# Census geographic data and applications in R

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2023-02-28

## 1. What is the purpose of having different folders? Why do we use R projects (.Rproj) files for everything we do?

RStudio projects eliminates so much of the early-stage hassle and confusion around reading in and exporting data. Setting up a working directory properly also helps build up good habits that are conducive to reproducible analysis.

RStudio projects solve the problem of ‘fragile’ file paths by making file paths relative. The RStudio project file is a file that sits in the root directory, with the extension .Rproj. When your RStudio session is running through the project file (.Rproj), the current working directory points to the root folder where that .Rproj file is saved.

RStudio projects, it’s a good practice to structure your directory in a way that helps anybody else you are collaborating with - or a future version of you trying to reproduce some analysis - to navigate the analysis easily.

## 2. Please explain what goes into each of these folders: bin, data, doc, results, src.

Keeping files in a project folder, is a good practice to keep all files for a given project in the same project-specific folder.

Folder sub-directories:

**project** is the top-level folder and contains all of the folders and files associated with that project. This folder should be renamed for each unique project.

**data** contains the raw data files used in the project. These files should not be altered and are ideally read-only.

**doc** contains any manuscripts or interim summaries produced with the project.

**bin** contains any plots, images, tables, or figures created and saved by your code. It should be possible to delete and regenerate this folder with the scripts in the project folder.

**output** contains non-figure objects created by the scripts. For example, processed data or logs.

**src** is an optional folder for any files you may want to source() in your scripts. This is not code that is run. For example, simple .R files containing functions.

# Basic usage of tigris

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library(tigris)
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## Warning: package 'tigris' was built under R version 4.2.2
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st <- states()
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class(st)
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## [1] "sf"         "data.frame"
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## Simple feature collection with 56 features and 14 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -179.2311 ymin: -14.60181 xmax: 179.8597 ymax: 71.43979
## Geodetic CRS:  NAD83
## First 10 features:
##    REGION DIVISION STATEFP  STATENS GEOID STUSPS           NAME LSAD MTFCC
## 1       3        5      54 01779805    54     WV  West Virginia   00 G4000
## 2       3        5      12 00294478    12     FL        Florida   00 G4000
## 3       2        3      17 01779784    17     IL       Illinois   00 G4000
## 4       2        4      27 00662849    27     MN      Minnesota   00 G4000
## 5       3        5      24 01714934    24     MD       Maryland   00 G4000
## 6       1        1      44 01219835    44     RI   Rhode Island   00 G4000
## 7       4        8      16 01779783    16     ID          Idaho   00 G4000
## 8       1        1      33 01779794    33     NH  New Hampshire   00 G4000
## 9       3        5      37 01027616    37     NC North Carolina   00 G4000
## 10      1        1      50 01779802    50     VT        Vermont   00 G4000
##    FUNCSTAT        ALAND      AWATER    INTPTLAT     INTPTLON
## 1         A  62266298634   489204185 +38.6472854 -080.6183274
## 2         A 138961722096 45972570361 +28.3989775 -082.5143005
## 3         A 143778561906  6216493488 +40.1028754 -089.1526108
## 4         A 206232627084 18949394733 +46.3159573 -094.1996043
## 5         A  25151992308  6979074857 +38.9466584 -076.6744939
## 6         A   2677763359  1323686988 +41.5964850 -071.5264901
## 7         A 214049931578  2391569647 +44.3484222 -114.5588538
## 8         A  23190115212  1025971768 +43.6726907 -071.5843145
## 9         A 125933327733 13456093195 +35.5397100 -079.1308636
## 10        A  23872569964  1030754609 +44.0589536 -072.6710173
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plot(st$geometry)
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nm_counties <- counties("NM")
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plot(nm_counties$geometry)
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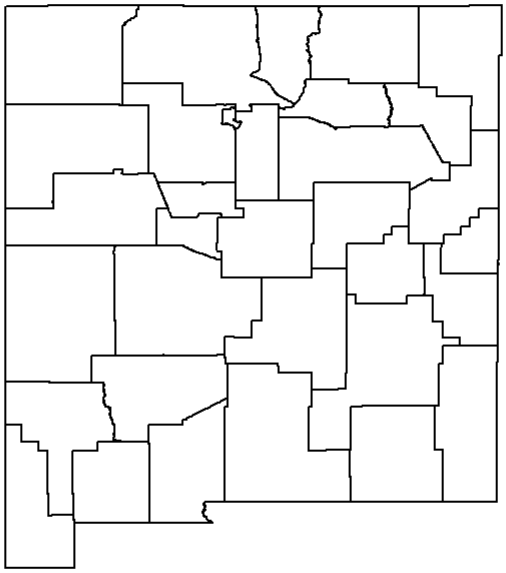

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la_tracts <- tracts("NM", "Los Alamos")
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plot(la_tracts$geometry)
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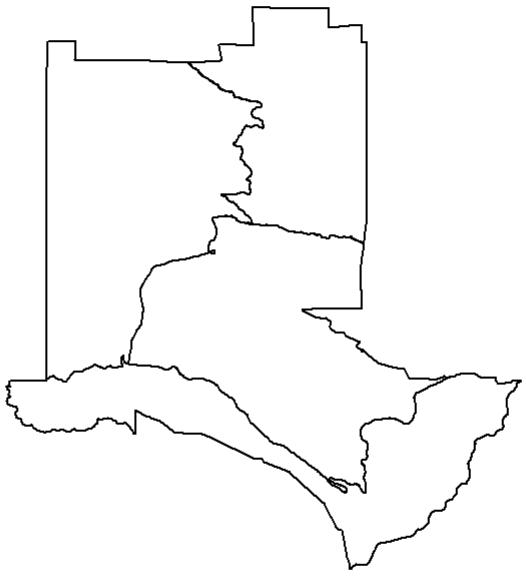

```
la_water <- area_water("NM", "Los Alamos")
```

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```
plot(la_water$geometry)
```

```
dc_landmarks <- landmarks("DC", type = "point")
```

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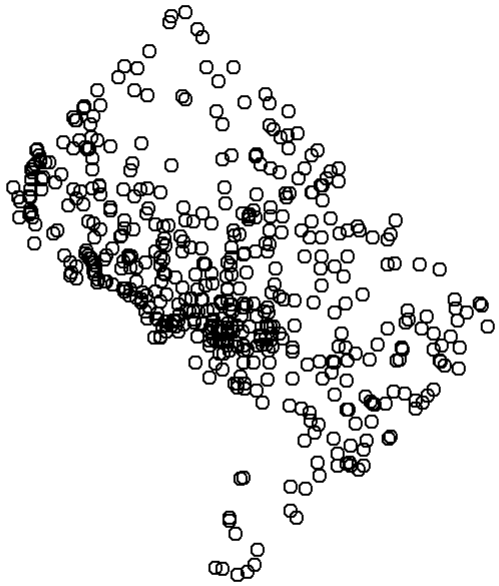
```
plot(dc_landmarks$geometry)
```



```
dc_roads <- primary_secondary_roads("DC")
```

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```
plot(dc_roads$geometry)
```

```
dc_block_groups <- block_groups("DC")
```

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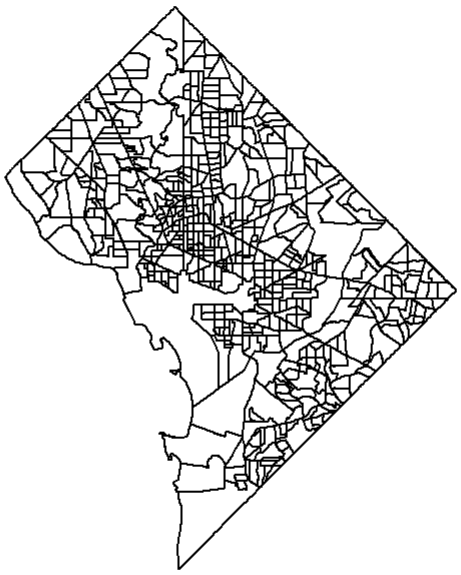
```
plot(dc_block_groups$geometry)
```

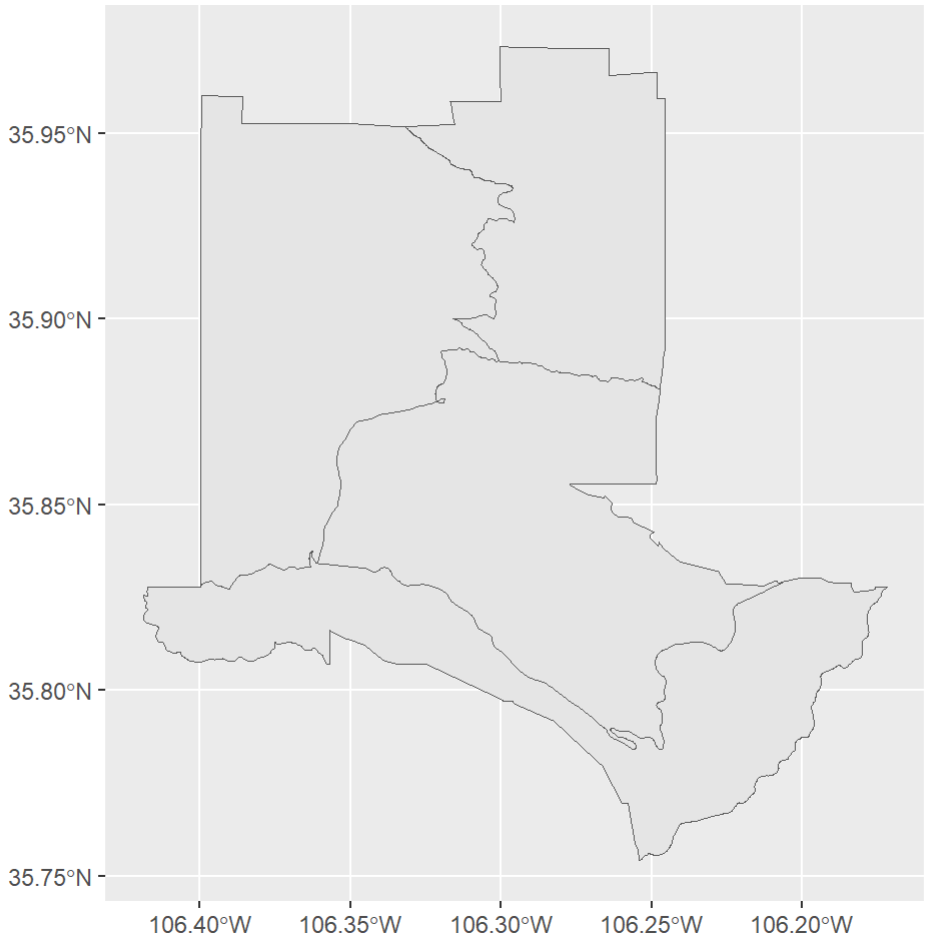


# Plotting geographic data

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 4.2.2
```

```
ggplot(la_tracts) +
  geom_sf()
```




```
ggplot(la_tracts) +
  geom_sf() +
  theme_void()
```

```
library(patchwork)
```

```
## Warning: package 'patchwork' was built under R version 4.2.2
```

```
la_block_groups <- block_groups("NM", "Los Alamos")
```

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```
gg1 <- ggplot(la_tracts) +
  geom_sf() +
  theme_void() +
  labs(title = "Census tracts")

gg2 <- ggplot(la_block_groups) +
  geom_sf() +
  theme_void() +
  labs(title = "Block groups")

gg1 + gg2
```

Census tracts

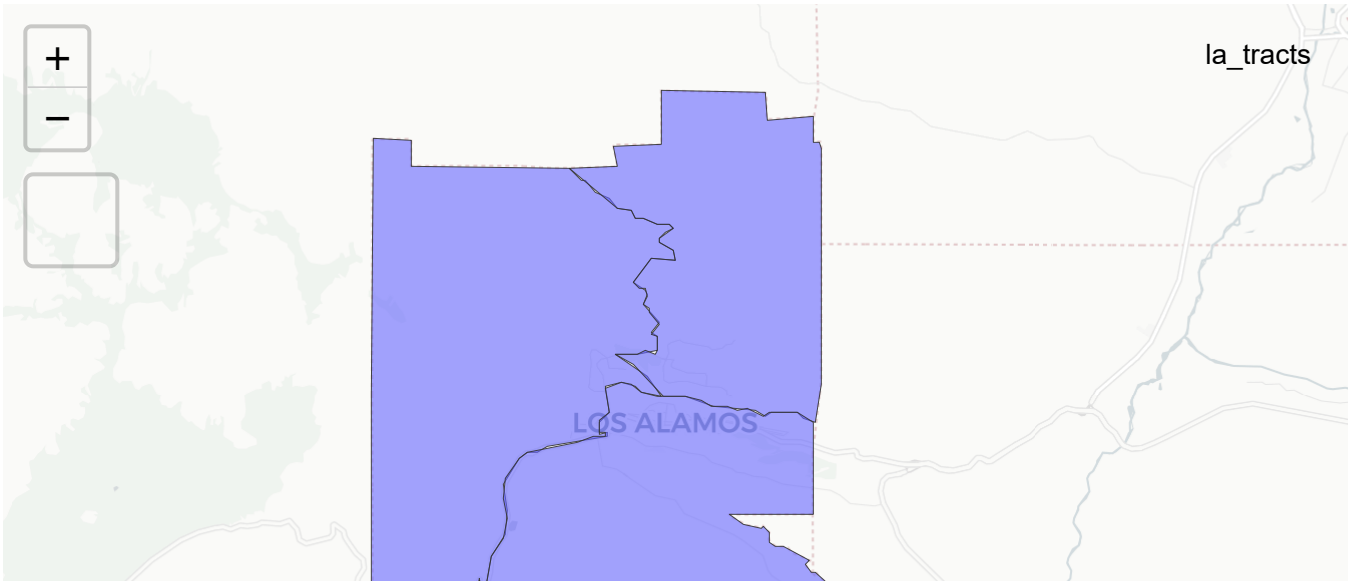
Block groups

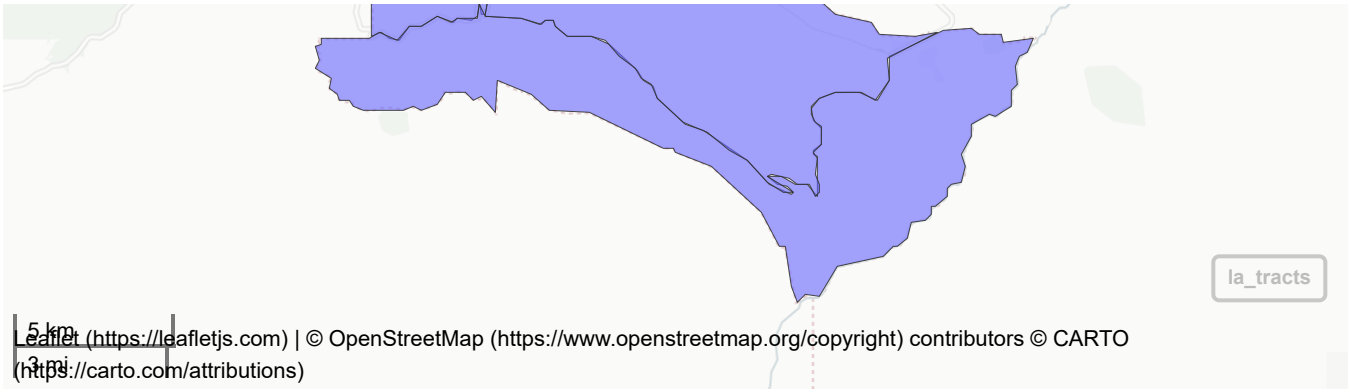
# Interactive viewing with mapview

```
library(mapview)
```

```
## Warning: package 'mapview' was built under R version 4.2.2
```

```
mapview(la_tracts)
```






# tigris workflows

```
mi_counties <- counties("MI")
mi_counties_cb <- counties("MI", cb = TRUE)
```

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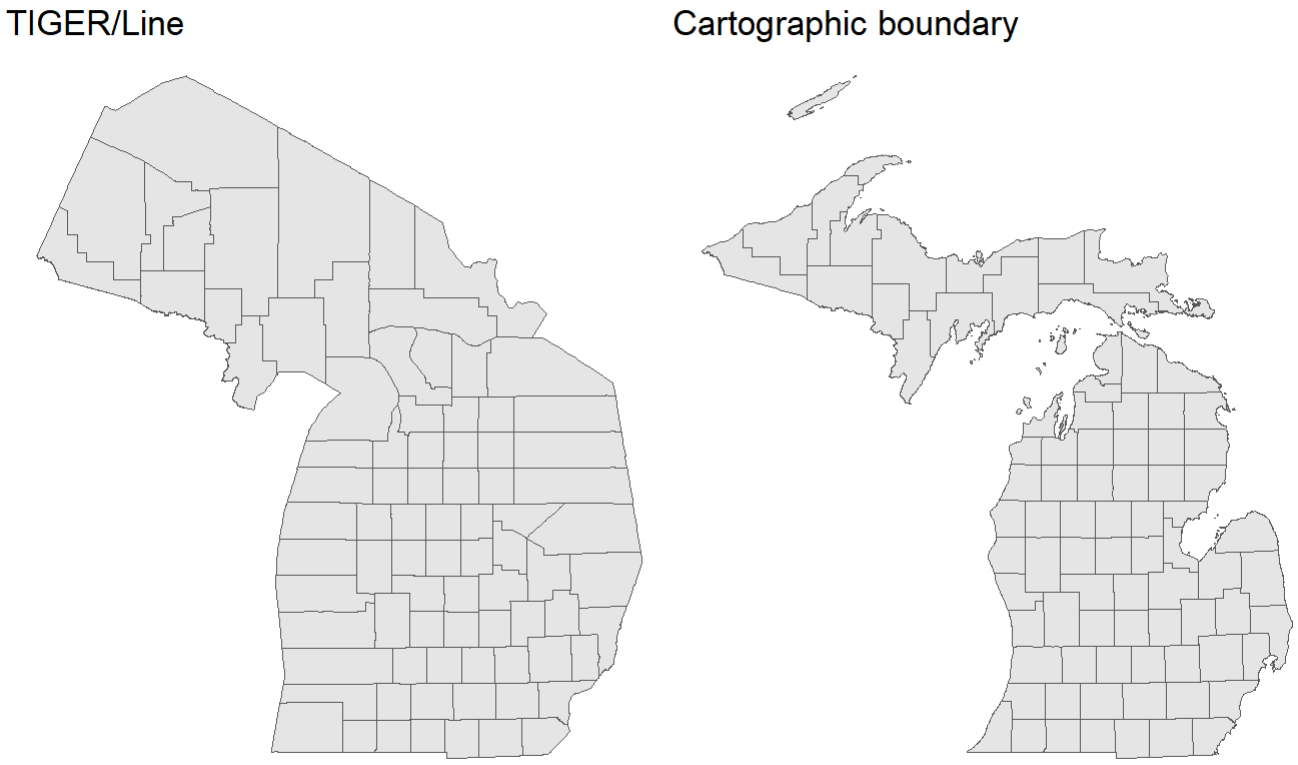
```
mi_tiger_gg <- ggplot(mi_counties) +
  geom_sf() +
  theme_void() +
  labs(title = "TIGER/Line")

mi_cb_gg <- ggplot(mi_counties_cb) +
  geom_sf() +
  theme_void() +
  labs(title = "Cartographic boundary")

mi_tiger_gg + mi_cb_gg
```




```
options(tigris_use_cache = TRUE)

rappdirs::user_cache_dir("tigris")
```

```
## [1] "C:\\Users\\manda\\AppData\\Local/tigris/tigris/Cache"
```

```
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 4.2.2
```

```
## Warning: package 'tidyr' was built under R version 4.2.2
```

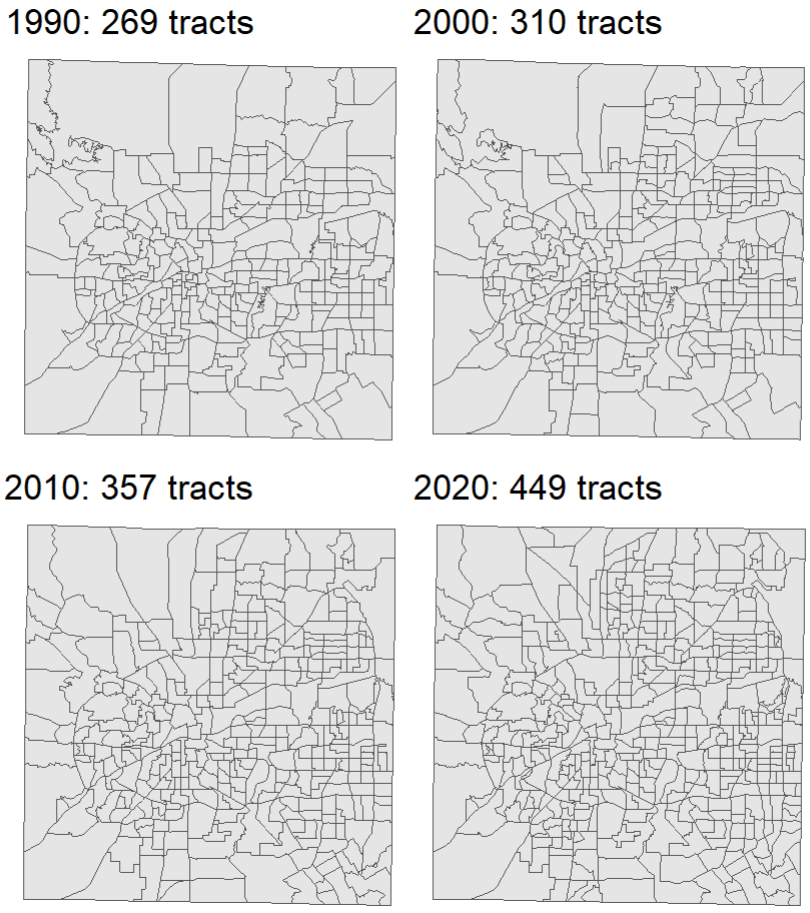
```
## Warning: package 'readr' was built under R version 4.2.2
```

```
## Warning: package 'purrr' was built under R version 4.2.2
```

```
## Warning: package 'stringr' was built under R version 4.2.2
```

```
## Warning: package 'forcats' was built under R version 4.2.2
```

```
library(patchwork)
library(glue)

yearly_plots <- map(seq(1990, 2020, 10), ~{
  year_tracts <- tracts("TX", "Tarrant", year = .x,
                        cb = TRUE)

  ggplot(year_tracts) +
    geom_sf() +
    theme_void() +
    labs(title = glue("{.x}: {nrow(year_tracts)} tracts"))
})

(yearly_plots[[1]] + yearly_plots[[2]]) /
  (yearly_plots[[3]] + yearly_plots[[4]])
```




```
us_bgs_2020 <- block_groups(cb = TRUE, year = 2020)
nrow(us_bgs_2020)
```

```
## [1] 242303
```

```
state_codes <- c(state.abb, "DC", "PR")
us_bgs_2018 <- map_dfr(
  state_codes,
  ~block_groups(
    state = .x,
    cb = TRUE,
    year = 2018
  )
)
nrow(us_bgs_2018)
```

```
## [1] 220016
```

# Coordinate reference systems

```
library(sf)

fl_counties <- counties("FL", cb = TRUE)
st_crs(fl_counties)
```

```
## Coordinate Reference System:
##   User input: NAD83
##   wkt:
## GEOGCRS["NAD83",
##     DATUM["North American Datum 1983",
##         ELLIPSOID["GRS 1980",6378137,298.257222101,
##             LENGTHUNIT["metre",1]]],
##     PRIMEM["Greenwich",0,
##         ANGLEUNIT["degree",0.0174532925199433]],
##     CS[ellipsoidal,2],
##         AXIS["latitude",north,
##             ORDER[1],
##             ANGLEUNIT["degree",0.0174532925199433]],
##         AXIS["longitude",east,
##             ORDER[2],
##             ANGLEUNIT["degree",0.0174532925199433]],
##     ID["EPSG",4269]]
```

```
library(crsuggest)
```

```
## Warning: package 'crsuggest' was built under R version 4.2.2
```

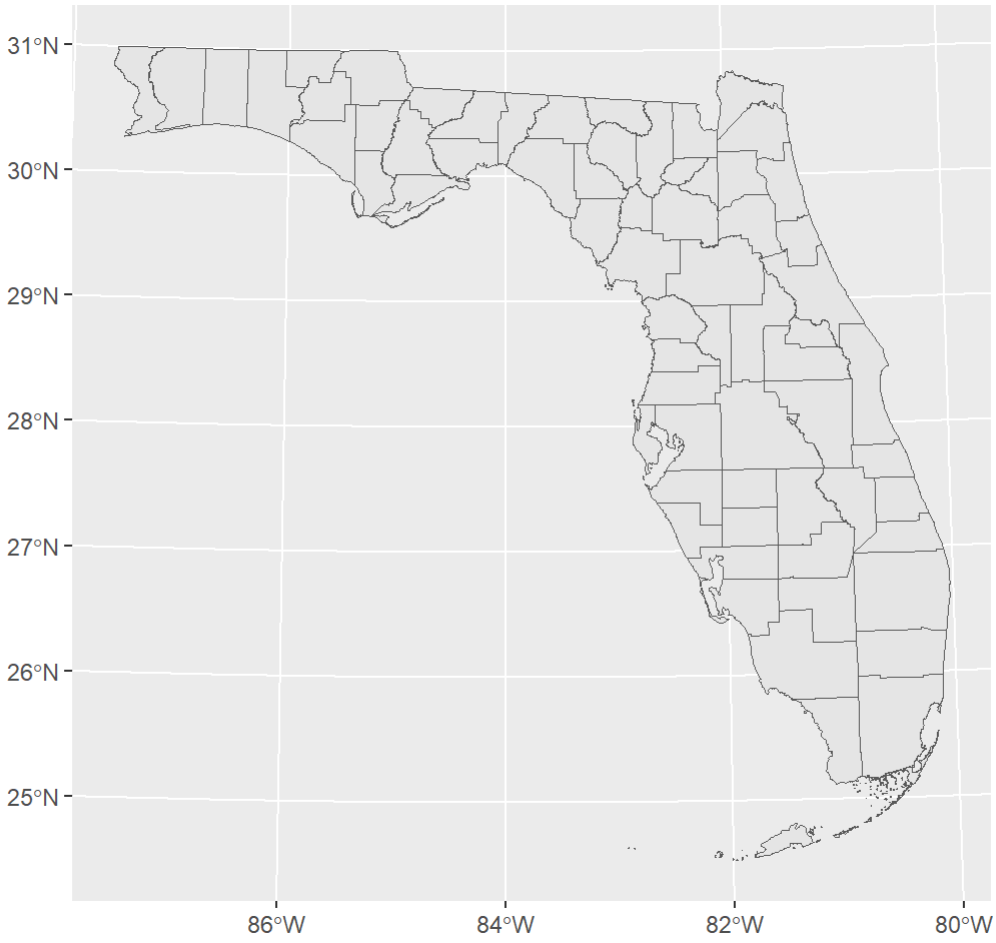
```
fl_crs <- suggest_crs(fl_counties)

fl_projected <- st_transform(fl_counties, crs = 3087)

head(fl_projected)
```

```
## Simple feature collection with 6 features and 12 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: 537215 ymin: 406036.2 xmax: 718307.8 ymax: 683112.8
## Projected CRS: NAD83(HARN) / Florida GDL Albers
##     STATEFP COUNTYFP COUNTYNS       AFFGEOID GEOID    NAME       NAMELSAD
## 67       12      095 00295750 0500000US12095 12095  Orange  Orange County
## 88       12      125 00306913 0500000US12125 12125   Union   Union County
## 96       12      069 00308551 0500000US12069 12069    Lake    Lake County
## 126      12      127 00306921 0500000US12127 12127 Volusia Volusia County
## 184      12      105 00295747 0500000US12105 12105    Polk    Polk County
## 215      12      119 00295740 0500000US12119 12119  Sumter  Sumter County
##     STUSPS STATE_NAME LSAD      ALAND    AWATER                       geometry
## 67      FL    Florida   06 2338519047 260364621 MULTIPOLYGON (((628232.9 52...
## 88      FL    Florida   06  630804541  16049423 MULTIPOLYGON (((537215 6656...
## 96      FL    Florida   06 2464981507 531018779 MULTIPOLYGON (((599838.7 49...
## 126     FL    Florida   06 2852382099 857613983 MULTIPOLYGON (((624847.1 59...
## 184     FL    Florida   06 4656518803 550424838 MULTIPOLYGON (((585432.3 47...
## 215     FL    Florida   06 1442978468  58762672 MULTIPOLYGON (((564282.7 55...
```

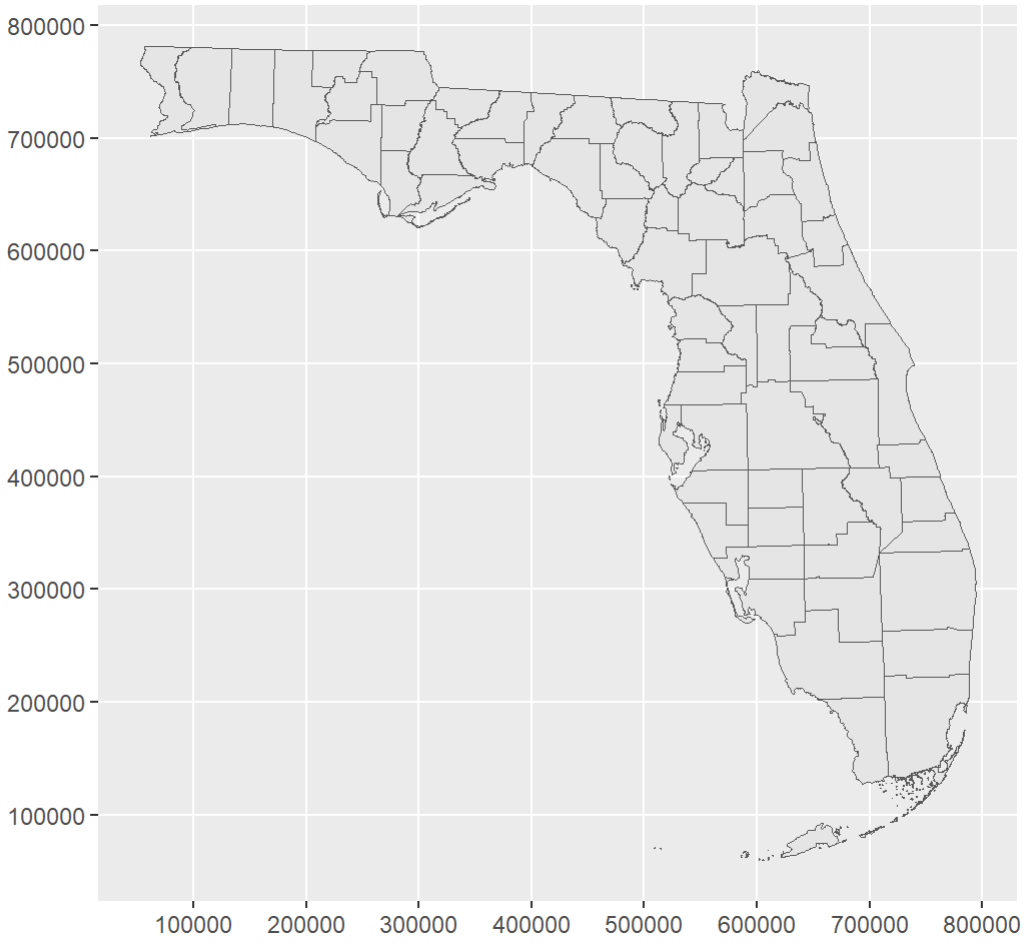
```
st_crs(fl_projected)
```

```
## Coordinate Reference System:
##   User input: EPSG:3087
##   wkt:
## PROJCRS["NAD83(HARN) / Florida GDL Albers",
##     BASEGEOGCRS["NAD83(HARN)",
##         DATUM["NAD83 (High Accuracy Reference Network)",
##             ELLIPSOID["GRS 1980",6378137,298.257222101,
##                 LENGTHUNIT["metre",1]]],
##         PRIMEM["Greenwich",0,
##             ANGLEUNIT["degree",0.0174532925199433]],
##         ID["EPSG",4152]],
##     CONVERSION["Florida GDL Albers (meters)",
##         METHOD["Albers Equal Area",
##             ID["EPSG",9822]],
##         PARAMETER["Latitude of false origin",24,
##             ANGLEUNIT["degree",0.0174532925199433],
##             ID["EPSG",8821]],
##         PARAMETER["Longitude of false origin",-84,
##             ANGLEUNIT["degree",0.0174532925199433],
##             ID["EPSG",8822]],
##         PARAMETER["Latitude of 1st standard parallel",24,
##             ANGLEUNIT["degree",0.0174532925199433],
##             ID["EPSG",8823]],
##         PARAMETER["Latitude of 2nd standard parallel",31.5,
##             ANGLEUNIT["degree",0.0174532925199433],
##             ID["EPSG",8824]],
##         PARAMETER["Easting at false origin",400000,
##             LENGTHUNIT["metre",1],
##             ID["EPSG",8826]],
##         PARAMETER["Northing at false origin",0,
##             LENGTHUNIT["metre",1],
##             ID["EPSG",8827]]],
##     CS[Cartesian,2],
##         AXIS["easting (X)",east,
##             ORDER[1],
##             LENGTHUNIT["metre",1]],
##         AXIS["northing (Y)",north,
##             ORDER[2],
##             LENGTHUNIT["metre",1]],
##     USAGE[
##         SCOPE["State-wide spatial data management."],
##         AREA["United States (USA) - Florida."],
##         BBOX[24.41,-87.63,31.01,-79.97]],
##     ID["EPSG",3087]]
```

```
options(scipen = 999)

ggplot(fl_counties) +
  geom_sf() +
  coord_sf(crs = 3087)
```



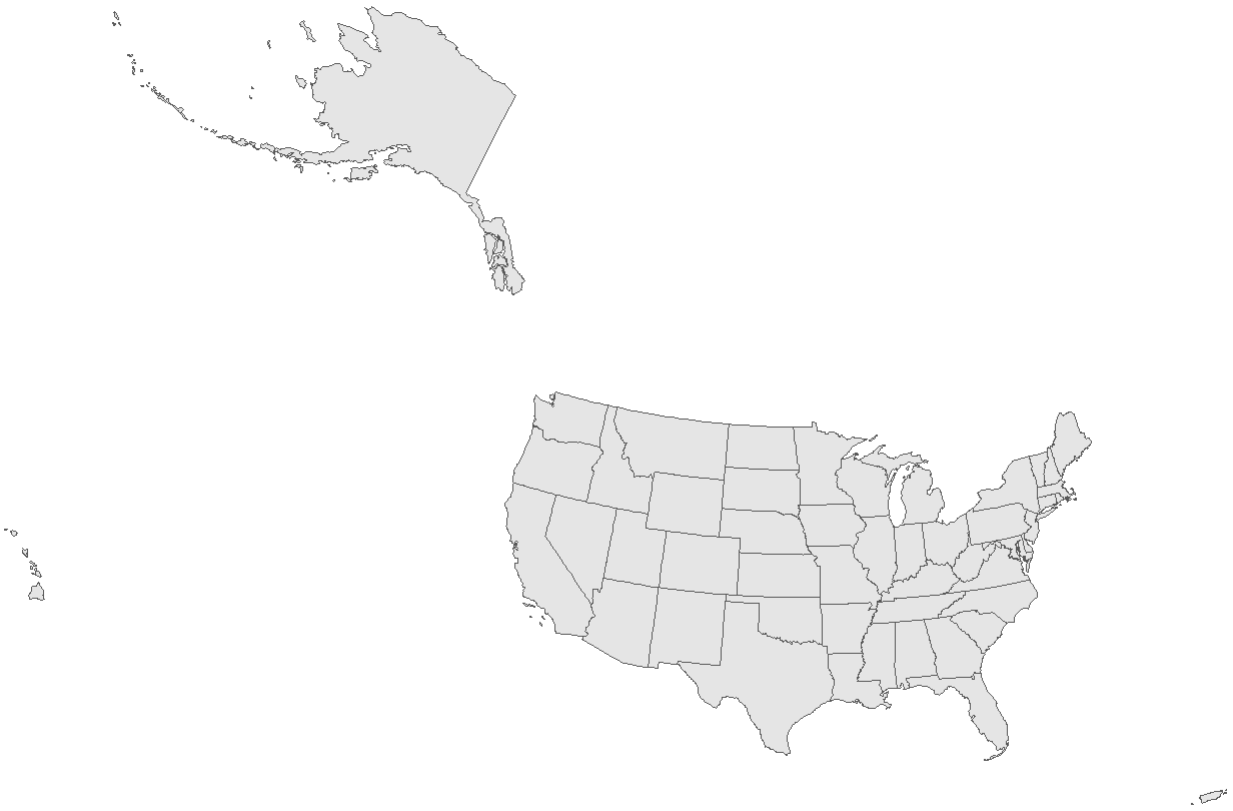

```
ggplot(fl_counties) +
  geom_sf() +
  coord_sf(crs = 3087, datum = 3087)
```



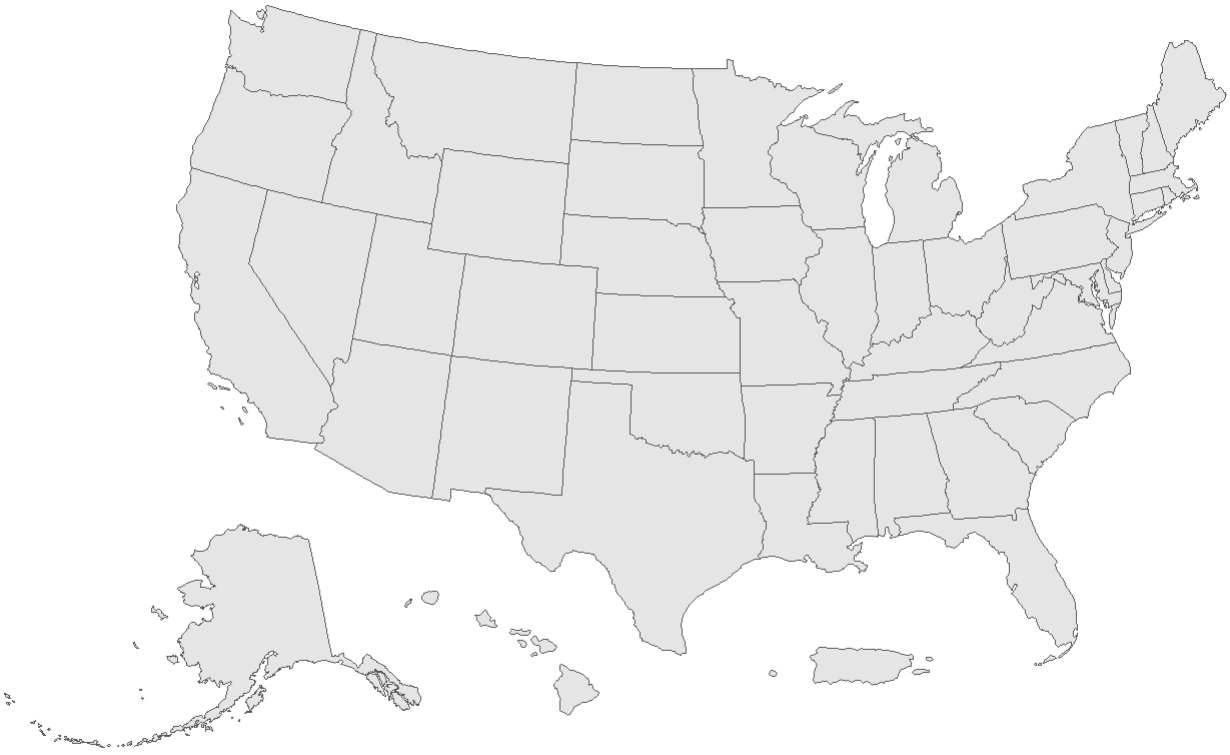

# Working with geometries

```
us_states <- states(cb = TRUE, resolution = "20m")

ggplot(us_states) +
  geom_sf() +
  theme_void()
```

```
ggplot(us_states) +
  geom_sf() +
  coord_sf(crs = 'ESRI:102003') +
  theme_void()
```

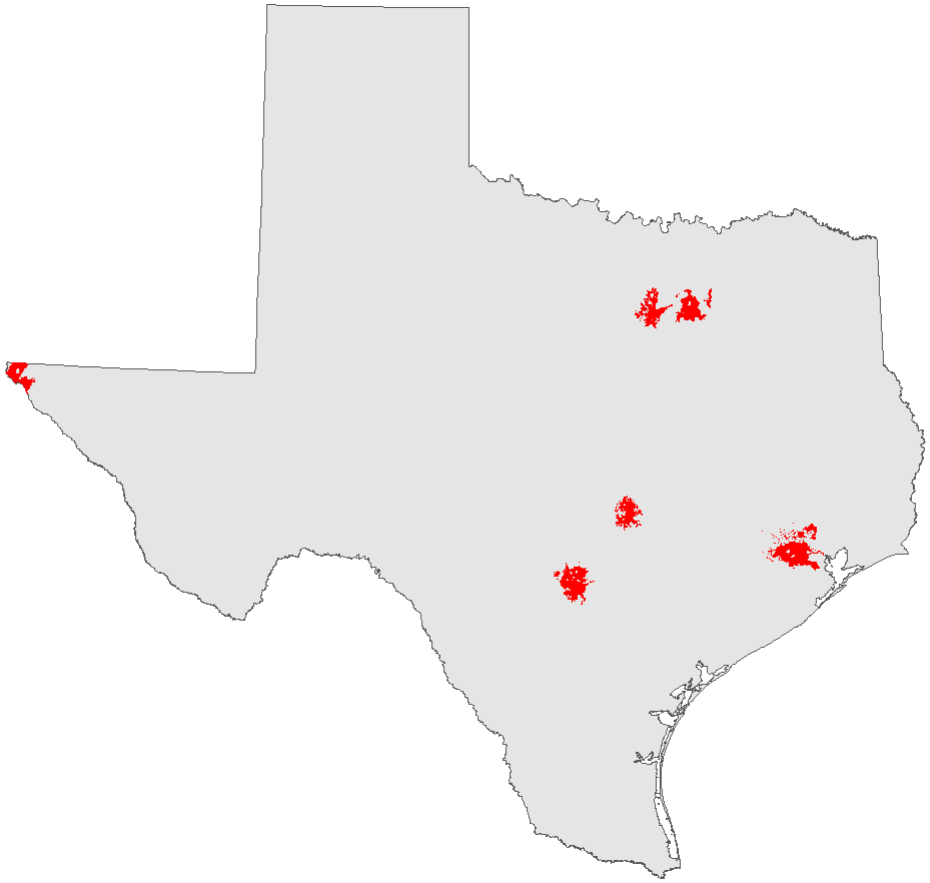


```
us_states_shifted <- shift_geometry(us_states)

ggplot(us_states_shifted) +
  geom_sf() +
  theme_void()
```



```
us_states_outside <- shift_geometry(us_states,
                                    preserve_area = TRUE,
                                    position = "outside")

ggplot(us_states_outside) +
  geom_sf() +
  theme_void()
```

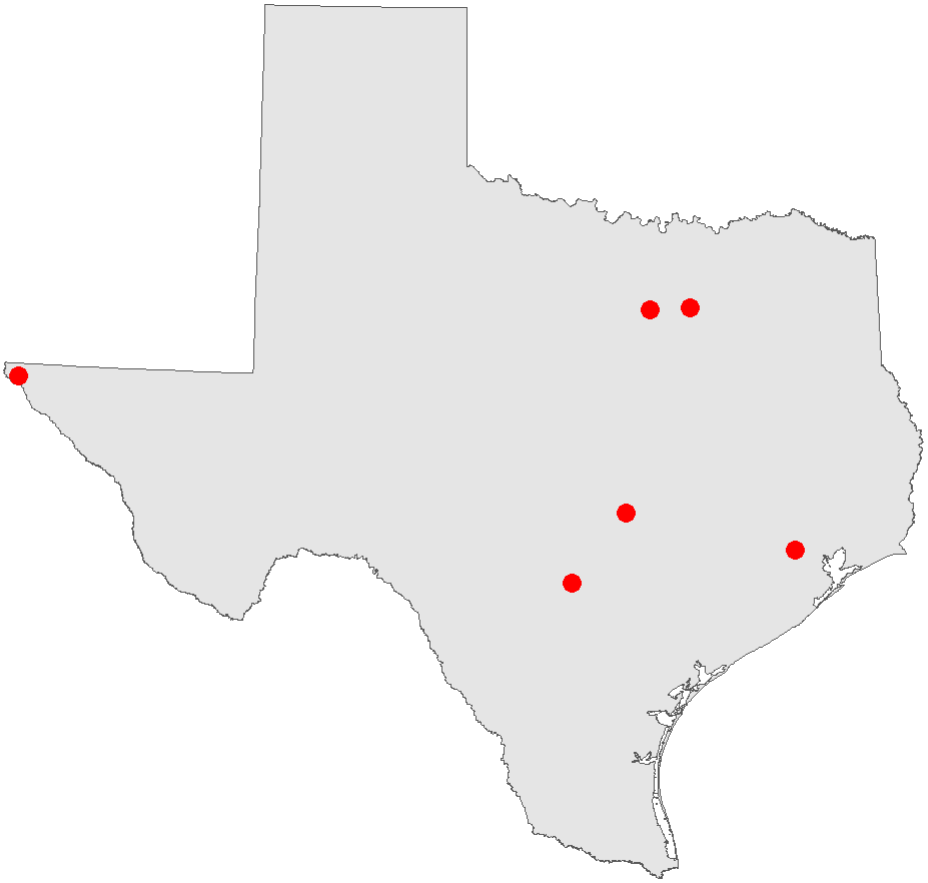
```
tx_places <- places("TX", cb = TRUE) %>%
  filter(NAME %in% c("Dallas", "Fort Worth", "Houston",
                     "Austin", "San Antonio", "El Paso")) %>%
  st_transform(6580)

tx_outline <- states(cb = TRUE) %>%
  filter(NAME == "Texas") %>%
  st_transform(6580)

ggplot() +
  geom_sf(data = tx_outline) +
  geom_sf(data = tx_places, fill = "red", color = NA) +
  theme_void()
```



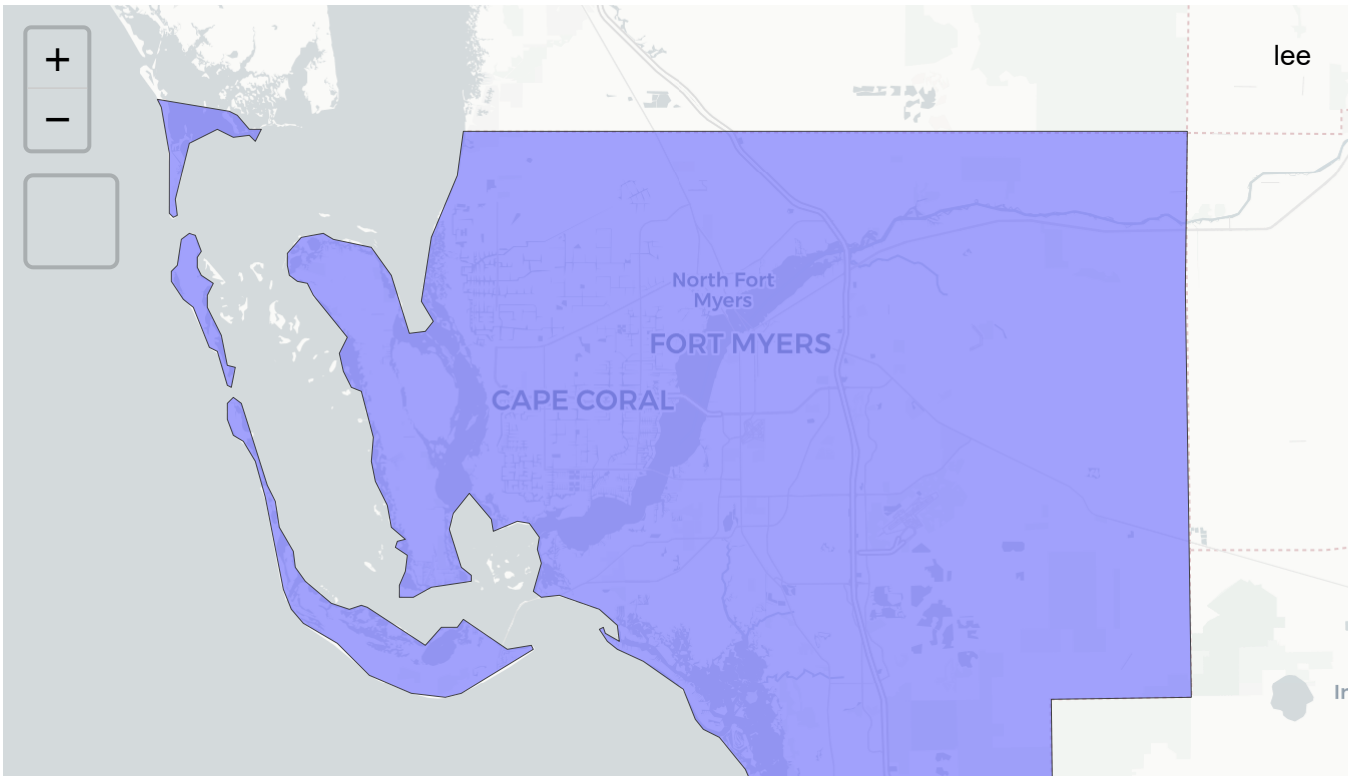
```
tx_centroids <- st_centroid(tx_places)
```

```
## Warning in st_centroid.sf(tx_places): st_centroid assumes attributes are
## constant over geometries of x
```

```
ggplot() +
  geom_sf(data = tx_outline) +
  geom_sf(data = tx_centroids, color = "red", size = 3) +
  theme_void()
```



```
lee <- fl_projected %>%
  filter(NAME == "Lee")

mapview(lee)
```




```
lee
```

```
## Simple feature collection with 1 feature and 12 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: 571477.3 ymin: 258767.6 xmax: 642721.2 ymax: 310583.5
## Projected CRS: NAD83(HARN) / Florida GDL Albers
##   STATEFP COUNTYFP COUNTYNS       AFFGEOID GEOID NAME   NAMELSAD STUSPS
## 1      12      071 00295758 0500000US12071 12071  Lee Lee County     FL
##   STATE_NAME LSAD      ALAND     AWATER                       geometry
## 1    Florida   06 2022803065 1900583561 MULTIPOLYGON (((580415.6 30...
```

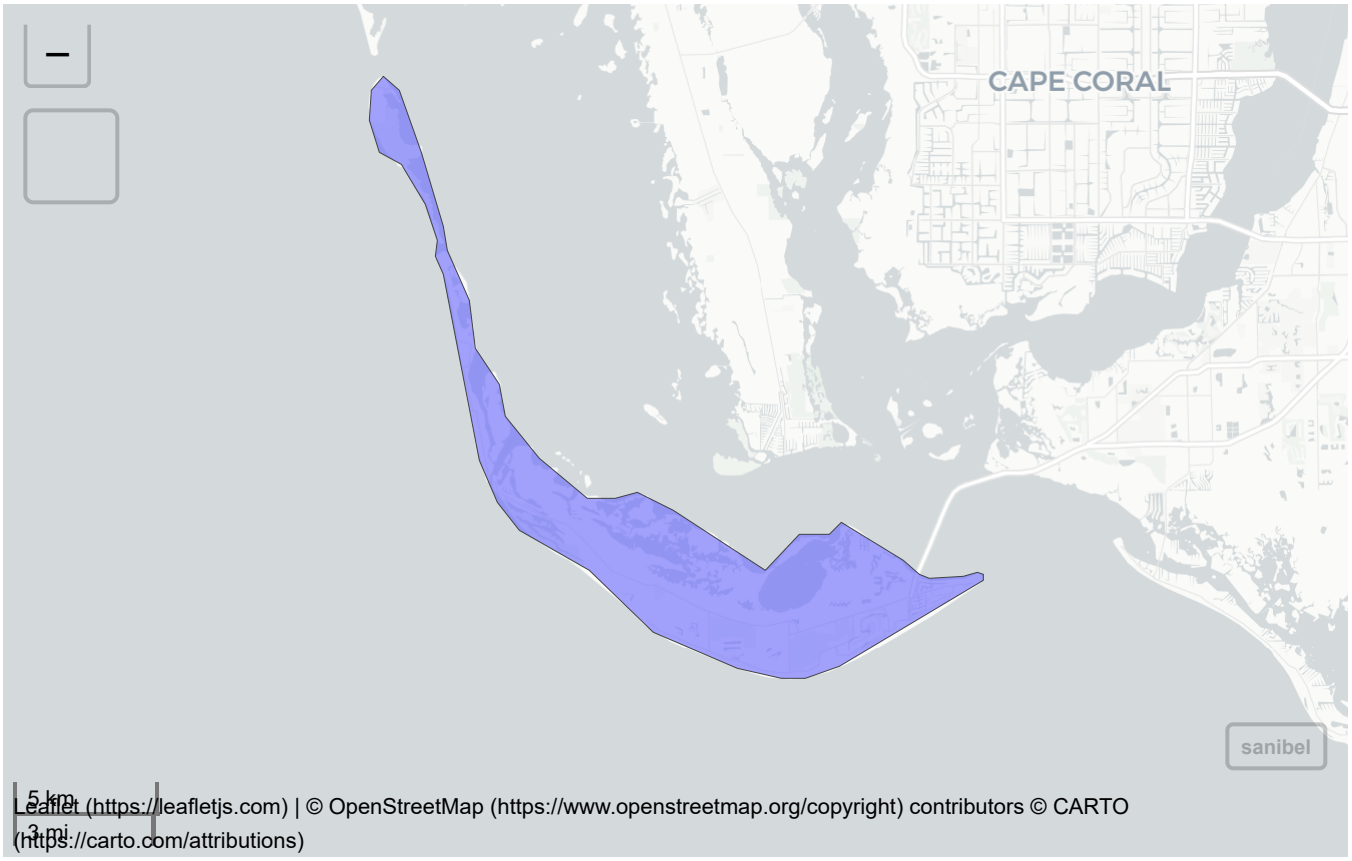
```
lee_singlepart <- st_cast(lee, "POLYGON")
```

```
## Warning in st_cast.sf(lee, "POLYGON"): repeating attributes for all
## sub-geometries for which they may not be constant
```

```
lee_singlepart
```

```
## Simple feature collection with 4 features and 12 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: 571477.3 ymin: 258767.6 xmax: 642721.2 ymax: 310583.5
## Projected CRS: NAD83(HARN) / Florida GDL Albers
##     STATEFP COUNTYFP COUNTYNS       AFFGEOID GEOID NAME   NAMELSAD STUSPS
## 1        12      071 00295758 0500000US12071 12071  Lee Lee County     FL
## 1.1      12      071 00295758 0500000US12071 12071  Lee Lee County     FL
## 1.2      12      071 00295758 0500000US12071 12071  Lee Lee County     FL
## 1.3      12      071 00295758 0500000US12071 12071  Lee Lee County     FL
##     STATE_NAME LSAD      ALAND     AWATER                         geometry
## 1      Florida   06 2022803065 1900583561 POLYGON ((580415.6 300219.1...
## 1.1    Florida   06 2022803065 1900583561 POLYGON ((576540.7 289935.2...
## 1.2    Florida   06 2022803065 1900583561 POLYGON ((572595.7 298880.5...
## 1.3    Florida   06 2022803065 1900583561 POLYGON ((571477.3 310583, ...
```

```
sanibel <- lee_singlepart[2,]

mapview(sanibel)
```


CAPE CORAL
sanibel
5 km
3 mi
Leaflet (https://leafletjs.com) | © OpenStreetMap (https://www.openstreetmap.org/copyright) contributors © CARTO (https://carto.com/attributions)

# Mapping Census data with R

Ram Mandava

2023-02-25

```
library(tidycensus)
```

```
## Warning: package 'tidycensus' was built under R version 4.2.2
```

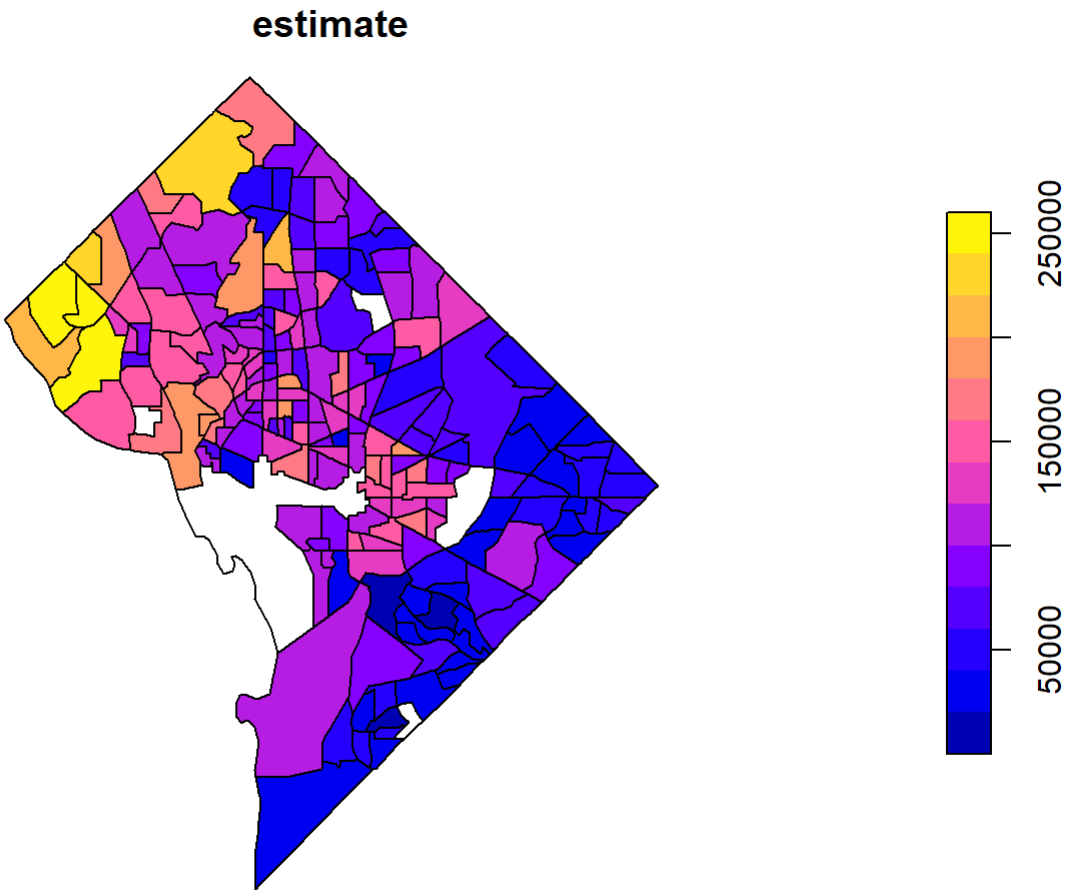
```
options(tigris_use_cache = TRUE)

dc_income <- get_acs(
  geography = "tract",
  variables = "B19013_001",
  state = "DC",
  year = 2020,
  geometry = TRUE
)
```

```
## Getting data from the 2016-2020 5-year ACS
```

```
dc_income
```

```
## Simple feature collection with 206 features and 5 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -77.11976 ymin: 38.79165 xmax: -76.9094 ymax: 38.99511
## Geodetic CRS:  NAD83
## First 10 features:
##          GEOID                                                       NAME
## 1  11001001702 Census Tract 17.02, District of Columbia, District of Columbia
## 2  11001002400    Census Tract 24, District of Columbia, District of Columbia
## 3  11001004100    Census Tract 41, District of Columbia, District of Columbia
## 4  11001006801 Census Tract 68.01, District of Columbia, District of Columbia
## 5  11001004300    Census Tract 43, District of Columbia, District of Columbia
## 6  11001007703 Census Tract 77.03, District of Columbia, District of Columbia
## 7  11001009801 Census Tract 98.01, District of Columbia, District of Columbia
## 8  11001009302 Census Tract 93.02, District of Columbia, District of Columbia
## 9  11001009903 Census Tract 99.03, District of Columbia, District of Columbia
## 10 11001005601 Census Tract 56.01, District of Columbia, District of Columbia
##      variable estimate   moe                       geometry
## 1  B19013_001   115000 17568 POLYGON ((-77.02286 38.9735...
## 2  B19013_001   111061 11613 POLYGON ((-77.0266 38.94613...
## 3  B19013_001   160313 20743 POLYGON ((-77.0582 38.91768...
## 4  B19013_001   109863 24472 POLYGON ((-76.98364 38.8898...
## 5  B19013_001   112197 16880 POLYGON ((-77.0365 38.91629...
## 6  B19013_001    46156 24087 POLYGON ((-76.9575 38.88363...
## 7  B19013_001    13510  6580 POLYGON ((-77.00386 38.8309...
## 8  B19013_001    91576 26095 POLYGON ((-76.99494 38.9239...
## 9  B19013_001    61172 27092 POLYGON ((-76.93005 38.8898...
## 10 B19013_001    67840  4603 POLYGON ((-77.05756 38.9027...
```

```
plot(dc_income["estimate"])
```




```
library(tidycensus)
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 4.2.2
```

```
## ── Attaching packages ─────────────────────────────────────── tidyverse 1.3.2 ──
## ✓ ggplot2 3.4.1      ✓ purrr   1.0.1
## ✓ tibble  3.1.8      ✓ dplyr   1.0.10
## ✓ tidyr   1.3.0      ✓ stringr 1.5.0
## ✓ readr   2.1.3      ✓ forcats 1.0.0
```

```
## Warning: package 'ggplot2' was built under R version 4.2.2
```

```
## Warning: package 'tidyr' was built under R version 4.2.2
```

```
## Warning: package 'readr' was built under R version 4.2.2
```

```
## Warning: package 'purrr' was built under R version 4.2.2
```

```
## Warning: package 'stringr' was built under R version 4.2.2
```

```
## Warning: package 'forcats' was built under R version 4.2.2
```

```
## ── Conflicts ─────────────────────────────────────── tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
```

```
library(tigris)
```

```
## Warning: package 'tigris' was built under R version 4.2.2
```

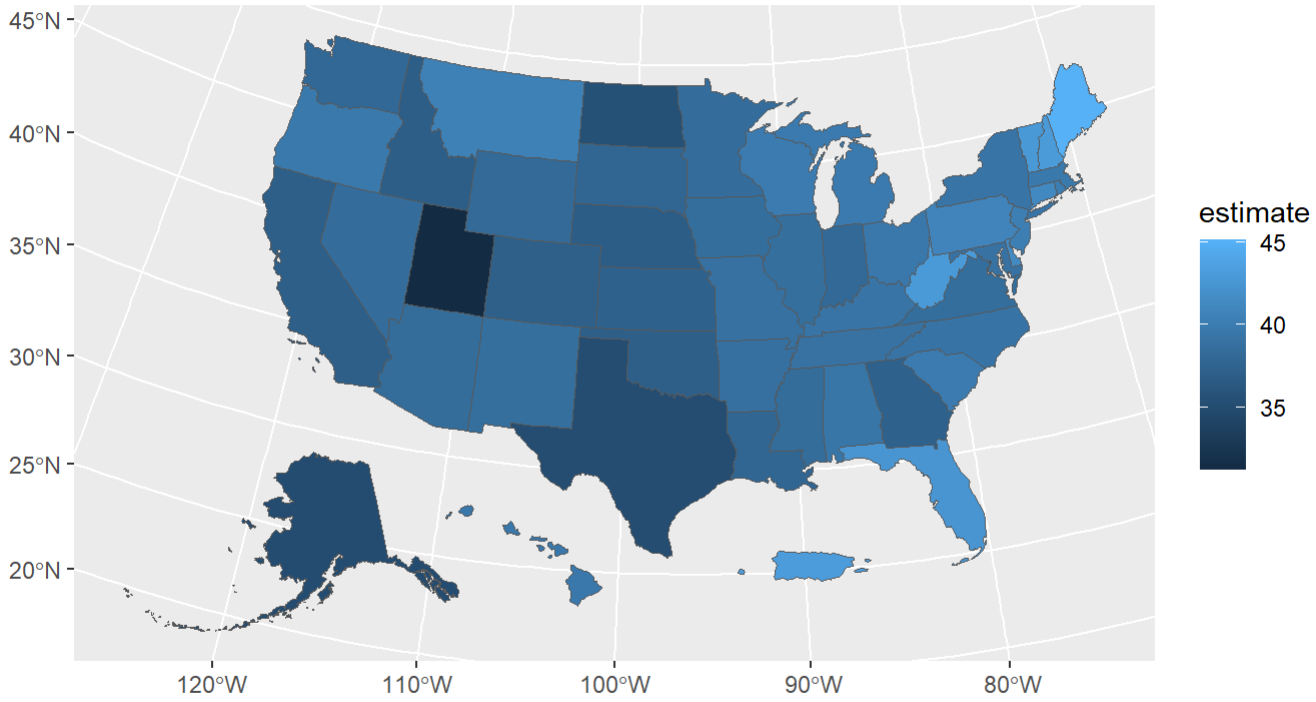
```
## To enable caching of data, set `options(tigris_use_cache = TRUE)`
## in your R script or .Rprofile.
```

```
us_median_age <- get_acs(
  geography = "state",
  variables = "B01002_001",
  year = 2019,
  survey = "acs1",
  geometry = TRUE,
  resolution = "20m"
) %>%
  shift_geometry()
```

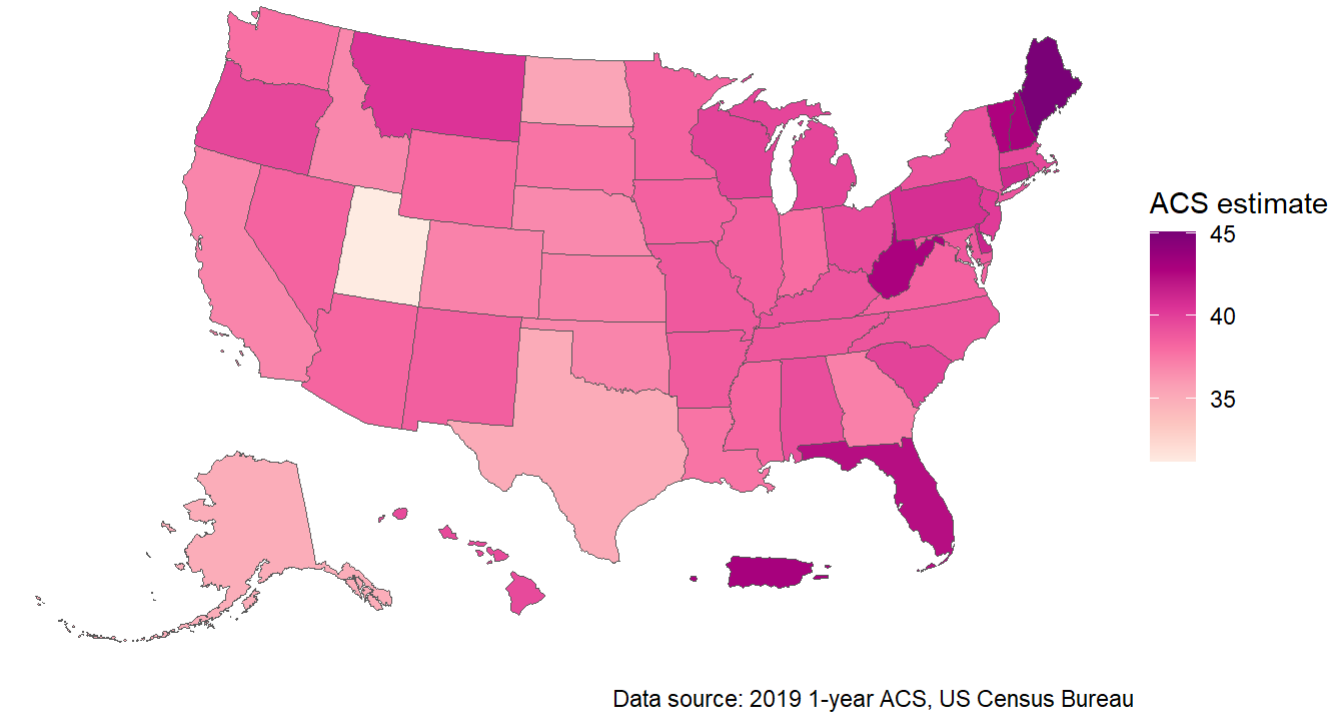
```
## Getting data from the 2019 1-year ACS
## The 1-year ACS provides data for geographies with populations of 65,000 and greater.
```

```
plot(us_median_age$geometry)
```

```
ggplot(data = us_median_age, aes(fill = estimate)) +
  geom_sf()
```




```
ggplot(data = us_median_age, aes(fill = estimate)) +
  geom_sf() +
  scale_fill_distiller(palette = "RdPu",
                       direction = 1) +
  labs(title = "  Median Age by State, 2019",
       caption = "Data source: 2019 1-year ACS, US Census Bureau",
       fill = "ACS estimate") +
  theme_void()
```




```
hennepin_race <- get_decennial(
  geography = "tract",
  state = "MN",
  county = "Hennepin",
  variables = c(
    Hispanic = "P2_002N",
    White = "P2_005N",
    Black = "P2_006N",
    Native = "P2_007N",
    Asian = "P2_008N"
  ),
  summary_var = "P2_001N",
  year = 2020,
  geometry = TRUE
) %>%
  mutate(percent = 100 * (value / summary_value))
```

```
## Getting data from the 2020 decennial Census
```

```
## Using the PL 94-171 Redistricting Data summary file
```

```
## Note: 2020 decennial Census data use differential privacy, a technique that
## introduces errors into data to preserve respondent confidentiality.
## ℹ Small counts should be interpreted with caution.
## ℹ See https://www.census.gov/library/fact-sheets/2021/protecting-the-confidentiality-of-the-2
020-census-redistricting-data.html for additional guidance.
## This message is displayed once per session.
```

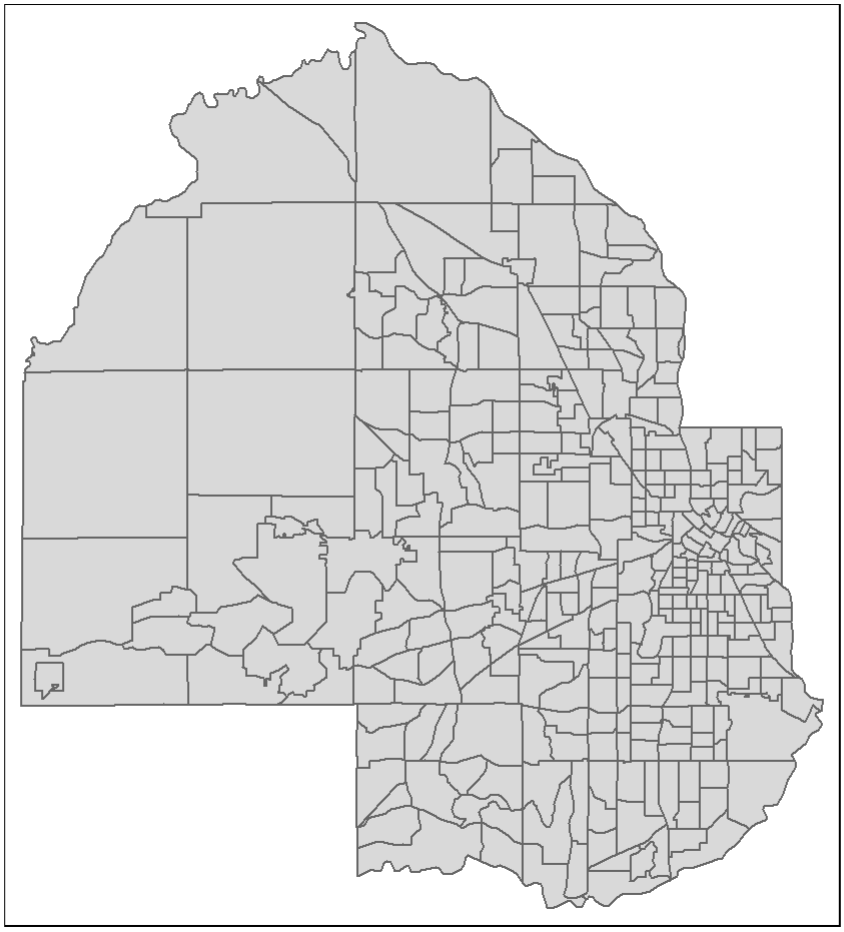
```
hennepin_race
```

```
## Simple feature collection with 1645 features and 6 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -93.76838 ymin: 44.78538 xmax: -93.17722 ymax: 45.24662
## Geodetic CRS:  NAD83
## # A tibble: 1,645 × 7
##    GEOID       NAME      varia…¹ value summa…²                   geometry percent
##  * <chr>       <chr>     <chr>   <dbl>   <dbl>        <MULTIPOLYGON [°]>   <dbl>
##  1 27053025802 Census T… Hispan…   124    2443 (((-93.3194 44.80474, -9…   5.08
##  2 27053025802 Census T… White    2028    2443 (((-93.3194 44.80474, -9…  83.0
##  3 27053025802 Census T… Black      61    2443 (((-93.3194 44.80474, -9…   2.50
##  4 27053025802 Census T… Native      7    2443 (((-93.3194 44.80474, -9…   0.287
##  5 27053025802 Census T… Asian      90    2443 (((-93.3194 44.80474, -9…   3.68
##  6 27053020600 Census T… Hispan…   391    2404 (((-93.30335 45.06204, -…  16.3
##  7 27053020600 Census T… White     960    2404 (((-93.30335 45.06204, -…  39.9
##  8 27053020600 Census T… Black     406    2404 (((-93.30335 45.06204, -…  16.9
##  9 27053020600 Census T… Native     13    2404 (((-93.30335 45.06204, -…   0.541
## 10 27053020600 Census T… Asian     476    2404 (((-93.30335 45.06204, -…  19.8
## # … with 1,635 more rows, and abbreviated variable names ¹variable,
## #   ²summary_value
```

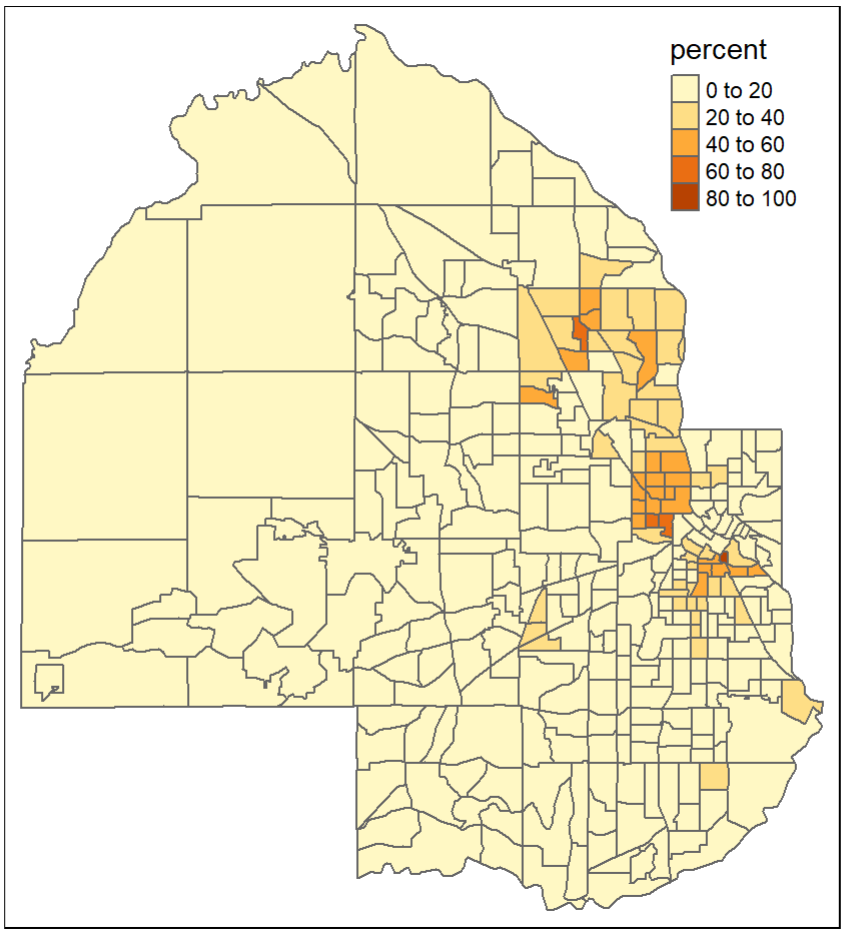
```
library(tmap)
```

```
## Warning: package 'tmap' was built under R version 4.2.2
```

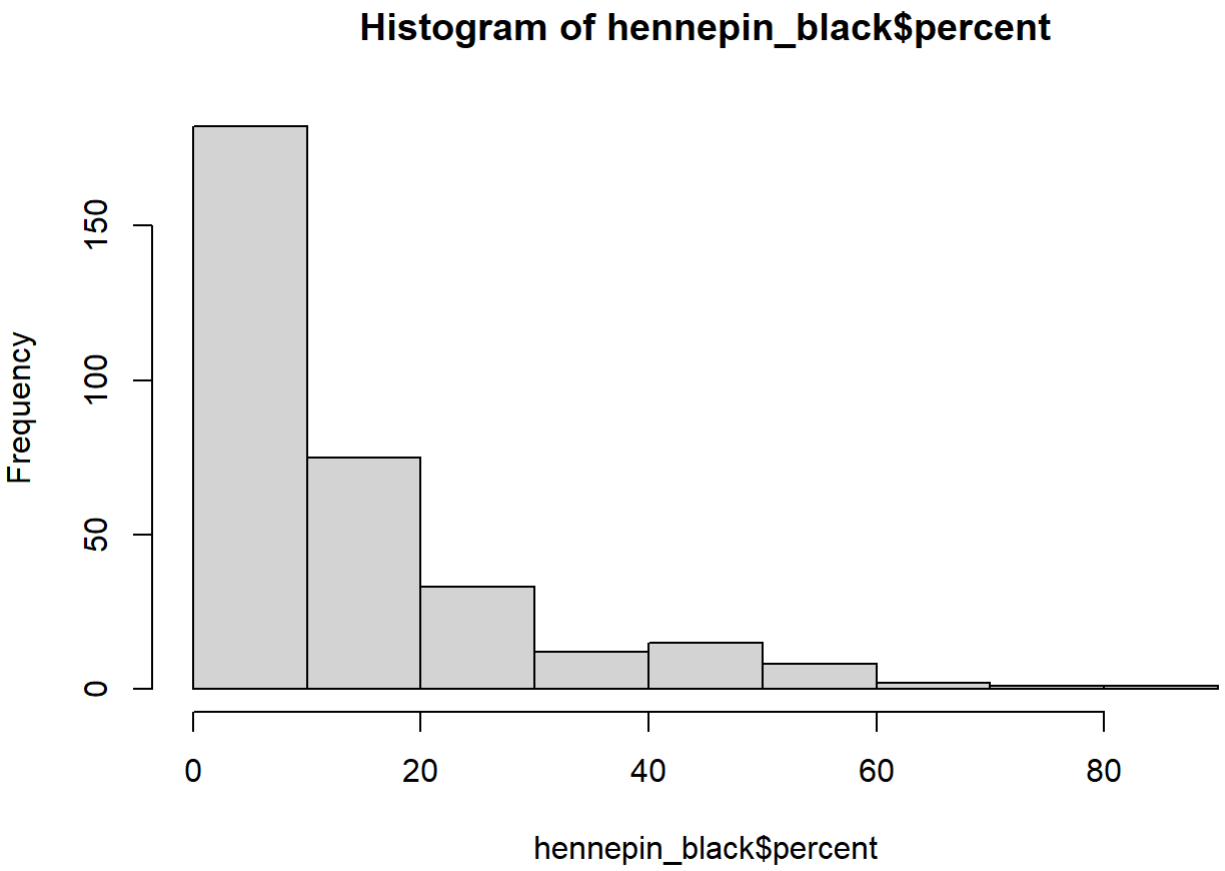
```
hennepin_black <- filter(hennepin_race,
                         variable == "Black")

tm_shape(hennepin_black) +
  tm_polygons()
```



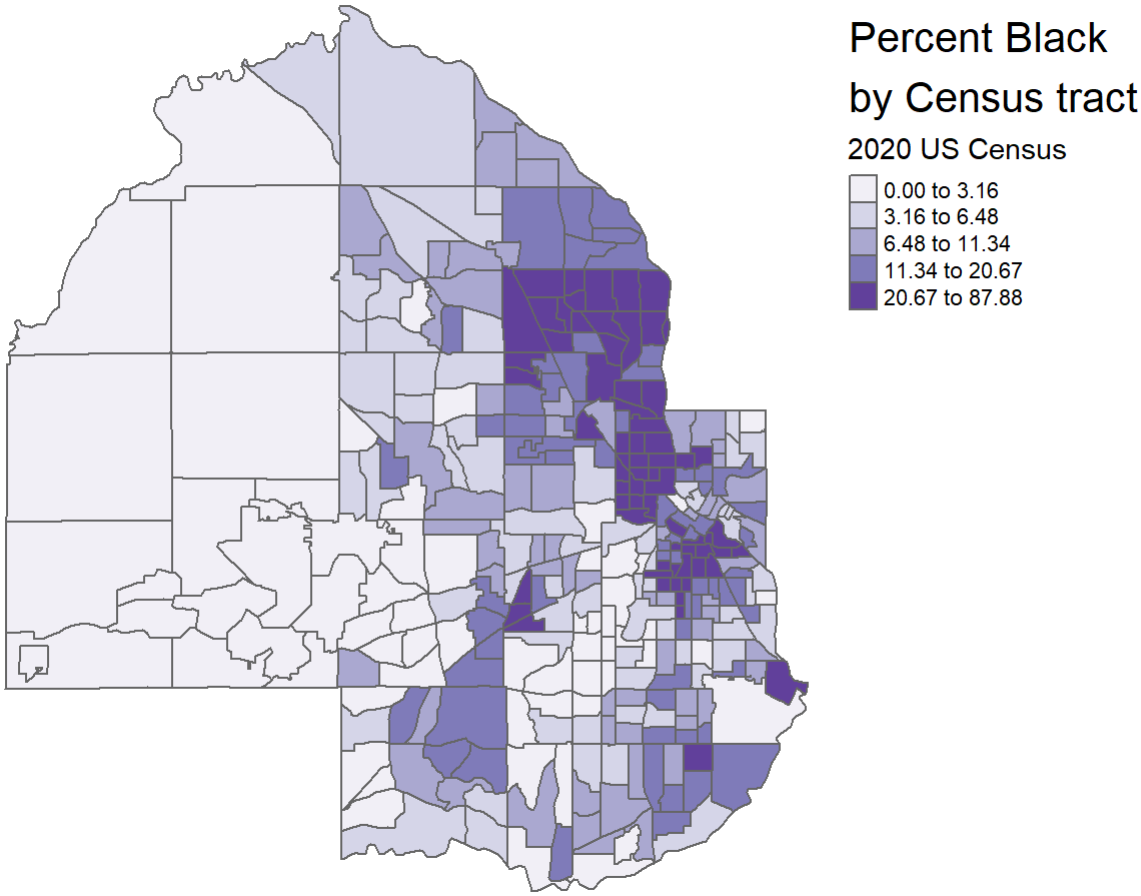
```
tm_shape(hennepin_black) +
  tm_polygons(col = "percent")
```




```
hist(hennepin_black$percent)
```

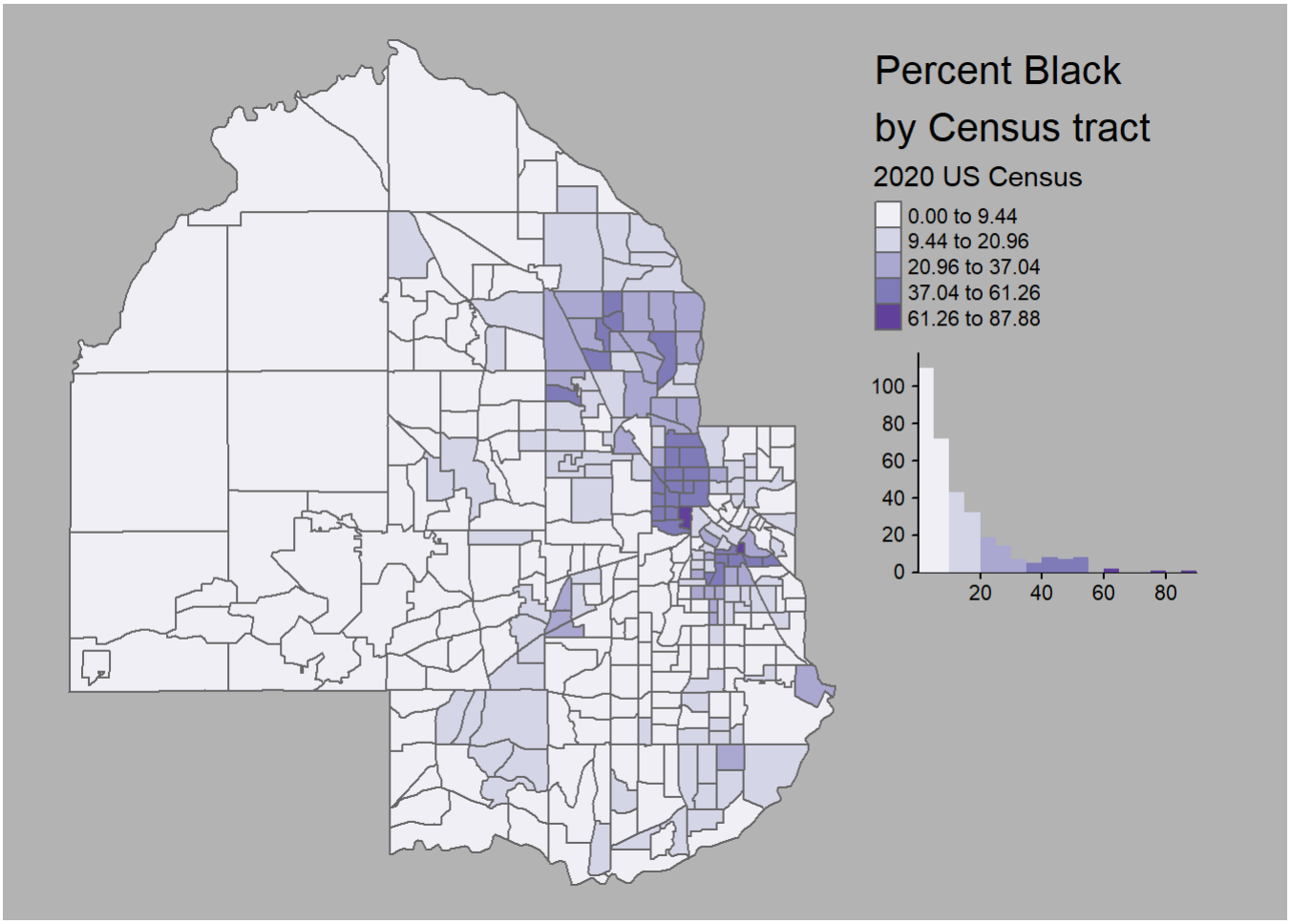



```
tm_shape(hennepin_black) +
  tm_polygons(col = "percent",
          style = "quantile",
          n = 5,
          palette = "Purples",
          title = "2020 US Census") +
  tm_layout(title = "Percent Black\nby Census tract",
            frame = FALSE,
            legend.outside = TRUE)
```




```
tm_shape(hennepin_black) +
  tm_polygons(col = "percent",
          style = "jenks",
          n = 5,
          palette = "Purples",
          title = "2020 US Census",
          legend.hist = TRUE) +
  tm_layout(title = "Percent Black\nby Census tract",
            frame = FALSE,
            legend.outside = TRUE,
            bg.color = "grey70",
            legend.hist.width = 5,
            fontfamily = "Verdana")
```

```
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database

## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database

## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database
```




```
library(mapboxapi)
```

```
## Warning: package 'mapboxapi' was built under R version 4.2.2
```

```
## Usage of the Mapbox APIs is governed by the Mapbox Terms of Service.
## Please visit https://www.mapbox.com/legal/tos/ for more information.
```

```
# Replace with your token below
#mb_access_token("pk.eyJ1Ijoicm1hbmRhdjEiLCJhIjoiY2xlajI2MW0yMDZicTN3bzZpcGlsY3BkNSJ9.Whmm4y5CHEoabgwMae5DzA")
```

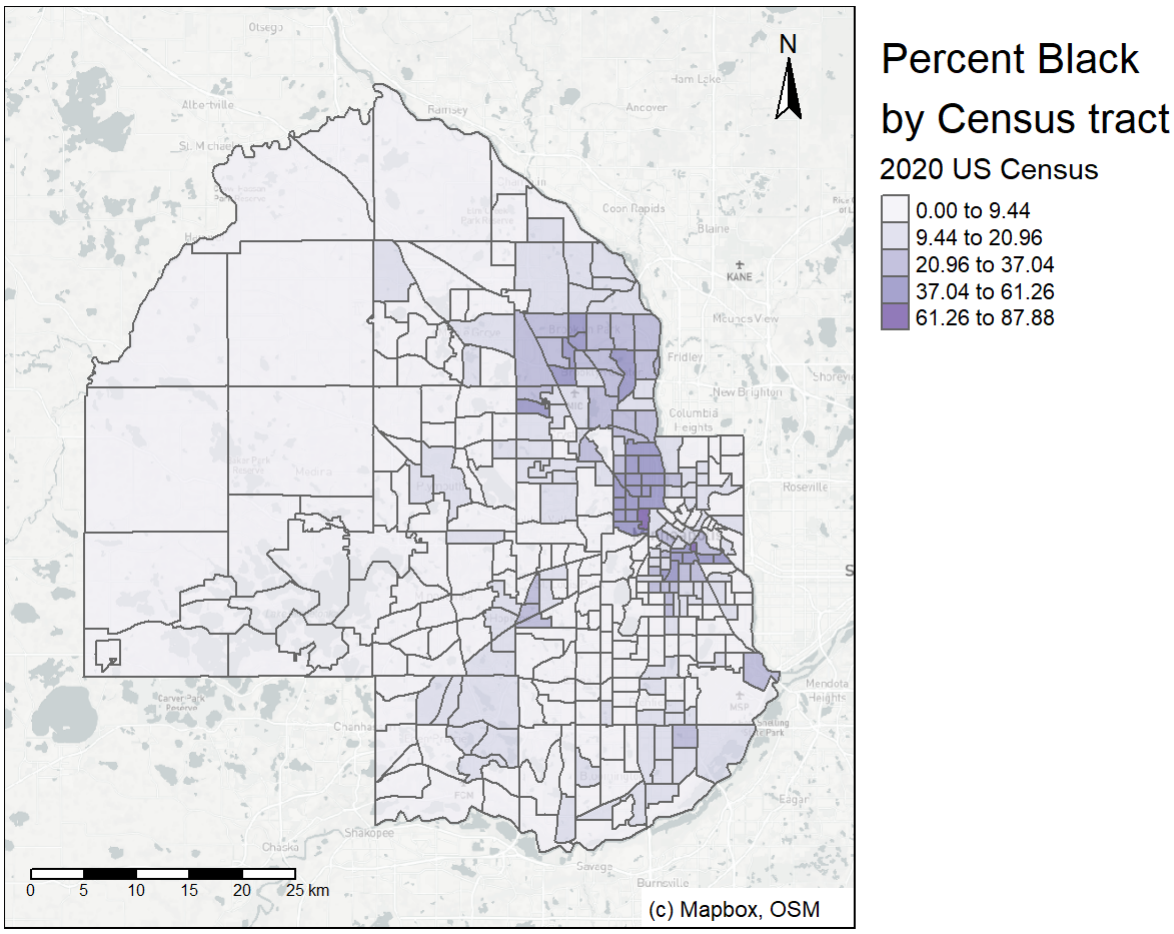
```
# If you don't have a Mapbox style to use, replace style_id with "light-v9"
# and username with "mapbox".  If you do, replace those arguments with your
# style ID and user name.
hennepin_tiles <- get_static_tiles(
  location = hennepin_black,
  zoom = 10,
  style_id = "light-v9",
  username = "mapbox"
)
```

```
## Attribution is required if using Mapbox tiles on a map.
## Add the text '(c) Mapbox, (c) OpenStreetMap' to your map for proper attribution.
```

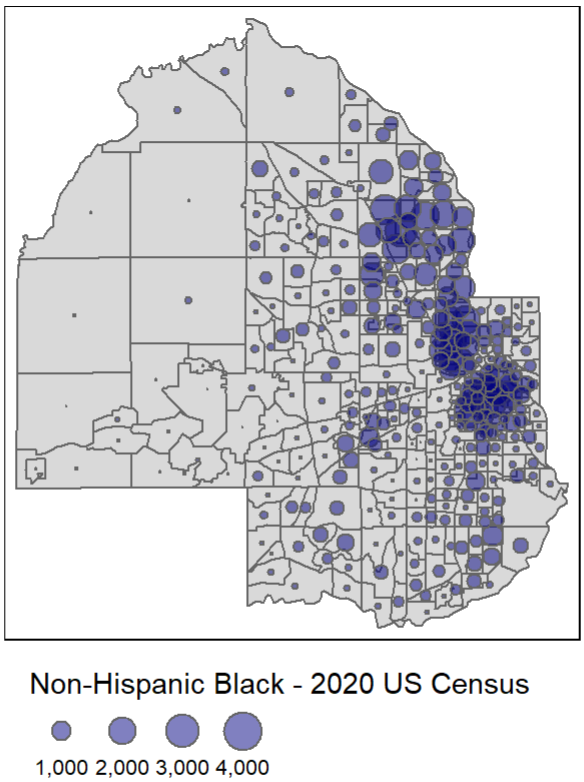
```
tm_shape(hennepin_tiles) +
  tm_rgb() +
  tm_shape(hennepin_black) +
  tm_polygons(col = "percent",
          style = "jenks",
          n = 5,
          palette = "Purples",
          title = "2020 US Census",
          alpha = 0.7) +
  tm_layout(title = "Percent Black\nby Census tract",
            legend.outside = TRUE,
            fontfamily = "Verdana") +
  tm_scale_bar(position = c("left", "bottom")) +
  tm_compass(position = c("right", "top")) +
  tm_credits("(c) Mapbox, OSM    ",
             bg.color = "white",
             position = c("RIGHT", "BOTTOM"))
```

```
## stars object downsampled to 960 by 1040 cells. See tm_shape manual (argument raster.downsampl
e)
```

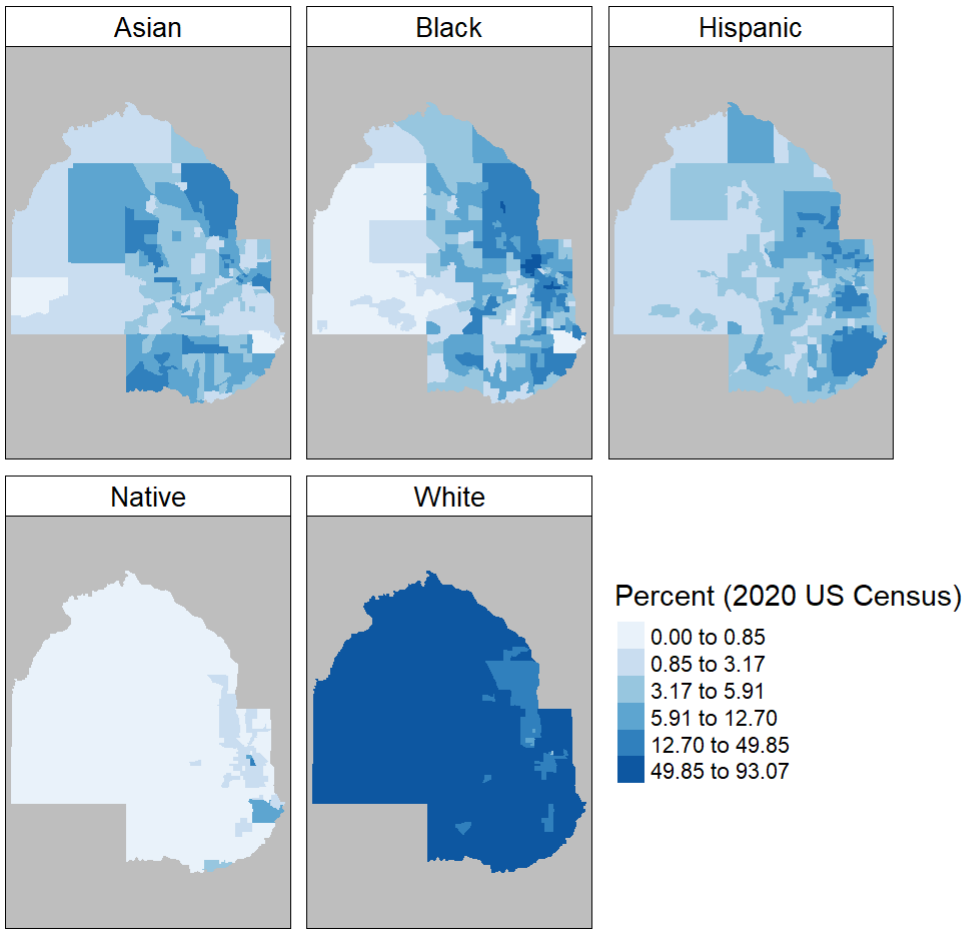
```
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database

## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database

## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database

## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database

## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database

## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database
```




```
tm_shape(hennepin_black) +
  tm_polygons() +
  tm_bubbles(size = "value", alpha = 0.5,
             col = "navy",
             title.size = "Non-Hispanic Black - 2020 US Census") +
  tm_layout(legend.outside = TRUE,
            legend.outside.position = "bottom")
```

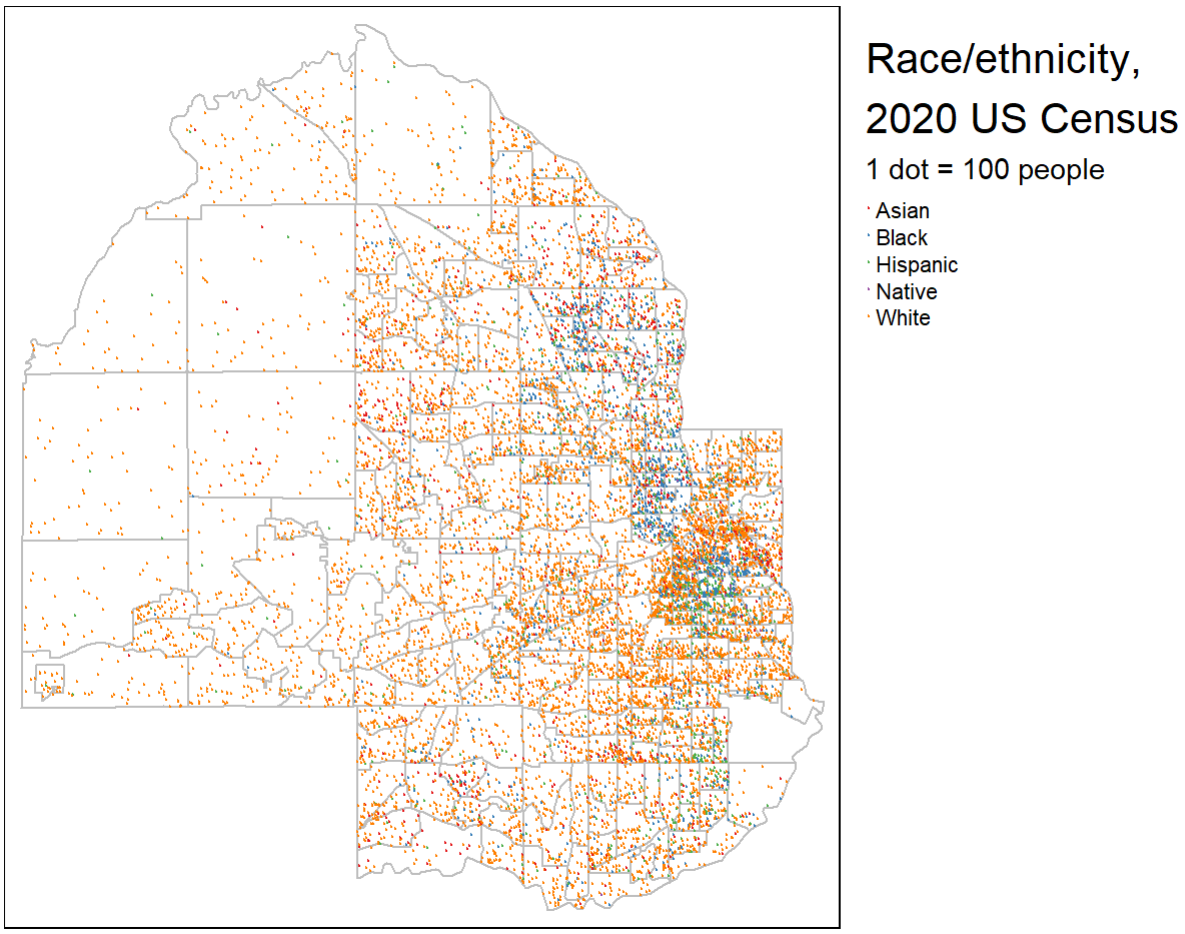



```
tm_shape(hennepin_race) +
  tm_facets(by = "variable", scale.factor = 4) +
  tm_fill(col = "percent",
          style = "quantile",
          n = 6,
          palette = "Blues",
          title = "Percent (2020 US Census)",) +
  tm_layout(bg.color = "grey",
            legend.position = c(-0.7, 0.15),
            panel.label.bg.color = "white")
```




```
hennepin_dots <- hennepin_race %>%
  as_dot_density(
    value = "value",
    values_per_dot = 100,
    group = "variable"
  )
```

```
background_tracts <- filter(hennepin_race, variable == "White")

tm_shape(background_tracts) +
  tm_polygons(col = "white",
              border.col = "grey") +
  tm_shape(hennepin_dots) +
  tm_dots(col = "variable",
          palette = "Set1",
          size = 0.005,
          title = "1 dot = 100 people") +
  tm_layout(legend.outside = TRUE,
            title = "Race/ethnicity,\n2020 US Census")
```




```
library(tidyverse)
library(tigris)

# Data source: https://cookpolitical.com/2020-national-popular-vote-tracker
vote2020 <- read_csv("data/us_vote_2020.csv")
```

```
## New names:
## Rows: 61 Columns: 22
## ── Column specification
## ──────────────────────────────────────────────────────── Delimiter: "," chr
## (10): state, called, final, dem_percent, rep_percent, other_percent, dem... dbl
## (7): EV, X, Y, State_num, Center_X, Center_Y, 2016 Margin num (4): dem_votes,
## rep_votes, other_votes, Total 2016 Votes lgl (1): ...20
## ℹ Use `spec()` to retrieve the full column specification for this data. ℹ
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## • `` -> `...20`
```

```
names(vote2020)
```

```
##  [1] "state"            "called"           "final"            "dem_votes"
##  [5] "rep_votes"        "other_votes"      "dem_percent"      "rep_percent"
##  [9] "other_percent"    "dem_this_margin"  "margin_shift"     "vote_change"
## [13] "stateid"          "EV"               "X"                "Y"
## [17] "State_num"        "Center_X"         "Center_Y"         "...20"
## [21] "2016 Margin"      "Total 2016 Votes"
```

```
us_states <- states(cb = TRUE, resolution = "20m") %>%
  filter(NAME != "Puerto Rico") %>%
  shift_geometry()
```

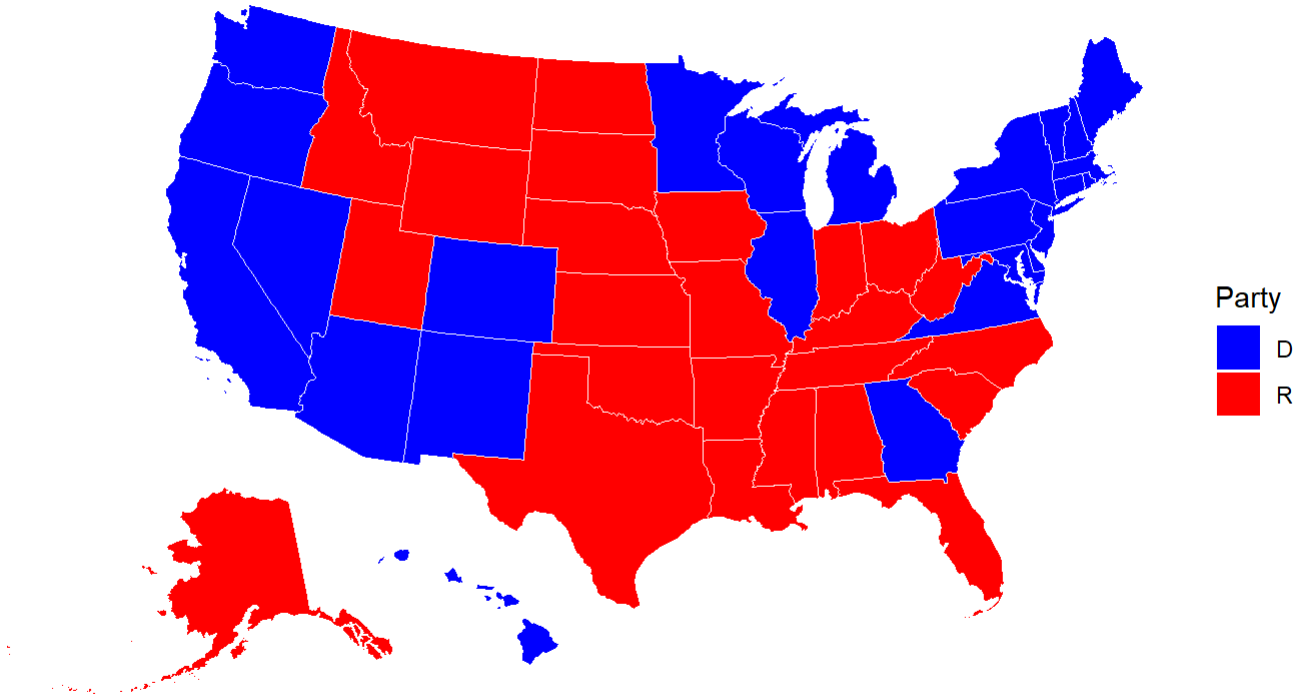
```
## Retrieving data for the year 2021
```

```
us_states_joined <- us_states %>%
  left_join(vote2020, by = c("NAME" = "state"))

table(is.na(us_states_joined$state))
```

```
##
## FALSE
##    51
```

```
ggplot(us_states_joined, aes(fill = called)) +
  geom_sf(color = "white", lwd = 0.2) +
  scale_fill_manual(values = c("blue", "red")) +
  theme_void() +
  labs(fill = "Party",
       title = " 2020 US presidential election results by state",
       caption = "Note: Nebraska and Maine split electoral college votes by congressional distri
ct")
```

2020 US presidential election results by state




Note: Nebraska and Maine split electoral college votes by congressional district

```
irs_data <- read_csv("https://www.irs.gov/pub/irs-soi/18zpallnoagi.csv")
```

```
## Rows: 27658 Columns: 153
## ── Column specification ────────────────────────────────────────────────────────
## Delimiter: ","
## chr   (3): STATEFIPS, STATE, ZIPCODE
## dbl (150): AGI_STUB, N1, MARS1, MARS2, MARS4, ELF, CPREP, PREP, DIR_DEP, N2,...
##
## ℹ Use `spec()` to retrieve the full column specification for this data.
## ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
ncol(irs_data)
```

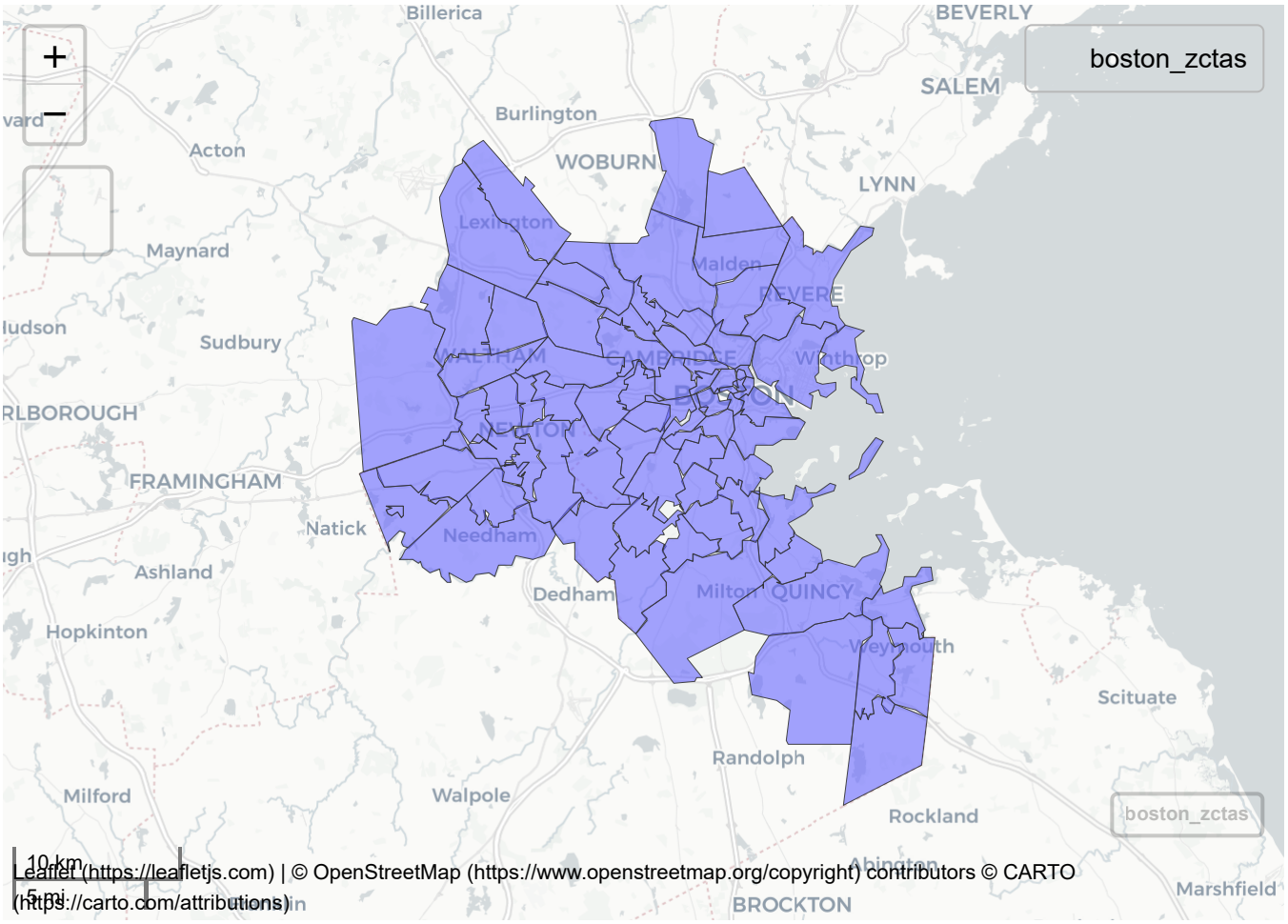
```
## [1] 153
```

```
self_employment <- irs_data %>%
  select(ZIPCODE, self_emp = N09400, total = N1)
```

```
library(mapview)
```

```
## Warning: package 'mapview' was built under R version 4.2.2
```

```
library(tigris)
options(tigris_use_cache = TRUE)

boston_zctas <- zctas(
  cb = TRUE,
  starts_with = c("021", "022", "024"),
  year = 2018
)

mapview(boston_zctas)
```

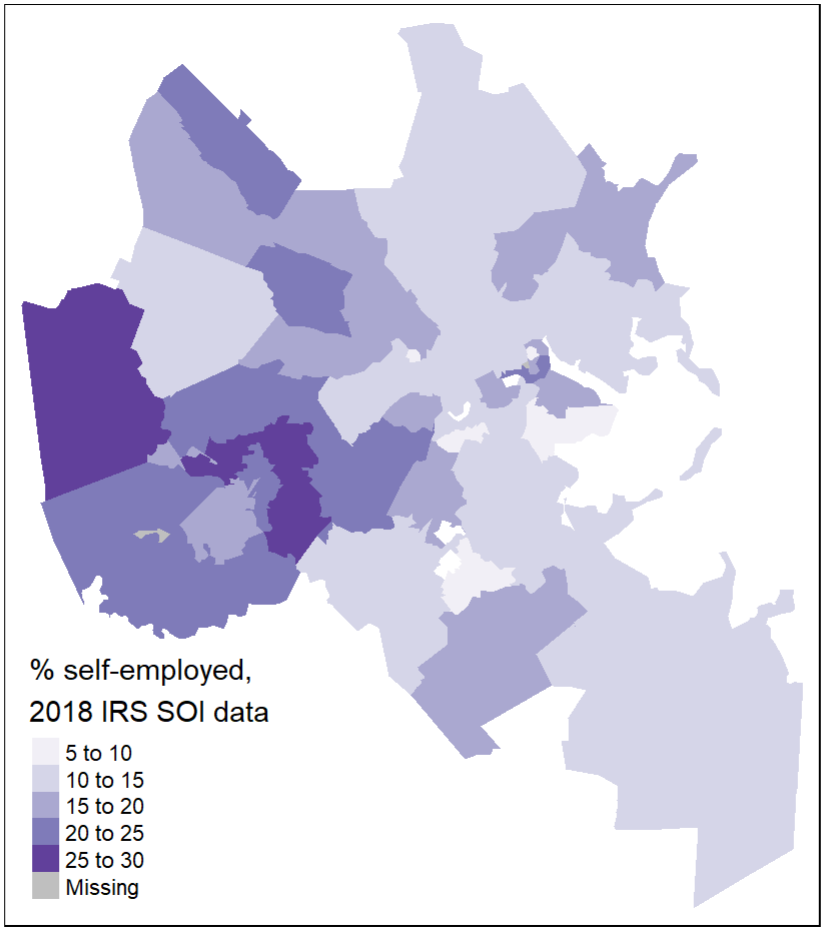



```
names(boston_zctas)
```

```
## [1] "ZCTA5CE10"  "AFFGEOID10" "GEOID10"    "ALAND10"    "AWATER10"
## [6] "geometry"
```

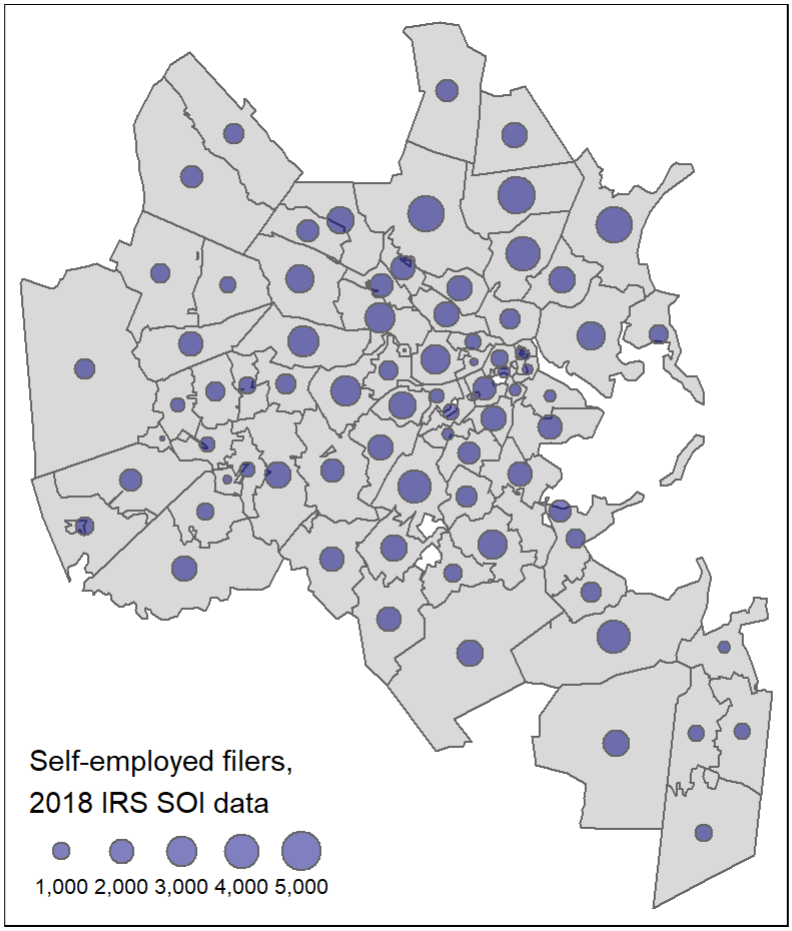
```
boston_se_data <- boston_zctas %>%
  left_join(self_employment, by = c("GEOID10" = "ZIPCODE")) %>%
  mutate(pct_self_emp = 100 * (self_emp / total)) %>%
  select(GEOID10, self_emp, pct_self_emp)
```

```
tm_shape(boston_se_data, projection = 26918) +
  tm_fill(col = "pct_self_emp",
          palette = "Purples",
          title = "% self-employed,\n2018 IRS SOI data")
```




```
tm_shape(boston_se_data) +
  tm_polygons() +
  tm_bubbles(size = "self_emp",
             alpha = 0.5,
             col = "navy",
             title.size = "Self-employed filers,\n2018 IRS SOI data")
```

```
## Legend labels were too wide. Therefore, legend.text.size has been set to 0.66. Increase legen
d.width (argument of tm_layout) to make the legend wider and therefore the labels larger.
```

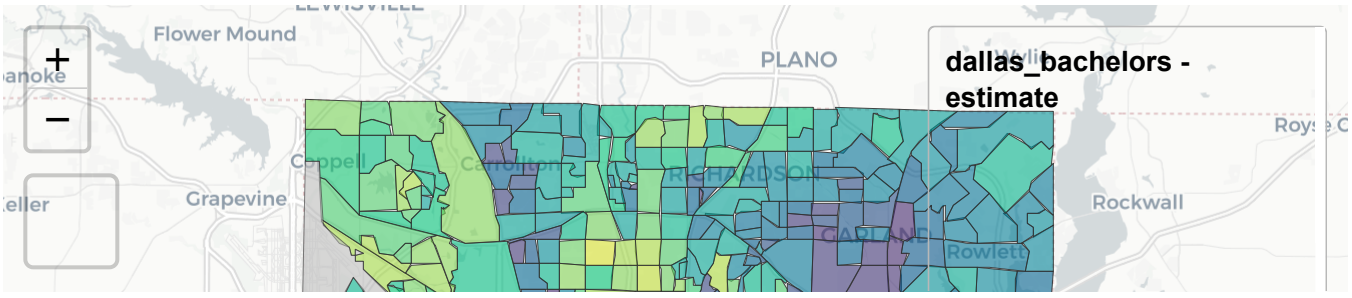


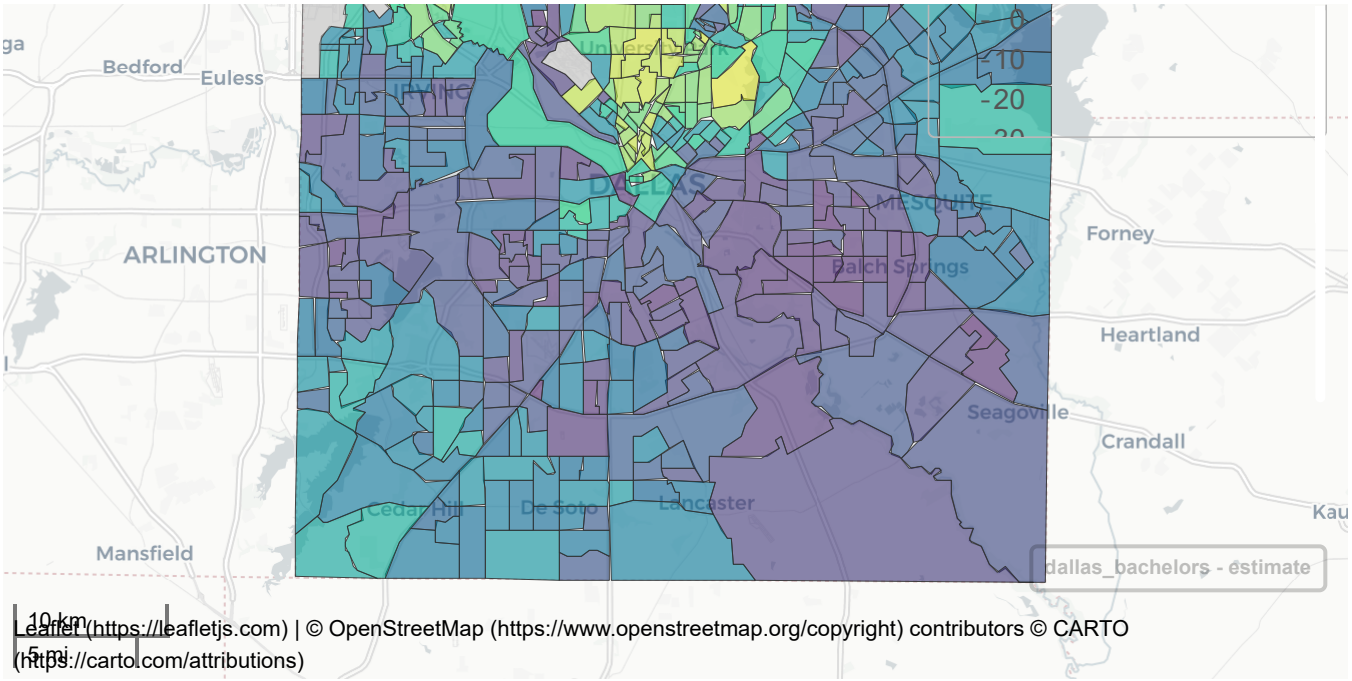

```
dallas_bachelors <- get_acs(
  geography = "tract",
  variables = "DP02_0068P",
  year = 2020,
  state = "TX",
  county = "Dallas",
  geometry = TRUE
)
```

```
## Getting data from the 2016-2020 5-year ACS
```

```
## Using the ACS Data Profile
```

```
library(mapview)
mapview(dallas_bachelors, zcol = "estimate")
```

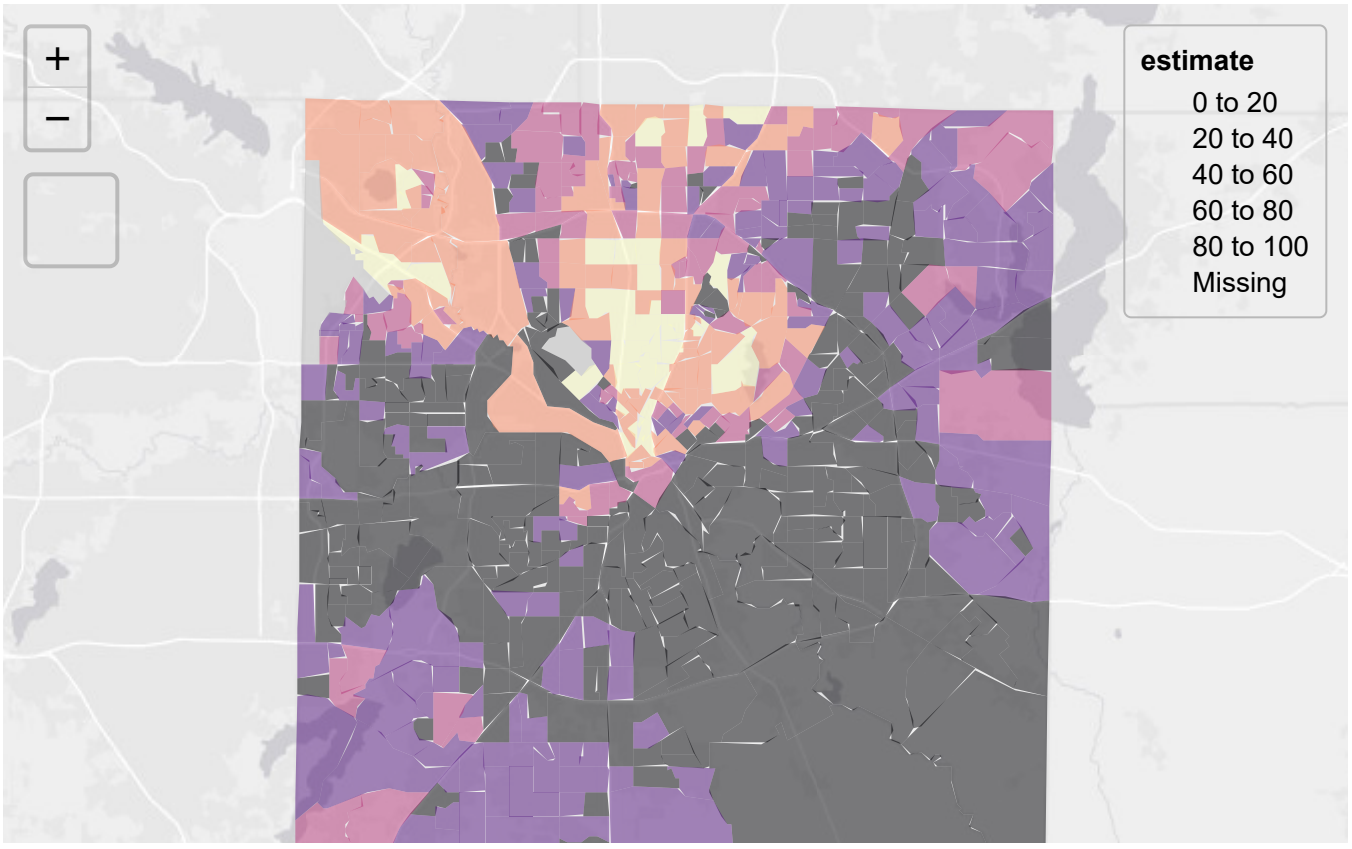





```
library(tmap)
tmap_mode("view")
```

```
## tmap mode set to interactive viewing
```

```
tm_shape(dallas_bachelors) +
  tm_fill(col = "estimate", palette = "magma",
          alpha = 0.5)
```




```
library(leaflet)
```

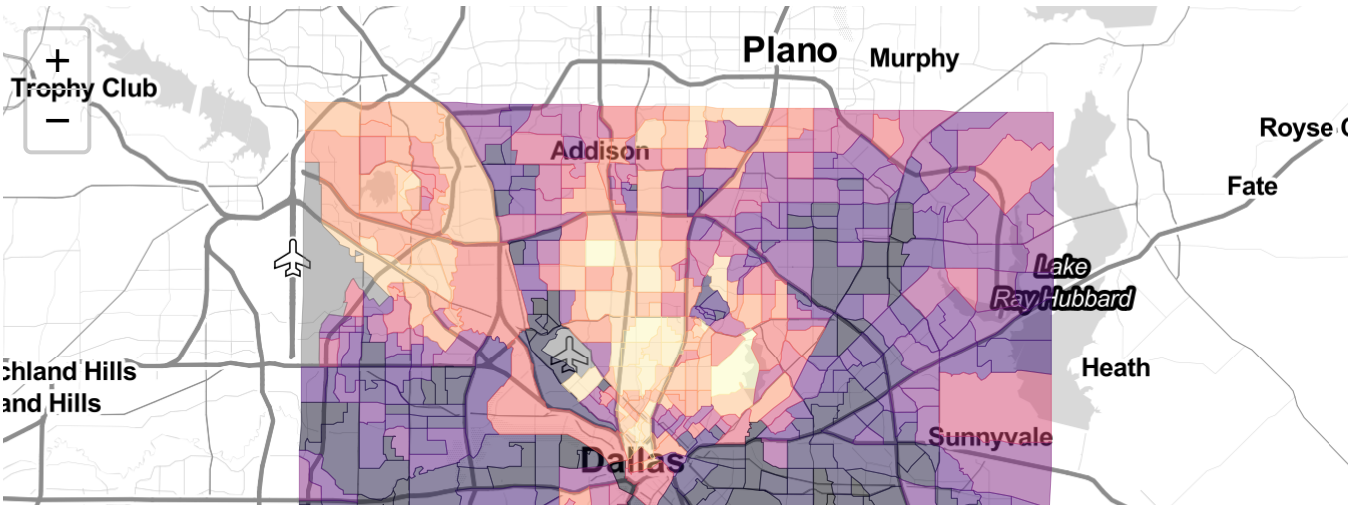
```
## Warning: package 'leaflet' was built under R version 4.2.2
```

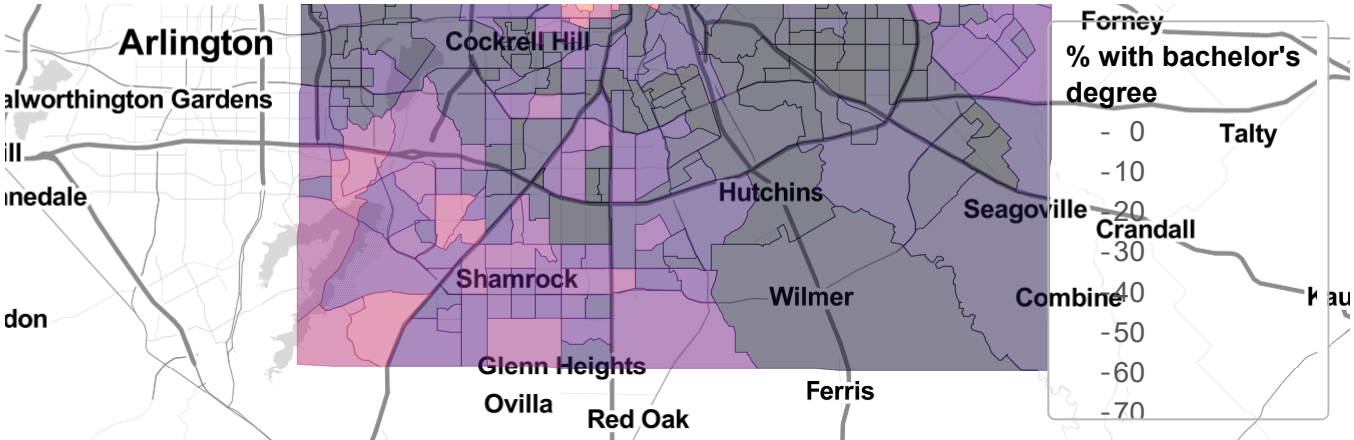
```
pal <- colorNumeric(
  palette = "magma",
  domain = dallas_bachelors$estimate
)

pal(c(10, 20, 30, 40, 50))
```

```
## [1] "#170F3C" "#420F75" "#6E1E81" "#9A2D80" "#C73D73"
```

```
leaflet() %>%
  addProviderTiles(providers$Stamen.TonerLite) %>%
  addPolygons(data = dallas_bachelors,
              color = ~pal(estimate),
              weight = 0.5,
              smoothFactor = 0.2,
              fillOpacity = 0.5,
              label = ~estimate) %>%
  addLegend(
    position = "bottomright",
    pal = pal,
    values = dallas_bachelors$estimate,
    title = "% with bachelor's<br/>degree"
  )
```

```
## Warning: sf layer has inconsistent datum (+proj=longlat +datum=NAD83 +no_defs).
## Need '+proj=longlat +datum=WGS84'
```






Leaflet (https://leafletjs.com) | Map tiles by Stamen Design (http://stamen.com), CC BY 3.0 (http://creativecommons.org/licenses/by/3.0) — Map data © OpenStreetMap (https://www.openstreetmap.org/copyright) contributors

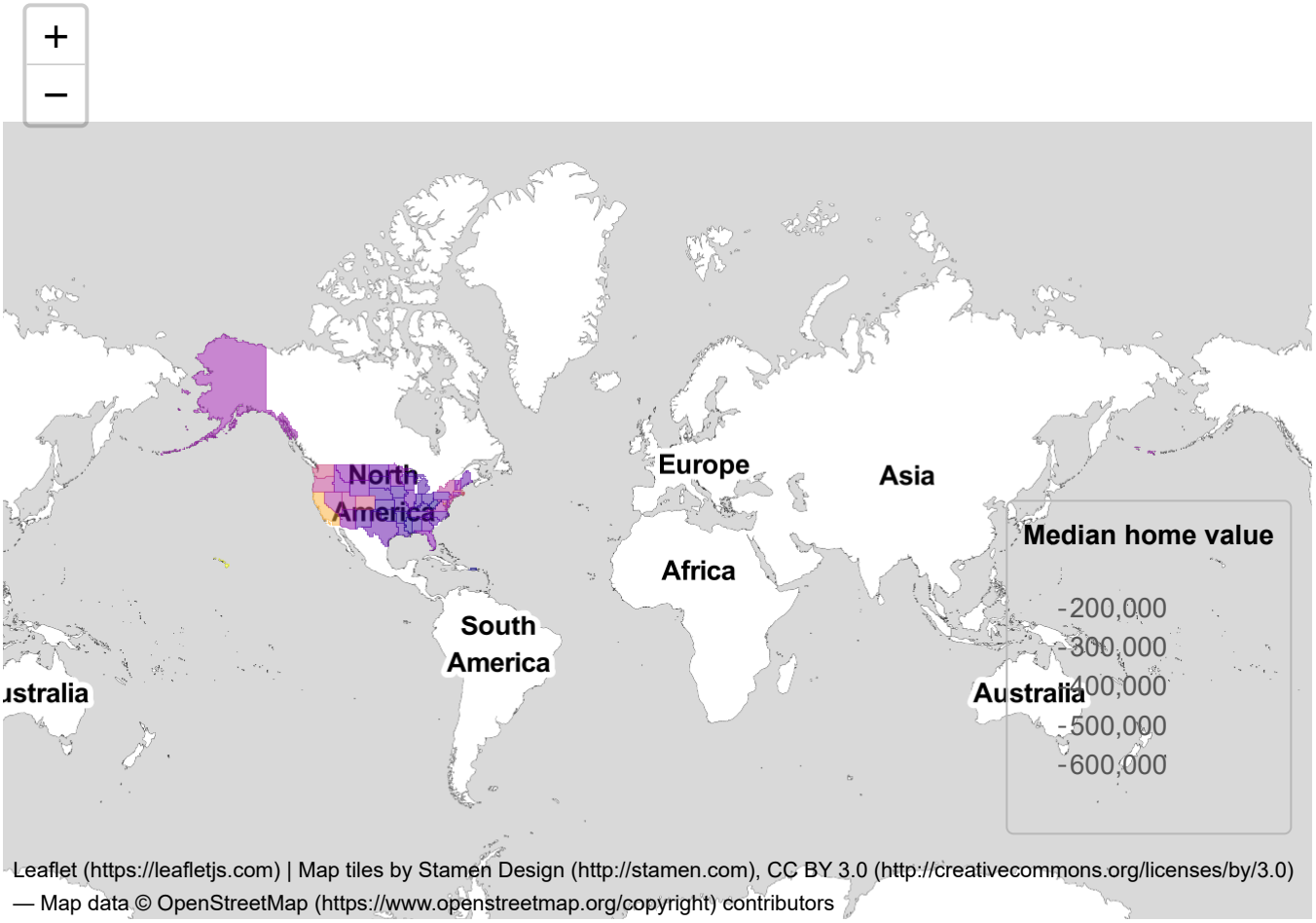
```
us_value <- get_acs(
  geography = "state",
  variables = "B25077_001",
  year = 2019,
  survey = "acs1",
  geometry = TRUE,
  resolution = "20m"
)
```

```
## Getting data from the 2019 1-year ACS
```

```
## The 1-year ACS provides data for geographies with populations of 65,000 and greater.
```

```
library(leaflet)

us_pal <- colorNumeric(
  palette = "plasma",
  domain = us_value$estimate
)

leaflet() %>%
  addProviderTiles(providers$Stamen.TonerLite) %>%
  addPolygons(data = us_value,
              color = ~us_pal(estimate),
              weight = 0.5,
              smoothFactor = 0.2,
              fillOpacity = 0.5,
              label = ~estimate) %>%
  addLegend(
    position = "bottomright",
    pal = us_pal,
    values = us_value$estimate,
    title = "Median home value"
  )
```

```
## Warning: sf layer has inconsistent datum (+proj=longlat +datum=NAD83 +no_defs).
## Need '+proj=longlat +datum=WGS84'
```




```
library(ggiraph)
```

```
## Warning: package 'ggiraph' was built under R version 4.2.2
```

```
library(scales)
```

```
## Warning: package 'scales' was built under R version 4.2.2
```

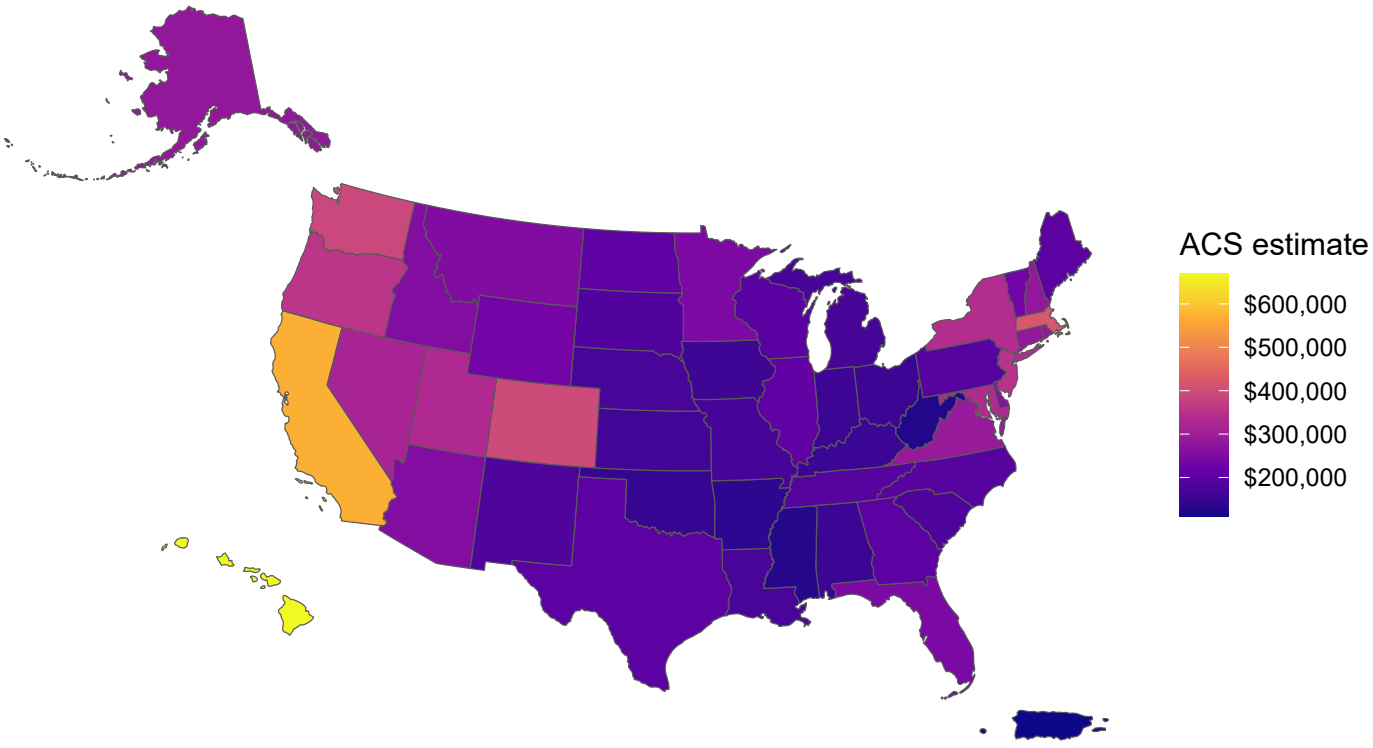
```
##
## Attaching package: 'scales'
```

```
## The following object is masked from 'package:purrr':
##
##     discard
```

```
## The following object is masked from 'package:readr':
##
##     col_factor
```

```
us_value_shifted <- us_value %>%
  shift_geometry(position = "outside") %>%
  mutate(tooltip = paste(NAME, estimate, sep = ": "))

gg <- ggplot(us_value_shifted, aes(fill = estimate)) +
  geom_sf_interactive(aes(tooltip = tooltip, data_id = NAME),
                      size = 0.1) +
  scale_fill_viridis_c(option = "plasma", labels = label_dollar()) +
  labs(title = "Median housing value by State, 2019",
       caption = "Data source: 2019 1-year ACS, US Census Bureau",
       fill = "ACS estimate") +
  theme_void()

girafe(ggobj = gg) %>%
  girafe_options(opts_hover(css = "fill:cyan;"),
                 opts_zoom(max = 10))
```

## Median housing value by State, 2019



```
travis_inflow <- get_flows(
  geography = "county",
  state = "TX",
  county = "Travis",
  geometry = TRUE
) %>%
  filter(variable == "MOVEDIN") %>%
  na.omit() %>%
  arrange(desc(estimate))
```

```
library(mapdeck)
```

```
## Warning: package 'mapdeck' was built under R version 4.2.2
```

```
##
## Attaching package: 'mapdeck'
```

```
## The following object is masked from 'package:tibble':
##
##     add_column
```

```
token <- "YOUR TOKEN HERE"

travis_inflow %>%
  slice_max(estimate, n = 30) %>%
  mutate(weight = estimate / 500) %>%
  mapdeck(token = token) %>%
  add_arc(origin = "centroid2",
          destination = "centroid1",
          stroke_width = "weight",
          update_view = FALSE)
```

```
## Registered S3 method overwritten by 'jsonify':
##   method     from
##   print.json jsonlite
```

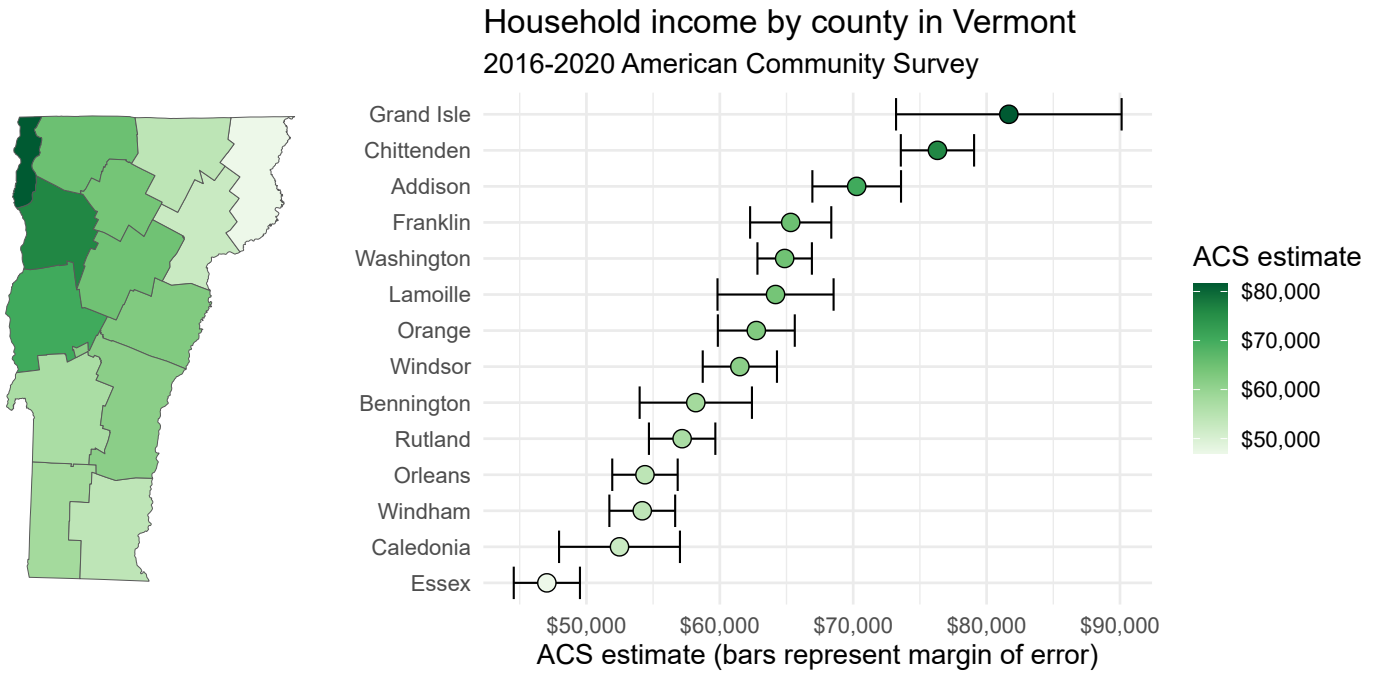
```
library(tidycensus)
library(ggiraph)
library(tidyverse)
library(patchwork)
```

```
## Warning: package 'patchwork' was built under R version 4.2.2
```

```
library(scales)

vt_income <- get_acs(
  geography = "county",
  variables = "B19013_001",
  state = "VT",
  year = 2020,
  geometry = TRUE
) %>%
  mutate(NAME = str_remove(NAME, " County, Vermont"))
```

```
## Getting data from the 2016-2020 5-year ACS
```

```
vt_map <- ggplot(vt_income, aes(fill = estimate)) +
  geom_sf_interactive(aes(data_id = GEOID)) +
  scale_fill_distiller(palette = "Greens",
                       direction = 1,
                       guide = "none") +
  theme_void()

vt_plot <- ggplot(vt_income, aes(x = estimate, y = reorder(NAME, estimate),
                                 fill = estimate)) +
  geom_errorbar(aes(xmin = estimate - moe, xmax = estimate + moe)) +
  geom_point_interactive(color = "black", size = 4, shape = 21,
                         aes(data_id = GEOID)) +
  scale_fill_distiller(palette = "Greens", direction = 1,
                       labels = label_dollar()) +
  scale_x_continuous(labels = label_dollar()) +
  labs(title = "Household income by county in Vermont",
       subtitle = "2016-2020 American Community Survey",
       y = "",
       x = "ACS estimate (bars represent margin of error)",
       fill = "ACS estimate") +
  theme_minimal(base_size = 14)

girafe(ggobj = vt_map + vt_plot, width_svg = 10, height_svg = 5) %>%
  girafe_options(opts_hover(css = "fill:cyan;"))
```




```
# app.R
library(tidycensus)
library(shiny)
```

```
## Warning: package 'shiny' was built under R version 4.2.2
```

```
library(leaflet)
library(tidyverse)

census_api_key("1840a214a15b3834c5308103bdaf17009f4db1b4")
```

```
## To install your API key for use in future sessions, run this function with `install = TRUE`.
```

```
twin_cities_race <- get_acs(
  geography = "tract",
  variables = c(
    hispanic = "DP05_0071P",
    white = "DP05_0077P",
    black = "DP05_0078P",
    native = "DP05_0079P",
    asian = "DP05_0080P",
    year = 2019
  ),
  state = "MN",
  county = c("Hennepin", "Ramsey", "Anoka", "Washington",
             "Dakota", "Carver", "Scott"),
  geometry = TRUE
)
```

```
## Getting data from the 2017-2021 5-year ACS
```

```
## Fetching data by table type ("B/C", "S", "DP") and combining the result.
```

```
groups <- c("Hispanic" = "hispanic",
            "White" = "white",
            "Black" = "black",
            "Native American" = "native",
            "Asian" = "asian")

ui <- fluidPage(
  sidebarLayout(
    sidebarPanel(
      selectInput(
        inputId = "group",
        label = "Select a group to map",
        choices = groups
      )
    ),
    mainPanel(
      leafletOutput("map", height = "600")
    )
  )
)

server <- function(input, output) {

  # Reactive function that filters for the selected group in the drop-down menu
  group_to_map <- reactive({
    filter(twin_cities_race, variable == input$group)
  })

  # Initialize the map object, centered on the Minneapolis-St. Paul area
  output$map <- renderLeaflet({

    leaflet(options = leafletOptions(zoomControl = FALSE)) %>%
      addProviderTiles(providers$Stamen.TonerLite) %>%
      setView(lng = -93.21,
              lat = 44.98,
              zoom = 8.5)

  })

  observeEvent(input$group, {

    pal <- colorNumeric("viridis", group_to_map()$estimate)

    leafletProxy("map") %>%
      clearShapes() %>%
      clearControls() %>%
      addPolygons(data = group_to_map(),
                  color = ~pal(estimate),
                  weight = 0.5,
                  fillOpacity = 0.5,
                  smoothFactor = 0.2,
                  label = ~estimate) %>%
```

```
      addLegend(
        position = "bottomright",
        pal = pal,
        values = group_to_map()$estimate,
        title = "% of population"
      )
  })

}

shinyApp(ui = ui, server = server)
```

```
## PhantomJS not found. You can install it with webshot::install_phantomjs(). If it is installe
d, please make sure the phantomjs executable can be found via the PATH variable.
```

Shiny applications not supported in static R Markdown documents

```
hennepin_map <- tm_shape(hennepin_black) +
  tm_polygons(col = "percent",
          style = "jenks",
          n = 5,
          palette = "Purples",
          title = "ACS estimate",
          legend.hist = TRUE) +
  tm_layout(title = "Percent Black\nby Census tract",
            frame = FALSE,
            legend.outside = TRUE,
            bg.color = "grey70",
            legend.hist.width = 5,
            fontfamily = "Verdana")
```

```
tmap_save(
  tm = hennepin_map,
  filename = "images/hennepin_black_map.png",
  height = 5.5,
  width = 8,
  dpi = 300
)
```

```
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database

## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database

## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## font family not found in Windows font database
```

```
## Map saved to C:\GES_486\Rworks\Lab3\images\hennepin_black_map.png
```

```
## Resolution: 2400 by 1650 pixels
```

```
## Size: 8 by 5.5 inches (300 dpi)
```

```
library(htmlwidgets)
```

```
## Warning: package 'htmlwidgets' was built under R version 4.2.2
```

```
dallas_map <- mapview(dallas_bachelors, zcol = "estimate")

saveWidget(dallas_map@map, "dallas_mapview_map.html", selfcontained = TRUE)
```

```
library(tidycensus)
library(sf)
```

```
## Linking to GEOS 3.9.1, GDAL 3.4.3, PROJ 7.2.1; sf_use_s2() is TRUE
```

```
options(tigris_use_cache = TRUE)

dc_income <- get_acs(
  geography = "tract",
  variables = "B19013_001",
  state = "DC",
  year = 2020,
  geometry = TRUE
)
```

```
## Getting data from the 2016-2020 5-year ACS
```

```
##st_write(dc_income, "dc_income.shp")
```

```
##Variable=string
##State=string
##County=string
##Output=output vector
##library(tidycensus)

##Output = get_acs(
##    geography = "tract",
##    variables = Variable,
##    state = State,
##    county = County,
##    geometry = TRUE
##)
```

# Spatial analysis with US Census data

Ram Mandava

2023-02-25

```
library(tigris)
```

```
## Warning: package 'tigris' was built under R version 4.2.2
```

```
## To enable caching of data, set `options(tigris_use_cache = TRUE)`
## in your R script or .Rprofile.
```

```
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 4.2.2
```

```
## ── Attaching packages ─────────────────────────────────────── tidyverse 1.3.2
## ──
```

```
## ✓ ggplot2 3.4.1      ✓ purrr   1.0.1
## ✓ tibble  3.1.8      ✓ dplyr   1.0.10
## ✓ tidyr   1.3.0      ✓ stringr 1.5.0
## ✓ readr   2.1.3      ✓ forcats 1.0.0
```

```
## Warning: package 'ggplot2' was built under R version 4.2.2
```

```
## Warning: package 'tidyr' was built under R version 4.2.2
```

```
## Warning: package 'readr' was built under R version 4.2.2
```

```
## Warning: package 'purrr' was built under R version 4.2.2
```

```
## Warning: package 'stringr' was built under R version 4.2.2
```

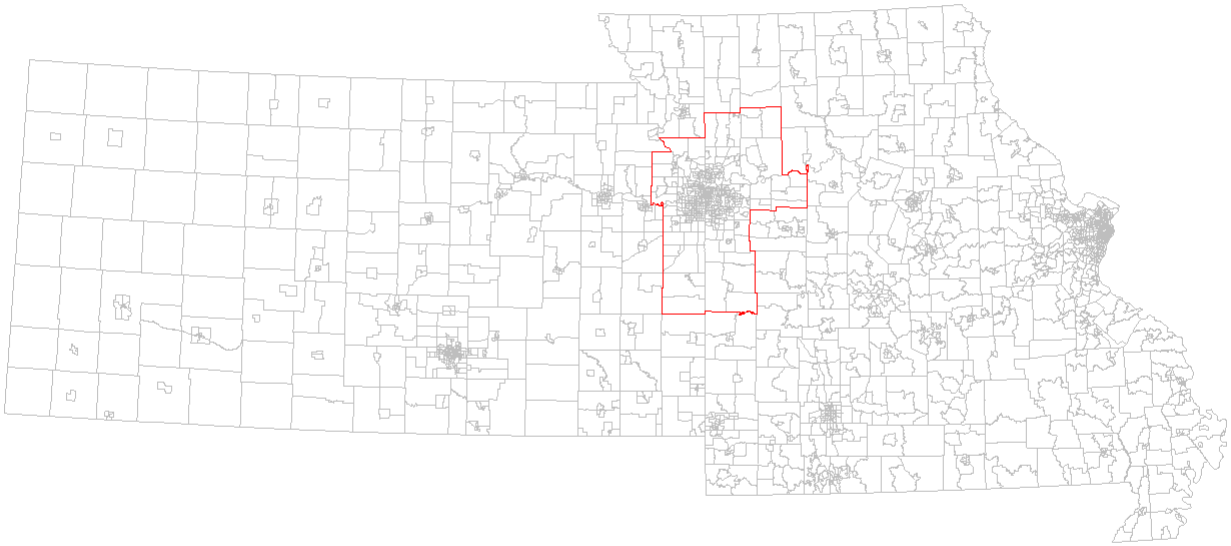
```
## Warning: package 'forcats' was built under R version 4.2.2
```

```
## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
```

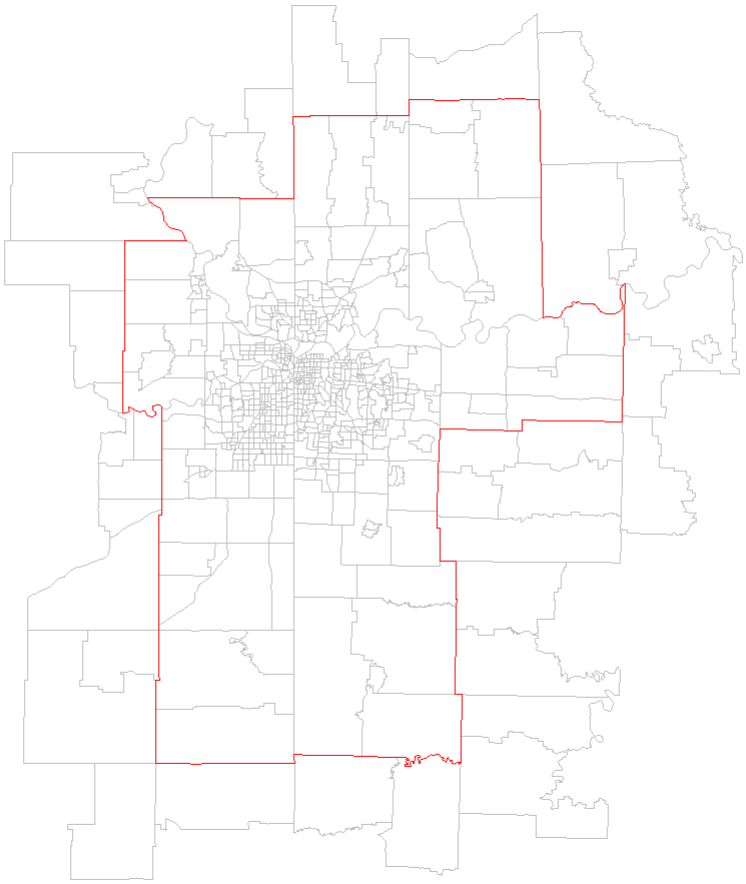
```
library(sf)
```

```
## Linking to GEOS 3.9.1, GDAL 3.4.3, PROJ 7.2.1; sf_use_s2() is TRUE
```

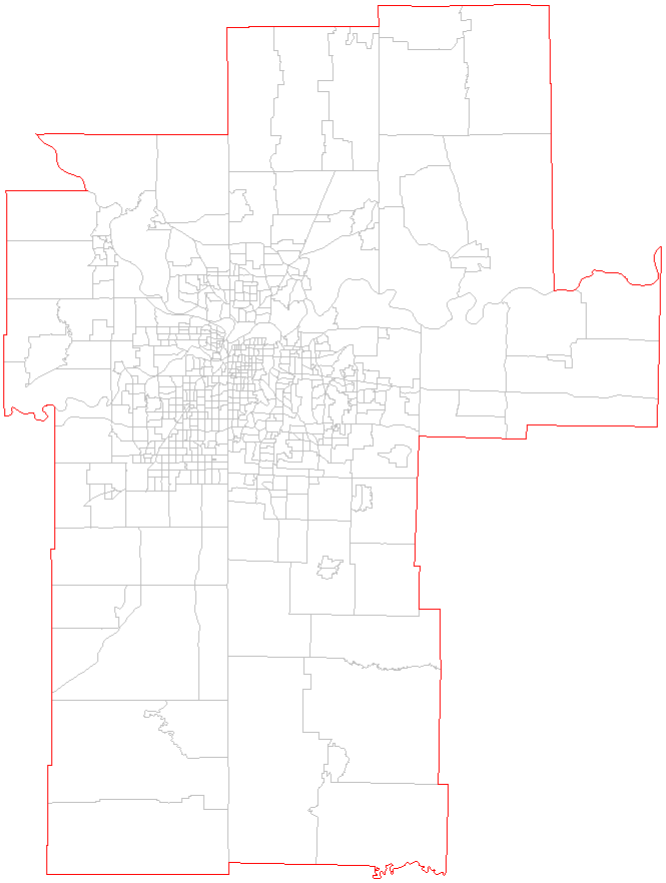
```
options(tigris_use_cache = TRUE)

# CRS used: NAD83(2011) Kansas Regional Coordinate System
# Zone 11 (for Kansas City)
ks_mo_tracts <- map_dfr(c("KS", "MO"), ~{
  tracts(.x, cb = TRUE, year = 2020)
}) %>%
  st_transform(8528)

kc_metro <- core_based_statistical_areas(cb = TRUE, year = 2020) %>%
  filter(str_detect(NAME, "Kansas City")) %>%
  st_transform(8528)

ggplot() +
  geom_sf(data = ks_mo_tracts, fill = "white", color = "grey") +
  geom_sf(data = kc_metro, fill = NA, color = "red") +
  theme_void()
```



```
kc_tracts <- ks_mo_tracts[kc_metro, ]

ggplot() +
  geom_sf(data = kc_tracts, fill = "white", color = "grey") +
  geom_sf(data = kc_metro, fill = NA, color = "red") +
  theme_void()
```



```
kc_tracts_within <- ks_mo_tracts %>%
  st_filter(kc_metro, .predicate = st_within)

# Equivalent syntax:
# kc_metro2 <- kc_tracts[kc_metro, op = st_within]

ggplot() +
  geom_sf(data = kc_tracts_within, fill = "white", color = "grey") +
  geom_sf(data = kc_metro, fill = NA, color = "red") +
  theme_void()
```



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

```
## Warning: package 'tidycensus' was built under R version 4.2.2
```

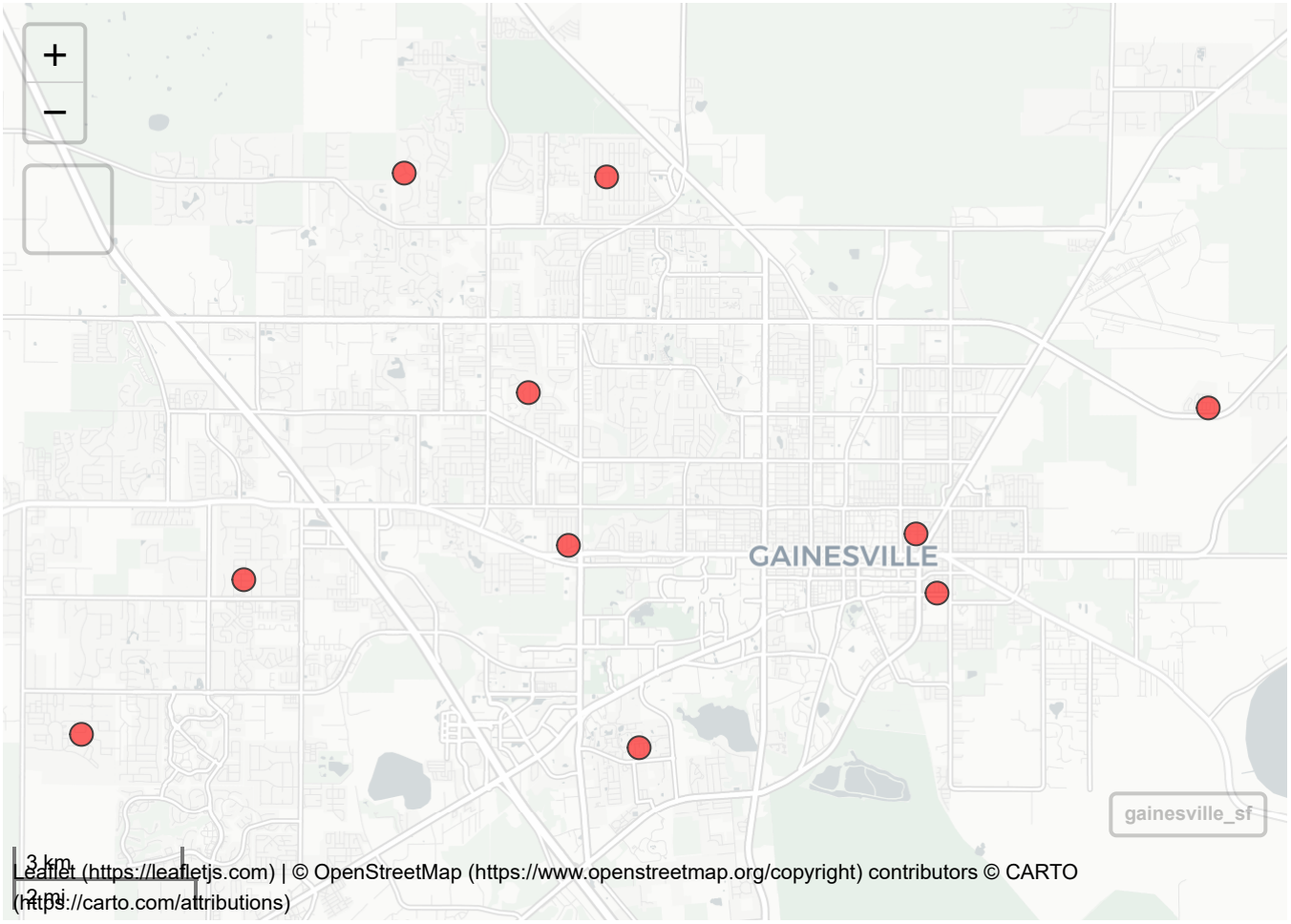
```
library(mapview)
```

```
## Warning: package 'mapview' was built under R version 4.2.2
```

```
gainesville_patients <- tibble(
  patient_id = 1:10,
  longitude = c(-82.308131, -82.311972, -82.361748, -82.374377,
                -82.38177, -82.259461, -82.367436, -82.404031,
                -82.43289, -82.461844),
  latitude = c(29.645933, 29.655195, 29.621759, 29.653576,
               29.677201, 29.674923, 29.71099, 29.711587,
               29.648227, 29.624037)
)
```

```
# CRS: NAD83(2011) / Florida North
gainesville_sf <- gainesville_patients %>%
  st_as_sf(coords = c("longitude", "latitude"),
           crs = 4326) %>%
  st_transform(6440)
```

```
mapview(
  gainesville_sf,
  col.regions = "red",
  legend = FALSE
)
```

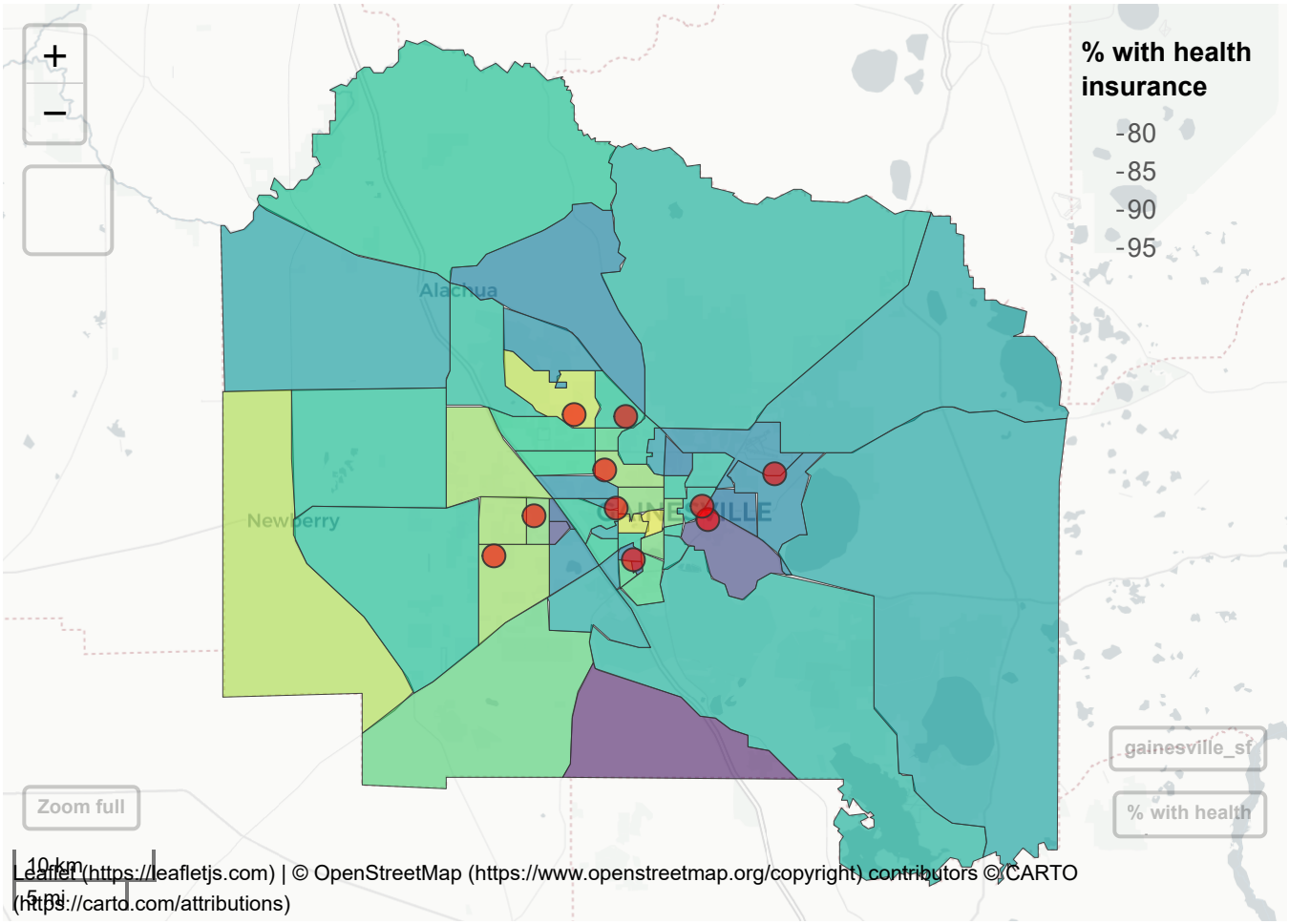



```
alachua_insurance <- get_acs(
  geography = "tract",
  variables = "DP03_0096P",
  state = "FL",
  county = "Alachua",
  year = 2019,
  geometry = TRUE
) %>%
  select(GEOID, pct_insured = estimate,
         pct_insured_moe = moe) %>%
  st_transform(6440)
```

```
## Getting data from the 2015-2019 5-year ACS
```

```
## Using the ACS Data Profile
```

```
mapview(
  alachua_insurance,
  zcol = "pct_insured",
  layer.name = "% with health<br/>insurance"
) +
  mapview(
    gainesville_sf,
    col.regions = "red",
    legend = FALSE
  )
```




```
patients_joined <- st_join(
  gainesville_sf,
  alachua_insurance
)

patients_joined
```

```
## Simple feature collection with 10 features and 4 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 797379.2 ymin: 70862.57 xmax: 816865.2 ymax: 80741.87
## Projected CRS: NAD83(2011) / Florida North
## # A tibble: 10 × 5
##    patient_id            geometry GEOID       pct_insured pct_insured_moe
##  *      <int>         <POINT [m]> <chr>             <dbl>           <dbl>
##  1          1 (812216.7 73640.25) 12001000700        81.6             7
##  2          2 (811825.2 74659.57) 12001000500        91               5.1
##  3          3 (807076.4 70862.57) 12001001515        85.2             6.2
##  4          4 (805787.7 74365.85) 12001001603        88.3             5.1
##  5          5  (805023.4 76970.8) 12001001100        96.2             2.7
##  6          6 (816865.2 76944.63) 12001001902        86               5.9
##  7          7 (806340.6 80741.36) 12001001803        92.3             4
##  8          8   (802799 80741.87) 12001001813        97.9             1.4
##  9          9 (800134.3 73668.88) 12001002207        95.7             2.4
## 10         10 (797379.2 70937.49) 12001002205        96.5             1.6
```

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

# CRS: NAD83(2011) / Texas Centric Albers Equal Area
tx_cbsa <- get_acs(
  geography = "cbsa",
  variables = "B01003_001",
  year = 2019,
  survey = "acs1",
  geometry = TRUE
) %>%
  filter(str_detect(NAME, "TX")) %>%
  slice_max(estimate, n = 4) %>%
  st_transform(6579)
```

```
## Getting data from the 2019 1-year ACS
```

```
## The 1-year ACS provides data for geographies with populations of 65,000 and greater.
```

```
pct_hispanic <- get_acs(
  geography = "tract",
  variables = "DP05_0071P",
  state = "TX",
  year = 2019,
  geometry = TRUE
) %>%
  st_transform(6579)
```

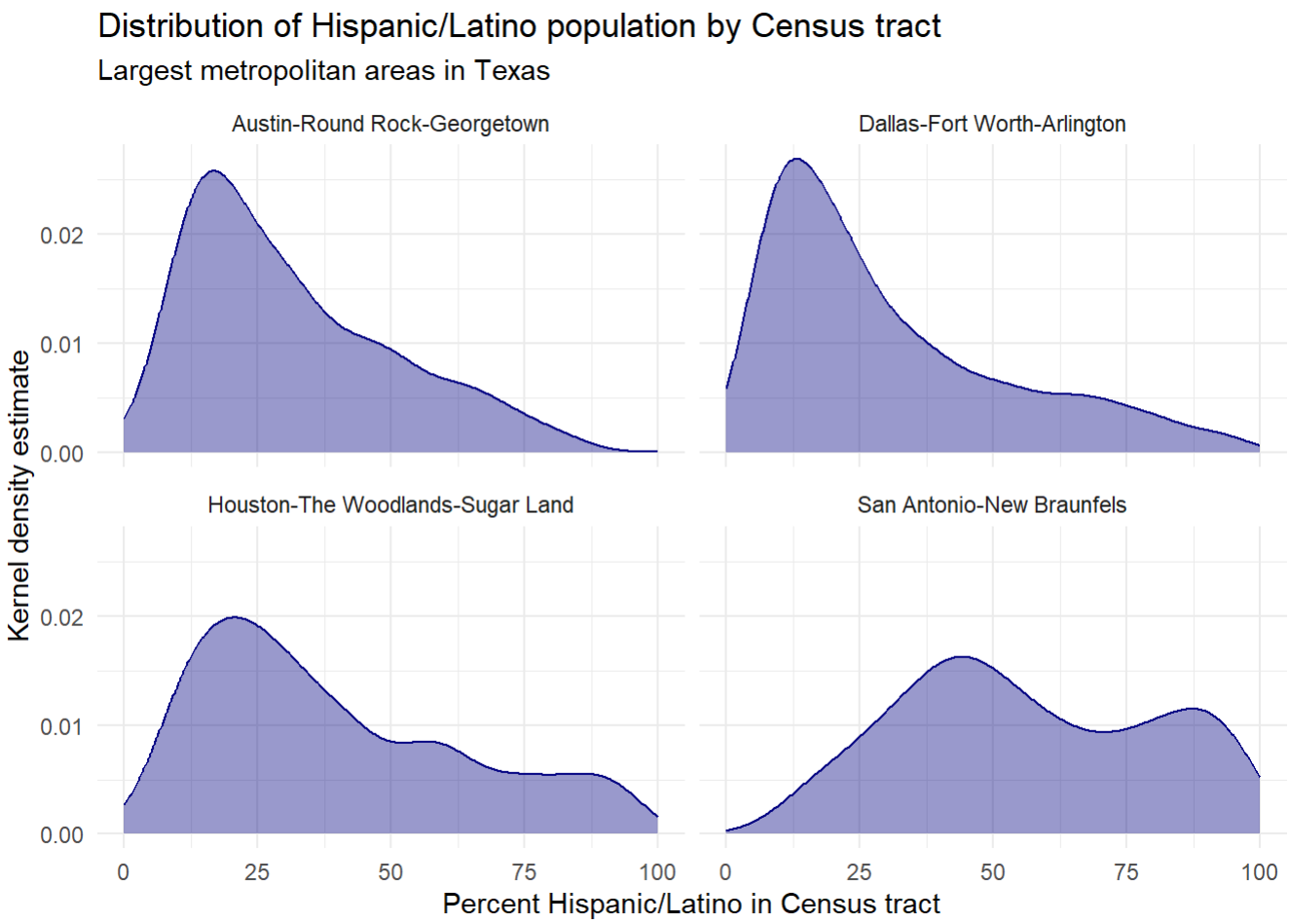
```
## Getting data from the 2015-2019 5-year ACS
```

```
## Using the ACS Data Profile
```

```
hispanic_by_metro <- st_join(
  pct_hispanic,
  tx_cbsa,
  join = st_within,
  suffix = c("_tracts", "_metro"),
  left = FALSE
)
```

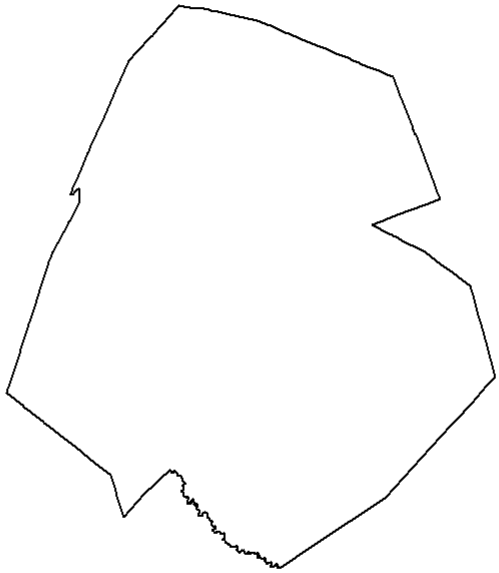
```
hispanic_by_metro %>%
  mutate(NAME_metro = str_replace(NAME_metro, ", TX Metro Area", "")) %>%
  ggplot() +
  geom_density(aes(x = estimate_tracts), color = "navy", fill = "navy",
               alpha = 0.4) +
  theme_minimal() +
  facet_wrap(~NAME_metro) +
  labs(title = "Distribution of Hispanic/Latino population by Census tract",
       subtitle = "Largest metropolitan areas in Texas",
       y = "Kernel density estimate",
       x = "Percent Hispanic/Latino in Census tract")
```

```
## Warning: Removed 9 rows containing non-finite values (`stat_density()`).
```




```
median_by_metro <- hispanic_by_metro %>%
  group_by(NAME_metro) %>%
  summarize(median_hispanic = median(estimate_tracts, na.rm = TRUE))
```

```
plot(median_by_metro[1,]$geometry)
```



```
library(tidycensus)
library(tidyverse)
library(tigris)
library(sf)
options(tigris_use_cache = TRUE)

# CRS: NAD 83 / Arizona Central
wfh_15 <- get_acs(
  geography = "tract",
  variables = "B08006_017",
  year = 2015,
  state = "AZ",
  county = "Maricopa",
  geometry = TRUE
) %>%
  select(estimate) %>%
  st_transform(26949)
```

```
## Getting data from the 2011-2015 5-year ACS
```

```
wfh_20 <- get_acs(
  geography = "tract",
  variables = "B08006_017",
  year = 2020,
  state = "AZ",
  county = "Maricopa",
  geometry = TRUE
 ) %>%
  st_transform(26949)
```

```
## Getting data from the 2016-2020 5-year ACS
```

```
wfh_interpolate_aw <- st_interpolate_aw(
  wfh_15,
  wfh_20,
  extensive = TRUE
) %>%
  mutate(GEOID = wfh_20$GEOID)
```

```
## Warning in st_interpolate_aw.sf(wfh_15, wfh_20, extensive = TRUE):
## st_interpolate_aw assumes attributes are constant or uniform over areas of x
```

```
## Warning in NextMethod(): number of items to replace is not a multiple of
## replacement length
```

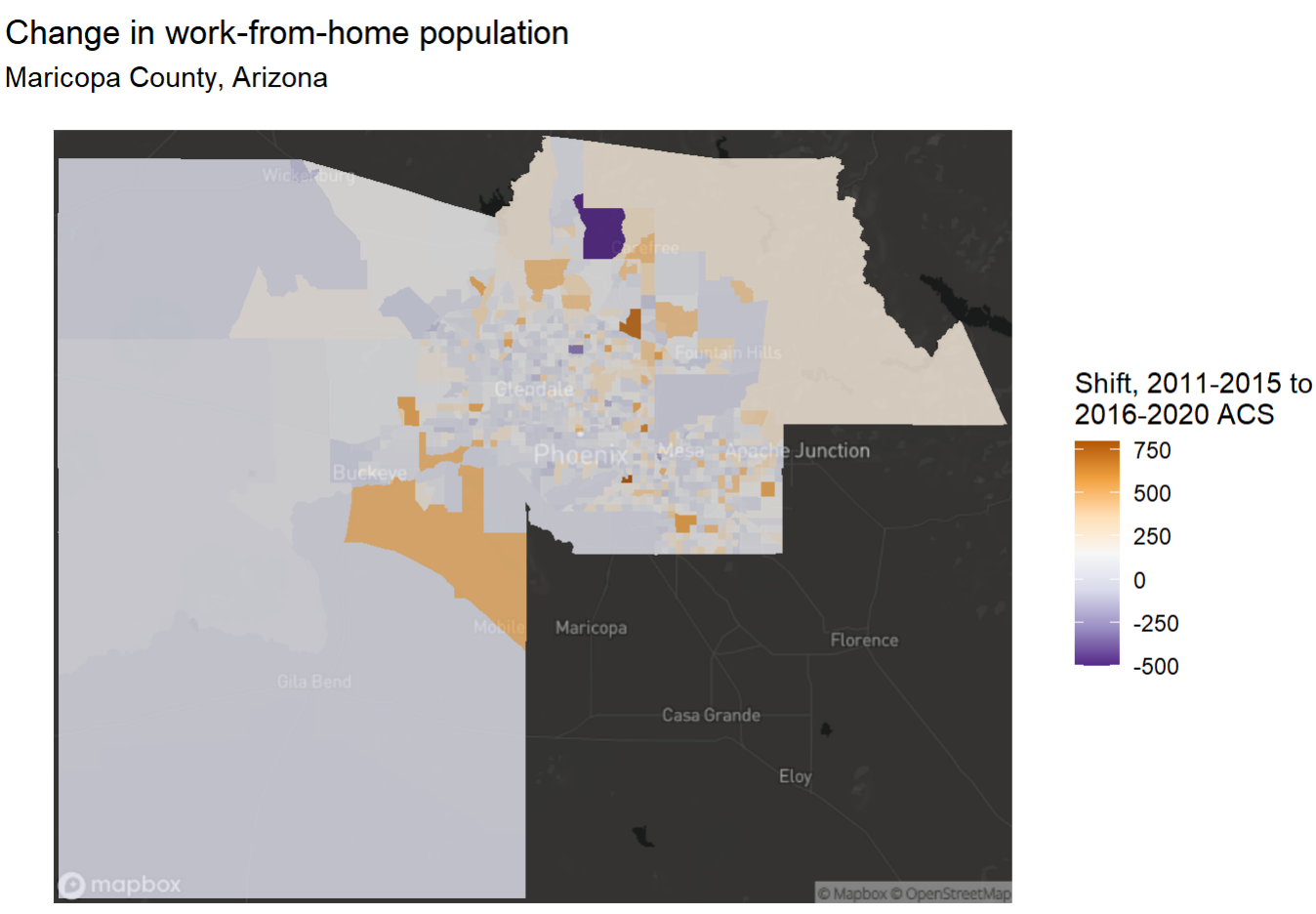
```
maricopa_blocks <- blocks(
  state = "AZ",
  county = "Maricopa",
  year = 2020
)

wfh_interpolate_pw <- interpolate_pw(
  wfh_15,
  wfh_20,
  to_id = "GEOID",
  extensive = TRUE,
  weights = maricopa_blocks,
  weight_column = "POP20",
  crs = 26949
)
```

```
library(mapboxapi)
```

```
## Warning: package 'mapboxapi' was built under R version 4.2.2
```

```
## Usage of the Mapbox APIs is governed by the Mapbox Terms of Service.
## Please visit https://www.mapbox.com/legal/tos/ for more information.
```

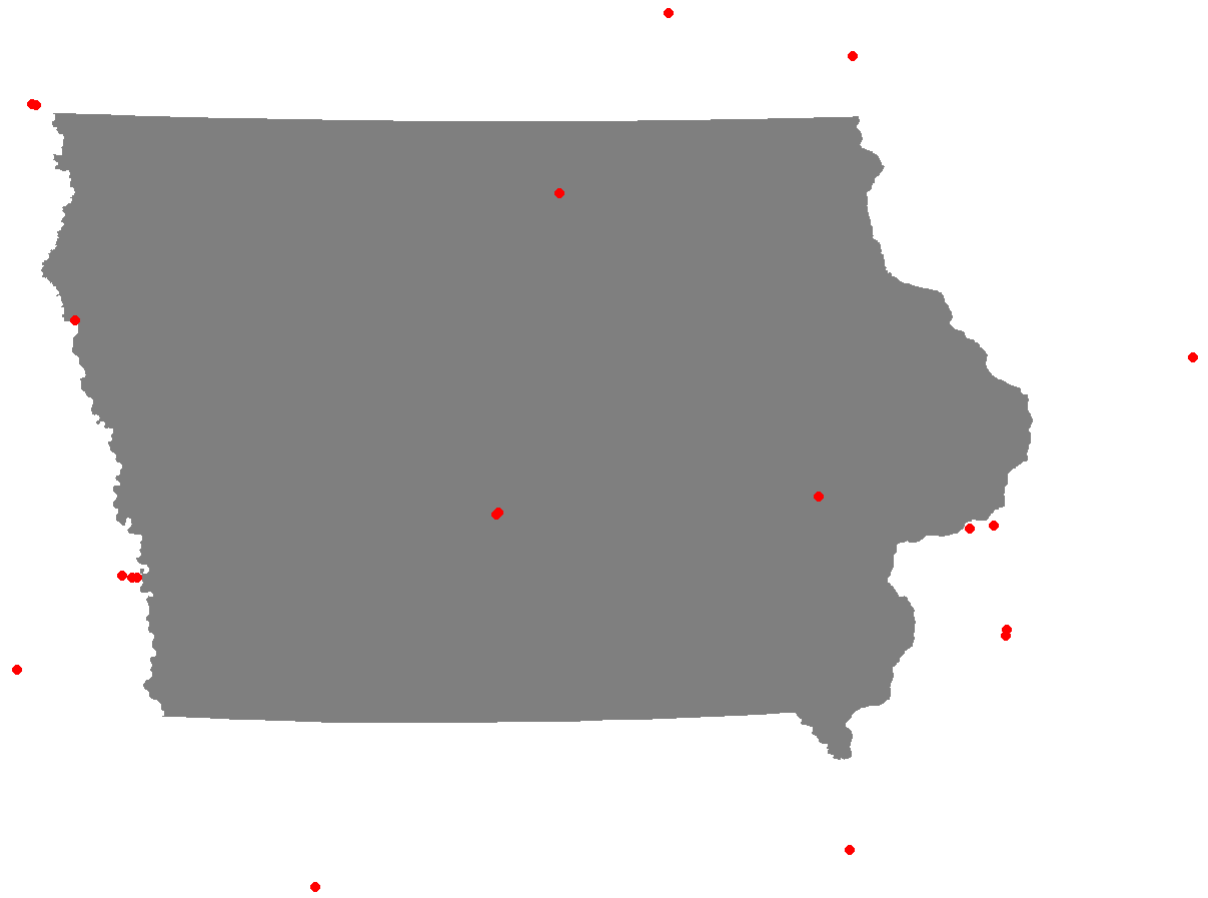
```
wfh_shift <- wfh_20 %>%
  left_join(st_drop_geometry(wfh_interpolate_pw),
            by = "GEOID",
            suffix = c("_2020", "_2015")) %>%
  mutate(wfh_shift = estimate_2020 - estimate_2015)

maricopa_basemap <- layer_static_mapbox(
  location = wfh_shift,
  style_id = "dark-v9",
  username = "mapbox"
)

ggplot() +
  maricopa_basemap +
  geom_sf(data = wfh_shift, aes(fill = wfh_shift), color = NA,
          alpha = 0.8) +
  scale_fill_distiller(palette = "PuOr", direction = -1) +
  labs(fill = "Shift, 2011-2015 to\n2016-2020 ACS",
       title = "Change in work-from-home population",
       subtitle = "Maricopa County, Arizona") +
  theme_void()
```



```r
library(tigris)
library(sf)
library(tidyverse)
options(tigris_use_cache = TRUE)

# CRS: NAD83 / Iowa North
ia_tracts <- tracts("IA", cb = TRUE, year = 2019) %>%
  st_transform(26975)

hospital_url <- "https://services1.arcgis.com/Hp6G80Pky0om7QvQ/arcgis/rest/services/Hospital/Fea
tureServer/0/query?outFields=*&where=1%3D1&f=geojson"

trauma <- st_read(hospital_url) %>%
  filter(str_detect(TRAUMA, "LEVEL I\\b|LEVEL II\\b|RTH|RTC")) %>%
  st_transform(26975) %>%
  distinct(ID, .keep_all = TRUE)
```

```
## Reading layer `OGRGeoJSON' from data source
##   `https://services1.arcgis.com/Hp6G80Pky0om7QvQ/arcgis/rest/services/Hospital/FeatureServer/
0/query?outFields=*&where=1%3D1&f=geojson'
##   using driver `GeoJSON'
## Simple feature collection with 8013 features and 32 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: -176.6403 ymin: -14.29024 xmax: 145.7245 ymax: 71.29773
## Geodetic CRS:  WGS 84
```

```r
ia_trauma <- trauma %>%
  st_filter(ia_tracts,
            .predicate = st_is_within_distance,
            dist = 100000)

ggplot() +
  geom_sf(data = ia_tracts, color = "NA", fill = "grey50") +
  geom_sf(data = ia_trauma, color = "red") +
  theme_void()
```



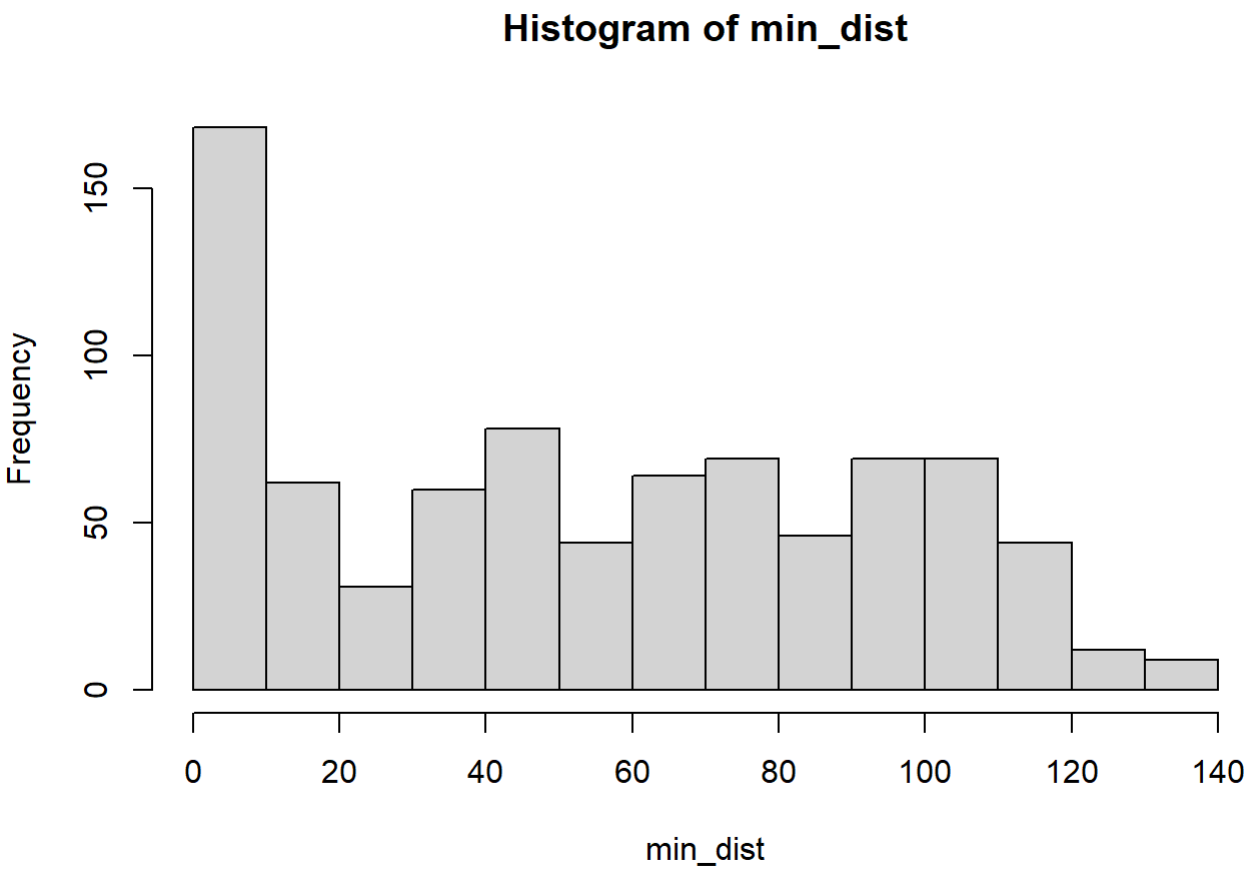
```
dist <- ia_tracts %>%
  st_centroid() %>%
  st_distance(ia_trauma)
```

```
## Warning in st_centroid.sf(.): st_centroid assumes attributes are constant over
## geometries of x
```

```
dist[1:5, 1:5]
```

```
## Units: [m]
##          [,1]      [,2]       [,3]      [,4]     [,5]
## [1,] 257675.1 279570.18 266595.998 279188.81 385140.7
## [2,] 276887.3 298851.01 284447.086 298409.46 400428.5
## [3,] 404511.8 350121.53 303529.967 347800.57 353428.8
## [4,] 369333.5 361742.20 331904.542 360450.59 421691.6
## [5,] 193886.8  66762.19   9716.301  63479.67 143552.1
```

```
min_dist <- dist %>%
  apply(1, min) %>%
  as.vector() %>%
  magrittr::divide_by(1000)

hist(min_dist)
```




```
library(mapboxapi)
# mb_access_token("pk.eybcasq...", install = TRUE)

times <- mb_matrix(ia_tracts, ia_trauma)
```

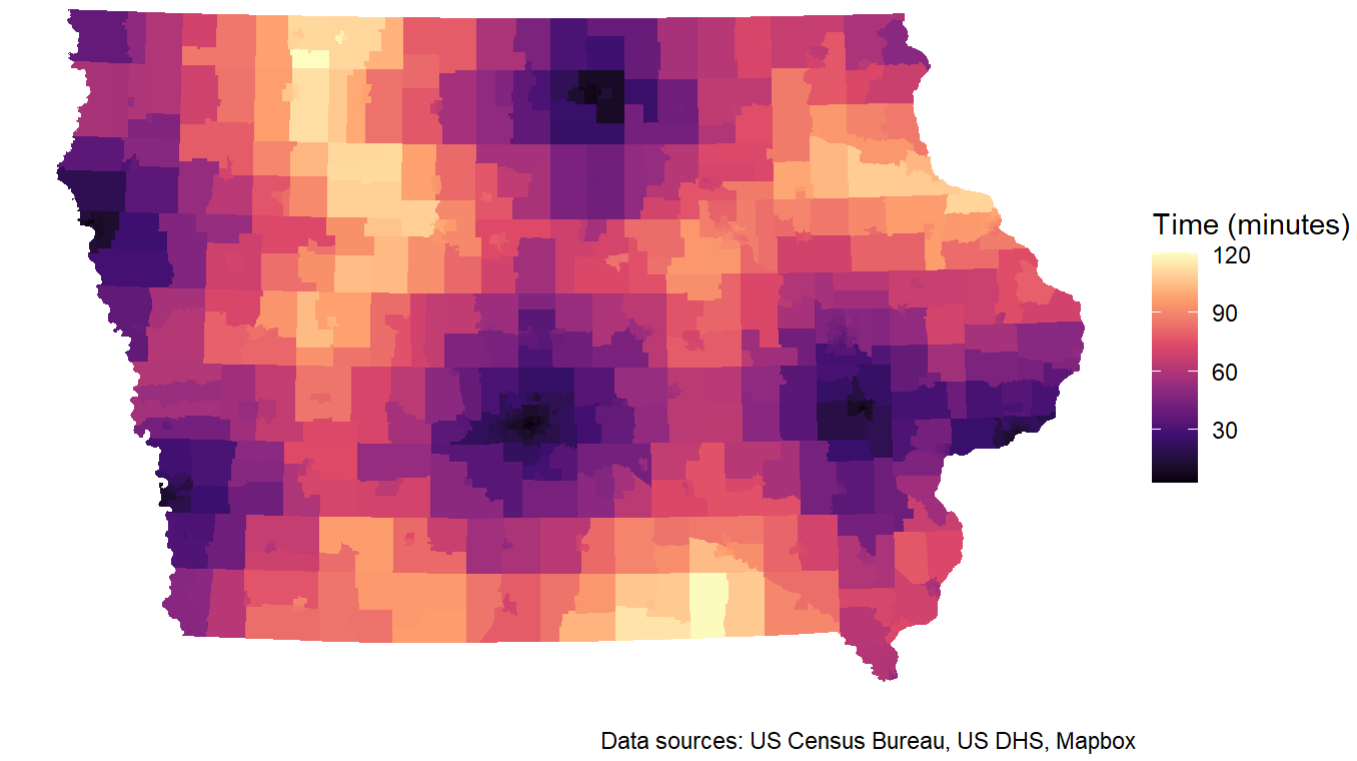
```
## Splitting your matrix request into smaller chunks and re-assembling the result.
```

```
## Using feature centroids for origins
```

```
times[1:5, 1:5]
```

```
##          [,1]     [,2]      [,3]     [,4]     [,5]
## [1,] 217.6650 217.1950 190.67833 215.2533 290.0150
## [2,] 232.3733 227.5683 192.46667 222.9183 291.8033
## [3,] 301.1483 282.2917 247.19000 277.6417 297.5700
## [4,] 305.4283 286.5717 251.47000 281.9217 301.8500
## [5,] 156.8317  55.6350  18.38833  50.9850 126.0100
```

```
min_time <- apply(times, 1, min)

ia_tracts$time <- min_time

ggplot(ia_tracts, aes(fill = time)) +
  geom_sf(color = NA) +
  scale_fill_viridis_c(option = "magma") +
  theme_void() +
  labs(fill = "Time (minutes)",
       title = "Travel time to nearest Level I or Level II trauma hospital",
       subtitle = "Census tracts in Iowa",
       caption = "Data sources: US Census Bureau, US DHS, Mapbox")
```



```
iowa_methodist <- filter(ia_trauma, ID == "0009850308")

buf5km <- st_buffer(iowa_methodist, dist = 5000)

iso10min <- mb_isochrone(
  iowa_methodist,
  time = 10,
  profile = "driving-traffic",
  depart_at = "2022-04-05T17:00"
  )
```

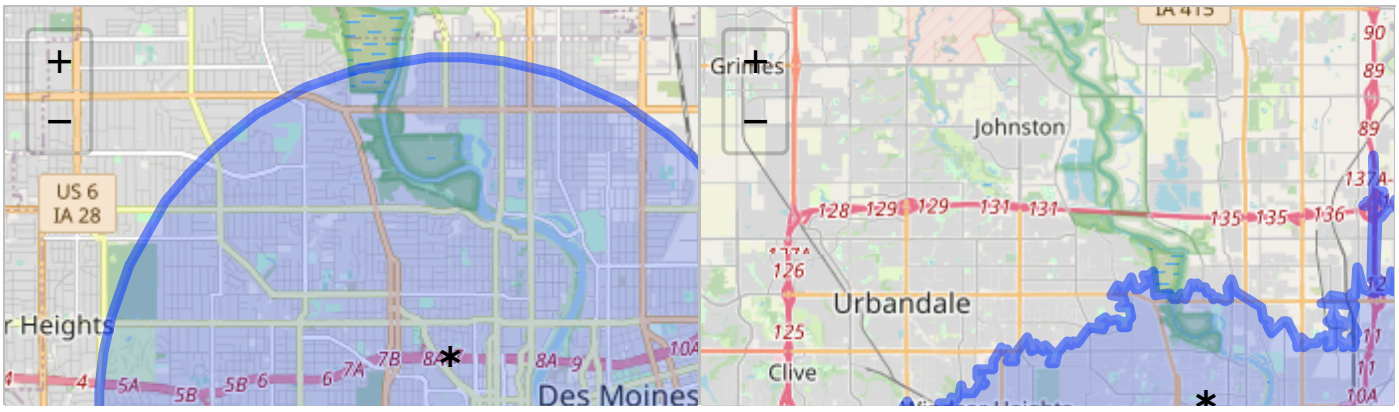
```
library(leaflet)
```

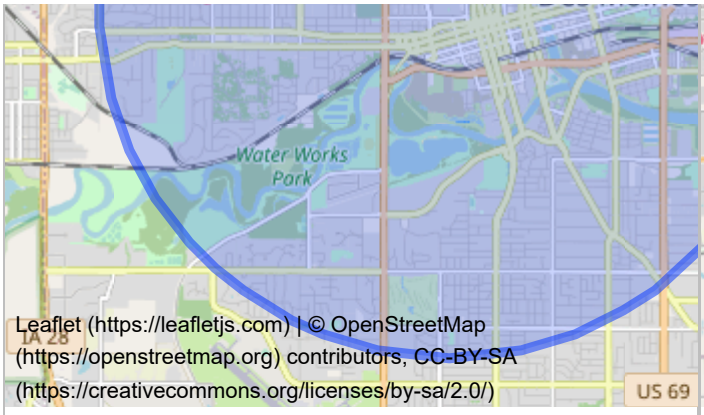
```
## Warning: package 'leaflet' was built under R version 4.2.2
```

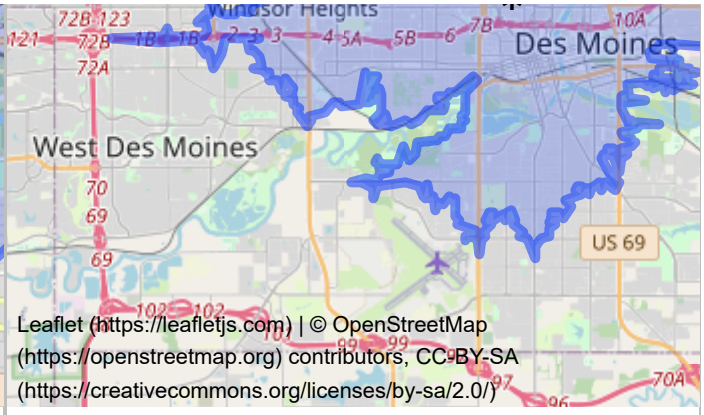
```
library(leafsync)
```

```
## Warning: package 'leafsync' was built under R version 4.2.2
```

```
hospital_icon <- makeAwesomeIcon(icon = "ios-medical",
                                 markerColor = "red",
                                 library = "ion")

# The Leaflet package requires data be in CRS 4326
map1 <- leaflet() %>%
  addTiles() %>%
  addPolygons(data = st_transform(buf5km, 4326)) %>%
  addAwesomeMarkers(data = st_transform(iowa_methodist, 4326),
                    icon = hospital_icon)

map2 <- leaflet() %>%
  addTiles() %>%
  addPolygons(data = iso10min) %>%
  addAwesomeMarkers(data = st_transform(iowa_methodist, 4326),
                    icon = hospital_icon)

sync(map1, map2)
```






```
polk_poverty <- get_acs(
  geography = "block group",
  variables = c(poverty_denom = "B17010_001",
                poverty_num = "B17010_002"),
  state = "IA",
  county = "Polk",
  geometry = TRUE,
  output = "wide",
  year = 2020
) %>%
  select(poverty_denomE, poverty_numE) %>%
  st_transform(26975)
```

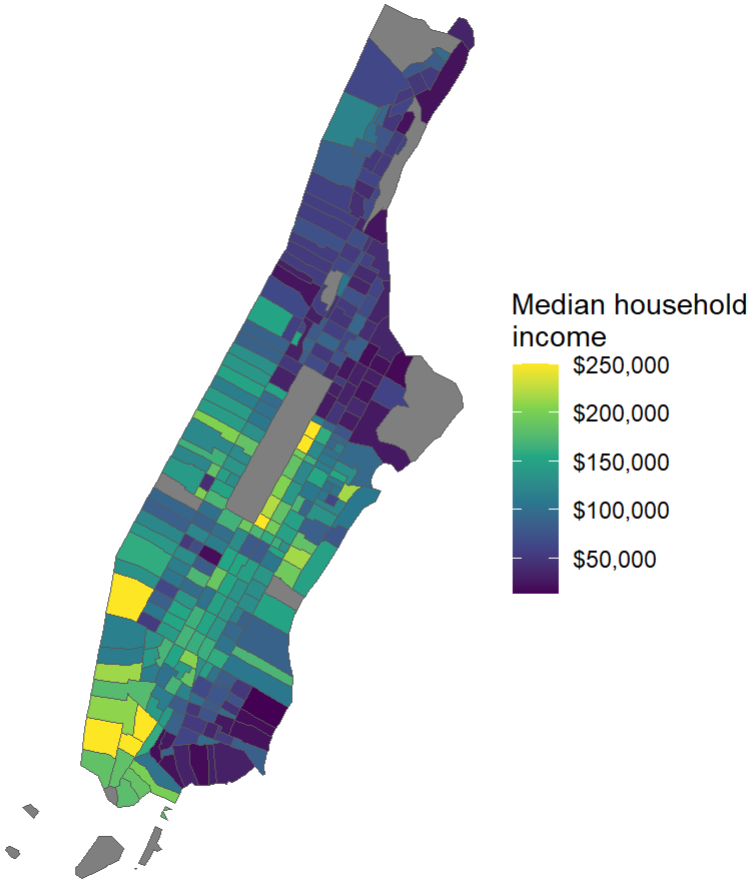
```
## Getting data from the 2016-2020 5-year ACS
```

```
library(glue)

polk_blocks <- blocks(
  state = "IA",
  county = "Polk",
  year = 2020
)

buffer_pov <- interpolate_pw(
  from = polk_poverty,
  to = buf5km,
  extensive = TRUE,
  weights = polk_blocks,
  weight_column = "POP20",
  crs = 26975
) %>%
  mutate(pct_poverty = 100 * (poverty_numE / poverty_denomE))

iso_pov <- interpolate_pw(
  from = polk_poverty,
  to = iso10min,
  extensive = TRUE,
  weights = polk_blocks,
  weight_column = "POP20",
  crs = 26975
) %>%
  mutate(pct_poverty = 100 * (poverty_numE / poverty_denomE))
```

```
library(tidycensus)
library(tidyverse)
options(tigris_use_cache = TRUE)

ny <- get_acs(
  geography = "tract",
  variables = "B19013_001",
  state = "NY",
  county = "New York",
  year = 2020,
  geometry = TRUE
)
```

```
## Getting data from the 2016-2020 5-year ACS
```

```
ggplot(ny) +
  geom_sf(aes(fill = estimate)) +
  scale_fill_viridis_c(labels = scales::label_dollar()) +
  theme_void() +
  labs(fill = "Median household\nincome")
```




```
ny2 <- get_acs(
  geography = "tract",
  variables = "B19013_001",
  state = "NY",
  county = "New York",
  geometry = TRUE,
  year = 2020,
  cb = FALSE
) %>%
  st_transform(6538)
```

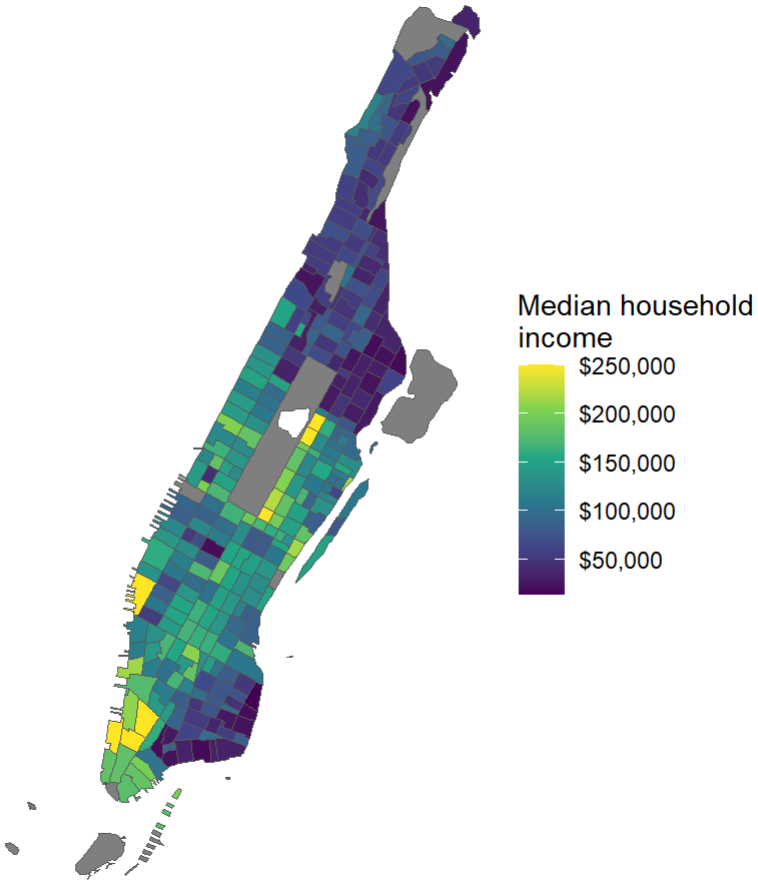
```
## Getting data from the 2016-2020 5-year ACS
```

```
ny_erase <- erase_water(ny2)
```

```
## Fetching area water data for your dataset's location...
```

```
## Erasing water area...
## If this is slow, try a larger area threshold value.
```

```
ggplot(ny_erase) +
  geom_sf(aes(fill = estimate)) +
  scale_fill_viridis_c(labels = scales::label_dollar()) +
  theme_void() +
  labs(fill = "Median household\nincome")
```




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

```
## Warning: package 'spdep' was built under R version 4.2.2
```

```
## Loading required package: sp
```

```
## Loading required package: spData
```

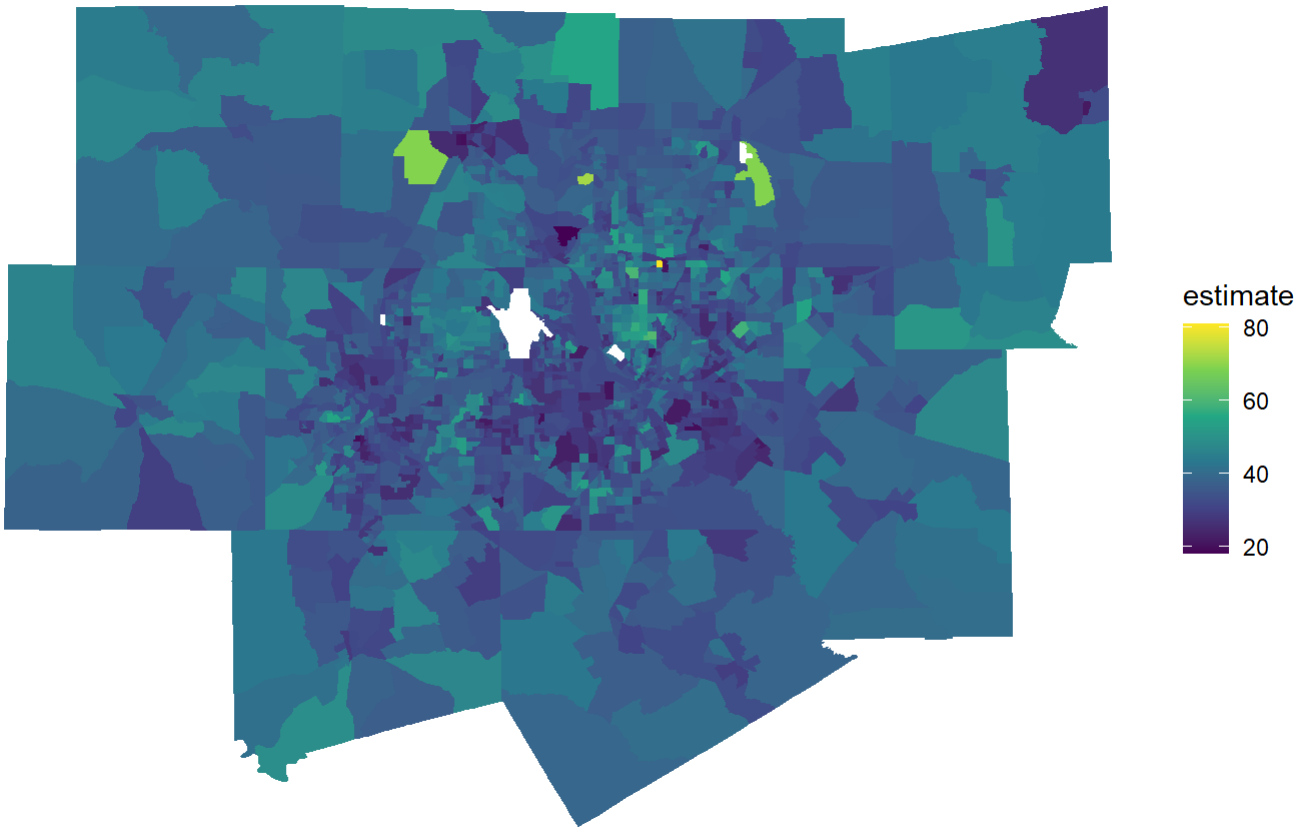
```
## Warning: package 'spData' was built under R version 4.2.2
```

```
## To access larger datasets in this package, install the spDataLarge
## package with: `install.packages('spDataLarge',
## repos='https://nowosad.github.io/drat/', type='source')`
```

```
options(tigris_use_cache = TRUE)

# CRS: NAD83 / Texas North Central
dfw <- core_based_statistical_areas(cb = TRUE, year = 2020) %>%
  filter(str_detect(NAME, "Dallas")) %>%
  st_transform(32138)

dfw_tracts <- get_acs(
  geography = "tract",
  variables = "B01002_001",
  state = "TX",
  year = 2020,
  geometry = TRUE
) %>%
  st_transform(32138) %>%
  st_filter(dfw, .predicate = st_within) %>%
  na.omit()
```

```
## Getting data from the 2016-2020 5-year ACS
```

```
ggplot(dfw_tracts) +
  geom_sf(aes(fill = estimate), color = NA) +
  scale_fill_viridis_c() +
  theme_void()
```



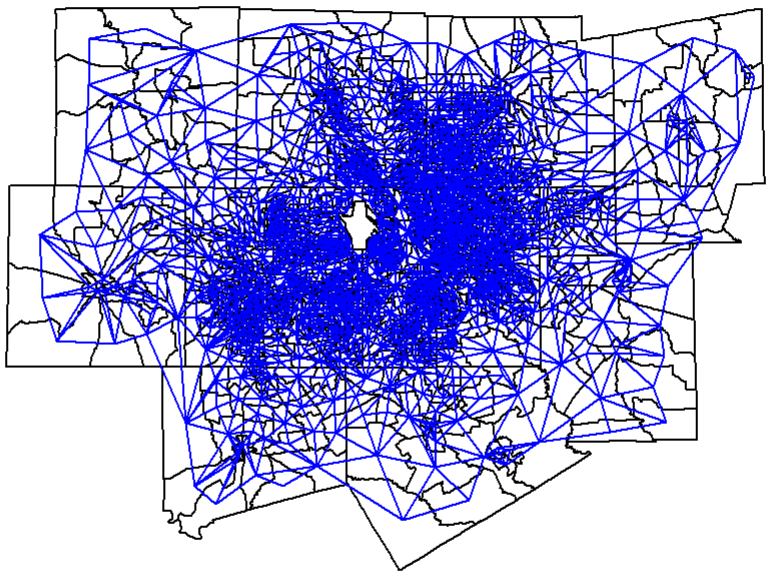

```
neighbors <- poly2nb(dfw_tracts, queen = TRUE)

summary(neighbors)
```

```
## Neighbour list object:
## Number of regions: 1699
## Number of nonzero links: 10928
## Percentage nonzero weights: 0.3785767
## Average number of links: 6.432019
## Link number distribution:
##
##   2   3   4   5   6   7   8   9  10  11  12  13  14  15  17
##   8  51 173 305 397 341 221 110  45  28  11   5   2   1   1
## 8 least connected regions:
## 75 156 206 1201 1237 1548 1597 1646 with 2 links
## 1 most connected region:
## 1047 with 17 links
```

```
dfw_coords <- dfw_tracts %>%
  st_centroid() %>%
  st_coordinates()
```

```
## Warning in st_centroid.sf(.): st_centroid assumes attributes are constant over
## geometries of x
```

```
plot(dfw_tracts$geometry)
plot(neighbors,
     coords = dfw_coords,
     add = TRUE,
     col = "blue",
     points = FALSE)
```



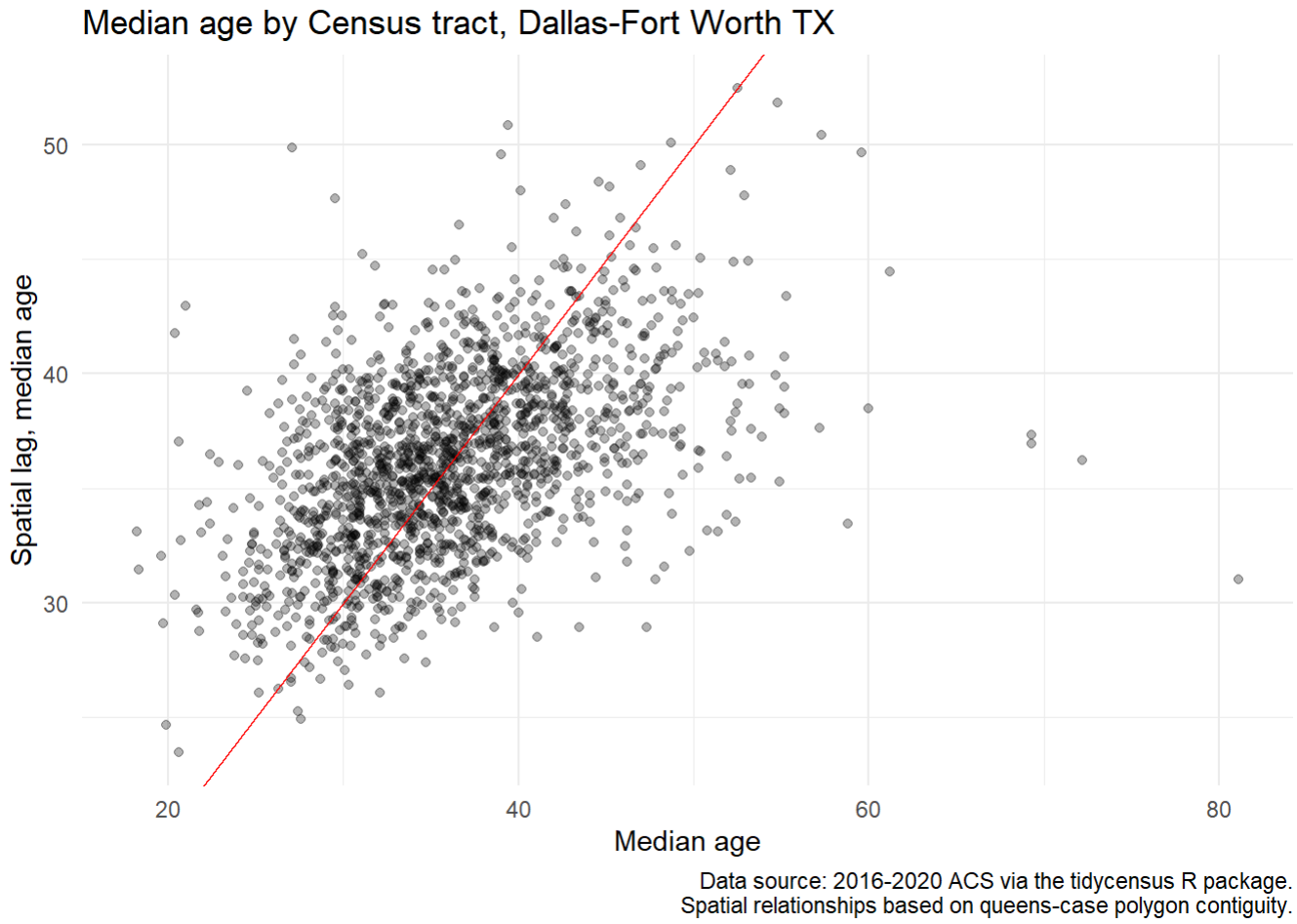
```
# Get the row indices of the neighbors of the Census tract at row index 1
neighbors[[1]]
```

```
## [1]  198  291  352  381 1216 1360
```

```
weights <- nb2listw(neighbors, style = "W")

weights$weights[[1]]
```

```
## [1] 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667 0.1666667
```

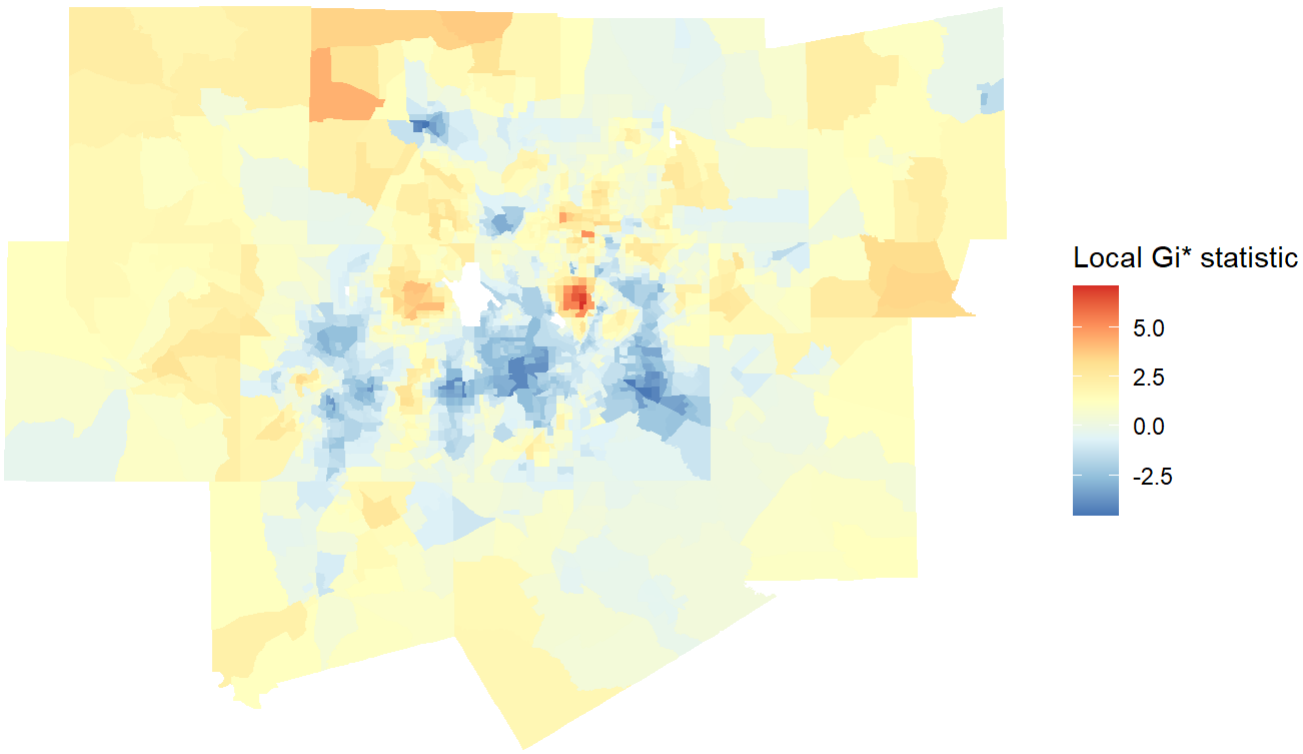
```
dfw_tracts$lag_estimate <- lag.listw(weights, dfw_tracts$estimate)

ggplot(dfw_tracts, aes(x = estimate, y = lag_estimate)) +
  geom_point(alpha = 0.3) +
  geom_abline(color = "red") +
  theme_minimal() +
  labs(title = "Median age by Census tract, Dallas-Fort Worth TX",
       x = "Median age",
       y = "Spatial lag, median age",
       caption = "Data source: 2016-2020 ACS via the tidycensus R package.\nSpatial relationship
s based on queens-case polygon contiguity.")
```



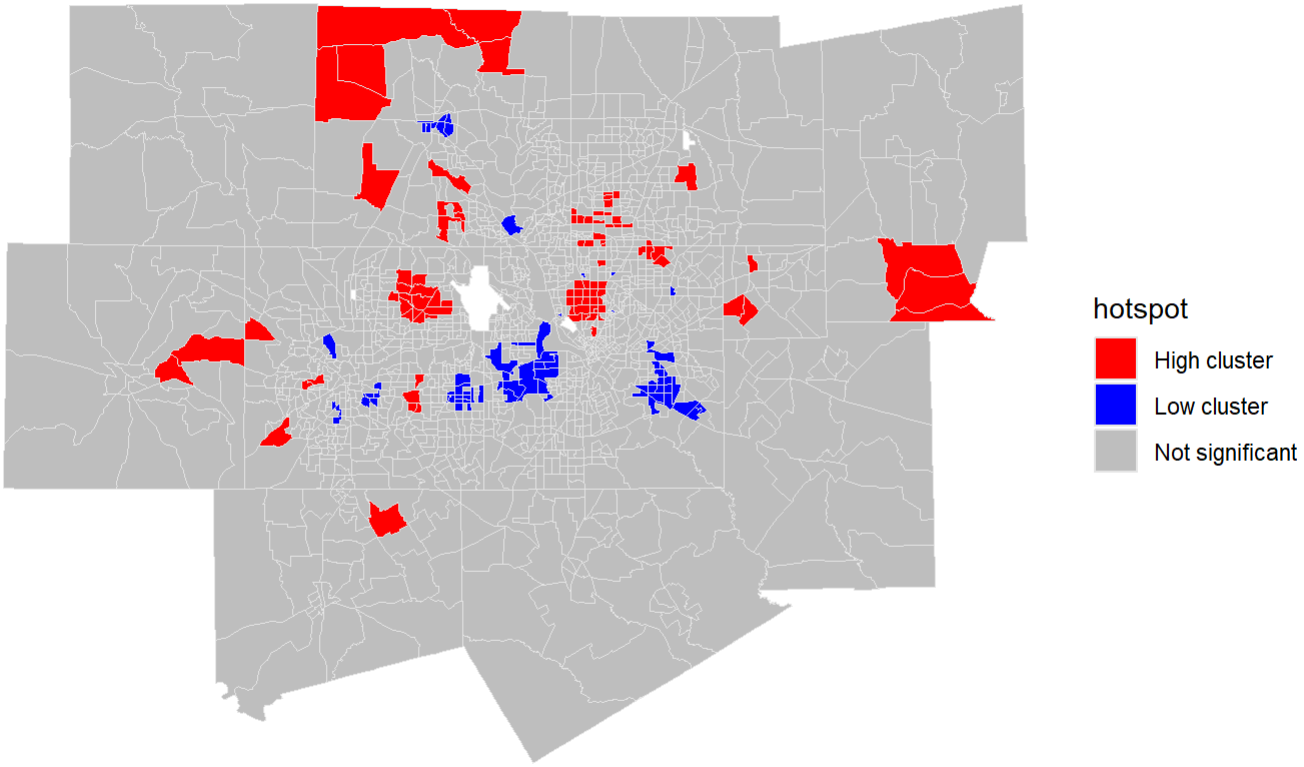

```
moran.test(dfw_tracts$estimate, weights)
```

```
##
##  Moran I test under randomisation
##
## data:  dfw_tracts$estimate
## weights: weights
##
## Moran I statistic standard deviate = 21.246, p-value < 2.2e-16
## alternative hypothesis: greater
## sample estimates:
## Moran I statistic       Expectation          Variance
##      0.2922819779     -0.0005889282      0.0001900200
```

```
# For Gi*, re-compute the weights with `include.self()`
localg_weights <- nb2listw(include.self(neighbors))

dfw_tracts$localG <- localG(dfw_tracts$estimate, localg_weights)

ggplot(dfw_tracts) +
  geom_sf(aes(fill = localG), color = NA) +
  scale_fill_distiller(palette = "RdYlBu") +
  theme_void() +
  labs(fill = "Local Gi* statistic")
```



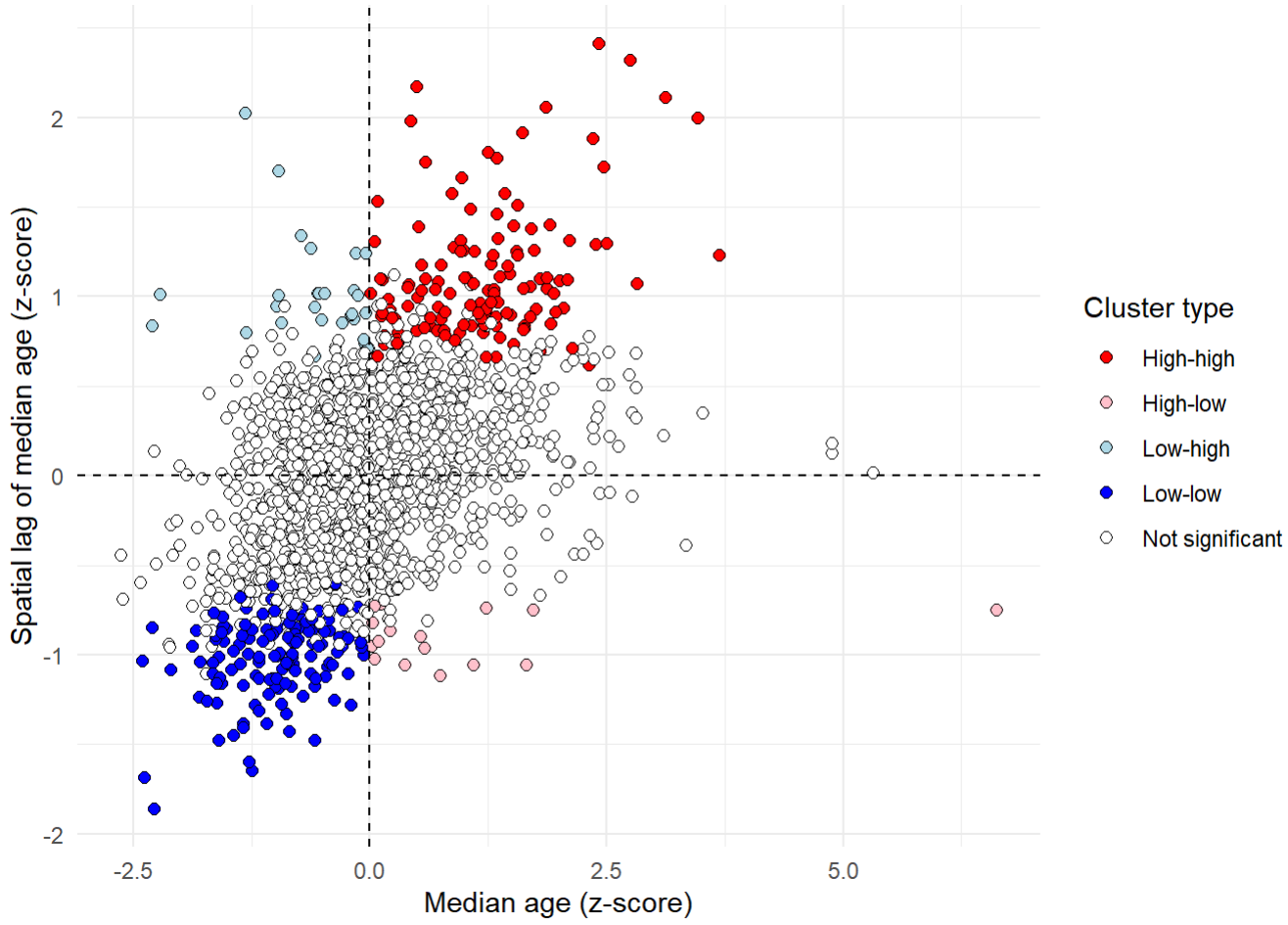
```
dfw_tracts <- dfw_tracts %>%
  mutate(hotspot = case_when(
    localG >= 2.576 ~ "High cluster",
    localG <= -2.576 ~ "Low cluster",
    TRUE ~ "Not significant"
  ))

ggplot(dfw_tracts) +
  geom_sf(aes(fill = hotspot), color = "grey90", size = 0.1) +
  scale_fill_manual(values = c("red", "blue", "grey")) +
  theme_void()
```



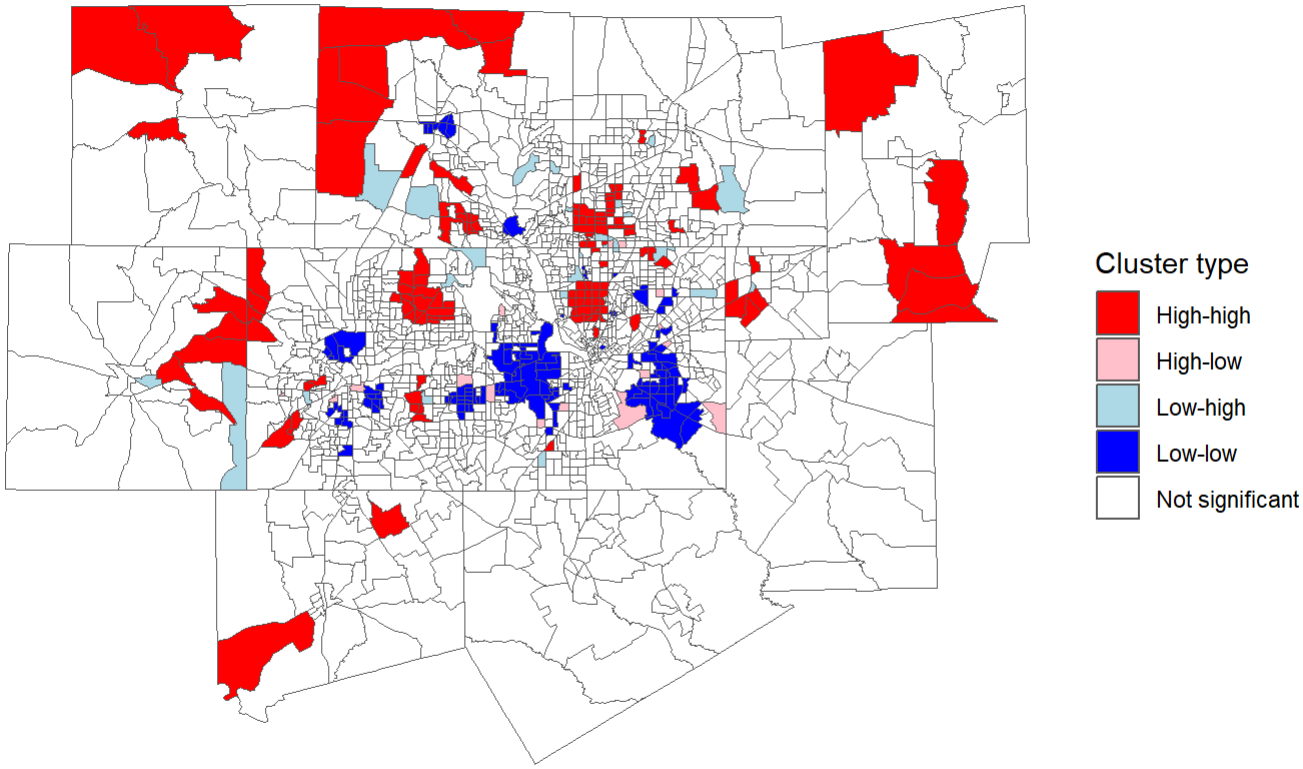
```
set.seed(1983)

dfw_tracts$scaled_estimate <- as.numeric(scale(dfw_tracts$estimate))

dfw_lisa <- localmoran_perm(
  dfw_tracts$scaled_estimate,
  weights,
  nsim = 999L,
  alternative = "two.sided"
) %>%
  as_tibble() %>%
  set_names(c("local_i", "exp_i", "var_i", "z_i", "p_i",
              "p_i_sim", "pi_sim_folded", "skewness", "kurtosis"))

dfw_lisa_df <- dfw_tracts %>%
  select(GEOID, scaled_estimate) %>%
  mutate(lagged_estimate = lag.listw(weights, scaled_estimate)) %>%
  bind_cols(dfw_lisa)
```

```
dfw_lisa_clusters <- dfw_lisa_df %>%
  mutate(lisa_cluster = case_when(
    p_i >= 0.05 ~ "Not significant",
    scaled_estimate > 0 & local_i > 0 ~ "High-high",
    scaled_estimate > 0 & local_i < 0 ~ "High-low",
    scaled_estimate < 0 & local_i > 0 ~ "Low-low",
    scaled_estimate < 0 & local_i < 0 ~ "Low-high"
  ))
```

```
color_values <- c(`High-high` = "red",
                  `High-low` = "pink",
                  `Low-low` = "blue",
                  `Low-high` = "lightblue",
                  `Not significant` = "white")

ggplot(dfw_lisa_clusters, aes(x = scaled_estimate,
                              y = lagged_estimate,
                              fill = lisa_cluster)) +
  geom_point(color = "black", shape = 21, size = 2) +
  theme_minimal() +
  geom_hline(yintercept = 0, linetype = "dashed") +
  geom_vline(xintercept = 0, linetype = "dashed") +
  scale_fill_manual(values = color_values) +
  labs(x = "Median age (z-score)",
       y = "Spatial lag of median age (z-score)",
       fill = "Cluster type")
```




```
ggplot(dfw_lisa_clusters, aes(fill = lisa_cluster)) +
  geom_sf(size = 0.1) +
  theme_void() +
  scale_fill_manual(values = color_values) +
  labs(fill = "Cluster type")
```


Cluster type
High-high
High-low
Low-high
Low-low
Not significant