INTRO TO CENSUS DATA AND MAPPING

Data Practicum Community Analytics

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Agenda

- Working with US Census Data
- Introduction to Mapping
- Creating Maps in R (Part 1)
  - w/ `tigris` & `getcensus`
- Creating Maps in R (Part 2)
  - w/ `tidycensus`

Working with US Census Data

- Data scientists using R often run into two problems:
  - Understanding what data the Census Bureau publishes.
  - Understanding what R packages on CRAN are available to help with their project.

Intro to Census Data

- The U.S. Census Bureau is the premier source of data about US people, places and economy.
- This makes the Bureau a natural source of information for data analysts.
- The Census Bureau publishes two types of data:
  - demographic and geographic

Demographic Data

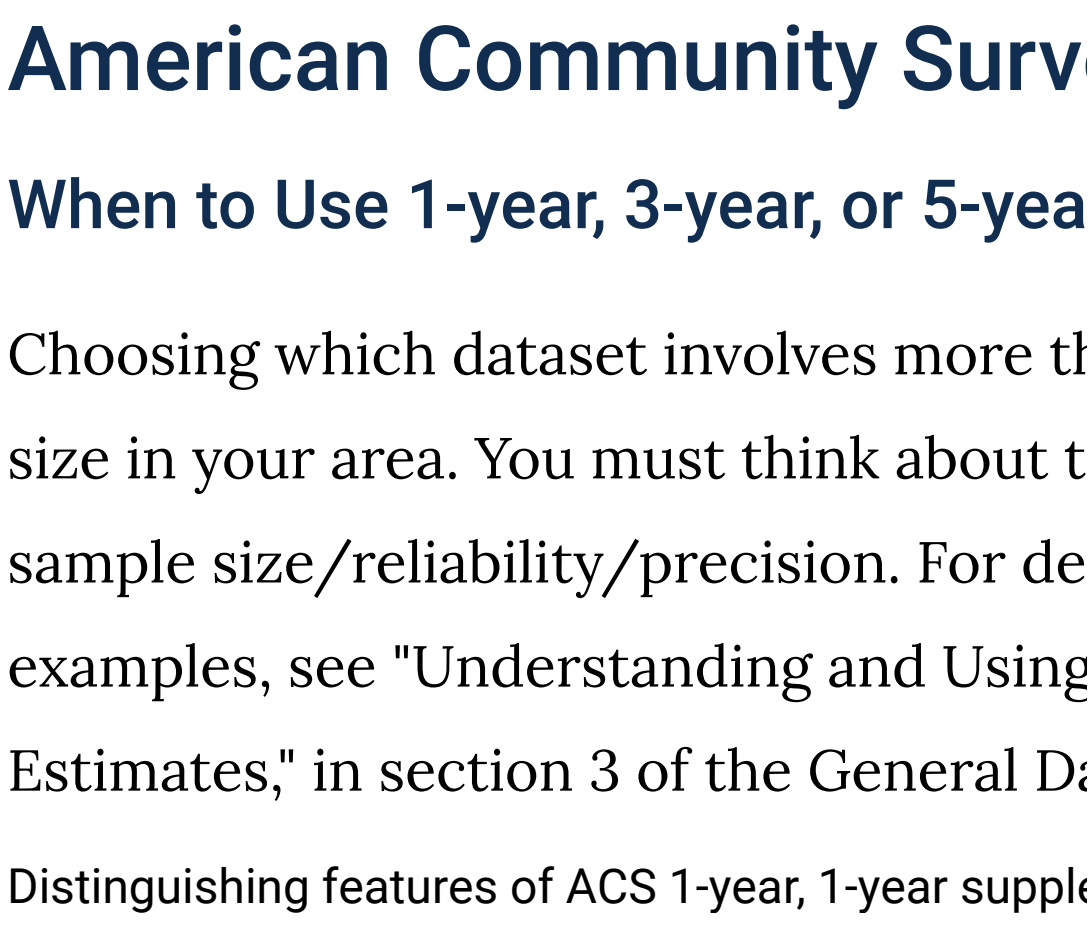
- The Census Bureau conducts over 100 Censuses, Surveys and Programs.
- You can view the full list of programs **here**.
- Top 5 most popular(by API requests):

1. American Community Survey
2. Decennial Census of Population and Housing
3. Population Estimates Program
4. Survey of Business Owners
5. International Data Base

American Community Survey (ACS).

- Info on ancestry, education, income, language, migration, disability, employment, housing
- Used to allocate government funding, track shifting demographics, plan for emergencies, and learn about local communities.
- Sent to approximately 295,000 addresses monthly (or 3.5 million per year)
- largest household survey that the Census Bureau administers

1, 3, 5 year ACS estimates



American Community Surv

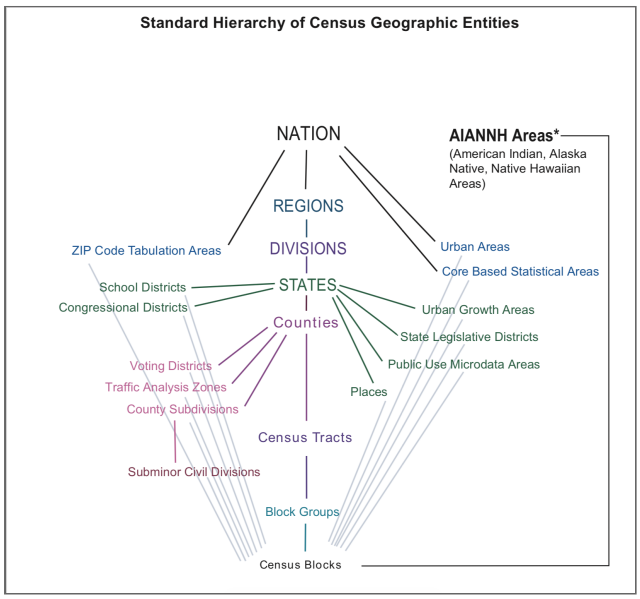
When to Use 1-year, 3-year, or 5-yea

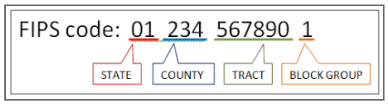
Choosing which dataset involves more th
size in your area. You must think about t
sample size/reliability/precision. For de
examples, see "Understanding and Using
Estimates," in section 3 of the General Da

Distinguishing features of ACS 1-year, 1-year supple

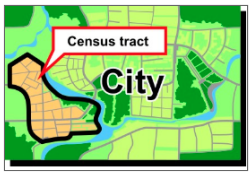
Geographic Data

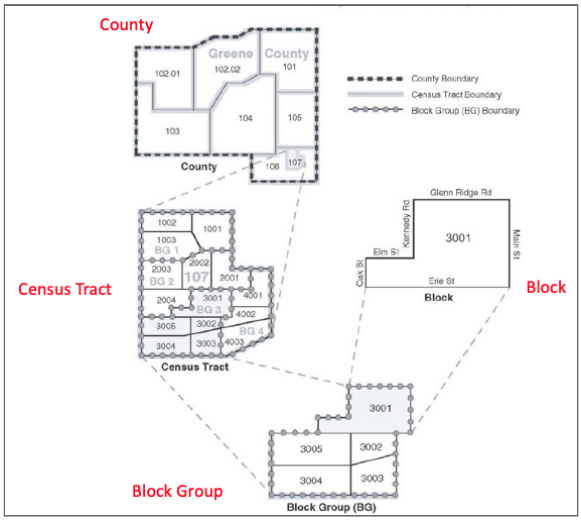
The Census Bureau's geographic hierarchy!





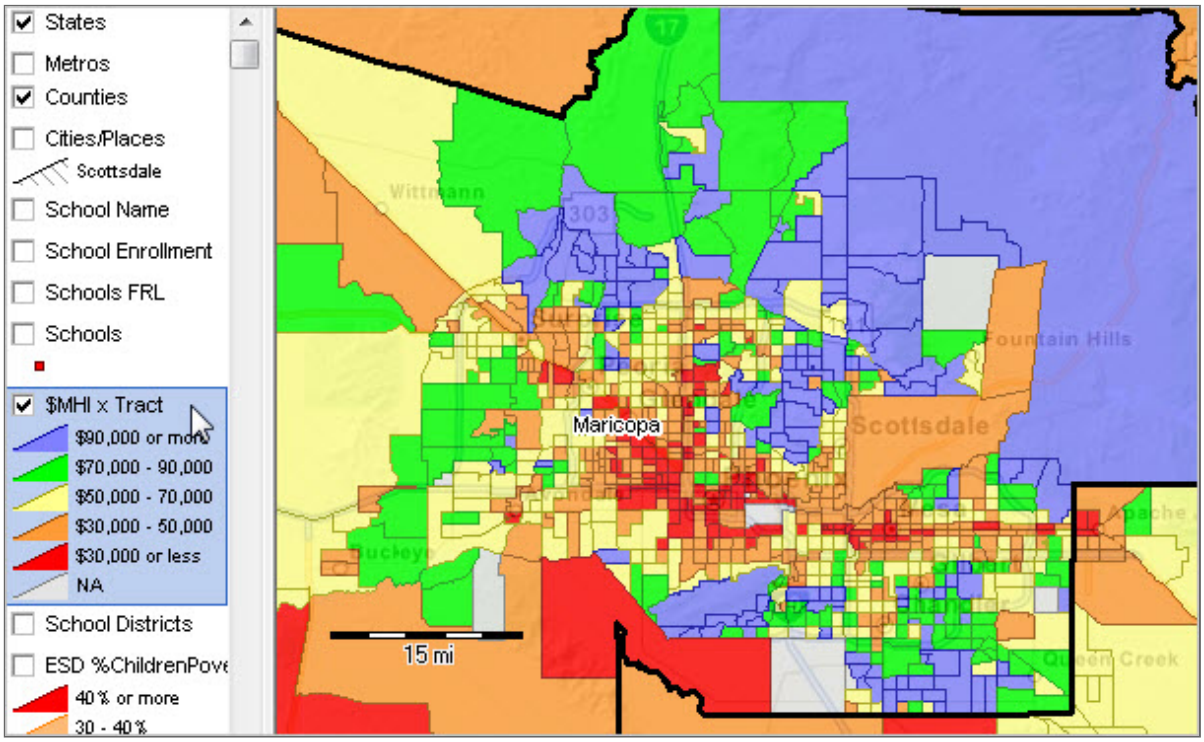
What is a Census Tract?





- Designed to be relatively homogeneous, e.g. population characteristics, economic status, living conditions
- Average about 4,000 inhabitants

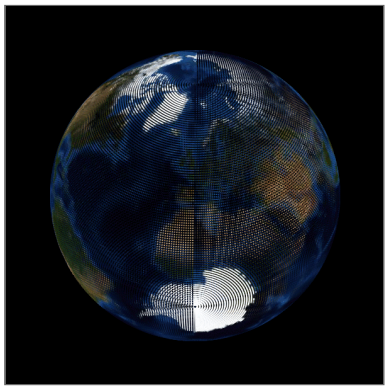
Phoenix Census Tracts



Introduction to Mapping

- Every house, every tree, every city has its own unique latitude and longitude coordinates.
- There are two underlying important pieces of information for spatial data:
    - Coordinates of the object (Lat/Long)
    - How the Lat/Long relate to a physical location on Earth
        - Also known as coordinate reference system or **CRS**

CRS



- Geographic
  - Uses three-dimensional model of the earth to define specific locations on the surface of the grid
  - longitude (East/West) and latitude (North/South)
- Projected
  - A translation of the three-dimensional grid onto a two-dimensional plane

CRS

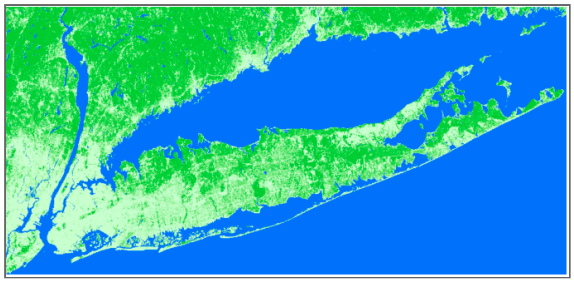
.

Types of Spatial Data

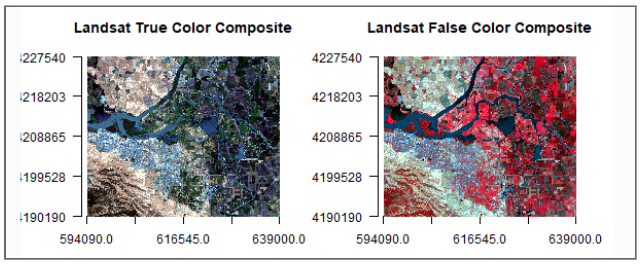
- Raster
  - Are values within a grid system
  - Example: Satellite imagery
- Vector
  - Based on points that can be connected to form lines and polygons
  - Located with in a coordinate reference system
  - Example: Road map

Raster

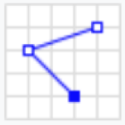
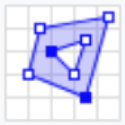
- Discrete (Land Cover/use maps)
  - Discrete values represent classes, i.e. 1=water; 2=forest



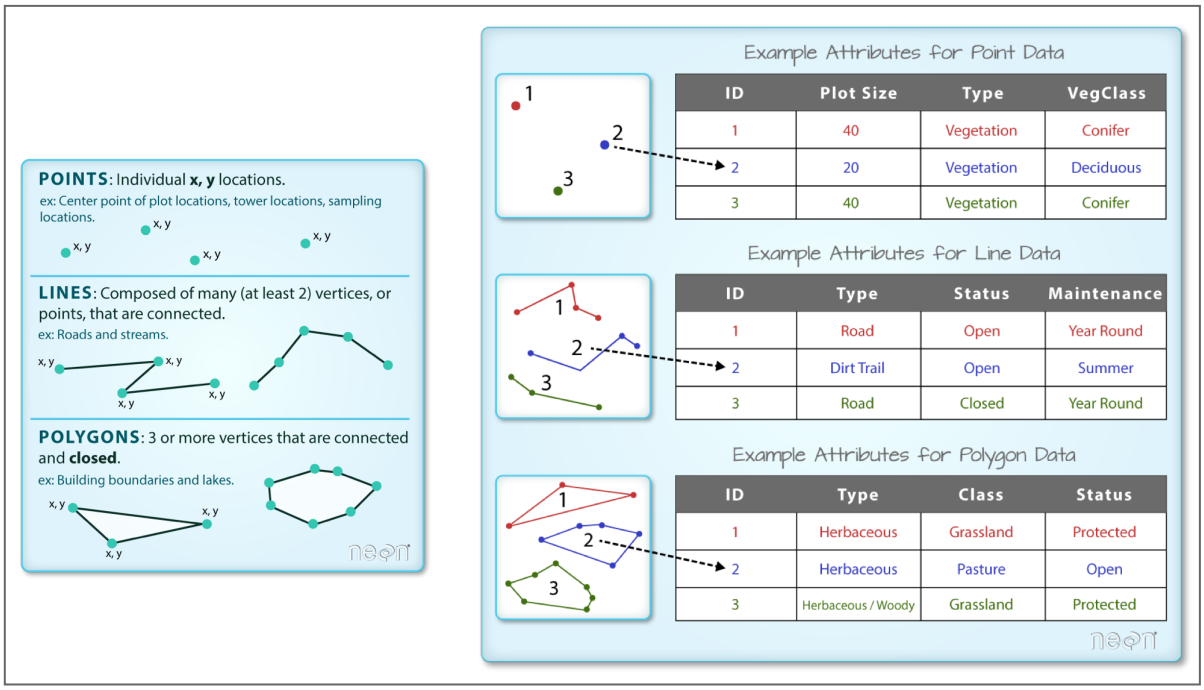
- Continuous (Satellite Imagery)
  - Grid cells with gradual changing



Vector

Type	Examples	
Point		`POINT (30 10)`
LineString		`LINESTRING (30 10, 10 30, 40 40)`
Polygon		`POLYGON ((30 10, 40 40, 20 40, 10 20, 30 10))`
		`POLYGON ((35 10, 45 45, 15 40, 10 20, 35 10), (20 30, 35 35, 30 20, 20 30))`

Vector (Cont.)


POINTS: Individual x, y locations.
ex: Center point of plot locations, tower locations, sampling locations.
x, y
LINES: Composed of many (at least 2) vertices, or points, that are connected.
ex: Roads and streams.
POLYGONS: 3 or more vertices that are connected and closed.
ex: Building boundaries and lakes.
Example Attributes for Point Data
ID | Plot Size | Type | VegClass
1 | 40 | Vegetation | Conifer
2 | 20 | Vegetation | Deciduous
3 | 40 | Vegetation | Conifer
Example Attributes for Line Data
ID | Type | Status | Maintenance
1 | Road | Open | Year Round
2 | Dirt Trail | Open | Summer
3 | Road | Closed | Year Round
Example Attributes for Polygon Data
ID | Type | Class | Status
1 | Herbaceous | Grassland | Protected
2 | Herbaceous | Pasture | Open
3 | Herbaceous / Woody | Grassland | Protected

Shape files for Vector

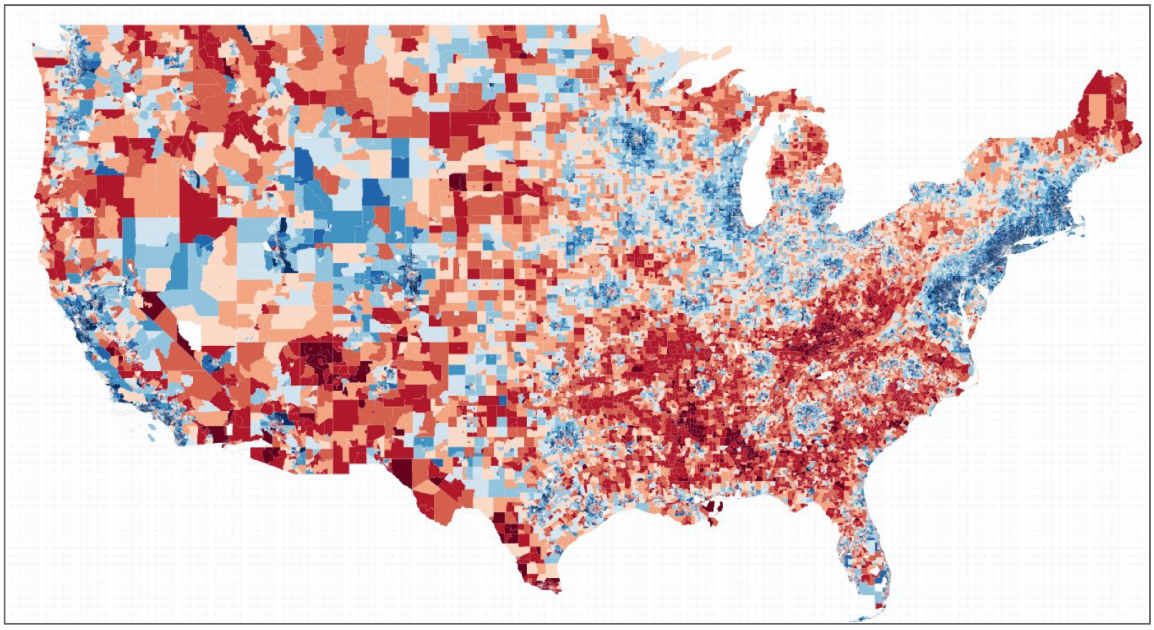
Though we refer to a shape file in the singular, it's actually a collection of at least three basic files:

- .shp - lists shape and vertices
- .shx - has index with offsets
- .dbf - relationship file between geometry and attributes (data)

All files must be present in the directory and named the same (except for the file extension) to import correctly.

Mapping

- Use vector data and shapefiles to create choropleth maps
- Household Income by Census Tract



Creating Maps in R

- Download map shapefiles and census data
  - via online downloads (Old School – and it sucks!)
  - via API w/ `tigris` for maps & `getcensus` for census data
  - via API w/`tidycensus` for maps and census data (WINNER!)

Old School Mapping Approach

Old School Mapping Approach

1. **Download data and transform data**
    - Excel
2. **Find and download shapefiles**
    - Census TIGER
3. **Import maps and join with data and style**
    - ArcGIS or QGIS
4. **Export and tweak for style further**
    - Tableau, CartoDB, Illustrator

Download Data

Find and Download Shapefiles

Download a shape file of state boundaries from the **Census**.

Find downloaded data on computer

Point R (or other spatial software) to correct filepath find File Paths, folders, etc.

- Time consuming and difficult (esp. for beginners) to even read-in the shapefile and census data to spatial software

New Approach! Downloading shape files directly into R

Using the **tigris** package, which lets us download **Census shapefiles** directly into R without having to unzip and point to directories, etc.

Simply call any of these functions (with the proper location variables):

- `tracts()`
- `counties()`
- `school_districts()`
- `roads()`

Downloading Census data into R via API

Instead of downloading data from the horrible-to-navigate Census **FactFinder** or pleasant-to-navigate **CensusReporter.org** we can pull the code with the **censusapi package** from Hannah Recht, of Bloomberg.

Load the censusapi library

First, sign up for a **census key**.

Second, replace `YOURKEYHERE` with your Census API key.

```
# Add key to .Renviron
Sys.setenv(CENSUS_KEY="YOURKEYHERE")
# Check to see that the expected key is output in your R consc
Sys.getenv("CENSUS_KEY")
```

```
library(censusapi)
```

Look up Census tables

Check out the dozens of data sets you can access.

```
apis <- listCensusApis()
View(apis)
```

Downloading Census data

We'll focus on using the `getCensus()` function from the package. It makes an API call and returns a data frame of results.

These are the arguments you'll need to pass it:

- `name` - the name of the Census data set, like "acs5" or "timeseries/bds/firms"
- `vintage` - the year of the data set
- `vars` - one or more variables to access
- `region` - the geography level of data, like county or tracts or state

Get Census metadata

You can use `listCensusMetadata()` to see what tables might be available from the ACS Census survey.

```
acs_vars <- listCensusMetadata(name="acs/acs5", type="variable
View(acs_vars)
```

Slow Process! Please don't run this right now.

Search for data variable names

In the search finder window, type variable of interest, i.e. `median household income`

Census variables names

- **B21004_001E**, **B19013_001M**, etc.
  - This is reference to a Census table of information.
  - For example, **A14009** is Average Household Income by Race for that polygon of data in that row
  - When you export data from the Census, the variables get translated to this sort of format
  - You'll have to remember when you download it or **look it up**.

Downloading median income

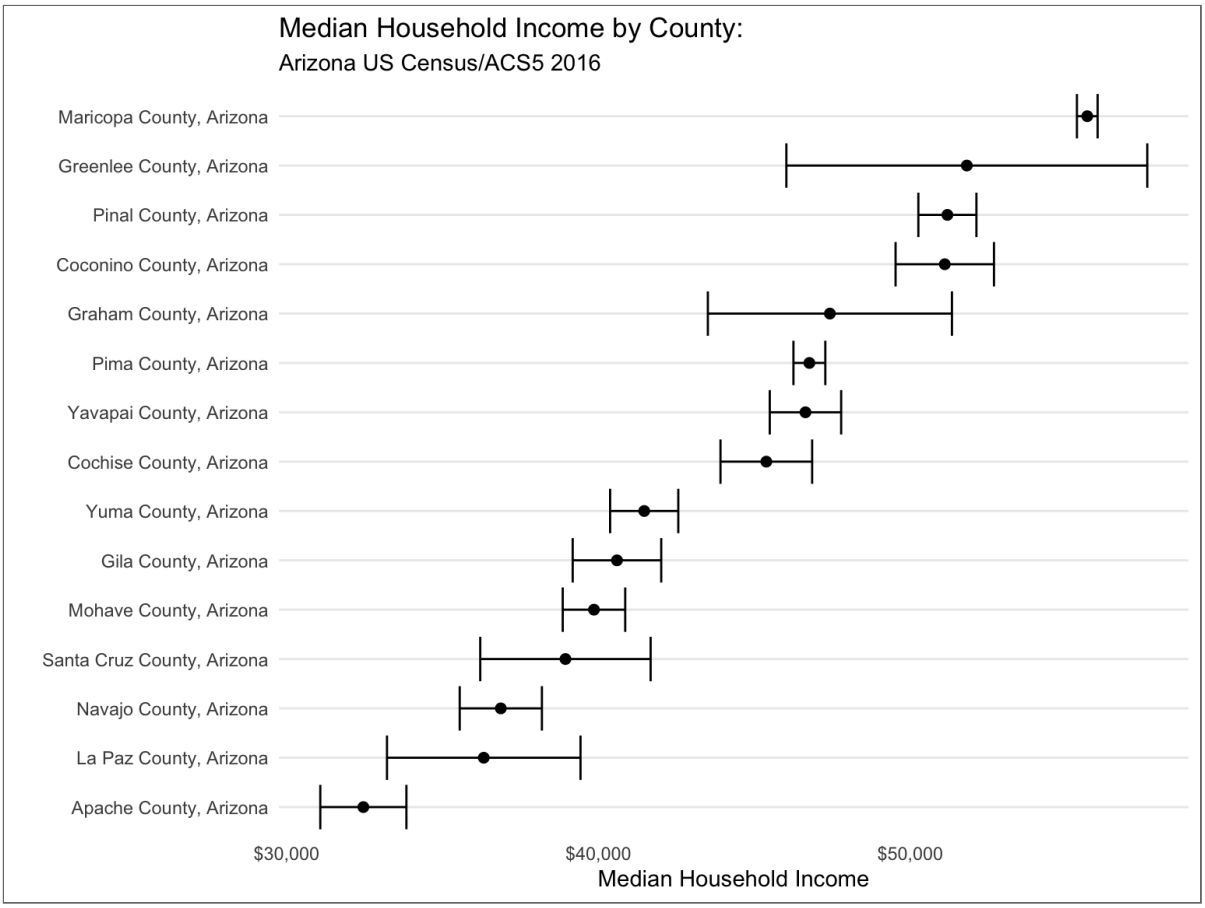
```
az_income <- getCensus(name = "acs/acs5", vintage = 2016,
    vars = c("NAME", "B19013_001E", "B19013_001M"),
    region = "county:*", regionin = "state:04")
head(az_income)
```

```
##   state county                    NAME B19013_001E B19013_
## 1    04    001   Apache County, Arizona       32460
## 2    04    003  Cochise County, Arizona       45383
## 3    04    005 Coconino County, Arizona       51106
## 4    04    007     Gila County, Arizona       40593
## 5    04    009   Graham County, Arizona       47422
## 6    04    011 Greenlee County, Arizona       51813
```

Data Exploration

```
## Data Wrangling
az_income %>%
rename(MHI_est = B19013_001E ,
MHI_moe = B19013_001M)%>%
mutate(se = MHI_moe/1.645,
cv = (se/MHI_est)*100) %>% #CV is the coefficient of
  variation

  ##Plot
ggplot( aes(x = MHI_est,
y = reorder(NAME, MHI_est))) +
geom_point(color = "black", size = 2) +
geom_errorbarh(aes(xmin = MHI_est - MHI_moe,
xmax = MHI_est + MHI_moe )) +
labs(title = "Median Household Income by County:",
subtitle =
paste0("Arizona US Census/ACS5 2016"),
x = "Median Household Income", y="") +
scale_x_continuous(labels = scales::dollar) +
theme_minimal() +
theme(panel.grid.minor.x = element_blank(),
panel.grid.major.x = element_blank())
```

Data Exploration



Downloading Arizona Shapefile

First, let's make sure the shape files download as **sf** files (because it can also handle **sp** versions, as well)

If **cb** is set to TRUE, it downloads a generalized (1:500k) counties file. Default is FALSE (the most detailed TIGER file).

```
library(tigris)
options(tigris_use_cache = TRUE)
options(tigris_class = "sf")
az <- counties("AZ", cb=T)
```

What the az object looks like

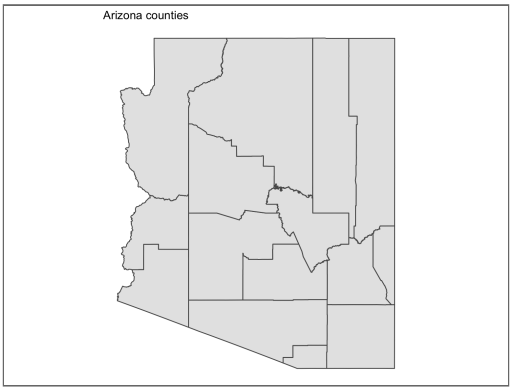
```
View(az)
```

What are the variables

- **STATEFP** is the state fips code.
  - That stands for the Federal Information Processing Standard. It's a standardized way to identify states, counties, census tracts, etc.
- **GEOID** is also part of the fips code.
  - In this instance it's only two digits wide.
  - The more specific you get into the Census boundaries, the longer the number gets.
- **geometry**
  - This is the Coordinate Reference System (CRS) data

Mapping Arizona

```
ggplot(az) +
  geom_sf() +
  theme_void() +
  theme(panel.grid.major = element_line(colour =
  'transparent')) +
  labs(title="Arizona counties")
```



Notes on some code

```
    theme_void() +
    theme(panel.grid.major = element_line(colour = 'transparent'
```

- **theme_void()** is a special function that gets rid of grids and gray space for maps
- **theme()** is how you can alter specific styles of the visualization
- **theme_void()** is a collection of individual **theme()** modifications

Time to join the map data and median income data

Join Income Data (**az_income**) and Spatial (**az**) Map Data

```
head(az_income,1) # county variable name
```

```
  state county                    NAME B19013_001E B19013_001M
1    04    001 Apache County, Arizona       32460        1381
```

```
az[[2]] # CountryFP variable name
```

```
 [1] "015" "005" "009" "013" "027" "001" "025" "021" "011" "02
[12] "017" "019" "012" "007"
```

```
az4ever <- left_join(az, az_income,
  by=c("COUNTYFP"="county"))
```

Did it work?

```
names(az4ever)
```

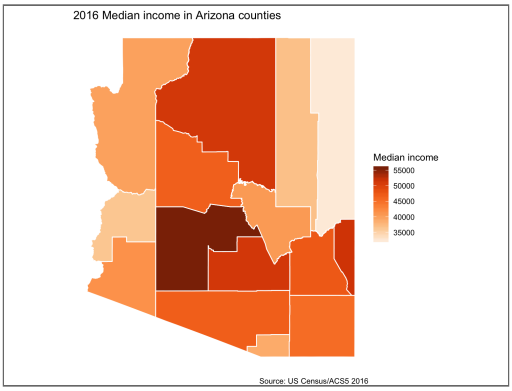
```
##  [1] "STATEFP"     "COUNTYFP"    "COUNTYNS"    "AFFGEOID"
##  [6] "NAME.x"      "LSAD"        "ALAND"       "AWATER"
## [11] "NAME.y"      "B19013_001E" "B19013_001M" "geometry"
```

```
head(az4ever, 1)
```

```
## Simple feature collection with 1 feature and 13 fields
## geometry type:  MULTIPOLYGON
## dimension:      XY
## bbox:           xmin: -114.7548 ymin: 34.20963 xmax: -112.5
## epsg (SRID):    4269
## proj4string:    +proj=longlat +ellps=GRS80 +towgs84=0,0,0,0
##   STATEFP COUNTYFP COUNTYNS       AFFGEOID GEOID NAME.x LSA
## 1      04      015 00025445 0500000US04015 04015 Mohave   0
##      AWATER state                NAME.y B19013_001E B19013
## 1 387344307    04 Mohave County, Arizona       39856
##                           geometry
## 1 MULTIPOLYGON (((-114.7532 3...
```

Arizona median income

```
ggplot(az4ever) +
  geom_sf(aes(fill=B19013_001E), color="white") +
  theme_void() +
  theme(panel.grid.major = element_line(colour =
  'transparent')) +
  scale_fill_distiller(palette="Oranges", direction=1,
  name="Median income") +
  labs(title="2016 Median income in Arizona counties",
  caption="Source: US Census/ACS5 2016")
```



Download Census data and shapefiles together

Newest package for Census data: **tidycensus**

With **tidycensus**, you can download the shape files with the data you want already attached. No joins necessary.

Let's get right into mapping. We'll calculate unemployment percents by Census tract in Maricopa County. It'll involve wrangling some data. But querying the data with `get_acs()` will be easy and so will getting the shape file by simply passing it `geometry=T`.

Load up tidycensus

```
library(tidycensus)
```

Pass it your Census key.

```
census_api_key("YOUR API KEY GOES HERE")
```

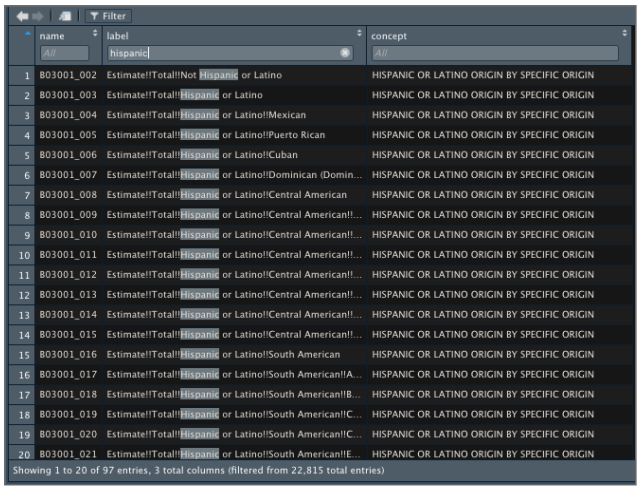
Search for variables

```
VarSearch <- load_variables( 2017, "acs5", cache=TRUE )

# convert all letters to upper case

VarSearch$label <- toupper(VarSearch$label)


unemployment <-  VarSearch %>%

  mutate( contains.unemployment = grepl( "UNEMPLOYED",
  label ) ) %>%
  #Create new variable with Mutate that has UNEMPLOYED in
  title using grepl

  filter( contains.unemployment )

head(unemployment, 1)
```

```
## # A tibble: 1 x 4
##   name    label                     concept               c
##   <chr>   <chr>                     <chr>                 <
## 1 B12006… ESTIMATE!!TOTAL!!NEVER M… MARITAL STATUS BY SE… T
```

Search for Variables with `View`

```
View(VarSearch)
```



	name	label	concept
	All	hispanic	All
1	B03001_002	Estimate!!Total!!Not Hispanic or Latino	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
2	B03001_003	Estimate!!Total!!Hispanic or Latino	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
3	B03001_004	Estimate!!Total!!Hispanic or Latino!!Mexican	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
4	B03001_005	Estimate!!Total!!Hispanic or Latino!!Puerto Rican	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
5	B03001_006	Estimate!!Total!!Hispanic or Latino!!Cuban	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
6	B03001_007	Estimate!!Total!!Hispanic or Latino!!Dominican (Domin...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
7	B03001_008	Estimate!!Total!!Hispanic or Latino!!Central American	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
8	B03001_009	Estimate!!Total!!Hispanic or Latino!!Central American!!...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
9	B03001_010	Estimate!!Total!!Hispanic or Latino!!Central American!!...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
10	B03001_011	Estimate!!Total!!Hispanic or Latino!!Central American!!...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
11	B03001_012	Estimate!!Total!!Hispanic or Latino!!Central American!!...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
12	B03001_013	Estimate!!Total!!Hispanic or Latino!!Central American!!...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
13	B03001_014	Estimate!!Total!!Hispanic or Latino!!Central American!!...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
14	B03001_015	Estimate!!Total!!Hispanic or Latino!!Central American!!...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
15	B03001_016	Estimate!!Total!!Hispanic or Latino!!South American	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
16	B03001_017	Estimate!!Total!!Hispanic or Latino!!South American!!A...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
17	B03001_018	Estimate!!Total!!Hispanic or Latino!!South American!!B...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
18	B03001_019	Estimate!!Total!!Hispanic or Latino!!South American!!C...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
19	B03001_020	Estimate!!Total!!Hispanic or Latino!!South American!!C...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN
20	B03001_021	Estimate!!Total!!Hispanic or Latino!!South American!!E...	HISPANIC OR LATINO ORIGIN BY SPECIFIC ORIGIN

Showing 1 to 20 of 97 entries, 3 total columns (filtered from 22,815 total entries)

- Select `Filter` (top left). In `label` box, type `Hispanic`
- We want the total non-hispanic population (`B03001_002`)

Getting unmployment figures

```
jobs <- c(labor_force = "B23025_005E",
             unemployed = "B23025_002E")
arizona <- get_acs(geography="tract", year=2017,
  survey="acs5",
                   variables= jobs, county = "Maricopa",
                   state="AZ", geometry=T)
```

```
head(arizona)
```

```
## Simple feature collection with 6 features and 5 fields
## geometry type:  MULTIPOLYGON
## dimension:      XY
## bbox:           xmin: -112.0654 ymin: 33.46573 xmax: -111.0
## epsg (SRID):    4269
## proj4string:    +proj=longlat +ellps=GRS80 +towgs84=0,0,0,0
##         GEOID                                          NAME
## 1 04013010101 Census Tract 101.01, Maricopa County, Arizona
## 2 04013010101 Census Tract 101.01, Maricopa County, Arizona
## 3 04013010102 Census Tract 101.02, Maricopa County, Arizona
## 4 04013010102 Census Tract 101.02, Maricopa County, Arizona
## 5 04013030401 Census Tract 304.01, Maricopa County, Arizona
## 6 04013030401 Census Tract 304.01, Maricopa County, Arizona
##   estimate moe                       geometry
## 1     1681 333 MULTIPOLYGON (((-111.7869 3...
## 2       87  59 MULTIPOLYGON (((-111.7869 3...
## 3     1767 431 MULTIPOLYGON (((-112.0654 3...
## 4       54  47 MULTIPOLYGON (((-112.0654 3...
## 5     1354 296 MULTIPOLYGON (((-111.9648 3...
## 6       30  49 MULTIPOLYGON (((-111.9648 3...
```

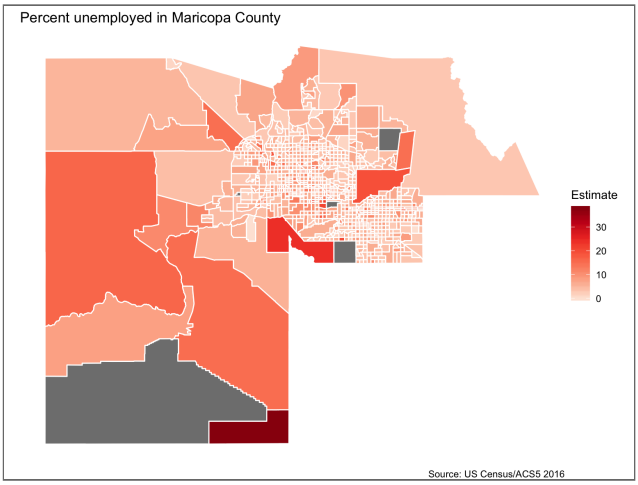
Transforming the data

```
library(tidyr)
arizona<-arizona %>%
  mutate(variable=case_when(
    variable=="B23025_005" ~ "Unemployed",
    variable=="B23025_002" ~ "Workforce")) %>%
  select(-moe) %>%
  spread(variable, estimate) %>%  #Spread moves rows into
  columns

  mutate(percent_unemployed=round(Unemployed/Workforce*100,2))
```

```
head(arizona)
```

Mapping the data

```
library(tidyr)
ggplot(arizona, aes(fill=percent_unemployed)) +
  geom_sf(color="white") +
  theme_void() + theme(panel.grid.major =
  element_line(colour = 'transparent')) +
  scale_fill_distiller(palette="Reds", direction=1,
  name="Estimate") +
  labs(title="Percent unemployed in Maricopa County",
  caption="Source: US Census/ACS5 2016") +
  NULL
```



Faceting maps (Small multiples)

```
racevars <- c(White = "B02001_002",
              Black = "B02001_003",
              Asian = "B02001_005",
              Hispanic = "B03003_003")
maricopa <- get_acs(geography = "tract", variables =
  racevars,
                  state = "AZ", county = "Maricopa County",
  geometry = TRUE,
                  summary_var = "B02001_001", year=2017,
  survey = "acs5")
```

Faceting maps (Small multiples)

```
head(maricopa)
```

```
head(maricopa)
```

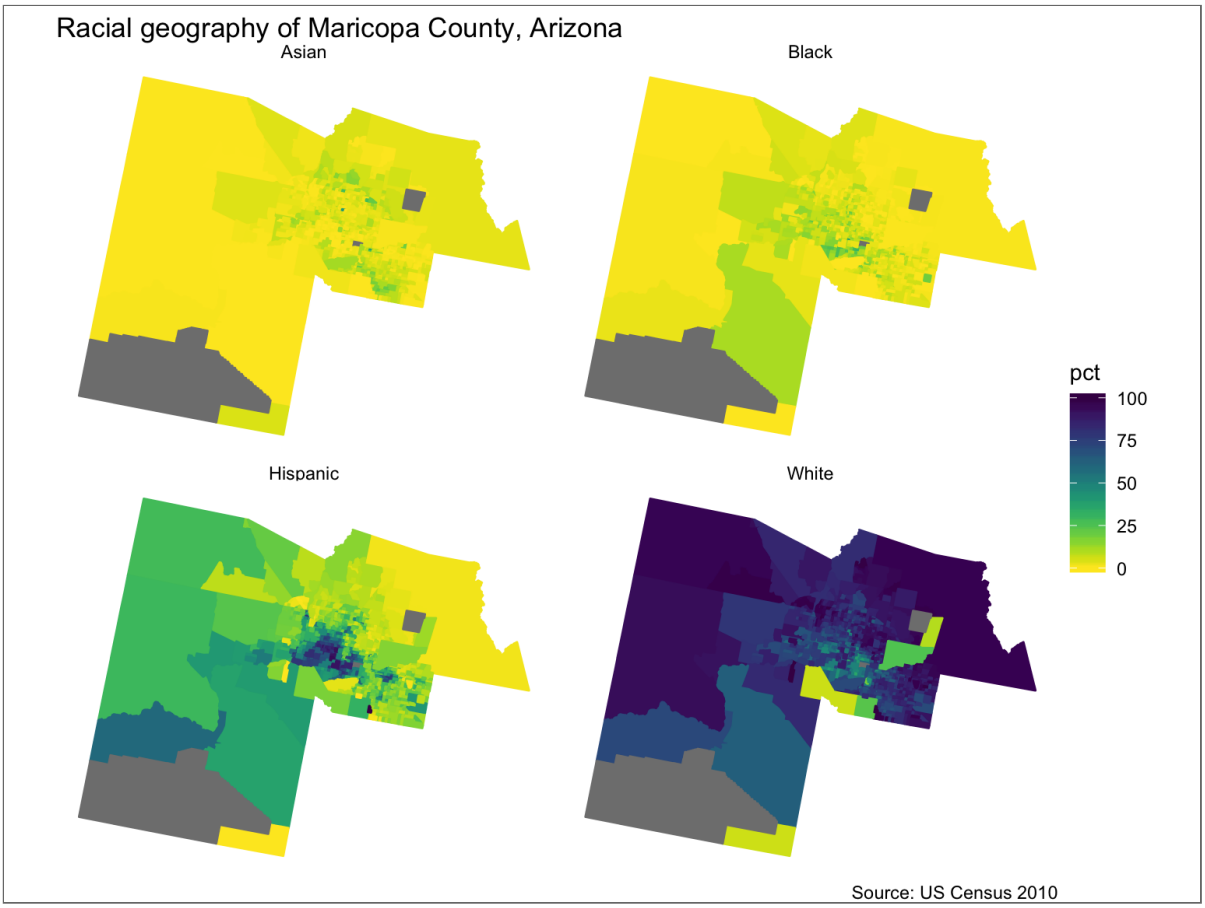
```
## Simple feature collection with 6 features and 7 fields
## geometry type:  MULTIPOLYGON
## dimension:      XY
## bbox:           xmin: -112.0654 ymin: 33.46573 xmax: -111.0
## epsg (SRID):    4269
## proj4string:    +proj=longlat +ellps=GRS80 +towgs84=0,0,0,0
##         GEOID                                          NAME
## 1 04013010101 Census Tract 101.01, Maricopa County, Arizona
## 2 04013010101 Census Tract 101.01, Maricopa County, Arizona
## 3 04013010101 Census Tract 101.01, Maricopa County, Arizona
## 4 04013010101 Census Tract 101.01, Maricopa County, Arizona
## 5 04013010102 Census Tract 101.02, Maricopa County, Arizona
## 6 04013010102 Census Tract 101.02, Maricopa County, Arizona
##   estimate moe summary_est summary_moe
## 1     4814 513        4915         517 MULTIPOLYGON (((-111
## 2        0  12        4915         517 MULTIPOLYGON (((-111
## 3       19  33        4915         517 MULTIPOLYGON (((-111
## 4       78 104        4915         517 MULTIPOLYGON (((-111
## 5     4408 592        4602         602 MULTIPOLYGON (((-112
## 6       25  38        4602         602 MULTIPOLYGON (((-112
```

Transform and map the data

Combine data wrangling and mapping into 1

```
library(viridis)
maricopa %>%
  mutate(pct = 100 * (estimate / summary_est)) %>%
  ggplot(aes(fill = pct, color = pct)) +
  facet_wrap(~variable) +
  geom_sf() +
  coord_sf(crs = 26915) +
  scale_fill_viridis(direction=-1) +
  scale_color_viridis(direction=-1) +
  theme_void() +
  theme(panel.grid.major = element_line(colour = 'transparent'
  labs(title="Racial geography of Maricopa County, Arizona", c
```

Transform and map the data

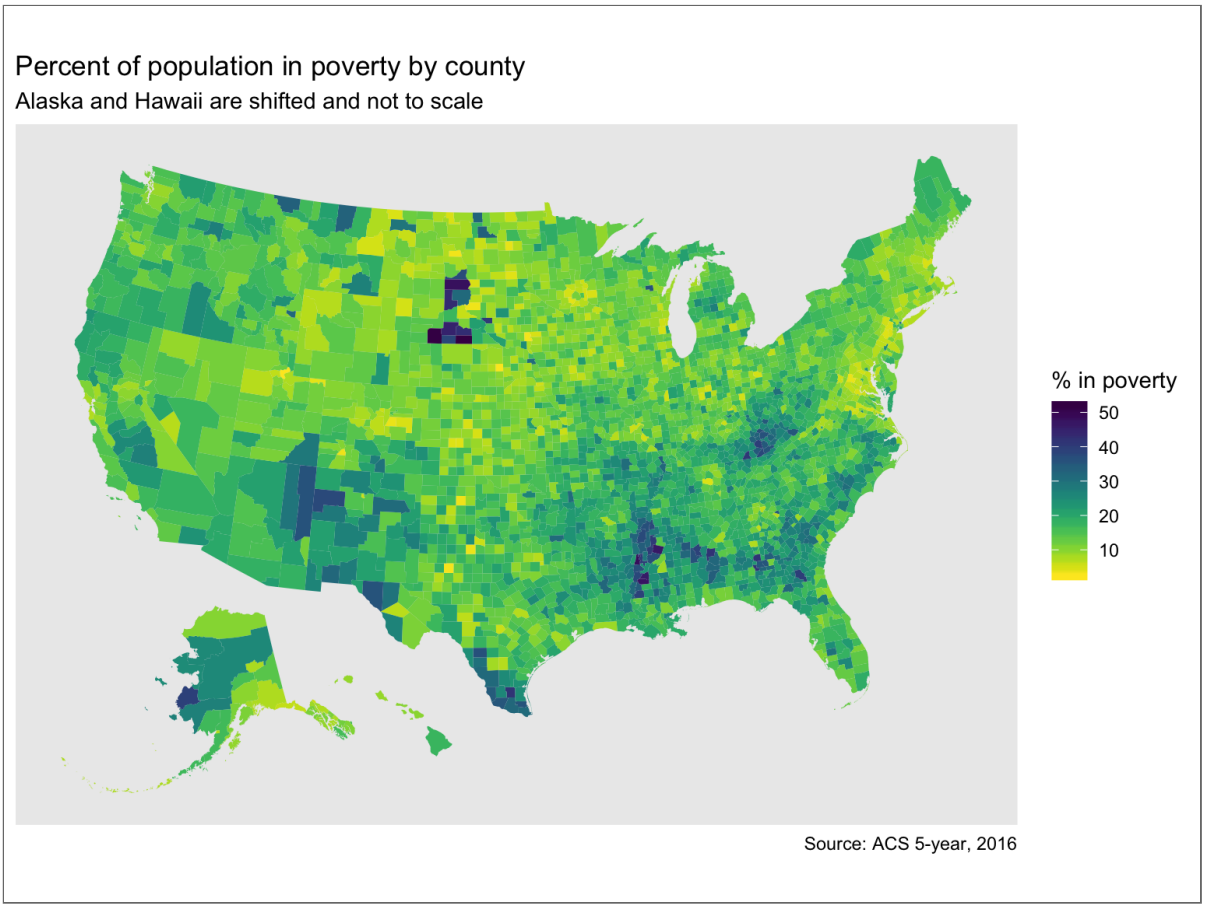


From here, easy to create US maps

Poverty = `B17001_002`

```
county_pov <- get_acs(geography = "county",
                      variables = "B17001_002",
                      summary_var = "B17001_001",
                      year = 2017,
                      survey = "acs5",
                      geometry = TRUE,
                      shift_geo = TRUE) %>%
  mutate(pctpov = 100 * (estimate/summary_est))

## Plot
ggplot(county_pov) +
  geom_sf(aes(fill = pctpov), color=NA) +
  coord_sf(datum=NA) +
  labs(title = "Percent of population in poverty by
  county",
       subtitle = "Alaska and Hawaii are shifted and not to
  scale",
       caption = "Source: ACS 5-year, 2016",
       fill = "% in poverty") +
  scale_fill_viridis(direction=-1)
```

US County Poverty Map



Lab 2