Measurement levels and quality of maps

Spatial Data Analysis and Simulation modelling,
2020, Simon Scheider

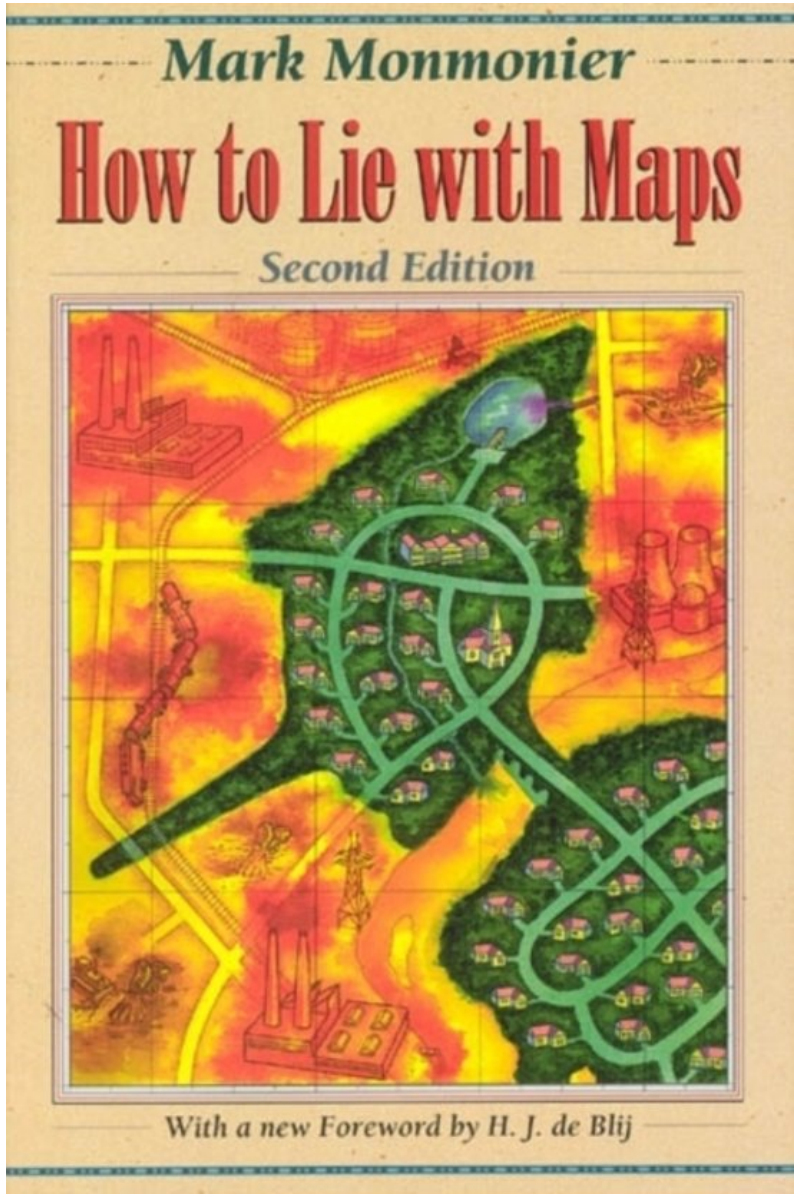
Quality of maps

Simon Scheider, Fred Toppen

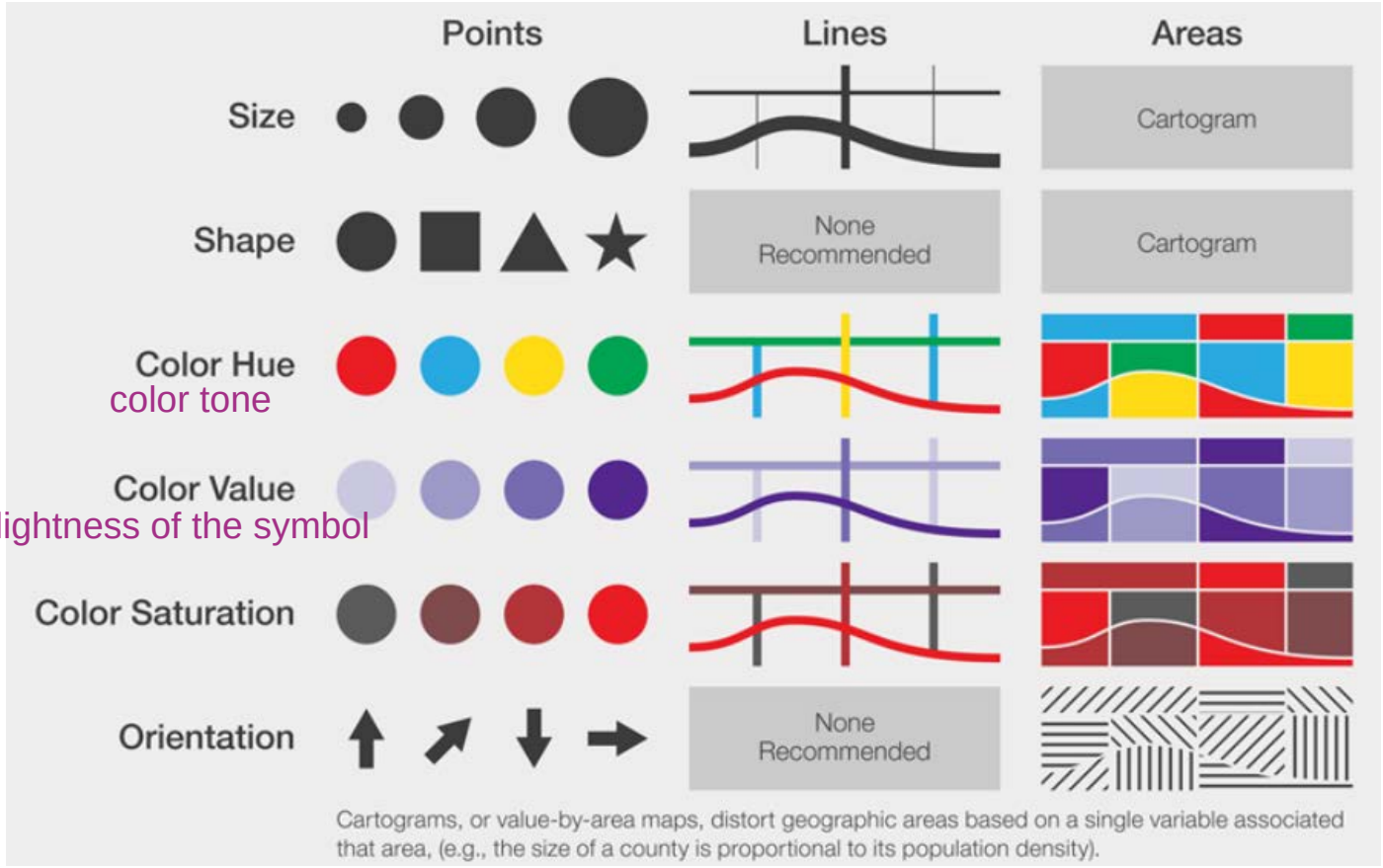
The quality of maps

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

data maps making nonsense of the senses prof favorite chapter in this book to misguide people
recommendation



Bertin’s (1967) visual variables



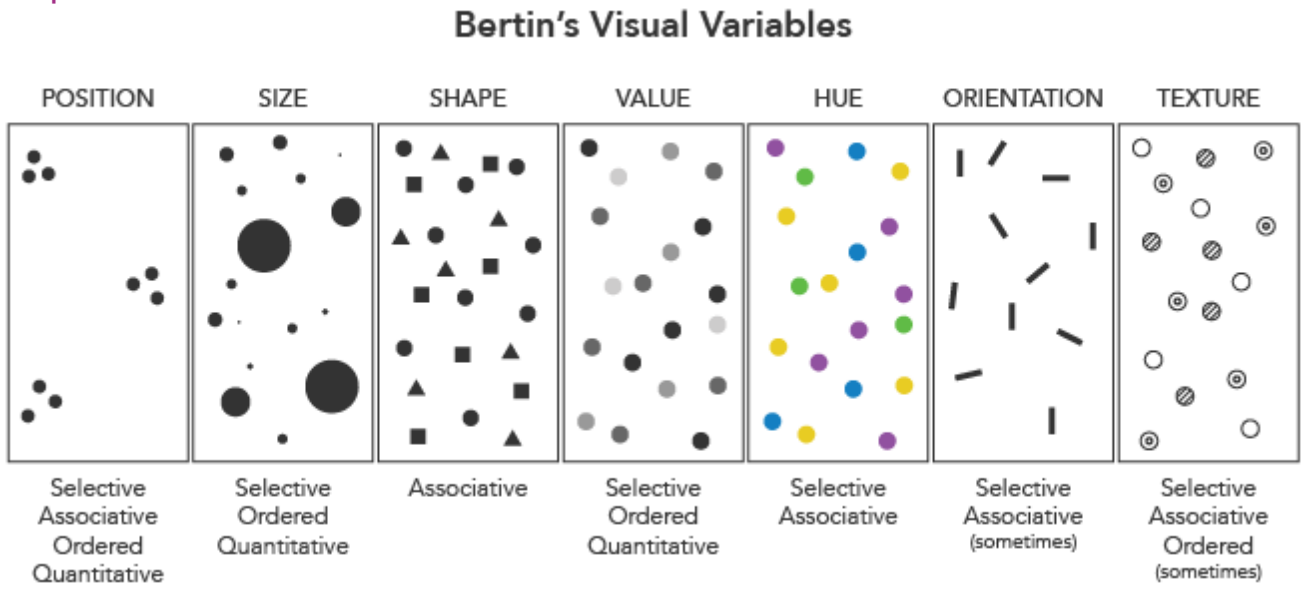
what's the difference between color value and color hue?

Did you mean shape and hue cannot be ordered as "cannot be ordered for every single value? Because they can be ordered by category/color?!

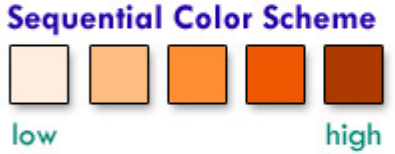
Visual variables and their properties

size and value (lightness) can be ordered

shape and hue cannot be ordered



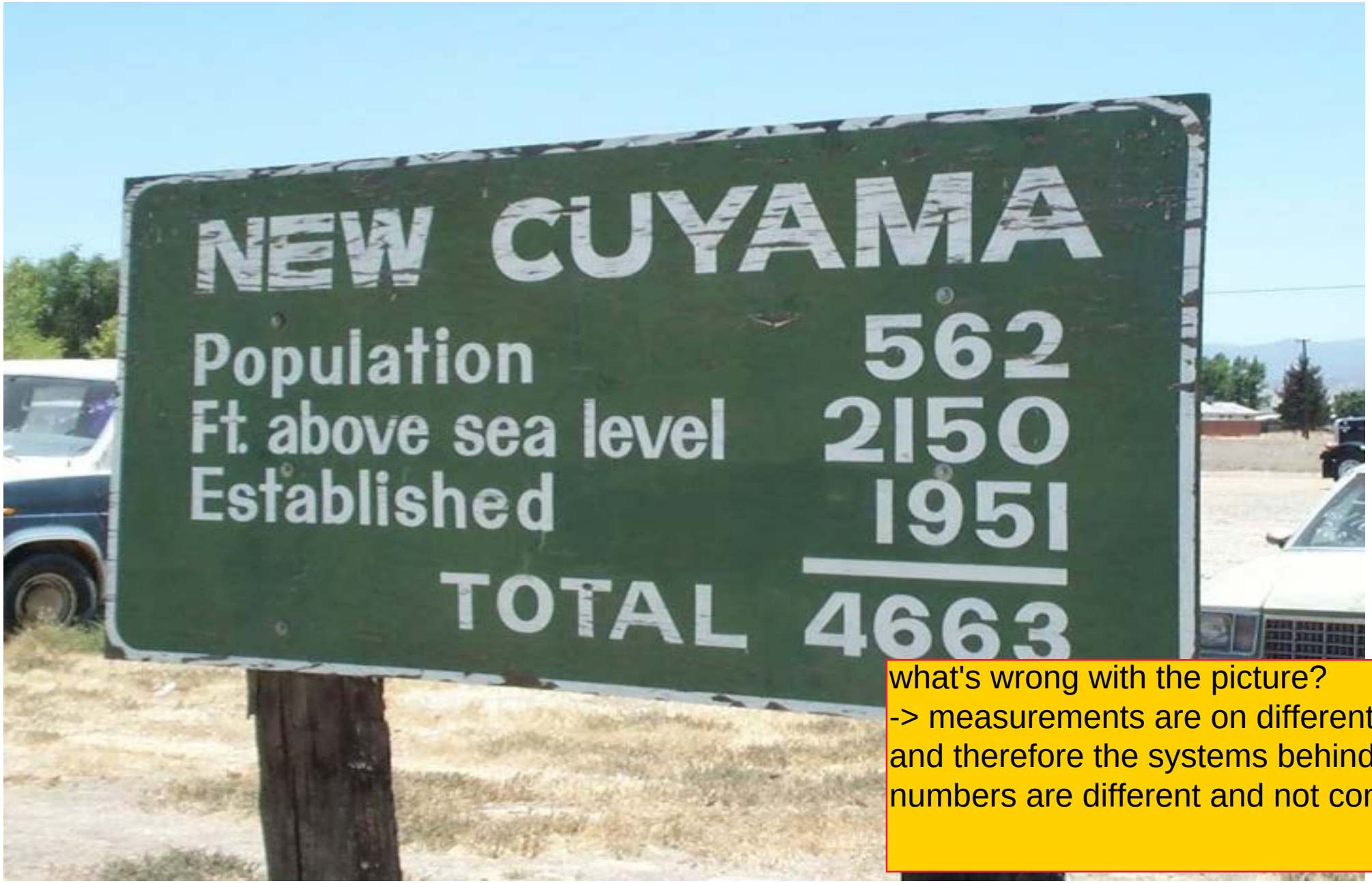
different hues that keep lightness and saturation constant should be used for nominal data (i.e., un-orderable categories, not numerical data).



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*

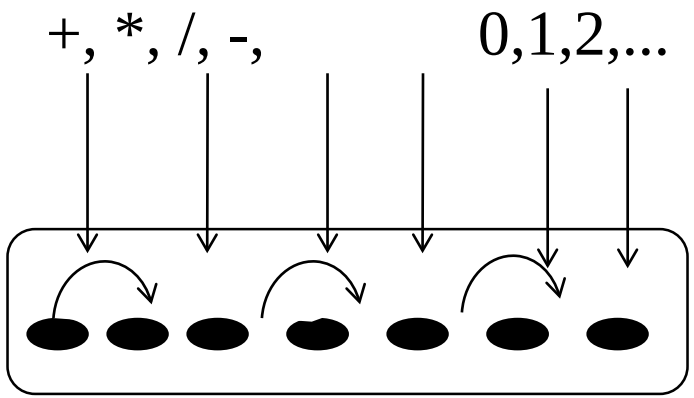


what's wrong with the picture?
-> measurements are on different scales and therefore the systems behind the numbers are different and not comparable

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)

relation between domains is set by convention



Terms (relational symbols, numbers)

Interpretation / Convention

Domain

Levels of measurement (scale type)

class of scales - what operation can meaningfully used with this scale?

- 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

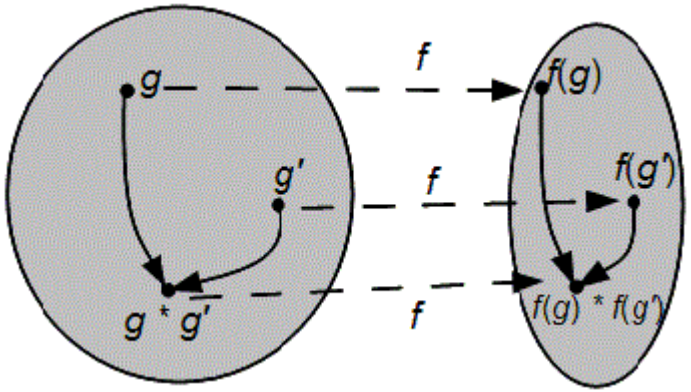
relation between symbols and measurements

- 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

same unit but different "0"

mapping can preserve the differences between the different types of measurements

ratio not the same relations are not preserved



Levels of measurement (Stevens 1946)

temperature

weight - interpretation of zero is fixed
population

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

what interpretation of numbers can change?

Effectiveness of visual variables for levels of measurement

representing numbers with size better - compare size

	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

lightness

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

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

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

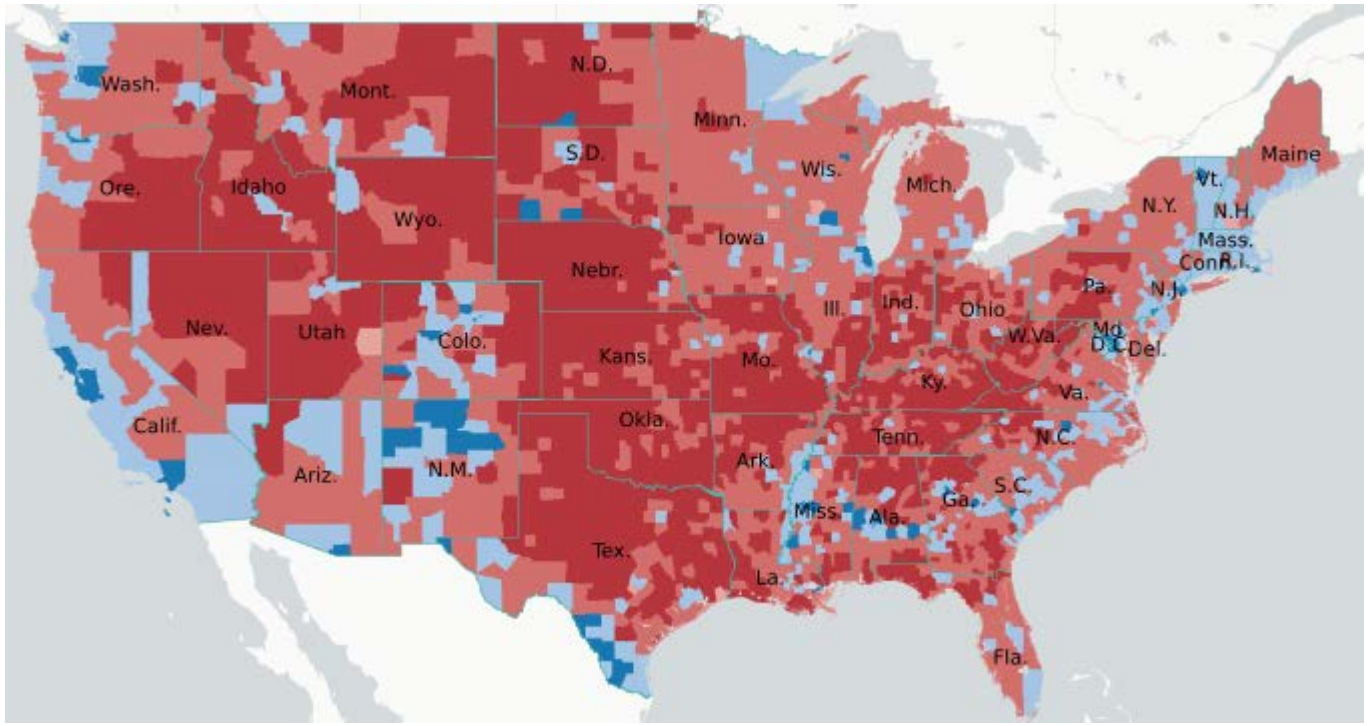
exam: showing map and describing what is good/bad in regard to table - use of appropriate variable

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

classes represented by colors, shapes, etc.



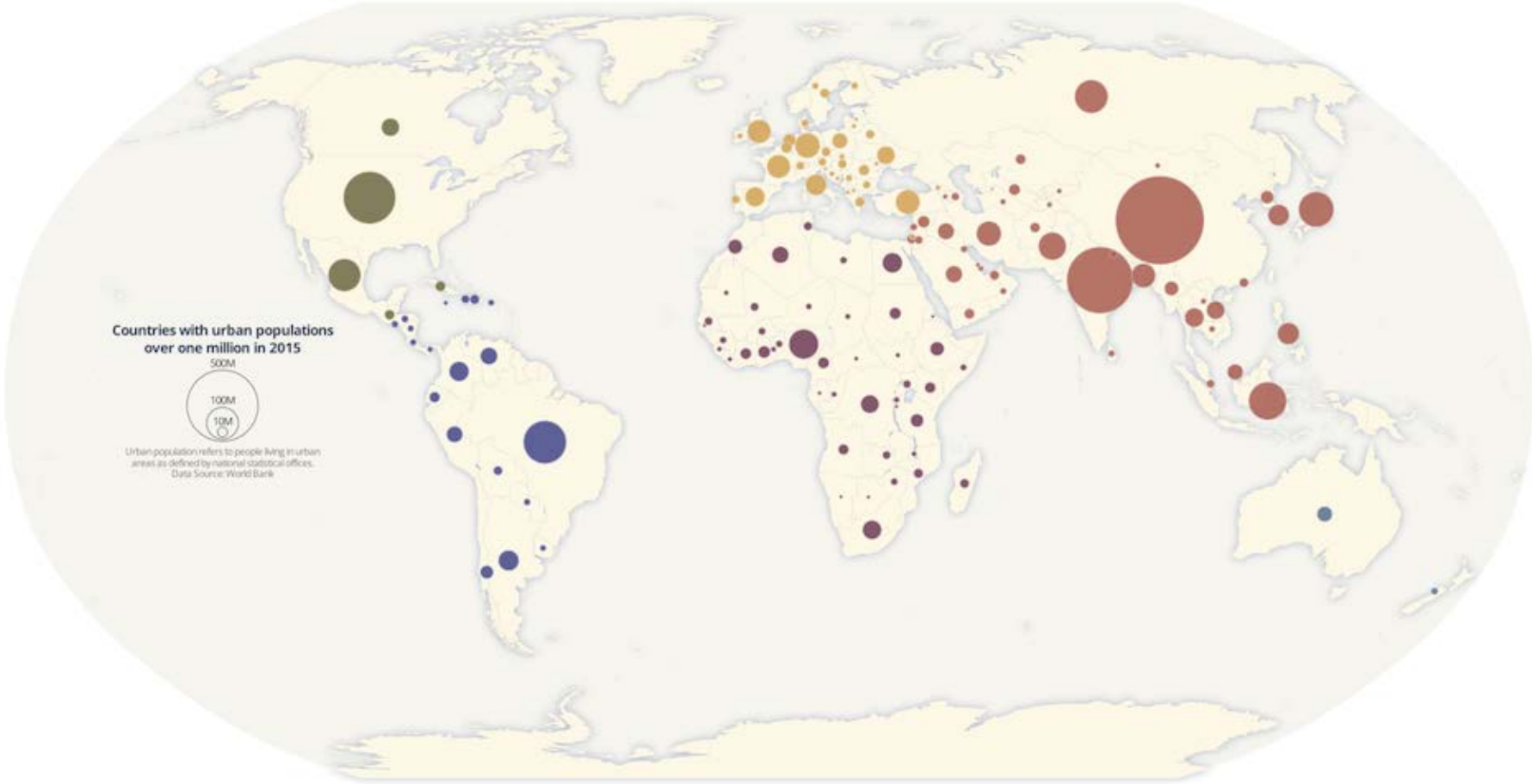
Example:
Percentage democratic votes

- Blue = >0.5

percentage is darker/lighter

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 size of 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)

found out that deaths clustered around well

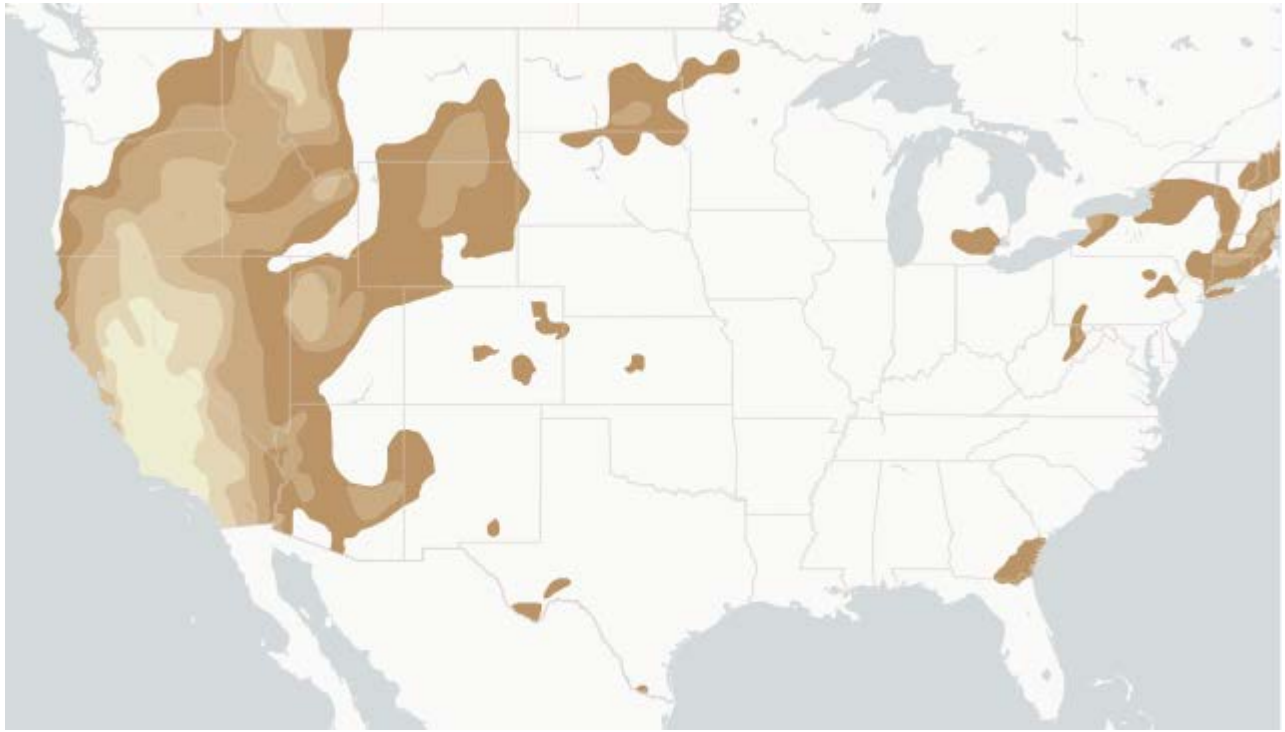
What does this map show?

Popular map types: Contour maps

Contour maps show intensities in terms of contour intervals

Every colour corresponds to an attribute interval

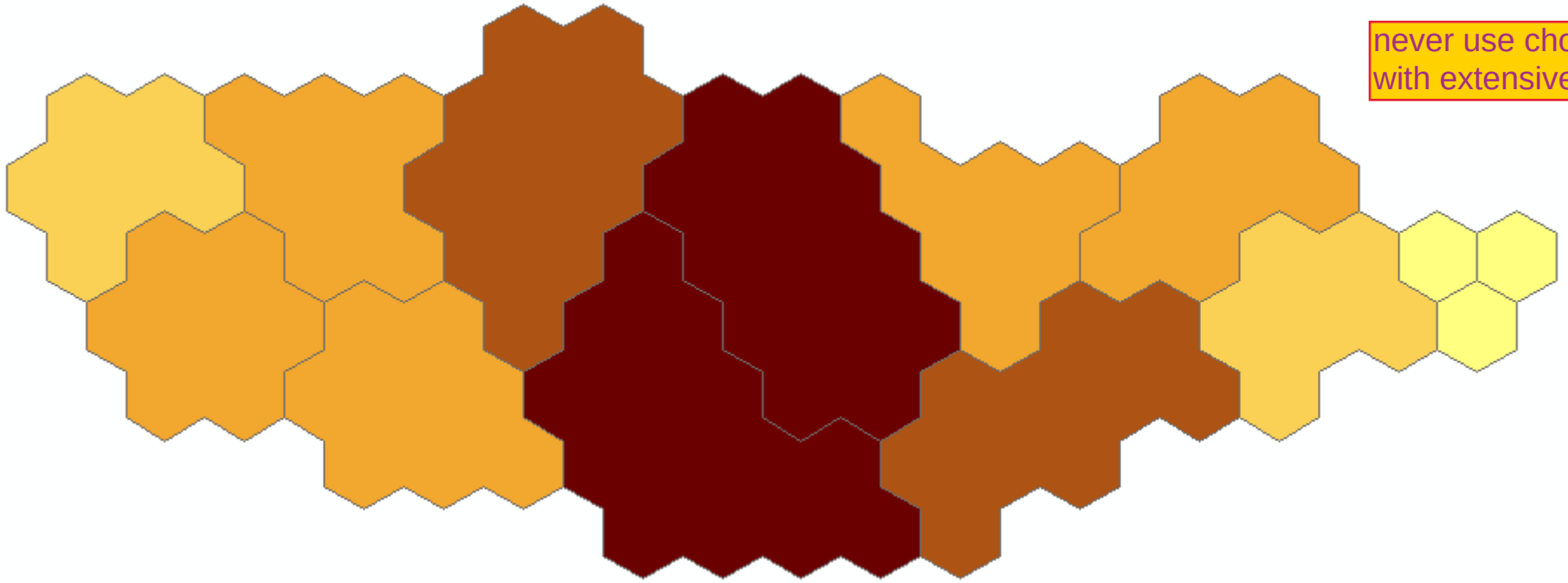
For example: drought severity 2017 in the US



Attribute normalization and map types: Extensive vs intensive attributes

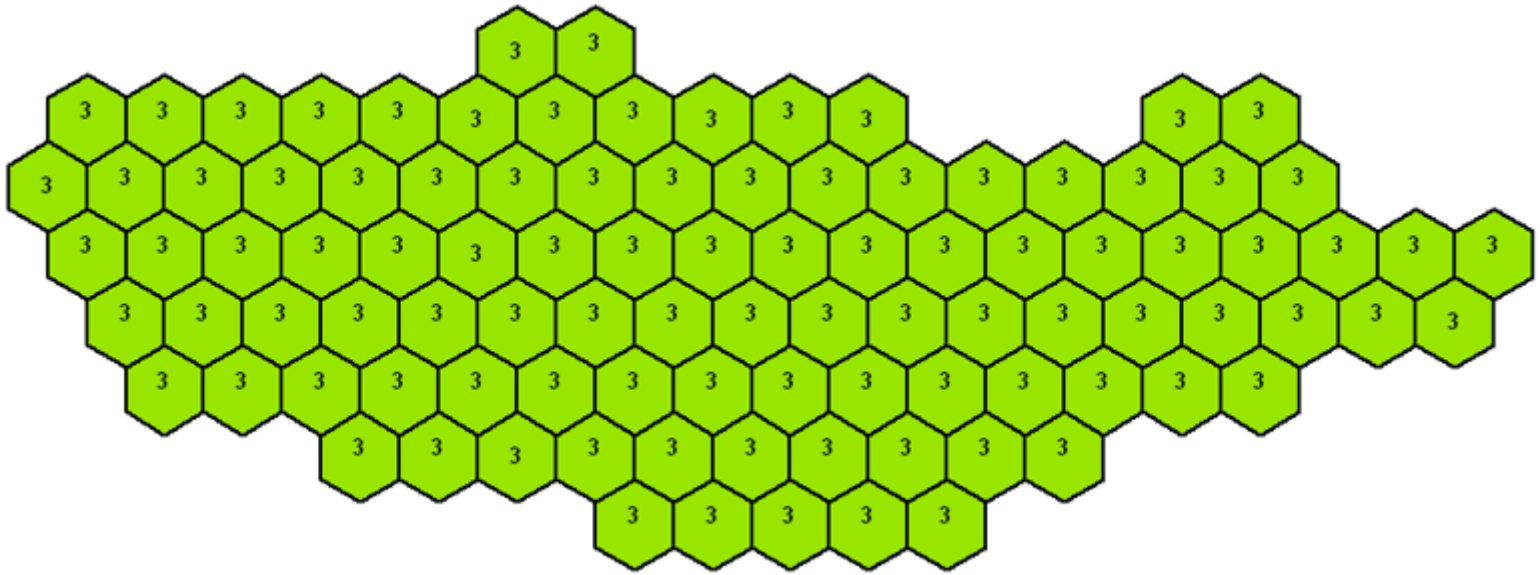
normalized or not? example: where are the camels concentrated one would think the dark color, however every part of the map has the same amount of camels. each area has a sum of camels however and just because of the sum = size of the region it shows the different colors. Wrong impression of the underlying distribution of objects.

never use choropleth maps with extensive values



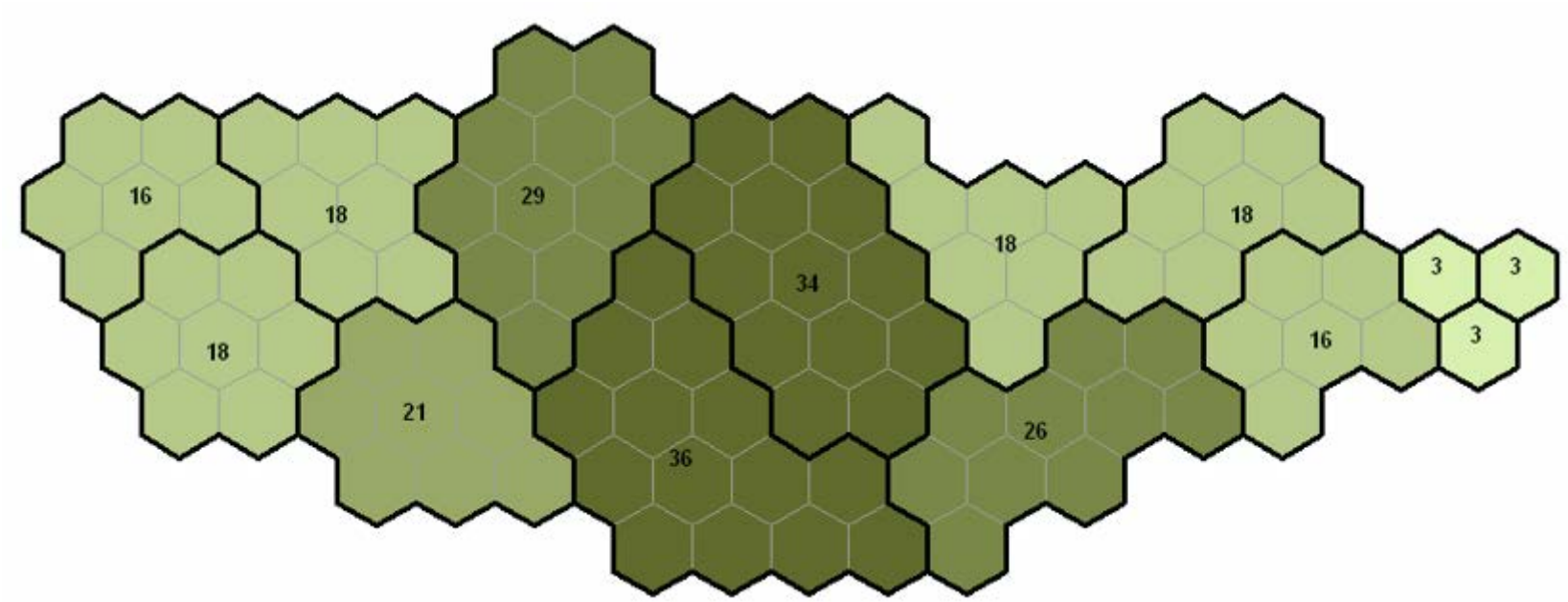
Choropleth map of camels in Mongolia:
where do you think they are concentrated?

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

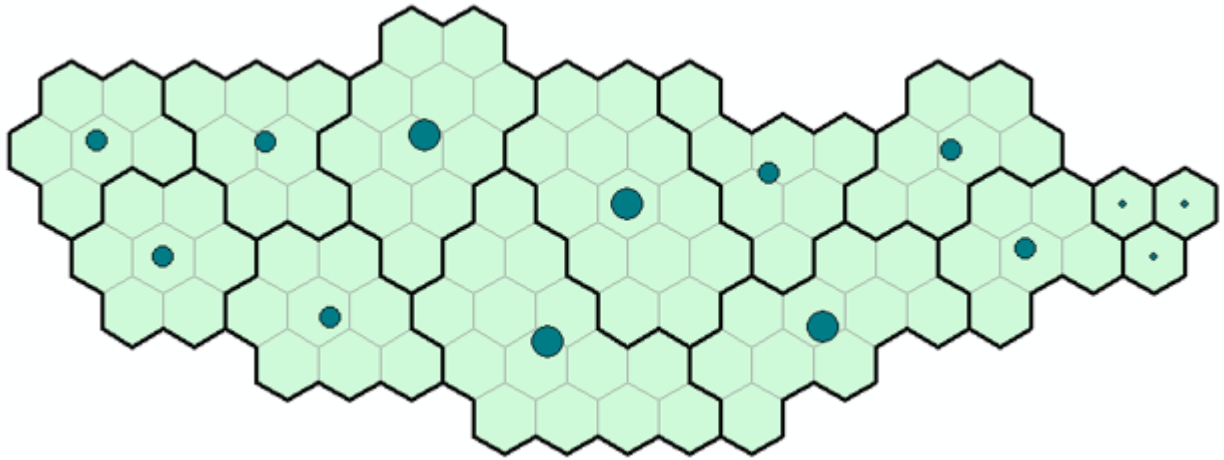


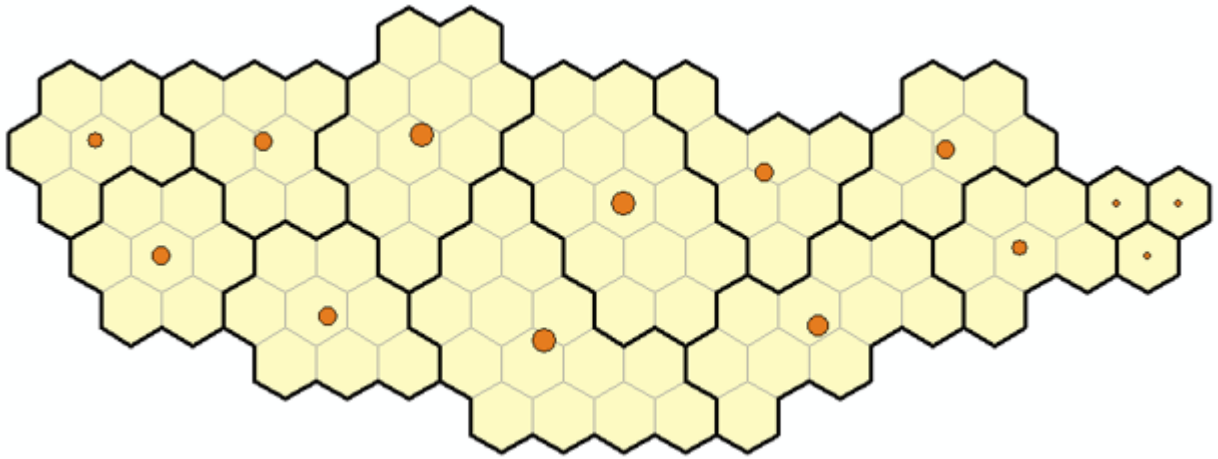
Choropleth map was produced by summing up camels without normalization

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

Attribute normalization and map type: Extensive vs intensive attributes

if you want to show sums - use normalized map





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

summary

Slocum's list of items to consider for map quality

specific use?

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*)

what should be use to represent the phenomena

3. What is the *level of measurement*?

what measuring scale?

(Stevens' scale levels -> selection of *visual variables/color schemes*)

never use choropleth maps with extensive values - always normalized data

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