Lab Exercise #7: Environmental justice analysis using census data

Due: Oct 24, Tuesday

CRP 4080: Introduction to Geographic Information Systems
Fall 2024

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Location: Sibley 305, Barclay Gibbs Jones Computer Lab
Points Possible: 80

Overview of Weekly Exercise:

The lab this week is concerned with utilizing GIS to undertake census level data analysis. In this exercise, we will utilize GIS to explore and document issues of environmental justice in Massachusetts. What is the relationship between race and proximity to locally unwanted land uses? Are certain segments of the population disproportionately impacted when compared with their population distribution statewide?

Introduction

To undertake this analysis, we will need several datasets: 1) Cartographic boundary files (census tract boundaries), 2) Demographic or race data aggregated to census tracts, and 3) point data for locally unwanted land uses (landfills).

Moreover, in order to determine whether the impact is disproportionate to a specific population, we will need some sort of benchmark with which to compare our findings and conduct our analysis. In this case, we will compare our findings to the state population.

To undertake the analysis, we will calculate the percent of the total population living within 1 mile of a landfill that is African American. We will then compare this to the statewide African American population. This comparison is the basis for distributive forms of environmental justice. As our population data is aggregated through enumerated units identified by the Census Bureau, and not according to the distance from landfills, we will have to do that calculation as well.

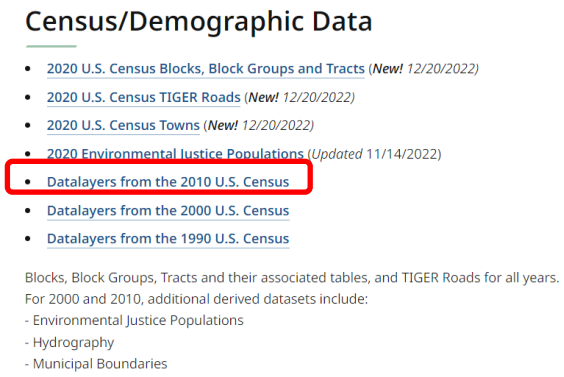
Data

Often state governments or public agencies will compile a range of data sets that are relevant to the state and make this data publicly available through a GIS clearinghouse. These sources are often helpful, as the data has already been formatted accordingly to local projections and cleaned in other ways. However, it poses the additional task of reading and understanding how the data have been changed from their raw format. For this lab, we will utilize data made available by the state of Massachusetts.

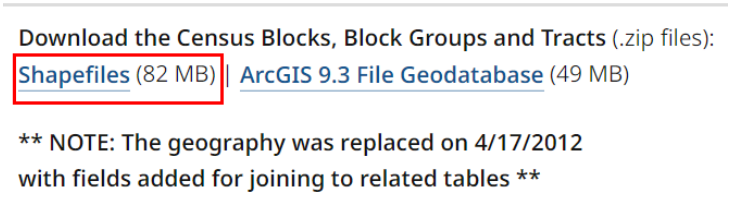
https://www.mass.gov/info-details/massgis-data-layers

Take a look at the available datasets.

1) Scroll down to “Census/Demographic data” in the Table of Contents section of the website
2) Click on “Datalayers from the 2010 US Census.”

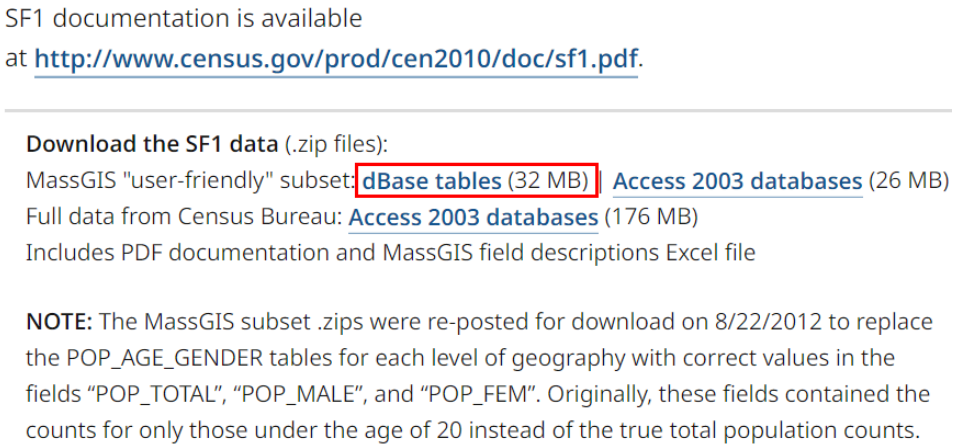


3) Under Table of Content, click Geography – Census Boundary Areas, Download the Census Tracts shapefile, linked under the description of the data set:



Note that some users click a download data link and nothing happens. This is a browser security issue that can be overcome in several ways. Either try a different browser or right-click the download link and use one of the "Save As" options in the dropdown menu. When you unzip the data file, you will note that census blocks, tracts, and block groups are included.

4) Download Summary File (SF1) dataset available on the same page.



5) Unzip this data into the Lab 7 folder you created and take a look. You should see 3 sets of geographies: blocks (B), block groups (BG), and tracts (CT). You should also have a number of .dbf files for each of those geographies (note that there are also xml versions of these). This is the SF1 disaggregated into separate files: HHsize, Pop_race, Hou_own_ren, and so forth. Note that there is an excel file included with the metadata (SF1_2011_MGISfields). Opening this up, you will notice how the individual variables are organized by table.

Now we can begin to work on the data in ArcGIS.

1) Open ArcGIS Pro and start a new project. Add the Census Tract shapefile (CENSUS2010TRACTS_POLY)

Note that they are already projected (State Plane_Massachusetts_Mainland), however, also please note that the map units being used are meters. It is only convention that associates State Plane with feet. If you open the attribute table, note that the column headings have been already formatted for you.

2) Add the appropriate SF1 database containing population and race data (POP_RACE). This will be used for estimating the Black population. **Be sure you are adding tract level attribute information, not blocks or block groups!**
3) Open the attribute/ dbf tables for the census tract and the boundary files to determine the appropriate join fields.
4) Join the SF1 database to the 2010 Census Tracts. Check to make sure the join worked.
5) Export your joined layer as a new shapefile!

Now we have created a file with the data from the SF1 table to the associated geographies. We can turn our attention to the waste disposal sites. Our task is to calculate the proportion of Black people living within a 1-mile buffer of a solid waste disposal site. Because our race-population data is aggregated to Census tracts, we have to weight the population within the buffer based on the area within the buffer. In other words, if ½ of the area of a Census tract is within a buffer, we will attribute ½ of the Black population to that buffer.

1) Download the point level solid waste disposal data https://www.mass.gov/info-details/massgis-data-massdep-solid-waste-diversion-and-disposal#downloads-

There are a number of datasets included in the zip file, but the one we are interested in is the Solid Waste Land Disposal point data layer (**SW_LD_PT),** compiled by the Massachusetts Department of Environmental Protection (DEP) to track the locations of land disposal of solid waste.

2) Add the Solid Waste Land Disposal data as a point layer (**SW_LD_PT)** in ArcGIS**.** Open the attribute table and take a look at the type of variables included.

3) Buffer the distance to 1 mile:
   a) Open the Buffer tool.

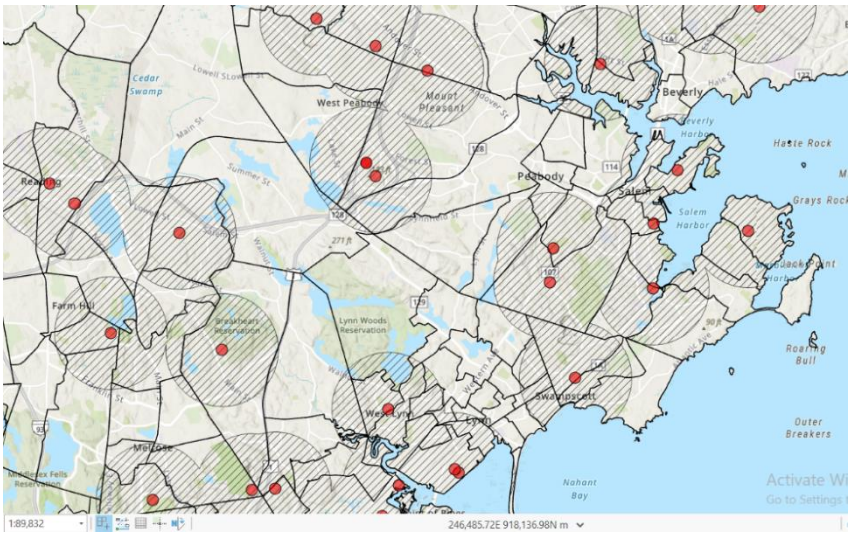


Figure 1: Setting a 1-mile buffer to the Landfill layer

b) Set the input to the solid waste point layer.
c) Specify the name and output **within the project geodatabase.**
d) Set the buffer distance to 1 mile.
e) Select 'Dissolve all output features into a single feature' as the Dissolve type.
f) Click Run.

4) Clip the census tracts to the dissolved buffer layer.
5) Set the output location and name.
6) Click Run.

You will recall from the geoprocessing lab that the clip function does not affect the original attribute information in some cases. Verify that you have an accurate "area" for each feature.

7) Open the attribute table of the clipped buffered layer.

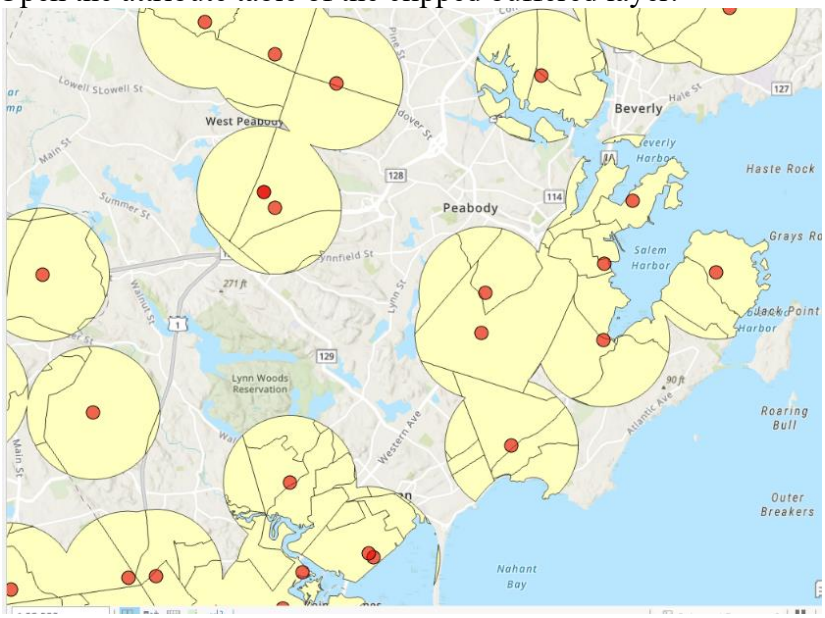


Figure 2: Clip the census tracts to the dissolved buffer layer

Notice the 'Shape_Area' field at the end of the table. This is the newly calculated area (remember: it was calculated in square meters!). As a point of comparison, zoom in on a tract and compare the 'Shape_Area' for both the clipped layer as well as the original census tract, you will notice that they are different. However, notice that both these layers include a field titled 'AREA_SQFT' and 'AREA_ACRES'). These are the original attributes associated with the census tract (not calculated by Arc).

Stop for a moment to reflect on what we have done. If you select one of your clipped areas, you will notice that you are selecting a tract that may include parts of several each buffered areas (see figure 2 for an example), meaning there is one multi-polygon representing the tract area. We also have the

area of the original tract ('AREA_SQFT' and 'AREA_ACRES'), and the area of the multi-polygon buffers ("Shape_Area" using square meters)

We will use this relative area ratio to apportion the distribution of the Black and Hispanic populations accordingly, based on the relative proportion of each census tract that lies within the buffered area to the total area of the Census tract. To do this, you will need to convert square meters of the buffered area to square feet.

8) Create a new numeric column in the buffered and clipped layer. Name it 'Popblk_clip' or something similar, set the type to Double and Number format to Numeric (this time, no decimals or significant digits). Click Save.
9) Populate the new field/ column with the results of a formula that multiplies the total black population by the ratio of area within the buffer, converted to the correct units, to the original Tract area (Question 1 below). Note: You will need a multiplier to convert square meters to square feet. Use the 'POP_BLACK' variable for the African American totals.

Note: *for all the numbers you will answer below, **DO NOT** utilize more than 2 decimal places.*

Question 1: What formula did you use to apportion? (5 points).

You should now have the total African American population (count) living within 1 mile of landfills.

Question 2: What percent of population living within 1 mile of landfills is African American? (10 points). **Hint:** To calculate this, you will first need to create a new field to calculate the total population living within the 1 mile of landfills (use the same method as above, but using POP2010). You can then quickly get summary statistics by right clicking on a column heading in the table.

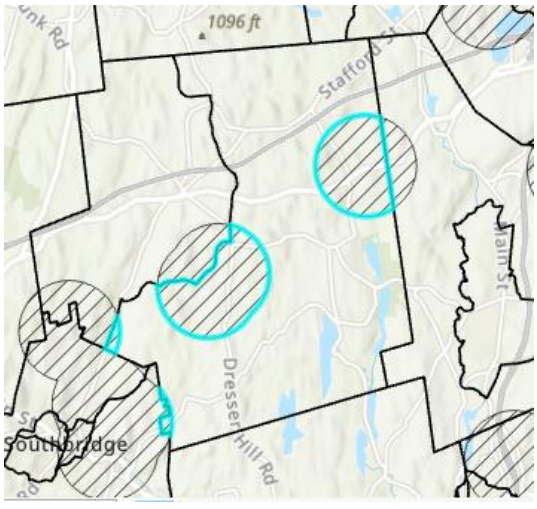


Figure 3. The selected area here is one multipolygon for one Census tract

Question 3: How does this percentage compare to the statewide percent African American population? (10 points). **Hint:** use the original census tracts layer (with 1472 features) rather than the clipped layer to calculate total population statewide.

Question 4: What are your conclusions concerning the spatial distribution of African Americans across Massachusetts relative to the population of African Americans living within 1 mile of landfills? (10 points)

Question 5: What are some of the weaknesses of this approach, particularly in terms of accuracy? (5 points) How could you undertake a more accurate spatial analysis? (5 points)

LAB 7 DELIVERABLES

Questions 1-5. (45 points)

Homework Part 1 (10 points): Now compare and contrast the African American population living within 1 mile of landfills for the Boston metropolitan area. In defining the metropolitan Boston spatial extent, utilize the boundary of the Metropolitan Are Planning Council (MAPC, statewide Regional Planning Agencies available https://www.mass.gov/info-details/massgis-data-regional-planning-agencies). Download the data and select the appropriate feature.

- Calculate the percent of the total population that is African American for the Boston Metro area (4 points). *Note that:* to identify those tracts within the Boston Metropolitan Are Planning Council, please select all tracts that 'have their center in' the boundary. *Do not simply clip* (anyone know why?) Arc will calculate a new Shape_Area variable for you, but you should be able to reuse your field calculations from above.
- Calculate the percent of population living within 1 mile of landfills that is African American in the Boston metropolitan area. Do African Americans in Boston tend to be disproportionately concentrated around landfills compared with their metro-wide population? (4 points). Again, you should be able to reuse your field calculations from above.
- Compare this with percent of population living within 1 mile of landfills that is African American statewide (2 points)

Homework Part 2 (25 points): Now calculate the same set of statistics for the Hispanic population (use the variable 'Hisp'):

- statewide Hispanic population (5 points)
- percent of population living within 1 mile of landfills that is Hispanic statewide (5 points)
- Percent of Metro Boston area population that is Hispanic (5 points).
- percent of population living within 1 mile of landfills in the metropolitan Boston area that is Hispanic (5 points).
- Analyze and interpret these statistics (5points).