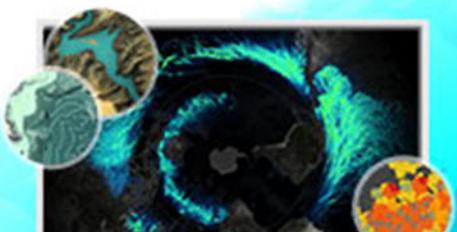


Exercise

Thematic Maps

Section 3 Exercise 2

05/2018



Thematic Maps

Instructions

Use this guide and ArcGIS Pro to reproduce the results of the exercise on your own.

Note: The version of ArcGIS Pro that you are using for this course may produce slightly different results from the screenshots that you see in the course materials.

Time to complete

Approximately 75-90 minutes.

Software requirements

ArcGIS Pro 2.1

Introduction

Special purpose maps, as opposed to general reference maps, are termed "thematic maps." These maps tend to display a single theme of information by indicating the spatial distribution of a single attribute or the relationship among many attributes. Thematic maps illustrate the structural characteristics of the geographical distribution of a dataset.

Thematic maps vary considerably, but examples include maps depicting precipitation, population distribution, hurricane incidence, and pollution. Thematic maps tend to be small scale (<https://bit.ly/2JCw8pC>) because the geographical distribution of a theme is often most appropriately shown and accurately depicted over a large area.

Thematic mapping requires the transfer of empirical measurements into graphical signs that can be mapped to illustrate the spatial variation in the difference between measured values. Essentially, aspatial, tabular data is converted into a spatial form that, by definition, adds further to the information by giving the map reader the distance, direction, shape, and location of the theme. In a thematic map, the transformation of data from tabular to map form adds spatial understanding.

In this exercise, you'll develop a range of alternative thematic maps that tell a story of the 2015 general election in the United Kingdom. To see various types of thematic maps, you should look at the ArcGIS Online thematic mapping gallery (<https://bit.ly/2GQhgC6>), which shows a range of different ways of mapping the 2016 U.S. presidential election and includes discussions of the map type and use.

For your reference, the project package includes a map view containing the final maps for this exercise. Your final maps may not match exactly. You are encouraged to experiment with the options available in ArcGIS Pro.

Step 1: Download the exercise file

In this step, you will download the exercise file.

- a Open a new web browser tab or window.
- b Go to <https://bit.ly/2qiq51q> and download the exercise file.
- c Save the file in a location that you will remember.

Step 2: Open an ArcGIS Pro project

- a From the main ArcGIS Pro start page, click Open Another Project, and browse to the **Sec3Ex2_ThematicMapping.ppkx** project package file that you saved on your computer.

When the project opens, you will see a map of electoral constituencies for the 2015 UK Election.



- b Save your project with a name such as **Sec3Ex2_ThematicMapping_<yourfirstandlastname>.aprxF** in the folder on your computer where you are saving your work.

This dataset is the same one that you used in Section 2 Exercise 2 - *Exploring Data Classification*, so **you should be familiar** with its general contents. From that exercise, you'll also use data classification concepts to process some of this data for mapping.

A single layer in the Contents pane shows the electoral constituencies of Great Britain and Northern Ireland. Additionally, a version of the data represents the election results as points, each in the center of the constituency. Whether you use the area or point version of the data depends on the map type, which is addressed later in this exercise.

Step 3: Explore the election data

If you completed the data classification exercise in Section 2, you are already familiar with the UK election data. This exercise uses the same dataset.

- a Right-click the **Constituencies** layer and choose Attribute Table to review the fields and their contents to refamiliarize yourself with the data.

OBJECTID	Shape	ID	Constituency	Headline	Winning_MP	First	First_Votes	First_Share	Second	Party
1	Polygon	W07000049	Aberavon	Labour hold with a 3...	Stephen Kinnock	LAB	15416	48.9	UKIP	
2	Polygon	W07000058	Aberconwy	Conservative hold wi...	Guto Bebb	CON	12513	41.5	LAB	
3	Polygon	S14000001	Aberdeen North	Scottish National Par...	Kirsty Blackman	SNP	24793	56.4	LAB	
4	Polygon	S14000003	Airdrie & Shotts	Scottish National Par...	Neil Gray	SNP	23887	53.9	LAB	
5	Polygon	E14000530	Aldershot	Conservative hold wi...	Gerald Howarth	CON	23369	50.6	LAB	
6	Polygon	E14000531	Aldridge-Brownhills	Conservative hold wi...	Wendy Morton	CON	20558	52	LAB	
7	Polygon	E14000532	Altrincham & Sale W...	Conservative hold wi...	Graham Brady	CON	26771	53	LAB	
8	Polygon	W07000043	Alyn & Deeside	Labour hold with a 8...	Mark Tami	LAB	16540	40	CON	
9	Polygon	E14000533	Amber Valley	Conservative hold wi...	Nigel Mills	CON	20106	44	LAB	
10	Polygon	S14000004	Angus	Scottish National Par...	Mike Weir	SNP	24130	54.2	CON	
11	Polygon	W07000057	Arfon	Plaid Cymru hold wi...	Hywel Williams	PC	11790	43.9	LAB	
12	Polygon	E14000534	Arundel & South Do...	Conservative hold wi...	Nick Herbert	CON	34331	60.8	UKIP	
13	Polygon	E14000535	Ashfield	Labour hold with a 1...	Gloria De Piero	LAB	19448	41	CON	

The layer attribute table contains a number of fields, which are described below:

Field name	Description
ID	Alphanumeric code used to identify individual constituencies.
Constituency	The name of the constituency.
Headline	The result of the election showing which political party won and by how much.
Winning_MP	The name of the winning member of Parliament who represents the winning political party.
First	Abbreviated name of the winning political party in that constituency.
First_Votes	The number of votes for the winning political party in that constituency.
First_Share	The overall share of votes for the winning political party in that constituency (largest share wins).
Second	Abbreviated name of the political party that came second in that constituency.
Second_Votes	The number of votes for the political party that came second in that constituency.
Second_Share	The overall share of votes for the party that came second in that constituency.
Third	Abbreviated name of the political party that came third in that constituency.
Third_Votes	The number of votes for the political party that came third in that constituency.
Third_Share	The overall share of votes for the party that came third in that constituency.
Other_Votes	The number of votes for all other political parties combined in that constituency.
Other_Share	The overall share of votes for all other political parties combined in that constituency.
Turnout	The number of people who actually voted in the constituency.
Electorate	The total number of eligible voters in the constituency.
First_code	A numeric code that can be used to reference the winning political party.

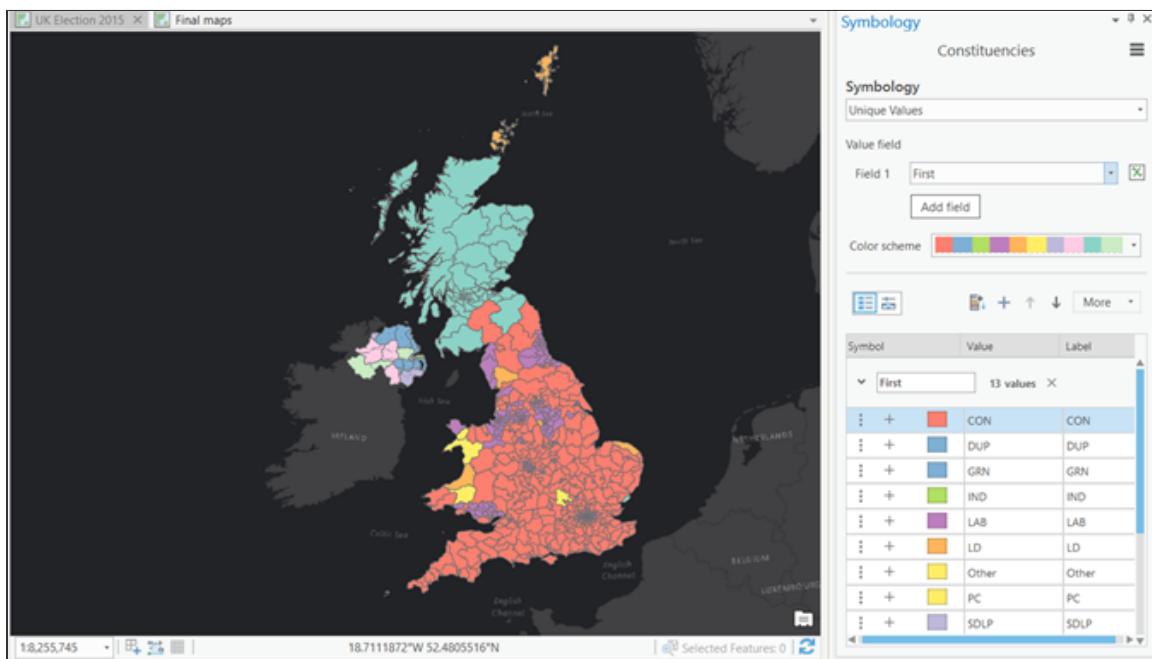
- b When you are finished exploring the data, close the attribute table.

First, you will make a simple thematic map showing the winning political party in each constituency.

Step 4: Create a unique values map

The purpose of a unique values thematic map is to show how areas differ in type.

- a In the Contents pane, turn off the Constituency Points layer.
- b Right-click the Constituencies layer and choose Symbology to open the Symbology pane.
- c From the Symbology drop-down list, choose Unique Values.
- d For Field 1, choose First.

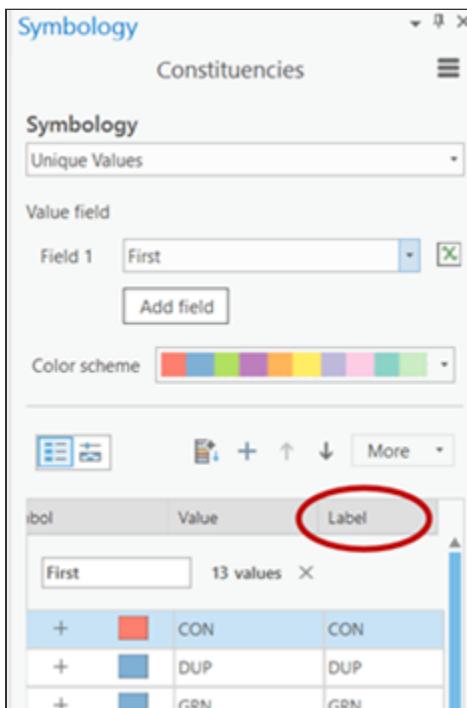


This data is a text field that identifies the abbreviation of the political party that won that constituency. The result is a basic, descriptive map of the result of the election.

Default colors and labels rarely make an elegant map (as you can hopefully see!). First you will update the labels to make them more meaningful.

Note: You can dock the Symbology pane next to your map by right-clicking the pane title and choosing Dock. To auto hide the Symbology pane, click the pin at the top of the pane.

- e At the bottom of the Symbology pane, scroll to the right, if necessary, to view the Label column in the grid. Alternatively, you can make the Symbology pane larger by dragging its border.



- f Under the Label column, double-click each label and change it to the appropriate political party label, as shown in the following table.

Value	Label
CON	Conservative
DUP	Democratic Unionist Party
GRN	Green
IND	Independent
LAB	Labour
LD	Liberal Democrats
Other	Other
PC	Plaid Cymru
SDLP	Social Democratic and Labour Party
SF	Sinn Fein
SNP	Scottish National Party
UKIP	UK Independence Party
UUP	Ulster Unionist Party

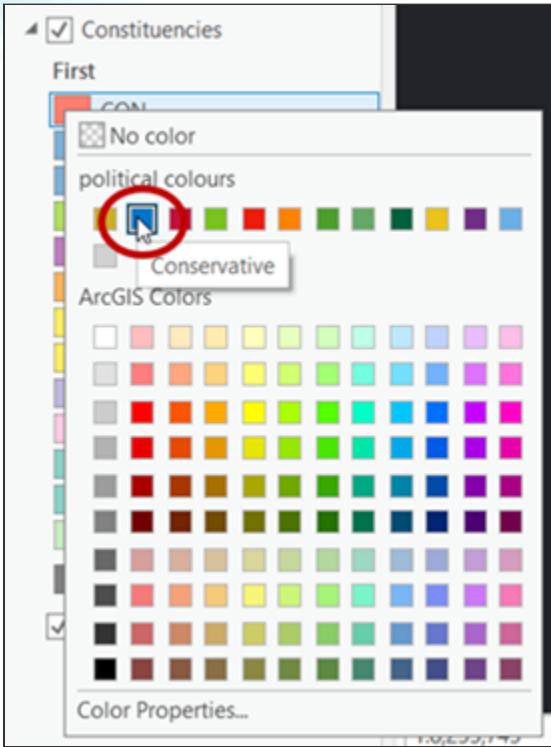
The party names are now updated in the Contents pane. Remember, it's vital that your map reader can interpret the map, and the way data is stored is often not in an immediately recognizable form.

It is useful to make use of sensible symbology to reinforce the map's message. For instance, for this dataset, the default uses randomly selected colors, yet political parties have their own color schemes. This project comes preconfigured with a style file of colors that are ready to use, but you can always use a color picker to change them to what you prefer.

Next, you will change the colors for each of the political parties to match their party color from the Political Colours style file.

- g In the Contents pane (not the Symbology pane!), right-click the color chip for Conservative, which opens the color picker.
- h In the color picker, in the Political Colours group, click the blue Conservative color.

Hint: Hover the pointer over a color chip to see its name.



- i Repeat this process to assign party colors based on party name.

When you are finished, the symbols for the parties should look like the following graphic:

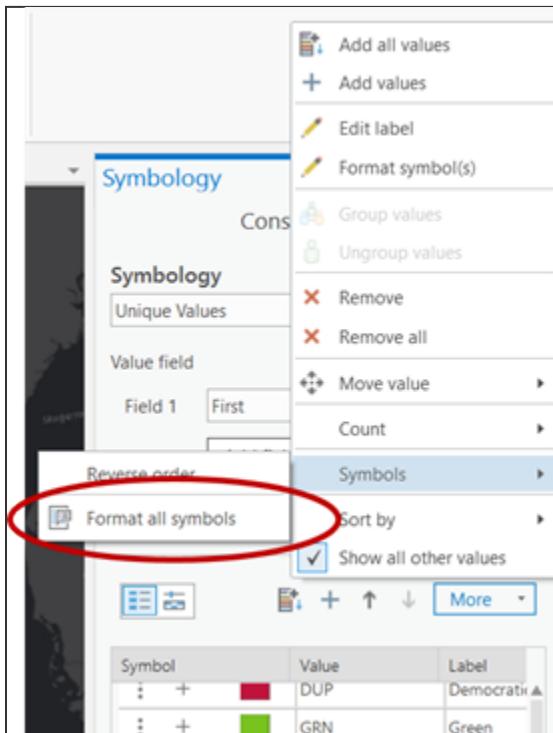


- j In the Symbology pane, click More, and uncheck the box next to Show All Other Values.

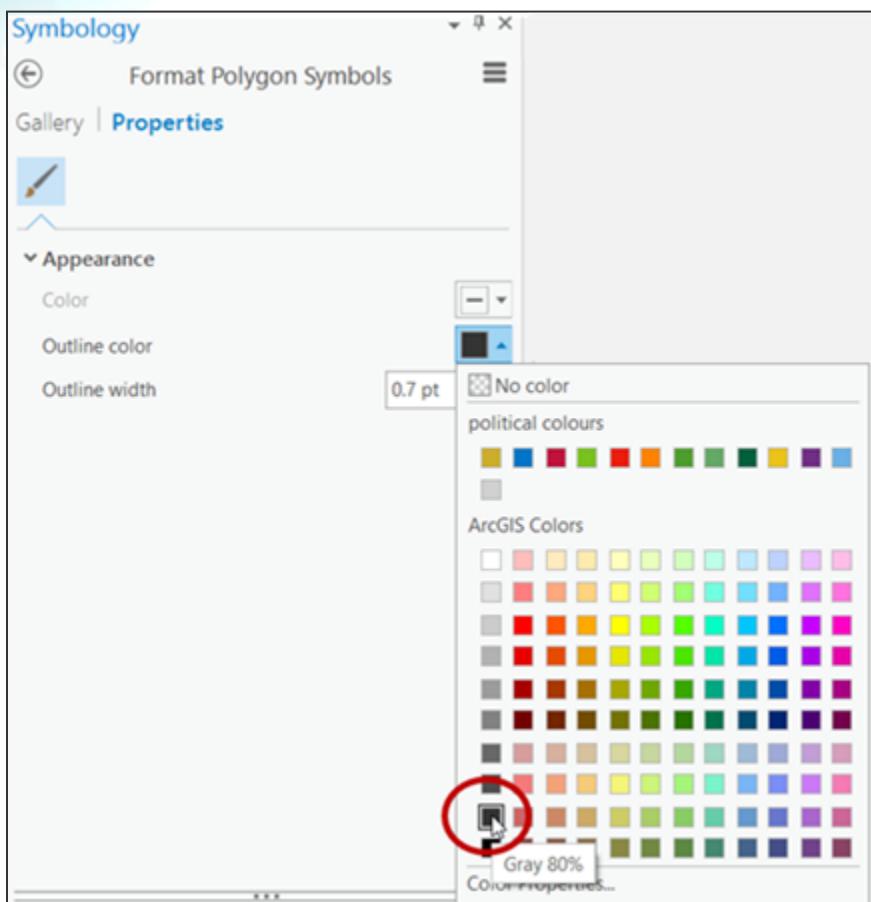
You will also change the color of the outline of each symbol so it better matches the basemap. It's always worth remembering that changing the outline of your area symbols is

often as important as the fill color itself. Sometimes, you may even make the outline transparent or with a width of 0pt to make it disappear, which can give a very nice effect and avoid a lot of lines getting in the way.

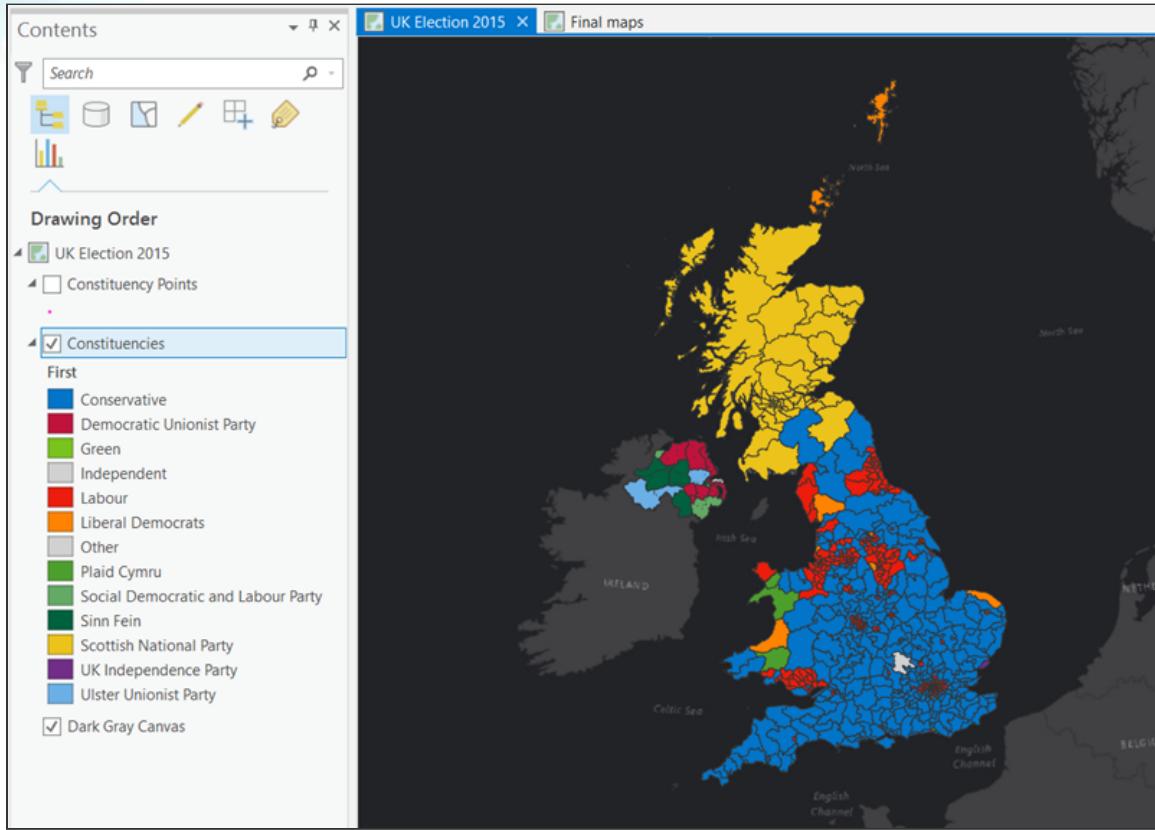
- (k) In the Symbology pane, click More, point to Symbols, and choose Format All Symbols.



- (l) In the Format Polygon Symbols pane, from the Properties tab, change the outline color to Gray 80% to better match the dark gray basemap, and then click Apply.



- m Close the Symbology pane to view the unique values map.



Final unique values political color map.

- ➊ Zoom and pan the map to explore how this thematic map effectively shows the winning political party in each area using a unique value (winning party) symbolized by the political party color. Much better than the default, right?
- ➋ When you are finished exploring, save your work.

Step 5: Create a choropleth map

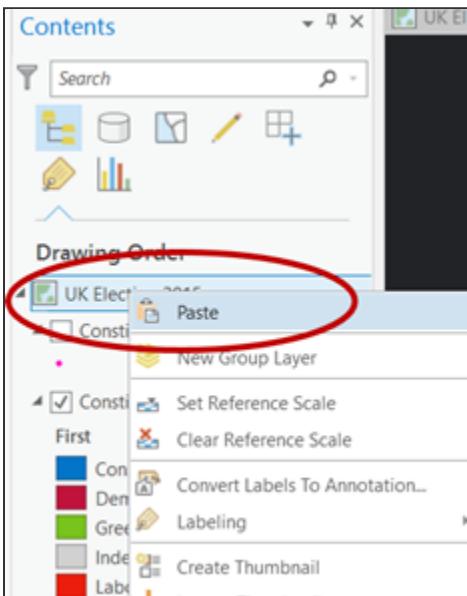
Unique value maps show us one aspect of the political data that you're mapping, but there is so much more that you can explore and map using alternative techniques.

You will now make a simple graduated colors (choropleth map) to show the share of votes that the winning member of Parliament (MP) received. This data is in the First_Share field in the Constituencies layer attribute table.

OBJECTID	Shape	ID	Constituency	Headline	Winning_MP	First	First_Votes	First_Share	Second
1	Polygon W07000049	Aberavon	Labour hold with a 3...	Stephen Kinnock	LAB	15416	48.9	UKIP	
2	Polygon W07000058	Aberconwy	Conservative hold wi...	Guto Bebb	CON	12513	41.5	LAB	
3	Polygon S14000001	Aberdeen North	Scottish National Par...	Kirsty Blackman	SNP	24793	56.4	LAB	
4	Polygon S14000003	Airdrie & Shotts	Scottish National Par...	Neil Gray	SNP	23887	53.9	LAB	
5	Polygon E14000530	Aldershot	Conservative hold wi...	Gerald Howarth	CON	23369	50.6	LAB	
6	Polygon E14000531	Aldridge-Brownhills	Conservative hold wi...	Wendy Morton	CON	20558	52	LAB	
7	Polygon E14000532	Altrincham & Sale W...	Conservative hold wi...	Graham Brady	CON	26771	53	LAB	
8	Polygon W07000043	Alyn & Deeside	Labour hold with a 8...	Mark Tami	LAB	16540	40	CON	
9	Polygon E14000533	Amber Valley	Conservative hold wi...	Nigel Mills	CON	20106	44	LAB	
10	Polygon S14000004	Angus	Scottish National Par...	Mike Weir	SNP	24130	54.2	CON	
11	Polygon W07000057	Arfon	Liberal Democrat hold with...	Ullswater McGuinness	nc	14760	42.0	LAB	

You will use a copy of the Constituencies layer.

- In the Contents pane, make a copy of the Constituencies layer.
- Right-click the UK Election 2015 map item and choose Paste.



The Contents pane now shows two layers named Constituencies.

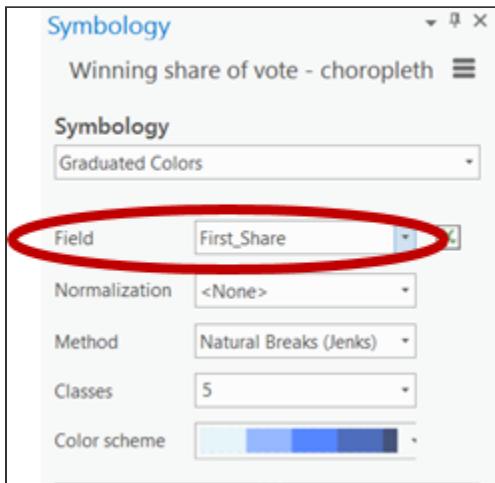
- Rename the layer that you just created to **Winning share of vote - choropleth**.
- Turn off the Constituencies layer.

You will now work on the copy.

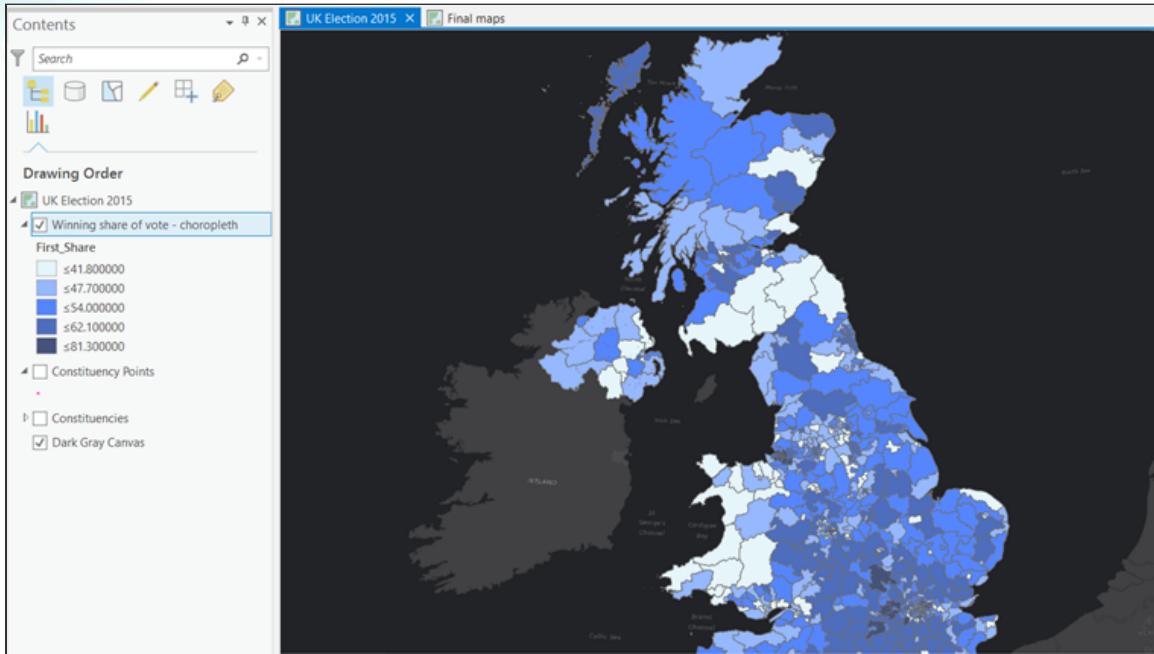
- Open the Symbology pane for the Winning Share Of Vote - Choropleth layer, and update the symbology to Graduated Colors.

Graduated colors are used to symbolize the layer by quantities. In Section 2 Exercise 2 - *Exploring Data Classification*, choropleth maps were used to explore the principles of data classification. In this case, the quantity is the percentage or share of votes that the winner received.

- f For Field, choose First_Share.



Do you recall from Section 2 Exercise 2 - *Exploring Data Classification* that you cannot use a choropleth map to map totals? You are fine here, however, since you are mapping data that has already been normalized by converting the raw totals to percentages.



The final choropleth map based on the *First_Share* percentage. Note that your final map may be different if you applied different options.

If you didn't adjust the number of classes or classification technique, now you have a default choropleth map showing the share of the vote received by the winning MP classified into five classes using the natural breaks method. Lower values are shown in lighter colors (a lighter hue), and higher values are shown in a darker color (a darker hue).

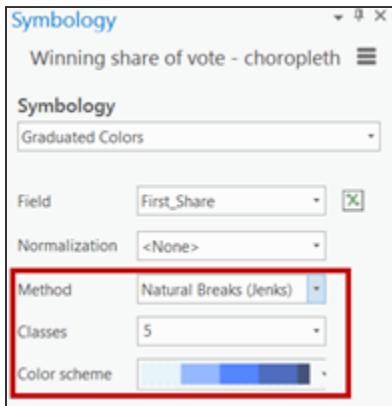
Challenge: Experiment with data classification and colors

In this optional challenge, create a map that shows enough variation to effectively represent the results. With too few classes, the map will be too general. With too many classes, the map will be too complicated. A good guide is four, five, or six classes.

Hint: Refer to Section 2 Exercise 2 - *Exploring Data Classification* for a reminder of the data classification options. You can also refer to ArcGIS Pro Help for more information about [data classification options](https://bit.ly/2qnFLzI) (<https://bit.ly/2qnFLzI>).

You can use your default choropleth map (make a copy of the Winning Share Of Vote - Choropleth layer and name the new layer something such as **Choropleth - challenge**) to experiment with the following:

- Different classification types, which are available in the Symbology pane from the Method drop-down list.
- Number of classes (available from the Classes drop-down list).
- Color Schemes (use the drop-down list in the Symbology pane).



For a choropleth map, the best way to represent data that varies from high to low is to use a color scheme that visually reflects that. A single-hue color scheme works well. A spectral color scheme doesn't work well because there's no intuitive way to determine whether one hue is "higher" or "lower" than the other. This is referred to as the classic "rainbow color problem".

- Set the border (outline) color.

Hint: You previously changed the outline color of the constituencies in Step 5 of this exercise.

You could also remove the border.

- In the Symbology pane, in the Label section, change the way that the labels appear to remove the trailing zeros and clean up the legend.

You could change the style so that you have an upper and lower label such as 0-40%, 41-50%, and so on. Avoid overlapping classes (where you use the same label at the higher end of one class and the lower end of the next class).

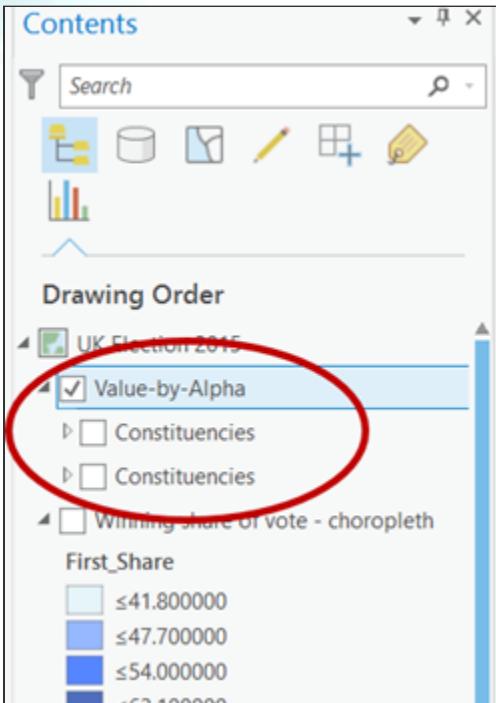
Step 6: Create a value-by-alpha map

This type of thematic map mutes the less important areas, making them fade into the background and bringing focus to the key areas. A value-by-alpha map is a type of area-based thematic map, such as a unique values or a choropleth map. A value-by-alpha map has two layers. The layer below is the standard unique values map or choropleth map. The layer above has area shading that varies from transparent to opaque to encode a secondary variable.

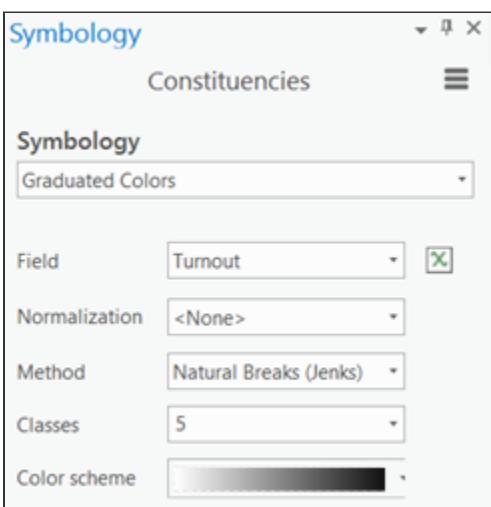
For a political map like the one you're working with, areas are somewhat arbitrary and show the simple metric of who won. But you can create nuance by adding information, such as the proportion of voters in the area or the turnout.

In ArcGIS Pro, a group layer contains multiple individual layers and can help you organize related kinds of layers. Because there will be two layers in the value-by-alpha map, you will use a group layer.

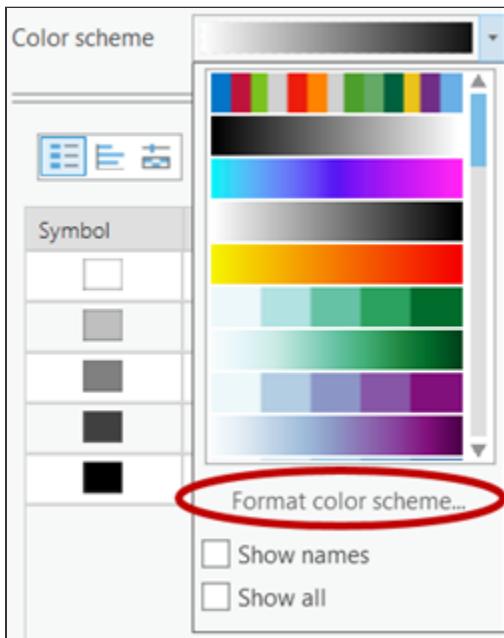
- a In the Contents pane, make sure that the Constituencies layer is still turned off, and also turn off the Winning Share of Vote - Choropleth layer. If you completed the challenge at the end of Step 5, also turn off that layer.
- b Right-click the UK Election 2015 map item and choose New Group Layer.
- c Rename the group layer **Value-by-Alpha**.
- d Make a copy of the unique values map (Constituencies layer) that you made in Step 5.
- e In the Value-by-Alpha group layer, paste two copies.



- f Turn on the upper layer.
- g Right-click the upper layer and choose Symbology to open the Symbology pane.
- h Change the symbolization to Graduated Colors, and update the Field to Turnout.
- i Choose a White to Black gradient color scheme.

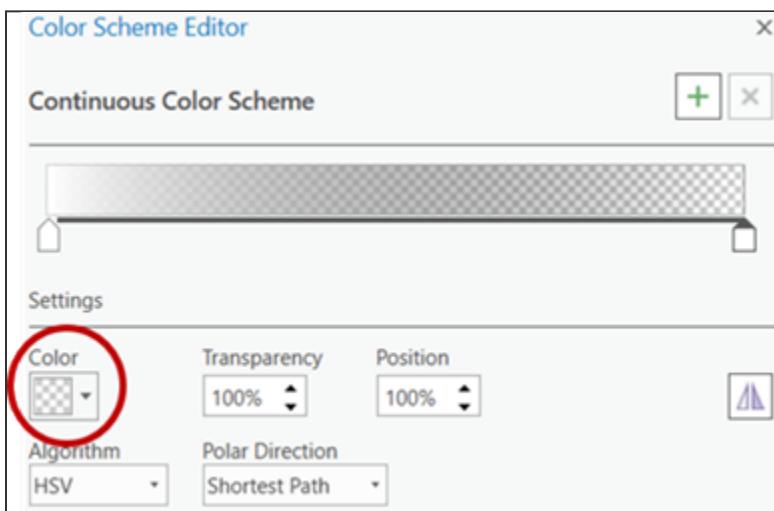


- j In the Symbology pane for the top layer in your Value-by-Alpha group layer, once you've selected a black-white color scheme, click the down arrow next to Color Scheme and select Format Color Scheme.



- k In the Color Scheme Editor, change the black color chip to be 100% transparent.

Hint: Click Color and in the color picker, choose No Color.



- l Click OK to update the color scheme.

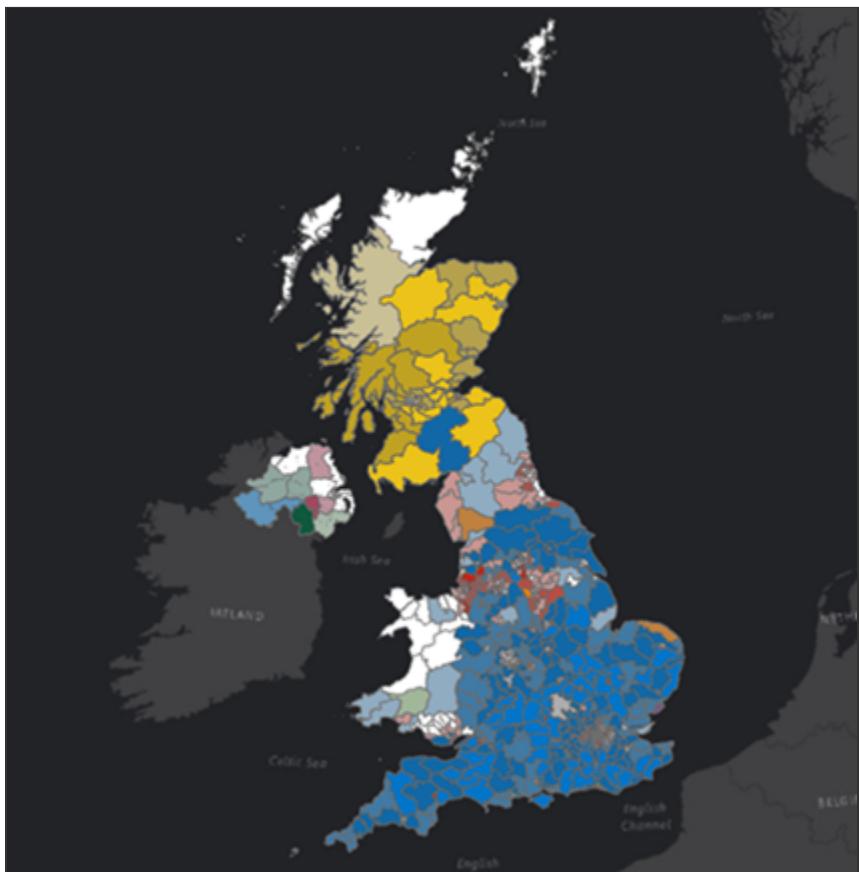
The idea is to make high values (high turnout) completely transparent and low values (low turnout) more opaque.

Now you've built the value-by-alpha overlay.

- m If it's not already turned on, turn on the second, lower Constituencies layer in the Value-by-Alpha group layer, and then save your work.

For a well-balanced result, you can use the various controls in the Symbology pane to adjust how the white-transparent color ramp stretches across the data values.

The map brings into focus constituencies that had higher turnouts. The top layer in the group effectively mutes areas where there were lower turnouts. This is a useful technique to show how two related pieces of data interact with one another.



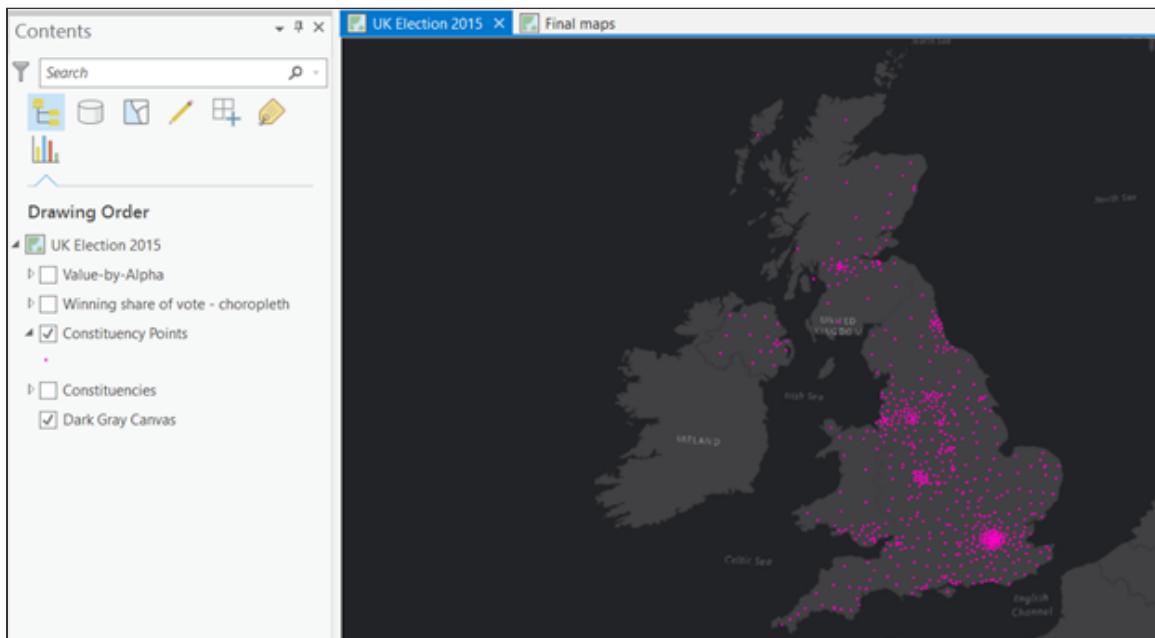
The final value-by-alpha map based on Turnout.

Step 7: Create a graduated-symbol map

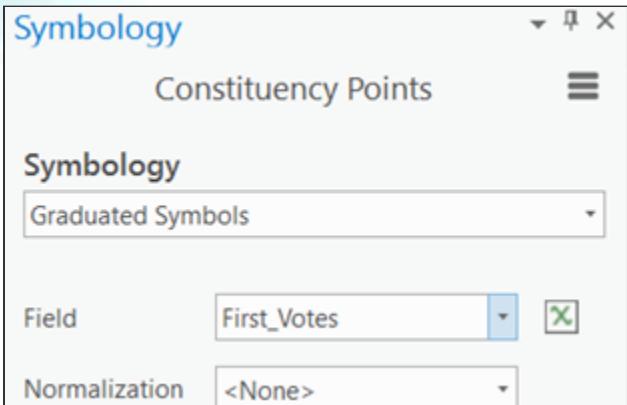
Graduated-symbol maps allow you to use totals directly on the map without first converting data into ratios or percentages. Instead of using colors or shades of color that you process and see as "more or less" across the map, a graduated-symbol map uses size of symbol to communicate the relative difference between quantities. Larger symbols mean more; smaller mean less.

For this step, you'll use the point-based data because you're going to change a single symbol in size that represents the area for which the data has been collected.

- a In the Contents pane, turn off all layers except the Constituency Points layer and the Dark Gray Canvas basemap layer.

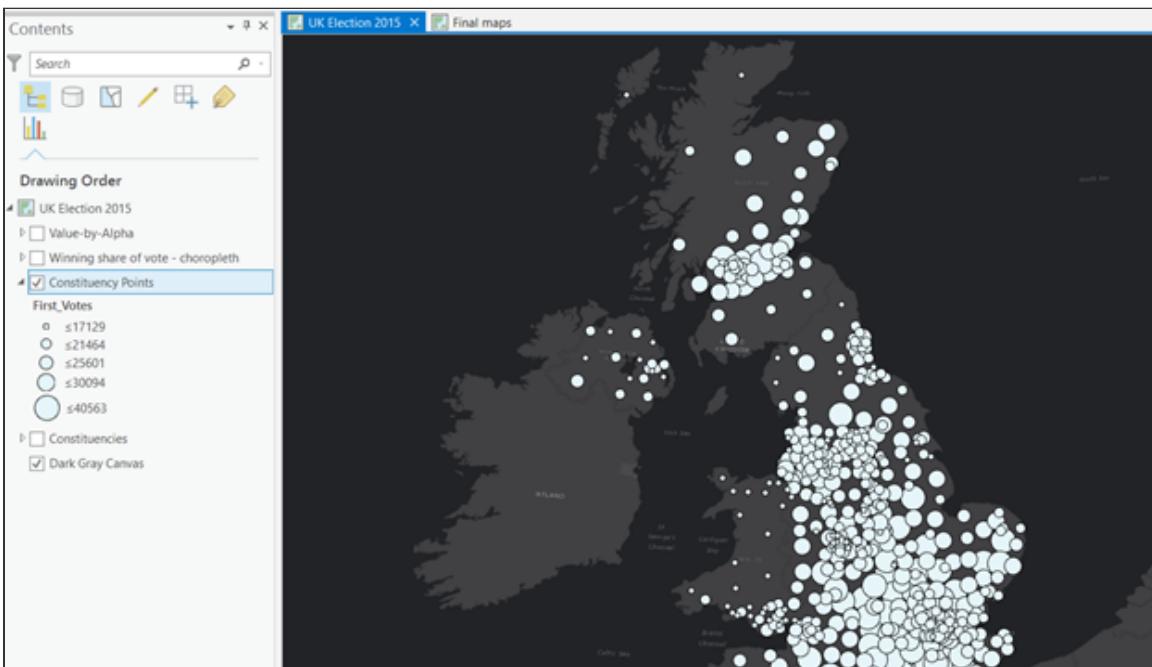


- b Open the Symbology pane for the Constituency Points data and choose Graduated Symbols as the Symbology type.
- c Use First_Votes as the field to symbolize.



The default classification is Natural Breaks using five classes. Every data value falls into one of these symbol classes.

- d) Using the Symbology pane, experiment with changing the color fill, outline, and sizes of the symbols.



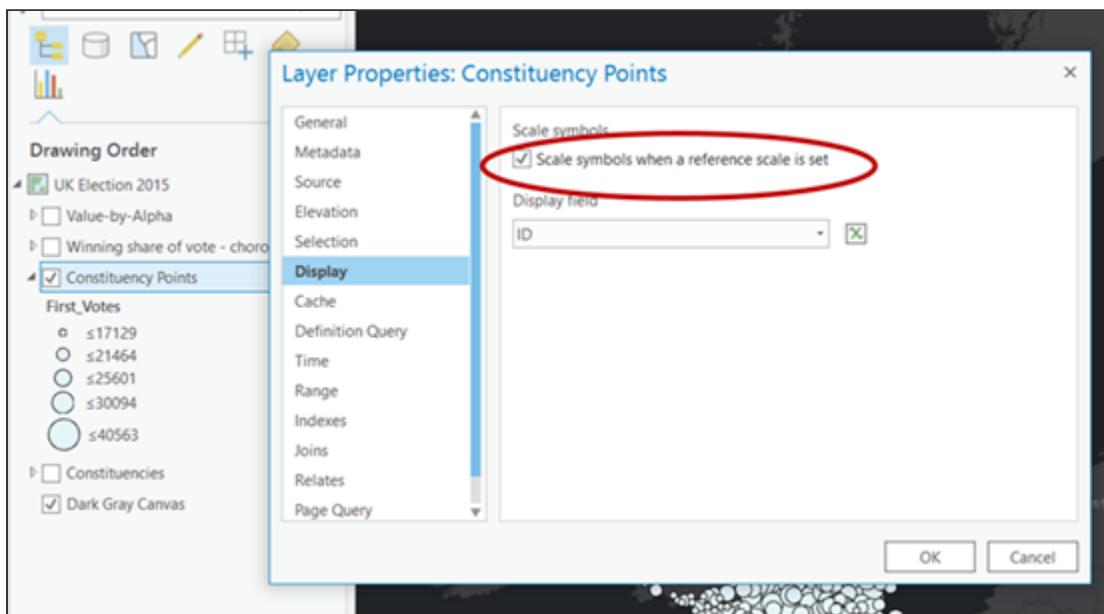
One of the challenges with any symbol-based map is congestion in parts of the map. Balancing the symbol size with the appearance of the overall map is a good goal to keep in mind. Transparent symbols with a solid outline can sometimes work, so include those in your experimentation.

Also, notice how, as you zoom in and out of the map, the symbols remain the same size at which you designed them. This means that as you zoom in to a larger map scale, your

overlapping symbols tend to become separated from one another. This is an extremely useful feature of a multiscale mapping environment and counteracts the problems of seeing overcrowded symbols at smaller scales.

If you prefer that your symbols stay at their relative size as you zoom in and out, you can achieve this by setting a reference scale (<https://bit.ly/2GLmeUC>).

- e In the Contents pane, right-click the UK Election 2015 map item and select Set Reference Scale.
- f Right-click the Constituency Points (graduated symbols) layer and choose Properties.
- g From the Display tab, ensure that the Scale Symbols When A Reference Scale Is Set option is selected.



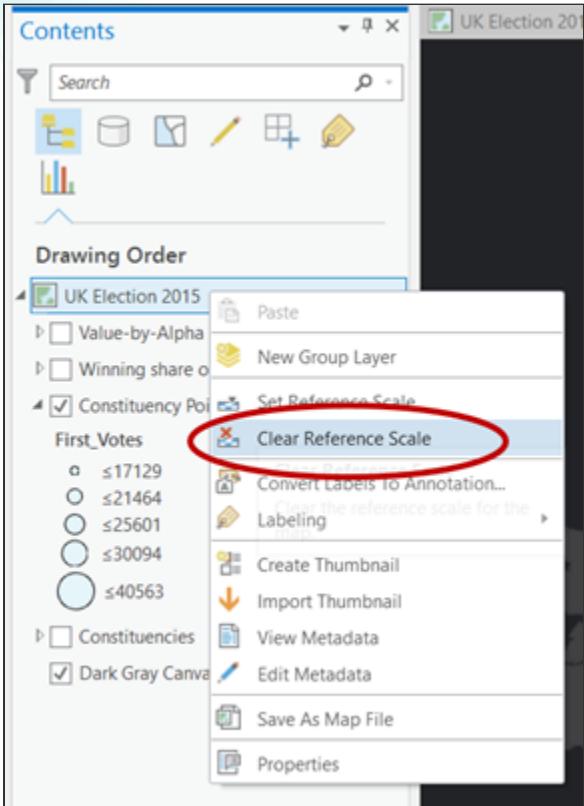
- h Click OK and zoom and pan the map to see the result of changing the reference scale settings.

Effectively, this freezes the symbol sizes at the scale at which the reference scale was set. As you zoom in and out, they become larger and smaller while maintaining their relative size to the map and each other symbol.



A zoomed in view of the final graduated symbol map.

- i Clear the reference scale by right-clicking the UK Election 2015 map item and choosing Clear Reference Scale.



Clearing the reference scale will take you back to the default for the next step in this exercise.

- j Save your work.

Step 8: Create a proportional-symbol map

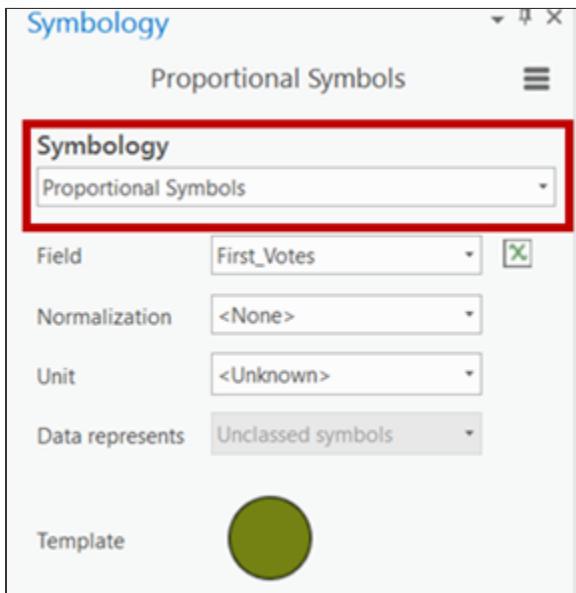
Another type of thematic map, the proportional-symbol map, can show how features differ in quantity for the theme being mapped. It's a variation on the graduated-symbol map, but scales all symbols independently of any classification method.

- a In the Contents pane, make a copy of the Constituency Points layer.
- b Right-click the UK Election 2015 map item and choose Paste.
- c Turn off the original Constituency Points layer.
- d Rename the new Constituency Points layer to **Proportional Symbols**.

Now you will change the symbology type.

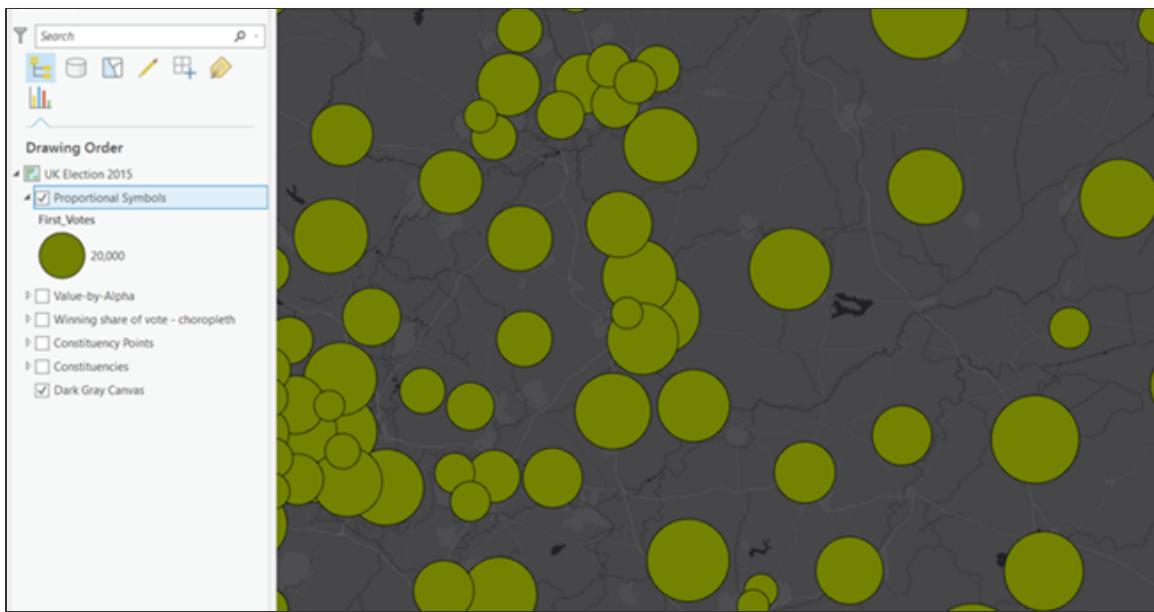
- e Open the Symbology pane for the Proportional Symbols layer.

- f Update the Symbology to Proportional Symbols.



- g Zoom in to more clearly see the proportional symbols.

Note: Refer to ArcGIS Pro help to learn more about varying symbology by size and graduated symbols and proportional symbols (<https://bit.ly/2JwLVGd>).



A zoomed in view of the proportional symbols map.

- h Use the First_Votes field as the field to symbolize again, or experiment with other fields.

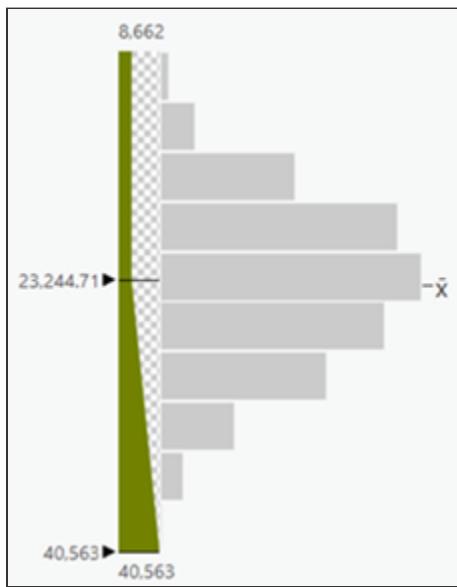
In this map, the data value is scaled to the symbol size, so each symbol on the map is a proportional representation of the data. Every value of data is represented uniquely, so this map type shows much more variation in symbol sizes than a graduated-symbol map.

- i Experiment with the scaling settings and symbol design to achieve a nice visual balance.

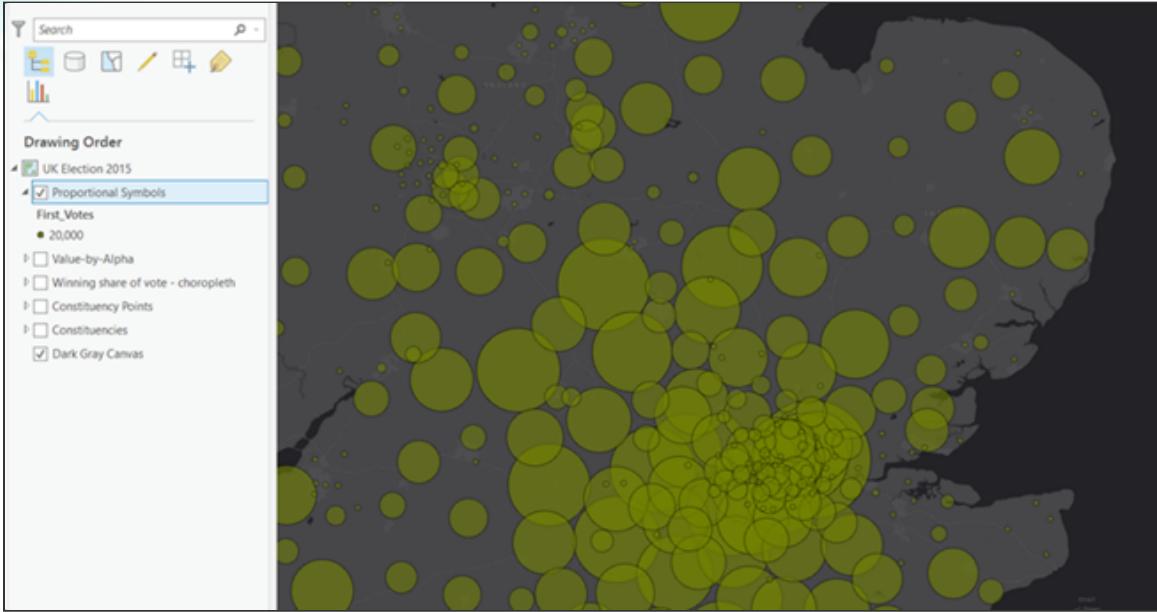
You are trying to achieve a balance where there is enough variation in size across the map to show highs and lows in the data, *but* without symbols becoming either too large and dominating or too small and difficult to see. This isn't a perfect science, and experimentation is important to go back and forth until you feel like you've captured the optimum settings for the dataset at hand. Importantly, ask yourself what you want the map to tell the reader. That should help you consider whether your scaling settings and symbol design have met that goal.

One final aspect to scaling settings to consider is whether you need all your symbols to be scaled uniquely. In the histogram view of the Symbology pane for this layer, you can move the sliders to change the way scaling is applied.

- j Move the top slider (lowest-level data value) down, as shown in the following graphic.



Updating this will lead to all data values below the threshold that you set being shown at the same size. This can be useful to highlight variation at one end of the data array, or conversely, if you have outliers (<https://bit.ly/2qW89ca>) or many data values of an extremely small or large size, you can cluster them together and show them (and them only) with a symbol of the same size.



A zoomed in view of the final proportional symbols thematic map based on the *First_Votes* field values.

Now you will modify the symbol color to make each of your symbols in a single layer represent more than one data item using attribute-driven symbology. Taking the proportional-symbol map that you just made, let's make it multivariate.

Step 9: Create a multivariate proportional symbol map

The proportional symbol map showed the number of votes that the winner in each constituency polled. However, the color is the same for every symbol. The map might tell a more interesting story if the symbols were also colored like the unique values map to additionally show the winning party by their political color. For this, you will use attribute-driven symbology.

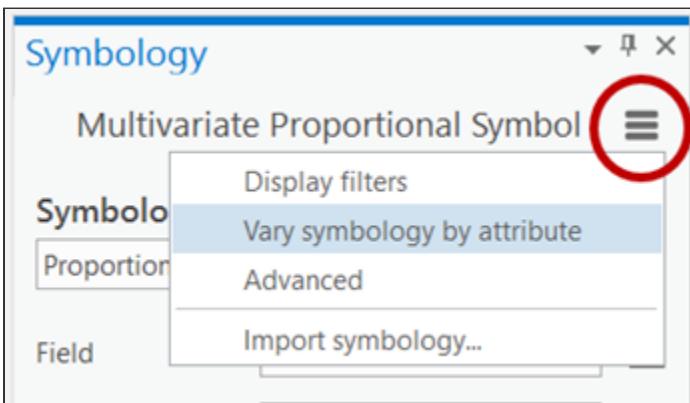
Note: For more information about [attribute-driven symbology](https://bit.ly/2Hk2JTo) (<https://bit.ly/2Hk2JTo>), refer to ArcGIS Pro help.

Because attribute-driven symbology works on numeric fields in the attribute table, you will use a column called *First_code* rather than *First*.

The *First_code* column references the political parties as shown in the following graphic:

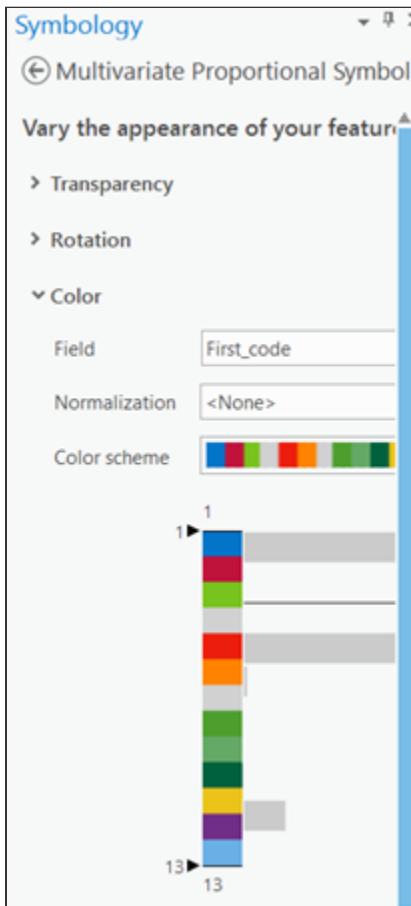
Symbol	Value	Label	First_code
■ Blue	CON	Conservative	1
■ Red	DUP	Democratic Unionist Party	2
■ Green	GRN	Green	3
■ Grey	IND	Independent	4
■ Red	LAB	Labour	5
■ Orange	LD	Liberal Democrats	6
■ Grey	Other	Other	7
■ Green	PC	Plaid Cymru	8
■ Green	SDLP	Social Democratic and Labour Party	9
■ Dark Green	SF	Sinn Fein	10
■ Yellow	SNP	Scottish National Party	11
■ Purple	UKIP	UK Independence Party	12
■ Light Blue	UUP	Ulster Unionist Party	13

- a In the Contents pane, make a copy of your Proportional Symbols layer.
- b Paste the copy and rename it **Multivariate Proportional Symbol**.
- c Turn off the original Proportional Symbols layer.
- d At the top of the Symbology pane for the Multivariate Proportional Symbol layer, click the Menu button and choose Vary Symbology By Attribute.

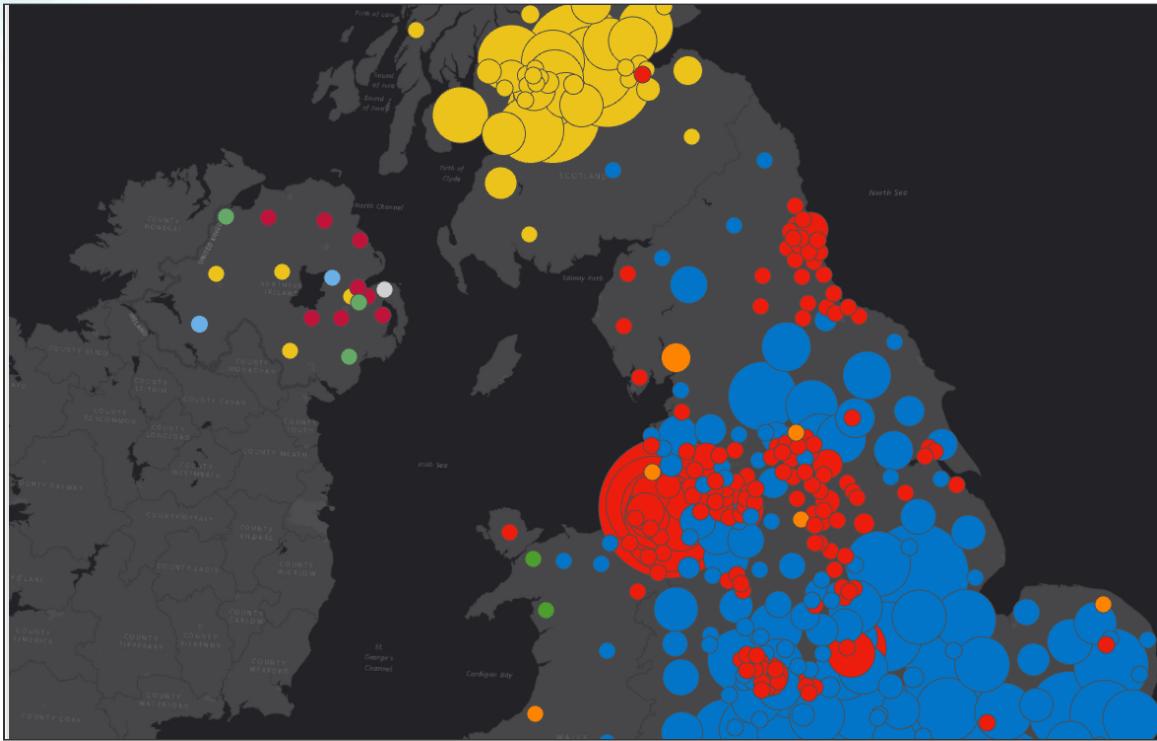


- e Expand the Color section.

- f For Field, select First_code, and use the preloaded UK Political Parties discrete color scheme. This is a discrete color scheme that simply matches color stops to the codes used for each political party.



Now you have a proportional symbol map with size related to total number of votes for the winning party and color representing the party itself.



A zoomed in view of the final multivariate proportional symbol thematic map based on the First Code field values.

- g Zoom and pan the map to explore the proportional symbols. The addition of more sensible colors really helps to communicate the patterns more meaningfully.
- h When you are finished exploring, save your work.

Step 10: Create a dot-density map

One drawback of the choropleth map is the way in which the different-sized areas take on different visual prominence. In short, large areas are seen as more important than smaller ones. The oddity of geography is that most people tend to live in dense urban areas represented by small administrative units. Sparse populations live in much larger units, so the problem of understanding the real situation is confounded by geography itself.

Look back at the unique values or choropleth maps that you made in previous steps. You can easily see the large expanse of yellow in Scotland, which is relatively sparsely populated. Now zoom in to the London area (that's a test for those not familiar with where London is in the UK!) and see all those much smaller constituencies. The value-by-alpha technique helped mute sparsely populated constituencies in Scotland a bit, but when viewed at small scale (zoomed out), those smaller constituencies in London are still hard to see by comparison. And you've seen how using differently sized symbols (graduated or proportional symbols rather

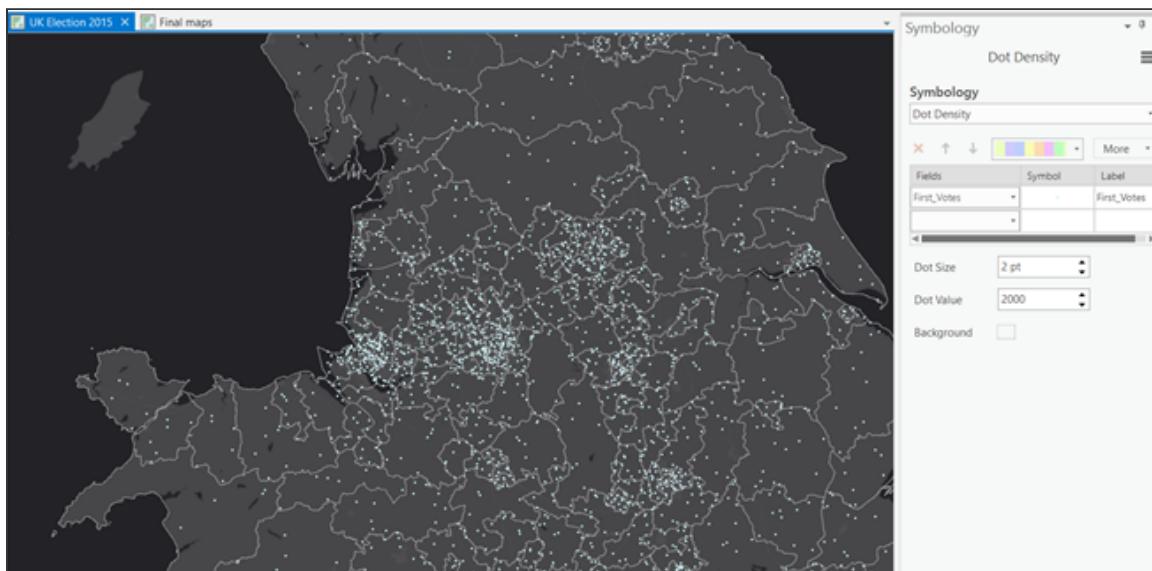
than choropleth fills) helps overcome some of those drawbacks — though large symbol overlaps can also compromise the map.

Another alternative thematic mapping technique is dot density, which uses small dots to represent some value of the data to create a patterned fill. Multiple dots are used to reflect the total value.

- a In the Contents pane, make a copy of the Winning Share Of Vote - Choropleth map that you made earlier, paste it, and rename it **Dot Density**.
 - b Turn off all layers except the Dot Density layer and the Dark Gray Canvas basemap layer.
 - c In the Contents pane, ensure that Dot Density is selected.
 - d In the Symbology pane, update the Symbology to Dot Density.
- The map is still using the values from the First_Votes field, which is the number of votes gained by the winning party.
- e Set the Dot Size to 2 pt and the Dot Value to 2000.

A single dot is positioned randomly, in every area, for every 2,000 votes for the winning party. You can begin to see the distribution of the voting population now with dense and sparse areas being made visible simply through the mapping technique. The visually dominant colors of the larger geographical areas in the choropleths are, to some extent, overcome with this technique.

Challenge: Change the symbol to a point that does not have an outline.



- f Experiment with changing the dot value to 1000 (people).
- g Try some other values for both the dot size and dot value.

A good dot-density map has a balance between a dot size that is visible and a dot value that creates a map where the dense areas have coalescing dots but which are not simply a large splotch!

You will also remove the background line from the area because it gets in the way of this sort of map.

- h In the Symbology pane, click the Background symbol.
- i From the Properties tab, set the Outline Color to No Color, make the Outline Width 0 pt, and click Apply.

This update improves the overall appearance. Without the administrative borders, the map takes on a smoother appearance.

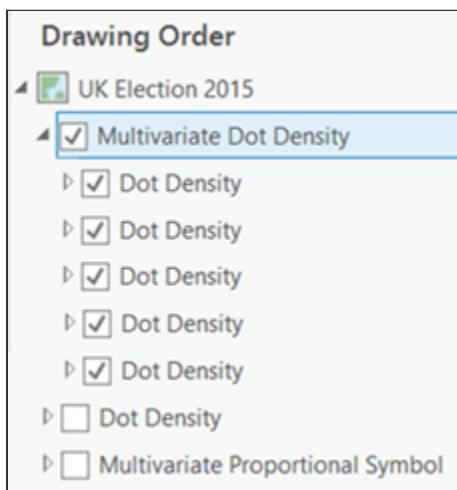


A zoomed in view of the final dot-density map.

Step 11: Create a multivariate dot-density map

At the moment, all dots are the same color. You will improve the map a little further by creating a version where the dots are the same color as the political party, like you did for the proportional symbol map. First, you will make a few copies of the data.

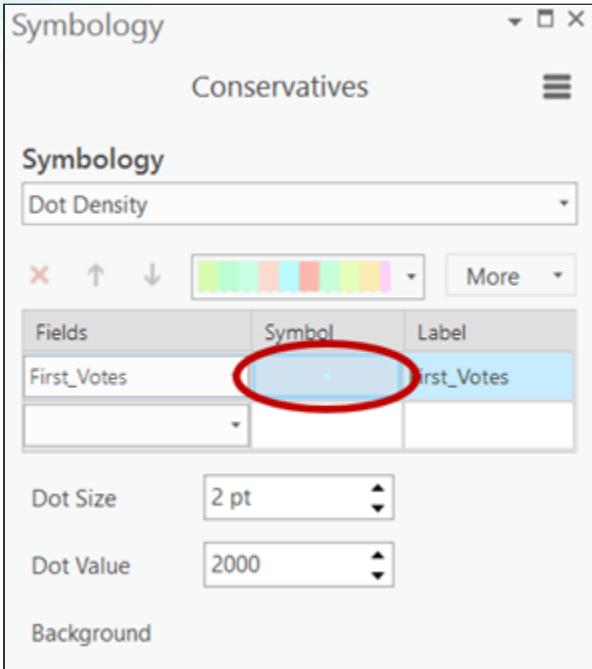
- a Create a new group layer and name it **Multivariate Dot Density**.
- b Copy the Dot Density layer and paste it into the group layer.
- c Paste four more copies of the Dot Density layer into the group layer so that you have a total of five layers.
- d Turn off the original Dot Density layer.



- e In the Multivariate Dot Density group layer, rename the first Dot Density layer **Conservatives**.

Next, you will use a definition query to set the dot colors to the political party colors.

- f Double-click the Conservatives layer to open the layer properties, and click the Definition Query tab.
- g Click Add Clause, and set the clause so that First Is Equal To CON.
- h Click Add and then OK.
- i In the Symbology pane for the Conservatives layer, in the Symbol column, click the box next to First_Votes to open the Format Point Symbol pane.



- j Change the dot's color to the Conservative blue, and click Apply.

Note: Because there are so many dots on the map, it may take some time for the map to redraw.

Now you have a map with only the partial dataset shown.

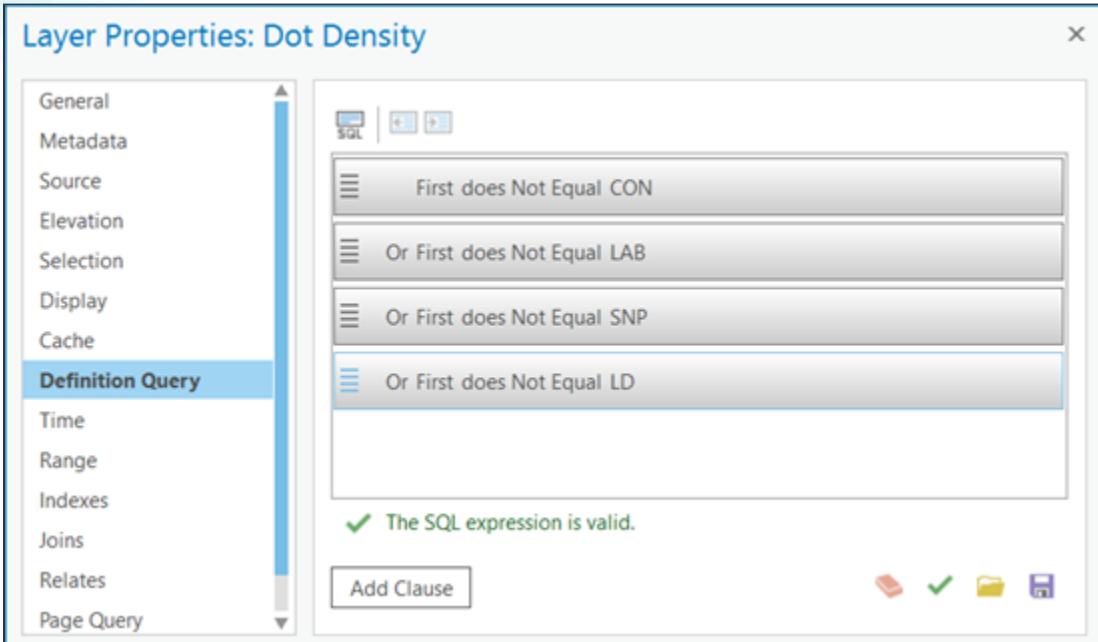
- k Repeat the above steps for the second layer, using the following information:

- Name: **Labour** (and turn on the layer)
- Definition query: First Is Equal To LAB
- Dot color: Labour red

- l Use the same approach to specify definition queries and symbol colors for two additional layers—one each for the SNP (Scottish National Party) and LD (Liberal Democrats) parties.

- m Finally, for the fifth copy of the Dot Density layer, specify a definition query that has four clauses:

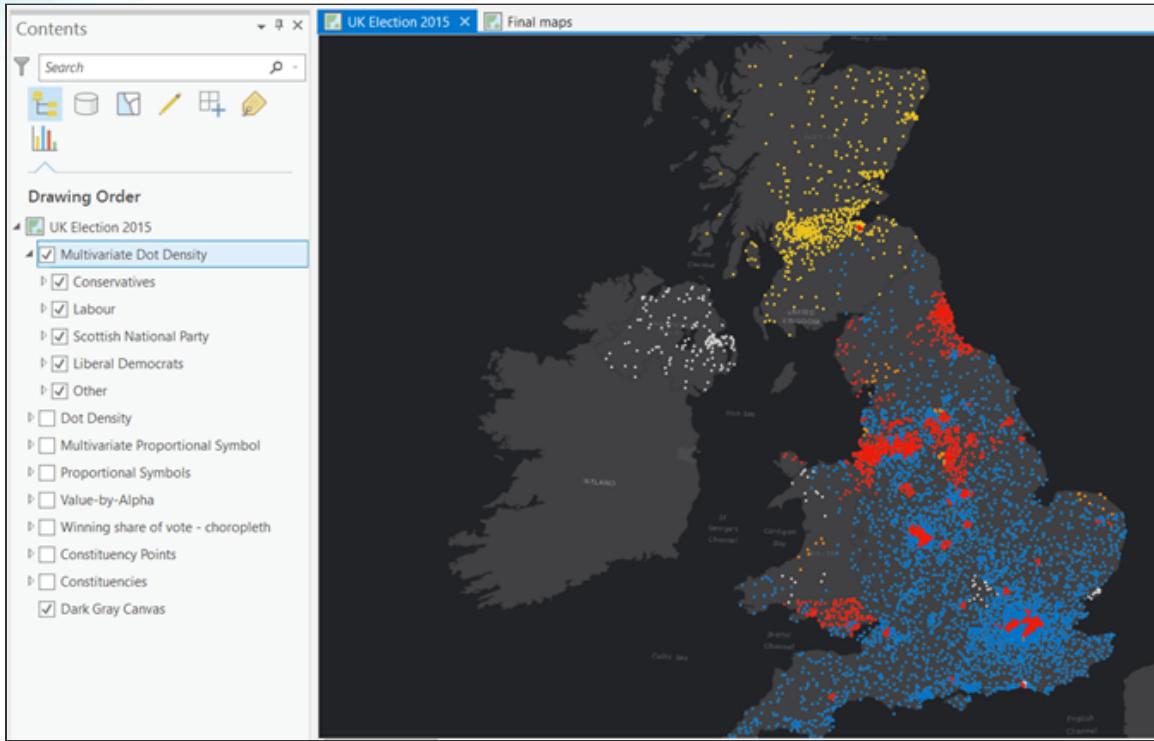
- First Does Not Equal CON
- Or First Does Not Equal LAB
- Or First Does Not Equal SNP
- Or First Does Not Equal LD



This captures all other constituencies that have not been shown by the other layers in this group.

- n Rename the fifth layer to **Other** and symbolize it with the light gray Independent/Other color.

Now you have an overall effect where dot density is colored by the winning political party. You could create a separate layer for every party if you wish, though sometimes a map is far clearer if you remove some of the detail. Here, you're showing the predominant parties and removing a bit of visual noise by grouping every other constituency as Other.



Final multivariate dot density map.

- ➊ When you are finished, close the Symbology pane and save the project.
- ➋ If you are continuing to the stretch goals, leave ArcGIS Pro open; otherwise, exit ArcGIS Pro.

Conclusion

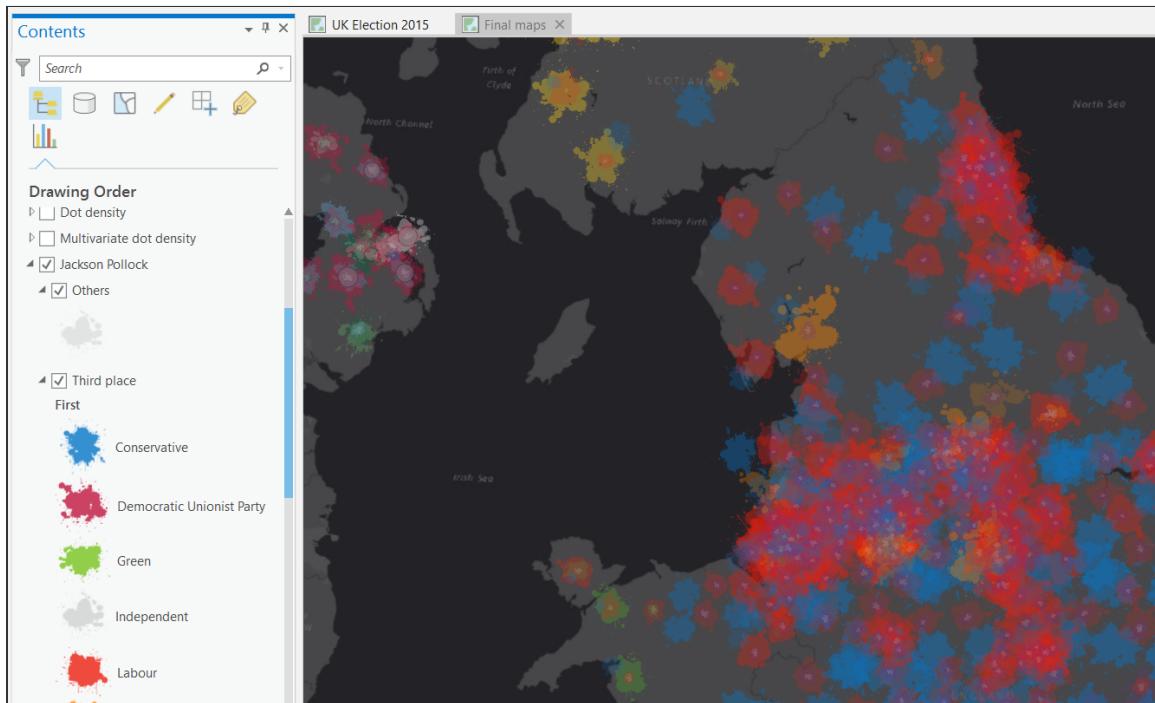
You have designed a range of different thematic maps that each show the data in different ways. Along the way, you've learned about the differences between area-based thematic maps and point-based thematic maps. You've applied some of the ideas that were covered in the Section 2 Exercise 2 for classifying data, and you've explored ways to design and modify symbology to show both single and multiple pieces of information. Ultimately, there is never a perfect thematic map, but making sure your data classification, map type, and symbology work in harmony will help make your choices make sense for your map reader.

Stretch Goal: Make a Jackson Pollock inspired map

The [Jackson Pollock](https://bit.ly/1PF2EqC) (<https://bit.ly/1PF2EqC>) inspired map is an artistic method of representing thematic data. It's a little unusual, but it demonstrates what you can achieve with a little lateral thinking, working with symbol layers and attribute-driven symbology.

Before starting this stretch goal, take a look at the final Jackson Pollock map in the Final Maps map view.

Hint: At the top of the map view, click the Final Maps tab and turn on the Jackson Pollock layer.



The map is covered in apparently randomly positioned paint splats. Actually, there are four paint splats per constituency. They represent the winning political party, the runners-up, the third place party, and a final symbol that represents the remaining candidates. But, what else is going on? Symbols are different sizes, so they are proportional to reflect the number of votes. They are different colors, so they represent the political party colors. The symbols are randomly rotated to create a more organic appearance. There's quite a lot going on here, so you will slowly work your way through how it's constructed.

The tasks in this stretch goal are intentionally high-level. Use what you have learned in this exercise to create your Jackson Pollock inspired map. Pour yourself a cup of coffee — this will take a bit of effort.

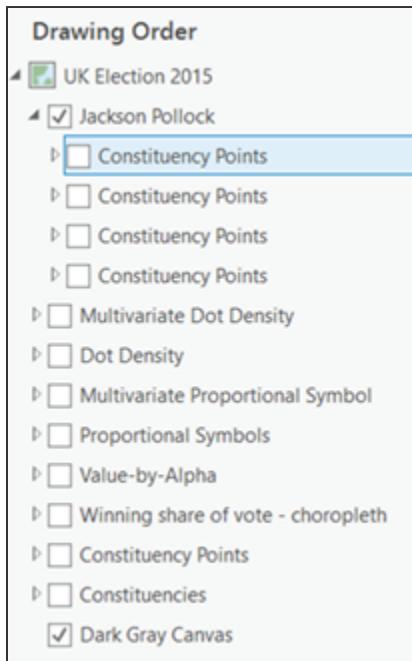
Step 12: Create map layers

First, create the map layers.

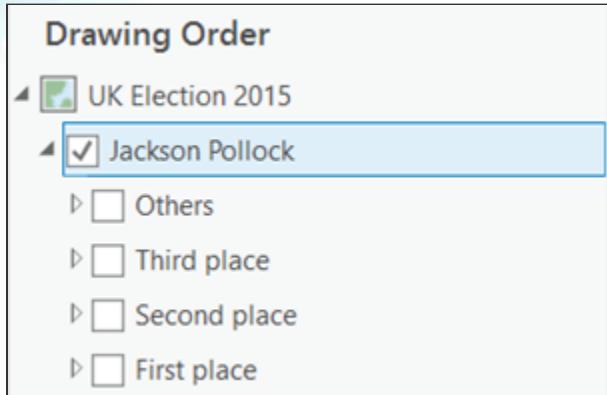
- a In the UK Election 2015 map view, in the Contents pane, turn off all layers except the Dark Gray Canvas basemap.

Again, you will use a point feature class of the election data to create a group layer.

- b Right-click the UK Election 2015 map item, and create a new group layer named **Jackson Pollock**.
- c Make a copy of the original Constituency Points layer, and in the Jackson Pollock group layer, paste four copies.



- d Rename the layers, starting with the first layer, as follows:
 - **Others**
 - **Third place**
 - **Second place**
 - **First place**



The order is important because you're going to have four layers showing at once, and you want the larger symbols at the bottom of the stack (the winners) with the others (second place and so on) atop. If you positioned these in the reverse order, the larger symbols would occlude those underneath.

Step 13: Assign and scale picture marker symbols

Next, you will assign picture marker symbols for the paint splats and use an [Arcade Expression](https://bit.ly/2n9T6JP) (<https://bit.ly/2n9T6JP>) to scale them proportionally.

- a For the First Place layer, open the Symbology pane.
- b Update the Symbology to Unique Values, and for Field 1, choose First.

You will assign picture marker symbols from the preloaded electionsplat style (located under Gallery in the Format Point Symbol pane) to each point symbol so that each party has the correctly colored paint splat. The paint splats will be quite large initially; you will scale them after they are loaded.

- c For each symbol in the grid at the bottom of the Symbology pane, click the point symbol and then, in the Format Point Symbol pane, on the Gallery tab, using the same colors as before, choose the appropriate paint splat symbol for that value from the electionsplat collection.

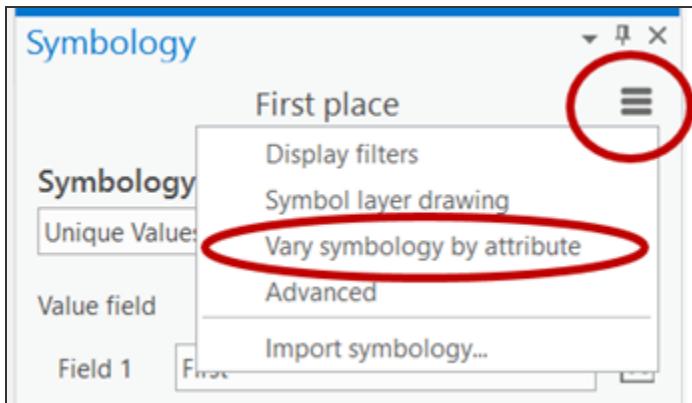
Note: On the Gallery tab, click once on the paint splat symbol to choose it, and then click the back arrow to return to the Symbology pane. Because the initial paint splats are quite large, you may need to scroll down in the grid at the bottom of the Symbology pane.

- d Use the following chart for assistance, if needed.

Party	Party name	Color splat picture marker symbol
CON	Conservative	
DUP	Democratic Unionist Party	
GRN	Green	
IND	Independent	
LAB	Labour	
LD	Liberal Democrats	
Other	Other	
PC	Plaid Cymru	
SDLP	Social Democratic and Labour Party	
SF	Sinn Fein	
SNP	Scottish National Party	
UKIP	UK Independence Party	
UUP	Ulster Unionist Party	

Now you'll vary the symbol size by an attribute to turn them into proportionally scaled paint splats.

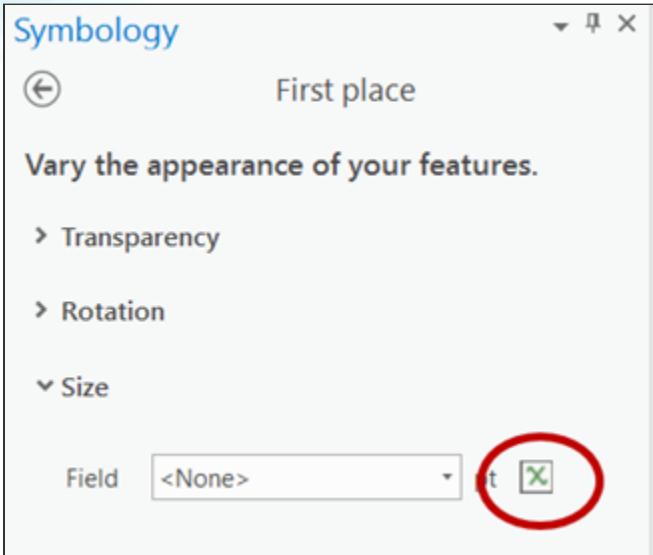
- e In the Symbology pane, click the menu button, and then choose Vary Symbology By Attribute.



- f Expand Size.

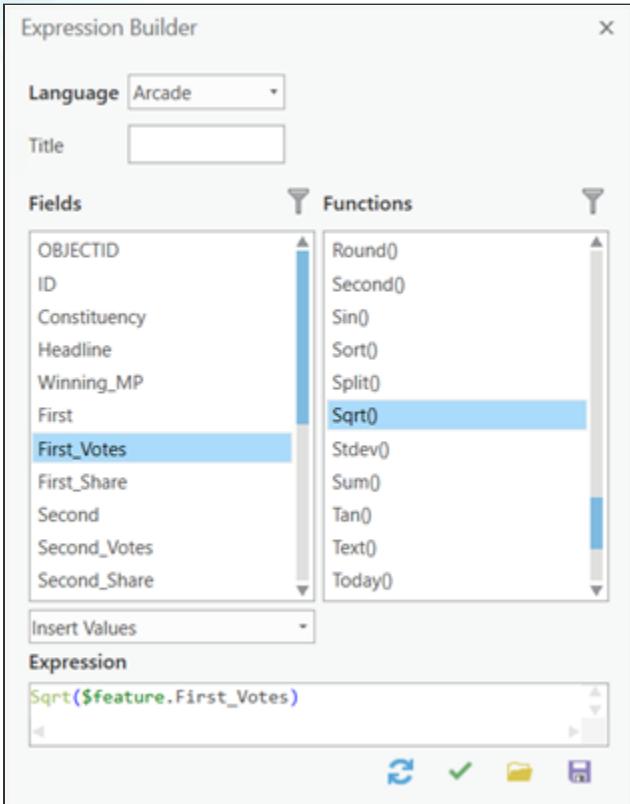
You will now define a size based on the square root of the total votes received by the winning candidate (this is how proportional symbols are calculated to ensure the area of a symbol relates to the value being mapped).

- g To the right of the Field drop-down list, click the Set An Expression button.



- h In the Expression Builder dialog box, ensure that the Language is set to Arcade.
- i In the Functions list, double-click Sqrt().
- j In the Expression field, click between the parentheses.
- k In the Fields list, double-click First_Votes to insert it into the expression.

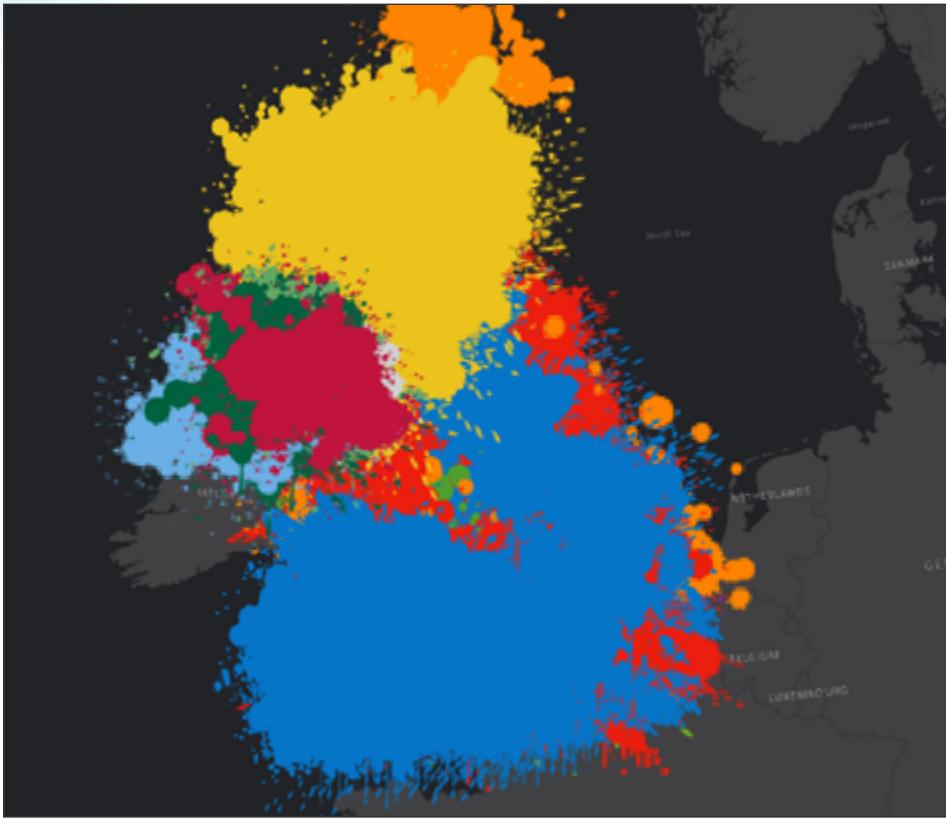
You should end up with an expression that reads: `Sqrt ($feature.First_Votes)`, as shown below:



- I Validate your expression and click OK.

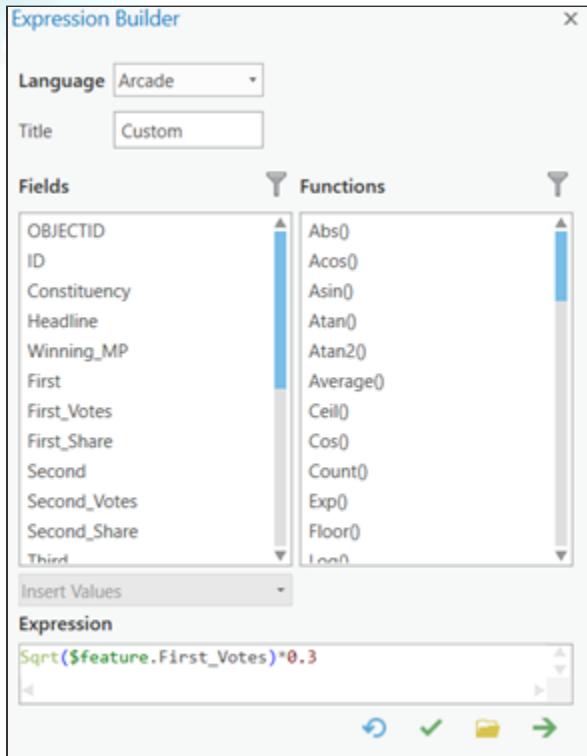
All symbols are now resized proportionally to the data value.

- m With the First Place layer turned on, zoom in to see the symbols on the map.

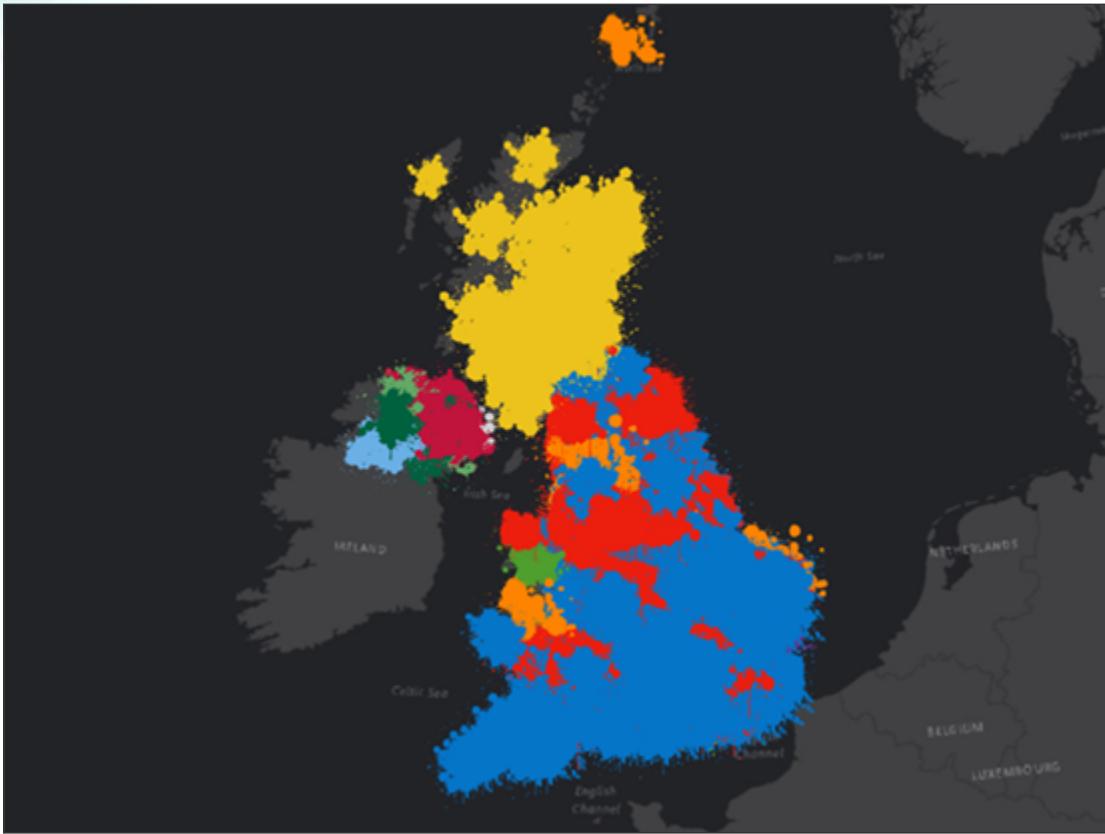


You'll notice a problem. All the symbols are on the large side, so you can add a constant to the equation to scale them all larger or smaller.

- ➊ Update the expression to add a scaling constant, such as `Sqrt($feature.First_Votes)*0.3`, to reduce all the symbols by a factor of 70%.



- At the top of the pane, click the Back arrow to return to the Symbology pane.



You now have a map of the winning parties for each constituency with a proportionally scaled paint splat symbol. This looks good, but the symbols all look a little regular and overlap one another.

Step 14: Refine symbol appearance and position

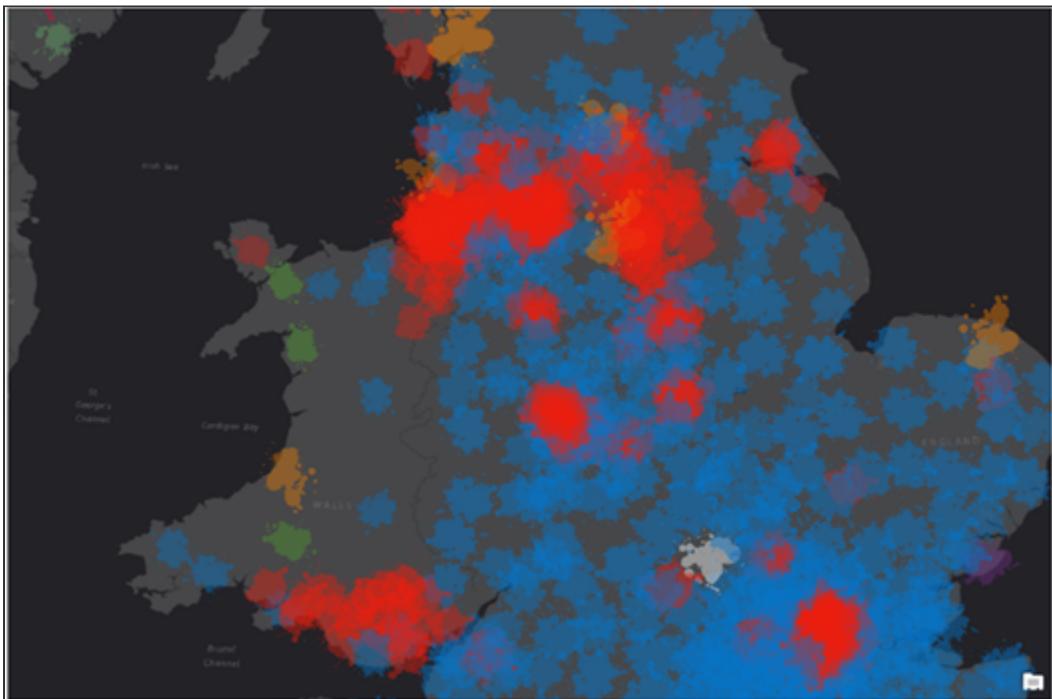
You will add symbol rotation and use transparency to create a better result.

- a To add rotation to the symbols, in the Symbology pane, click the menu button and choose Vary Symbology By Attribute.
- b Collapse Size, and then expand Rotation.
- c For Field, choose <random>.
- d Expand the Transparency section, and then for Field, choose First_Share.

This modifies the symbols by scaling the range of data values across a transparency range so that the overlaps appear like mixed paint. You can experiment with the controls to achieve a

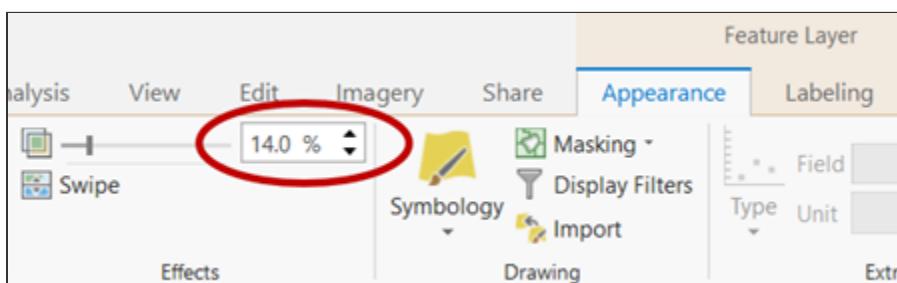
result that you like. The random rotation makes the symbols appear irregular, a bit more like, well ... paint!

- e Zoom and pan the map to see the variation.



You have changed transparency at the symbol level, but you can also change the transparency of the whole layer.

- f In the Contents pane, ensure that the First Place layer is selected.
- g From the Appearance tab on the ribbon, in the Effects group, use the Layer Transparency tool slider to adjust the percentage of transparency to 14.0%.



- h When you are finished, close the Symbology pane.

Now you will apply the same approach to the other three layers to add the results for the second place party, third place party, and others data in the dataset. Instead of repeating steps, you will use a shortcut.

- i In the Jackson Pollock layer group, right-click the First Place layer, point to Sharing, and choose Save As Layer File.
- j Browse to the same location that you saved your exercise data file, name the layer **Pollock_First**, and then click Save.

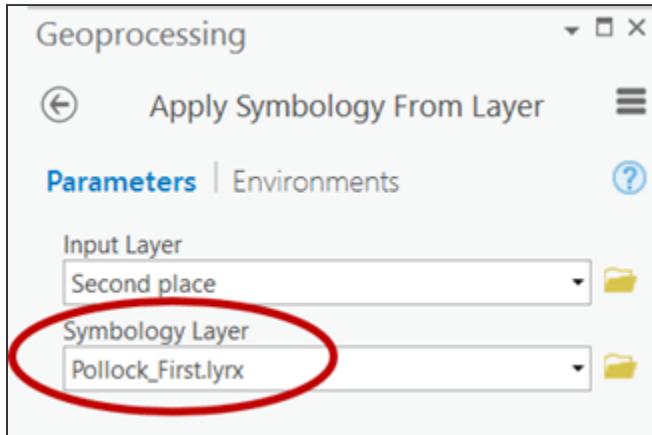
The symbology specifications that you just set for the First Place layer are saved to a reusable file.

- k Open the Symbology pane for the Second Place layer, choose Unique Values, and then specify Second as the field to map.
- l At the top of the Symbology pane, click the menu button and choose Import Symbology.

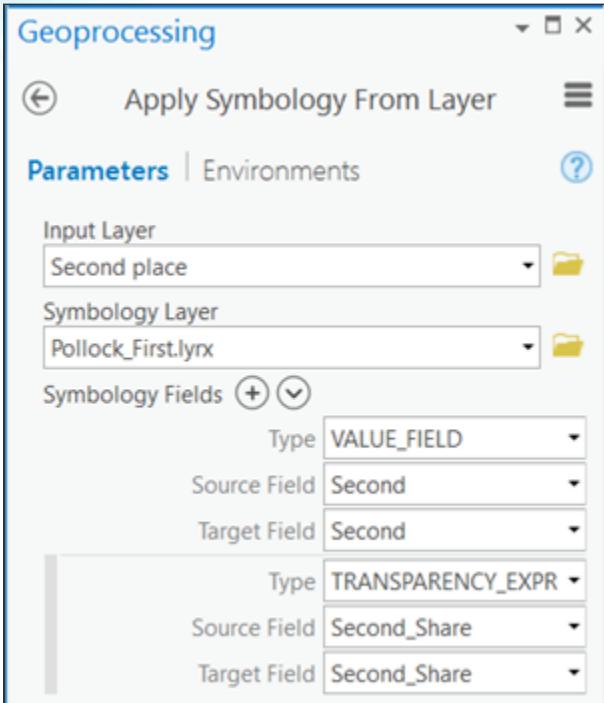
The Geoprocessing pane opens.

- m In the Apply Symbology From Layer pane, for the Symbology Layer field, click the Browse button.
- n Browse to and select the Pollock_First layer file that you just saved, and click OK.

Note: You can also use an existing layer.

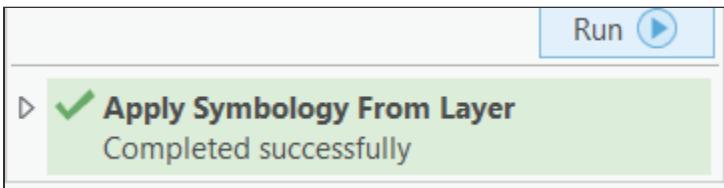


- o In the Geoprocessing pane, under Symbology Fields, for the VALUE_FIELD section, set the Source Field and the Target Field to Second.
- p For the TRANSPARENCY_EXPRESSION_FIELD section, set the Source Field and the Target Field to Second Share.



- q Click Run.

At the bottom of the Geoprocessing pane, you should see a successfully completed message. If you don't, it's likely you entered something slightly wrong, so go back and check your work.



The symbology specification is now applied to the Second Place layer.

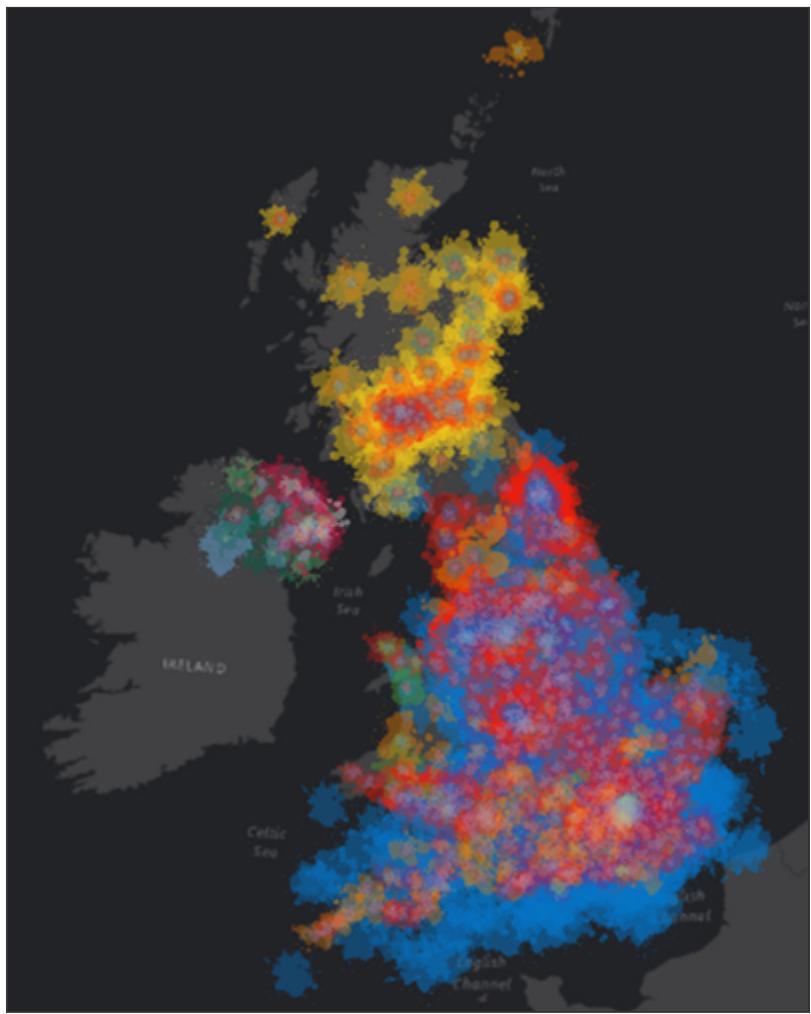
You might want to adjust the symbology settings for the Second Place layer to modify the transparency and size. You could make the symbols a little smaller and more transparent than those of the first layer, for instance. Second place isn't nearly as important on the map as first place, so the Second Place layer symbols should not dominate.

- r Repeat the process to apply the symbology from the layer file for the Third Place layer, again making the symbols a little smaller and more transparent.
- s For the final layer (Others), use the Symbology pane to create a single symbol, using a gray paint splat for Other.

Hint: Don't forget to scale the gray paint splat.

- t In the same way that you applied 14% transparency to the First Place layer, change the overall transparency of the Second Place layer to 39%, the Third Place layer to 20%, and the Others layer to 46%.

You should end up with a Jackson Pollock style mix of symbols that quite literally paints a picture of the mess of the election.



Final Jackson Pollock inspired thematic map based on attribute-driven symbology.

- u If you are continuing to the next stretch goal, leave the Geoprocessing pane and ArcGIS Pro open; otherwise, save the project and exit ArcGIS Pro.

Stretch Goal: Publish maps to ArcGIS Online

There are many different ways that you can publish content from ArcGIS Pro to ArcGIS Online. The method outlined here is a basic catch-all and provides an entry-point way to create a web map that you can share with others. That entry point is to publish all your maps as raster tiles. These tiles are effectively pictures of your data that people can pan and zoom in a web browser.

Alternative methods (like publishing features or vector tiles) can be used for specific map types, but there are limitations on what the ArcGIS Online renderer (<https://bit.ly/2qW2O4Q>) can support, particularly when you use more advanced capabilities for creative cartography.

You'll make a [web map](https://bit.ly/2HWWxxS) (<https://bit.ly/2HWWxxS>) for the unique values map as an example, and then you can experiment with others as you wish.

First, let's deal with the question of the projection of your map. For very good reason, Web Mercator has evolved as the default for web mapping. Computationally, it is a good solution and it supports sharing of data across different maps because it's now a standard format. However, for many thematic maps, it's an unsuitable projection because its main drawback is that it's not equal-area. It distorts area so it over-emphasizes some geographies more than others.

Here, let's presume that you want your map in the appropriate projection rather than a generic Web Mercator web map. Should you prefer to publish in Web Mercator we'll get to that in a moment. First, you will create a specification for ArcGIS Pro to use when publishing your map.

Step 15: Create a tiling scheme file for publishing a map

You will create a tiling scheme file and set scales for the map that you will publish and share.

- a Open and dock the Geoprocessing pane, if necessary.

Note: If you left the Geoprocessing pane open in the last stretch goal, click the Back arrow. To open the Geoprocessing pane, from the Analysis tab on the ribbon, in the Geoprocessing group, click Tools.

- b Search for and open the **Generate Map Server Cache Tiling Scheme** tool.
- c Confirm that the Map Document is set to UK Election 2015, or whatever you have called your map document in this exercise.
- d For Output Tiling Scheme, click the Browse button.
- e Browse to the same location where you saved your previous documents, name your file **OSGBschema**, and click Save.

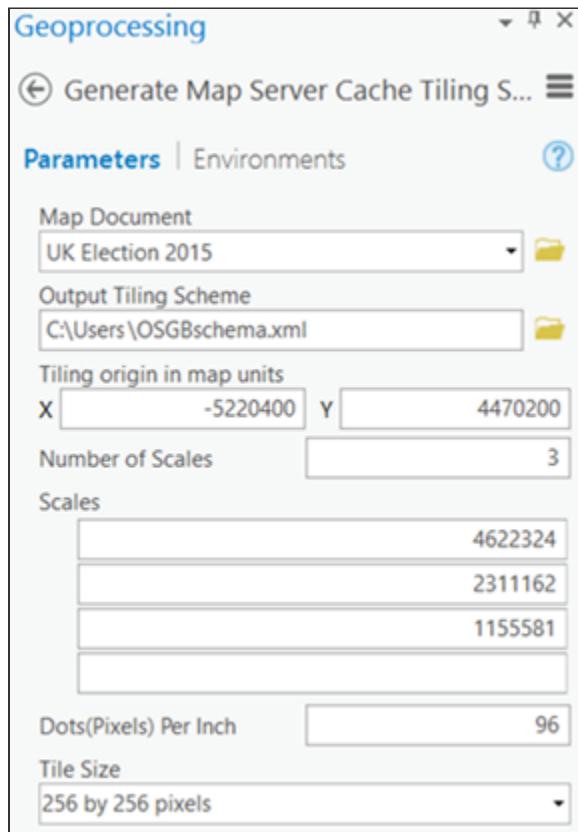
Note: OSGB stands for Ordnance Survey Great Britain.

You will specify three scales.

- f For Scales, type the following numbers, pressing Enter after each record:

- 4622324
- 2311162
- 1155581

Note: These figures represent three of the standard zoom levels for web maps. You can find others by customizing the scale properties in the bottom left of your map view to load ArcGIS Online / Bing Maps / Google scales.





This process creates a small xml file that contains the specifications for how ArcGIS Online is going to publish the map. You are only specifying three map scales, which make sense for the map that you're publishing. It is absolutely imperative that you **DO NOT** publish at too many scales or at very large scales. For every additional smaller scale, you would be requiring a doubling of the previous number of tiles made. This would generate millions of unnecessary cached tiles.

- g Leave the other settings as they are and click Run.

When the process successfully completes, a message will display at the bottom of the Geoprocessing pane.

► **Generate Map Server Cache Tiling Scheme**
Completed successfully

This tiling scheme file can now be used for all subsequent map publishing processes where you want the map to be published in Ordnance Survey Great Britain coordinate system for the three map scales specified.

Step 16: Share the map as a web layer

Now you will share the map as a web layer.

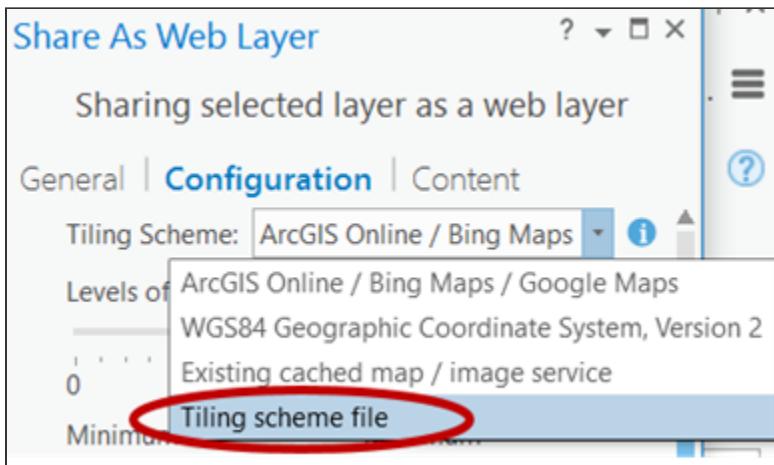
- a In the Contents pane, if necessary, turn on the Constituencies unique values layer (the layer you created in Step 5 of the exercise).
- b Right-click the Constituencies unique values layer, point to Sharing, and choose Share As Web Layer.

The Share As Web Layer pane opens.

- c Name your map **UK_election_2015_UV_<yourfirstandlastname>**.

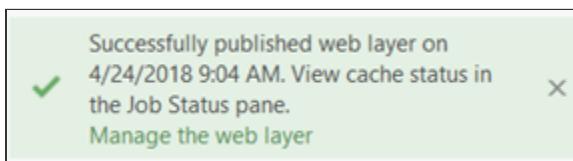
Note: Adding your first and last name to the file name ensures that your map is unique within the Cartography organization in ArcGIS Online.

- d For Layer Type, select the Tile option, and then provide the following information:
- For Summary, type **Map of UK election results as unique values**.
 - For Tags, add some keywords to help people find your map in ArcGIS Online, such as **UK election map** and **unique values map**.
 - For Sharing Options, select Everyone.
 - At the top of the pane, on the Configuration tab, for Tiling Scheme, choose Tiling Scheme File and browse to and select the OSGBs schema.xml file that you created in the previous step.



- e Leave the other settings as the default and click Publish.

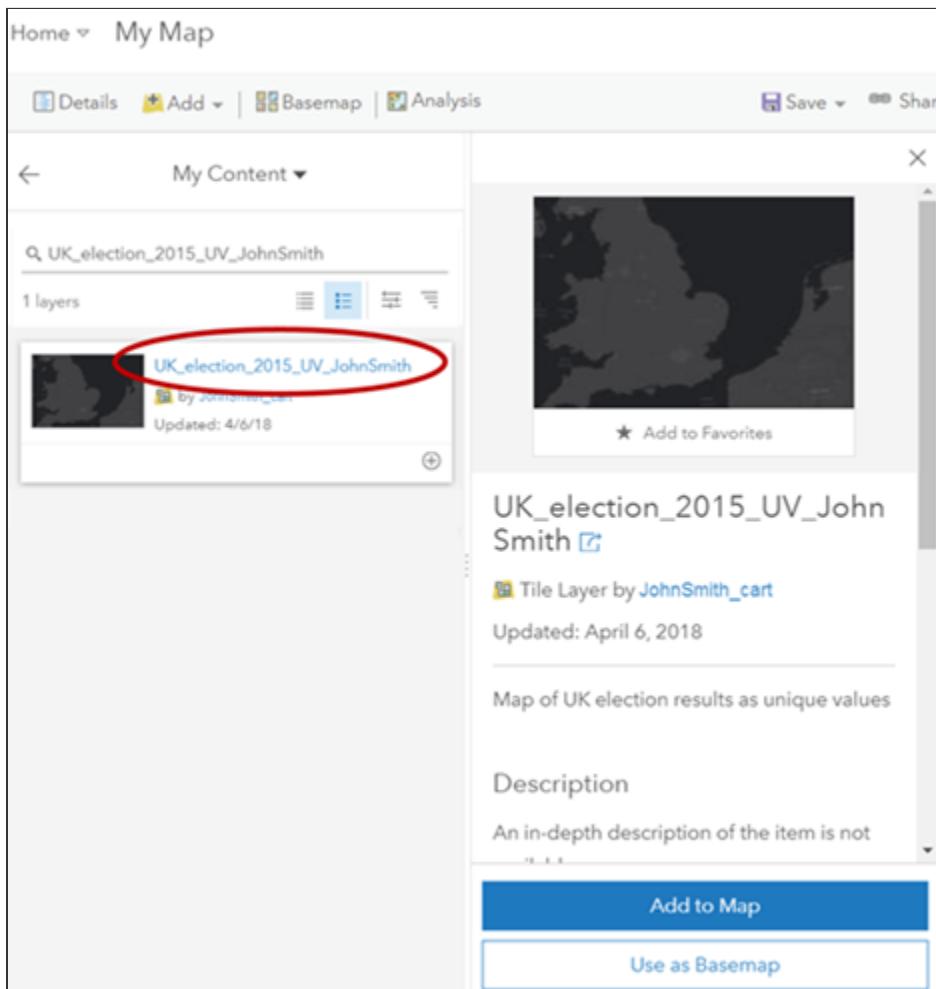
This process can take several minutes depending on the complexity and the settings. When the process successfully completes, a message will display at the bottom of the Share As Web Layer pane.



Next, you will sign in to your ArcGIS Online account.

- f Open a new private or incognito web browser and go to www.arcgis.com and sign in using your course credentials, as explained in Section 1 Exercise 2 - Getting Started with ArcGIS Online.
- g From the organization home page, click Map.

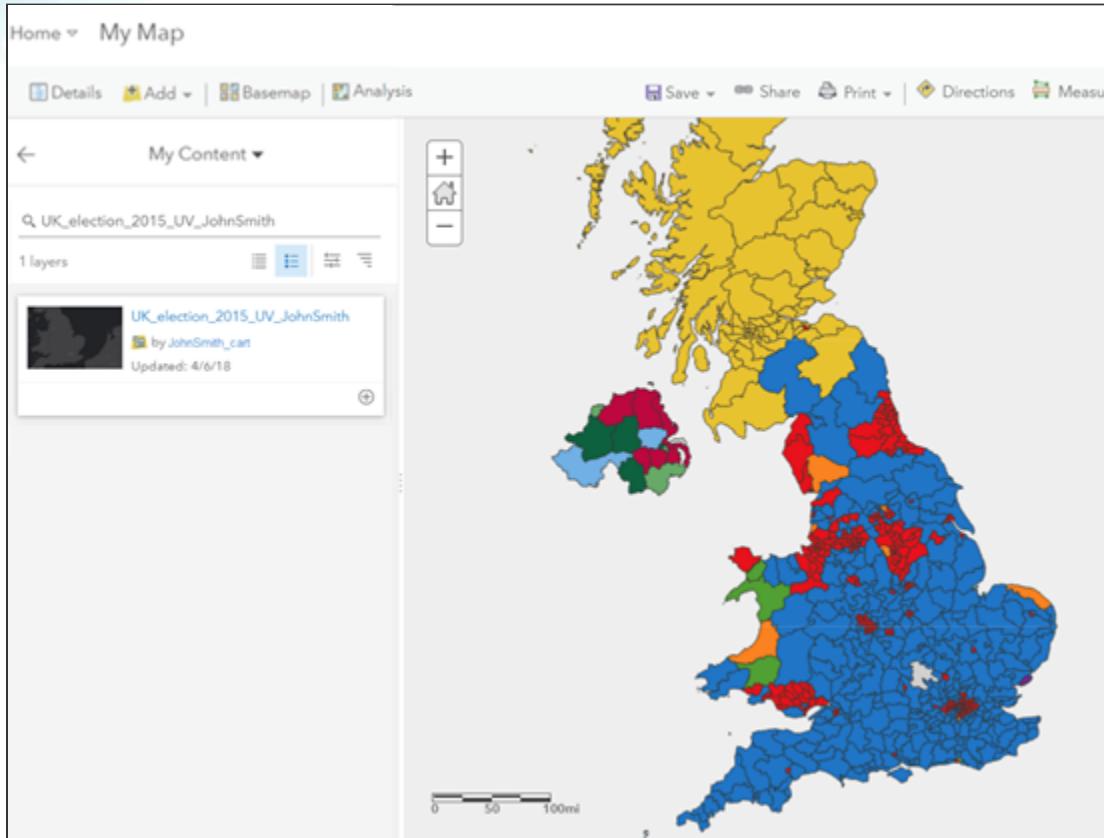
- h Above the left pane, click Add and choose Search For Layers.
- i In the Search For Layers pane, type **UK_election_2015_UV_<yourfirstandlastname>** and press Enter.
- j In the results list, click the title of your tile layer item.



The item details pane opens to the right.

- k At the bottom of the item details pane, click Use As Basemap.

Your map should update and is now available in Ordnance Survey Great Britain projection at the three scales that you specified.



Because you've specified this map as the basemap, the underlying default Web Mercator map disappears. The only way to use preconfigured maps underneath your own is to forego the projection and instead of specifying a tile scheme file in the Publishing pane, choose the ArcGIS Online / Bing Maps / Google Maps tiling Scheme. In this situation, when you see your map listed in the ArcGIS Online results pane, you can simply add it and it will sit on top of whatever pre-published basemap that you want to use.

- 1 If you plan to continue with the next stretch goal, stay signed in to ArcGIS Online with your map displayed.
- 2 If you are finished, sign out of ArcGIS Online, close your web browser and exit ArcGIS Pro, saving if prompted.

Hint: To sign out of ArcGIS Online, at the top right of the window, click your name and select Sign Out.

Stretch Goal: Augment and publish your map as an app

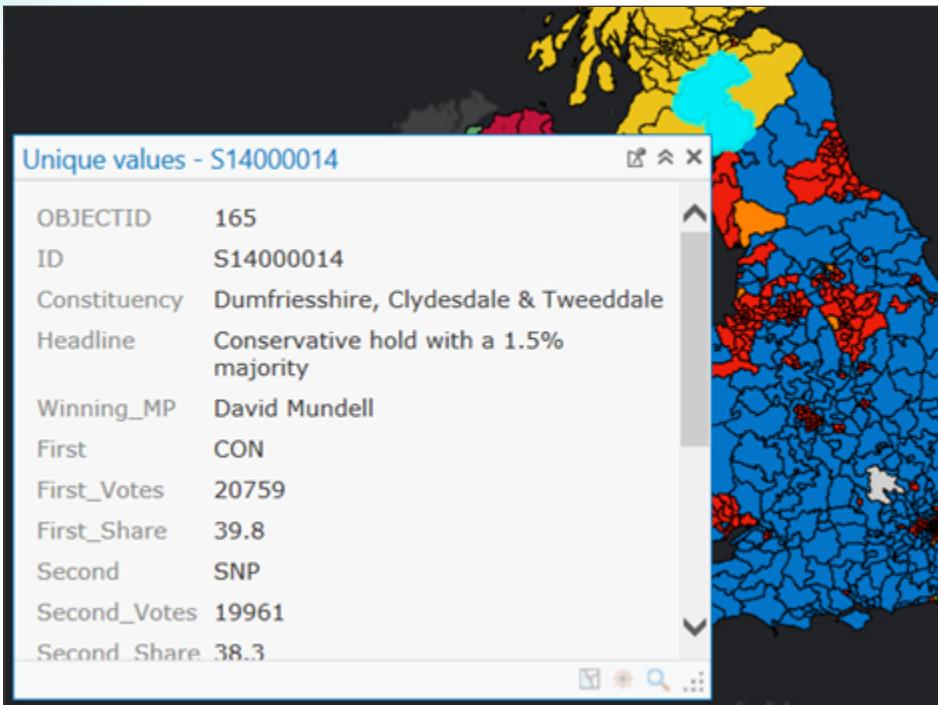
When you click your map in ArcGIS Online, you just see pictures of your map published as raster tiles. But, it'd be useful to have a click-event that returned some details about the underlying data. If you had published the map as a feature service, you could configure pop-ups immediately. Because you haven't done that yet, here's a trick that you can use to generate the same outcome.

You will create pop-ups and use features with invisible symbology to create efficient operational layers atop your published maps.

Step 17: Configure pop-ups

Pop-ups identify attribute information about a particular feature. You can configure pop-ups to display relevant information to the users of your election map.

- a Back in ArcGIS Pro, copy the Constituencies unique values layer and paste a new version into the Contents pane.
- b Rename the layer **Unique Values**.
- c Ensure that this layer and the Dark Gray Canvas basemap layer are the only layers turned on.
- d In the map, click one of the areas to see a pop-up that includes data from the layer attribute table.



e Examine the title of the pop-up, as well as the information it contains.

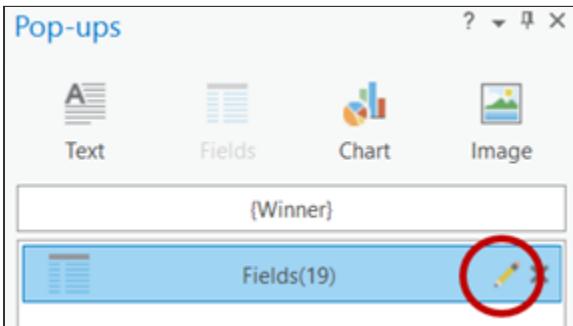
f Close the pop-up.

You can modify the pop-up to display information in a more usable manner.

g In the Contents pane, right-click the Unique Values layer and choose Configure Pop-ups.

h In the Pop-ups pane, click {ID} to edit the title of the pop-up. Replace the text between the curly brackets with your own title text, such as **Winner**.

i Click the Back button.



j To the right of the Fields bar, click the Edit pencil icon to edit pop-up content.

In the Fields Options pane, you can choose which fields are displayed in the pop-up. You can click areas on the map to see the result of your changes.

Pop-ups can contain many different elements, but let's keep it simple for now.

- (k) Use the checkboxes to show or hide various fields in the pop-up.

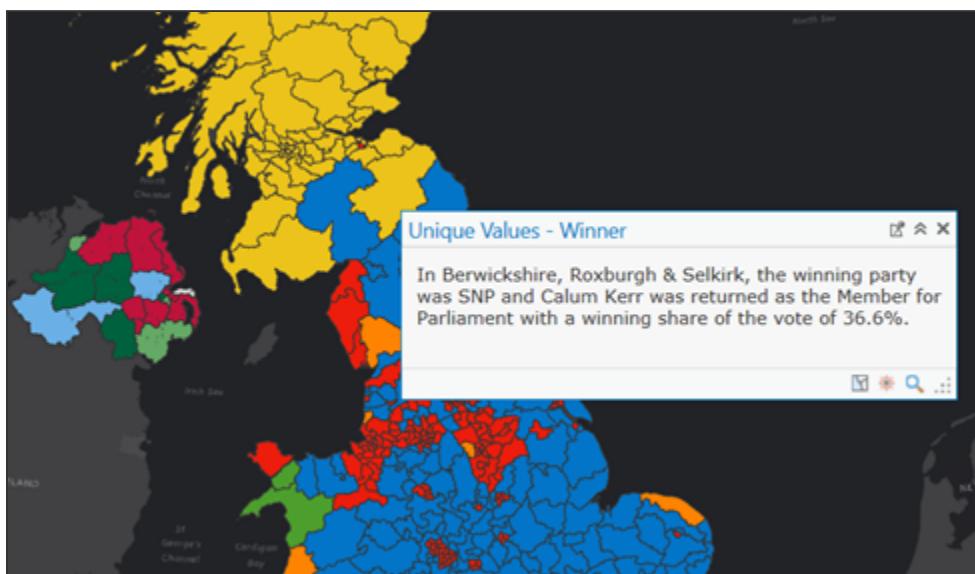
- (l) Click the Back arrow.

You can add text to the pop-up to reference data from the attribute table fields within a sentence.

- (m) At the top of the Pop-ups pane, click Text, and then click the Edit pencil icon. Type the following text: **In {Constituency}, the winning party was {First} and {Winning_MP} was returned as the Member for Parliament with a winning share of the vote of {First_Share}%.**

Hint: Use the Field drop-down list to select fields or type curly brackets and text.

- (n) Click the Back arrow, and then click one of the areas in the map to see the text that you added.



- (o) Close the pop-up and the Pop-ups pane.

Step 18: Simplify the data

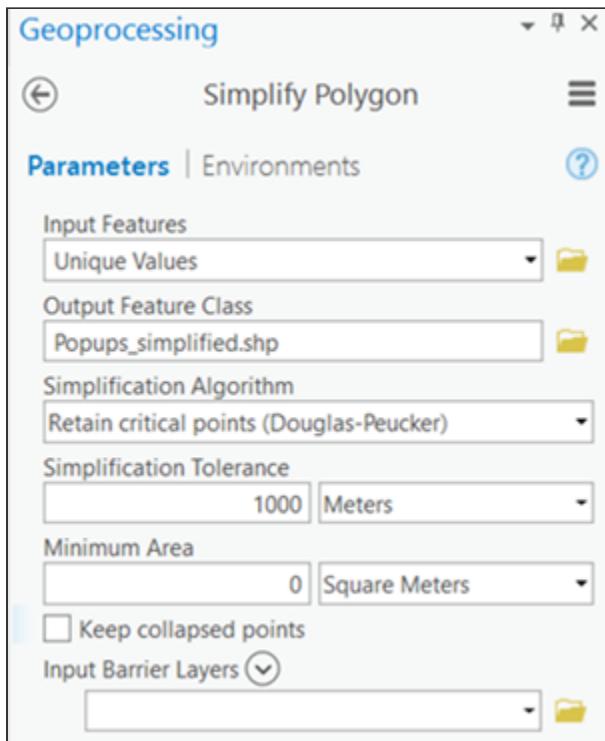
If you zoom in to the map, you'll see how detailed the boundary lines are. A good basic tenet of web mapping is to simplify data wherever possible. This helps it to render quickly in the

browser. This is important because no one likes a slow, unresponsive web map. If you published this data as it is, it would take a long time to draw. Because you're going to use invisible symbology, anyway, you can get away with a simplified version. So, you're going to use a standard cartographic technique of generalizing the data—using simplification to reduce the number of vertices (and, hence, data).

- a In the Geoprocessing pane, search for and open the **Simplify Polygon** tool.
- b In the Simplify Polygon pane, for Input Features, use the drop-down list to specify your Unique Values layer.

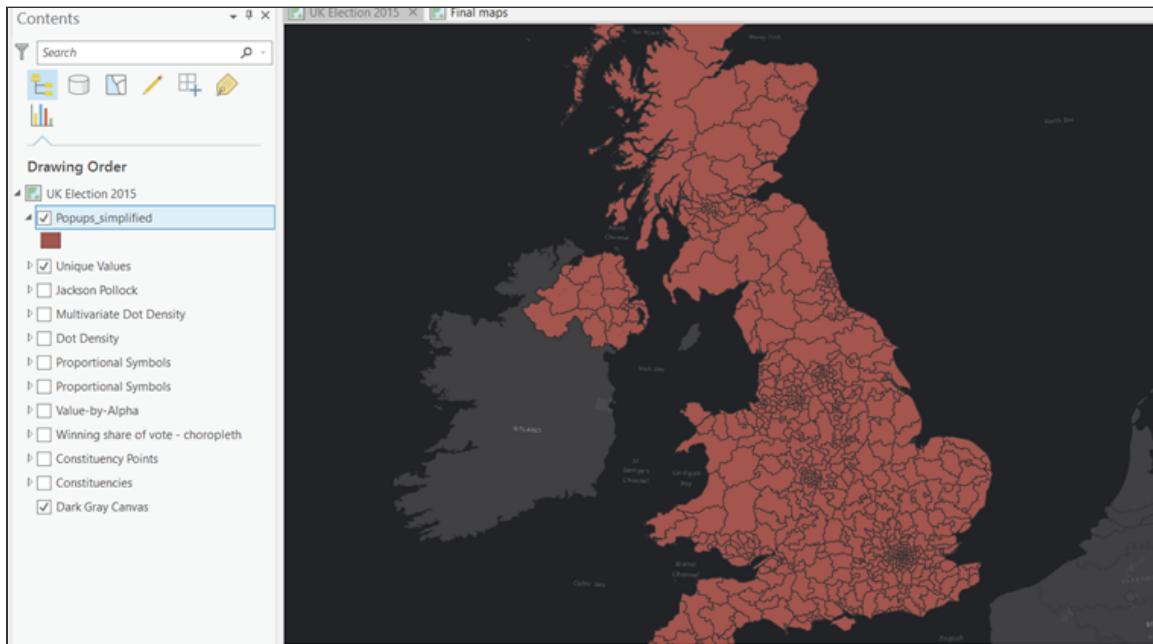
Hint: This is the layer you just configured pop-ups for.

- c For Output Feature Class, browse to the location where you saved your previous files, and name the file **Popups_simplified**.
- d Set a Simplification Tolerance of **1000** Meters, uncheck the Keep Collapsed Points check box.



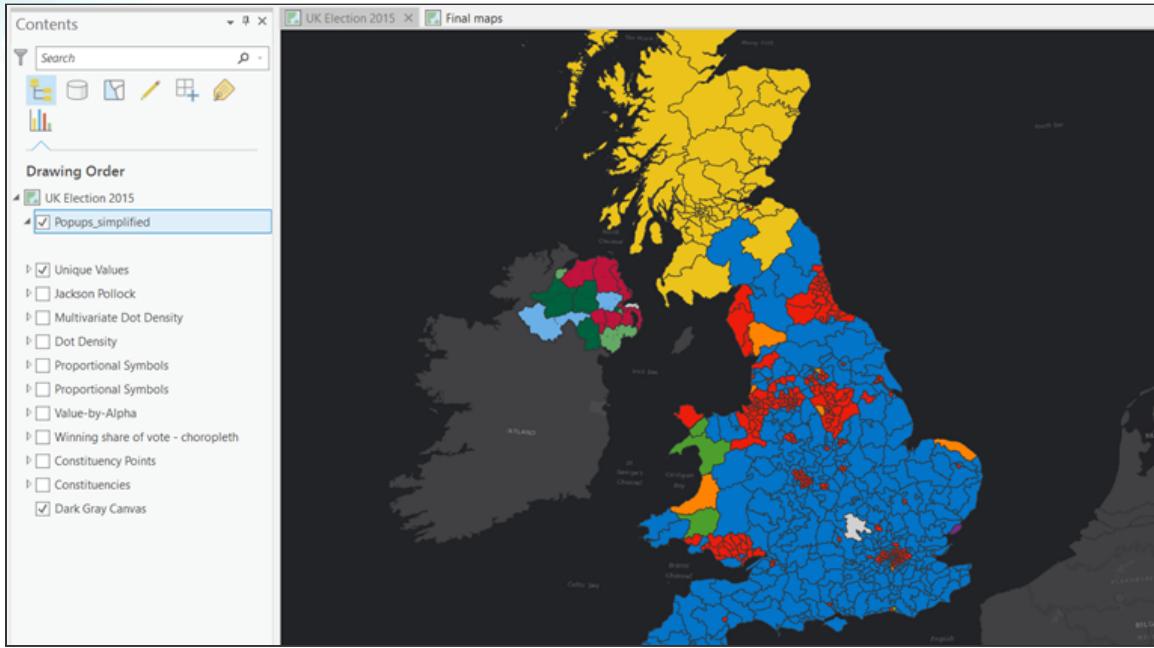
- e Click Run.

This process might take a moment. When it is complete, your new Popups_simplified layer is created. If you zoom and pan, you'll see how the boundaries are now more angular and generalized.



- f Use the layer's Symbology pane to make the symbology for the outline and fill completely transparent.

In the previous graphic, you see a default generalized popups layer obscuring the unique values map. In the following graphic, once you set transparency, even though the Popups_simplified layer is still selected, you can see the unique values layer underneath.



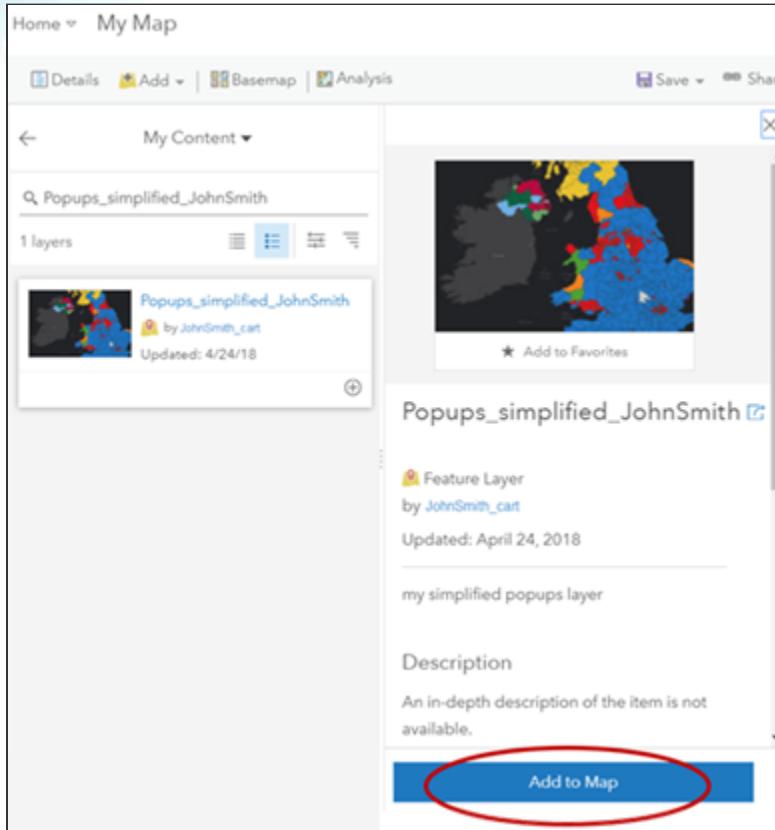
Now, you will share this generalized layer as a feature.

- g** In the Contents pane, right-click the Popups_simplified layer, point to Sharing, and choose Share As A Web Layer.
- h** Name your layer **Popups_simplified_<yourfirstandlastname>**, keep the Layer Type set as Feature, add a short summary and tags, share with Everyone, and click Publish.

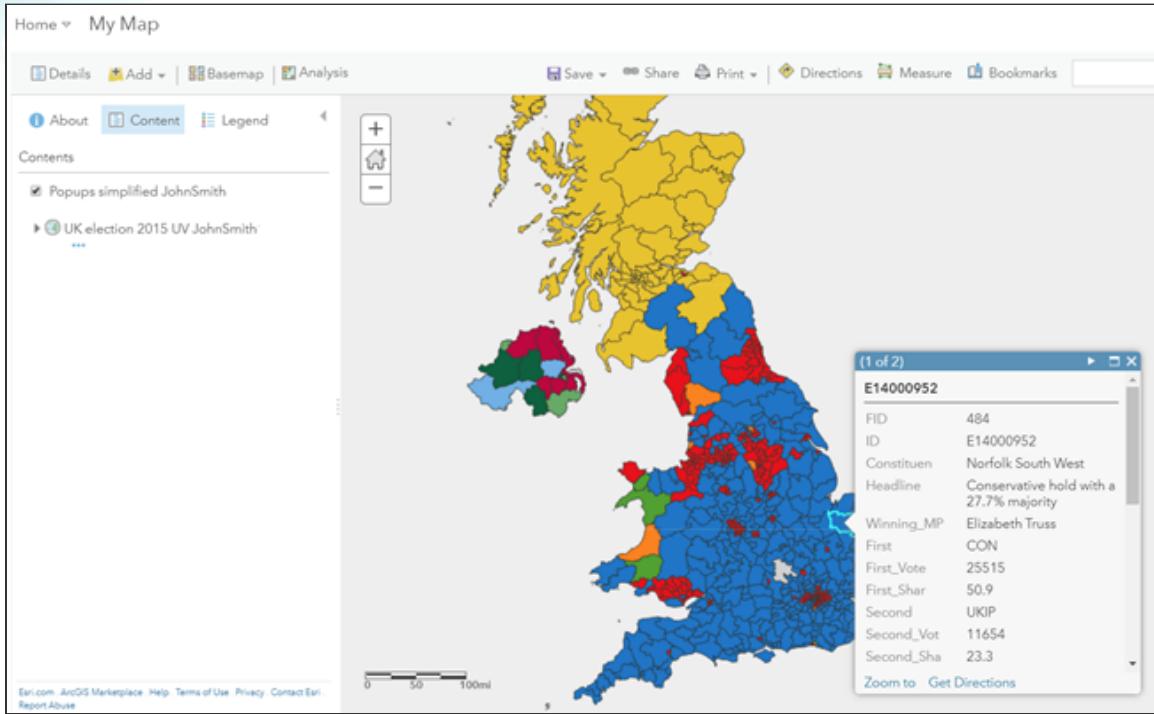
After you have shared to your ArcGIS Online account, you can add this layer to your map and it'll add a layer of invisible polygons.

- i** In ArcGIS Online, go to your map and search for the feature service name (the Popups layer that you just created), and then simply add it to your map.

Hint: In the results list, click the name of the item to open the item details pane, then click Add to Map.



After you have added it, you can click the map and your pop-up will appear. You can use the same feature service across any of your maps that you publish to ArcGIS Online. Invisible symbology is an efficient and useful way to add pop-ups to your maps.



After you have shared your basemap layers and any feature layers to your ArcGIS Online account, you'll likely have created a web map. You'll also have saved it as a new web map that you can return to. This is what we refer to as your working document—a bit like a view of your data and layers with some cartographic styling. But, it's unlikely that you want others to see or use this as a finished product since it comes with the standard ArcGIS Online user interface.

- j At the top of the ArcGIS Online window, click Save and choose Save As.
- k Type a title for your map, such as **My Web Map_<yourfirstandlastname>**. Add tags and a summary, then click Save Map.

Save Map

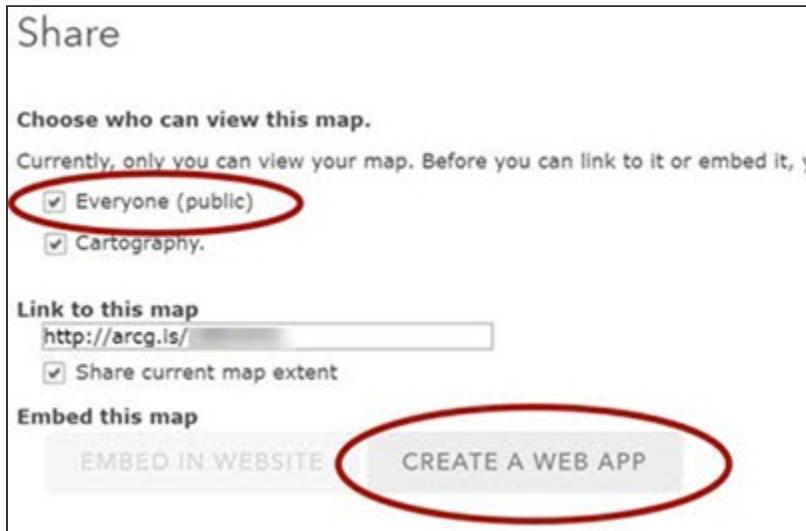
Title:	My Web Map_John Smith
Tags:	popups X unique values map X Add tag(s)
Summary:	A transparent unique values map.
Save in folder:	John Smith_cart
<input type="button" value="SAVE MAP"/> <input type="button" value="CANCEL"/>	

After you've created and saved your web map in ArcGIS Online, it's a simple process to build an app.

Step 19: Create a web app

You will create a web app using the web that contains your Unique Values map as a basemap and your generalized Pop-ups layer as an overlayed operational layer.

- a Click Share.
- b In the Share dialog box, check the Everyone check box, and if a message appears, click OK.



- c Click Create A Web App.

There are so many ways that you can publish a web map app, but you'll go with a simple option for now and use Web AppBuilder for ArcGIS.

- d Click the Web AppBuilder tab.

The information you provided when you saved your web map is provided.

- e Click Get Started.

Hint: You may need to scroll down.

- f Explore the ways in which you can customize your web map app, change the style, add widgets, and so forth, in Web AppBuilder for ArcGIS (<https://bit.ly/2HcLF0N>).

Hint: The Dart theme is particularly clean and simple.

Note: Refer to Web AppBuilder for ArcGIS help for more information on using themes (<https://bit.ly/2HoWkCq>).

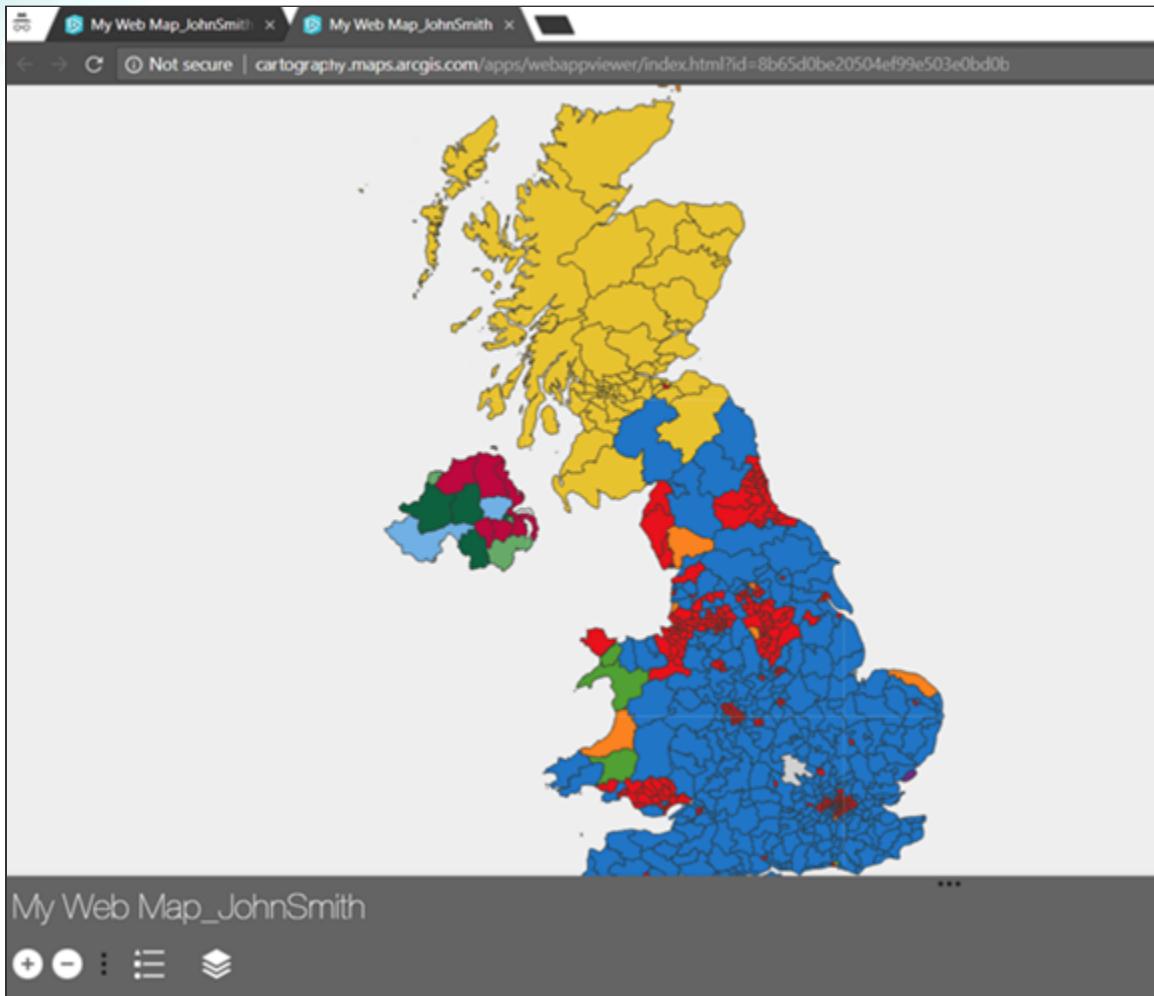
On the Map tab, you can customize visible scales to just those of your basemap tiles:

- 4622324
- 2311162
- 1155581

g When you're done, at the bottom of the pane, click Save.

You can then see your web map app in your Content collection in ArcGIS Online.

- h** At the top of the Web AppBuilder window, click Home and choose Content.
- i** Click the title of your web mapping application and then click View Application to open it.



By opening the web mapping app, you can see the URL and then share the map anywhere.

There are plenty of options for turning your web map into an app. You have two basic options: story map templates or Web AppBuilder for ArcGIS. Both pathways give you different opportunities. Most of the templates are configurable. Web AppBuilder gives you a lot of flexibility for developing a clean, uncluttered app, and you have considerable control over what is included in the interface. You can keep sharing your web map to different apps to see how they differ.

Remember, the web map is like your working document. A web map app is akin to putting your web map into a layout. Web AppBuilder allows you to completely declutter the user interface to give your map reader just the map.

You've really only just scratched the surface of making good-looking web map apps, but check out the following resources to explore the different ways that you can configure web maps and apps:

- [Web AppBuilder for ArcGIS \(https://bit.ly/2HcLF0N\)](https://bit.ly/2HcLF0N)
- [Story maps \(https://bit.ly/1X8Bkl4\)](https://bit.ly/1X8Bkl4)

j When you are finished, close the web browser and exit ArcGIS Pro, saving if prompted.

Congratulations on completing the stretch goals. Think back on what you've achieved in this exercise. It's a lot and arms you with many skills, knowledge of techniques, and key information about how to achieve great thematic cartography in ArcGIS Pro and ArcGIS Online.