https://presemo.aalto.fi/enyc2005/

KIG-C1010 Introduction to geoinformatics

Lecture 9: Communication with maps

Aalto University
School of Engineering

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8.2.2023

Based on materials developed by Paula Ahonen-Rainio

Topics for today

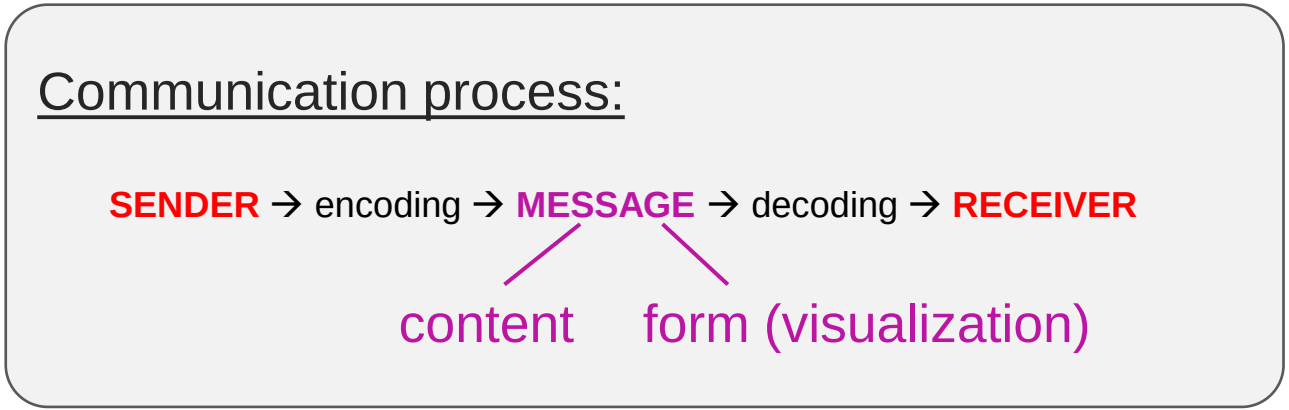
- **Communication by maps**
  - Information & aesthetics
- **For whom, what, and why?**
- **Map Design**
  - Data, method, scale, background, title, and metadata
- **Some remarks regarding the use of color**

Examples of potential exam questions

- **There is a poorly composed thematic map in the attachment. Which three mistakes and/or missing elements would you correct in the first place? What other mistakes there are in the map?**
- **Explain what it means that data to be presented in a map has to be normalized. When is the normalization necessary, and how can it be done?**
- **Name the visual variables that can be used on map symbols (and in information visualisation in general). How does the measurement scale (nominal, ordinal, interval, ratio) of attribute data rule which visual variables should be used?**
- **Liitteenä on huonosti toteutettu teemakartta. Mitkä kolme virhettä ja/tai puutetta ensisijaisesti korjaisit kartassa? Mitä muita virheitä kartassa on?**
- **Selitä mitä tarkoittaa, että kartassa esitettävä tieto on normalisoitava. Milloin normalisointi on tarpeen, ja miten se voidaan tehdä?**
- **Nimeä visuaaliset muuttujat, joita voidaan käyttää karttamerkeissä (ja yleensäkin tiedon visualisoinnissa). Miten esitettävän ominaisuustiedon mitta-asteikko (nominaalinen, ordinaalinen, intervalli-, suhdeluku-) vaikuttaa siihen, mitä visuaalisia muuttujia tulisi käyttää?**

Maps as means of communication

Maps as means of communication

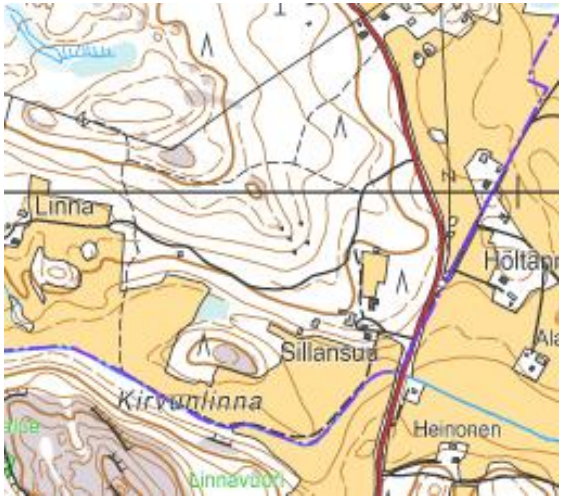


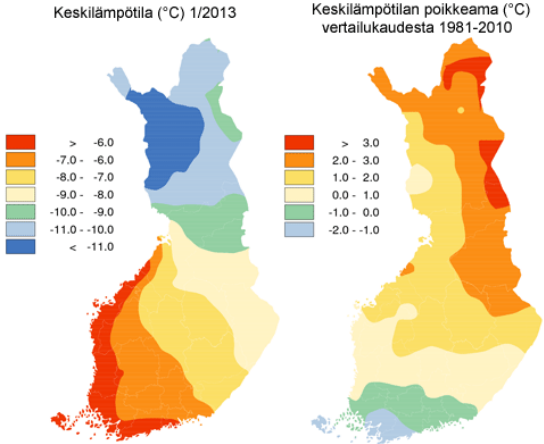
“The purpose of visualization is insight, not pictures”

Jacques Bertin

Maps as means of communication

Visual representation can reveal elements, numbers, or spatial relationships, show patterns, distributions, trends…





http://ilmatieteenlaitos.fi/kuukausitilastot

"A picture is worth a thousand words"

Maps as means of communication

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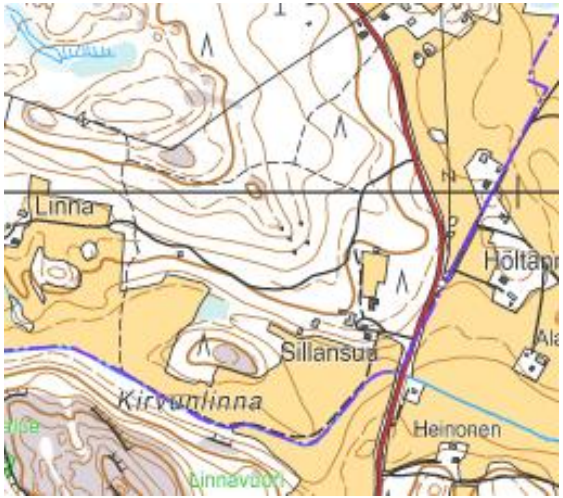

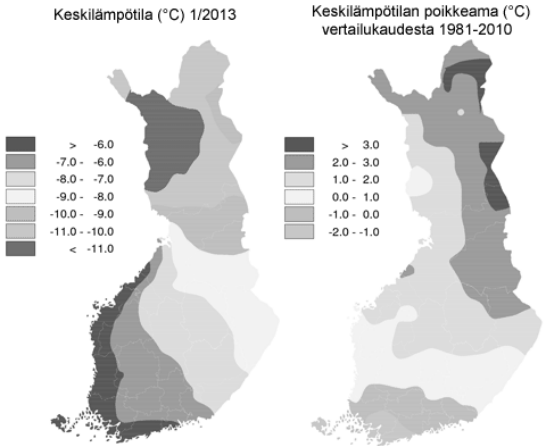

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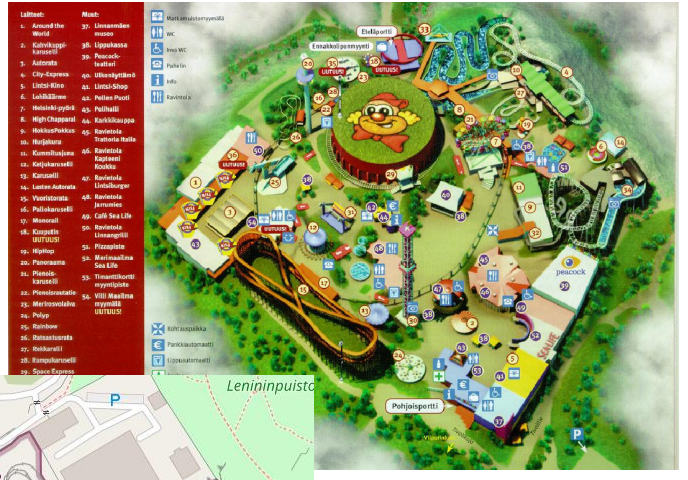
"A picture is worth a thousand words"

Maps as means of communication: cartography

- A (modern) map visualizes data (information)
- Cartography is the art and science of making good maps
- What is a good map is very much situation dependent



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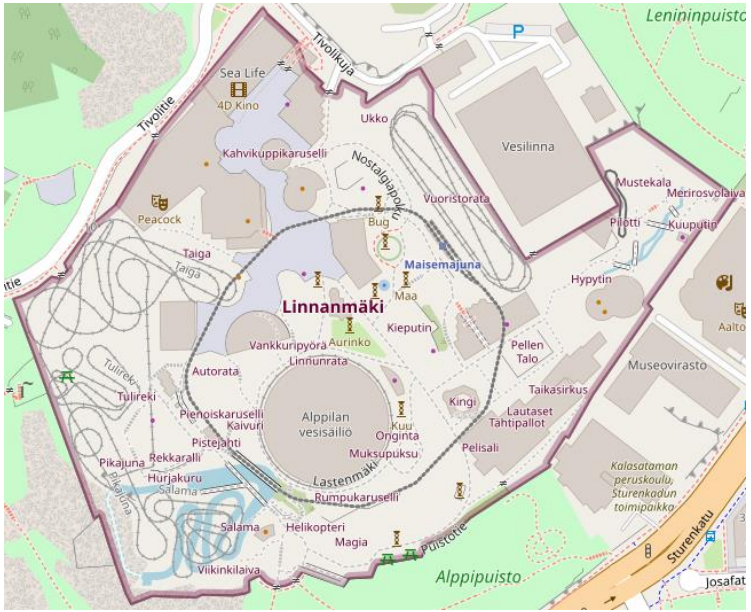
Classroom exercise: comparison of maps

A



B

Classroom exercise: comparison of maps

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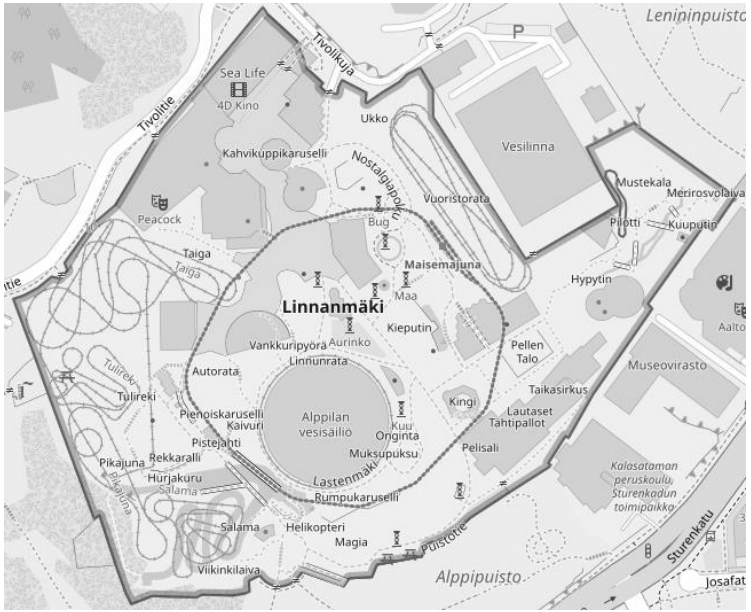
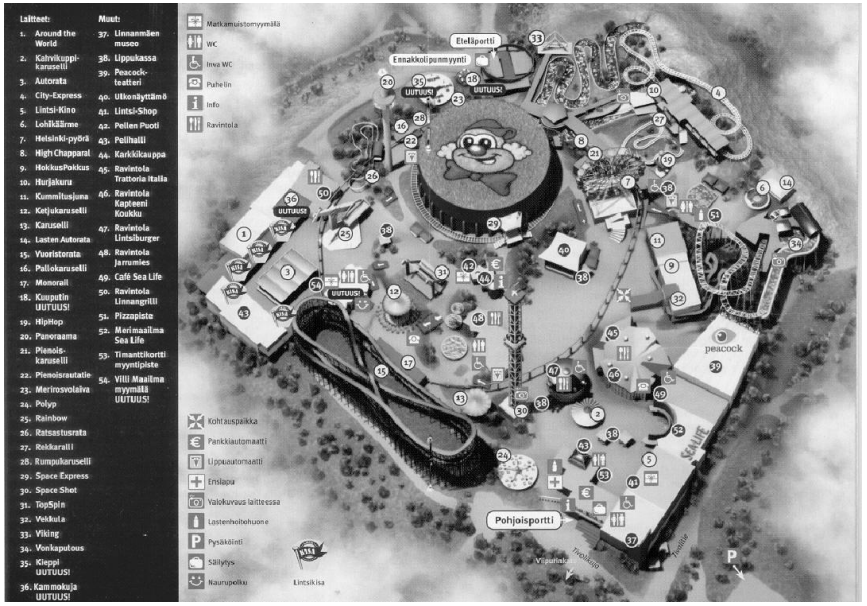
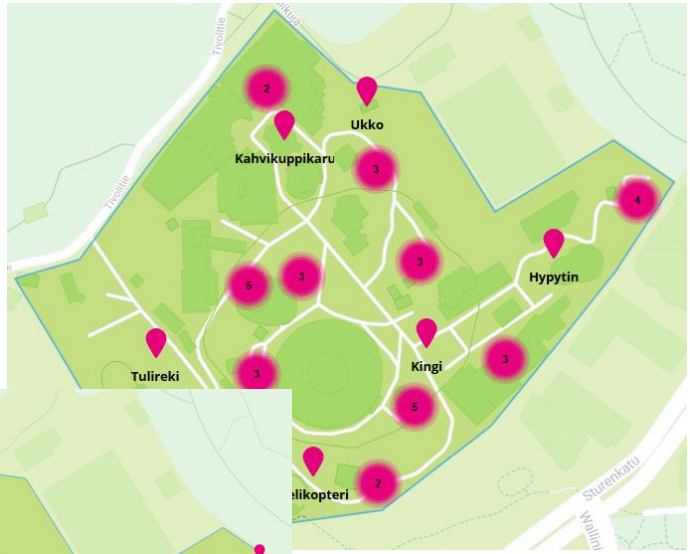


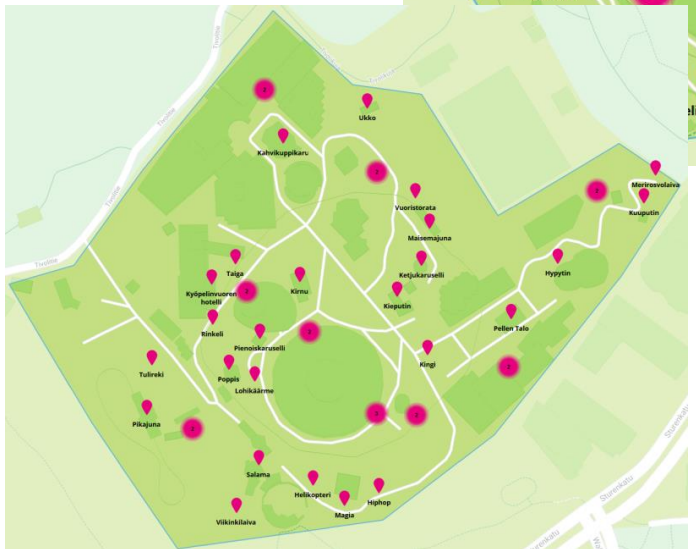
B



Maps as means of communication: data visualization

- Data is often shown on a map
- **Spatial data visualization** is the art and science of how to represent data in a map format
- (somewhat) distinct from cartography





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Comparison of data visualizations

Comparison of data visualizations

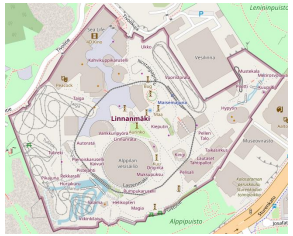
Aims of map design

- **Informativeness**

  For example, attributes of a building signify…
  - Discrimination (residental, administrative, industrial, office)
  - Order (buildings of 1-2; 3-5; over 5 floors)
  - Emphasis (buildings with geothermal heating)
- **Clarity, visual hierarchy, logic**

- **Aesthetics**
  - a factor of usability: ”satisfaction”
  - connotations: eg style ↔ up-to-dateness
- **Affect map reading and interpretation**

“Fun”

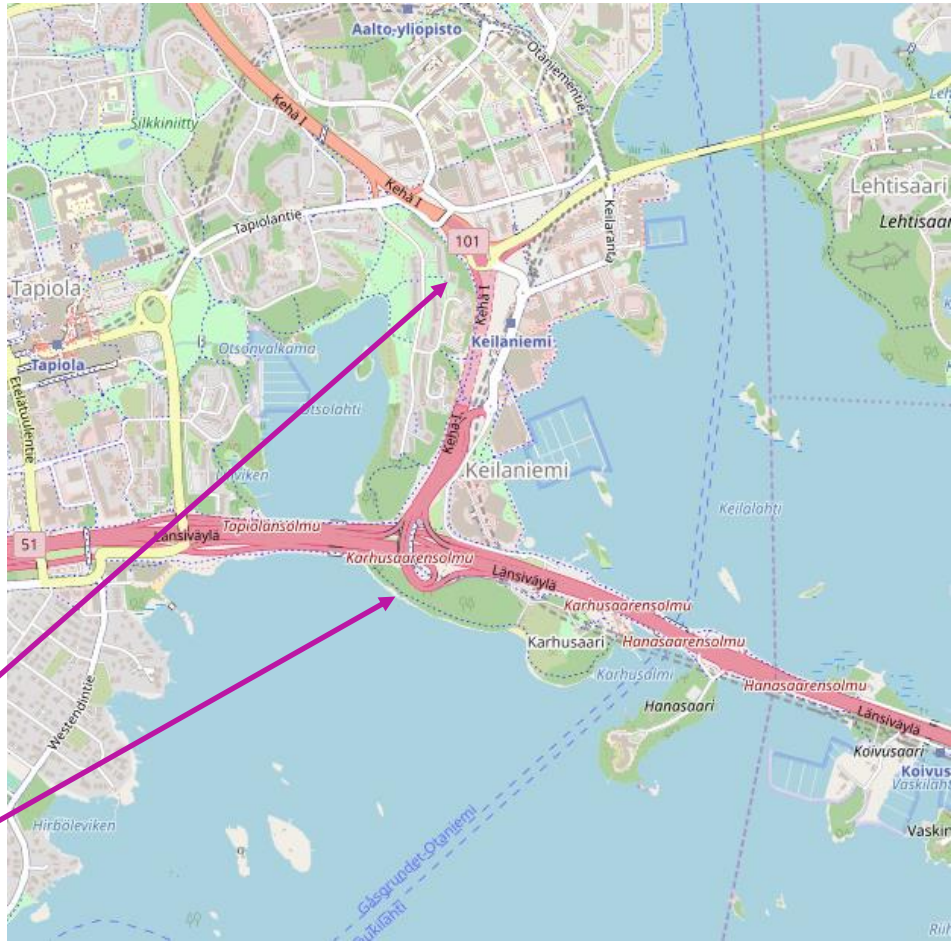


“Informative (boring)”

There are no neutral choices in map desing

Visual hierarchy

- **We attach an order of importance on the elements we perceive**
- **Therefore, maps should emphasize important aspects of the message to be delivered**
- **Emphasis can be achieved with many methods**
  - Color, size and symbology
  - Arrangement
  - Negative (empty) space
  - Etc.



Size and color of main roads emphasize them. Size, color, and location of Karhusaarensolmu all emphasize it.

Visual hierarchy

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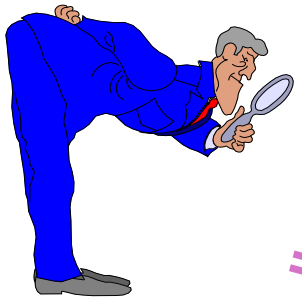
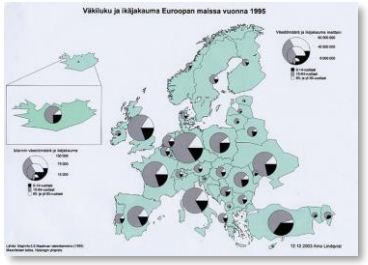
Aims of map design: form whom, what and why?

Phenomenon & data

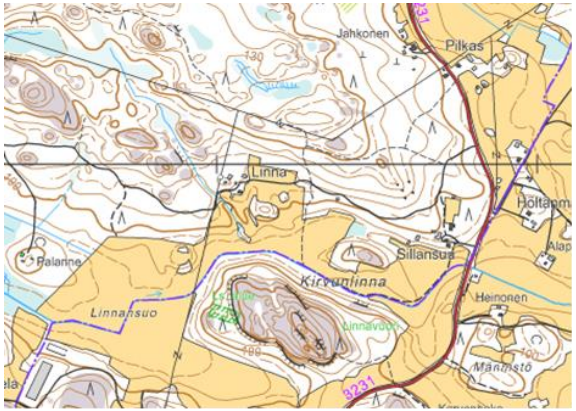




User
- visual perception
- profession, age,…
- cultural context
- motivation, expectations, tiredness,…

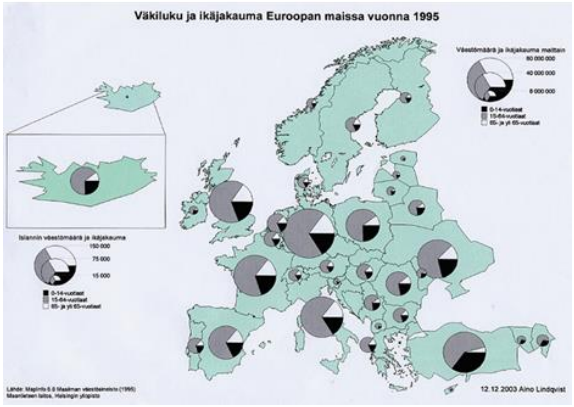
Purpose
- specific...generic
- big picture…detailed study
- convincing, provoking, exploring,…

Some important terms



Topographic map

Large scale map



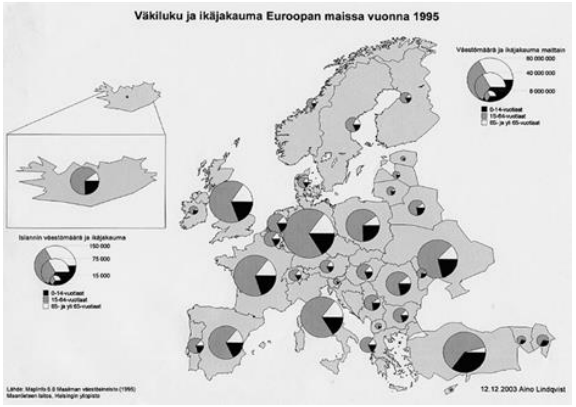
Thematic map

Small scale map

Some important terms

Topographic map

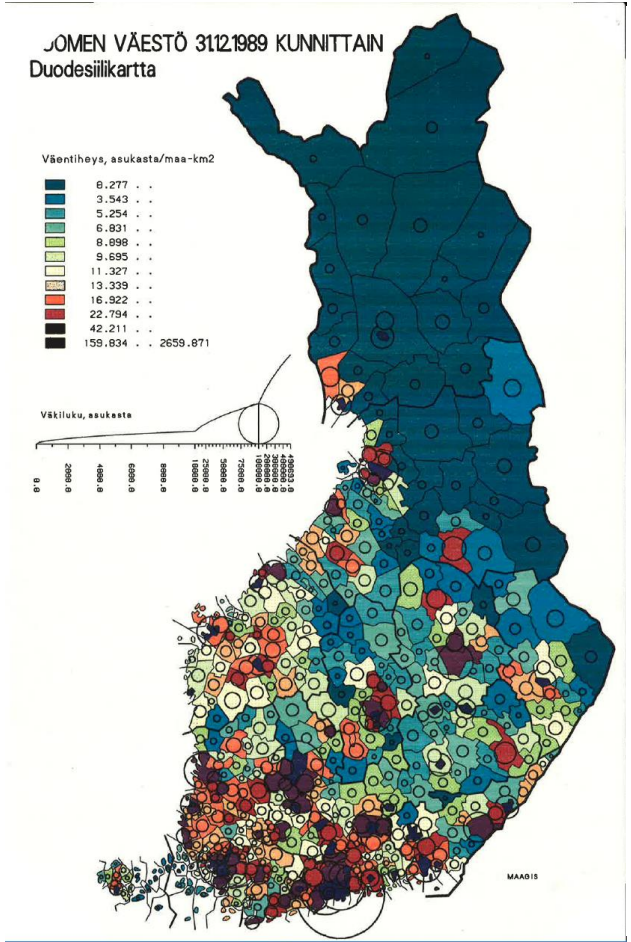
Large scale map

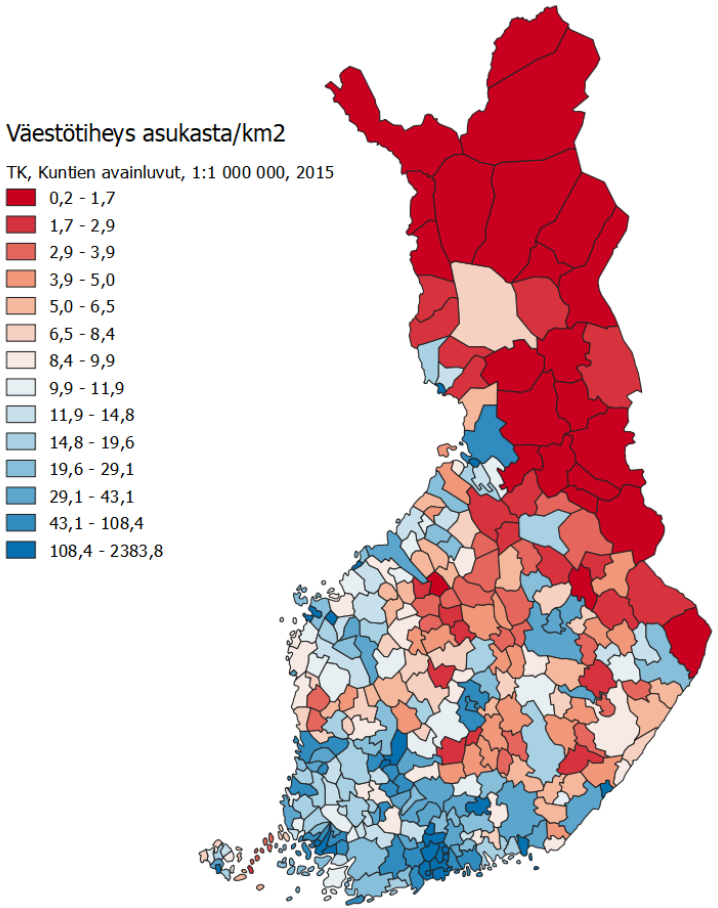


Thematic map

Small scale map

Good maps, bad maps

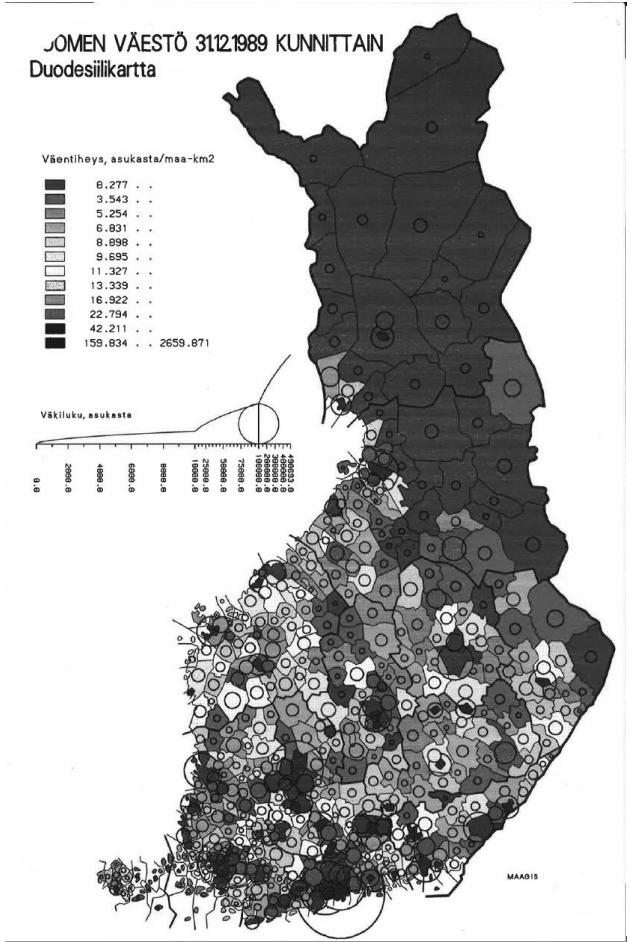


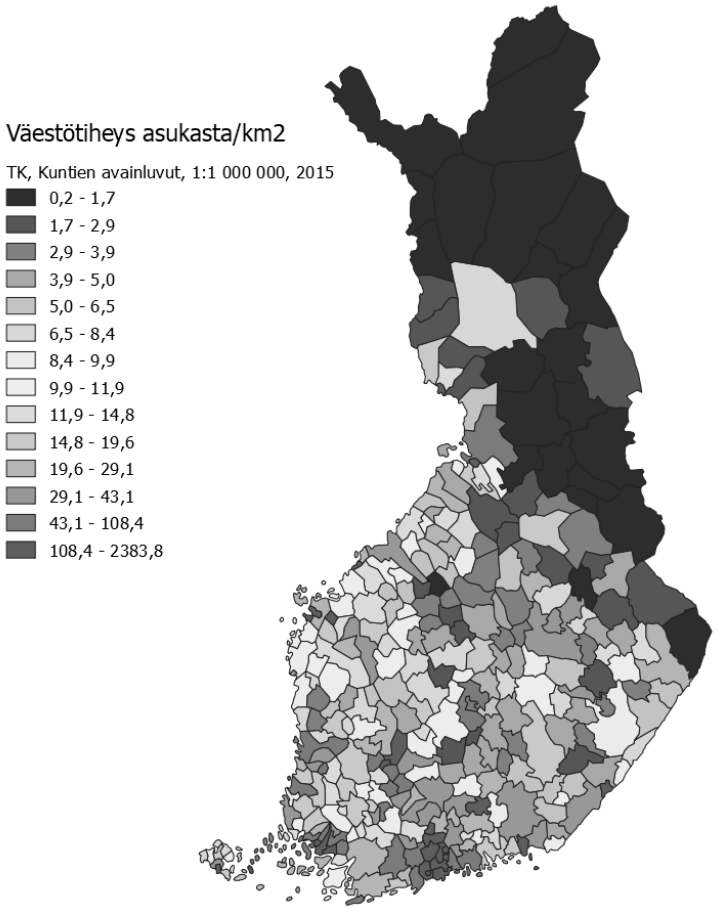


Note: the maps are not directly comparable

1. Population compared to ground area vs area incl. inland waters
2. Different method of calculating the area (surveying results vs. calculation from generalized polygon)

Good maps, bad maps





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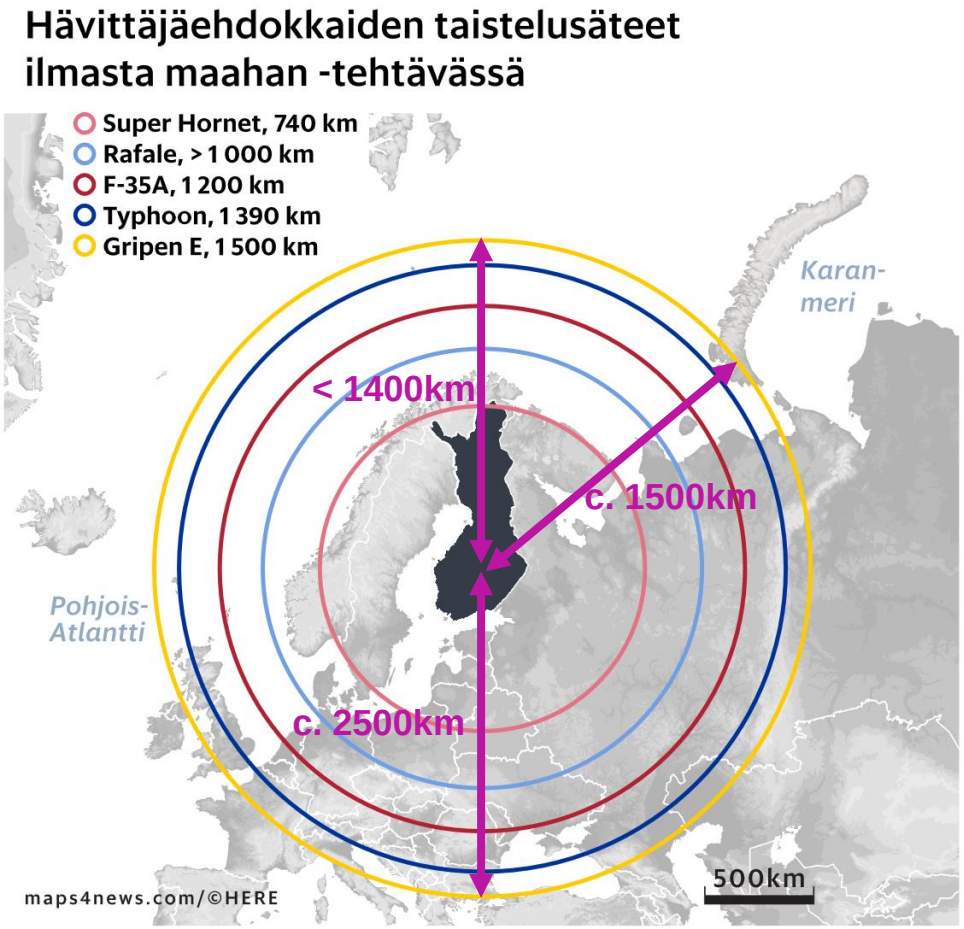
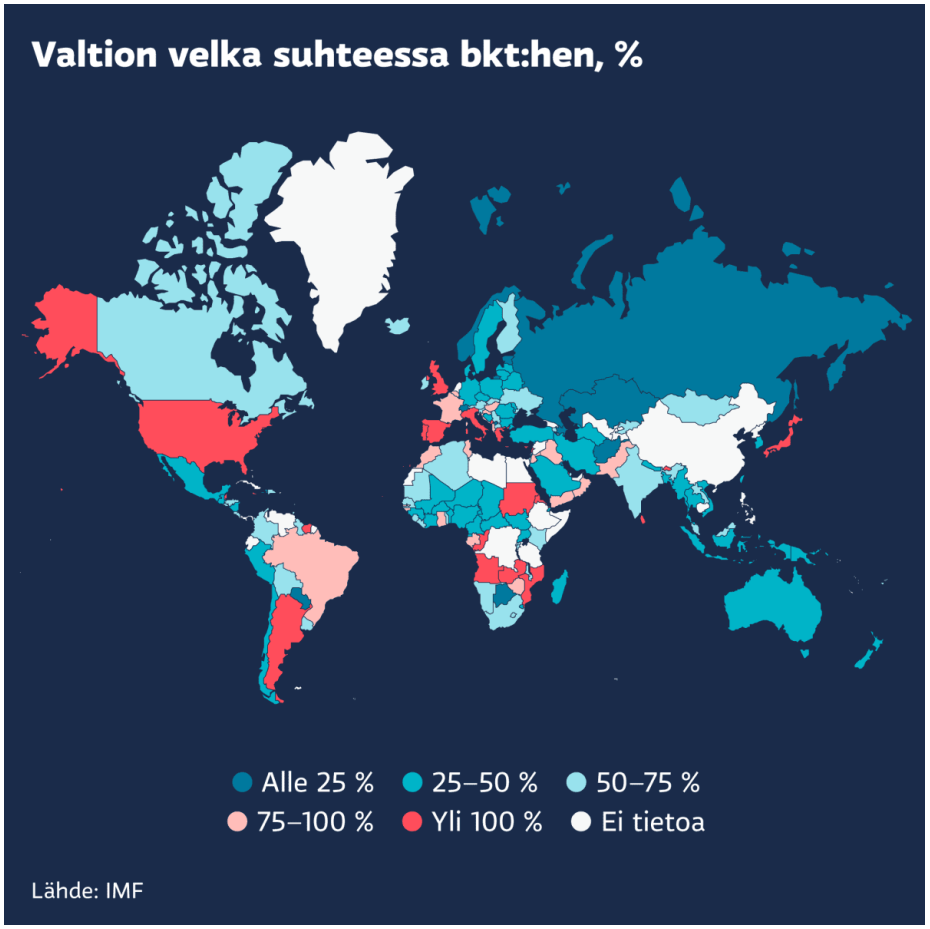
Example

- **In this example: Consider the map for a moment**
- **What is the message of the map?**
- **Is there something wrong with it?**

Good maps, bad maps





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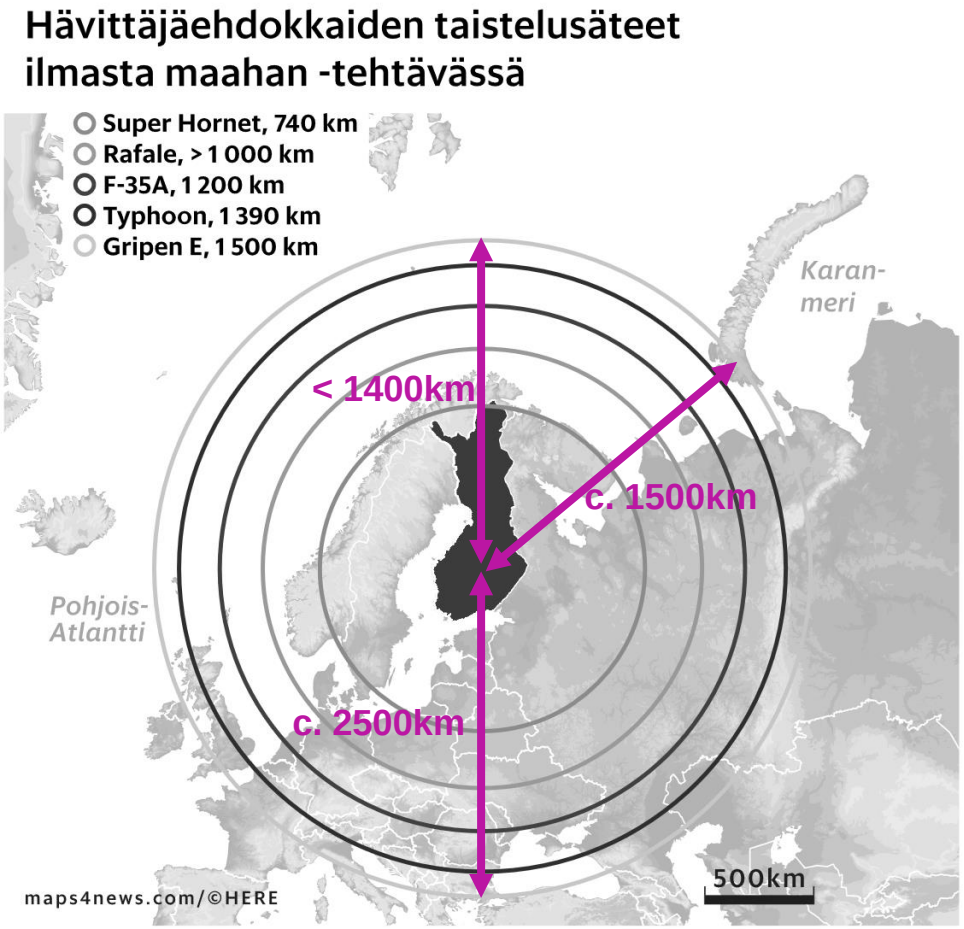


Good maps, bad maps

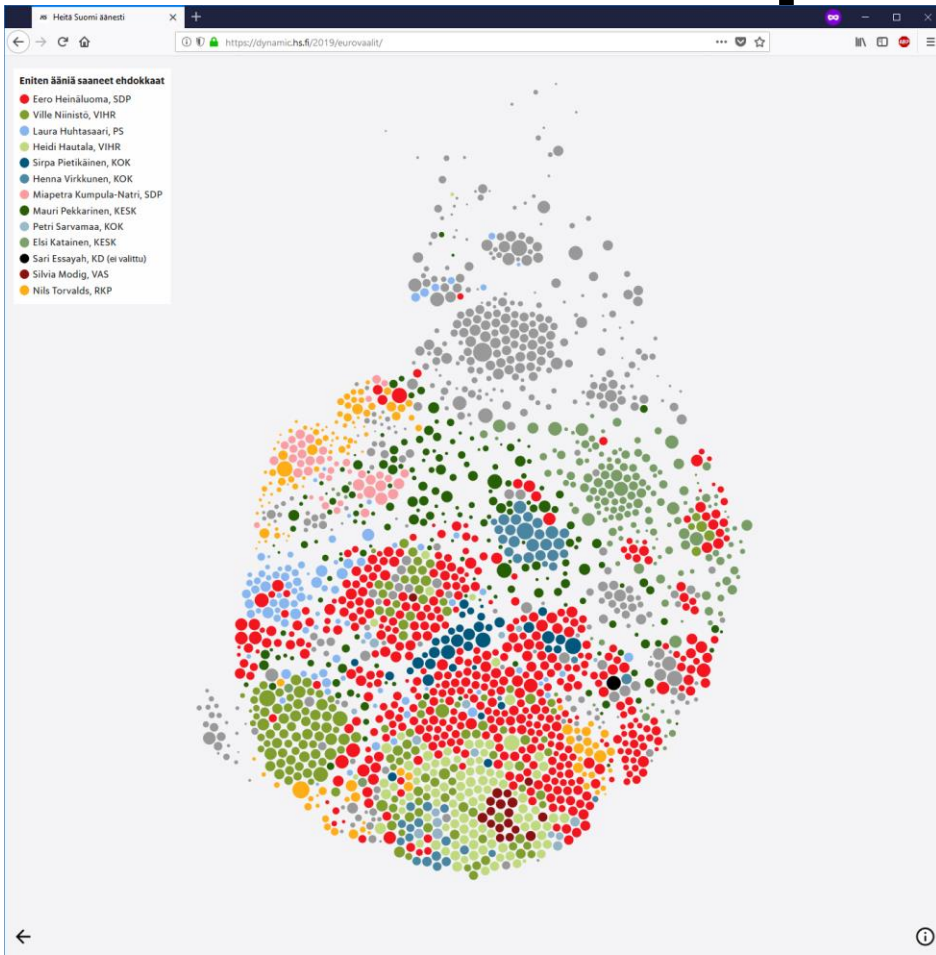
- **Finland is rather big is it not? Big enough to stretch from Baltic to Sicily (a distance of about 1900 km)**
- **In reality, Finland is a bit over 1100km long (north-south)**
- **Greenland is bigger than the whole Europe on the map**
- **Mercator projection exaggerates areas near poles significantly**

https://en.wikipedia.org/wiki/Mercator_projection#/media/File:Worlds_animate.gif

Map design

What and how? Elements of a map design

1. **Data to be included (and excluded)**
   - Normalization, classification
2. **Mapping method**
   - Different symbolization, colours
3. **Area of the map & presentation scale**
   - Generalization of geometry
4. **Background for the theme**
   - Relevant content, visual hierarcy
5. **Key for interpretation: title and legend**
6. **Metadata**



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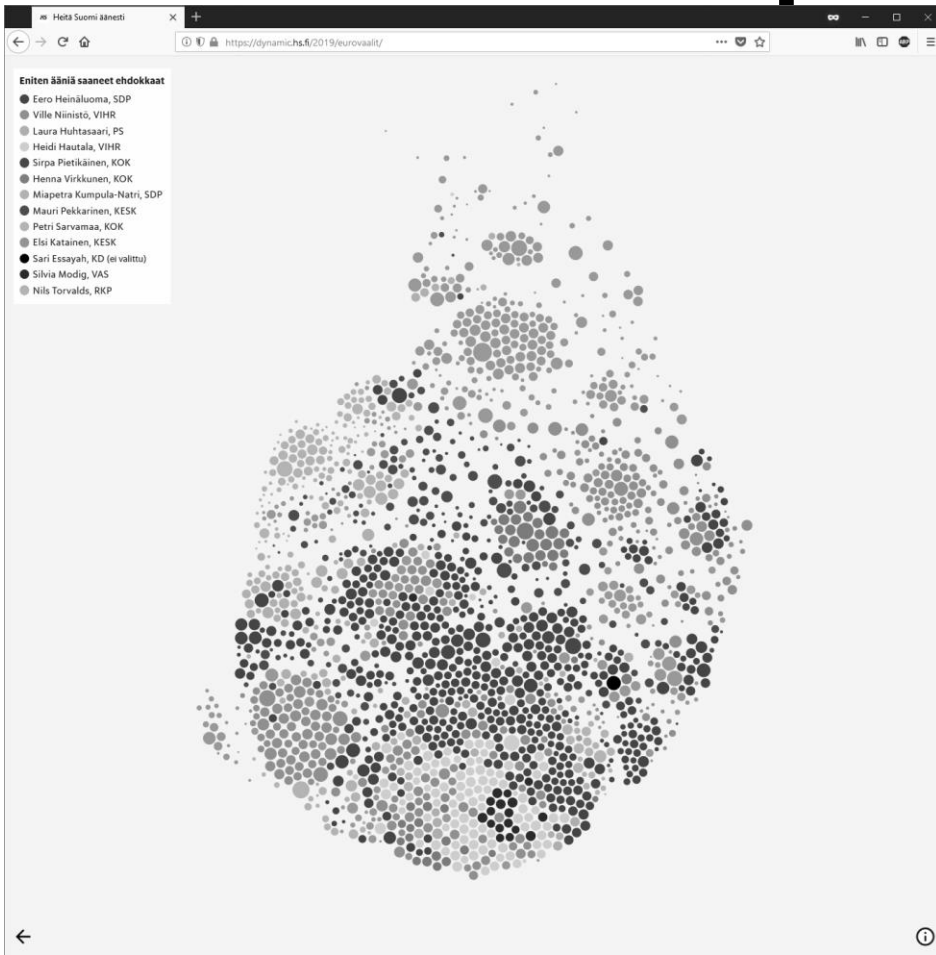


1. Data to be included

1. Data to be included (or excluded)

- **What data to include, and what to exclude**
  - Object classes and their attributes
  - One or more attributes per object (how many we can visualize)

  OR
  - Spatially continuous variable(s)
- **Data analysis**
  - Which measurement scale (nominal, ordinal, interval, ratio)
  - Range and distribution of values
  - Counts or proportions? Need for normalization?
  - Unclassified or classified?
  - Need for preprocessing of data?

Measurement scales

- **Nominal**
  - Distinct categories: e.g. industrial/residential/ commercial buildings
- **Ordinal**
  - Ranked categories: e.g. sparse/low/medium/high population density
- **Interval**
  - Difference between units is equal, but zero point is arbitrary: e.g. Celcius scale
- **Ratio**
  - Difference between units is equal, and zero point represents zero value: e.g. distance measures
- **Cyclic**
  - Values cycle back to zero: e.g. direction or time of day

Data normalization

- **Remember from a previous slide:**

Note: the maps are not directly comparable

1. Population compared to ground area vs area incl. inland waters
2. Different method of calculating the area (surveying results vs. calculation from generalized polygon)

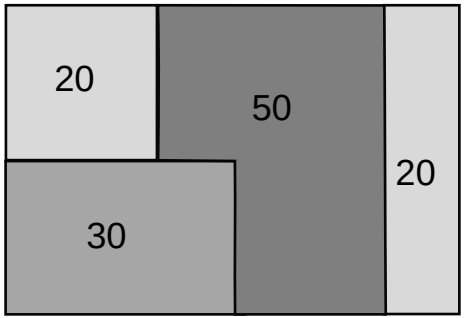
- **Example of normalization**
- **Normalization eliminates the effect of varying size of the enumeration areas - or some other distorting effects: spatial or other dependencies**
- **Relevant with ratio scale values only**
- **Normalization**
  - per area
    - e.g. population density: number of people per area
    - e.g. productivity: tons of wheat harvested per area (yield)
  - per another variable
    - e.g. proportion of Swedish speaking people per population
    - e.g. birth rate per women of child-bearing age

Normalization: a simple example

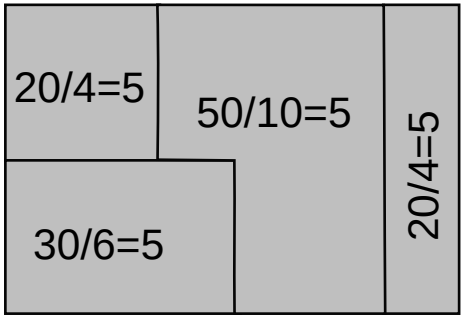
Example:
5 objects in each grid cell.
4 regions of varying size.

5	5	5	5	5	5
5	5	5	5	5	5
5	5	5	5	5	5
5	5	5	5	5	5

Map of non-normalized values:
The larger the region the higher the value.



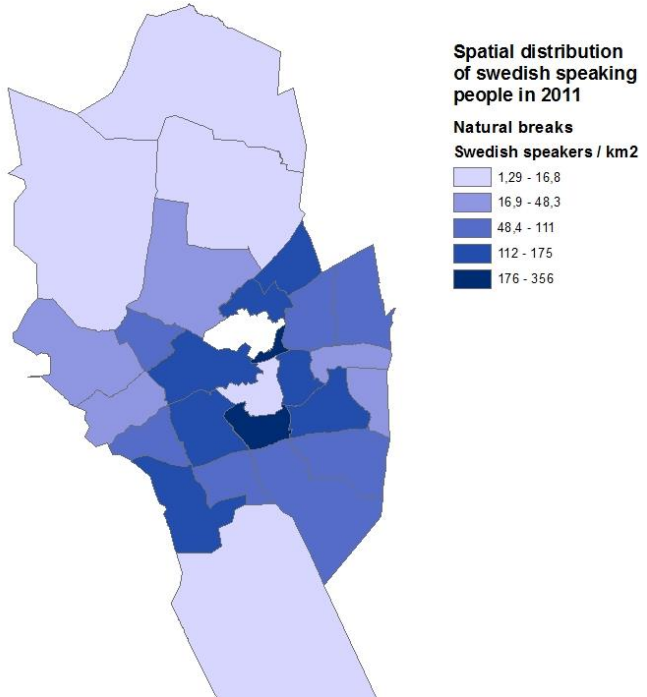
Map of normalized values reveals
the constant density across the area.



Normalization: another example

Consider what is the message of the map, what makes sense.

Swedish speaking people in Espoo



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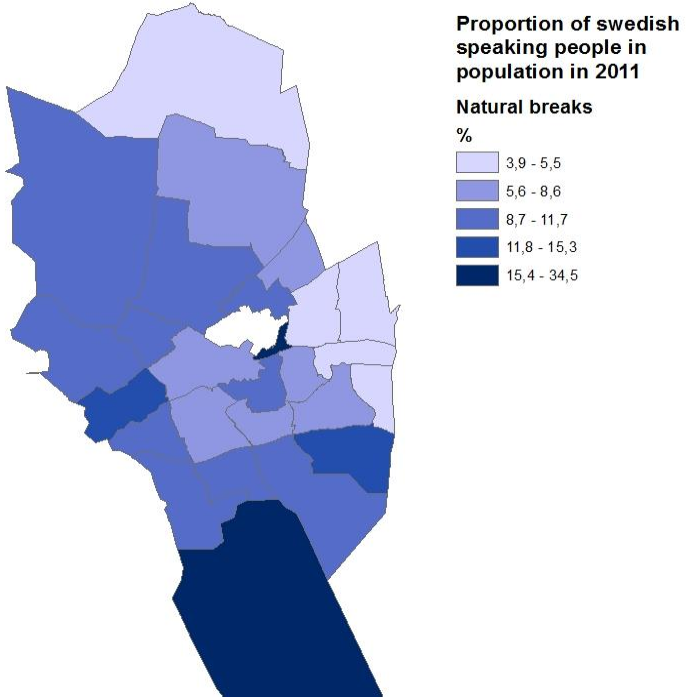


A?

Data classification

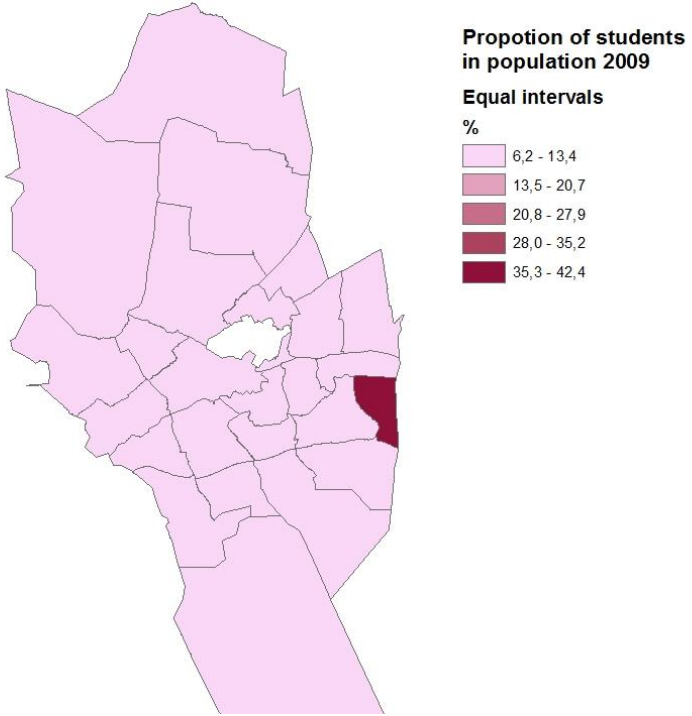
- **Systematic grouping of data based on one or more attributes**
- **The aim is for a clearer map, even if this map image is generalised**
  - “Less is more” principle
- **The classification, and the resulting map, should reflect those patterns or structures that are characteristic for the mapped phenomenon**
  - And each class should contain its share of the observed values

- **How data is classified is an important choice**
  - Different classifications for the same data may communicate a completely different message

Data classification example

Does the map clearly communicate the phenomenon?

Students in Espoo



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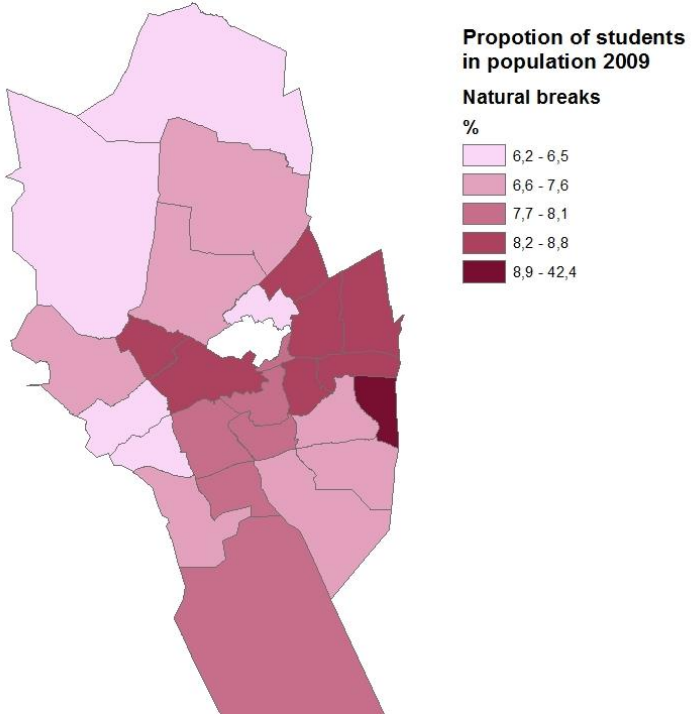


Data classification

Aim: Homogeneous classes + contrast between the classes

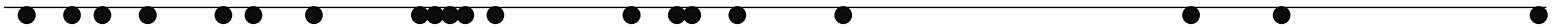
What is the suitable number of classes depends on...

- map users: the lower the number of classes, the easier to interpret the map – but not too low, either ⇒ what is the sufficient level of information
  - We can perceive 5 classes without counting, or keep in working memory about 7 meaningful chunks at a time
- **characteristics of the phenomenon: present essential behaviour**
  - Avoid deciding the number of classes before studying the data
- **the number of objects in the map (if very small, avoid too many classes)**
- **visualisation of classes: what we can perceive & how it is presented**
- For example, bipolar data (diverging from a meaningful turning point, such as 0° for temperature) affords more classes: use two hues that vary in lightness

What is the suitable classification method?

Data classification example

Here measured values of 20 data objects ⇒ Classified into five classes



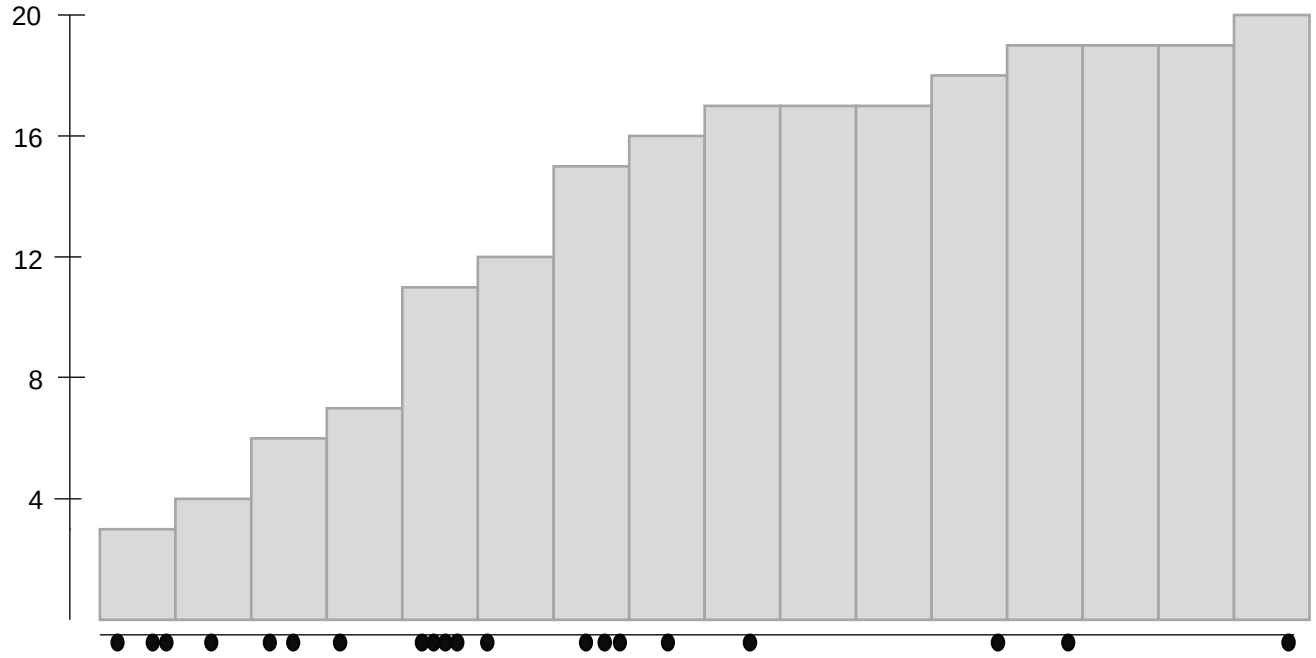
Classification by equal intervals:

Classification by quantiles (equal count):

Classification by maximum breaks:

Data classification example

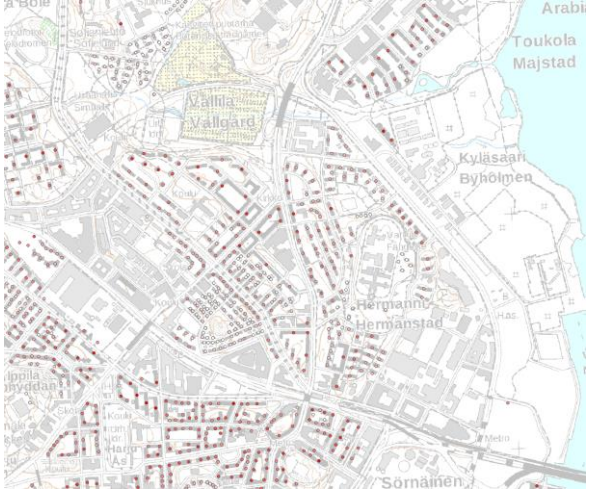
Searching natural breaks visually by a cumulative frequency diagram



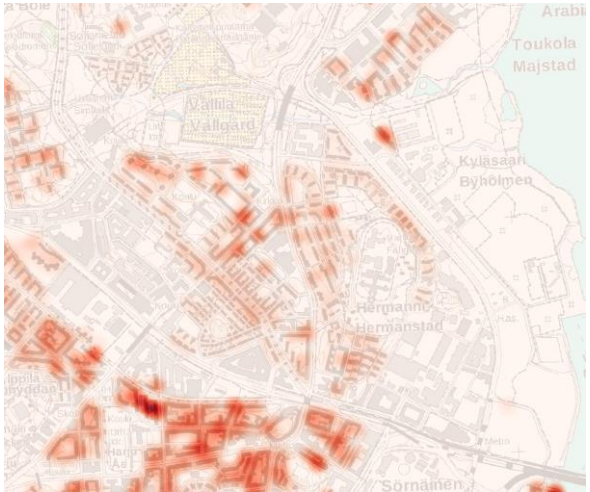
2. Mapping method

2. Mapping method

- **What is the appropriate map type for a specific visualization?**
- **Depends on the phenomenon and the data**
- **Type of phenomenon**
  - Objects or fields?
- **Type of data visualization**
  - Points, lines, polygons
  - Raster
- **Attribute types** (interval/ratio/ordinal/nominal)

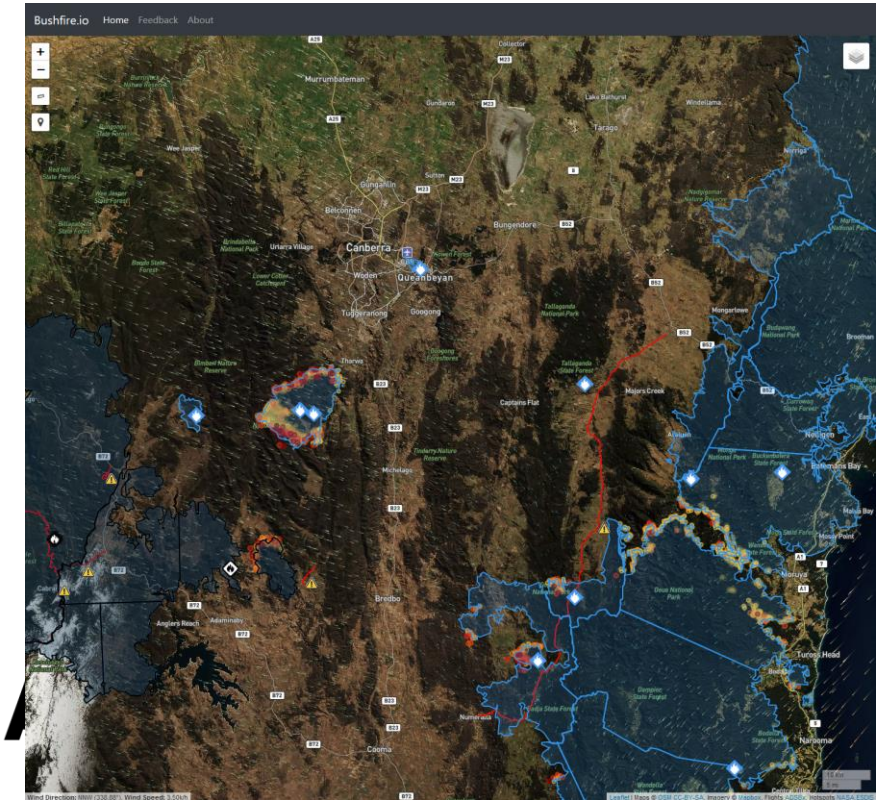


Same data
different visualizations

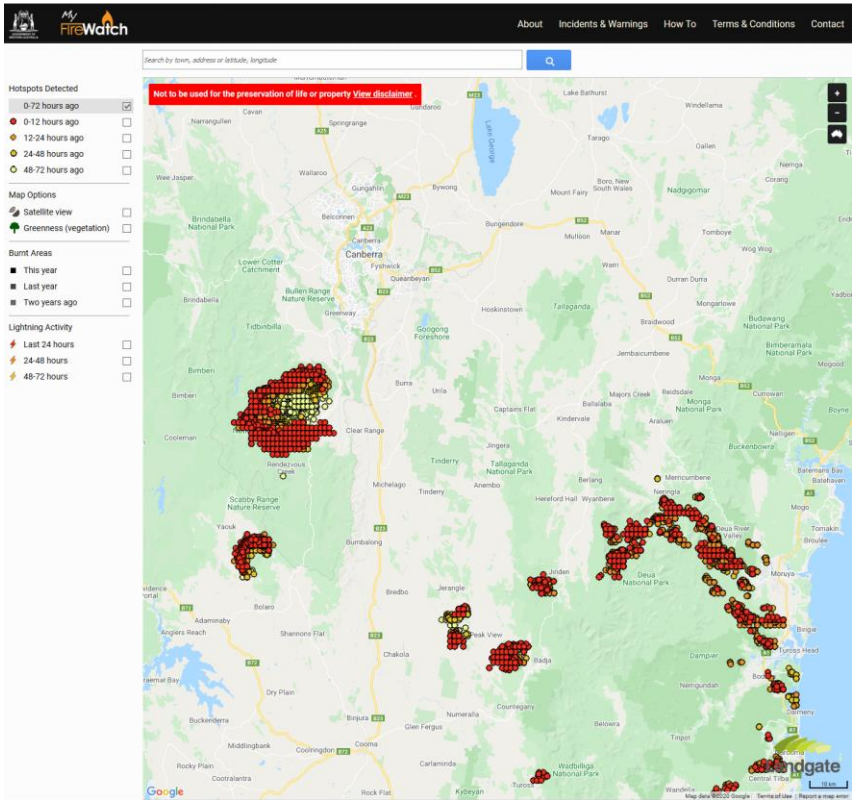


Visualizations of the same phenomenon can be very different

A

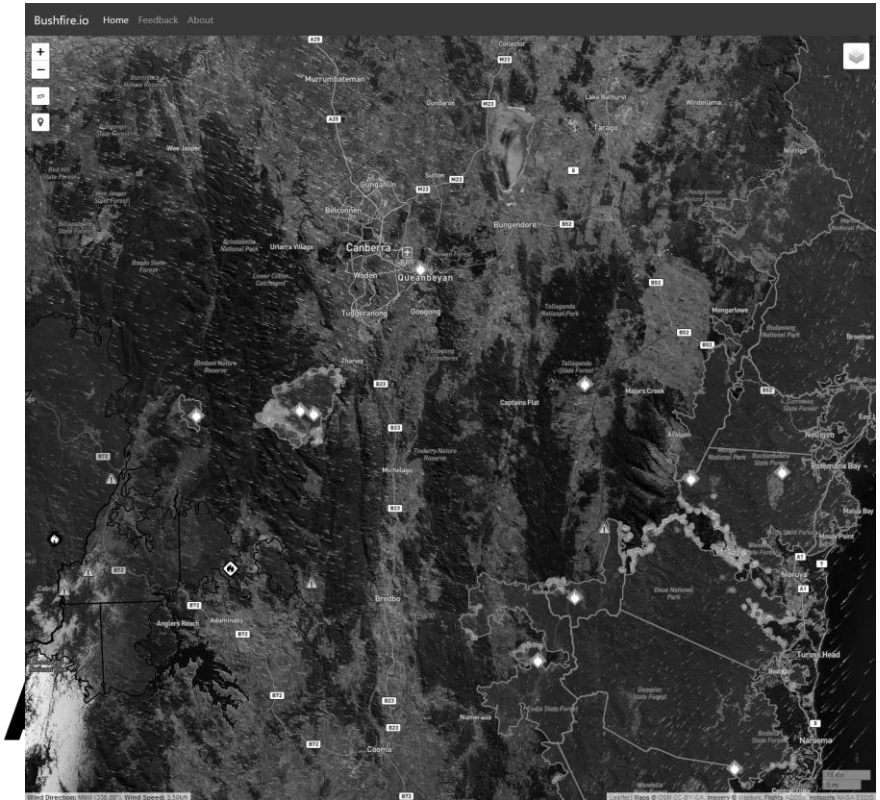


B



Visualizations of the same phenomenon can be very different

A



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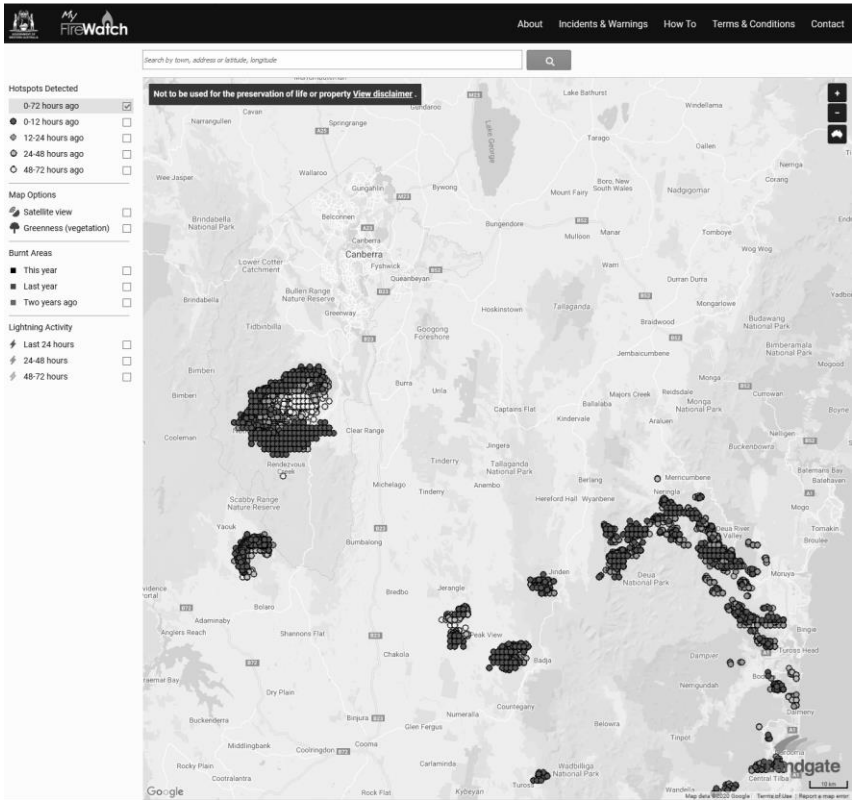
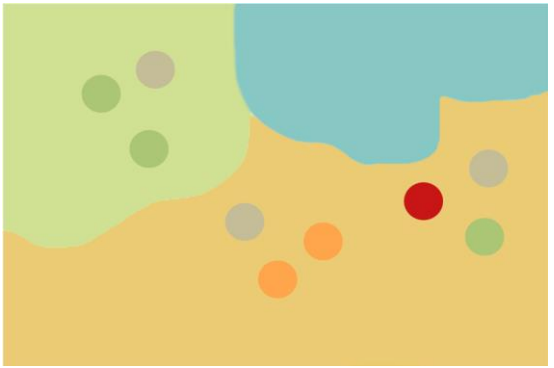
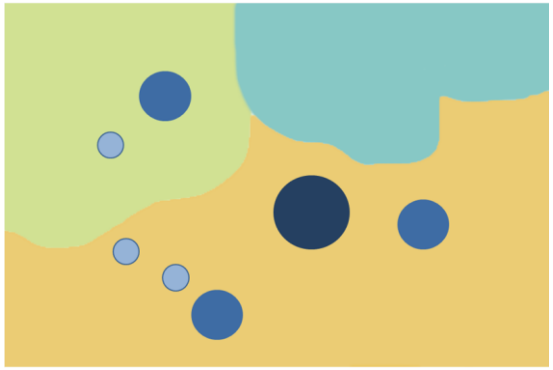


Use of visual variables

- Notice the color, size, and shape
- Intuitive interpretation of visual variables varies
- Interpretation of a variable can also depend on the type of map





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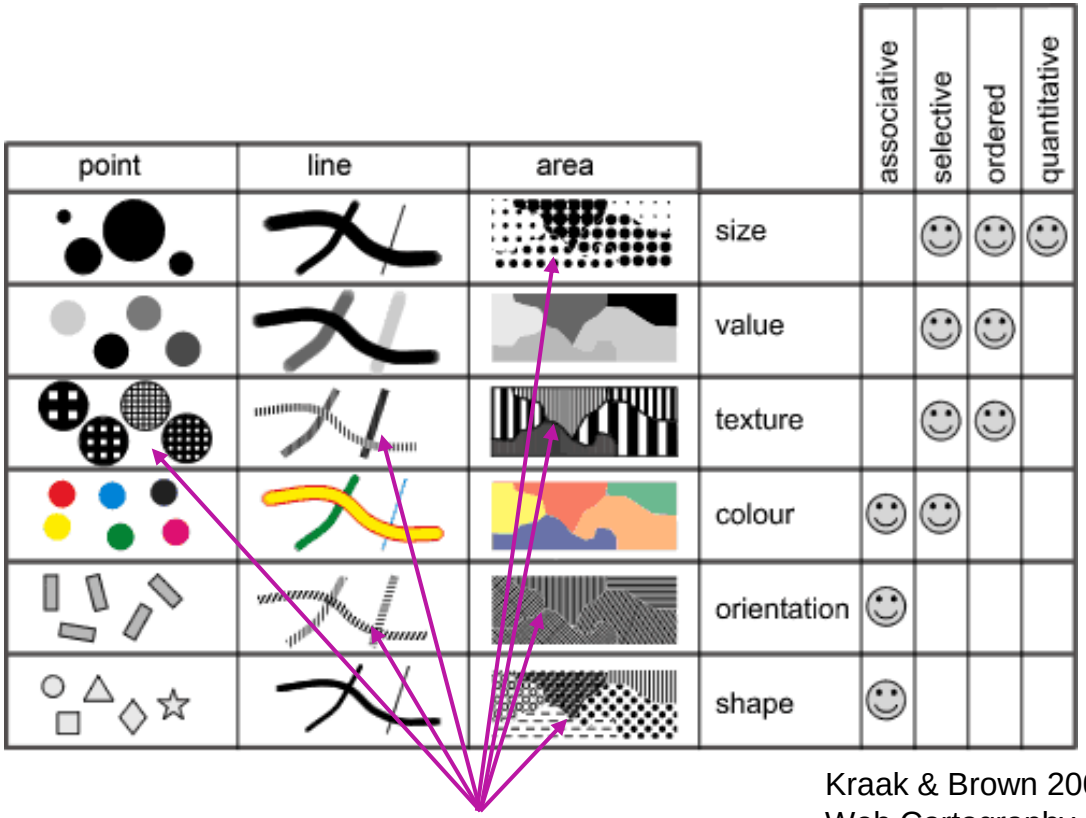
Different types of visual variables

- **Originally described in Sémiologie graphique by Jacques Bertin (1968)**
- **There are different ways to encode data as visual varibles in a map**
- **Originally developed for paper maps**
- **Web cartography requires additional elements, such as transparency**



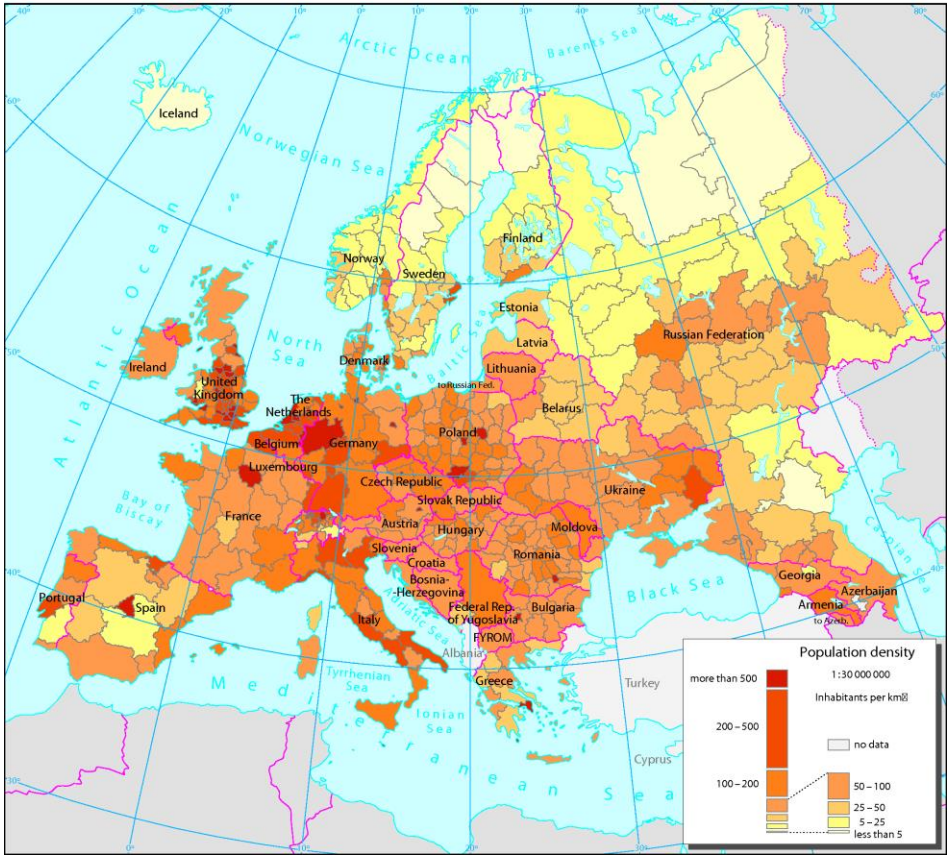
Kraak & Brown 2001
Web Cartography

Some of these are less often relevant on a computer screen than on a black-and-white paper map.

Area-based visualization example: Choropleth map

- **In a choropleth map geographic areas are colored relative to a numeric variable**
  - Colors represent order
- **Notice the map projection (Lambert conic proj.)**
  - North direction varies
  - North direction represented using grid lines
  - No scale bar

Map 1.1 Population density in Europe.
Source: WHO



Source: eea.europa.eu

Choropleth map drawbacks

- **Bigger areas grab more attention**
- **Map is intuitively interpreted as representing homogeneous areas**
  - Typically its not: areas are selected separately from the data
- **A dasymmetric map correct this drawback: homogeneous areas are derived from the data**
  - Requires more detailed data to create than choropleth map

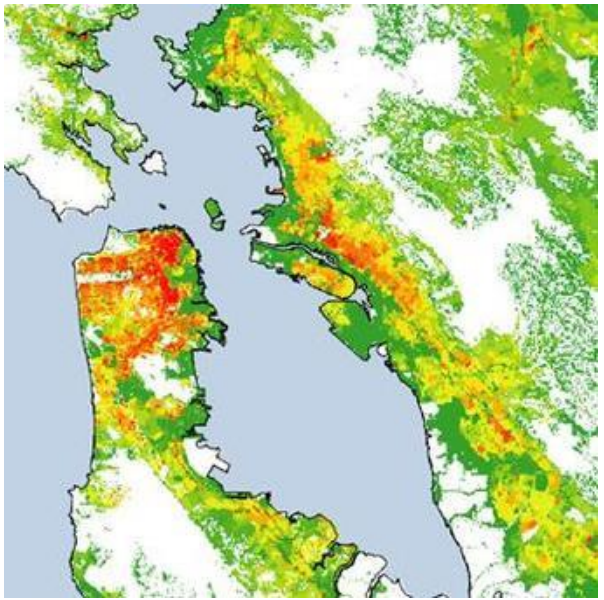


Image source: USGS (public domain)

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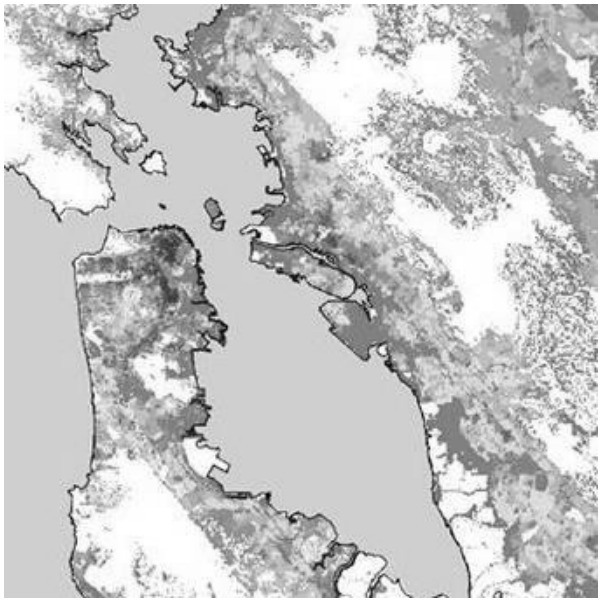
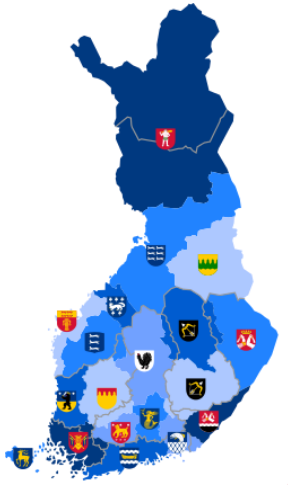


Image source: USGS (public domain)

Thematic maps for nominal data: Chorochromatic maps



Don’t follow this example! Colour here suggests and order.

Provinces in Finland – commons.wikimedia.org

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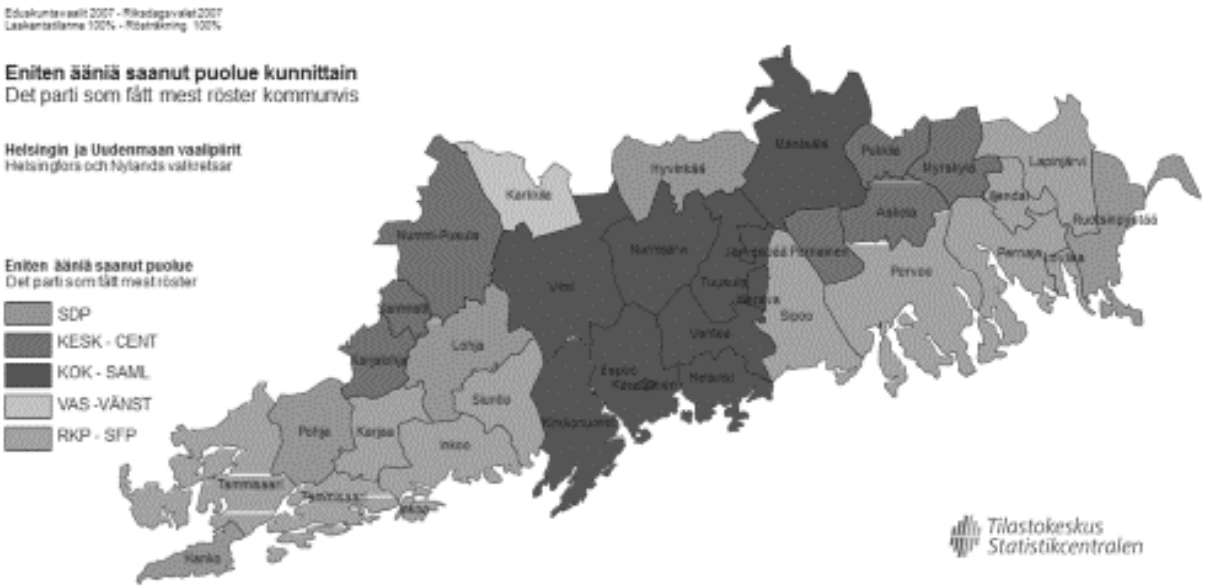

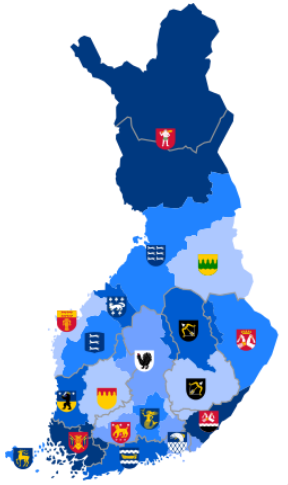

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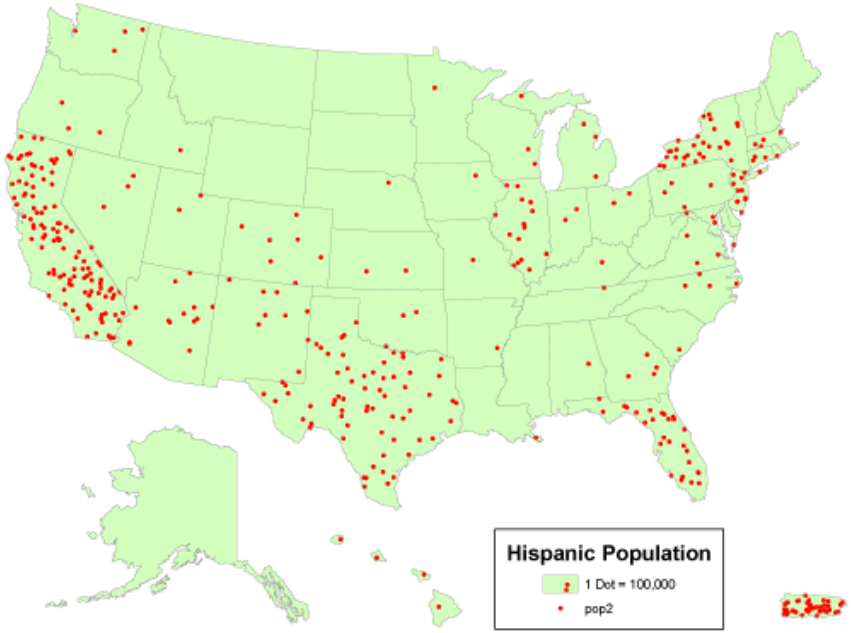
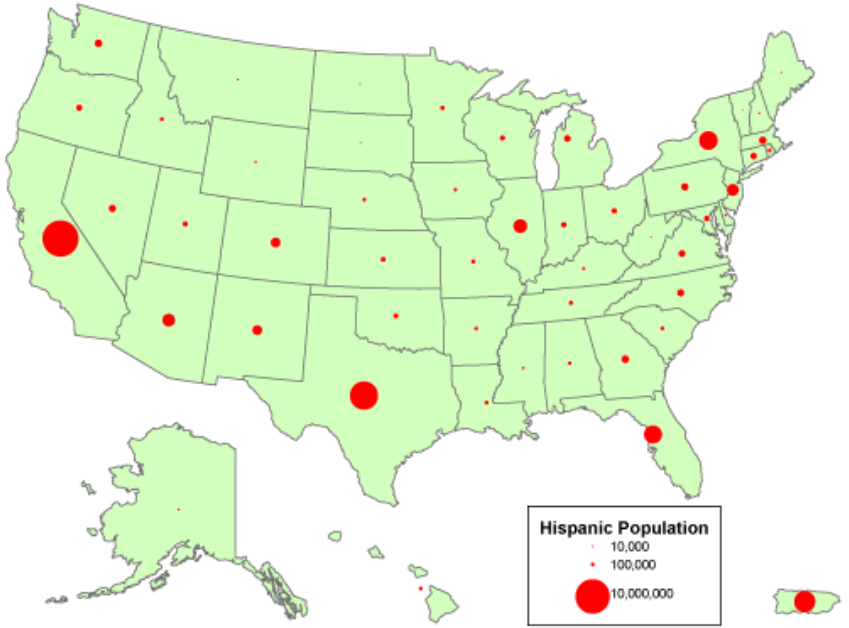
Point visualization: dot density and proportional point symbols





Note: the dots are distributed randomly within a unit of measurement

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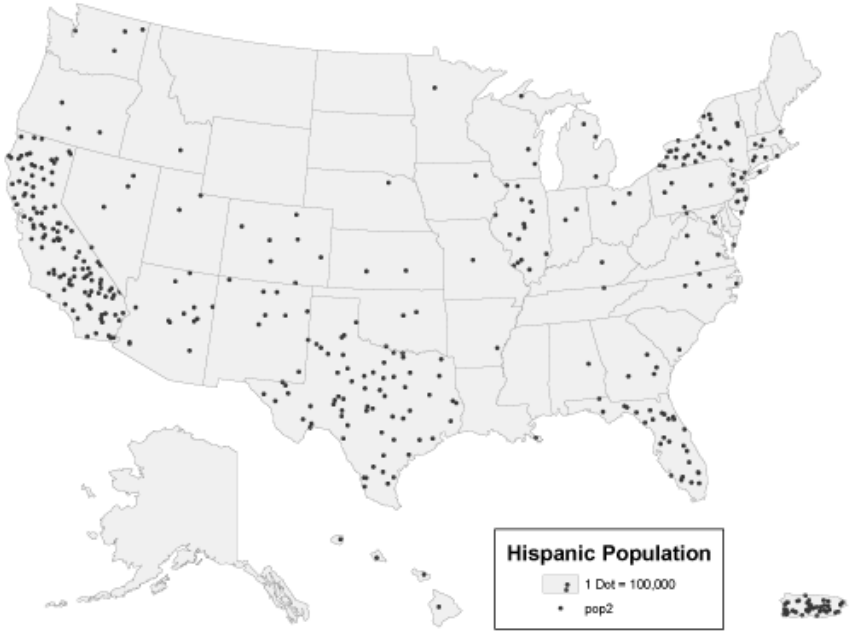

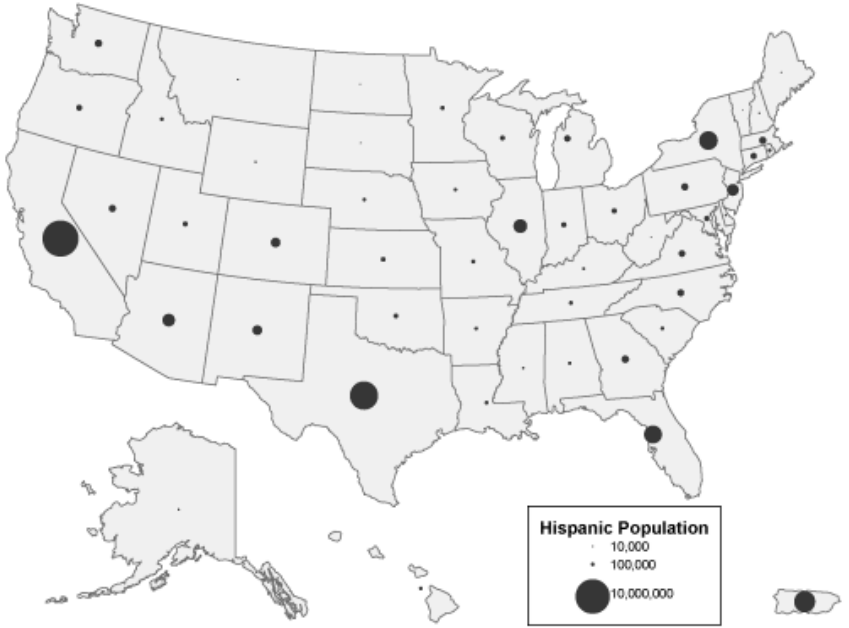

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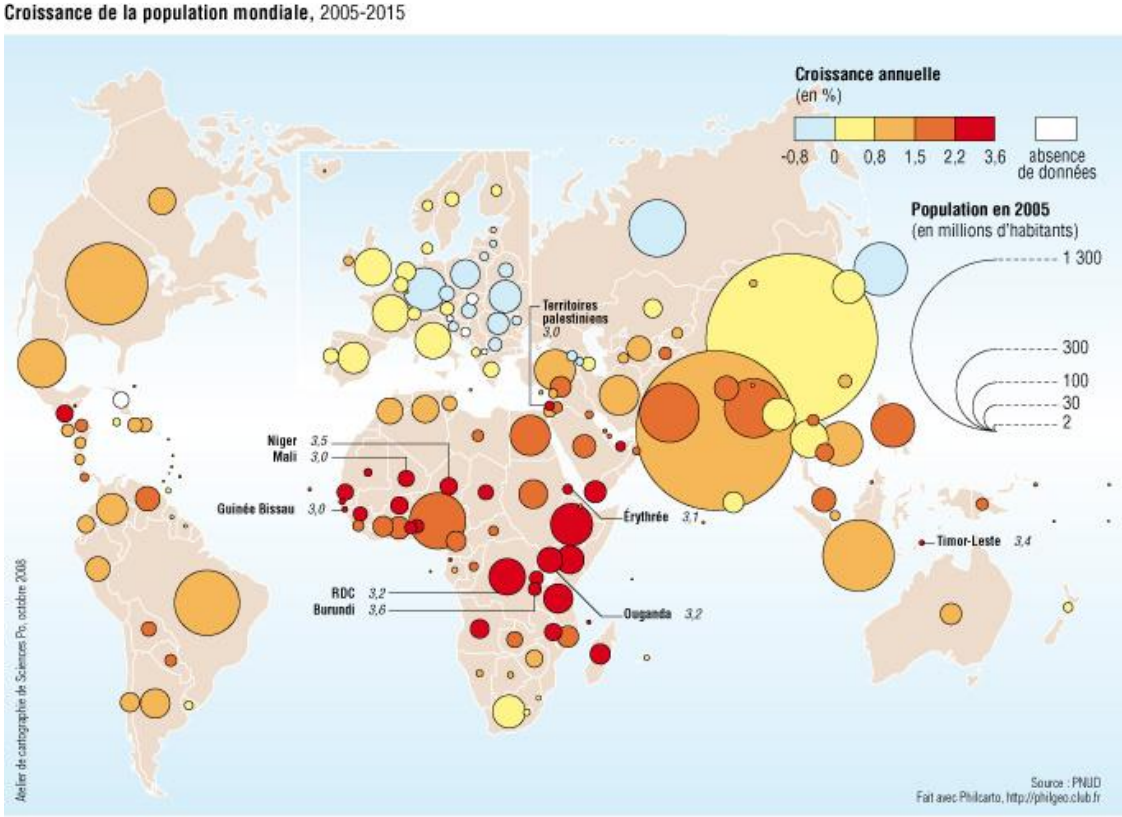
Note: the dots are distributed randomly within a unit of measurement

e-education.psu.edu / Geoff Hatchard

Two quantitative / ordinal attributes per point symbol

- **Both population (size of the symbol) and its change (color) represented at the same time**



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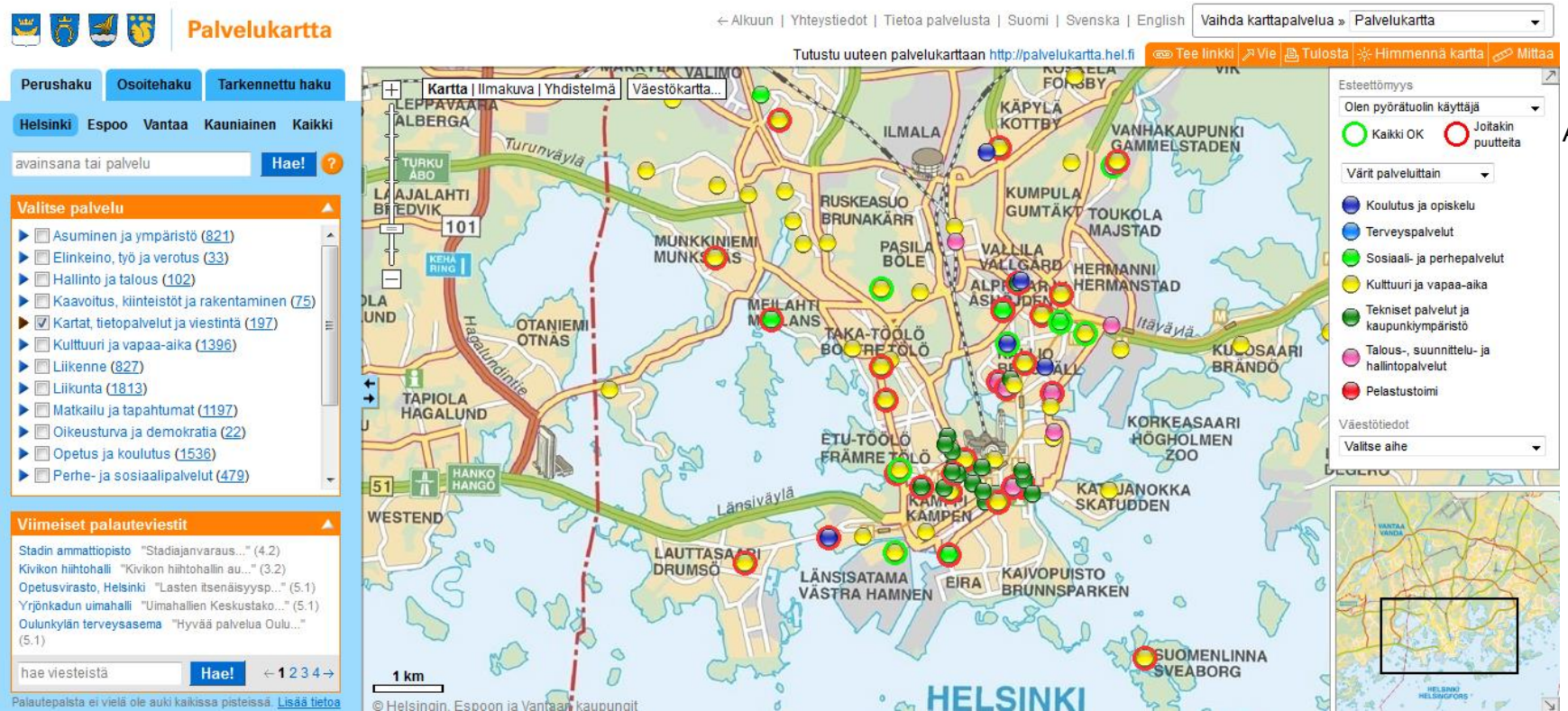
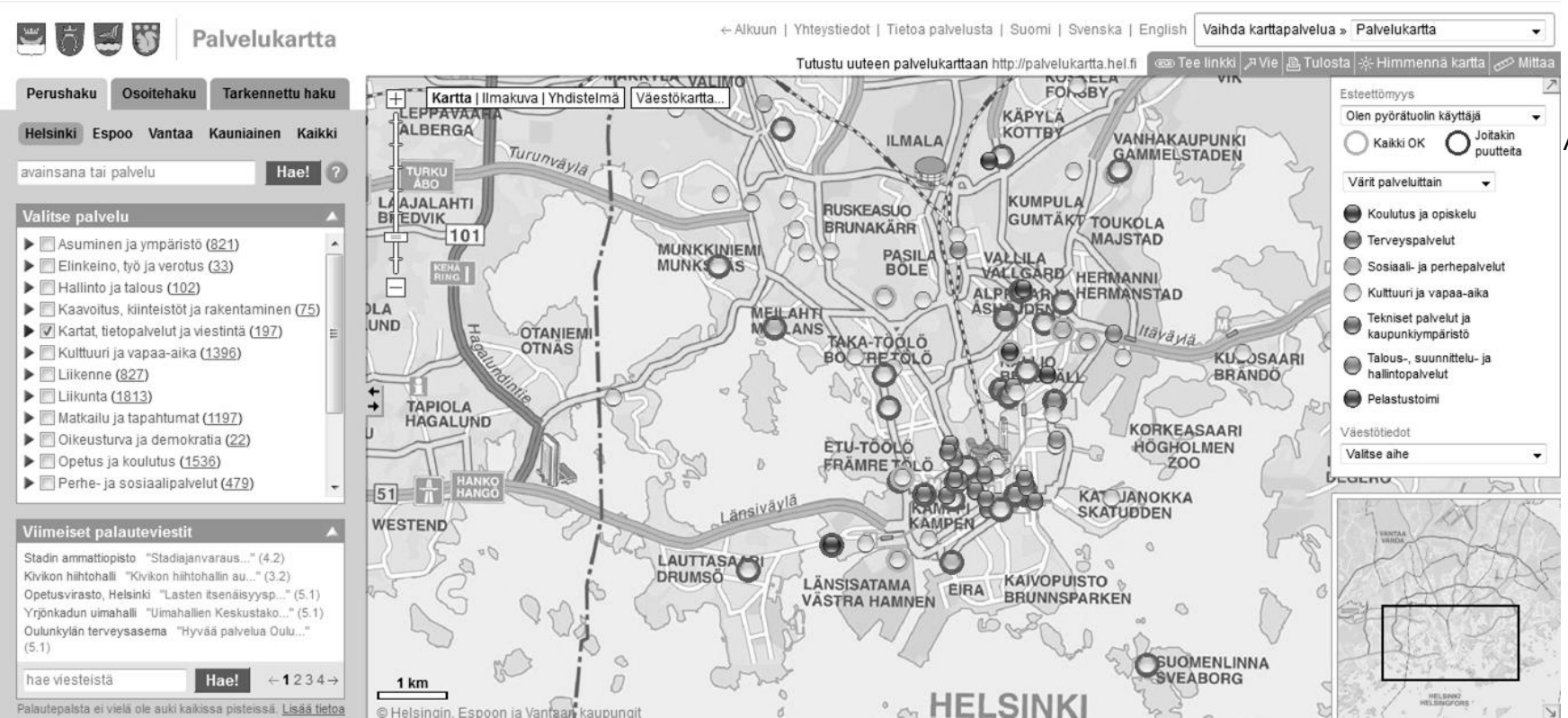
Two nominal attributes per point symbol



Accessibility

Type of service

Two nominal attributes per point symbol

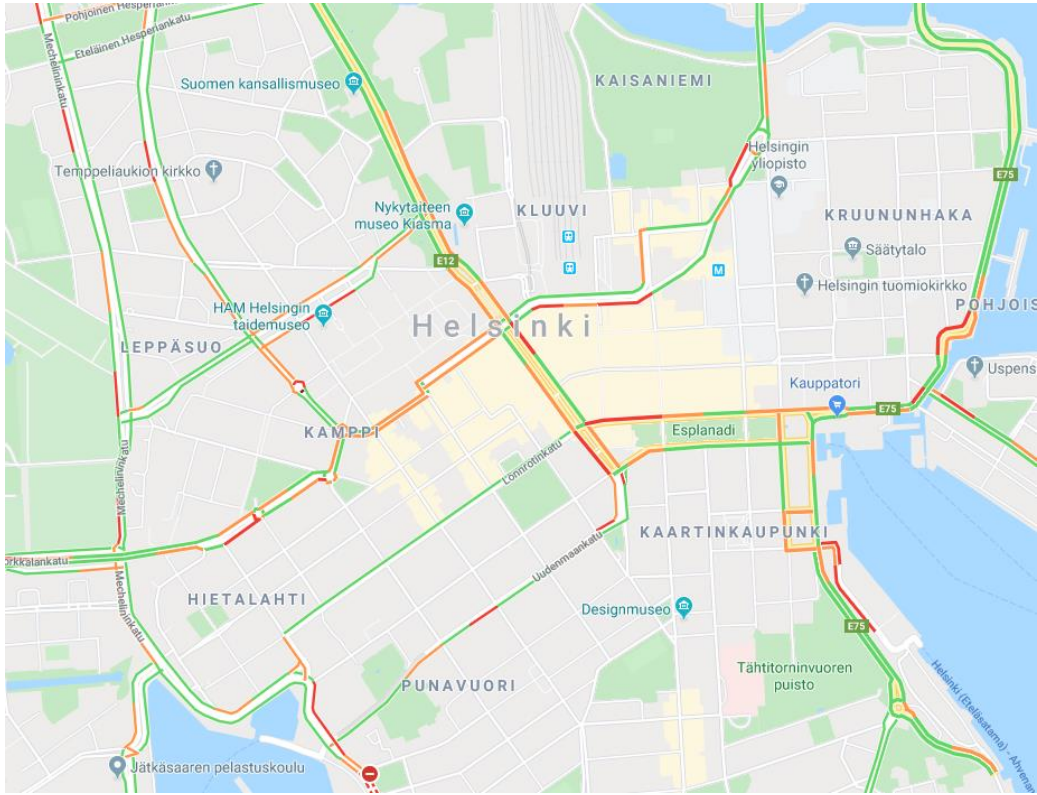


Accessibility

Type of service

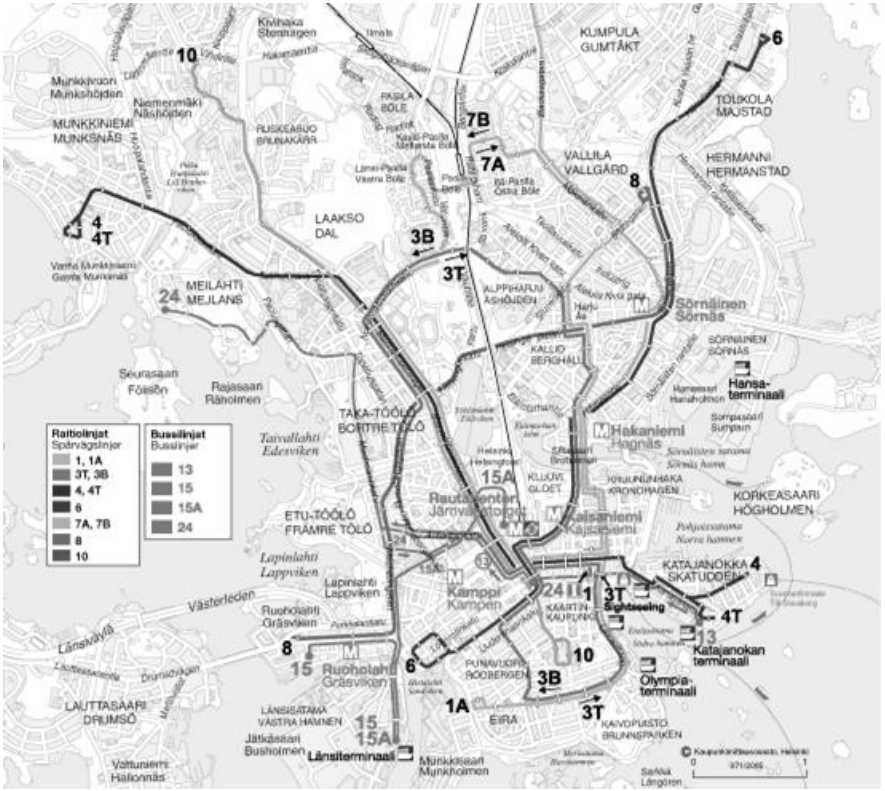
Line data visualization: flow maps

Nominal data



Ordinal data presented with associative hues

Line data visualization: flow maps

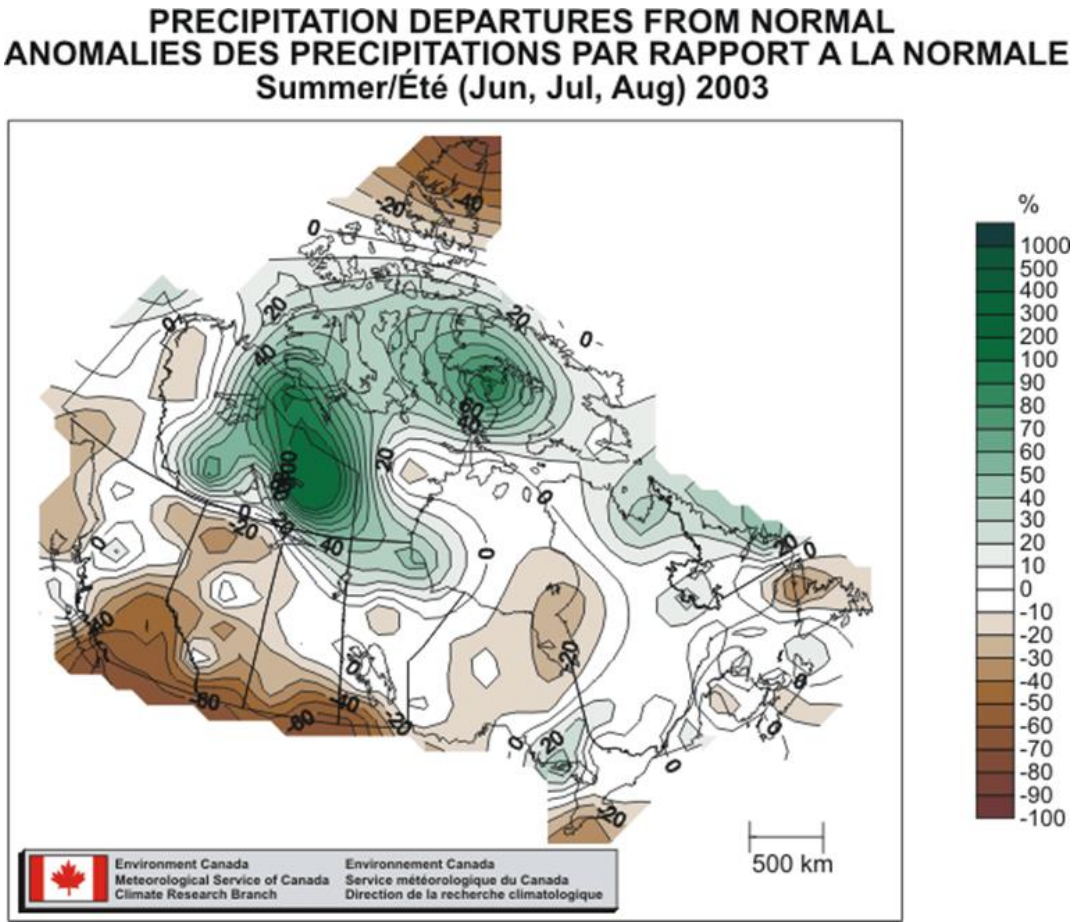


Nominal data

Ordinal data presented with associative hues

Qualitative values for field data: Isarithmic map

- Note the bipolar scale
- Different colors for extreme values, neutral white for zero values
- Also note the different scales for increase and decrease from normal
- Isolines used to separate different values



3. Area and scale

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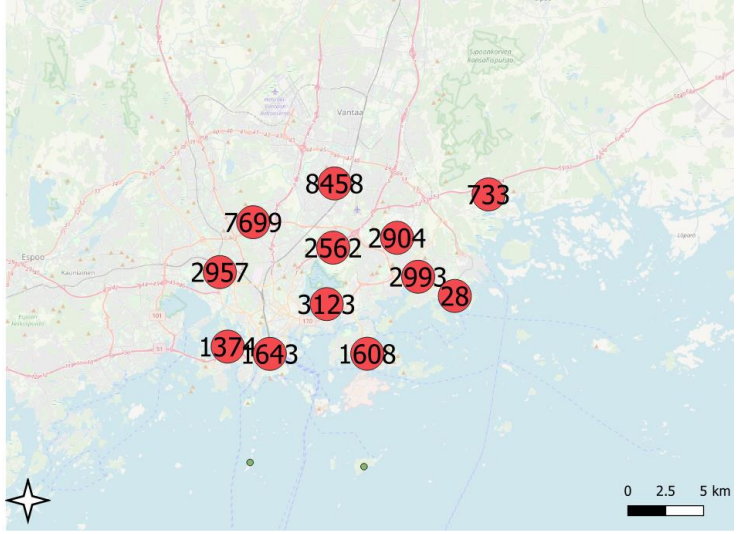
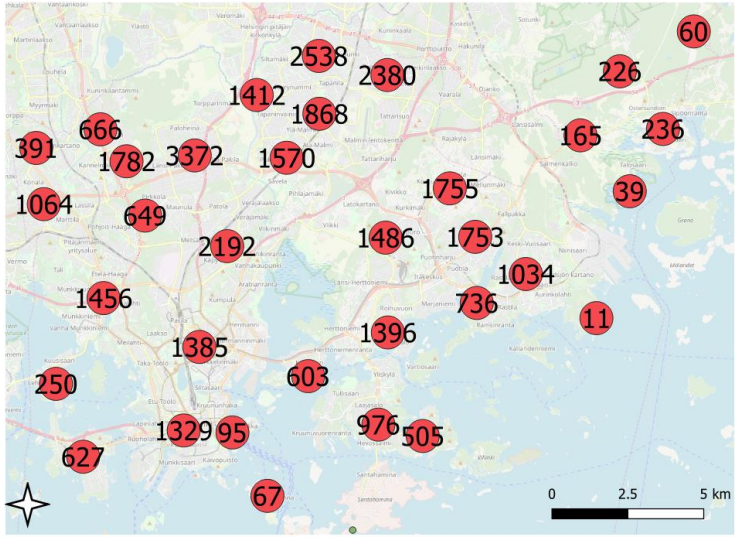
- What is the geographic extent of the phenomenon to be visualized?
- What is the extent and scale of the map?
- Scale and orientation: scale bar and north arrow





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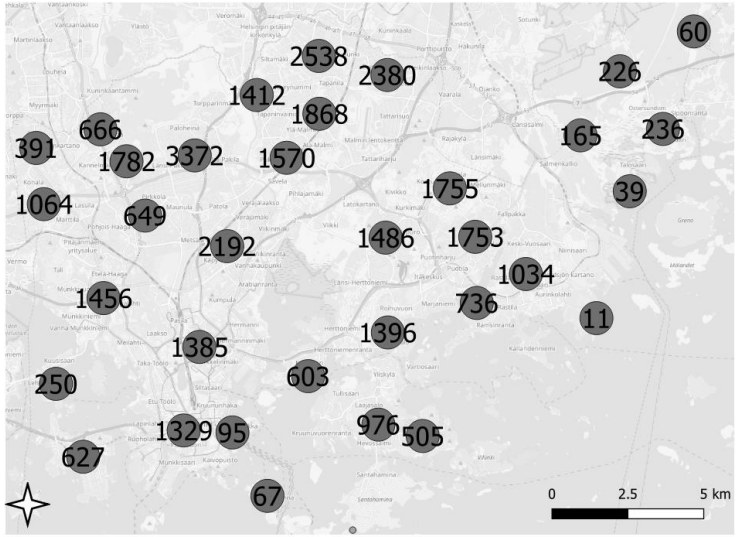
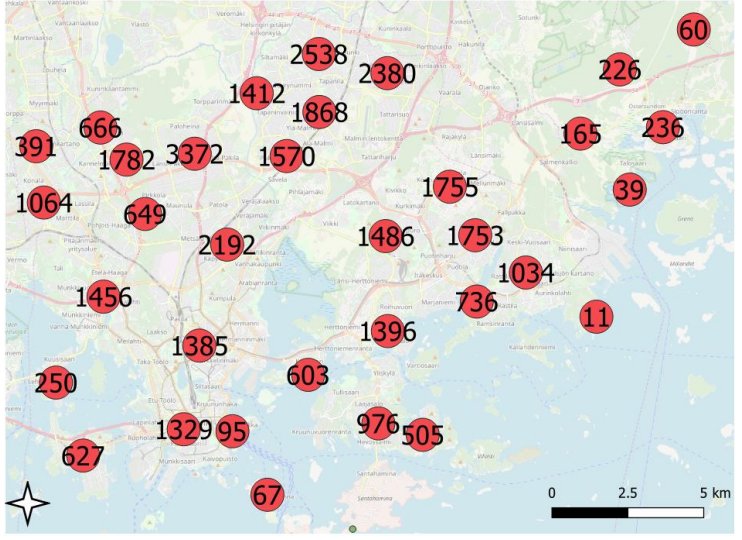
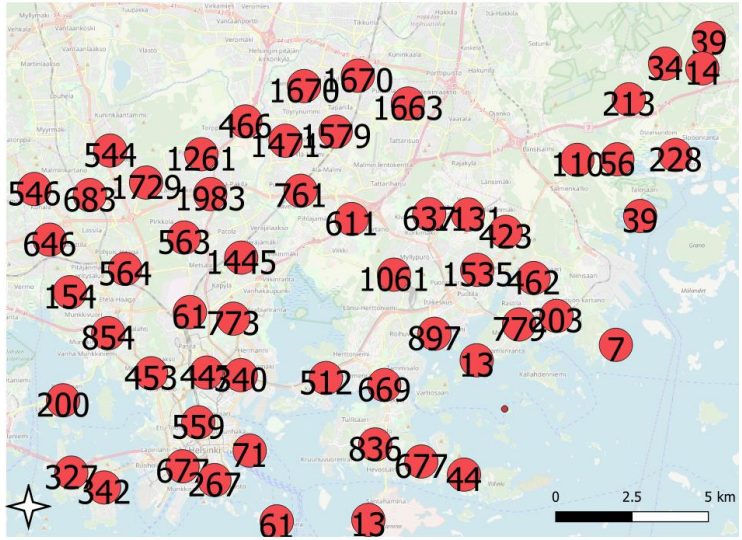


Data generalization

- **What is the generalization level of the data**
  - How it is represented on the map
- **Data can be visualized on different levels of detail**
  - Provide different insight on the data
- **On the right, the same data is visualized with the same visualization method, using two different levels of generalization**





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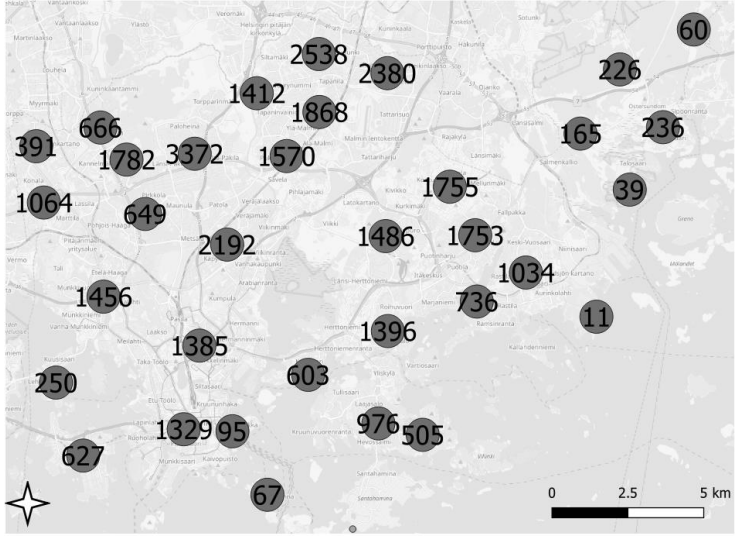

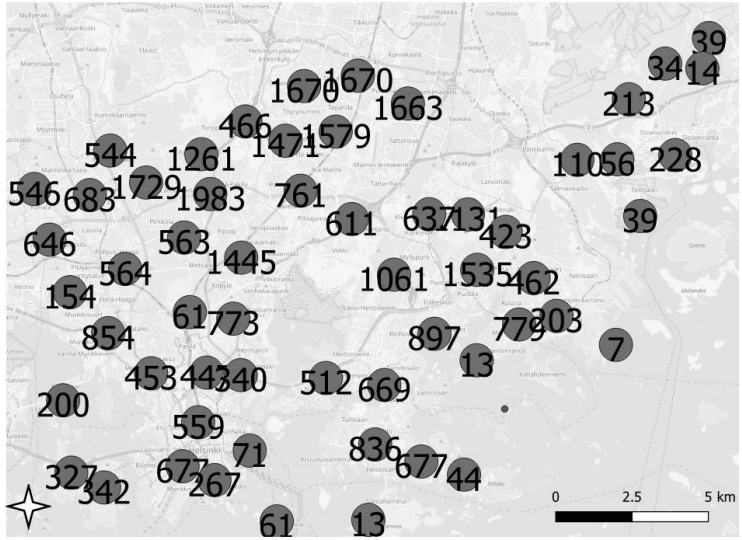

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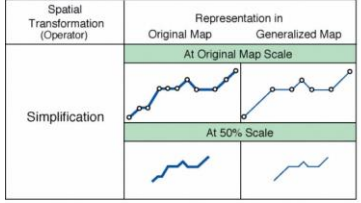
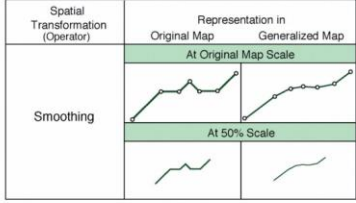
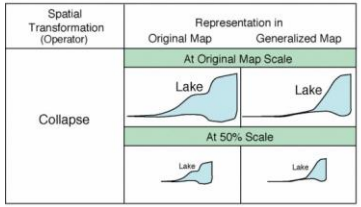
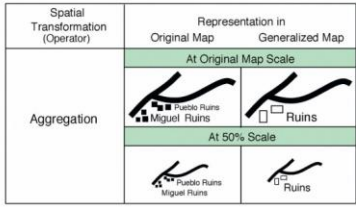
Generalization in cartography

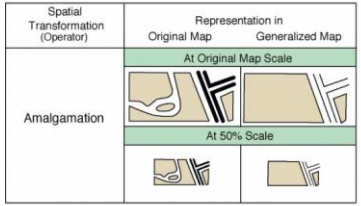
- **Generalization also is done for cartographic symbols**
- **E.g. at certain map resolution Helsinki contains details**
  - At a smaller scale, it turns into a polygon
  - At an even smaller scale, into a point
  - At an even smaller scale, it may disappear completely

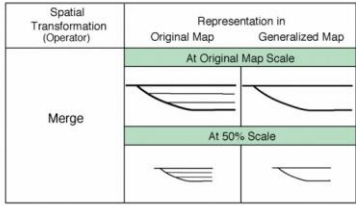


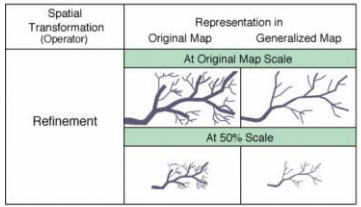


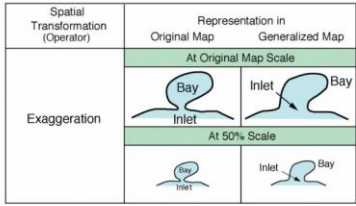


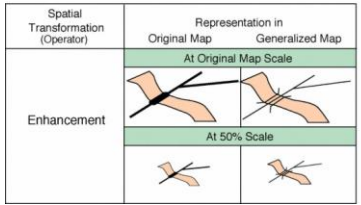


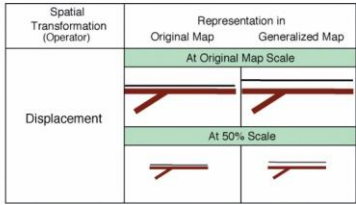












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Illustrations from McMaster and Shea of their 10 forms of generalization
Contains original compared to 50% coarser scale

Methods for generalization

- **Simplification (yksinkertaistaminen)**
  - E.g. buildings to squares, remove small curves from a line
  - It is important to save the characteristics of a shape
  - See Douglas-Poiker (Peucker) algorithm for line generalization: p. 73 in Longley et al. (2015)
  - esim. rakennus suorakulmioksi, viivan pienet mutkat pois; oleellista on muodon pääpiirteiden säilyminen
- **Collapse (typistys)**
  - Area-type object is presented with line or point
  - E.g. airport to point symbol, wide rivers to lines
- **Amalgamation (alueiden yhdistäminen)**
  - E.g. areas close to each other are combined to one
- **Refinement (valinta)**
  - Complex group of objects is presented by a sample of them
  - E.g. branches of a river
- **Enhancement (symbolien korostaminen)**
  - E.g. road line is wider than its areal geometry
- **Smoothing (viivan pehmennys)**
  - E.g. coast line
- **Aggregation (pisteiden yhdistäminen alueeksi)**
  - E.g. separate buildings -> built-up areas
- **Merge (yhteensulauttaminen)**
  - Multiple parallel lines to one, e.g. roads
- **Exaggeration (korostaminen, liioittelu)**
  - E.g. curve in the road
- **Displacement (siirtäminen)**
  - Bigger distance between parallel lines (road and coastline), buildings along the road

4. Background for a theme

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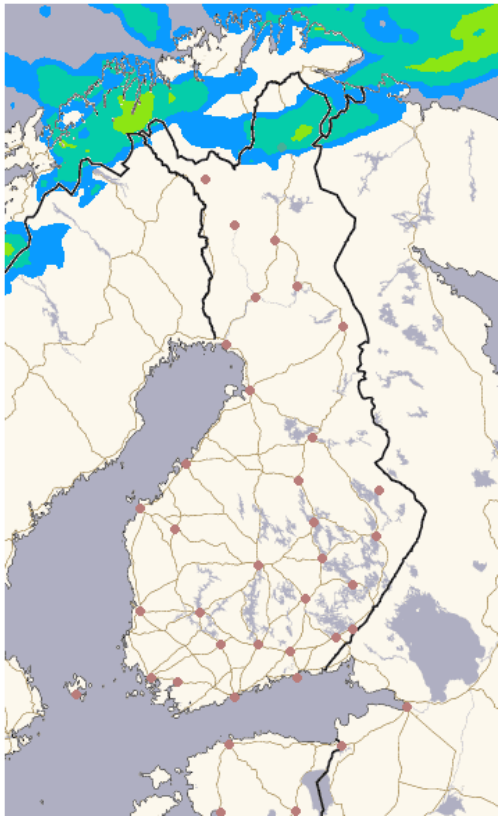
- **Spatial data is almost always visualized on top of a background map**
  - The role of the background map is to provide location reference (spatial context)
  - Appropriate background map depends on the visualization
  - It must not overwhelm the data to be visualized



Contents of the background map

- **The background map is low in visual hierarchy**
  - De-emphasized compared to the data
- **Elements that provide context can, however, be considered important**
  - E.g. place names

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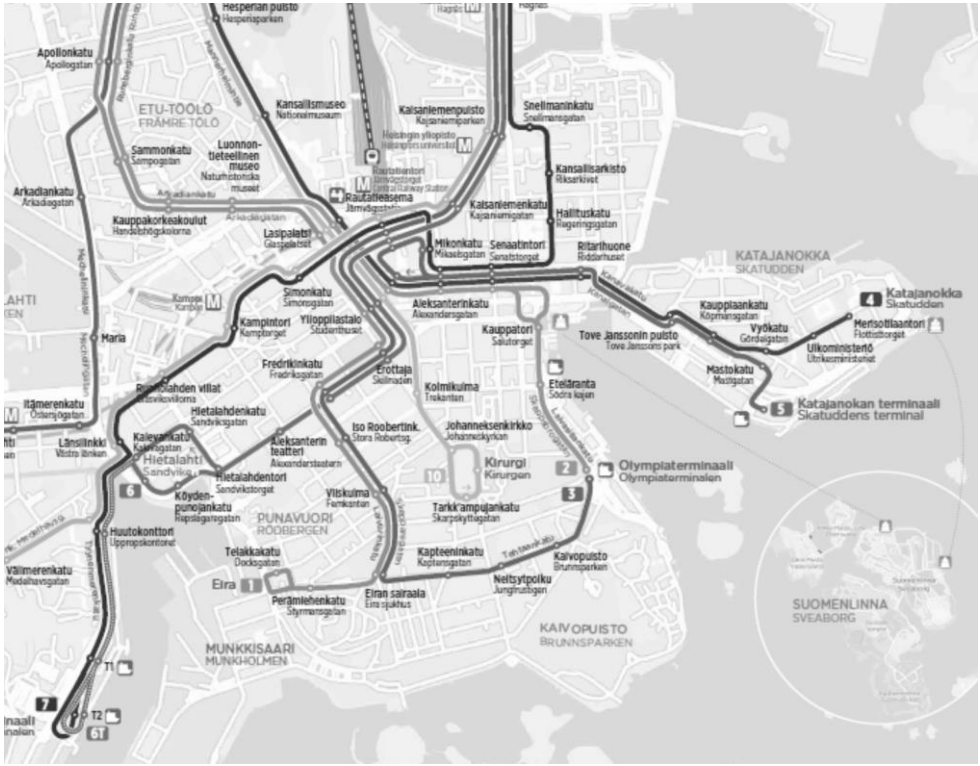

5. Title and legend

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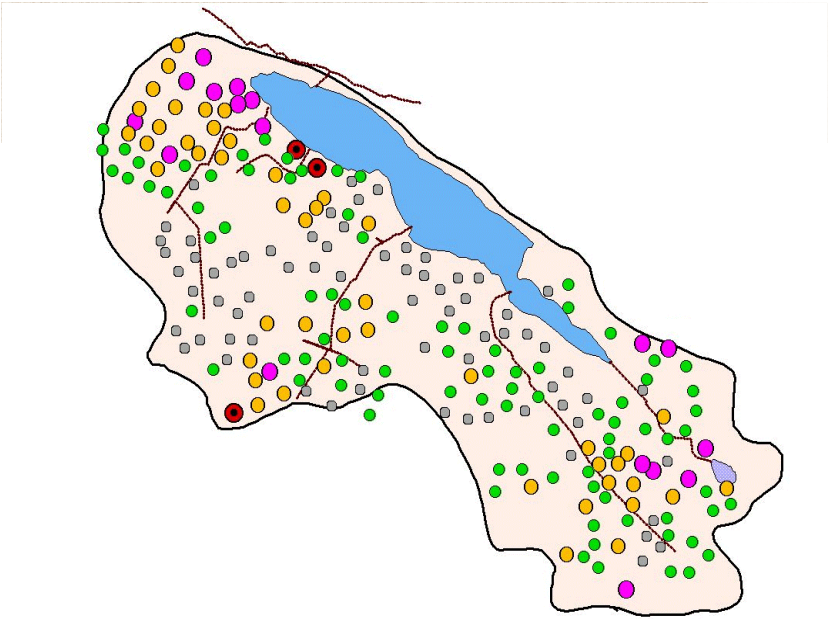

When they are missing…

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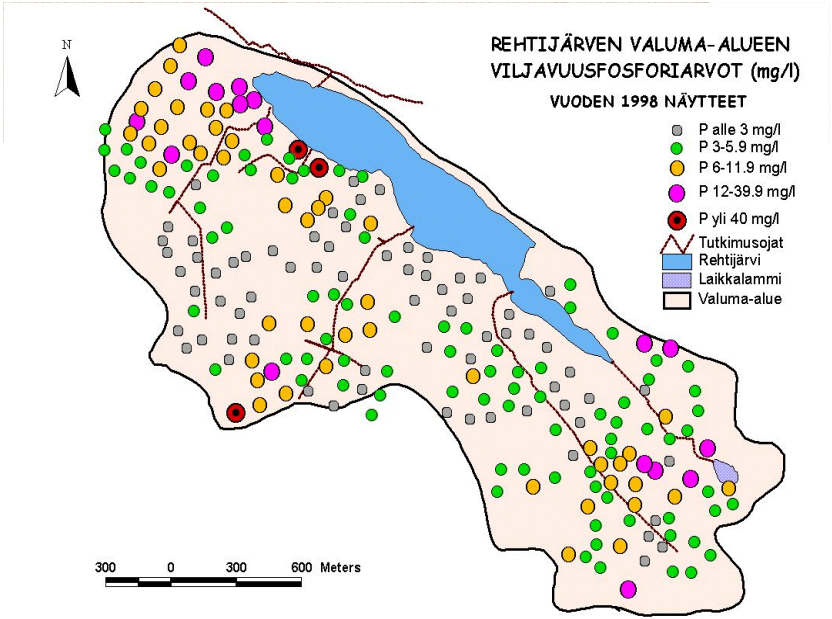

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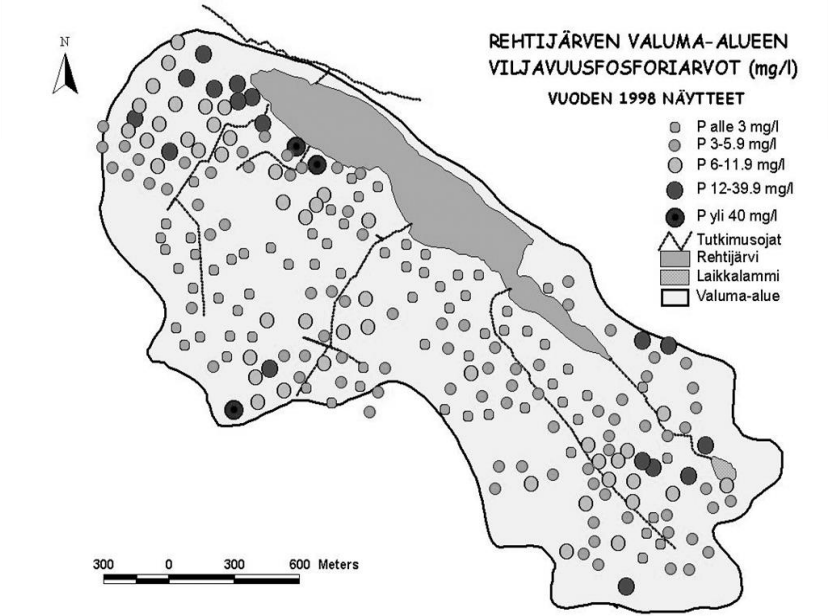
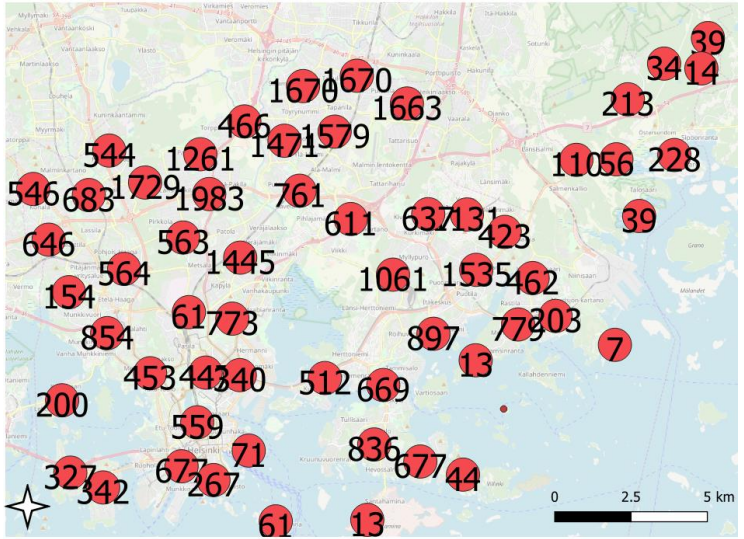


When they are missing…

Title and legend provide the context

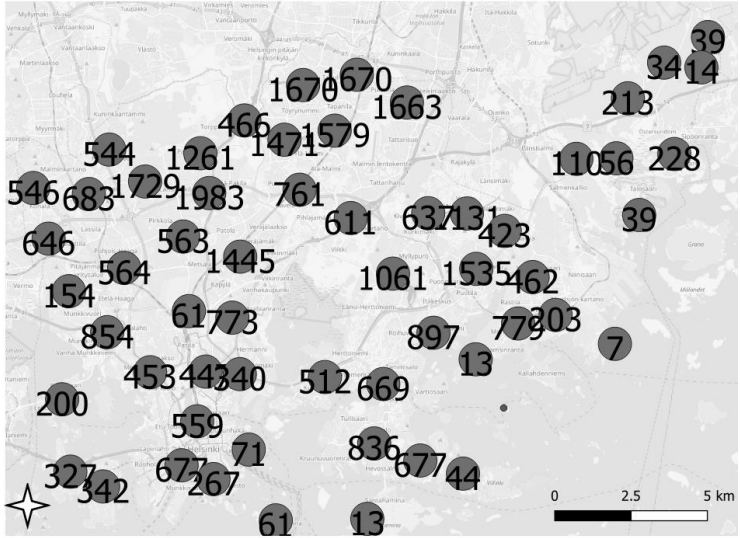
- **Check the title once more**
  - Does it tell what the map is about, really
  - Is the spelling correct (yes, these mistakes happen)
- **Check the text in the legend**
  - Is it logical addition to the title
  - Does it make clear what the values are, incl. the units
  - Do not duplicate values in adjacent class ranges
  - The visual sample should look exactly the same as in the map
- **Consider how the title and legend set in the visual hierarchy**



- **What does this data represent again?**
  - (Number of residential buildings in Helsinki)

Title and legend provide the context

- **Check the title once more**
  - Does it tell what the map is about, really
  - Is the spelling correct (yes, these mistakes happen)
- **Check the text in the legend**
  - Is it logical addition to the title
  - Does it make clear what the values are, incl. the units
  - Do not duplicate values in adjacent class ranges
  - The visual sample should look exactly the same as in the map
- **Consider how the title and legend set in the visual hierarchy**

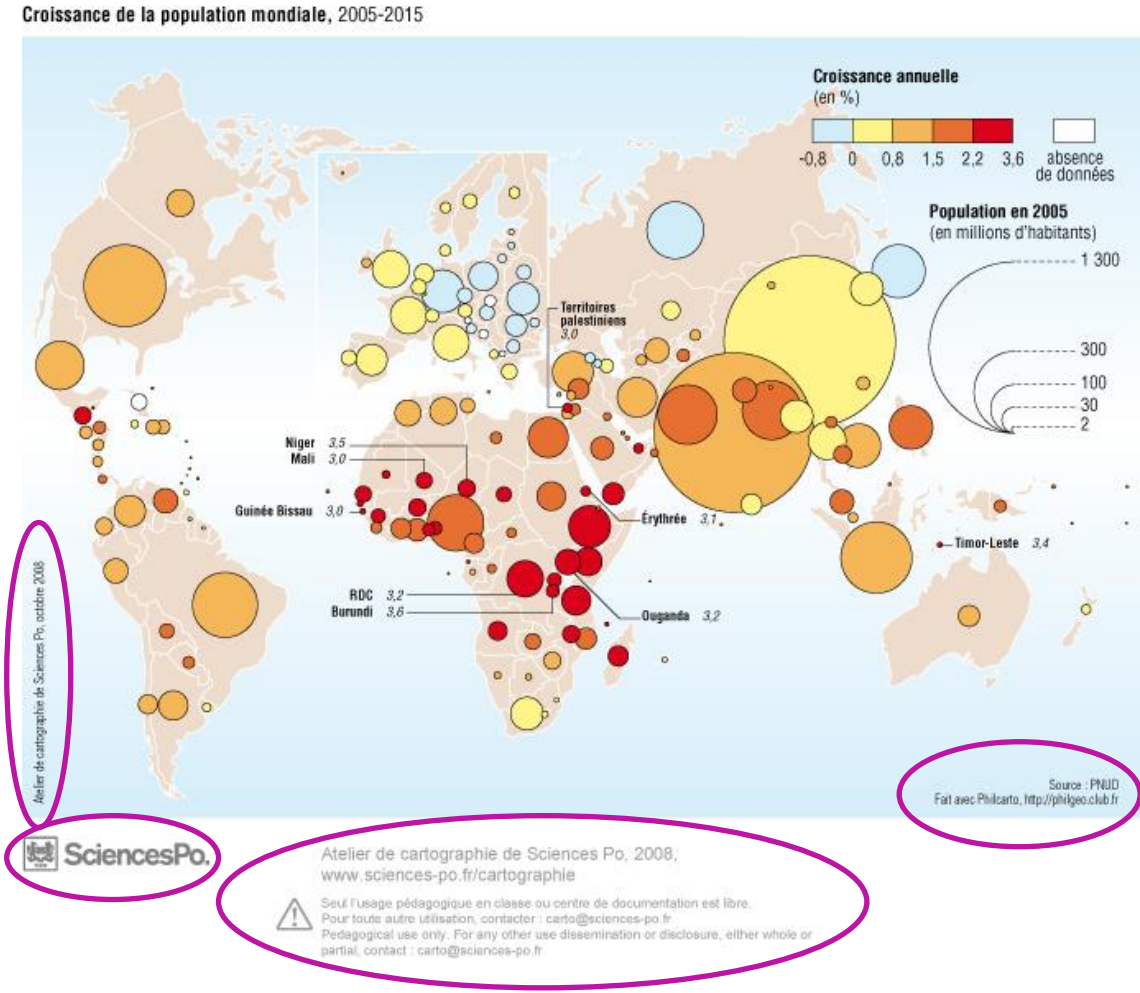


- **What does this data represent again?**
  - (Number of residential buildings in Helsinki)

6. Metadata

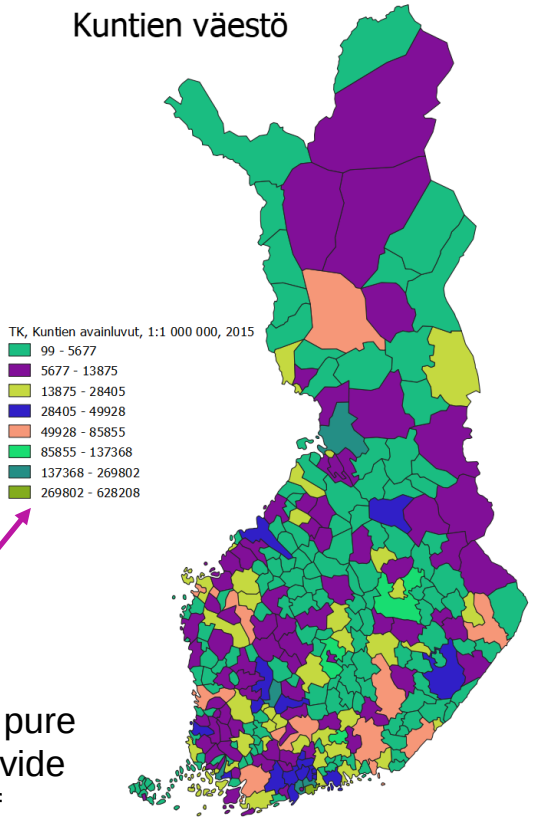
6. Metadata

- **What other information a map user would need?**
- **Source(s) of the data**
  - Possible data processing
- **Timing of the data**
  - If not already in the title
- **Reference system**
  - Essential in topographic maps
- **Author, publisher**
- **Any other relevant information**



Some remarks about color in maps

- **Colors matter, don't use them randomly!**
- **Background – theme**
  - Cool colours for background, warm colours for theme
  - Less saturated (”greyish”) colours for background, bright and vivid colours for theme
  - Background maps that are not designed for background tend to be problematic: too much details, too many and bright colours
    - Try a (white) transparent layer on the base map, under the theme
- **Balance and order**
  - Large objects draw attention more than small ones; you may try to balance this by colour design
- **Harmony**
  - Use colours reasonably, but don't make the map dull
- **For support with colour schemes, look at ColorBrewer at http://colorbrewer2.org**



The colors here are pure nonsense! They provide no representation of order!

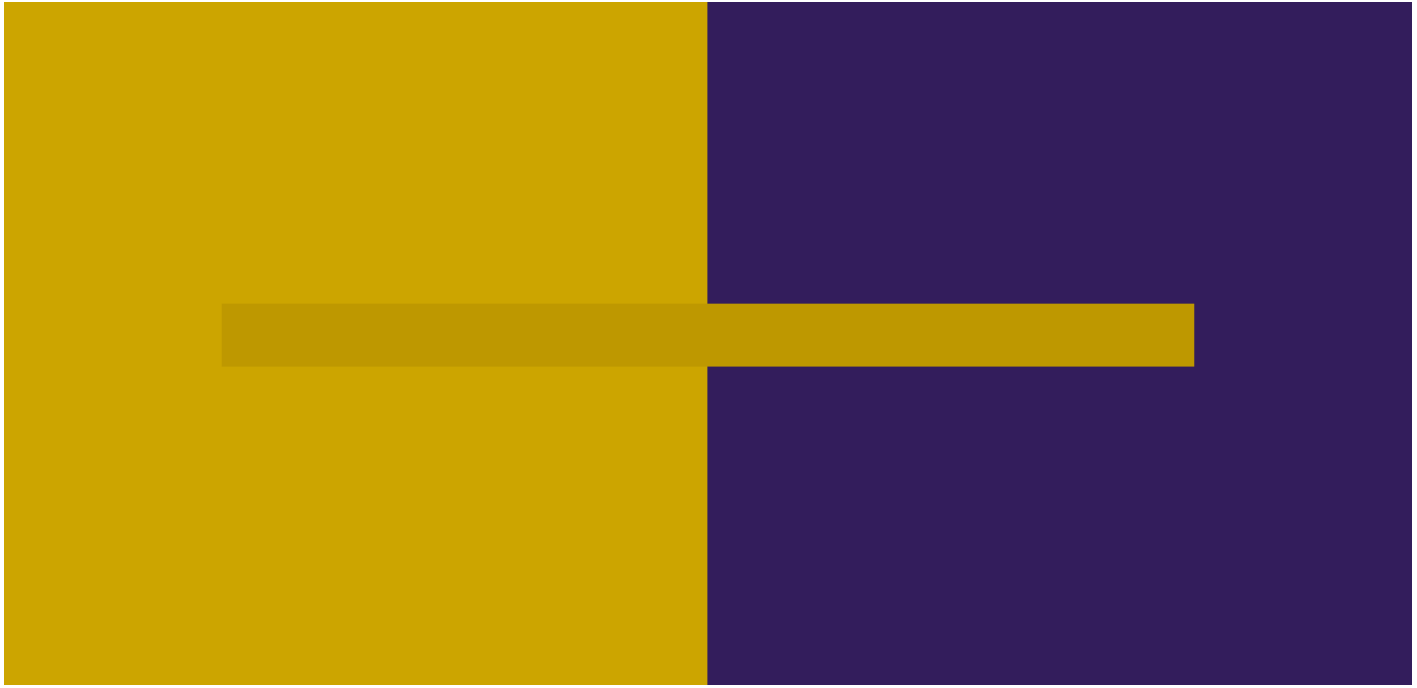
Visual variables for color

- **Hue (sävy)**
  - wavelength of the light

- **Value, lightness, brightness (vaaleus, kirkkaus)**
  - intensity
  - “light” vs. “dark”

- **Saturation, croma (kylläisyys)**
  - decreases >>
  - “purity”of the colour
  - saturated vs. achromatic

Color dynamics: change in perceived color



Reading for the lecture

Longley et al. (2015): Chapter 3.8

Scanned materials in MyCourses:

- Mark Monmonier: How to Lie with Maps (2nd ed.)1996 - example of normalization and the meaning of classification
- Terry Slocum et al.: Thematic Cartography and Geovisualization (3rd ed.) 2009 - classification methods