



MAPPING GUIDE

CARTOGRAPHY IN ESPON 2013

CONTENT

- **Enhancing information.** This part explain how symbolize ESPON 2013 data with the good rules of graphic semiology.
- **Maps are tool for communication.** This part insists on the fact that a map has necessarily to deliver a clear message.

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LIST OF AUTHORS

Christine Zanin, University Paris 7, UMS 2414 RIATE

Nicolas Lambert, UMS 2414 RIATE

Ronan Ysebaert, UMS 2414 RIATE

Contact

christine.zanin@univ-paris-diderot.fr

nicolas.lambert@ums-riate.fr

ronan.ysebaert@ums-riate.fr

tel. + 33 1 57 27 65 32

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Introduction

Maps are a great way of displaying statistical data. It allows summarizing a complex and important information into clear and compact presentation. They can bring a great help in spotting patterns within data.

Maps are accessible for many reasons. People understand maps (at least, think they do). People like maps because they attract attention and brighten up presentation. Nevertheless, and in a scientific versus, the interest of the representation of geographical information on maps can be summarized in three main points¹.

The localisation is the most elementary subject related to geographic information. It allows answering to question "Where can we find this phenomenon?" The precision of the localisation depends on the quality of this kind of information such as statistical databases, statistical yearbook and so on. Locate a geographical object has generally a sense only if it is possible to compare it to other one "Why this object is located here and not there?". Answers can be read off directly from the map without any other help.

The comparison: Geographical objects analysis makes a concrete sense when it is possible to compare them. "What is the situation of this region as compare to the other one?"; "Can we observe geographical pattern, such as discontinuities, concentration?" Maps are useful tools for interpreting and pointing out specific geographical patterns, which are impossible to catch with an only statistical analysis.

Planning: Since the relations between European territories are very intensive, territorial planning on a special location must interfere with other territories and have to.

Despite many interests to use maps within ESPON, these kinds of documents have also their limits. Maps always generalise and simplify information. Mapping is more than just rendering; it also getting to know the phenomenon which is to be mapped. That's why mapping is not an easy action. Deliver the right message must remain the first objective of map design and mapping allows you to orchestrate the elements of the map to best convey its message to its audience. Thus, the design of maps is mainly concerned with making choices: the choice of mapping method (proportional symbol or choropleth map, isoline or grid map or even a cartogram), the choice of the aggregation level on which information as to be depicted, the choice on the level of statistic areas and the type of data (absolute or relative representation), the choice of graphic variables (such as differences in size, value, grain, colour, direction and shape) to be used. These choices are fundamental's one, they influence people's conception and visualisation of space.

This technical report is not a formal cartography book but allows everyone to understand easily how to produce an effective and operational map in the ESPON 2013 program. The report is organized in two parts: (i) Enhancing information (mapping methods and graphic semiology); (ii) Maps and communication (map is to deliver a simple and clear message).

¹ Béguin M., Pumain D., 2003, *La représentation des données géographiques – statistique et cartographie*, Armand Colin, 192p.

1 Enhancing information

1.1 Differentiation of data type

Many possibilities exist to show data on map. Choosing relevant representation is not an obvious task and has to be considered seriously. Indeed, choosing the wrong type of map can completely misrepresent the data. It is important to keep in mind that **the choice in cartography is always dependant on the type of data**. It is possible to identify four main types of data:

1. Qualitative data
2. Quantitative data with absolute values
3. Quantitative data with ratios values
2. Ordinal (or ranked) data

For each type of data it is possible to relate it to a **geographical reference: points, lines or areas**.

There are many possibilities to show correctly data on maps. The aim of this paper is not to present all types of correct visualisation, but an extract of the most usual and efficient ones.

1.1.1 Qualitative data

A data is qualitative when its value is a nominal one with qualitative differences: components do not allow establishing range relations between them.

For example, considering the different geographical references:

Points: location universities by type (university, polytechnics...) – **Figure 1**

Lines: communication network without hierarchy (ferry connections, main roads) – **Figure 2**

Areas: results from typology (rural area, urban area...) – **Figure 3**

Qualitative data have to be shown such a manner that do not suggest rank either quantity. Two possibilities: use **geometric symbols** or **differential colour** in order to **differentiate** the different elements of the map.

With points (figure 1) the most efficient is to show information by colour or geometric symbols. It is important to use a limited quantity of symbols or colours to make the map understandable.

For lines or areas, differential colours should be used (figure 2 and 3).

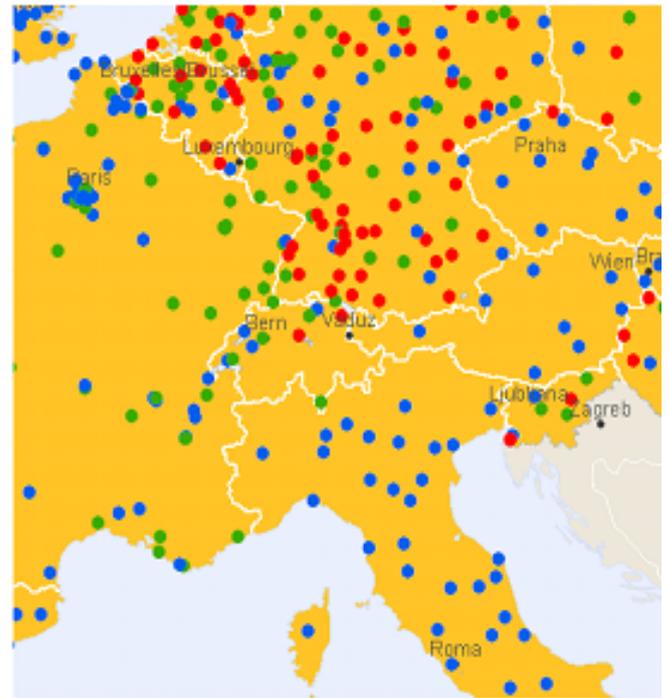
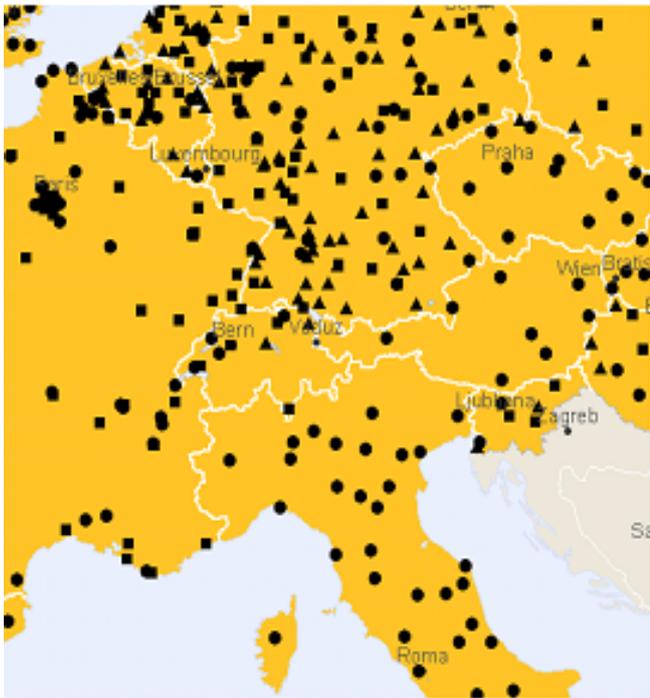


Figure 1 - Universities by types - Two possibilities
Good map = points + symbols or points + colours

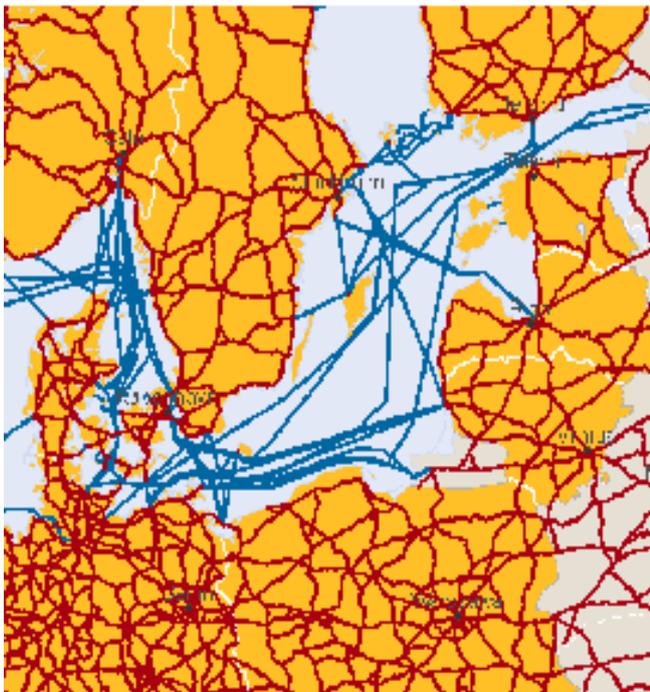


Figure 2 - Mains roads and ferry connections
Good map = line + colours

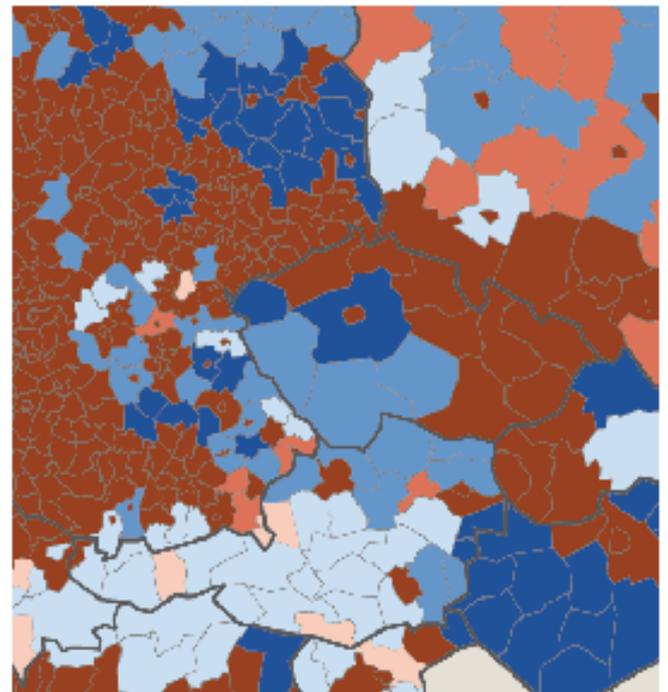


Figure 3 - Results from Urban-Rural typology
Good map = areas + colours

1.1.2 Quantitative data with absolute values

Quantitative data with absolute values means concrete **quantity**; the sum of the different values can be calculated and has a real sense. For example, population, GDP, CO2 emissions are absolute quantitative data if we consider the number of inhabitants, number of euros or tons of gas emissions.

For example, considering the different geographical references:

Points: Cities of Europe (number of inhabitants)

Lines: Containers flows across the world (millions tons) – **Figure 4**

Areas: Population of NUTS 3 – **Figure 5**

Whatever the type of geographical objects (points, line, areas), the cartography of quantitative data with absolute values has to **respect the quantity** and differences of proportionality. For points or areas objects, the most common representation is to use maps with area **proportional circles**. The circled area is proportional to the size of the data value.

The map showing data in line format (**figure 4**) has to use lines of different width. The width of the line is proportional to the data value.

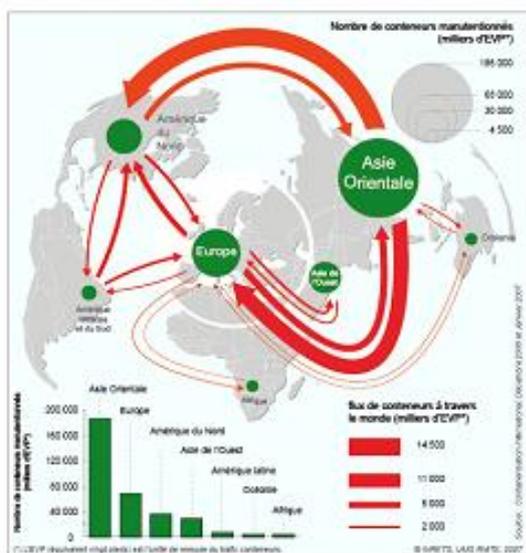


Figure 4 - Containers flows across the World
Good map = line + variation of line size

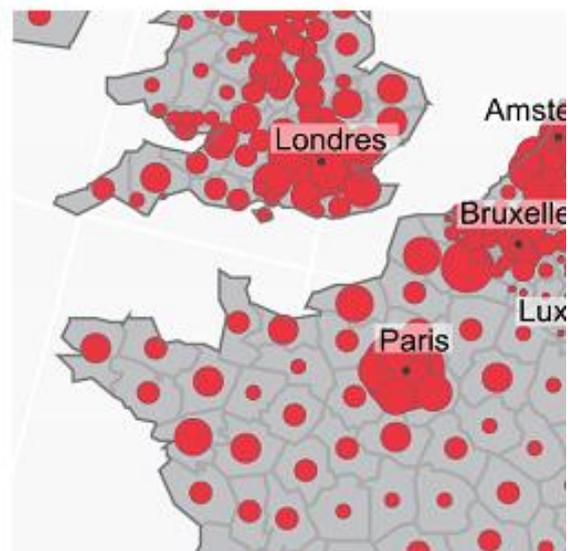


Figure 5 - Population of NUTS 3 in Europe
Good map = dot + proportional variation of size

1.1.3 Quantitative data with interval or ratio values

The ratio values are calculated and expressed a series of ratios or proportional values, such as percentage, per km, per inhabitant. This kind of data is the most common.

For example, considering the different geographical references:

Points: Cities of France (cinema attendance index) **Figure 6**

Lines: GDP per inhabitants discontinuities (relative difference between two territories) – **Figure 7**

Areas: Abstention, European elections 2009, in Ile-de-France municipalities – **Figure 8**

For ratios values, the most relevant representation is a choropleth map where density is linked to the class of the data value for each area. The efficiency of the map depends on the range between the least dense (lightest) area and the densest (darkest) area. When correctly applied, percentage or densities that are twice as high are represented by a grey value that is twice as dark.

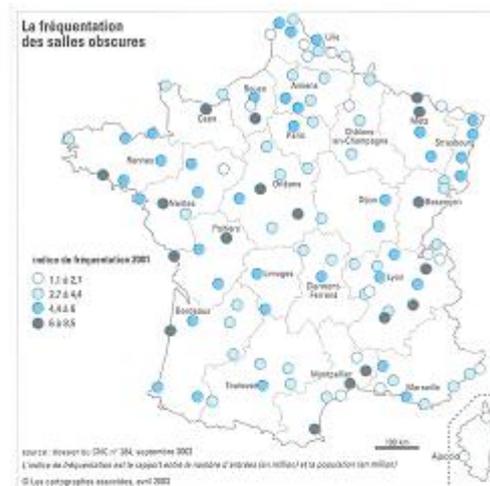


Figure 6: Cinema attendance Index in French main cities

Good map = dots + variation of colours

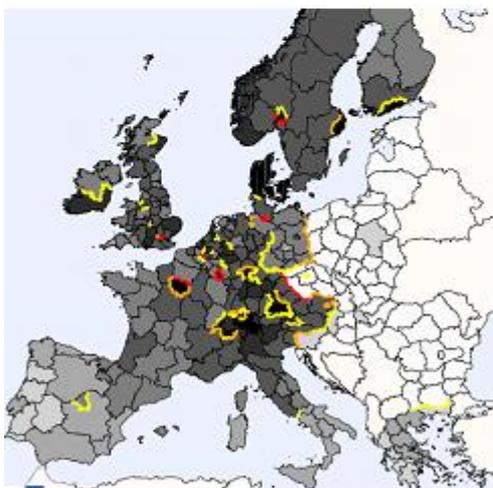


Figure 7: GDP per inhabitants discontinuities

Good map = lines + variation of colours

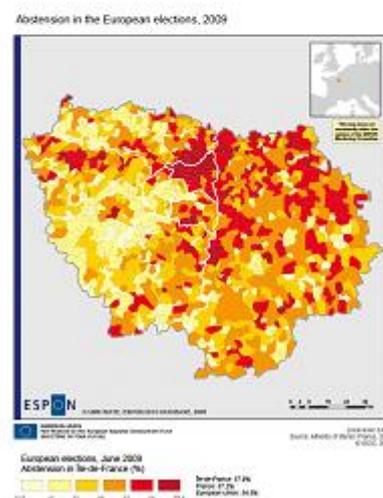


Figure 8: Abstention European votes in Île-de-France

Good map = area + variation of colours

1.1.4 Ordinal or ranked data

Ordinal data are categorical data where there is a logical ordering to the categories. A good example is the Likert scale that you see on many surveys: 1=strongly disagree; 2=Disagree; 3=Neutral; 4=Agree; 5=strongly agree. Another example could be found with modalities like first, second, third etc., or small, medium and high.

For example, considering the different geographical references:

Points: Typology of Functional Urban Areas – MEGA, national FUA, regional FUE

Figure 9

Lines: Road hierarchy – **Figure 10**

Areas: Degree of policentricity – **Figure 11**

The representation of these data is based on the expression of natural modalities order. Considering the different geographical references (point, line or area) you can only use 2 graphics variables: grey value or the intensity of a colour. They allow denoting differences in intensity of a phenomenon and expressing order between geographical areas, points or lines. Because differences in grey value or in intensity of colour are used, a hierarchy or order between ordinal modalities can be perceived.

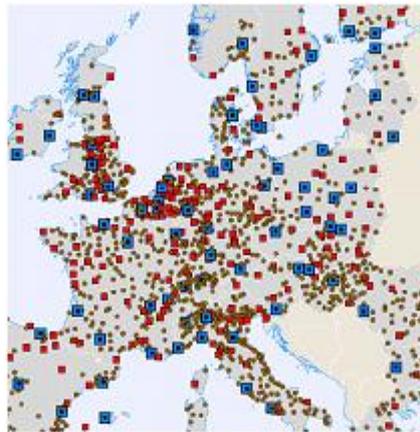


Figure 9: Typology of Functional Urban Areas
Good map: points + variation of colour (or size)



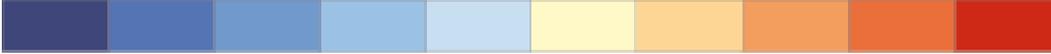
Figure 10: Road hierarchy in Europe
Good map: lines + variation of colour



Figure 11: Degree of policentricity in Europe
Good map: areas + variation of colour

1.2 When using two variations of colour?

It is sometimes necessary to show a phenomenon by a variation of two colours fundamentally different:



This kind of representation is very useful since it allows making more differentiation between the classes of the map. However, it is possible to use these oppositions of colours only if the **break has an objective sense** in the dataset, for instance:

- Opposition between negative and positive values (decrease and increase of population between two periods)
- Values above/under the average value or median value of the dataset (level of accessibility above or under the EU27 average)
- Values above/under a value which have a concrete reality (unemployment rate under/above the threshold of 10 %).

Opposition of variation of two colours should be used only for quantitative data with ratio values and ranked data.

To ensure the **harmonisation** of all maps produced by ESPON projects, it is important that also the use of colours is being guided in the case of opposite colours. In general, it is advised not to combine red and green in one map in order to serve the colour-blind people. Other general rules do not exist. The choice of opposite colors is very subjective and cultural. However, it is quite confusing if two different ESPON maps are published where red has a positive meaning in one of the maps and a negative meaning in the other map. Therefore, in the case of ESPON maps with opposite colours, it is decided to have the following principle as guideline:

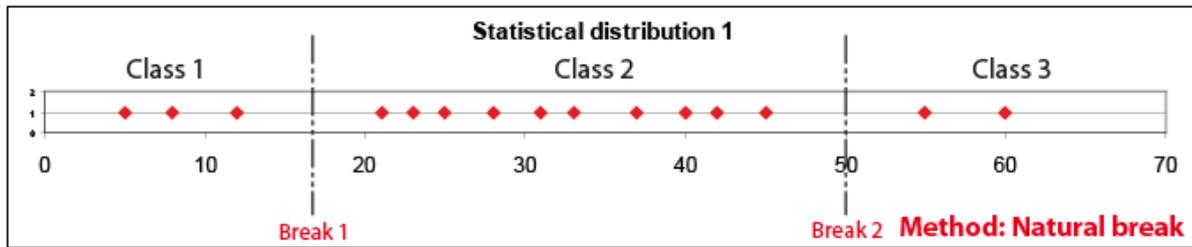
When combining red (warm colours) and blue (cold colours), **red is 'not good'/'negative'** and **blue is 'good'/'positive'**

1.3 Choice of data ranges

Nevertheless, this kind of representation introduces always a **loss of information** since it transforms a complex statistical distribution into a limited number of classes. Information becomes more generalised and simplified. The accuracy of original values is lost, but **this operation is needed in order to present a synthetic overview of the dataset**. Indeed, a good class division will focus on what is the main content of the dataset, and minimise the loss of accuracy by generalisation. Further below you will find five different classes dividing methods ranging data values. Of course it is also possible to combine different methods, in particular when there are an important number of records. This step before mapping is needed for quantitative values with ratios only.

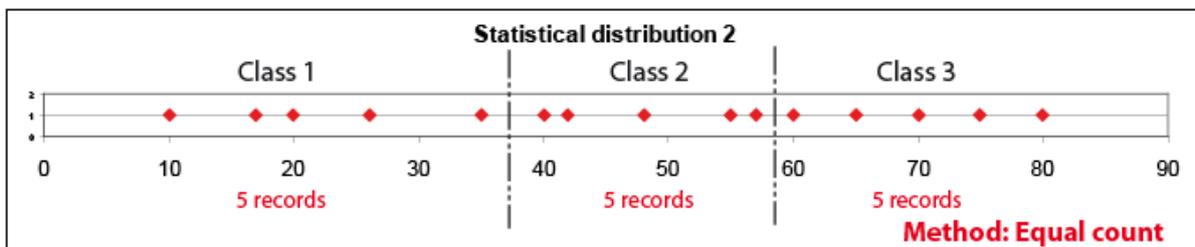
1.3.1 Natural Break

This method sets the breakpoint to “natural points” in the dataset. The strength of this method is that it increases the information content. **This method is suited when important breaks** describe the dataset.



1.3.2 Equal Count or quantile

Equal range contains approximately the same number of records. With 5 classes, each contains 20 % of the total number of the data values. **This method is suited for comparing one dataset with datasets from other themes.** If the data deviate from a linear distribution, the absolute class width will show large variations. Equal count methodology does not take into account exceptional values in the distribution.



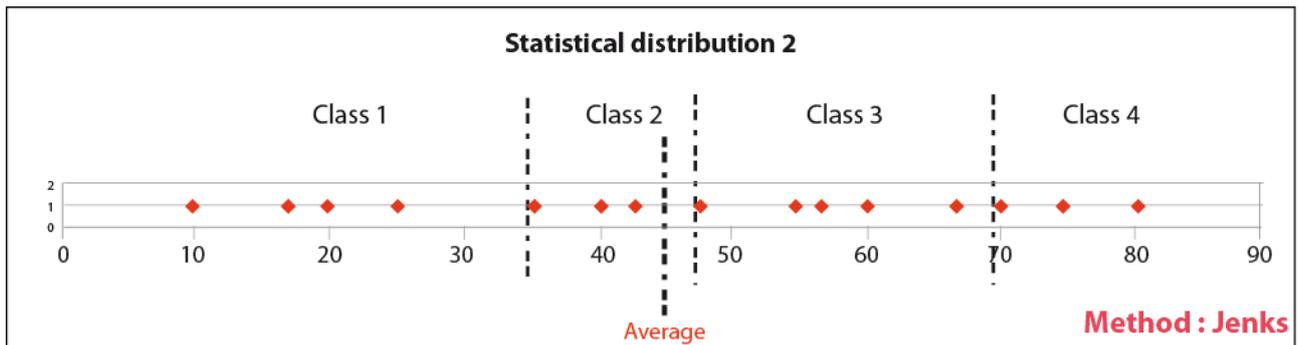
1.3.3 Equal Ranges

The difference between the top and bottom values in each range is the same. This means that we can use values like 0-20; 20-40 etc. or calculate the width of the dataset, and divide by the number of classes wanted. In this case the lowest class will start with the lowest value; the width between the classes will be the same, and the top of the highest value in the dataset. **This method is suited for datasets with a smooth linear distribution.** If the method is used on dataset that are not linear distributed, you will have some classes with many values and others with few or no values.



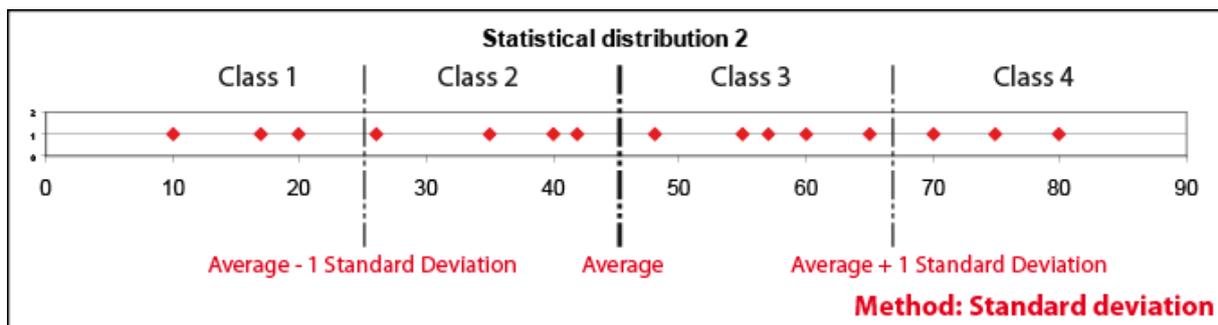
1.3.4 Jenks method

The Jenks' optimization method is also known as the **goodness of variance fit (GVF)**. It is a data classification to determine the best arrangement of values into classes. It is used to minimize the squared deviations of the class means while maximizing each class's deviation from the means of other groups. The method first specifies an arbitrary grouping of the numeric data, and then observations are moved from one class to another ensuring maximum homogeneity within groups and maximum heterogeneity between groups.



1.3.5 Standard deviation

The class borders are calculated from the mean value and the standard deviation. Standard deviation is a way to describe statistical dispersion. The width of the class is equal to the standard dispersion (or an half depending on the number of classes expected). **This method is suited for normal distributed datasets only.**



1.3.6 Geometric progression

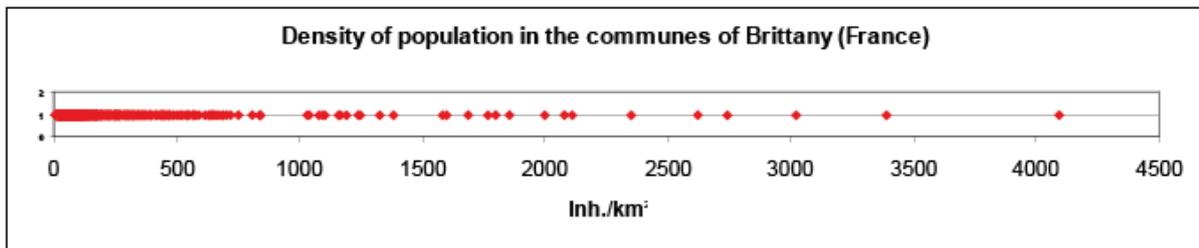
The widths of the class follow a geometric progression. To calculate the width of the different class, it is necessary to estimate the geometric ratio, such as:

$$\log R = (\log_{10} \text{Max} - \log_{10} \text{Min}) / \text{number of classes wanted}$$

$$R = 10^{\log r}$$

Width of the Classes = (min, min x R); (min x R; min x R x R) and so on.

This method is suited for uneven distribution and particularly distribution described by a lot of low values and few high values, such as density of population distribution.



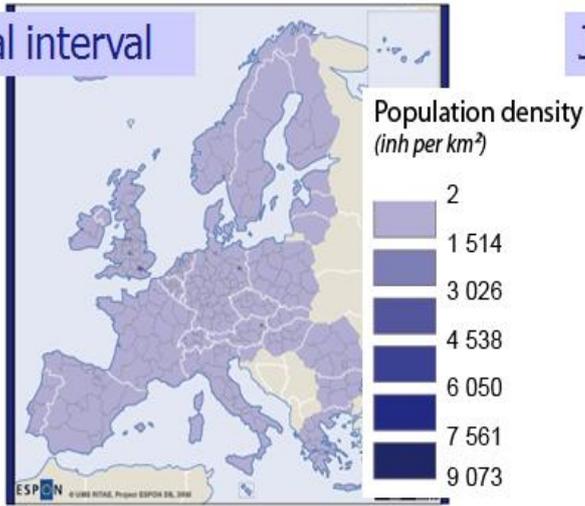
From the example of Brittany, the data ranges, following the geometric progression, should be in 6 classes:

Class	Class boundaries	Number of communes
1	[9;25[128
2	[25;70[626
3	[70;190[343
4	[190;525[117
5	[525;1470[39
6	[1470;4100[15

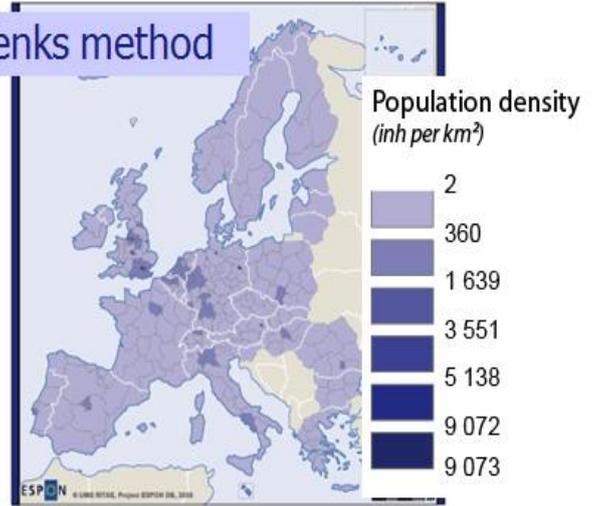
Whatever the method chosen for ranging the distribution, it is important to use smooth values for the break, in order to understand and memorize easier the sense of the map, e.g. use 30 instead of 29,77; 1500 instead of 1508 etc.

Figure 12 shows the importance of the choice of data range on the visualisation of phenomena.

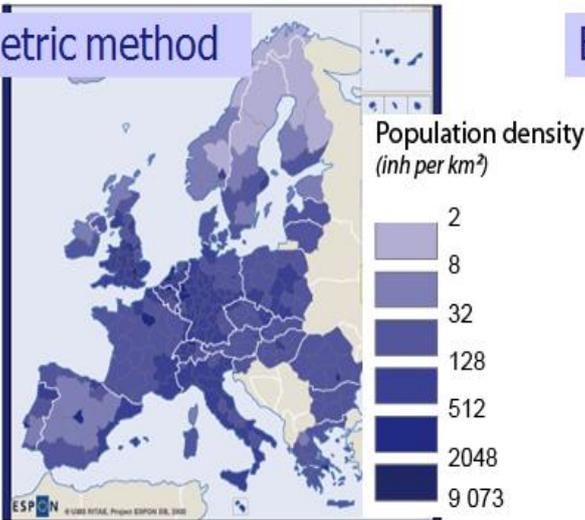
Equal interval



Jenks method



Geometric method



Equal number of elements

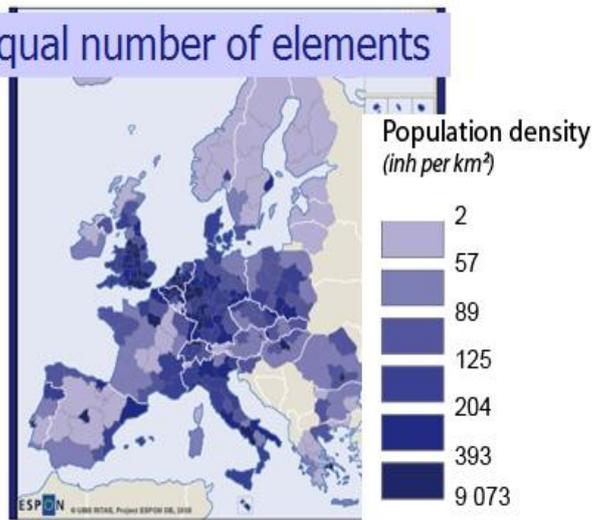


Figure 12: Result and efficiency are dependent upon the data classification method

2 Maps are tool for communication

As we explain in the introduction of this technical report: "Maps are perhaps as fundamental to society as language and the written word. They are the preeminent means of recording and communicating information about the location and spatial characteristics of the natural world and of society and culture²".

Maps are produced all over the world and used by people as different as scientists, researchers, scholars, governments or businesses. These maps are most of the time statistical ones connected with the environment, the economy, the politics, the society etc.

The biggest strength of these maps is to allow an effective and relevant communication of the information. However, cartography is a special type of visual communication that does require some preliminary learning: a special purpose language for describing spatial relationships. "The analogy with language also helps explain why training in principles of effective cartography is so important--it allows us to communicate more effectively. Without knowledge of some of these basic principles, the beginning cartographer is likely to be misunderstood or cause confusion²".

Of course, cartographers must pay special attention to coordinate systems, map projections, and issues of scale and direction but that's not the first issue of map as a tool for communication. Maps are symbolic abstractions and representations. **The first question when mapping is related to know how to simplify, generalize, represent and symbolize the relationships being represented with graphics symbols.** In other words, what is a good map?

If a design is always more effective than a long speech, the measure of a good map is how well it conveys the right information to its readers and how well it communicates with its audience. This raises a series of questions that must be addresses at the start of a map conception: What is the motive, intent, or goal of the map? Who will read the map? Where will the map be used? What data is available for the composition of the map?

Beyond aesthetic characteristics, the communication also passes by a complete and effective layout: some elements must appear within the base map and the thematic representation, a complete legend, explicit title and source, a precise date of data or even a scale.

² Kenneth E. Foote and Shannon Crum, *The Geographer's Craft Project*, Department of Geography, The University of Colorado at Boulder

From data to map, 7 fundamental goals need to be identified to realize a good map:

1. Identify the goal of the map;
2. Identify the audience of the map and where it will be used;
3. Identify the information to be communicated;
4. Identify the geographical reference (point, line or area?);
3. Choose the base map (map projection and scale);
4. Choose the visual variable (symbolic graphic language);
5. Choose layout and identify all the elements to be added.

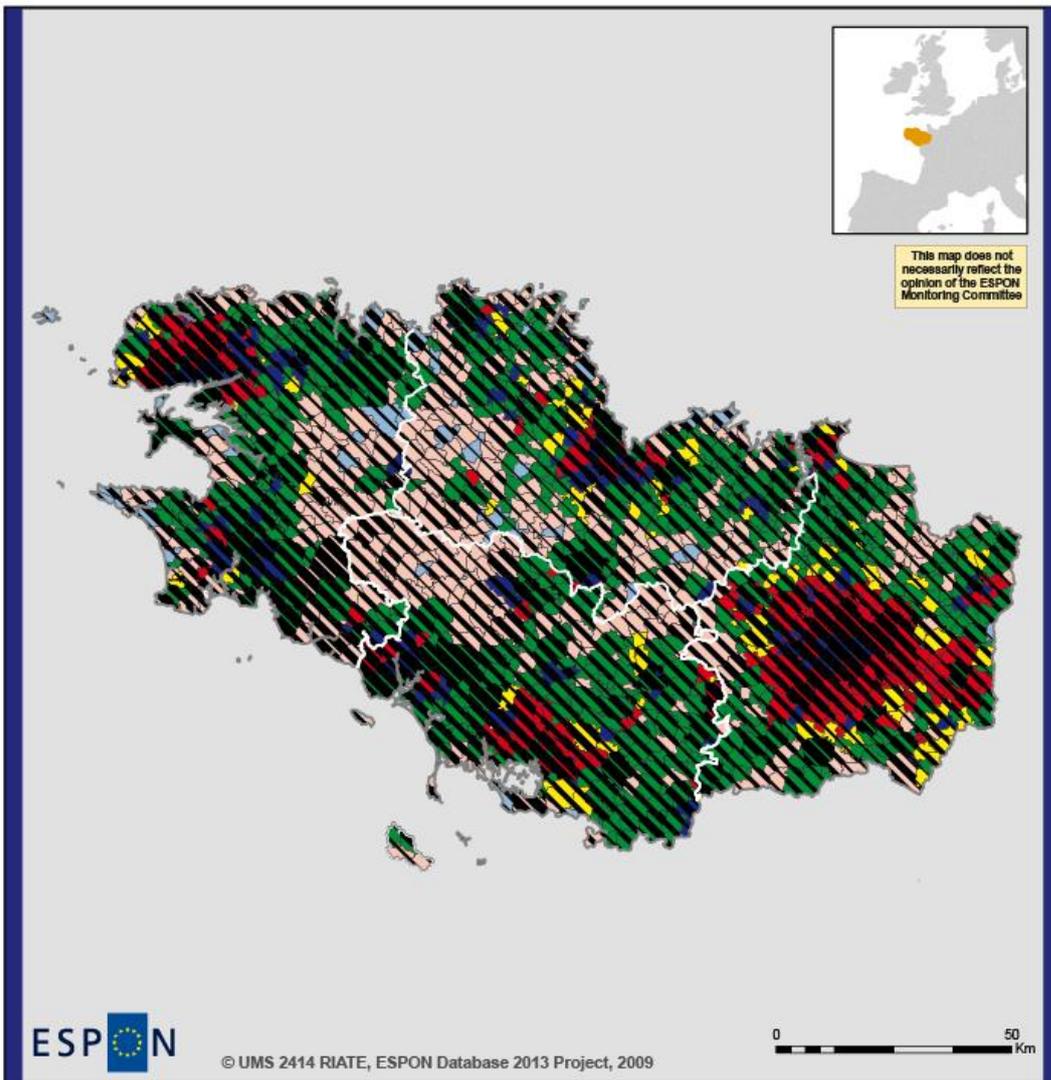
When these different elements are not correctly taking into account, the map will be characterised probably by some mistakes and misunderstandings.

2.1 Bad choices in term of representation of the data

Most of the problems of visualisation and map design are generally linked to **bad choices in term of representation of the data** (cf. part 2 of the technical report). When comparing **figures 13 and 14**, which represent the same information, e.g. a typology showing age structure and total population in the municipalities from Brittany (France), it is quite clear that the second map is really clearer than the first one. Two main reasons can explain it (**figure 13**):

- Absolute values (e.g. total population in 2000) don't have to be shown by variation of intensity of black (hachure). This kind of representation does not respect the ratio of proportionality of the indicator, which is fundamental and needed information. Using hachure is also a visual mistake; the map is not readable at all and the representation is not the most efficient. These data have to be shown by proportional symbols, circles for instance.
- This typology, derived from age structure cannot be considered as a qualitative data, since there is an implicit order when considering the progression in term of age. In concrete terms, showing each class by a different colour is not the best solution. To show correctly this data it is important to think about the goal of the map. Here, it is important to represent the municipalities described by high share of young, active and old people. As a consequence, it is important to differentiate these information (3 colours) and also to make possible the analyse of the graduation of the phenomenon (high/medium shares), e.g. using variation of intensity of these 3 colours.

The solution proposed in **figure 14** try to correct these different elements. The most adapted solution for the representation of these data is to combine circles and colours in order to make the map as clear as possible. On top of that, it allows nuancing the interpretation of the map, e.g. Brittany is a region where ageing is important, but it concerns specific small and rural cities.



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Local level: LAU2
Source: UMS 2414 RIATE, 2009
Origin of data: INSEE, 2009
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TYPE OF AGE STRUCTURE IN 2000

- A) Excedent of young population
 - Type A.1
- B) Excedent of active population
 - Type B.1
 - Type B.2
- C) Excedent of old population
 - Type C.1
 - Type C.2
- D) Medium profile
 - Type D

TOTAL POPULATION IN 2000 (inh.)

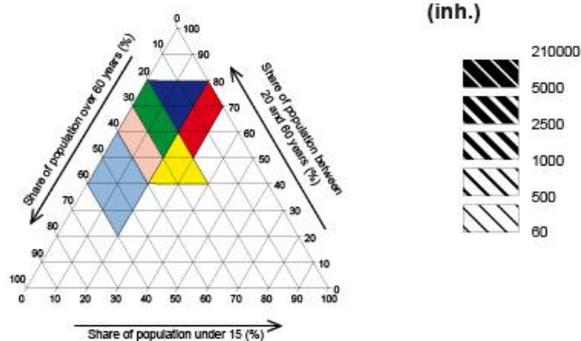
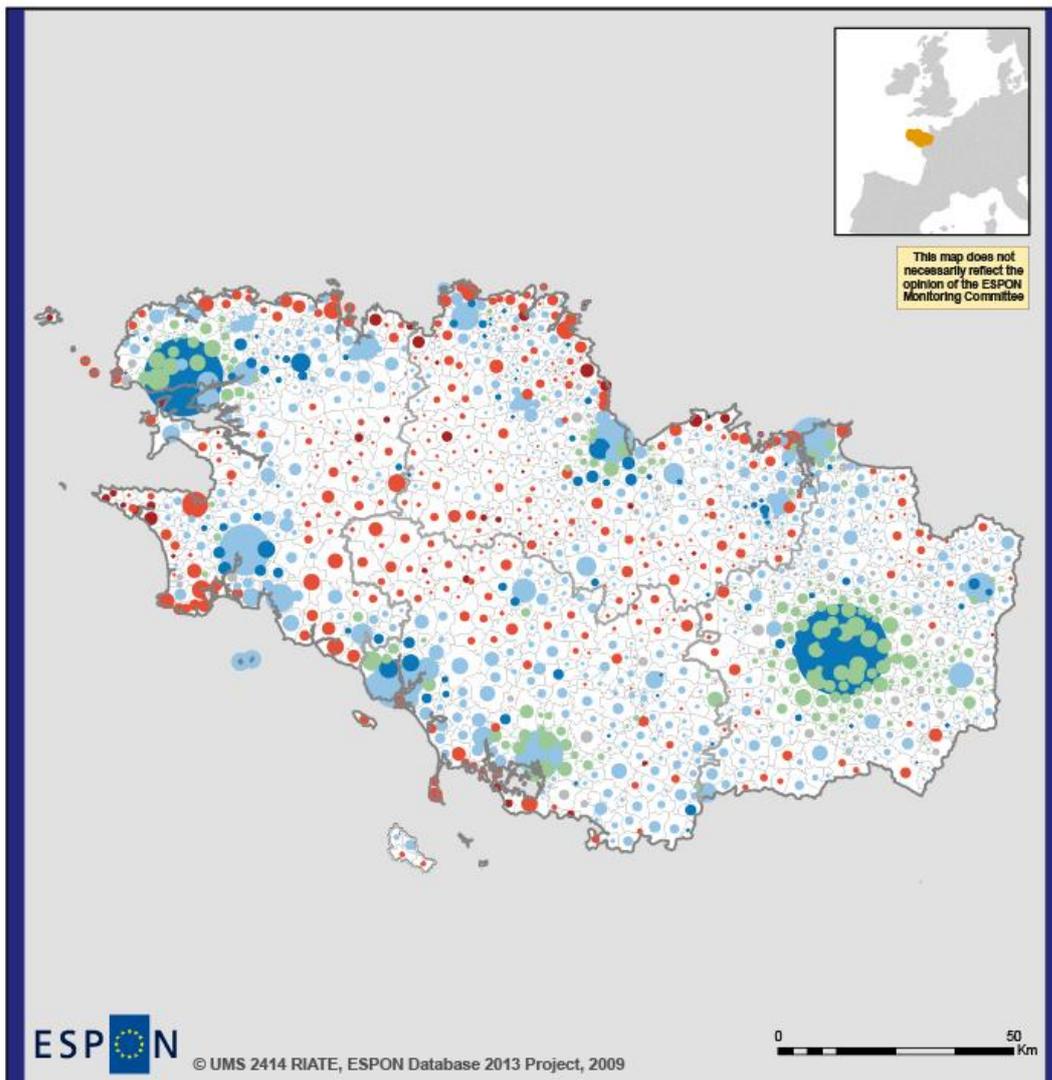


Figure 13: Population and age structure in Brittany (France) – with semiologic problems

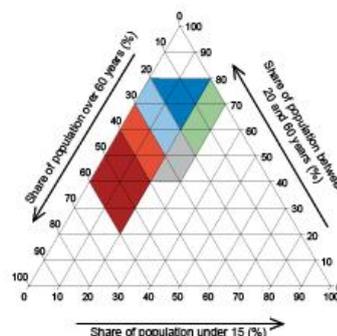


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Local level: LAU2
Source: DG-IPOL, *Shrinking Regions: a paradigm shift in demography and territorial development*, European Parliament, 2008
Origin of data: INSEE, 2009
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TYPE OF AGE STRUCTURE IN 2000

- A) Excedent of young population
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TOTAL POPULATION IN 2000 (inh.)

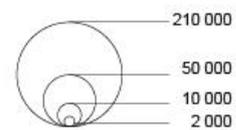


Figure 14: Population and age structure in Brittany (France) – **without semiologic problems**

2.2 Improving the efficiency of the map

Other problem which appears regularly is the degree of complexity of the map. The aim of the maps is to be synthetic. When representing too much information, the eye cannot distinguish the different elements of the map. This kind of figure can be solved by thinking to the design of the map: where is the best location for legend? How using with the most efficiency the place available?

The figures 15 and 16 show the same information, e.g. a typology of population development by components during the period 1995-2004 in EU27; this data is crossed with expected population evolution in 2030.

Figure 15 proposes solution which is correct in term of graphic semiology: ordinal data are shown by variation of colour (green/red) and shrinking/non shrinking regions (qualitative data) are represented by the opposition of hachure and no hachure. However, the combination of these two visual variables makes the map hard to interpret and the message become not so clear!

When there is too much information it becomes difficult to be able to synthesise the message of the map. That is why in some cases it is more efficient to split information in two maps instead of concentrating all the elements in a single one. This has been done on figure 16, where the map located on left of the document shows the regions described by an expected growth of population; and the map on the right shows the regions where a demographic decrease is planned. This template allows immediately to observe that during the period 1995-2005 most of the 'shrinking regions' have witnessed a downturn linked to both natural change and a negative migratory balance.

There is never an optimal solution

Whatever the examples proposed and demonstrated, it is important to keep in mind that there is never a single solution to show information on maps. In fact, each person has his own perception when interpreting graphic documents or pictures. **Map is always a compromise.** But during the creation of the map, is fundamental to try to make the map as understandable as possible. In concrete terms, it is not an obvious task and it is kindly recommended to make different attempts and share the results with other colleagues before saying "OK, my map is ready for the report"!

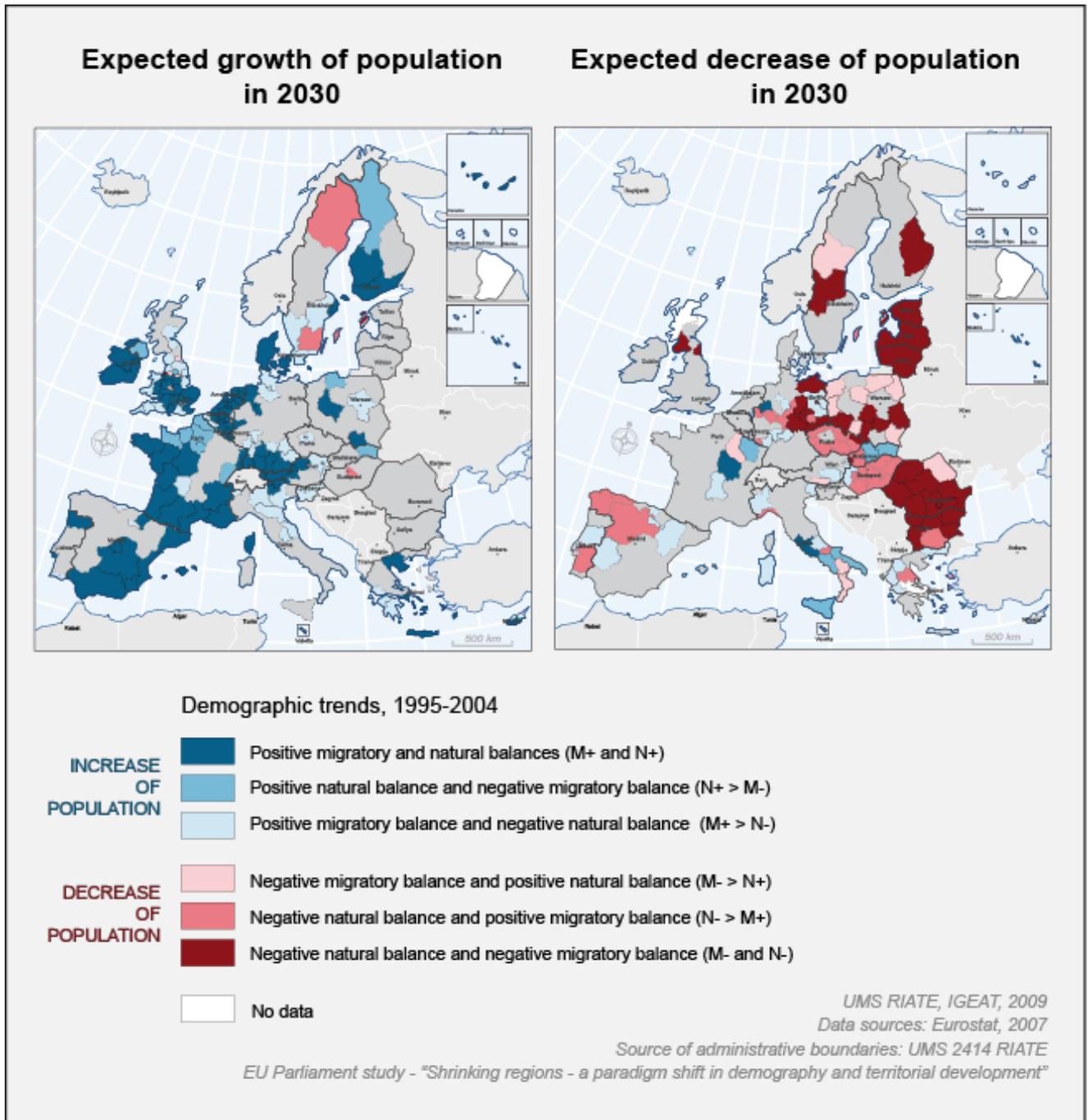


Figure 15: Typology of regional growth patterns – Possibility 2

ANNEXES

These annexes allow you to choose some efficient graphic variables to communicate differences in size, order or quality.

ANNEXE 1 - Relation of graphical variables to perceptual characteristics

Graphical variable	Type of data			
	nominal	ordinal	Interval/ratio	quantity
Size		x	x	x
Grey or colour value		x	x	
Grain/texture		x	x	
Colour hue	x			
Orientation	x			
Shape	x			

ANNEXE 2 - Numbers of categories that can be perceived at a glance

Graphical variable	Point	Line	Area
Size	4	4	5
Grey or colour value	3	4	5
Grain/texture	2	4	5
Colour hue	7	7	8
Orientation	4	2	4
Shape	3	3	3

ANNEXE 3: Differences in value or lightness

COLOUR INTENSITY			
Blue	Green	Red	Brown
4 classes			
 rgb(0,147,193)	 rgb(31,115,42)	 rgb(235,107,57)	 rgb(126,70,53)
 rgb(118,188,218)	 rgb(100,175,64)	 rgb(246,170,65)	 rgb(195,118,70)
 rgb(208,232,244)	 rgb(191,217,159)	 rgb(255,227,125)	 rgb(229,170,81)
 rgb(235,246,252)	 rgb(230,239,207)	 rgb(255,249,200)	 rgb(255,237,170)
5 classes			
 rgb(0,147,193)	 rgb(18,94,39)	 rgb(229,53,64)	 rgb(126,70,53)
 rgb(118,188,218)	 rgb(60,145,60)	 rgb(235,107,57)	 rgb(195,118,70)
 rgb(167,212,233)	 rgb(129,188,96)	 rgb(246,170,65)	 rgb(229,170,81)
 rgb(208,232,244)	 rgb(191,217,159)	 rgb(255,227,125)	 rgb(255,221,139)
 rgb(235,246,252)	 rgb(230,239,207)	 rgb(255,249,200)	 rgb(255,237,170)
6 classes			
 rgb(0,124,176)	 rgb(18,94,39)	 rgb(229,53,64)	 rgb(97,68,55)
 rgb(0,147,193)	 rgb(60,145,60)	 rgb(235,107,57)	 rgb(126,70,53)
 rgb(118,188,218)	 rgb(107,178,76)	 rgb(246,170,65)	 rgb(195,118,70)
 rgb(167,212,233)	 rgb(151,197,110)	 rgb(255,227,125)	 rgb(229,170,81)
 rgb(208,232,244)	 rgb(200,218,140)	 rgb(255,249,200)	 rgb(255,221,139)
 rgb(235,246,252)	 rgb(239,241,199)	 rgb(255,253,238)	 rgb(255,237,170)
8 classes			
 rgb(0,98,140)	 rgb(11,82,34)	 rgb(173,26,34)	 rgb(97,68,55)
 rgb(0,124,176)	 rgb(31,115,42)	 rgb(207,54,65)	 rgb(126,70,53)
 rgb(0,147,193)	 rgb(62,146,44)	 rgb(229,53,64)	 rgb(165,94,57)
 rgb(68,170,207)	 rgb(100,175,64)	 rgb(235,107,57)	 rgb(195,118,70)
 rgb(118,188,218)	 rgb(145,191,91)	 rgb(246,170,65)	 rgb(219,145,73)
 rgb(167,212,233)	 rgb(180,209,121)	 rgb(255,227,125)	 rgb(229,170,81)
 rgb(208,232,244)	 rgb(200,218,140)	 rgb(255,249,200)	 rgb(255,221,139)
 rgb(235,246,252)	 rgb(239,241,199)	 rgb(255,253,238)	 rgb(255,237,170)

GREY VALUE

4 classes



5 classes



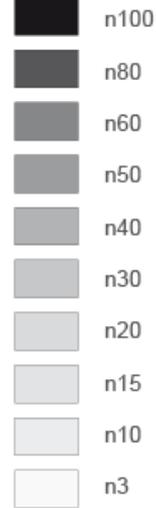
6 classes



8 classes



10 classes



OPPOSITE COLOURS

 rgb(0,98,140)

 rgb(0,147,193)

 rgb(118,188,218)

 rgb(235,246,252)

 rgb(252,208,211)

 rgb(234,122,133)

 rgb(196,55,79)

 rgb(142,3,17)

 rgb(90,93,122)

 rgb(114,118,159)

 rgb(147,153,199)

 rgb(196,200,226)

 rgb(249,230,239)

 rgb(240,184,210)

 rgb(236,141,181)

 rgb(226,2,128)

 rgb(32,115,43)

 rgb(66,145,44)

 rgb(145,191,92)

 rgb(222,229,157)

 rgb(247,229,196)

 rgb(250,210,147)

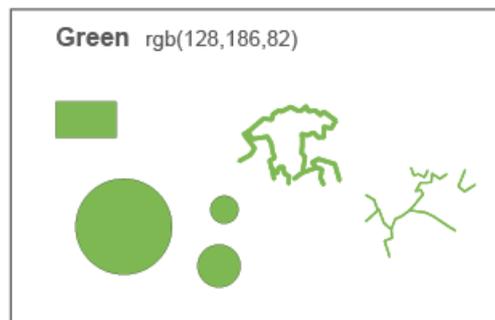
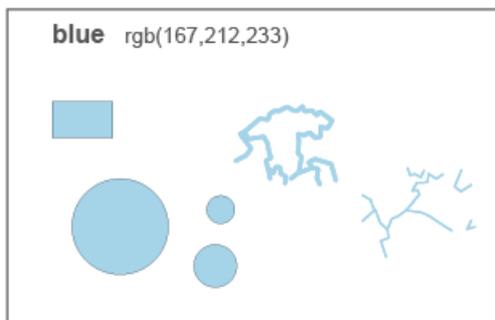
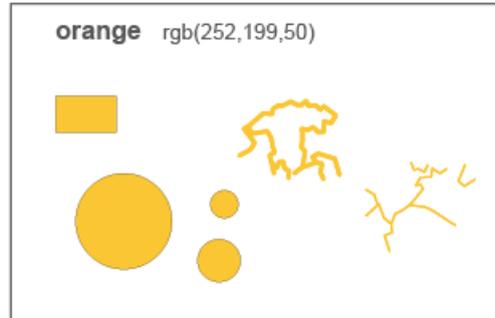
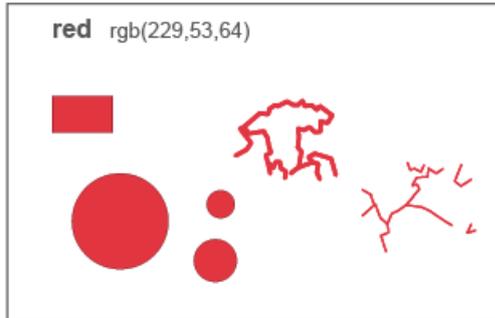
 rgb(244,171,42)

 rgb(175,110,22)

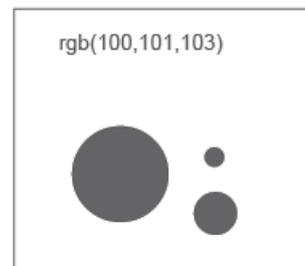
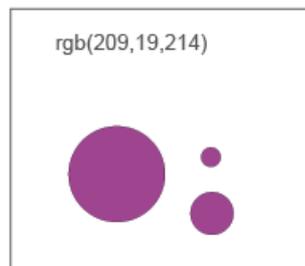
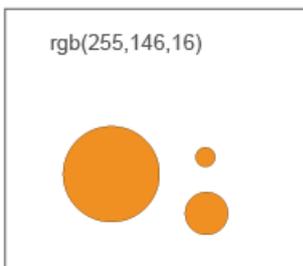
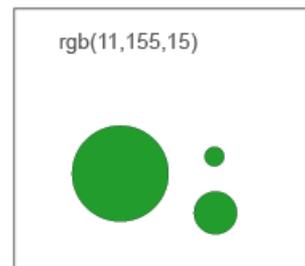
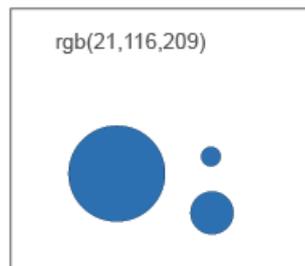
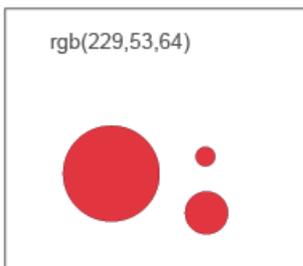
ANNEXE 4: Colours for differences typology or qualitative value

QUALITATIVE VALUES

(circles and discontinuities)



(circles)



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• *Websites*

Colorbrewer 2.0 is an online tool designed to help people select good color schemes for maps and other graphics: <http://colorbrewer2.org/>

Philcarto is a free tool for cartography, available on the net: <http://philcarto.free.fr/>

Quantum GIS is an Open Source Geographic Information System. It runs on Linux, Unix, Mac OSX, and Windows and supports numerous vector, raster, and database formats and functionalities: <http://www.qgis.org/>