Tidycensus

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Learning Resources

This workshop was developed using the following resources:

- Kyle Walker - Census Data Workshop - University of Michigan 2022
- Walker, K. (2023). *Analyzing US census data: Methods, maps, and models in R*. CRC Press. https://doi.org/10.1201/9780203711415

Requirements

Install Packages

```
install.packages("tidycensus")
install.packages("tidyverse")
install.packages("sf")
install.packages("tigris")
```

Load Packages

```
library(tidycensus)
library(tidyverse)
library(sf)
library(tigris)
```

Set your working directory

```
setwd()
```

Set your API key

```
census_api_key("", install = TRUE, overwrite = TRUE)
```

About Tidycensus

tidycensus is an R package that allows users to interface with a select number of the US Census Bureau's data APIs and return tidyverse-ready data frames, optionally with simple feature geometry included.

- tidycensus documentation

Decennial Census Data

This is the demographic census of the United States which takes place once every 10 years as mandated by Article I, Section 2 of the Constitution. The Decennial Census determines the number of House of Representative seats assigned to States as well the redistricting of state legislative districts.

Function: get_decennial()

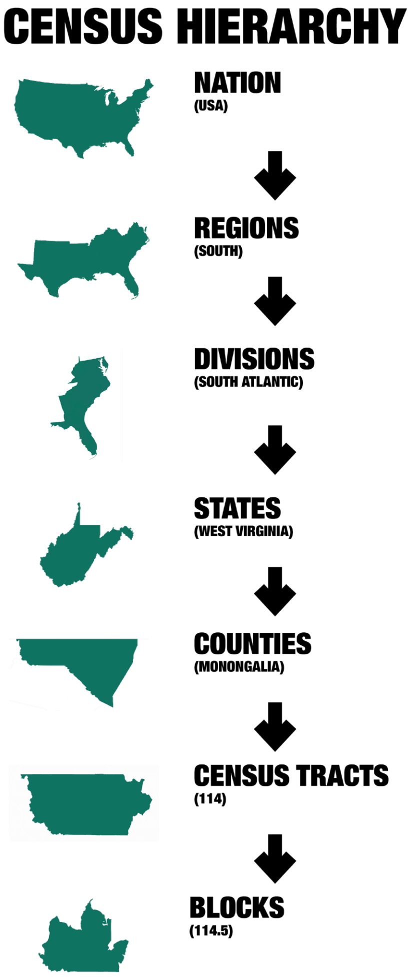
the get_decennial() function allow us to obtain data and feature geometry for the decennial US Census

data sets available:

- 1990
- 2000
- 2010
- 2020

```
# data on the hispanic population by state

hispanic_by_state <- get_decennial(
  geography = "state",
  variables = "P2_002N",
  year = 2020)
hispanic_by_state
```



Census Regions

Census Regions in Tidycensus

geography in tidycensus; If state or county is in bold face; you are required to supply a state and/or county for the given geography

Geography	Definition	Available by	Available in
“us”	United States		get_acs ( ) , get_decennial( )
“region”	Census region		get_acs ( ) , get_decennial( )
“division”	Census division		get_acs ( ) , get_decennial( )
“state”	State or equivalent	state	get_acs ( ) , get_decennial( )
“county”	County or equivalent	state, county	get_acs ( ) , get_decennial( )
“county subdivision”	County subdivision	state, county	get_acs ( ) , get_decennial( )
“tract”	Census tract	state, county	get_acs ( ) , get_decennial( )
“block group”	Census block group	state, county	get_acs ( ) , get_decennial( )
“block”	Census block	state, county	get_decennial( )
“place”	Census designated place	state	get_acs ( ) , get_decennial( )
“alaska native regional corporation”	Alaska native regional corporation	state	get_acs ( ) , get_decennial( )
“american indian area/ alaska native area / hawaiian home land”	Federal and state-recognized American Indian reservations and Hawaiian home lands	state	get_acs ( ) , get_decennial( )

Call decennial data from a region

```
wv_hispanic <- get_decennial(
  geography = "county",
  variables = "P2_002N",
  state = "WV",
  year = 2020
)

wv_hispanic
```

American Community Survey (ACS) Data

The ACS is a survey issued by the US Census Bureau that covers one (1) and five (5) year estimates. This survey provides detailed population and housing information about the United States and has variable not covered in the Decennial Cenus.

Function: get_acs()

the get_acs() function allows us to obtain data and feature geometry for the American Community Survey

- The get_acs() function in tidycensus allows you to access ACS data from 2005 through 2020.
- Other required arguments: geography, for the level of aggregation, and variables, for one or more ACS variables
- get_acs() defaults to the 5-year ACS with the argument survey = “acs5”; survey = “acs1” is used for 1-year ACS data

```
wv_hispanic_acs <- get_acs(
  geography = "county",
  variables = "B03001_001",
  state = "WV",
  year = 2020,
  survey = "acs5"
)

wv_hispanic_acs
```

Variables in ACS and Decennial Census

We can view what variables are available using the load_variables() function. We can open those variables in a new tab using the view() function. That tab will allow us to search the variables.

```
vars20 <- load_variables(2020, "pl")

vars10 <- load_variables(2010, "pl" )

acs_vars20 <- load_variables(2020, "acs5")

view(acs_vars20)
```

Variables and Tables

call data from full tables versus individual variables

Table Codes in Decennial Census

- Table Codes in ACS

```
wv_quarters <- get_decennial(
  geography = "state",
  table = "P5",
  year = 2020,
  output = "wide"
)

wv_quarters
```

Tidy and Wide outputs

Tidy format

By default tidycensus outputs that data in a tidy format where variables are stacked by row

```
group_quarters <- get_decennial(
  geography = "state",
  table = "P5",
  year = 2020
)
group_quarters
```

Wide format

Setting data as “wide” - one row per geographic unite and one column per variables

```
group_quarters_wide <- get_decennial(
  geography = "state",
  table = "P5",
  year = 2020,
  output = "wide"
)
group_quarters_wide
```

Renaming Census Variables

Vector

call data with multiple variables using vectors

```
vacancies_wide <- get_decennial(
  geography = "county",
  state = "WV",
  variables = c(vacant_households = "H1_003N",
                total_households = "H1_001N"),
  year = 2020,
  output = "wide"
)
vacancies_wide
```

Objects

create a object containing vector of combined variables

```
race_vars <- c(
  Hispanic = "P2_002N",
  White = "P2_005N",
  Black = "P2_006N",
  Native = "P2_007N",
  Asian = "P2_008N",
  HIPI = "P2_009N"
)
```

call data with multiple variables using objects

```
wv_race <- get_decennial(
  geography = "block",
  state = "WV",
  variables = race_vars,
  year = 2020,
  output = "wide"
)

wv_race
```

Tidyverse

the tidyverse package provides functions that allows for data cleaning, data manipulation, and data visualization.

note: tidyverse works best with tidy format over wide format

Function: Filter, Arrange, and Select

the filter() function allows us to filter out observations in a variable, based on criteria that we establish.

the arrange() function allows us to sort observations in a variable, based on criteria that we establish

the select() function allows us to remove variables from a data frame

```
# example: using filter and arrange functions to view largest and smallest counties in
IL

# get the data set

il_population <- get_decennial(
  geography = "county",
  variables = (total_population = "P1_001N"),
  year = 2020,
  state = "IL"
)
il_population

# arrange by smallest - total population

arrange(il_population, value)

# arrange by largest - total population

arrange(il_population, desc(value))

# find counties with population less than 7000 and show only the county name and popula
tion total

below10k <- il_population %>%
  filter(value < 10000) %>%
  select(NAME, value) %>%
  arrange(desc(value))
below10k
```

Summary variables

- Many decennial Census and ACS variables are organized in tables in which the first variable represents a *summary variable*, or denominator for the others
- The parameter summary_var can be used to generate a new column in long-form data for a requested denominator, which works well for normalizing estimates

```
wv_race <- get_decennial(
  geography = "county",
  state = "WV",
  variables = race_vars,
  summary_var = "P2_001N",
  year = 2020
)
arrange(wv_race, NAME)
```

Function: Mutate

the mutate() function allows you to create new variables based of of existing observations in your data frame

```
#using mutate and select to get percentages

wv_race_percent <- wv_race %>%
  mutate(percent = round(100* (value/summary_value), digits = 2)) %>%
  select(NAME, variable, percent)


arrange(wv_race_percent, NAME)
```

```
wv_race_percent
```

Function: Group By and Summarise

the group_by() and summarise() functions allow us to group observations in a categorical variable and get descriptive statistics of these groups.

```
# get mean percent of Monongalia and Preston County races

mon_race_by_group <- wv_race_percent %>%
  filter(NAME == "Monongalia County, West Virginia" | NAME == "Preston County, West Vir
ginia") %>%
  group_by(variable) %>%
  summarise(mean_pct = mean(percent))
mon_race_by_group
```

Function: Join and Rename

the join() function allows us to join two data frames together based on a comparable variable.

the rename() function allows us to rename variables.

```
# comparing 2010 and 2020 census data using the join() function

#view 2010 variables

vars10 <- load_variables(2010, "pl")
view(vars10)

# get 2010 county population statistics

county_pop_10 <- get_decennial(
  geography = "county",
  variables = "P001001",
  state = "WV",
  year = 2010
)
county_pop_10

#clean 2010 data

county_pop_10_clean <- county_pop_10 %>%
  select(GEOID, value10 = value)

# clean 2020 data

county_pop_20 <- get_decennial(
  geography = "county",
  variables = "P1_001N",
  state = "WV",
  year = 2020
) %>%
  select(GEOID, NAME, value20 = value)
```

```
# joining the 2010 and 2020 data

county_joined <- county_pop_20 %>%
  left_join(county_pop_10_clean, by = "GEOID") %>%
  rename("County" = NAME, "2020" = value20, "2010" = value10) %>%
  select(-GEOID)

county_joined

summary(county_joined)
```

NA Test

county and boundary names can change over time. check to see if there is any missing data

```
county_na_check <- which(is.na(county_joined))
county_na_check
```

Data Visualization

we can use the ggplot2 package in Tidyverse to plot data

```
# race by county in West Virginia

wv_race_wide <- get_decennial(
  geography = "county",
  state = "WV",
  variables = race_vars,
  summary_var = "P2_001N",
  year = 2020,
  output = "wide"
) %>% mutate(percent_white = 100 * (White / summary_value),
             percent_black = 100 * (Black / summary_value))

wv_race_wide
```

Histogram

We can visualize the distribution of a variable using the geom_histogram() function.

```
wv.hist <- ggplot(wv_race_wide, aes(percent_black))

wv.hist + geom_histogram(bins = 10)
```

Scatterplot

We can visualize the distributions of two quantitative variables using the **geom_point() function and we can find the trend lines using the **geom_smooth() function

```
options(scipen = 999)
```

```
wv.scatter <- ggplot(wv_race_wide, aes(x=summary_value, y = percent_black))

wv.scatter + geom_point() +
  geom_smooth(method = "lm")

#Changing a scale from linear to logarithmic can help with exploratory visualization wh
en data is heavily skewed due to baseline variance

wv.scatter + geom_point() +
   scale_x_log10() +
  geom_smooth(method = "lm")
```

Bar graph

We can visualize the number of cases in variables using the geom_col() function.

```
# get the data from ACS

wv_income <- get_acs(
  geography = "county",
  variables = "B19013_001",
  state = "WV",
  year = 2020
)

wv_income <- wv_income %>%
  mutate(NAME = str_remove(NAME, " County, West Virginia")) %>%
  filter(estimate > 50000)
wv_income

# Create a bar graph

wv_income.bar <- ggplot(wv_income, aes(x = estimate,
                                       y = reorder(NAME, estimate)))

wv_income.bar + geom_col() +
  labs(title = "Median Household Income",
       subtitle = "Counties West Virginia",
       x = "ACS Estimate",
       y = NULL) +
  theme_minimal() +
  scale_x_continuous(labels = scales::dollar_format(scale = .001, suffix = "K"))
```

Spatial data

Census TIGER/Line shape files

TIGER/Line shape files are geographic datasets released by US Census bureau that can be accessed using the tigris package

How tigris works When you call a tigris function, it does the following:

- Downloads your data from the US Census Bureau website;
- Stores your data in a temporary directory by default;
- Loads your data into R as a simple features object using sf::st_read()

```
#cache downloaded shapefiles and prevent having to re-download every time you use them

options(tigris_use_cache = TRUE)
```

```
# set the data

wv_counties <- counties(state = "WV")
wv_counties

# plot the data

plot(wv_counties$geometry)
```

The sf package

the simple features package allows us to map data onto features

```
install.packages("sf")
library(sf)
```

Available Datasets in tigris

- Legal entities: units that have legal significance in the US (e.g. states, counties)
- Statistical entities: units that are used to tabulate Census data but do not have legal standing (e.g. Census tracts or block groups)
- Geographic features: other geographic datasets provided by the Census Bureau that are not used for demographic tabulation (e.g. roads, water)

Polygons: statistical entities

```
mon_tracts = tracts(state = "WV", county = "Monongalia")
plot(mon_tracts$geometry)
```

Lines: geographic features

```
mon_roads = roads(state = "WV", county = "Monongalia")
plot(mon_roads$geometry)
```

Points: geographic features

```
dc_landmarks <- tigris::landmarks("DC", type = "point")
plot(dc_landmarks$geometry)
```

Arguments in tigris files

- cb = cartography boundaries true/false
- year = year of shapefile (goes back to 1990 census)

Mapping Census Data onto Features

```
# adding geometry = TRUE allows for mapping data

wv_population <- get_decennial(
  geography = "county",
  variables = "P1_001N",
  state = "WV",
  year = 2020,
  geometry = TRUE
)

wv_population

#using the plot function will place the value onto the feature

plot(wv_population["value"])
```

Spatial data with ggplot2

We can map spatial data in ggplot using the geom_sf()

```
wv.map <- ggplot(wv_population, aes(fill = value))

wv.map + geom_sf()
```