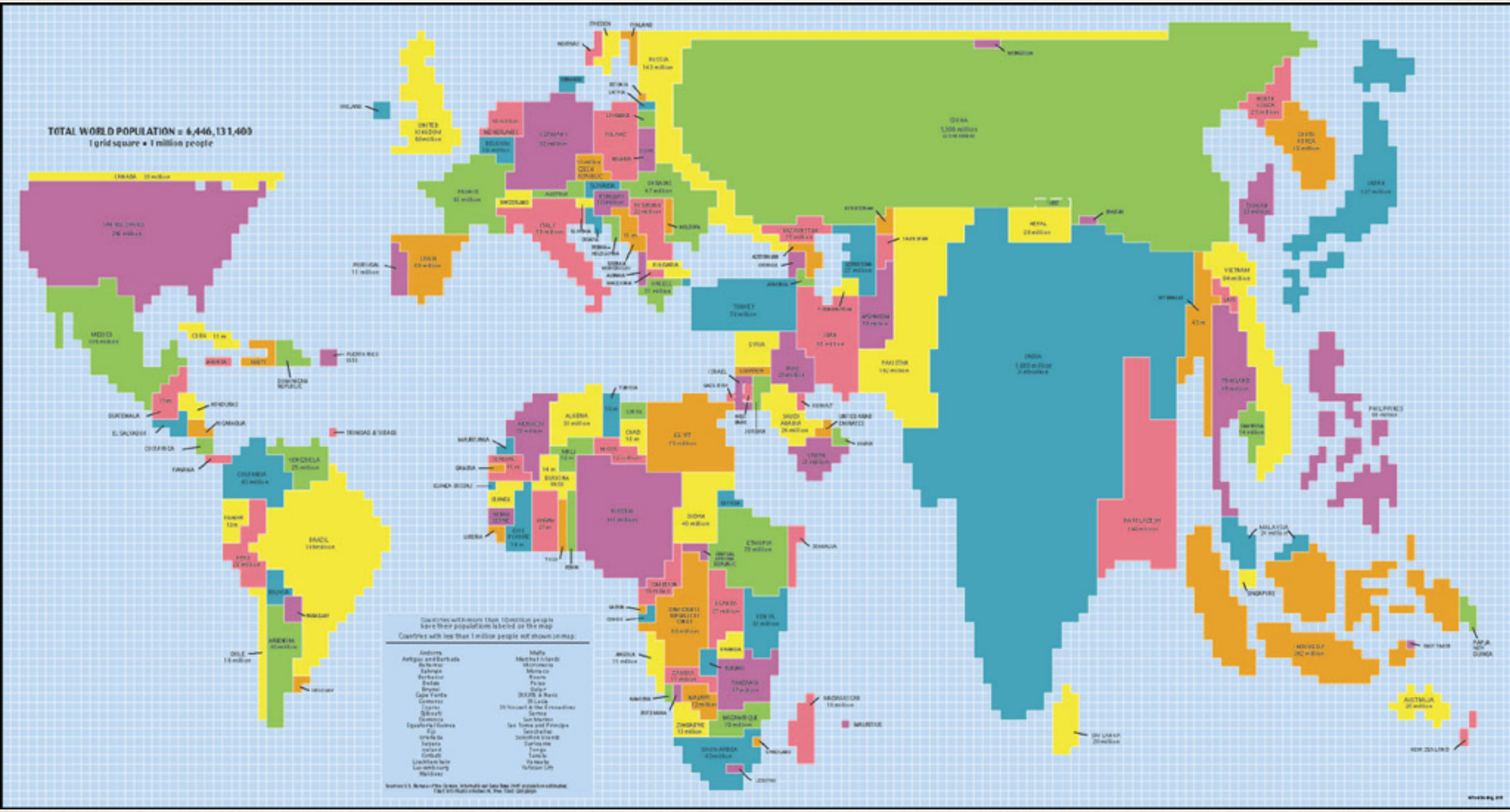
http://citysdk.waag.org/buildings

Cartograms



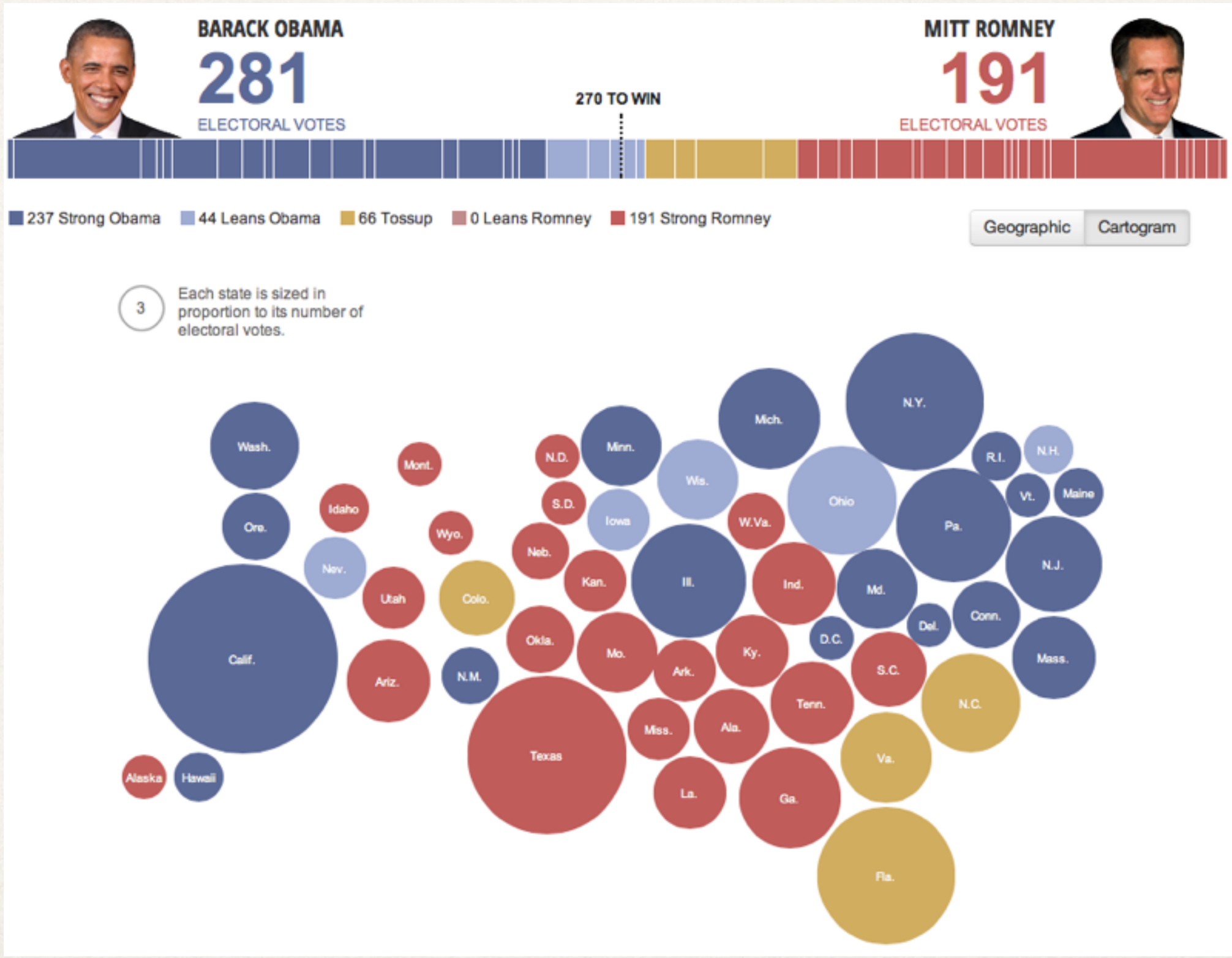
http://www-personal.umich.edu/~mejn/election/2012/

Rectangular cartogram



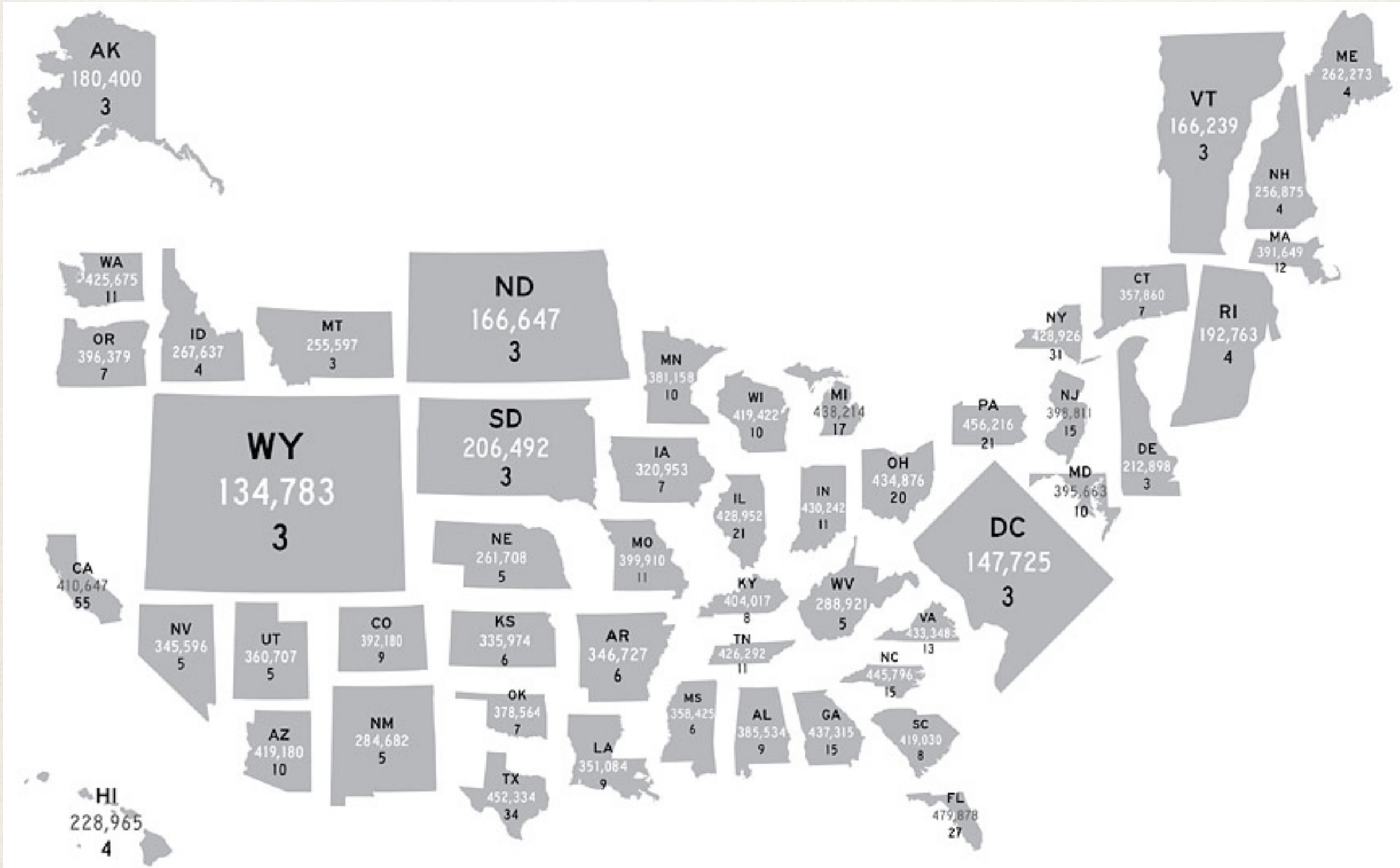
http://aphuge-ch2-population.blogspot.com

Circular cartogram



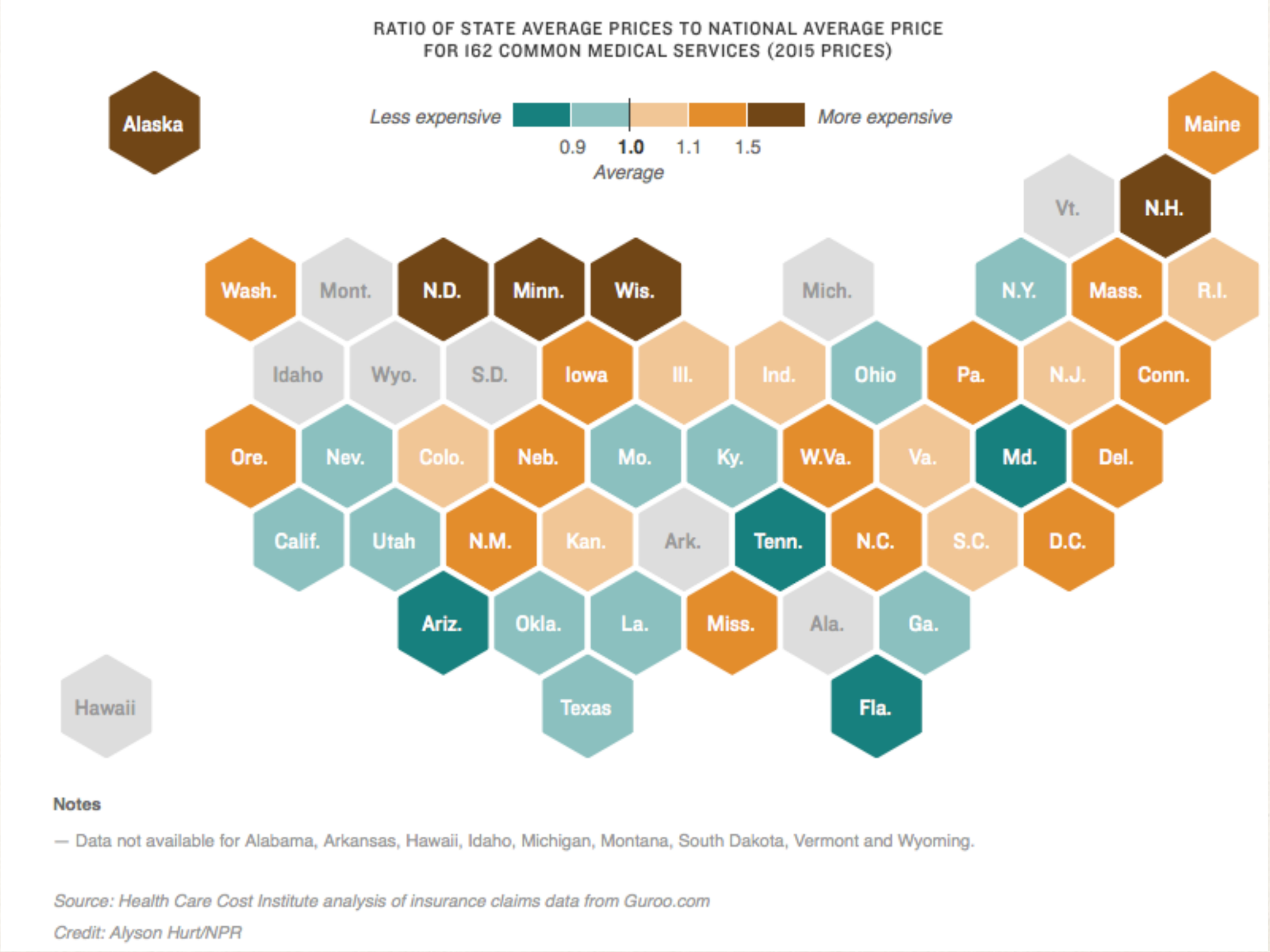
http://elections.huffingtonpost.com/2012/romney-vs-obama-electoral-map#cartogram

Non-contiguous cartograms



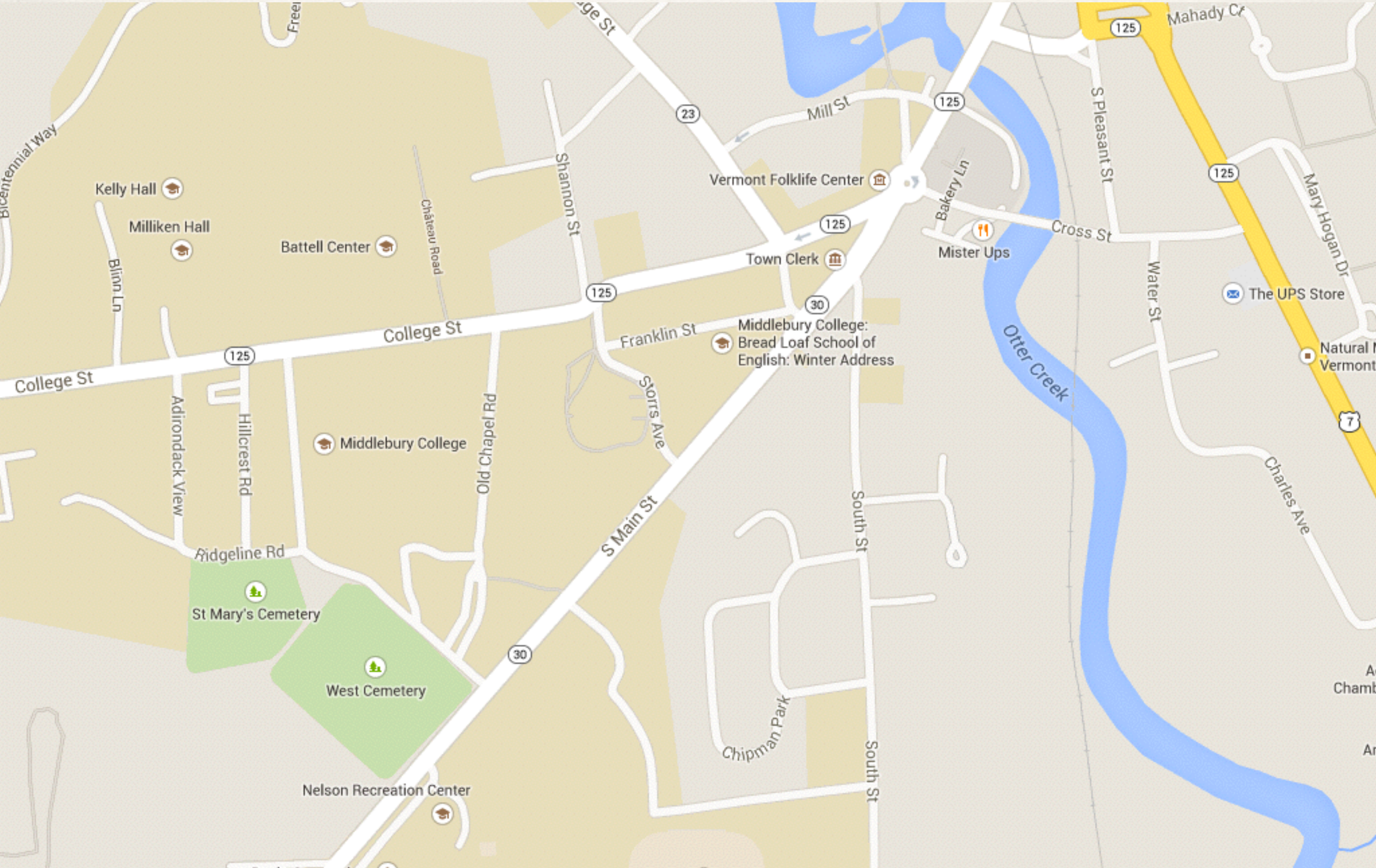
http://indiemaps.com/

Approximating geography



http://www.npr.org/sections/health-shots/2016/04/27/475880565/that-surgery-might-cost-you-a-lot-less-in-another-town

Line data


Bicentennial Way
Kelly Hall
Milliken Hall
Blinn Ln
Battell Center
Château Road
Shannon St
23
Mill St
Vermont Folklife Center
125
Town Clerk
Bakery Ln
Mister Ups
Cross St
S Pleasant St
Mahady Ct
125
Mary Hogan Dr
The UPS Store
Water St
College St
125
College St
Adirondack View
Hillcrest Rd
Middlebury College
Old Chapel Rd
Storrs Ave
Franklin St
Middlebury College: Bread Loaf School of English: Winter Address
Otter Creek
Natural R
Vermont
7
Charles Ave
Ridgeline Rd
St Mary's Cemetery
West Cemetery
S Main St
30
South St
Chipman Park
South St
Nelson Recreation Center

Network data

THE GRID | SOURCES OF POWER | POWER PLANTS | SOLAR POWER | WIND POWER

About This Map »

Click on the links below to switch layers on and off.

EXISTING LINES

- 345-499 kV
- 500-699 kV
- 700-799 kV
- 1,000 kV (DC)

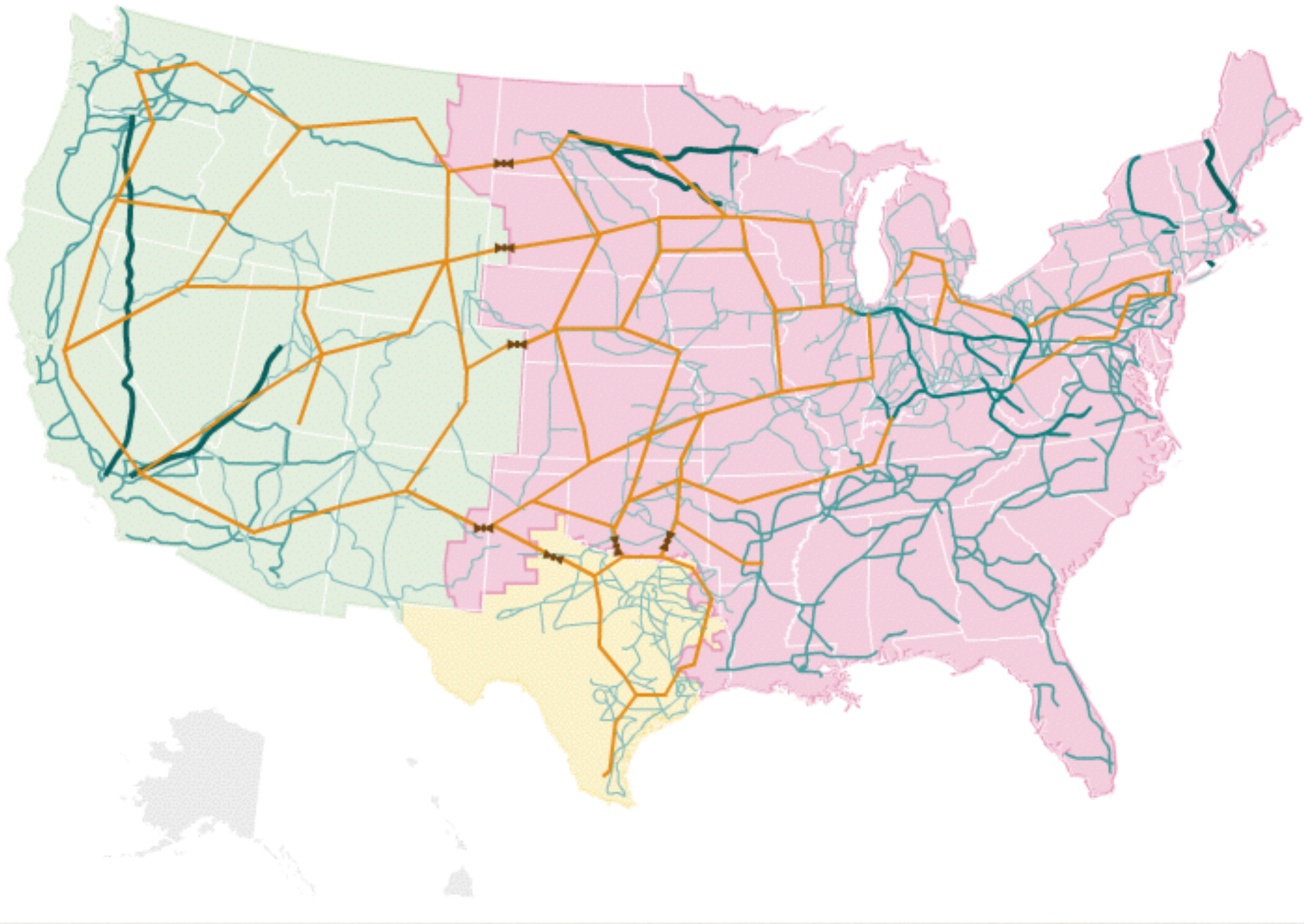
PROPOSED LINES

- New 765 kV
- AC-DC-AC Links

INTERCONNECTIONS

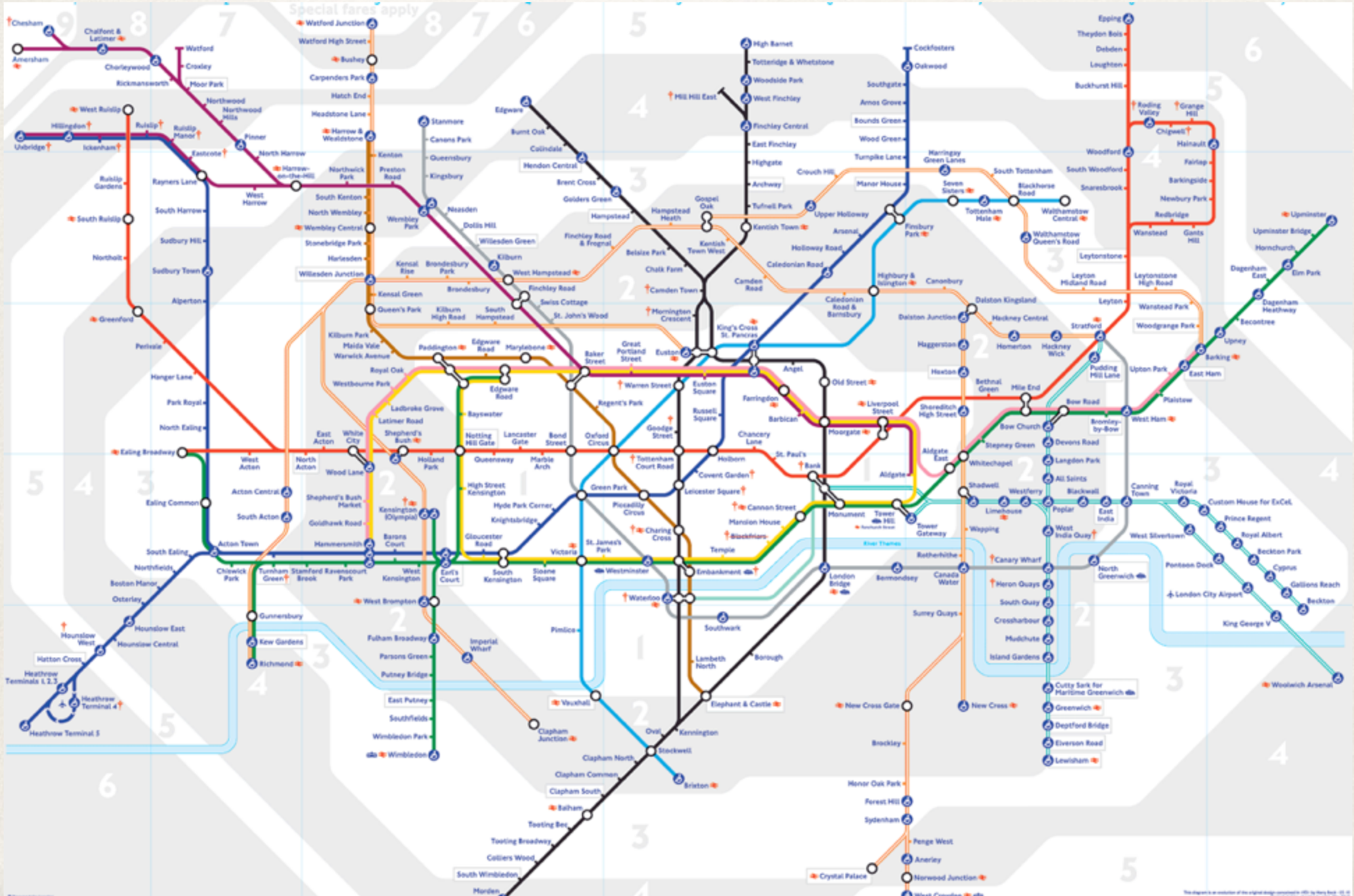
Major sectors of the U.S. electrical grid

- Eastern
- Western
- Texas (ERCOT)

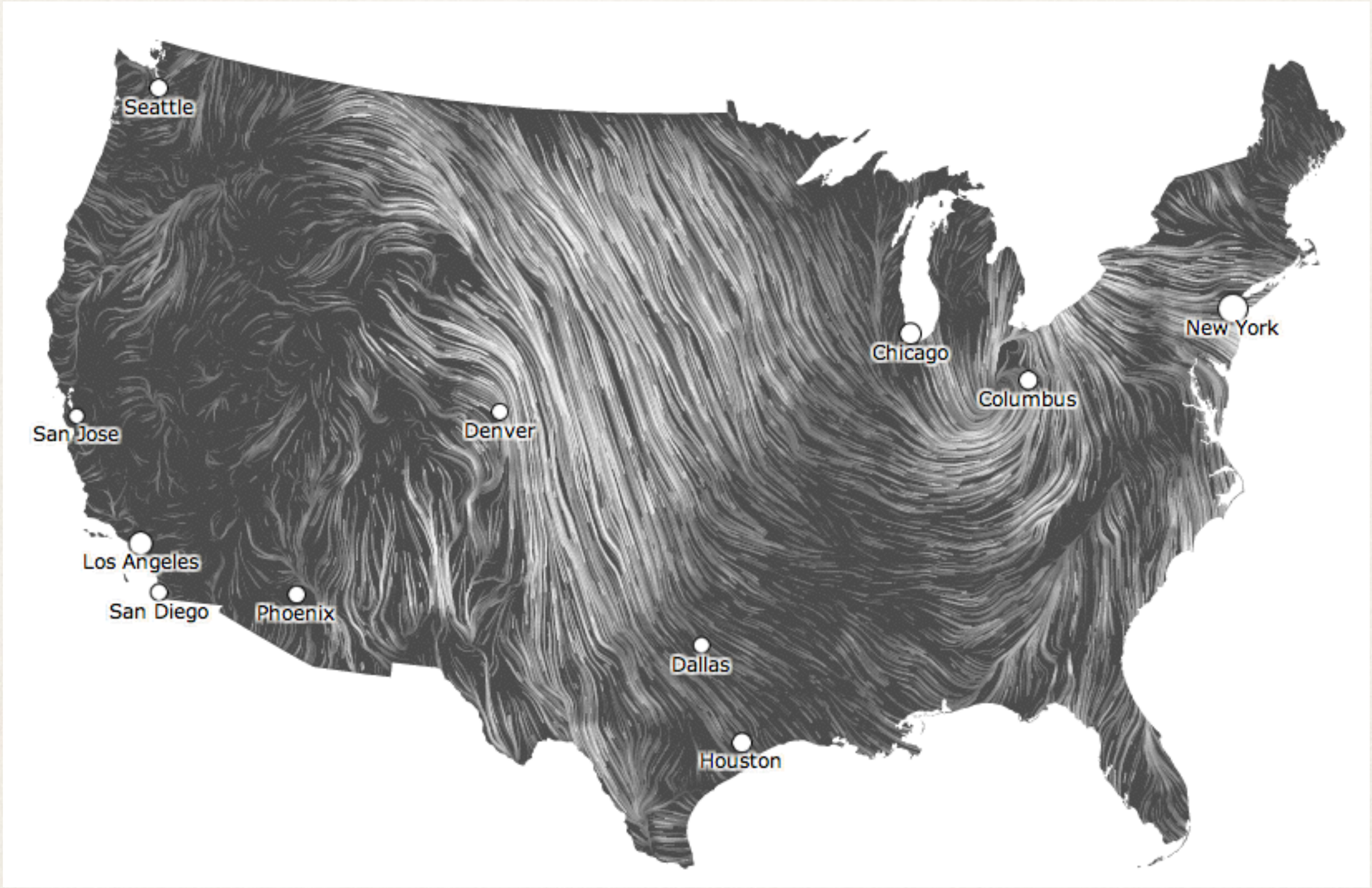


http://www.npr.org/templates/story/story.php?storyId=110997398

London tube map

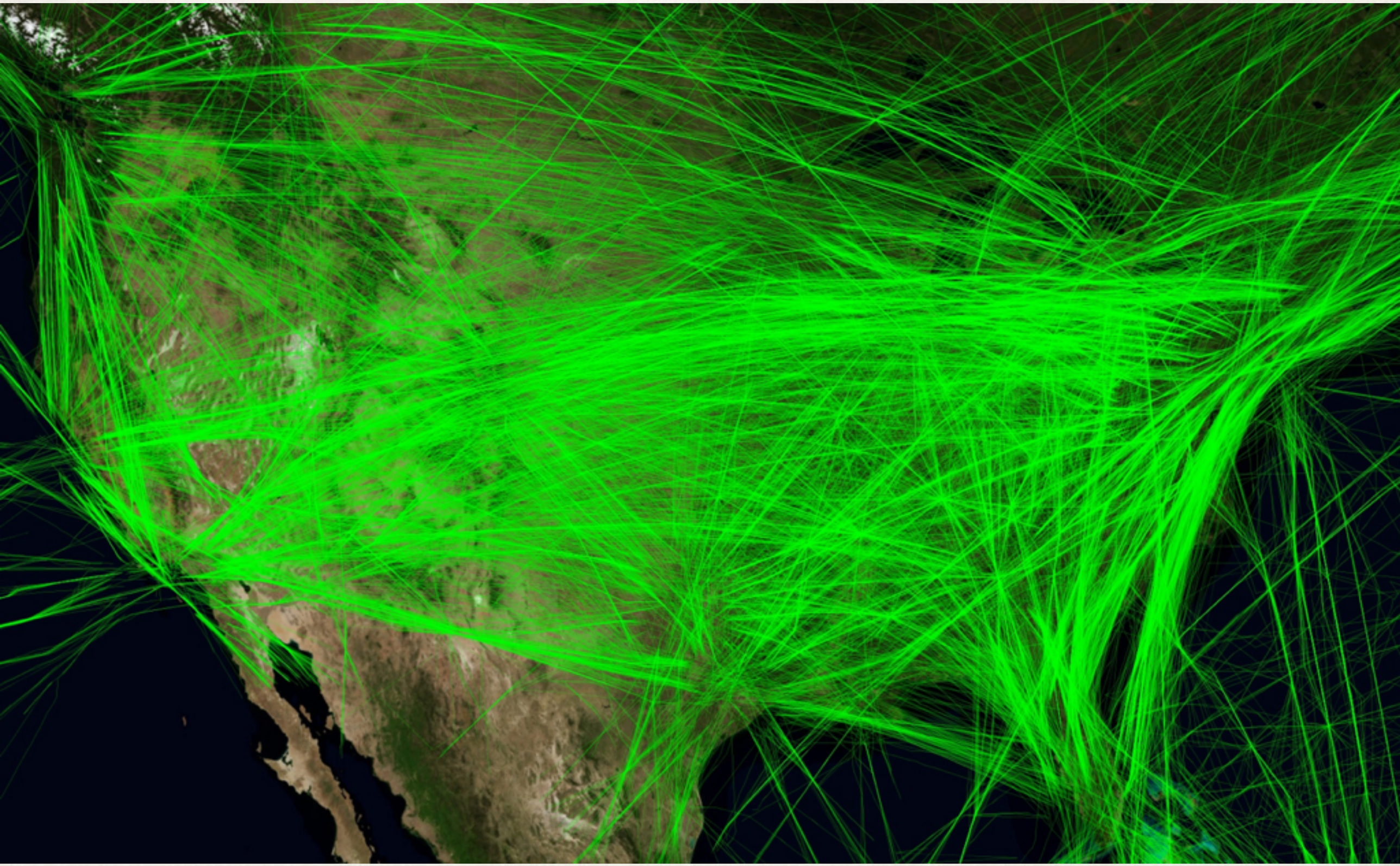


Flow map

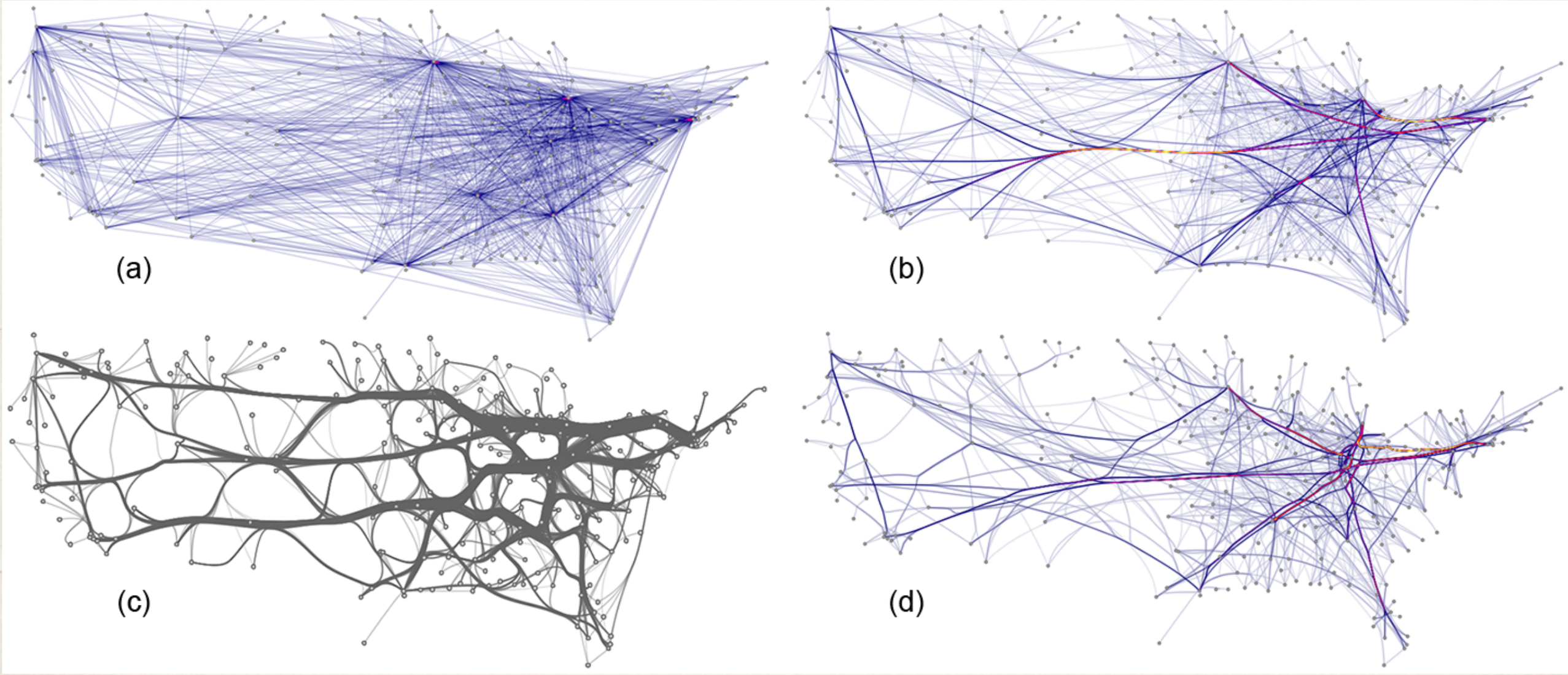


http://hint.fm/wind/

Airline flight path



https://www.metabunk.org/threads/visualizing-flight-paths-above-30-000-feet.812/



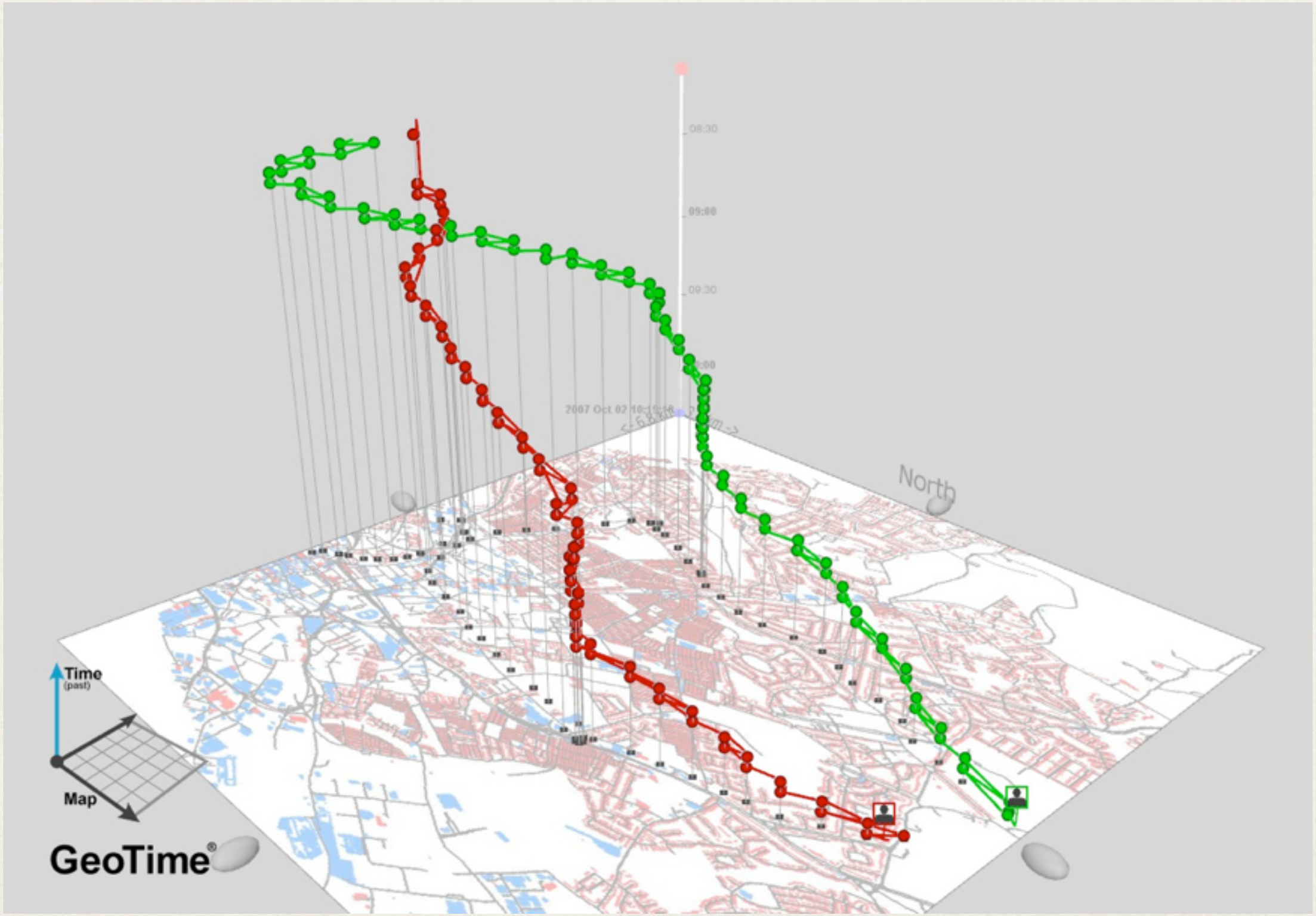
Holden and van Wijk, “Force Directed Edge Bundling for Graph Visualization”, 2009

http://www.spatialanalysis.ca/2011/global-connectivity-mapping-out-flight-routes/

Alternatives - Bristle maps

Kim et al., “Bristle Maps: A Multivariate Abstraction Technique for Geovisualization”

Alternatives - GeoTime



http://www.geotime.com