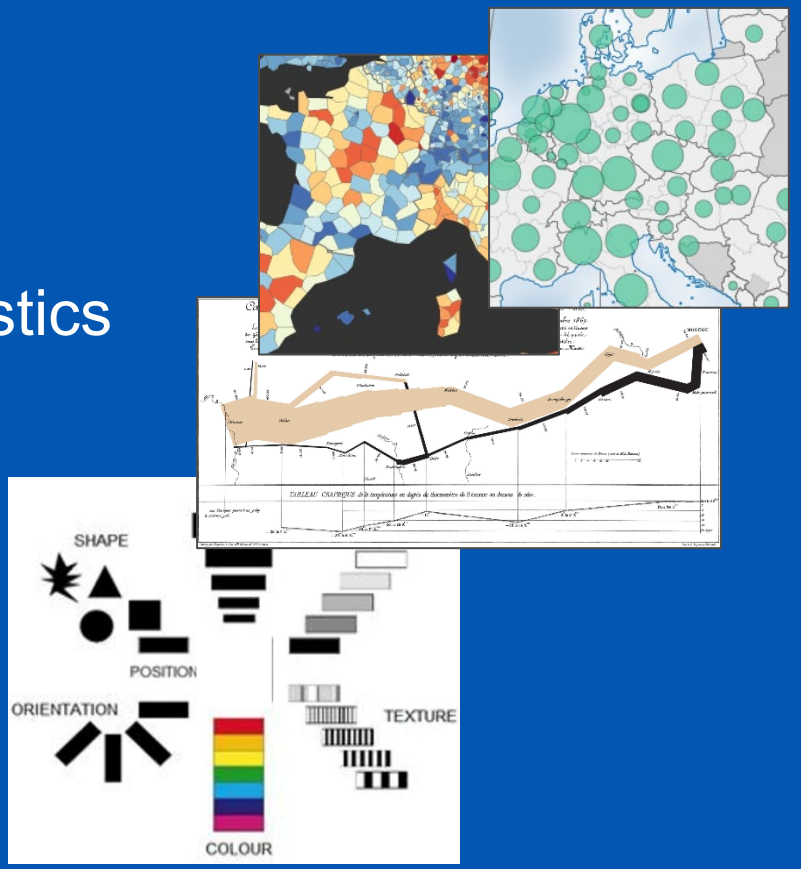
Statistical cartography

A short introduction for mapmaking from official statistics



EMOS webinar – 30th March 2021

Julien Gaffuri – Eurostat-GISCO

Objective

- Introduce base cartographic design principles for statistical maps.
- “Dos and don’ts” for correct and efficient map making.
- Examples of maps.

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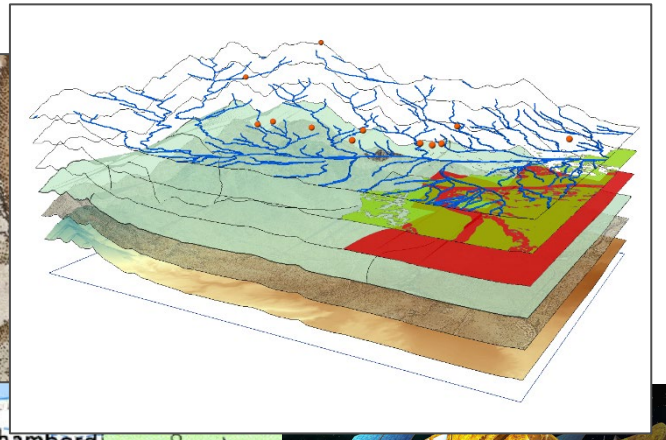
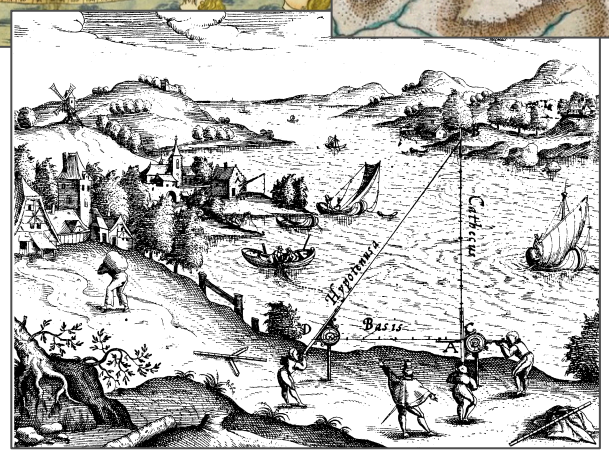
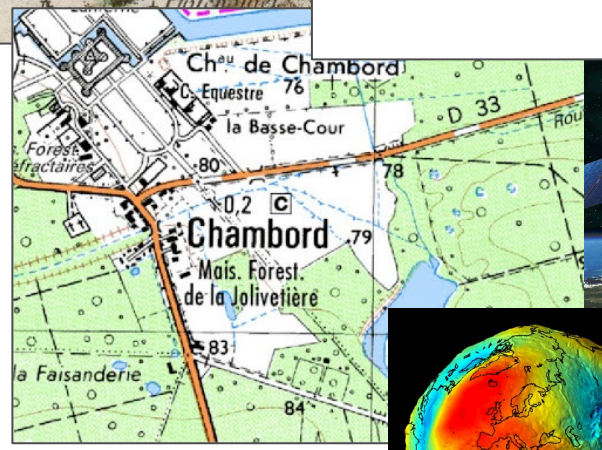
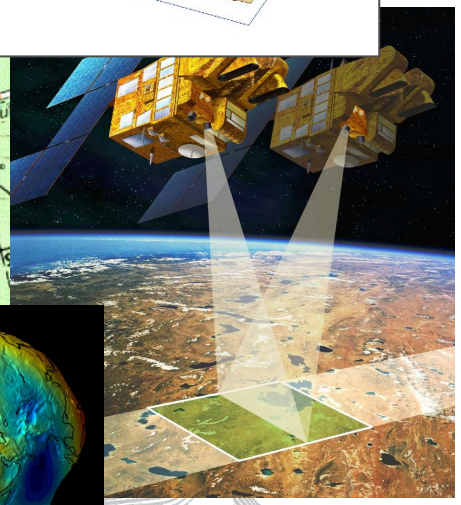
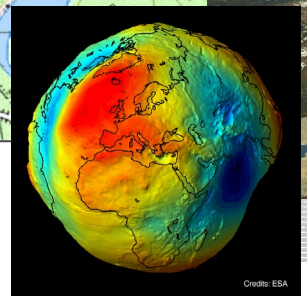
Cartography, GIS, spatial analysis











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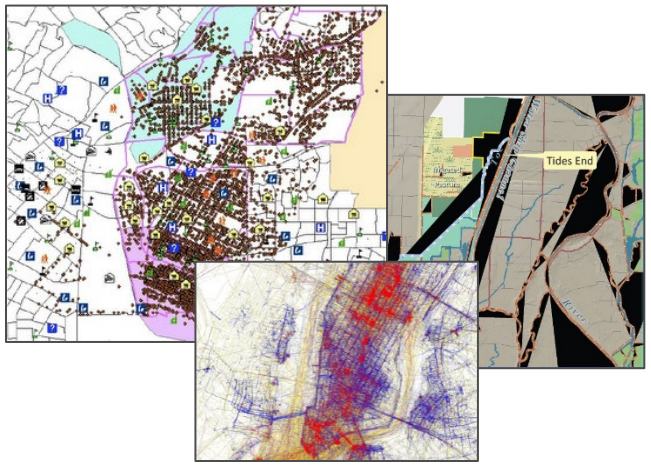
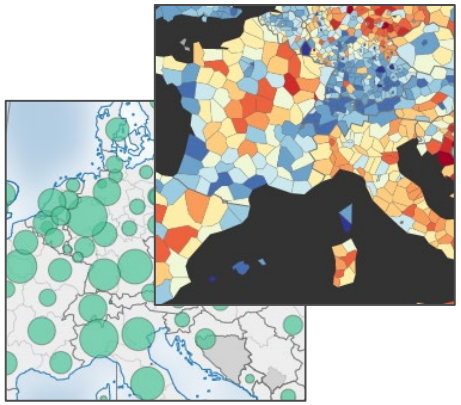
The cartographic language

From meaningless gibberish…



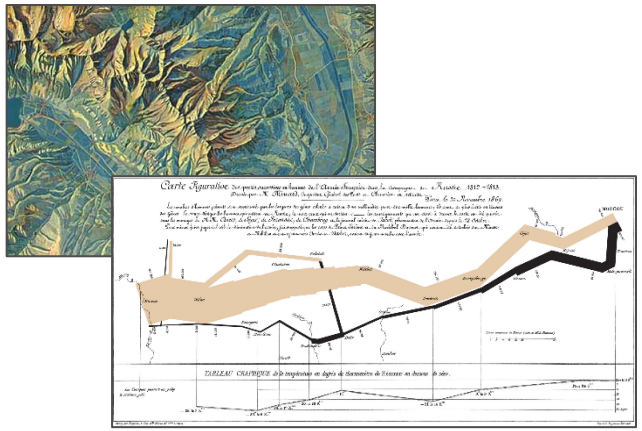
hW3Xe kjh#^eh 3y%t !!!

… to efficient message…



The dog is in the garden.

… to masterpiece



To be, or not to be.

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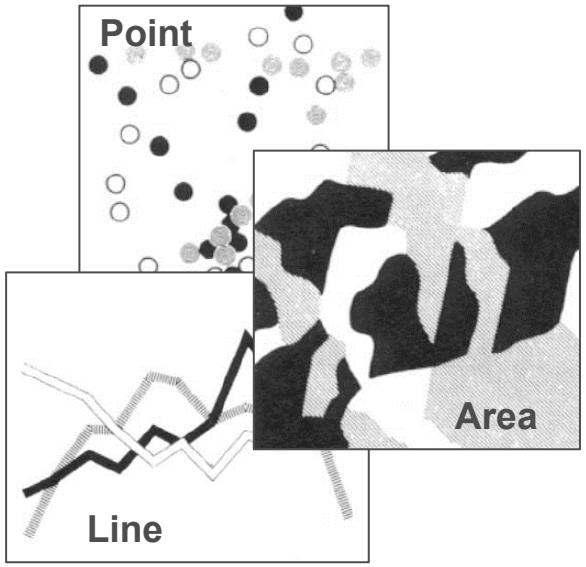
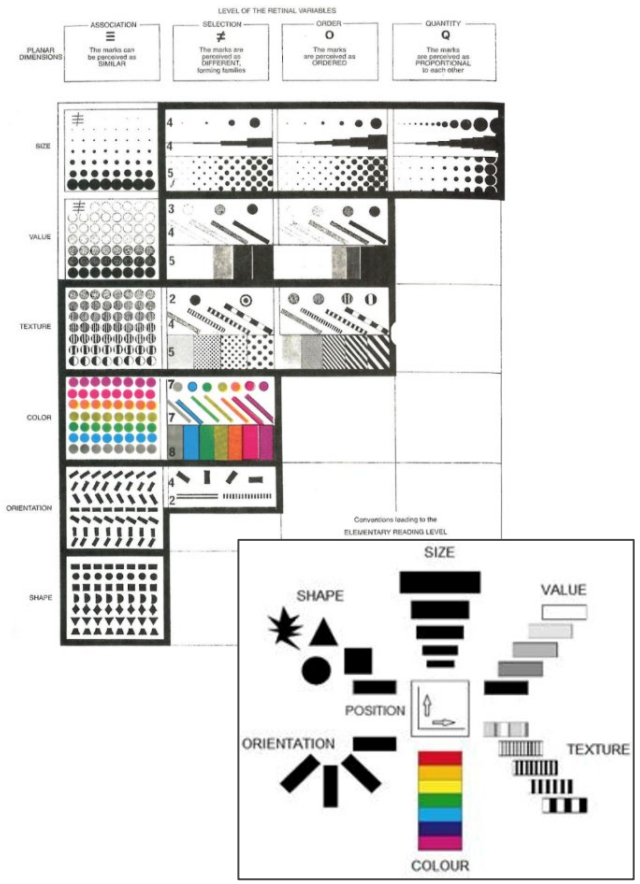
The cartographic language

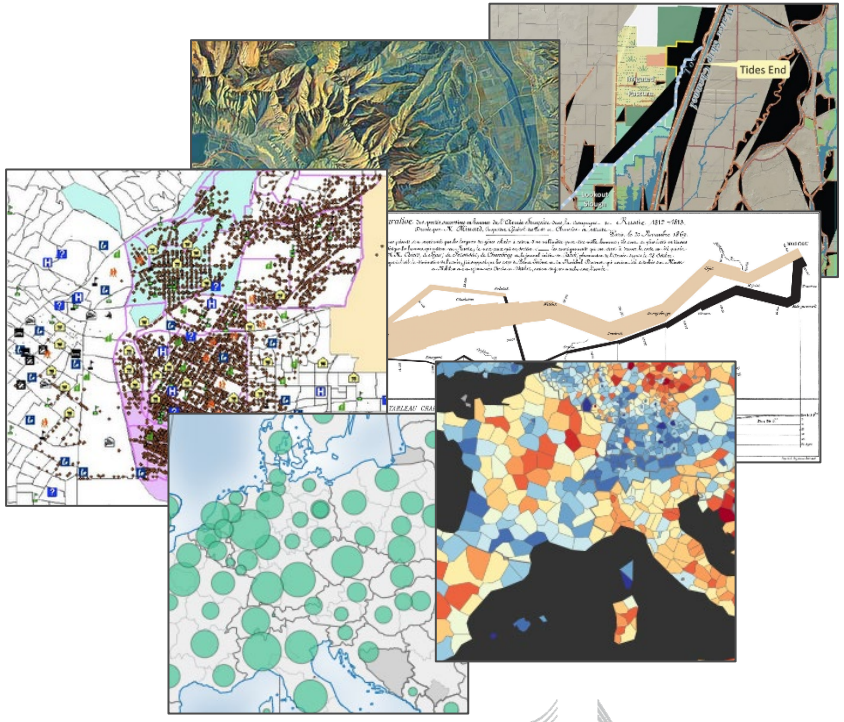
Words



Grammar, rules



Litterature



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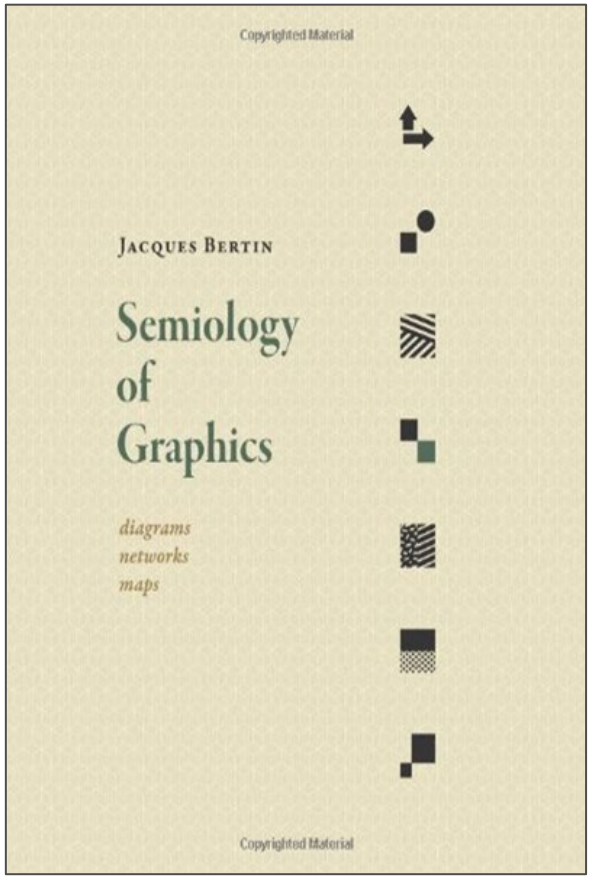
Semiology of graphics



Bertin, J. (1968). Semiology of Graphics: Diagrams, Networks, Maps, Esri Press books, ISBN: 9781589482616.

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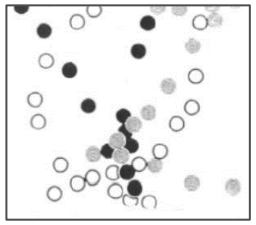
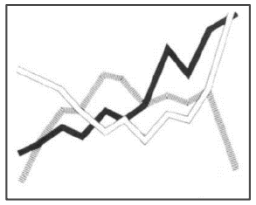
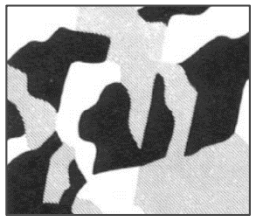
Visual implantations

- Point
  - Show location
- Line
  - Show a limit, a trajectory, a connection
- Area
  - Show a portion of the plan







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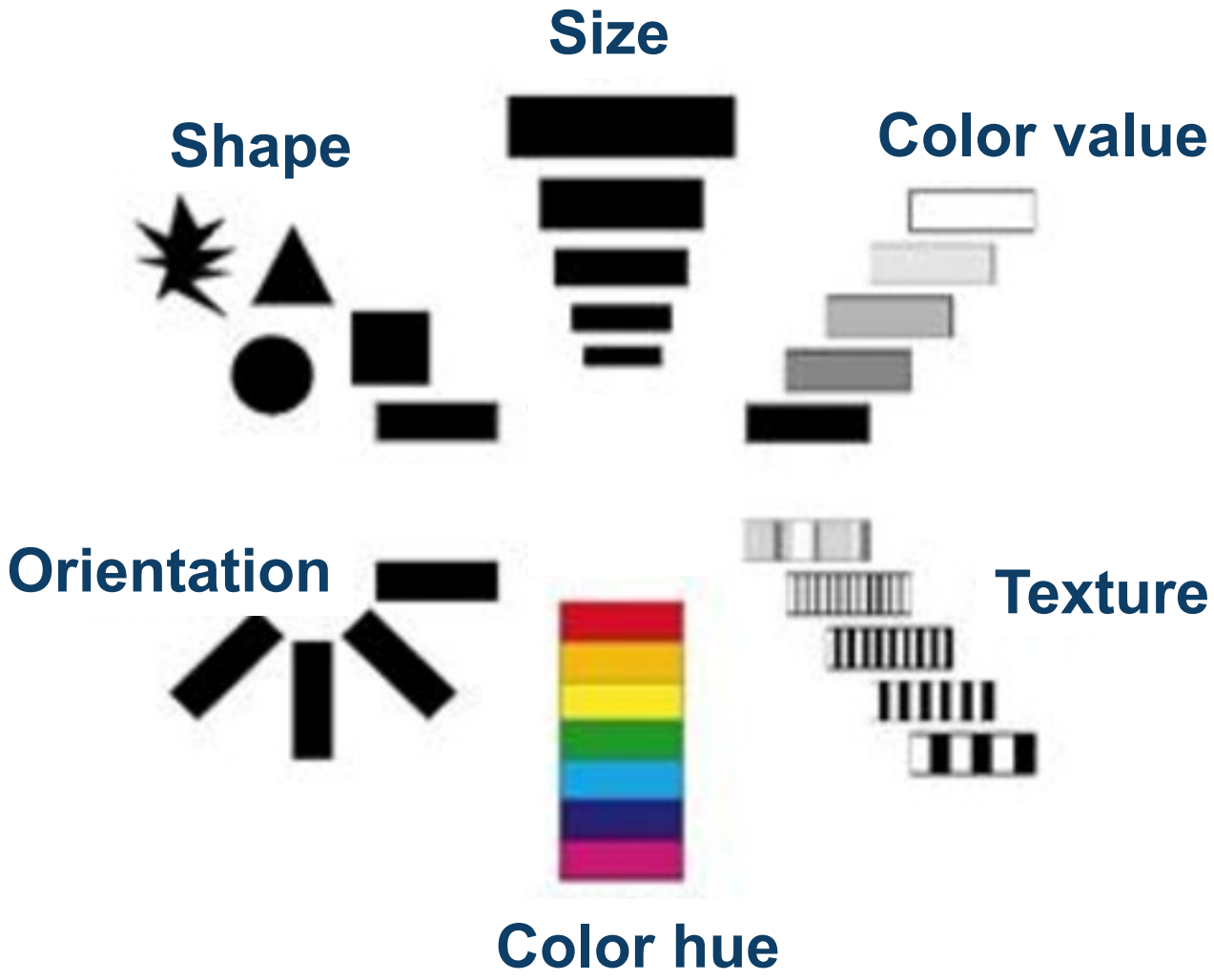
Visual variables



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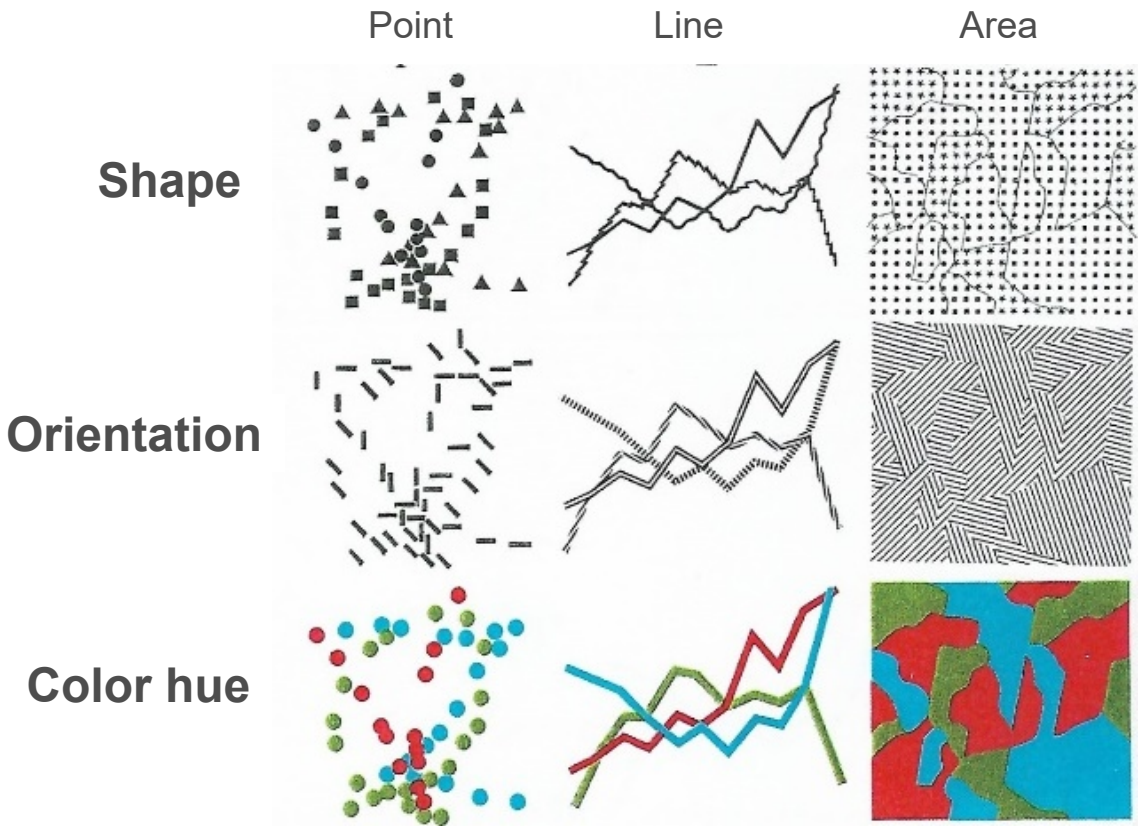
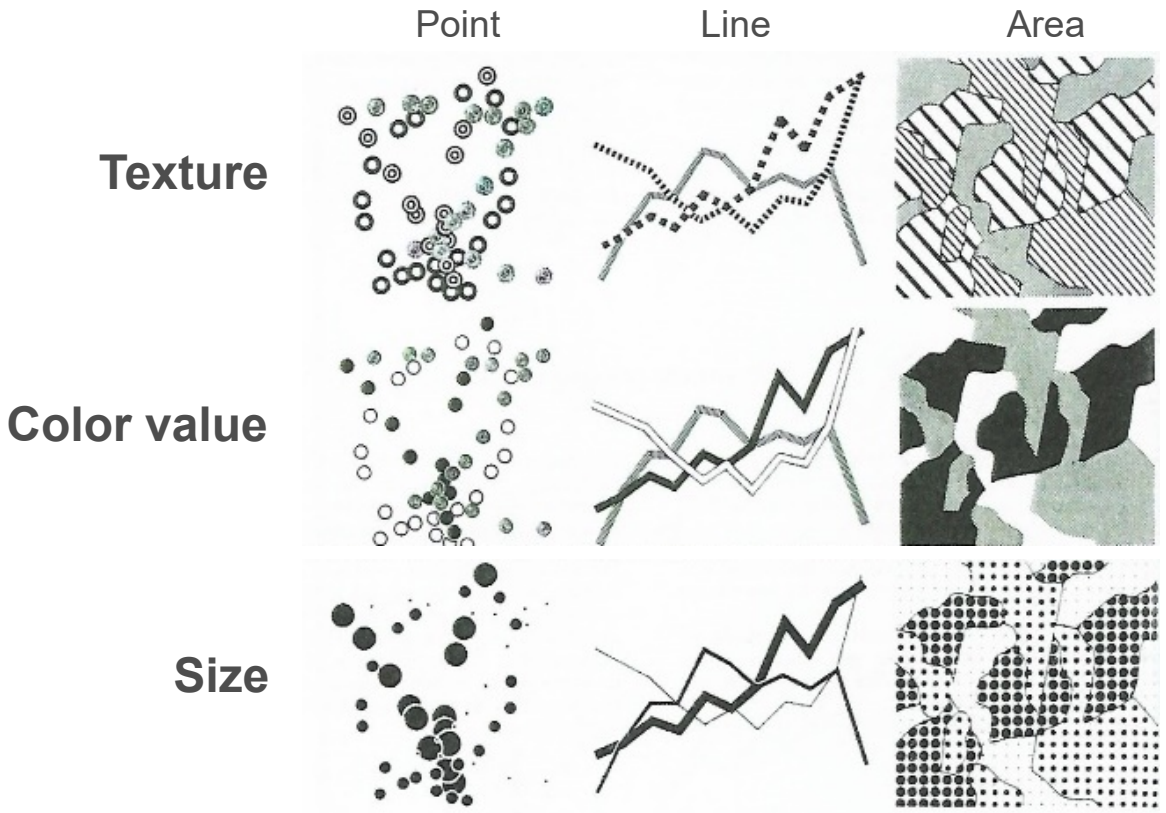
Visual variables





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Visual variables – levels and lengths

- Levels
  - **Association** – Elements can be perceived as similar.
  - **Selection** – Elements are perceived as different, forming families.
  - **Order** – Elements are perceived as ordered.
  - **Quantity** – Elements are perceived as proportional to each other.
- Length
  - Number of differenciable categories which can be represented.
  - Depends on the implantation and visual variable.

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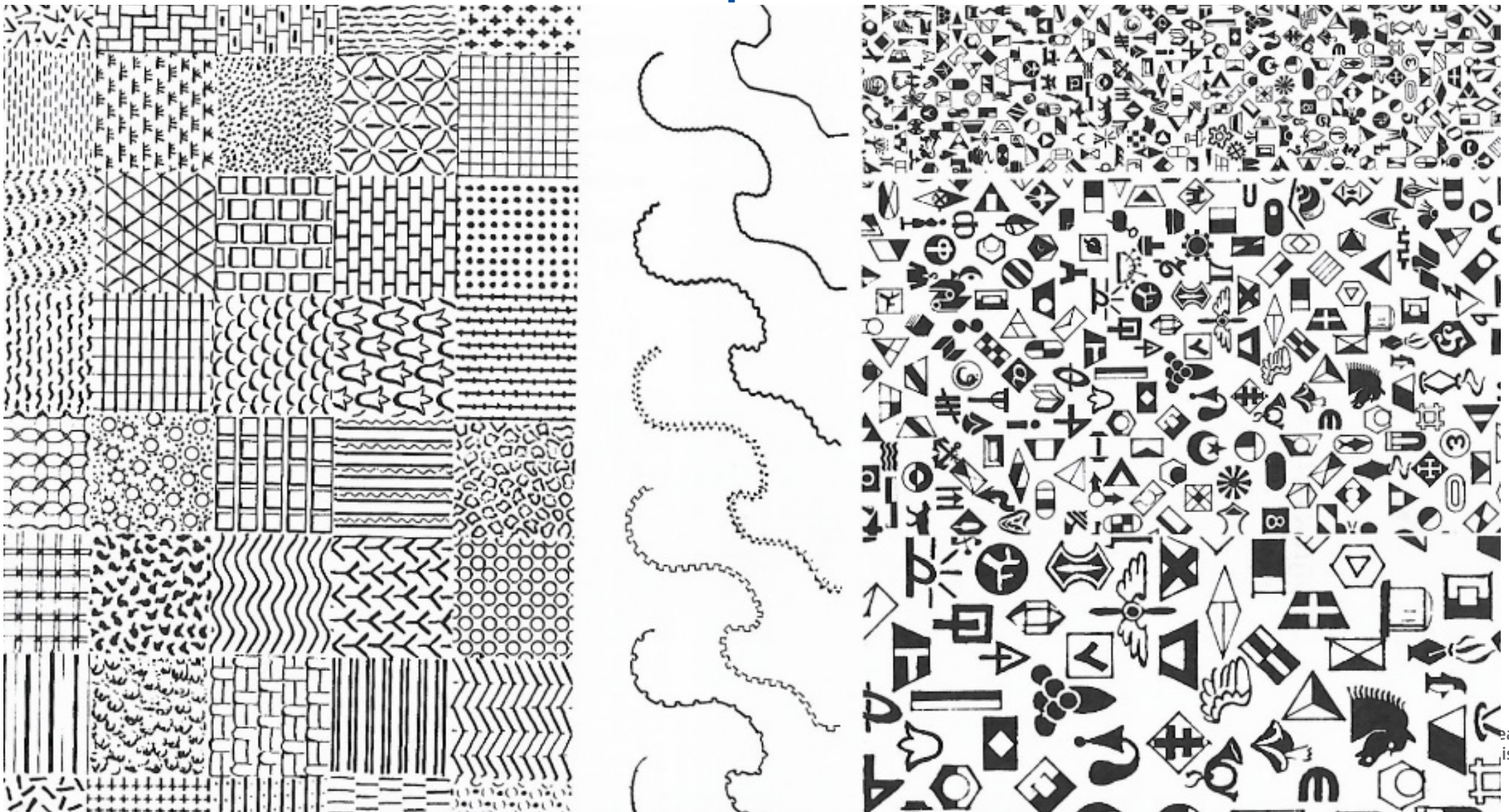
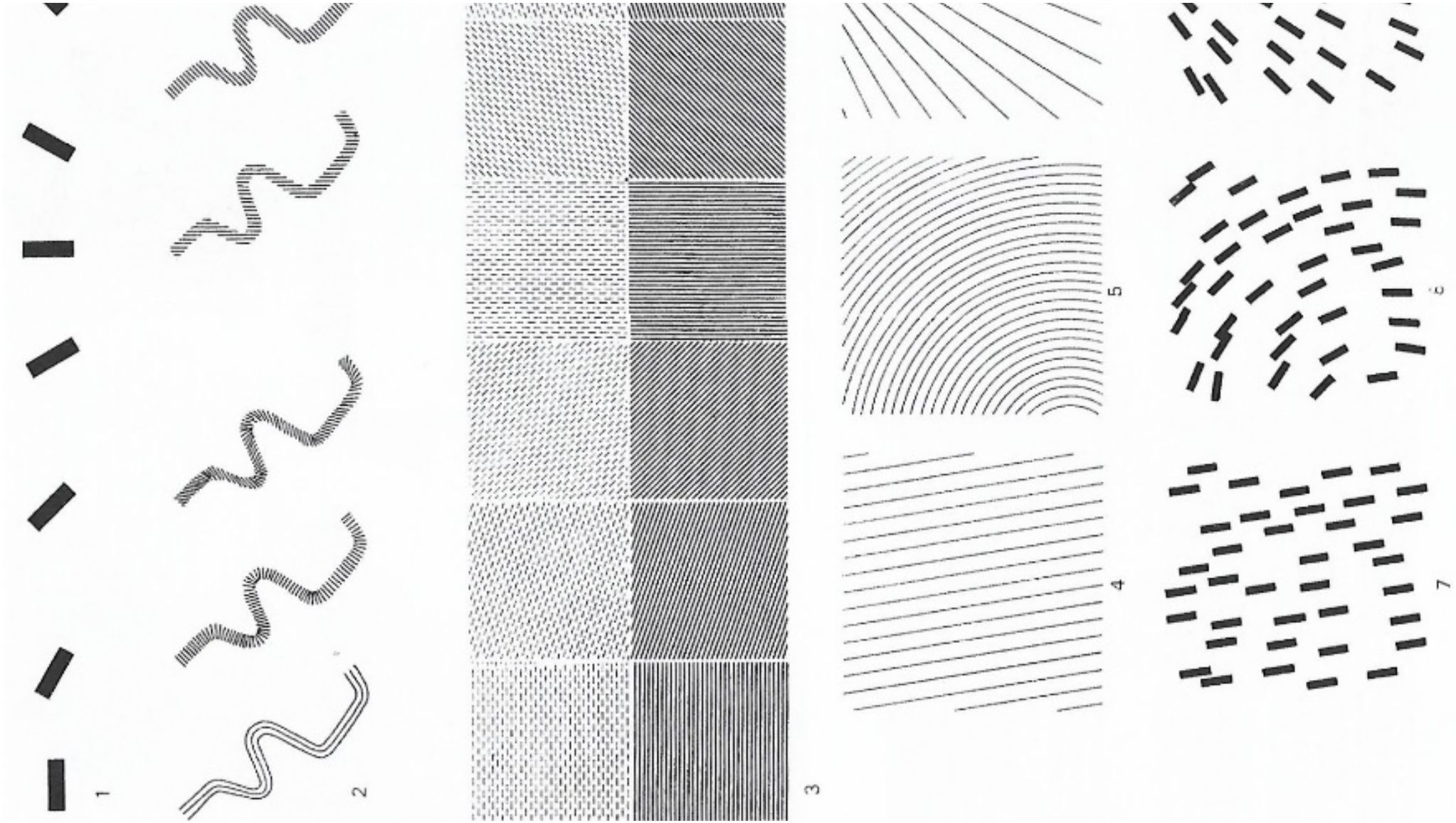
Visual variables - Shape

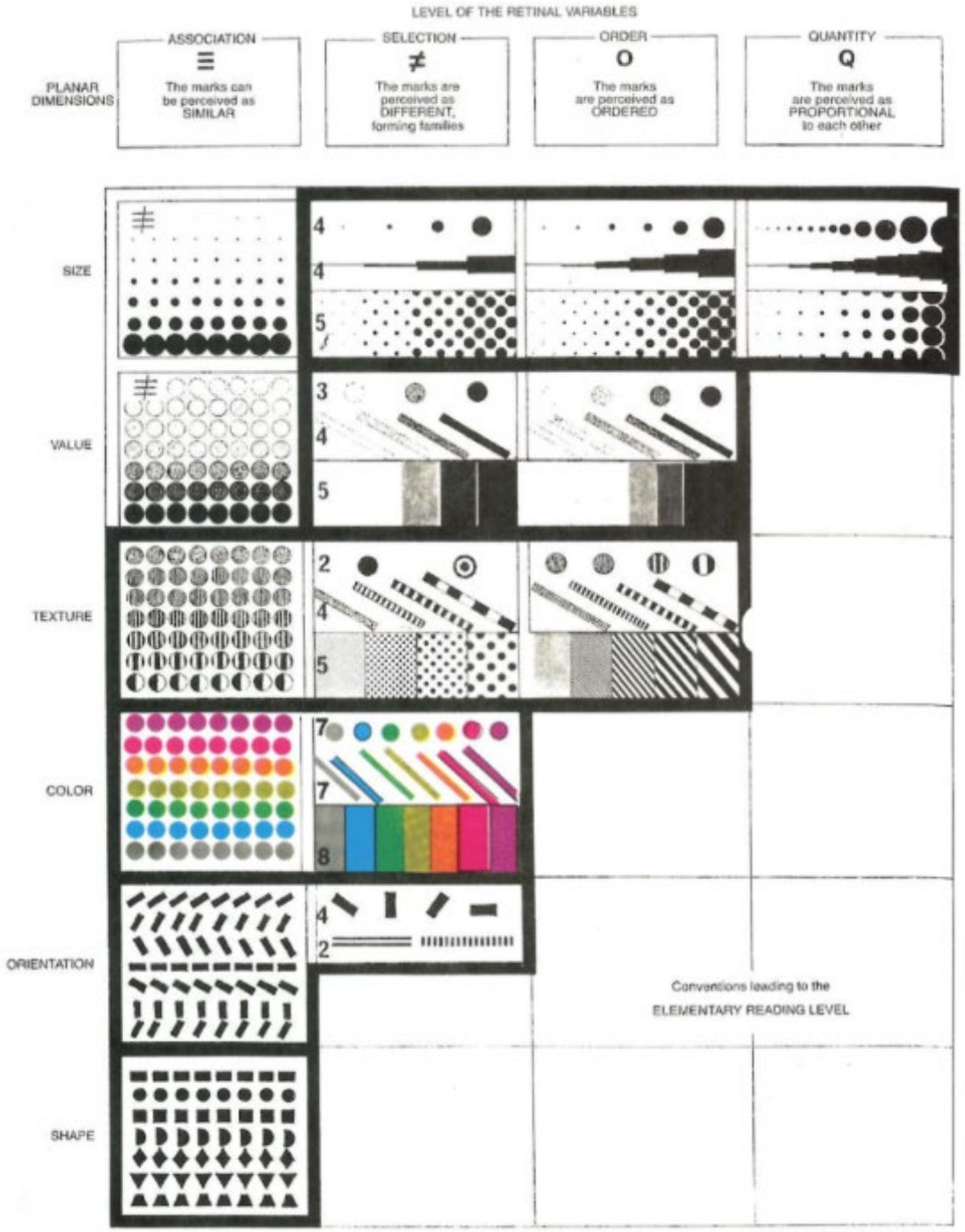


Visual variables - Orientation



Synthesis

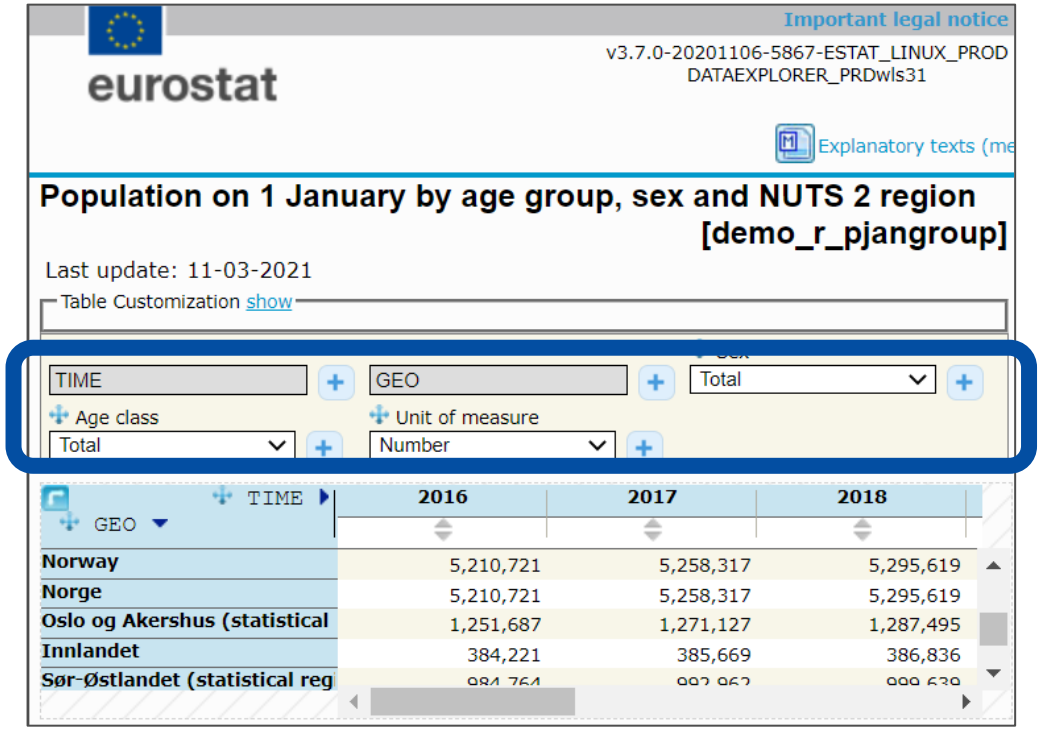
A grammar for mapmaking

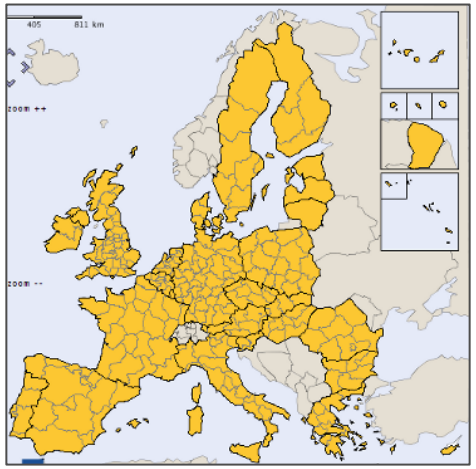


Focus on official statistics

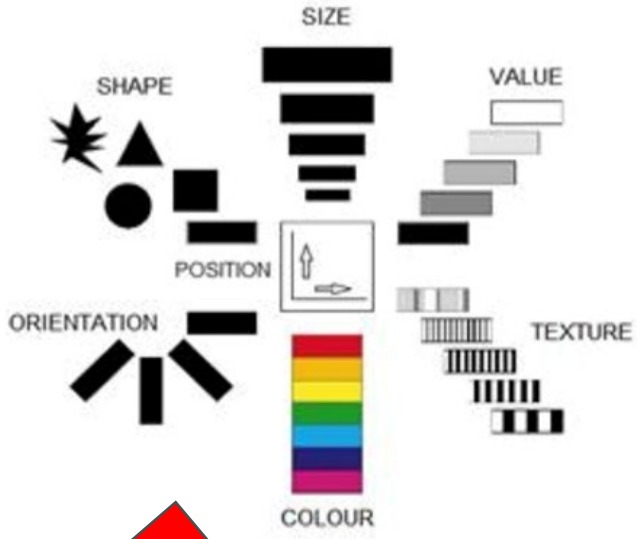
- Types of variables: Nominal, ordinal, numeric (absolute / relative)
- Organised into a hypercube structure, X dimensions.
- Implantation:
  - Aggregates, usually on areal statistical units.
  - Sometimes micro data, on point unit records.
  - More rarelly, on linear statistical units (network).

Focus on official statistics - Eurostat





Hypercube dimensions



How ?

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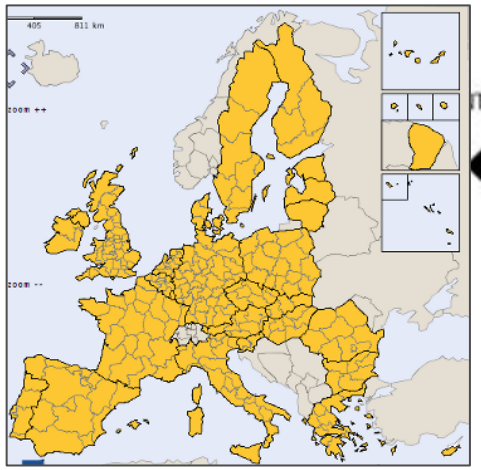
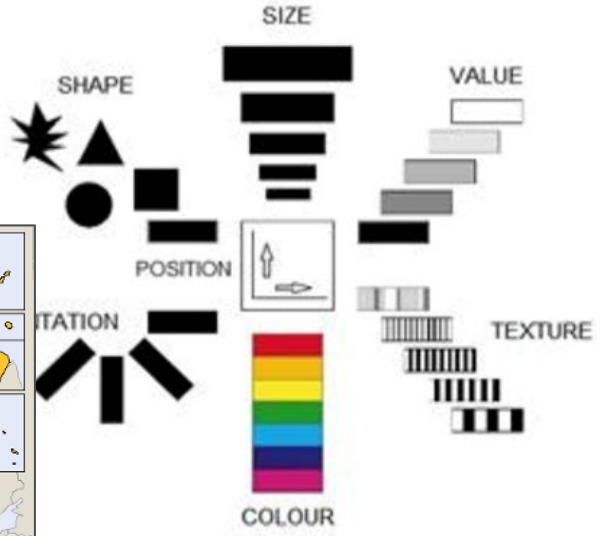
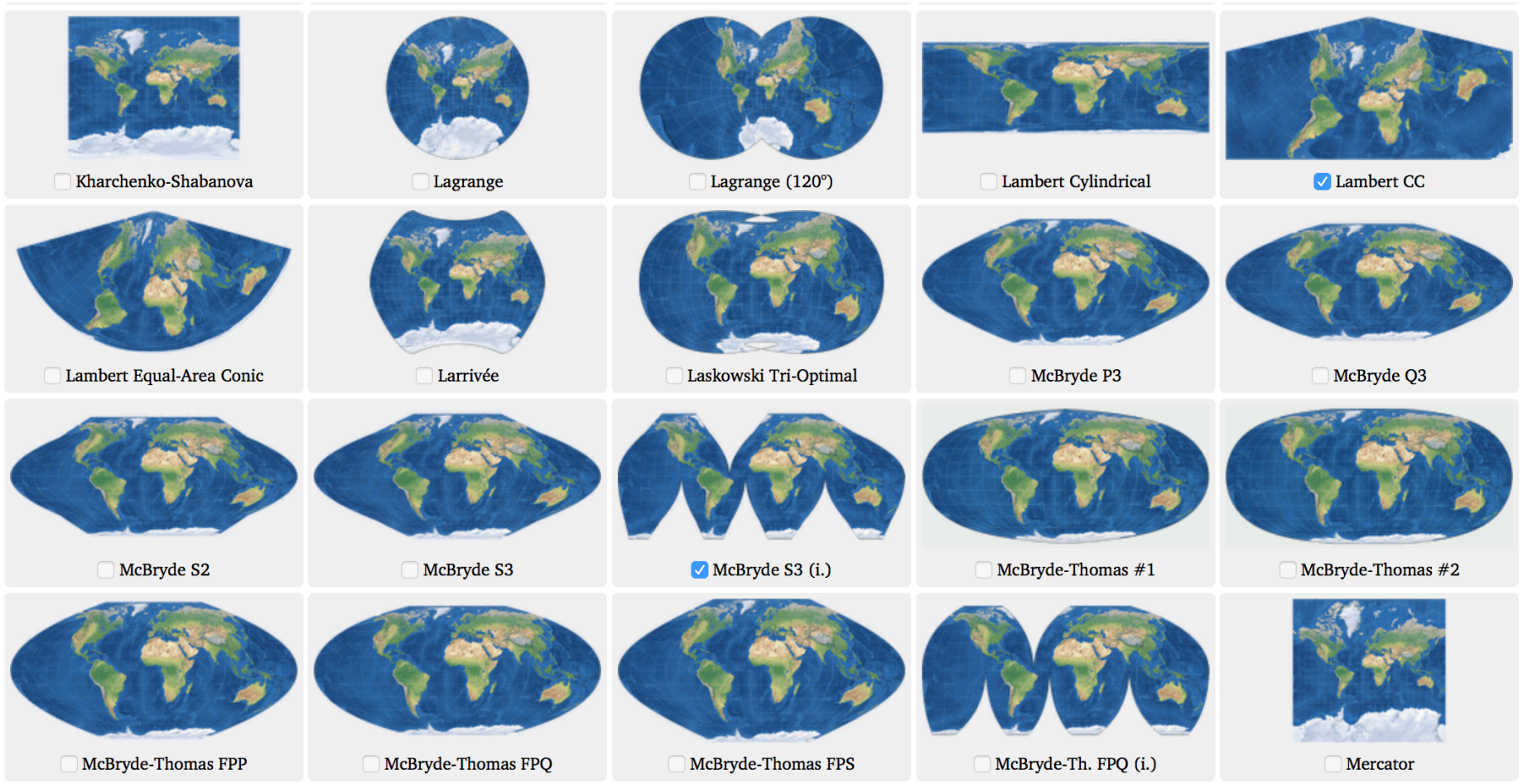
Some rules for statistical map template

- Cartographic projections
- Generalisation – aggregation
- MAUP





Cartographic projections



Cartographic projections

- Projection introduce distortion in size, shape or both.
  - Equal area projections preserve size.
  - Conformal projections preserve shape/angle.
  - Compromise projections
- Illustration with Tissot's indicatrix

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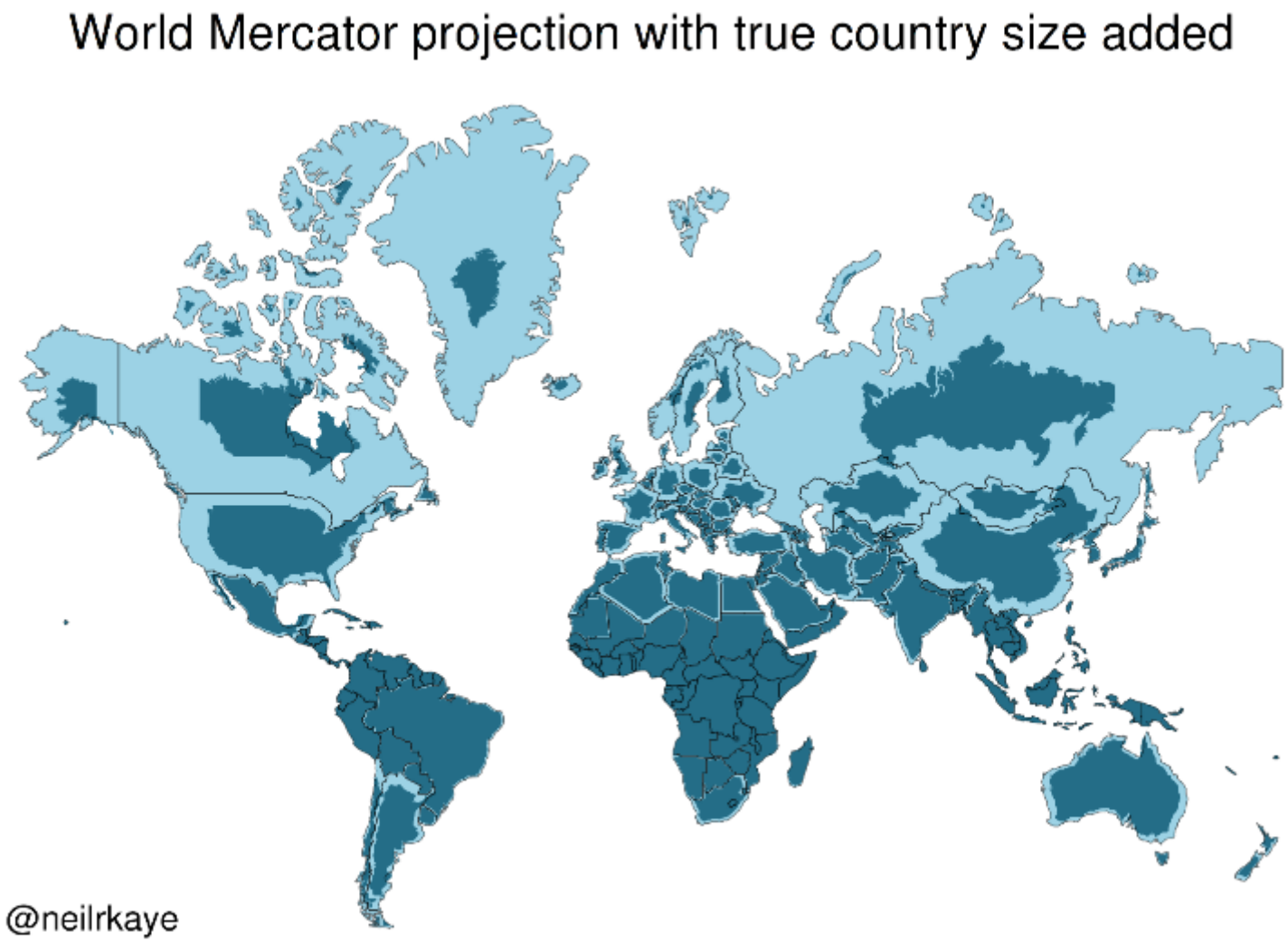
Cartographic projections



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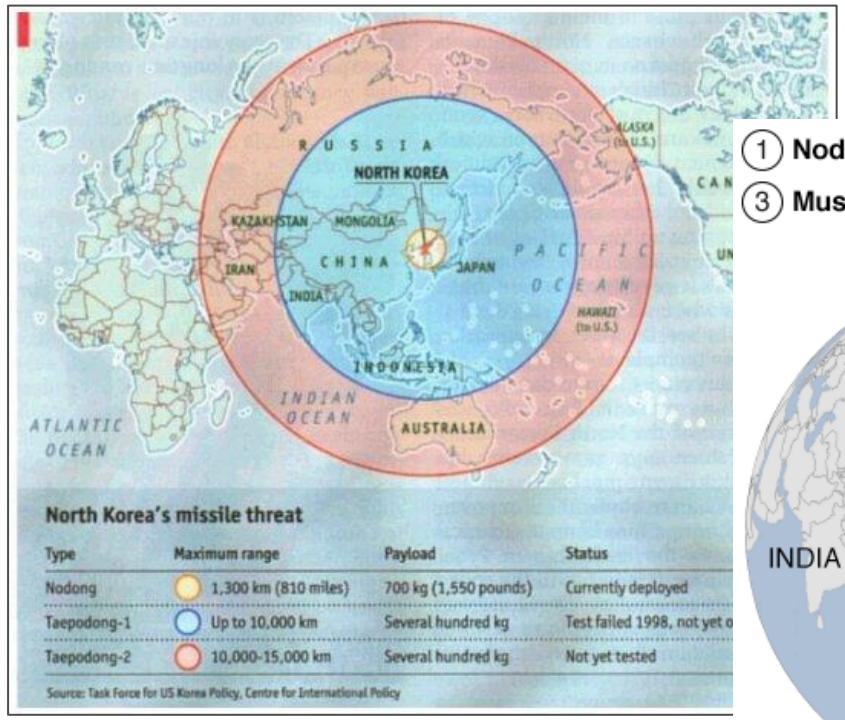
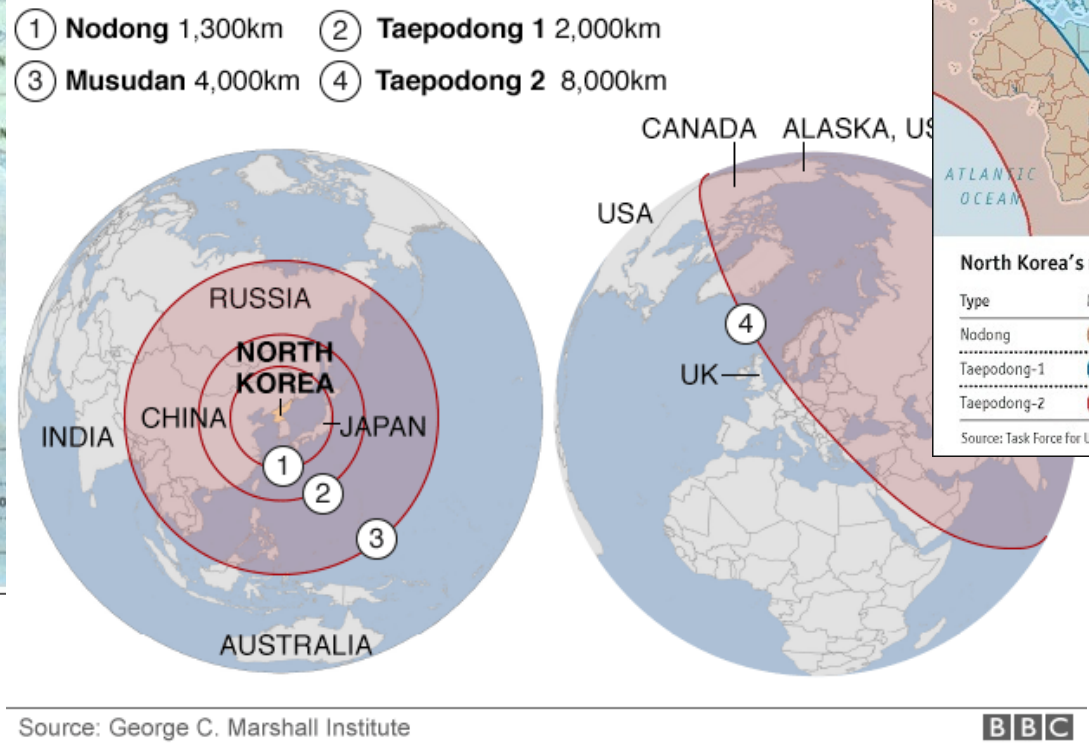
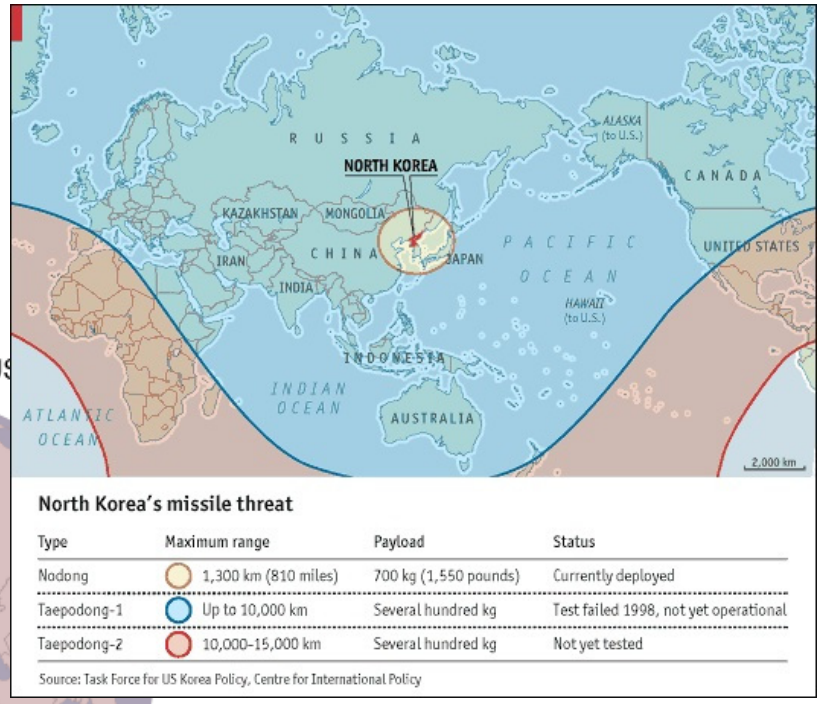
Cartographic projections

North Korea's missiles range, the Economist, 2003







Source: George C. Marshall Institute BBC

https://georeferenced.wordpress.com/2014/05/22/worldmapblunders/

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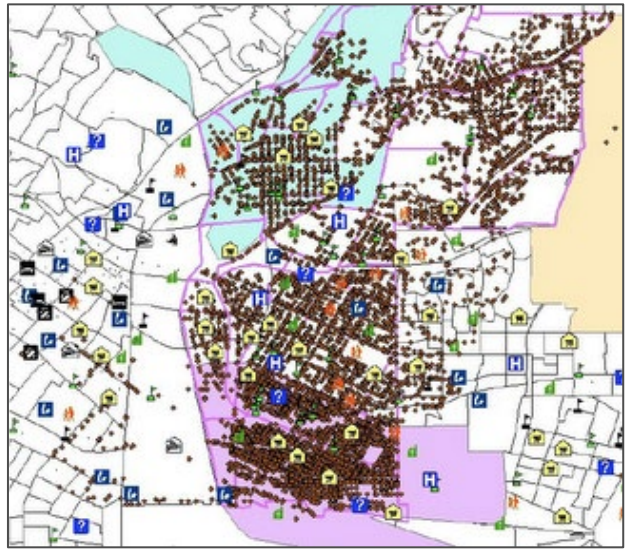
Cartographic projections

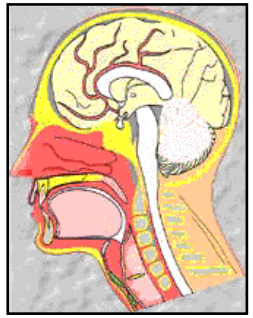
- Spilhaus projection

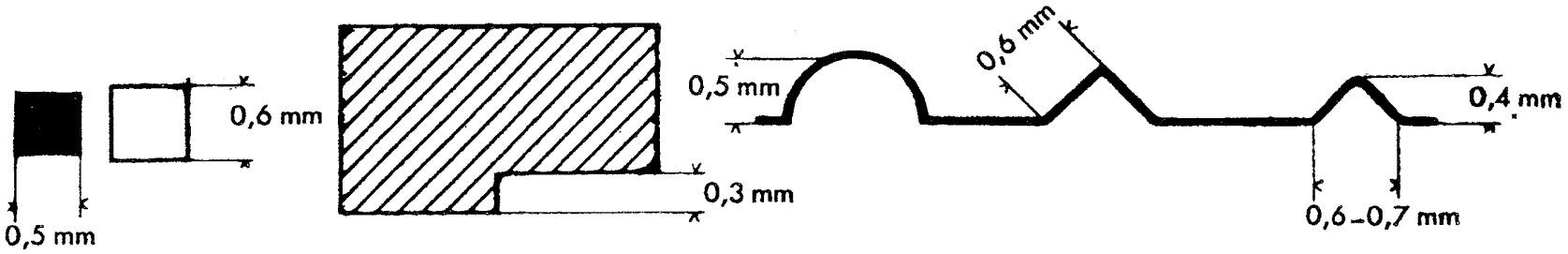
Spilhaus, A. (1942). "Maps of the whole world ocean." *Geographical Review*, 32 (3), p. 431–5. doi: 10.2307/210385

Simplification – generalisation

- Need to keep information simple
- Keep suitable information density, depending on the scale
- Improve legibility







[Salichtchev 1967; Cuenin 1972]

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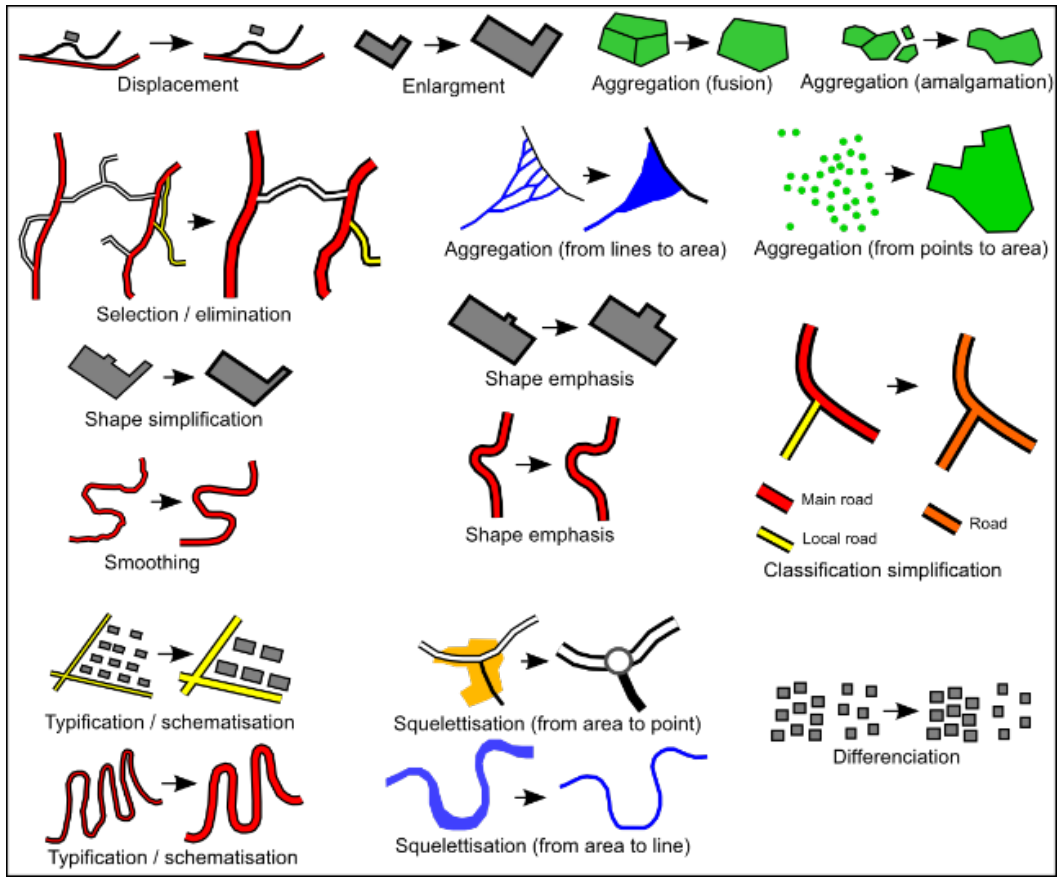
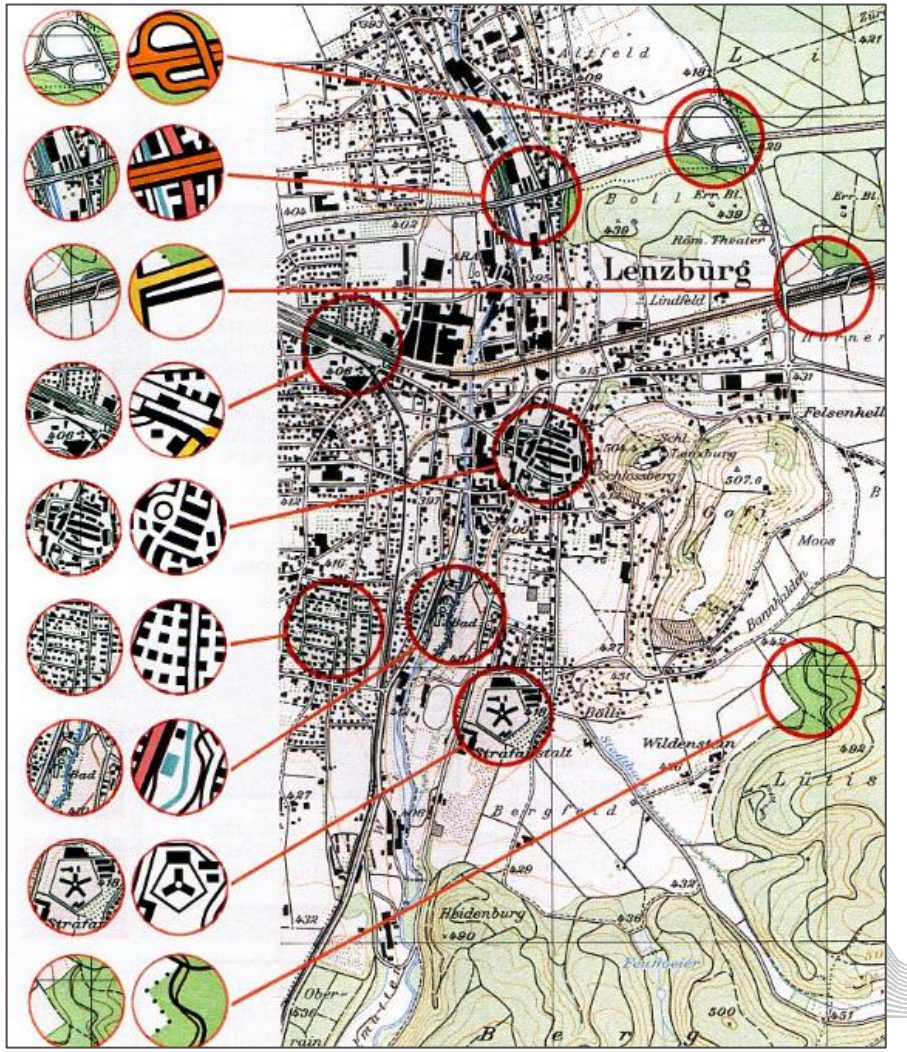
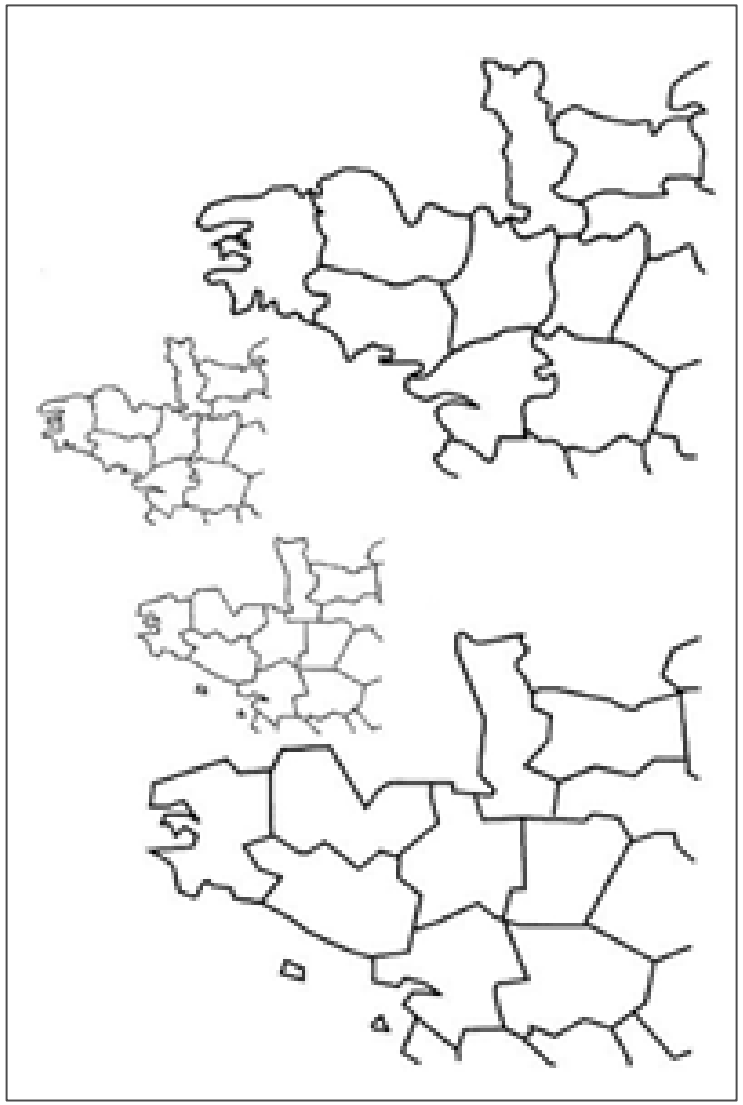
Simplification – generalisation

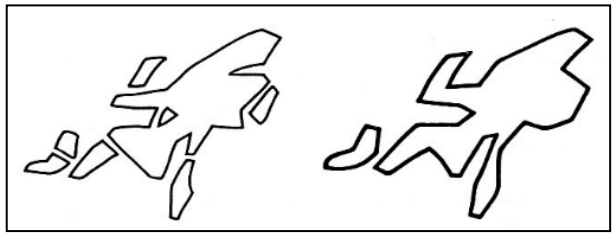
- The case of topographic maps.

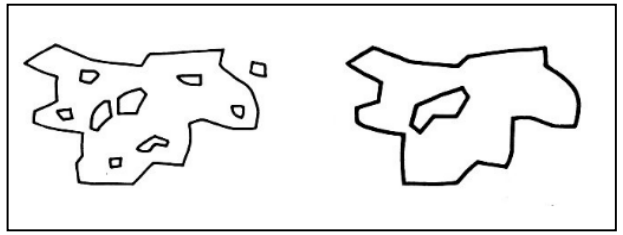


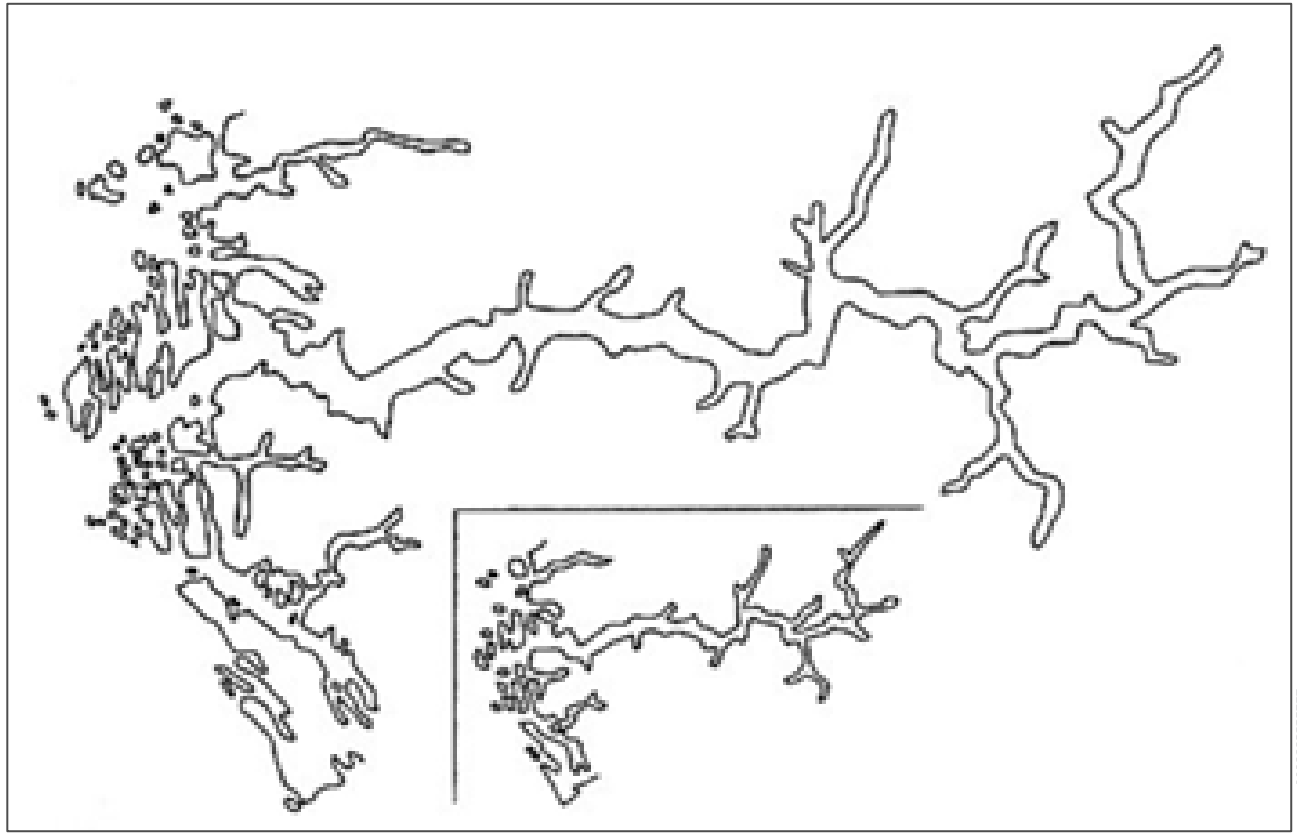


Simplification – generalisation



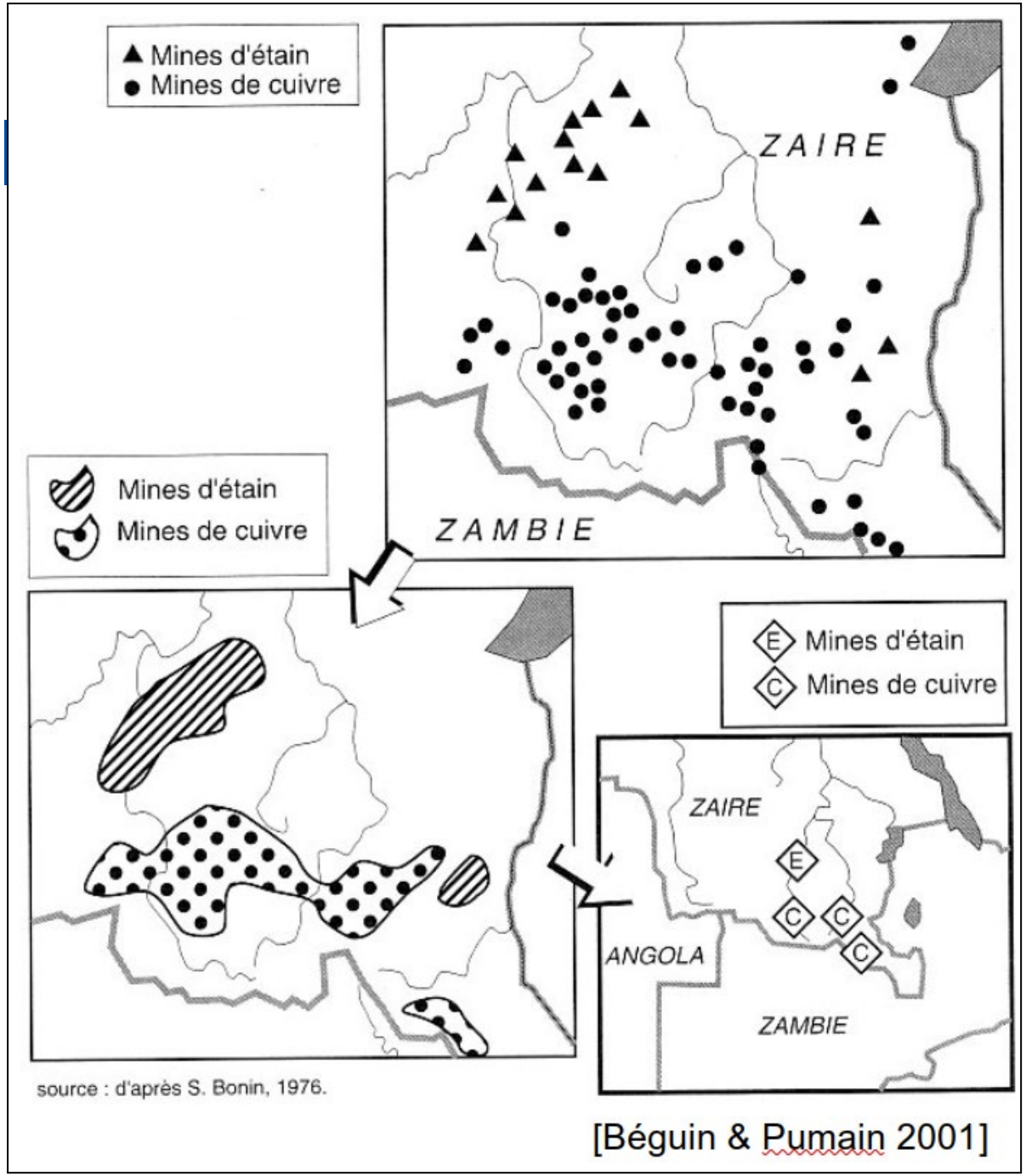






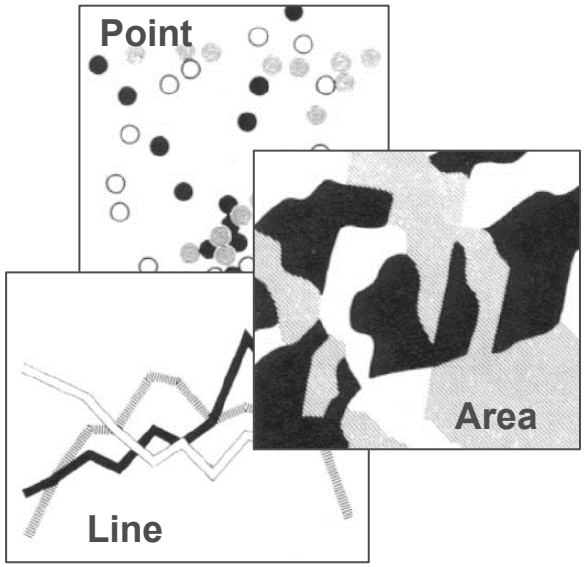
Simplification – general

- For thematic maps, need to adapt implantation to the scale.
- Aggregation units.
- Show clusters – as proportional symbols.
- Show as isoline – kernel density.

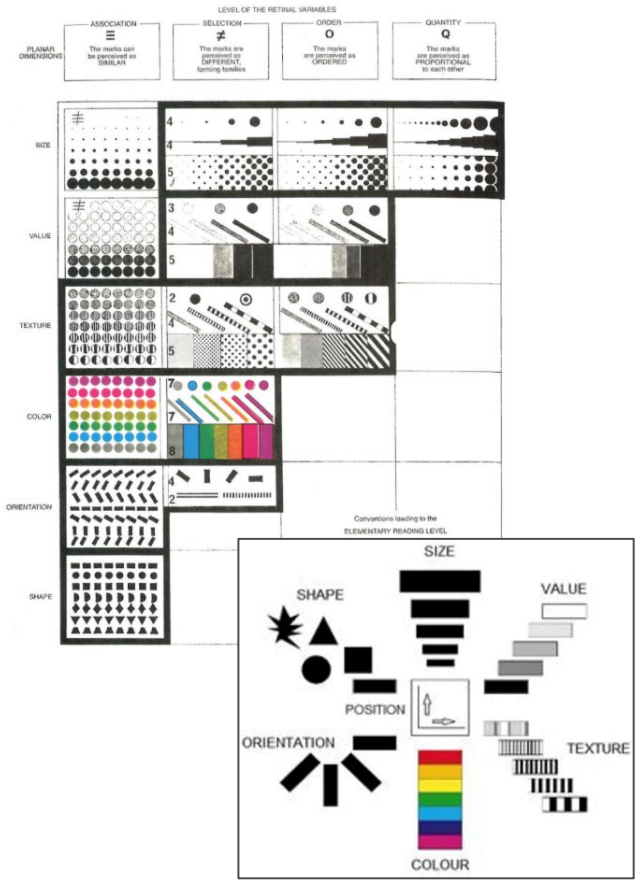


The cartographic language

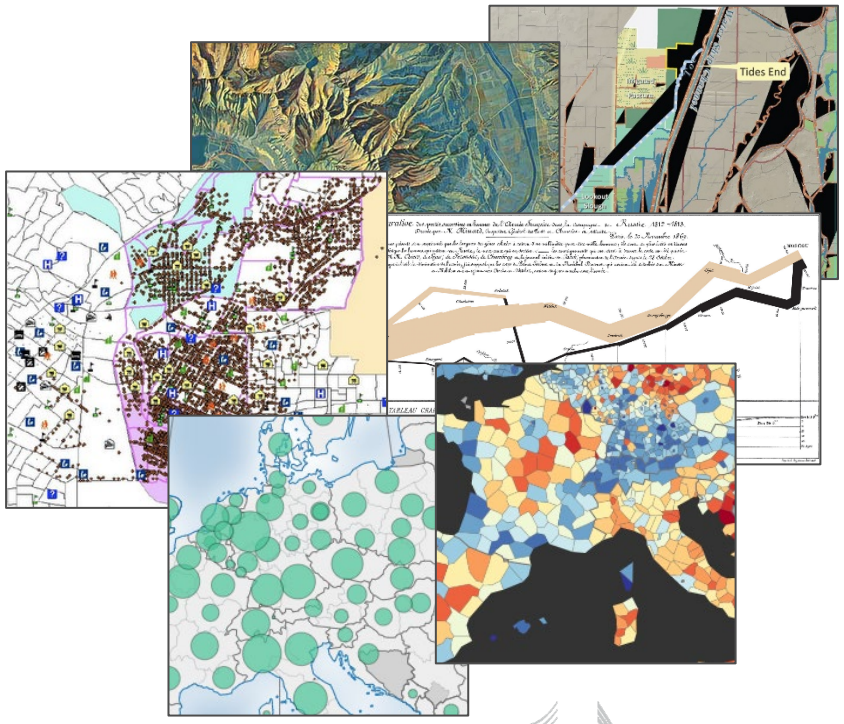
Words



Grammar, rules



Litterature



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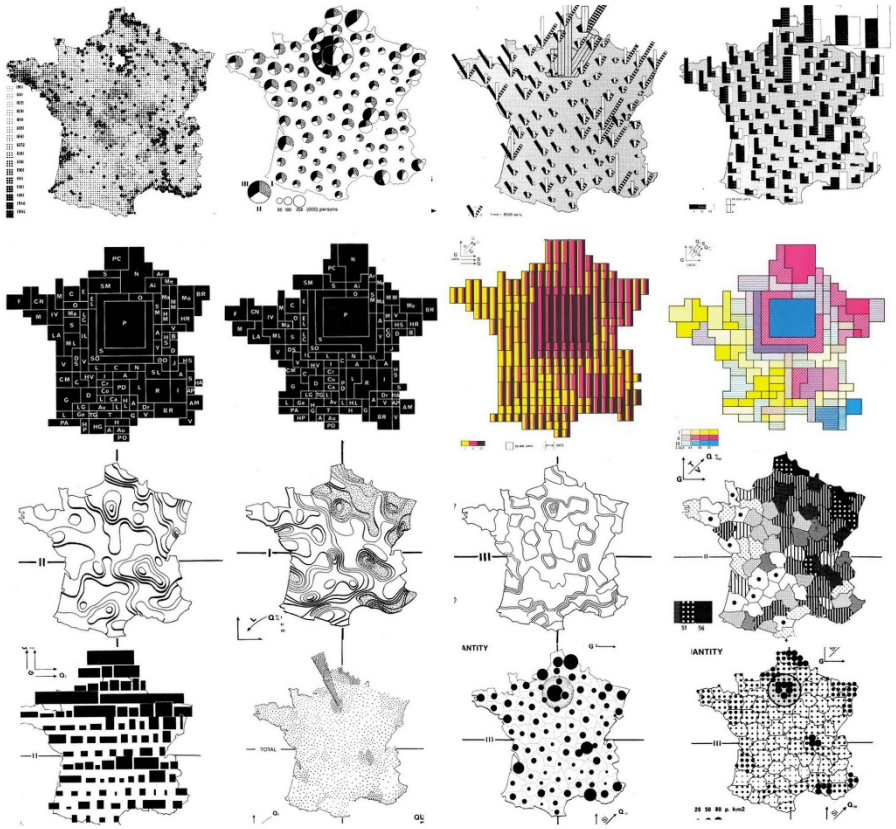
Gallery of statistical maps

Choropleth, proportional symbols, isopleth/isoline, dot density, dasymetric, proportional composition, proportional shades, small multiple, cartograms, flow maps, multivariate, time series, Chernoff faces, etc.



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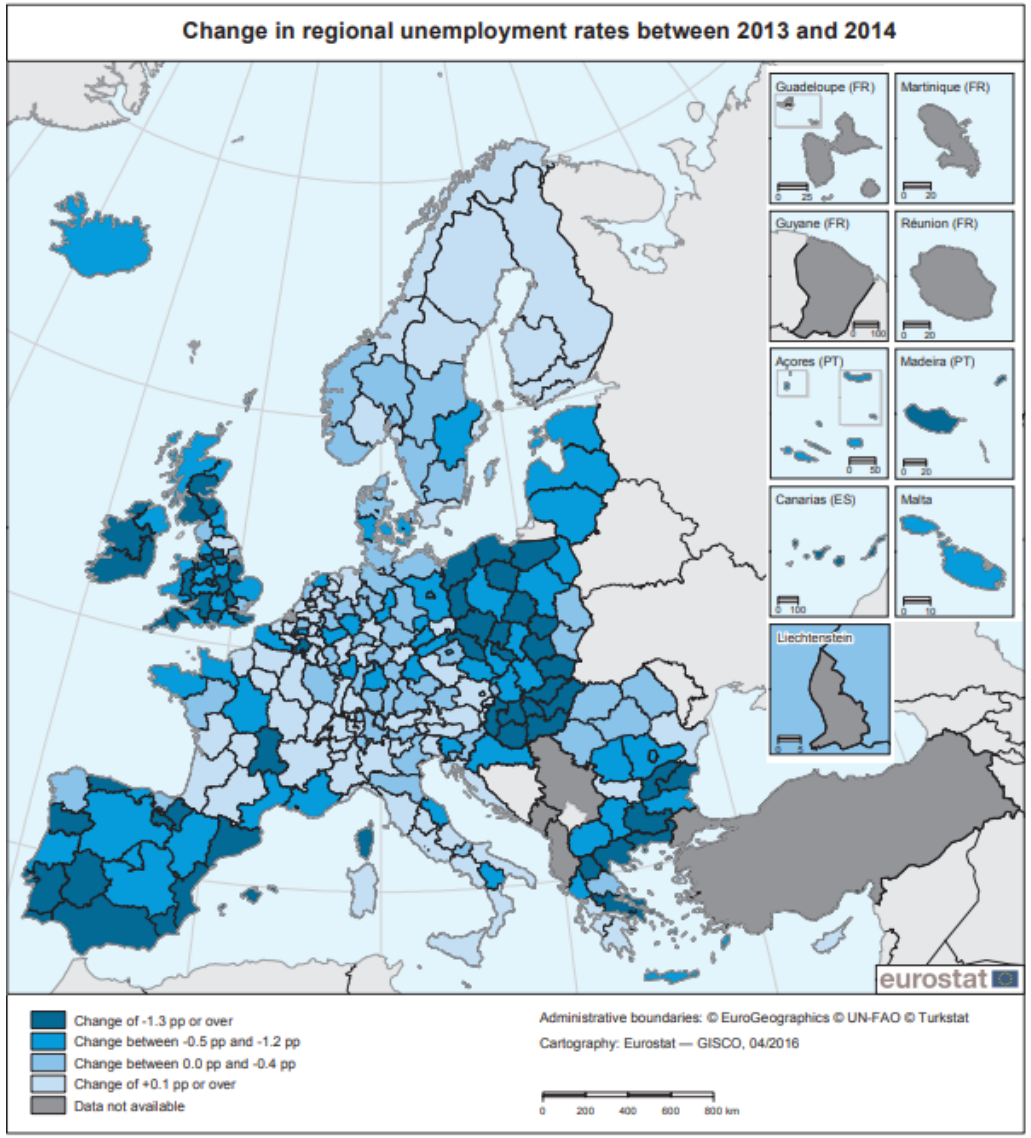
Choropleth

- From greek: **choros** (space) and **plethus** (quantity).
- Use color value (or ordered texture) to show the variation of a statistical variable.
- To show relative values (rates, percentages, densities, etc.).



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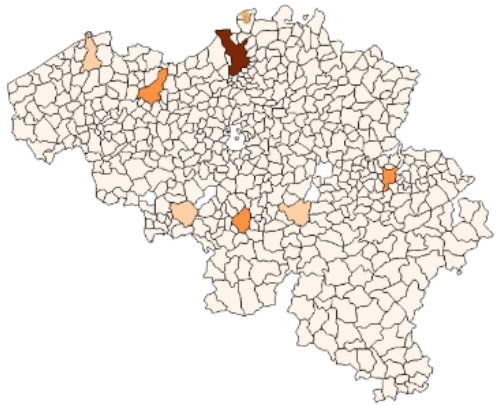
Choropleth – classification

- How many classes?
  - Depends on the number of values and their spatial distribution.
  - Keep colors ordered and differenciable. Usually, around 7.
  - Continuous colors also possible

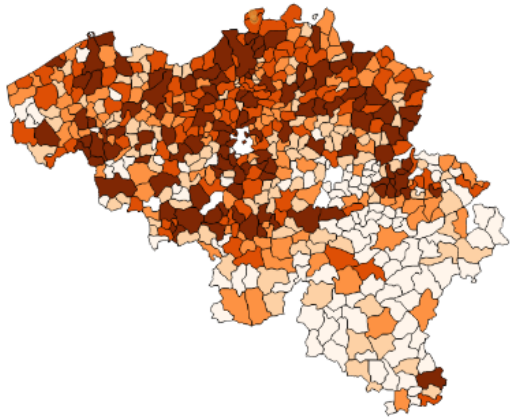
- More usual methods offered by GIS:
  - Equal intervals, Quantile, Natural breaks (Jenks optimized), Standard deviation, …
- What is the most suitable classification method ?

Choropleth – classification

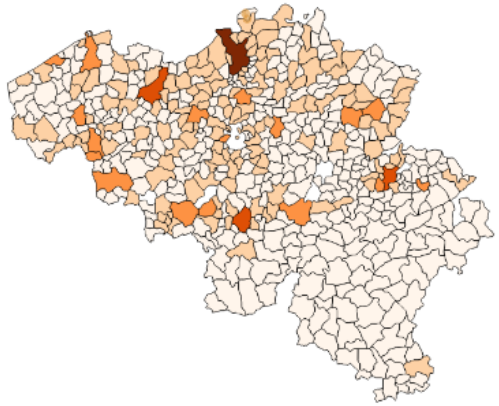
Equal intervals



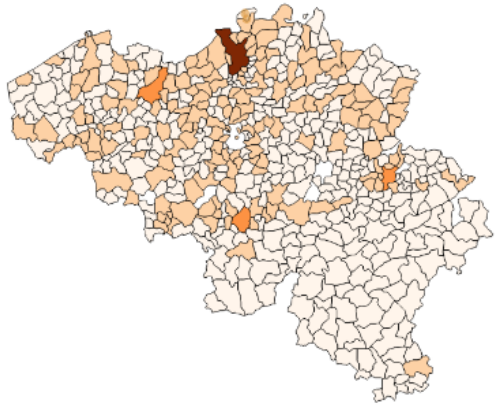
Quantiles

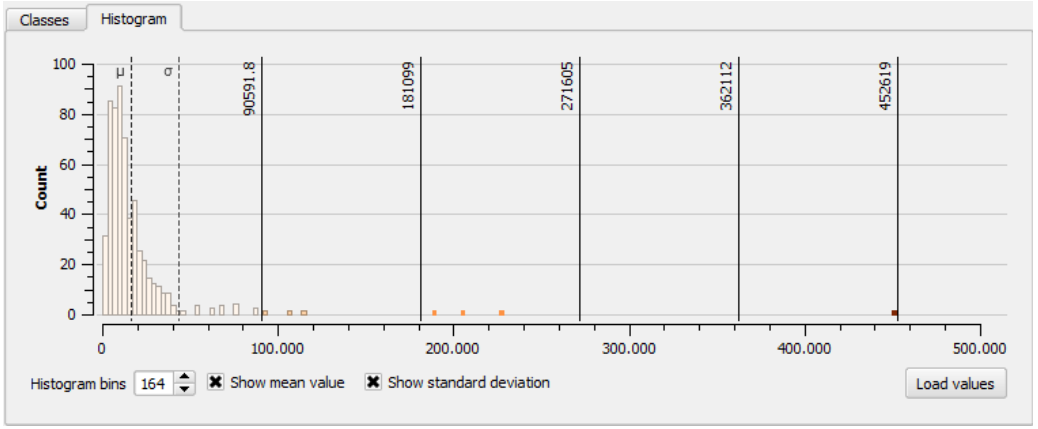


Natural breaks (Jenks)



Standard deviation

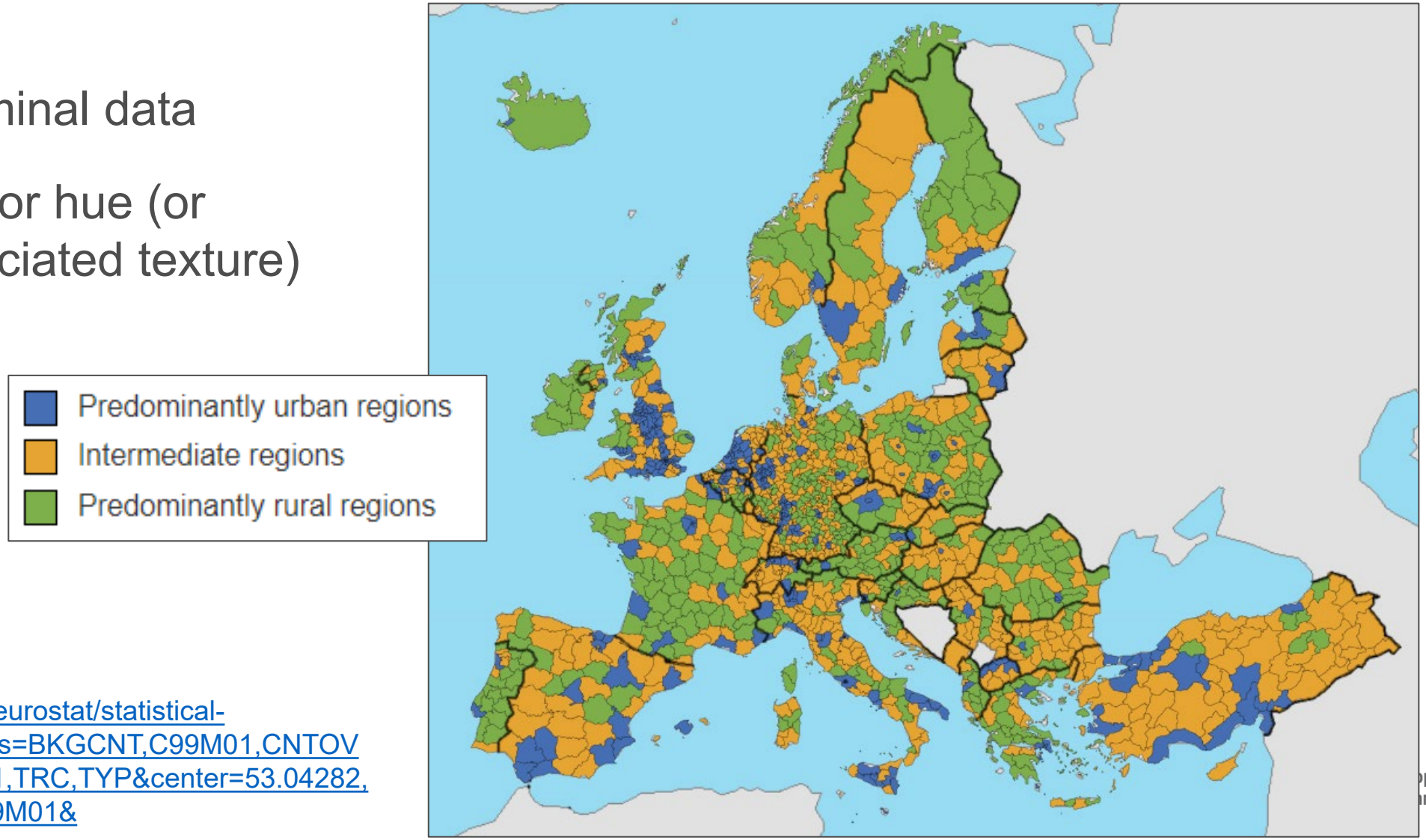




European Commission

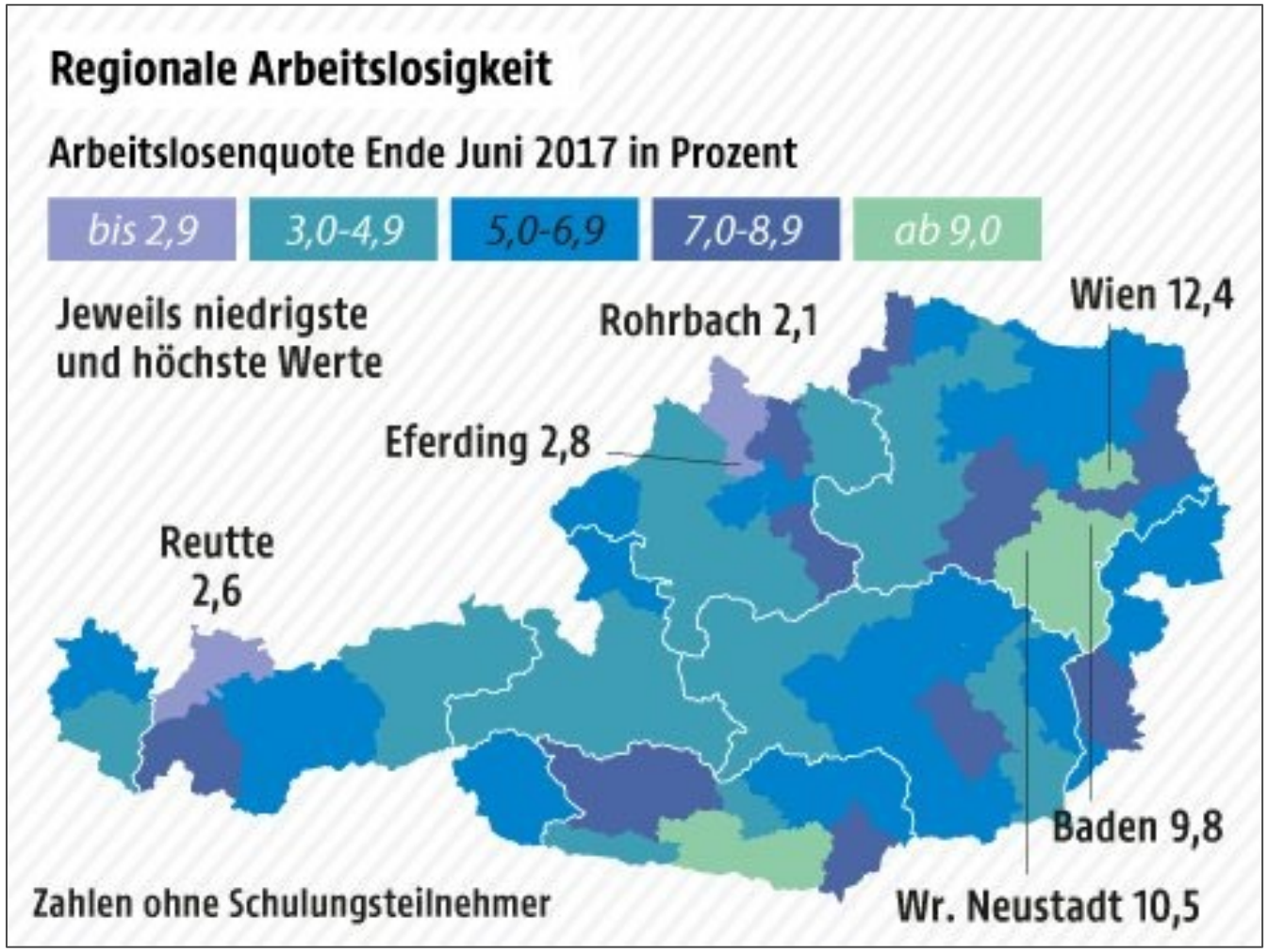
Choropleth – categorical

- For nominal data
- Use color hue (or differenciated texture)



https://ec.europa.eu/eurostat/statistical-atlas/gis/viewer/?mids=BKGCNT,C99M01,CNTOVL&o=1,1,0.7&ch=C01,TRC,TYP&center=53.04282,20.92576,3&lcis=C99M01&

Choropleth – Color

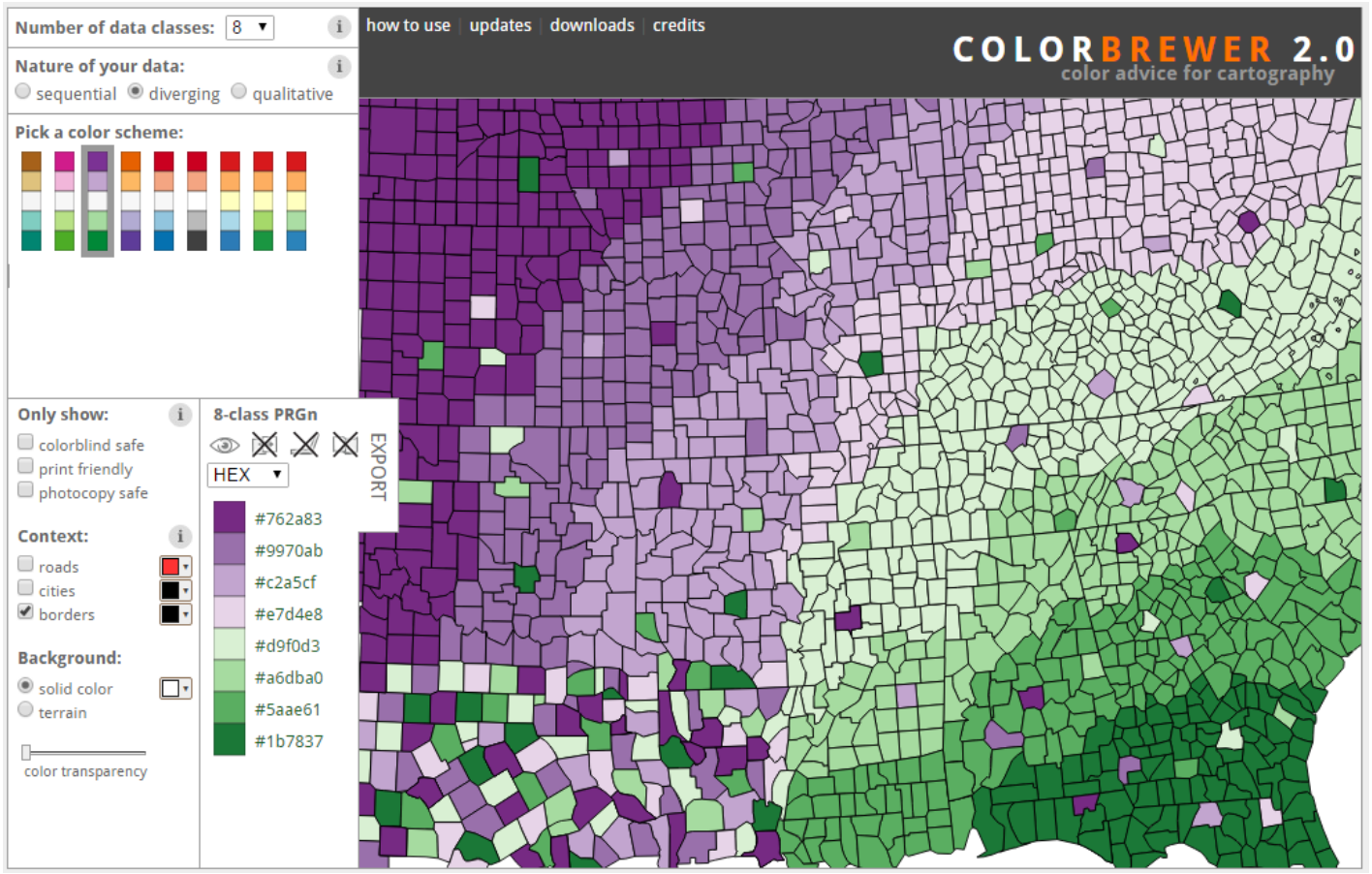


Color value: order
Color hue: selection

European Commission

Choropleth – Color palettes

- ColorBrewer

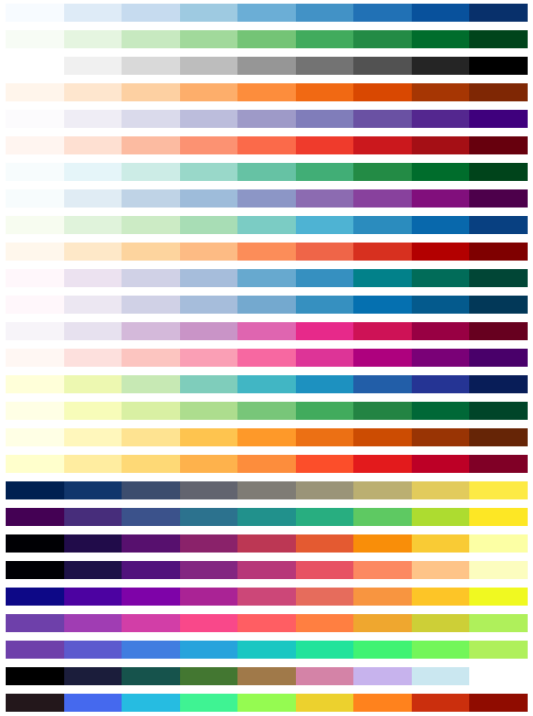


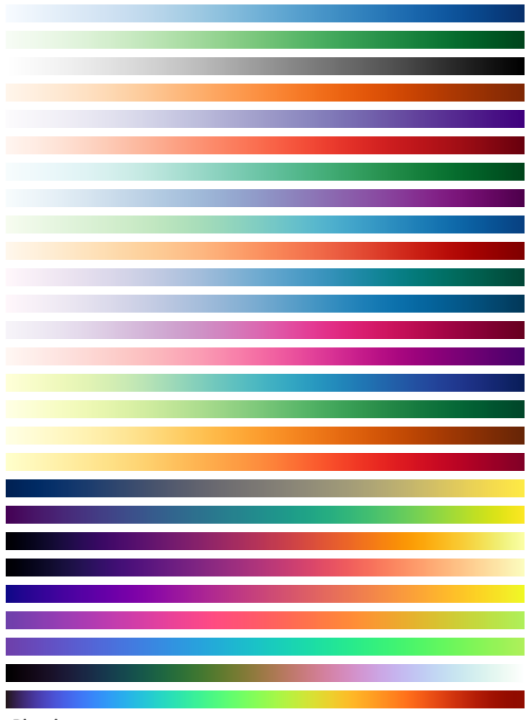
https://colorbrewer2.org

Choropleth – Color palettes

- Exemple from d3-scale-chromatic library.
  - **Sequencial palettes** (ordered color values)

Discrete
(9 classes)





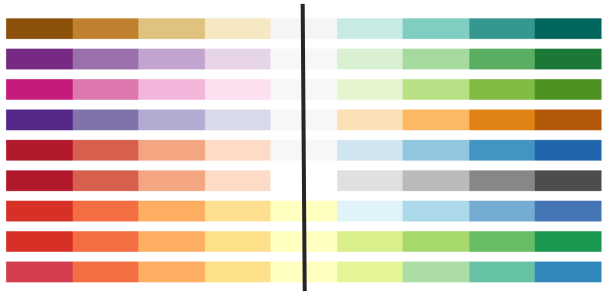
Continuous

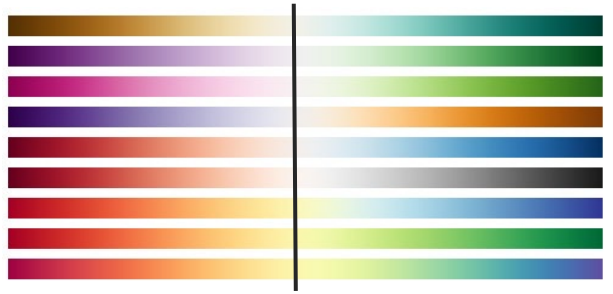
European Commission

Choropleth – Color palettes

- **Diverging palettes** (ordered color values, with 2 color hues for differenciation around a central value)

Discrete
(9 classes)





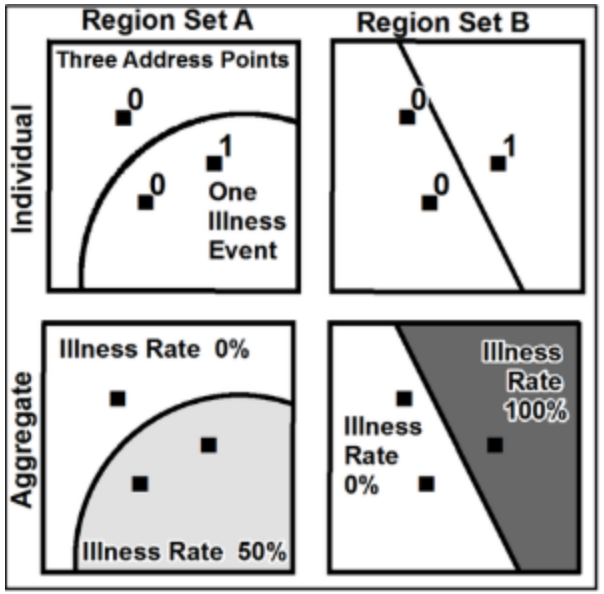
Continuous

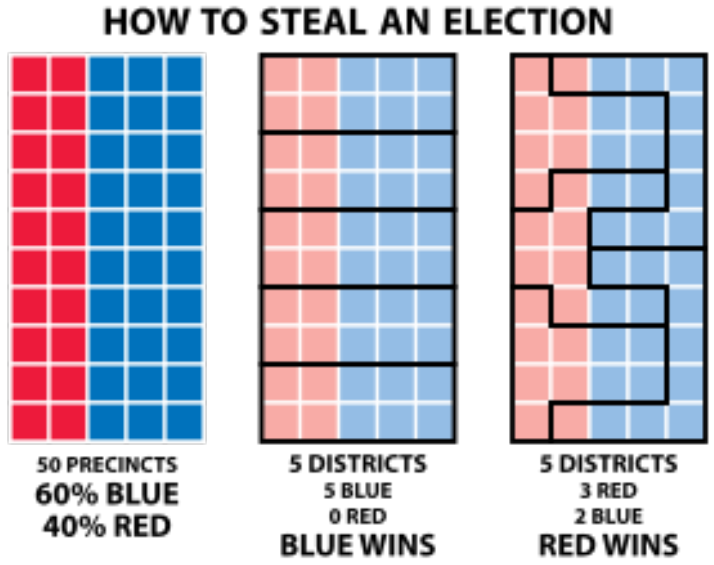
- **Categorical palettes** (differenciable color hues)

European Commission

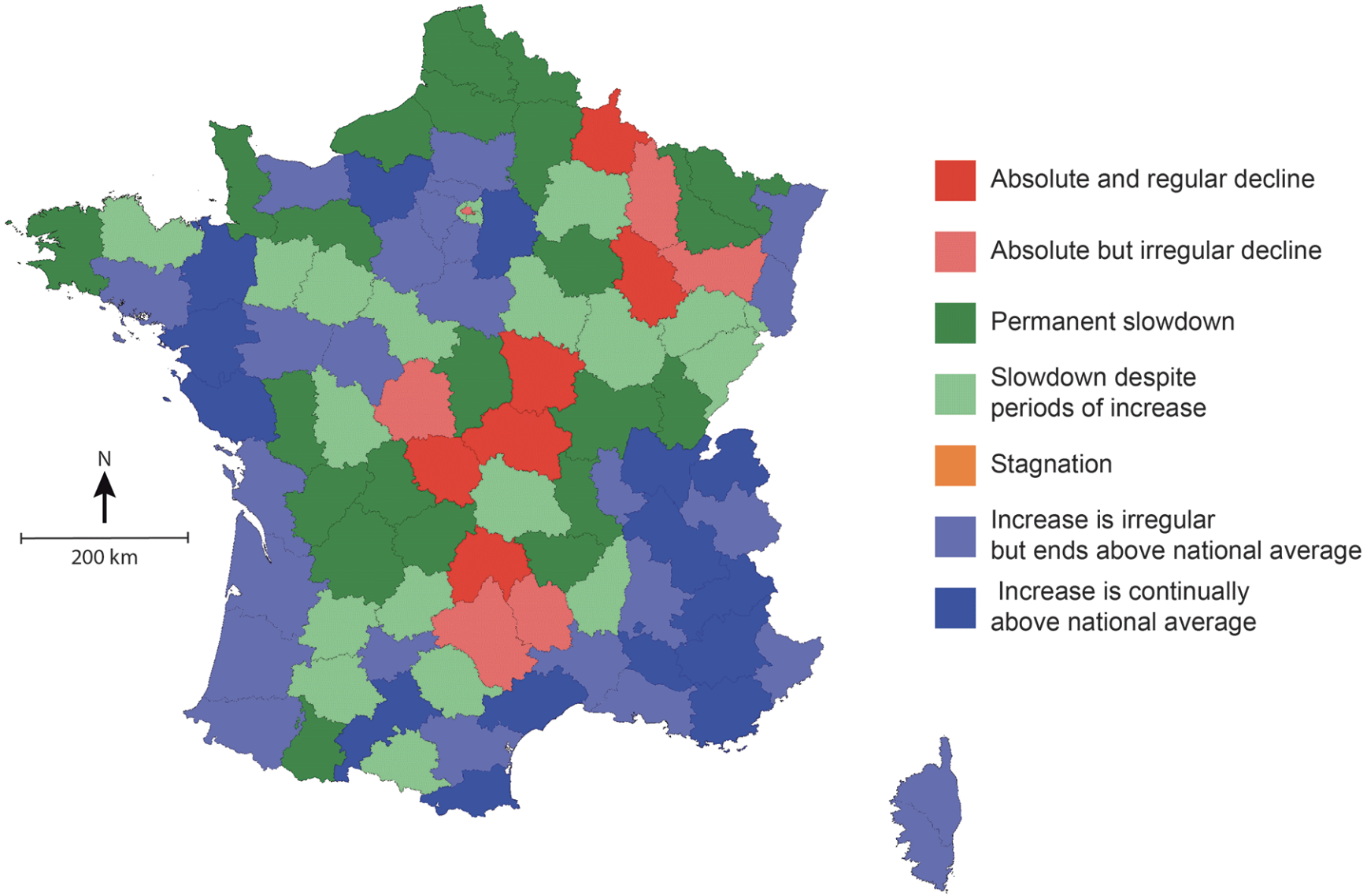
The modifiable areal unit problem (MAUP)

- Influence of the size and shape of the statistical unit on the aggregated statistical figure.





Typology of population growth trajectories of the French counties ("départements") between 1968 and 2009

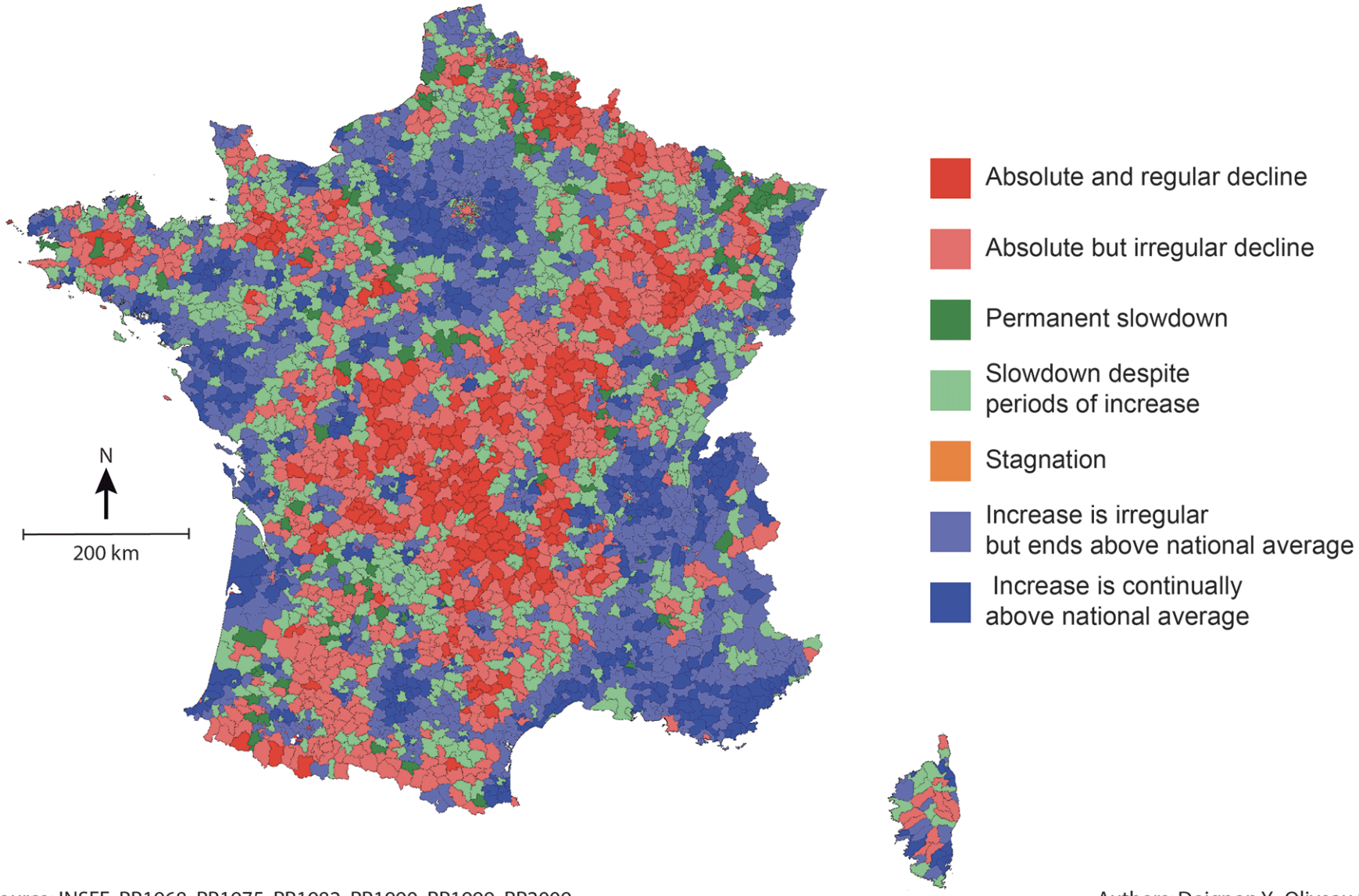


Source: INSEE, RP1968, RP1975, RP1982, RP1990, RP1999, RP2009

Authors: Doignon Y., Oliveau S. (2016)

European Commission

Typology of population growth trajectories of the French districts ("cantons") between 1968 and 2009

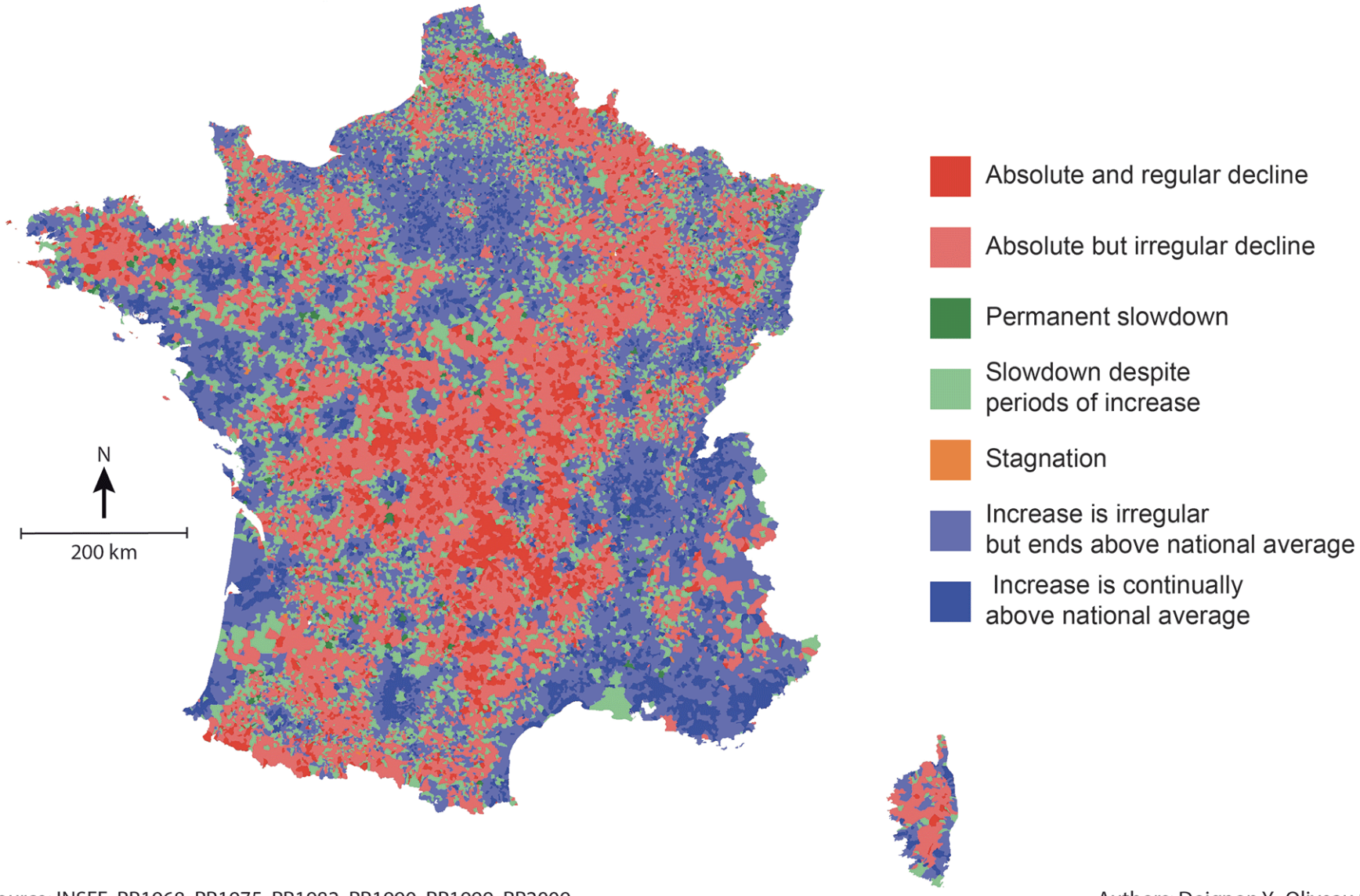


Source: INSEE, RP1968, RP1975, RP1982, RP1990, RP1999, RP2009

Authors: Doignon Y., Oliveau S. (2016)

European Commission

Typology of population growth trajectories of the French municipalities ("communes") between 1968 and 2009



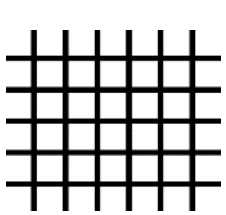
Source: INSEE, RP1968, RP1975, RP1982, RP1990, RP1999, RP2009

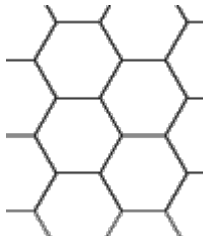
Authors: Doignon Y., Oliveau S. (2016)

European Commission

The modifiable areal unit problem (MAUP)

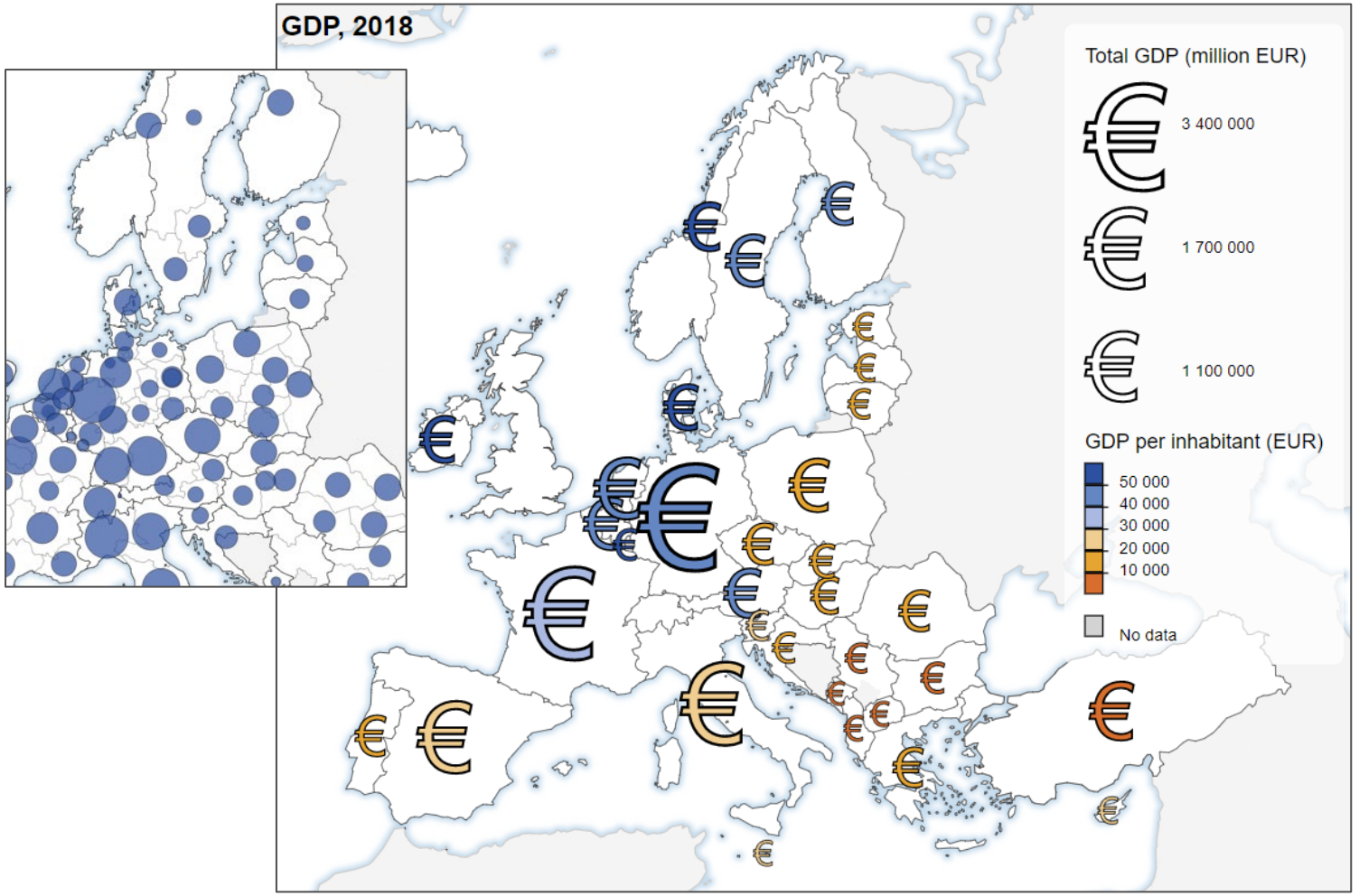
- Recommendations:
  - Use pertinent spatial level: Inter-region disparities should be higher than intra-region disparities
  - Use regions with comparable sizes and shapes
  - Best solution: Regular tesselations - Grids





Proportional symbols

- Size visual variable.
- To show absolute values (quantities, numbers, etc.).
- Can be used in combination with color, to show a second variable.

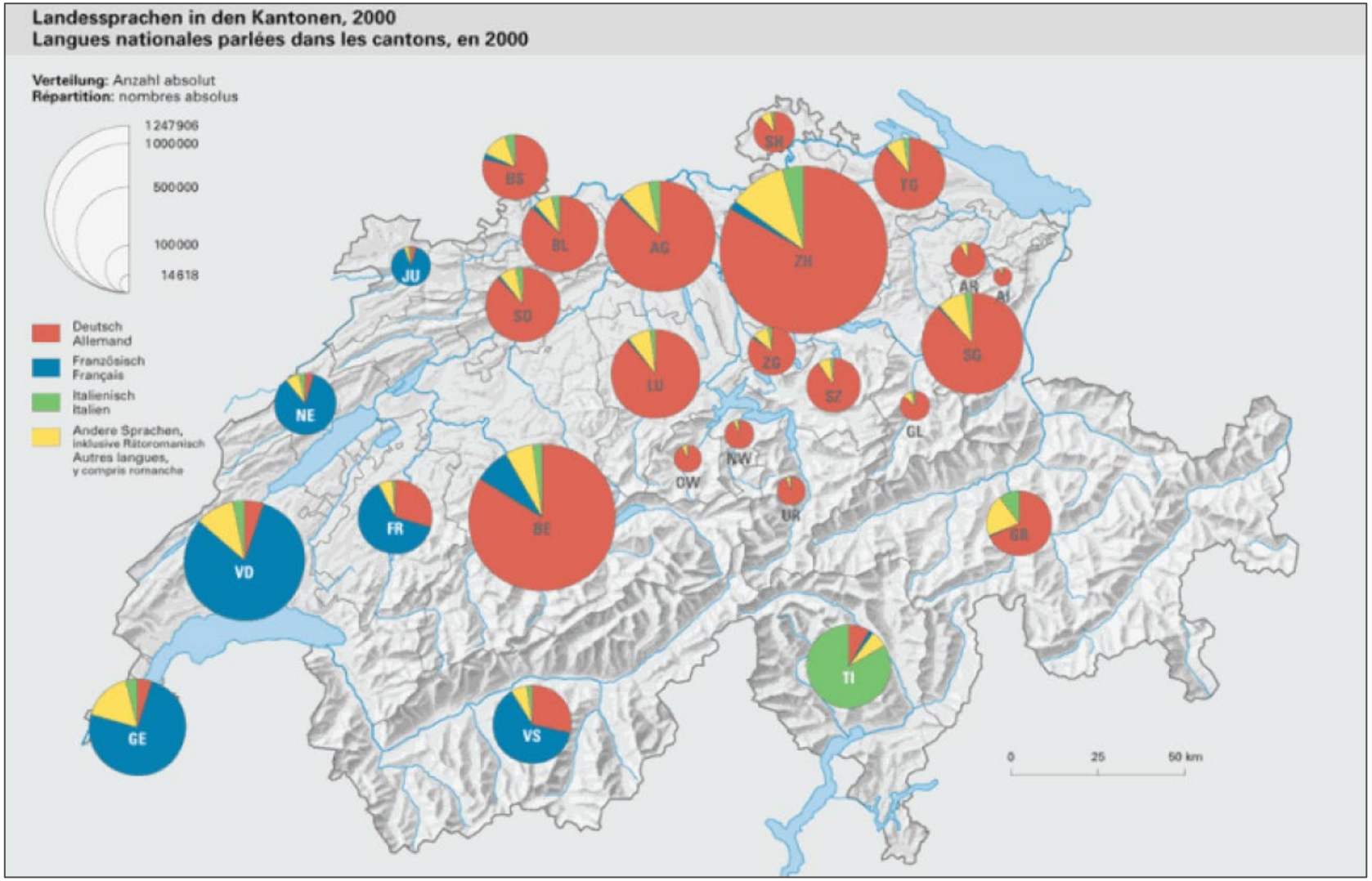


European Commission

Proportional compositions

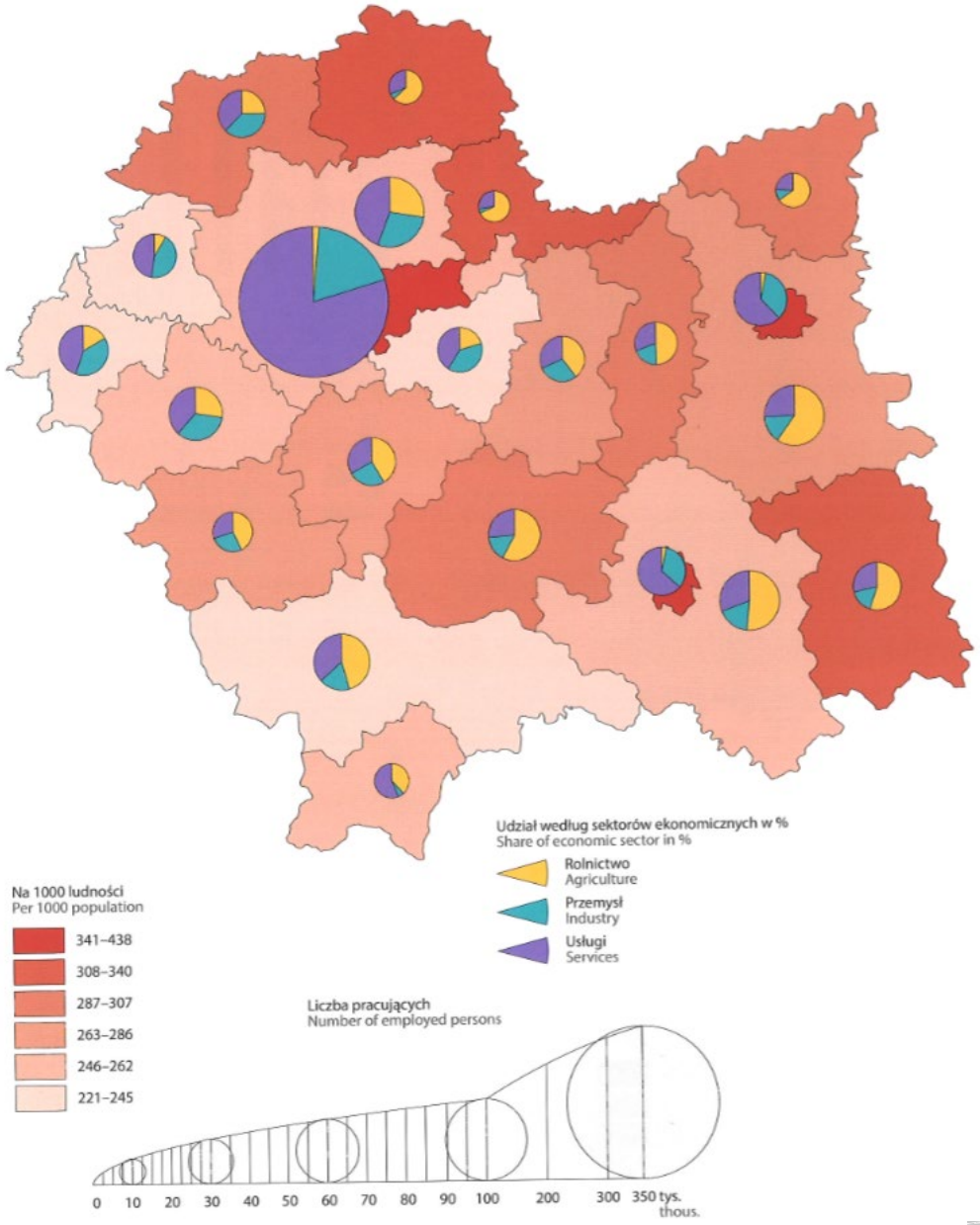
Langages of Switzerland

(as proportional pie chart map)



Combinations

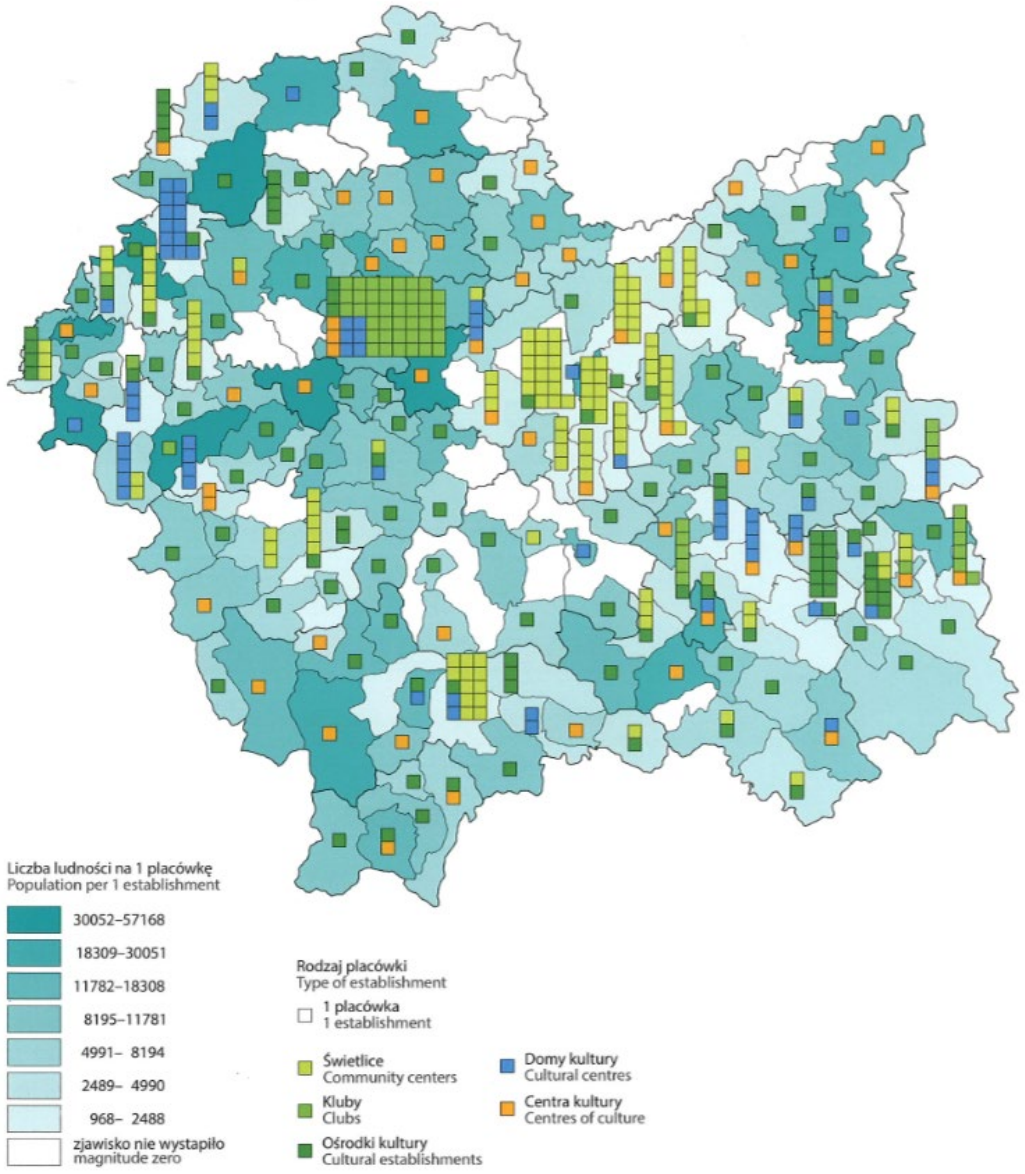
- Employment in 2016
  - Rate (choropleth)
  - Number (circle size)
  - By sector (circle color hue)



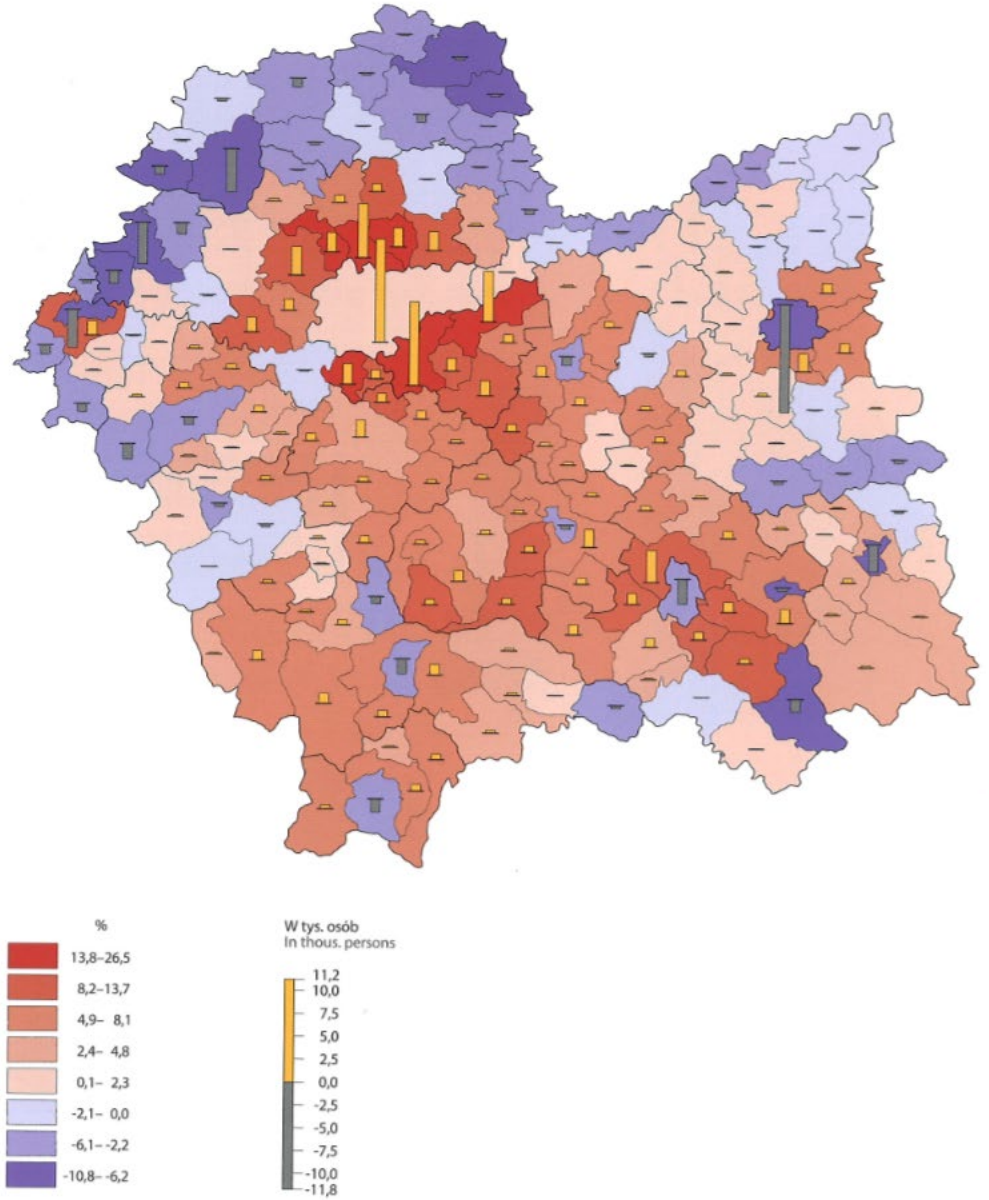
Statistical Atlas of Poland and statistical atlases of voivodships

European Commission

Culture centres in 2016



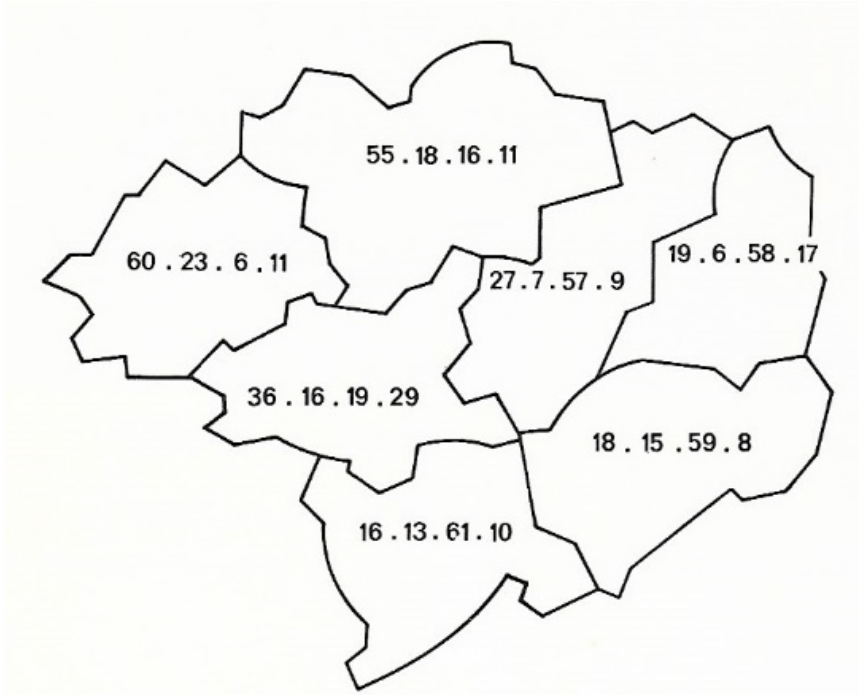
Population change, 2017-2030



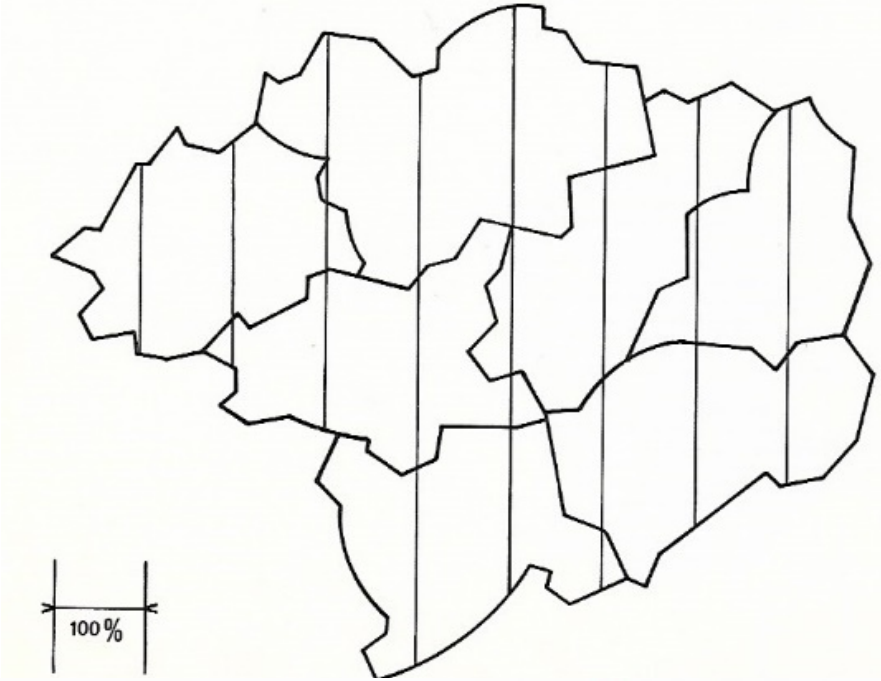
Statistical Atlas of Poland and statistical atlases of voivodships

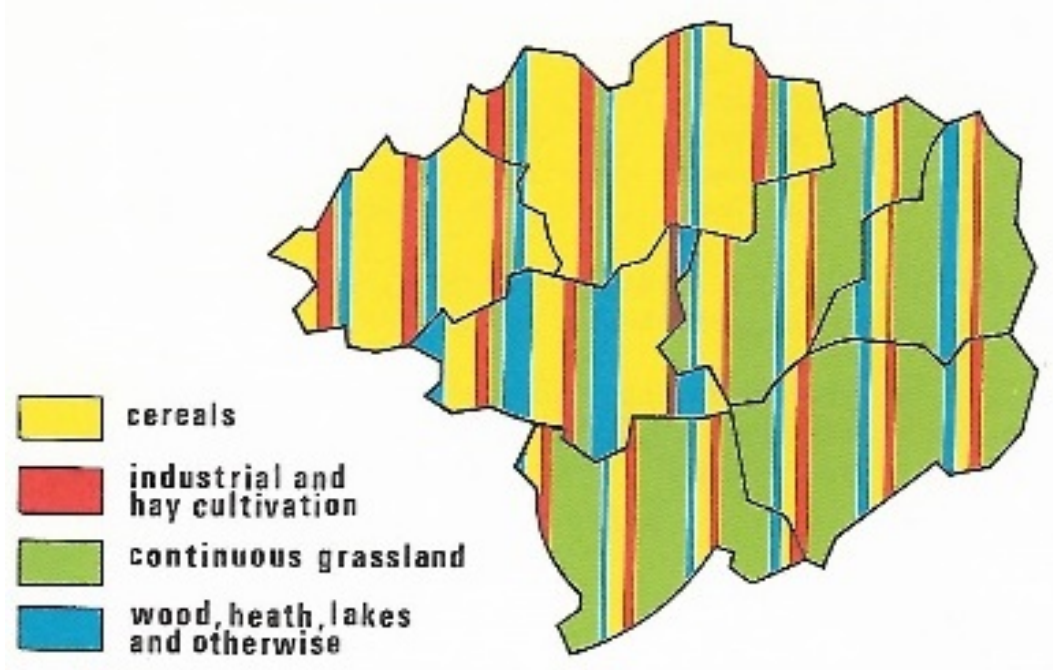
Proportional shading

- Area texture representing a composition

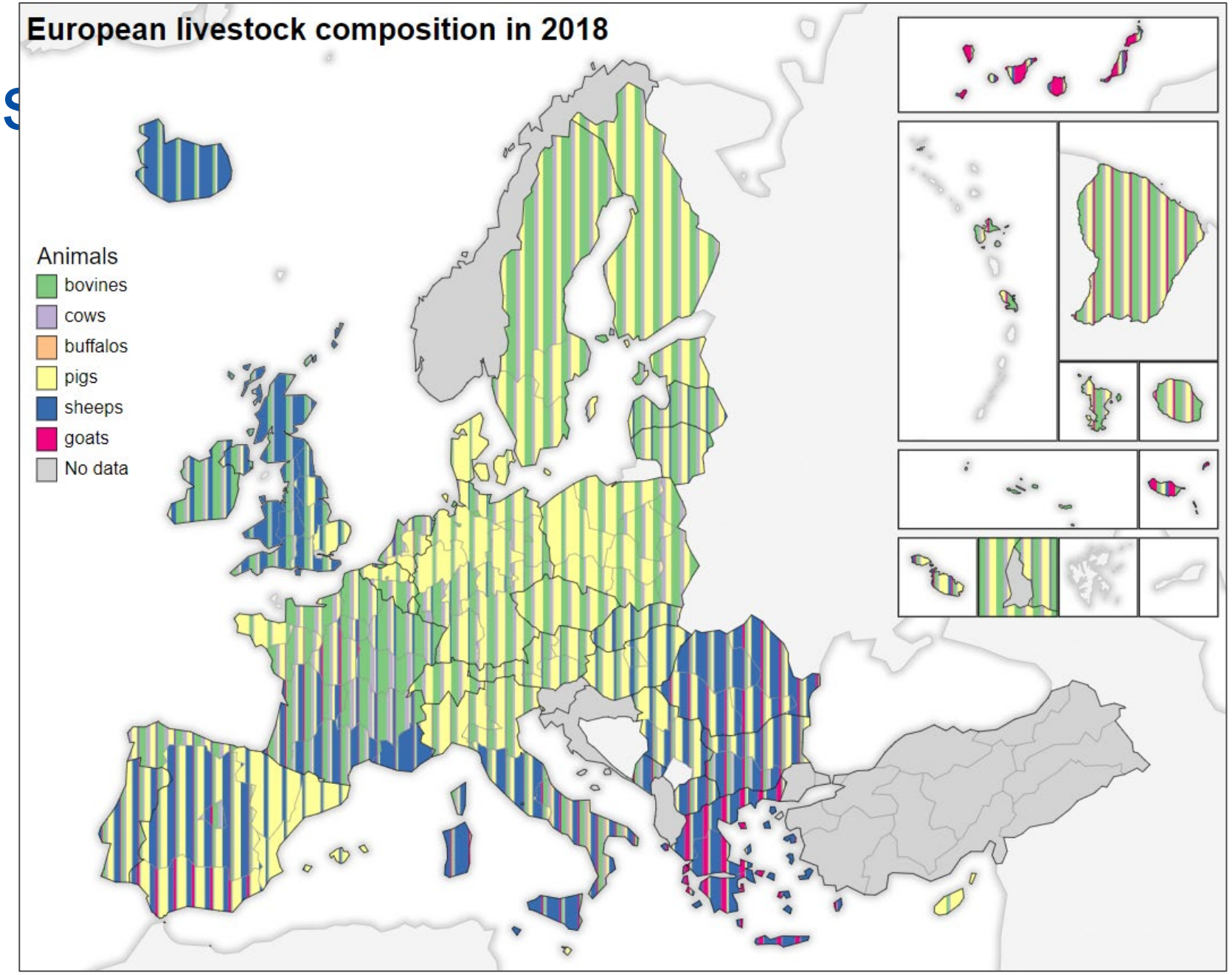


1. Cereals
2. Industrial crops and hay cultivation
3. Continuous grassland
4. Woods, heath, lakes, and other





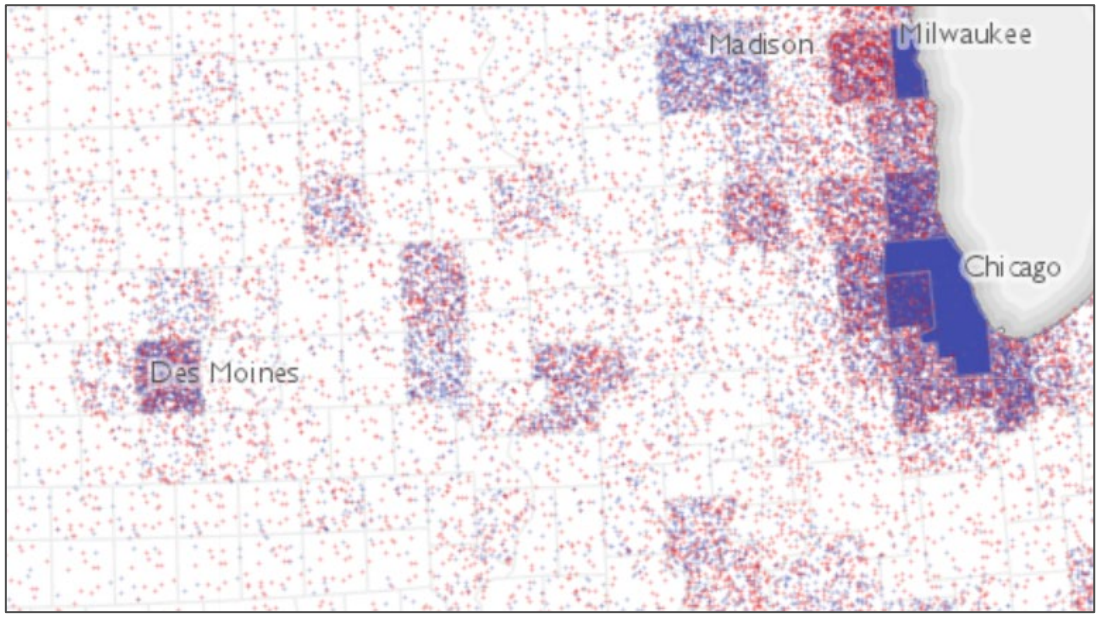
Proportional s

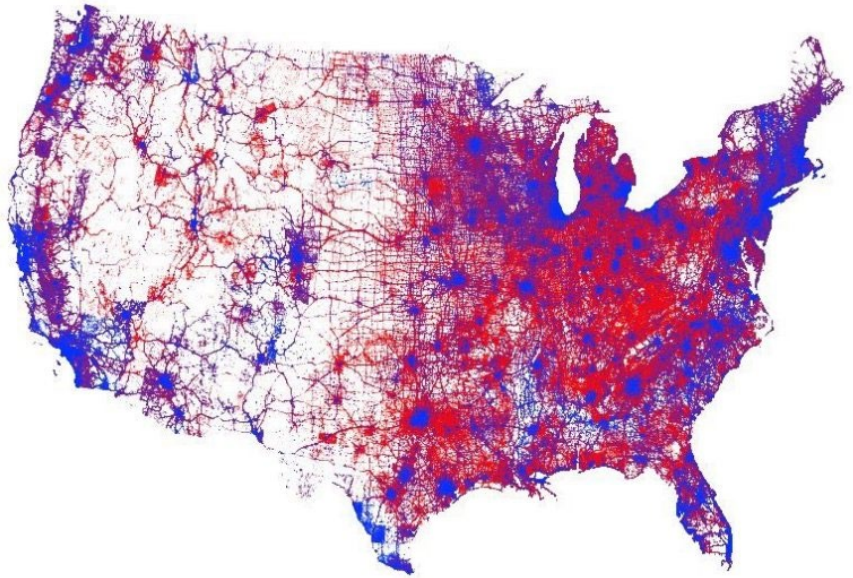


https://eurostat.github.io/eurostat-map.js/examples/livestock_composition.html

Dot density

- Use a pattern of pseudo-random point symbols to represent intensity of a phenomena.
- Example: 1 dot = 1’000 votes

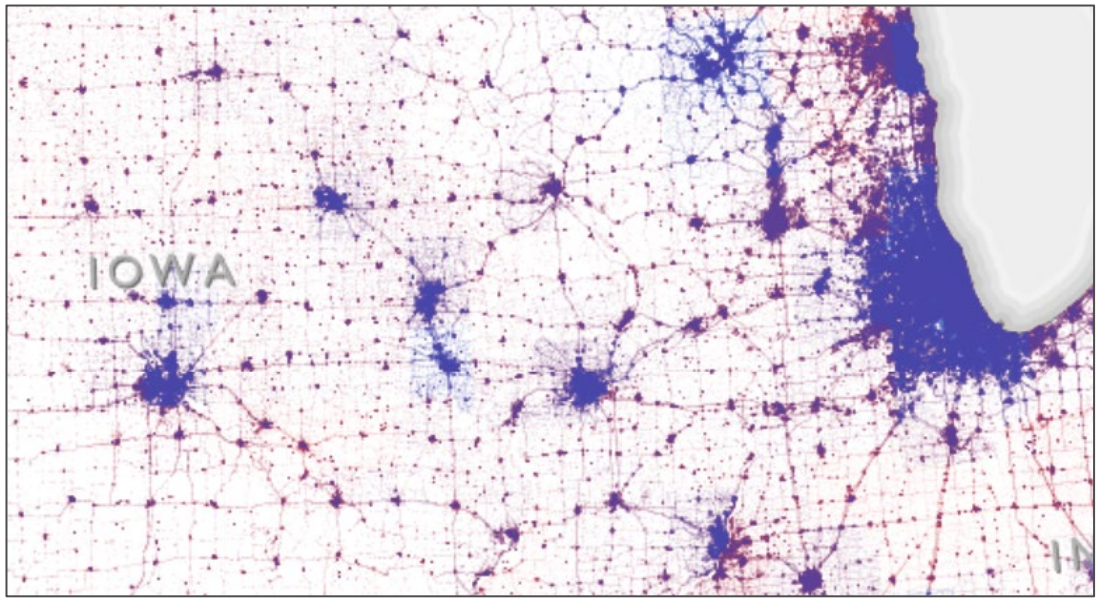


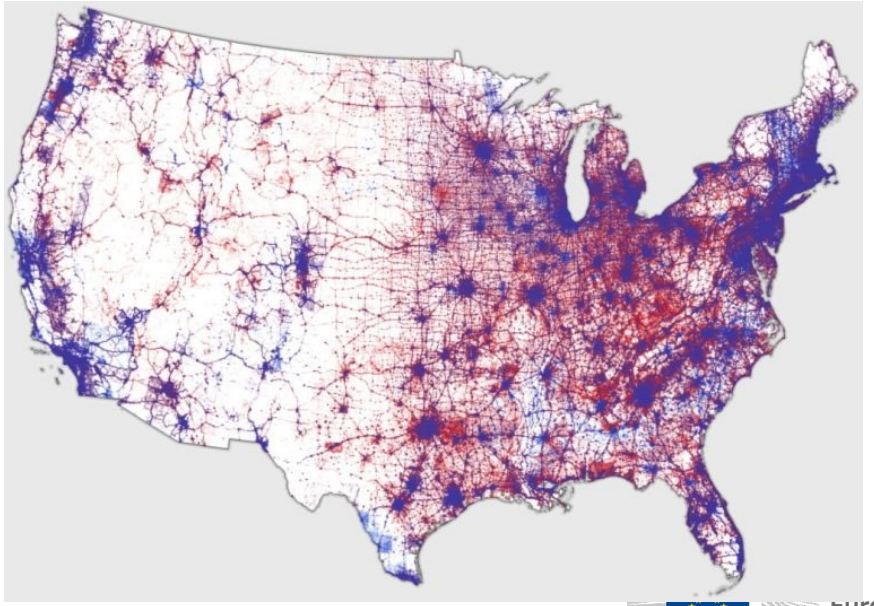


https://carto.maps.arcgis.com/apps/webappviewer/index.html?id=92b34567b8144b93a9f302ea0e3443b9

Dasymetric dot density

- Utilisation of auxilary geographical data to reapportion from one location to another.
- Example: 1 dot = 1’000 votes

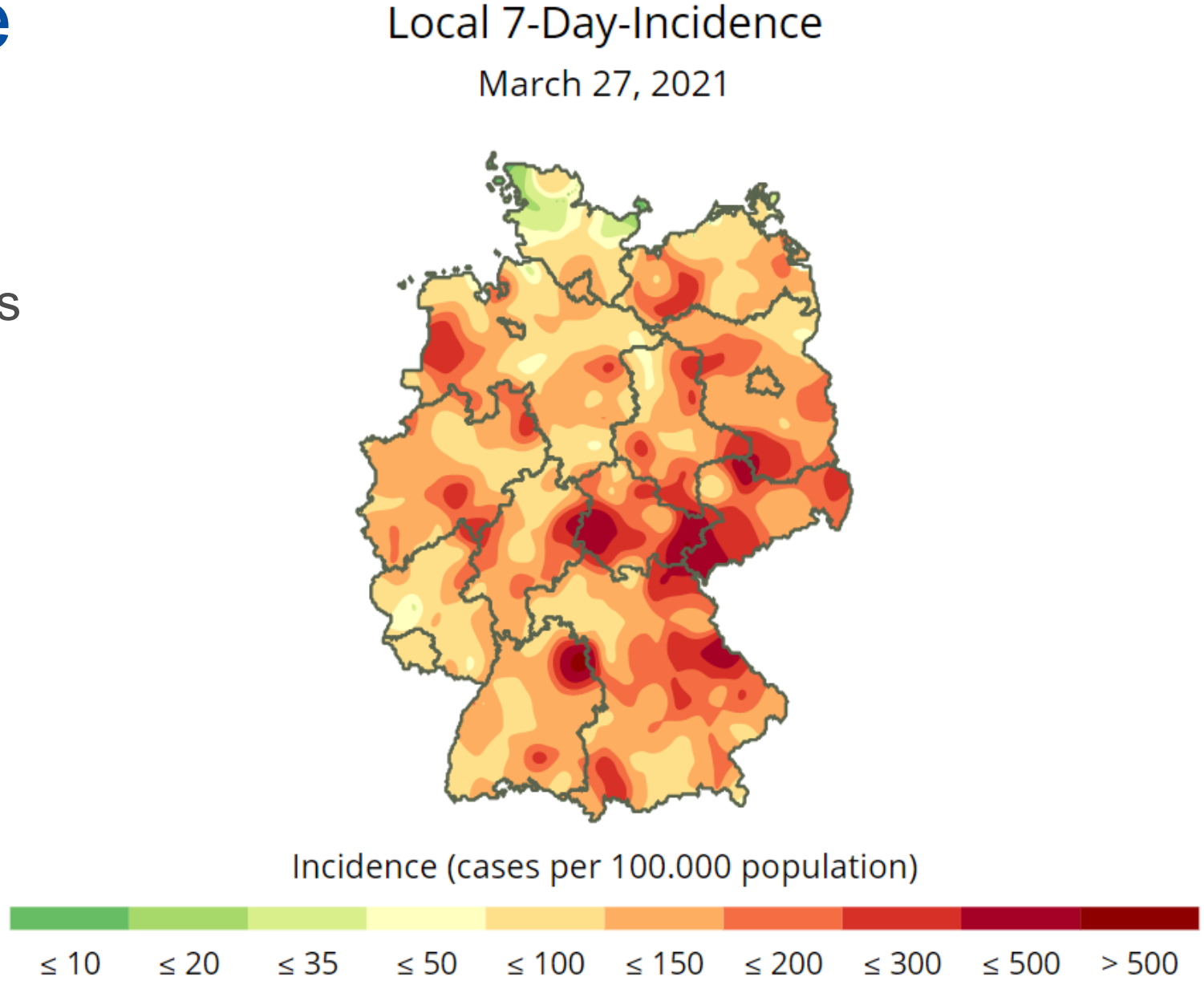




https://carto.maps.arcgis.com/apps/webappviewer/index.html?id=8732c91ba7a14d818cd26b776250d2c3

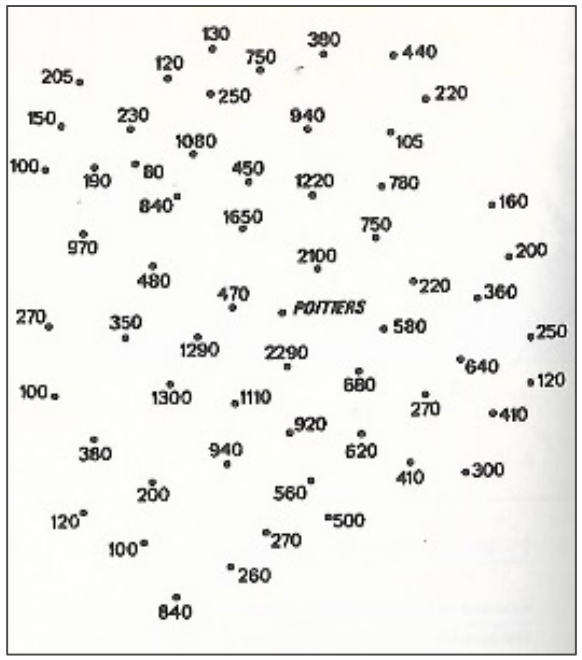
Isopleth – isoline

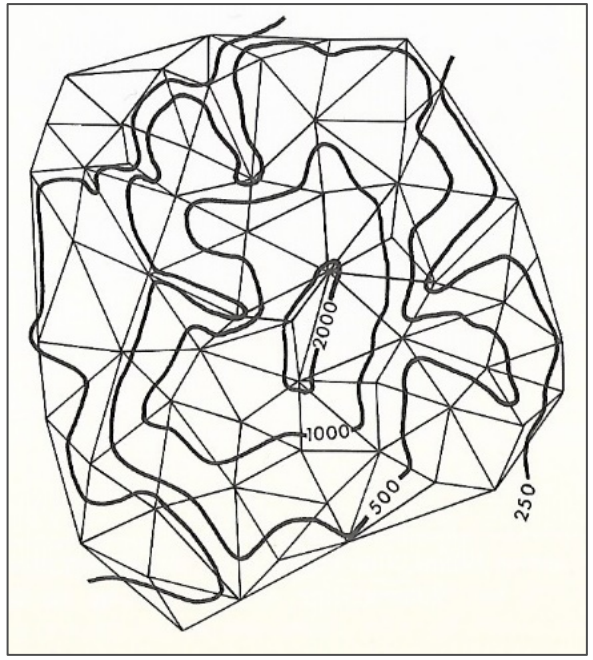
- Show lines of equal values
- Show smoothed continuous variations accross space

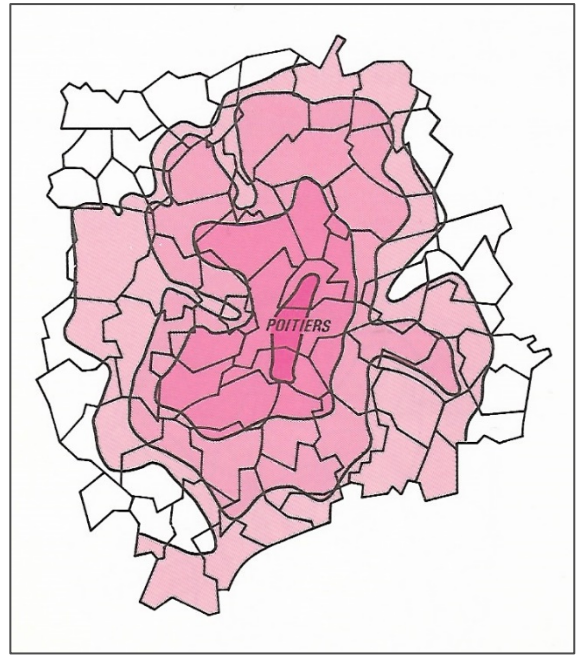


https://www.inwt-statistics.com/read-blog/covid-19_heat-map_of-local_7-day_incidences_over_time.html

Isopleth – isoline



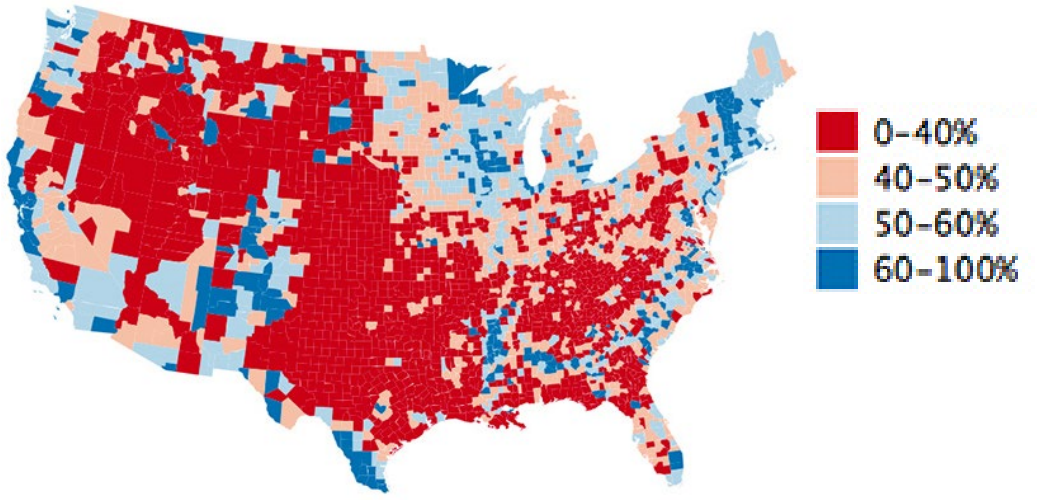


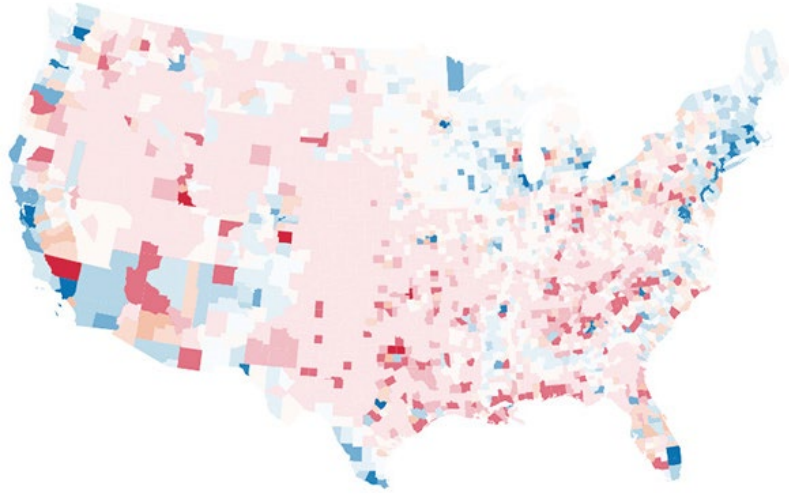


European Commission

Value-by-alpha choropleth

- Make less important regions transparent



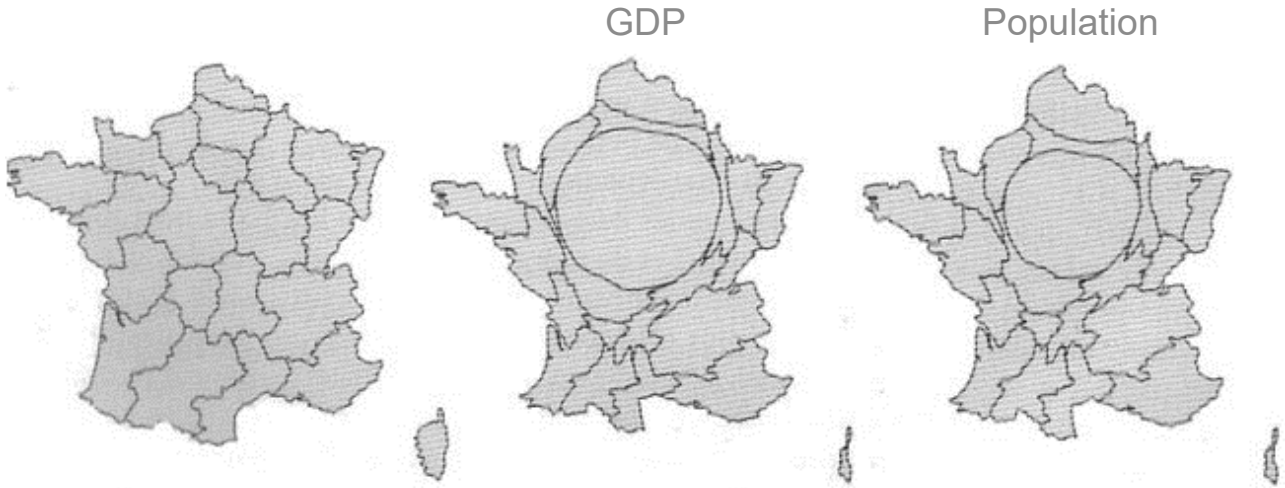


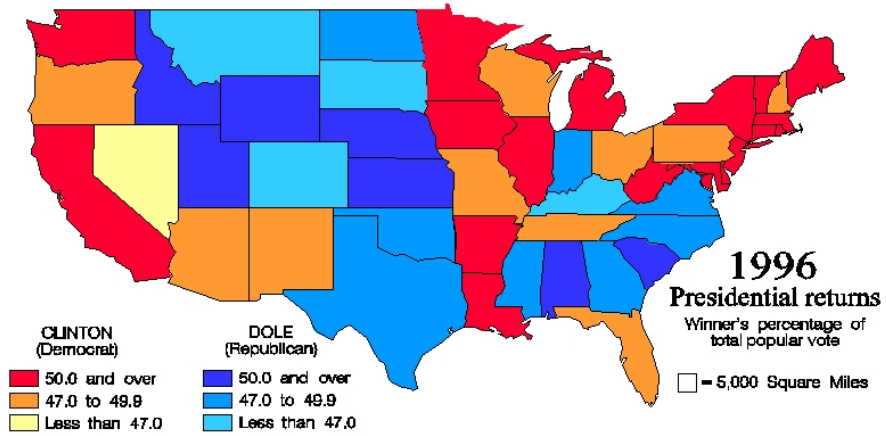
The less voters, the more transparent

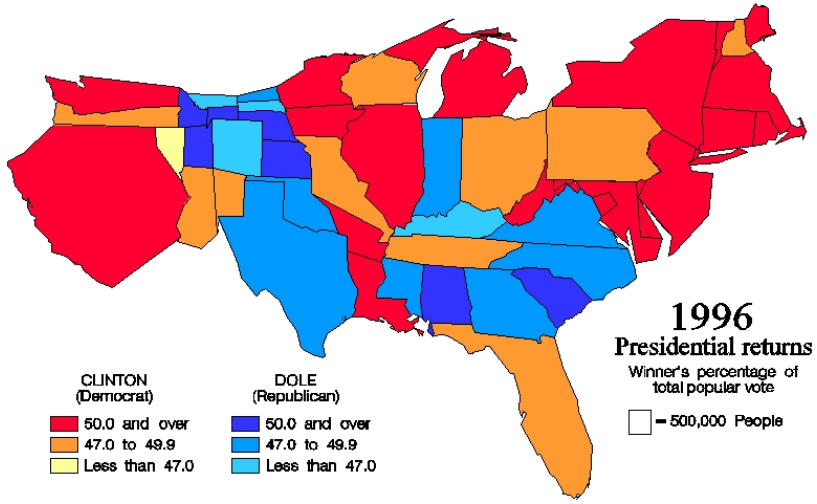
http://andywoodruff.com/blog/how-to-make-a-value-by-alpha-map/

Cartogram

- Deformation of space to change the relative importance of map regions.





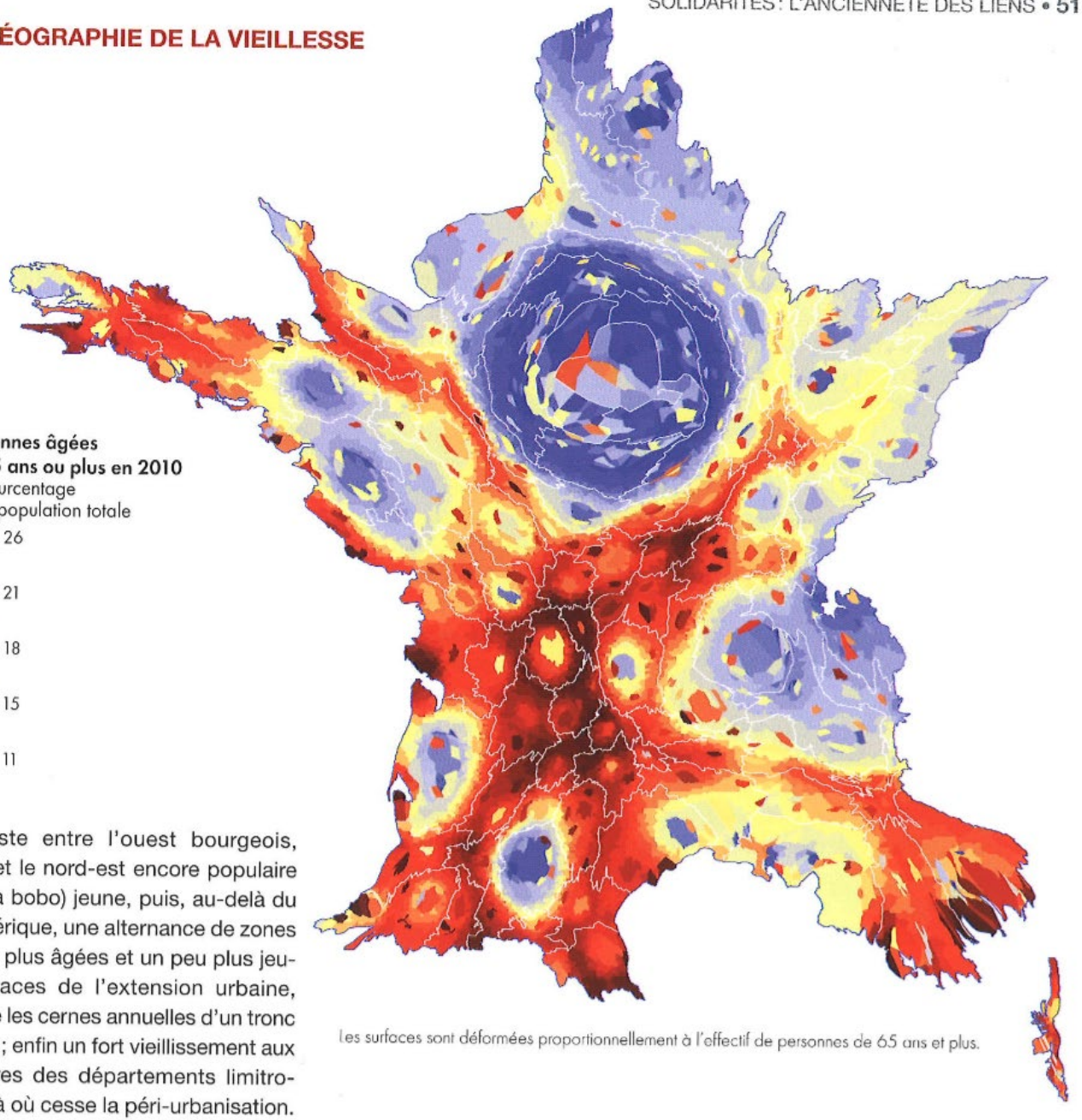


https://github.com/shawnbot/topogram

European Commission

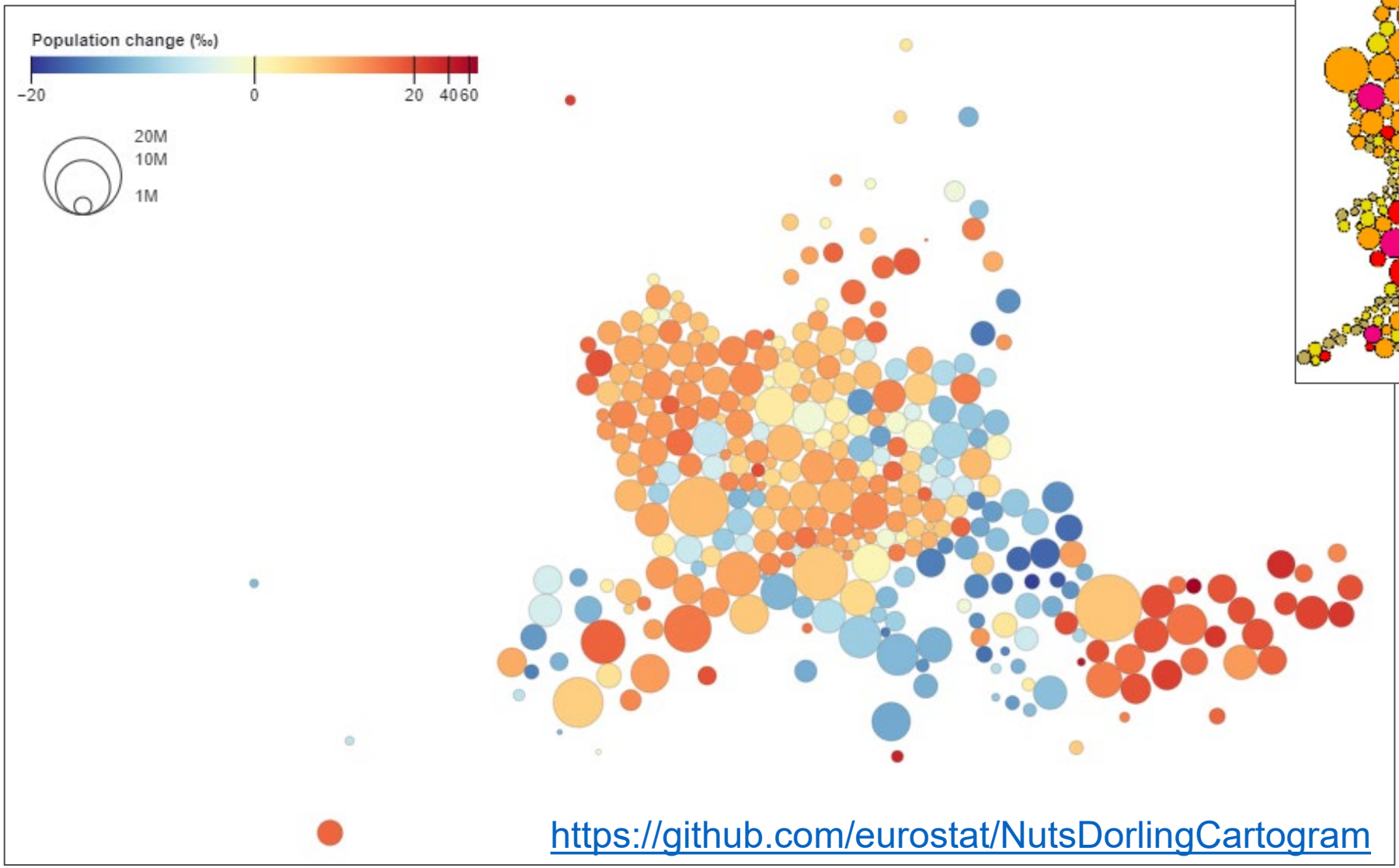
Cartogram

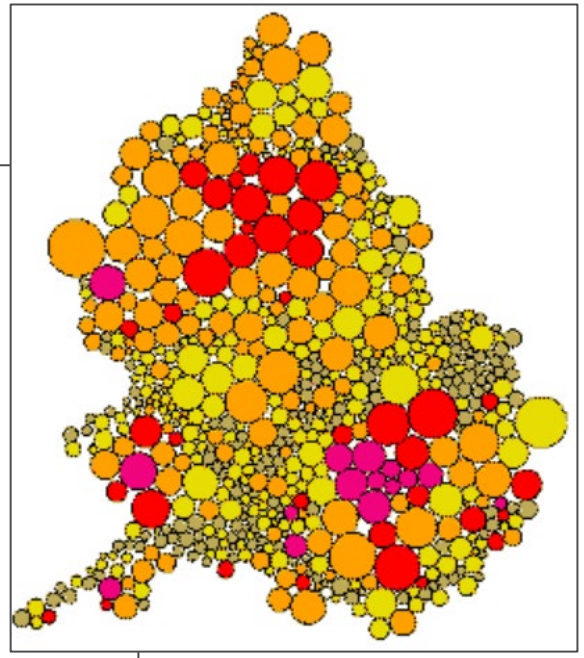
LA GÉOGRAPHIE DE LA VIEILLESSE



contraste entre l'ouest bourgeois, vieilli, et le nord-est encore populaire (et déjà bobo) jeune, puis, au-delà du périphérique, une alternance de zones un peu plus âgées et un peu plus jeunes, traces de l'extension urbaine, comme les cernes annuelles d'un tronc d'arbre ; enfin un fort vieillissement aux frontières des départements limitrophes, là où cesse la péri-urbanisation.

Cartogram - Dorling

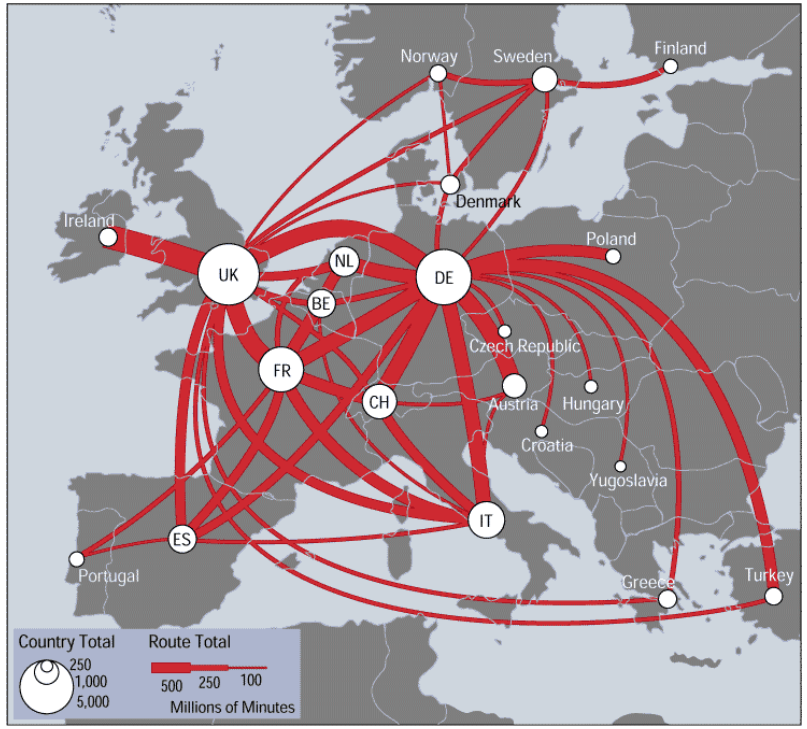




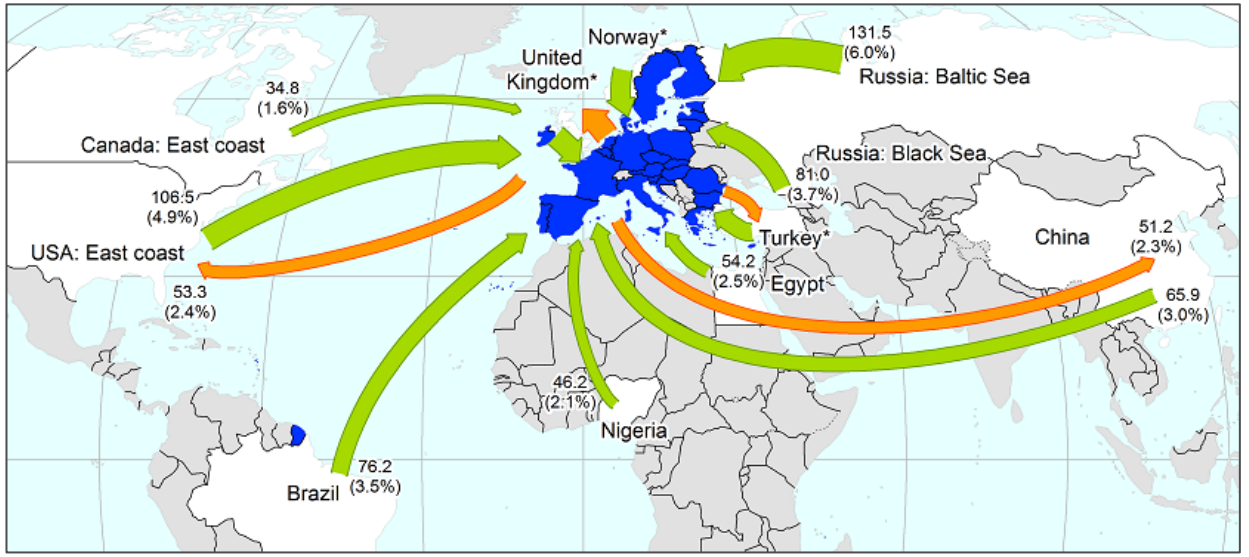
https://github.com/eurostat/NutsDorlingCartogram

Flows

- Origin/destination matrix



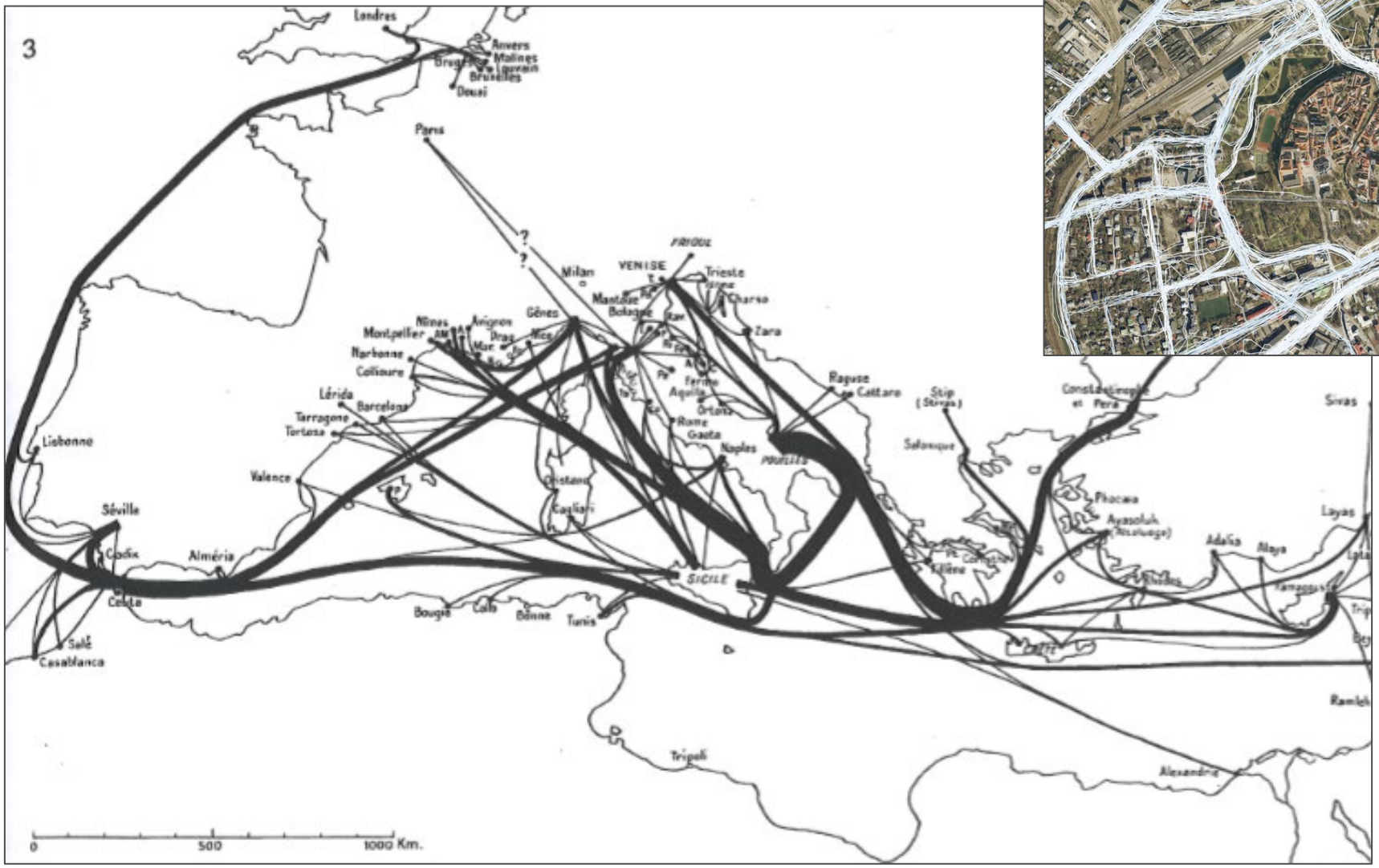
https://mappa.mundi.net/maps/maps_014/telegeography.html



https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Maritime_freight_and_vessels_statistics#Seaborne_freight_handled_in_European_ports

European Commission

Flows

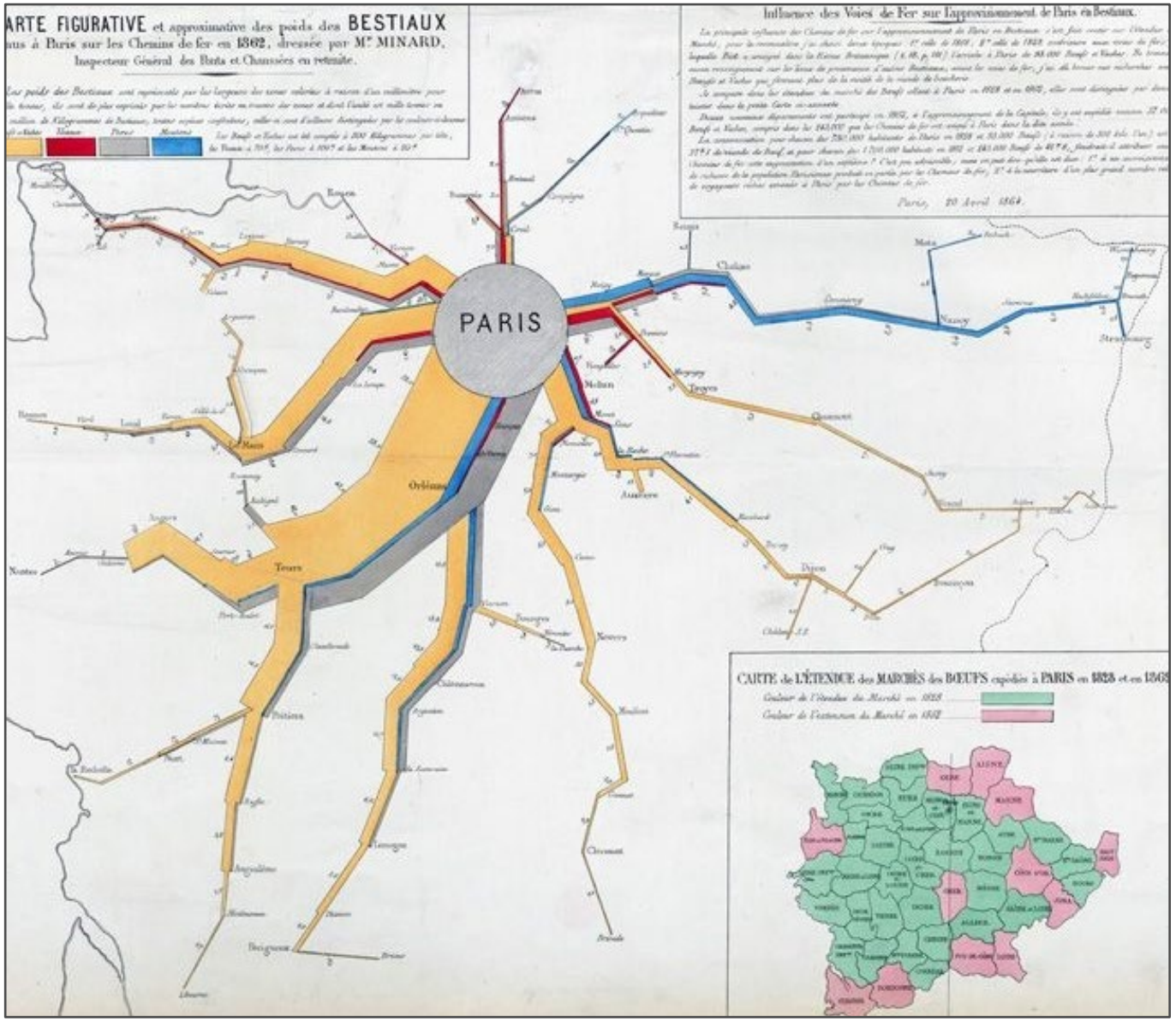


Flow lines bundling

European Commission

Flows

Flow composition



Minard, 1862, Collections de l'École des Ponts ParisTech

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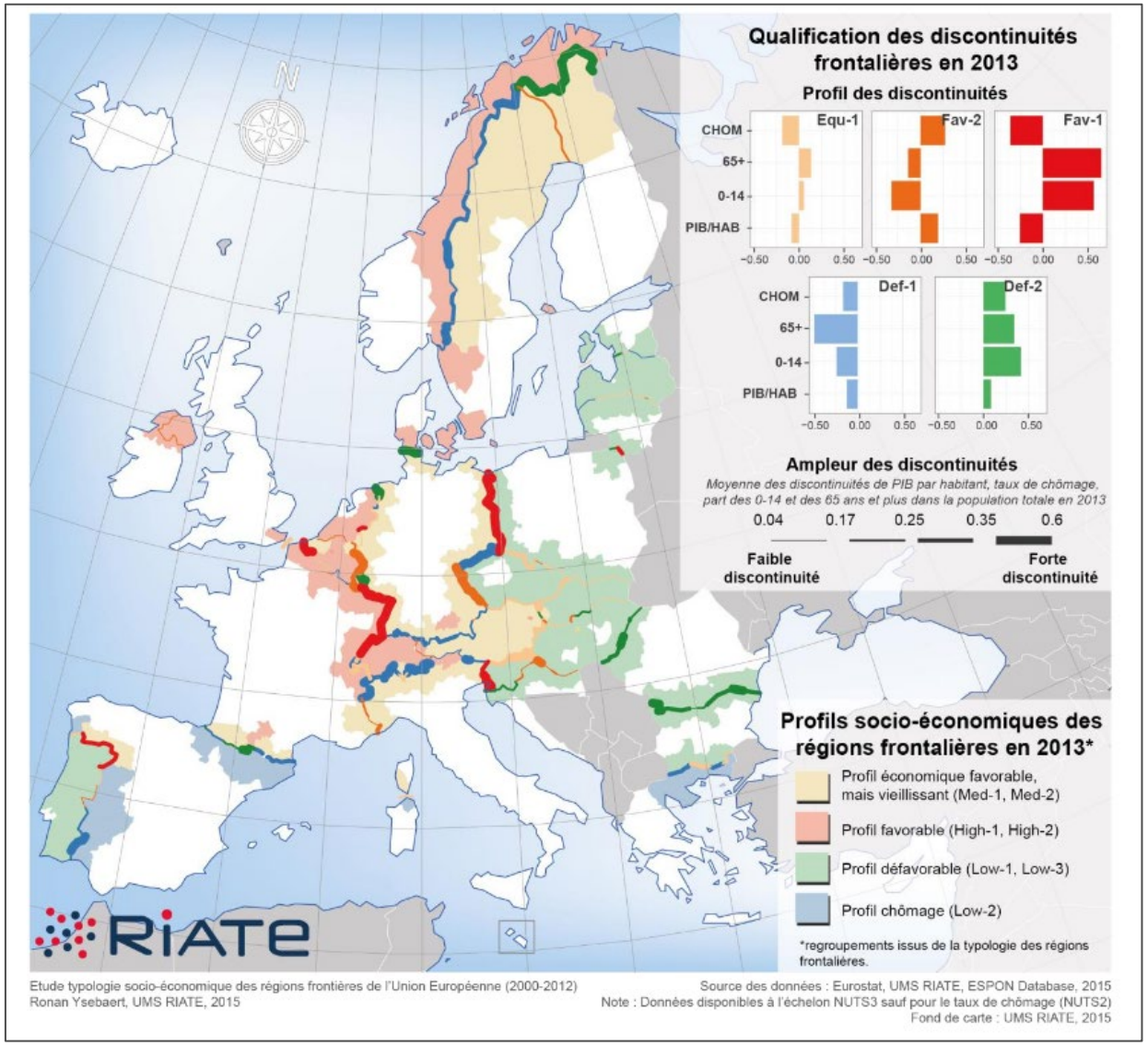
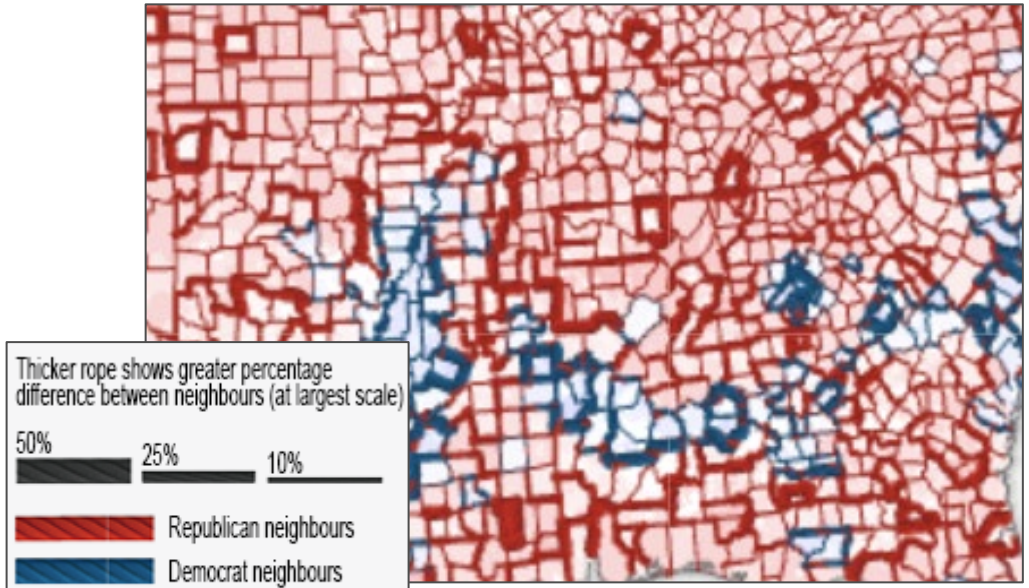
Discontinuities





https://carto.maps.arcgis.com/apps/webappviewer/index.html?id=92c66b6d241c4542b1e5afe2bb3b7beb

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Multivariate

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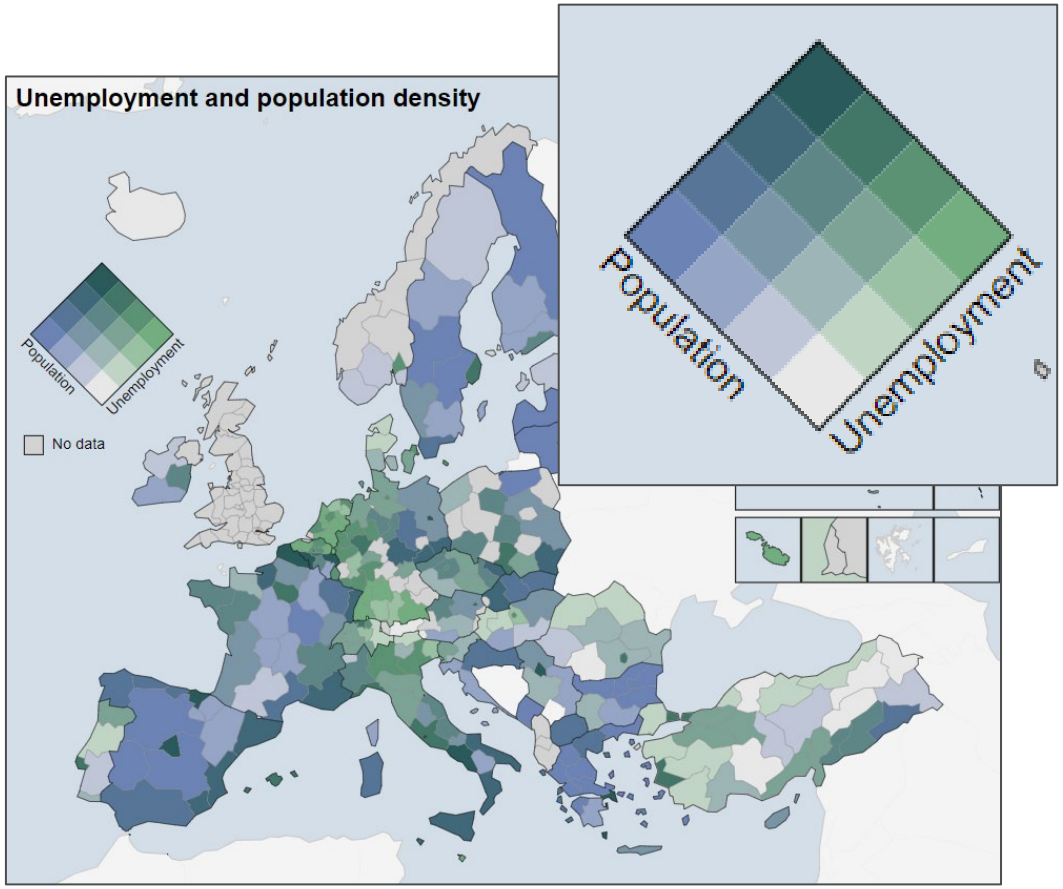
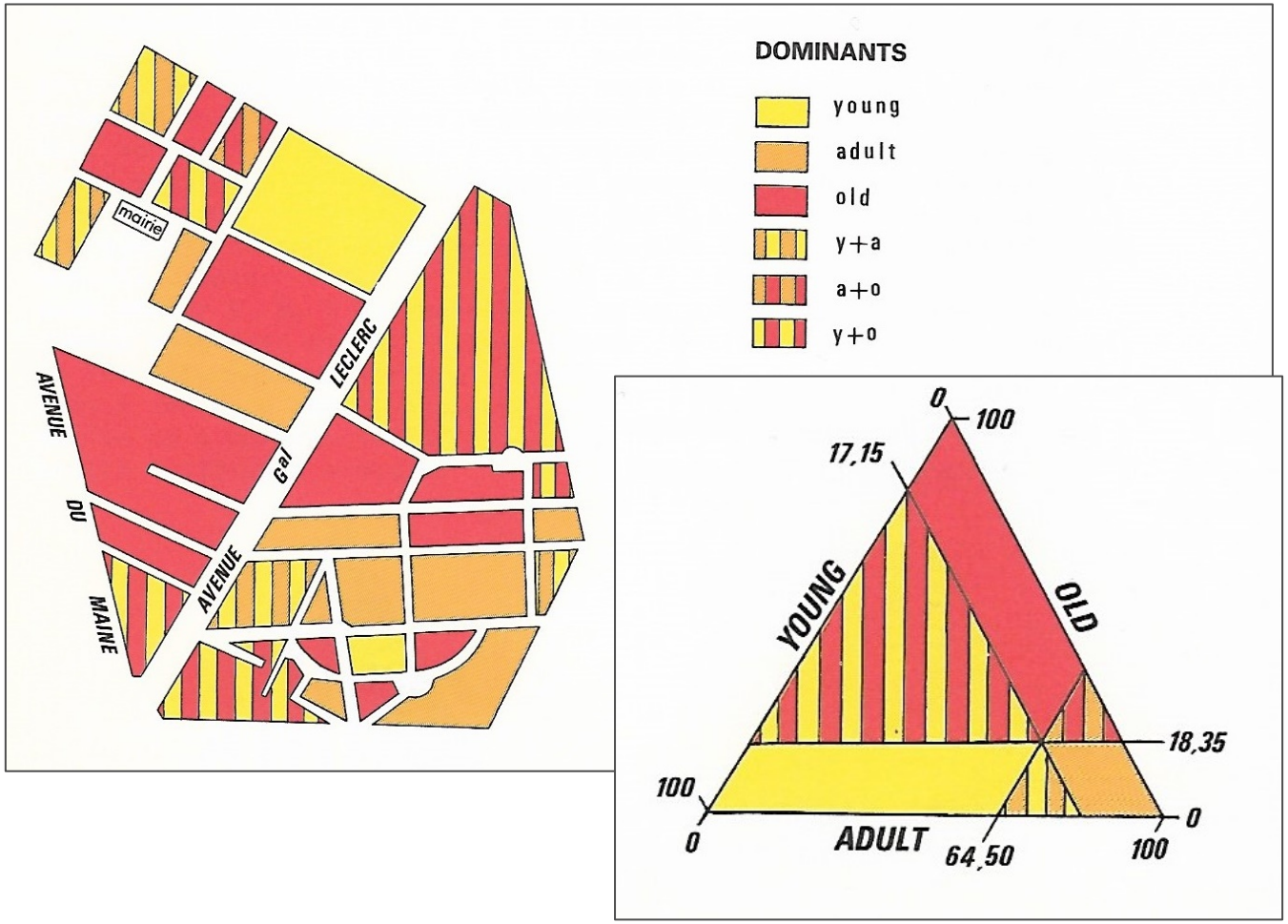
Bivariate / trivariate choropleth

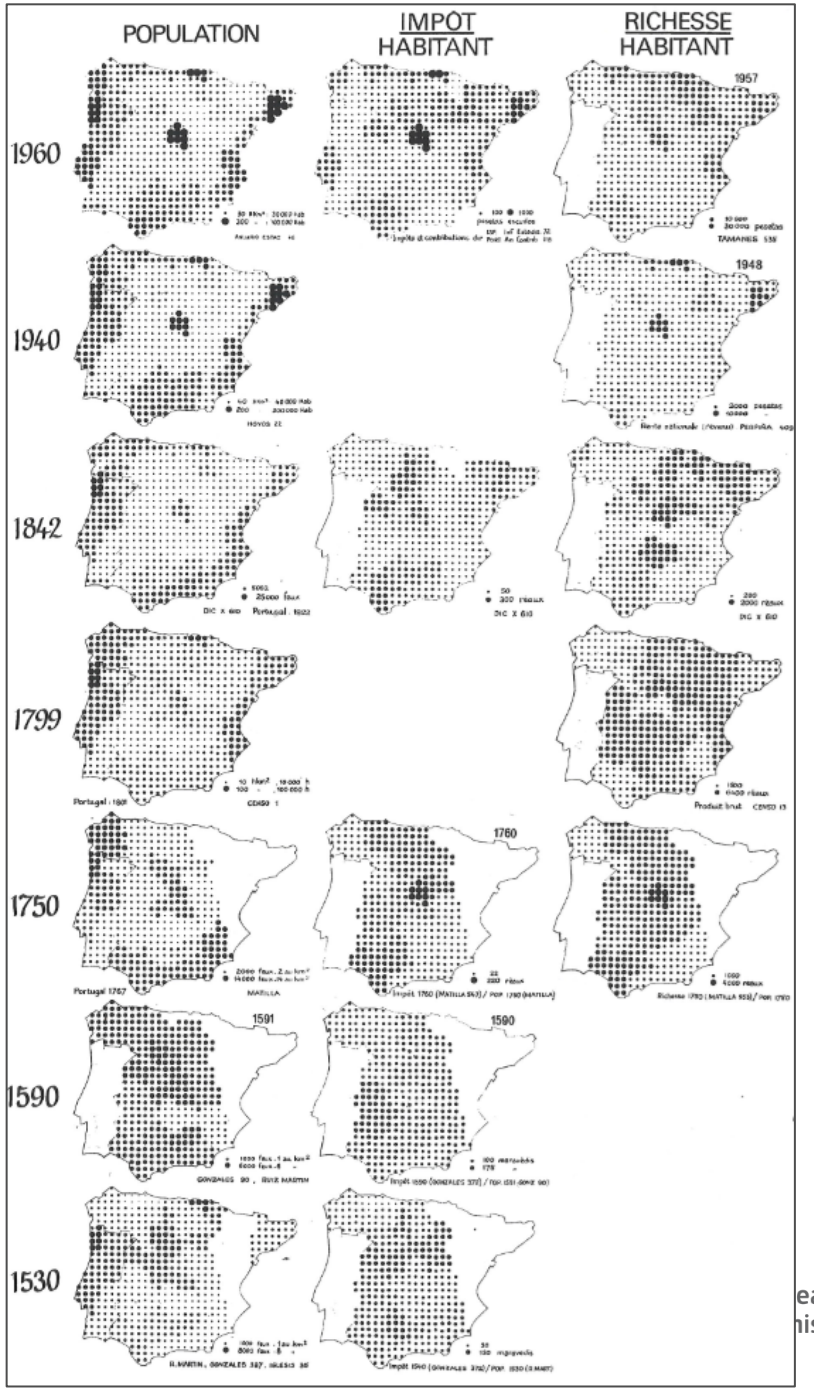




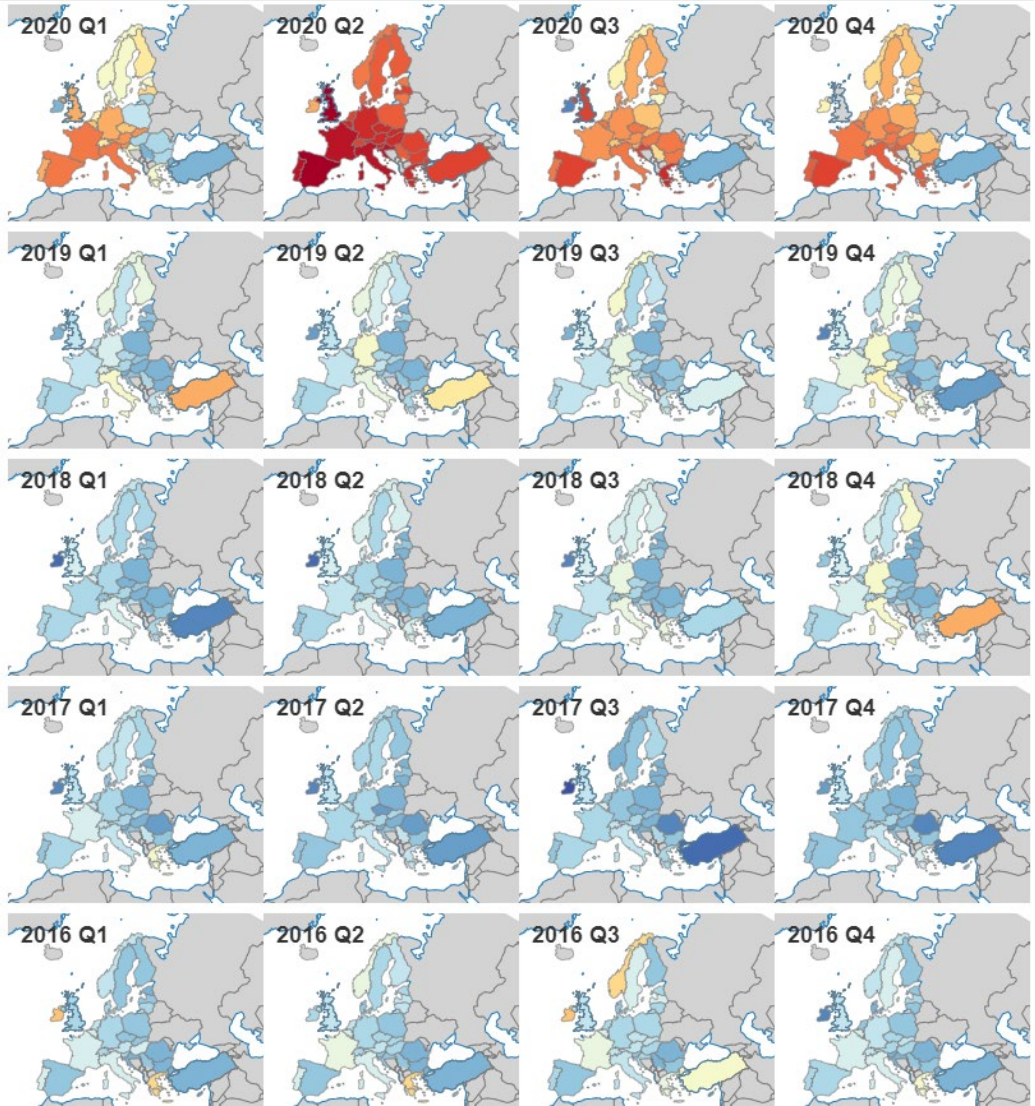
https://eurostat.github.io/eurostat-map.js/examples/pop-unemploy-bivariate.html

Small multiples

- One or several maps ?
- Multivariate maps VS small multiples
- For maps with low spatial granularity



Small multiples



20 years of GDP change in Europe

https://observablehq.com/@jgaffuri/20-years-of-gdp-change-in-europe

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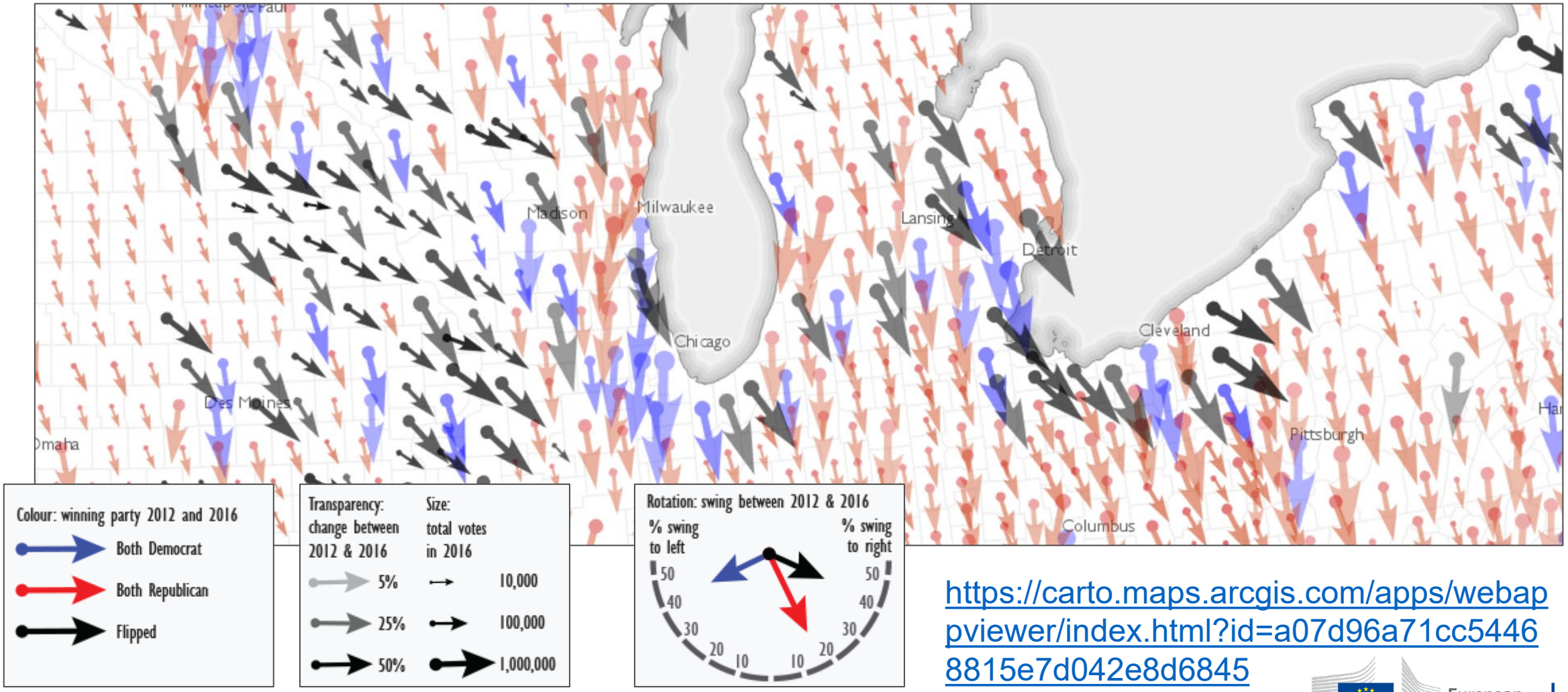
Multivariate



https://carto.maps.arcgis.com/apps/webappviewer/index.html?id=a07d96a71cc54468815e7d042e8d6845

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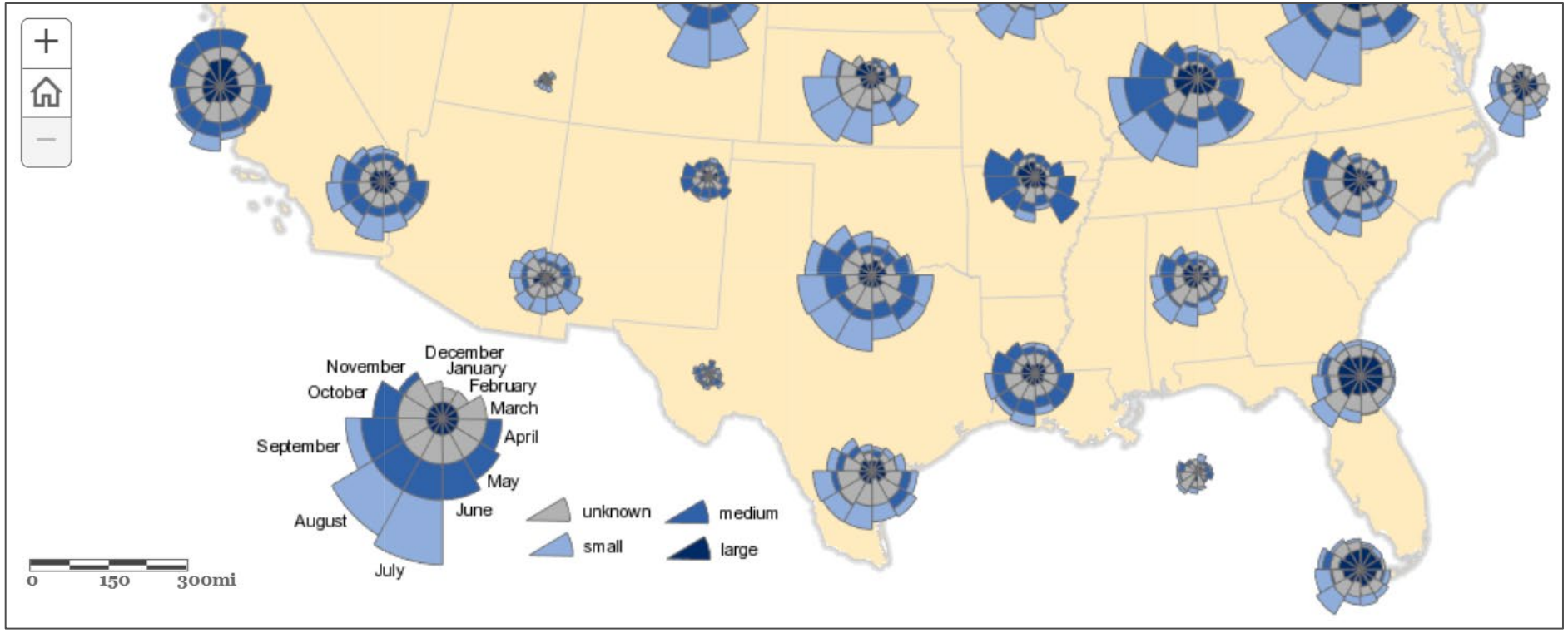
Coxcomb

Wildlife Strikes by month

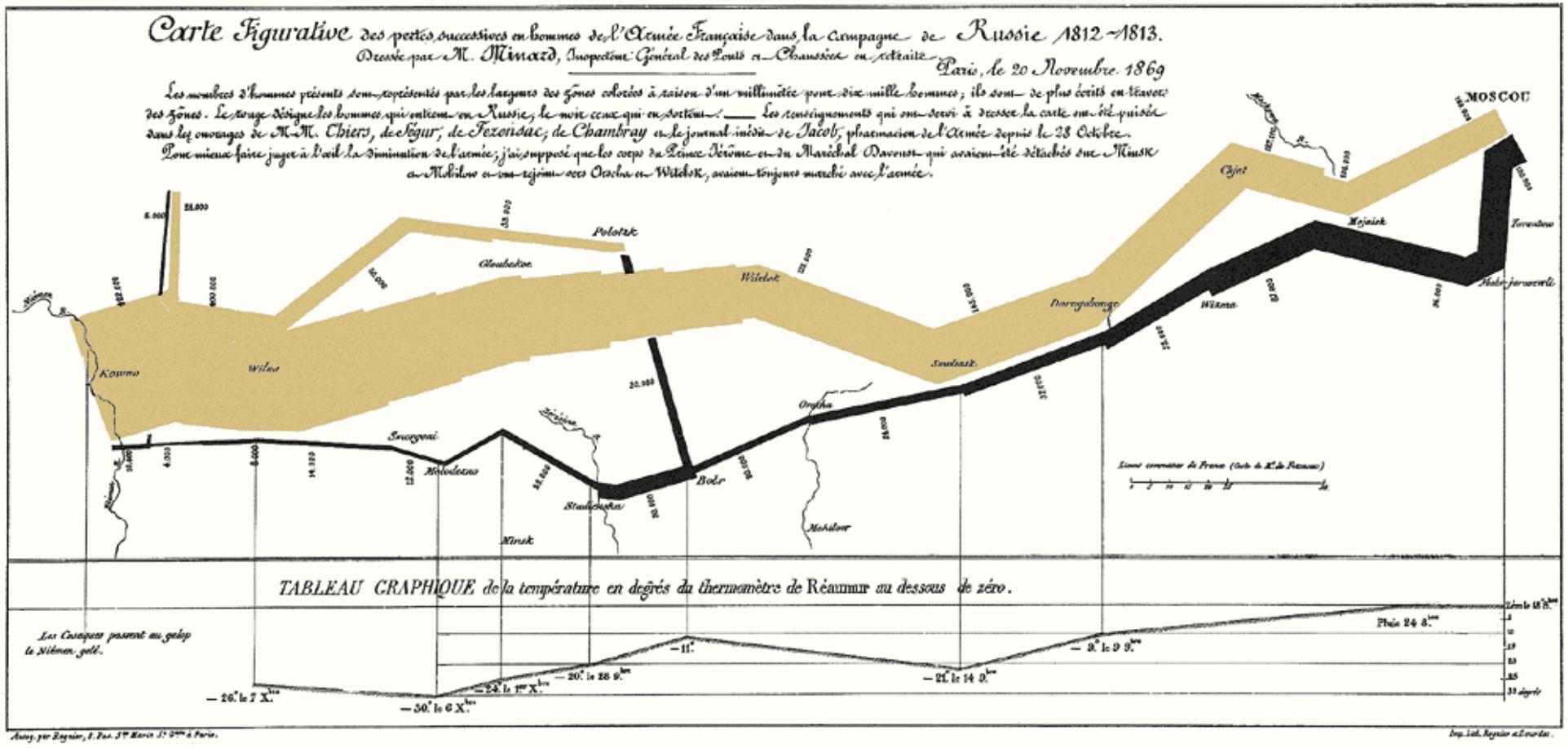
Aviation-related wildlife strikes by month and size



https://carto.maps.arcgis.com/apps/MinimalGallery/index.html?appid=218a0e2e4c2540e39b793efeb34c4685#viewer=30066075caa947178f6c2ae438e7efa4

The (famous) Minard's map of Napoleon's 1812 Russian campaign

- Napoleon's army across space, time and temperature.



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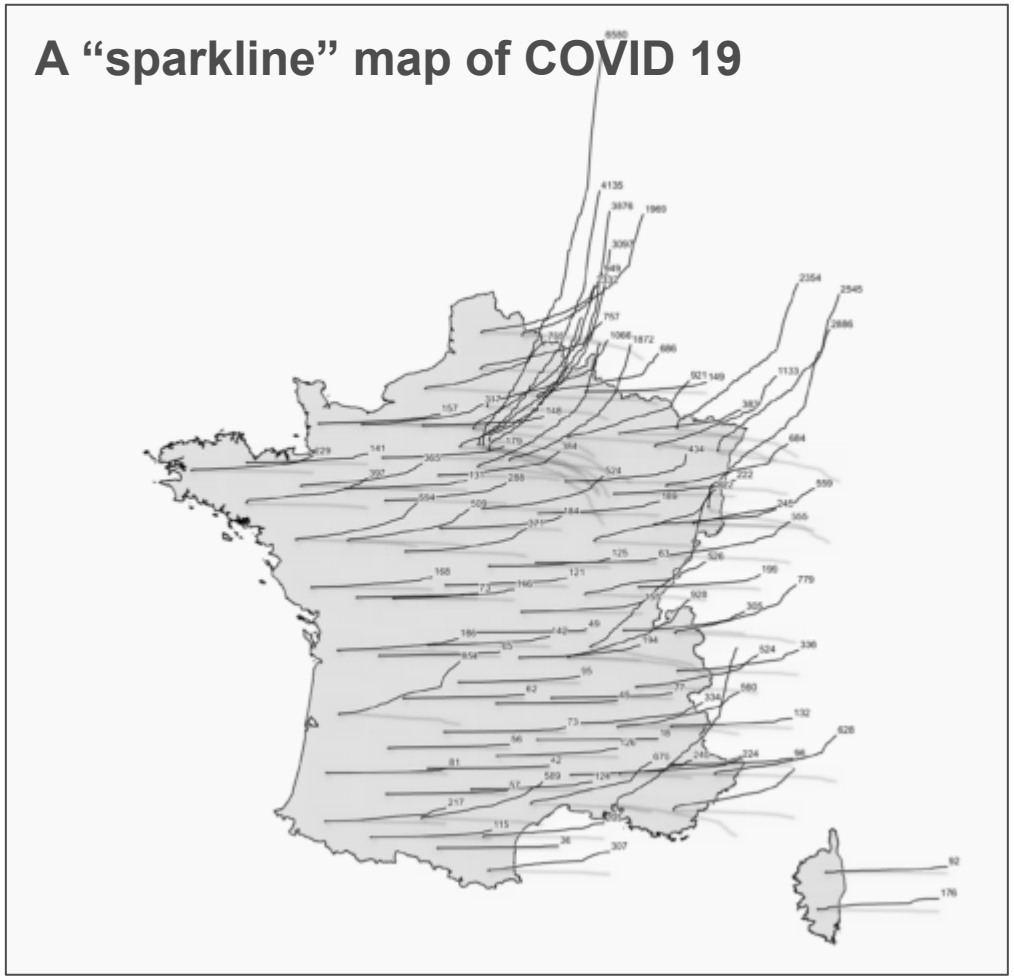
Time series

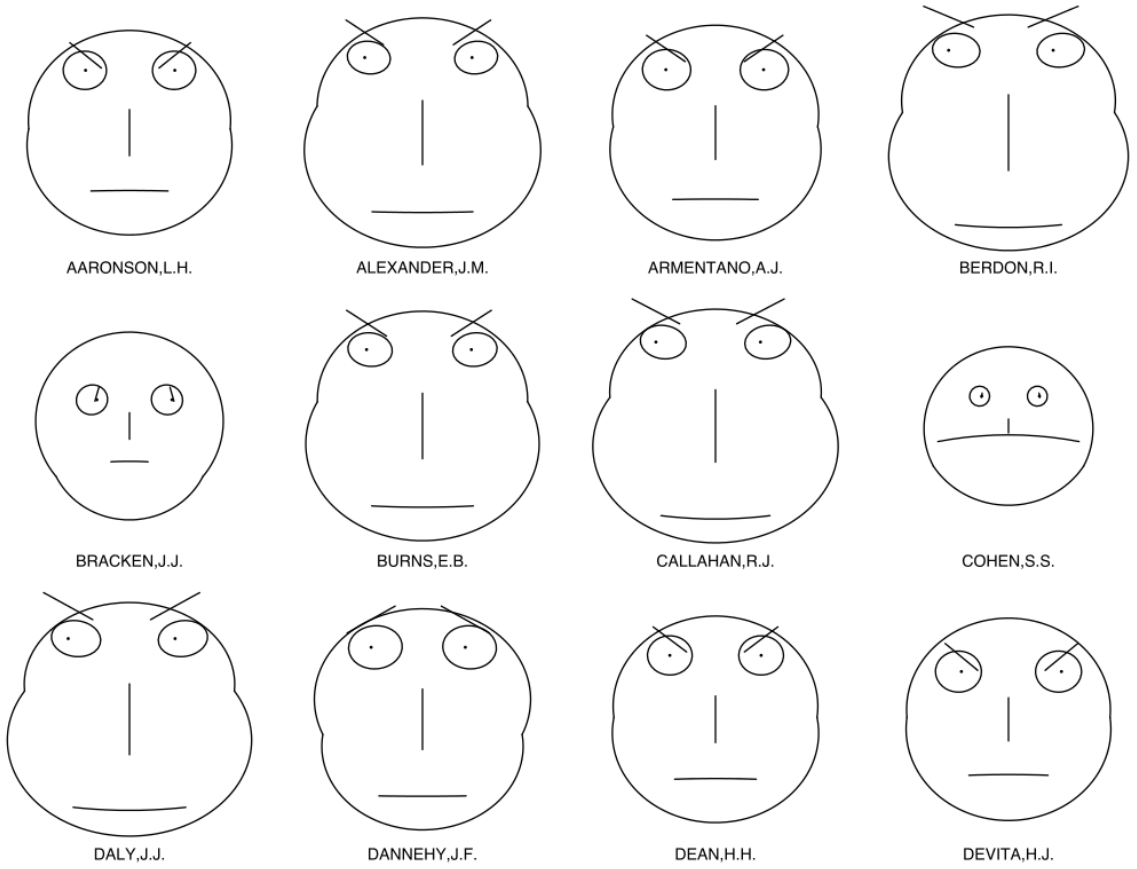


@datagistips
https://datagistips.hypotheses.org/488

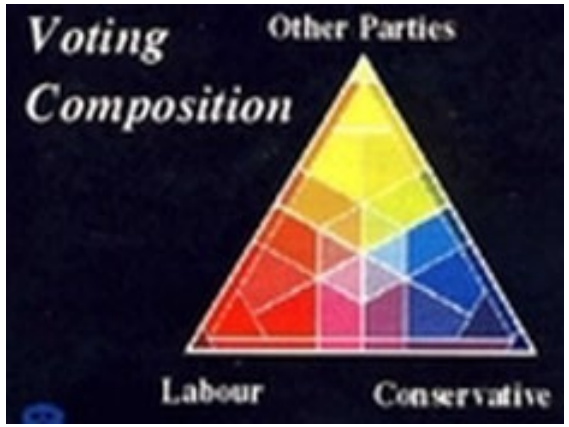
https://www.theguardian.com/politics/2016/may/06/holyrood-elections-see-rise-of-team-ruth-and-demise-of-labour-vision

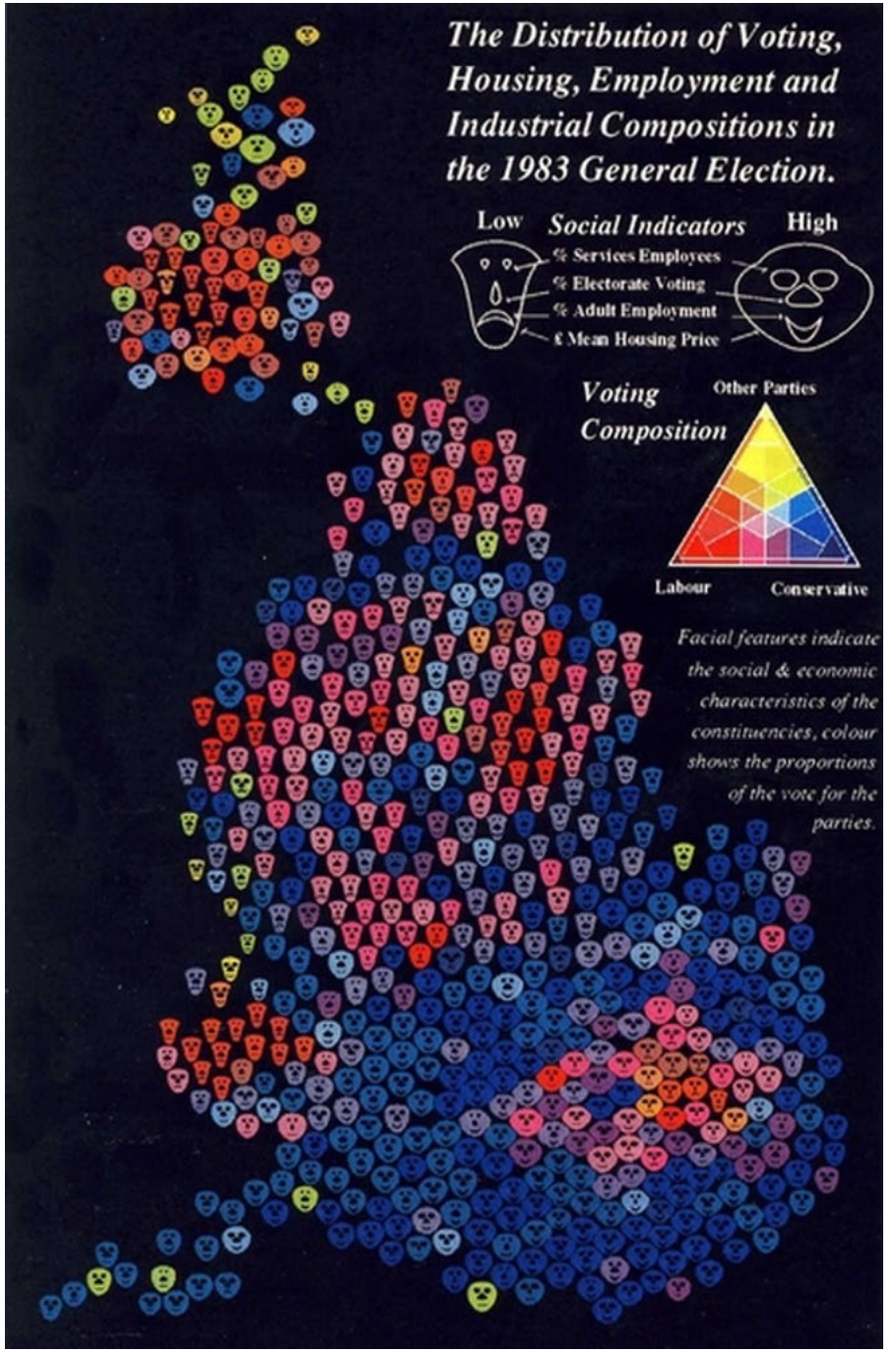
Chernoff faces

- High capability of the human brain to read emotions on human faces.



Chernoff faces

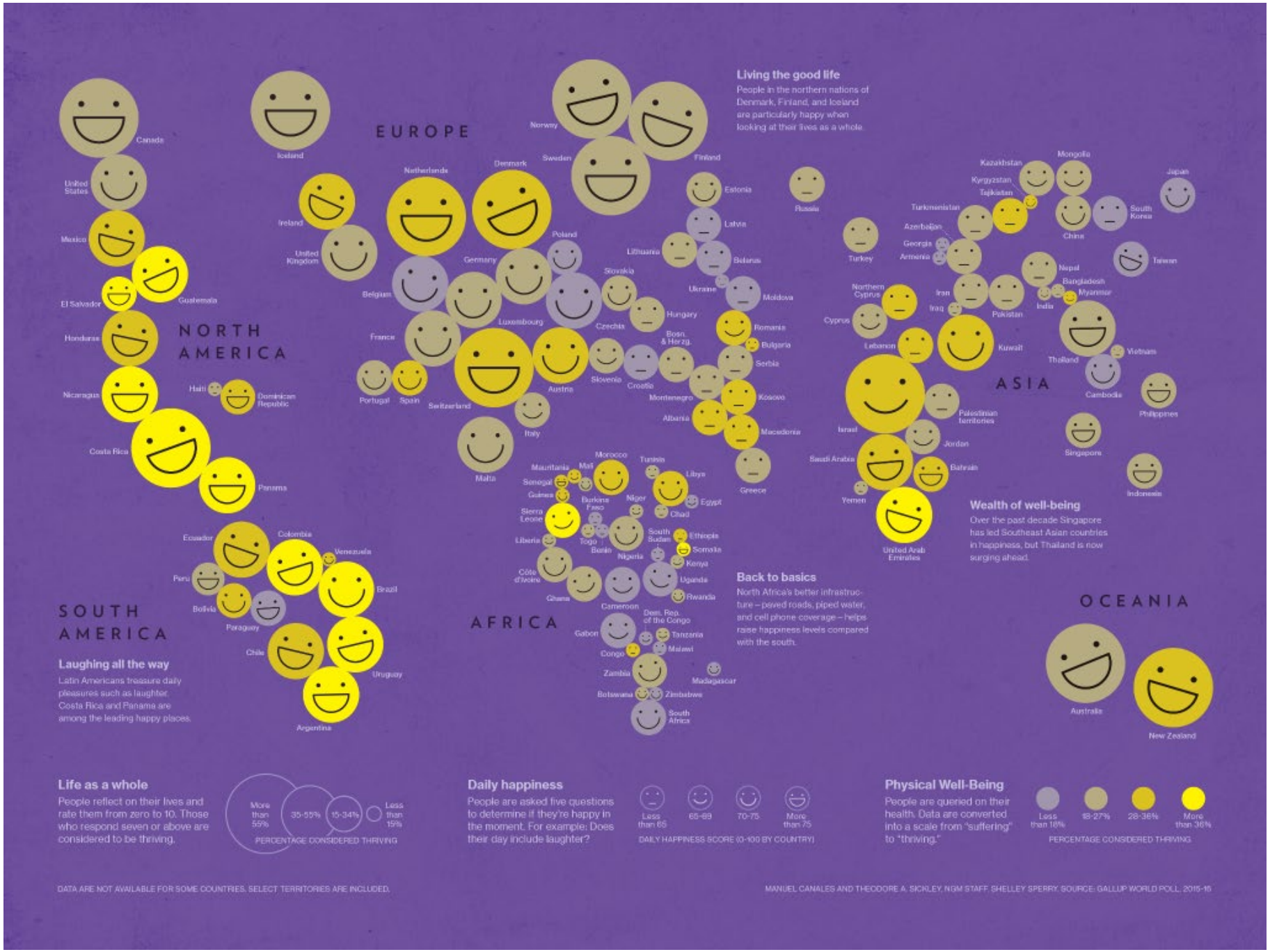




Danny Dorling, 1991
http://www.dannydorling.org/

Atlas of happiness

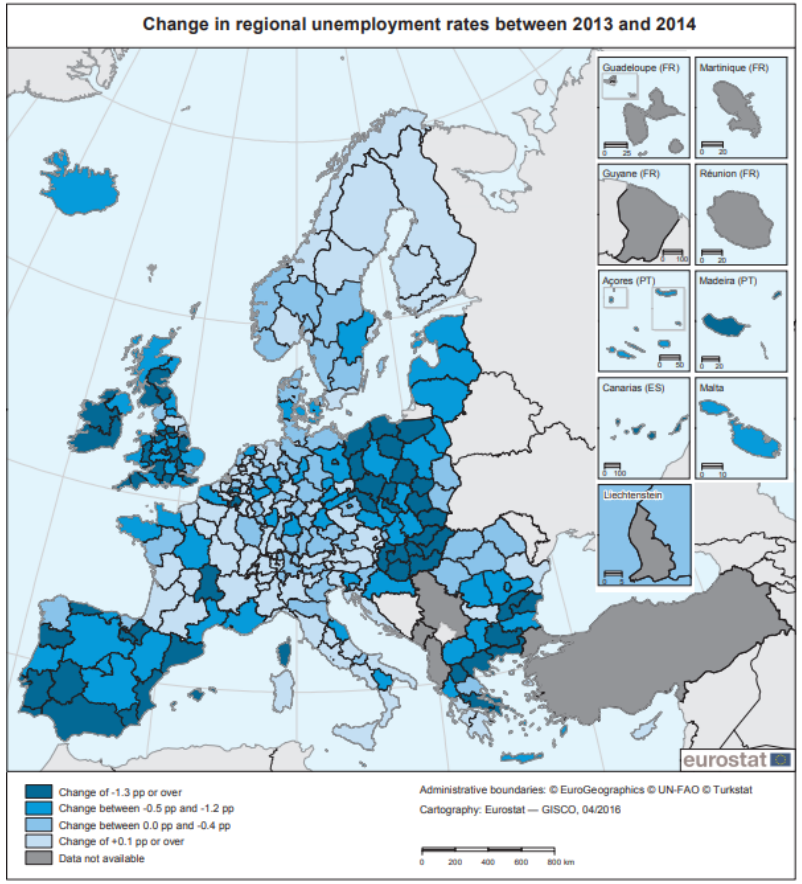
by national geographic magazine



https://www.nationalgeographic.org/media/atlas-happiness/

Map components, layout

- **Map components** - Frame, title, legend, source, copyright, scale bar, north arrow or compass rose, insets, graticule, logo, disclaimers, etc.
- **Layout** – Balance, along grid.
- Map lettering and fonts.



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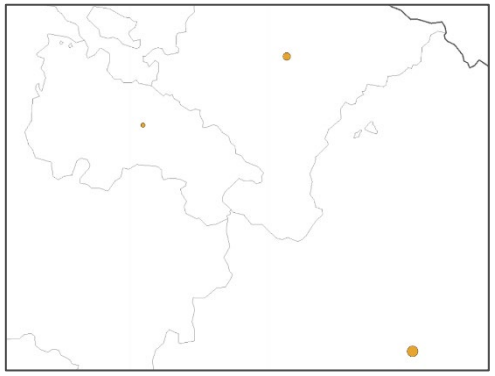
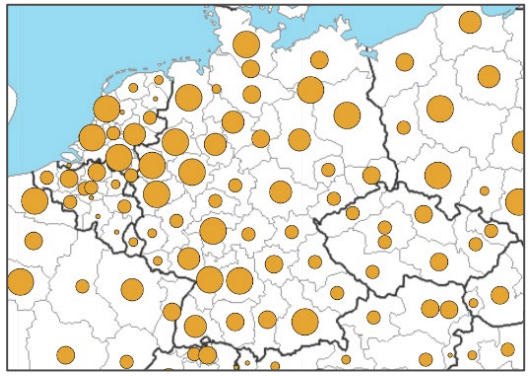
Interactivity and exploration

- Maps for communication – to maps for exploration
- Present – synthetise – analyse – explore
- **Zooming**: Only when necessary. Show multi-scale versions of the map. Case with clutter (too much zoom out), and no data (too much zoom in)





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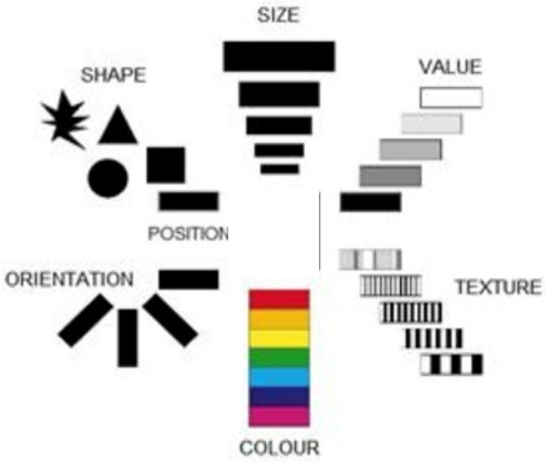
Dos and don’ts



- Properly map the visual variables to the statistical dimensions
- Use only one single visual variable per statistical variable, to avoid confusion
- Use an equal-area map projection
- Simplify the geometries, aggregate the data to fit the scale/zoom levels
- Do not use diverging color palette in the absence of central value
- Do not show quantities/numbers on a choropleth map
- Be aware of the MAUP
- Adapt to the media: Printed? Screen? Dimensions ?
- Do not show a map background with transparency below choropleth map.
- Etc.

Dos and don’ts

- Specify your map independently from the technology. Take a pen ! Choose the technology based on your need, and not the opposite.
- Choose whatever tool and technology you need. (almost) everything is possible.
- Start coding, share your code, interact with developers, experiment.
  - Github - https://github.com/eurostat
  - ObservableHQ - https://observablehq.com

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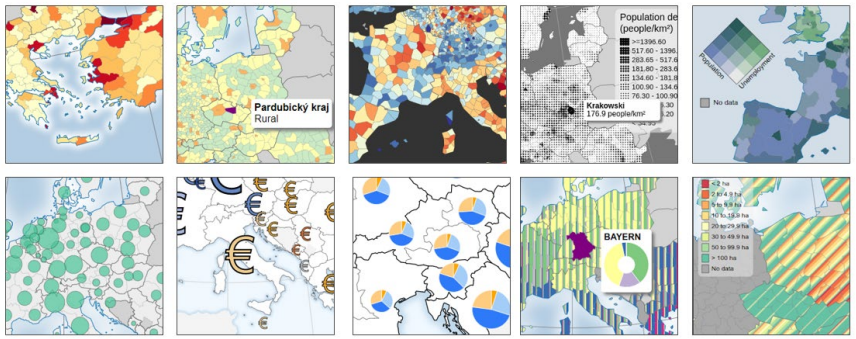
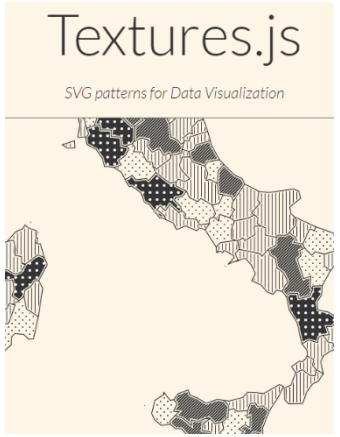
Resources and tools



- ColorBrewer: Color Advice for Maps, https://colorbrewer2.org/
- https://riccardoscalco.it/textures/
- R (Package cartography, see also http://riatelab.github.io/cartography/vignettes/cheatsheet/cartography_cheatsheet.pdf)
- By Eurostat
  - https://github.com/eurostat/eurostat-map.js
  - https://github.com/eurostat/GridViz
  - https://github.com/eurostat/RegionSimplify



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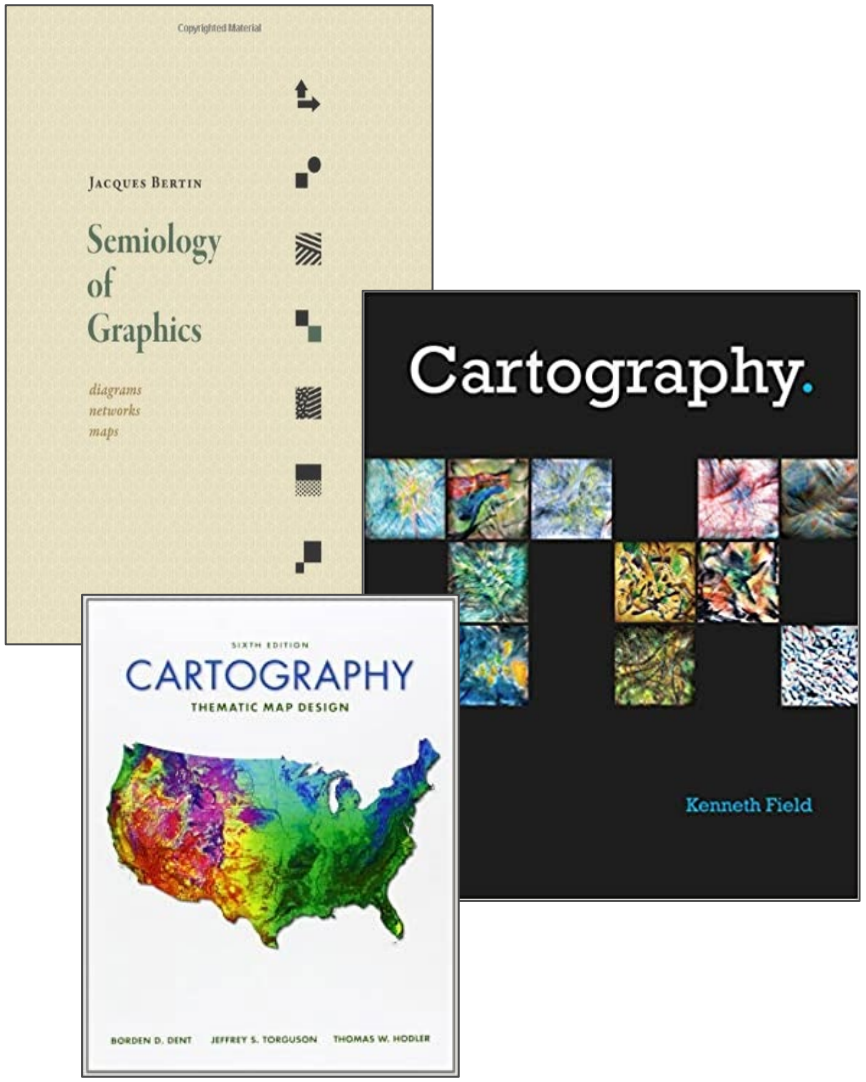
Dent, B. D., Torguson, J. S., & Hodler, T. W. (2008). Cartography: Thematic Map Design, 6th Edition. McGraw-Hill.

Robinson, A. H., Morrison, J. L., Muehrcke, P. C., Kimerling, A. J., & Guptill, S. C. (1995). Elements of Cartography, 6th ed. New York: John Wiley and Sons.



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Thank you !

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