

# API-231 / GIS-PubPol

## Meeting 11 (Lab Exercise + Problem Set 6)

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**Goal:** integrate spatially-misaligned data

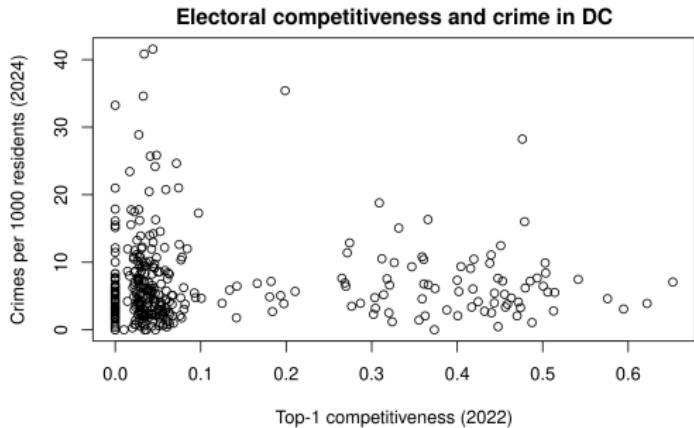


Figure 1: We'll make this

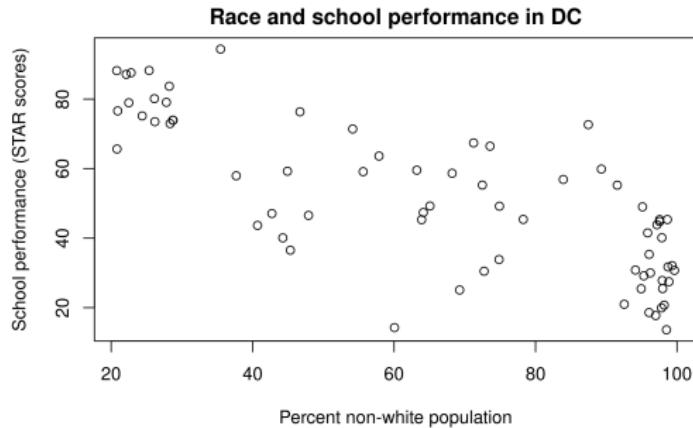


Figure 2: You'll make this

## Overview of lab exercise and problem set

### 1. Lab exercise

- a) Use areal interpolation to estimate per capita crime in DC electoral districts
- b) Create a scatterplot of electoral competitiveness and per capita crime in DC

### 2. Problem set

- a) Use areal interpolation to estimate racial makeup of DC school zones
- b) Create a scatterplot of racial disparities in school performance in DC

*Use case: different data are collected for different spatial units*

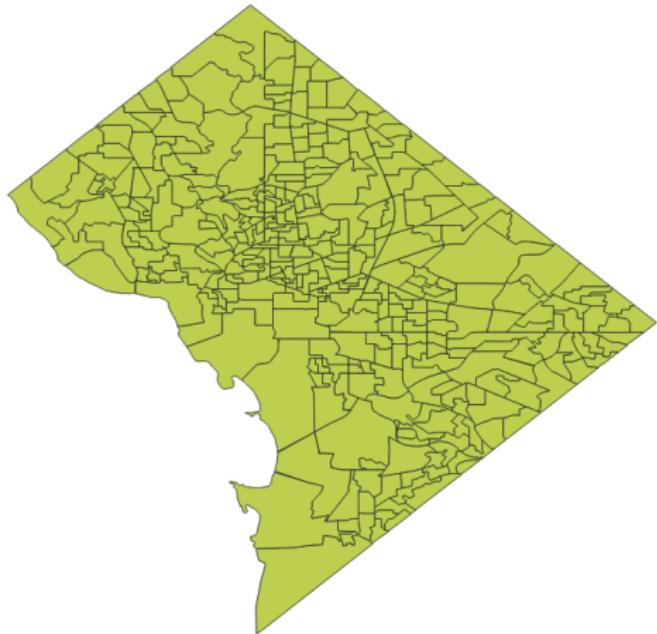


Figure 3: Elections @ single-member districts

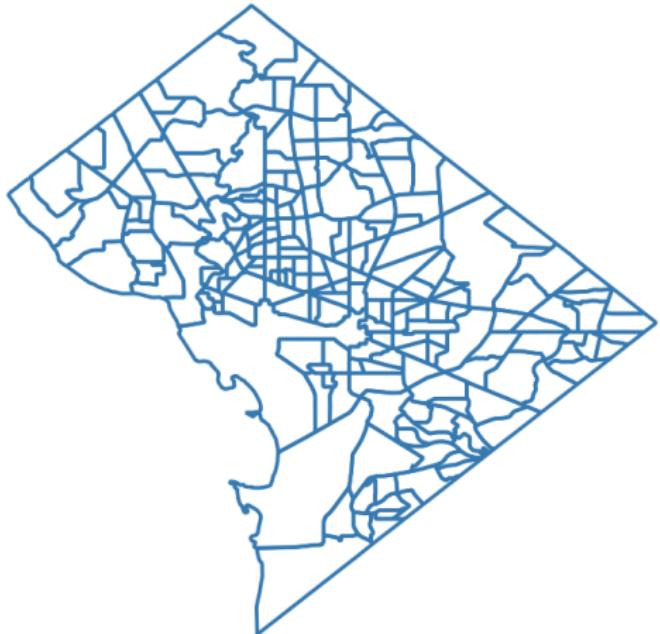


Figure 4: Population counts @ census tracts

*Solution:* change the support of the data → single member districts

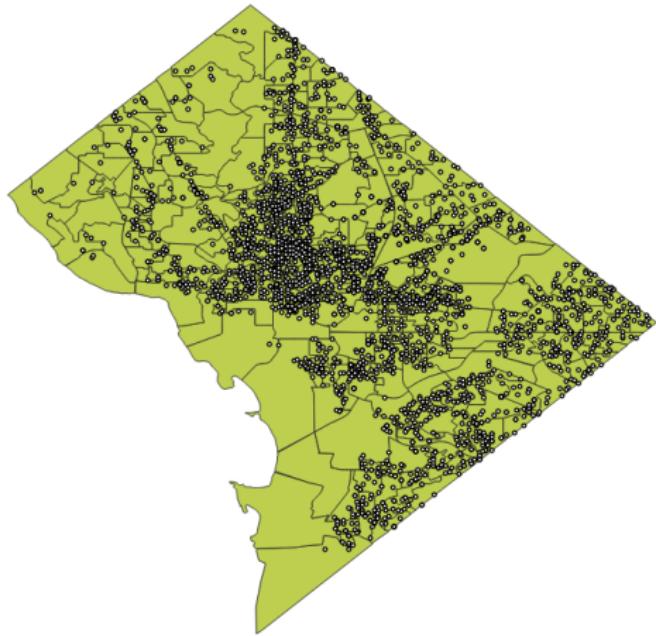


Figure 5: Count crimes in SMDs

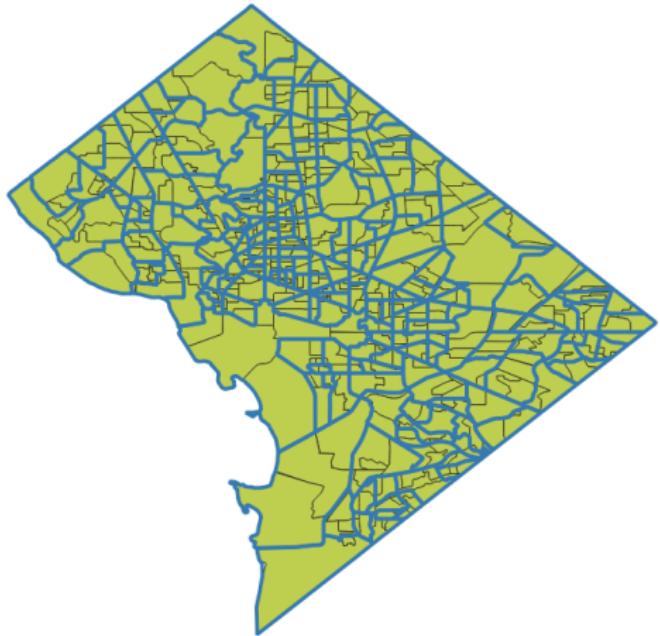


Figure 6: Interpolate population to SMDs

# Analyze relationship between electoral competitiveness and per capita crime in SMDs

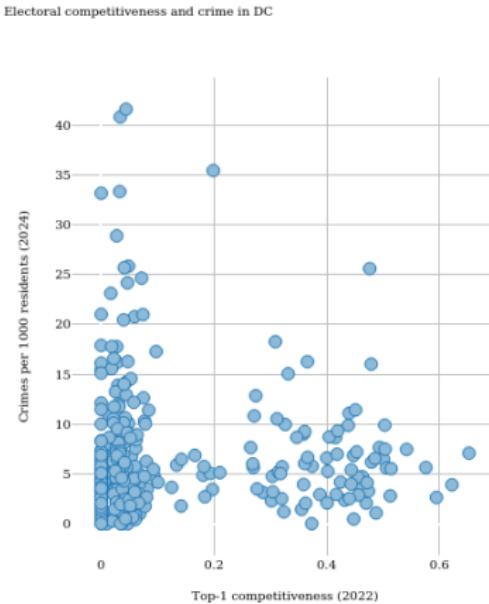


Figure 7: Scatterplot

**Scatterplots:** plots displaying data as points, with one variable on the horizontal axis and another on the vertical axis



## Positive correlation

As one variable increases so does the other variable.



## Negative correlation

As one variable increases the other variable decreases.



## No correlation

There is no relationship between the two variables.

Figure 8: Scatterplots are useful to assess direction/strength of correlations

### The five types of Nicolas Cage movies

Domestic box office in 2018 dollars vs. Rotten Tomatoes score

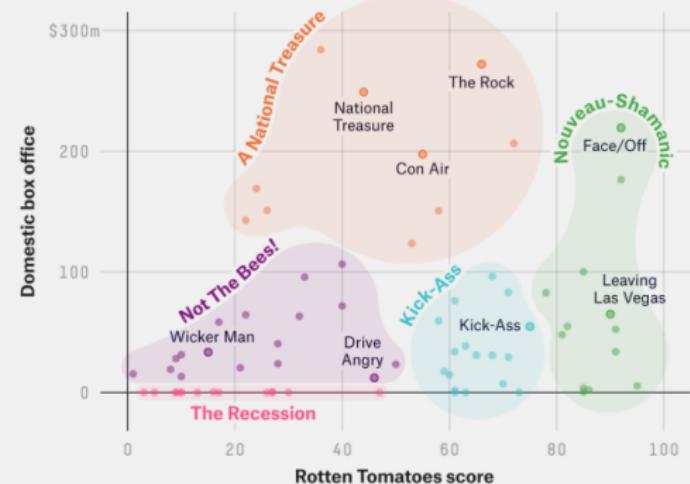


Figure 9: ... and to identify outliers

The problem set will investigate a similar use case

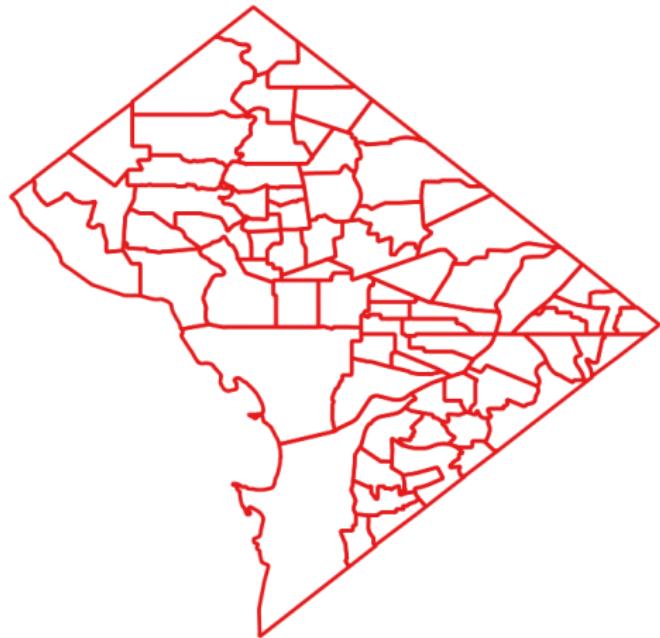


Figure 10: Scores @ school attendance zones

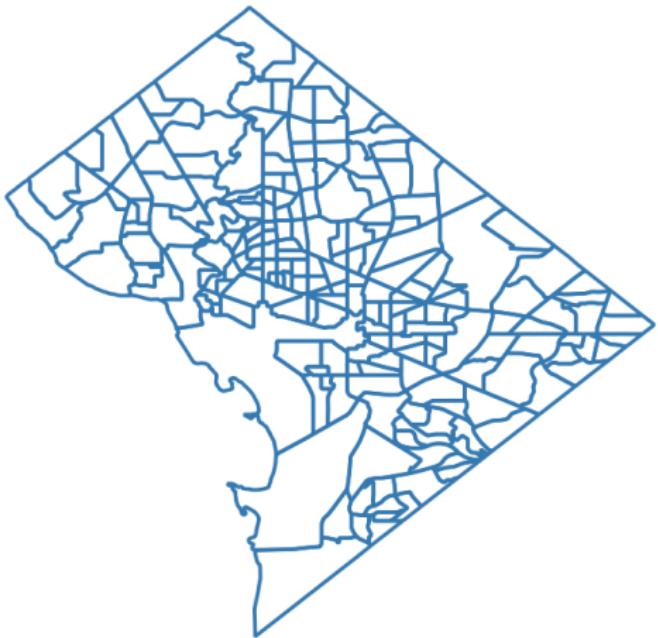


Figure 11: Demographics @ census tracts

*Solution:* change the support of the data → school attendance zones

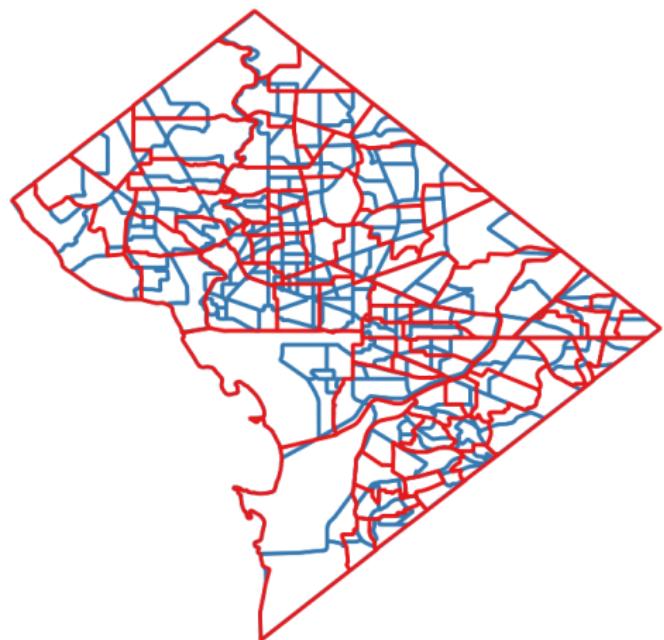


Figure 12: Interpolate demographics to SAZs

Race and school performance in DC

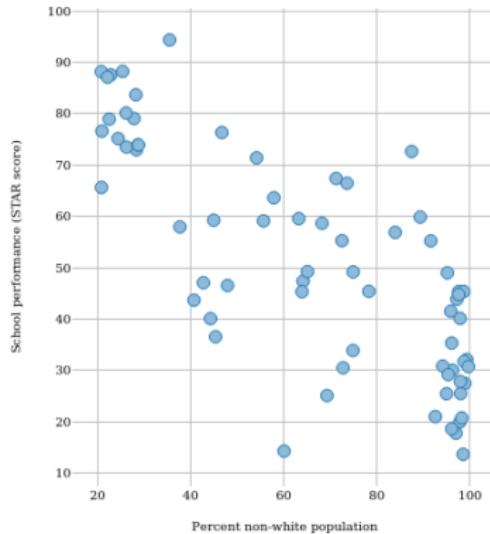


Figure 13: Scatterplot

You can make these plots in QGIS or in R. Instructions for both are below.

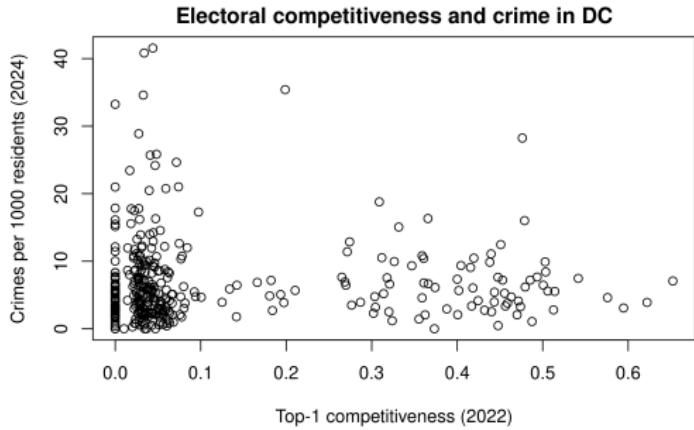


Figure 14: Scatterplot 1 in R

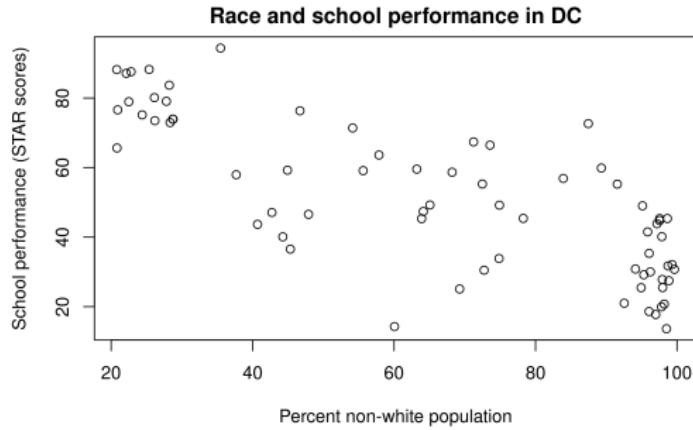


Figure 15: Scatterplot 2 in R

We have four (and a half) sources of data:

Category	Type	Format	Data source
Single member districts	Vector (polygon)	.geojson	DC OpenData
ACS DC Census Tract	Vector (polygon)	.geojson	DC OpenData
Crime Incidents in 2024	Vector (point)	.geojson	DC OpenData
School Attendance Zones, Elementary + School STAR Scores	Vector (polygon) Table (non-spatial)	.geojson .csv	DC OpenData

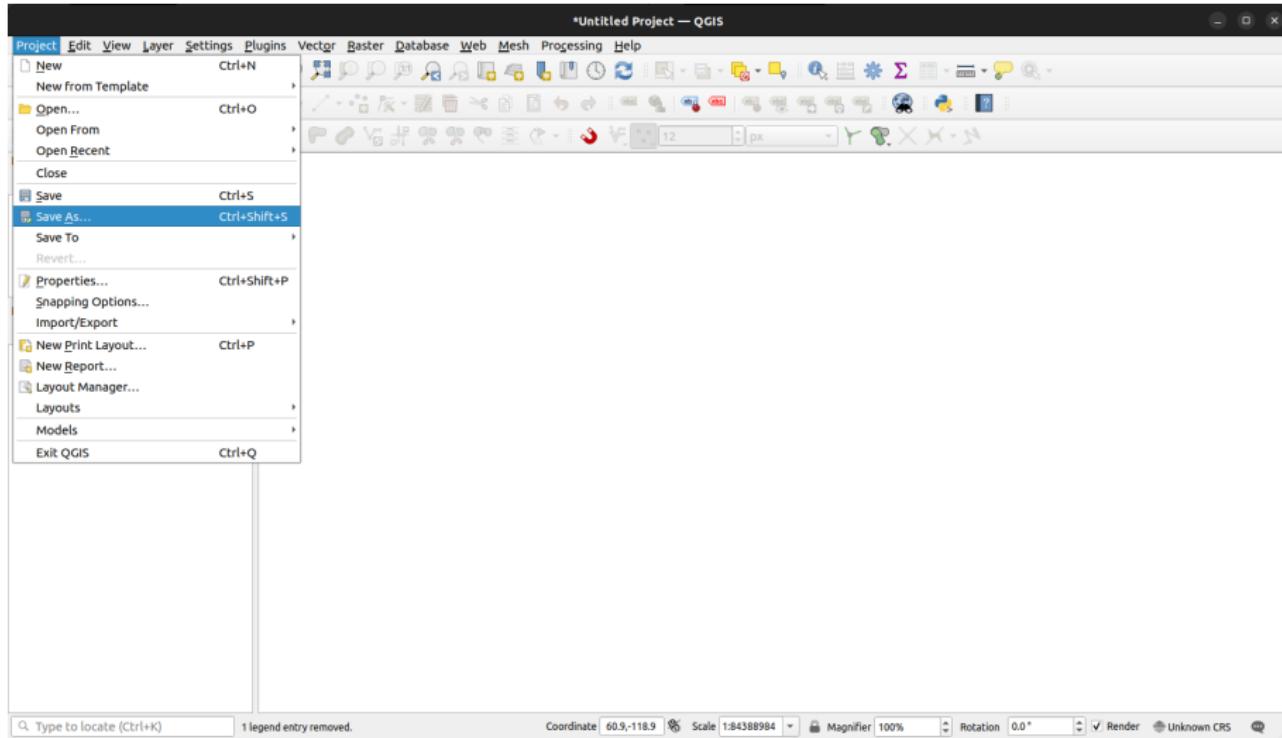
These are all in the PS07.zip file posted on Canvas.

Let's open QGIS...

# QGIS

# Always save your progress!

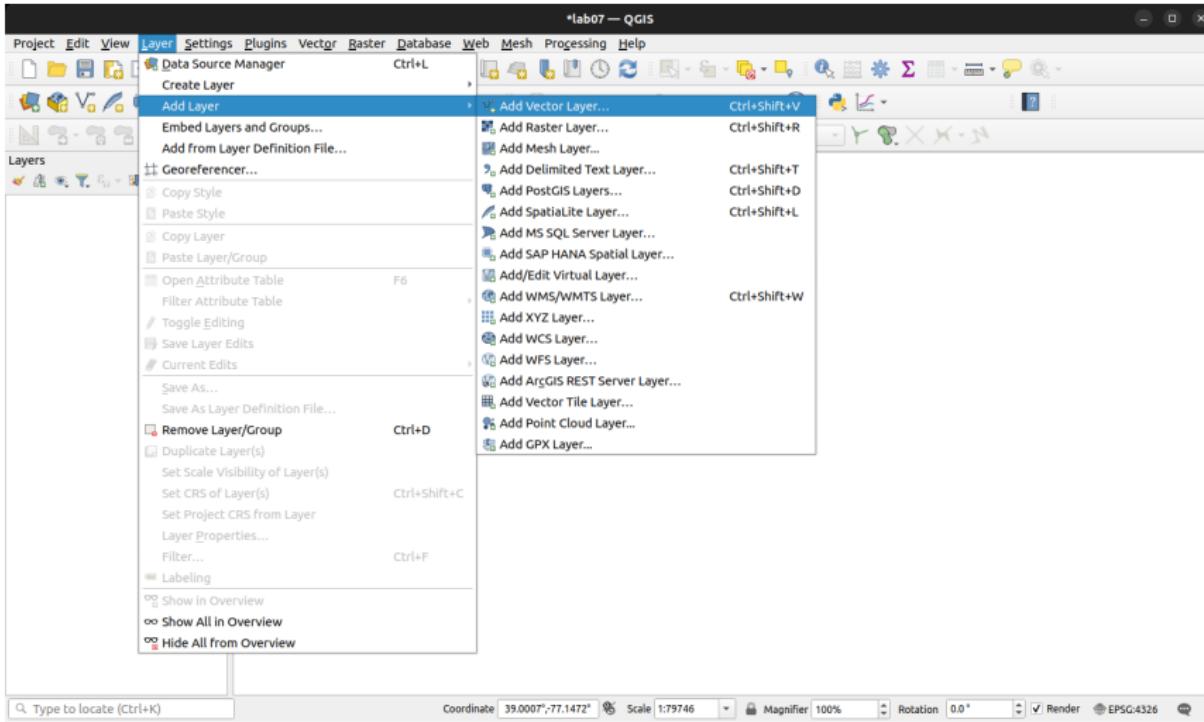
Go to Project → Save As...



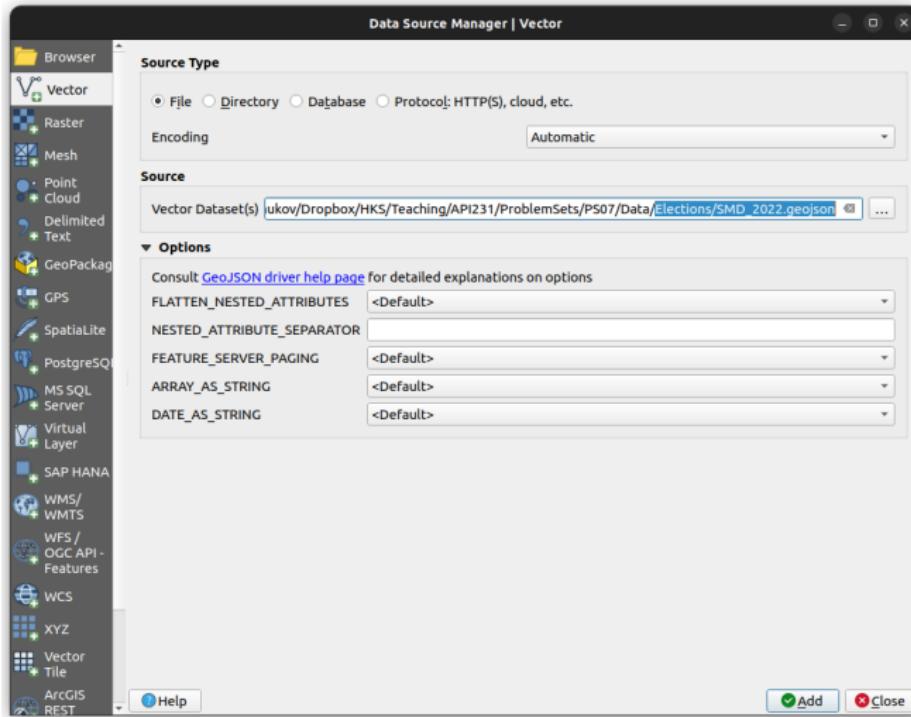
# Interpolation

Load the Single Member Districts file:

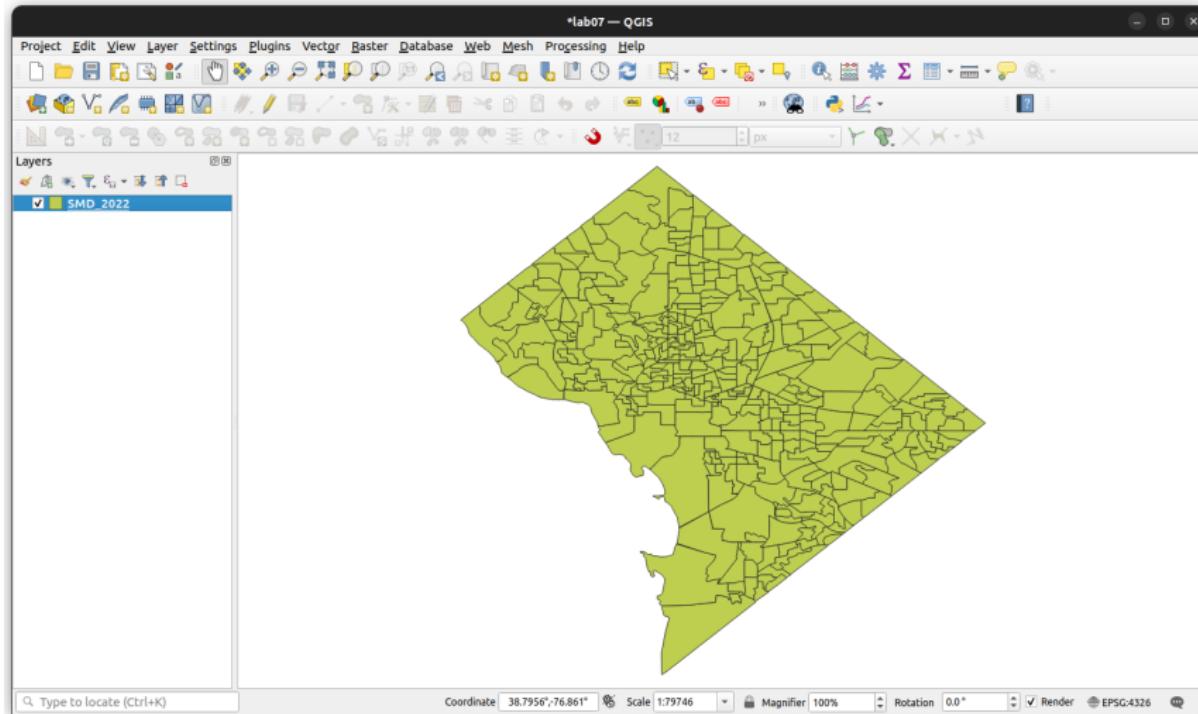
Layer → Add Layer → Add Vector Layer...



Navigate to the SMD\_2022.geojson file in the Data/Elections directory:

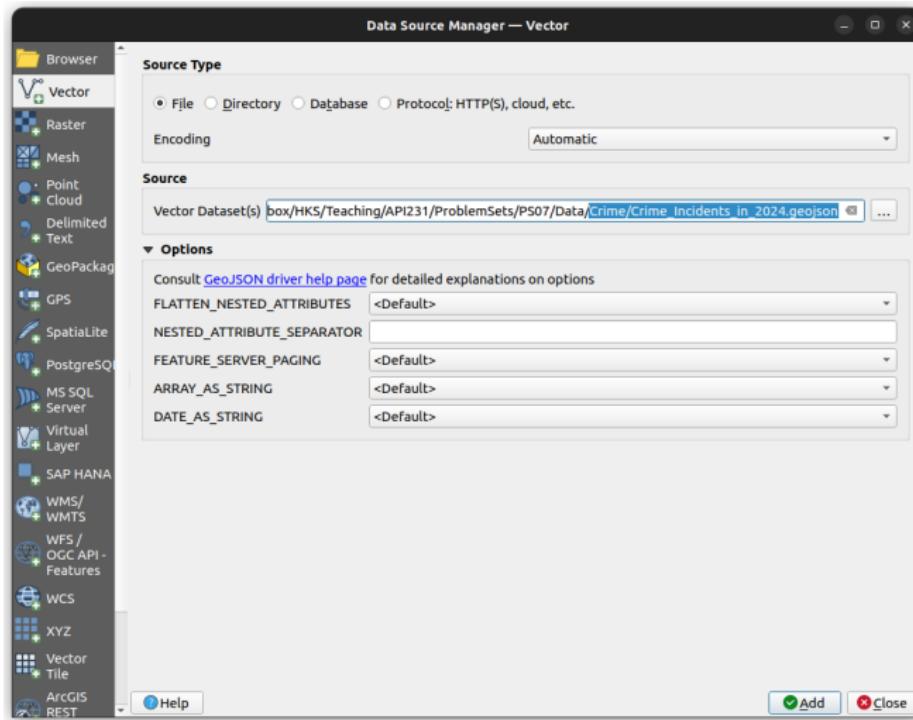


The SMD\_2022 layer should appear in your project window. These polygons are the lowest-level electoral units in DC (DC has 8 Wards, 46 Advisory Neighborhood Commissions, 345 SMDs)

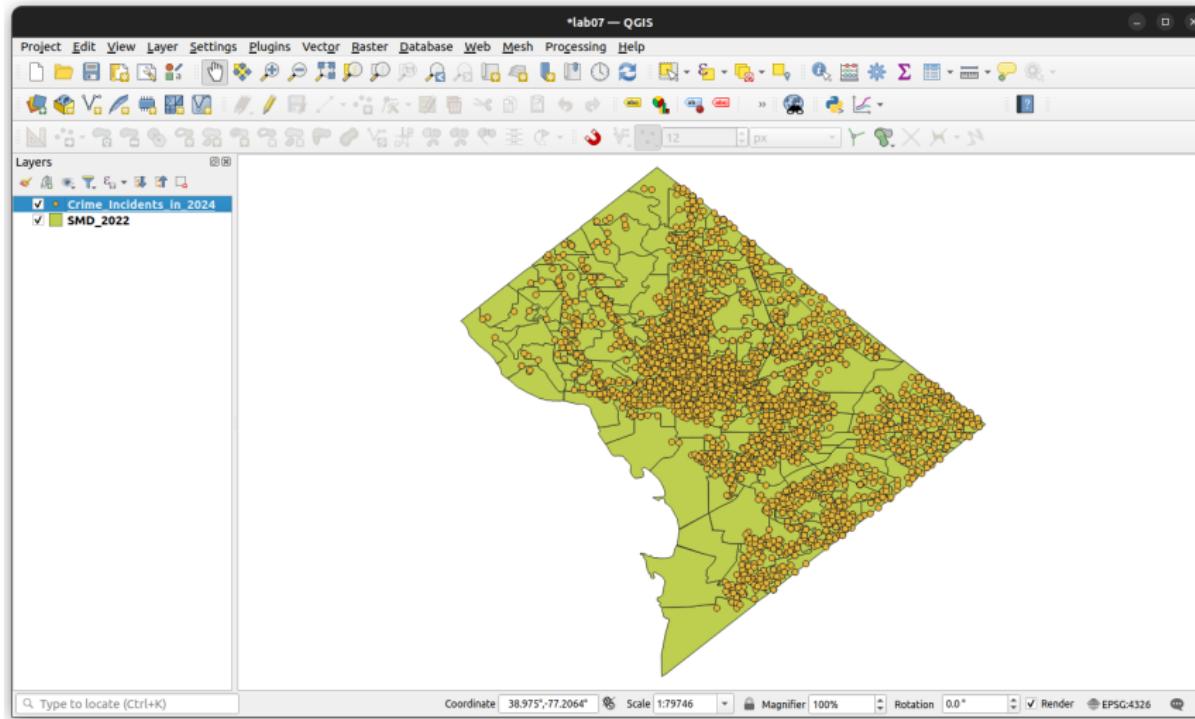


Load the crime incidents vector data:

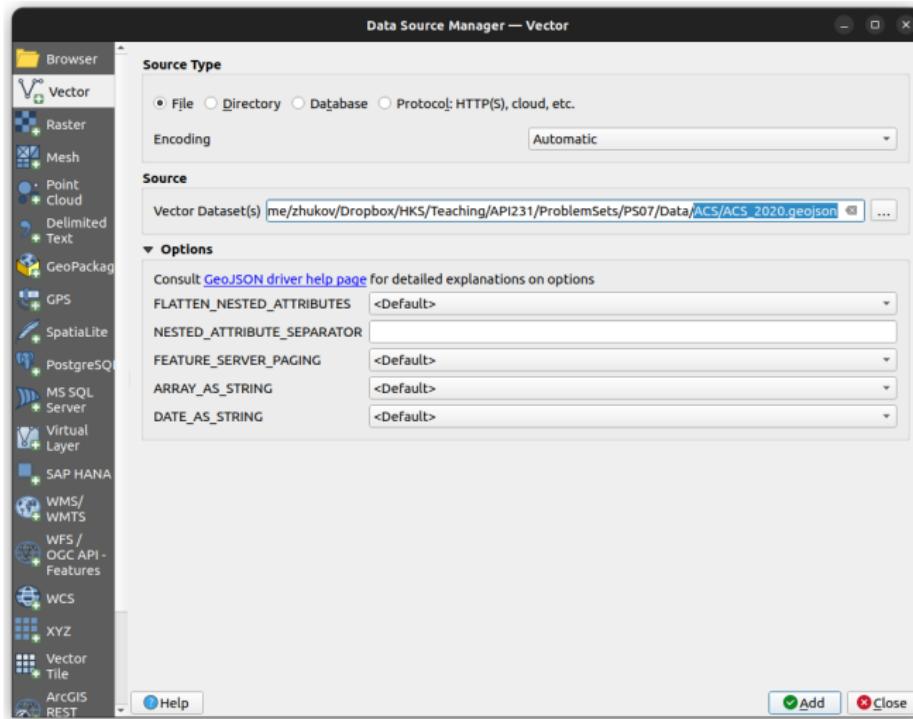
Navigate to the Crime\_Incidents\_in\_2024.geojson file in Data/Crime



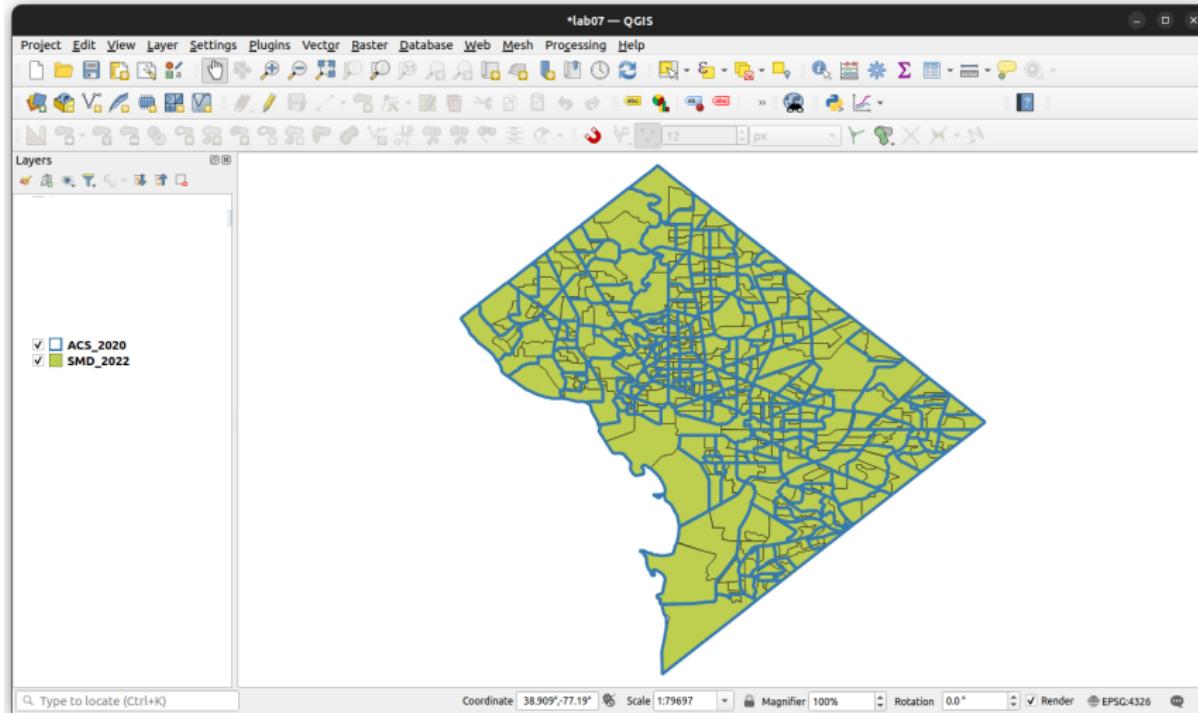
The Crime\_Incidents\_in\_2024 layer should appear in the project window. These are points, representing the locations of reported crimes



The third set of data we need is the ACS\_2020.geojson file in Data/ACS folder



This layer contains American Community Survey data on local demographics (including population counts, which we need to estimate per capita crime). These data are at the level of Census Tracts, the borders of which do not align with SMDs



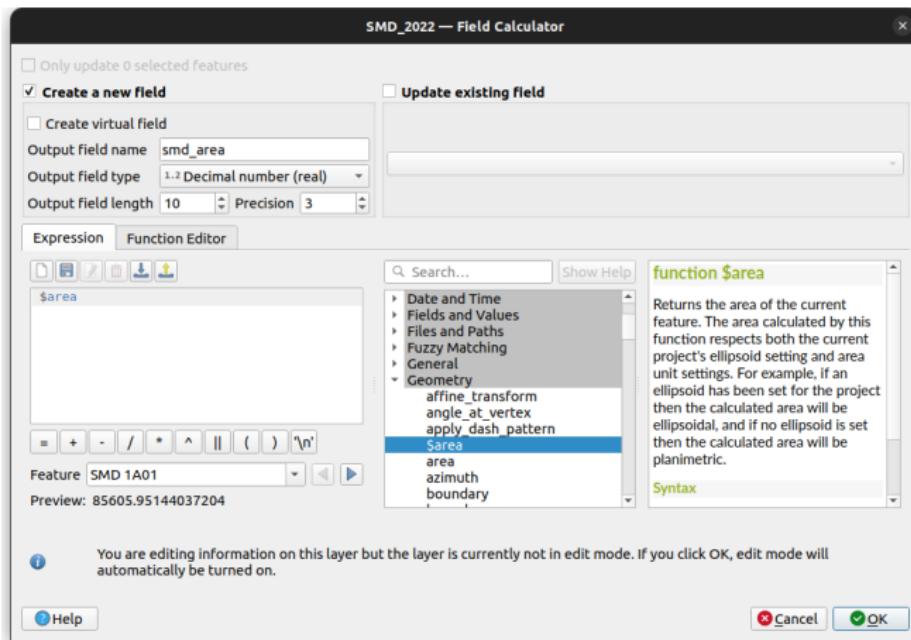
Our first order of business is to *construct the area weights* we will be using for interpolation, starting with  $a_j$  (area of destination polygons). Open the Attribute Table for SMD\_2022 (destination layer) and open the Field Calculator

SMD_2022 — Features Total: 345, Filtered: 345, Selected: 0													
	SMD_ID	OBJECTID	ANC_ID	WEB_URL	NAME	Open field calculator (Ctrl+I)	LAST_NAME	FIRST_NAME	ADDRESS	MIDDLE_NAME	SF	APT	ZIP
1	1A01	2932	1A	<a href="http://anc1...">http://anc1...</a>	SMD 1A01	DIETER LE...	JASPAL BH...	BHATIA	JASPAL	1468 HARV...	NULL	NULL	APT# 42
2	1A02	2922	1A	<a href="http://anc1...">http://anc1...</a>	SMD 1A02	DIETER LE...	DIETER LE...	MORALES	DIETER	3460 14TH ...	LEHMANN	NULL	APT# 49
3	1A03	2931	1A	<a href="http://anc1...">http://anc1...</a>	SMD 1A03	DIETER LE...	CARLO PERRI	PERRI	CARLO	1400 IRVIN...	NULL	NULL	APT# 315
4	1A04	2918	1A	<a href="http://anc1...">http://anc1...</a>	SMD 1A04	DIETER LE...	JEREMY SH...	SHERMAN	JEREMY	1309 PARK ...	NULL	NULL	UNIT# 001
5	1A05	2925	1A	<a href="http://anc1...">http://anc1...</a>	SMD 1A05	DIETER LE...	STEPHEN C...	KENNY	STEPHEN	1451 PARK ...	COLEMAN	NULL	APT# 216
6	1A06	2923	1A	<a href="http://anc1...">http://anc1...</a>	SMD 1A06	DIETER LE...	ANTHONY ...	THOMAS-D...	ANTHONY	1390 KENY...	NULL	NULL	NULL
7	1A07	2917	1A	<a href="http://anc1...">http://anc1...</a>	SMD 1A07	DIETER LE...	MUKTA GH...	GHORPADEY	MUKTA	3501 13TH ...	NULL	NULL	APT# 309
8	1A08	2933	1A	<a href="http://anc1...">http://anc1...</a>	SMD 1A08	DIETER LE...	DAVID SEG...	SEGALL	DAVID	1333 EUCLI...	NULL	NULL	APT# 102
9	1A09	2926	1A	<a href="http://anc1...">http://anc1...</a>	SMD 1A09	DIETER LE...	JAMES A. T...	TURNER	JAMES	1236 GIRA...	A.	NULL	NULL
10													
	<a href="#">Show All Features</a>												

Create a new field called `smd_area` of type Decimal number (real).

Set the Expression to `$area`

This will give us the area calculation for destination polygons (in square meters)



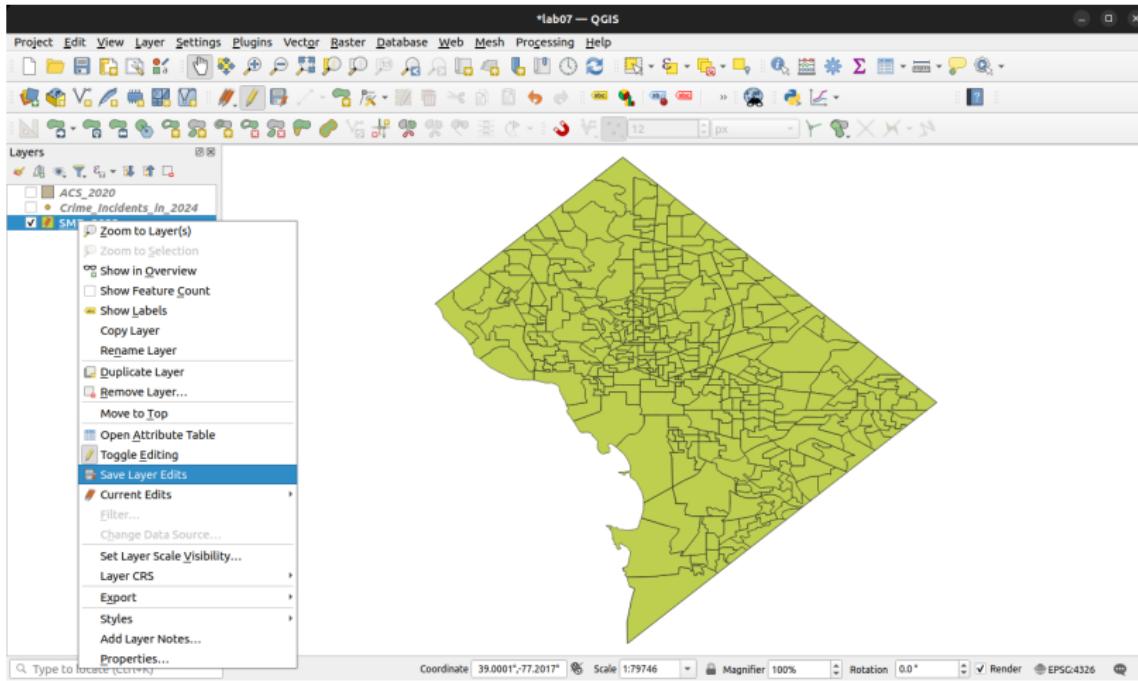
The new field `smd_area` should appear in the Attribute Table for SMD\_2022

SMD\_2022 — Features Total: 345, Filtered: 345, Selected: 0

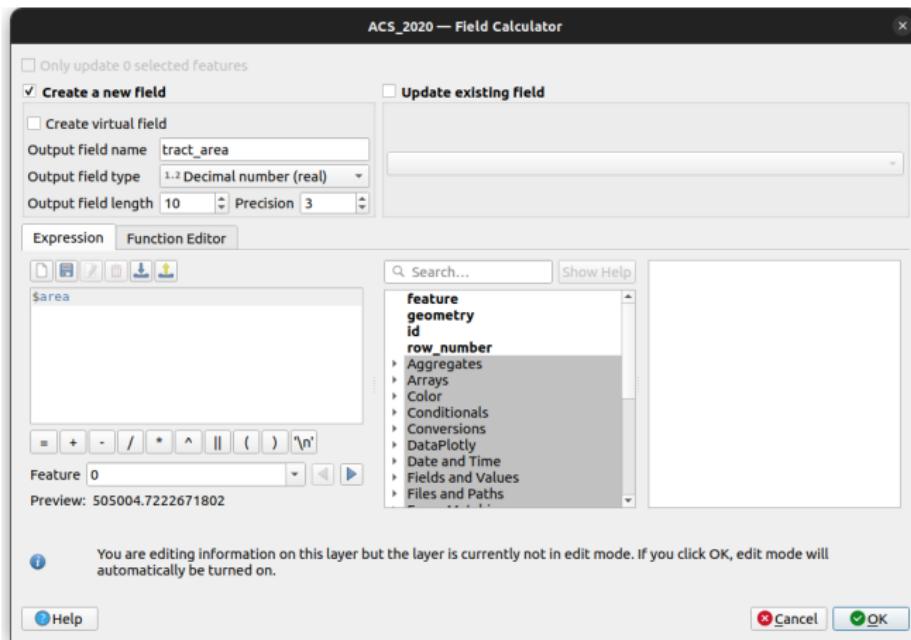
The screenshot shows the QGIS attribute table for the 'SMD\_2022' layer. The table has 14 columns and 8 rows of data. The columns are: iDate, ElectionName, ContestNumber, ContestName, WardNumber, votes\_1st, votes\_2nd, votes\_cast, voteshare\_1st, voteshare\_2nd, votemargin, imprecitive\_top, imprecitive\_top, and smd\_area. The 'smd\_area' column is the last one on the right. The data includes various election results for different wards, with the 'smd\_area' values ranging from 85605.951 to 139006.208.

	iDate	ElectionName	ContestNumber	ContestName	WardNumber	votes_1st	votes_2nd	votes_cast	voteshare_1st	voteshare_2nd	votemargin	imprecitive_top	imprecitive_top	smd_area
1	22 ...	General Ele...	18	ANC - 1A01...	1	481	7	488	98.565573...	1.434426...	97.131147...	0.0286885...	0.0143442...	85605.951
2	22 ...	General Ele...	19	ANC - 1A02...	1	406	10	416	97.596153...	2.4038461...	95.192307...	0.0480769...	0.0240384...	90463.969
3	22 ...	General Ele...	20	ANC - 1A03...	1	291	8	299	97.324414...	2.6755852...	94.648829...	0.0535117...	0.0267558...	65689.035
4	22 ...	General Ele...	21	ANC - 1A04...	1	505	15	520	97.115384...	2.8846153...	94.230769...	0.0576923...	0.0288461...	137899.862
5	22 ...	General Ele...	22	ANC - 1A05...	1	346	6	352	98.295454...	1.7045454...	96.590909...	0.0340909...	0.0170454...	139006.208
6	22 ...	General Ele...	23	ANC - 1A06...	1	146	0	146	100	0	100	0	0	114353.210
7	22 ...	General Ele...	24	ANC - 1A07...	1	498	18	516	96.511627...	3.4883720...	93.023255...	0.0697674...	0.0348837...	120606.540
8	22 ...	General Ele...	25	ANC - 1A08...	1	352	11	363	96.969696...	3.0303030...	93.939393...	0.0606060...	0.0303030...	81005.655

Remember to save your layer edits after every operation like this! Right-click on SMD\_2022 → Save Layer Edits (simply entering Ctrl-S or Cmd-S will save the project file, but not the underlying data layers we are editing)

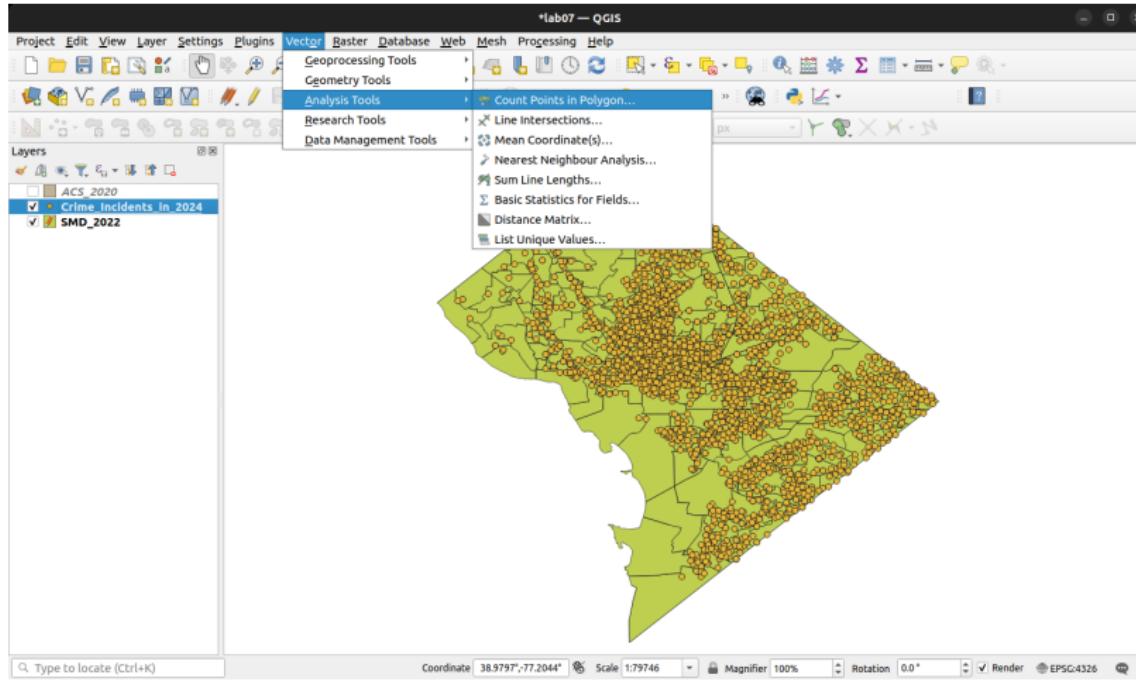


Let's also calculate the area of source polygons ( $a_i$ ). Open the Field Calculator for ACS\_2020 and create a new field called tract\_area of type Decimal number (real). Set the Expression to \$area

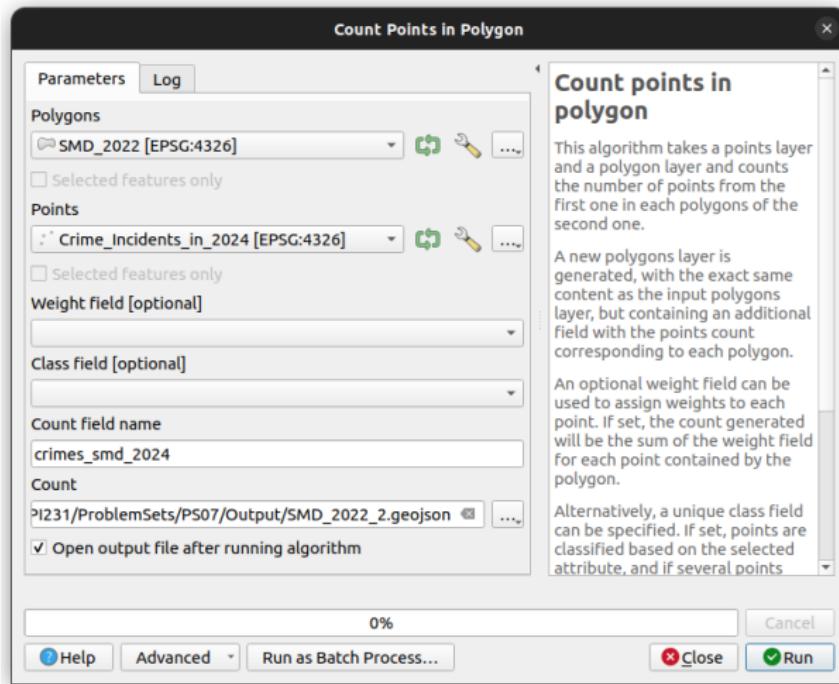


Let's calculate the number of crimes in each SMD (the "nominator" of our future interpolated variable).

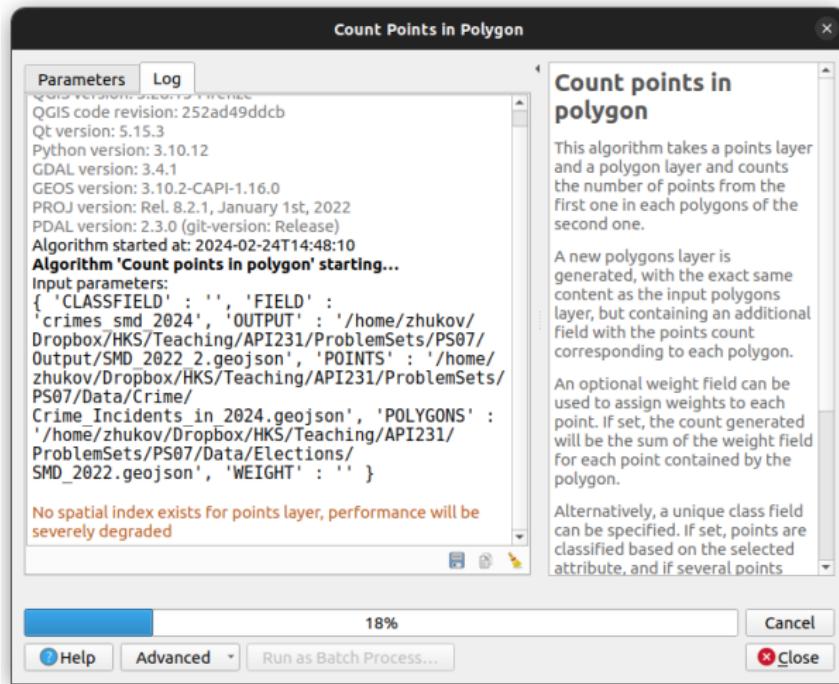
Go to Vector menu → Analysis Tools → Count Points in Polygon...



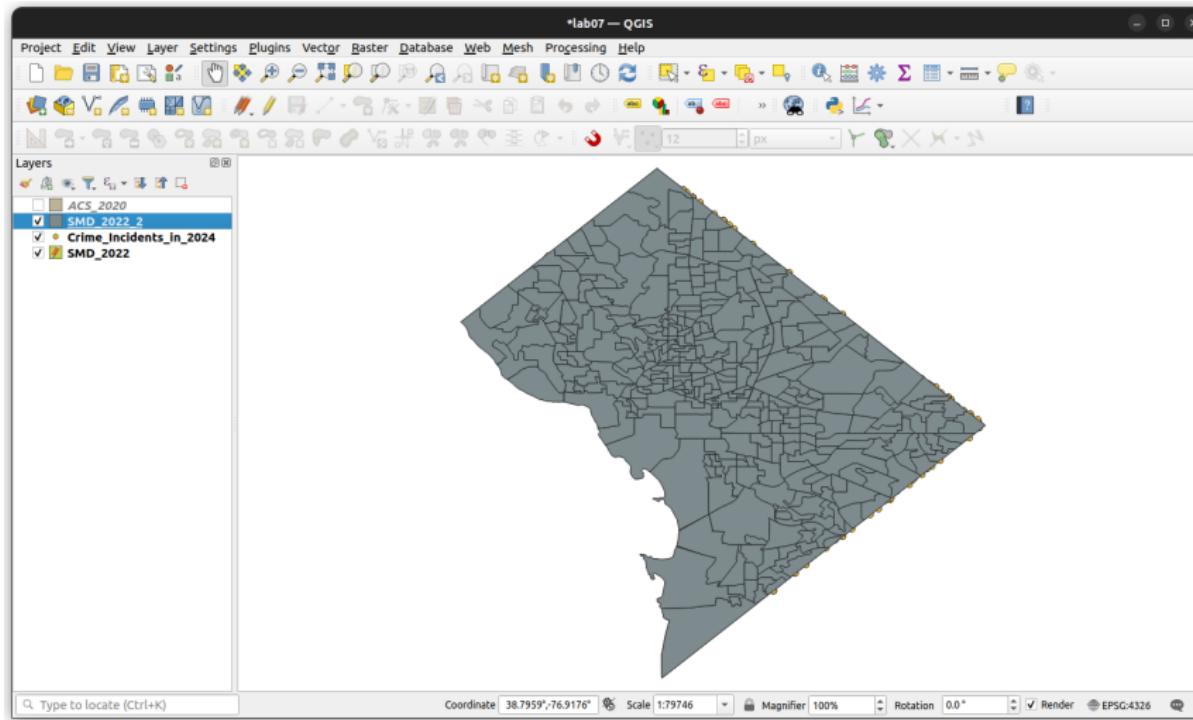
Select SMD\_2022 as the Polygons layer and Crime\_Incidents\_in\_2024 as the Points layer. Name the count field crimes\_smd\_2024 and save the output to a new file called SMD\_2022\_2.geojson. Click Run



You may see a `No spatial index...` warning message in the log, but this won't affect the calculation (only the processing speed). Just be patient and wait for the algorithm to finish



The newly-created SMD\_2022\_2 layer should appear in the project window. You can hide the other two layers for now, if you like

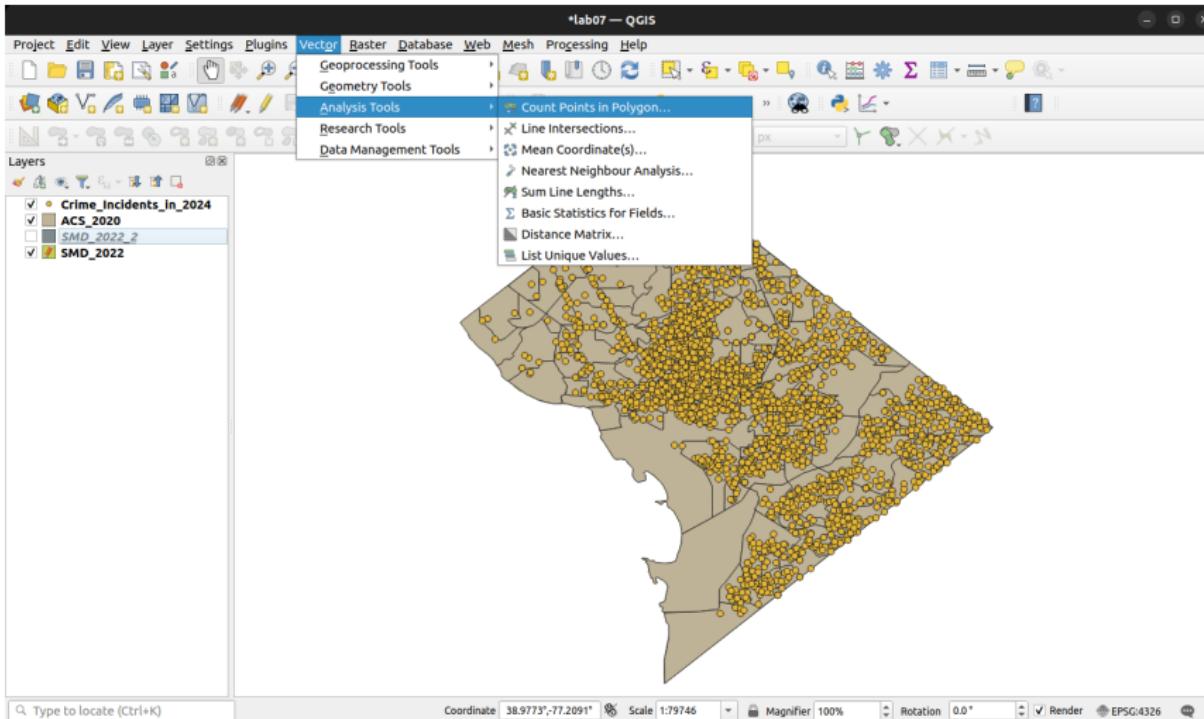


Check the Attribute Table for SMD\_2022\_2 to make sure the crimes\_smd\_2024 variable is there

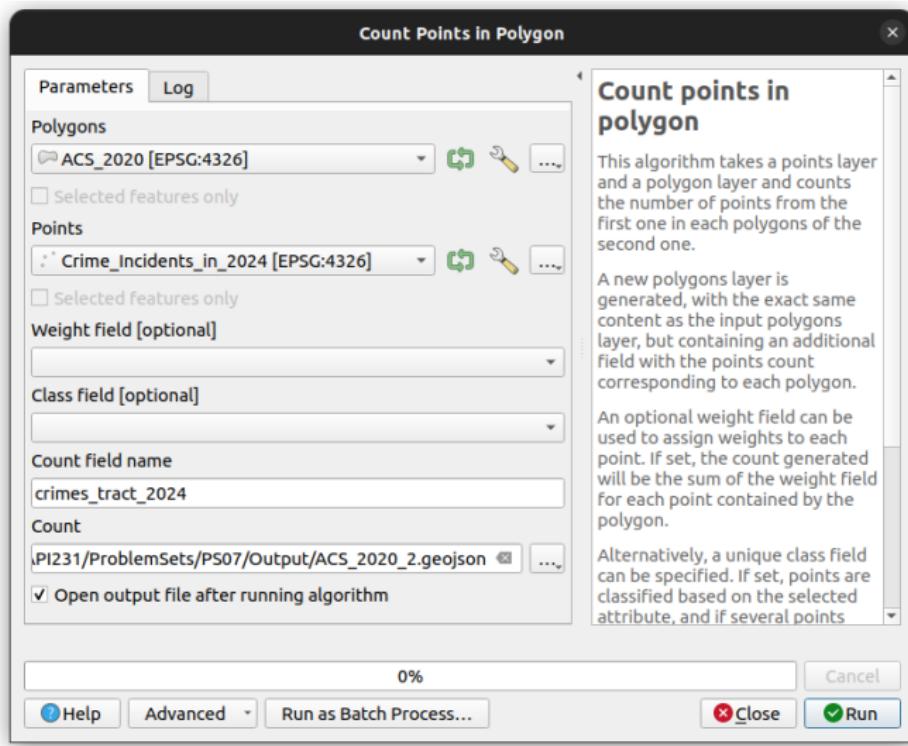
SMD\_2022\_2 — Features Total: 345, Filtered: 345, Selected: 0

ite	ElectionName	ContestNumber	ContestName	WardNumber	votes_1st	votes_2nd	votes_cast	voteshare_1st	voteshare_2nd	votemargin	competitive_top	competitive_top	smd_area	crimes_smd_2024
70	General Ele...	87	ANC - 2E04...	2	4	0	4	100	0	100	0	0	180485....	1
71	General Ele...	88	ANC - 2E05...	2	261	17	278	93.884892...	6.1151079...	87.769784...	0.1223021...	0.0611510...	180454...	33
72	General Ele...	89	ANC - 2E06...	2	576	14	590	97.627118...	2.3728813...	95.254237...	0.0474576...	0.0237288...	407027....	11
73	General Ele...	90	ANC - 2E07...	2	559	21	580	96.379310...	3.6206896...	92.758620...	0.0724137...	0.0362068...	794351....	3
74	General Ele...	91	ANC - 2E08...	2	17	0	17	100	0	100	0	0	113952....	3
75	General Ele...	92	ANC - 2F01...	2	564	16	580	97.241379...	2.7586206...	94.482758...	0.0551724...	0.0275862...	174266....	40
76	General Ele...	93	ANC - 2F02...	2	534	19	553	96.564195...	3.4358047...	93.128390...	0.0687160...	0.0343580...	138109....	13
77	General Ele...	94	ANC - 2F03...	2	90	0	90	100	0	100	0	0	81919.9...	37
78	General Ele...	95	ANC - 2F04...	2	426	9	435	97.931034...	2.0689655...	95.862068...	0.0413793...	0.0206896...	68863.6...	11

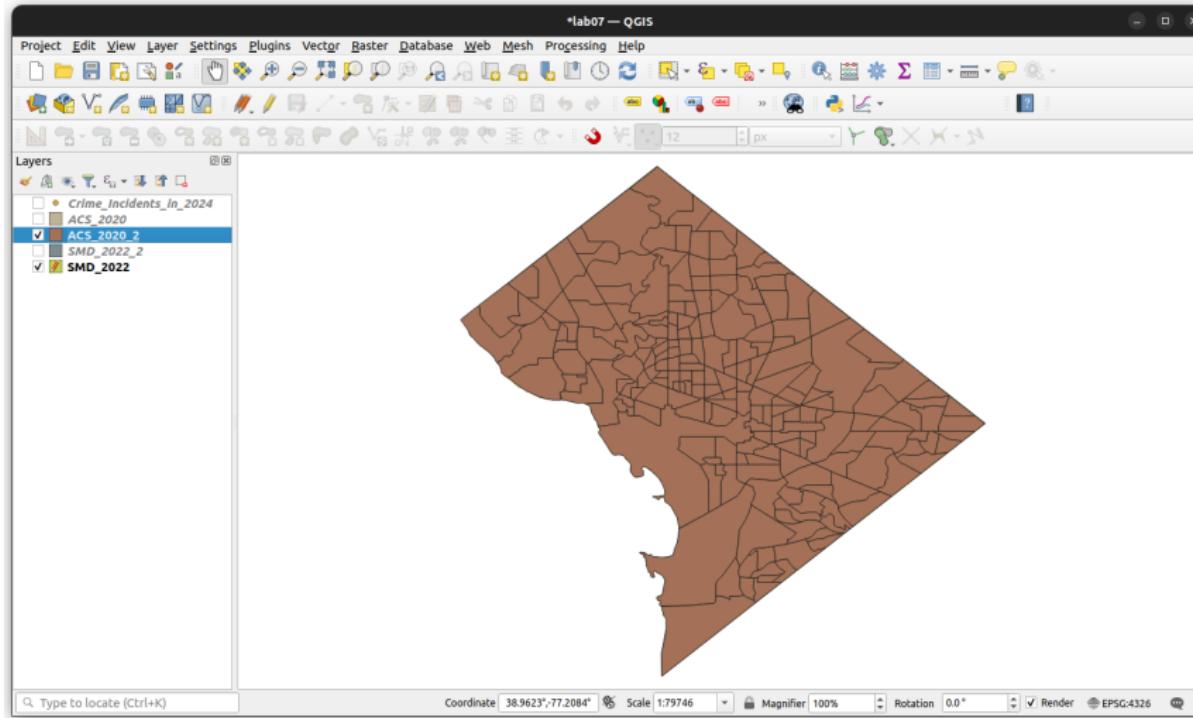
To facilitate a “whole vs. parts” comparison (i.e. transforming a variable directly versus reconstructing it from transformed components) we can do the same kind of points-in-polygons calculation with the ACS\_2020 layer...



Same approach as before, except with ACS\_2020 as polygon layer, crimes\_tract\_2024 as field name, and ACS\_2020\_2.geojson as output file



The new ACS\_2020\_2 layer should appear in the project window.  
Let's open its Attribute Table

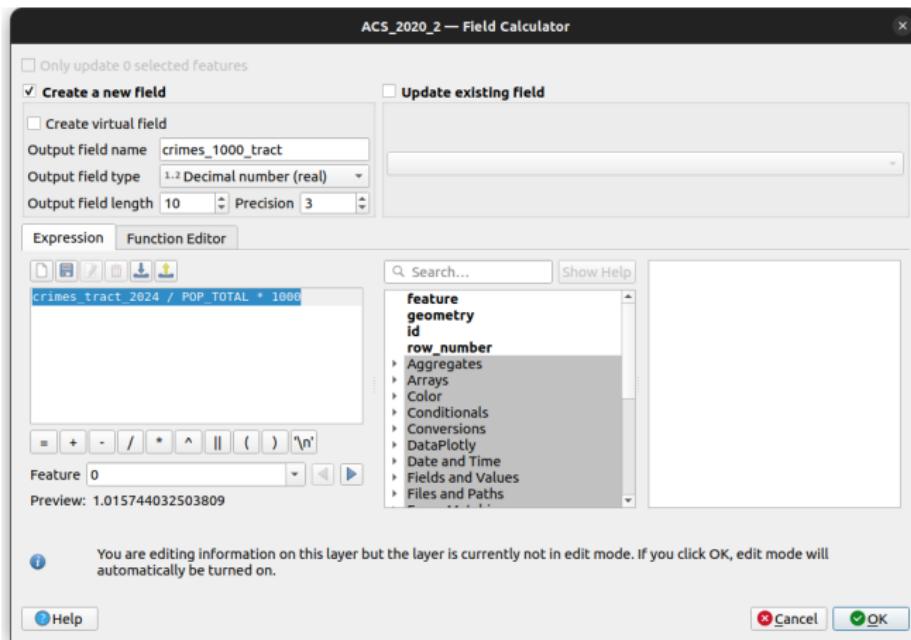


Make sure the `crimes_tract_2024` variable is there.  
Then launch the Field Calculator

ACS\_2020\_2 — Features Total: 206, Filtered: 206, Selected: 0

	MAFISEHOLDS_CD	DOL_ENROLLMENT	NATIONAL_ATTAIN	FOREIGN_BORIE_HOME	Open field calculator (Ctrl+I)	E	CT_NONWHIT	MARRIEDCOIF_FOREIGNBO:T	NONENGLI:SCHOOLNR:T	BROADBAN	crimes_tract_2024
1	306	30	83	1150	149	274	744	93.676814...	6.3231850...	44.094488...	11.631537...
2	809	75	456	2824	746	544	1752	85.497365...	14.502634...	48.920863...	23.117446...
3	0	0	3874	84	731	1461	0	58.506856...	41.493143...	0	18.562722...
4	536	64	1782	2639	793	1228	1776	80.429378...	19.570621...	33.314825...	17.920903...
5	013	167	1881	3989	1308	1527	2355	82.903117...	17.096882...	47.011952...	21.924237...
6	259	60	470	1117	349	417	553	67.2	32.8	53.885135...	23.266666...
7	562	251	544	2888	545	519	2013	68.877849...	31.122150...	39.294345...	15.926358...
8	650	199	529	2697	467	700	1706	75.409365...	24.590634...	49.075144...	13.415685...
9	885	38	834	3636	593	565	2083	79.991467...	20.008532...	41.539153...	12.649317...
10											

Calculate the “crimes per 1000 residents” variable for ACS\_2020\_2. Name the field crimes\_1000\_tract, set type to Decimal number (real), and set the Expression to crimes\_tract\_2024 / POP\_TOTAL \* 1000

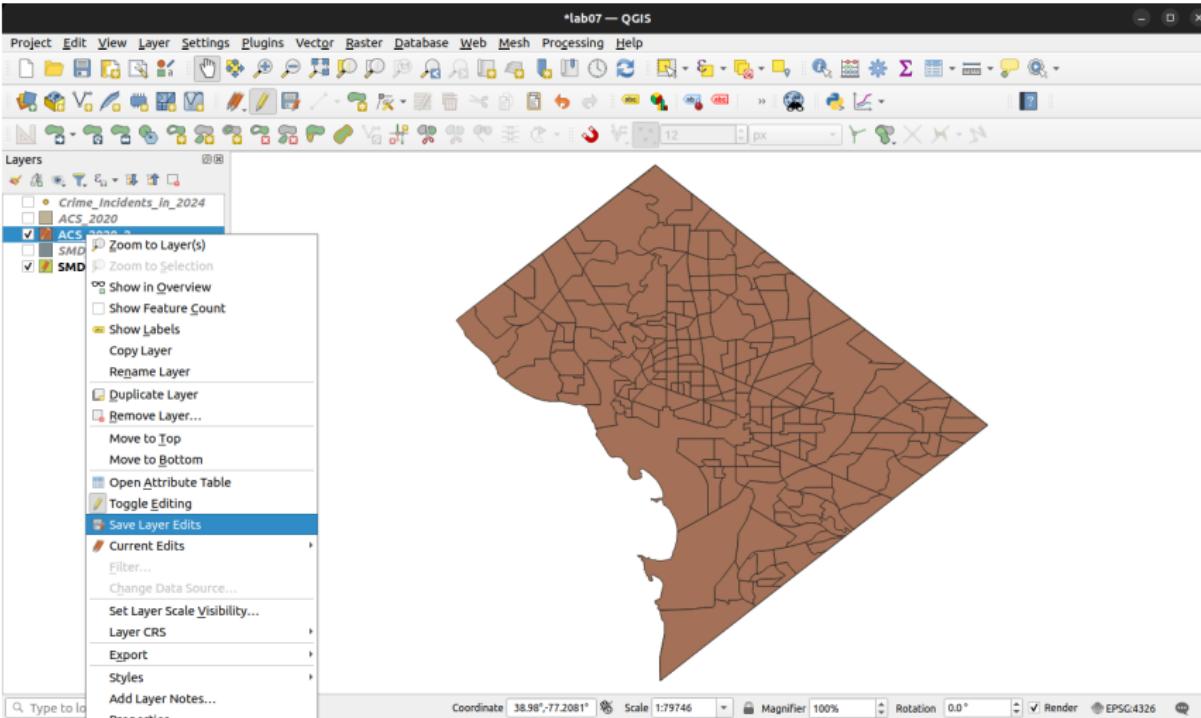


The new `crimes_1000_tract` variable should appear in the Attribute Table

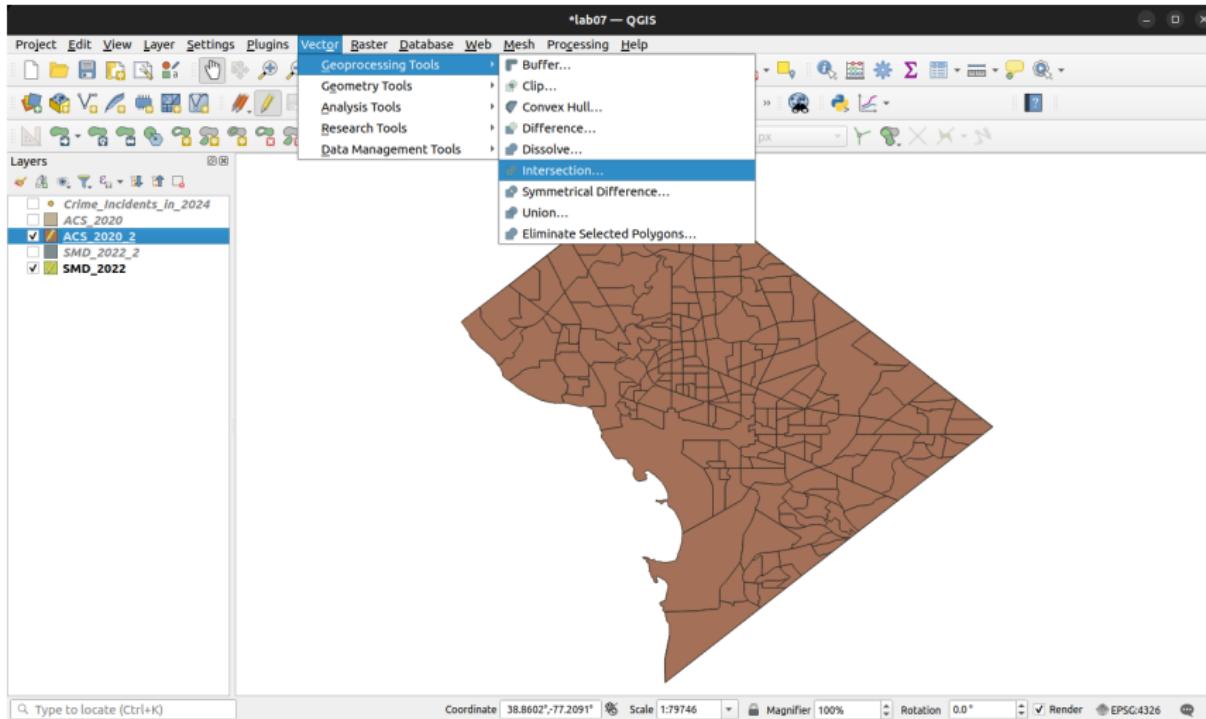
ACS\_2020\_2 — Features Total: 206, Filtered: 206, Selected: 0

	abc	TRACTCE	CODOL	ENROLL	NATIONAL_ATTAI	OREIGN_BORIE	HOME_NORNET	BROADB	PCT_WHITE	CT_NONWHIT	MARRIEDCOIT	FOREIGNBO	T_NONENGLIS	SCHOOLNR	T_BROADBAN	crimes_tract_2024	mes_1000_tract
1	30	83	1150	149	274	744	93.676814...	6.3231850...	44.094488...	11.631537...	21.389539...	6.4793130...	97.637795...	5	3.903		
2	75	456	2824	746	544	1752	85.497365...	14.502634...	48.920863...	23.117446...	16.857762...	14.130771...	96.956281...	34	10.536		
3	0	3874	84	731	1461	0	58.506856...	41.493143...		0	18.562722...	37.100050...	98.374809...	0	4	1.016	
4	64	1782	2639	793	1228	1776	80.429378...	19.570621...	33.314825...	17.920903...	27.751412...	40.271186...	98.611882...	36	8.136		
5	167	1881	3989	1308	1527	2355	82.903117...	17.096882...	47.011952...	21.924237...	25.595038...	31.528662...	93.824701...	16	2.682		
6	60	470	1117	349	417	553	67.2	32.8	53.885135...	23.266666...	27.8	31.333333...	93.412162...	2	1.333		
7	251	544	2888	545	519	2013	68.877849...	31.122150...	39.294345...	15.926358...	15.166569...	15.897136...	97.293378...	23	6.721		
8	199	529	2697	467	700	1706	75.409365...	24.590634...	49.075144...	13.415685...	20.109164...	15.196782...	98.612716...	7	2.011		

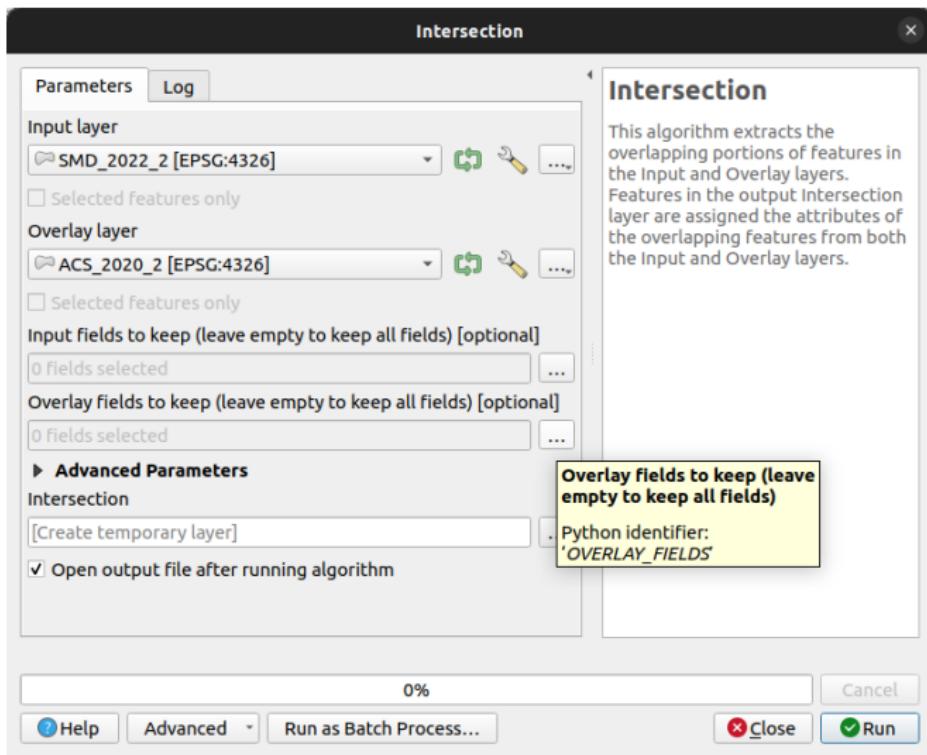
Remember to save your layer edits!



The next step is to calculate the area of each intersection between source and destination polygons, or  $a_{i \cap j}$ . To do this, we first need to create the intersection. Go to Vector menu → Geoprocessing Tools → Intersection...



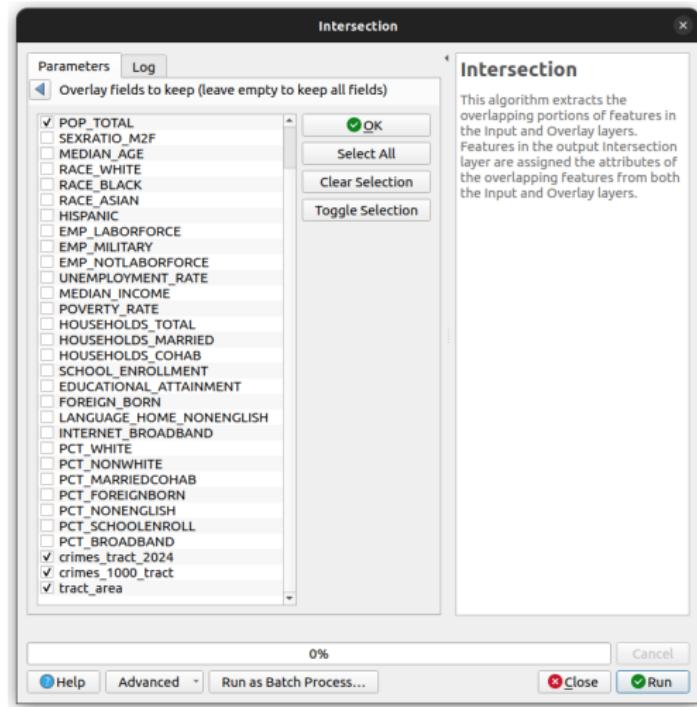
For the intersection, select SMD\_2022\_2 as Input Layer, ACS\_2020\_2 as Overlay layer. Then click the [...] button next to “Overlay fields to keep”



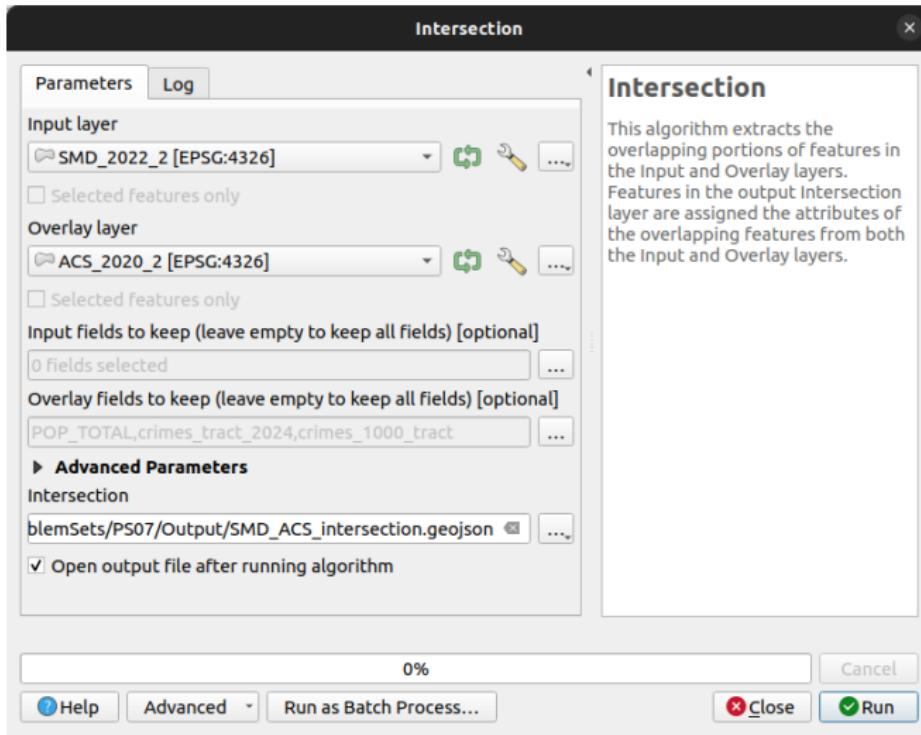
On the next screen check the boxes next to

- ✓ POP\_TOTAL
- ✓ crimes\_tract\_2024
- ✓ crimes\_1000\_tract
- ✓ tract\_area

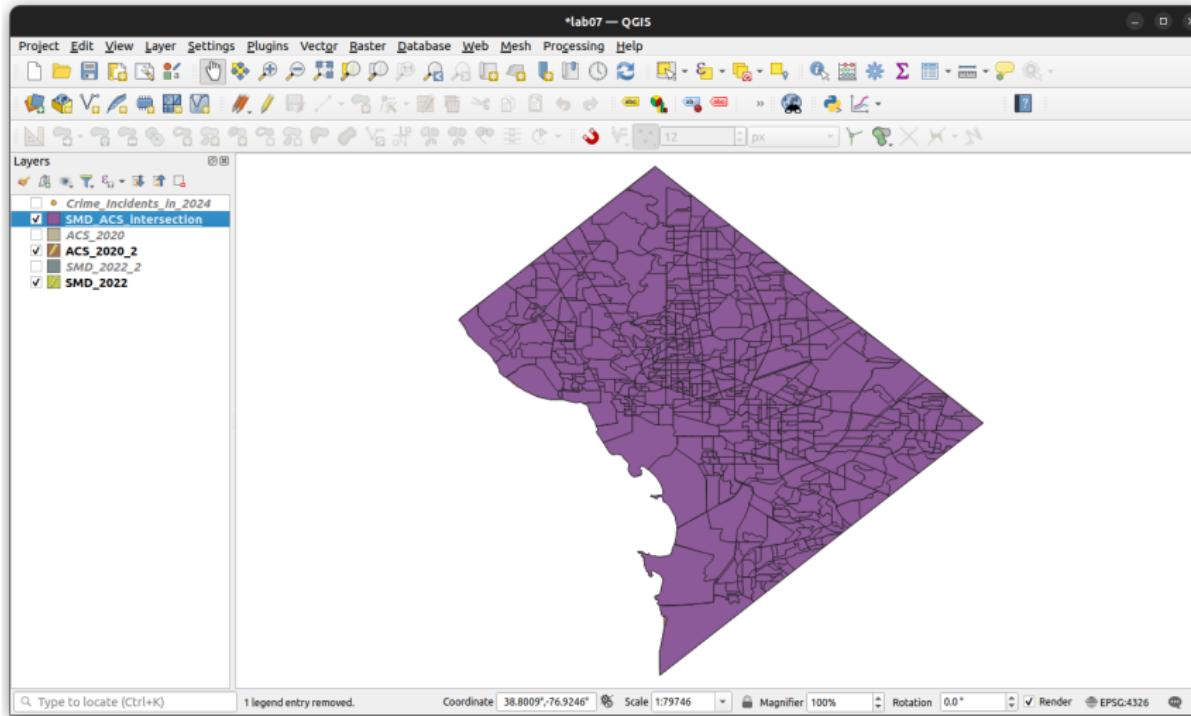
Click OK



Save the output file to SMD\_ACS\_intersection.geojson, click Run



The SMD\_ACS\_intersection layer should appear in your project window



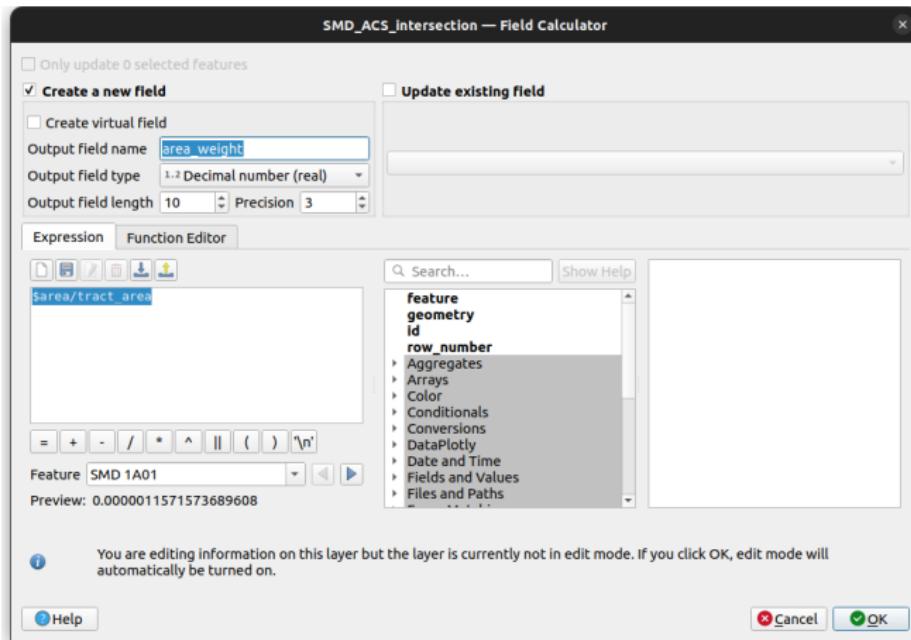
Open the Attribute Table for SMD\_ACS\_intersection and launch the Field Calculator

SMD\_ACS\_intersection -- Features Total: 1516, Filtered: 1516, Selected: 0

stName	WardNumber	votes_1st	votes_2nd	votes_cast	votes_sh	Open field calculator (Ctrl+I)	margin	competitive_top	competitive_top	smd_area	imes_smd_20	POP_TOTAL	imes_tract_20	mes_1000_tr
1 A01...	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	5219	92	17.628
2 A01...	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	4517	24	5.313
3 A01...	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	2084	11	5.278
4 A01...	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	3088	13	4.21
5 A01...	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	3430	31	9.038
6 A01...	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	2551	13	5.096
7 A02...	1	406	10	416	97.596153...	2.4038461...	95.192307...	0.0480769...	0.0240384...	90463.969	10	2289	6	2.621
8 A02...	1	406	10	416	97.596153...	2.4038461...	95.192307...	0.0480769...	0.0240384...	90463.969	10	4087	12	2.936
9 A02...	1	406	10	416	97.596153...	2.4038461...	95.192307...	0.0480769...	0.0240384...	90463.969	10	5219	92	17.628
10														

Create a new field called `area_weight` of type Decimal Number (real).

Set Expression to  $\$area / \text{tract\_area}$  (this is equivalent to  $w_{i \cap j}^{(\text{ext})} = \frac{a_{i \cap j}}{a_i}$ )

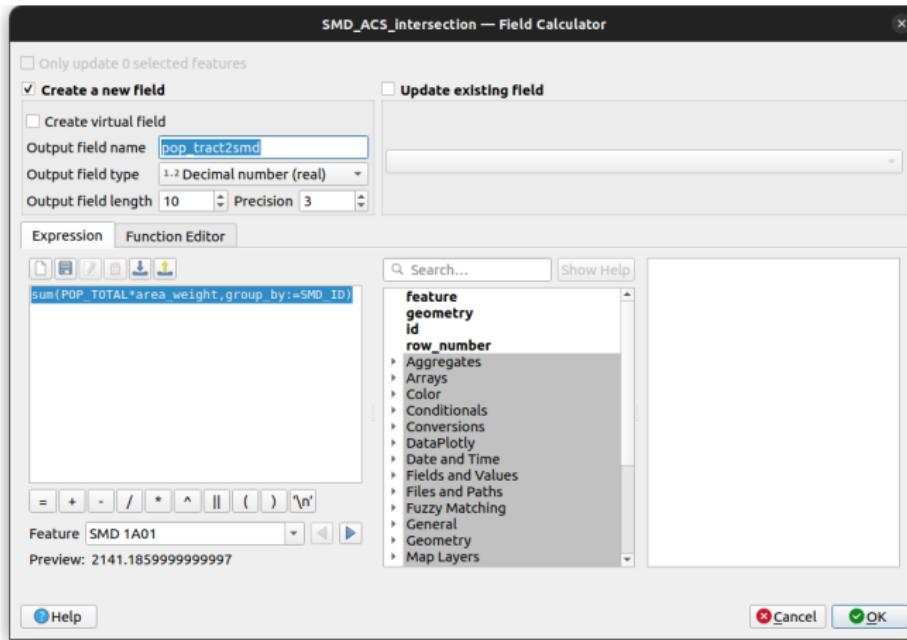


The area\_weight field should appear in the Attribute Table.

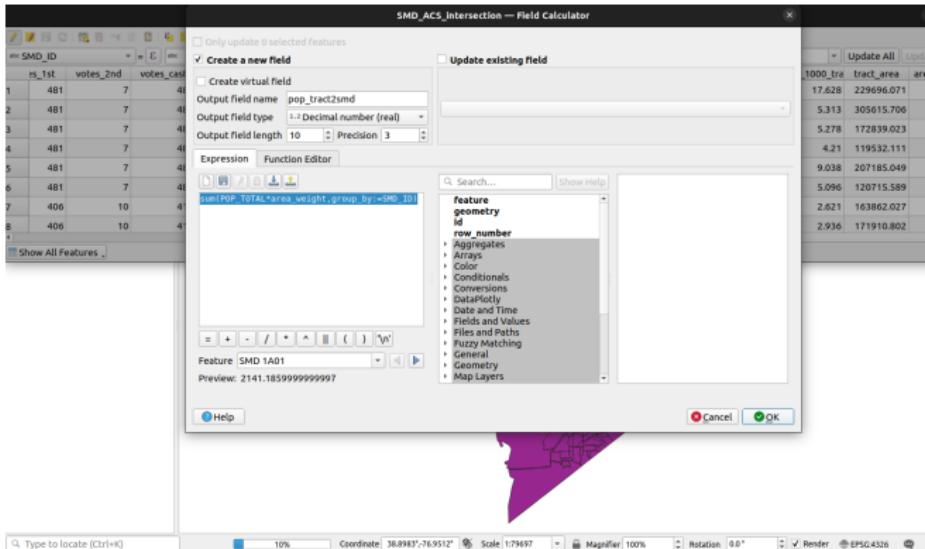
Now go back to the Field Calculator, where we will create weighted population variables for destination polygons

SMD_ACS_intersection — Features Total: 1516, Filtered: 1516, Selected: 0																
abc SMD_ID		abc														
Number	votes_1st	votes_2nd	votes_cast	voteshare_1st	voteshare_2nd	votemargin	competitive_top	competitive_top	smd_area	imes_smd_20%	POP_TOTAL	imes_tract_20	mes_1000_tra	area_weight		
1	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	5219	92	17.628	0.272	
2	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	4517	24	5.313	0	
3	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	2084	11	5.278	0	
4	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	3088	13	4.21	0.728	
5	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	3430	31	9.038	0	
6	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	2551	13	5.096	0	
7	1	406	10	416	97.596153...	2.4038461...	95.192307...	0.0480769...	0.0240384...	90463.969	10	2289	6	2.621	0	
8	1	406	10	416	97.596153...	2.4038461...	95.192307...	0.0480769...	0.0240384...	90463.969	10	4087	12	2.936	0.491	

Now let's sum the weighted population numbers for each SMD. Create a new field called `pop_tract2smd` of type Decimal Number (real). Set Expression to `sum(POP_TOTAL*area_weight,group_by:=SMD_ID)`  
(this is equivalent to  $\sum_{i \cap j} w_{i \cap j}^{(ext)} x_{i \cap j}$ )

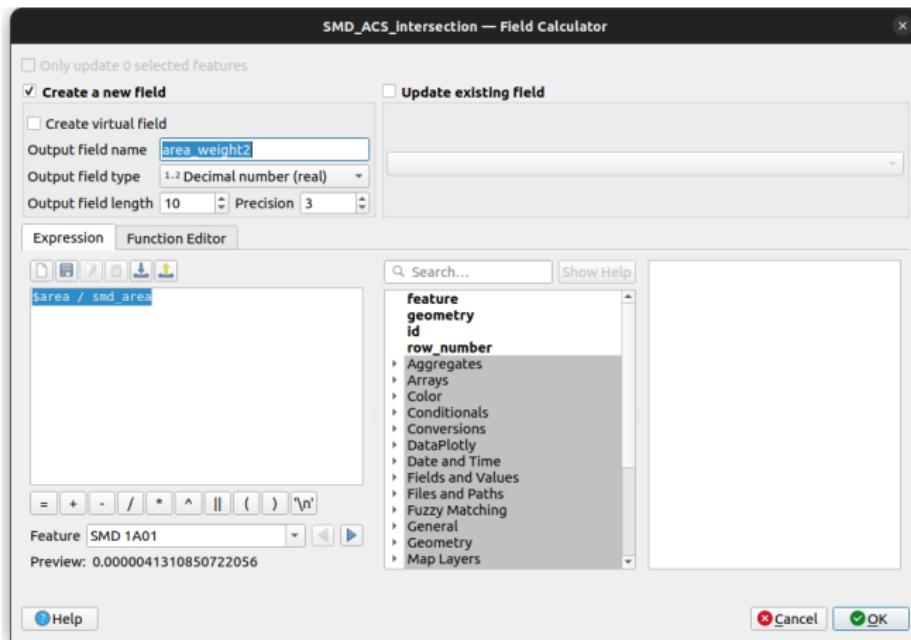


This will take several minutes to compute (you can follow the progress bar at bottom, or use this time to stretch your legs)

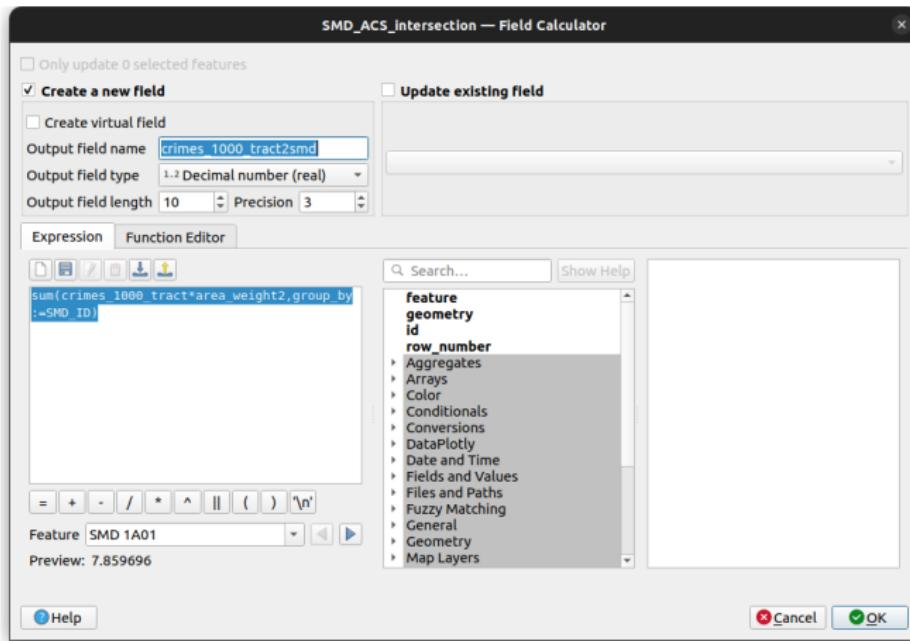


(OPTIONAL) Create a new field called area\_weight2 of type Decimal Number (real).

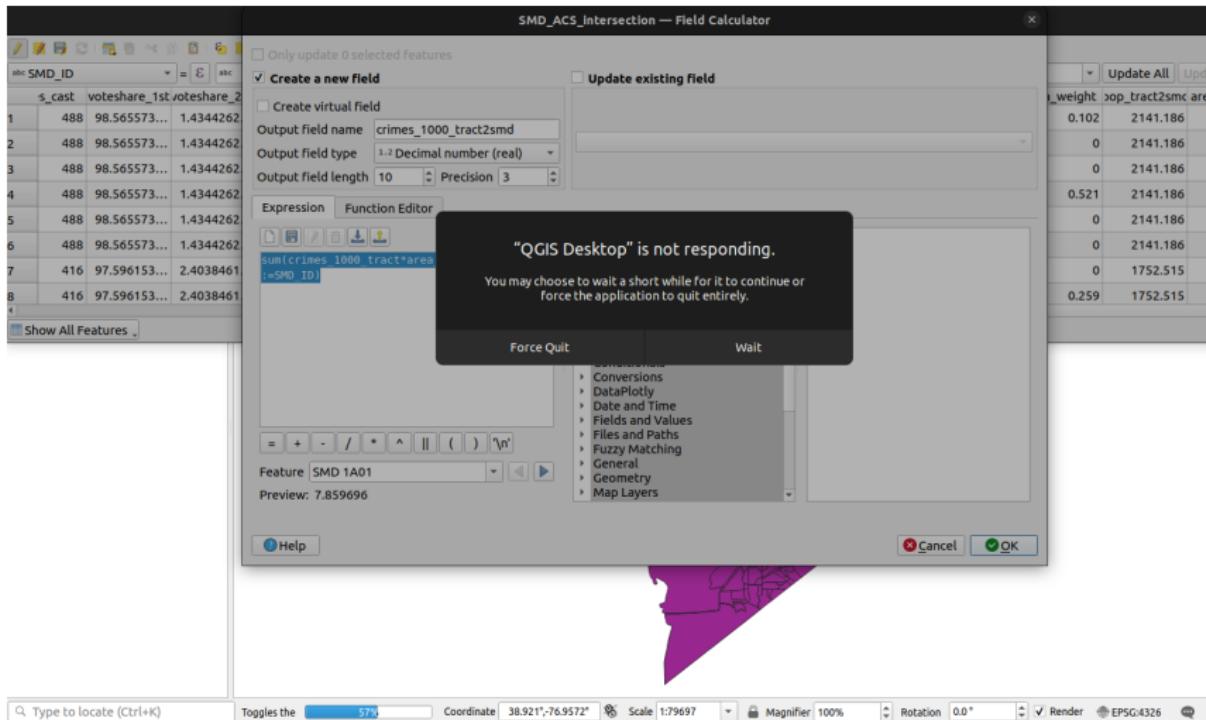
Set Expression to \$area / smd\_area (this is equivalent to  $w_{i \cap j}^{(int)} = \frac{a_{i \cap j}}{a_j}$ )



Now let's do a weighted average (intensive) of crimes per 1000 residents. Create a new field called `crimes_1000_tract2smd` of type Decimal Number (real). Set Expression to `sum(crimes_1000_tract*area_weight2,group_by:=SMD_ID)` (this is equivalent to  $\sum_{i \in j} w_{i \cap j}^{(int)} x_{i \cap j}$ )



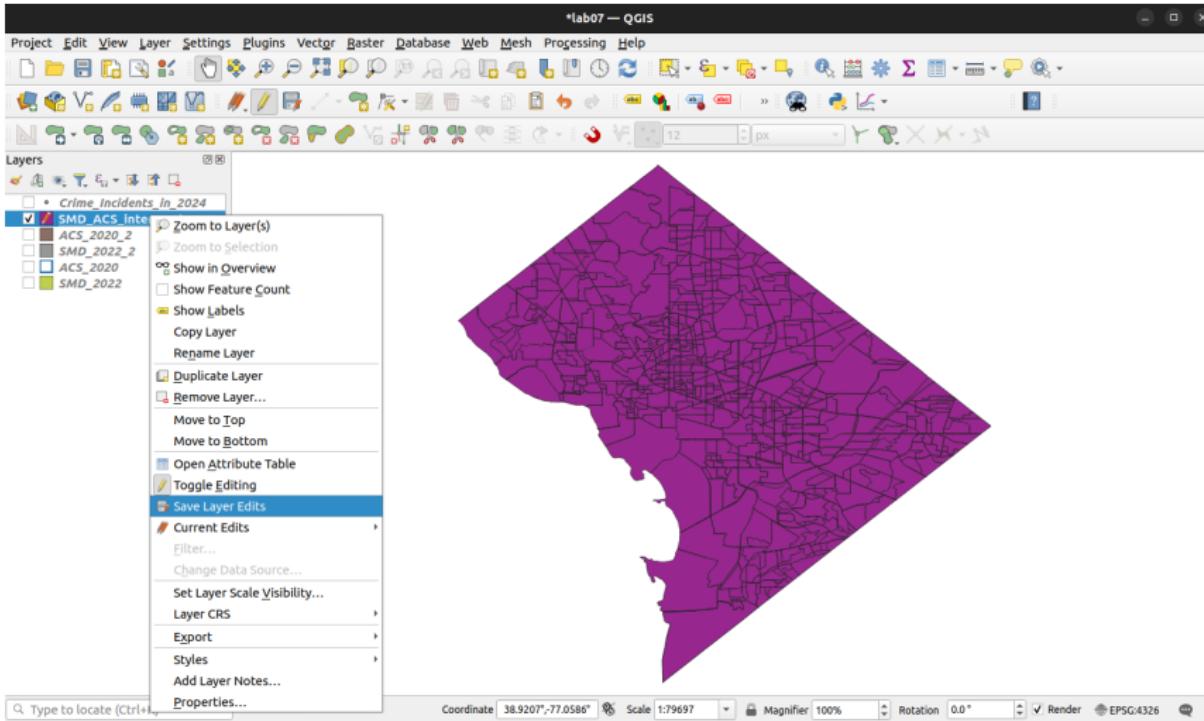
(OPTIONAL) This will also take a while to run. I even received a “program not responding” message, which I ignored (but check the progress bar to make sure the program is actually still running)



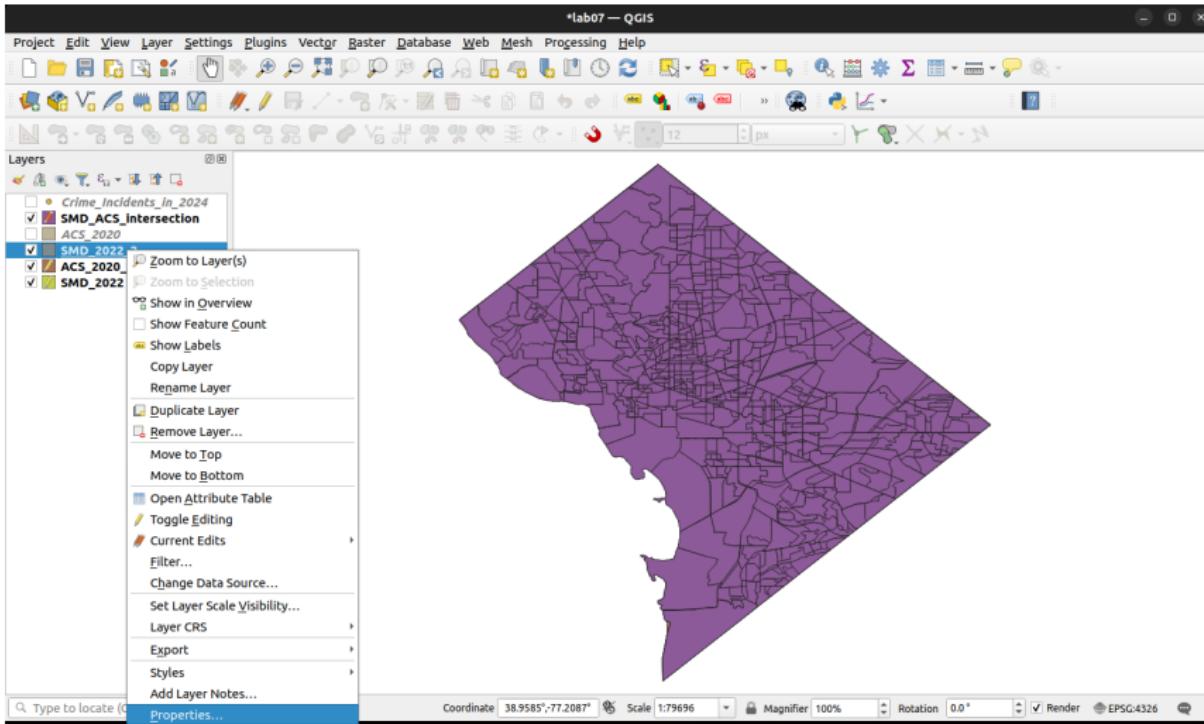
When it finishes running, you will see both new variables in the Attribute Table.  
Note that these values should be constant within SMDs (i.e. values will be repeated for intersections within each destination polygon)

SMD_ACS_Intersection — Features Total: 1516, Filtered: 1516, Selected: 0																
	SMD_ID	vare_1st	voteshare_2nd	votemargin	competitive_top	competitive_top	smd_area	imes_smd_20	POP_TOTAL	imes_tract_20	imes_1000_tract	tract_area	area_weight	pop_tract2smc	area_weight2smc	imes_1000_tract
1	55573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	0.0143442...	85605.951	9	5219	92	17.628	229696.071	0.102	2141.186	0.272	7.860
2	55573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	0.0143442...	85605.951	9	4517	24	5.313	305615.706	0	2141.186	0	7.860
3	55573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	0.0143442...	85605.951	9	2084	11	5.278	172839.023	0	2141.186	0	7.860
4	55573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	0.0143442...	85605.951	9	3088	13	4.21	119532.111	0.521	2141.186	0.728	7.860
5	55573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	0.0143442...	85605.951	9	3430	31	9.038	207185.049	0	2141.186	0	7.860
6	55573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	0.0143442...	85605.951	9	2551	13	5.096	120715.589	0	2141.186	0	7.860
7	96153...	2.4038461...	95.192307...	0.0480769...	0.0240384...	0.0240384...	90463.969	10	2289	6	2.621	163862.027	0	1752.515	0	5.327
8	96153...	2.4038461...	95.192307...	0.0480769...	0.0240384...	0.0240384...	90463.969	10	4087	12	2.936	171910.802	0.259	1752.515	0.491	5.327

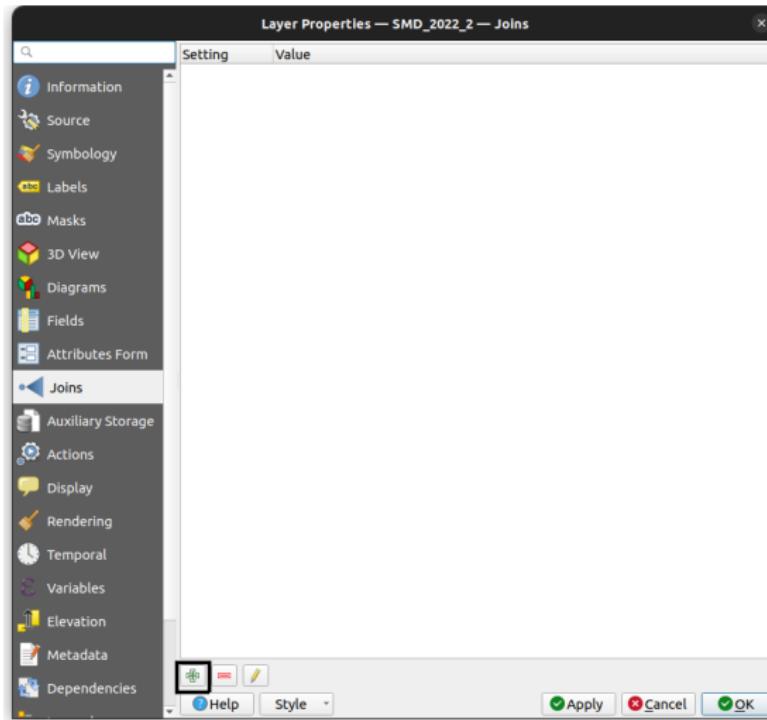
After the algorithm finishes running is a good time to save your layer edits!



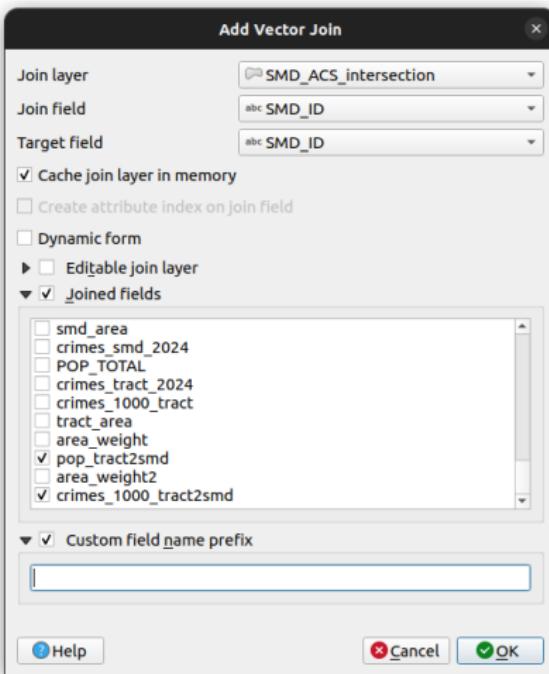
Our next step is to import these weighted values into the SMD\_2022\_2 layer, and divide crimes by population size. Right-click on SMD\_2022\_2 → Properties



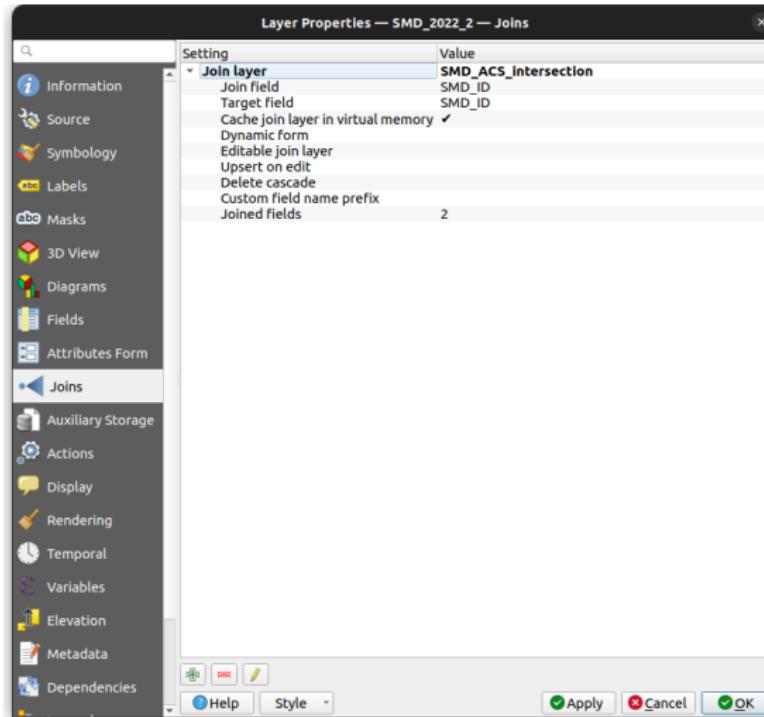
Go to Joins tab in SMD\_2022\_2 Properties and click + button to add a new join



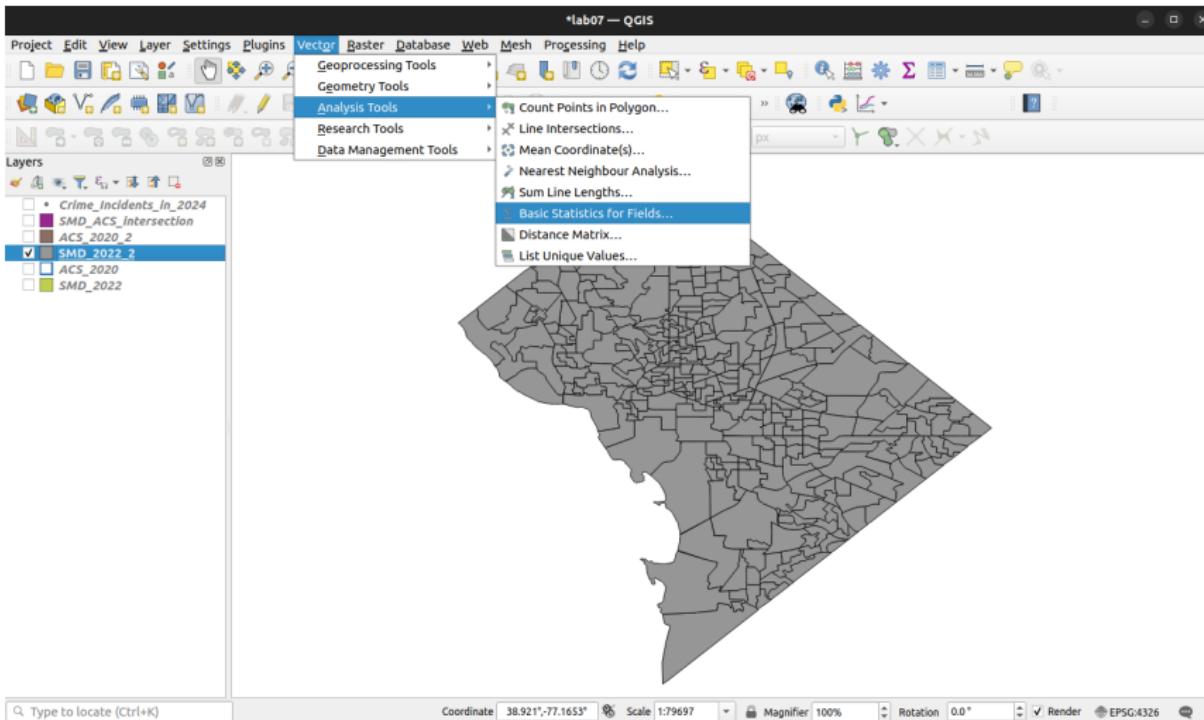
Set SMD\_ACS\_intersection as the “Join layer”, SMD\_ID as the “Join” and “Target” field, and under “Joined fields” select  pop\_tract2smd and  crimes\_1000\_tract2smd (if you created this variable, too). Check the box next to Custom field name prefix and clear the contents (i.e. no prefix). Click OK



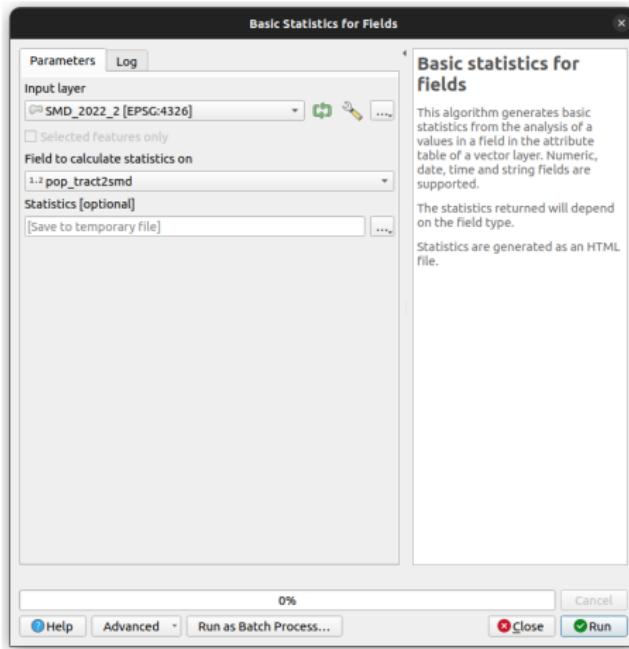
You should now see the new join layer in Properties



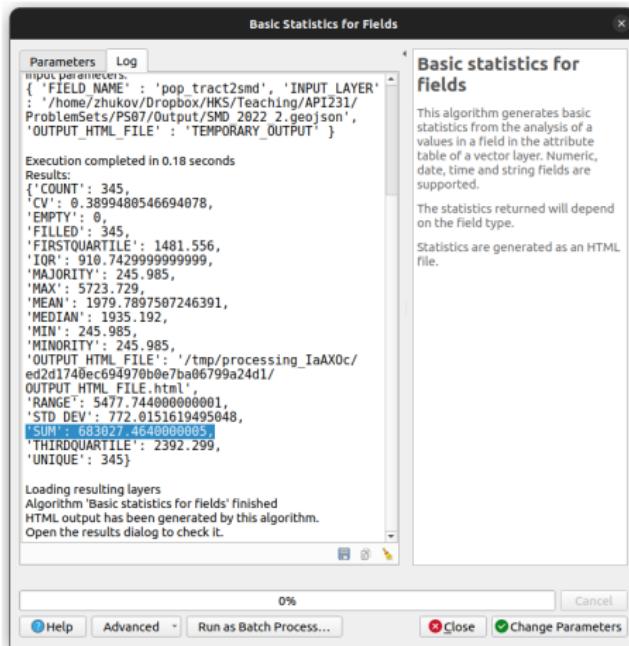
*Quality check!* Let's see if the sum of interpolated population values is close to the sum of this variable in the original data. Go to Vector menu → Vector Analysis → Basic Statistics for Fields



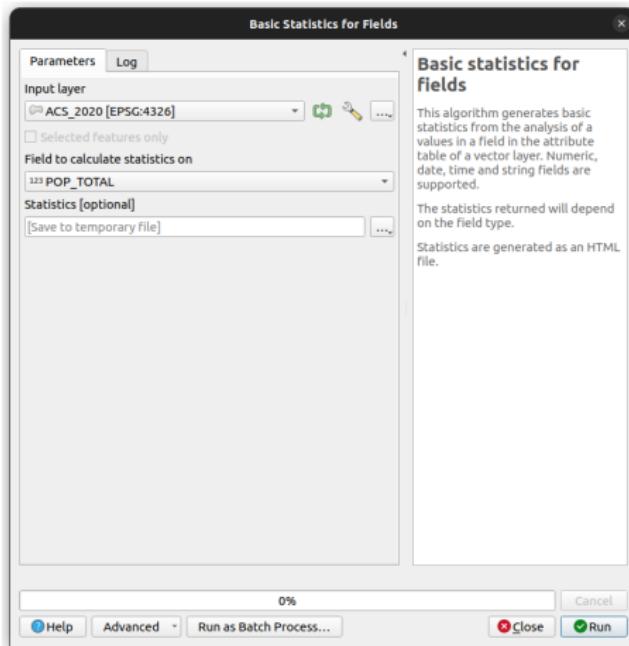
In the next window, set “Input layer” to SMD\_2022\_2 and “Field” to pop\_tract2smd. Click Run



Make note of the value in the log after "SUM:"



Now do the same with “Input layer” ACS\_2020 and “Field” POP\_TOTAL



The population sums look numerically close (683,027 vs 683,154).  
Interpolation was a success!



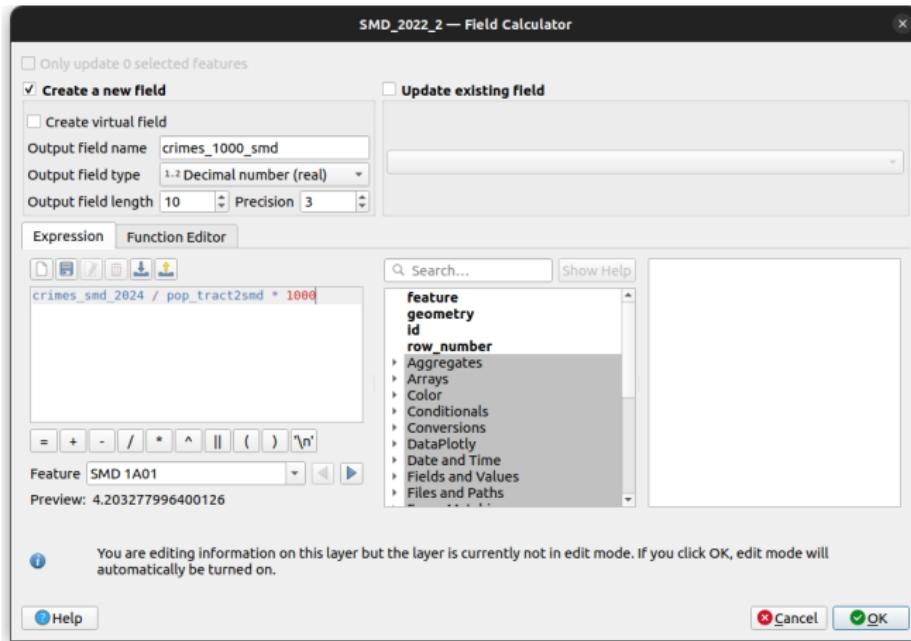
Last step (for interpolation): calculate number of crimes per 1000 residents! Go to the Attribute Table for SMD\_2022\_2 and open the Field Calculator

SMD\_2022\_2 -- Features Total: 345, Filtered: 345, Selected: 0

The screenshot shows the QGIS attribute table for the 'SMD\_2022\_2' layer. The table has 345 features. A 'Field Calculator' dialog is open over the table, with the cursor positioned in the 'vote' field. The table includes columns for stNumbe, ContestName, WardNumber, votes\_1st, votes\_2nd, vote, are\_2nd, votemargin, competitive\_top, competitive\_top\_smd\_area, crimes\_smd\_2024, pop\_tract2smc, is\_1000\_tract, and a row number column (1-9).

stNumbe	ContestName	WardNumber	votes_1st	votes_2nd	vote	are_2nd	votemargin	competitive_top	competitive_top_smd_area	crimes_smd_2024	pop_tract2smc	is_1000_tract		
1	18 ANC - 1A01...	1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.9...	9	3667.632	1.310
2	19 ANC - 1A02...	1	406	10	416	97.596153...	2.4038461...	95.192307...	0.0480769...	0.0240384...	90463.9...	10	4298.181	1.066
3	20 ANC - 1A03...	1	291	8	299	97.324414...	2.6755852...	94.648829...	0.0535117...	0.0267558...	65689.0...	11	5219.000	3.526
4	21 ANC - 1A04...	1	505	15	520	97.115384...	2.8846153...	94.230769...	0.0576923...	0.0288461...	137899....	16	4497.000	1.890
5	22 ANC - 1A05...	1	346	6	352	98.295454...	1.7045454...	96.590909...	0.0340909...	0.0170454...	139006....	73	5219.000	3.526
6	23 ANC - 1A06...	1	146	0	146	100	0	100	0	0	114353....	12	4042.385	1.238
7	24 ANC - 1A07...	1	498	18	516	96.511627...	3.4883720...	93.023255...	0.0697674...	0.0348837...	120606....	14	4474.206	1.894
8	25 ANC - 1A08...	1	352	11	363	96.969696...	3.0303030...	93.939393...	0.0606060...	0.0303030...	81005.6...	7	3505.344	1.513
9	26 ANC - 1A09...	1	413	18	431	95.823665...	4.1763341...	91.647331...	0.0835266...	0.0417633...	127768....	11	4352.892	0.976

Create a new field called `crimes_1000_smd` of type Decimal number (real).  
Set Expression to `crimes_smd_2024 / pop_tract2smd * 1000`



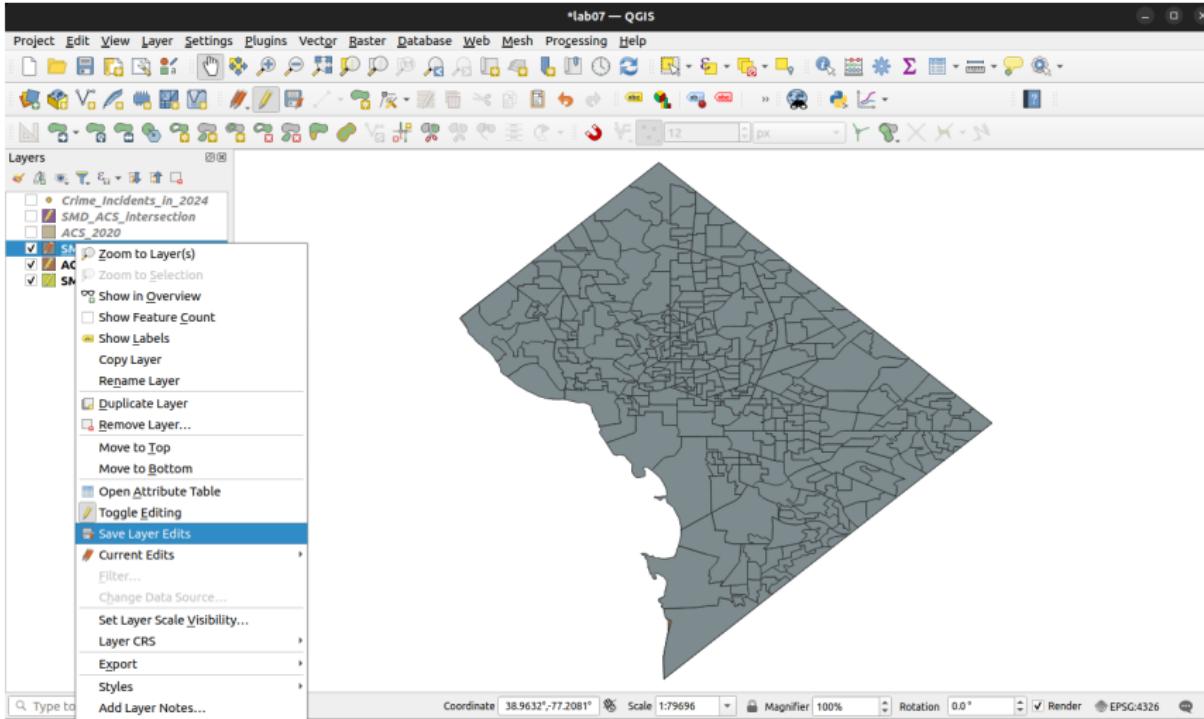
(OPTIONAL) Whole vs. parts: compare the values for the field we just constructed (`crimes_1000_smd`) from components to the `crimes_1000_tract2smd` variable we interpolated whole-cloth.

SMD\_2022\_2 — Features Total: 345, Filtered: 345, Selected: 0

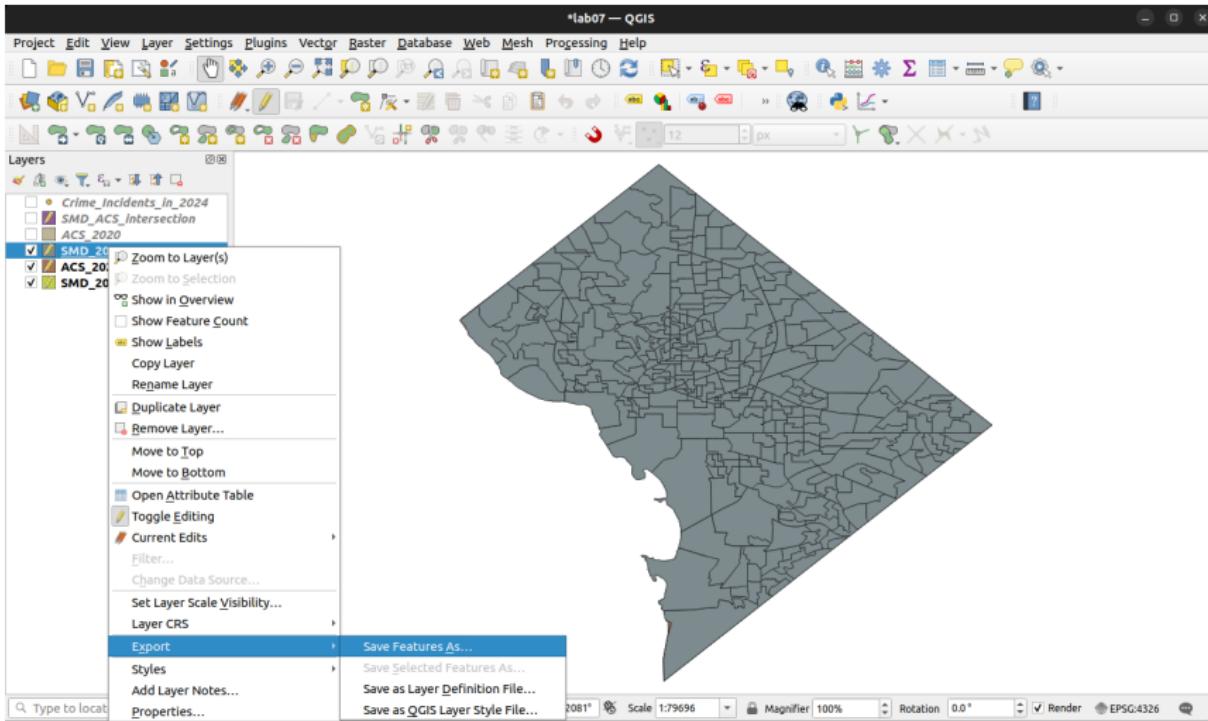
The screenshot shows a QGIS attribute table for the layer SMD\_2022\_2. The table has 345 features. The columns include SMD\_ID, ContestName, WardNumber, votes\_1st, votes\_2nd, votes\_cast, voteshare\_1st, voteshare\_2nd, votemargin, competitive\_top, rimes\_smd\_202, op\_tract2smd, crimes\_1000\_tract2smd, and crimes\_1000\_smd. A red box highlights the last two columns. The 'crimes\_1000\_smd' column contains values like 4.203, 5.706, 7.370, etc., while the 'crimes\_1000\_tract2smd' column contains values like 7.86, 5.327, 17.628, etc. The 'Show All Features' button is visible at the bottom left.

#	SMD_ID	ContestName	WardNumber	votes_1st	votes_2nd	votes_cast	voteshare_1st	voteshare_2nd	votemargin	competitive_top	rimes_smd_202	op_tract2smd	crimes_1000_tract2smd	crimes_1000_smd		
1	18 ANC - 1A01...		1	481	7	488	98.565573...	1.4344262...	97.131147...	0.0286885...	0.0143442...	85605.951	9	2141.186	7.86	4.203
2	19 ANC - 1A02...		1	406	10	416	97.596153...	2.4038461...	95.192307...	0.0480769...	0.0240384...	90463.969	10	1752.515	5.327	5.706
3	20 ANC - 1A03...		1	291	8	299	97.324414...	2.6755852...	94.648829...	0.0535117...	0.0267558...	65689.035	11	1492.634	17.628	7.370
4	21 ANC - 1A04...		1	505	15	520	97.115384...	2.8846153...	94.230769...	0.0576923...	0.0288461...	137899.862	16	2064.123	7.561	7.751
5	22 ANC - 1A05...		1	346	6	352	98.295454...	1.7045454...	96.590909...	0.0340909...	0.0170454...	139006.208	73	3157.495	17.628	23.120
6	23 ANC - 1A06...		1	146	0	146	100	0	100	0	0	114353.21	12	2085.813	4.953	5.753
7	24 ANC - 1A07...		1	498	18	516	96.511627...	3.4883720...	93.023255...	0.0697674...	0.0348837...	120606.54	14	1798.362	7.576	7.785
8	25 ANC - 1A08...		1	352	11	363	96.969696...	3.0303030...	93.939393...	0.0606060...	0.0303030...	81005.655	7	1825.957	4.539	3.834

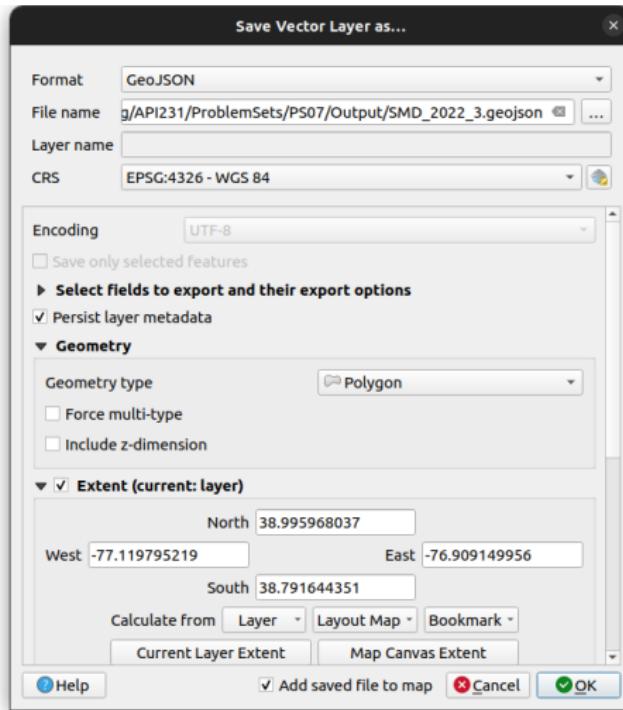
Save the edits to the SMD\_2022\_2 layer!



To be extra-safe, let's export the layer to a new geojson file (to preserve the join).  
Right-click SMD\_2022\_2 in layer menu → Export → Save Features As...

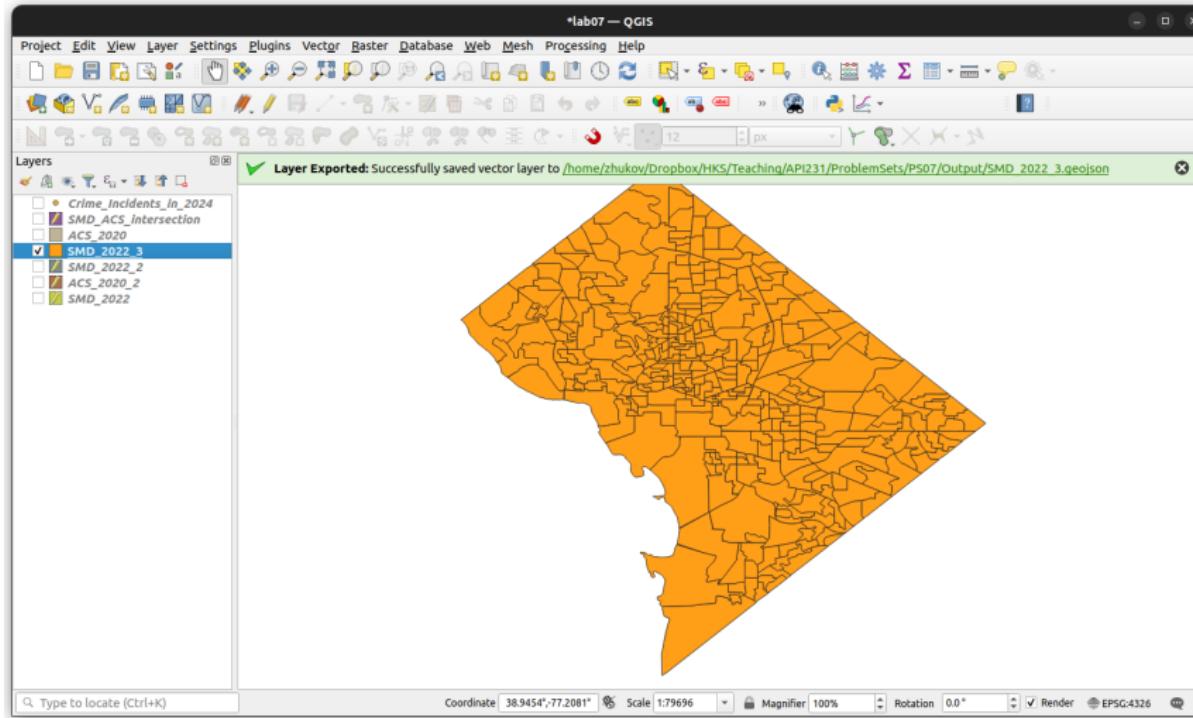


Save the layer as SMD\_2022\_3.geojson with Geometry type: Polygon. Check the box next to Extent (current: layer). Click OK



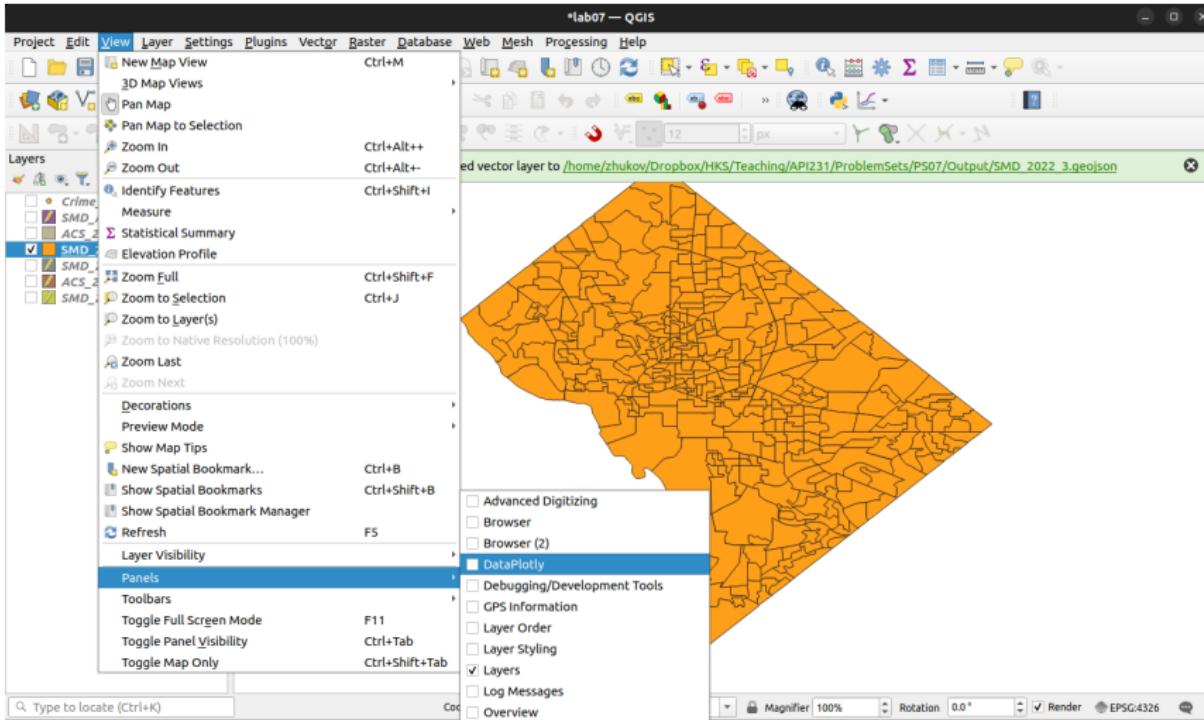
The new layer should appear in your project window.

Now we're ready to *make a scatterplot* of electoral competitiveness and crime!



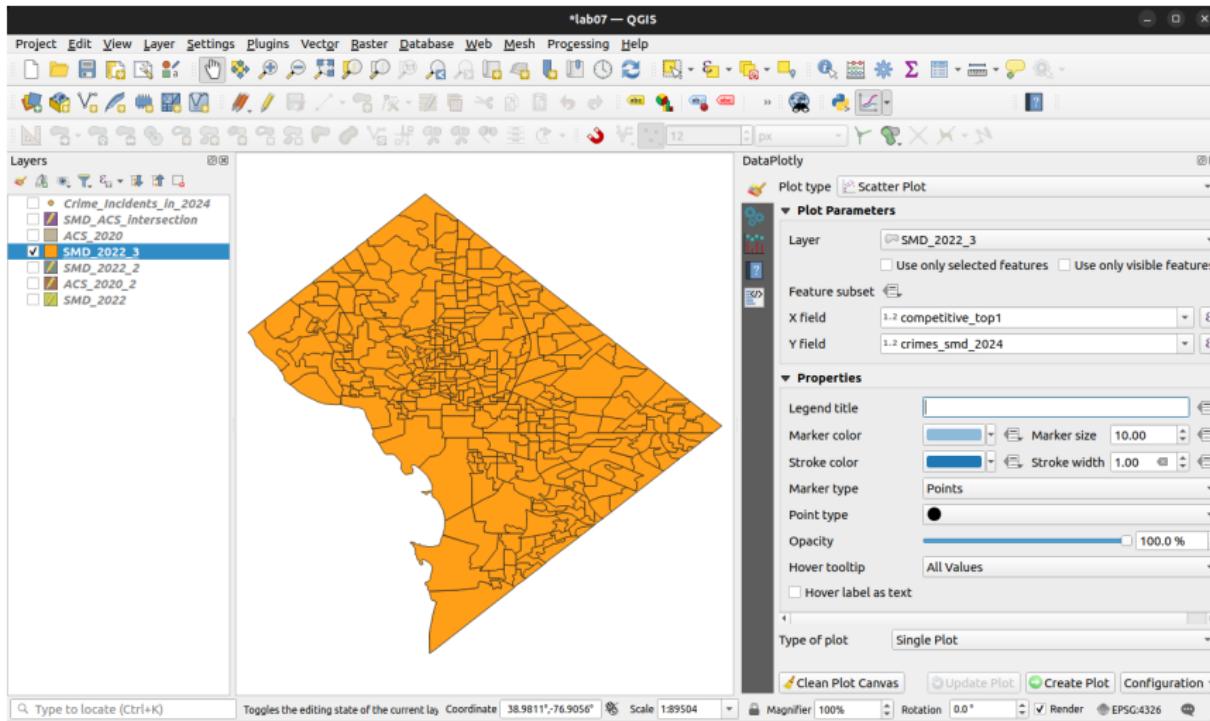
# Scatterplot

To make the scatterplots, we will be using the DataPlotly plugin.  
Go to View menu → Panels → ✓ DataPlotly



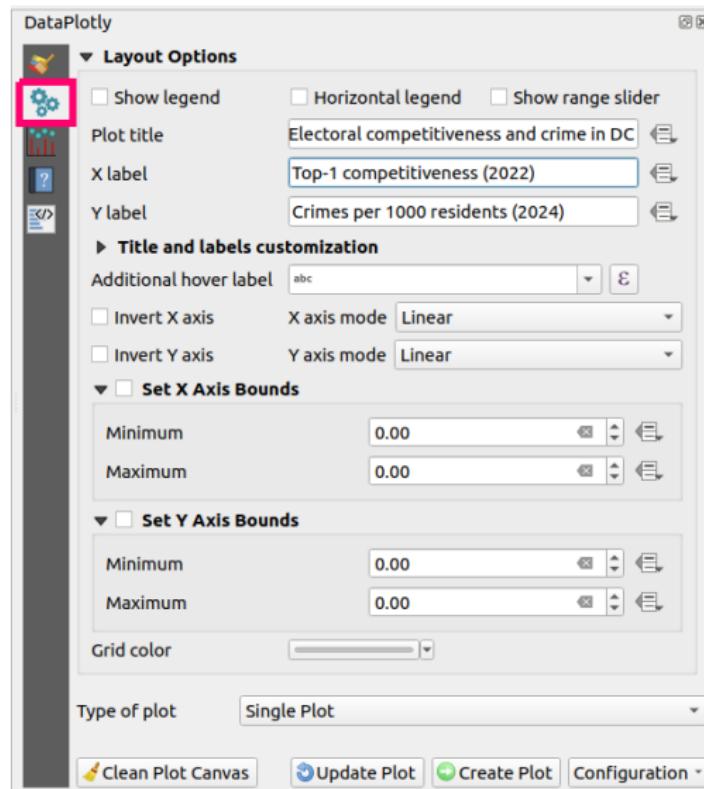
In the DataPlotly panel, set the following parameters:

Plot type: Scatter Plot; Layer: SMD\_2022\_3; X field: competitive\_top1; Y field: crimes\_smd\_2024; Legend title: [empty]

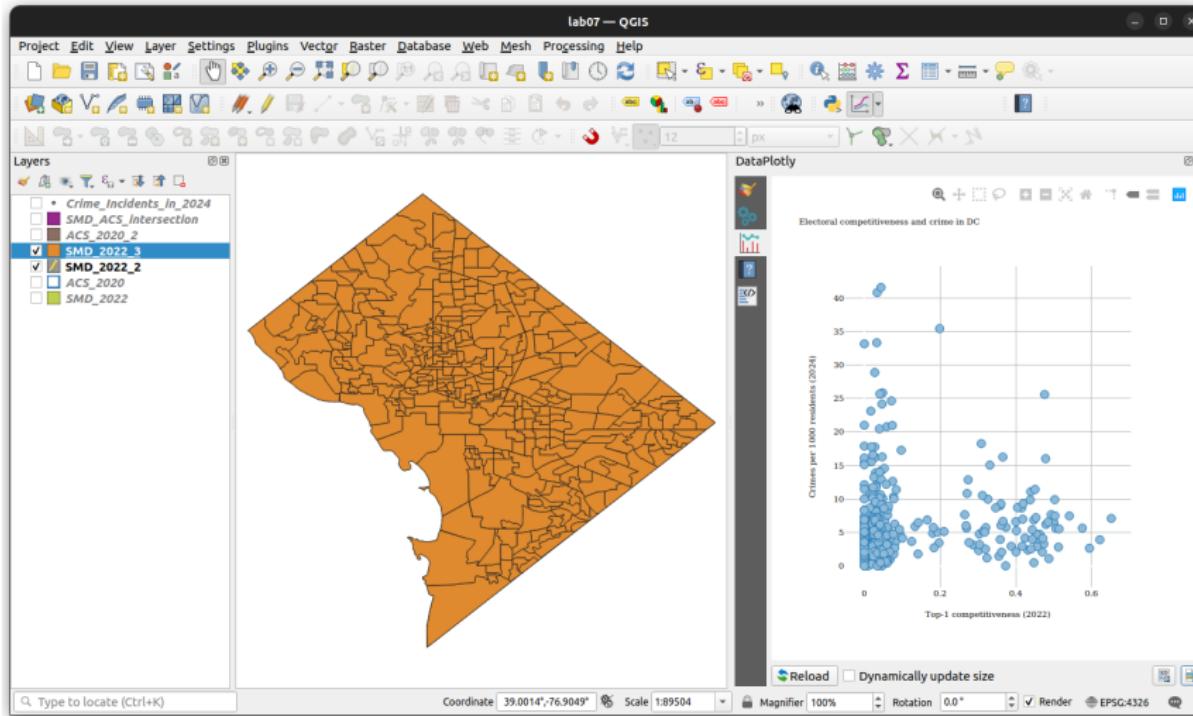


In the Layout Options tab, set the following parameters:

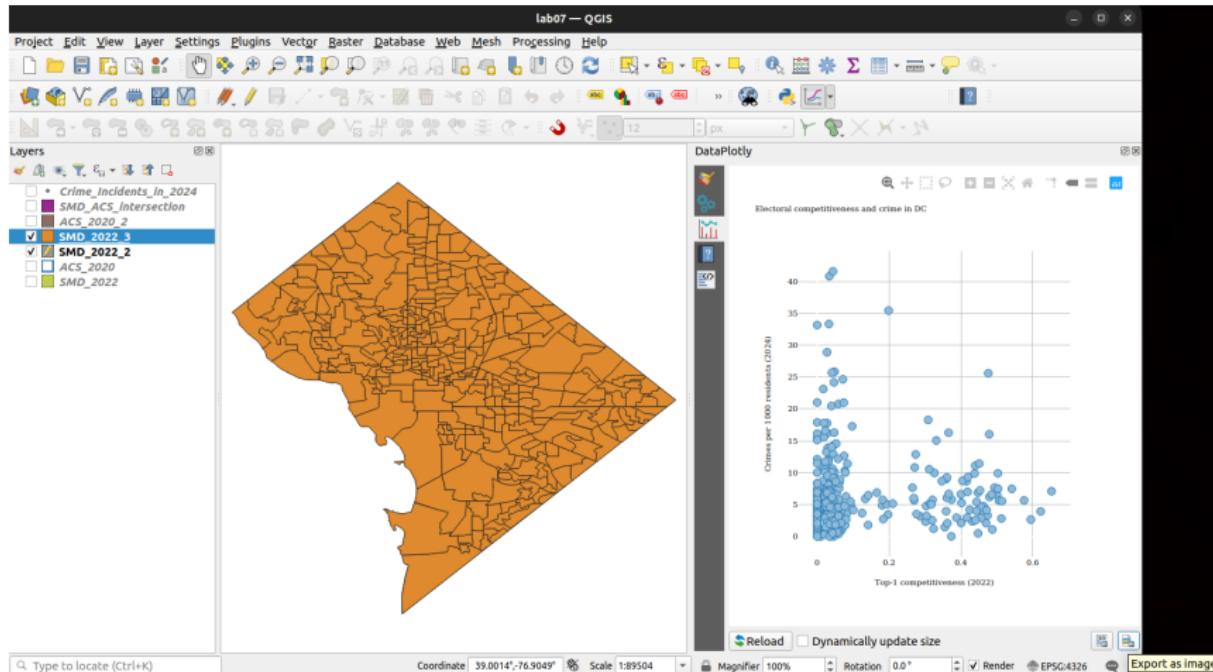
- Show legend:  (off)
- Plot title:  
Electoral competitiveness and crime in DC
- X label:  
Top-1 competitiveness (2022)
- Y label:  
Crimes per 1000 residents (2024)
- Click Create Plot



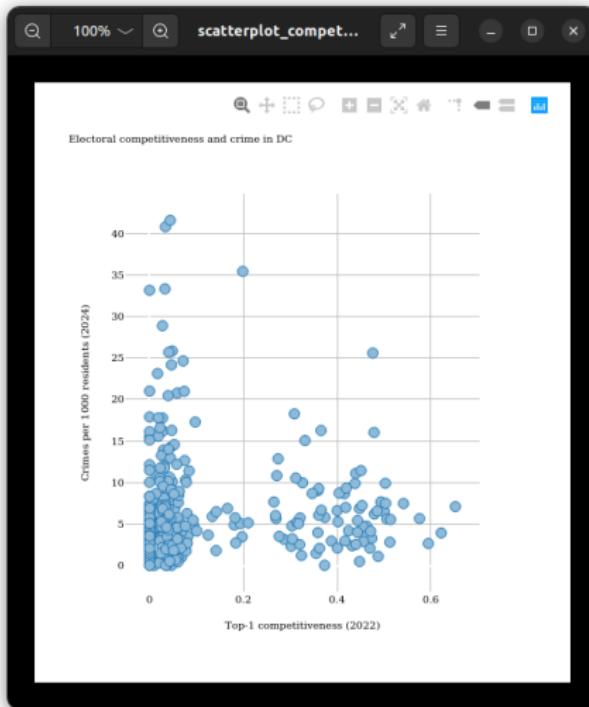
The scatterplot should appear on the next screen.



To save the scatterplot, click the Export as image button in lower-right corner



Name the file `scatterplot_competitiveness_crime.png`.  
It should look something like this:



## Problem Set 7

*Your assignment* (if using QGIS): create a scatterplot of school performance and race

- perform areal interpolation:
  - source polygons: ACS census tracts (`AFS_2020.geojson`)  
*x* variables: neighborhood population size and racial makeup
  - destination polygons: elementary school attendance zones (`SAZ_Elementary.geojson`)  
*y* variables: STAR school performance scores
- make and export a scatterplot:
  - percent non-white on *x*-axis
  - school STAR score on *y*-axis
  - name the file  
`scatterplot_race_schools.png`
- upload plot to Canvas

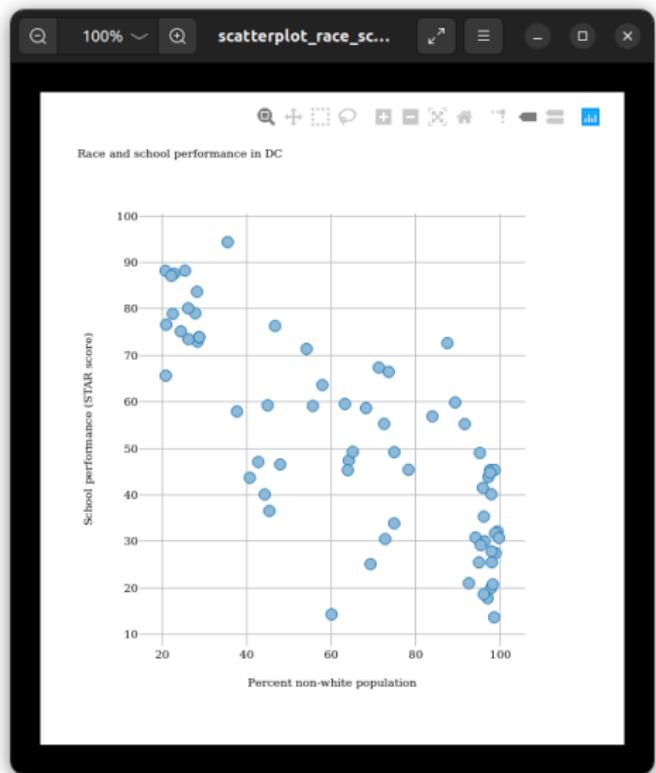
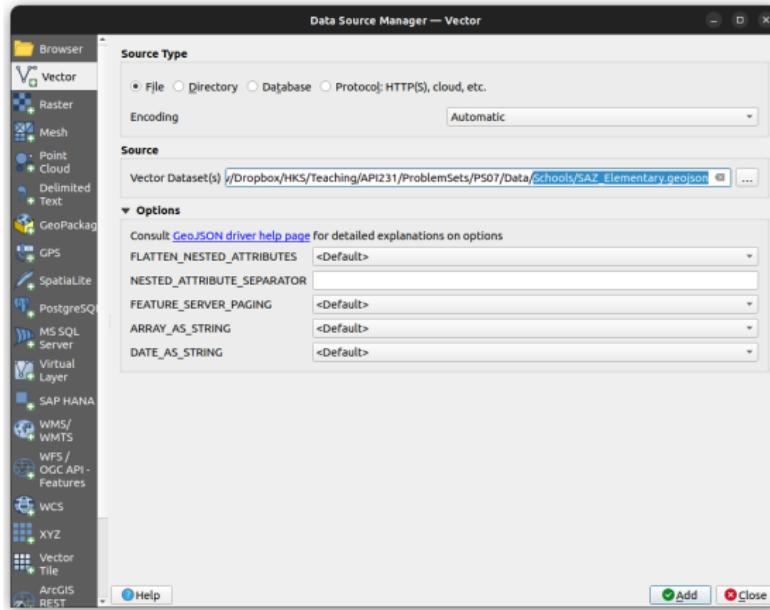


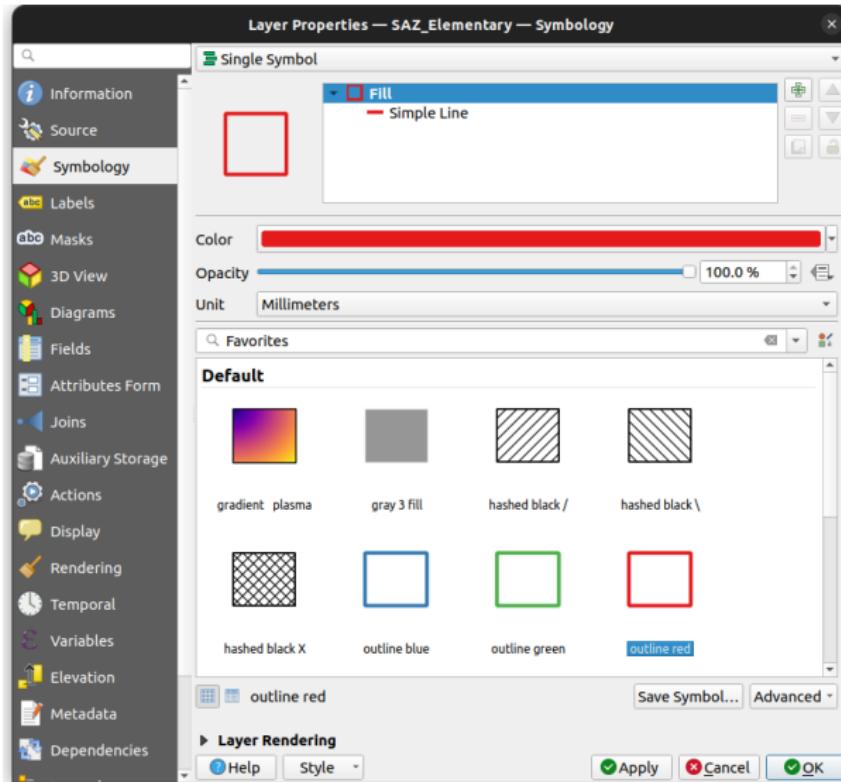
Figure 16: Can you make this?

Here's a *quick preview* of the assignment.

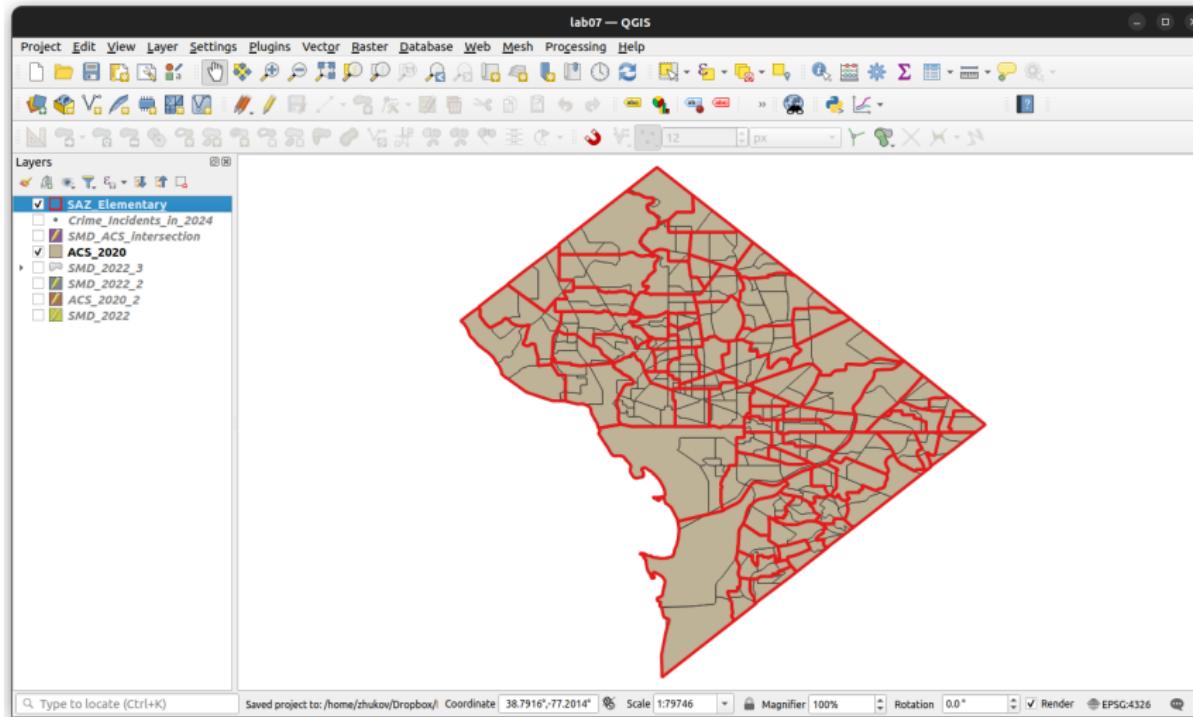
Load the vector data file SAZ\_Elementary.geojson from Data/Schools



To see how SAZ\_Elementary overlays with census tracts, select a symbology with bright thick borders and a transparent inside, like outline\_red



Because SAZs are (mostly) larger and fewer in number than tracts (74 vs 206), it seems more appropriate for SAZs to be the destination units

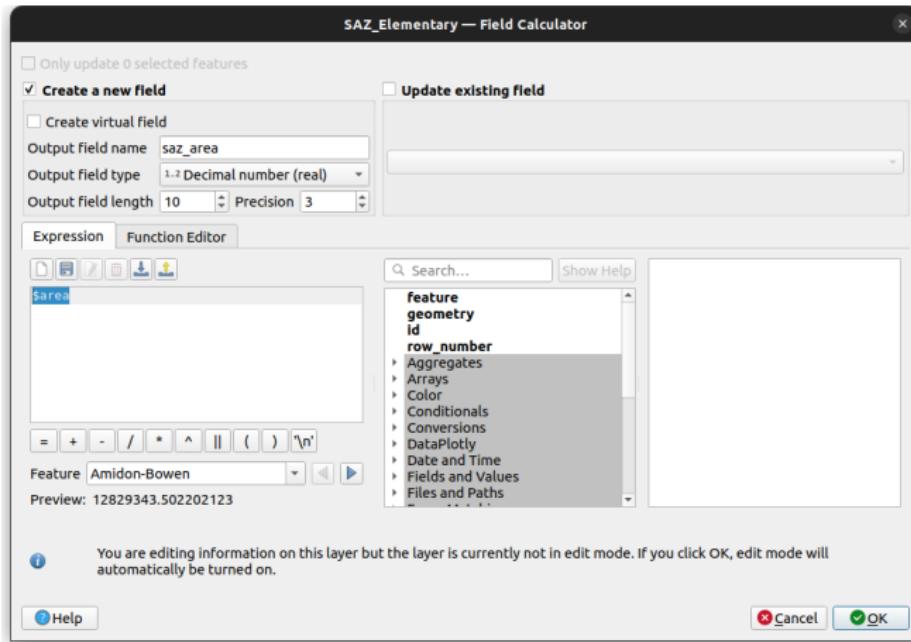


Let's construct the area weights, starting with the area of destination polygons,  $a_j$ . Recall that we already calculated the area of source polygons,  $a_i$  (tract\_area in ACS\_2020). Go to the Field Calculator for SAZ\_Elementary

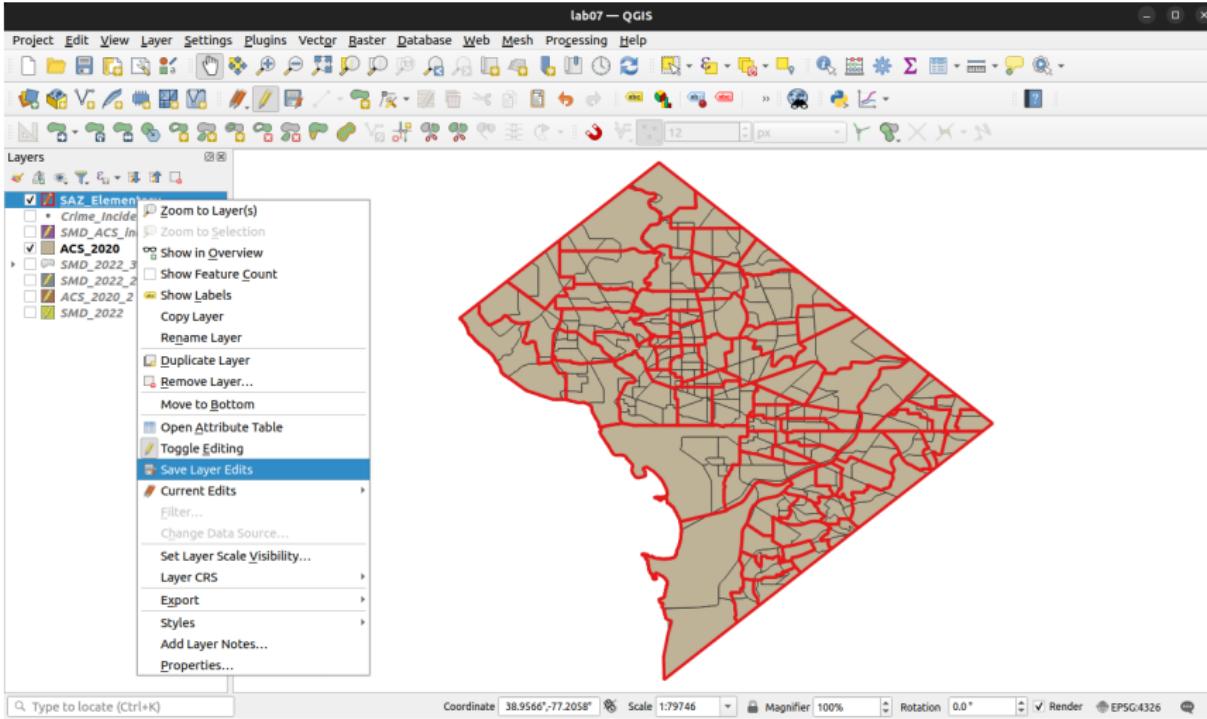
SAZ\_Elementary — Features Total: 74, Filtered: 74, Selected: 0

	NAME	GIS_ID	DCPS_ID	GLOBALID	CREATOR	Open field calculator (Ctrl+I)	EDITED	SHAPEAREA	SHAPELEN	OBJECTID	STAR_Score	STAR_Rating
1	Cleveland	dcps_224	dcps_224	{EE5CC32E...}	JLAY	3/15/23 17.... JLAY	3/15/23 17....	0	0	641	47.37	3
2	Langley	dcps_965	dcps_370	{3BA49621...}	JLAY	3/15/23 17.... JLAY	3/15/23 17....	0	0	642	14.26	1
3	Brightwood	dcps_213	dcps_213	{10343358...}	JLAY	3/15/23 17.... JLAY	3/15/23 17....	0	0	643	59.87	3
4	Reed, Marie	dcps_284	dcps_284	{010474A1...}	JLAY	3/15/23 17.... JLAY	3/15/23 17....	0	0	644	83.7	5
5	School Wit...	dcps_409	dcps_409	{9198BD09...}	JLAY	3/15/23 17.... JLAY	3/15/23 17....	0	0	645	NULL	NULL
6	Hyde-Addis...	dcps_252	dcps_252	{006CF9A9...}	JLAY	3/15/23 17.... JLAY	3/15/23 17....	0	0	646	87.57	5
7	Langdon	dcps_262	dcps_262	{E7DE2E97...}	JLAY	3/15/23 17.... JLAY	3/15/23 17....	0	0	647	72.65	4
8	Browne	dcps_404	dcps_404	{9459F46C...}	JLAY	3/15/23 17.... JLAY	3/15/23 17....	0	0	648	NULL	NULL
9	Thomas	dcps_325	dcps_325	{637BE8B6...}	JLAY	3/15/23 17.... JLAY	3/15/23 17....	0	0	649	19.94	1

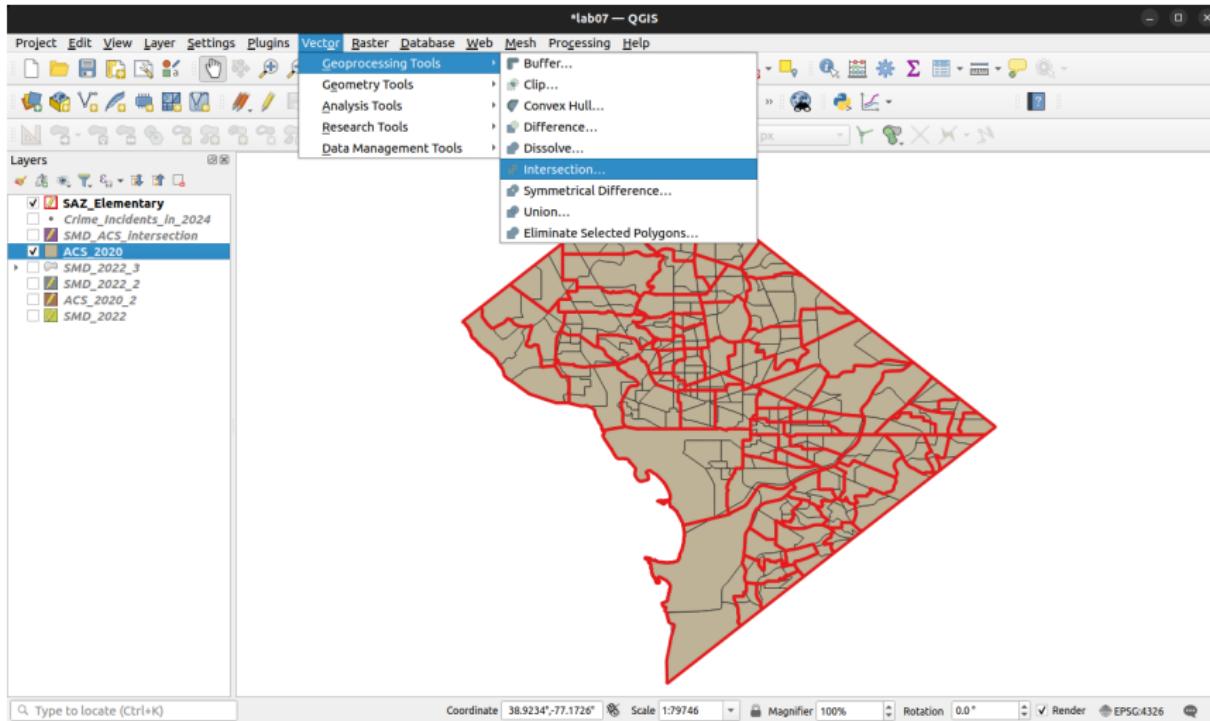
Create a new field named `saz_area` of type Decimal number.  
Set the expression to `$area`



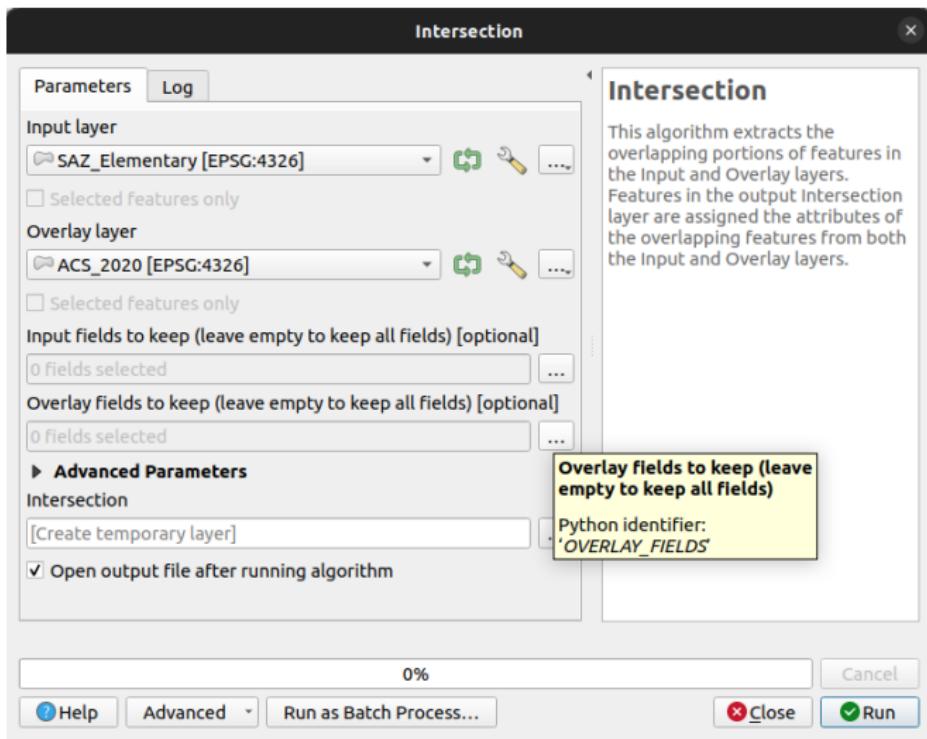
Remember to save your layer edits regularly!



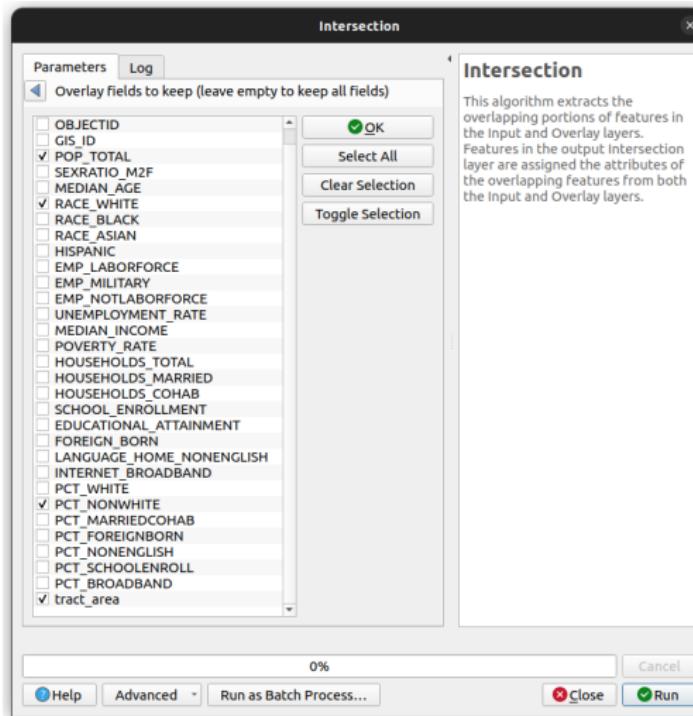
Now let's intersect SAZ\_Elementary with ACS\_2020 to calculate intersection areas,  $a_{i \cap j}$ . Go to Vector menu → Geoprocessing Tools → Intersection...



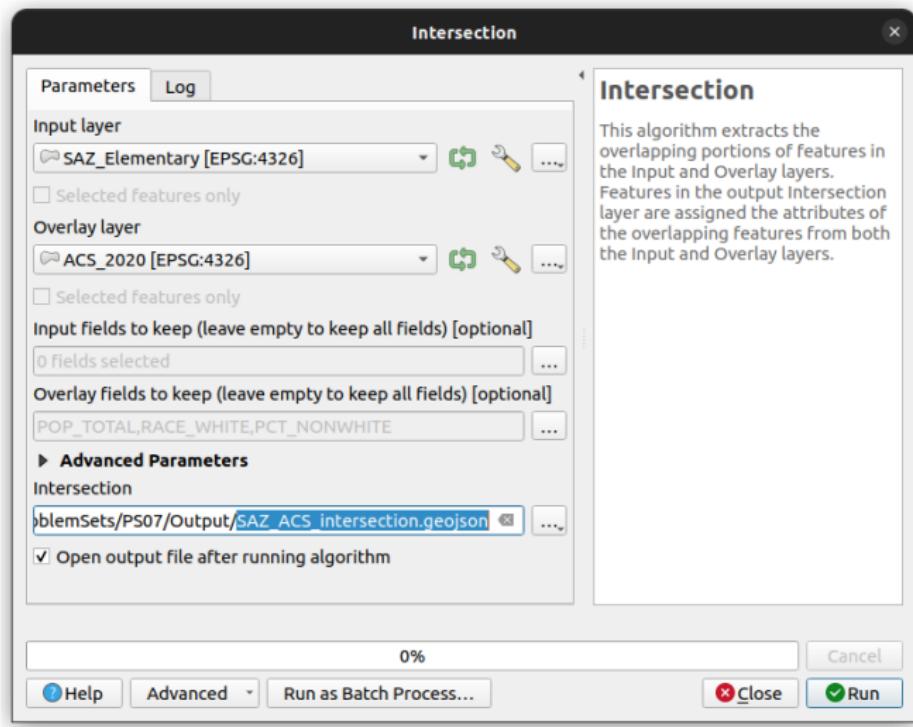
For the intersection, select SAZ\_Elementary as Input Layer, ACS\_2020 as Overlay layer. Then click the [...] button next to “Overlay fields to keep”



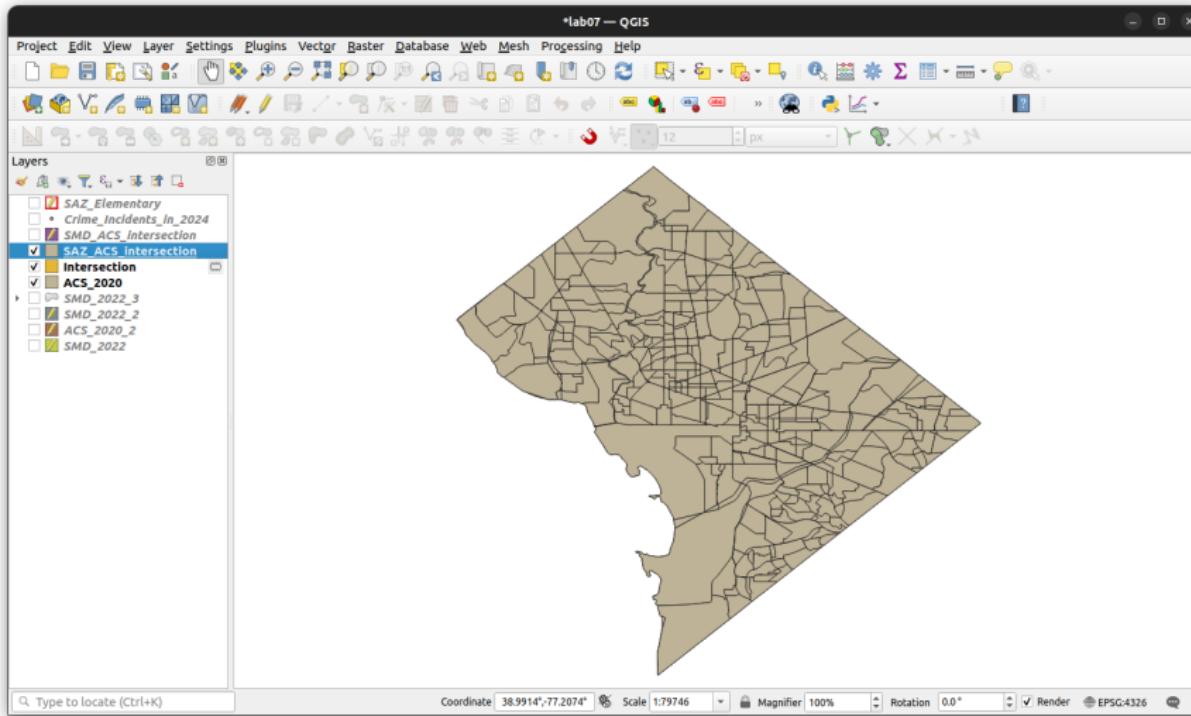
On the next screen check the boxes next to ✓ POP\_TOTAL, ✓ RACE\_WHITE,  
✓ PCT\_NONWHITE and ✓ tract\_area. Click OK



Save the output file to SAZ\_ACS\_intersection.geojson, click Run



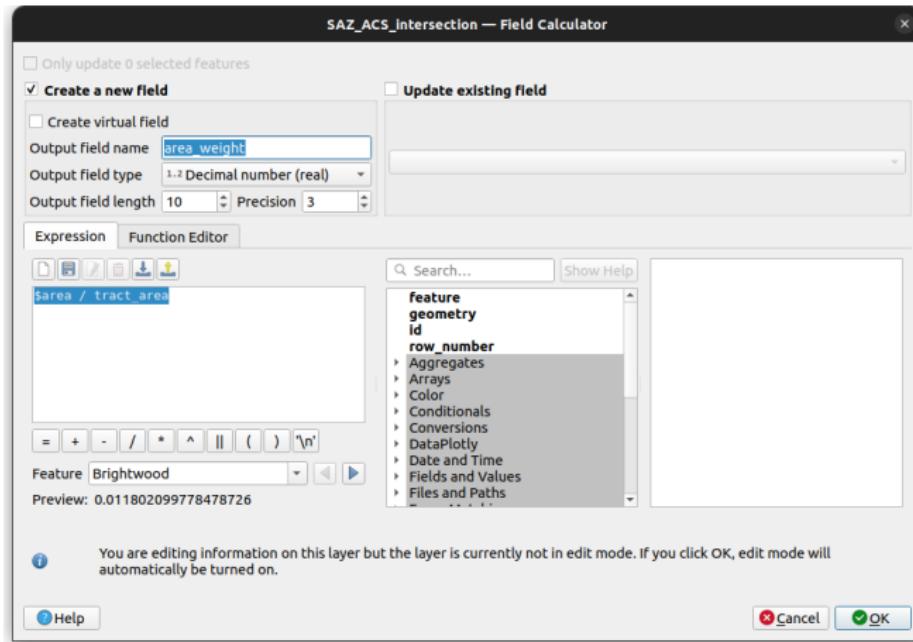
The intersection should appear in your project window



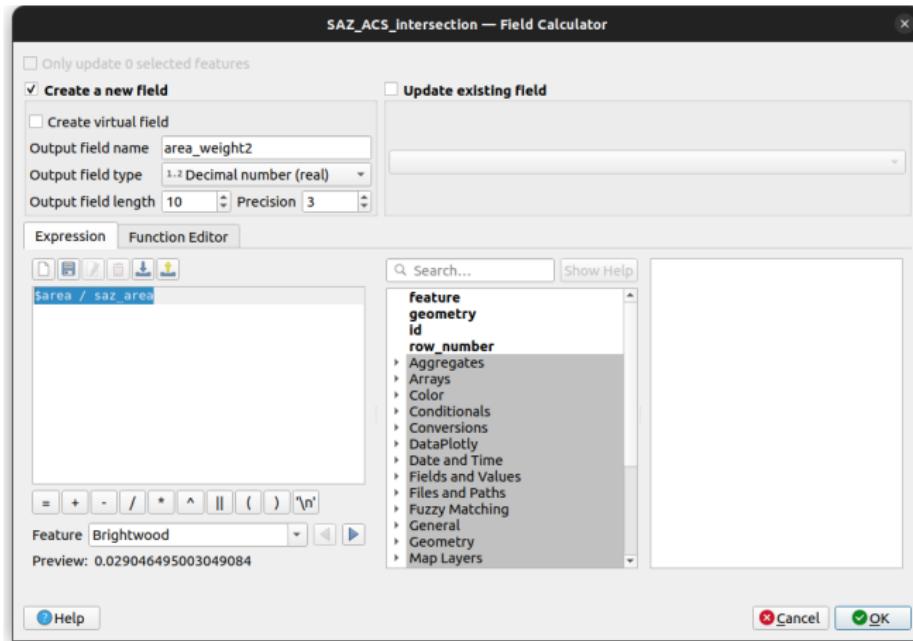
## Launch the Field Calculator for SAZ\_ACS\_intersection

CPS_ID	GLOBALID	CREATOR	CREATED	EDITOR	ED	ELEN	OBJECTID	STAR_Score	STAR_Rating	saz_area	POP_TOTAL	RACE_WHITE	CT_NONWHIT
1_224	{EE5CC32E...}	JLAY	3/15/23 17:...	JLAY	3/15/23 17:...	0	0	641	47.37	3	1428079.583	1648	602 63.470873...
2_224	{EE5CC32E...}	JLAY	3/15/23 17:...	JLAY	3/15/23 17:...	0	0	641	47.37	3	1428079.583	4646	1503 67.649591...
3_224	{EE5CC32E...}	JLAY	3/15/23 17:...	JLAY	3/15/23 17:...	0	0	641	47.37	3	1428079.583	3994	2173 45.593390...
4_224	{EE5CC32E...}	JLAY	3/15/23 17:...	JLAY	3/15/23 17:...	0	0	641	47.37	3	1428079.583	4711	1519 67.756315...
5_224	{EE5CC32E...}	JLAY	3/15/23 17:...	JLAY	3/15/23 17:...	0	0	641	47.37	3	1428079.583	4619	1291 72.050227...
6_224	{EE5CC32E...}	JLAY	3/15/23 17:...	JLAY	3/15/23 17:...	0	0	641	47.37	3	1428079.583	3432	2003 41.637529...
7_224	{EE5CC32E...}	JLAY	3/15/23 17:...	JLAY	3/15/23 17:...	0	0	641	47.37	3	1428079.583	2602	1505 42.159877...
8_224	{EE5CC32E...}	JLAY	3/15/23 17:...	JLAY	3/15/23 17:...	0	0	641	47.37	3	1428079.583	3031	1426 52.952820...
9_224	{EE5CC32E...}	JLAY	3/15/23 17:...	JLAY	3/15/23 17:...	0	0	641	47.37	3	1428079.583	2997	1516 49.416082...

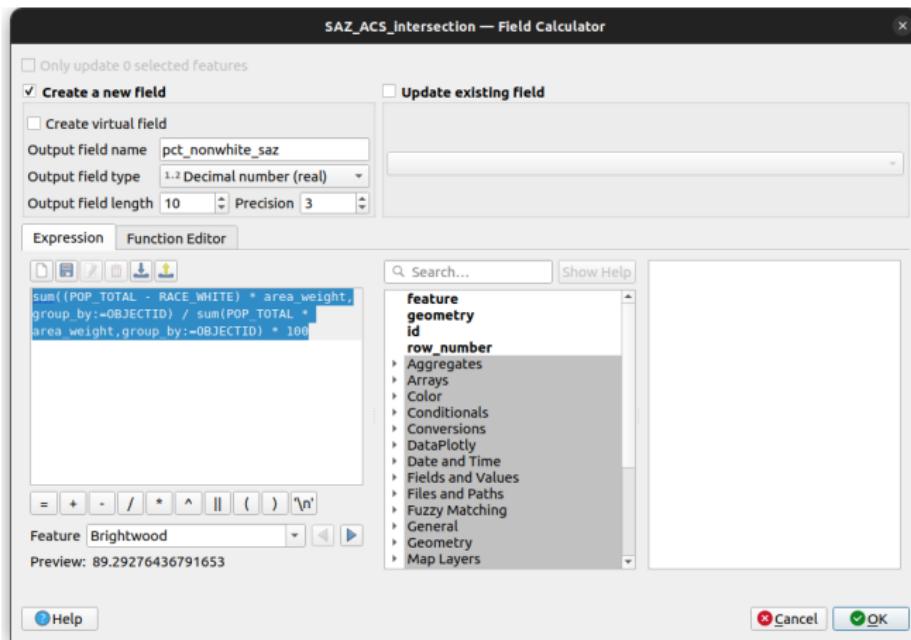
Create a new field `area_weight` of type Decimal number.  
Set expression to `$area / tract_area`. Click OK



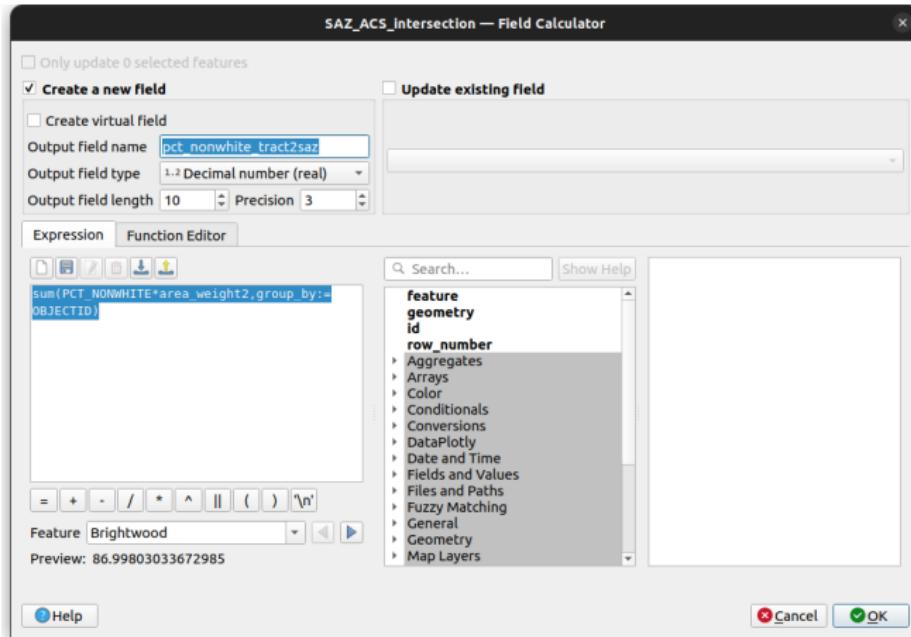
(OPTIONAL) For the intensive transformation, create a new field `area_weight2` of type Decimal number. Set expression to `$area / saz_area`. Click OK



Create a new field pct\_nonwhite\_saz of type Decimal number. Set expression to  
`sum((POP_TOTAL - RACE_WHITE) * area_weight,group_by:=OBJECTID) /  
sum(POP_TOTAL * area_weight,group_by:=OBJECTID) * 100`



(OPTIONAL) Create a new field `pct_nonwhite_tract2saz` of type Decimal number. Set expression to  
`sum(PCT_NONWHITE * area_weight2,group_by:=OBJECTID)`

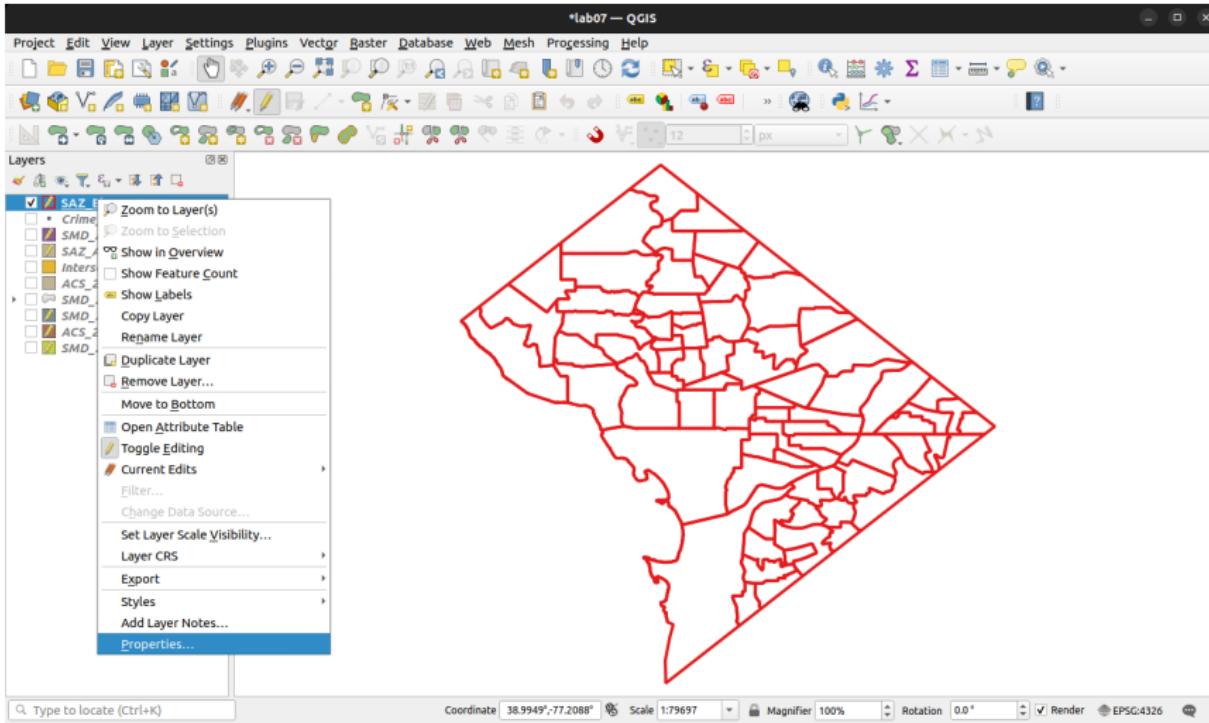


Inspect the pct\_nonwhite\_saz variable in the Attribute Table.  
Is it constant within SAZs? If so, we're ready to join it to the SAZs

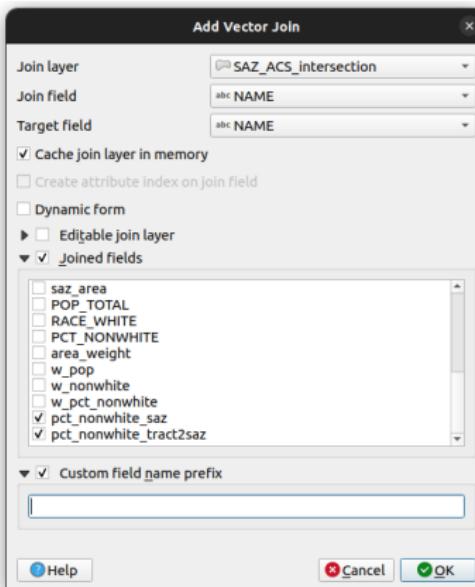
SAZ\_ACS\_Intersection — Features Total: 658, Filtered: 658, Selected: 0

	NAME	EDITOR	EDITED	SHAPEAREA	SHAPELEN	OBJECTID	STAR_Score	STAR_Rating	saz_area	POP_TOTAL	RACE_WHITE	CT_NONWHIT	tract_area	area_weight	area_weight2	nonwhite tract	t_nonwhite_s
1	17.... JLAY	3/15/23 17....		0	0	641	47.37	3	1428079.583	1648	602	63.470873...	2016221.386	0.002	0.002	65.283	64.132
2	17.... JLAY	3/15/23 17....		0	0	641	47.37	3	1428079.583	4646	1503	67.649591...	447929.044	0.004	0.001	65.283	64.132
3	17.... JLAY	3/15/23 17....		0	0	641	47.37	3	1428079.583	3994	2173	45.593390...	442119.023	0	0	65.283	64.132
4	17.... JLAY	3/15/23 17....		0	0	641	47.37	3	1428079.583	4711	1519	67.756315...	1071051.035	0.963	0.722	65.283	64.132
5	17.... JLAY	3/15/23 17....		0	0	641	47.37	3	1428079.583	4619	1291	72.050227...	382021.505	0.532	0.142	65.283	64.132
6	17.... JLAY	3/15/23 17....		0	0	641	47.37	3	1428079.583	3432	2003	41.637529...	242895.743	0	0	65.283	64.132
7	17.... JLAY	3/15/23 17....		0	0	641	47.37	3	1428079.583	2602	1505	42.159877...	274747.646	0.186	0.036	65.283	64.132
8	17.... JLAY	3/15/23 17....		0	0	641	47.37	3	1428079.583	3031	1426	52.952820...	437421.469	0.008	0.002	65.283	64.132
9																	

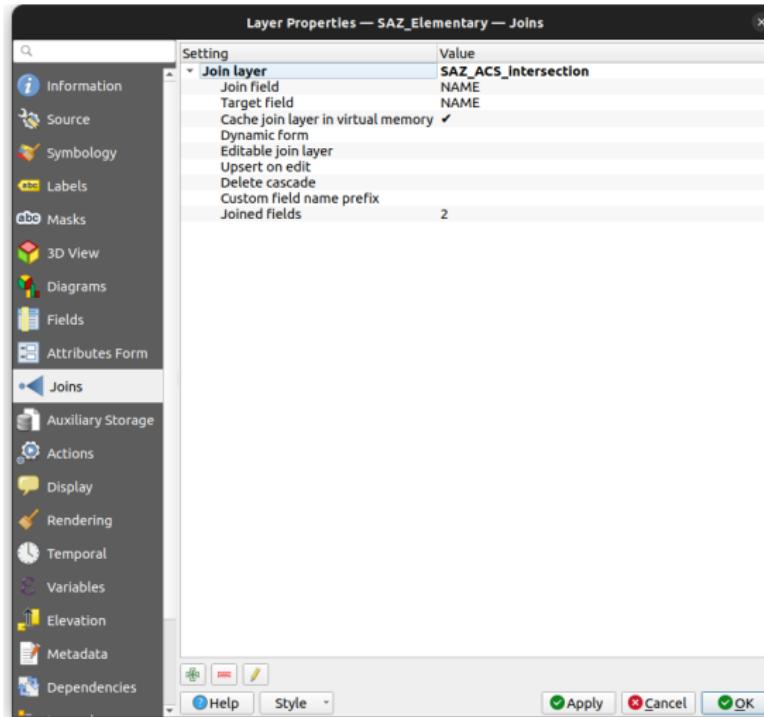
Now let's import these weighted values into the SAZ\_Elementary layer. Right-click on SAZ\_Elementary → Properties



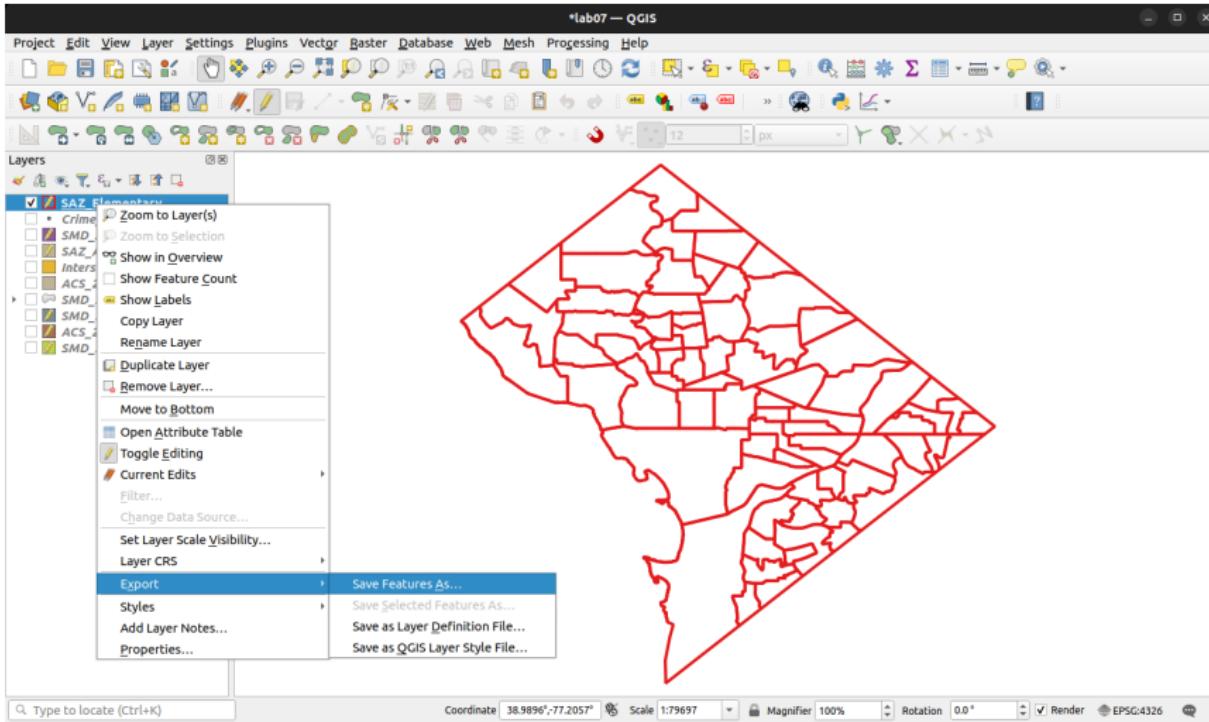
Go to Joins tab and click + to add a new join. Set SAZ\_ACS\_intersection as the “Join layer”, NAME as the “Join” and “Target” field, and under “Joined fields” select ✓ pct\_nonwhite\_saz and ✓ pct\_nonwhite\_tract2saz (if you created this variable, too). Check the box next to Custom field name prefix and clear the contents (i.e. no prefix). Click OK



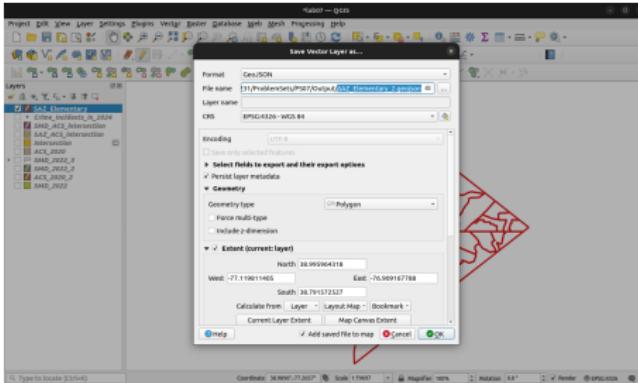
You should now see the new join layer in Properties



Export the layer to a new geojson file (to preserve the join). Right-click SAZ\_Elementary in layer menu → Export → Save Features As...

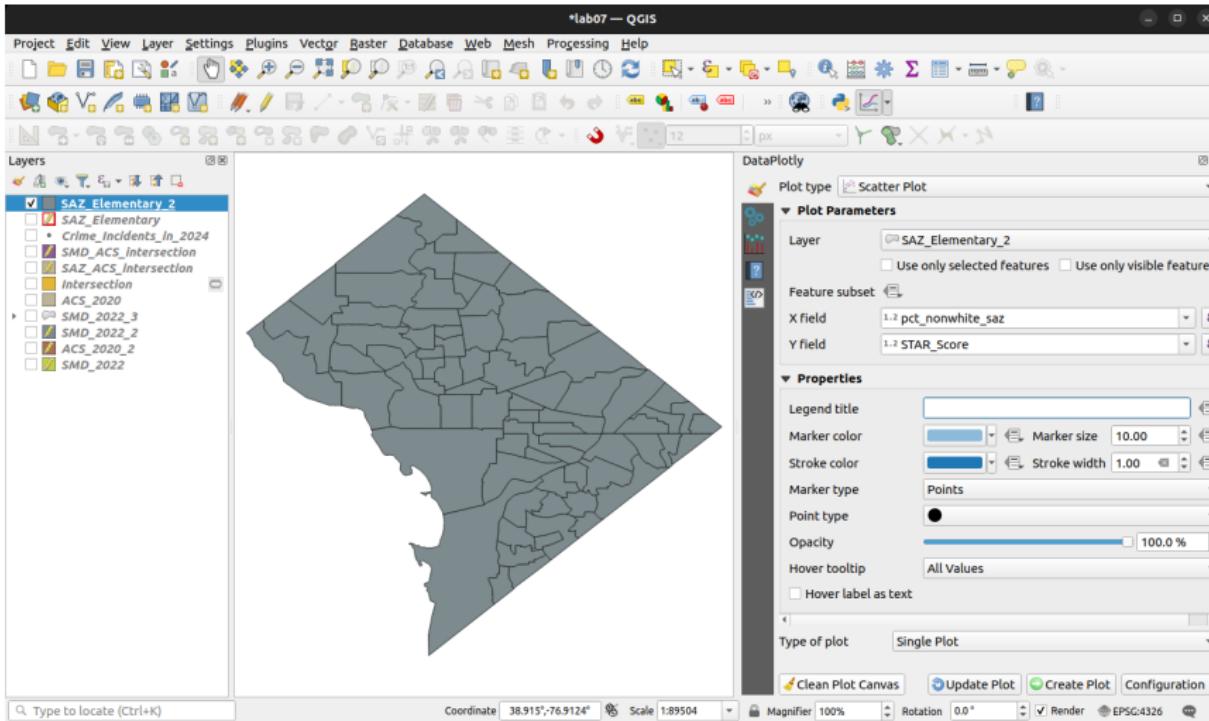


Save the layer as SAZ\_Elementary\_2.geojson with Geometry type: Polygon.  
Check the box next to Extent (current: layer). Click OK



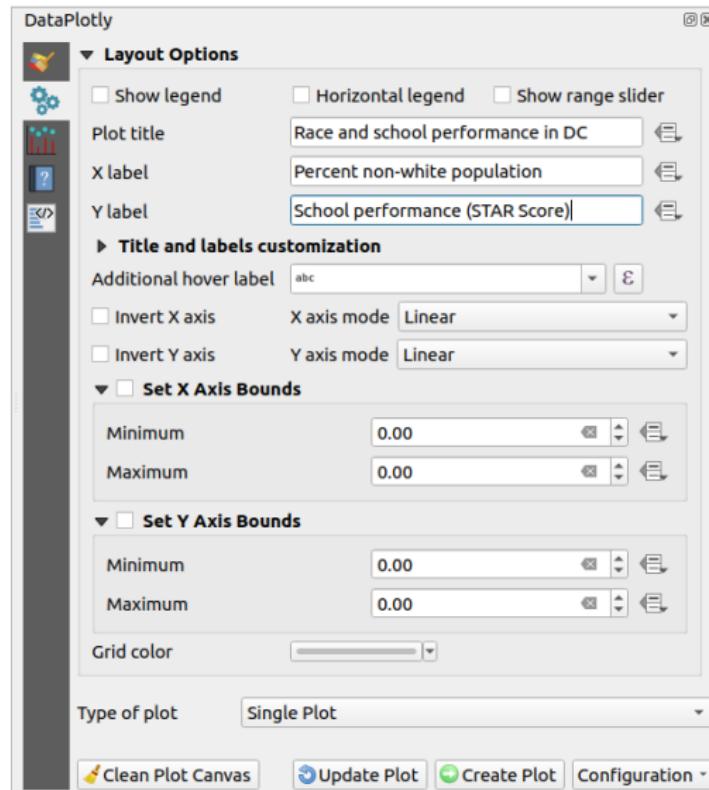
In the DataPlotly panel, set the following parameters:

Plot type: Scatter Plot; Layer: SAZ\_Elementary\_2; X field: pct\_nonwhite\_saz; Y field: STAR\_Score; Legend title: [empty]

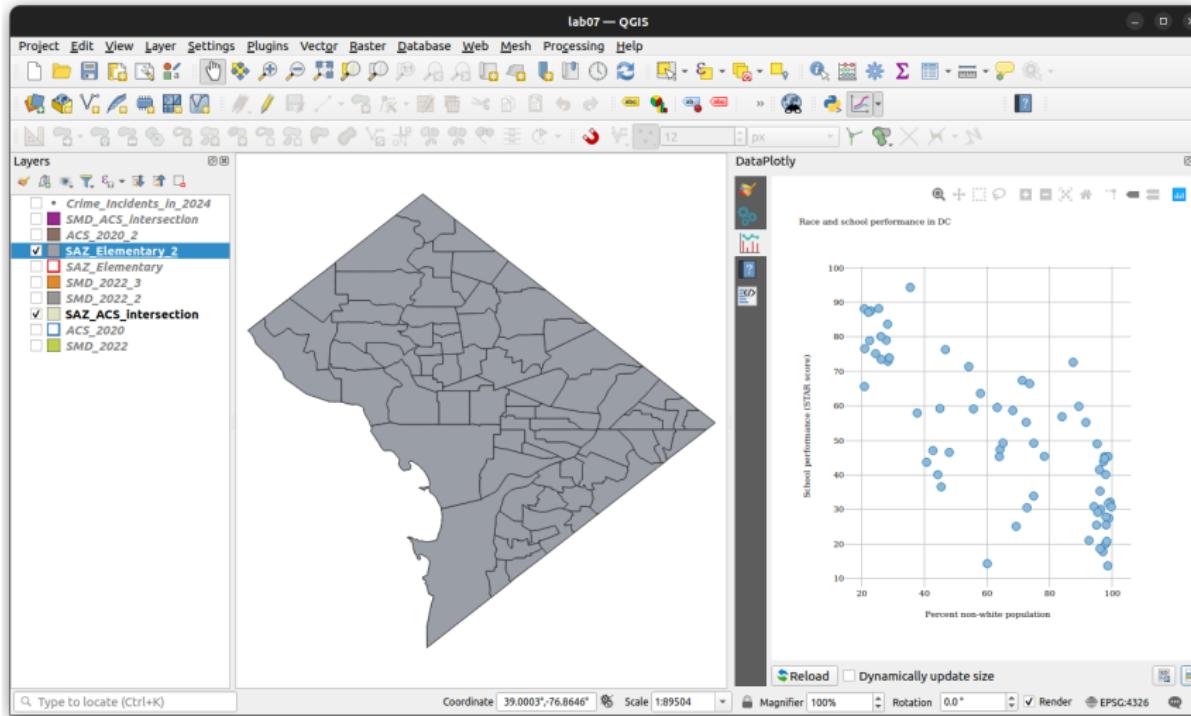


In the Layout Options tab, set the following parameters:

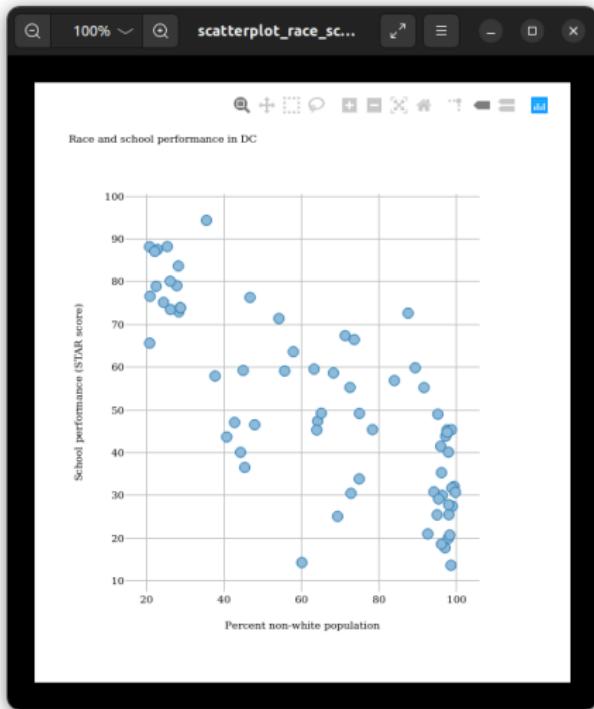
- Show legend:  (off)
- Plot title:  
Race and school performance  
in DC
- X label:  
Percent non-white population
- Y label:  
School performance (STAR  
Score)
- Click Create Plot



The scatterplot should appear on the next screen.



Export the image as scatterplot\_race\_schools.png.  
It should look something like this:



R

## Loading R packages

To implement these steps in R, we will be using the `sf` and `SUNGEO` packages

```
library(sf)
library(SUNGEO)
```

NOTE: The demo code for R is in `ps07_demo.R` on RStudio Cloud, and in `PS07.zip` (posted on Canvas).

# Interpolation

## Loading spatial data

Let's load the *single member district boundaries* into R, using `sf::read_sf()`:

```
smd_2022 = sf::read_sf("Data/Elections/SMD_2022.geojson")
plot(smd_2022["geometry"])
```



Now load the *ACS census tracts* into R:

```
acs_2020 = sf::read_sf("Data/ACS/ACS_2020.geojson")
plot(acs_2020["geometry"])
```



... and the *crime incidents data*:

```
crimes_2024 = sf::read_sf("Data/Crime/Crime_Incidents_in_2024.geojson")
plot(crimes_2024["geometry"])
```



Let's calculate *relative scale and nesting* metrics for a change of support from acs\_2020 (census tracts) to smd\_2022 (single member districts)

```
SUNGEO::nesting(acs_2020,smd_2022,metrix=c("rn","rs"))
```

```
## $rn
## [1] 0.4594585
##
## $rs
## [1] 0.1793275
```

Yikes! What if we switched to (smaller) census block groups as source units?

```
census_2020 = sf::read_sf("Data/Census/CENSUS_2020.geojson")
SUNGEO::nesting(census_2020,smd_2022,metrix=c("rn","rs"))
```

```
## $rn
## [1] 0.6907815
##
## $rs
## [1] 0.8217758
```

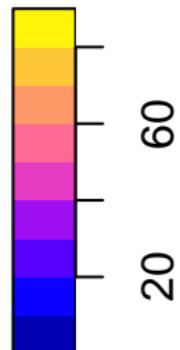
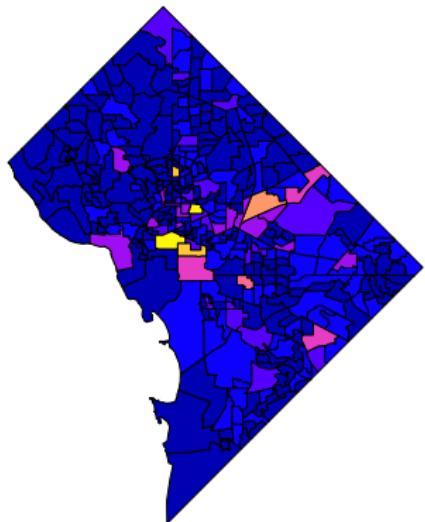
Much better! But for consistency with QGIS, we'll stick with the tracts here.

Let's do some point-in-polygon analysis to count crimes per SMD:

```
smd_2022$crimes_smd_2024 = lengths(sf::st_intersects(smd_2022,  
                                              crimes_2024))
```

```
plot(smd_2022["crimes_smd_2024"])
```

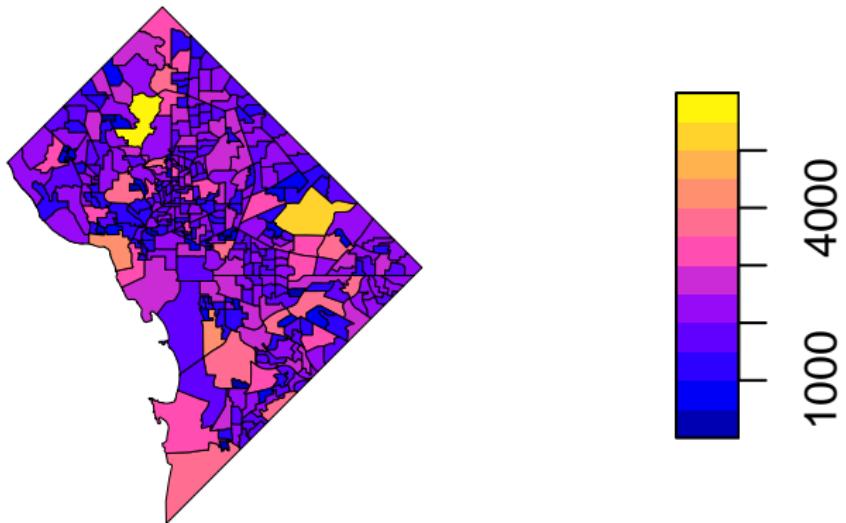
**crimes\_smd\_2024**



Let's *interpolate population counts* per SMD (this is a one-step routine in R)

```
smd_2022$pop_tract2smd = sf:::st_interpolate_aw(acs_2020["POP_TOTAL"],  
                                              smd_2022, extensive=TRUE)$POP_TOTAL  
plot(smd_2022["pop_tract2smd"])
```

**pop\_tract2smd**



Let's check the quality of transformation: how close are the population counts?

```
sum(smd_2022$pop_tract2smd) # Interpolated
```

```
## [1] 683070.1
```

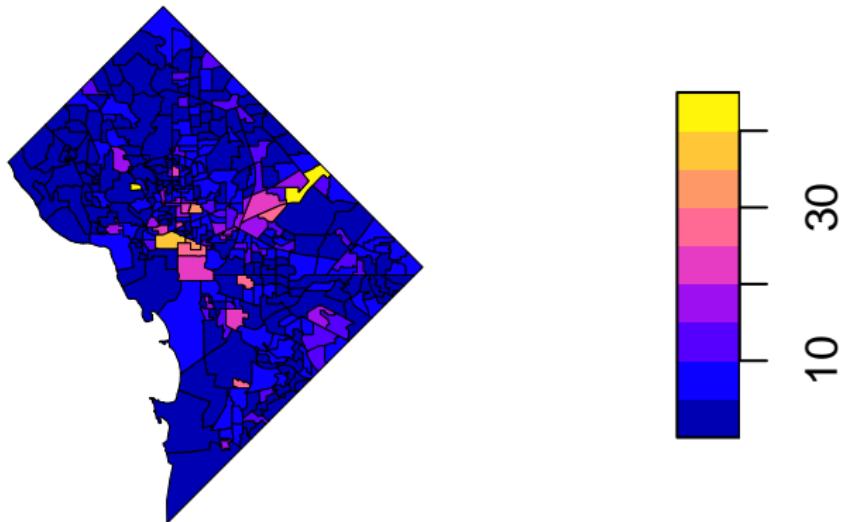
```
sum(acs_2020$POP_TOTAL)      # Original
```

```
## [1] 683154
```

Let's calculate *crimes per 1000 residents*

```
smd_2022$crimes_1000_smd = smd_2022$crimes_smd_2024 /  
                           smd_2022$pop_tract2smd * 1000  
plot(smd_2022["crimes_1000_smd"])
```

**crimes\_1000\_smd**

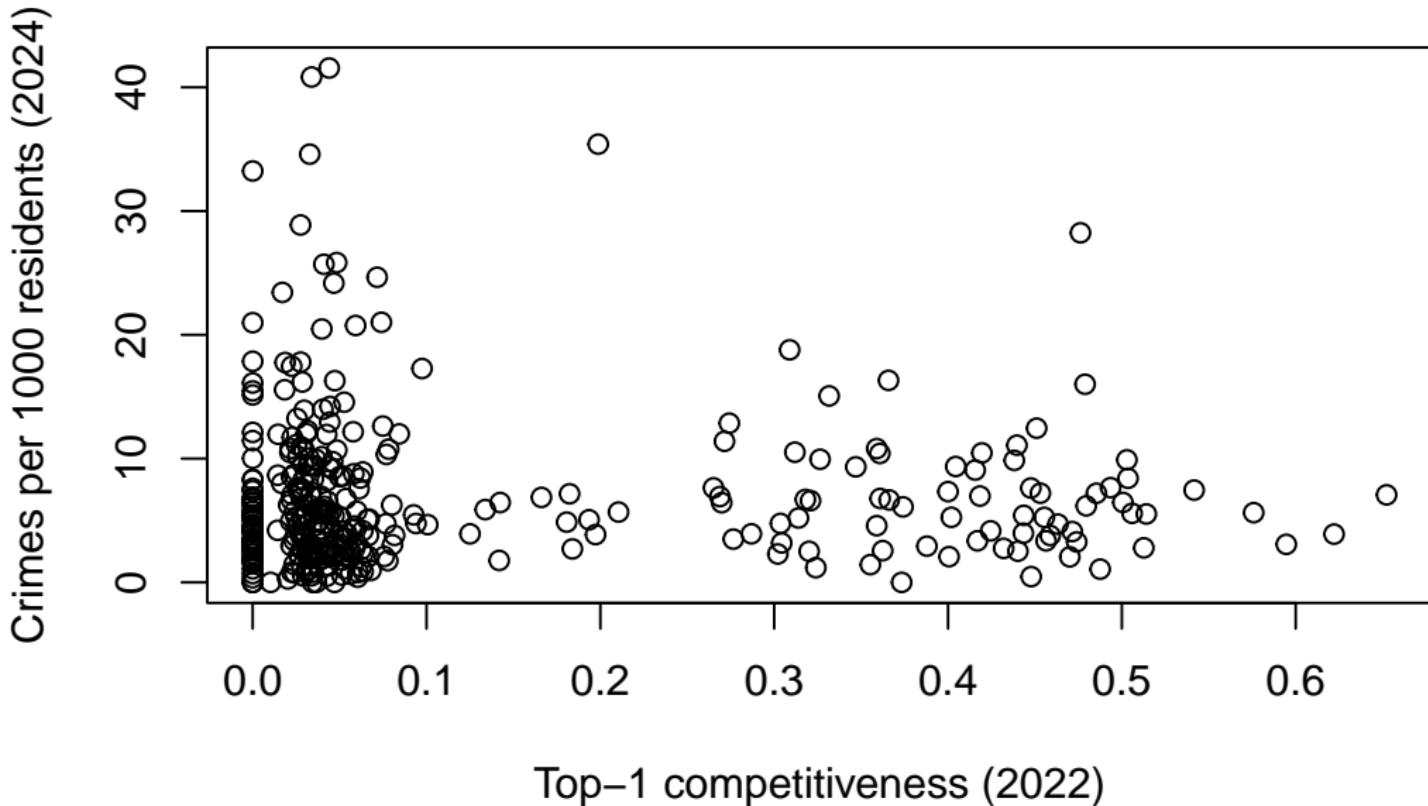


## Scatterplot

Let's create the scatterplot

```
plot(x=smd_2022$competitive_top1,  
      y=smd_2022$crimes_1000_smd,  
      xlab="Top-1 competitiveness (2022)",  
      ylab="Crimes per 1000 residents (2024)",  
      main="Electoral competitiveness and crime in DC"  
)
```

# Electoral competitiveness and crime in DC



## Problem Set 7

Your assignment (if using R):

- create a scatterplot of race and school performance in DC!
- perform areal interpolation:
  - source polygons: AFS\_2020.geojson
  - y variables: POP\_TOTAL and RACE\_WHITE
  - destination polygons: SAZ\_Elementary.geojson
  - y variables: STAR\_Score
- make and export a scatterplot:
  - percent non-white on *x*-axis
  - school STAR score on *y*-axis
  - name the file scatterplot\_race\_schools\_R.png
- upload map to Canvas  
(by next Wednesday)

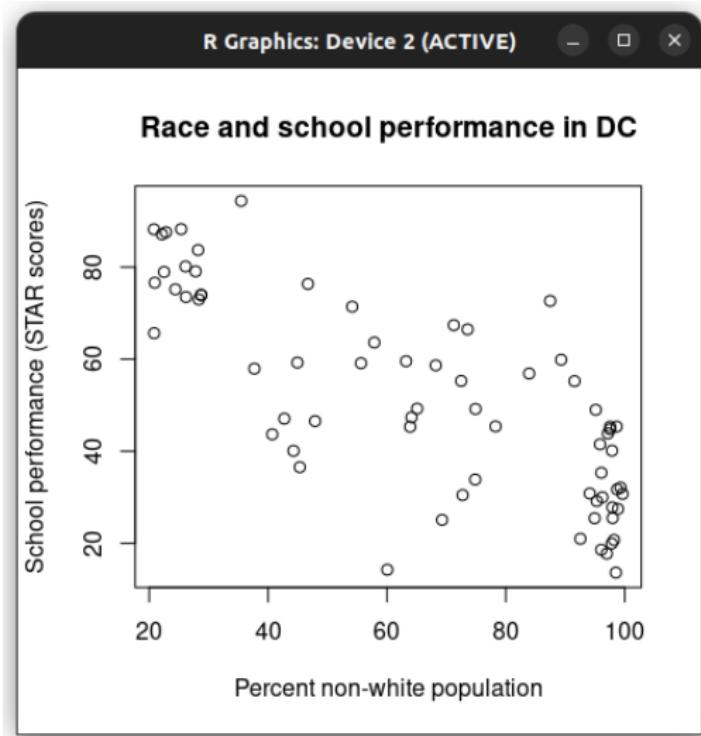


Figure 17: Can you make this?