Data Visualization - 7. Make Maps (1)

Kieran Healy
Code Horizons

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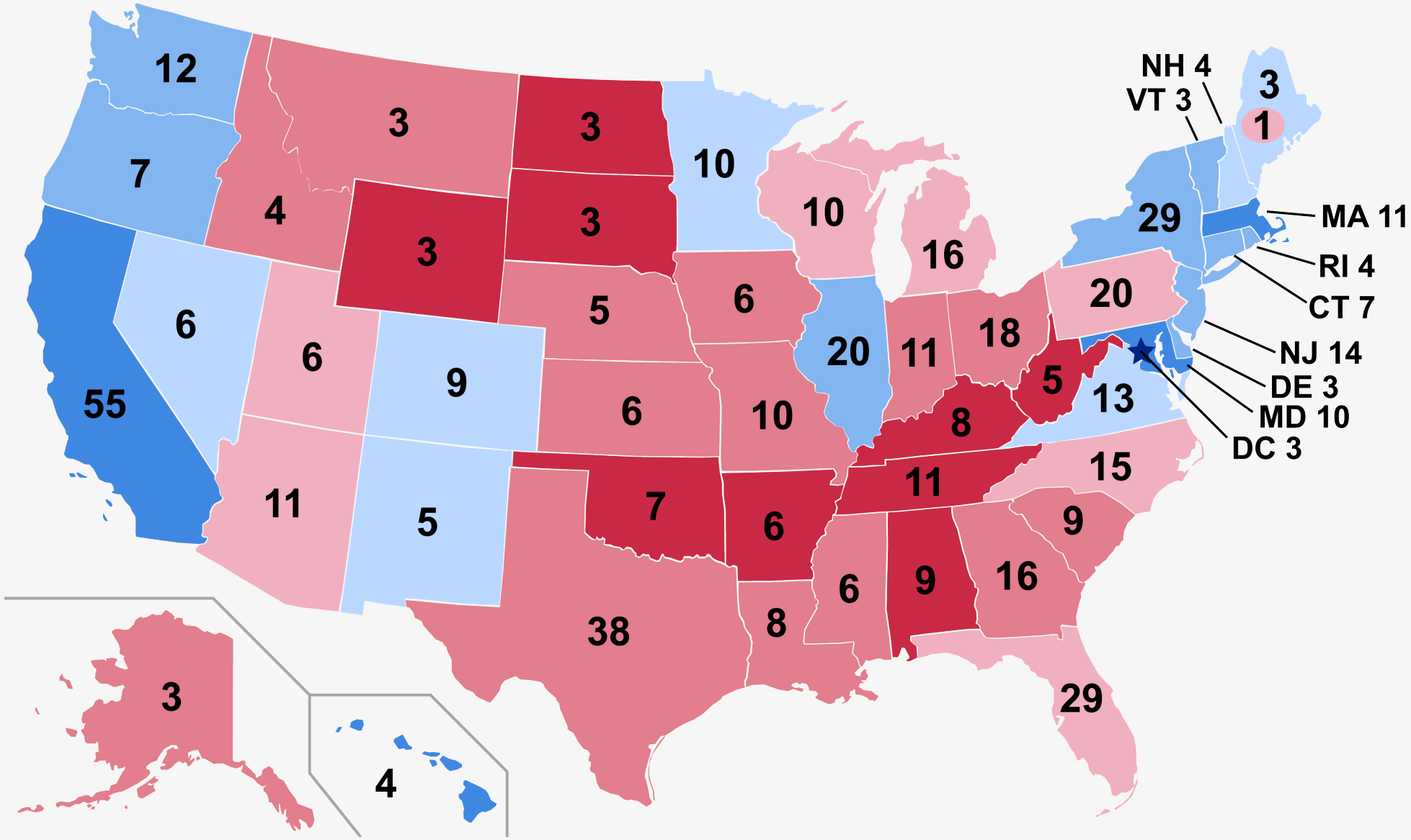
Making Maps

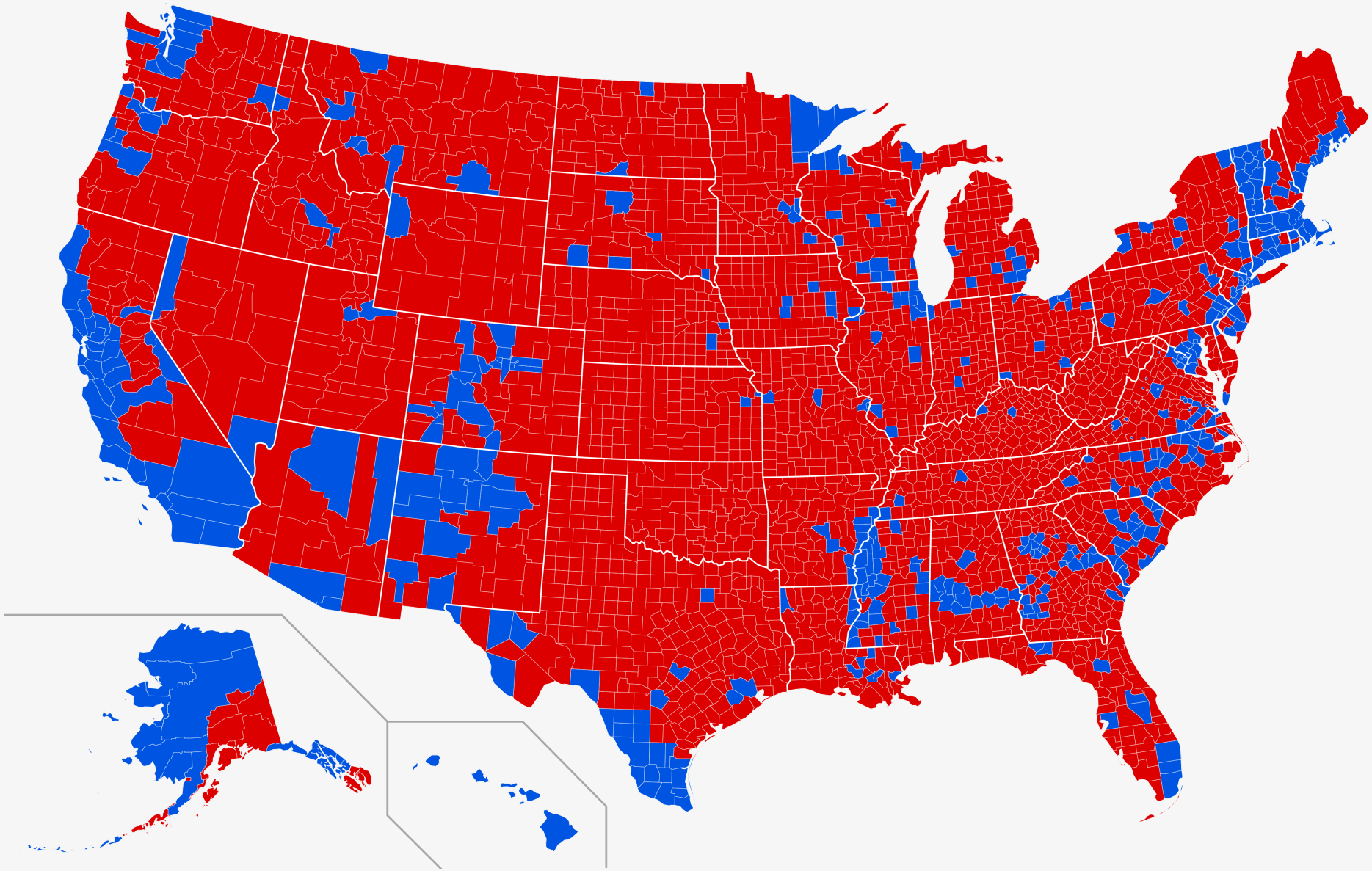
Load our packages

```
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
```

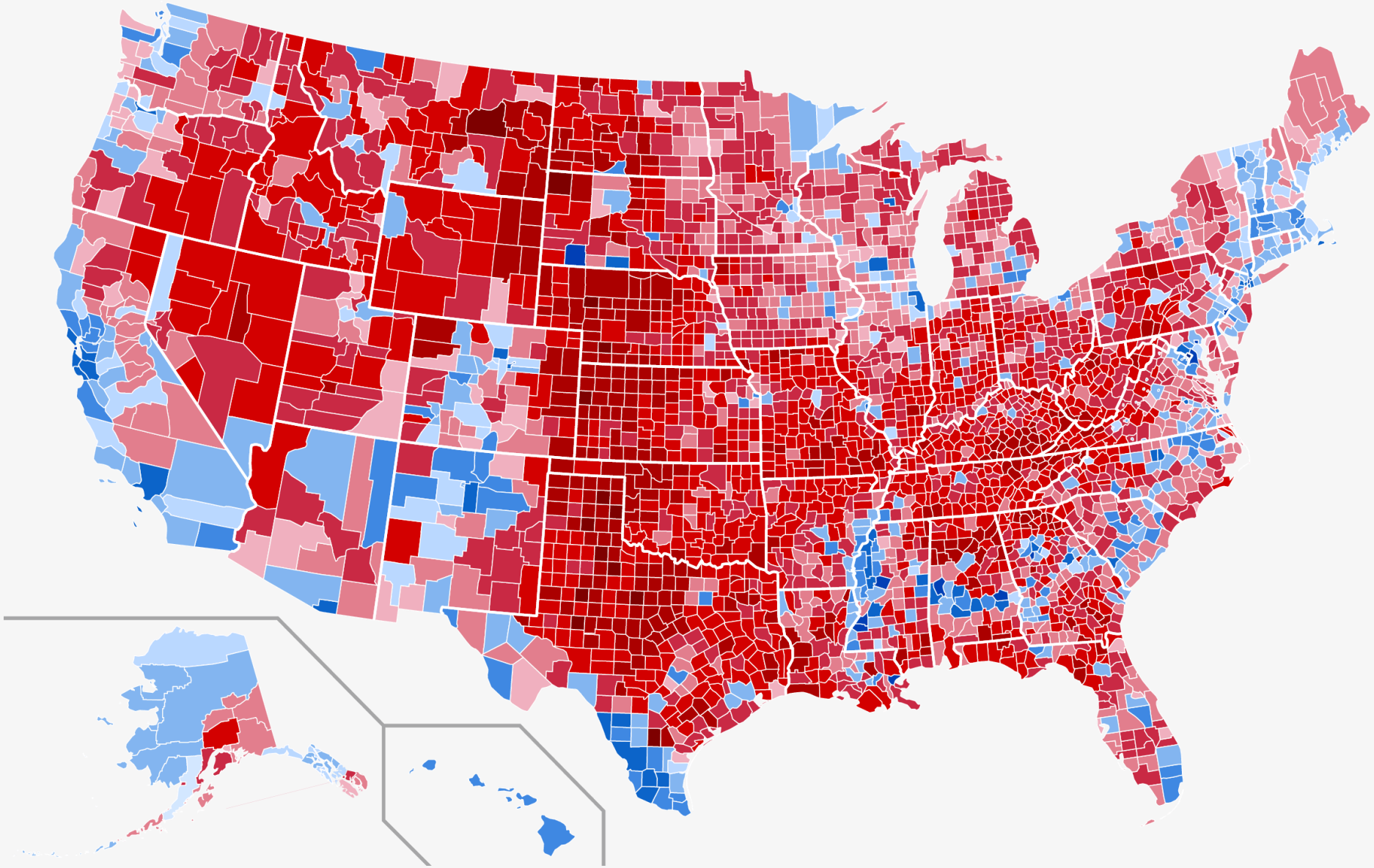
Choropleths



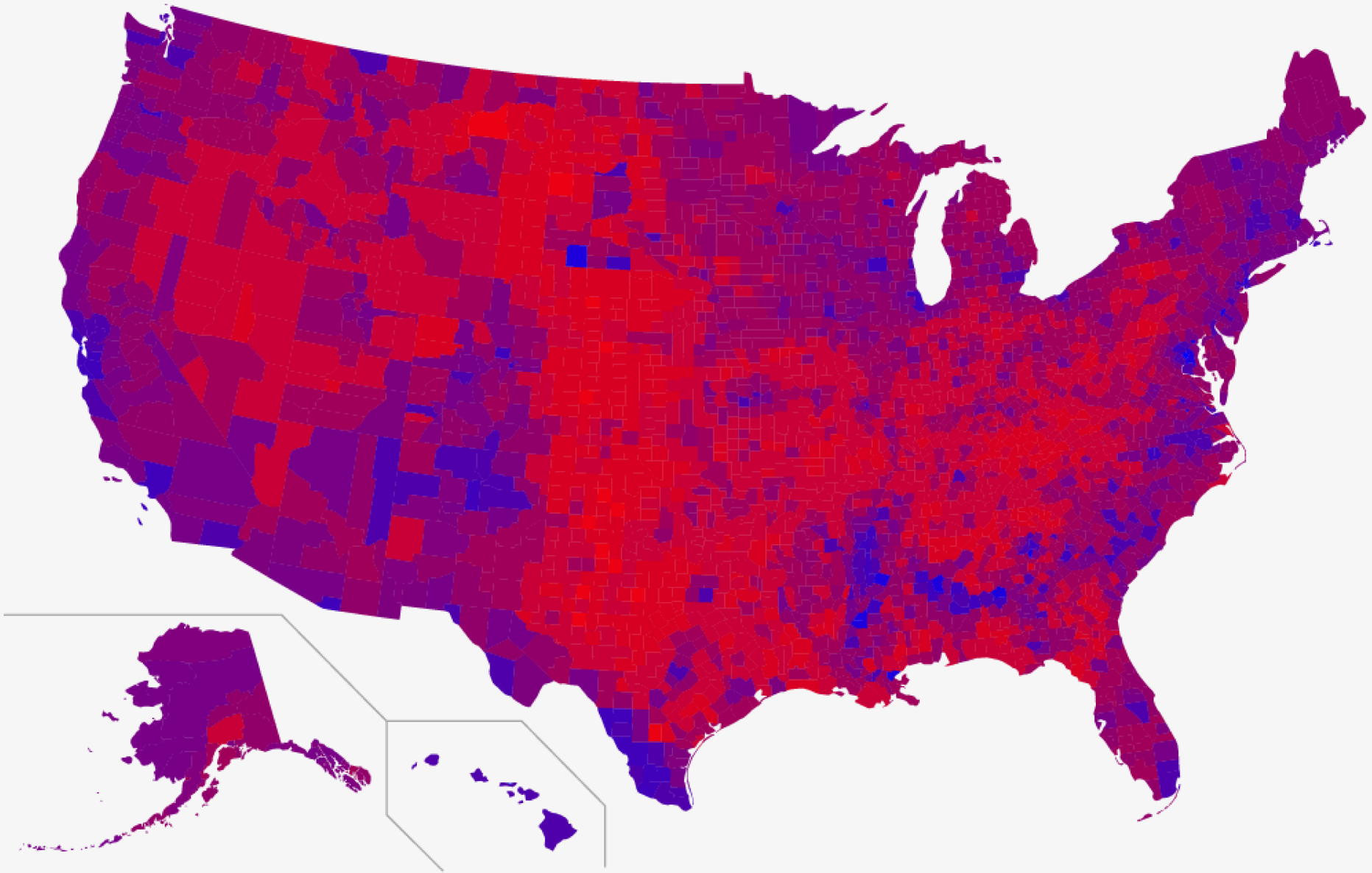
State-level; vote share; diverging; binned into four categories.



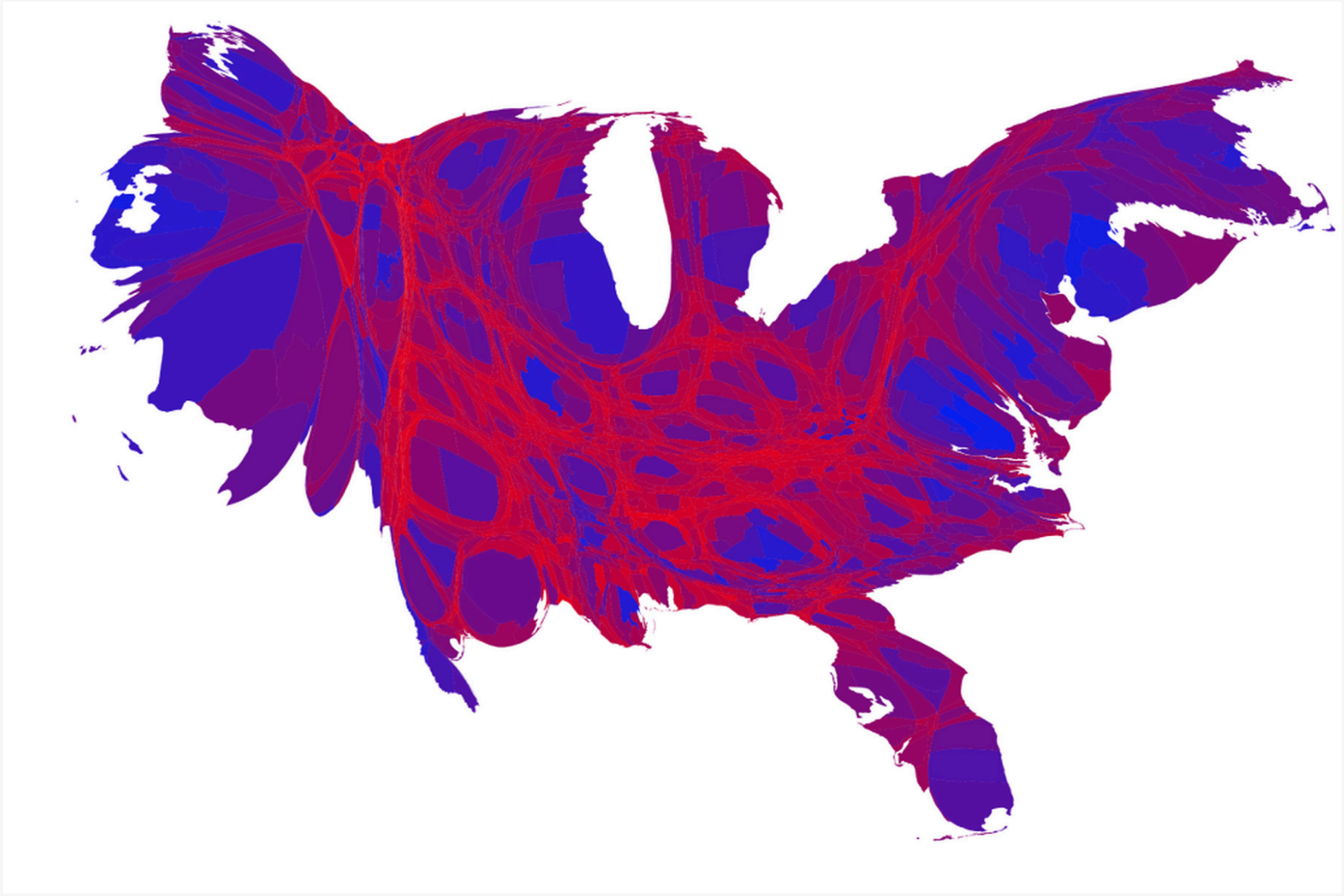
County level; winner only



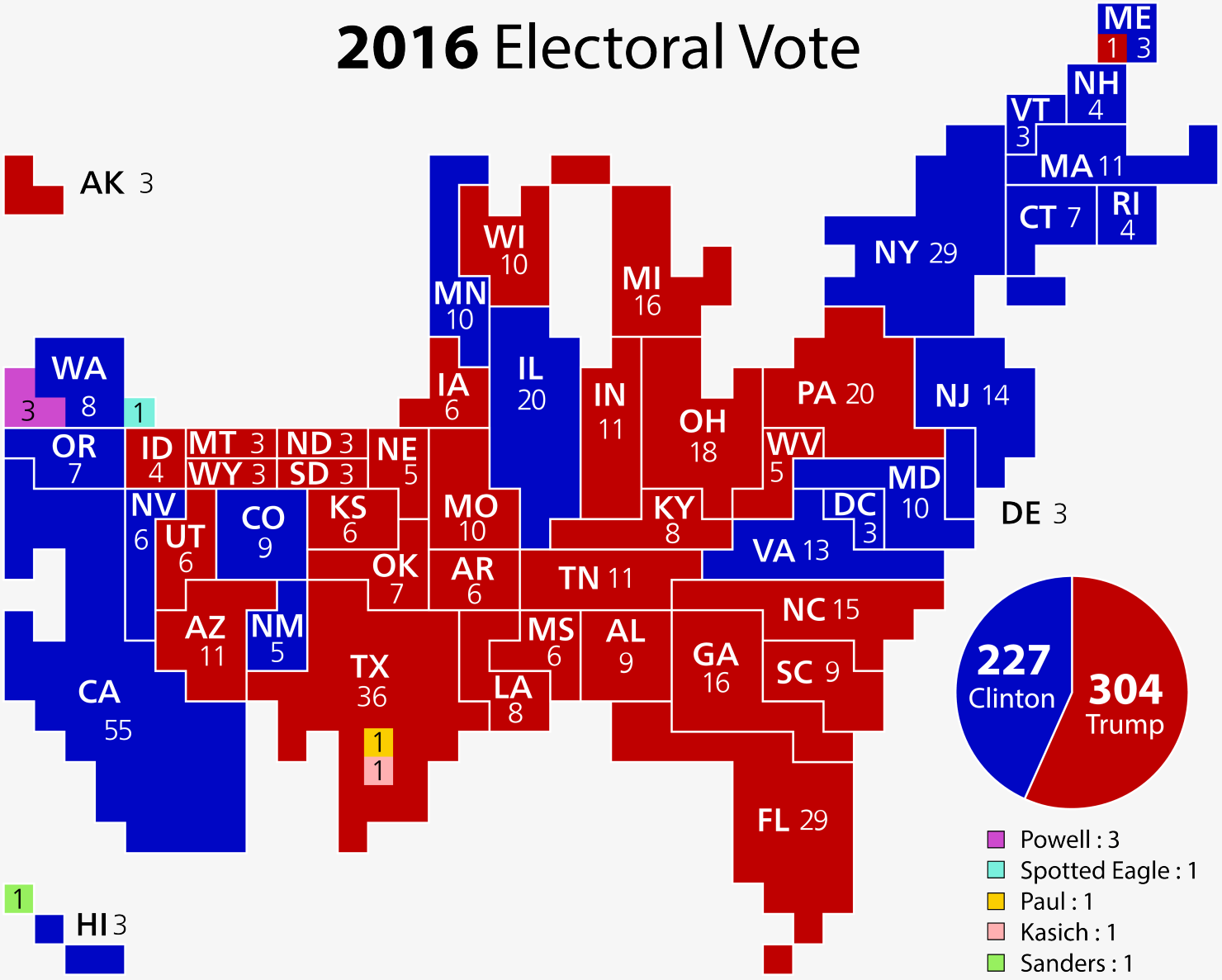
County level vote share; diverging; binned into six categories



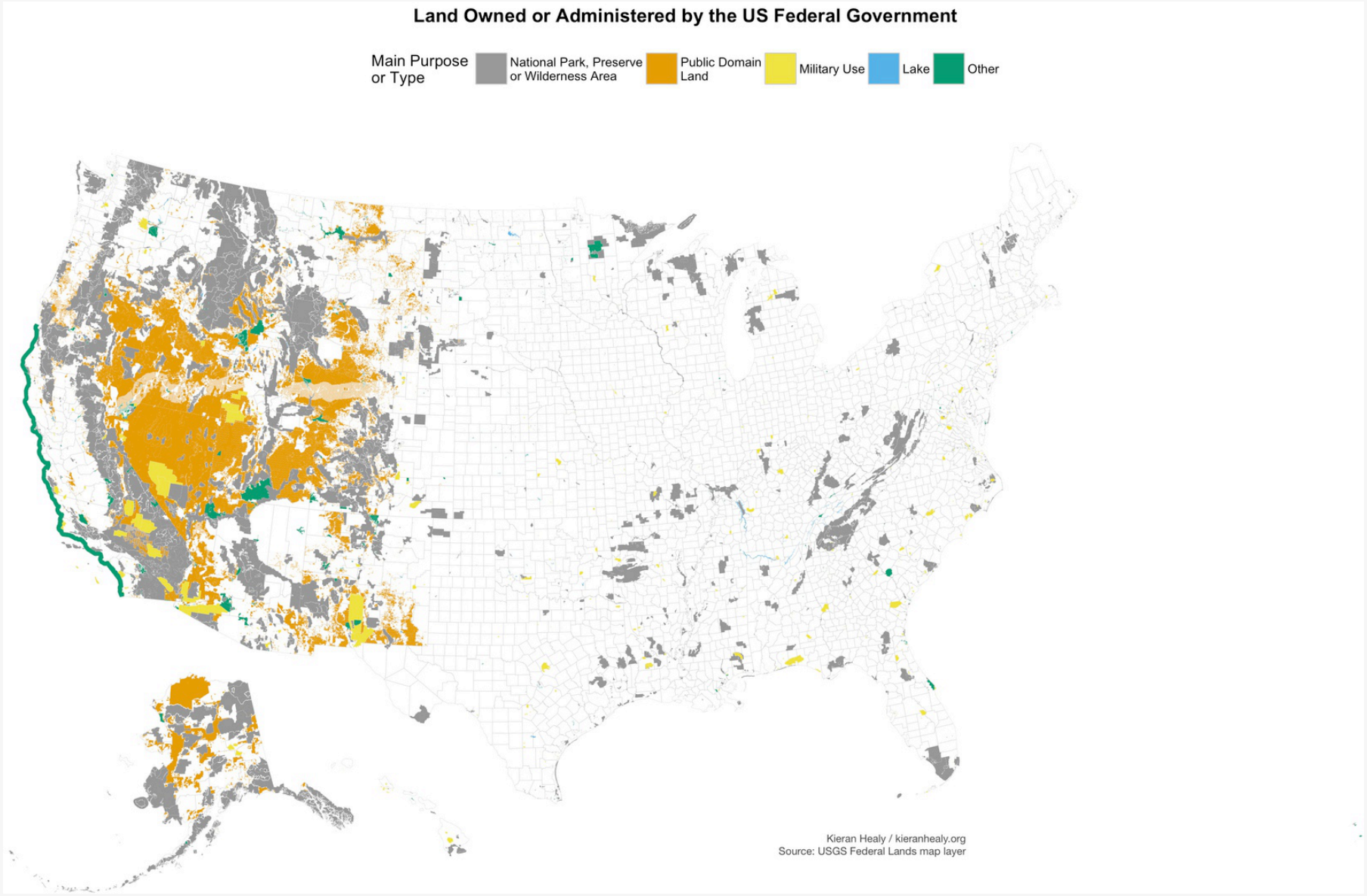
County level vote share; diverging continuous; purple midpoint



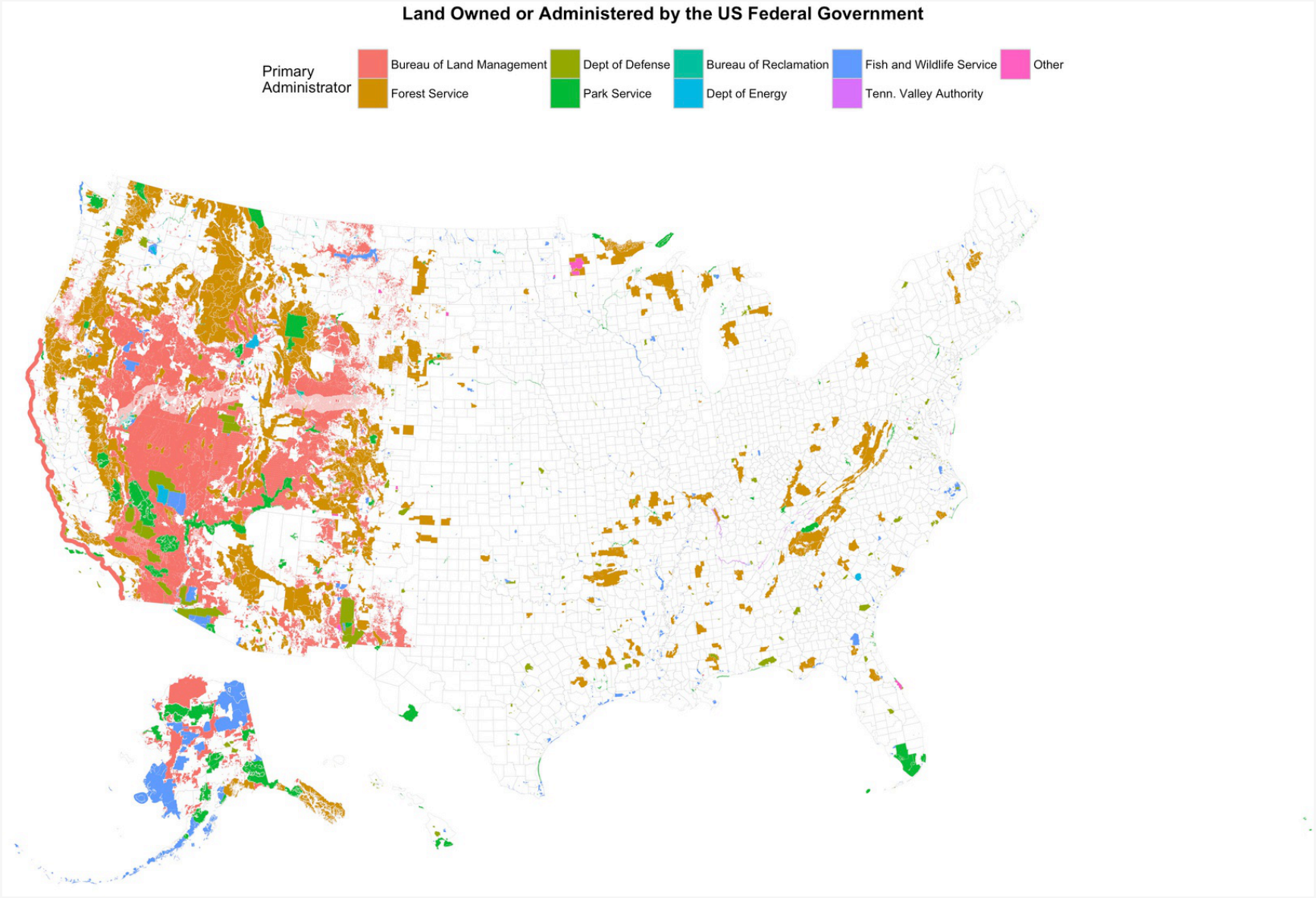
County level vote share; purple midpoint; county area deformed in proportion to population. By Mark Newman



Electoral college cartogram (NYT)

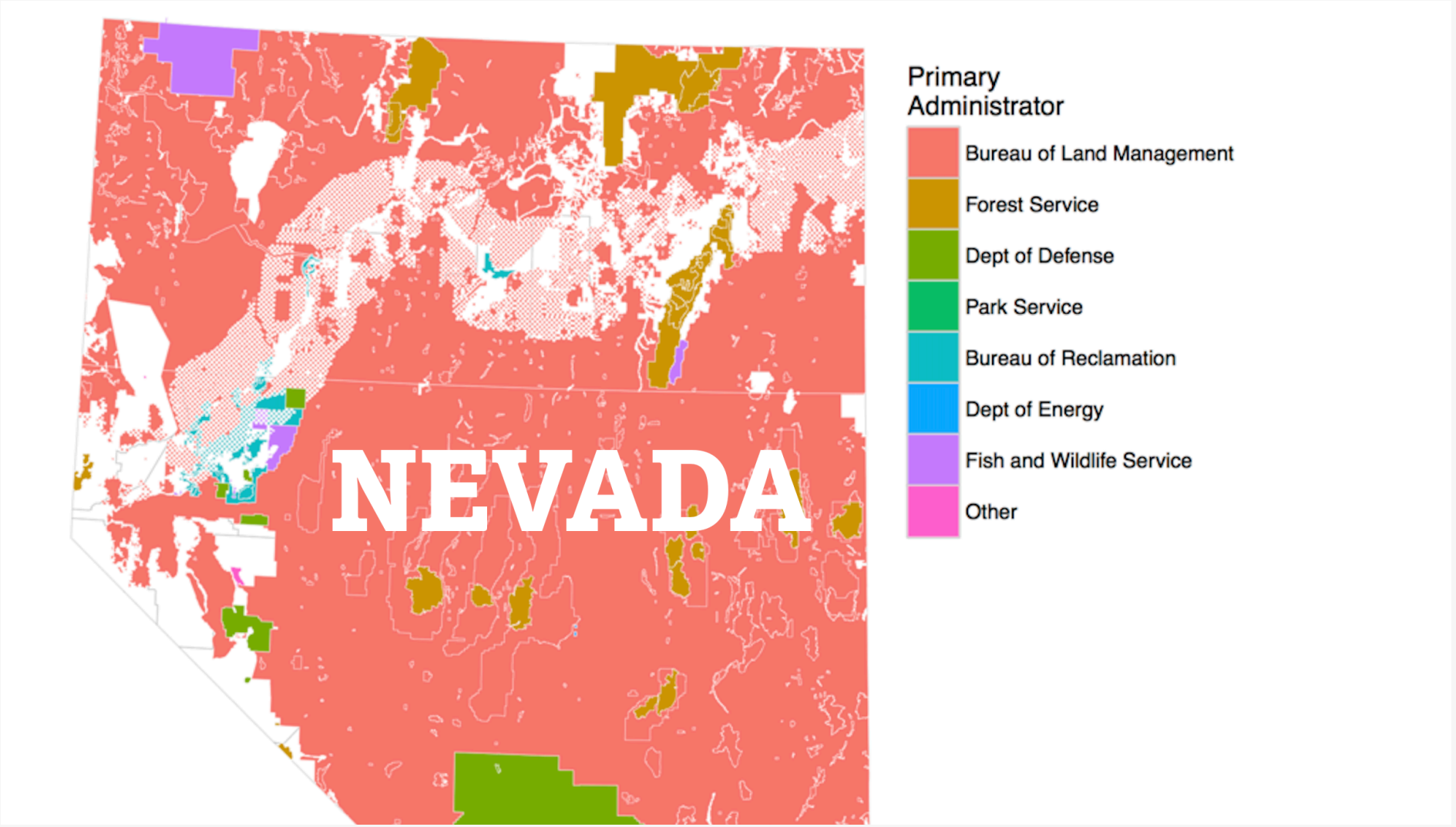


Pretty, Big, and Pretty Empty

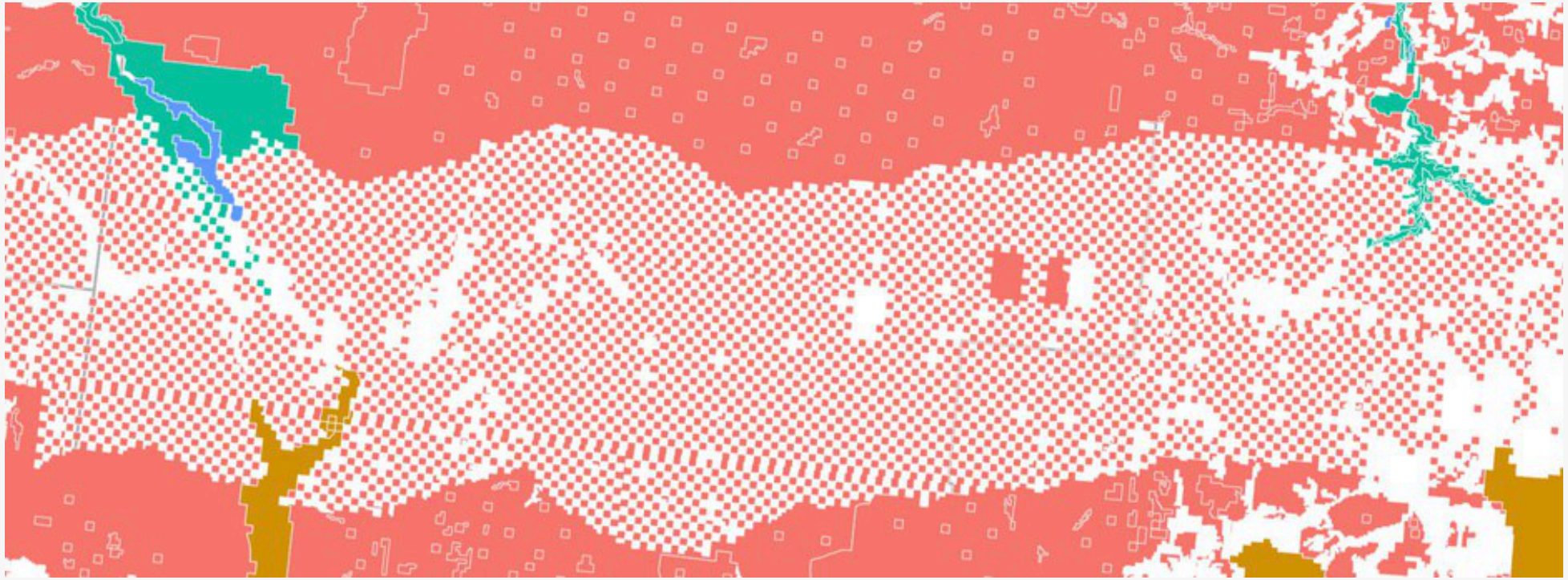


Pretty, Big, and Pretty Empty

Aside: What the hell's that?

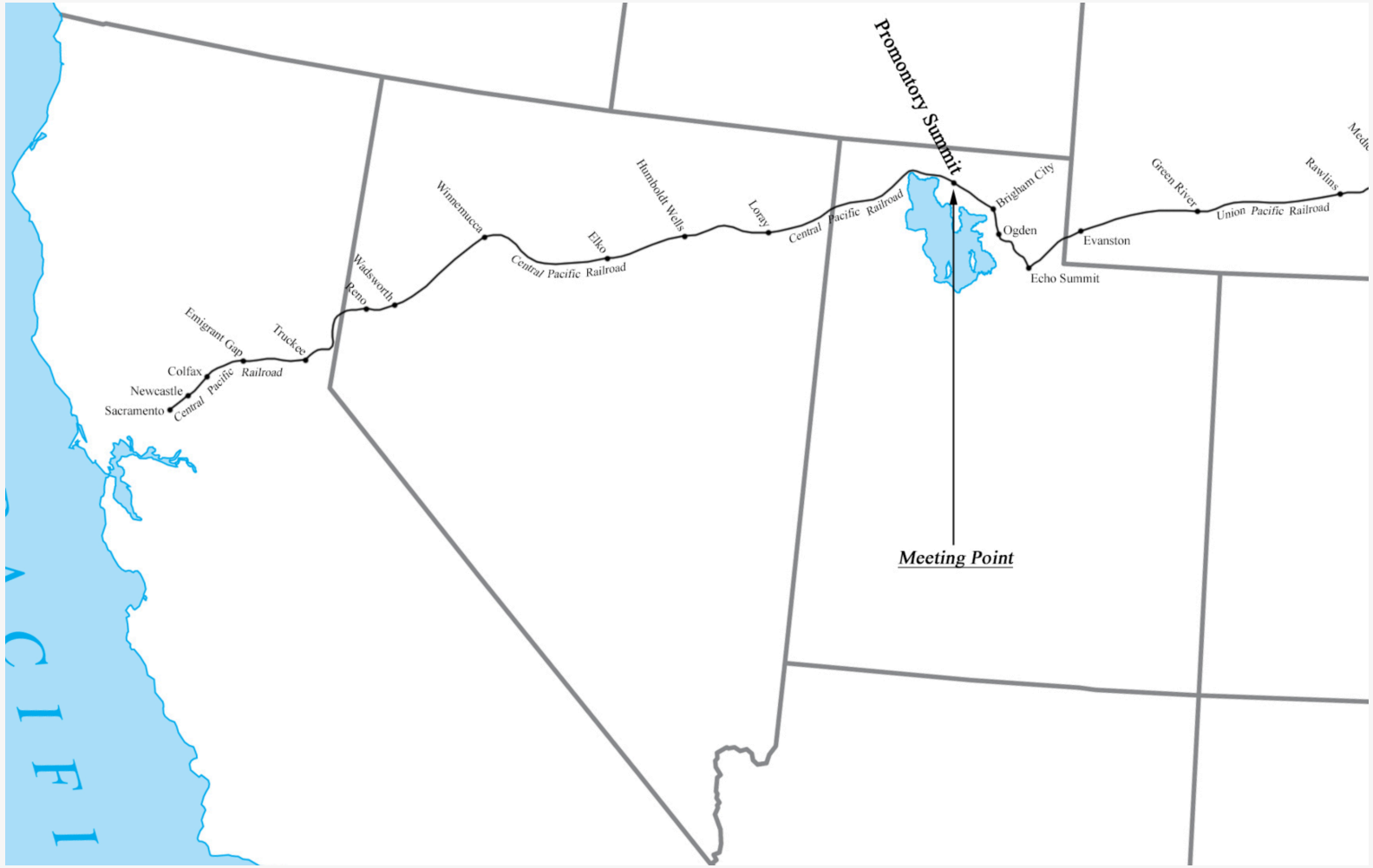


Zoom and Enhance



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.

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     1    10 alabama <NA>
# ℹ 15,527 more rows
```

What is this, at root?

```
us_states
```

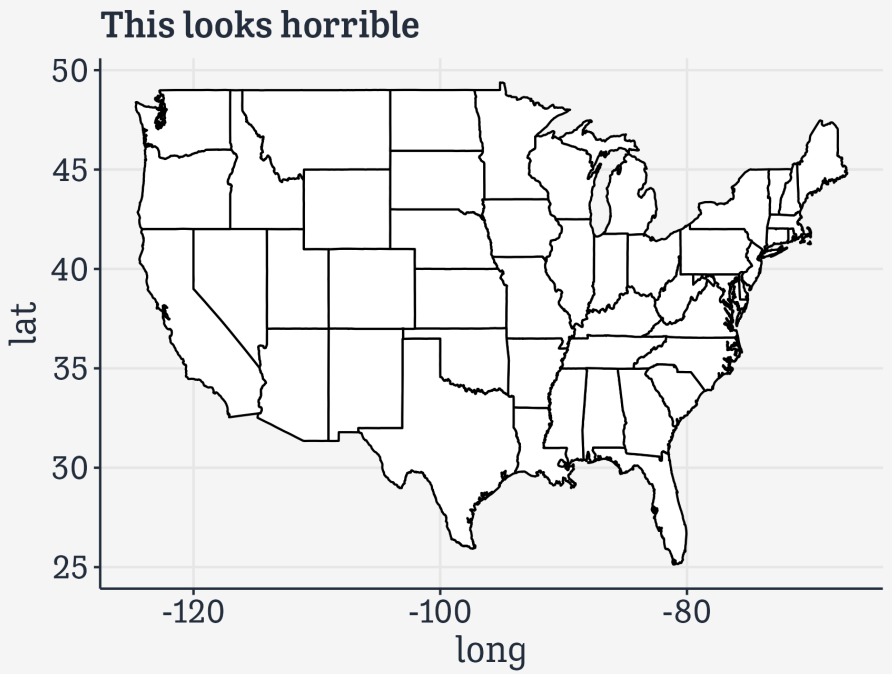
```
# A tibble: 15,537 × 6
    long   lat group order region  subregion
   <dbl> <dbl> <dbl> <int> <chr>   <chr>
 1 -87.5  30.4     1     1 alabama <NA>
 2 -87.5  30.4     1     2 alabama <NA>
 3 -87.5  30.4     1     3 alabama <NA>
 4 -87.5  30.3     1     4 alabama <NA>
 5 -87.6  30.3     1     5 alabama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

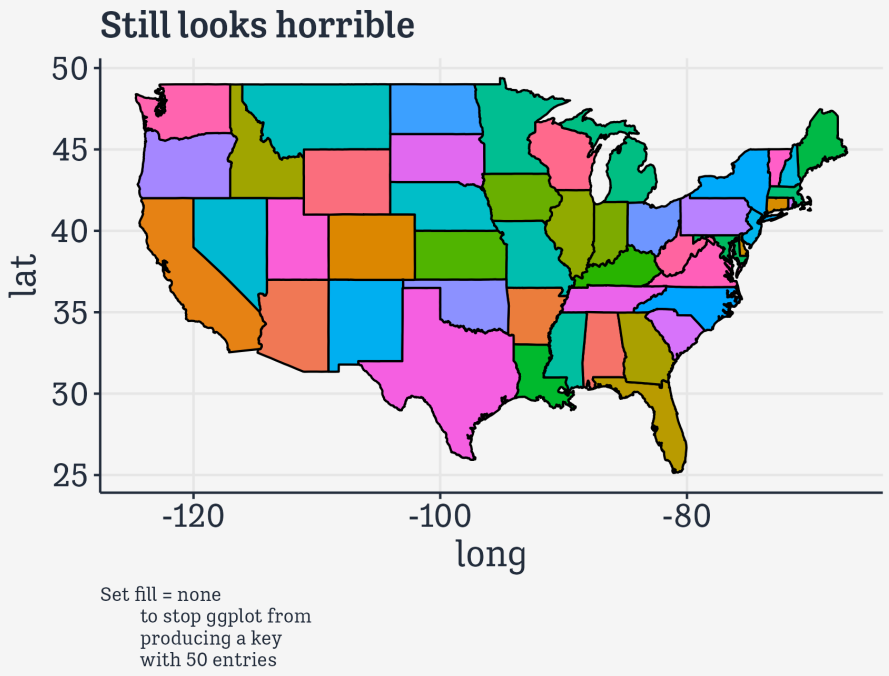
Like this, with `geom_polygon()`

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



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"))
```

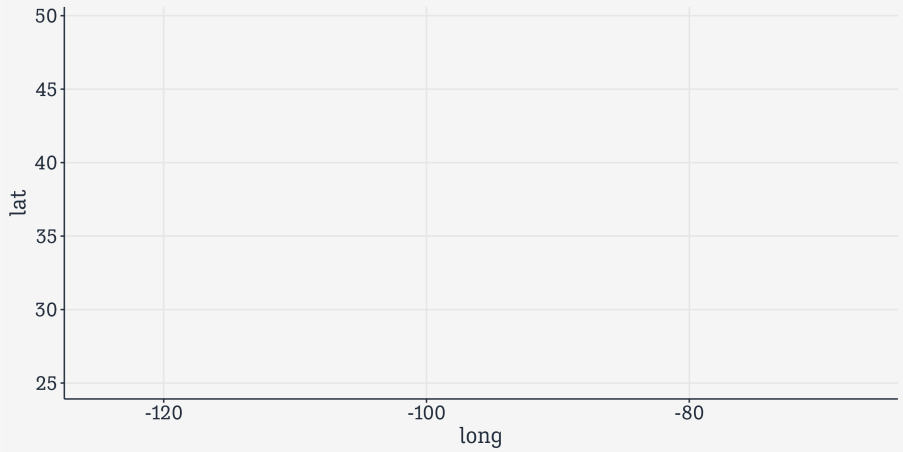
Fix the projection

```
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
```

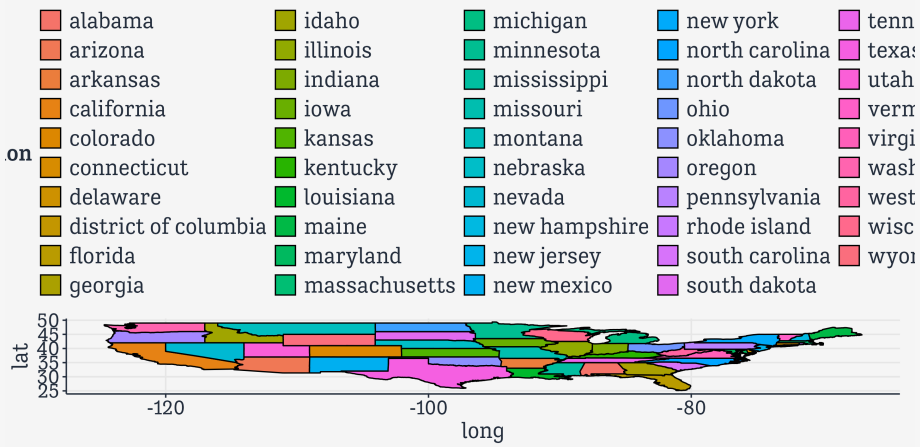
Fix the projection

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

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



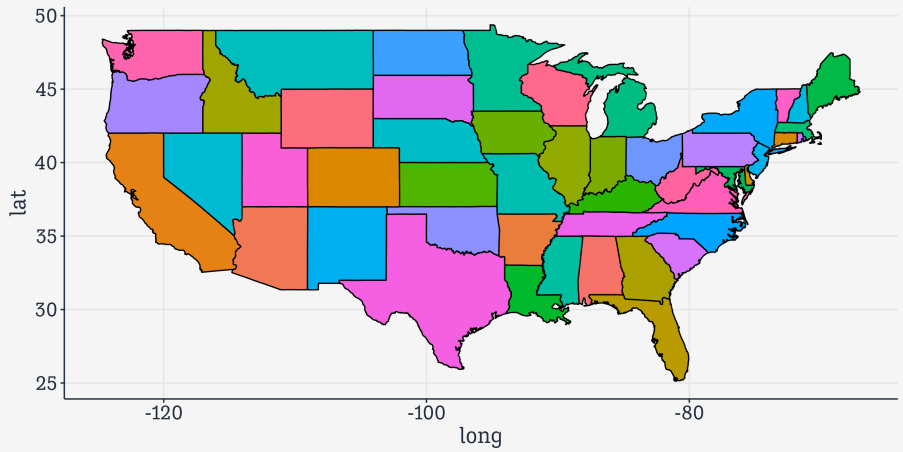
Fix the projection

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

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



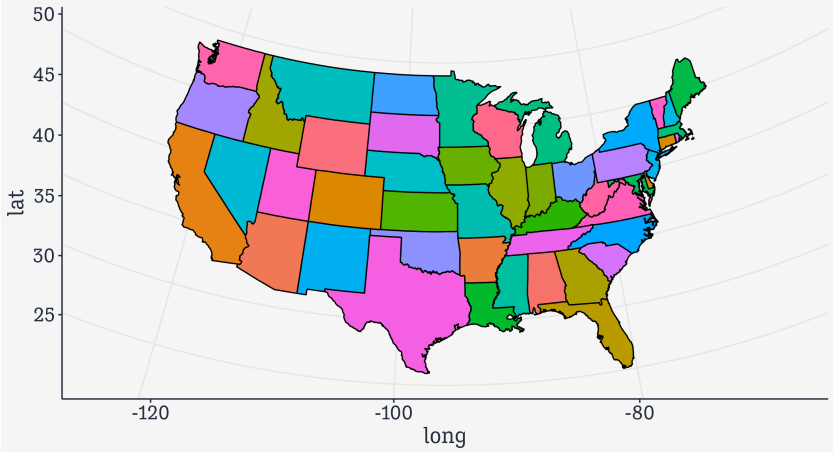
Fix the projection

```
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")
```

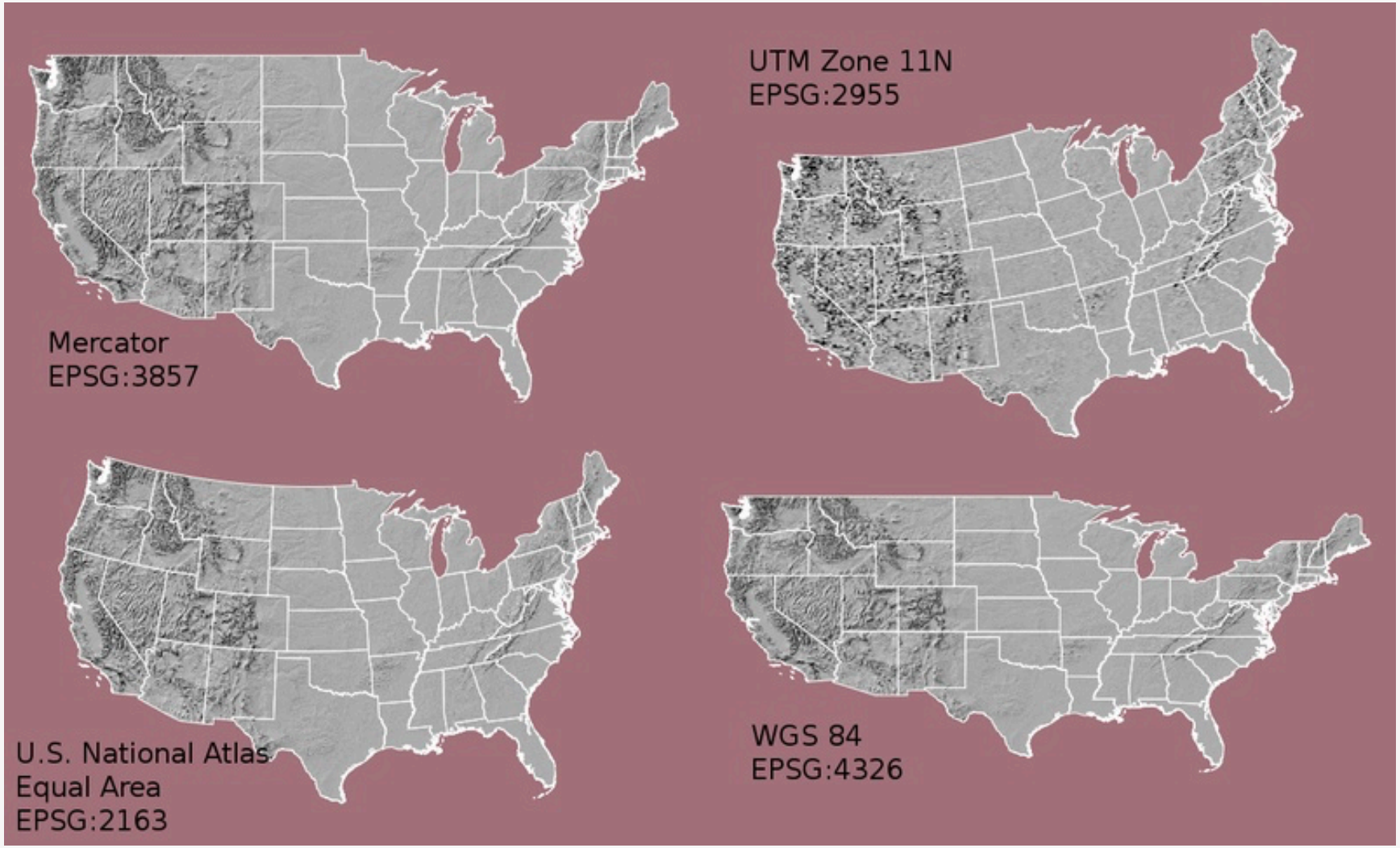


Fix the projection

```
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)
```



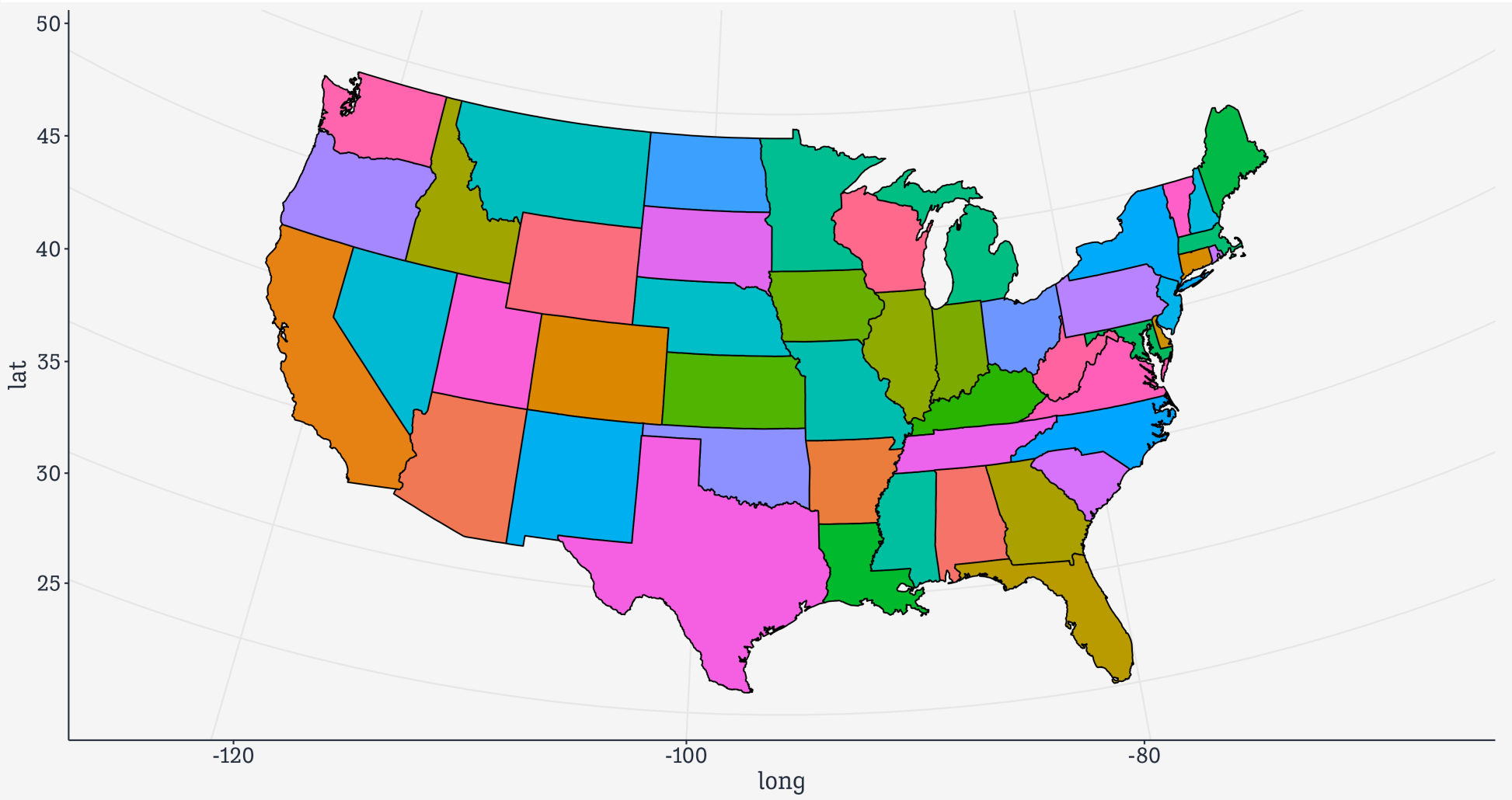
U.S. Map Projections



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 winner
party pct_margin r_points
   <chr>     <chr> <dbl>      <dbl>       <dbl> <chr>
<chr>      <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 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 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
```

This is a *left join*

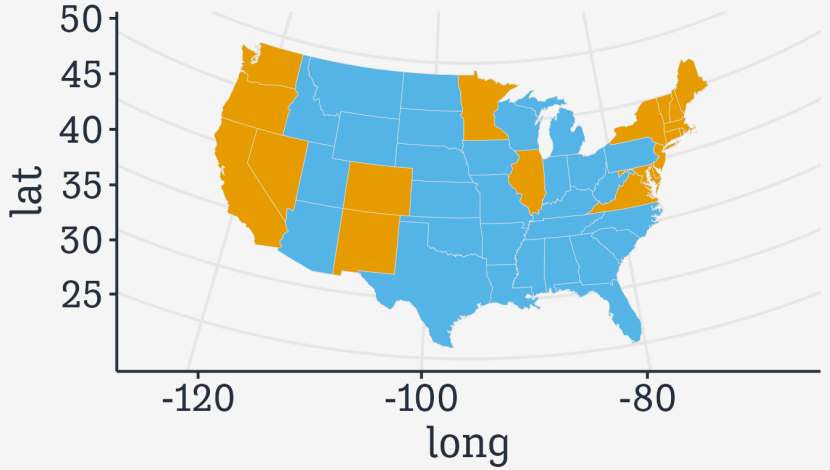
```
us_states_elec ← left_join(us_states, election, by = "region")

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")
```



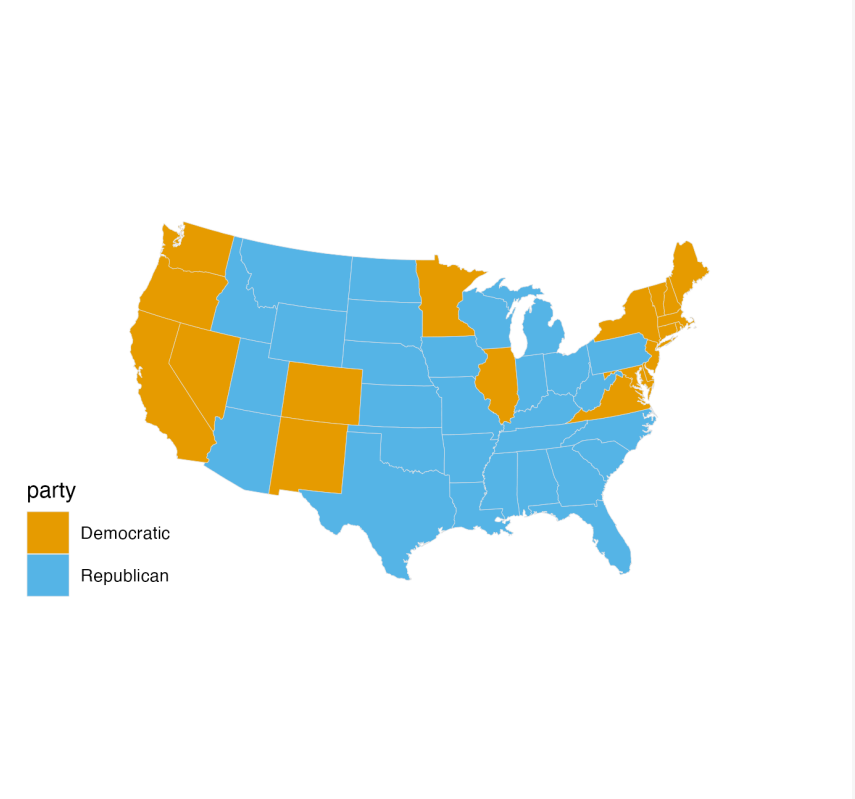
Let’s turn off the gridlines

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)
              )
}
```

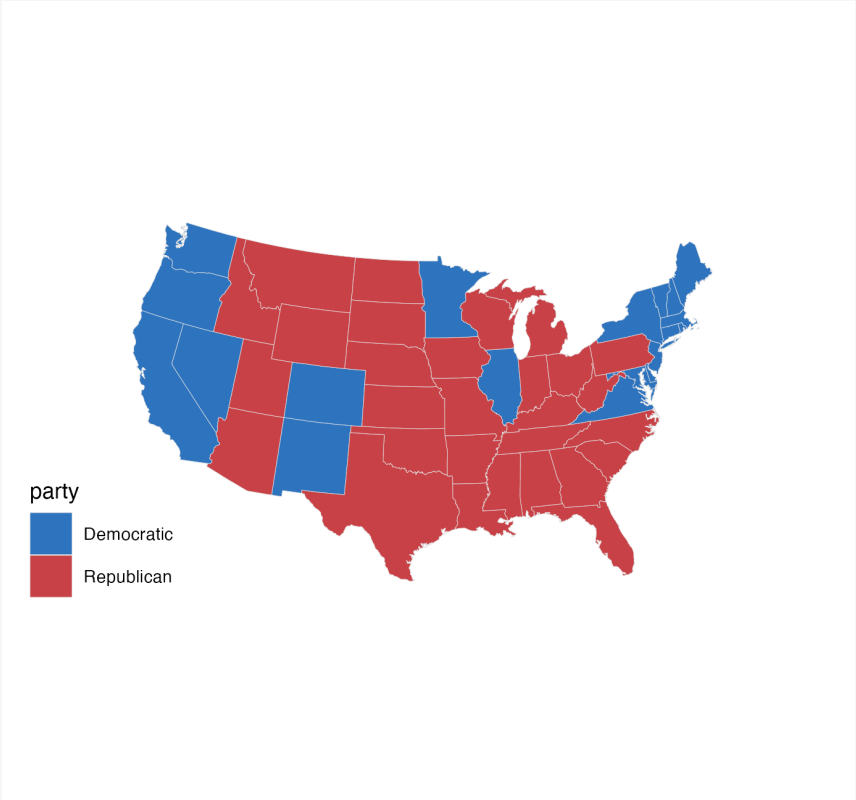
Add the theme function at the end

```
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()
```



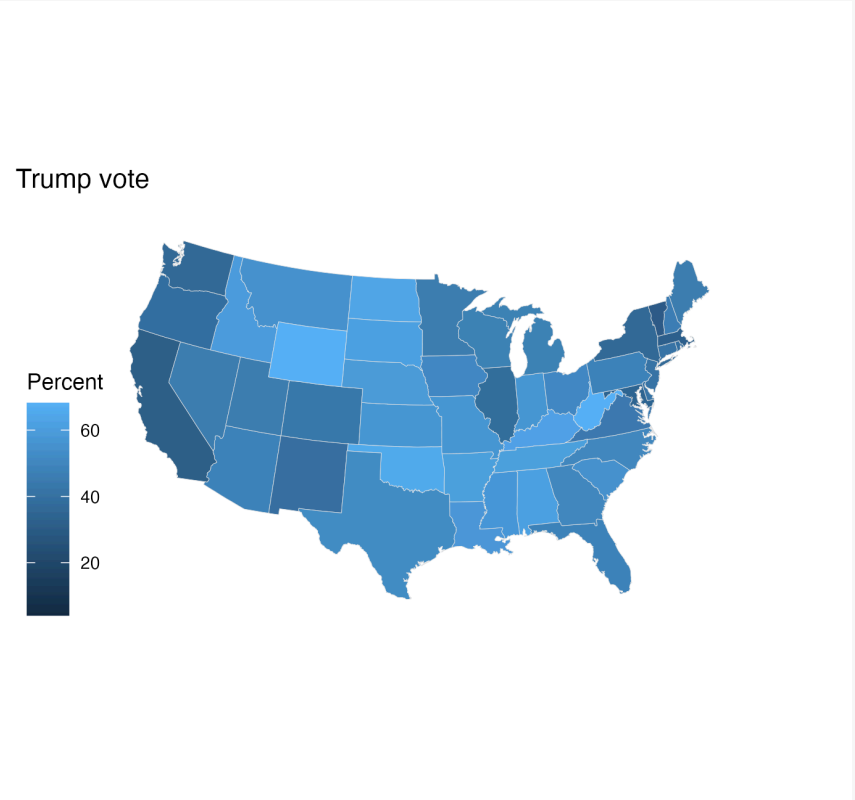
Fix the Party Colors

```
## Hex color codes for Democratic Blue and Republican R
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()
```



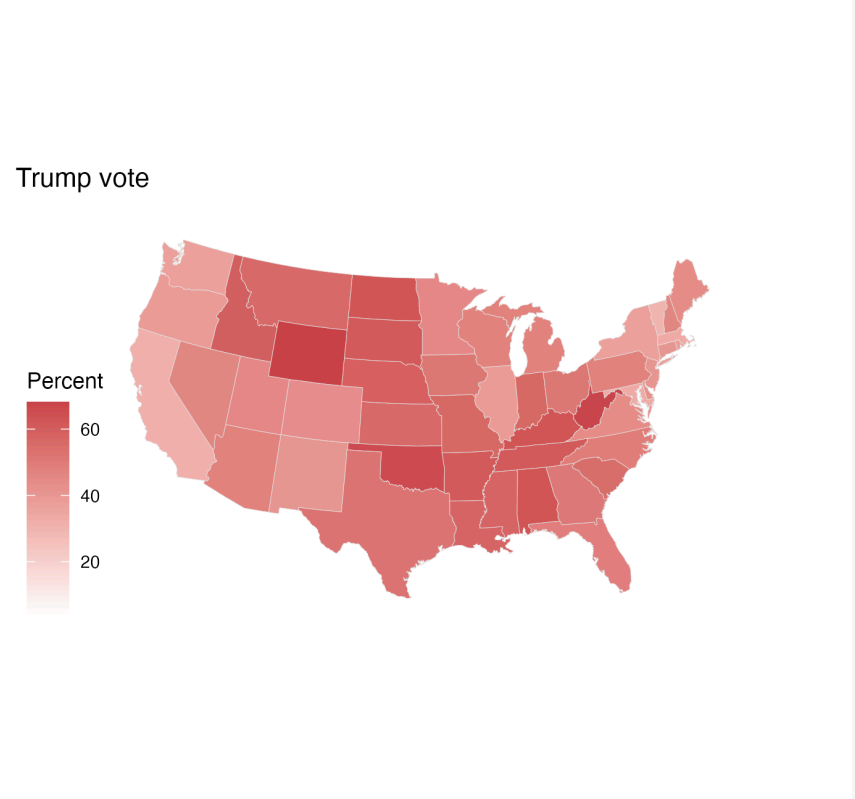
Continuous measures are *gradients*

```
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()
```



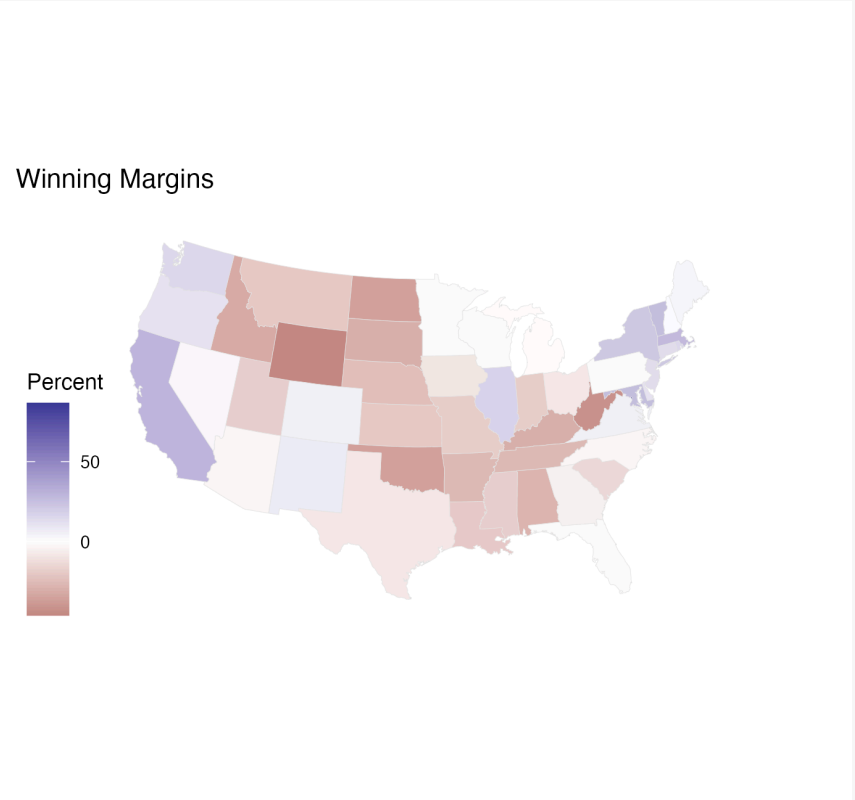
Fix the gradient with a scale function

```
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()
```



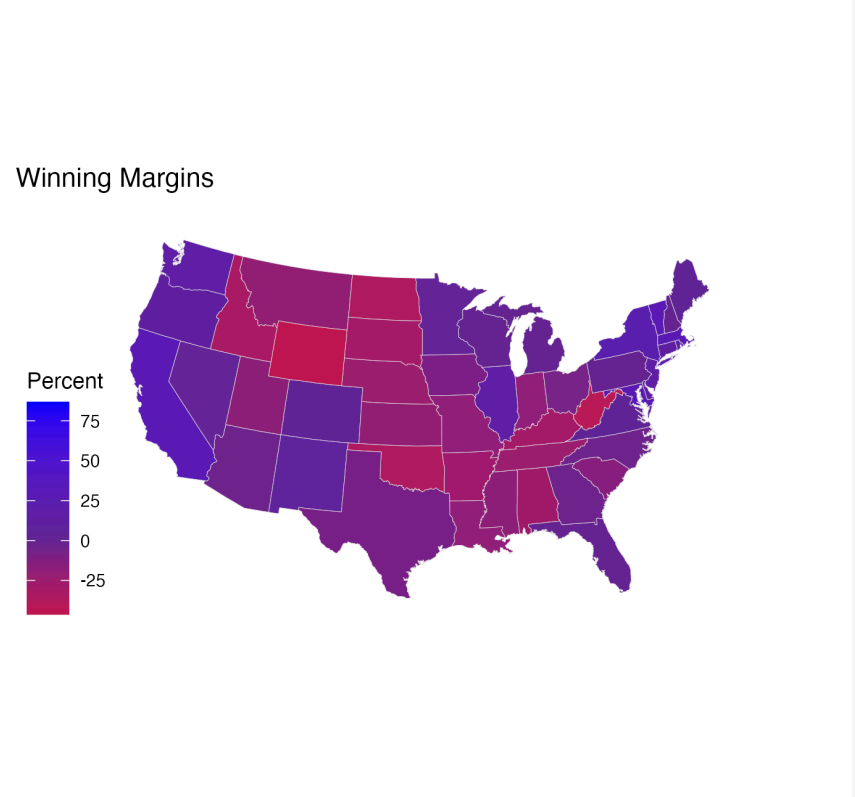
Some gradients are *diverging*

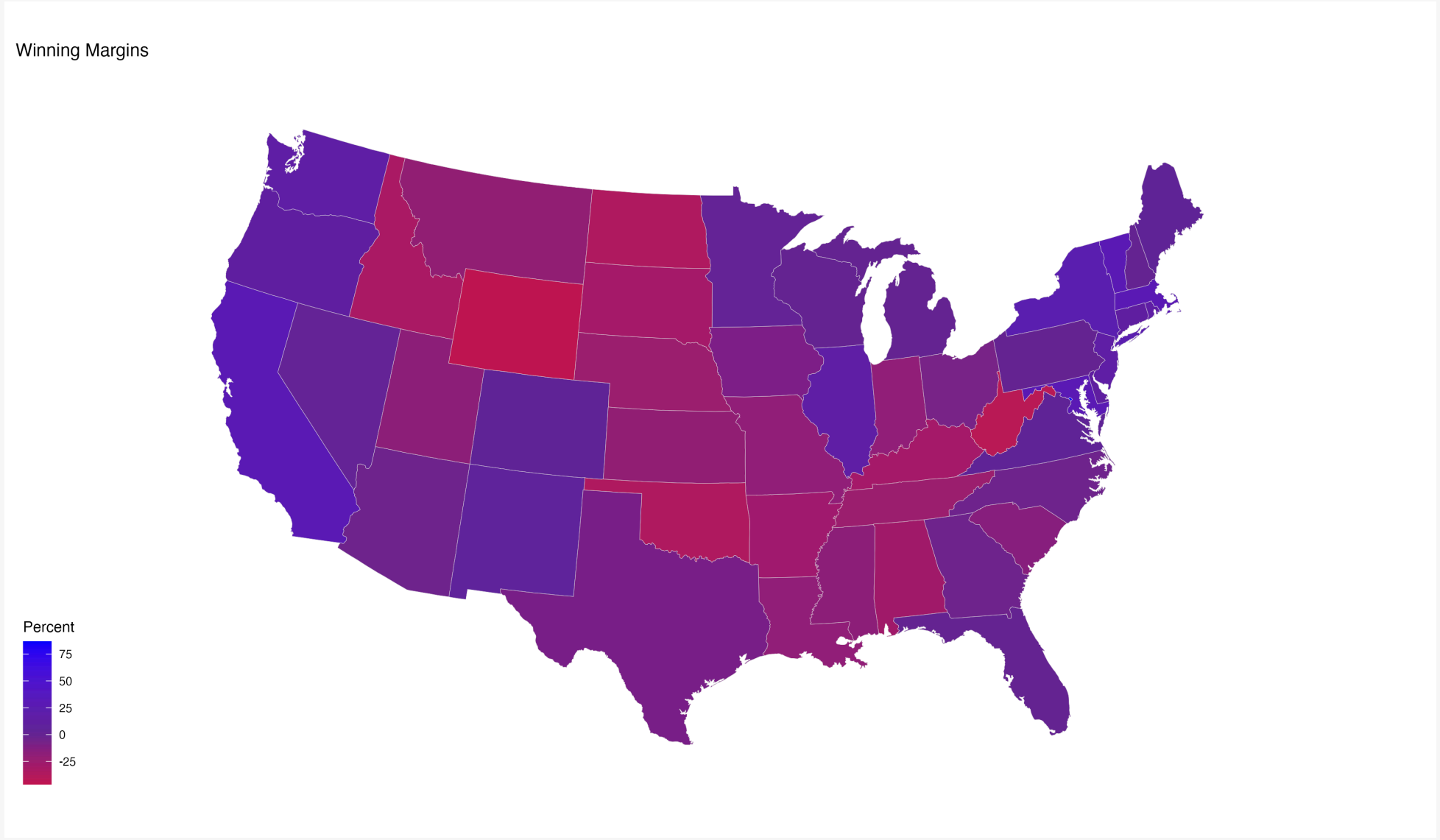
```
us_states_elec ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = d_points,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_gradient2() +
  coord_map(projection = "albers",
            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()
```



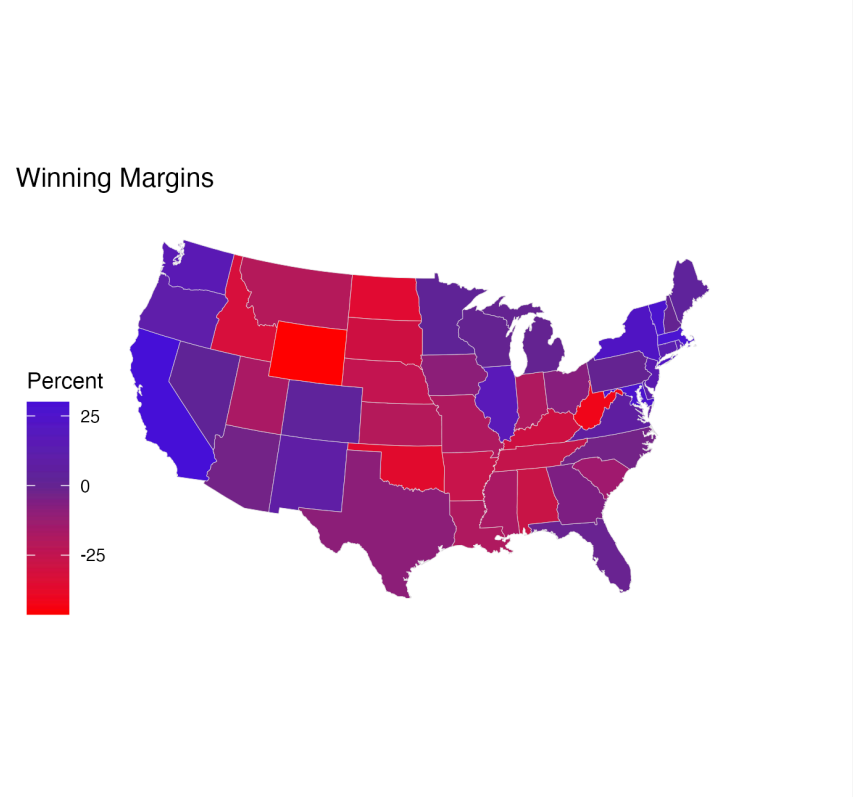


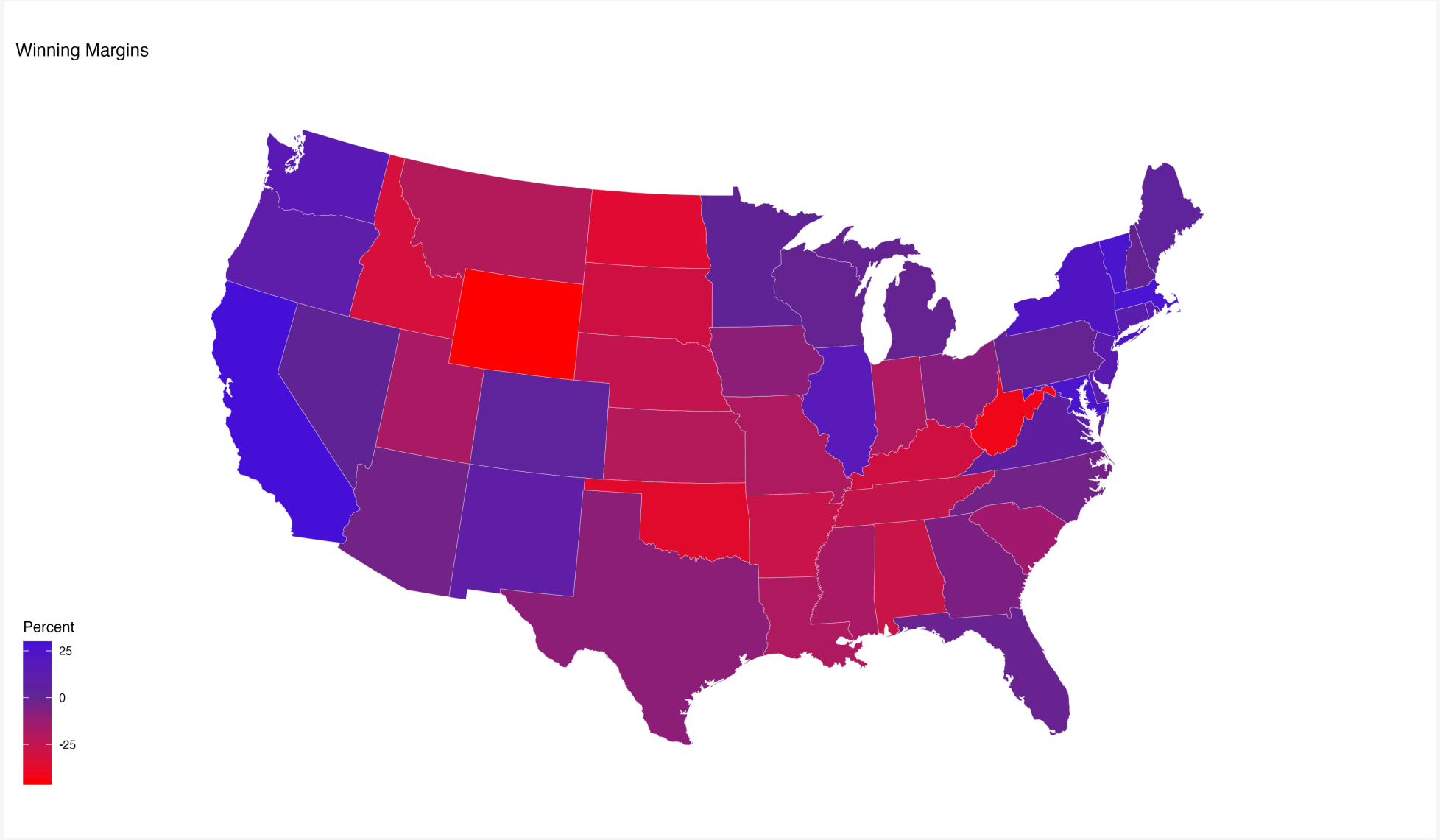
Take a closer look at this, though.

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()
```





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 51580 Covington city   VA    [ 1000, 5000) [10.0,15.0)
 2 48251 Johnson County   TX    [  100,  500) [ 2.0, 5.0)
 3 32005 Douglas County   NV    [   50,  100) [ 0.0, 2.0)
 4 20169 Saline County    KS    [   50,  100) [ 2.0, 5.0)
 5 31143 Polk County      NE    [   10,   50) [ 0.0, 2.0)
 6 51009 Amherst County   VA    [   50,  100) [15.0,25.0)
 7 24027 Howard County    MD    [ 1000, 5000) [15.0,25.0)
 8 35035 Otero County     NM    [    0,   10) [ 2.0, 5.0)
 9 41057 Tillamook County OR    [   10,   50) [ 0.0, 2.0)
10 48423 Smith County     TX    [  100,  500) [15.0,25.0)
```

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"))
```

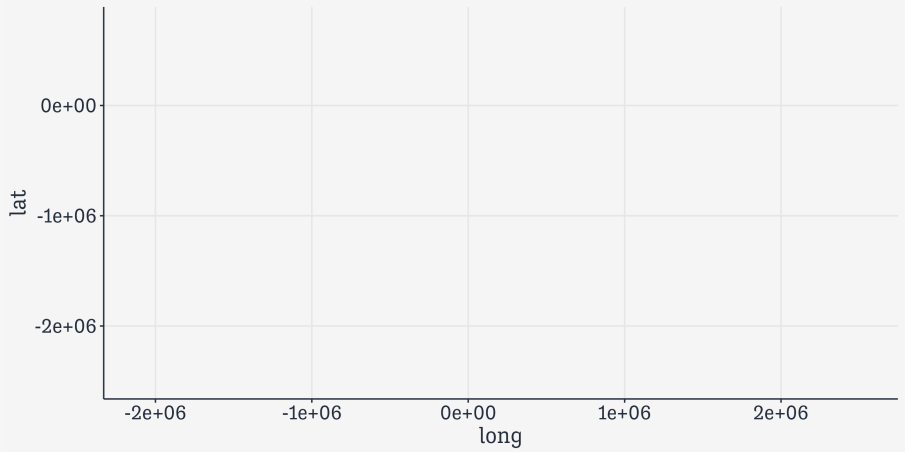
County Population Density

```
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
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>, …
```

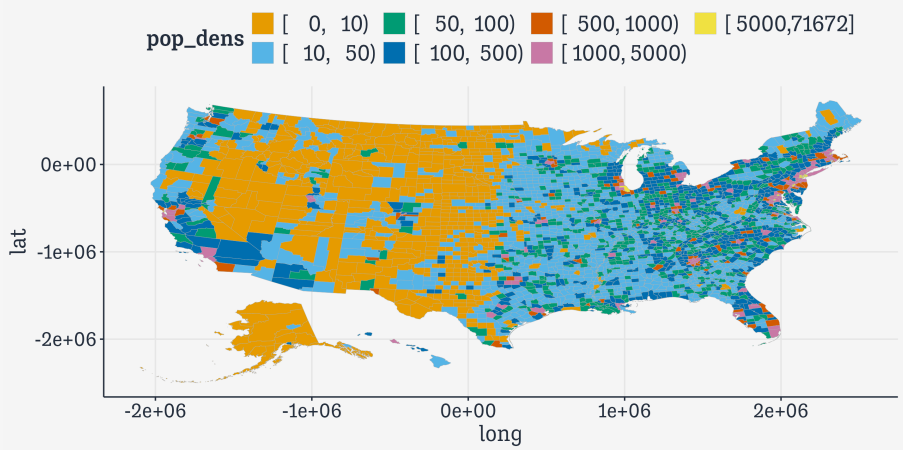
County Population Density

```
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))
```



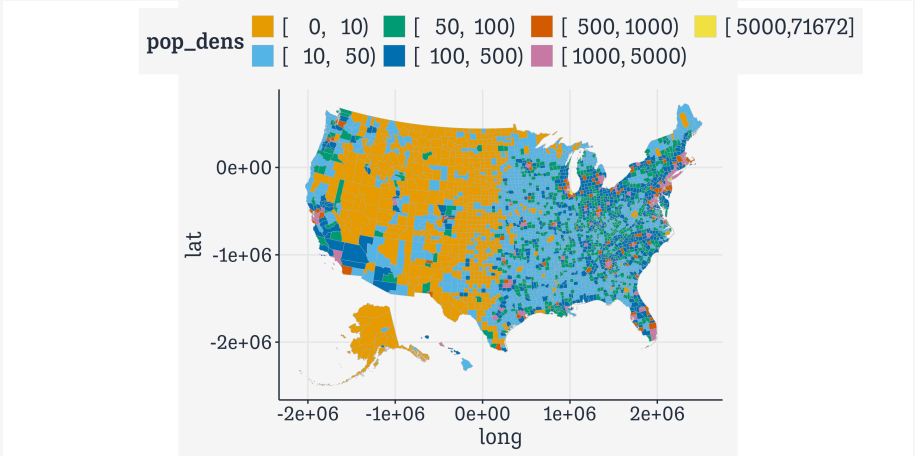
County Population Density

```
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)
```



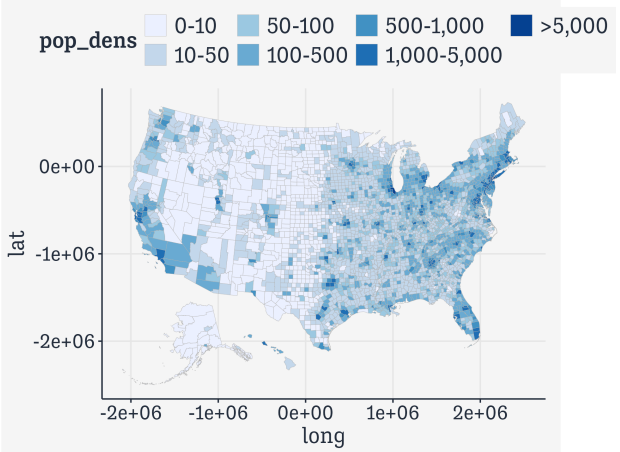
County Population Density

```
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()
```



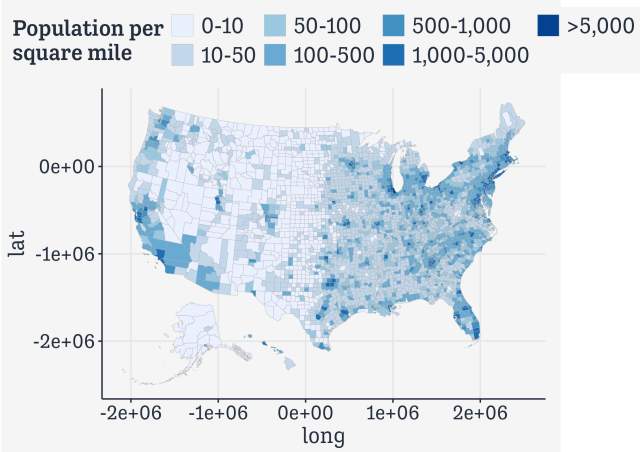
County Population Density

```
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"))
```



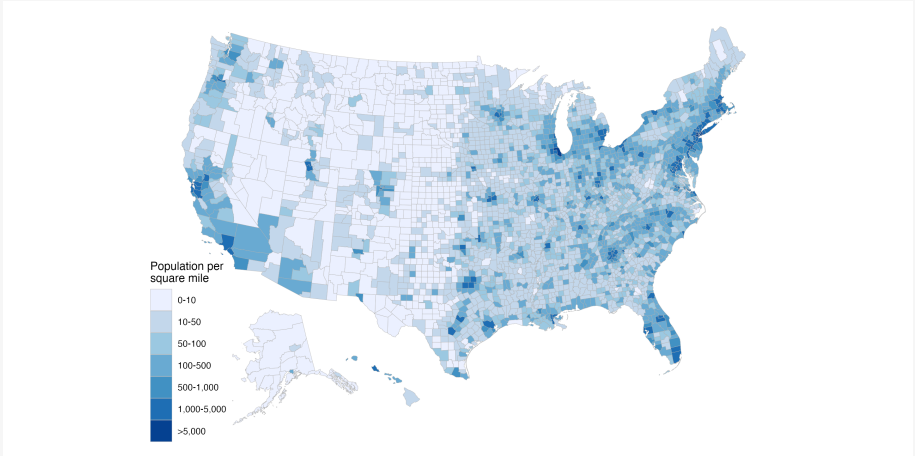
County Population Density

```
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")
```



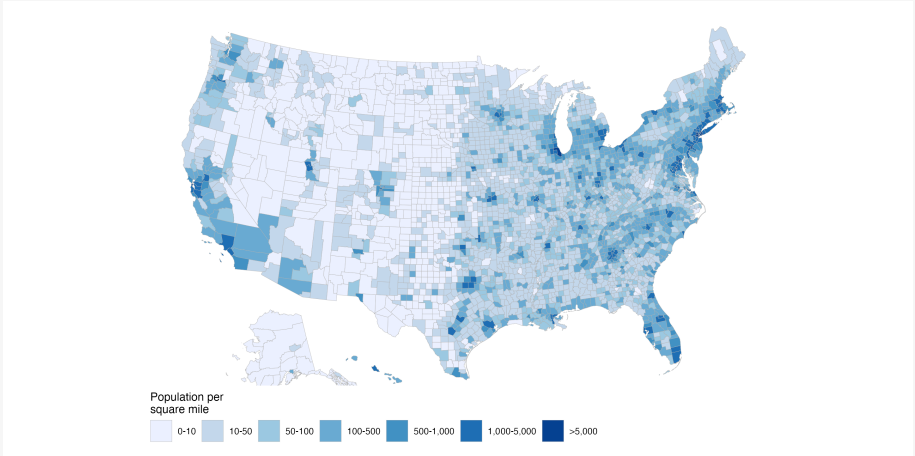
County Population Density

```
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()
```



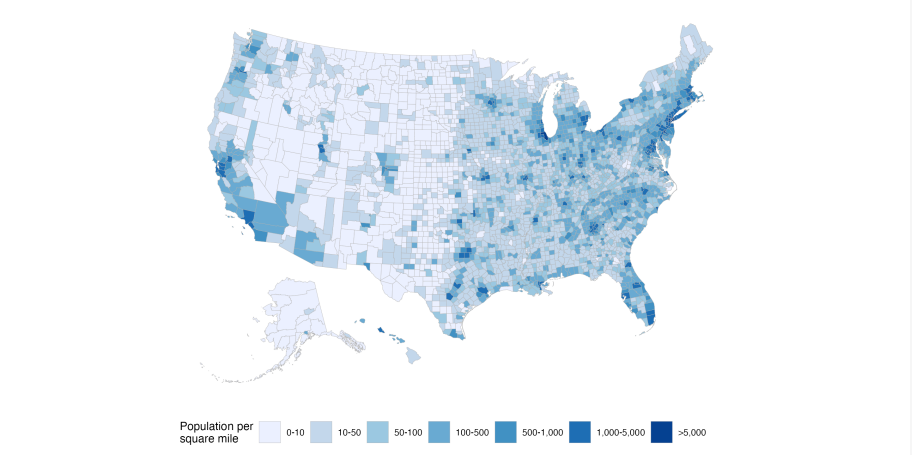
County Population Density

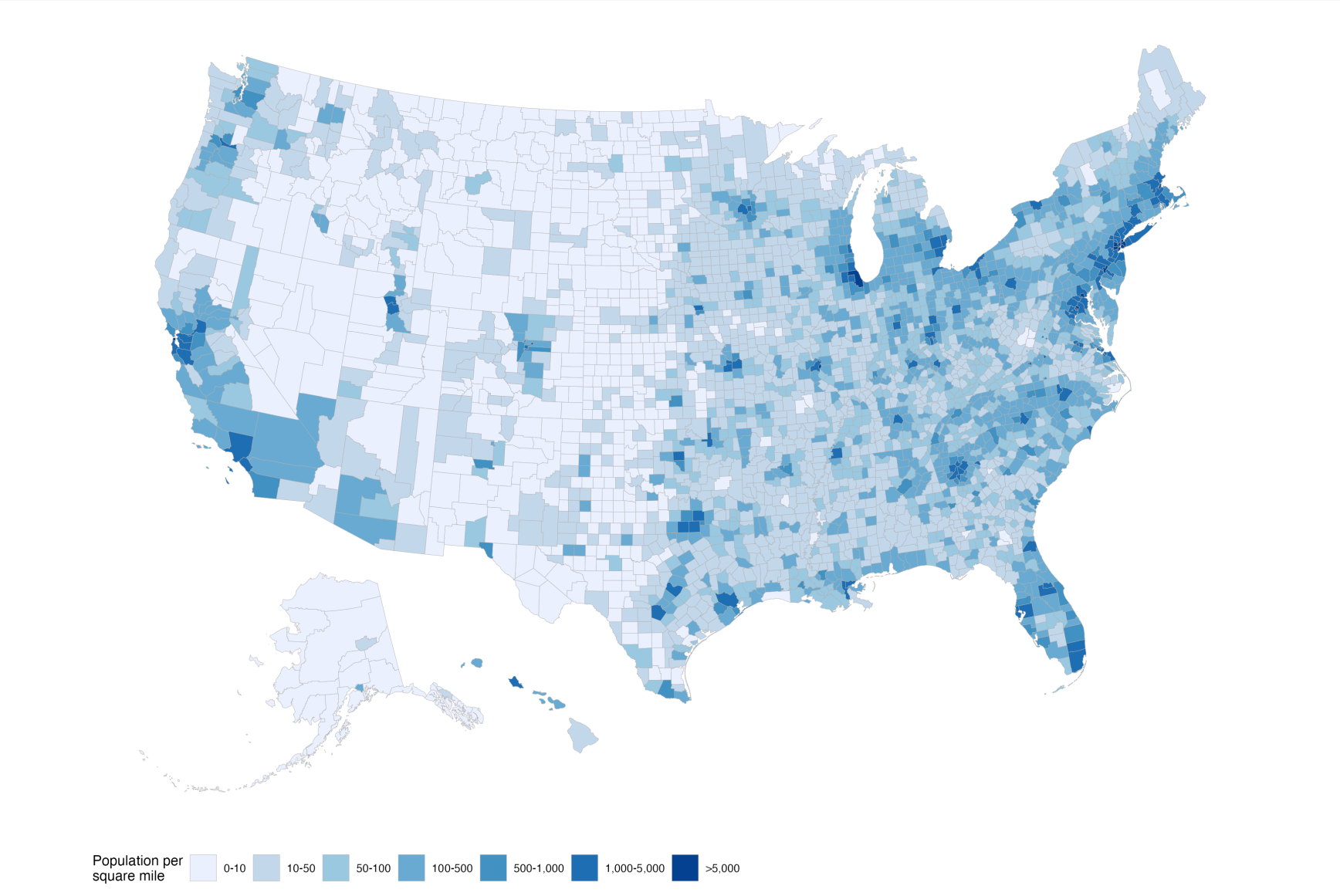
```
county_full ← as_tibble(left_join(county_map, county_data, by = "id"))


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 = "id"))
```

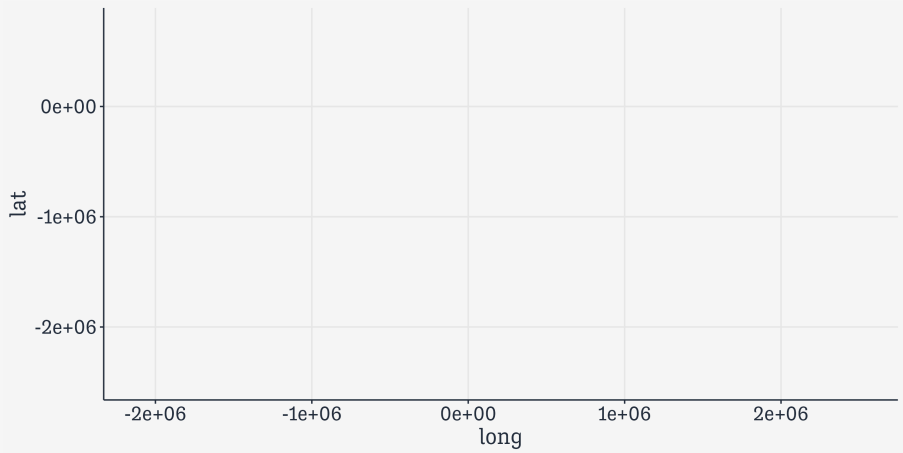
Same again for Percent Black

```
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
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>, …
```

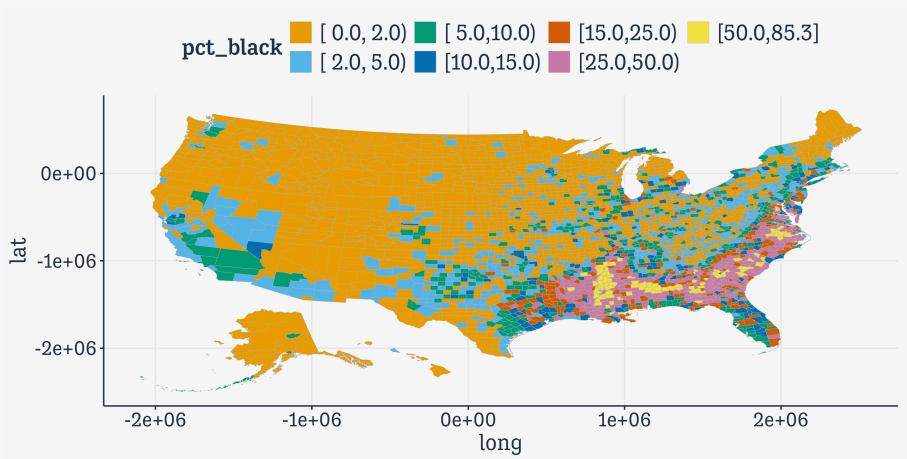
Same again for Percent Black

```
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))
```



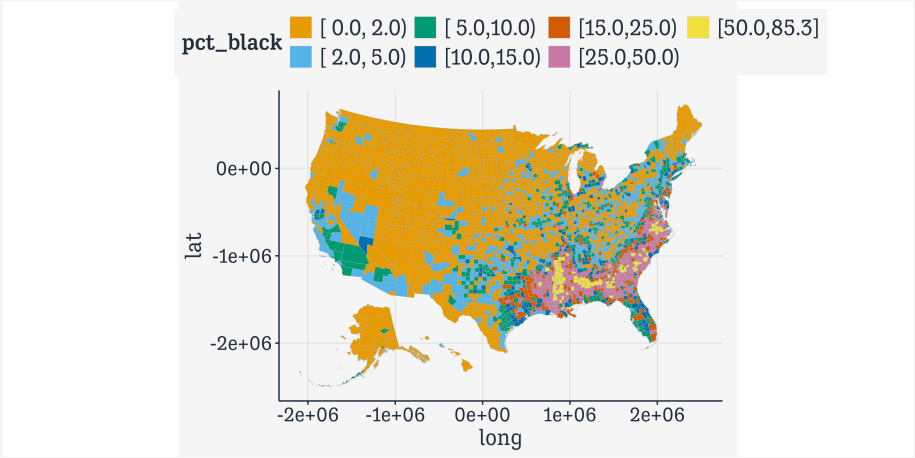
Same again for Percent Black

```
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)
```



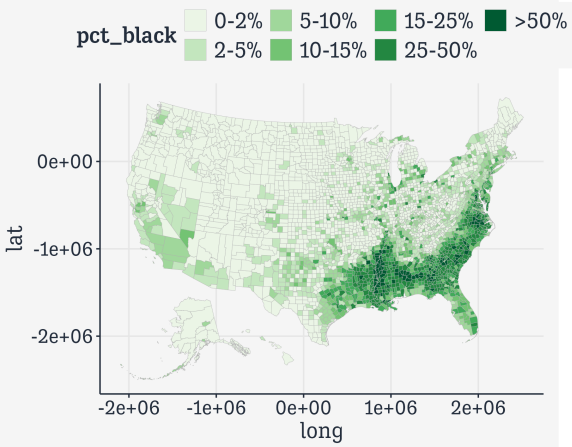
Same again for Percent Black

```
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()
```



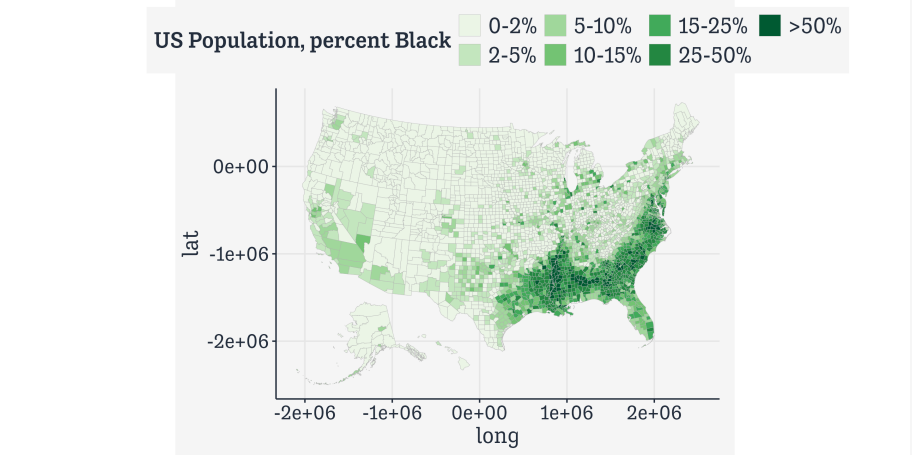
Same again for Percent Black

```
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%"))
```



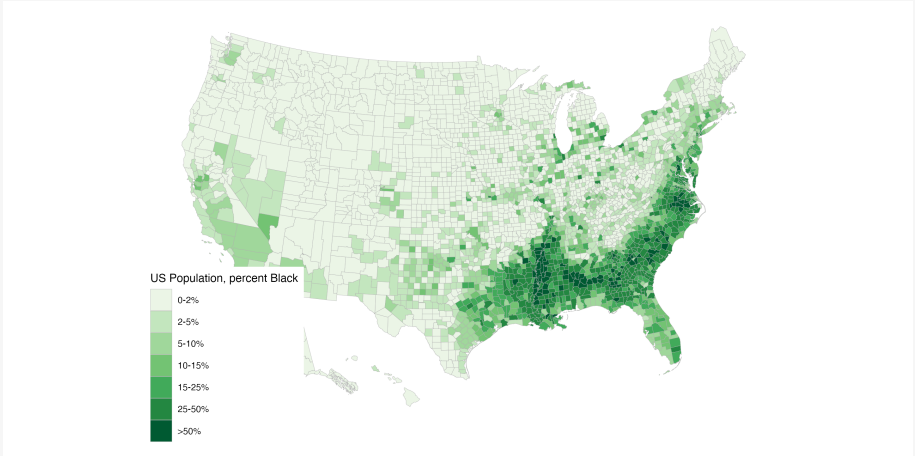
Same again for Percent Black

```
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")
```



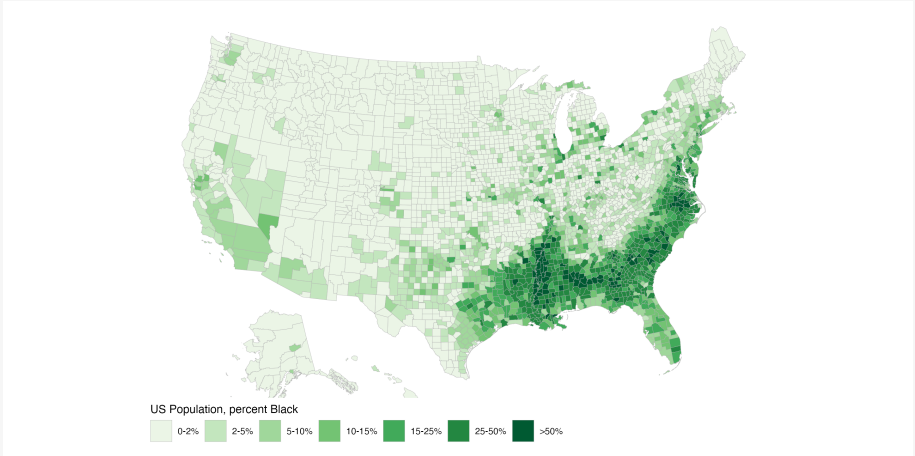
Same again for Percent Black

```
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()
```



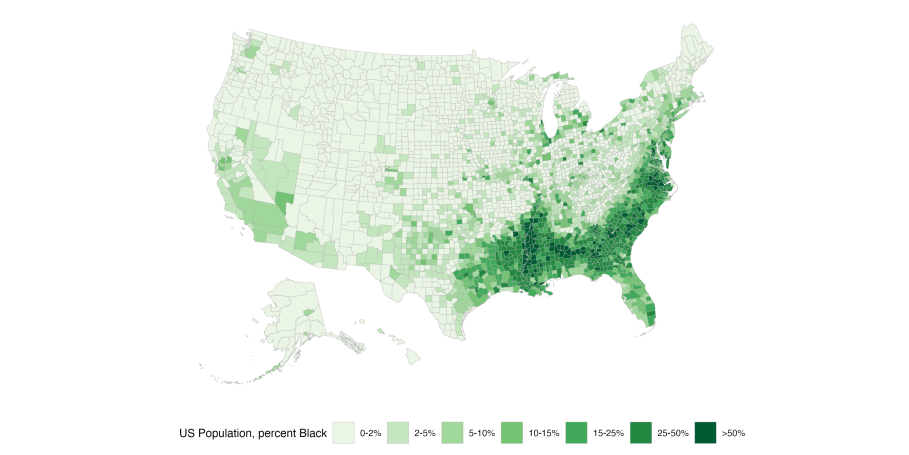
Same again for Percent Black

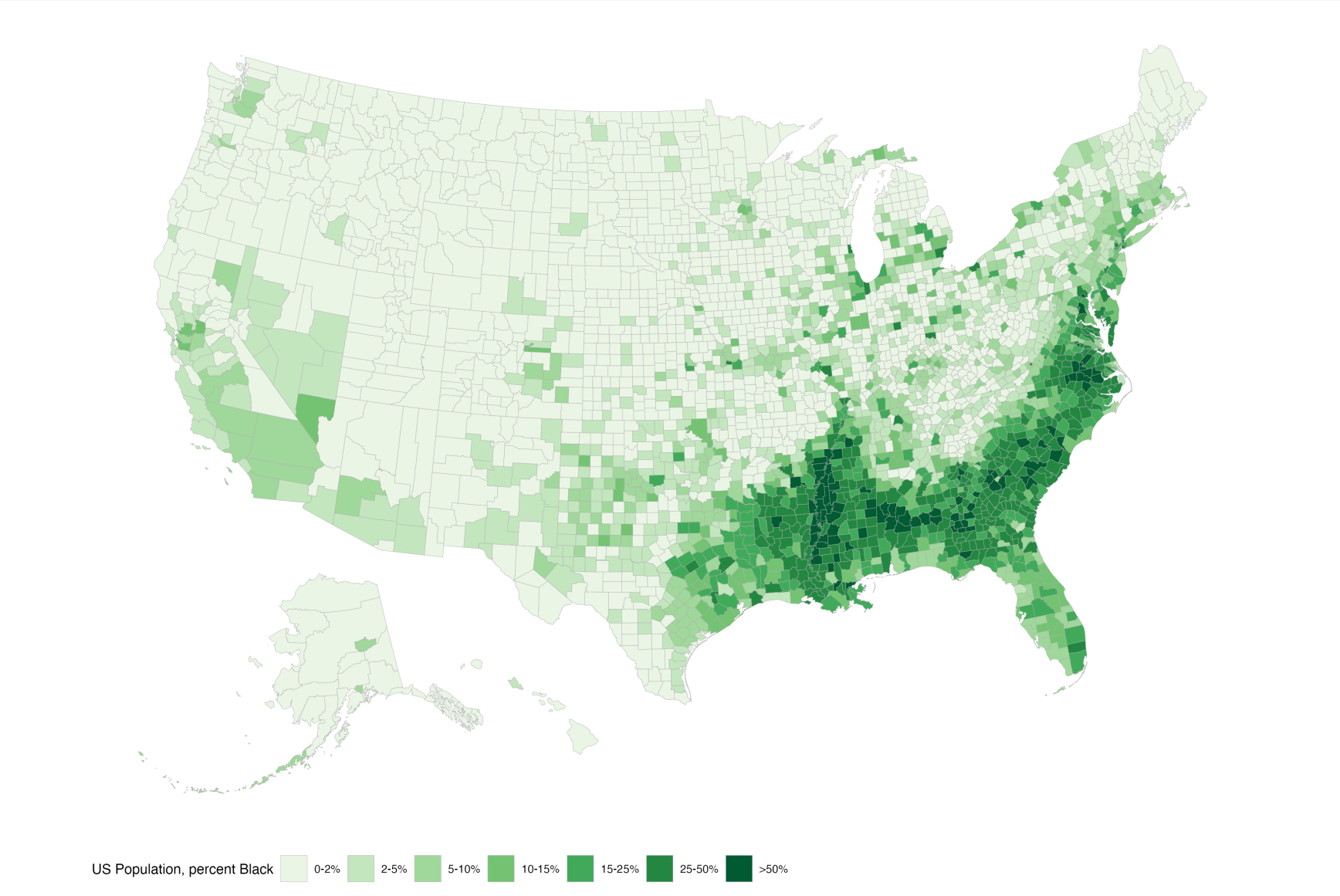
```
county_full ← as_tibble(left_join(county_map, county_data, by = "id"))

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

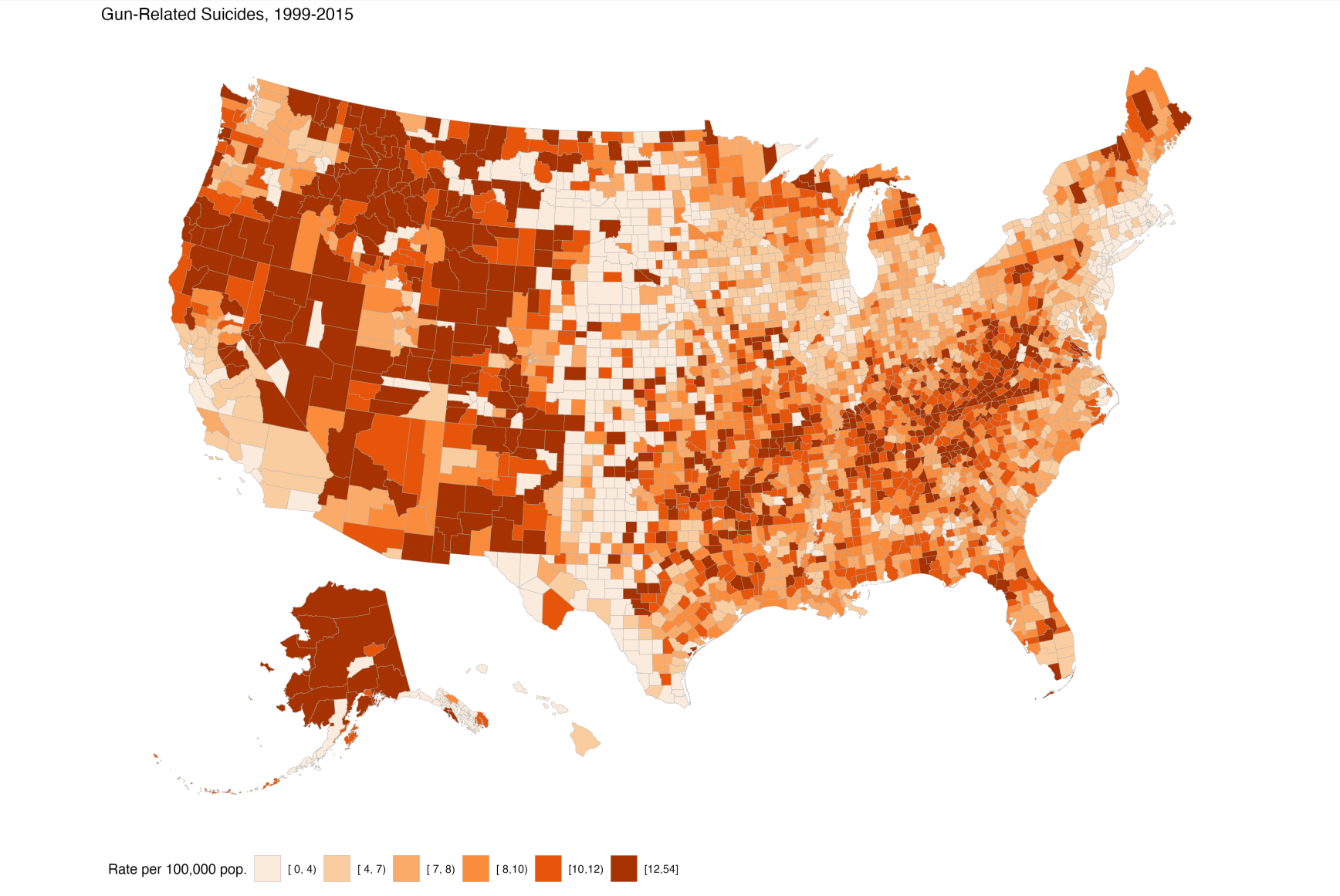
Code | Reverse

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

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

Build a plot

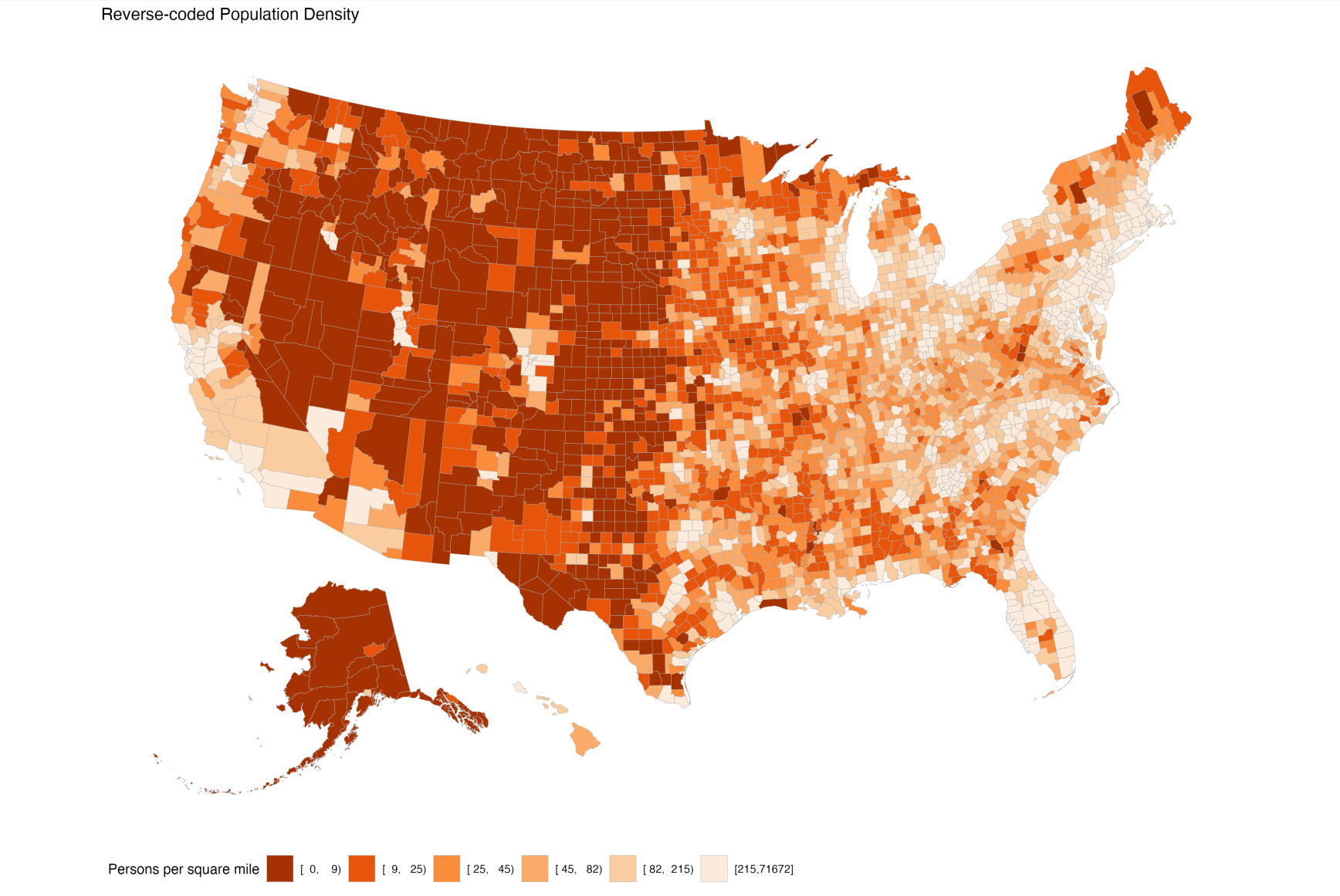
```
p_g1 ← county_full ▷
  ggplot(mapping = aes(x = long, y = lat,
                       fill = su_gun6,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_manual(values = orange_pal) +
  labs(title = "Gun-Related Suicides,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



Regular palette

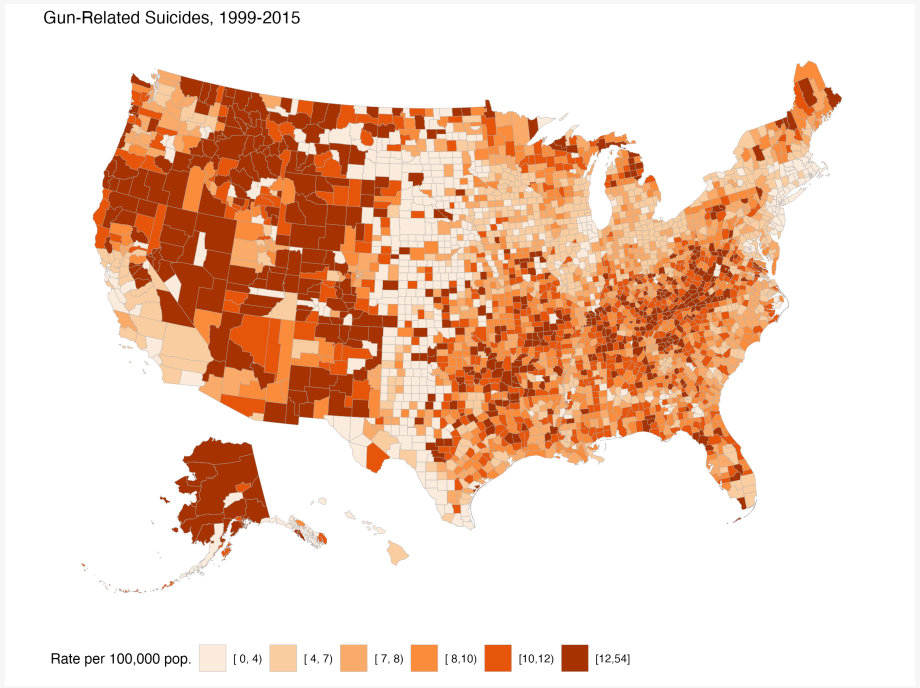
And another

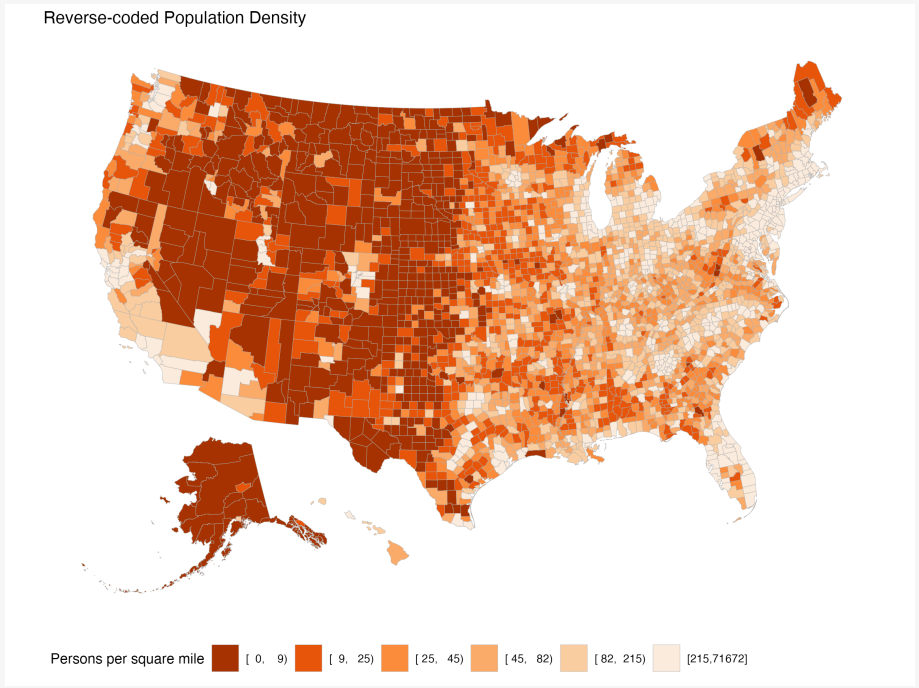
```
p_g2 ← county_full ▷
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pop_dens6,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_manual(values = orange_rev) +
  labs(title = "Reverse-coded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



Reverse-coded density

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

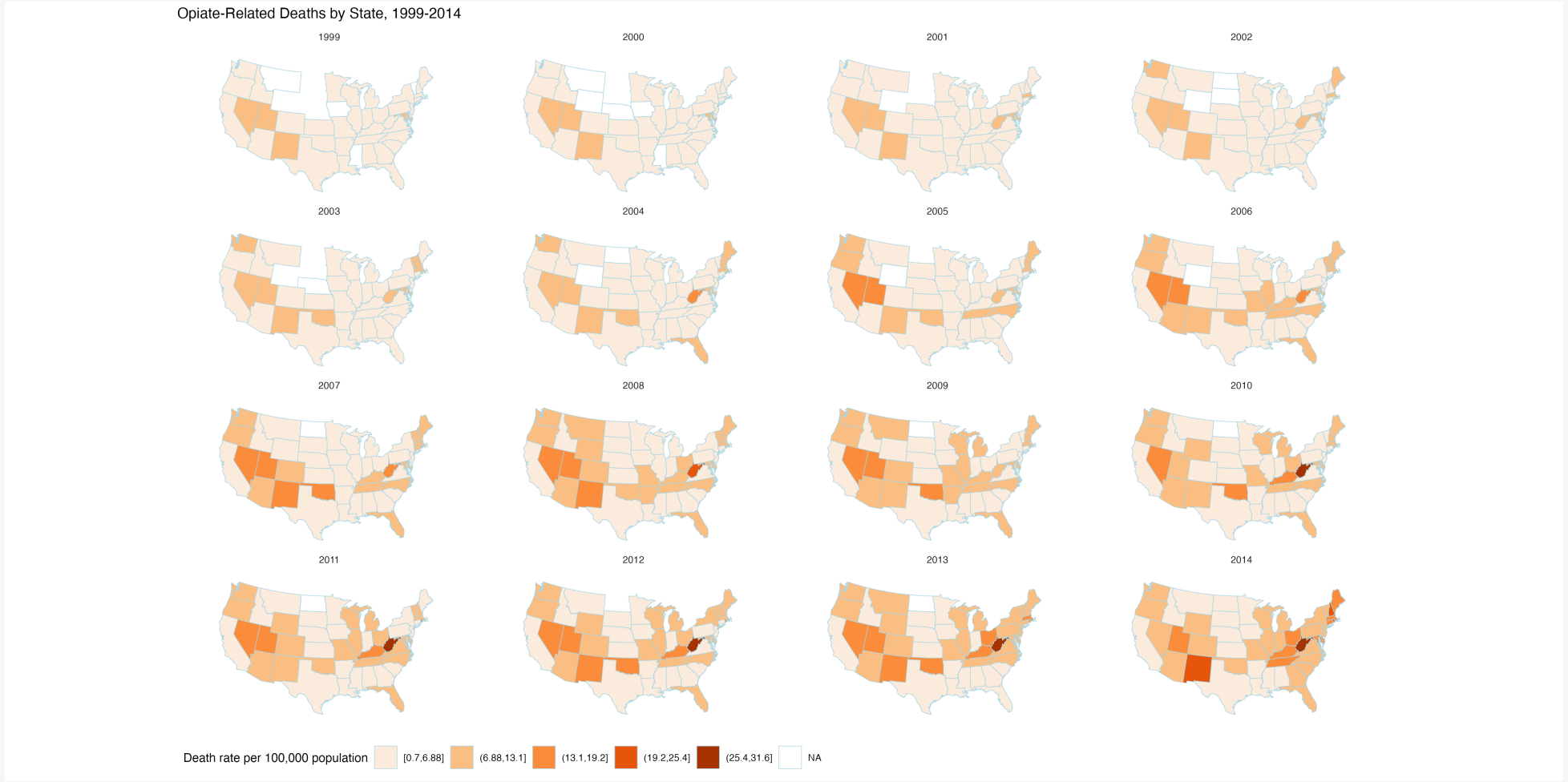
Opiate-related Mortality, 1999-2014

```
opiates
```

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

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 adjusted_se
region abbr
   <int> <chr>   <int>  <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
```

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 adjusted_se
region abbr
   <int> <chr>   <int>  <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
```

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 adjusted_se
region abbr
  <int> <chr>    <int>  <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         1   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 adjusted_se
region abbr
  <int> <chr>    <int>  <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         1   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 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
```

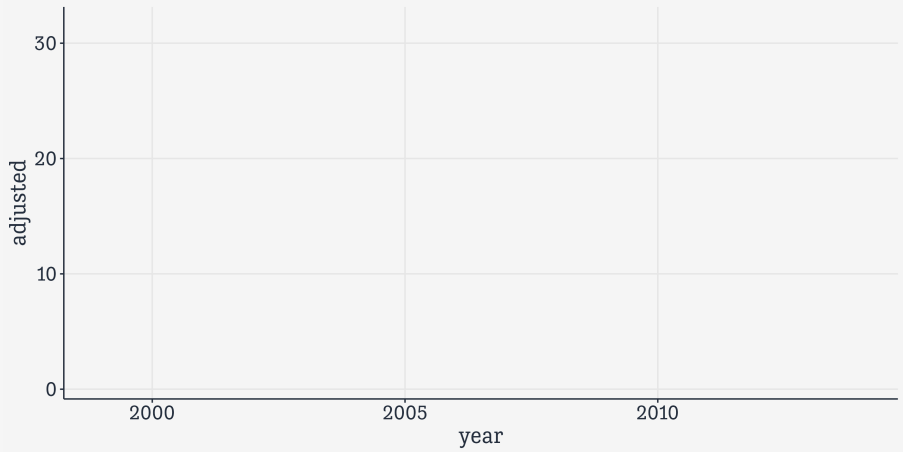
Opiates Time Series plot

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

opiates ▷
  mutate(top = state %in% st_top$state)
```

```
# A tibble: 800 × 12
    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
```

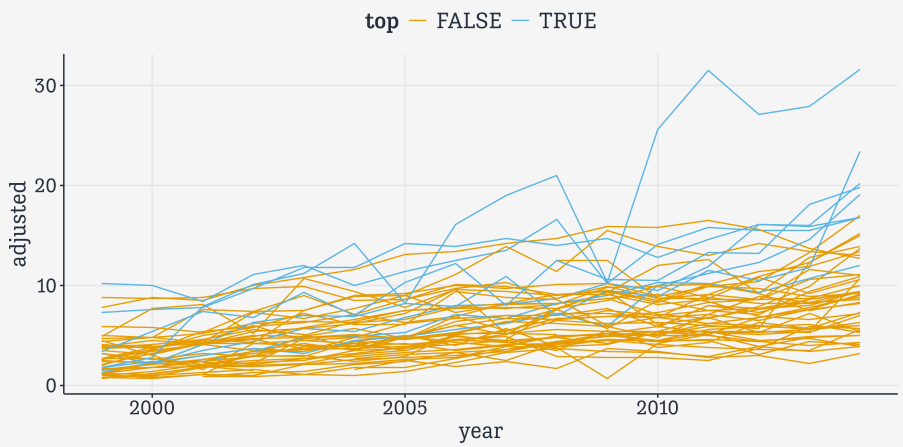
Opiates Time Series plot

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

opiates ▷
  mutate(top = state %in% st_top$state) ▷
  ggplot(aes(x = year,
             y = adjusted))
```



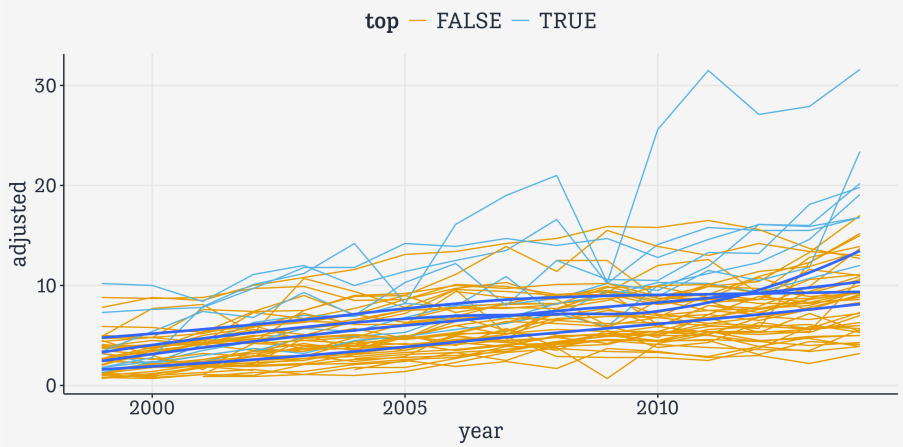
Opiates Time Series plot

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

opiates ▷
  mutate(top = state %in% st_top$state) ▷
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state, color = top))
```



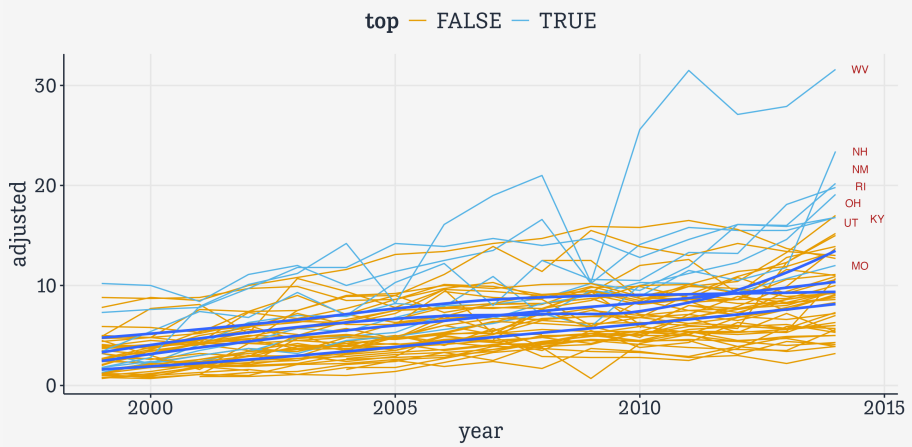
Opiates Time Series plot

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

opiates ▷
  mutate(top = state %in% st_top$state) ▷
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state, color = top)) +
  geom_smooth(aes(group = region),
              se = FALSE)
```



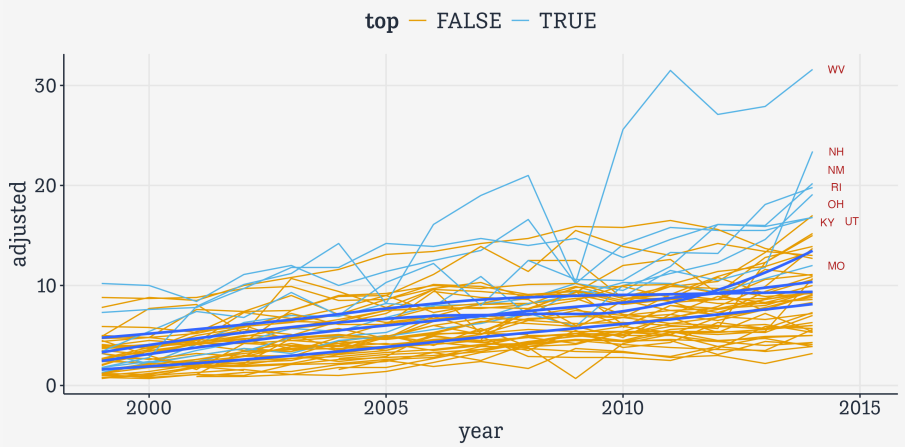
Opiates Time Series plot

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

opiates ▷
  mutate(top = state %in% st_top$state) ▷
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state, color = top)) +
  geom_smooth(aes(group = region),
              se = FALSE) +
  ggrepel::geom_text_repel(
    data = st_top,
    mapping = aes(x = year,
                  y = adjusted,
                  label = abbr),
    size = 3,
    color = "firebrick",
    segment.color = NA,
    nudge_x = 0.5)
```



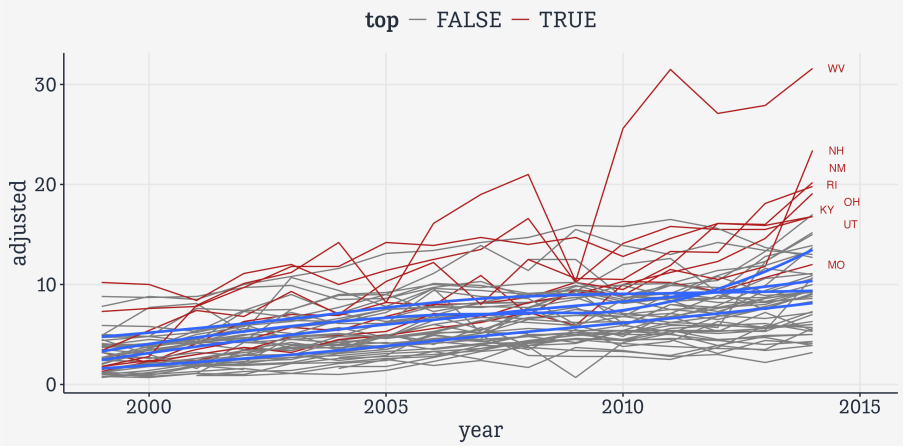
Opiates Time Series plot

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

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



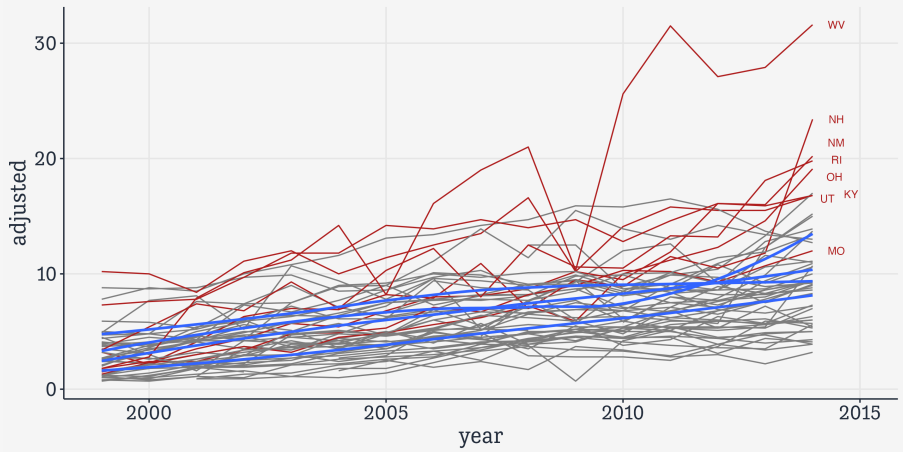
Opiates Time Series plot

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

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



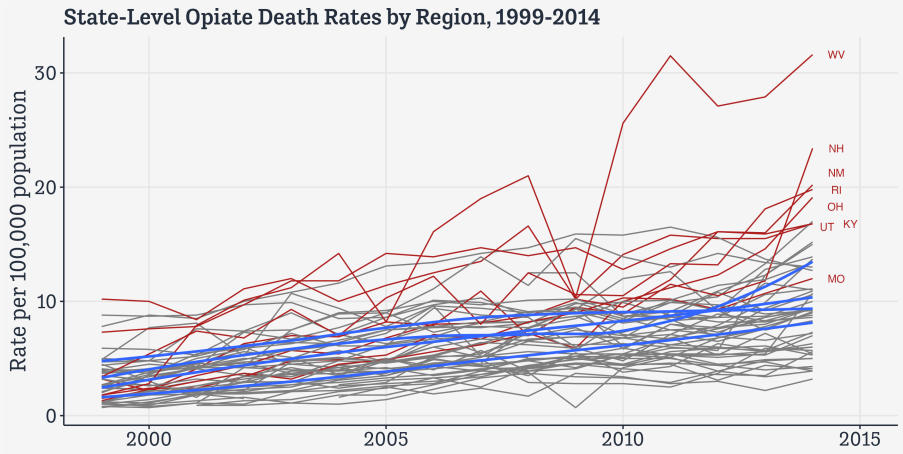
Opiates Time Series plot

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

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



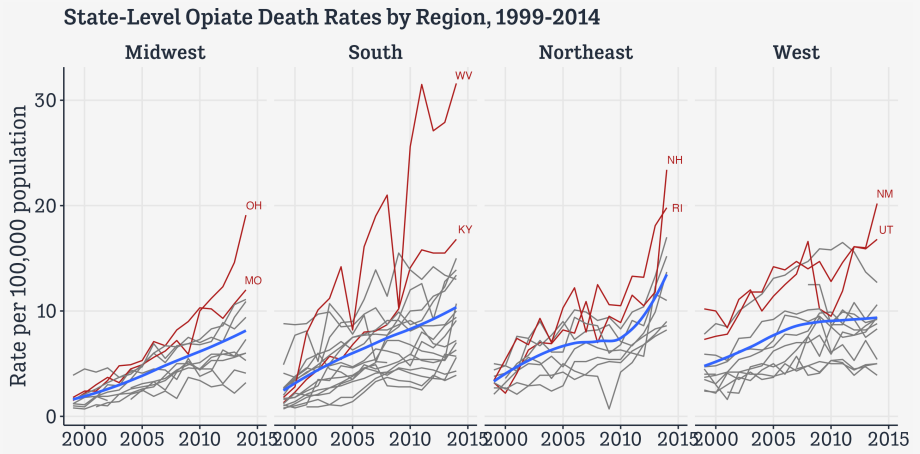
Opiates Time Series plot

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

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



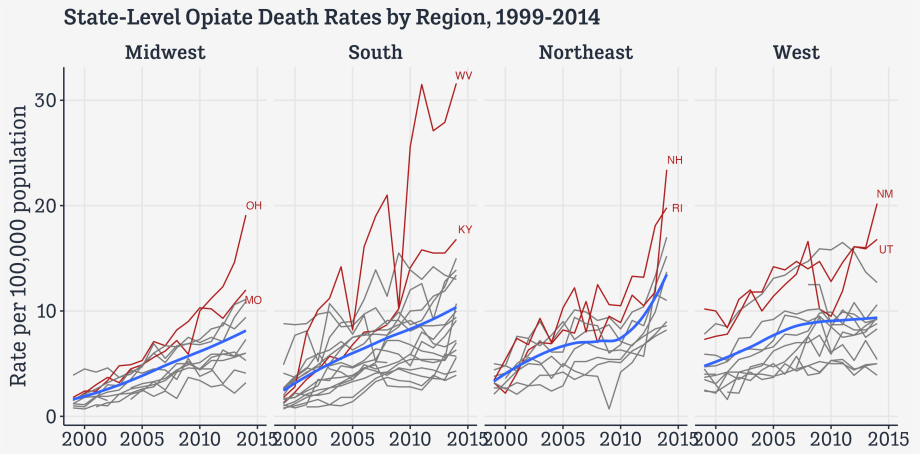
Opiates Time Series plot

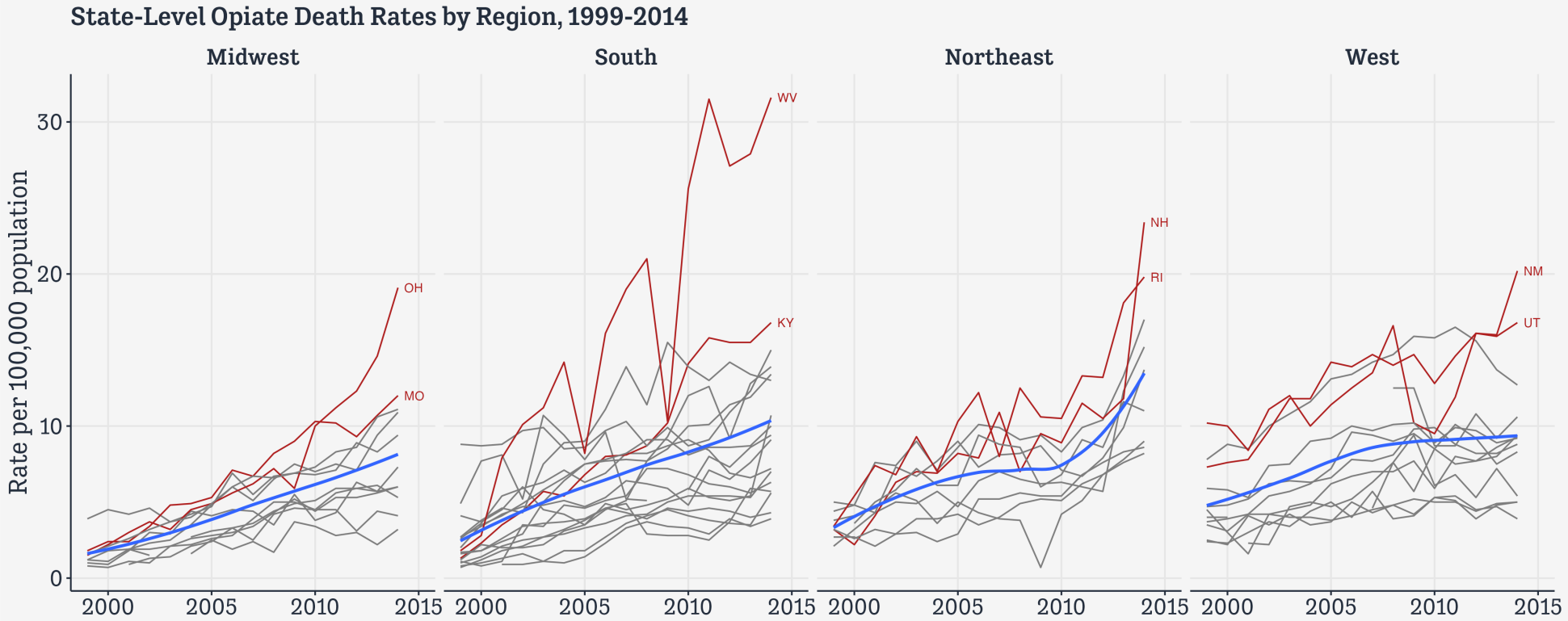
```
st_top ← opiates ▷  filter(year == max(year), abbr ≠ "DC") ▷
  group_by(region) ▷
  slice_max(order_by = adjusted, n = 2)

opiates ▷
  mutate(top = state %in% st_top$state) ▷
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state, color = top)) +
  geom_smooth(aes(group = region),
              se = FALSE) +
  ggrepel::geom_text_repel(
    data = st_top,
    mapping = aes(x = year,
                  y = adjusted,
                  label = abbr),
    size = 3,
    color = "firebrick",
    segment.color = NA,
    nudge_x = 0.5) +
  coord_cartesian(c(min(opiates$year),
                    max(opiates$year) + 1)) +
  scale_color_manual(values = c("gray50", "firebrick")) +
  guides(color = FALSE) +
  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 ▷
  mutate(top = state %in% st_top$state) ▷
  ggplot(aes(x = year,
             y = adjusted)) +
  geom_line(aes(group = state, color = top)) +
  geom_smooth(aes(group = region),
              se = FALSE) +
  ggrepel::geom_text_repel(
    data = st_top,
    mapping = aes(x = year,
                  y = adjusted,
                  label = abbr),
    size = 3,
    color = "firebrick",
    segment.color = NA,
    nudge_x = 0.5) +
  coord_cartesian(c(min(opiates$year),
                    max(opiates$year) + 1)) +
  scale_color_manual(values = c("gray50", "firebrick")) +
  guides(color = FALSE) +
  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.