GeoViZ Toolkit

A guide to geographic data visualisations

GOVERNMENT GEOGRAPHY PROFESSION

BCS GEOVIZ PROGRAM

BRITISH CARTOGRAPHIC SOCIETY

Introduction

The way we use and visualise geographic data continues to evolve. Data is everywhere and is used to inform, educate and solve global issues.

To help make sense of this data, we must ensure we have the tools and understanding to analyse and visualise that data in the best way possible, making sure it's accessible to those trying to make sense of it.

GEOVIZ is a programme created by the British Cartographic Society which supports and nurtures the visualisation of geographic data in whatever form that might take.

This toolkit, made in collaboration with the Government Geography Profession, is part of the GEOVIZ programme. It provides the basis for creating maps and data types to interactive apps. To keep it digestible, summaries and links are provided for individual sections.

To find out more about the British Cartographic Society and the GEOVIZ Programme visit cartography.org.uk/geoviz.

Copyright

How to use this guide

The GEOVIZ Toolkit was created with a general audience in mind, and it covers the basics of data collection, analysis and visualisation. It was built for anyone with a personal or professional interest in the field, though it is not an in-depth guide.

Content overview

1. Understanding data
2. Graphs and charts
3. Types of maps
4. Map elements
5. Projections
6. Design and layout
7. Tools and software
8. Resources and feedback

Flowchart

This is a guide to the process of making a data visualisation. It provides an overview of gathering, analysing and presenting data. Within the flowchart, all chapters and sub-sections are highlighted.

Linked tables

The *How to's, Going further* and, *Inspiration* links take you to external basic tutorials, more advanced tutorials and visualisation ideas relating to the section topic.

How to's	Going further	Inspiration
• ArcGIS Pro • QGIS • Blender	• Terrain in Photoshop	• Thailand • Switzerland

Summary tables

Here, the information on a given topic is presented in a bite-sized format. These are great general guides to save and/or print for future reference and quick refreshers

Resources and Feedback

At the end of the guide, a spreadsheet gathers all the resources used to make this toolkit alongside the recommended links. These can be sorted by type, chapter and section.

A feedback form is provided for any comments, suggestions, or questions. We value feedback so don't hesitate to use it to help us improve!

Table of Contents

What are you trying to find out/demonstrate?
Define your purpose, aim and question.

Follow the flowchart to see where you are in the data visualisation process

CAPTURE

Do you have the data ?

yes

Is it ready to be used?

yes

- **Data quality**
- **Data classification**
- **Data analysis**

no

In which format is it?
e.g. text, csv, xls, shp, jpeg, etc.

- **Data types**

Does it have a geospatial component?
e.g. region, place, street

no

Does that data already exist?

yes

- **Data collection**

no

CREATE

yes

- **Map types**
- **Map elements**
- **Projections**
- **Mapping tips**

Maps

no

Graphs & Charts

- **Chart types**
- **Choosing charts**

Tools and software

- **GIS**
- **Charts and graphs**
- **Dashboards**
- **Coding**
- **Design**
- **Story maps**

COMMUNICATE

Design & Layout

- **Purpose and design**
- **Layout and spacing**
- **Text, spacing and images**
- **Accessibility and size**

1.

Understanding data

DATA

/DEɪ.TƏ/

NOUN:

Information, facts or numbers, collected to be examined and considered and used to help decision-making or information in an electronic form that can be stored and used by a computer.

1.1. Spatial data types

Spatial data can usually be classified into two categories: Vector and Raster.

Vector data

Vector data represents information as individual elements with attributes. Each point, line or polygon is discrete and precise, taking up less storage. It is good for analytics of individual features, precise measurements, spatial queries and geometric calculations (e.g. buffering, intersection, overlay, etc.) and can be used for qualitative, quantitative, and sequential purposes.

Point data

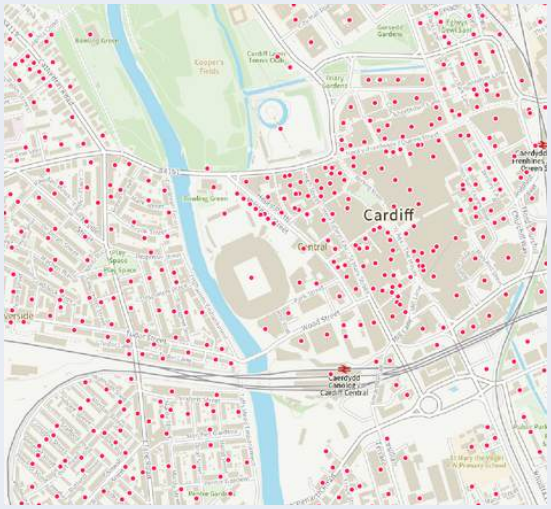
Point data represents specific locations or points on the Earth's surface. Each point has a defined set of coordinates (latitude and longitude or projected coordinates) that denote its exact position.

Common formats

- .csv
- .shp/.shx
- .tab
- .kml/.kmz
- .json
- .dbf

Examples

- City location
- Landmarks
- Soil samples
- Coordinates



Line data

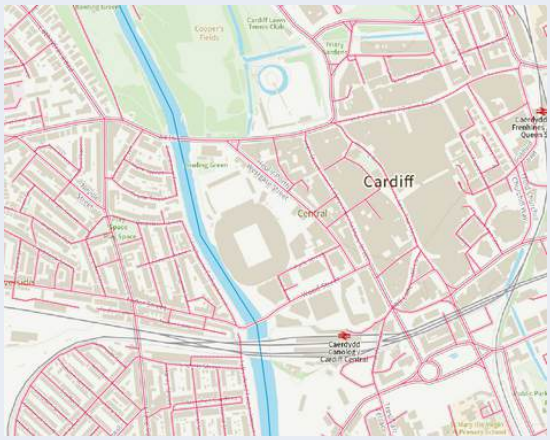
Line data consists of connected sets of points, forming lines or linear features and entities.

Common formats

- .gpx
- .shp/.shx
- .tab
- .kml/.kmz
- .json
- .dbf

Examples

- Roads
- Rivers
- Railway
- Pipelines



Polygon data

VECTOR DATA

Polygon data represents areas or regions on the Earth's surface. It consists of closed shapes formed by connecting sets of points, typically using straight lines.

Common formats

- .gpx
- .shp/.shx
- .tab
- .kml/.kmz
- .json
- .dbf

Examples

- Administrative units
- Land parcels
- Building and area footprint
- Climate zones

Raster data

Raster data is in a grid or pixel format. Each cell or pixel has a value and/or attribute. It divides an area into equal-sized cells, making it great for continuous data. The grid structure of the raster tends to make the files larger but provides a smooth and continuous analysis of spatial patterns.

Raster and image data

RASTER DATA

Often collected with remote sensing technology (aircrafts, satellites, sensors, etc.), imagery and rasters are great as a basemap and data changing continuously across a landscape respectively.

Common formats

- .img
- .tif/.tiff
- .kml/.kmz
- .jpeg/.jp2
- .sid/.sdw
- .adf

Examples

- Elevation
- Aerial images
- Climate data
- Land cover

3D and surface data

RASTER DATA

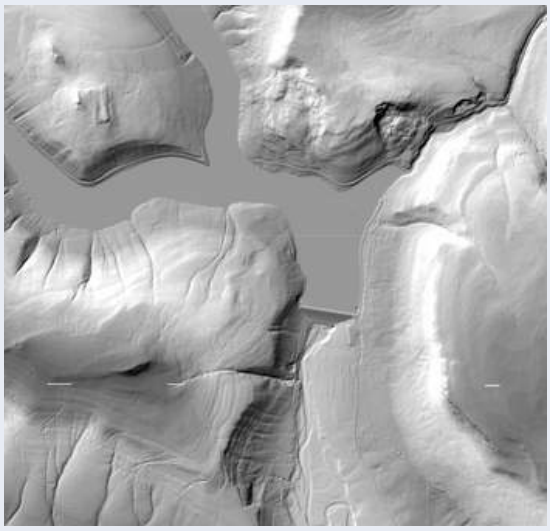
3D and surface data represent spatial features in three dimensions, incorporating height or elevation information. It is used to represent structures with height and volumetric attributes

Common formats

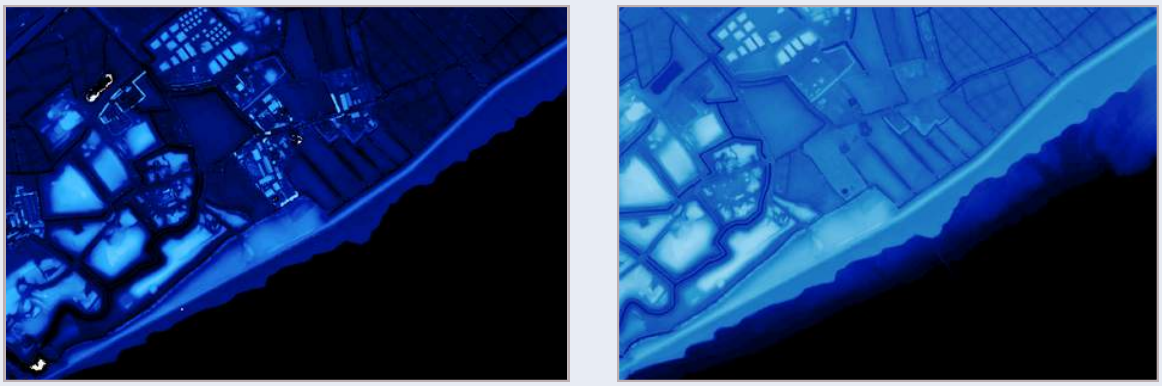
- .3ds
- .dgn
- .dwg/.dwf/.dxf
- .dxf
- .dbf
- dem/dtm

Examples

- Terrain
- Buildings
- Forests
- Sea floor



Terrain,© Crown copyright and database rights. Ordnance Survey 2024



DSM (left) and DTM (right) Images. Defra Survey Data Download.

1.2. Data collection

Acquiring the data is a core part of any spatial data visualisation and can be the most time-consuming part of a project.

Primary data collection

Primary data collection typically involves directly acquiring data through fieldwork. For vector data, this often means using tools like Global Positioning Systems (GPS) or surveying equipment for direct data capture.

Pros	Cons	Methods
• Answers the exact focus of the study • Approach and methods tailored to the question being answered	• Data capture can be time consuming • Can be costly • Need of resources for the data collection	• Survey equipment (GPS units, total stations, geo-tagged photos, etc.) • Questionnaires (Interviews, survey apps, printed forms, etc.)

Secondary data collection

Secondary data collection involves using geospatial data available in digital and hard-copy formats. Before starting any Geographic Information System (GIS) project, it's a good idea to search online resources for pre-existing GIS data that could meet your mapping requirements, so you can avoid the potentially laborious process of creating data from scratch.

Pros	Cons	Methods
• More time-efficient • Otherwise non-collectible data • Credible sources	• No control over quality • Potential access restrictions and/or fees • Not familiar as collected by someone else	• Downloading datasets • Digitizing and geo-referencing scanned maps or satellite images • Joining and relating data in reports and documents

Data sources

- International agencies (CGIAR, United Nations, World Bank, …)
- Governments (USGS, NASA, NOAA, Defra, …)
- Universities
- Commercial websites (ESRI, EDINA, OS, ...)

TIP

Whether open-source or commercial, make sure to always check authorised uses of the data and to state it's sources/author.

1.3. Data quality

A data visualisation can only be as good as the data that goes into it. Many dimensions contribute to data quality, including its content, processes, governance and design. Here we cover the basic ways to ensure the data is fit for purpose and credible.

Metadata

Metadata is the information about the data. In a geospatial data context, the metadata of a data set should include:

- **Spatial scale**: the wider the area, the more generalised the data will be
- **Projection**: the smaller the area, the more important the projection is.
- **Date** of collection and/or update frequency: is the information up-to-date?
- **Description** of the content: what information on the attributes is given?
- **Area and/or period** covered: does it cover the time/area needed for analysis?

Good metadata helps to understand the context of the data collection. It comes in different forms of written documentation (txt., doc., ...).

C.A.S.C.

Combining information requires assessing each source to see if it meets the set standards. It's worth considering whether your data matches four criteria: completeness, accuracy and precision, source scale, an consistency.

- **Completeness:** Do the datasets show all the features intended? Has anything been omitted?
- **Accuracy and precision**: Are the objects in the right place? Is the level of detail appropriate for the scale? Is the source data reasonable in its generalisation?
- **Source scale**: Has all the data or information been collected at a similar scale? E.g. different projections and spatial resolutions.
- **Consistency:** Do the datasets show similar objects in the same way, and have they been classified consistently?

It's good to remember that data quality will vary across companies, bodies and governments. Usually, guidelines will be available on this.

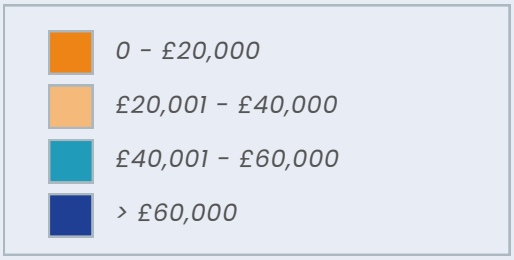
1.4. Data classification

Often, you will need to map a table of data. If there is too much data to map each item, you need to engage in data classification. Classification is dividing data into groups with meaning according to the statistics being mapped and meaning to the map's audience. The purpose of mapping a set of statistics is to visualise the geographical patterns that the statistics reveal, and good classification can aid that process.

There is no foolproof way of classifying data, and therein lies the potential to mislead an audience. As seen in the examples below, different data classification methods can result in different visualisations derived from the same dataset. Therefore, you need to understand the different methods of classification. The characteristics and significant aspects of the mapped phenomenon must be well represented.

Arbitrary

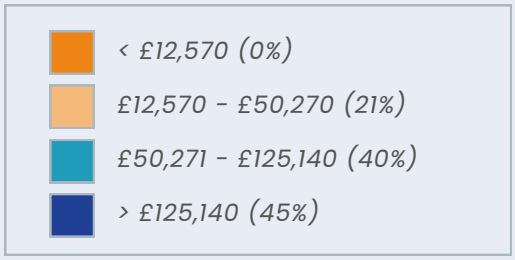
Division by regular rounded numbers (e.g. 10, 20, 30 , …). This is easy to use and the legend is understood by the reader. However, it reveals very little about the data



Here, income data is classified by bands of £20,000.

Exogenous

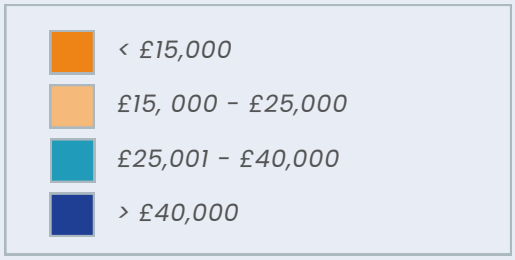
Divisions imposed from the outside (e.g. tax bands, national income level/classes standards)



Here, income classification follows the bands of the UK income tax rates (%)

Idiographic

Natural breakpoints and divisions in the data. This method is often used when mathematical methods fail to produce a useful classification. The intervals are mis-understood by the reader.



Here, the classification follows 10%-population-income brackets (e.i. 10% of the population earns under £15,000)

TIP

Ideally, **use at least 4 classes** (to avoid generalisation) **and no more than 8** (to keep the categories distinguishable) with any classification

Mathematical or serial

How often do values of a dataset occur. This is the most rigorous methods.

Equal interval

Often the default output of GIS analysis and easily understood by the reader.

However, the intervals rarely show much about the data. This classification often results in one or more empty data classes but can be useful if the spread of stats is even across the range.

Medians or quantiles

Data are set out in rank order, and the median value found. The median can be a break point for two data classes. Otherwise the ranked order can be divided into 3 (terciles), 4 (quartiles), or 5 (quintiles) etc. groups with equal numbers of observations in each class.

Quartiles reveal the inter-quartile range (the 50% of observations around the median). Revealing for stats with an even spread across the range, but often the interest lies in the extreme values (e.g. high or low mortality).

Means and standard deviation

Means and standard deviations. If the mean is close to the median and there are very few extreme values, your data may be normally distributed. However, most geographical data are not normally distributed. The mean is calculated and may be a break point between classes.

Standard deviations can be used to determine class intervals; fractions of a standard deviation can also be used. An example of data that might be normally distributed would be journey-to-work travel-time.

Arithmetic and geometric series

Appropriate if your data are slightly or strongly skewed. Arithmetic series are useful when the data are slightly positively skewed and you want smaller intervals at the lower end of the data. They are based on class intervals that get bigger by a set amount that doubles, then triples, quadruples etc.

Geometric series are suitable for very strong positive skews in data; data classes are determined by powers of a number that form the classes — for example 10, 10^2 , 10^3 , 10^4 , … giving class break points of 10, 100, 1000, 10,000, …

1.5. Data analysis

Geospatial data analysis is the process of extracting information from spatial data. This data can be in the form of maps, satellite imagery, or other forms of geospatial data. Geospatial data analysis can be used to solve a variety of problems, such as:

- Planning and development
- Resource management
- Public safety
- Transportation
- Healthcare
- Humanitarian relief

It is a growing field with many applications. Here are some commonly used techniques:

Spatial queries

A spatial query is a question about the spatial location of objects and their relationship. This can include:

- Finding points within a certain distance of one or more points/locations
- Identifying overlapping polygons

Geostatistics

Geostatistical techniques are used to map and define values based on spatial and geospatial phenomena. They have also advanced to define the probability of the value of the unsampled locations.

Spatial data mining

Spatial data mining involves extracting knowledge from large spatial datasets. It combines traditional data mining techniques with spatial analysis to identify patterns and relationships that are specific to geographic space. This can include clustering, classification, association rule mining, and outlier detection. Spatial data mining is useful for tasks like identifying hotspots, discovering spatial trends, or detecting anomalies.

These approaches are not mutually exclusive and can be combined depending on the specific requirements and nature of the geo-spatial analysis task at hand. Successful analysis often involves a combination of several methods to gain comprehensive insights into spatial patterns and relationships.

The use of GIS software provides a comprehensive framework for managing, analysing, and visualising geospatial data. GIS applications combine various tools and techniques mentioned above and others while allowing users to create maps and overlay different layers.

Summary

Preparing data for visualisation can be summarised in 4 steps. This is a simplified approach. Plenty of resources are freely available online. Not sure where to start looking? We have a few listed in our *Resources list.*

1

Define question

Before diving head-first into a visualisation, be sure to know what information you are trying to display. What data is needed to answer the question?

2

Collect

Does the dataset needed already exist? If so, is it available and accessible? If not, plan your data collection thoroughly.

3

Check

Once collected/found, check the data quality using the metadata and CASC. Is the format compatible with the data visualisation tool/software?

4

Classify and analyse

Once imported, experiment with the data: what is the best way to classify it and does any analysis need to be done to extract information?

Head to the *Graphs and Charts* or *Map Types* to learn about visualisation options. If you already know with visualisation to use, see Chapter 6 for guidance on design and layout.

2.
Graphs & charts

Chart

/tʃɑːt/

noun:

A drawing that shows information in a simple way, often using lines and curves to show amounts.

Graph

/græf/

noun:

A picture that shows how two sets of information or variables are related, usually by lines or curves.

2.1 Common chart types

Charts and graphs come in various shapes, forms and combinations. Choosing the type of chart depends on the data to be presented, which question(s) need answering and who the audience is. Generally, the simpler the better. Here, we cover the most well-known ones and what they usually represent.

For more types of charts and inspiration, the Financial Times Visual Vocabulary is a good place to start. CHARTIO also offers a great collection of chart guides and how to's.

Pie chart

Pie charts are a circular graph divided into sections showing proportions of the whole.

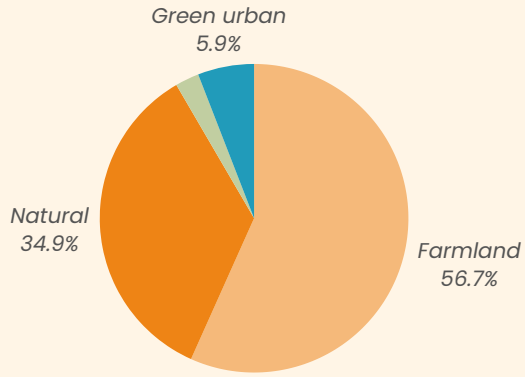
Data type Categorical

Objective Composition, comparison

Pros
- Easy to create
- Easy to understand
- Great for dashboards

Cons
- Limited to one timeframe
- Data subtilities can be lost
- Can easily be overcrowded

Find out more about pie charts here.



Generalised land cover of the UK. Corine Land Cover Inventory.

Line chart

Also called line plot, line charts use connected points to show a change in value over time of one or more series.

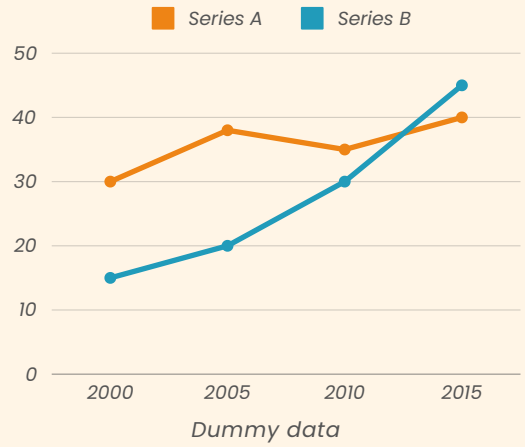
Data type Continuous

Objective Change (over time)

Pros
- Easy to create
- Easy to understand
- Great to reveal flow
- Great for accessibility

Cons
- Hard to depict exact values
- Can easily be overcrowded

Find out more about line charts here.



Dummy data

Bar chart

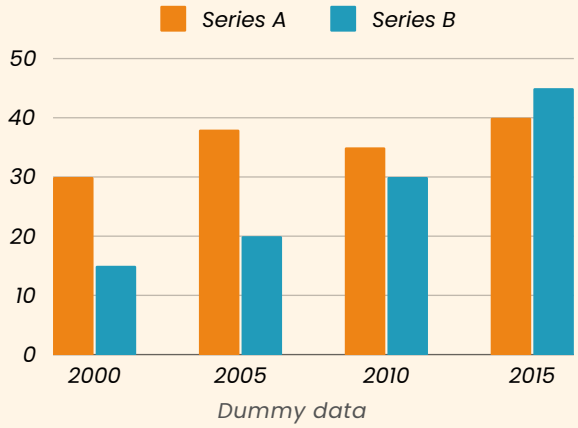
Bar graphs use vertical or horizontal bars to represent and compare numerical values of one or more series.

Data type Categorical

Objective Comparison

Pros
- Easy to create
- Easy to understand
- Great for categories

Cons
- Not very versatile
- Easily overcrowded



Dummy data

Find out more about bar charts here.

Area chart

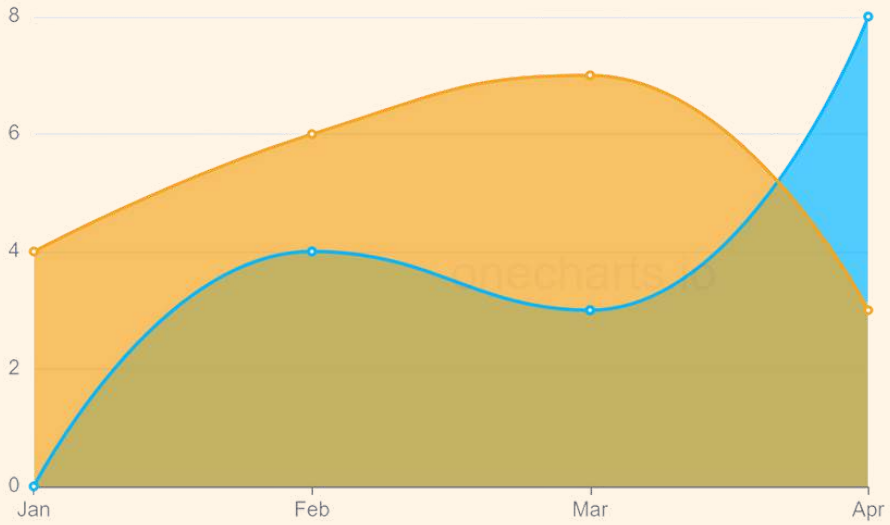
An area chart is a combination of line and bar charts. It shows changes of one or more numeric values over time.

Data type Continuous

Objective Trend, distribution

Pros
- Reveals data density
- Easy comparison
- Intuitive

Cons
- Hard to read exact values
- Not ideal for 3 or more categories



Find out more about area charts here.

Scatter plot

Scatter plots, also known as scattergrams, show the relationship between two or more data sets. These can be used to identify patterns and sometimes make predictions.

Data type Continuous

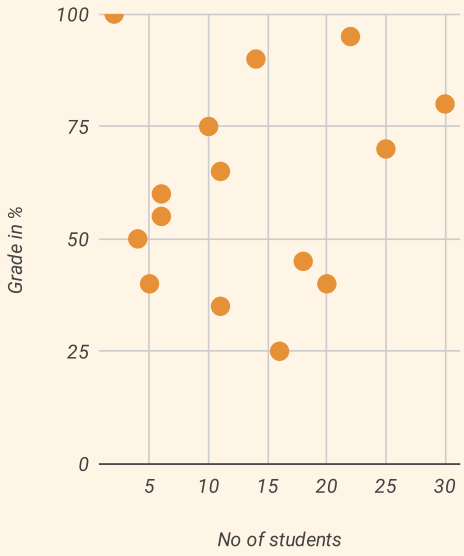
Objective Relationship, comparison, distribution

Pros

- Easy to spot patterns, relationships and outliers
- Easy to understand
- Great for large data sets
- Works with most continuous data

Cons

- Hard to depict distribution, correlation and patterns with accuracy
- Can easily be overcrowded



This chart displays how many students received a certain grade.

Find out more about scatter plots here.

Bubble chart

A bubble chart is an extension of scatter plots. The points are replaced by bubbles. The size of these bubbles represent another dimension of the data.

Data type Continuous

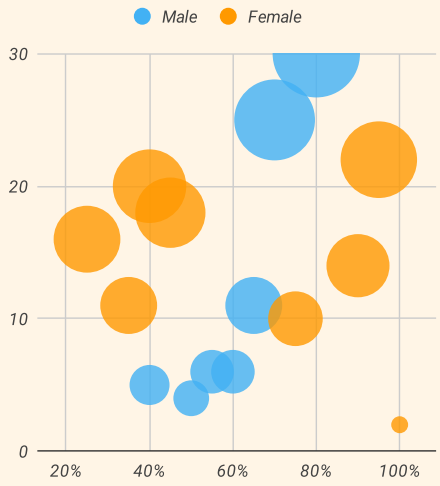
Objective Distribution

Pros

- Displays up to four variables
- Easy to understand
- Great for complex data set insights
- Great for showing relationships

Cons

- Can easily be cluttered

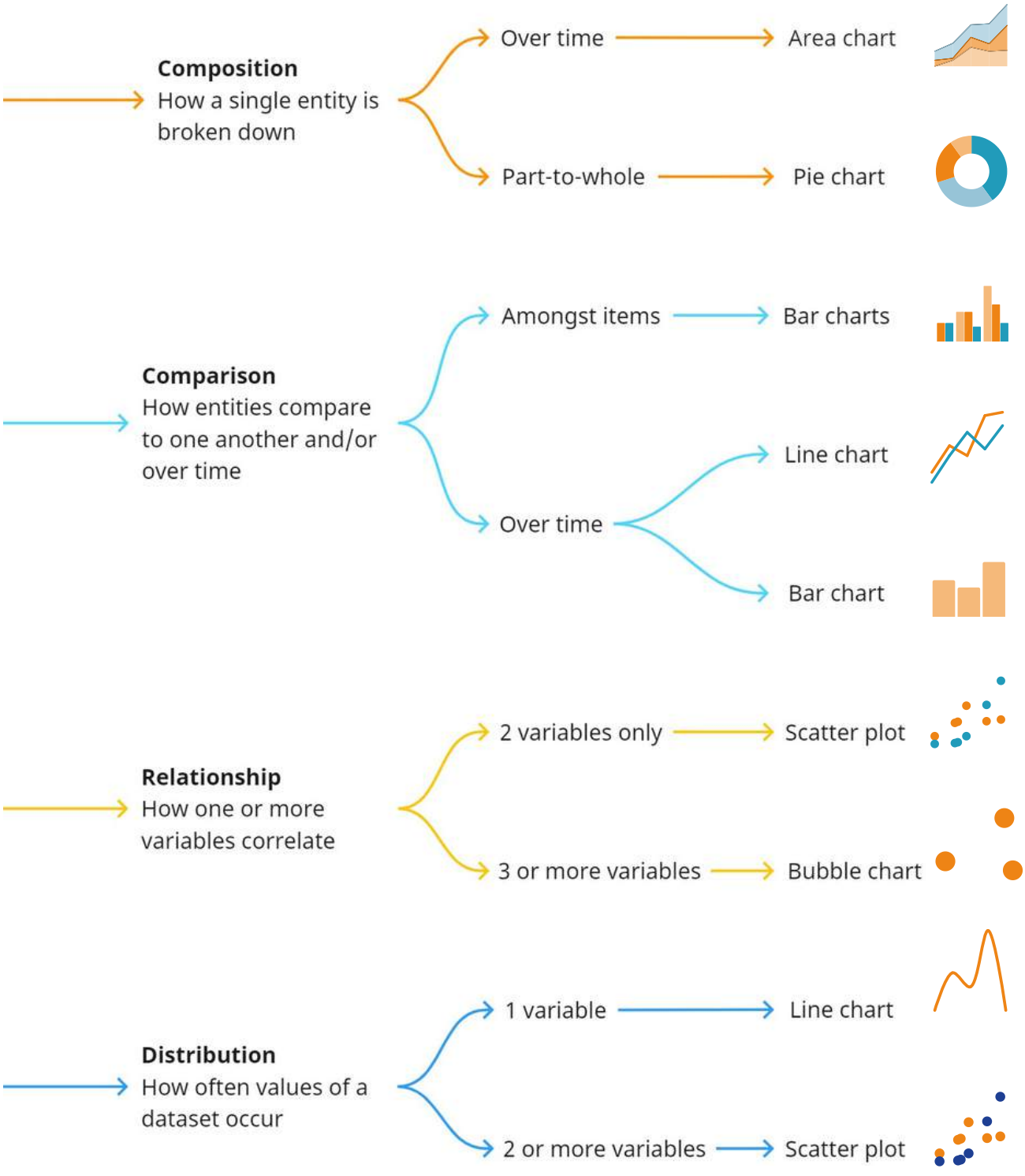


Compared to the Scatter plot above, this chart shows gender and the percentage of students (bubble size) which have that grade

Find out more about bubble charts here.

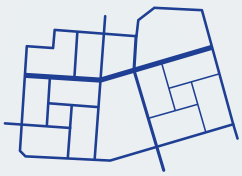
2.2. Choosing a chart

There are an infinite number of possibilities when it comes to choosing charts. The diagram below can be used as a starting point for selecting the most relevant chart, depending on what you are trying to communicate.



3.

Map Types



Map

/mæp/

noun:

A drawing that gives you a particular type of information about a particular area.

Before choosing a map type

Choosing the right map can be challenging. Here are a few questions to ask yourself before diving into it.

Purpose

What will the map be used for?

Audience

Who will see, read, and use the map?

Data

Do you have the right information?

Output

Will it be print, static or interactive?

Below is an example of two completely different maps using the same data points.

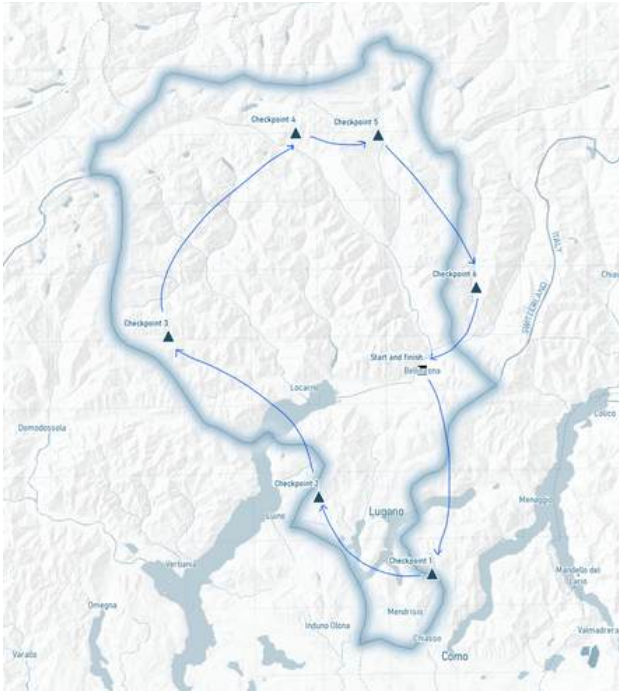
Map 1

Purpose and audience: Informing friends and family of the cycle race plan giving some context of the location and terrain

Data: Start/finish location, checkpoints and geographic context (borders, lakes, main cities and towns)

Format: An image, easy to share using text messages

Tool used: QGIS 3.20.



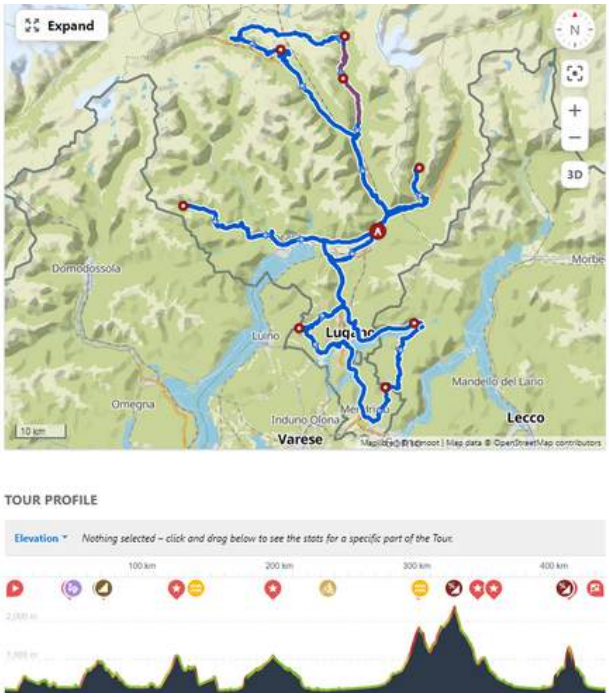
Map 2

Purpose and audience: Visualisaing the elevation and terrain in detail for the competitors

Data: Start/finish location, checkpoints, hills, urban areas and resupply points, exact distances.

Format: Interactive map with an overview and details of specific locations.

Tool used: Komoot.com



3.1. Topographic maps

Topographic maps are reference maps showing a set range of general features in the landscape. These maps aim to indicate the character of the terrain and symbolise a wide range of features that are considered useful to most users. Related to topographic maps are maritime and air charts that emphasise features of relevance to navigators, often making use of general topographic backgrounds

1. Data

Topographic maps usually represent features like roads, rivers, boundaries, buildings, points of interest, landmarks, contours, vegetation, etc. This is adapted to the target audience.

2. Symbology

As topographic maps are usually rich in features, they contain a wide range of colours and symbols; including lines, areas and points. These symbols are constantly refined and vary from one map producer to another. It is important to choose symbols that are easily identified and understood.

3. Basemap

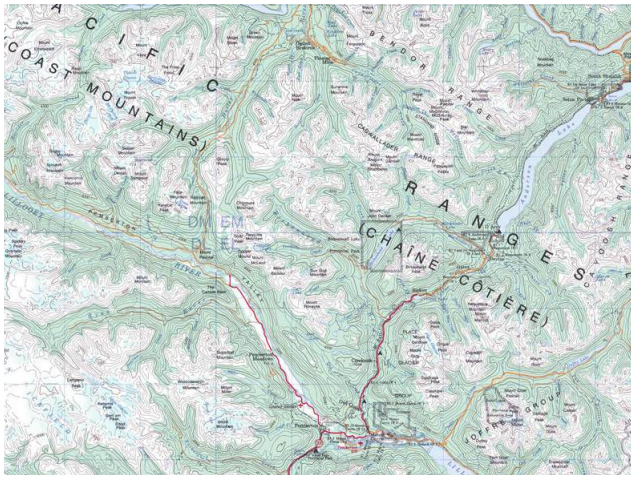
- Topographic maps can be used as base maps
- Hillshade

4. Legend

- Symbols categorised by types (roads, Points of Interest - POI, landcover, etc)
- Scale
- Every symbol used on the map
- The most important/prioritised value is usually placed at the top
- The legend is place beside or below the map

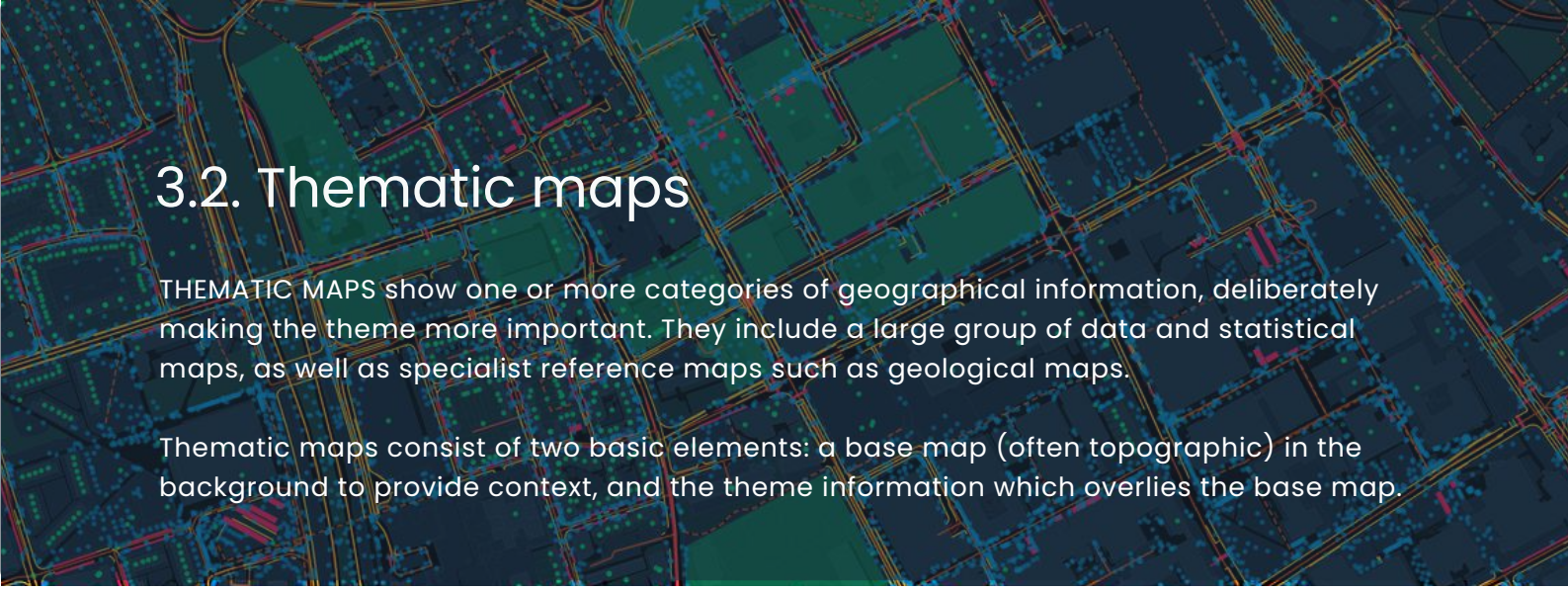
5. Uses

- Navigation and expeditions
- Military operations
- Civil emergency response
- Search and rescue
- Atlases



How to
[ArcGIS Pro] [QGIS] [Mapinfo] [Cadcorp] [Mapbox]

Inspiration
[Northern Italy, 1943] [Shaded Relief Archive] [Panoramas]



3.2. Thematic maps

THEMATIC MAPS show one or more categories of geographical information, deliberately making the theme more important. They include a large group of data and statistical maps, as well as specialist reference maps such as geological maps.

Thematic maps consist of two basic elements: a base map (often topographic) in the background to provide context, and the theme information which overlies the base map.

Viewer locations in Eastern London on a dark basemap

Thematic maps come in various forms and types. In the toolkit, we cover the following:

- Choropleth
- Dot maps
- Isoline maps
- Heat maps
- Cartograms

TIP

> Every data set, purpose and audience will require a different type of data visualisation. Is a map really the best way to present and understand the data?

Map type	How to's	Going further	Inspiration
Choropleth	• ArcGIS Pro • QGIS • Mapbox	• Dot density	• Thailand • Switzerland
Dot maps	• ArcGIS Pro • QGIS • Mapbox		• Central Park Squirrel Census • Earthquake swarms
Isoline maps	• ArcGIS Pro • QGIS		• Hurricane Sandy • Hurricane Florence rain
Heat maps	• ArcGIS Pro • QGIS • Mapbox		• Light pollution • U.S. dams
Cartograms	• ArcGIS Pro • QGIS • Go-cart		• Strategic place mentions • River transit maps

Choropleth maps

The CHOROPLETH MAP is a 'value by area' map. It is a common way of mapping data gathered by area and can be a very effective way of conveying spatial variation in a set of statistics. Areas used do not have to be predefined administrative units, HEX maps used hexagons enabling consistent comparison over a given area.

Choropleth maps combine a base map showing the areal units on which the information was gathered. Infill patterns or colours represent the data class assigned to the area.

1. Data

Choropleth maps are used to display ratio data, not absolute. They show data by predefined areas (postcode, country, country, hexagons, ...)

2. Symbology

- Ideally, no more than 6 or 7 classes/colours
- The basic principle of shading is that, as data figures go from least to most, the colour sequence goes from lightest to darkest, or most saturated
- Lighter colours represent lower data values and darker colours represent higher values.

3. Basemap

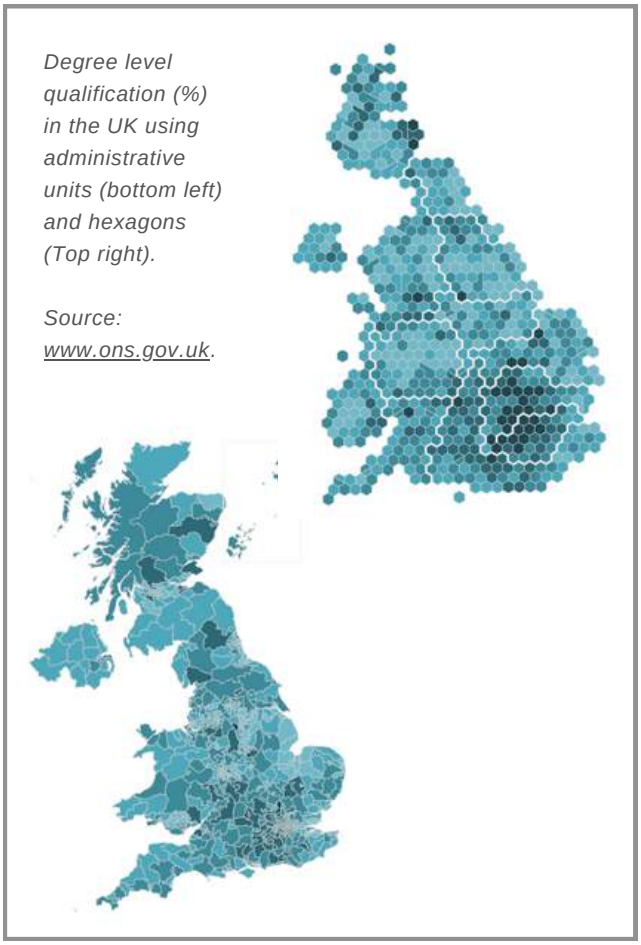
- Boundaries of the units of the dataset
- Enough topographic information to give context

4. Legend

- Colour fills or patterns used
- The data range for each category
- Units and/or ratio used
- The highest value is usually at the top

5. Uses

- Human population
- Agricultural production
- Income
- And many more!



Degree level qualification (%) in the UK using administrative units (bottom left) and hexagons (Top right).

Source: www.ons.gov.uk.

Dot density maps

The DOT DENSITY MAP can effectively show the relative density of a phenomenon within an area. A dot map gives an impression of the density and spread of the subject being mapped and, as statistical maps, they are easily understood by the map reader.

The variables that the cartographer has to choose are the value of the dot and the size of the dot.

1. Data

Dot maps are used to show absolute data. They work best when the subject being mapped has a wide distribution across the mapped area.

2. Symbology

- Big enough to be seen and small enough to not overcrowd dense areas
- Correlate placement with the real distribution
- Consider including boundaries and geography of the area

3. Basemap

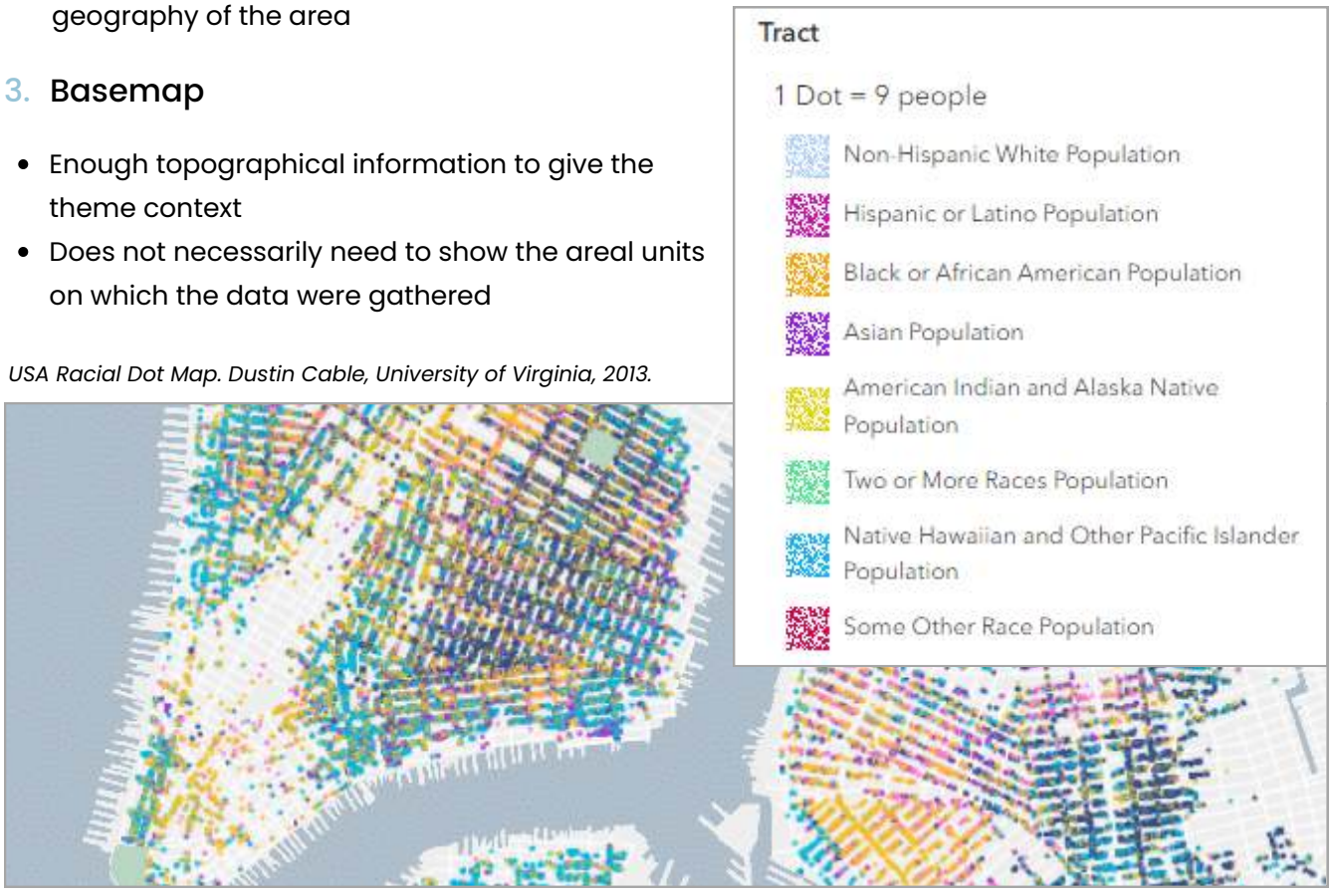
- Enough topographical information to give the theme context
- Does not necessarily need to show the areal units on which the data were gathered

4. Legend

- A clear statement of the dot value
- 3 or more identical categories with representative densities: low, medium, high (as needed)

5. Uses

- Human population
- Agricultural production
- And many more!



USA Racial Dot Map. Dustin Cable, University of Virginia, 2013.

Isoline maps

ISOLINE MAPS REPRESENT QUANTITIES by lines. The most familiar symbols are height contours — lines which connect points of equal elevation above sea level.

Isoline maps come into two groups: those that represent data that really exists at points, and those that represent data that does not exist at points. Isoline maps are often called isorhythmic maps.

1. Data

- Point data for isoline maps include heights, depths, temperatures, air pressure, sunshine, and rainfall. They are all continuous phenomena and any point can be given a value.
- Ratio data can be used if the areal units are sufficiently small and roughly equal-sized and shaped, and continuous.

2. Symbology

- Equal interval isolines represented by continuous lines
- Hexagonal sampling grid
- Hypsometric tinting can make the interpretation of isolines easier

3. Basemap

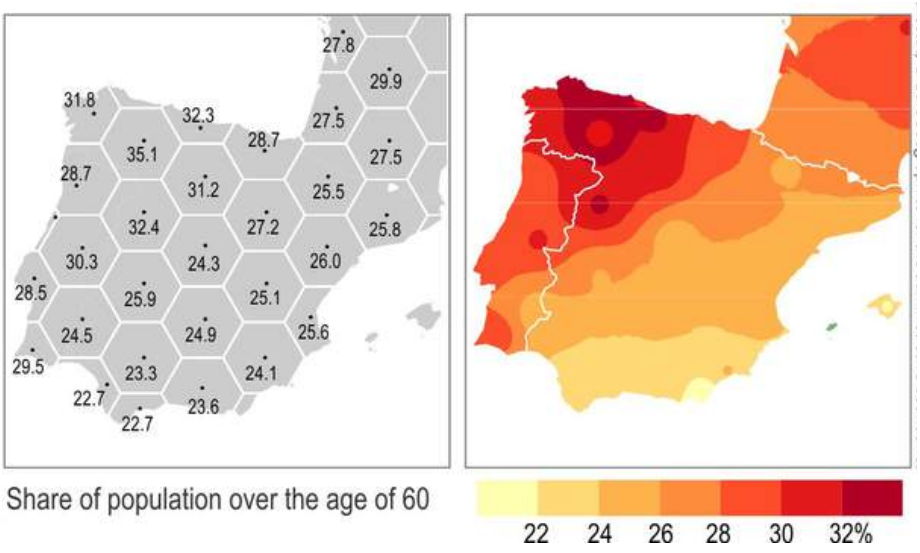
- Enough topographical information to give the data context

4. Legend

- Labelling of isoline or index isolines on the map directly OR indicating ranges in the legend
- If used, the hypsometric tinting range values

5. Uses

- Weather (rain and temperature)
- Air pressure
- And many more!



Share of population over the age of 60 (%), Golebiowska, I. et al., 2021

Heat maps

Heat maps show locations of higher densities of geographic entities. The 'heat' in the name refers to the concentration of the geographic entity within any given spot.

1. Data

Points or polylines are used when making heat maps.

2. Symbology

- Darker colours (usually) represent higher density.
- Lighter colours show lower point densities.

3. Basemap

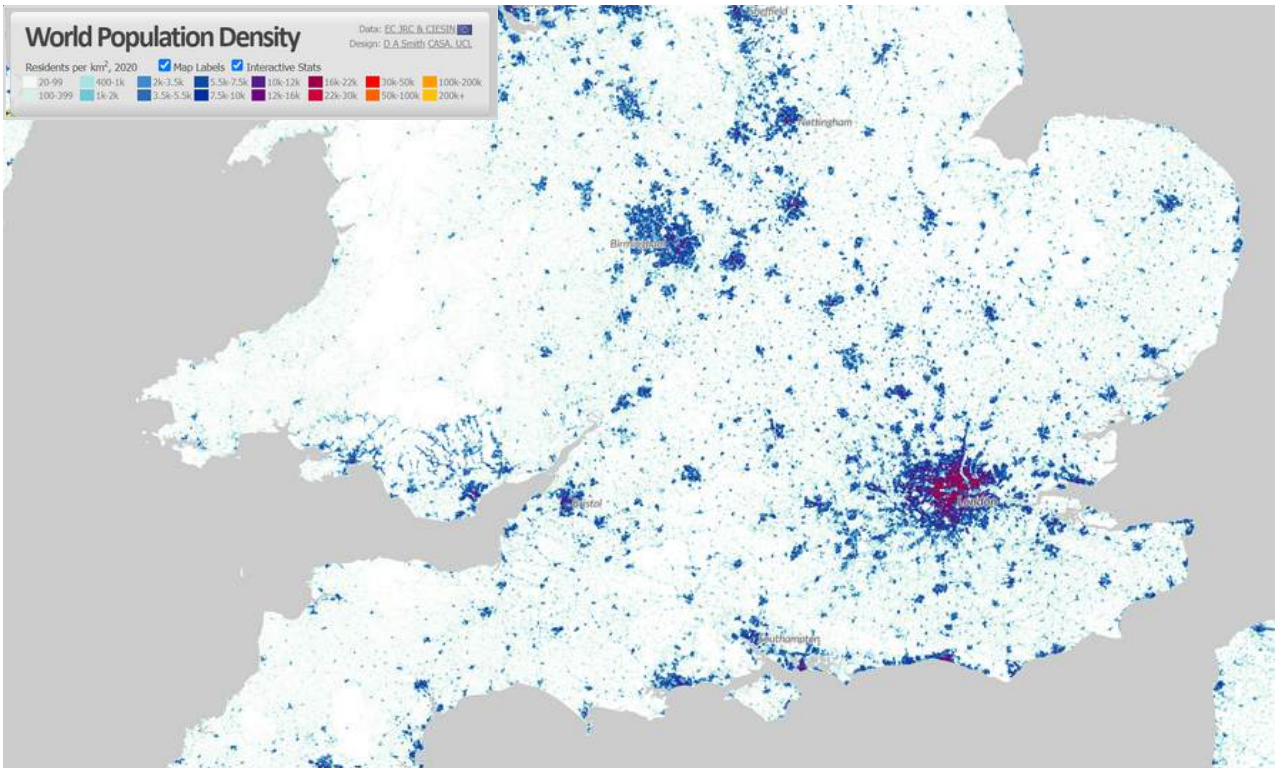
- Enough topographical information to give the map context

4. Legend

- The data range values
- Units and/or ratios used
- The highest value is usually at the top

5. Uses

- Urban heat density
- Job listing density
- Disease hotspots
- Happiness levels
- Any social data
- And many more!



Population density of [part of] the UK in 2020.
Data: EC JRC & CIESIN. Design: D A Smith CASA, UCL

Cartograms

Cartograms are becoming increasing popular in data visualisation. They come in various formats. Generally, cartograms do not depict the geographic space. Instead, these value-by-area maps change the size of the object (e.g. country) according to its attribute (e.g. population) value.

Contiguous cartograms

Contiguous cartograms maintain the connectivity of the objects (e.g. counties) and, as much as possible, their shape whilst increasing in size proportionally to the data.

1. Data

Cartograms use value-by-area data (e.g. population by province, trees per national park, deaths by country, etc.)

2. Symbology

- Contiguous cartograms use the features themselves and colour scales to represent data
- They keep the topological relationships of the units but not the shape.
- Dorling cartograms use geometrical shapes (e.g. circles or hexagons).

3. Basemap

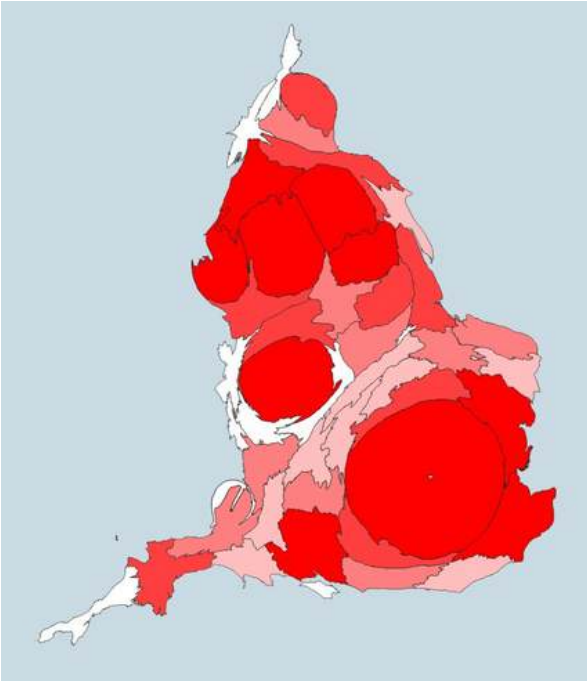
Typically, cartograms do not use background maps.

4. Legend

- Range values of the unit shape, size, and/or colour

5. Uses

- Election results
- Diseases
- Precipitation rates
- Population
- And many more!



2021 Population count per county, England.

Non - contiguous cartograms

Non-contiguous cartograms, do not maintain the connectivity of the objects (e.g. counties). By being disconnected, the objects can keep their respective shapes. Objects can be overlapping if the geographic centroid is preserved. Alternatively, they can be moved away from one another for better visibility. This alters the distance between them.

1. Data

Cartograms use attribute data where areal units are assigned a value.

2. Symbology

- These cartograms keep their unit shapes and adjust in size according to their value
- Colour scales make map interpretation easier
- Typically, objects do not overlap

3. Basemap

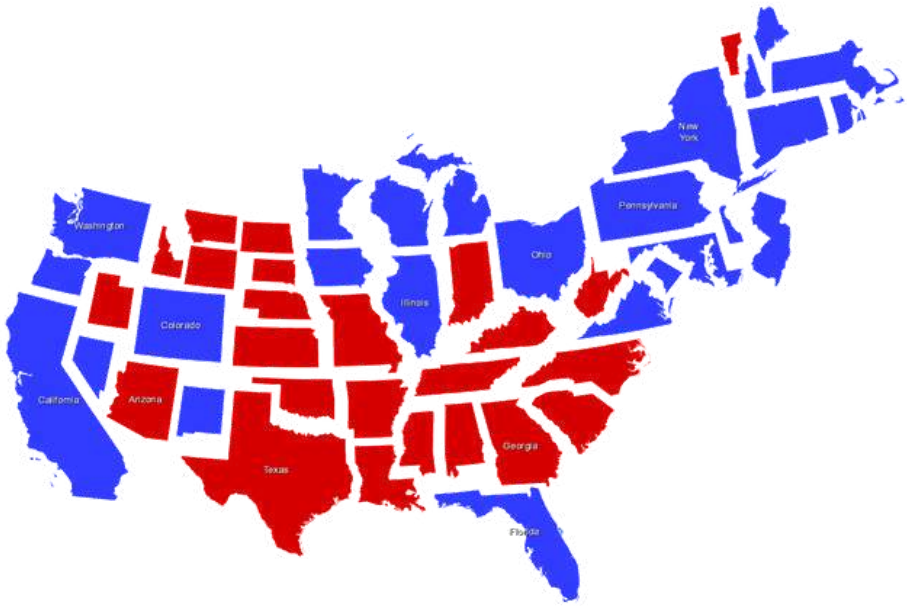
Typically, cartograms do not use background maps.

4. Legend

- Range values of the unit shape, size, and/or colour

5. Uses

- Election results
- Diseases
- Precipitation rates
- Population
- And many more!



2012 U.S. Presidential election results. Field K, 2017. UCGIS.

Other cartograms

Unlike the contiguous and non-contiguous cartograms, these ones do not maintain the object's shape, size, topology or centroid. The objects are replaced with a uniform shape (circles, hexagons, rectangles, squares, etc..) with a size proportional to its attribute data value.

1. Data

Cartograms use attribute data where areal units are assigned a value.

2. Symbology

- Objects are simplified with geometrical shapes (e.g. circles or hexagons)
- Typically, they do not overlap
- Some cartograms will use a colour scale to make the map interpretation easier

3. Basemap

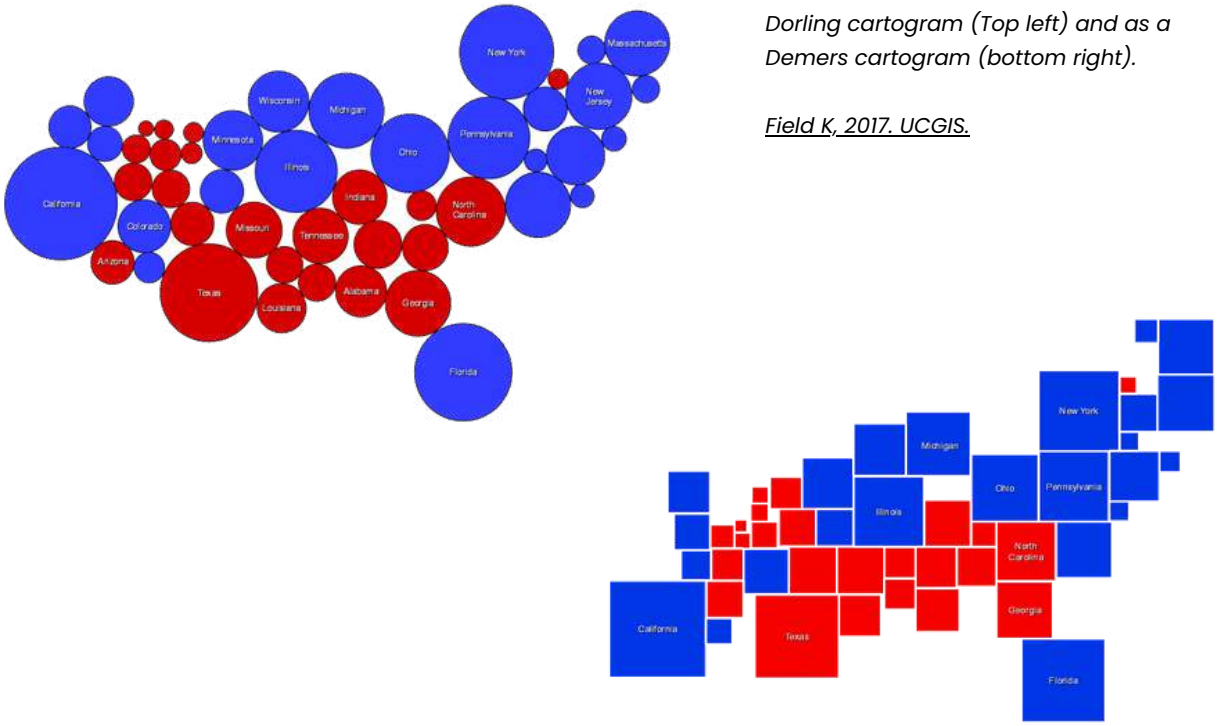
Typically, cartograms do not use background maps.

4. Legend

- Range values of the unit shape, size, and/or colour.

5. Uses

- Election results
- Diseases
- Precipitation rates
- Population
- And many more!



2012 U.S. Presidential election results as a Dorling cartogram (Top left) and as a Demers cartogram (bottom right).

Field K, 2017. UCGIS.

	Choropleth	Dot density	Isoline	Heat map	Cartogram
Description	Value-by-area map which conserves aerial unit proportions	Relative density of a phenomenon	Line-resented quantities	Concentration of chosen entities	Proportional unit distortions
Data	Ratio data	Absolute data	Point or ratio-data	Points or polylines	Attribute data
Symbology	Colour shading and gradients	Dots	Lines and/or hypsometric tinting	Colour shading and gradients	Value-proportional shape, size and colour
Basemap	Aerial unit boundaries and topographical context	Topographical context	Topographical context	Topographical context	None
Legend	Colour range values and units and ratios	Dot value and/or dot density value	Line values and colour range values	Colour-range values, units and ratios	Range values

4.

Map elements

Legend

/ˈledʒ.ənd/

noun:

The words written on or next to a picture, map, chart, etc. that explain what it is about or what the symbols on it mean

4.1. Basemaps

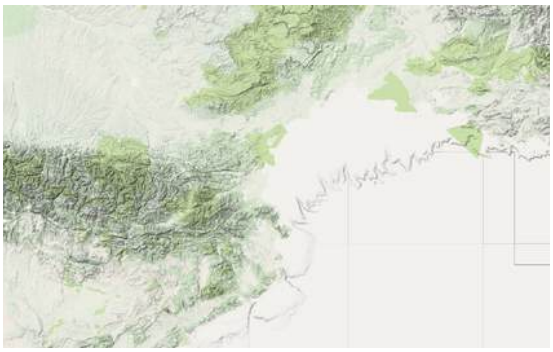
Basemaps provide a **background reference** for the thematic information. They are not the focus of the map but **provide context for the theme**. In some cases, the content of the base map will be obvious, for example, a choropleth map must show the boundaries between the geographical units for which you are showing statistics (counties, census districts, etc).

Street

Aerial imagery

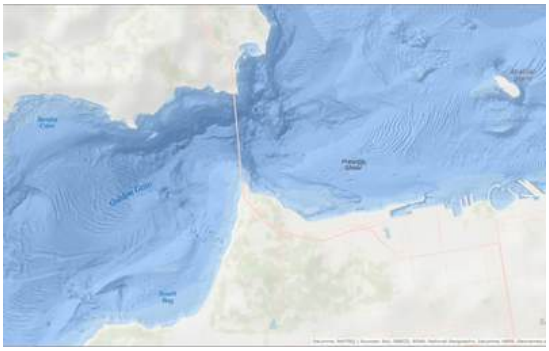
Hybrid

Terrain



Dark

Bathymetric (underwater topography)



Questions to ask when choosing a basemap:

> Does it give context to the information displayed on the map?

> Does it help orient the map reader?

4.2. Relief & elevation

From early times, maps have tried to show the ups and downs of the landscape. Early maps used pictorial symbols of hills to depict relief, but it is hard to tell much about the heights of the mountains or hills shown or about more gently changing scenery in between. Depicting relief has always been a challenge for cartographers, and showing height and slope without graphically overloading the map can be difficult.

There are a number of techniques employed to depict both height and slope on maps. Many maps use more than one method to show relief, for instance by combining spot heights, contours and hypsometric tinting.

This section looks at various ways of representing height and elevation on maps including:

- Contours
- Spot heights
- Hachures
- Hypsometric tinting
- Hillshading
- Digital elevation

For every element, links to how-to guides, resources and inspiration will be given in a table like below:

How to's	Going further	Inspiration
• ArcGIS Pro • QGIS • Blender	• Terrain in Photoshop	• Thailand • Switzerland

Contours

Contours are lines of equal height printed in a neutral colour such as brown or orange. They are usually derived from aerial photography. The contour interval will not only vary with the scale of the map — the smaller the scale, the greater the contour interval — but also with the terrain. Flat areas may have an increased contour interval to show locally significant variations in height. Maps will often show spot heights at summits or low points in addition to contours.

On a maritime chart, contours relate to the chart datum and the spot heights shown are depth soundings. Although widely used as a method of relief depiction, many people find it hard to visualise a 3-D landscape from contours.

Peaks of Parc Cenedlaethol Eryri (Snowdonia National Parc), Northern Wales using contours, shading and spot heights to show elevation. explore.osmaps.com.

Tip

Contour values should read uphill and only the index contours need to be labelled

How to's	Going further	Inspiration
• ArcGIS Pro • QGIS	Smoothing contour lines	• Contour map generator • Lake District contours

Spot heights

Spot heights show the height at points above (or below) a datum, usually sea level. They are often used to mark the top of a hill or mountain. They can be used with contours or as standalone height information (see previous page for an example).

How to's	Going further	Inspiration
• ArcGIS Pro • QGIS	• Personalised point symbol - ArcGIS • Personalised point symbol - QGIS	• OS maps Explorer

Hachures

Hachures are patterns of fine lines which run parallel to the direction of the slope. Line length varies according to the length of the slope depicted. Steeper slopes are represented by thicker lines or closer spacing.

Here hachure is used with contours and shading to show slopes.
Ordnance Survey, 1:63360, 5th Edition physical features alone, Land's End and Lizard, 1934; Author's collection.

How to's	Going further	Inspiration
• ArcGIS Pro • QGIS	• Chevalier-style hachures • Monochrome hachure map	• San Francisco

Hypsometric tinting

Heights are grouped into different bands and colour is applied to each band, typically ranging from greens and yellows for low areas, to oranges and browns for the highest areas.

Also called layer tinting, elevation tinting, elevation colouring or hypsometric colouring, it can be symbolised in two ways:

Using classified values

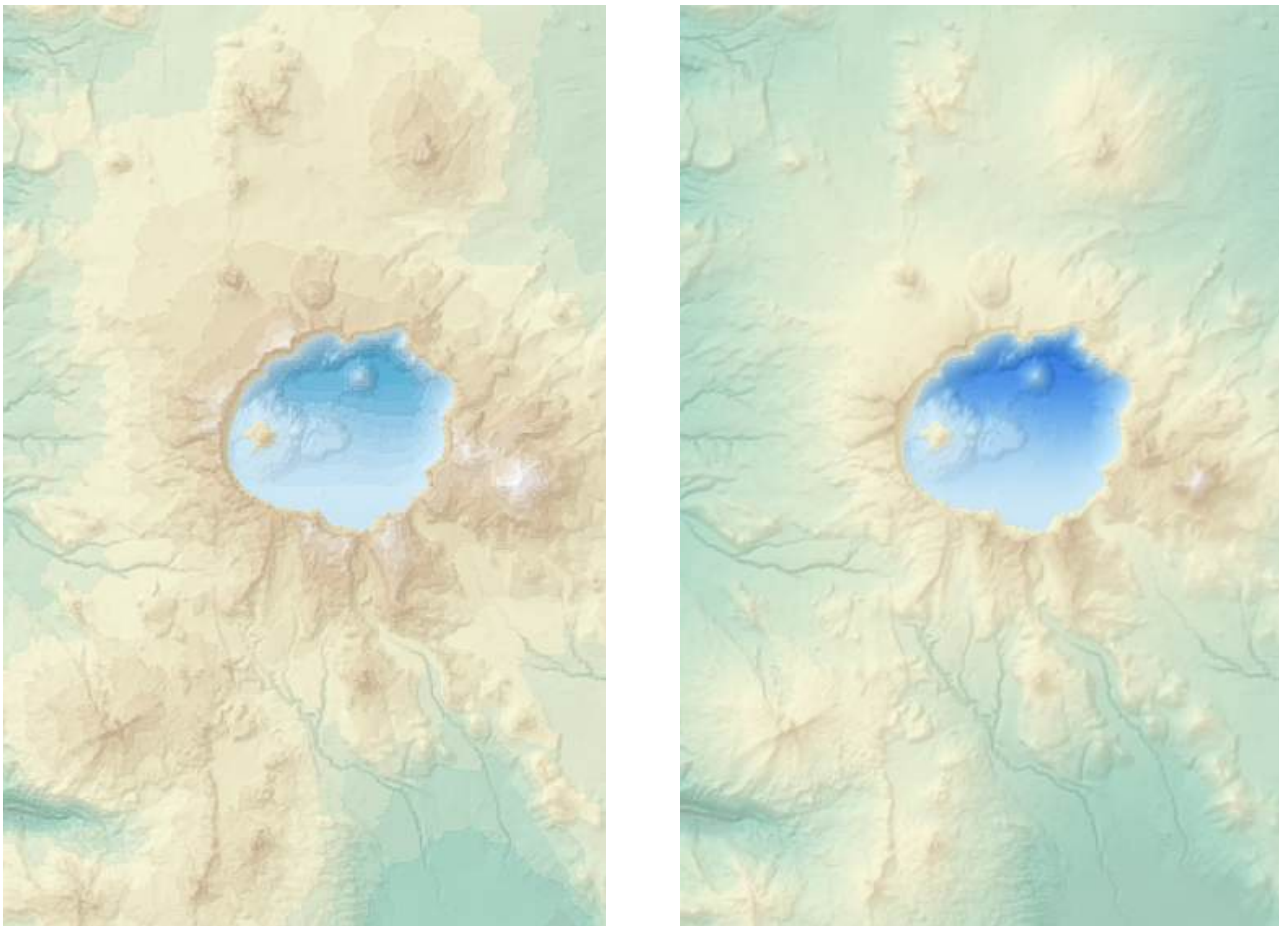
In this method, the cartographer sets the value ranges and colours to give full control of the colours used.

Picking the colour shades for each value range can be time-consuming.

Using a colour ramp

This method enables a smooth transition of colours throughout the full range of elevation values.

This is done using pre-set colour ramps, giving less control over which colours are assigned to elevations.



Elevation with hypsometric tinting with classified values (left) and a colour ramp (right).
Aileen Buckley, 2008.

Hillshading

Hillshading is effective to give maps a 3-dimensional appearance. The data is usually extracted from a Digital Elevation Model (DEM). Hills and mountains are made to stand out by illuminating them, making slopes in one direction appear sunlit and slopes in the opposite direction appear in shadow. Hill-shaded maps almost always show the light coming from the top left (usually NW — in a direction the sun rarely shines from). If it comes from the bottom right, mountains look like valleys and vice versa.

Traditionally, hill shading uses uni-directional light (coming from one direction). Details can be enhanced with multidirectional shading - a technique which displays a lot more detail making the map 'pop'.

Usually in black and white, hill shading can be combined with colour shading to display the elevation and the aspect of a given terrain.

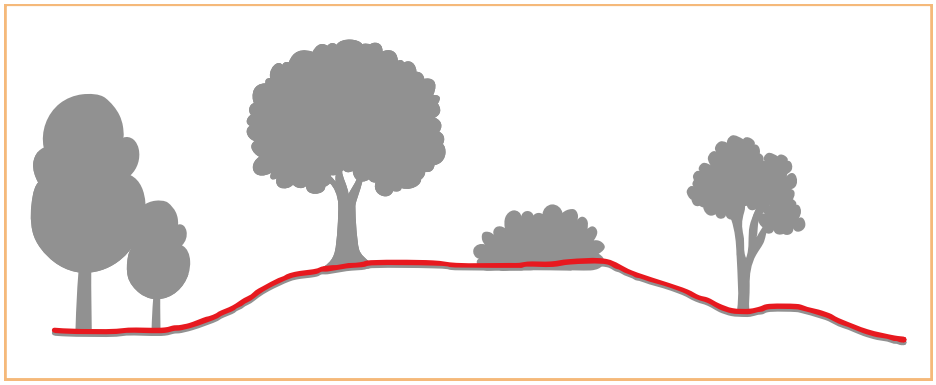
How to's	Going further	Inspiration
• ArcGIS Hillshade function • Generating hillshade in QGIS	• Hillshade with MapTiler Plugin in QGIS • Quick hillshade effects in ArcGIS Pro	• Physical landscape of Clackamas region, Oregon • Hillshade demo app

Digital Terrain Models

Digital methods of depicting relief use height data captured from maps to model a landscape in a GIS. They include digital terrain models (DTM) and digital surface models (DSM).

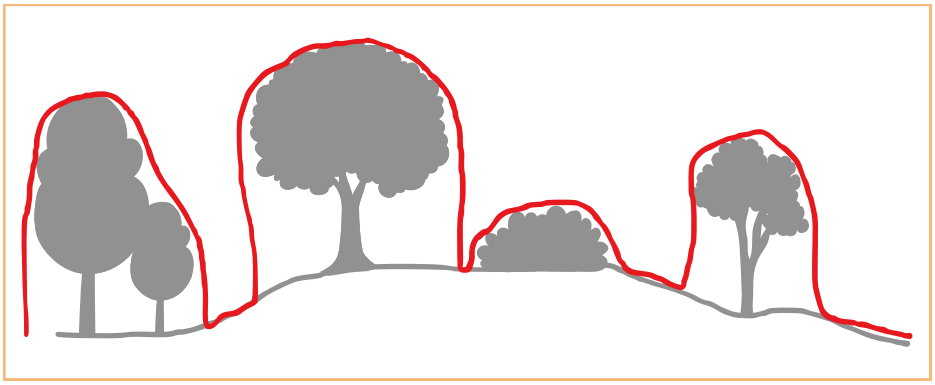
A DTM is an elevation model of the bare Earth, removing non-ground points such as infrastructure and vegetation. It is particularly useful for land planning, hydrology, and soil mapping.

On the other hand, a DSM does include those features. Lidar enables the creation of a massive point cloud with elevation values of natural and built features. This is useful to understand view obstructions (e.g. aviation runways) and vegetation management (e.g. canopy height).



Digital Terrain Model (DTM)

Digital Surface model (DSM)



Data sources

- UK DTM
- Global DEM
- Others

4.3. Text & labels

Good text can add much to a map; poor text detracts from an otherwise good map by making it difficult to read. Here are things to look out for when adding text

Typeface, style & font

A typeface is a particular design of type, a group of characters, letters and numbers. Simple typefaces work best on maps and shouldn't cause problems for readers of digital maps. Special fonts have been created that allow greater on-screen legibility.

Determined by the chosen font, the typestyle is either with or without serif. Serif typefaces are often used for natural features and sans-serif for human features, but there are many exceptions to this rule. Serif typefaces aren't old-fashioned, either — they can be easier to read in paragraph texts.

Once a typeface is chosen, it can be in different fonts which refers to the type style with a set of type characteristics, size and spacing. For example, Roboto is a typeface and 14pt Roboto Bold is a font.

Sans serif

Arimo	Cartography
Bebas Neue	CARTOGRAPHY
Roboto	Cartography
Open sans	Cartography
Montserrat	Cartography
Lato	Cartography

Serif

Alegreya	Cartography
Baskerville	Cartography
Roboto Slab	Cartography
EB Garamond	Cartography
Merriweather	Cartography
Lora	Cartography

Type characteristics

Characteristics of a font include the letter case format (upper or lower), and its positioning and weight (e.g. light, bold).

TIP

Usually, text formatting is similar across maps. For example, italic is used for Oceans and features, bold to showcase hierarchy and capitals for country names.

Roboto

Bold Upper Case	CARTOGRAPHY
Mono Thin	Cartography
Condensed	Cartography
Italic, spacing 130	*Cartography*

Type size

Maps use smaller type sizes, typically 6 to 12 points. Most people can read 6pt map text without a problem. Large texts take up space and look bad. Even map titles look better in small sizes; large titles look unprofessional and can unbalance a graphic.

Work out a hierarchy of feature classes and then vary the size, case, spacing or colour of typeface to differentiate them, e.g. distinguish counties from districts by using a larger size for counties. Keep associated features in the same font using size and weight to indicate importance — such as towns ranging from 5pt Helvetica Regular to 12pt Helvetica Bold according to population category.

Placement

Letter spacing, known as tracking, is the adjustment of the space in-between letters. It can improve the readability of text and infer the extent of a map feature. In maps, it is commonly used over countries or mountain ranges.

Decreased Cartography

Regular Cartography

Increased C a r t o g r a p h y

Tracking

Placement

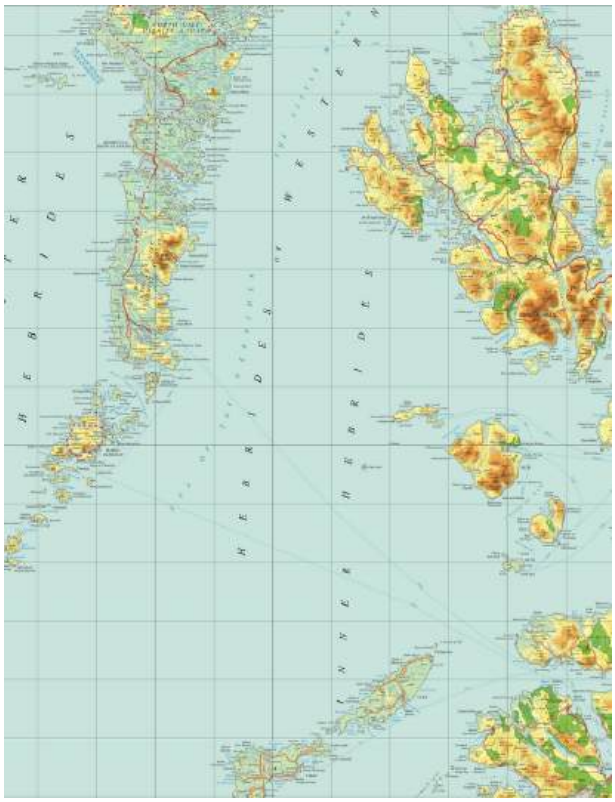
Line spacing, called leading, refers to the space between the lines of text. Increasing the space can make the text of map features easier to read and indicate their geographical extent.

Leading

Decreased 1 pt British Cartographic Society

Regular 1.2 pt British Cartographic Society

Increased 2 pt British Cartographic Society



Good placement of labels in the Scottish Inner Hebrides, OS map extract.

4.4. Legends

The purpose of the legend is to explain map symbols. Many map symbols may be obvious to the reader, especially if they are conventional or the map is part of a familiar series, but the more technical or specialist the map, the more it is likely to need a legend.

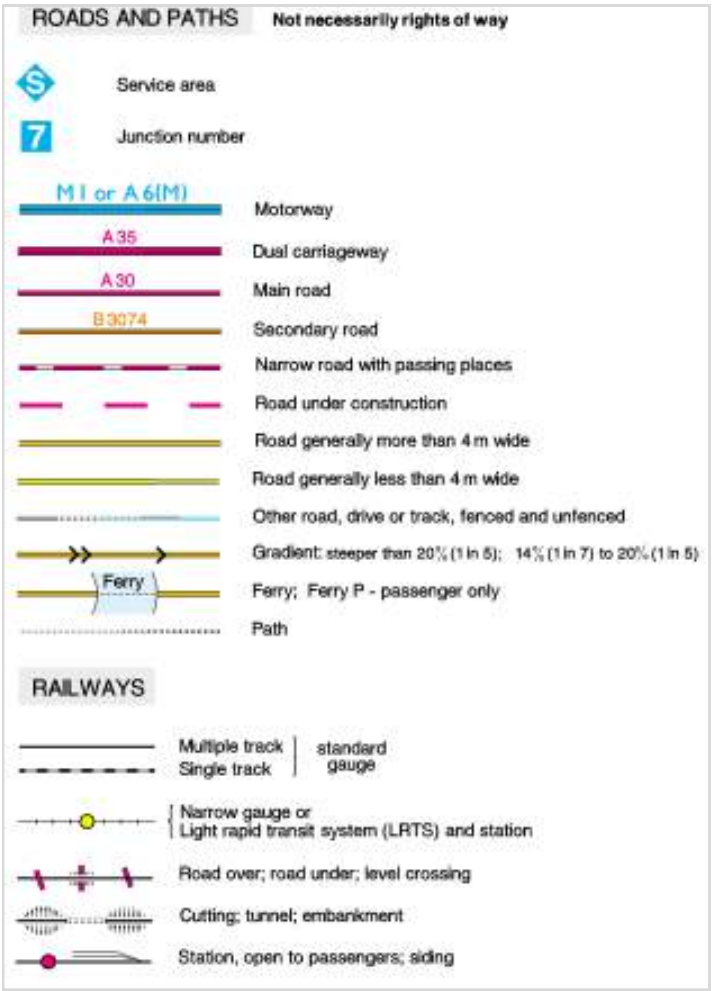
If you have a legend, it should be comprehensive, although symbols that are self-explanatory (such as coastlines) can be excluded. Basic information such as roads and rivers can also be omitted if you really do not have room. Otherwise, include all symbols shown on the map, even if familiar. Symbols should be shown in the legend exactly the same size, colour and manner as on the map.

Legend layout

- Group related features together
- Where possible, group items with the same graphic types (Lines, points, symbols, ...)
- Use the same fonts, symbology, symbol size, and colours as used on the map
- It's not always necessary to add a title to the legend

Legends for data maps

- State the units being used
- This should include time-frames like the frequency and/or the dates
- Keep it consistent across map series



OS Map 1:25,000 Explorer communications symbols

How to's	Going further	Inspiration
• ArcGIS Pro • QGIS	• Artisanal legends • Interactive map legends on PowerBI	• OS Map 25k Explorer legend

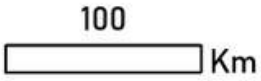
4.5. Scale bars

Scale bars need not necessarily be placed within the legend area. It may be more appropriate to position a scale bar with the title or elsewhere on the map. Whatever the map, a scale bar should use logical units and divisions based on whole numbers which are easily understood (so 0, 5, 10 not 0, 2.3, 4.6, etc).

The complexity of the scale bar should be matched to the type of map you are producing; a very detailed scale bar for a basic location map is probably not necessary. Here are a few common styles of scale bars.

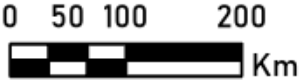
Scale bars

Single division bar



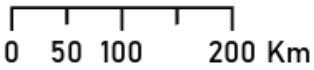
Alternating bar

Double alternating bar

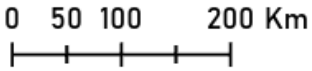


Scale lines

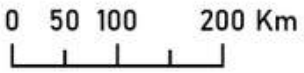
Scale line down



Scale line centered



Scale line up



TIP

When creating scales bars it's important to:

- Keep the scale and distances represented relevant to the map
- Make sure it does not hide map features
- Match the fonts, style and colours of the map

Like symbols on a map, scale bars are endlessly customisable from the height of the division marks to their colour and the texture of the bar itself.

How to's	Going further	Inspiration
• ArcGIS Pro • QGIS	• Stylised scape bar in ArcGIS Pro	• Vector scale bars

4.6. Sources, disclaimers & copyright

When producing a data visualisation, it is essential to specify where the data used comes from and who created it. This lets the reader learn more about the topic and trust the visual production.

Sources

Structure

- Author/publisher and year of the dataset(s)

Placement

- Bottom of the map
- Usually in a corner or outside the map frame

Format

- Size: smaller than the main map text and labels (e.g. 6-8pt on a printed map)
- Colours: Neutral colour. (e.g. black or dark grey for a light background)
- Font: Normal, italic, sans serif for easy reading

Example

> *"Source: UN Women, 2023. Data compiled from Permanent Missions to the United Nations, official government websites and *publicly available information."*

Disclaimers

Structure

- Full phrases
- Information about liability issues specific to the content

Placement

- Bottom of the map
- Usually in a corner or outside the map frame

Format

- Size: smaller than the main map text and labels (e.g. 6-8pt on a printed map)
- Colours: Neutral colour. (e.g. black or dark grey for a light background)
- Font: Normal, sans serif for easy reading

Example

> "The designations employed on this map do not imply the expression of any opinion whatsoever on the part of the [publisher] concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries."

Copyright

Structure

This will depend on the license used for the published product. It can be:

- Full (standard): all the rights, terms, and conditions are mentioned on the map along with the license type and number.
- Shortened (linked): Only the license type and year are mentioned with a link to the terms and conditions.

Placement

- Bottom of the map
- Usually in a corner or outside the map frame

Example

© Crown copyright [*and database rights*] [*year of supply*] OS [*licence number*]. Use of this data is subject to terms and conditions.

Format

- Size: smaller than the main map text and labels (e.g. 6-8pt)
- Colours: Neutral colour. (e.g. black or dark grey for a light background)
- Font: Normal, italic, sans serif for easy reading (e.g. Arial on digital and Source Sans Pro on paper)

Example

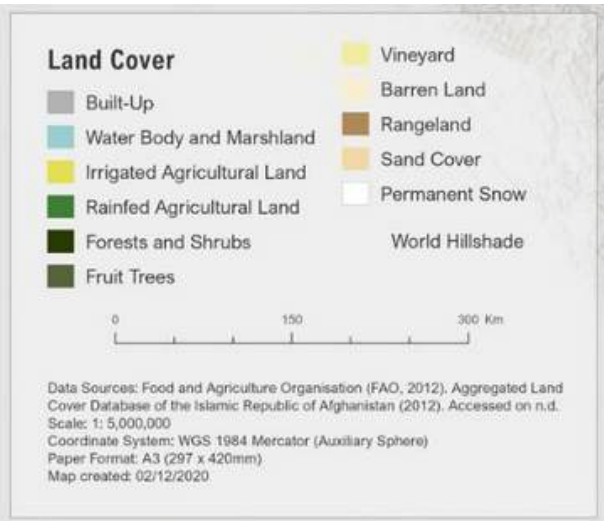
© Crown copyright *[and database rights]* [*year of supply*] OS *[licence number*]. You are granted a non-exclusive, royalty-free, revocable licence solely to view the Licensed Data for non-commercial purposes for the period during which *[insert name of Licensee*] makes it available. You are not permitted to copy, sub-license, distribute, sell or otherwise make available the Licensed Data to third parties in any form. Third-party rights to enforce the terms of this licence shall be reserved to OS.

Other text

As every map is unique, some may or maybe not include the following:

- Map scale
- Coordinate systems
- Contact details
- Techniques used
- Additional links and resources
- Map notes and explanations

Here, the sources and additional map details were placed under the legend. Author: C. Rahier



How to's	Going further	Inspiration
• Dynamic text - ArcGIS Pro • Dynamic layout - QGIS	• Matching polygon and text style in ArcGIS Pro	• Sarahbellmaps portfolio

4.7. Locator & inset maps

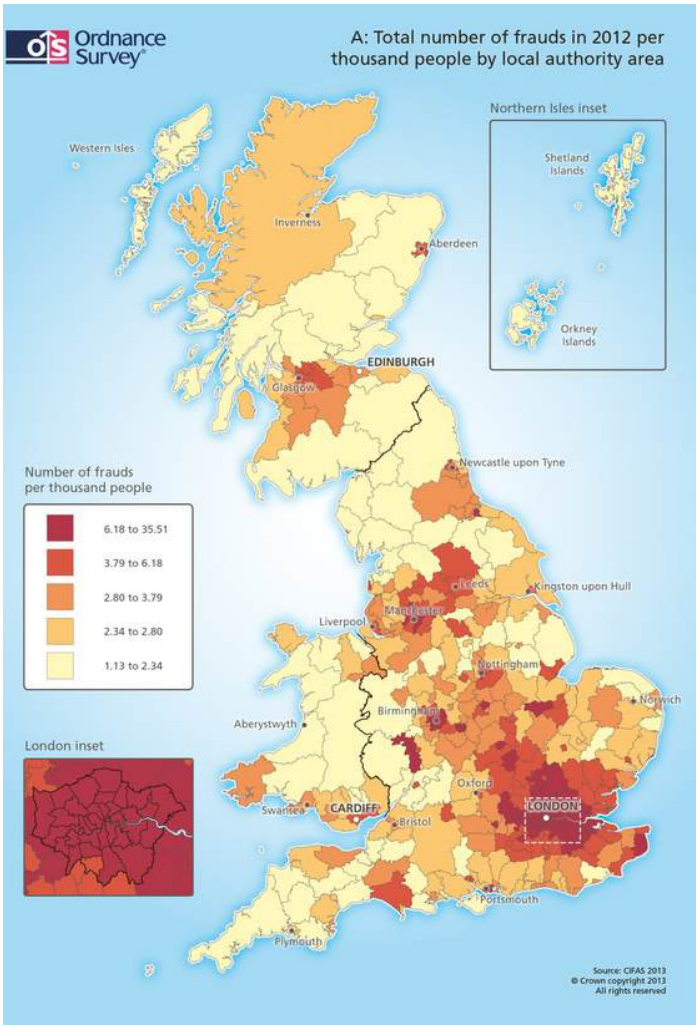
Locator and inset maps are used to provide additional information to the main map. Both of these can help reiterate the message of the map by giving it a focus.

Locator maps

A locator shows a larger area, providing context to the map. It can be a valuable addition to provide a wider geographical context to the reader.

Inset maps

An inset shows areas of the map in more detail. If the main map has a grid or the graticule shows it, inset maps should show it as well, with grid numbers or latitude and longitude marked. The area shown in the inset should be indicated on the main map; using narrow-width lines to indicate the inset area helps not to overload the map. Insets to show one or more areas can be used.



Here the inset is at a different scale from the rest of the map.
Total number of frauds in 2012 per thousand people by local authority area
© Crown copyright and database rights. Ordnance Survey 2024

TIP

Like the scale bar, locators and insets should remain relatively discreet (e.g. thin borders) and be placed out of the way, keeping in mind spacing and margins between map elements.

How to's	Going further	Inspiration
• ArcGIS Pro • QGIS • R	• Atlas mapbook in QGIS • Map book in ArcGIS	• Inset maps for the web

4.8. Grids and graticules

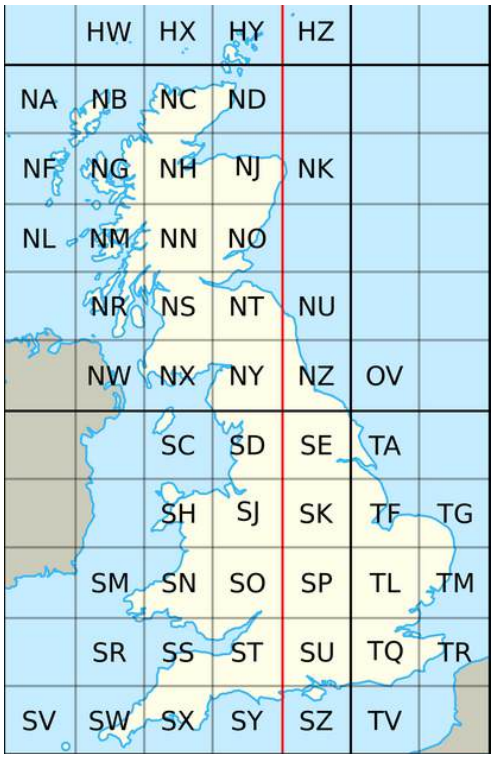
Also known as a grid system or coordinate grid, a map grid is a reference system that defines locations in a given area. It is a network of evenly spaced horizontal and vertical lines intersecting at a right angle. Each intersection is given coordinates to pinpoint an exact location.

Almost all countries in the world have their map grids. Picking the right grid depends on the map scale, the region represented, and the map's purpose.

Grids are helpful for the following:

- Navigation
- Military operations
- Land surveying and planning
- Emergency response

The Universal Transverse Mercator (UTM) Coordinates are commonly used for regional and local maps. UTM divide the globe into zones and represents locations on a 2-dimensional plane.



Great Britain National Grid of 100 x 100 km. © Crown copyright and database rights. Ordnance Survey 2024

The graticule on a map is the depiction of the lines of latitude and longitude which invisibly surround the Earth. It can either be shown as a continuous web or as a series of intersecting crosses which show the latitude and longitude values at a particular point.

Choosing a grid

Choosing a grid is not always straightforward. Sometimes the data set will dictate the grid to use. However, it might not be suitable for your map if the data set is global and the map is regional. Usually, the UTM grid is a good place to start. Online tools like "Which UTM Zone am I in?" can help you find your map's zone.

Sometimes, it is a case of testing and verifying different systems. GIS softwares offer a great range of local and international grids and can convert datasets from one grid to another.

How to's	Going further	Inspiration
• ArcGIS Pro • QGIS	• Converting grids on QGIS • Converting grid on ArcGIS	• Hurricane map

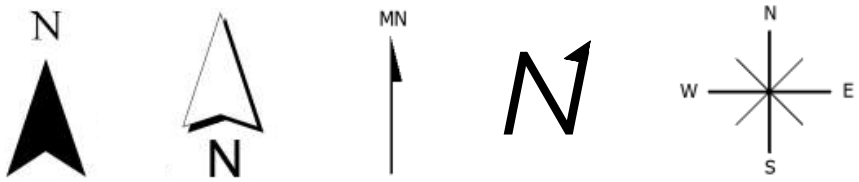
4.9. North Arrows

North arrows are not always essential, especially if the map is of a familiar area and in the conventional orientation. However, a north arrow should be included if the north is not at the top of the map. On dynamic maps (e.g. maps for hand-held devices), they are very useful if the map changes orientation on-screen.

If a north arrow is included, its design and graphic complexity should be appropriate to the general parameters of the map; complex arrows look out of place on a simple map. In most cases, the North arrow should be kept minimal.

World maps should have graticules or a grid on them, instead of a North arrow. For regional or continental maps, including a north arrow is wrong as the north varies in direction across the map and is only correct on the point where it sits.

Simple north arrows



Ornate north arrows

How to's	Going further	Inspiration
• ArcGIS • QGIS	• How to customise a North Arrow in ArcGIS Pro (Video)	• North Arrows - OS

5.
Projections

Coordinate

/kəʊˈɔːdɪneɪt/

noun:

One of a sequence of numbers designating the position of a point

5.1. Coordinate systems

Like any other data, spatial data is made of an array of numbers. The difference Is that spatial data has numerical information as part of a coordinate system. This reference allows us to map features on earth and their relative position.

Geographic coordinate systems (GCS)

Geographic coordinate systems define locations on Earth based on a spherical globe. It uses angular units such as degrees. E.g. SGB 36, WGS 84.

Projected coordinate systems (PCS)

Projected coordinate systems define locations on Earth based on a flattened surface. They use metric units, usually metres. A PCS is a flattened GCS, and the rendering depends on the projection algorithm. E.g., British National Grid and UTM Grid Zones.

Here, ESRI compares a GCS (left) using degrees and a PCS (right) using meters. The PCS grid shows how country dimensions can easily be distorted by the algorithm in an attempt to flatten the world.

How to's	Going further	Inspiration
• ArcGIS Pro • QGIS	• Creating a coordinate system in ArcGIS Pro	• A map is like an orange peel

5.2. Map Projections

The Earth is a 3-dimensional object, but most maps are 2-dimensional. A systematic, mathematical approach is needed to transfer the shape of land or oceans from the round globe to the flat map to ensure that each point on the globe appears at the right point on the map. This is known as a map projection.

Equal area/Equivalent

Preserves areas at the expense of angles, so some shapes of places are skewed.

Good for

- Global maps
- Distribution maps: population, climate zones, and land cover.

Examples

- Cylindrical equal area
- Mollweide
- Sinusoidal
- Eckert IV
- Hammer-Aitoff

Equidistant

Distances are correct, but for specific points and along certain lines only. The projections will have different points of reference like the North and South Poles or the Equator.

Good for

- World raster datasets (e.g. NASA World Wind) - simple relationship between the pixel on the map and its corresponding geographic location.

Examples

- Cylindrical equidistant (Equator)
- Cassini (Equator)
- Azimuthal equidistant (North Pole)
- Plate carrée

Conformal

Project angles correctly locally, keeping the shapes of features. However, areas and distances are distorted.

Good for

- Regional maps
- Navigational routes
- Where relative distance between points is important for analyses

Examples

- Mercator
- Lambert Conformal Conic
- Stereographic

Compromise

Represents the Earth in a not-perfect yet not-badly distorted way. Often used as the shapes often 'look right'.

Good for

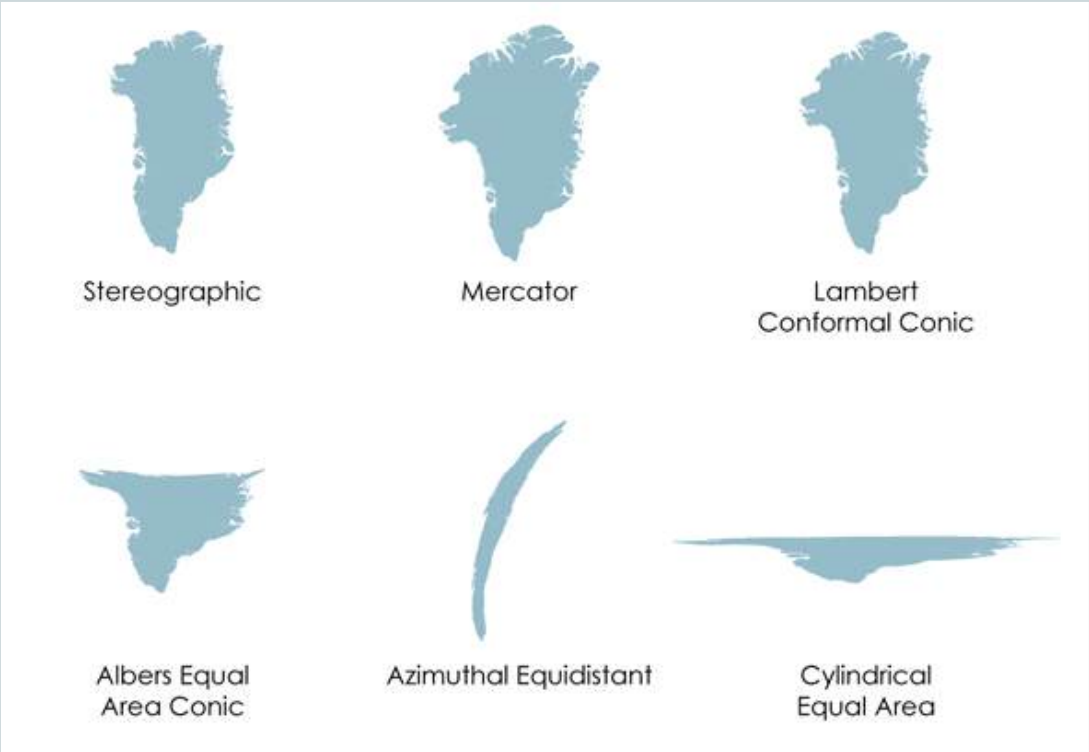
- Aesthetic maps while reducing excessive distortions
- Areas around the Equator

Examples

- Robinson
- Natural Earth
- Winkel Tripel

Cartographers need to use the right projection if mapping any area of the world larger than a small country. For maps of small areas, the projection chosen becomes less important because the distortions reduce as the area of the world shown gets smaller. There are no 'right' or 'wrong' projections to use — only good and poor choices for particular purposes.

Here is one of the many examples of how projections can change Greenland's appearance completely.



How to's	Going further	Inspiration
• Find a projection • ArcGIS Pro projections • QGIS projections	• Table of Map Projections characteristics • Distortions on maps	• Thailand • Switzerland

6.
Map design & layout

Design

/dɪˈzaɪn/

noun:

A plan or drawing.

6.1. Map purpose & design brief

Before starting a design, **it is essential to think about its purpose**. The readers, publishing medium and aim of that map will have a high impact on the design of the visualisation. Here are some questions to keep in mind when planning visualisations.

Who is the audience?

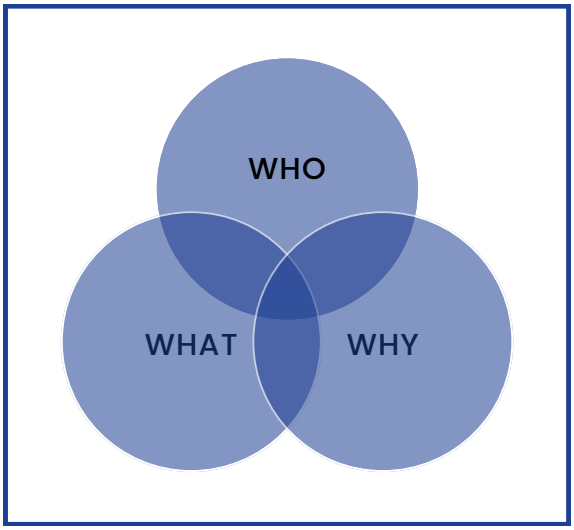
- **Are they experts or the general public?**
  - Non-experts may need simpler presentations
  - Experts on the data being mapped will expect a multi-layered presentation
- **Do they know the mapped area?**
  - On a city map, tourists will want other information than locals
- **How long will they be reading the map?**
  - A hiker will spend more time looking at a map than a commuter taking the tube, needing less detail
- **Is the map accessible?**
  - Is the audience younger (more illustrative) or older (bigger text)?
  - Are they likely to be part of the 4% with colour blindness (higher contrast)?

How will it be published?

- **Will it be on-screen or printed?**
  - Unlike prints, screen maps will use smaller, simpler fonts
  - Web and mobile layouts will vary with screen size
  - When printing, white space should be more prominent to avoid ink-heavy paper.
- **Will it be published in multiple formats?**
  - If using multiple formats, multiple versions of the map should be made
- **Are there any copyright, time and budget limitations?**
  - Resources and deadlines might limit the number of hours spent on the map

What is the purpose?

- **What are some expected map-use tasks?**
  - Digital driving maps will be much simpler to limit distractions whilst on the road.
  - Terrain and vegetation are essential for hiking maps
- **Which elements should be noticed first?**
  - The purpose dictates **Hierarchy**: which information is at the forefront of the map, which labels are more prominent and what colours/symbols stand out



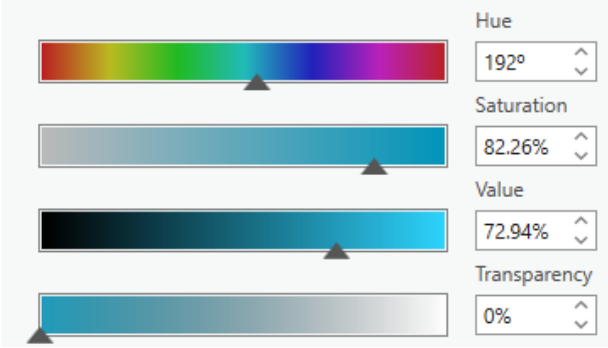
6.2. Colours

Good use of colour on maps can greatly aid the communication of mapped detail. Colour can also enhance legibility and contrast and it can make the important elements of the map stand out from the background material. Most map designers are working with colour, and colour output is the norm for both printed and on-screen maps.

There are a variety of colour systems to pick map colours including HSV (Hue-Saturation Colour), CMYK (Cyan-Magenta-Yellow-Black), and RGB (Red-Green-Blue). It is good to be aware of these systems as they approach colours differently.

HSV

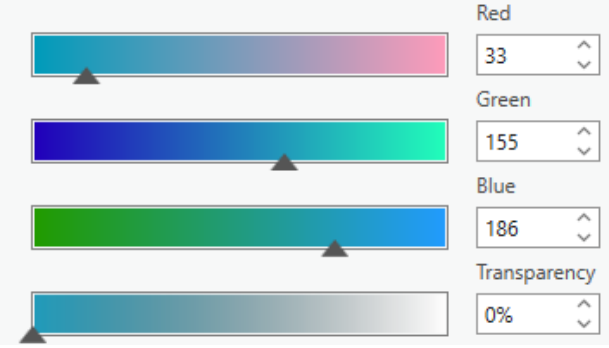
HSV is used to adjust colours using hues, brightness and saturation.



ArcGIS colour lab

RGB

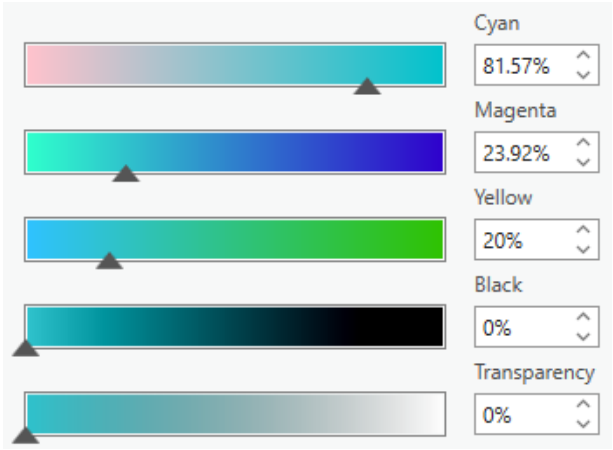
RGB is used for screen graphics and enables the choice of colour.



ArcGIS colour lab

CMYK

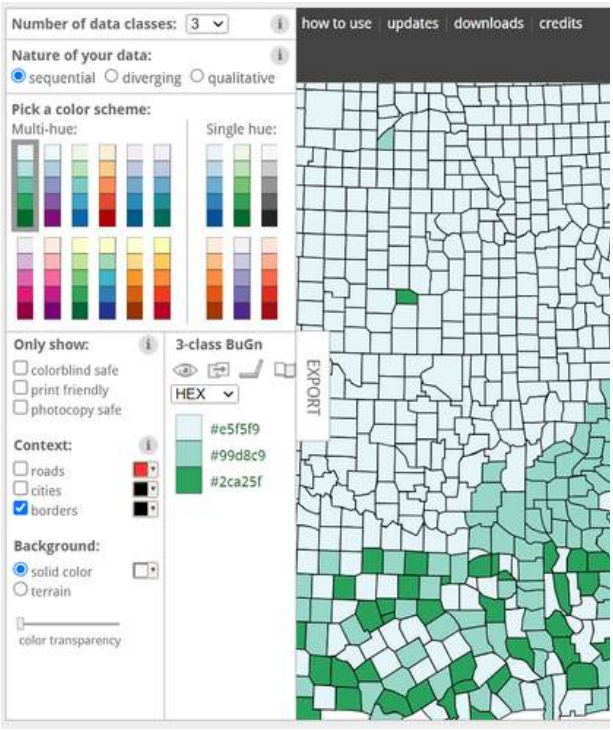
CMYK is better for paper maps as it is used for printed graphic arts.



ArcGIS colour lab

TIP

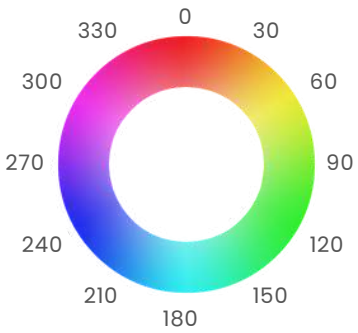
Colour Brewer is a reference tool when it comes to making map colour schemes.



Colour Brewer 2.0 interface

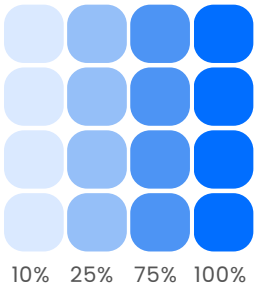
Hue

Based on wavelengths, the hue is what we associate with colour names. Saturated hues are placed in order like seen in the rainbow and spectrum. It is referred to in degrees (0 to 360)



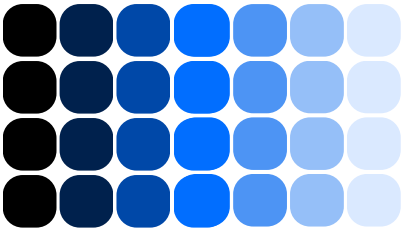
Saturation

Saturation is the vividness of the colour (hue). Calculated in percentages, it indicates how much of that colour is being put in an object.



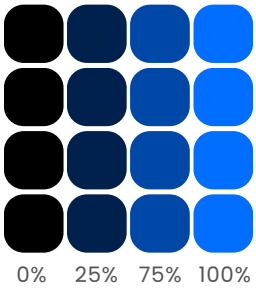
Lightness

Sometimes confused with saturation, lightness is the brightness of a colour compared to its background. It is a measure of perceived light.



Brightness

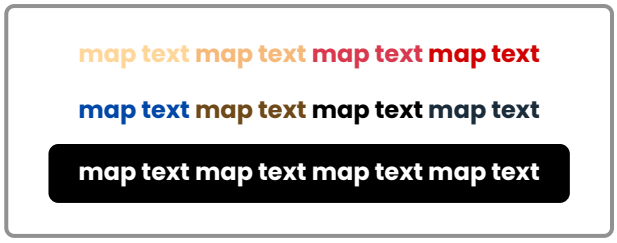
Unlike lightness, brightness is an absolute measure of light reflected from an object, given in percentage
(0 to 100%).



Using colours effectively

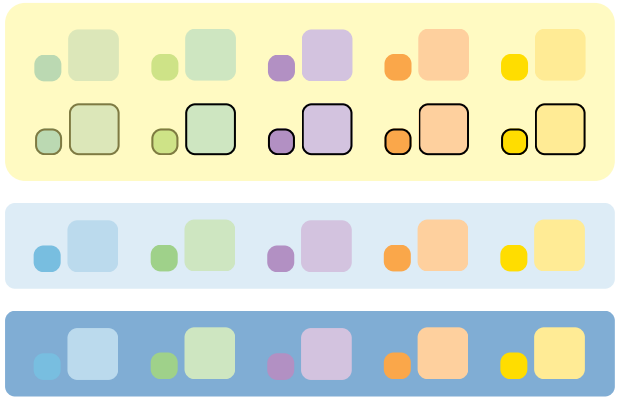
Text

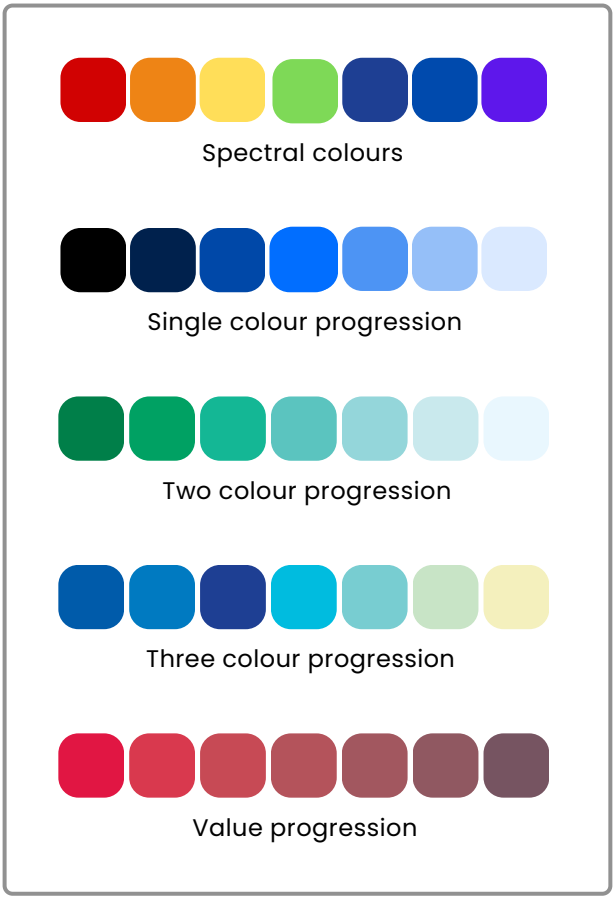
- Small letters and symbols need more intense colours.
- On white, the most legible colours for text are black, dark brown or dark blue. On black, it's white or very light colours.



Symbols & features

- Where appropriate use conventional (e.g. green = vegetation) and associative colours (e.g. red = warm)
- Colour perception changes with the size of the symbol
- Lighter symbols can look smaller than darker ones
- Avoid using more than 10 colours on a map





Background

- Choose the colours depending on their background
- Darker background = lighter features and symbols
- Lighter background = darker features and symbols

Qualitative maps

- In these maps, symbols are not more important than the others - colours should keep the same visual value/saturation
- Using part of the spectrum makes a good sequence

Quantitative maps

- Colours show a hierarchy
- Dark colours signify greater numbers or importance

6.3. Symbology

In addition to colour symbols, cartography uses a variety of shapes to represent features such as point symbols, lines, and area symbols. The combination of colours and forms opens up endless combinations to create unique symbols. This enables you to match them perfectly to the map style.

Points

Size

- Qualitative maps: similar size representing different classes of information
- Quantitative maps: proportional size representing the point value, usually totals of a given feature or area.

Shape

- Qualitative maps: geometric, conventional or mimetic. Familiar and self-evident when possible.
- Quantitative maps: bars, circles, squares, triangles, custom-made, 2D or 3D.

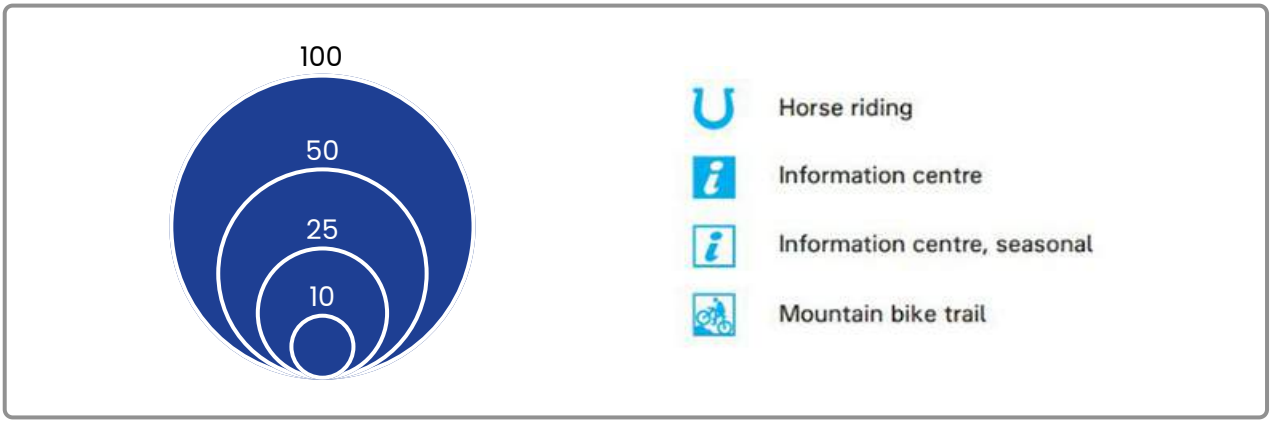
Orientation

Although not very effective in most cases, angled symbols can be useful for directional and cyclical maps like wind and water movements.

Uses

- Qualitative: points of interest, cities, services.
- Quantitative: number of deaths per area, water usage per household, light pollution extent

Source

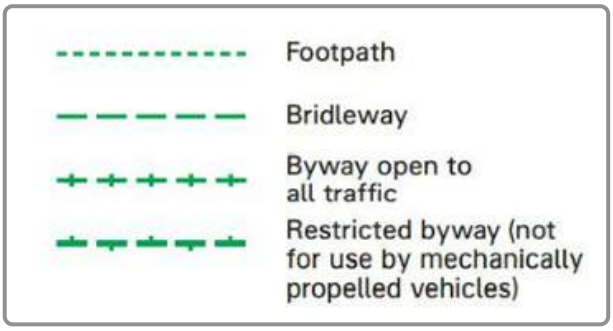


How to's	Going further	Inspiration
• Point Symbols in ArcGIS Pro • Point Symbols in QGIS	• Using two types of symbologies for one feature	• Firefly Style

Lines

Size

- Qualitative maps: similar characteristics (width, visual weight and complexity) with variations in colour or design for each feature.
- Quantitative maps: proportional line or arrow width representing the value or flow direction.



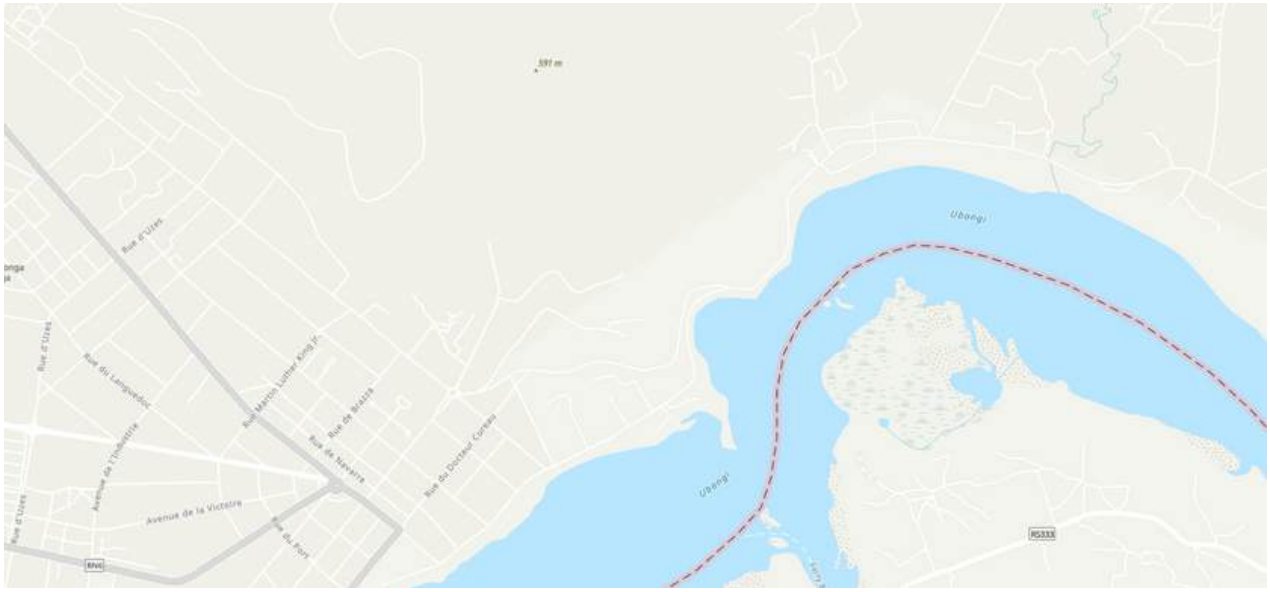
Ordnance Survey key for public rights of way.

Shape

- Qualitative maps: line straight or curved, continuous, dashed, dotted or custom-made.
- Quantitative maps: Curves, lines, arrows

Patterns

- Common patterns are dashing and casing
- Different symbols are created by changing the dash orientation, height, space and length.
- Casing superposes lines of different widths and colours to create new symbols
- Casing and dashing can be combined



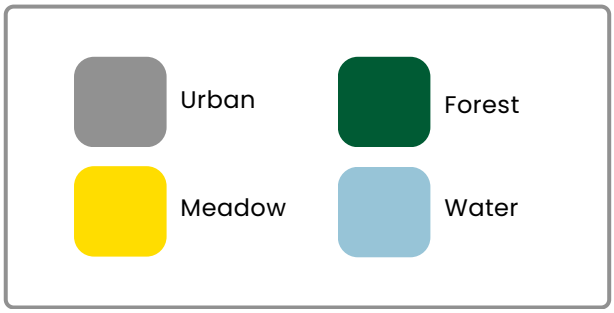
ESRI street basemap with various line types for roads, boundaries and natural features

How to's	Going further	Inspiration
• Line symbols in ArcGIS Pro • Line symbols in QGIS	• Add arrow heads to line features	• The great Glen and Mallaig extension railway

Areas

Colour

- Similar-sized areas can be symbolised by different colours of the same saturation and lightness
- Where there are size variations, colour saturation might have to be increased for smaller areas
- Colours should be associative with the feature they represent



Example of symbology using colour

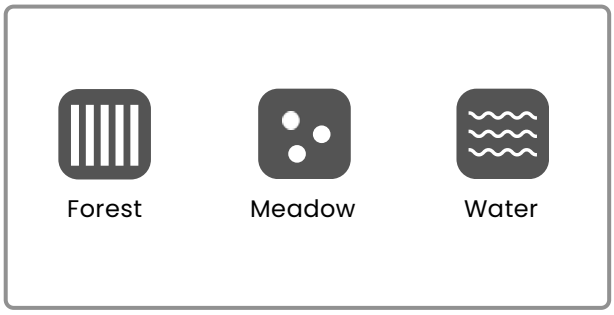
Shape

- A wide variety of patterns and fill symbols can be used in cartography: literal or abstract.
- Literal symbols resemble what they represents (e.g. trees for forests)
- Abstract symbols (e.g. squiggles for water; curved lines for air currents)

Example of symbology using shaped icons

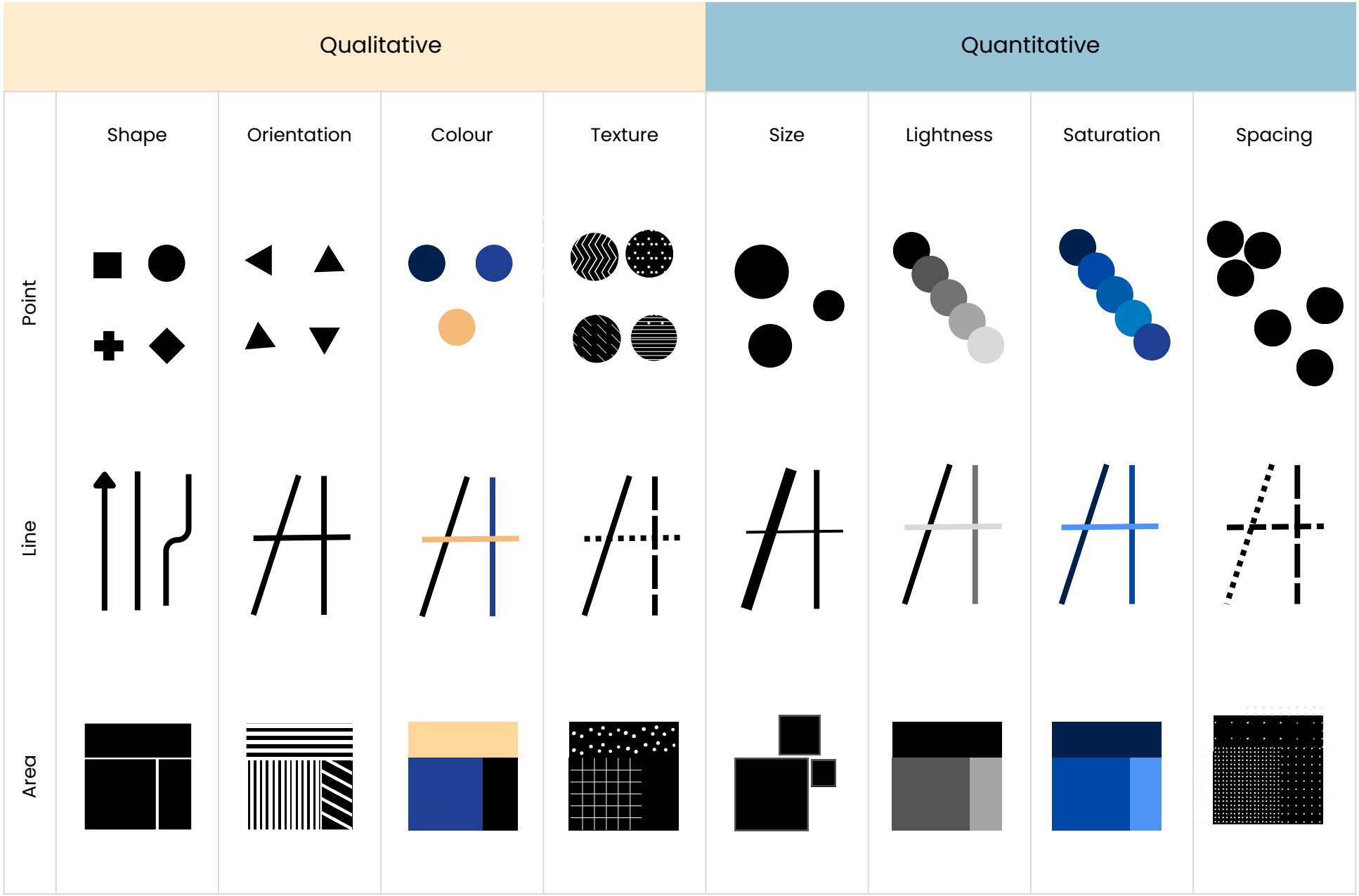
Patterns

- It is good practice to associate the pattern with the feature it represents (e.g. with colours)
- Textures can be used to represent values (e.g. loosely spaced = low value)
- Similarly, a smaller fill symbol can represent lower values.



Example of symbology using patterns

How to's	Going further	Inspiration
• Polygons in ArcGIS • Polygon symbols in QGIS		• Urbanization of Virginia


Qualitative
Quantitative
Shape
Orientation
Colour
Texture
Size
Lightness
Saturation
Spacing
Point
Line
Area

6.5. Margins

Margins are crucial in visual representations. they are the "free space" surrounding elements of a design.

Margins are used to define space between elements, text and images/charts/maps. They help create a sense of balance, a visual hierarchy and focus for the viewer's attention. Margins can be used to make text, images or other elements stand out. Below is an example of the same map done with and without even spacing.

Balanced

Unbalanced

TIPS

- Create margins before placing elements (if possible)
- Set a line, letter and element spacing
- Align elements, graphics and images as much as possible
- Leave enough space between the border of the page and the elements
- Keep it consistent

6.6. Logos & images

Logos and images are a great way to add context to a visualisation. However, they must be used carefully to not obstruct the data itself.

Here are a few tips to keep it mind:

Use logos and images sparingly
Too many will clutter the visualisation and make it harder to read.

Make sure they are relevant
Images should complement the visualisation, not confuse the reader

Keep them small and discreet
Don't make them the focal point of the visualisation

Use high-quality logos and images
Lower resolutions look unprofessional and can be less effective.

Get a second opinion
An image that might seem relevant and clear to you, might not be for others. make sure to get a few opinions on their relevance.

Use icons if you can
Icons are usually more recognisable and easier to understand.

Keep the style consistent
Make sure images have a similar tint, logos are consistent and icons are of the same style for a more cohesive and consistent look.

Label images
If using images, make sure they are labelled as needed.

How to's	Going further	Inspiration
• Add graphics, text and pictures in ArcGIS Pro • Picture item in QGIS	• Geotagged photos to point features in ArcGIS Pro • Geotagged photos to point features in QGIS	• flickr photo map

6.7. Accessibility

Improving accessibility of data visualisations is essential. Keeping accessibility in mind throughout the design process can improve engagement levels, make the data visualisation more legible, widen the audience, and increase inclusivity.

Visual

Impairements

- Colour blindness
- Colour Vision Deficiency (CVD)
- Deutoranopia and protanopia
- Tritanopia
- Achromatopsia
- Blindness and reduced vision

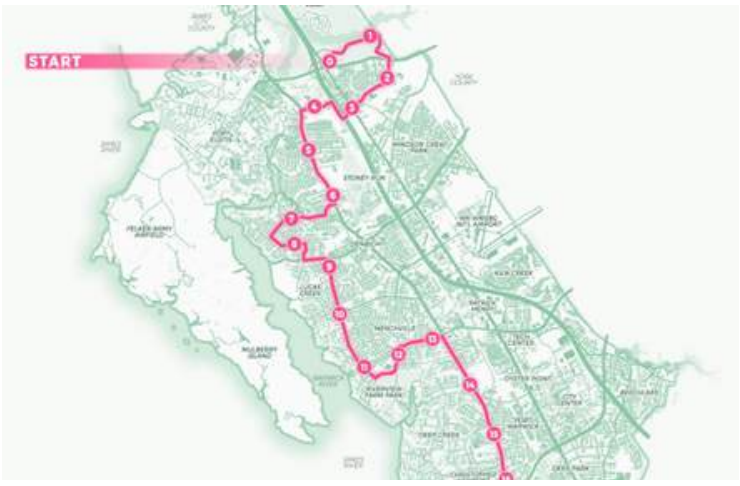
Solutions

COLOURS

- Alter contrast, not hue - Is it usable in black and white?
- Use patterns, symbols, icons and shapes instead of colours for symbology
- Use resources like Colour Brewer, Adobe Colour, and Oracle Colour to verify suitability and pick the right colours and increase contrast
- Use the Ordenance Survey Stylesheets
- Make it interactive or use alrternatives e.i. Tactile, acoustic, touch-and-speak, braille

LABELS

- Explain the goal of the map and what it's showing
- Keep the typeface and style simple (e.i. common sans serif fonts)
- Use upper and lower case to emphasise importance
- Increase text size and contrast against the background (halos, highlights, etc.)
- For labels of a single category but of different importance use black %



Jonah Adkins - Newport News Marathon.

The colours and symbology of the map make it easy to understand. Clear labels and numbers lead the reader through the trail..

The base map is of a complementary colour and its symbols are size-based.

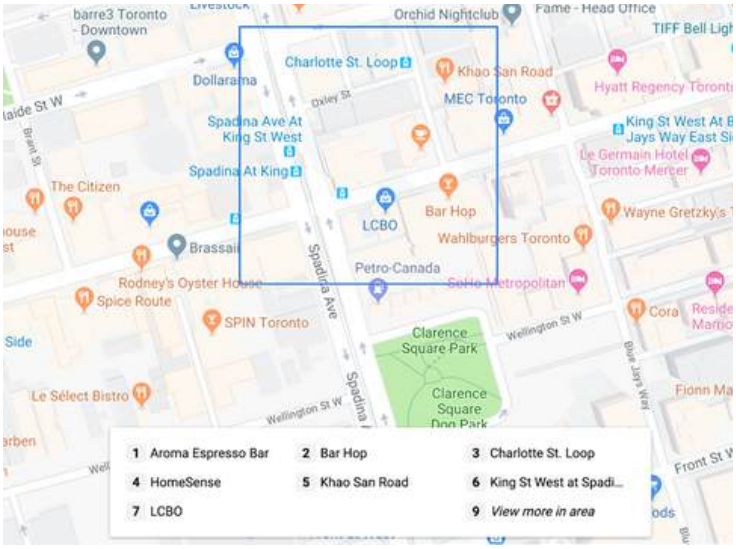
Auditive

Impairements

- Deaf
- Hard-of-hearing

Solutions

- Simple language
- Clear and easy-to-understand symbols



Google Maps

Google Maps uses a smaller box on the main map. Listed bellow or the points of interests in that box.

Using *Shift + item-number* brings up the information of the point of interest. This makes it easier for anyone who finds precise movement dificult.

Motor

Impairements

- Reduced mobility
- Loss or damage of limb(s)
- Affected fine motor controls
- Muscular dystrofy
- Cerebral palsy

Solutions

- Wider clicking areas in interractive visualisations
- Mouse AND keyboard controls
- Speech control

Accessible route mapping - Ordnance Survey collaboration with the Rose Road Association

This map depicts things which could hinder someones journey. This includes slanted terrain, busy/queit areas.
Using handrawn features keeps the map interesting and colours are CVD-friendly.

Cognitive

Impairements

- Dyslexia, ADHD, and others
- Intellectual disabilities

Solutions

- Provide nformation in multiple formats
- Use simpler terms and/or provide definitions as needed
- Label as much as possible to reduce the cognitive load
- Utilise white space for visual separations
- Test it with users
- Simplify text with the Hemingway App.
- Keep the design, labels and colours consistent

Tactile map

Often 3D printed for blind users, tactile maps allows them to feel their way around a place. They can get a sense of where places are in relation to other locations.

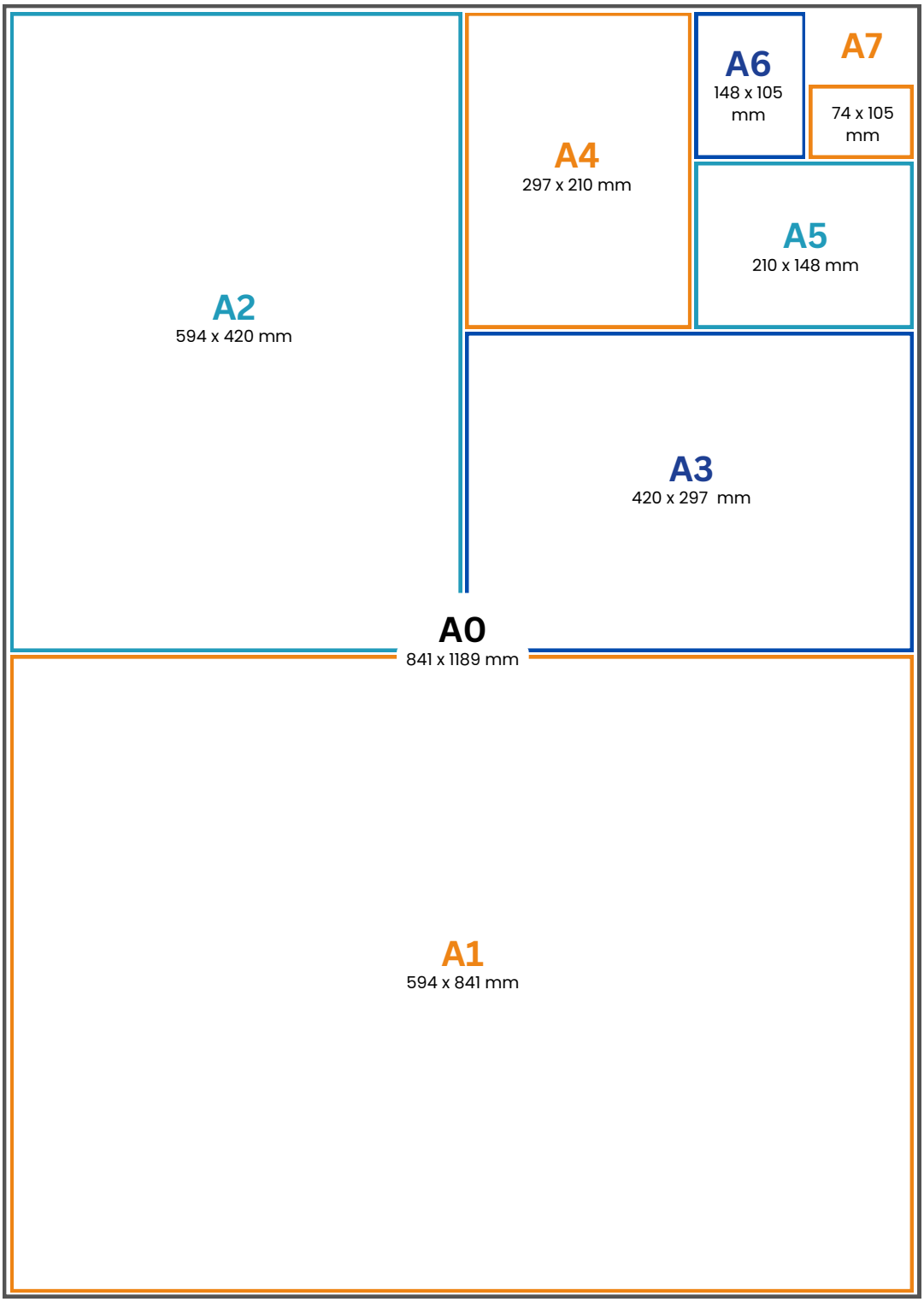
This can be used in conjunction with braille or audio to describe the text elements.

Perhaps this could be done for charts?

6.8. Visualisation sizes

Where your data visualisation will be published will affect it's size and dimension ratio. Will it be printed? Will it a be integrated in a web page? Is it for an ad poster or social media? All these formats use different dimensions of the final product. Here is a guidance for social media posts, websites and print media.

Print



Social media

Instagram

Stories and ads post
1080 x 1920 px

Square post
1080 x 1080 px

Portrait post
1080 x 1350 px

Landscape post
1080 x 566 px

LinkedIn

Carousel images
1080 x 1080 px

Page post image
1200 x 628 px

Pinterest

Square image
1000 x 1000 px

Facebook

Post image
1080 x 1350 px

Twitter / X

In-stream image
1600 x 900 px

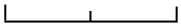
TIP

Here we use millimeters for printing formats and pixels for digital content. Some software might use dpi (dots per inch), a measure of the resolution of an image. It is used in digital and print images. A good place to start is setting the resolution to 72 dpi for online images and 300-350 dpi for standard printing quality. A higher dpi might be needed if the image is bigger (e.g. larger screen, big poster).

6.9. Better visualisations

In 5 minutes

Legend
Are all the symbols matching and inclusive?



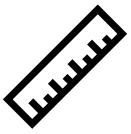
Scale
Is the map scale correct and clear?

Title
Is it brief, clear and explanatory?

Insets
Do they all have a title and a scale bar as needed?

In 15 minutes

Ratio
Will the map fit the screen/page with no scrolling?



Units
Does the legend state the right units and dates?

Spelling
Is everything spelt correctly?

Labels
Are they correct, distinct and seperate?

In 50 minutes

Print
Print it out to proof it - mistakes are easier to spot.

Web
Test it on various browsers if its a web map

Feedback
Ask for opinions on the design and spelling

Balance
Check the balance and spacing on the map

7.
Tools & software

Dashboard

/ˈdaʃbɔːd/

noun

a graphical summary of various pieces of important information, typically used to give an overview of a business.

7.1. Mapping tools

QGIS

FREE

QGIS is a software application that lets you view, edit, and analyze geographic data. The program offers a variety of tools to help you create maps that reflect your data. It is a free and open-source software, which is used to work with spatial data.

Best for

- Spatial analysis
- Plugins for additional features
- MacOS, Windows and Lenux servers

Difficulty Medium

Link https://qgis.org/en/site/about/index.html

ArcGIS

YEARLY SUBSCRIPTION

ArcGIS is geospatial software to view, edit, manage and analyze geographic data. Esri develops ArcGIS for mapping on desktop, mobile, and web. Their motto is “Science of Where”. As such, the focus for ArcGIS is on location intelligence and analytics.

Best for

- Spatial analysis
- Plugins for additional features
- MacOS, Windows and Lenux servers

Difficulty Medium

Link https://www.esri.com/en-us/arcgis/about-arcgis/overview

Google Earth Engine

FREE FOR RESEARCH

Google Earth Engine combines a multi-petabyte catalogue of satellite imagery and geospatial datasets with planetary-scale analysis capabilities. Scientists, researchers, and developers use it to detect, quantify and map trends on the Earth's surface.

Best for

- Remote sensing
- Cloud processing
- Web use

Difficulty Medium

Link https://earthengine.google.com/

Felt

SUBCRIPTION

Felt is an online mapping tool created for team collaboration.

Best for

- Quick maps
- Collaboration
- Online

Difficulty Easy

Link https://felt.com/product

CARTO

SUBSCRIPTION

CARTO provides a cloud-based platform that allows users to visualize, analyze, and gain insights from geospatial data. It offers a user-friendly interface for creating interactive maps and data visualizations. Users can import their own geospatial datasets or access a variety of public and commercial data sources.

Best for

- Spatial data analysis
- Interactive maps
- Heat maps and hex maps
- Online

Difficulty Easy **Link** https://carto.com/

mapbox

SUBSCRIPTION

Mapbox is a mapping platform that provides tools, APIs (Application Programming Interfaces), and services to create custom maps, geospatial applications, and data visualizations including map rendering, geocoding, routing, and data hosting.

Best for

- Interactive maps
- Routing and geocoding
- Web and mobile maps
- Online

Difficulty Easy **Link** https://www.mapbox.com/

7.2. Chart tools

Like chart types, the number of tools to create them are numerous. Here, we offer an overview of three categories with a few examples of popular tools used: Software, online/web, and programming language tools.

Microsoft Excel

SUBCRIPTION

Excel is a widely used spreadsheet programme based on rows and columns. Each of those can contain various types of data like numbers, text, formulas and functions. The data can then be summarised in simple, effective charts.

Pros

- A good range of chart types
- Familiar interface
- Visual flexibility and customisation
- Integration with Excel features
- Interactive charts available

Cons

- Charts limited to traditional formats
- Data size limitations
- Design possibilities are limited
- Limited compatibility with other software
- Interactive charts are harder to create

Google sheets

FREE

Google Sheets is a cloud-based spreadsheet programme. It is similar to Excel but with better web access, cloud-based storage and collaboration features. Along with basic charting capabilities, it offers various extensions.

Pros

- A good range of chart types
- Easy data integration
- Visual flexibility and customisation
- Realtime collaboration
- Sharing and embedding options

Cons

- Limited advanced chart features
- Slower performance with large datasets
- Design possibilities are limited
- Limited compatibility with other software
- Advanced charts are harder to create

Other data visualisation tools

- Canva
- Visme
- PowerBI
- Piktochart
- Venngage
- Plotly
- Zoho sheet
- Seaborn
- Tableau

Infogram

FREE

Infogram is a web-based data visualization and infographic creation tool. It allows users to create visually engaging charts, graphs, maps, infographics, and dashboards without the need for advanced design or coding skills.

Pros

- Chart type customisation
- Infographic creation
- Interactive feature available
- Realtime data connections
- Collaboration and integration options

Cons

- Charts limited to traditional formats
- Data size limitations
- Design possibilities are limited
- Internet connection dependency
- Subscription to access all features

Datawrapper

FREE

Datawrapper is a web-based data visualization tool that allows users to create interactive and visually appealing charts, maps, and tables. It is designed to make data visualization accessible without requiring programming or design skills.

Pros

- A good range of chart types and maps
- Easy data integration
- Responsive and mobile-friendly
- Interactive features available
- Sharing and embedding options

Cons

- Limited advanced analysis features
- Data size limitations
- Design possibilities are limited
- Internet connection dependency
- Subscription to access all features

Matplotlib

FREE

Matplotlib is a popular data visualization library for the Python programming language. It provides a comprehensive set of functions and methods for creating various types of plots, including line plots, bar plots, scatter plots, histograms, and more.

Pros

- High-level customisation and flexibility
- Integration with other Python libraries
- Active user community
- Powerful capabilities for sophisticated visualisations

Cons

- Complex for beginners
- Complex syntax compared to others
- No aesthetically pleasing default styles
- Limited interactivity
- Slower rendering with larger datasets

ggplot2

FREE

ggplot2 is a data visualization package for the R programming language. It provides a structured approach to creating visualizations. ggplot2 allows users to layer graphical elements and provides a varied set of tools for customization

Pros

- Wide range of chart types
- Known for aesthetically pleasing charts
- Active user community
- Powerful capabilities for publication-quality visualisations

Cons

- Complex for beginners
- Limited built-in interactivity
- Limitations for high-level customisation
- Lack of native 3D visualisations
- Slower performance with larger datasets

7.3. Programming languages

Python is a high-level programming language widely used for web development, data analysis, artificial intelligence, scientific computing, and more. It was created by Guido van Rossum and first released in 1991.

FREE

Python is a high-level programming language used for web development, data analysis, artificial intelligence, scientific computing, and more. It was created by Guido van Rossum and first released in 1991. It has a growing and supportive community.

Best for

- Learning programming
- Accessible libraries
- MacOS, Windows and Linux

Popular libraries & packages

- Matplotlib
- Seaborn
- Plotly
- Bokeh
- Pandas
- Altair

Difficulty

Easy

Link

https://www.python.org/

FREE

R is a programming language and software environment commonly used for statistical computing and graphics. It was developed by Ross Ihaka in the early 1990s. R provides statistical and graphical techniques.

Best for

- Statistics
- Data manipulation
- Machine-learning
- Reproducible workflows

Popular libraries & packages

- Gg2plot
- Ggvis
- Plotly
- Lattice
- rCharts
- Dygraphs

Difficulty

Medium

Link

https://www.r-project.org/

FREE

JavaScript is the primary language for web development and is often used for interactive data visualizations on the web. Libraries like D3.js, Chart.js, and Highcharts.js provide extensive options for creating dynamic and interactive visualizations in the browser. It was created by Brendan Eich at Netscape Communications in 1995.

Best for

- Interactive and dynamic visualisations
- Web elements integration (HTML, text, ...)
- Machine-learning
- Reproducible workflows

Popular libraries & packages

- D3.js
- Chart.js
- React
- Highcharts
- Plotly.js
- Angular

Difficulty

Hard

Link

https://www.javascript.com/

7.4. Design

Illustrator

SUBSCRIPTION

Adobe Illustrator is a vector graphics editor and design program developed and marketed by Adobe Inc.

Best for

- Editing maps
- Stylising designs
- MacOS

Difficulty Medium

Link https://www.adobe.com/uk/products/illustrator.html?

COLORBREWER

FREE

This online tool allows users to create colour schemes for maps and other graphics in order to show data that is readily readable. It is possible to create maps using up to 12 different data classes which can be sequential, divergent or qualitative.

Best for

- Choosing map colour scales
- Accessibility
- Online

Difficulty Easy

Link https://colorbrewer2.org/

7.5. Dashboards

Power BI

SUBSCRIPTION

Power BI is a business analytics tool developed by Microsoft that provides interactive visualizations. It allows users to connect to various data sources, transform and shape the data, and create interactive visualisations.

Best for

- Dashboards
- Business analytics and reports
- Software

Difficulty Medium

Link https://powerbi.microsoft.com

tableau

SUBSCRIPTION

Tableau is a data visualization software that helps people see and understand their data. It connects to various data sources, like spreadsheets, databases, or cloud services, and creates interactive dashboards, reports, and charts.

Best for

- Interactive dashboards and charts
- Large and complex datasets
- Online or desktop

Difficulty Medium

Link https://www.tableau.com

7.6. Story maps

This online tool allows users to create colour schemes for maps and other graphics in order to show data that is readily readable. It is possible to create maps using up to 12 different data classes which can be sequential, divergent or qualitative.

ArcGIS StoryMaps

SUBSCRIPTION

ArcGIS StoryMaps turns ArcGIS work into interactive content. It uses existing web maps, surveys, dashboards to create a more media-focused visualisation.

Best for

- Dashboards
- Business analytics and reports
- ArcGIS Online Maps
- Online

Difficulty Easy

Link https://storymaps.arcgis.com/

StoryMaps

SUBSCRIPTION

StoryMaps is an online tool dedicated to story maps. It is designed to be easy to use, allowing users to integrate maps, images and other media in a compelling and interactiveway.

Best for

- Story maps
- Simple maps
- Media-based storytelling
- Online or mobile app

Difficulty Easy

Link https://www.storymaps.com/

StoryMap JS

SUBSCRIPTION

StoryMapJS is an open-source tool developed by Northwestern University's Knight Lab. It enables users to create interactive stories by combining maps, images, and text. StoryMapJS provides a user-friendly interface and offers various templates.

Best for

- Event reporting
- Mapbox maps
- Large media files
- Online

Difficulty Easy

Link https://storymap.knightlab.com/

Resources

SCAN THE QR CODE to get access to the resources used in the guide and other useful links like inspirational content, tutorials, websites and data sources.

Alternatively, you can use the link below:
https://rb.gy/l3ozv

Acknowledgements & further information

Thank you to BCS and GGP for their valuable contributions to this toolkit.

The British Cartographic Society is a registered charity open to all with an interest in maps and cartography. Its aim is to promote all aspects of cartography in the UK and abroad by offering a forum for the exchange of ideas and the sharing of cartographic knowledge.

Details on GEOVIZ activities can be found on the Society's website www.cartography.org.uk.

Got feedback?

Let us know what you think of the toolkit, whether it's good or bad.
For comments, suggestions and questions, head over to our feedback form:
https://forms.gle/oYPzs6gACkPvQvZc8

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