ISA

Geographic Information Systems 2025/2026

Lesson 19 -Map types and how to build a map in ArcGIS Pro/QGIS

U LISBOA | UNIVERSIDADE DE LISBOA INSTITUTO SUPERIOR DE AGRONOMIA

Topics

Types of maps
- Reference maps
- Thematic maps
- Photograph maps/ Photomaps
- 3D model maps

Map Elements
- Essential
- Accessories

Map design

How to build a map
- QGIs
- ArcGIS

Maps

- **Reference/base maps**: as a **reference map** when it provides a **general information** about a geographic context, such as terrain, roads, or political boundaries, and as **base map** when it is used as a **foundational layer** upon which other data can be overlaid

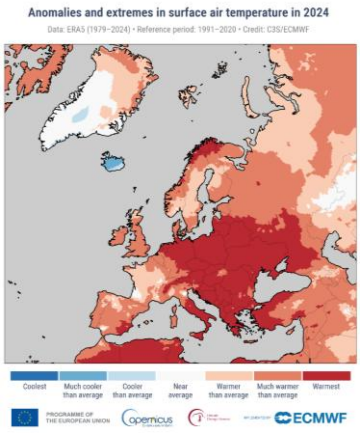
Topographic map

Hydrographic map

Maps

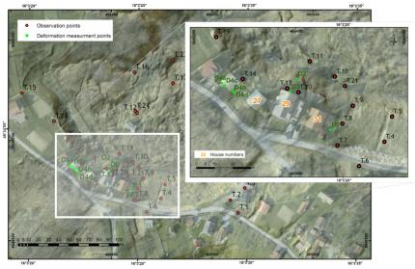
- **Thematic maps**:

Great diversity of types/ themes (climate maps, geological maps, agricultural maps, demographic maps, etc)

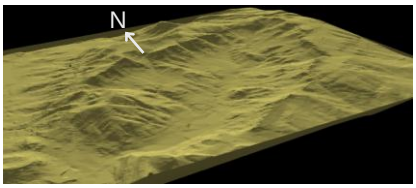


Maps

- **Photograph maps**: orthophotos, satellite images



- **3D model maps**



Map Types

Difference Between Reference Maps and Thematic Maps

Reference Maps
•**Purpose:** Show the location and names of geographic features, both natural and human-made, with the goal of accurately representing geographic reality.
•**Content:** Treat all features equally, without emphasizing any particular attribute or theme.
•**Examples:** Political maps, topographic maps, street maps, base maps, navigation charts, cadastral maps, and aerial/photographic maps.
•**Question Answered:** *Where is it? What is it?* (e.g., Where is the city of Paris? Where are the rivers in this region?)

Thematic Maps
•**Purpose:** Focus on the spatial distribution of a specific theme, variable, or phenomenon, often abstract or statistical in nature
•**Content:** Emphasize a particular subject (e.g., population density, rainfall, land use) and often use reference map features as a backdrop.
•**Examples:** Choropleth maps, dot density maps, isopleth maps, proportional symbol maps, cartograms.
•**Question Answered:** *How is it there? How does it vary?* (e.g., What is the average income in each region? Where are the highest rates of rainfall?)

Note: These categories are not mutually exclusive-a thematic map may contain reference information, and vice versa.

Map Types

Maps	Description & Examples	Map Type
Topographic Map	Shows elevation, landforms, hydrography, roads, and boundaries.	Reference
Political Map	Depicts countries, states, cities, and borders.	Reference
Street/Road Map	Shows transportation networks, streets, and routes.	Reference
Cadastral Map	Displays property boundaries and land ownership.	Reference
Navigation Chart (Nautical/Aeronautical)	Specialized for safe navigation, with detailed hydrographic/aeronautical data.	Reference
Photographic Map (Orthophoto, Satellite Image)	Map based on aerial or satellite imagery, often used as a base layer.	Photograph maps
3D Model Map	Represents terrain or structures in three dimensions (e.g., DEM, 3D city models).	3D model maps
Diagrammatic/Abstract Map	Transit maps, network diagrams & spatializations that may not correspond directly to geography.	Reference/Thematic
Indoor Map	Maps of building interiors (e.g., airports, malls), often for navigation.	Reference

Maps Types

Map Type	Description & Examples	Main Category
Choropleth Map	Uses color shading to represent data values in predefined areas (e.g., population density).	Thematic
Dot Density Map	Uses dots to represent the frequency of a variable (e.g., number of people, incidents).	Thematic
Isoline/Isopleth Map	Uses lines to connect points of equal value (e.g., temperature, elevation).	Thematic
Proportional Symbol Map	Uses symbols of varying size to represent data magnitude (e.g., city population).	Thematic
Cartogram	Distorts geographic space to represent a variable (e.g., resizing countries by GDP).	Thematic
Flow Map	Shows movement of goods, people, or information between locations.	Thematic
Bivariate Map	Displays two variables simultaneously, often using color and symbol combinations.	Thematic
Time-Series Map	Shows changes in a theme over time (animations or sequenced static maps).	Thematic

Maps elements

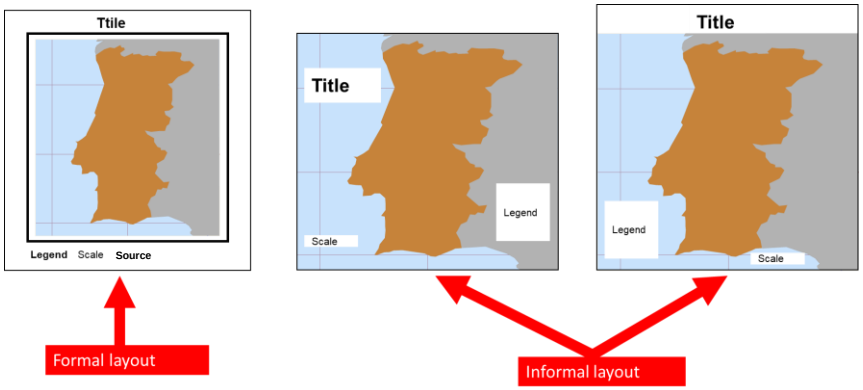
Essentials:

- Data or map frame
- Title
- Legend
- Scale

Accessories:

- Grids and Graticules
- Orientation
- Inset map
- Base map
- Map border or neatline
- Toponyms
- Metadata (citation, data source, notes, …)

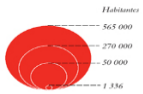
Map elements- overall design

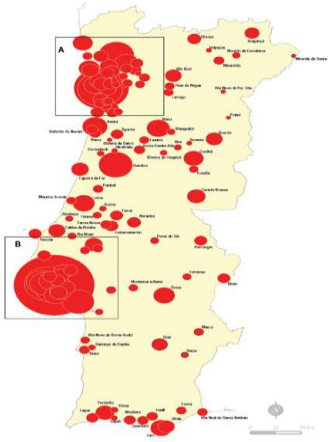


Map design - symbology

- **Maps of points and proportional symbols (Dot density map)**

1. choice of point value
2. calculation of density in test areas (**how many dots should represent the data within a given sample area**)
3. choice of point size
4. checking the distance (or coalescence) of points
5. if there is coalescence, decrease in size or value

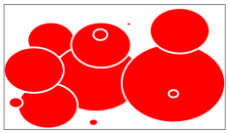




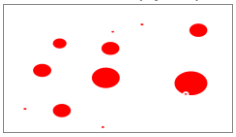
Map design - Maps of points and proportional symbols

- **Right size**

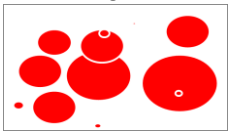
The circles “crush”



Sense of empty map

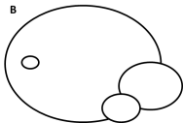


Searching for balance

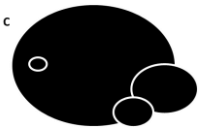


- **Right design**

A. advantageous solution, especially if there are numerous intersections of circles and information that does not need to be hidden



B. disadvantageous solution, due to the lack of contrast of the subject in relation to the background and if there are multiple intersections

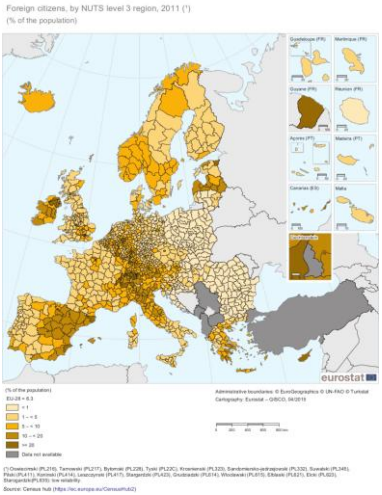


C. and D. advantageous solution due to the emphasis on the subject, but it may hide other information; need for separated halos (too big in C. and too small in D.)

Map design - symbology

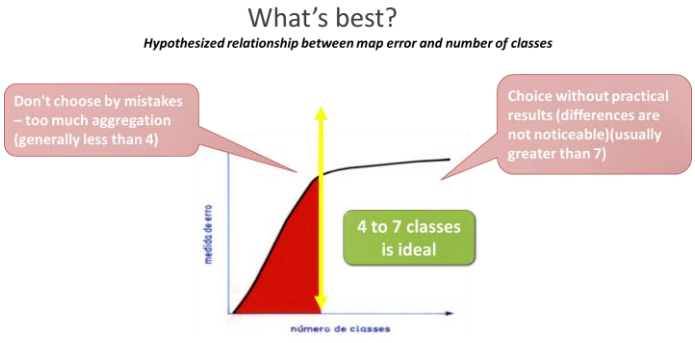
- **Choropleth maps**
  - Qualitative data
    - Symbols express differences in the phenomenon of graphic variation (color, pattern, or texture)
  - Quantitative data
    - Symbols express differences in the phenomenon of graphic variation (color, pattern, or texture)
    - Relative values (%, inhabitants/km2,…)
    - Classified data

Representations that depict phenomena within polygons, using data collected specifically for those spatial units.



Map design - Choropleth maps

- **Classes: n.º and intervals**



Map design - Choropleth maps

- Classes: methods

Method	How It Works	Best For	Data Distribution
Natural Breaks (Jenks)	Class breaks are created in a way that best groups similar values together & maximizes the differences between classes. Not useful for comparing multiple maps built from different underlying information.	Highlighting natural groupings and patterns.	Clustered or skewed
Equal Interval	Use equal interval to divide the range of data into equal-sized subranges. If you specify 3 classes for a field whose values range from 0 to 300, three classes with ranges of 0–100, 101–200, and 201–300 are created. This method emphasizes the amount of an attribute value relative to other values.	Best applied to familiar data ranges (e.g., % & temperature)	Uniform
Quantile	Assigns an equal number of features to each class. There are no empty classes or classes with too few or too many values. The resulting map can often be misleading. Similar features can be placed in adjacent classes, or features with widely different values can be put in the same class.	Comparing ranks or percentiles (e.g., quartiles)	Linearly distributed data
Standard Deviation	Uses the mean and standard deviation to define class breaks.	Emphasizing how far values deviate from average	Normally distributed
Geometrical Interval	Uses a geometric progression to create class ranges that grow proportionally. It is a compromise between the equal interval, natural breaks (Jenks), and quantile methods. It creates a balance between highlighting changes in the middle values and the extreme values, thereby producing a result that is visually appealing and cartographically comprehensive.	Exponentially increasing or skewed data.	Continuous data

Map design - Choropleth maps

- Classes: methods

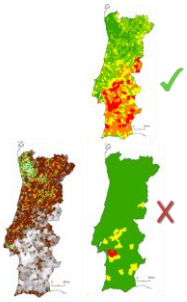
Method	How It Works	Best For	Data Distribution
Manual (Defined Interval) / Rule-based Classification (QGIS)	User defines specific class breaks manually. Interval size must be small enough to fit the minimum number of classes allowed (3 classes). In QGIS, this can be extended to combine multiple criteria for classification.	Applying domain-specific thresholds or rules	Any
Pretty Breaks (QGIS)	Creates rounded break values that are aesthetically pleasing & easy to understand. Focuses on creating "nice" numbers for legend labels (e.g., 100, 250, 500 instead of 103, 247, 506).	Maps for general audiences where round numbers enhance readability	Any
Logarithmic Scale (QGIS)	Transforms data using logarithms before applying classification, which compresses the range of high values and expands the range of low values.	Data with extreme outliers or exponential distributions	Highly skewed data
Fixed Interval (QGIS)	Sets a specific interval size between class breaks rather than a specific number of classes. Number of classes is determined by the range of data and interval size.	Comparing datasets using consistent measurement intervals	Regular interval data

Map design - Choropleth maps

- **General Rules**

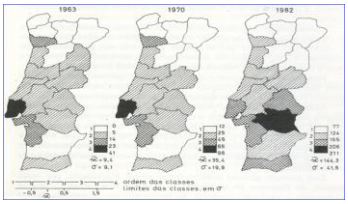
- N.° of classes (ideal min 4)
- Obtain “balanced” spatial contrasts

✓All values must be represented
✓ Each value can only belong to one class
✓ There must be no empty classes (zero effectives)
✓ There must not be exaggerated precision (in the legend)



Map comparison

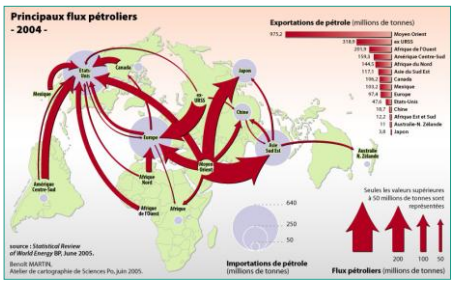
Must have similar classes:
a) Number and Interval
or
b) Classification method



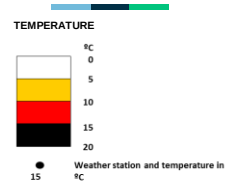
Colors and symbols used should be as similar as possible. Ideally, a single legend should be used for all maps.

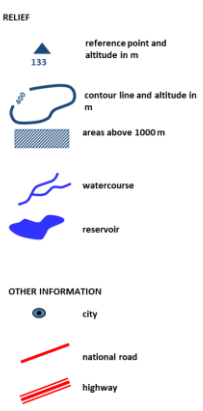
Map elements - Legend

- According to the nature of the data
  - Qualitative
  - Quantitative
- According to the form of theme representation
  - Point-based (e.g., proportional circles, spheres…)
  - Linear (e.g., isolines, flow maps…)
  - Areal (e.g., choropleth maps…)
- According to the number of themes
  - Single-theme
  - Multi-theme
    - By graphic juxtaposition/ contrast
    - By combination



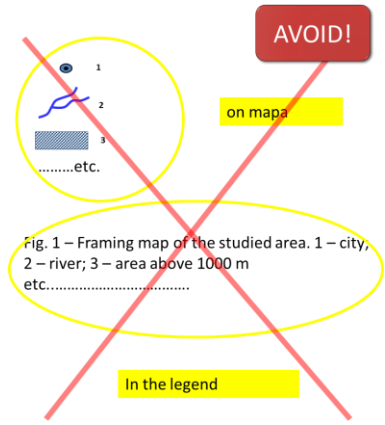
Map elements - Legend





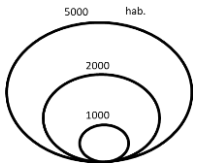
Distinct

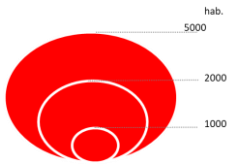
Symbols with greater visual prominence on the base layer

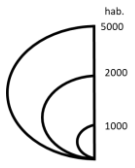


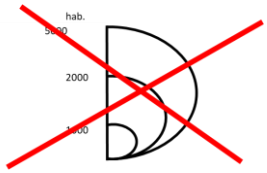
Map elements - Legend

Maps of points and proportional symbols







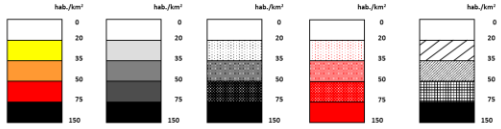


- **Legend with 3 to 4 circles (or semi-circles): larger, smaller, and 1 or 2 in between**
- **Most common but least recommended solution**
- **Difficulties in estimating unlabelled map values**

Map elements - Legend

Choropleth maps

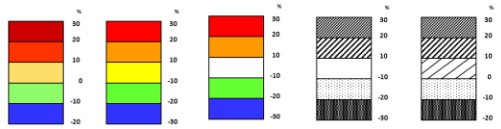
Progression
- Unipolar
- Bipolar (divergent)



Unipolar

The color scale starts with a light shade for low values and becomes darker for higher values (or vice versa).

Never change the plot symbol in unipolar sequences



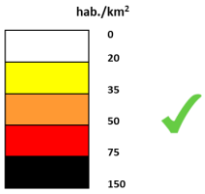
Bipolar

The color scale has a neutral color at the midpoint (zero) and diverges into two contrasting colors for positive and negative values.

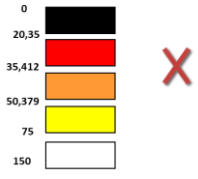
Map elements - Legend

Choropleth maps

- Symbol – description
- Never forget units (quantitative)
- To not have much detail in the descriptions



- Visual order should correspond to that of the values
- Greater visual weight should be at the bottom (seq. Unipolar)
- Continuous values / continuous symbols (inverse)



Map elements - Legend

Color connotation

Color	Color connotation	Use in Cartography
	Purity, cleanliness, disease, faith	Background information, weak value classes
	Joy, warm, dry, youth, hate, cowardice, optimism	Areas of little vegetation or drought
	Fire, autumn, tasty, abundance, attention	(see red; brown: relief, terrain)
	Action, importance, danger, passion, power, anger, bravery	Hot and dry areas, roads, positive variations
	Youth, nature, peace, immaturity, envy, ignorance	Green, wooded or low areas
	Cold, serenity, solitude, formality, melancholy	Water, cold areas, heavy rainfall, negative variations
	Quietness, reserve, sadness	Marginal areas
	Mystery, strength, weight	Buildings, border, toponymy

Map elements - Scale

- "1 centimetre on the map represents 500m on the ground"

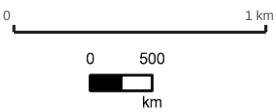
Verbal
(always with predefined units)

used in a speech, in oral statement

- 1:500 000

Representative Fraction (RF) - Fractional Scale - Ratio Scale
(without predefined units)

used on wall maps, in the source of information

- 

Bar Scale - Graphic Scale - Linear Scale
(always with predefined units)

used on maps for measuring distances, maps that can be reduced or enlarged

Map elements - Representative Fraction

1:25 000

Preferable

1/25 000

$$\frac{1}{25\,000}$$

Any distance measured on the map is 25,000 times smaller
=
1 mm on the map corresponds to 25 m in reality
=
1 cm on the map corresponds to 250 m in reality etc.

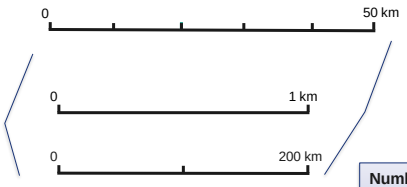
Avoid!

⇩⇩

1 : 25 000
1:25000
1:25.000
1:25,000
1:25 000 cm
1:25 123

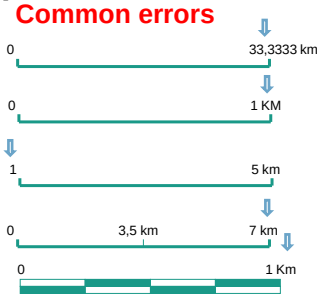
Map elements - Scale bar -graphical

Scale size: as it serves better based on the dimensions of the map
Subdivision: only necessary in large segments



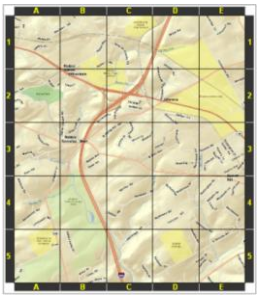
Start always with: 0

Common errors



Numbers at the end of the graphic scale: 1, 2, 5 or 10, 20, 50 or 100, 200, 500…
Map units: m, km, mi, etc. (**abbreviations** in **lowercase** letters!)

Map elements - Grids and Graticules



- A grid is a network of evenly spaced horizontal and vertical lines used to identify locations on a map.

- Grids are also used to display measured locations using projected coordinates on the map (blue lines)
- Graticules are lines showing parallels of latitude and meridians of longitude for the earth.

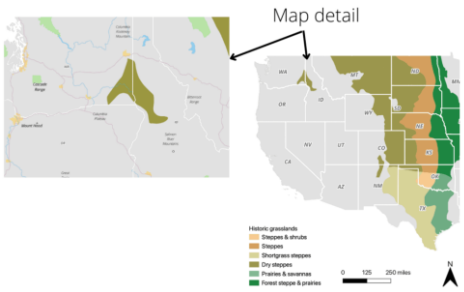
Map elements - Orientation

We don't use the north arrow whenever North is facing the top, and in this case, we replace it with the graticules.

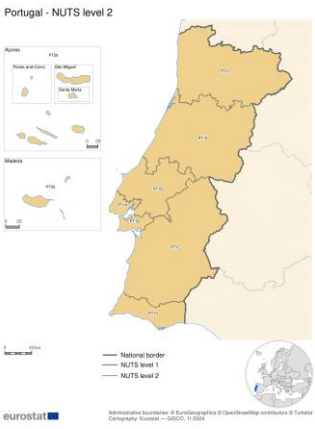
If necessary, choose a graphically simple solution.

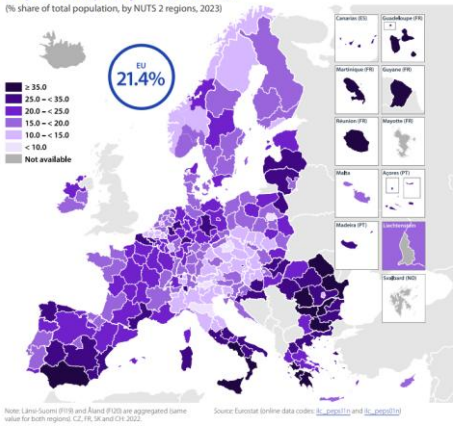
Map elements - Insert Map

- To help provide geographic context
- To show an area of detail



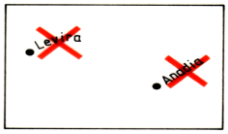
Map elements - Metadata





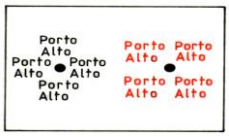
Map elements - Toponyms (point symbols)

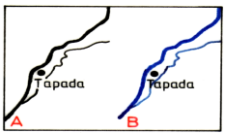
rule: horizontal



conflits

possible positions



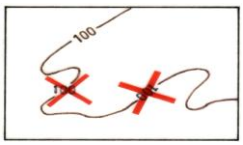


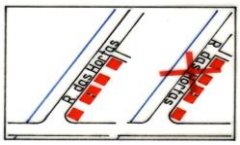
symbol interruption

Make reading easier!

Map elements - Toponyms (linear symbols)

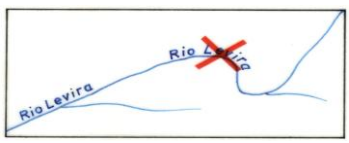
legible and coherent





vertical or close alignments

watercourse



Make reading easier!

Map elements -Toponyms (linear symbols)

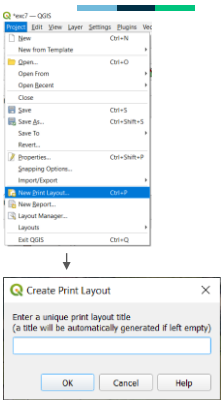
On the outside, following the orientation of the patch

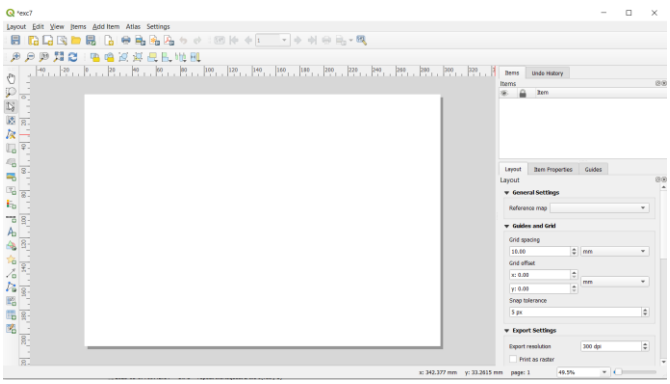
The same, following the general rule (horizontal)

Internal identification

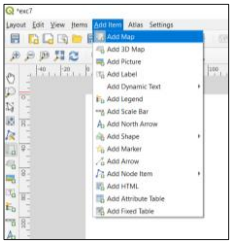
Make reading easier!

How to build a Map - QGIS

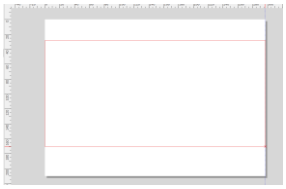




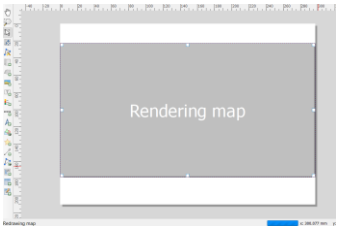
How to build a Map - QGIS

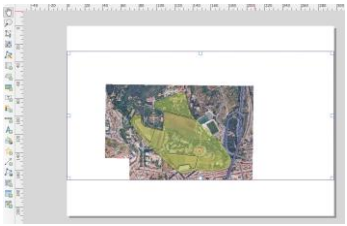


Once the **Add Map** button is activated, hold the left mouse bottom and drag a rectangle where you want to place the map

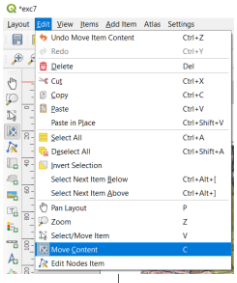


This rectangle window will be rendered with the map from the main QGIS canvas. The map may need adjustment to focus on the focus area of mapping.

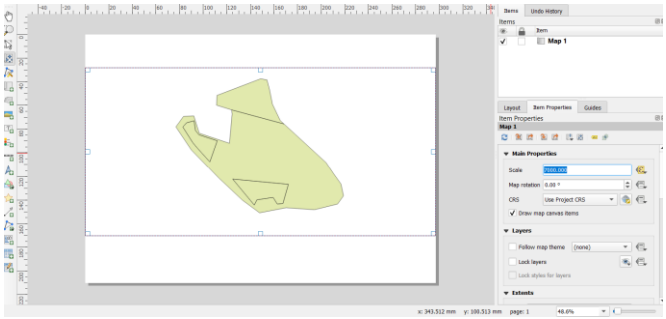




How to build a Map - QGIS

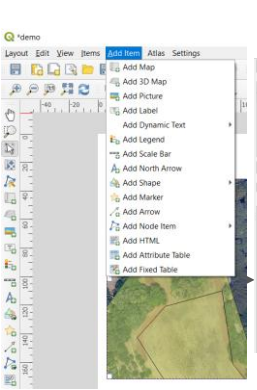


Move the item content to pan the map in the window and center it in the composer, adjust the zoom.

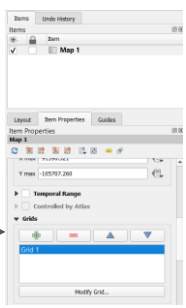


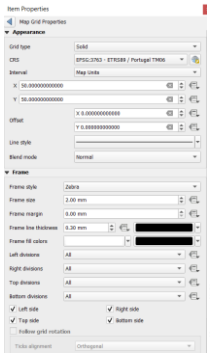
To adjust the zoom level based on a given scale, in the item properties tab, enter the value next to scale.

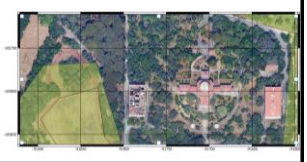
How to build a Map - QGIS



Add graticules

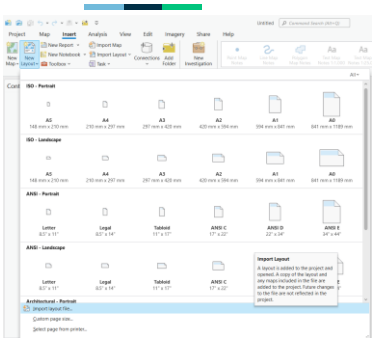


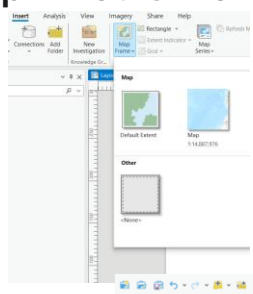


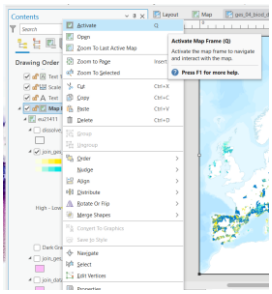


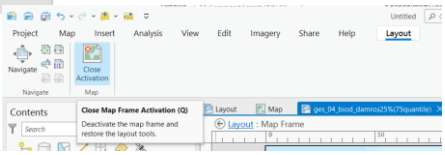
Add map elements

How to build a Map - ArcGIS Pro





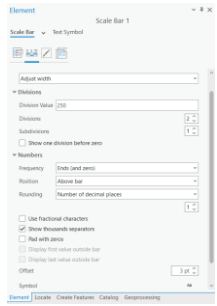


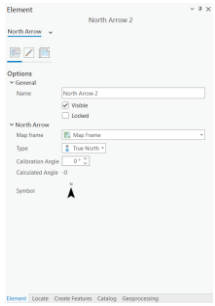


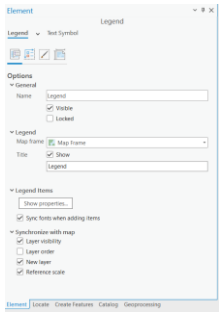
- Create a new layout or import one already built.
- Add the map frame, adjust the focus on the area of interest by activating the map framework
- Close activation when it is ready

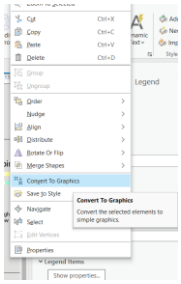
How to build a Map - ArcGIS Pro

- Add map elements from the Insert tab
- Edit the elements in the element window



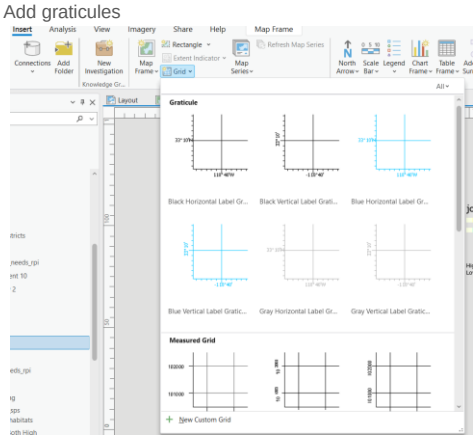


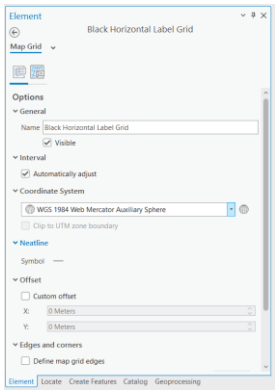




How to build a Map - ArcGIS Pro

- Add graticules





Credits

The content of this class is developed partially based on material developed by the Cartography course team of the Institute of Geography and Spatial Planning (IGOT), University of Lisbon.