TUTORIAL 5 | USING CENSUS DATA

Goals

- Parse regional and local census data.
- Link census data to TIGER shapefile.
- Examine opportunities and limitations of census data.
- Compare variables across time.
- Produce choropleth map of chosen census feature.
- Add multiple maps at different scales to a print layout.

Introduction

In this tutorial, you'll be looking at State and City census data. You will look at the decennial census's racial information, and compare that data 1) between geographies (contextualize your city within the state), and 2) between years (contextualize today). In this tutorial we'll only use one census question: P1, the race question. We will not also be looking at H1, the ethnicity question (hispanic or non-hispanic), but keep in mind that the P1 question does not consider ethnicity, so it presents a limited picture of diversity.

As you've learned GIS data typically has two components: the data itself, usually in spreadsheet form, and the geographical shape that the data links to. The shapefiles are vectors, which means they are defined as points connected by lines (eg, the outline of a census district or building). Each polygon within a shapefile has an associated ID number. The data spreadsheet will have a corresponding ID column that links data (aka "attributes") with shape.

To use the Census data, we need to download both the shapefile (known as a TIGER/Line Shapefile. TIGER stands for Topologically Integrated Geographic Encoding and Referencing), and the spreadsheet of census information. The spreadsheet will link to the shapefile by associating their shared ID numbers. In this case, each polygon of a shapefile – whether a state, county, census district, and so on – has an official ID number. Typically, the counties within the state begin with the state's ID number, and the census tracts within the county begin with the county ID number, and so on. For instance, Virginia's ID number is 51, and Roanoke County's ID number is 51770 (51 + 770), and Roanoke's 10th Census Tract has ID number 517700010. Note that, because the ID numbers correspond to a certain size of data, you must also use the corresponding TIGER file. So, you must link county-level census data to the county-level TIGER shapefile.

The order of size is:
country > state > county > tract > block group > block

Census data is measured from the state level all the way down to the block level, which generally correspond to single city blocks. Not all data is available at every level. More importantly, the smallest level of data is not always the best for a given purpose. If you use block-level data when looking at a variable across an entire county, for instance, you won't be able to see meaningful patterns because the geographic unit is too small. Typically, you only want to use 1 or maybe 2 levels smaller of a dataset to look at patterns. So for instance if you are looking at data across the United States, you might look at the state or census tract level.

Note 1: your census data and shapefile year must match. The boundaries of geographical areas (census tracts, blocks, etc) CHANGE every 10-year census (so, your 2020 census data won't accurately match your 2010 shapefile). We'll be using both the 2010 and 2020 shapefiles in this tutorial to compare changes across the decades.

Note 2: the US government does a major, Decennial census every 10 years. The American Community Survey (ASC) supplements the major census by collecting annual data through a smaller, randomized poll that is then aggregated and used to predict the un-polled population changes. We'll use Decennial data in this tutorial, and talk more about the ACS in future tutorials.

Step 1: Download US Census shapefiles and data from the Data folder.

1a In the Data folder, you'll find the 2010 and 2020 TIGER/Line shapefiles for the state of Virginia, as well as for your individual city. Download both the "Virginia Census" folder, as well as the census folder for your city. As always, unzip and keep all files in all folders, both primary and helper files.

The state data we'll be looking at is broken down to the county level, and the city data is at the block group level. You'll see once you bring the data into QGIS that these scales make it easier to see patterns in the data. The folders you download contain both the shapefiles and the spreadsheet data, which you'll join in QGIS using their shared GeoID fields.

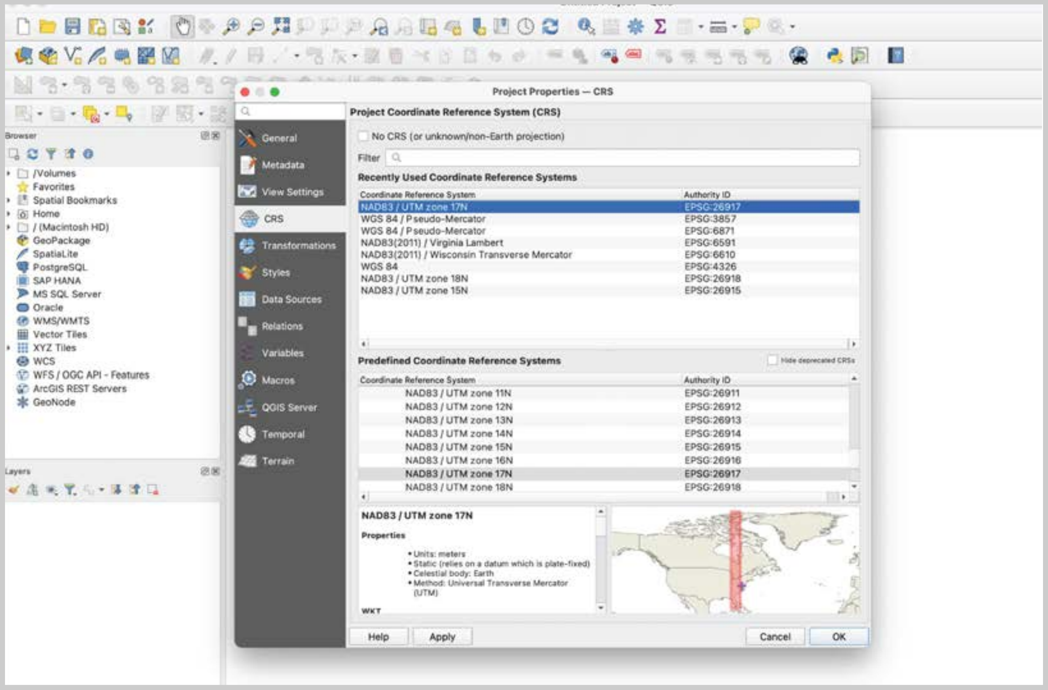
The Shapefile Data was downloaded from
https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html
and the csv files downloaded from
https://data.census.gov/

For more information on how to download and clean census data, which can be an involved process, see the later tutorial on this subject.

Step 2: Import the State data to QGIS.

2a Open a new QGIS file.

2b Set your **CRS** in Project > Properties to **NAD / UTM 17N**.



Project Properties — CRS

Project Coordinate Reference System (CRS)

□ No CRS (or unknown/non-Earth projection)

Filter

Recently Used Coordinate Reference Systems

Coordinate Reference System	Authority ID
NAD83 / UTM zone 17N	EPSG:26917
WGS 84 / Pseudo-Mercator	EPSG:3857
WGS 84 / Pseudo-Mercator	EPSG:6871
NAD83(2011) / Virginia Lambert	EPSG:6591
NAD83(2011) / Wisconsin Transverse Mercator	EPSG:6610
WGS 84	EPSG:4326
NAD83 / UTM zone 18N	EPSG:26918
NAD83 / UTM zone 15N	EPSG:26915

Predefined Coordinate Reference Systems □ Hide deprecated CRSs

Coordinate Reference System	Authority ID
NAD83 / UTM zone 11N	EPSG:26911
NAD83 / UTM zone 12N	EPSG:26912
NAD83 / UTM zone 13N	EPSG:26913
NAD83 / UTM zone 14N	EPSG:26914
NAD83 / UTM zone 15N	EPSG:26915
NAD83 / UTM zone 16N	EPSG:26916
NAD83 / UTM zone 17N	EPSG:26917
NAD83 / UTM zone 18N	EPSG:26918

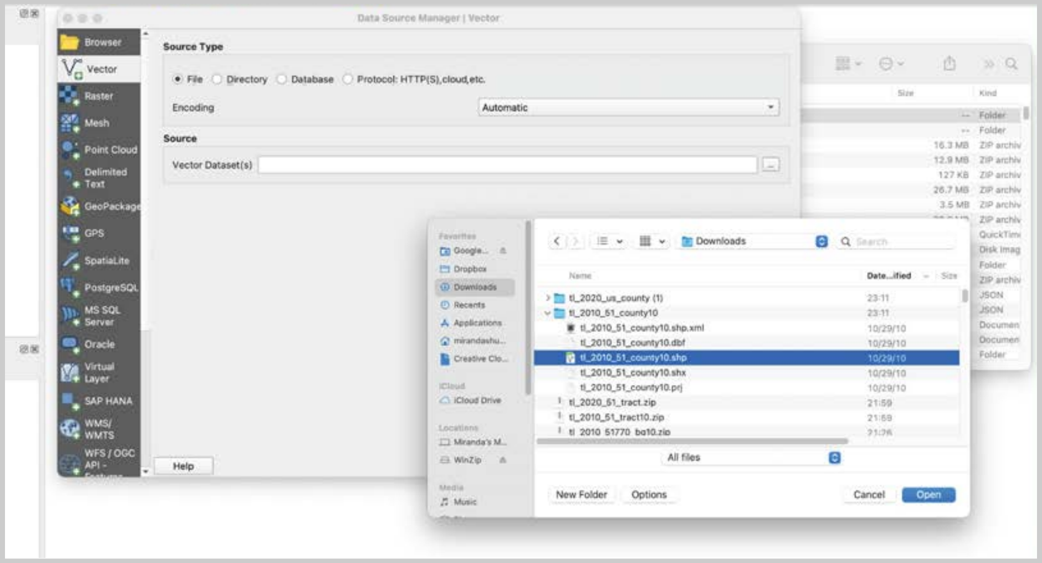
NAD83 / UTM zone 17N

Properties

- Units: meters
- Static (relies on a datum which is plate-fixed)
- Celestial body: Earth
- Method: Universal Transverse Mercator (UTM)

WKT

2c First, add the state of Virginia shapefiles. Go to **Layer > Add Layer > Add Vector Layer**… and select the 2010 shapefile. Click “Add”. Then, the 2020 shapefile and “Add”



Data Source Manager | Vector

Source Type

● File ○ Directory ○ Database ○ Protocol: HTTP(S), cloud, etc.

Encoding: Automatic

Source

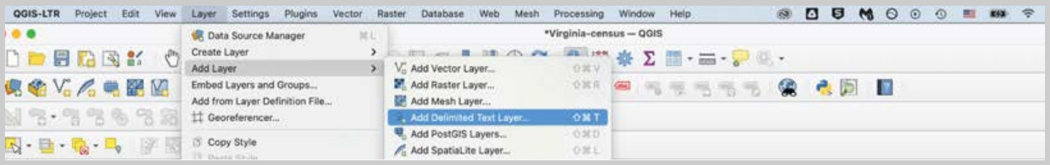
Vector Dataset(s)

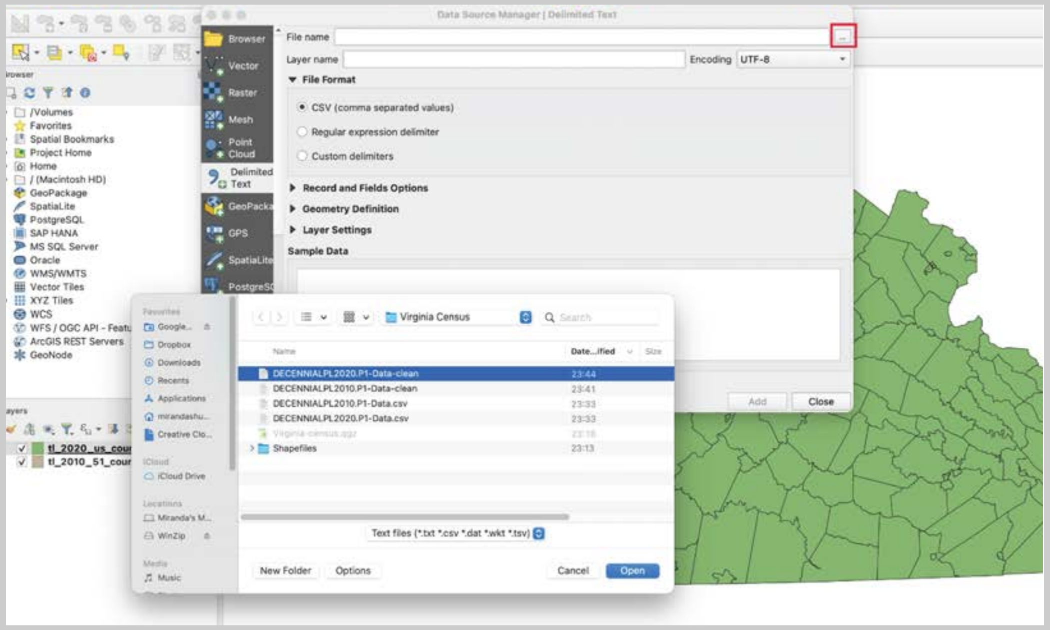
Downloads

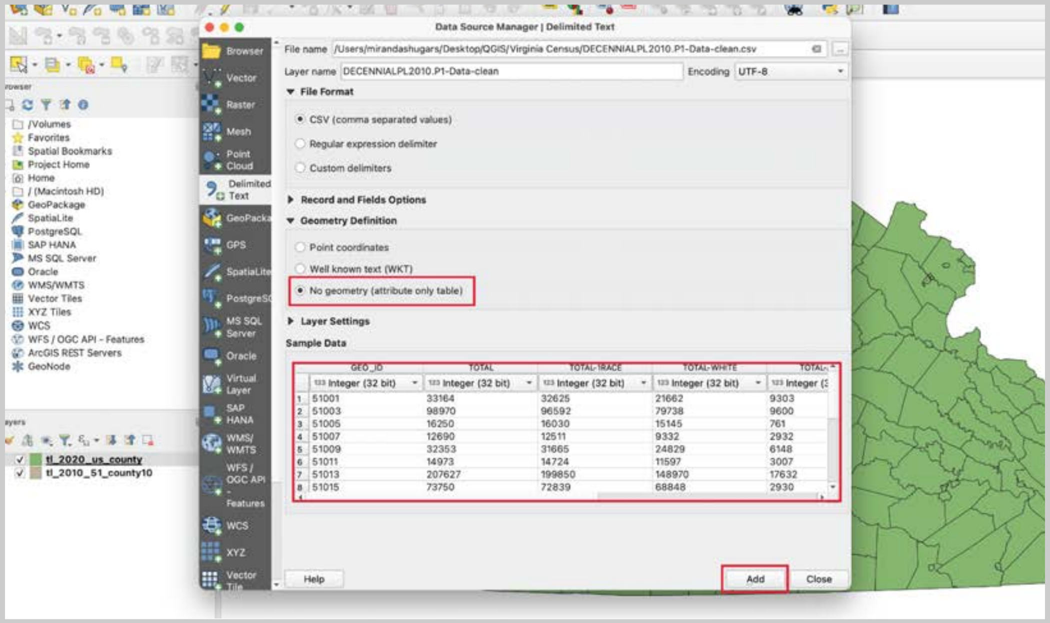
Name	Date...ified
tl_2020_us_county (1)	23:11
tl_2010_51_county10	23:11
tl_2010_51_county10.shp.xml	10/29/10
tl_2010_51_county10.dbf	10/29/10
tl_2010_51_county10.shp	10/29/10
tl_2010_51_county10.shx	10/29/10
tl_2010_51_county10.prj	10/29/10
tl_2020_51_tract.zip	21:59
tl_2010_51_tract10.zip	21:59
tl_2010_51770_bg10.zip	21:26

All files

2d Next, add the spreadsheet data, the .csv files, for the state. Go to **Layer > Add Layer > Add Delimited Text Layer** and select your **2010 and 2020** P1 csv files. Make sure that under “Geometry Definition” that **“No Geometry”** is selected. Check that the Sample Data display looks ok and click **“Add”**.




Data Source Manager | Delimited Text
File name
Layer name
Encoding UTF-8
File Format
CSV (comma separated values)
Regular expression delimiter
Custom delimiters
Record and Fields Options
Geometry Definition
Layer Settings
Sample Data
Virginia Census
DECENNIALPL2020.P1-Data-clean
DECENNIALPL2010.P1-Data-clean
DECENNIALPL2010.P1-Data.csv
DECENNIALPL2020.P1-Data.csv
Shapefiles
Text files (*.txt *.csv *.dat *.wkt *.tsv)
New Folder
Options
Cancel
Open
Add
Close



Data Source Manager | Delimited Text

File name /Users/mirandashugars/Desktop/QGIS/Virginia Census/DECENNIALPL2010.P1-Data-clean.csv

Layer name DECENNIALPL2010.P1-Data-clean

Encoding UTF-8

File Format

● CSV (comma separated values)

○ Regular expression delimiter

○ Custom delimiters

Record and Fields Options

Geometry Definition

○ Point coordinates

○ Well known text (WKT)

● No geometry (attribute only table)

Layer Settings

Sample Data

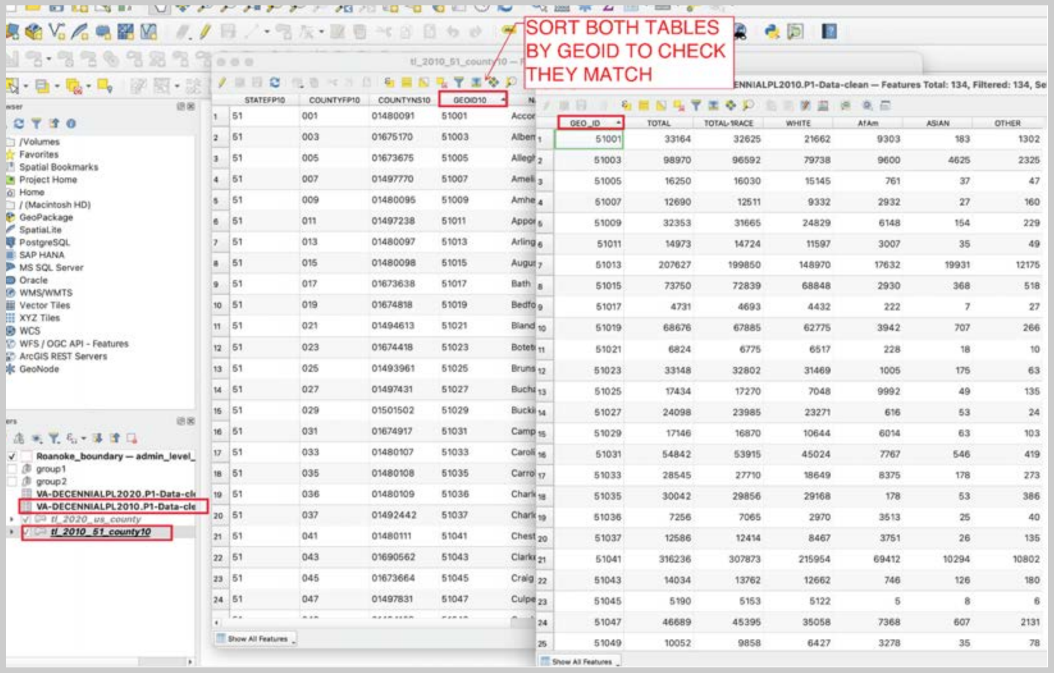
	GEO_ID	TOTAL	TOTAL-1RACE	TOTAL-WHITE	TOTAL-
	Integer (32 bit)	Integer (32 bit)	Integer (32 bit)	Integer (32 bit)	Integer (
1	51001	33164	32625	21662	9303
2	51003	98970	96592	79738	9600
3	51005	16250	16030	15145	761
4	51007	12690	12511	9332	2932
5	51009	32353	31665	24829	6148
6	51011	14973	14724	11597	3007
7	51013	207627	199850	148970	17632
8	51015	73750	72839	68848	2930

Step 3: Associate Census data with TIGER shapefiles.

3a First, we’re going to open the Attribute Tables of the shapefile layers and the data table (csv) layers and compare them. Open the Attribute Tables for the 2010 shapefile and the 2010 csv.

Look over the fields in both files. You’ll see that the shapefile has some standard information on county name, number, and area. The csv file has a few fields on racial information. In this tutorial we’ll only use the “White” and “Total” columns, but you might look at other racial breakdowns for your own final project. This csv file is significantly reduced from the file you download from the census factfinder website, which contains well over a hundred fields breaking down race into combinations of 1, 2, 3, or more racial identities, plus margins of error.

Notice that the csv also has an ID field: GEO_ID. If you align the two Attribute Tables side by side, you’ll see that this column matches the GEOID field in the shapefile. You can order both Attribute Tables by this column (click on the column name to sort the table) to check that the GEOIDs match. You will use this GEOID field to match the rows of data in the csv with the rows of data in the shapefile, thereby expanding the data associated with the shapefile geometry – along with area and name, this supplemental table will also add race information to the county shapes. Check that the GEOID column in the Attribute Tables in the 2020 files match as well.



SORT BOTH TABLES BY GEOID TO CHECK THEY MATCH

tl_2010_51_county10 — F

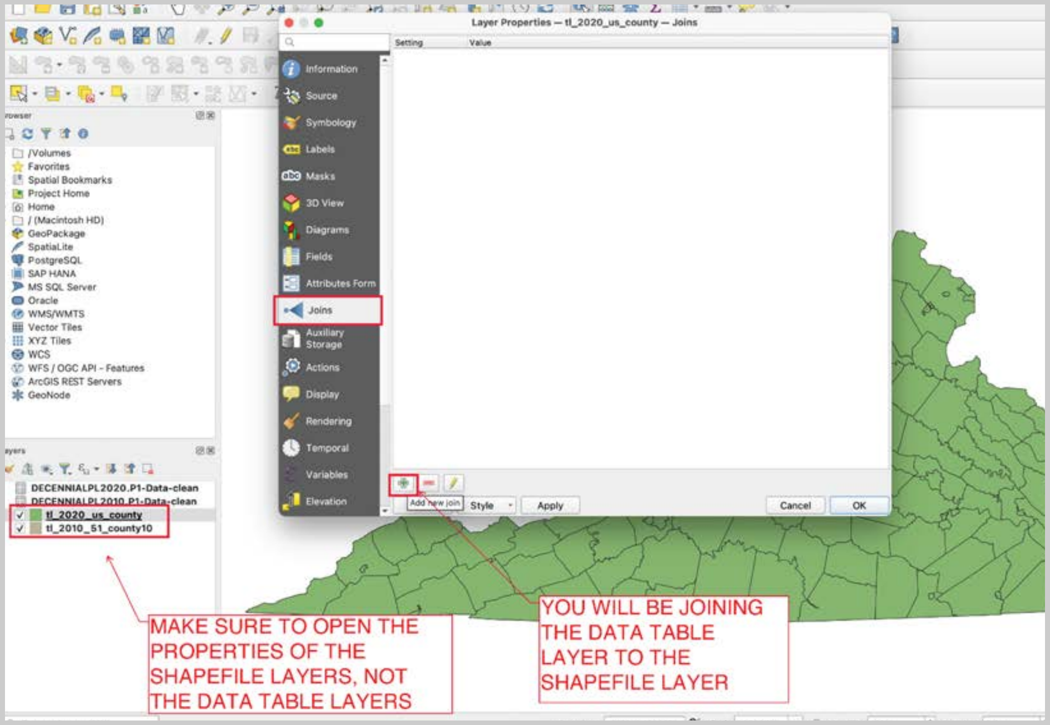
	STATEFP10	COUNTYFP10	COUNTYNS10	GEOID10	N
1	51	001	01480091	51001	Accor
2	51	003	01675170	51003	Alberr
3	51	005	01673675	51005	Alleg
4	51	007	01497770	51007	Ameli
5	51	009	01480095	51009	Amhe
6	51	011	01497238	51011	Appor
7	51	013	01480097	51013	Arling
8	51	015	01480098	51015	Augus
9	51	017	01673638	51017	Bath
10	51	019	01674818	51019	Bedfo
11	51	021	01494613	51021	Bland
12	51	023	01674418	51023	Botet
13	51	025	01493961	51025	Bruns
14	51	027	01497431	51027	Bucha
15	51	029	01501502	51029	Bucki
16	51	031	01674917	51031	Camp
17	51	033	01480107	51033	Caroli
18	51	035	01480108	51035	Carro
19	51	036	01480109	51036	Charl
20	51	037	01492442	51037	Charl
21	51	041	01480111	51041	Chest
22	51	043	01690562	51043	Clark
23	51	045	01673664	51045	Craig
24	51	047	01497831	51047	Culpe

ENNIALPL2010.P1-Data-clean — Features Total: 134, Filtered: 134, Se

	GEO_ID	TOTAL	TOTAL-1RACE	WHITE	AfAm	ASIAN	OTHER
1	51001	33164	32625	21662	9303	183	1302
2	51003	98970	96592	79738	9600	4625	2325
3	51005	16250	16030	15145	761	37	47
4	51007	12690	12511	9332	2932	27	160
5	51009	32353	31665	24829	6148	154	229
6	51011	14973	14724	11597	3007	35	49
7	51013	207627	199850	148970	17632	19931	12175
8	51015	73750	72839	68848	2930	368	518
9	51017	4731	4693	4432	222	7	27
10	51019	68676	67885	62775	3942	707	266
11	51021	6824	6775	6517	228	18	10
12	51023	33148	32802	31469	1005	175	63
13	51025	17434	17270	7048	9992	49	135
14	51027	24098	23985	23271	616	53	24
15	51029	17146	16870	10644	6014	63	103
16	51031	54842	53915	45024	7767	546	419
17	51033	28545	27710	18649	8375	178	273
18	51035	30042	29856	29168	178	53	386
19	51036	7256	7065	2970	3513	25	40
20	51037	12586	12414	8467	3751	26	135
21	51041	316236	307873	215954	69412	10294	10802
22	51043	14034	13762	12662	746	126	180
23	51045	5190	5153	5122	5	8	6
24	51047	46689	45395	35058	7368	607	2131
25	51049	10052	9858	6427	3278	35	78

NOTE: The reason you can’t join both 2010 and 2020 csvs to the same 2020 or 2010 shapefile is because the geographic boundaries of the census tracts, counties, blocks, and so on change slightly every decade. If you look closely, you’ll see differences between the 2010 and 2020 county shapefiles.

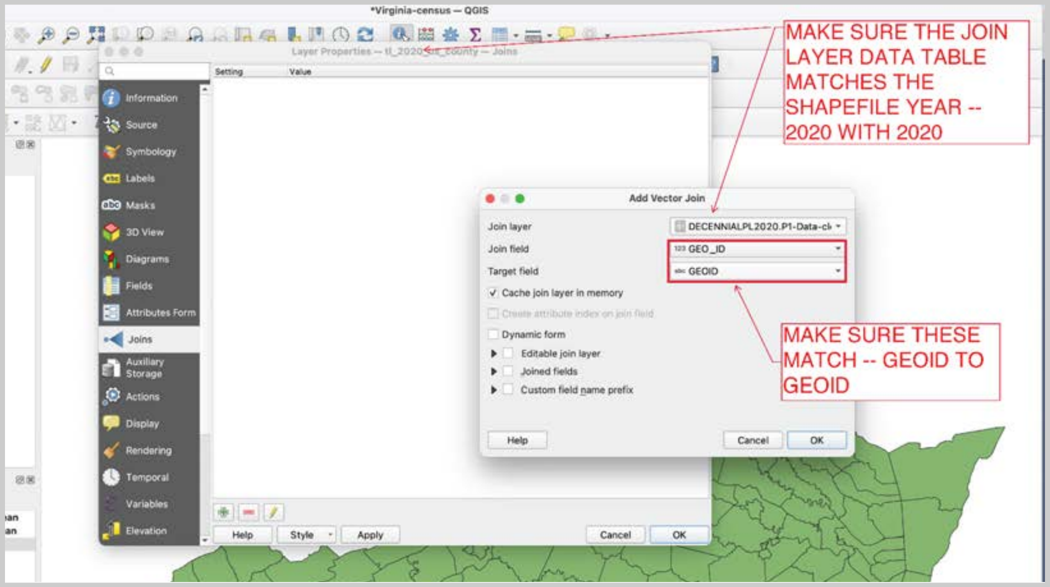
3b To join the csv with the shapefile, open the **2010 shapefile** Layer Properties (double click) and select the **“Joins”** tab (blue arrow). Click the “Add” symbol at the bottom.



MAKE SURE TO OPEN THE PROPERTIES OF THE SHAPEFILE LAYERS, NOT THE DATA TABLE LAYERS

YOU WILL BE JOINING THE DATA TABLE LAYER TO THE SHAPEFILE LAYER

Select the 2010 csv as your "**Join Layer**". Then make sure that the "**Join Field" and "Target Field"** are both set to **"GEOID".**

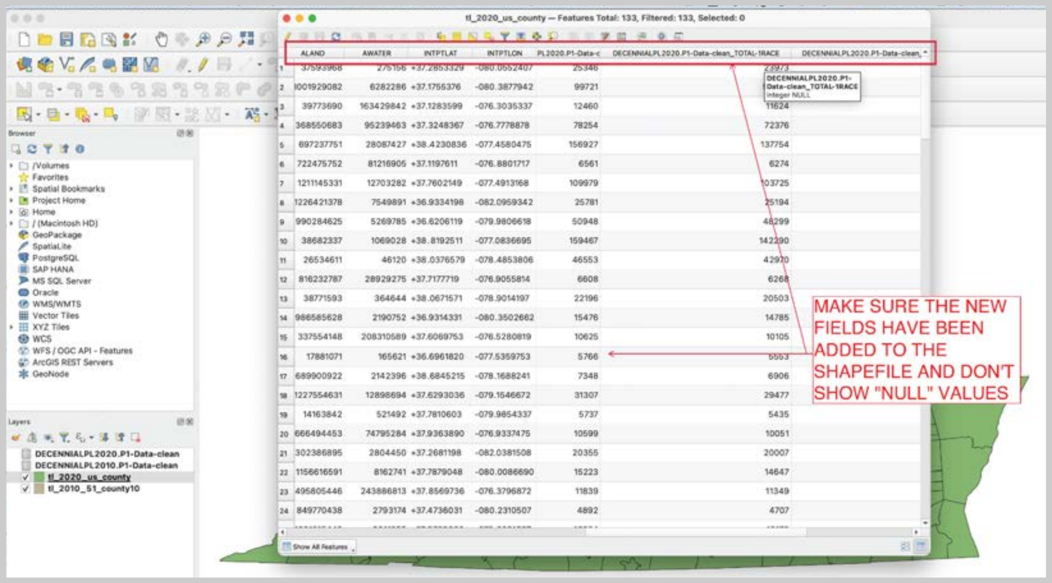


Join layer: DECENNIALPL2020.P1-Data-cl
Join field: GEO_ID
Target field: GEOID
☑ Cache join layer in memory
☐ Create attribute index on join field
☐ Dynamic form
☐ Editable join layer
☐ Joined fields
☐ Custom field name prefix

MAKE SURE THE JOIN LAYER DATA TABLE MATCHES THE SHAPEFILE YEAR -- 2020 WITH 2020

MAKE SURE THESE MATCH -- GEOID TO GEOID

3c Open the 2010 Shapefile Attribute Table, and make sure that you don't see "NULL" for the fields (this happens when the merge fails).



tl_2020_us_county — Features Total: 133, Filtered: 133, Selected: 0

	ALAND	AWATER	INTPTLAT	INTPTLON	PL2020.P1-Data-c	DECENNIALPL2020.P1-Data-clean_TOTAL-1RACE	DECENNIALPL2020.P1-Data-clean_
1	37593968	275156	+37.2853329	-080.0552407	25346	23973	
2	1001929082	6282286	+37.1755376	-080.3877942	99721	[illegible]	
3	39773690	163429842	+37.1283599	-076.3035337	12460	11624	
4	368550683	95239463	+37.3248367	-076.7778878	78254	72376	
5	697237751	28087427	+38.4230836	-077.4580475	156927	137754	
6	722475752	81216905	+37.1197611	-076.8801717	6561	6274	
7	1211145331	12703282	+37.7602149	-077.4913168	109979	103725	
8	1226421378	7549891	+36.9334198	-082.0959342	25781	25194	
9	990284625	5269785	+36.6206119	-079.9806618	50948	48299	
10	38682337	1069028	+38.8192511	-077.0836695	159467	142290	
11	26534611	46120	+38.0376579	-078.4853806	46553	42970	
12	816232787	28929275	+37.7177719	-076.9055814	6608	6268	
13	38771593	364644	+38.0671571	-078.9014197	22196	20503	
14	986585628	2190752	+36.9314331	-080.3502662	15476	14785	
15	337554148	208310589	+37.6069753	-076.5280819	10625	10105	
16	17881071	165621	+36.6961820	-077.5359753	5766	5553	
17	689900922	2142396	+38.6845215	-078.1688241	7348	6906	
18	1227554631	12898694	+37.6293036	-079.1546672	31307	29477	
19	14163842	521492	+37.7810603	-079.9854337	5737	5435	
20	666494453	74795284	+37.9363890	-076.9337475	10599	10051	
21	302386895	2804450	+37.2681198	-082.0381508	20355	20007	
22	1156616591	8162741	+37.7879048	-080.0086690	15223	14647	
23	495805446	243886813	+37.8569736	-076.3796872	11839	11349	
24	849770438	2793174	+37.4736031	-080.2310507	4892	4707	

MAKE SURE THE NEW FIELDS HAVE BEEN ADDED TO THE SHAPEFILE AND DON'T SHOW "NULL" VALUES

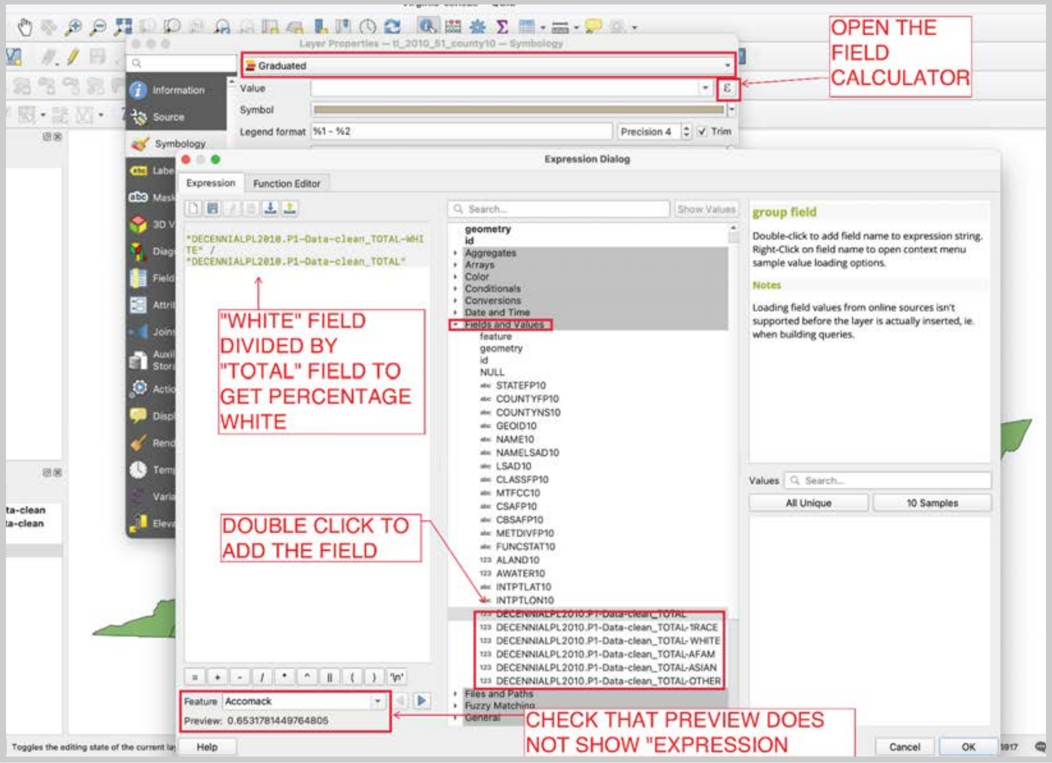
3d **Repeat** for the 2020 shapefile.

Step 4: Color map by percentage of white and nonwhite residents.

4a To get the percentage of white population, we need to divide the total number of white residents by the total number of residents (WHITE and TOTAL columns). We can do this using the field calculator. This field calculator allows you to manipulate one or multiple fields using algebra, but it also allows you to perform more sophisticated functions like converting text to numbers or using conditional statements (IF, THEN).

To open the field calculator, go to **Symbology** of your 2010 shapefile and select "**Graduated**". Click the **sigma (Σ symbol)** to the left of the "Value" field to bring up the Expression Dialog window. Here, you'll see all the possible functions in drop-down lists, as well as the "Fields and Values" of your layer. This is a useful way to easily see and add the fields in your Attribute Table without having to look up their exact wording every time. You can simply open up the "Fields and Values" section and double click to add your fields.

Add the "**White**" field, the division symbol (**/**), and then your "**Total**" field to get the percentage. You'll see it as a decimal number, which you can later convert manually to a percentage in your legend. To make sure you entered the formula correctly, check the "**Preview**" box near the bottom. If you see "Invalid Expression", re-check your formula.


Layer Properties — tl_2010_51_county10 — Symbology
Information
Source
Symbology
Expression Dialog
Expression
Function Editor
Search...
Show Values
geometry
id
Aggregates
Arrays
Color
Conditionals
Conversions
Date and Time
Fields and Values
feature
geometry
id
NULL
STATEFP10
COUNTYFP10
COUNTYNS10
GEOID10
NAME10
NAMELSAD10
LSAD10
CLASSFP10
MTFCC10
CSAFP10
CBSAFP10
METDIVFP10
FUNCSTAT10
ALAND10
AWATER10
INTPTLAT10
INTPTLON10
DECENNIALPL2010.P1-Data-clean_TOTAL
DECENNIALPL2010.P1-Data-clean_TOTAL-1RACE
DECENNIALPL2010.P1-Data-clean_TOTAL-WHITE
DECENNIALPL2010.P1-Data-clean_TOTAL-AFAM
DECENNIALPL2010.P1-Data-clean_TOTAL-ASIAN
DECENNIALPL2010.P1-Data-clean_TOTAL-OTHER
Files and Paths
Fuzzy Matching
General
group field
Double-click to add field name to expression string. Right-Click on field name to open context menu sample value loading options.
Notes
Loading field values from online sources isn't supported before the layer is actually inserted, ie. when building queries.
Values
All Unique
10 Samples
Help
Cancel
OK

Graduated

Value

Symbol

Legend format: %1 - %2 | Precision 4 | ✓ Trim

```
"DECENNIALPL2010.P1-Data-clean_TOTAL-WHITE" /
"DECENNIALPL2010.P1-Data-clean_TOTAL"
```

Feature: Accomack

Preview: 0.6531781449764805

OPEN THE FIELD CALCULATOR

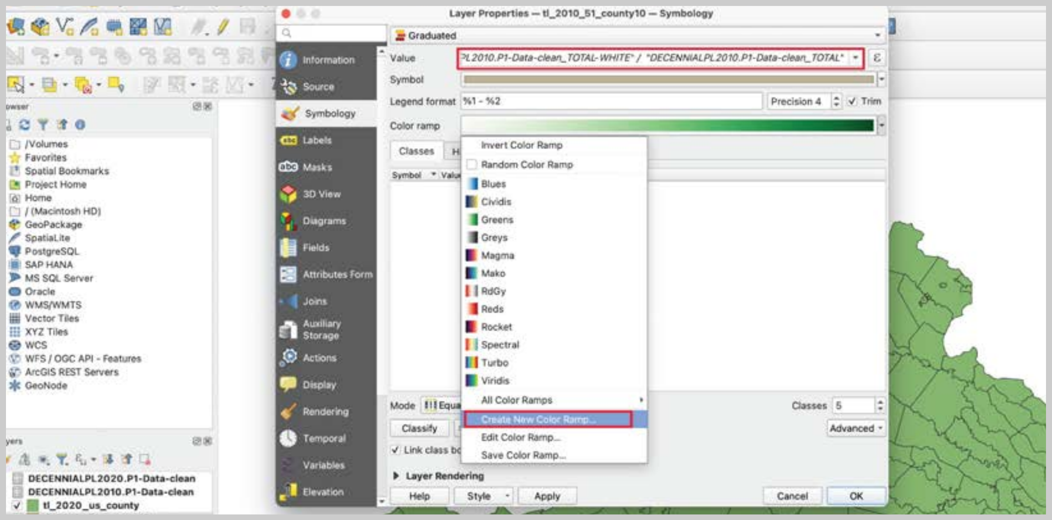
"WHITE" FIELD DIVIDED BY "TOTAL" FIELD TO GET PERCENTAGE WHITE

DOUBLE CLICK TO ADD THE FIELD

CHECK THAT PREVIEW DOES NOT SHOW "EXPRESSION

NOTE: If you want to avoid the manual conversion, you can make the function produce a round percentage number by adding a couple elements: ROUND (("White-field-name" / "Total-field-name")*100, 0), where 0 refers to the number of decimal places to round to.

4b Rather than a preset gradient, I prefer to make my own for this variable. I'm going to create a purple to orange gradient. In "Color ramp", select "Create new Color Ramp…". Then, you can set the Color 1 and Color 2 to your liking.

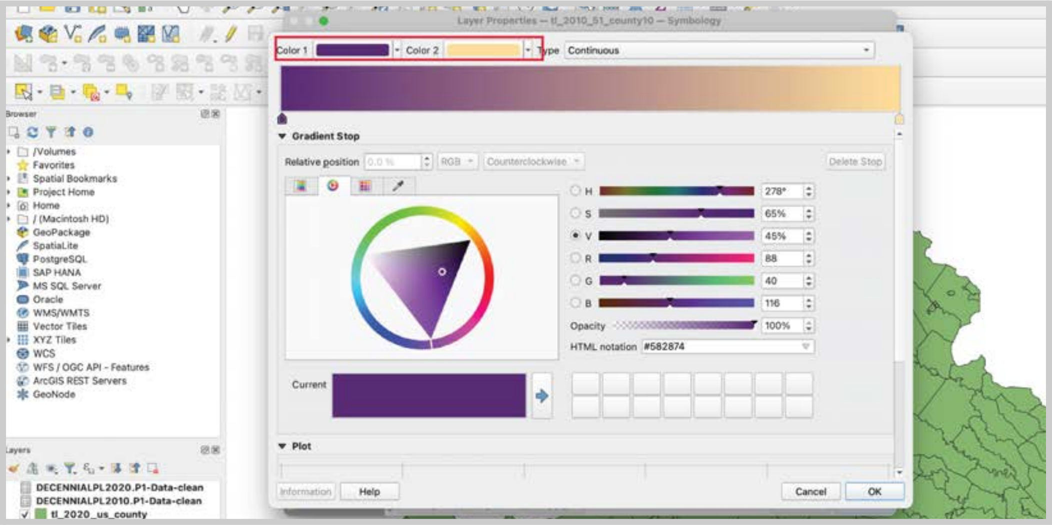

Layer Properties — tl_2010_51_county10 — Symbology

Graduated

Value: "L2010.P1-Data-clean_TOTAL-WHITE" / "DECENNIALPL2010.P1-Data-clean_TOTAL"

Legend format: %1 - %2   Precision 4   ✓ Trim

Classes 5

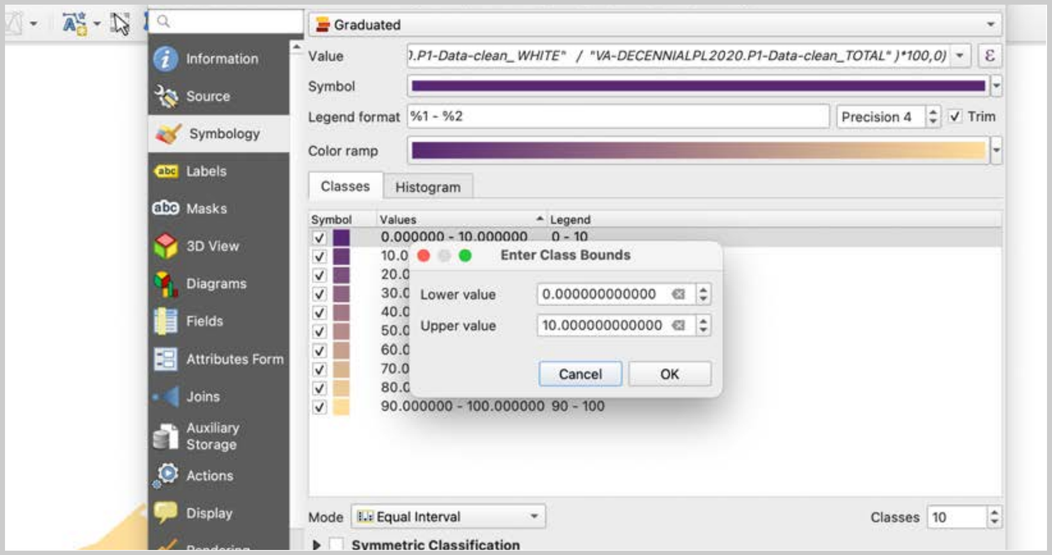

Layer Properties — tl_2010_51_county10 — Symbology

Color 1   Color 2   Type: Continuous

Relative position 0.0 %   RGB   Counterclockwise

H 278°
S 65%
V 45%
R 88
G 40
B 116
Opacity 100%
HTML notation #582874

4c To show the data most accurately, you'll need to **manually** edit the values. Set your classes to "10", and then adjust the upper and lower values of each class bound to be a 10-percentage point range (eg 0-0.1, 0.1-0.2, 0.2-0.3, and so on – or, 0-10, 10-20, etc if you used the "Round" note above). To edit the class bounds, double click on the numbers in the "**Values**" column beside each Symbol.



Graduated

Value).P1-Data-clean_WHITE" / "VA-DECENNIALPL2020.P1-Data-clean_TOTAL")*100,0)

Legend format %1 - %2 Precision 4 ☑ Trim

Color ramp

Symbol	Values	Legend
☑	0.000000 - 10.000000	0 - 10
☑	10.0	
☑	20.0	
☑	30.0	
☑	40.0	
☑	50.0	
☑	60.0	
☑	70.0	
☑	80.0	
☑	90.000000 - 100.000000	90 - 100

Enter Class Bounds

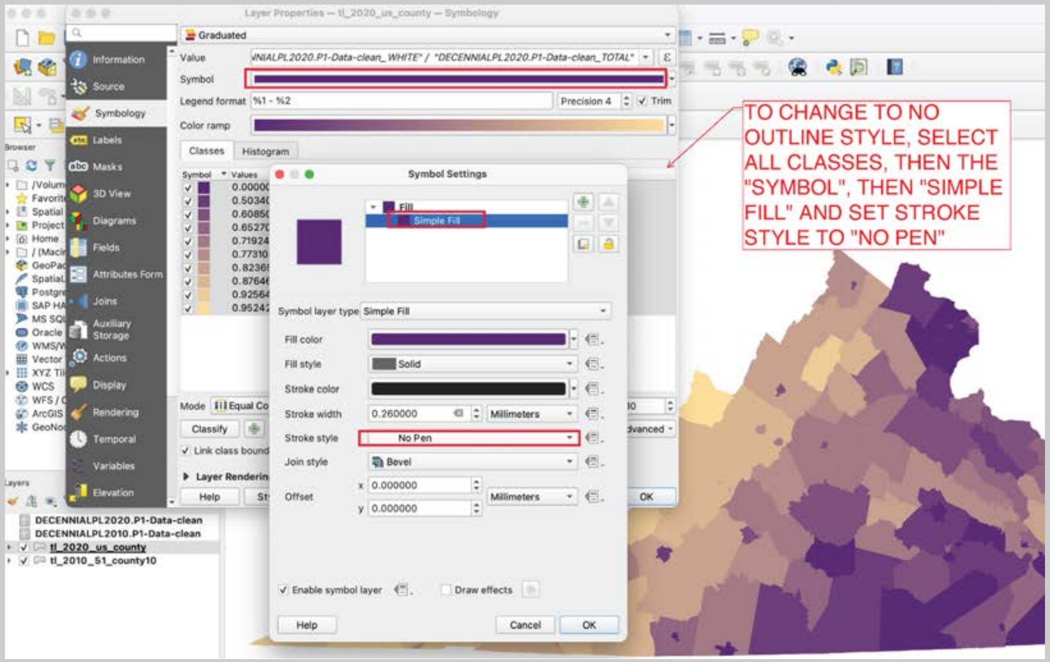
Lower value 0.000000000000

Upper value 10.000000000000

Mode Equal Interval Classes 10

Symmetric Classification

4d If your symbols have an outline, consider removing them to see the data patterns more clearly, especially on smaller polygons. Select all of your classes and click on the "Symbol" dropdown near the top. Select "Simple Fill", and then dropdown "Stroke style" to "**No Pen**".



TO CHANGE TO NO OUTLINE STYLE, SELECT ALL CLASSES, THEN THE "SYMBOL", THEN "SIMPLE FILL" AND SET STROKE STYLE TO "NO PEN"

Graduated

Value NIALPL2020.P1-Data-clean_WHITE" / "DECENNIALPL2020.P1-Data-clean_TOTAL"

Legend format %1 - %2 Precision 4 ☑ Trim

Symbol layer type Simple Fill

Fill style Solid

Stroke width 0.260000 Millimeters

Stroke style No Pen

Join style Bevel

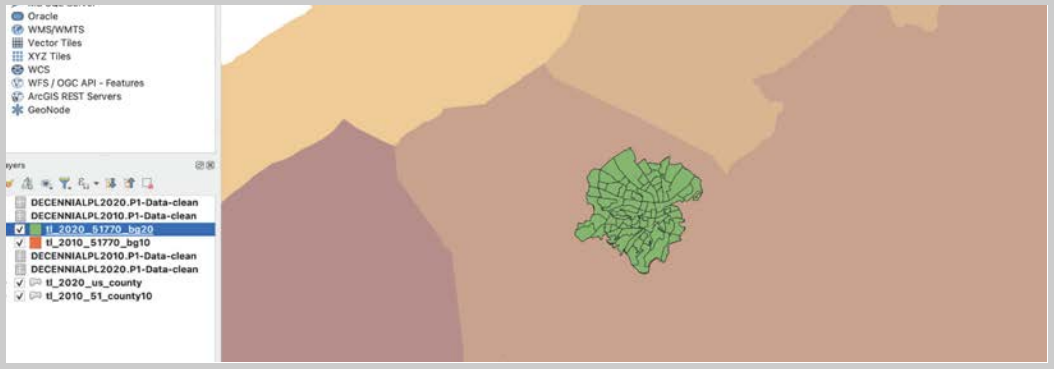
Offset x 0.000000 y 0.000000 Millimeters

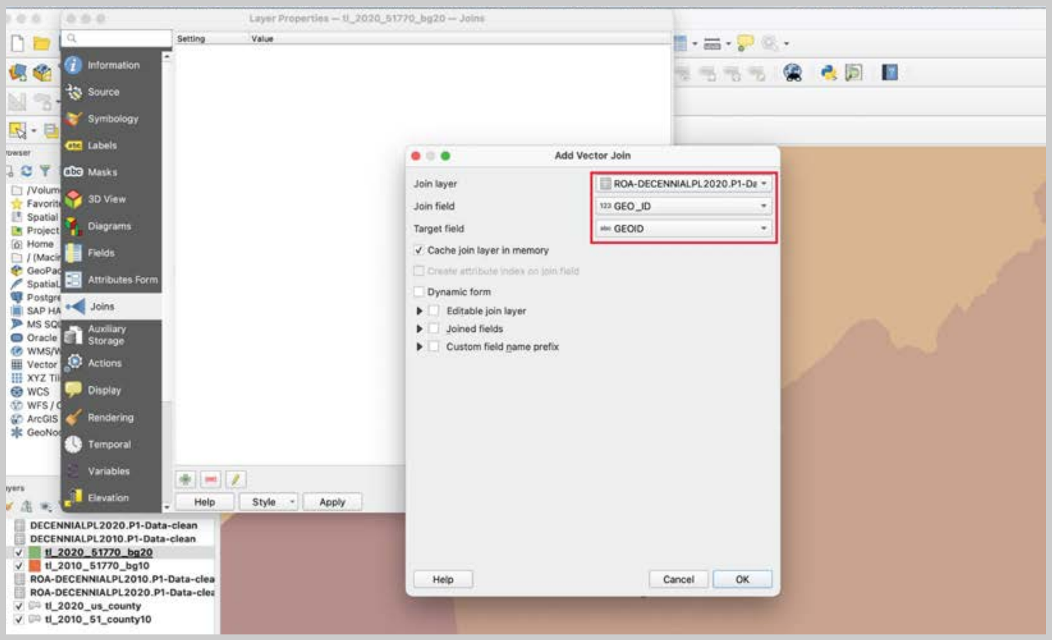
4e **Save** your layer style to use on the other layers, so that you can easily compare the data.

4f **Load** your saved style for the 2020 layer. NOTE that you will need to **update the fields in the field calculator,** since their names will be different ("2010" instead of "2020").

Step 5: Add the city-level census data, join, and style.

5a Using the previous steps as a reference, import the city-level block group shapefiles and csvs. Remember to choose the “DECENNIALP1” csv files for this tutorial. Join the 2010 to 2010 and 2020 to 2020, making sure to **join from the shapefile Layer Properties**, and not the csv layer properties.





Add Vector Join

Join layer: ROA-DECENNIALPL2020.P1-Da

Join field: GEO_ID

Target field: GEOID

☑ Cache join layer in memory

☐ Create attribute index on join field

☐ Dynamic form

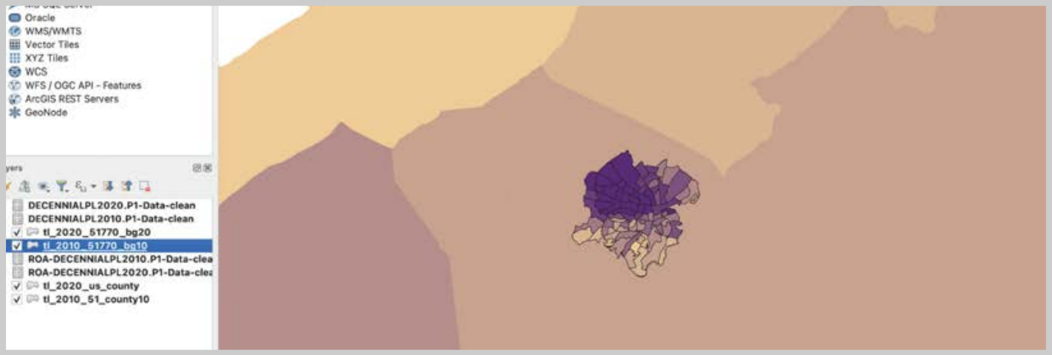
☐ Editable join layer

☐ Joined fields

☐ Custom field name prefix

Help Cancel OK

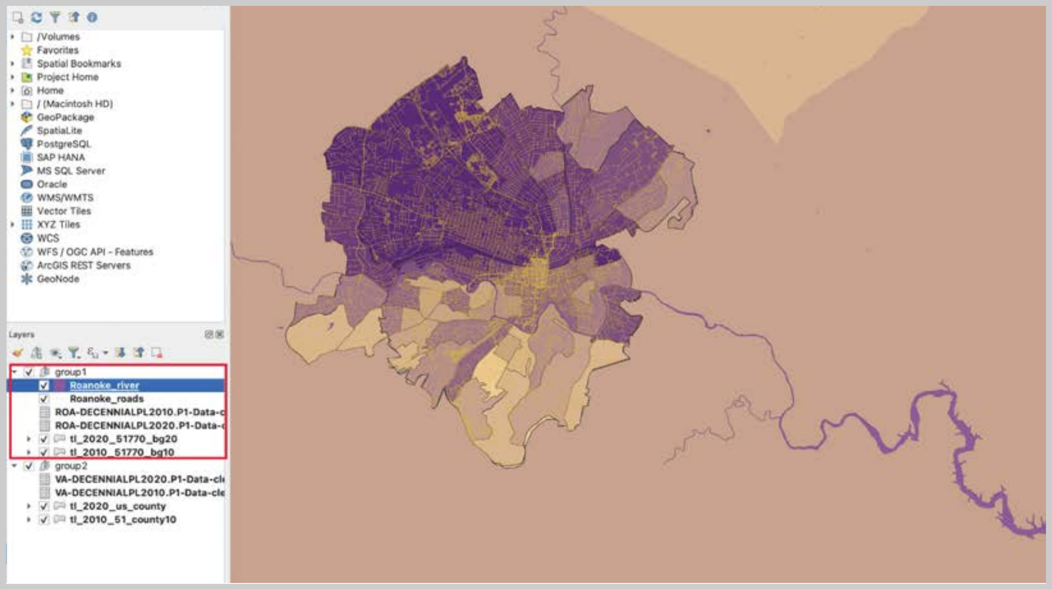
5b Style these layers using the same saved style. Again, you will need to update the fields in the field calculator.



Step 6: Add context physical geography layers.

6a Similar to previous tutorials, we're going to add in a few layers to contextualize the data. I added in the Roads and River layers. You might also add in the Railroad layer, which will often draw the racial divide of a city.

Since we'll be showing the state and city levels both, we want to turn off the city layer when we show the state layer and vice-versa. We also don't need to show the roads and river when we're looking at the state level. To facilitate this, I grouped the shapefiles, data tables, and other geographies into group 1 (city-level census files, roads, and river), and group 2 (state-level information).

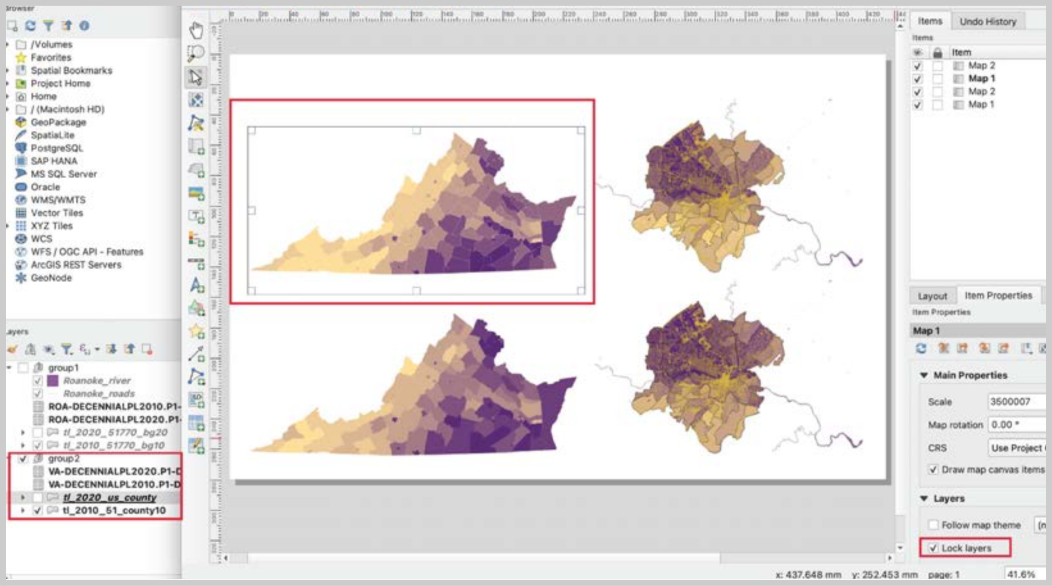


Step 7: Create print layout to compare the maps and years.

7a Set your page to 11”x17”.

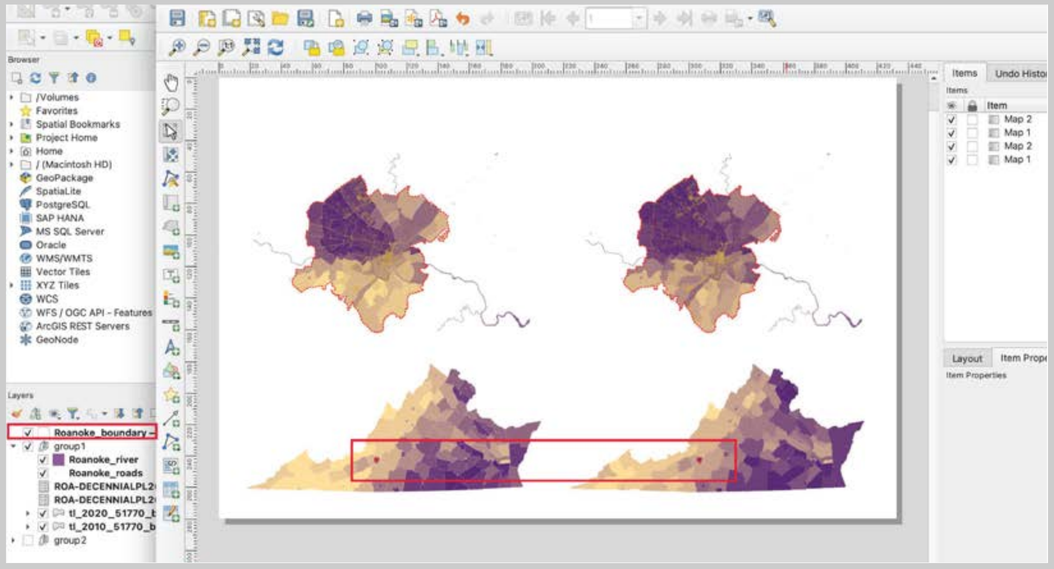
7b Next, add a map of the state of Virginia. Turn off your city layers and your 2020 state-level layer. Check **“Lock Layers”.** Copy the state map, turn on 2020, and then uncheck and re-check “lock layers” to update the second state map to show the 2020 data.

7c Do the same for the city-level data, turning off the state-level data and zooming in.

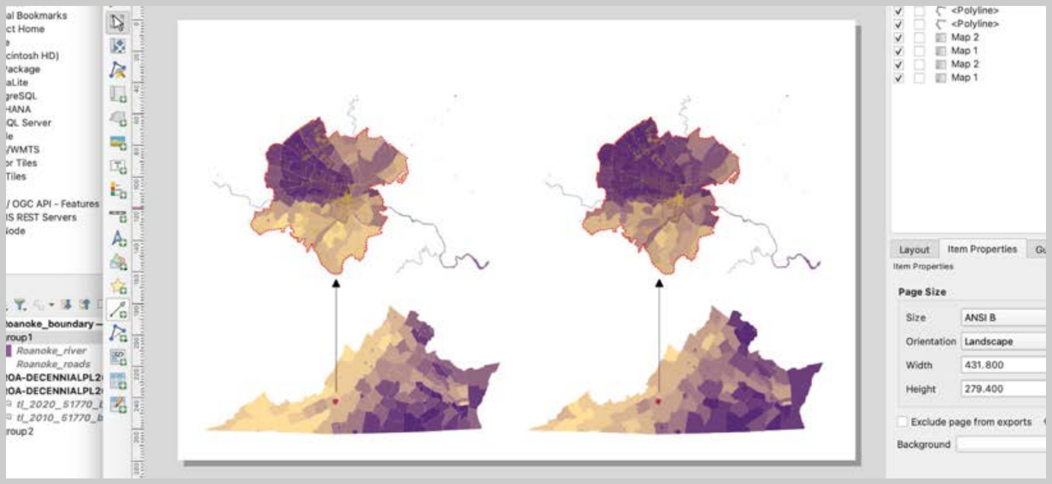


Scale 3500007
Map rotation 0.00 °
CRS Use Project
☑ Draw map canvas items
☑ Lock layers
x: 437.648 mm y: 252.453 mm page: 1 41.6%

7d Now we can see the state-wide change in data between 2010 and 2020 as well as in the specific city, but without linking the two the information is not as legible. To make it clear what part of the state you’re zooming in to, add the “boundary” layer to your map. Color it something bright like dashed red outline, and put it above the other layers so it always shows up.



Unlock and re-lock all your maps, turning off and on the relevant layers. You should now see the boundary clearly indicating the city's location on the Virginia map. Add an arrow from the city in the state map to the blown-up city map, to make things even clearer.



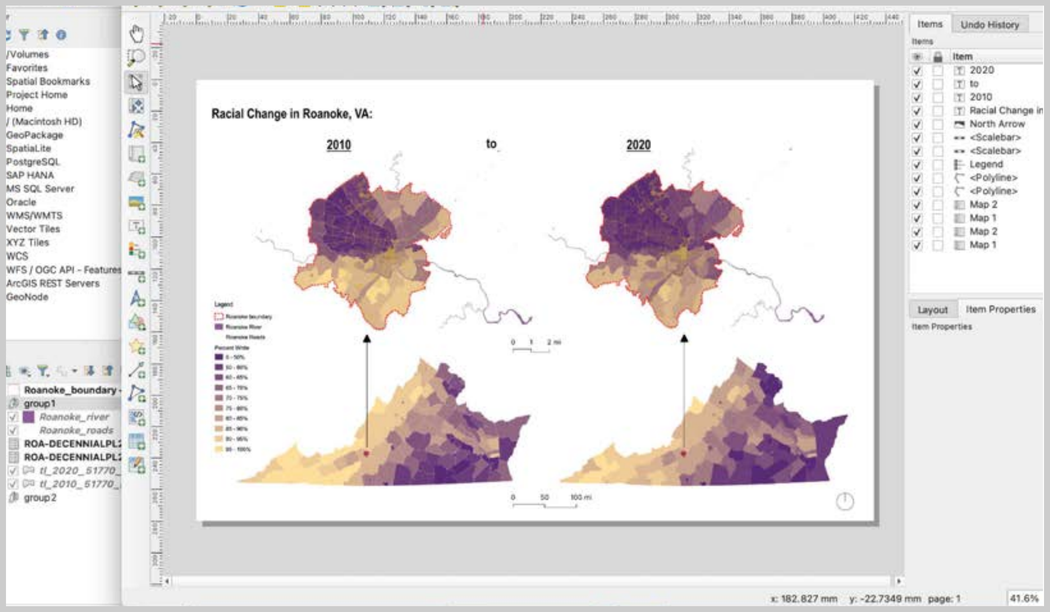
☑ □ <Polyline>
☑ □ <Polyline>
☑ □ Map 2
☑ □ Map 1
☑ □ Map 2
☑ □ Map 1

Item Properties

Page Size

Size: ANSI B
Orientation: Landscape
Width: 431.800
Height: 279.400
□ Exclude page from exports
Background

7d Arrange your maps by year. Add a legend (be sure to indicate units, in the case "percentage"), north arrow, and title / subtitle. Add a byline and sources. Add separate scales for the city-level and state-level maps.



Items

		Item
☑	□	2020
☑	□	to
☑	□	2010
☑	□	Racial Change in
☑	□	North Arrow
☑	□	<Scalebar>
☑	□	<Scalebar>
☑	□	Legend
☑	□	<Polyline>
☑	□	<Polyline>
☑	□	Map 2
☑	□	Map 1
☑	□	Map 2
☑	□	Map 1

Item Properties

x: 182.827 mm y: -22.7349 mm page: 1 41.6%

- **Bonus (STRONGLY RECOMMENDED) -**

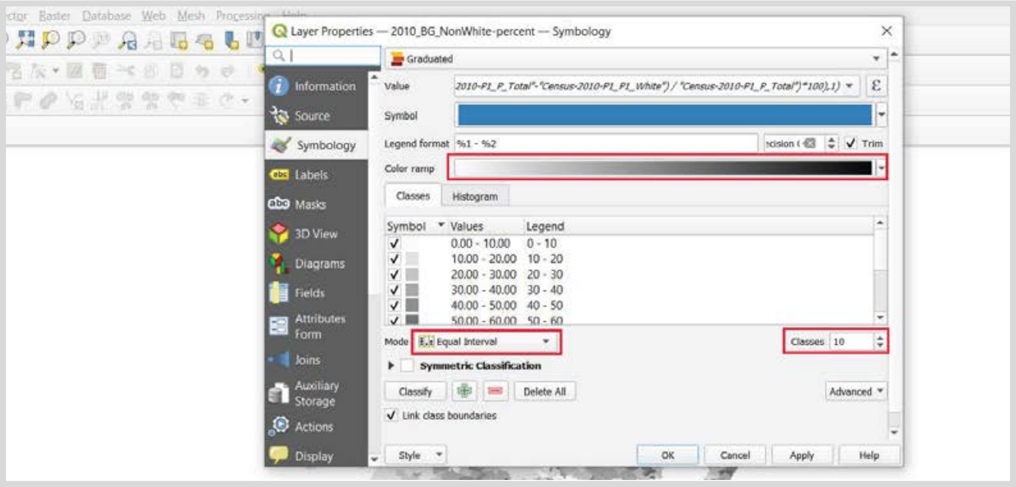
Step 8: Raster analysis.

In the previous steps, you visually analyzed the difference between 2010 and 2020. However, it's difficult to see the difference without flipping between the layers. You could create a GIF to make the change more evident, but you can also perform raster analysis on the two images. QGIS has a tool called the Raster Calculator that allows you to perform math on the pixels in images. In other words, you can export the two years of census data and use simple subtraction to visualize the change between them as a new image.

This is especially useful when comparing the changes between census decades, since their shapefile outlines have changed. Because of this, you can't get an entirely accurate picture just by comparing their spreadsheet tables. The Raster Calculator will compare them pixel by pixel, rather than using attribute tables to compare them block ID by block ID.

> **NOTE:** to accurately compare the two datasets, first make sure that they're styled identically. In other words, both maps should have the same color scheme and the same percentage ranges (use "Equal Interval" in the graduated styling mode and set the same number of "Classes").

8a First, style your 2010 and 2020 maps with a **black and white gradient** rather than a color gradient. This will make the Raster Calculation easier. Double check that your percentage ranges match between the two layers.



Layer Properties — 2010_BG_NonWhite-percent — Symbology

Graduated

Value: 2010-P1_P_Total"-"Census-2010-P1_P1_White") / "Census-2010-P1_P_Total")*100),1)

Legend format: %1 - %2

☑ Trim

Symbol	Values	Legend
✓	0.00 - 10.00	0 - 10
✓	10.00 - 20.00	10 - 20
✓	20.00 - 30.00	20 - 30
✓	30.00 - 40.00	30 - 40
✓	40.00 - 50.00	40 - 50
✓	50.00 - 60.00	50 - 60

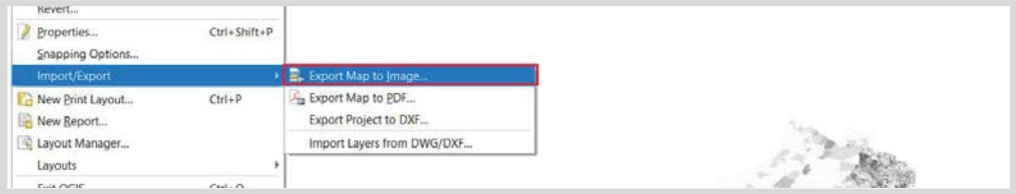
Mode: Equal Interval

Classes: 10

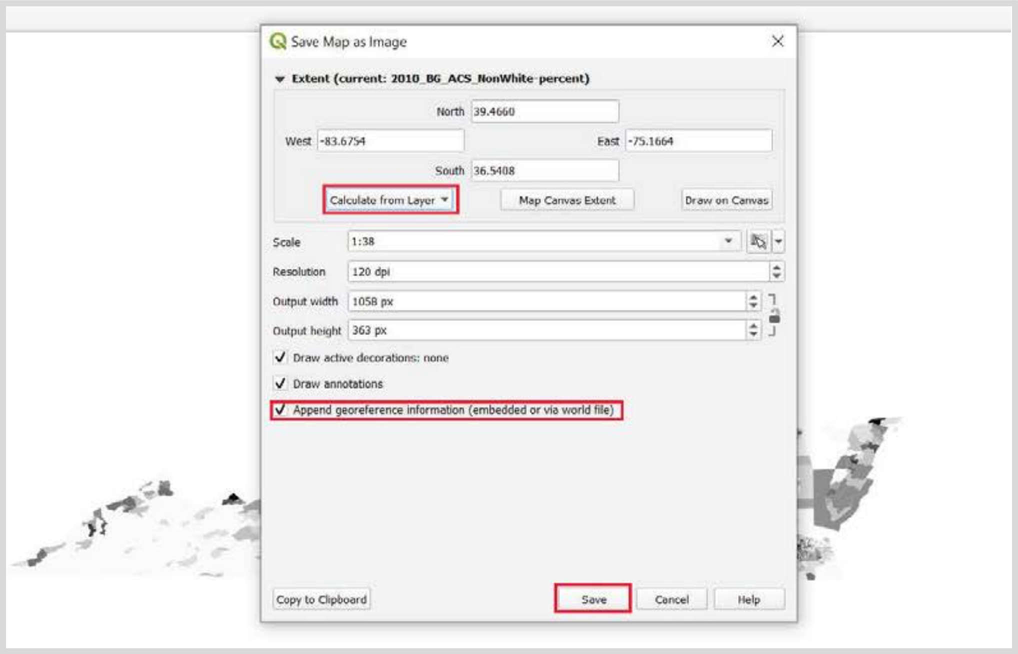
□ Symmetric Classification

☑ Link class boundaries

8b Next, export both the 2010 and 2020 maps as images. Turn off all your other layers, and only leave on the 2010 map. Go to **Project > Import/Export > Export Map to Image…**



In the dialogue box, set the **Extent with “Calculate by Layer”,** and select your 2010 layer. Leave the other fields as their defaults; make sure that “Append georeference information” is checked.



Save Map as Image

▾ Extent (current: 2010_BG_ACS_NonWhite-percent)

North 39.4660

West -83.6754

East -75.1664

South 36.5408

Scale 1:38

Resolution 120 dpi

Output width 1058 px

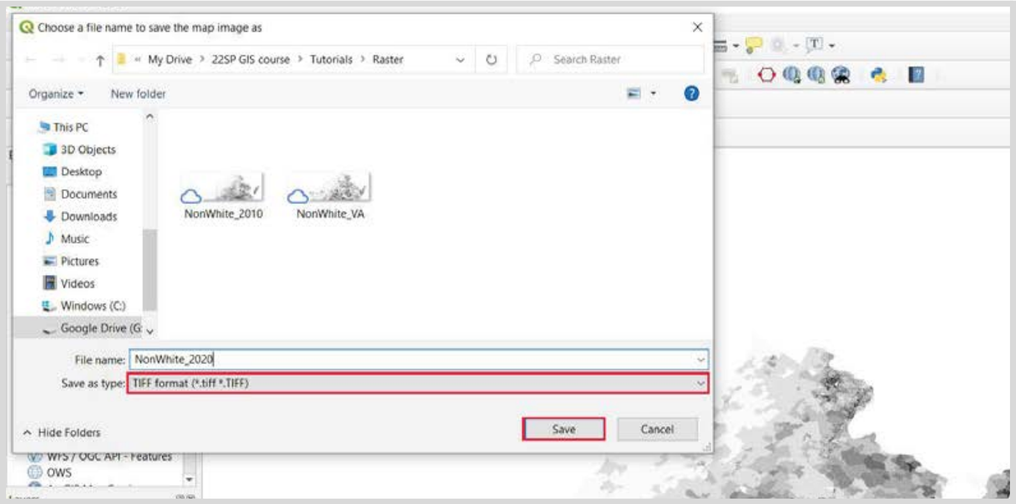
Output height 363 px

☑ Draw active decorations: none

☑ Draw annotations

☑ Append georeference information (embedded or via world file)

Click Save, select **“TIFF”,** and save your new Raster image somewhere safe. Repeat this step for the 2020 layer.



Choose a file name to save the map image as

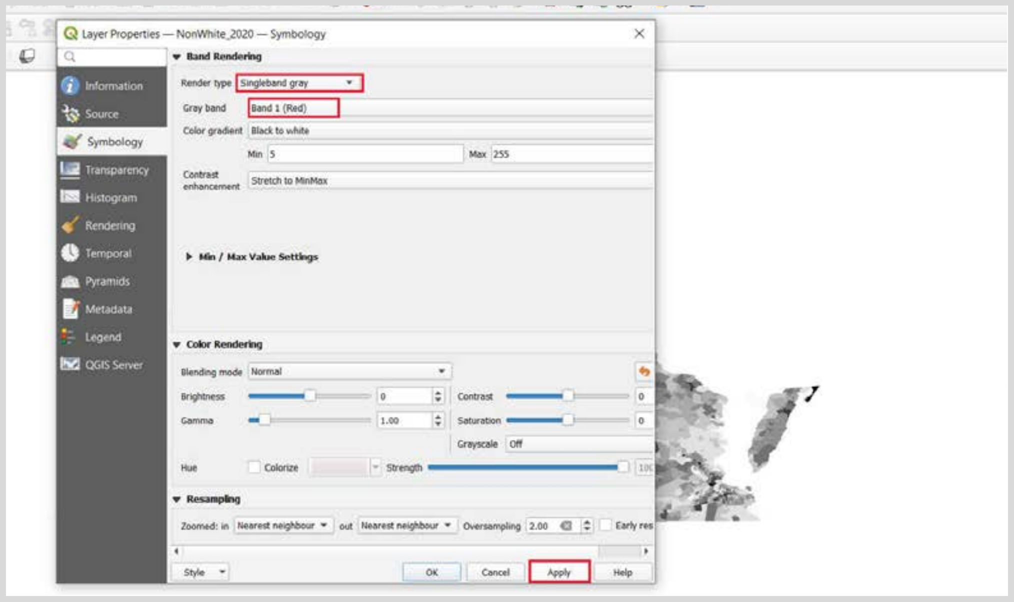
« My Drive › 22SP GIS course › Tutorials › Raster

File name: NonWhite_2020

Save as type: TIFF format (*.tiff *.TIFF)

8c Add in your new Raster layers with Layer > Add Layer > Add Raster Layer…

8d Double click on one of your census raster layers. Set the property “Band Rendering” (the first property under “Symbology”) to “**Singleband Grey**”. You can leave the “Grey Band” to “Band 1 (Red)”. Make a note of this, since we’ll want to compare the Band 1 of both layers in the next step. Select “Apply”



Layer Properties — NonWhite_2020 — Symbology

Band Rendering

Render type: Singleband gray
Gray band: Band 1 (Red)
Color gradient: Black to white
Min: 5 Max: 255
Contrast enhancement: Stretch to MinMax

Color Rendering

Blending mode: Normal
Brightness: 0 Contrast: 0
Gamma: 1.00 Saturation: 0
Grayscale: Off

Resampling

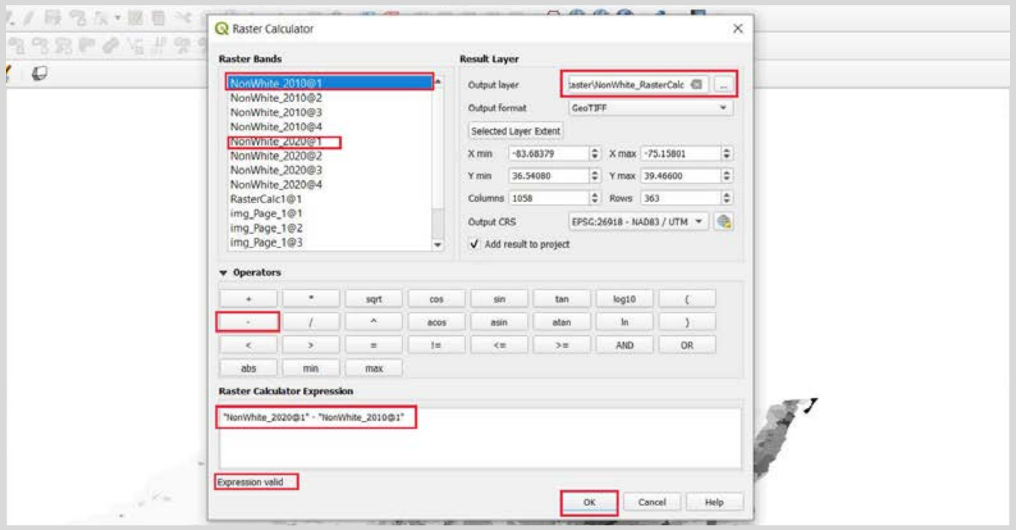
Zoomed: in: Nearest neighbour out: Nearest neighbour Oversampling: 2.00

Repeat this for both layers.

8e Now, open **Raster > Raster Calculator**. Since we can see that the Nonwhite percentage has grown between 2010 and 2020, we want to subtract 2010 from 2020. As with the Graduated Symbology expression editor, you can double click to add layers to your Raster Calculator expression. First, Double click on the 2020 Band 1 layer listed in the "Raster Bands" list (upper left). Then click the minus (-) symbol in "Operators".

> **Note:** Notice that at this point, before completing the expression, you have a text message in the bottom left that says **"Expression invalid"**. This text, which appears in all QGIS expression editors, is a useful indicator to keep an eye on.

Now, double click on your 2010 Band 1 layer in the "Raster Bands" list to complete the expression. In the upper right, set the "Output Layer" to a safe place with a logical name. Click "OK".



Raster Calculator

Raster Bands

NonWhite_2010@1
NonWhite_2010@2
NonWhite_2010@3
NonWhite_2010@4
NonWhite_2020@1
NonWhite_2020@2
NonWhite_2020@3
NonWhite_2020@4
RasterCalc1@1
img_Page_1@1
img_Page_1@2
img_Page_1@3

Result Layer

Output layer: aster\NonWhite_RasterCalc
Output format: GeoTIFF
X min: -83.68379 X max: -75.15801
Y min: 36.54080 Y max: 39.46600
Columns: 1058 Rows: 363
Output CRS: EPSG:26918 - NAD83 / UTM
✓ Add result to project

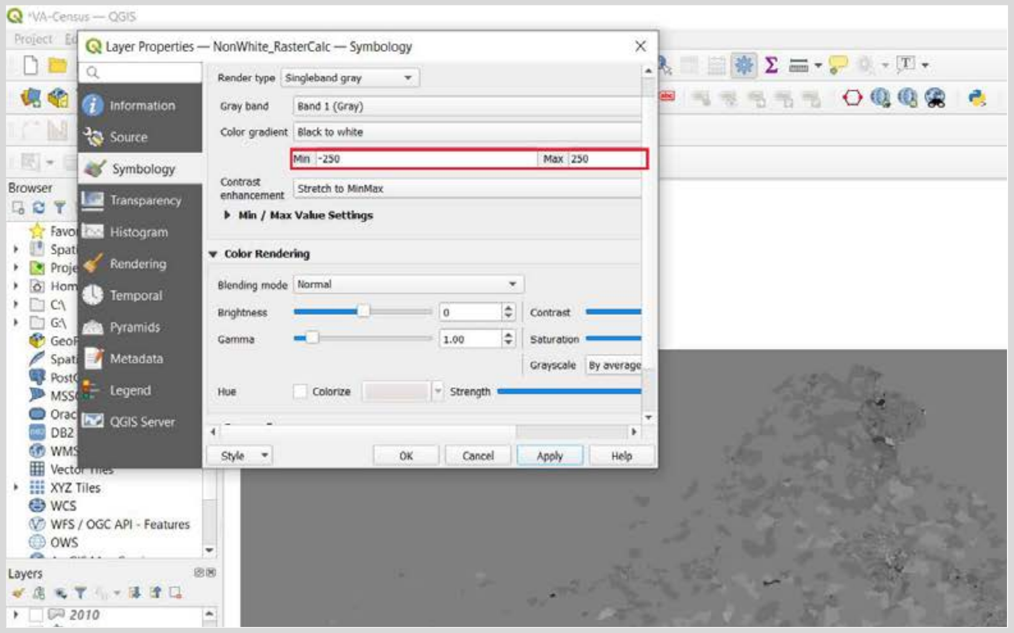
Raster Calculator Expression

```
"NonWhite_2020@1" - "NonWhite_2010@1"
```

Expression valid

8f You should now see the new Raster Calculated layer added to your map. It will automatically set its color scale from -250 to 250. The grays that are LIGHTER than the background gray are negative values (eg areas where

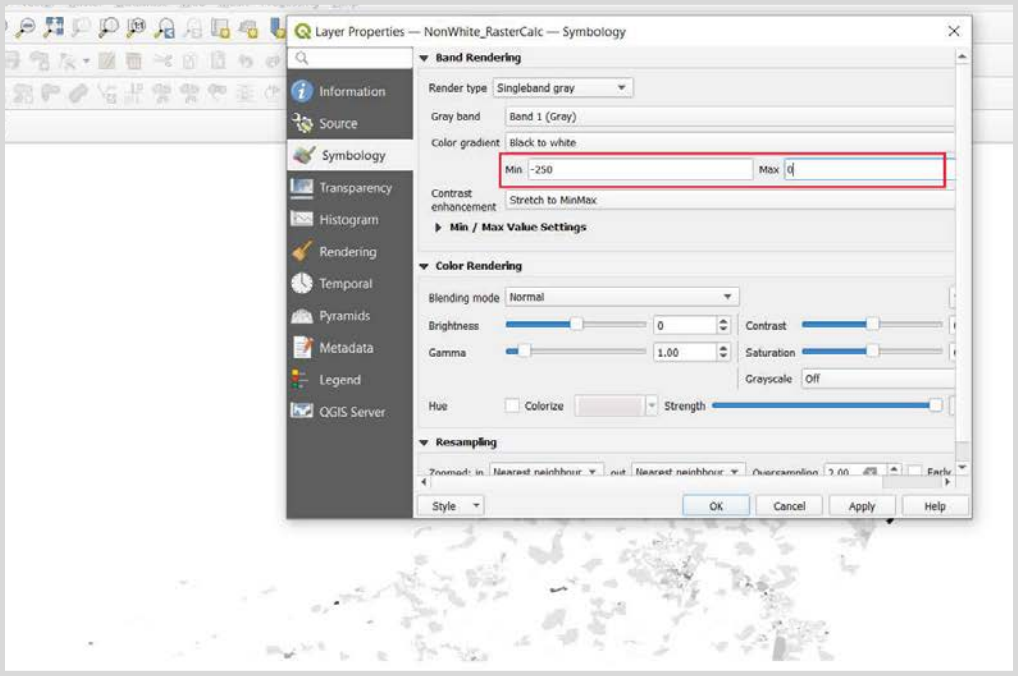
NonWhite percentage DECREASED from 2010 to 2020); the grays that are DARKER than the background are positive values (where NonWhite percentage INCREASED).


Layer Properties — NonWhite_RasterCalc — Symbology

Render type: Singleband gray
Gray band: Band 1 (Gray)
Color gradient: Black to white
Min: -250 Max: 250
Contrast enhancement: Stretch to MinMax
Min / Max Value Settings

Color Rendering
Blending mode: Normal
Brightness: 0
Gamma: 1.00
Grayscale: By average

If you only want to see the decrease, double click on the layer and set your Band Rendering MIN to 0. Leave your MAX at 250. Likewise, if you only want to see the increase, set the MIN to -250 and the MAX to 0.


Layer Properties — NonWhite_RasterCalc — Symbology

Band Rendering
Render type: Singleband gray
Gray band: Band 1 (Gray)
Color gradient: Black to white
Min: -250 Max: 0
Contrast enhancement: Stretch to MinMax
Min / Max Value Settings

Color Rendering
Blending mode: Normal
Brightness: 0
Gamma: 1.00
Grayscale: Off

Resampling
Zoomed: in Nearest neighbour out Nearest neighbour Oversampling 2.00

8g Add a page to your print layout with this new map. Title it something like “change in nonwhite population 2010 to 2020”