# Making Maps

**Data Visualization: Session 7**

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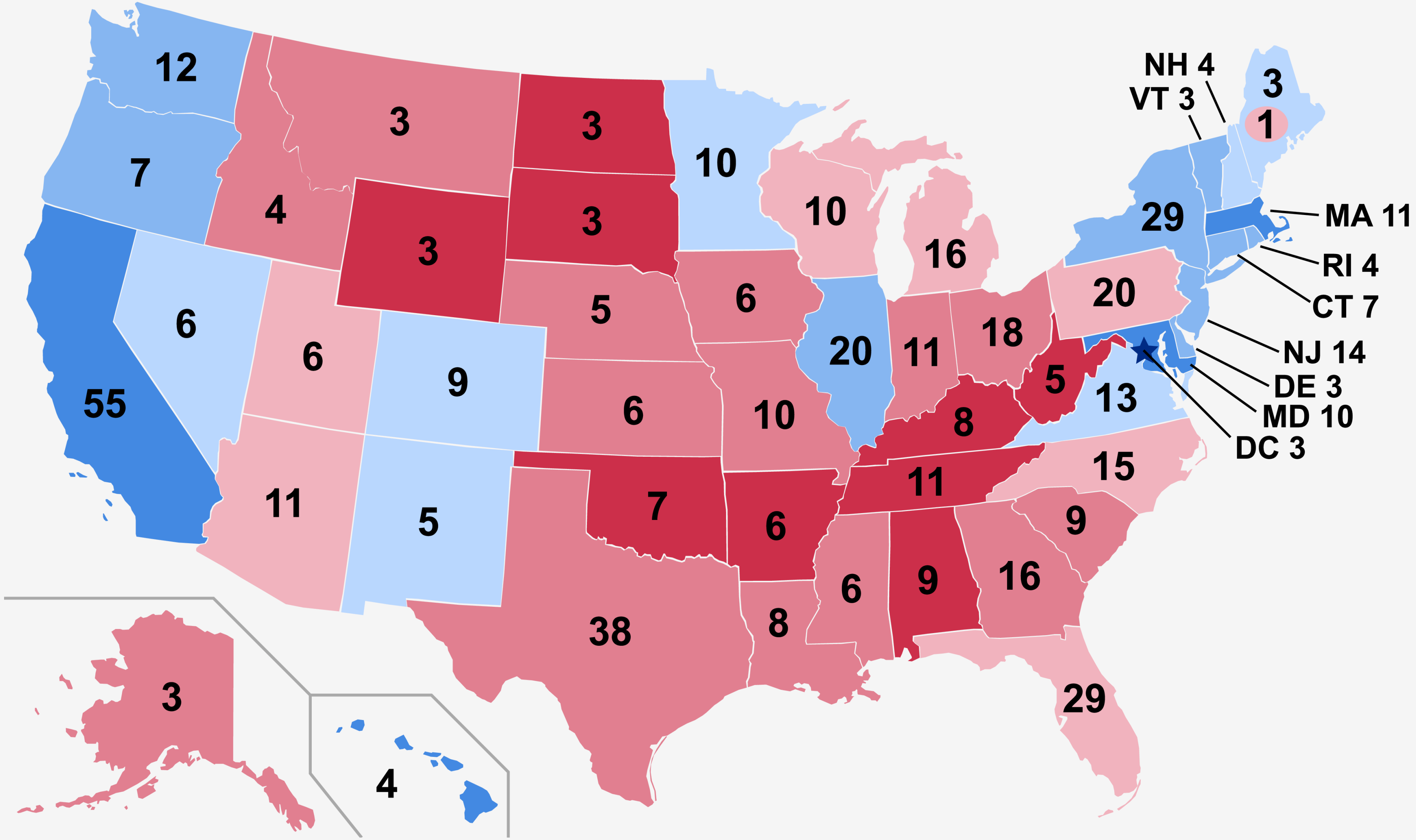
Code Horizons, April 2023

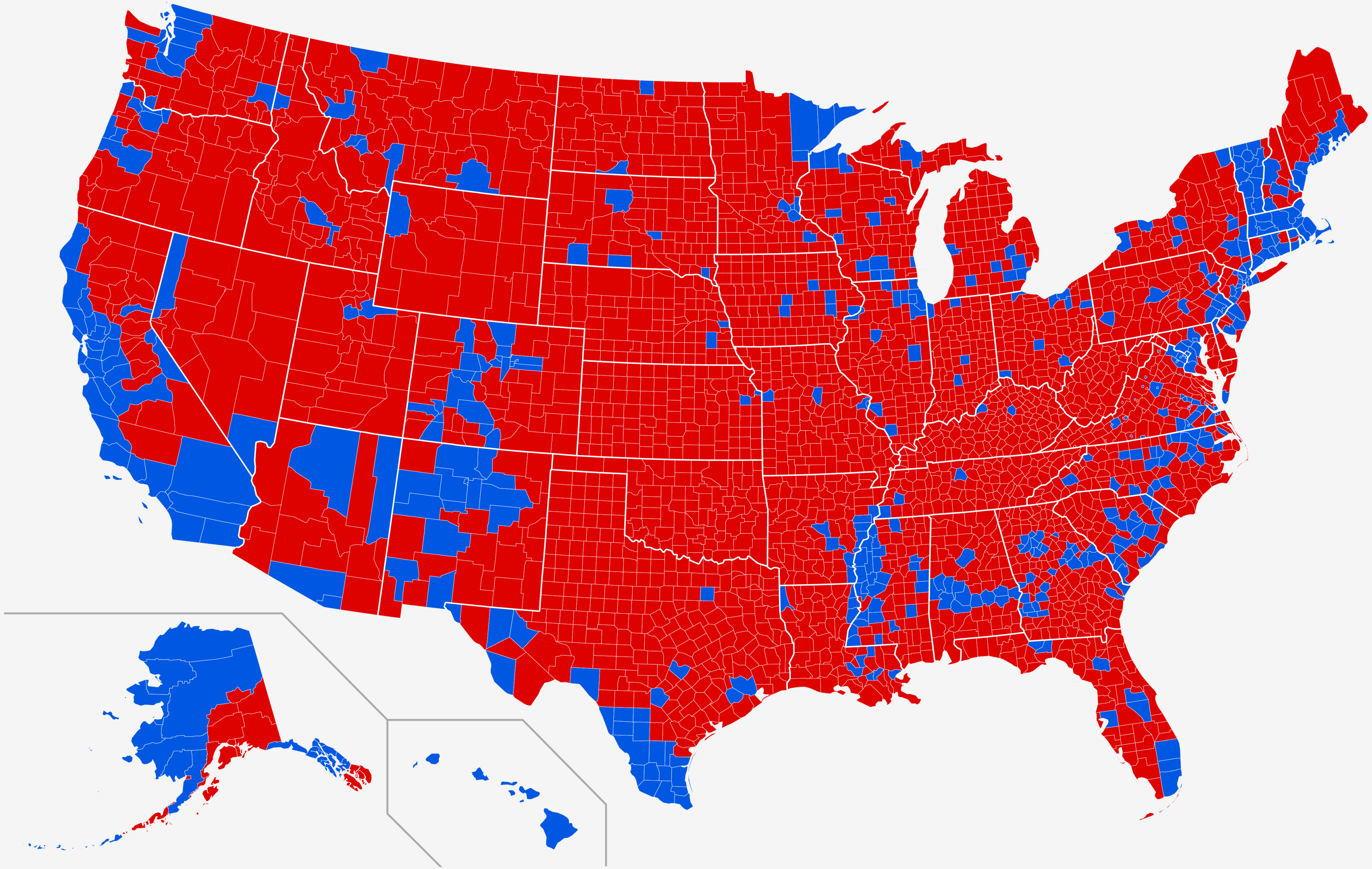
# Load our libraries

```
library(here)       # manage file paths
library(socviz)     # data and some useful functions
library(tidyverse) # your friend and mine
library(maps)       # Some basic maps
library(sf)         # Simple Features Geometries and geom_sf()
library(ggforce)    # Useful enhancements to ggplot
```

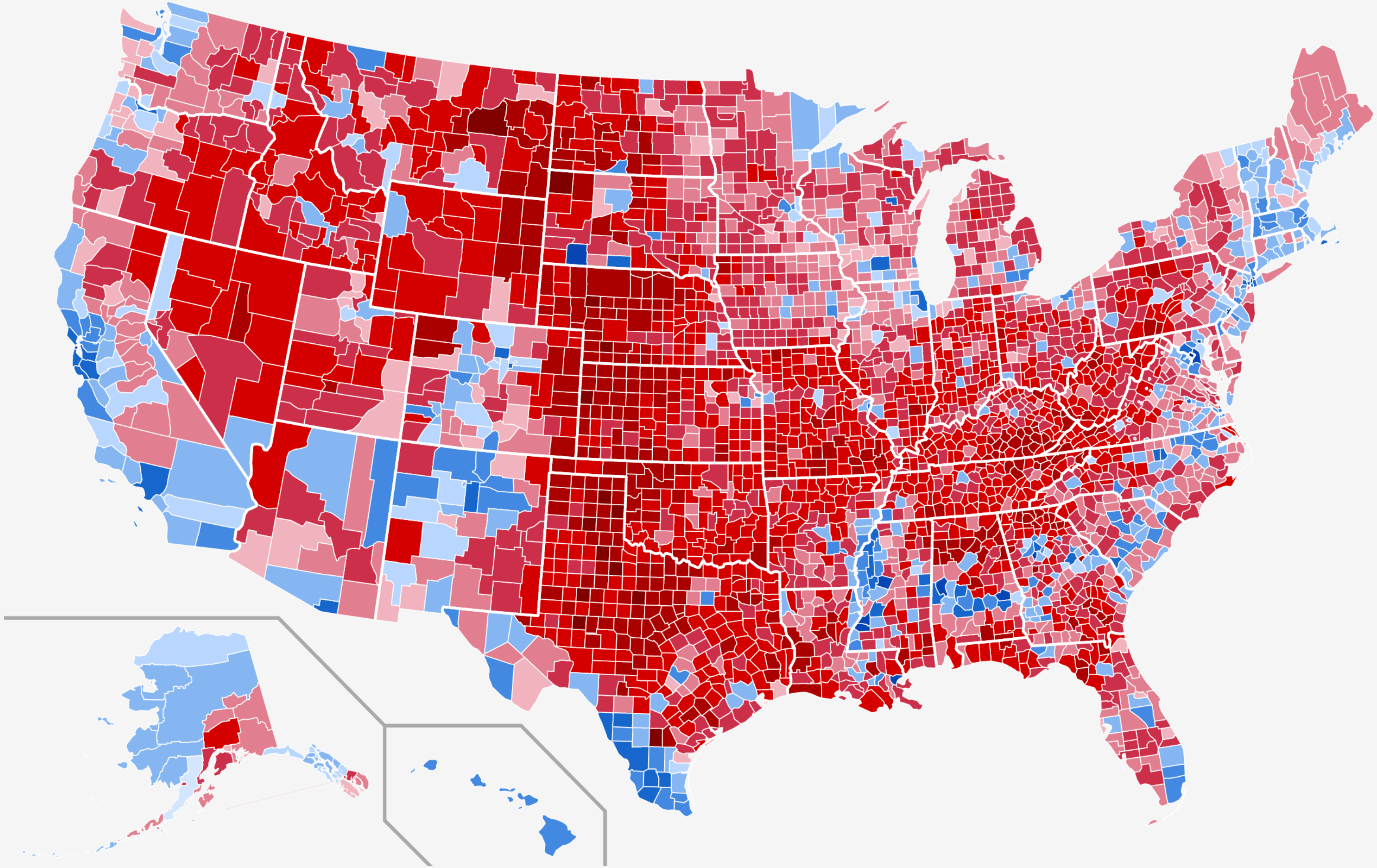
# Choropleths



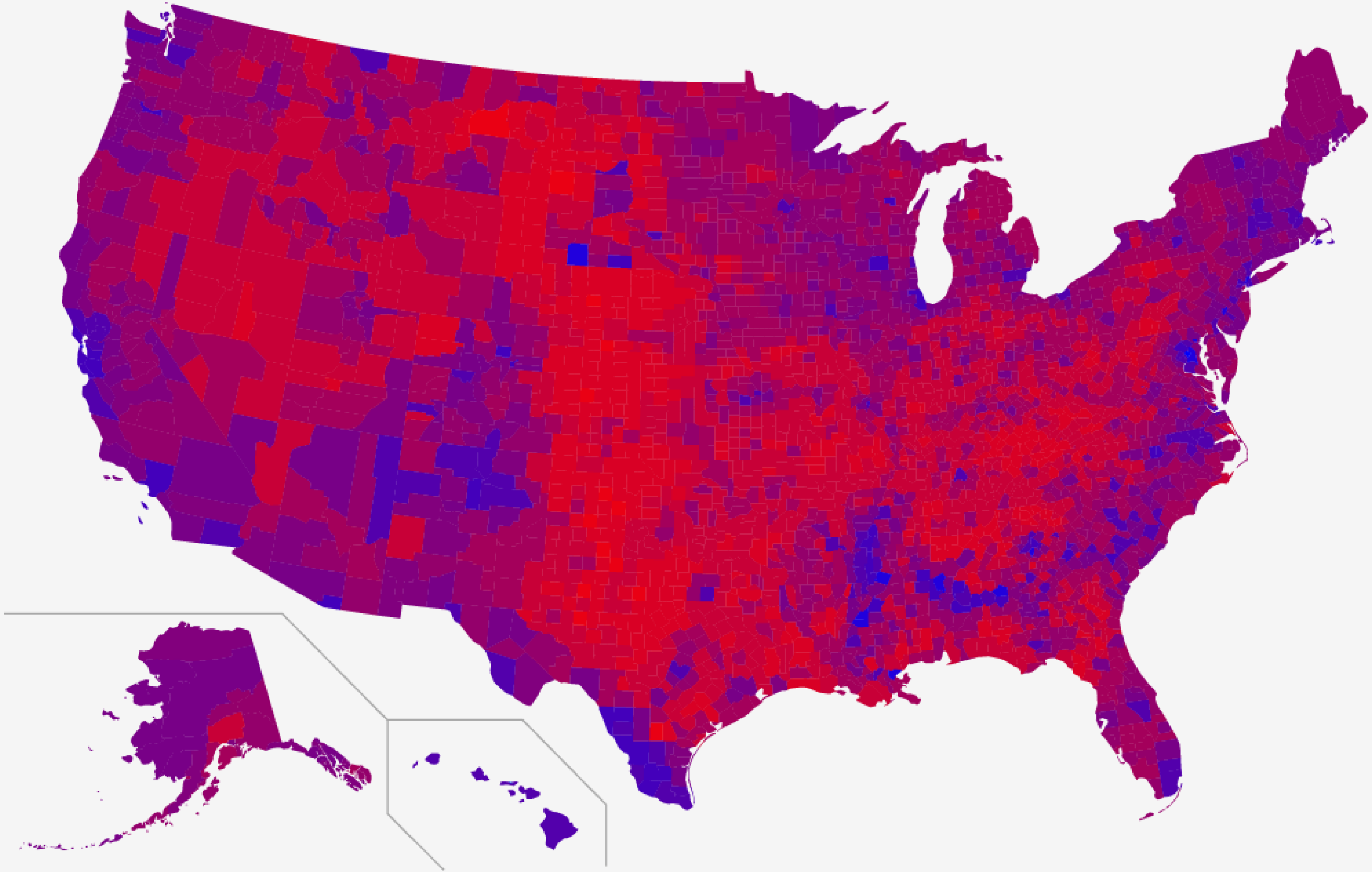

State-level; vote share; diverging; binned into four categories.



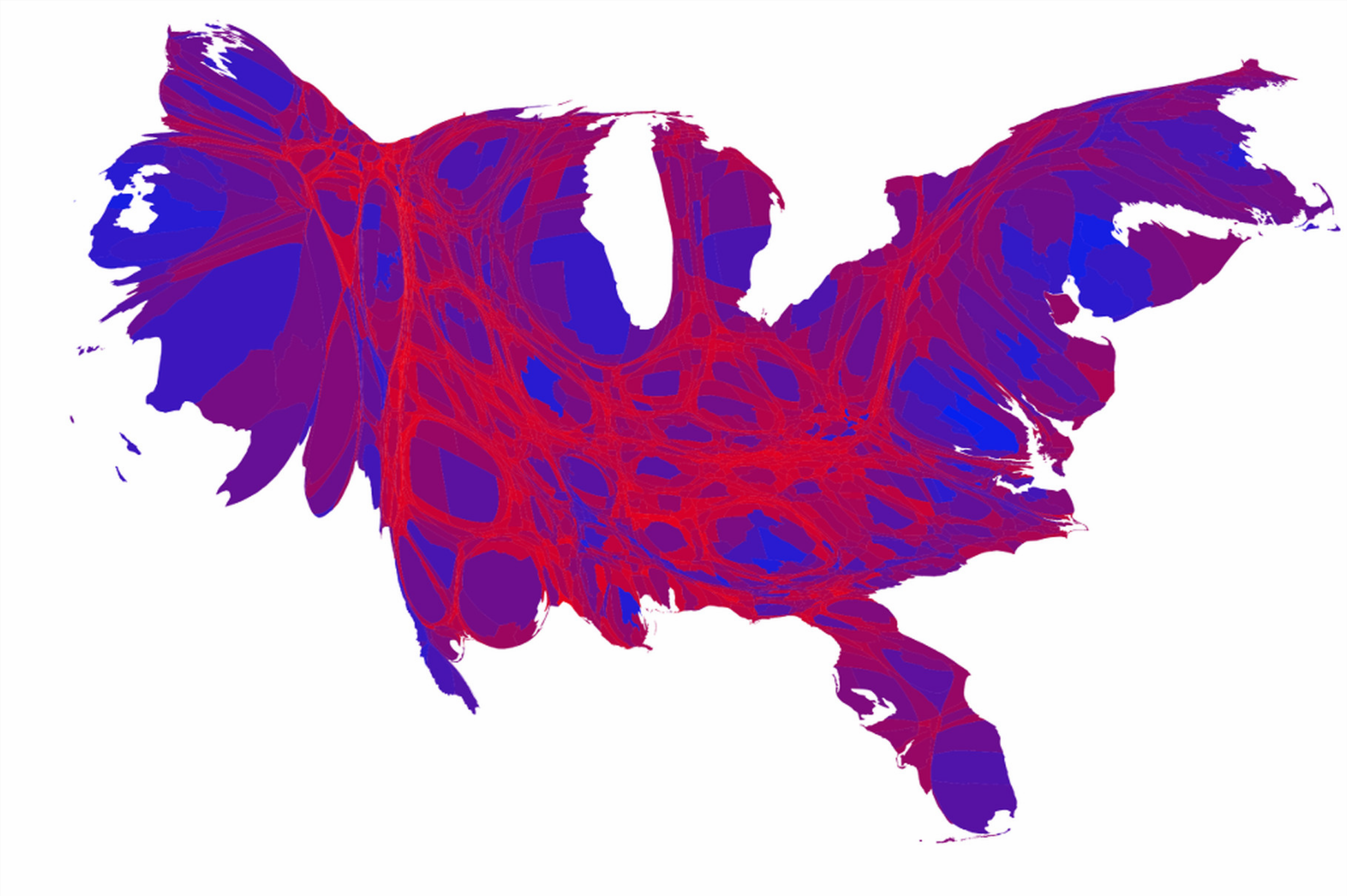
County level; winner only



County level vote share; diverging; binned into six categories

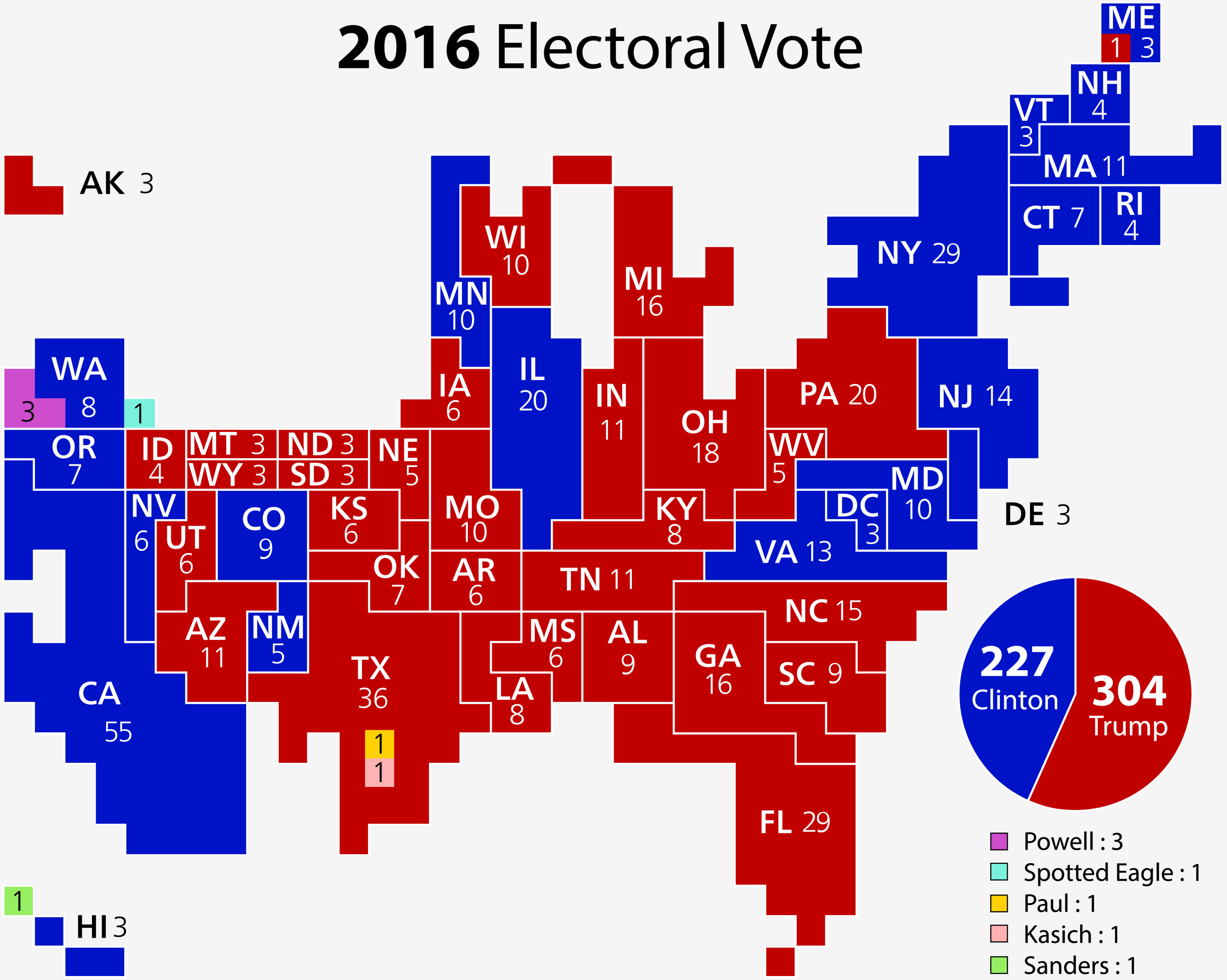


County level vote share; diverging continuous; purple midpoint



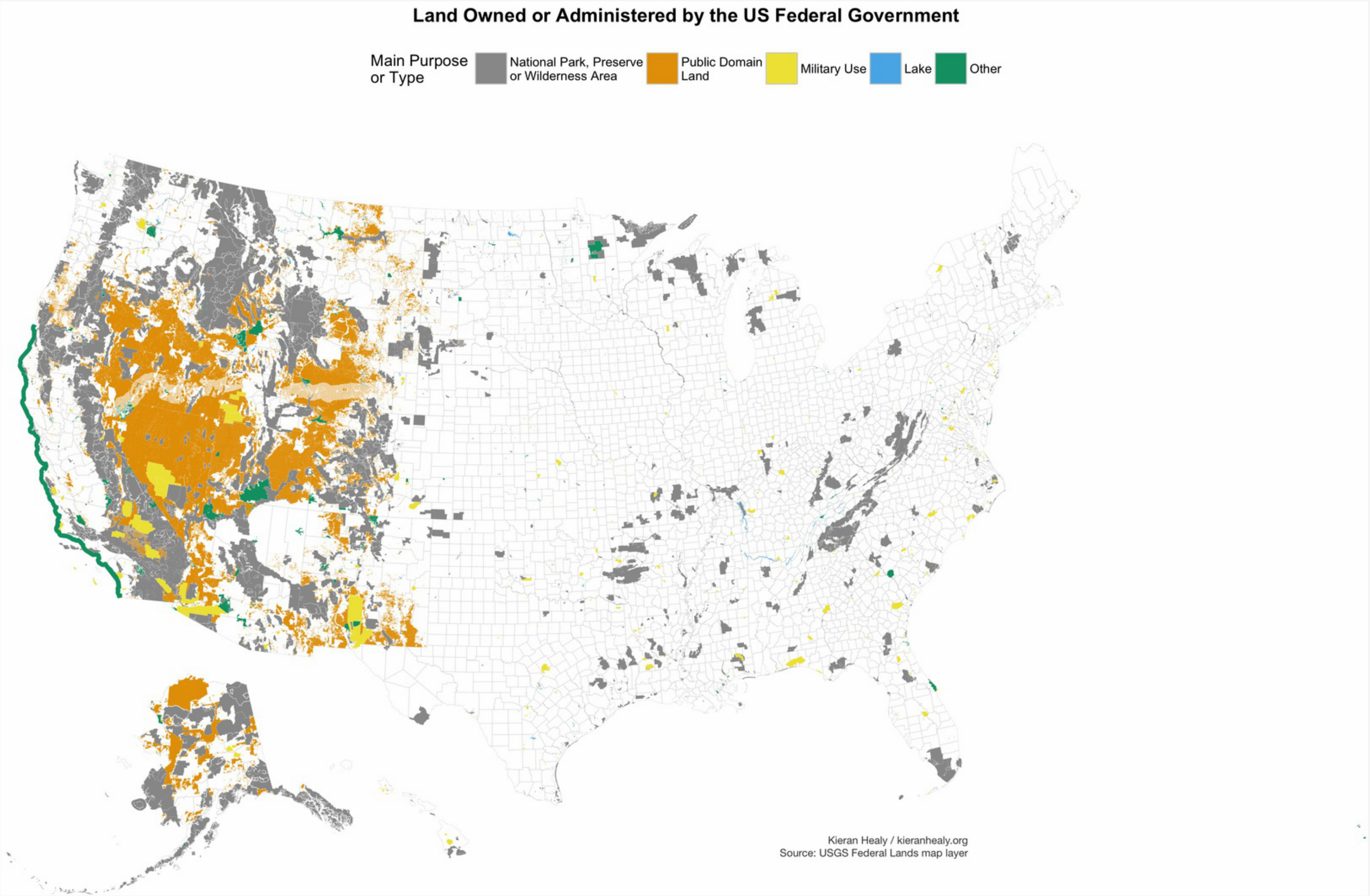
County level vote share; purple midpoint; county area deformed in proportion to population. By Mark Newman

# 2016 Electoral Vote

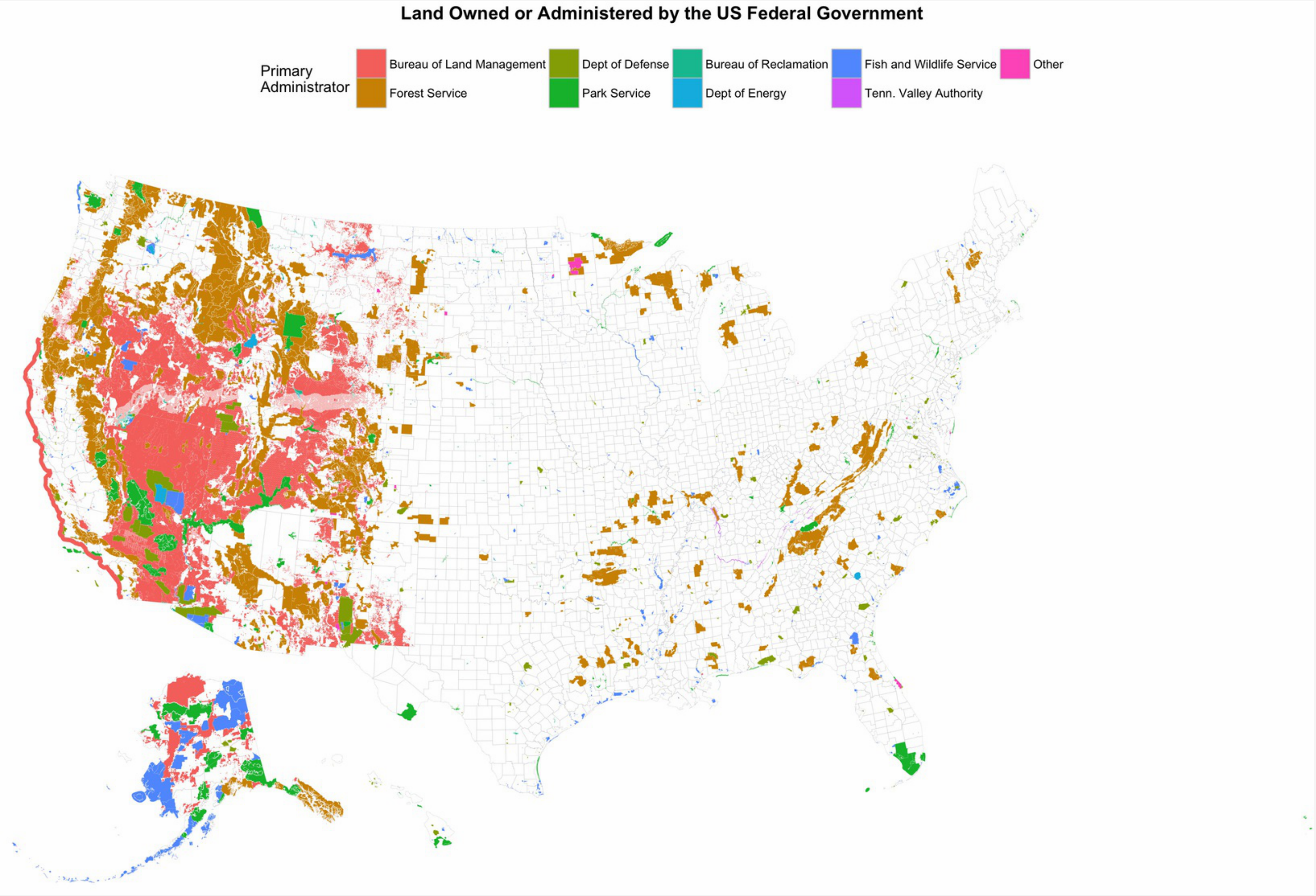



Electoral college cartogram

# Problems showing Non-Spatial Data in choropleth maps

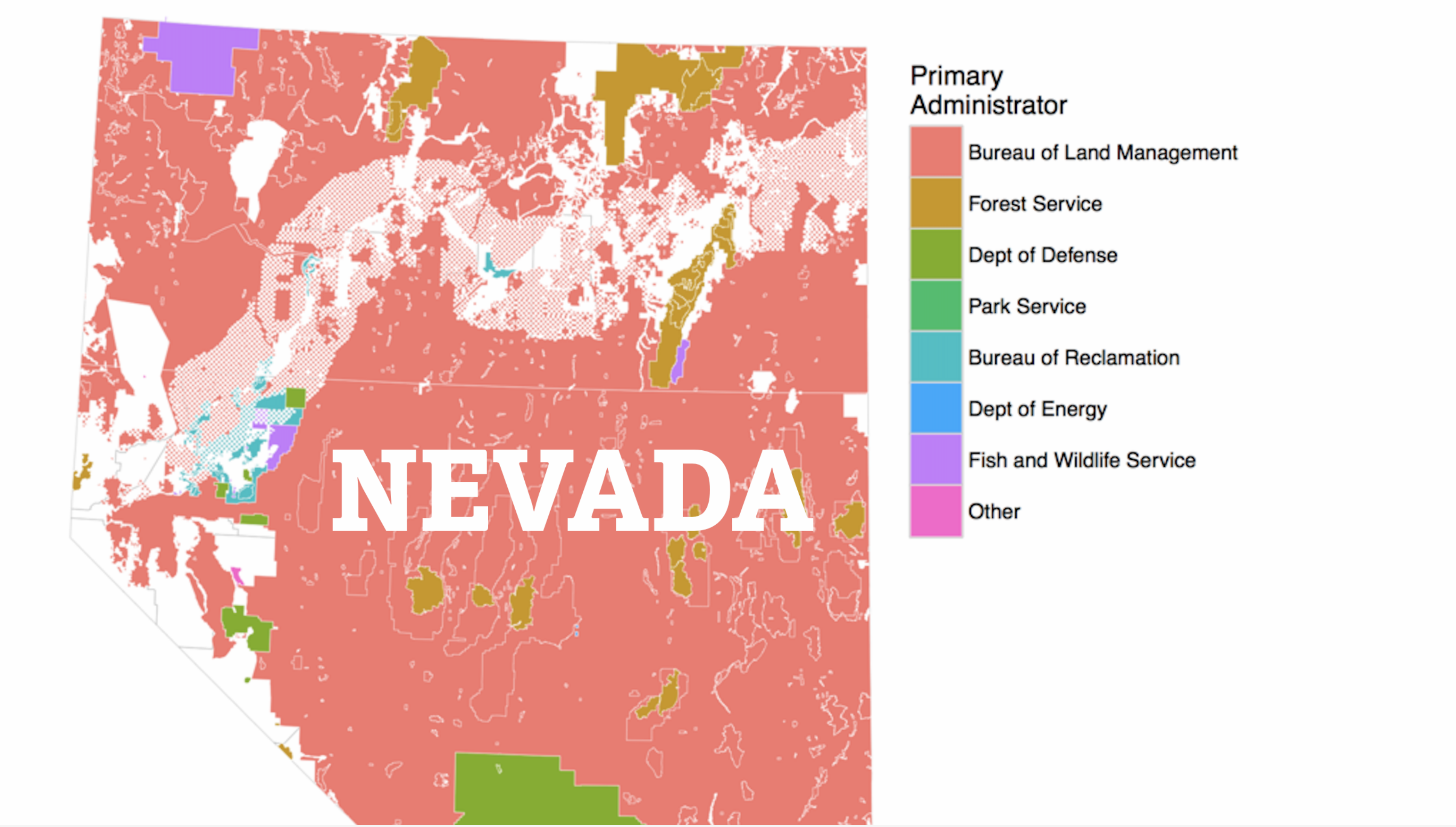



# Pretty, Big, and Pretty Empty

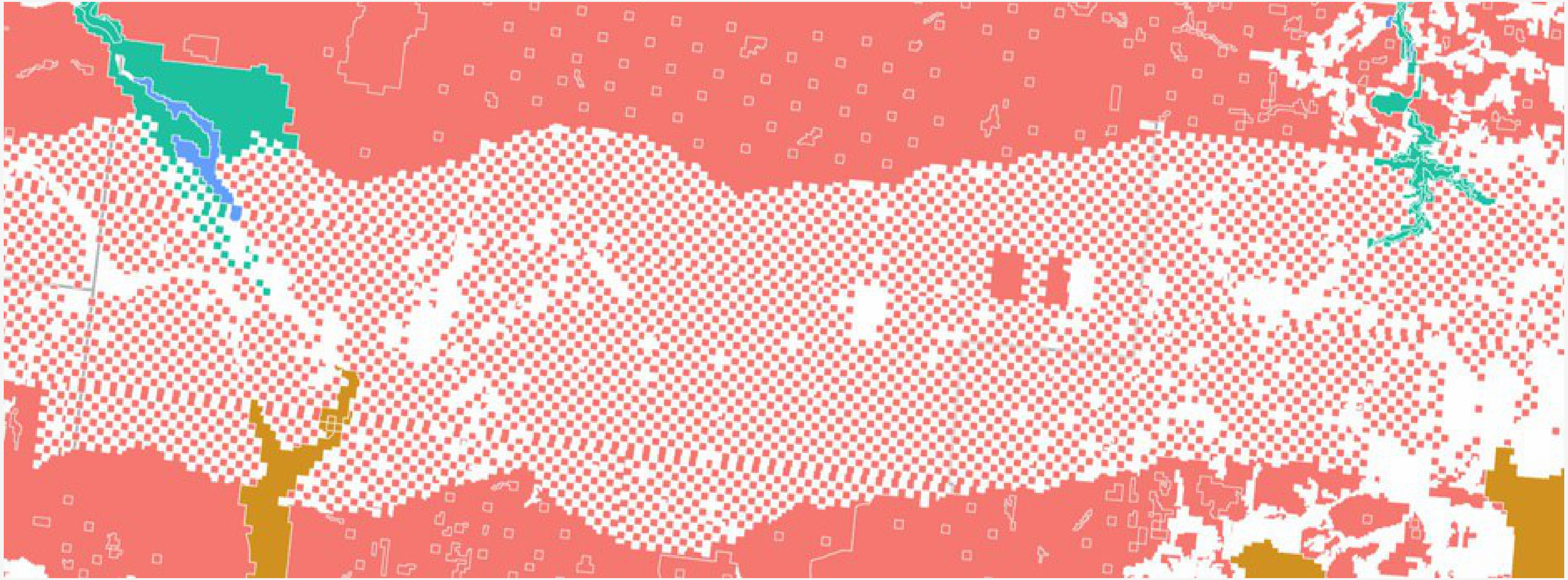



# Pretty, Big, and Pretty Empty

# Aside: What the hell's that?

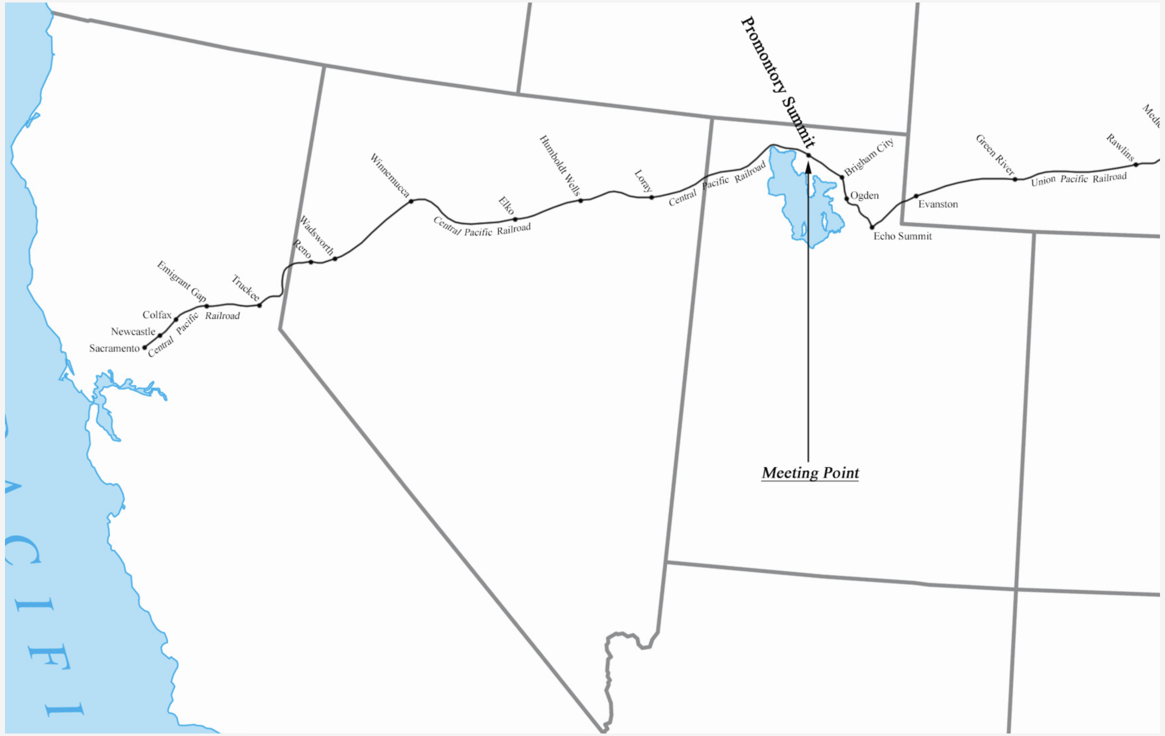


# Zoom and Enhance



Suprisingly, not a coding error on my part.

# It's the Transcontinental Railroad




Making its way through the Great Basin, America's largest endorheic watershed. The checkerboard is a deliberate assignation of property rights along the borders of the railway line.

# Still with us, too


Not identical, as Interstate 80 was able to go through some parts the railroad had to go around. OK, now back to scheduled programming.

# U.S. State-Level Election Data

# Set up the data

```r
## Hex color codes for Democratic Blue and Republican Red
party_colors <- c("#2E74C0", "#CB454A")
```

```r
election |>
  select(state, total_vote, r_points, pct_trump, party, census)
```

```
## # A tibble: 51 × 6
##    state                total_vote r_points pct_trump party      census
##    <chr>                     <dbl>    <dbl>     <dbl> <chr>      <chr>
##  1 Alabama                 2123372    27.7      62.1  Republican South
##  2 Alaska                   318608    14.7      51.3  Republican West
##  3 Arizona                 2604657     3.5      48.1  Republican West
##  4 Arkansas                1130635    26.9      60.6  Republican South
##  5 California             14237893   -30.0      31.5  Democratic West
##  6 Colorado                2780247    -4.91     43.2  Democratic West
##  7 Connecticut             1644920   -13.6      40.9  Democratic Northeast
##  8 Delaware                 443814   -11.4      41.7  Democratic South
##  9 District of Columbia     311268   -86.8       4.09 Democratic South
## 10 Florida                 9502747     1.19     48.6  Republican South
## # ℹ 41 more rows
```

# Look before Mapping

```
## Hex color codes for Democratic Blue and Republican Re
party_colors <- c("#2E74C0", "#CB454A")
```

# Look before Mapping

```r
## Hex color codes for Democratic Blue and Republican Re
party_colors <- c("#2E74C0", "#CB454A")

election
```

```
## # A tibble: 51 × 22
##    state      st     fips total_vote vote_margin winner party pct_marg
##    <chr>      <chr> <dbl>      <dbl>       <dbl> <chr>  <chr>     <db
##  1 Alabama    AL        1    2123372      588708 Trump  Repu…     0.27
##  2 Alaska     AK        2     318608       46933 Trump  Repu…     0.14
##  3 Arizona    AZ        4    2604657       91234 Trump  Repu…     0.03
##  4 Arkansas   AR        5    1130635      304378 Trump  Repu…     0.26
##  5 Californ… CA        6   14237893     4269978 Clint… Demo…     0.30
##  6 Colorado   CO        8    2780247      136386 Clint… Demo…     0.04
##  7 Connecti… CT        9    1644920      224357 Clint… Demo…     0.13
##  8 Delaware   DE       10     443814       50476 Clint… Demo…     0.11
##  9 District… DC       11     311268      270107 Clint… Demo…     0.86
## 10 Florida    FL       12    9502747      112911 Trump  Repu…     0.01
## # ℹ 41 more rows
## # ℹ 13 more variables: d_points <dbl>, pct_clinton <dbl>, pct_trump <
## #   pct_johnson <dbl>, pct_other <dbl>, clinton_vote <dbl>, trump_vot
## #   johnson_vote <dbl>, other_vote <dbl>, ev_dem <dbl>, ev_rep <dbl>,
## #   ev_oth <dbl>, census <chr>
```

# Look before Mapping

```r
## Hex color codes for Democratic Blue and Republican Re
party_colors <- c("#2E74C0", "#CB454A")

election |>
  filter(st %nin% "DC")
```

```
## # A tibble: 50 × 22
##    state       st     fips total_vote vote_margin winner party pct_marg
##    <chr>       <chr> <dbl>      <dbl>       <dbl> <chr>  <chr>     <db
##  1 Alabama     AL        1    2123372      588708 Trump  Repu…     0.27
##  2 Alaska      AK        2     318608       46933 Trump  Repu…     0.14
##  3 Arizona     AZ        4    2604657       91234 Trump  Repu…     0.03
##  4 Arkansas    AR        5    1130635      304378 Trump  Repu…     0.26
##  5 Californ…   CA        6   14237893     4269978 Clint… Demo…     0.30
##  6 Colorado    CO        8    2780247      136386 Clint… Demo…     0.04
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##  8 Delaware    DE       10     443814       50476 Clint… Demo…     0.11
##  9 Florida     FL       12    9502747      112911 Trump  Repu…     0.01
## 10 Georgia     GA       13    4141447      211141 Trump  Repu…     0.05
## # ℹ 40 more rows
## # ℹ 13 more variables: d_points <dbl>, pct_clinton <dbl>, pct_trump <
## #   pct_johnson <dbl>, pct_other <dbl>, clinton_vote <dbl>, trump_vot
## #   johnson_vote <dbl>, other_vote <dbl>, ev_dem <dbl>, ev_rep <dbl>,
## #   ev_oth <dbl>, census <chr>
```
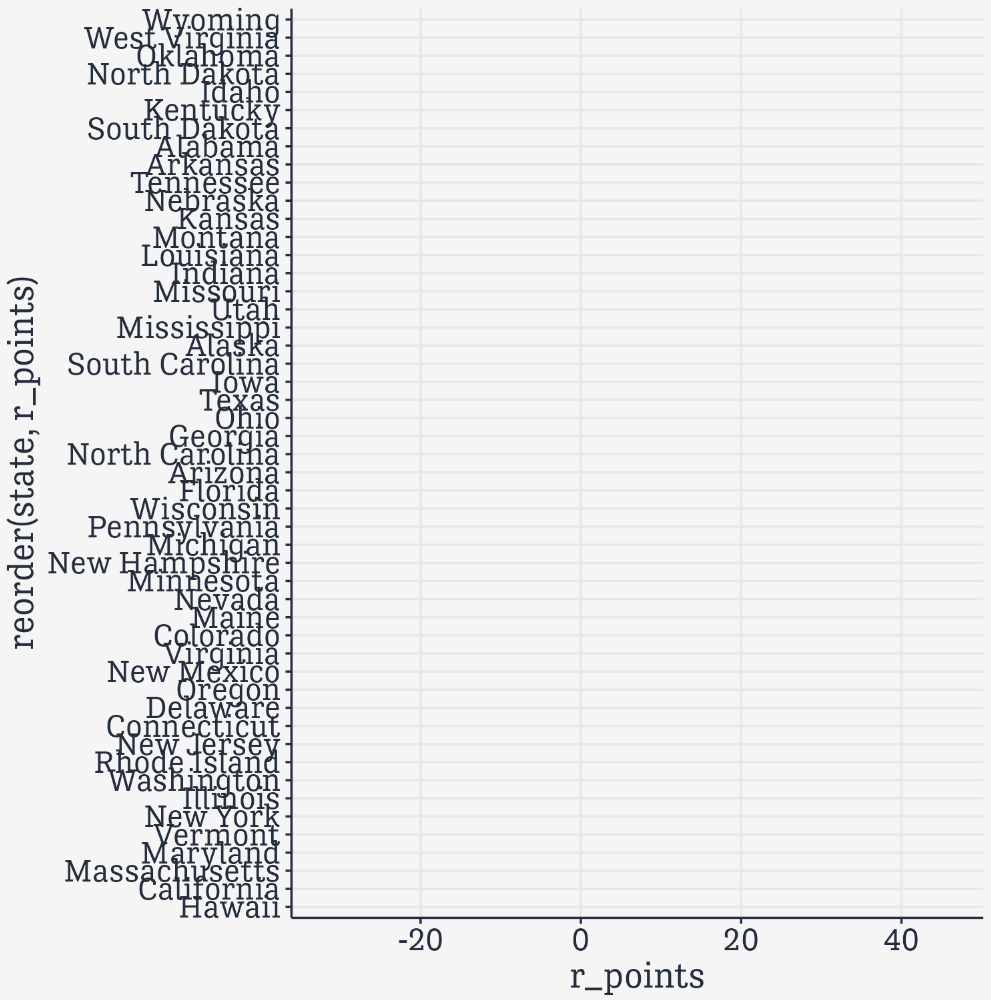
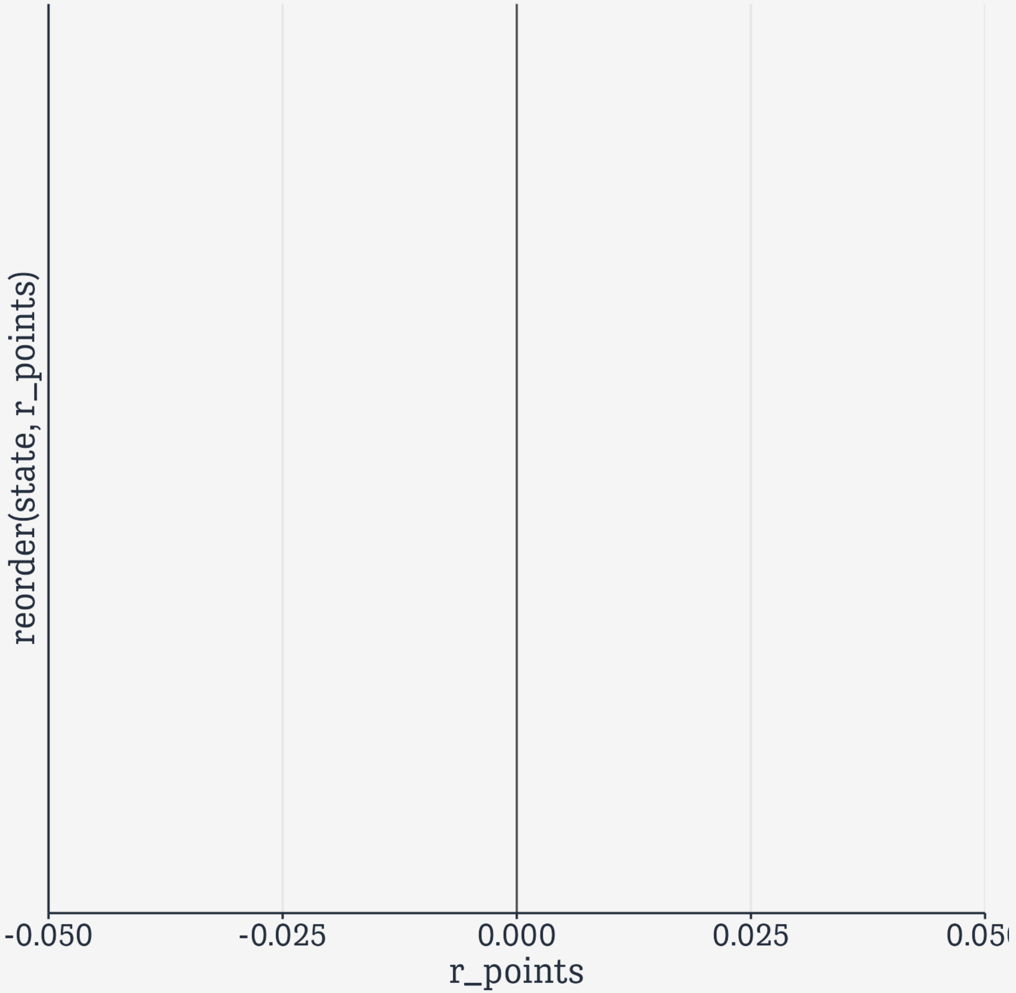

# Look before Mapping

```r
## Hex color codes for Democratic Blue and Republican Re
party_colors <- c("#2E74C0", "#CB454A")

election |>
  filter(st %nin% "DC") |>
  ggplot(mapping = aes(x = r_points,
                       y = reorder(state, r_points),
                       color = party))
```



# Look before Mapping

```r
## Hex color codes for Democratic Blue and Republican Re
party_colors <- c("#2E74C0", "#CB454A")

election |>
  filter(st %nin% "DC") |>
  ggplot(mapping = aes(x = r_points,
                       y = reorder(state, r_points),
                       color = party)) +
  geom_vline(xintercept = 0,
             color = "gray30")
```



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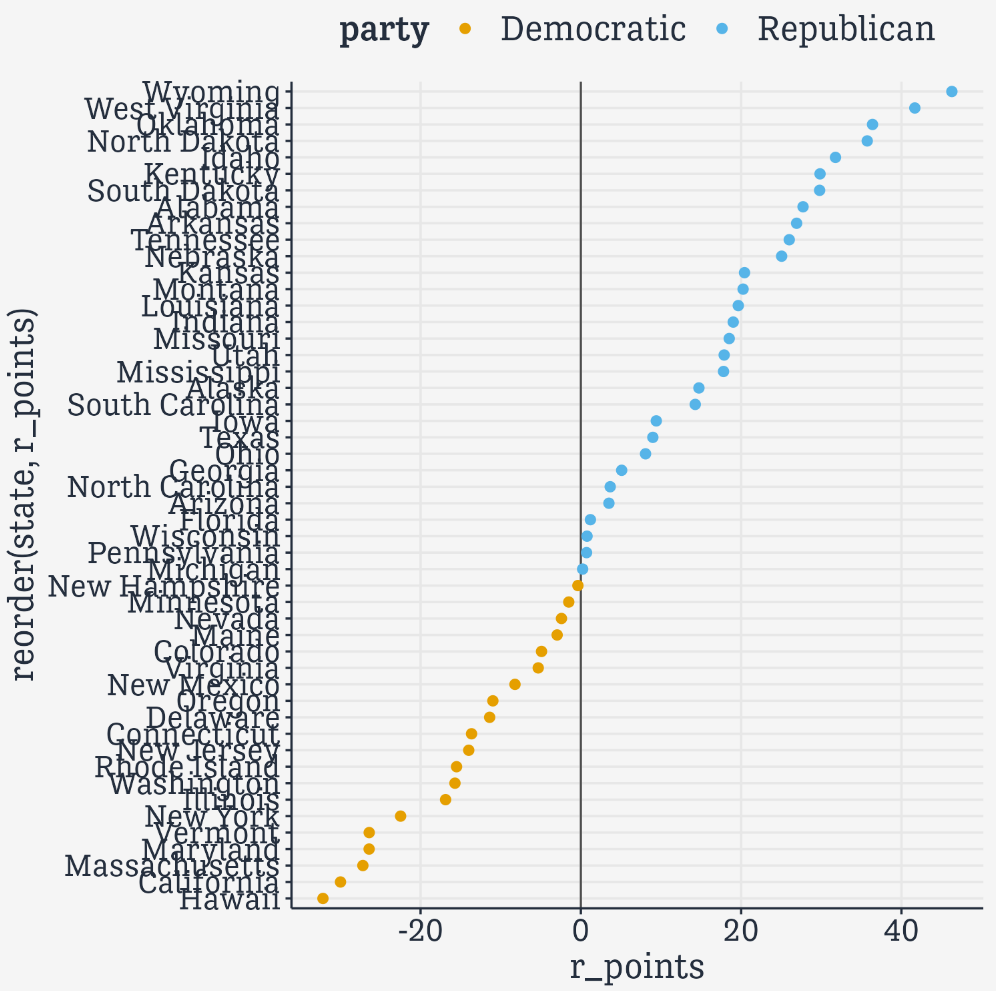
  filter(st %nin% "DC") |>
  ggplot(mapping = aes(x = r_points,
                       y = reorder(state, r_points),
                       color = party)) +
  geom_vline(xintercept = 0,
             color = "gray30") +
  geom_point(size = 2)
```



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  geom_vline(xintercept = 0,
             color = "gray30") +
  geom_point(size = 2) +
  scale_color_manual(values = party_colors)
```

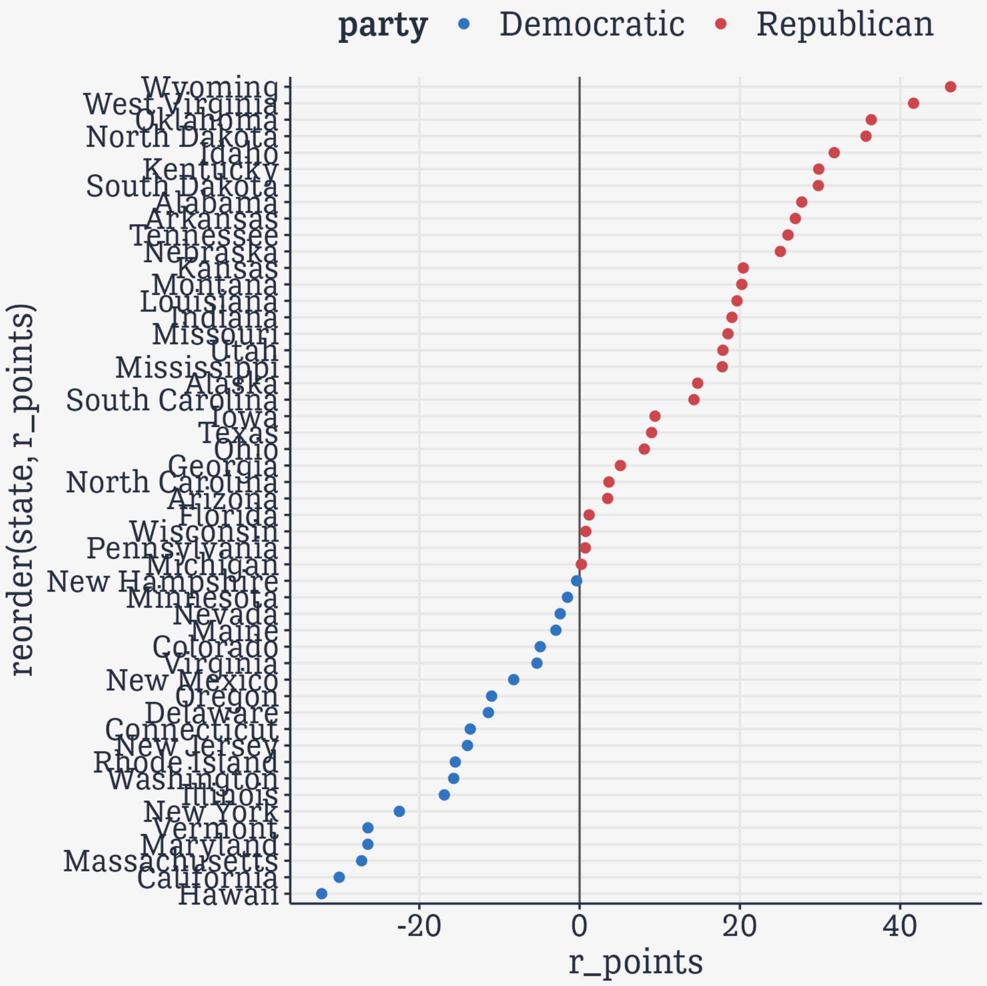

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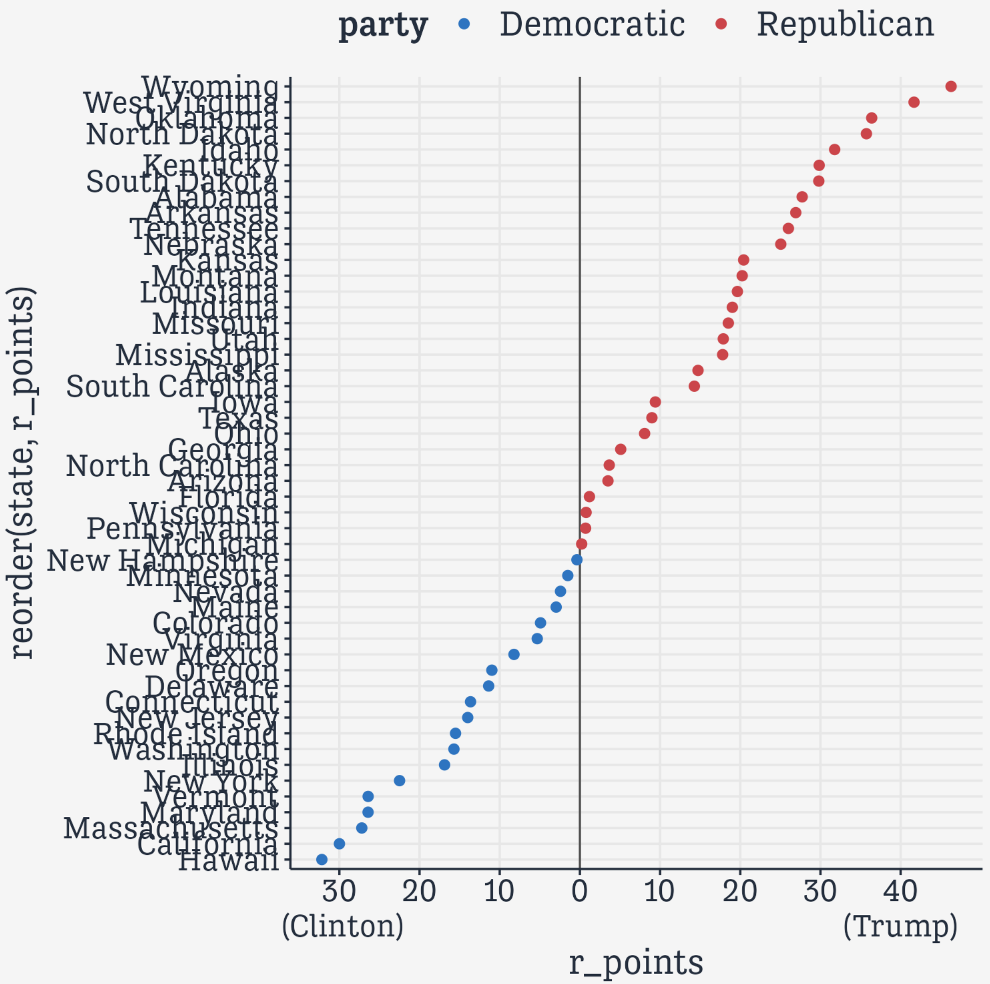
  geom_point(size = 2) +
  scale_color_manual(values = party_colors) +
  scale_x_continuous(breaks = c(-30, -20, -10, 0,
                                10, 20, 30, 40),
                     labels = c("30\n (Clinton)",
                                "20", "10", "0",
                                "10", "20", "30",
                                "40\n(Trump)"))
```



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  geom_point(size = 2) +
  scale_color_manual(values = party_colors) +
  scale_x_continuous(breaks = c(-30, -20, -10, 0,
                                10, 20, 30, 40),
                     labels = c("30\n (Clinton)",
                                "20", "10", "0",
                                "10", "20", "30",
                                "40\n(Trump)")) +
  facet_wrap(~ census, ncol=2,
             scales="free_y")
```

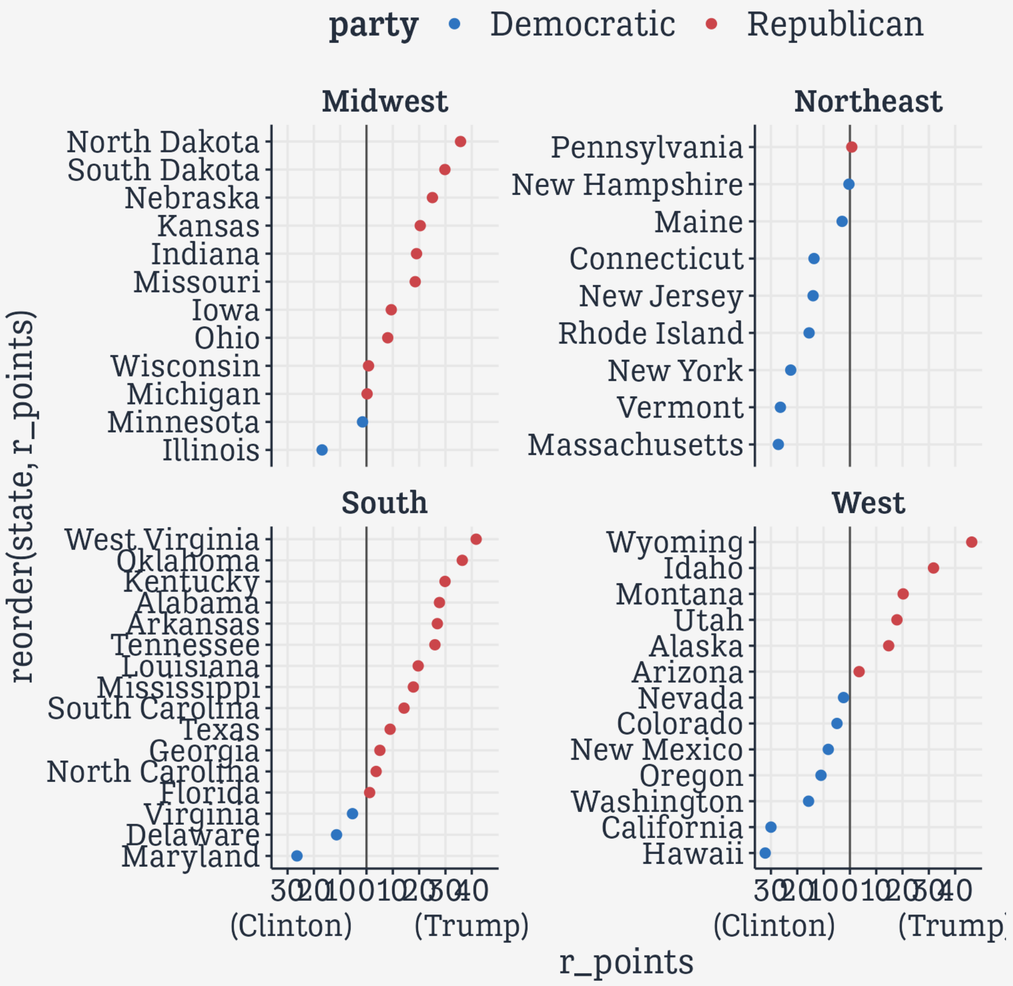

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election ▷
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  ggplot(mapping = aes(x = r_points,
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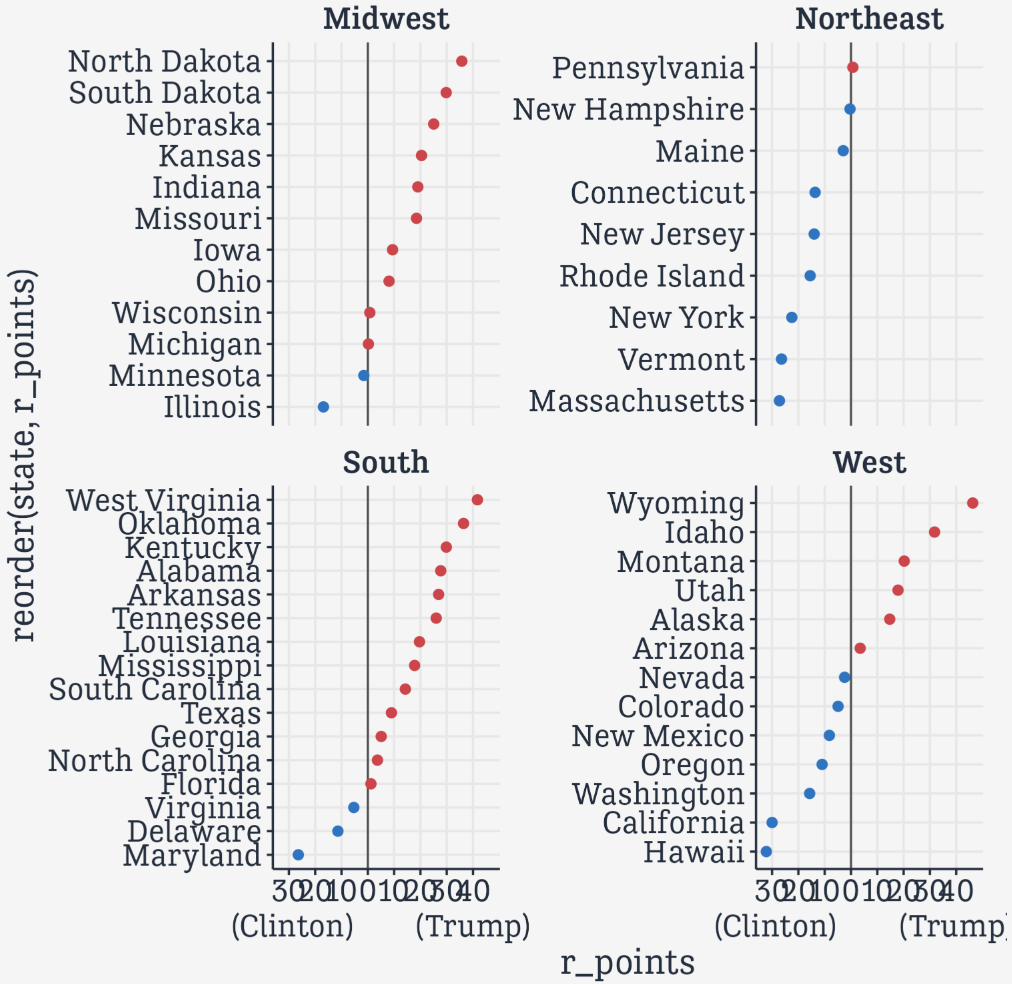
  scale_x_continuous(breaks = c(-30, -20, -10, 0,
                                10, 20, 30, 40),
                     labels = c("30\n (Clinton)",
                                "20", "10", "0",
                                "10", "20", "30",
                                "40\n(Trump)")) +
  facet_wrap(~ census, ncol=2,
             scales="free_y") +
  guides(color = "none")
```



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                       color = party)) +
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             color = "gray30") +
  geom_point(size = 2) +
  scale_color_manual(values = party_colors) +
  scale_x_continuous(breaks = c(-30, -20, -10, 0,
                                10, 20, 30, 40),
                     labels = c("30\n (Clinton)",
                                "20", "10", "0",
                                "10", "20", "30",
                                "40\n(Trump)")) +
  facet_wrap(~ census, ncol=2,
             scales="free_y") +
  guides(color = "none") +
  labs(x = "Point Margin", y = NULL)
```

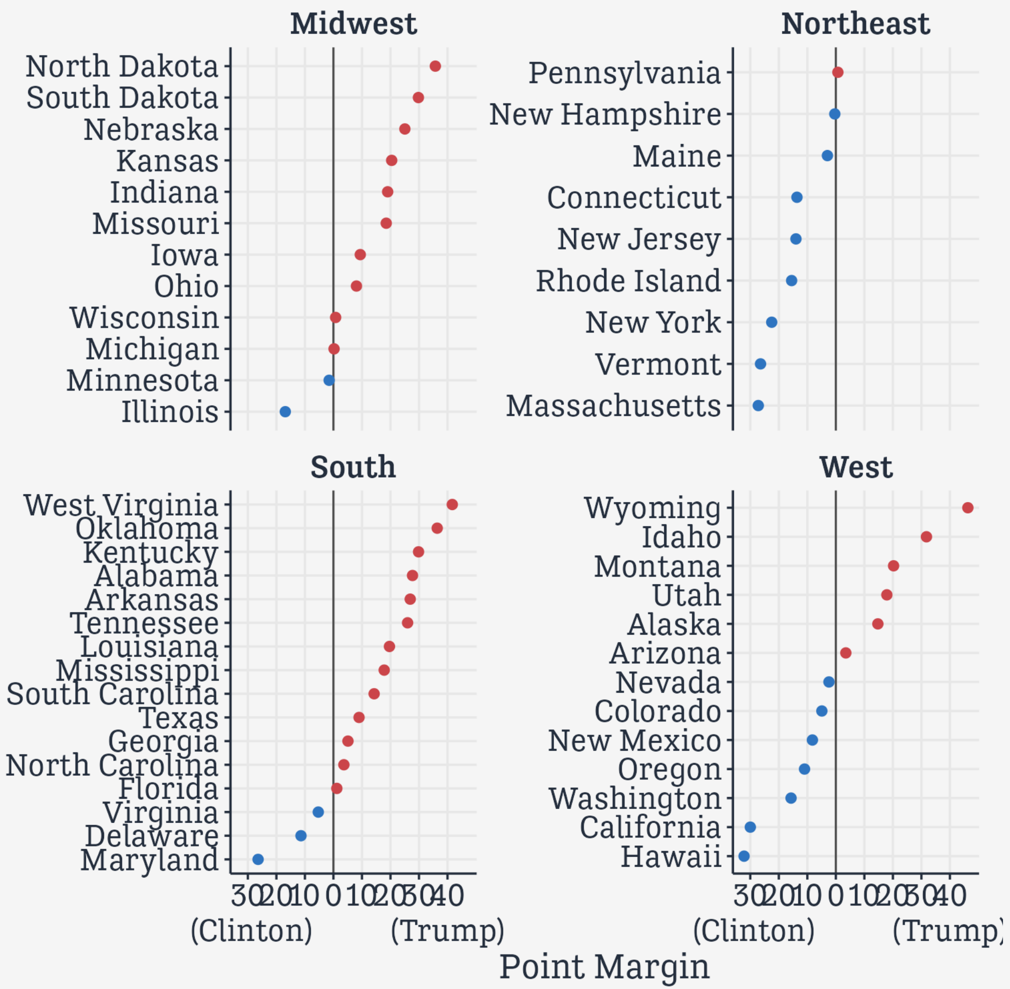

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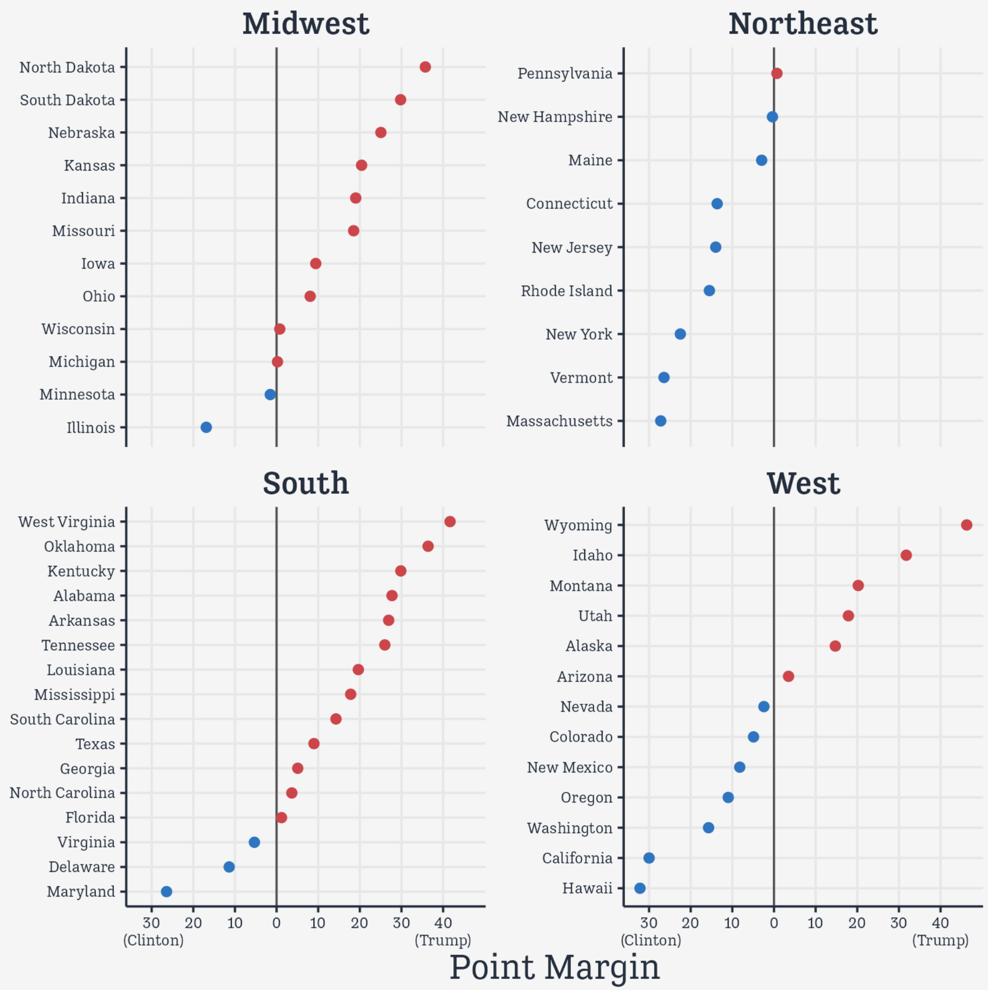
election |>
  filter(st %nin% "DC") |>
  ggplot(mapping = aes(x = r_points,
                       y = reorder(state, r_points),
                       color = party)) +
  geom_vline(xintercept = 0,
             color = "gray30") +
  geom_point(size = 2) +
  scale_color_manual(values = party_colors) +
  scale_x_continuous(breaks = c(-30, -20, -10, 0,
                                10, 20, 30, 40),
                     labels = c("30\n (Clinton)",
                                "20", "10", "0",
                                "10", "20", "30",
                                "40\n(Trump)")) +
  facet_wrap(~ census, ncol=2,
             scales="free_y") +
  guides(color = "none") +
  labs(x = "Point Margin", y = NULL) +
    theme(axis.text=element_text(size=8))
```



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  geom_vline(xintercept = 0,
             color = "gray30") +
  geom_point(size = 2) +
  scale_color_manual(values = party_colors) +
  scale_x_continuous(breaks = c(-30, -20, -10, 0,
                                10, 20, 30, 40),
                     labels = c("30\n (Clinton)",
                                "20", "10", "0",
                                "10", "20", "30",
                                "40\n(Trump)")) +
  facet_wrap(~ census, ncol=2,
             scales="free_y") +
  guides(color = "none") +
  labs(x = "Point Margin", y = NULL) +
    theme(axis.text=element_text(size=8))
```
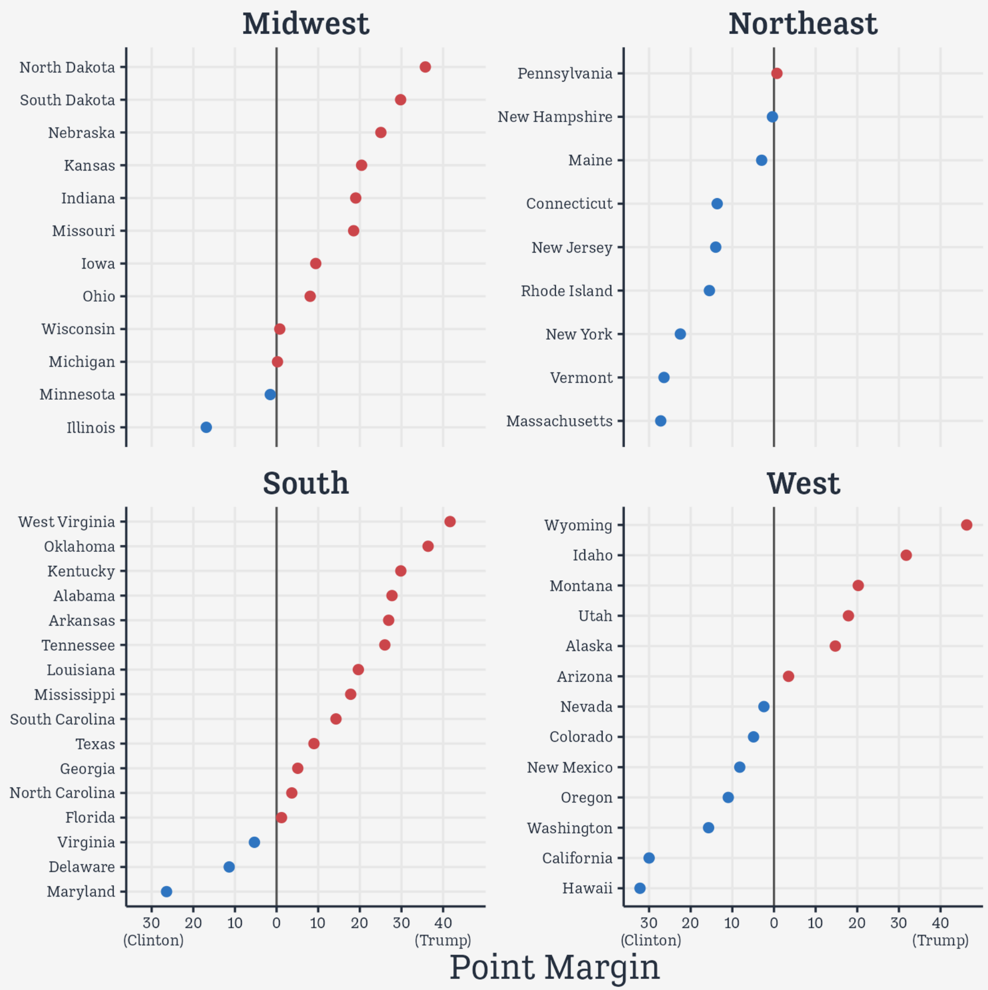
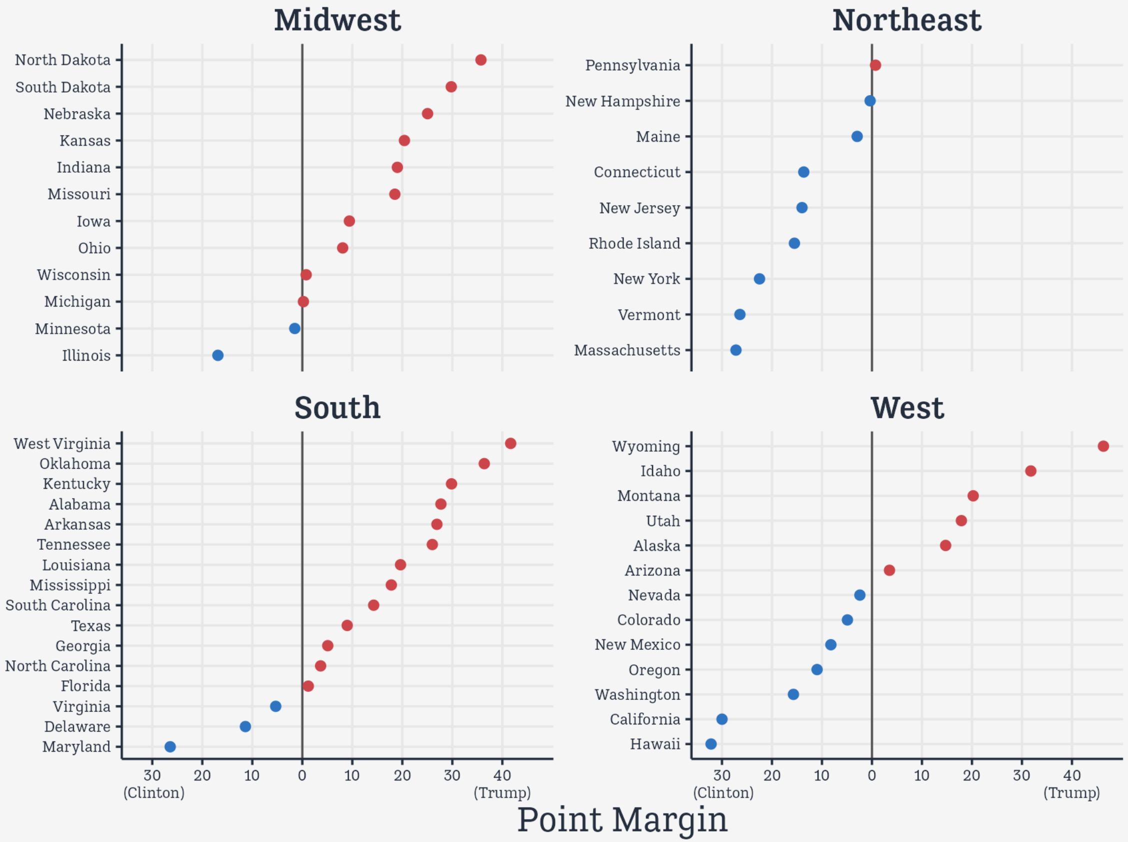
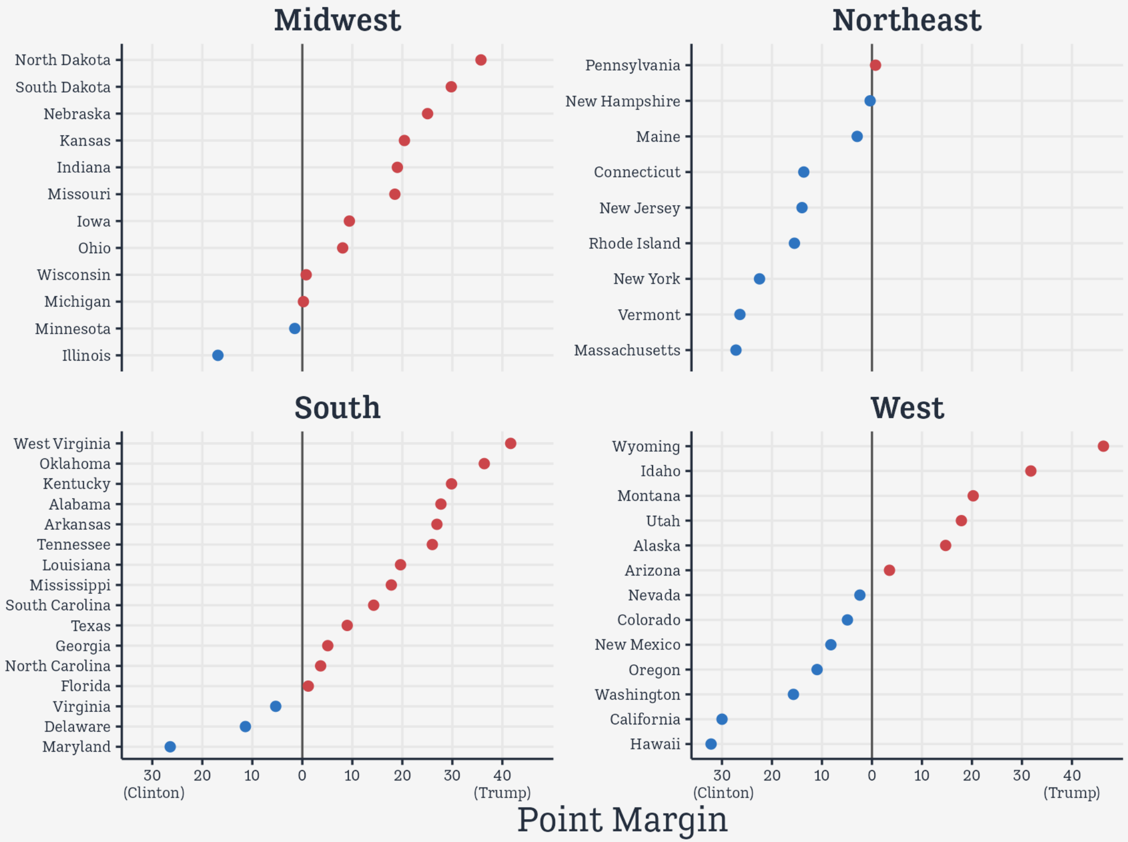



# With a bit more room



# With a bit more room




See how the panels are unbalanced, even with `scales = "free_y"`?

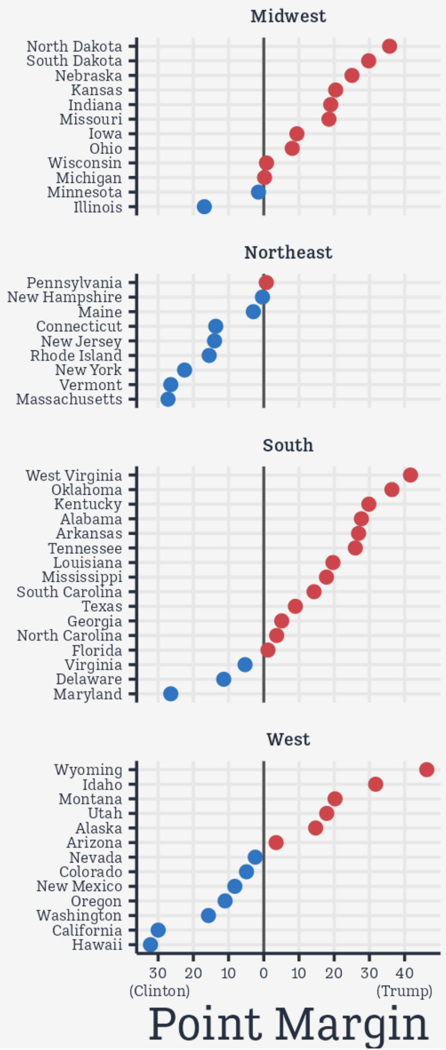
This happens because we have unequal number of states per region.

# We can use facet_col() from ggforce

```r
p_out <- election |>
  filter(st %nin% "DC") |>
  ggplot(mapping = aes(x = r_points,
                       y = reorder(state, r_points),
                       color = party)) +
  geom_vline(xintercept = 0,
             color = "gray30") +
  geom_point(size = 2) +
  scale_color_manual(values = party_colors) +
  scale_x_continuous(breaks = c(-30, -20, -10, 0,
                                10, 20, 30, 40),
                     labels = c("30\n (Clinton)",
                                "20", "10", "0",
                                "10", "20", "30",
                                "40\n(Trump)")) +
  facet_col(~ census,
            scales="free_y",
            space = "free") +
  guides(color = "none") +
  labs(x = "Point Margin", y = NULL) +
    theme(axis.text=element_text(size=6),
          strip.text = element_text(size = rel(0.6)))

p_out
```

# We can use `facet_col()` from `ggforce`

```r
p_out <- election |>
  filter(st %nin% "DC") |>
  ggplot(mapping = aes(x = r_points,
                       y = reorder(state, r_points),
                       color = party)) +
  geom_vline(xintercept = 0,
             color = "gray30") +
  geom_point(size = 2) +
  scale_color_manual(values = party_colors) +
  scale_x_continuous(breaks = c(-30, -20, -10, 0,
                                10, 20, 30, 40),
                     labels = c("30\n (Clinton)",
                                "20", "10", "0",
                                "10", "20", "30",
                                "40\n(Trump)")) +
  facet_col(~ census,
            scales="free_y",
            space = "free") +
  guides(color = "none") +
  labs(x = "Point Margin", y = NULL) +
    theme(axis.text=element_text(size=6),
          strip.text = element_text(size = rel(0.6)))

p_out
```



# Basic Maps

# Maps as polygons

# Take a look at this data

```r
## This is from the map library
# library(maps)

us_states <- map_data("state")

dim(us_states)
```

```
## [1] 15537     6
```

```r
## Making it a tibble prevents crashes
## in the slide rendering later on
us_states <- as_tibble(us_states)

us_states
```

```
## # A tibble: 15,537 × 6
##     long   lat group order region  subregion
##    <dbl> <dbl> <dbl> <int> <chr>   <chr>
##  1 -87.5  30.4     1     1 alabama <NA>
##  2 -87.5  30.4     1     2 alabama <NA>
##  3 -87.5  30.4     1     3 alabama <NA>
##  4 -87.5  30.3     1     4 alabama <NA>
##  5 -87.6  30.3     1     5 alabama <NA>
##  6 -87.6  30.3     1     6 alabama <NA>
##  7 -87.6  30.3     1     7 alabama <NA>
##  8 -87.6  30.3     1     8 alabama <NA>
##  9 -87.7  30.3     1     9 alabama <NA>
## 10 -87.8  30.3     1    10 alabama <NA>
## # ℹ 15,527 more rows
```

# What is this, at root?

```
us_states
```

```
## # A tibble: 15,537 × 6
##     long   lat group order region  subregion
##    <dbl> <dbl> <dbl> <int> <chr>   <chr>
##  1 -87.5  30.4     1     1 alabama <NA>
##  2 -87.5  30.4     1     2 alabama <NA>
##  3 -87.5  30.4     1     3 alabama <NA>
##  4 -87.5  30.3     1     4 alabama <NA>
##  5 -87.6  30.3     1     5 alabama <NA>
##  6 -87.6  30.3     1     6 alabama <NA>
##  7 -87.6  30.3     1     7 alabama <NA>
##  8 -87.6  30.3     1     8 alabama <NA>
##  9 -87.7  30.3     1     9 alabama <NA>
## 10 -87.8  30.3     1    10 alabama <NA>
## # ℹ 15,527 more rows
```

It's a series of rows defining `x` and `y` coordinatates on a plane.

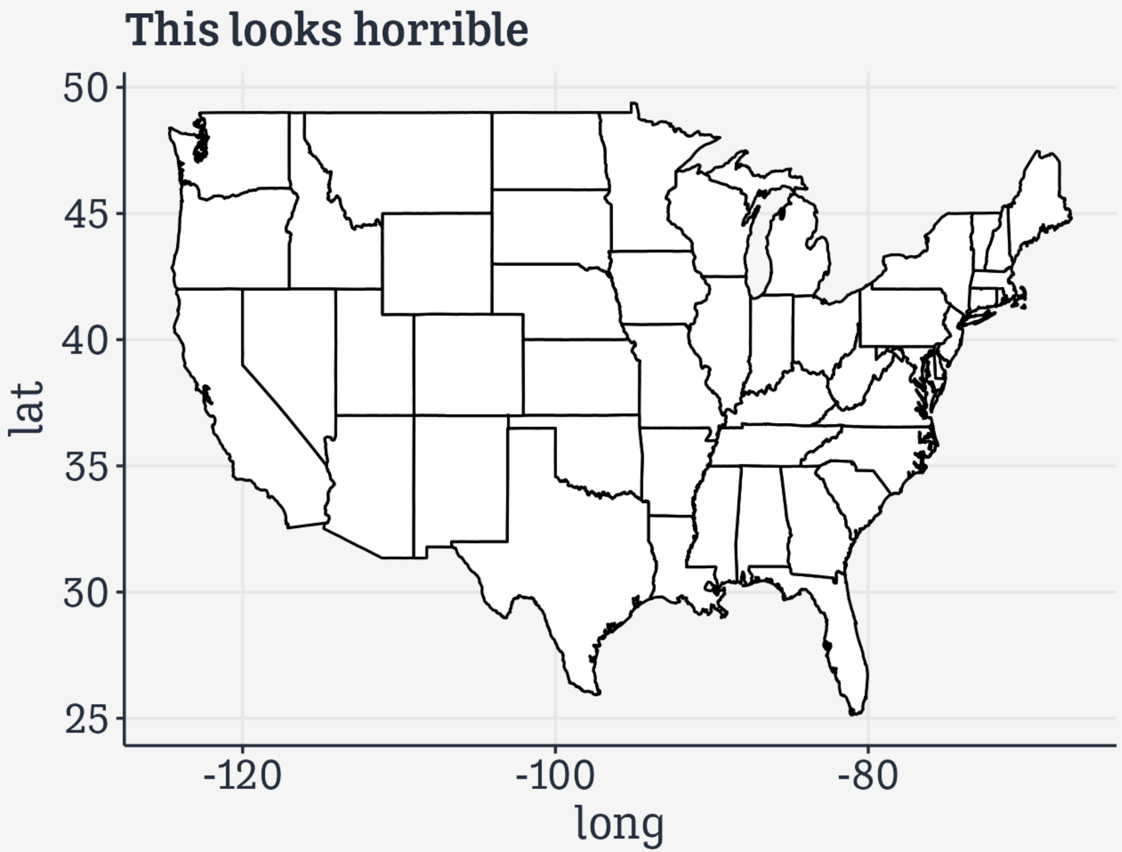
If we join those points up as lines while respecting their `group` (i.e. so `ggplot` knows when to "lift the pen", as with the `gapminder` line plot), we will get an outline map of states in the U.S.

# Like this, with `geom_polygon()`

```
us_states |>
  ggplot(mapping = aes(x = long,
                       y = lat,
                       group = group)) +
  geom_polygon(fill = "white",
               color = "black") +
  labs(title = "This looks horrible")
```

# Like this, with `geom_polygon()`

```r
us_states ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       group = group)) +
  geom_polygon(fill = "white",
               color = "black") +
  labs(title = "This looks horrible")
```

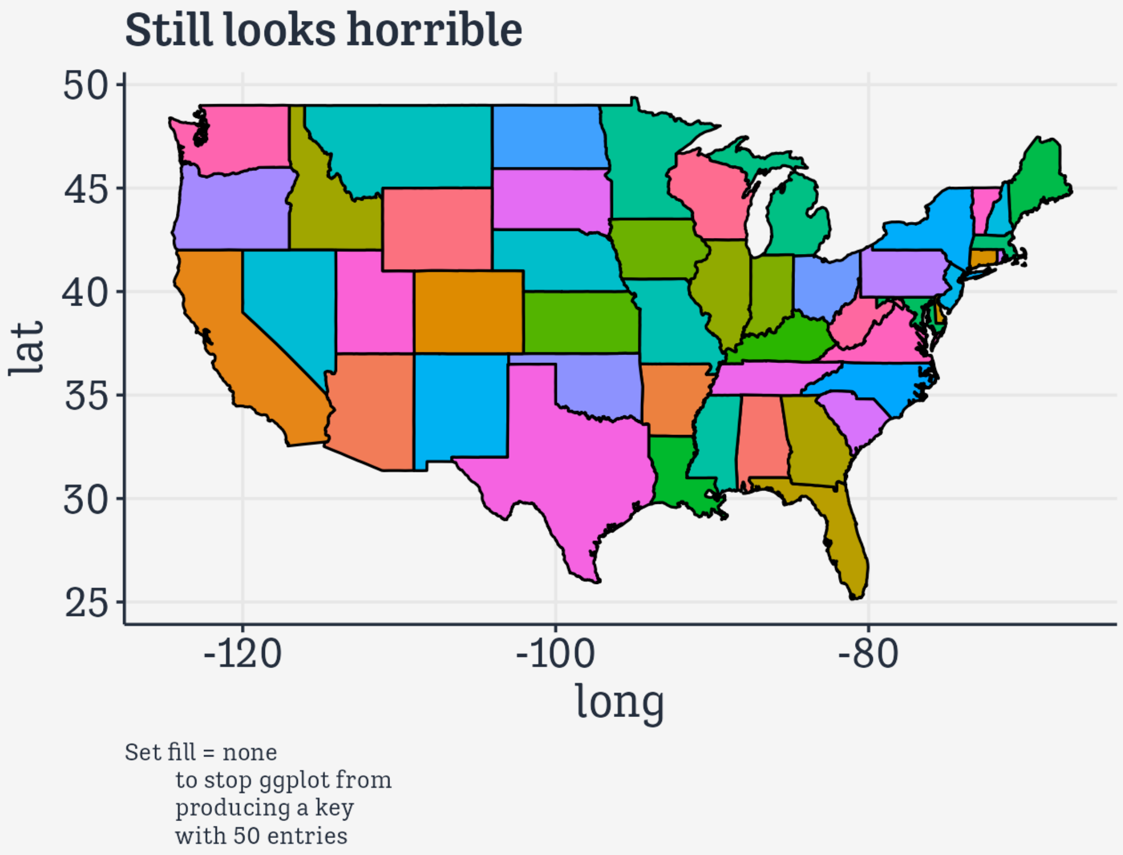


# We can represent a `fill`, too, like any geom

```
us_states ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = region,
                       group = group)) +
  geom_polygon(color = "black") +
  guides(fill = "none") +
  labs(title = "Still looks horrible",
       caption = "Set fill = none
         to stop ggplot from
         producing a key
         with 50 entries")
```

# We can represent a `fill`, too, like any geom

```r
us_states ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = region,
                       group = group)) +
  geom_polygon(color = "black") +
  guides(fill = "none") +
  labs(title = "Still looks horrible",
       caption = "Set fill = none
         to stop ggplot from
         producing a key
         with 50 entries")
```



# We need to do two things

**1: Fix the map projection**

**2: Add some data to fill with.**

# For now, we'll do it the direct way

To make explicit what's happening, and to emphasize how *it's all just points and lines made from tables* we'll first do it at the level of the `ggplot` grammar with a geom that just draws shapes, `geom_polygon()`. After that, we'll introduce a new package, `sf` and a new geom, `geom_sf()` that will handle this for us, and more.

# Fix the projection

```
us_states <- as_tibble(map_data("state"))
```

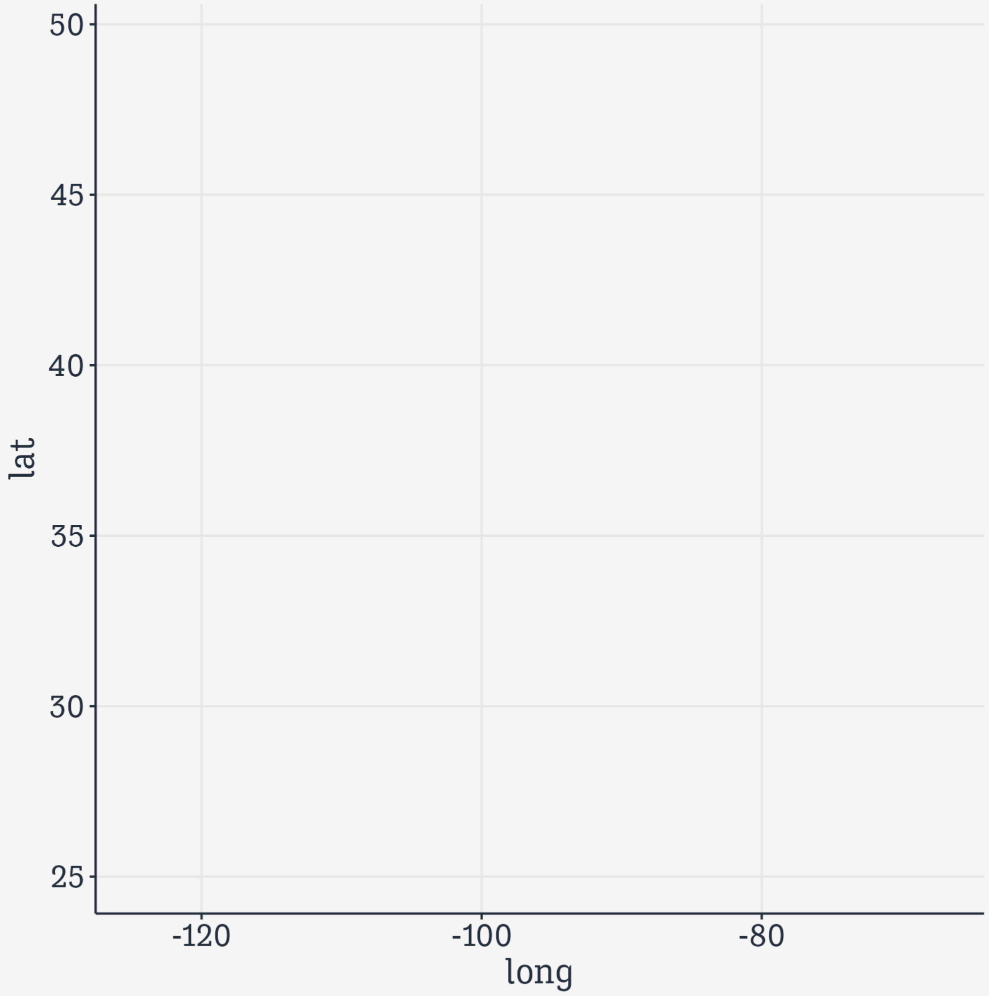
# Fix the projection

```r
us_states <- as_tibble(map_data("state"))

us_states
```

```
## # A tibble: 15,537 × 6
##     long   lat group order region  subregion
##    <dbl> <dbl> <dbl> <int> <chr>   <chr>
##  1 -87.5  30.4     1     1 alabama <NA>
##  2 -87.5  30.4     1     2 alabama <NA>
##  3 -87.5  30.4     1     3 alabama <NA>
##  4 -87.5  30.3     1     4 alabama <NA>
##  5 -87.6  30.3     1     5 alabama <NA>
##  6 -87.6  30.3     1     6 alabama <NA>
##  7 -87.6  30.3     1     7 alabama <NA>
##  8 -87.6  30.3     1     8 alabama <NA>
##  9 -87.7  30.3     1     9 alabama <NA>
## 10 -87.8  30.3     1    10 alabama <NA>
## # ℹ 15,527 more rows
```

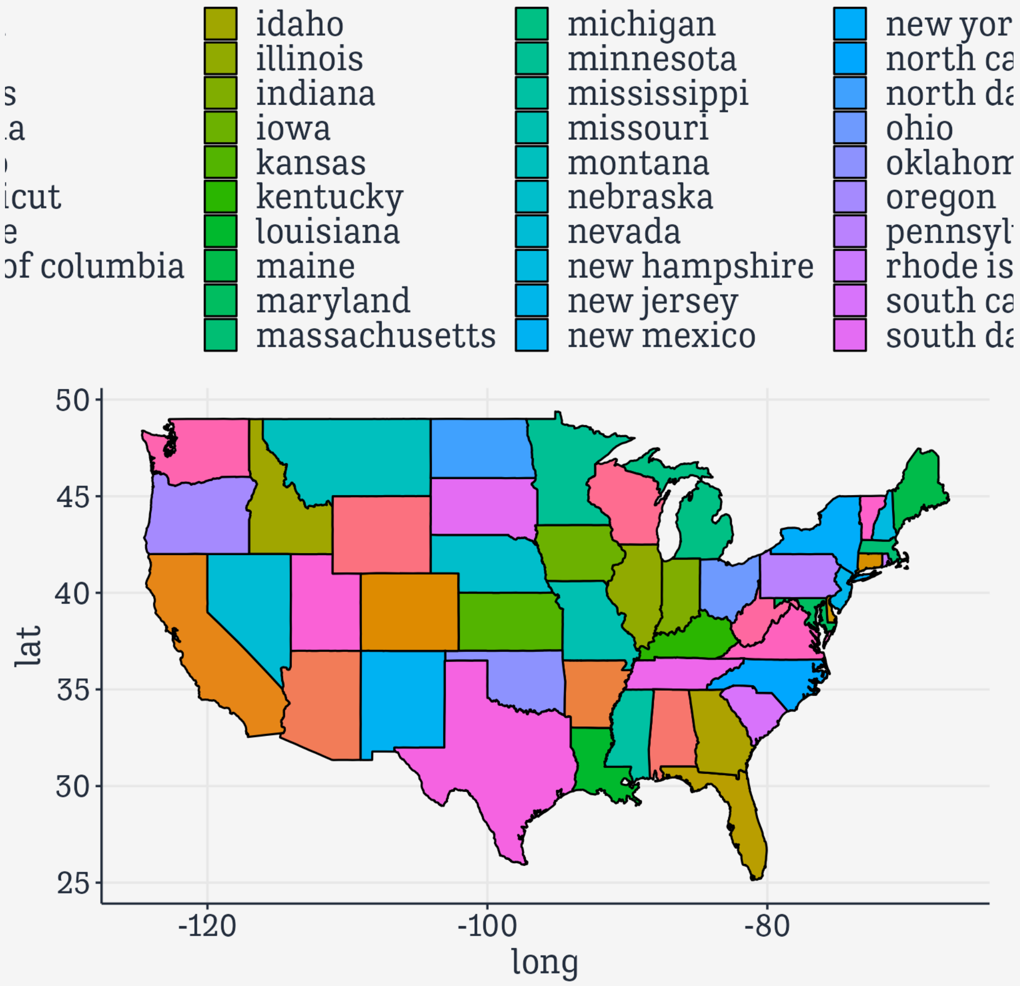
# Fix the projection

```
us_states <- as_tibble(map_data("state"))

us_states |>
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = region,
                       group = group))
```



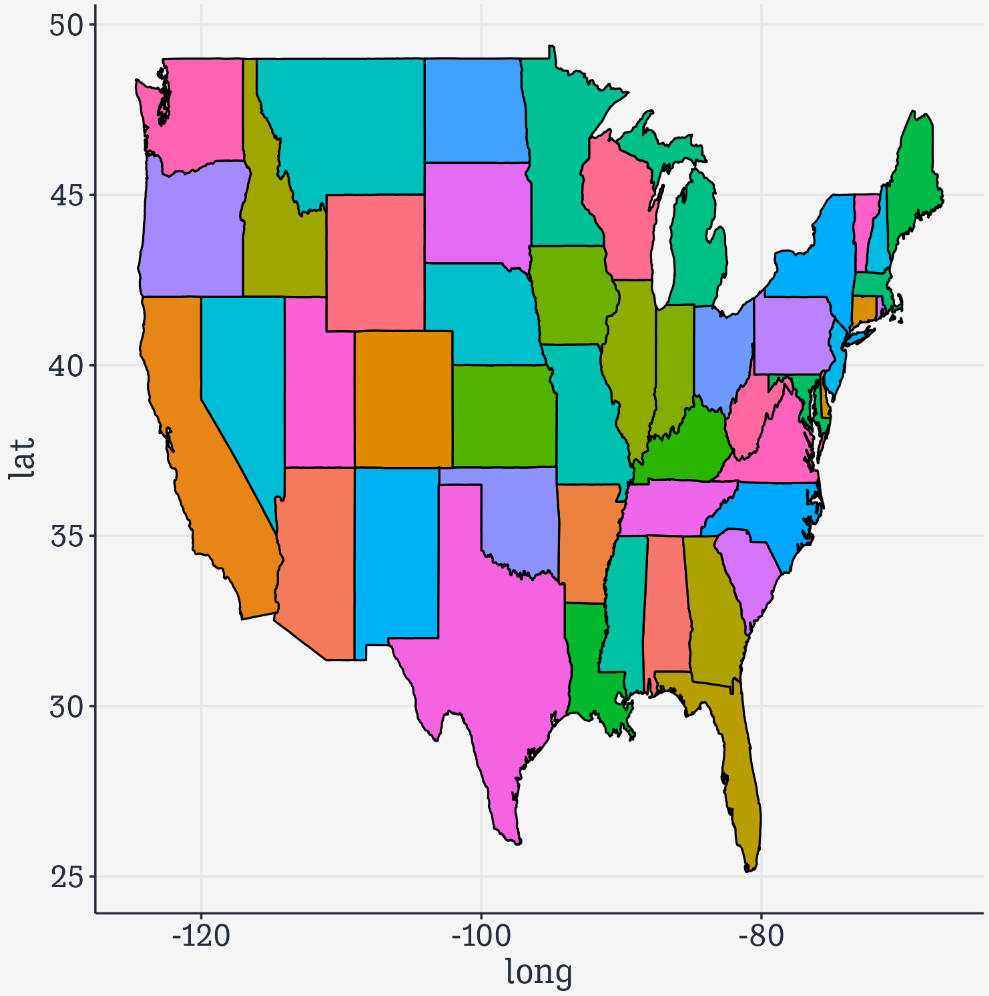
# Fix the projection

```
us_states ← as_tibble(map_data("state"))

us_states ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = region,
                       group = group)) +
  geom_polygon(color = "black")
```



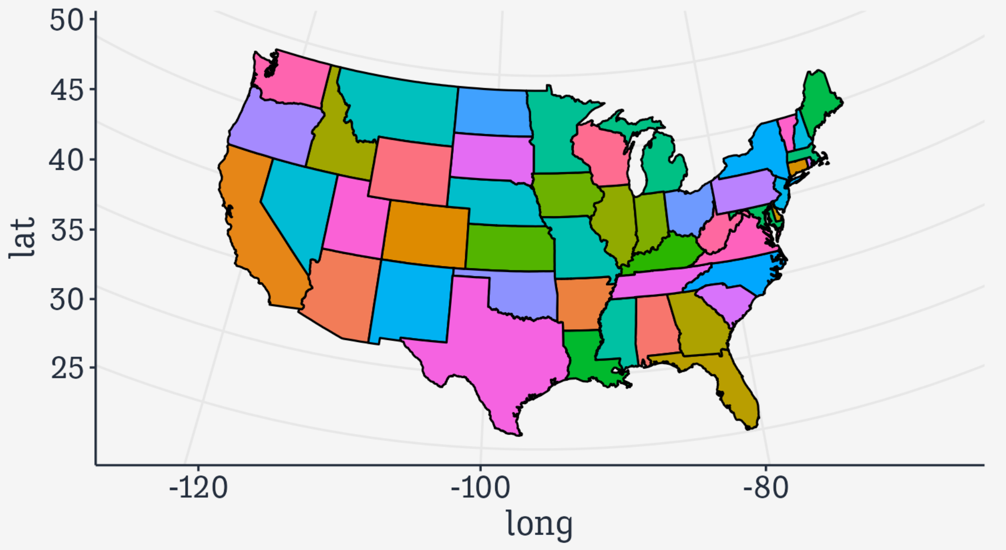
# Fix the projection

```
us_states <- as_tibble(map_data("state"))

us_states |>
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = region,
                       group = group)) +
  geom_polygon(color = "black") +
  guides(fill = "none")
```



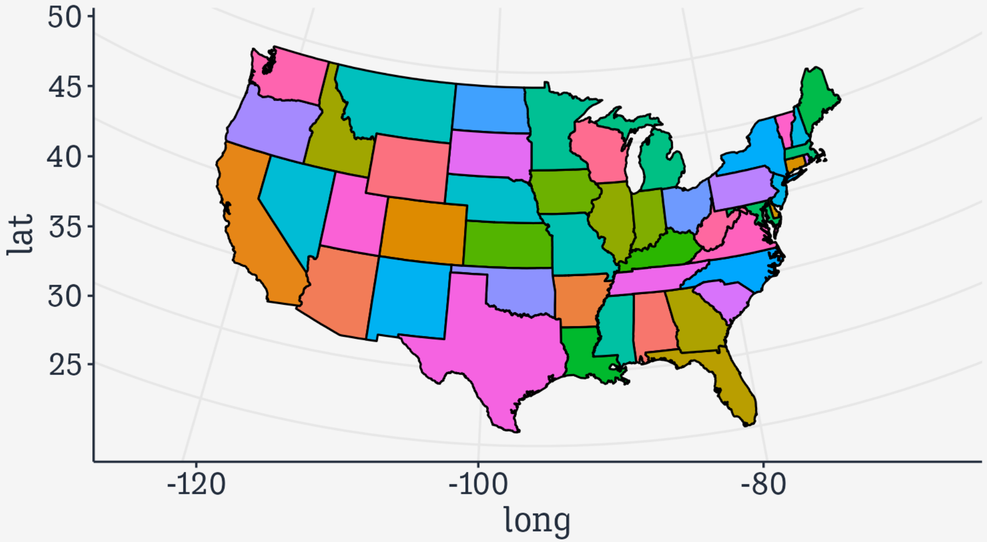
# Fix the projection

```
us_states <- as_tibble(map_data("state"))

us_states |>
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = region,
                       group = group)) +
  geom_polygon(color = "black") +
  guides(fill = "none") +
  coord_map(projection = "albers",
            lat0 = 39,
            lat1 = 45)
```



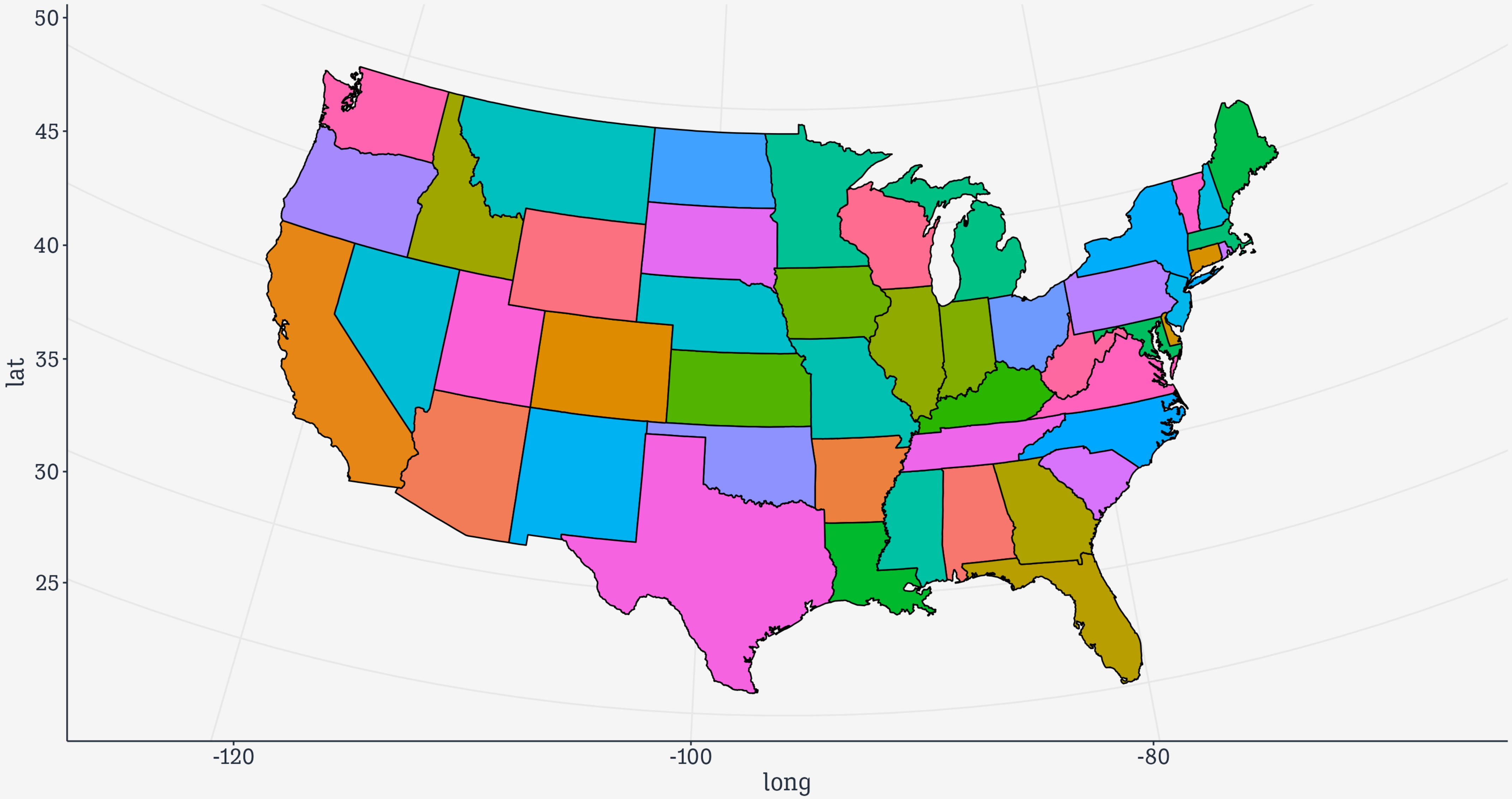
# Fix the projection

```r
us_states <- as_tibble(map_data("state"))

us_states |>
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = region,
                       group = group)) +
  geom_polygon(color = "black") +
  guides(fill = "none") +
  coord_map(projection = "albers",
            lat0 = 39,
            lat1 = 45)

## A coordinate transformation!
```



# U.S. Map Projections

# U.S. Map Projections




Our U.S. Map again, now transformed

# Next, some data

We can merge our state-level `election` data with the `us_states` table, but we need to do a little work.

```
us_states
```

```
## # A tibble: 15,537 × 6
##     long   lat group order region  subregion
##    <dbl> <dbl> <dbl> <int> <chr>   <chr>
##  1 -87.5  30.4     1     1 alabama <NA>
##  2 -87.5  30.4     1     2 alabama <NA>
##  3 -87.5  30.4     1     3 alabama <NA>
##  4 -87.5  30.3     1     4 alabama <NA>
##  5 -87.6  30.3     1     5 alabama <NA>
##  6 -87.6  30.3     1     6 alabama <NA>
##  7 -87.6  30.3     1     7 alabama <NA>
##  8 -87.6  30.3     1     8 alabama <NA>
##  9 -87.7  30.3     1     9 alabama <NA>
## 10 -87.8  30.3     1    10 alabama <NA>
## # ℹ 15,527 more rows
```

```
election
```

```
## # A tibble: 51 × 22
##    state     st     fips total_vote vote_margin winner par
##    <chr>     <chr> <dbl>      <dbl>       <dbl> <chr>  <ch
##  1 Alabama   AL        1    2123372      588708 Trump  Rep
##  2 Alaska    AK        2     318608       46933 Trump  Rep
##  3 Arizona   AZ        4    2604657       91234 Trump  Rep
##  4 Arkansas  AR        5    1130635      304378 Trump  Rep
##  5 Californ… CA        6   14237893     4269978 Clint… Dem
##  6 Colorado  CO        8    2780247      136386 Clint… Dem
##  7 Connecti… CT        9    1644920      224357 Clint… Dem
##  8 Delaware  DE       10     443814       50476 Clint… Dem
##  9 District… DC       11     311268      270107 Clint… Dem
## 10 Florida   FL       12    9502747      112911 Trump  Rep
## # ℹ 41 more rows
## # ℹ 13 more variables: d_points <dbl>, pct_clinton <dbl>,
## #   pct_johnson <dbl>, pct_other <dbl>, clinton_vote <dbl>
## #   johnson_vote <dbl>, other_vote <dbl>, ev_dem <dbl>, ev
## #   ev_oth <dbl>, census <chr>
```

# Next, some data

We can merge our state-level `election` data with the `us_states` table, but we need to do a little work.

```r
us_states
```

```
## # A tibble: 15,537 × 6
##     long   lat group order region  subregion
##    <dbl> <dbl> <dbl> <int> <chr>   <chr>
##  1 -87.5  30.4     1     1 alabama <NA>
##  2 -87.5  30.4     1     2 alabama <NA>
##  3 -87.5  30.4     1     3 alabama <NA>
##  4 -87.5  30.3     1     4 alabama <NA>
##  5 -87.6  30.3     1     5 alabama <NA>
##  6 -87.6  30.3     1     6 alabama <NA>
##  7 -87.6  30.3     1     7 alabama <NA>
##  8 -87.6  30.3     1     8 alabama <NA>
##  9 -87.7  30.3     1     9 alabama <NA>
## 10 -87.8  30.3     1    10 alabama <NA>
## # ℹ 15,527 more rows
```

```r
election
```

```
## # A tibble: 51 × 22
##    state      st     fips total_vote vote_margin winner par
##    <chr>      <chr> <dbl>      <dbl>       <dbl> <chr>  <ch
##  1 Alabama    AL        1    2123372      588708 Trump  Rep
##  2 Alaska     AK        2     318608       46933 Trump  Rep
##  3 Arizona    AZ        4    2604657       91234 Trump  Rep
##  4 Arkansas   AR        5    1130635      304378 Trump  Rep
##  5 Californ… CA        6   14237893     4269978 Clint… Dem
##  6 Colorado   CO        8    2780247      136386 Clint… Dem
##  7 Connecti… CT        9    1644920      224357 Clint… Dem
##  8 Delaware   DE       10     443814       50476 Clint… Dem
##  9 District… DC       11     311268      270107 Clint… Dem
## 10 Florida    FL       12    9502747      112911 Trump  Rep
## # ℹ 41 more rows
## # ℹ 13 more variables: d_points <dbl>, pct_clinton <dbl>,
## #   pct_johnson <dbl>, pct_other <dbl>, clinton_vote <dbl>
## #   johnson_vote <dbl>, other_vote <dbl>, ev_dem <dbl>, ev
## #   ev_oth <dbl>, census <chr>
```

To merge, or *join* these tables, they need to have a column in common to act as a key.

# Recode to make a key

```
election <- election |>
  mutate(region = tolower(state)) |>
  relocate(region)

election
```

```
## # A tibble: 51 × 23
##    region         state st     fips total_vote vote_margin winner party pct_margin
##    <chr>          <chr> <chr> <dbl>      <dbl>       <dbl> <chr>  <chr>      <dbl>
##  1 alabama        Alab… AL        1    2123372      588708 Trump  Repu…     0.277
##  2 alaska         Alas… AK        2     318608       46933 Trump  Repu…     0.147
##  3 arizona        Ariz… AZ        4    2604657       91234 Trump  Repu…     0.035
##  4 arkansas       Arka… AR        5    1130635      304378 Trump  Repu…     0.269
##  5 california     Cali… CA        6   14237893     4269978 Clint… Demo…     0.300
##  6 colorado       Colo… CO        8    2780247      136386 Clint… Demo…     0.0491
##  7 connecticut    Conn… CT        9    1644920      224357 Clint… Demo…     0.136
##  8 delaware       Dela… DE       10     443814       50476 Clint… Demo…     0.114
##  9 district of…   Dist… DC       11     311268      270107 Clint… Demo…     0.868
## 10 florida        Flor… FL       12    9502747      112911 Trump  Repu…     0.0119
## # ℹ 41 more rows
## # ℹ 14 more variables: r_points <dbl>, d_points <dbl>, pct_clinton <dbl>,
## #   pct_trump <dbl>, pct_johnson <dbl>, pct_other <dbl>, clinton_vote <dbl>,
## #   trump_vote <dbl>, johnson_vote <dbl>, other_vote <dbl>, ev_dem <dbl>,
## #   ev_rep <dbl>, ev_oth <dbl>, census <chr>
```

# Now we can join them

```
us_states
```

```
## # A tibble: 15,537 × 6
##     long   lat group order region  subregion
##    <dbl> <dbl> <dbl> <int> <chr>   <chr>
##  1 -87.5  30.4     1     1 alabama <NA>
##  2 -87.5  30.4     1     2 alabama <NA>
##  3 -87.5  30.4     1     3 alabama <NA>
##  4 -87.5  30.3     1     4 alabama <NA>
##  5 -87.6  30.3     1     5 alabama <NA>
##  6 -87.6  30.3     1     6 alabama <NA>
##  7 -87.6  30.3     1     7 alabama <NA>
##  8 -87.6  30.3     1     8 alabama <NA>
##  9 -87.7  30.3     1     9 alabama <NA>
## 10 -87.8  30.3     1    10 alabama <NA>
## # ℹ 15,527 more rows
```

```
election
```

```
## # A tibble: 51 × 23
##    region       state st     fips total_vote vote_margin w
##    <chr>        <chr> <chr> <dbl>      <dbl>       <dbl> <
##  1 alabama      Alab… AL        1    2123372      588708 T
##  2 alaska       Alas… AK        2     318608       46933 T
##  3 arizona      Ariz… AZ        4    2604657       91234 T
##  4 arkansas     Arka… AR        5    1130635      304378 T
##  5 california   Cali… CA        6   14237893     4269978 C
##  6 colorado     Colo… CO        8    2780247      136386 C
##  7 connecticut  Conn… CT        9    1644920      224357 C
##  8 delaware     Dela… DE       10     443814       50476 C
##  9 district of… Dist… DC       11     311268      270107 C
## 10 florida      Flor… FL       12    9502747      112911 T
## # ℹ 41 more rows
## # ℹ 14 more variables: r_points <dbl>, d_points <dbl>, pct
## #   pct_trump <dbl>, pct_johnson <dbl>, pct_other <dbl>, c
## #   trump_vote <dbl>, johnson_vote <dbl>, other_vote <dbl>
## #   ev_rep <dbl>, ev_oth <dbl>, census <chr>
```

# This is a *left join*

```r
us_states_elec <- left_join(us_states, election, by = "region")

us_states_elec
```

```
## # A tibble: 15,537 × 28
##     long   lat group order region  subregion state   st     fips total_vote
##    <dbl> <dbl> <dbl> <int> <chr>   <chr>     <chr>   <chr> <dbl>      <dbl>
##  1 -87.5  30.4     1     1 alabama <NA>      Alabama AL        1    2123372
##  2 -87.5  30.4     1     2 alabama <NA>      Alabama AL        1    2123372
##  3 -87.5  30.4     1     3 alabama <NA>      Alabama AL        1    2123372
##  4 -87.5  30.3     1     4 alabama <NA>      Alabama AL        1    2123372
##  5 -87.6  30.3     1     5 alabama <NA>      Alabama AL        1    2123372
##  6 -87.6  30.3     1     6 alabama <NA>      Alabama AL        1    2123372
##  7 -87.6  30.3     1     7 alabama <NA>      Alabama AL        1    2123372
##  8 -87.6  30.3     1     8 alabama <NA>      Alabama AL        1    2123372
##  9 -87.7  30.3     1     9 alabama <NA>      Alabama AL        1    2123372
## 10 -87.8  30.3     1    10 alabama <NA>      Alabama AL        1    2123372
## # ℹ 15,527 more rows
## # ℹ 18 more variables: vote_margin <dbl>, winner <chr>, party <chr>,
## #   pct_margin <dbl>, r_points <dbl>, d_points <dbl>, pct_clinton <dbl>,
## #   pct_trump <dbl>, pct_johnson <dbl>, pct_other <dbl>, clinton_vote <dbl>,
## #   trump_vote <dbl>, johnson_vote <dbl>, other_vote <dbl>, ev_dem <dbl>,
## #   ev_rep <dbl>, ev_oth <dbl>, census <chr>
```

# This is a *left join*

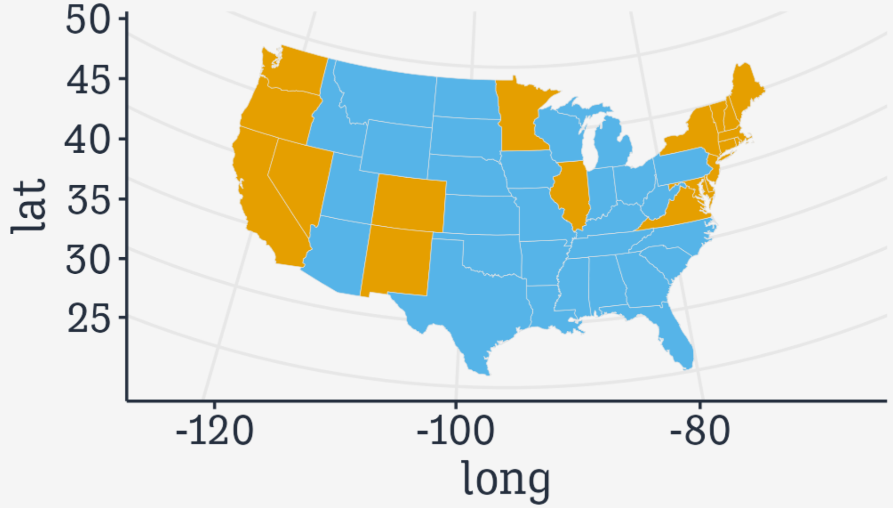
```r
us_states_elec <- left_join(us_states, election, by = "region")

us_states_elec
```

```
## # A tibble: 15,537 × 28
##     long   lat group order region  subregion state   st     fips total_vote
##    <dbl> <dbl> <dbl> <int> <chr>   <chr>     <chr>   <chr> <dbl>      <dbl>
##  1 -87.5  30.4     1     1 alabama <NA>      Alabama AL        1    2123372
##  2 -87.5  30.4     1     2 alabama <NA>      Alabama AL        1    2123372
##  3 -87.5  30.4     1     3 alabama <NA>      Alabama AL        1    2123372
##  4 -87.5  30.3     1     4 alabama <NA>      Alabama AL        1    2123372
##  5 -87.6  30.3     1     5 alabama <NA>      Alabama AL        1    2123372
##  6 -87.6  30.3     1     6 alabama <NA>      Alabama AL        1    2123372
##  7 -87.6  30.3     1     7 alabama <NA>      Alabama AL        1    2123372
##  8 -87.6  30.3     1     8 alabama <NA>      Alabama AL        1    2123372
##  9 -87.7  30.3     1     9 alabama <NA>      Alabama AL        1    2123372
## 10 -87.8  30.3     1    10 alabama <NA>      Alabama AL        1    2123372
## # ℹ 15,527 more rows
## # ℹ 18 more variables: vote_margin <dbl>, winner <chr>, party <chr>,
## #   pct_margin <dbl>, r_points <dbl>, d_points <dbl>, pct_clinton <dbl>,
## #   pct_trump <dbl>, pct_johnson <dbl>, pct_other <dbl>, clinton_vote <dbl>,
## #   trump_vote <dbl>, johnson_vote <dbl>, other_vote <dbl>, ev_dem <dbl>,
## #   ev_rep <dbl>, ev_oth <dbl>, census <chr>
```

Now our `us_states_elec` table has both the line-drawing information and (very redundantly) the election data merged in, with rows repeated as necessary.

# Now we can start drawing choropleths

```
us_states_elec |>
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = party,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  guides(fill = "none")
```



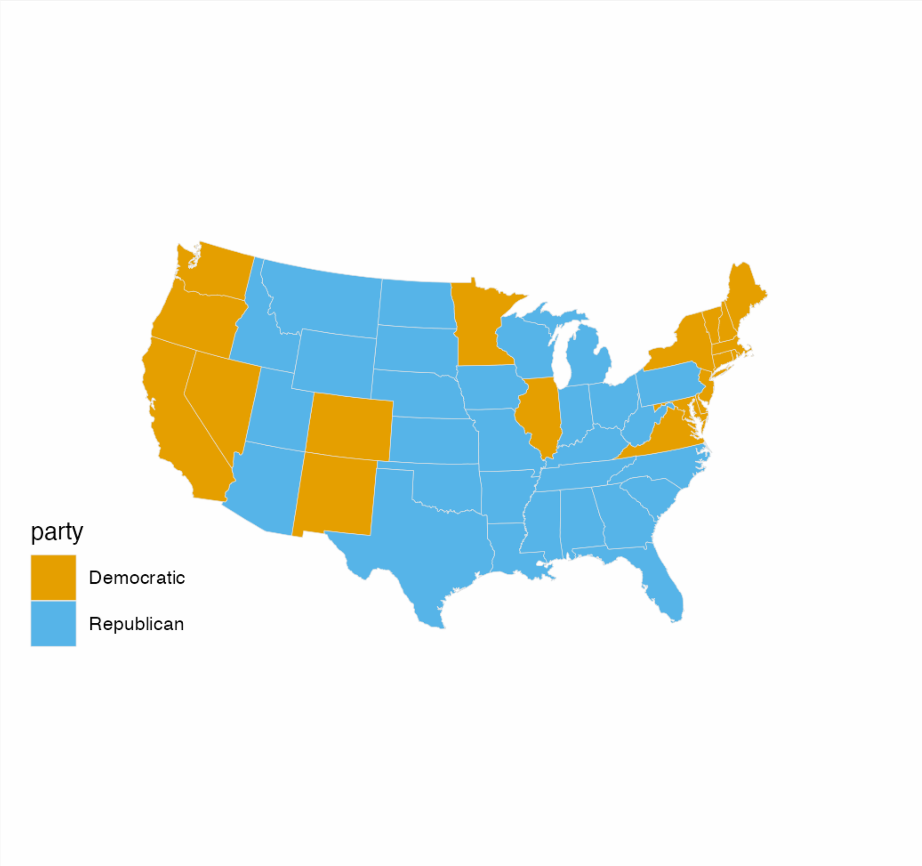
# Let's turn off the gridlines

This is a *theme function*.

```
theme_map <- function(base_size=9, base_family="") {
    require(grid)
    theme_bw(base_size=base_size, base_family=base_family) %+replace%
        theme(axis.line=element_blank(),
              axis.text=element_blank(),
              axis.ticks=element_blank(),
              axis.title=element_blank(),
              panel.background=element_blank(),
              panel.border=element_blank(),
              panel.grid=element_blank(),
              panel.spacing=unit(0, "lines"),
              plot.background=element_blank(),
              legend.justification = c(0,0),
              legend.position = c(0,0)
              )
}
```

# Add the theme function at the end

```r
us_states_elec |> 
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = party,
                       group = group)) + 
  geom_polygon(color = "gray90",
               size = 0.1) +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  theme_map()
```

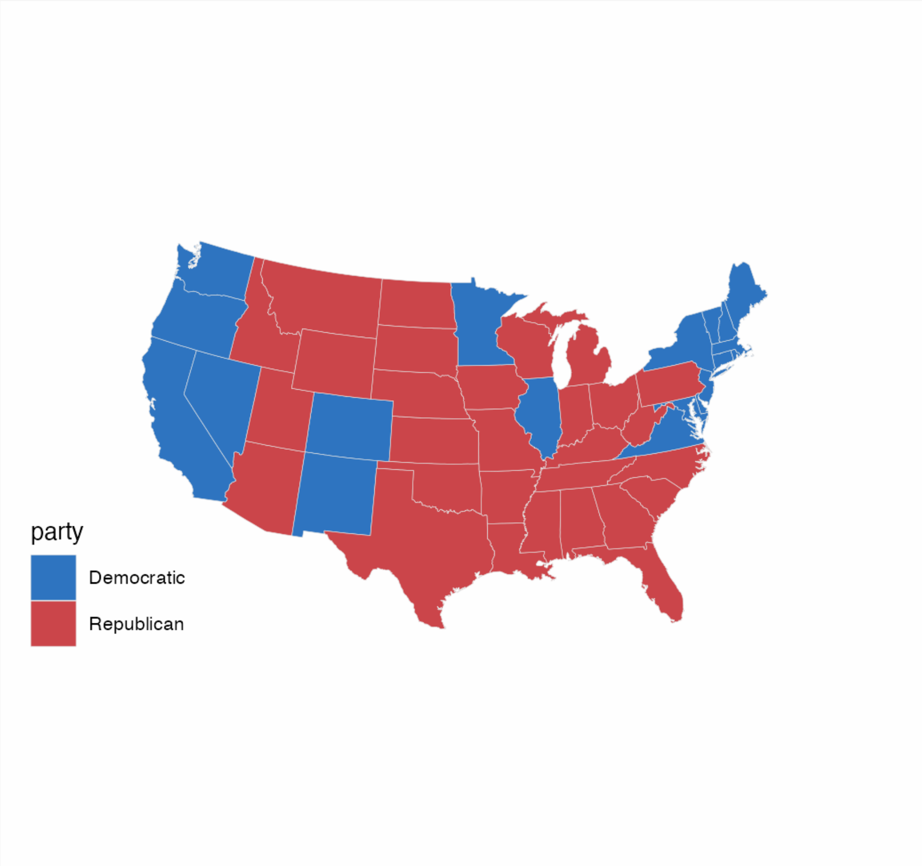


# Fix the Party Colors

```r
## Hex color codes for Democratic Blue and Republican Red
party_colors <- c("#2E74C0", "#CB454A")


us_states_elec |>
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = party,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_manual(values = party_colors) +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  theme_map()
```

# Fix the Party Colors

```r
## Hex color codes for Democratic Blue and Republican Red
party_colors <- c("#2E74C0", "#CB454A")


us_states_elec |>
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = party,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_manual(values = party_colors) +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  theme_map()
```

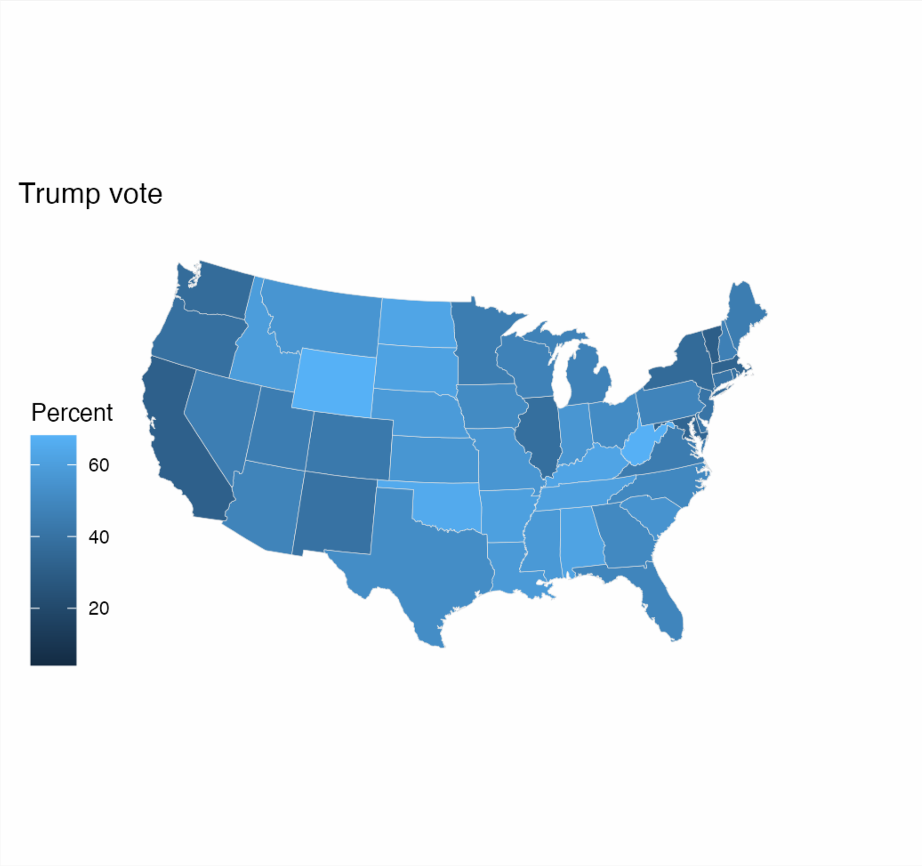


# On maps, continuous measures are *gradients*

```
us_states_elec ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = pct_trump,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  labs(title = "Trump vote",
       fill = "Percent") +
  theme_map()
```

# On maps, continuous measures are *gradients*

```r
us_states_elec ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = pct_trump,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  labs(title = "Trump vote",
       fill = "Percent") +
  theme_map()
```

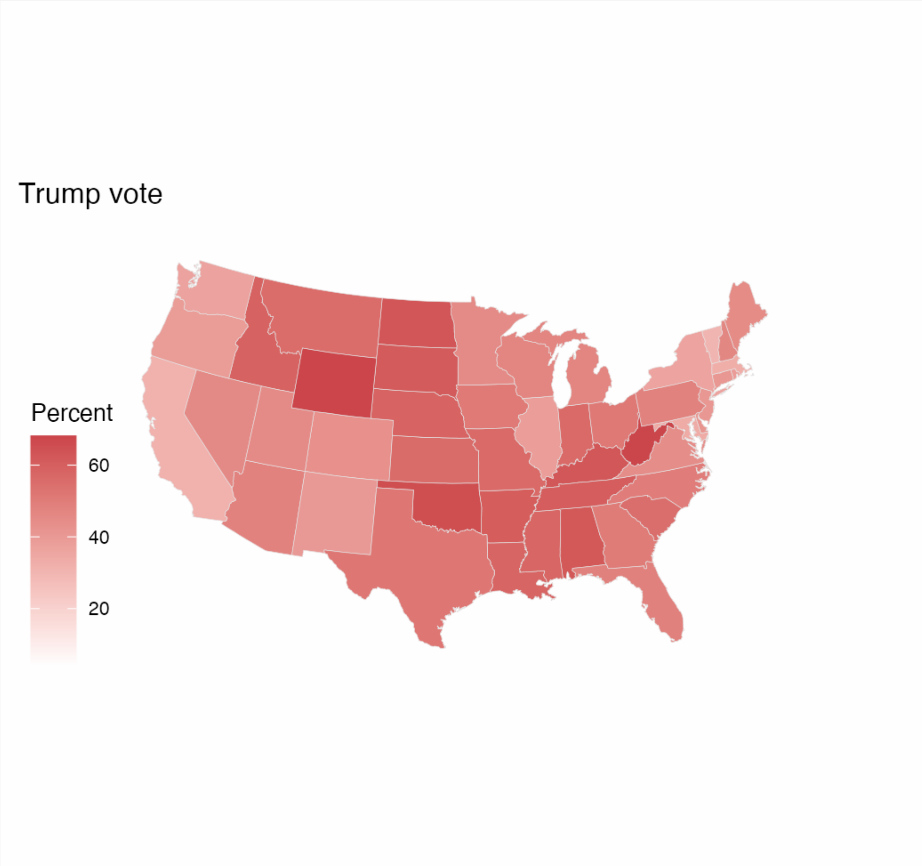


# Fix the gradient scale with its scale function

```
us_states_elec ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = pct_trump,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_gradient(low = "white",
                      high = "#CB454A") +
        labs(title = "Trump vote") +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  labs(title = "Trump vote",
       fill = "Percent") +
  theme_map()
```

# Fix the gradient scale with its **scale function**

```
us_states_elec ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = pct_trump,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_gradient(low = "white",
                      high = "#CB454A") +
        labs(title = "Trump vote") +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  labs(title = "Trump vote",
       fill = "Percent") +
  theme_map()
```

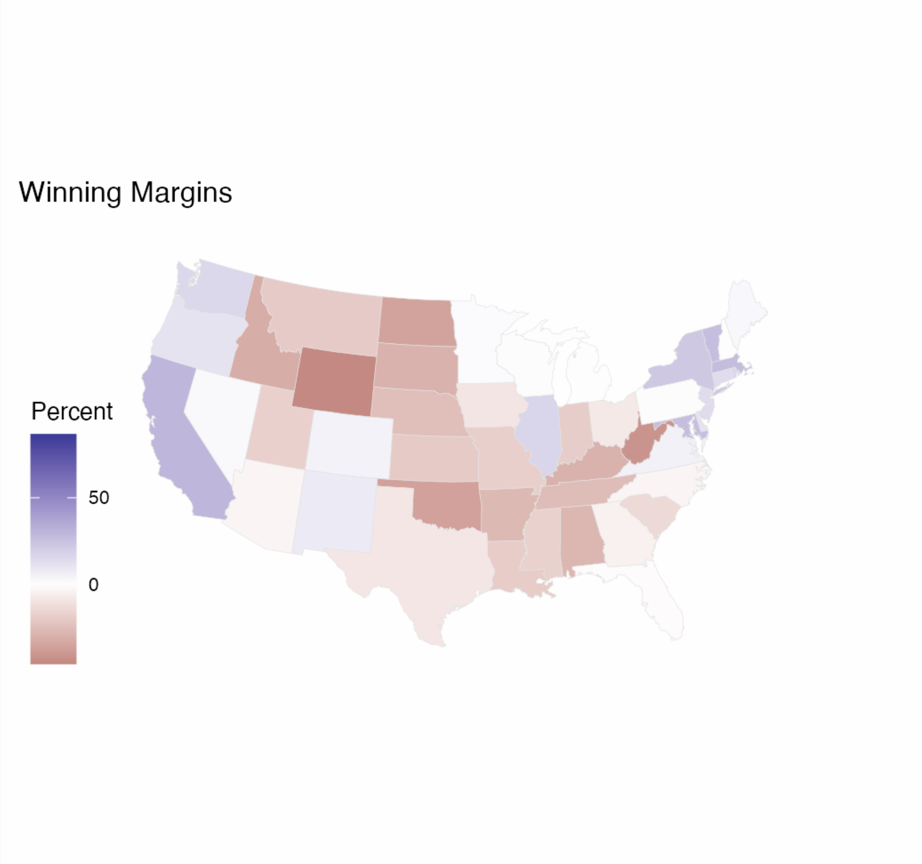


# Some gradients are *diverging*

```r
us_states_elec |>
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = d_points,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_gradient2() +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  labs(title = "Winning Margins",
       fill = "Percent") +
  theme_map()
```

# Some gradients are *diverging*

```
us_states_elec ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = d_points,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_gradient2() +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  labs(title = "Winning Margins",
       fill = "Percent") +
  theme_map()
```

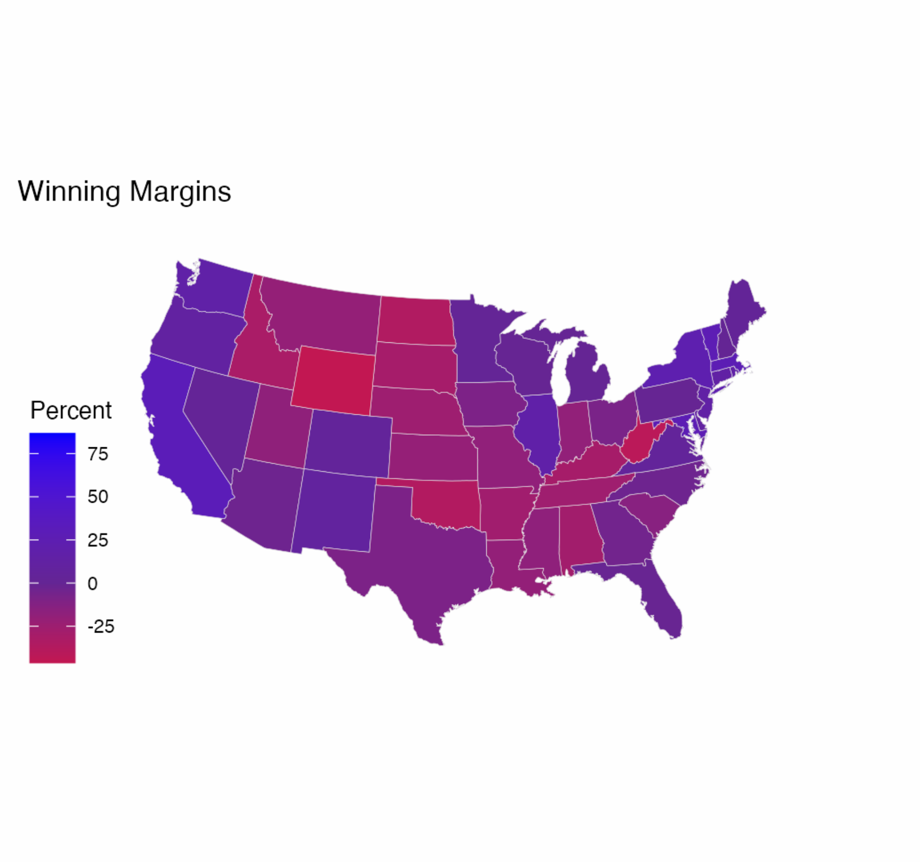


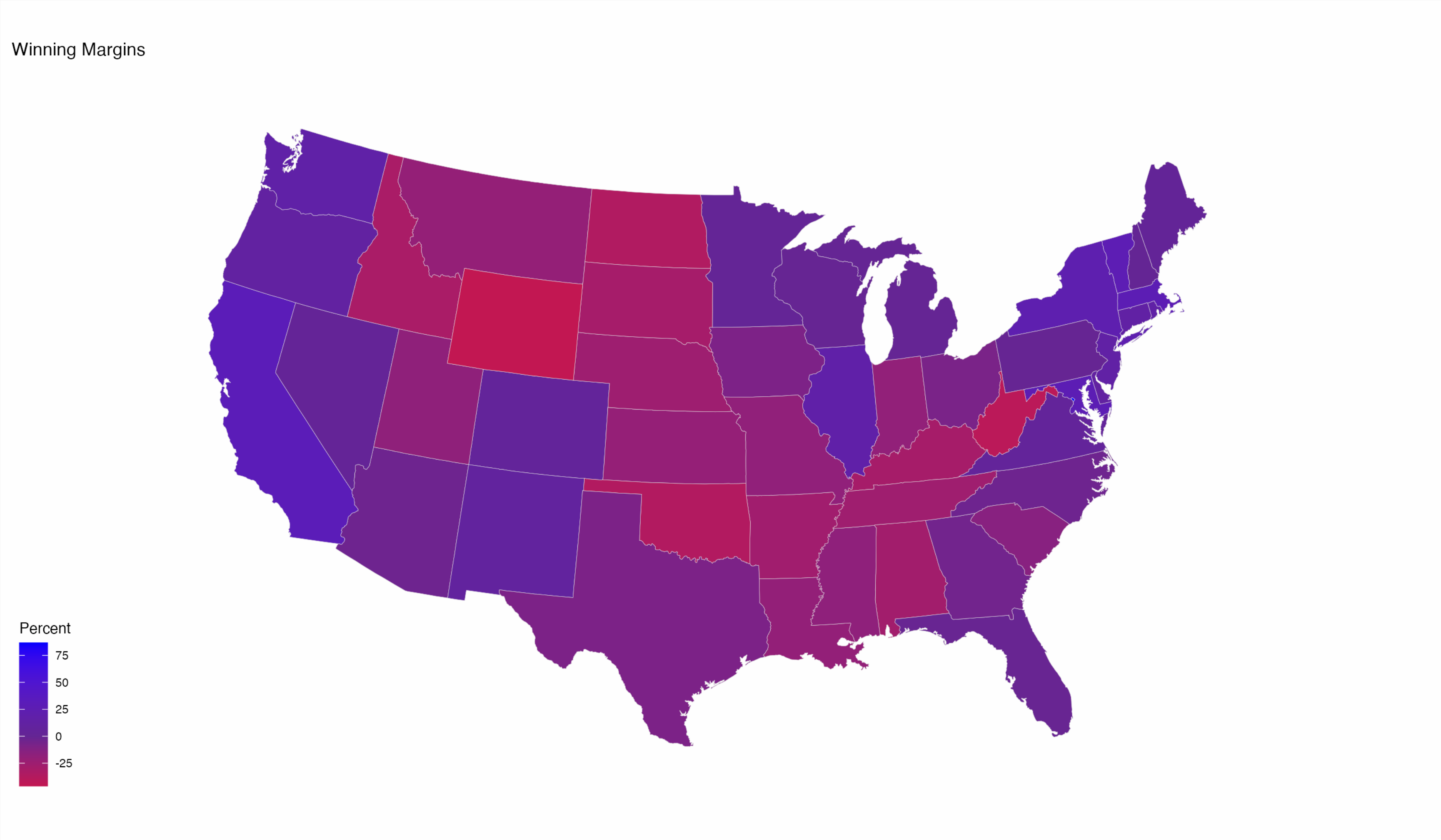
# Purple America Map

```
us_states_elec ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = d_points,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_gradient2(low = "red",
                mid = scales::muted("purple"),
                high = "blue",
                breaks = c(-25, 0, 25,
                        50, 75)) +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  labs(title = "Winning Margins",
       fill = "Percent") +
  theme_map()
```

# Purple America Map

```r
us_states_elec ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = d_points,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_gradient2(low = "red",
               mid = scales::muted("purple"),
               high = "blue",
               breaks = c(-25, 0, 25,
                          50, 75)) +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  labs(title = "Winning Margins",
       fill = "Percent") +
  theme_map()
```






Take a closer look at this, though.

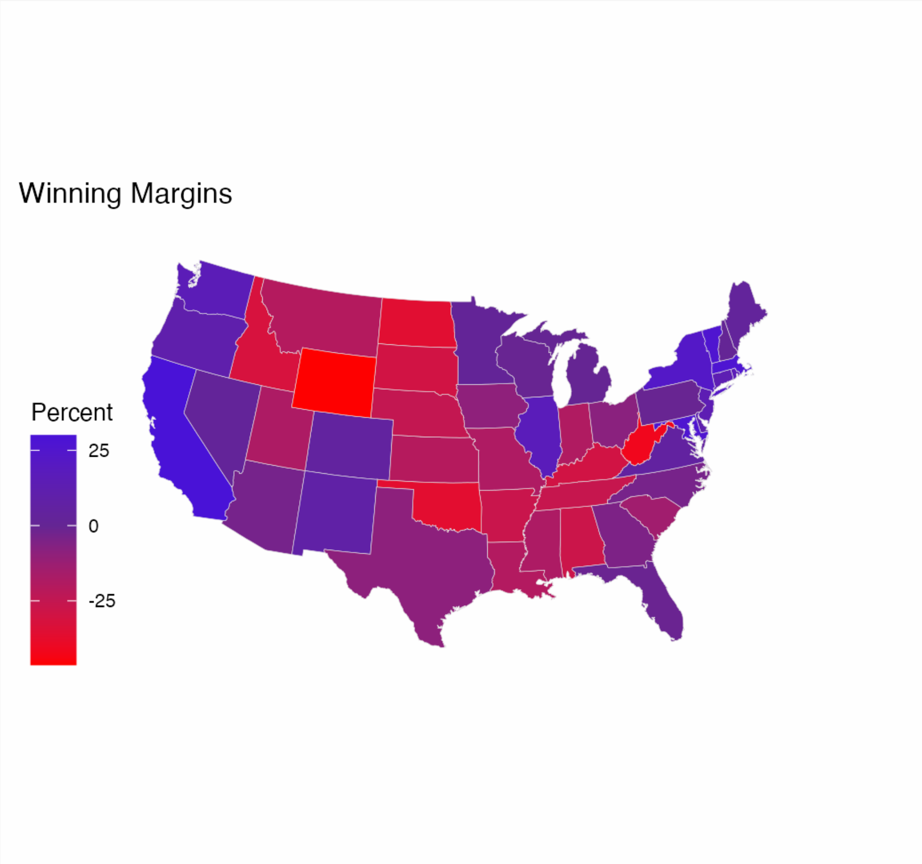
Washington, DC

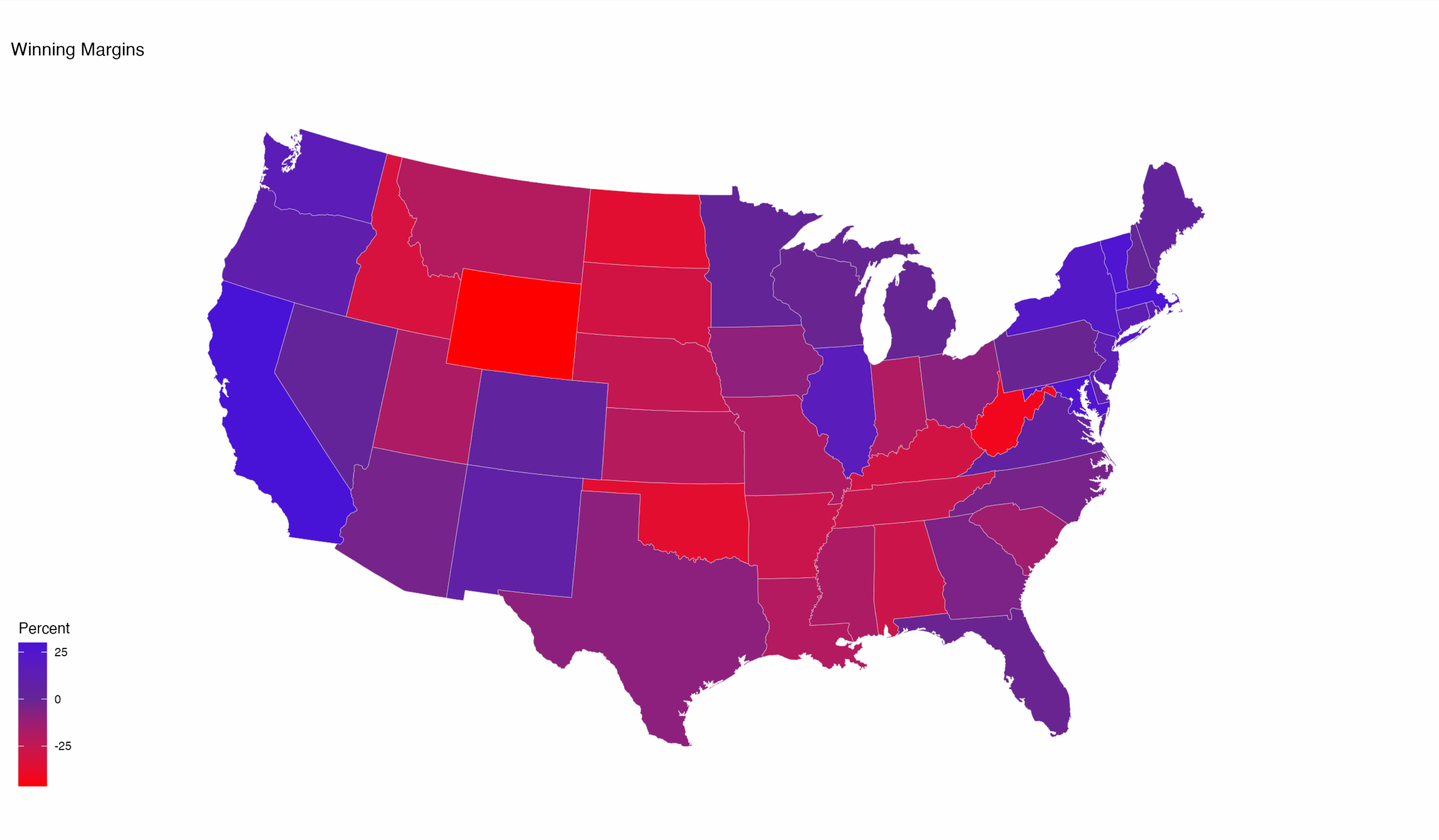
# Purple America Map, without DC

```
us_states_elec ▷
  filter(region %nin% "district of columbia") ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = d_points,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_gradient2(low = "red",
                mid = scales::muted("purple"),
                high = "blue") +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  labs(title = "Winning Margins",
       fill = "Percent") +
  theme_map()
```

# Purple America Map, without DC

```
us_states_elec ▷
  filter(region %nin% "district of columbia") ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = d_points,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_gradient2(low = "red",
                mid = scales::muted("purple"),
                high = "blue") +
  coord_map(projection = "albers",
            lat0 = 39, lat1 = 45) +
  labs(title = "Winning Margins",
       fill = "Percent") +
  theme_map()
```






More balanced.

# America's
# Ur-Choropleths

# County-level choropleths

Conceptually identical to state ones. The tables are just bigger, because there are way more lines to draw.

```
county_map <- as_tibble(county_map)
county_map
```

```
## # A tibble: 191,382 × 7
##        long      lat order hole  piece group           id
##       <dbl>    <dbl> <int> <lgl> <fct> <fct>           <chr>
##  1 1225889. -1275020.    1 FALSE 1     0500000US01001.1 01001
##  2 1235324. -1274008.    2 FALSE 1     0500000US01001.1 01001
##  3 1244873. -1272331.    3 FALSE 1     0500000US01001.1 01001
##  4 1244129. -1267515.    4 FALSE 1     0500000US01001.1 01001
##  5 1272010. -1262889.    5 FALSE 1     0500000US01001.1 01001
##  6 1276797. -1295514.    6 FALSE 1     0500000US01001.1 01001
##  7 1273832. -1297124.    7 FALSE 1     0500000US01001.1 01001
##  8 1272727. -1296631.    8 FALSE 1     0500000US01001.1 01001
##  9 1272513. -1299771.    9 FALSE 1     0500000US01001.1 01001
## 10 1269950. -1302038.   10 FALSE 1     0500000US01001.1 01001
## # ℹ 191,372 more rows
```

191,000 or so rows

`id` here is the county FIPS code.

# County-level choropleths

```r
county_data <- as_tibble(county_data)
county_data
```

```
## # A tibble: 3,195 × 32
##    id    name  state census_region pop_dens pop_dens4 pop_dens6 pct_black    pop
##    <chr> <chr> <fct> <fct>         <fct>    <fct>     <fct>     <fct>      <int>
##  1 0     <NA>  <NA>  <NA>          [   50,… [ 45,  1… [ 82,  2… [10.0,15… 3.19e8
##  2 01000 1     AL    South         [   50,… [ 45,  1… [ 82,  2… [25.0,50… 4.85e6
##  3 01001 Auta… AL    South         [   50,… [ 45,  1… [ 82,  2… [15.0,25… 5.54e4
##  4 01003 Bald… AL    South         [  100,… [118,716… [ 82,  2… [ 5.0,10… 2.00e5
##  5 01005 Barb… AL    South         [   10,… [ 17,   … [ 25,   … [25.0,50… 2.69e4
##  6 01007 Bibb… AL    South         [   10,… [ 17,   … [ 25,   … [15.0,25… 2.25e4
##  7 01009 Blou… AL    South         [   50,… [ 45,  1… [ 82,  2… [ 0.0, 2… 5.77e4
##  8 01011 Bull… AL    South         [   10,… [ 17,   … [  9,   … [50.0,85… 1.08e4
##  9 01013 Butl… AL    South         [   10,… [ 17,   … [ 25,   … [25.0,50… 2.03e4
## 10 01015 Calh… AL    South         [  100,… [118,716… [ 82,  2… [15.0,25… 1.16e5
## # ℹ 3,185 more rows
## # ℹ 23 more variables: female <dbl>, white <dbl>, black <dbl>,
## #   travel_time <dbl>, land_area <dbl>, hh_income <int>, su_gun4 <fct>,
## #   su_gun6 <fct>, fips <dbl>, votes_dem_2016 <int>, votes_gop_2016 <int>,
## #   total_votes_2016 <int>, per_dem_2016 <dbl>, per_gop_2016 <dbl>,
## #   diff_2016 <int>, per_dem_2012 <dbl>, per_gop_2012 <dbl>, diff_2012 <int>,
## #   winner <chr>, partywinner16 <chr>, winner12 <chr>, partywinner12 <chr>, …
```

# County-level choropleths

3,195 entities, including states (FIPS `id` ends in four zeros)

And the US as a whole (FIPS `id` of `0`)

Sample a few rows, with specific columns:

```
county_data  ▷
    select(id, name, state, pop_dens, pct_black) %>%
    sample_n(10)
```

```
## # A tibble: 10 × 5
##    id    name               state pop_dens      pct_black
##    <chr> <chr>              <fct> <fct>         <fct>
##  1 13093 Dooly County       GA    [   10,   50) [25.0,50.0)
##  2 48243 Jeff Davis County  TX    [    0,   10) [ 0.0, 2.0)
##  3 13241 Rabun County       GA    [   10,   50) [ 0.0, 2.0)
##  4 44007 Providence County  RI    [ 1000, 5000) [10.0,15.0)
##  5 08045 Garfield County    CO    [   10,   50) [ 0.0, 2.0)
##  6 05141 Van Buren County   AR    [   10,   50) [ 0.0, 2.0)
##  7 49019 Grand County       UT    [    0,   10) [ 0.0, 2.0)
##  8 08001 Adams County       CO    [  100,  500) [ 2.0, 5.0)
##  9 39057 Greene County      OH    [  100,  500) [ 5.0,10.0)
## 10 55079 Milwaukee County   WI    [ 1000, 5000) [25.0,50.0)
```

# Joined table

```r
county_full <- left_join(county_map, county_data, by = "id")

county_full
```

```
## # A tibble: 191,382 × 38
##         long       lat order hole  piece group    id    name  state census_region
##        <dbl>     <dbl> <int> <lgl> <fct> <fct>    <chr> <chr> <fct> <fct>
##   1 1225889. -1275020.     1 FALSE 1     0500000… 01001 Auta… AL    South
##   2 1235324. -1274008.     2 FALSE 1     0500000… 01001 Auta… AL    South
##   3 1244873. -1272331.     3 FALSE 1     0500000… 01001 Auta… AL    South
##   4 1244129. -1267515.     4 FALSE 1     0500000… 01001 Auta… AL    South
##   5 1272010. -1262889.     5 FALSE 1     0500000… 01001 Auta… AL    South
##   6 1276797. -1295514.     6 FALSE 1     0500000… 01001 Auta… AL    South
##   7 1273832. -1297124.     7 FALSE 1     0500000… 01001 Auta… AL    South
##   8 1272727. -1296631.     8 FALSE 1     0500000… 01001 Auta… AL    South
##   9 1272513. -1299771.     9 FALSE 1     0500000… 01001 Auta… AL    South
##  10 1269950. -1302038.    10 FALSE 1     0500000… 01001 Auta… AL    South
## # ℹ 191,372 more rows
## # ℹ 28 more variables: pop_dens <fct>, pop_dens4 <fct>, pop_dens6 <fct>,
## #   pct_black <fct>, pop <int>, female <dbl>, white <dbl>, black <dbl>,
## #   travel_time <dbl>, land_area <dbl>, hh_income <int>, su_gun4 <fct>,
## #   su_gun6 <fct>, fips <dbl>, votes_dem_2016 <int>, votes_gop_2016 <int>,
## #   total_votes_2016 <int>, per_dem_2016 <dbl>, per_gop_2016 <dbl>,
## #   diff_2016 <int>, per_dem_2012 <dbl>, per_gop_2012 <dbl>, diff_2012 <int>, …
```

# County Population Density

```r
county_full <- left_join(county_map, county_data,
```

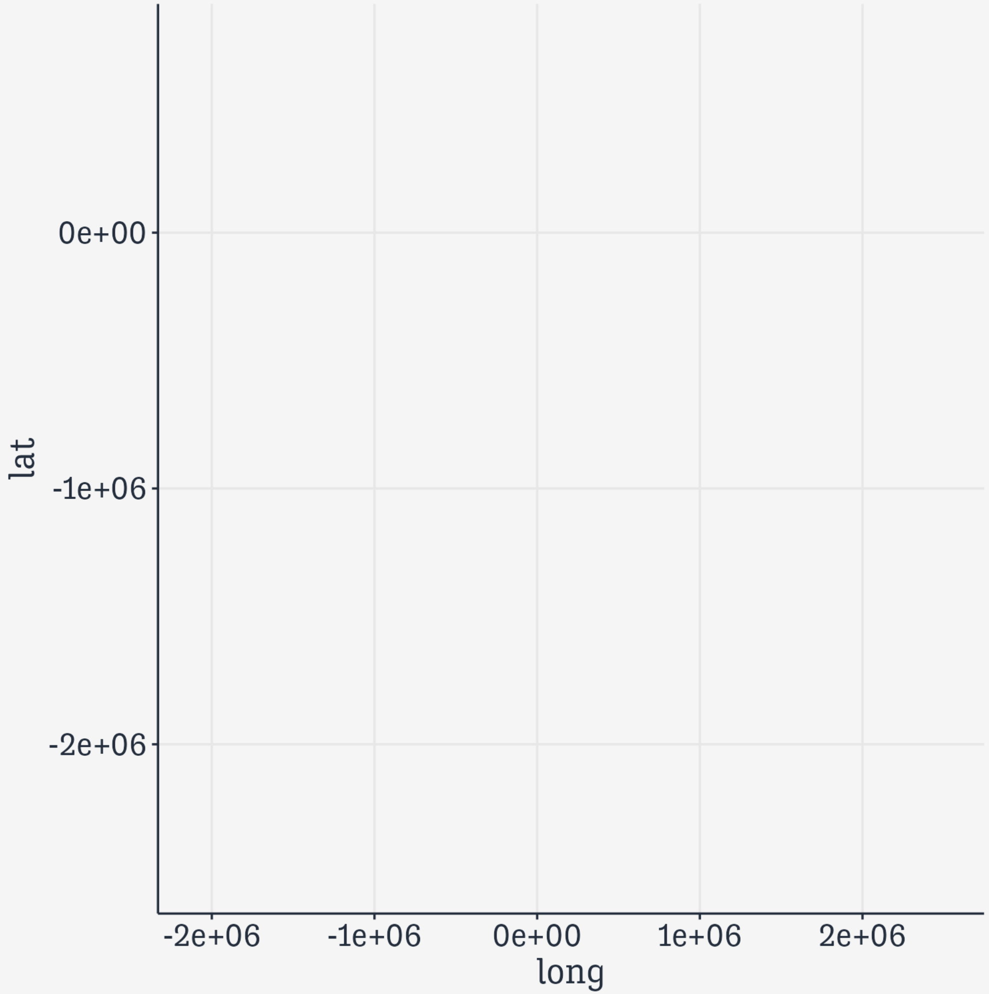
# County Population Density

```r
county_full <- left_join(county_map, county_data,

county_full
```

```
## # A tibble: 191,382 × 38
##         long       lat order hole  piece group    id    name  state census_re
##        <dbl>     <dbl> <int> <lgl> <fct> <fct>    <chr> <chr> <fct> <fct>
##  1 1225889. -1275020.     1 FALSE 1     0500000… 01001 Auta… AL    South
##  2 1235324. -1274008.     2 FALSE 1     0500000… 01001 Auta… AL    South
##  3 1244873. -1272331.     3 FALSE 1     0500000… 01001 Auta… AL    South
##  4 1244129. -1267515.     4 FALSE 1     0500000… 01001 Auta… AL    South
##  5 1272010. -1262889.     5 FALSE 1     0500000… 01001 Auta… AL    South
##  6 1276797. -1295514.     6 FALSE 1     0500000… 01001 Auta… AL    South
##  7 1273832. -1297124.     7 FALSE 1     0500000… 01001 Auta… AL    South
##  8 1272727. -1296631.     8 FALSE 1     0500000… 01001 Auta… AL    South
##  9 1272513. -1299771.     9 FALSE 1     0500000… 01001 Auta… AL    South
## 10 1269950. -1302038.    10 FALSE 1     0500000… 01001 Auta… AL    South
## # ℹ 191,372 more rows
## # ℹ 28 more variables: pop_dens <fct>, pop_dens4 <fct>, pop_dens6 <fct>,
## #   pct_black <fct>, pop <int>, female <dbl>, white <dbl>, black <dbl>,
## #   travel_time <dbl>, land_area <dbl>, hh_income <int>, su_gun4 <fct>,
## #   su_gun6 <fct>, fips <dbl>, votes_dem_2016 <int>, votes_gop_2016 <int>,
## #   total_votes_2016 <int>, per_dem_2016 <dbl>, per_gop_2016 <dbl>,
## #   diff_2016 <int>, per_dem_2012 <dbl>, per_gop_2012 <dbl>, diff_2012 <int
```

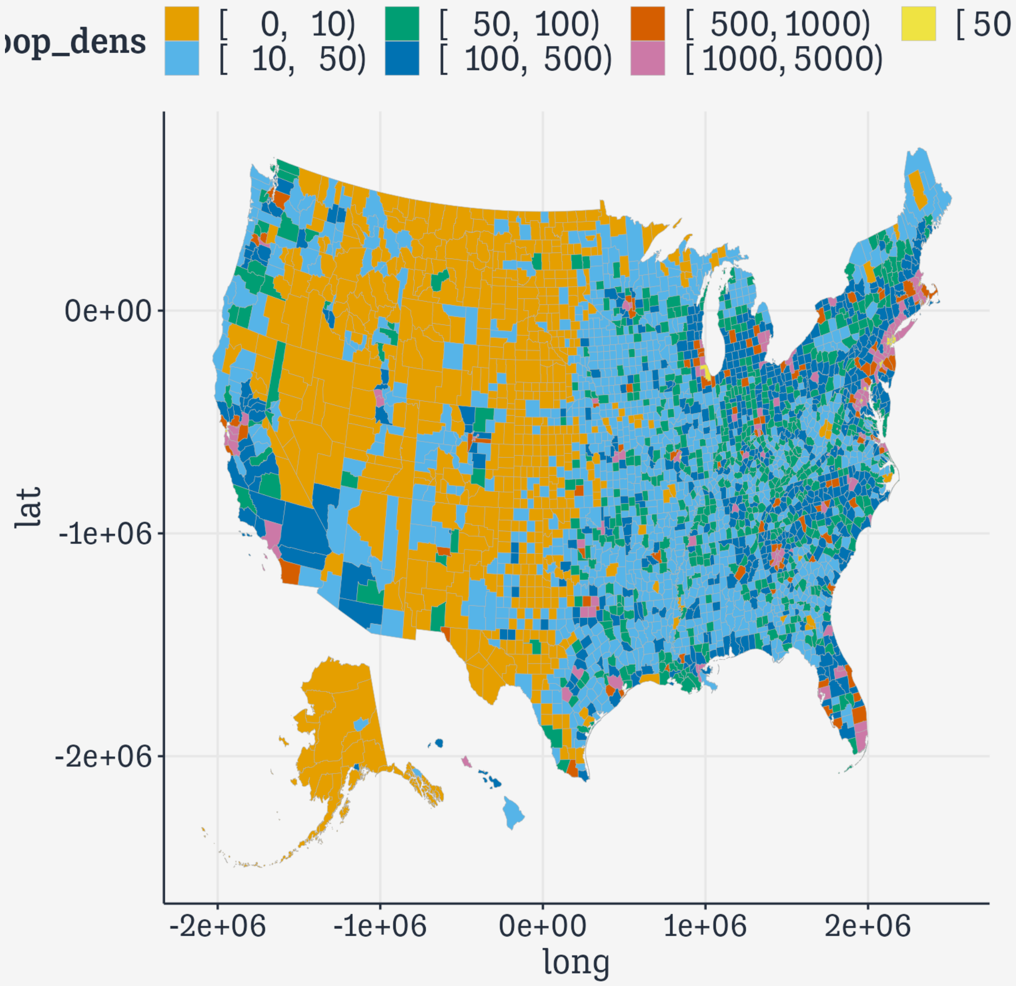
# County Population Density

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pop_dens,
                       group = group))
```



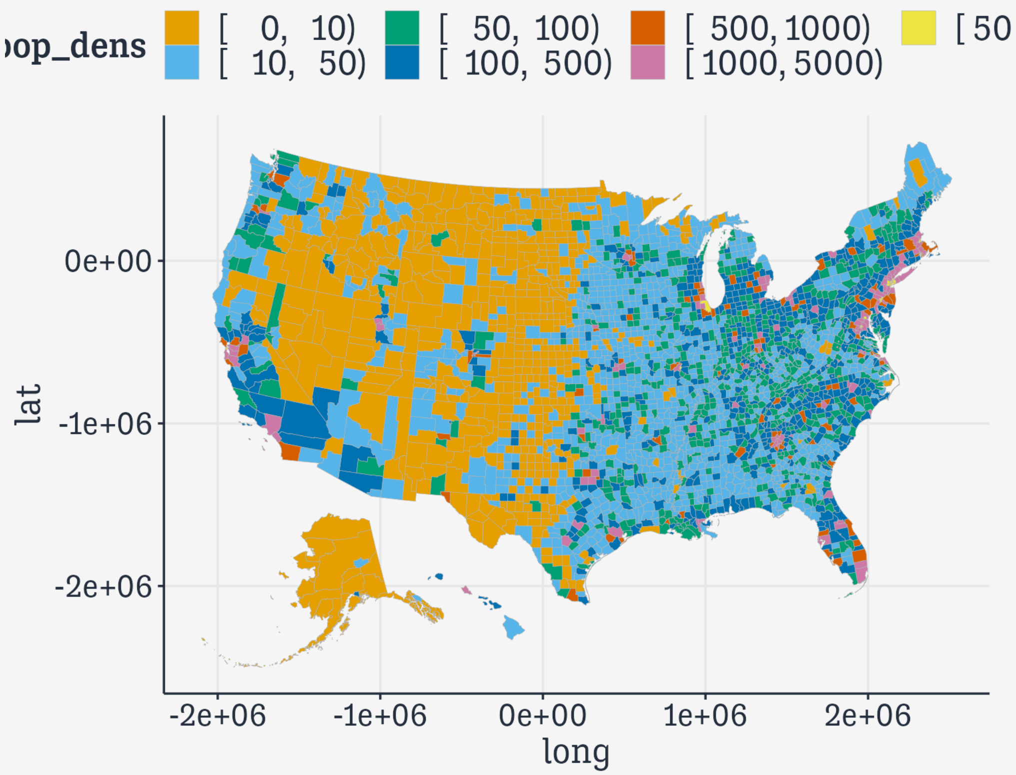
# County Population Density

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pop_dens,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1)
```



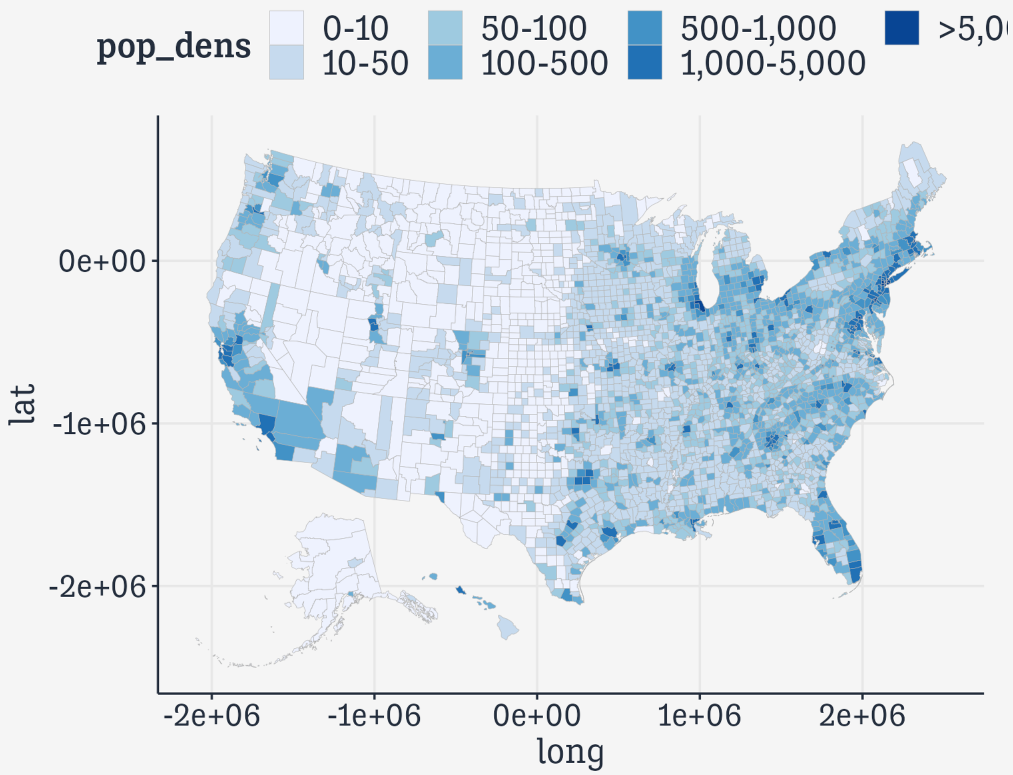
# County Population Density

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pop_dens,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed()
```



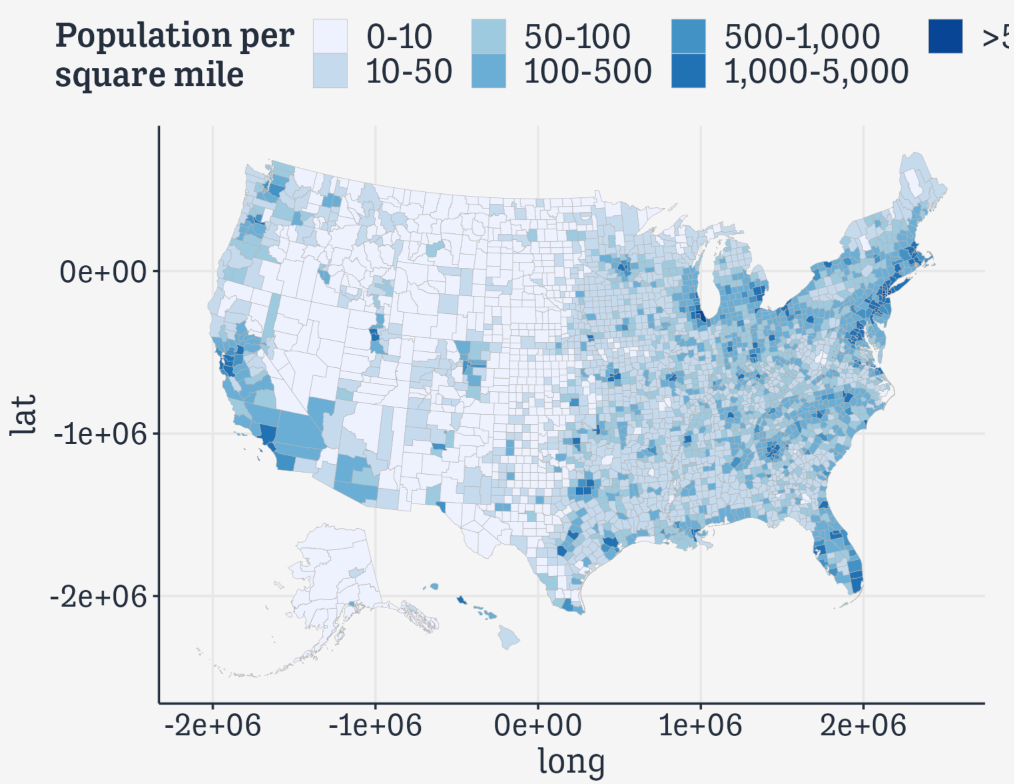
# County Population Density

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pop_dens,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Blues",
                    labels = c("0-10", "10-50", "5
                     "100-500", "500-1,000",
                      "1,000-5,000", ">5,000"))
```



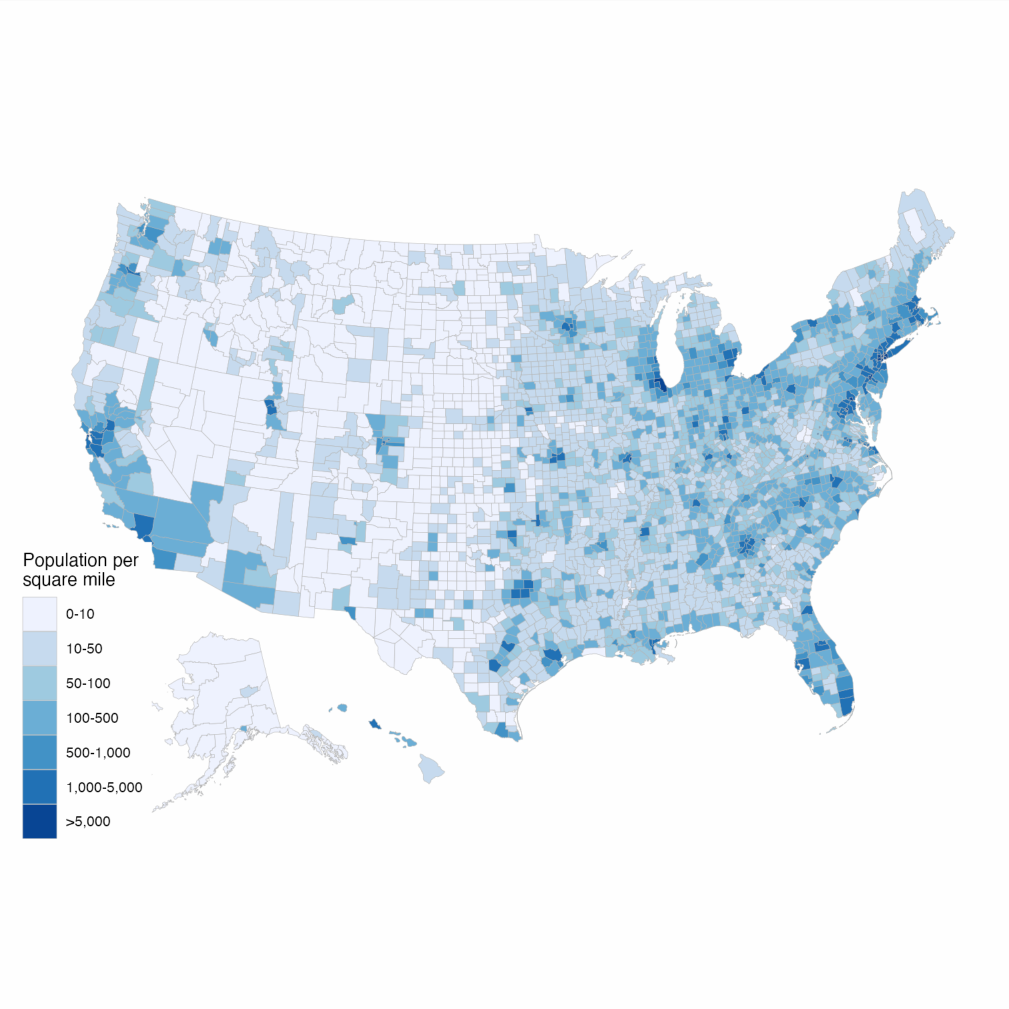
# County Population Density

```
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pop_dens,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Blues",
                    labels = c("0-10", "10-50", "5
                     "100-500", "500-1,000",
                      "1,000-5,000", ">5,000")) +
  labs(fill = "Population per\nsquare mile")
```



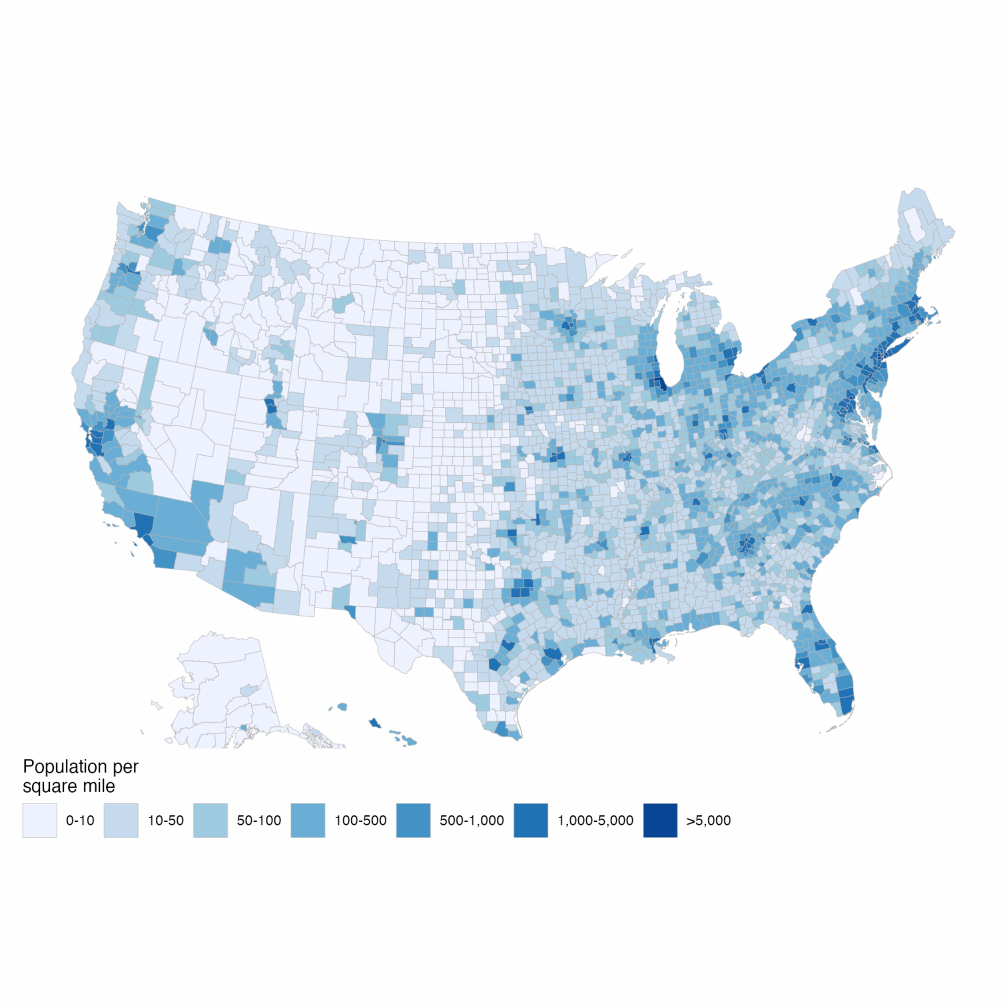
# County Population Density

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pop_dens,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Blues",
                    labels = c("0-10", "10-50", "5
                     "100-500", "500-1,000",
                      "1,000-5,000", ">5,000")) +
  labs(fill = "Population per\nsquare mile") +
  kjhslides::kjh_theme_map()
```



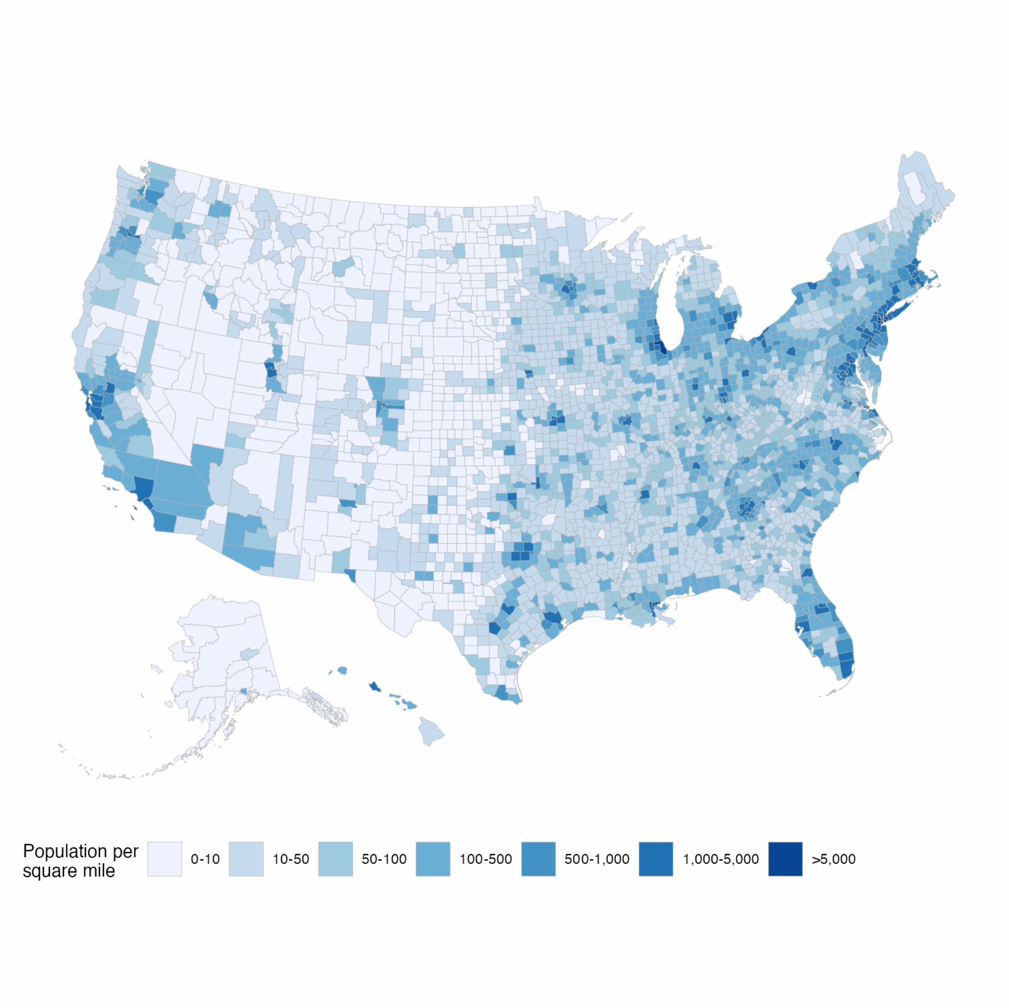
# County Population Density

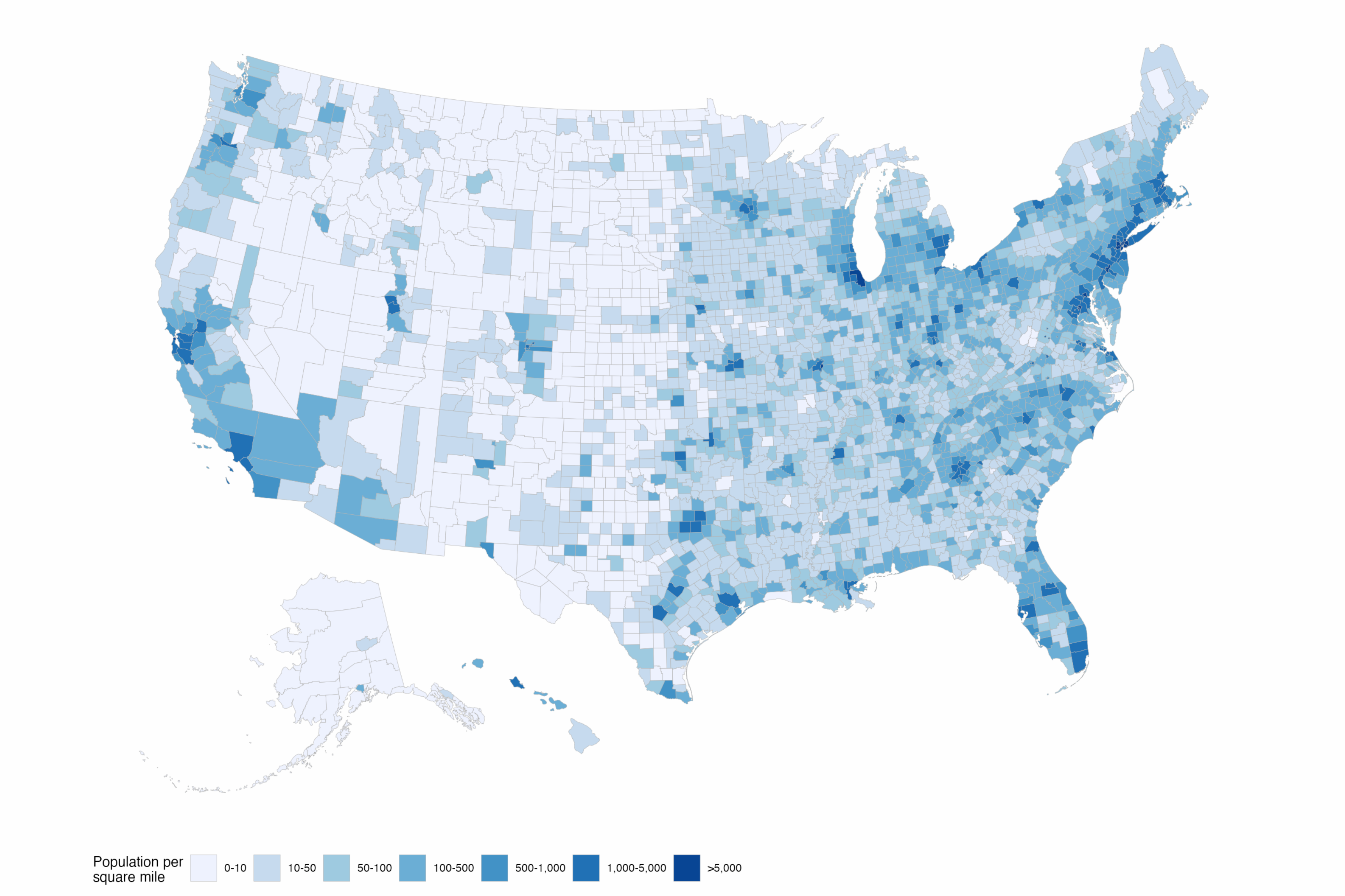
```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pop_dens,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Blues",
                    labels = c("0-10", "10-50", "5
                     "100-500", "500-1,000",
                      "1,000-5,000", ">5,000")) +
  labs(fill = "Population per\nsquare mile") +
  kjhslides::kjh_theme_map() +
  guides(fill = guide_legend(nrow = 1))
```



# County Population Density

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pop_dens,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Blues",
                    labels = c("0-10", "10-50", "5
                     "100-500", "500-1,000",
                      "1,000-5,000", ">5,000")) +
  labs(fill = "Population per\nsquare mile") +
  kjhslides::kjh_theme_map() +
  guides(fill = guide_legend(nrow = 1)) +
  theme(legend.position = "bottom")
```






Population Density by County, binned

# Same again for Percent Black

```
county_full <- left_join(county_map, county_data,
```

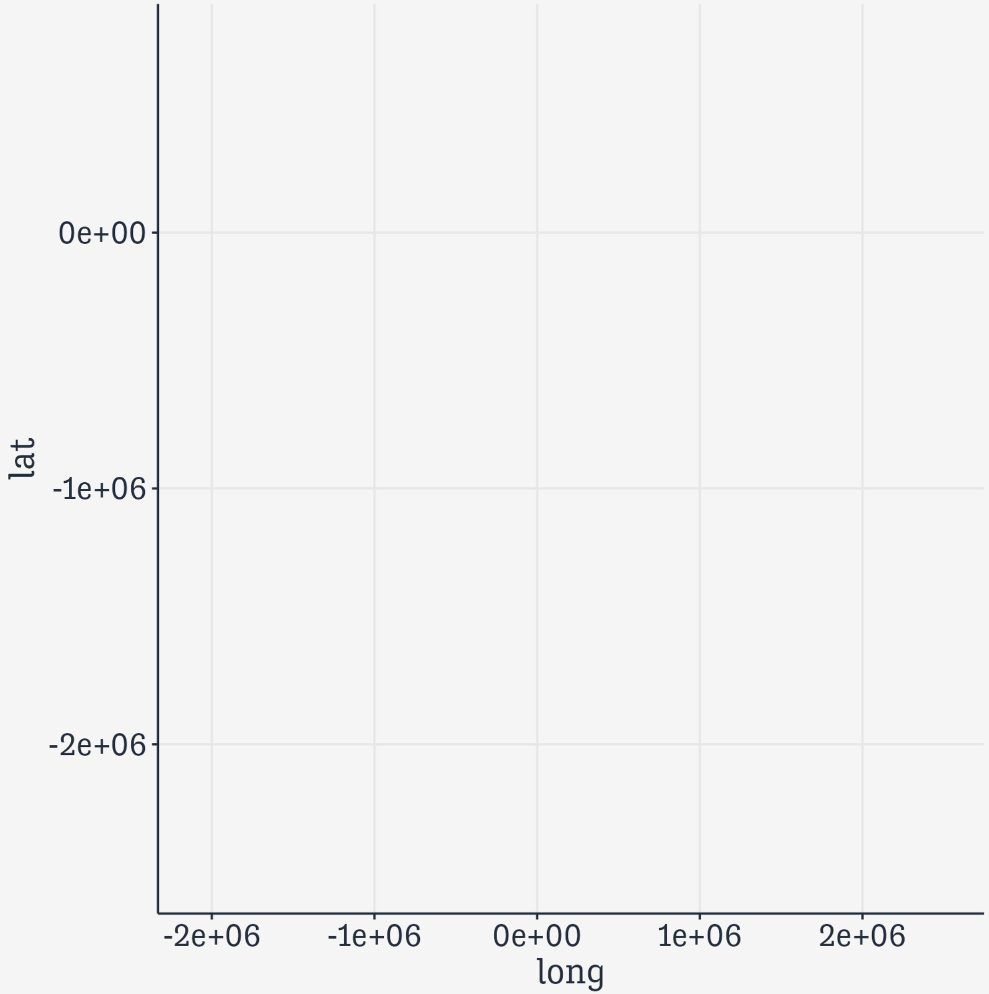
# Same again for Percent Black

```r
county_full <- left_join(county_map, county_data,
county_full
```

```
## # A tibble: 191,382 × 38
##         long       lat order hole  piece group     id    name  state census_re
##        <dbl>     <dbl> <int> <lgl> <fct> <fct>     <chr> <chr> <fct> <fct>
##  1 1225889. -1275020.     1 FALSE 1     0500000… 01001 Auta… AL    South
##  2 1235324. -1274008.     2 FALSE 1     0500000… 01001 Auta… AL    South
##  3 1244873. -1272331.     3 FALSE 1     0500000… 01001 Auta… AL    South
##  4 1244129. -1267515.     4 FALSE 1     0500000… 01001 Auta… AL    South
##  5 1272010. -1262889.     5 FALSE 1     0500000… 01001 Auta… AL    South
##  6 1276797. -1295514.     6 FALSE 1     0500000… 01001 Auta… AL    South
##  7 1273832. -1297124.     7 FALSE 1     0500000… 01001 Auta… AL    South
##  8 1272727. -1296631.     8 FALSE 1     0500000… 01001 Auta… AL    South
##  9 1272513. -1299771.     9 FALSE 1     0500000… 01001 Auta… AL    South
## 10 1269950. -1302038.    10 FALSE 1     0500000… 01001 Auta… AL    South
## # ℹ 191,372 more rows
## # ℹ 28 more variables: pop_dens <fct>, pop_dens4 <fct>, pop_dens6 <fct>,
## #   pct_black <fct>, pop <int>, female <dbl>, white <dbl>, black <dbl>,
## #   travel_time <dbl>, land_area <dbl>, hh_income <int>, su_gun4 <fct>,
## #   su_gun6 <fct>, fips <dbl>, votes_dem_2016 <int>, votes_gop_2016 <int>,
## #   total_votes_2016 <int>, per_dem_2016 <dbl>, per_gop_2016 <dbl>,
## #   diff_2016 <int>, per_dem_2012 <dbl>, per_gop_2012 <dbl>, diff_2012 <int
```

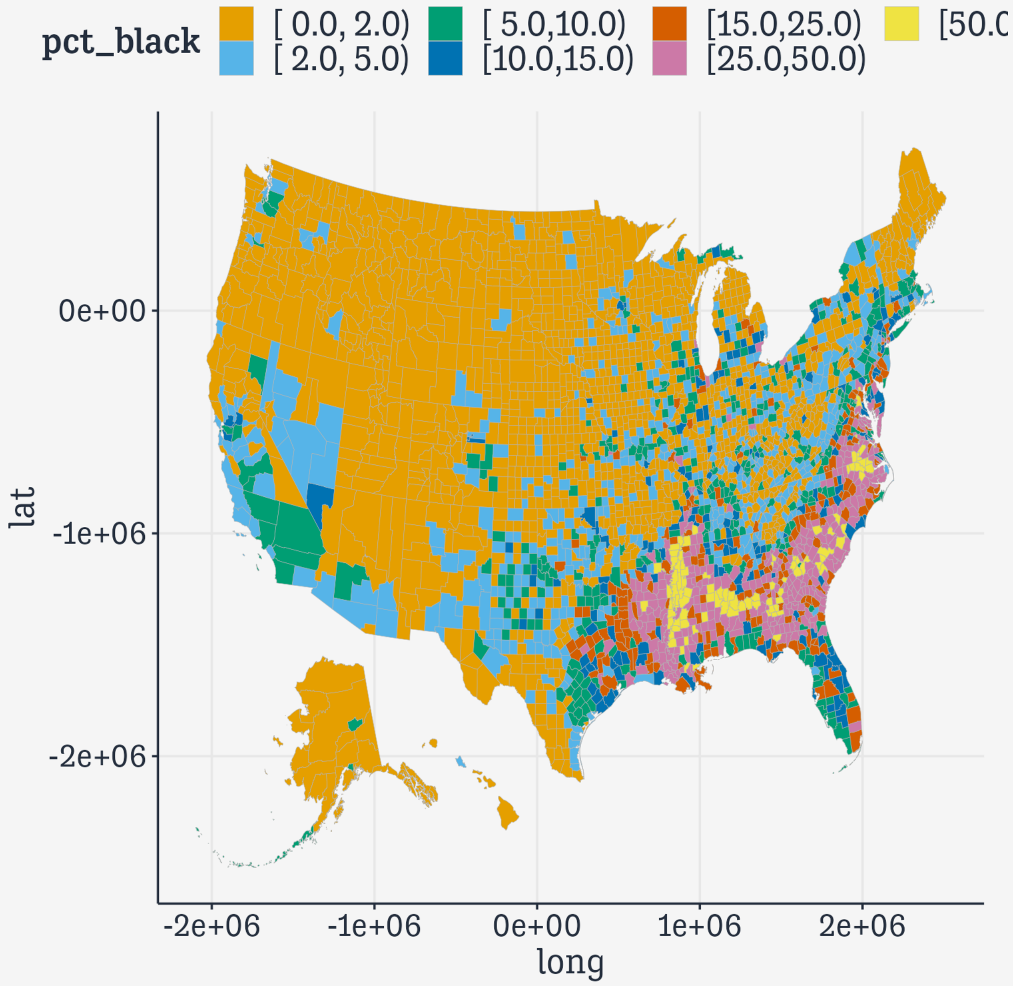
# Same again for Percent Black

```
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pct_black,
                       group = group))
```



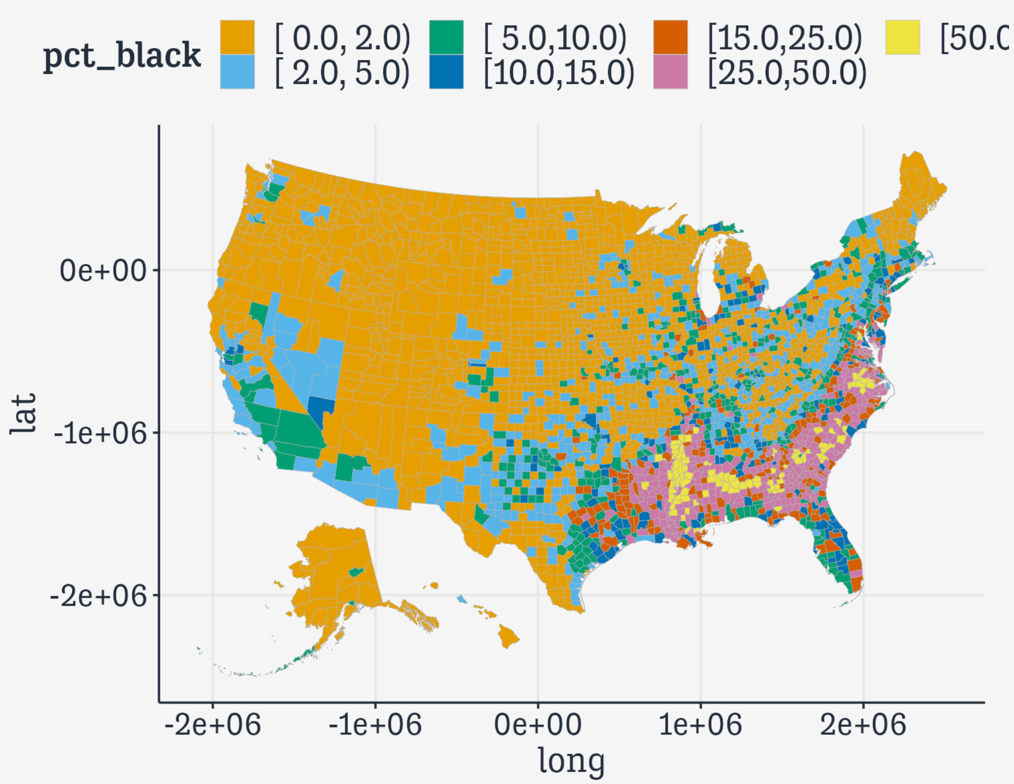
# Same again for Percent Black

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pct_black,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1)
```



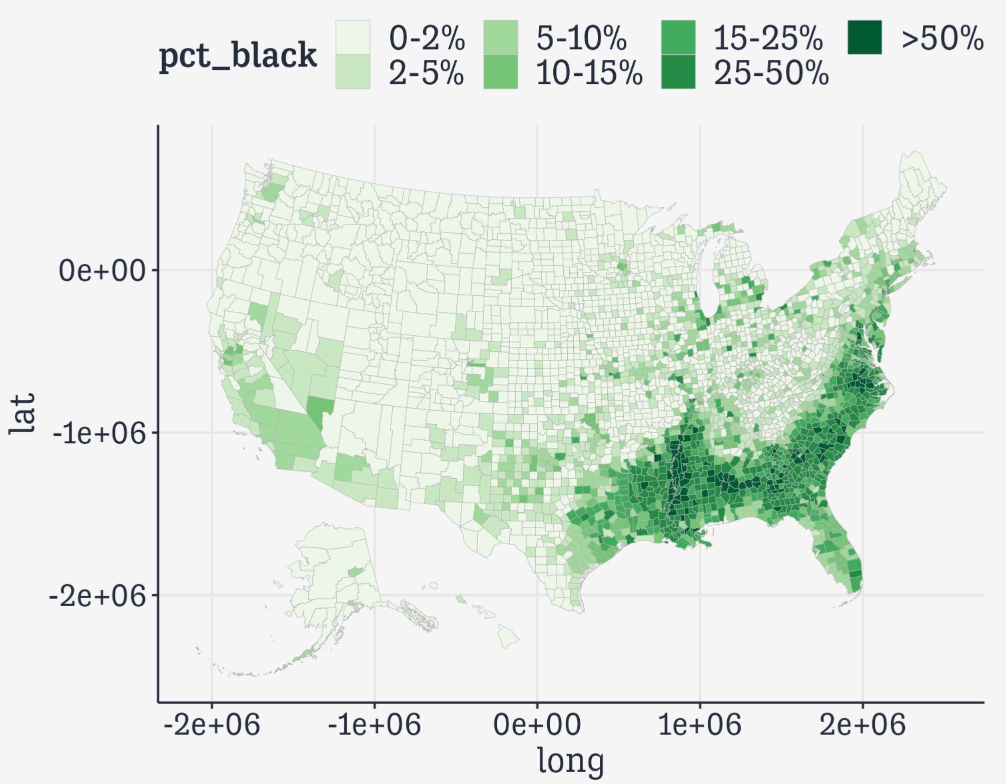
# Same again for Percent Black

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pct_black,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed()
```



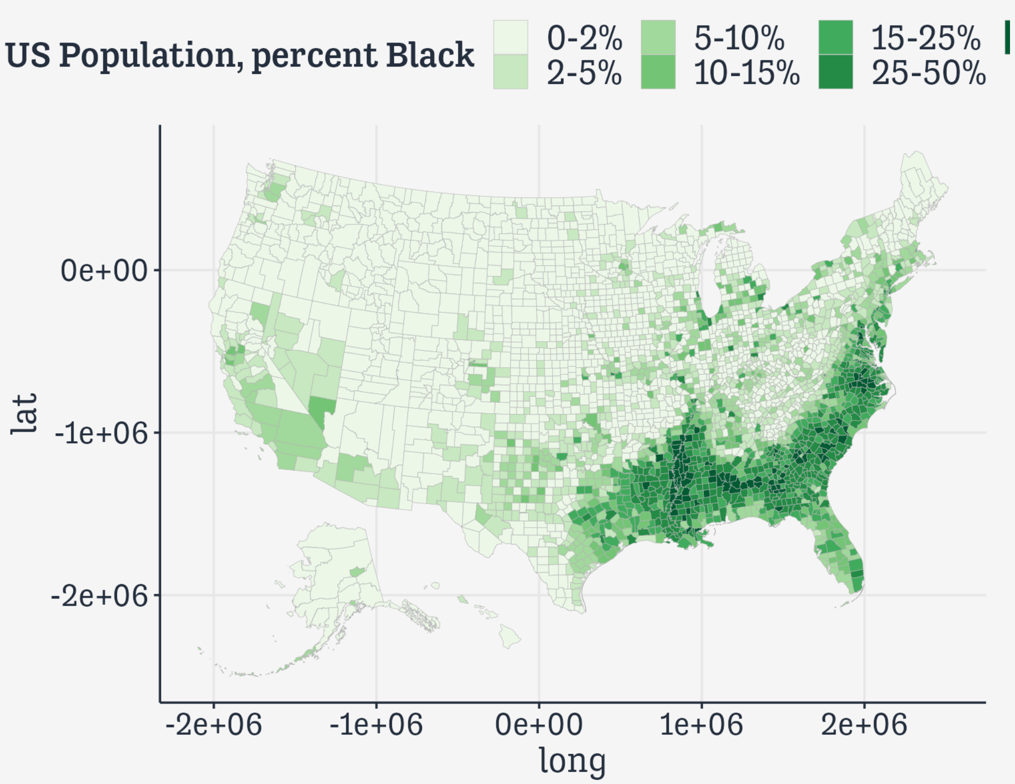
# Same again for Percent Black

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pct_black,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Greens",
                    labels = c("0-2%", "2-5%", "5-
                               "10-15%", "15-25%",
                               "25-50%", ">50%"))
```



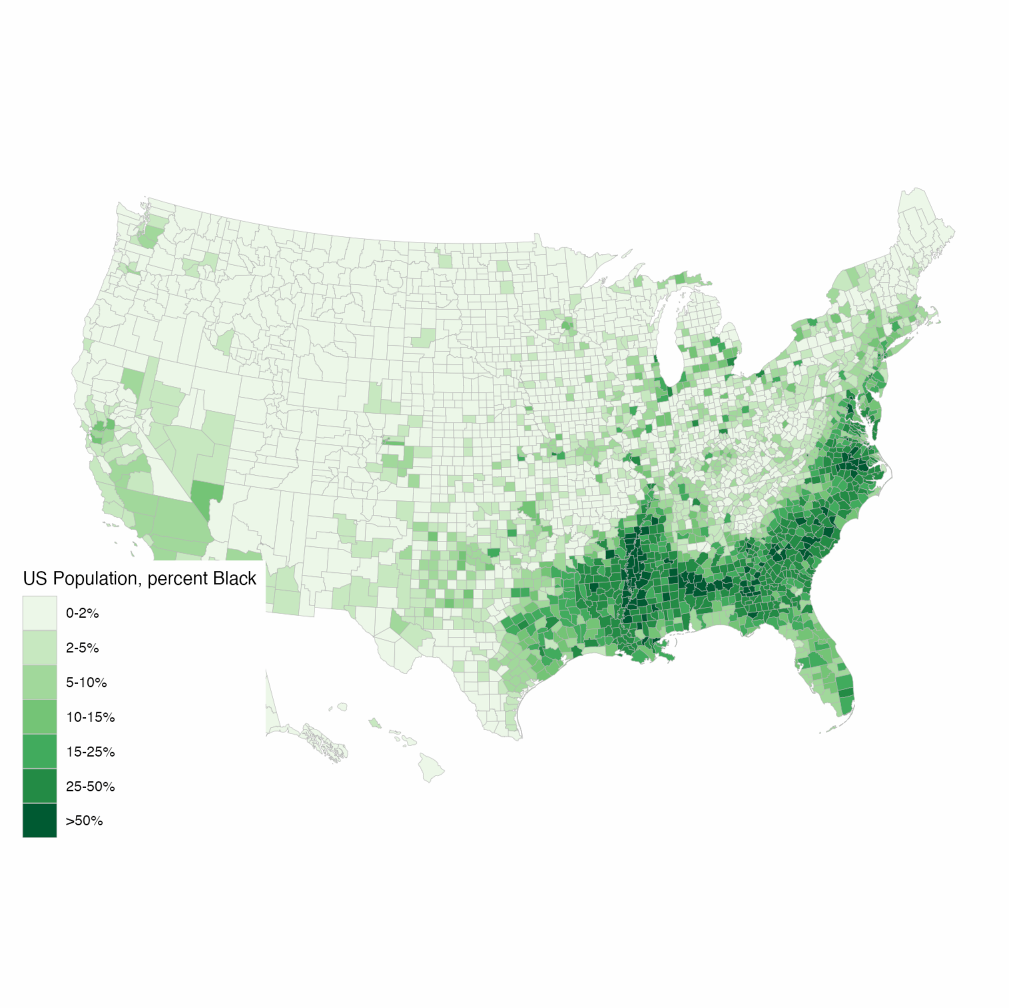
# Same again for Percent Black

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pct_black,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Greens",
                    labels = c("0-2%", "2-5%", "5-
                               "10-15%", "15-25%",
                               "25-50%", ">50%")) +
  labs(fill = "US Population, percent Black")
```



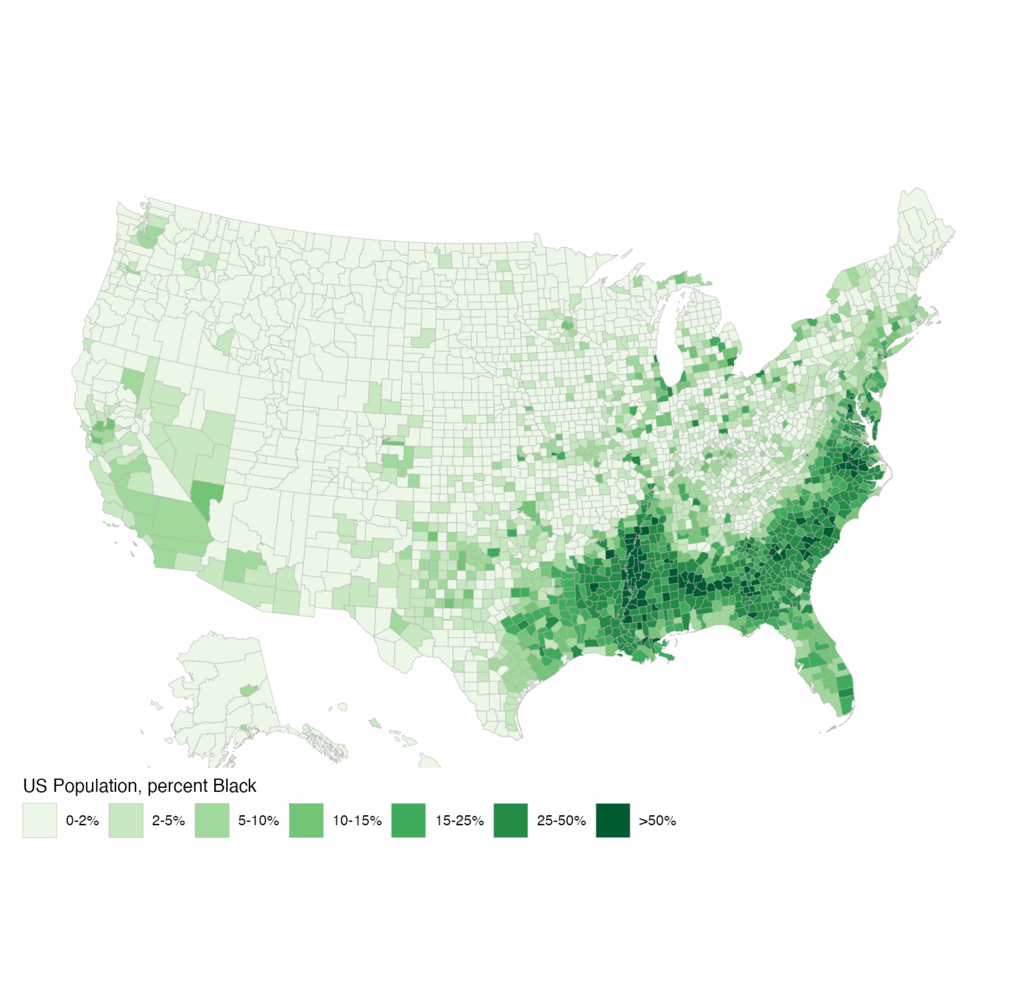
# Same again for Percent Black

```r
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pct_black,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Greens",
                    labels = c("0-2%", "2-5%", "5-
                               "10-15%", "15-25%",
                               "25-50%", ">50%")) +
  labs(fill = "US Population, percent Black") +
  kjhslides::kjh_theme_map()
```



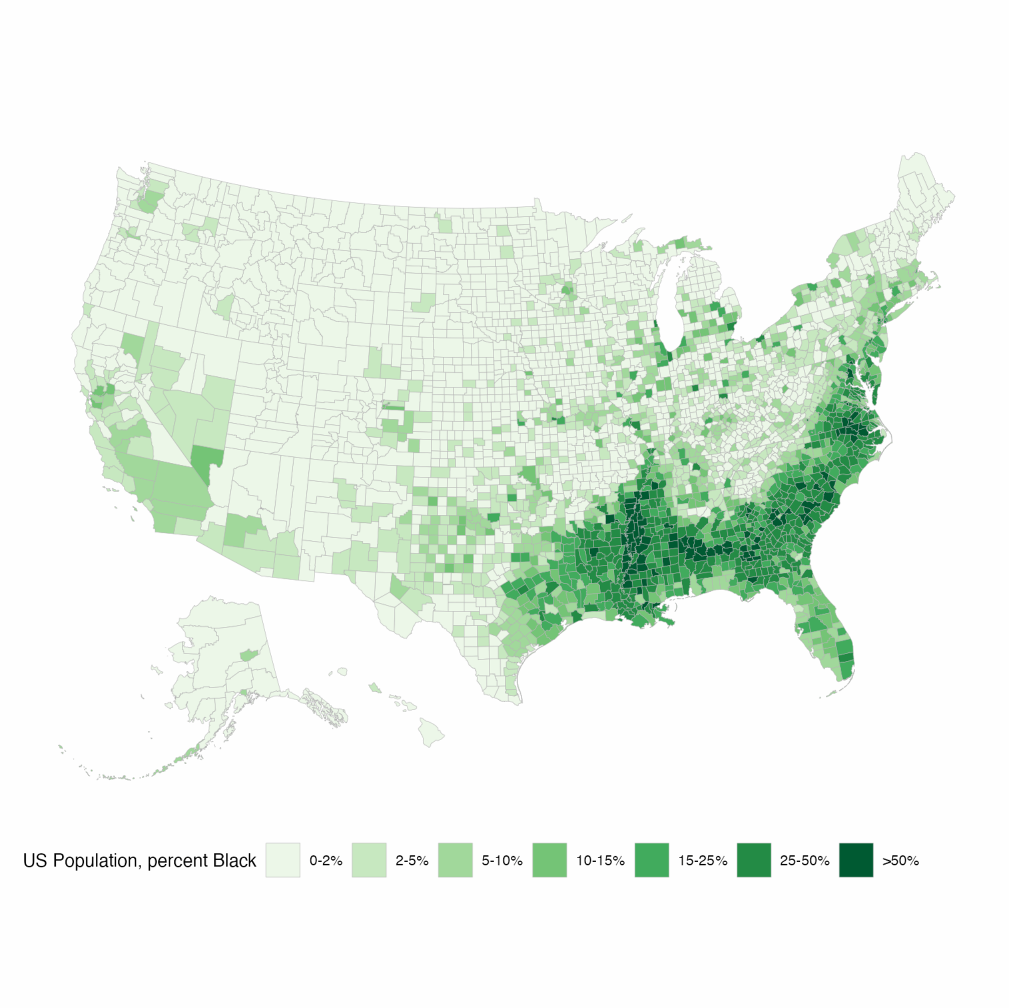
# Same again for Percent Black

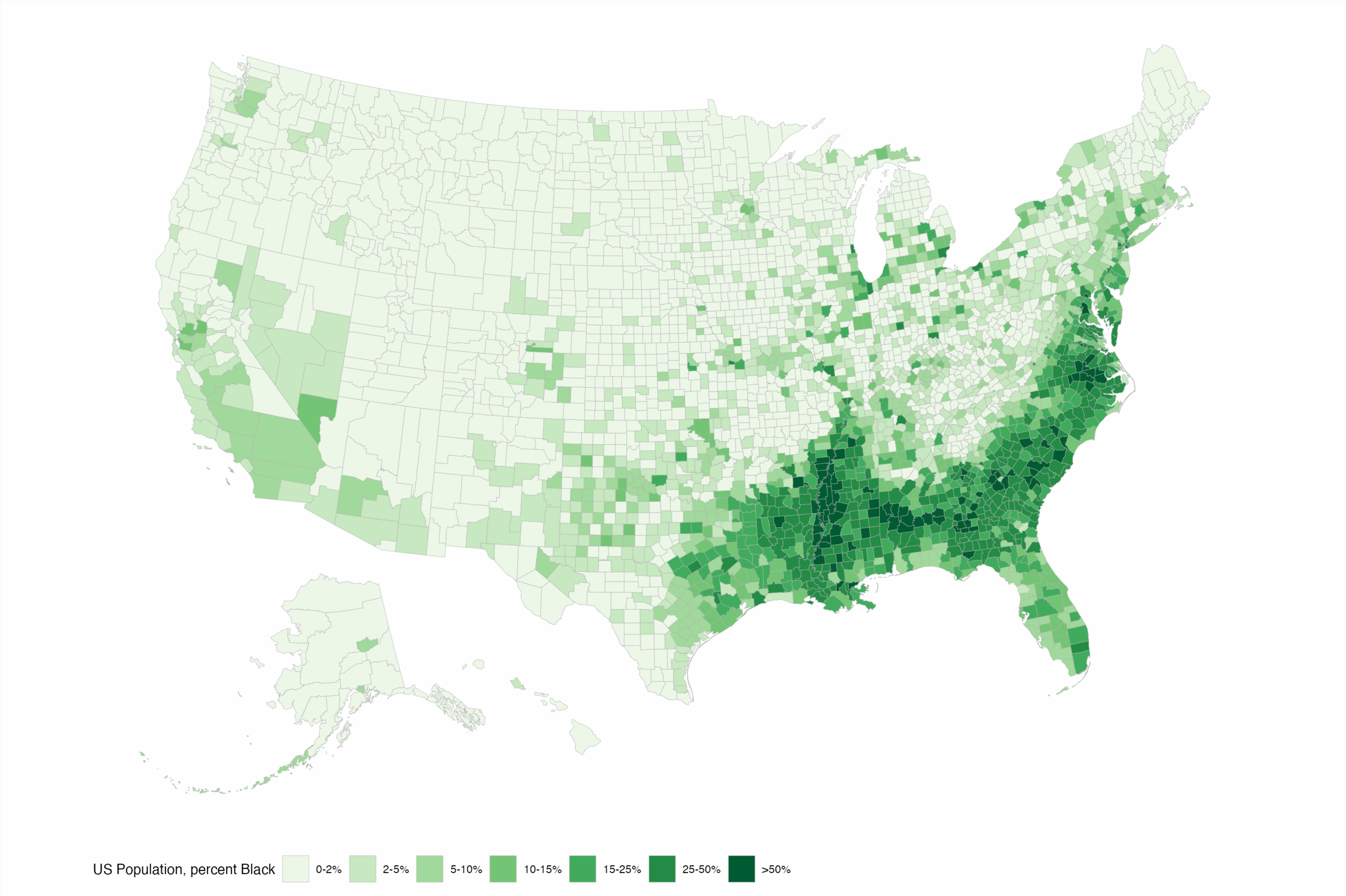
```
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pct_black,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Greens",
                    labels = c("0-2%", "2-5%", "5-
                               "10-15%", "15-25%",
                               "25-50%", ">50%"))
  labs(fill = "US Population, percent Black") +
  kjhslides::kjh_theme_map() +
  guides(fill = guide_legend(nrow = 1))
```



# Same again for Percent Black

```
county_full <- left_join(county_map, county_data,

county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pct_black,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Greens",
                    labels = c("0-2%", "2-5%", "5-
                               "10-15%", "15-25%",
                               "25-50%", ">50%"))
  labs(fill = "US Population, percent Black") +
  kjhslides::kjh_theme_map() +
  guides(fill = guide_legend(nrow = 1)) +
  theme(legend.position = "bottom")
```






Percent Black, by County, binned

# Big counties, small populations, rare events

# Example: Reverse coding

```r
orange_pal <- RColorBrewer::brewer.pal(n = 6,
                                        name = "Oranges")
orange_pal
```

```
## [1] "#FEEDDE" "#FDD0A2" "#FDAE6B" "#FD8D3C" "#E6550D" "#A63603"
```

# Example: Reverse coding

```r
orange_pal <- RColorBrewer::brewer.pal(n = 6,
                                       name = "Oranges")
orange_pal
```

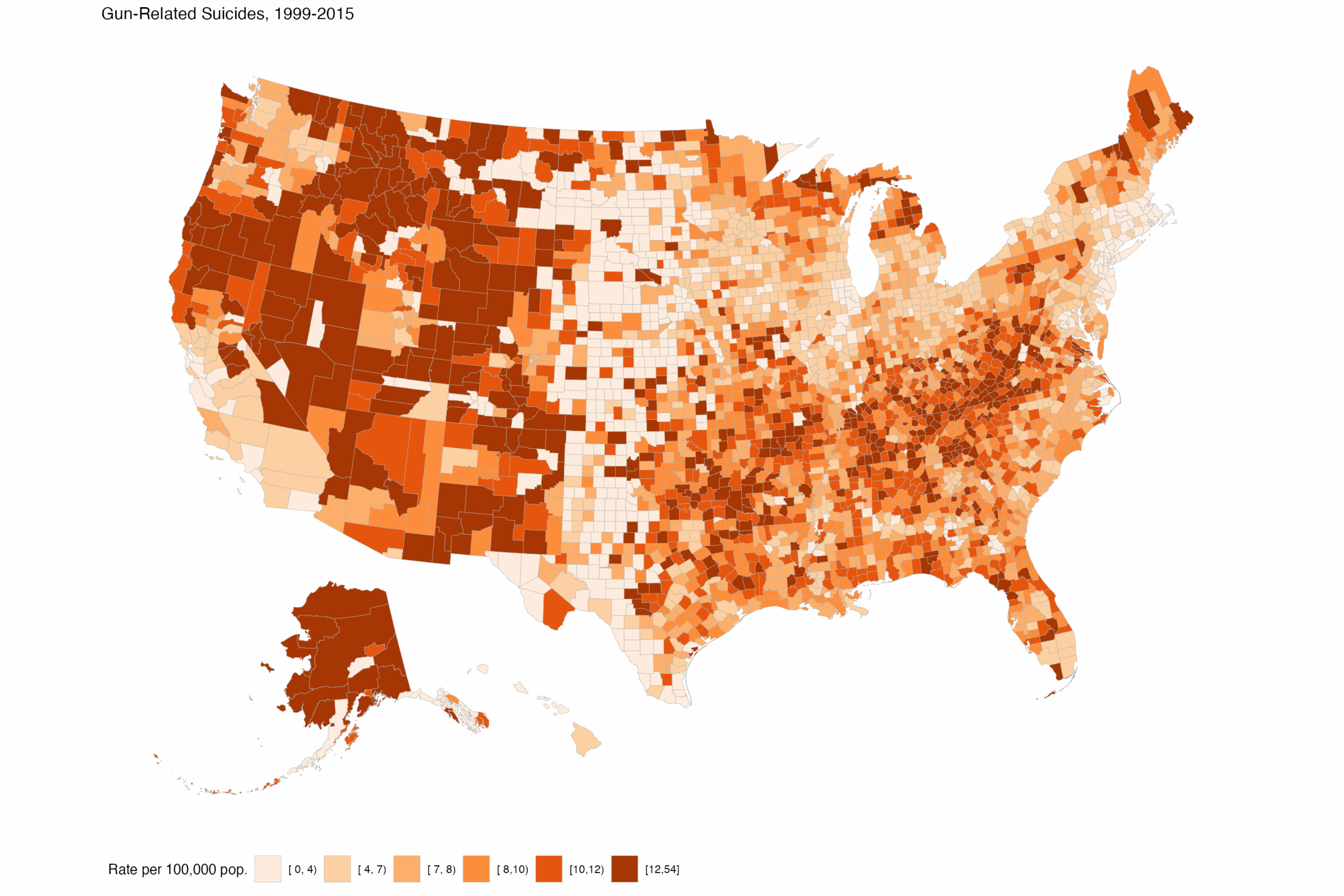
```
## [1] "#FEEDDE" "#FDD0A2" "#FDAE6B" "#FD8D3C" "#E6550D" "#A63603"
```

```r
# Just reverse it
orange_rev <- rev(orange_pal)
orange_rev
```

```
## [1] "#A63603" "#E6550D" "#FD8D3C" "#FDAE6B" "#FDD0A2" "#FE
```

# Build a plot

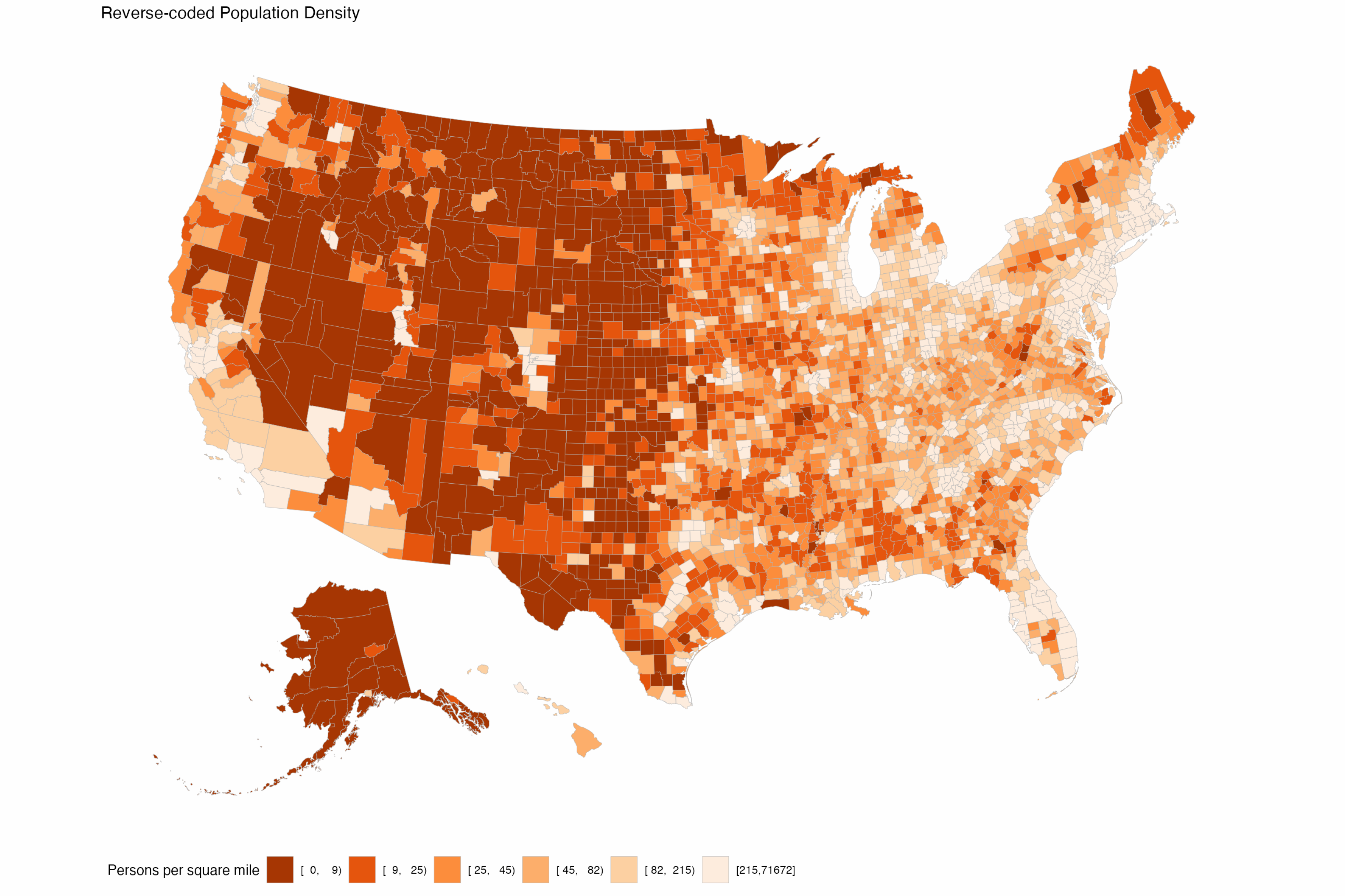
```r
p_g1 <- county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = su_gun6,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_manual(values = orange_pal) +
  labs(title = "Gun-Related Suicides, 1999-2015",
       fill = "Rate per 100,000 pop.") +
  theme_map() +
  guides(fill = guide_legend(nrow = 1)) +
  theme(legend.position = "bottom")
```



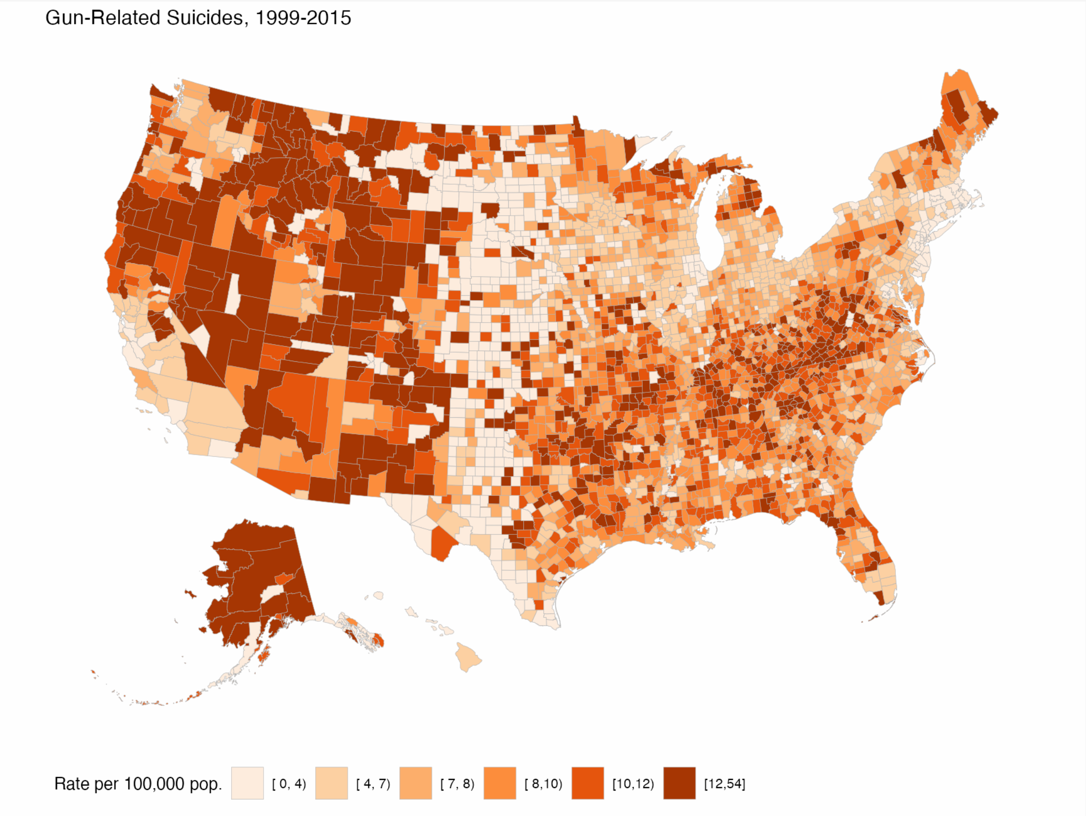

Regular palette

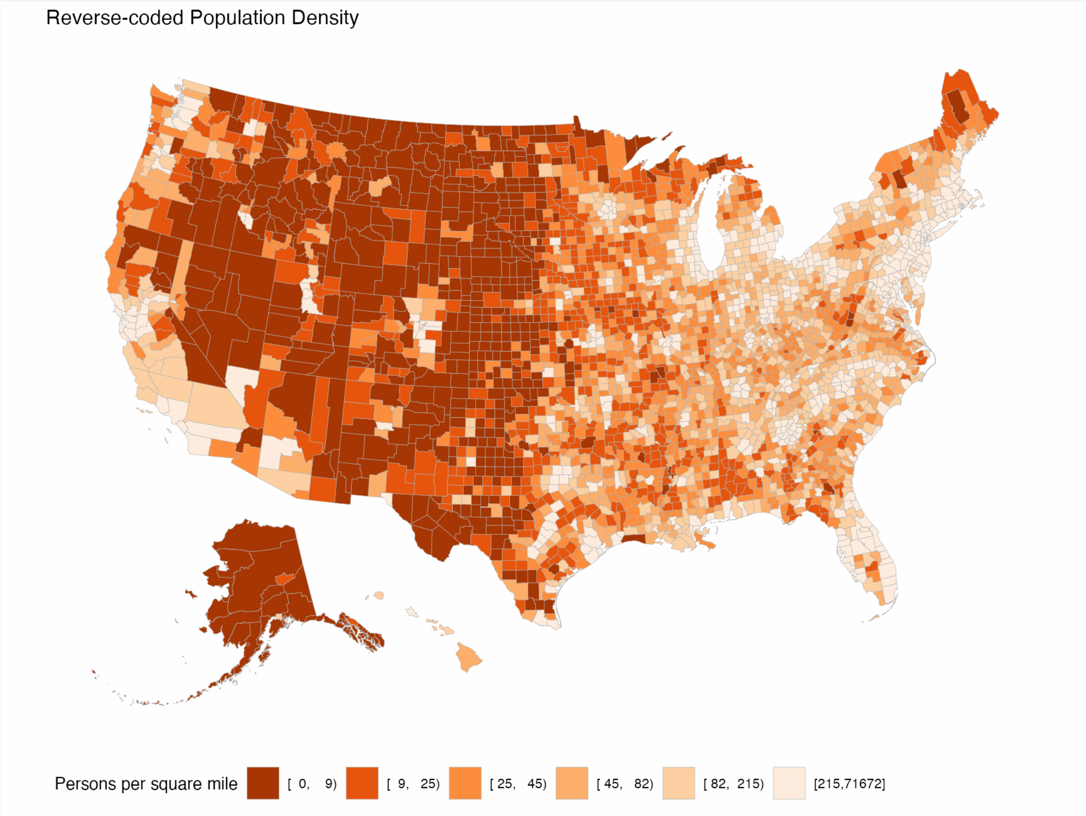
# And another

```
p_g2 <- county_full |>
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pop_dens6,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_manual(values = orange_rev) +
  labs(title = "Reverse-coded Population Density",
       fill = "Persons per square mile") +
  theme_map() +
  guides(fill = guide_legend(nrow = 1)) +
  theme(legend.position = "bottom")
```




Reverse-coded density




## Comparing the plots

# Small multiples for maps

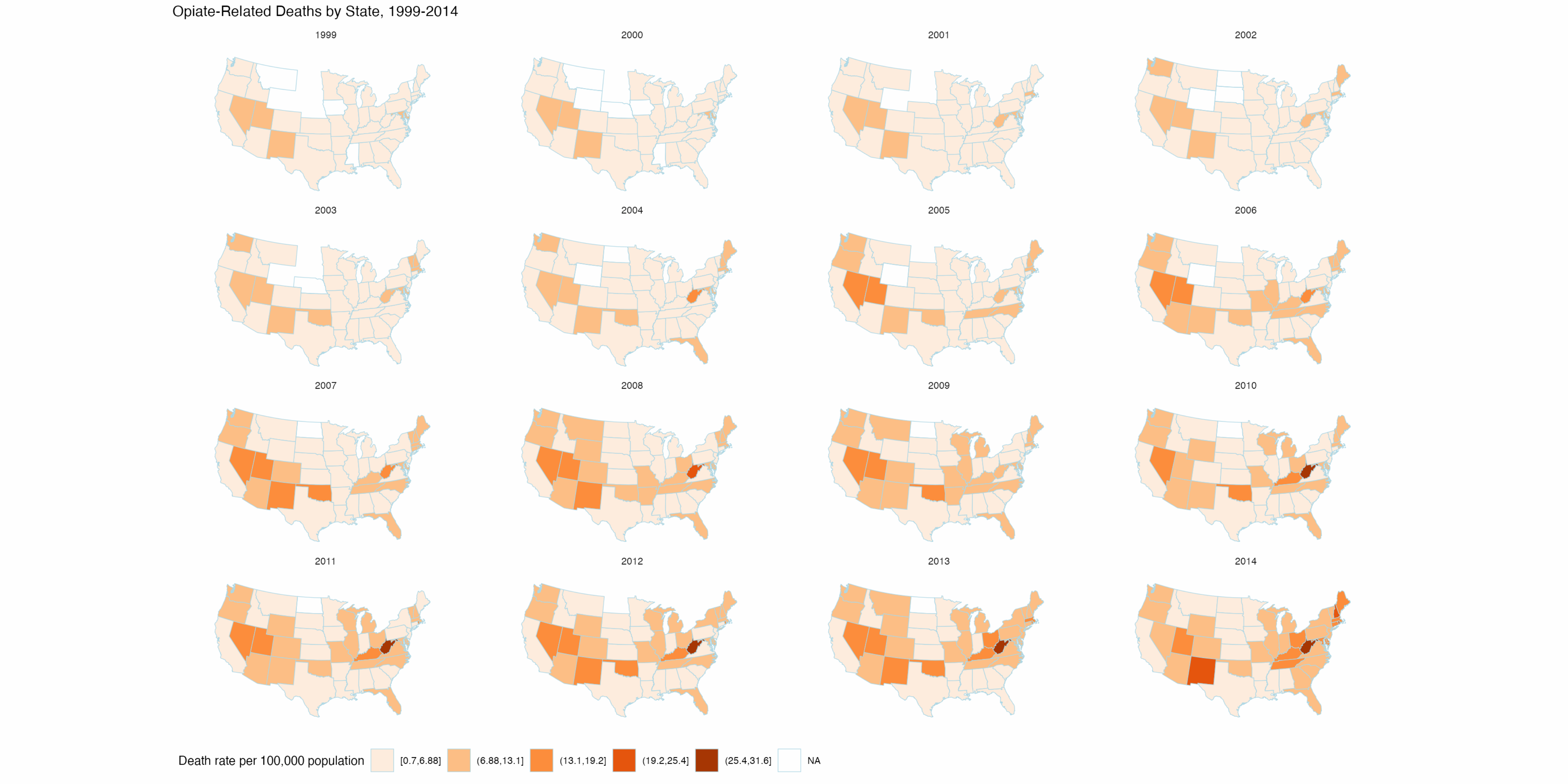
# Opiate-related Mortality, 1999-2014

```r
opiates
```

```
## # A tibble: 800 × 11
##     year state    fips deaths population crude adjusted adjusted_se region abbr
##    <int> <chr>   <int>  <int>      <int> <dbl>    <dbl>       <dbl> <ord>  <chr>
##  1  1999 Alabama     1     37    4430141   0.8      0.8         0.1 South  AL
##  2  1999 Alaska      2     27     624779   4.3      4           0.8 West   AK
##  3  1999 Arizona     4    229    5023823   4.6      4.7         0.3 West   AZ
##  4  1999 Arkans…     5     28    2651860   1.1      1.1         0.2 South  AR
##  5  1999 Califo…     6   1474   33499204   4.4      4.5         0.1 West   CA
##  6  1999 Colora…     8    164    4226018   3.9      3.7         0.3 West   CO
##  7  1999 Connec…     9    151    3386401   4.5      4.4         0.4 North… CT
##  8  1999 Delawa…    10     32     774990   4.1      4.1         0.7 South  DE
##  9  1999 Distri…    11     28     570213   4.9      4.9         0.9 South  DC
## 10  1999 Florida    12    402   15759421   2.6      2.6         0.1 South  FL
## # ℹ 790 more rows
## # ℹ 1 more variable: division_name <chr>
```

```r
opiates$state <- tolower(opiates$state)
us_states$state <- us_states$region
opiates_map <- left_join(us_states, opiates, by = "state")
```

```r
p_out <- opiates_map |>
  ggplot(mapping = aes(x = long, y = lat,
                       group = group,
                       fill = cut_interval(adjusted, n = 5))) +
  geom_polygon(color = "lightblue", size = 0.2) +
  coord_map(projection = "albers", lat0 = 39, lat1 = 45) +
  scale_fill_brewer(type = "seq", palette = "Oranges") +
  kjhslides::kjh_theme_map() +
  facet_wrap(~ year, ncol = 4) +
  guides(fill = guide_legend(nrow = 1)) +
  theme(legend.position = "bottom",
        strip.background = element_blank()) +
  labs(fill = "Death rate per 100,000 population",
       title = "Opiate-Related Deaths by State, 1999-2014")
```




Faceting works just as it would for any other kind of plot.

# Is your data really spatial?

# The two leading states in each region in 2014

```r
## Put this in an object called `st_top`
opiates
```

```
## # A tibble: 800 × 11
##      year state    fips deaths population crude adjusted adjusted_se region a
##     <int> <chr>   <int>  <int>      <int> <dbl>    <dbl>       <dbl> <ord>  <
##  1   1999 alabama     1     37    4430141   0.8      0.8         0.1 South  A
##  2   1999 alaska      2     27     624779   4.3      4           0.8 West   A
##  3   1999 arizona     4    229    5023823   4.6      4.7         0.3 West   A
##  4   1999 arkans…     5     28    2651860   1.1      1.1         0.2 South  A
##  5   1999 califo…     6   1474   33499204   4.4      4.5         0.1 West   C
##  6   1999 colora…     8    164    4226018   3.9      3.7         0.3 West   C
##  7   1999 connec…     9    151    3386401   4.5      4.4         0.4 North… C
##  8   1999 delawa…    10     32     774990   4.1      4.1         0.7 South  D
##  9   1999 distri…    11     28     570213   4.9      4.9         0.9 South  D
## 10   1999 florida    12    402   15759421   2.6      2.6         0.1 South  F
## # ℹ 790 more rows
## # ℹ 1 more variable: division_name <chr>
```

# The two leading states in each region in 2014

```r
## Put this in an object called `st_top`
opiates |>
  filter(year == max(year),
         abbr != "DC")
```

```
## # A tibble: 50 × 11
##     year state    fips deaths population crude adjusted adjusted_se region a
##    <int> <chr>   <int>  <int>      <int> <dbl>    <dbl>       <dbl> <ord>  <
##  1  2014 alabama     1    270    4849377   5.6      5.6         0.3 South  A
##  2  2014 alaska      2     76     736732  10.3     10.6         1.2 West   A
##  3  2014 arizona     4    589    6731484   8.7      8.8         0.4 West   A
##  4  2014 arkans…     5    173    2966369   5.8      6.3         0.5 South  A
##  5  2014 califo…     6   2024   38802500   5.2      5           0.1 West   C
##  6  2014 colora…     8    517    5355866   9.7      9.4         0.4 West   C
##  7  2014 connec…     9    525    3596677  14.6     15.2         0.7 North… C
##  8  2014 delawa…    10    124     935614  13.3     13.9         1.3 South  D
##  9  2014 florida    12   1399   19893297   7        7.2         0.2 South  F
## 10  2014 georgia    13    710   10097343   7        7           0.3 South  G
## # ℹ 40 more rows
## # ℹ 1 more variable: division_name <chr>
```

# The two leading states in each region in 2014

```r
## Put this in an object called `st_top`
opiates |>
  filter(year == max(year),
         abbr != "DC") |>
  group_by(region)
```

```
## # A tibble: 50 × 11
## # Groups:   region [4]
##     year state    fips deaths population crude adjusted adjusted_se region a
##    <int> <chr>   <int>  <int>      <int> <dbl>    <dbl>       <dbl> <ord>  <
##  1  2014 alabama     1    270    4849377   5.6      5.6         0.3 South  A
##  2  2014 alaska      2     76     736732  10.3     10.6         1.2 West   A
##  3  2014 arizona     4    589    6731484   8.7      8.8         0.4 West   A
##  4  2014 arkans…     5    173    2966369   5.8      6.3         0.5 South  A
##  5  2014 califo…     6   2024   38802500   5.2      5           0.1 West   C
##  6  2014 colora…     8    517    5355866   9.7      9.4         0.4 West   C
##  7  2014 connec…     9    525    3596677  14.6     15.2         0.7 North… C
##  8  2014 delawa…    10    124     935614  13.3     13.9         1.3 South  D
##  9  2014 florida    12   1399   19893297   7        7.2         0.2 South  F
## 10  2014 georgia    13    710   10097343   7        7           0.3 South  G
## # ℹ 40 more rows
## # ℹ 1 more variable: division_name <chr>
```

# The two leading states in each region in 2014

```r
## Put this in an object called `st_top`
opiates |>
  filter(year == max(year),
         abbr != "DC") |>
  group_by(region) |>
  slice_max(order_by = adjusted,
            n = 2)
```

```
## # A tibble: 8 × 11
## # Groups:   region [4]
##    year state      fips deaths population crude adjusted adjusted_se region a
##   <int> <chr>     <int>  <int>      <int> <dbl>    <dbl>       <dbl> <ord>  <
## 1  2014 new ham…     33    297    1326813  22.4     23.4         1.4 North… N
## 2  2014 rhode i…     44    205    1055173  19.4     19.8         1.4 North… R
## 3  2014 ohio         39   2106   11594163  18.2     19.1         0.4 Midwe… O
## 4  2014 missouri     29    696    6063589  11.5     12           0.5 Midwe… M
## 5  2014 new mex…     35    402    2085572  19.3     20.2         1   West   N
## 6  2014 utah         49    455    2942902  15.5     16.8         0.8 West   U
## 7  2014 west vi…     54    554    1850326  29.9     31.6         1.4 South  W
## 8  2014 kentucky     21    729    4413457  16.5     16.8         0.6 South  K
## # ℹ 1 more variable: division_name <chr>
```

# The two leading states in each region in 2014

```r
## Put this in an object called `st_top`
opiates |>
  filter(year == max(year),
         abbr != "DC") |>
  group_by(region) |>
  slice_max(order_by = adjusted,
            n = 2)
```

```
## # A tibble: 8 × 11
## # Groups:   region [4]
##     year state      fips deaths population crude adjusted adjusted_se region a
##    <int> <chr>     <int>  <int>      <int> <dbl>    <dbl>       <dbl> <ord>  <
## 1  2014 new ham…     33    297    1326813  22.4     23.4         1.4 North… N
## 2  2014 rhode i…     44    205    1055173  19.4     19.8         1.4 North… R
## 3  2014 ohio         39   2106   11594163  18.2     19.1         0.4 Midwe… O
## 4  2014 missouri     29    696    6063589  11.5     12           0.5 Midwe… M
## 5  2014 new mex…     35    402    2085572  19.3     20.2         1   West   N
## 6  2014 utah         49    455    2942902  15.5     16.8         0.8 West   U
## 7  2014 west vi…     54    554    1850326  29.9     31.6         1.4 South  W
## 8  2014 kentucky     21    729    4413457  16.5     16.8         0.6 South  K
## # ℹ 1 more variable: division_name <chr>
```

# Opiates Time Series plot

```
st_top <- opiates |> filter(year == max(year), ab
```

# Opiates Time Series plot

```
st_top <- opiates |>  filter(year == max(year), ab
  group_by(region)
```

# Opiates Time Series plot

```
st_top <- opiates |>  filter(year == max(year), ab
  group_by(region) |>
  slice_max(order_by = adjusted, n = 2)
```

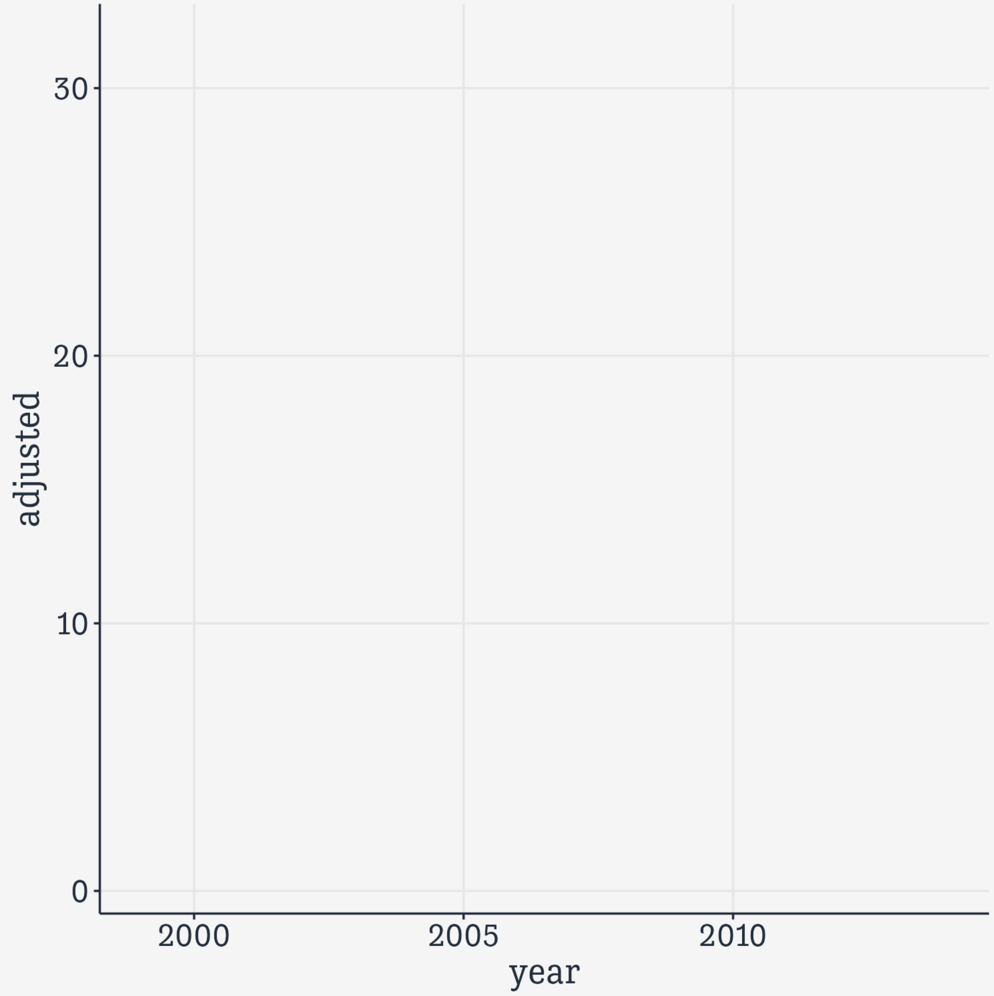
# Opiates Time Series plot

```r
st_top <- opiates |> filter(year == max(year), ab
  group_by(region) |>
  slice_max(order_by = adjusted, n = 2)

opiates
```

```
## # A tibble: 800 × 11
##     year state    fips deaths population crude adjusted adjusted_se region a
##    <int> <chr>   <int>  <int>      <int> <dbl>    <dbl>       <dbl> <ord>  <
##  1  1999 alabama     1     37    4430141   0.8      0.8         0.1 South  A
##  2  1999 alaska      2     27     624779   4.3      4           0.8 West   A
##  3  1999 arizona     4    229    5023823   4.6      4.7         0.3 West   A
##  4  1999 arkans…     5     28    2651860   1.1      1.1         0.2 South  A
##  5  1999 califo…     6   1474   33499204   4.4      4.5         0.1 West   C
##  6  1999 colora…     8    164    4226018   3.9      3.7         0.3 West   C
##  7  1999 connec…     9    151    3386401   4.5      4.4         0.4 North… C
##  8  1999 delawa…    10     32     774990   4.1      4.1         0.7 South  D
##  9  1999 distri…    11     28     570213   4.9      4.9         0.9 South  D
## 10  1999 florida    12    402   15759421   2.6      2.6         0.1 South  F
## # ℹ 790 more rows
## # ℹ 1 more variable: division_name <chr>
```

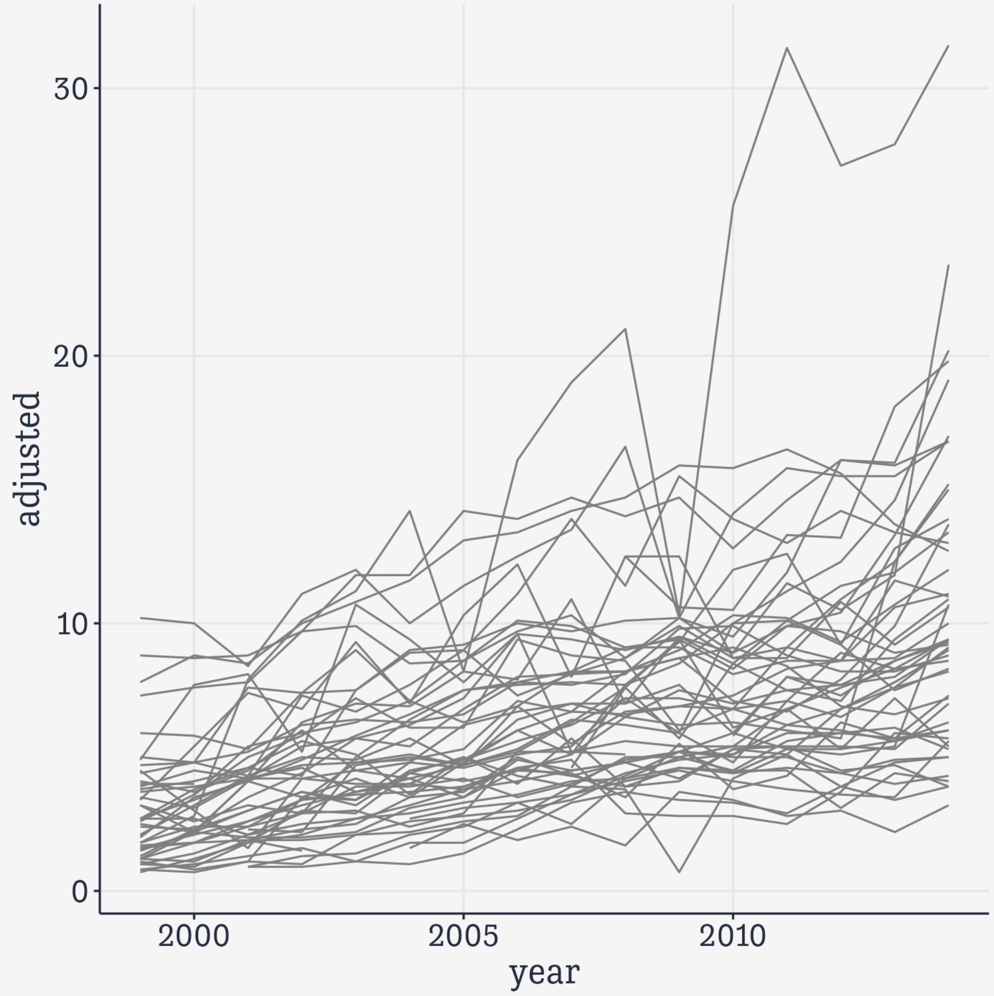
# Opiates Time Series plot

```
st_top <- opiates |>  filter(year == max(year), ab
  group_by(region) |>
  slice_max(order_by = adjusted, n = 2)

opiates |>
  ggplot(aes(x = year,
             y = adjusted))
```



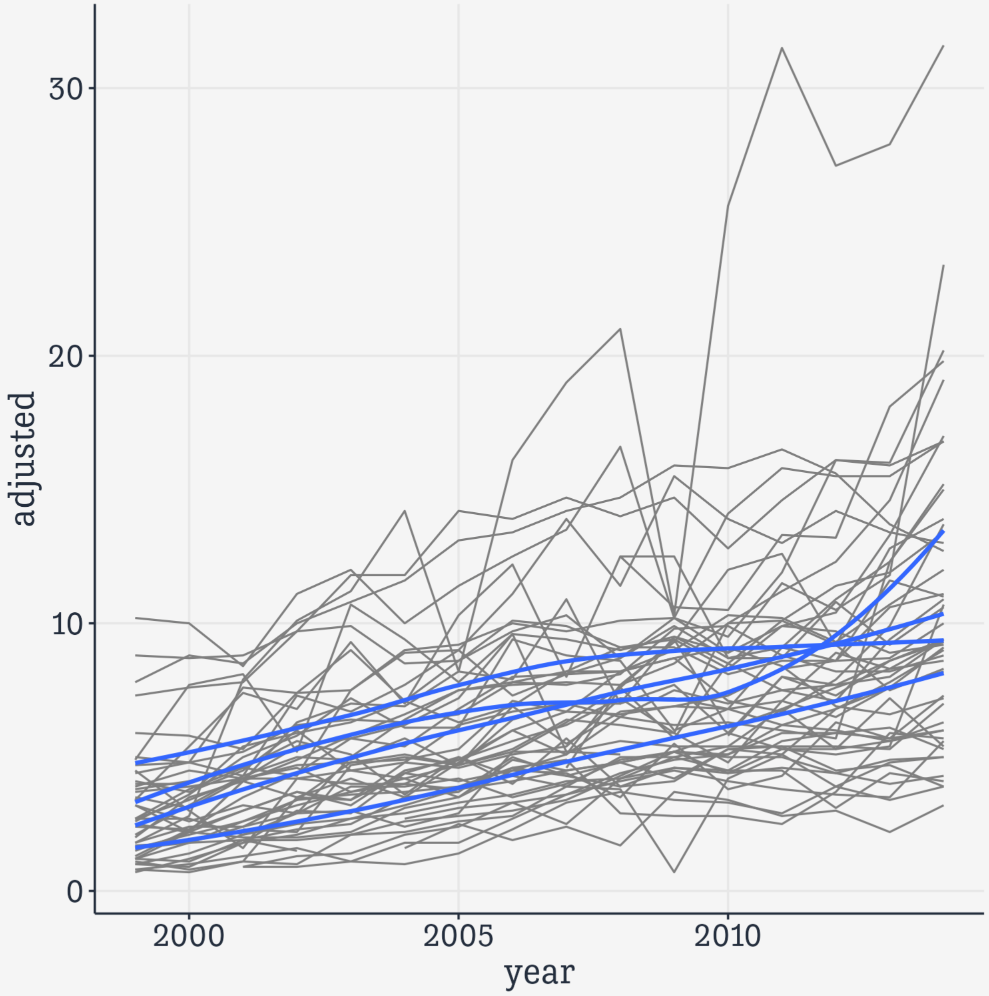
# Opiates Time Series plot

```
st_top <- opiates |> filter(year == max(year), ab
  group_by(region) |>
  slice_max(order_by = adjusted, n = 2)

opiates |>
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state),
            color = "gray50")
```



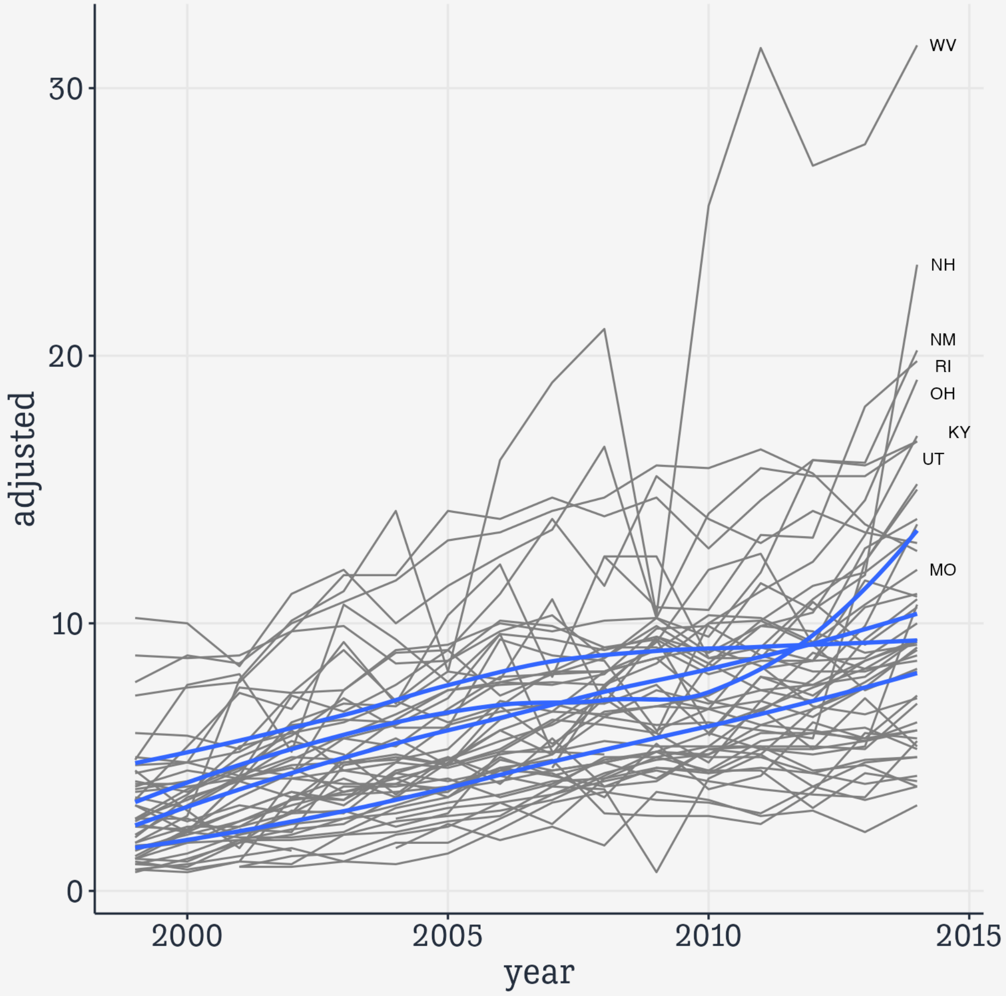
# Opiates Time Series plot

```r
st_top <- opiates |> filter(year == max(year), ab
  group_by(region) |>
  slice_max(order_by = adjusted, n = 2)

opiates |>
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state),
            color = "gray50") +
  geom_smooth(aes(group = region),
              se = FALSE)
```



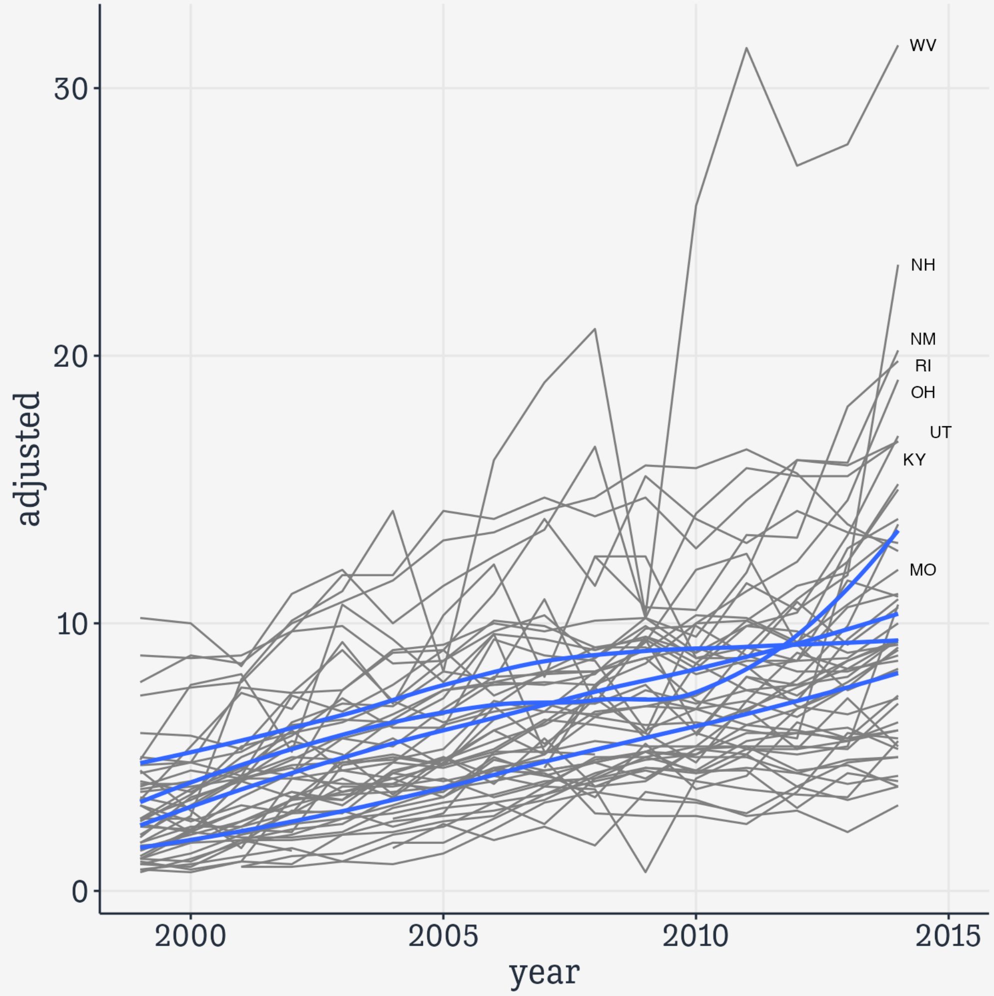
# Opiates Time Series plot

```
st_top <- opiates |>  filter(year == max(year), ab
  group_by(region) |>
  slice_max(order_by = adjusted, n = 2)

opiates |>
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state),
            color = "gray50") +
  geom_smooth(aes(group = region),
              se = FALSE) +
  ggrepel::geom_text_repel(
    data = st_top,
    mapping = aes(x = year,
                  y = adjusted,
                  label = abbr),
    size = 3,
    segment.color = NA,
    nudge_x = 0.5)
```



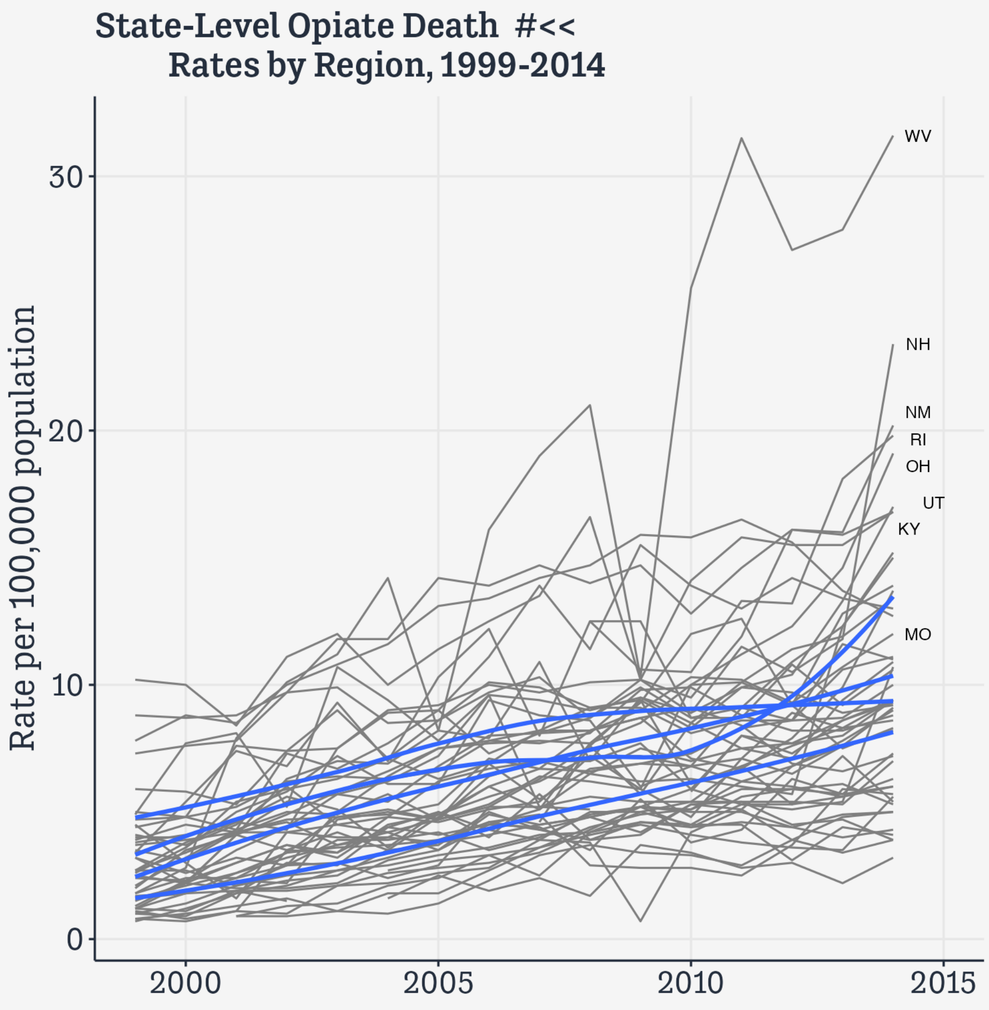
# Opiates Time Series plot

```r
st_top <- opiates |>  filter(year == max(year), ab
  group_by(region) |>
  slice_max(order_by = adjusted, n = 2)

opiates |>
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state),
            color = "gray50") +
  geom_smooth(aes(group = region),
              se = FALSE) +
  ggrepel::geom_text_repel(
    data = st_top,
    mapping = aes(x = year,
                  y = adjusted,
                  label = abbr),
    size = 3,
    segment.color = NA,
    nudge_x = 0.5) +
  coord_cartesian(c(min(opiates$year),
                    max(opiates$year) + 1))
```



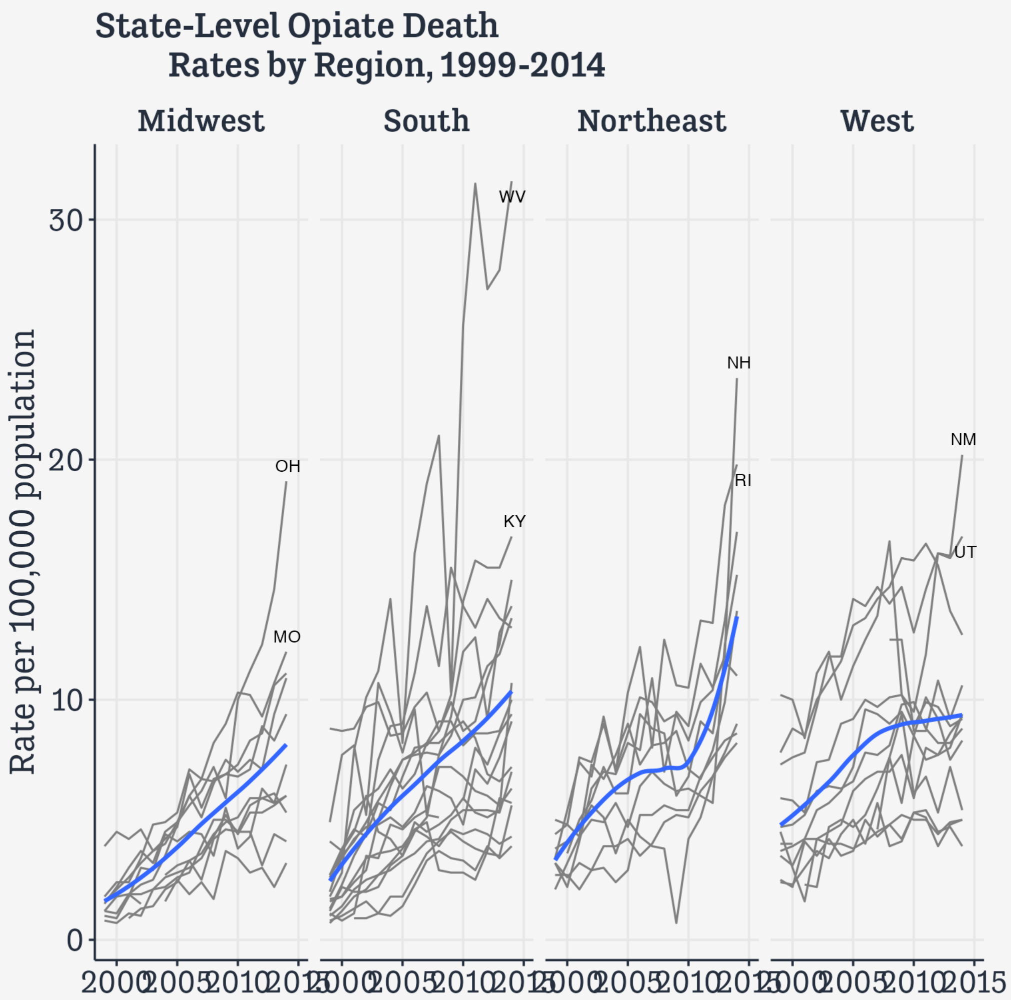
# Opiates Time Series plot

```r
st_top <- opiates |> filter(year == max(year), ab
  group_by(region) |>
  slice_max(order_by = adjusted, n = 2)

opiates |>
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state),
            color = "gray50") +
  geom_smooth(aes(group = region),
              se = FALSE) +
  ggrepel::geom_text_repel(
    data = st_top,
    mapping = aes(x = year,
                  y = adjusted,
                  label = abbr),
    size = 3,
    segment.color = NA,
    nudge_x = 0.5) +
  coord_cartesian(c(min(opiates$year),
                    max(opiates$year) + 1)) +
  labs(x = NULL,
       y = "Rate per 100,000 population",
       title = "State-Level Opiate Death
          Rates by Region, 1999-2014")
```



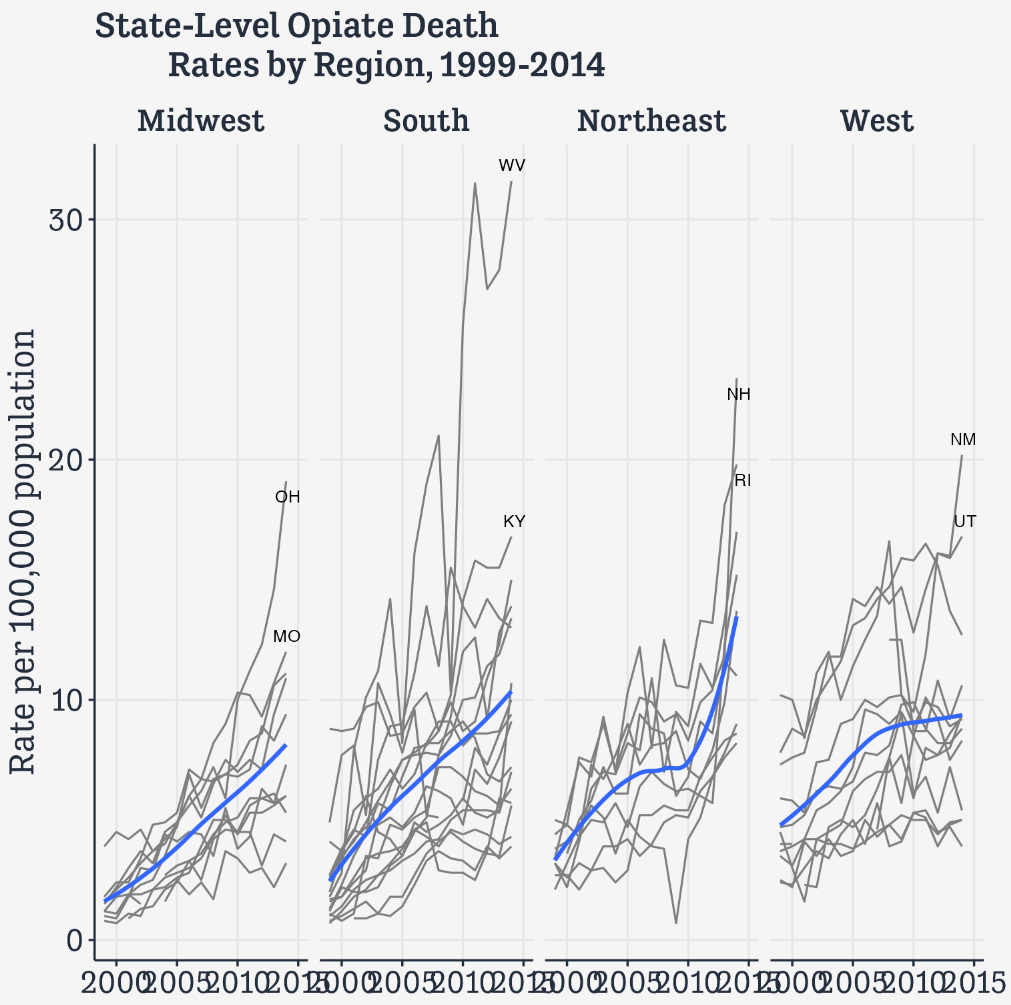
# Opiates Time Series plot

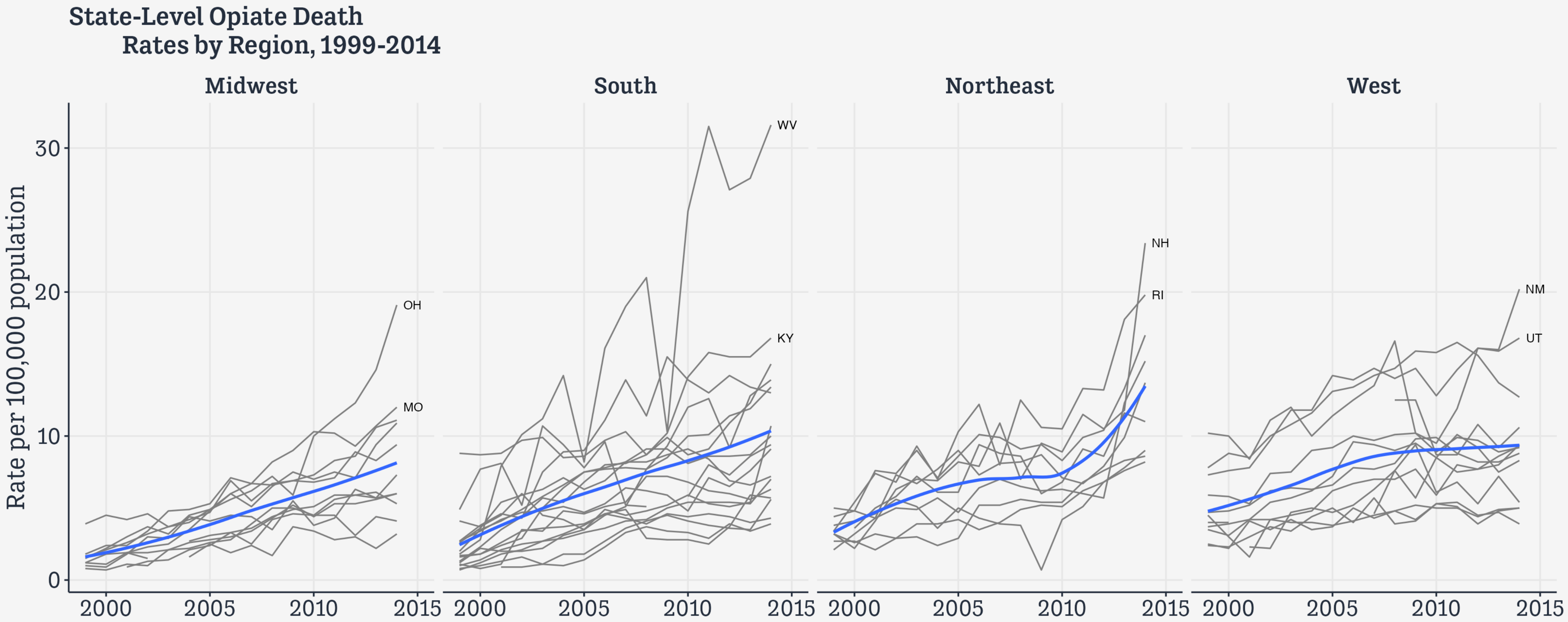
```
st_top <- opiates |> filter(year == max(year), ab
  group_by(region) |>
  slice_max(order_by = adjusted, n = 2)

opiates |>
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state),
            color = "gray50") +
  geom_smooth(aes(group = region),
              se = FALSE) +
  ggrepel::geom_text_repel(
    data = st_top,
    mapping = aes(x = year,
                  y = adjusted,
                  label = abbr),
    size = 3,
    segment.color = NA,
    nudge_x = 0.5) +
  coord_cartesian(c(min(opiates$year),
                    max(opiates$year) + 1)) +
  labs(x = NULL,
       y = "Rate per 100,000 population",
       title = "State-Level Opiate Death
          Rates by Region, 1999-2014") +
  facet_wrap(~ reorder(region, adjusted,
                       na.rm = TRUE),
             nrow  = 1)
```



# Opiates Time Series plot

```r
st_top <- opiates |> filter(year == max(year), ab
  group_by(region) |>
  slice_max(order_by = adjusted, n = 2)

opiates |>
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state),
            color = "gray50") +
  geom_smooth(aes(group = region),
              se = FALSE) +
  ggrepel::geom_text_repel(
    data = st_top,
    mapping = aes(x = year,
                  y = adjusted,
                  label = abbr),
    size = 3,
    segment.color = NA,
    nudge_x = 0.5) +
  coord_cartesian(c(min(opiates$year),
                    max(opiates$year) + 1)) +
  labs(x = NULL,
       y = "Rate per 100,000 population",
       title = "State-Level Opiate Death
          Rates by Region, 1999-2014") +
  facet_wrap(~ reorder(region, adjusted,
                       na.rm = TRUE),
             nrow  = 1)
```






Regional trends in opiate-related mortality.

# Simple Features

# `geom_polygon()` is limiting

It's very useful to have the intuition that, when drawing maps, we're just working with tables of x and y coordinates, and shapes represent quantities in our data, in a way that's essentially the same as any other geom. This makes it worth getting comfortable with what `geom_polygon()` and `coord_map()` are doing. But the business of having very large map tables and manually specifying projections is inefficient.

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It's very useful to have the intuition that, when drawing maps, we're just working with tables of x and y coordinates, and shapes represent quantities in our data, in a way that's essentially the same as any other geom. This makes it worth getting comfortable with what `geom_polygon()` and `coord_map()` are doing. But the business of having very large map tables and manually specifying projections is inefficient.

In addition, sometimes our data *really is* properly spatial, at which point we need a more rigorous and consistent way of specifying those elements. There's a whole world of Geodesic standards and methods devoted to specifying these things for GIS applications. R is not a dedicated GIS, but we can take advantage of these tools.

# `geom_polygon()` is limiting

It's very useful to have the intuition that, when drawing maps, we're just working with tables of x and y coordinates, and shapes represent quantities in our data, in a way that's essentially the same as any other geom. This makes it worth getting comfortable with what `geom_polygon()` and `coord_map()` are doing. But the business of having very large map tables and manually specifying projections is inefficient.

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## Enter simple features, the `sf` package, and `geom_sf()`

# The Simple Features package

When we load `sf` it creates a way to use several standard GIS concepts and tools, such as the GEOS library for computational geometry, the PROJ software that transforms spatial coordinates from one reference system to another, as in map projections, and the Simple Features standard for specifying the elements of spatial attributes.

```
library(sf)
```

```
## Linking to GEOS 3.11.0, GDAL 3.5.3, PROJ 9.1.0; sf_use_s2() is TRUE
```

# The Simple Features package

When we load `sf` it creates a way to use several standard GIS concepts and tools, such as the GEOS library for computational geometry, the PROJ software that transforms spatial coordinates from one reference system to another, as in map projections, and the Simple Features standard for specifying the elements of spatial attributes.

```r
library(sf)
```

```
## Linking to GEOS 3.11.0, GDAL 3.5.3, PROJ 9.1.0; sf_use_s2() is TRUE
```

Let's see the main upshot for us as end-users.

# The nycdogs package

```r
library(nycdogs)
nyc_license
```

```
## # A tibble: 493,072 × 9
##    animal_name animal_gender animal_birth_year breed_rc         borough zip_code
##    <chr>       <chr>                     <dbl> <chr>            <chr>      <int>
##  1 Paige       F                          2014 Pit Bull (or Mi… Manhat…    10035
##  2 Yogi        M                          2010 Boxer            Bronx      10465
##  3 Ali         M                          2014 Basenji          Manhat…    10013
##  4 Queen       F                          2013 Akita Crossbreed Manhat…    10013
##  5 Lola        F                          2009 Maltese          Manhat…    10028
##  6 Ian         M                          2006 Unknown          Manhat…    10013
##  7 Buddy       M                          2008 Unknown          Manhat…    10025
##  8 Chewbacca   F                          2012 Labrador (or Cr… Manhat…    10013
##  9 Heidi-Bo    F                          2007 Dachshund Smoot… Brookl…    11215
## 10 Massimo     M                          2009 Bull Dog, French Brookl…    11201
## # ℹ 493,062 more rows
## # ℹ 3 more variables: license_issued_date <date>, license_expired_date <date>,
## #   extract_year <dbl>
```

# The nycdogs package

The metadata tells you this is not a regular tibble.

```
nyc_zips
```

```
## Simple feature collection with 262 features and 11 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -74.25576 ymin: 40.49584 xmax: -73.6996 ymax: 40.91517
## Geodetic CRS:  WGS 84
## # A tibble: 262 × 12
##    objectid zip_code po_name     state borough st_fips cty_fips bld_gpostal_code
##       <int>    <int> <chr>       <chr> <chr>   <chr>   <chr>               <int>
##  1        1    11372 Jackson He… NY    Queens  36      081                     0
##  2        2    11004 Glen Oaks   NY    Queens  36      081                     0
##  3        3    11040 New Hyde P… NY    Queens  36      081                     0
##  4        4    11426 Bellerose   NY    Queens  36      081                     0
##  5        5    11365 Fresh Mead… NY    Queens  36      081                     0
##  6        6    11373 Elmhurst    NY    Queens  36      081                     0
##  7        7    11001 Floral Park NY    Queens  36      081                     0
##  8        8    11375 Forest Hil… NY    Queens  36      081                     0
##  9        9    11427 Queens Vil… NY    Queens  36      081                     0
## 10       10    11374 Rego Park   NY    Queens  36      081                     0
## # ℹ 252 more rows
## # ℹ 4 more variables: shape_leng <dbl>, shape_area <dbl>, x_id <chr>,
## #   geometry <POLYGON [°]>
```

# The nycdogs package

```r
nyc_zips |>
  select(objectid:borough)
```

```
## Simple feature collection with 262 features and 5 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -74.25576 ymin: 40.49584 xmax: -73.6996 ymax: 40.91517
## Geodetic CRS:  WGS 84
## # A tibble: 262 × 6
##    objectid zip_code po_name         state borough                       geometry
##       <int>    <int> <chr>           <chr> <chr>                    <POLYGON [°]>
##  1        1    11372 Jackson Heights NY    Queens  ((-73.86942 40.74916, -73.89…
##  2        2    11004 Glen Oaks       NY    Queens  ((-73.71068 40.75004, -73.70…
##  3        3    11040 New Hyde Park   NY    Queens  ((-73.70098 40.7389, -73.703…
##  4        4    11426 Bellerose       NY    Queens  ((-73.7227 40.75373, -73.722…
##  5        5    11365 Fresh Meadows   NY    Queens  ((-73.81089 40.72717, -73.81…
##  6        6    11373 Elmhurst        NY    Queens  ((-73.88722 40.72753, -73.88…
##  7        7    11001 Floral Park     NY    Queens  ((-73.70098 40.7389, -73.699…
##  8        8    11375 Forest Hills    NY    Queens  ((-73.85625 40.73672, -73.85…
##  9        9    11427 Queens Village  NY    Queens  ((-73.74169 40.73682, -73.73…
## 10       10    11374 Rego Park       NY    Queens  ((-73.86451 40.73407, -73.85…
## # ℹ 252 more rows
```

The `polygon` column is a list of lat/lon points that, when joined, draw the outline of the zip code area. This is *much* more compact than a big table where every row is a single point.

# Let's make a summary table

# Let's make a summary table

```r
nyc_license
```

```
## # A tibble: 493,072 × 9
##    animal_name animal_gender animal_birth_year breed_rc          borough zip_
##    <chr>       <chr>                     <dbl> <chr>             <chr>      <
##  1 Paige       F                          2014 Pit Bull (or Mi… Manhat…    1
##  2 Yogi        M                          2010 Boxer             Bronx      1
##  3 Ali         M                          2014 Basenji           Manhat…    1
##  4 Queen       F                          2013 Akita Crossbreed Manhat…    1
##  5 Lola        F                          2009 Maltese           Manhat…    1
##  6 Ian         M                          2006 Unknown           Manhat…    1
##  7 Buddy       M                          2008 Unknown           Manhat…    1
##  8 Chewbacca   F                          2012 Labrador (or Cr… Manhat…    1
##  9 Heidi-Bo    F                          2007 Dachshund Smoot… Brookl…    1
## 10 Massimo     M                          2009 Bull Dog, French Brookl…    1
## # ℹ 493,062 more rows
## # ℹ 3 more variables: license_issued_date <date>, license_expired_date <date
## #   extract_year <dbl>
```

# Let's make a summary table

```r
nyc_license |>
  filter(extract_year == 2018)
```

```
## # A tibble: 117,371 × 9
##    animal_name animal_gender animal_birth_year breed_rc          borough zip_
##    <chr>       <chr>                     <dbl> <chr>             <chr>      <
##  1 Ali         M                          2014 Basenji           Manhat…     
##  2 Ian         M                          2006 Unknown           Manhat…     
##  3 Chewbacca   F                          2012 Labrador (or Cr… Manhat…     
##  4 Lola        F                          2006 Miniature Pinsc… Manhat…     
##  5 Lucy        F                          2014 Dachshund Smoot… Brookl…     
##  6 June        F                          2010 Cavalier King C… Brookl…     
##  7 Apple       M                          2013 Havanese          Manhat…     
##  8 Muneca      F                          2013 Beagle            Brookl…     
##  9 Benson      M                          2010 Boxer             Brookl…     
## 10 Bigs        M                          2004 Pit Bull (or Mi… Brookl…     
## # ℹ 117,361 more rows
## # ℹ 3 more variables: license_issued_date <date>, license_expired_date <date
## #   extract_year <dbl>
```

# Let's make a summary table

```r
nyc_license |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code)
```

```
## # A tibble: 117,371 × 9
## # Groups:   breed_rc, zip_code [18,945]
##    animal_name animal_gender animal_birth_year breed_rc           borough zip_
##    <chr>       <chr>                     <dbl> <chr>              <chr>      <
##  1 Ali         M                          2014 Basenji            Manhat…
##  2 Ian         M                          2006 Unknown            Manhat…
##  3 Chewbacca   F                          2012 Labrador (or Cr… Manhat…
##  4 Lola        F                          2006 Miniature Pinsc… Manhat…
##  5 Lucy        F                          2014 Dachshund Smoot… Brookl…
##  6 June        F                          2010 Cavalier King C… Brookl…
##  7 Apple       M                          2013 Havanese           Manhat…
##  8 Muneca      F                          2013 Beagle             Brookl…
##  9 Benson      M                          2010 Boxer              Brookl…
## 10 Bigs        M                          2004 Pit Bull (or Mi… Brookl…
## # ℹ 117,361 more rows
## # ℹ 3 more variables: license_issued_date <date>, license_expired_date <dat
## #   extract_year <dbl>
```

# Let's make a summary table

```r
nyc_license |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally()
```

```
## # A tibble: 18,945 × 3
## # Groups:   breed_rc [311]
##    breed_rc      zip_code     n
##    <chr>            <int> <int>
##  1 Affenpinscher    10005     1
##  2 Affenpinscher    10011     1
##  3 Affenpinscher    10013     1
##  4 Affenpinscher    10014     1
##  5 Affenpinscher    10016     1
##  6 Affenpinscher    10017     1
##  7 Affenpinscher    10018     1
##  8 Affenpinscher    10019     1
##  9 Affenpinscher    10021     1
## 10 Affenpinscher    10023     1
## # ℹ 18,935 more rows
```

# Let's make a summary table

```r
nyc_license |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally() |>
  mutate(freq = n / sum(n))
```

```
## # A tibble: 18,945 × 4
## # Groups:   breed_rc [311]
##    breed_rc      zip_code     n   freq
##    <chr>            <int> <int>  <dbl>
##  1 Affenpinscher    10005     1 0.0303
##  2 Affenpinscher    10011     1 0.0303
##  3 Affenpinscher    10013     1 0.0303
##  4 Affenpinscher    10014     1 0.0303
##  5 Affenpinscher    10016     1 0.0303
##  6 Affenpinscher    10017     1 0.0303
##  7 Affenpinscher    10018     1 0.0303
##  8 Affenpinscher    10019     1 0.0303
##  9 Affenpinscher    10021     1 0.0303
## 10 Affenpinscher    10023     1 0.0303
## # ℹ 18,935 more rows
```

# Let's make a summary table

```r
nyc_license |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally() |>
  mutate(freq = n / sum(n)) |>
  filter(breed_rc == "French Bulldog")
```

```
## # A tibble: 161 × 4
## # Groups:   breed_rc [1]
##    breed_rc       zip_code     n    freq
##    <chr>             <int> <int>   <dbl>
##  1 French Bulldog    10001    27 0.0167
##  2 French Bulldog    10002    20 0.0123
##  3 French Bulldog    10003    36 0.0222
##  4 French Bulldog    10004     9 0.00555
##  5 French Bulldog    10005    15 0.00925
##  6 French Bulldog    10006     8 0.00494
##  7 French Bulldog    10007    17 0.0105
##  8 French Bulldog    10009    51 0.0315
##  9 French Bulldog    10010    31 0.0191
## 10 French Bulldog    10011    88 0.0543
## # ℹ 151 more rows
```

# Let's make a summary table

```r
nyc_license |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally() |>
  mutate(freq = n / sum(n)) |>
  filter(breed_rc == "French Bulldog") ->
  nyc_fb
```

# Let's make a summary table

```
nyc_license |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally() |>
  mutate(freq = n / sum(n)) |>
  filter(breed_rc == "French Bulldog") ->
  nyc_fb
```

# Now we have two tables again

```r
nyc_zips ▷ select(objectid:st_fips)
```

```
## Simple feature collection with 262 features and 6 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -74.25576 ymin: 40.49584 xmax: -73.6996 ymax: 40.91517
## Geodetic CRS:  WGS 84
## # A tibble: 262 × 7
##    objectid zip_code po_name      state borough st_fips                  geometry
##       <int>    <int> <chr>        <chr> <chr>   <chr>               <POLYGON [°]>
##  1        1    11372 Jackson He… NY    Queens  36      ((-73.86942 40.74916, -7…
##  2        2    11004 Glen Oaks   NY    Queens  36      ((-73.71068 40.75004, -7…
##  3        3    11040 New Hyde P… NY    Queens  36      ((-73.70098 40.7389, -73…
##  4        4    11426 Bellerose   NY    Queens  36      ((-73.7227 40.75373, -73…
##  5        5    11365 Fresh Mead… NY    Queens  36      ((-73.81089 40.72717, -7…
##  6        6    11373 Elmhurst    NY    Queens  36      ((-73.88722 40.72753, -7…
##  7        7    11001 Floral Park NY    Queens  36      ((-73.70098 40.7389, -73…
##  8        8    11375 Forest Hil… NY    Queens  36      ((-73.85625 40.73672, -7…
##  9        9    11427 Queens Vil… NY    Queens  36      ((-73.74169 40.73682, -7…
## 10       10    11374 Rego Park   NY    Queens  36      ((-73.86451 40.73407, -7…
## # ℹ 252 more rows
```

# Now we have two tables again

```
nyc_zips ▷ select(objectid:st_fips)
```

```
## Simple feature collection with 262 features and 6 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -74.25576 ymin: 40.49584 xmax: -73.6996 ymax: 40.91517
## Geodetic CRS:  WGS 84
## # A tibble: 262 × 7
##    objectid zip_code po_name     state borough st_fips                  geometry
##       <int>    <int> <chr>       <chr> <chr>   <chr>               <POLYGON [°]>
##  1        1    11372 Jackson He… NY    Queens  36      ((-73.86942 40.74916, -7…
##  2        2    11004 Glen Oaks   NY    Queens  36      ((-73.71068 40.75004, -7…
##  3        3    11040 New Hyde P… NY    Queens  36      ((-73.70098 40.7389, -73…
##  4        4    11426 Bellerose   NY    Queens  36      ((-73.7227 40.75373, -73…
##  5        5    11365 Fresh Mead… NY    Queens  36      ((-73.81089 40.72717, -7…
##  6        6    11373 Elmhurst    NY    Queens  36      ((-73.88722 40.72753, -7…
##  7        7    11001 Floral Park NY    Queens  36      ((-73.70098 40.7389, -73…
##  8        8    11375 Forest Hil… NY    Queens  36      ((-73.85625 40.73672, -7…
##  9        9    11427 Queens Vil… NY    Queens  36      ((-73.74169 40.73682, -7…
## 10       10    11374 Rego Park   NY    Queens  36      ((-73.86451 40.73407, -7…
## # ℹ 252 more rows
```

```
nyc_fb ▷ select(breed_rc:n)
```

```
## # A tibble: 161 × 3
## # Groups:   breed_rc [1]
##    breed_rc       zip_code     n
##    <chr>             <int> <int>
##  1 French Bulldog    10001    27
##  2 French Bulldog    10002    20
##  3 French Bulldog    10003    36
##  4 French Bulldog    10004     9
##  5 French Bulldog    10005    15
##  6 French Bulldog    10006     8
##  7 French Bulldog    10007    17
##  8 French Bulldog    10009    51
##  9 French Bulldog    10010    31
## 10 French Bulldog    10011    88
## # ℹ 151 more rows
```

# Now we have two tables again

```r
nyc_zips |> select(objectid:st_fips)
```

```
## Simple feature collection with 262 features and 6 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -74.25576 ymin: 40.49584 xmax: -73.6996 ymax: 40.91517
## Geodetic CRS:  WGS 84
## # A tibble: 262 × 7
##    objectid zip_code po_name     state borough st_fips                  geometry
##       <int>    <int> <chr>       <chr> <chr>   <chr>               <POLYGON [°]>
##  1        1    11372 Jackson He… NY    Queens  36      ((-73.86942 40.74916, -7…
##  2        2    11004 Glen Oaks   NY    Queens  36      ((-73.71068 40.75004, -7…
##  3        3    11040 New Hyde P… NY    Queens  36      ((-73.70098 40.7389, -73…
##  4        4    11426 Bellerose   NY    Queens  36      ((-73.7227 40.75373, -73…
##  5        5    11365 Fresh Mead… NY    Queens  36      ((-73.81089 40.72717, -7…
##  6        6    11373 Elmhurst    NY    Queens  36      ((-73.88722 40.72753, -7…
##  7        7    11001 Floral Park NY    Queens  36      ((-73.70098 40.7389, -73…
##  8        8    11375 Forest Hil… NY    Queens  36      ((-73.85625 40.73672, -7…
##  9        9    11427 Queens Vil… NY    Queens  36      ((-73.74169 40.73682, -7…
## 10       10    11374 Rego Park   NY    Queens  36      ((-73.86451 40.73407, -7…
## # ℹ 252 more rows
```

```r
nyc_fb |> select(breed_rc:n)
```

```
## # A tibble: 161 × 3
## # Groups:   breed_rc [1]
##    breed_rc       zip_code     n
##    <chr>             <int> <int>
##  1 French Bulldog    10001    27
##  2 French Bulldog    10002    20
##  3 French Bulldog    10003    36
##  4 French Bulldog    10004     9
##  5 French Bulldog    10005    15
##  6 French Bulldog    10006     8
##  7 French Bulldog    10007    17
##  8 French Bulldog    10009    51
##  9 French Bulldog    10010    31
## 10 French Bulldog    10011    88
## # ℹ 151 more rows
```

Join them:

```r
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_code")
```

# Ready to map

```r
fb_map ▷ select(zip_code, po_name, borough, breed_rc:freq, geometry)
```

```
## Simple feature collection with 262 features and 6 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -74.25576 ymin: 40.49584 xmax: -73.6996 ymax: 40.91517
## Geodetic CRS:  WGS 84
## # A tibble: 262 × 7
##    zip_code po_name    borough breed_rc      n     freq                  geometry
##       <int> <chr>      <chr>   <chr>     <int>    <dbl>             <POLYGON [°]>
##  1    11372 Jackson H… Queens  French …     13  8.02e-3 ((-73.86942 40.74916, -7…
##  2    11004 Glen Oaks  Queens  French …      1  6.17e-4 ((-73.71068 40.75004, -7…
##  3    11040 New Hyde … Queens  <NA>         NA NA       ((-73.70098 40.7389, -73…
##  4    11426 Bellerose  Queens  French …      1  6.17e-4 ((-73.7227 40.75373, -73…
##  5    11365 Fresh Mea… Queens  French …      7  4.32e-3 ((-73.81089 40.72717, -7…
##  6    11373 Elmhurst   Queens  French …     14  8.64e-3 ((-73.88722 40.72753, -7…
##  7    11001 Floral Pa… Queens  <NA>         NA NA       ((-73.70098 40.7389, -73…
##  8    11375 Forest Hi… Queens  French …      8  4.94e-3 ((-73.85625 40.73672, -7…
##  9    11427 Queens Vi… Queens  French …      2  1.23e-3 ((-73.74169 40.73682, -7…
## 10    11374 Rego Park  Queens  French …      6  3.70e-3 ((-73.86451 40.73407, -7…
## # ℹ 252 more rows
```

# A NYC map theme

Just moving the legend, really.

```r
theme_nymap <- function(base_size=9, base_family="") {
    require(grid)
    theme_bw(base_size=base_size, base_family=base_family) %+replace%
        theme(axis.line=element_blank(),
              axis.text=element_blank(),
              axis.ticks=element_blank(),
              axis.title=element_blank(),
              panel.background=element_blank(),
              panel.border=element_blank(),
              panel.grid=element_blank(),
              panel.spacing=unit(0, "lines"),
              plot.background=element_blank(),
              legend.justification = c(0,0),
              legend.position = c(0.05, 0.58),
              legend.direction = "horizontal"
        )
}
```

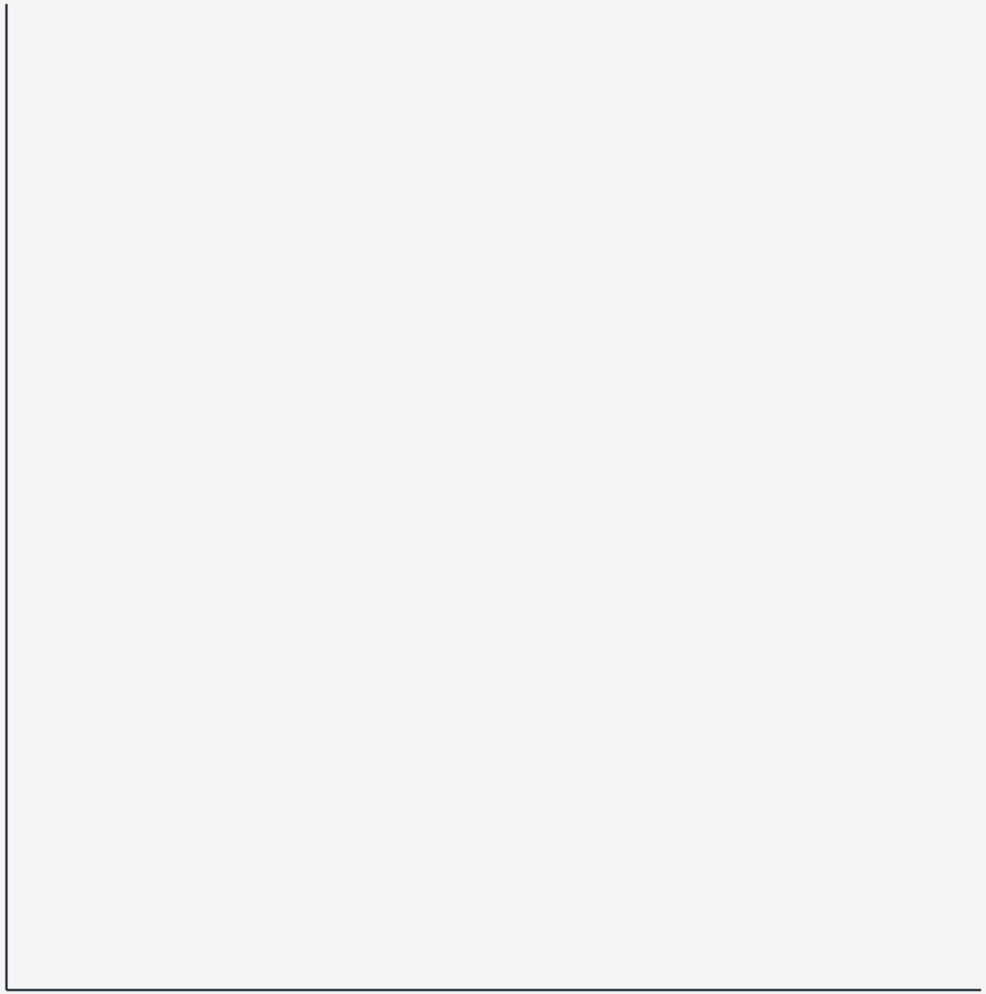
# First cut at a map

```r
fb_map
```

```
## Simple feature collection with 262 features and 14 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -74.25576 ymin: 40.49584 xmax: -73.6996 ymax: 40.91517
## Geodetic CRS:  WGS 84
## # A tibble: 262 × 15
##    objectid zip_code po_name      state borough st_fips cty_fips bld_gpostal_
##       <int>    <int> <chr>        <chr> <chr>   <chr>   <chr>                <
##  1        1    11372 Jackson He… NY    Queens  36      081
##  2        2    11004 Glen Oaks    NY    Queens  36      081
##  3        3    11040 New Hyde P…  NY    Queens  36      081
##  4        4    11426 Bellerose    NY    Queens  36      081
##  5        5    11365 Fresh Mead…  NY    Queens  36      081
##  6        6    11373 Elmhurst     NY    Queens  36      081
##  7        7    11001 Floral Park  NY    Queens  36      081
##  8        8    11375 Forest Hil…  NY    Queens  36      081
##  9        9    11427 Queens Vil…  NY    Queens  36      081
## 10       10    11374 Rego Park    NY    Queens  36      081
## # ℹ 252 more rows
## # ℹ 7 more variables: shape_leng <dbl>, shape_area <dbl>, x_id <chr>,
## #   geometry <POLYGON [°]>, breed_rc <chr>, n <int>, freq <dbl>
```

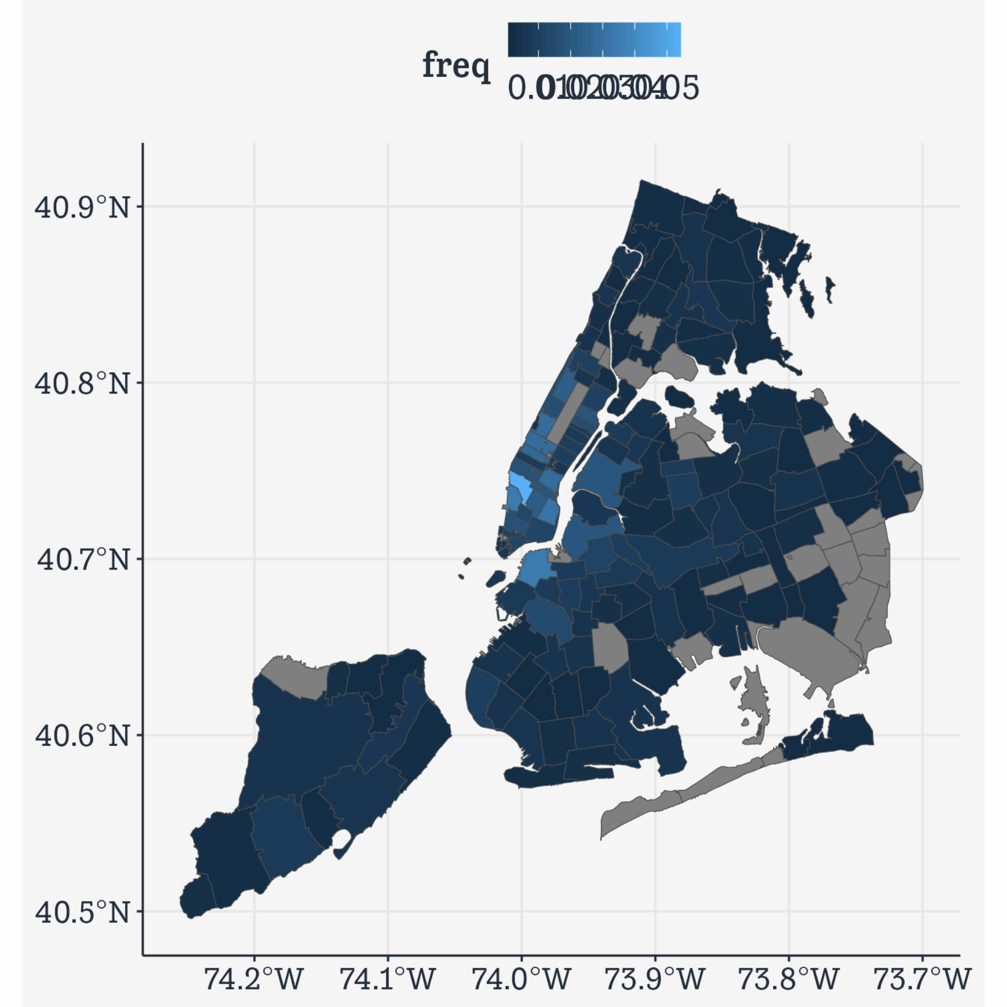
# First cut at a map

```r
fb_map %>%
    ggplot(mapping = aes(fill = freq))
```



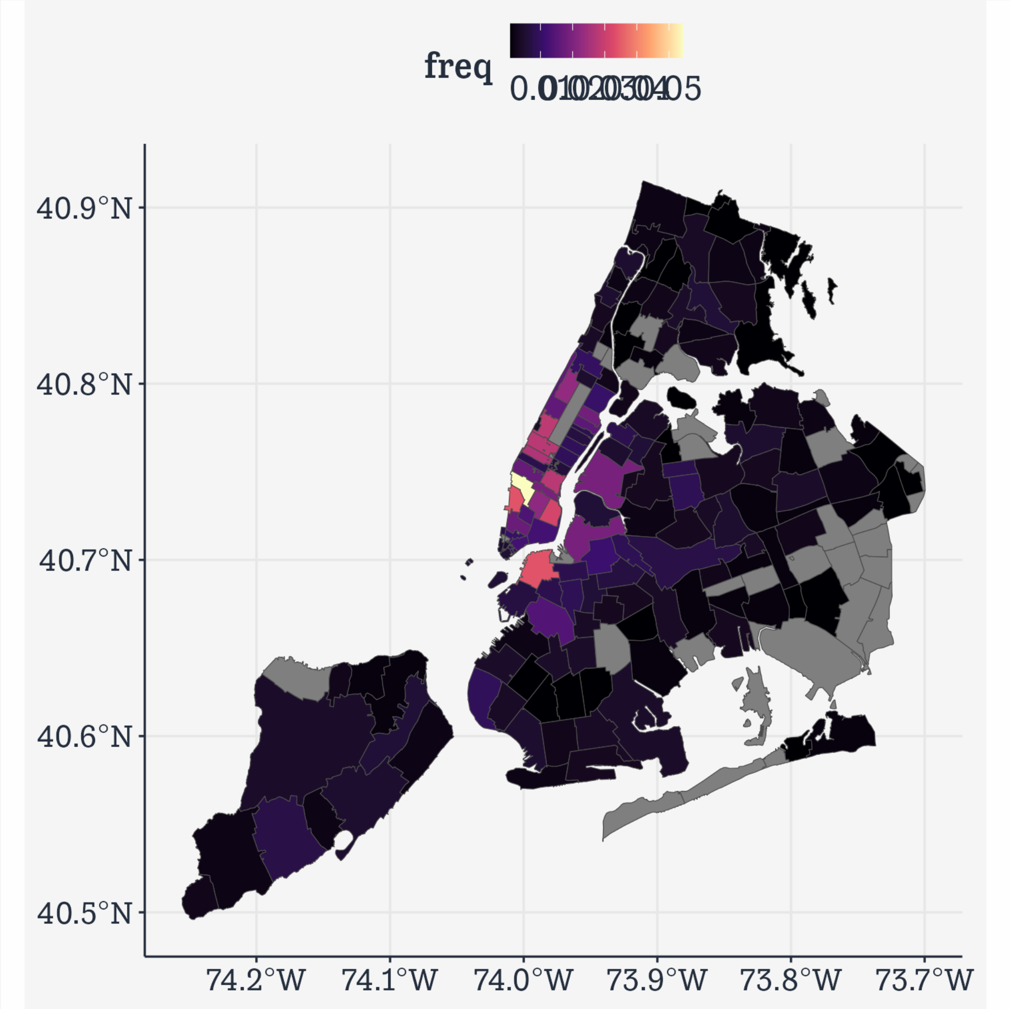
# First cut at a map

```
fb_map %>%
    ggplot(mapping = aes(fill = freq)) +
    geom_sf(color = "gray30", size = 0.1)   #<<
```



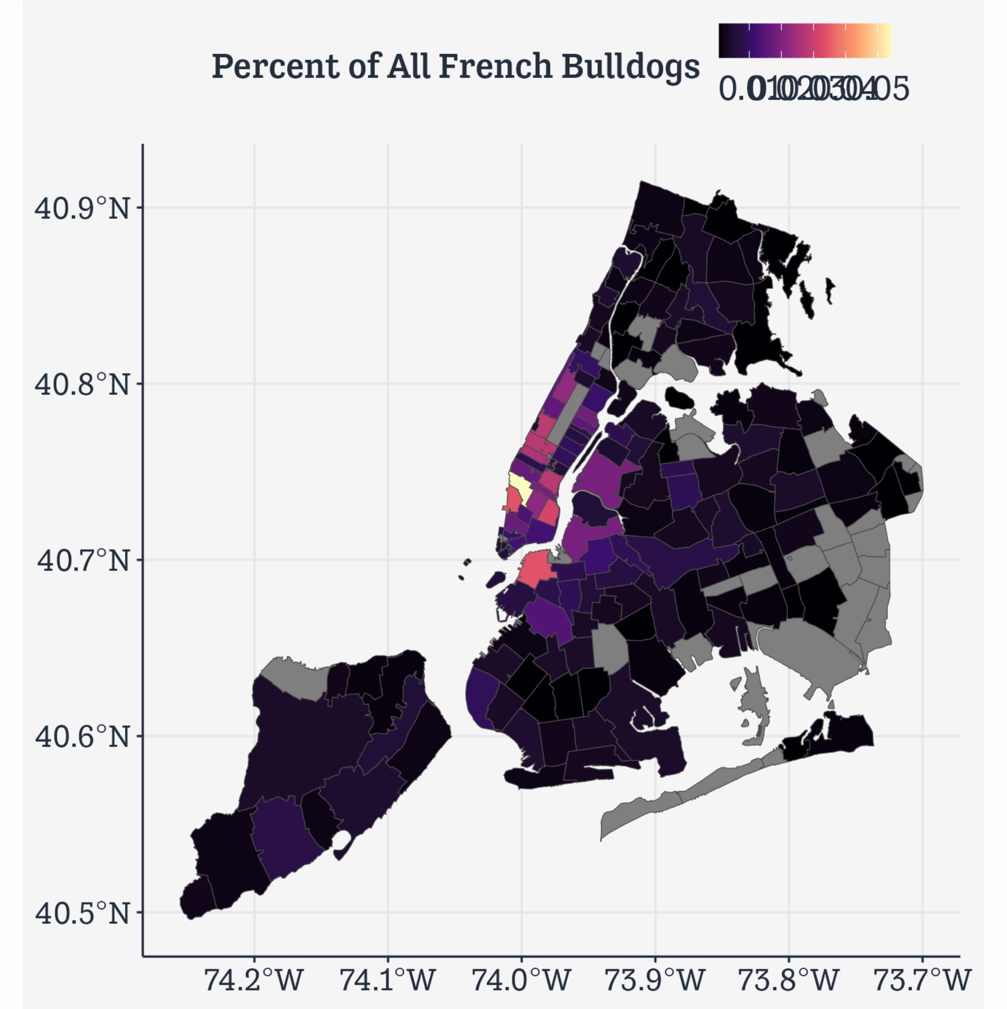
# First cut at a map

```r
fb_map %>%
    ggplot(mapping = aes(fill = freq)) +
    geom_sf(color = "gray30", size = 0.1) +
    scale_fill_viridis_c(option = "A")
```



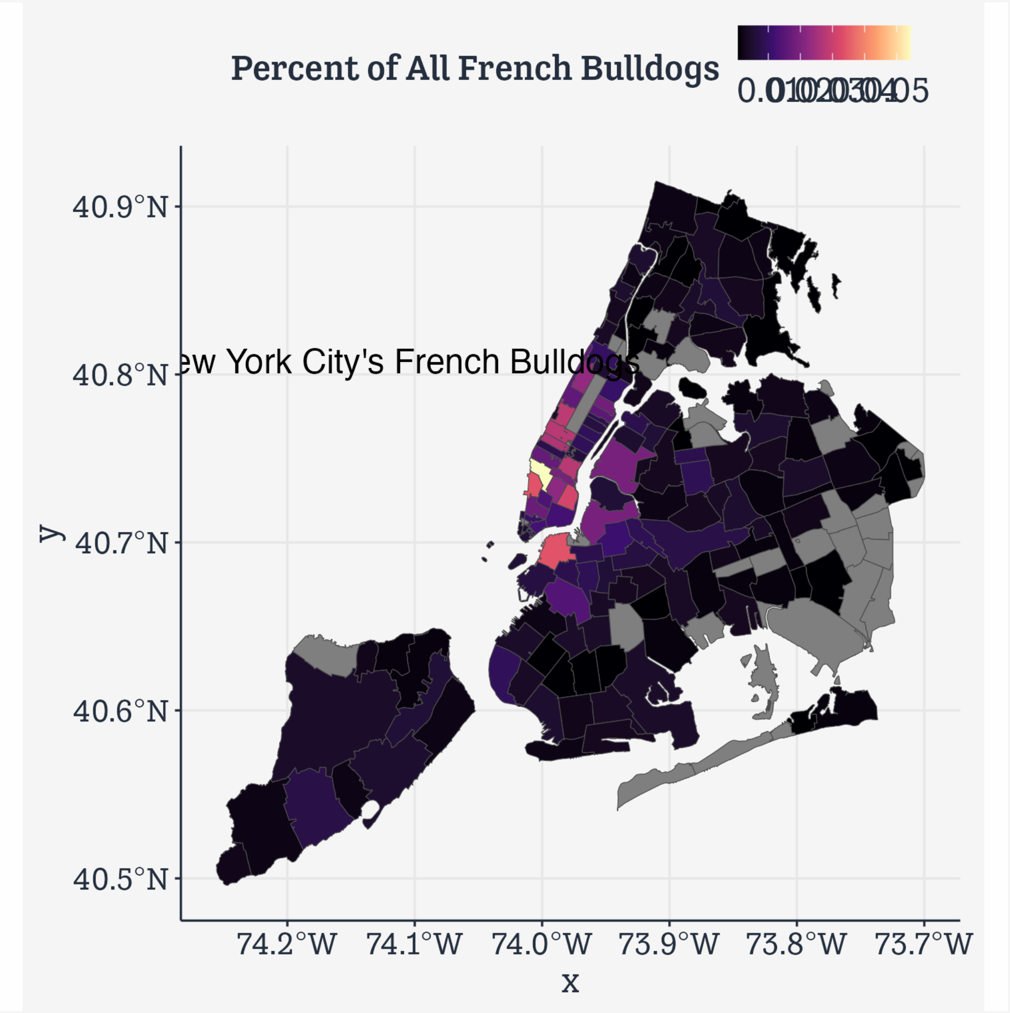
# First cut at a map

```r
fb_map %>%
    ggplot(mapping = aes(fill = freq)) +
    geom_sf(color = "gray30", size = 0.1) +
    scale_fill_viridis_c(option = "A") +
    labs(fill = "Percent of All French Bulldogs")
```



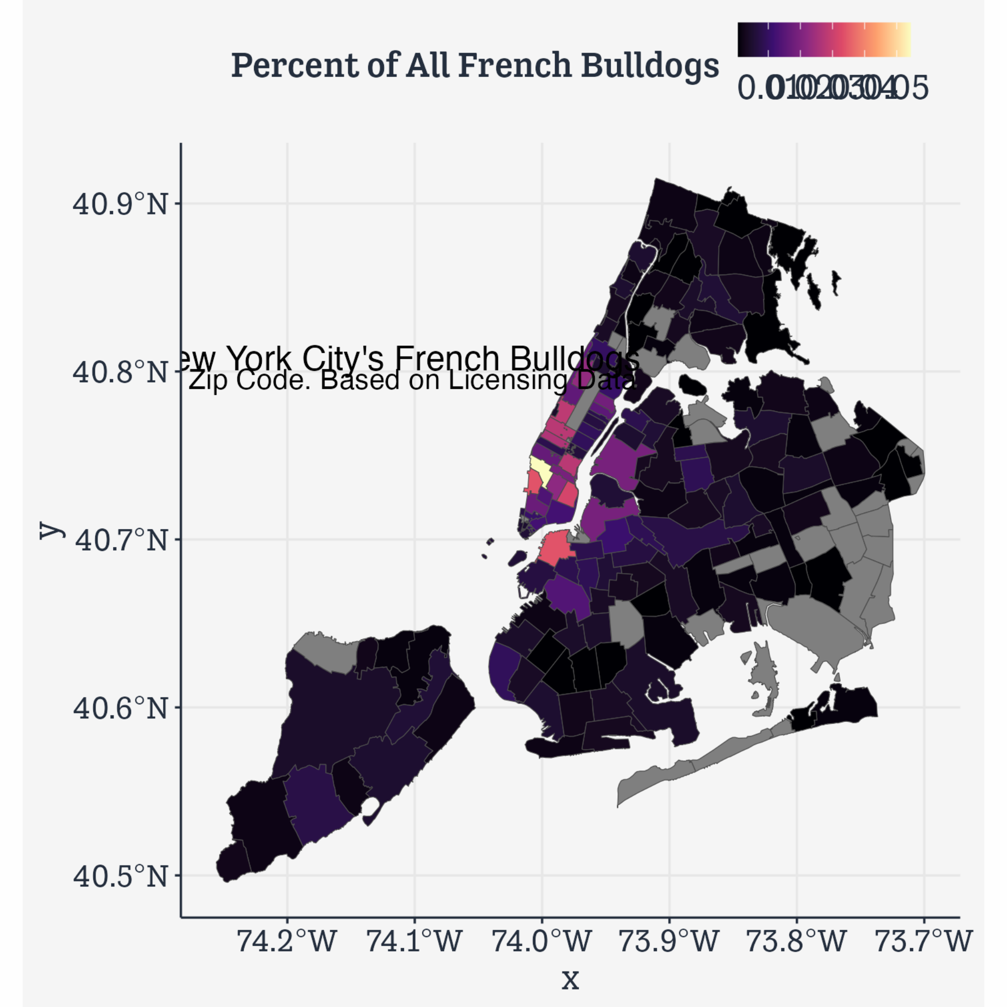
# First cut at a map

```r
fb_map %>%
    ggplot(mapping = aes(fill = freq)) +
    geom_sf(color = "gray30", size = 0.1) +
    scale_fill_viridis_c(option = "A") +
    labs(fill = "Percent of All French Bulldogs")
    annotate(geom = "text",
             x = -74.145 + 0.029,
             y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6)
```



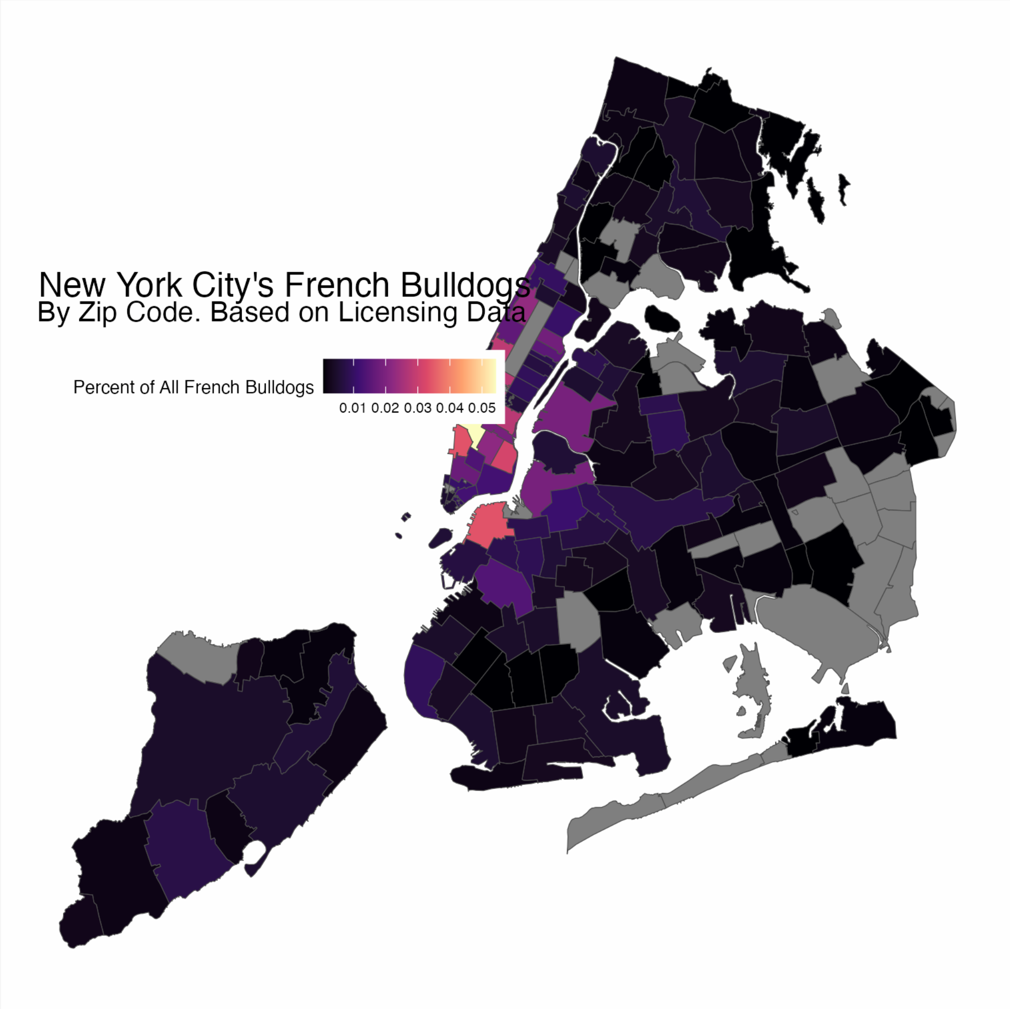
# First cut at a map

```
fb_map %>%
    ggplot(mapping = aes(fill = freq)) +
    geom_sf(color = "gray30", size = 0.1) +
    scale_fill_viridis_c(option = "A") +
    labs(fill = "Percent of All French Bulldogs") +
    annotate(geom = "text",
             x = -74.145 + 0.029,
             y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
    annotate(geom = "text",
             x = -74.1468 + 0.029,
             y = 40.8075-0.012,
           label = "By Zip Code. Based on Licensir
           size = 5)
```



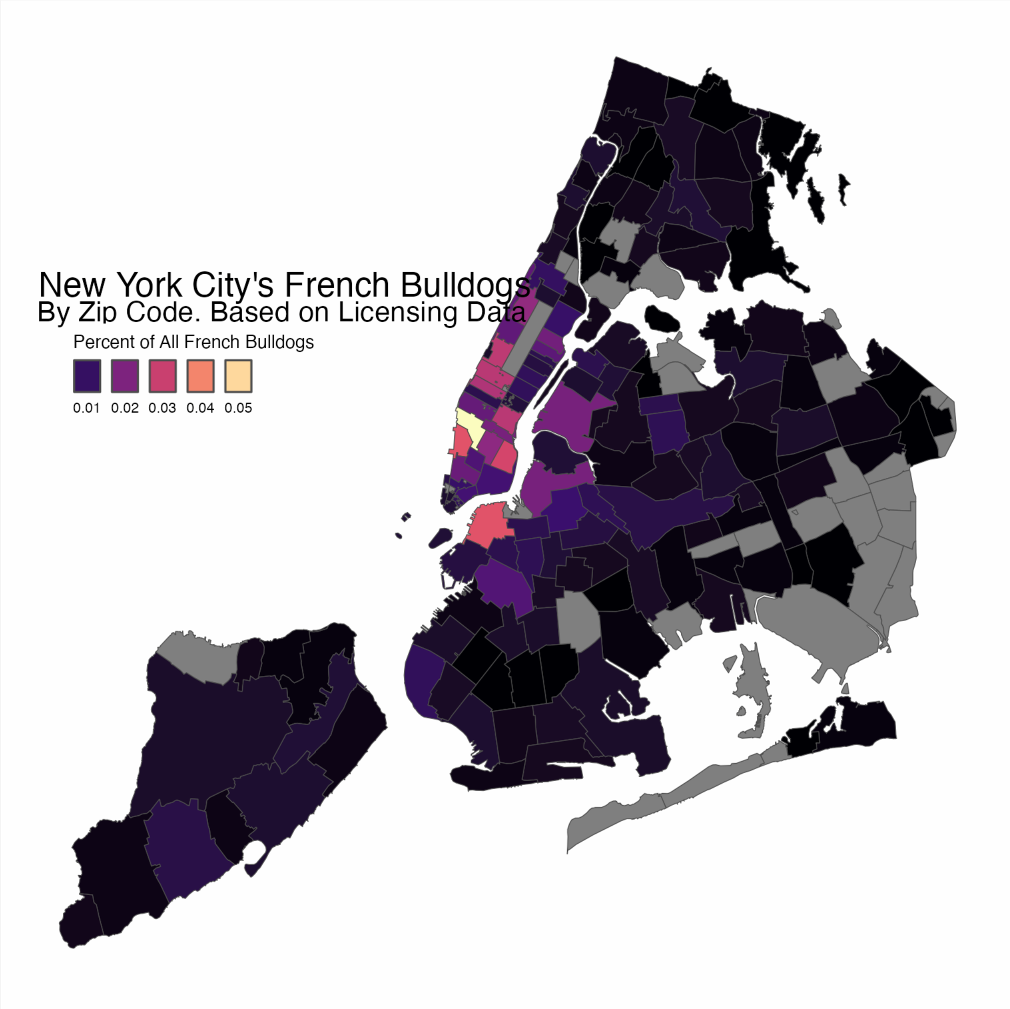
# First cut at a map

```
fb_map %>%
    ggplot(mapping = aes(fill = freq)) +
    geom_sf(color = "gray30", size = 0.1) +
    scale_fill_viridis_c(option = "A") +
    labs(fill = "Percent of All French Bulldogs")
    annotate(geom = "text",
             x = -74.145 + 0.029,
             y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
    annotate(geom = "text",
             x = -74.1468 + 0.029,
             y = 40.8075-0.012,
           label = "By Zip Code. Based on Licensir
           size = 5) +
    kjhslides::kjh_theme_nymap()
```



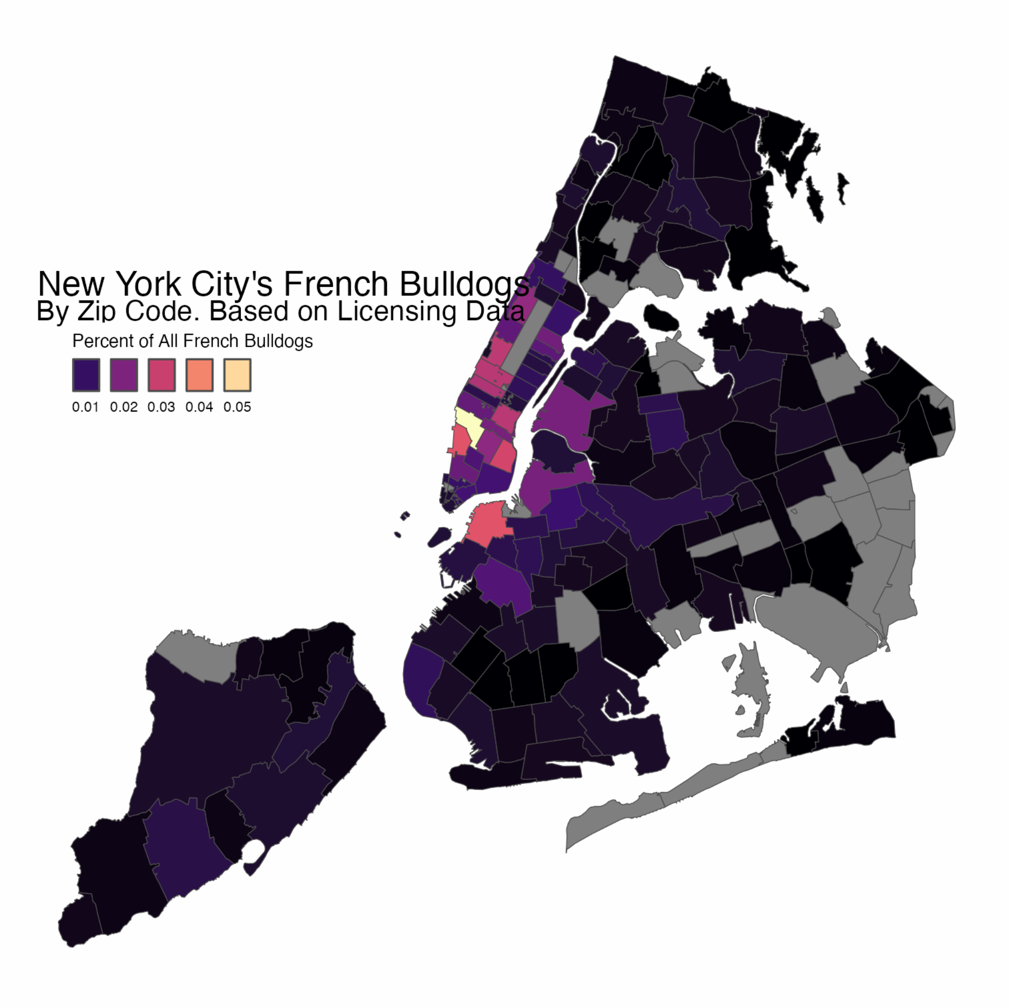
# First cut at a map

```r
fb_map %>%
    ggplot(mapping = aes(fill = freq)) +
    geom_sf(color = "gray30", size = 0.1) +
    scale_fill_viridis_c(option = "A") +
    labs(fill = "Percent of All French Bulldogs") +
    annotate(geom = "text",
             x = -74.145 + 0.029,
             y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
    annotate(geom = "text",
             x = -74.1468 + 0.029,
             y = 40.8075-0.012,
           label = "By Zip Code. Based on Licensir
           size = 5) +
    kjhslides::kjh_theme_nymap() +
   guides(fill =
           guide_legend(title.position = "top",
                label.position = "bottom",
                keywidth = 1,
                nrow = 1))
```



# First cut at a map

```
fb_map %>%
    ggplot(mapping = aes(fill = freq)) +
    geom_sf(color = "gray30", size = 0.1) +
    scale_fill_viridis_c(option = "A") +
    labs(fill = "Percent of All French Bulldogs")
    annotate(geom = "text",
             x = -74.145 + 0.029,
             y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
    annotate(geom = "text",
             x = -74.1468 + 0.029,
             y = 40.8075-0.012,
           label = "By Zip Code. Based on Licensin
           size = 5) +
    kjhslides::kjh_theme_nymap() +
   guides(fill =
           guide_legend(title.position = "top",
                label.position = "bottom",
                keywidth = 1,
                nrow = 1))
```



# Use a different palette

```r
library(colorspace)
```

# Use a different palette

```
library(colorspace)
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_co
```

# Use a different palette

```r
library(colorspace)
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_co

fb_map
```

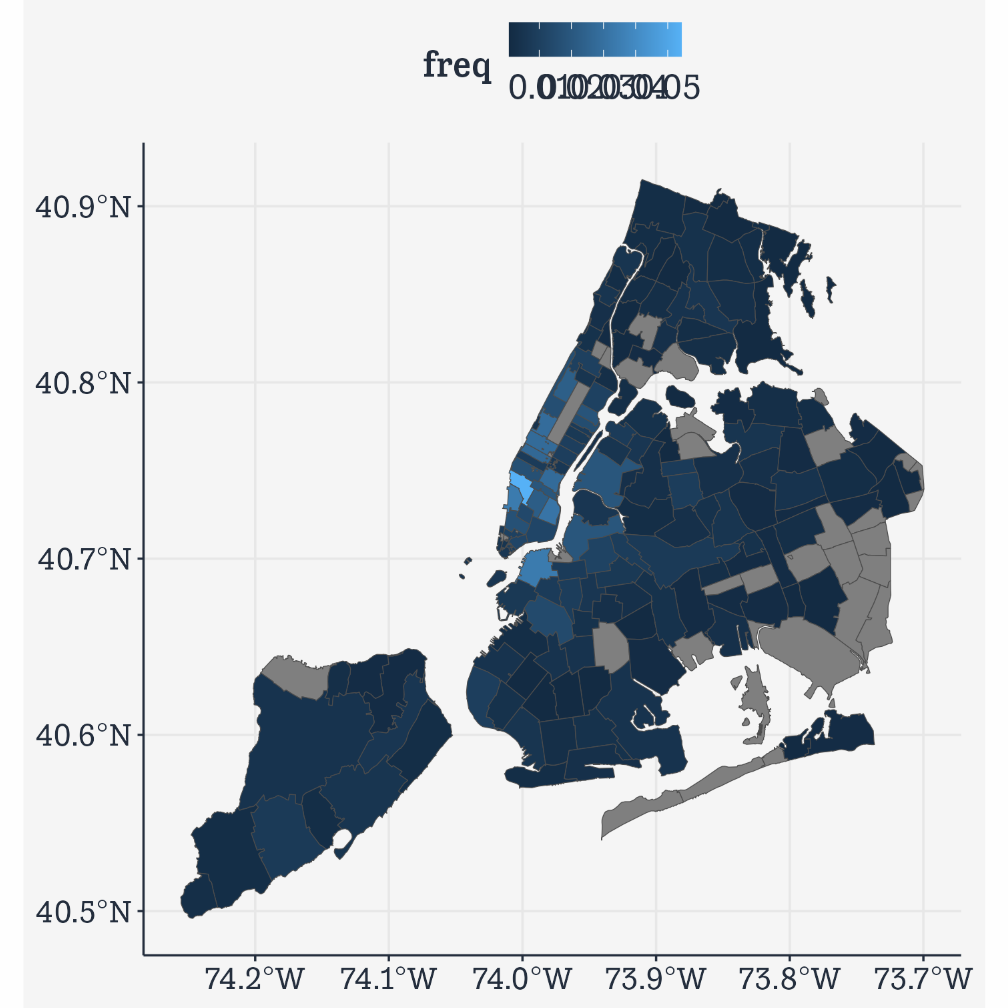
```
## Simple feature collection with 262 features and 14 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -74.25576 ymin: 40.49584 xmax: -73.6996 ymax: 40.91517
## Geodetic CRS:  WGS 84
## # A tibble: 262 × 15
##    objectid zip_code po_name      state borough st_fips cty_fips bld_gpostal_
##       <int>    <int> <chr>        <chr> <chr>   <chr>   <chr>               <
##  1        1    11372 Jackson He… NY    Queens  36      081
##  2        2    11004 Glen Oaks   NY    Queens  36      081
##  3        3    11040 New Hyde P… NY    Queens  36      081
##  4        4    11426 Bellerose   NY    Queens  36      081
##  5        5    11365 Fresh Mead… NY    Queens  36      081
##  6        6    11373 Elmhurst    NY    Queens  36      081
##  7        7    11001 Floral Park NY    Queens  36      081
##  8        8    11375 Forest Hil… NY    Queens  36      081
##  9        9    11427 Queens Vil… NY    Queens  36      081
## 10       10    11374 Rego Park   NY    Queens  36      081
## # ℹ 252 more rows
## # ℹ 7 more variables: shape_leng <dbl>, shape_area <dbl>, x_id <chr>,
## #   geometry <POLYGON [°]>, breed_rc <chr>, n <int>, freq <dbl>
```

# Use a different palette

```
library(colorspace)
fb_map ← left_join(nyc_zips, nyc_fb, by = "zip_c

fb_map ▷
  ggplot(mapping = aes(fill = freq))
```

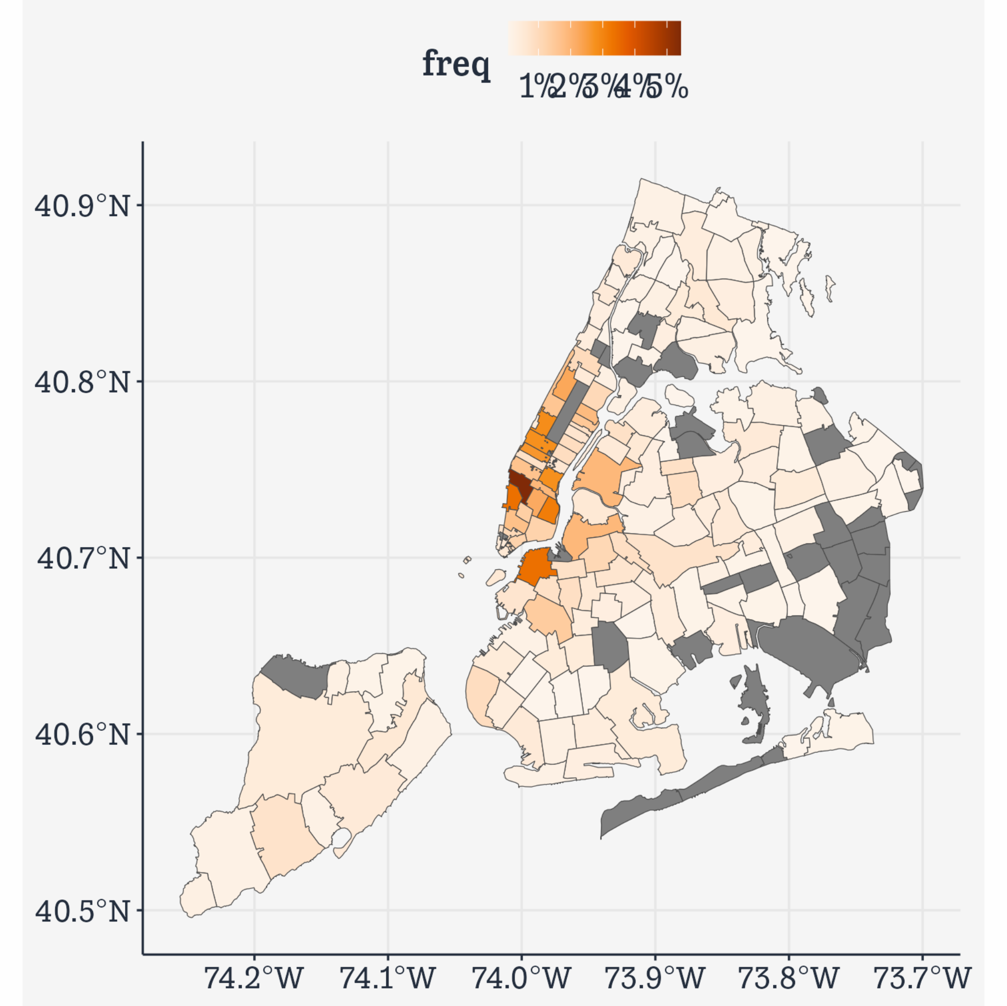
# Use a different palette

```
library(colorspace)
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_co

fb_map |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1)
```



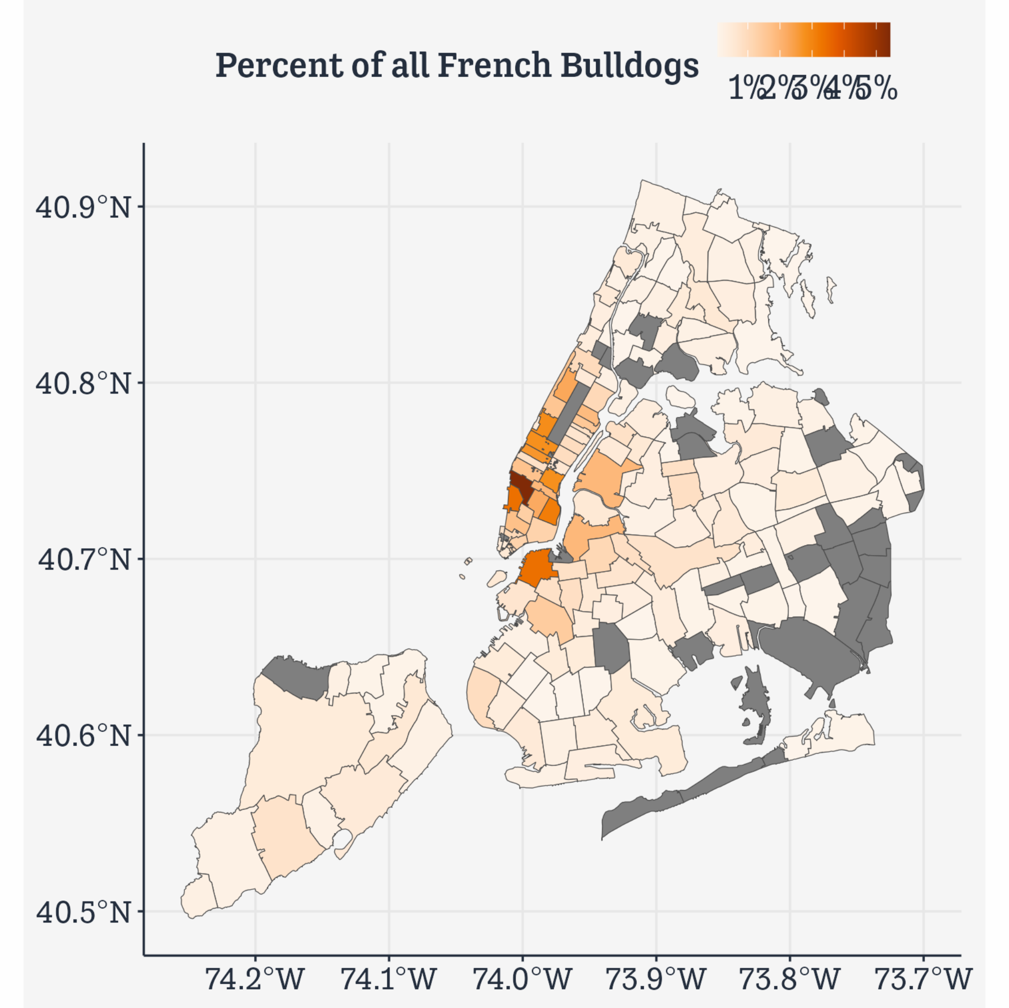
# Use a different palette

```
library(colorspace)
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_co

fb_map |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent())
```



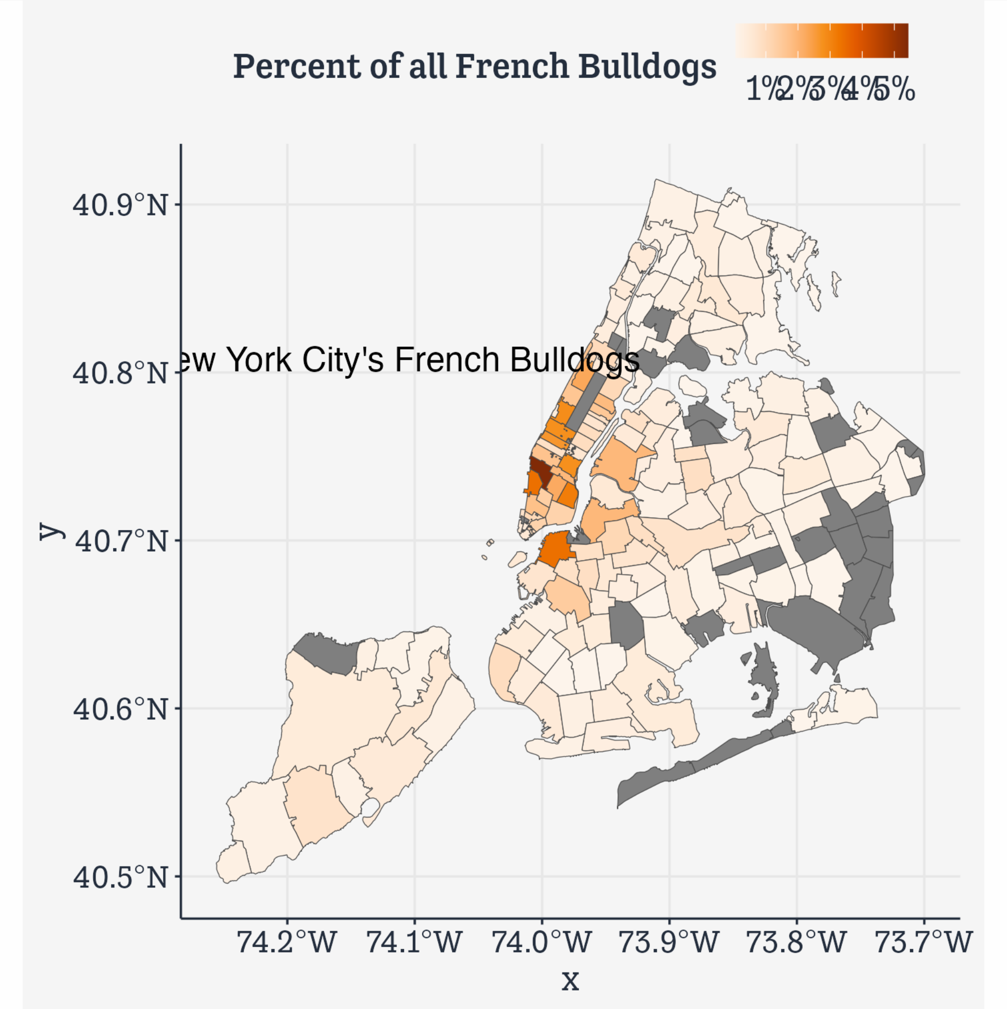
# Use a different palette

```r
library(colorspace)
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_cc

fb_map |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs")
```



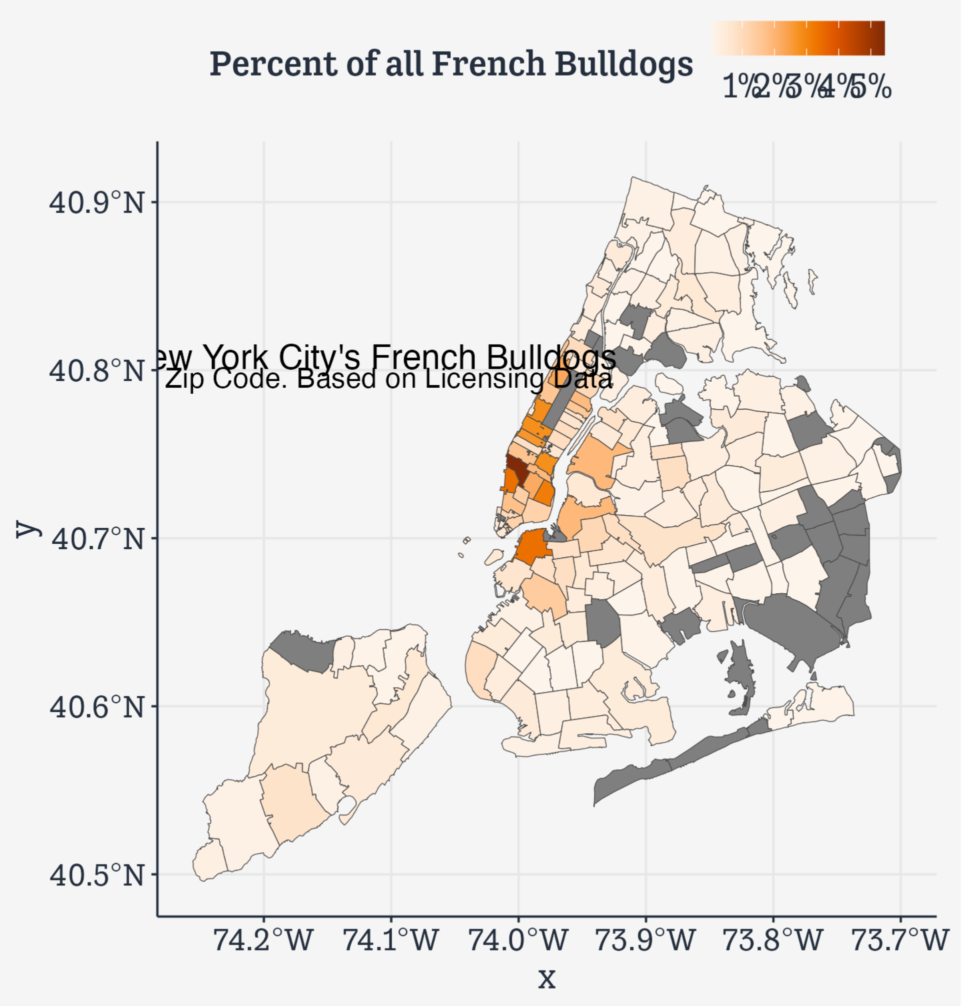
# Use a different palette

```r
library(colorspace)
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_co

fb_map |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs") +
  annotate(geom = "text",
           x = -74.145 + 0.029,
           y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6)
```



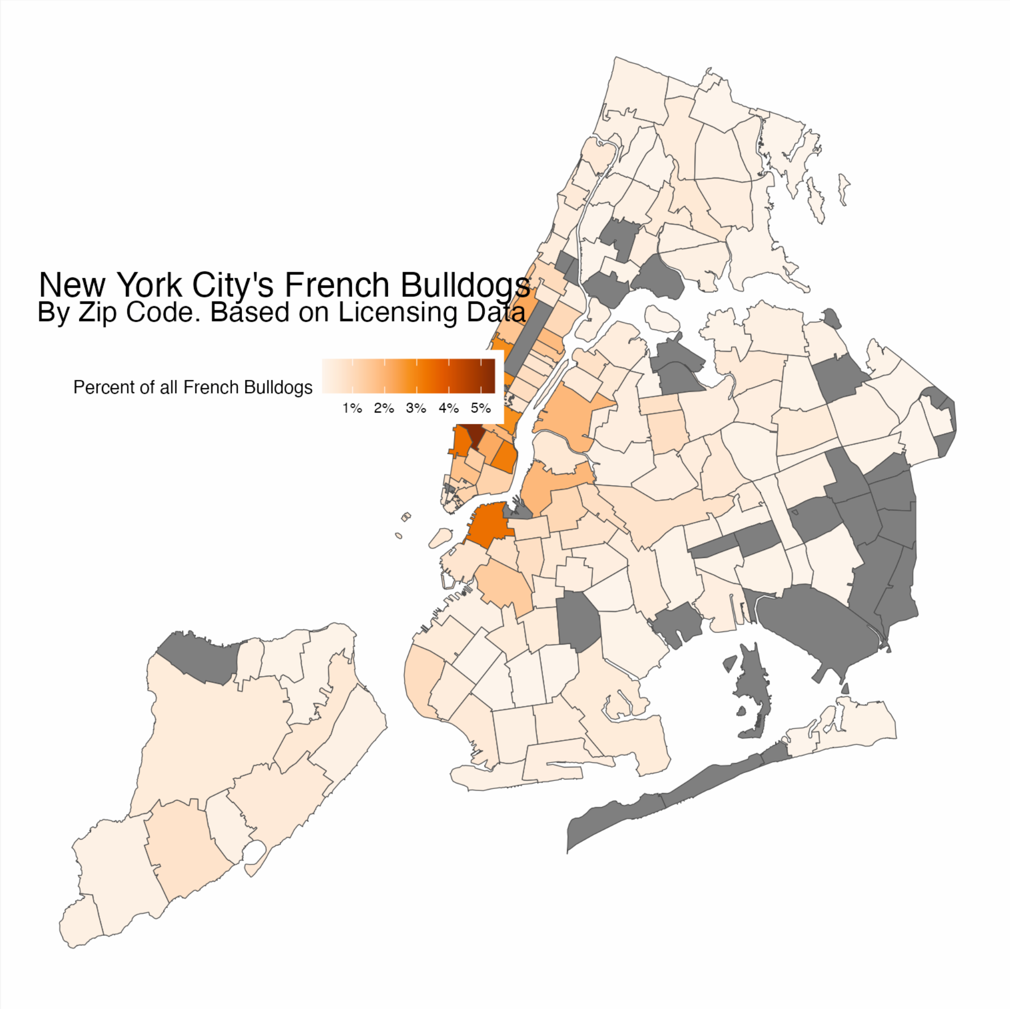
# Use a different palette

```r
library(colorspace)
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_cc

fb_map |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs") +
  annotate(geom = "text",
           x = -74.145 + 0.029,
           y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
  annotate(geom = "text",
           x = -74.1468 + 0.029,
           y = 40.7955,
           label = "By Zip Code. Based on Licensir
           size = 5)
```



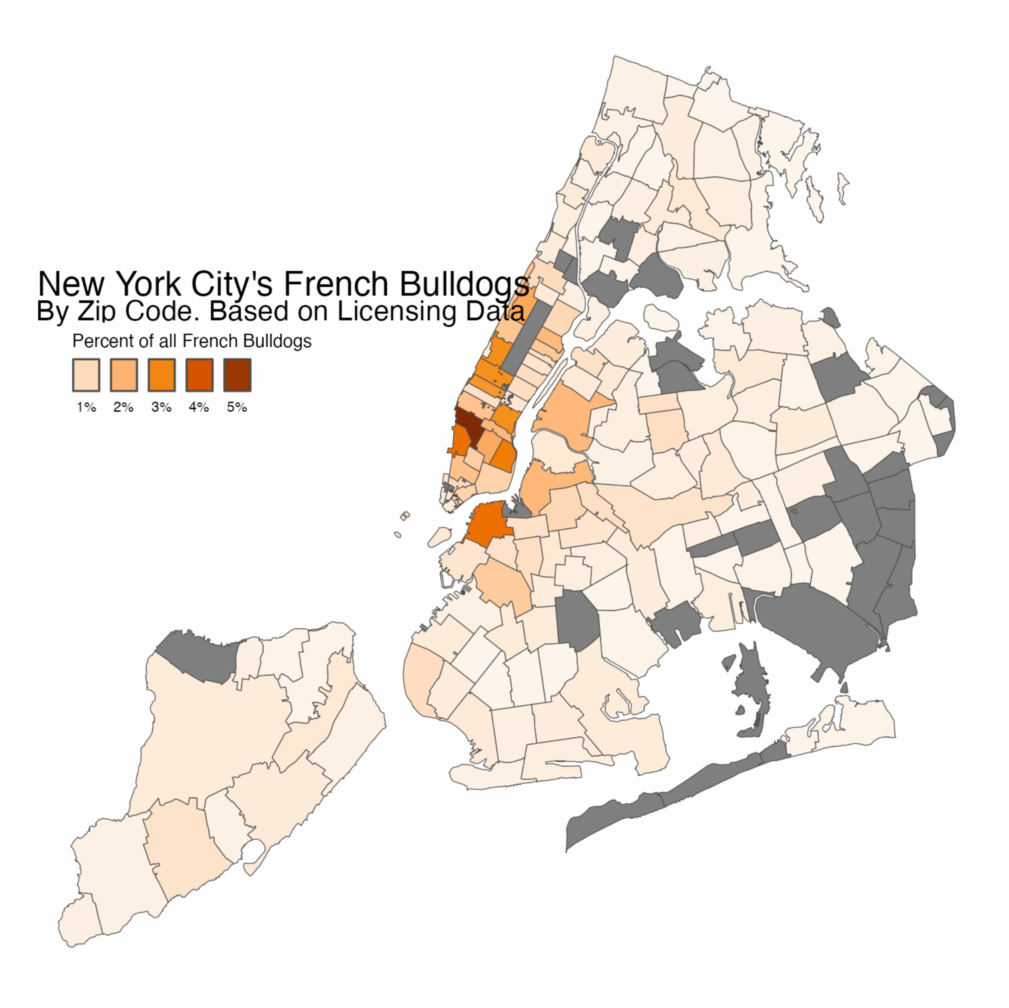
# Use a different palette

```r
library(colorspace)
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_co

fb_map |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs") +
  annotate(geom = "text",
           x = -74.145 + 0.029,
           y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
  annotate(geom = "text",
           x = -74.1468 + 0.029,
           y = 40.7955,
           label = "By Zip Code. Based on Licensin
           size = 5) +
  kjhslides::kjh_theme_nymap()
```



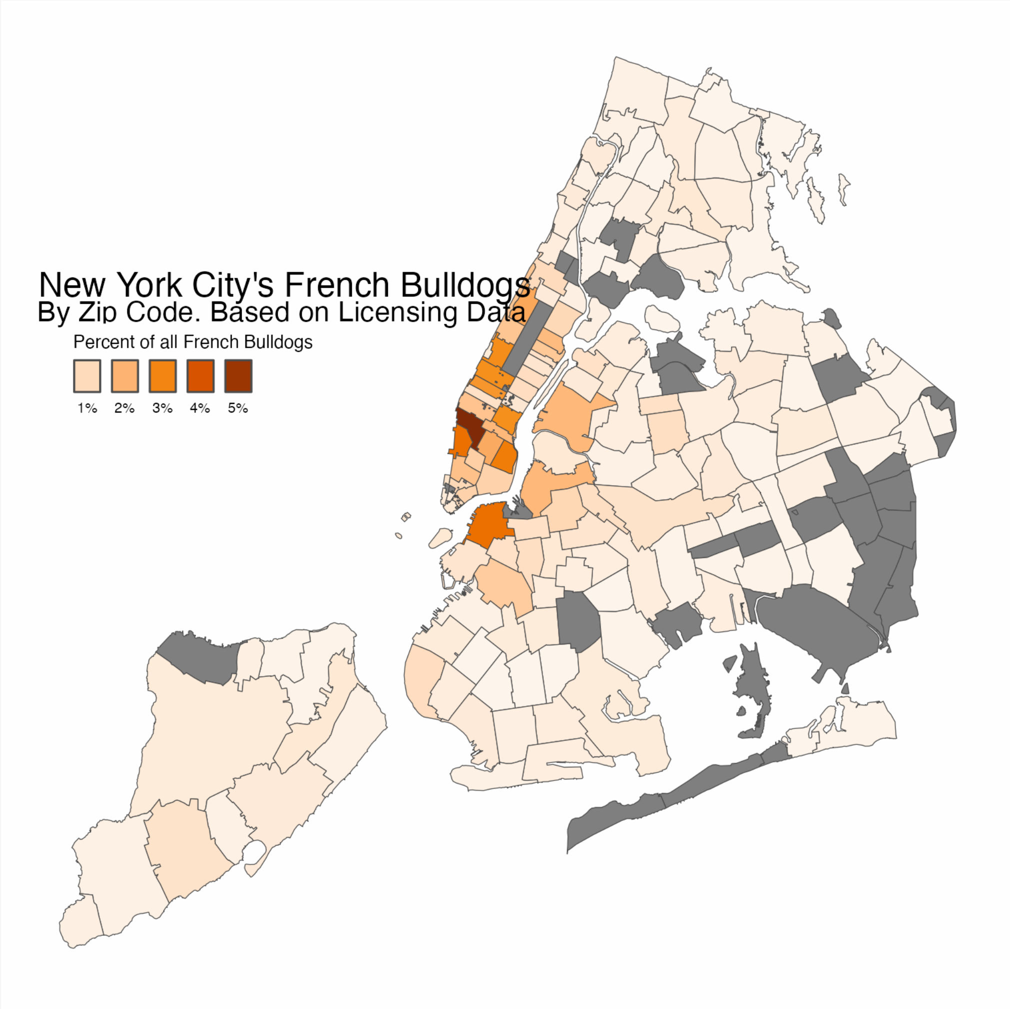
# Use a different palette

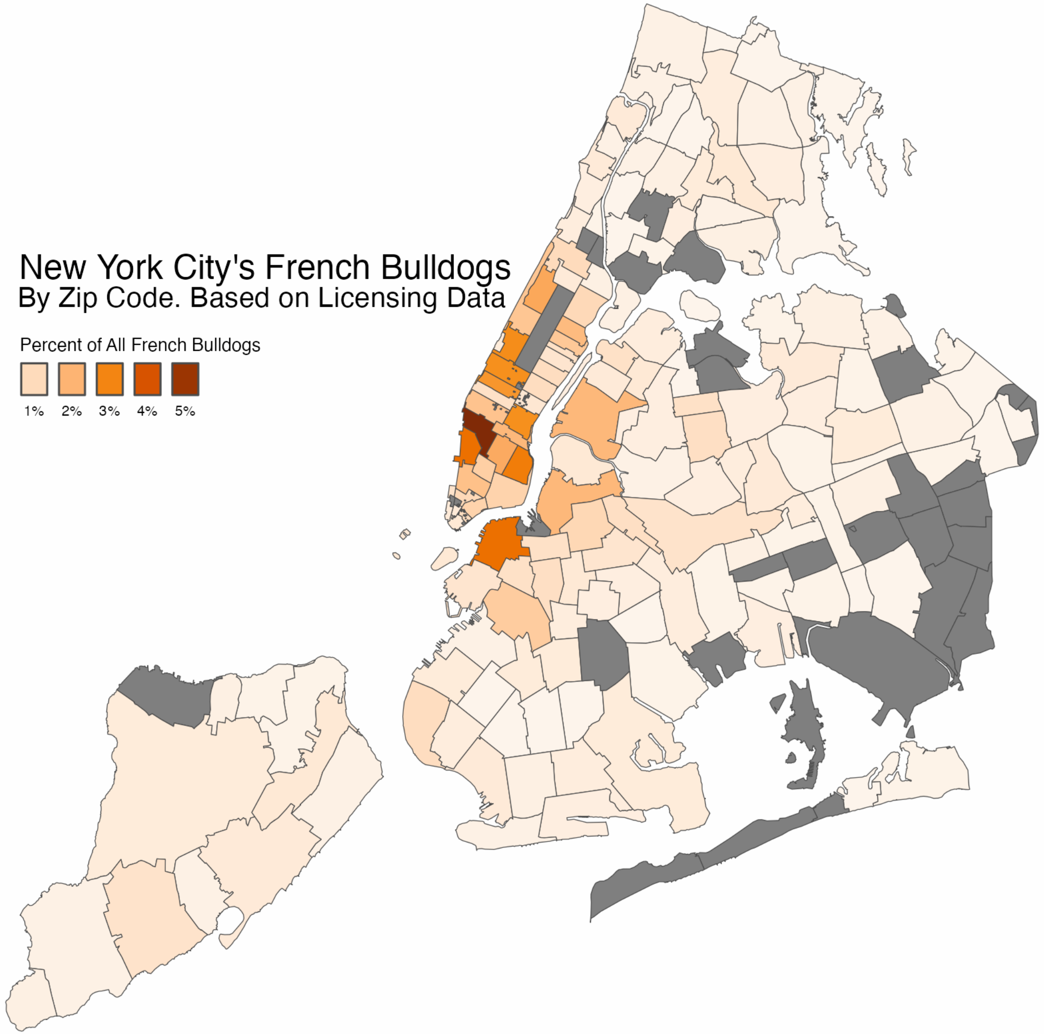
```r
library(colorspace)
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_cc

fb_map |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs") +
  annotate(geom = "text",
           x = -74.145 + 0.029,
           y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
  annotate(geom = "text",
           x = -74.1468 + 0.029,
           y = 40.7955,
           label = "By Zip Code. Based on Licensir
           size = 5) +
  kjhslides::kjh_theme_nymap() +
  guides(fill =
           guide_legend(title.position = "top",
                label.position = "bottom",
                keywidth = 1,
                nrow = 1))
```



# Use a different palette

```r
library(colorspace)
fb_map <- left_join(nyc_zips, nyc_fb, by = "zip_cc

fb_map |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs") +
  annotate(geom = "text",
           x = -74.145 + 0.029,
           y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
  annotate(geom = "text",
           x = -74.1468 + 0.029,
           y = 40.7955,
           label = "By Zip Code. Based on Licensir
           size = 5) +
  kjhslides::kjh_theme_nymap() +
  guides(fill =
           guide_legend(title.position = "top",
                label.position = "bottom",
                keywidth = 1,
                nrow = 1))
```






NYC Dogs Map mark 2

# Keep the Zero count zips

```r
nyc_license
```

```
## # A tibble: 493,072 × 9
##    animal_name animal_gender animal_birth_year breed_rc          borough zip_
##    <chr>       <chr>                     <dbl> <chr>             <chr>      <
##  1 Paige       F                          2014 Pit Bull (or Mi… Manhat…    1
##  2 Yogi        M                          2010 Boxer             Bronx      1
##  3 Ali         M                          2014 Basenji           Manhat…    1
##  4 Queen       F                          2013 Akita Crossbreed Manhat…    1
##  5 Lola        F                          2009 Maltese           Manhat…    1
##  6 Ian         M                          2006 Unknown           Manhat…    1
##  7 Buddy       M                          2008 Unknown           Manhat…    1
##  8 Chewbacca   F                          2012 Labrador (or Cr… Manhat…    1
##  9 Heidi-Bo    F                          2007 Dachshund Smoot… Brookl…    1
## 10 Massimo     M                          2009 Bull Dog, French Brookl…    1
## # ℹ 493,062 more rows
## # ℹ 3 more variables: license_issued_date <date>, license_expired_date <date
## #   extract_year <dbl>
```

# Keep the Zero count zips

```r
nyc_license |>
  filter(extract_year == 2018)
```

```
## # A tibble: 117,371 × 9
##    animal_name animal_gender animal_birth_year breed_rc           borough zip_
##    <chr>       <chr>                     <dbl> <chr>              <chr>
##  1 Ali         M                          2014 Basenji            Manhat…
##  2 Ian         M                          2006 Unknown            Manhat…
##  3 Chewbacca   F                          2012 Labrador (or Cr… Manhat…
##  4 Lola        F                          2006 Miniature Pinsc… Manhat…
##  5 Lucy        F                          2014 Dachshund Smoot… Brookl…
##  6 June        F                          2010 Cavalier King C… Brookl…
##  7 Apple       M                          2013 Havanese           Manhat…
##  8 Muneca      F                          2013 Beagle             Brookl…
##  9 Benson      M                          2010 Boxer              Brookl…
## 10 Bigs        M                          2004 Pit Bull (or Mi… Brookl…
## # ℹ 117,361 more rows
## # ℹ 3 more variables: license_issued_date <date>, license_expired_date <dat
## #   extract_year <dbl>
```

# Keep the Zero count zips

```r
nyc_license ▷
  filter(extract_year == 2018) ▷
  group_by(breed_rc, zip_code)
```

```
## # A tibble: 117,371 × 9
## # Groups:   breed_rc, zip_code [18,945]
##    animal_name animal_gender animal_birth_year breed_rc           borough zip_
##    <chr>       <chr>                     <dbl> <chr>              <chr>      <
##  1 Ali         M                          2014 Basenji            Manhat…    
##  2 Ian         M                          2006 Unknown            Manhat…    
##  3 Chewbacca   F                          2012 Labrador (or Cr… Manhat…    
##  4 Lola        F                          2006 Miniature Pinsc… Manhat…    
##  5 Lucy        F                          2014 Dachshund Smoot… Brookl…    
##  6 June        F                          2010 Cavalier King C… Brookl…    
##  7 Apple       M                          2013 Havanese           Manhat…    
##  8 Muneca      F                          2013 Beagle             Brookl…    
##  9 Benson      M                          2010 Boxer              Brookl…    
## 10 Bigs        M                          2004 Pit Bull (or Mi… Brookl…    
## # ℹ 117,361 more rows
## # ℹ 3 more variables: license_issued_date <date>, license_expired_date <date
## #   extract_year <dbl>
```

# Keep the Zero count zips

```r
nyc_license |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally()
```

```
## # A tibble: 18,945 × 3
## # Groups:   breed_rc [311]
##    breed_rc      zip_code     n
##    <chr>            <int> <int>
##  1 Affenpinscher    10005     1
##  2 Affenpinscher    10011     1
##  3 Affenpinscher    10013     1
##  4 Affenpinscher    10014     1
##  5 Affenpinscher    10016     1
##  6 Affenpinscher    10017     1
##  7 Affenpinscher    10018     1
##  8 Affenpinscher    10019     1
##  9 Affenpinscher    10021     1
## 10 Affenpinscher    10023     1
## # ℹ 18,935 more rows
```

# Keep the Zero count zips

```r
nyc_license  ▷
  filter(extract_year == 2018) ▷
  group_by(breed_rc, zip_code) ▷
  tally() ▷
  ungroup()
```

```
## # A tibble: 18,945 × 3
##    breed_rc      zip_code     n
##    <chr>            <int> <int>
##  1 Affenpinscher    10005     1
##  2 Affenpinscher    10011     1
##  3 Affenpinscher    10013     1
##  4 Affenpinscher    10014     1
##  5 Affenpinscher    10016     1
##  6 Affenpinscher    10017     1
##  7 Affenpinscher    10018     1
##  8 Affenpinscher    10019     1
##  9 Affenpinscher    10021     1
## 10 Affenpinscher    10023     1
## # ℹ 18,935 more rows
```

# Keep the Zero count zips

```r
nyc_license  ▷
  filter(extract_year == 2018) ▷
  group_by(breed_rc, zip_code) ▷
  tally() ▷
  ungroup() ▷
  complete(zip_code, breed_rc,
           fill = list(n = 0))
```

```
## # A tibble: 137,151 × 3
##    zip_code breed_rc                      n
##       <int> <chr>                     <int>
##  1     1135 Affenpinscher                 0
##  2     1135 Afghan Hound                  0
##  3     1135 Afghan Hound Crossbreed       0
##  4     1135 Airedale Terrier              0
##  5     1135 Akita                         0
##  6     1135 Akita Crossbreed              0
##  7     1135 Alaskan Malamute              0
##  8     1135 American Bully                0
##  9     1135 American English Coonhound    0
## 10     1135 American Eskimo Dog           0
## # ℹ 137,141 more rows
```

# Keep the Zero count zips

```r
nyc_license  |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally() |>
  ungroup() |>
  complete(zip_code, breed_rc,
           fill = list(n = 0)) |>
# Regroup to get the right denominator
  group_by(breed_rc)
```

```
## # A tibble: 137,151 × 3
## # Groups:   breed_rc [311]
##    zip_code breed_rc                           n
##       <int> <chr>                          <int>
##  1     1135 Affenpinscher                      0
##  2     1135 Afghan Hound                       0
##  3     1135 Afghan Hound Crossbreed            0
##  4     1135 Airedale Terrier                   0
##  5     1135 Akita                              0
##  6     1135 Akita Crossbreed                   0
##  7     1135 Alaskan Malamute                   0
##  8     1135 American Bully                     0
##  9     1135 American English Coonhound         0
## 10     1135 American Eskimo Dog                0
## # ℹ 137,141 more rows
```

# Keep the Zero count zips

```r
nyc_license  |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally() |>
  ungroup() |>
  complete(zip_code, breed_rc,
           fill = list(n = 0)) |>
# Regroup to get the right denominator
  group_by(breed_rc) |>
  mutate(freq = n / sum(n))
```

```
## # A tibble: 137,151 × 4
## # Groups:   breed_rc [311]
##    zip_code breed_rc                          n  freq
##       <int> <chr>                         <int> <dbl>
##  1     1135 Affenpinscher                     0     0
##  2     1135 Afghan Hound                      0     0
##  3     1135 Afghan Hound Crossbreed           0     0
##  4     1135 Airedale Terrier                  0     0
##  5     1135 Akita                             0     0
##  6     1135 Akita Crossbreed                  0     0
##  7     1135 Alaskan Malamute                  0     0
##  8     1135 American Bully                    0     0
##  9     1135 American English Coonhound        0     0
## 10     1135 American Eskimo Dog               0     0
## # ℹ 137,141 more rows
```

# Keep the Zero count zips

```r
nyc_license  |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally() |>
  ungroup() |>
  complete(zip_code, breed_rc,
           fill = list(n = 0)) |>
# Regroup to get the right denominator
  group_by(breed_rc) |>
  mutate(freq = n / sum(n)) |>
  filter(breed_rc == "French Bulldog")
```

```
## # A tibble: 441 × 4
## # Groups:   breed_rc [1]
##    zip_code breed_rc           n  freq
##       <int> <chr>          <int> <dbl>
##  1     1135 French Bulldog     0     0
##  2     1175 French Bulldog     0     0
##  3     1305 French Bulldog     0     0
##  4     6403 French Bulldog     0     0
##  5     6473 French Bulldog     0     0
##  6     6518 French Bulldog     0     0
##  7     6615 French Bulldog     0     0
##  8     6901 French Bulldog     0     0
##  9     7002 French Bulldog     0     0
## 10     7010 French Bulldog     0     0
## # ℹ 431 more rows
```

# Keep the Zero count zips

```r
nyc_license  |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally() |>
  ungroup() |>
  complete(zip_code, breed_rc,
           fill = list(n = 0)) |>
# Regroup to get the right denominator
  group_by(breed_rc) |>
  mutate(freq = n / sum(n)) |>
  filter(breed_rc == "French Bulldog") ->
  nyc_fb2
```

# Keep the Zero count zips

```r
nyc_license  |>
  filter(extract_year == 2018) |>
  group_by(breed_rc, zip_code) |>
  tally() |>
  ungroup() |>
  complete(zip_code, breed_rc,
           fill = list(n = 0)) |>
# Regroup to get the right denominator
  group_by(breed_rc) |>
  mutate(freq = n / sum(n)) |>
  filter(breed_rc == "French Bulldog") ->
  nyc_fb2

fb_map2 <- left_join(nyc_zips,
                     nyc_fb2,
                     by = "zip_code")
```

# Keep the Zero count zips

```
nyc_license  ▷
  filter(extract_year == 2018) ▷
  group_by(breed_rc, zip_code) ▷
  tally() ▷
  ungroup() ▷
  complete(zip_code, breed_rc,
           fill = list(n = 0)) ▷
# Regroup to get the right denominator
  group_by(breed_rc) ▷
  mutate(freq = n / sum(n)) ▷
  filter(breed_rc == "French Bulldog") ->
  nyc_fb2

fb_map2 <- left_join(nyc_zips,
                     nyc_fb2,
                     by = "zip_code")
```

# Ready to map, again

```
fb_map2 ▷ select(zip_code, po_name, borough, breed_rc:freq, geometry)
```

```
## Simple feature collection with 262 features and 6 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -74.25576 ymin: 40.49584 xmax: -73.6996 ymax: 40.91517
## Geodetic CRS:  WGS 84
## # A tibble: 262 × 7
##    zip_code po_name      borough breed_rc      n    freq                  geometry
##       <int> <chr>        <chr>   <chr>     <int>   <dbl>            <POLYGON [°]>
##  1    11372 Jackson He… Queens   French …     13 8.02e-3 ((-73.86942 40.74916, -7…
##  2    11004 Glen Oaks   Queens   French …      1 6.17e-4 ((-73.71068 40.75004, -7…
##  3    11040 New Hyde P… Queens   French …      0 0       ((-73.70098 40.7389, -73…
##  4    11426 Bellerose   Queens   French …      1 6.17e-4 ((-73.7227 40.75373, -73…
##  5    11365 Fresh Mead… Queens   French …      7 4.32e-3 ((-73.81089 40.72717, -7…
##  6    11373 Elmhurst    Queens   French …     14 8.64e-3 ((-73.88722 40.72753, -7…
##  7    11001 Floral Park Queens   French …      0 0       ((-73.70098 40.7389, -73…
##  8    11375 Forest Hil… Queens   French …      8 4.94e-3 ((-73.85625 40.73672, -7…
##  9    11427 Queens Vil… Queens   French …      2 1.23e-3 ((-73.74169 40.73682, -7…
## 10    11374 Rego Park   Queens   French …      6 3.70e-3 ((-73.86451 40.73407, -7…
## # ℹ 252 more rows
```

This time, a number of previous NA rows are now zeroes instead.

# Now redraw the map

```
fb_map2 <- left_join(nyc_zips, nyc_fb2, by = "zip_
```

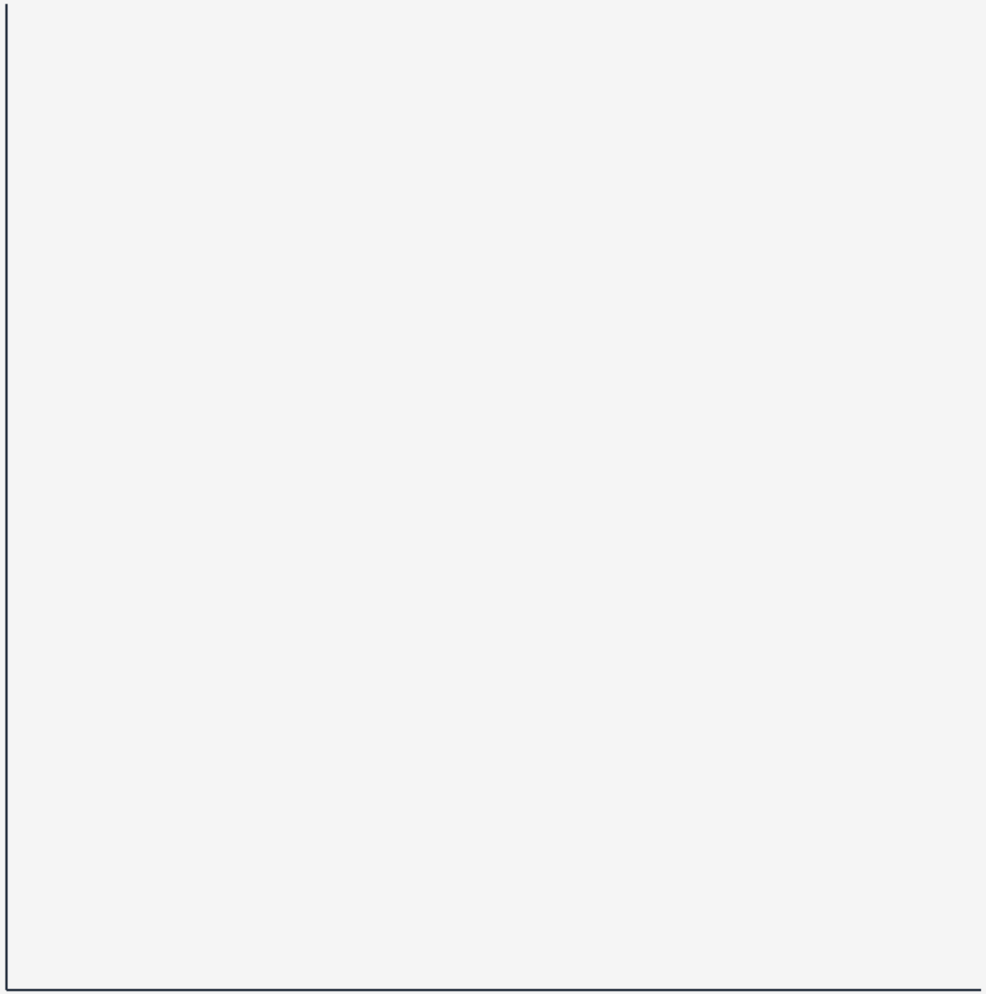
# Now redraw the map

```
fb_map2 <- left_join(nyc_zips, nyc_fb2, by = "zip_

fb_map2
```

```
## Simple feature collection with 262 features and 14 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -74.25576 ymin: 40.49584 xmax: -73.6996 ymax: 40.91517
## Geodetic CRS:  WGS 84
## # A tibble: 262 × 15
##    objectid zip_code po_name      state borough st_fips cty_fips bld_gpostal_
##       <int>    <int> <chr>        <chr> <chr>   <chr>   <chr>               <
##  1        1    11372 Jackson He… NY    Queens  36      081
##  2        2    11004 Glen Oaks   NY    Queens  36      081
##  3        3    11040 New Hyde P… NY    Queens  36      081
##  4        4    11426 Bellerose   NY    Queens  36      081
##  5        5    11365 Fresh Mead… NY    Queens  36      081
##  6        6    11373 Elmhurst    NY    Queens  36      081
##  7        7    11001 Floral Park NY    Queens  36      081
##  8        8    11375 Forest Hil… NY    Queens  36      081
##  9        9    11427 Queens Vil… NY    Queens  36      081
## 10       10    11374 Rego Park   NY    Queens  36      081
## # ℹ 252 more rows
## # ℹ 7 more variables: shape_leng <dbl>, shape_area <dbl>, x_id <chr>,
## #   geometry <POLYGON [°]>, breed_rc <chr>, n <int>, freq <dbl>
```

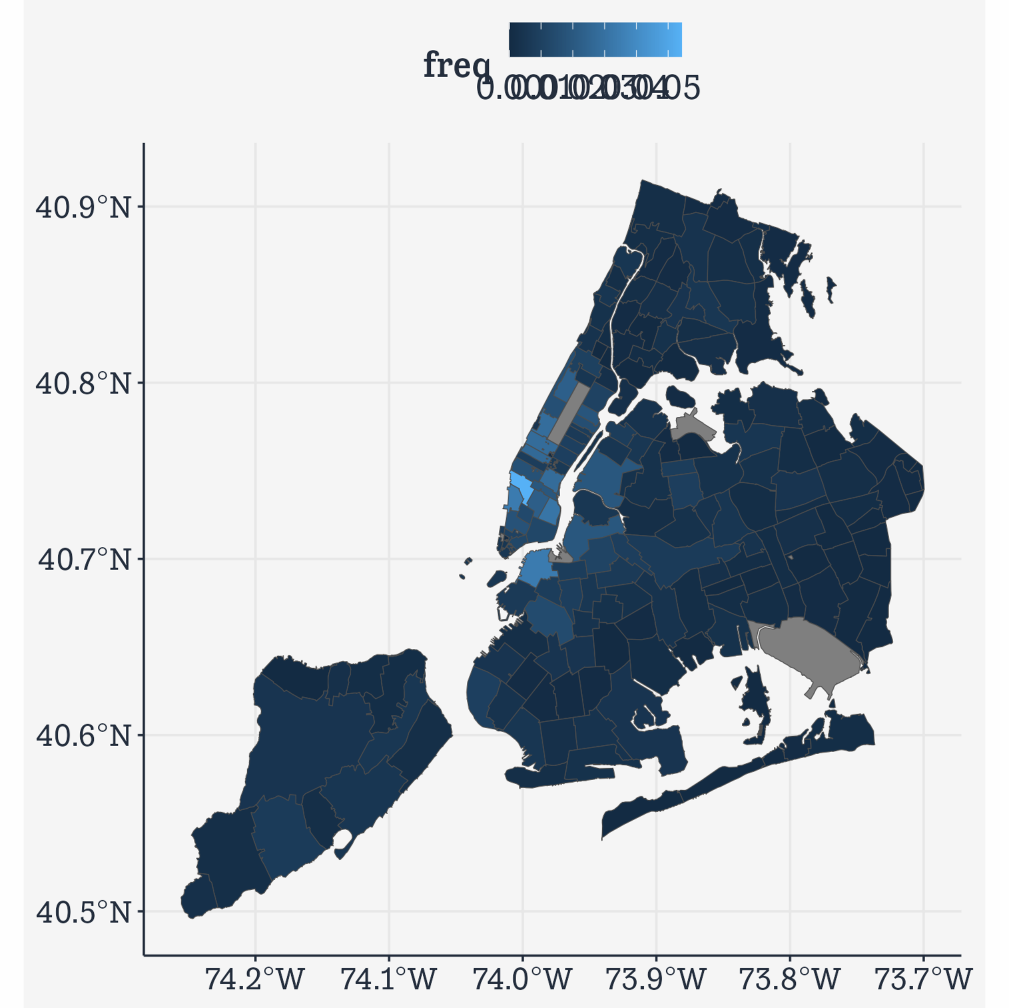
# Now redraw the map

```
fb_map2 <- left_join(nyc_zips, nyc_fb2, by = "zip_

fb_map2 |>
  ggplot(mapping = aes(fill = freq))
```



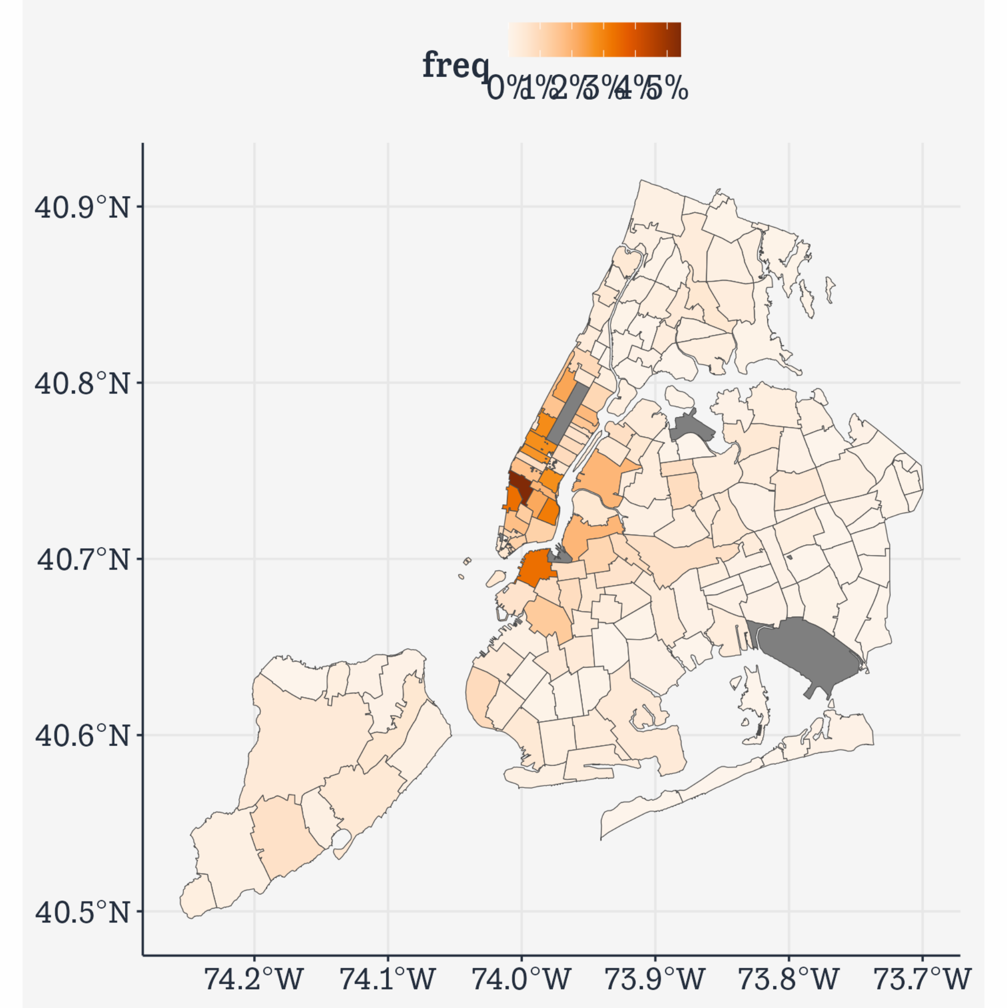
# Now redraw the map

```
fb_map2 <- left_join(nyc_zips, nyc_fb2, by = "zip_
fb_map2 |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1)
```



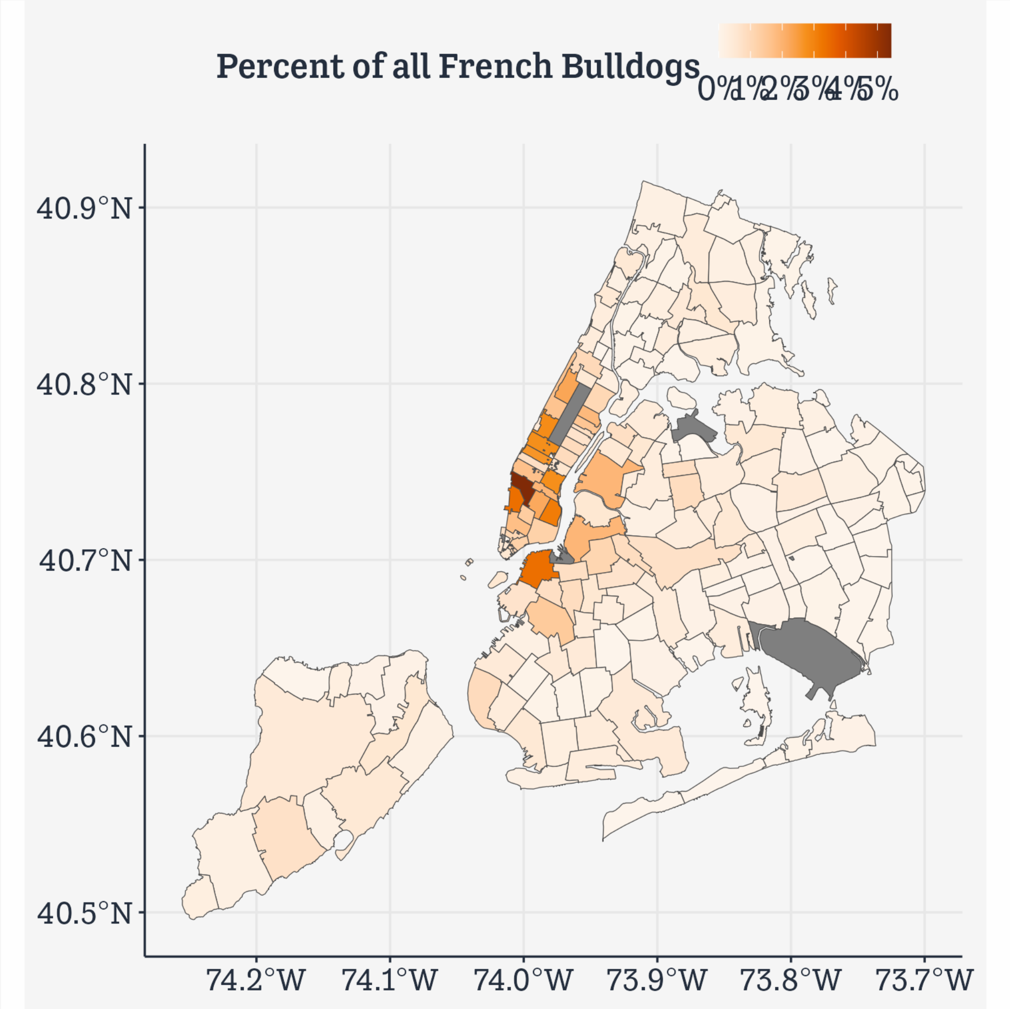
# Now redraw the map

```
fb_map2 <- left_join(nyc_zips, nyc_fb2, by = "zip_

fb_map2 |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent())
```



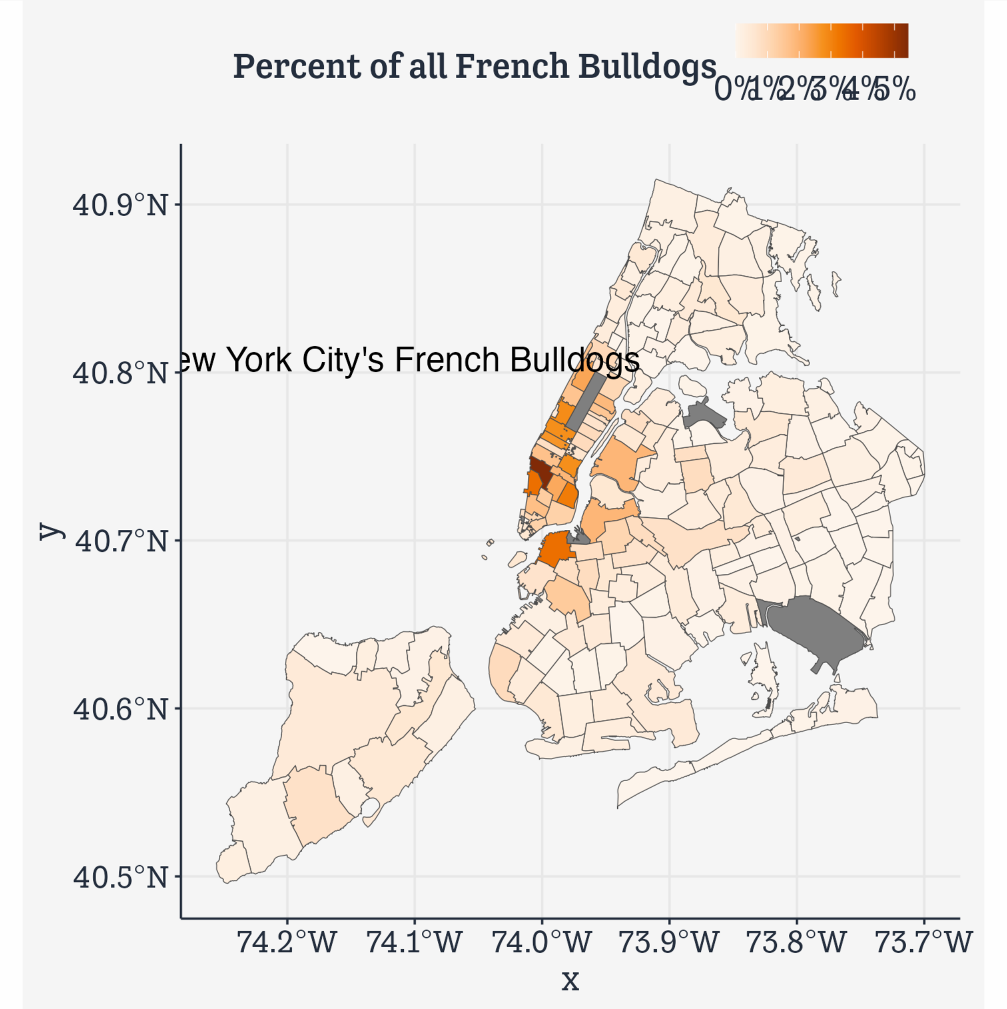
# Now redraw the map

```
fb_map2 ← left_join(nyc_zips, nyc_fb2, by = "zip_

fb_map2 ▷
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs")
```



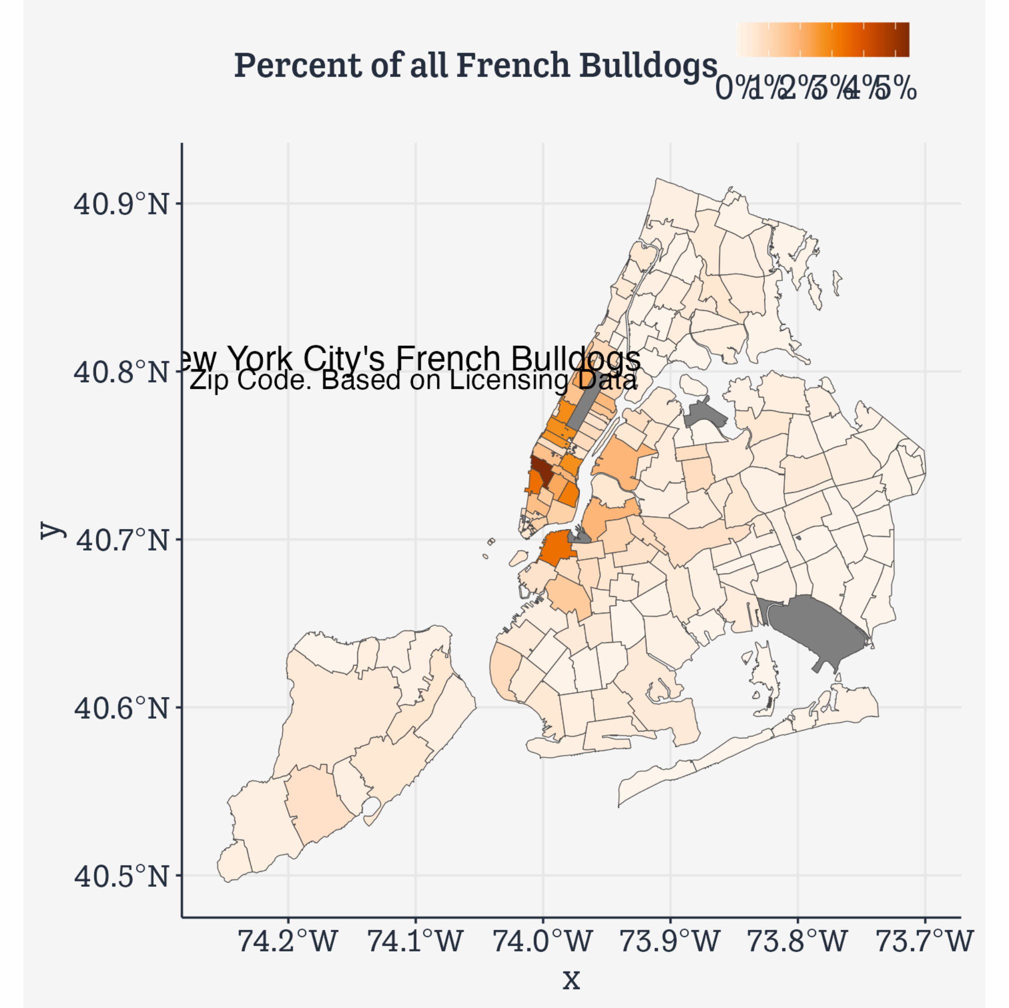
# Now redraw the map

```
fb_map2 <- left_join(nyc_zips, nyc_fb2, by = "zip_

fb_map2 |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs") +
  annotate(geom = "text",
           x = -74.145 + 0.029,
           y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6)
```



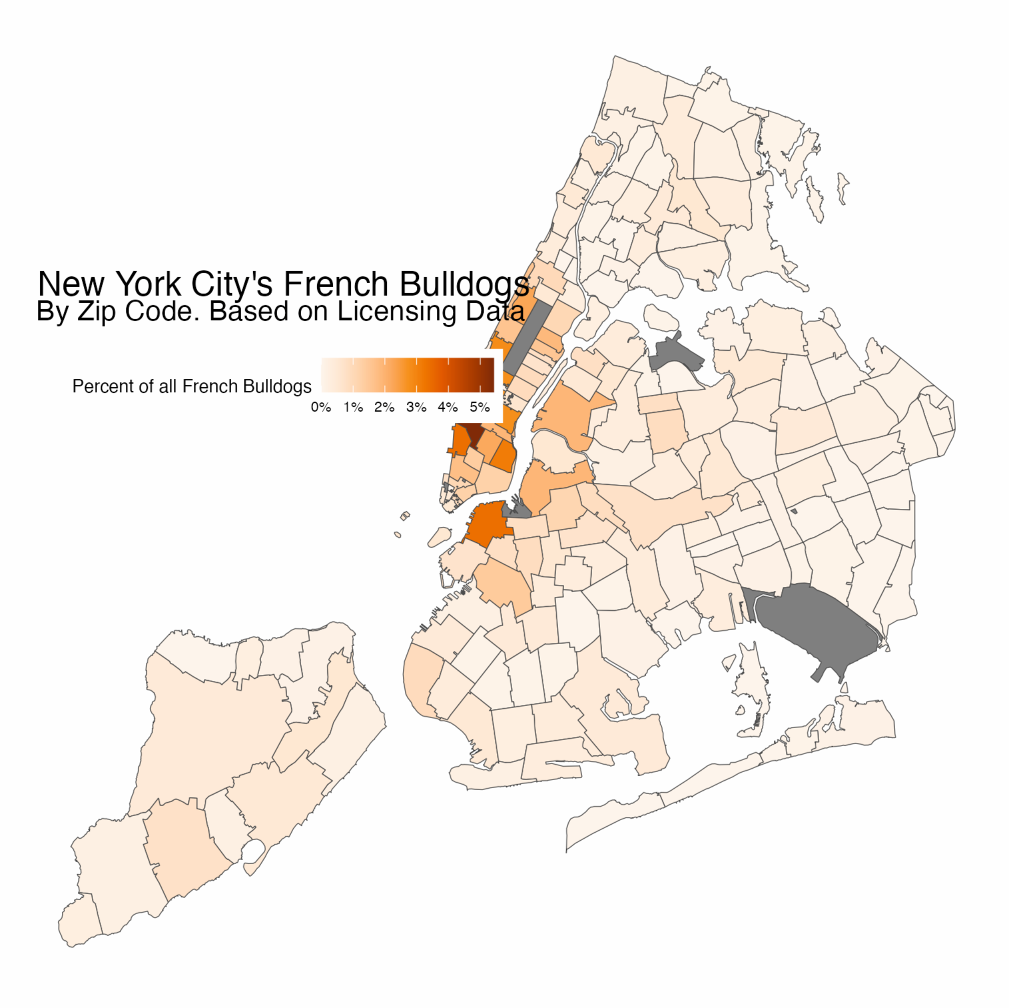
# Now redraw the map

```
fb_map2 <- left_join(nyc_zips, nyc_fb2, by = "zip_

fb_map2 |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs") +
  annotate(geom = "text",
           x = -74.145 + 0.029,
           y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
  annotate(geom = "text",
           x = -74.1468 + 0.029,
           y = 40.7955,
           label = "By Zip Code. Based on Licensir
           size = 5)
```



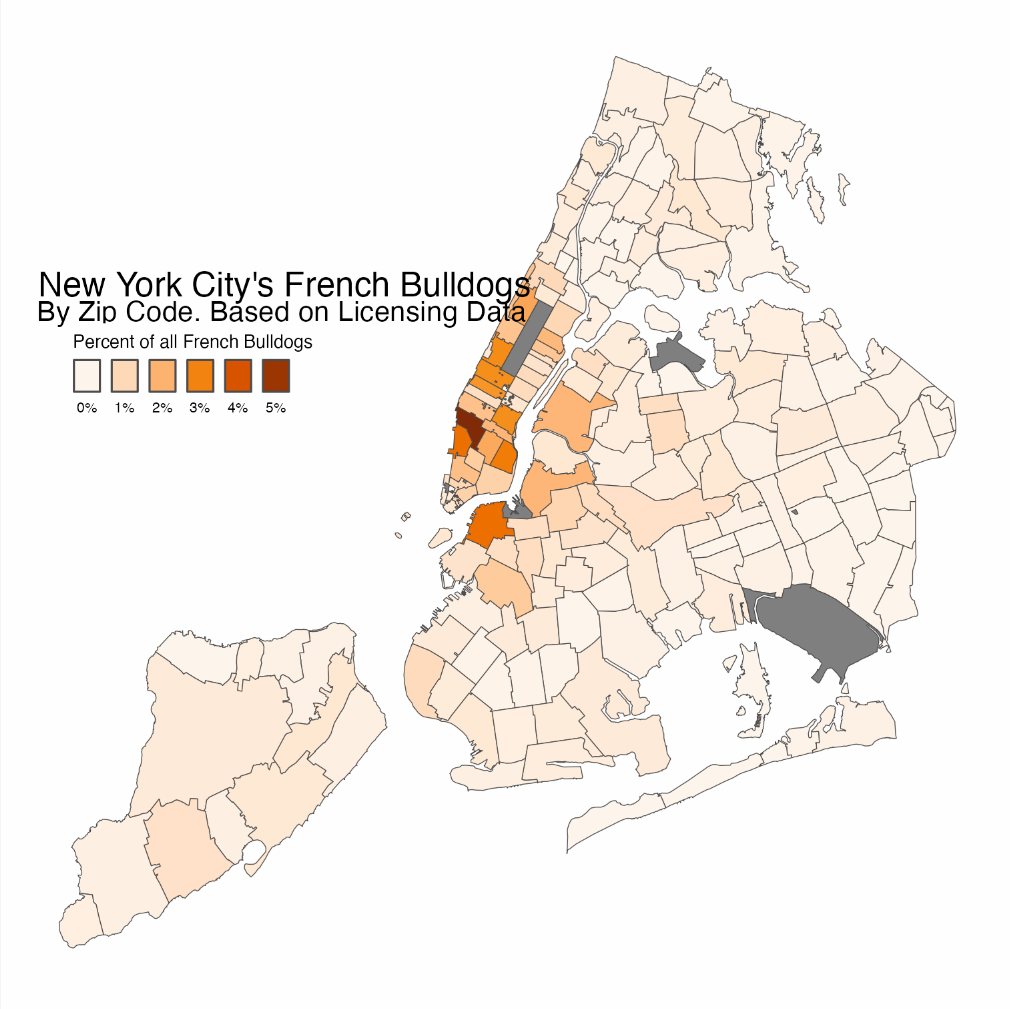
# Now redraw the map

```
fb_map2 <- left_join(nyc_zips, nyc_fb2, by = "zip_

fb_map2 |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs") +
  annotate(geom = "text",
           x = -74.145 + 0.029,
           y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
  annotate(geom = "text",
           x = -74.1468 + 0.029,
           y = 40.7955,
           label = "By Zip Code. Based on Licensir
           size = 5) +
  kjhslides::kjh_theme_nymap()
```



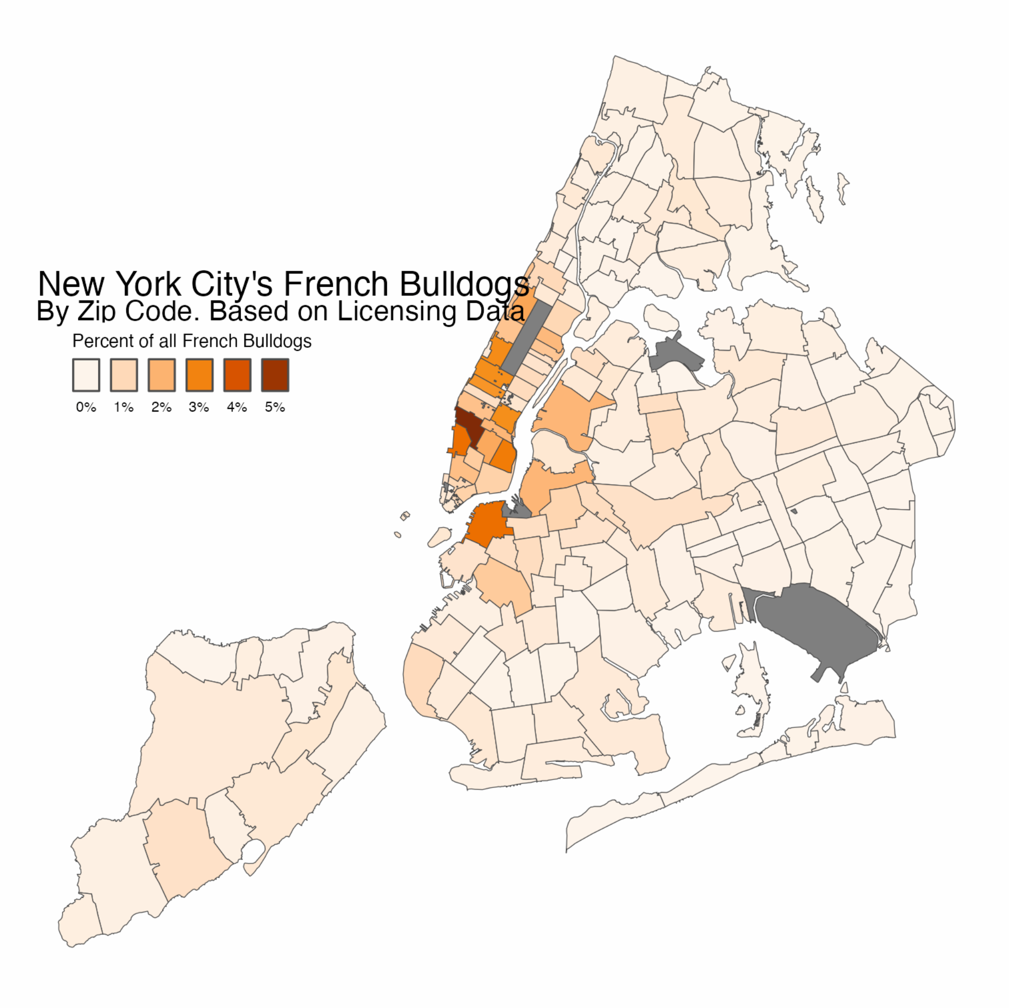
# Now redraw the map

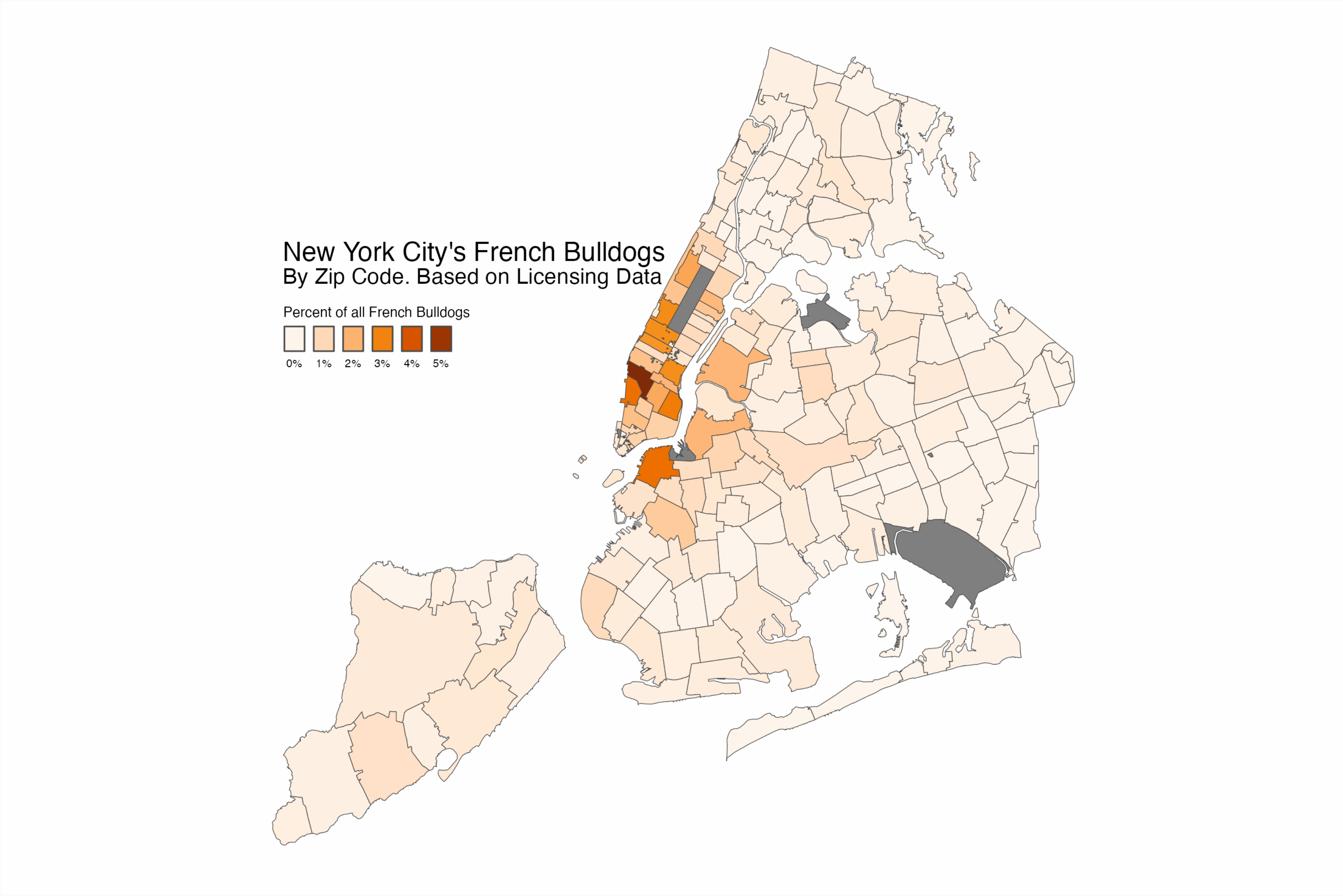
```r
fb_map2 <- left_join(nyc_zips, nyc_fb2, by = "zip_

fb_map2 |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs") +
  annotate(geom = "text",
           x = -74.145 + 0.029,
           y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
  annotate(geom = "text",
           x = -74.1468 + 0.029,
           y = 40.7955,
           label = "By Zip Code. Based on Licensir
           size = 5) +
  kjhslides::kjh_theme_nymap() +
  guides(fill =
           guide_legend(title.position = "top",
                        label.position = "bottom",
                        keywidth = 1,
                        nrow = 1))
```



# Now redraw the map

```r
fb_map2 <- left_join(nyc_zips, nyc_fb2, by = "zip_

fb_map2 |>
  ggplot(mapping = aes(fill = freq)) +
  geom_sf(color = "gray30", size = 0.1) +
  scale_fill_continuous_sequential(
    palette = "Oranges",
    labels = scales::label_percent()) +
  labs(fill = "Percent of all French Bulldogs") +
  annotate(geom = "text",
           x = -74.145 + 0.029,
           y = 40.82-0.012,
           label = "New York City's French Bulldog
           size = 6) +
  annotate(geom = "text",
           x = -74.1468 + 0.029,
           y = 40.7955,
           label = "By Zip Code. Based on Licensin
           size = 5) +
  kjhslides::kjh_theme_nymap() +
  guides(fill =
           guide_legend(title.position = "top",
                        label.position = "bottom",
                        keywidth = 1,
                        nrow = 1))
```






Zero areas properly zero, missing areas properly missing.