Cartography. MOOC

Exercise

Scale and Generalization

Section 3 Exercise 1

05/2018

esri
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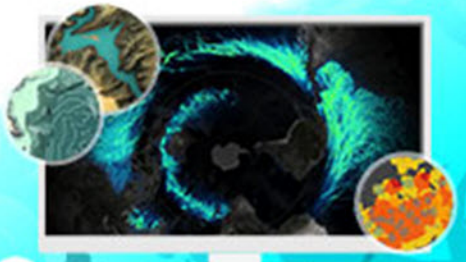


Scale and Generalization

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 45-50 minutes.

Software requirements

ArcGIS Pro 2.1

Introduction

A map is a scaled representation of reality—scaled because whatever you are mapping is likely larger than the sheet of paper or computer screen that you want to show it on. So, you must reduce the size of the representations of reality in a deliberate way to make it fit the page or screen.

However, you must simplify some things and omit some others altogether to fit everything into this much smaller space while retaining clarity and the character of the area. The challenge is to make these subjective decisions intelligently to best retain the overall density and distribution of the mapped phenomena. This process is called generalization.

Generalization is necessary to make a multiscale map. A multiscale map shows different levels of detail at different scales. They help you navigate to a place by first orienting you with a general overview of a large area, and then allowing you to zoom in to a smaller area with more detail.

Generalization processes include elimination, reduction, simplification, exaggeration, displacement, and aggregation. The goal with generalization is to do it so well that the result is intrinsic. Ideally, your map reader does not notice your generalization choices at all, and the transition between scales feels seamless.

What will you learn?

This exercise has you work with a map of New Zealand. It is a general reference map, like the one that you worked with for Massachusetts back in Section 1 Exercise 3 - *Make a Map*. This

time, though, the goal is to make a map that can be used as a basemap layer, not a static layout. That means it must work across multiple scales. You will need to manage the display of the data so that an appropriate representation of it is shown at each scale.

Making a map like this map takes time but has tremendous utility. It is unrealistic to go through the process of every layer within this exercise, so you will only work with a few examples of the entire workflow. When you're done, you can use the skills that you learn to further refine this map, or download your own set of OpenStreetMap data (https://bit.ly/X0TWdO) and make a multiscale map of a different area.

Part 1: Symbols and Scale

The amount of resizing—or the *scale*—of a map is usually expressed as a ratio. The first number, the numerator, is usually 1. It represents a distance on the map. The second number, the denominator, represents how far that distance corresponds to in reality. For example, a map with a scale of 1:100,000 means that one linear unit on the map represents 100,000 of those same units in reality. Scale (https://bit.ly/2qlAiJF) is unitless. The ratio is true whether you measure in inches, centimeters, or furlongs (https://bit.ly/2GQLwgb).

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/2EAx89Z and download the exercise file.

c. Save the file in a location that you will remember.

Step 2: Open an ArcGIS Pro project

a. If necessary, start ArcGIS Pro, signing in if necessary.

b. From the main ArcGIS Pro start page, click Open Another Project, and browse to the Sec3Ex1_ScaleAndGeneralization.ppkx exercise project file that you saved on your computer.

You will see a small-scale map of New Zealand.

c. Save your project with a name such as **Sec3Ex1_ScaleAndGeneralization_<yourfirstandlastname>.aprx** in the folder on your computer where you are saving your work.

d Zoom in and out on the map.

Because scale is expressed as a ratio, a map with a small numeric scale (a ratio with a large denominator) is considered a *small-scale* map of a large place, with limited detail. A map with a large numeric scale (a ratio with a small denominator) is a *large-scale* map of a small place with high detail.

e As you zoom in and out, keep an eye on the scale control at the bottom of the map.

Note: You can type directly into the scale control box to get to an exact scale.

Step 3: Reduce map content at smaller scales

To make an effective multiscale map, you typically begin by showing all the data that you have at all scales. As you inspect the map, you'll make note of which layers become too complex and detailed as you decrease scale. The goal is to always show as much detail as the map can handle at each scale with clarity. Adequate feature attribution can be helpful to filter data.

a Starting at the largest scale and working outward to the smallest scale, zoom out at different areas across New Zealand.

Note: Pick a variety—urban areas, rural areas, inland areas, coastal areas, and so on. In the scale control box at the bottom of the map, notice how the numerical scale ratio changes as you zoom.

Notice at what point the amount of map information is too detailed or dense to retain map clarity and legibility.

Step 4: Use a definition query to limit building display

a. On the Map tab on the ribbon, in the Navigate group, click Bookmarks and select the Wellington bookmark.

b. Zoom in and pan the map.

As you explore the map, you will notice that the Buildings layer is very detailed in some areas. All kinds of structures are shown; perhaps not all of these structures are necessary on this map. Here, you'll filter out a few kinds of buildings to clear up your map at all scales using a definition query.

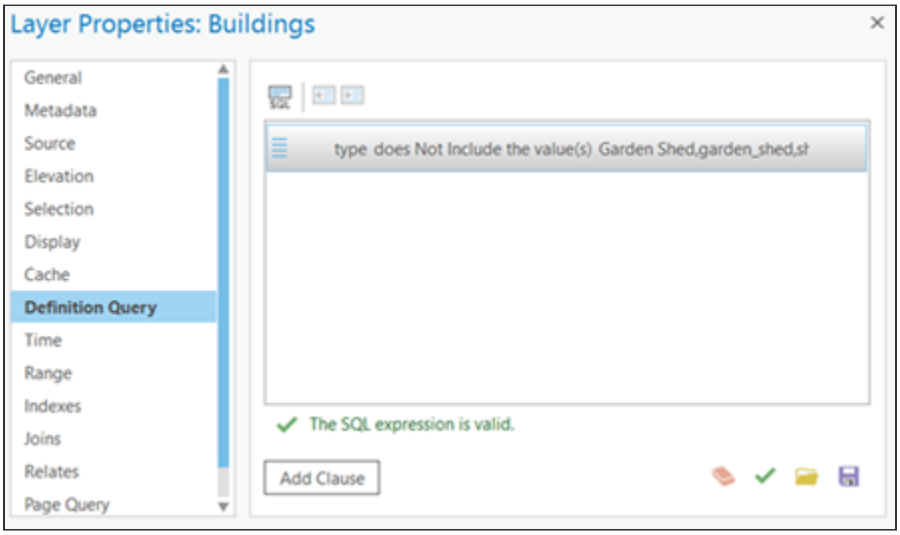
c. Open the layer properties for the Buildings layer, and click the Definition Query tab.

d Click Add Clause to build the following query:

- For the first field, choose Type.
- For the operator, choose Does Not Include The Value(s).
- From the Values drop-down list, check Garden Shed, garden_shed, and shed.

Note: Because OpenStreetMap included user-contributed data, standardization in attribution is sometimes missing, which is why you see variations in capitalization and punctuation.

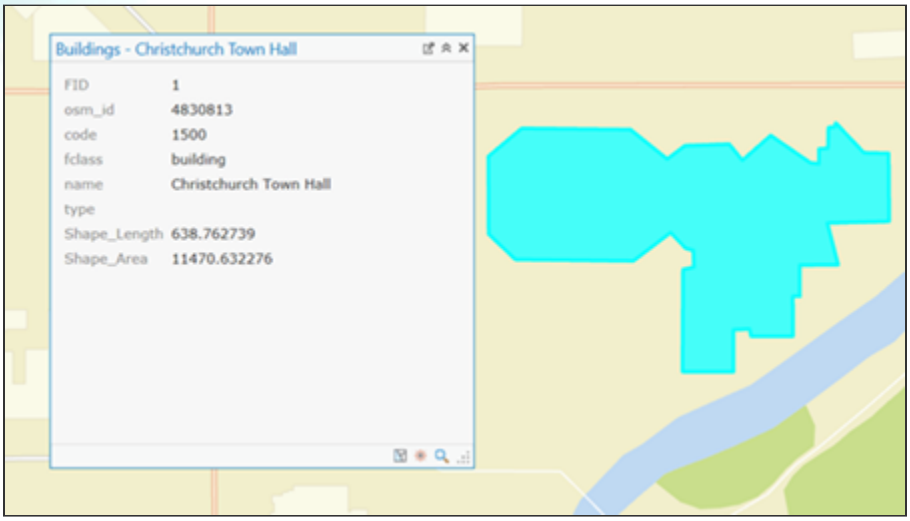
e Click Add, and then click the green check mark to validate the expression.



f Click OK to close the Layer Properties dialog box.

This action gets rid of a handful (about 4,000) of relatively insignificant features. However, if you inspect the large concentrations of buildings in the populated places, you'll see that many very small building features are still shown. Many of these features have no value for the Type field.

Hint: With the Explore tool active, zoom in and click a building to see a pop-up window with its attribute values.



You can add to the definition query to also eliminate very small buildings, based just on their size.

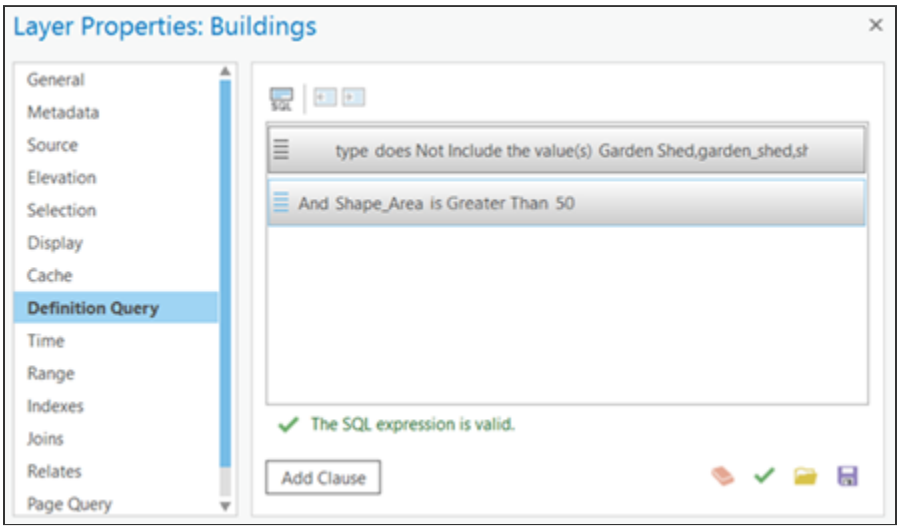
g Close the pop-up window.

h Open the Buildings layer properties again.

On the Definition Query tab, the clause that you added is still active. You will add another clause.

i Click Add Clause, and create the following clause: `And Shape_Area Is Greater Than 50`.

j Click Add, and then verify that the expression is valid.



k Click OK to close the dialog box.

Adding this clause filters about 83,000 building features from the original data set, but the overall character, distribution, and density of the buildings are still visually apparent.

Step 5: Limit the scale range of a layer

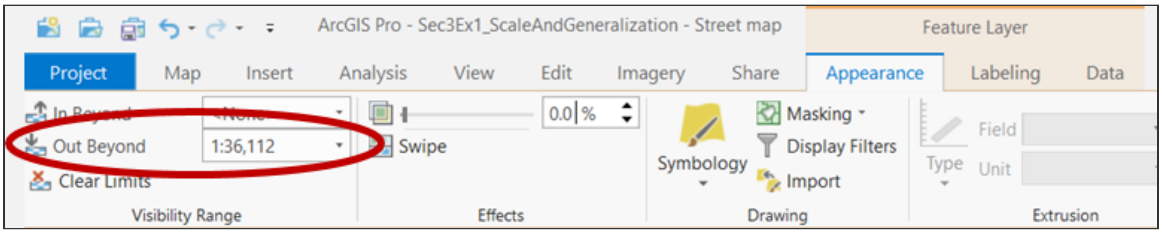
In addition to limiting the features that appear in a layer with a definition query, you can limit the scale range (https://bit.ly/2v6967c), or scales at which a layer is visible on a map. This is another way to ensure that only an appropriate amount of detail is shown at smaller scales. The Buildings layer is an obvious choice for imposing this sort of limit. The buildings are very detailed and don't add much to the smaller-scale views of the country. And, the map already includes an Urban Area layer for a general overview of where the inhabited places are.

So, in addition to having thinned many insignificant structures from the Buildings layer, you'll now remove all buildings at the smaller scales of your map using a scale range. Scale ranges can be open on either end of the range (*"only show this layer at smaller scales than this"* or *"only show this layer at larger scales than this"*), or can be constrained on both ends.

a In the Contents pane, ensure that the Buildings layer is selected.

Note: You will use the Appearance tab, which is contextual. This means that the tab only displays under certain circumstances. This tab in particular only appears if a certain layer is selected in the Contents pane.

b From the Appearance tab, in the Visibility Range group, use the drop-down menu to set the Out Beyond visibility to 1:36,112.



This limits the display of the buildings to scale ranges smaller than 1:36,112.

Note: These numbers are not round numbers because they relate to a tiling scheme. You will learn more about tiling schemes in the final section of this exercise.

c Zoom in and out on the map to see when buildings are visible and when they aren't.

Note: In the Contents pane, the checkbox next to the Buildings layer will become gray when you are zoomed outside of the scale range you specified.

Controlling which features are shown at which scales

Cartographers commonly make multiple copies of a feature layer in a map. They then combine these two techniques—definition queries and scale ranges—to get more control over which features are shown at which scales. A unique definition query and a scale range are set on each layer copy so that it displays differently at different scales.

While this can be an effective approach, it is cumbersome to maintain multiple layers of the same features as it involves a lot of duplicated effort and data. There are two other approaches to use to avoid this duplication of layers: display filters and scale-based symbology.

Step 6: Work with display filters

In the case of the buildings, the way that they are filtered is independent of how they are symbolized. The buildings are all symbolized the same way with the symbol defined with Single Symbol symbology. In this case, instead of making duplicate layers with unique scale ranges and definition queries, you can set up display filters to get more control over which buildings are shown at which scales. Display filters allow you to specify the query in clauses the same way, but also specify a scale range, all on a single layer.

In this step, you will use display filters to control the display of buildings at different scales.

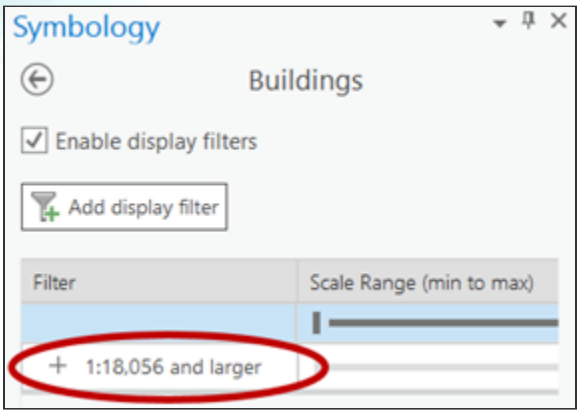
a. Clear the scale range and definition query that you previously established on this layer.

Hint:

- *Scale range: Select the Buildings layer, and on the Appearance tab on the ribbon, in the Visibility Range group, click Clear Limits*  .
- *Definition query: In the Contents pane, double-click the Buildings layer, and on the Definition Query tab of the Layer Properties dialog box, click Clear Expression*  .

b. With the Buildings layer selected, from the Appearance tab, in the Drawing group, click Display Filters.

c. In the Symbology pane, double-click <all features>, replace it by highlighting the text and typing **1:18,056 and larger**, and then press Enter.



d. To the left of the filter text, click the plus sign + to show the query window.

Next, you will create a query in the same manner that you created the definition query earlier.

e. Click Add Clause to build the first query as follows: `Type Does Not Include The Value(s) Garden Shed, garden_shed, shed.`

f. Click Add, and then click Add Clause to add the second part of the query: `And Shape_Area Is Greater Than` **50**.

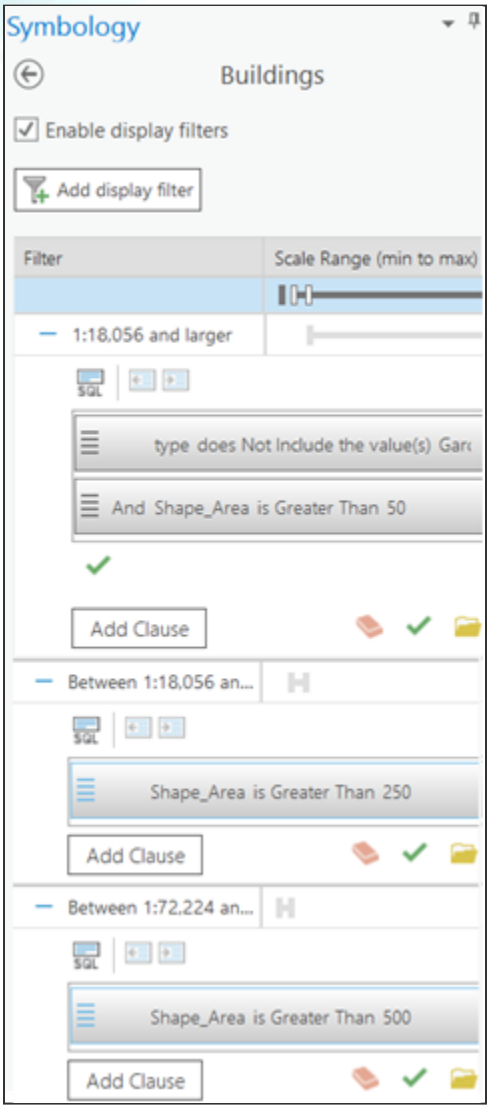
g. Click Add.

h. Click Add Display Filter twice to add two additional display filters. Set up the filter names and their definition query clauses as specified in the following table.

Note: You already input the first entry.

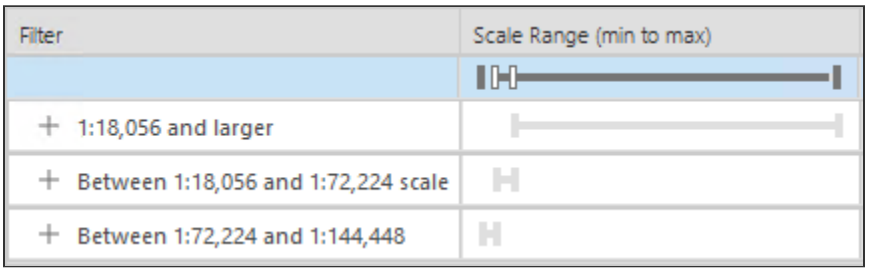
Scale range display filter	Definition query clause
1:18,056 and larger scale	Show all buildings larger than 50m^2 that are not sheds.
Between 1:18,056 and 1:72,224 scale	Show all buildings that are larger than 250m^2
Between 1:72,224 and 1:144,448 scale	Show all buildings that are larger than 500m^2

Note: The display filters should look like the following graphic when you are done.

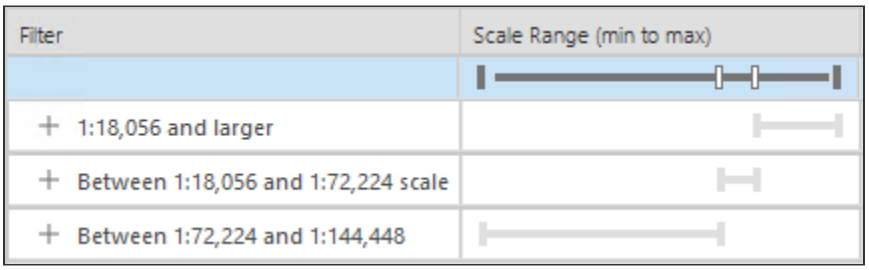


Once you've verified the naming of each display filter and the clauses, collapse each filter.

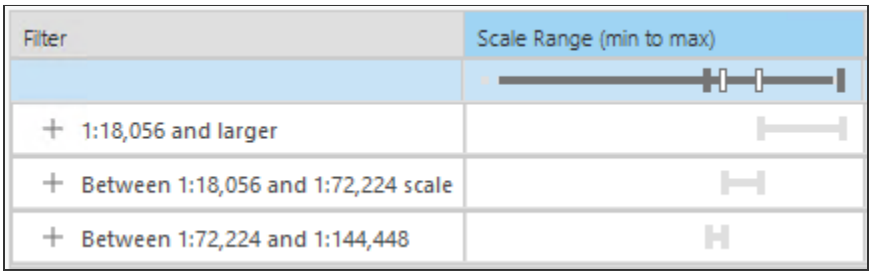
Hint: *Click the minus sign* *to the left of the filter.*



j. Move the two hollow sliders at the top of the grid to correspond to the scale ranges specified in the display filter names. You can either click-drag the slider stops until the tooltip matches the correct boundary scale, or you can pick the boundary scales (1:18,056 and 1:72,224) from the drop-down menus that appear when you click a hollow stop. When you are finished, it should look like this



k. Move the minimum scale stop (the left-most solid stop) to 1:144,448. Now the scale ranges for each display filter are set to match their names.



l. Zoom in and out on the map.

Observe how display filters control visibility of features in the map at different scale ranges based on the queries that you just created.

Step 7: Work with scale-based symbol classes

Another approach to limit the amount of detailed data displayed at smaller scales without having to make multiple versions of a layer, each with a different definition query, is called scale-based symbology. When a layer is symbolized with either unique-value or graduated-color symbology, you can specify the visible scale range for each symbol class.

In your map, roads are symbolized by road class. In this case, you can set scale ranges directly on the symbol classes.

a. In the Contents pane, if necessary, turn on the Roads layer and expand the layer to see its symbology for the different types of roads in the data.

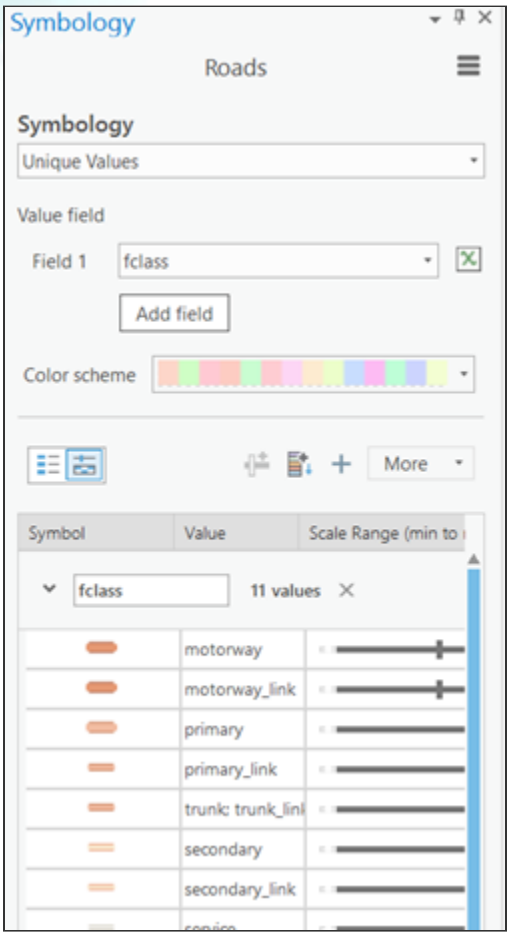
b Zoom in and out in various areas (including urban areas) to see how additional road classes appear as you move into larger scales.

c Open the Symbology pane for the Roads layer.

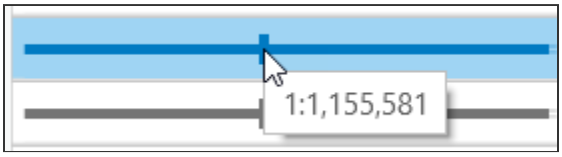
Hint: Right-click Roads and choose Symbology.

d Investigate the way that the road classifications are designed and symbolized.

e In the Symbology pane, click the Scale Range View button.



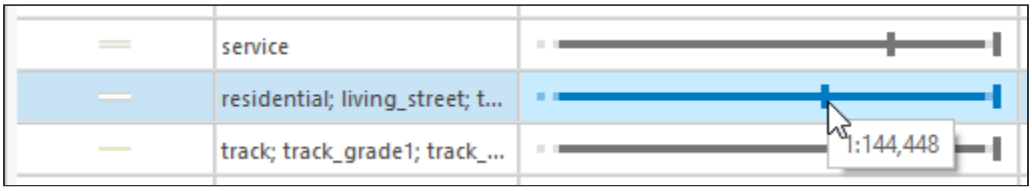
f Investigate the scale ranges on each road class by hovering the pointer over each stop to see the scale range boundaries. Do not click on them or move them.



Note: In the Scale Range column, hover your pointer over the stops (vertical bars) on the slider to view the values. You may need to expand the width of the Symbology pane or scroll to the right to see the slider.

Note that the Residential road class (third from the bottom) is set to show at all scales. This setting is obviously too much detail at smaller scales, and inconsistent with the way that the other road symbol classes are defined.

g Use the scale stops on the slider to adjust the scale range of the Residential roads so that they appear only from 1:144,448 to infinity (none) at the largest scales.

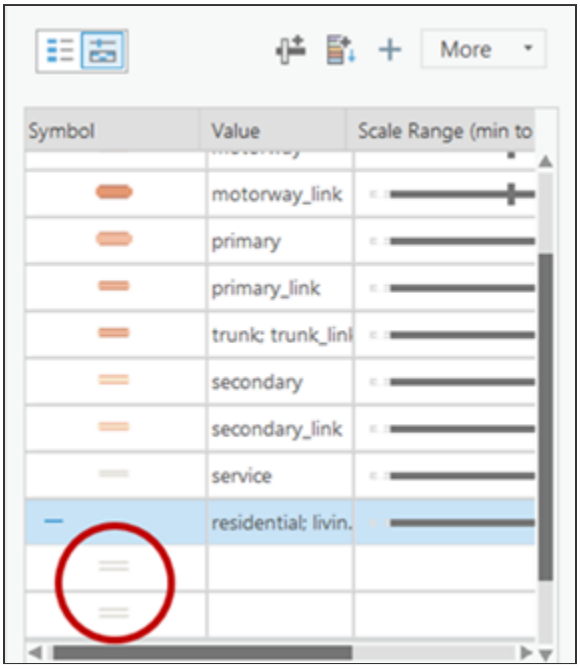


h From the Map tab, in the Navigate group, click Bookmarks and choose the Wellington bookmark.

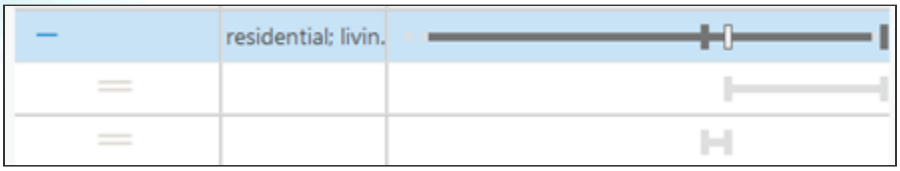
Note that there is a range of scales from 1;144,000 to 1:72,000 where it would be nice to show the residential roads, but they are too detailed as cased roads. They would be better as simple single solid lines. You can modify the symbol class symbology to accomplish this.

i In the Symbology pane, while still in the Scale Range View, highlight the Residential Roads class and click the Add Alternate Symbol button .

Now there are two identical symbol classes, both with different scale ranges.



j If necessary, adjust the scale boundary between these two by dragging the hollow scale stop to 1:72,224.



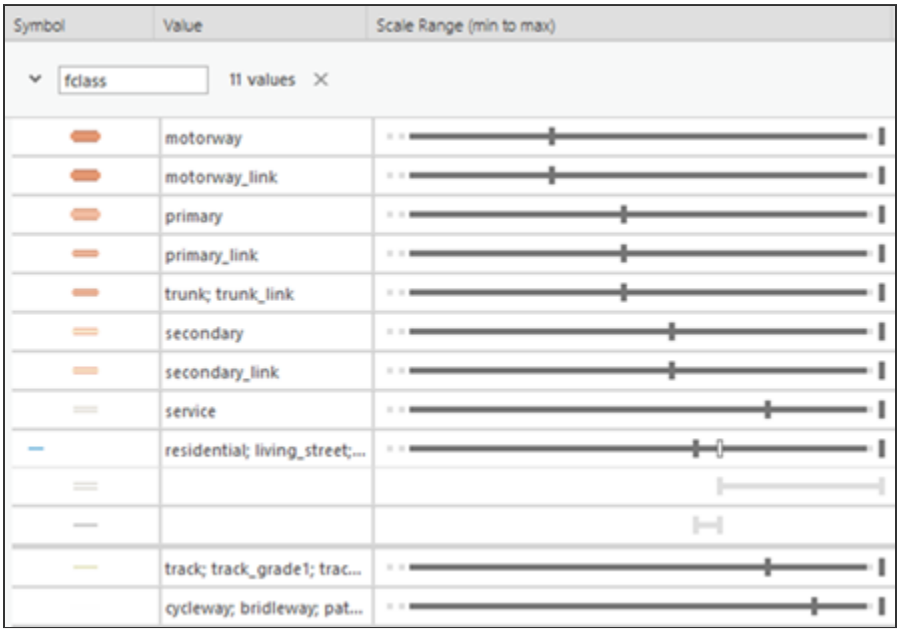
k. Click the symbol of the second duplicated class to change it. (This is the one that is set to a 1:444,448 to 1:72,224 scale.)

l. Use the options on the Properties tab to change the symbol so that it has only a solid stroke layer that is 1 pt wide and colored Gray 30%.

Hint: Use the Structure tab (the third tab) to delete one of the two stroke symbol layers. Then use the Layers tab (the middle tab) to adjust the properties of the remaining stroke symbol layer.

m. Click Apply, then use the Back arrow to return to the Symbology pane.

Your symbol classes should look like the following graphic.



n. Zoom in and out on the map through the scale ranges and note how the residential roads are drawn with a different symbol at different scales.

Notice how the same road features are symbolized differently depending on the scale. At the largest scales, they are cased roads. At medium scales they are a simple gray line, and at the smallest scales, they are not drawn at all.

o Close the Symbology pane.

So far, managing which features are shown at which scales with which symbols got you to a decent multiscale map. (Ideally, you'll eventually work this magic on all the map layers, not just the Roads and Buildings layers. See the Stretch Goals section at the end of this exercise.)

Part 2: Generalization

In this section, you'll learn about the process of generalization (https://bit.ly/2JCFscT), which evaluates and alters the actual features themselves.

Generalization is a broad term that encompasses many operators that transform the data. There are different classifications and accountings of all the possible generalization operators and their nuances, but they can be generally categorized as the following:

- **Eliminate**: Remove inessential features or feature detail.
- **Simplify**: Remove inessential feature complexity.
- **Exaggerate**: Enlarge or enhance representative feature detail.
- **Aggregate**: Combine unique features together to form a homogeneous collection.
- **Displace**: Reposition details or features to reduce graphic conflict, simplify, or exaggerate.

In ArcGIS Pro, generalization processes are run as geoprocessing tools (https://bit.ly/ 2HbTiV9). Geoprocessing typically makes copies of input layers and transforms those copies.(In some cases, the input layer itself is modified.) The power of geoprocessing is that these processes can be linked together so that the output of one process becomes the input of another, and so on. These workflows can be performed by opening the tools in ArcGIS Pro, supplying parameter information, and running them. Or, after you've worked out the details of a complex workflow, you can run them from ModelBuilder, a visual programming language for building geoprocessing workflows, or as a script.

Although seemingly contradictory (simplify *and* exaggerate?), these operations are often employed in conjunction with one another, sometimes in quite detailed workflows. For this exercise, you will apply the process of generalization to the Vegetation layer to simplify the vegetation polygons to show less detail in the forest stands at smaller scales.

Step 8: Simplify vegetation polygons

a In the Contents pane, turn on the Vegetation layer, if necessary, and expand the layer to see its symbology.

This layer is currently set to draw at all scales.

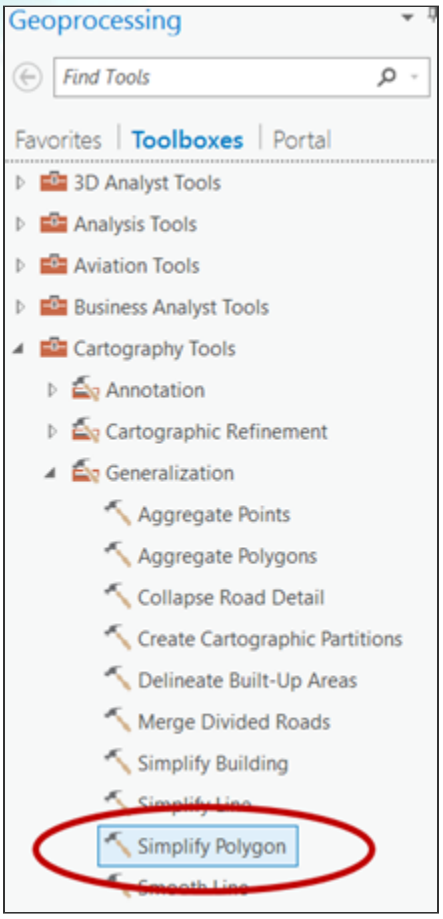
b. Zoom in and out in various areas across the map to get a feel for how detailed the vegetation polygons are.

You will use a generalization geoprocessing tool called Simplify Polygon (https://bit.ly/ 2v3qZUb) to simplify this layer for use at smaller scales. As before, the goal is to limit the detail and complexity at smaller scales subtly enough to not be readily noticeable.

c. On the Analysis tab, in the Geoprocessing group, click Tools to open the Geoprocessing pane.

d. On the Toolboxes tab, expand the Cartography Tools toolbox.

e. Expand the Generalization toolset, and click the Simplify Polygon tool to open it.

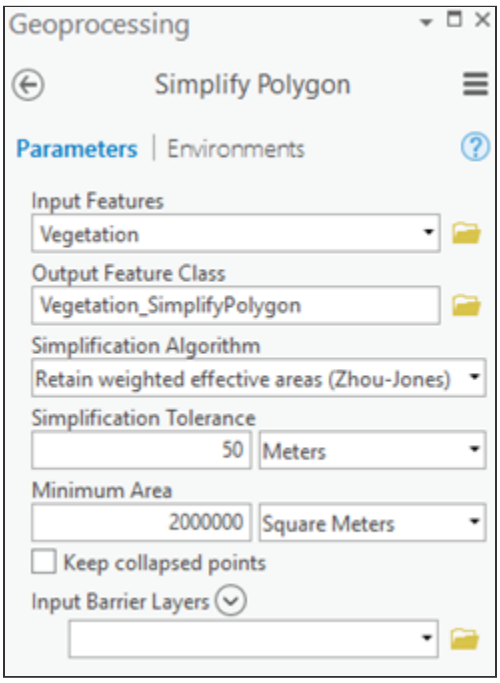


f Set the parameters as follows:

Parameter	Value
Input Features	Vegetation
Output Feature Class	**Vegetation_SimplifyPolygon**
Simplification Algorithm	Retain Weighted Effective Areas (Zhou-Jones)
Simplification Tolerance	**50** meters
Minimum Area	2000000 square meters
Keep Collapsed Points	Unchecked
Input Barrier Layers	Leave blank

Note: Keep the data path for the Output Feature Class as is; just rename the feature class.

The completed parameters pane should look like the following graphic.



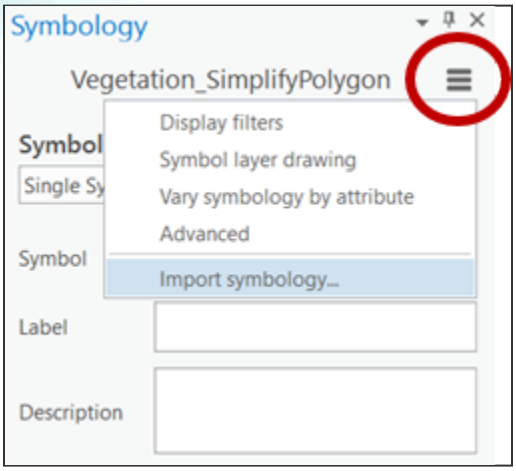
g Click Run to execute the tool.

Execution may take a few minutes. The bottom of the Geoprocessing pane shows the tool's progress. After the process has completed successfully, you will see a confirmation message.

The Vegetation_SimplifyPolygon layer should be highlighted in the Contents pane.

h From the Contents pane, open the Vegetation_SimplifyPolygon layer's Symbology pane.

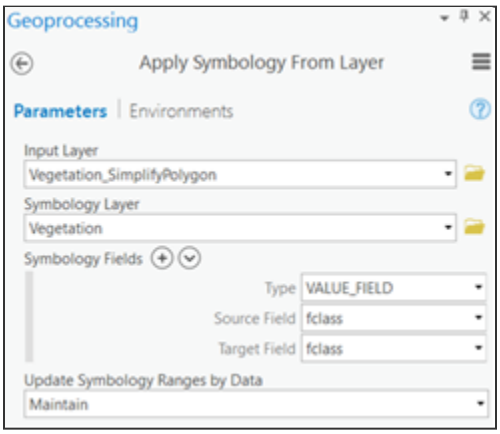
i At the top of the Vegetation_SimplifyPolygon pane, click the menu button and choose Import Symbology to open the Apply Symbology From Layer tool.



j Set the parameters as follows:

Parameter	Value
Input Layer	Vegetation_SimplifyPolygon
Symbology Layer	Vegetation
Type	VALUE_FIELD
Source Field	fclass
Target Field	fclass
Update Symbology Ranges By Data	Maintain

The completed parameters pane should look like the following graphic.



k Click Run to execute the tool.

Note: You may need to zoom in to see the result.

The symbology and grouping from the Vegetation layer is applied to the simplified vegetation layer.

I Use what you have learned so far to apply scale ranges to the two layers, Vegetation and Vegetation_SimplifyPolygon, so that vegetation polygons appear in appropriate detail across the scale ranges of the map.

Hint: On the Appearance tab, use the fields in the Visibility Range group. The original polygons are detailed and therefore suitable for the largest scales (zoomed in close) in your map. The simplified polygons are better suited for the smaller scales (zoomed out far).

Challenge:

1. Run the Simplify Polygon tool on the Vegetation layer again, this time with different values for Simplification Tolerance and Minimum Size, and a unique output feature class name.
2. Use scale range visibility to manage the display of the three layers across the scales of your map.

m. Zoom in and out on the map to see how simplifying the vegetation polygons affects the display of features at different scales.

There are many other generalization tools (https://bit.ly/2GRk2He) and processes that are appropriate for other layers in the map. Learn more and experiment as you wish.

Part 3: Vector Tiles

A multiscale map like the one that you are making is often used as a basemap (https://bit.ly/ 2v1YAxE). It becomes a backdrop for other content and needs to be functional across scale ranges. Traditionally, basemaps are made as a series of image tiles for each scale. This works well but has some limitations:

- Image tiles are large. They take a long time to create and use up a lot of storage space. This means that they are cumbersome to update.
- Labels and symbols are embedded into the tiles as pixels (https://bit.ly/2jII0QB). So, rotating the map means that there will be labels that are difficult to read. Changes to labels or symbols mean recreating the tiles.
- Image tiles have an inherent resolution (https://bit.ly/2HIlDzI), so they may not render crisply on high-resolution displays.

For this exercise, you will make vector tiles instead. The resulting tiles can be used in a web map or a web app, but you will bring them back into ArcGIS Pro as a single vector tile basemap layer for use with other operational data.

Step 9: Create vector tiles

Next, you'll publish a web layer of vector tiles of your map.

a. In the Contents pane, click the Street Map item at the top to select the whole map.

b. On the Share tab, in the Share As group, click the Web Layer down arrow and choose Publish Web Layer.

c. In the Share As Web Layer pane, on the General tab, in the Name field, type your first and last name at the end of the layer name.

Note: The layer name needs to be unique, since all students are saving their map as a web layer to the same ArcGIS Online organization.

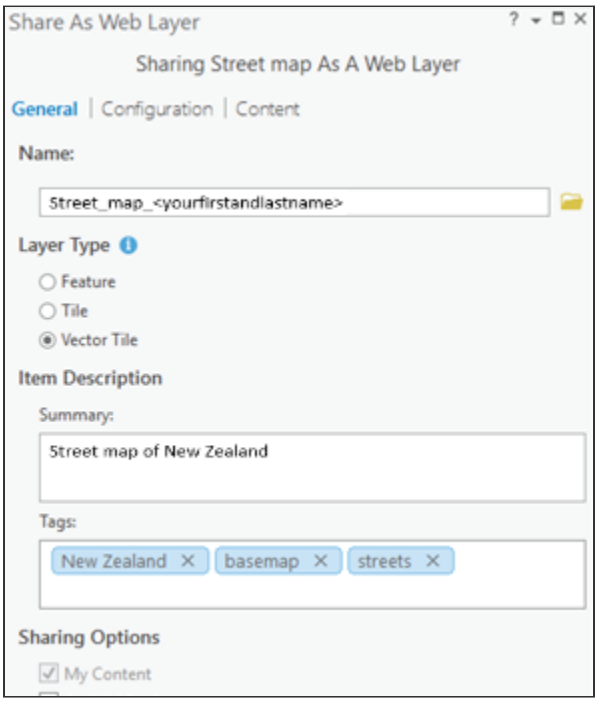
d. Under the Layer Type heading, choose Vector Tile.

e. Type a summary for your street map, such as **Street map of New Zealand**, and any tags you'd like.

Note: Tags already include New Zealand, basemap, and streets, but you can choose to add more.

f. In the Sharing Options section, accept the default value of My Content. This will save the web layer to your Content collection in ArcGIS Online.

The General tab should look like the following graphic.



g. At the top of the Share As Web Layer pane, click the Configuration tab.

h. For Tiling Scheme, choose ArcGIS Online / Bing Maps / Google Maps.

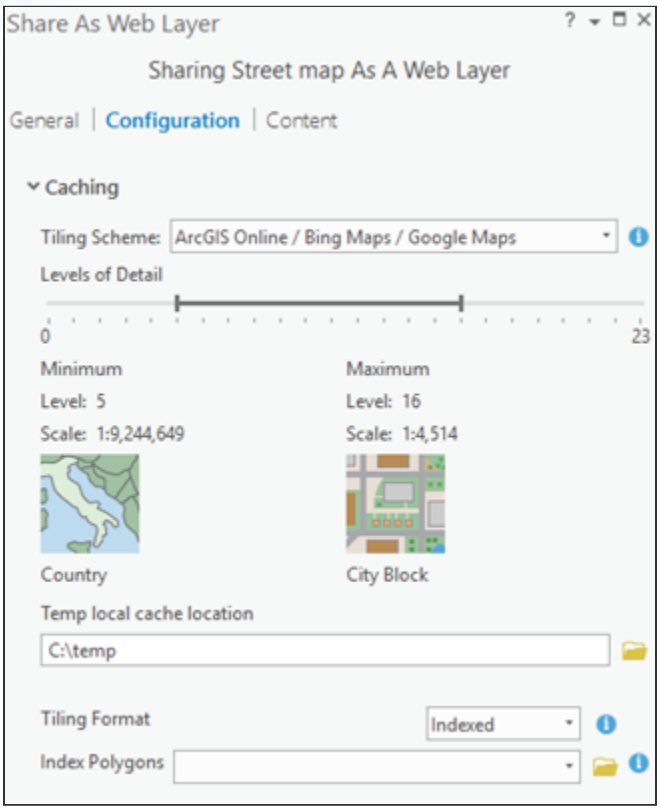
Because you are working with just New Zealand and not the whole world, you can reduce the scale range for which you'll generate tiles.

i. Slide the first stop on the Levels Of Detail slider to the right to select a Minimum level of detail of Level 5 (1:9,244,649).

j. Slide the other stop on the slider to the left to select a Maximum level of detail of Level 16 (1:4,514).

k. Set the Tiling Format to Indexed, if necessary.

The Configuration tab should look like the following graphic.



Note: Your Temp Local Cache Location will be filled in automatically.

l. Click Analyze.

Analyzing identifies any potential performance delays and errors.

m. Click Publish to create the vector tile package and save the web layer.

Note: This may take a few minutes. When the process is complete, you will see a message that indicates that the web layer was successfully published.

n. Save your project.

o. Close all the panes except the Contents and Catalog panes.

p. At the top of the map view, on the Street Map tab, click the X to close the project, but keep ArcGIS Pro open.

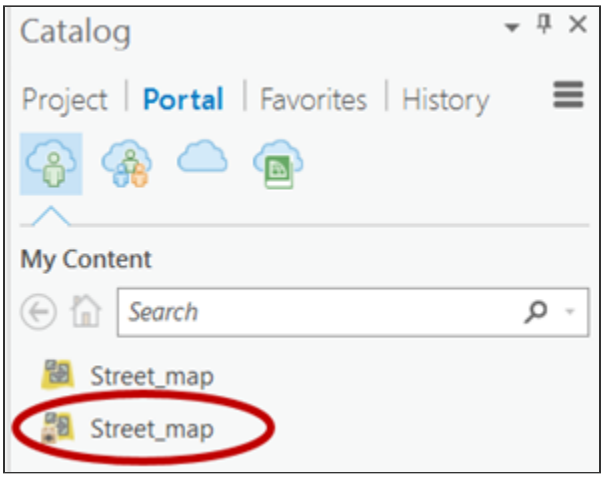
Step 10: Use vector tiles as a basemap in ArcGIS Pro

Now that the New Zealand map that you made exists as a vector tile package (.vtpk) on your portal, you can use it to make a new basemap in ArcGIS Pro.

a. On the Insert tab, in the Project group, click the New Map down arrow and choose New Basemap.

b. In the Catalog pane, on the Portal tab, find the vector tile package that you generated in the previous step and drag it into the map.

Note: You will see both a vector tile layer (https://bit.ly/2hc6NWB) and a vector tile package (https://bit.ly/2HbYOHi) with the same name. Hover your pointer over each of the items to locate the vector tile package.



Note: Because tiles were only generated for levels 5 - 16 to reduce processing time and data size, you need to be over New Zealand and zoomed in to at least Level 5 (1:9,244,649) to see anything. You can zoom in to a scale of 1:9,244,649 and pan around the map.

c. In the Contents pane, rename Basemap to **New Zealand Basemap**.

Now you can create a new map and use this as the basemap.

d. On the Insert tab, in the Project group, click the New Map down arrow and choose New Map.

e. On the Map tab, in the Layer group, click the Basemap down arrow.

f. Scroll to the bottom of the Gallery and choose New Zealand Basemap.

Note: As before, be sure you are zoomed in and then pan around the map.

The multiscale map that you made throughout this exercise is now ready to be used as a single background reference layer to any operational layers that you choose to add to it.

g. Save your project.

Conclusion

In this exercise, you've learned how to manage and manipulate the display and appearance of symbolized features at different scales. You've been introduced to the basics of generalization geoprocessing, and you've learned how to create vector tiles from a multiscale map to use as a reference layer for other content.

Stretch Goals

- Apply what you learned to further process other layers in the map. Reference: Author a multiscale map (https://bit.ly/2qmrbZ7)
- To simplify the exercise and keep redraws efficient, labeling is paused on this map. However, a detailed reference map of this nature requires labels. Unpause the labels and apply what you learned about scales and appropriate feature density to work with the labels on the map. References: Labeling basics (https://bit.ly/2JzVLHv) and Label classes (https://bit.ly/2v49KSx)
- Make a layout that shows the north island only, but with an inset of Auckland and an overview map of all New Zealand, showing appropriate detail, content, and labels for each. Reference: Add and modify map frames (https://bit.ly/2EASbt4)
- Download OpenStreetMap data for another part of the world and make your own multiscale map using these techniques.

Use the Lesson Forum to post your questions, observations, and map examples.