An Introduction to GIS Fundamentals

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Training event (C1) of Daylighting rivers

2017-1-IT02-KA201-036968 Florence Oct. 1st – 5th 2018

Goals of the training workshop

- Describe the foundational concepts of spatial analysis and mapmaking
- Describe the general structure and purpose of Geographic Information Systems (GIS)
- Describe spatial data formats and sources of spatial data
- Apply concepts of spatial analysis using open data sets to answer site-related problem
- Discuss resources for further information and instruction on QGIS and other spatial analysis tools

Structure of the training workshop

- Part 1. Introduction
- Part 2. QGIS fundamentals
- Part 3. QGIS configuration (Panels, Toolbars, Plugins, Projections)
- Part 4. Layer and Data
- Part 5. Vector tools
- Part 6. WEB tools
- Part 7.Raster tools
- Part 8. Print composer
- Part 9. Digitizing tools
- Part 10. Case study

Outline of the contents

- ❑ Why map?
- ❑ What is GIS?
- ❑ Orientation to QGIS
  - Open a shapefile
- ❑ Basic operations in QGIS
  - Make a basic map
  - Add a shapefile layer with points
  - Query and filter by attributes
  - Apply basic styling
- ❑ More operations in QGIS
  - Select by location/attribute
  - Import/Export data
  - Introduction to file structure
  - Adding base maps in QGIS
  - Working with TXT/CSV data
  - Projections
- ❑ Basic operations with Raster files
- ❑ Using Print Composer to create a map

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PART 1. INTRODUCTION

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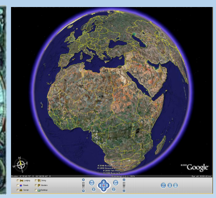
WHY DO WE CREATE MAPS?

- Historically, maps have been the primary means to store and communicate spatial data.
- **Objects** and their **attributes** can be readily depicted, and the human eye can quickly discern **patterns** and **anomalies** in a well-designed map.
- **Points** can be shown as symbols of various kinds, depicting anything from a windmill to a church; **lines** can be symbolised to distinguish between major roads, minor roads, and rivers; and **areas** can be symbolised with colour, shading, or annotation.







TYPES of MAPS

- **General Reference Maps**:

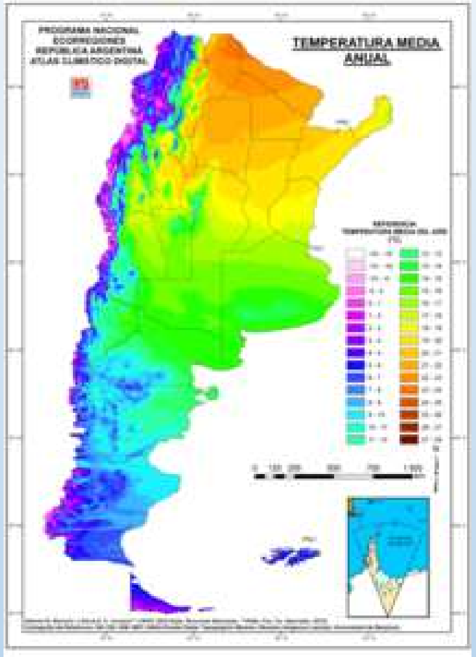
show important physical features of an area; Include natural and man-made features; Usually meant to help aid in the navigation or discovery of locations; Can be stylized based on the intended audience (tourists vs locals).

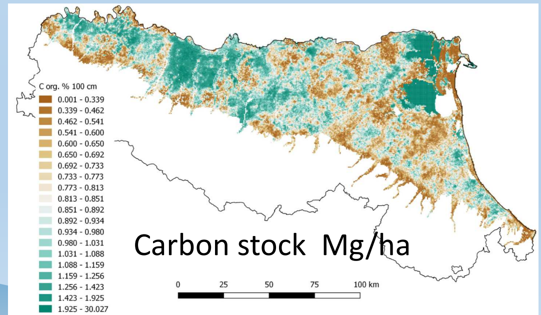
- **Thematic Maps**:
- Focuses on a specific theme or subject area; Features on the map represent the phenomenon being mapped; Spatial features used for reference.

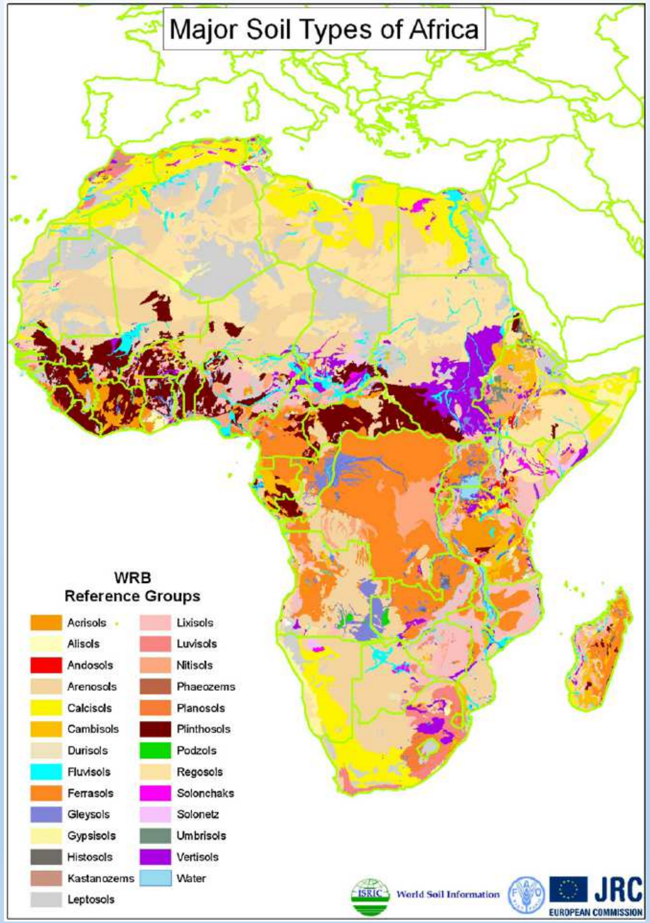
TYPES of MAPS

❑ General Reference Maps

❑ Thematic Maps

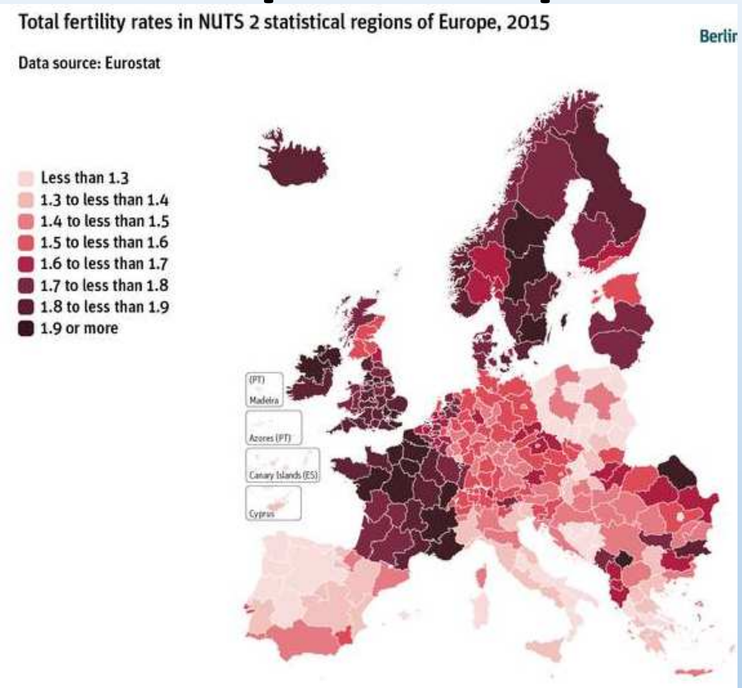


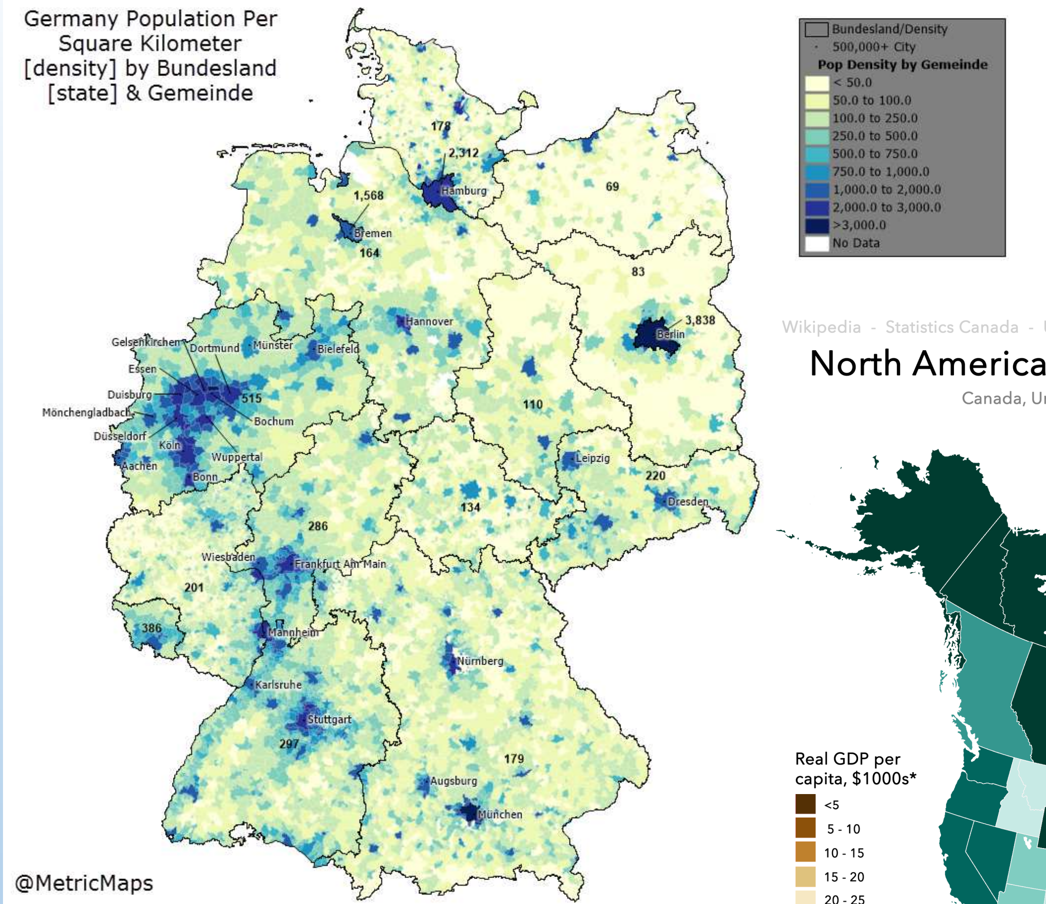


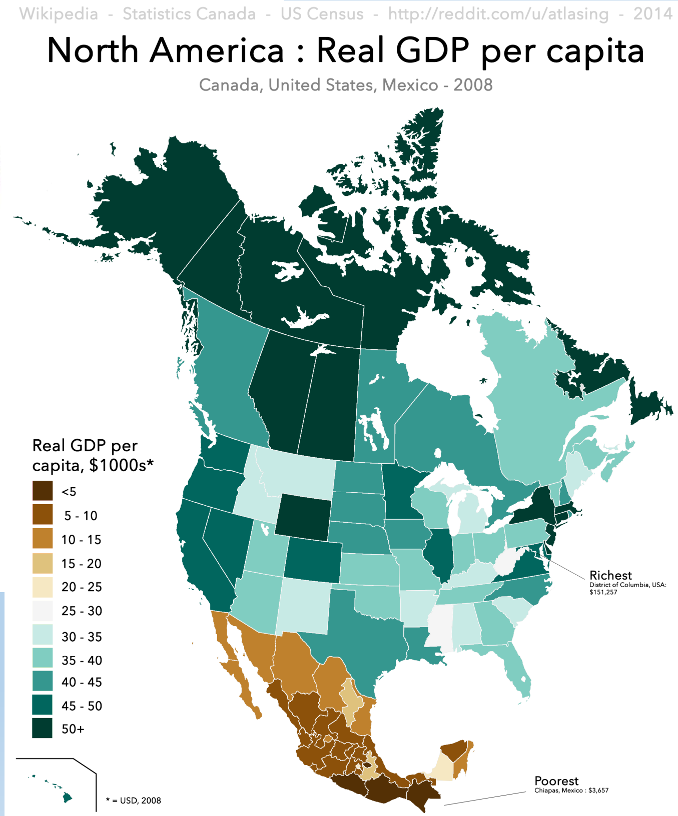


TYPES of MAPS

❑ Choropleth maps







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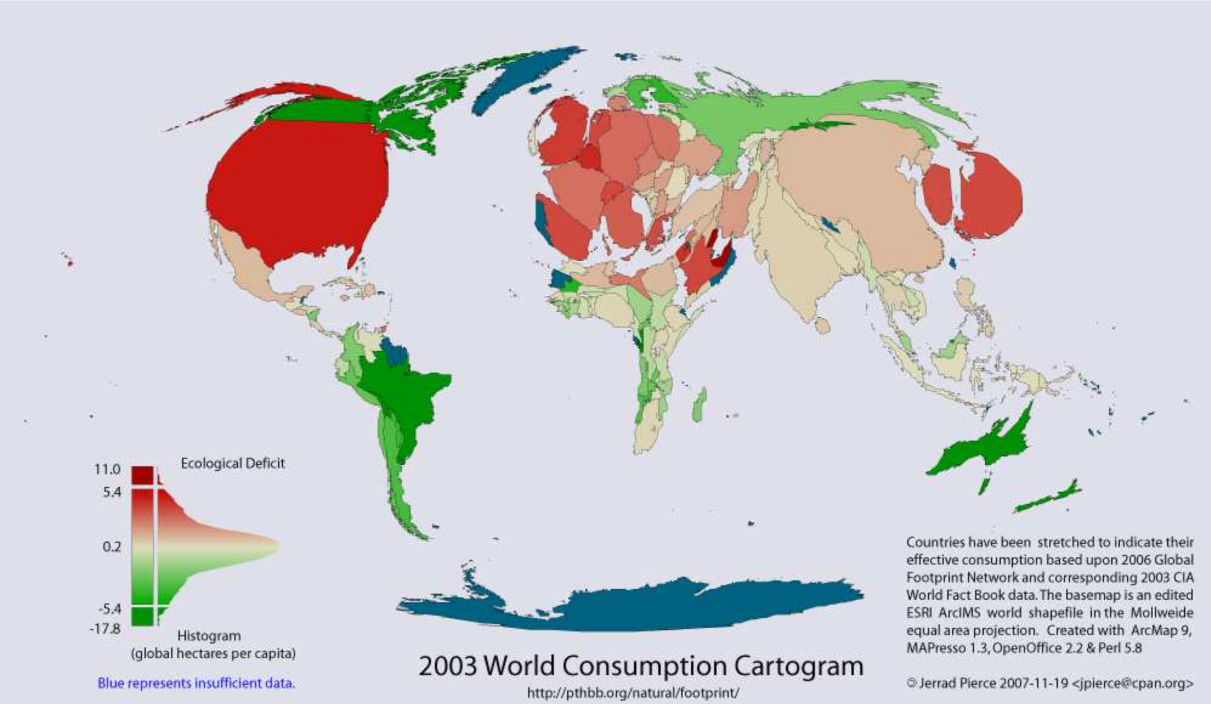
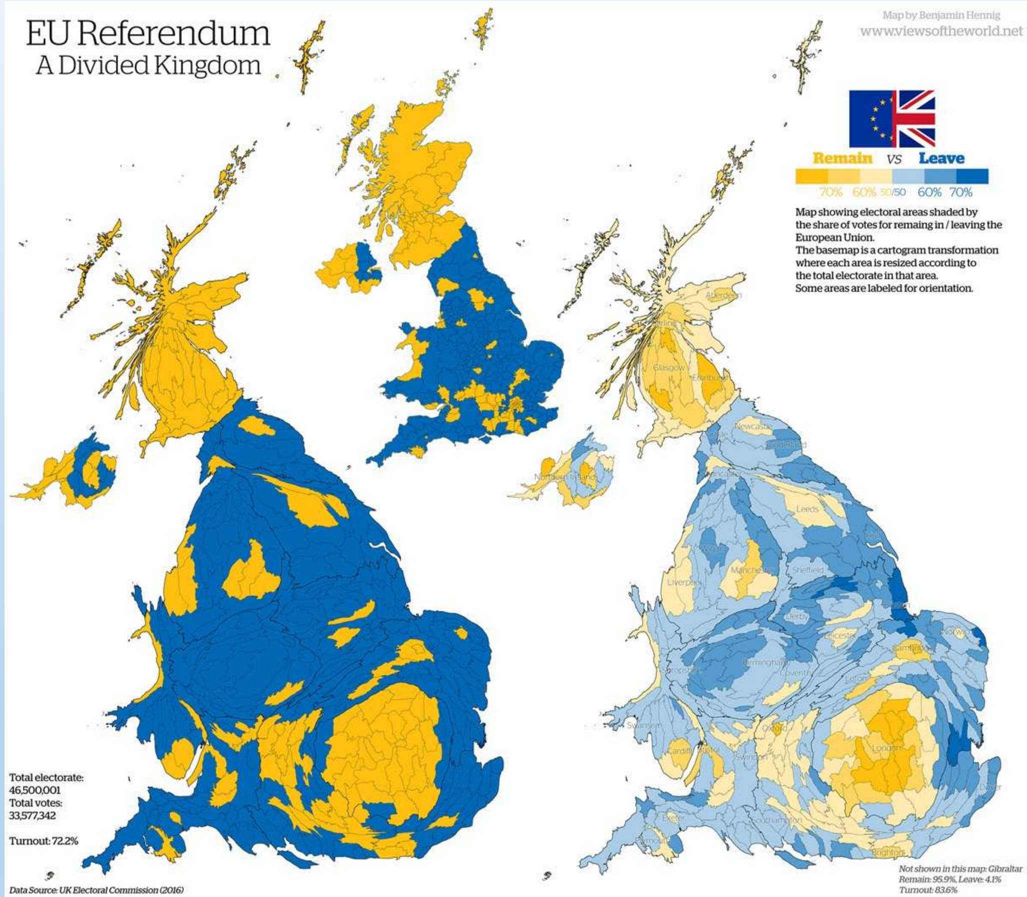
TYPES of MAPS

❑ Area cartograms





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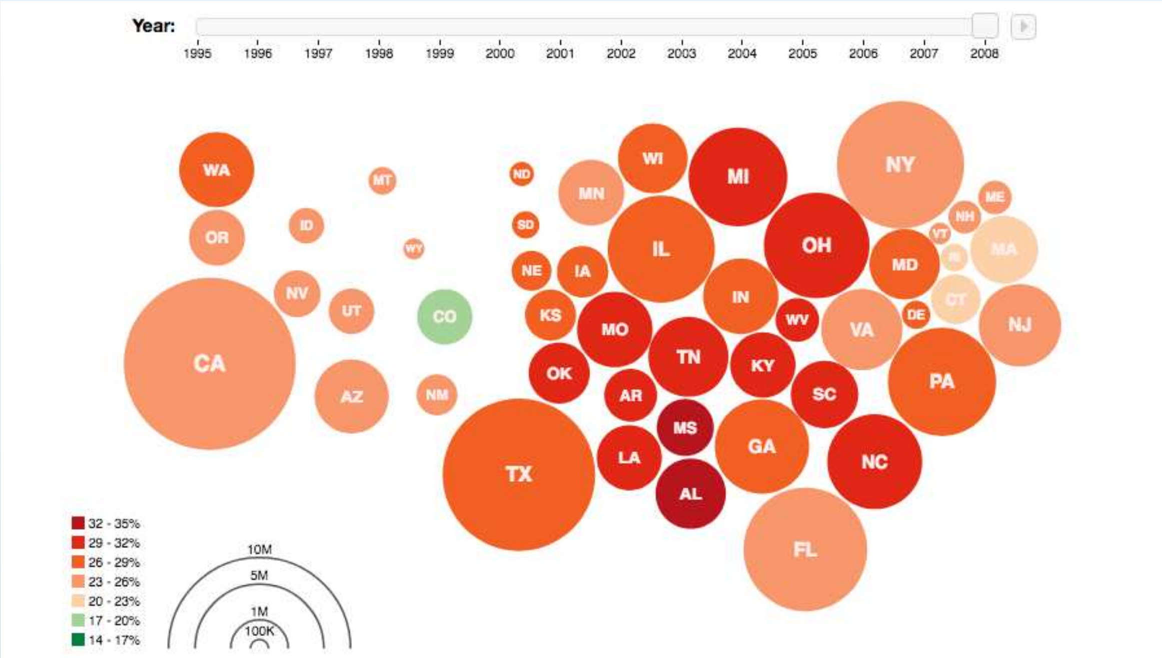
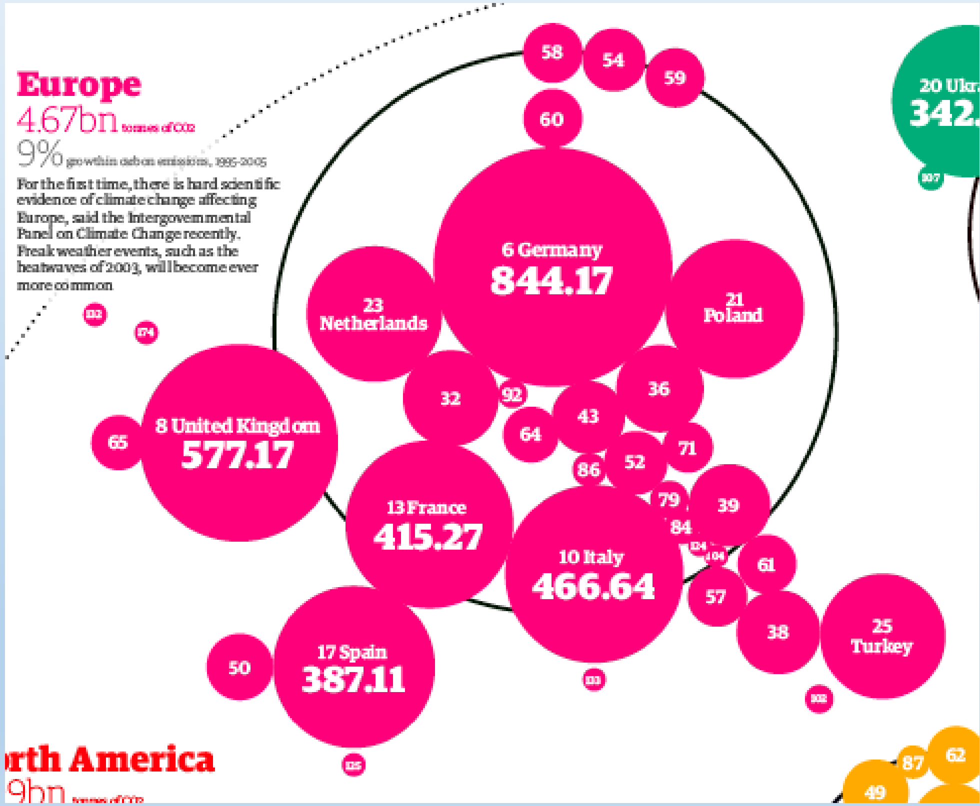
TYPES of MAPS

❑ Dorling cartograms



Obesity by State U.S.

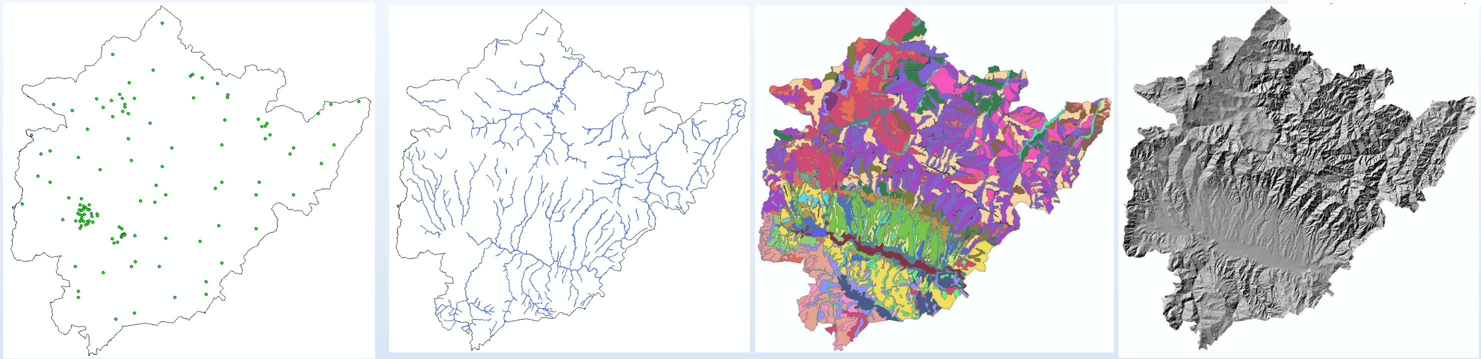
CO2 emissions Europe



SPATIAL OBJECTS

Objects displayed on maps are:

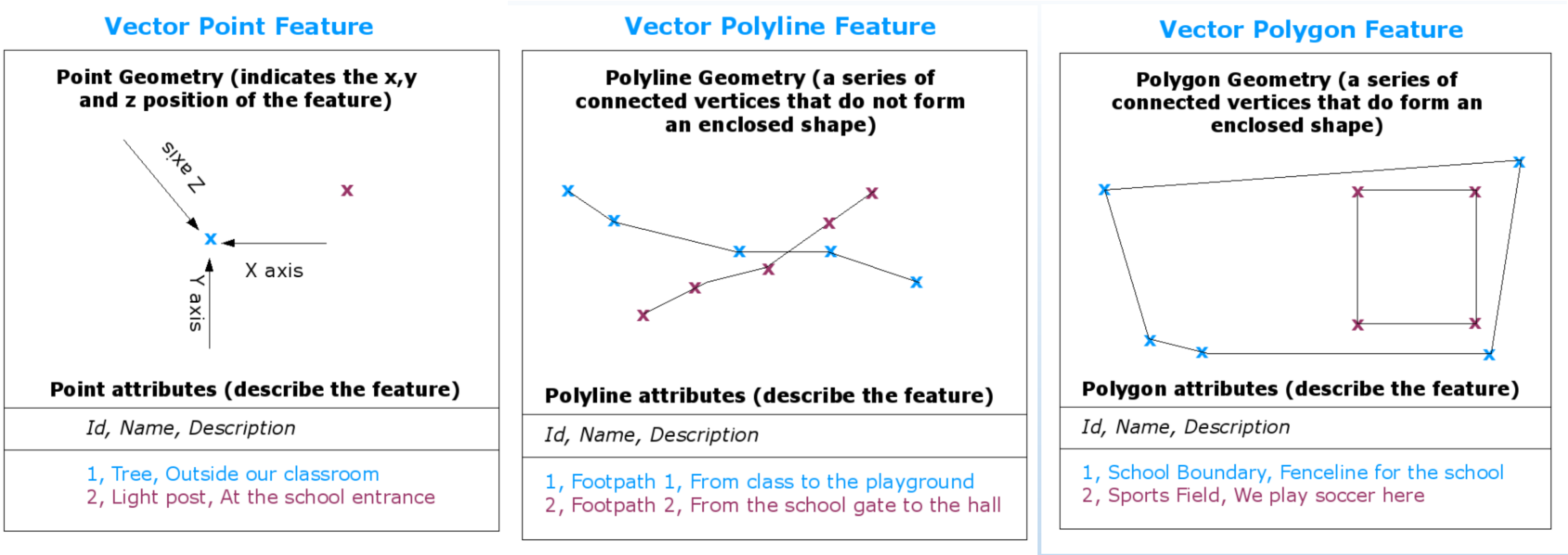
- ❑ **Points** (1D)
- ❑ **Lines** (1D)
- ❑ **Areas** (2D)
- ❑ **Surfaces** and **Volumes** (3D)



Each of these five classes of ***OBJECTS*** has its own techniques of representation in digital systems:

- **POINTS** as pairs of coordinates, in latitude/longitude or some other standard system;
- **LINES** as ordered sequences of points connected by straight lines;
- **AREAS** as ordered rings of points, also connected by straight lines to form polygons;
- **SURFACES** and **VOLUMES**: no standard representation yet

The software for capturing and storing spatial data, analysing and visualising them, and reporting the results of analysis must recognise and handle each of these classes.



Spatial objects are described by **ATTRIBUTES** i.e. recorded data or characteristics associated to an object.

Attributes can be:

Nominal. An attribute is nominal if it successfully distinguishes between locations, but without any implied ranking or potential for arithmetic. For example, assigning arbitrary numerical values to ***classes of land use***, e.g. 1=arable, 2=woodland, 3=urban, 4=other.

Ordinal. An attribute is ordinal if it implies a ranking, in the sense that Class 1 may be better than Class 2, but as with nominal attributes no arithmetic operations make sense, and there is no implication that Class 3 is worse than Class 2 by the precise amount by which Class 2 is worse than Class 1. An example of an ordinal scale might be the ***Land Capability Classification***.

Attributes can be:

The remaining three types of attributes are all quantitative, representing various types of measurements.

Interval. Attributes are interval if differences make sense, as they do for example with measurements of temperature on the Celsius or Fahrenheit scales, or for measurements of elevation above sea level.

Ratio. Attributes are ratio if it makes sense to divide one measurement by another. For example, it makes sense to say that one person weighs twice as much as another person, but it makes no sense to say that a temperature of 20 Celsius is twice as warm as a temperature of 10 Celsius, because while weight has an absolute zero Celsius temperature does not. It follows that negative values cannot exist on a ratio scale

Cyclic. Finally, some attributes represent directions or cyclic phenomena, and to encounter the property that two distinct points on the scale can be equal (for example, 0° and 360° are equal). Directional data are cyclic, as are calendar dates.

Spatial objects are described by **ATTRIBUTES**. These can be:

Explicit In this case they are typically stored as one or more fields in tables linked to a set of objects.

Implicit (sometimes referred to as intrinsic), in this case they are stored but hidden or computed as and when required (e.g. polyline length, polygon centroid, area, coordinates).

Raster/grid datasets typically have a single explicit attribute (a value/class) associated with each cell, rather than an attribute table containing as many records as there are cells in the grid.

Another relevant distinction is the following:

Spatially extensive attributes include for example total population, measures of a place's area or perimeter length, and total income: they are true only of the place as a whole.

Spatially intensive attributes include for example population density, average income, and percent unemployed: if the place is homogeneous they will be true of any part of the place as well as of the whole.

For many purposes it is necessary to keep spatially intensive and spatially extensive attributes apart, because they respond very differently when places are merged or split, and when many types of spatial analysis are conducted.

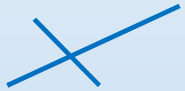
Three types of different relationships can be established between spatial objects:

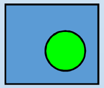
- **Relationships which are used to construct complex objects from simple primitives**

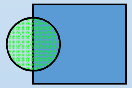
relationship between a line (chain) and the ordered set of points which defines it;

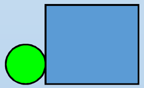
relationship between an area (polygon) and the ordered set of lines which defines it;

- **Relationships which can be computed from the coordinates of the objects**

two lines can be examined to see if they cross - the "crosses" relationship can be computed; 

areas can be examined to see which one encloses a given point - the "is contained in" relationship can be computed; 

areas can be examined to see if they overlap - the "overlaps" relationship; 

areas can be checked for adjacencies with neighboring areas; 

- **Relationships which cannot be computed from coordinates**

these must be coded in the database during input: we can compute if two lines cross, but not if the highways they represent intersect (may be an overpass)

TOPOLOGY

In mathematics, a property is said to be **topological** if it survives stretching and distorting of space. Many properties of importance to spatial analysis are topological, including:

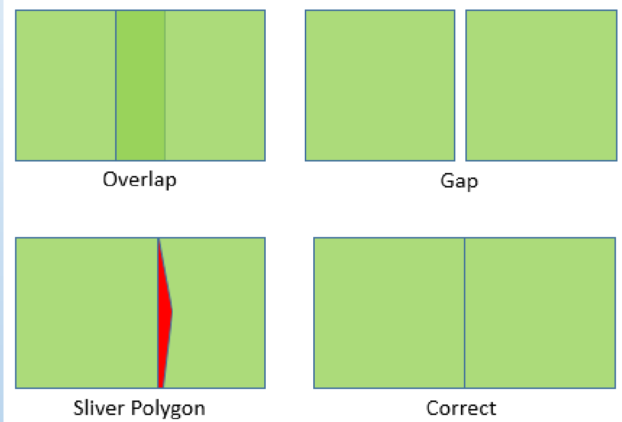
- The **distinction** between point, line, area, and volume, which are said to have topological dimensions of 0, 1, 2, and 3 respectively
- **Adjacency**, including the touching of land parcels, counties, etc
- **Connectivity**, including junctions between streets, roads, rivers, etc
- **Containment**, when a point lies inside rather than outside an area

Many spatial objects are subject to **topological constraints**: for example, two map units cannot overlap, two contours cannot cross, and the boundary of an area cannot cross itself.

TOPOLOGY

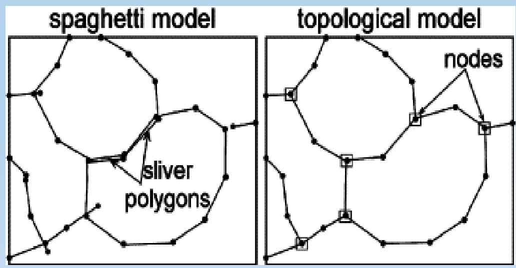
GIS geodatabases support an approach to modeling geography that integrates the behavior of different feature types and supports different types of key relationships.

In this context, topology is a collection of rules and relationships that, coupled with a set of editing tools and techniques, enables the geodatabase to more accurately model geometric relationships found in the world.



In GIS topology is employed for:

- ❑ Manage shared geometry
- ❑ Define and enforce data integrity rules
- ❑ Support topological relationship queries and navigation
- ❑ Support editing tools that enforce the topological constraints of the data model
- ❑ Construct features from unconstructed geometry (the "spaghetti" issue)



How do we make maps?

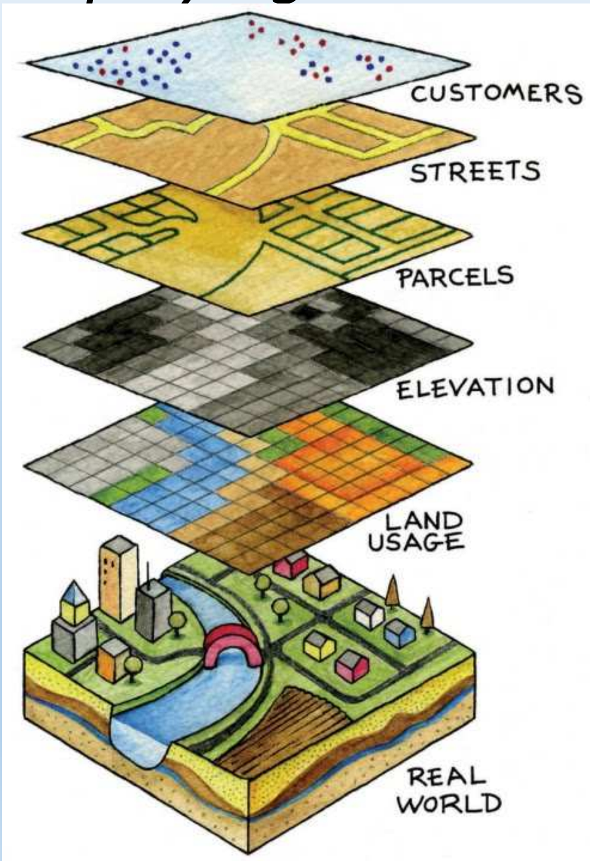
Geographic Information System (GIS)

“Any system for capturing, storing, checking, and displaying data related to positions on the Earth's surface”

…or more simply:

“In a GIS, you connect data with geography”.

The Remarkable Story of GIS https://gisgeography.com/history-of-gis/
https://www.gislounge.com/history-of-gis/



Geographic Information Systems (GIS)

- Analyze spatial information
- Create interactive queries (user-created searches)
- Operations on objects geometry
- Edit data in maps, create and/or modify attributes
- Present the results of all these operations