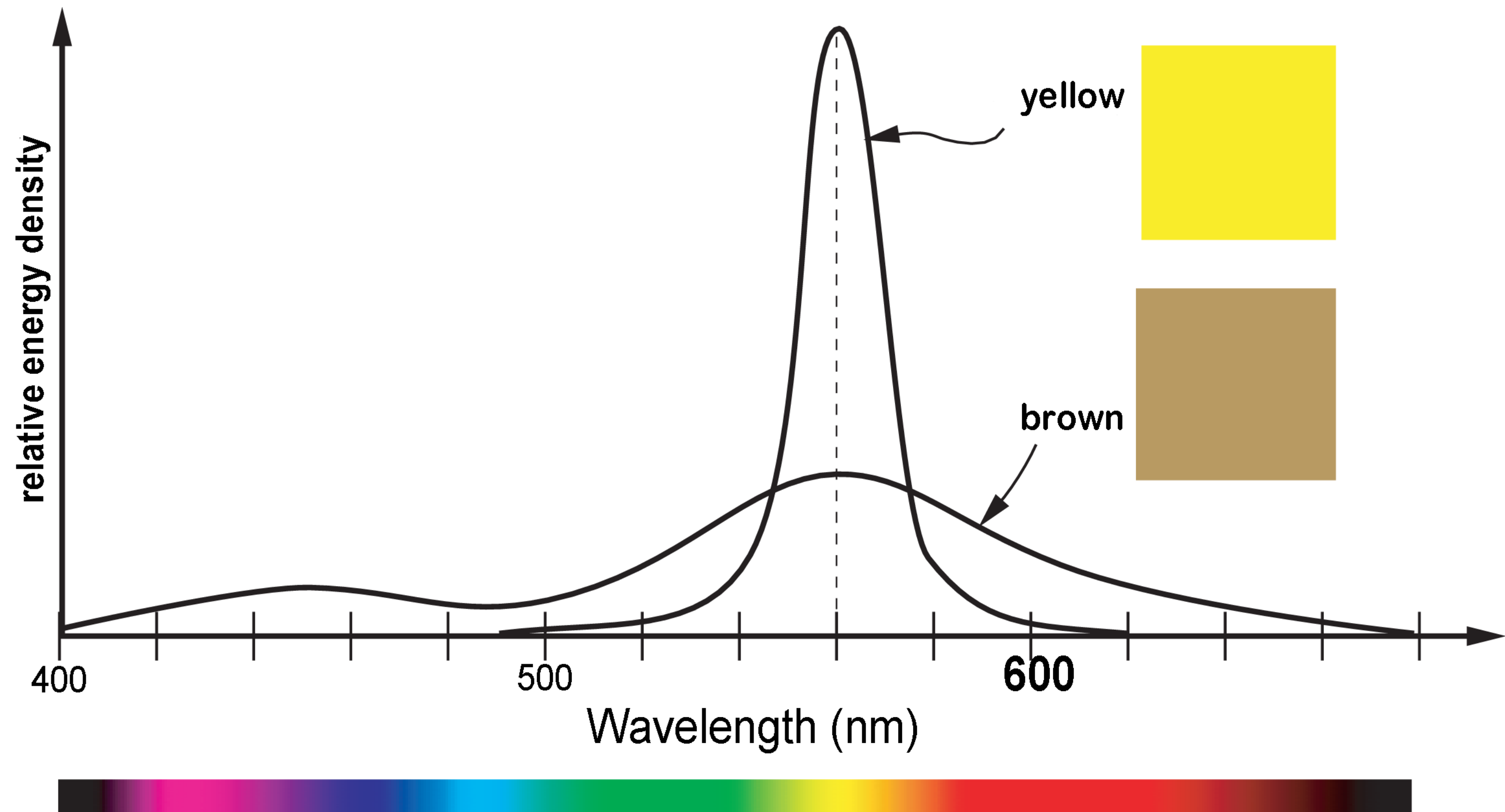


Data Visualization (CSCI 627/490)

Geospatial Data

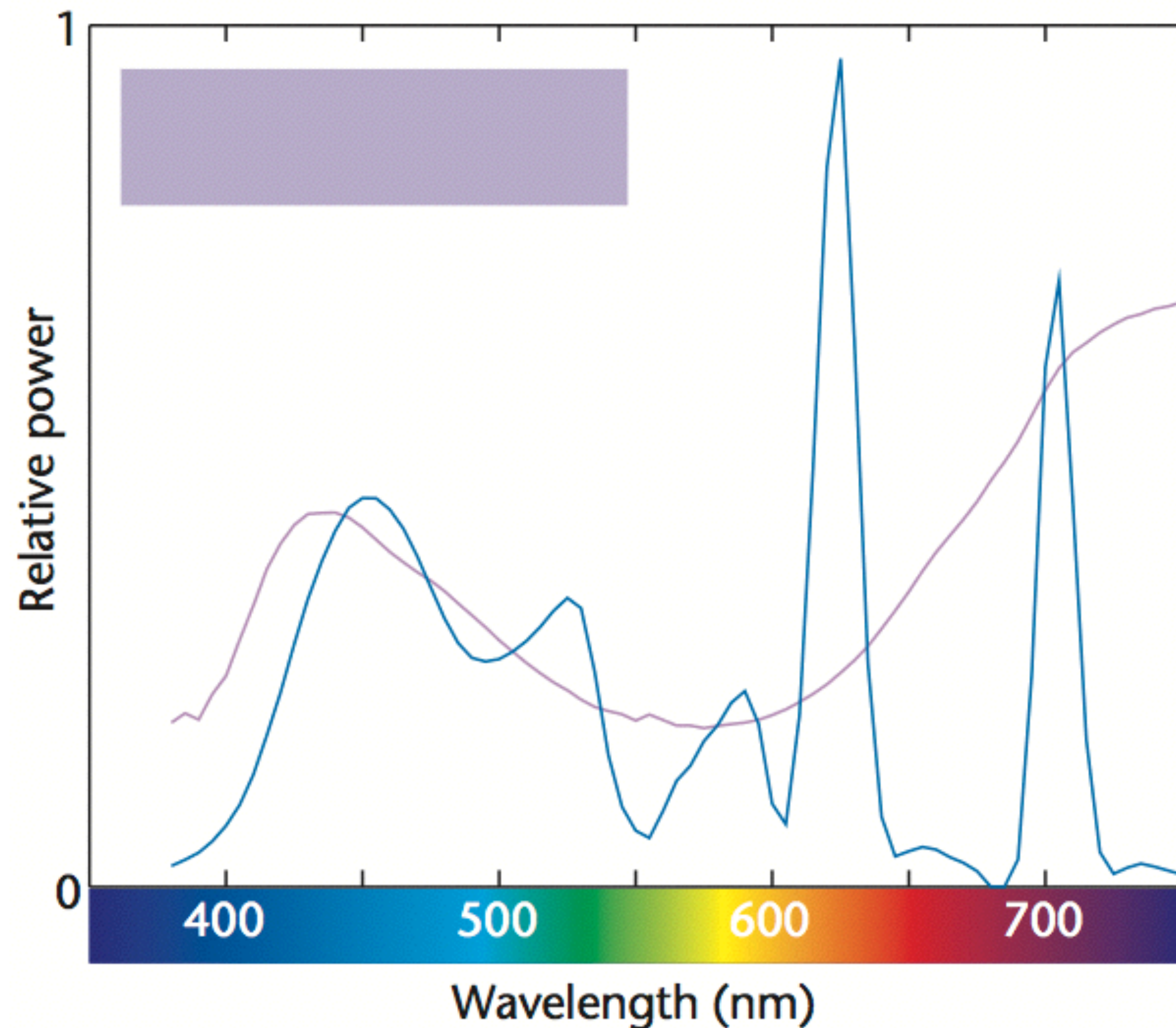
Dr. David Koop

Color != Wavelength



[via M. Meyer]

Rods, Cones, and Metamerism

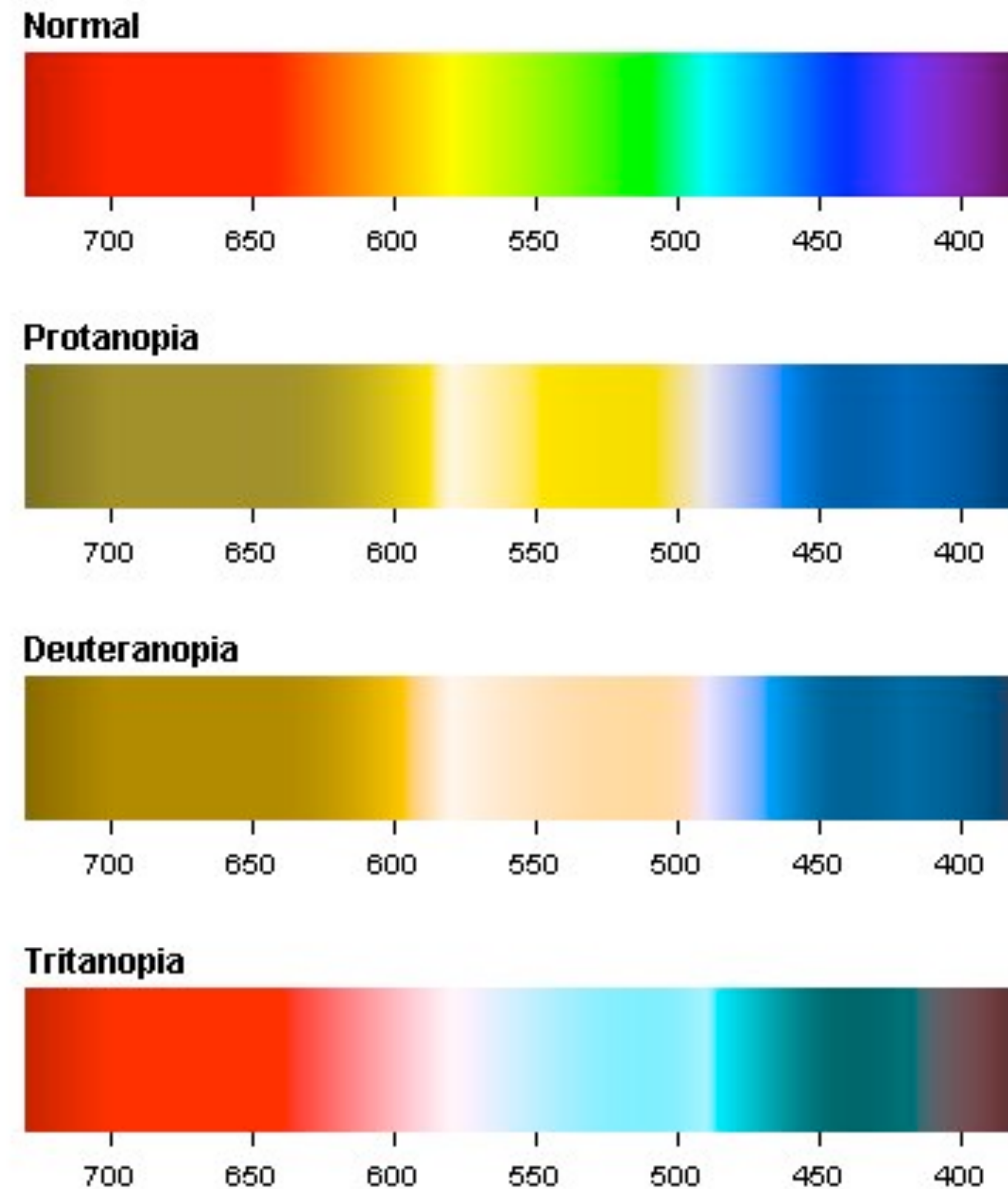


- Humans are not spectrometers, have rods and cones
- Do not get the whole function
- Three cones $\rightarrow$ numbers $\sim$ color
- Different spectra can be same color (metamerism)



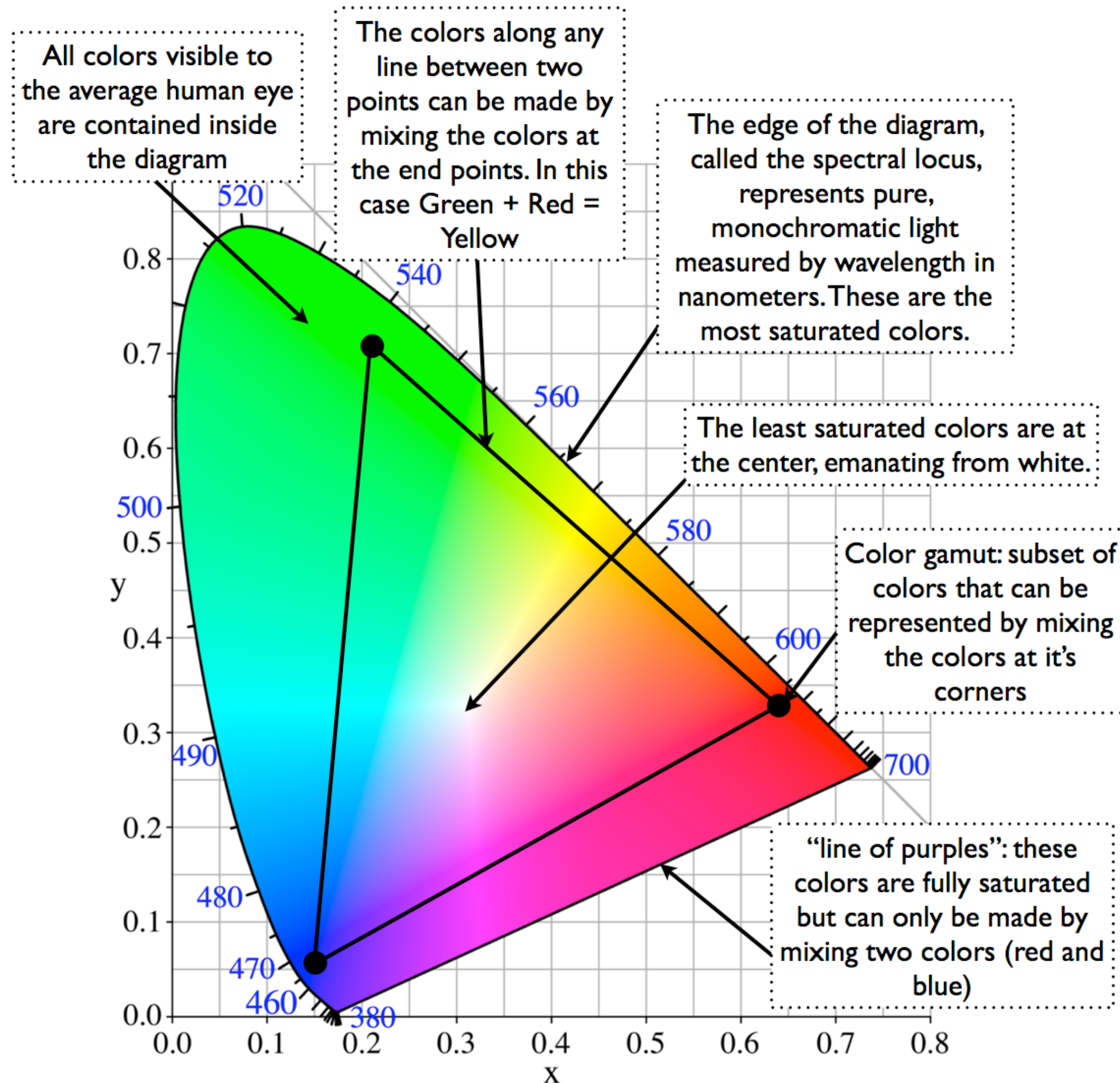
[via M. Meyer]

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]

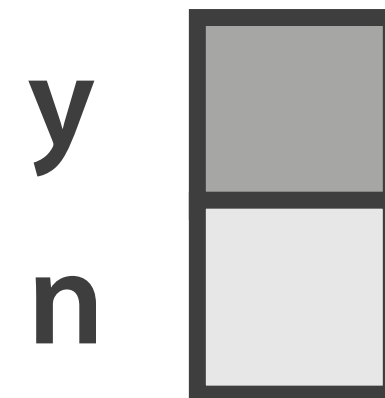
What does this mean for visualization?

- 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

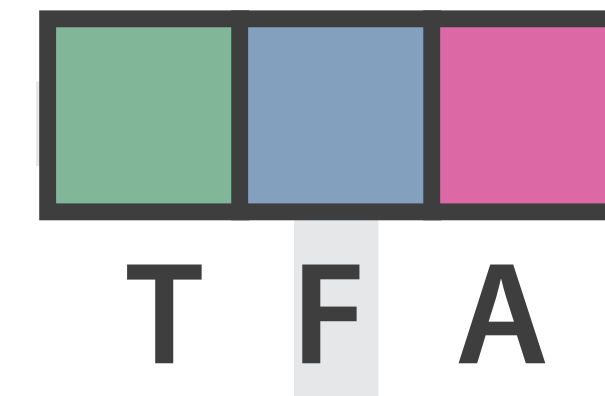
Colormap

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

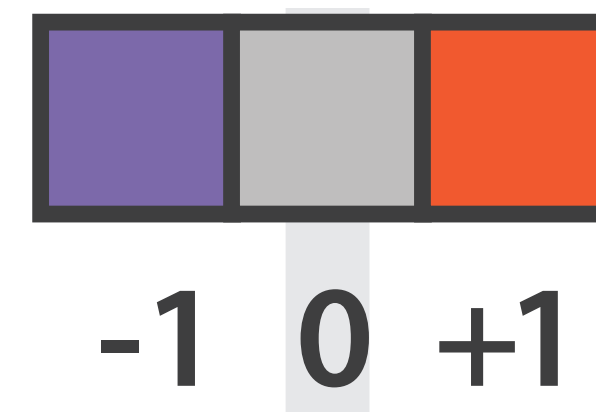
Binary



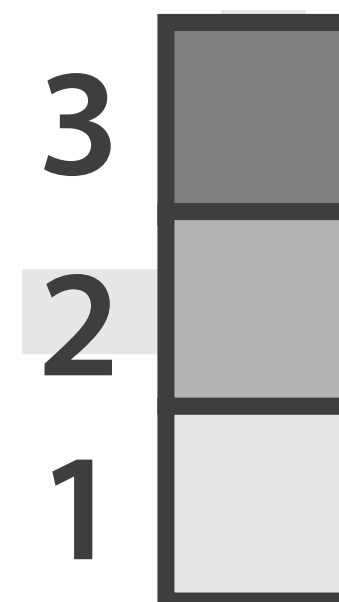
Categorical



Diverging

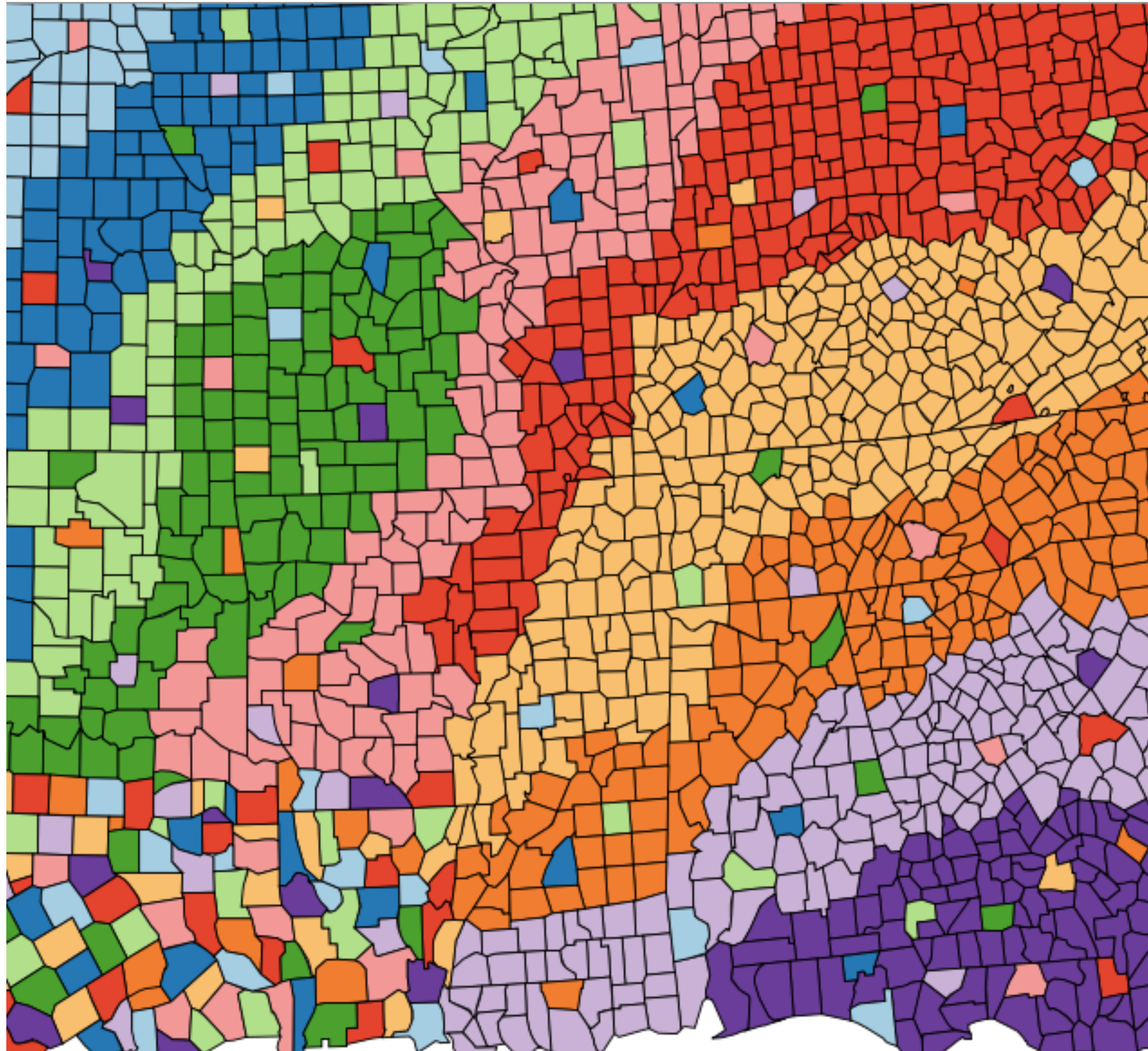


Sequential



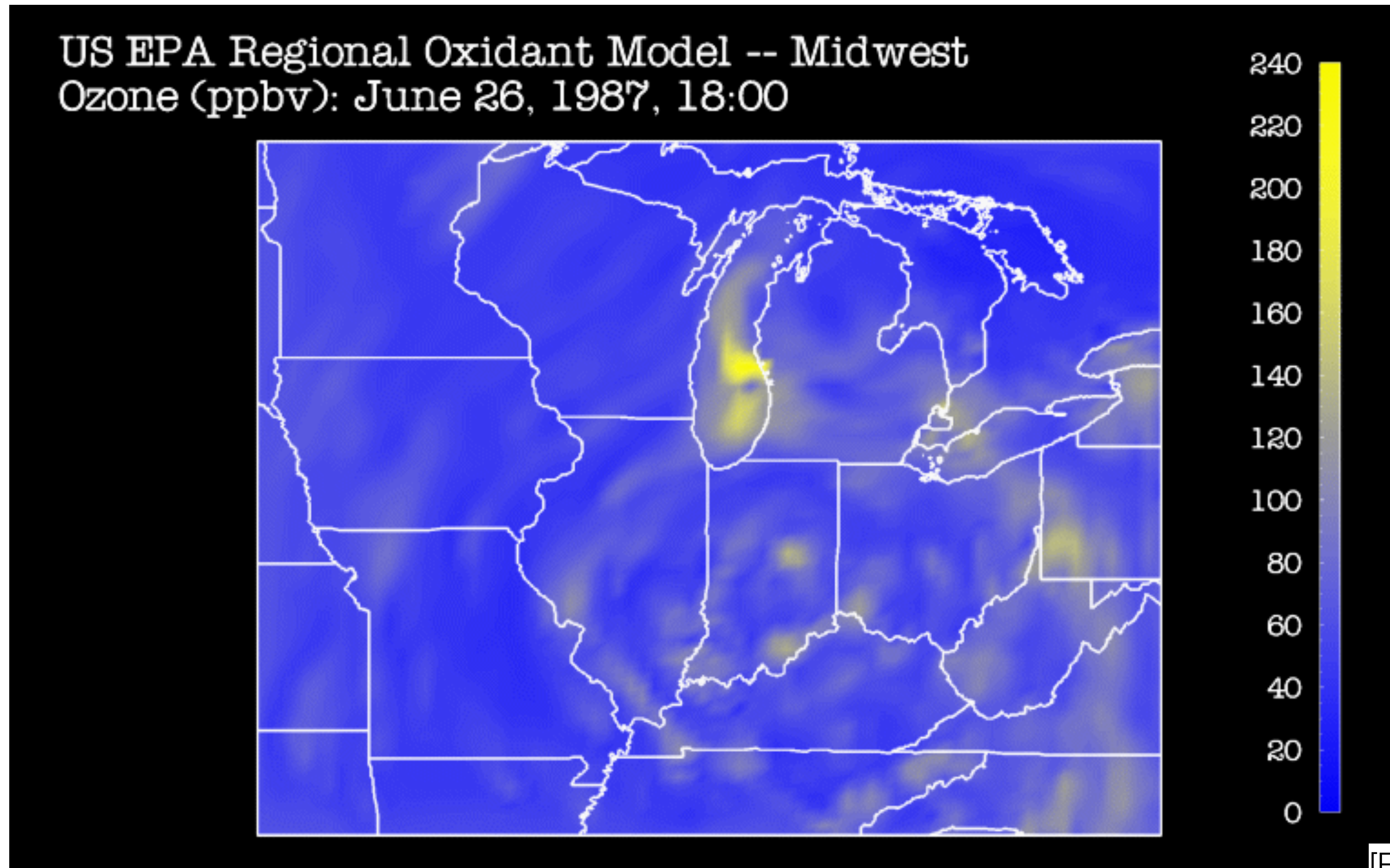
[Munzner (ill. Maguire), 2014]

Categorical Colormap Guidelines

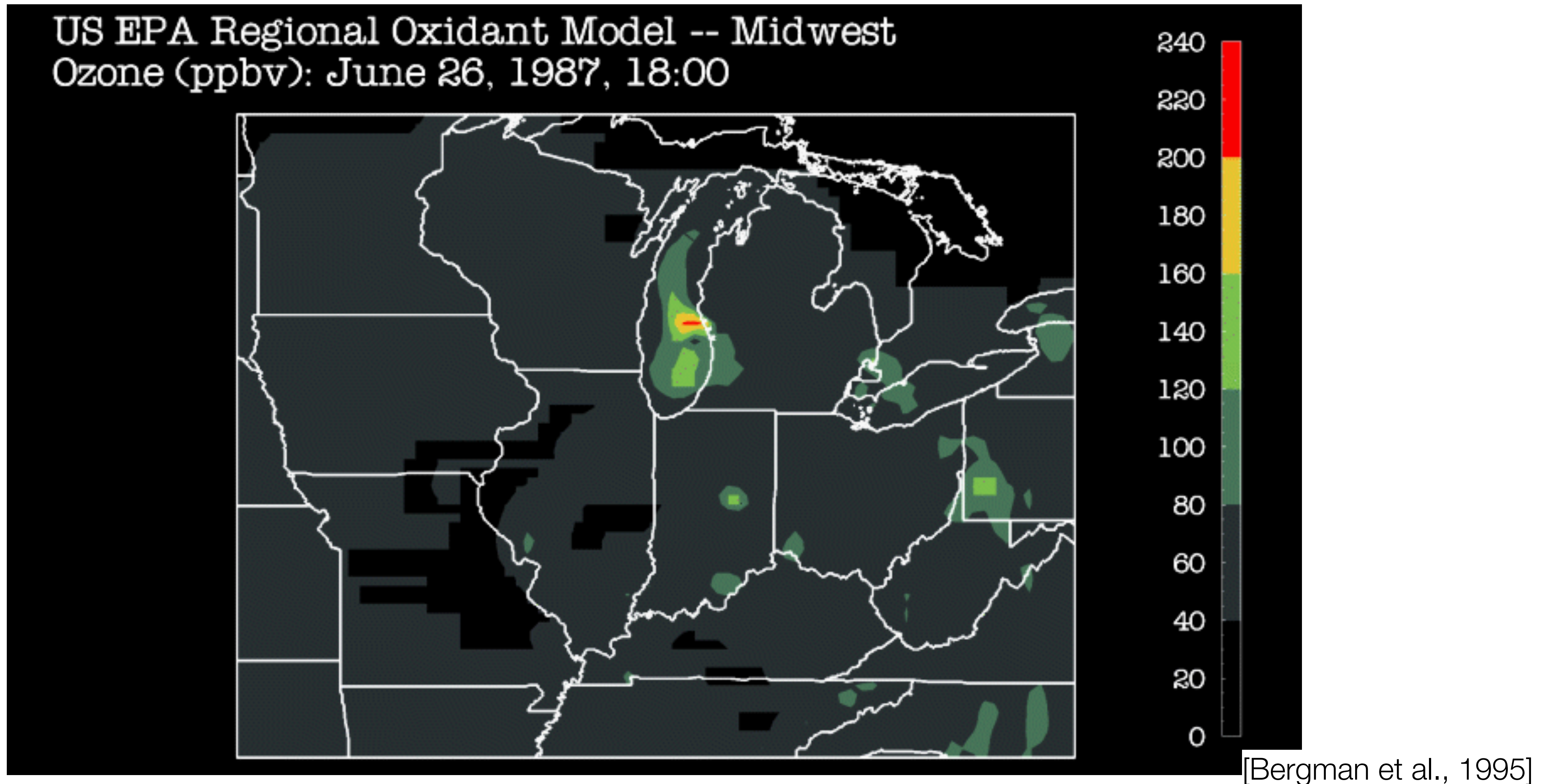


- Don't use too many colors (~12)
- Use other categories or create groups if you have too many values!
- Nameable colors help
- Be aware of luminance (e.g. difference between blue and yellow)
- Think about other marks you might wish to use in the visualization

Continuous Colormap for Ordered Data



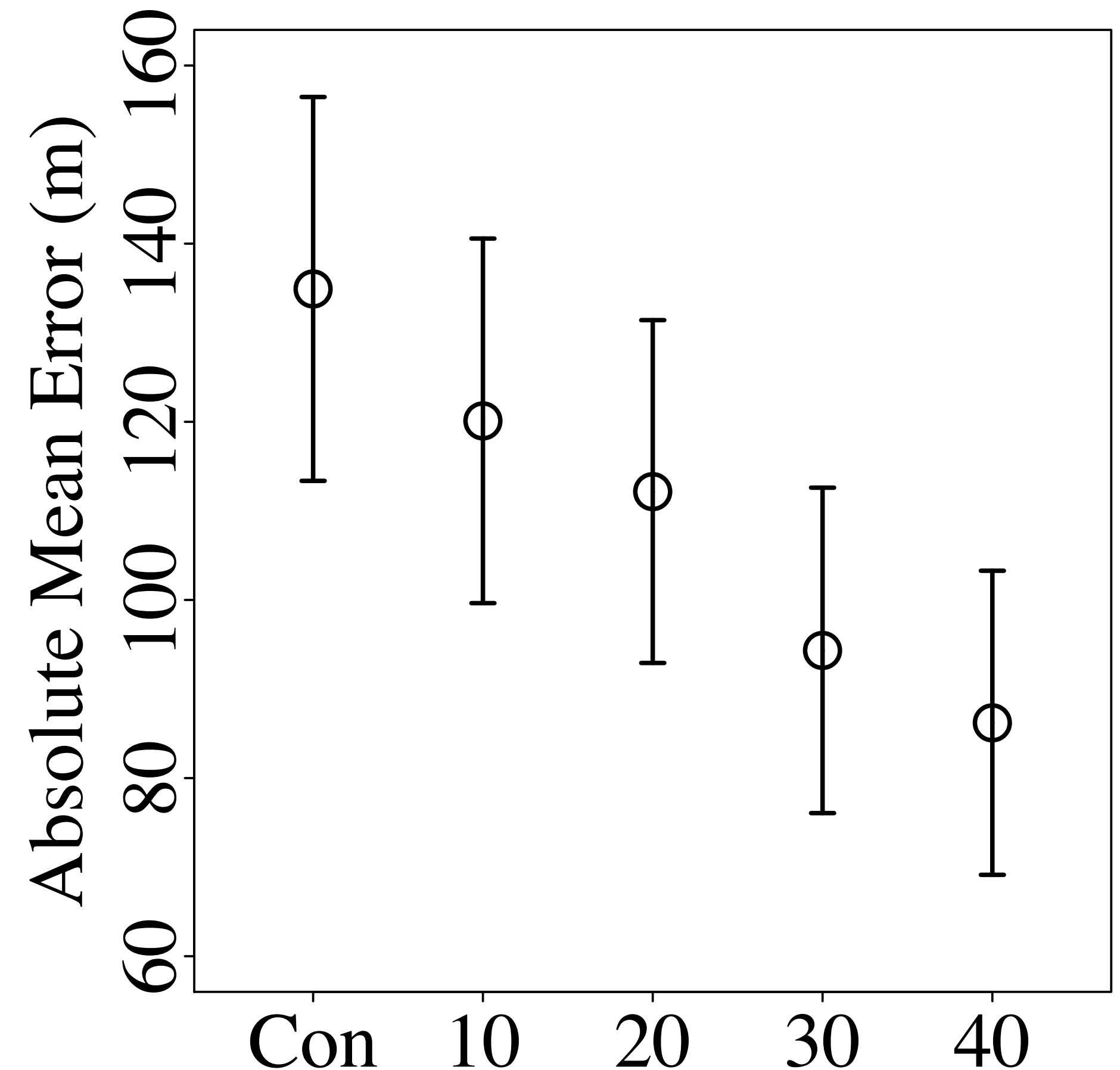
Segmented Colormap for Ordered Data



Continuous vs. Segmented Test Results

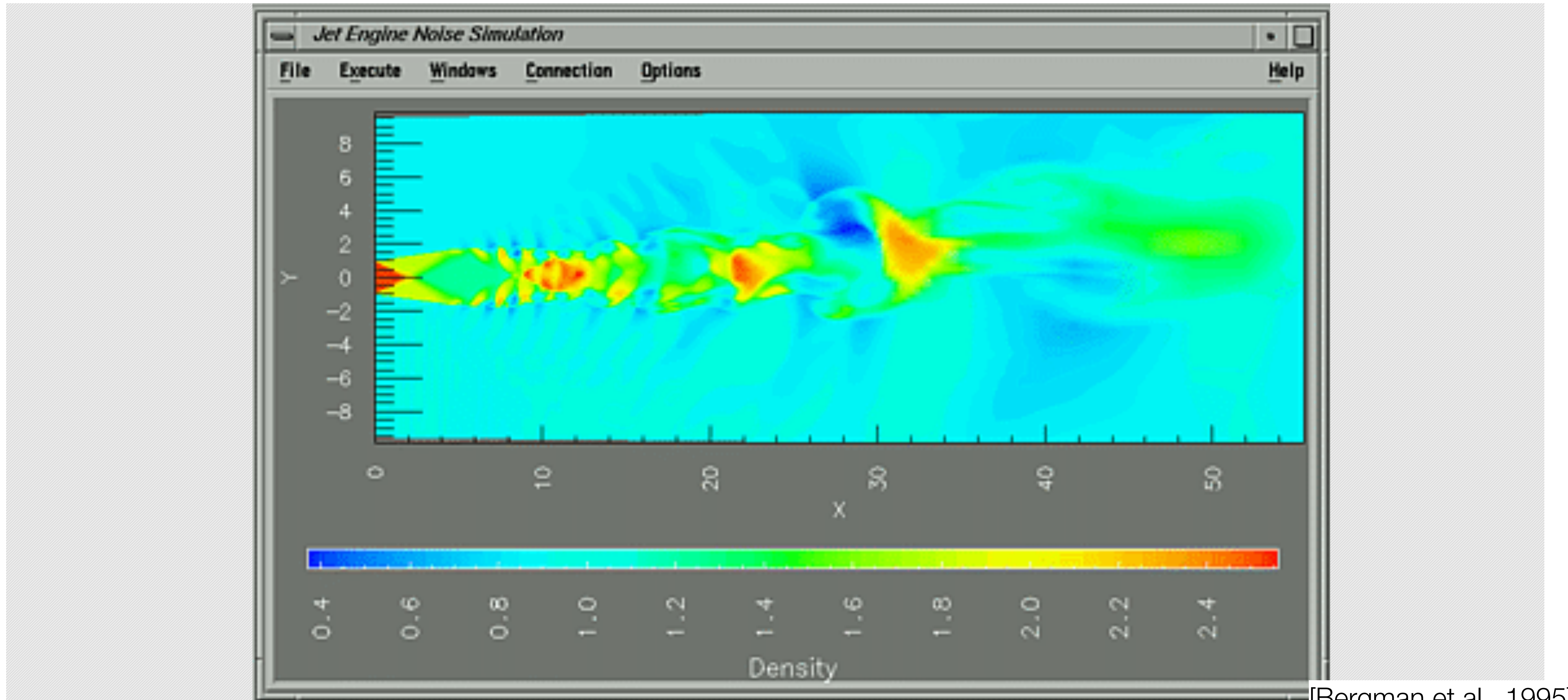
- "[C]ontrary to the expressiveness principle, no cases were found in which a continuous encoding of 2D scalar field data was advantageous for task accuracy, and for some tasks, specific binned encodings facilitated accuracy."
- "[S]upport for the counterintuitive finding that decisions with binned encoding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

Lookup Task (Lower)



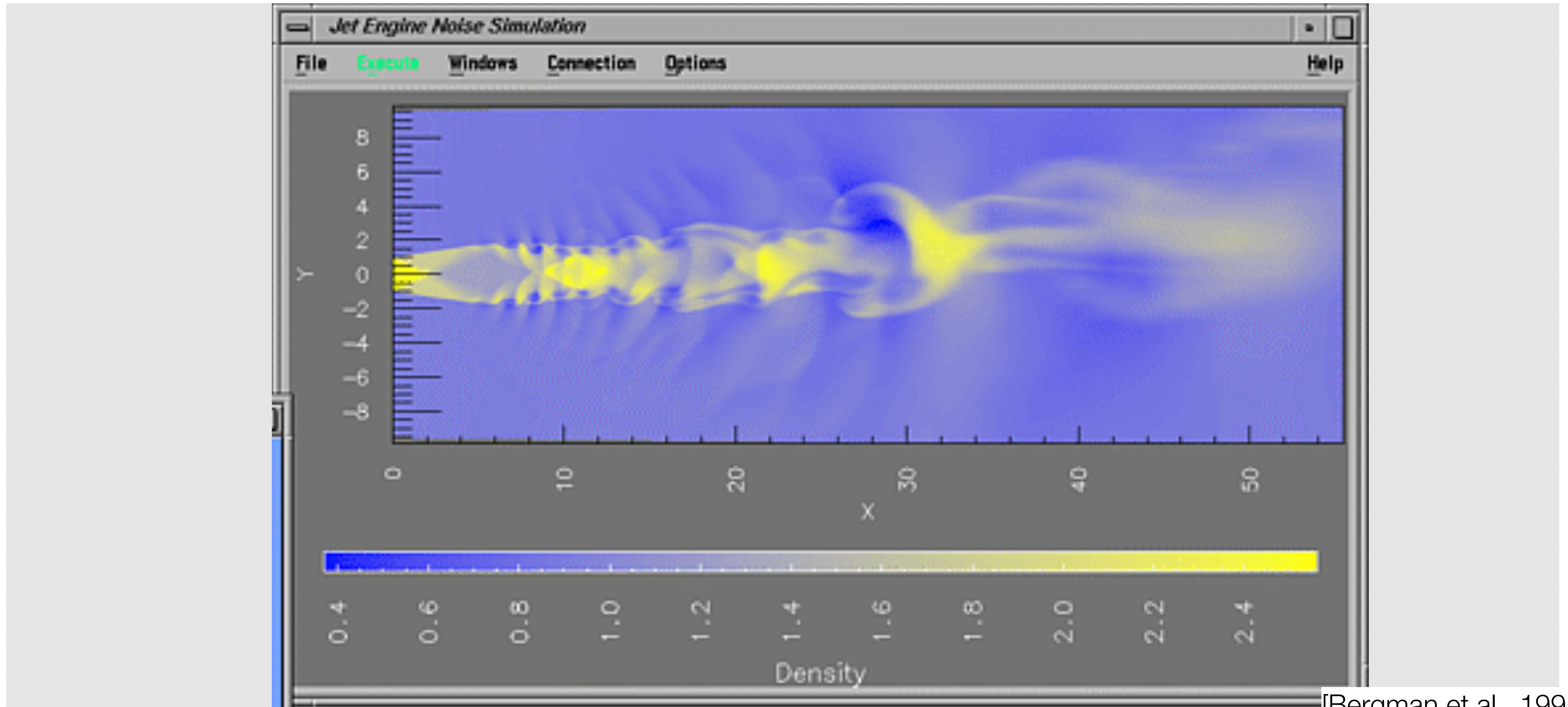
[Padilla et al., 2017]

Rainbow Colormap



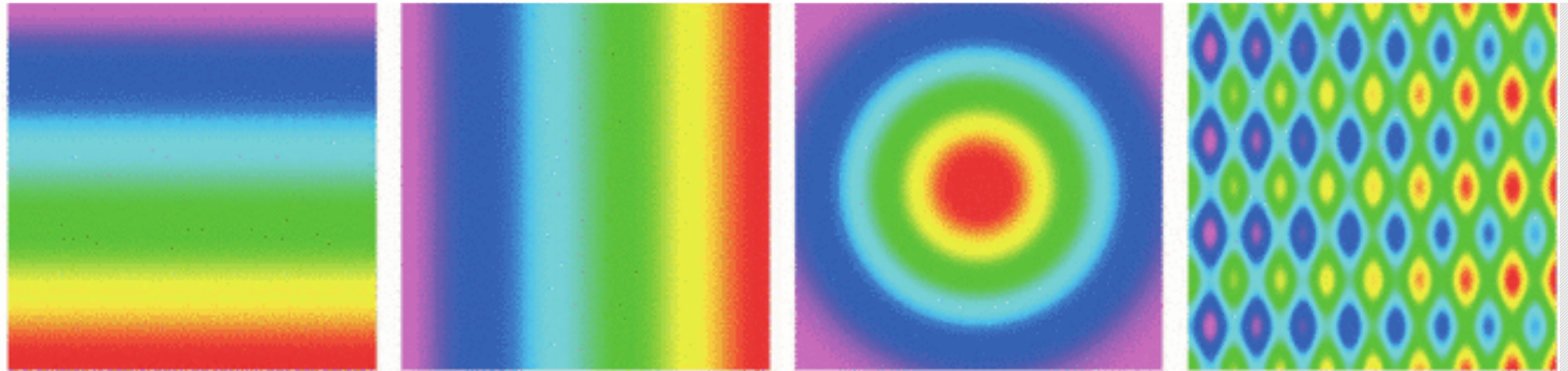
[Bergman et al., 1995]

Two-Hue Colormap



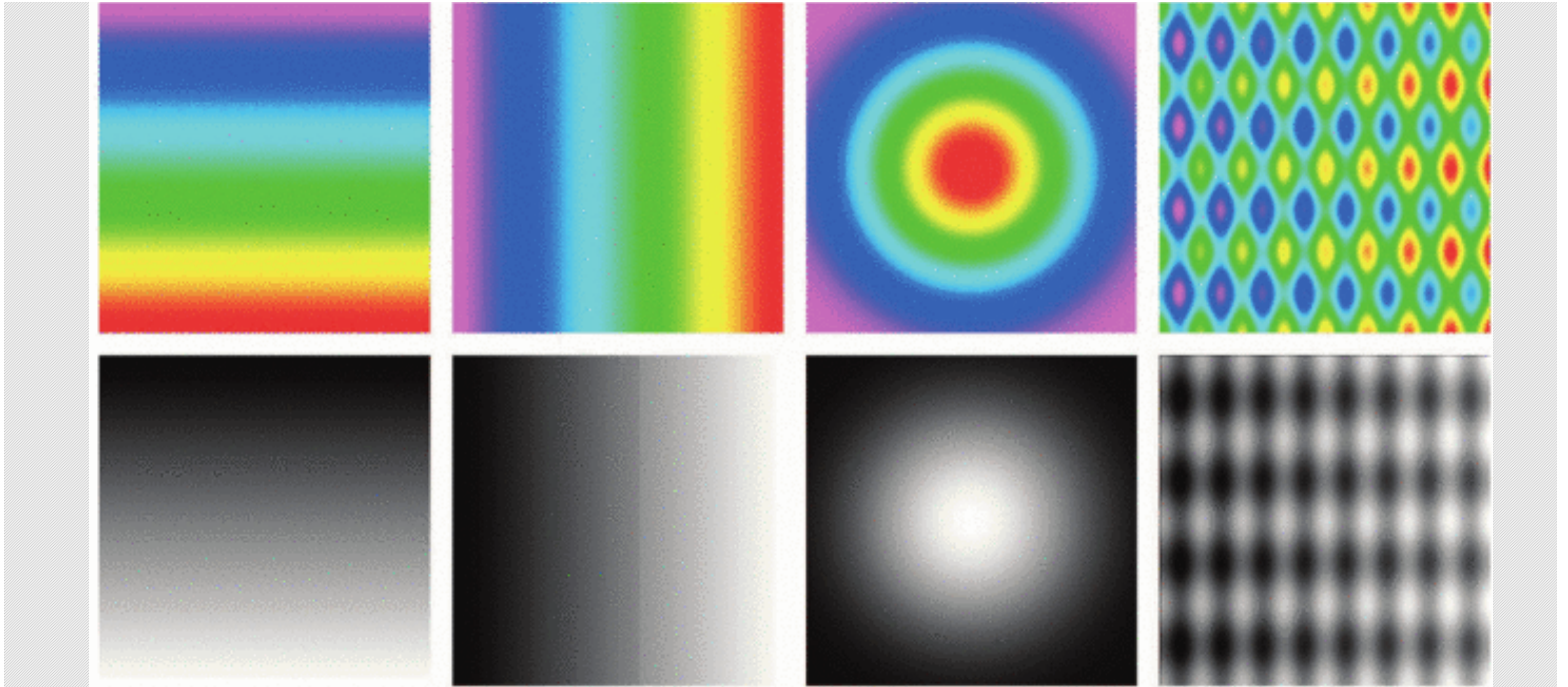
[Bergman et al., 1995]

Artifacts from Rainbow Colormaps



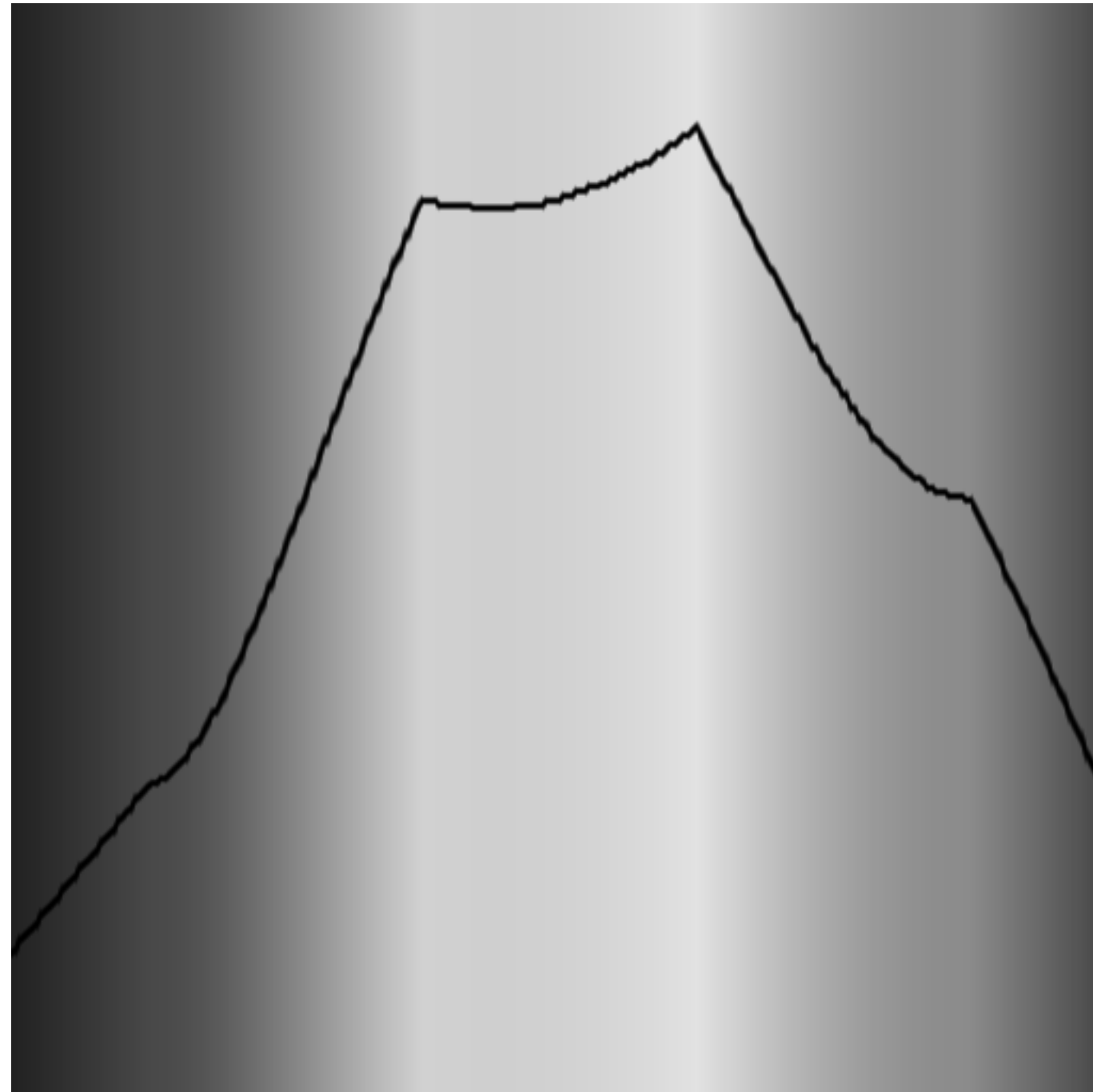
[Borland & Taylor, 2007]

Artifacts from Rainbow Colormaps

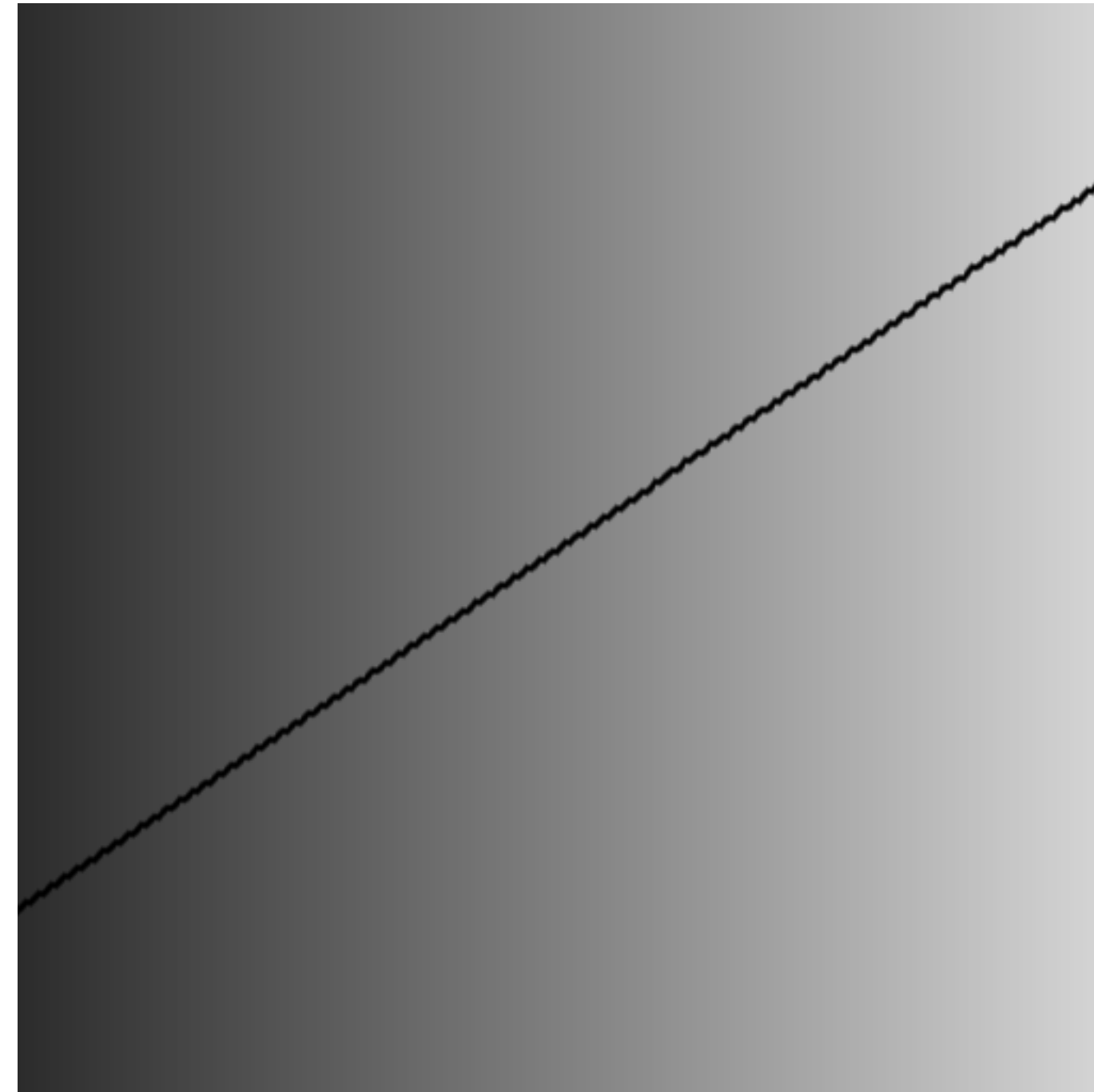


[Borland & Taylor, 2007]

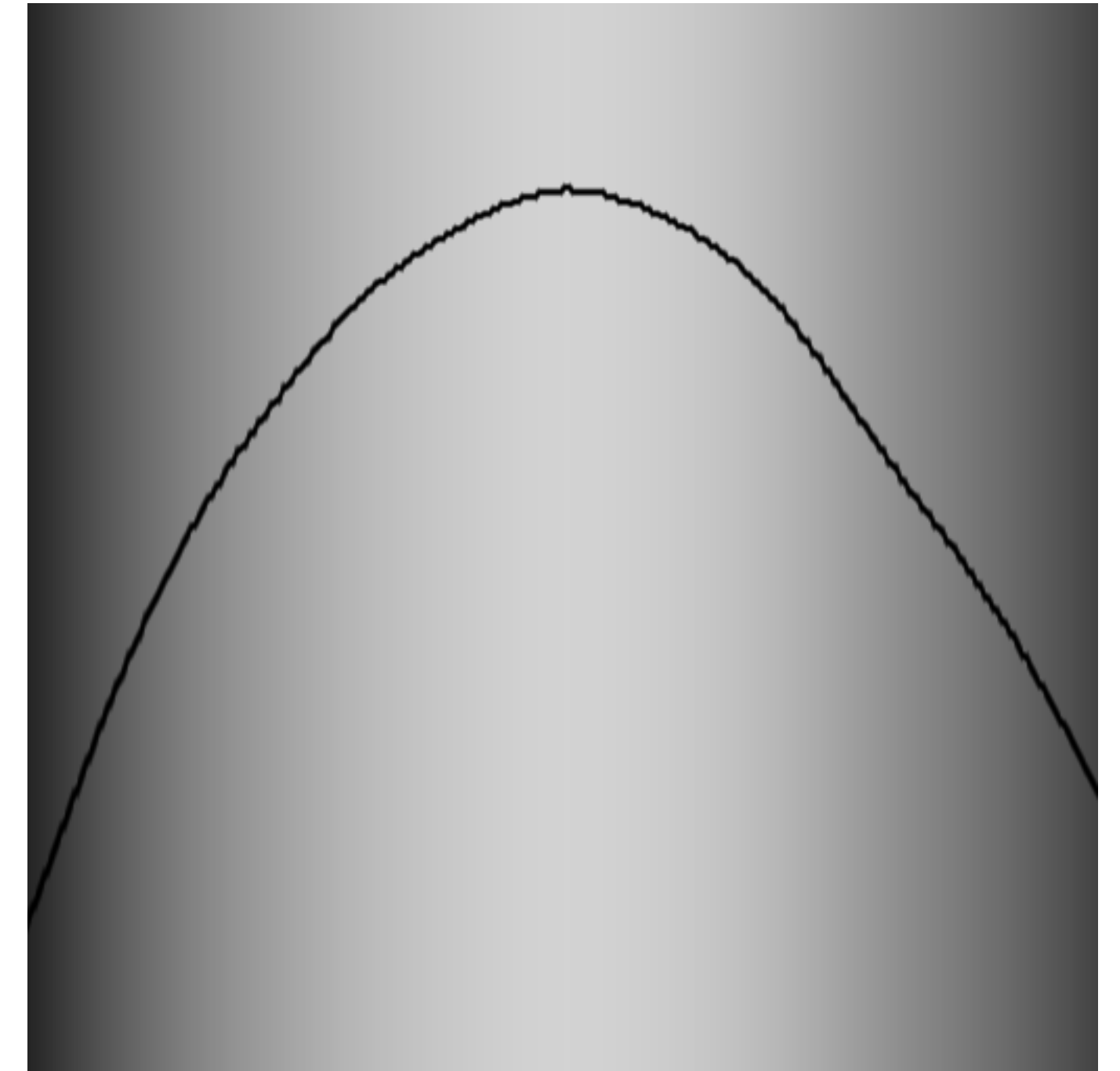
Turbo: Improving Rainbow Colormaps



Jet



Viridis



Turbo

[A. Mikhailov]

Midterm

- In-class, Wednesday, March 5, 9:30-10:45am
- 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

Project Proposal

- Final Goal: custom, interactive visualization
- Proposal: What & Why
 - Decide on dataset
 - Analyze attributes
 - Brainstorm Tasks
- Research ideas also possible: proposal is more of a research proposal then
- Due Friday, March 7

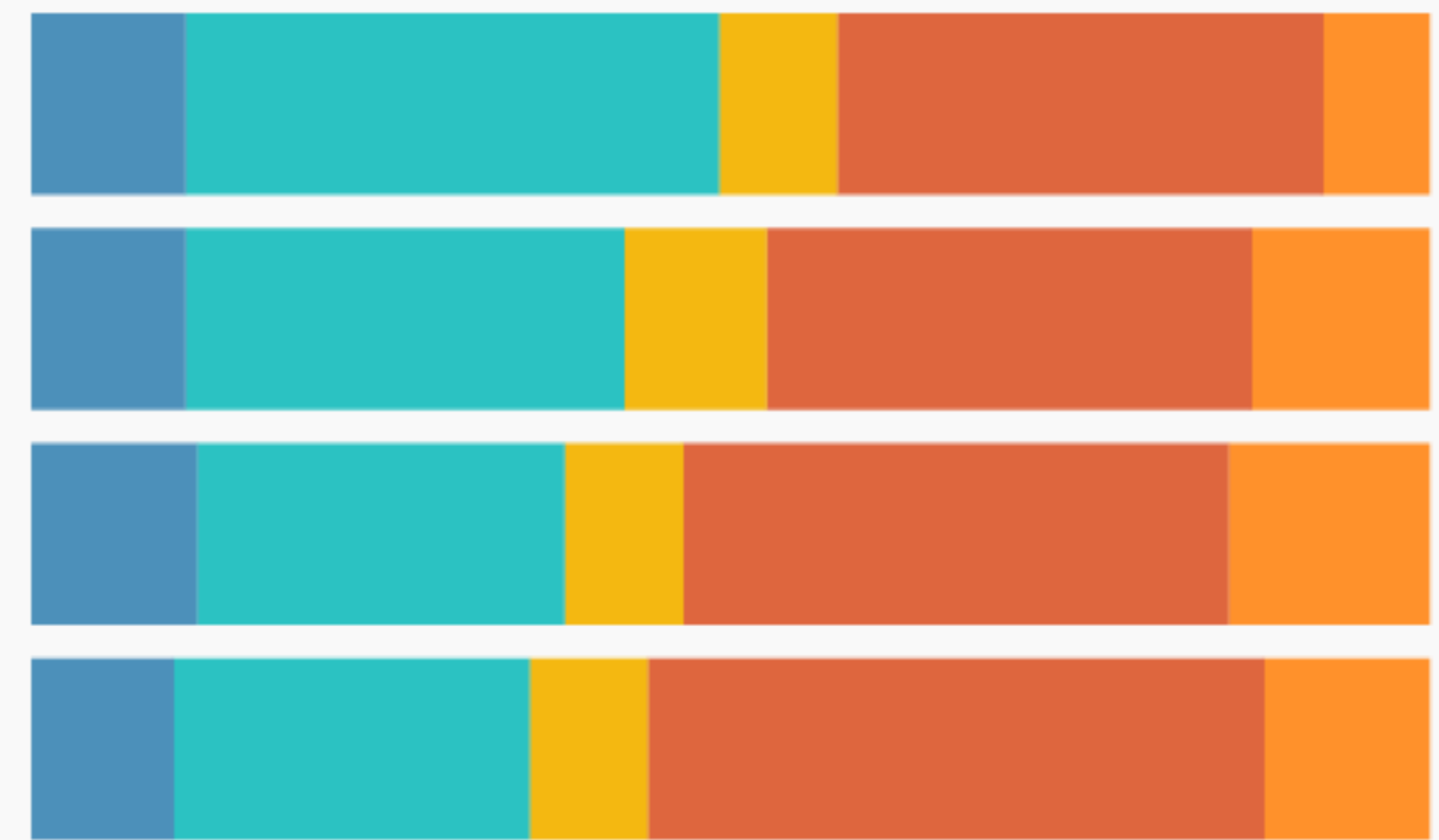
More Guidelines

- 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



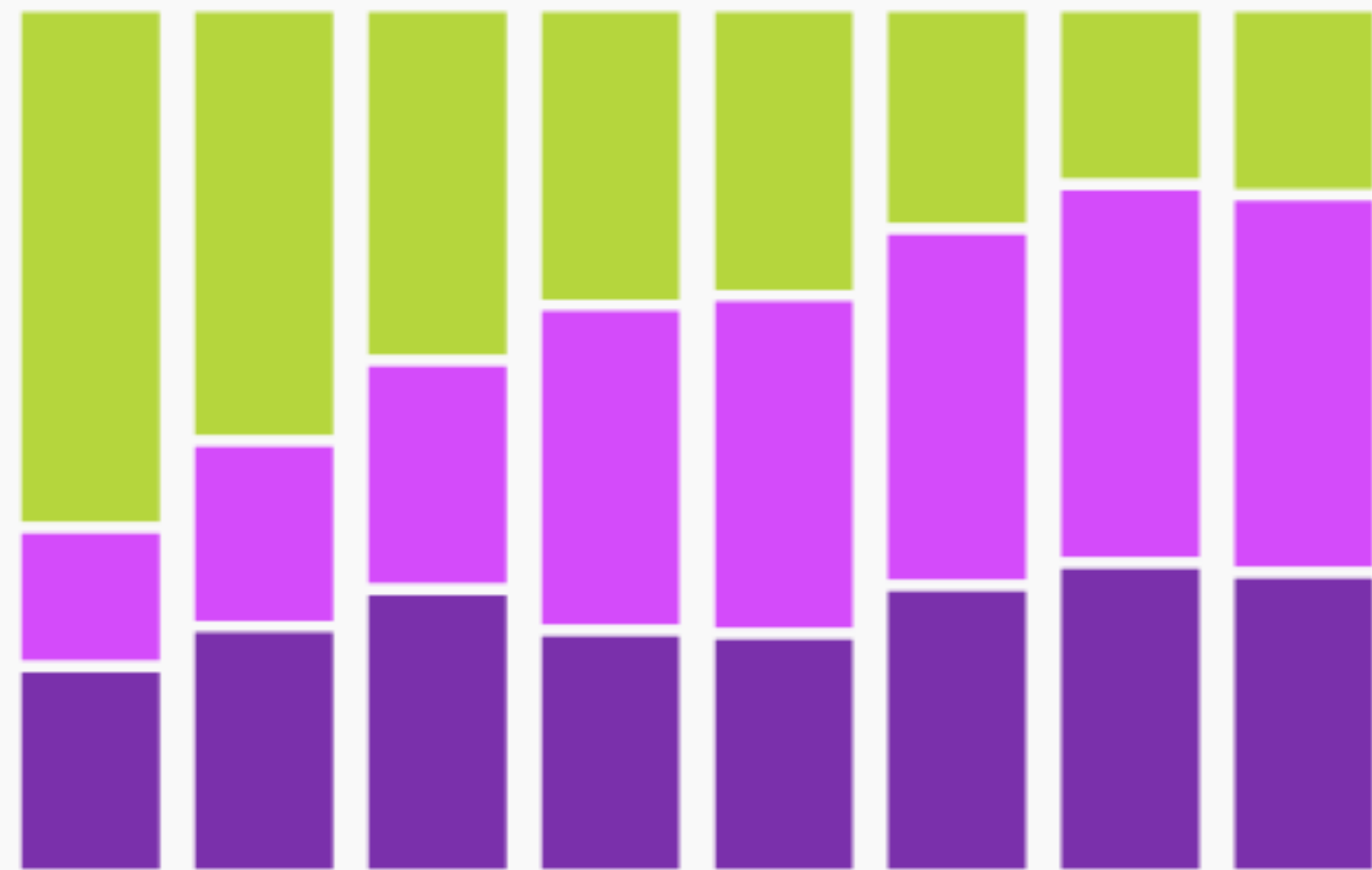
NOT IDEAL



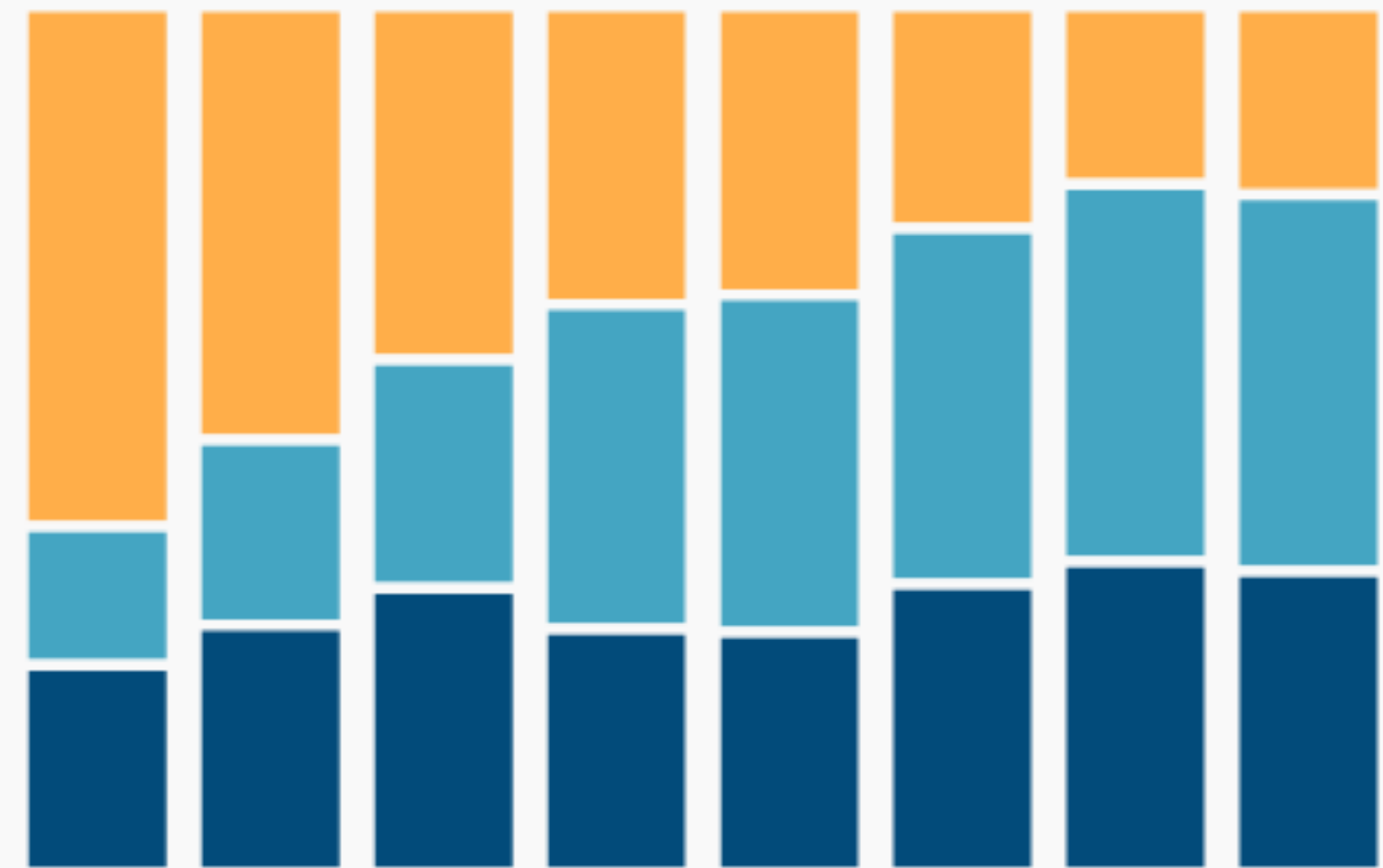
BETTER

[L. C. Rost]

Use Warm Colors & Blue



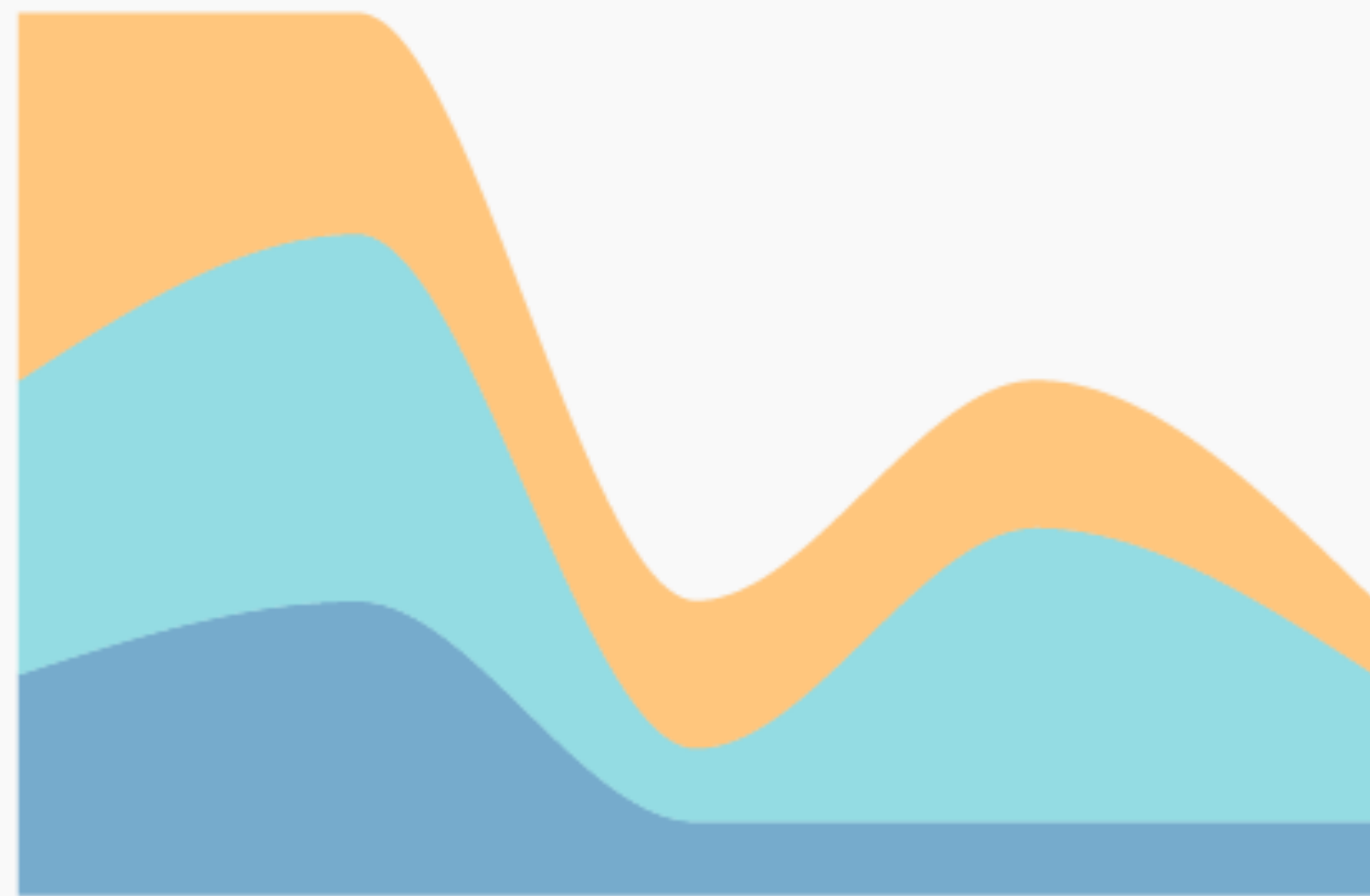
NOT IDEAL



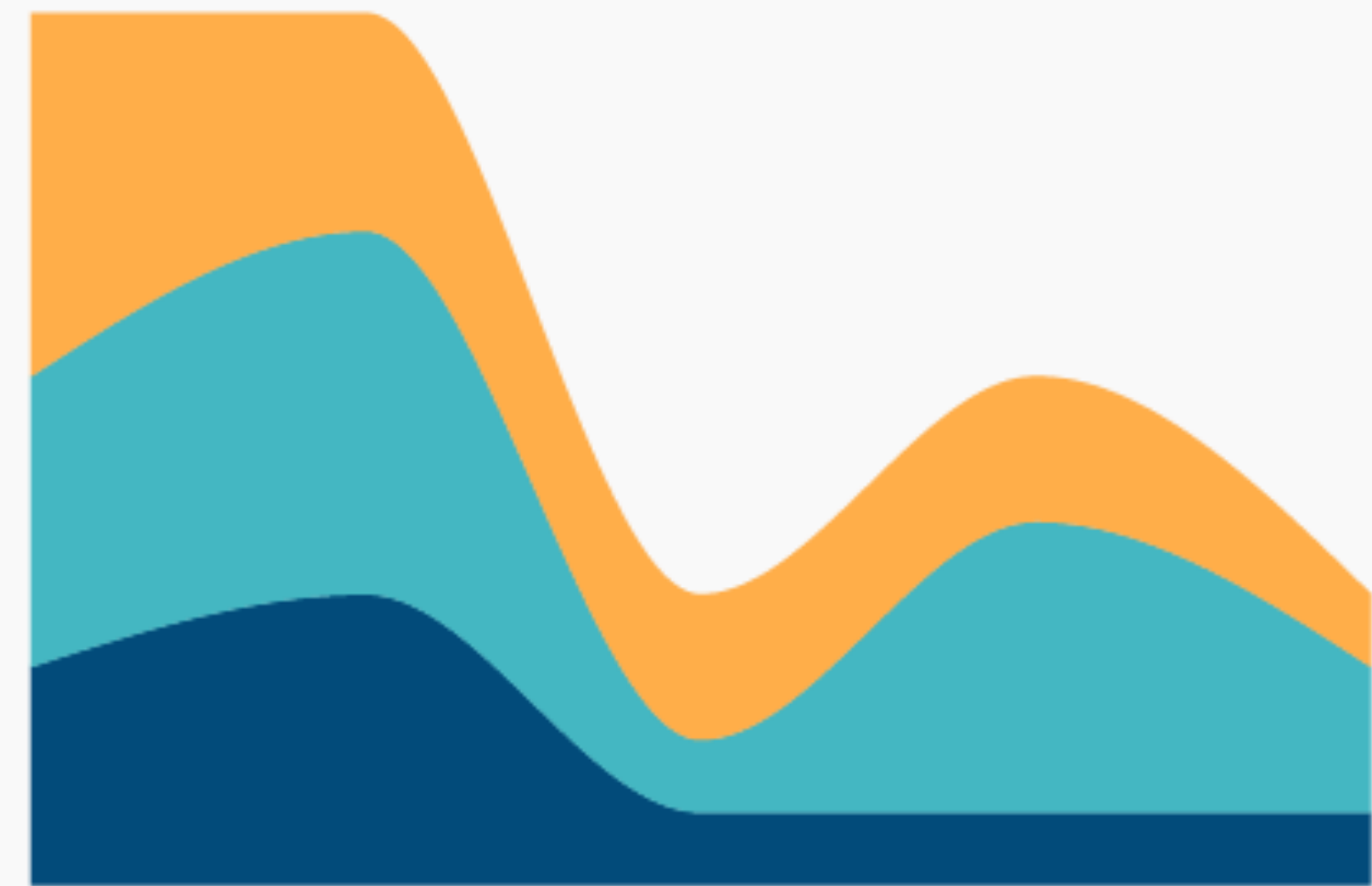
BETTER

[L. C. Rost]

Avoid Too Little Contrast to Background



NOT IDEAL



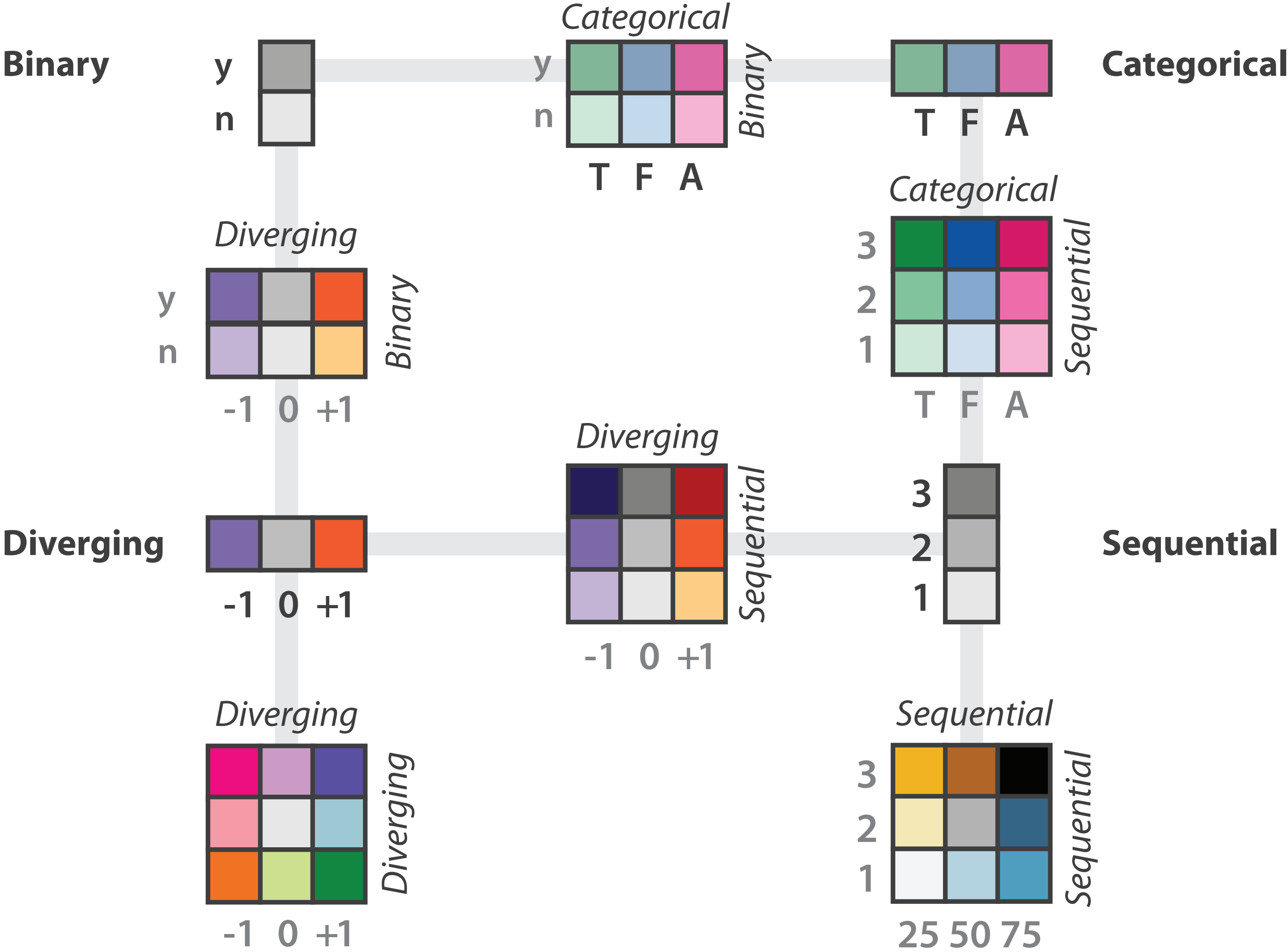
BETTER

[L. C. Rost]

D3's color scales

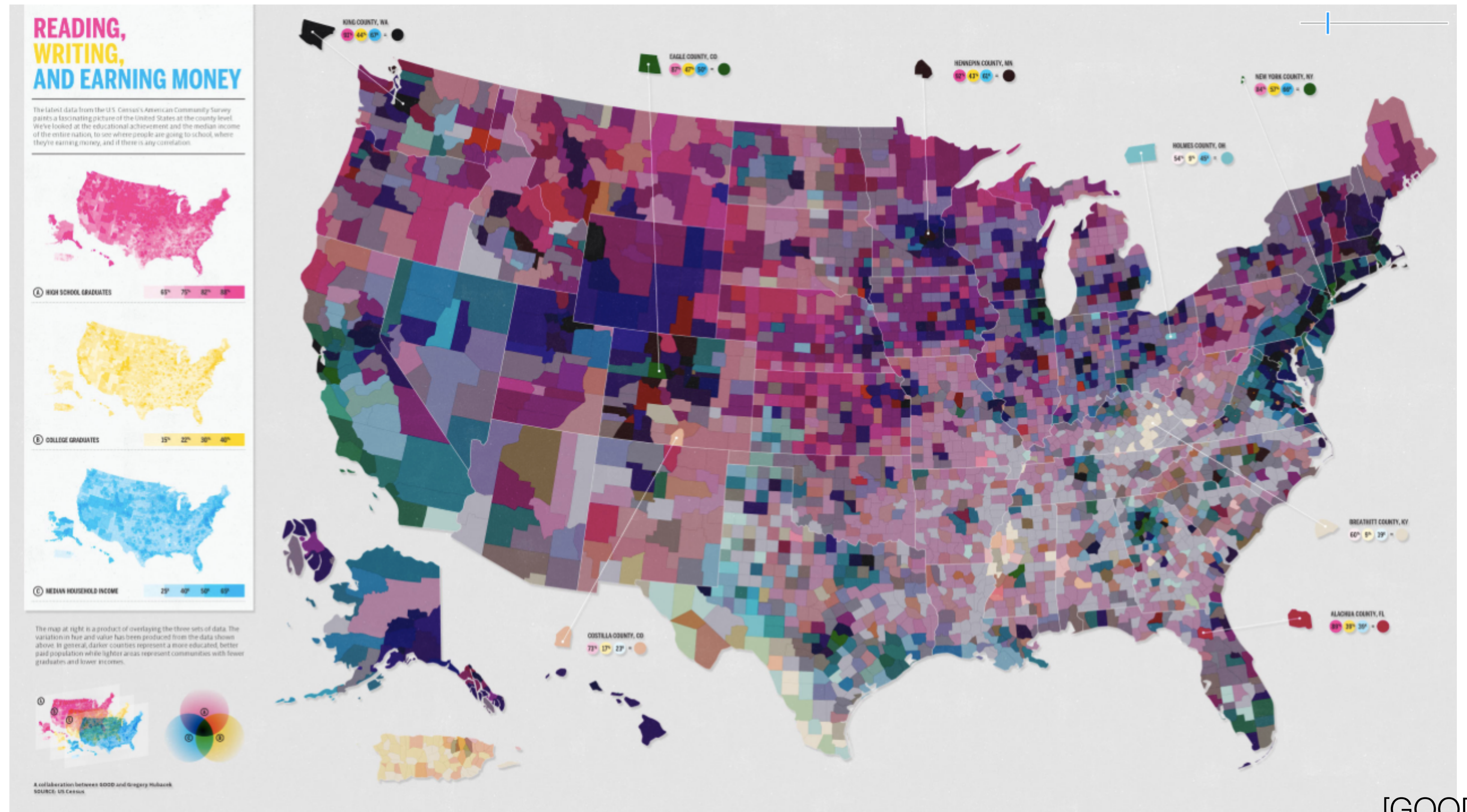
- <https://github.com/d3/d3-scale-chromatic>
- In v7, included in default bundle (no separate import)
- D3's built-in color scales
- Derived from [ColorBrewer](#)
- Sequential and diverging scales created using interpolation
- Hue **can** change, but be careful
- [Color ramp](#) [M. Bostock]

Bivariate Colormaps



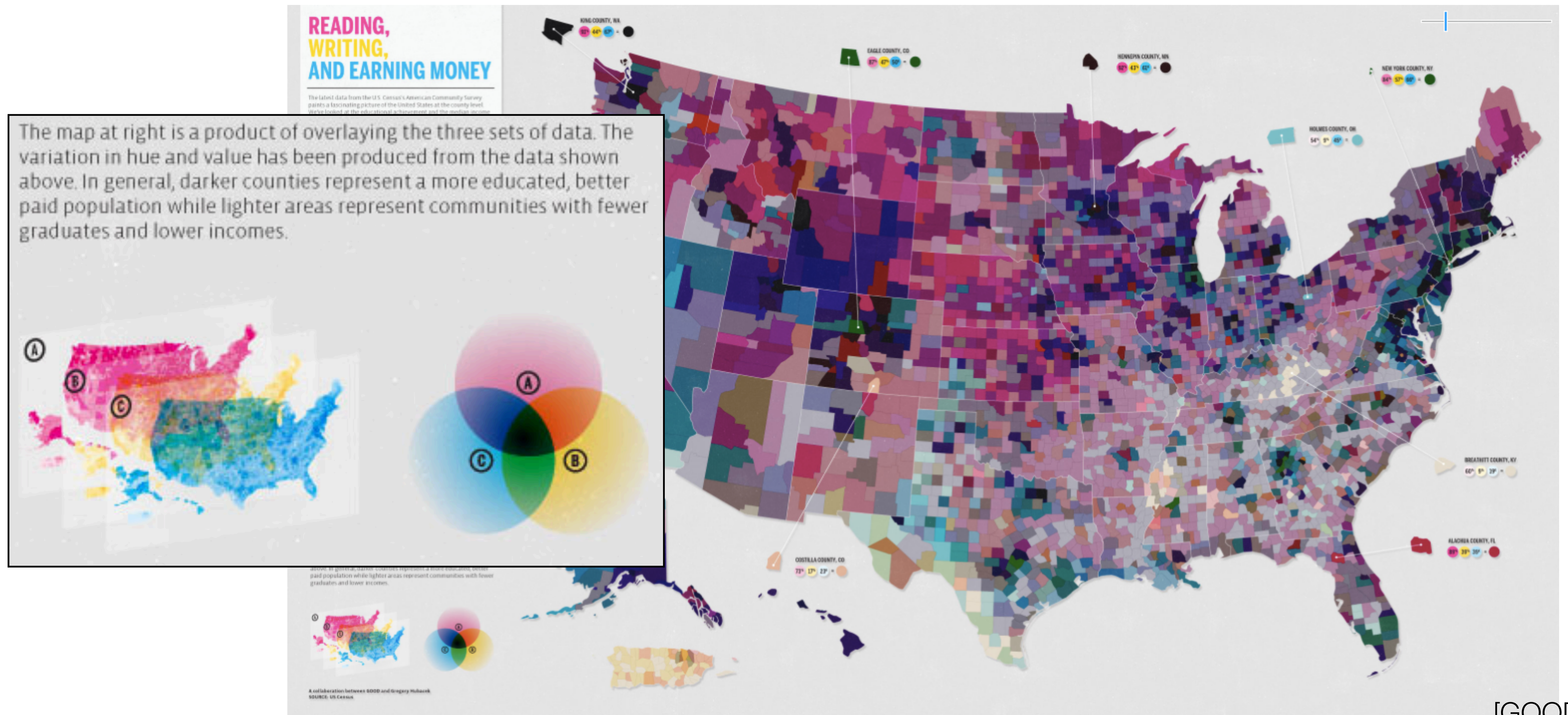
[Munzner (ill. Maguire), 2014]

Remember Separable vs. Integral



[GOOD]

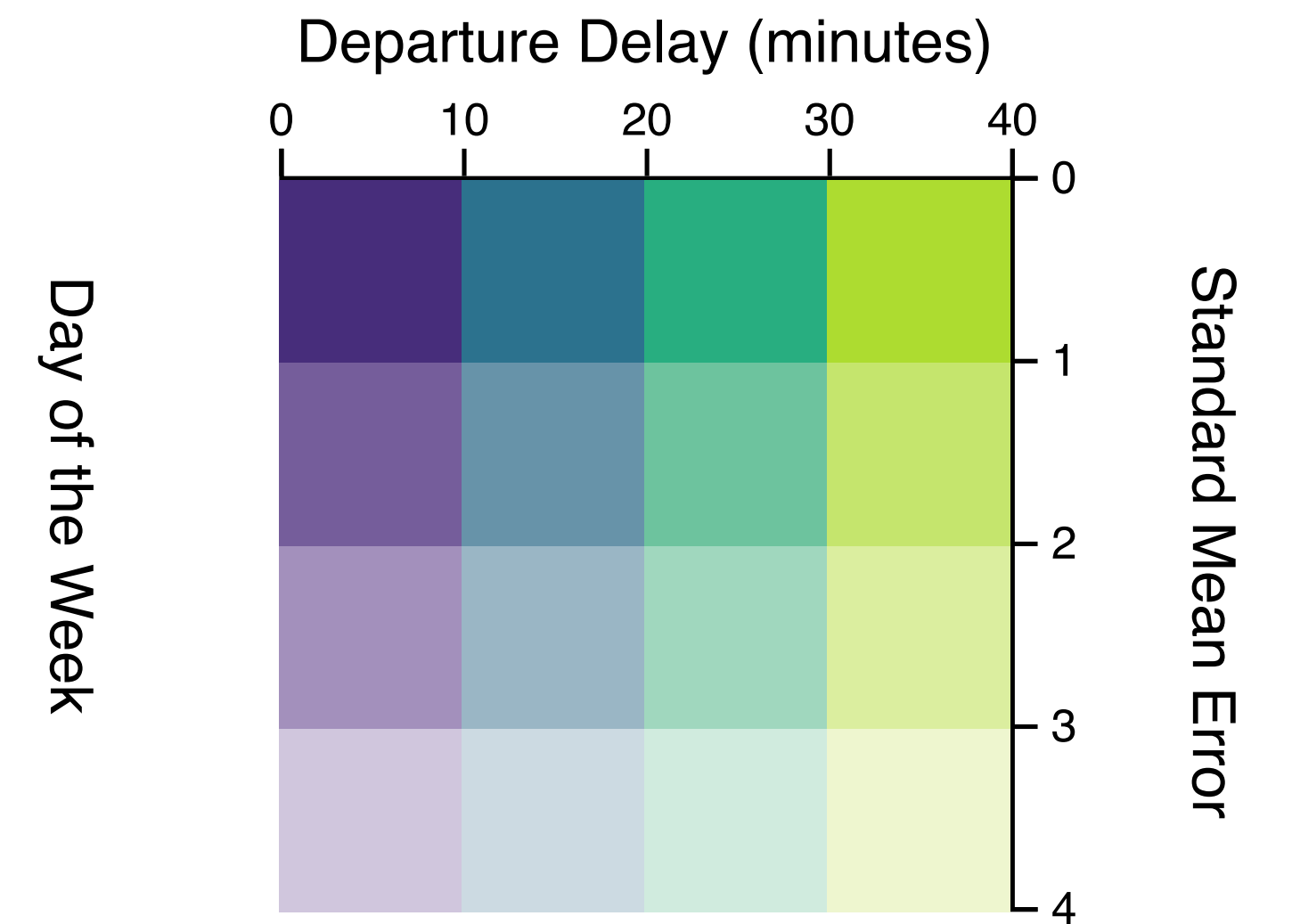
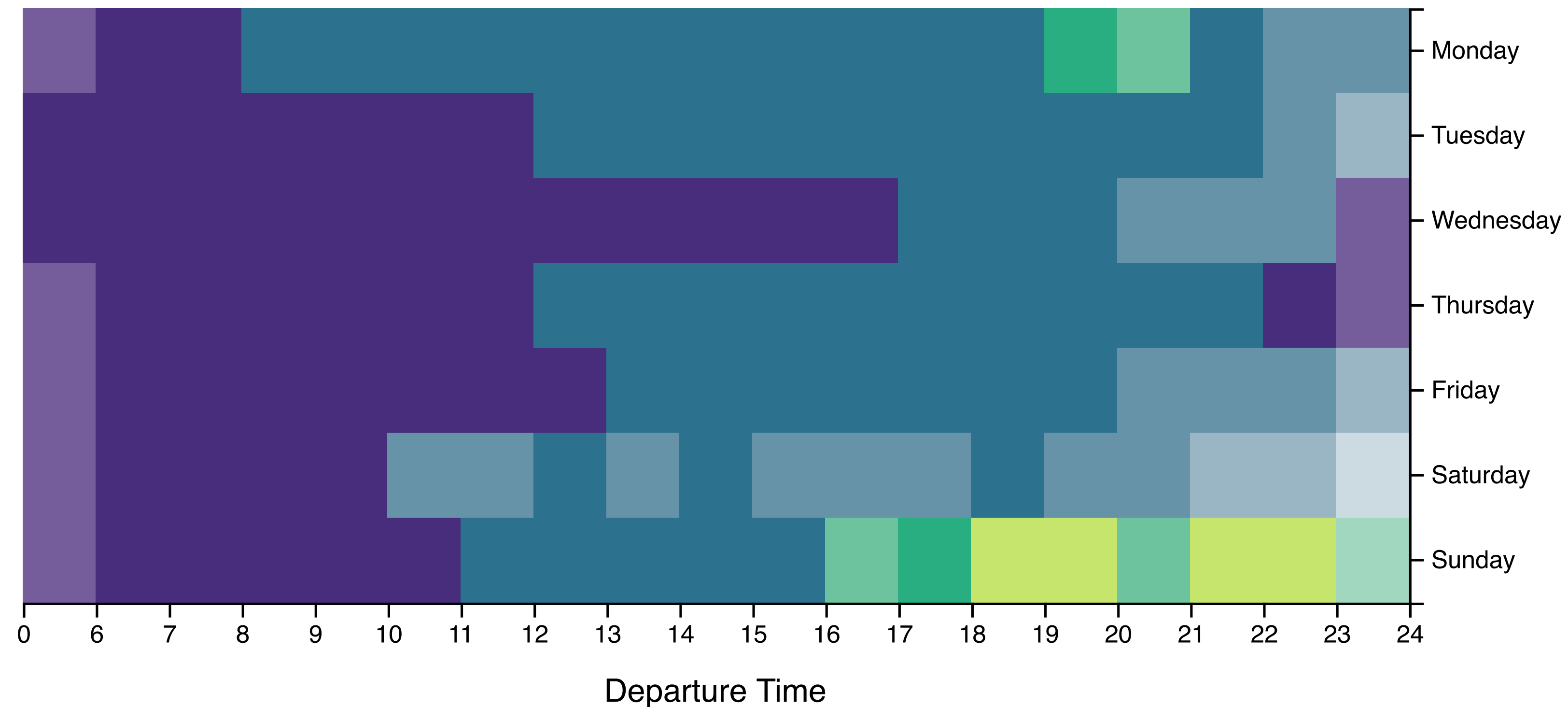
Remember Separable vs. Integral



[GOOD]

What about uncertain data?

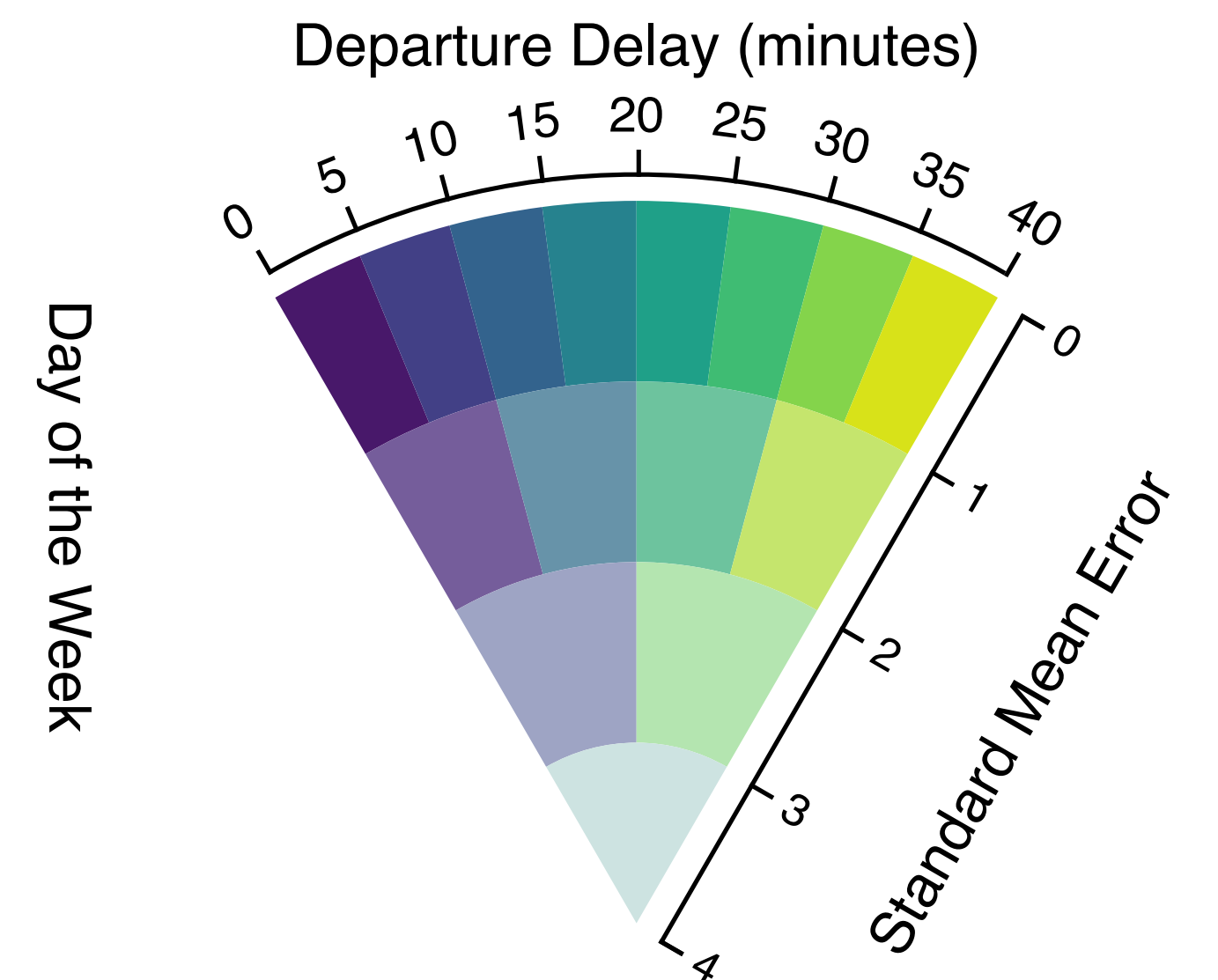
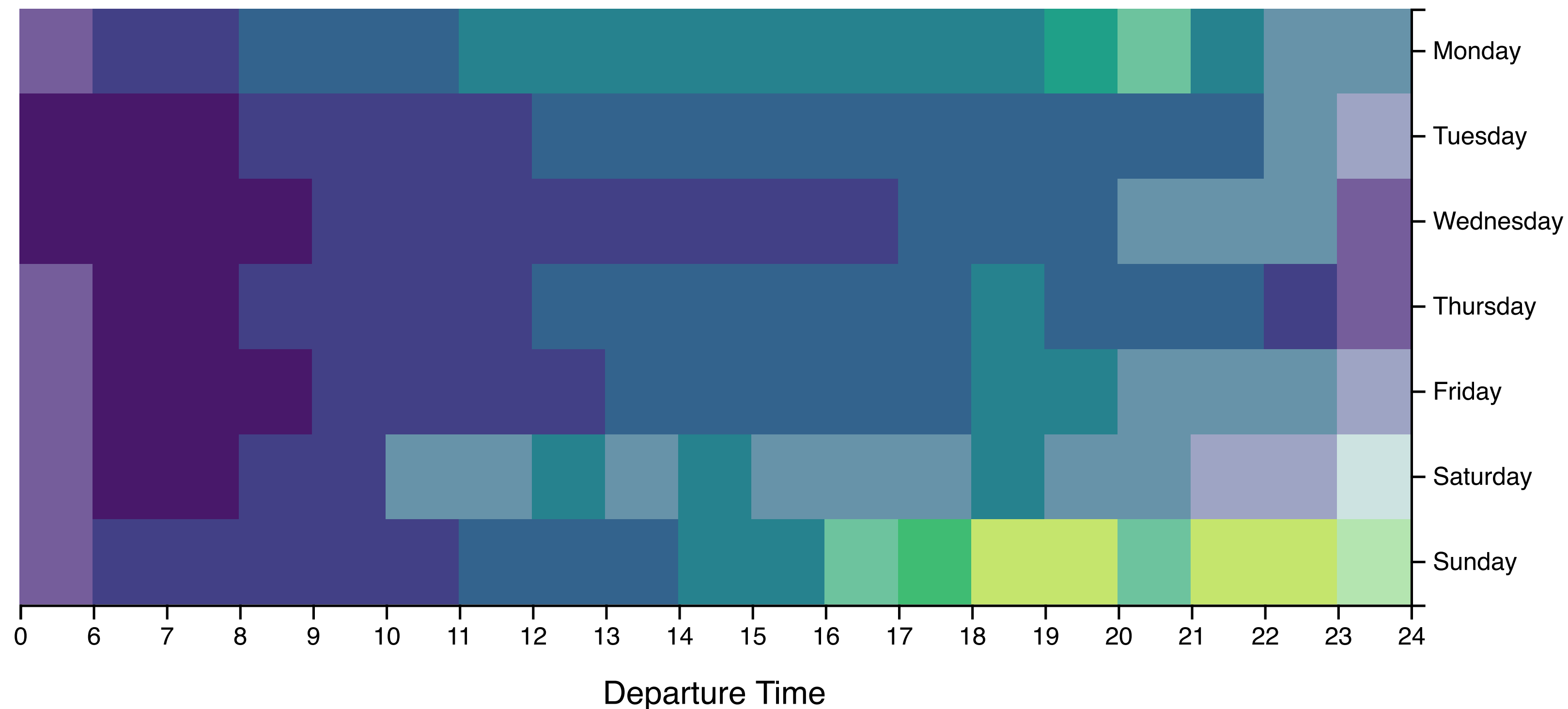
Bivariate Colormap (Uncertainty → Saturation)



[Correll et al., 2018]

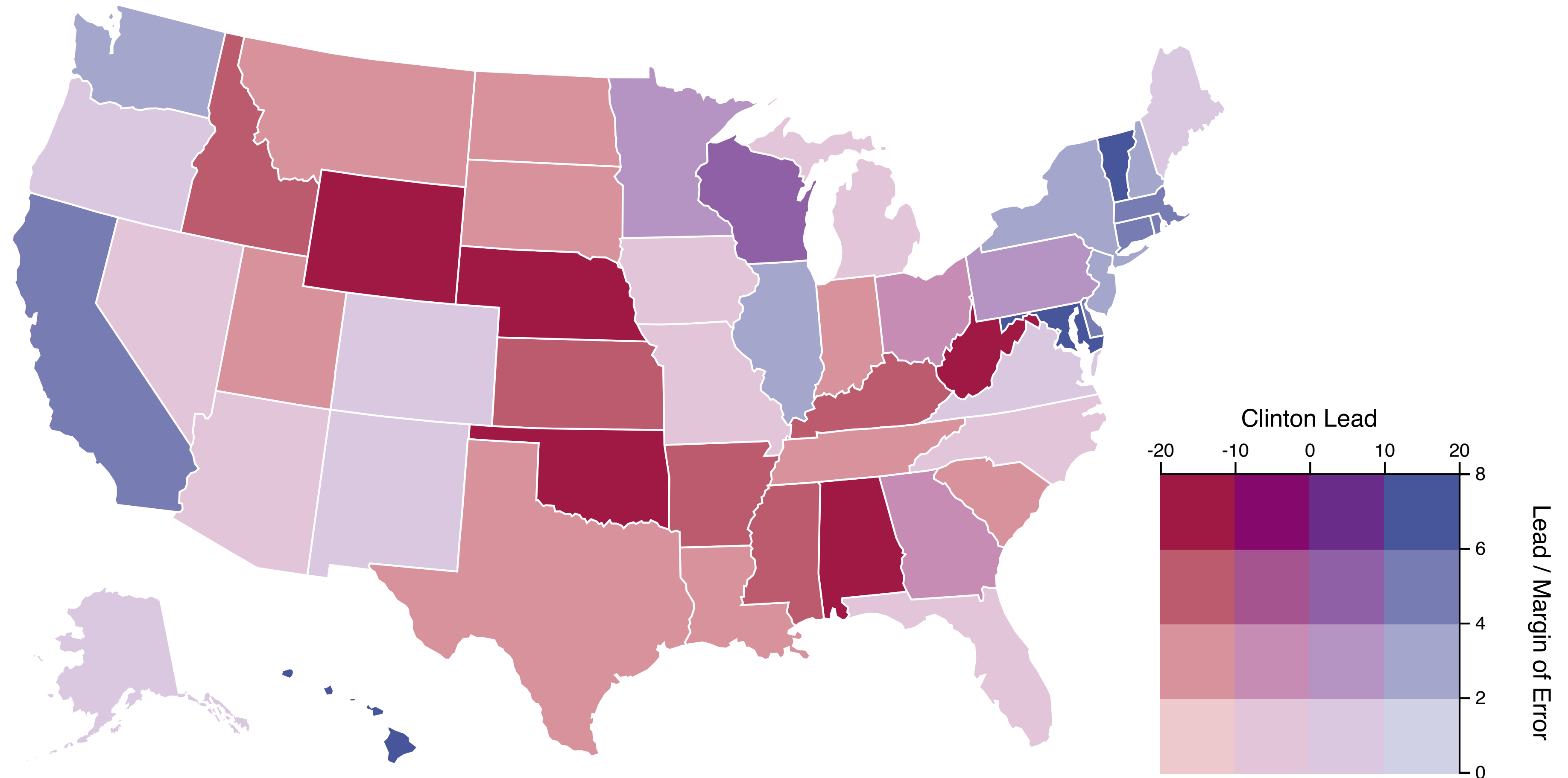
Value-Suppressing Uncertainty Palette (VSUP)

Same Channels, just binned differently



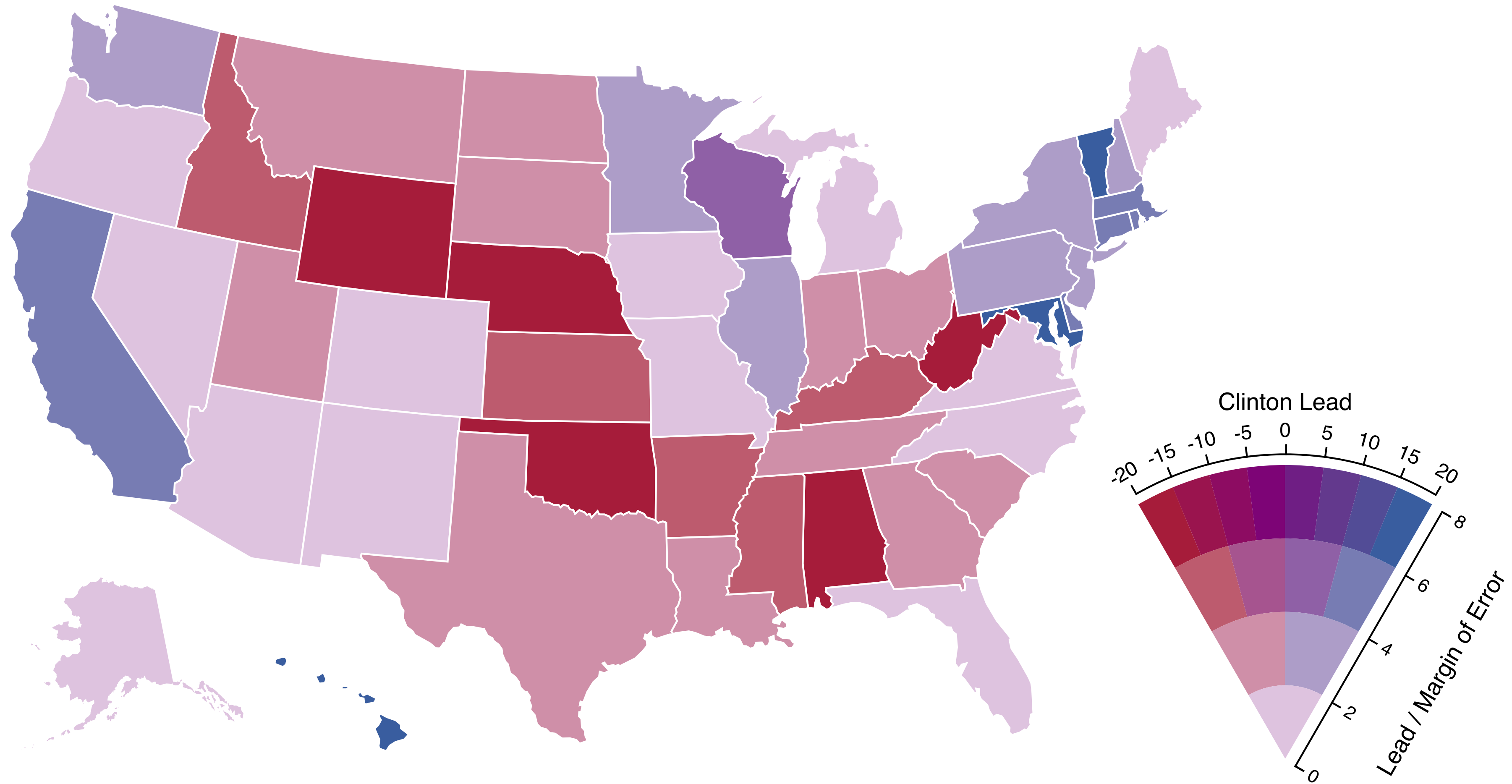
[Correll et al., 2018]

Bivariate Colormap (Uncertainty → Saturation)



[Correll et al., 2018]

Value-Suppressing Uncertainty Palette

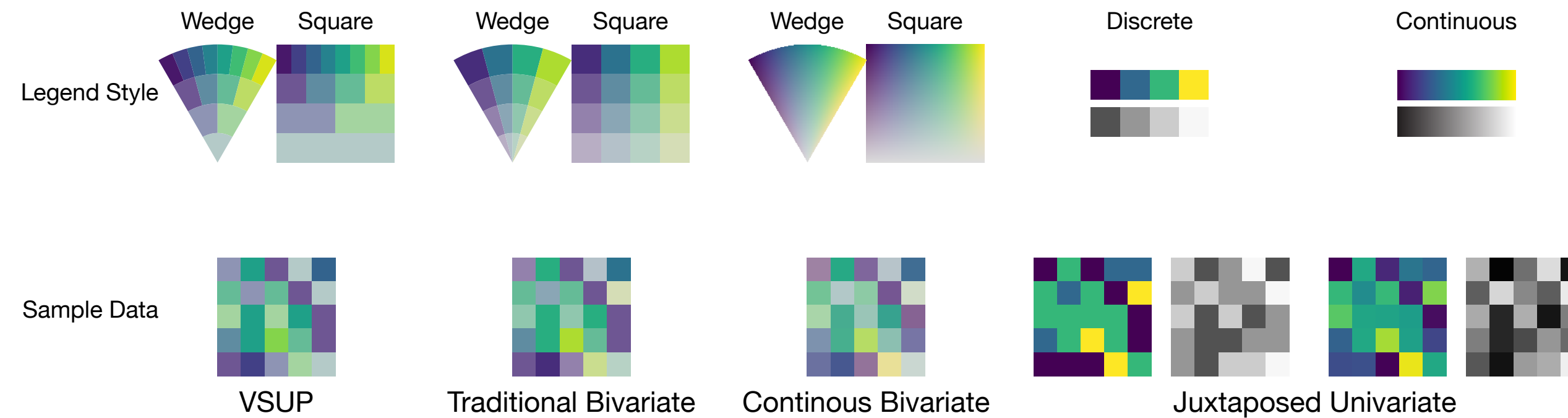


[Correll et al., 2018]

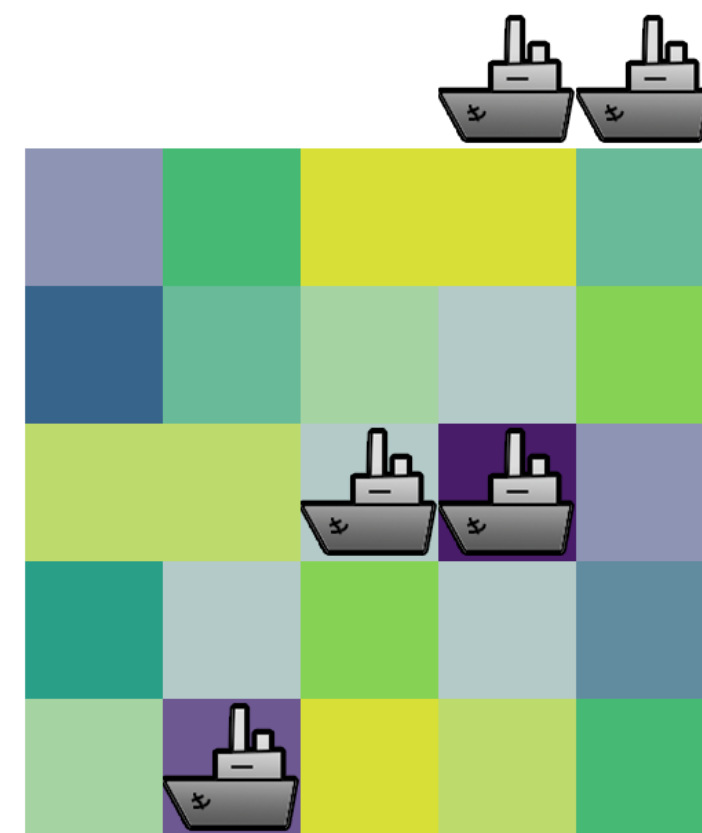
Evaluation

- Tasks:

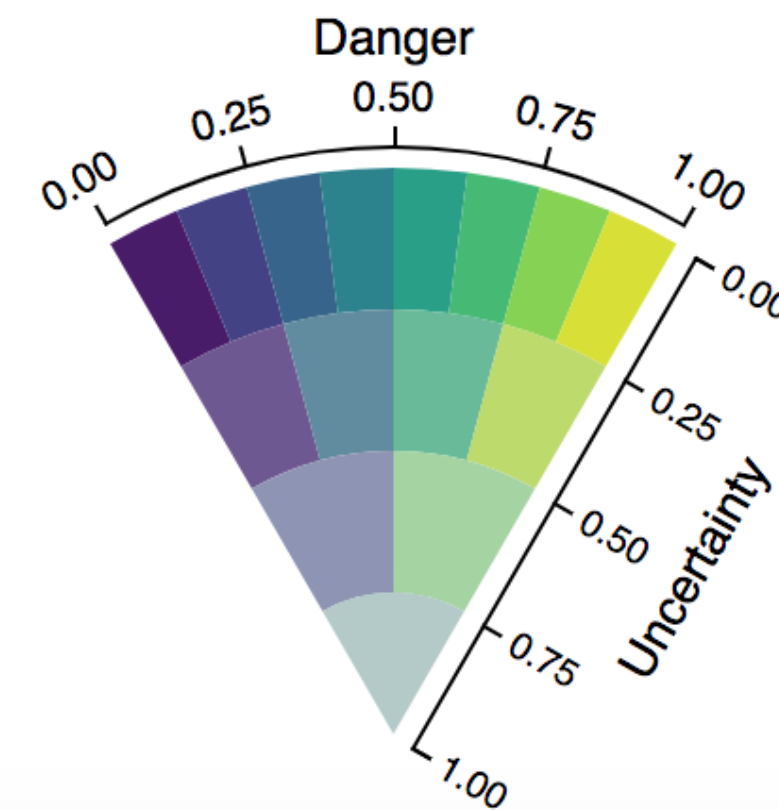
- Identification: locate spatial regions



- Prediction: place

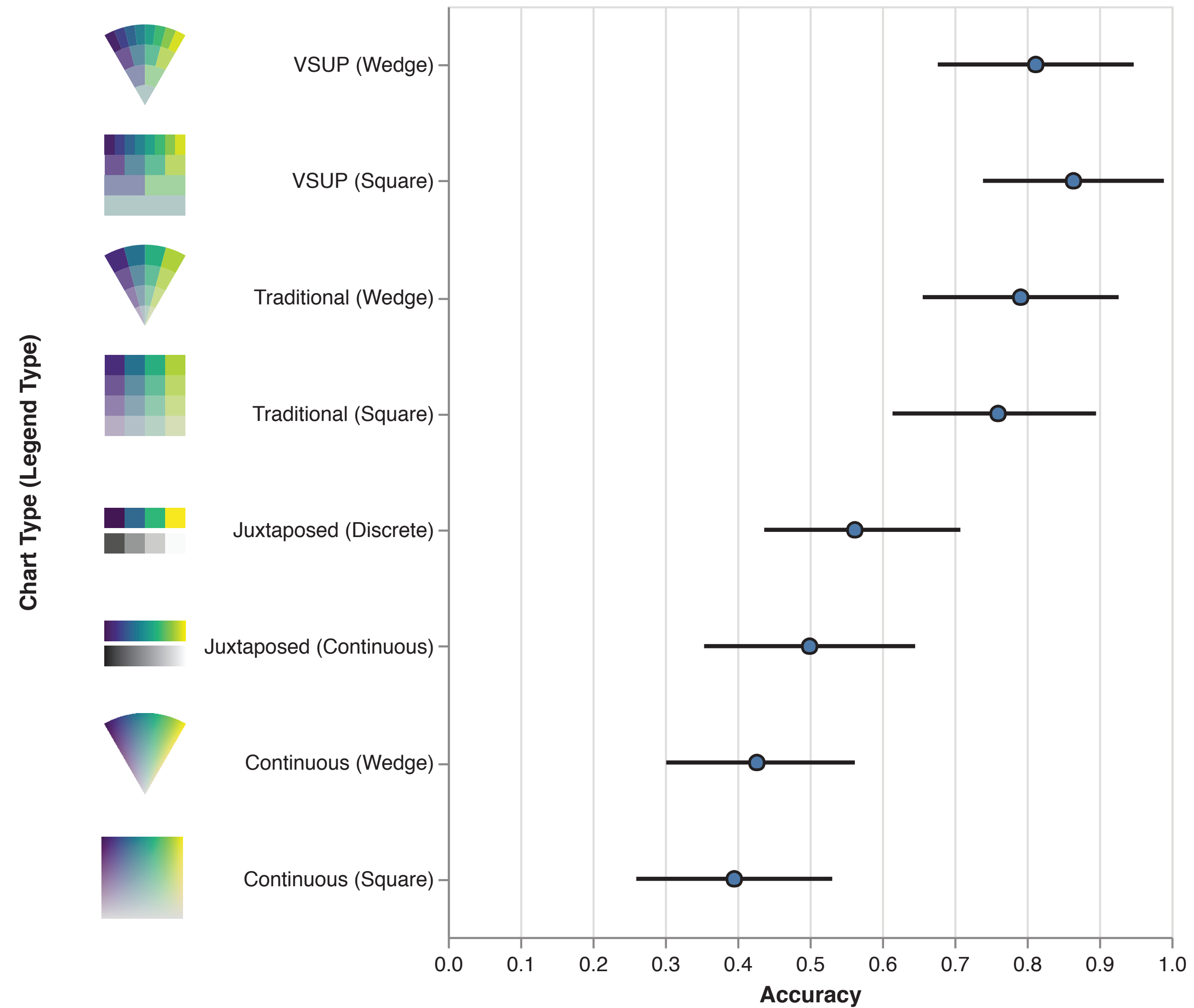


"safest locations"



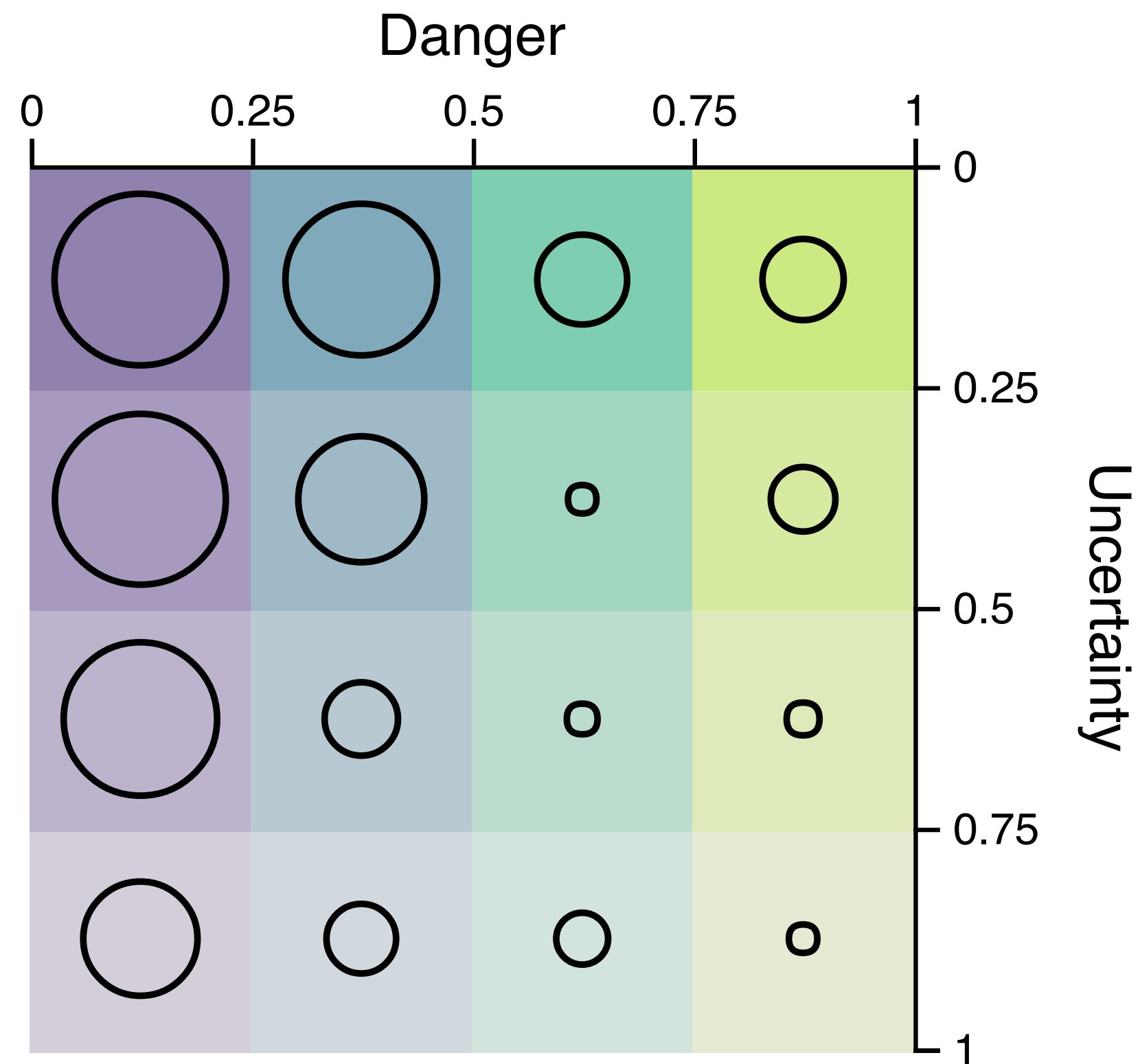
[Correll et al., 2018]

Identification Results

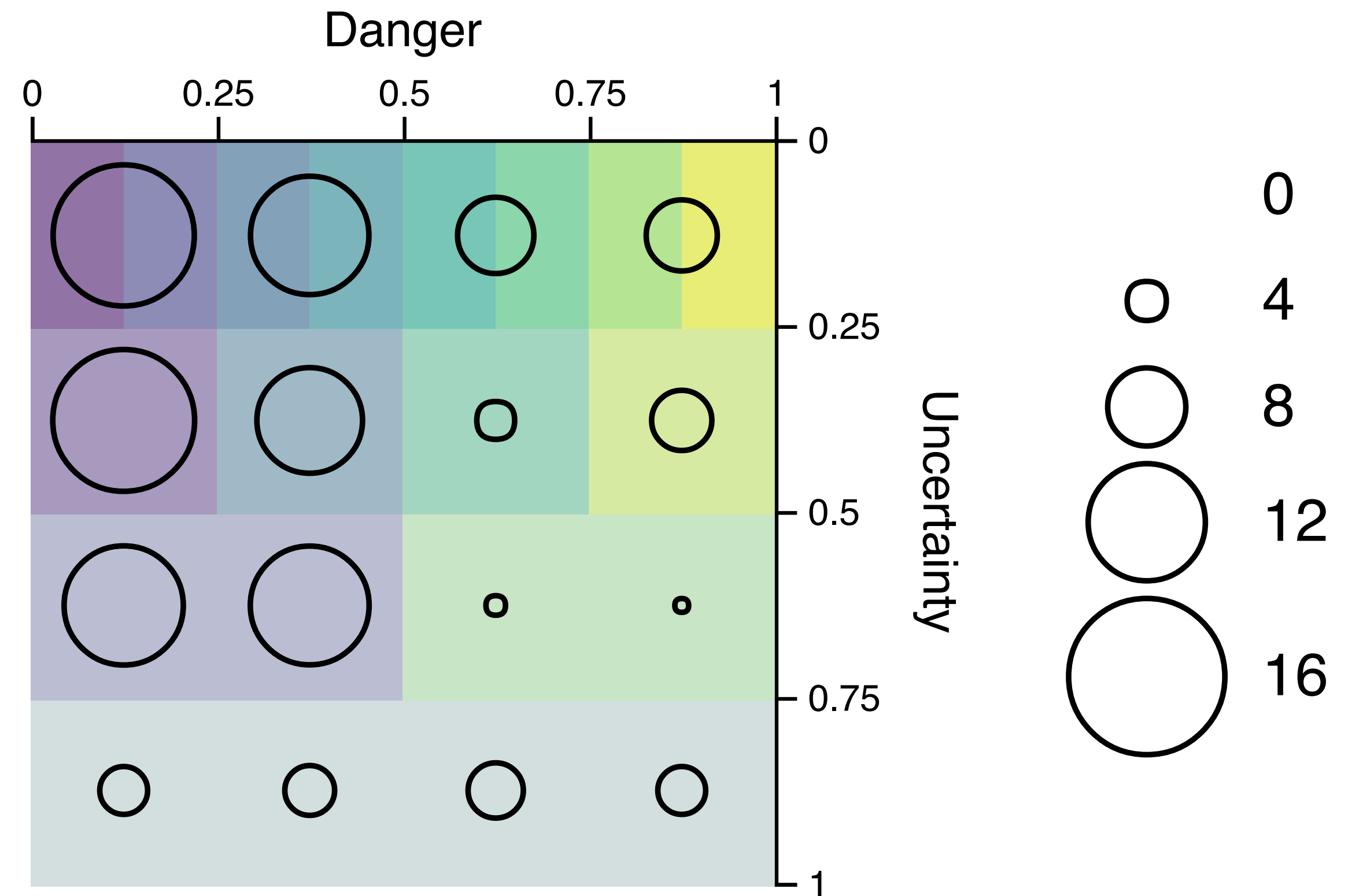


[Correll et al., 2018]

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

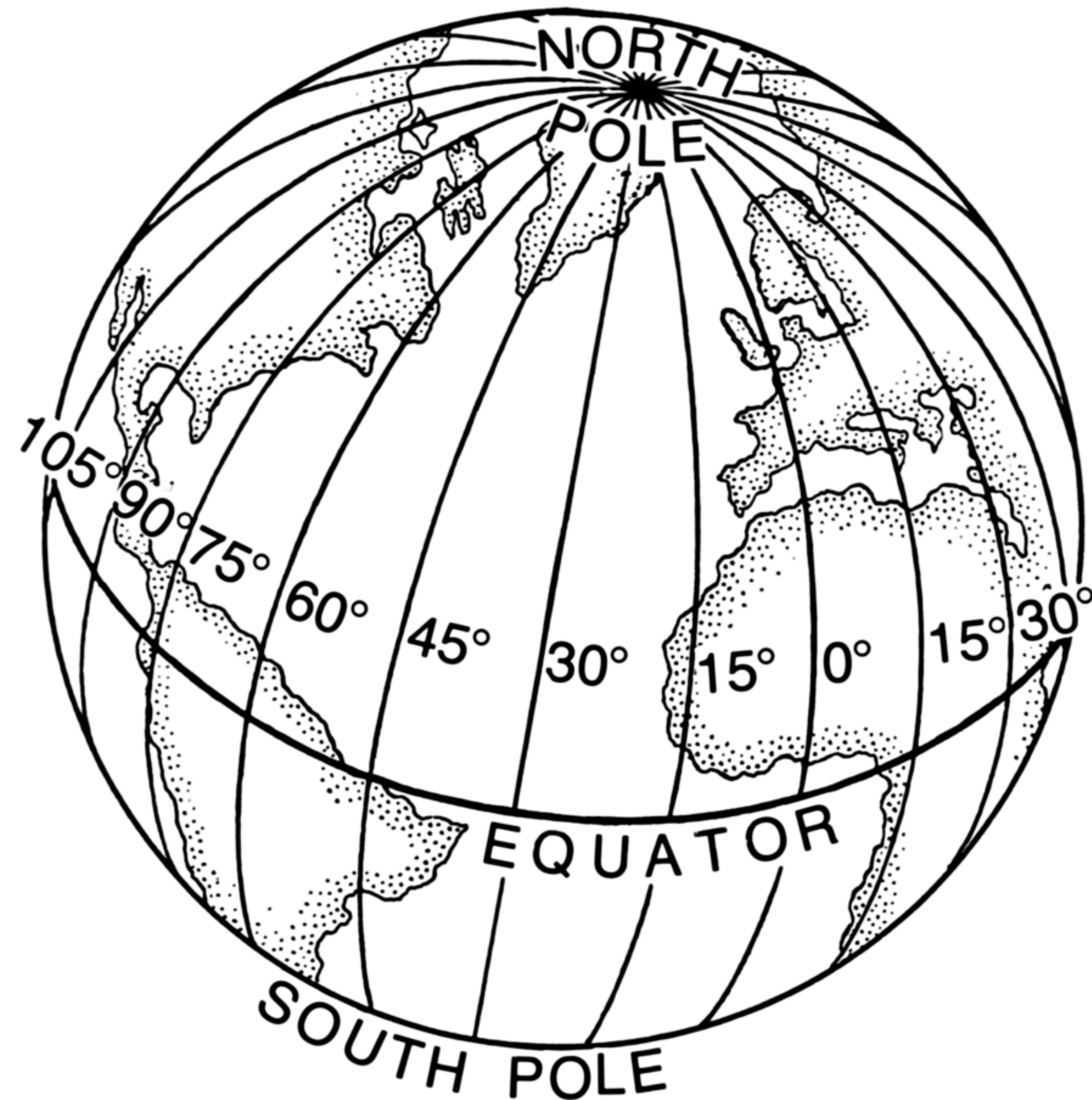
[Correll et al., 2018]

Geospatial Data

Geographic Data

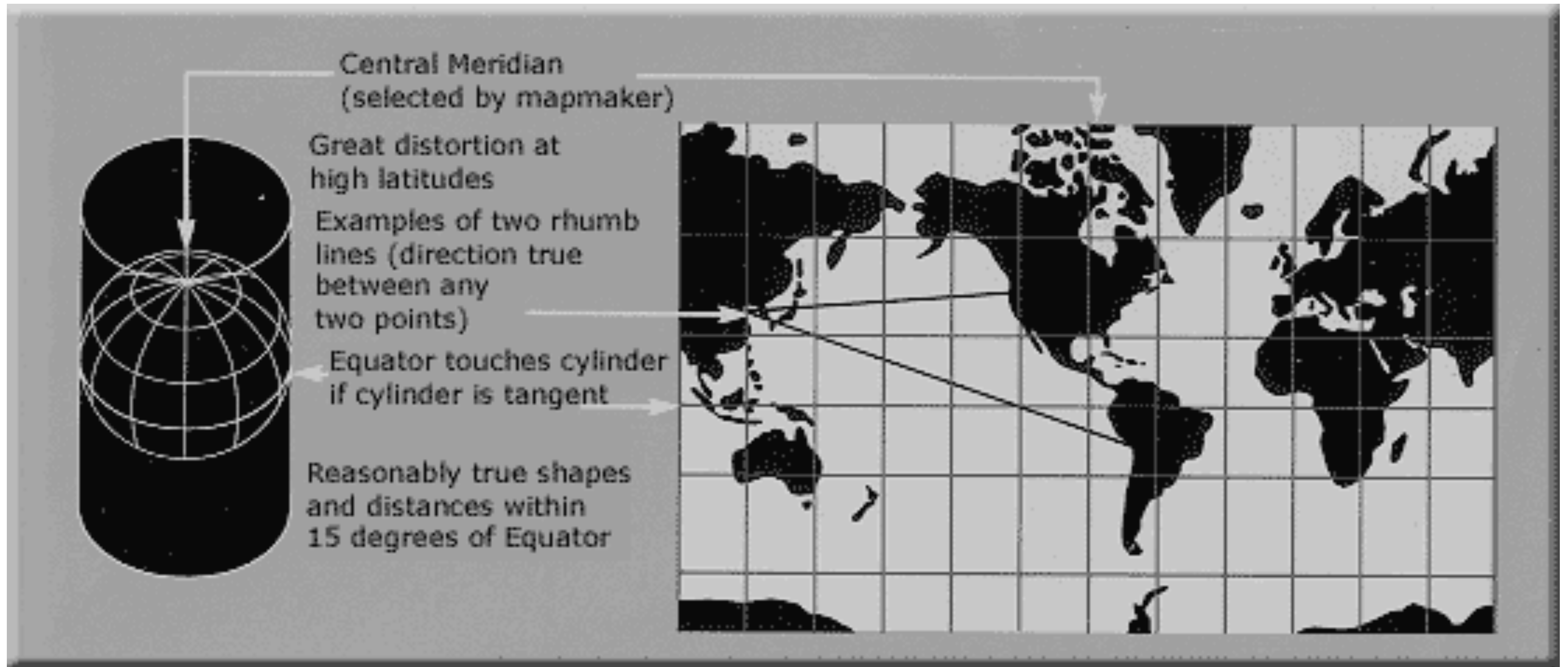
- Spatial data (have positions)
- Cartography: the science of drawing maps
 - Lots of history and well-established procedures
 - May also have non-spatial attributes associated with items
 - Thematic cartography: integrate these non-spatial attributes (e.g. population, life expectancy, etc.)
- Goals: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

Map Projection



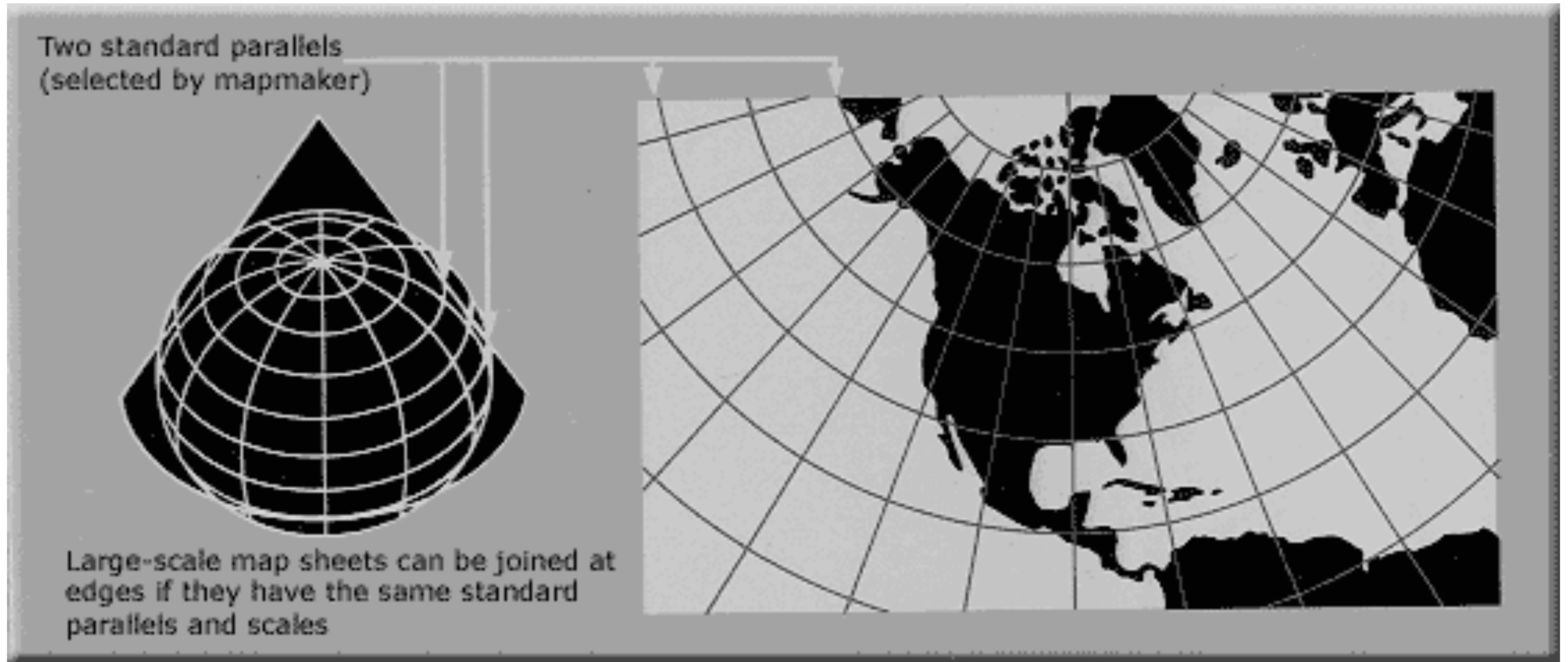
[P. Foresman, Wikimedia]

Flattening the Sphere?



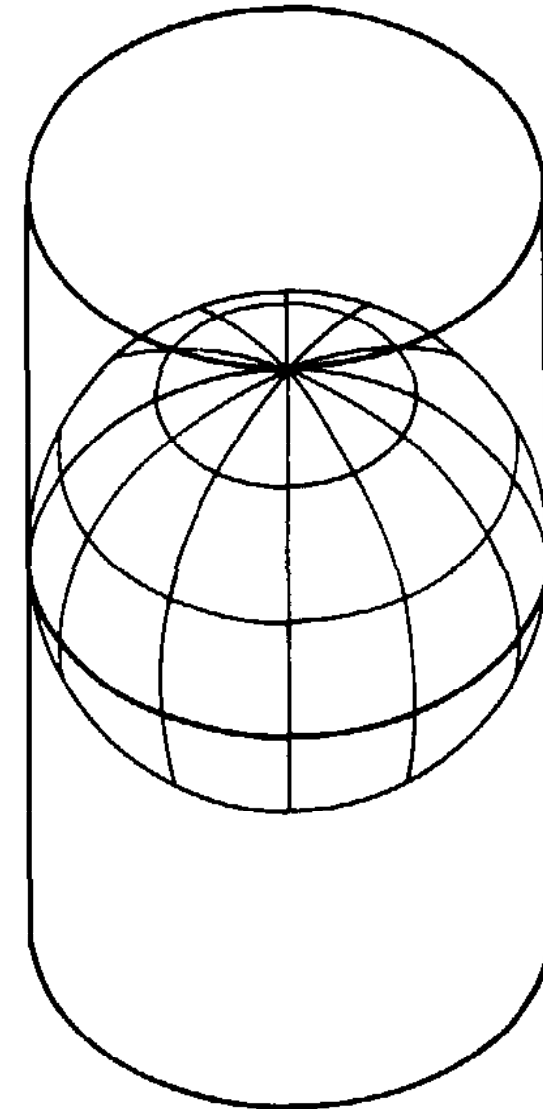
[USGS Map Projections]

Lambert Conformal Conic Projection

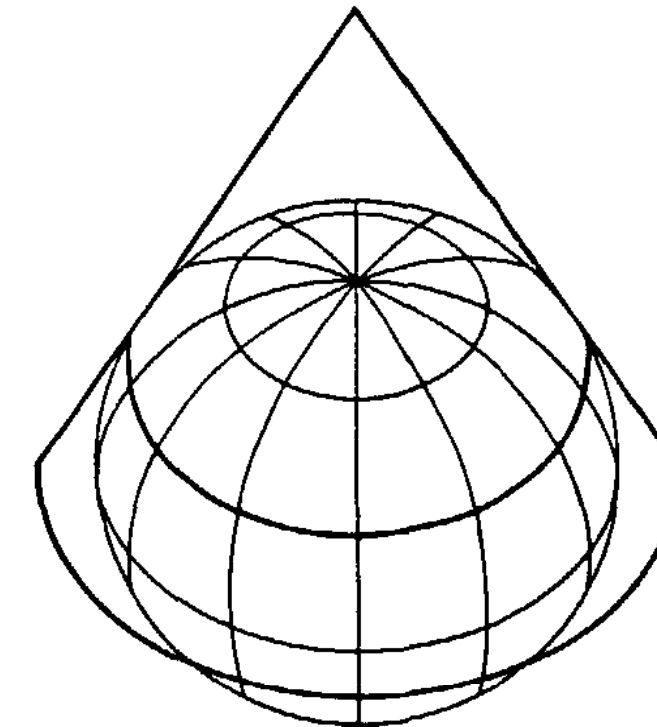


[USGS Map Projections]

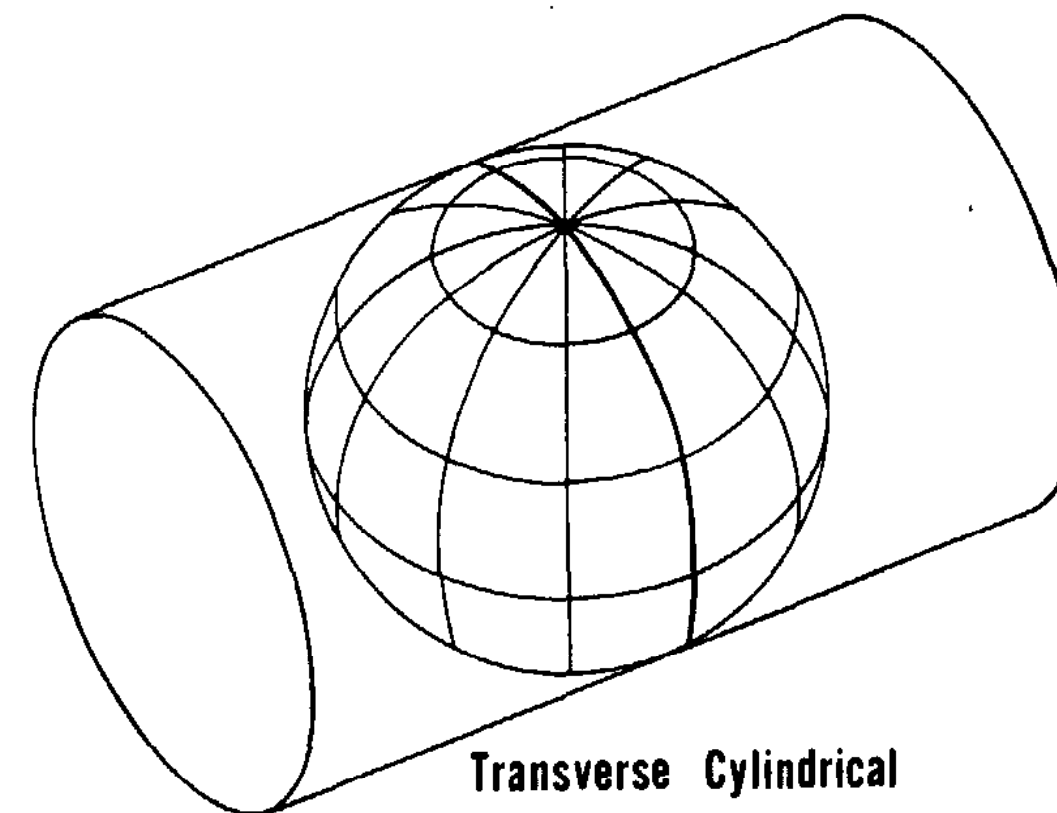
Standard Projections



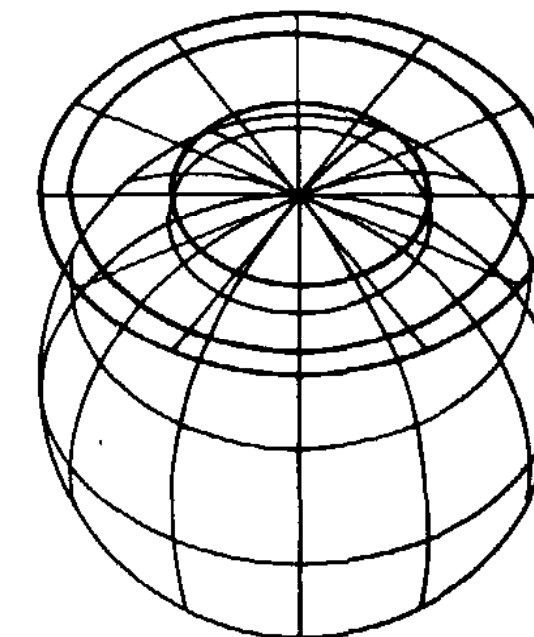
Regular Cylindrical



Regular Conic



Transverse Cylindrical



Polar Azimuthal
(plane)

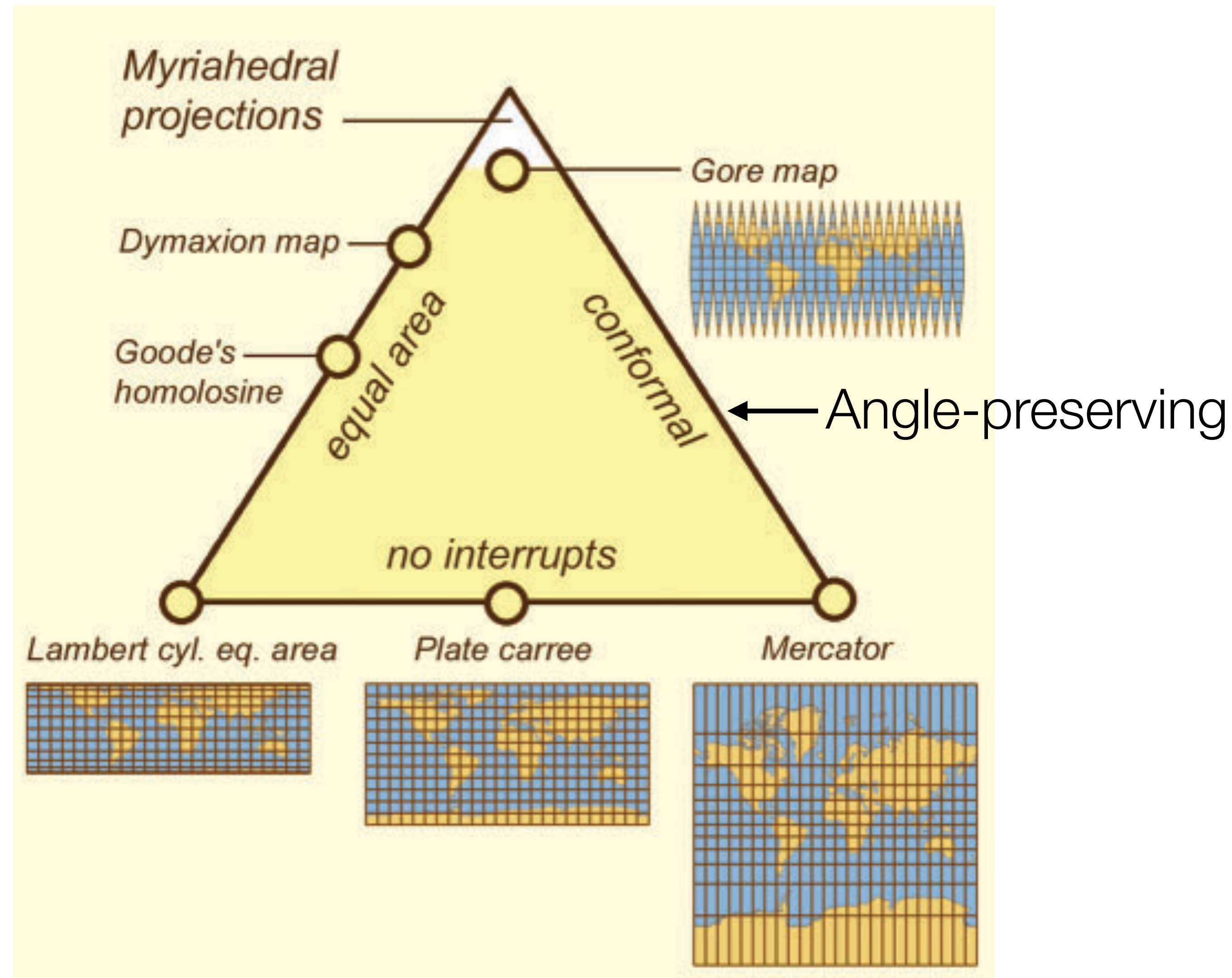
[J. P. Snyder, USGS]

Map Projections



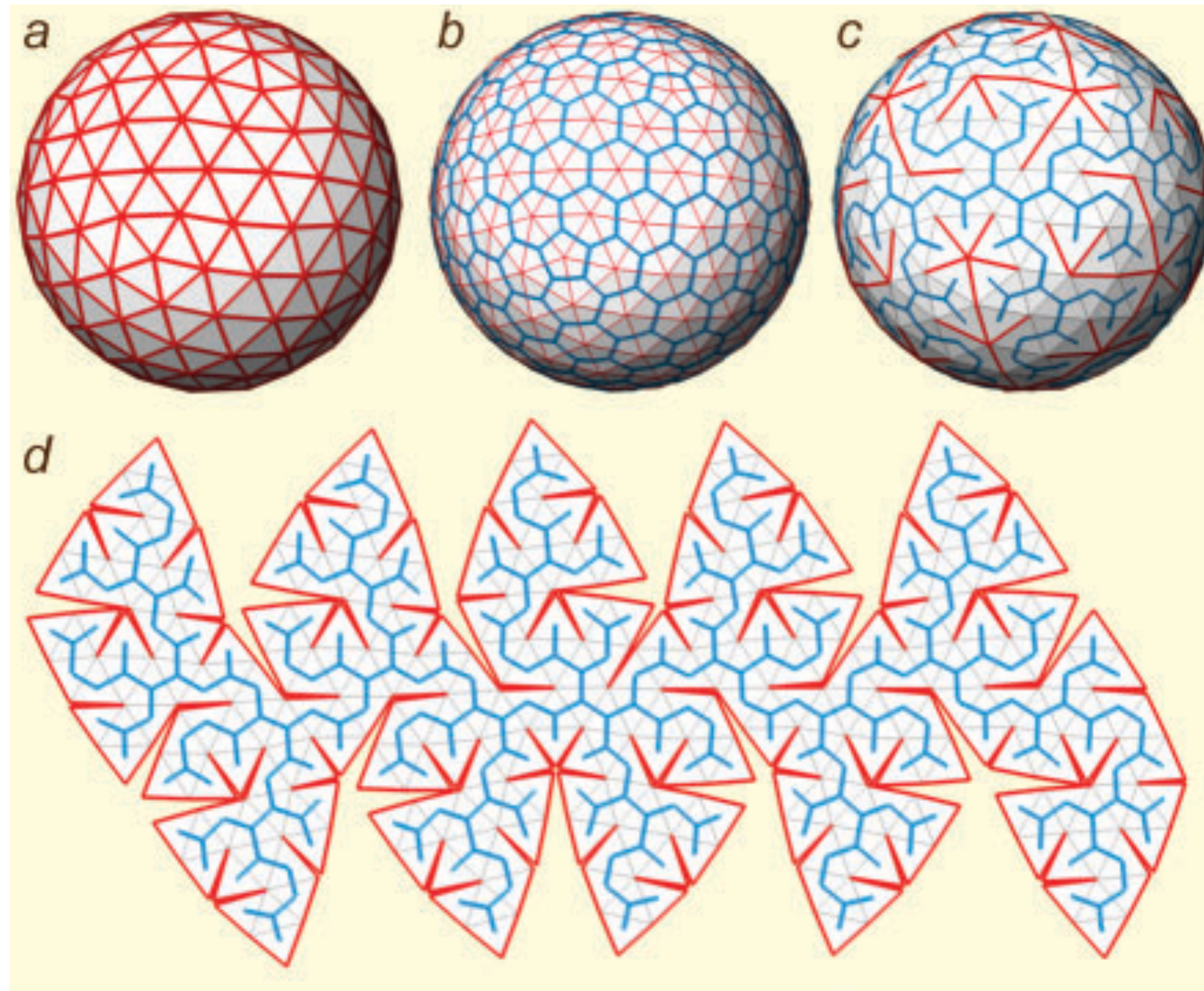
[xkcd]

Projection Classification



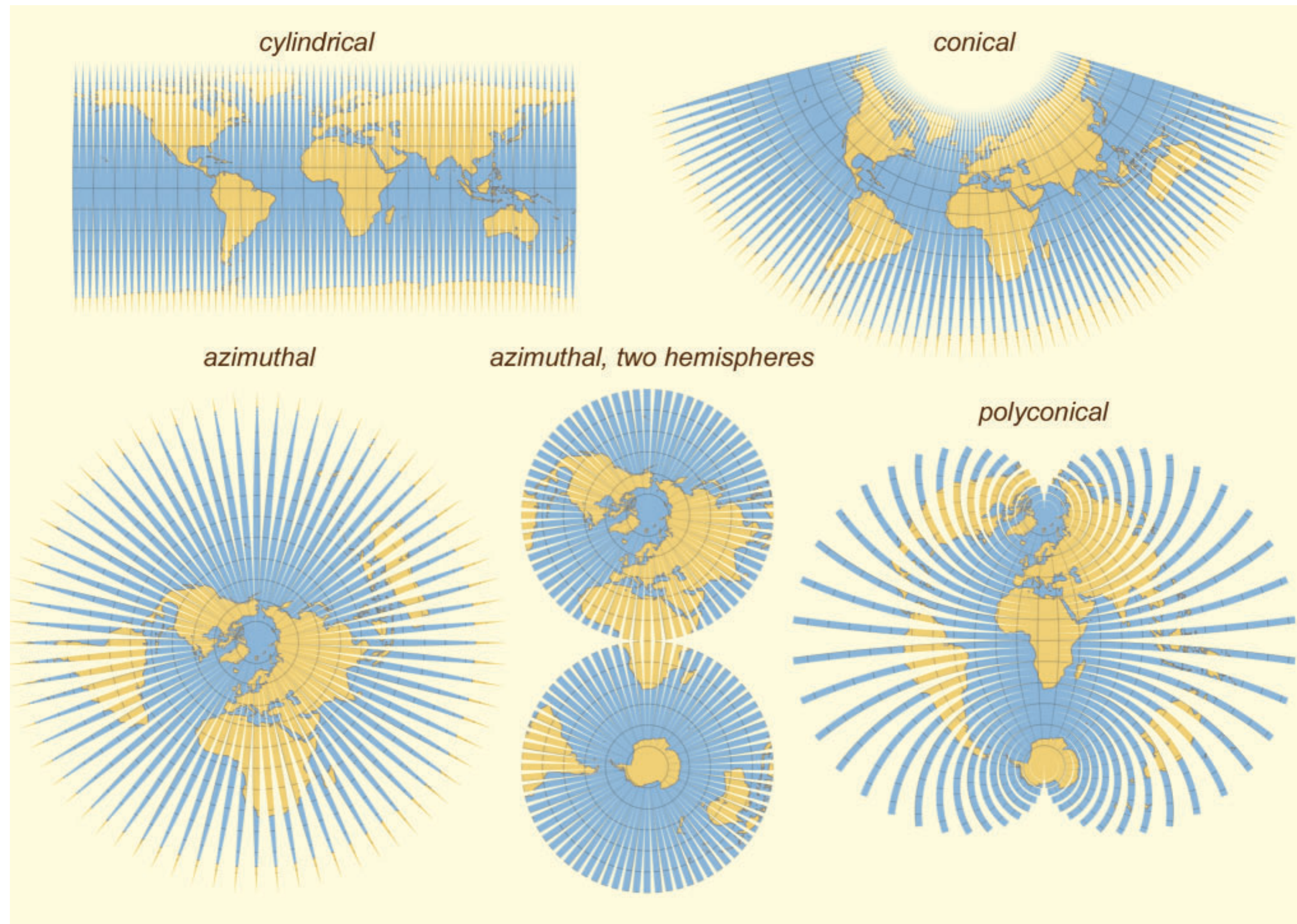
[J. van Wijk, 2008]

Myriahedral Projections



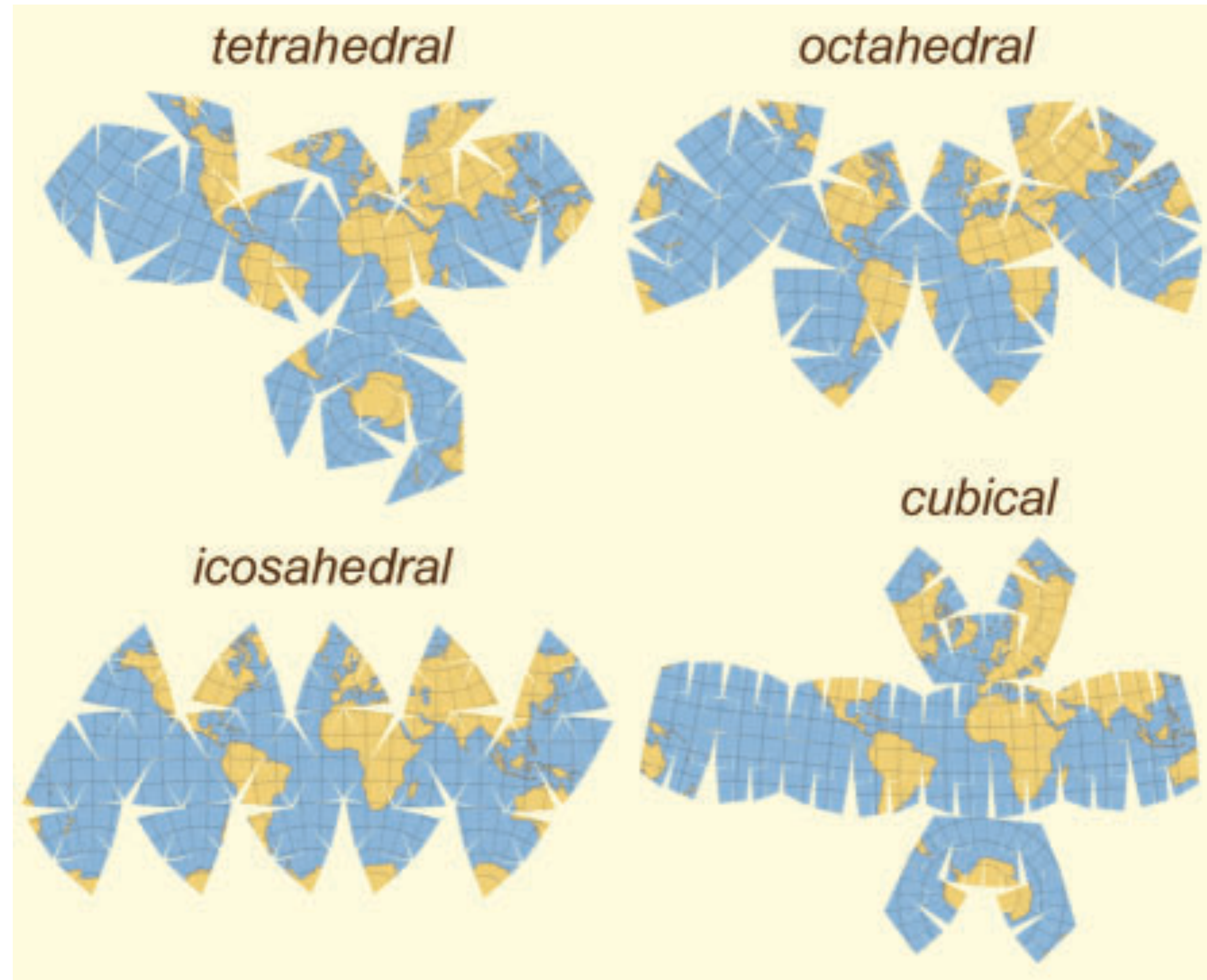
[J. van Wijk, 2008]

Cut along parallels or meridians (graticules)



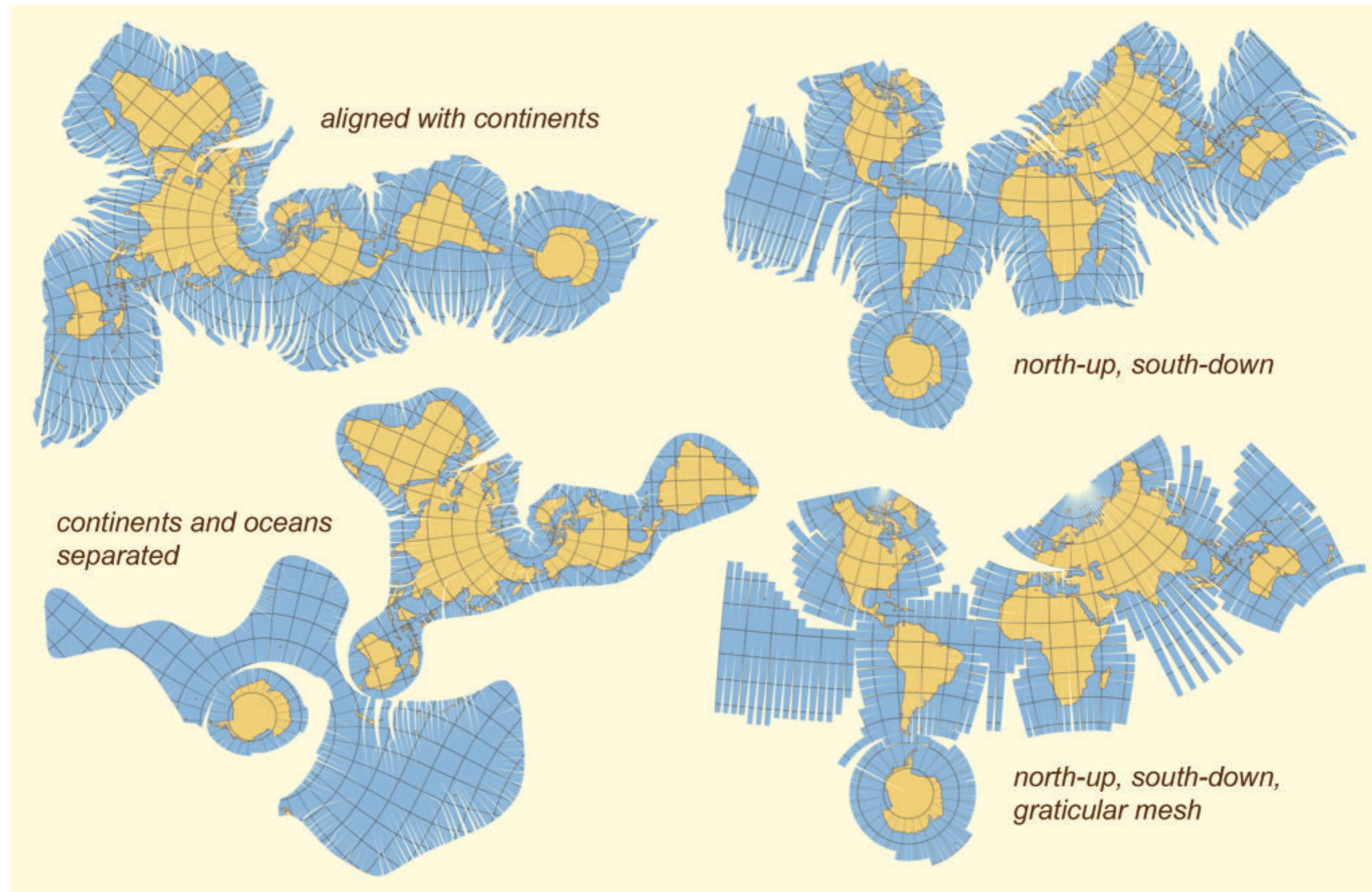
[J. van Wijk, 2008]

Subdividing regular polyhedra



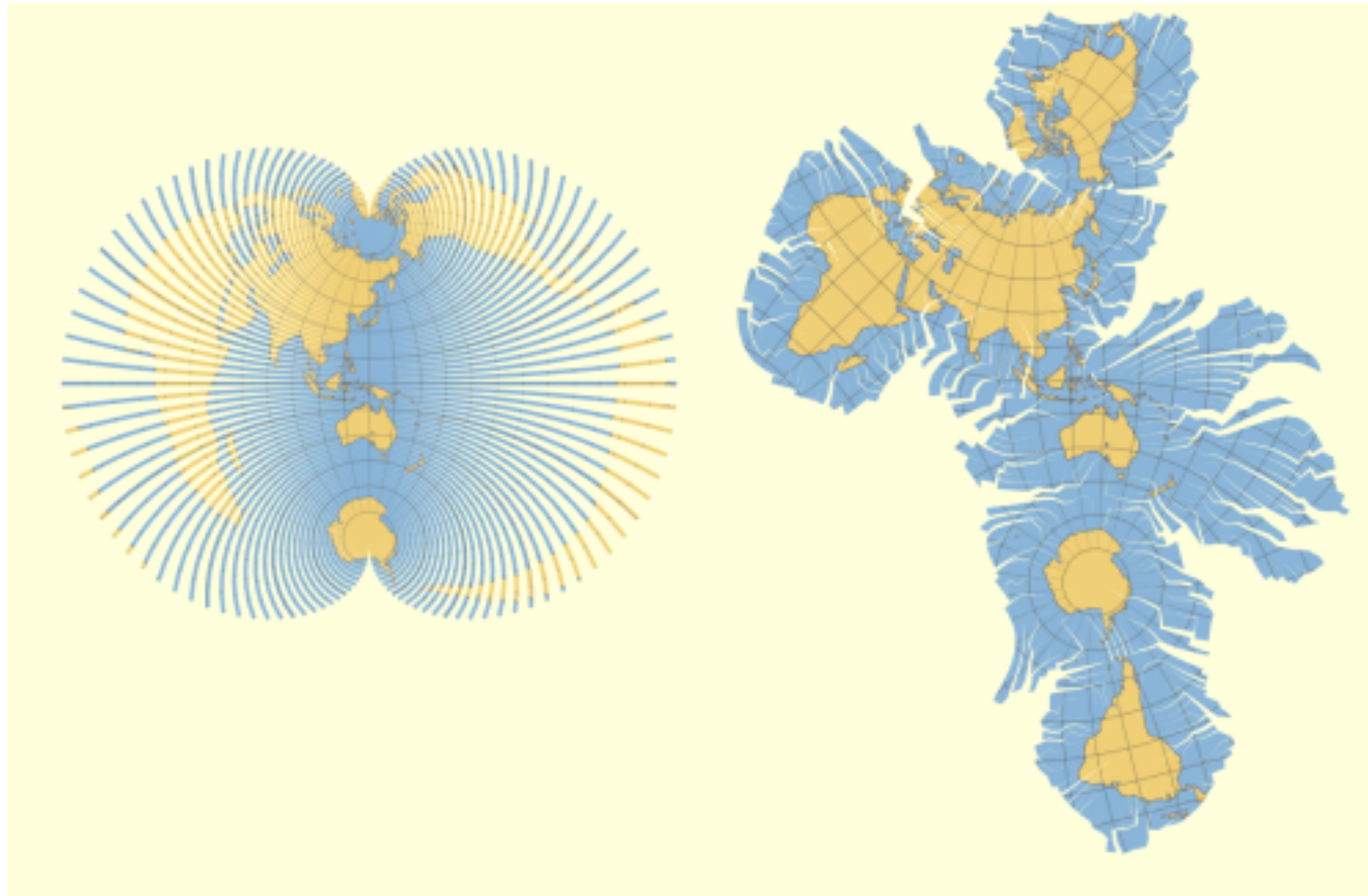
[J. van Wijk, 2008]

Geographically-aligned



[J. van Wijk, 2008]

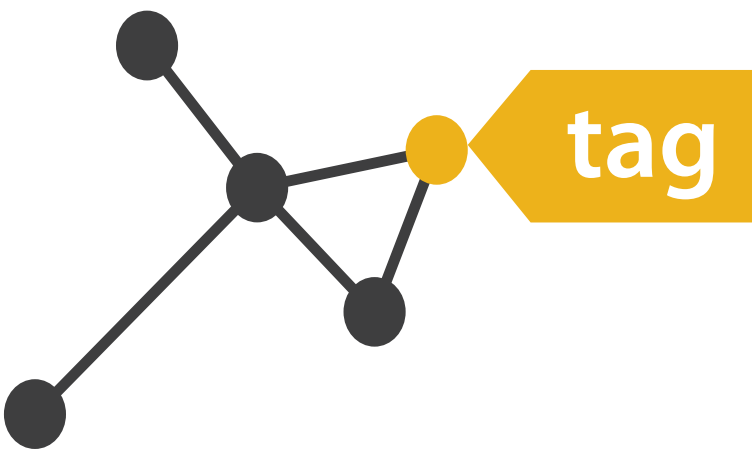
Australia-centric



[J. van Wijk, 2008]

Search Tasks

• *Associate*



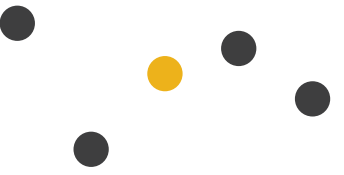
• *Record*



• *Derive*



➔ Search

	Target known	Target unknown
Location known	 <i>Lookup</i>	 <i>Browse</i>

[Munzner (ill. Maguire), 2014]

Lookup

Northern Illinois University, Lincoln

Northern Illinois University

4.2 ★★★★★ (206)

University

Directions

Save

Nearby

Send to your phone

Share

1425 Lincoln Hwy, DeKalb, IL 60115

Located in: Northern IL univ. Graham Hall

Open now: Open 24 hours

niu.edu

W6MG+M9 DeKalb, Illinois

Suggest an edit

Add missing information

Add phone number

Photos

All

By owner

Videos

Add a photo

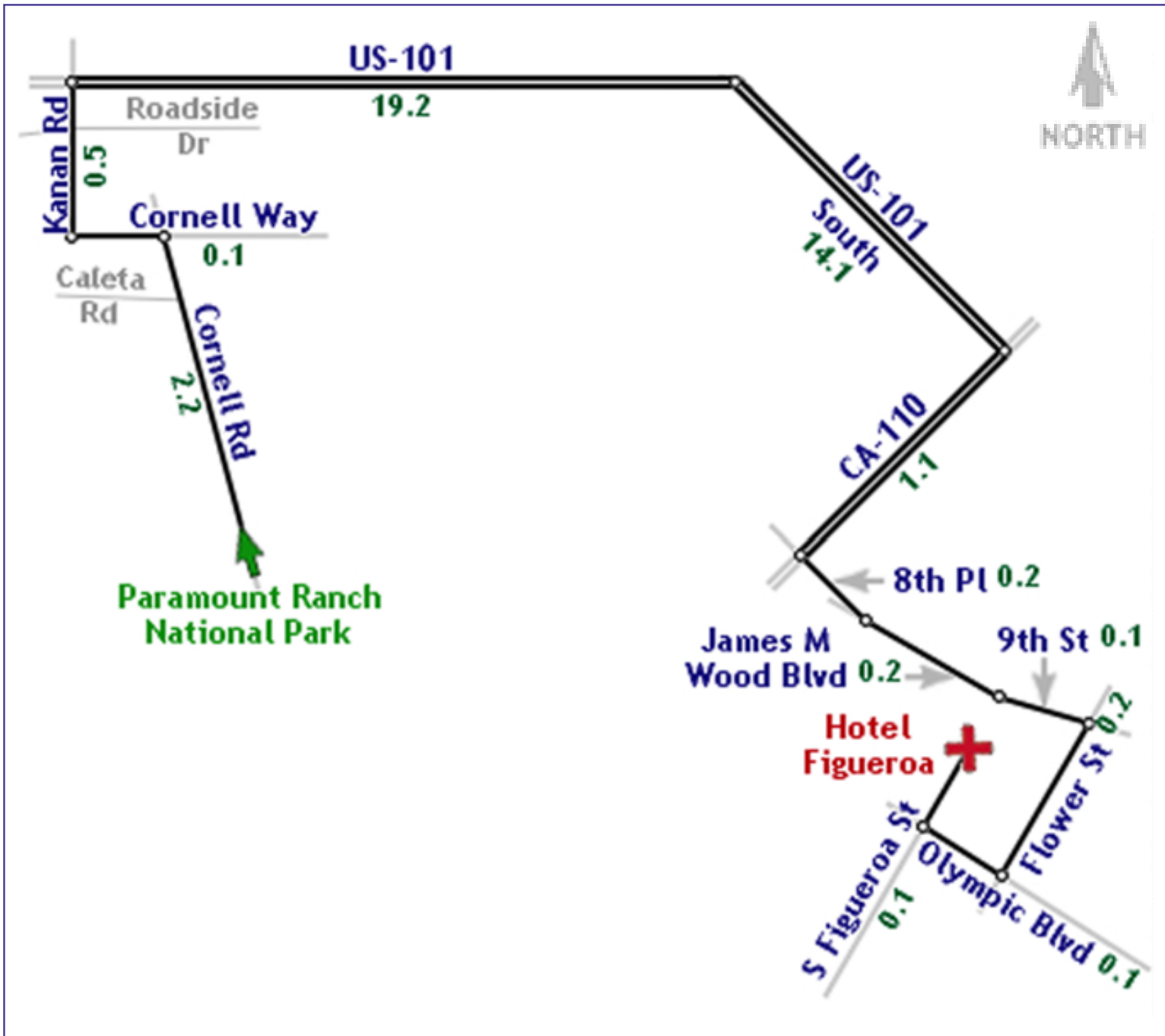
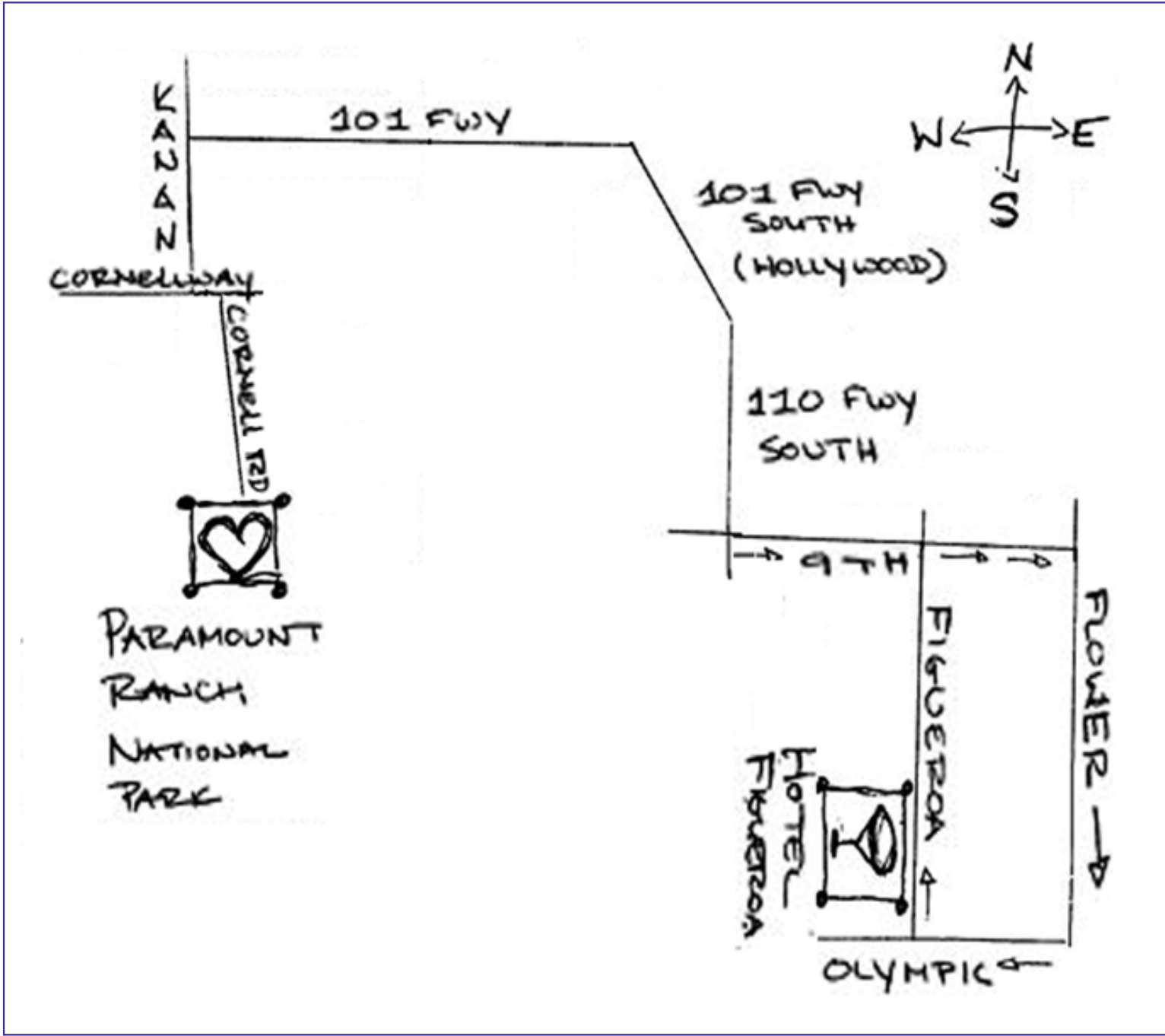
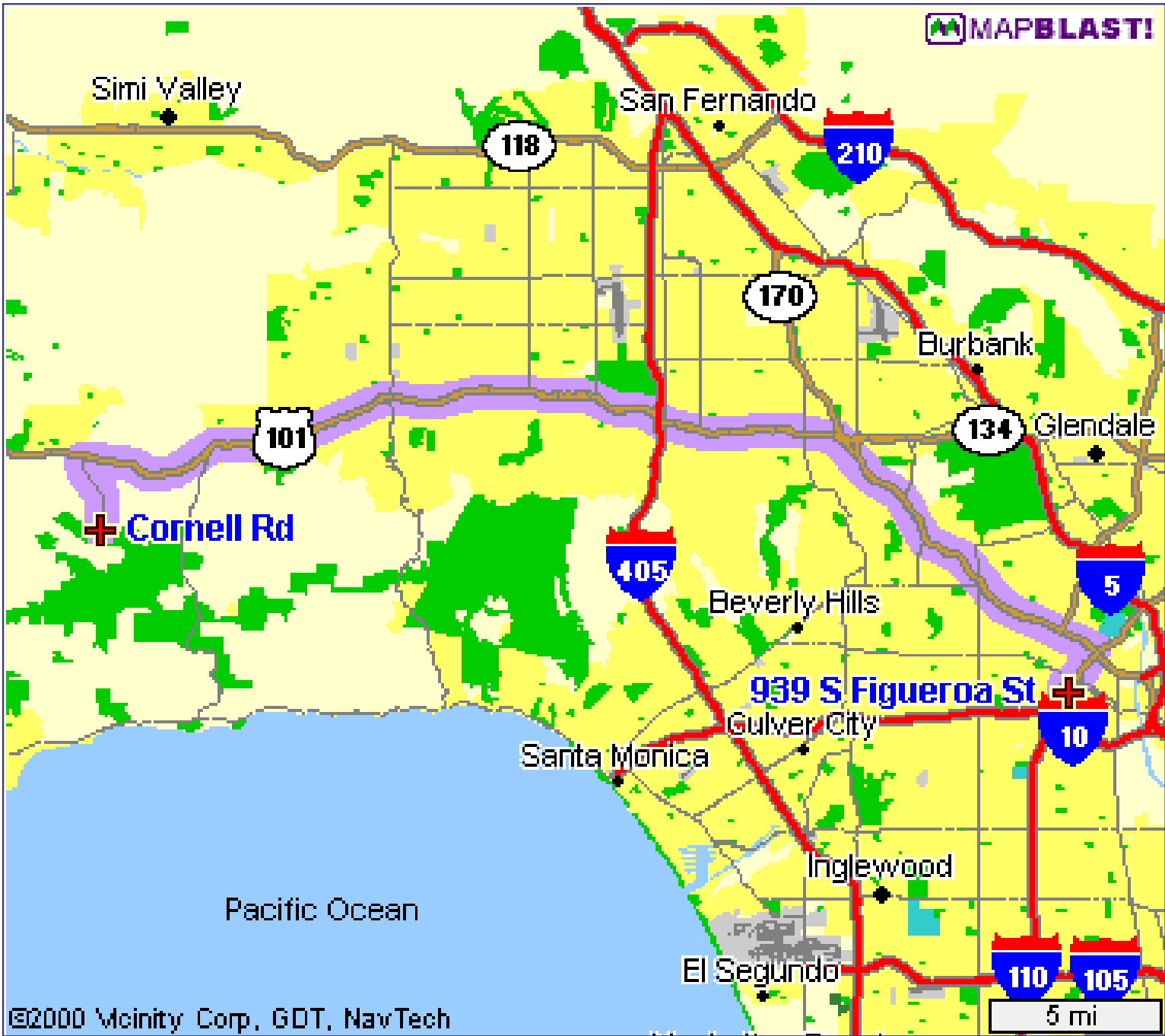
[Google Maps]

D. Koop, CSCI 627/490, Spring 2025

Northern Illinois University

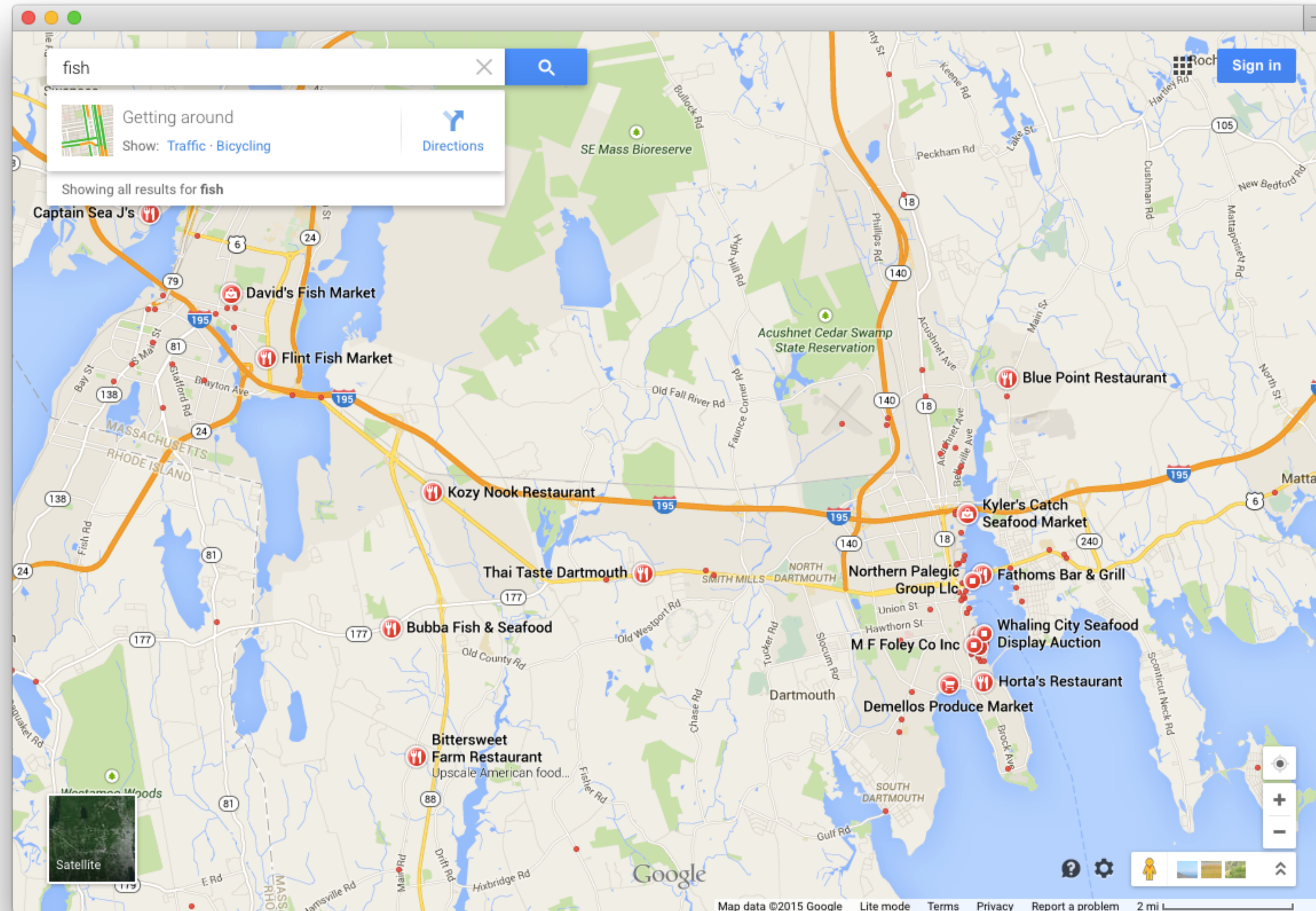
48

Route Maps



[Agrawala & Stolte, 2001]

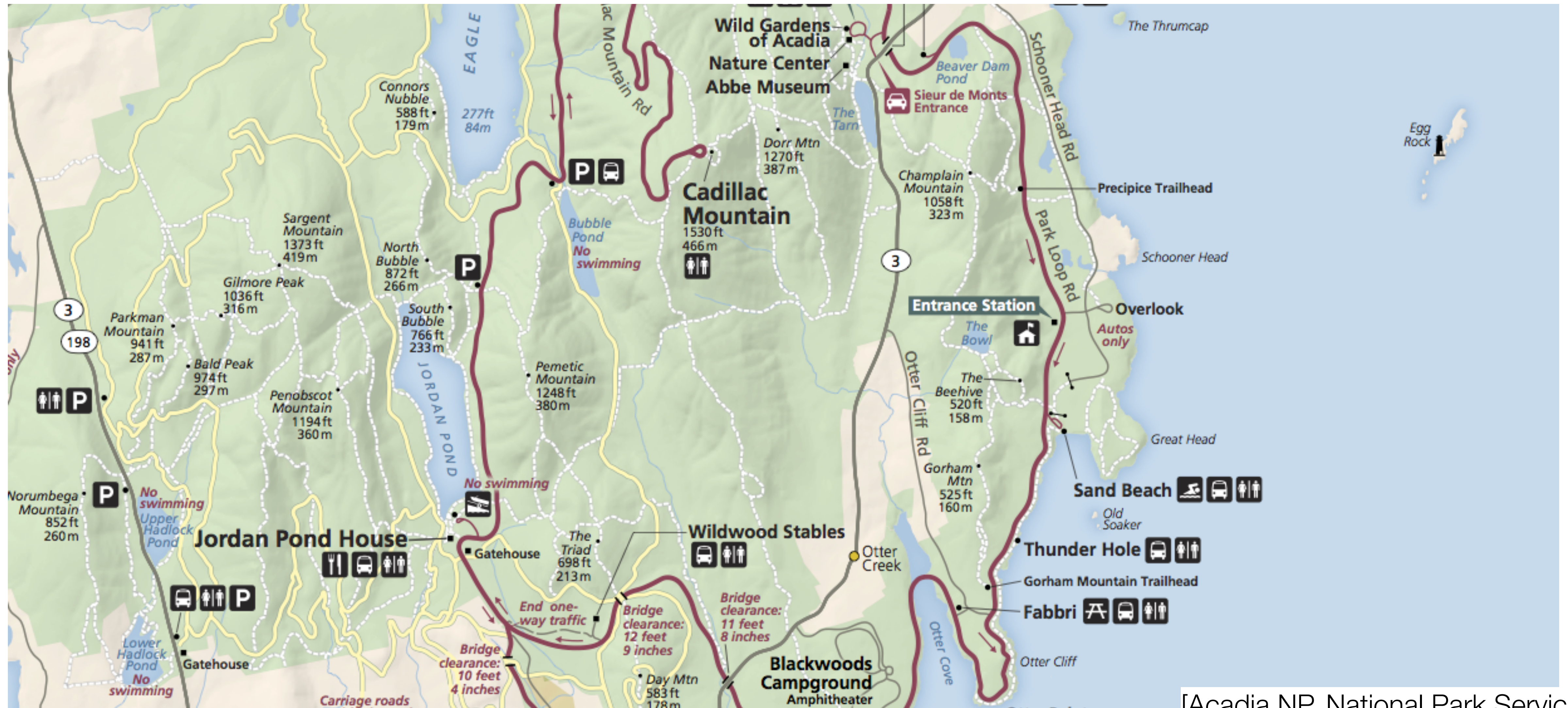
Locate



Adding Data

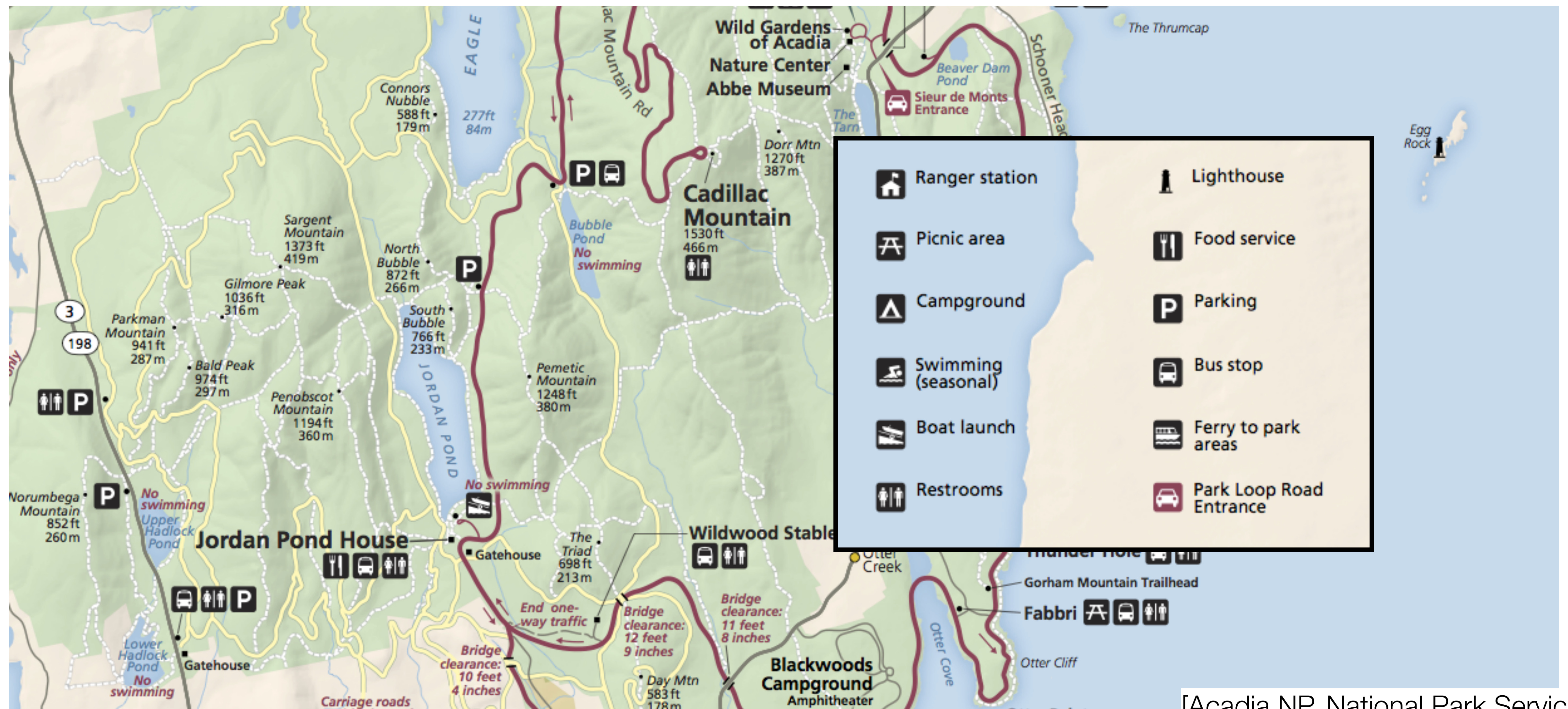
- Discrete: a value is associated with a specific position
 - Size
 - Color Hue
 - Charts
- Continuous: each spatial position has a value (fields)
 - Heatmap
 - Isolines

Discrete Categorical Attribute: Shape



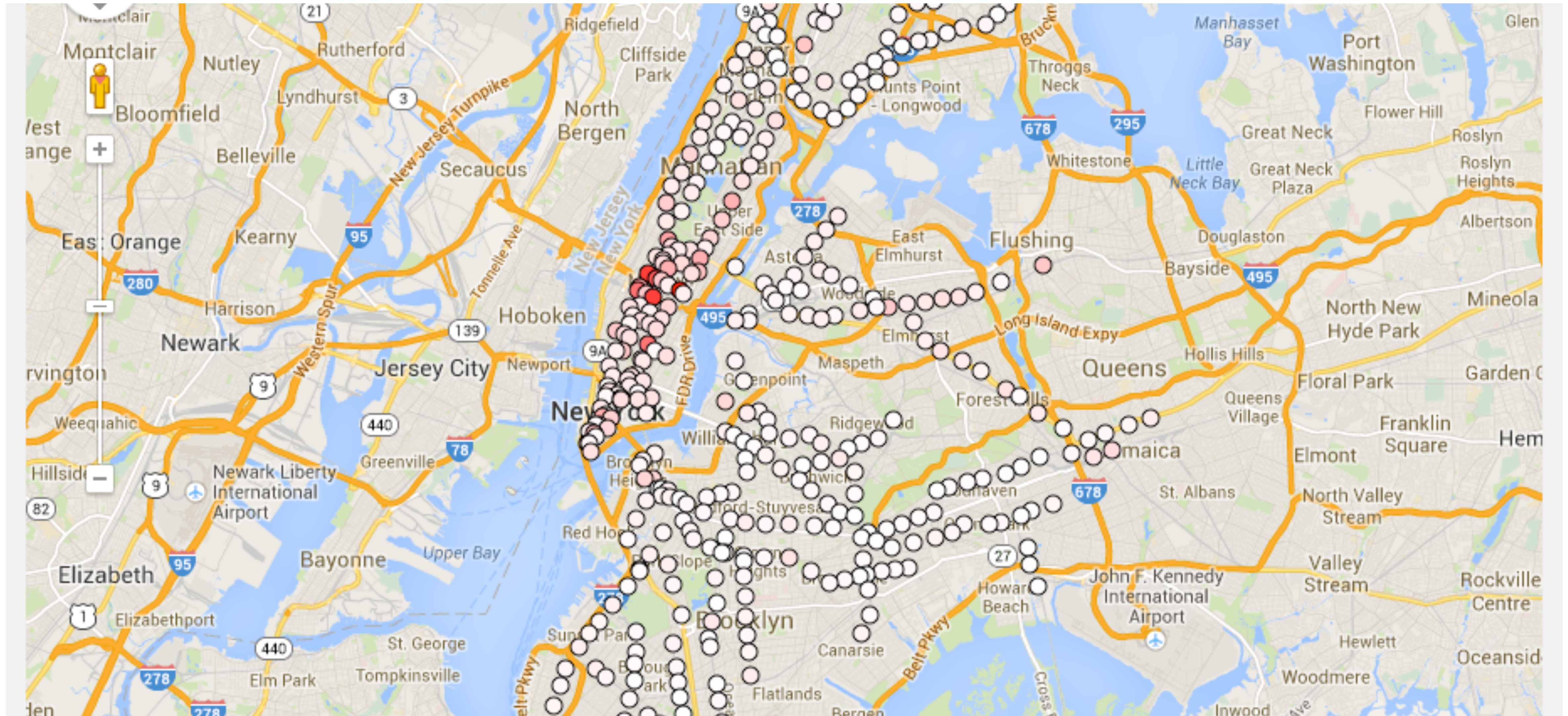
[Acadia NP, National Park Service]

Discrete Categorical Attribute: Shape

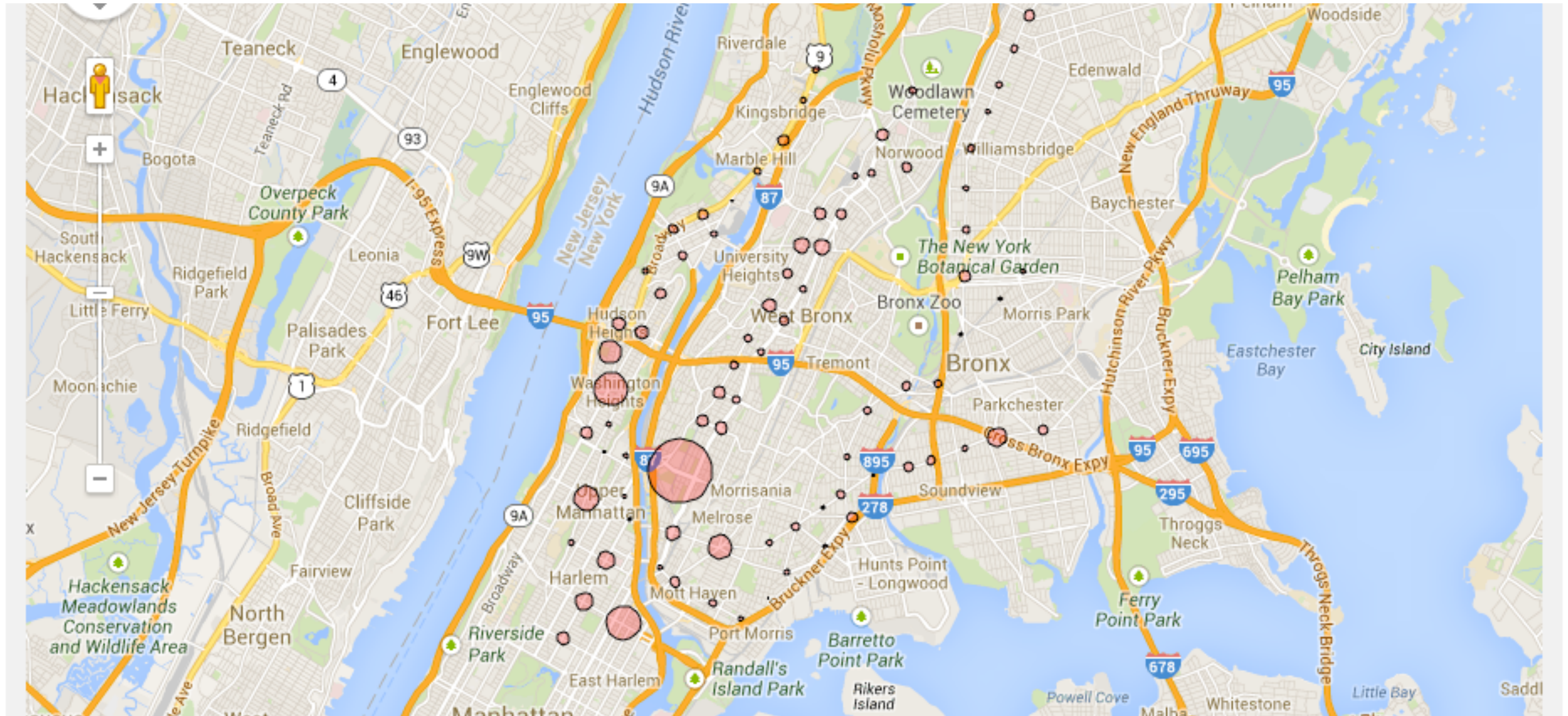


[Acadia NP, National Park Service]

Discrete Quantitative Attribute: Color Saturation

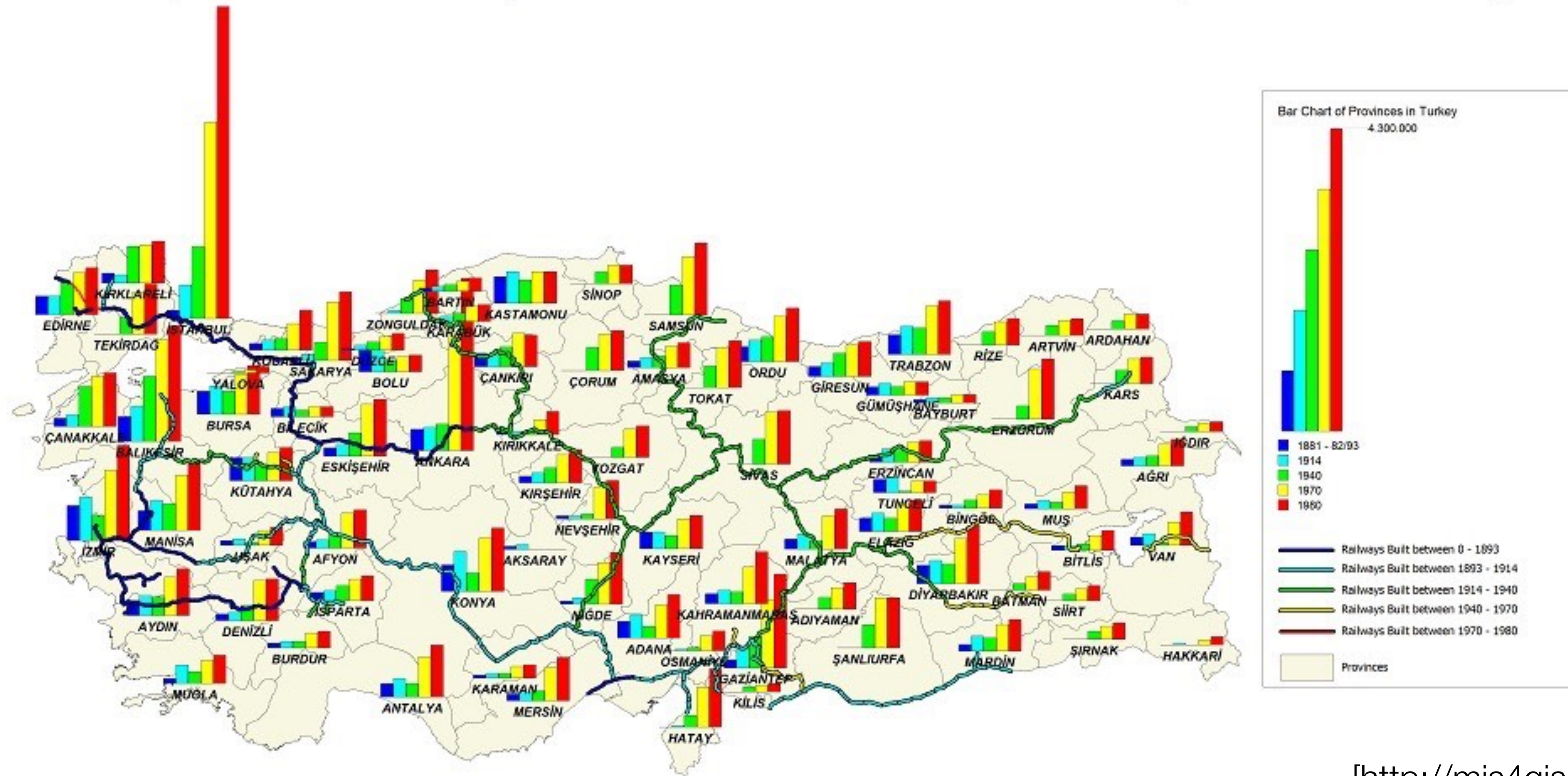


Discrete Quantitative Attribute: Size



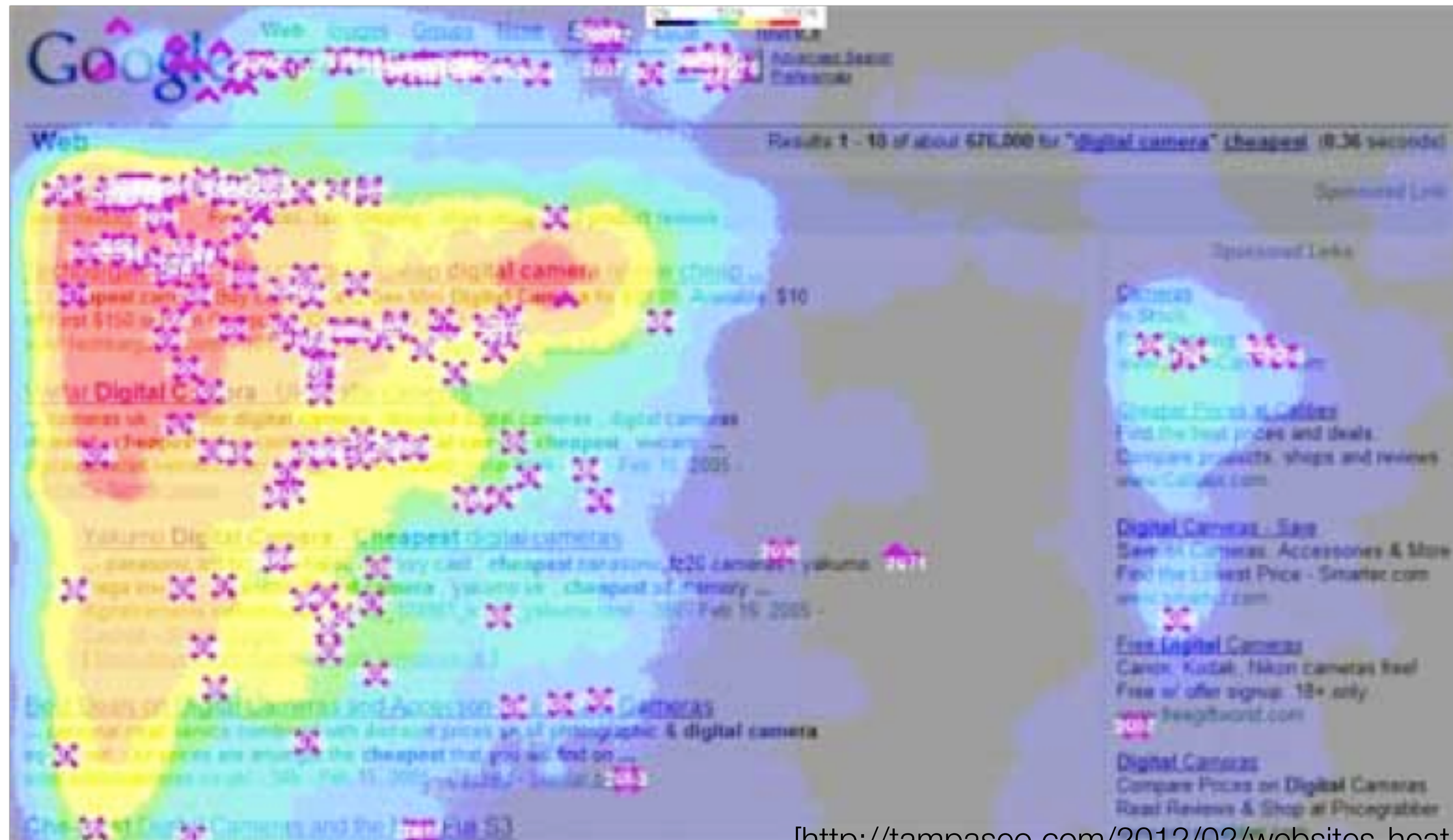
Discrete Quantitative Attributes: Bar Chart

Railway Network Development and Bar Chart of Province Population in Turkey



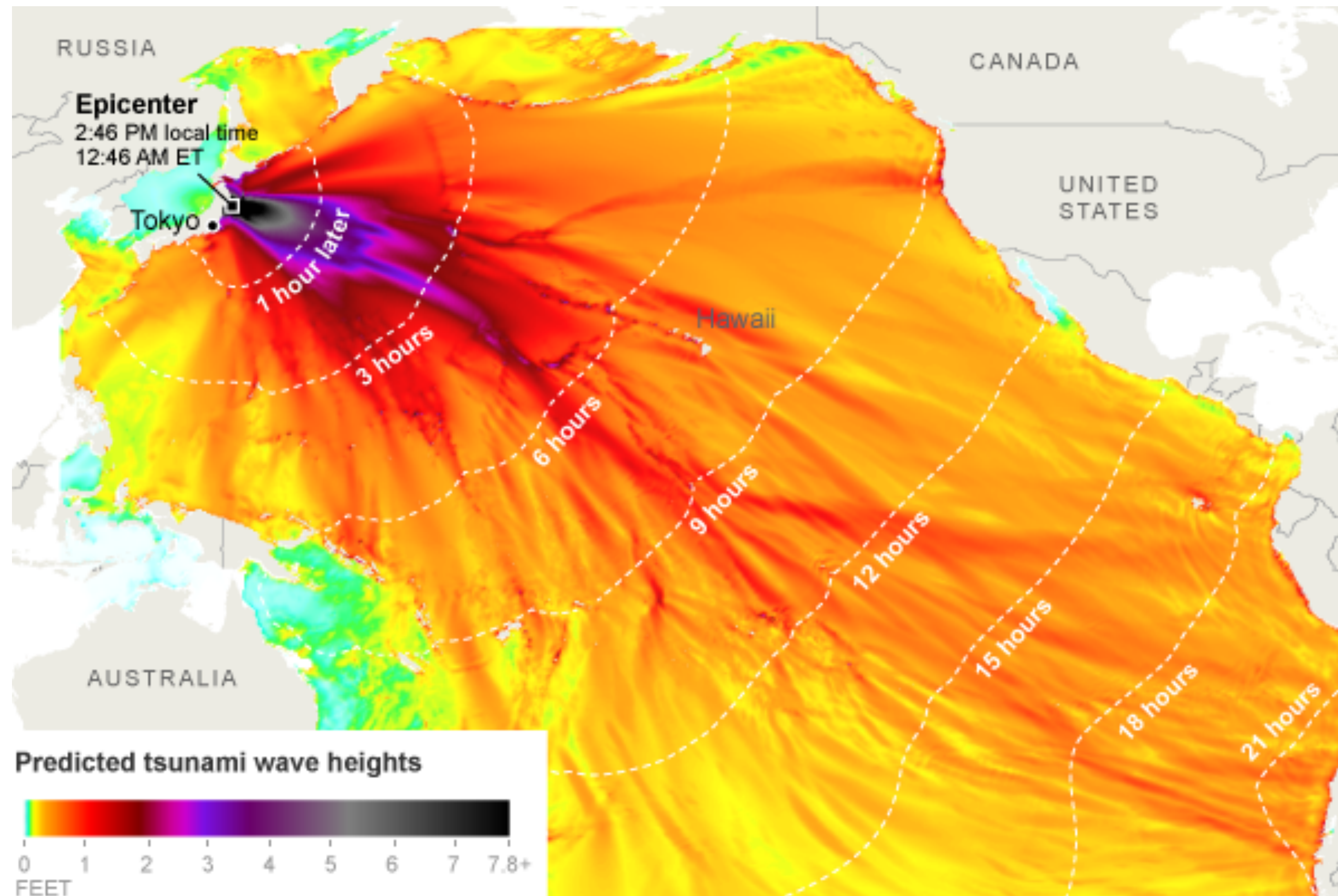
[<http://mis4gis.com/hgistr.org/>]

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?