Information Visualization

Geospatial Visualization

Dr. David Koop

Critical Response to Reading

1. Describe, in your own words, what the problem addressed is and what the key contributions are
2. Respond to the paper
   - How would you add to the work that was presented?
   - What evaluation was not done that should have been?
   - No vague statements like "The paper is well-written"
   - Does the direction of the work make sense?
   - Questions are fine, but they should be specific & show your understanding
   - Keep track of points in favor, points against
   - Should focus on specific parts of the paper, make sure you understand everything about that part of the technique/system

Types of Visualization Papers

- Techniques (Algorithms)
- Applications (Design Studies)
- Systems (Toolkits)
- Evaluation (Summative User Studies)
- Model (Taxonomy, Formalism, Commentary)
- +Surveys

- and Combinations of the above

[T. Munzner, 2008]

General Paper Writing Pitfalls

- What I Did Over My Summer Vacation: a diary is not a paper
  - Should not be chronological
  - Should not dwell on implementation details (which may have taken a long time)
- Least Publishable Unit: Don't try to squeeze too many papers out of the same project
- Dense As Plutonium (Inverse of LPU): too dense, and can often miss important details of the work due to space
- Bad Slice and Dice: Dividing papers leads to too much overlap or neither paper being standalone

[T. Munzner, 2008]

Laramee's Suggested Structure

- Introduction (Motivation)
- Related Work
- Method (Computational Model)
- Enhancements/Extensions
- Implementation
- Results & Performance
- Conclusions & Future Work

[R. S. Laramee, 2009]

Pitfalls

- Stealth Contributions: “Do not leave your contributions implicit or unsaid”
- I Am So Unique: Don't try to sneak things past reviewers
- Enumeration Without Justification: Explain why your work is different
- Straw Man Comparison: Compare against other contemporary solutions
- But My Friends Liked It: Informal evidence is not compelling
- Unjustified Tasks: Test tasks that users actually do
- Story-Free Captions: Use captions to tell the story of your work
- My Picture Speaks For Itself: Write your take-away points in the captions

[T. Munzner, 2008]

Project Proposal

- Due **Today**
- Turn in via Blackboard
- Write up your ideas as they currently stand
- Things can change, that's ok!
- Focus on motivation (why should we care?) and the core idea (how does your work improve on existing techniques?)

Paper Presentation Schedule

- Any concerns with this schedule?

Date	Topic	Primary	Secondary
2021-09-30	Temporal Data	Venkata Devesh Reddy Seethi	Mohammed Murtuza Shahzad Syed
2021-10-12	Uncertainty Visualization	Colin Brown	Abdul Rahman Shaikh
2021-10-26	High-Dimensional Data & Dimensionality Reduction	Md Ashiqur Rahman	Colin Brown
2021-11-04	Machine Learning & Explainable AI	Mohammed Murtuza Shahzad Syed	Md Ashiqur Rahman
2021-11-16	Multiple Views, Layouts, and Interaction	Abdul Rahman Shaikh	Venkata Devesh Reddy Seethi

Topic Format

- Three class sessions:
  1. Introduction: background lecture related to topic
  2. Paper Presentations:
     - Primary presents the paper, generally in a positive light
     - Secondary critiques the paper (what could have been improved, etc.)
  3. Discussion: discuss topics related to the paper, ideas, etc.
- Everyone reads the paper(s), comes ready with questions for presenters

Next Class

A Declarative Rendering Model for Multiclass Density Maps

Jaemin Jo, Frédéric Vernier, Pierre Dragicevic, and Jean-Daniel Fekete, *Senior Member, IEEE*

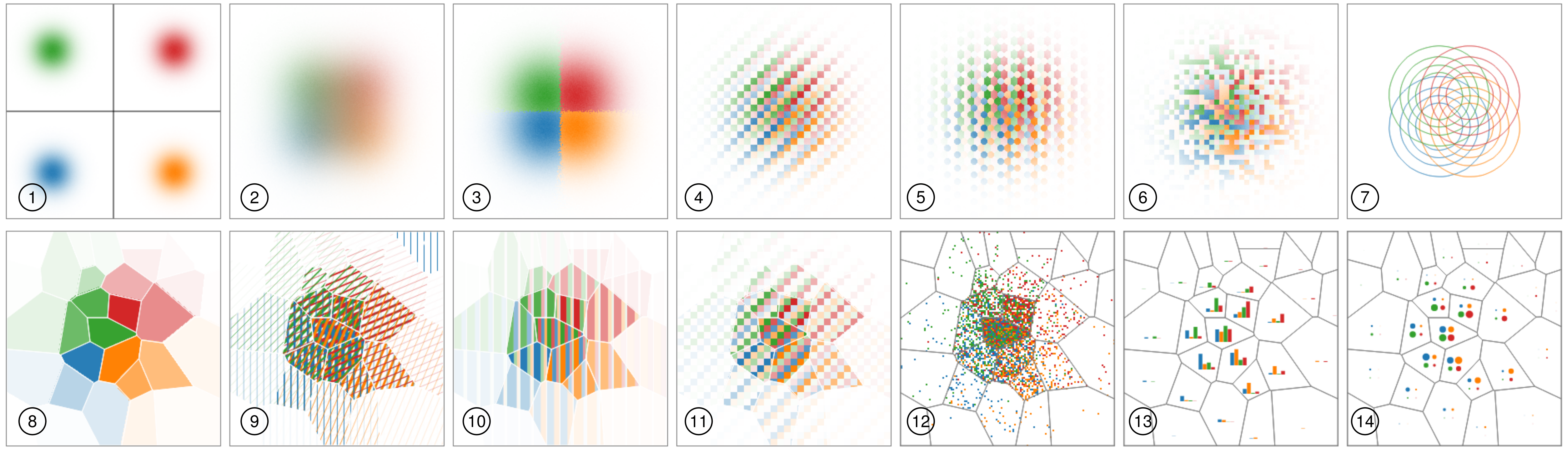


Fig. 1: Design alternatives for a four-class density map. ① shows small multiples where each density map is individually presented with a unique color; ② stacks the density maps and blends the color at each pixel; ③ shows the color of the pixel with the highest density; ④-⑥ use regular and irregular weaving patterns; ⑦ shows a contour plot for each class; and ⑧–⑭ use rebinning (binning and aggregation over the density maps) with tiles produced by a random Voronoï tessellation. The aggregated values are rendered in ⑧ with a flat color showing the highest density, ⑨ with hatching, ⑩ with proportional bars, ⑪ with regular weaving, ⑫ with a dot density plot, ⑬ with bar-chart glyphs, and ⑭ with circle sizes.

Abstract—Multiclass maps are scatterplots, multidimensional projections, or thematic geographic maps where data points have a categorical attribute in addition to two quantitative attributes. This categorical attribute is often rendered using shape or color, which does not scale when overplotting occurs. When the number of data points increases, multiclass maps must resort to data aggregation to remain readable. We present *multiclass density maps*: multiple 2D histograms computed for each of the category values. Multiclass density maps are meant as a building block to improve the expressiveness and scalability of multiclass map visualization. In this article, we first present a short survey of aggregated multiclass maps, mainly from cartography. We then introduce a declarative model—a simple yet expressive JSON grammar associated with visual semantics—that specifies a wide design space of visualizations for multiclass density maps. Our declarative model is expressive and can be efficiently implemented in visualization front-ends such as modern web browsers. Furthermore, it can be reconfigured dynamically to support data exploration tasks without recomputing the raw data. Finally, we demonstrate how our model can be used to reproduce examples from the past and support exploring data at scale.

Index Terms—Scalability, multiclass scatterplots, density maps, aggregation, declarative specification, visualization grammar

Application Papers

- Visualizations as they are applied to application-specific data
- Less focus on the originality of the algorithm, more focus on domain-specific challenges and decisions
- Related work should contain domain-specific papers
- Additional Background section to provide readers outside of the CS domain with the necessary background
- Method may be more focused on the decisions and process and compare different approaches
- Results often revolve around expert study (evaluation from experts that have used the proposed visualizations)

[R. S. Laramee, 2009]

Writing Goals

- Write for the **audience**.
  - "Don't just write what you want to say, write what the audience needs to hear."
- Get your audience to **nod**: if the reviewer doesn't agree or wonders if you're wrong, they are less likely to like your paper
  - Avoid weasel-y words: "Some researchers think…" Who?
- Make your writing **predictable**
  - Readers are lazy
  - "You are not writing a mystery novel"
  - Upside-down pyramid writing: Important things at **start** of paper, section, paragraph

[R. Chang, 2019]

Abstract Template

- sentence 1: background
- sentence 2: missing gap (e.g. "however, there's a problem blah")
- sentence 3: why is this bad
- sentence 4: "In this paper, we propose SystemX"
- sentence 5, 6 (and/or 7): technical depth on what SystemX is. That is, what is the secret sauce that makes SystemX possible?
- sentence 8: benefits of SystemX, aka the primary contribution of the paper (should echo sentence 3 in that SystemX should have addressed the problem)
- sentence 9: "We evaluate SystemX..."
- sentence 10: "Our results indicate that (problem stated in sentence 3 is no longer a problem)..."

[R. Chang]

Exercise: Write a Pie Chart Paper

- Pretend you just discovered pie charts and want to write an abstract for the VIS conference

- Abstract Template:
  - Background
  - Motivation including problem
  - Summarize technique
  - Contributions
  - Evaluation and Results

[R. Chang]

Exercise: Pie Chart Q&A

- What kind of paper is this?
  - Technique
- Why pie charts?
  - Similar to bar charts in that they show magnitudes per object
  - Better in that they show "parts to whole" relations
  - Aesthetically pleasing and easier to read for some users
- How do you evaluate pie charts?
  - Study 1: A-B study of pie vs. bar. Quantitative measure that pie is better at "parts to whole"
  - Study 2: Qualitative study to show that pie charts are aesthetically pleasing and easy to understand

[R. Chang]

Survey Paper

- "[A]ssist the reader in the hunt for previously published research papers on a given topic"
- Full-length surveys can be 20-30 pages
- Contributions:
  - A novel classification of the literature (how your classification differs from previous surveys, or whether the survey is the first of it’s kind in the field).
  - A compilation of future challenges or trends in the domain.
  - The identification of both mature and less explored research directions in the field.

[L. McNabb & R. S. Laramee]

Survey Paper Challenges

- Managing the amount of previously published literature
- Identifying a starting point
- Deciding on a topic
- Performing a search
- Interpreting individual research papers
- Deriving a classification of literature on the given topic
- Determining related unsolved problems and future challenges

[L. McNabb & R. S. Laramee]

Finding Sources

- A search can yield thousands of papers
- Use known "good" papers to locate more sources
- "Cited by…" in Google Scholar

Literature Sources
Google Scholar [Goo16]
IEEE Xplore Digital Library [IEE16]
ACM Digital Library
Vispubdata [IHK*17]
The Annual EuroVis Conference
IEEE TVCG Journal
IEEE Pacific Visualization Symposium
IEEE VAST Conference
The Annual Eurographics Conference
The Eurographics Digital Library
Journal of Visual Languages & Computing
Information Visualization Journal
Computer Graphics Forum
Computer & Graphics
ACM Computing Surveys

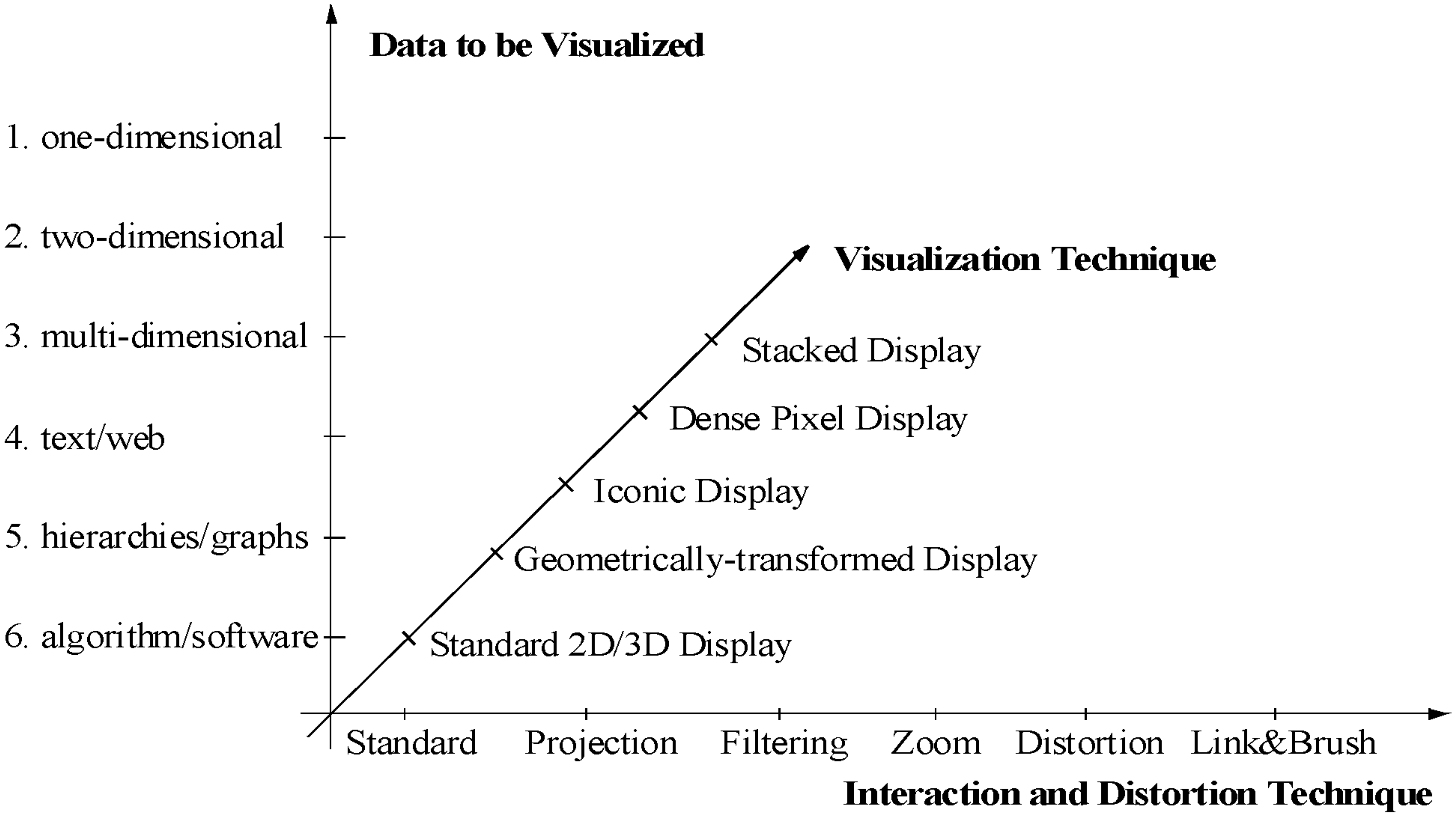
[L. McNabb & R. S. Laramee]

Other Decisions

- Classification of Topics/Papers
  - Often multiple dimensions, tables used
  - One is often topics, others can be data dimensionality
- Scope of the Survey
  - Beware of being too broad or too narrow
  - Aim to create a scope of 40-50 papers
- Organization of the Survey
  - Classification helps
  - Break up smaller pieces into similar paragraphs

[L. McNabb & R. S. Laramee]

Keim's InfoVis Classificiation



[D. Keim, 2002]

Classification

- Try to find 2D classification
- Dimensions that are well-known are useful
  - Example: Shneiderman's task by data-type taxonomy (overview, zoom, filter, details-on-demand, relate, history, extract)
- Can structure the classification using unique mapping or 1-N mapping
- Tables are very helpful

	D_1		
D_2		L_1	L_1, L_2
	L_2		L_2
		L_1	L_1, L_2

(A)

	D_1			D_2		
L_1		✓	✓	✓		✓
L_2			✓	✓	✓	✓
L_n	✓				✓	

(B)

(C)

D_1	L_1,L_4,L_5,L_6,L_7
	L_3,L_6,L_7,L_8
	L_2, L_6,L_7

	D_1		
D_2		L_1	
	L_n		
			L_2

(A)

	D_1			D_2		
L_1		✓		✓		
L_2			✓			✓
L_n	✓				✓	

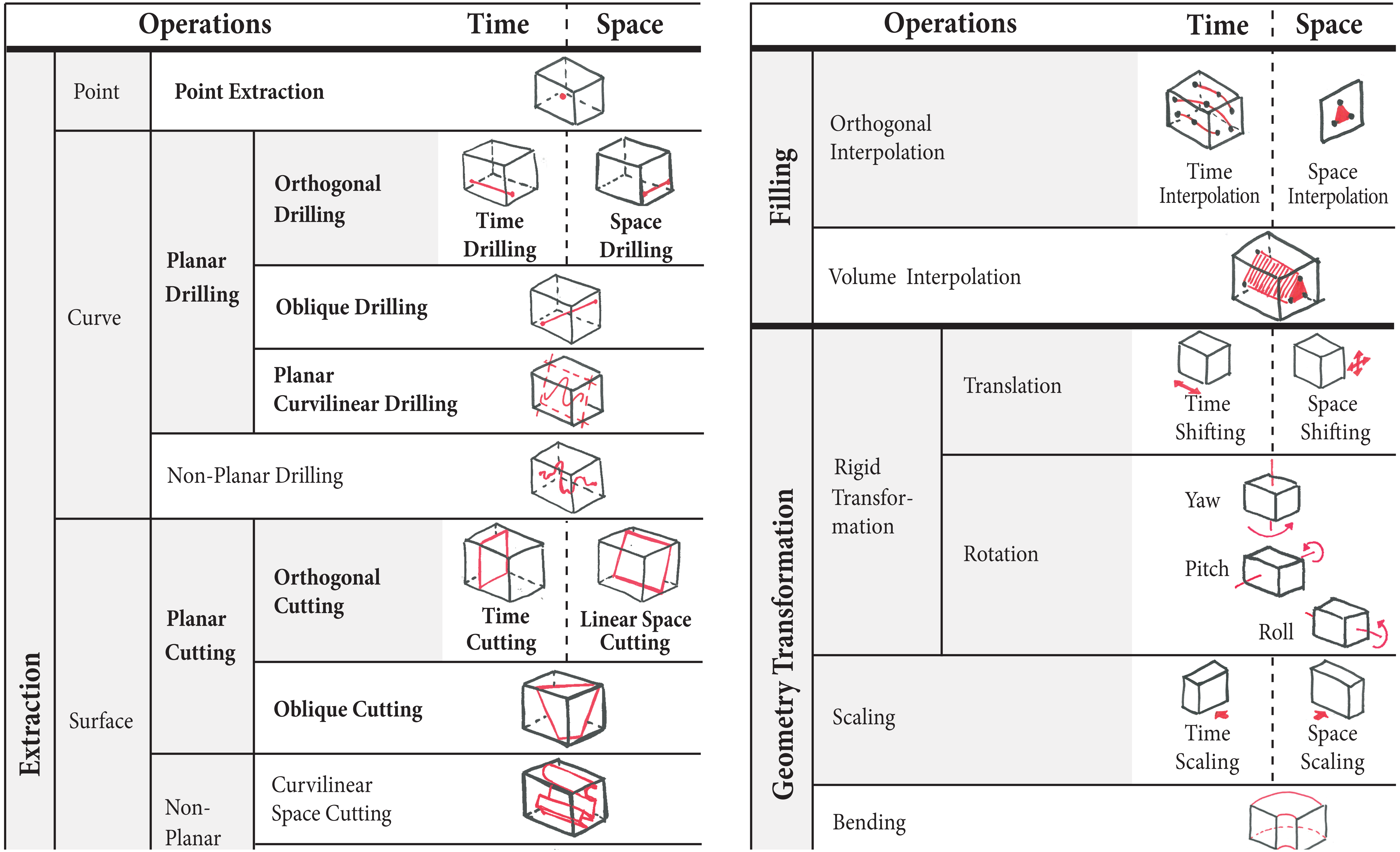
(B)

(C)

D_1	L_1,L_4,L_5
	L_3,L_6,L_7,L_8
	L_2

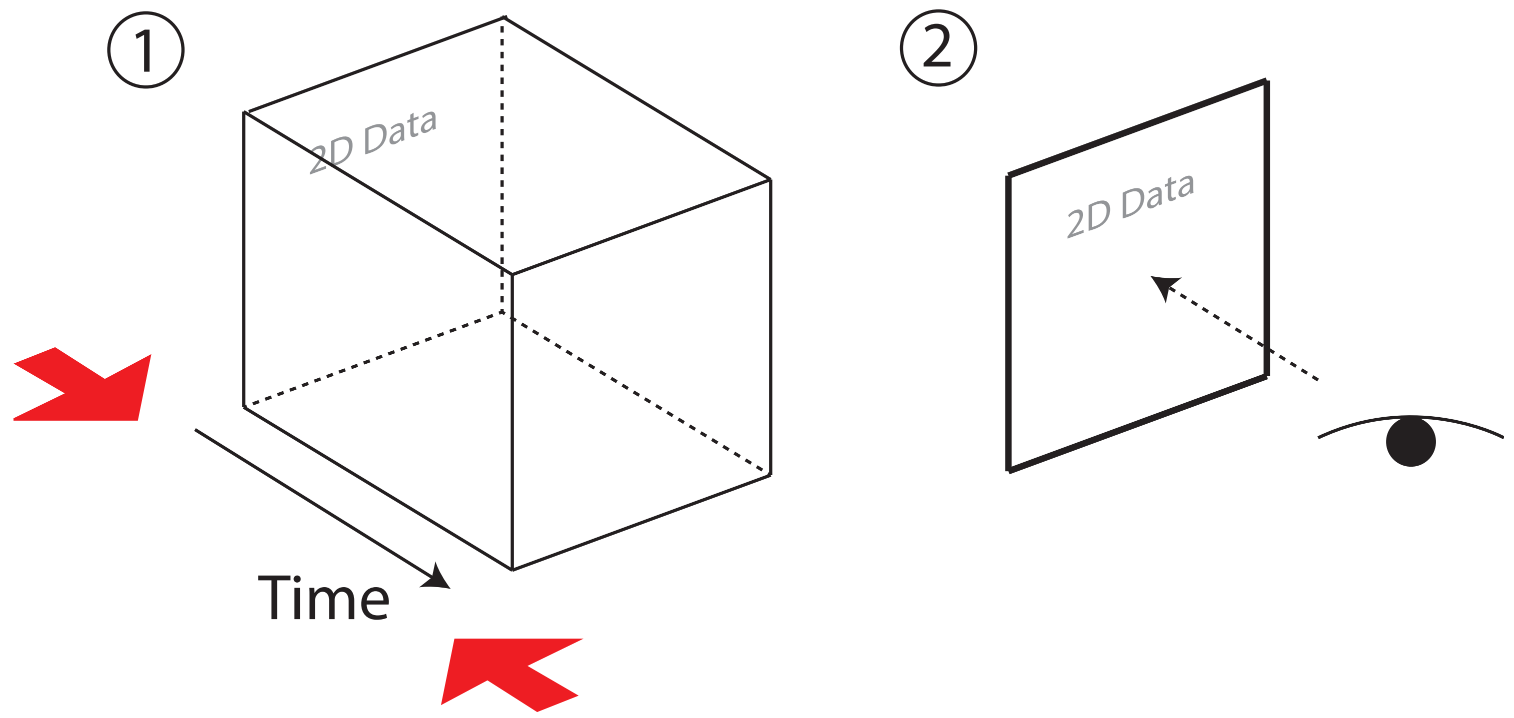
[L. McNabb & R. S. Laramee]

Figures Help in Surveys, too



[Bach et al., 2014]

Existing Figures & Sketches



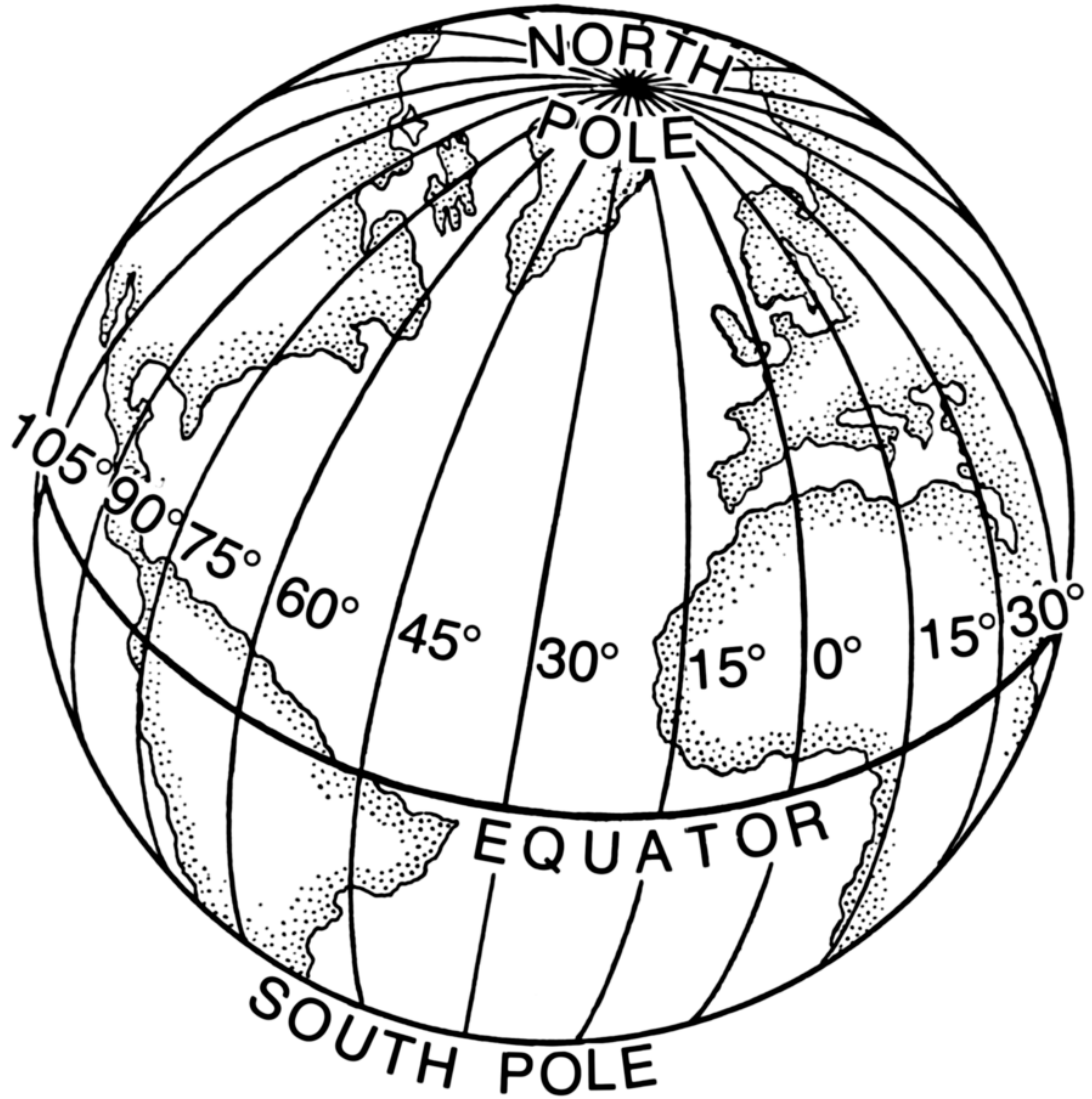
[Bach et al., 2014]

Geospatial Visualization

Geographic Data

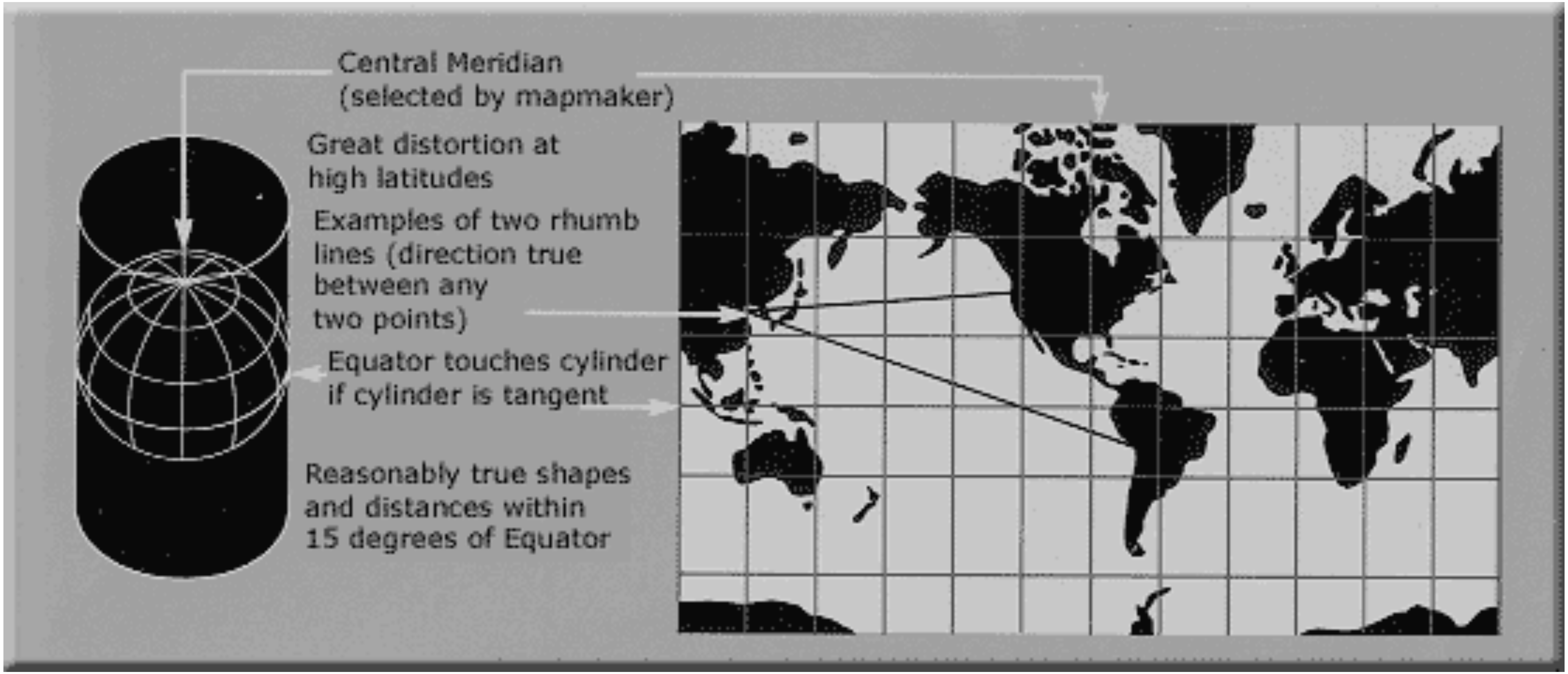
- Spatial data (have positions)
- Cartography: the science of drawing maps
  - Lots of history and well-established procedures
  - May also have non-spatial attributes associated with items
  - Thematic cartography: integrate these non-spatial attributes (e.g. population, life expectancy, etc.)
- Goals:
  - Respect cartographic principles
  - Understand data with geographic references with the visualization principles

Map Projection



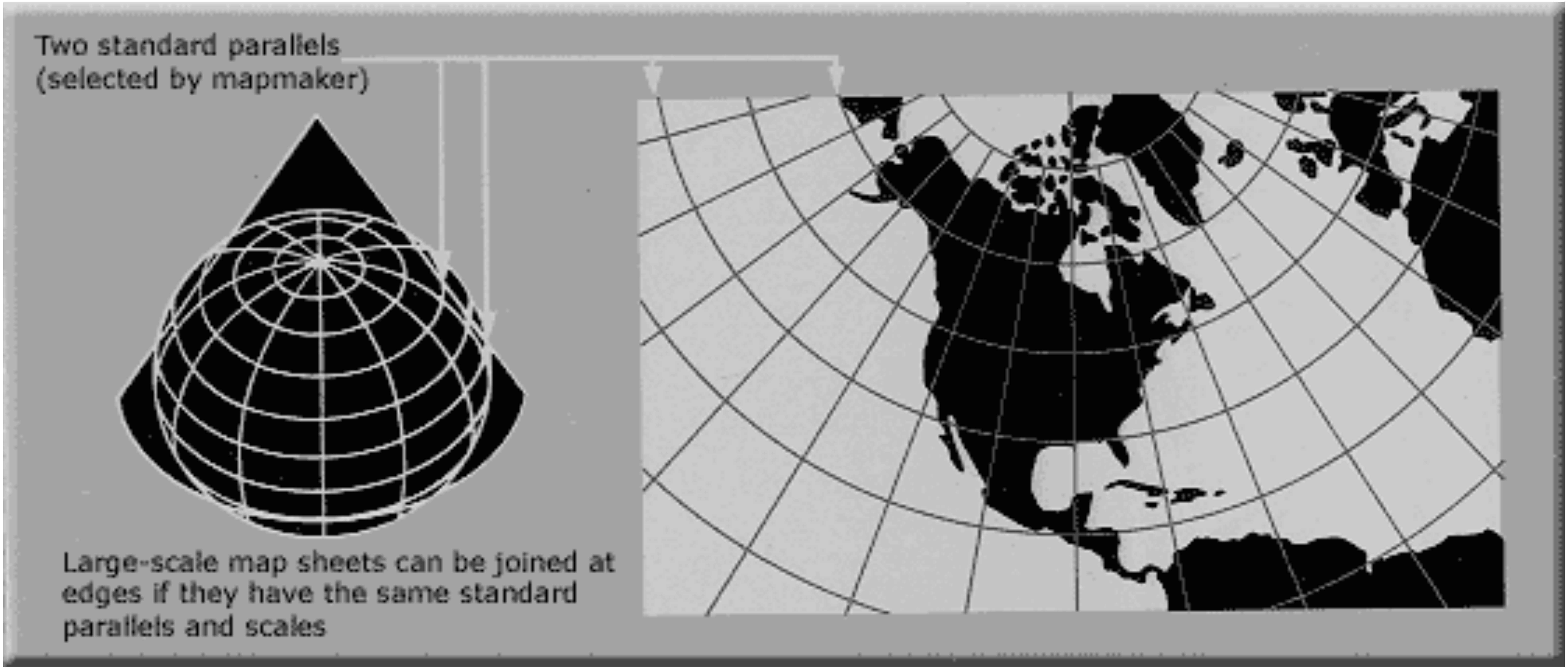
[P. Foresman, Wikimedia]

Flattening the Sphere?



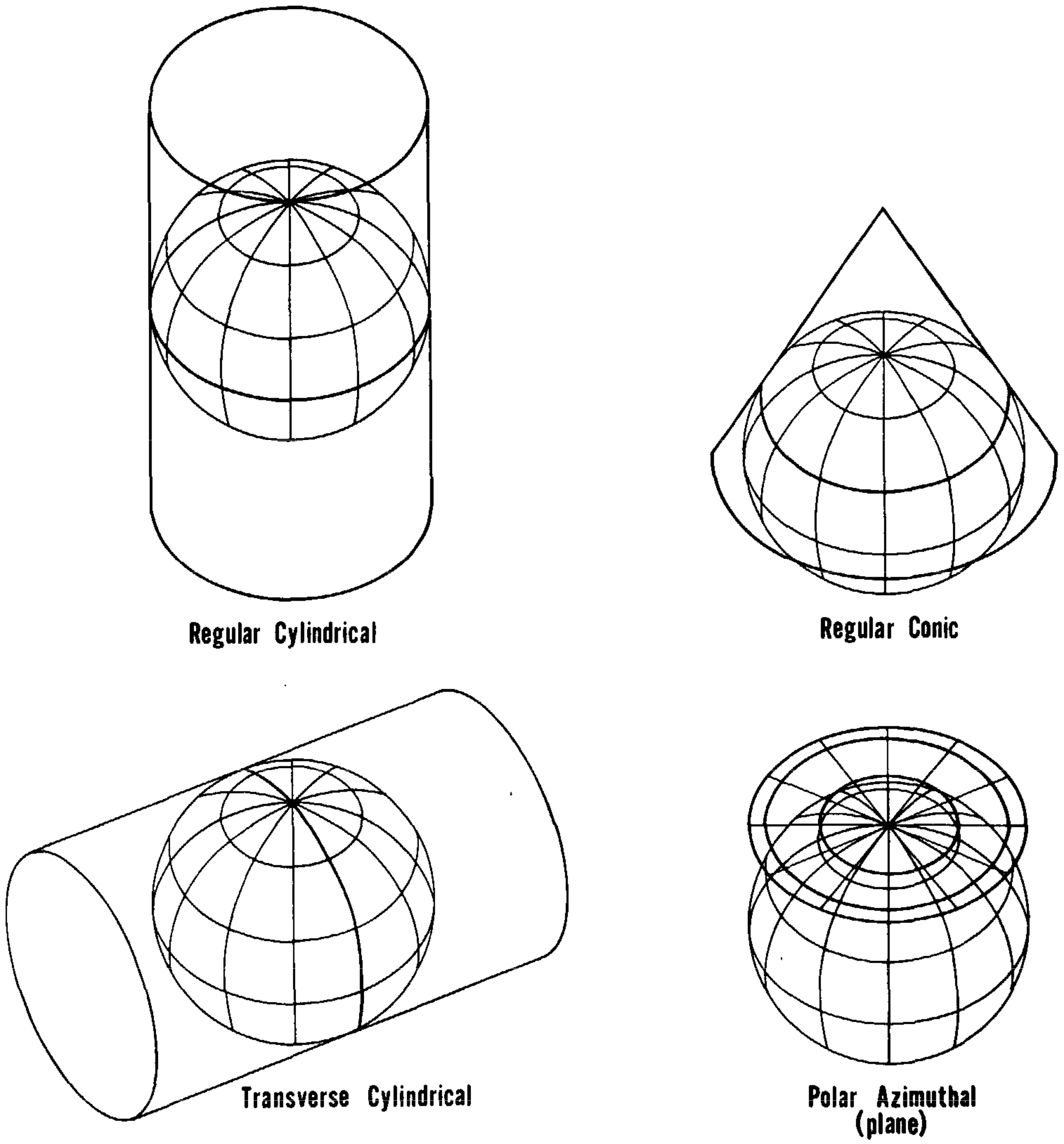
[USGS Map Projections]

Lambert Conformal Conic Projection



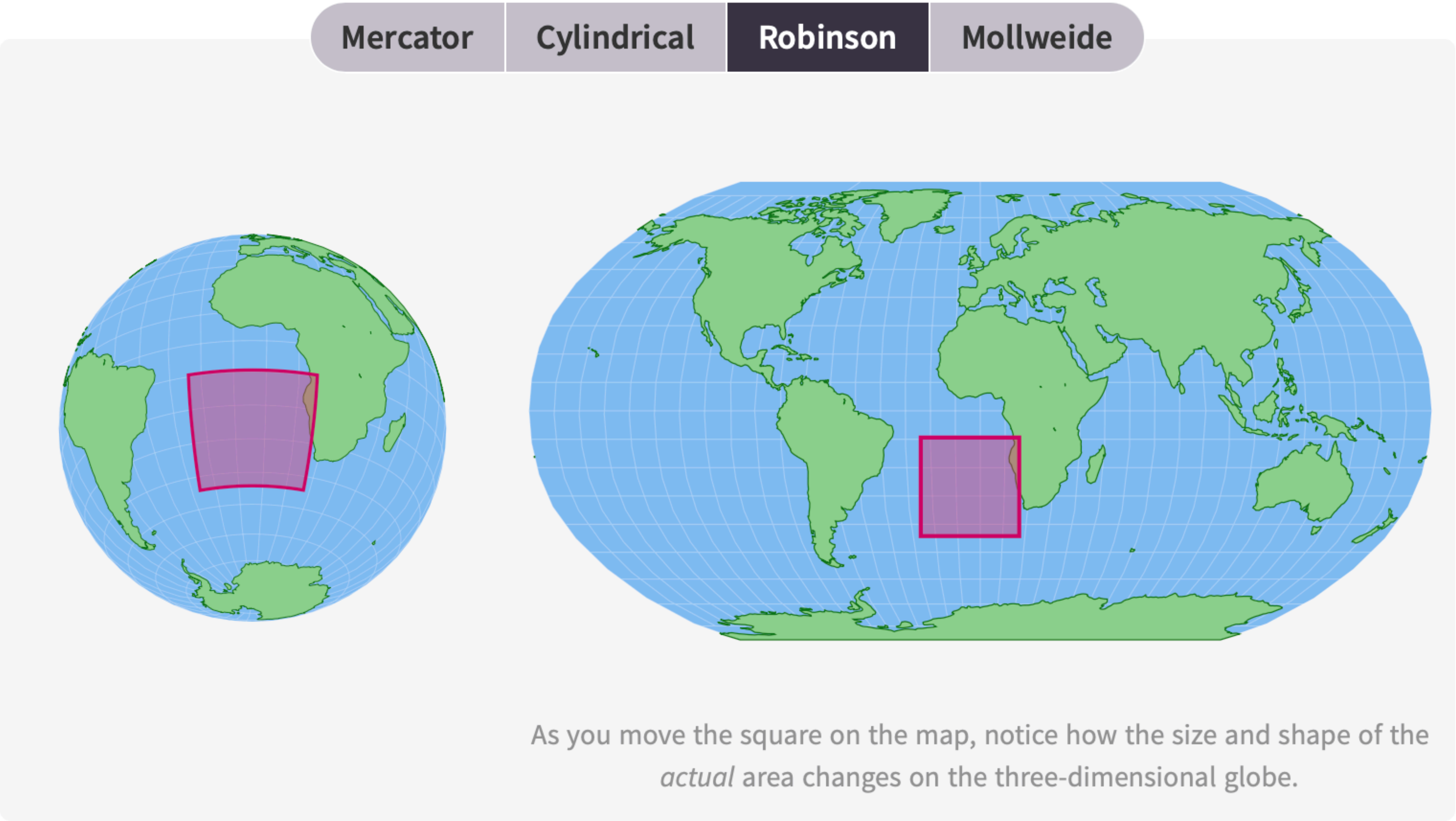
[USGS Map Projections]

Standard Projections



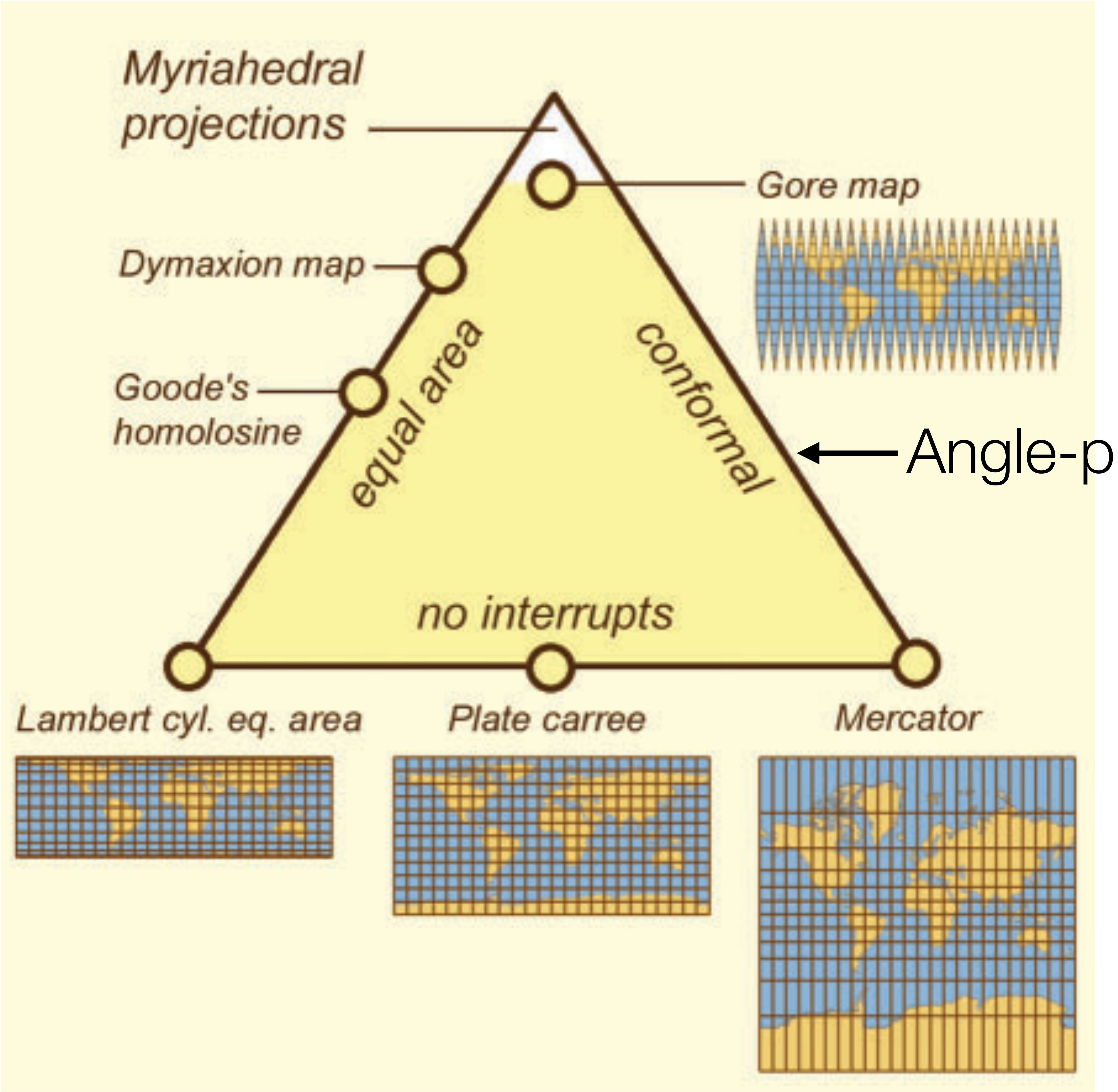
[J. P. Snyder, USGS]

Projection Distortion



[Mathigon]

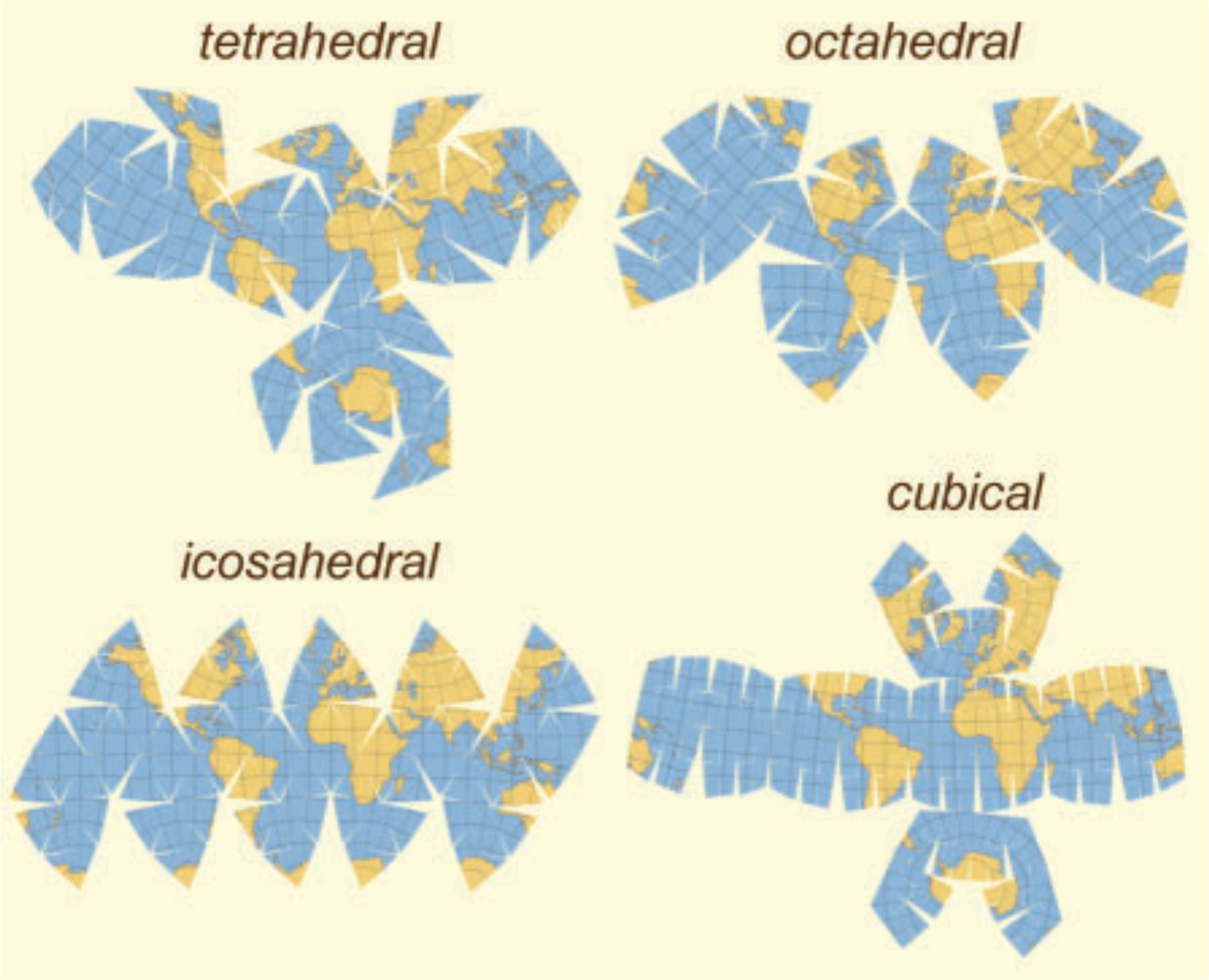
Projection Classification



Angle-preserving

[J. van Wijk, 2008]

Subdividing regular polyhedra



[J. van Wijk, 2008]

Adding Data to Maps

- Discrete: a value is associated with a specific position
  - Size
  - Color Hue
  - Charts
- Continuous: each spatial position has a value (fields)
  - Heatmap
  - Isolines

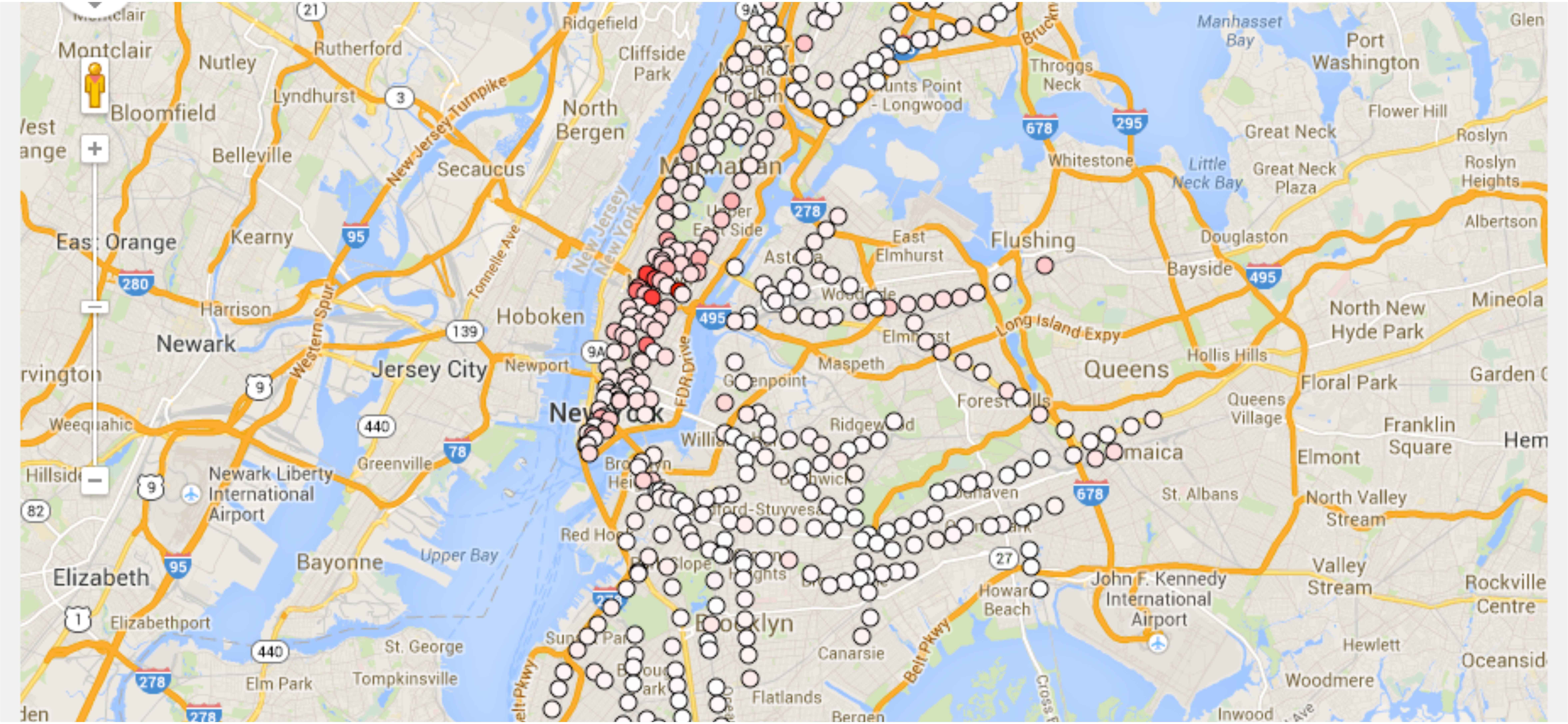
Discrete Categorical Attribute: Shape

[Acadia NP, National Park Service]

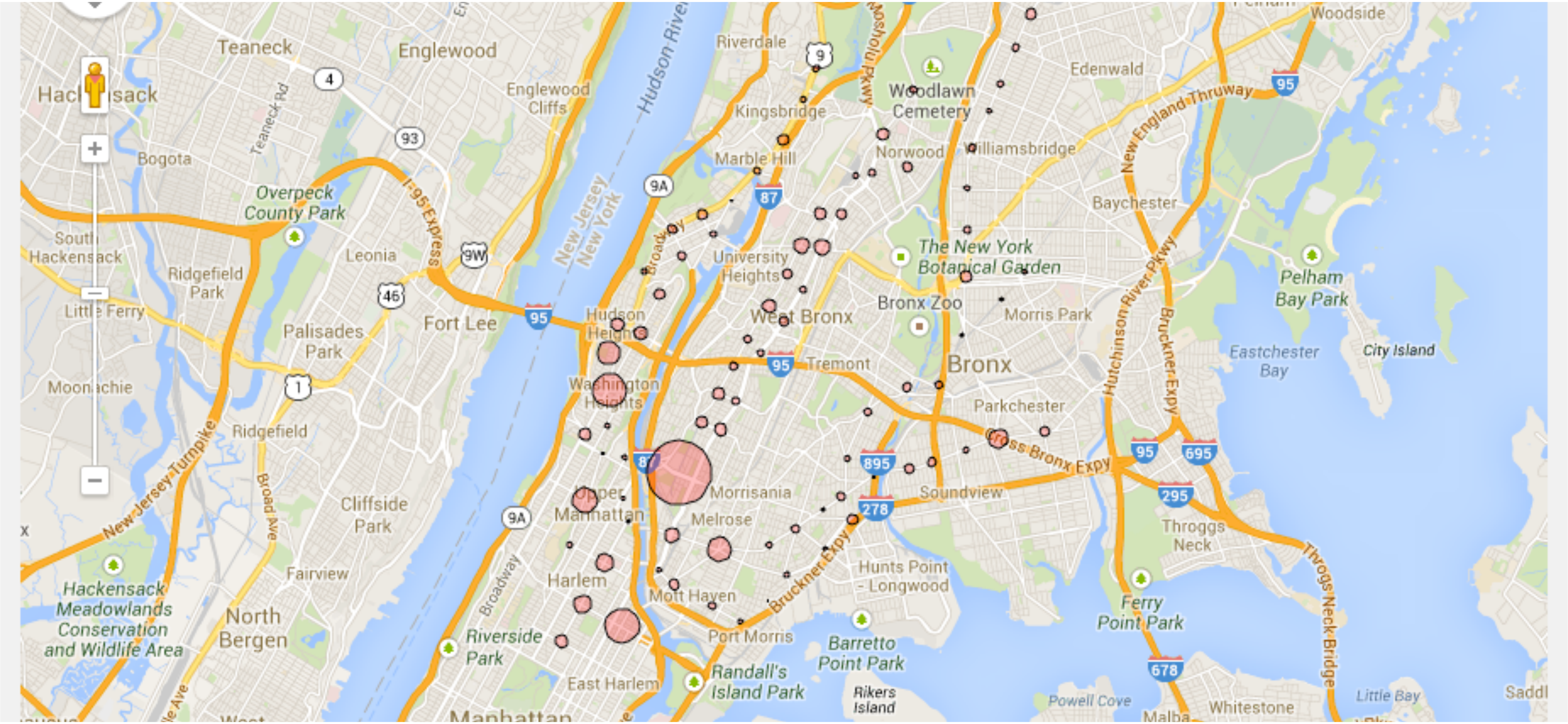
Discrete Categorical Attribute: Shape

[Acadia NP, National Park Service]

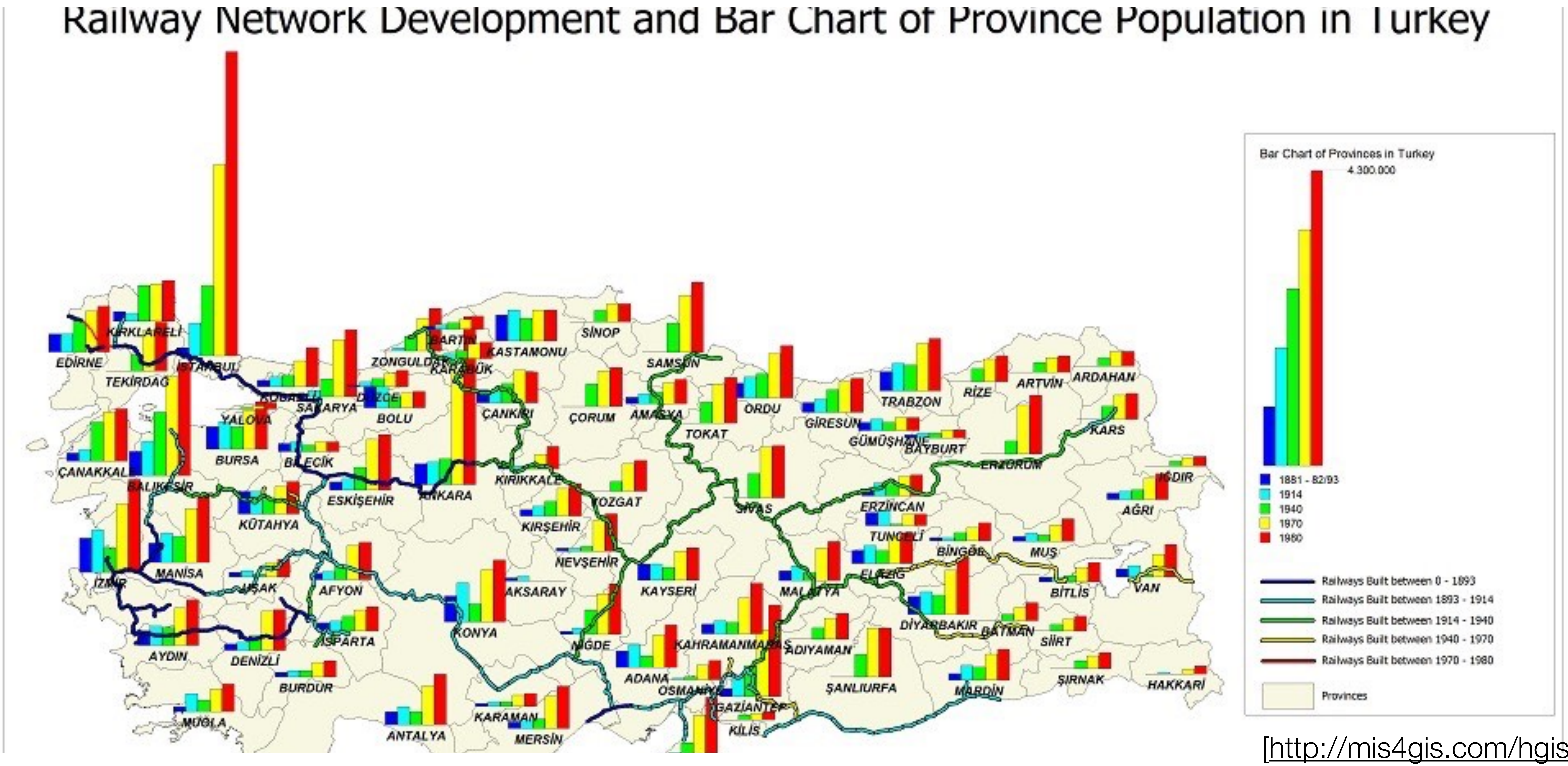
Discrete Quantitative Attribute: Color Saturation



Discrete Quantitative Attribute: Size

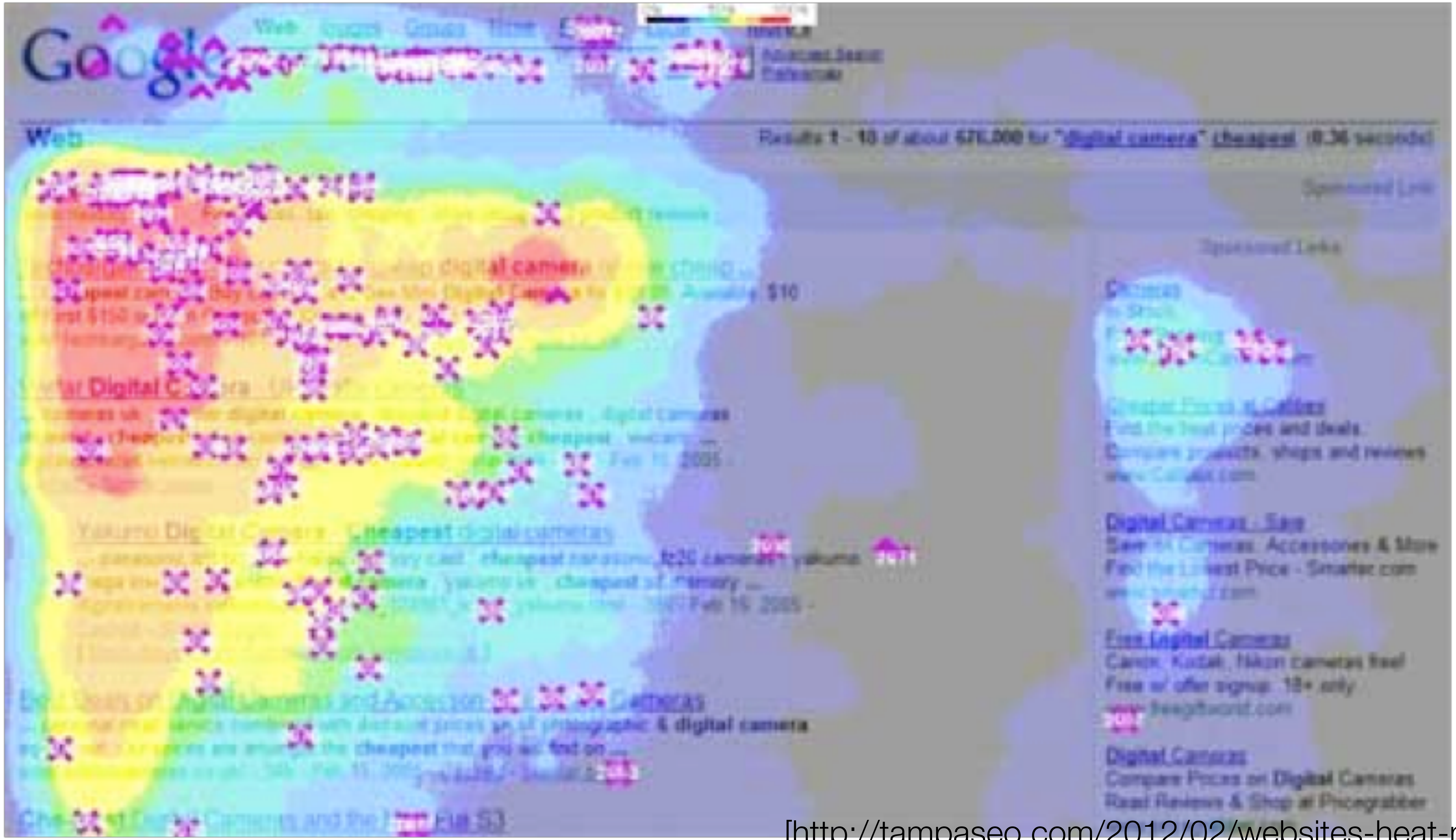


Discrete Quantitative Attributes: Bar Chart



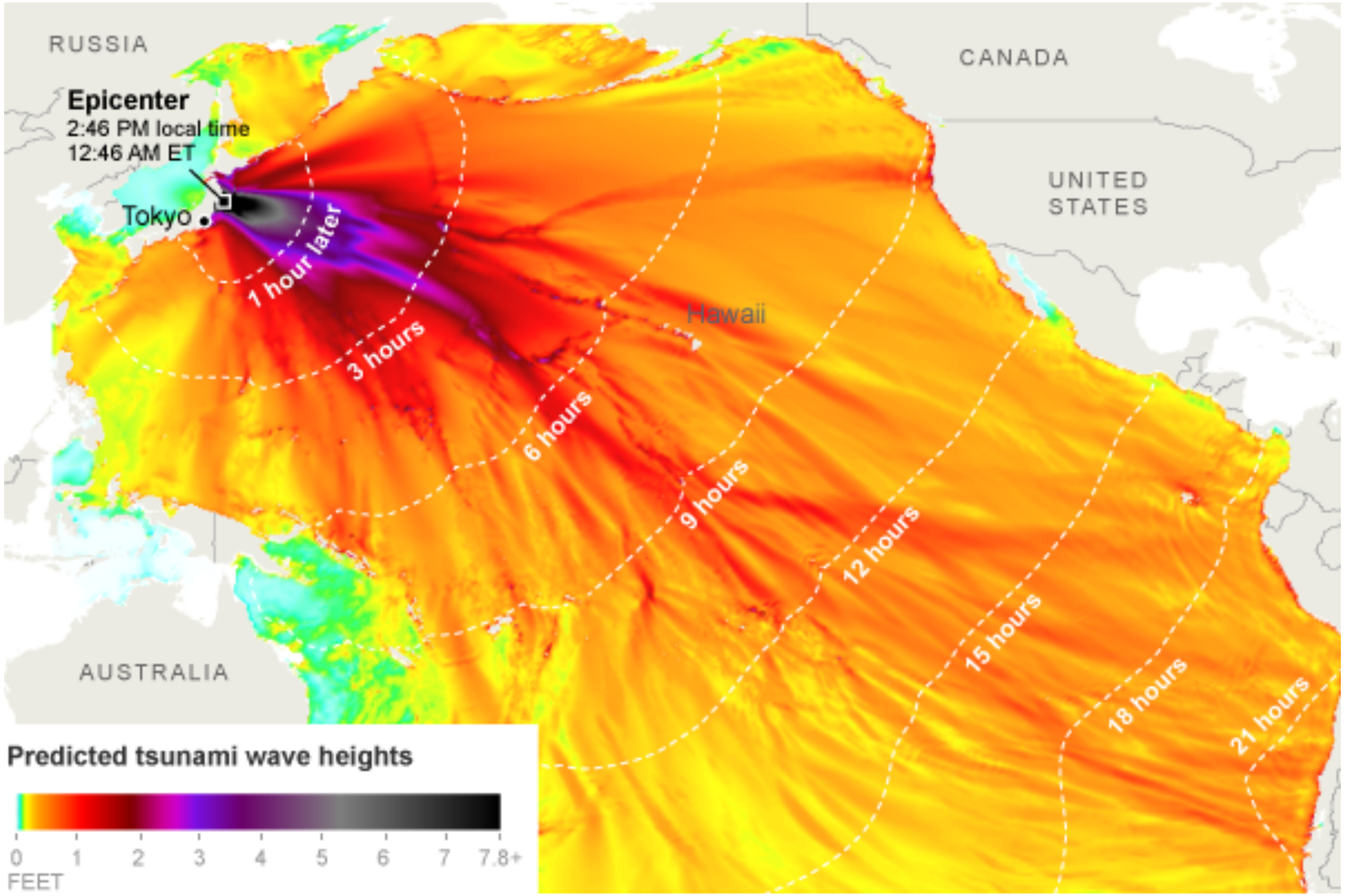
[http://mis4gis.com/hgistr.org/]

Continuous Quantitative Attribute: Color Hue



[http://tampaseo.com/2012/02/websites-heat-mapping-users/]

Time as the attribute



[NYTimes]

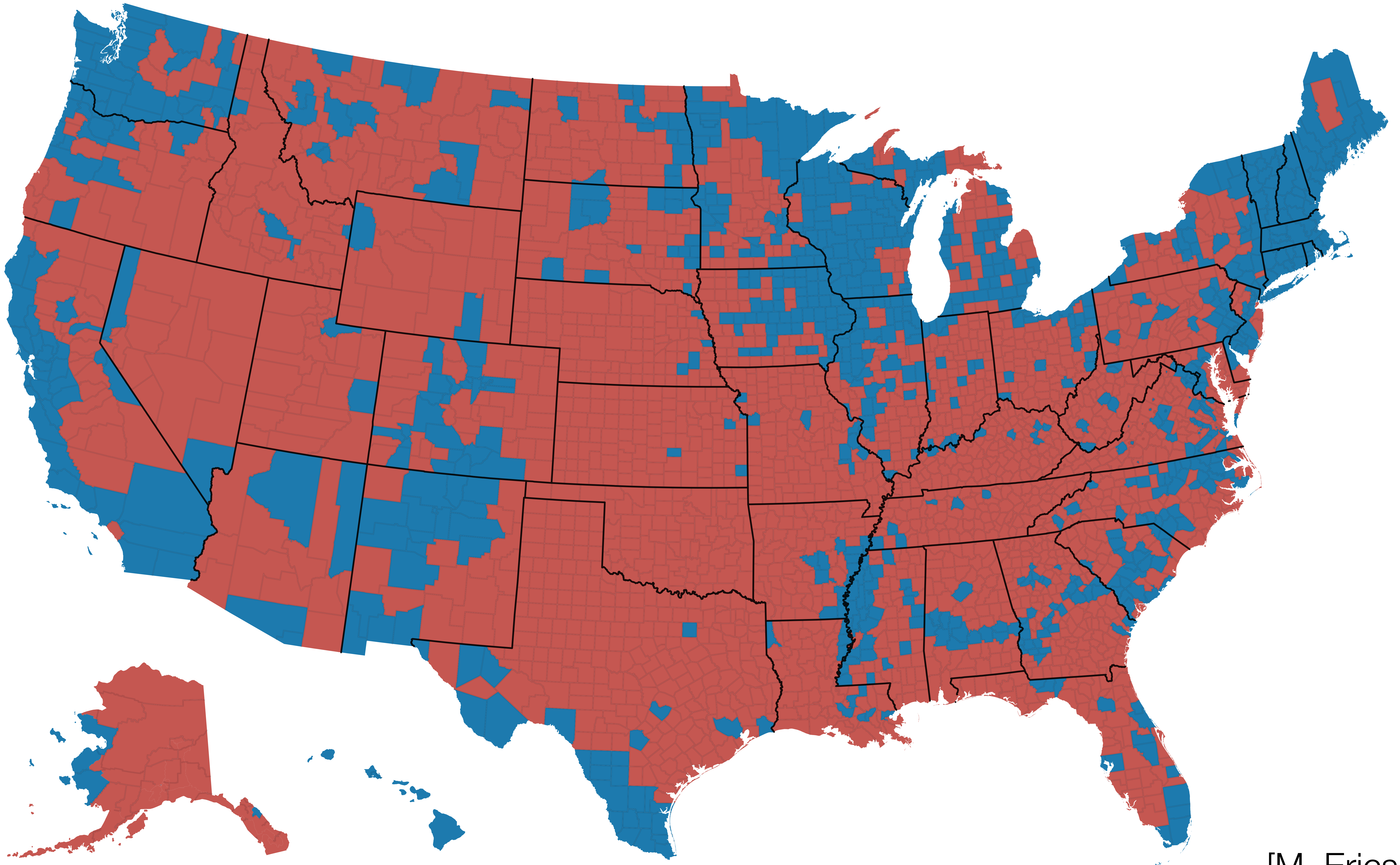
Isolines

[USGS via Wikipedia]

Isolines

- Scalar fields:
  - value at each location
  - sampled on grids
- Isolines use **derived data** from the scalar field
  - Interpret field as representing continuous values
  - Derived data is **geometry**: new lines that represent the same attribute value
- Scalability: dozens of levels
- Other encodings?

Choropleth (Two Hues)



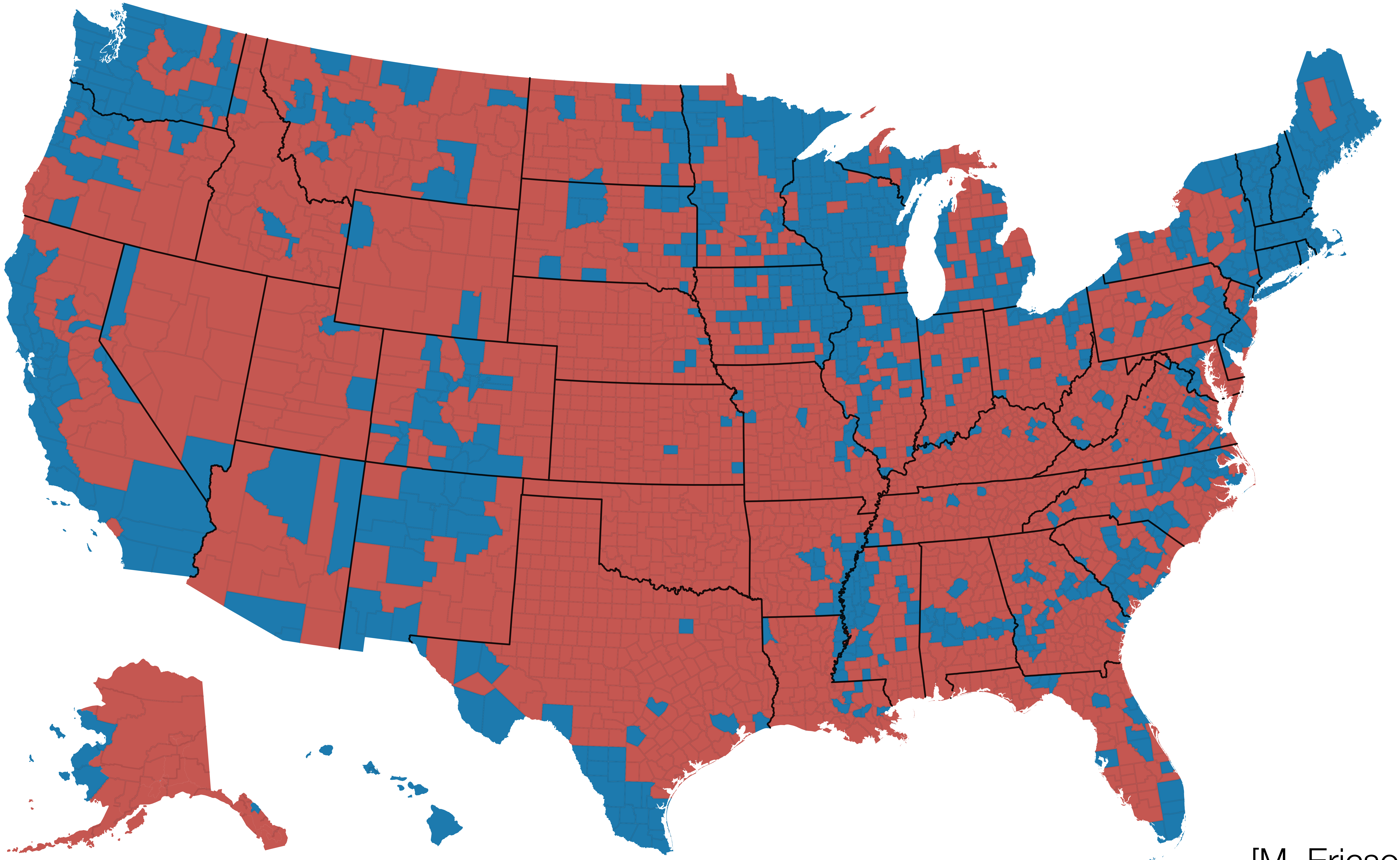
[M. Ericson, New York Times]

Choropleth Map

- Data: geographic geometry data & one quantitative attribute per region
- Tasks: trends, patterns, comparisons
- How: area marks from given geometry, color hue/saturation/luminance
- Scalability: thousands of regions

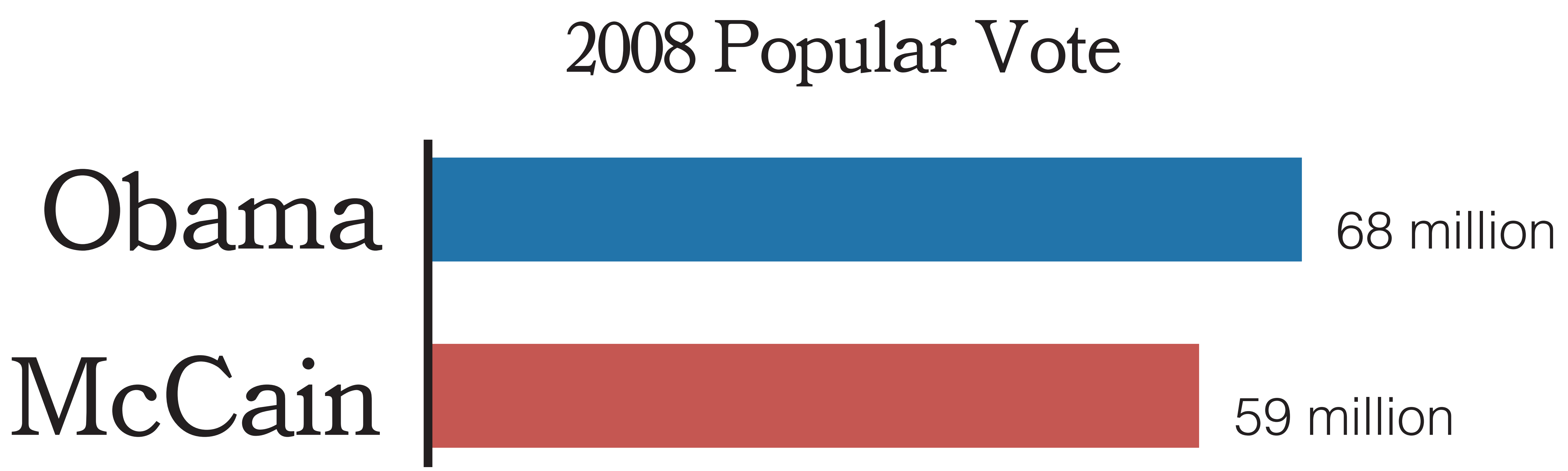
- Design choices:
  - Colormap
  - Region boundaries (level of summarization)

Choropleth (Two Hues)



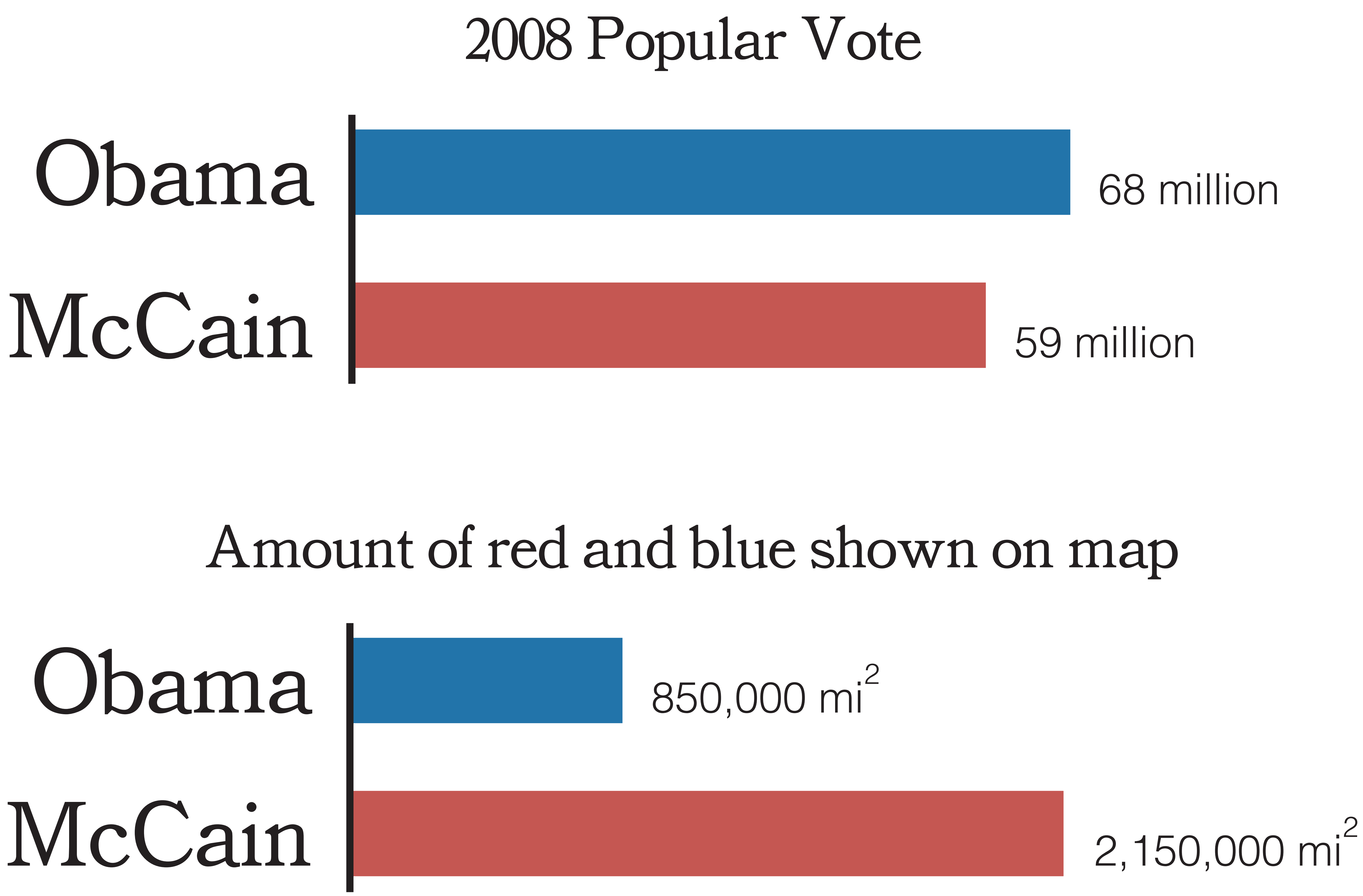
[M. Ericson, New York Times]

Problem?



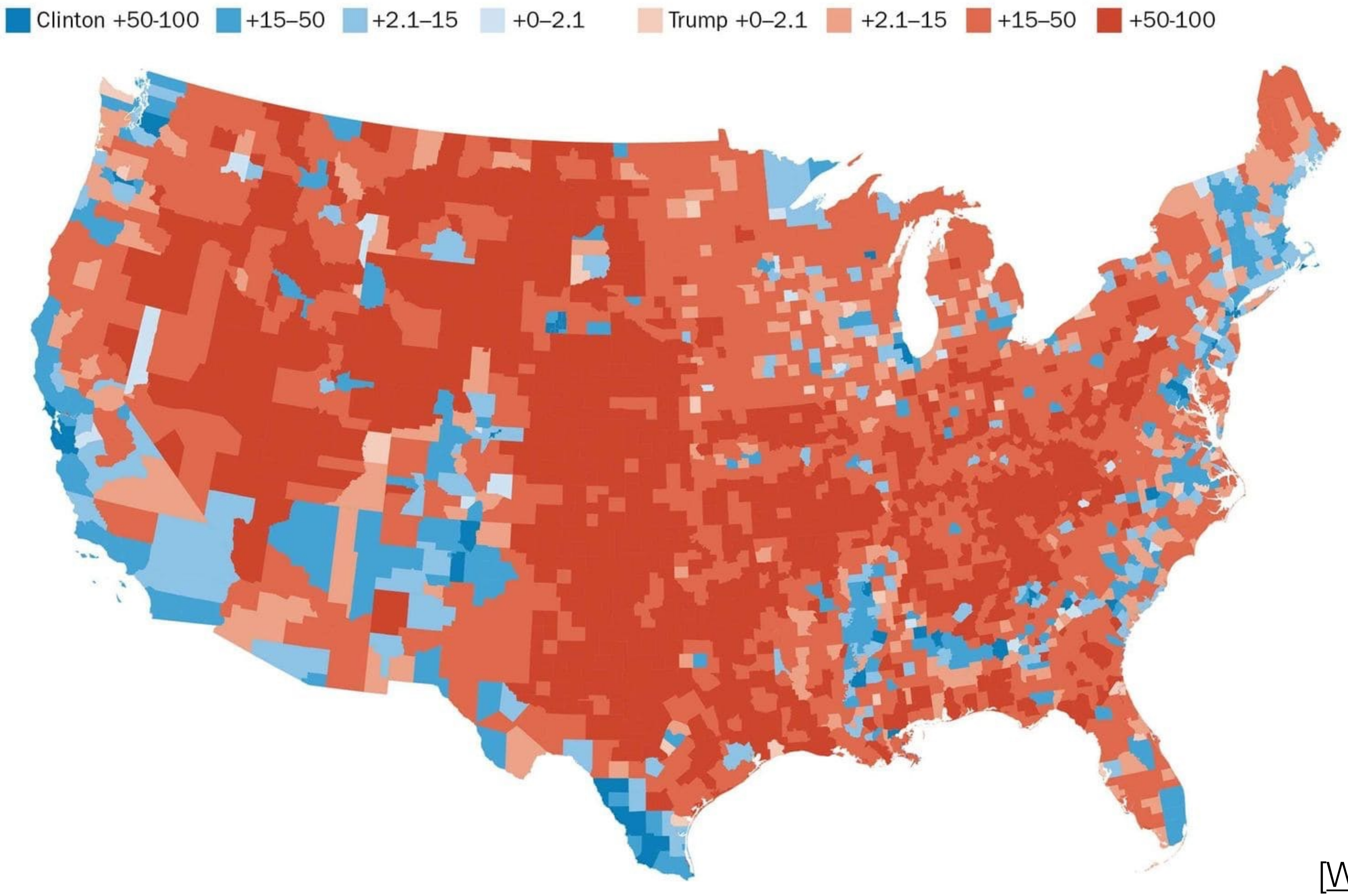
[M. Ericson, New York Times]

Problem?



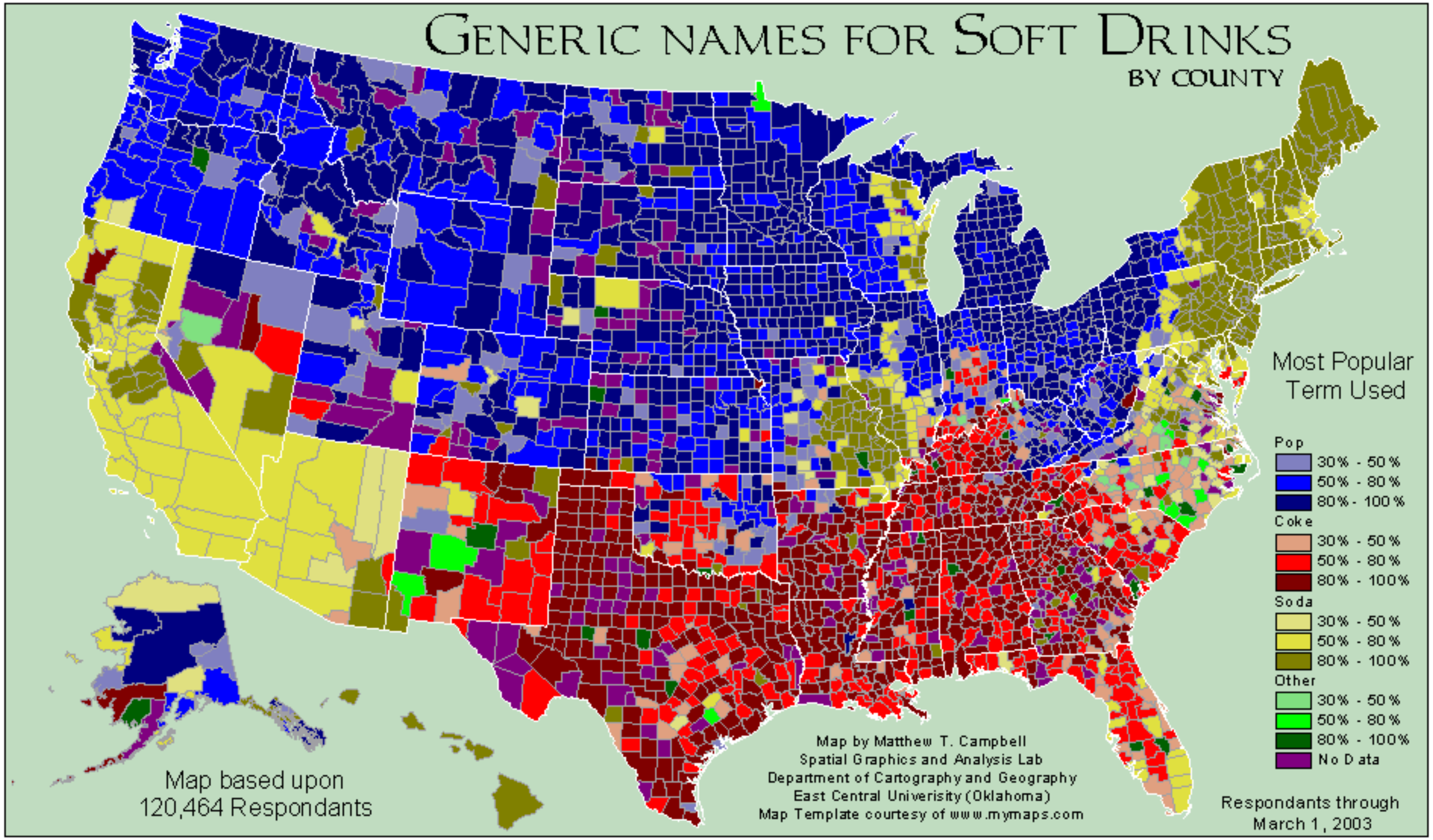
[M. Ericson, New York Times]

Adding Saturation



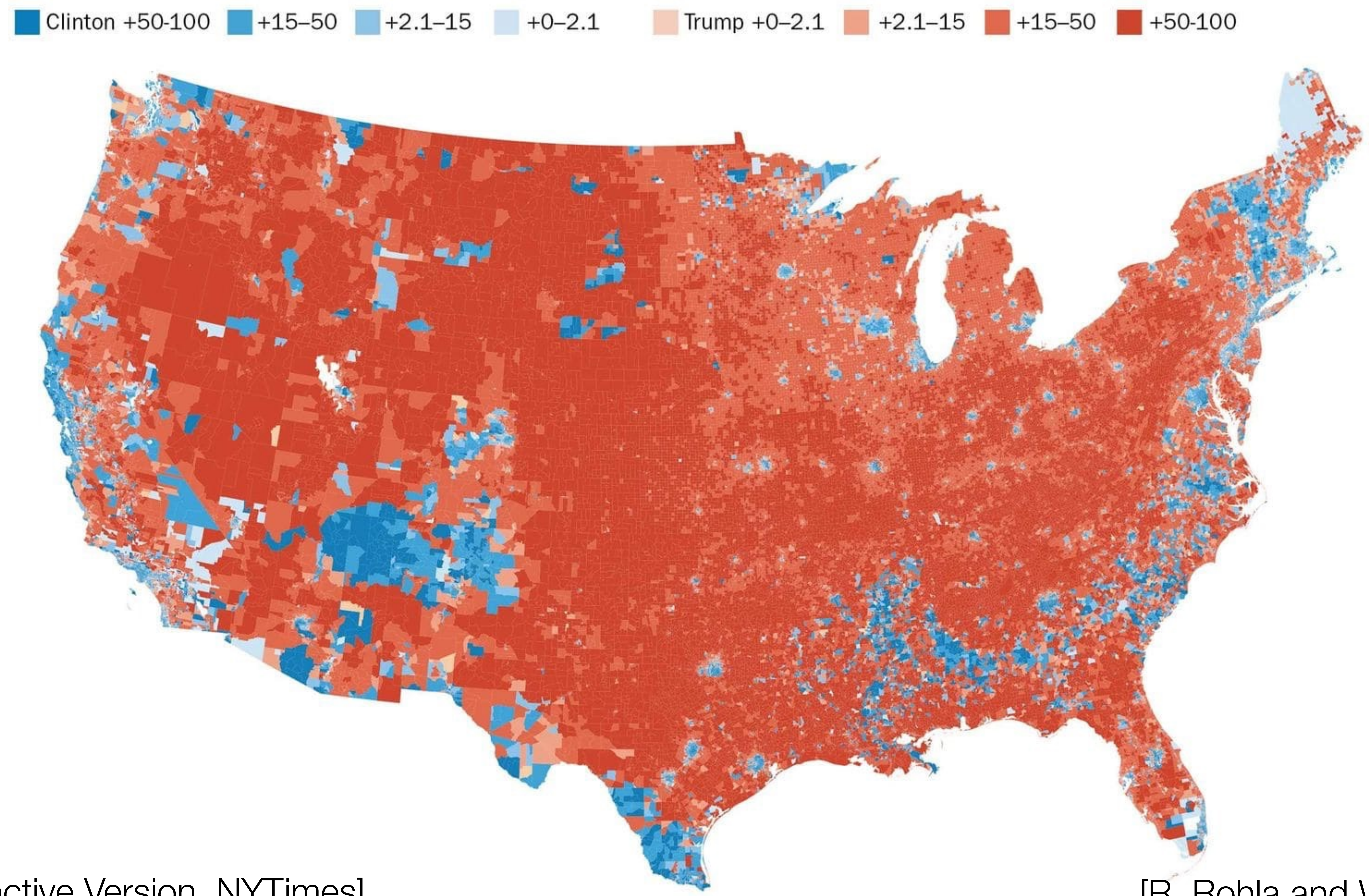
[Washington Post, 2018]

Area Marks and Color Hue & Saturation



[popvssoda.com]

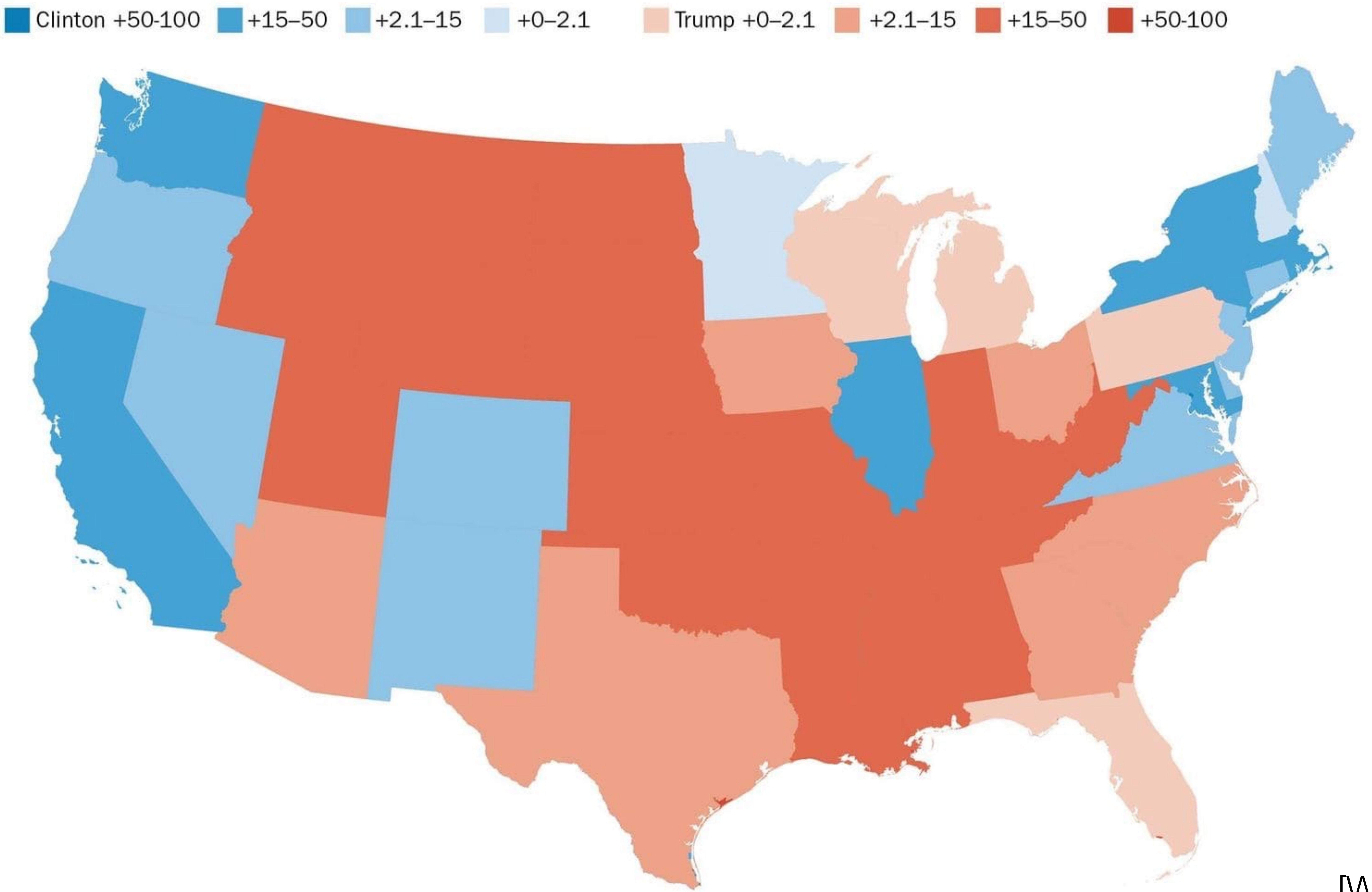
Aggregation: 2016 Election by Precinct



[Interactive Version, NYTimes]

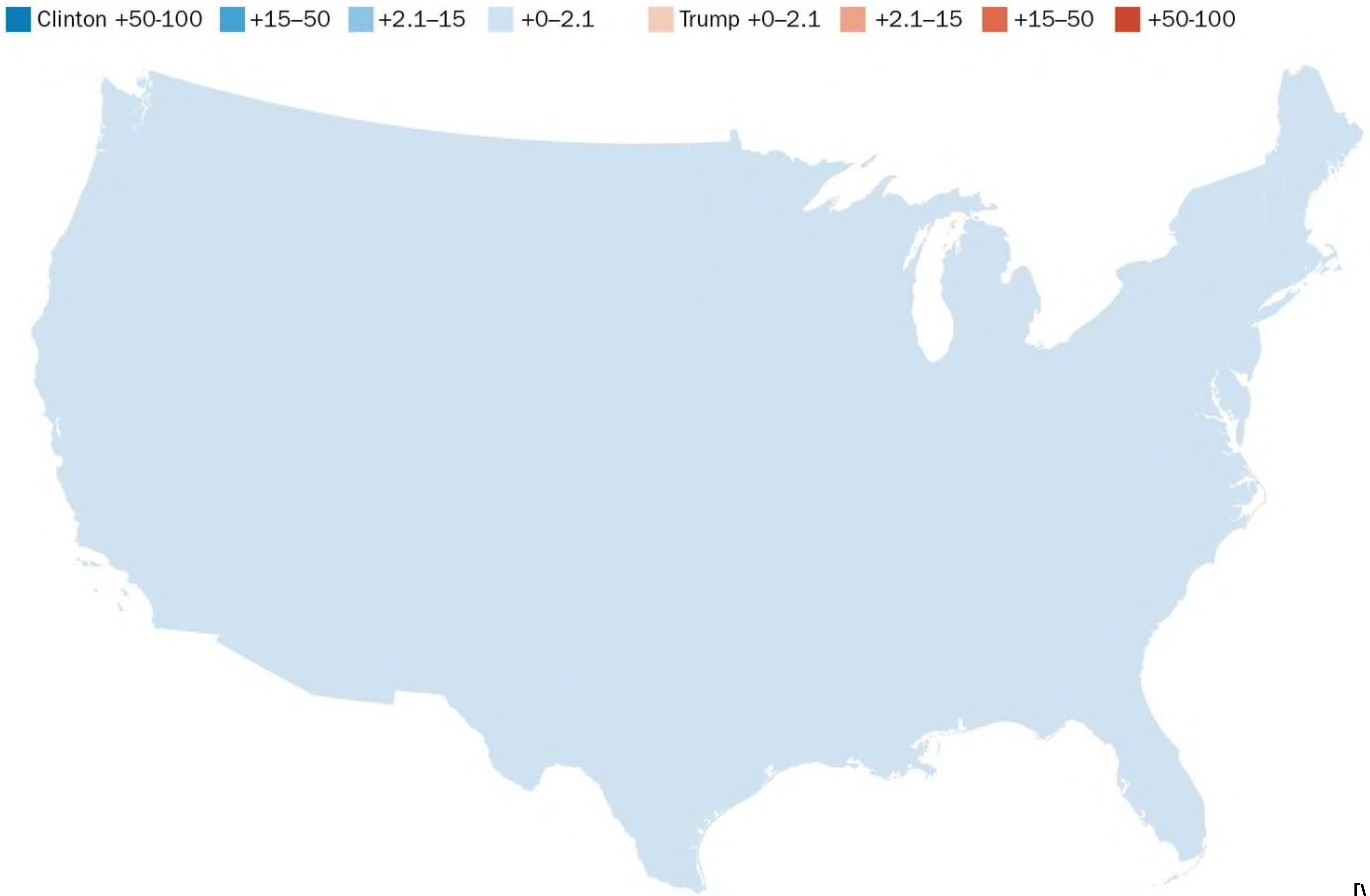
[R. Rohla and Washington Post, 2018]

Aggregation: 2016 Election by State



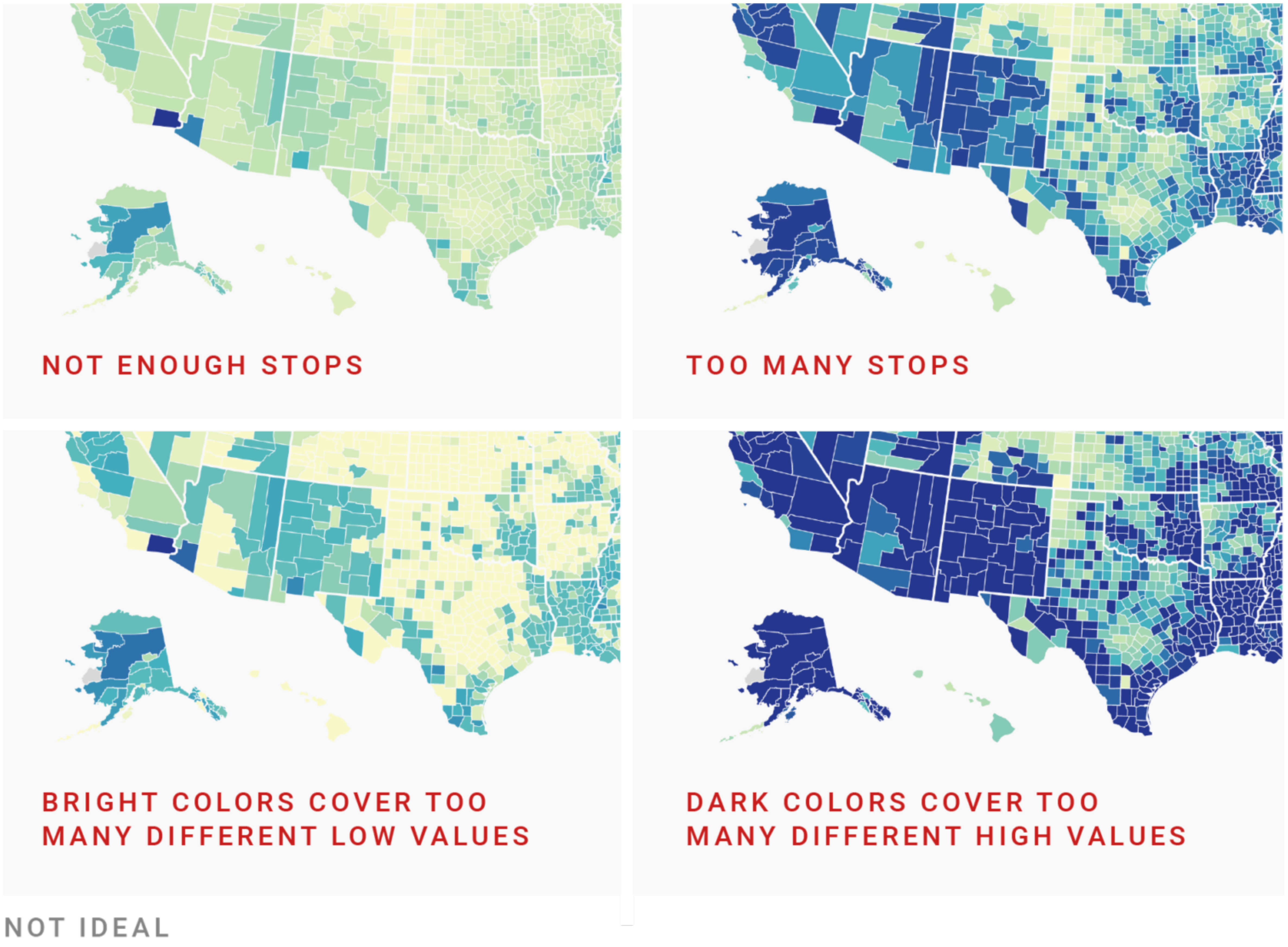
[Washington Post, 2018]

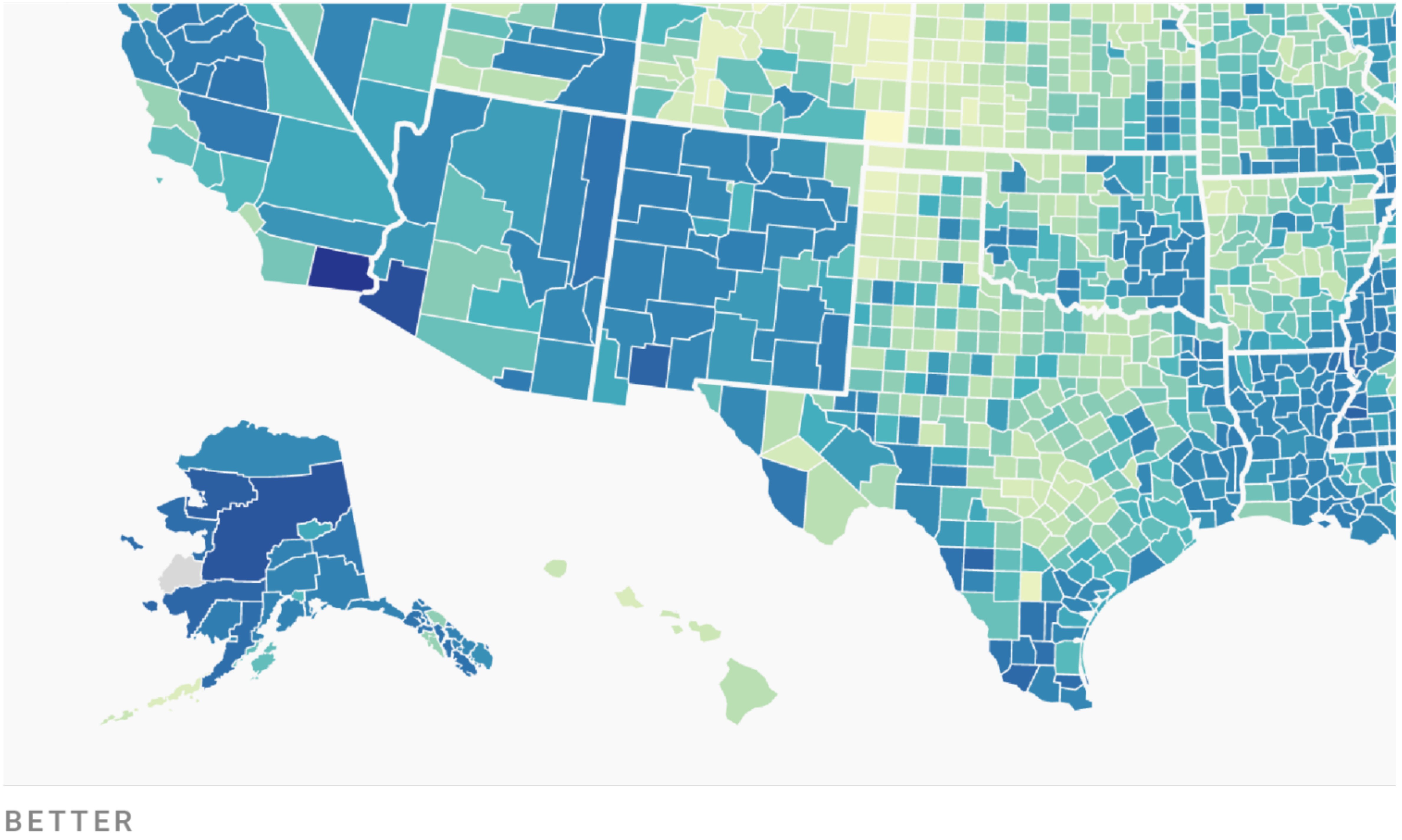
Aggregation: 2016 Election by Country



[Washington Post, 2018]

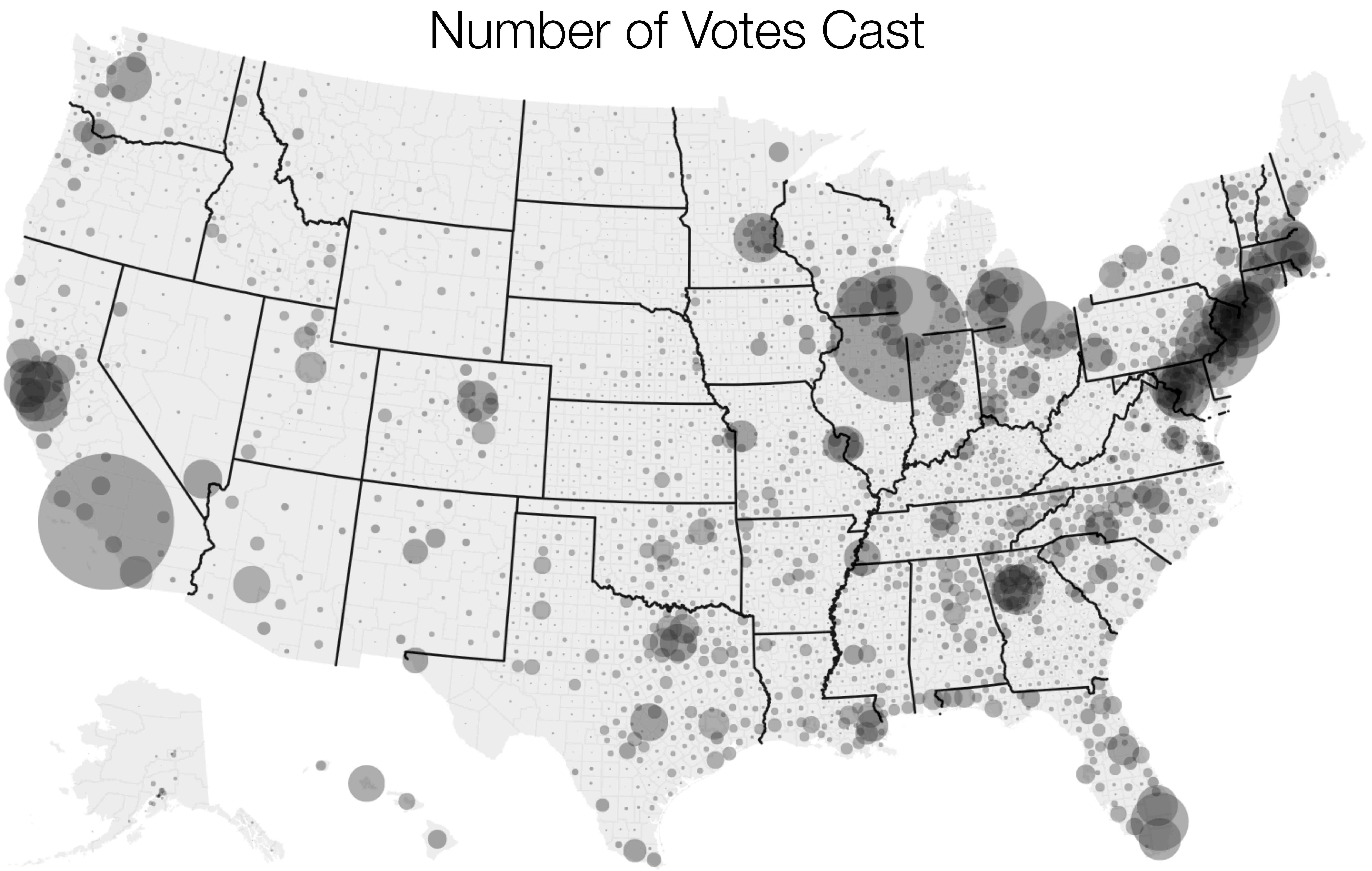
When to Use Choropleth Maps





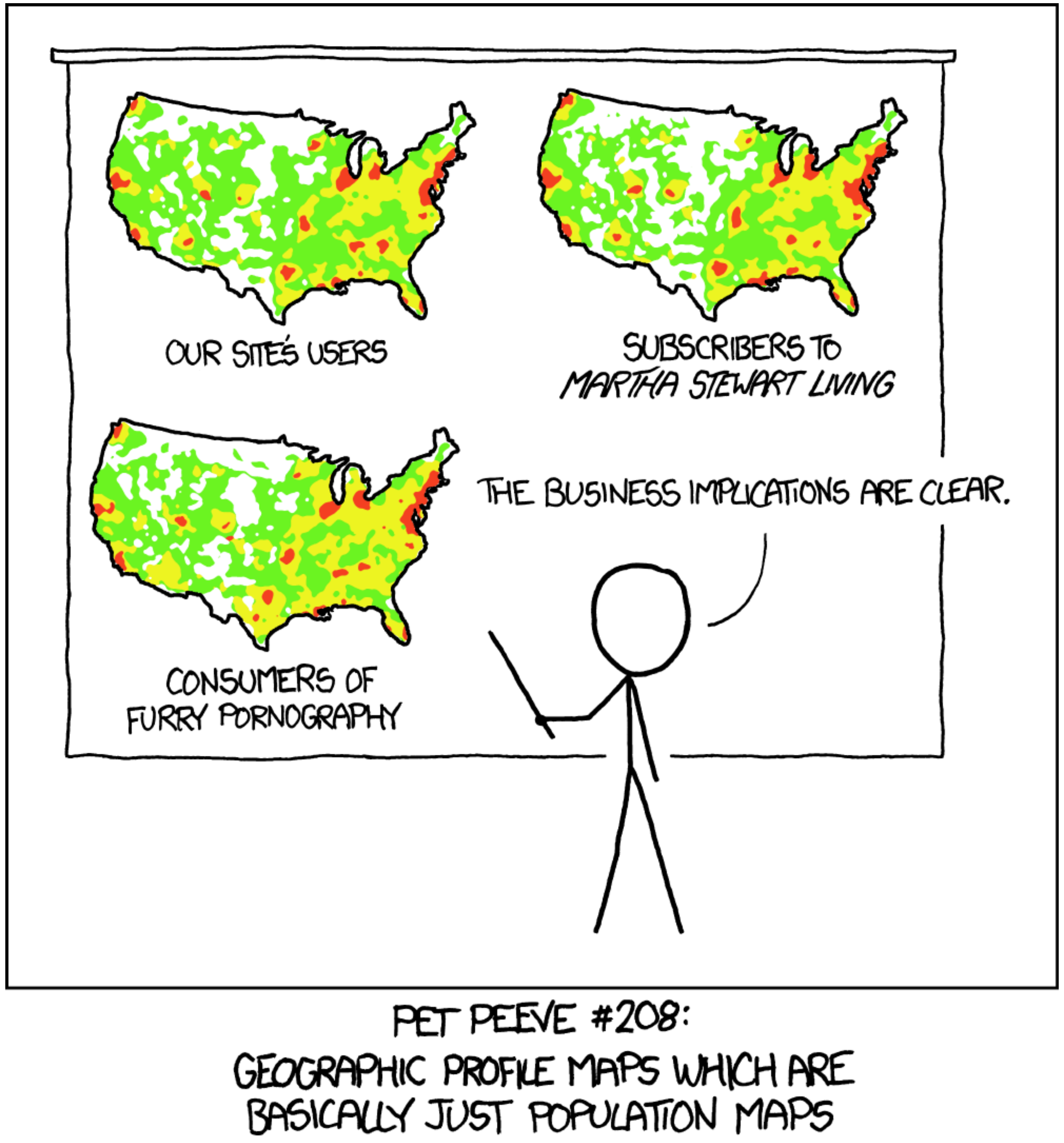
[L. C. Muth]

Maps: What trends do you see?



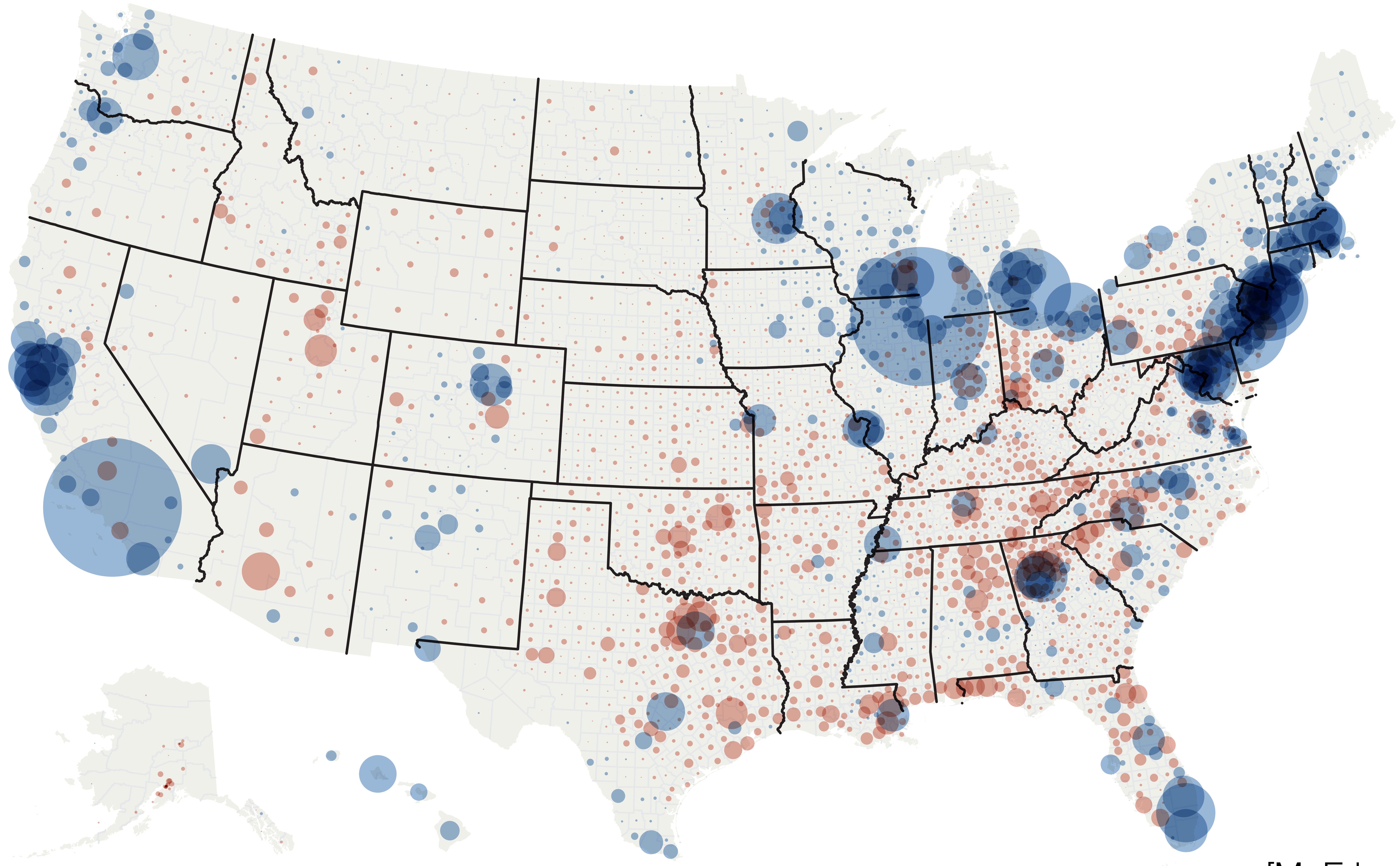
[Desaturated by D. Koop, M. Ericson, New York Times]

Don't Just Create Population Maps!



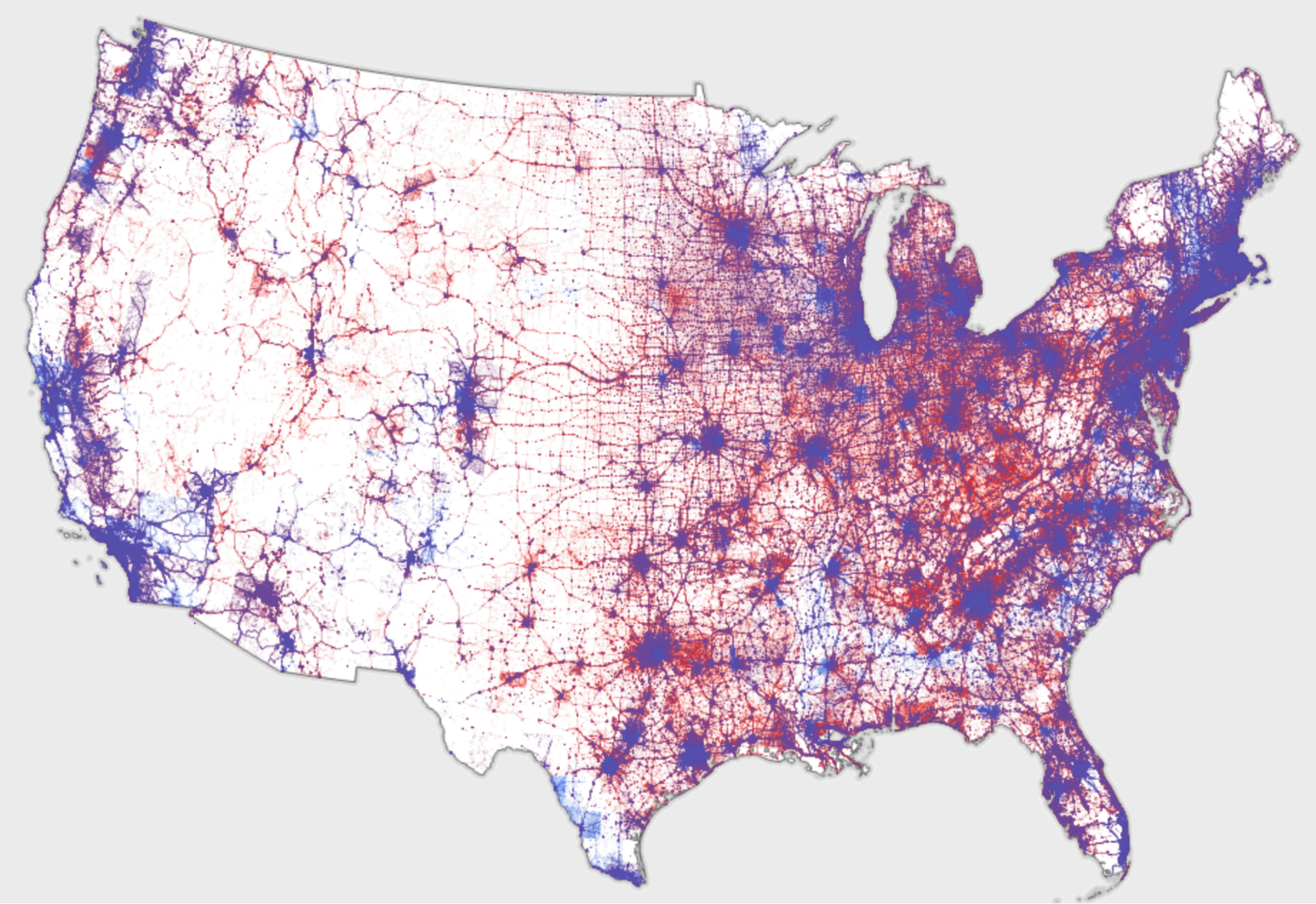
[xkcd]

Size Encoding



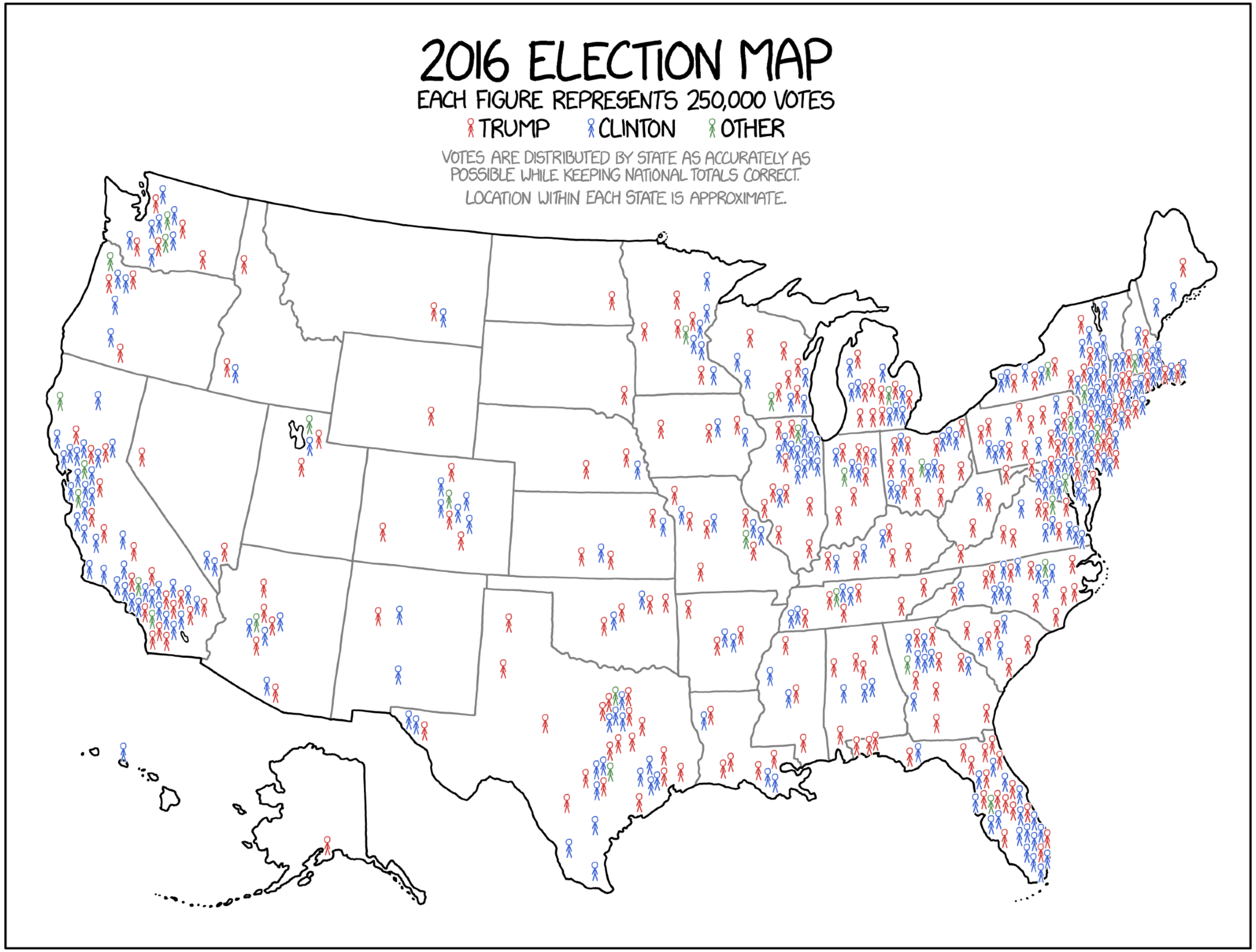
[M. Ericson, New York Times]

Dasymetric Dot Density



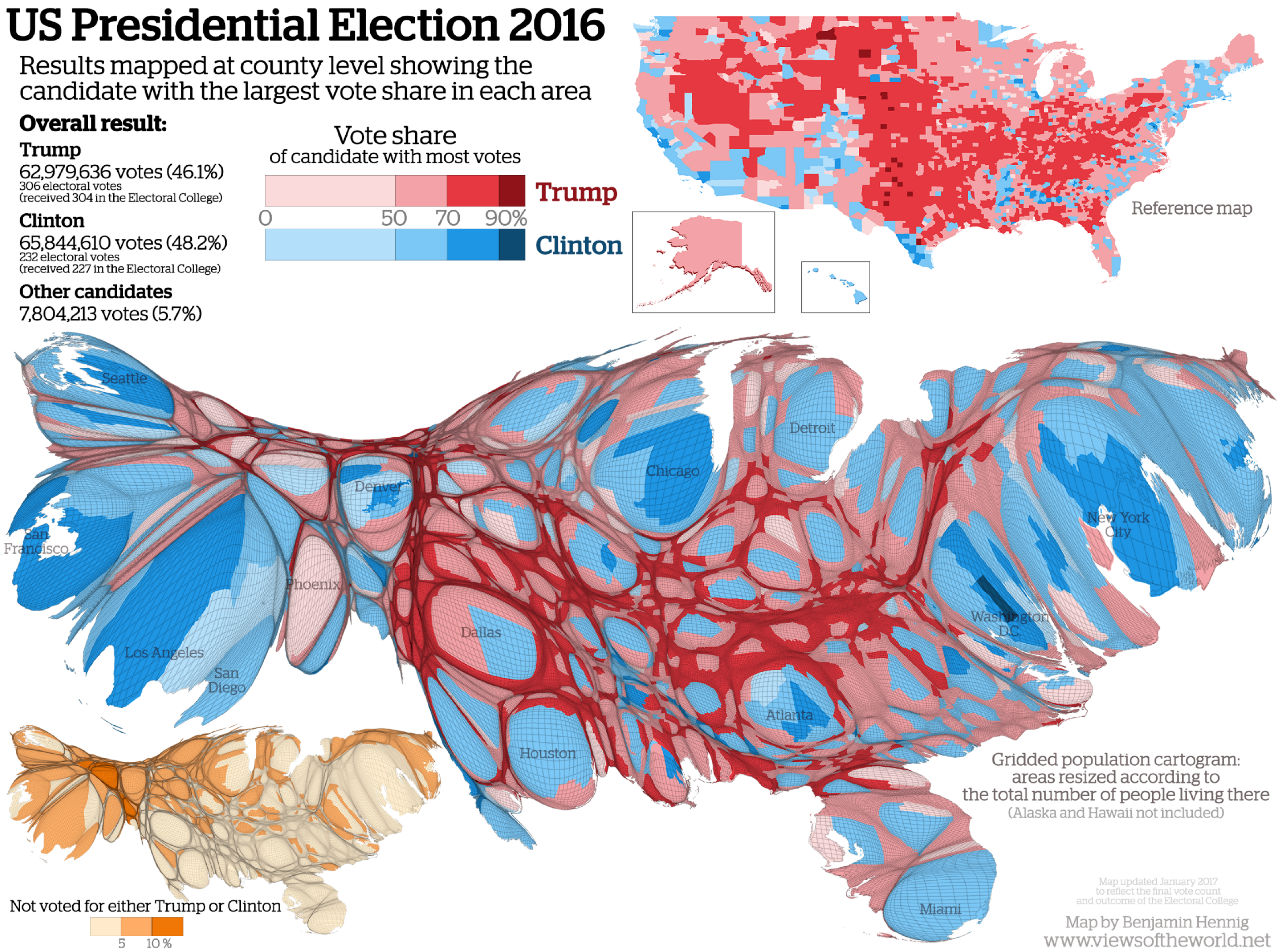
[K. Field]

Glyphs: xkcd's Map



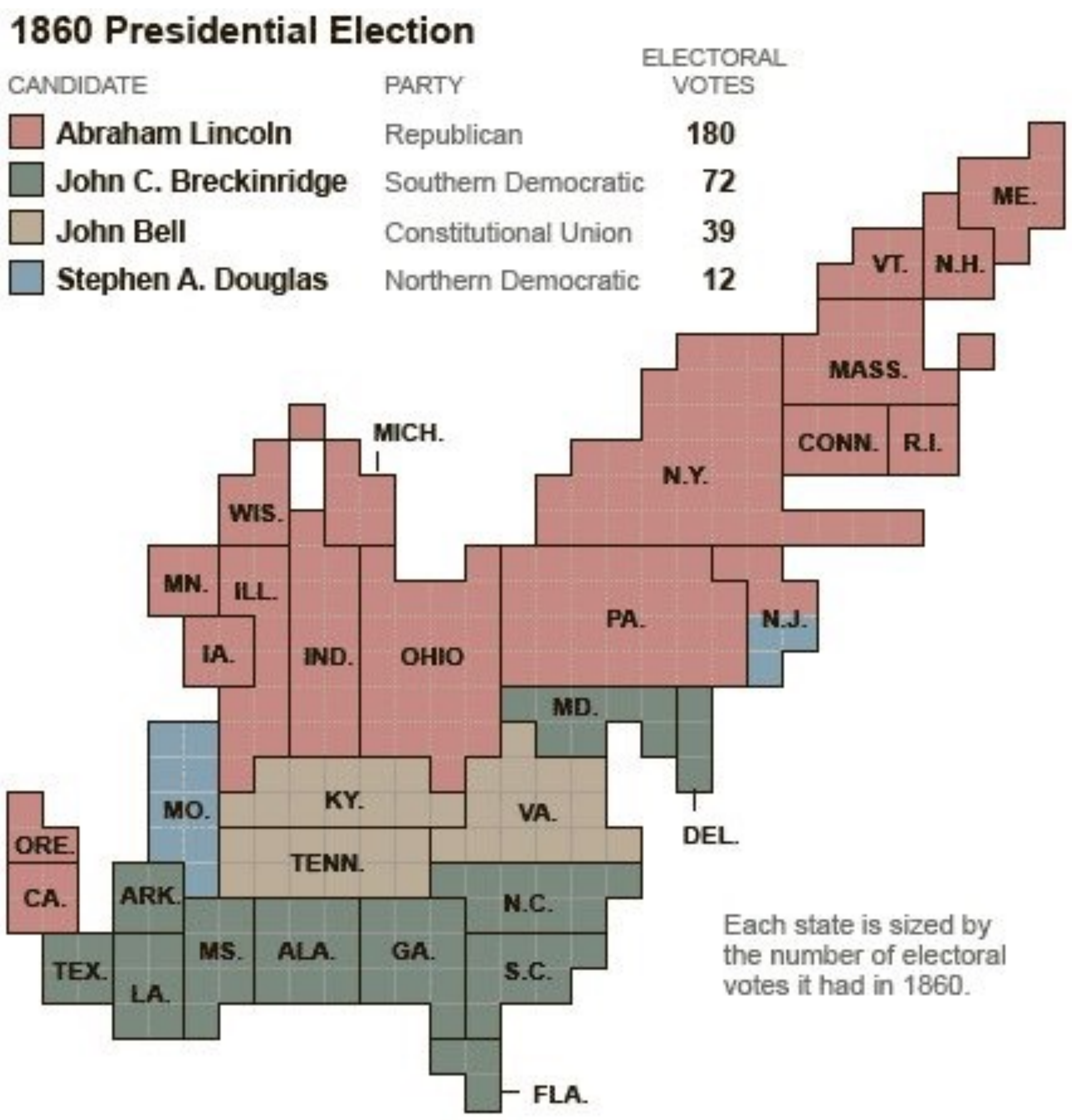
[xkcd]

Cartograms



[B. Hennig]

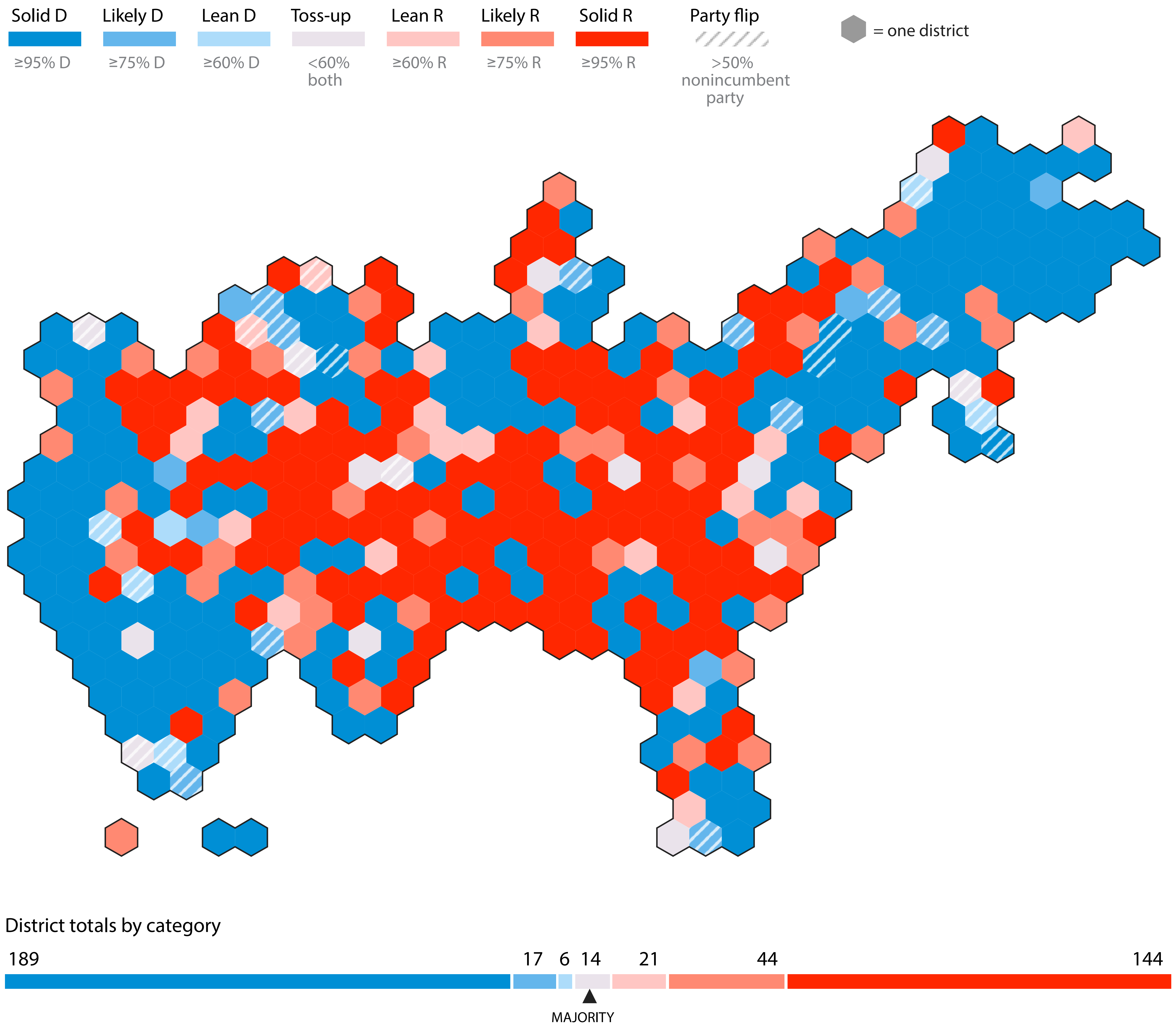
Cartograms



- Data: geographic geometry data & **two** quantitative attributes (one part-of-whole)
- Derived data: new geometry derived from the part-of-whole attribute
- Tasks: trends, comparisons, part-of-whole
- How: area marks from derived geometry, color hue/saturation/luminance
- Scalability: thousands of regions
- Design choices:
  - Colormap
  - Geometric deformation

[New York Times]

Hexagonal Cartogram



[FiveThirtyEight, 2018]

Next Class

A Declarative Rendering Model for Multiclass Density Maps

Jaemin Jo, Frédéric Vernier, Pierre Dragicevic, and Jean-Daniel Fekete, *Senior Member, IEEE*

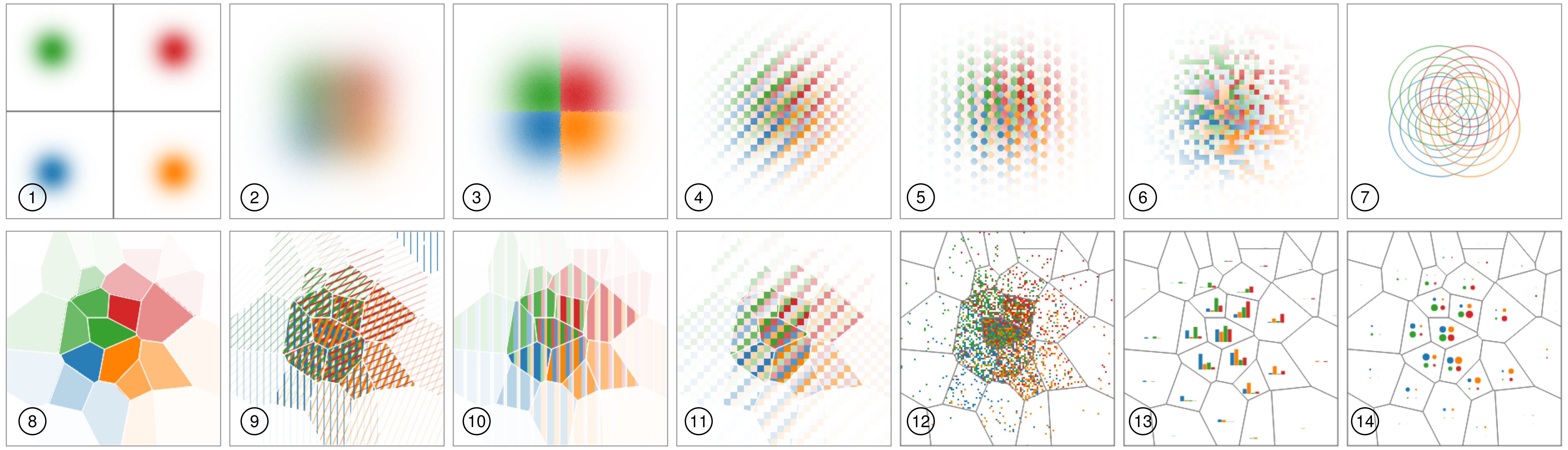


Fig. 1: Design alternatives for a four-class density map. 1 shows small multiples where each density map is individually presented with a unique color; 2 stacks the density maps and blends the color at each pixel; 3 shows the color of the pixel with the highest density; 4-6 use regular and irregular weaving patterns; 7 shows a contour plot for each class; and 8–14 use rebinning (binning and aggregation over the density maps) with tiles produced by a random Voronoï tessellation. The aggregated values are rendered in 8 with a flat color showing the highest density, 9 with hatching, 10 with proportional bars, 11 with regular weaving, 12 with a dot density plot, 13 with bar-chart glyphs, and 14 with circle sizes.

Abstract—Multiclass maps are scatterplots, multidimensional projections, or thematic geographic maps where data points have a categorical attribute in addition to two quantitative attributes. This categorical attribute is often rendered using shape or color, which does not scale when overplotting occurs. When the number of data points increases, multiclass maps must resort to data aggregation to remain readable. We present *multiclass density maps*: multiple 2D histograms computed for each of the category values. Multiclass density maps are meant as a building block to improve the expressiveness and scalability of multiclass map visualization. In this article, we first present a short survey of aggregated multiclass maps, mainly from cartography. We then introduce a declarative model—a simple yet expressive JSON grammar associated with visual semantics—that specifies a wide design space of visualizations for multiclass density maps. Our declarative model is expressive and can be efficiently implemented in visualization front-ends such as modern web browsers. Furthermore, it can be reconfigured dynamically to support data exploration tasks without recomputing the raw data. Finally, we demonstrate how our model can be used to reproduce examples from the past and support exploring data at scale.

Index Terms—Scalability, multiclass scatterplots, density maps, aggregation, declarative specification, visualization grammar