[CV-04-011] Common Thematic Map Types

Abstract

Thematic maps cover a wide variety of mapping solutions, and include choropleth, proportional symbol, isoline, dot density, dasymetric, and flow maps as well as cartograms, among others. Each thematic map type requires a different data processing method and employs different visual variables, resulting in representations that are either continuous or discrete and smooth or abrupt. As a result, each solution highlights different aspects of the mapped phenomena and shapes the message for the map readers differently. Thematic maps are tools for understanding spatial patterns, and the choice of thematic map type should support this understanding. Therefore, the main consideration when selecting a thematic map type is the purpose of the map and the nature of the underlying spatial patterns.

This entry reviews the common types of thematic maps, describes the visual variables that are applied in them, and provides design considerations for each thematic map type, including their legends. It also provides an overview of the relative strengths and limitations of each thematic map type.

Keywords: choropleth maps, map design techniques

Author & citation

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Explanation

1. Definitions

cartogram: a thematic map that scales the size of an enumeration unit proportionally to the represented value

choropleth map: a thematic map that uniformly colors each non-overlapping enumeration unit according to the represented value

dasymetric map: a thematic map that uses additional data to determine the new borders of enumeration units to improve the representation of the spatial distribution of the mapped phenomenon

dot density map: a thematic map that places dots within an enumeration unit in proportion to the represented value to preserve the distribution and variation of density of a phenomenon

flow map: a thematic map that represents the direction and/or magnitude of a phenomenon along linear objects or between locations

graduated symbol map: a classified proportional symbol map

isoline/isarithm: a line derived through interpolation that connects points of equal attribute value on a map

isoline interval: the numerical distance between successive isolines/isarithms

isometric map: a thematic map that uses isolines resulting from interpolating values collected at sample points

isoplethic map: a thematic map that uses isolines resulting from interpolating values enumerated across areas

proportional symbol map: a thematic map that scales the size of a point symbol proportional to the represented value

Supplementary isolines are lines placed between isolines resulting from regular isoline interval in order to capture small but important pattern of mapped phenomenon that regular interval is not able to show

thematic map: a map that shows the spatial distribution of one or more geographic phenomena

2. Design and Use of Common Thematic Maps

A **thematic map** shows the spatial distribution of one or more geographic phenomena. In thematic maps, the main subject is distinctly visible against the base map, rising to the figure in the visual hierarchy (see **Visual Hierarchy and Layout**). In contrast, a reference map usually does not present a main theme that clearly stands out against other map layers and map elements. This entry reviews common univariate thematic map types; see **Multivariate Mapping** for additional thematic map types depicting two or more phenomena.

Thematic mapping enables the representation of both qualitative and quantitative data. Quantitative attributes can be collected at individual points, but often are enumerated across areal units (see **Statistical Mapping**). Thematic map types differ in their dimensionality and encoded visual variable (Monmonier, 2001; MacEachren, 2004; Slocum et al., 2009; Bertin, 2010; Tyner, 2014). Accordingly, each thematic map suggests a different way of thinking about the same mapped phenomenon, and thus may lead to different insights and conclusions about the represented topic (MacEachren & DiBiase, 1991; Kraak et al., 2020) (Figure 1).

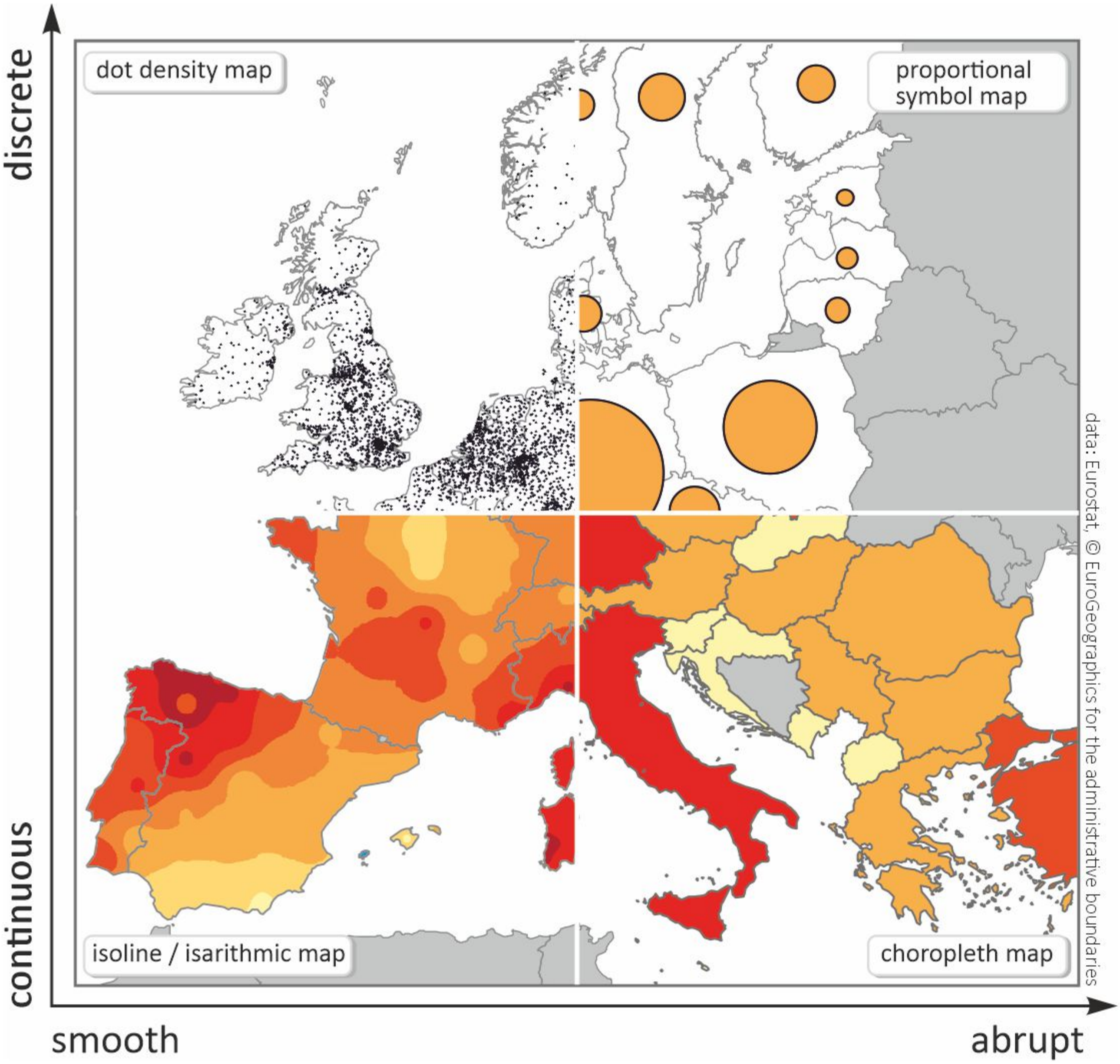
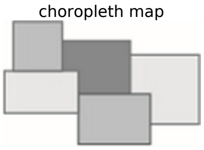
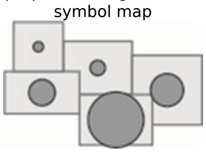
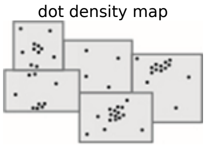
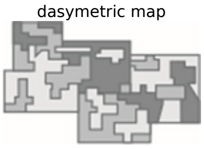
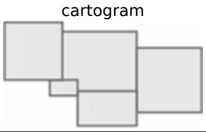
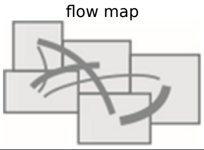


Figure 1. Each thematic map type provides a different insight into the mapped phenomenon. Based on: MacEachren & DiBiase (1991). Source: authors.

Each thematic map type has relative strengths and limitations, and any one type is not objectively better than any other. Table 1 outlines the design and use of common thematic map types, which are summarized in the following section.

Table 1. Design and Use of Common Thematic Map Types

thematic map type	mapped data	most commonly applied visual variable	symbol dimensionality	classification needed	data type	strengths	limitations
choropleth map 	enumerated	color value	area	yes (except for seldomly applied, unclassed, choropleth maps)	derived values (e.g., densities, rates, proportions, indices, percent changes)	enables general patterns to be read allows easy reading and understanding due to class ranges allows good representation of a theme, tied to well-defined enumeration units familiar to many audiences, since they are common in news media, educational materials, etc. represents abrupt, continuous surfaces	creates the risk of unintentionally masking important details due to improper choice of the number of classes and classification methods may misleadingly suggest homogeneity within the enumeration unit boundaries of the enumeration units (e.g., census units) often do not associate with the distribution of the phenomenon often has enumeration units of different sizes, and the largest ones visually dominate does not allow exact values to be derived
proportional / graduated symbol map 	individual or enumerated	size	line (bars), area, volume	yes: for graduated symbol maps no: for proportional symbol maps	totals or derived	effectively represents datasets with a large range of values can represent individual point data and enumerated data represents discrete, abrupt surfaces	may cause problems with overlapping symbols causes a risk of underestimating symbol values as they grow larger (proportional symbol maps only) does not allow exact values to be read (graduated symbol maps only)
isoline/isarithmic map 	individual (isometric lines) enumerated (isopleths)	location, color value (when tinted)	line, area (if color tints applied)	yes (line interval) no (when continuous tints are applied with no lines)	totals (isometric lines) derived (isopleths)	effectively represents the arrangement of magnitudes, the orientation of surface gradients, and the main lines of distribution represents smooth, continuous surfaces	does not allow exact values to be read often exhibit edge and island effects from interpolation
dot density map 	enumerated	numerous	point	no	totals (as input data, but the density is visually normalized by areas)	represents distribution and variations in pattern, such as clustering provides an easily understood visual impression of related densities, easily interpreted on an ordinal scale represents smooth, discrete surfaces	does not allow characteristics with uniform distribution to be represented does not allow quantities to be read; the individual dots should not be counted to determine totals
dasymetric map 	enumerated	color value (when modifying choropleth maps), numerousness (when modifying dot density maps)	area (when modifying choropleth maps), point (when modifying dot density maps)	yes (when modifying choropleth maps)	depends on improved thematic map type	includes variations within enumeration units improves other common thematic map types when enumeration units are poorly matched to geographic distribution	requires ancillary information does not allow exact values to be read involves time consuming map making process
cartogram 	enumerated	size, color value (when mapping a second variable)	area	no	totals	not limited by the size of the enumeration units has very strong visual impact due to its unconventional appearance	may be ineffective when the map reader does not know the real shape of the enumeration units
flow map 	individual and enumerated	size or color value (representing magnitude)	line	yes/no (both possible)	totals	simulates a sense of movement	may cause reading problems when lines overlap or hide other line symbols

3. Design Considerations

3.1 Choropleth maps

A **choropleth map** is a thematic map that uniformly colors each non-overlapping enumeration unit according to the represented value. Choropleth maps typically receive sequential color schemes varying color value as a primary visual variable, using a “dark-is-more” order for light backgrounds and the reverse “light-is-more” order for dark backgrounds (Brewer, 2016; Figure 2). Apart from color value, choropleth maps also may employ color hue and color saturation in multihued spectral schemes and in diverging schemes. Diverging schemes are used to emphasize a critical value (Figure 3). Qualitative or “rainbow” color schemes are generally not recommended due to the numerical enumerated values represented in choropleth maps (see **Color Theory**). Choropleth maps only represent enumerated data, often enumerated to political boundaries or a tessellation of regular shapes (Figure 4), with coloring of regions based on nominal differences (e.g., different soil types, land cover types, etc.) not considered as choropleth maps.

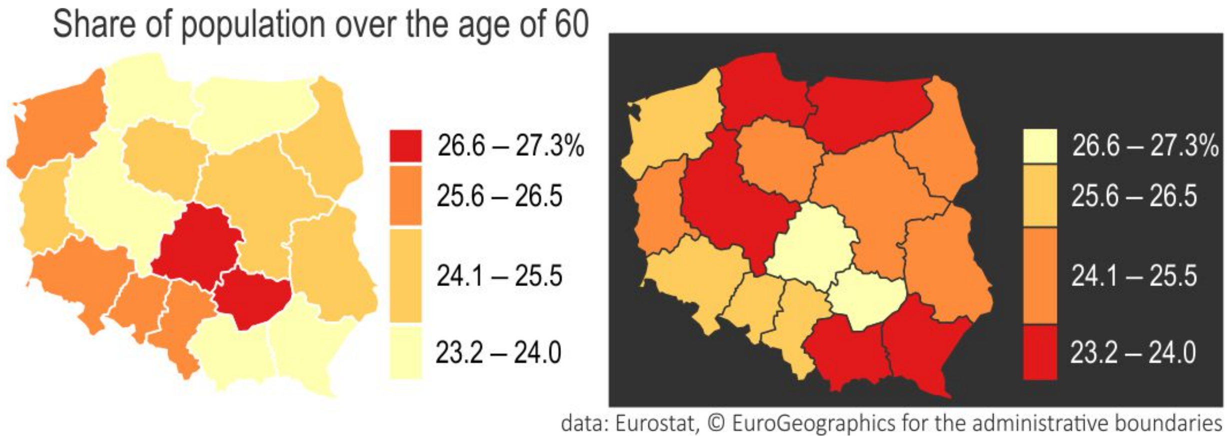


Figure 2. The color contrast of the background should be taken into consideration when choosing the order of colors for quantitative data: dark-is-more on light background (left) or light-is-more on a dark background (right). Source: authors.

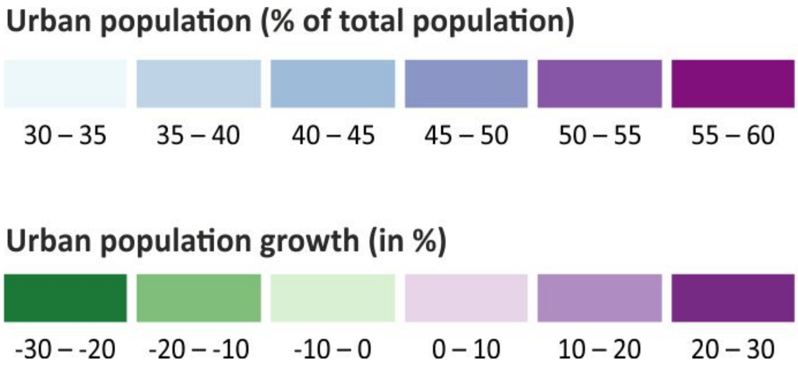


Figure 3. The use of sequential versus diverging color schemes is driven by the type of dataset represented and importance of critical values within the dataset. Source: authors.

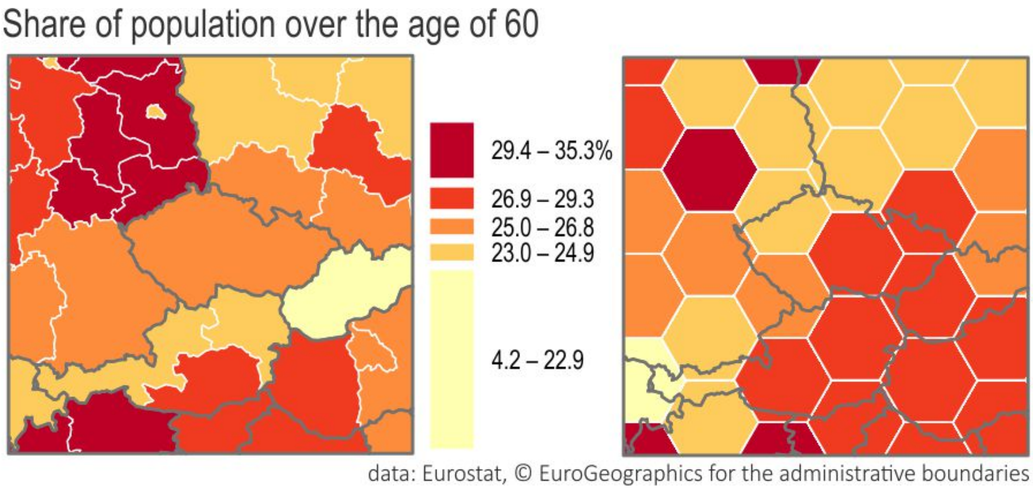


Figure 4. Enumeration units on a choropleth map may be political boundaries (e.g., census (left)) or a tessellation of regular shapes like hexagons (right). Source: authors.

Choropleth maps use area as the symbol dimension. Patterns in choropleth maps are strongly influenced by the distribution of the enumeration units, perhaps more so than other thematic maps given the application of a single symbol (the color) uniformly throughout the entire enumeration unit. Accordingly, absolute attributes need to be statistically normalized into relative values for choropleth maps to account for enumeration units of varying sizes and shapes (Dent et al., 2008; Kraak & Ormeling, 2009; Longley et al., 2015; see Figure 5). Common forms of normalization for choropleth maps include creating a density, calculating a per capita rate, producing a relative proportion or composite index, and mapping change between two data captures (see **Statistical Mapping**). Absolute data only should be used when all the enumeration areas are the same size and shape (Figure 4 right).

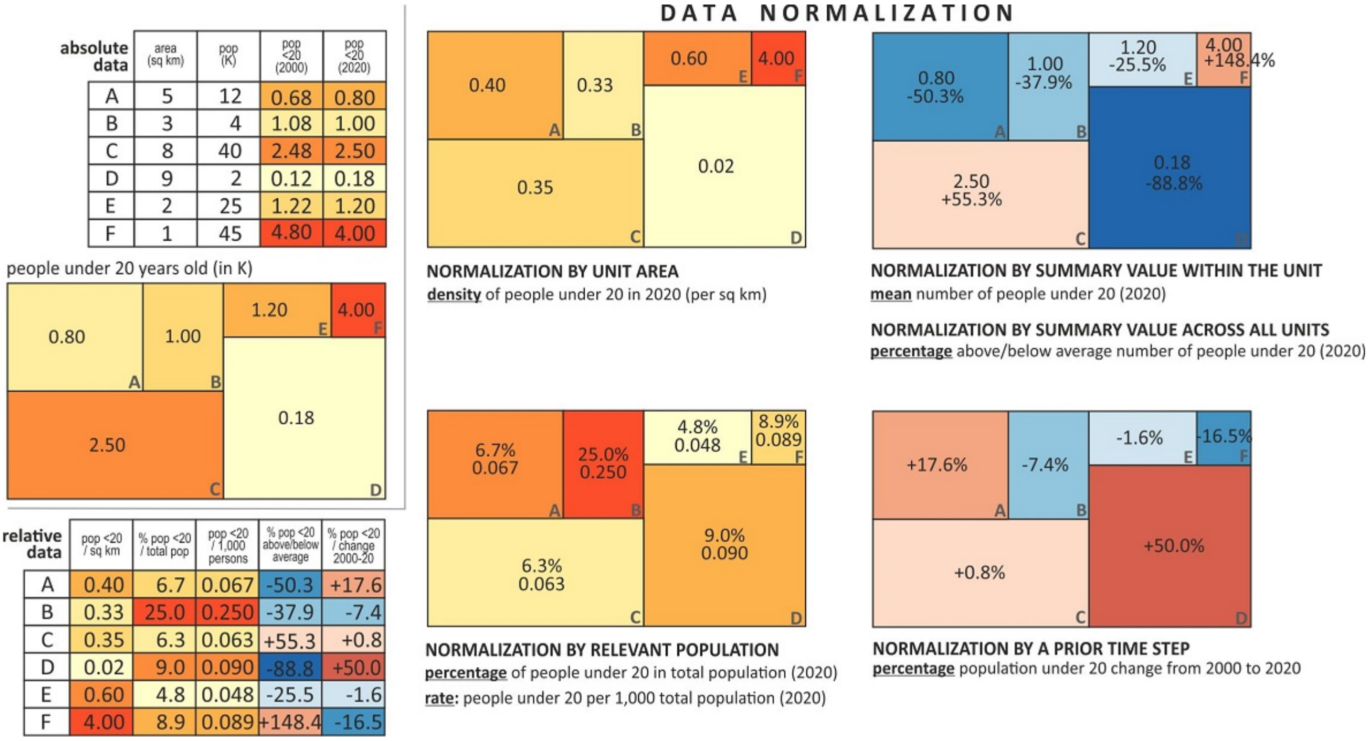


Figure 5. Differently sized areas and their mapped values alter the impression of the distribution when using absolute values on choropleth maps. Source: authors.

Choropleth maps typically require data classification (Figure 6), given the ordinal level of reading for the visual variable color value (see **Statistical Mapping**; **Symbolization & the Visual Variables**). Classification involves decisions on the number of classes (Figure 7) and the class breaks. Classification also reduces color-based simultaneous contrast effects in the map (see **Color Theory**).

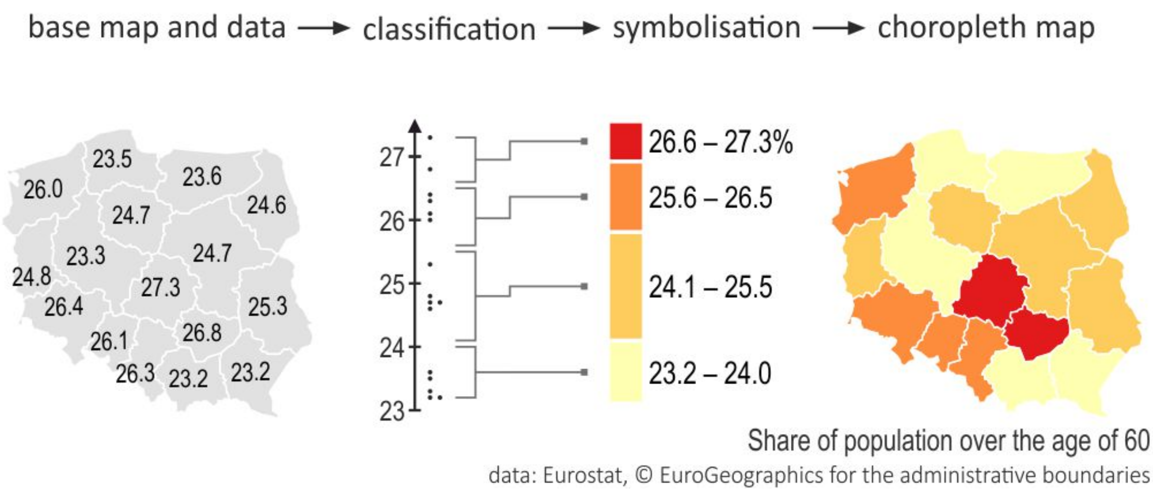


Figure 6. A choropleth map typically requires data classification. Source: authors.

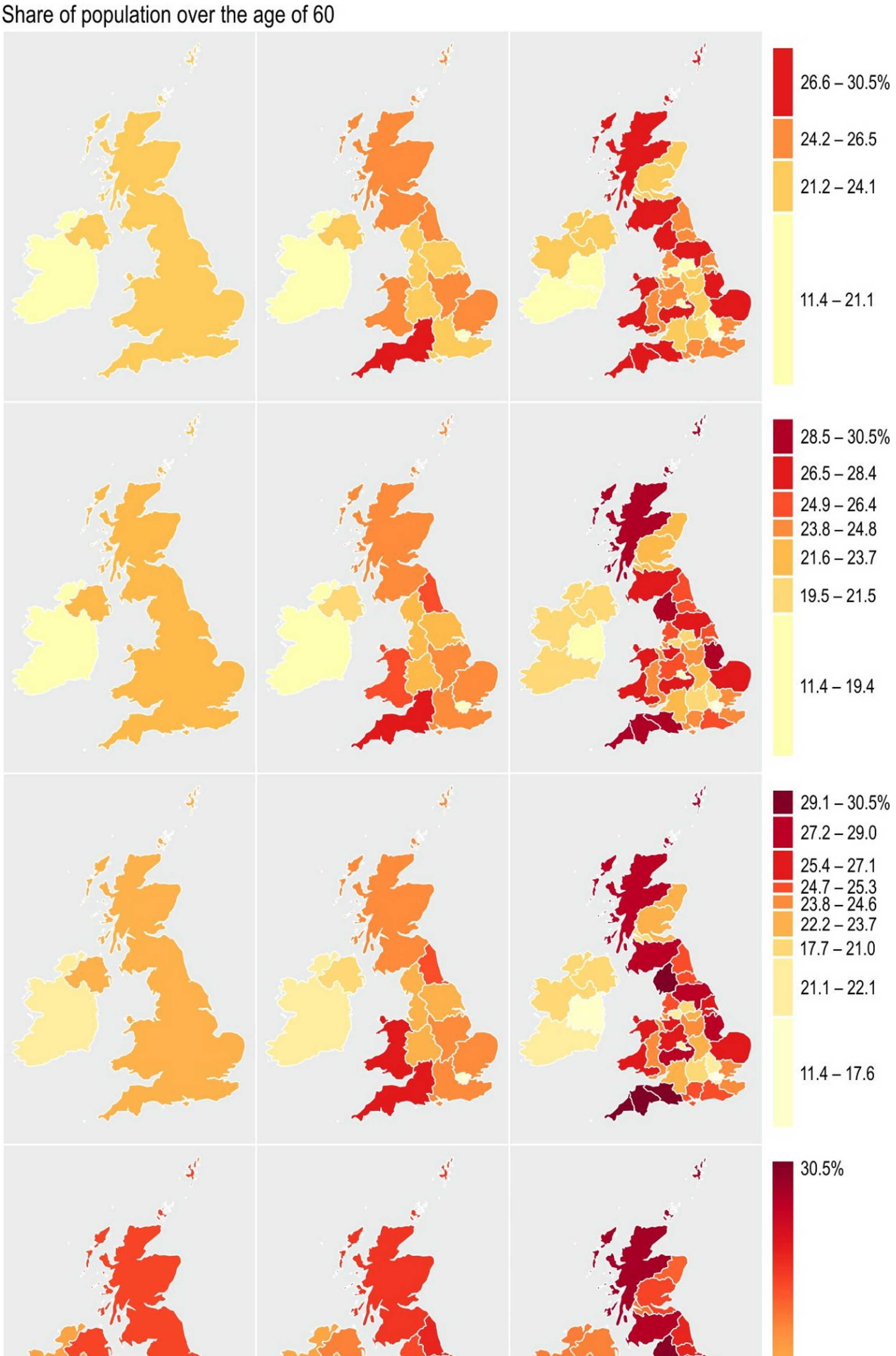

Share of population over the age of 60
26.6 – 30.5%
24.2 – 26.5
21.2 – 24.1
11.4 – 21.1
28.5 – 30.5%
26.5 – 28.4
24.9 – 26.4
23.8 – 24.8
21.6 – 23.7
19.5 – 21.5
11.4 – 19.4
29.1 – 30.5%
27.2 – 29.0
25.4 – 27.1
24.7 – 25.3
23.8 – 24.6
22.2 – 23.7
17.7 – 21.0
21.1 – 22.1
11.4 – 17.6
30.5%
11.4
data: Eurostat, © EuroGeographics for the administrative boundaries

Figure 7. The level of detail on a choropleth map increases—not due to changes in the map scale but through increasing the number of enumeration units (from left to right) and the number of classes (from top to bottom). Source: authors.

A choropleth map suggests continuous and abrupt phenomena closely tied to enumeration units. Since political units often are employed as enumeration units, choropleth maps congruently represent phenomena related to governmental activities (Figure 1; Kraak et al., 2020). Choropleth maps are perhaps the most frequently used thematic maps for portraying statistical data, and therefore benefit from their familiarity across general audiences.

3.2 Proportional Symbol Maps

A **proportional symbol map** is a thematic map that scales the size of a point symbol proportional to the represented value. Proportional symbol maps use the visual variable size—one of the only visual variables read quantitatively—and thus provide a relatively reliable estimate of numerical data compared to other thematic map types (see **Symbolization & the Visual Variables**), although still require some recalling to account for perceptual effects depending on the shape of the proportional symbol.

Accordingly, the scaling ratio is the first important design consideration for proportional symbol maps. The symbol sizes should be large for the values of the phenomenon to be easily estimated and compared. Proportional symbols growing in one dimension, like bars, are read reliably. However, proportional symbols growing in two dimensions are systematically underestimated as they grow larger due to an emergent dimension of size caused by the change in symbol area, and thus require perceptual scaling. Each simple symbol shape (e.g., circle, square, triangle) has a different scaling ratio, such as Flannery's ratio for circles; therefore, complex shapes are not recommended due to unknown or unpredictable perceptual scaling. Three-dimensional proportional symbols are generally not recommended given the unreliability of perception of volume (Figure 8).

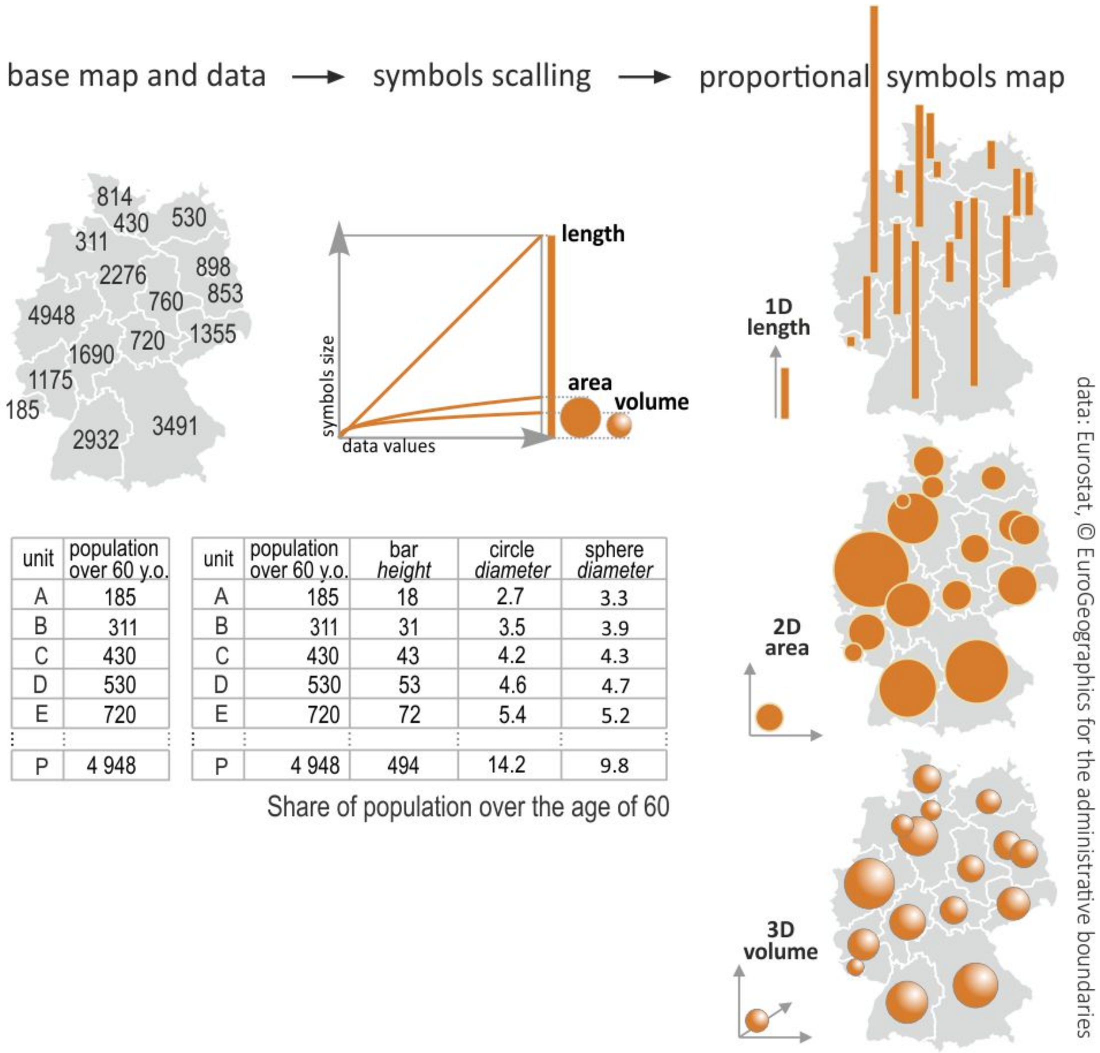


Figure 8. Symbol scaling by dimensionality: length for bar (1D), area for squares and other geometric figures (2D), volume for spheres, cubes, and other solids (3D). Source: authors.

The color fill of proportional symbols can be uniform or variable (Slocum et al., 2009). The latter can be used to redundantly encode the same attribute as the symbol size or to portray a second dataset (see **Multivariate Mapping**; Figure 9).

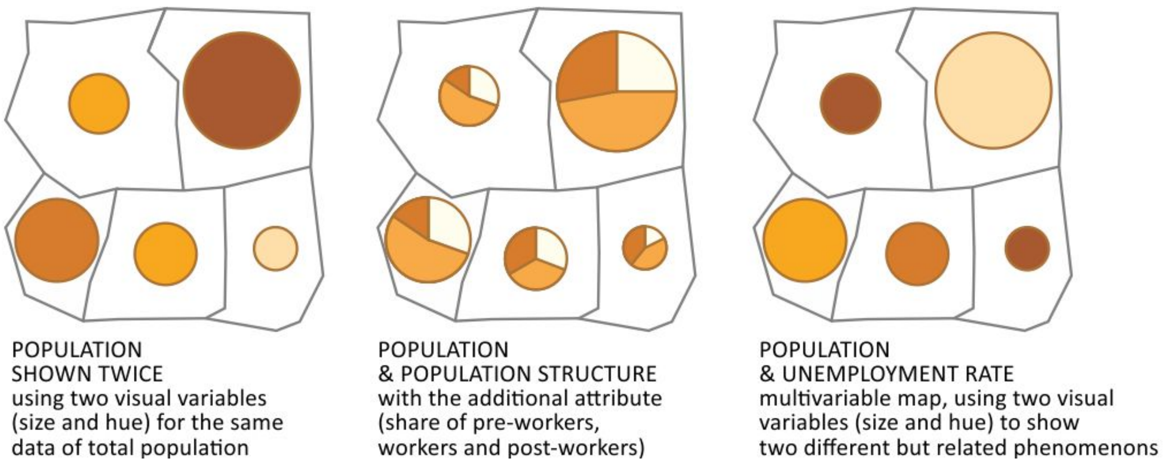


Figure 9. The fill of symbols may represent the same phenomenon as the symbol size (left) or represent additional data: structure (middle), additional phenomenon (right). Source: authors.

A proportional symbol map can represent individual or enumerated data (Dent et al., 2008). Symbols related to areas are placed in the centroid of the enumeration unit—for example, state, county; whereas symbols showing data related to points are placed on the map at the coordinates where the phenomenon occurs (Figure 10).

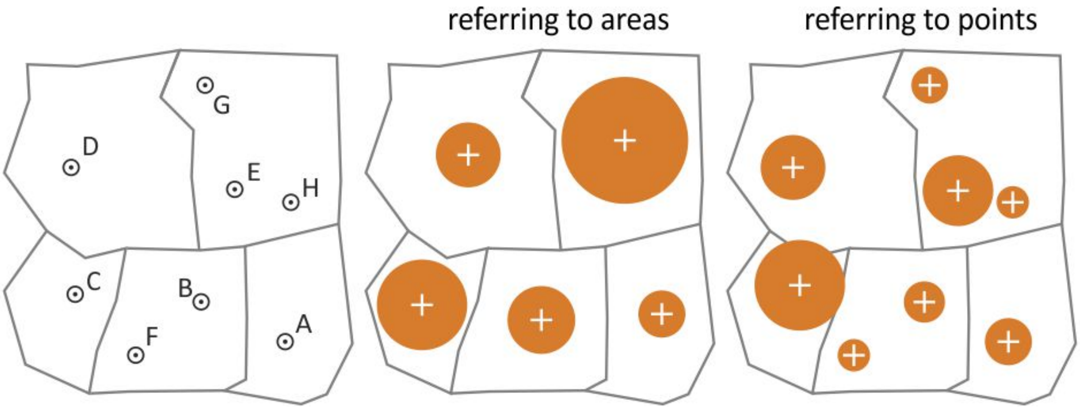


Figure 10. Proportional symbols referring to points and areas look the same on proportional symbol maps; they only differ in their symbol locations. Source: authors.

Proportional symbol maps also are more flexible in terms of input data type compared to other common thematic map types like the choropleth. Proportional symbols typically represent absolute data due to the quantitative reading of the visual variable size, but normalized data (excluding densities) also can be mapped with proportional symbols. While flexible with the input data selection, proportional symbol maps may have problems with overlapping symbols (Tyner, 2010). Overlapping symbols are acceptable to a limited extent—for example, in several areas where symbols are clustered and overlap to a small degree. When this happens, the largest symbol should always be at the bottom of the layering order and the smallest at the top (Figure 11).

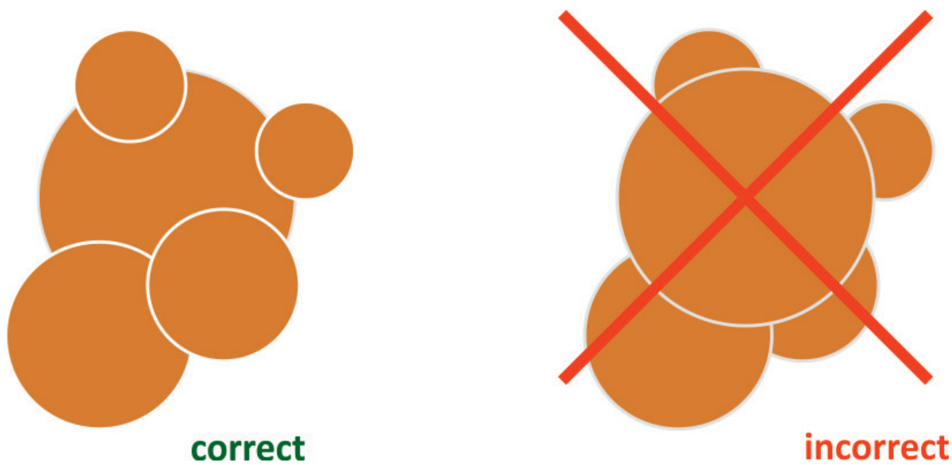


Figure 11. When symbols overlap, they must be placed so that large symbols do not obscure small ones. Source: authors.

A **graduated symbol map**, sometimes called range-graded symbols, is a classified proportional symbol map (see **Statistical Mapping**; Figure 12). Graduated symbols are used to reduce the visual complexity of the map, such as when there is a large number of symbols or a wide data range.

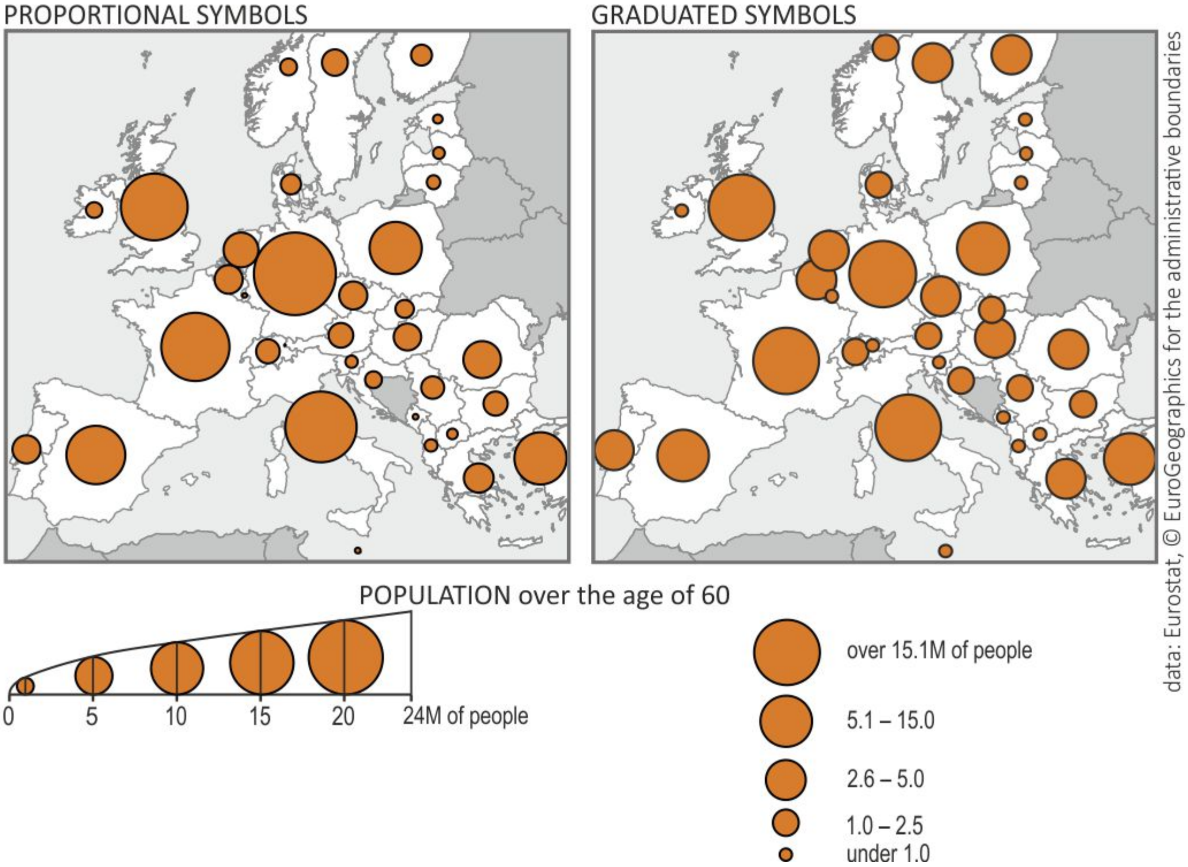


Figure 12. A graduated symbol map is easier for users to read than a proportional symbol map, which requires users to estimate the size of the symbols, but at the cost of no longer being able to read exact values from the graduated symbols. Source: authors.

The shape of graduated area symbols can be geometric or pictorial to make the symbol more intuitive (Figure 13). The scaling of complex symbols is more complicated than that of geometric symbols; therefore, complex symbols more frequently are applied for graduated symbol maps with clear symbol size differences between consecutive classes. Graduated symbols also commonly are used for shaded proportional symbols, given the added complexity of bivariate maps (see **Multivariate Mapping**). Graduated symbol maps can represent several sets of data, such as supplementary topics (Figure 14) or temporal comparisons (e.g., two halves of symbols representing two different years).

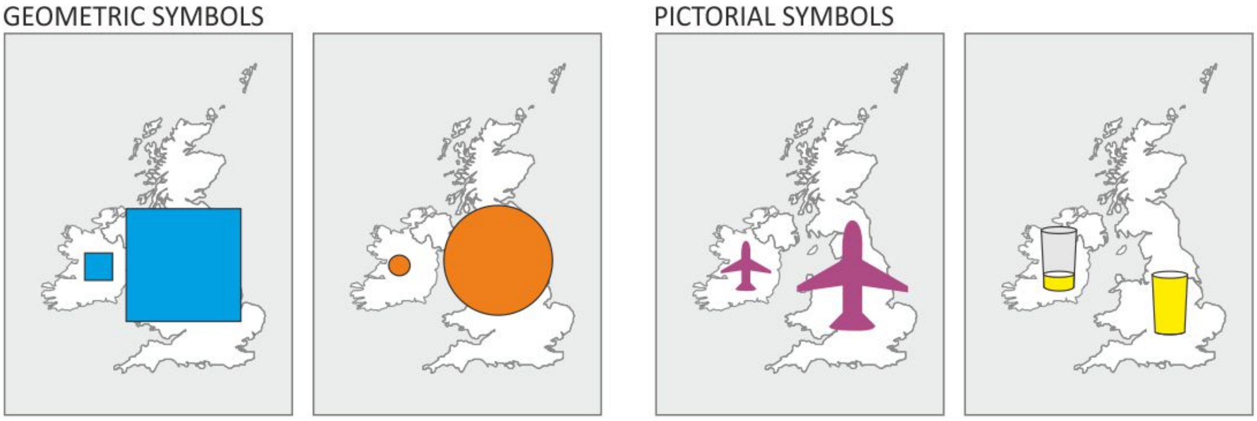


Figure 13. Different shapes can be applied on a graduated symbol map. Source: authors.

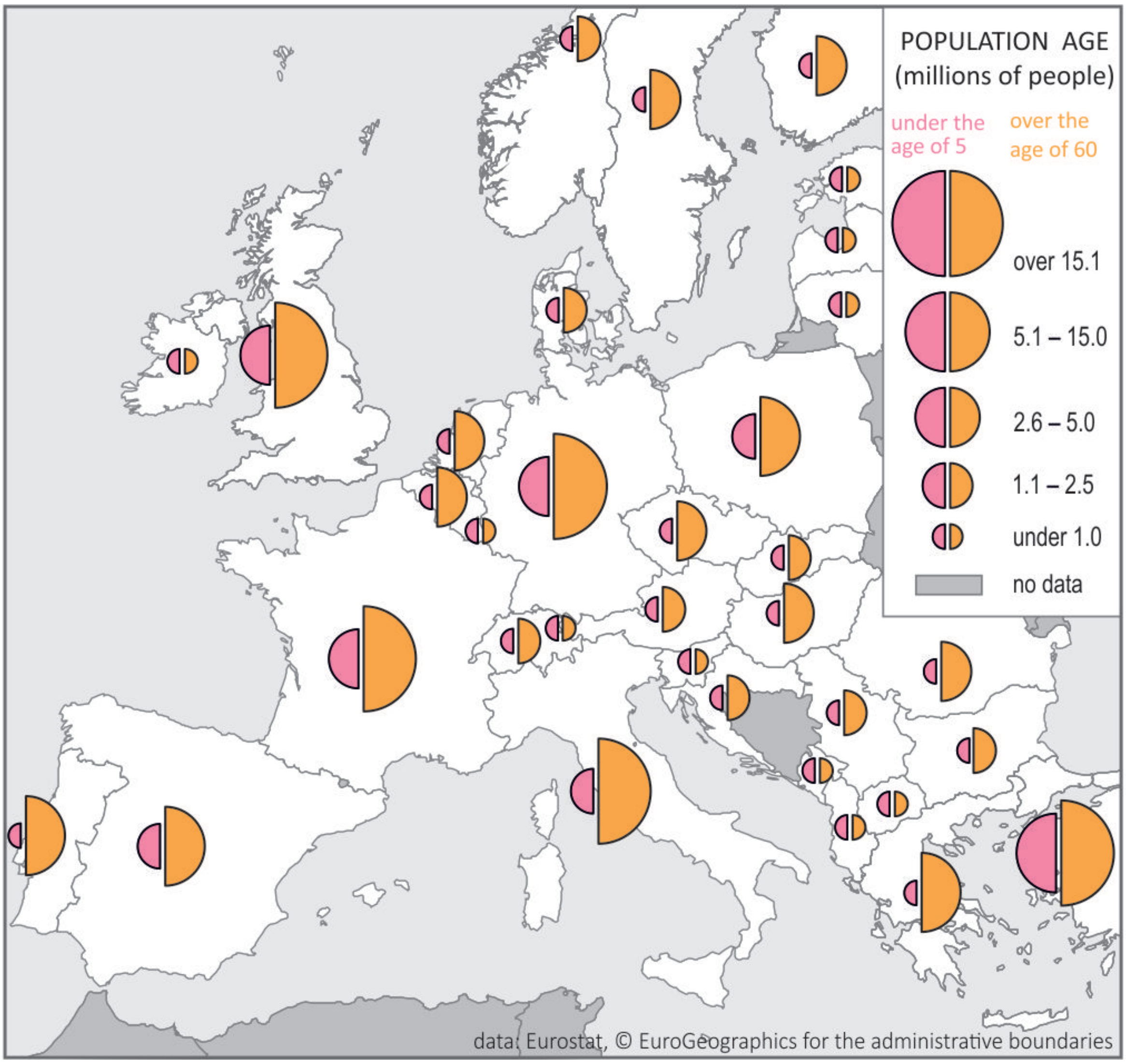


Figure 14. A graduated symbol map can represent more than one set of data. Source: authors.

Proportional symbol maps and graduated symbol maps evoke discrete and abrupt metaphors, such as sites of economic activity (Figure 1; Kraak et al., 2020).

3.3. Isoline Maps

An **isoline map** is a thematic map that represents data with lines derived through interpolation that connect points of equal attribute value on a map. The lines are called isolines or isarithms (the two terms are synonymous; for sake of conciseness only the former is used in the following sections). Depending on the representation of individual versus enumerated data, two kinds of isoline maps can be distinguished (Figure 15). **Isometric maps** are thematic maps that use isolines resulting from interpolating values collected at sample points. For isometric maps, sample points already may exist (e.g., weather stations). In contrast, **isoplethic maps** are thematic maps that use isolines resulting from interpolating values enumerated across areas.

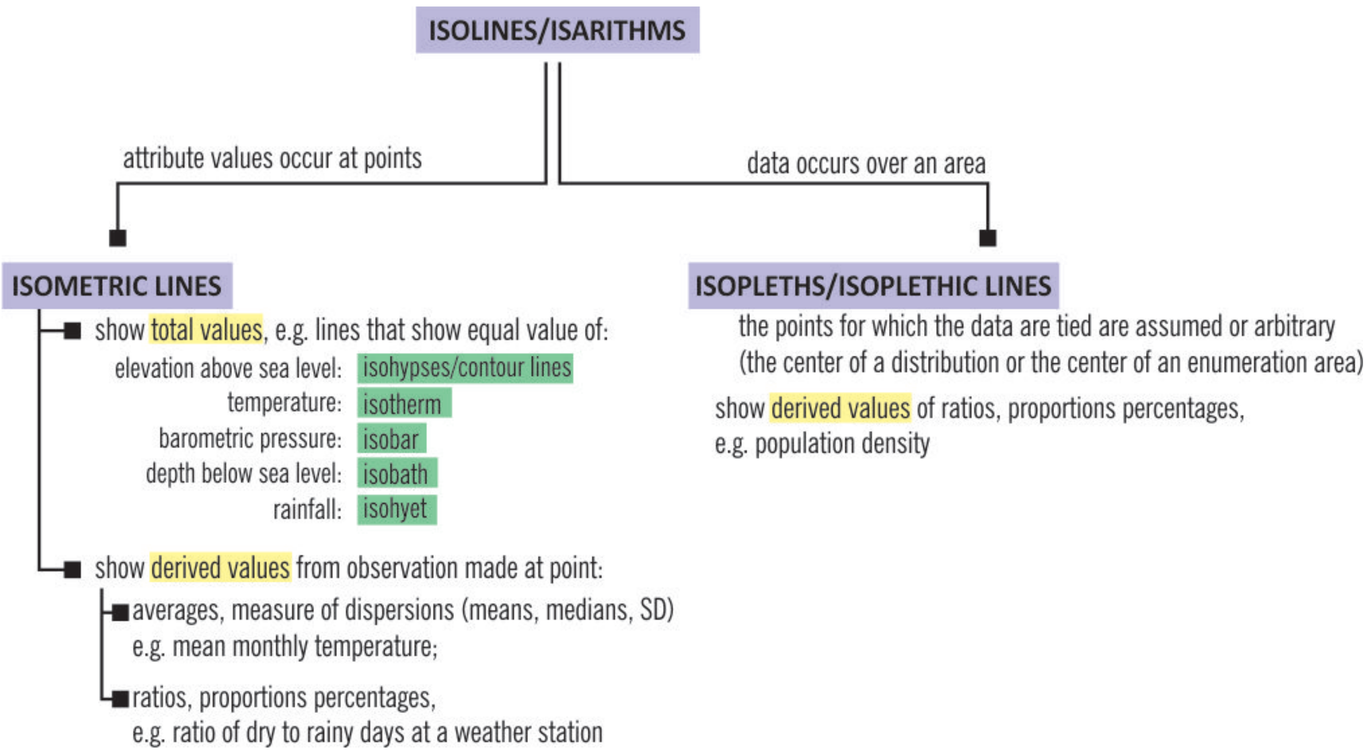


Figure 15. Isolines are named differently depending upon the type of data that is being mapped. Source: authors.

A first important design consideration for isoline maps is the distribution of sample points. For isometric maps it can be systematic, random, stratified, or purposeful sampling whereas for isopleth maps, only the centroid is used (Figure 16).

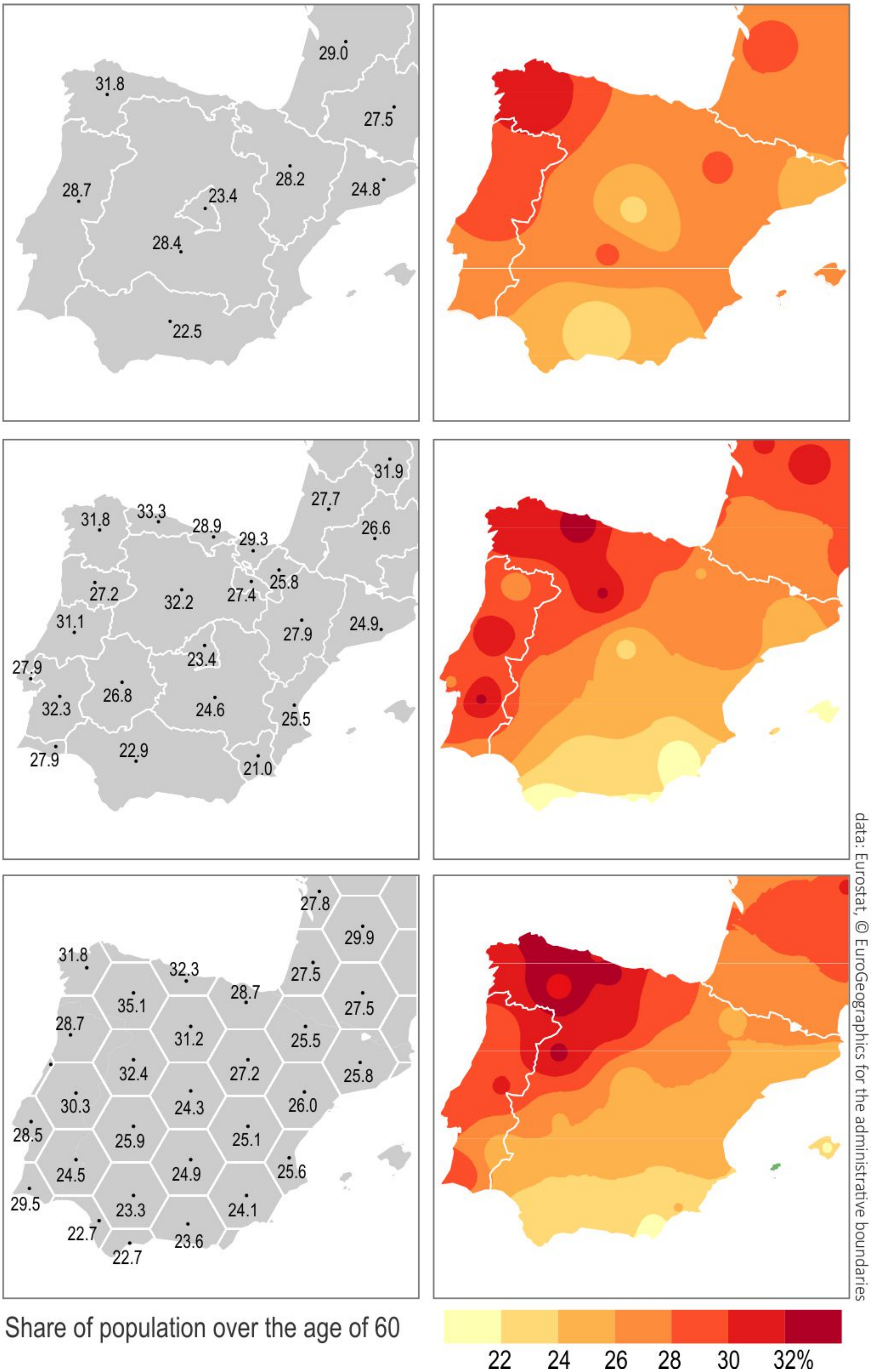


Figure 16. The selection—including number, distribution, and location—of sample points

affects the resulting isoline map. The maps represent the same attribute: referring to NUTS1 areas (top row) and NUTS2 (middle row), grid of control points (bottom row). Source: authors.

A second design consideration is the interpolation methods selected (Figure 17), or the manner by which a continuous statistical surface is estimated from a distribution of sample points. Different interpolation methods—for example, inverse distance weighting, bi-cubic spline fitting, and kriging—are suitable for different datasets (see **Interpolation Methods**) and the selected interpolation method results in different statistical output surfaces. Some methods result in surfaces that include the values collected in sample points (e.g., nearest neighbor interpolation). The surface may feature great variability and abrupt changes in isolines to match the values of the sample points. Other interpolation methods smooth the statistical surface and, therefore, do not always coincide with the values collected in sample points (Dent et al., 2008). Inverse distance weighting and kriging interpolation methods, perhaps the two most common interpolation methods for isoline maps, produce a regular output grid through which exact or smoothed isolines can be woven.

Once selecting a sample distribution and interpolation method, a third design consideration for isoline maps is the numerical interval between isolines placed in the map. The **isoline interval** is the numerical distance between successive lines. Use of a single, regular interval improves map reading, as the distance between consecutive lines suggests the rate of change of the phenomenon (Tyner, 2010). When regular intervals do not capture the spatial pattern of the mapped phenomenon, additional **supplementary isolines** can be added to provide additional detail between regular isolines.

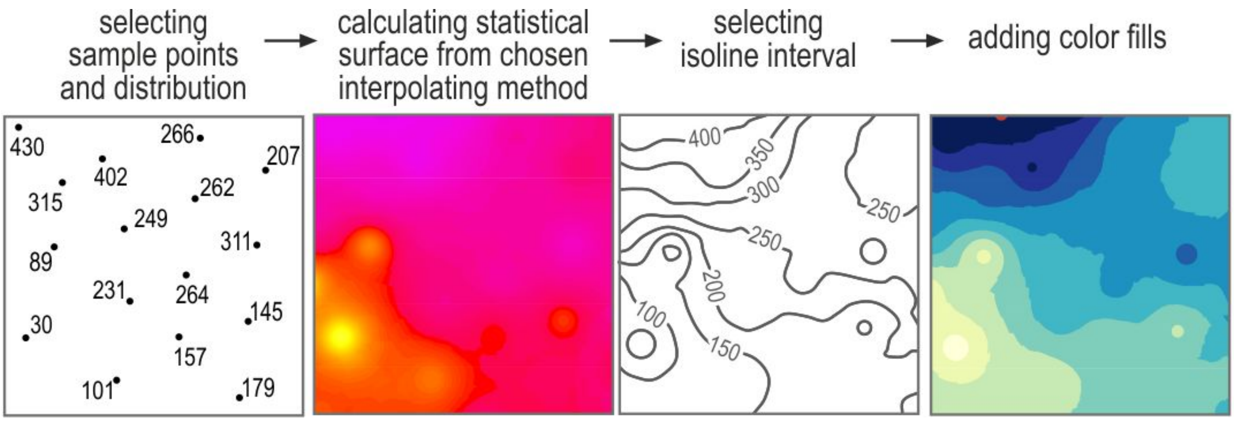


Figure 17. Isoline map involves several major design considerations. Source: authors.

A final design consideration for isoline maps is the use of color tinting between isolines. Isoline maps use lines as a symbol dimension, whereas adding color tinting between isolines changes the symbol dimensionality into area. Color tinting (described as hypsometric tinting for elevation contours; see **Terrain Representation**) between isolines can improve the users' interpretation of the map (Brewer, 2016; Tyner, 2010), for example, to find where relatively higher and lower values are located across the map (compare the third and fourth maps in Figure 17). As with choropleth maps, an equal area projection is needed when using color given the distortion of relative areas of color shading (see **Map Projections**). Color schemes for isoline maps generally follow the same principles as color schemes for choropleth maps (see **Color Theory**), such as following a more=up metaphor against the basemap and using diverging schemes for datasets with a critical midpoint (Figure 18). Isoline maps without tinting should symbolize the isolines with a consistent width and color, excepting supplementary isolines, and can include labels placed directly atop the line with a line break (e.g., the third map in Figure 17; see **Typography**).

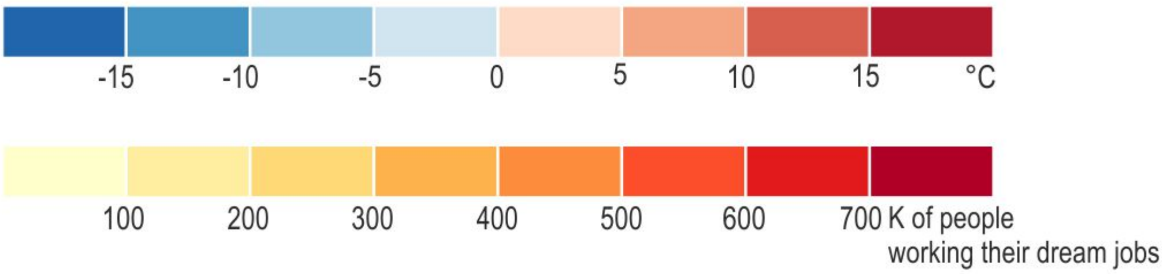


Figure 18. Only datasets with a specific value point should be represented with a double-ended divergent color scheme. Source: authors.

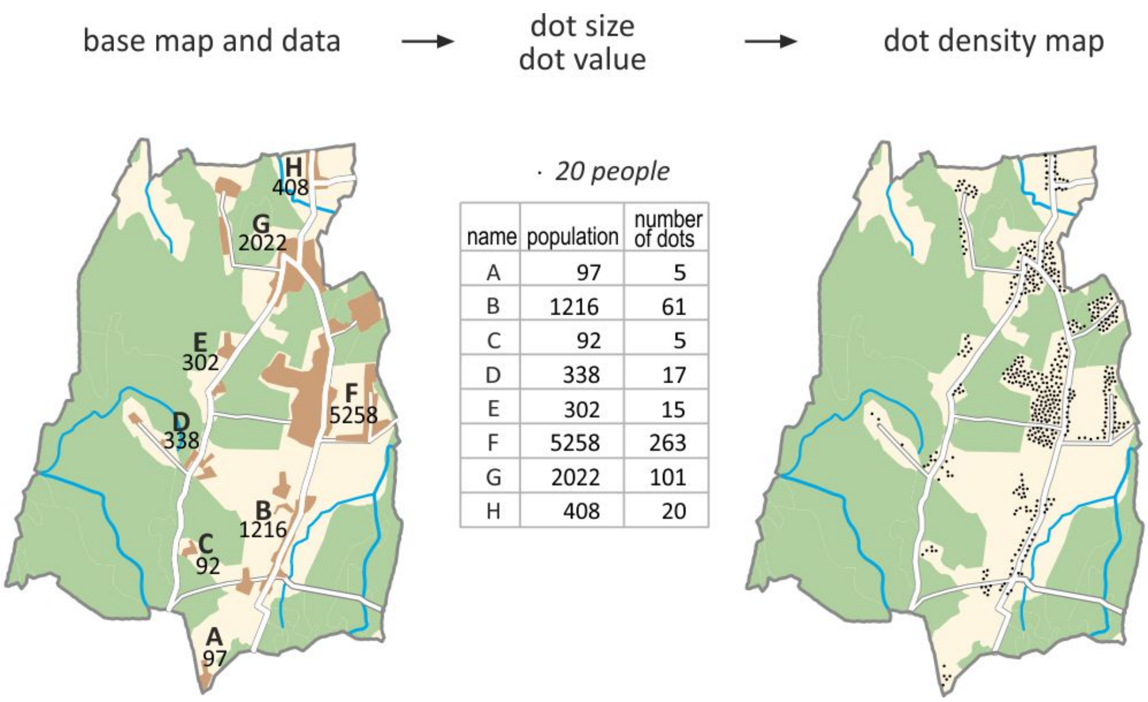
Isoline maps evoke continuous and smooth metaphors (but may often exhibit edge and island effects from interpolation), primarily suggesting environmental phenomena—for example, temperatures or rainfall, which are typically represented on isoline maps (Figure 1; Kraak et al., 2020).

3.4. Dot Density Maps

A **dot density map** is a thematic map that places dots within an enumeration unit in proportion to the represented value, to preserve the distribution and variation of density of a phenomenon. A dot density map uses the composite visual variable numerousness, which combines arrangement and size to give a sense of sparseness or dense clustering (see **Symbolization & the Visual Variables**). A dot density map can have color hue applied to encode different categories to give a sense of relatively homogenous versus heterogeneous regions by category (see **Multivariate Mapping**). Therefore, a dot density map differs from a dot map, i.e. qualitative point icons (see **Map Icon Design**), in that each dot represents an enumerated amount of the mapped attribute versus a specific coordinate location.

A first consideration for dot density maps is the dot value (Figure 19), or number of the phenomenon that each dot represents. The dot value should be optimized in relation to the total enumerated total, as an unsuitably large dot value results in too few dots to show the density variations clearly in sparser enumeration units and an unsuitably low dot value results in too many dots leading to overplotting and boundary effects in the densest enumeration units.

A second design consideration is the dot size. The dot size is the diameter of the dot that is placed multiple times on the map. The dot size should be constant across the dot density map to avoid confusion with proportional symbol maps. An unsuitably large dot size results in overlapping dots and an unsuitably small dot size makes the dots recede to the ground in the visual hierarchy. Dot value and dot size both are contingent on the cartographic scale (see **Scale & Generalization**) and the range of mapped values, and therefore often requires exploration of alternative designs to find an effective visual balance (Figure 20).



name	population	number of dots
A	97	5
B	1216	61
C	92	5
D	338	17
E	302	15
F	5258	263
G	2022	101
H	408	20

Figure 19. Dot value and dot size are primary design considerations for dot density maps. Source: authors.

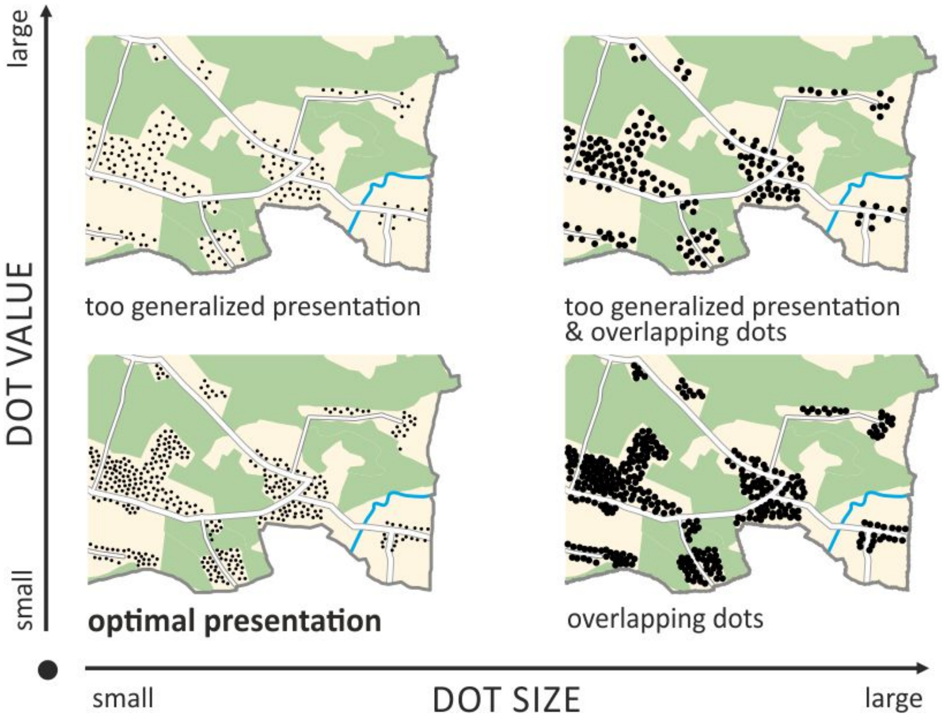


Figure 20. Dot size and value are related to the cartographic scale and quantities to be mapped. Source: authors.

The final design consideration for dot density maps is the dot placement. Any particular dot does not represent the specific location of a single instance of some phenomenon (Krygier & Wood, 2016). While once placed by hand using expert knowledge, dot placement for dot density maps typically is randomized in contemporary mapping software. Therefore, additional information—for example, information on land use—should be used to improve the location of dots (see discussion of dasymetric maps below; Figure 21).

A dot density map uses area as a major dimensionality, even though a dot is applied as a single symbol. The distribution and variation of density of a phenomenon across an enumeration unit is the main message conveyed on a dot density map. The map is used to visualize absolute data—for example, the number of unemployed rather than the unemployment rate (Krygier & Wood, 2016), but as a final product, a dot density map visually normalized the absolute data much like a density normalization in a choropleth map. A dot density map evokes a discrete and smooth phenomenon, and therefore is effective for representing people and other social phenomena (Figure 1).

3.5. Dasymetric map

A **dasymetric map** is a thematic map that uses ancillary data to determine new more meaningful borders of enumeration units, improving the representation of the spatial distribution of the mapped phenomenon. The ancillary data may be of two kinds: exclusionary datasets (those that indicate where the mapped phenomenon cannot appear) and inclusionary datasets (those that enable readers to assume a high positive correlation between the additional variable and the mapped phenomenon) (Robinson et al., 1995;

Kraak et al., 2020). For example, while mapping croplands, urban areas serve as exclusionary data to remove areas known not to have crops. At the same time, urban and built-up areas are inclusionary data for population density mapping. Once the ancillary data is applied, the attribute values then are redistributed within the newly drawn boundaries, resulting in new densities when normalized statistically (as in choropleth maps) or visually (as in dot density maps) (Figure 21). Accordingly, a dasymetric map uses enumerated data collected at an area dimensionality.

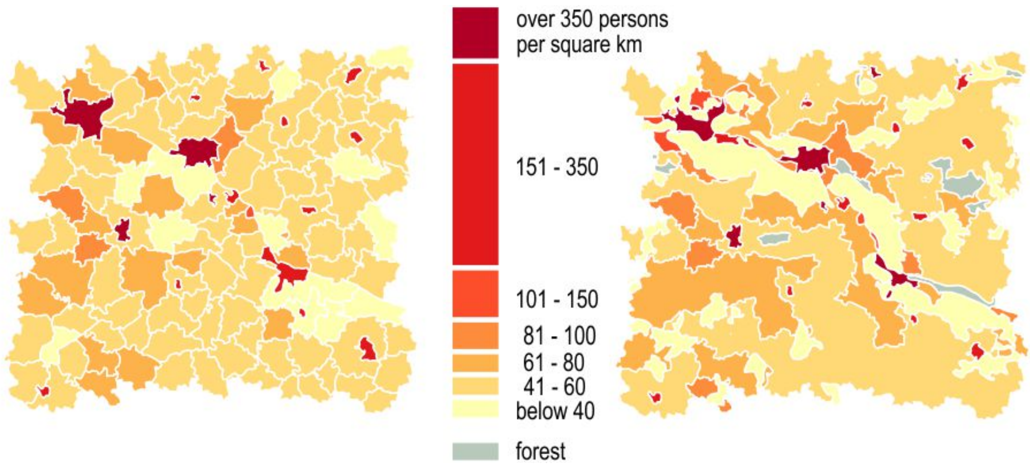


Figure 21. Dasymetric maps need ancillary data to redraw enumeration units that better fit the distribution of the mapped phenomenon—for example, forest serving as exclusionary data for population density mapping. Source: authors.

A dasymetric map can modify any of the common thematic map types reviewed above (Figure 1). The enumeration units on choropleth maps and dot density maps are most commonly improved with dasymetric mapping. In relation to the former, dasymetric mapping addresses the limitation of a choropleth map in showing heterogeneity within the enumeration units (Slocum et al., 2009). For the latter, dasymetric mapping improves dot placement to capture nuanced densities within the enumeration unit. Once attribute values are redistributed in the dasymetric maps, the map design itself follows other recommendations for the associated thematic map types described above (e.g., normalization, classification, symbolization).

3.6. Cartograms

A **cartogram** is a thematic map that scales the size of an enumeration unit proportionally to the represented value. Cartograms display enumerated data, often political units like countries (Figure 22) or other administrative units, with cartograms perhaps most commonly applied for election mapping. Cartograms may represent patterns more clearly than choropleth maps since the area symbols are not limited (or biased) by the size of the enumeration unit. A cartogram represents absolute values (e.g., population, income), but visually normalizes data by modified area.

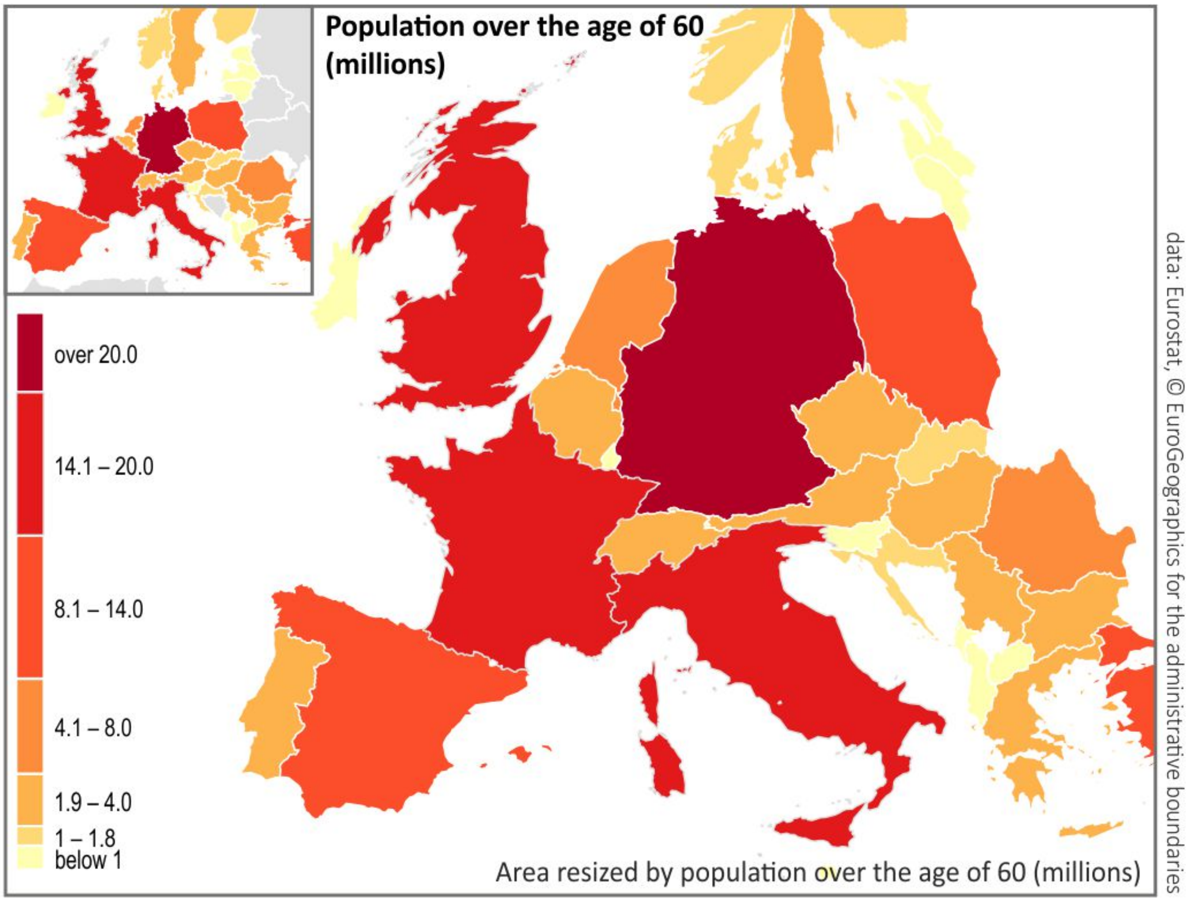


Figure 22. Enumeration units in a cartogram may be filled with color hues according to the same data that are represented by areas. Source: authors.

As an unconventional solution, the cartogram is eye-catching and may jar the audience out of problematic misconceptions about the mapped phenomenon (Figure 22). However, because of the unconventional geographies resulting in cartograms, they are not as effective for unfamiliar locations to the intended audience. See **Cartograms** for more information about design considerations.

3.7. Flow Maps

A **flow map** represents the direction and/or magnitude of a phenomenon along linear objects or between locations. A flow map shows lines that may represent a real course or a generalized schematic connection between locations (Tyner, 2010). The types of flow lines include (Figure 23): radial (with places mapped as nodes of common origin/destination), network (showing interconnectivity between places), and distributive flow (e.g., of commodities or migration). A flow map can represent individual data (phenomena between specific locations, such as cities) and enumerated data (representing flow between, e.g., countries) with flow lines connecting the centroids of the enumeration units. Flow maps use line symbols and do not require normalization, typically represents absolute values (e.g., the value or quantity of goods transported, the volume of passenger traffic).

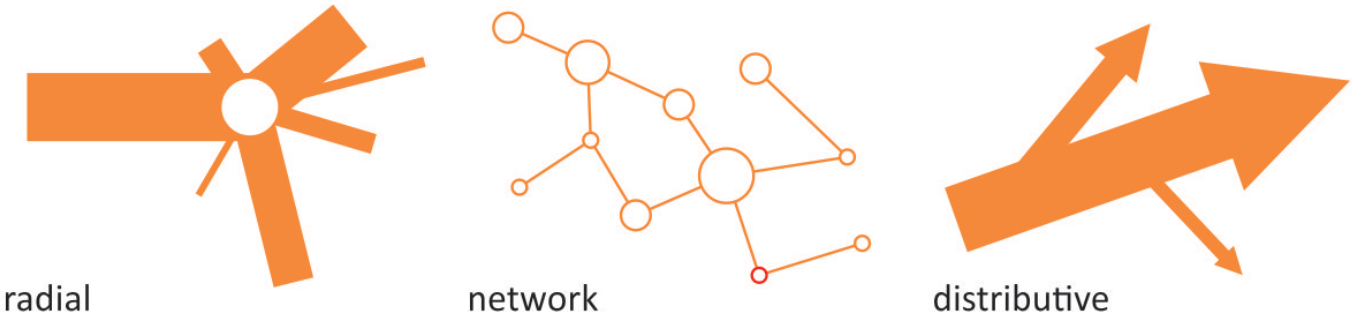


Figure 23. A flow map can be designed with different flow line types. Source: authors.

Lines can also be graduated or proportional to represent the magnitude of the movement (See **Statistical Mapping**; Figure 24). Magnitude typically is shown through size (width of line) or color value if resizing results in a great amount of symbol overlap. See **Flow maps** for more information about design considerations.

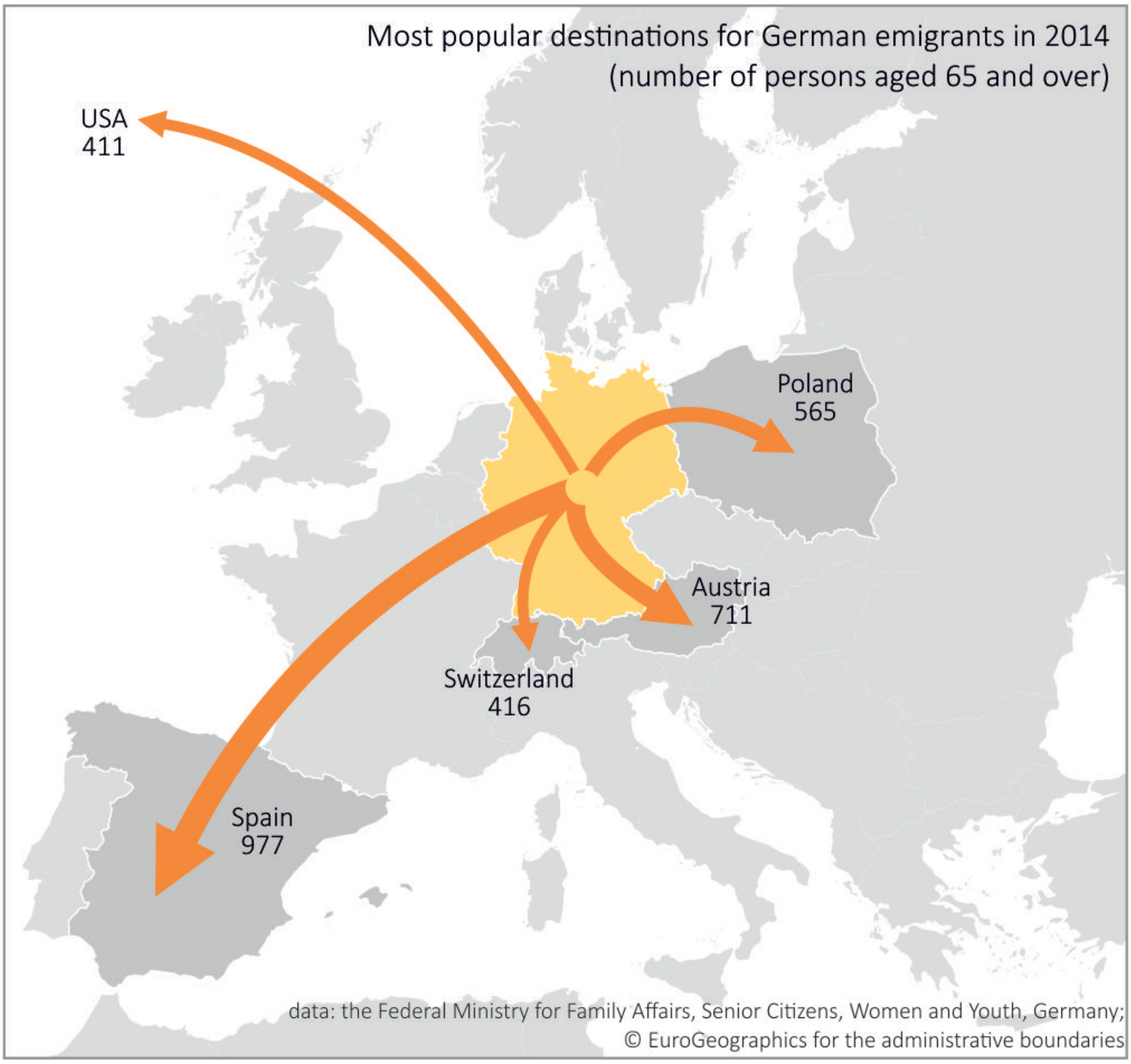


Figure 24. A flow map can show the direction and magnitude of a phenomenon. Source: authors.

4. Legend Design

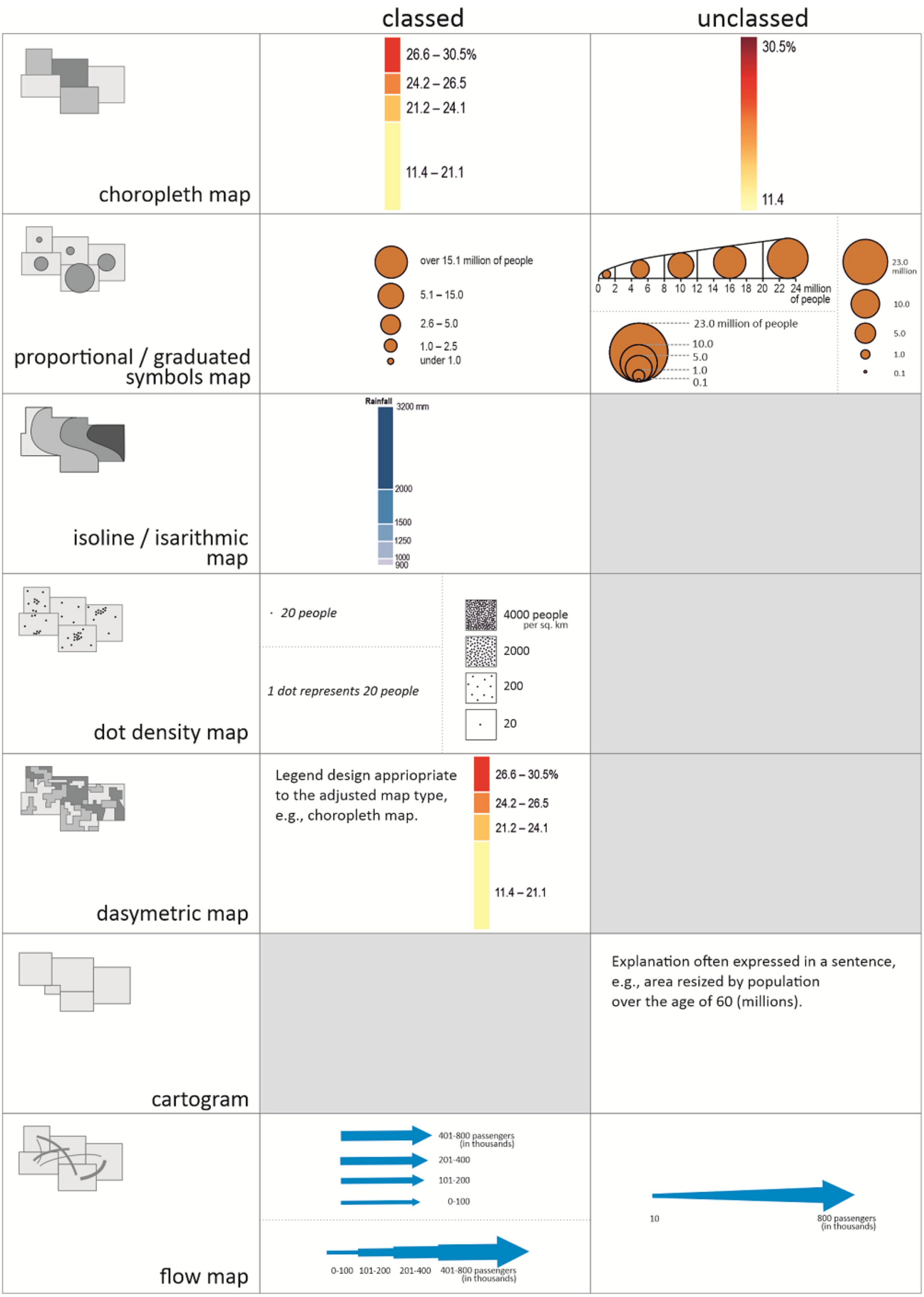
A map legend explains the meaning of symbols in the map, both quantitative and qualitative. While not all maps require a legend, legends are common on many thematic maps as a way to clarify the relatively abstract representation of statistical information, particularly the method of normalization and classification if applicable. Some parts of the design considerations of legends are common for all thematic map types, whereas others are specific to a particular thematic map type.

Ordinal or numerical data should be ordered with the highest values at the top of the legend and the lowest values at the bottom to resemble a vertical axis and provide a metaphor of “more=up”. The horizontal presentation of symbols is also possible; in this case, the symbols are ordered from left to right to evoke reading of a number line.

Ordinal or numerical data legend items should be arranged without gaps, and to suggest the continuity of the data on a number line (Kraak et al., 2020), although this is not a universal recommendation (e.g., Dent et al., 2008). In contrast, nominal data legend items should be separated by gaps in the legend to reinforce their discontinuous categorical nature.

Unclassed data are explained in the legend with representative symbols only (Table 2 right column), whereas classes are explained with every symbol applied on the map (Table 2, middle column). In the case of classed symbols, map users only have to compare the size of the symbols on the map and in the legend (Kimerling et al., 2016). In contrast, map users must estimate intermediate values between representative symbols for unclassed symbols, leaving room for error and thus a limitation of unclassed thematic maps (Krygier & Wood, 2016).

Table 2. Legend Design for Classed and Unclassed Common Thematic Map Types


classed
unclassed
choropleth map
26.6 – 30.5%
24.2 – 26.5
21.2 – 24.1
11.4 – 21.1
30.5%
11.4
proportional / graduated symbols map
over 15.1 million of people
5.1 – 15.0
2.6 – 5.0
1.0 – 2.5
under 1.0
0 2 4 6 8 10 12 14 16 18 20 22 24 million of people
23.0 million of people
10.0
5.0
1.0
0.1
23.0 million
10.0
5.0
1.0
0.1
isoline / isarithmic map
Rainfall
3200 mm
2000
1500
1250
1000
900
dot density map
20 people
1 dot represents 20 people
4000 people per sq. km
2000
200
20
dasymetric map
Legend design appropriate to the adjusted map type, e.g., choropleth map.
26.6 – 30.5%
24.2 – 26.5
21.2 – 24.1
11.4 – 21.1
cartogram
Explanation often expressed in a sentence, e.g., area resized by population over the age of 60 (millions).
flow map
401-800 passengers (in thousands)
201-400
101-200
0-100
0-100 101-200 201-400 401-800 passengers (in thousands)
10
800 passengers (in thousands)

Some thematic map types have several acceptable legend design options (Table 2). For instance, proportional symbol or graduate symbol maps can use linear or nested symbol layouts, with nested recommended when space is lacking.

Isoline legend design depends on whether color tinting is applied. For isolines with no color fills, the values are labeled directly on the map and there is no need to provide further explanation in a legend, perhaps only including a note of the isoline interval. Isoline maps with color tinting must be supported by an appropriate color scale in the legend (Table 2).

Dot density maps also have several possible legend options (Brewer, 2016). The simplest legend provides the value of one dot, expressed in a sentence, or shows one dot with a labeled quantity (Table 1). A recommended density legend is a more informative version. This solution has a set of boxes containing dots of different densities, preferably from the highest density that appears on the map to the lowest.

Labeling in legends differs between isoline and choropleth maps, even though both map types involve data classification (Figure 25). In choropleth maps, the classes represented by hues are of primary interest; therefore, the consecutive hues are labeled with a range of numbers—the maximum and minimum values of each class. Isoline maps have lines of interest; therefore, breaks between colors are labeled, since they represent the values of isolines.

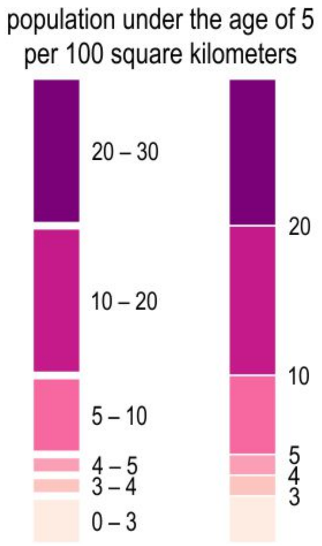


Figure 25. Legends of choropleth (left) and isoline (right) maps differs in terms of their designs. Source: authors.

Legends can be integrate with other types of charts and diagrams to provide information on the statistical distribution or to compare the mapped phenomenon to other attributes of interest.

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