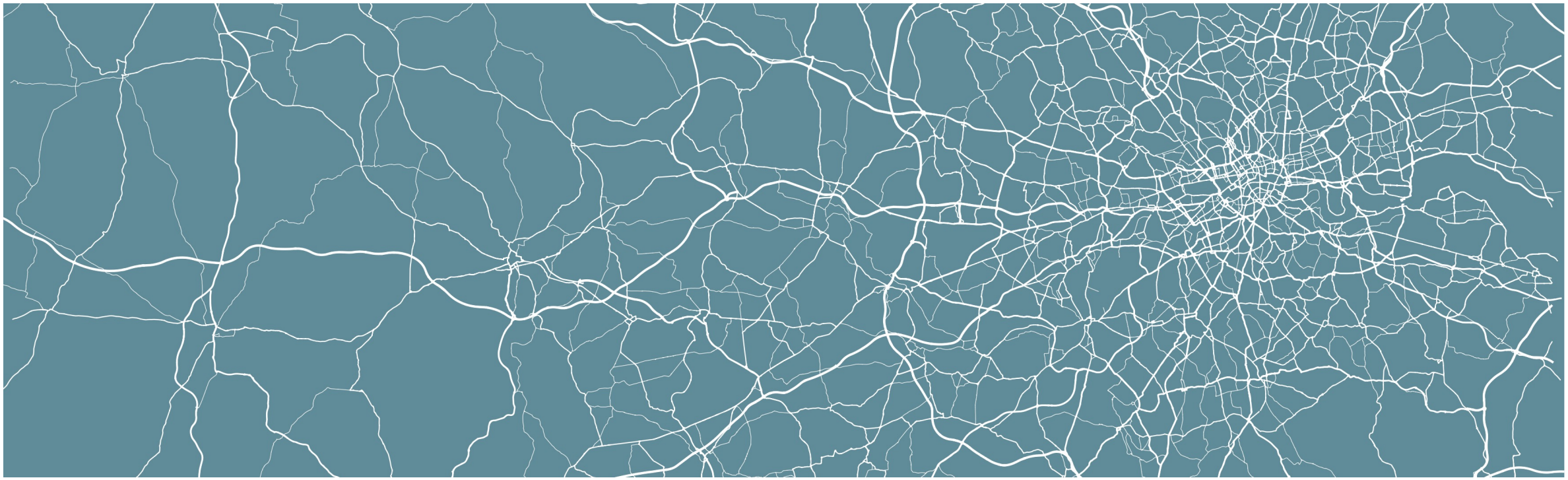
Geocomputation

W2 – GIScience and GIS software



UCL

Where are we at?

Part I: Foundational Concepts

W1 Geocomputation: An Introduction

W2 **GIScience and GIS Software**

W3 Cartography and Visualisation

] QGIS

W4 Programming for Data Analysis

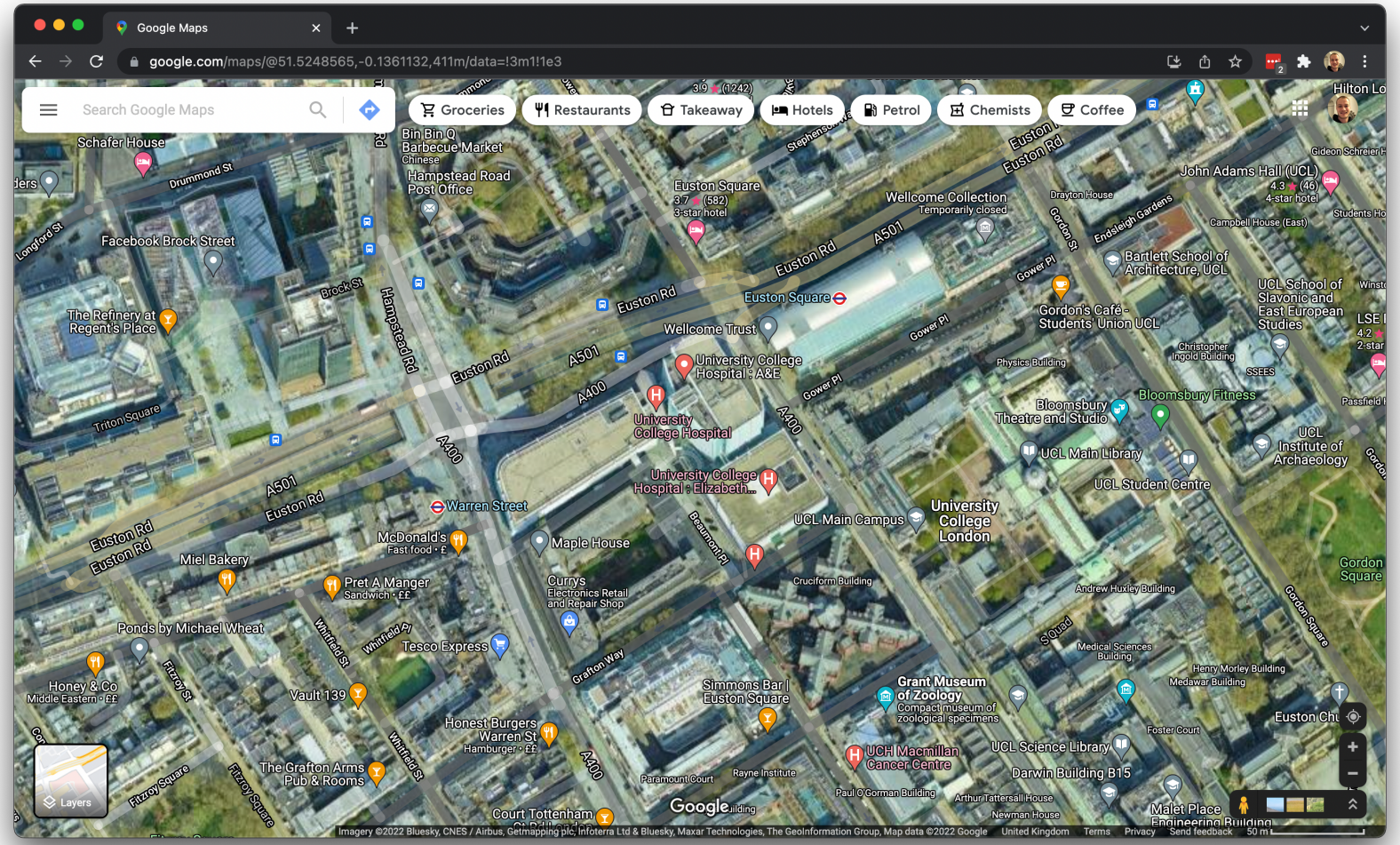
W5 Programming for Spatial Analysis

] R

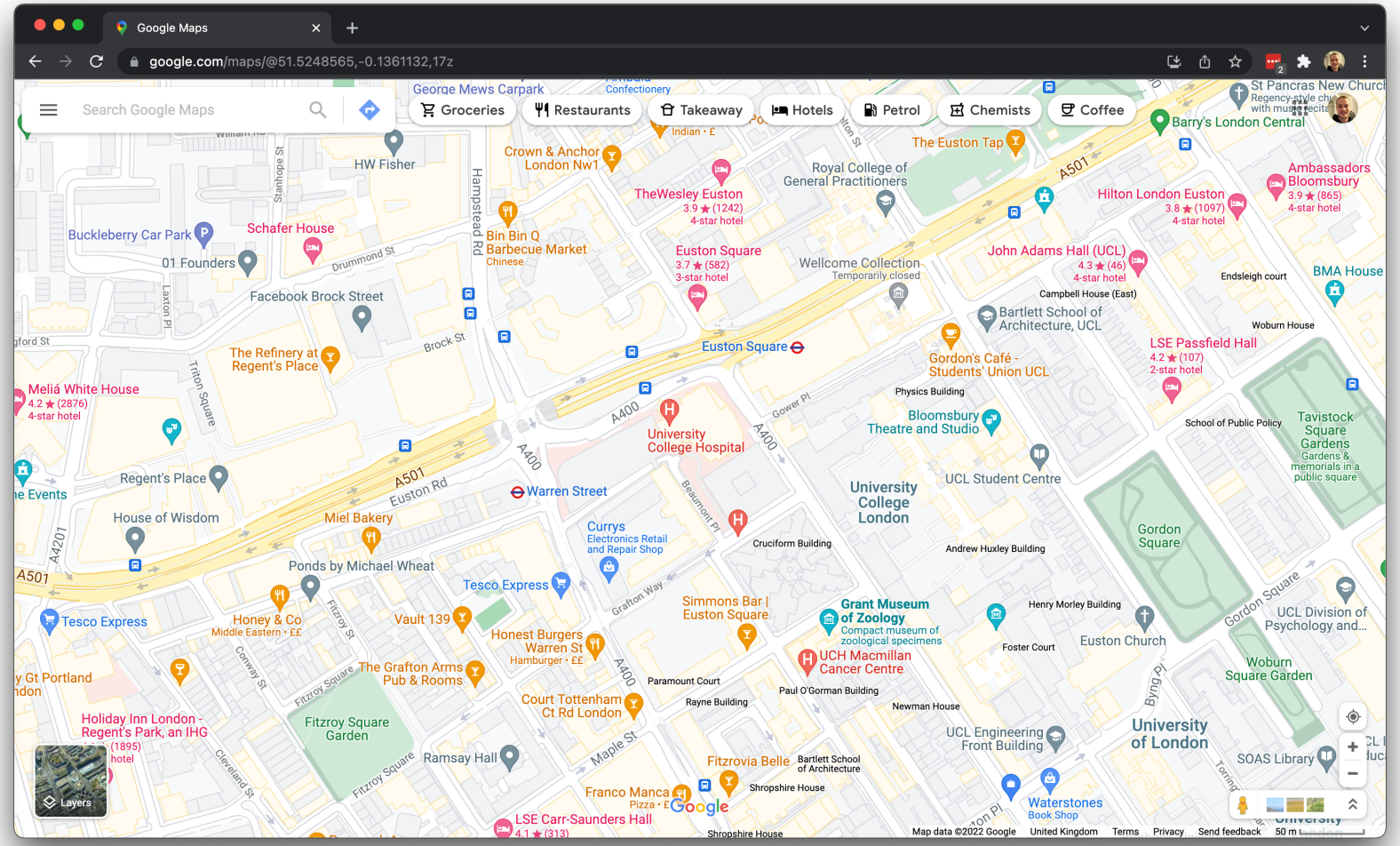
This week

- Digitally representing spatial data within GIS software
  - Vector data
  - Raster data
- GIS software and file types

Spatial modelling and digital representation I



Spatial modelling and digital representation II

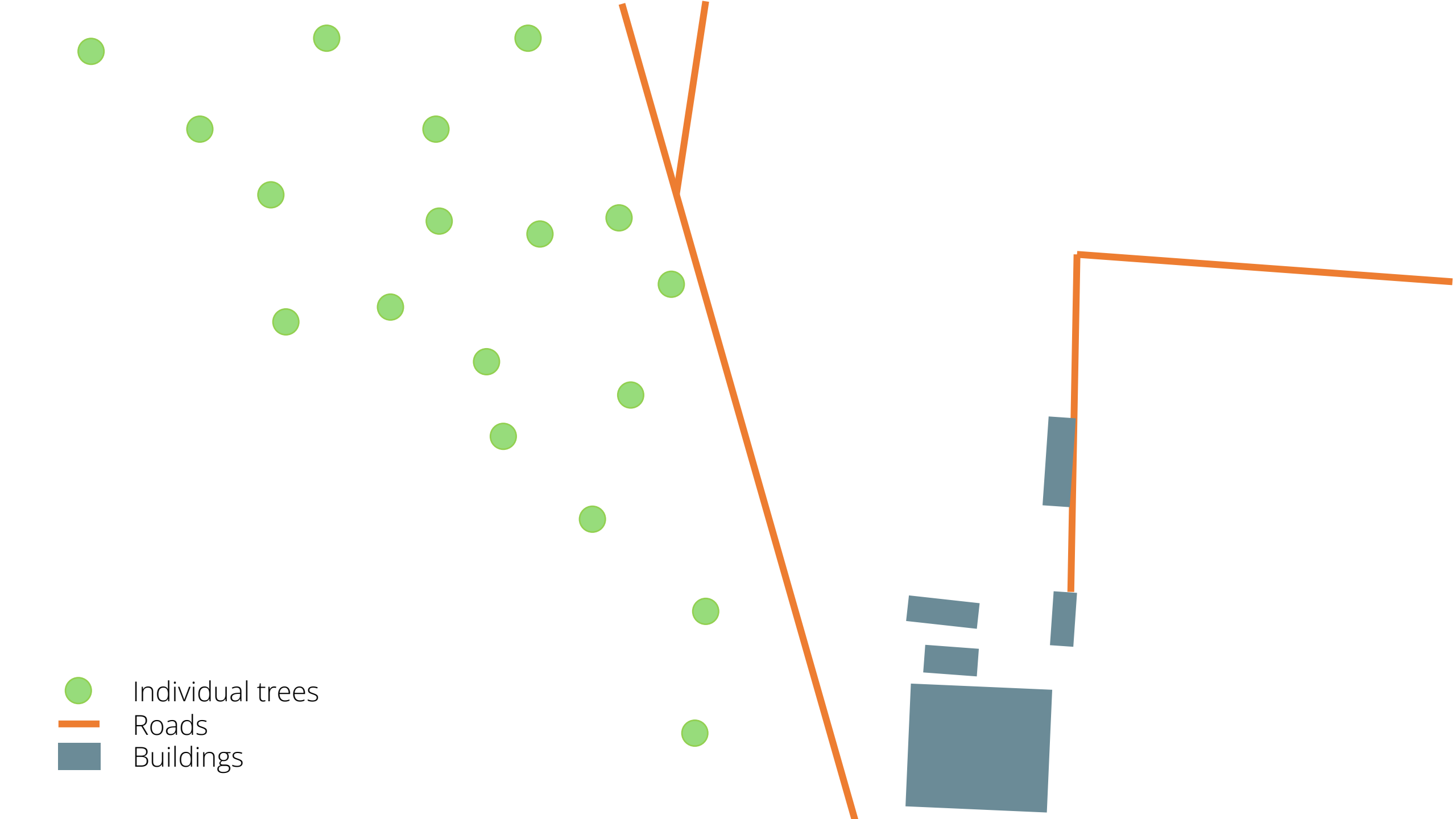


GIS data models

- GIScience requires spatial information to be represented in a digital format
- Traditionally, geographic information is represented in two ways:

  vector: a finite set of discrete geometric objects

  raster: images representing a surface (values, colours)


Individual trees
Roads
Buildings

Features

The objects created are called Features. A feature can be described according to its characteristics which is termed an Attribute in GIS. The attribute of a feature can be a numeric or text observation.

Types of features

- Individual tree: type of tree, height, width. Point feature.
- Roads: type of road, length of road, speed limit. Polyline feature.
- Buildings: type of building (commercial, residential), number of people living in the building, number of stories. Polygon feature.

Vector data

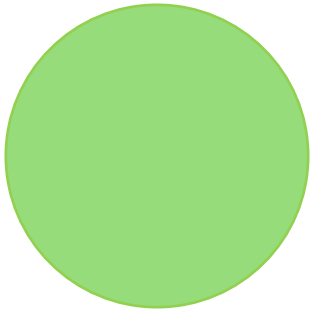
- The objects that we created of discrete entities are called vector data.
- Three types of vector data: point vectors, polylines or line vectors, and polygon vectors.

Point vector I

Characteristics of a point vector in a GIS data model:

- Single XY location (coordinate)
- Has no area
- Has no length
- Geometry consists of a single node or vertex
- Used for: discrete features

Point vector II



Point vector II

Point vector III

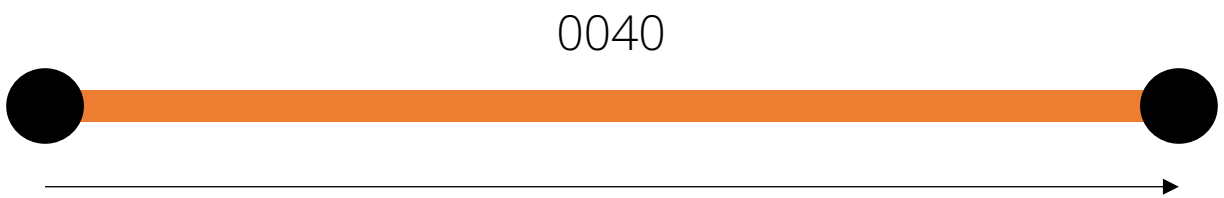
FeatureID	Type	Height
0030	Ent	500

Polyline vector

Characteristics of a polyline vector in a GIS data model:

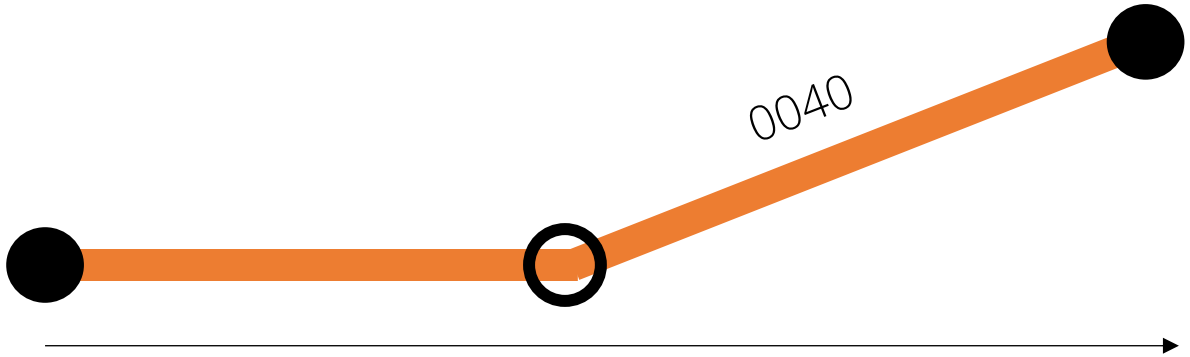
- Series of XY locations (coordinates) to form a line
- Has no area
- Has a length
- Has a direction importance when it comes to roads, rivers, etc)
- Can be connected to other polyline vectors to form a network
- Geometry consists of a 2 nodes (start node and end node) and can have one or more vertices
- Used for: features without an area but with a length

Polyline vector II



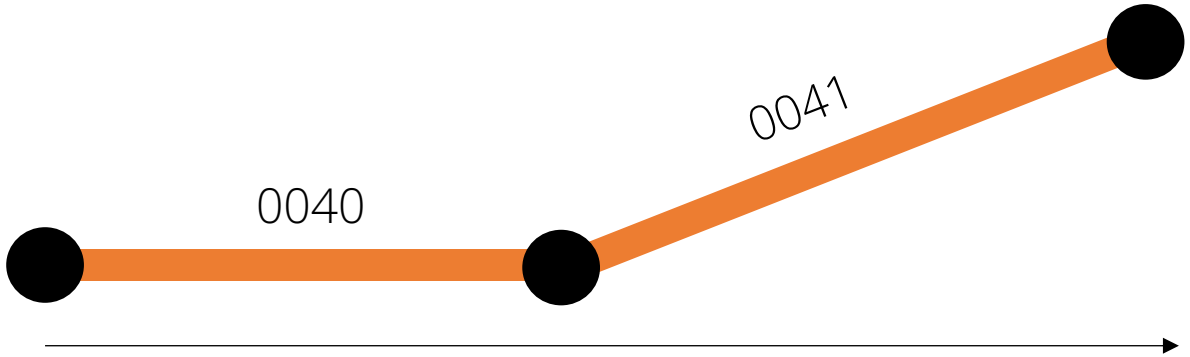
FeatureID	Type	Length
0040	Bicycle lane	1,500

Polyline vector II



FeatureID	Type	Length
0040	Bicycle lane	1,650

Polyline vector II



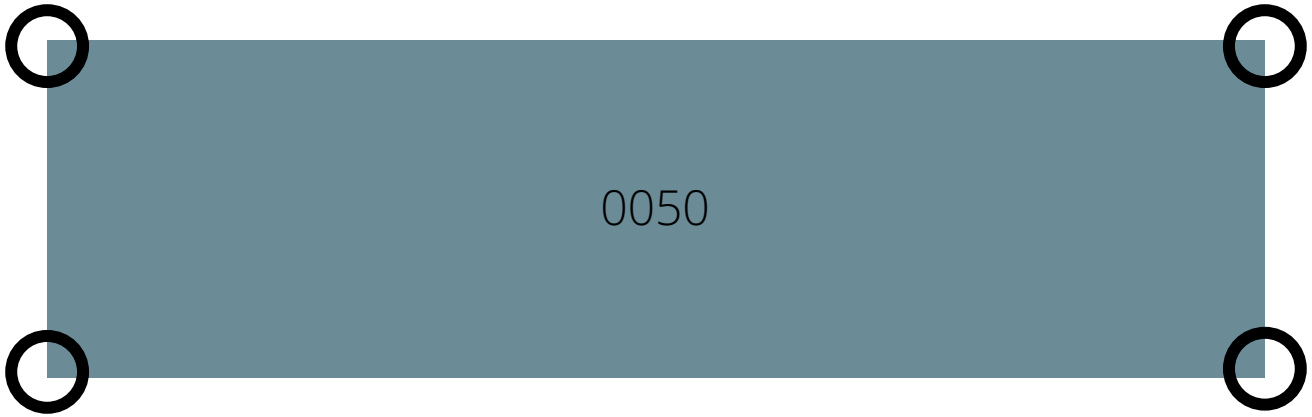
FeatureID	Type	Length
0040	Bicycle lane	600
0041	Bicycle lane	1,050

Polygon vector

Characteristics of a polyline vector in a GIS data model:

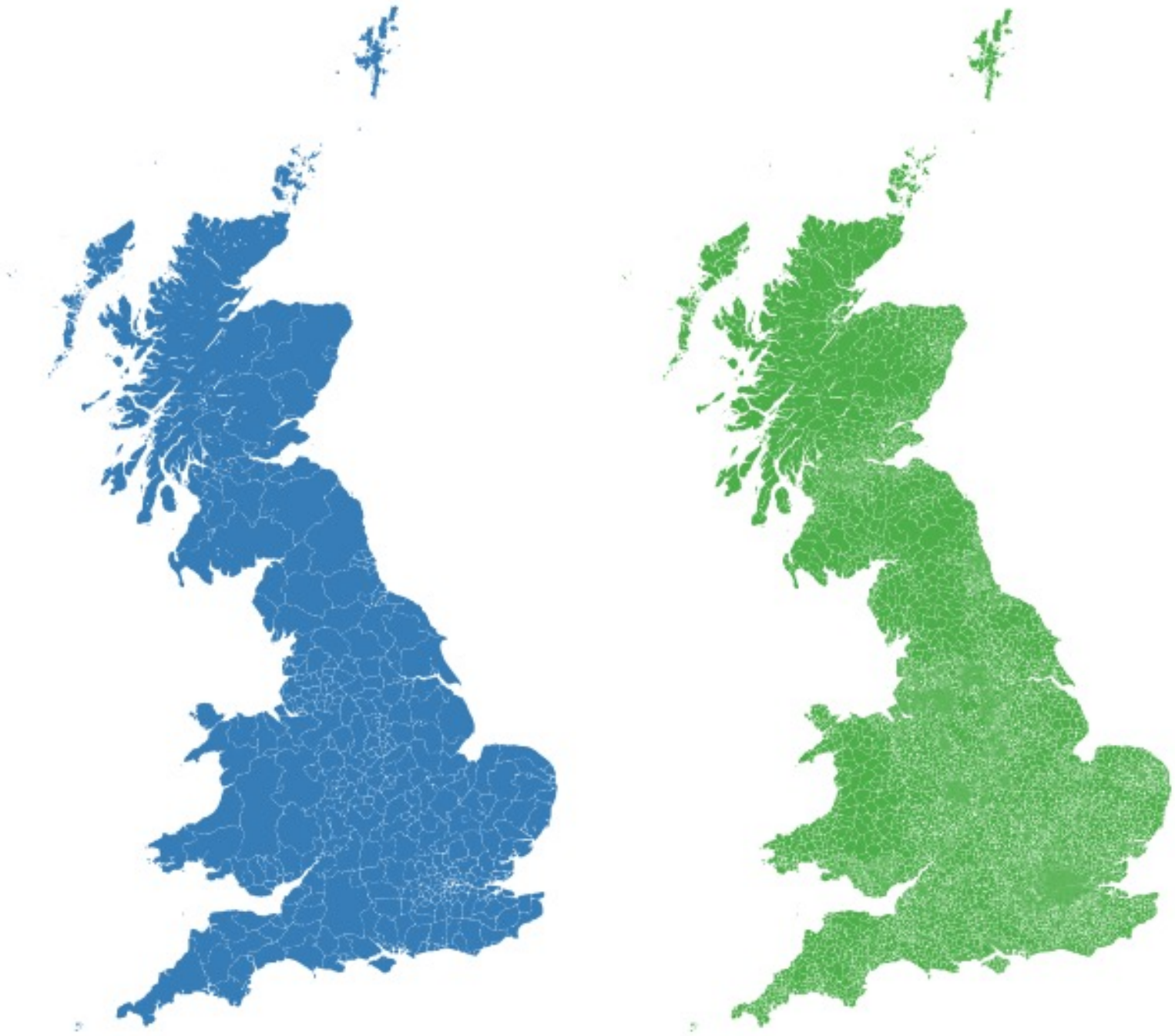
- Series of XY locations (coordinates) to form an enclose region
- Has an area
- Has no length, but does have a perimeter
- Geometry consists of at least 3 nodes or vertices whereby the first node or vertex connects with the last one.
- Used for: features with enclosed regions such as buildings and administrative areas

Polygon vector II

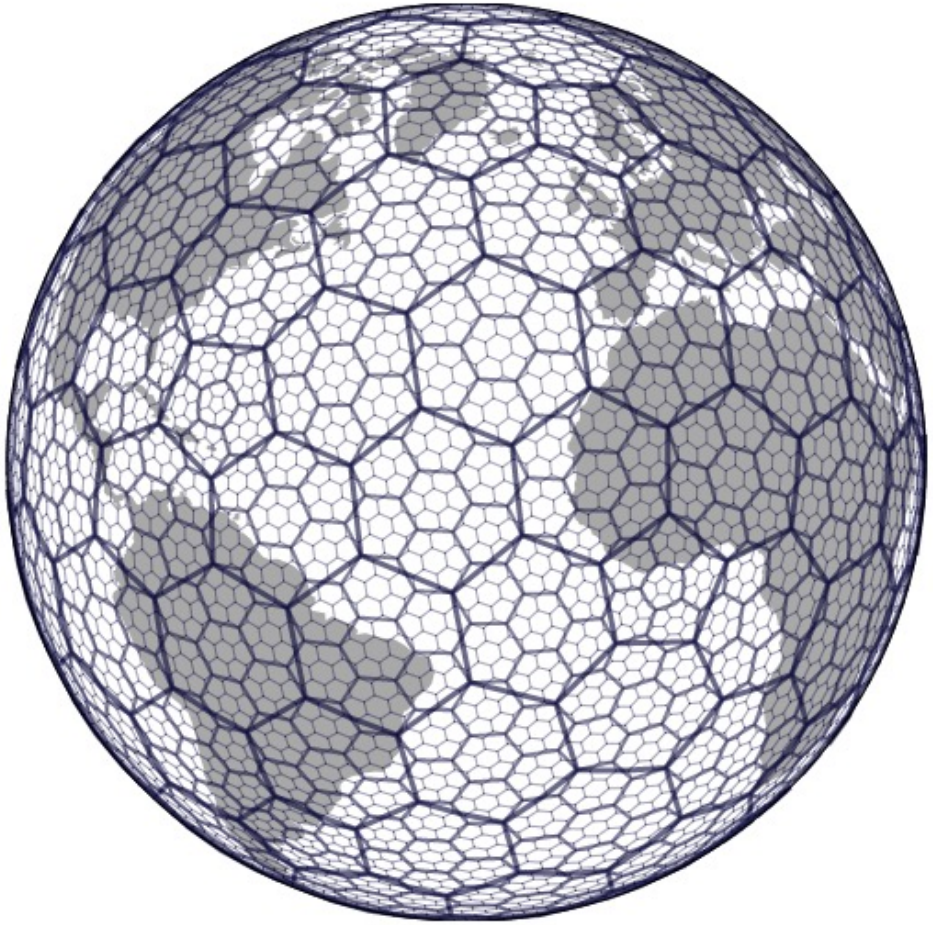


FeatureID	Type	Area
0050	University building	2000

Vector I



Vector II

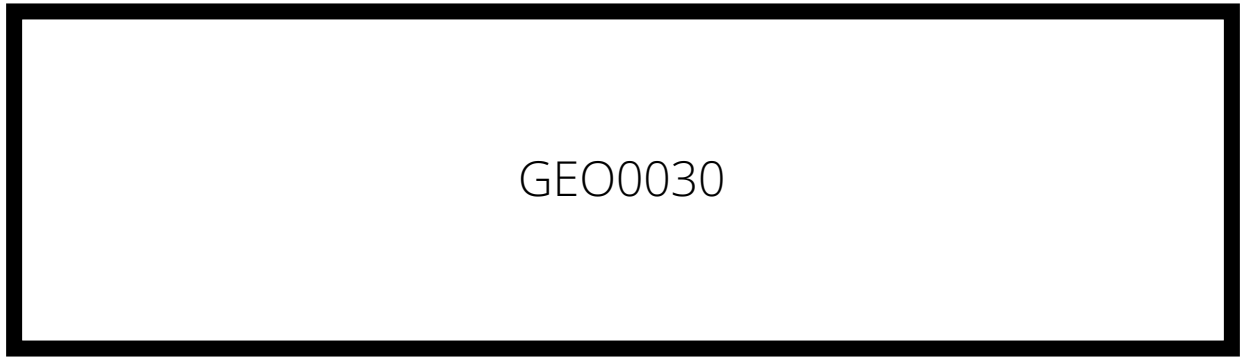


Uber. 2018. *H3: Uber's Hexagonal Hierarchical Spatial Index*. [online] https://eng.uber.com/h3/

Attribute joins I

GeoID	GeoID
GEO0030	540
GEO0031	320

Attribute joins II



FeatureID	GeoID
0050	GEO0030

Attribute joins III

FeatureID	GeoID
0050	GEO0030

GeoID	Population
GEO0030	540
GEO0031	320

Attribute joins III

FeatureID	GeoID
0050	GEO0030

GeoID	Population
GEO0030	540
GEO0031	320

Attribute joins IV

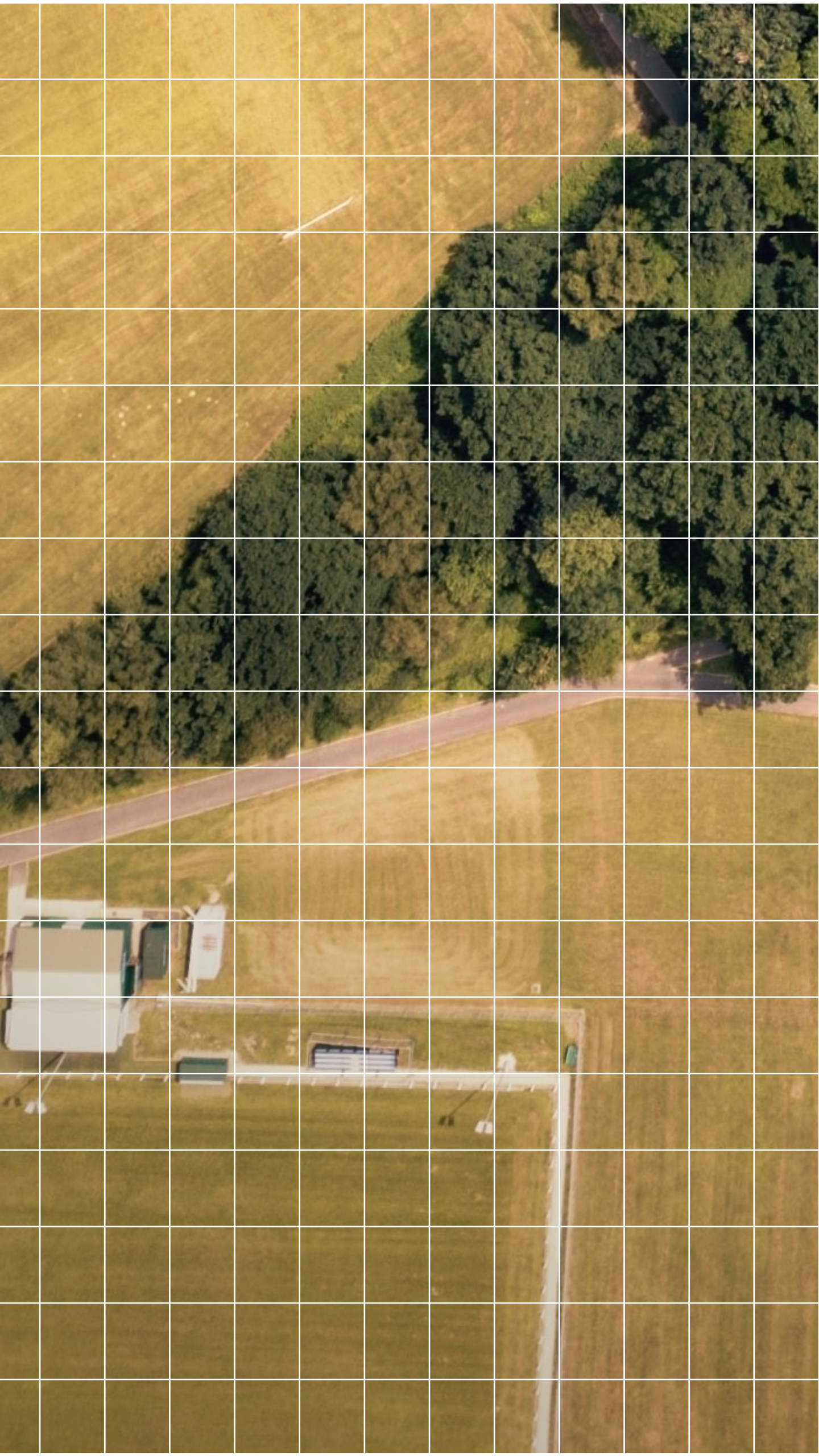
FeatureID	GeoID	Population
0050	GEO0030	540

Covid Cases in the UK

GIS data models

Traditionally, geographic information is represented in two ways:

- vector: a finite set of geometric objects
- raster: images representing a surface (values, colours)



8	9	9	10	0	10	10	10	0	0	0	7	5	3	0	0	0	0	1
8	9	9	10	10	0	10	9	9	0	0	5	3	0	0	0	0	0	0
8	8	9	9	10	0	0	9	8	7	5	0	0	0	1	0	0	0	0
5	8	8	9	10	10	0	9	7	5	0	0	5	5	5	0	0	0	1
3	5	8	9	9	10	0	0	3	0	0	0	5	0	0	1	0	0	2
2	5	8	8	9	9	10	0	0	0	1	5	0	0	0	0	0	0	1
2	4	6	8	8	9	0	0	0	1	5	0	0	5	5	5	0	0	1
0	3	6	8	8	0	0	0	0	5	0	5	5	5	5	5	0	0	0
2	2	5	8	0	0	0	0	0	0	5	5	5	5	5	5	3	0	0
0	2	5	0	0	1	2	3	4	4	4	4	4	4	4	5	0	0	0
0	0	0	0	1	1	1	1	4	4	4	4	4	4	4	5	0	0	0
0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	4	0	3	0
1	1	1	1	2	2	3	3	3	3	1	1	1	1	1	2	3	4	3

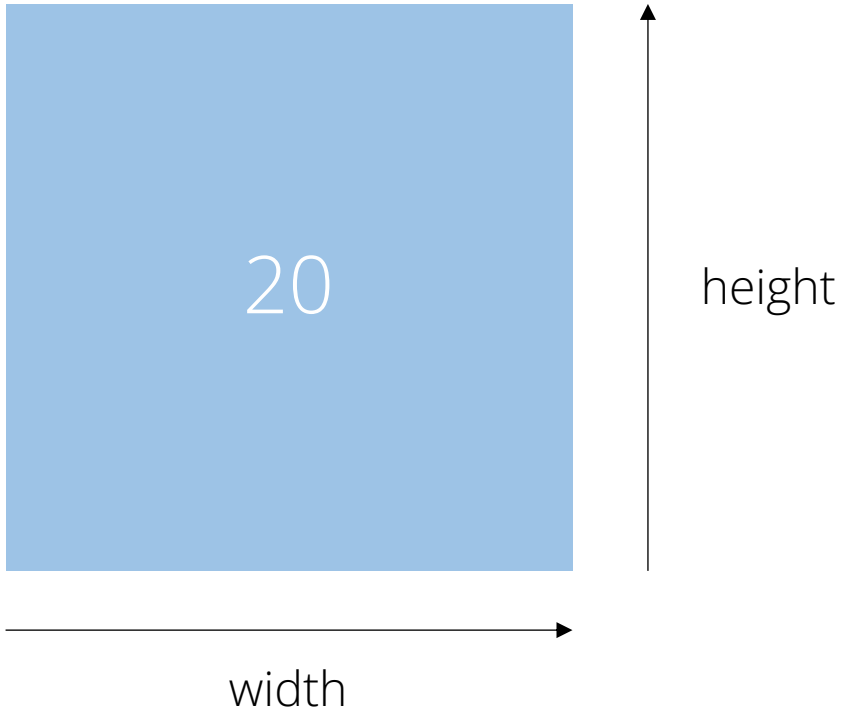
Raster data I

- Unlike the vector data. The above feature describes rainfall levels across the surface of the landscape – the feature is is not measured discretely but on a continuous surface to show gradient in changes.
- This non-discrete feature is classed a raster data.

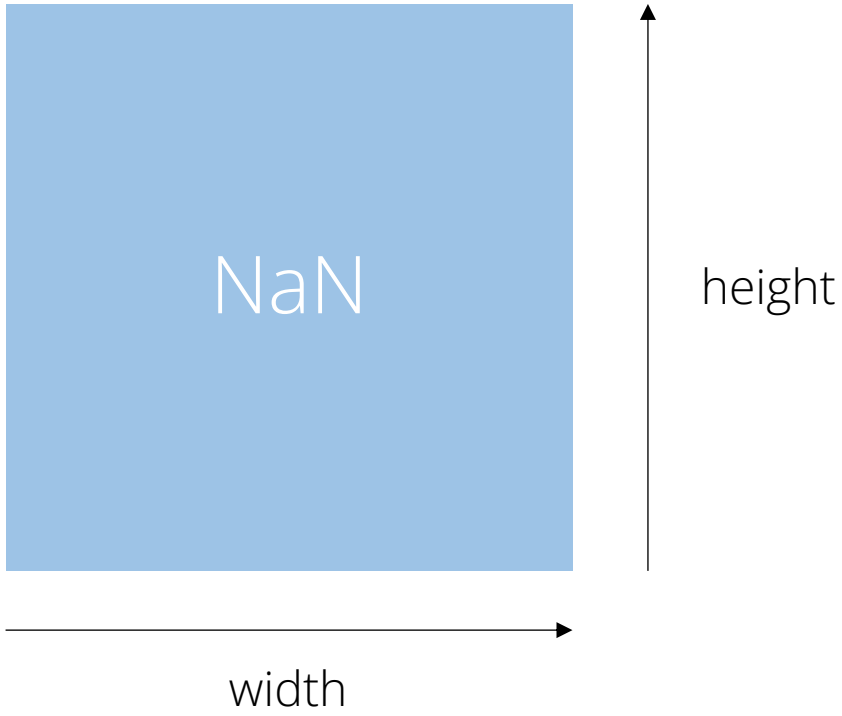
Raster data II

- Raster data is represented by a matrix of pixels or grid-cells that contains a numeric or text value for a feature its representing.
- It is composed of rows and columns.
- Each pixel or grid-cell has a resolution (or size for height and width).

Raster data III



Raster data III



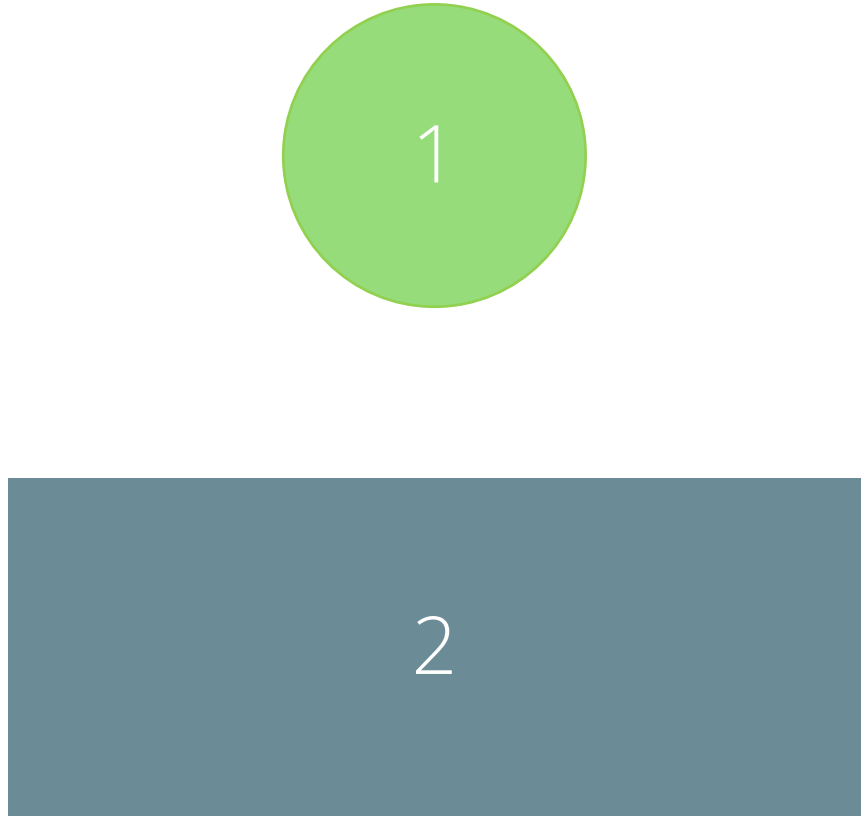
Raster data IV

Sample scheme I

- Both for the vector and raster data model real life features are ‘sampled’ or represented in a certain way. How to represent the spatial information?
- It must be fine enough to provide general consistency in our feature or field as well as accurately represent its distribution.
- It must be fine enough also to capture the important changes in our feature or field, e.g. a turn in a road, or a certain measurement change in a variable, such as temperature or rainfall.
- But we must also not over sample – we need to consider efficiency and efficacy of our sampling as we a) collect the data and b) store it digitally.

Sample scheme II

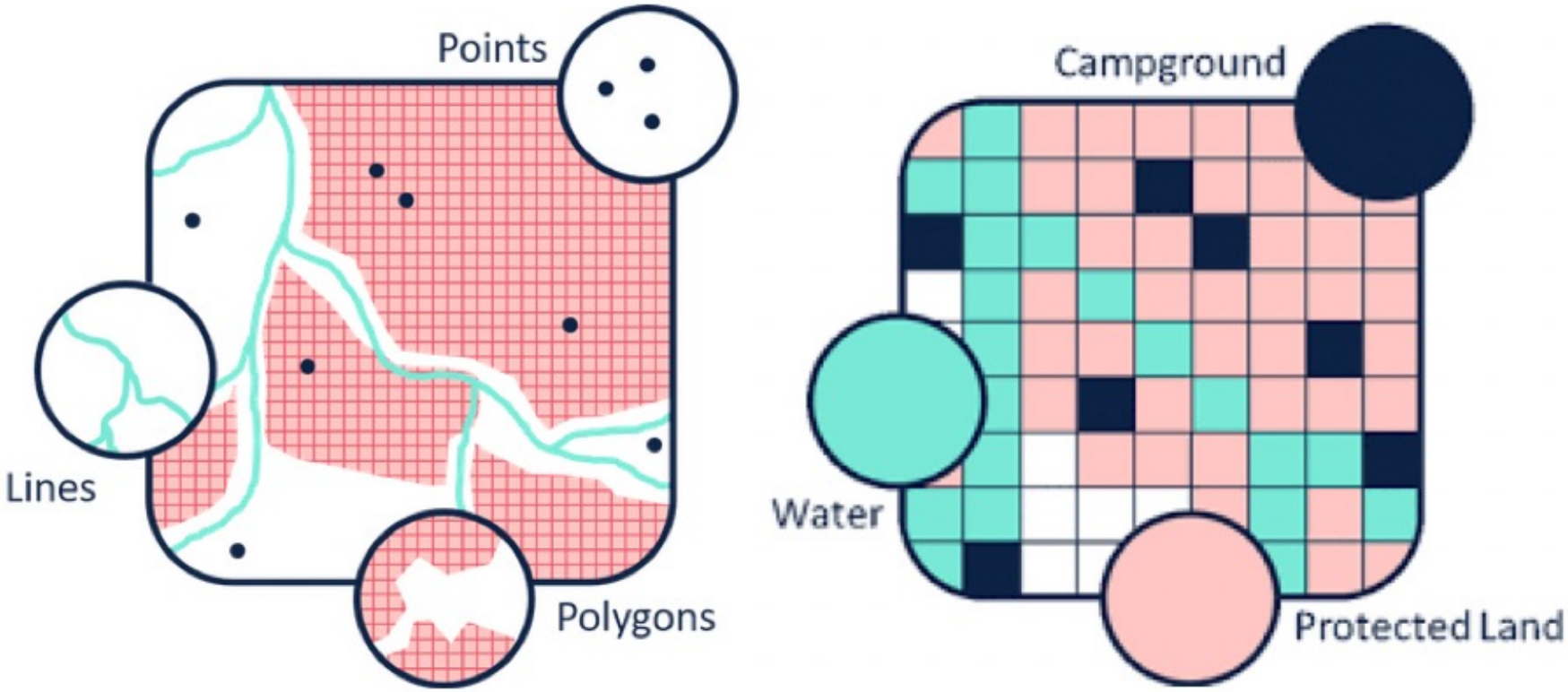
Representing Torrington Place 1-19



Vector versus raster I

- Why not vectorise everything? Can add as many attributes as we like?
- ”Raster is faster but vector is corrector”
- Depends on your application and intended analysis.
- Vector and raster data both have their advantages and disadvantages.

Vector versus raster II



Vector versus raster III

	Advantages	Disadvantages
Raster	Map Algebra with raster data is usually quick and easy to perform	Linear features and paths are difficult to display
	Some specific use cases can only be achieved with raster data (e.g. modeling water flow over the land surface)	Subject to a pixelated look and feel
		Datasets can become very large because they record values for each cell
Vector	Graphical output is generally more aesthetically-pleasing	Continuous data is poorly stored and displayed
	Higher geographic accuracy because data isn't dependent on grid size	Needs a lot of work and maintenance to ensure that it is accurate and reliable

Spatial data formats

- There are a number of commonly used file formats that store vector and raster data, some of which you will come across during this course and it is important to understand what they are, how they represent data and how you can use them.
- Different file formats for vector data and raster data.
- Common vector formats: shapefile, GeoJSON, GeoPackage
- Common raster formats: GeoTIFF, GeoPackage

Shapefiles I

- Perhaps the most (in)famous file format.
- Developed by ESRI, one of the first and now certainly the largest commercial GIS company in the world. Despite being developed by a commercial company, they are mostly an open format and can be used (read and written) by a host of GIS Software applications.
- Widely used, despite being outdated, especially limitations of `.dbf` format.
- A shapefile is not a single file, but a collection of files of which at least three are needed for the data to be displayed in GIS software.

Shapefiles II

- `.shp` contains the feature geometry. *Mandatory.*
- `.shx` index file which stores the position of the feature's ID in the `.shp` file. *Mandatory.*
- `.dbf` stores alle attribute information associated with the records. *Mandatory.*
- `.prj` contains the coordinate system information and projection. *Optional but not really.*
- `.xml` general metadata. *Optional.*
- `.cpg` encoding information. *Optional.*
- `.sbn` optimisation file for spatial queries. *Optional.*

Shapefiles III

GeoJSON I

- GeoJSON (Geospatial Data Interchange format for JavaScript Object Notation) is becoming an increasingly popular spatial data file, particularly for web-based mapping as it is based on JavaScript Object Notation.
- Unlike a shapefile in a GeoJSON, the attributes, boundaries and projection information are all contained in the same file.
- How to spot in the wilde: `.json` or .geojson

GeoJSON II

- Point
```
{"type": "Point", "coordinates": [30.0, 10.0]}
```
- LineString
```
{"type": "LineString", "coordinates": [[30.0, 10.0], [10.0, 30.0], [40.0, 40.0] ]}
```
- Polygon
```
{"type": "Polygon", "coordinates": [[[30.0, 10.0], [40.0, 40.0], [20.0, 40.0], [10.0, 20.0], [30.0, 10.0]]]}
```

GeoPackage

- A GeoPackage is an open, standards-based, platform-independent, portable, self-describing, compact format for transferring geospatial data.
- It stores spatial data layer as a single file, based upon an SQLite database.
- How to spot in the wild: .gpkg

GeoTIFF

- Geostationary Earth Orbit Tagged Image File Format.
- Created by NASA and is a standard public domain format.
- All necessary information to establish the location of the data on Earth’s surface is embedded into the image. This includes all details on map projection.
- How to spot in the wild: .tiff

GI file formats and GI systems

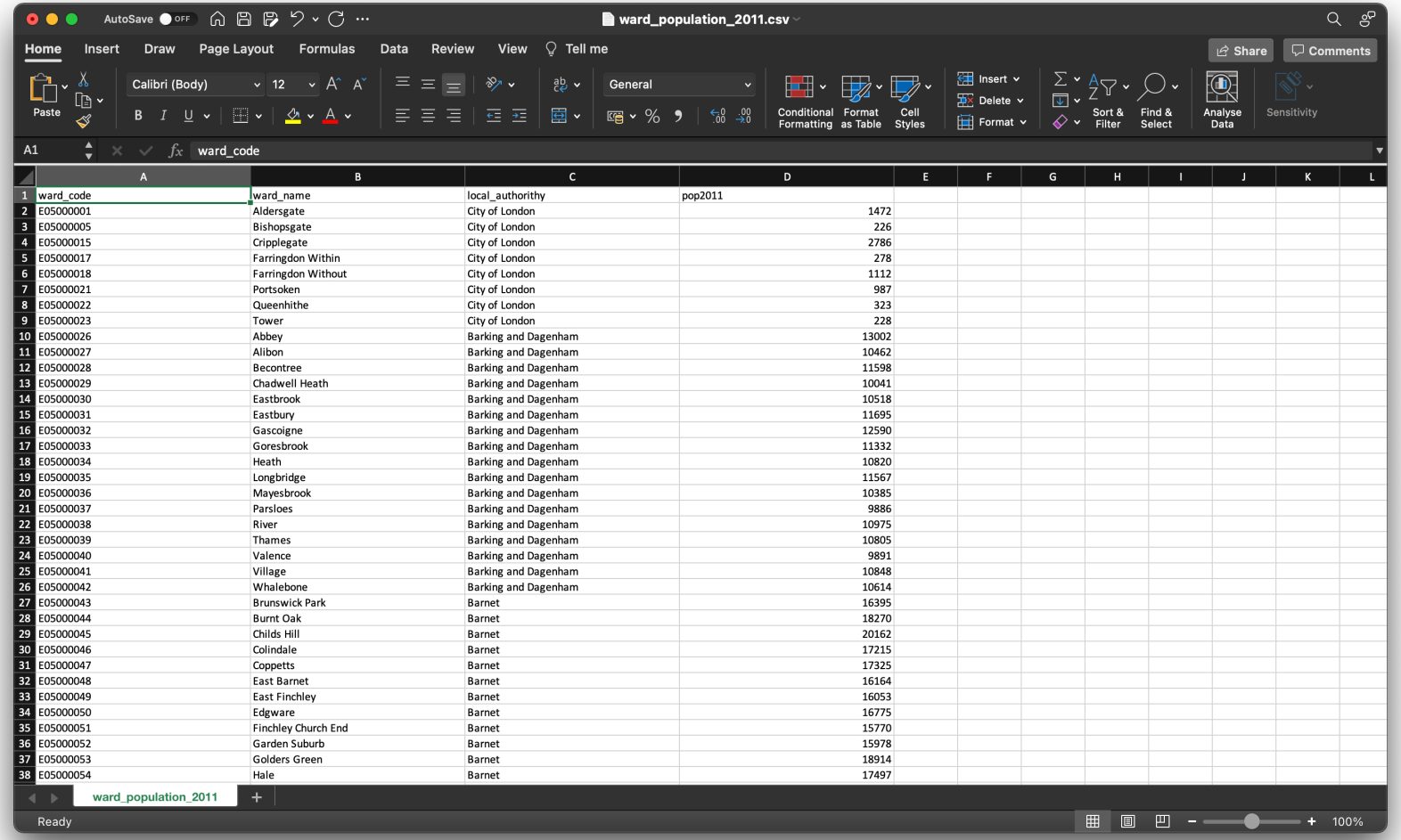
- Standard GI systems can read most file types without any problems or need for conversion.
- When using a programming language it is sometimes necessary to use a dedicated function to read in the data – so important to know which format you are dealing with (but libraries / packages exist to do just that).

On the topic of file formats: to join attribute data to your spatial files: .csv

CSV files I

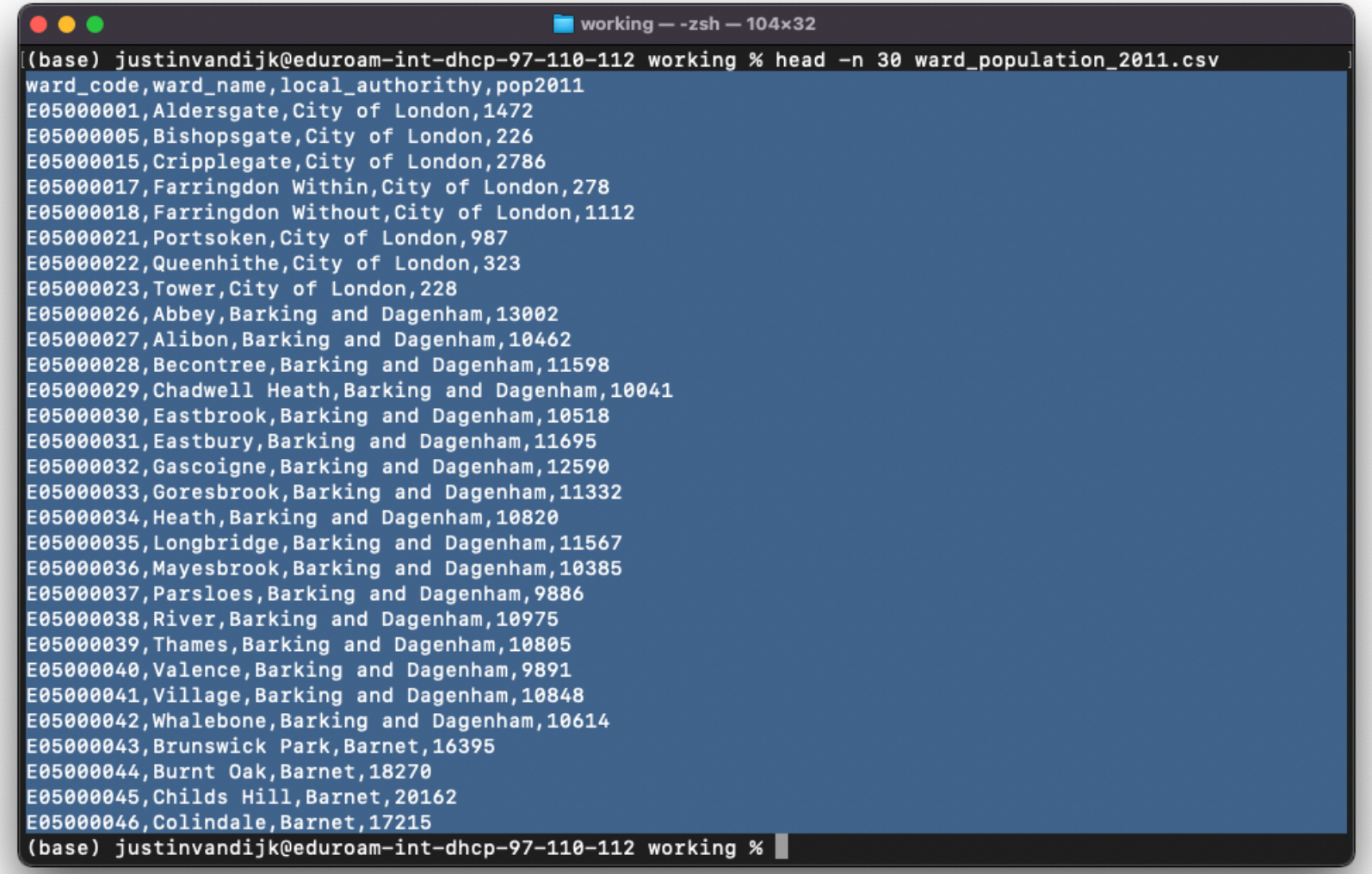
- “Comma Separated Values” or “Character Separated Values”.
- Format to store tabular data in rows and columns.
- Plain text rather than a binary file (e.g. Microsoft Excel).
- No limits on number of rows, columns, cells.

CSV files II



ward_code	ward_name	local_authority	pop2011
E05000001	Aldersgate	City of London	1472
E05000005	Bishopsgate	City of London	226
E05000015	Cripplegate	City of London	2786
E05000017	Farringdon Within	City of London	278
E05000018	Farringdon Without	City of London	1112
E05000021	Portsoken	City of London	987
E05000022	Queenhithe	City of London	323
E05000023	Tower	City of London	228
E05000026	Abbey	Barking and Dagenham	13002
E05000027	Alibon	Barking and Dagenham	10462
E05000028	Becontree	Barking and Dagenham	11598
E05000029	Chadwell Heath	Barking and Dagenham	10041
E05000030	Eastbrook	Barking and Dagenham	10518
E05000031	Eastbury	Barking and Dagenham	11695
E05000032	Gascoigne	Barking and Dagenham	12590
E05000033	Goresbrook	Barking and Dagenham	11332
E05000034	Heath	Barking and Dagenham	10820
E05000035	Longbridge	Barking and Dagenham	11567
E05000036	Mayesbrook	Barking and Dagenham	10385
E05000037	Parsloes	Barking and Dagenham	9886
E05000038	River	Barking and Dagenham	10975
E05000039	Thames	Barking and Dagenham	10805
E05000040	Valence	Barking and Dagenham	9891
E05000041	Village	Barking and Dagenham	10848
E05000042	Whalebone	Barking and Dagenham	10614
E05000043	Brunswick Park	Barnet	16395
E05000044	Burnt Oak	Barnet	18270
E05000045	Childs Hill	Barnet	20162
E05000046	Colindale	Barnet	17215
E05000047	Coppetts	Barnet	17325
E05000048	East Barnet	Barnet	16164
E05000049	East Finchley	Barnet	16053
E05000050	Edgware	Barnet	16775
E05000051	Finchley Church End	Barnet	15770
E05000052	Garden Suburb	Barnet	15978
E05000053	Golders Green	Barnet	18914
E05000054	Hale	Barnet	17497

CSV files III



Conclusion

- Two GIS data models: the vector data model and the raster data model.
- The vector model uses points, line, and polygon segments to identify locations on the earth while the raster model uses a series of cells to represent locations on the earth.
- Both GIS data models accommodate attributes: the qualitative or quantitative descriptions of the feature.
- Per definition any data model is an incomplete representation of reality.
- GI systems have been designed to work with a variety of different file types.

Computer tutorial I

Computer tutorial II

- Today: joining attribute data to a spatial feature layer in QGIS.
- Carefully read the instructions as there *may* be small deviations in where to find certain menu buttons.
- Assignment: no need to hand-in but if you want to leave before the end of the computer tutorial you should be able to show your results.

Questions

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