

## 11.205 – Intro to Spatial Analysis – Fall 2019

### Week 3 – Quantitative Mapping: U.S. Census Data, Geography, and Other Data Sources

[OCW Users: The following document refers to the course website (Stellar) which is not available to users outside MIT.]

#### ArcMap Exercise

### Week 3 Objectives – Part 1 – Social Explorer and Using Excel

- I. Acquire American Community Survey Data from Social Explorer
- II. Use Excel with GIS
- III. Make a Map with downloaded Data
- IV. Make a Chart using GIS data in Excel
- V. Create a Layout with Multiple Maps

#### Lab Data

Download the class files from Stellar and load them onto your external hard drive.

The unzipped file consists of the following folders:

1. DOCUMENTS: This folder includes Word documents for this week's in-class exercise(s).
2. DATA: This folder contains all the data needed for this week's in-class exercise.
3. PROBLEM SET 1: This folder contains all of the instructions, data required to complete the take home problem set, and three reference materials:
  - a. Working with Excel: Why can't I change my 'Geo\_FIPS' field from numeric to text?!
  - b. How to Make a Nice Bar Chart
  - c. Writing Effective Policy Memos

### ACQUIRING AND MAPPING U.S. CENSUS BUREAU DATA

This week in lecture, we discussed various sources of spatial data and how they can and should be used in a GIS setting. In lab today, we are going to look at the spatial patterns of educational attainment using American Community Survey data for 2012-2016. You will see similarities with the dataset we worked with in Week 1, but instead we are going to work at the **Tract level and not the Block Group level** (remember the various Census Geographies from lecture). The Charles River Watershed Association is seeking to build an educational center, and would like information on the various education levels in the Watershed. The most recent American Community Survey (2012-2016) files contain this data, so we are going to acquire tract level data for three counties in the Boston metro area, then create a map that focuses only on the census tracts that are contained in the Charles River Watershed.

#### OBJECTIVE 1: ACQUIRE ACS DATA FROM SOCIAL EXPLORER

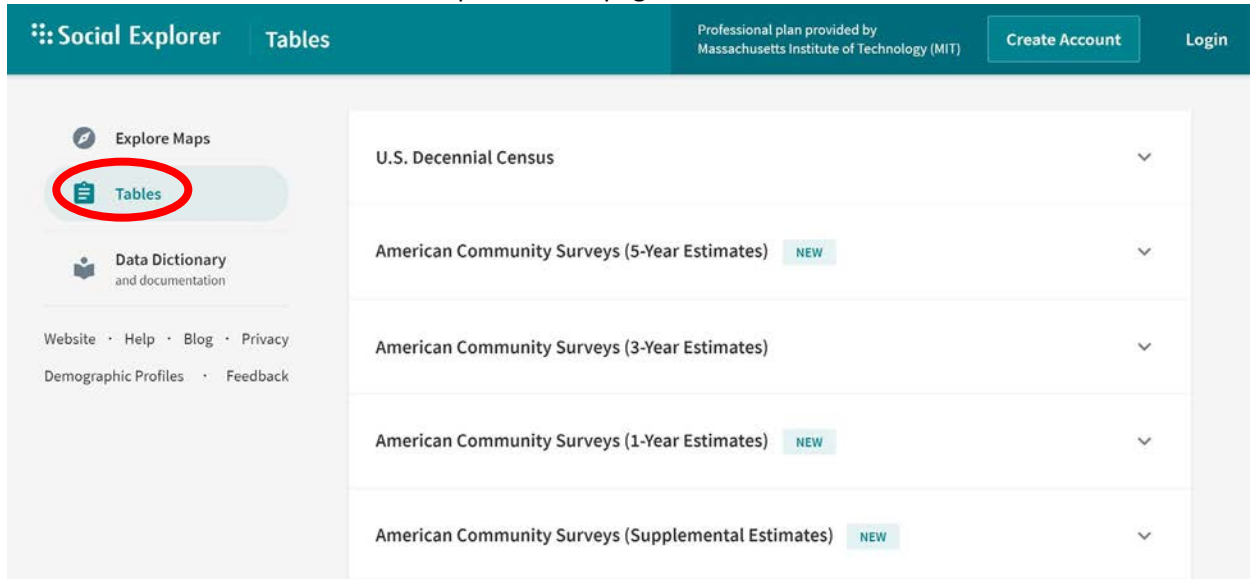
As mentioned in class, there are many ways to download American Community Survey data. The MIT Libraries has a subscription to a tool called Social Explorer that contains much Census and ACS data. We

are going to use this for the exercise, because it is the easiest way to download the data we need in spreadsheet format. If you are on the MIT campus, Social Explorer should automatically recognize the MIT subscription. Otherwise, if you are working from home, for example, you will need to connect to the MIT network first via Cisco's AnyConnect VPN software.

## 1. Begin our Data Mining on Social Explorer

Navigate to <https://www.socialexplorer.com/explore-tables>. The website looks like the following image.

A. Click on 'Tables' on the top bar of the page.



After Social Explorer loads, you will see a list of the various datasets available on Social Explorer. There are two ways to access data, either by table, or by selecting on a map. We are going to use the Table method, where we can obtain data on the level of various census geographies.

B. Click on American Community Survey (5-Year Estimates).

**Social Explorer** Tables Professional plan provided by Massachusetts Institute of Technology (MIT) [Create Account](#) [Login](#)

- Explore Maps
- Tables**
- Data Dictionary and documentation

Website · Help · Blog · Privacy  
Demographic Profiles · Feedback

- U.S. Decennial Census
- American Community Surveys (5-Year Estimates)** NEW
- American Community Surveys (3-Year Estimates)
- American Community Surveys (1-Year Estimates) NEW
- American Community Surveys (Supplemental Estimates) NEW

C. We will be using the most recent, “2013-2017 (5-year Estimates).” Select the corresponding “Begin Report” link.

### American Community Surveys (5-Year Estimates) ^

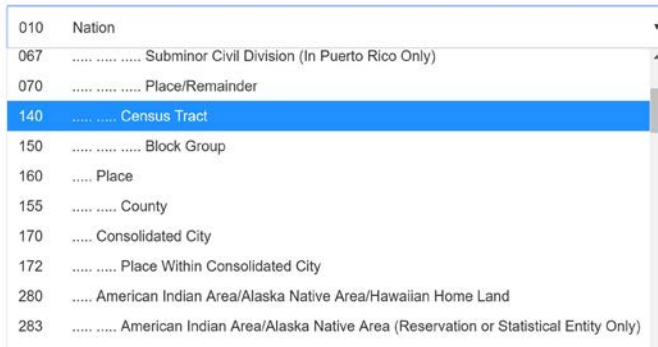
ACS 5-Year Estimates (available down to the Census Block Group geography) data plus Social Explorer tables which include easy reports with age, sex, race, Hispanic origin, household relationship, place of birth, education, employment status, income, tenure, cost and value of housing, year structure built and other data.

American Community Survey (ACS) 2013--2017 (5-Year Estimates)	NEW	<b>Begin Report</b>	More info
American Community Survey (ACS) 2012--2016 (5-Year Estimates)		Begin Report	More info
American Community Survey (ACS) 2011--2015 (5-Year Estimates)		Begin Report	More info

## 2. Select the Desired Geography

For this exercise, we are going to work at the Census Tract level. When you begin your report, you are prompted to list the geographies for which you would like to download data. We are going to select Census Tracts for Middlesex, Suffolk, and Norfolk counties. The geography listing operates in a drill-down type manner. First, set the geographic type to be Census Tract. Second, select a state, and third, select each county. Fill out your selection to match the following.

Select a geographic type: [\(Show all geographies\)](#)



Select Census Tract

Select a Geographic Type: State ->  
County -> Census Tract  
*(Important: make sure you select the Census Tracts at level 140, not level 080. This will simplify the unique ID.)*

Select a State: **Massachusetts**

Select a County: We are working with three counties (**Middlesex, Suffolk, and Norfolk**). You are

***Sample Selection pictured for Norfolk County. Do this for all three counties: Norfolk, Middlesex, Suffolk***

going to have to select each county one by one in order to get our three counties. Every time you select a county, then select “All census tracts in” that county. Add it to the Current Geography Selections by double clicking on it or by clicking on the “ Add” button. Your final window should look like the screenshot shown below.

Select a geographic type: [\(Show all geographies\)](#)

140 ..... Census Tract

Select a State:

Massachusetts

Select a County:

Norfolk County, Massachusetts

Select one or more geographic areas and click 'add':

All census tracts  
 All census tracts in Massachusetts  
 All census tracts in Norfolk County, Massachusetts

=====  
 ===== Individual Census Tracts =====  
 Census Tract 4001, Norfolk County, Massachusetts  
 Census Tract 4002, Norfolk County, Massachusetts  
 Census Tract 4003, Norfolk County, Massachusetts  
 Census Tract 4004, Norfolk County, Massachusetts

Add Remove

Current Geography Selections:

=====  
 ===== Census Tract - 140 =====  
 All census tracts in Suffolk County, Massachusetts  
 All census tracts in Middlesex County, Massachusetts  
 All census tracts in Norfolk County, Massachusetts

Proceed to Tables

Click **“Proceed to Tables”** to begin the selection of datasets available for download.

In the datasets window, select the table we are seeking on **Educational Attainment For Population 25 Years And Over**. It should be table **A12001** in the Social Explorer Tables: ACS 2017 (5-year Estimates). Note all of the data layers, datasets, and tables available in the American Community Survey. There is a huge amount of information collected that can be analyzed and mapped! Select your dataset by scrolling through the **List Tables**, or click on **Search by Keyword** and enter some keywords for the variables you are looking for (for example, search Education to find Educational Attainment). Your selection window should look like the following. Click on **‘add’** and then **‘show results’** once you have selected your datasets. Make sure you highlight the data table in the window before you click on **“Show Results”** button.

Select a dataset:

Social Explorer Tables: ACS 2017 (5-Year Estimates) ▼

Select one or more tables and click 'add':

- A12002B. Highest Educational Attainment for Female Population 25 Years and Over
- A10021. Housing Units by Educational Attainment of Householder
- A12005B. Educational Attainment of Householder (Renter-Occupied Housing Units)**
- A12004. School Enrollment for the Population 3 Years and Over
- A12006. Level of School by Type of School for Enrolled in School Population 3 Years and Over
- A12003. School Dropout Rate for Population 16 to 19 Years
- A12003A. School Dropout Rate for Male Population 16 to 19 Years
- A12003B. School Dropout Rate for Female Population 16 to 19 Years
- A17002. Employment Status for Total Population 16 Years and Over
- A17002A. Employment Status for Male Population 16 Years and Over
- A17002B. Employment Status for Female Population 16 Years and Over
- A17001. Labor Force for Population 16 Years and Over
- A17005. Unemployment Rate for Civilian Population in Labor Force 16 Years and Over
- A17005A. Unemployment Rate for Civilian Male Population

Abbreviations: **AIAN** - American Indian and Alaska Native; **NHPI** - Native Hawaiian and Other Pacific Islander

Add ▼ Remove ▲

Current Table Selections:

==== Social Explorer Tables: ACS 2017 (5-Year Estimates) =====  
A12001. Educational Attainment for Population 25 Years and Over

Show results ▶

Click the 'Show results' button. The next page should show you a report view of the data we selected.

Statistics	Census Tract 3001, Middlesex County, Massachusetts	Census Tract 3011.01, Middlesex County, Massachusetts	Census Tract 3011.02, Middlesex County, Massachusetts	Census Tract 3101, Middlesex County, Massachusetts	Census Tract 3102, Middlesex County, Massachusetts
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SE:A12001. Educational Attainment for Population 25 Years and Over						
Population 25 Years and Over:	2,338	2,787	3,620	3,933	4,195	
Less than High School	196 8.4%	181 6.5%	145 4.0%	773 19.7%	484 11.5%	
High School Graduate (Includes Equivalency)	869 37.2%	802 28.8%	1,094 30.2%	1,021 26.0%	1,996 47.6%	
Some College	604 25.8%	831 29.8%	1,041 28.8%	914 23.2%	921 22.0%	
Bachelor's Degree	447 19.1%	634 22.8%	860 23.8%	657 16.7%	423 10.1%	
Master's Degree	170 7.3%	311 11.2%	377 10.4%	412 10.5%	333 7.9%	
Professional School Degree	31 1.3%	9 0.3%	31 0.9%	37 0.9%	13 0.3%	
Doctorate Degree	21 0.9%	19 0.7%	72 2.0%	119 3.0%	25 0.6%	

For documentation and detailed source information click on a table title. All percents are taken against table universe which is the first row in each table.

### Sources & Notes

ACS 2017 (5-Year Estimates)   [Documentation](#)   [Data Dictionary](#)

Social Explorer Tables: ACS 2017 (5-Year Estimates)(SE), ACS 2017 (5-Year Estimates), Social Explorer, U.S. Census Bureau

#### Notes

When selecting more than one component from the same geographical level, Social Explorer provides a total for these components in the "All Selected Geographies" column. This total is for the available geographical level. Social Explorer denotes it with an asterisk (\*) in the All Selected Geographies column.

## 3. Download the Data

In the Report window, click on the Data Download tab. Here you are presented with a number of different options for downloading the dataset. Put a check next to "Output column labels in the first row", and click to download "Census Tract data (CSV)". This will download a comma-separated variable file that we can open in Microsoft Excel.

## ACS 2017 (5-Year Estimates)

[Choose survey/year](#) ▶ [Geographies](#) ▶ [Tables](#) ▶ [Results](#)

[Report](#) [Excel](#) [Data Download](#)

Download data in CSV format. CSV stands for Comma Separated Values, and it is a highly portable format that can be read by many : Western Latin-1 (ISO-8859-1).

Please set options before you download any data or import programs (these options affect both).

**Output options:**

- TAB delimited files (STATA users should use this option to make import more efficient & accurate!)
- Output column labels in the first row
- Output ALL geographic identifiers
- Output percents (first variable in each table is the base)
- Output DBF friendly column names

Download data by geography type:

- Census Tract data (CSV)
  - Summary Level: 140
  - Geography Nesting: **State-County-Census Tract**
  - Selected: 652

Download programs to import and label data:

- SAS
- SPSS
- STATA: (please select TAB delimited files in Output Options above)
- Data dictionary (text file)

This will download a file that will be given a temporary name. **Save it to your weekly workspace.** Open up the CSV file in Microsoft Excel. CSV files are readable and editable in Microsoft Excel, but you will need to select 'All Files' from the dropdown menu to see the .csv file.

## OBJECTIVE 2: USING EXCEL WITH GIS

### 1. Clean up the Data/Prepare it for GIS

Open the new .csv file from where you saved it. The first thing we need to do is prepare the file to be read into GIS software without any errors. We can also get rid of fields that we will not be using. There are several fields in this table that we do not need, remove them by selecting them, right clicking on the selection, and deleting them. In our case, most of these fields are empty, making them useless to us. In some circumstances however, there is data in the field, we just will not be using it for our purposes.

We can get rid of many of the fields, as they either contain no data or are filled with redundant data. This will vary based on census variables, but it is much easier to work with a small file.



Delete all columns for fields that are **NOT** listed below by right-clicking on the column, then clicking 'Delete.' The fields we need to KEEP include:

1. FIPS - (Geo\_FIPS) – *THIS WILL BE OUR PRIMARY KEY*
2. Name of Area - (Geo\_NAME)
3. Population 25 Years and over - (SE\_A12001\_001)
4. Population 25 Years and over: Less Than High School - (SE\_A12001\_002)
5. Population 25 Years and over: High School Graduate (includes equivalency) - (SE\_A12001\_003)
6. Population 25 Years and over: Some college - (SE\_A12001\_004)
7. Population 25 Years and over: Bachelor's degree - (SE\_A12001\_005)
8. Population 25 Years and over: Master's degree - (SE\_A12001\_006)
9. Population 25 Years and over: Professional school degree - (SE\_A12001\_007)
10. Population 25 Years and over: Doctorate degree - (SE\_A12001\_008)

With our spreadsheet now much more lightweight, we must rename fields so that ArcGIS can read them properly. We downloaded the first row in the table to make it easier to figure out what the fields' names are, but GIS will not like the length of the names, or the fact that they contain spaces. Use the second field name where the names are eight characters or less. These names would be fine to use, however, as they are hard to understand, let's make them a little clearer by changing the names of the fields to the ones specified in the following table.

Rename the following fields (by typing the new names in the second row):

Population 25 Years and over - **SE\_A12001\_001** => **POP\_EDU**  
Population 25 Years and over: Less Than High School - **SE\_A12001\_002** => **LESS\_HS**  
Population 25 Years and over: High School Graduate (includes equivalency) - **SE\_A12001\_003** => **MORE\_HS**  
Population 25 Years and over: Some college - **SE\_A12001\_004** => **SOME\_COL**  
Population 25 Years and over: Bachelor's degree - **SE\_A12001\_005** => **HAS\_BA**  
Population 25 Years and over: Master's degree - **SE\_A12001\_006** => **HAS\_MAST**  
Population 25 Years and over: Professional school degree - **SE\_A12001\_007** => **HAS\_PROF**  
Population 25 Years and over: Doctorate degree - **SE\_A12001\_008** => **HAS\_PHD**

**IMPORTANT: Delete the row that contains the first heading of the file**, the long one with spaces. Right click on the row and select delete. Your cleaned file should look like the following.

Now, this table is in a manageable size and format.

But wait! There are four more things we can do to prepare this file: set the field data types, set up the unique field for joining to GIS, add and calculate any new fields, and properly name the Excel sheet we are working in.

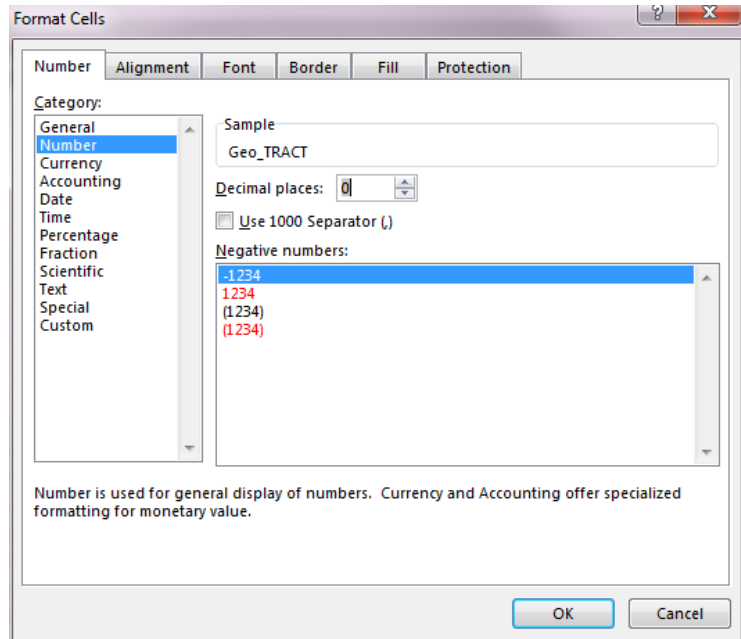
#### ***a. Change and Set Field Data Types***

In Excel, field data types are called ‘formats’. Change the format of the cells to make sure that GIS will read it correctly. Select the columns for each field, right click them, and select ‘Format cells.’ Change the format to the correct one if it’s not correct. Below is a list of the correct field type.

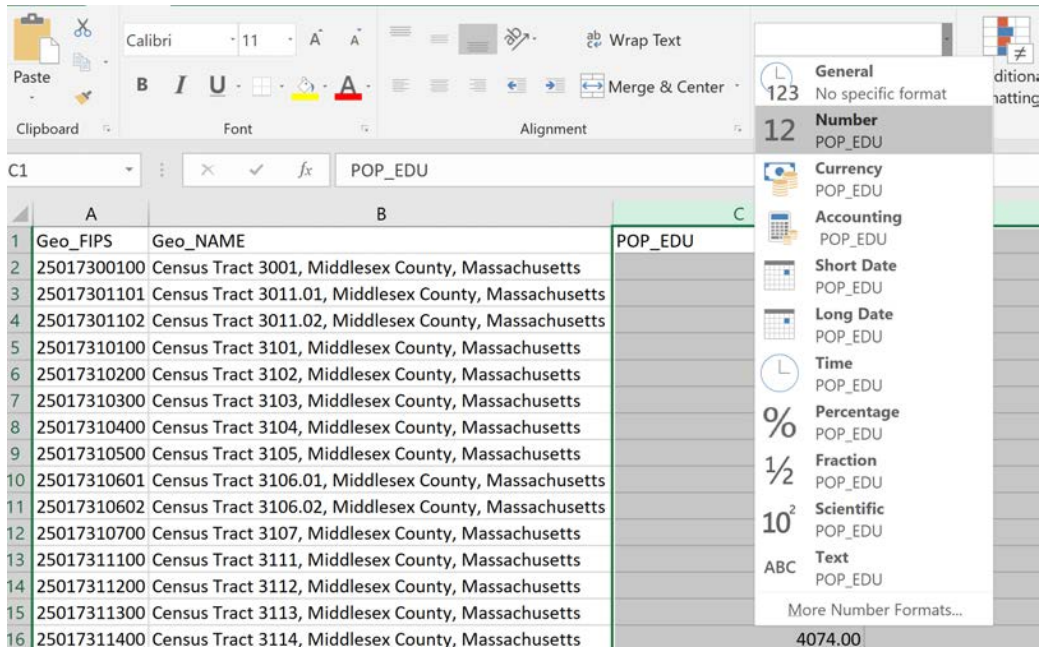
Geo_FIPS	Geo_NAME	POP_EDU	POP_EDU	MORE_HS
25017300100	Census Tract 3001, Middlesex County, Massachusetts			160.00
25017301101	Census Tract 3011.01, Middlesex County, Massachusetts			165.00
25017301102	Census Tract 3011.02, Middlesex County, Massachusetts			122.00
25017310100	Census Tract 3101, Middlesex County, Massachusetts			784.00
25017310200	Census Tract 3102, Middlesex County, Massachusetts			496.00
25017310300	Census Tract 3103, Middlesex County, Massachusetts			786.00
25017310400	Census Tract 3104, Middlesex County, Massachusetts			456.00
25017310500	Census Tract 3105, Middlesex County, Massachusetts			266.00
25017310601	Census Tract 3106.01, Middlesex County, Massachusetts			611.00
25017310602	Census Tract 3106.02, Middlesex County, Massachusetts			452.00
25017310700	Census Tract 3107, Middlesex County, Massachusetts			510.00
25017311100	Census Tract 3111, Middlesex County, Massachusetts			555.00
25017311200	Census Tract 3112, Middlesex County, Massachusetts			818.00
25017311300	Census Tract 3113, Middlesex County, Massachusetts			589.00
25017311400	Census Tract 3114, Middlesex County, Massachusetts	4074.00		723.00
25017311500	Census Tract 3115, Middlesex County, Massachusetts	1969.00		338.00
25017311600	Census Tract 3116, Middlesex County, Massachusetts	3735.00		510.00
25017311700	Census Tract 3117, Middlesex County, Massachusetts	3011.00		681.00
25017311800	Census Tract 3118, Middlesex County, Massachusetts	2231.00		784.00

Make sure your field types are the same as the below list.

1. Geo\_FIPS = Text
2. Geo\_NAME = Text
11. POP\_EDU= Number (no decimals)
12. LESS\_HS= Number (no decimals)
13. MORE\_HS= Number (no decimals)
14. SOME\_COL= Number (no decimals)
15. HAS\_BA= Number (no decimals)
16. HAS\_MAST= Number (no decimals)
17. HAS\_PROF = Number (no decimals)
18. HAS\_PHD = Number (no decimals)



**You can also do this by using the drop-down menu in the Home tab of Excel:**



**Save your current version as a 'Microsoft Excel 97-2003' Worksheet. Backsave it to xls. Name it Education\_ACS2017.xls**

**IT IS VERY IMPORTANT THAT YOU SAVE AS AN EXCEL FILE.**

**THE .CSV FILE WILL NOT SAVE THE FORMATTING YOU HAVE DONE AND MIGHT CAUSE PROBLEMS WHEN YOU JOIN.**

**IMPORTANT: Save as xls file (Excel 97-2003) ... NOT as an xlsx file.**

***b. Locate the Unique Key to Join to GIS***

The Unique Key in our downloaded Social Explorer data is called **GEO\_FIPS**. This will be the field we join to our GIS file.

In the GIS shapefile we'll be working with later, you'll notice a **GEOID10** field that contains matching rows. GEOID10 is type Text, so that's why we made sure that the GEO\_FIPS field is formatted to be Text data type too. As noted above, make sure you save as an Excel file to preserve the formatting.

***c. Use Excel Formulas to Add Fields and Derive Variables***

When joining data from Excel to a GIS file, you can normalize and add derived data either in GIS software, or you can calculate numbers in Excel before you perform the join. We will do both today to show the methods and introduce you to Excel formulas. In this exercise, we are going to create two maps of educational data in the Charles River watershed. One of the maps will show the percentage of individuals that possess a Master's Degree by Census Tract, and the other will show individuals that have Less than a High School Education by Census Tract.

We will look at them side by side at the end of the lab exercise. Using a formula in Excel, let's create a new field and calculate the percentage of population age 25 and over that have a Master's Degree for each Census Tract.

1. Click on the column at the end of your Excel sheet to the right of HAS\_PHD. In the top row with the other headers and type PERC\_MAST in the column header.

Geo_FIPS	Geo_NAME	POP_EDU	LESS_HS	MORE_HS	SOME_COL	HAS_BA	HAS_MAST	HAS_PROF	HAS_PHD	PERC_MAST
25017300100	Census Tract 3001, Middlesex County, Massachusetts	2157	148	699	713	362	196	14	25	
25017301101	Census Tract 3011.01, Middlesex County, Massachusetts	2744	172	893	883	570	217	1	8	
25017301102	Census Tract 3011.02, Middlesex County, Massachusetts	3381	175	1219	892	781	255	38	21	
25017310100	Census Tract 3101, Middlesex County, Massachusetts	3304	596	526	1034	651	363	50	84	
25017310200	Census Tract 3102, Middlesex County, Massachusetts	4631	646	1662	1436	592	249	0	46	
25017310300	Census Tract 3103, Middlesex County, Massachusetts	3952	967	1237	1058	509	178	8	0	

2. In this column, we are going to use what is called an Excel formula. Formulas allow us to fill in spreadsheet cells based on criteria, logical tests, and values from other cells. In simple terms, we want this field to hold the percentage of the population age 25 years and older that has a Master's Degree, and we can create this by combining other fields. In this circumstance, we need to take HAS\_MAST and divide it by POP\_EDU to get the percentage of individuals that possess a Master's Degree.

$$\text{PERC\_MAST} = \text{HAS\_MAST} / \text{POP\_EDU}$$

There is a problem with this statement, however. There are a handful of census tracts that have zero population. (POP\_EDU = 0) You cannot divide by zero, so we need to tell Excel what to do with these tracts. We can accomplish this using an IF statement. An IF statement will look at each cell we are calculating and if POP\_EDU is equal to zero, it will place a zero in the cell instead of throwing an undefined error.

In Excel, an IF statement looks like the following:

$$=IF(\text{<logical\_test>}, \text{<value\_if\_true>}, \text{<value\_if\_false>})$$

In this circumstance, our <logical test> is POP\_EDU=0, our <value if true> should be 0, and our <value if false> is HAS\_MAST/POP\_EDU. Your IF statement should be the following. Place it in the first row beneath our PERC\_MAST header.

$$=IF(C2=0,0,(H2/C2)*100)$$

If you wrote your statement properly, you will see the following:

	A	B	C	D	E	F	G	H	I	J	K
1	Geo_FIPS	Geo_NAME	POP_EDU	LESS_HS	MORE_HS	SOME_COL	HAS_BA	HAS_MAST	HAS_PROF	HAS_PHD	PERC_MAST
2	25017300100	Census Tract 3001, Middlesex County, Massachusetts	2338	196	869	604	447	170	31	21	7.271172
3	25017301101	Census Tract 3011.01, Middlesex County, Massachuset	2787	181	802	831	634	311	9	19	
4	25017301102	Census Tract 3011.02, Middlesex County, Massachuset	3620	145	1094	1041	860	377	31	72	
5	25017310100	Census Tract 3101, Middlesex County, Massachusetts	3933	773	1021	914	657	412	37	119	
6	25017310200	Census Tract 3102, Middlesex County, Massachusetts	4195	484	1996	921	423	333	13	25	
7	25017310300	Census Tract 3103, Middlesex County, Massachusetts	3788	747	1713	841	291	144	0	52	

Double click the little green box in the lower right corner to fill the rest of the field with the correct values for each row.

- The cells in Excel do not contain values at this point, but rather contain the IF statement we just wrote. To make the calculations permanent, copy and paste values in the newly calculated field. To do this, select all the values in the column, right-click and copy them, **then right-click on the selected area and click Paste Values**. This will change the value of each cell to be the proper numeric value.

Double-click here to fill the field

	I	J	K
T	HAS_PROF	HAS_PHD	PERC_MAST
)	31	21	7.271172
L	9	19	
7	31	72	
2	37	119	
3	13	25	
4	0	52	

When complete, your Excel file will contain a new field that has the percentage of individuals that possess Masters Degrees called PERC\_MAST and will look like the following:

	A	B	C	D	E	F	G	H	I	J	K
1	Geo_FIPS	Geo_NAME	POP_EDU	LESS_HS	MORE_HS	SOME_COL	HAS_BA	HAS_MAST	HAS_PROF	HAS_PHD	PERC_MAST
2	25017300100	Census Tract 3001, Middlesex County, Massachusetts	2338	196	869	604	447	170	31	21	7.271172
3	25017301101	Census Tract 3011.01, Middlesex County, Massachuset	2787	181	802	831	634	311	9	19	11.15895
4	25017301102	Census Tract 3011.02, Middlesex County, Massachuset	3620	145	1094	1041	860	377	31	72	10.41436
5	25017310100	Census Tract 3101, Middlesex County, Massachusetts	3933	773	1021	914	657	412	37	119	10.47546
6	25017310200	Census Tract 3102, Middlesex County, Massachusetts	4195	484	1996	921	423	333	13	25	7.938021
7	25017310300	Census Tract 3103, Middlesex County, Massachusetts	3788	747	1713	841	291	144	0	52	3.801478
8	25017310400	Census Tract 3104, Middlesex County, Massachusetts	1866	378	875	433	120	60	0	0	3.215434
9	25017310500	Census Tract 3105, Middlesex County, Massachusetts	1895	295	636	537	254	165	8	0	8.707124
10	25017310601	Census Tract 3106.01, Middlesex County, Massachuset	4452	592	1537	1321	522	436	28	16	9.793351
11	25017310602	Census Tract 3106.02, Middlesex County, Massachuset	3759	542	1308	1008	484	335	28	54	8.911945
12	25017310700	Census Tract 3107, Middlesex County, Massachusetts	2452	485	1058	529	266	96	18	0	3.915171
13	25017311100	Census Tract 3111, Middlesex County, Massachusetts	1661	602	447	366	149	79	0	18	4.756171
14	25017311200	Census Tract 3112, Middlesex County, Massachusetts	2002	729	582	335	247	100	9	0	4.995005

#### d. Change your Sheet Name

The final step is to change the sheet name in Excel to something that makes sense. When you import an Excel spreadsheet to ArcGIS, you do not import the entire workbook, rather you import individual sheets of data. We only have one sheet in this dataset. Find the name of it at the bottom of the Excel interface. Change the name to **Education\_2017**. Save your file.

12		96.00		18.00		0.00	3.915171				
13		79.00		0.00		18.00	4.756171				
14		100.00		9.00		0.00	4.995005				
15		184.00		50.00		20.00	7.101505				
16		558.00		45.00		57.00	13.19773				
17		336.00		19.00		25.00	16.72474				
18		361.00		44.00		43.00	9.423127				
19		105.00		20.00		11.00	3.381643				
20		43.00		0.00		1.00	1.948346				

For some pointers on table formatting from ESRI, check out the following link.

<http://desktop.arcgis.com/en/arcmap/10.3/manage-data/tables/formatting-a-table-in-microsoft-excel-for-use-in-arcgis.htm>

Now let's make a map! Close Microsoft Excel so that ArcGIS can read our new file.

## OBJECTIVE 3: MAKE A MAP FROM AN EXCEL SPREADSHEET

After the Excel file preparation, the spreadsheet is now ready to join to a Census Tract file and be mapped. To complete Objective 3, we are going to make a map. Our final output for this map is going to show **Educational Attainment by Census Tract for all tracts that fall within the Lower Charles River Watershed in the metropolitan Boston area.**

In the next steps, we will add our data, join the spreadsheet to the geometry file, extract only the tracts in the geometry file that fall within the Lower Charles River Watershed, and symbolize our data.

## 1. Add Data and Join Tables

1. Open ArcMap and create a new Blank Map. Then add the following files.

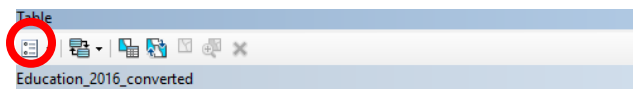
- *ACS\_boston\_2019\_tracts\_final.shp* – These represent ACS Census Tract boundaries in Norfolk, Suffolk, and Middlesex Counties.
- The sheet “Education\_2017” from the Excel file *Education\_ACS2017.xls* – This is the Excel file with the educational attainment data that we downloaded from Social Explorer. Add the *Education\_2017* sheet that contains the data.

2. In order to join two tables, the columns we are joining on must be the same data type. For example, we can't join a text column to a number column, so we have to make sure that both are **NUMBER** columns. We are going to perform our table join based on two fields, **Geo\_FIPS** and **GEOID**, so we need to ensure that the column data type is the same for both. Check the properties of each column to see this.

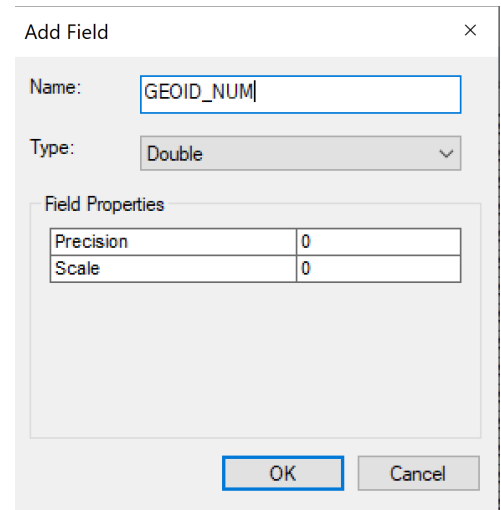
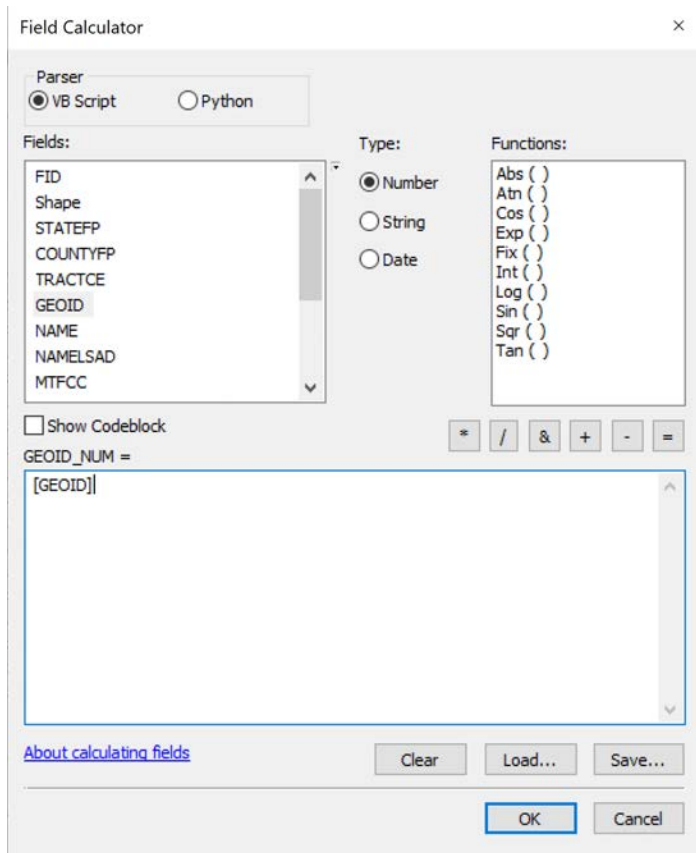
3. Open the Attribute Tables for both *Education\_2017\_converted.dbf* and *ACS\_boston\_2019\_tracts\_final.shp* files. Right click the header of the respective fields (GEOID and Geo\_FIPS) to view **Properties**. If they match, we can skip this...but they don't! Geo\_FIPS is numeric (double) and GEOID is a text (string). So, what we need to do is create a new field in the *ACS\_boston\_2019\_tracts\_final.shp* with **Double** data type, call it a new name (**GEOID\_NUM**) and populate it with the data in **GEOID**.

a. To create a new field in the shapefile, open the attribute table for *ACS\_boston\_2019\_tracts\_final.shp*. Click on the **Table Options** button in the upper left corner of the table. Select **Add Field**.

Select Add Field from Table Options



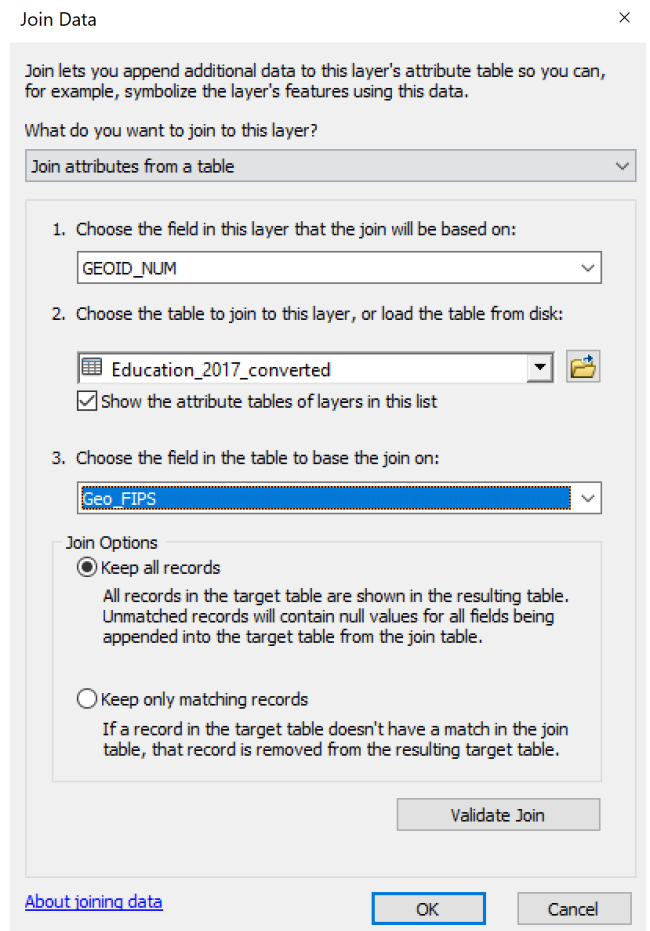
- b. Create a new field, call it **GEOID\_NUM**, and give it type **Double**.
- c. Use the Field Calculator to populate our new field. Set the **GEOID\_NUM** field to be equal to the **GEOID** field, and click OK. Our field will populate. Close the attribute. We will perform our join next on the Education\_2017\_converted layer.



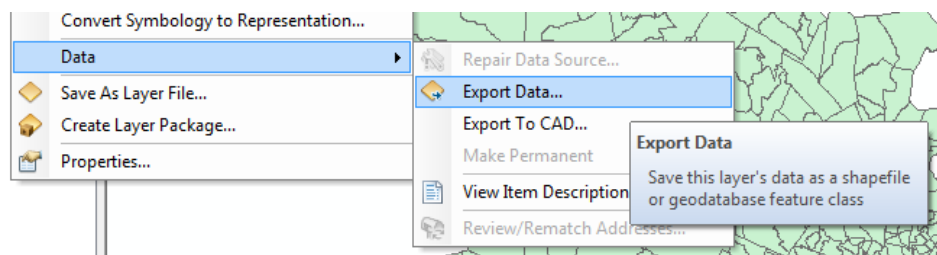
4. Using the methods we learned to join tables in the exercises from last week, join the Education\_2017\_converted data to ACS\_boston\_2019\_tracts\_final.shp. (That means you **right click on ACS\_boston\_2019\_tracts\_final.shp** to perform the join.) Perform the join on **GEOID\_NUM** from the Tracts shapefile, choose the Education\_2017\_converted table as the table to join to the layer, and base the join on the **Geo\_FIPS** field. Click validate join to see if there are any errors. Click OK to complete the join.

**NOTE:** You can only join fields of the same data type. (i.e. Number to Number, Text to Text). This is a common cause of errors when joining Census data to geometry (i.e. attempting to join a Number field to a Text field). If this does not work, see the previous step once more.

Open the attribute table to see if the join worked. You should see your spreadsheet appended to the shapefile now.

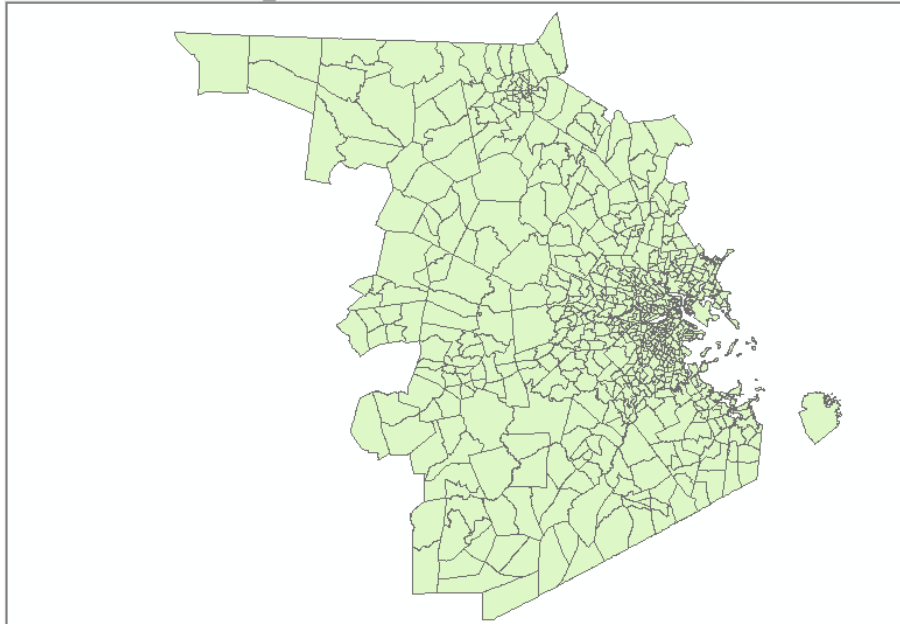


3. Export a copy of the tracts file with the joined data. Right click on the ACS\_boston\_2019\_tracts\_final.shp layer and navigate to Data -> Export Data. Save this as Tracts\_Education\_2017.shp in your working space for the week.



Add the Tracts\_Education\_2016.shp file that you just created to your map document. Your file should look something like this.



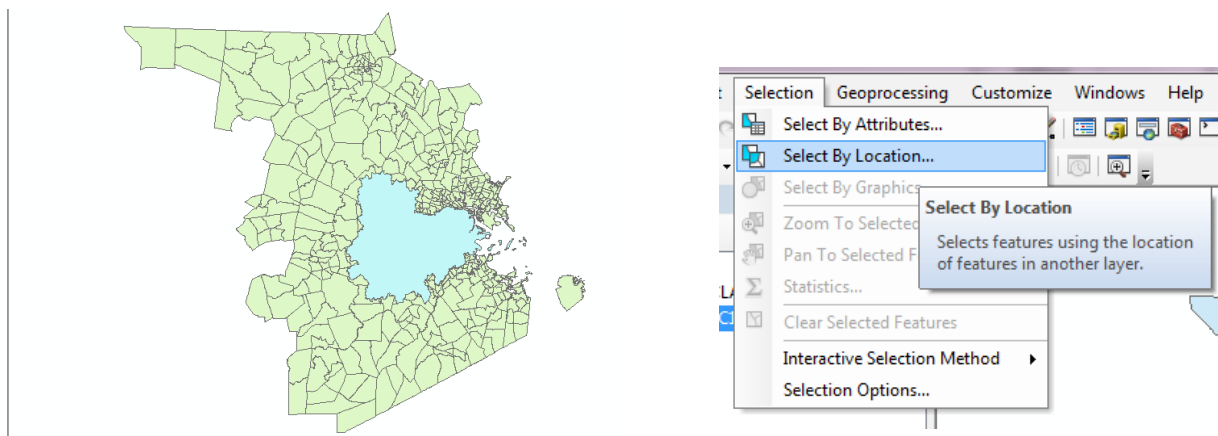


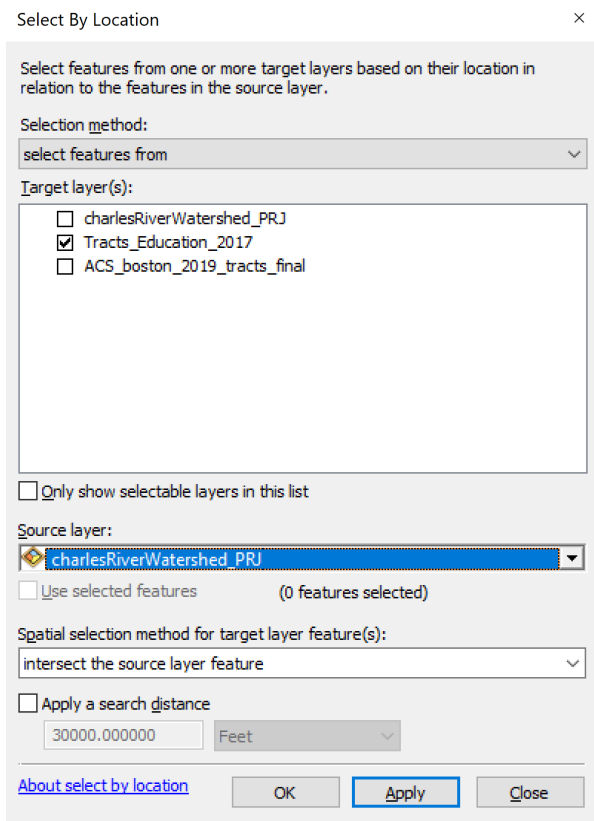
## 2. Extract Data for the Lower Charles River Watershed

The data currently shows all tracts in all of Middlesex, Norfolk, and Suffolk Counties. These counties make up a large portion of the Boston Metropolitan Area, and we don't need to show all of the tracts, only the ones that are in the Lower Charles River Watershed. To do this, we are going to extract the tracts that fall within the Lower Charles River Watershed using a shapefile for the Watershed. There are a couple of methods to complete this.

### 1. Add the Watershed shapefile

The first step is to add the Charles River Watershed shapefile provided in our weekly materials. Go to Add Data and navigate to your workspace. Click and add **CharlesRiverWatershed\_PRJ.shp** to your map document.





## 2. Extract Tracts that Fall within the Watershed

Extracting the tracts that are within the watershed can be accomplished in a number of ways. We are going to use the **Select by Location** tool and extract all the tracts that intersect (are contained by or touch the boundary of) the Lower Charles River Watershed. The Select by Location tool is in the Selection dropdown menu at the top of your screen.

The Select by Location dialog allows you to select features in a layer according to a spatial relationship with another layer. Following through the dialog, set the Selection method to 'select features from' and then the **target layer** to be **Tracts\_Education\_2017**.

The **source layer** is the basis of selection. Set this to be the Lower **Charles River Watershed layer**.

The selection method offers many options, we encourage you to explore them. For this, set the selection method to '**intersect the source layer feature**'. Do not enter a search distance.

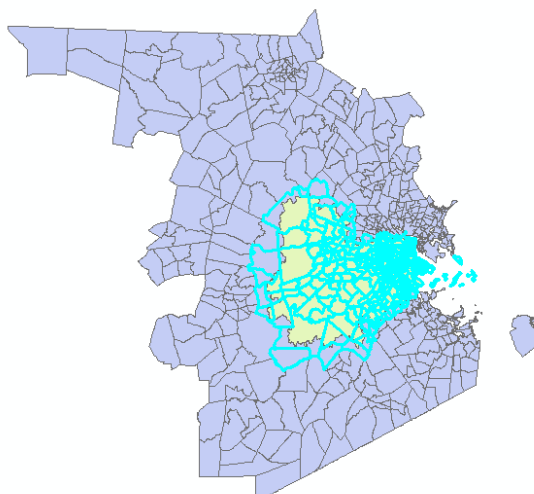
In simple terms, this tells the software to select all tracts from the tracts layer that intersect the watershed layer.

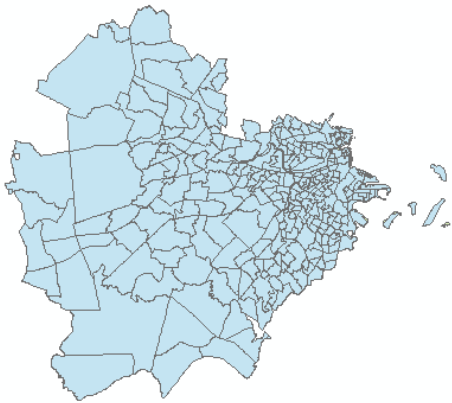
Your selection should look like the following.

### Export this as its own shapefile.

With the Tracts selected, right click on the Tracts\_Education\_2017 layer and export your data. Make sure you export the **Selected features**. Save it as **Watershed\_Tracts\_Edu\_2017.shp** in your workspace.

Add it to your map when the export is completed. Turn off your other layers **and make sure all selections are cleared**.





Turn off all layers except for **Watershed\_Tracts\_Edu\_2017.shp**. Your map should currently look like this. Colors may vary.

*Hint: Right click on Watershed\_Tracts\_Edu\_2017 and select Zoom to Layer. Toggle off the visibility of the other layers.*

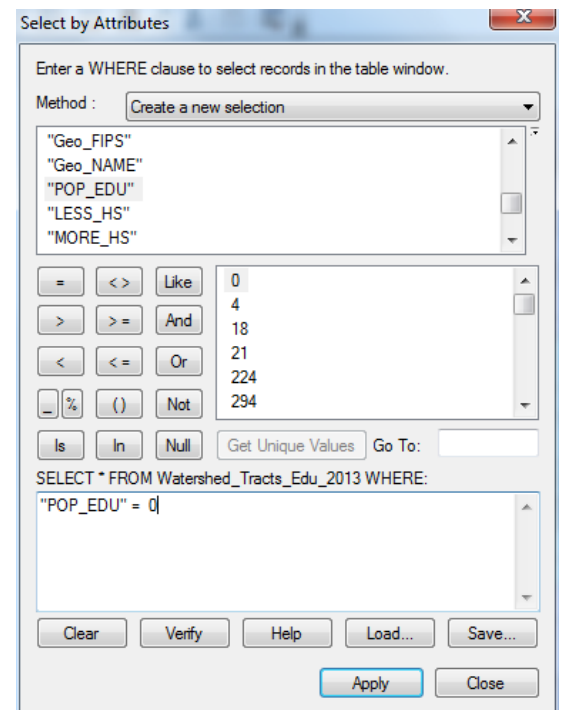
### 3. Symbolize your Data

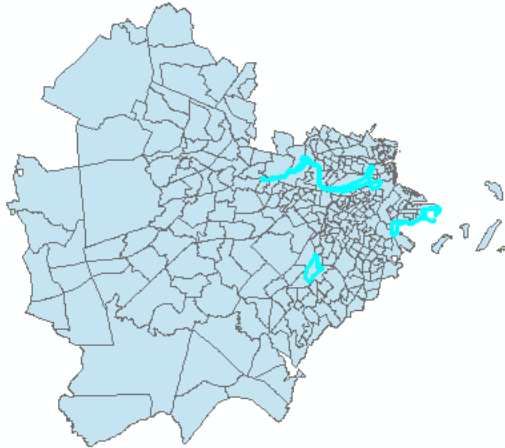
Using the methods we have learned in previous weeks, symbolize the map to make a choropleth map showing some attributes. Let's explore the data to make sure everything looks okay. First, we can check if tracts with zero population actually make sense.

#### 1. Find tracts with zero population


One good way to check the accuracy of the data is see where zero values are found. Zero values can expose where parks or other non-residential features are located. Open the attribute table for **Watershed\_Tracts\_Edu\_2017** and **Select by Attributes** from the Table Options menu. Set our Selection query to read "POP\_EDU" = 0.

Your data should now look like the following. Tracts with zero population are highlighted. Notice that this appears to be correct. Tracts with zero population include the Boston Common, Arnold Arboretum, parks in South Boston, and the Esplanade along the Charles River.



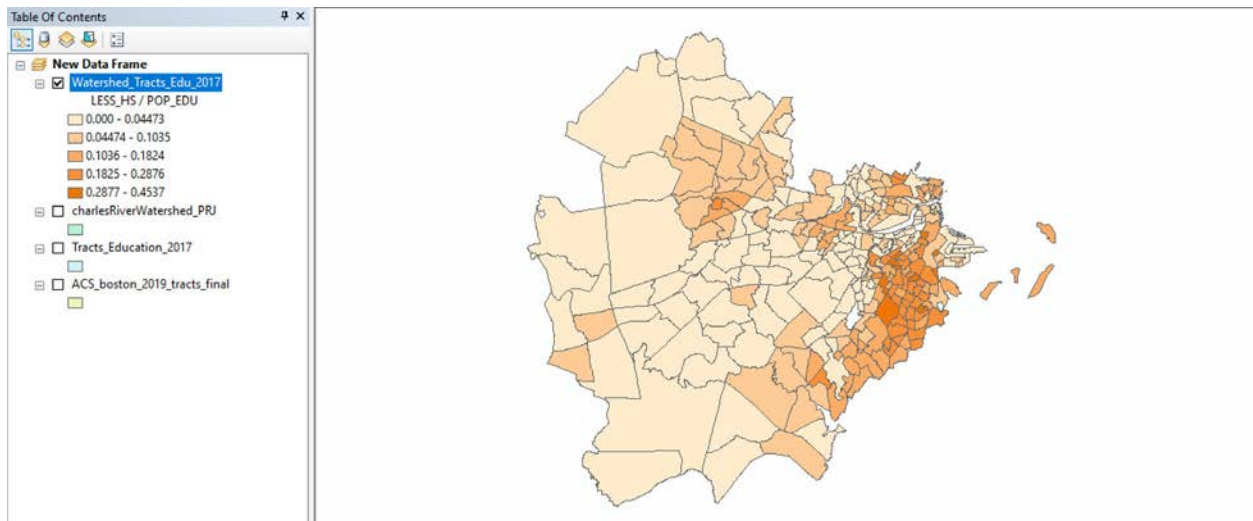


## 2. Normalize on the Fly

Clear our selection by going to **Selection -> Clear Selected Features**. Use the  button to do so. Now let's make a Population map showing percentage of individuals that have less than a High School degree.

Right-click the layer and go to **Properties -> Symbology** to make a map that shows the **percentage of the population 25 years and older (POP\_EDU) that have less than a high school degree (LESS\_HS)**. Give it five classes, and use a natural breaks classification.

The Value field ought to have **LESS\_HS** and you ought to normalize your data using the **POP\_EDU** field.

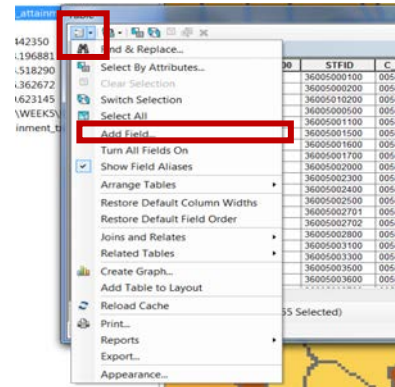


Notice that there are certain locations that are not filled in. These are the same tracts that have zero population. These are often parks or non-residential areas. When you normalize, you are really taking the number of individuals with no high school diploma (**LESS\_HS**) and dividing it by the total population of persons 25 and over (**POP\_EDU**). **GIS is doing the division on the fly and removing those parcels**

where there are zeros in the denominator. GIS automatically will remove those from the visualization. To make this a permanent change, we have to make a new field in our database that contains our normalized data.

### 3. Create a new field to hold a normalized value

Earlier in this exercise, we added a field in Excel to hold the normalized value of Master’s Degree holders. Then we added a field to our DBF. Let’s do this again in GIS with a Shapefile, but this time, find the percentage of individuals who have not received a high school diploma, as opposed to those individuals who possess a Master’s level degree.



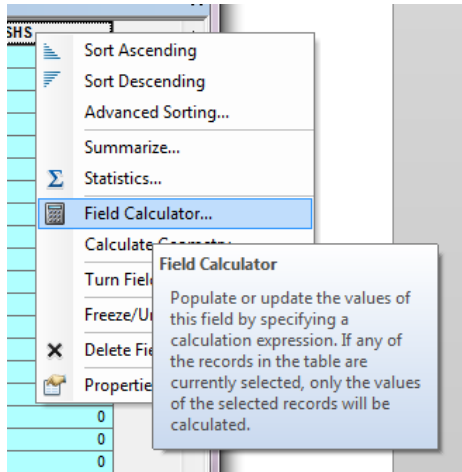
First make sure nothing is selected by going to **Selection > Clear Selected Features**. Then open the attribute table and click on the Options tab. Navigate to Add Field.

Call the field P\_LESSHS and make it data type Double. Double allows the field to contain decimal points. Leave Precision and Scale as the defaults. Click OK.

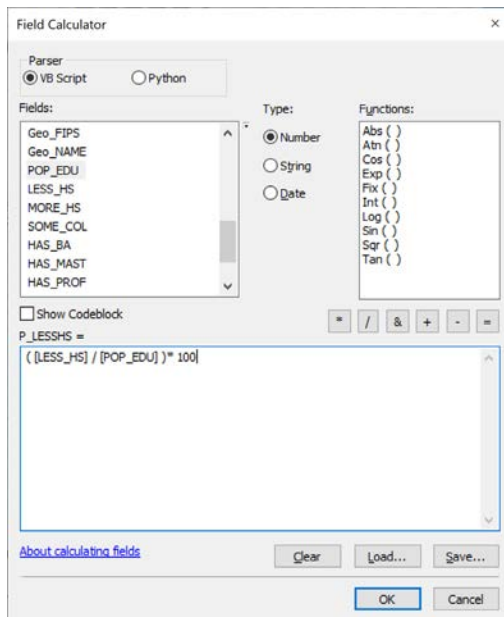
Scroll over in the attribute table to see the new blank field. Next we want to calculate the values in the field. We are going to fill the field with the value of LESS\_HS/POP\_EDU. In order to ensure we don’t divide where the denominator is 0, we need to perform the calculation where POP\_EDU is not equal to 0. Recall we addressed this issue in Excel by using an IF statement.

In the Attribute Table, go to Table Options -> Select by Attributes, and enter “POP\_EDU” <math>\neq 0</math> (the <math>\neq</math> sign means NOT EQUAL TO). Click Apply. When you use Field Calculator, it will only run the calculation on features you have selected, meaning our calculator will only run on census tracts that have POP\_EDU not equal to zero.

Highlight the P\_LESSHS field, right click, and select Field Calculator. A dialog will appear asking if you want to calculate outside of an edit session. Click OK.



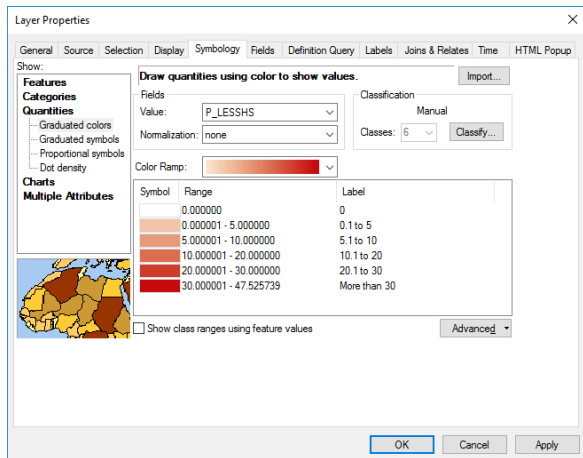
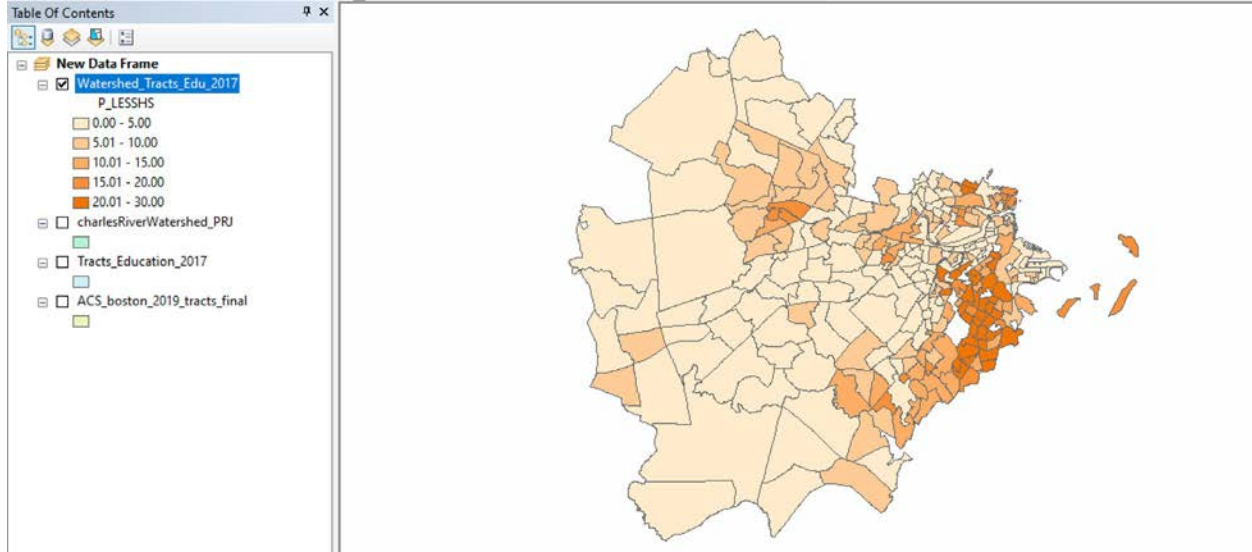
The Field Calculator dialog will open. In the calculation window, type  $([LESS\_HS]/[POP\_EDU]) * 100$ . This will populate the P\_LESSHS field with a value representing the percentage of people 25 years and older with less than a high school degree. Click OK.



Be sure to clear selected features.

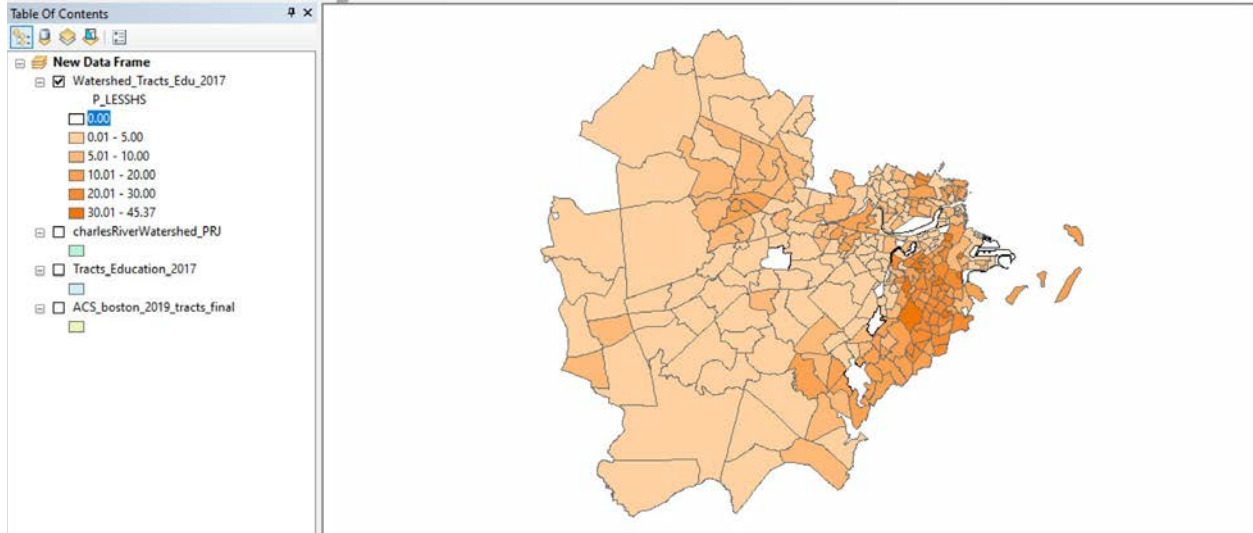
#### 4. Symbolize using the Normalized Value

Now we can symbolize our map based on P\_LESSHS. Taking a look at the field will show the percentage of people 25 years and older with less than a high school degree for each census tract. Right-click the layer and go to Properties > Symbology to make a map that shows the percent of people that have less than a high school degree. I am going to make mine by giving myself **five categories** and use the Jenks Natural Breaks classification scheme. Using this scheme gives unrounded number breaks for each class, so adjust your classification breaks to be 5, 10, 20, 30, and leave the last value as is. Your symbolized map should look like the following.



**Alternative Classification Strategy:** You will notice if you do the above classification and symbolization, you lose the zero values into a class. These are often important to call out in our datasets, as they represent parks, cemeteries, ponds, or another anomalous areas. First, change our classification to **six classes**. Because we set the map to have five classifications above, we can keep the breaks the same (5, 10, 20, and 30), but let's change our symbology to have six classifications. Make the break for the first class zero. This will add a zero classification to our dataset that will specifically call out all tracts with percentage value zero.

With regards to color, give the 0 value a white, and adjust your ramp. Your map, with the alternative classification scheme, will look like the following:



## 5. Add Context and Supplemental Data

We have a symbolized map of the tracts in the Lower Charles River Watershed, but as we all know, the Boston area does not float in a vacuum. Add some additional data like the watershed boundary, water features, town boundaries, and major highways to add context to your map.

### a. Add Data

Add the following files to your map:

*BOUNDARY\_POLY\_PRJ* – City Boundaries

*EOTMAJROADS\_RTE\_MAJOR\_PRJ* – Major Roads and Highways

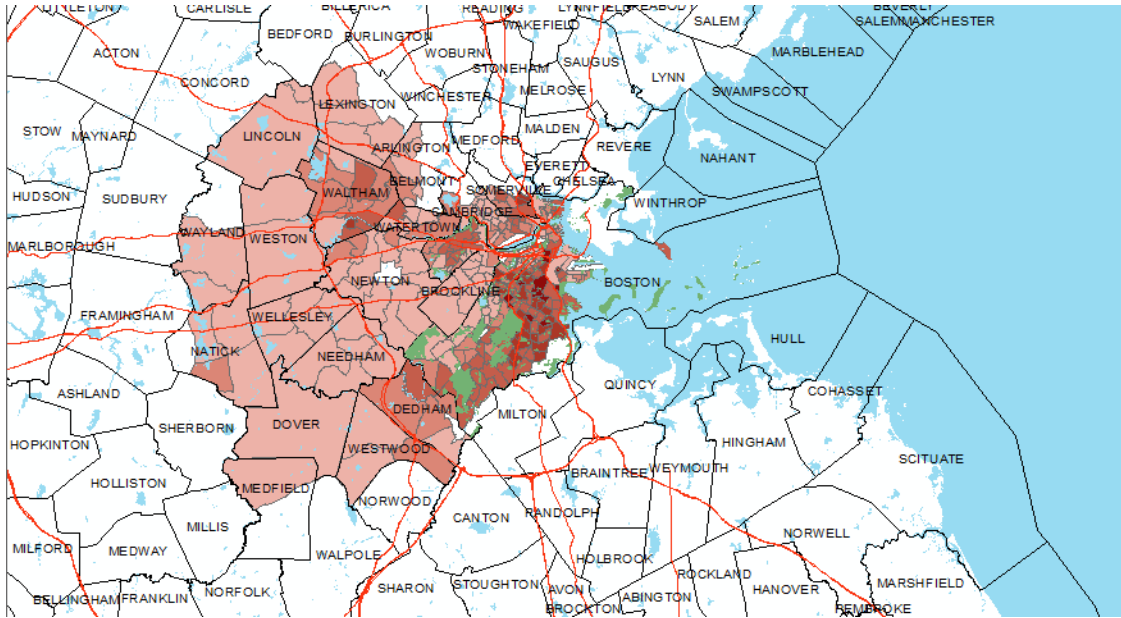
*MassHydro\_PRJ* – Waterbodies

*boston\_openspace\_prj* - Parks

### b. Organize your Table of Contents and Symbolize

Just as we have done in previous maps, organize the layers in the Table of Contents so that the tracts layer is on the bottom, and the boundaries and roads are on the top. For the watershed boundary and town boundaries, set the polygon fill to be none. This will allow the tract data to be visible. Your map should look like the following. Don't worry about the legend yet, we will add it later. Save your map as *Boston\_Education\_ACS2017.mxd* to your weekly workspace.



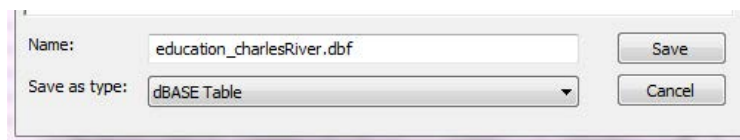


## OBJECTIVE 4: MAKE A CHART FROM GIS DATA IN EXCEL

We have been working with the Charles River Watershed Association on some statistics for an environmental education center. The reports would like them to **include a spread of the education levels throughout the watershed**. Now that we have selected all the data for the watershed we can use graphics (such as bar charts) for them to insert into their report. It is a lot easier to make these in Excel – so we will export our data and open it in Excel.

a. Export the Attribute Data of 'Watershed\_Tracts\_Edu\_2017.shp' to DBF

Open the Attribute table for Watershed\_Tracts\_Edu\_2017. Go to Table Options > Export. Save the attribute table with the name 'education\_charlesRiver.dbf' and save it as type 'dBASE Table'. **Do not add the table to your map. If you do, ArcGIS will lock it and it will not open elsewhere.** We are going to open it in Excel.



b. To open the DBF file in Excel, you must open Excel first. Remember when opening a DBF file in Excel you need to Go to File >Open. Then navigate to the folder where you saved your DBF. In order to see your DBF as a possible file to open you need to choose "All Files" next to the file name.

d. **We will make a bar chart that displays educational attainment in the Lower Charles River Watershed.** Scroll to the right in the spreadsheet to find the educational attainment data.

HINT: Freeze the top row so you can always see your column headers. You can do this by going to View > Freeze Panes > “Freeze Top Row”

1. First, sum each column to find the total population, total population with less than a high school diploma, total population with a high school diploma, etc. To do this, at the bottom of the data, in the POP\_EDU column, enter “=SUM(…)” and then highlight all of the data in the column. Close the parenthesis, and hit enter. This will give you a total for the column, and the total number of persons age 25 or over in tracts that intersect the Lower Charles River Watershed. Repeat this for each column.

Geo_FIPS	Geo_NAME	POP_EDU	LESS_HS	MORE_HS	SOME_COL	HAS_BA	HAS_MAST
25025010600.00000000000	Census Tract 106, Suffolk County, Massachusetts	2829.00000000000	74.00000000000	193.00000000000	250.00000000000	990.00000000000	718.00000000000
25025120500.00000000000	Census Tract 1205, Suffolk County, Massachusetts	1965.00000000000	158.00000000000	393.00000000000	237.00000000000	658.00000000000	362.00000000000
25025070600.00000000000	Census Tract 706, Suffolk County, Massachusetts	1996.00000000000	25.00000000000	62.00000000000	164.00000000000	829.00000000000	549.00000000000
25025082100.00000000000	Census Tract 821, Suffolk County, Massachusetts	3363.00000000000	774.00000000000	1255.00000000000	752.00000000000	342.00000000000	129.00000000000
25025070900.00000000000	Census Tract 709, Suffolk County, Massachusetts	2179.00000000000	322.00000000000	226.00000000000	235.00000000000	603.00000000000	413.00000000000
25025101101.00000000000	Census Tract 1011.01, Suffolk County, Massachusetts	2579.00000000000	625.00000000000	919.00000000000	654.00000000000	222.00000000000	159.00000000000
25025120600.00000000000	Census Tract 1206, Suffolk County, Massachusetts	1794.00000000000	63.00000000000	70.00000000000	125.00000000000	702.00000000000	361.00000000000

2. Create a new sheet in your workbook and copy these totals into the new sheet. Highlight the cells you want, (the top row, and our calculations), right-click and copy, then click on the new sheet. Right-click and **Paste Values**. Do the same with your heading names. The new sheet should look like this (the numbers might be different). **Delete P\_LESSHS and PERC\_MAST, we do not need it for this chart, nor do the values make sense.**

POP_EDU	LESS_HS	MORE_HS	SOME_COL	HAS_BA	HAS_MAST	HAS_PROF	HAS_PHD
799347.00000000000	69481.00000000000	124714.00000000000	120341.00000000000	229800.00000000000	156181.00000000000	50149.00000000000	48681.00000000000

3. Select the data and choose Copy. Click on an empty cell below the data and choose Paste > Transpose. Your new sheet should now look like the following. Transposing our data makes it easier to make a chart.

POP_EDU	LESS_HS	MORE_HS	SOME_COL	HAS_BA	HAS_MAST	HAS_PROF	HAS_PHD
2889.00000000000	132.00000000000	758.00000000000	678.00000000000	604.00000000000	488.00000000000	93.00000000000	136.00000000000
3094.00000000000	174.00000000000	484.00000000000	292.00000000000	797.00000000000	888.00000000000	246.00000000000	213.00000000000
799347.00000000000	69481.00000000000	124714.00000000000	120341.00000000000	229800.00000000000	156181.00000000000	50149.00000000000	48681.00000000000
POP_EDU	799347.00000000000						
LESS_HS	69481.00000000000						
MORE_HS	124714.00000000000						
SOME_COL	120341.00000000000						
HAS_BA	229800.00000000000						
HAS_MAST	156181.00000000000						
HAS_PROF	50149.00000000000						
HAS_PHD	48681.00000000000						

4. Now we need to make a percent field. Highlight the first empty cell to the right of the LESS THAN HIGH SCHOOL DEGREE and enter the formula “=(B5/\$B\$4)”. This will calculate your percentage of the population 25 years and older. Drag the formula down so that it is applied to all the cells. **(The dollar**

signs in the denominator means that the data will always reference the total population when you drag the data down.)

POP_EDU	LESS_HS	MORE_HS	SOME_COL	HAS_BA	HAS_MAST	HAS_PROF	HAS_PHD
2889.000000000000	132.000000000000	758.000000000000	678.000000000000	604.000000000000	488.000000000000	93.000000000000	136.000000000000
3094.000000000000	174.000000000000	484.000000000000	292.000000000000	797.000000000000	888.000000000000	246.000000000000	213.000000000000
799347.000000000000	69481.000000000000	124714.000000000000	120341.000000000000	229800.000000000000	156181.000000000000	50149.000000000000	48681.000000000000
POPULATION 25 AND	799347.000000000000						
LESS THAN HIGH SCHC	69481.000000000000	=B5/\$B\$4					
MORE THAN HIGH SCH	124714.000000000000						
SOME COLLEGE	120341.000000000000						
HAS BACHELORS DEGF	229800.000000000000						
HAS MASTERS DEGREE	156181.000000000000						
HAS PROFESSIONAL DI	50149.000000000000						
HAS PHD	48681.000000000000						

5. Rename the fields to create headings that make better sense. These should be descriptive for the reader.

- POP\_EDU** = POPULATION 25 AND OVER
- LESS\_HS** = LESS THAN HIGH SCHOOL DEGREE
- MORE\_HS** = MORE THAN HIGH SCHOOL DEGREE
- SOME\_COL** = SOME COLLEGE
- HAS\_BA** = HAS BACHELORS DEGREE
- HAS\_MAST** = HAS MASTERS DEGREE
- HAS\_PROF** = HAS PROFESSIONAL DEGREE
- HAS\_PHD** = HAS PHD

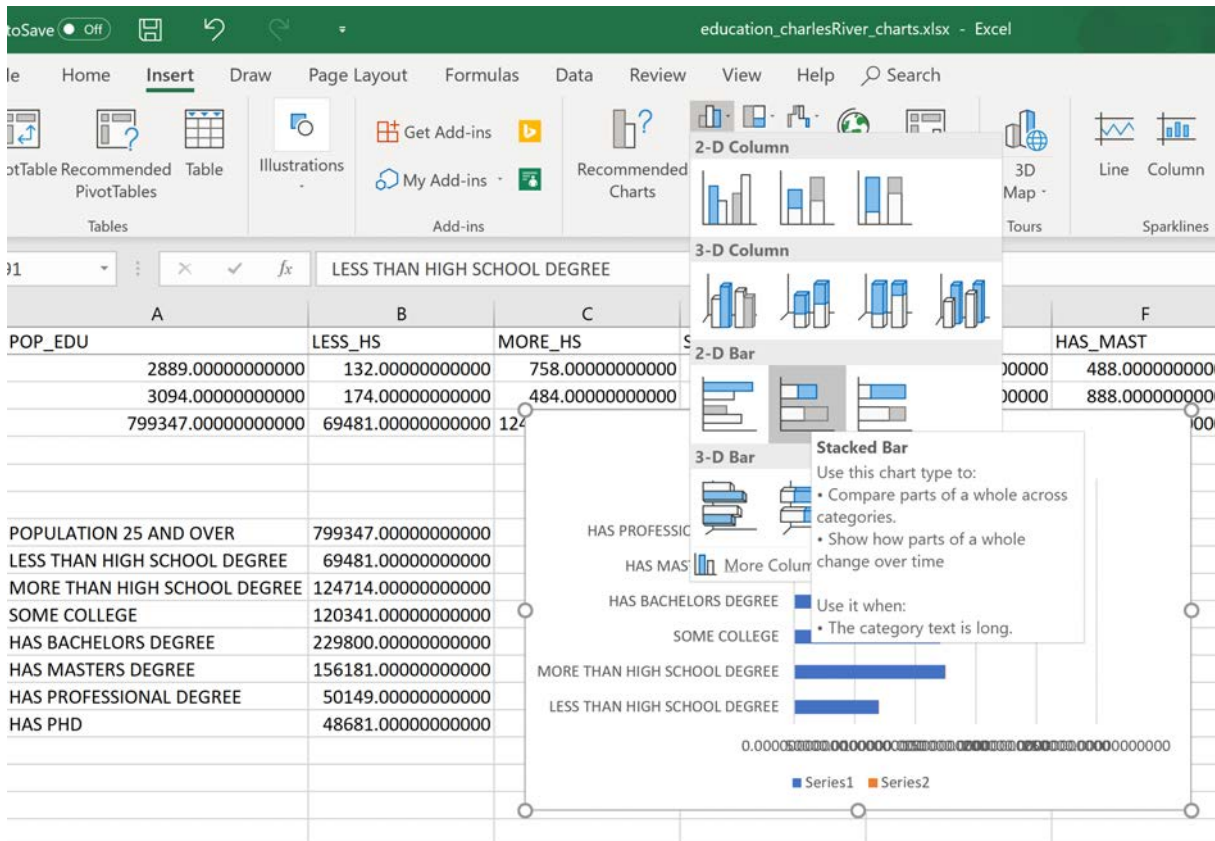
Following these changes, the table should look like the following.

POPULATION 25 AND	799347.000000000000	
LESS THAN HIGH SCHC	69481.000000000000	0.08692220025
MORE THAN HIGH SCH	124714.000000000000	0.15601985120
SOME COLLEGE	120341.000000000000	0.15054913573
HAS BACHELORS DEGF	229800.000000000000	0.28748465935
HAS MASTERS DEGREE	156181.000000000000	0.19538573361
HAS PROFESSIONAL DI	50149.000000000000	0.06273745945
HAS PHD	48681.000000000000	0.06090096041

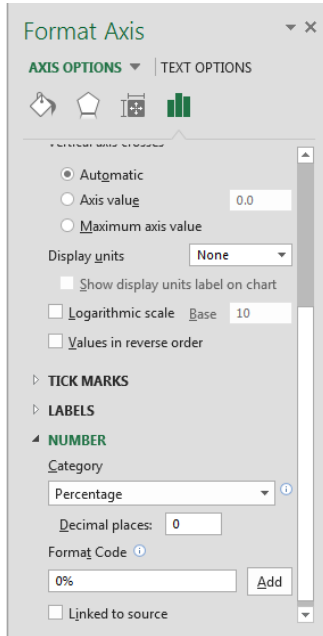
6. With your Ctrl key pressed down (or option-control on an Apple keyboard), highlight the fields you want to make the table with. When you highlight the fields, it will look like below.

POPULATION 25 AND OVER	799347	
LESS THAN HIGH SCHOOL DEGREE	69481	0.09
MORE THAN HIGH SCHOOL DEGREE	124714	0.16
SOME COLLEGE	120341	0.15
HAS BACHELORS DEGREE	229800	0.29
HAS MASTERS DEGREE	156181	0.20
HAS PROFESSIONAL DEGREE	50149	0.06
HAS PHD	48681	0.06

7. Click on the Insert tab and select the Column or Bar Chart option in the Charts section. Choose 2-D Stacked Bar. You should get a chart like the following.



Adjust the formatting to improve your chart, remember that labeling your chart is very important. Give the name of the title to something that logically represents the chart. Helping the reader interpret your chart is important, if numbers are not visible or legible, the teaching staff will not be able to grade your assignment and your potential clients will not be able to understand the information you are presenting.



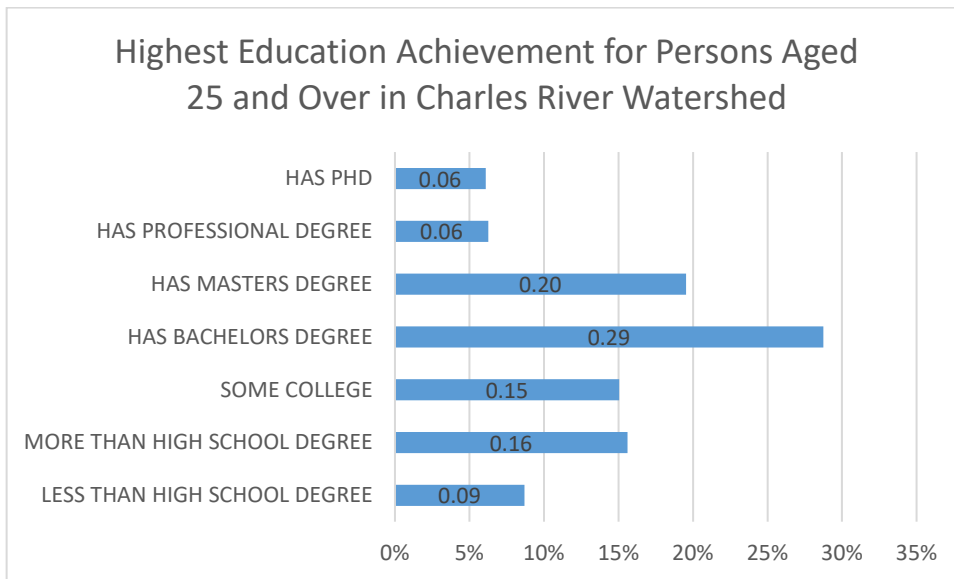
To access formatting options, click on the various components of your chart.

To label the bottom axis, click on the bottom axis, then go to Format Axis. Axis Options -> Number -> Category -> Percentage. This will change the bottom axis labels to a percentage value.

To label the individual bars, right-click on the bars in the chart and go to Add Data Labels. To format these, click again once you have added data labels and navigate to Format Data Labels... Here in Label Options, you will see a Number option. Set the category to Percentage, and use 1 decimal place.

To change the title, click on the Chart Title and edit the text.

Your final chart should look something like the following. This is a very basic bar chart. While effective, we encourage you to be creative and explore the various chart settings.



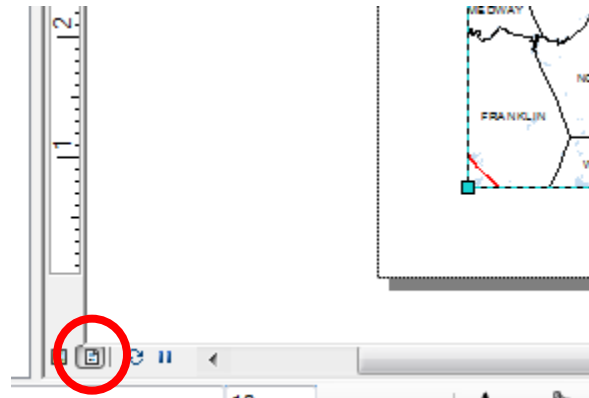
## OBJECTIVE 5: CREATE A LAYOUT WITH MULTIPLE MAPS

In the following part of this exercise, we are going to create two maps side by side that show the variables we created. One map will show the Percentage of Individuals with a Masters Degree, which we

created in Excel, and the other map will show the Percentage of Individuals without a High School diploma, which we created in ArcGIS. The practice of this is the same as creating a locator map.

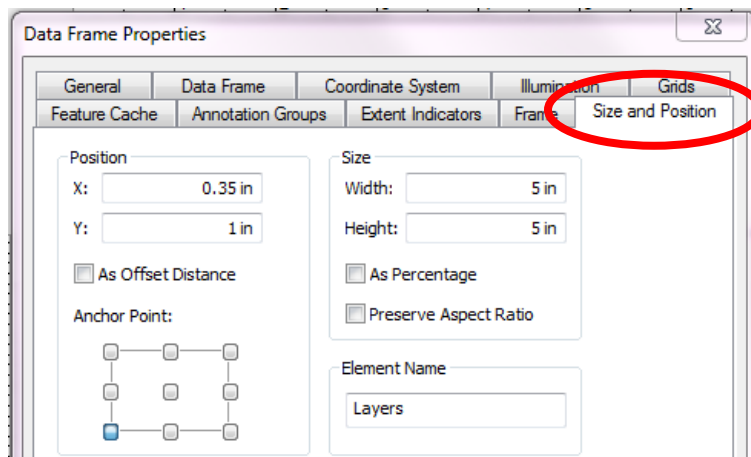
1. Return to ArcMap and open Boston\_Education\_2017\_ACS.mxd (the map document we have been working in).

2. In the bottom of the map document, toggle from Data View to Layout View to see our page layout. Remember we have done this to compose maps in previous weeks.

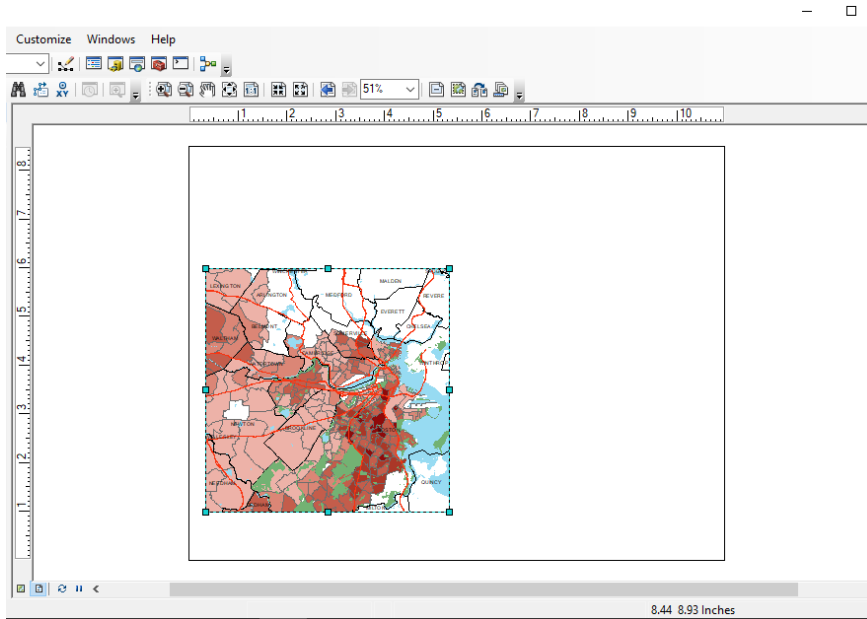


3. In File -> Page and Print Setup, set the orientation to be Landscape. Click OK. We are going to lay our two maps side by side.

4. Adjust the location of your data frame. If you right click on the data frame and enter the Data Frame Properties, you can be precise with your layout size and position. When adjusting size and position settings, remember you are working on an 8.5 inch by 11-inch page in Landscape orientation. The origin in your measurements is in the lower left corner, 0 inches, 0 inches. In the screenshot below, I set the anchor to be in the lower left, then set a left margin at .35 inches, and a bottom margin at 1 inch. The size of the data frame is set to 5 inches by 5 inches. Click OK.



Your map will look like the following. You might need to zoom into the Boston area to adjust the extent of area shown in your map.



5. Add a second data frame by going to Insert -> Data Frame. A new data frame will appear in the center of your view.

6. Adjust the location of your new data frame. Right click on the data frame and enter the Data Frame Properties. Again, when adjusting size and position settings, remember you are working on an 8.5 inch by 11 inch page in Landscape orientation. The origin in your measurements is in the lower left corner, 0 inches, 0 inches. In the screenshot below, I set the anchor to be in the lower right, then set a left margin at .35 inches by using 10.65 inches (11 inches minus .35 inches), and a bottom margin at 1 inch. The size of the data frame is set to 5 inches by 5 inches. Click OK.

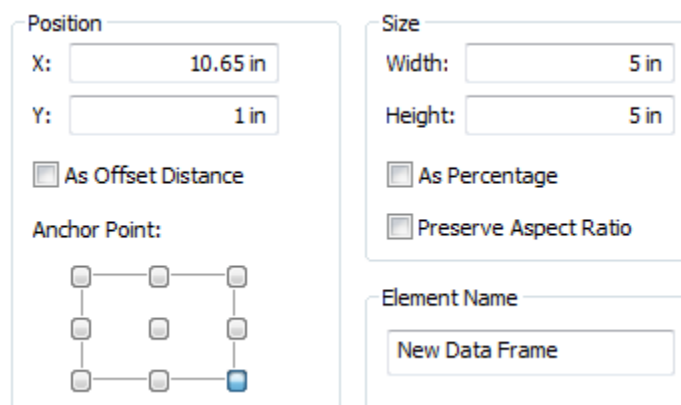
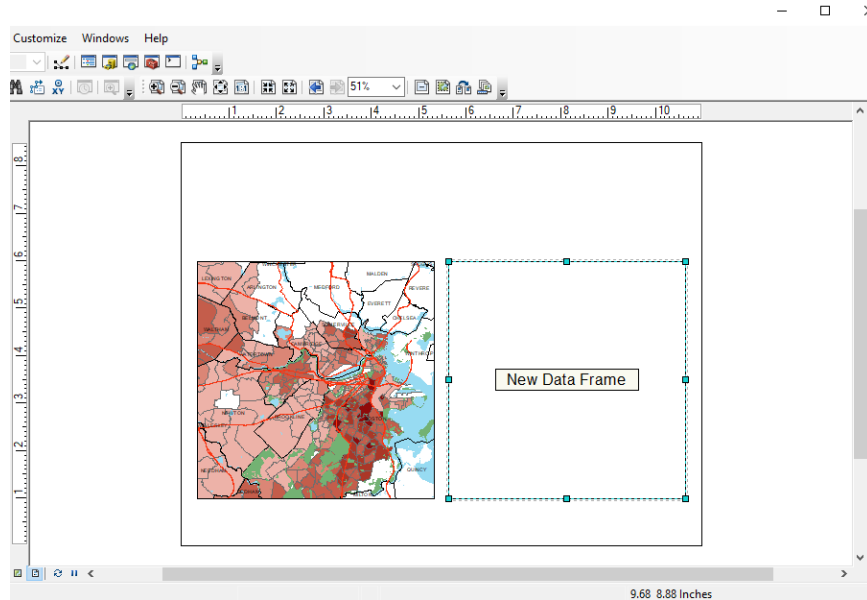


Figure 56. Set the parameters

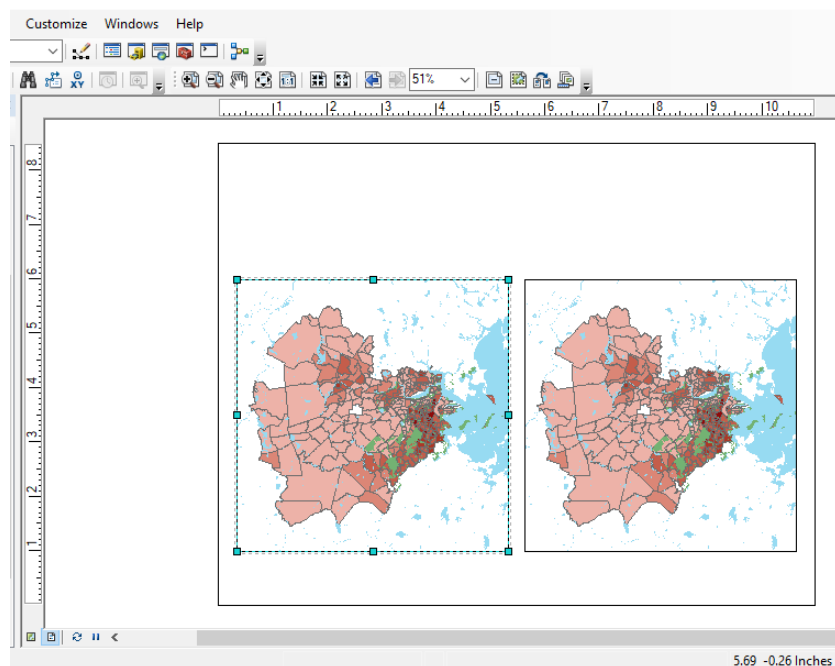
Your layout should now look like the following:



7. Rename the Data Frames. Click on the names of the data frames (in the 'Table of Contents' ) and edit them. Call the left data frame "Less HS" and the right data frame "Has Masters".

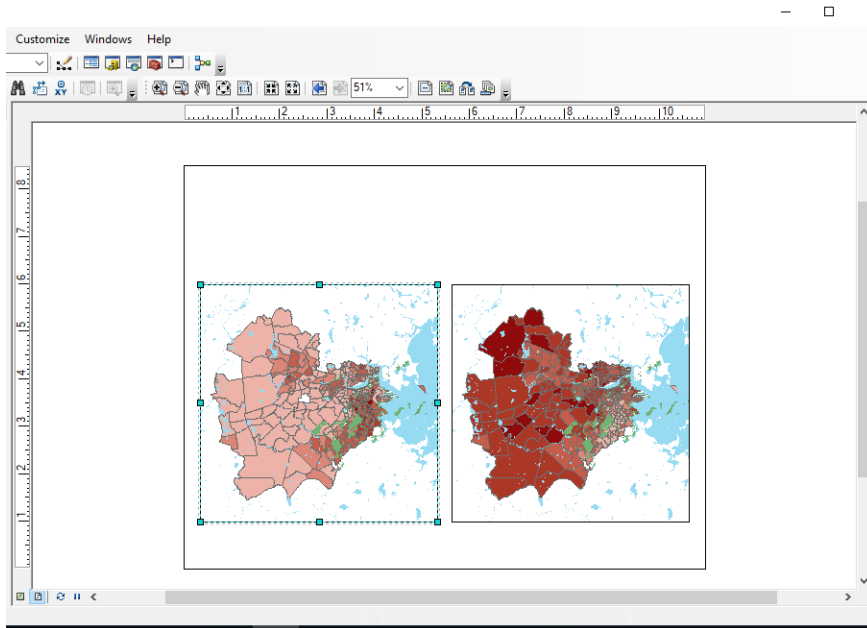
8. We need data in our new data frame. This is easy to do, drag the layers in 'Less HS' to 'Has Masters'. It will create a copy for you. You will likely need to zoom into Boston to see the data clearly. Note, I'm also going to turn off my town boundaries and roads.

At this point, your map will look like the following.





9. The maps both show the same variables. Re-symbolize the right map to be symbolized based on the normalized Master's Degree data we created in Excel. Right click on Watershed\_Tracts\_Edu\_2016 in the Has Masters data frame and go to Properties -> Symbolize. Remember the field containing our data is called PERC\_MAST. Set the colors and breaks to be the same as the other map. Symbolized, your map will look like the following.

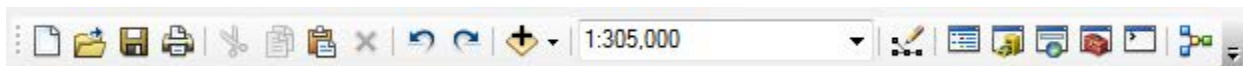


10. When comparing two maps, it is important to compare apples to apples. This means making the scale the same on each map, and the display extent the same for each map. Let's set this up.

a. Right click on 'Less HS' in 'Table of Contents' to activate the 'Less HS' data frame.

b. Set the display extent for 'Less HS' by right-clicking on 'Watershed\_Tracts\_Edu\_2017' and selecting zoom to layer. The map will zoom to the extent of your layer.

c. Set the map scale. The map is not completely centered. At the top of your map document is the map scale control. Change this for 'Less HS' to 1:305,000.

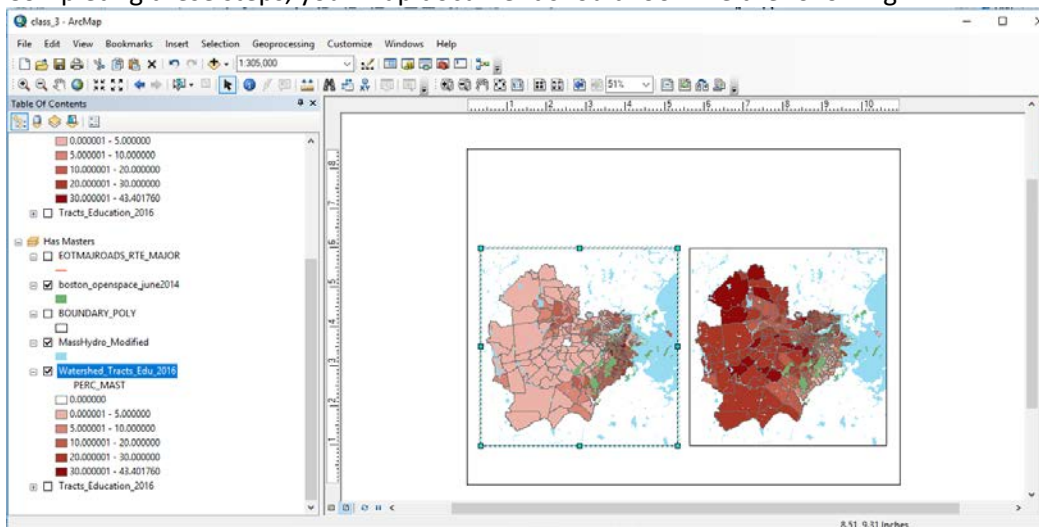


d. Click on 'Has Masters' (in 'Layout View', right frame) to activate the 'Has Masters' data frame.



e. We are going to set the extent of this data frame to match the LESS HS frame. Right click and go to Properties. Click on Data Frame, and set Extent to be Other Data Frame. Here select LESS HS, and set the margin to be 100%.

Completing these steps, your map document should look like the following.



11. Add a Legend. Let's right click on our Watershed\_Tracts\_Edu\_2016 layer, go to Properties > Symbology Under labels, edit text to contain the following breaks:

- 0**
- 0.1-5%**
- 5.01-10%**
- 10.1-20%**
- 20.1-30%**
- More than 30%**

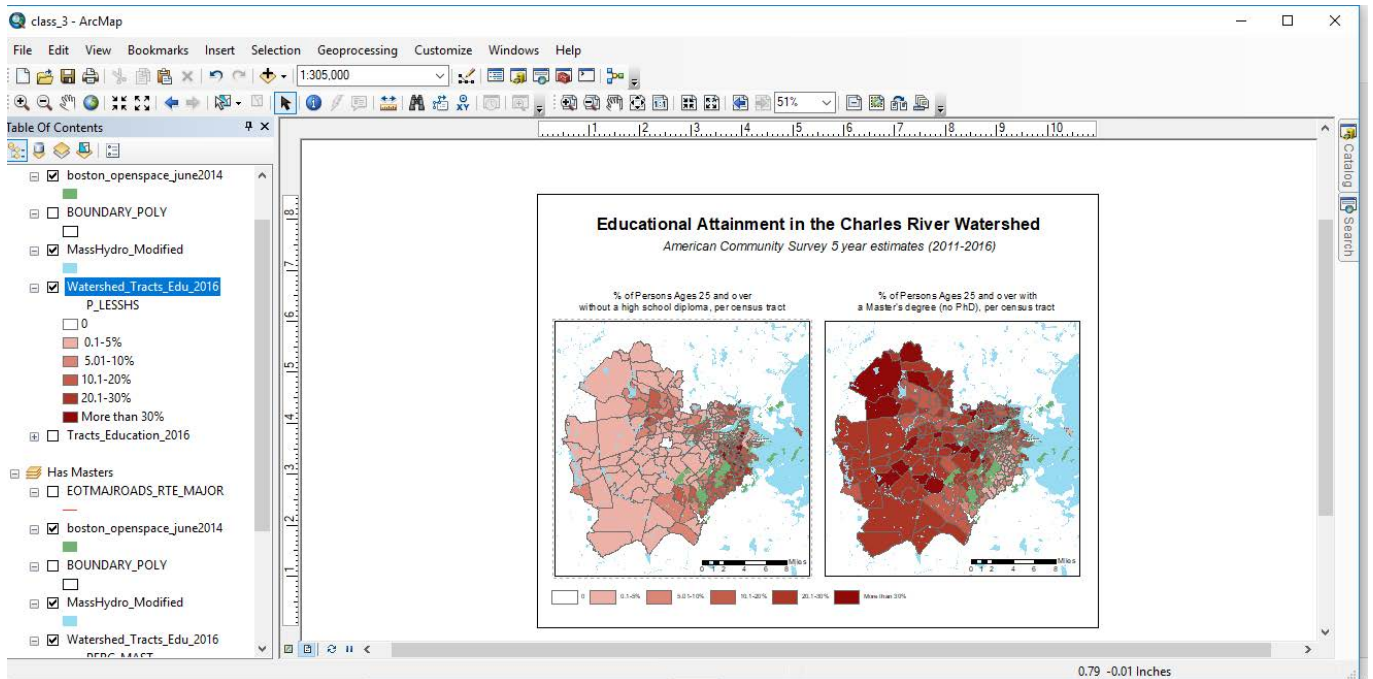
This will allow us to create only one legend for both of our maps. One legend won't always be an option because datasets can be very different, but it does in this circumstance.

Because we used the same scale for each map, we can add one legend that will work for both maps. Go to Insert -> Legend. Symbolize the Legend based upon the Watershed\_Tracts\_Edu\_2017 layer. Using the

legend design skills you have learned in the first couple weeks of class, add the legend in a nice location at the bottom of your map.

*If you had differing scales and legends, you can right click the data frame names and scroll down to activate in order to ensure you are creating a legend for the appropriate data frame.*

12. Add the other map elements to complete your map. Click on the map to activate its respective data frame, then for each, add an informative title, scale bar, and north arrow, and in your layout, put information on date, author, and data source. Use the map design skills you learned in the first two weeks of class. Your final output will vary based on design and preference. My final map looked like the following. Note the differences between the two datasets!



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11.205 Introduction to Spatial Analysis  
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