

Introduction to QGIS

using v3.14 Pi

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Chapter 1

Introduction to QGIS (using v3.14)

1.1 Online resources

QGIS tutorials: <https://docs.qgis.org/3.4/en/docs/>
Online forums: <https://stackexchange.com/>

1.2 This tutorial

1.2.1 We will cover these QGIS skills

- 1) Introduction to the QGIS software environment
- 2) Loading data into QGIS
- 3) Viewing spatial data (with and without geometry fields)
- 4) Adding symbology
- 5) Using a base map
- 6) Brief introduction to using expressions
- 7) Creating print layout

1.2.2 Tutorial data

The tutorial's example is based on data for the five forces in the SW England (Devon & Cornwall, Avon & Somerset, Wiltshire, Gloucestershire, Dorset) for three years (September 2016 - August 2019). Data for this tutorial was downloaded from <https://data.police.uk/data> and edited to be in a usable format. QGIS can use many types of data, including raster and vector layers. In this tutorial we will only use vector data.

This tutorial will use 4 data files:

- 1) **Shapefile** containing the visual boundaries of the LSOA polygons for the counties covered by the five forces
LSOA_2011_sw5forces_BGC_V2.shp
- 2) **CSV file without geometry fields** containing crime type (count) from each LSOA
sw_5forces_street_by_lsoa.csv
- 3) **CSV file with geometry fields** containing location of stop and searches
sw_5forces_stop_and_search.csv
- 4) **CSV file with geometry fields** containing the location of police headquarters
headquarters.csv

Using these files, we will produce maps to visually represent the:

- 1) number of crimes per Lower Super Output Area (LSOA)
- 2) locations of stop and search incidences
- 3) locations of Police headquarters

Below is an example of a map showing data for items #1 and #3 above.

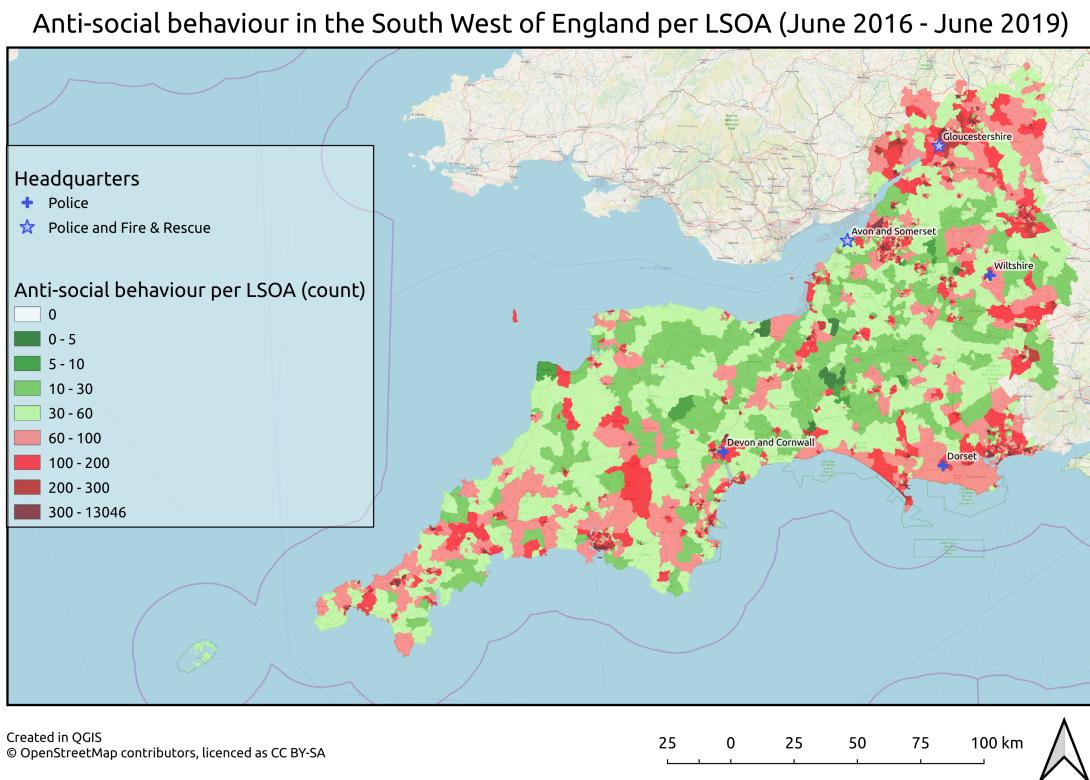


Figure 1.1: An example of a map we will create in this tutorial. Using QGIS, LSOA shapefile, and own data in csv files

Chapter 2

The QGIS software environment

Open QGIS software (may need to open it in your program files manager).

The welcome window contains a number of panels.

When you have existing projects, you can open them from this welcome screen in the *Recent Projects* panel.

To begin a new QGIS project, select *new project* . (top left, highlighted in red)

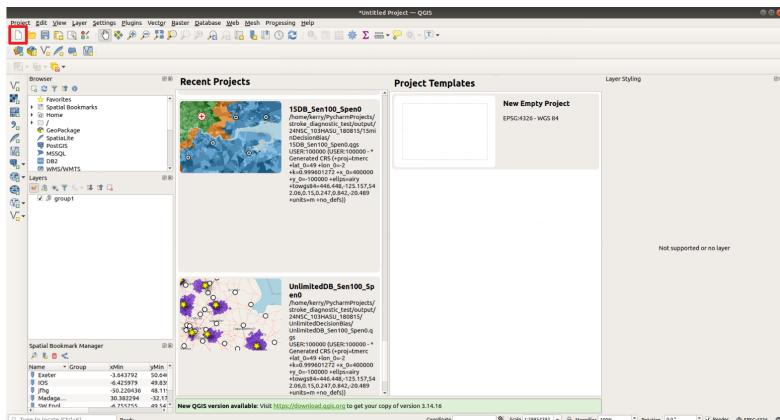


Figure 2.1: Screenshot of the QGIS welcome window

Here is the QGIS project window, showing a new empty project.

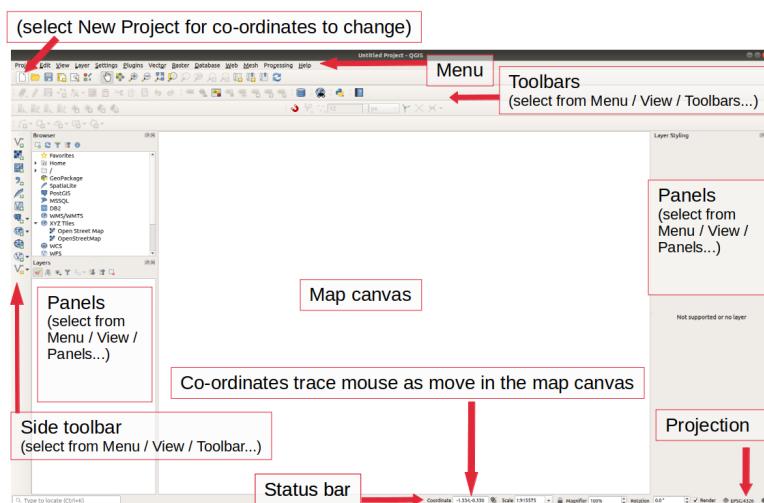


Figure 2.2: Screenshot of the QGIS project window

Become familiar with:

1) **Menu**

2) **Map canvas**

This is where the map is displayed

3) **Status bar**

Shows information about the current map view, and allows you to adjust the map scale and see the mouse cursors coordinates on the map (may need to select new project [blank page]). "Projection" contains the code for the current Coordinate Reference System (CRS) for the project (how software visually represents a 3D globe onto 2D screen).

4) **Toolbars**

Give you easy access to frequently used tools (tools not visible in a toolbar, will remain accessible via the menus).

Select which toolbars to have open from View → Toolbars menu

Icons are disabled when they are not relevant (depending on the layers present in your project).

Each icon has a useful tool tip.

Useful toolbars for this tutorial are:

- (a) Map navigation
- (b) Data source manager
- (c) Project
- (d) Manage layers
- (e) Attributes

5) **Panels**

Select which to have open from View → Panels menu

If you use a command that requires a specific panel for the output, the relevant panel will automatically open.

Panels can be docked to the side of the window, share the docked space, be full size using tabs, or float within the window.

Useful panels for this tutorial are:

- (a) Browser Panel
 - Navigate your file manager to open data files.
- (b) Layers
 - List of all the layers open in the project. Expanding collapsed items provides you with more information on the layers current appearance. Right-clicking on a layer will give you a menu with lots of extra options. The order of the layers in this list determines the order that they are rendered on the map canvas.
- (c) Layer styling
 - Control the visual appearance of the layer on the map canvas (known as the symbology of a layer).

Chapter 3

Base maps

A base map provides a background to give context to your map.

Always make sure your base map remains your bottom most layer within the *Layers Panel* - this will become more clear later.

You may wish to make any data layers that we put on top of a base map slightly transparent so that you can see some of the detail of the base map - a styling preference, so your choice.

I will introduce you to two options of a base map. There are many more.

3.1 Add a simple world map

In the coordinate field (in the status bar) type *world* & press enter to get a quick map of the world on the canvas.

Visual representation of a World map (countries) will appear in the map canvas.

The layer name will appear in the *Layers Panel*

Notice the projection = EPSG4326.

Now the Layers Styling panel (if open) will have content.

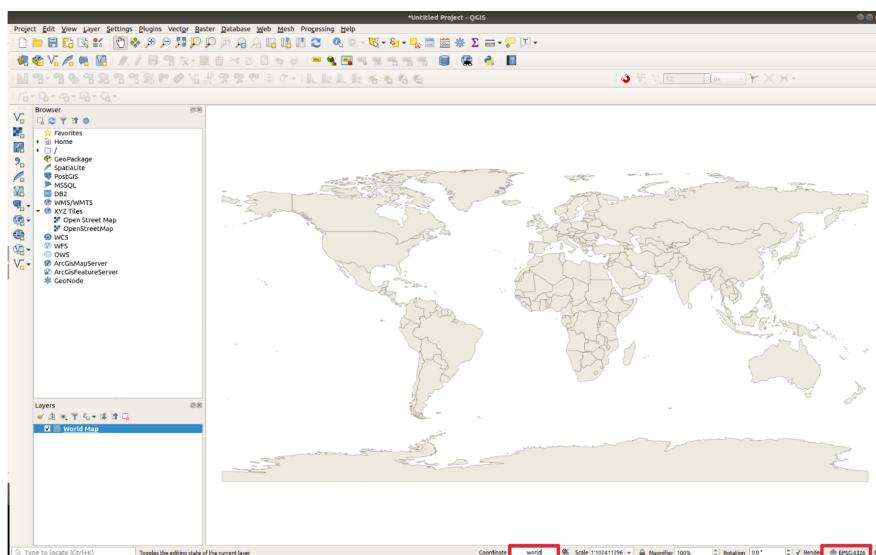


Figure 3.1: World map (type "World" in the co-ordinate field in the status bar)

3.2 Add open street map

This option requires internet connection (it is a predefined online datasource).

In Browser Panel find *XYZ Tiles* → *OpenStreetMap* and add it to your map canvas by either:

1. double clicking
2. drag and drop it outside of the Browser panel

It will now appear in the *Layers Panel*.

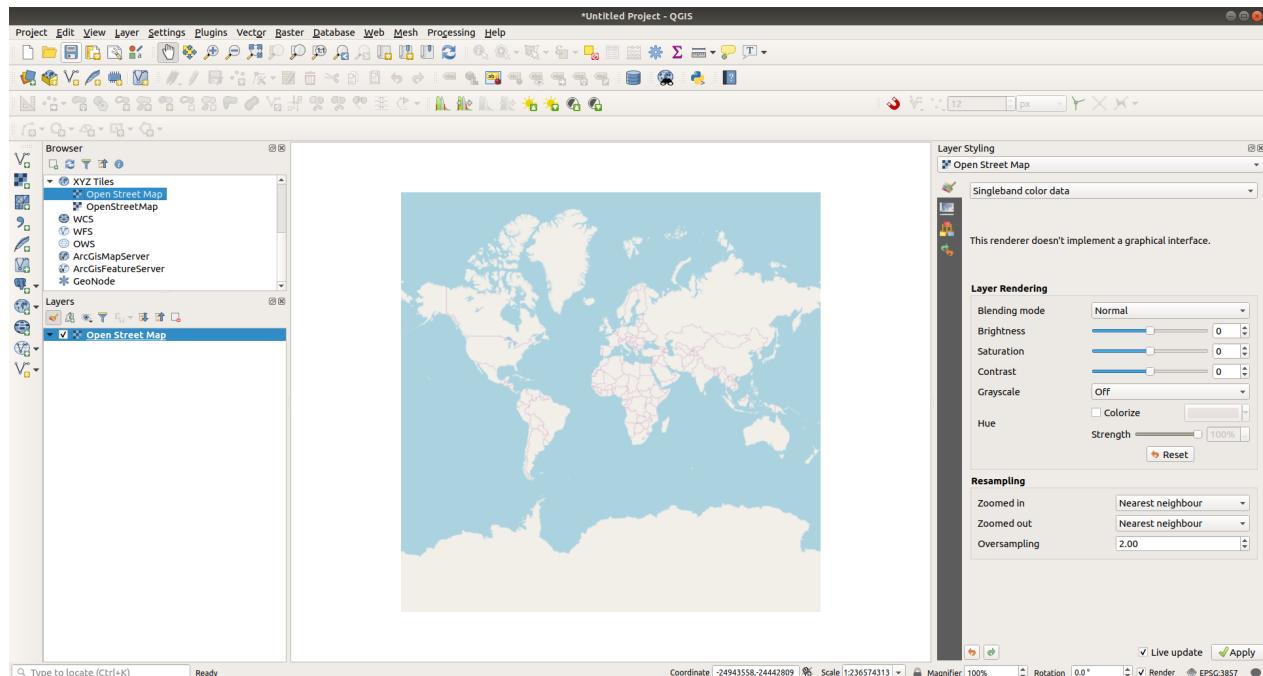


Figure 3.2: Open Street Map to use as a base map

If you do use OpenStreetMap, please pay attention to their copyright and licence <https://www.openstreetmap.org/copyright>. We will accredit this data in our *print layout* that we create at the end of the tutorial.

Chapter 4

Map navigation

Play about with the map canvas view:

- 1) See the Co-ordinates change in status bar as move mouse
- 2) Use the icons in the *Map Navigation Toolbar*: Pan, Zoom (in, out, full, layer, backward, forward). Can also use the mouse wheel to zoom (use ctrl key for finer control). Any yellow on an icon indicates that it is about selected features (we will visit this later). *Zoom to Layer* is a frequently used feature, which can also be accessed by right clicking the layer in the Layers Panel, and selecting the top option *Zoom to Layer*.



Figure 4.1: Map Navigation Toolbar icons

- 3) The scale in the *Status Bar* (at the bottom of the window) changes as you zoom. Can type the desired scale.
- 4) *Bookmarking* specific map views so can revisit them easily (this opens the relevant *Spatial Bookmarks Panel*)



Figure 4.2: Spatial bookmarks panel with two saved map views

- 5) *Map Views* are useful when comparing two or more areas. Select the New Map View icon to create a pop-up window that are independent of the main window view. Can dock these sub-windows to the side of the main window.

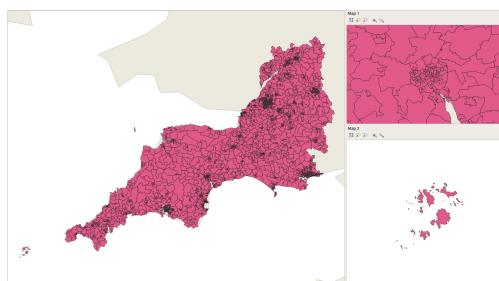


Figure 4.3: Map canvas on left with two map views docked to the right of the window

Chapter 5

Layers

The term layer is given to each sheet of data mapped on the canvas.

The world map is a layer. The open street map is another layer.

We will be adding a few more layers to this QGIS project: location of headquarters will be another layer. So will the number of crimes per LSOA.

The order in which they exist in the *Layers* panel will determine the order in which they are drawn.

Each layer can have it's own projection, but the software can re-project each layer onto the chosen project projection. More on this later.

5.1 Attribute table

Each vector layer has it's own attribute table.

If the layer contains point data, each row in the attribute table will correspond to a point on the map. Similarly, if the layer contains polygon data, each row in the attribute table will correspond to a polygon on the map. The World layer contains polygons - as you can see in the map canvass.

To open a layer's *attribute table*, select the relative layer in the *Layers Panel*, and then click  , or right click on layer name in the *Layers Panel* and select *Open Attribute Table*. Take note of the other functionality available in this list.

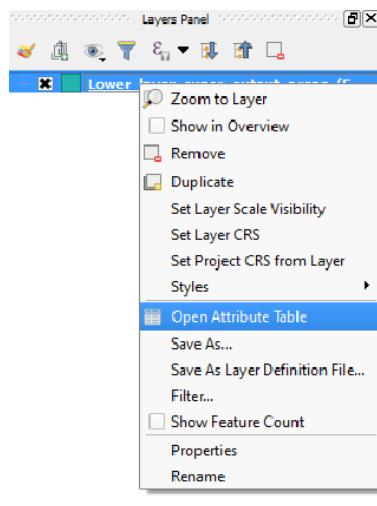


Figure 5.1: Right click on later name in Layers panel

Can sort the data (like in excel) by clicking on the title row. Variables (columns) are referred to as *fields* in GIS software. And rows as *features*.

	scalarank	featurecla	LABELRANK	SOVEREIGNT	SOV_A3	ADM0_DIF	LEVEL	TYPE	ADMIN	AD
1	5	Admin-0 co...	5	Australia	AU1	1	2	Dependency	Heard Islan...	HMD
2	0	Admin-0 co...	2	Indonesia	IDN	0	2	Sovereign	Indonesia	IDN
3	6	Admin-0 co...	6	United Kin...	GB1	1	2	Country	Isle of Man	IMN
4	0	Admin-0 co...	5	Haiti	HTI	0	2	Sovereign	Haiti	HTI
5	0	Admin-0 co...	5	Hungary	HUN	0	2	Sovereign	Hungary	HUN
6	0	Admin-0 co...	3	Greece	GRC	0	2	Sovereign	Greece	GRC
7	3	Admin-0 co...	6	Grenada	GRD	0	2	Sovereign	Grenada	GRD
8	0	Admin-0 co...	6	Guinea Biss...	GNB	0	2	Sovereign	Guinea Biss...	GNB
9	0	Admin-0 co...	4	Equatorial ...	GNQ	0	2	Sovereign	Equatorial ...	GNQ
10	5	Admin-0 co...	6	United Stat...	US1	1	2	Dependency	Guam	GUM
11	0	Admin-0 co...	4	Guyana	GUY	0	2	Sovereign	Guyana	GUY
12	0	Admin-0 co...	3	Denmark	DN1	1	2	Country	Greenland	GRL
13	0	Admin-0 co...	3	Guatemala	GTM	0	2	Sovereign	Guatemala	GTM

Figure 5.2: Attribute table for World layer

5.1.1 Relationship between the attribute table and the map canvas

From attribute table to map canvas

Can select row(/s) in attribute table and see where they are in the map canvas (they become highlighted in yellow on the map).

Select a row (polygon) in the attribute table. Notice the *Attribute table* window title reports the number of total features, and any selected.

	scalarank	featurecla	LABELRANK	SOVEREIGNT	SOV_A3	ADM0_DIF	LEVEL	TYPE	ADMIN	AD
1	5	Admin-0 co...	5	Australia	AU1	1	2	Dependency	Heard Islan...	HMD
2	0	Admin-0 co...	2	Indonesia	IDN	0	2	Sovereign	Indonesia	IDN
3	6	Admin-0 co...	6	United Kin...	GB1	1	2	Country	Isle of Man	IMN
4	0	Admin-0 co...	5	Haiti	HTI	0	2	Sovereign	Haiti	HTI
5	0	Admin-0 co...	5	Hungary	HUN	0	2	Sovereign	Hungary	HUN
6	0	Admin-0 co...	3	Greece	GRC	0	2	Sovereign	Greece	GRC
7	3	Admin-0 co...	6	Grenada	GRD	0	2	Sovereign	Grenada	GRD
8	0	Admin-0 co...	6	Guinea Biss...	GNB	0	2	Sovereign	Guinea Biss...	GNB
9	0	Admin-0 co...	4	Equatorial ...	GNQ	0	2	Sovereign	Equatorial ...	GNQ
10	5	Admin-0 co...	6	United Stat...	US1	1	2	Dependency	Guam	GUM
11	0	Admin-0 co...	4	Guyana	GUY	0	2	Sovereign	Guyana	GUY
12	0	Admin-0 co...	3	Denmark	DN1	1	2	Country	Greenland	GRL
13	0	Admin-0 co...	3	Guatemala	GTM	0	2	Sovereign	Guatemala	GTM

Figure 5.3: World attribute table with 1 feature selected. Red boxes highlight: 1) Number of features selected 2) Map navigation function buttons 3) Dock attribute table icon

TIP: We can dock the attribute table to the main window, so we can see both the map canvas and the attribute table

Sometimes we can not instantly see where the selected feature(s) are on our map. Use the map navigation function buttons: *Pan to selected* & *Zoom to selected*. These function buttons are in the Attributes & Map Navigation toolbars, and in the Attribute Table title bar. For some cases, need to press this button a couple of times for it to take effect. Icons that contain **yellow** refer to functions that act on selected features.



Figure 5.4: Function buttons in the Attributes & Map Navigation toolbars

Here we see the world layer zoomed in on the Isle of man.

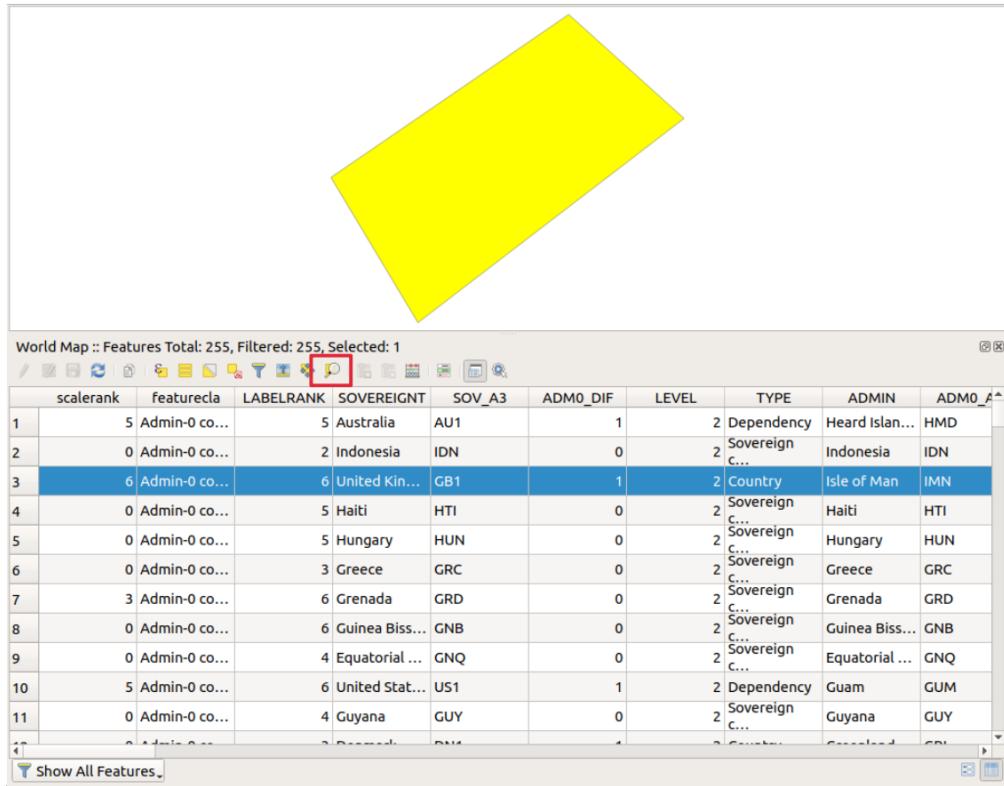


Figure 5.5: World layer zoomed in on selected feature (Isle of man)

Deselect features from all layers and zoom full (to the shapefile layer) .

Moving the other way: from map canvas to attribute table using the *Identify Feature* tool

This function will only work on the top layer (as in the *Layers Panel*, even if the top layer is unselected.

Click the *Identify Feature* icon .

Click on a feature (polygon). Information about that feature (polygon) will be displayed in the *Identify Results Panel*, this is essentially the values of the fields in the layer's *Attribute Table*:

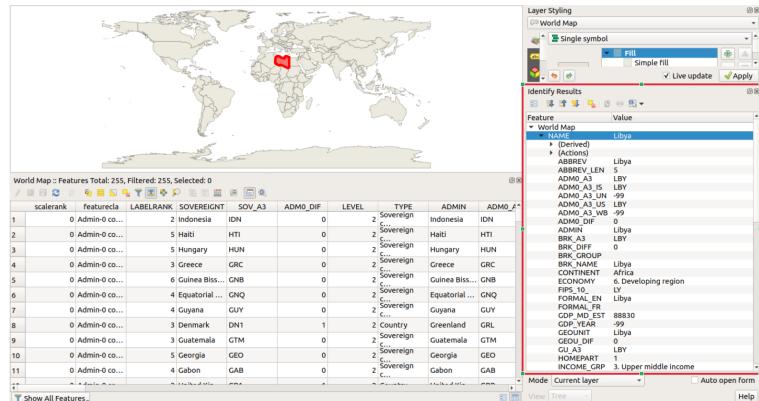


Figure 5.6: Identify Feature tool for a polygon in the world layer

From map canvas to attribute table using the *Select Feature(s)* tool

Alternatively, can select multiple features (polygons) on the map using the *Select Feature(s)* tool, the icon is in the top toolbar  , (right click to end selection) and view their field values in the *Attribute Table* by moving the related rows to the top:  . This is a live update feature, each time you select a different polygon(s), the corresponding row(s) will move to the top of the attribute table. Works the best with the *Attribute table* docked. Make sure the *Attribute table* is scrolled to show the top rows.

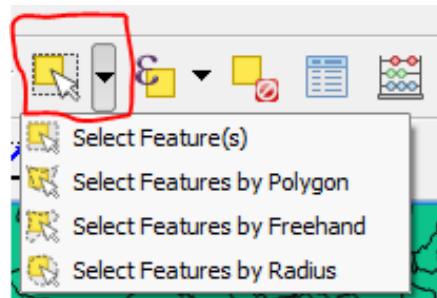


Figure 5.7: Select feature(s) tool options

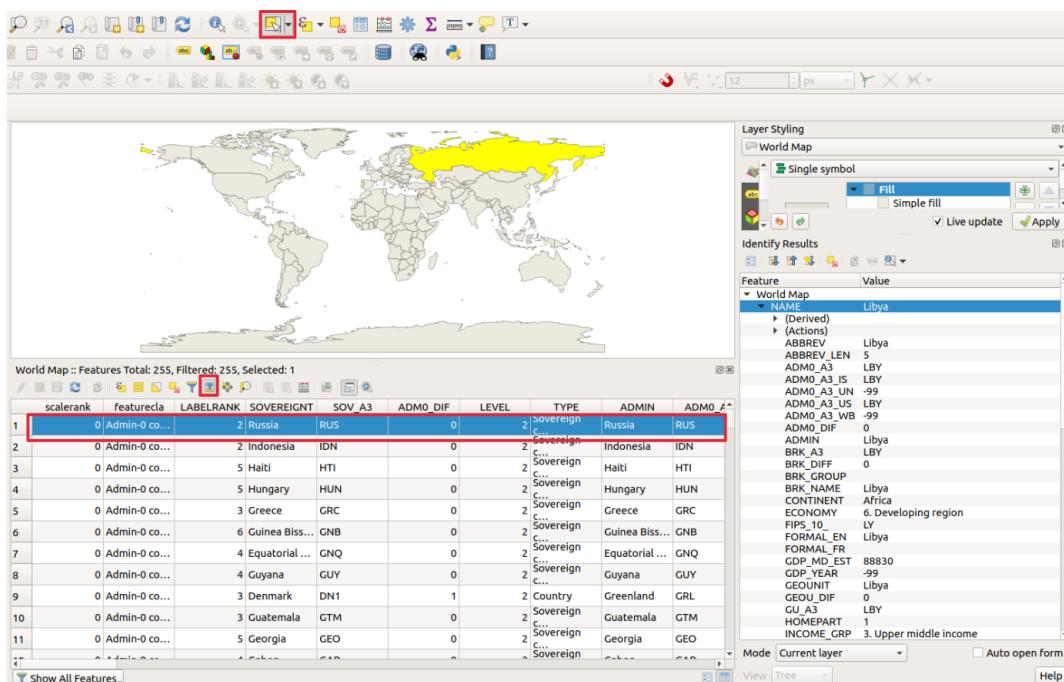


Figure 5.8: Select features on map, and move those features to the top of the attribute table

We will learn more about attribute tables throughout this tutorial.

Let's now close the attribute table (x in top right of attribute table window) and deselect features from all layers 

5.2 Layer Properties window

Most of the work we will do with our layers can be initiated through the *Layer Properties* window. To open the Layer Properties window, double click on the layer name in the Layers panel. Can also right click on layer name in *Layers* panel → Properties.

The LHS tabs on the Layer Properties window:

1. Information: Summary of the layer data
2. Source: Change the Layer Name (what is used in the Layer Panel), Coordinate reference system
3. Symbology: Style your layer using data from the Attribute table (can also use Layers Styling panel).
4. Labels: Add labels to the layer, using text fields from the Attribute table (can also use Layers Styling panel).
5. Diagrams: Add pie chart. Text or histograms to your maps. Be careful of overcrowding your map - only include this if your layer contains few well spaced polygons.
6. 3D view: If your data contains height information, this can incorporate it into the map. We've yet to use this.
7. Source Fields: View and edit the fields in the attribute table.
8. Attributes Form
9. Joins: Add spatial data to the layer. Requires a common field in both files (the layers Attribute table, and the new data), with a unique code for each polygon.
10. etc...

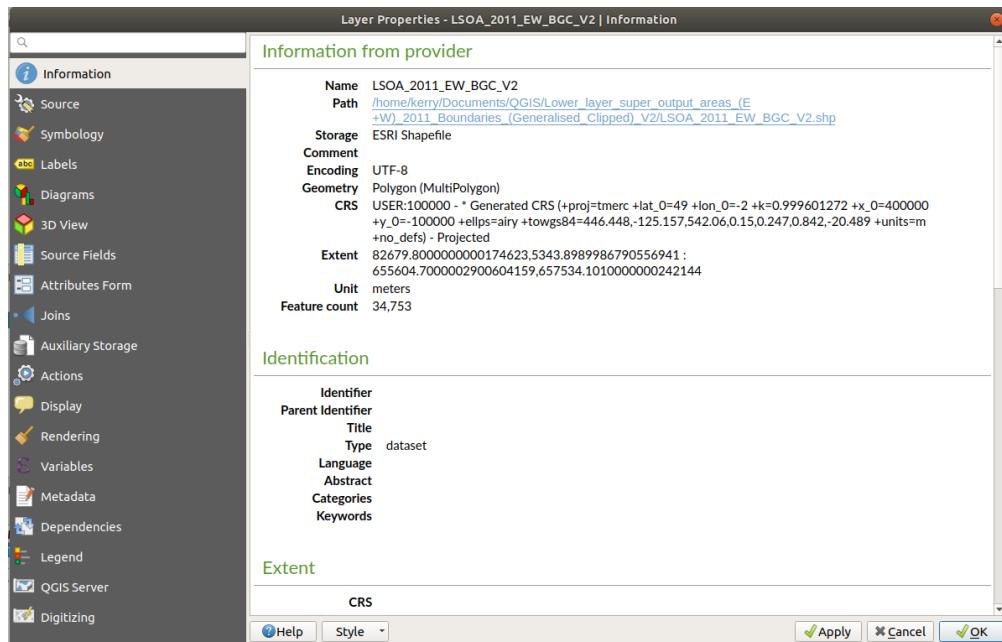


Figure 5.9: Layer properties window

Let's now save our project .

Close QGIS and reopen. Your project will show in the recent projects window (can select this here), or once QGIS is open use browse panel, or menu, or icon on toolbar . As with all programs, I'd recommend to save your work frequently.

Chapter 6

Projection

Our project is currently using has the coordinate reference system EPSG4326. This is the projection used by the World map layer. This is a good choice for the full world view.

Using our new found map navigation skills, let's zoom in on the UK. This projection makes the UK more stocky that we're used to seeing. If you are working on a map of a specific area of the world, then can use a projection that is tailored for that area.

Left click on the projection code in the status bar to open the Project Properties window.

In the Filter box type: *WGS 84*

In the *Coordinate reference system of the world* list window, scroll through and see the red area on the world map change, this represents the areas for which this projection is suitable.

Find & select "WGS 84 / UTM zone 30N EPSG:32630". Apply & OK.

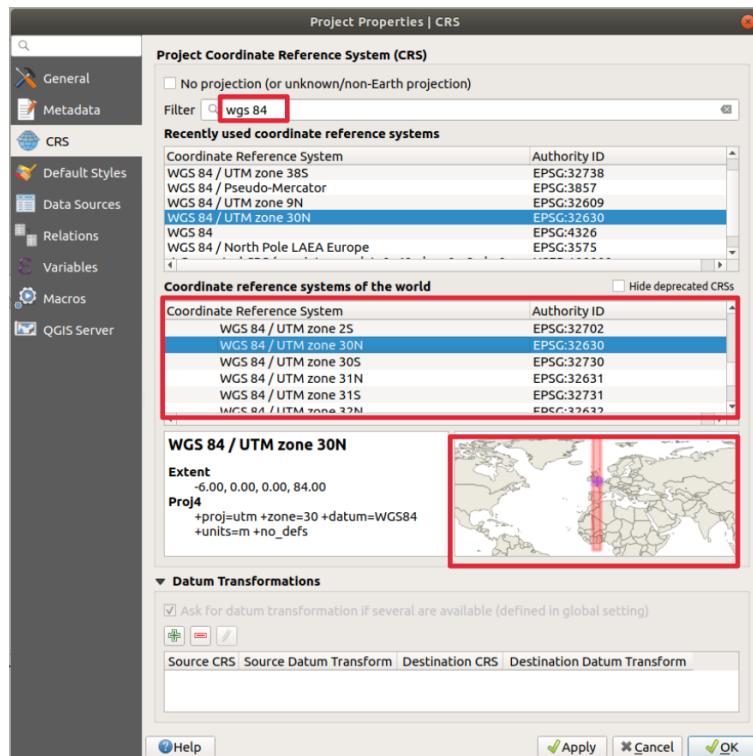


Figure 6.1: Project properties window, selecting a different Project Coordinate Reference System

By changing the CRS (from EPSG 4326 to EPSG 32630), the visual representation of the UK now has more familiar proportions.



Figure 6.2: The UK using projection EPSG 4326



Figure 6.3: The UK using projection EPSG 32630

Zoom to the world layer, to see how poor this projection works on the global scale.

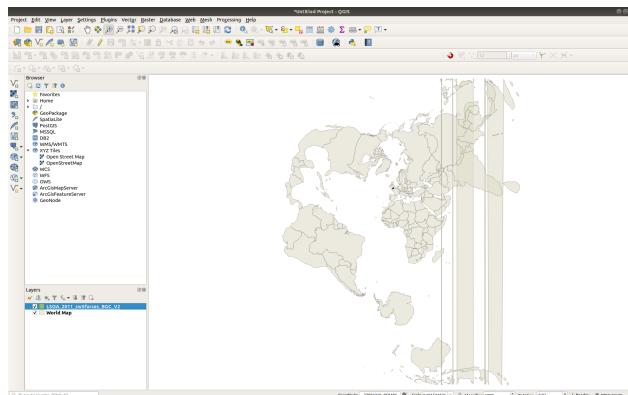


Figure 6.4: World map using projection EPSG 32630

Projections are also defined for each layer in your project. If your layer does not have the correct projection it will not appear in the expected location on your map canvas.

To change the projection of a layer, right click on the layer name in the *Layers* panel → Set CRS → Set layer CRS.

This will open a window very similar to the project properties window and allow you to specify a new projection for your layer.

Without more information about which is the correct projection, if the data is for the UK and is not projected onto the map canvas where I expect, I try changing it's projections to one of these:

1. EPSG: 4326
2. EPSG: 32630
3. EPSG: 27700
4. USER: 100000

Chapter 7

Selected features & save as new layer

In this section we are going to select a single feature (for this example, the polygon UK) and save it as a separate layer.

This is useful because we are only interested in the SW England, and so we can have this smaller layer open in our project - reduce computational time redrawing the base map layer.

7.1 Select a feature

There are many options available to us to select the polygon for UK.

1. Using the map canvas: Use the *Select Feature* icon to select the UK polygon from the map canvas. 
2. Using the layer's *Attribute table*: Open attribute table & select row with field *Name* = United Kingdom

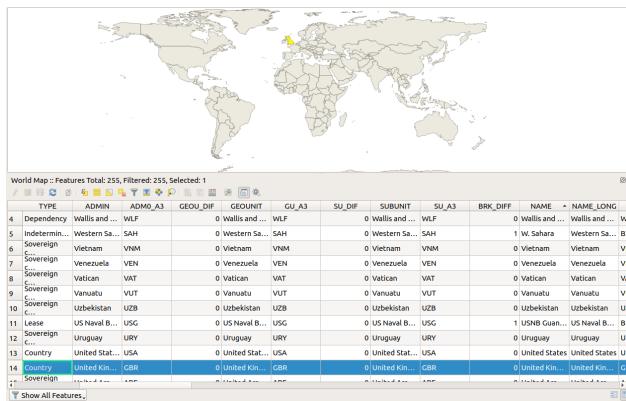


Figure 7.1: Selecting the feature that corresponds to the UK polygon in the attribute table

3. Using the *Select & filter form*: Instead of searching and selecting rows directly in the *Attribute Table*, we can construct our search (build an expression) using a form, that will select our features.

Open the *Attribute Table*. Click .

Interrogate the data and identify which field contains data in order for us to select those features that are just for UK. We have identified that field "Name" contains the country. Let's select features that contain "United Kingdom" in the field "Name" using the *Select or filter features using form*.

Click the icon at the top of the *Attribute Table*: .

Type *United Kingdom* in the textbox relating to field "Name". QGIS will prompt you with values that are present in the table.

From the dropdown select "Contains".

The screenshot shows the QGIS application interface. At the top, a status bar displays "World Map :: Features Total: 255, Filtered: 255, Selected: 0". The main window features a legend on the left with a tree view of countries, including Afghanistan, Akrotiri, Aland, Albania, Algeria, American Samoa, Andorra, and Angola. A search dialog is open in the center, showing the text "United Kingdom" in the "NAME" field. The dialog includes dropdowns for "MAPCOLOR7", "MAPCOLOR8", and "MAPCOLOR9", and a "NAME_SORT" dropdown. To the right of the search fields are several "Exclude Field" buttons. At the bottom of the interface, there are navigation buttons (Back, Forward, Home, etc.) and a "Show All Features" button.

Figure 7.2: Using the Select or Filter features form

Scroll to the bottom of this form. If we click the "Filter Features" button in the bottom right we can see the expression that this has built: "NAME" ILIKE '%United Kingdom%',

We can toggle between the form view and the attribute table using the buttons in the bottom right . See in the *Attribute Table* that only 1 features exists for UK.

Let's go back to our select & filter form, click .

At the bottom of the form, now click the "Select Features" button on the bottom. Look at the map. See that UK is yellow (these are the selected polygons). Can zoom or pan the map to them using the *Zoom map to selection* icon  and the *Pan map to selection* icon 

4. Write expression ()

This allows for more complex selections to be made. Once we are familiar with the expressions we can type it directly in. Click the *Select by expression* icon: .

And fill in the expression in the LHS pane, using the middle pane for prompts ("Field and Values" and "Operators" are very useful).

The screenshot shows the 'Select by Expression' dialog for a 'World Map' layer. The 'Expression' tab is selected, displaying the query `\"NAME\" = 'United Kingdom'`. A dropdown menu is open under the 'Fields and Values' section, listing items like 'Conditional', 'Conversions', 'Date and Time', and a expanded section for 'Fields and Values' containing 'NULL' and various geographical abbreviations and codes. A green box highlights the 'group field' button. A tooltip on the right explains how to add field names to expression strings. The 'Values' panel on the right shows a list of unique values with buttons for 'All Unique' and '10 Samples'.

Figure 7.3: Using the Select by Expression form, to select the UK feature

7.1.1 Save selected feature as a new feature layer

In the *Layers Panel* right click on the layer's name and select Export → Save selected features as...

Format: ESRI Shapefile

File name: your choice (click on to choose destination folder)

CRS: leave as default, unless you know something else!

Keep "Save only selected features" checked.

Keep "Add saved file to map" checked.

OK

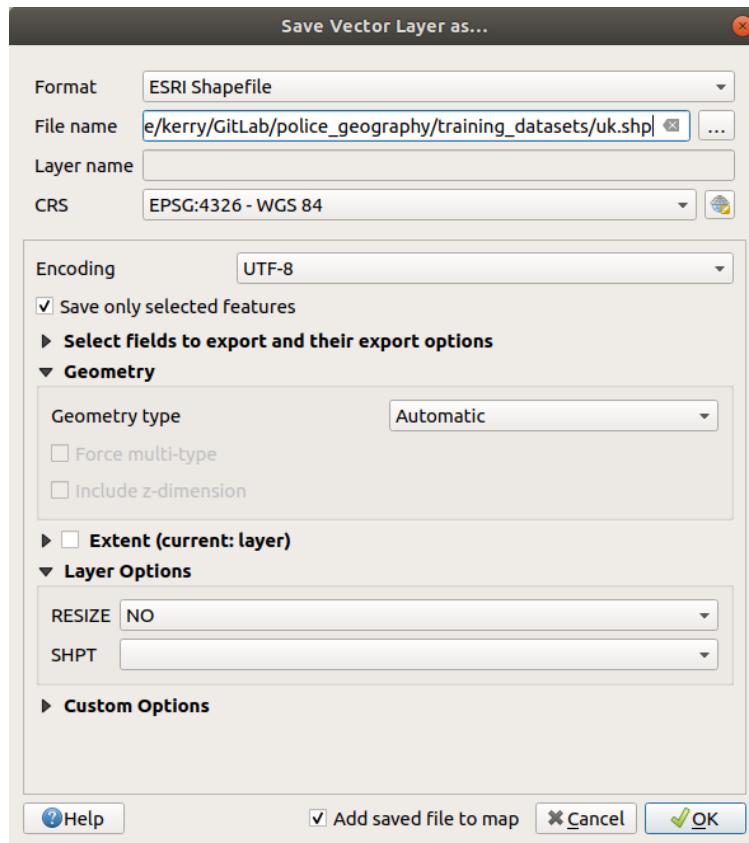


Figure 7.4: The window for Save Vector Layer as...

Can see our new layer in the *Layers Panel* and on the map canvas.

Within the *Layers Panel* can select and deselect which of these two layers to have visible on map canvas (use the checked boxes), and the order of the layers (drag and drop layer name within layer panel).

Can now delete the World layer (on layer name in *Layers panel* right click → *Remove layer...*).

Chapter 8

Symbology: Single symbol

The symbology of a layer is its visual appearance on the map.

Let's change the symbology of the World layer using the *Layers Styling* panel. Either open this panel using menu: View → Panels → Layer Styling, or the icon in the top of the *Layers* panel . Default location for the *Layers Styling* panel is on the RHS of the window.

8.1 Create a landmass and a coastline

Since we may not always have access to internet - like today - let's learn about single symbol symbology to turn the World layer (with grey area and black border) into a landmass and coast.

Within the *Layers Styling* panel follow these steps (and use the screenshots below to help guide you to the correct part):

1. Select layer: uk

2. Select Single symbol

3. In the top white box, highlight the option "Fill"

4. Click on Color bar to access the color selector pane

5. Select colour for the landmass

6. Click blue triangle to return to previous pane

7. In the top white box, highlight the option "Simple fill"

8. Select same colour for stroke colour as landmass (use either "Recent colours" or "Pick colour")

9. Expand *Layer Rendering*

10. Enable Draw effect

11. Click on yellow star (*Customize effects*)

12. Select & highlight *Outer Glow* (select adds it to the map, highlight allows you to change the settings)

13. Play about with settings. I chose Spread: 3.2. Blur radius 4.6. Single color: blue. Kept rest as default.

Note1 : Two useful buttons at bottom of Layer Styling panel (Undo & Redo): .

Note 2: Steps #12 & #13 be careful that you have the right option highlighted in the top window before you make changes in the settings below. It is possible to overwrite the *Effect type*.

This uk layer is a shapefile. We will explore more about shapefiles in a couple of chapters.

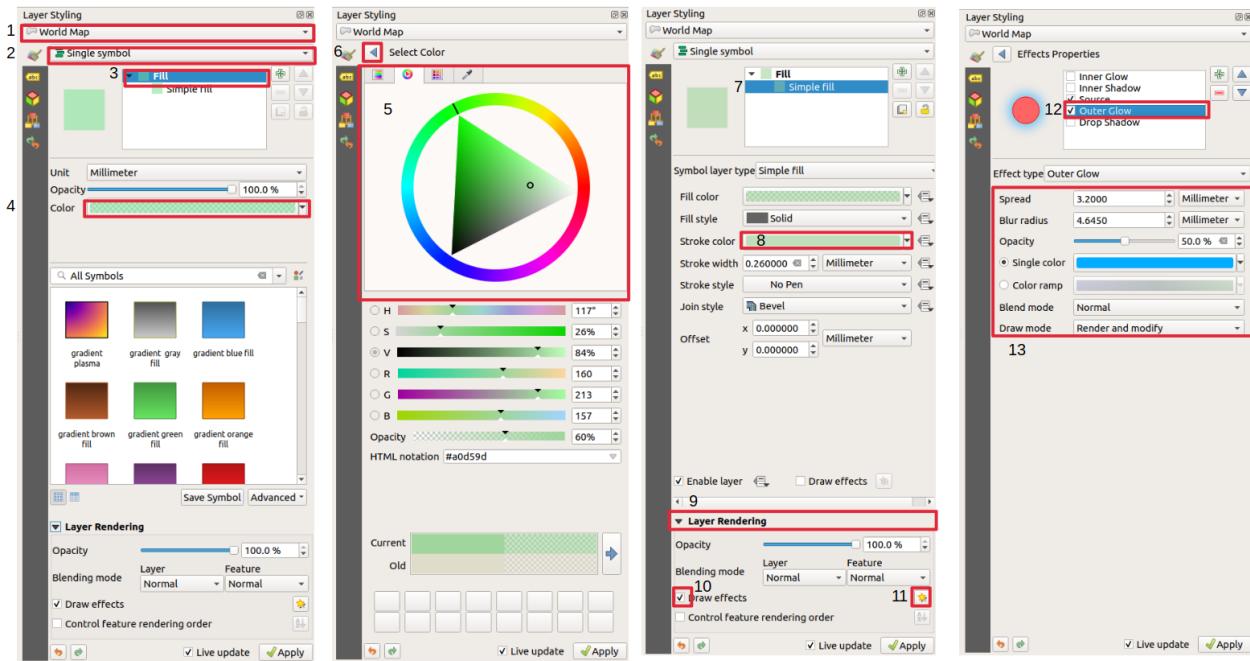


Figure 8.1: Settings in Layer Styling to create a landmass and coastal effect



Figure 8.2: Using simple symbol to create a landmass and coastal effect

Chapter 9

Adding dense point data (own data with geometry)

9.1 Data

We've yet to present data of this type, but it seems this is a very popular datatype for police, so here's an introduction. Please use the vast amount of online tutorials to find out more.

Filename to use for this section: *sw_5forces_stop_and_search.csv*

1	Type	A	B	C	D	E	F	G	H	I	J
2	Person search		2019-06-01T00:02:00+00:00		51.496817	-2.580971	Male	25-34	White - English/Welsh/Scottish/Northern Irish/British	White	Police and Crir
3	Person search		2019-06-01T01:15:00+00:00		51.454085	-2.599742	Male	25-34	Other ethnic group - Not stated	White	Misuse of Drug
4	Person search		2019-06-01T0127:00+00:00		50.983714	-3.2119592	Male	25-34	White - English/Welsh/Scottish/Northern Irish/British	White	Misuse of Drug
5	Person search		2019-06-01T01:27:00+00:00		50.983714	-3.2119592	Male	over 34	White - English/Welsh/Scottish/Northern Irish/British	White	Misuse of Drug
6	Person search		2019-06-01T0127:00+00:00		50.983714	-3.2119592	Male	over 34	White - English/Welsh/Scottish/Northern Irish/British	White	Misuse of Drug
7	Person search		2019-06-01T02:06:00+00:00		51.460433	-2.590887	Male	18-24		White	Misuse of Drug
8	Person search		2019-06-01T02:40:00+00:00				Male	over 34		White	Misuse of Drug
9	Person search		2019-06-01T02:40:00+00:00				Male	over 34		White	Misuse of Drug

Figure 9.1: CSV file containing 38,832 stop and search instances over 3 years

File contains our own geographical data regarding 38,832 stop and search instances over 3 years.
15 fields including: latitude, longitude and gender.

QGIS can simply take lat and long and plot point on map.

Tip: If get Lat and Long the wrong way round then your points will be in Africa!

9.2 Add delimited text layer

Opening a csv file is known as *adding a delimited text layer*. There are many ways to do this:

- 1) Menu: Layer → Add Layer → Add Delimited Text Layer
- 2) *Add delimited text layer* icon on a toolbar 
- 3) Use *browse panel* to navigate to the file location
- 4) Data Source Manager icon 

Within the *Data Source Manager / Delimited text* window, choose these settings:

File name: Navigate to the csv file: *sw_5forces_stop_and_search.csv*

Layer name (what appears in the *Layers Panel*, so choose something meaningful): *stop_search*

File Format: CSV (comma separated values)

Geometry definition → Point coordinates → **x field** = Longitude & **y field** = Latitude

Coordinate system: EPSG4326 WGS 84 (leave as default)

(Note: The top row of the csv file is used as the field titles.)

Add.

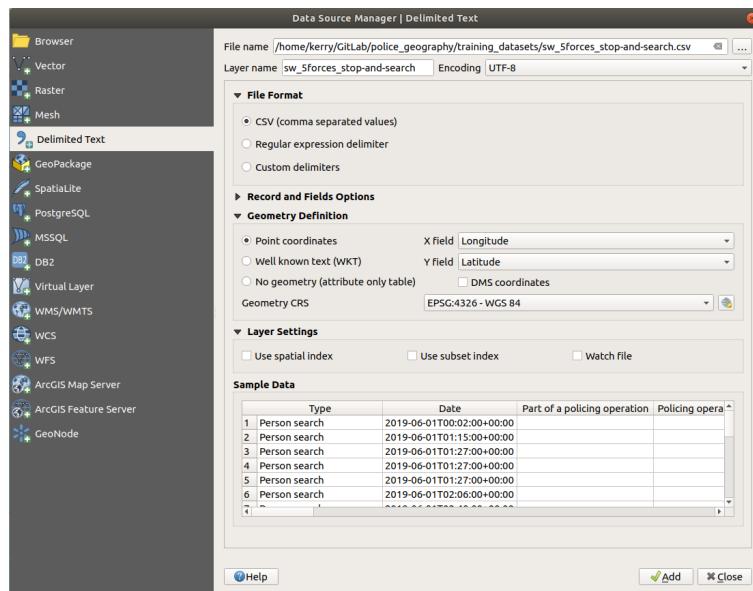


Figure 9.2: *Data Source Manager / Delimited text* window

All of the 38,832 instances will be added to your map canvas as points.



Figure 9.3: Stop and search points added to our base map

Instantly see a benefit for plotting geographical data in a mapping software: highlights oddities. This is the dataset for the 5 SW forces. I'm curious, is there a reason why the points exist outside this region?

The layer name will exist in the *Layers Panel*. Make sure the stop_search layer name is above the UK base map layer.

Play with changing the order of the layers within the *Layers Panel* (drag and drop).

9.3 Attribute table

As we saw for the World base map layer, each layer open in the project has an *attribute table*. For this layer, each point on the map has a row of data in the layer's *attribute table*.

9.3.1 Open attribute table

To open a layer's *attribute table*, make sure the relative layer is highlighted in the *Layers Panel*, and then click  in the top toolbar.

Or right click on layer name in the *Layers Panel* and select *Open Attribute Table*.

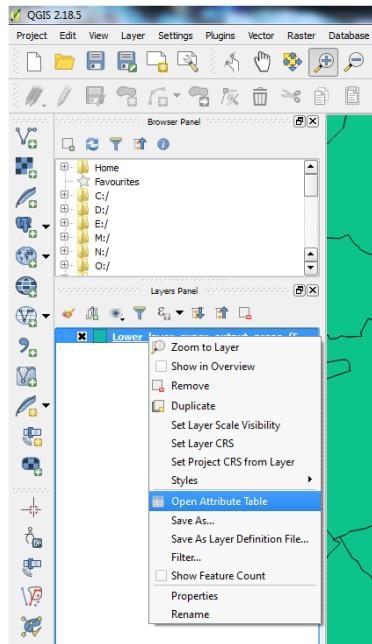


Figure 9.4: Open attribute table

The data in the *attribute table* is essentially the csv file. Can sort the data (like in excel) by clicking on the title row.

In GIS software, variables (columns) are referred to as *fields*, and rows as *features*.

stop_search :: Features Total: 38671, Filtered: 38671, Selected: 0								
Type	Date	a policing operation	Latitude	Longitude	Gender	Age range	undefined ethnicity	undefined ethnicity
1. Person sea...	2019-06-01...		51.496817	-2.580971	Male	25-34	White - Eng...	White - Eng...
2. Person sea...	2019-06-01...		51.454085	-2.599742	Male	25-34	Other eth...	White - Eng...
3. Person sea...	2019-06-01...		50.983714	-3.219592	Male	25-34	White - Eng...	White - Eng...
4. Person sea...	2019-06-01...		50.983714	-3.219592	Male	over 34	White - Eng...	White - Eng...
5. Person sea...	2019-06-01...		50.983714	-3.219592	Male	over 34	White - Eng...	White - Eng...
6. Person sea...	2019-06-01...		51.460433	-2.590887	Male	18-24		White - Eng...
7. Person sea...	2019-06-01...		NULL	NULL	Male	over 34		White - Eng...
8. Person sea...	2019-06-01...		NULL	NULL	Male	over 34		White - Eng...
9. Person sea...	2019-06-01...		NULL	NULL	Male	18-24		White - Eng...
10. Person sea...	2019-06-01...		NULL	NULL	Male	18-24	White - Any...	White - Eng...
11. Person sea...	2019-06-01...		51.460433	-2.590887	Male		Asian/Asia...	White - Eng...
12. Person and...	2019-06-01...		51.637864	-2.457564	Male	over 34	Mixed/Mul...	White - Eng...
13. Person and...	2019-06-01...		51.637864	-2.457564	Male	25-34	White - Any...	White - Eng...

Figure 9.5: Attribute table for Stop Search layer

9.3.2 Relationship between the attribute table and the map canvas

For data with many points, it is often the case that many points will lie in the same space. So even when you have a point highlighted, it may be hidden under another point and so not visible on your map.

From attribute table to map canvas

Can select row(s) in attribute table and see where they are in the map canvas (they become highlighted in yellow on the map - unless the point is under another point).

Select a row (point) in the attribute table. Notice the *Attribute table* window title reports the number of total features, and any selected.

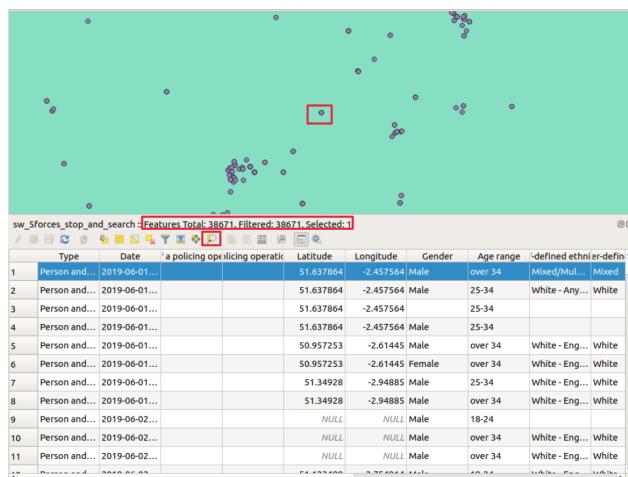


Figure 9.6: Stop and search attribute table, selected 1 row with relevant point highlighted, not in yellow as it's under another point. Red boxes highlight 1) Point selected 2) Number of features selected 4) Zoom to point button

Sometimes we can not instantly see where these features are on our map, so use the map navigation function buttons: *Pan to selected* & *Zoom to selected*. These function buttons are in the Attributes & Map Navigation toolbars, and in the Attribute Table title bar. For some cases, need to press this button a couple of times for it to take effect.



Figure 9.7: Function buttons in the Attributes & Map Navigation toolbars

Useful to know at this stage that we can dock the attribute table to the main window, so we can see both the map canvas and the attribute table 

If no yellow point exists, then it will be under another point. A useful tool to then use is Identify Feature tool. See the next section.

To get an example which only has one point at a location (so can see the yellow selected point) sort the attribute table by the field *Date*, select the top row and Zoom To Selected.

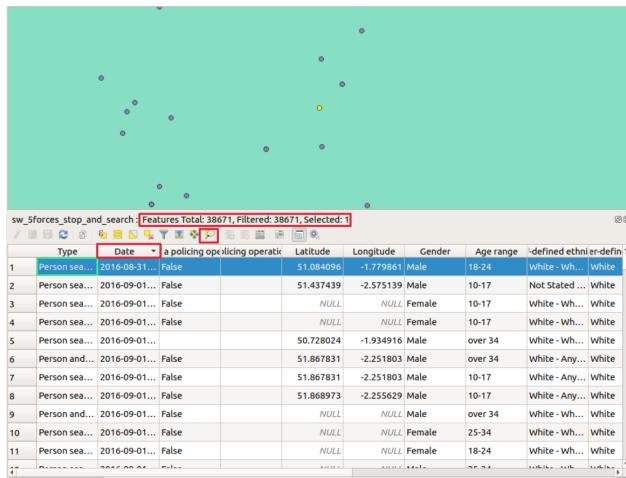


Figure 9.8: Stop and search attribute table. Red boxes highlight 1) Order by Date 2) Selecting the oldest feature 3) Number of features selected 4) Map navigation function buttons

From map canvas to attribute table using the *Identify Feature* tool

Click the *Identify Feature* icon

This function will only work on the top layer (as in the *Layers Panel*, even if the top layer is unselected. Click on a feature (point). Information about that feature (point) will be displayed in the *Identify Results Panel*, this is essentially the values of the fields in the layer's *Attribute Table*):

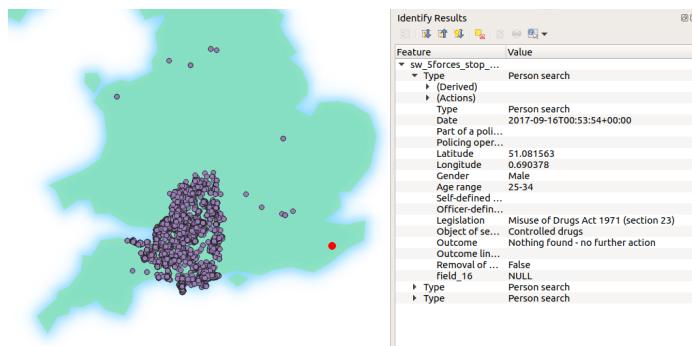


Figure 9.9: Identify features tool, and panel

For locations with multiple points on the same site, all of the features will appear in the *Identify Results Panel*.

From map canvas to attribute table using the *Select Feature(s)* tool

Alternatively, can select feature(s) (points) on the map using the *Select Feature(s)* tool, the icon is in the top toolbar , (right click to end selection).

View the field values in the *Attribute Table*, and move selection to top

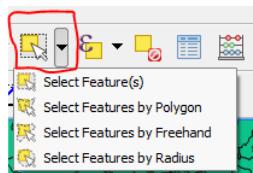


Figure 9.10: Options for the Select Feature(s) tool

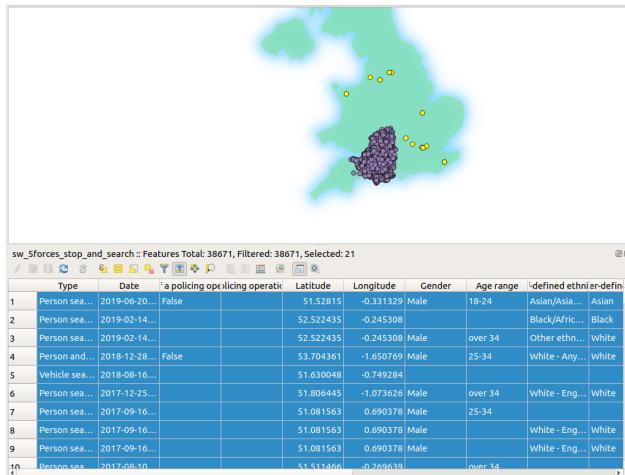


Figure 9.11: Selecting the outlying points, and bringing those features to the top of the attribute table

Close Attribute Table (x in top right of window)

Close Identify Results panel & Deselect all features.

9.4 Symbology for dense point data

For dense point data (with many points at the same location) there are at least two options available.

9.4.1 Heatmap

In the *Layer Styling Panel*, select in the dropdown: *Heatmap*. Play with the color ramp (I quite like *magma* for heatmap), radius, units, and opacity (expand Layer rendering).

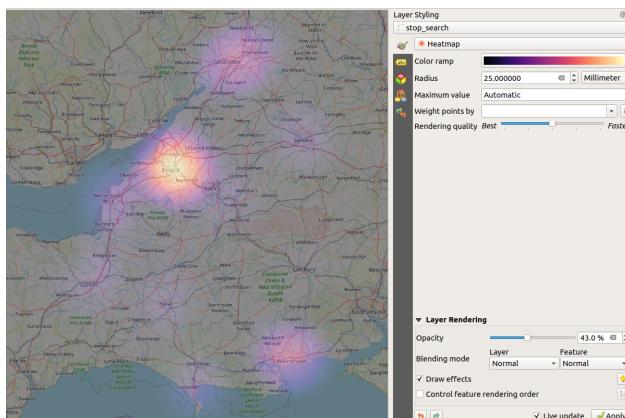


Figure 9.12: Heatmap for the stop and search dataset

For more information on styling heatmaps see https://www.qgistutorials.com/en/docs/3/creating_heatmaps.html, where the example data is conveniently about crimes.

9.4.2 Point Cluster Renderer

Create a duplicate of layer *stop_search* and rename layer.

This option is inspired by the maps I saw on the police website:

<https://www.police.uk/devon-and-cornwall/DEV.4055/crime/>.

I found this tutorial helpful: <https://www.youtube.com/watch?v=-ikF1oYIpa0>

In the *Layer Styling Panel*, select in the dropdown: *Point cluster*.

Experiment with the settings to get an uncluttered map where the points don't overlap and make it look too busy.

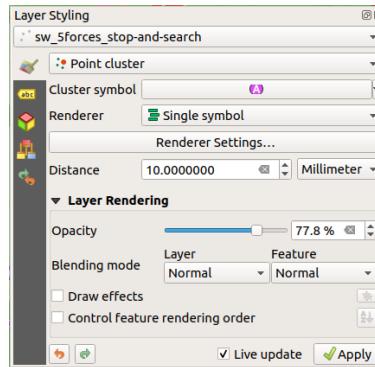


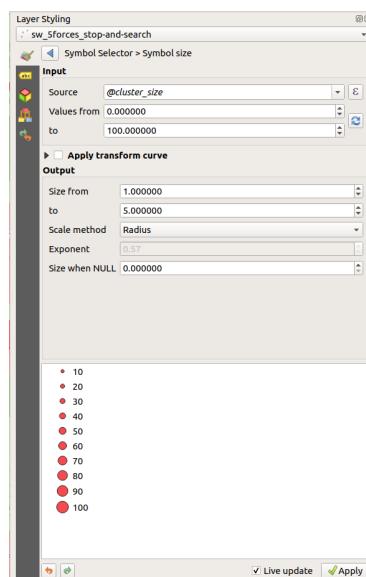
Figure 9.13: Layer Styling pane showing the settings available for Point cluster

Distance units: *Millimetre or Inches* - the points join together based on the scale. *Map units, pixels or point* - the points that are joined together are fixed.

Can also change point size depending on number:

Cluster symbol → Simple marker → Size → Assistant → Source: "@cluster_size"

Experiment with the range of "Values from" and "to". Also "Size from" and "to".



(a) Settings to make the point size change depending on the number of points in the cluster



(b) Point cluster symbology

Unselect the *stop_search* layer in the *Layers* panel.

Chapter 10

Create groups of layers

10.1 Set up a group

We now have multiple layers that contain the same data but with different symbology, some of your layers may be opaque. Having more than one of these selected is not useful. We can set up groups within the *Layers Panel* so that the layers within the group are mutually exclusive.

At the top of the *Layers Panel*, select *Add Group*  (and rename the group: "stop_search_layers").

This will add a group within the *Layers* panel. Drag and drop the layers into the group.

Right click on the group name within the *Layers Panel* and select *Mutually Exclusive Group*.

Make sure the base map is still at the bottom of the list of layers.

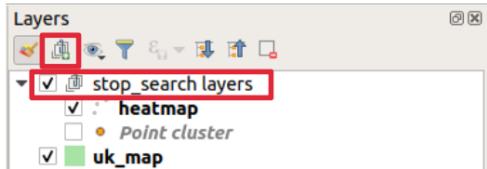


Figure 10.1: Create a group, then drag and drop the relevant layers in

Chapter 11

Adding sparse point data (own data with geometry)

11.1 Data

Filename to use for this section: *headquarters.csv*

This file contains our own geographical data regarding the location of the 5 police headquarters. It contains geometry data, as latitude and longitude. QGIS will use this information to plot the data on our map.

I created this data file from information I found online. I could only obtain postcode data for the HQ locations. QGIS can not plot postcodes. I needed to do a bit of data processing before can use this in QGIS. Use free online databases to convert each postcode to either (1) Eastings and Northings, or (2) Latitude and longitude (as required by QGIS to display a point position)

<https://www.ordnancesurvey.co.uk/business-and-government/products/code-point-open.html>
<https://www.freemaptools.com/convert-uk-postcode-to-lat-lng.htm>

	A	B	C	D	E	F
1	Head quarters	Address	Postcode	Latitude	Longitude	Fire_Rescue_HQ_site
2	Avon and Somerset	Valley Rd, Portishead, Bristol	BS20 8JJ	51.47575	-2.79543	TRUE
3	Dorset	Winfirth Dorchester, Dorset	DT2 8DZ	50.67927	-2.2467	FALSE
4	Devon and Cornwall	Middlemoor, Exeter, Devon	EX2 7HQ	50.71915	-3.47813	FALSE
5	Wiltshire	London Rd, Devizes	SN10 2DN	51.35609	-1.98371	FALSE
6	Gloucestershire	1 Waterwells Dr, Quedgeley, Gloucester	GL2 2AN	51.81453	-2.27618	TRUE

Figure 11.1: *headquarters.csv* file

11.2 Add delimited text file

Let's add this delimited file .

Within the *Data Source Manager / Delimited text* window, choose these settings:

File name: Navigate to the csv file: *headquarters.csv*

Layer name (what appears in the *Layers Panel*, so choose something meaningful): *headquarters*

File Format: CSV (comma separated values)

Geometry definition → Point coordinates → **x field** = Longitude & **y field** = Latitude

Coordinate system: EPSG4326 WGS 84 (leave as default)

(Note: The top row of the csv file is used as the field titles.)

Add.

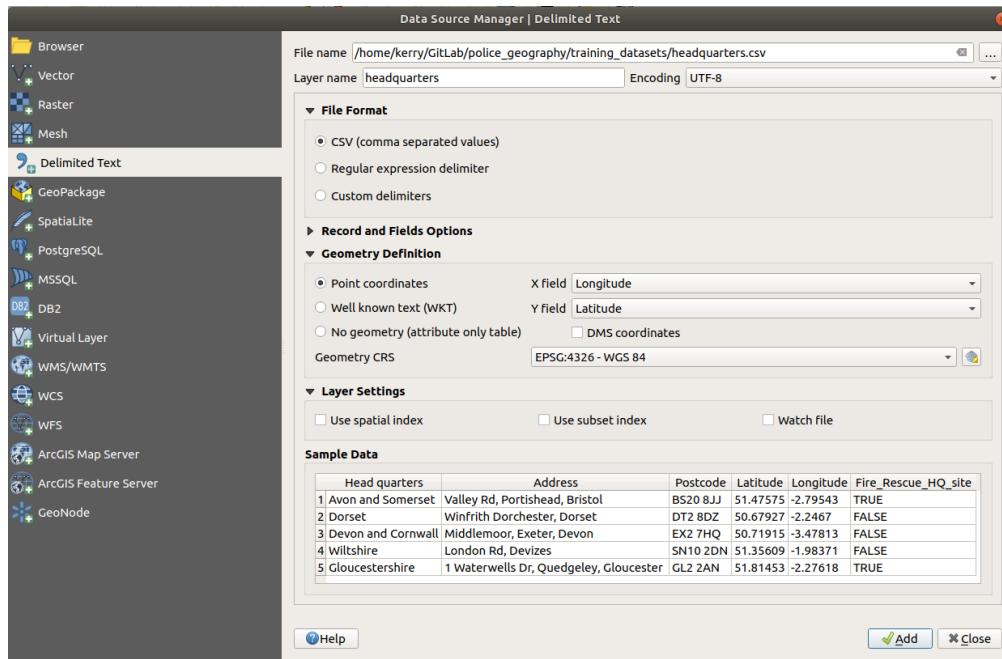


Figure 11.2: Add delimited text file

This new headquarters layer is added to the *layers* panel.

The points (with a single symbol) are added to the map canvas.

As with all layers, this has its own attribute table, with a row to represent each point on the map canvas. If we were keeping the symbol the same for all points we would edit the simple symbol settings in the *Layer styling* panel, by selecting a colour/shape for the marker to represent the headquarter locations.

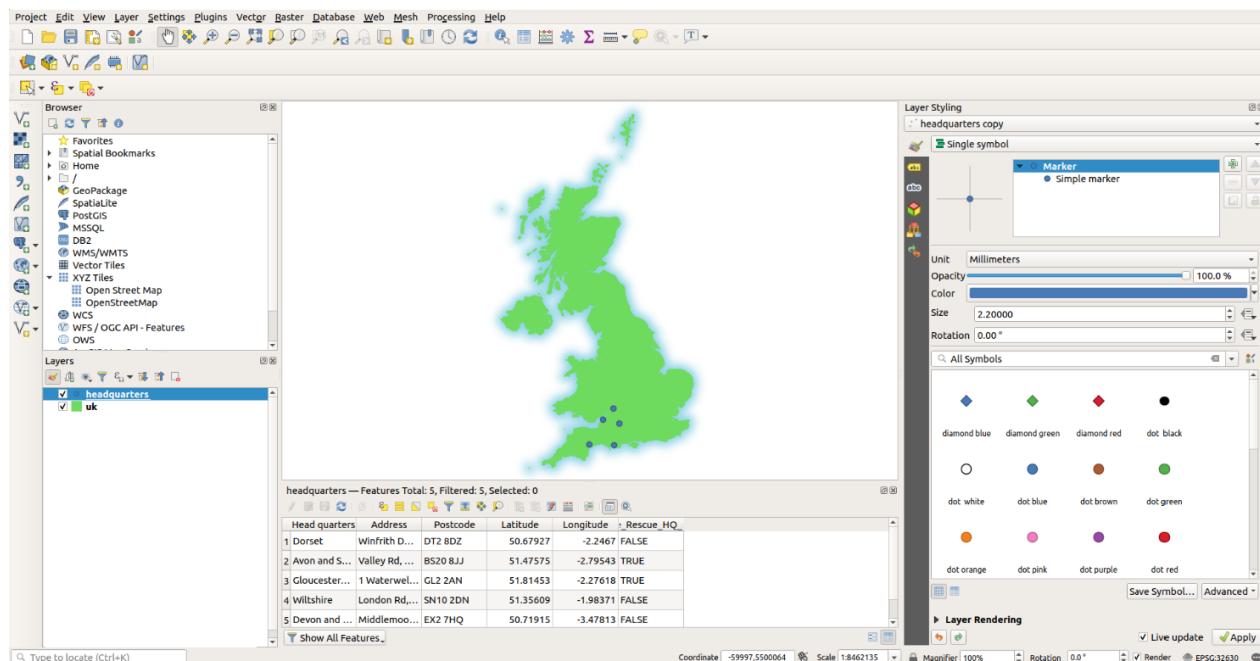


Figure 11.3: headquarters.csv data added to map canvas

11.3 Symbology: Categorized

We've already explored how to use the *Layers Styling Panel* to change the style of a *Single symbol* (to get the coastline and landmass of UK). Let's now look at how to add different symbol for our points based on a value of a categorical field.

This data has a field "Fire_Rescue_HQ_site" which stores a boolean to represent whether the Police HQ location is also the site for the Fire and Rescue HQ. Let's format our points to show this information.

In the *Layers Styling Panel*:

Select *headquarters*

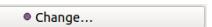
Select *Categorized*

Column: Fire_Rescue_HQ_site.

Classify

Can choose which of the individual categories to be shown on the map (check box next to symbol)

11.3.1 Choose the style for each symbol

To change the shape for all: have nothing highlighted in the pane and select *Symbol* 

To change just one of the symbols: double click an individual symbol.

Either have *Marker* highlighted (for one set of symbol options), or select *Simple marker* for more options (explore the options under the different Symbol layer type). It's very easy to get into a pickle here!!

Set legend text to *Police HQ* and *Police & Fire Rescue HQ*.

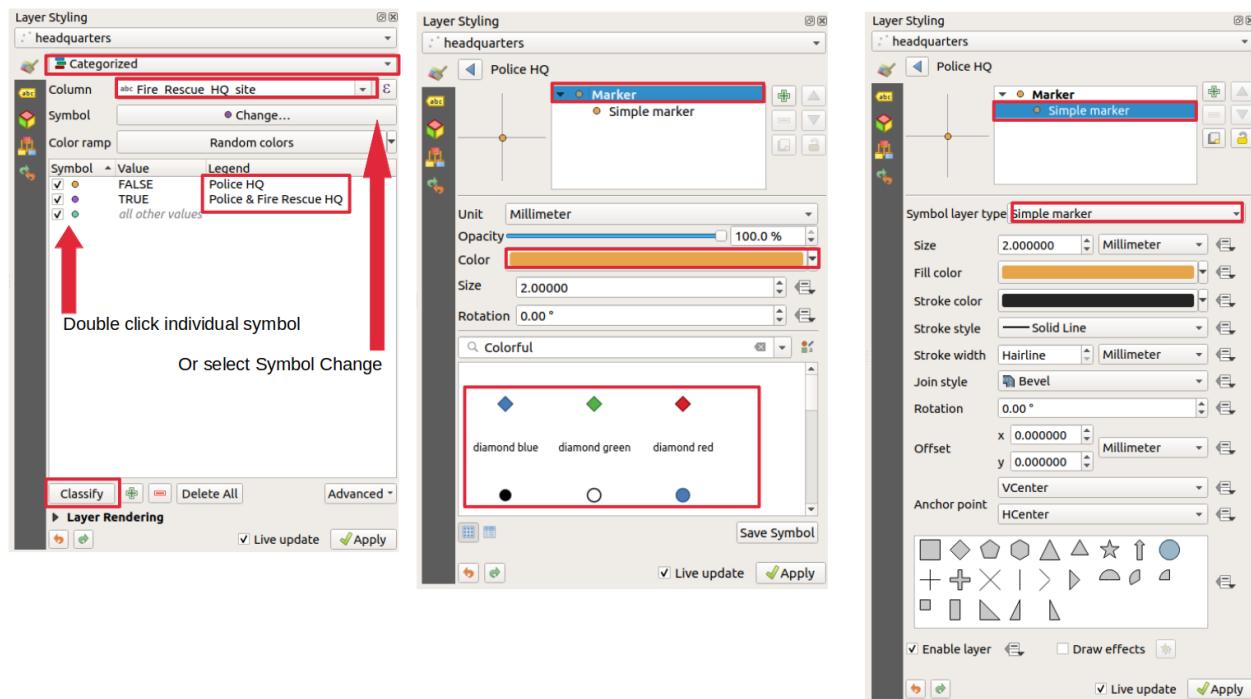


Figure 11.4: How to change symbols for point data using *Layers Styling* panel

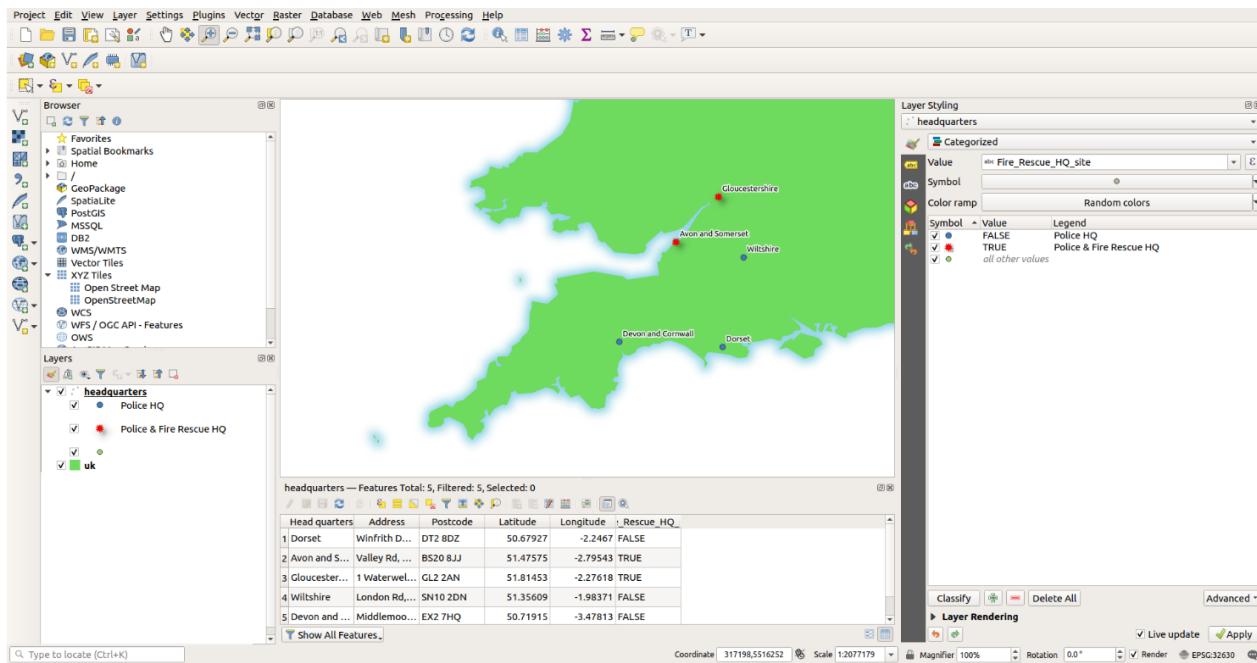


Figure 11.5: headquarters layer with categorized symbology

11.3.2 Use rule based styles

For more complicated allocation of a symbol to field values, can set up rules.

Can see the structure of the rules for the previous styling we chose by selecting Rule-based, to edit an existing rule double click on the rule, select the green + button to add a new rule.

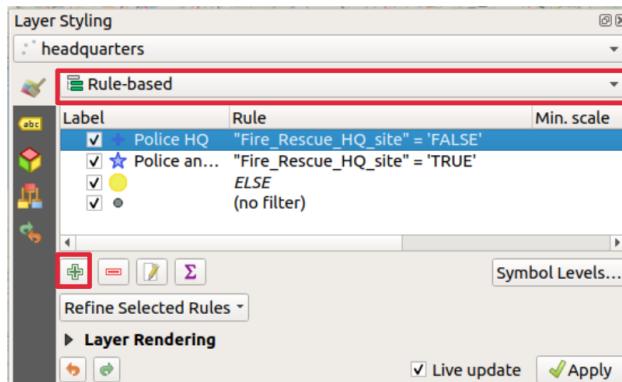


Figure 11.6: Rule-based styling

We will set up some rule based labels later, just showing that they are possible for the symbology as well.

Chapter 12

Add labels

12.1 Put a label next to a point

We're going to modify our layer *headquarters* by adding some labels.

In the *Layer Styling Panel* select the layer *headquarters*. Click the *Labels* icon on the LHS of the *Layer styling Panel*. Select Single labels Label with: Head quarters Change the settings under the various style tabs.

- 1) Text:
 - 1) Size: 7.2
 - 2) Colour: Black
- 2) Buffer:
 - 1) Size: 1
 - 2) Colour: White
 - 3) Opacity: 70
- 3) Placement
 - 1) Around point
 - 2) Distance: 1.5

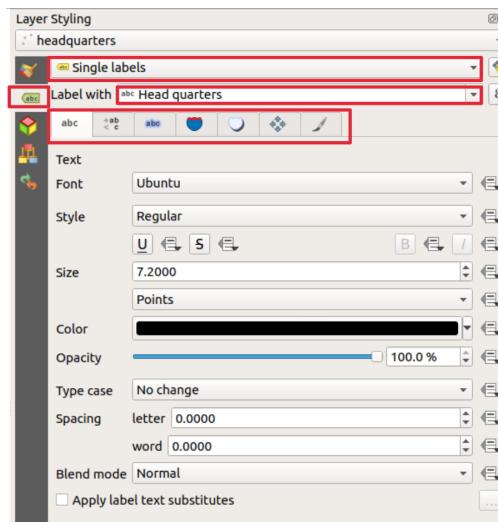


Figure 12.1: Add label with text from field *head quarters*

12.2 Using rule based labels

Take a duplicate of the headquarters layer and rename it.

Let's imagine we only want to show a label for the 2 HQs that are also the Fire and Rescue HQs. We will use the boolean field *Fire_Rescue_HQ_site* in *headquarters.csv*.

In the drop down click on "Single labels" and select: *Rule-based labelling*. Can see that under "Rule" there is "(no filter)". This is where we will put our filter. Double click on "(no filter)".

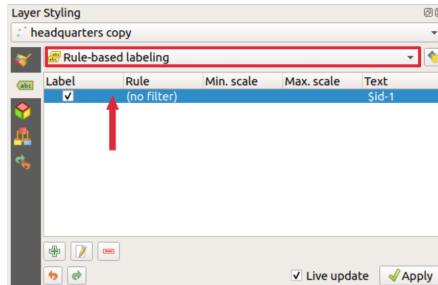


Figure 12.2: Layer Styling panel showing Rule-based labelling

If we know the syntax we can type the expression directly in the Filter text box. Otherwise click on the expression icon  to bring up the same style form we used to select our features in the attribute table.

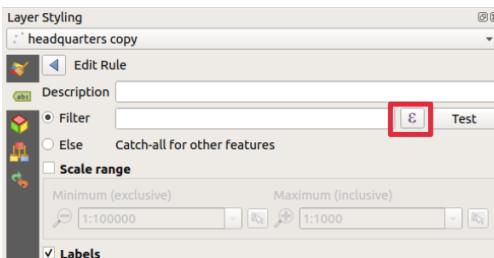


Figure 12.3: Rule-based styling window. Click the expression icon to use the expression string builder form

Use the middle pane to populate the LHS pane with the expression: **"Fire_Rescue_HQ_site" = 'TRUE'**. The bottom of the *Expression String Builder* window will remain "Expression is invalid", until it is correct.

OK & Apply & . Now see that only 2 labels exist on the map canvas.

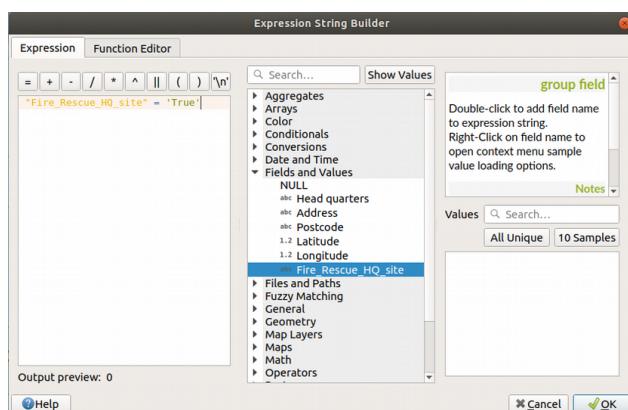


Figure 12.4: Expression string builder form to only have labels for locations also with Fire & Rescue

12.3 Put a number in a point

Take a duplicate layer of the headquarters, and rename it.

Going to use a unique integer from each HQ as the label, and place this at the location of the HQ. First we need to create this unique integer. I'll show you two options.

- 1) Add a new field to the layers attribute table

Open attribute table:  and click field calculator: 

In the field calculator form, you can calculate a new field using existing fields and variables of each feature. Use the search bar to find a variable that will contain a unique value, let's try "id". Great, there's a variable called **\$id**. From practice, I know \$id starts from 2 for this data, so type: **\$id - 1**. Output field name: "FID"

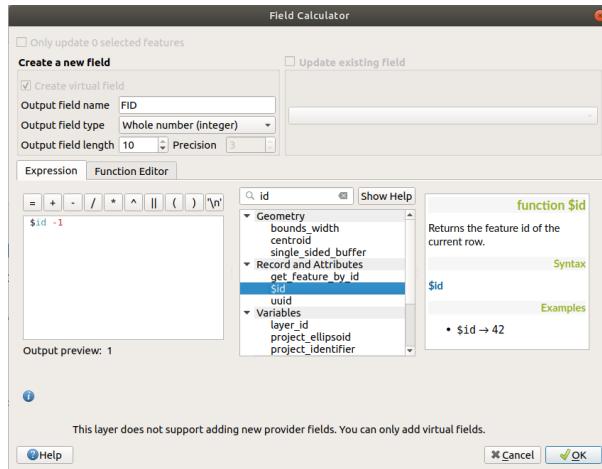


Figure 12.5: Calculating a new field and adding to attribute table

This new field has been added to the attribute table.

Close the attribute table (otherwise the new field does not seem to save)

headquarters :: Features Total: 5, Filtered: 5, Selected: 0						
	Head quarters	Address	Postcode	Latitude	Longitude	Fire_Rescue_HQ_site
1	Dorset	Winfirth D...	DT2 8DZ	50.67927	-2.2467	FALSE
2	Gloucester...	1 Waterwel...	GL2 2AN	51.81453	-2.27618	TRUE
3	Devon and ...	Middlemoor...	EX2 7HQ	50.71915	-3.47813	FALSE
4	Wiltshire	London Rd, ...	SN10 2DN	51.35609	-1.98371	FALSE
5	Avon and S...	Valley Rd, ...	BS20 8JJ	51.47575	-2.79543	TRUE

Figure 12.6: Headquarters layer attribute table with new field: FID

Additional information: To delete a field, either in the attribute table, or in *Layer Properties* → *Source* *Fields* select *Toggle editting mode* , select the field you wish to delete, then *Delete field* 

In the *Layer Styling Panel*.

Symbology: No symbols

Labels: Single labels

Label with: FID

2) Label with expression

In the *Layer Styling Panel*.

Symbology: No symbols

Labels: Single labels

Label with: 

In the expression dialog form, use the search bar to find a variable that will contain a unique value, let's try "id". Great, there's a variable called **\$id**. From practice, I know that \$id starts from 2 for this data, so type: **\$id - 1**.

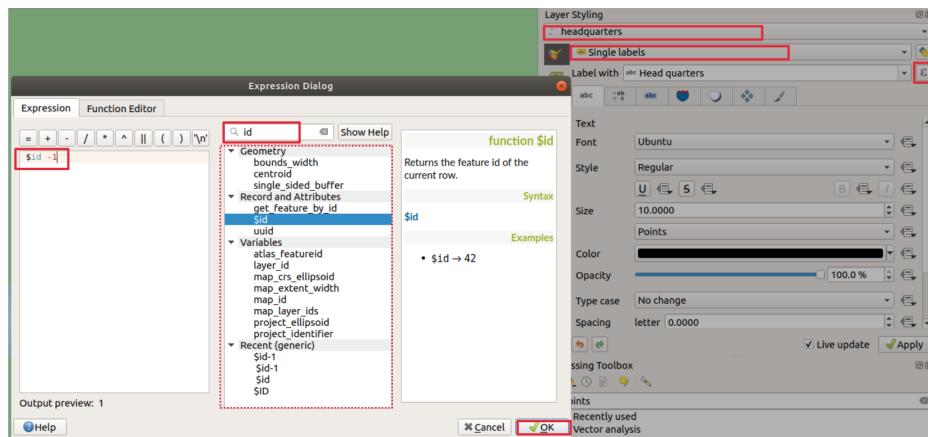


Figure 12.7: Using an expression as a label

You've now got your unique integer - now change the settings under the various style tabs:

1) Text:

- 1) Size: 9.2
- 2) Colour: White
- 3) Style: Bold

2) Background:

- 1) shape: Circle
- 2) Size type: Buffer
- 3) Fill & border colour: Black

3) Placement

- 1) Offset from point: Central

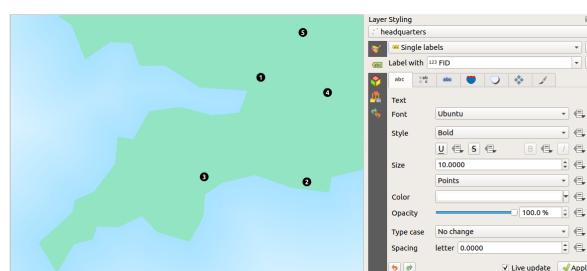


Figure 12.8: Displaying a unique number at each point

Chapter 13

Shapefiles

13.1 Data

Filename to use for this section: *LSOA_2011_sw5forces_BGC_V2.shp*

When we have some data that does not contain geometry, we need to make use of shapefiles. Can think of shapefiles as providing us with the borders of our regions (polygons), and we can colour in each polygon based on the feature values in our file for each corresponding region.

Information about the individual files that make up a shapefile can be found here: <https://desktop.arcgis.com/en/arcmap/10.3/manage-data/shapefiles/shapefile-file-extensions.htm>

13.2 Add a vector layer

Shapefiles are known as vectors. To open a shapefile in QGIS, this is known as *adding a vector layer*.

There are many ways to add a vector layer:

- 1) Menu: Layer → Add Layer → Add Vector Layer
- 2) *Add vector layer* icon on a toolbar 
- 3) Use *browse panel* to navigate to the file location
- 4) Data Source Manager icon 

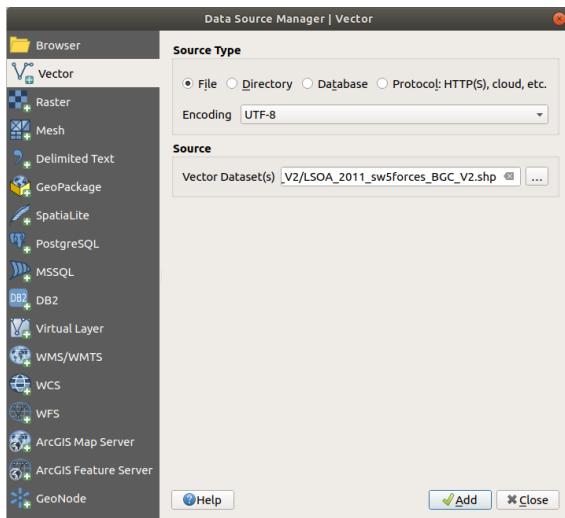
Navigate to the shapefile *LSOA_2011_sw5forces_BGC_V2.shp*
Add.

Result: The shapefile is displayed in the map canvas, the file is listed in the Layers panel, and (if you have it selected,) the Layers Styling panel is enabled.

From now on we will refer to this shapefile as a *layer*.

Each open layer is listed in the *Layers Panel*. The order they exist in this list determines the order that they are rendered on the map canvas.

Practice selecting and deselecting the layers open in your project (uk, point files and shapefile), and change the order they are rendered by dragging and dropping.



(a) Form to add a vector layer (shapefile)



(b) Shapefile containing LSOAs for SW England and UK basemap

13.3 Attribute table

As with all layers, this shapefile has an attribute table, layers property window, and can have its symbology changed using the *Layers Styling* panel.

Open the attribute table . It only contains 4 fields. In this next few steps we will be adding fields into this shapefile from our own datafile. We will use the unique code in field "LSOA11CD" in order to perform this join.

13.4 Practice what you've learnt on this shapefile

1. Move between selecting features on the map canvas (select feature tool), and identifying them in the attribute table (move selected rows to top of table)
2. Use Identify feature tool
3. Move between selecting features in the attribute table, and identifying them in the map canvas
 - (a) Select rows manually
 - (b) Use select & filter features form
 - (c) Use select by expression
4. Save selected features as new feature layer

Chapter 14

Adding data (without geometry) to a shapefile: table joins

14.1 Data

Filename to use for this section: *sw_5forces_street_by_lsoa.csv*

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	LSOA code	Anti-social behaviour	Bicycle theft	Burglary	Crime type	Criminal damage and arson	Drugs	Other crime	Other theft	Possession of weapons	Public order	Robbery	Shoplifting	Theft from the person	Vehicle crime	Violence and sexual offences	Total number crimes
2	E01000040	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
3	E01000055	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4	E01000547	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5	E01000568	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6	E01000689	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
7	E01000765	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
8	E0100096	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
9	E01000993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
10	E01001107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
11	E01001202	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
12	E01001240	n	n	n	n	n	n	n	n	n	n	n	n	n	n	1	1

Figure 14.1: *sw_5forces_street_by_lsoa.csv*

This file contains our own geographical data regarding the number of crimes per LSOA. Each row contains data for an LSOA. This file also contains a field with a unique code for each LSOA, which matches a field in the attribute table for the corresponding shapefile.

Note: QGIS has a function "point to polygon", but the third party LSOA shapefile contains errors which need addressing before this can work. Instead we do our calculations in python outside of QGIS and perform a table join.

14.2 Add delimited text layer

Let's add this delimited text layer .

Within the *Data Source Manager / Delimited text* window, choose these settings:

File name: Navigate to the csv file: *sw_5forces_street_by_lsoa.csv*

Layer name (what appears in the *Layers Panel*, so choose something meaningful): *street_crime*

File Format: CSV (comma separated values)

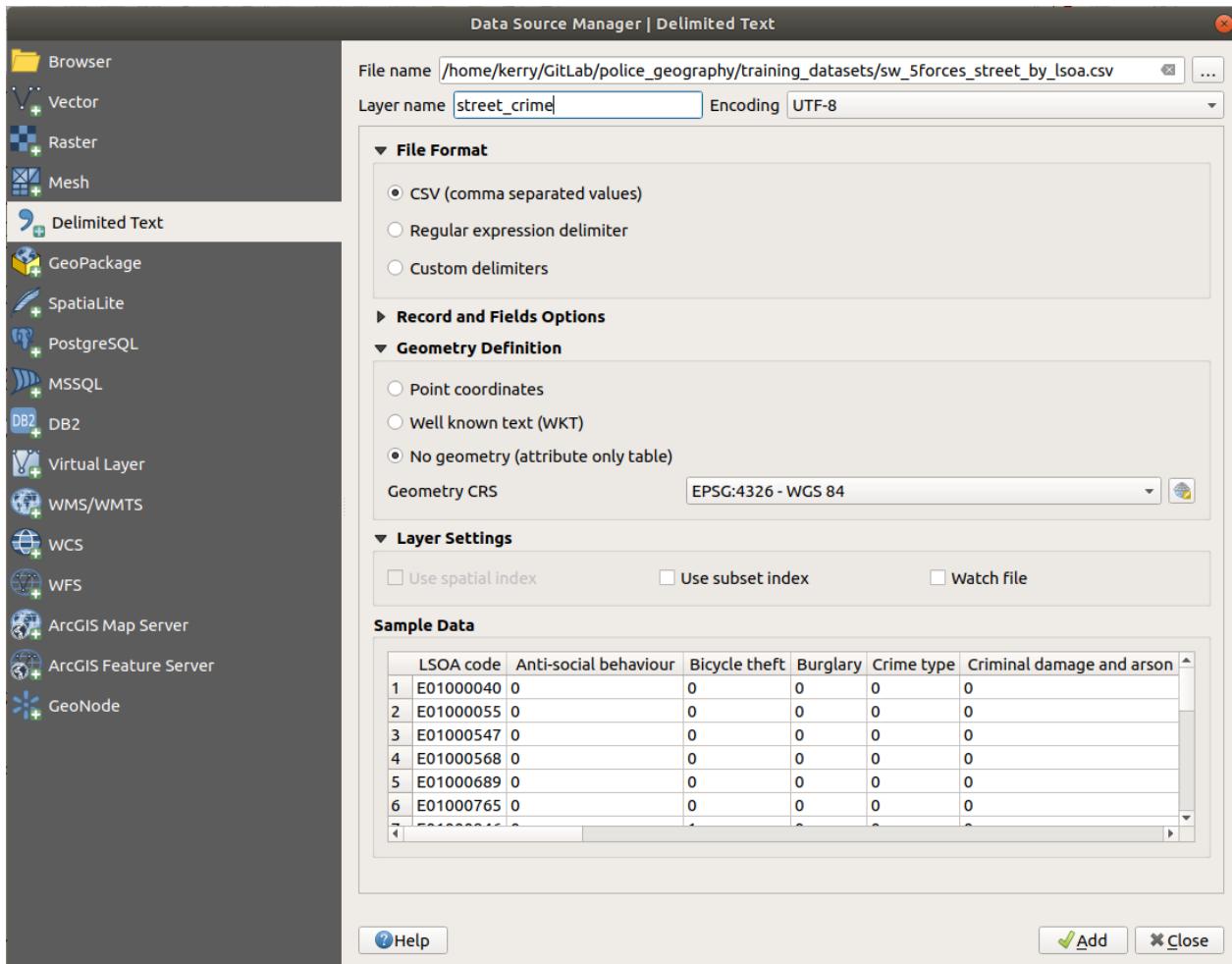
Geometry Definition: No geometry

Geometry CRS: EPSG4326 WGS 84 (leave as default)

(Note: The top row of the csv file is used as the field titles.)

Add.

The file will appear in the list in the *Layers Panel* but will not appear on the map canvas yet as it does not contain geometry data. Need to join this data to the LSOA shapefile.

Figure 14.2: Adding the delimited text file *sw_5forces_street_by_lsoa.csv*

14.3 Table join: Join data from csv file to shapefile

To join our geographical data to the shapefile layer, open layer properties for the shapefile layer: Right click → Properties, or double click on the layer name in the *Layers panel*.

Firstly, select *Source Fields* on the LHS pane. See there's only 4 fields in the original *Attribute Table*.

Select **Join** in the LHS pane.

To initiate a new join select  at bottom

Join layer = csv filename

Join field = field name in the csv file that contains the common codes

Target field = field name in the shapefile that contains the common codes

(Can check which fields we want to use by opening both attribute tables *attribute tables*, for LSOA shapefile, and for street_crime).

Apply

Select *Source Fields* on LHS pane. This shows that new fields have been added to the attribute of the shapefile layer. Can also see this in the shapefiles *attribute table*.

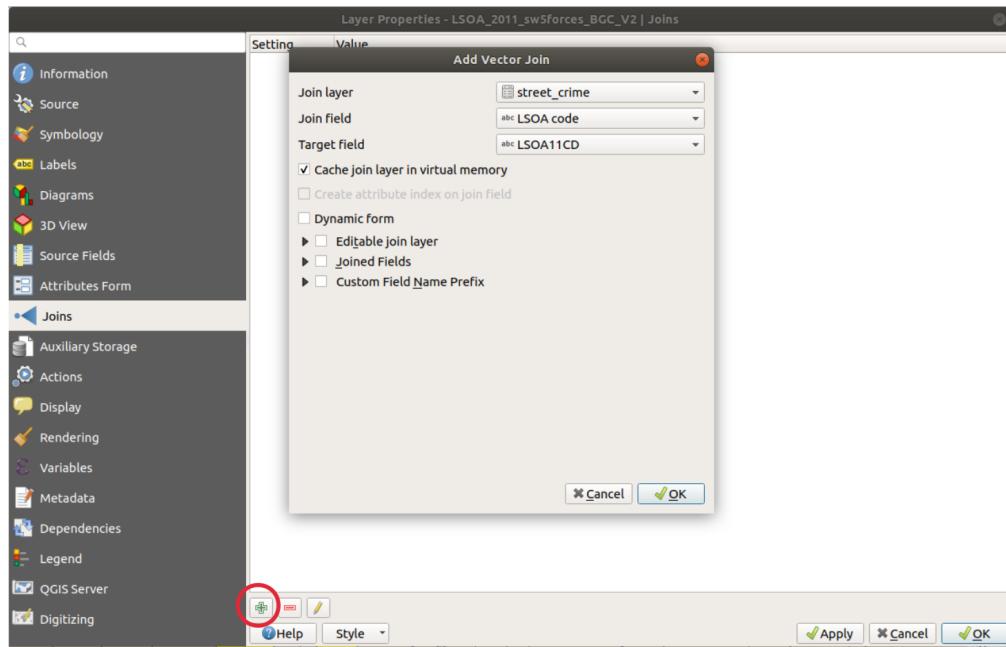


Figure 14.3: Joining the csv data to the shapefile based on a common unique field value

ID	Name	Alias	Type	Type name	Length	Precision	Comment	W
abc 0	LSOA11CD		QString	String	9	0		✓
abc 1	LSOA11NM		QString	String	254	0		✓
abc 2	LSOA11NMW		QString	String	254	0		✓
123 3	Area		qulonglong	Integer64	10	0		✓
4	street_crime_Anti-social behaviour		int	integer	0	0		✓
5	street_crime_Bicycle theft		int	integer	0	0		✓
6	street_crime_Burglary		int	integer	0	0		✓
7	street_crime_Crime type		int	integer	0	0		✓
8	street_crime_Criminal damage and arson		int	integer	0	0		✓
9	street_crime_Drugs		int	integer	0	0		✓
10	street_crime_Other crime		int	integer	0	0		✓
11	street_crime_Other theft		int	integer	0	0		✓
12	street_crime_Possession of weapons		int	integer	0	0		✓
13	street_crime_Public order		int	integer	0	0		✓
14	street_crime_Robbery		int	integer	0	0		✓
15	street_crime_Shoplifting		int	integer	0	0		✓
16	street_crime_Theft from the person		int	integer	0	0		✓
17	street_crime_Vehicle crime		int	integer	0	0		✓
18	street_crime_Violence and sexual offences		int	integer	0	0		✓
19	street_crime_Total number crimes		int	integer	0	0		✓

Figure 14.4: Source fields showing the original shapefile fields (yellow) and joined fields (green)

Click OK.

Nothing has changed in the map canvas yet. We need to add symbology to the shapefile layer.

Chapter 15

Symbology: Graduated

Graduated symbology is used to represent continuous fields. We will look at counts of crime per LSOA (the fields we have just joined to the LSOA shapefile).

Since these fields all have the same units (count of crime per LSOA) for different categories of crime, when you come to create maps for this type of data, it is often useful at the beginning to consider whether you would like a common colour scale that you will use for all of your fields, or whether you will use a colour scale tailored for each field. This is your choice and will depend on the scale of values in each of your fields.

The choice of symbology settings (for example number of classes, numerical ranges for each class, the colour scheme) will depend on what you are trying to show. The choices made here make a huge difference to the appearance of your maps.

We often ask the data holder to inform us about what to use, so we can represent any important thresholds.

Note: the human eye can only detect a difference between a small number (about 8) of monocolours.

15.1 Apply graduated symbology (colours represent numerical ranges)

Let's quickly put some colour in those shapefile polygons.

In the *Layer Styling Panel* ensure the layer to change is selected.

Select these settings (leaving the rest as default for now):

- 1) Click on *Single symbol* drop down, and choose **Graduated** (use graduated for continuous data, categorised for classes)
- 2) **Column:** Choose a column. For example, street_crime_Anti-social behaviour
- 3) **Mode:** Equal Interval
- 4) **Classify**

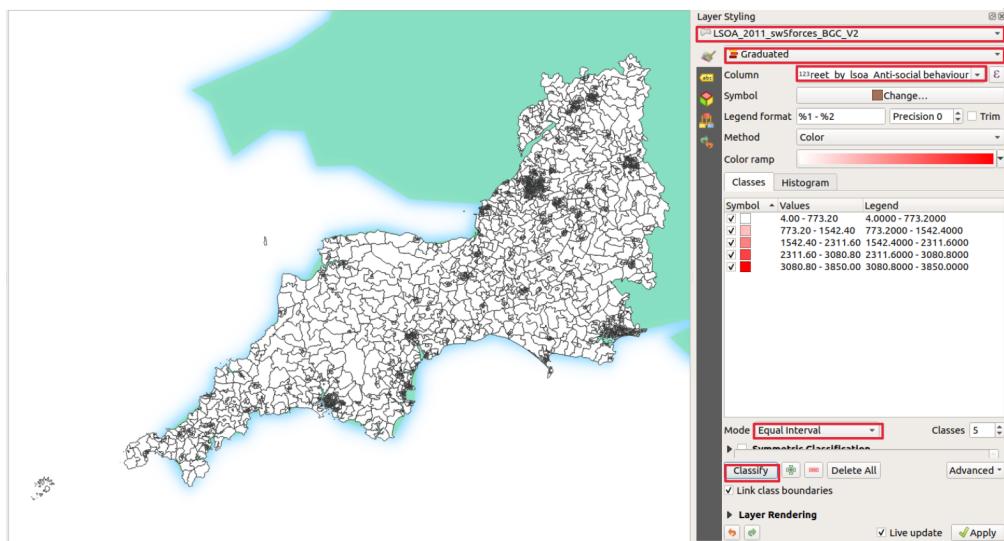


Figure 15.1: Graduated symbology to the street crime layer

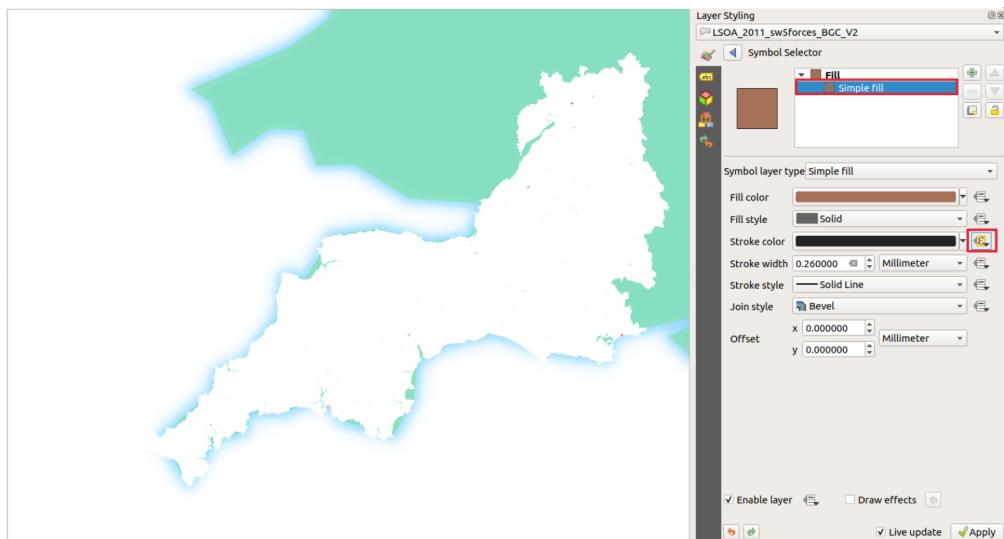


Figure 15.2: Result of removing the polygon stroke colour

Each polygon has the corresponding colour to the value in that field. I will explain why it looks like the map has no colour in a bit.

For the cities with many small polygons it is tricky to see their colour beyond the black border. We have a fix for this (see next section).

From this, can see we need to increase the width of the UK layers sea colour to maintain a useful basemap.

15.2 Set polygon boarders to automatically have fill colour

For areas with small polygons (the cities) it is tricky to see the colour beyond the black outline. You can make the polygons outline have the same colour as the fill either by changing each individually, or by using an expression so that it will be done automatically.

Make sure nothing is highlighted in the *Layer Styling* pane.

Symbol → Change

Simple fill

Stroke color → Edit

Expression type: `@symbol_color`

OK

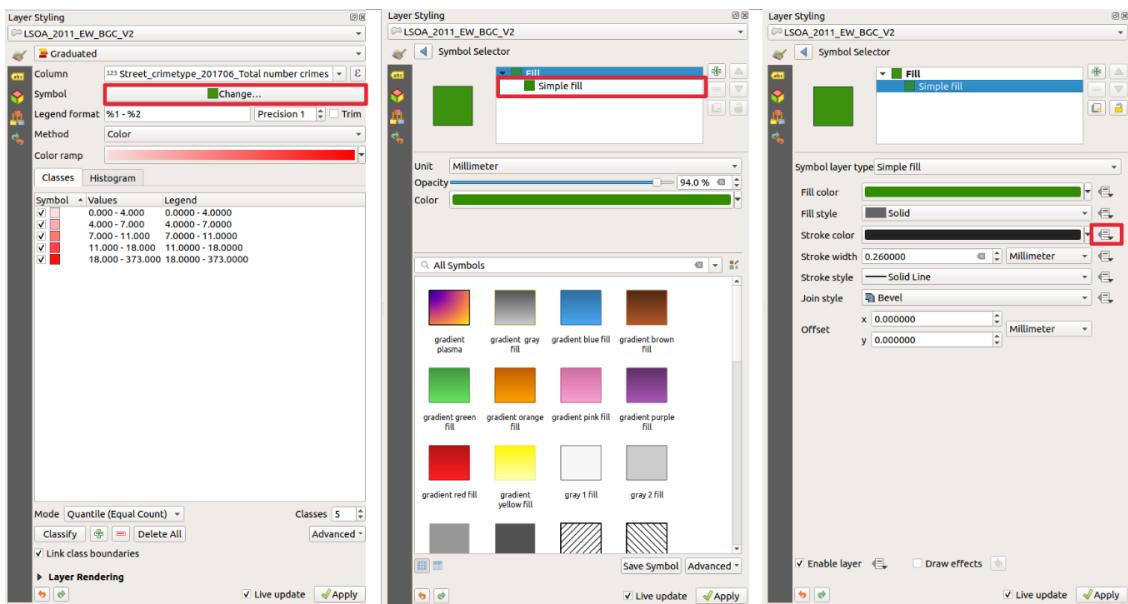


Figure 15.3: Settings in Layer Styling panel for borders to have same colour as fill (pt 1)



Figure 15.4: Settings in Layer Styling panel for borders to have same colour as fill (pt 2)

Notice the Edit button is now yellow. Shows that an expression exists there. If want to remove this expression, click on the icon and select clear (you can not delete the expression from the *Expression String Builder* and leave that field blank).

If your symbology colour scale includes white, then removing the black outline will lose references to a boundary. This example highlights the importance of using a base map.

15.3 Customising and choosing good graduated symbology

QGIS has many tools to help us select a good colour range. The default one that we have used so far has proven to be not suitable.

15.3.1 Use the histogram to inform the number of, & range for each class band

Within the *Layer Styling Panel*, view the histogram of the field. Select tab *Histogram* → Load Values. If a colour ramp has already been applied to the field, this will be represented in the histogram. Use this to inform the number & ranges of classes.

Note: If you have classes set up, then the histogram will only plot data within that numerical range, and so not necessarily all the data for the chosen column, even when click *Load Values*. If you change the column choice and want to see the full range of data, need to click *classify* first in the *Classes* tab, then view histogram.

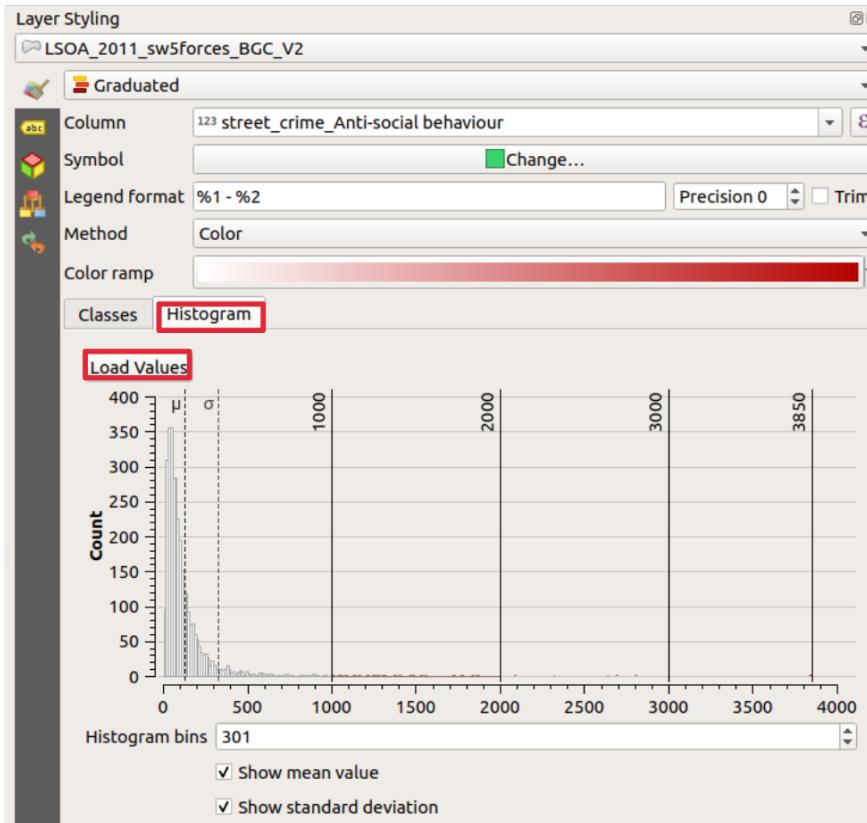


Figure 15.5: Using histogram to inform graduated symbology

15.3.2 Use predefined algorithms

QGIS has 5 modes (predefined methods) to divide your data into discrete classes:
 Equal Interval, Quantile (equal count), Natural breaks (Jenks), Standard deviation and Pretty breaks.

For our case, we had Equal Interval where the full range of the values are divided by the number of classes. For this field there is a large outlier and so most of the polygons fall in the smallest colour band. So for this data, this mode is not suitable.

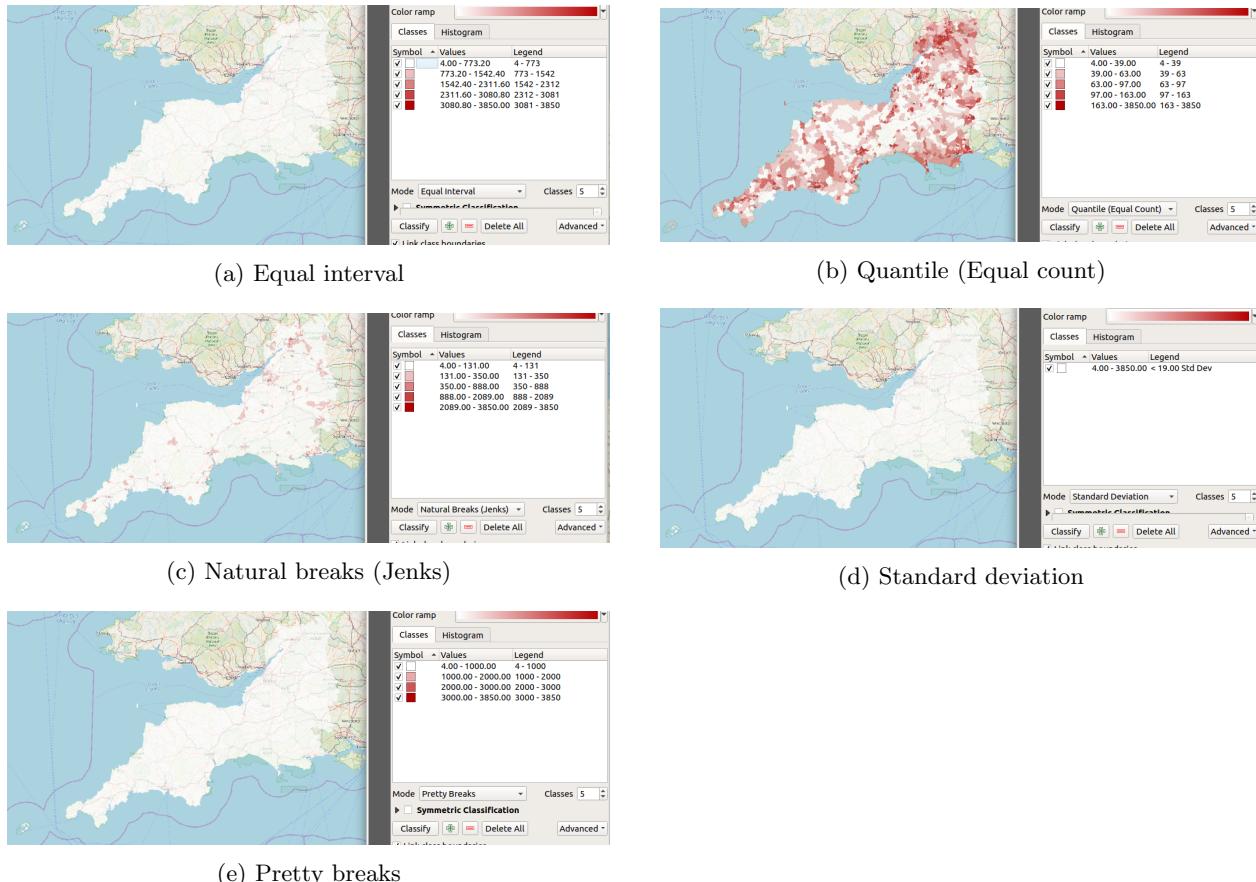


Figure 15.6: The five different algorithms to automatically create graduated bands

15.3.3 Number of classes

Change the number of classes. Your choice

15.3.4 Colour ramp

Can choose one of the predefined colour ramps. Your choice

15.3.5 Manually change the symbology

Instead of using predefined settings, you can also change the symbology of an individual item manually. Within the *Layers Styling Panel*, in the *Classes* tab, double click on the numerical range, or the symbol, to change it.

15.3.6 Opacity

If you have detail in the base map (for example Open Street Map) consider setting this layer's opacity (expand *Layers Rendering*) to 60

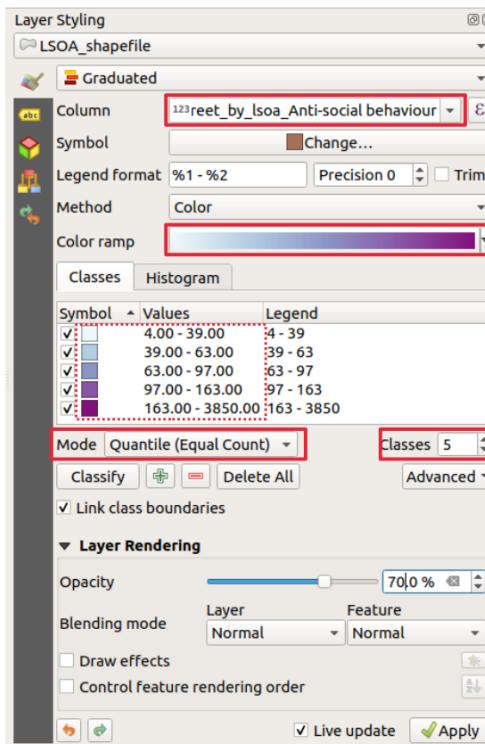


Figure 15.7: The four red boxes highlight what determines the automatic graduated symbology: column; colour; mode; classes. Double click within the dashed red box to manually change an individual number or colour

TASK

Change the symbology settings to give the most information about the data. There's no right answer.

Note: Two useful buttons at bottom of Layer Styling panel (Undo & Redo): .

15.4 Style the layer with values from another field

Unless you made sure the full range of values were included in your symbology, there may be some empty polygons when you change fields and use the same symbology. If want to use the same symbology for multiple columns its best to put time into thinking about ranges at the start.

In the *Layer Styling Panel* select a different column: For example, `street_crime_Bicycle_theft`. Then either:

15.4.1 Use existing symbology

Choose your new column, click **Apply**.

15.4.2 Update symbology based on new values

Choose your new column, click **Classify**. The numerical ranges and colours will be overwritten depending on the values in the new column and the symbology settings (mode, classes, color ramp).

15.5 Duplicate layer

Rather than keep changing the column in the same layer, can create duplicates of this layer and have a different column selected for each layer.

In the *Layers Panel*, right click on the layer name you want a copy of, select *Duplicate Layer*

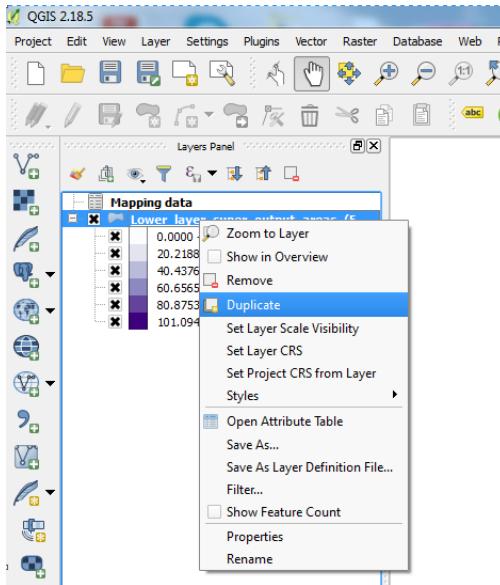


Figure 15.8: Create a duplicate layer

Now we have a duplicate layer, can select the new layer in the *Layer Styling Panel*, and choose a different column, and change the symbology should we require.

Click Apply.

15.6 Copy and paste style

Lets assume you've noticed an error in the symbology. Make a change to the symbology in the new layer you've just created (e.g. tidy up the legend text).

Tip: If you want to keep the colours already set, but need an additional class it is best to change the number of classes using the + & - buttons. If instead I chose to change the number of Classes, this would overwrite the current selection of colours and ranges using the inbuilt algorithms.

If you want to use this symbology for the other layer, can copy this symbology and paste it to the other layer:

1. Right click on the layer with the style you want: Styles → Copy style → Symbology
2. Right click on the layer with the style you want to change: Styles → Paste Style → Symbology
3. Re-select the column choice

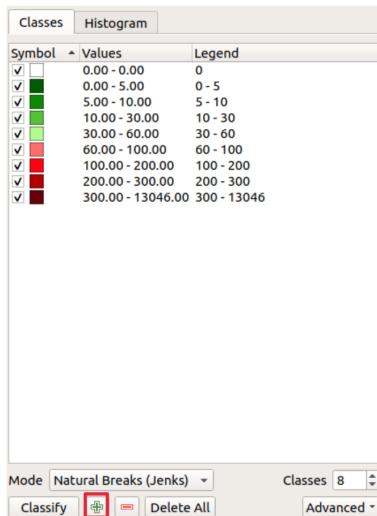


Figure 15.9: Add or remove a class without overwriting the current symbology

15.7 Save and Load Style

Once you have a style you like and will likely use in another project, then you can save this style as a file (.qml) and load it as a style in a new layer, and in a new QGIS project.

There are two mains ways to do this:

1. In the *Layers Panel*, Right click on layer name → Export → Save as QGIS Layer Style File

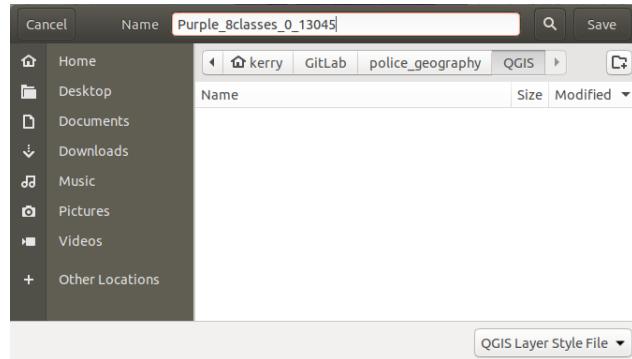


Figure 15.10: Save style from Layers panel

2. In the *Layer Properties* window → Symbology → Style (drop down) → Save style.

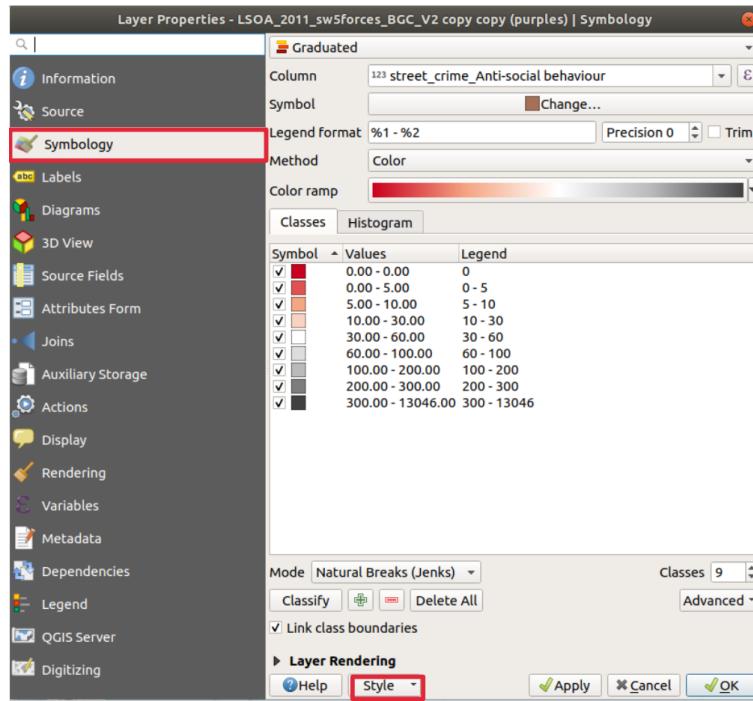


Figure 15.11: Save style from Layer Properties window

Load style can be done in the *Layers Styling Panel*.

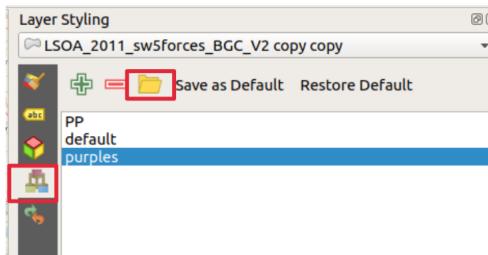


Figure 15.12: Load style within the Layers Styling panel

15.8 Rename layers

Now we have multiple layers with very similar names, eg with (copy) on the end. Give more useful names to each of these layers. In *Layers Panel* double click on layer name (to open properties window) → Source → Layer name.

Or right click on layer name in *Layers Panel* → Rename Layer.

Chapter 16

Export your map

To get the maps out of the software and into your report, apart from using Snipping tool/shutter, QGIS offers two options.

16.1 To save just the contents of the map canvas: Export

Project → Import/Export → Export map to pdf.

Project → Import/Export → Export map to image.

16.2 To save items in addition to the map canvas: Print layout

Compose a sheet with multiple items, such as the map, legend, titles, tables etc.

Project → New Print Layout.



Figure 16.1: Enter the title of your layout. This title will appear under Project → Layouts

Print layout has its own window, menu, tools and panels.

Once a layout has been created, can close the layout window and reopen it under Project → Layouts. The title you give the layout is what will appear in the Layouts list.

To change the orientation between Landscape & Portrait, right click on the page in the layout and select page properties. This will add the item properties tab on the RHS of the window

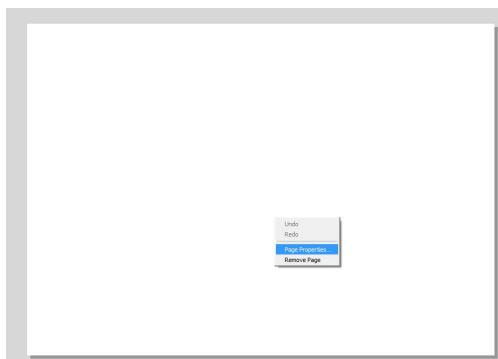


Figure 16.2: To change page orientation

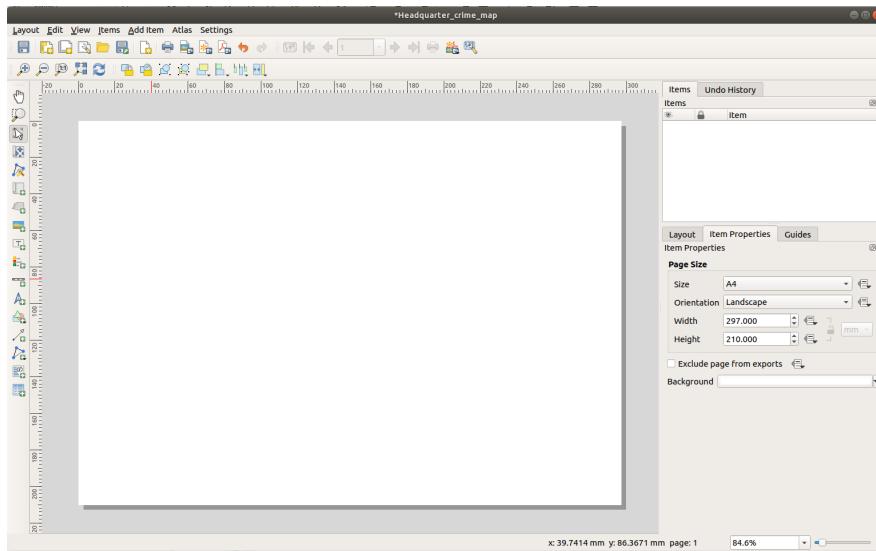


Figure 16.3: Layout window. Main tools on LHS toolbar

The main items that you will add to your layout are found in the LHS toolbar. Each item on the layout will be added to the list in the Items panel. To edit an item either select it on the layout, or highlight it from the items list.

-  Adds a new Map to the layout: will bring the map canvas from QGIS that you have just been working on.
-  Select/move item. So can grab an item on the layout and move it, resize it
-  Move item content. So can reposition the map content within the window. Its like panning about within the QGIS map canvas been doing previously
-  Refresh. If you have revisited the map in QGIS and made changes, may need to give the layout a nudge to update.
-  Add legend. As default all the layers are included in the legend. Customise which layers are included in the legend in the items panel on the RHS, untick Auto Update (under the Legend Items title). Use + & - buttons to have the items want. Edit the text in the print layout (double click) Size of the text does not scale automatically as resize the legend window. Instead edit each component size (text) and symbols (the colours).
-  Add a new label: give your map a title
-  Add attribute table. Choose the columns to include, the max number of rows to include, can filter the rows that can be included based on a column value
-  Add arrow
-  Add scale bars
- Item properties → Segments → Left 2
- Item properties → Segments → Right 4
-  Add image (choose image file from computer)

In the top toolbar find the useful undo and redo buttons  

Following the copyright and licencing rules if using OpenStreetMap <https://www.openstreetmap.org/copyright>, add a label to contain the information  **OpenStreetMap contributors**, licenced as **CC BY-SA**, and it is also good practice to acknowledge the software, **Created in QGIS**.

Export this map. Select: Layout → Export as image. Select location, file name and file type (PNG 7MB)

Chapter 17

L^AT_EX

This is completely unrelated to QGIS.

This document was created using L^AT_EX (using TeXstudio, a cross-platform open-source L^AT_EX editor). I found it easier to format my document than using word, and I believe that the overall appearance is more professional.

In case you were interested in giving L^AT_EX a go, I wanted to share with you the main resource I used to help me get started. It definitely made my first steps a lot easier.

<https://drive.google.com/drive/u/0/folders/0B4HppN1nEJ6KSTl5ekp1M2t4U00>

I did not watch the corresponding video, so I don't know how useful it is. But for completeness, it is here:

<https://www.youtube.com/watch?v=Qjp-a2uZWZc>

Chapter 18

Summary

Here are the main take away points for this QGIS tutorial.

1. Add data (layers) to your QGIS project.

For your own data from a csv file, add as a delimited file 

- (a) For point data: If your data contains Latitude & Longitude, or Easting & Northing, use these fields to plot your point data.
- (b) For polygon data: If your data contains a unique reference code for a spatial area, use a corresponding shapefile (do a google search to find the shapefile you need, and download it).

Add the shapefile to your QGIS project as a vector layer 

Join your csv data to the shapefile: double click on the layer name in the *Layers panel* → Select **Join** in the LHS pane.

Initiate a new join 

2. For each data layer, each feature on the map canvas (point or polygon) has a row of data in the attribute table .

3. Become familiar with your data layers (both within the map canvas and attribute table). Calculate any new fields in your attribute table that you want to visualise (or choose to do these within the relevant expression dialogs along the way).

4. Add symbology to your layers (their visual appearance) using the Layer Styling panel .

- (a) Single symbol (uniform appearance)
- (b) Categorized (for categorical fields)
- (c) Graduated (for continuous numerical fields)
- (d) Heatmap or Point cluster (for dense point data).

5. Include a basemap to give your data context

- (a) Use a shapefile and give it appropriate *single symbol* symbology (either use your own shapefile, or in the coordinate field type *world*)
- (b) Or in Browser Panel select *XYZ Tiles* → *OpenStreetMap*

6. Export your map.

- (a) Snipping/shutter
- (b) Menu: Project → Import/Export
- (c) Menu: Project → New Print Layout.