

Data Visualization - 7.

Make Maps (1)

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Code Horizons

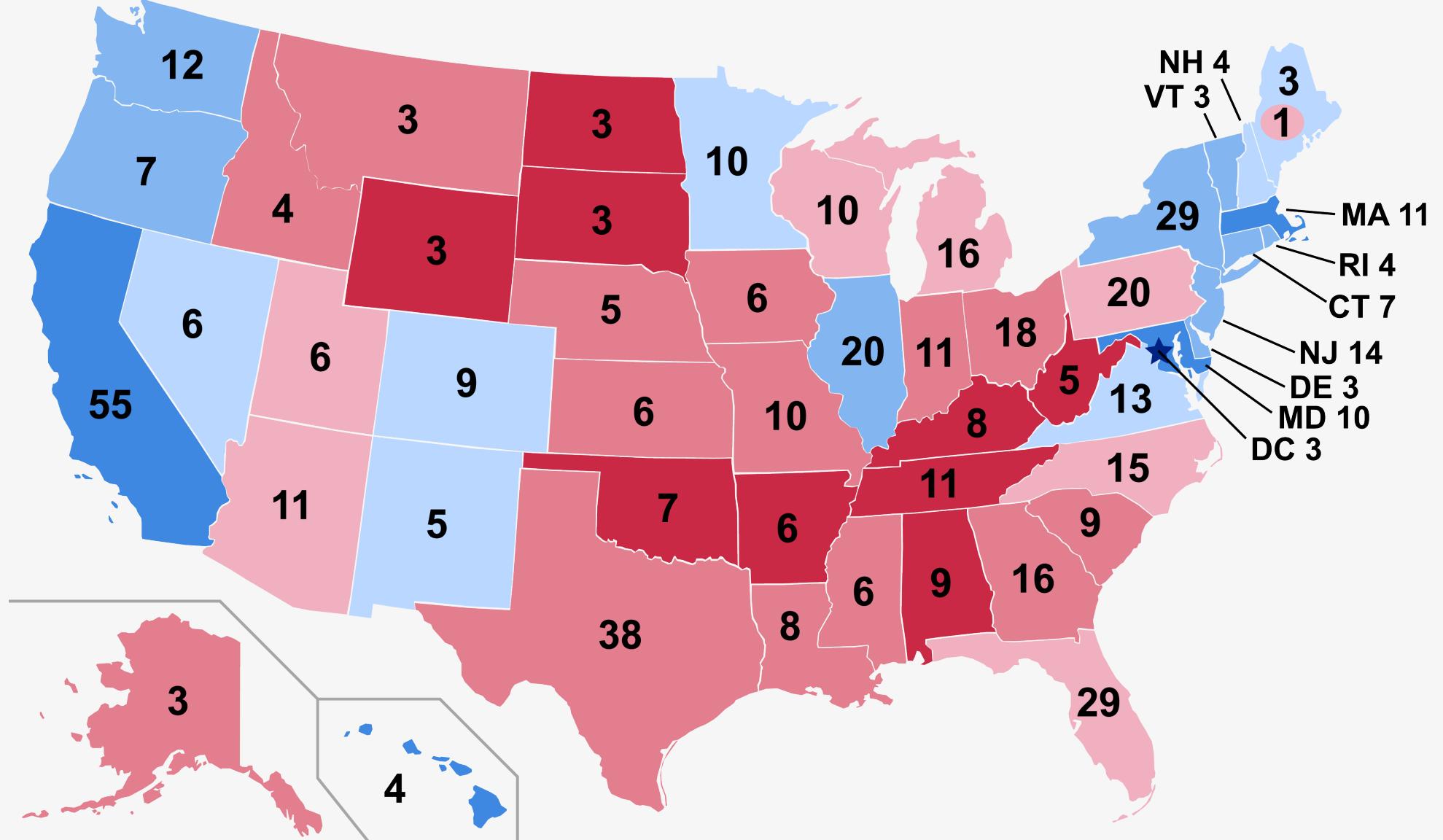
October 2, 2024

Making Maps

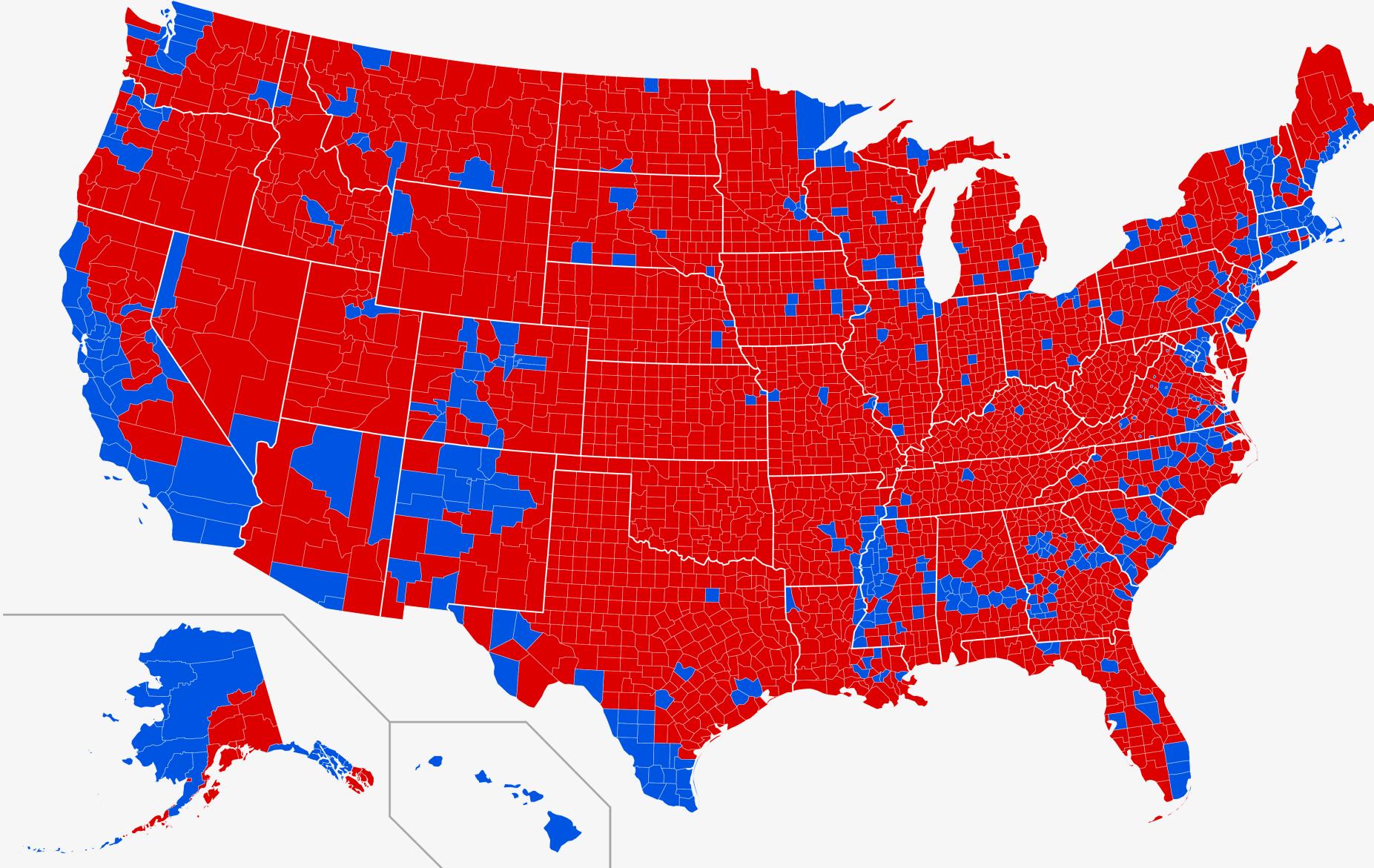
Load our packages

```
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
```

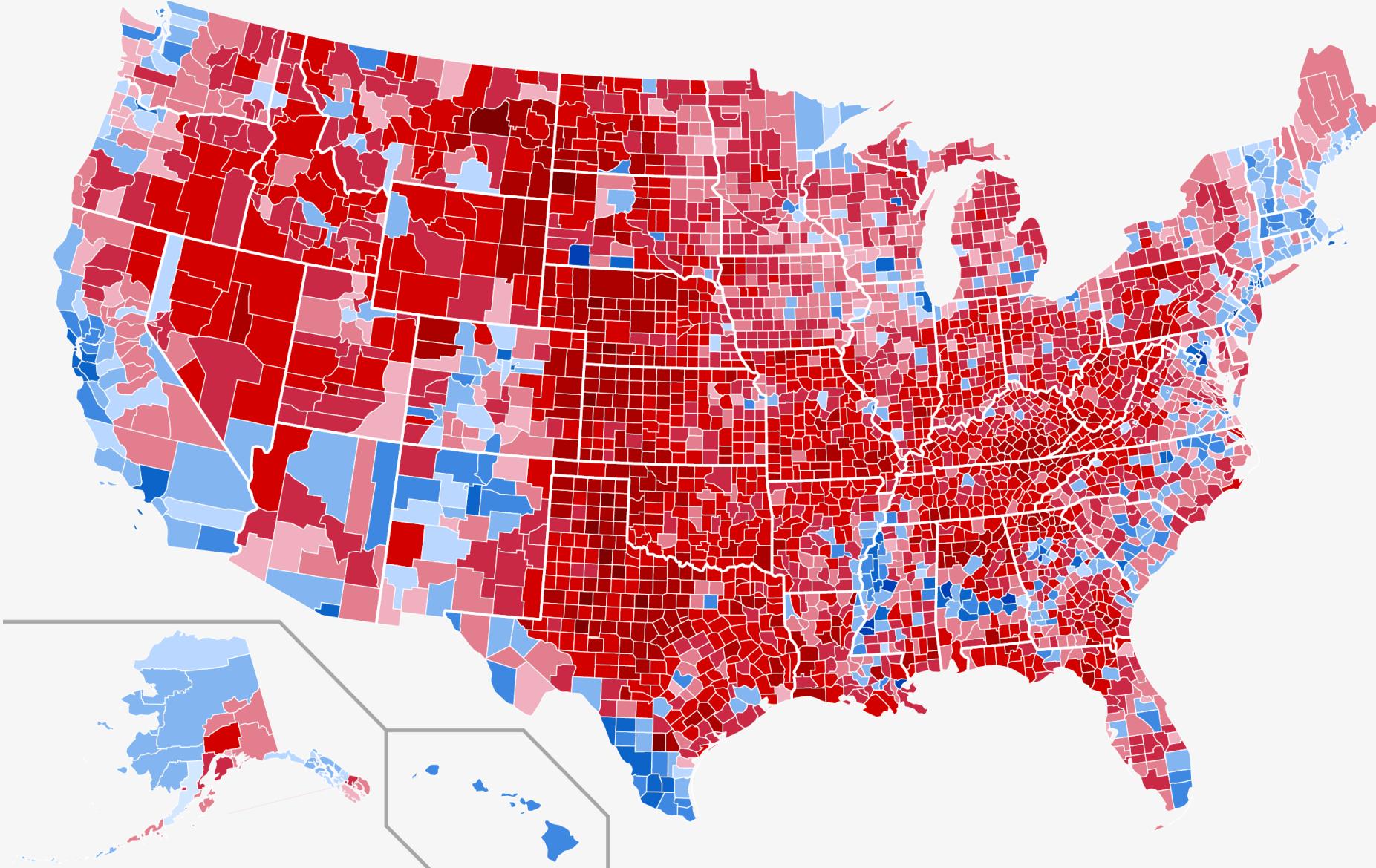

Choropleths



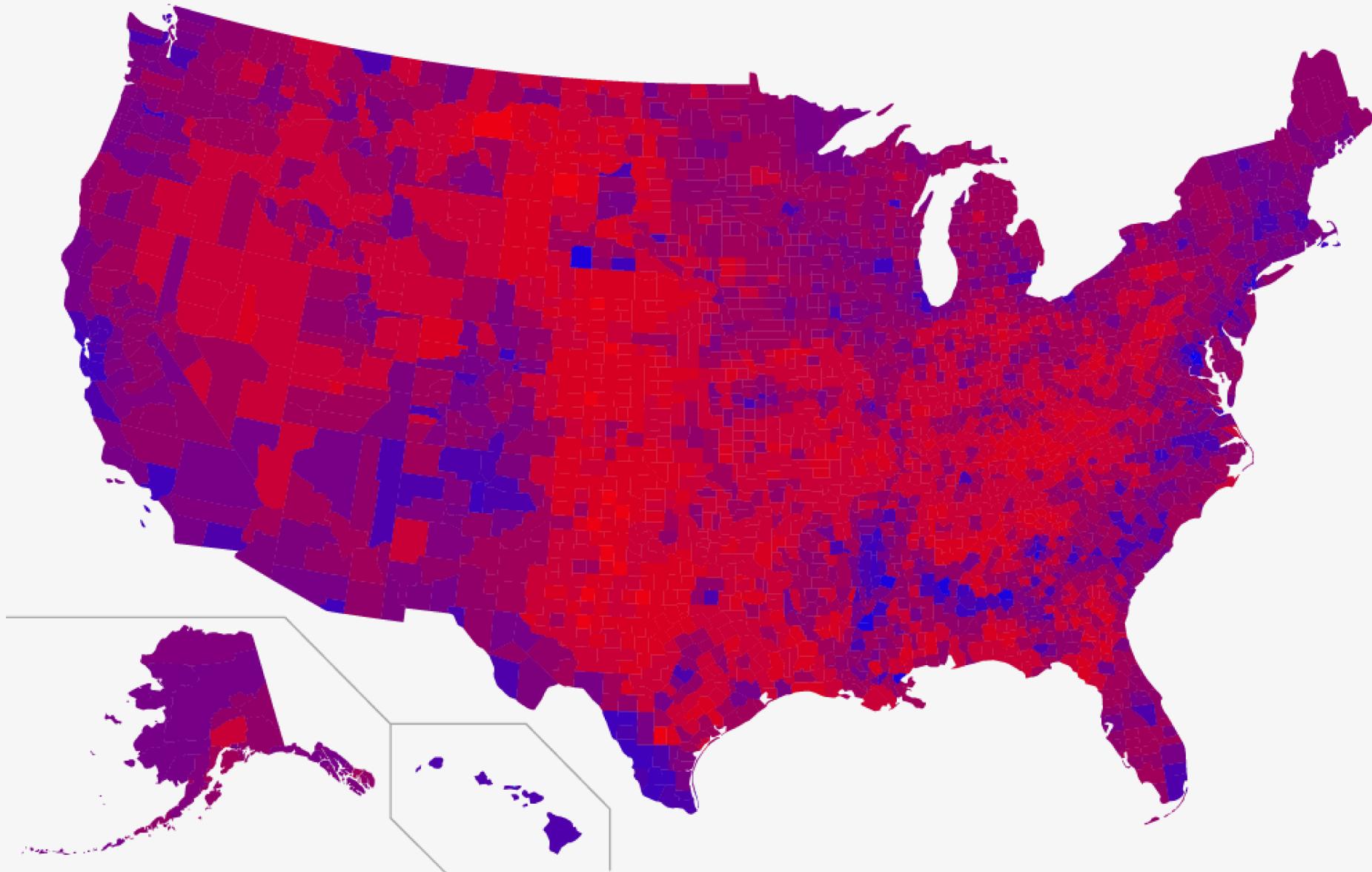
State-level; vote share; diverging; binned into four categories.



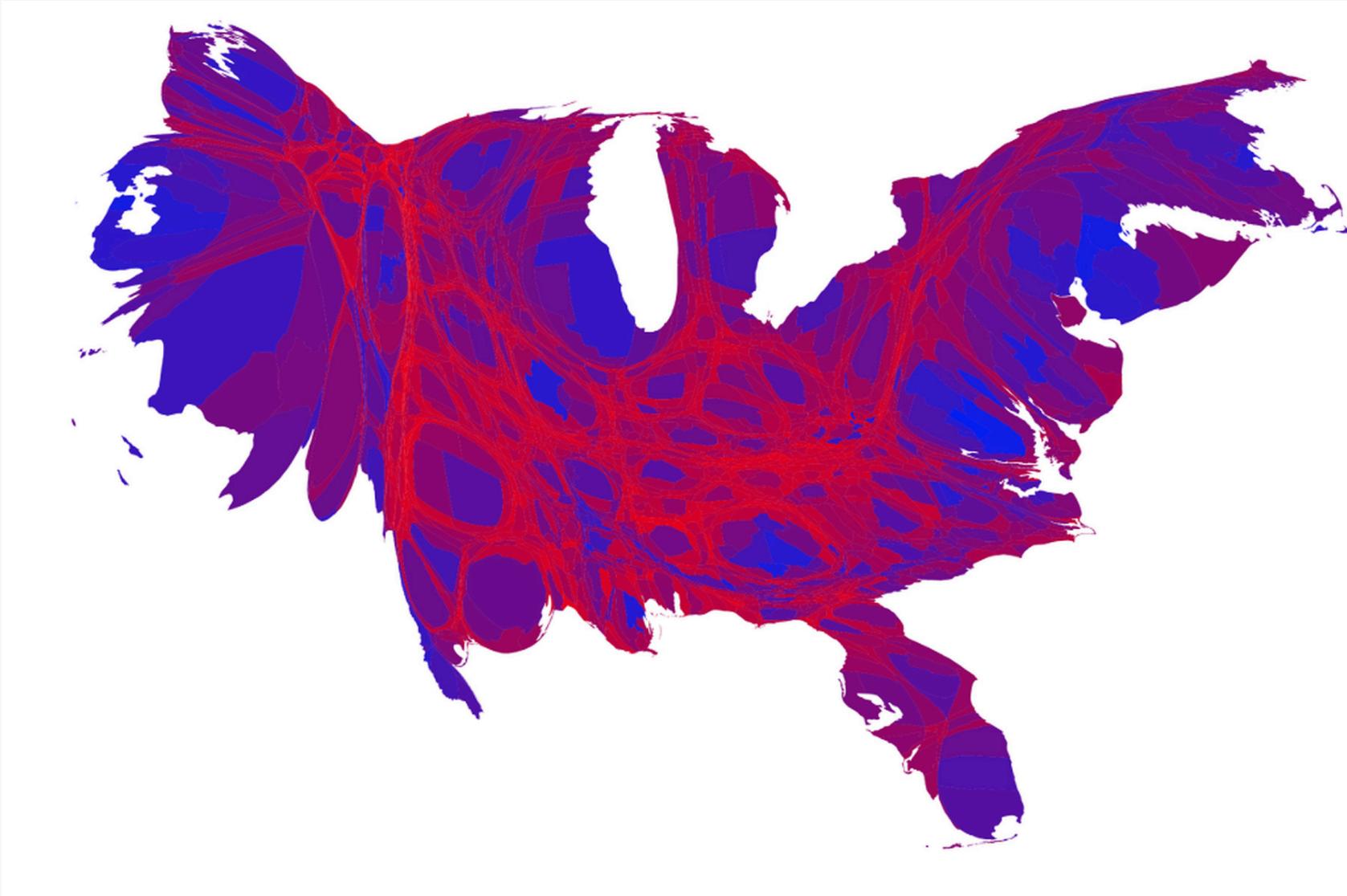
County level; winner only



County level vote share; diverging; binned into six categories

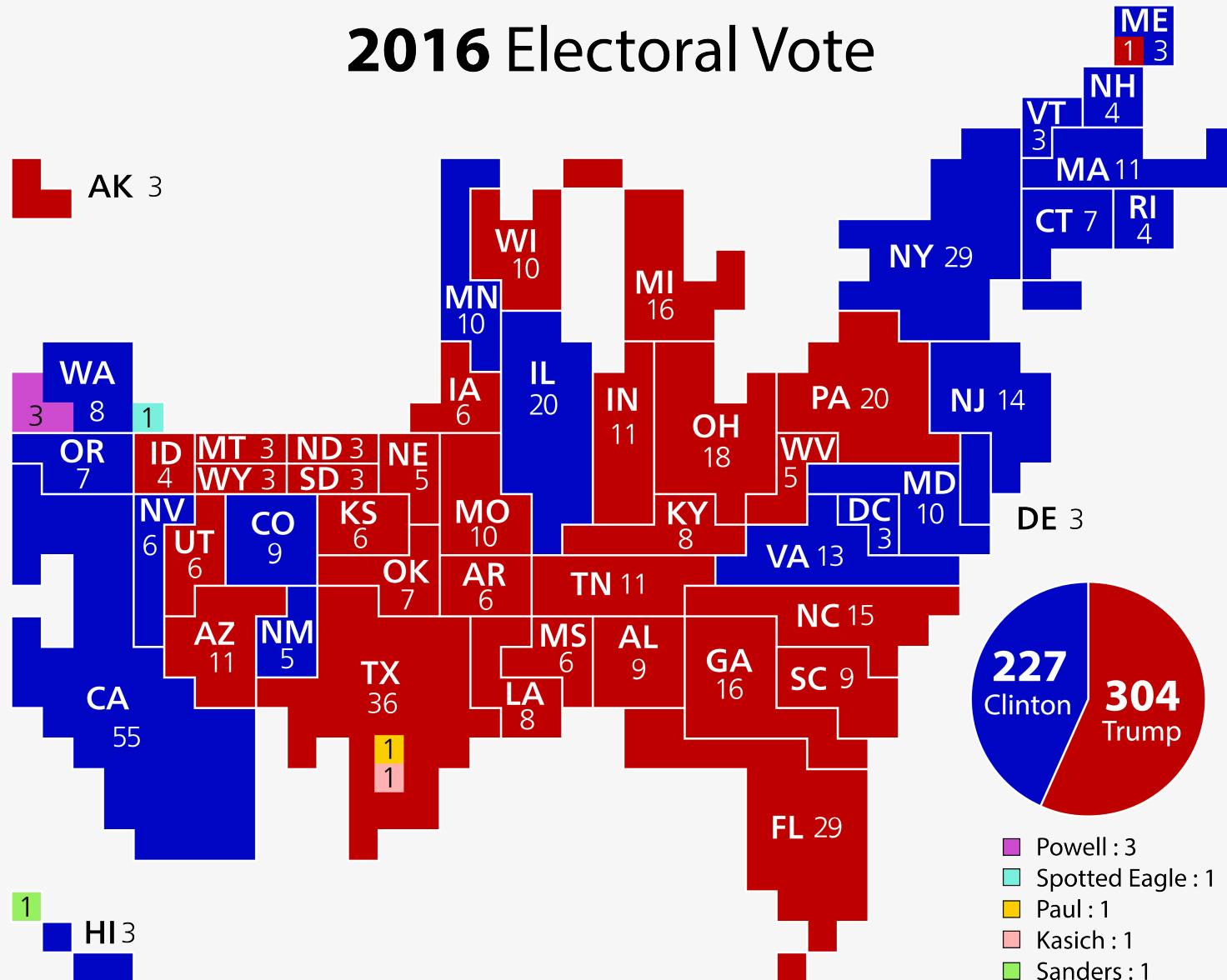


County level vote share; diverging continuous; purple midpoint

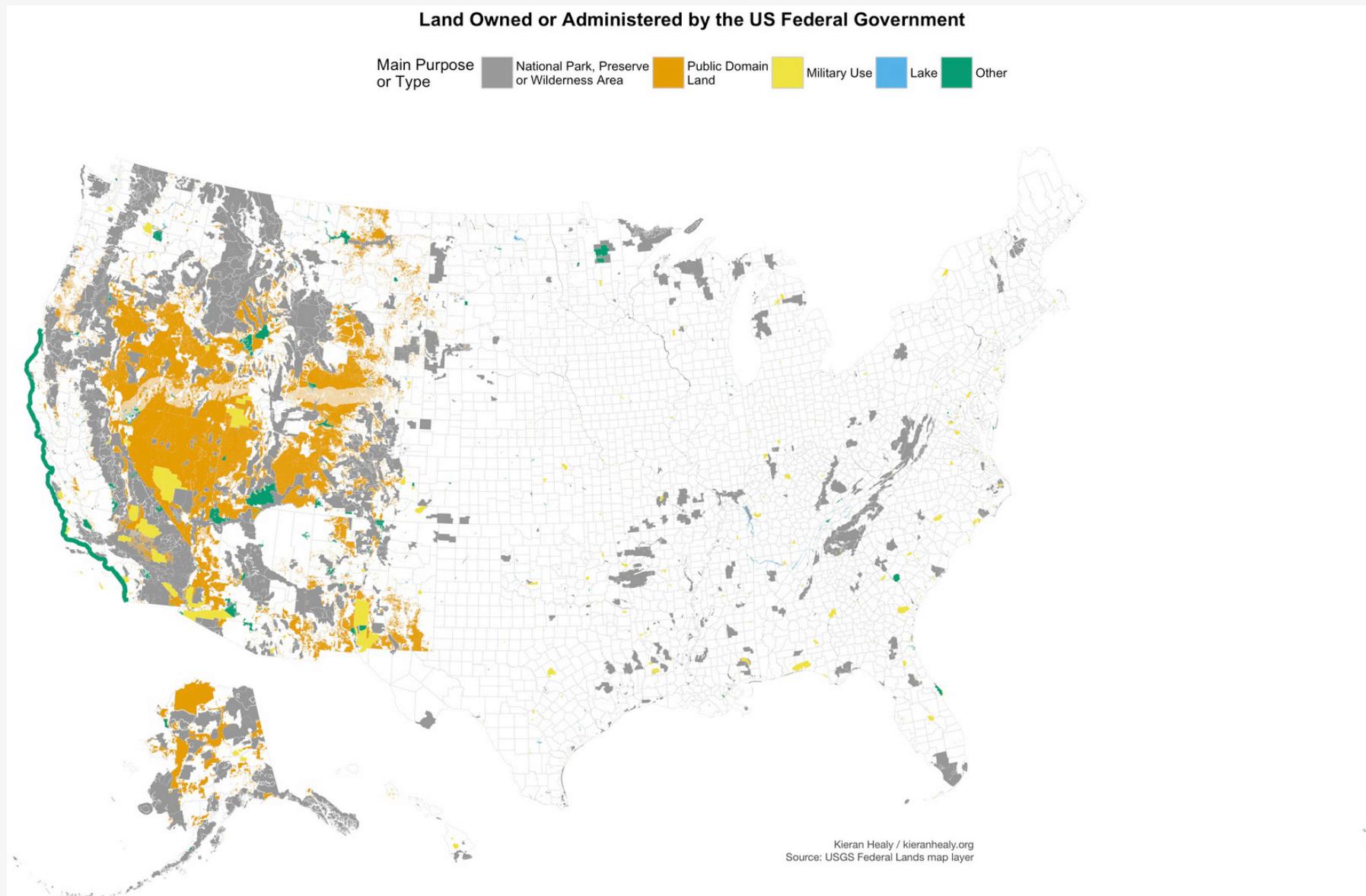


County level vote share; purple midpoint; county area deformed in proportion to population. By Mark Newman

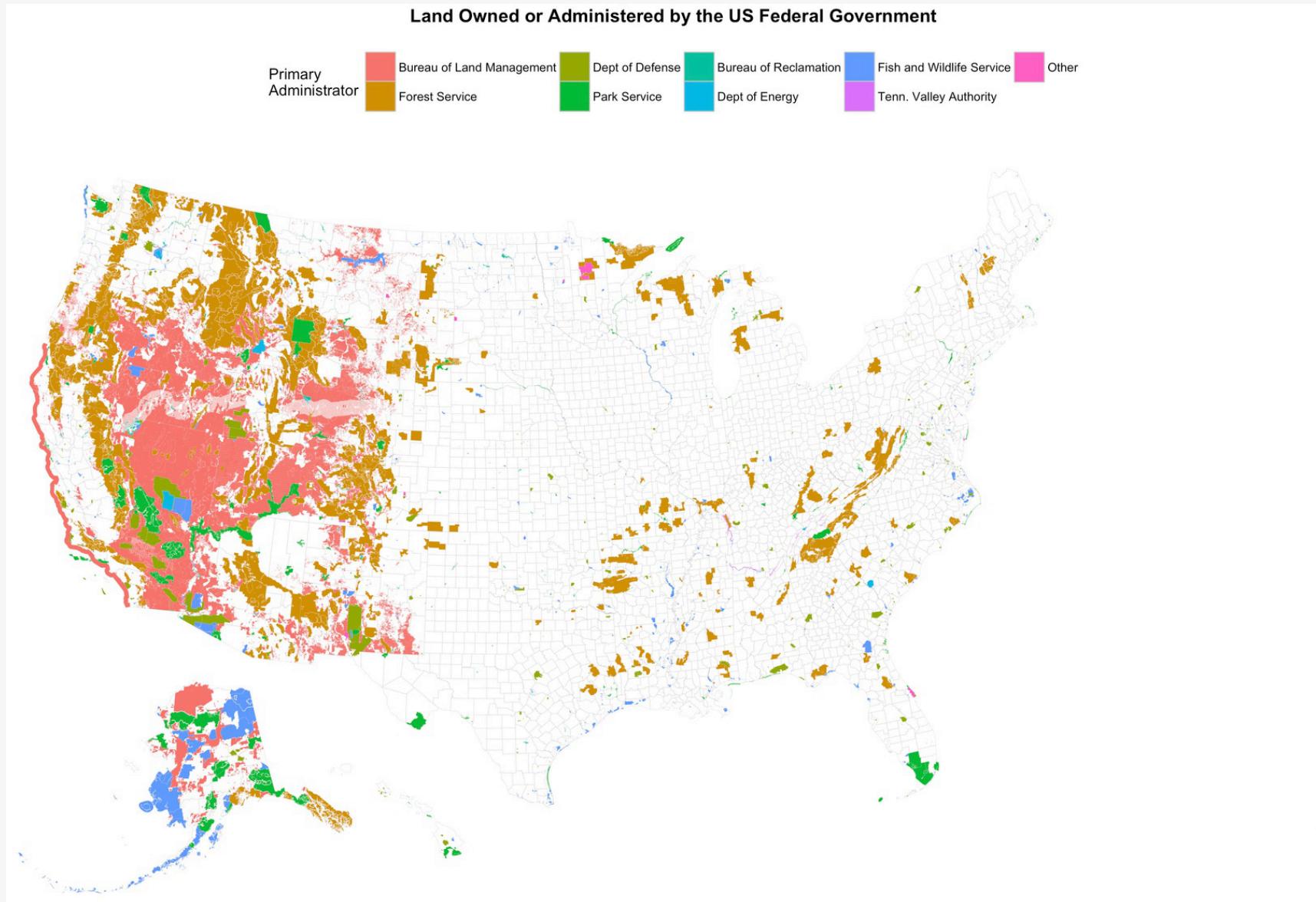
2016 Electoral Vote



Electoral college cartogram (NYT)

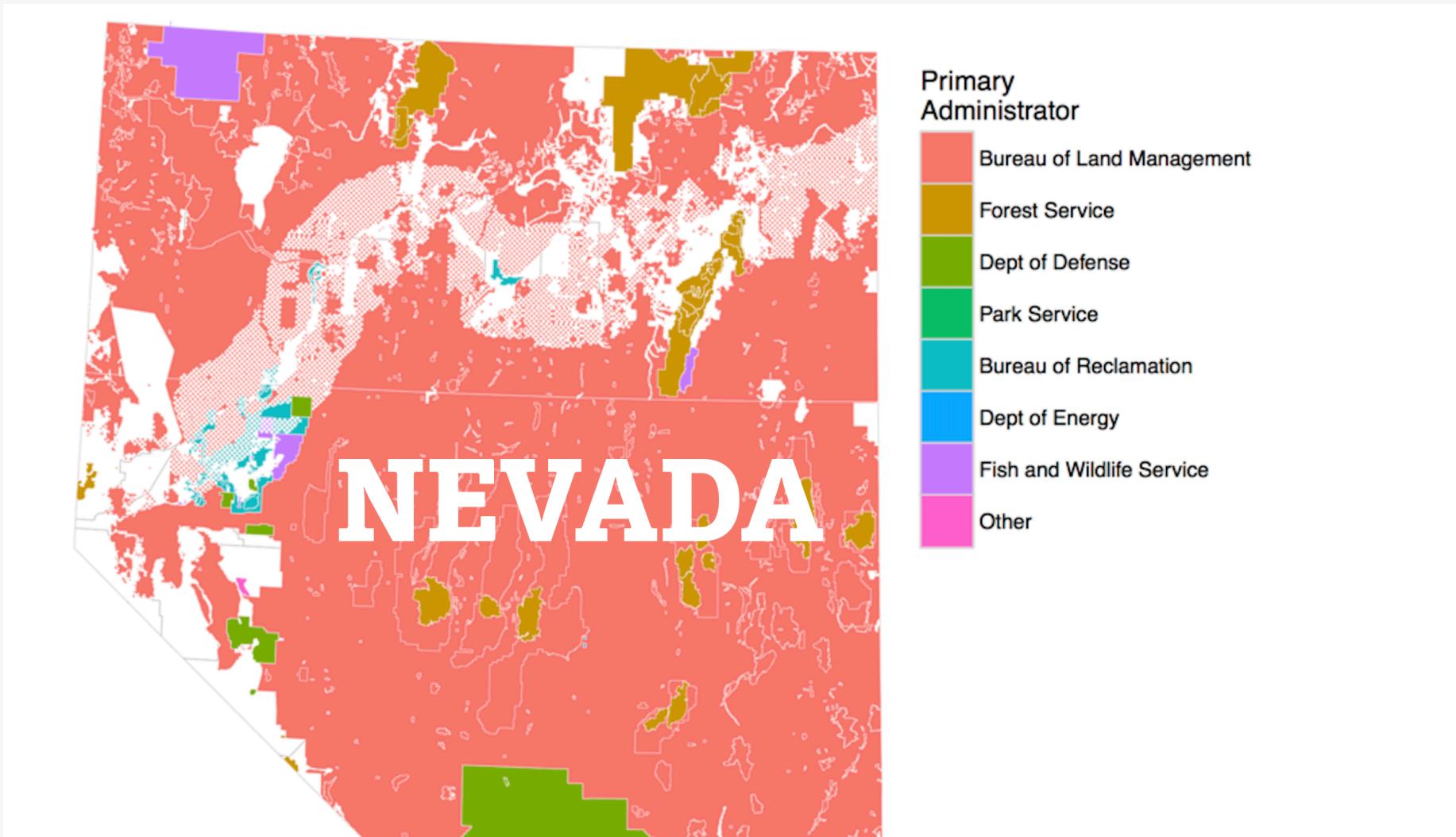


Pretty, Big, and Pretty Empty

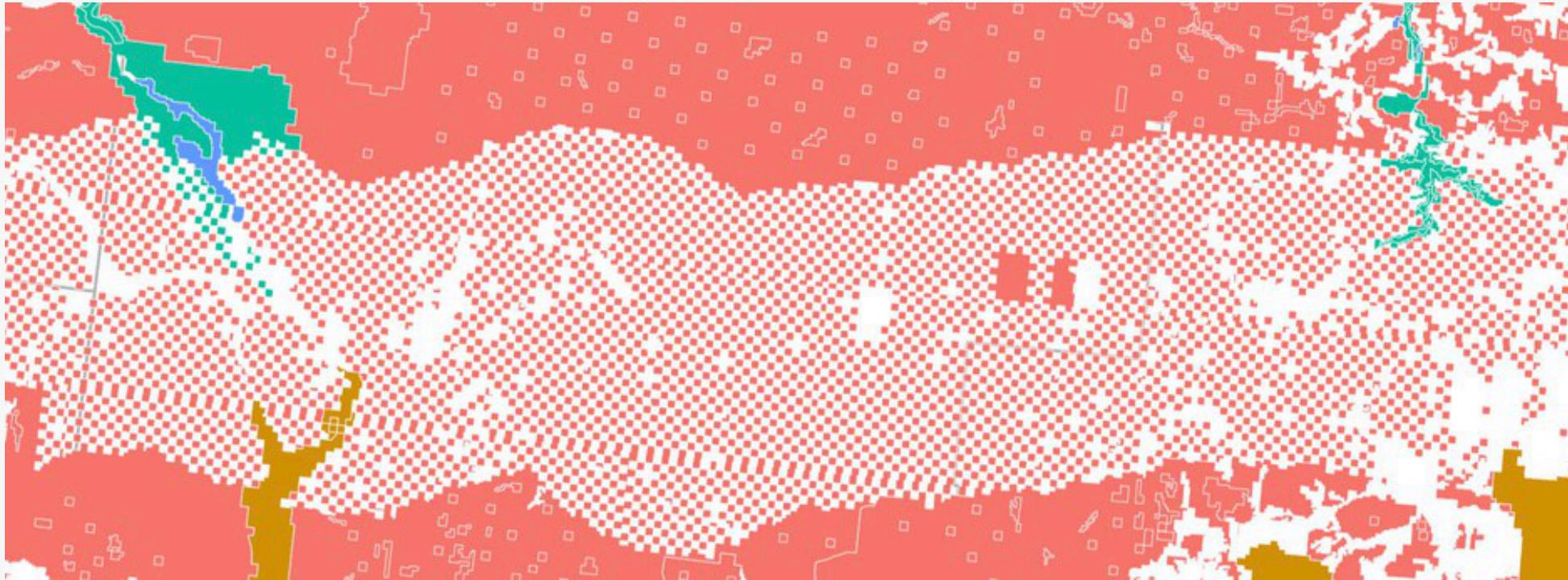


Pretty, Big, and Pretty Empty

Aside: What the hell's that?

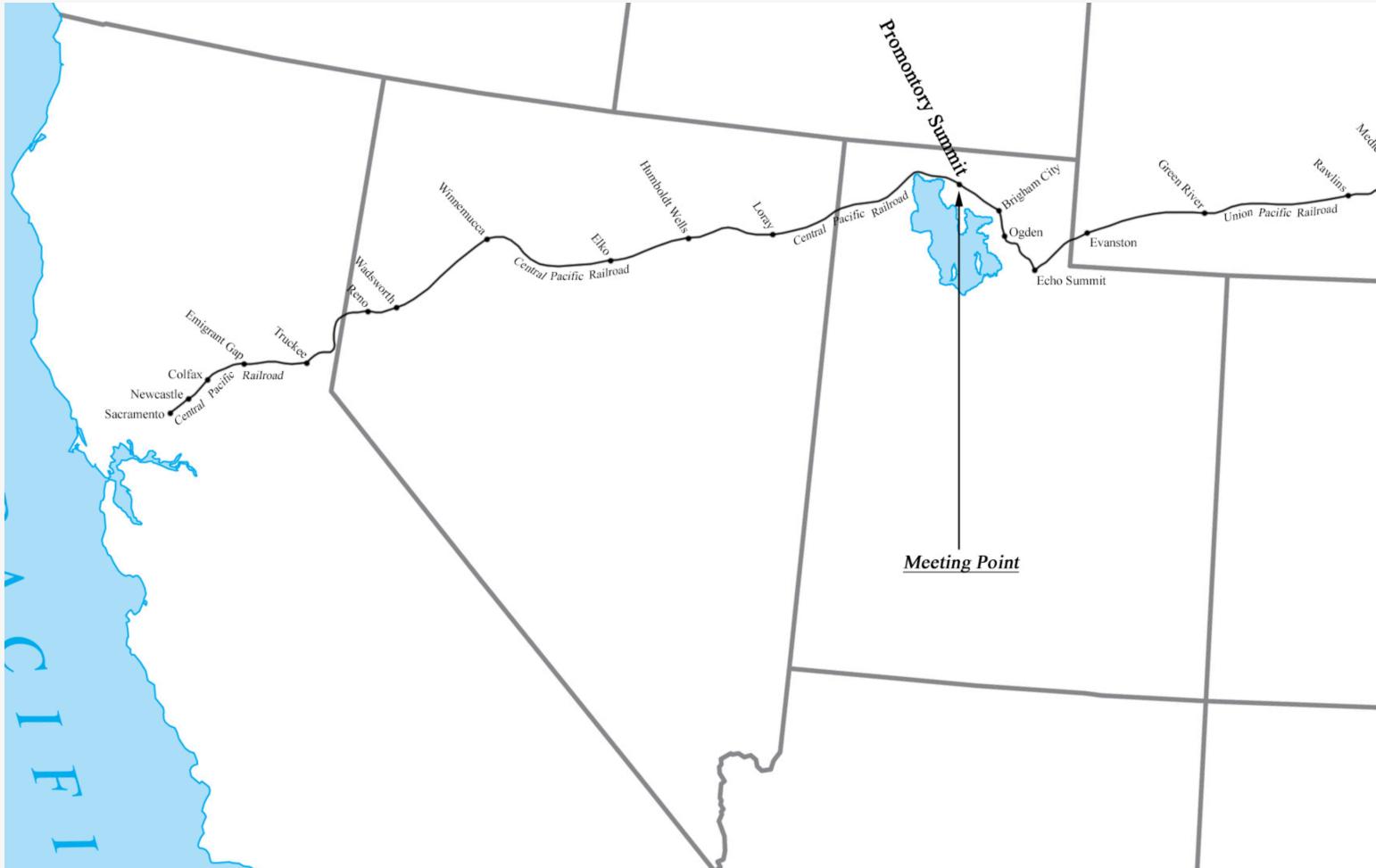


Zoom and Enhance



Surprisingly, 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.

Maps as polygons

Packages

```
library(here)      # manage file paths
library(socviz)    # data and some useful functions
library(tidyverse) # your friend and mine
library(maps)      # Some basic maps
library(ggforce)   # ggplot extensions
```

Take a look at this data

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

```
us_states ← map_data("state")
```

```
dim(us_states)
```

```
[1] 15537      6
```

```
## 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    10    10 alabama <NA>  
# i 15,527 more rows
```

What is this, at root?

```
us_states
```

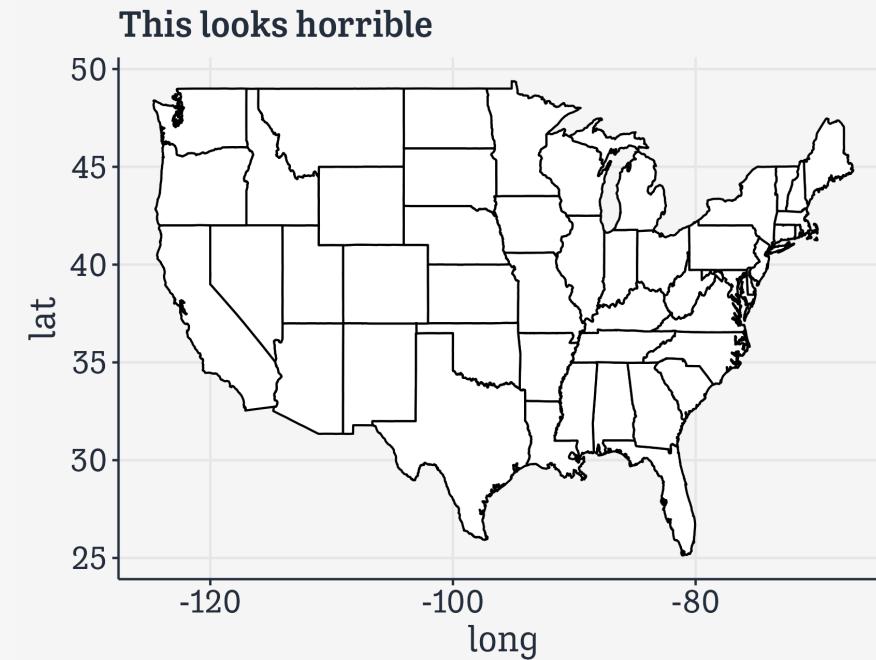
```
# A tibble: 15,537 × 6
  long    lat group order region subregion
  <dbl> <dbl> <dbl> <int> <chr>   <chr>
1 -87.5  30.4     1     1 alabama <NA>
2 -87.5  30.4     1     2 alabama <NA>
3 -87.5  30.4     1     3 alabama <NA>
4 -87.5  30.3     1     4 alabama <NA>
5 -87.6  30.3     1     5 alabama <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` coordinates 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.

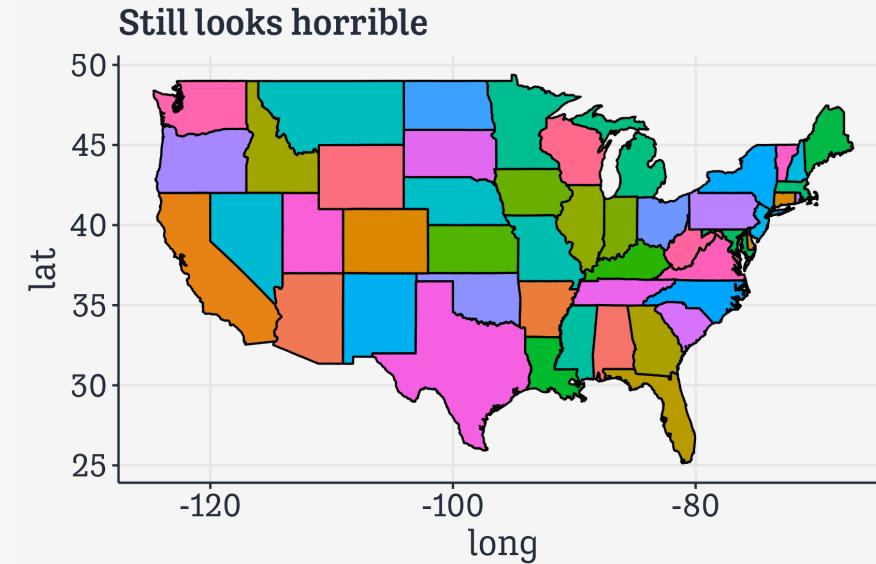
Like this, with `geom_polygon()`

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



We can show 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 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

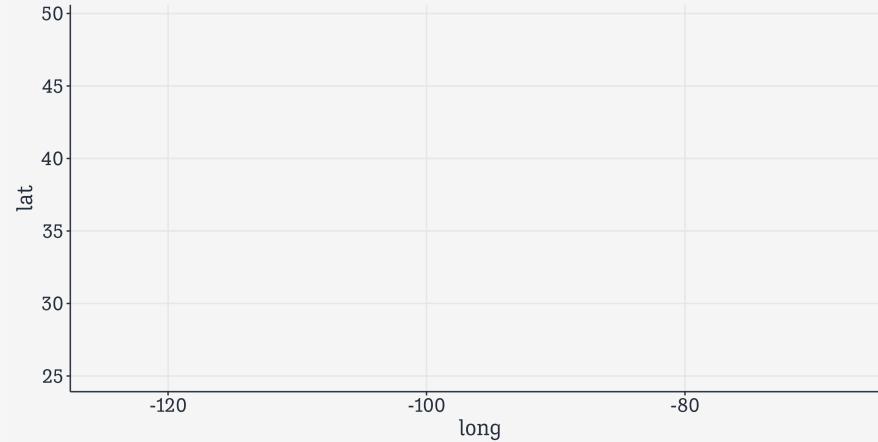
```
us_states ← as_tibble(map_data("state"))
us_states
```

```
# 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"))

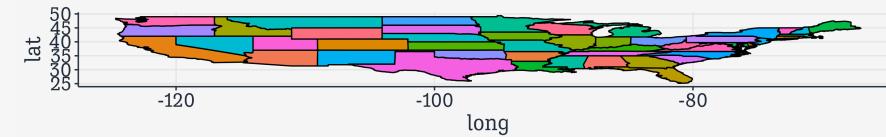
us_states >
  ggplot(mapping = aes(x = long,
                        y = lat,
                        fill = region,
                        group = group))
```



Fix the projection

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

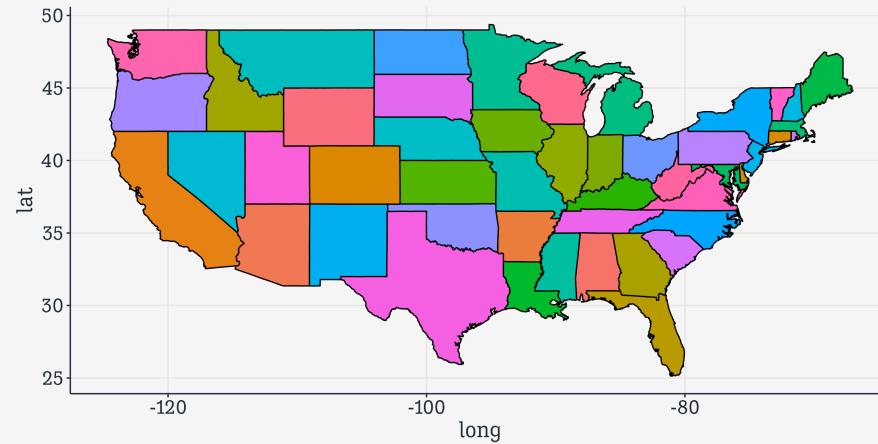
us_states >
  ggplot(mapping = aes(x = long,
                        y = lat,
                        fill = region,
                        group = group)) +
  geom_polygon(color = "black")
```



Fix the projection

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

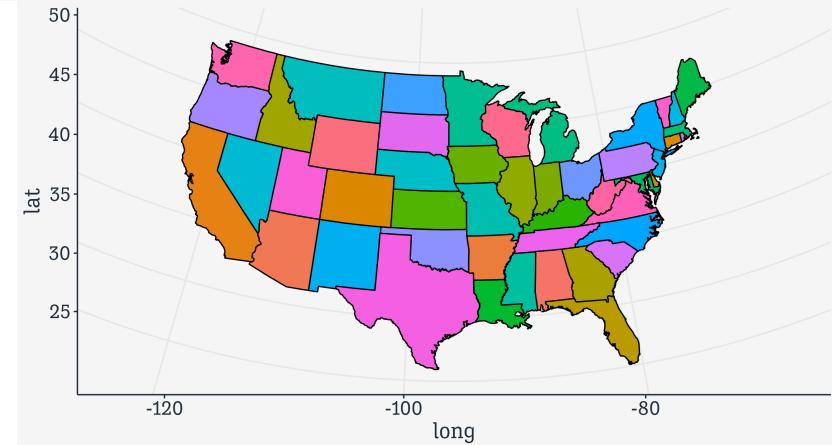
us_states %>
  ggplot(mapping = aes(x = long,
                        y = lat,
                        fill = region,
                        group = group)) +
  geom_polygon(color = "black") +
  guides(fill = "none")
```



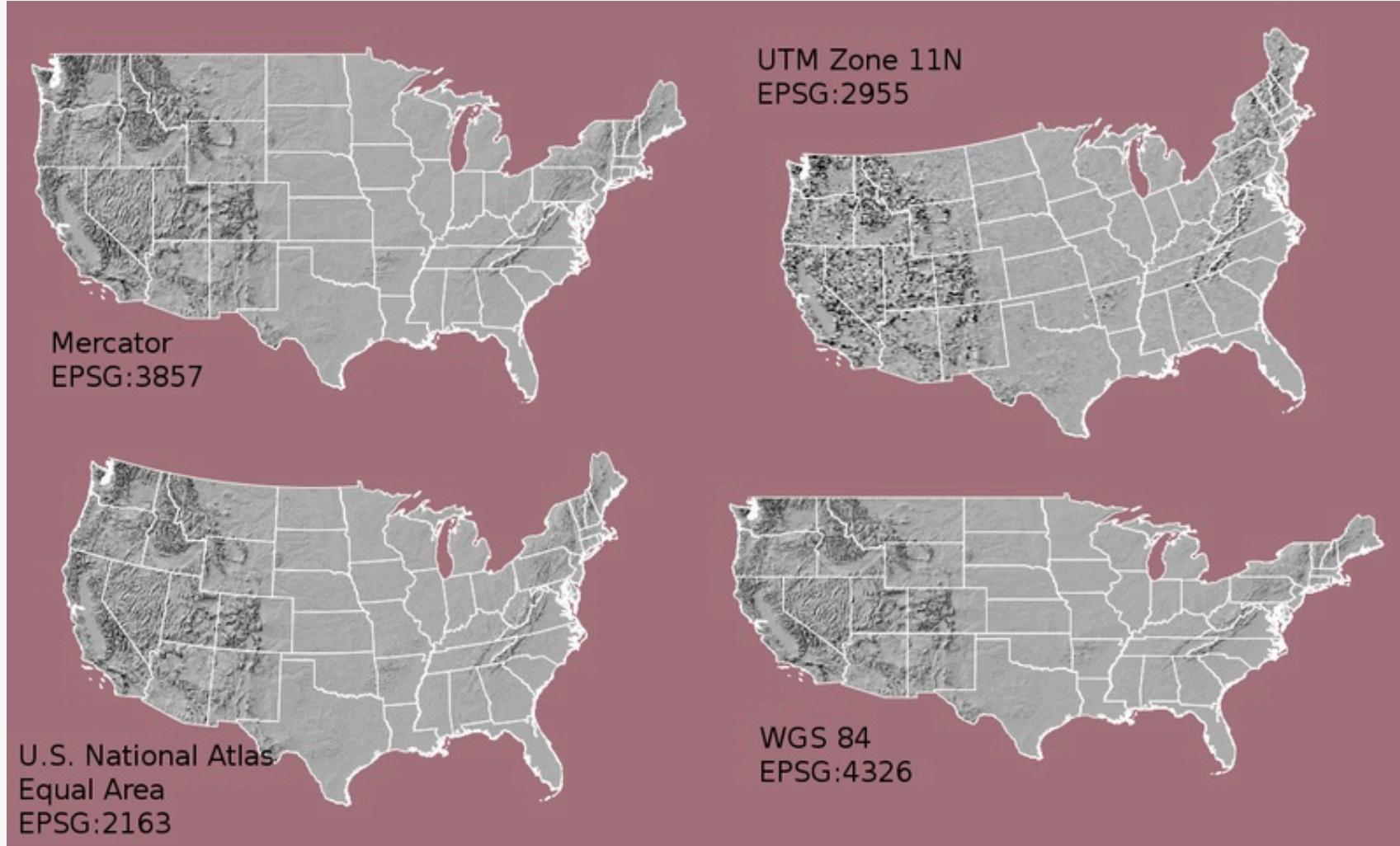
Fix the projection

```
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)
```

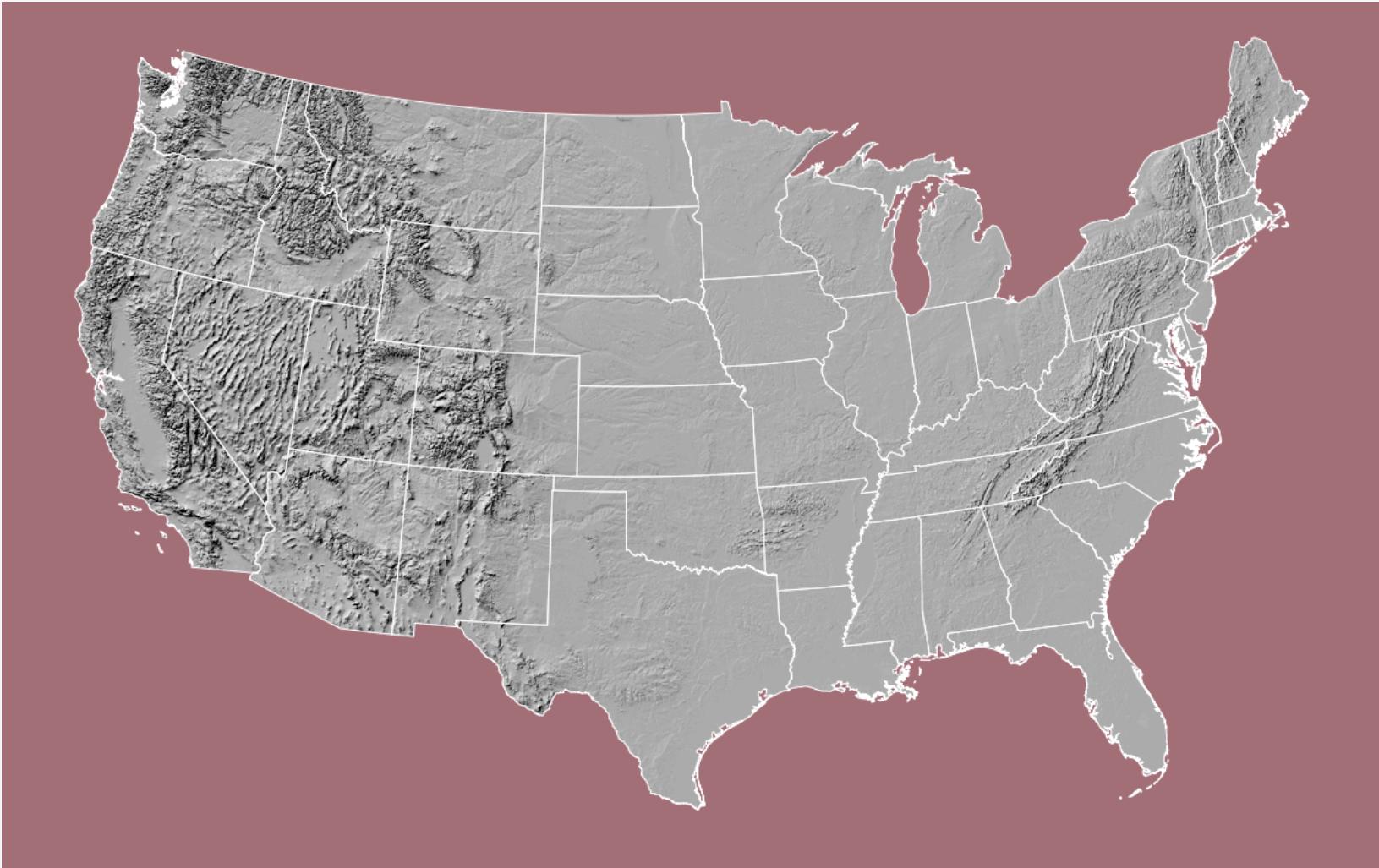


U.S. Map Projections

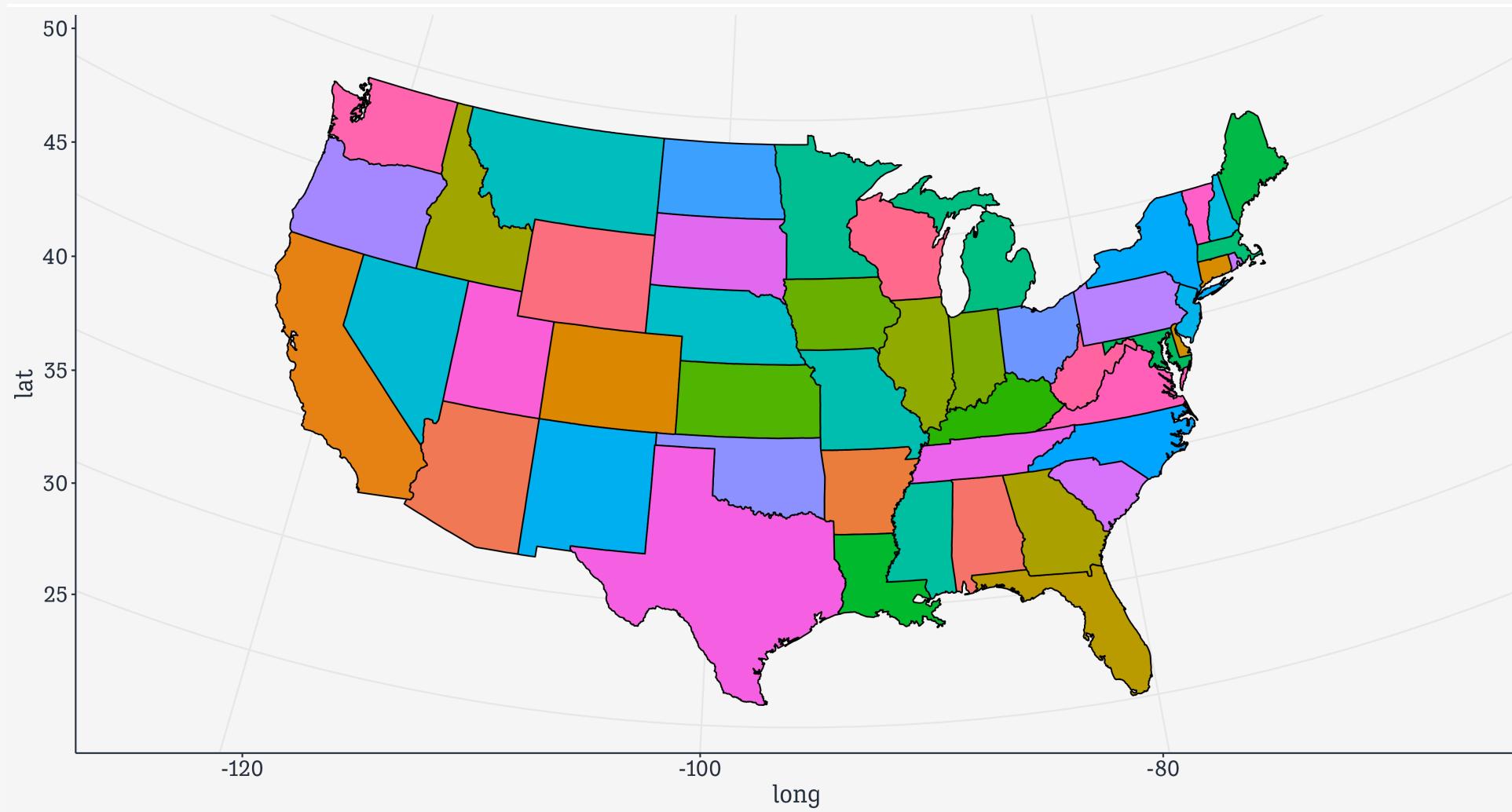


A selection of projections

U.S. Map Projections



Albers is the standard



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
  <chr>     <chr> <dbl>      <dbl>       <dbl>
  winner    party   pct_margin r_points
  <chr>     <chr> <dbl>      <dbl>       <dbl>
  1 Alabama   AL        1  2123372      588708
  Trump     Repu...  0.277     27.7
  2 Alaska    AK        2  318608       46933
  Trump     Repu...  0.147     14.7
  3 Arizona   AZ        4  2604657      91234
  Trump     Repu...  0.035      3.5
  4 Arkansas  AR        5  1130635      304378
  Trump     Repu...  0.269     26.9
  5 Californ... CA        6  14237893     4269978
  Clint...   Demo...  0.300     -30.0
  6 Colorado   CO        8  2780247      136386
  Clint...   Demo...  0.0491    -4.91
  7 Connecti... CT        9  1644920      224357
  Clint...   Demo...  0.136     -13.6
```

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

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
  <chr>        <chr> <chr> <dbl>      <dbl>
1 alabama     Alab... AL 1 2123372
2 alaska       Alas... AK 2 318608
3 arizona      Ariz... AZ 4 2604657
4 arkansas     Arka... AR 5 1130635
5 california   Cali... CA 6 14237893
6 colorado     Colo... CO 8 2780247
7 connecticut  Conn... CT 9 1644920
8 connecticut  Conn... CT 9 1644920
9 connecticut  Conn... CT 9 1644920
10 connecticut Conn... CT 9 1644920
# i 41 more rows
```

This is a *left join*

```
us_states_elec ← left_join(us_states, election, by = "region")

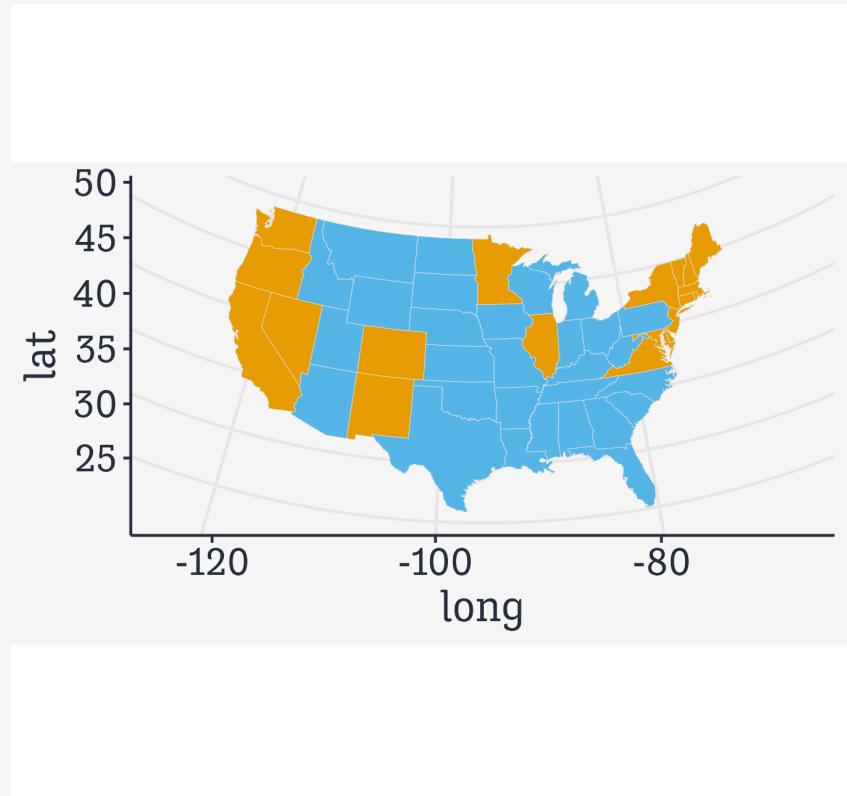
us_states_elec

# 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.

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")
```



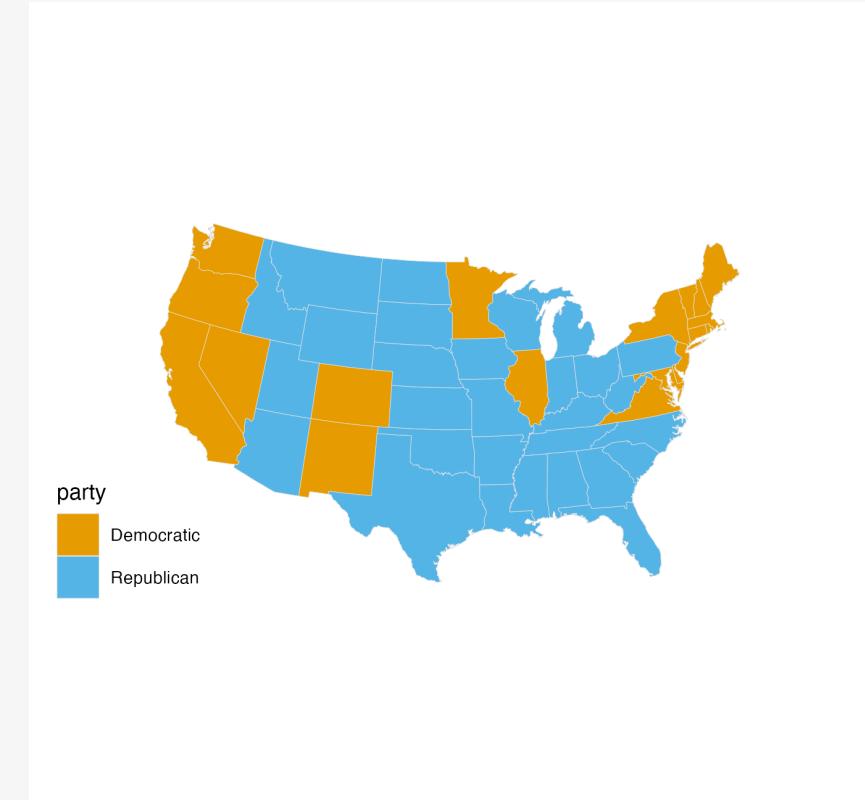
Let's turn off the gridlines

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)  
    )  
}
```

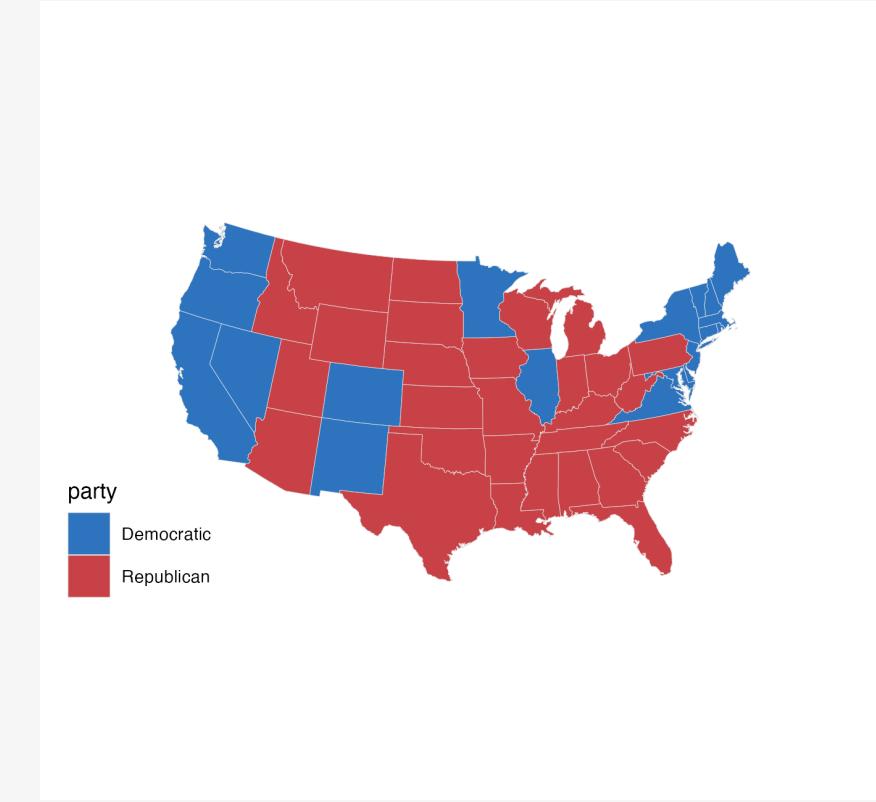
Add the theme function at the end

```
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()
```



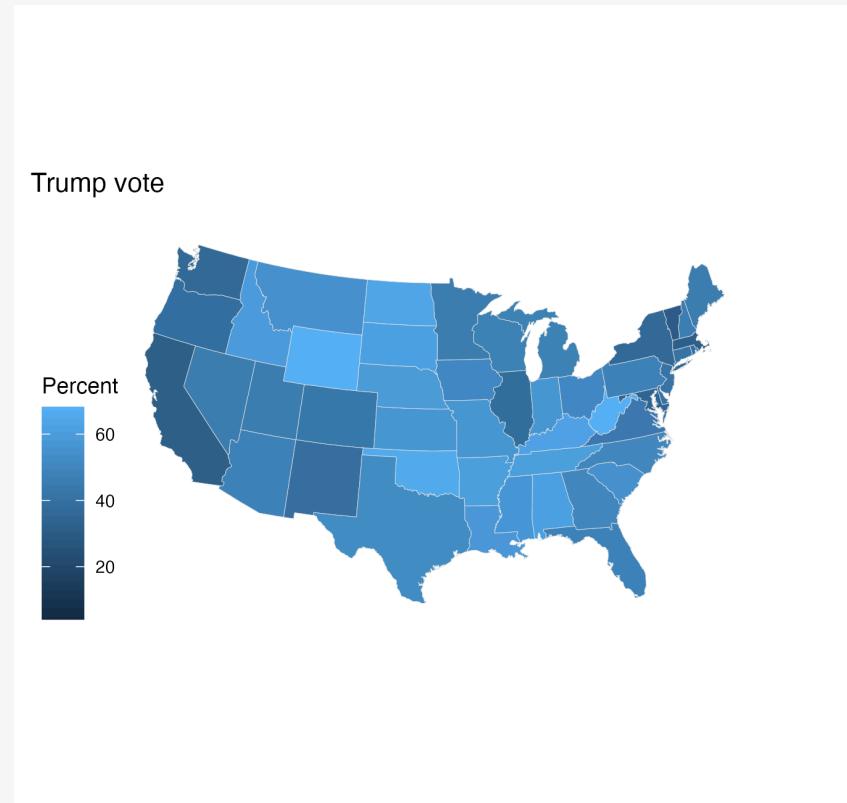
Fix the Party Colors

```
## Hex color codes for Democratic Blue and Repu  
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()
```



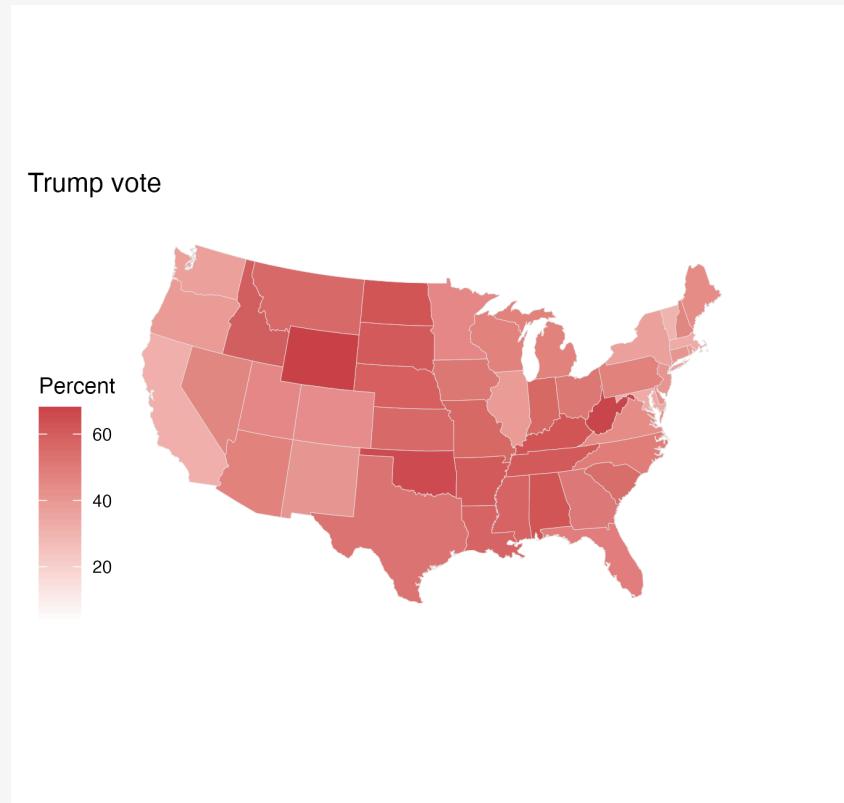
Continuous measures are *gradients*

```
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()
```



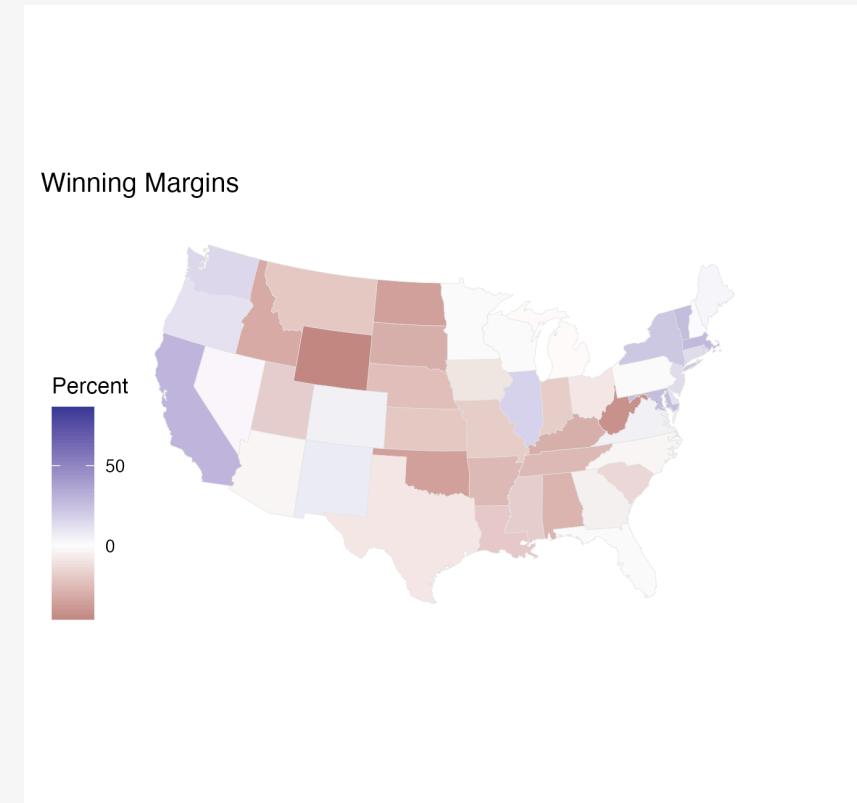
Fix the gradient with a `scale` function

```
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()
```



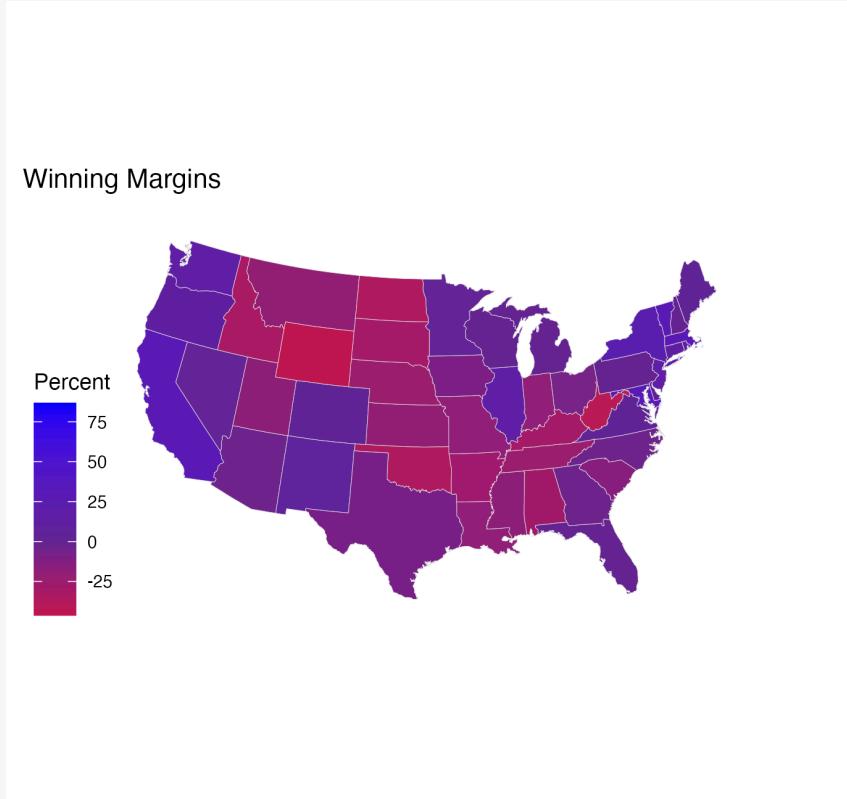
Some gradients are *diverging*

```
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()
```

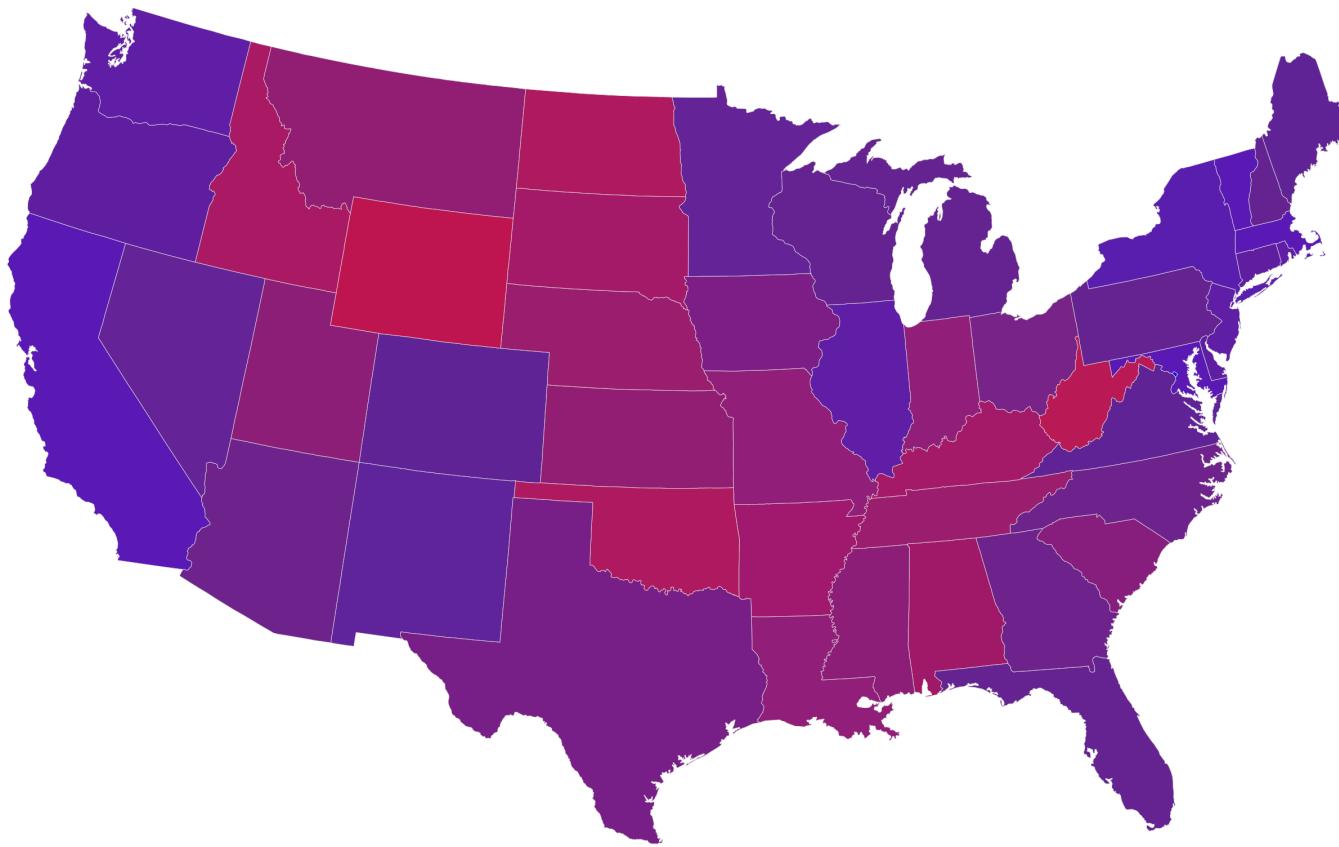


Purple America Map

```
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()
```



Winning Margins



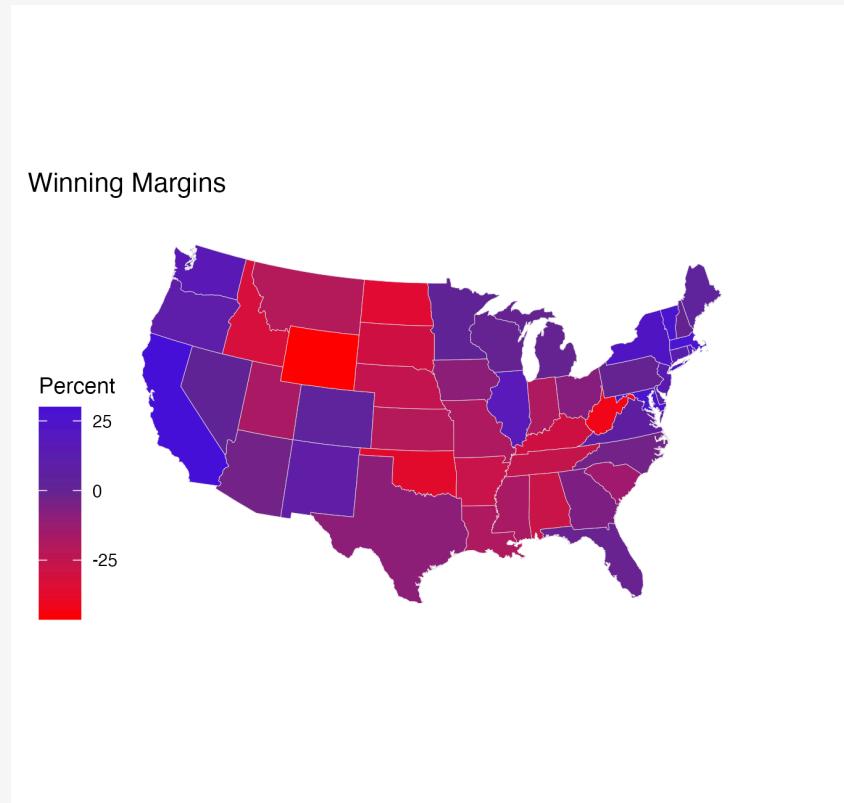
Take a closer look at this, though.



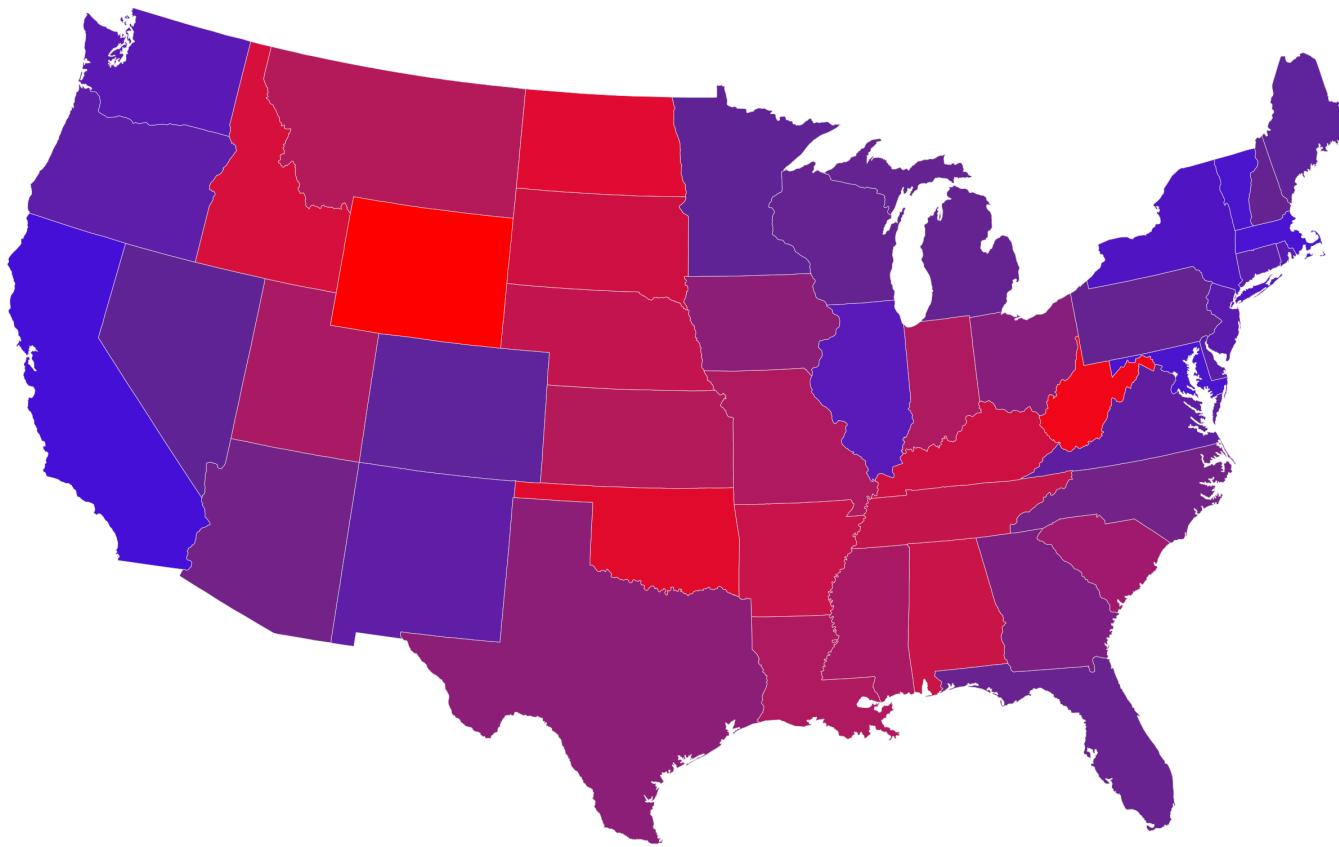
Washington, DC

Purple America Map, without DC

```
us_states_elec %>
  filter(region %in% "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()
```



Winning Margins



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

```
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>,
```

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 01027 Clay County    AL   [ 10,   50) [10.0,15.0)  
2 21145 McCracken County KY   [ 100,  500) [10.0,15.0)  
3 48103 Crane County   TX   [    0,   10) [ 2.0,  5.0)  
4 53013 Columbia County WA   [    0,   10) [ 0.0,  2.0)  
5 46061 Hanson County   SD   [    0,   10) [ 0.0,  2.0)  
6 37159 Rowan County    NC   [ 100,  500) [15.0,25.0)  
7 47131 Obion County    TN   [   50,  100) [10.0,15.0)  
8 18025 Crawford County IN   [  10,   50) [ 0.0,  2.0)  
9 39117 Morrow County   OH   [   50,  100) [ 0.0,  2.0)  
10 27021 Cass County    MN   [   10,   50) [ 0.0,  2.0)
```

Joined table

```
county_full ← as_tibble(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>,
```

County Population Density

```
county_full ← as_tibble(left_join(county_map, county_data, by = "id"))
```

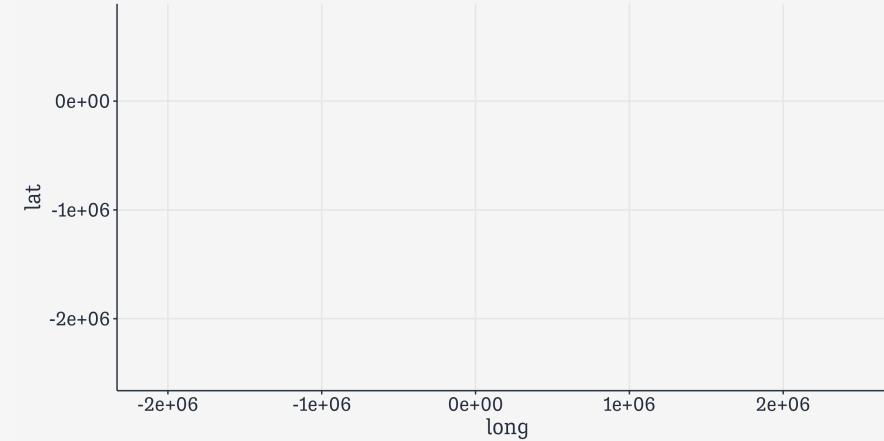
County Population Density

```
county_full ← as_tibble(left_join(county_map, county_data, by = "id")  
county_full
```

```
# A tibble: 191,382 × 38  
      long      lat order hole piece group     id    name state  
  <dbl>   <dbl> <int> <lgl> <fct> <fct>   <chr> <chr> <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
```

County Population Density

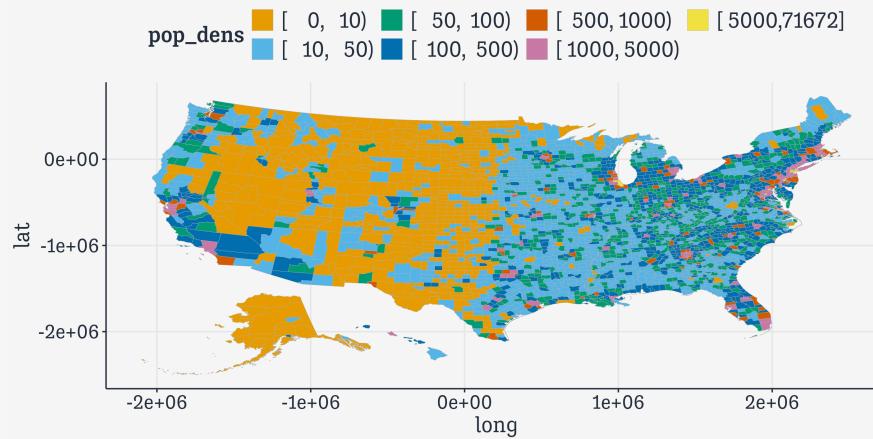
```
county_full <- as_tibble(left_join(county_map, county_data, by = "id")  
  
county_full %>%  
  ggplot(mapping = aes(x = long, y = lat,  
                      fill = pop_dens,  
                      group = group))
```



County Population Density

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

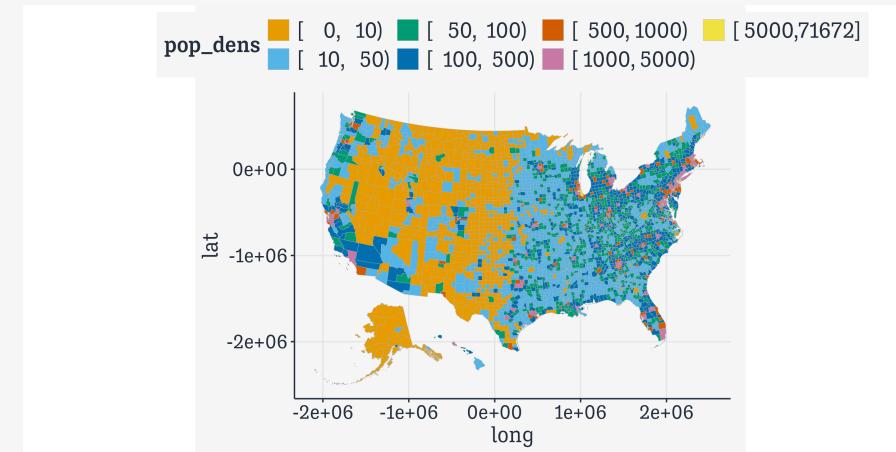
county_full %>%
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pop_dens,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1)
```



County Population Density

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

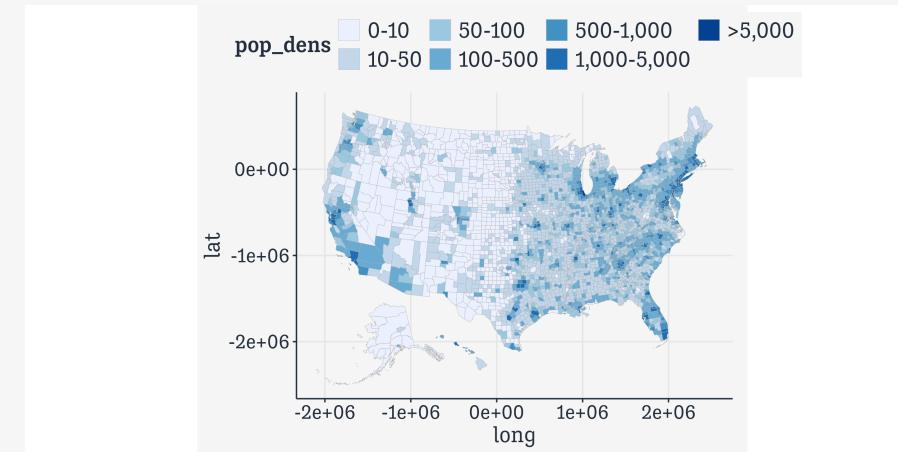
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pop_dens,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed()
```



County Population Density

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

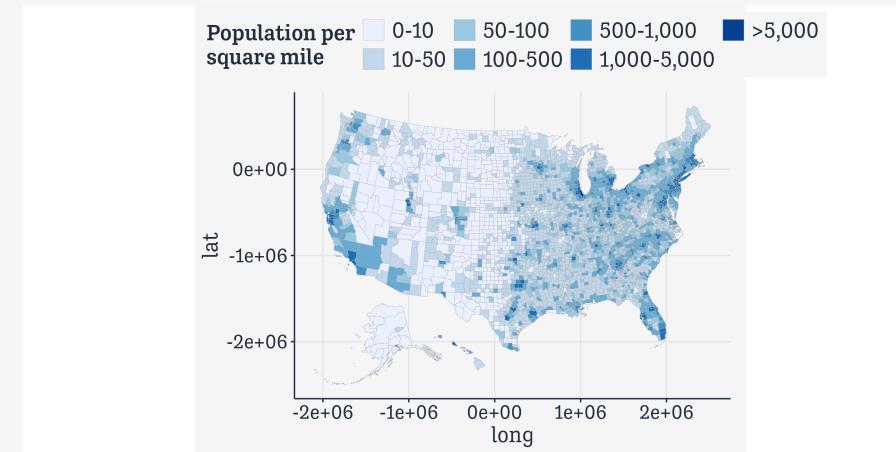
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pop_dens,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Blues",
                    labels = c("0-10", "10-50",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



County Population Density

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

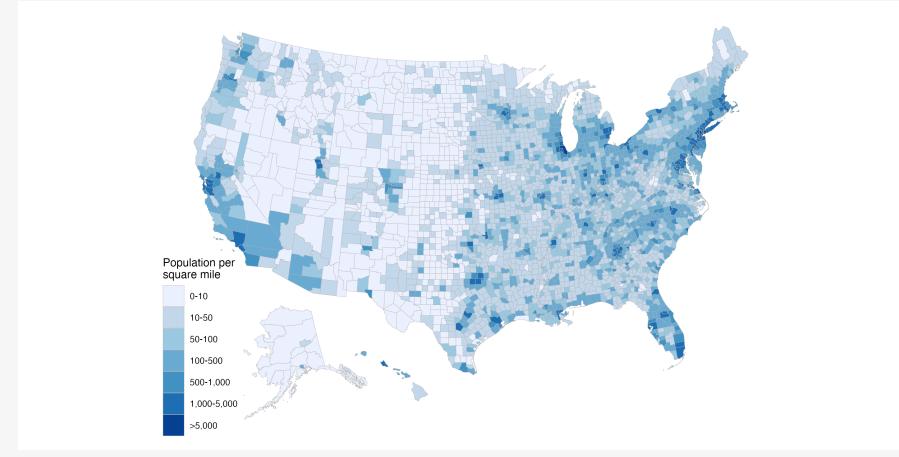
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pop_dens,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Blues",
                    labels = c("0-10", "10-50",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



County Population Density

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

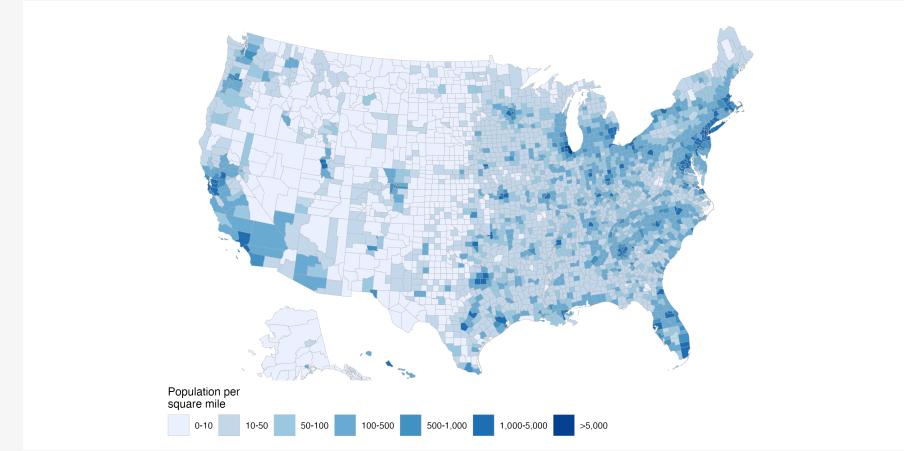
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pop_dens,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Blues",
                    labels = c("0-10", "10-50",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



County Population Density

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

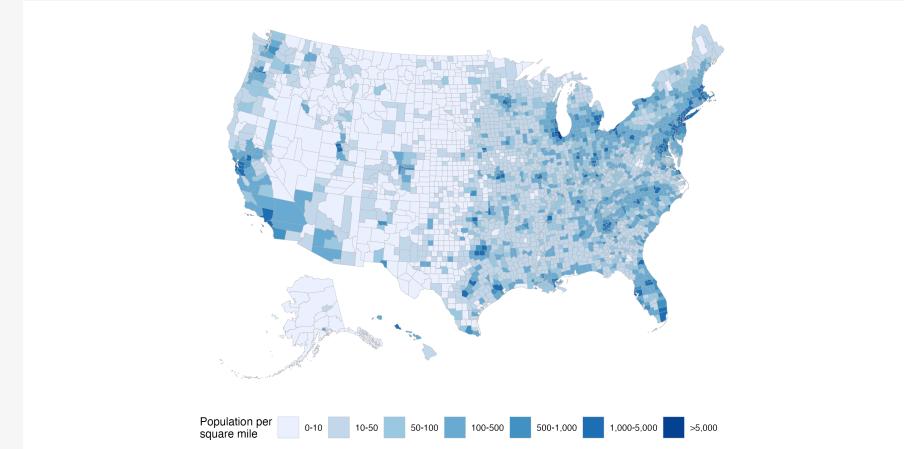
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pop_dens,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Blues",
                    labels = c("0-10", "10-50",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

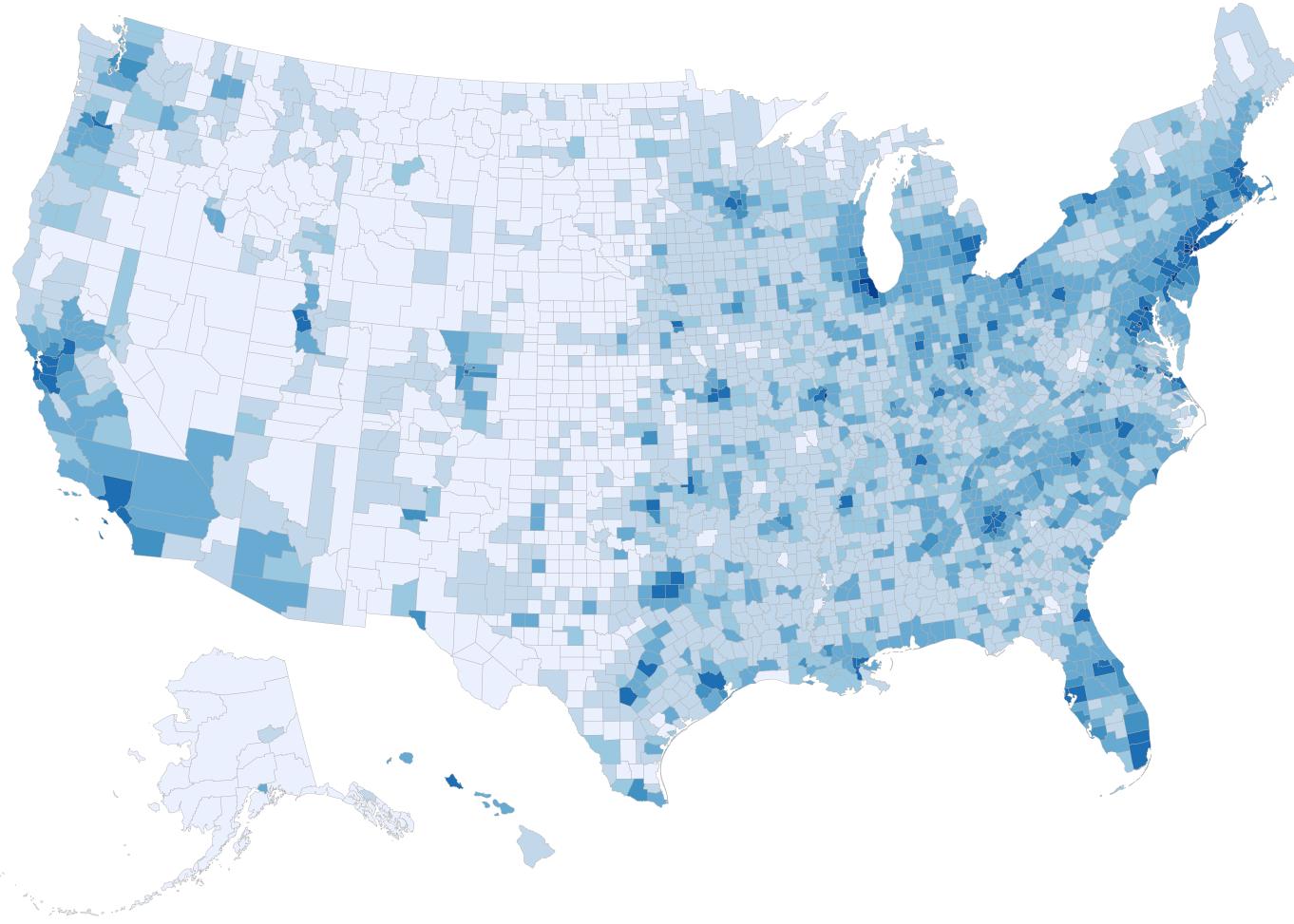


County Population Density

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

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", "50-100",
                              "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 ← as_tibble(left_join(county_map, county_data, by = "FIPS"))
```

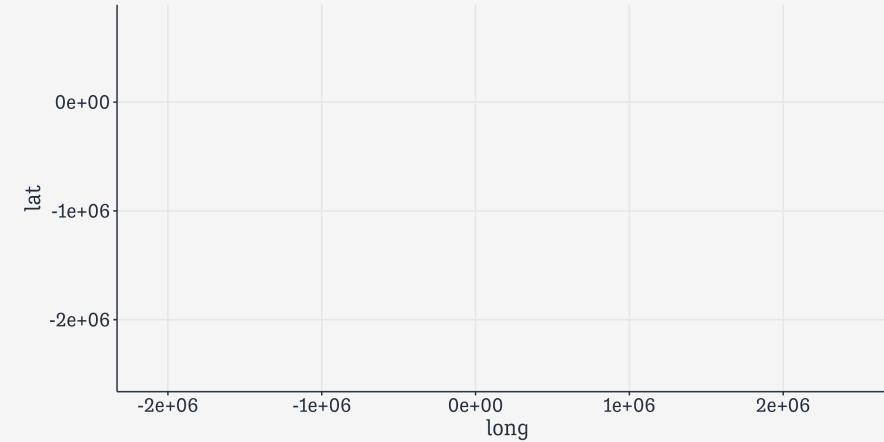
Same again for Percent Black

```
county_full ← as_tibble(left_join(county_map, county_data, by = "id"))  
county_full
```

```
# A tibble: 191,382 × 38  
      long      lat order hole piece group     id    name state  
  <dbl>   <dbl> <int> <lgl> <fct> <fct>   <chr> <chr> <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
```

Same again for Percent Black

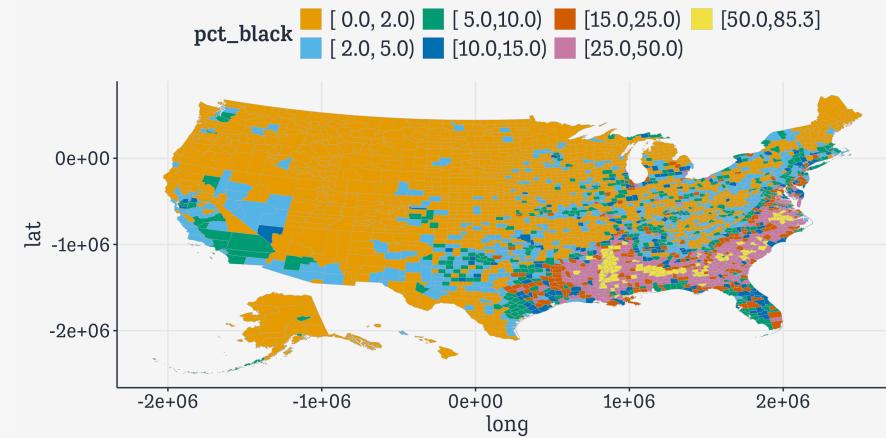
```
county_full <- as_tibble(left_join(county_map, county_data, by = "id")  
  
county_full %>%  
  ggplot(mapping = aes(x = long, y = lat,  
                      fill = pct_black,  
                      group = group))
```



Same again for Percent Black

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

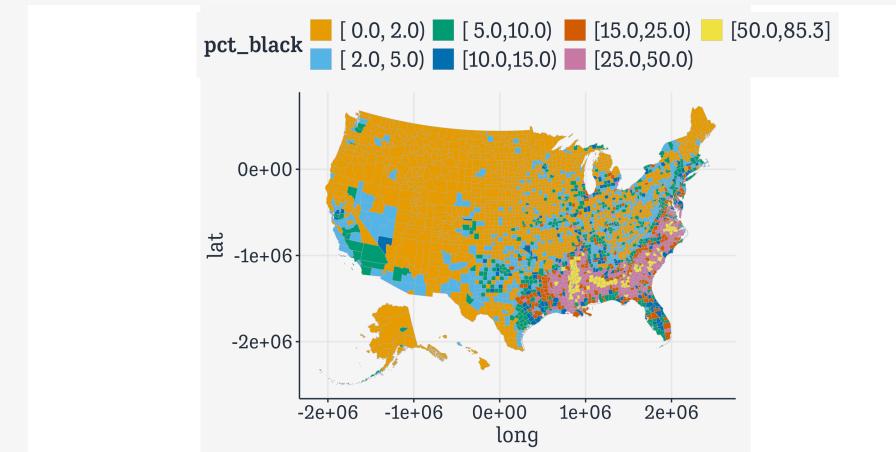
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pct_black,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1)
```



Same again for Percent Black

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

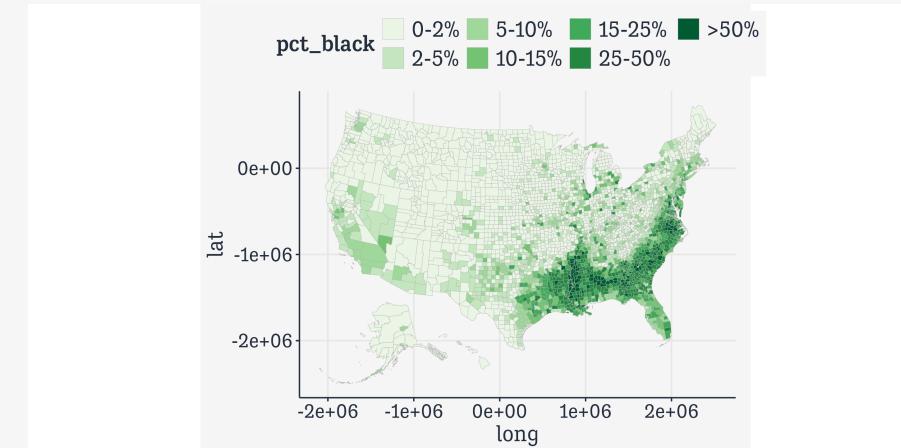
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pct_black,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed()
```



Same again for Percent Black

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

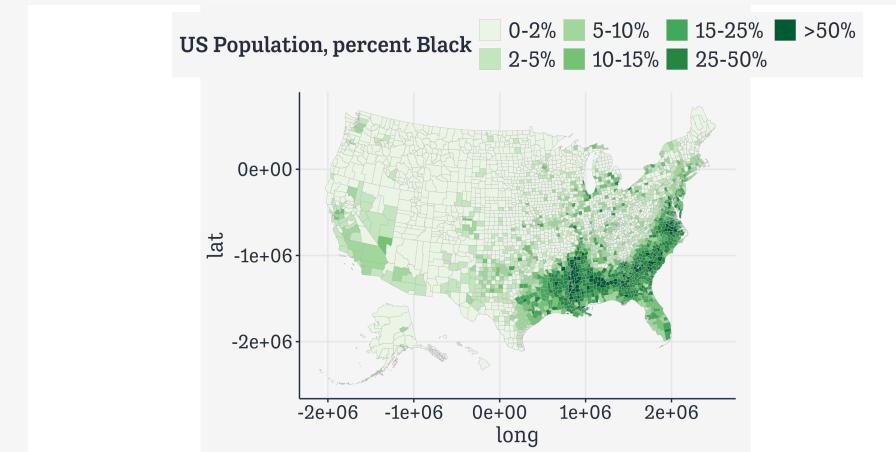
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pct_black,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Greens",
                    labels = c("0-2%", "2-5%",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



Same again for Percent Black

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

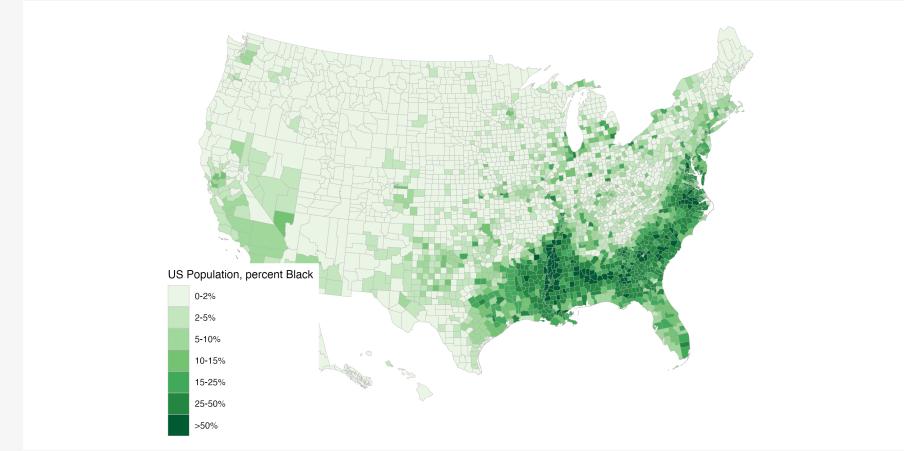
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pct_black,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Greens",
                    labels = c("0-2%", "2-5%",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



Same again for Percent Black

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

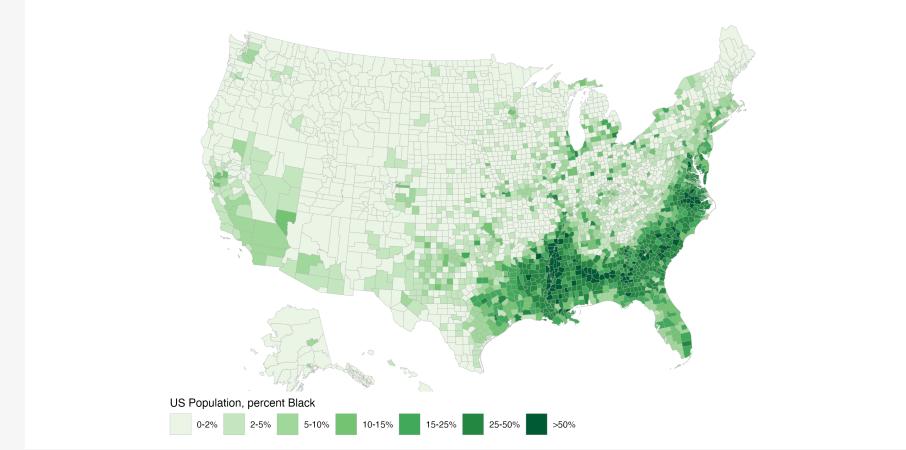
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pct_black,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Greens",
                    labels = c("0-2%", "2-5%",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



Same again for Percent Black

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

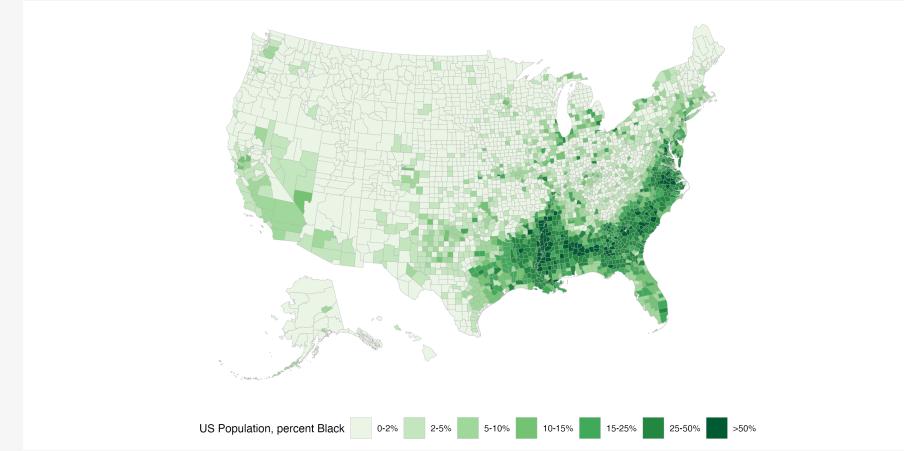
county_full %>
  ggplot(mapping = aes(x = long, y = lat,
                        fill = pct_black,
                        group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_brewer(palette="Greens",
                    labels = c("0-2%", "2-5%",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

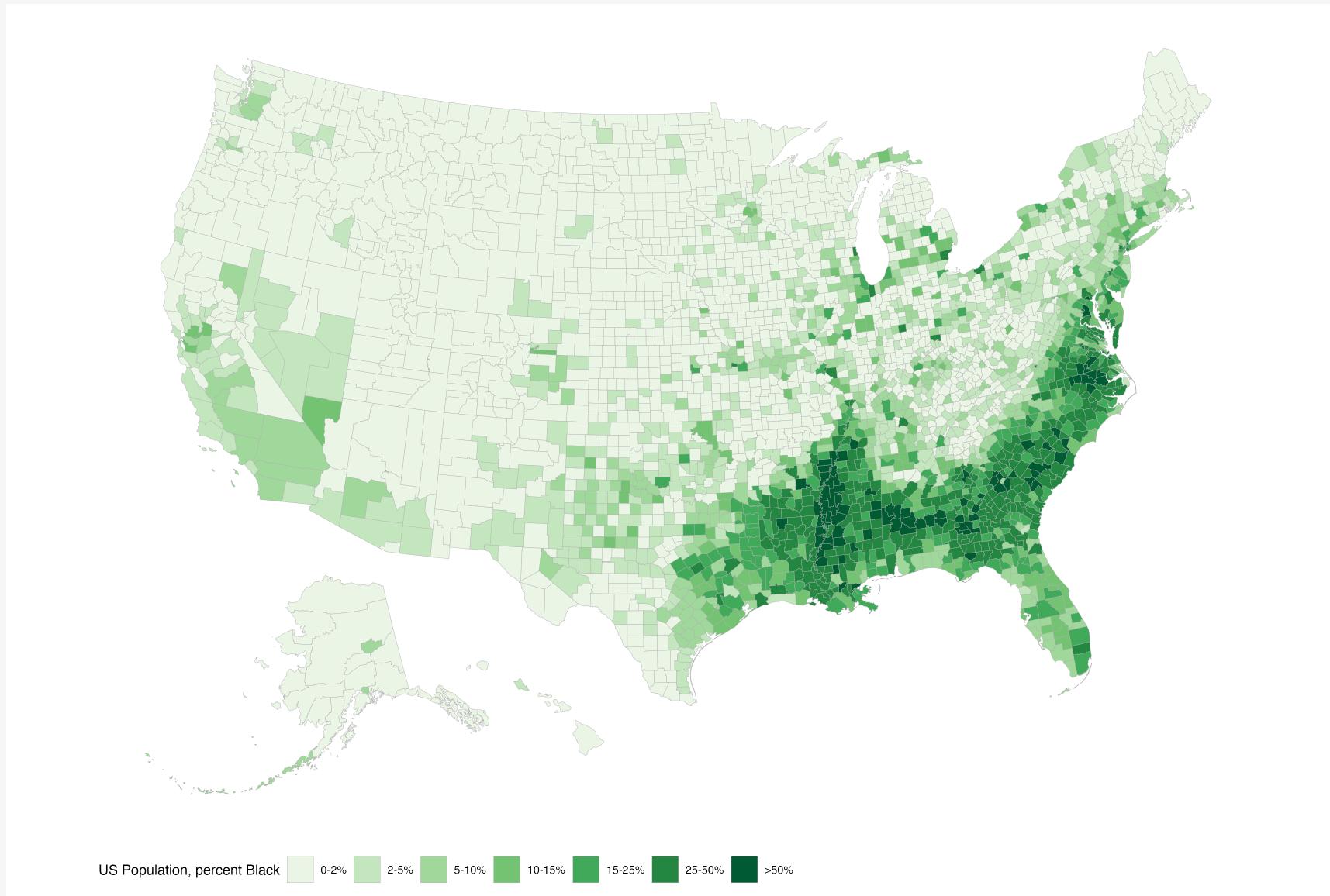


Same again for Percent Black

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

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%",
                              "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, few people, rare events

Example: Reverse coding

Code Reverse

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

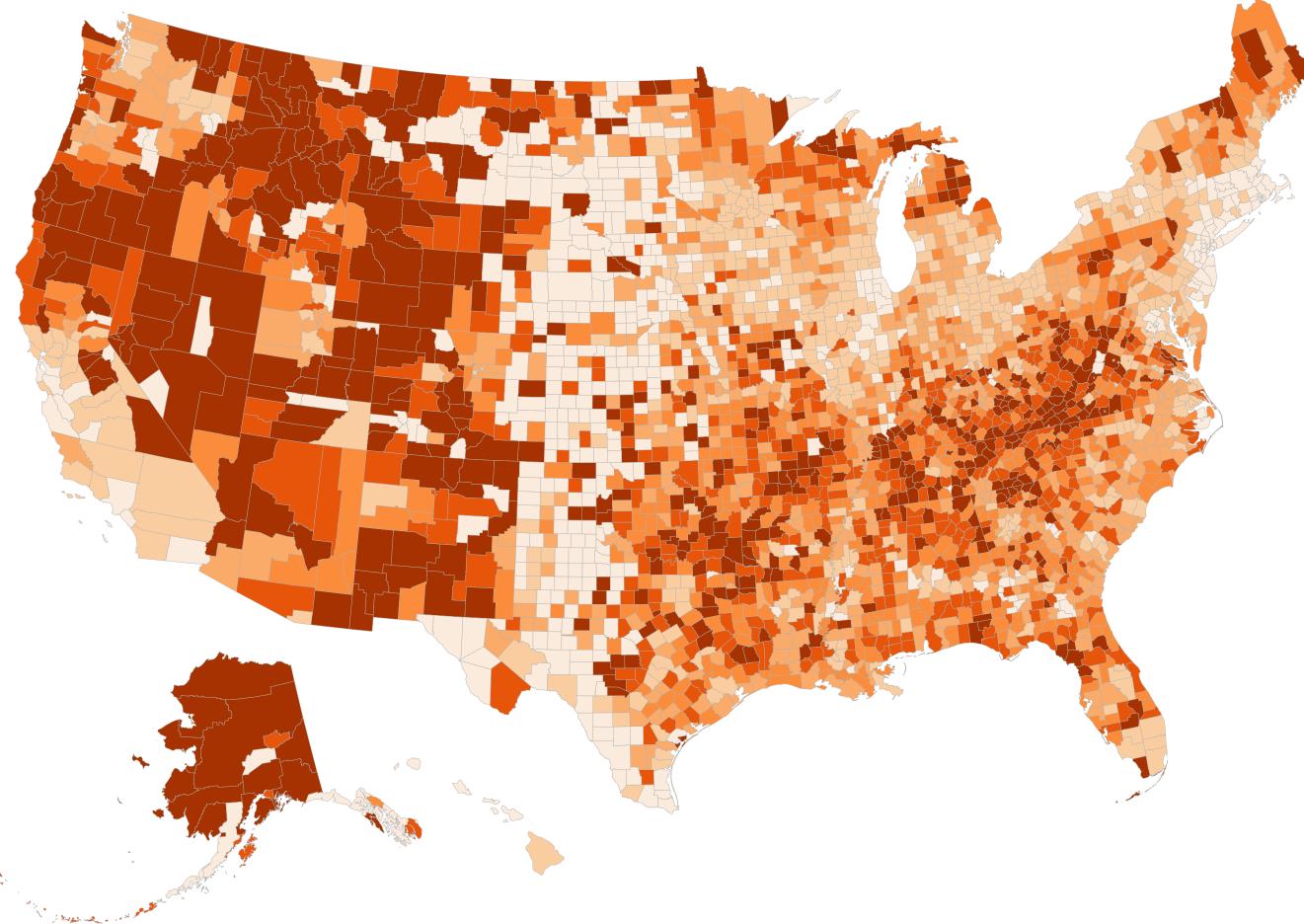
```
[1] "#FEEDDE" "#FDD0A2" "#FDAE6B" "#FD8D3C" "#E6550D" "#A63603"
```



Build a plot

```
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")
```

Gun-Related Suicides, 1999-2015

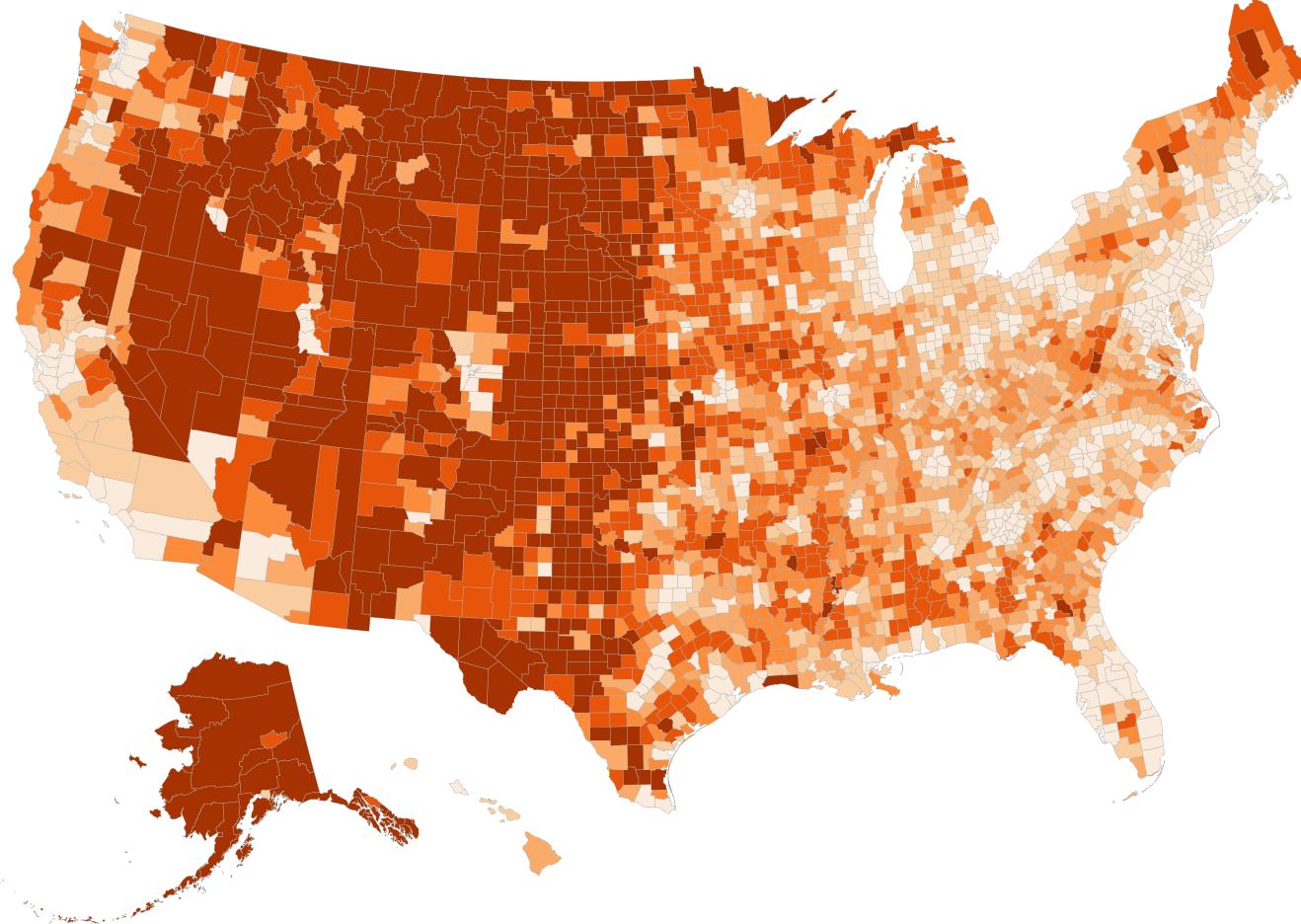


Regular palette

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 Population Density

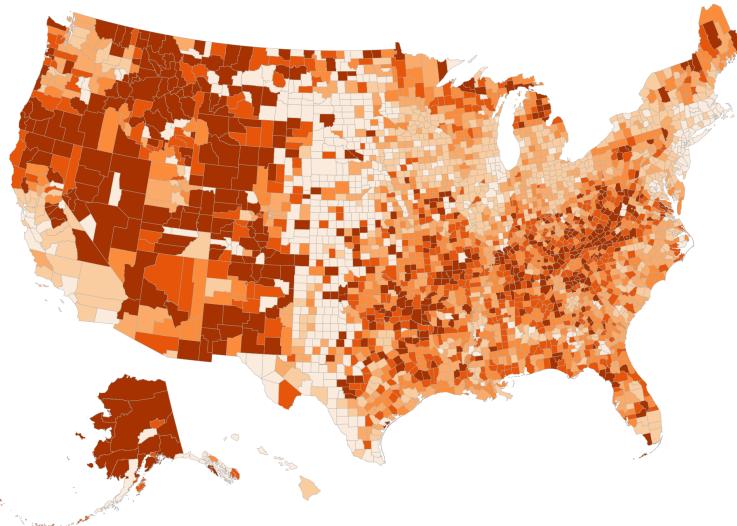


Persons per square mile [0, 9] [9, 25] [25, 45] [45, 82] [82, 215] [215,71672]

Reverse-coded density

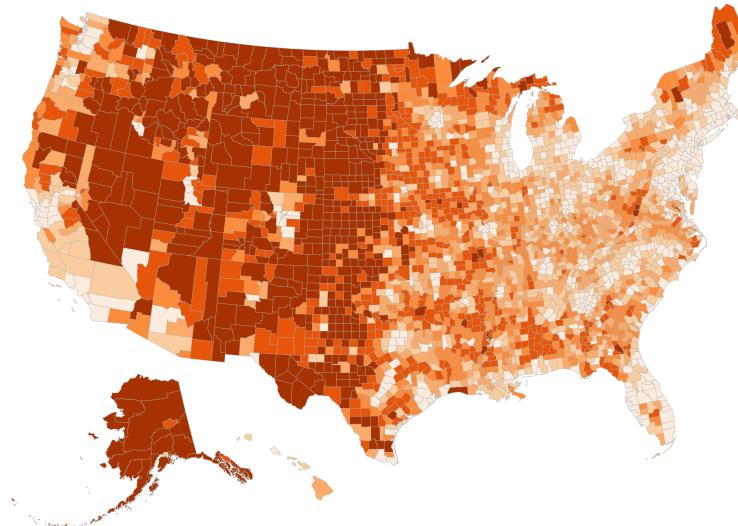
Comparison

Gun-Related Suicides, 1999-2015



Rate per 100,000 pop. [0, 4] [4, 7] [7, 8] [8, 10] [10, 12] [12, 54]

Reverse-coded Population Density



Persons per square mile [0, 9] [9, 25] [25, 45] [45, 82] [82, 215] [215, 71672]

Small multiples for maps

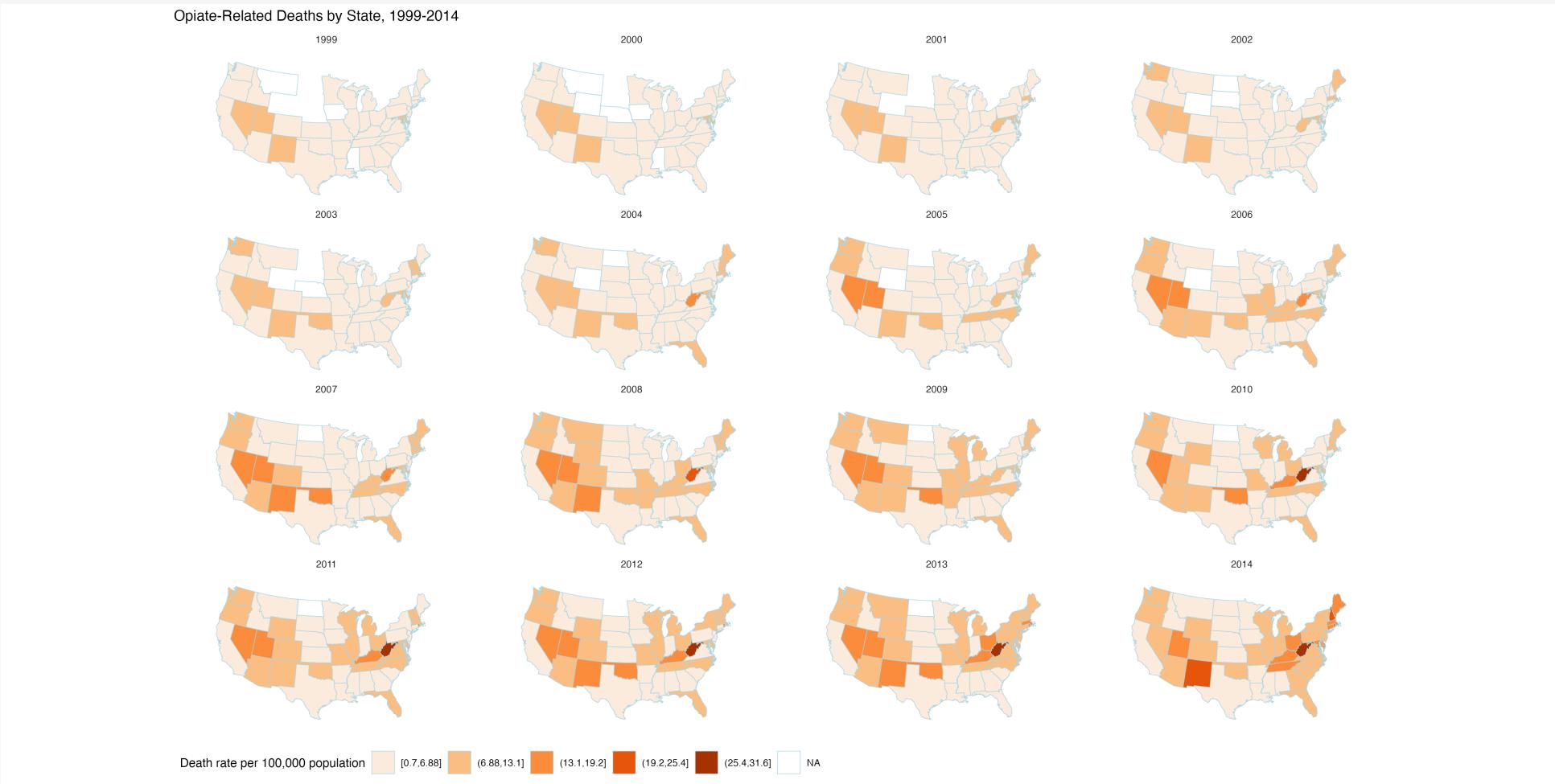
Opiate-related Mortality, 1999-2014

```
opiates
```

```
# A tibble: 800 × 11
  year state    fips deaths population crude adjusted adjusted_se region abbr
  <int> <chr>   <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>
```

```
opiates$state ← tolower(opiates$state)
us_states$state ← us_states$region
opiates_map ← left_join(us_states, opiates, by = "state")
```

```
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

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

```
# A tibble: 800 × 11  
#>   year state    fips deaths population crude adjusted  
#>   <int> <chr>    <int>  <int>     <dbl>    <dbl>    <dbl>  
#>   adjusted_se region abbr  
#>   <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>
```

The two leading states in each region in 2014

```
## 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  
  <int> <chr>  <int>  <int>    <dbl>    <dbl>  
1 2014 alabama 1 270 4849377 5.6 5.6  
0.3 South AL  
2 2014 alaska 2 76 736732 10.3 10.6  
1.2 West AK  
3 2014 arizona 4 589 6731484 8.7 8.8  
0.4 West AZ  
4 2014 arkans... 5 173 2966369 5.8 6.3  
0.5 South AR  
5 2014 califo... 6 2024 38802500 5.2 5  
0.1 West CA  
6 2014 colora... 8 517 5355866 9.7 9.4  
0.4 West CO  
7 2014 connec... 9 525 3596677 14.6 15.2  
0.7 North... CT  
8 2014 delawa... 10 124 935614 13.3 13.9  
1.3 South DE  
9 2014 florida 12 1399 19893297 7 7.2  
0.2 South FL  
10 2014 georgia 13 710 10097343 7 7  
0.3 South GA  
# i 40 more rows  
# i 1 more variable: division_name <chr>
```

The two leading states in each region in 2014

```
## 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  
  <int> <chr>    <int>  <int>      <dbl>    <dbl>  
  <dbl> <ord>    <chr>  
1 2014 alabama     1    270    4849377    5.6    5.6  
0.3 South AL  
2 2014 alaska      2     76    736732    10.3   10.6  
1.2 West AK  
3 2014 arizona     4    589    6731484    8.7    8.8  
0.4 West AZ  
4 2014 arkans...   5    173    2966369    5.8    6.3  
0.5 South AR  
5 2014 califo...   6    2024   38802500    5.2    5  
0.1 West CA  
6 2014 colora...  8    517    5355866    9.7    9.4  
0.4 West CO  
7 2014 connec...  9    525    3596677   14.6   15.2  
0.7 North... CT  
8 2014 delawa... 10    124    935614    13.3   13.9  
1.3 South DE  
9 2014 florida   12   1399   19893297    7     7.2  
0.2 South FL  
10 2014 georgia  13    710   10097343    7     7  
0.3 South GA  
# i 40 more rows
```

The two leading states in each region in 2014

```
## 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  
  <int> <chr>    <int>  <int>     <dbl> <dbl>  
  <dbl> <ord>    <chr>  
1 2014 new ham...    33    297  1326813  22.4  23.4  
1.4 North... NH  
2 2014 rhode i...    44    205  1055173  19.4  19.8  
1.4 North... RI  
3 2014 ohio        39    2106 11594163  18.2  19.1  
0.4 Midwe... OH  
4 2014 missouri    29    696  6063589  11.5  12  
0.5 Midwe... MO  
5 2014 new mex...    35    402  2085572  19.3  20.2  
West NM  
6 2014 utah        49    455  2942902  15.5  16.8  
0.8 West UT  
7 2014 west vi...    54    554  1850326  29.9  31.6  
1.4 South WV  
8 2014 kentucky    21    729  4413457  16.5  16.8  
0.6 South KY  
# i 1 more variable: division_name <chr>
```

The two leading states in each region in 2014

```
## 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  
  <int> <chr>    <int>  <int>     <dbl> <dbl>  
  <dbl> <ord>    <chr>  
1 2014 new ham...    33    297  1326813  22.4  23.4  
1.4 North... NH  
2 2014 rhode i...    44    205  1055173  19.4  19.8  
1.4 North... RI  
3 2014 ohio        39    2106 11594163  18.2  19.1  
0.4 Midwe... OH  
4 2014 missouri    29    696  6063589  11.5  12  
0.5 Midwe... MO  
5 2014 new mex...    35    402  2085572  19.3  20.2  
West NM  
6 2014 utah        49    455  2942902  15.5  16.8  
0.8 West UT  
7 2014 west vi...    54    554  1850326  29.9  31.6  
1.4 South WV  
8 2014 kentucky    21    729  4413457  16.5  16.8  
0.6 South KY  
# i 1 more variable: division_name <chr>
```

Opiates Time Series plot

```
st_top ← opiates ▷ filter(year == max(year), abbr ≠ "DC")
```

Opiates Time Series plot

```
st_top ← opiates ▷ filter(year = max(year), abbr ≠ "DC") ▷  
group_by(region)
```

Opiates Time Series plot

```
st_top ← opiates ▷ filter(year = max(year), abbr ≠ "DC") ▷  
group_by(region) ▷  
slice_max(order_by = adjusted, n = 2)
```

Opiates Time Series plot

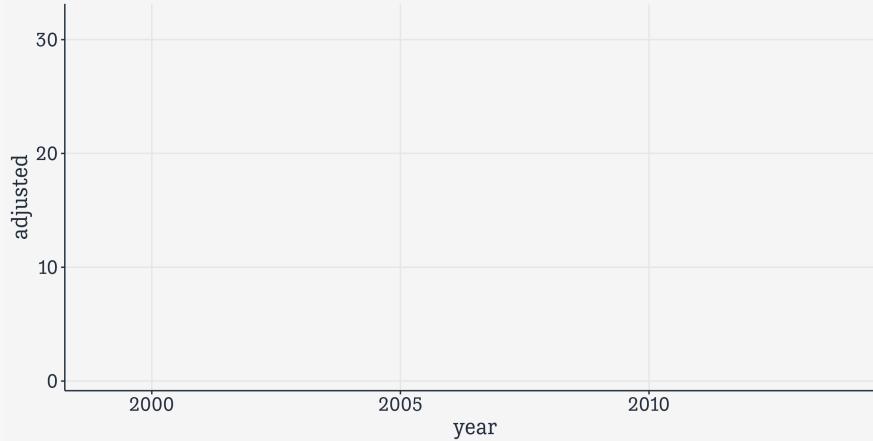
```
st_top <- opiates %> filter(year == max(year), abbr != "DC") %>
  group_by(region) %>
  slice_max(order_by = adjusted, n = 2)

opiates
```

```
# A tibble: 800 × 11
  year state   fips deaths population crude adjusted
  <int> <chr>   <int>   <int>      <dbl>    <dbl>
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
# i 790 more rows
# i 1 more variable: division name <chr>
```

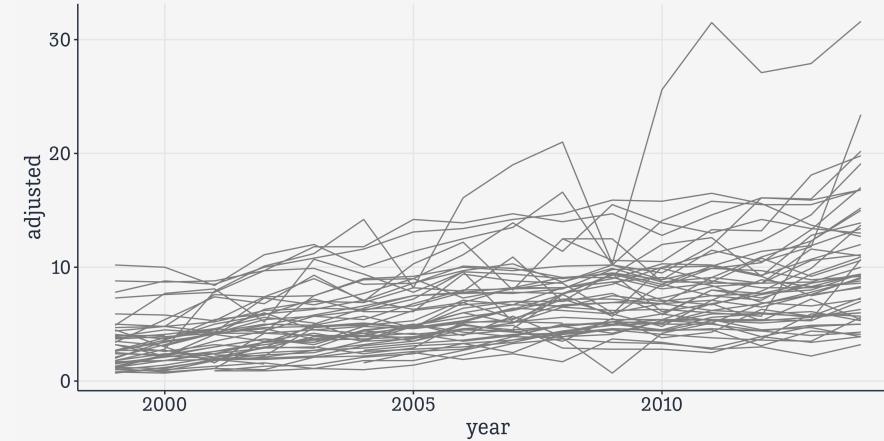
Opiates Time Series plot

```
st_top ← opiates ▷ filter(year = max(year), abbr ≠ "DC") ▷  
group_by(region) ▷  
slice_max(order_by = adjusted, n = 2)  
  
opiates ▷  
ggplot(aes(x = year,  
           y = adjusted))
```



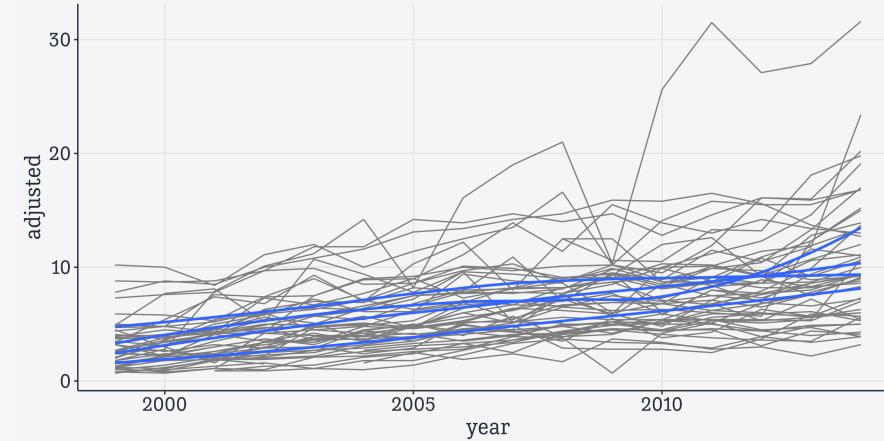
Opiates Time Series plot

```
st_top ← opiates ▷ filter(year = max(year), abbr ≠ "DC") ▷  
group_by(region) ▷  
slice_max(order_by = adjusted, n = 2)  
  
opiates ▷  
ggplot(aes(x = year,  
           y = adjusted)) +  
geom_line(aes(group = state),  
         color = "gray50")
```



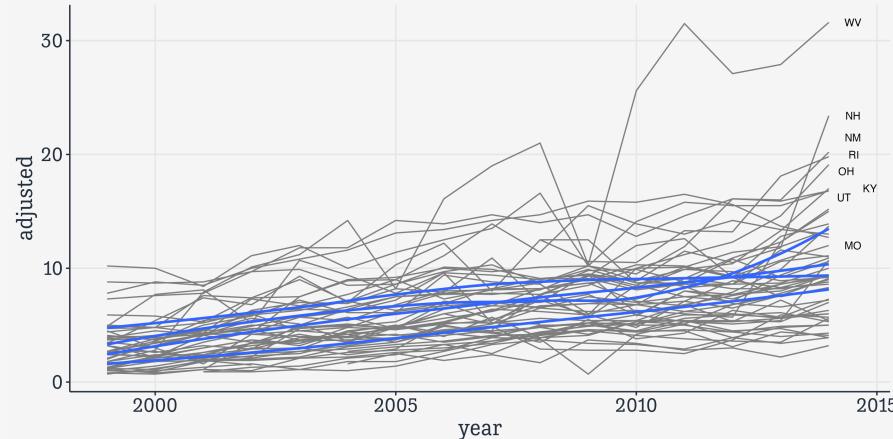
Opiates Time Series plot

```
st_top ← opiates ▷ filter(year = max(year), abbr ≠ "DC") ▷  
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)
```



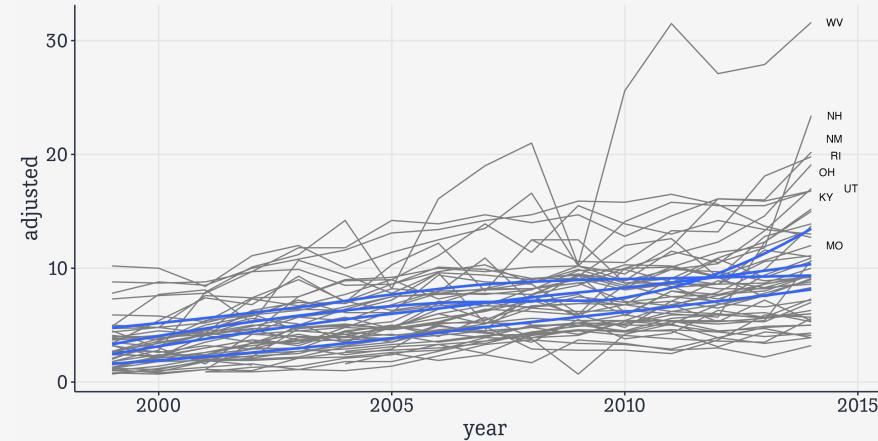
Opiates Time Series plot

```
st_top ← opiates %>% filter(year == max(year), abbr != "DC") %>%  
  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)
```



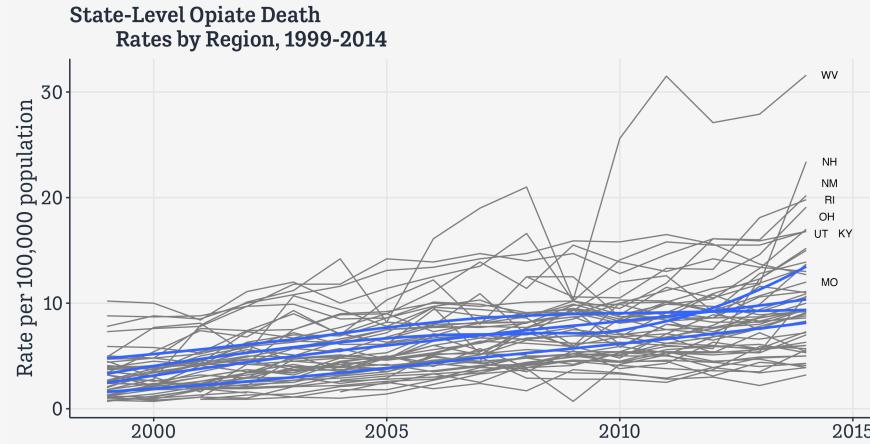
Opiates Time Series plot

```
st_top ← opiates %>% filter(year == max(year), abbr ≠ "DC") %>%  
  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))
```



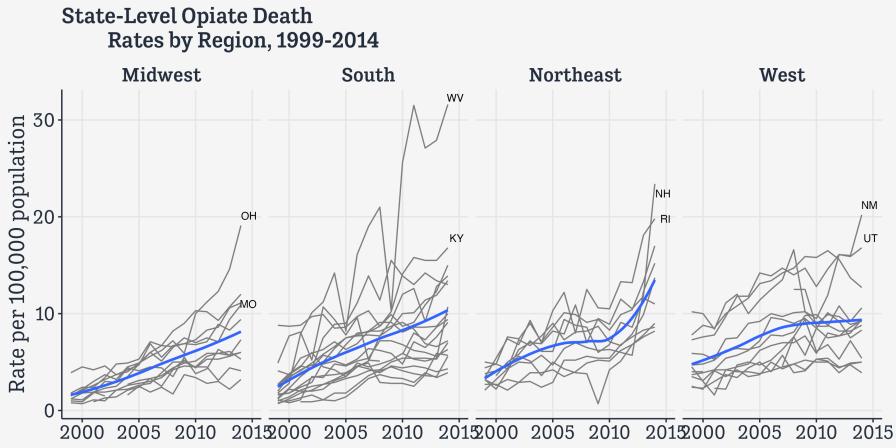
Opiates Time Series plot

```
st_top ← opiates %>% filter(year == max(year), abbr ≠ "DC") %>%  
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")
```



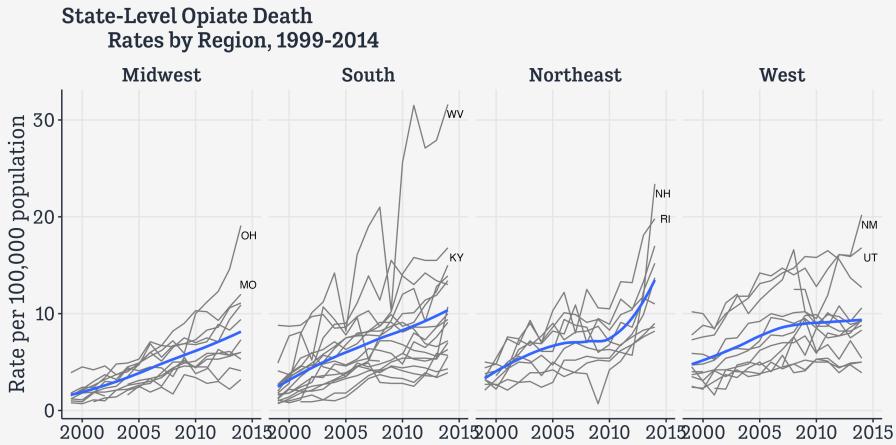
Opiates Time Series plot

```
st_top ← opiates %>% filter(year == max(year), abbr ≠ "DC") %>%  
  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)
```

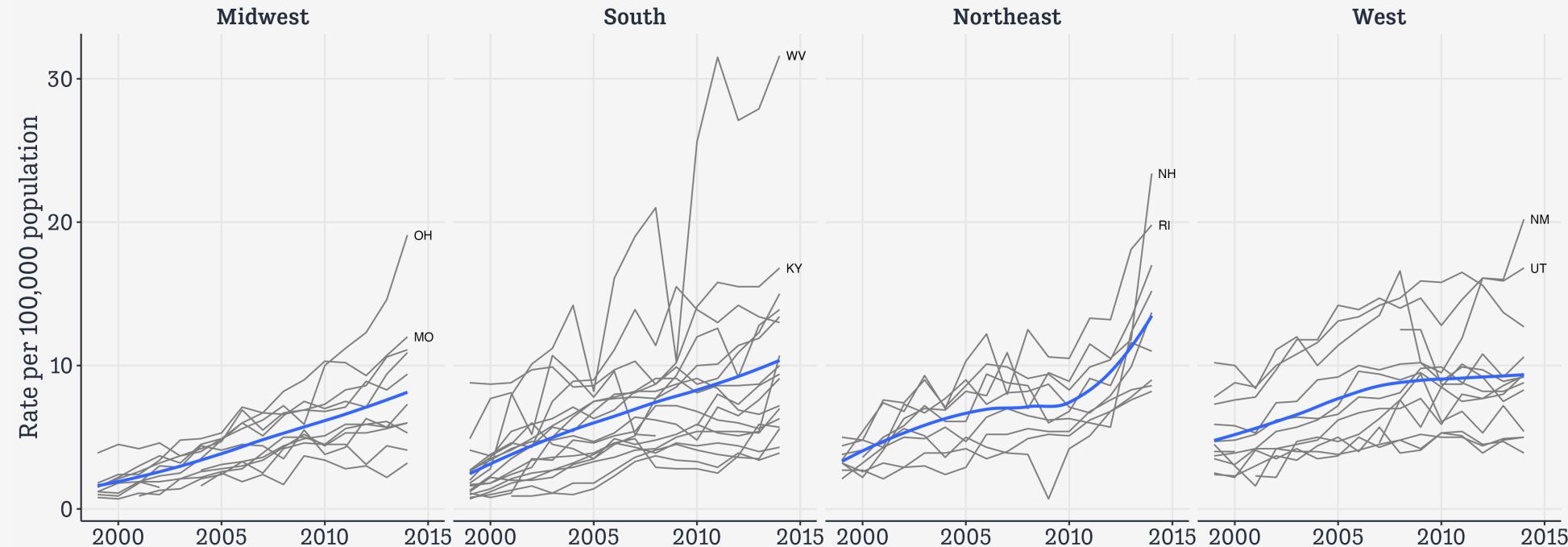


Opiates Time Series plot

```
st_top ← opiates %>% filter(year == max(year), abbr ≠ "DC") %>%  
  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)
```



**State-Level Opiate Death
Rates by Region, 1999-2014**



Regional trends in opiate-related mortality.