Measurement levels and quality of maps

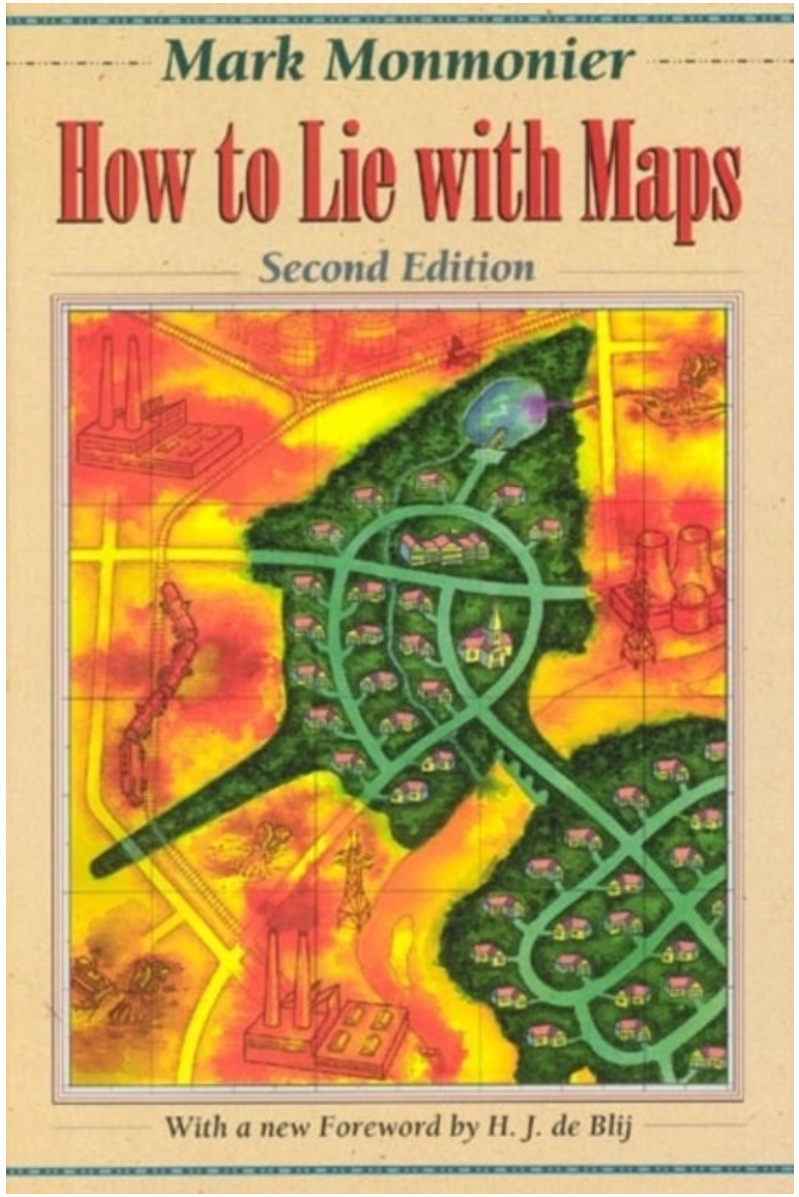
Spatial Data Analysis and Simulation modelling,
2020, Simon Scheider

Quality of maps

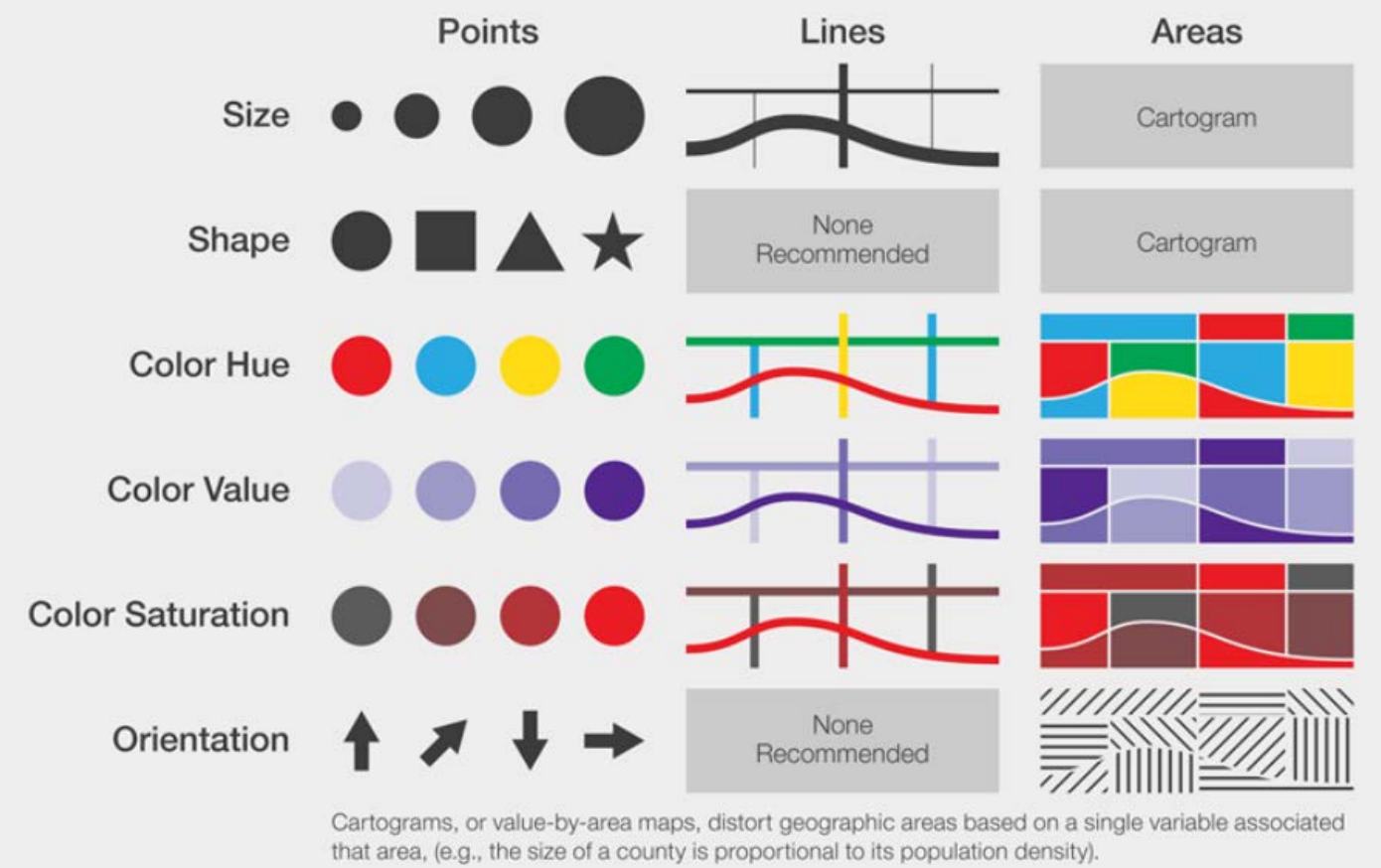
Simon Scheider, Fred Toppen

The quality of maps

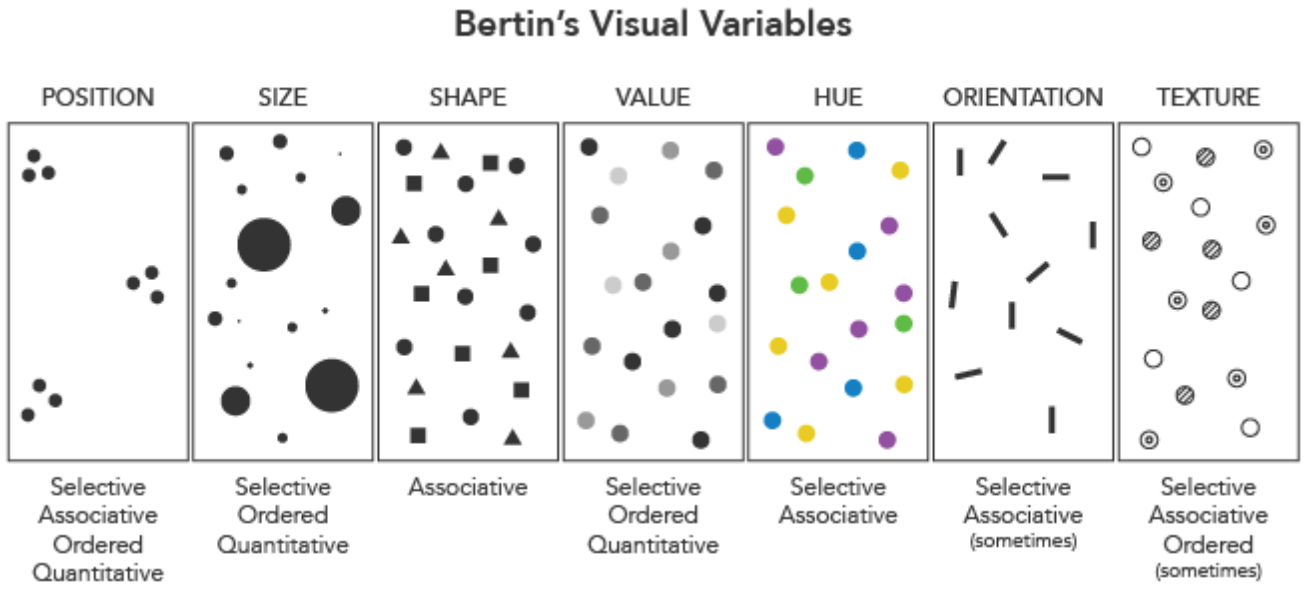
- See Mark Monmonier 1996: “How to lie with maps”



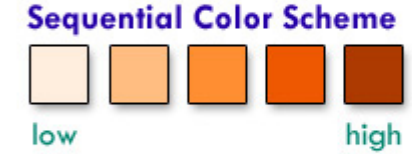
Bertin’s (1967) visual variables



Visual variables and their properties



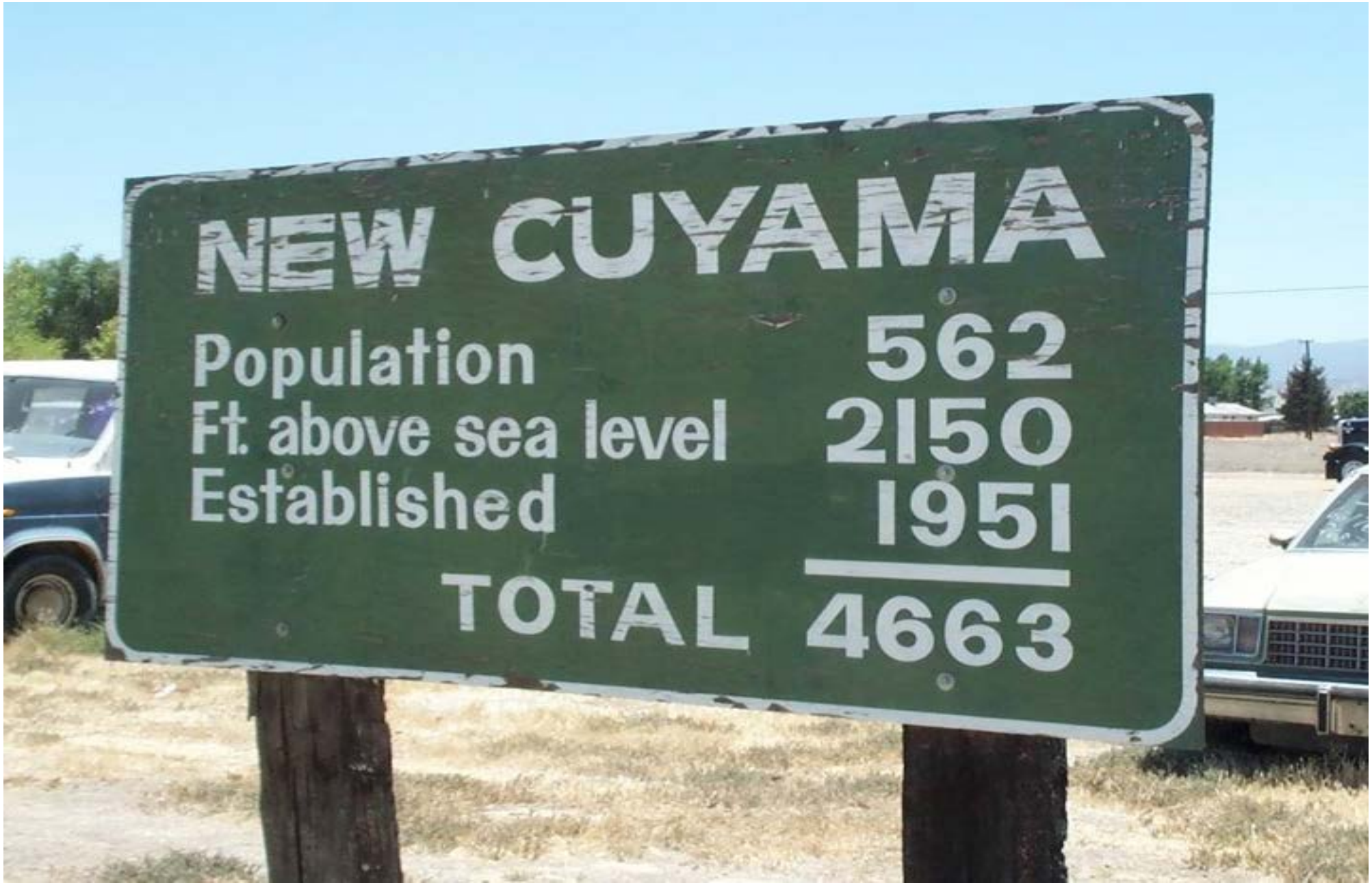
different hues that keep lightness and saturation constant should be used for nominal data (i.e., un-orderable categories, not numerical data).



any sequence that is dominated by changes in lightness can be used with orderable (rankable) categories (low/med/high) or with numerical data.

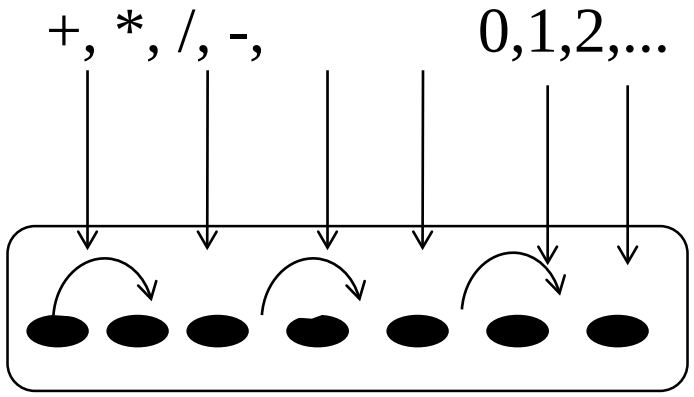
any numerical data that can be divided meaningful at a mid-point (e.g., national average, zero) can use a diverging scheme: the data are split in two around the lightest, middle color/class.

Decide about suitability for mapping an attribute which is on a certain *level of measurement*


NEW CUYAMA
Population 562
Ft. above sea level 2150
Established 1951
TOTAL 4663

Measurement scales (aka reference systems)

- Interpretations of signs into a domain of measurement
- For example, interpretation of “1” into a length (meter)
- Fixed by convention (think about the prototype meter)



Terms (relational symbols, numbers)

Interpretation / Convention

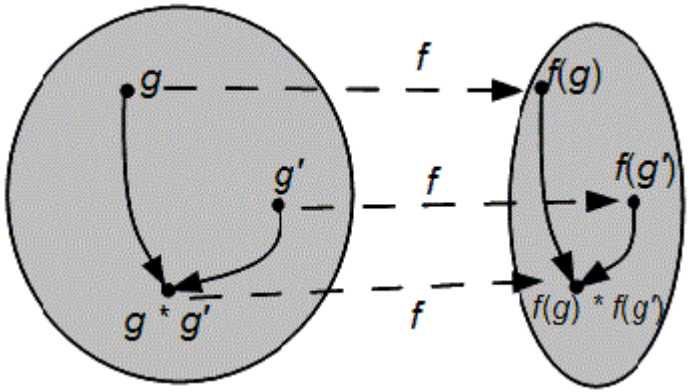
Domain

Levels of measurement (scale type)

- Define *which types of operations* are meaningfully applicable to a measurement scale
  (= which operations are preserved when going from one scale of measurement to the next)
- S.S. Stevens: “On the theory of scales of measurement." (1946)
- for geographic data, see N. Chrisman 1998: Reference Systems for Measurement, Chapter 2 of Exploring Geographic Information Systems ce

Levels of measurement: example temperature

- Temperature measured in °K und °C
- a homomorphic mapping (f) preserves „+“ and „-“ (differences)
- Other relations (*,/, the interpretation of 0°) are not preserved!
- Therefore, °K und °C are both on an „interval“ scale level
- … allows computing differences and sums, but no ratios

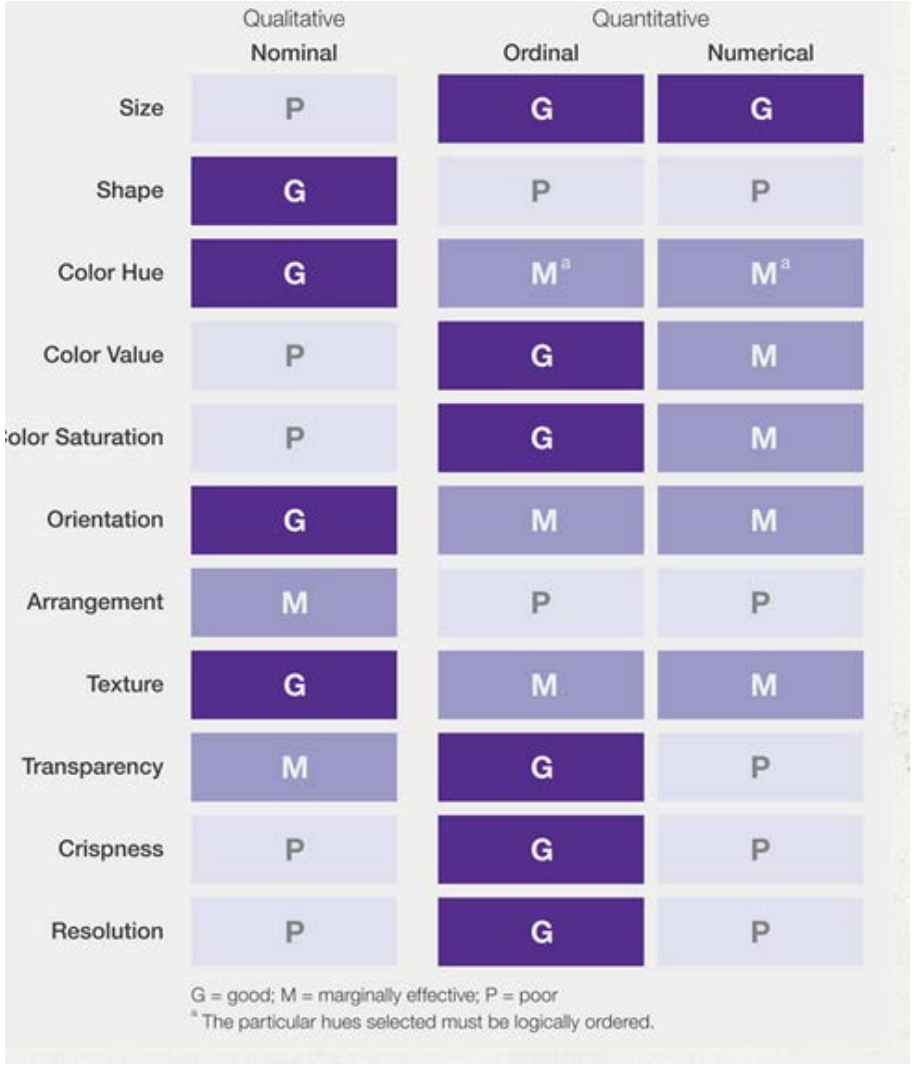


Levels of measurement (Stevens 1946)

LEVEL/ PROPERTY	Nominal	Ordinal	Interval	Ratio
Classify	X	X	X	X
Rank		X	X	X
Distance between points			X	X
Distance from zero				X

Effectiveness of visual variables for levels of measurement

White, T. (2017). Symbolization and the Visual Variables. *The Geographic Information Science & Technology Body of Knowledge*



	Qualitative	Quantitative	
	Nominal	Ordinal	Numerical
Size	P	G	G
Shape	G	P	P
Color Hue	G	M[a]	M[a]
Color Value	P	G	M
Color Saturation	P	G	M
Orientation	G	M	M
Arrangement	M	P	P
Texture	G	M	M
Transparency	M	G	P
Crispness	P	G	P
Resolution	P	G	P

G = good; M = marginally effective; P = poor

[a] The particular hues selected must be logically ordered.

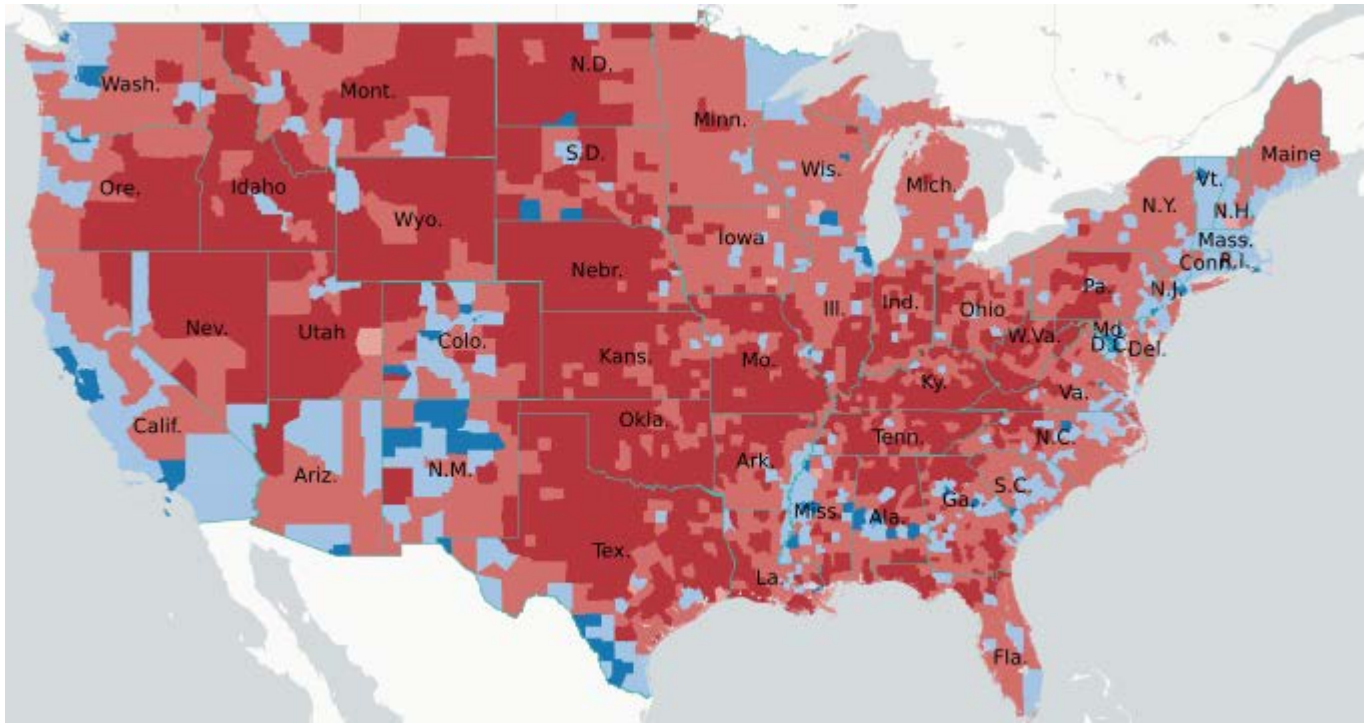
Popular thematic map types: Choropleth map

A choropleth map is a thematic map where geographic regions are colored, shaded, or patterned in relation to an attribute value.

- Regions are tessellated (non-overlapping, covering)
- Attribute values are classified

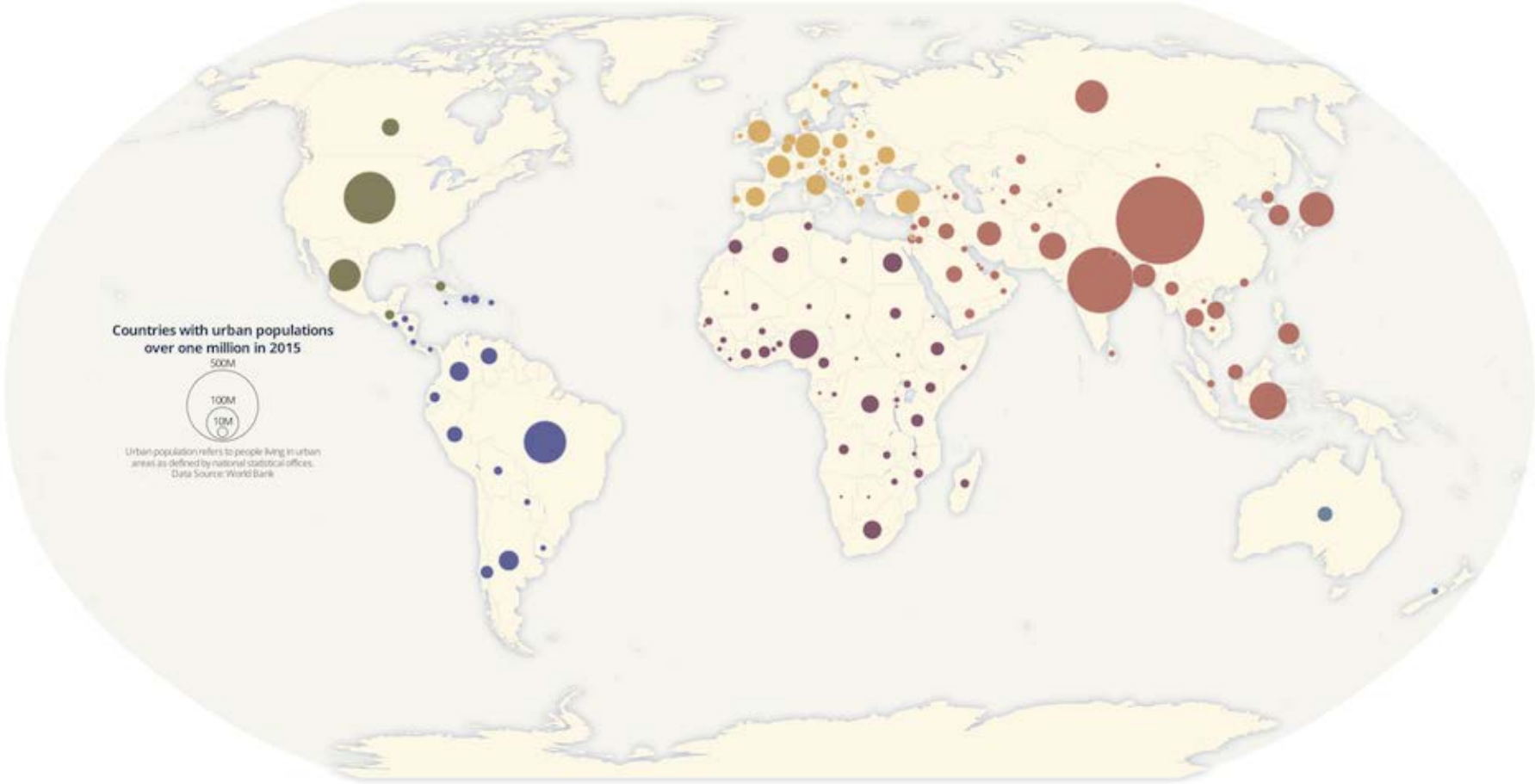
Example:
Percentage democratic votes

- Blue = >0.5



Popular map types: Proportional symbol map

A symbol is used to represent the data at that specific or aggregate point,
scaled
by value, so
that a larger
symbol
represents a
greater value.



Popular map types: Dot density maps

A dot density map uses a dot to represent a feature or attribute in your data.

Density of dots represent some amount.

Example: John Snow's Cholera deaths map (1855)

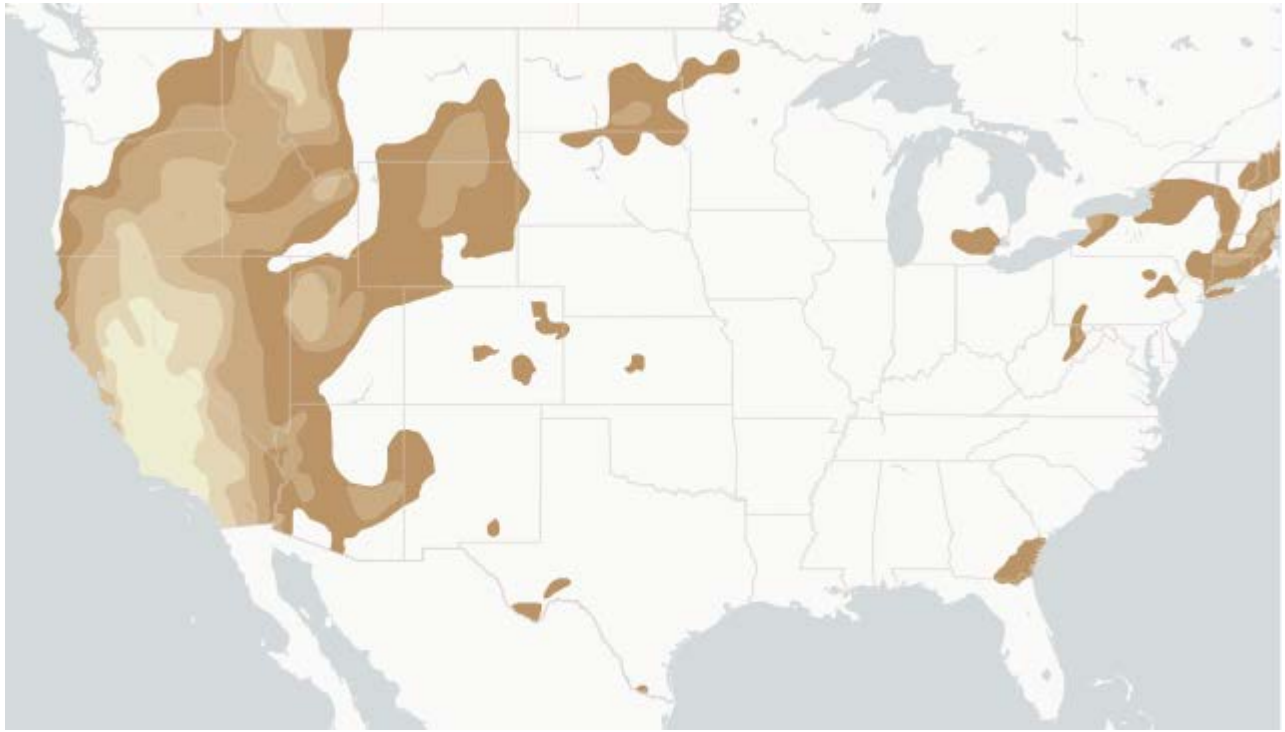
What does this map show?

Popular map types: Contour maps

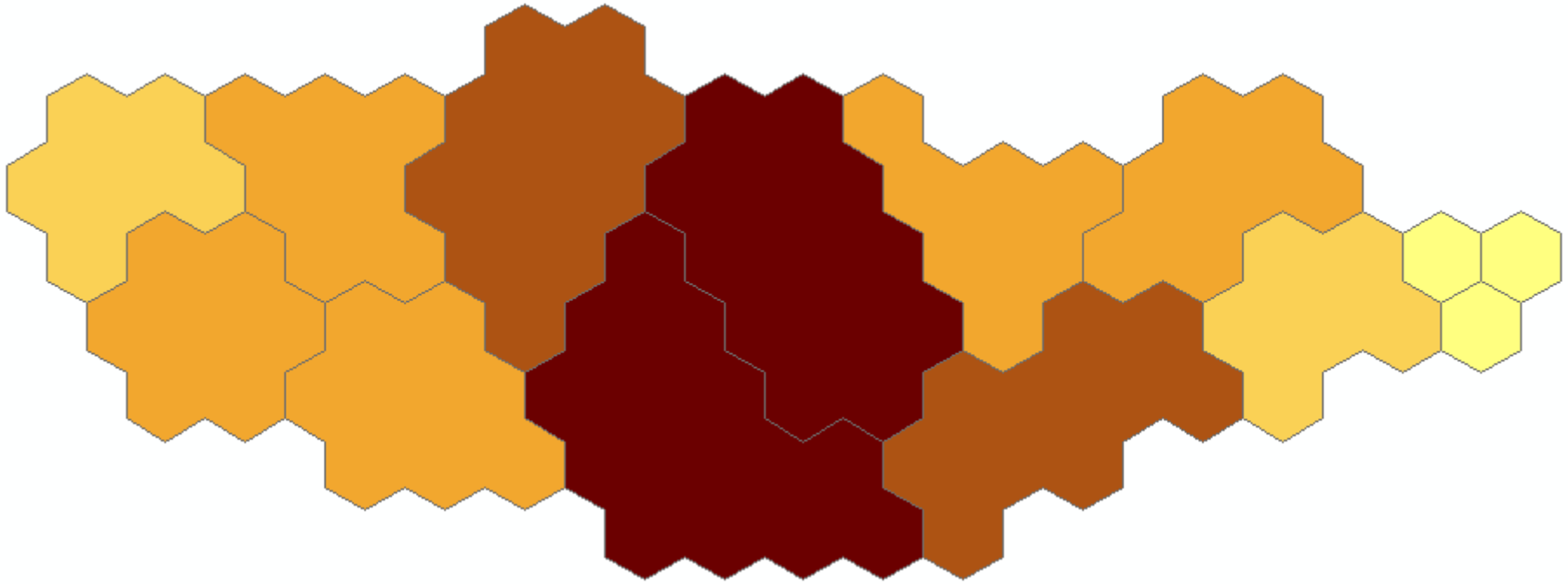
Contour maps show intensities in terms of contour intervals

Every colour corresponds to an attribute interval

For example: drought severity 2017 in the US

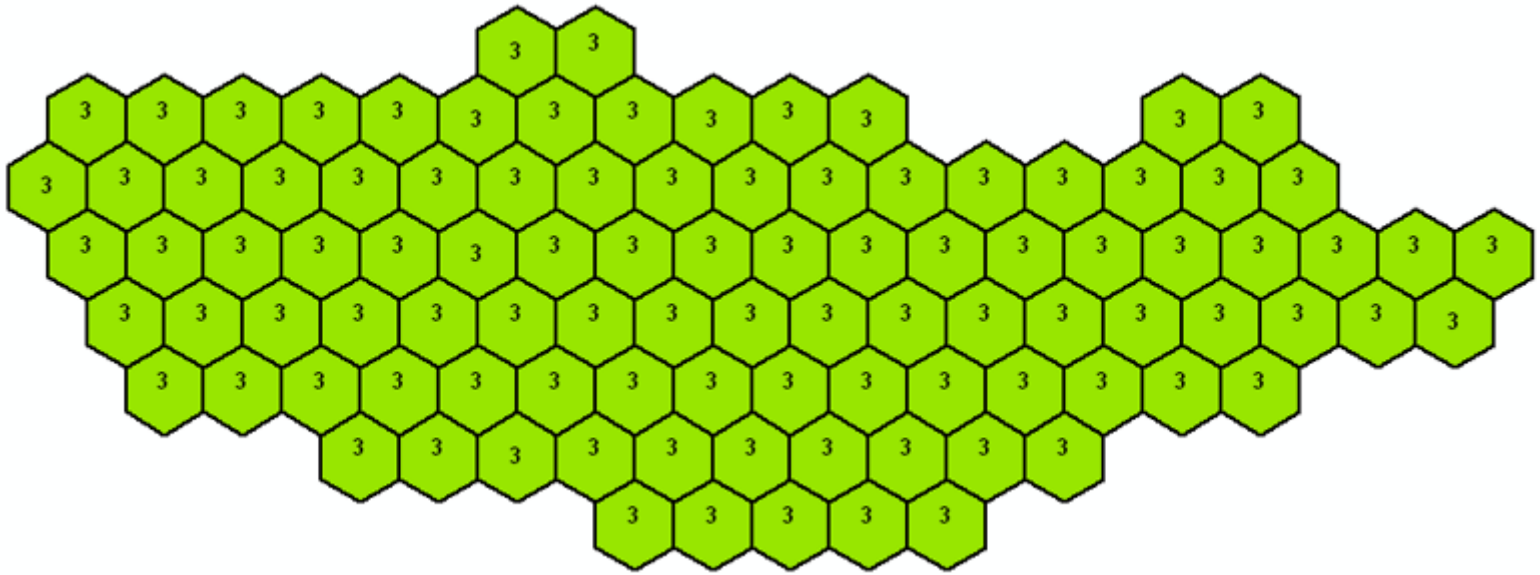


Attribute normalization and map types: Extensive vs intensive attributes



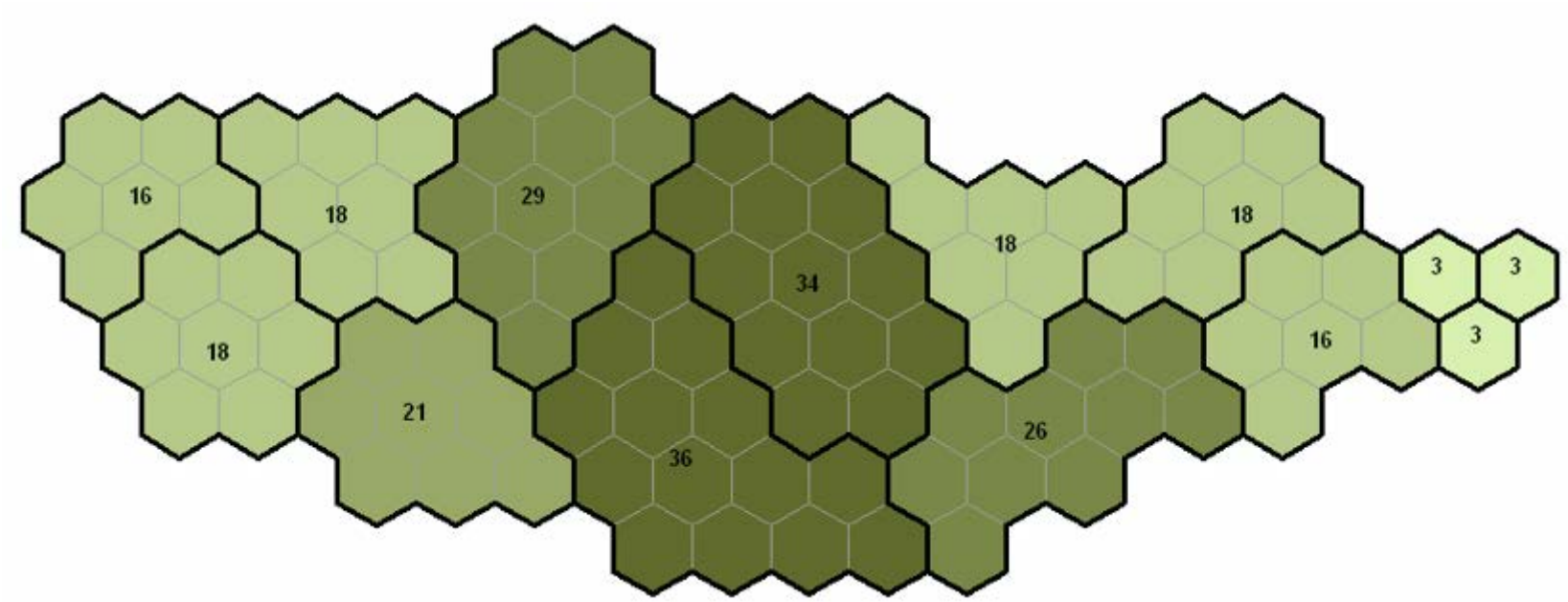
Choropleth map of camels in Mongolia:
where do you think they are concentrated?

Attribute normalization and map type: Extensive vs intensive attributes



Answer: nowhere, because we used a uniform distribution!

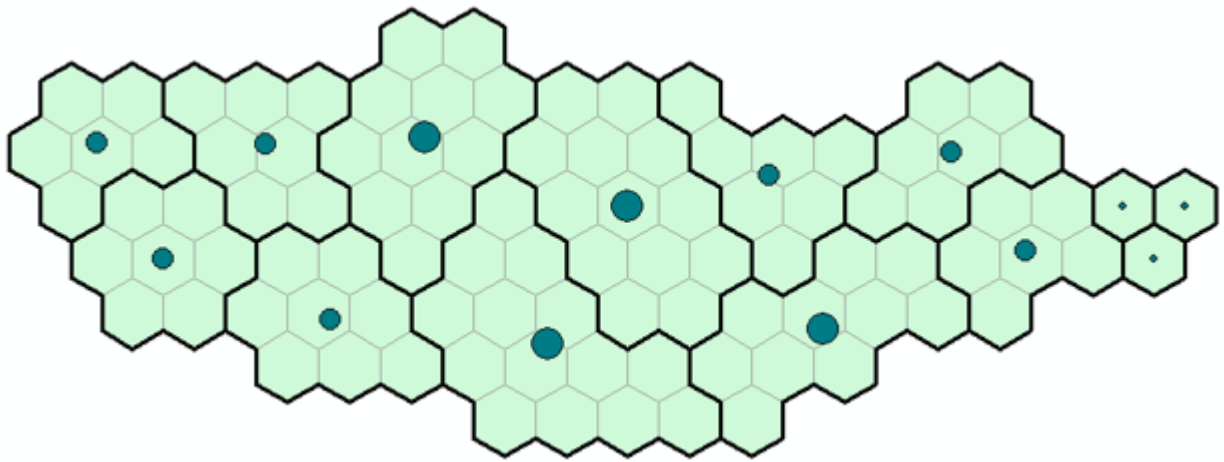
Attribute normalization and map type: Extensive vs intensive attributes

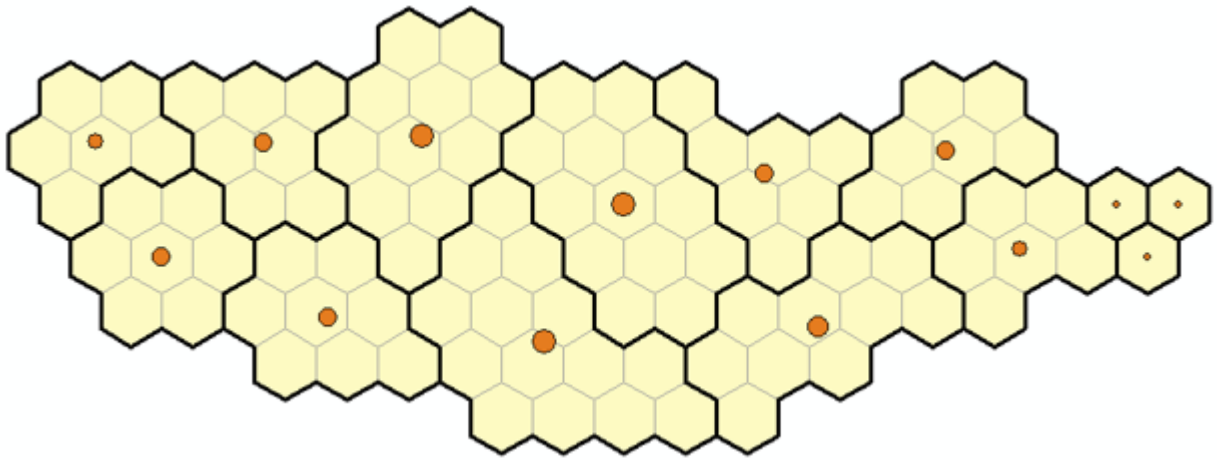


Choropleth map was produced by summing up camels without normalization

Note: Never use non-normalized (extensive) attributes with choropleth maps

Attribute normalization and map type: Extensive vs intensive attributes





Better use proportional/graduated symbol maps for extensive attributes!
Using Bertin variable: size

Slocum's list of items to consider for map quality

1. How will the map be used? *General* or *specific* (= thematic maps)?
2. What is the *spatial dimensionality* of the data and its *map scale*? (point, line, area, volume -> selection of *map symbols*)
3. What is the *level of measurement*? (Stevens' scale levels -> selection of *visual variables/color schemes*)
4. Do the data need *normalization (extensive/intensive)*? (totals, percentages -> choice of *map types (symbol, choropleth)*)
5. How *many attributes*? (*multivariate mapping*)
6. What is the *role of time*? (*temporal mapping*)
7. Cartographic design principles (…)

Slocum et al 2009: Thematic Cartography and Geographic Visualization

Questions?
(Q&A session)

References

- Slocum et al 2009: Thematic Cartography and Geographic Visualization
- White, T. (2017). Symbolization and the Visual Variables. *The Geographic Information Science & Technology Body of Knowledge*
- Stevens, S. S. (1946). On the theory of scales of measurement
- Monmonier, M. (1996): How to lie with maps
- Chrisman , N. (2002): Reference Systems for Measurement, Chapter 2 of Exploring Geographic Information systems