Geocoding Applications with Rstudio

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Presentation Objectives

- Understand the applications of Rstudio for geocoding in IR
- Demonstrate utilization of Rstudio geocoding packages / processes
- Iterate on several use cases for geocoding with Rstudio

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Need for Geocoding

- Need to inform stakeholders about their targeted audience such that they may adopt strategies better suited to their service population.

- Need for data driven and data informed strategies at institutions of higher education.

- Census geocoded can substitute for instances wherein institutional data is missing or lacking.

What is Rstudio?

- Rstudio is an Integrated development environment (IDE) providing users with an environment for writing and executing code.

- It is available with a GNU General public license meaning it is open source and available to users at no cost.

- Rstudio contains a library of ‘packages’ – sets of code and documentation which may be accessed from a centralized depository.

- As of Feb. 2023, there are at least 19,254 of such packages available for public use.

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Rstudio Geocoding Packages

- TidyVerse: Contains sets of R packages that are standard to most Rstudio functions.

- Tigris: Load Census TIGER/Line Shapefiles. Connects with US census API facilitating upload of shp files to your Rstudio IDE.

- Tidycensus: Connects with US census API to allow upload of census data files to your Rstudio IDE (IE: American Community Survey).

- Sf: supports a standardized way of encoding spatial vector data. Allows for conversion and manipulation of shp files.

- Tidygeocoder: allows for a the stepwise execution of queries made to numerous geocoding API services at once.

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TidyGeocode API

- The TidyGeocode Package is a tool used in Rstudio to geocode student addresses and extract lat and long coordinates.
- To the right are a set of geocoding APIs that can be queried using the Tidygeocode package.
- Tidygeocode has a ‘cascade’ feature that allows users to assign prioritization to certain API calls over others in an iterative sequence
- For this analysis, we are only using the two free API calls: the census batch query api and the Nominatim API

Details

The API documentation for each service is linked to below:

- Nominatim
- US Census
- ArcGIS
- Geocodio
- Location IQ
- Google
- OpenCage
- Mapbox
- HERE
- TomTom
- MapQuest
- Bing

SF Package

- The SF package supports the standardization of spatial vector data by representing geographic information as a dataframe.

- It interfaces with the GEOS C/C++ library used in Geographic information systems (GIS) software allowing transformations on projected geographic points.

- Additionally, it interfaces with PROJ, a coordinate transformation library that allows for performing conversions between cartographic projections.

- The combination of these two interfacing capacities (with GEOS and PROJ) facilitates the transformation of otherwise uni-dimensional data frames into multi-dimensional datafiles across spatial interfaces.

- Together with Tidygeocode and other packages – you can merge census data into your student records.

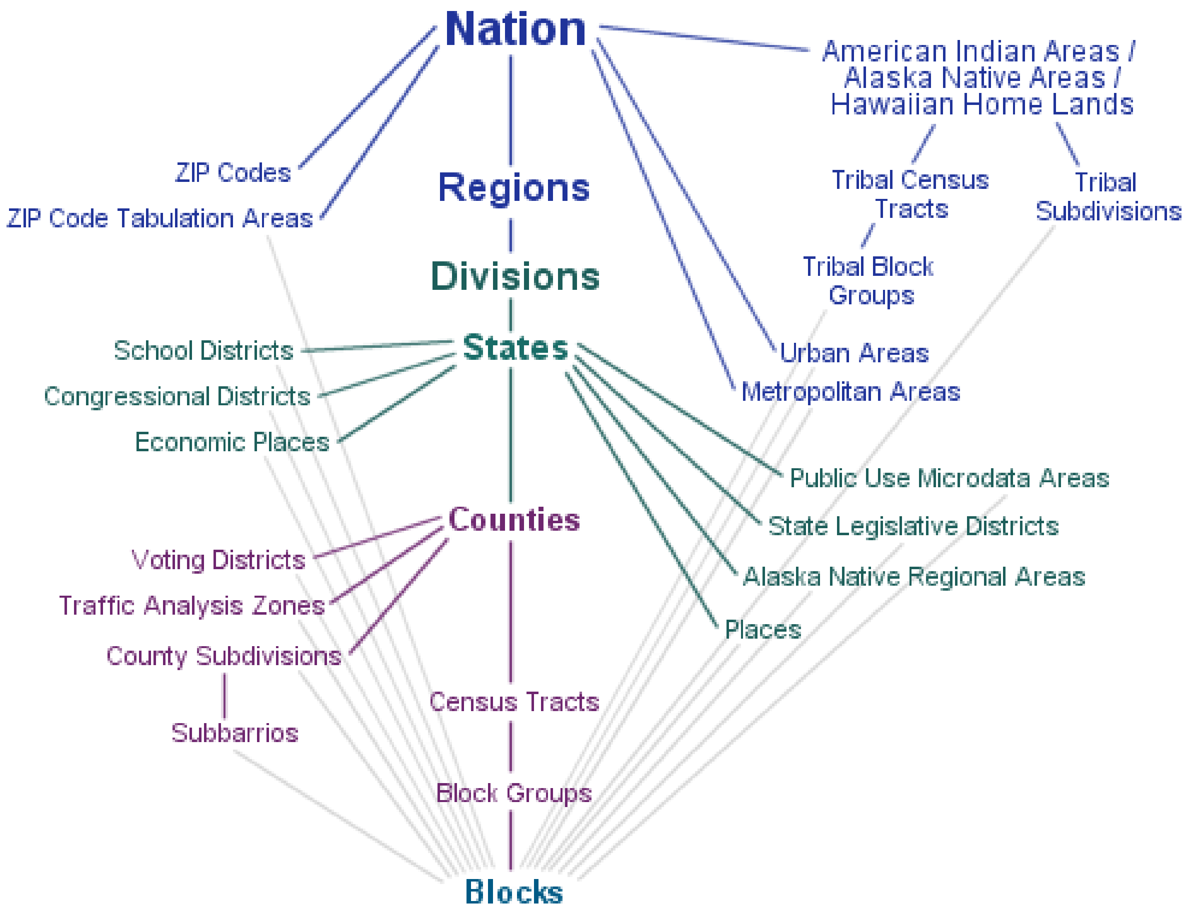
Census Geographies

- Census Geographies are the unit of analysis for the US census.

- Some census data instruments are only available at certain geographies

    - (IE S1701 poverty data is available at census tract level but not the block group level)

- The most granular census geography for which data may be matched and merged to student datafiles is the census block group level



Putting Rstudio to work: I

- Step 1 – install your packages.

```
#step1b - adding stage A packages
library("tidyverse")
library('readxl')
library("tidygeocoder")

#step1c - adding stage B packages
library(tidycensus)
library(tigris)
library(sf)
```

Putting Rstudio to work: II

- Step 2 – Initialize the geocoding function. Here we created the function 'geocode_chunked'. It breaks large address data frames into smaller ones and iterates a stepwise geocoding procedure on them. This was done for two reasons:

```
#this code executes a stepwise process for geocoding addresses by breaki
geocode_chunked <- function(df, chunk_size){
  chunk_count <- ceiling(nrow(df) / chunk_size)
  results_list <- list()

  for (i in 1:chunk_count) {
    start_index <- (i - 1) * chunk_size + 1
    end_index <- min(i * chunk_size, nrow(df))
    df_chunk <- df[start_index:end_index, ]

    df_chunk <- df_chunk %>%
      geocode_combine(
        queries = list(list(method= 'census'), list(method= 'osm')),
        global_params = list(address='ADDRESS'), cascade = TRUE
      )

    results_list[[i]] <- df_chunk
  }

  newdf <- bind_rows(results_list)
```

- Reason one: The census geocoding API only works with files less than 10,000 rows long. Breaking the dataframe into chunks allows users to geocode in one batch.

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Putting Rstudio to work: III

- Step 2 – Initialize the geocoding function. Here we created the function 'geocode_chunked'. It breaks large address data frames into smaller ones and iterates a stepwise geocoding procedure on them. This was done for two reasons:

```
Passing 20 addresses to the US Census batch geocoder
Query completed in: 0.7 seconds
Passing 6 addresses to the Nominatim single address geocoder
[==============================================================================]


Passing 18 addresses to the US Census batch geocoder
Query completed in: 0.6 seconds
Passing 6 addresses to the Nominatim single address geocoder
[==============================================================================]


Passing 12 addresses to the US Census batch geocoder
Query completed in: 0.4 seconds
Passing 3 addresses to the Nominatim single address geocoder
[==============================================================================]
```

- Reason Two: Large dataframes take a long time to geocode. Breaking the frames into chunks allow you to see that the geocoding process is working

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Putting Rstudio to work: IV

- Step 3 – Review the results. When the geocoding procedure is completed, it will produce at lat and long coordinate set in two respective columns. It will also generate a column indicating which geocoding API was used to produce a positive result. If no results were located then the lat, long, and query column will be NULL.

	INST_NAME	INST_IPEDS_CODE	DIGIT_ANON	ADDRESS	lat	long	query
34	Sul Ross State University	228501			30.35556	-103.67845	census
35	Sul Ross State University	228501			30.10718	-98.42077	census
36	Sul Ross State University	228501			30.35313	-103.61429	census
37	Sul Ross State University	228501			30.34860	-103.68219	census
38	Sul Ross State University	228501			31.76151	-106.30815	census
39	Sul Ross State University	228501			29.79140	-95.13488	census
40	Sul Ross State University	228501			29.75774	-99.02438	census
41	Sul Ross State University	228501			30.50989	-97.78177	census
42	Sul Ross State University	228501			29.56478	-104.36340	census
43	Sul Ross State University	228501			31.82239	-106.46536	census

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Putting Rstudio to work: IV

- Step 4 – Review the results. When the geocoding procedure is completed, it will produce at lat and long coordinate set in two respective columns. It will also generate a column indicating which geocoding API was used to produce a positive result. If no results were located then the lat, long, and query column will be NULL.

	INST_NAME	INST_IPEDS_CODE	DIGIT_ANON	ADDRESS	lat	long	query
34	Sul Ross State University	228501			30.35556	-103.67845	census
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42	Sul Ross State University	228501			29.56478	-104.36340	census
43	Sul Ross State University	228501			31.82239	-106.46536	census

Putting Rstudio to work: V

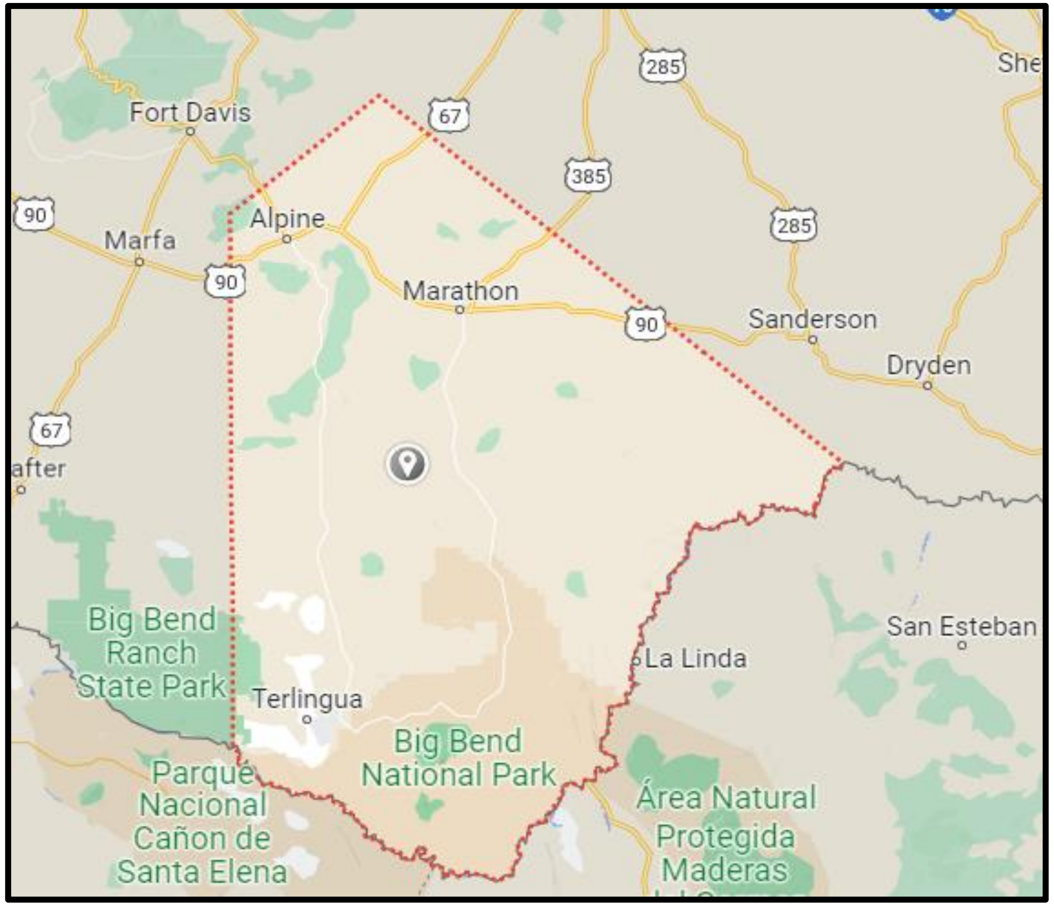
- Step 5 – Review data and make corrections. The code below identifies certain strings of letters in the Address dataframe and flags them for removal or separate analysis.

```
# this function creates a new column that is a flag identifying th
detect_address_types <- function(df, col_name) {
  df$address_type <- ""
  for (i in 1:nrow(df)) {
    row_text <- tolower(df[i, col_name])
    if (grepl("\\bpo box\\b", row_text)) {
      df[i, "address_type"] <- "PO BOX"
    } else if (grepl("\\bste\\b", row_text)) {
      df[i, "address_type"] <- "STE"
    } else if (grepl("\\bapt\\b", row_text)) {
      df[i, "address_type"] <- "APT"
    } else if (grepl("\\bunit\\b", row_text)) {
      df[i, "address_type"] <- "UNIT"
    } else if (grepl("\\bapartment\\b", row_text)) {
      df[i, "address_type"] <- "APARTMENT"
    } else if (grepl("\\bdepartment\\b", row_text)) {
      df[i, "address_type"] <- "DEPARTMENT"
    } else if (grepl("\\bdept\\b", row_text)) {
      df[i, "address_type"] <- "DEPT"
    }
  }
  return(df)
}


IPEDS_ID_2015 <-detect_address_types(IPEDS_ID_2015,"ADDRESS")
```

Putting Rstudio to work: VI

- Use Tidycensus and Tigris to query and pull census data files and census shp files into your Rstudio environment. Merge census data using sf functions:



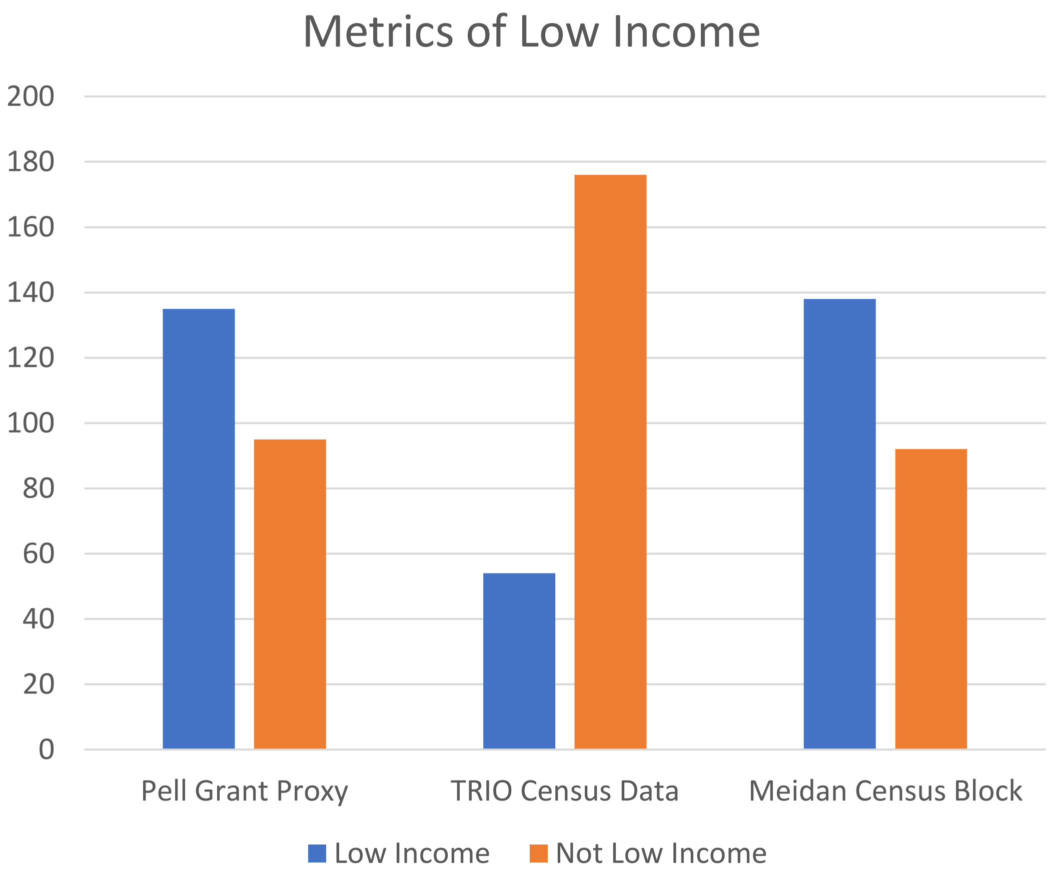
- st_transform – function in sf packaged used to convert a dataframe into a shp file. Also used to set CRS

- st_join – function in sf package used to join two separate shape file

- IE: If point X is contained within shape Y, execute merge

Low Income Proxy

- Situation: Pell grant recipient status is an imperfect proxy for low income status.

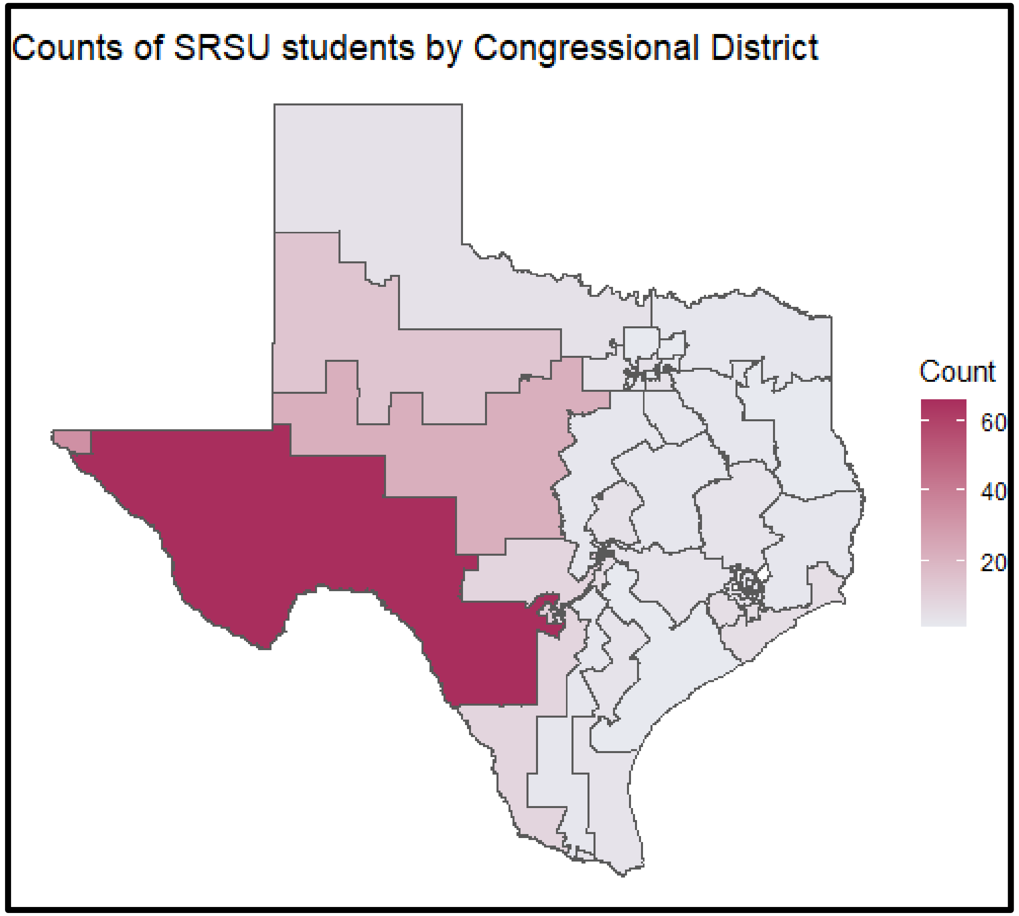


- Solution: You use geocoding procedures to create two separate alternatives to Pell Grant proxy

- The graph here shows a calculated metric of TRIO federal poverty status using B19013_001 (median house hold income) and B25010_001 (average household size)

The Irregular Data request

- Situation: An external data requester asks for a visualization of how many students reside in a given congressional district:



Congressional District	count
Congressional District 23	66
Congressional District 16	33
Congressional District 11	22
Congressional District 19	14
Congressional District 20	10
Congressional District 21	8
Congressional District 28	8
Other-In-State	73
Out-Of-State	6

Recruitment and Marketing

- Situation: Your institution's recruitment dept is collecting limited contact information from prospects who inquire about your institution's programs.

2000 Clusters

Cluster Numbers	Number of Block Groups	Median HH Income	% HH in Poverty	Unemploy-ment Rate	% Hispanic	% White	% Black	% Asi
1	502	$ 32,680.08	14.5%	8.1%	2.9%	94.2%	0.3%	0.7%
2	189	$ 27,998.97	27.0%	13.8%	17.6%	72.8%	1.9%	1.6%
3	474	$ 30,950.98	12.9%	6.5%	2.4%	91.5%	2.1%	2.5%
4	551	$ 44,489.93	7.9%	5.1%	2.3%	94.5%	0.6%	1.4%
5	695	$ 47,723.27	7.5%	5.1%	3.1%	88.1%	3.0%	4.4%
6	391	$ 30,567.18	20.7%	8.9%	4.0%	87.0%	3.6%	3.2%
7	69	$ 25,059.80	33.2%	15.4%	56.3%	38.0%	1.7%	0.7%
8	26	$ 25,762.40	33.7%	18.5%	3.5%	23.4%	0.1%	0.6%
9	73	$ 35,703.35	17.0%	7.9%	3.7%	37.7%	15.9%	40.6
10	66	$ 23,923.16	35.2%	14.3%	4.2%	24.5%	50.1%	18.7
11	651	$ 52,794.20	5.2%	3.9%	2.2%	93.1%	1.1%	2.7%
12	337	$ 78,325.60	2.8%	3.1%	1.7%	92.2%	0.8%	4.8%
13	453	$ 44,343.66	9.1%	4.1%	2.6%	85.2%	4.7%	6.5%
14	118	$ 23,528.77	26.4%	5.8%	4.0%	85.4%	3.5%	4.8%
15	25	$ 18,041.45	43.0%	7.5%	3.0%	85.5%	1.8%	9.1%

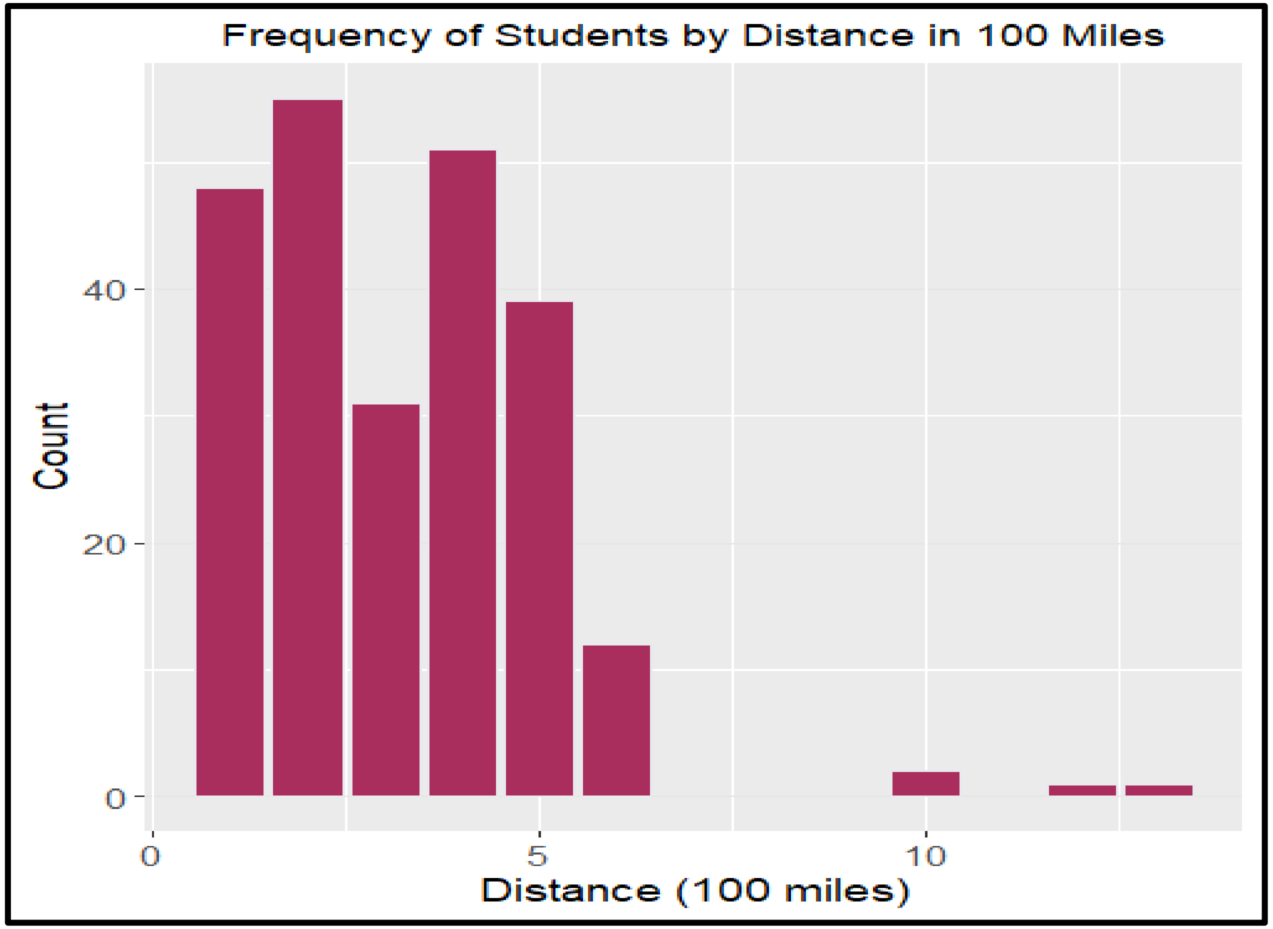
- You can geocode additional contextual information into your analysis and bin students into different groups based on shared census geography traits.

- Using this information, your recruiting or marketing dept may devise alternate marketing methodologies to different groups of students.

- Crosta, P. M., Leinbach, T., & Jenkins, D. (2006). Using Census Data to Classify Community College Students by Socioeconomic Status and Community Characteristics. CCRC Research Tools. Number 1. *Community College Research Center, Columbia University*.

Statistical Analyses

- Situation: Your department wants to conduct an 'At Risk' student analysis but you are missing the variable 'distance from university'.



Distance from Uni in 100 miles	Count
1	48
2	55
3	31
4	51
5	39
6	12
10	2
12	1
13	1

Alumni Affairs

- Situation: Your alumni department wants a metric of upward mobility.

- If your institution has address data from when a student first enrolled vs where they are X years later, you can contrast the economic characteristics of a given census geography against each other.
- Solution: If a student resided in a low income census geography and now resides in a higher income census geography, you may assume that upward mobility took place.

Anything You want

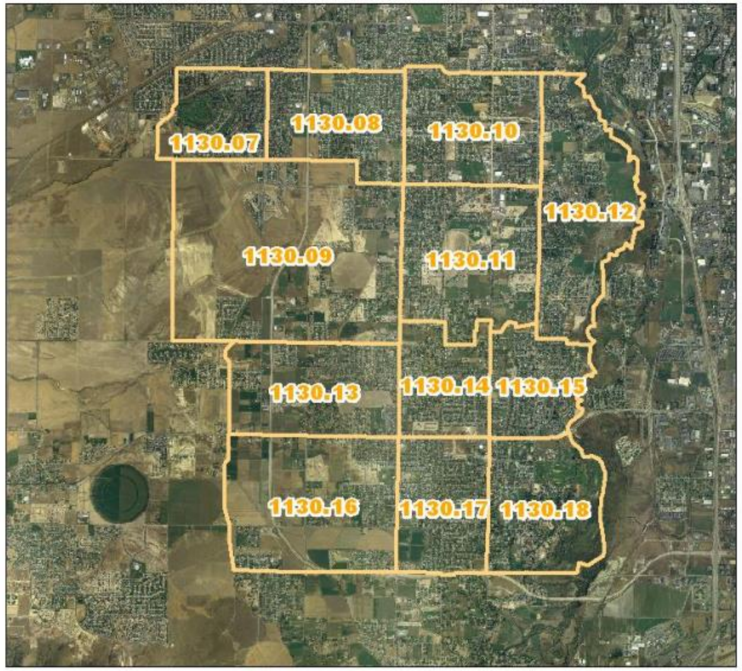
- “The limits of my [shape files] mark the limits of my world.” – ***Not*** Ludwig Wittgenstein, Tractatus logigo-philosphicus, 1922.

- FEMA flood maps: https://coast.noaa.gov/digitalcoast/data/flood.html
- EPA Super Fund sites: https://www.epa.gov/superfund/search-superfund-sites-where-you-live
- Criminal record proximity: https://www.hcdistrictclerk.com/Common/e-services/PublicDatasets.aspx *(data accessibility varies by county in TX)*
- Underserved community identification: https://www.ffiec.gov/cra/distressed.htm
- State Park boundaries: https://tpwd.texas.gov/gis/
- Others: https://catalog.data.gov/dataset/?tags=texas

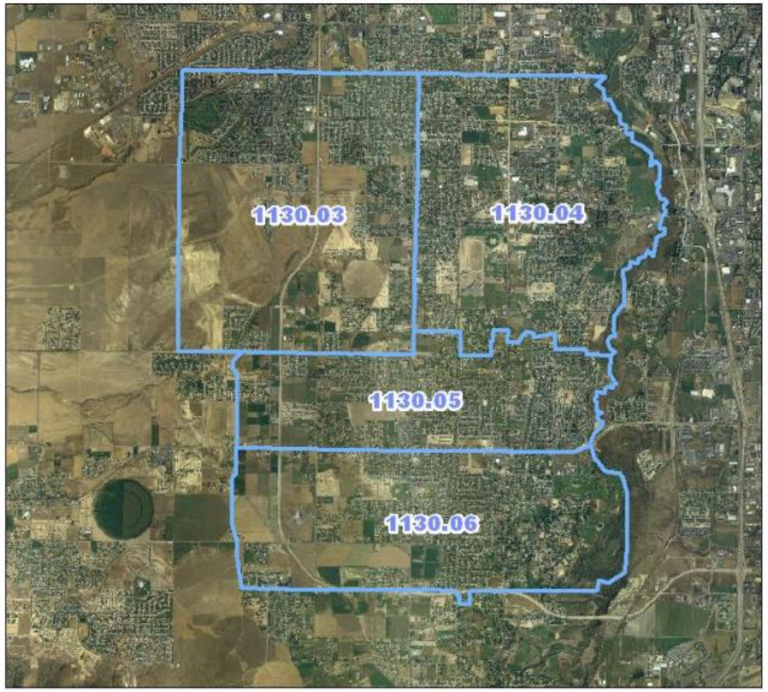
Additional Considerations

- Census Geographies may change with each instance of a census such that a geography bearing ID ‘XYZ’ from 2010 will not have the same shape in 2020.
- Solution: the census maintains a crosswalk of census files across census periods: https://www.census.gov/geographies/reference-files/time-series/geo/relationship-files.html

2000 Census Tracts



1990 Census Tracts



Additional Considerations

- **Centroids:** centroids are the centre point of a shp file object.

- If you have a PO box address, you cannot use the census block group unit of analysis; however, you can calculate the center point of a city and merge census data at the municipal unit of analysis

- This allows you to include students in your analysis that may otherwise be excluded.