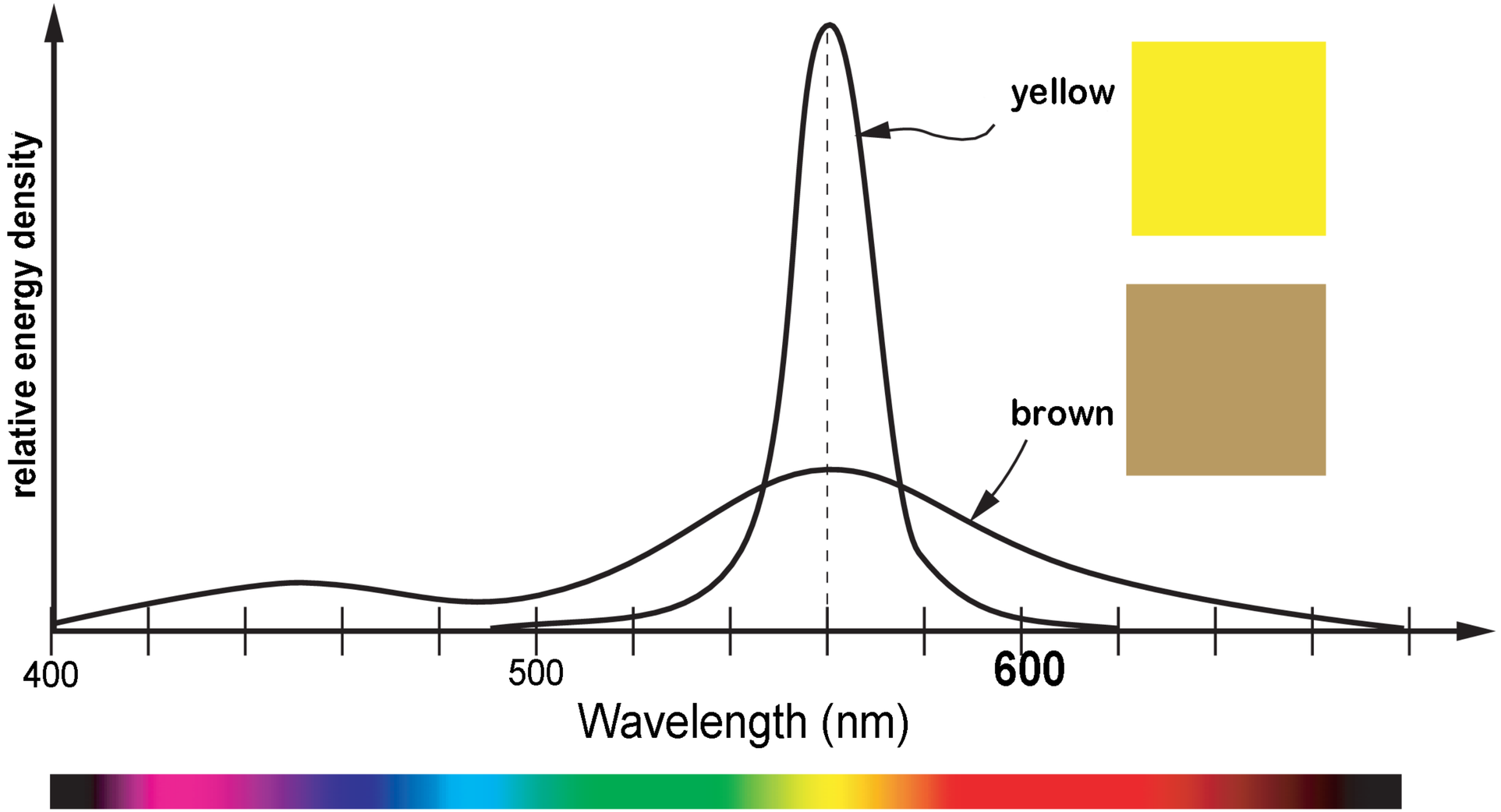
Data Visualization (CSCI 627/490)

Geospatial Data

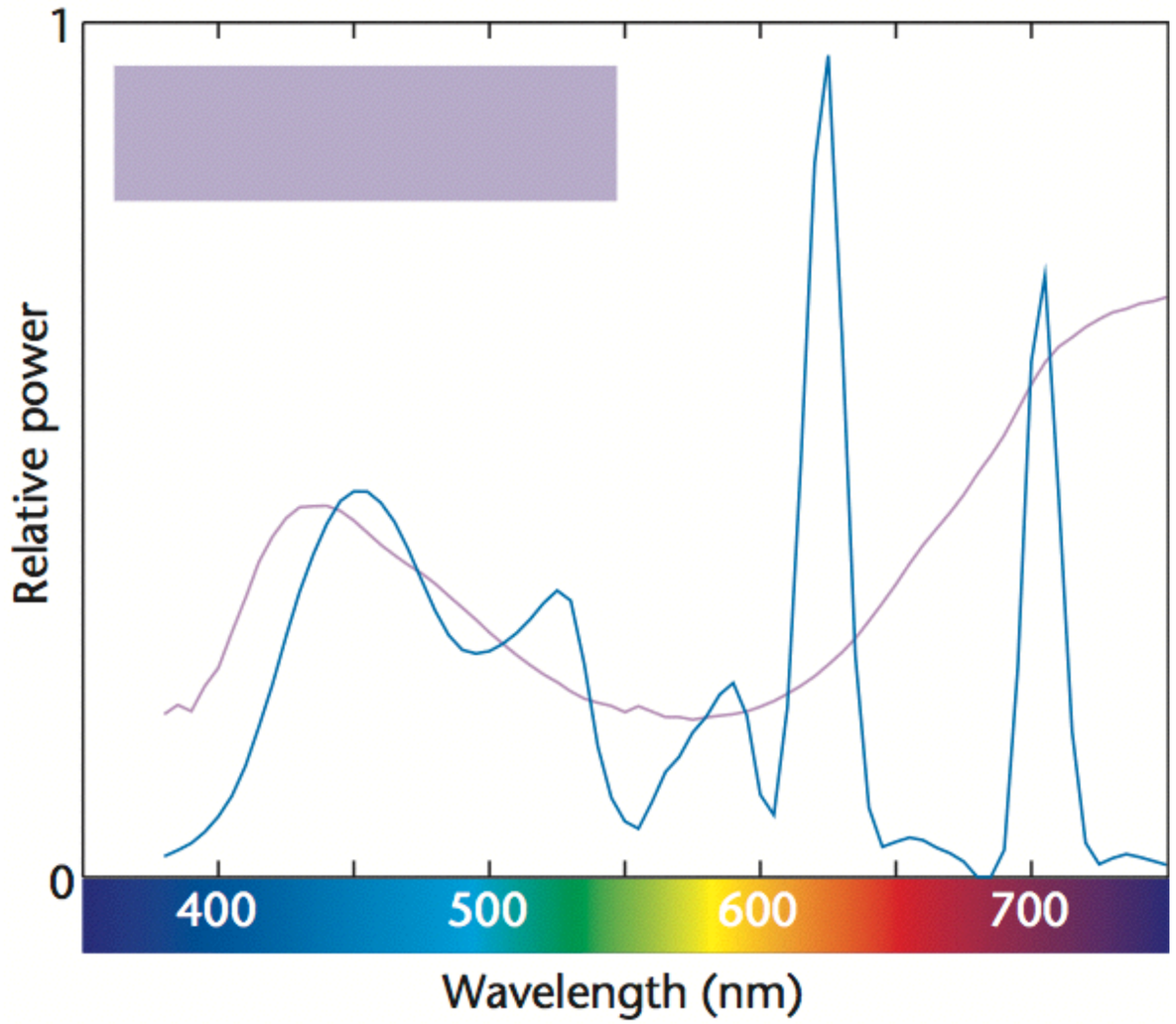
Dr. David Koop

Color != Wavelength



[via M. Meyer]

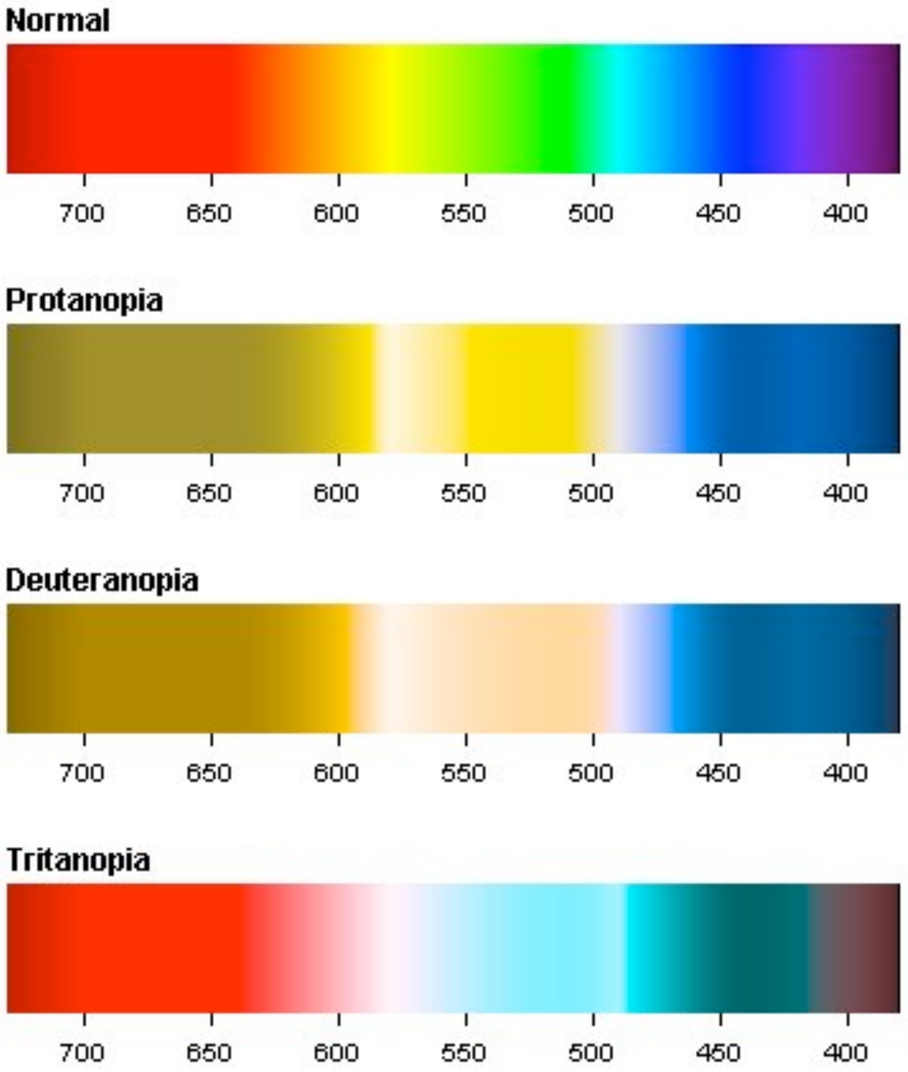
Rods, Cones, and Metamerism



- Humans are not spectrometers, have rods and cones
- Do not get the whole function
- Three cones → numbers ~ color
- Different spectra can be same color (metamerism)

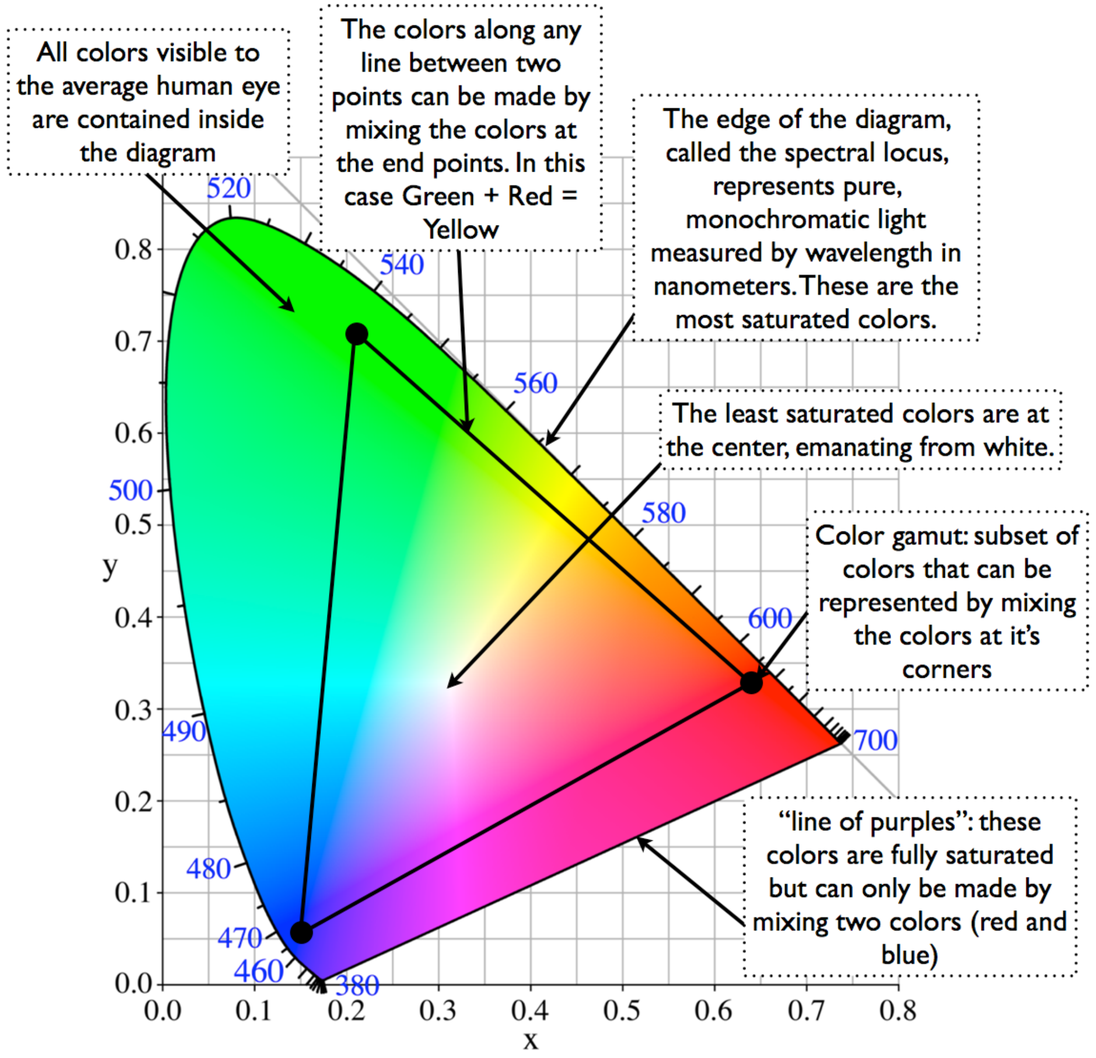
[via M. Meyer]

Color Blindness



[via M. Meyer]

Color Spaces, Gamuts, and Models



- **Color space**: the organization of all colors in space
  - Often human-specific, what we can see (e.g. CIELAB)
- **Color gamut**: a subset of colors
  - Defined by corners of color space
  - The gamut of your monitor != the gamut of someone else's or a printer
- **Color model**: a representation of color using some basis (RGB, HSL, HSV)
  - Remember luminance is non-linear

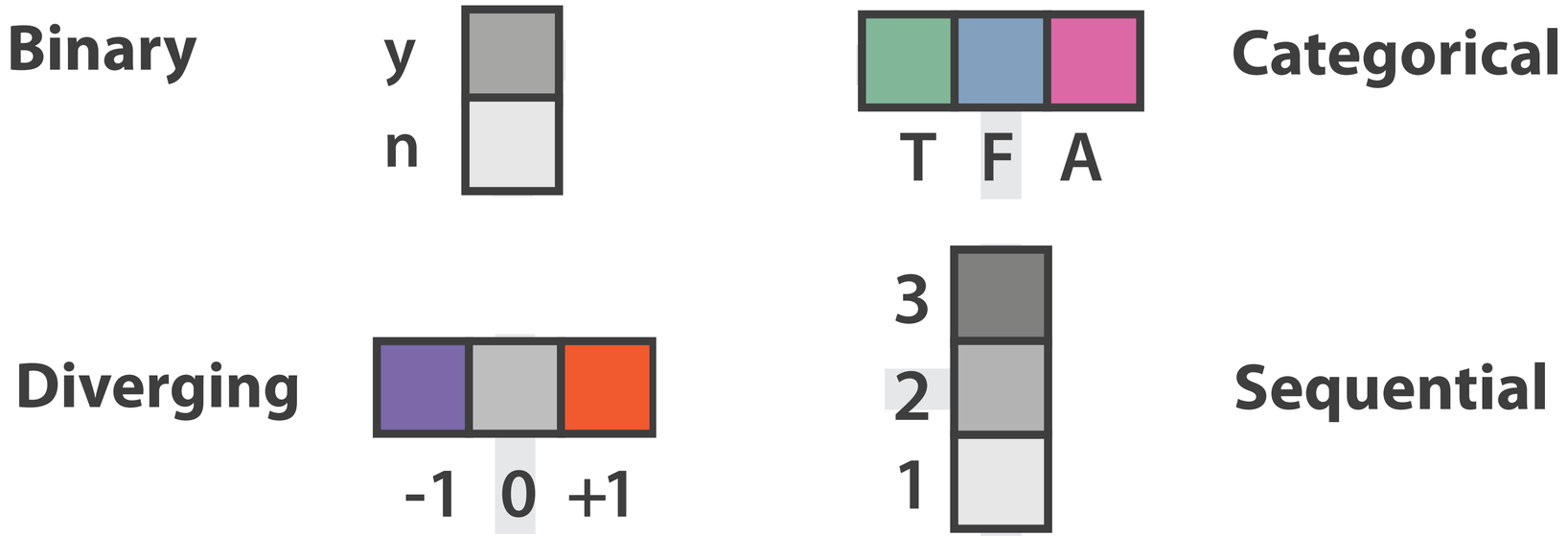
[Anatomy of a CIE Chromaticity Diagram]

What does this mean for visualization?

- We need to be aware of colorblindness when encoding via color
- Our brains may misinterpret color (surrounding colors matter!) even if we aren't colorblind
- Be careful! Don't assume that adding color always works the way you intended
- Use known colormaps when possible

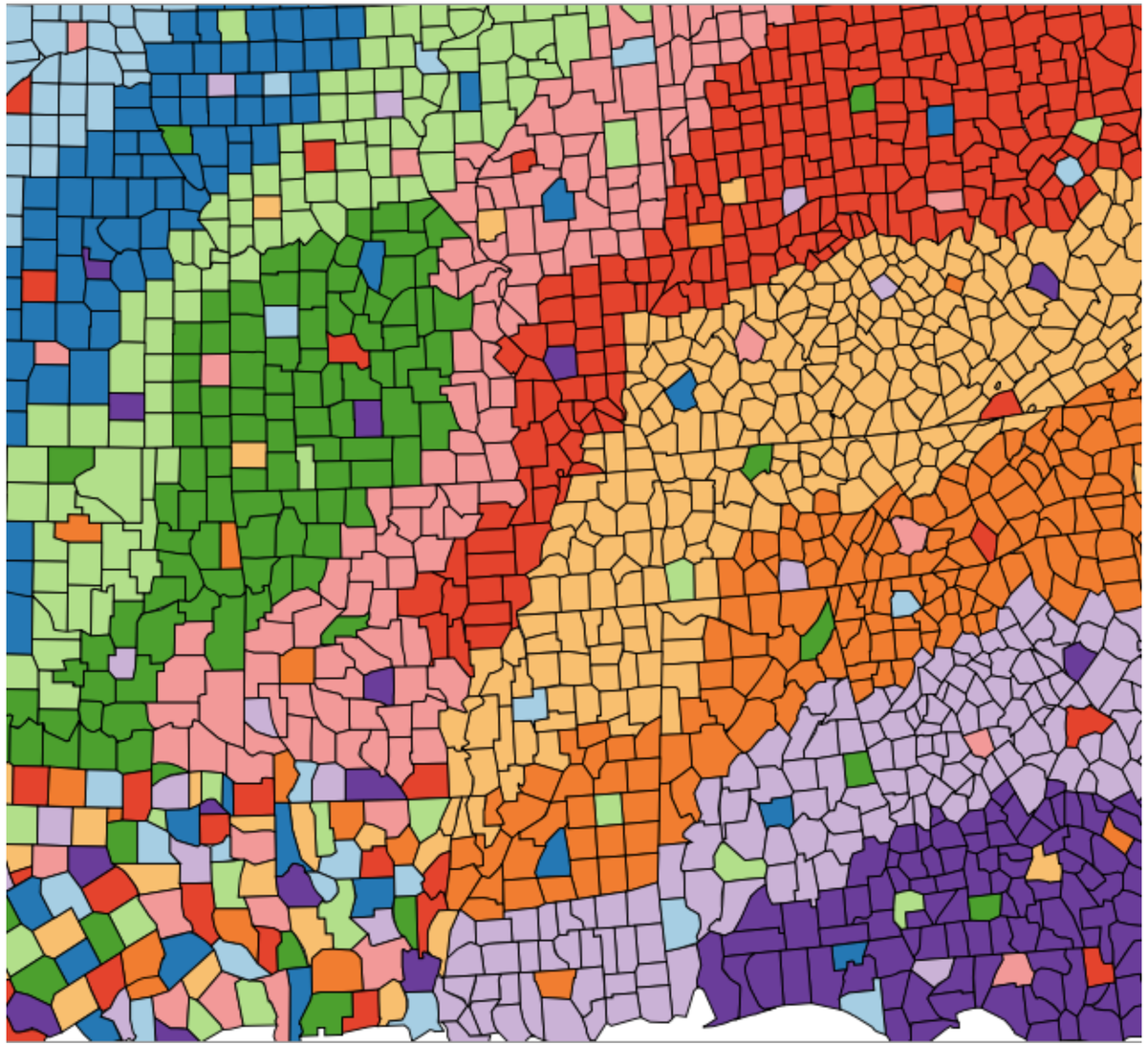
Colormap

- A colormap specifies a mapping between colors and data values
- Colormap should follow the expressiveness principle
- Types of colormaps:



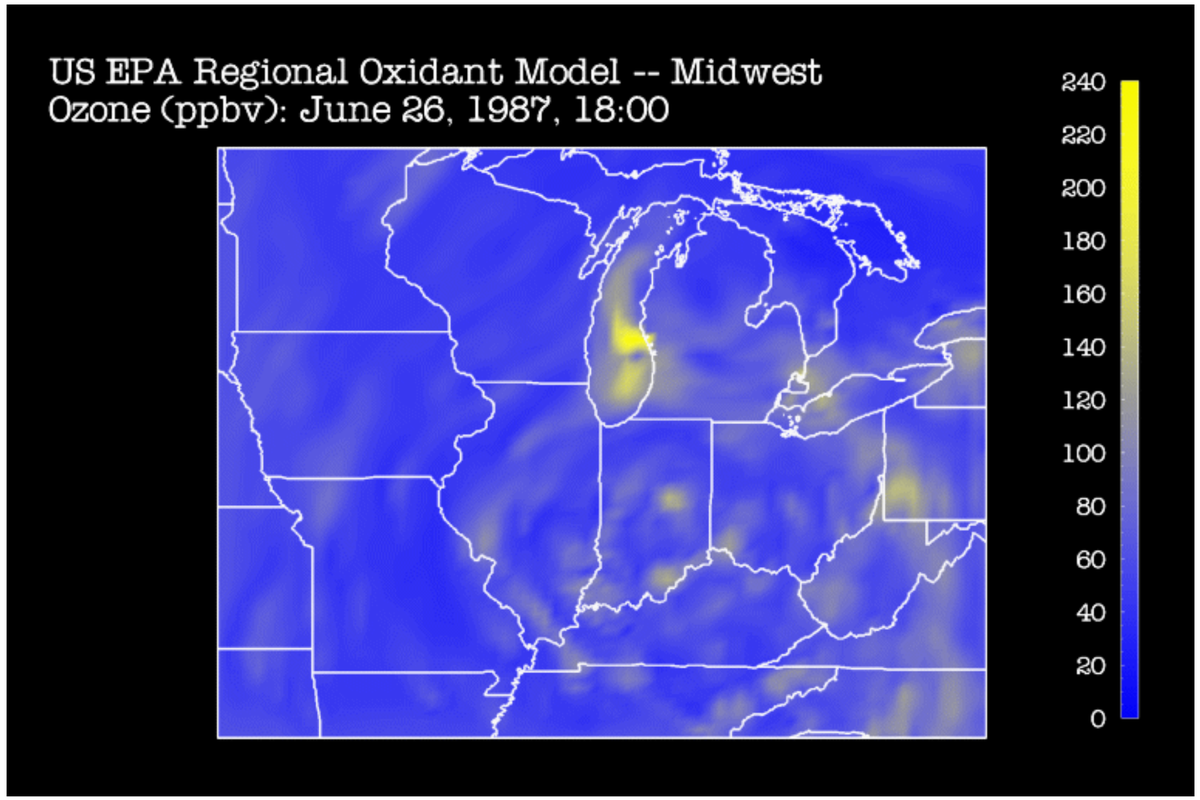
[Munzner (ill. Maguire), 2014]

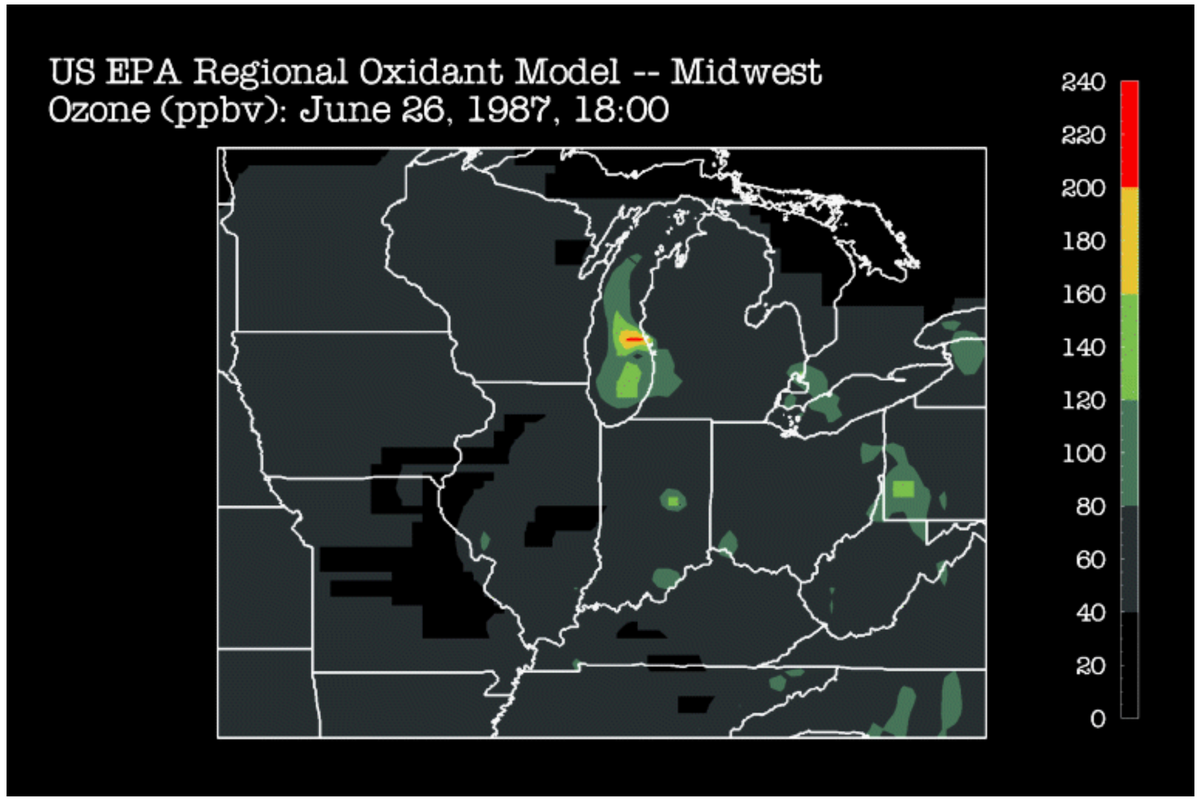
Categorical Colormap Guidelines



- Don't use too many colors (~12)
- Use other categories or create groups if you have too many values!
- Nameable colors help
- Be aware of luminance (e.g. difference between blue and yellow)
- Think about other marks you might wish to use in the visualization

Ordered Colormaps: Continuous and Segmented

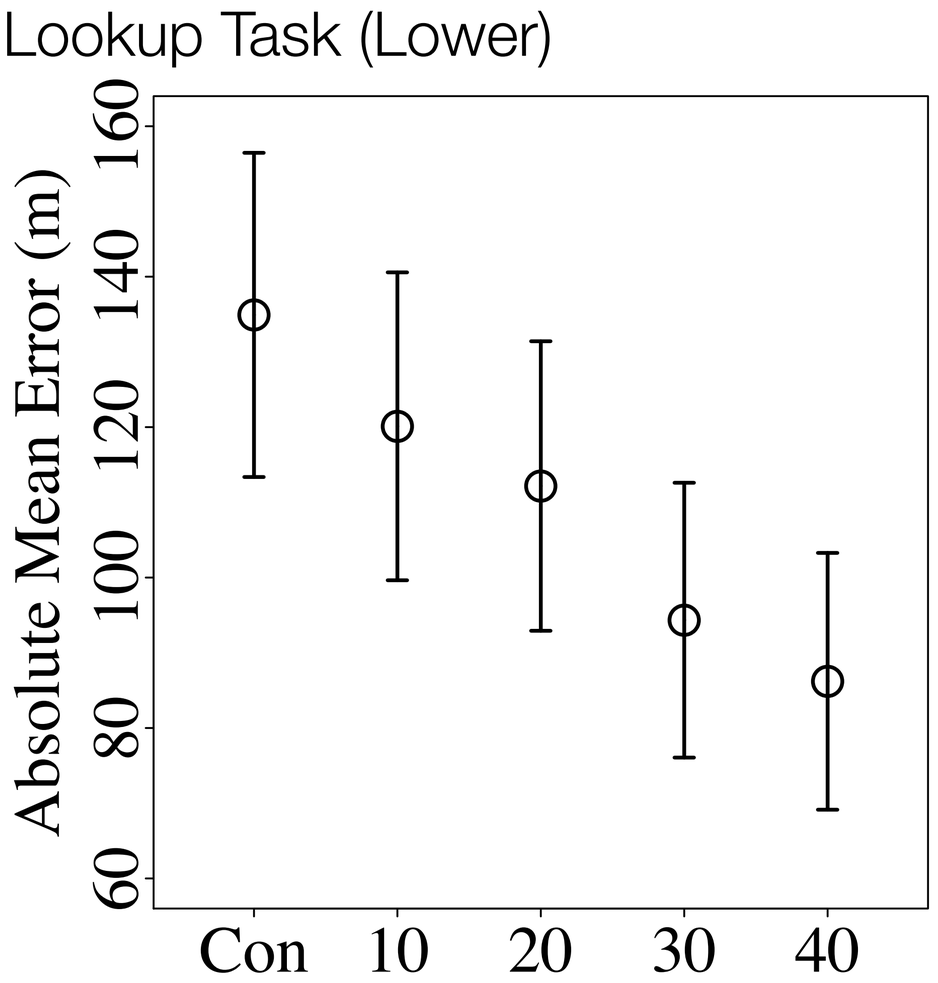




[Bergman et al., 1995]

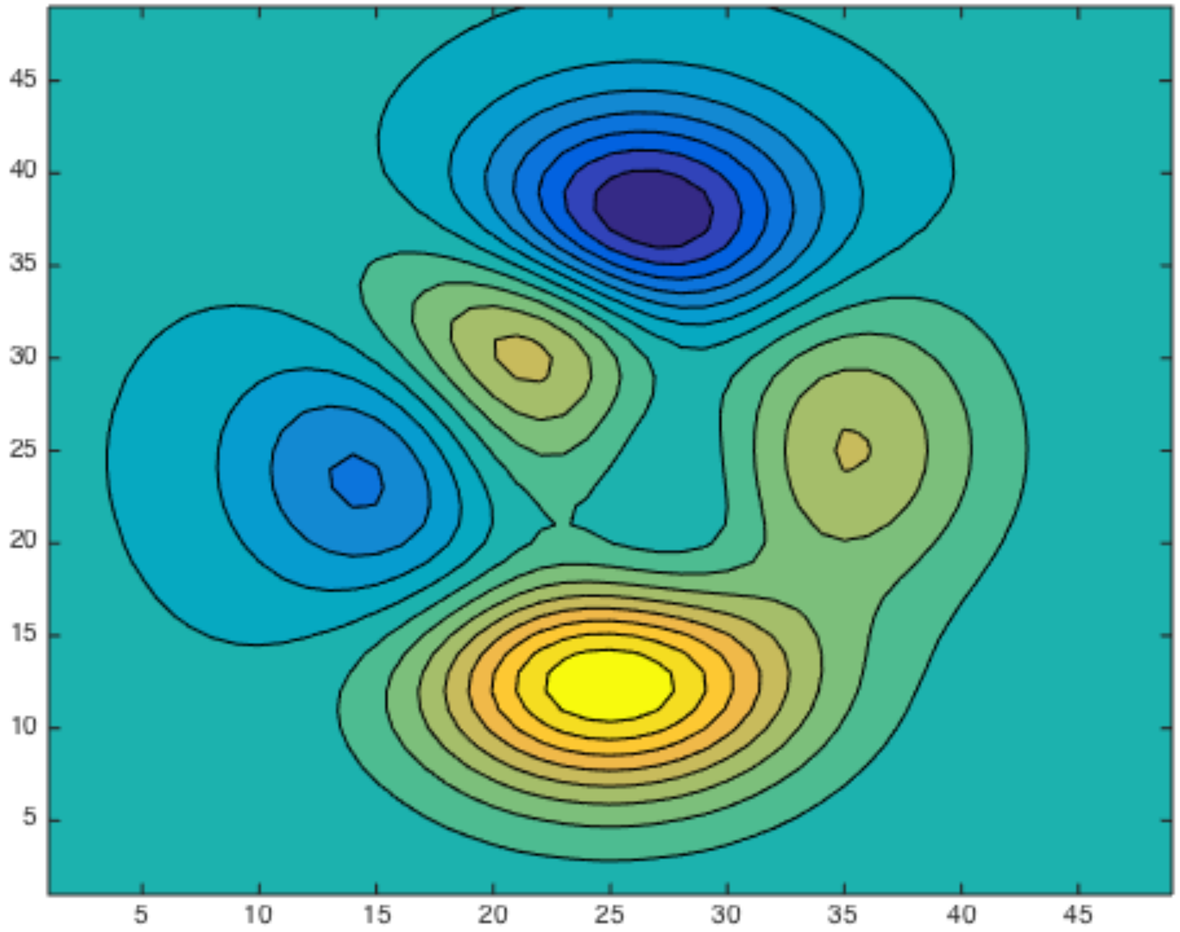
Continuous vs. Segmented Test Results

- "[C]ontrary to the expressiveness principle, no cases were found in which a continuous encoding of 2D scalar field data was advantageous for task accuracy, and for some tasks, specific binned encodings facilitated accuracy."
- "[S]upport for the counterintuitive finding that decisions with binned encoding were slower than those made with continuous encoding"
- Word of caution: single image!



[Padilla et al., 2017]

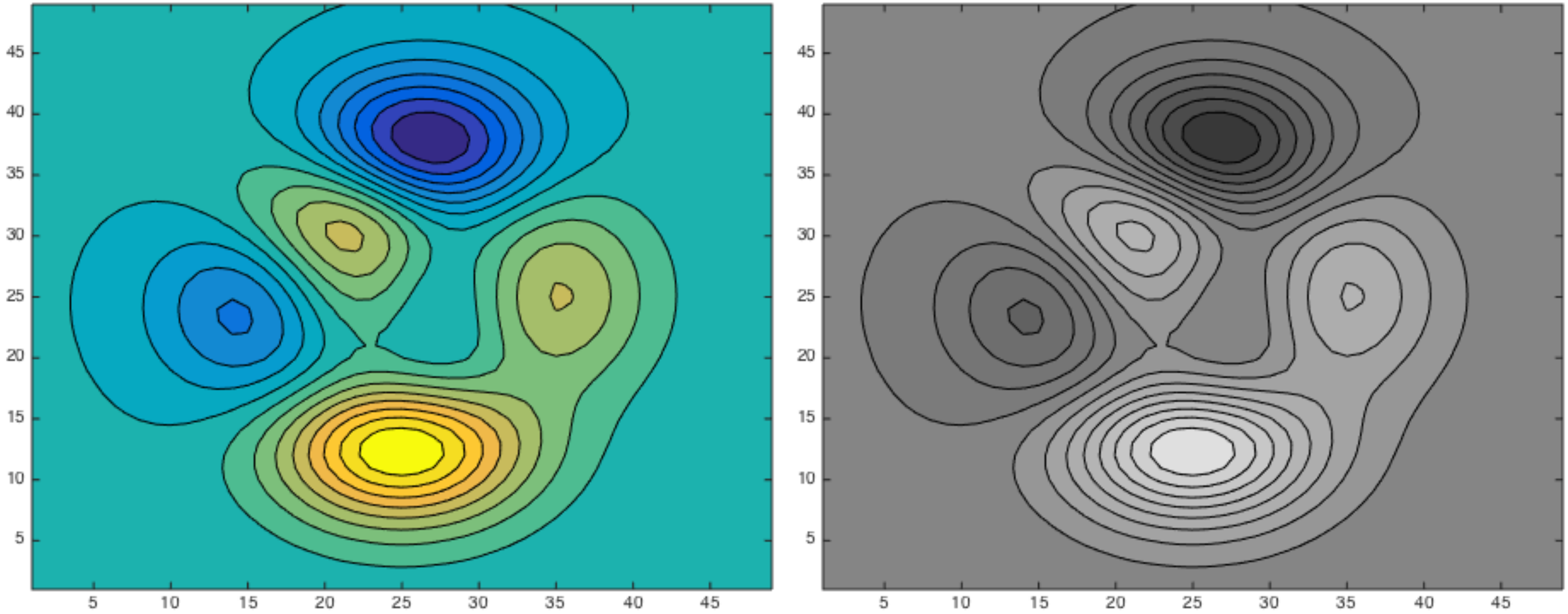
"Get It Right in Black and White" - M. Stone



parula colormap

[S. Eddins (Matlab Blog), 2014]

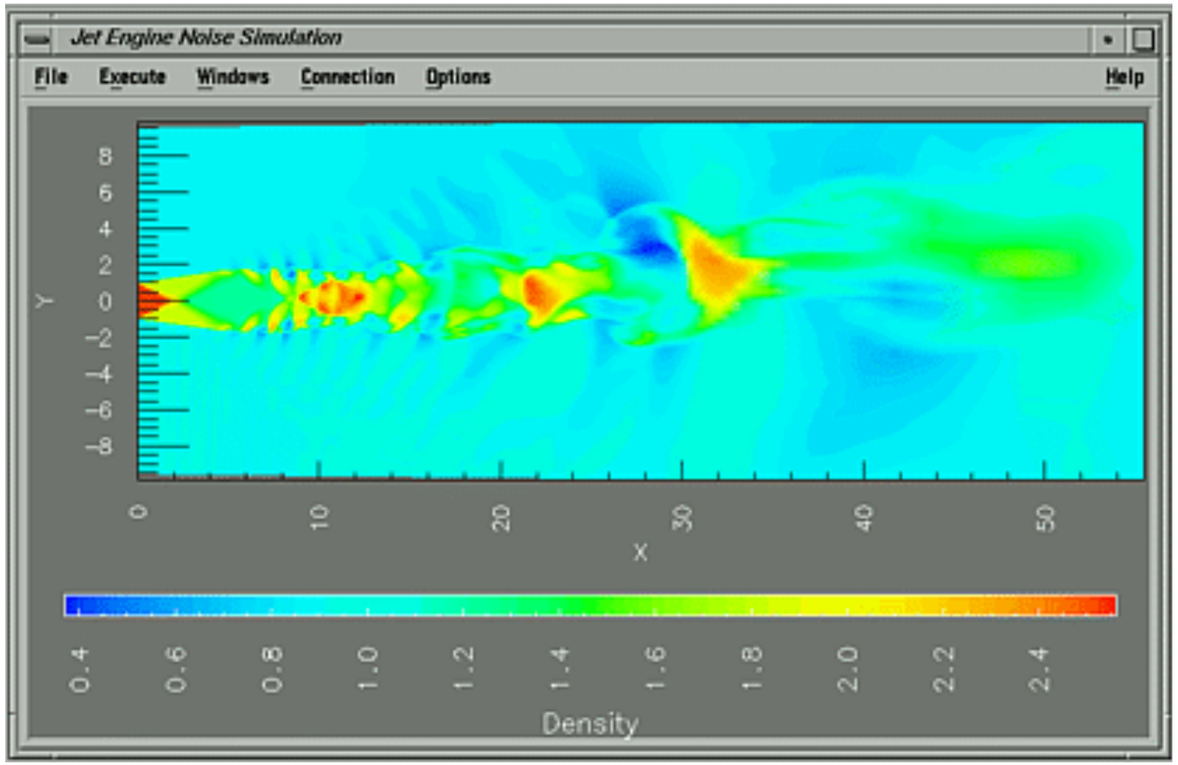
"Get It Right in Black and White" - M. Stone

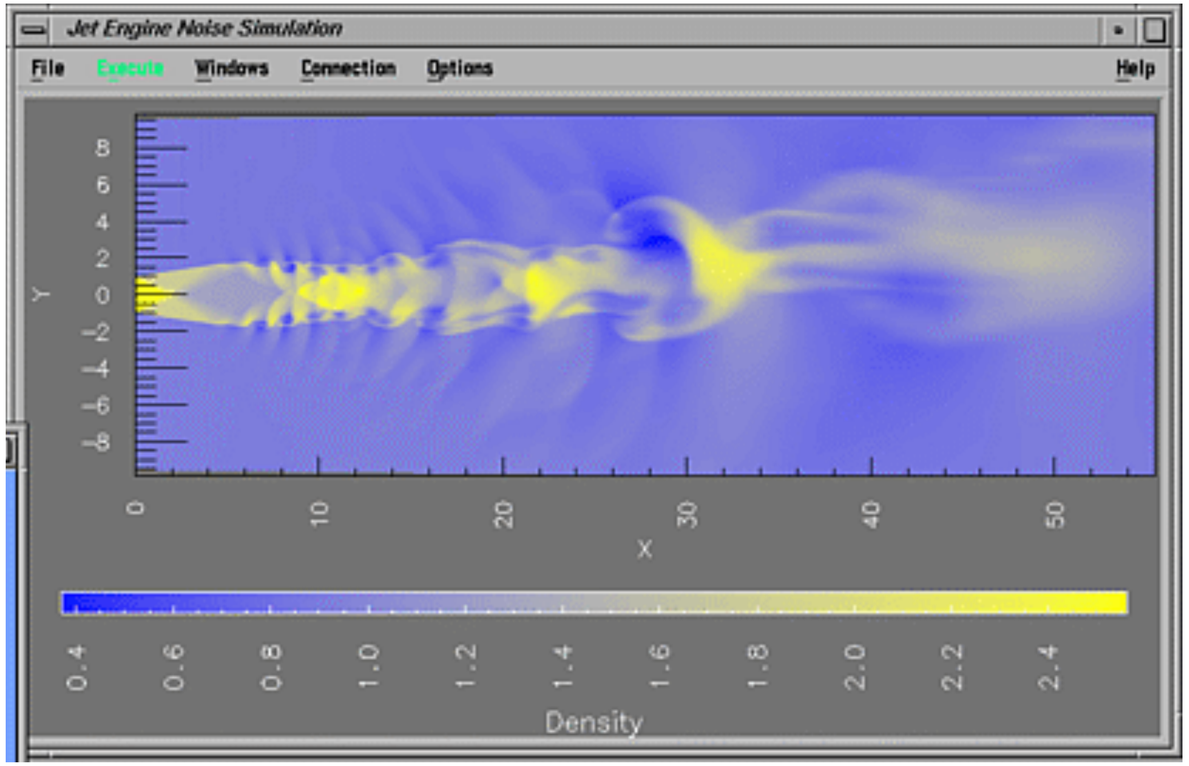


parula colormap

[S. Eddins (Matlab Blog), 2014]

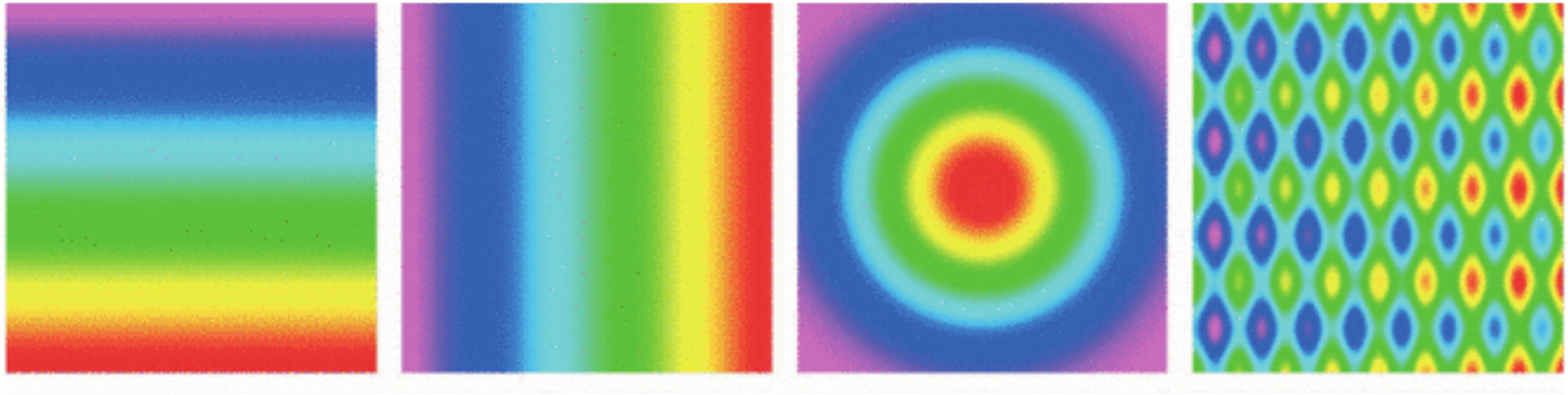
Rainbow vs. Two-Hue Colormap





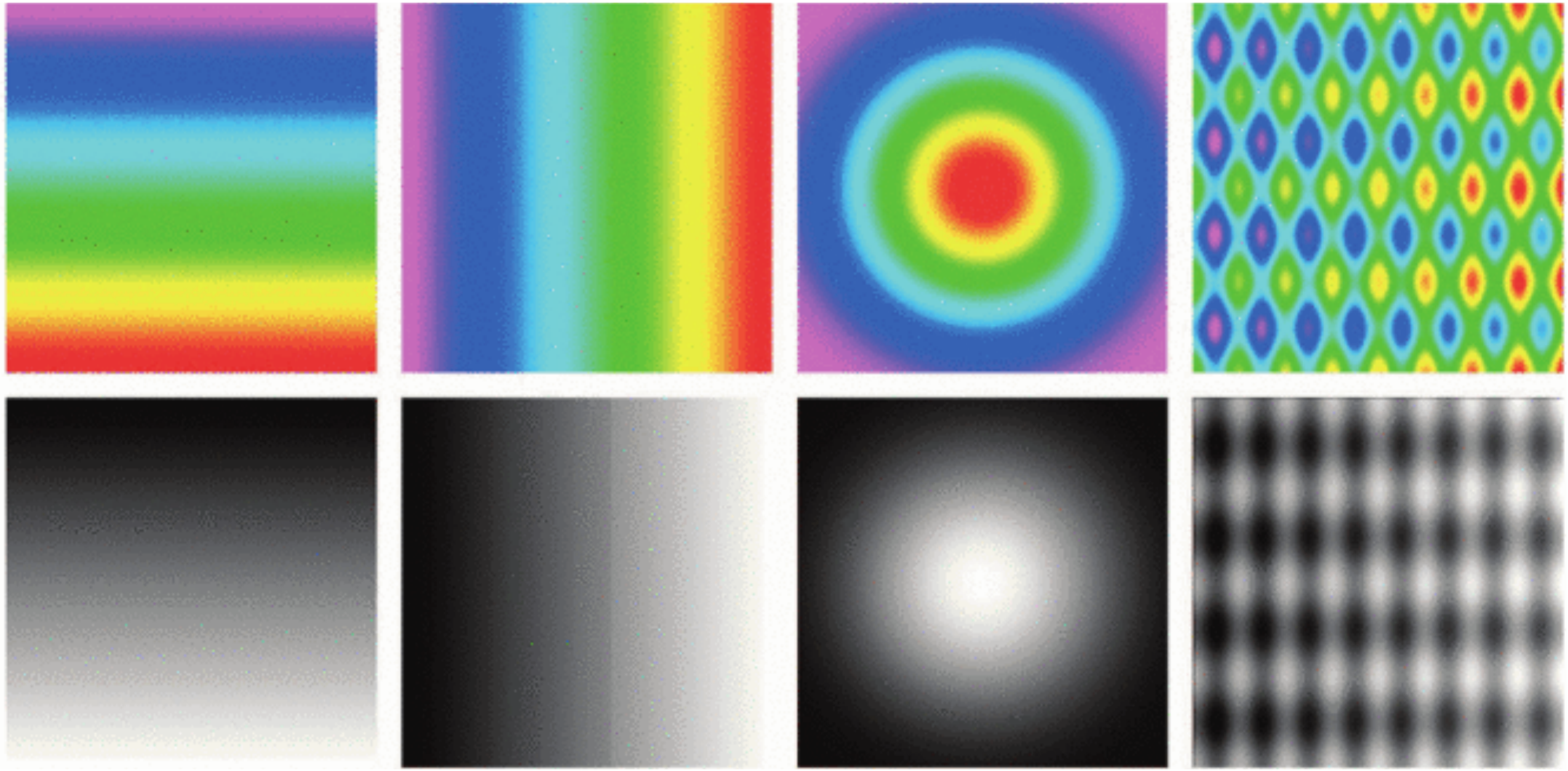
[Bergman et al., 1995]

Artifacts from Rainbow Colormaps



[Borland & Taylor, 2007]

Artifacts from Rainbow Colormaps

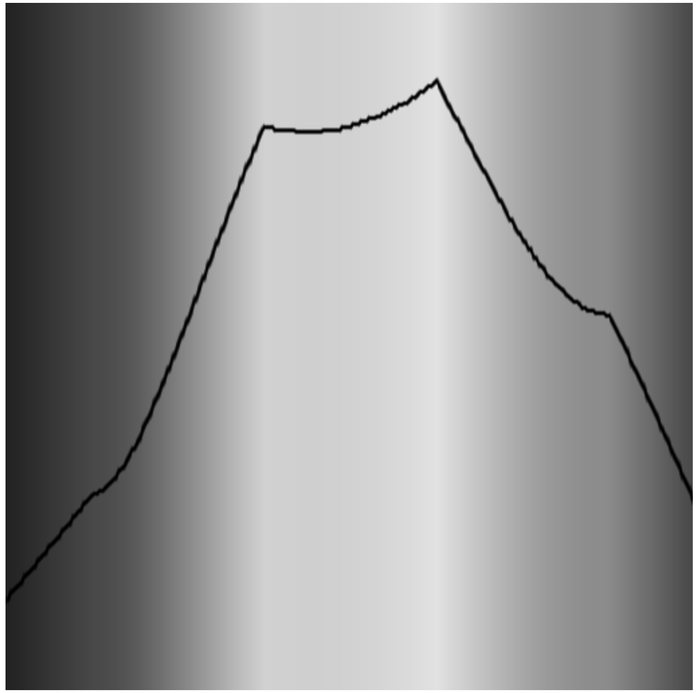


[Borland & Taylor, 2007]

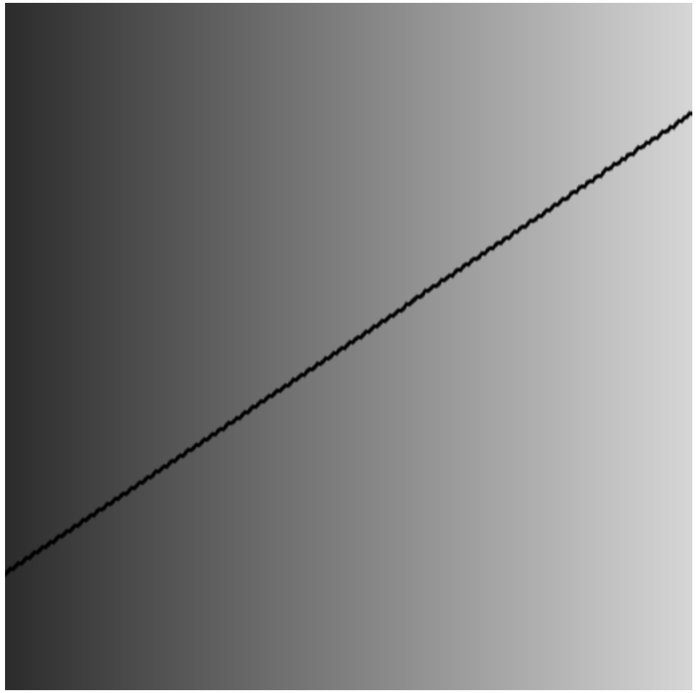
Rainbow Colormaps

- Issues:
  - Order is unclear
  - Luminance issues
  - Artifacts from discontinuities in luminance
- Attempts to fix:
  - Isoluminant rainbow
  - Turbo

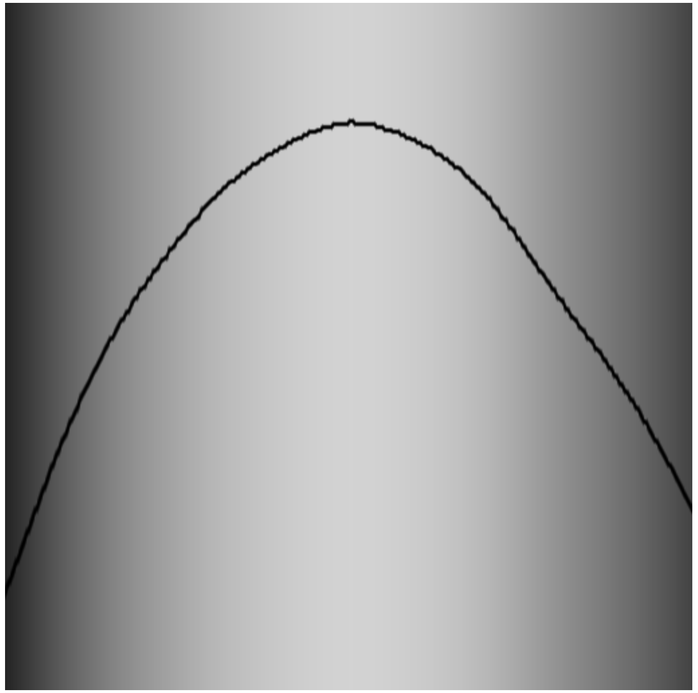
Turbo: Improving Rainbow Colormaps



Jet



Viridis



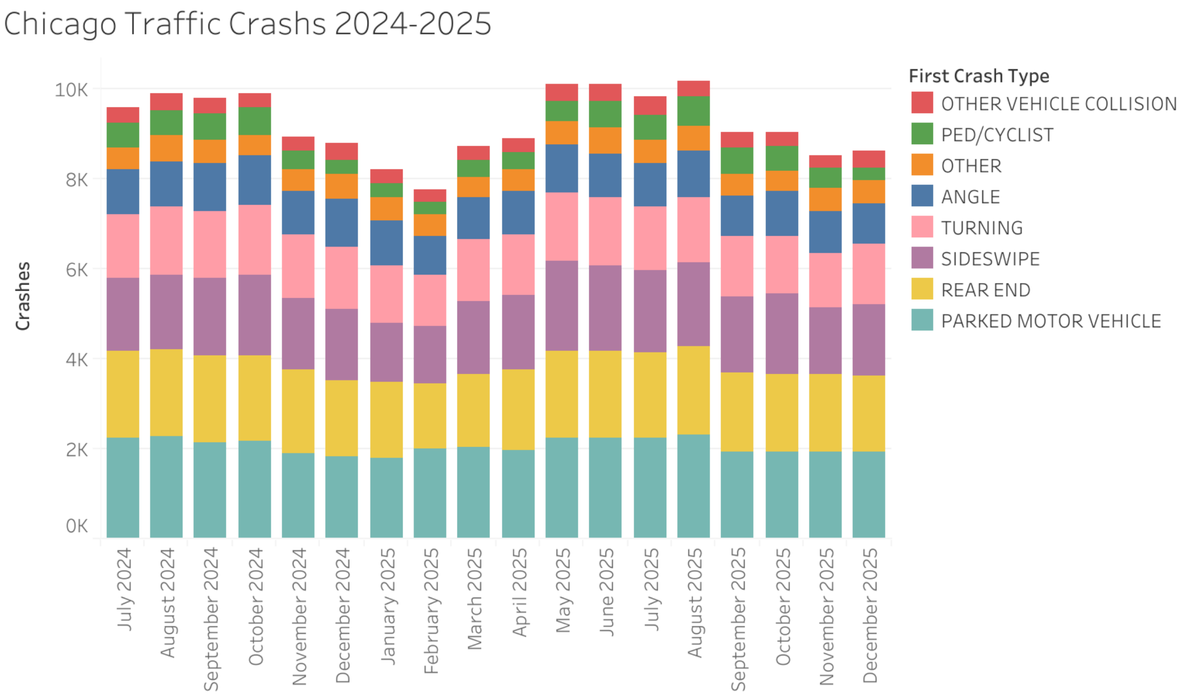
Turbo

[A. Mikhailov]

Assignment 2 Feedback

- You should not have sorted the data
- Not sorting the data does not imply an unordered bar chart!
- Use of AI to write code is **prohibited** on assignments

Assignment 3



- Due today
- Chicago Traffic Crashes Data
- Create same stacked bar chart with
  - Tableau Public
  - Observable Plot
  - D3
- D3 Stacked Bar Chart:
  - Required for CSCI 627 students
  - Extra credit for CSCI 490 students

Courselets

- Educational resources for visualization using notebooks
- Reviewed charts over the last couple of classes, how do we construct them?
- How do we use visualization libraries, including those in other contexts like Python?
  - matplotlib
  - pyobsplot
  - colormaps in pyobsplot

Midterm

- In-class, Wednesday, March 4, 12:30-1:45pm
- Only need writing utensil (+eraser)
- Format:
  - Multiple Choice
  - Free Response
- CSCI 627 students will have an extra double-sided page with more research-focused questions

More Guidelines

- Nice set of articles by Lisa Charlotte Rost:
  - https://blog.datawrapper.de/colorguide/
  - https://blog.datawrapper.de/beautifulcolors/
- Her guidelines on choosing colors:
  1. **Copy from others**
  2. **Use Tools**
  3. …

Don't Dance Around the Color Wheel

NOT IDEAL

BETTER

[L. C. Rost]

Use Warm Colors & Blue

NOT IDEAL

BETTER

[L. C. Rost]

Avoid Too Little Contrast to Background

NOT IDEAL

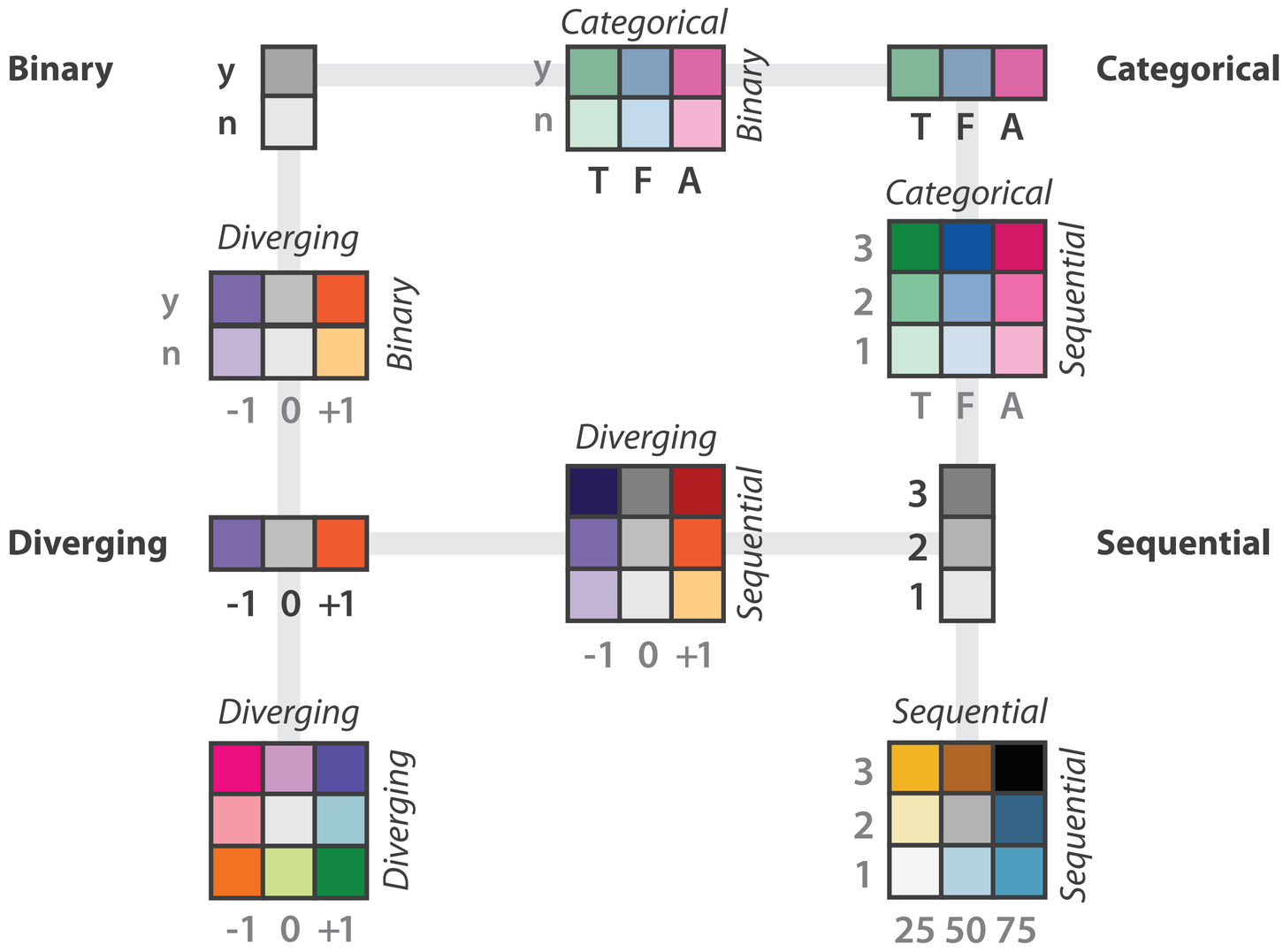
BETTER

[L. C. Rost]

D3's color scales

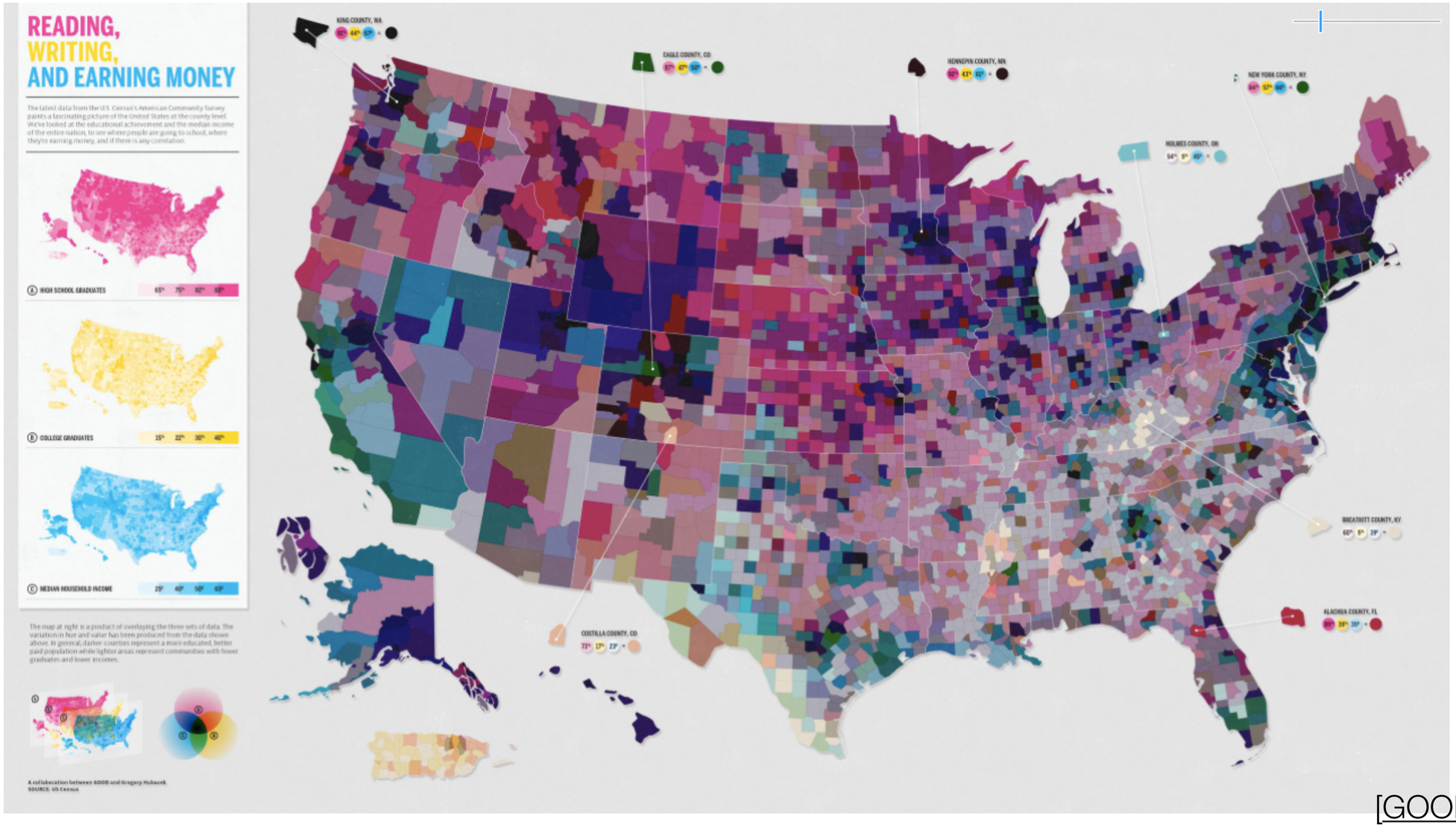
- https://github.com/d3/d3-scale-chromatic
- In v7, included in default bundle (no separate import)
- D3's built-in color scales
- Derived from ColorBrewer
- Sequential and diverging scales created using interpolation
- Hue **can** change, but be careful
- Color ramp [M. Bostock]

Bivariate Colormaps



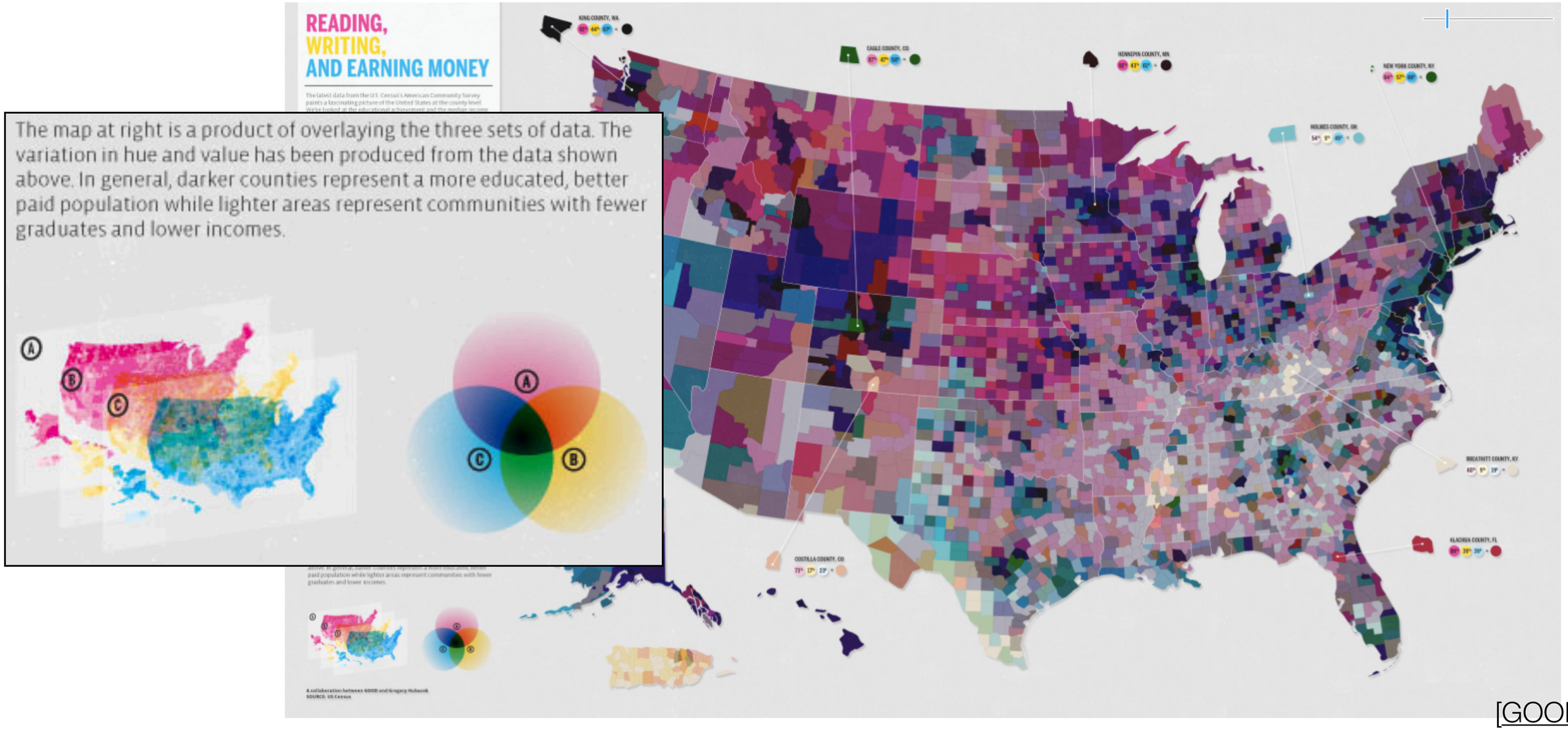
[Munzner (ill. Maguire), 2014]

Remember Separable vs. Integral



[GOOD]

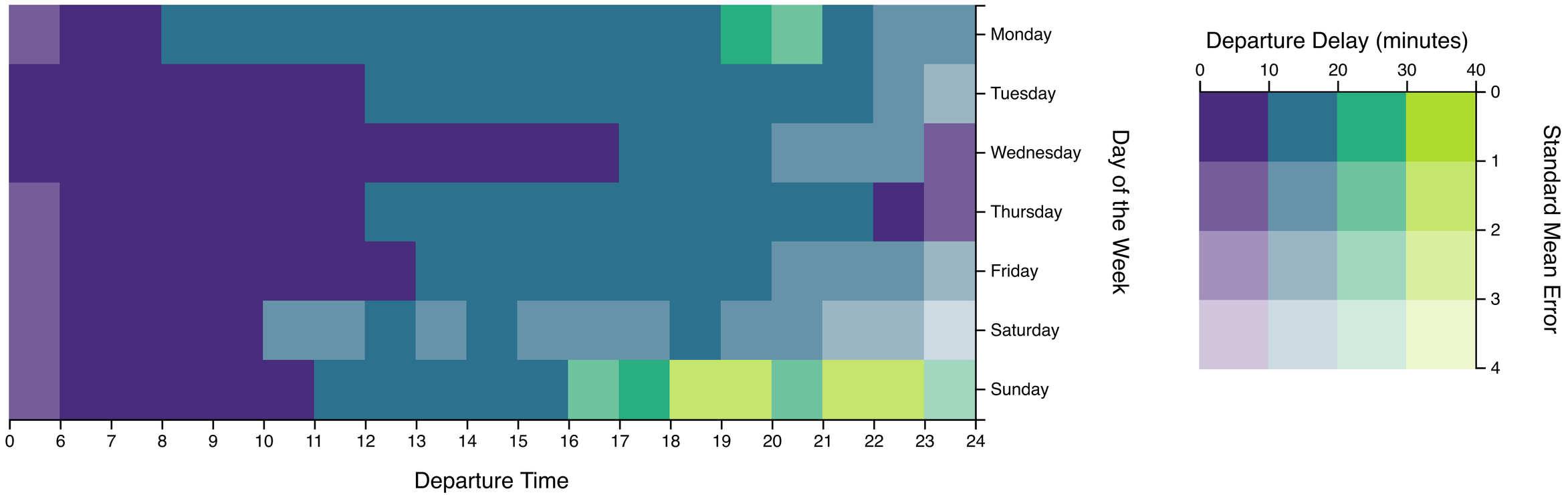
Remember Separable vs. Integral



[GOOD]

What about uncertain data?

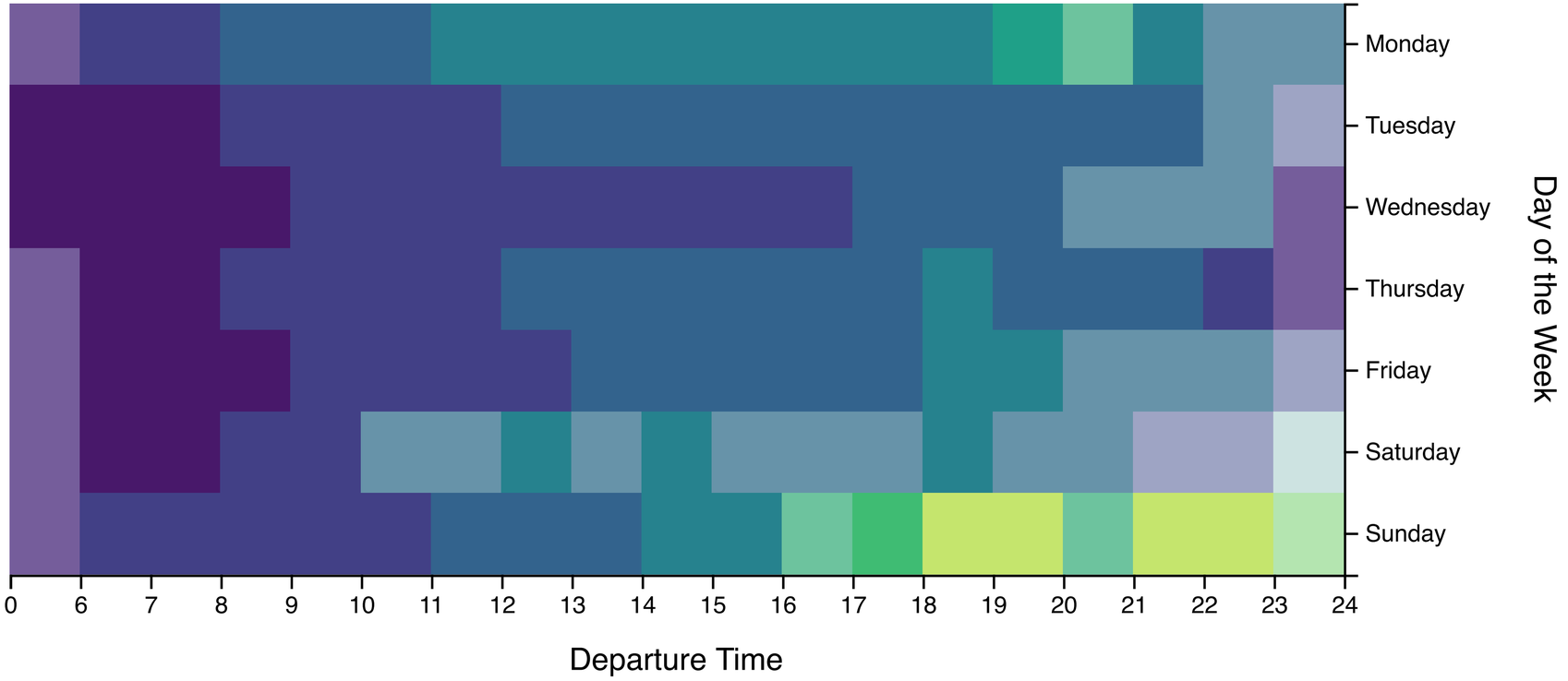
Bivariate Colormap (Uncertainty → Saturation)

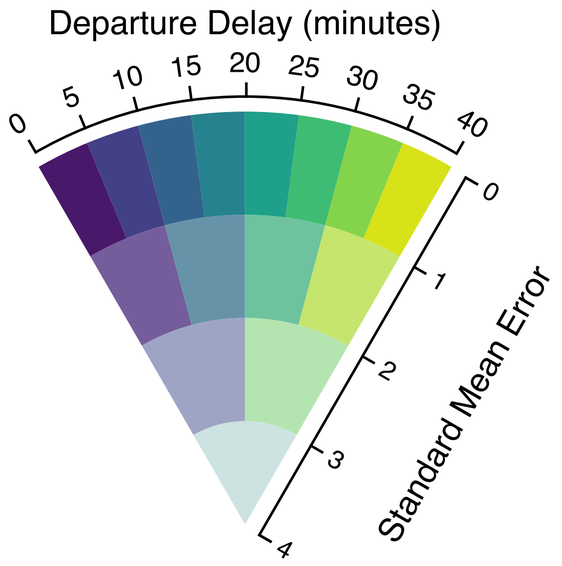


[Correll et al., 2018]

Value-Suppressing Uncertainty Palette (VSUP)

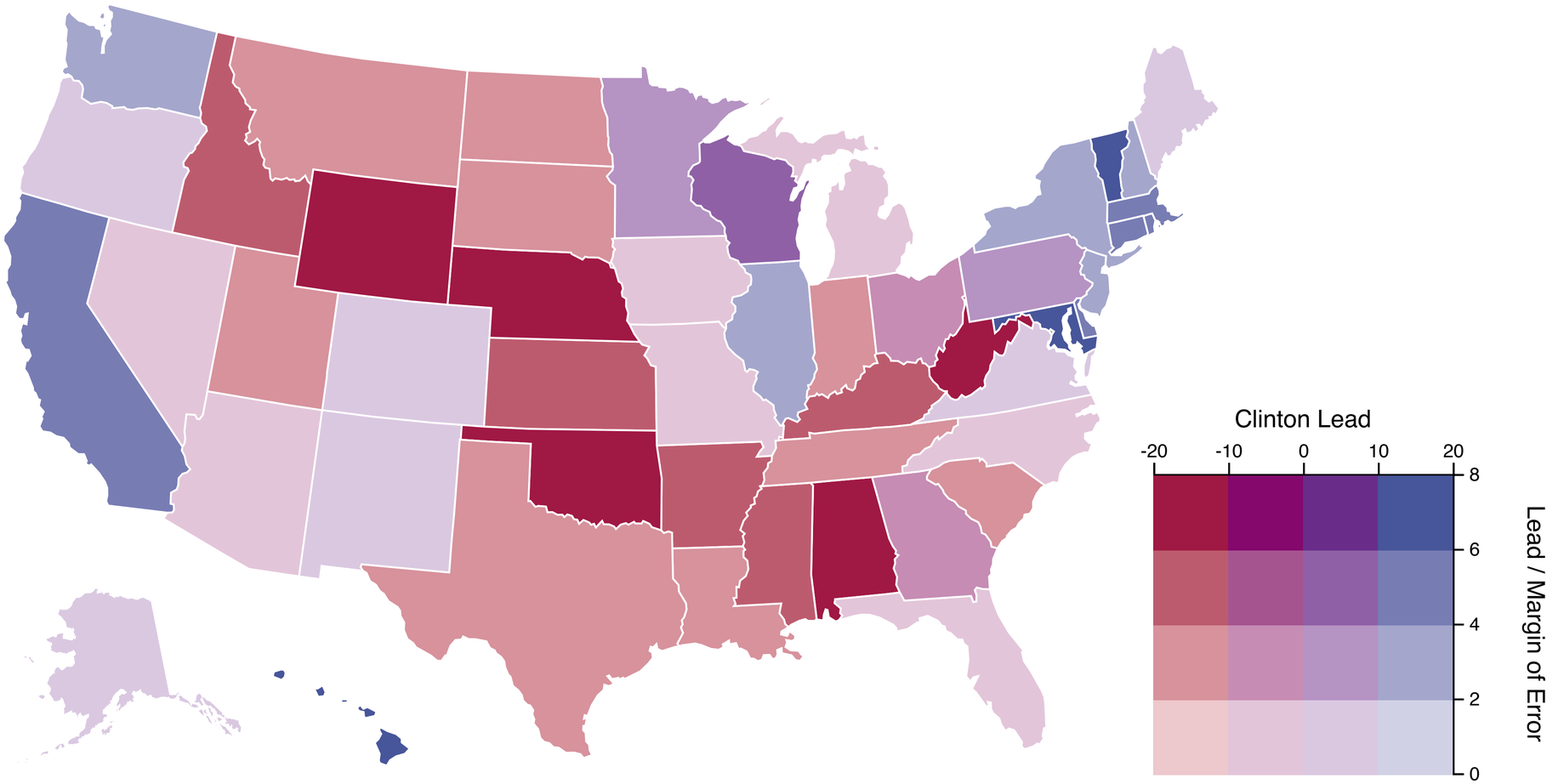
Same Channels, just binned differently





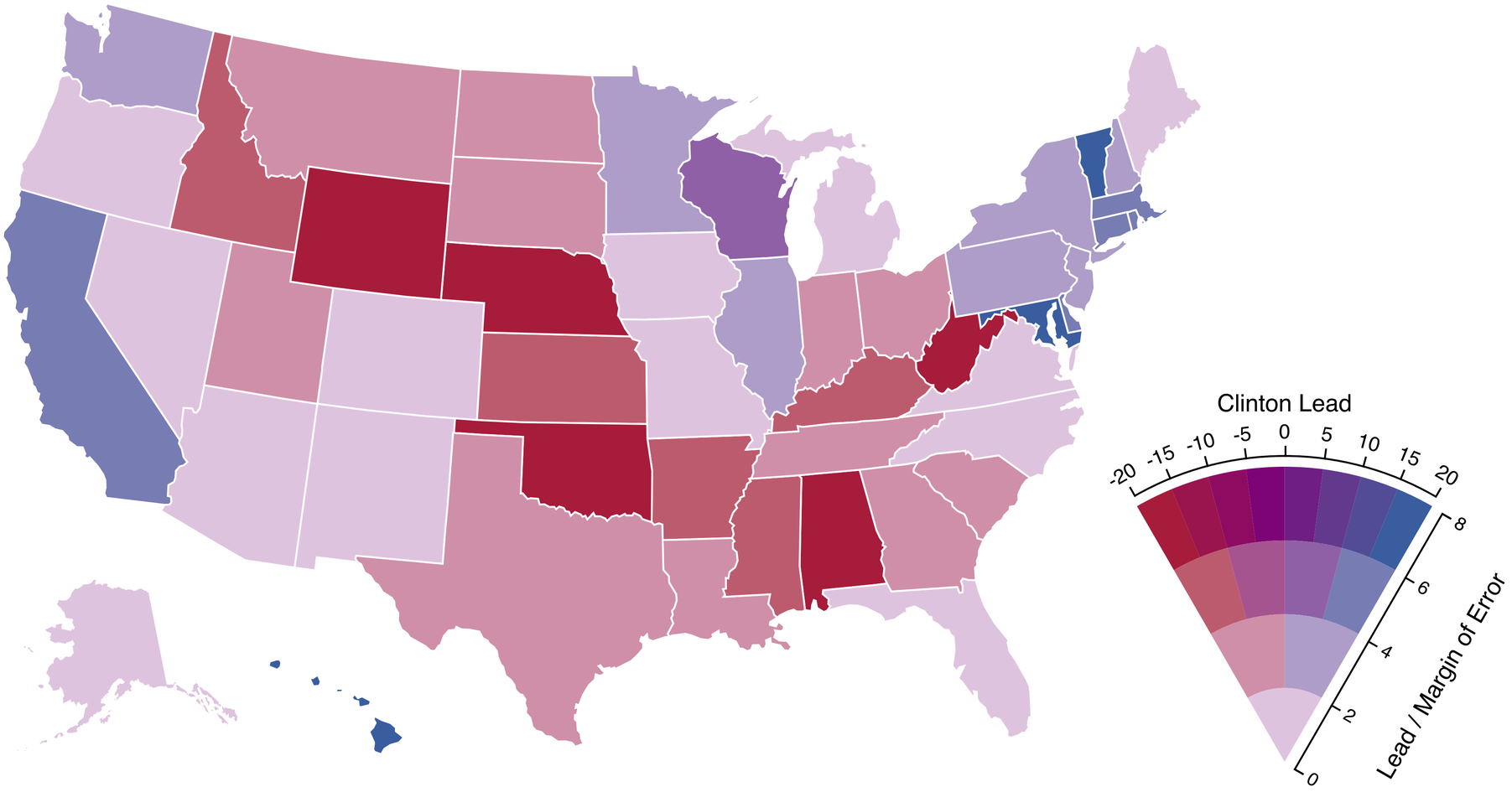
[Correll et al., 2018]

Bivariate Colormap (Uncertainty → Saturation)



[Correll et al., 2018]

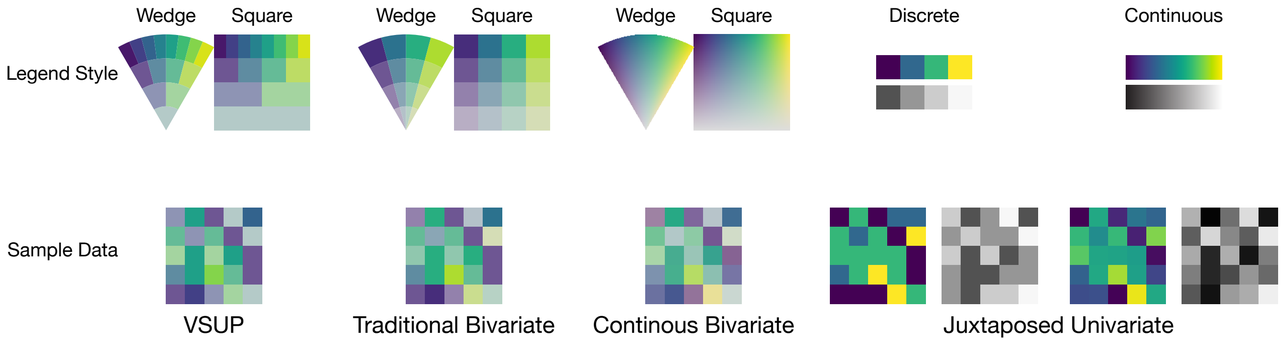
Value-Suppressing Uncertainty Palette



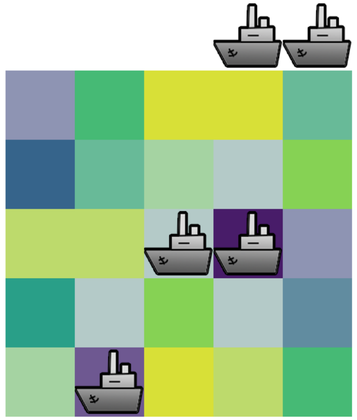
[Correll et al., 2018]

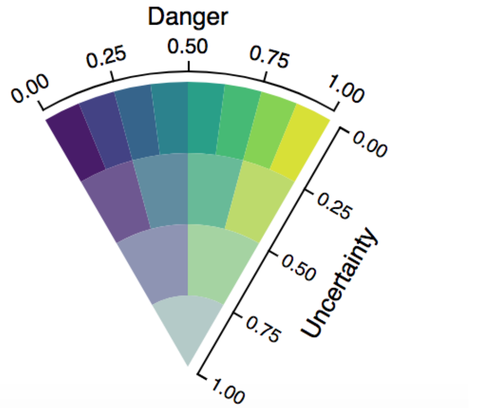
Evaluation

- Tasks:
  - Identification: locate spatial regions



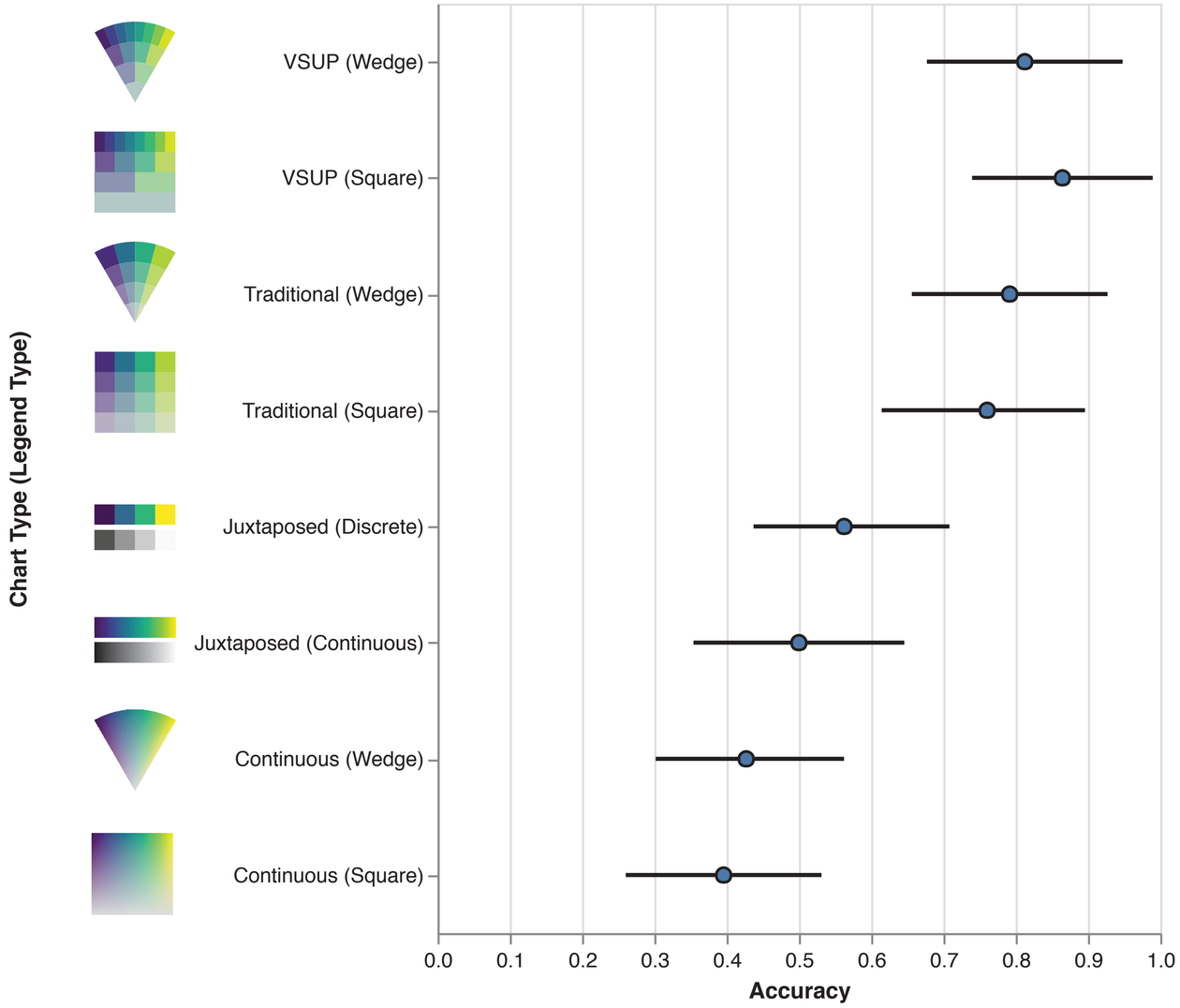
  - Prediction: place | "safest locations"





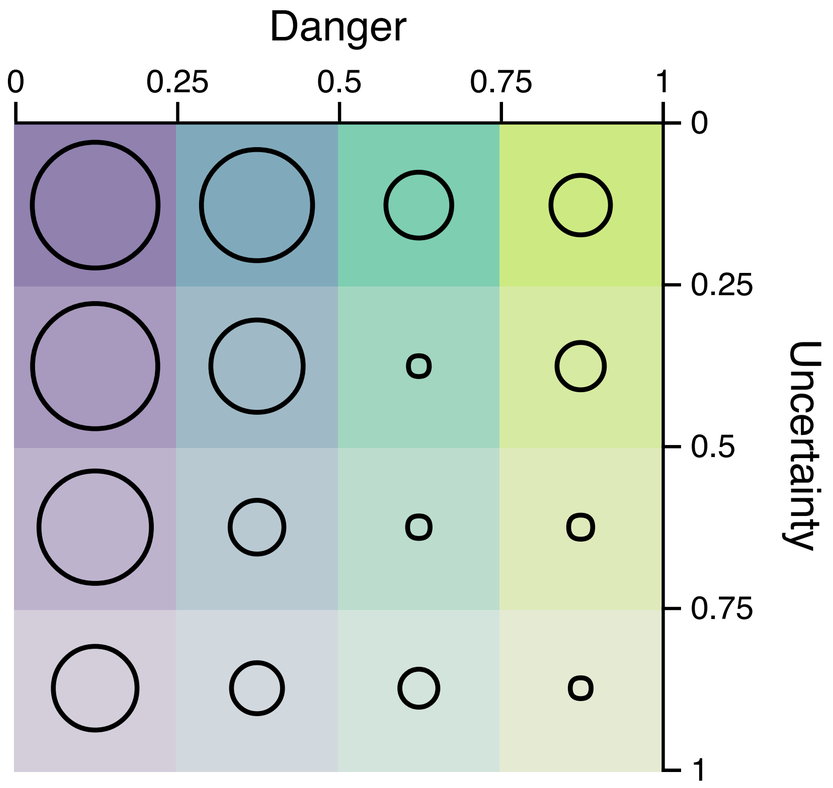
[Correll et al., 2018]

Identification Results

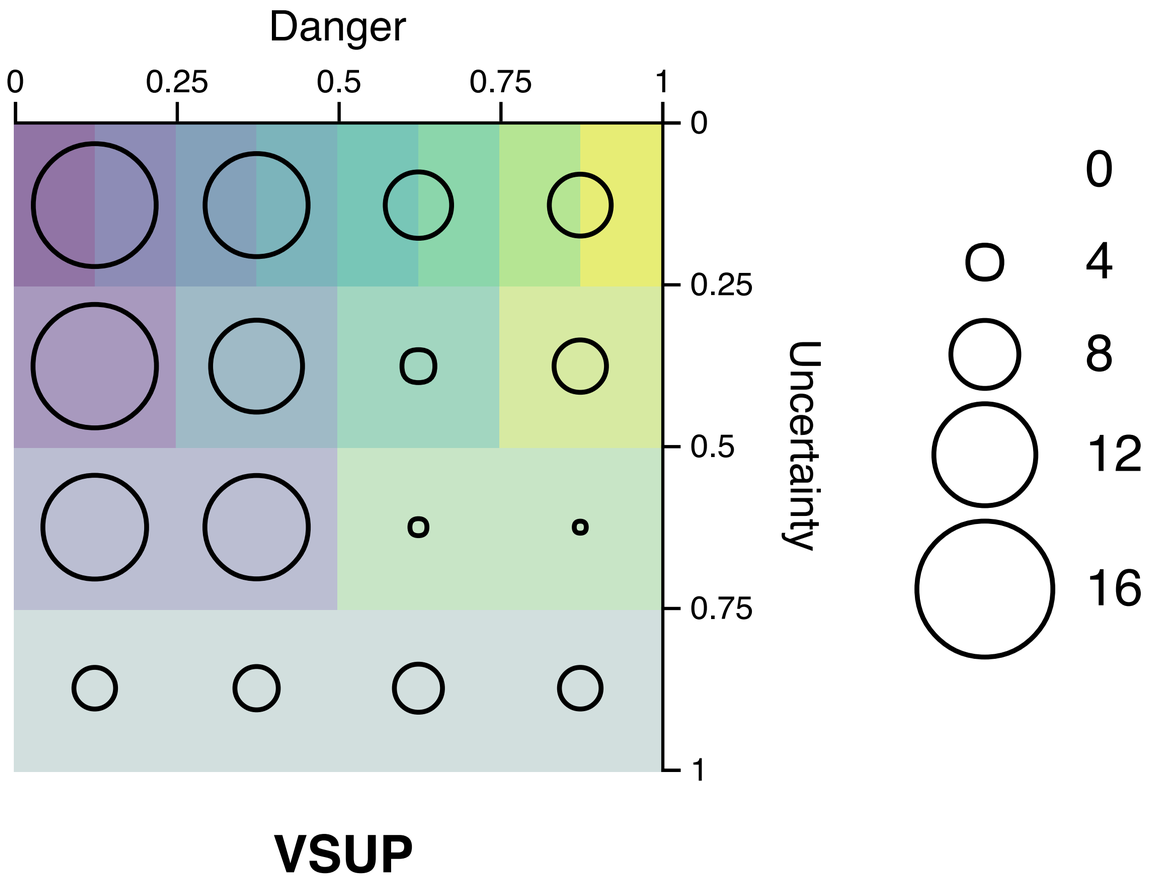


[Correll et al., 2018]

Prediction Results



Traditional Bivariate Map



VSUP

[Correll et al., 2018]

Results & Conclusions

- Legend shape has no significant effect
- Some indication that people avoid high uncertainty with VSUPs
- Tradeoff is that people do choose targets with higher danger when using a VSUP
- VSUPs present uncertainty information **simultaneously** (superimposed) instead of juxtaposed
- VSUPs encode value and uncertainty via **discrete, quantized bins** instead of continuously

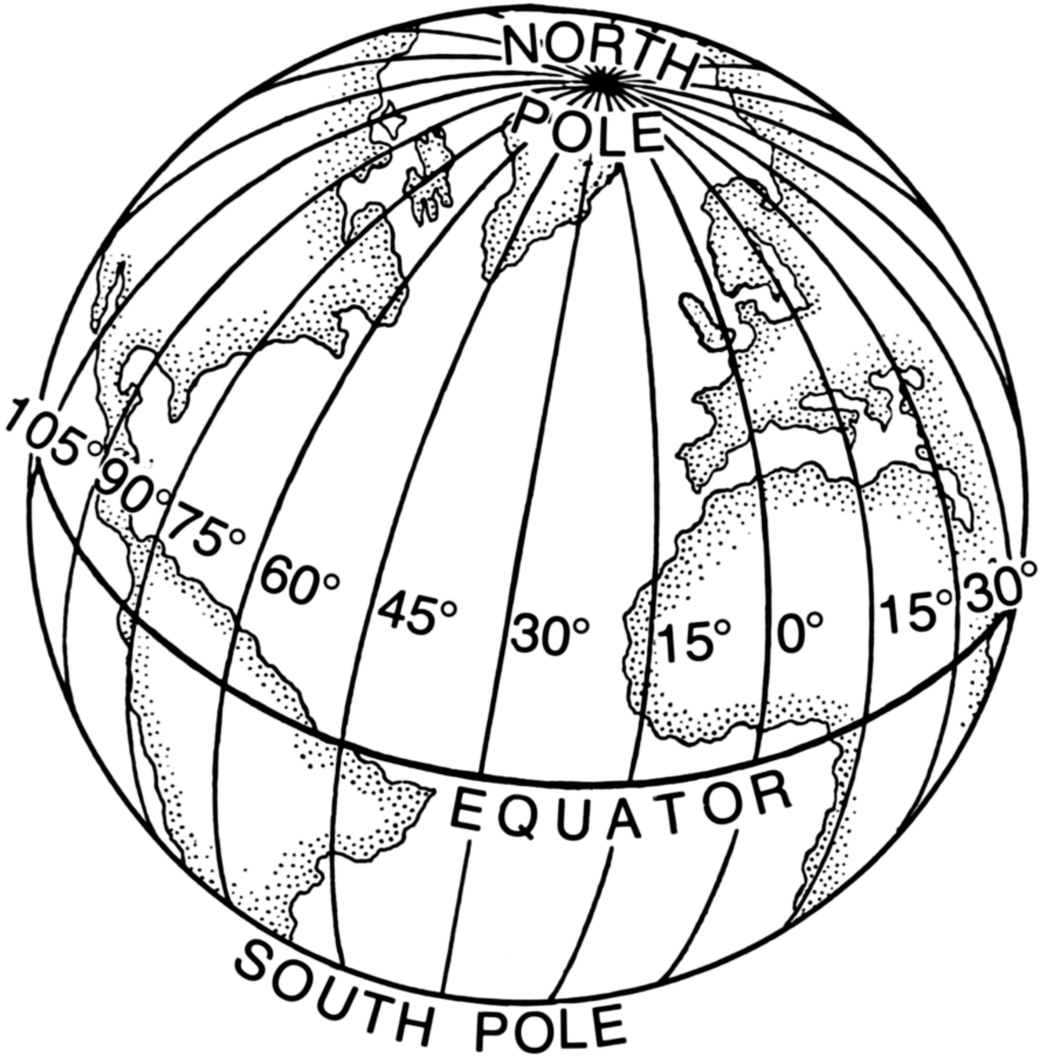
[Correll et al., 2018]

Geospatial Data

Geographic Data

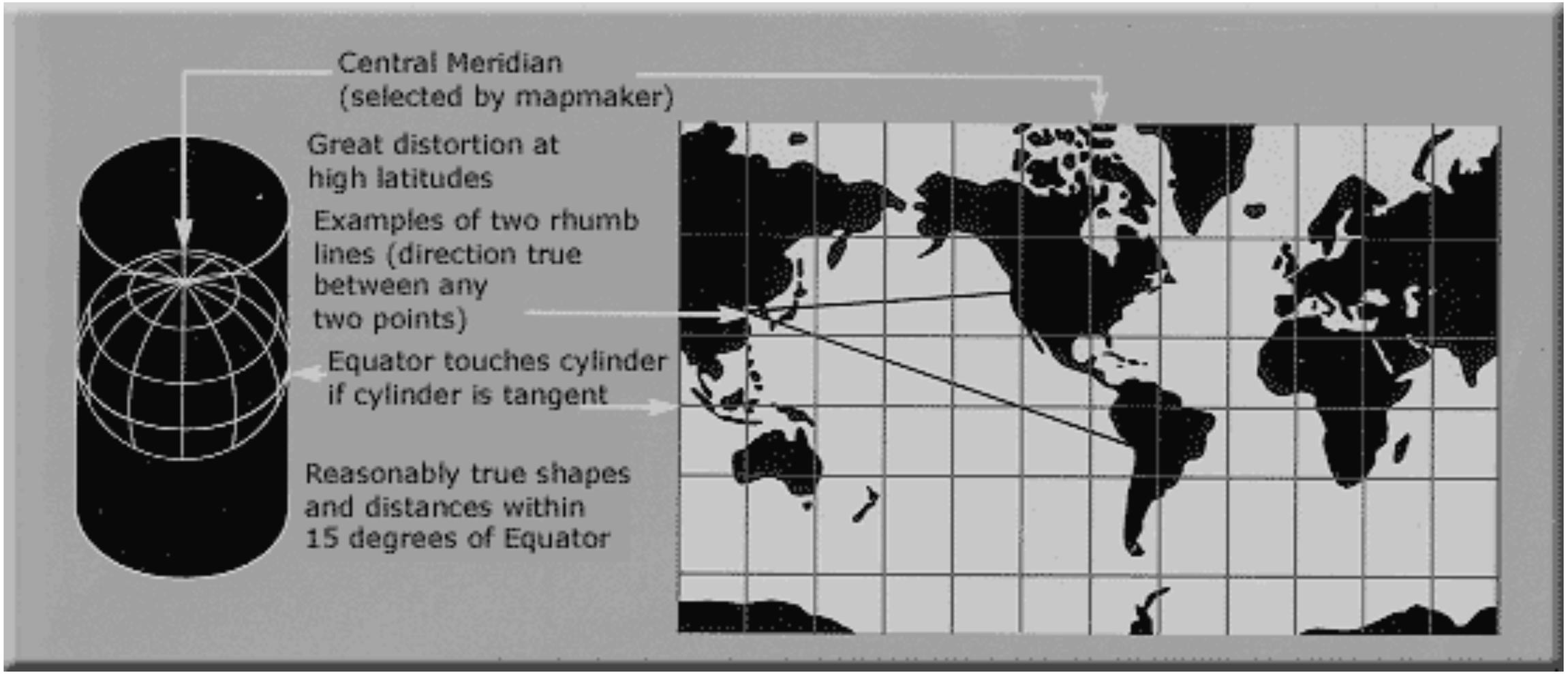
- Spatial data (have positions)
- Cartography: the science of drawing maps
  - Lots of history and well-established procedures
  - May also have non-spatial attributes associated with items
  - Thematic cartography: integrate these non-spatial attributes (e.g. population, life expectancy, etc.)
- Goals: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

Map Projection



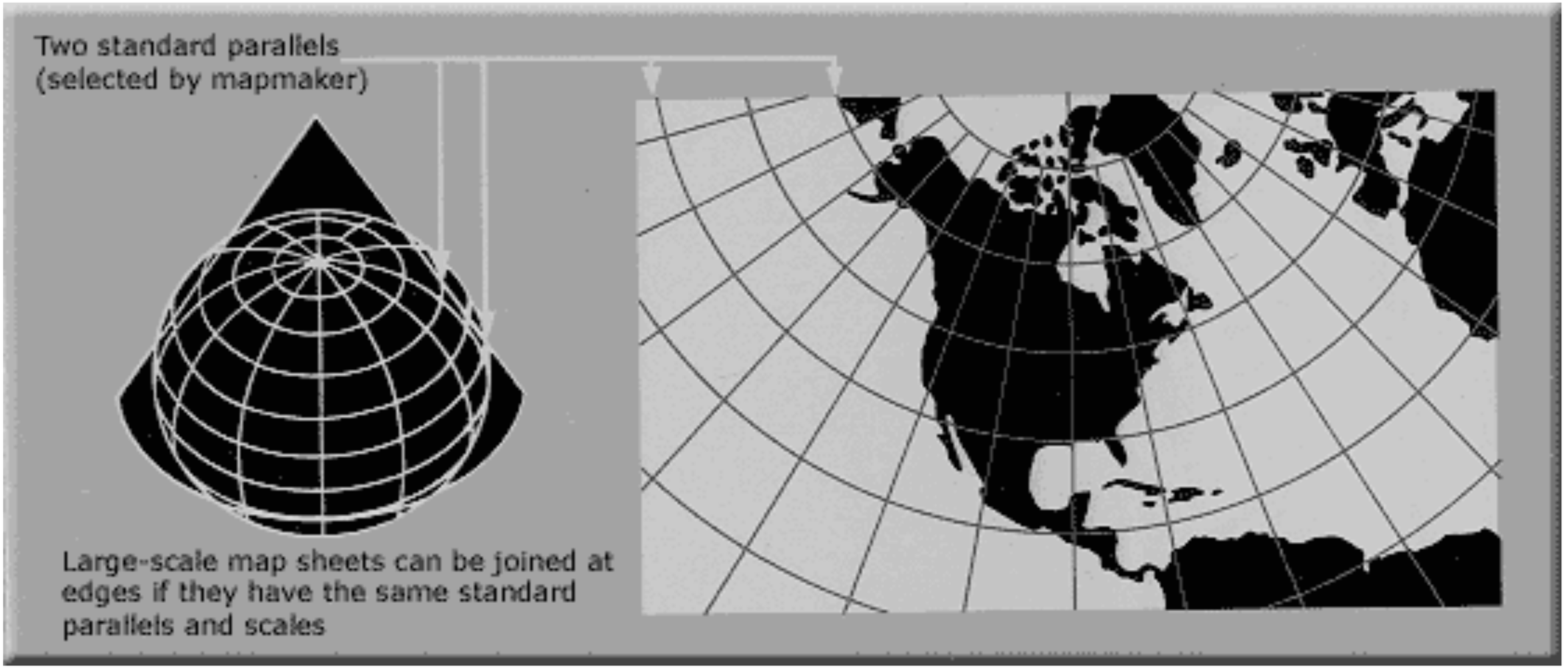
[P. Foresman, Wikimedia]

Flattening the Sphere?



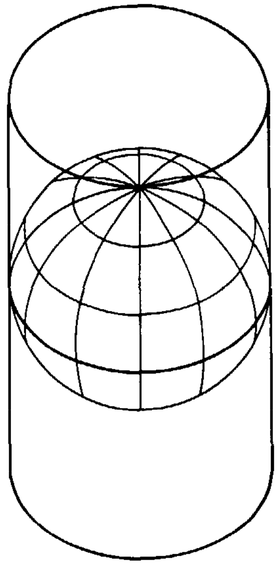
[USGS Map Projections]

Lambert Conformal Conic Projection

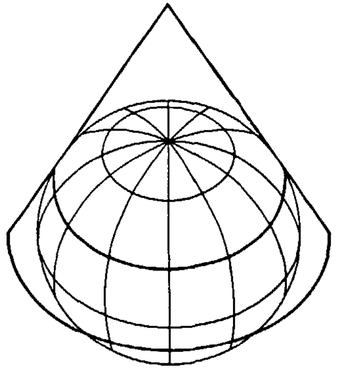


[USGS Map Projections]

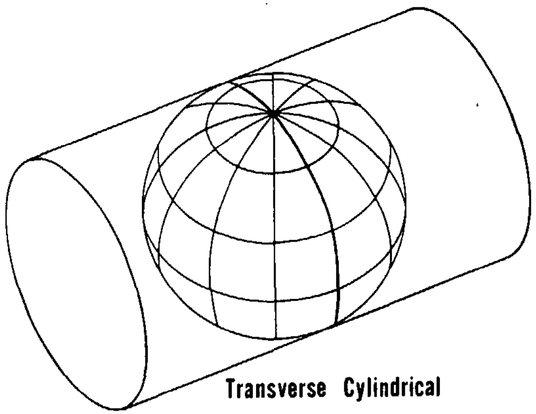
Standard Projections



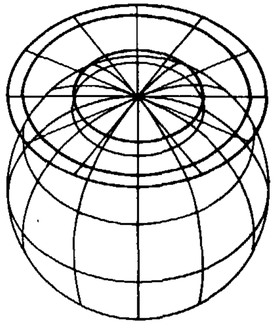
Regular Cylindrical



Regular Conic



Transverse Cylindrical



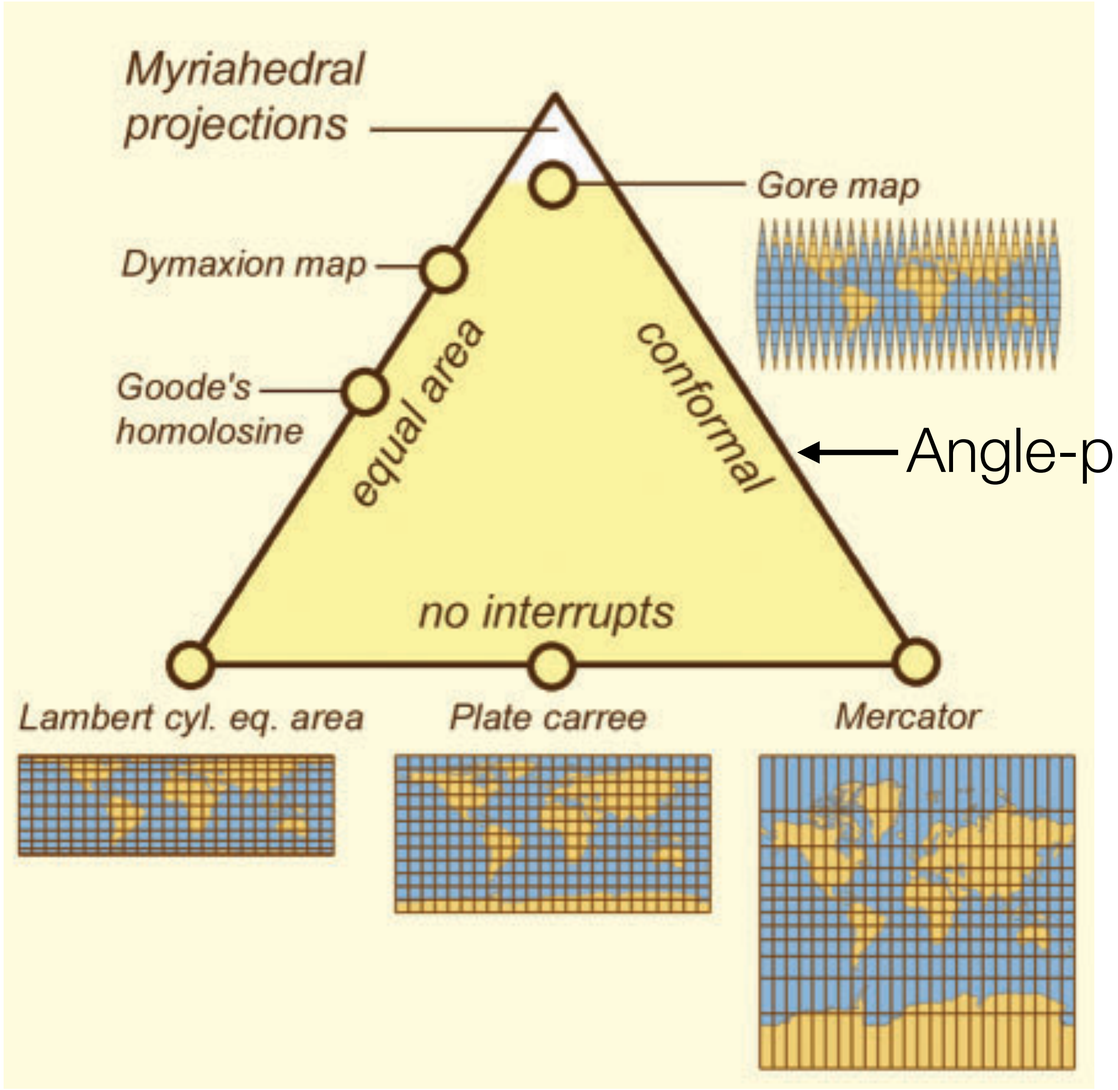
Polar Azimuthal (plane)

[J. P. Snyder, USGS]

Map Projections

[xkcd]

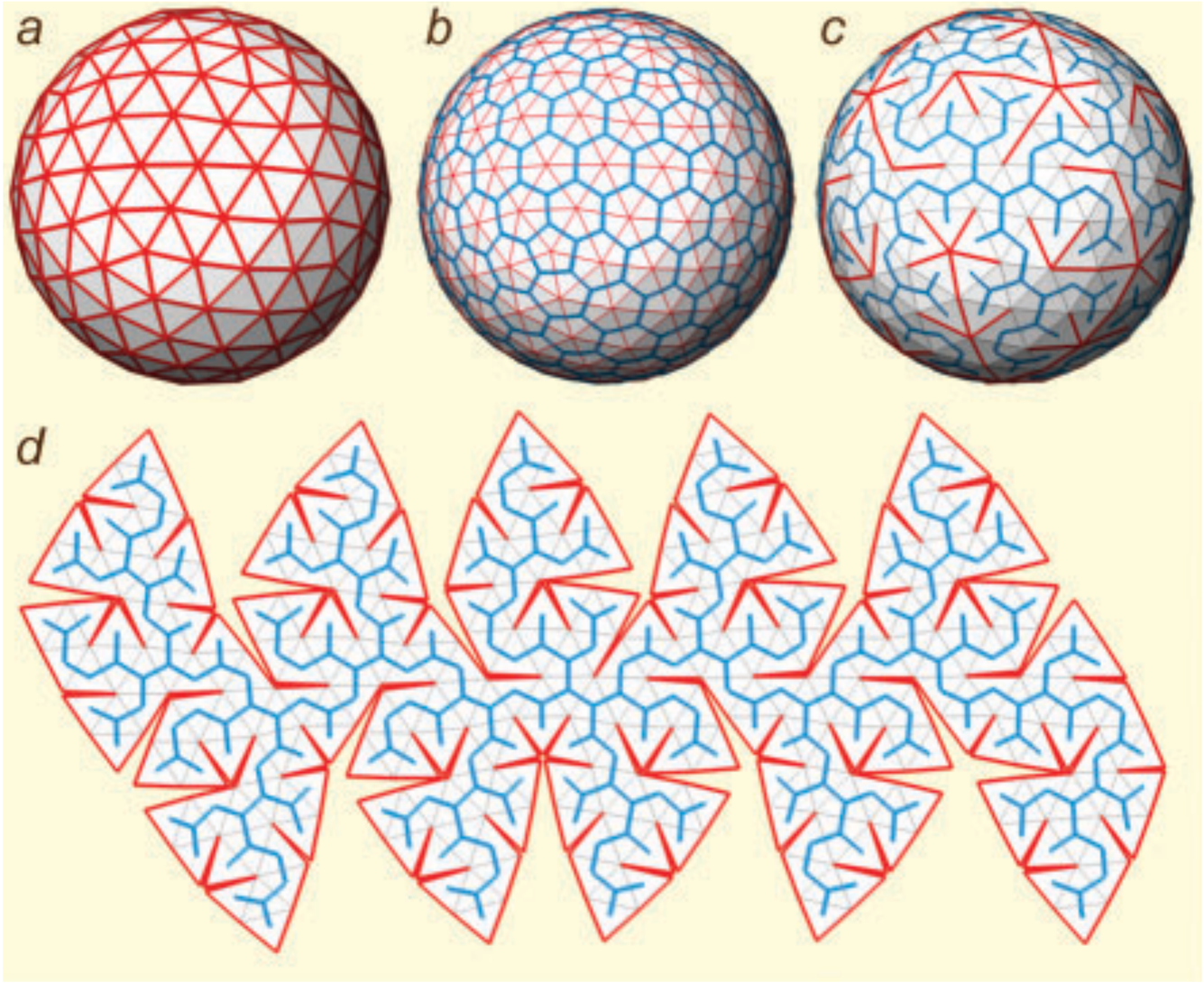
Projection Classification



← Angle-preserving

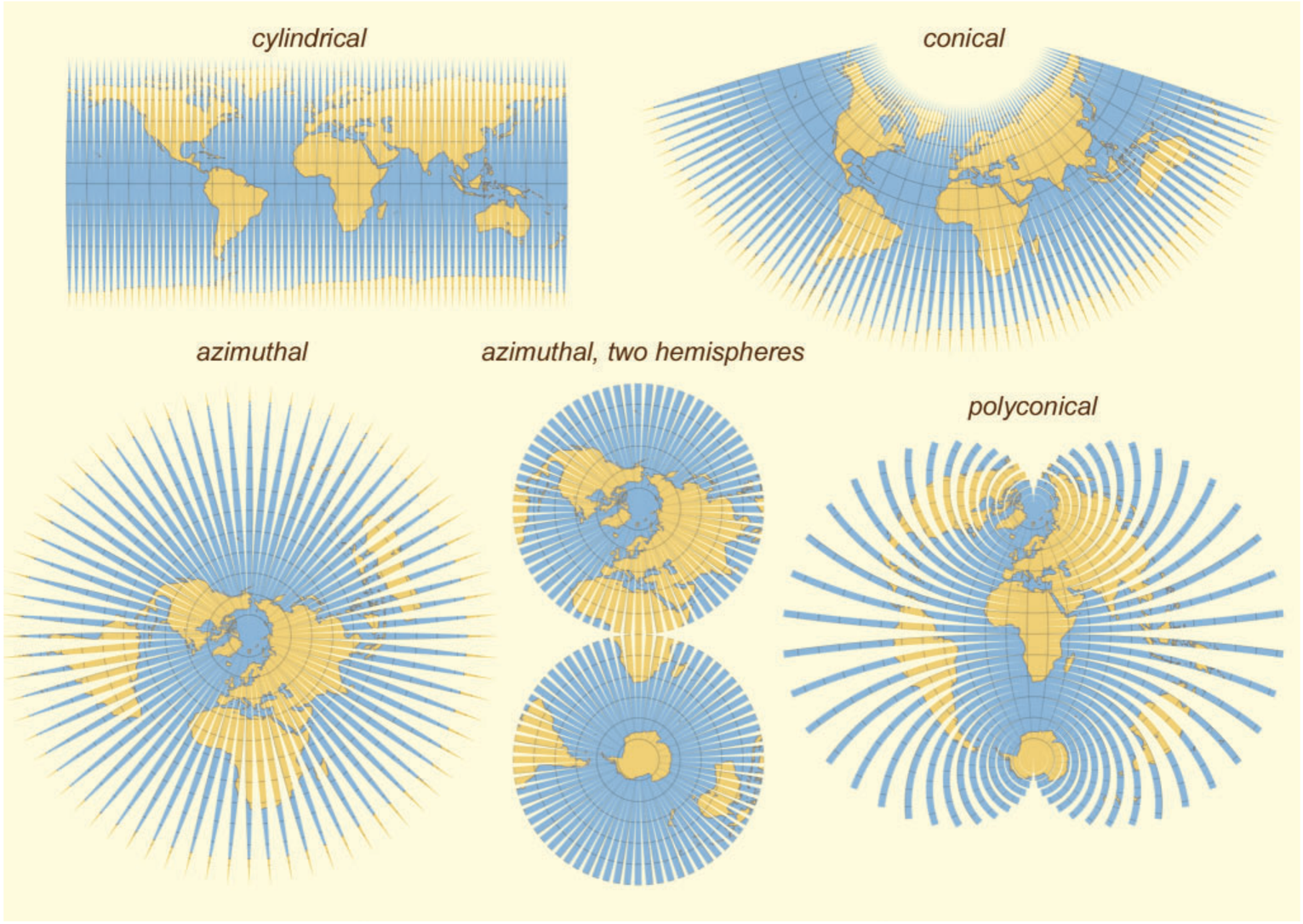
[J. van Wijk, 2008]

Myriahedral Projections



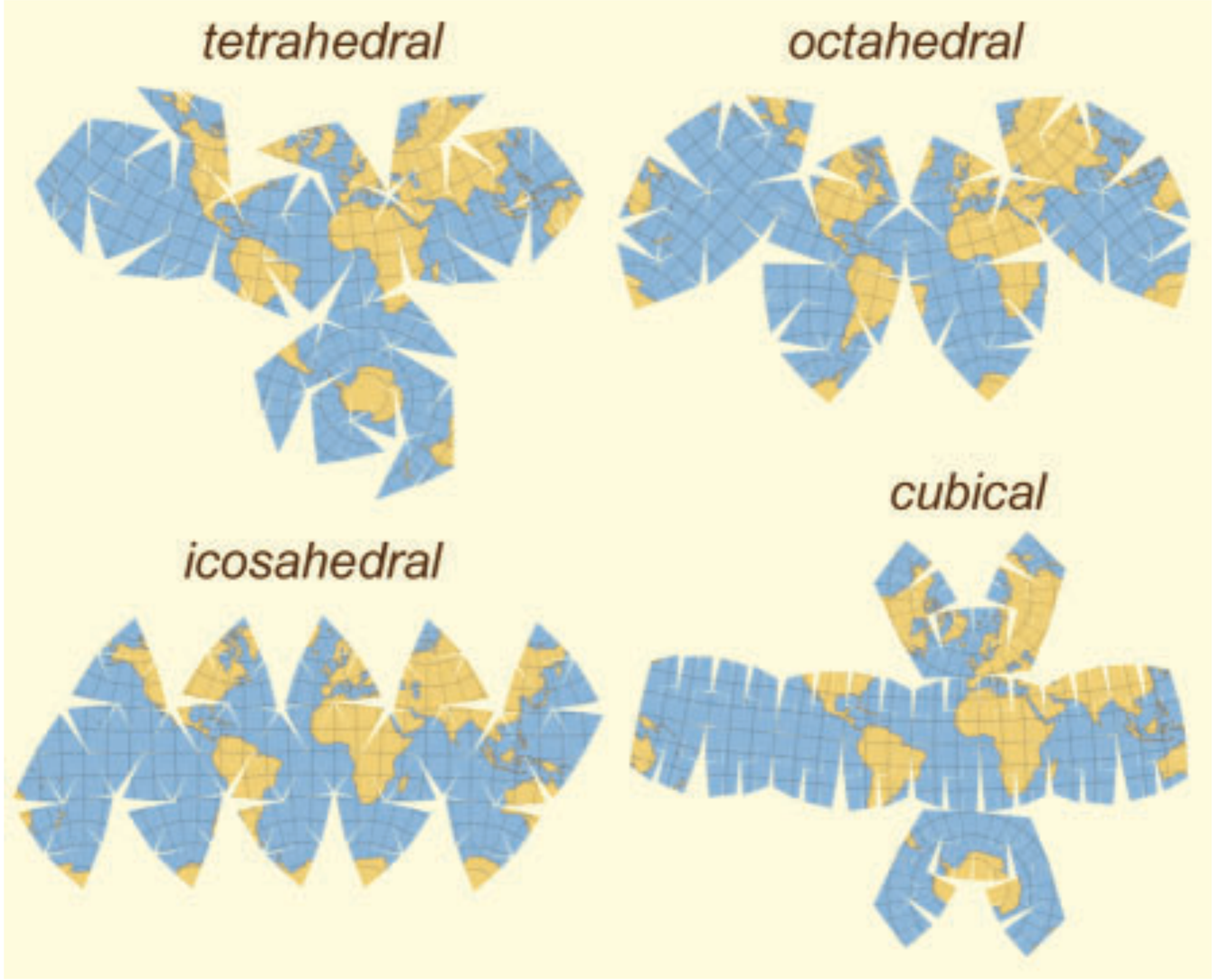
[J. van Wijk, 2008]

Cut along parallels or meridians (graticules)



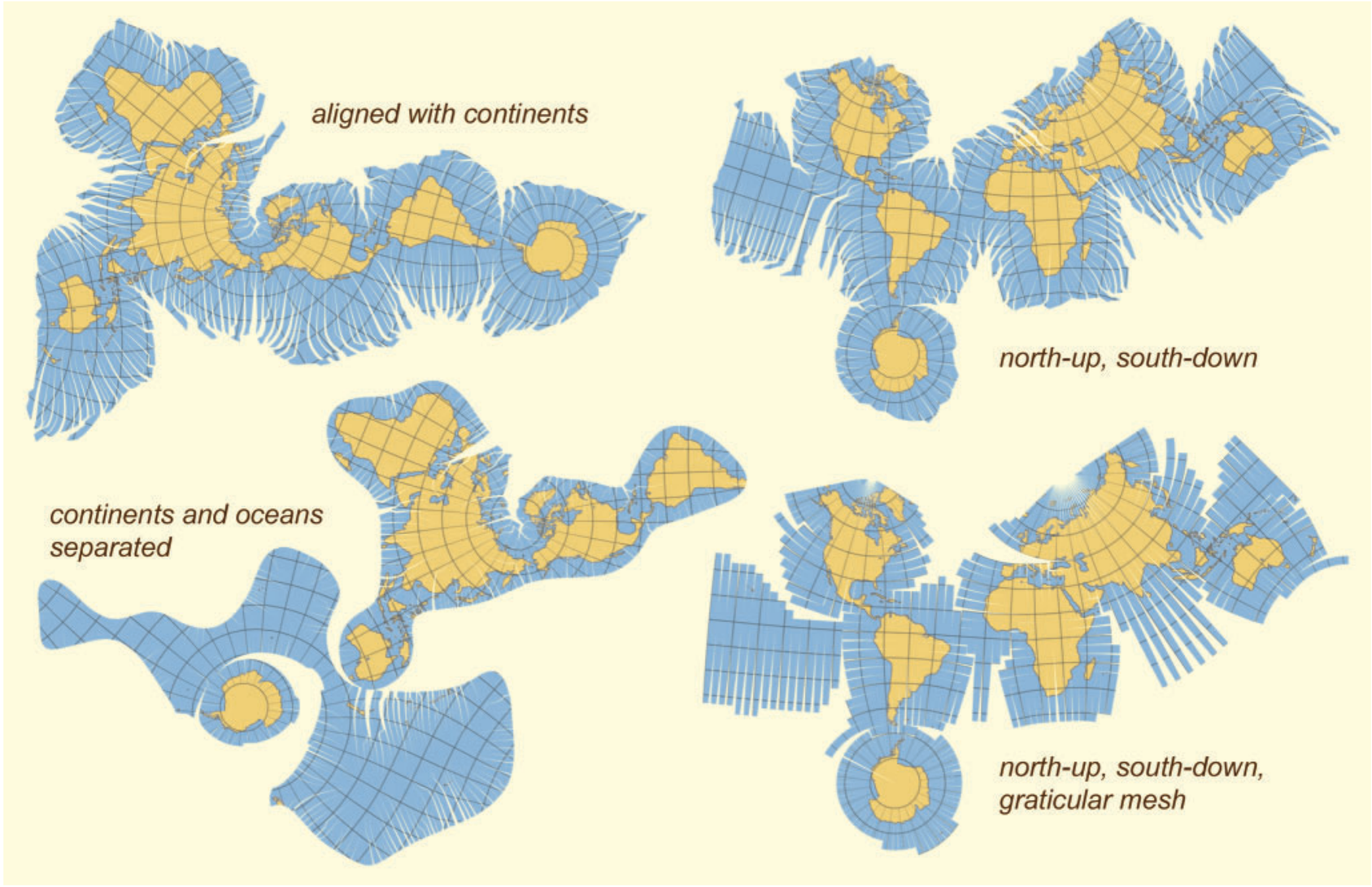
[J. van Wijk, 2008]

Subdividing regular polyhedra



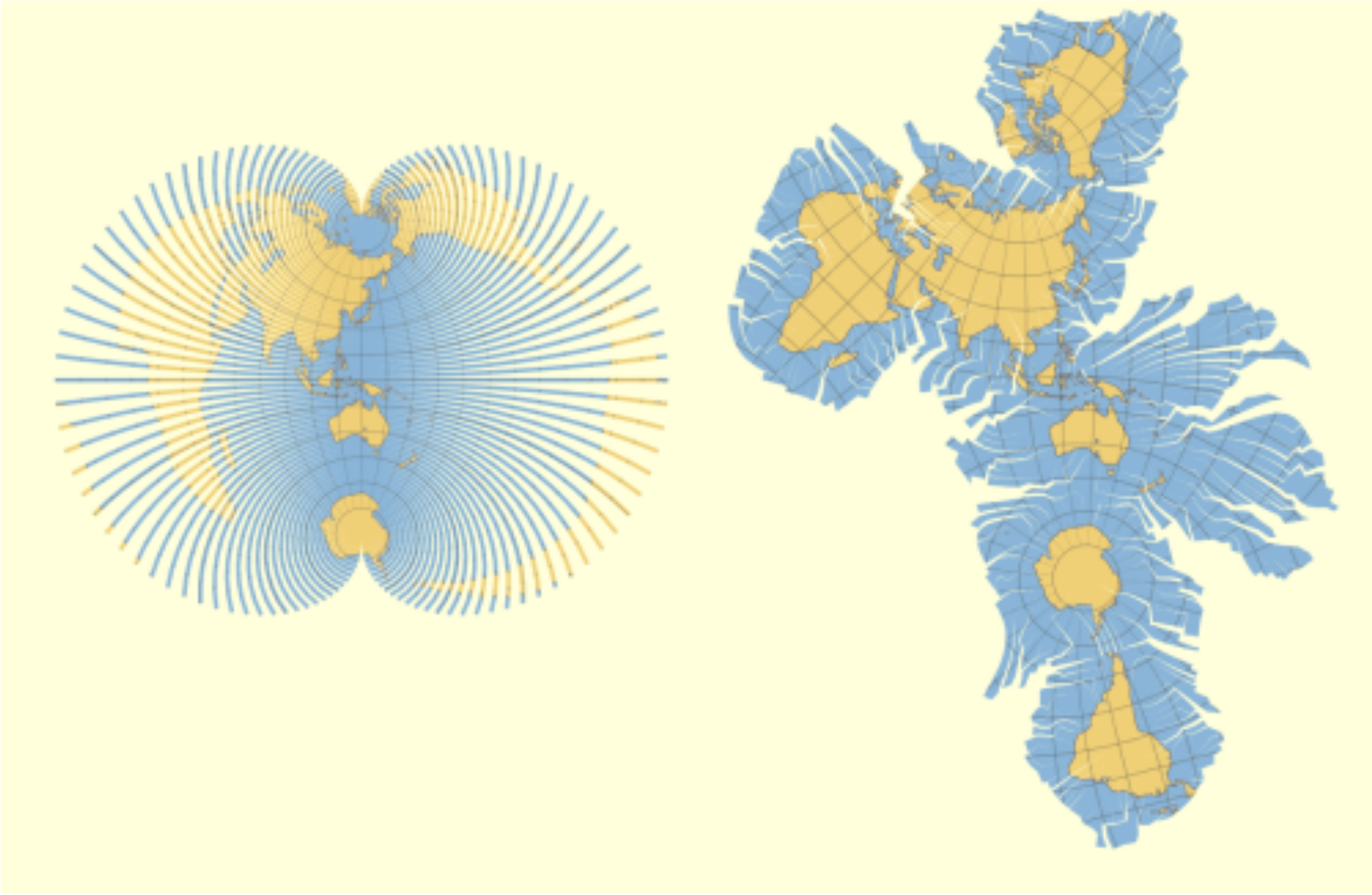
[J. van Wijk, 2008]

Geographically-aligned



[J. van Wijk, 2008]

Australia-centric



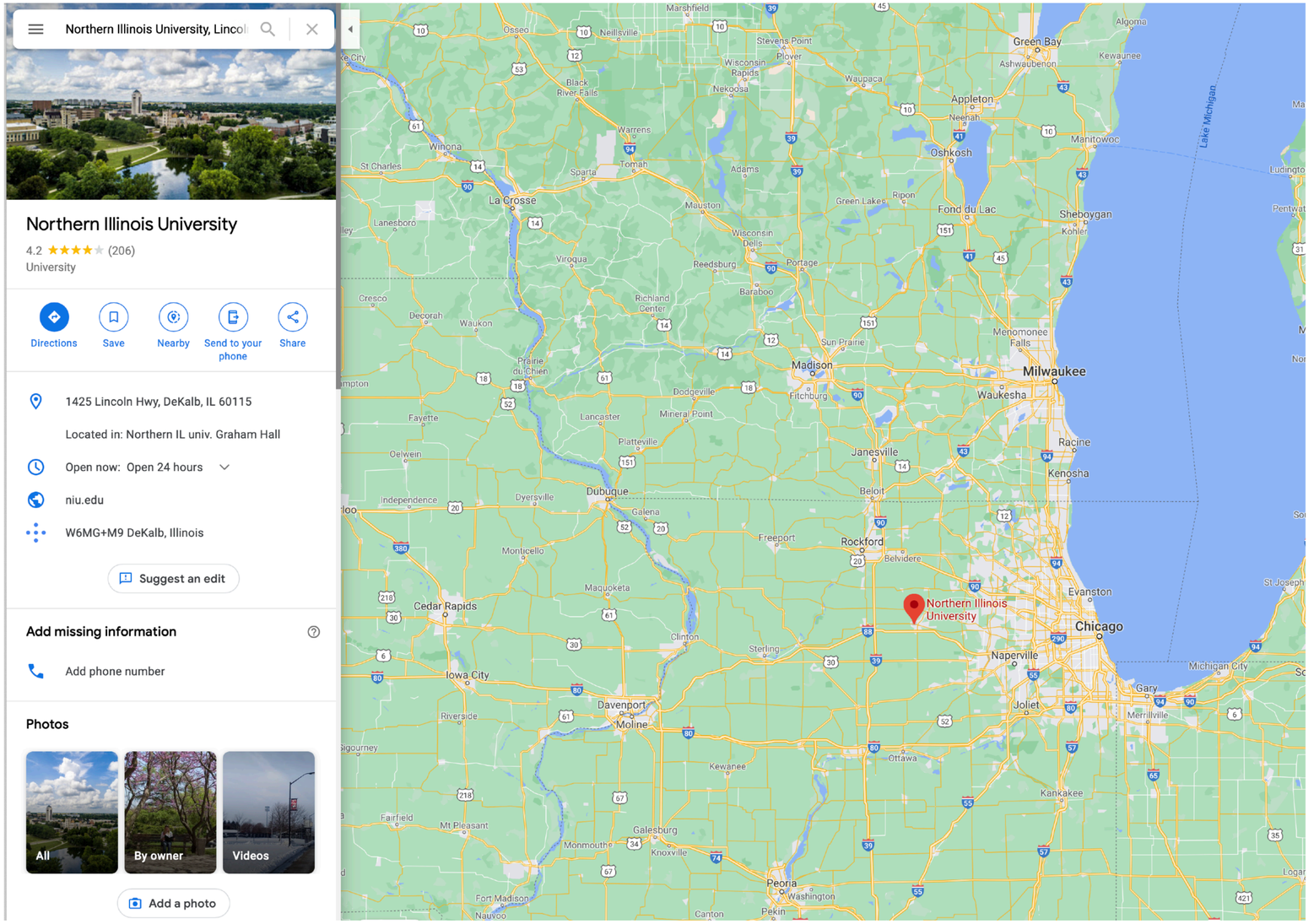
[J. van Wijk, 2008]

Search Tasks

	Target known	Target unknown
Location known	 *Lookup*	 *Browse*
Location unknown	 *Locate*	 *Explore*

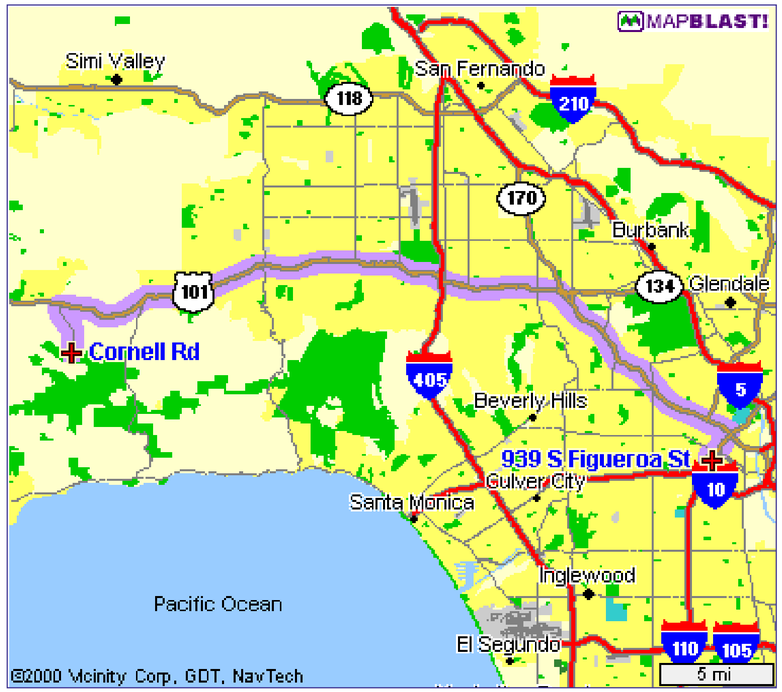
[Munzner (ill. Maguire), 2014]

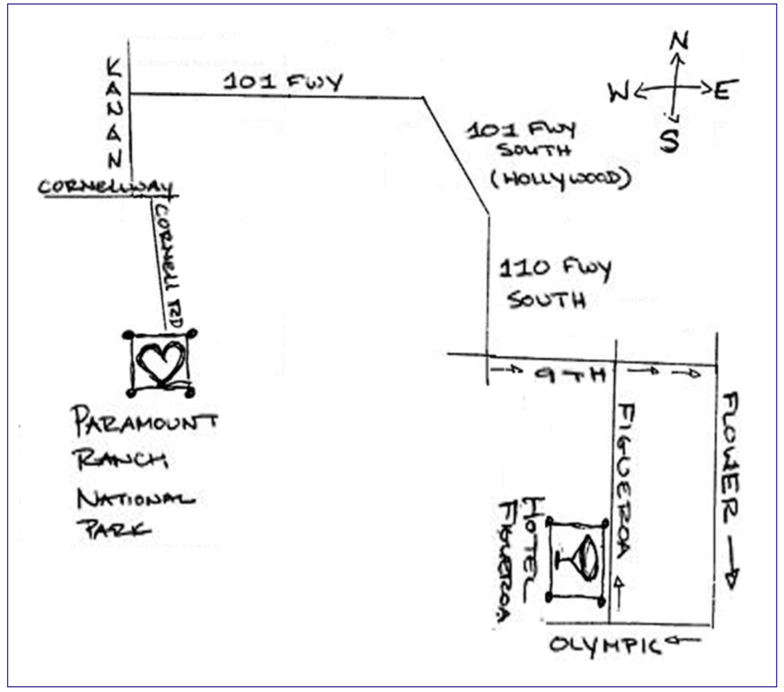
Lookup

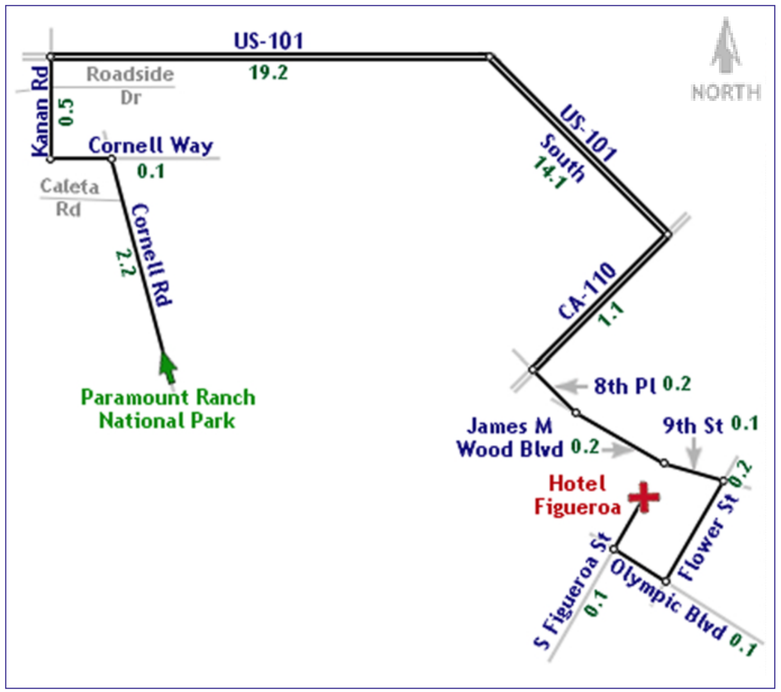


[Google Maps]

Route Maps

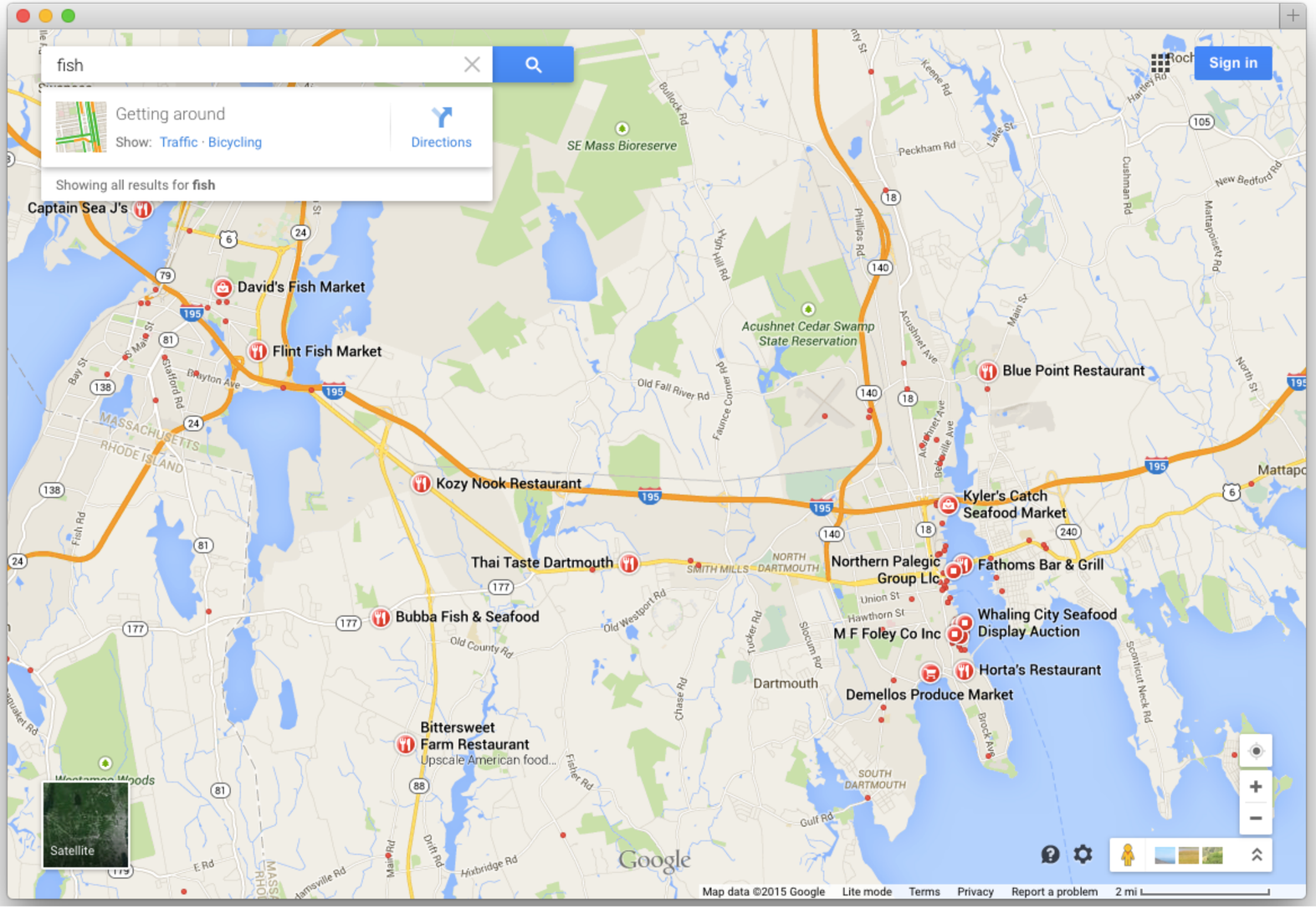






[Agrawala & Stolte, 2001]

Locate


fish
Sign in
Getting around
Show: Traffic · Bicycling
Directions
Showing all results for fish
Captain Sea J's
David's Fish Market
Flint Fish Market
Kozy Nook Restaurant
Thai Taste Dartmouth
Bubba Fish & Seafood
Bittersweet
Farm Restaurant
Upscale American food...
SE Mass Bioreserve
Acushnet Cedar Swamp
State Reservation
Blue Point Restaurant
Kyler's Catch
Seafood Market
Northern Palegic
Group Llc
Fathoms Bar & Grill
Whaling City Seafood
Display Auction
M F Foley Co Inc
Horta's Restaurant
Demellos Produce Market
Dartmouth
NORTH DARTMOUTH
SMITH MILLS
SOUTH DARTMOUTH
MASSACHUSETTS
RHODE ISLAND
Satellite
Google
Map data ©2015 Google
Lite mode
Terms
Privacy
Report a problem
2 mi

Adding Data

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

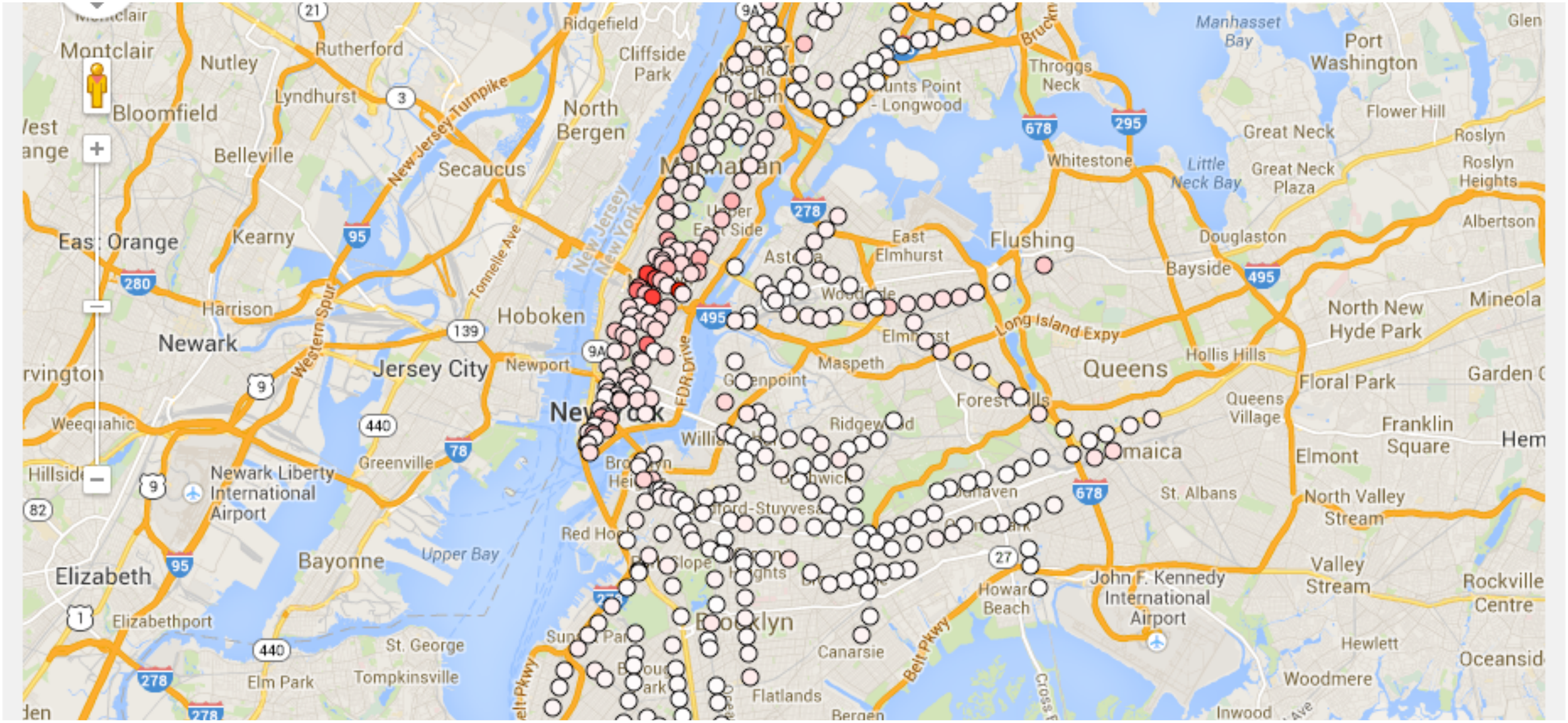
Discrete Categorical Attribute: Shape

[Acadia NP, National Park Service]

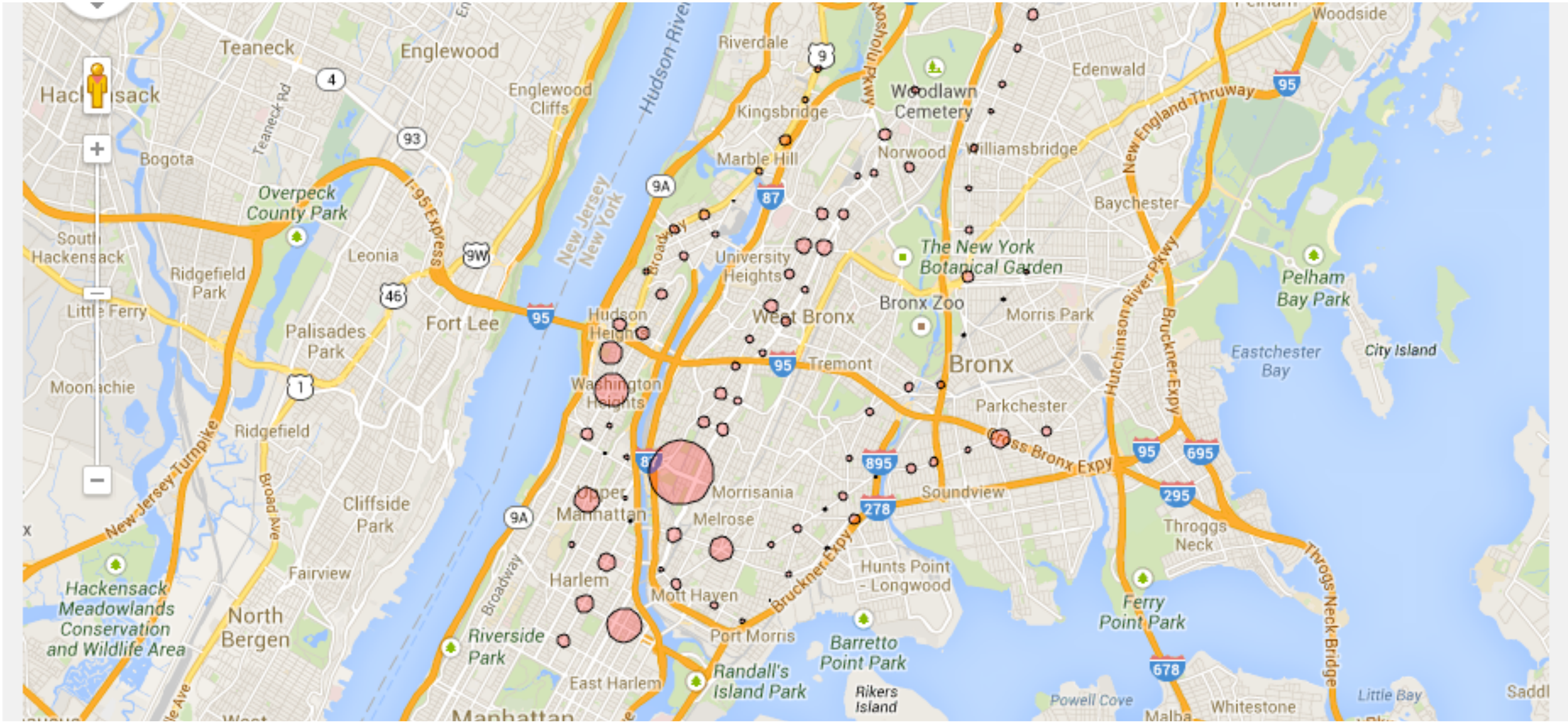
Discrete Categorical Attribute: Shape

[Acadia NP, National Park Service]

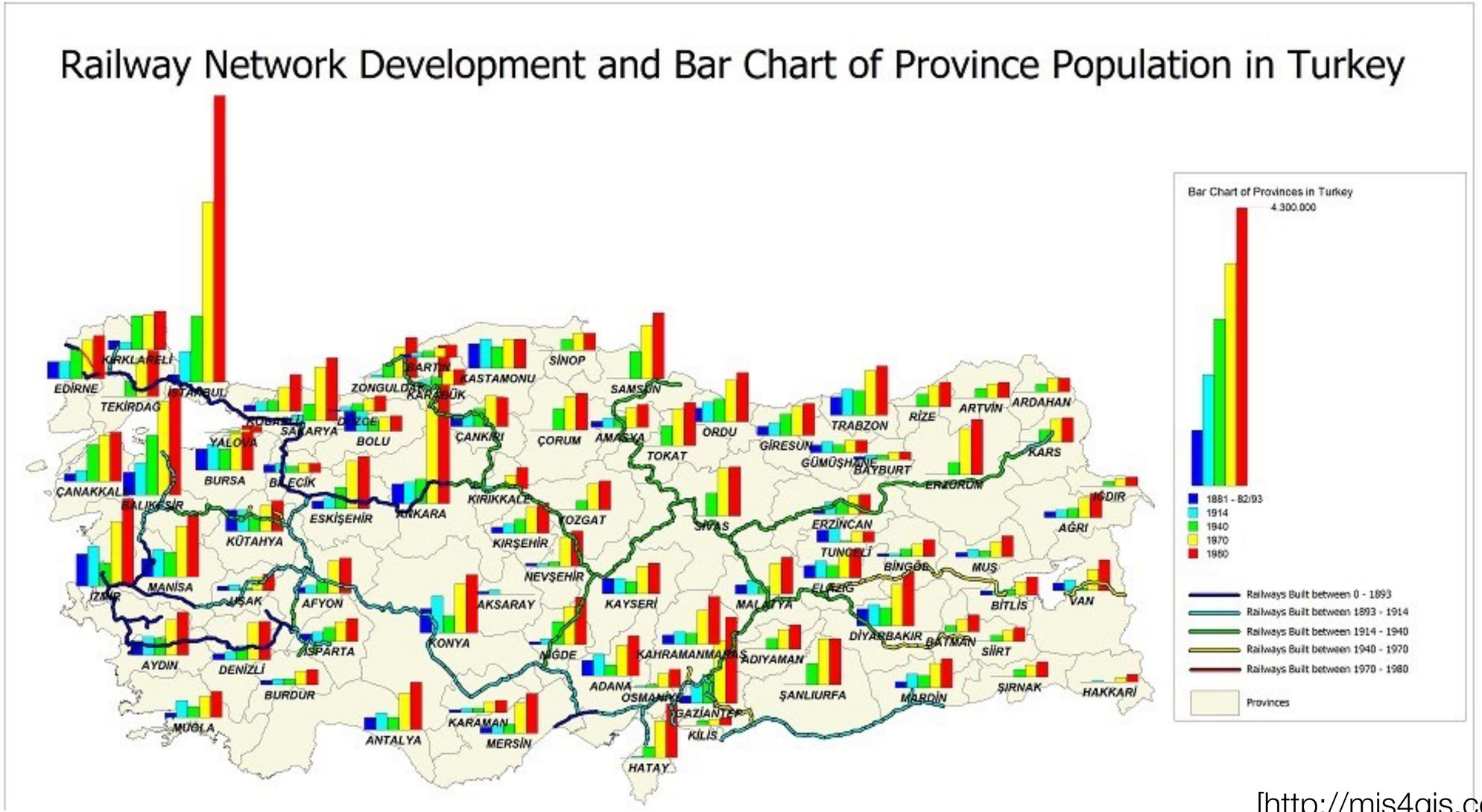
Discrete Quantitative Attribute: Color Saturation



Discrete Quantitative Attribute: Size

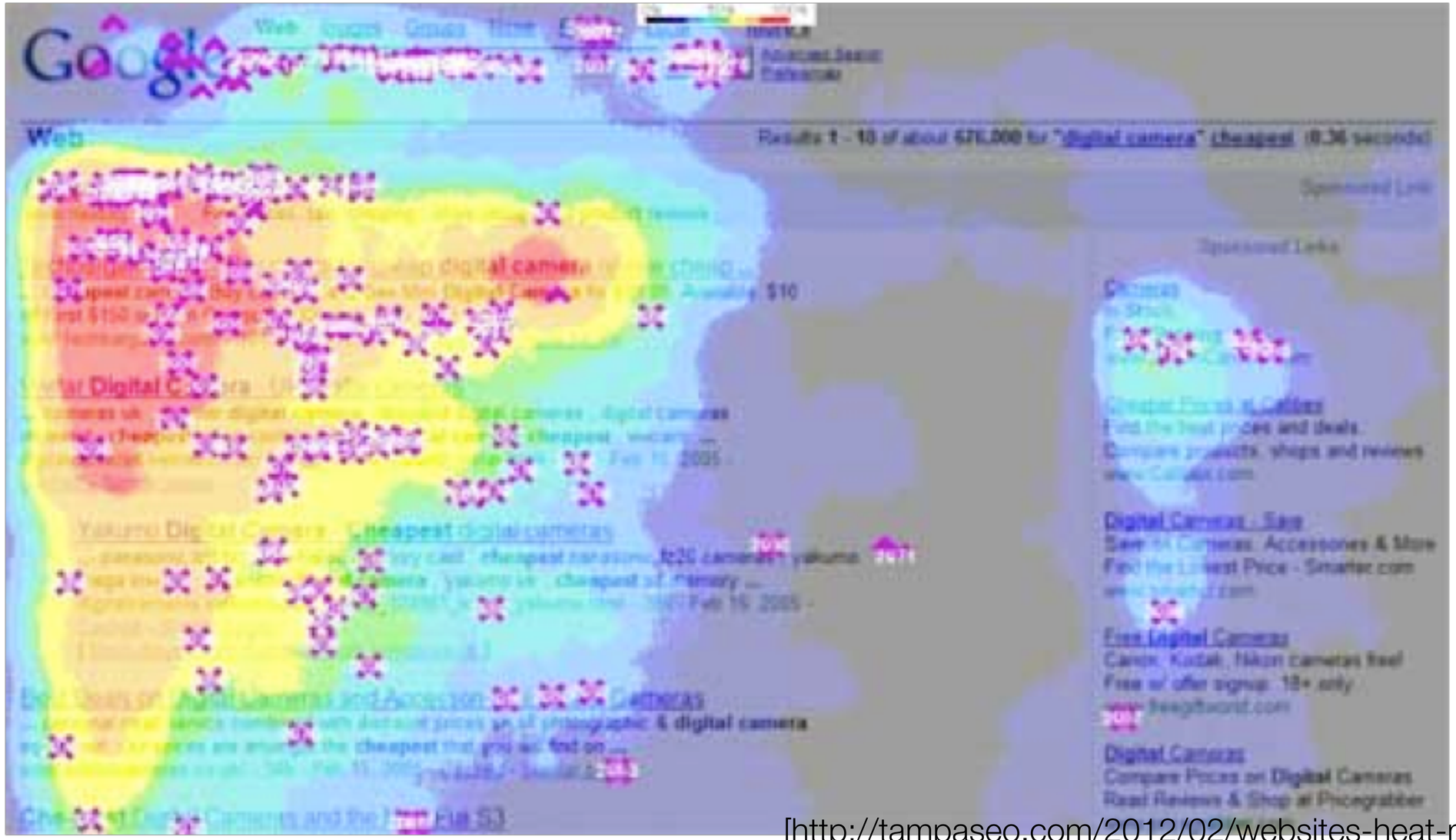


Discrete Quantitative Attributes: Bar Chart



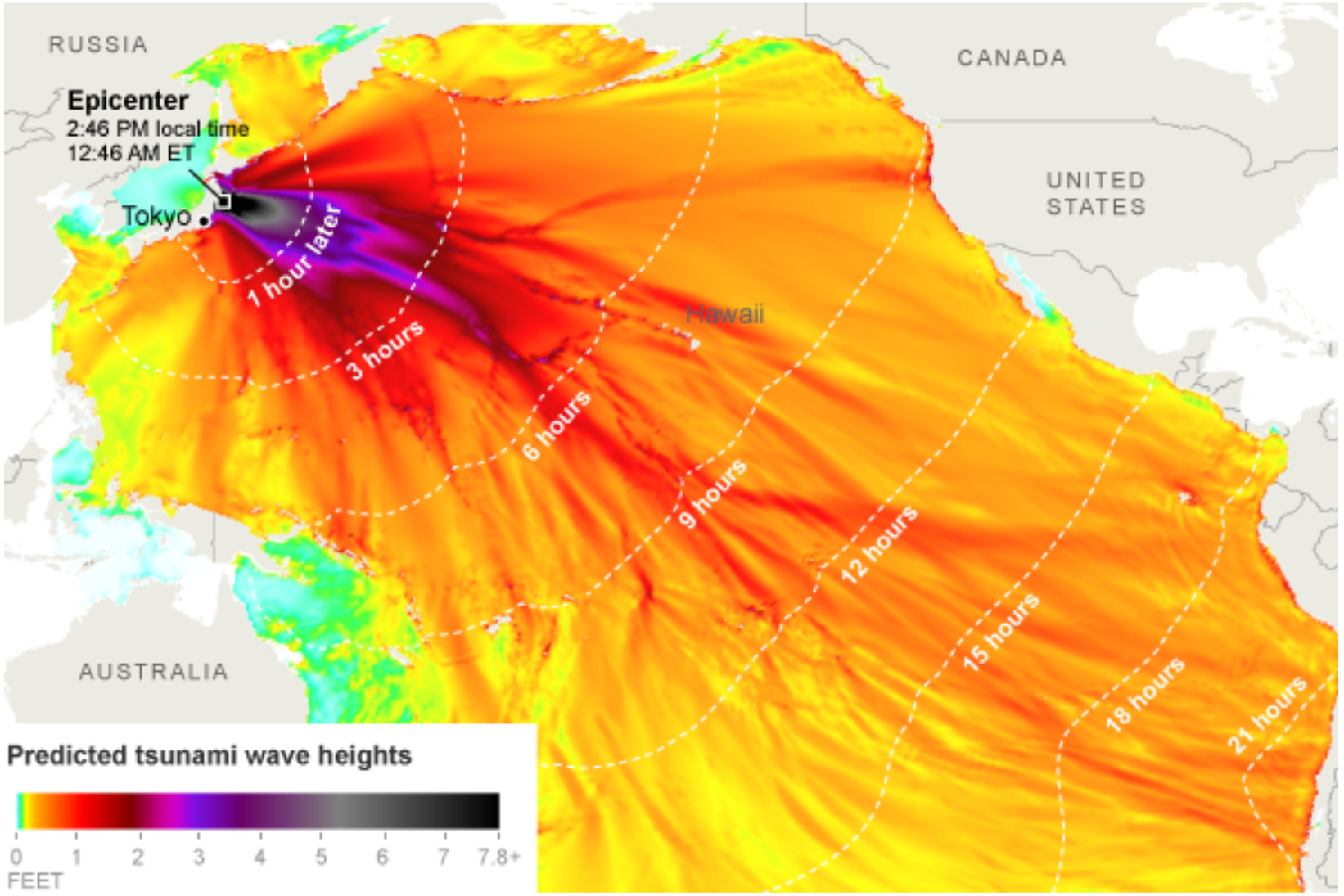
[http://mis4gis.com/hgistr.org/]

Continuous Quantitative Attribute: Color Hue



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

Time as the attribute



[NYTimes]

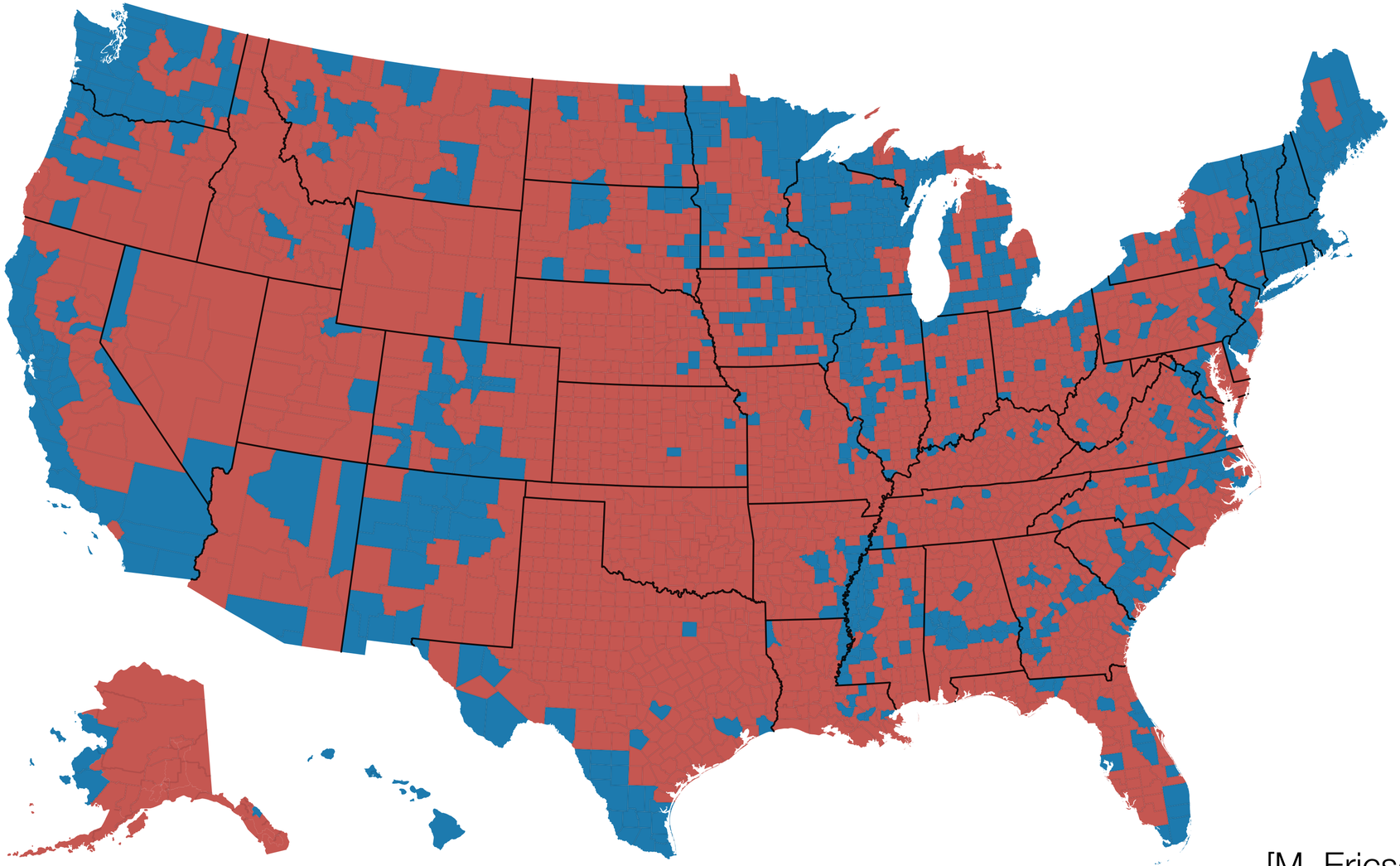
Isolines

[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)