09 — Maps and Spatial Data

Kieran Healy

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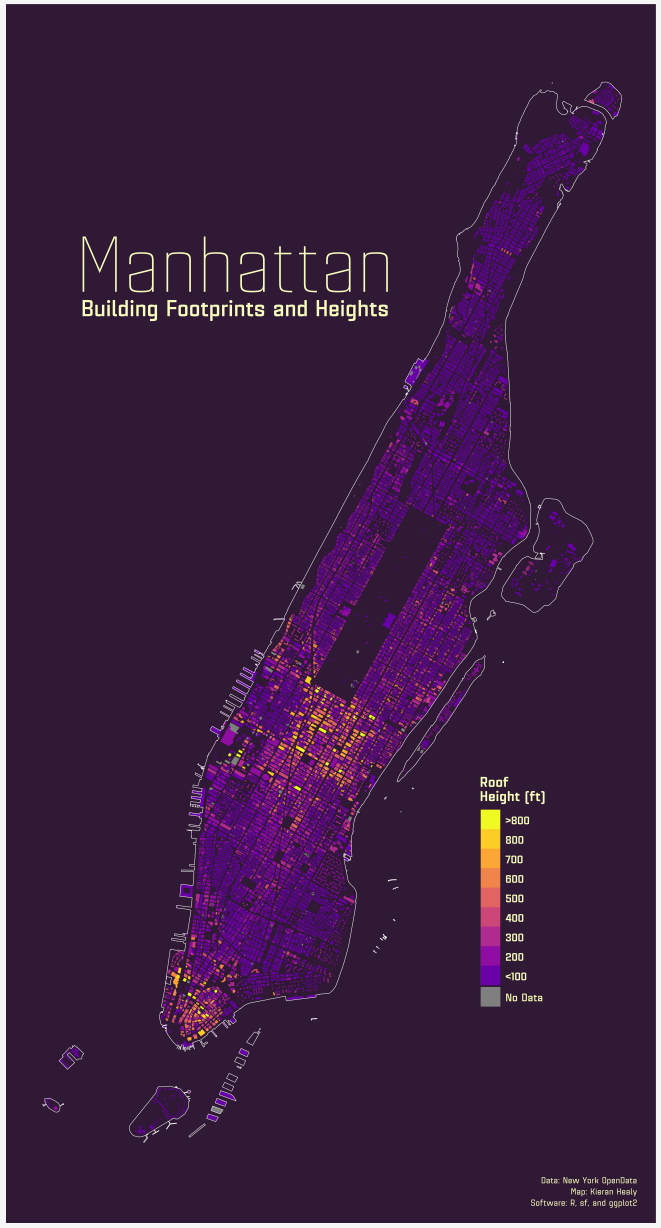
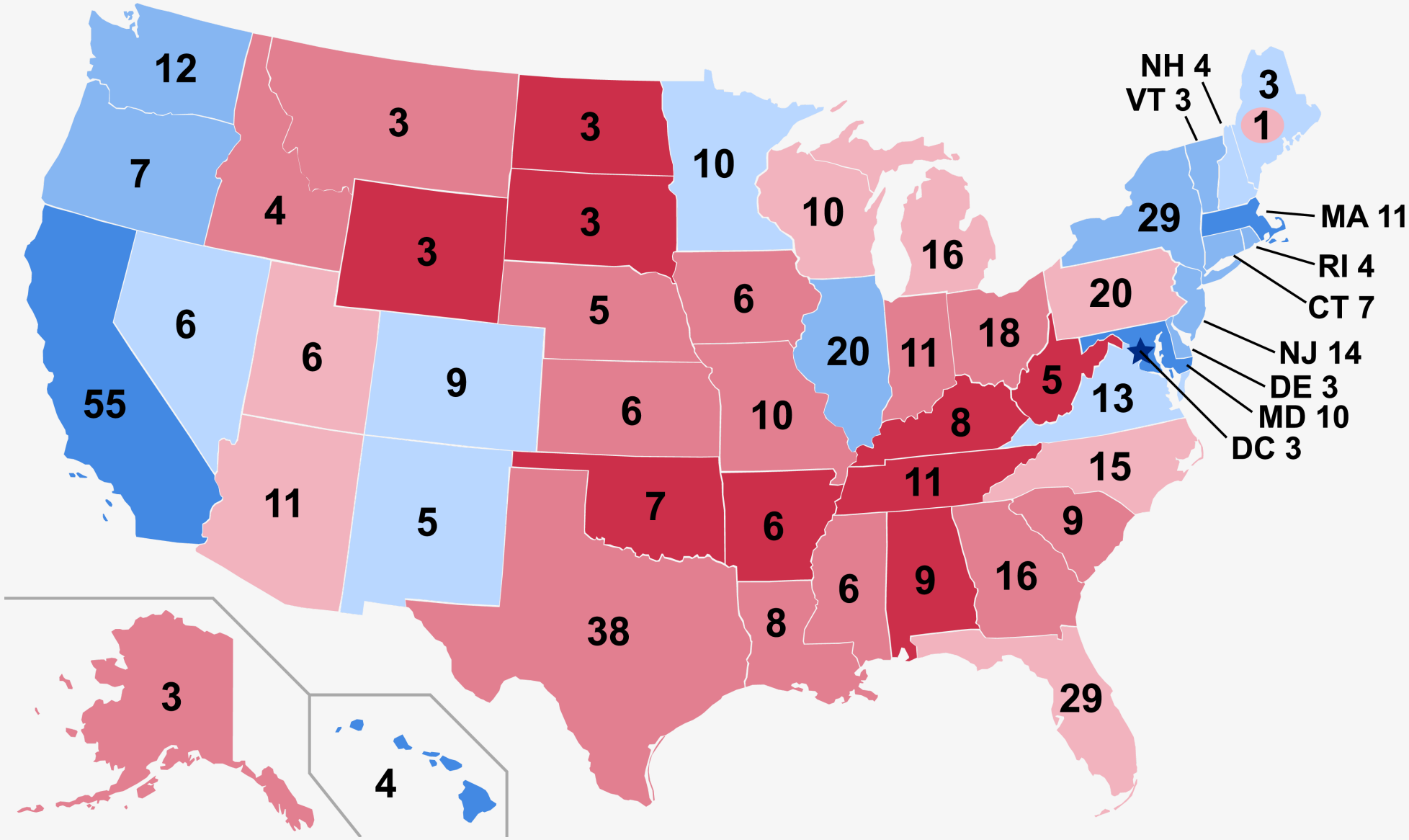
MAP DESCRIPTIVE OF LONDON POVERTY, 1898-9
(IN 12 SHEETS)

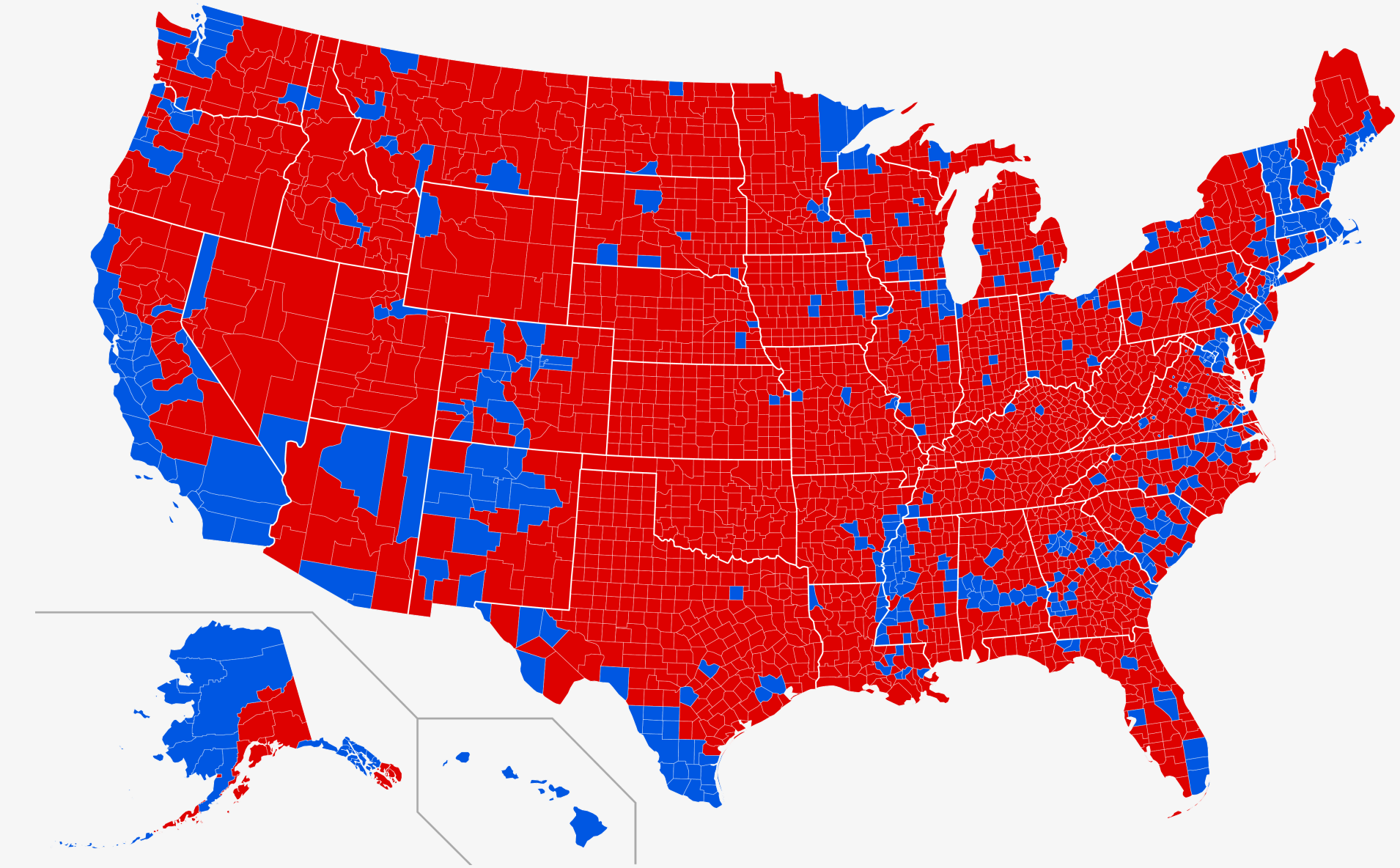
SHEET 7.
EASTERN DISTRICT.

CHRIST CHURCH
St JUDE
St PAUL
St JAMES the Less
ST LUKE
ST SIMON Zelotes
St ANDREW
St BARTHOLOMEW
CHRIST CHURCH Spitalfields
St PHILIP Stepney
ST THOMAS Arbour Sq. Stepney
CHRIST CHURCH Watney Street
St MARY Johnson Street
ST JAMES Ratcliffe
ST PAUL Shadwell
St PETER London Docks
ST JOHN Wapping
ST MARY Whitechapel
HOLY TRINITY
ALL SAINTS
ST BARNABAS
ST KATHERINE
ST LUKE
ST BARTHOLOMEW
ST JAMES Hatcham Park
ST NICHOLAS
ST MARK
ST LEONARD Bromley
St ANDREW Bromley
St MARK Victoria Park
St BENET Mile End
St PAUL Bow Common
St ANNE Limehouse
ST MATTHIAS
ST PETER Limehouse
ALL SAINTS
ST LUKE Millwall
ST CUTHBERT Millwall
ST MICHAEL AND ALL ANGELS
St GABRIEL Fen Street
ST ANDREW
CHRIST CHURCH
ST ALPHEGE Greenwich
Victoria Park
Hackney Marsh
Bow Cemetery
Tower Hamlets Cemetery
Millwall Docks
West India Docks
Blackwall Basin
Poplar Docks
Limehouse Basin
Regent's Canal Dock
Thames Tunnel
Greenwich Pier
Deptford Pier
Greenwich Pier
Hungerford Bridge
Blackfriars Bridge
Southwark Bridge
London Bridge
Tower Bridge
Rotherhithe Tunnel
Greenwich Foot Tunnel
Woolwich Ferry
Isle of Dogs
Bow Creek
Limehouse Cut
Lea Navigation
Lea Cut
Old Ford
Bow Bridge
Bow Road
Mile End Road
Commercial Road
Commercial Street
Whitechapel Road
Cable Street
Leman Street
Aldgate
Aldgate East
Minories
Tower Hill
Fenchurch Street
Mansion House
Cannon Street
Queen Victoria Street
Blackfriars
Ludgate Hill
St Paul's
Cheapside
Bank
Threadneedle Street
Liverpool Street
Bishopsgate
Shoreditch
Old Street
City Road
Finsbury Square
Moorfields
Finsbury Pavement
Great Eastern Street
Curtain Road
Hoxton Street
Kingsland Road
Dalston
Stamford Hill
Stoke Newington
Clapton
Hackney
Homerton
Victoria Park Road
Grove Road
Mile End Old Town
Stepney Green
Whitechapel
Spitalfields
Bethnal Green
Shadwell
Wapping
Ratcliff
Limehouse
Poplar
Blackwall
Millwall
Deptford
Greenwich
Rotherhithe
Bermondsey
Southwark
Lambeth
Vauxhall
Battersea
Clapham
Brixton
Camberwell
Peckham
Dulwich
Norwood
Streatham
Tooting
Wandsworth
Putney
Fulham
Chelsea
Kensington
Hammersmith
Shepherd's Bush
Notting Hill
Paddington
Marylebone
Regent's Park
Camden Town
Kentish Town
Highgate
Hampstead
Finchley
Golders Green
Hendon
Willesden
Kilburn
St John's Wood
Primrose Hill
Chalk Farm
Tufnell Park
Holloway
Upper Holloway
Crouch End
Muswell Hill
Wood Green
Tottenham
Edmonton
Enfield
Walthamstow
Leyton
Leytonstone
Wanstead
Ilford
Barking
Dagenham
Romford
Hornchurch
Upminster
Rainham
Purfleet
Erith
Crayford
Bexley
Sidcup
Chislehurst
Bromley
Beckenham
Penge
Anerley
Norwood
Croydon
Sydenham
Forest Hill
New Cross
Lewisham
Blackheath
Charlton
Woolwich
Plumstead
Abbey Wood
Eltham
Mottingham
Kidbrooke
Blackheath Hill
Greenwich Park
Maze Hill
Deptford Bridge
Evelyn Street
Surrey Commercial Docks
Rotherhithe Street
Jamaica Road
Old Kent Road
New Kent Road
Walworth Road
Camberwell New Road
Camberwell Road
Denmark Hill
Coldharbour Lane
Loughborough Park
Brixton Road
Clapham Road
Stockwell Road
Kennington Road
Kennington Park Road
Kennington Lane
Vauxhall Bridge Road
Vauxhall Bridge
Grosvenor Road
Millbank
Victoria Street
Westminster Bridge
Westminster Bridge Road
Lambeth Palace Road
Lambeth Bridge
Albert Embankment
Embankment
Waterloo Bridge
Waterloo Road
Strand
Fleet Street
Holborn
Holborn Viaduct
Newgate Street
Cheapside
Poultry
Lombard Street
Gracechurch Street
Leadenhall Street
Fenchurch Street
Minories
Aldgate
Aldgate East
Whitechapel Road
Commercial Road
Commercial Street
Bethnal Green Road
Shoreditch High Street

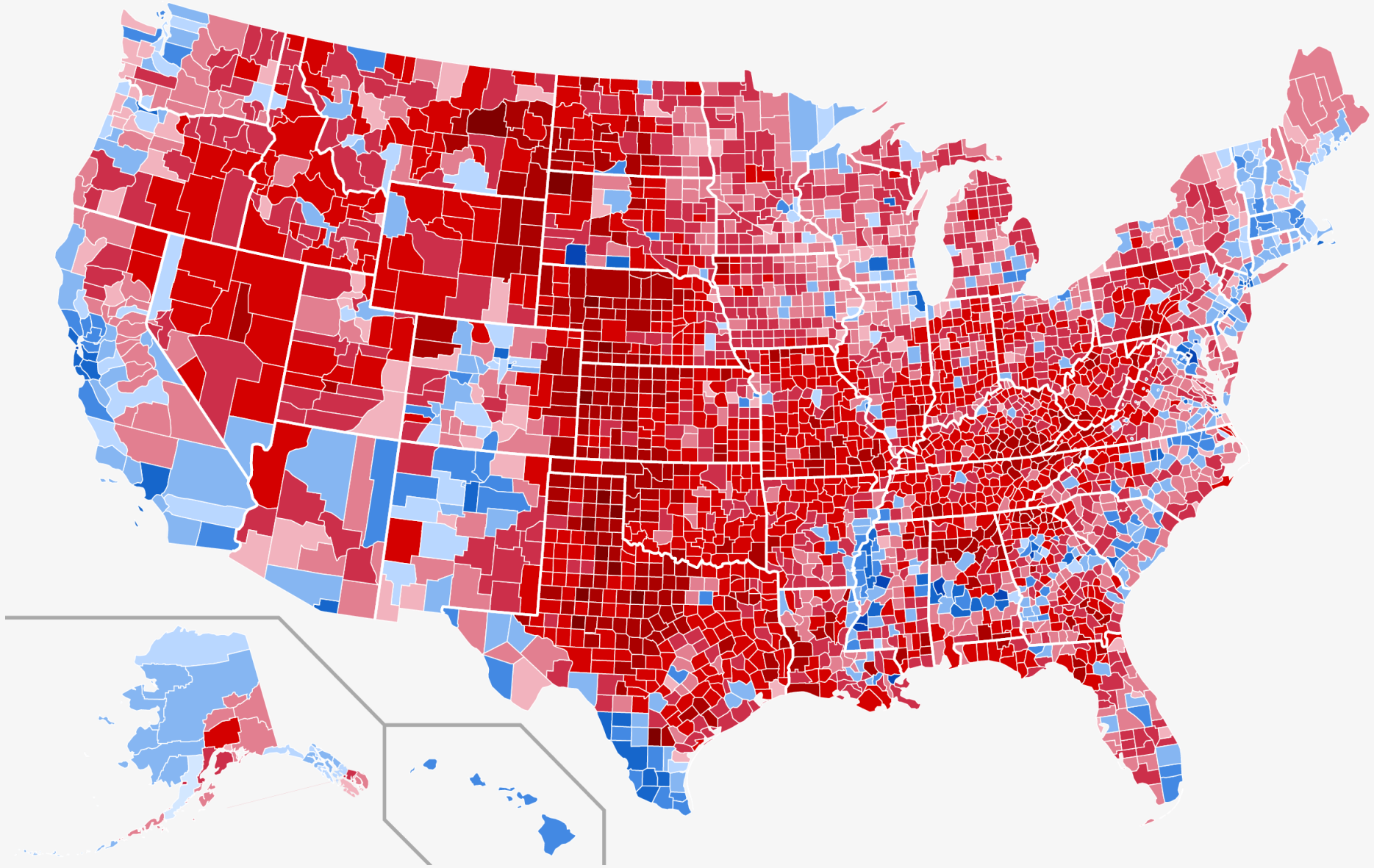

Manhattan
Building Footprints and Heights
Roof
Height [ft]
>800
800
700
600
500
400
300
200
<100
No Data
Data: New York OpenData
Map: Kieran Healy
Software: R, sf, and ggplot2



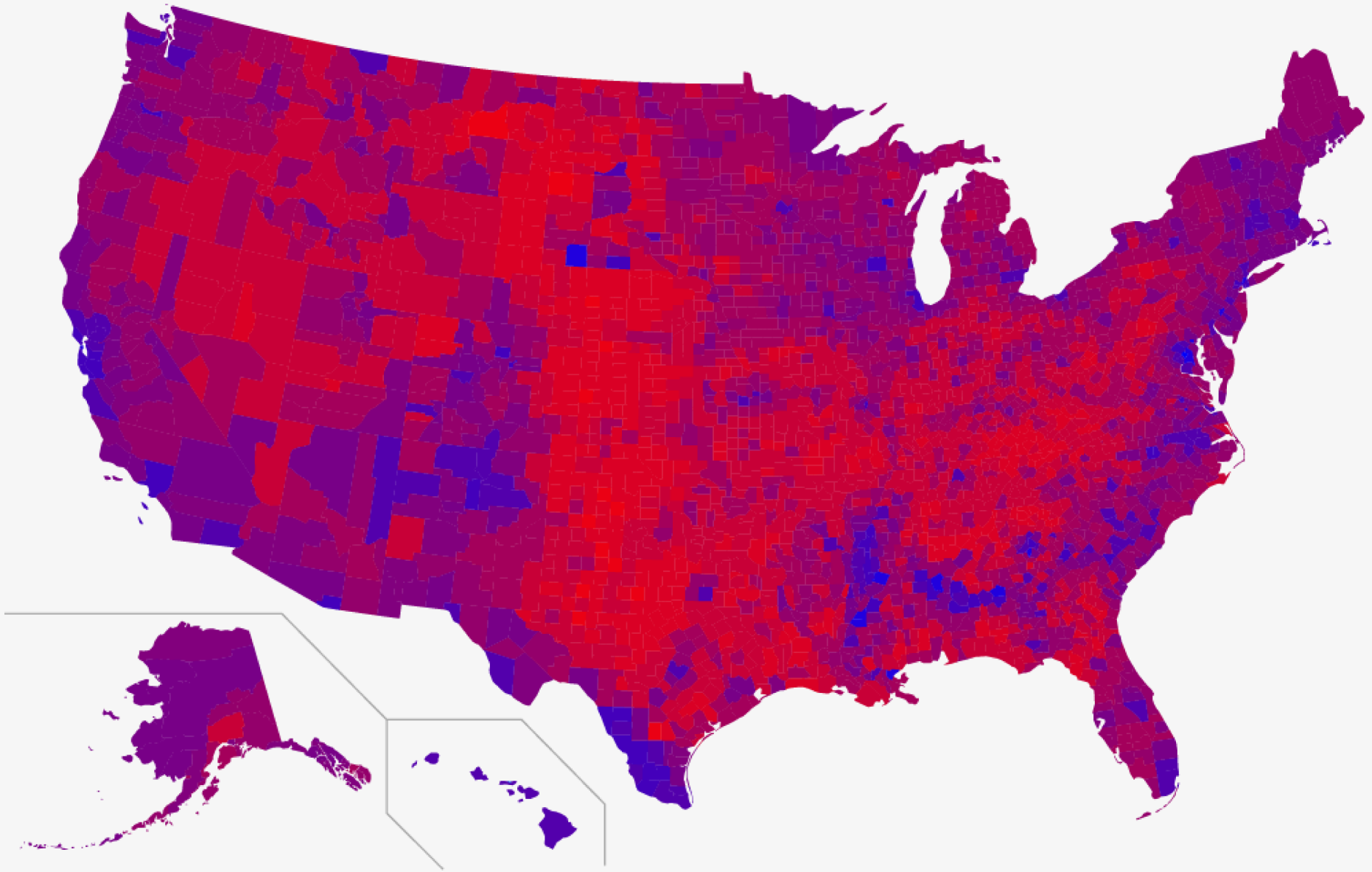
State-level; vote share; diverging; binned into four categories.



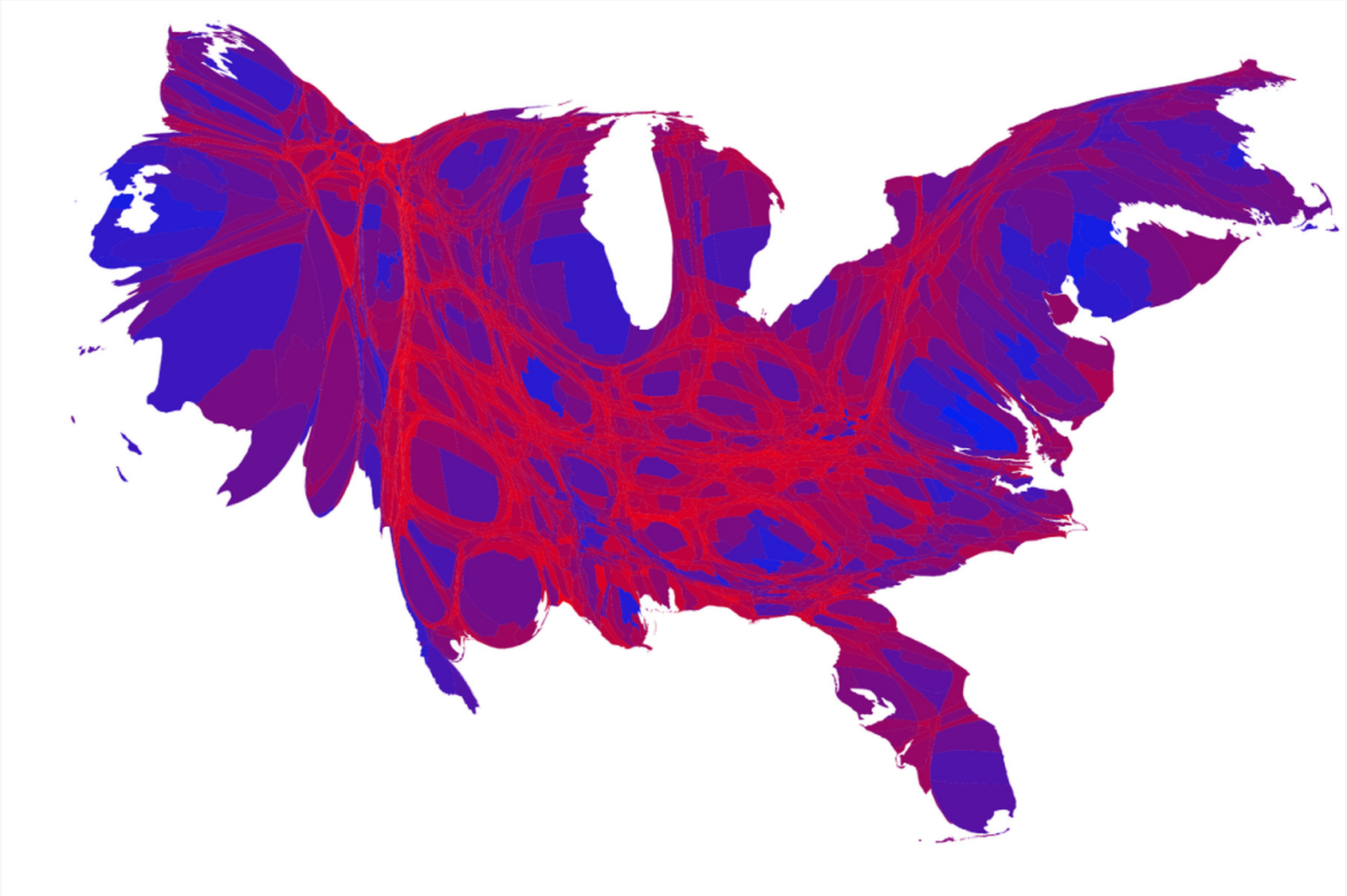
County level; winner only



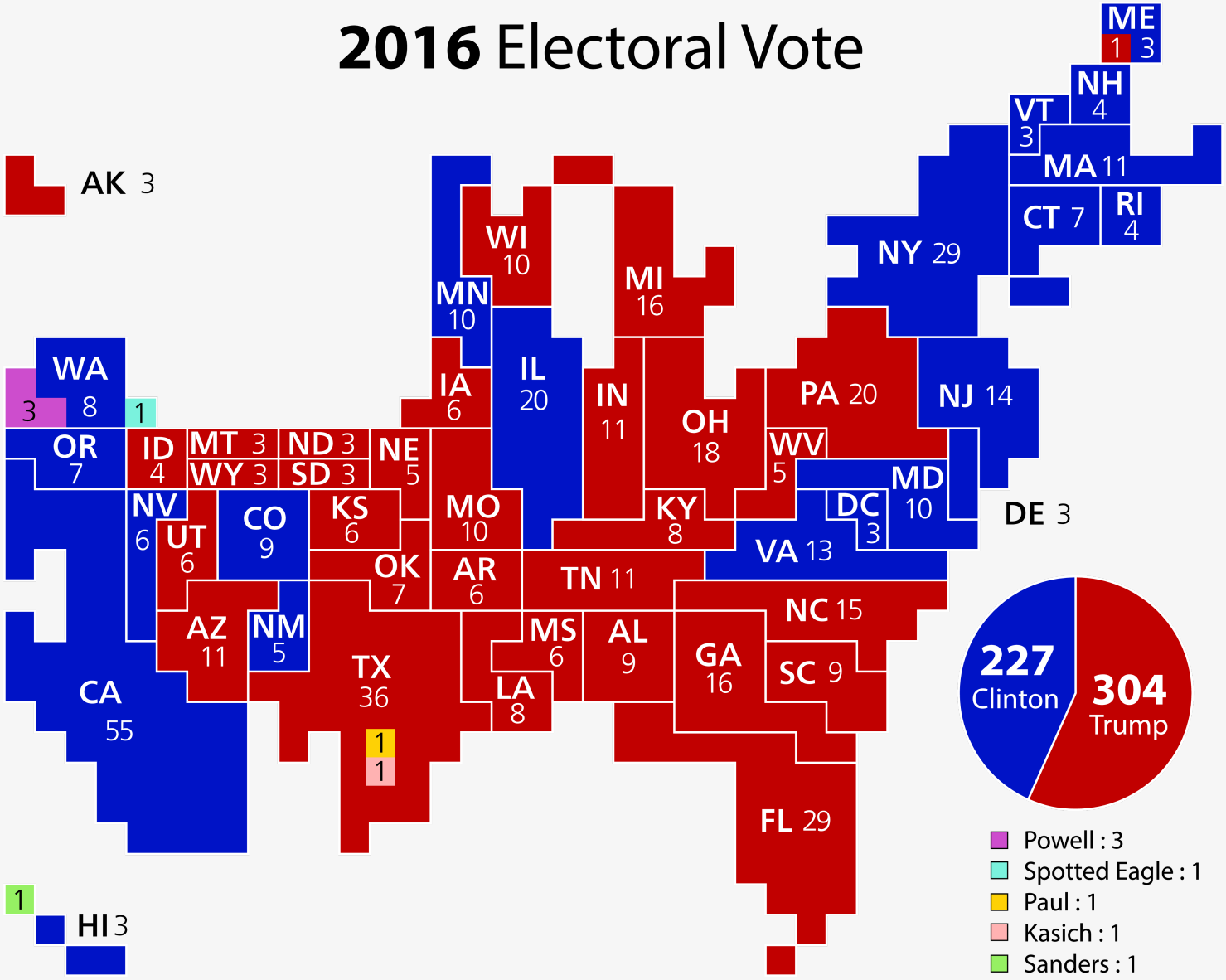
County level vote share; diverging; binned into six categories



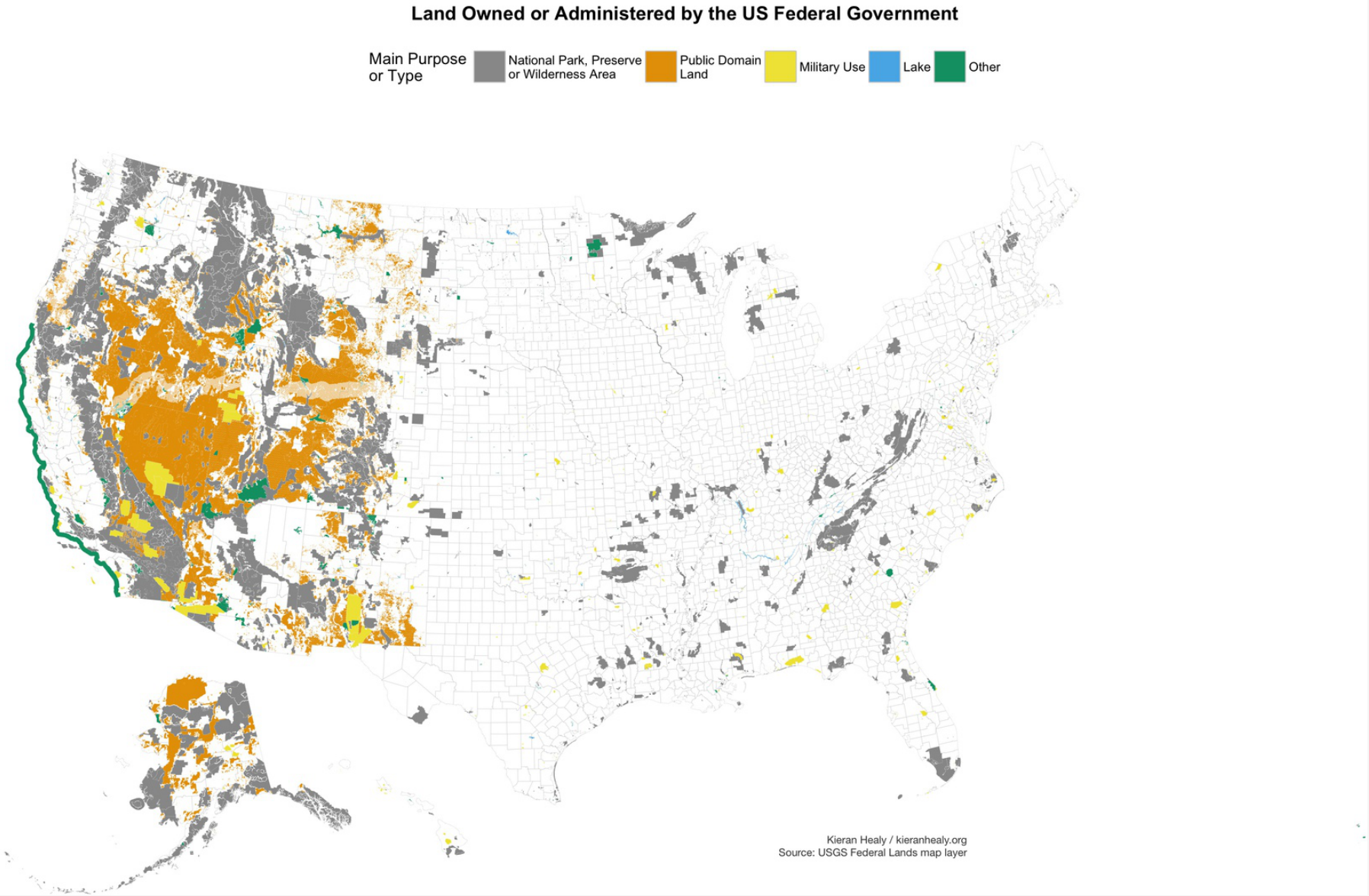
County level vote share; diverging continuous; purple midpoint



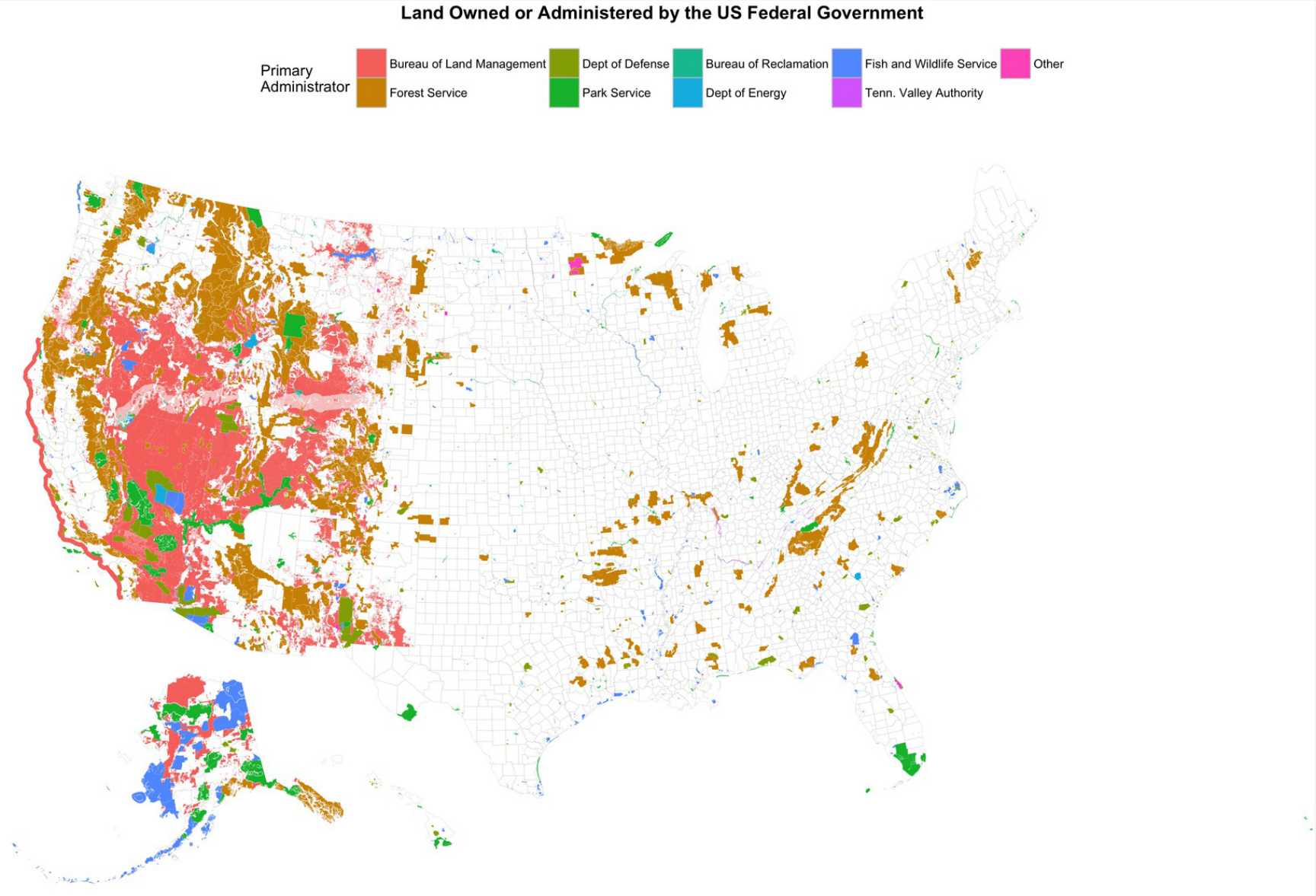
County level vote share; purple midpoint; county area deformed in proportion to population. By Mark Newman



Electoral college cartogram (NYT)

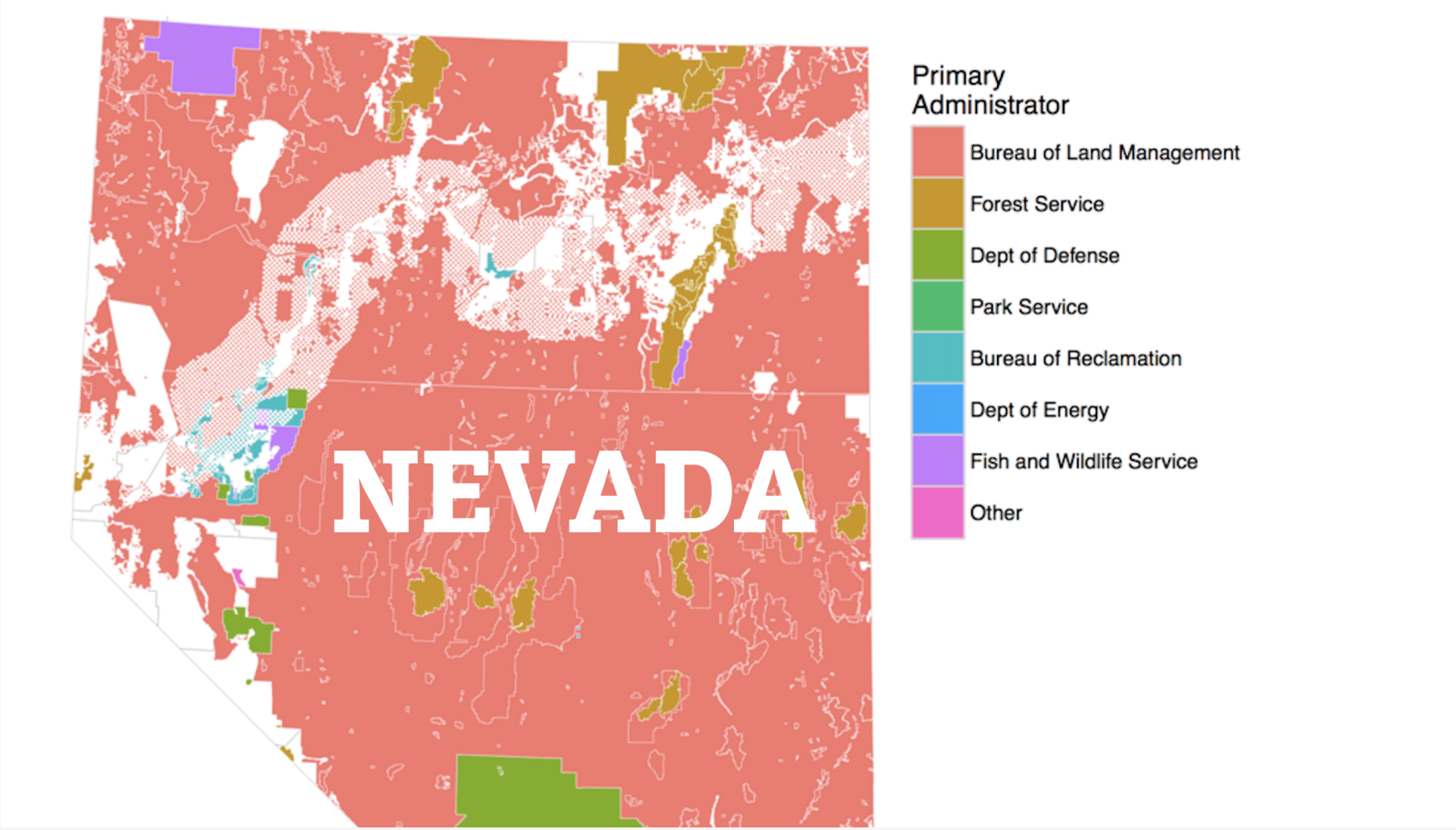


Pretty, Big, and Pretty Empty

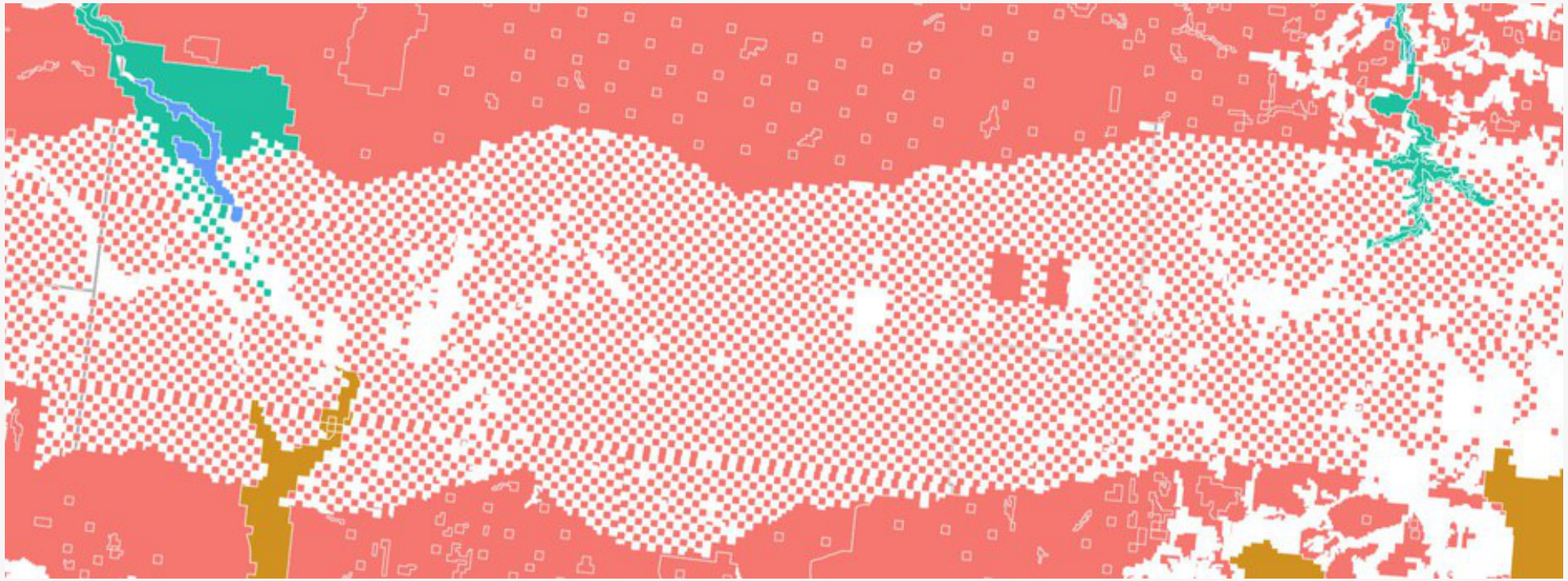


Pretty, Big, and Pretty Empty

Aside: What the hell's that?

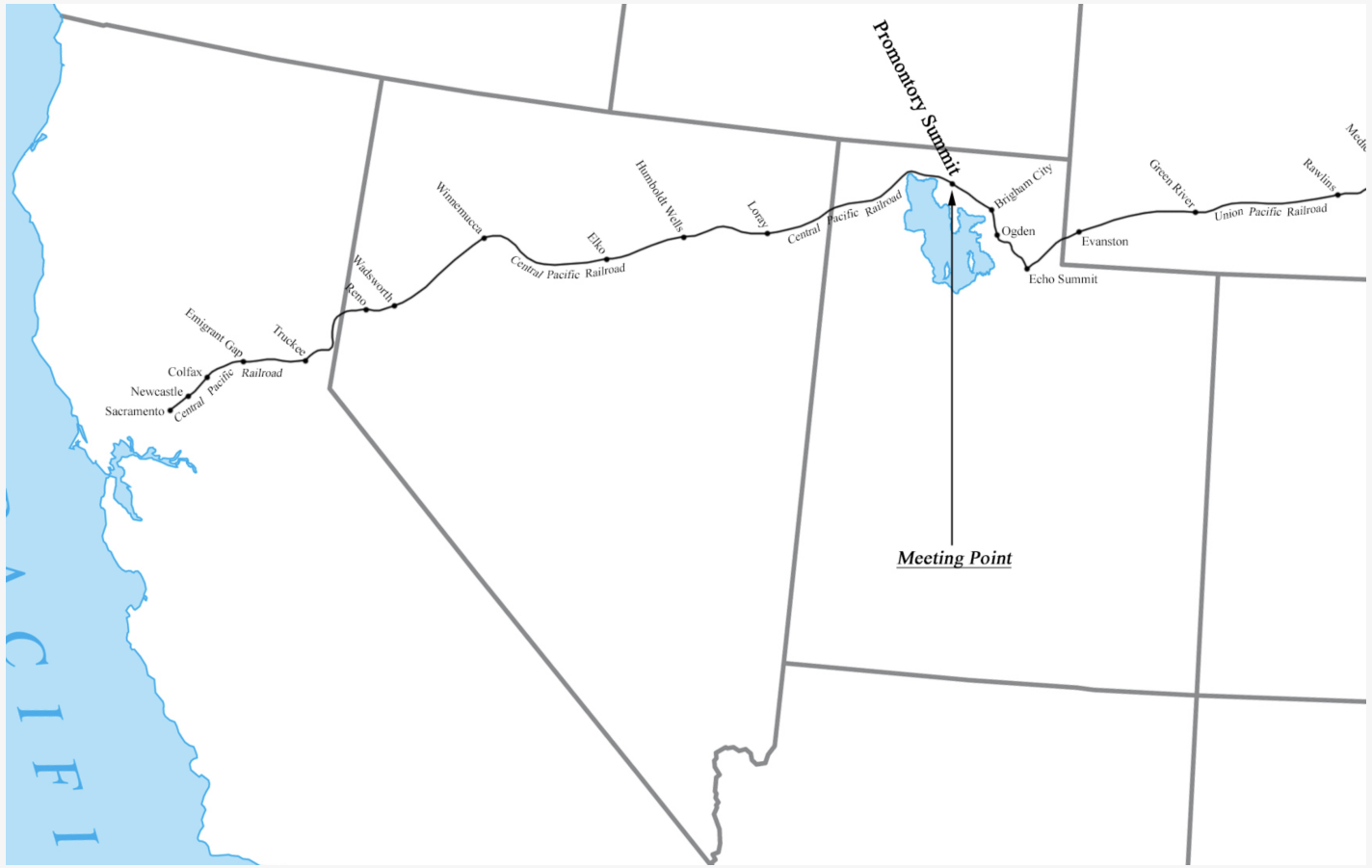


Zoom and Enhance



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>
```

What is this, at root?

```
us_states
```

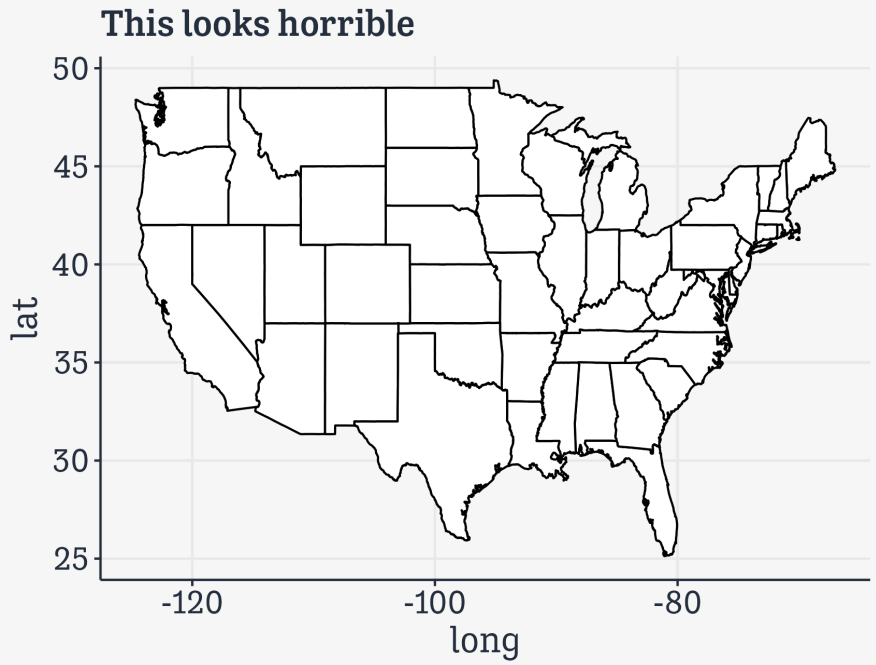
```
# A tibble: 15,537 × 6
    long   lat group order region  subregion
   <dbl> <dbl> <dbl> <int> <chr>   <chr>
 1 -87.5  30.4     1     1 alabama <NA>
 2 -87.5  30.4     1     2 alabama <NA>
 3 -87.5  30.4     1     3 alabama <NA>
 4 -87.5  30.3     1     4 alabama <NA>
 5 -87.6  30.3     1     5 alabama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

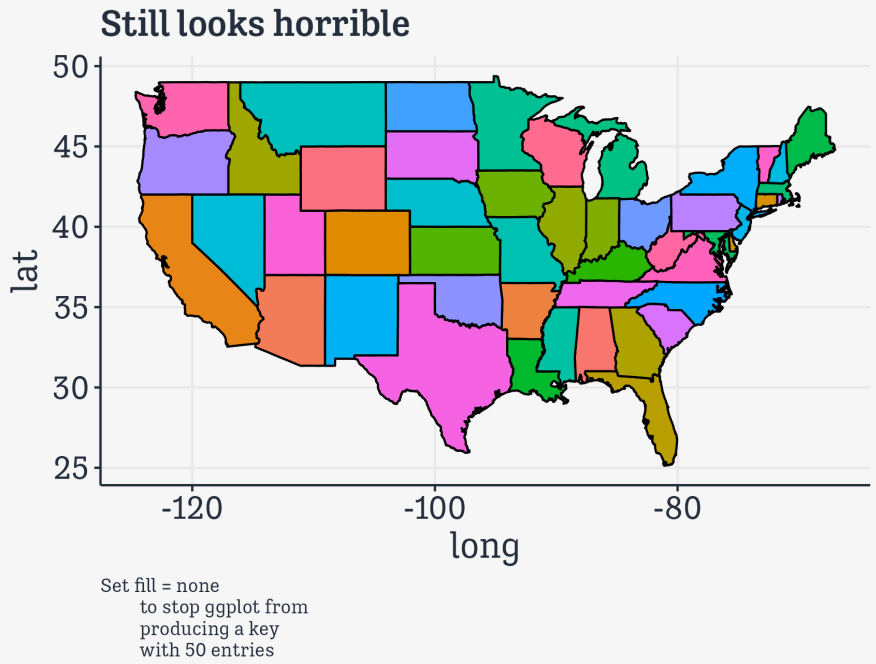
Like this, with `geom_polygon()`

```
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")
```

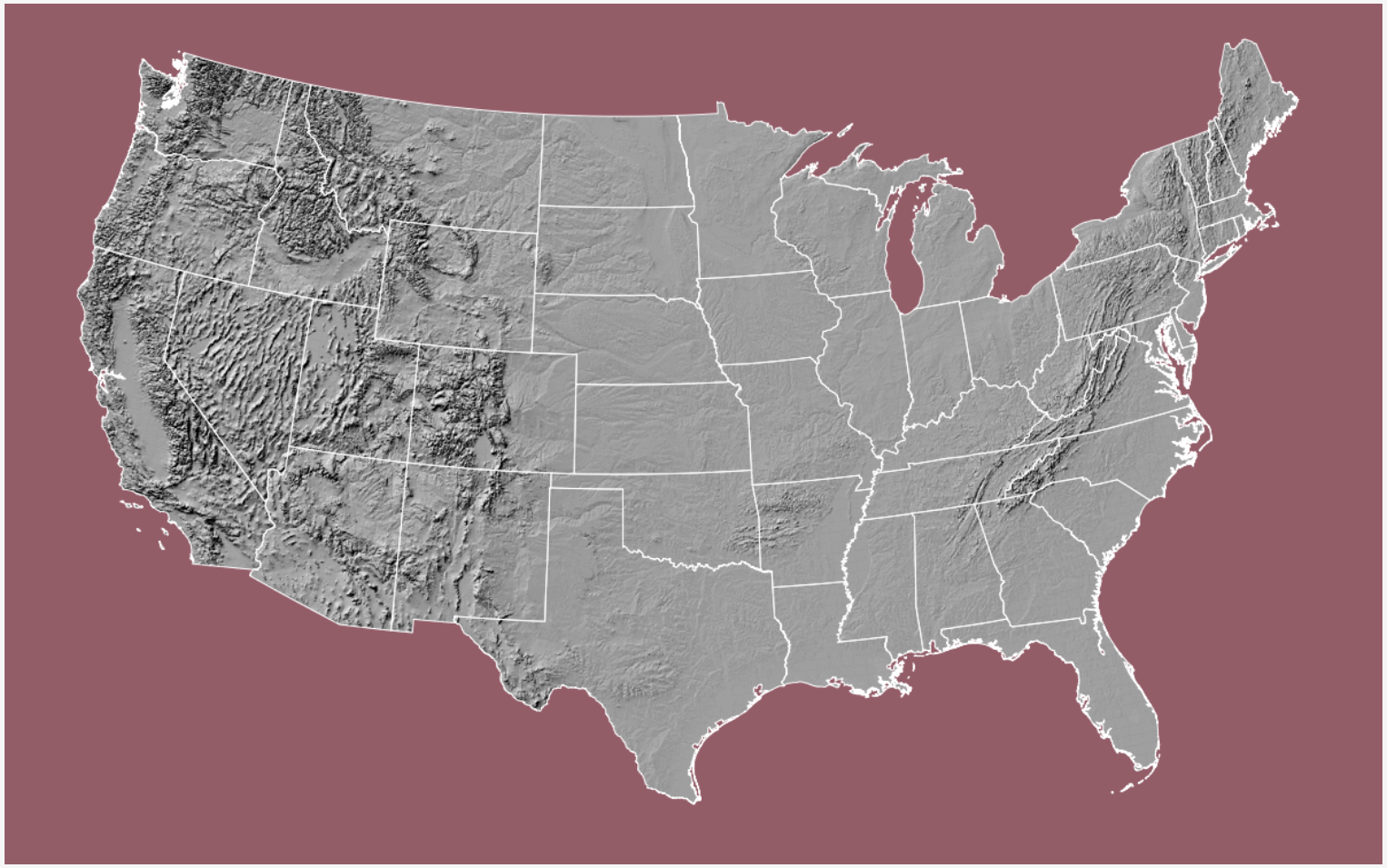
Fix the projection

```
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)
```

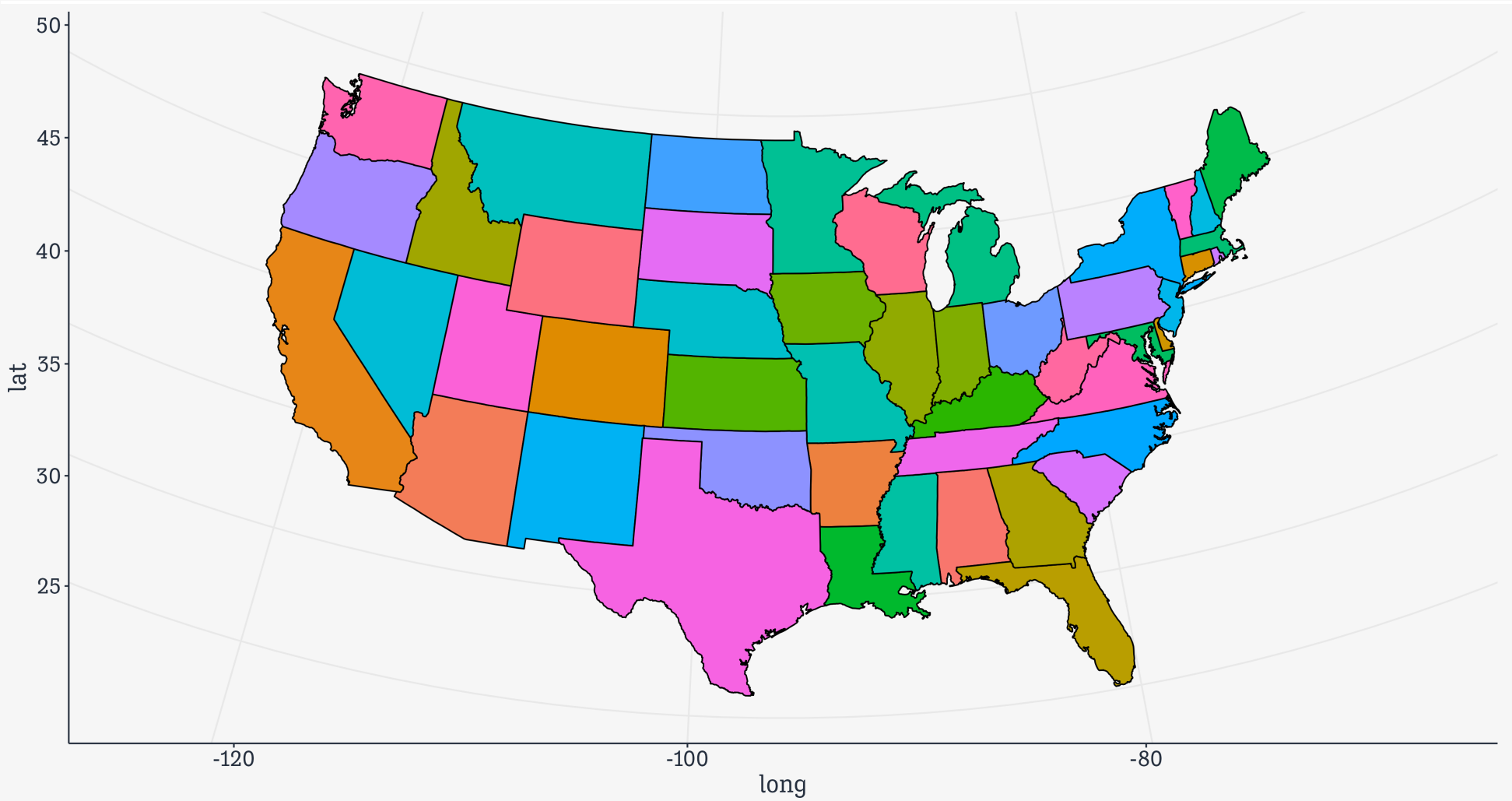
U.S. Map Projections

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
 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
```

This is a *left join*

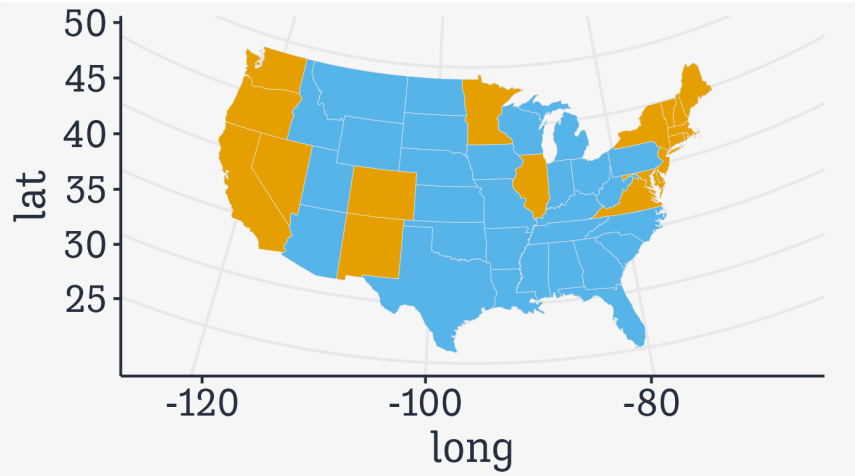
```
us_states_elec ← left_join(us_states, election, by = "region")

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")
```



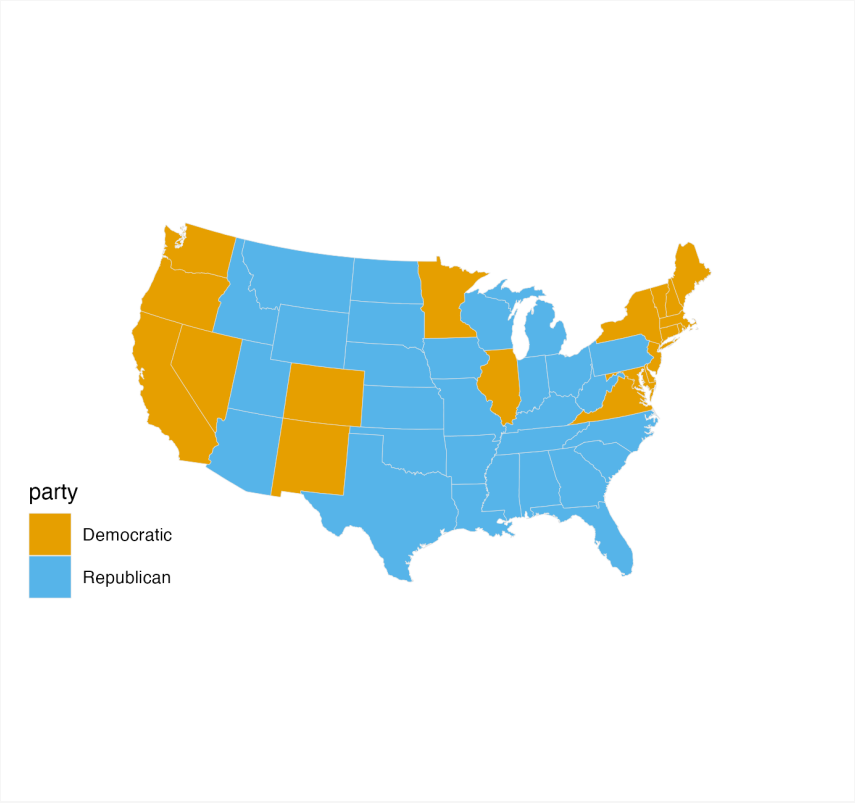
Let's turn off the gridlines

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)
              )
}
```

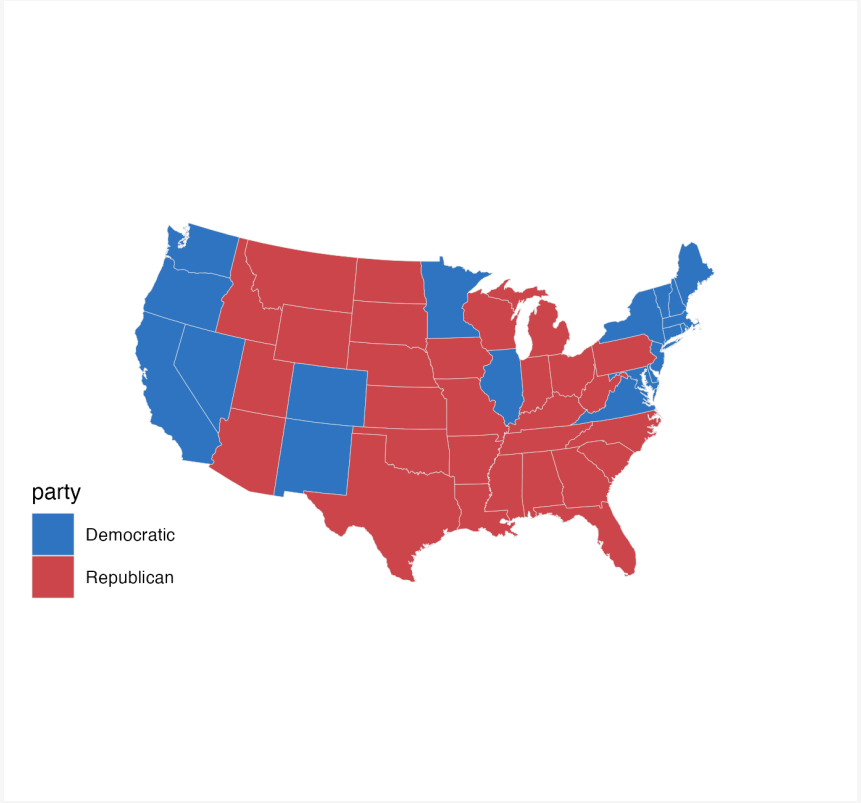
Add the theme function at the end

```
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()
```



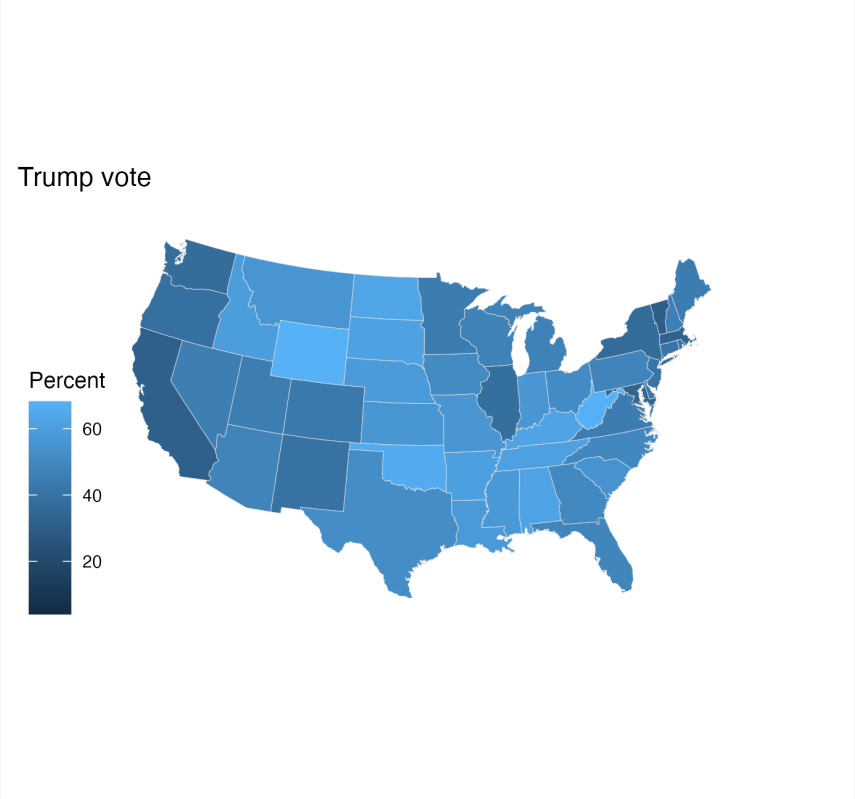
Fix the Party Colors

```
## 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()
```



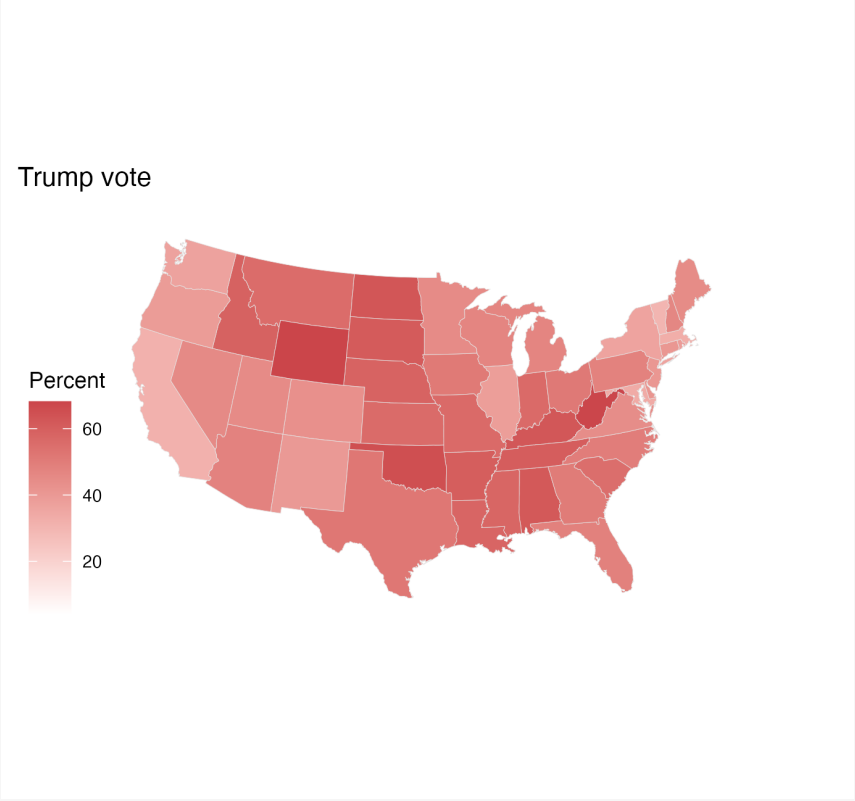
Continuous measures are *gradients*

```
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()
```



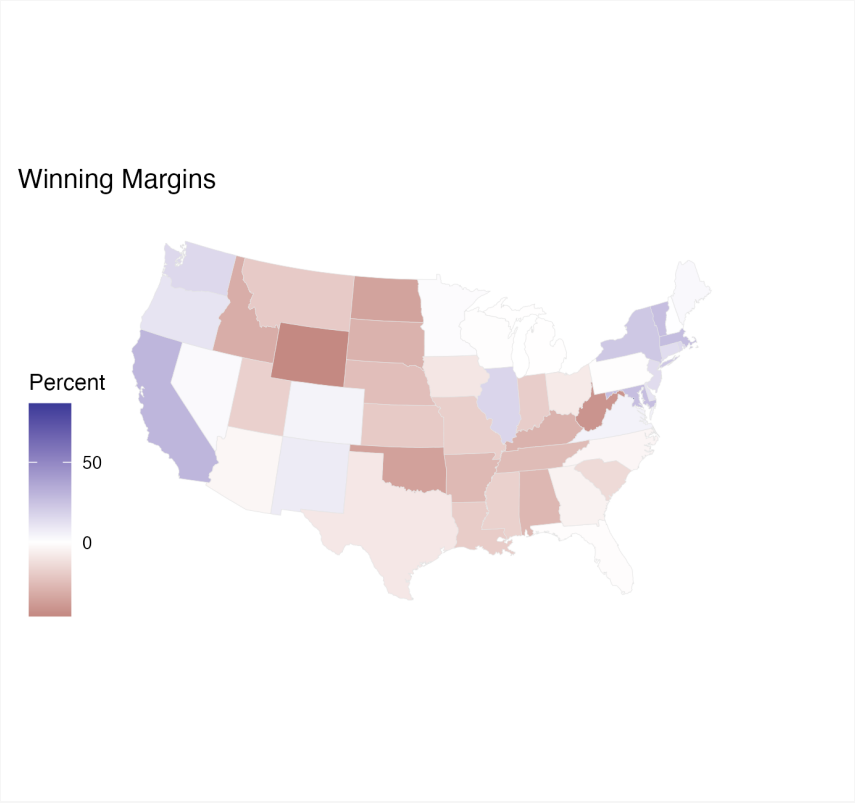
Fix the gradient with a scale function

```
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()
```



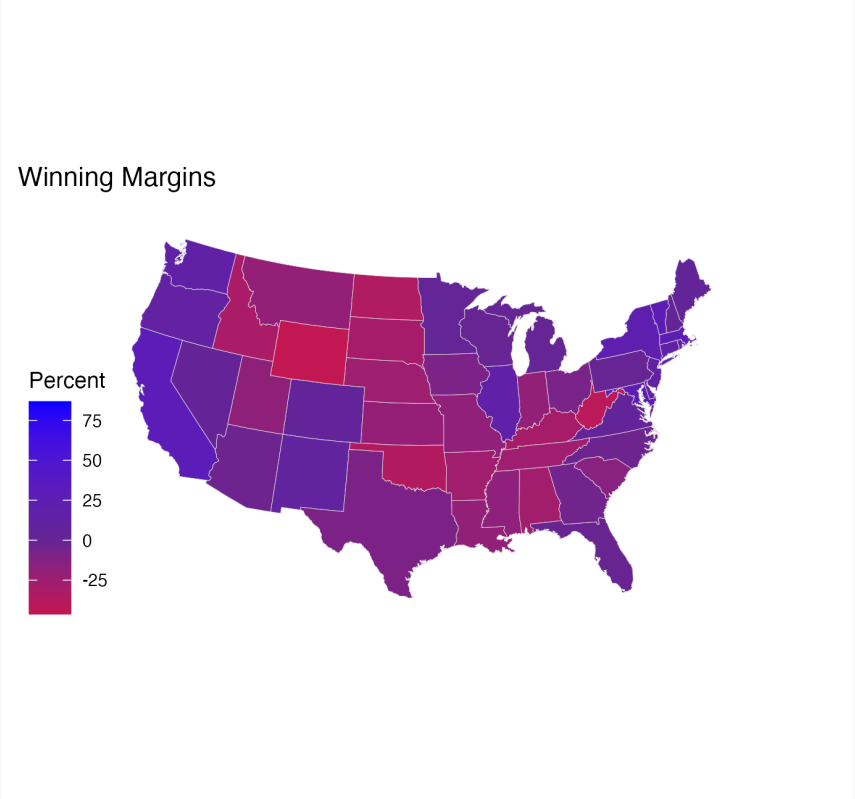
Some gradients are *diverging*

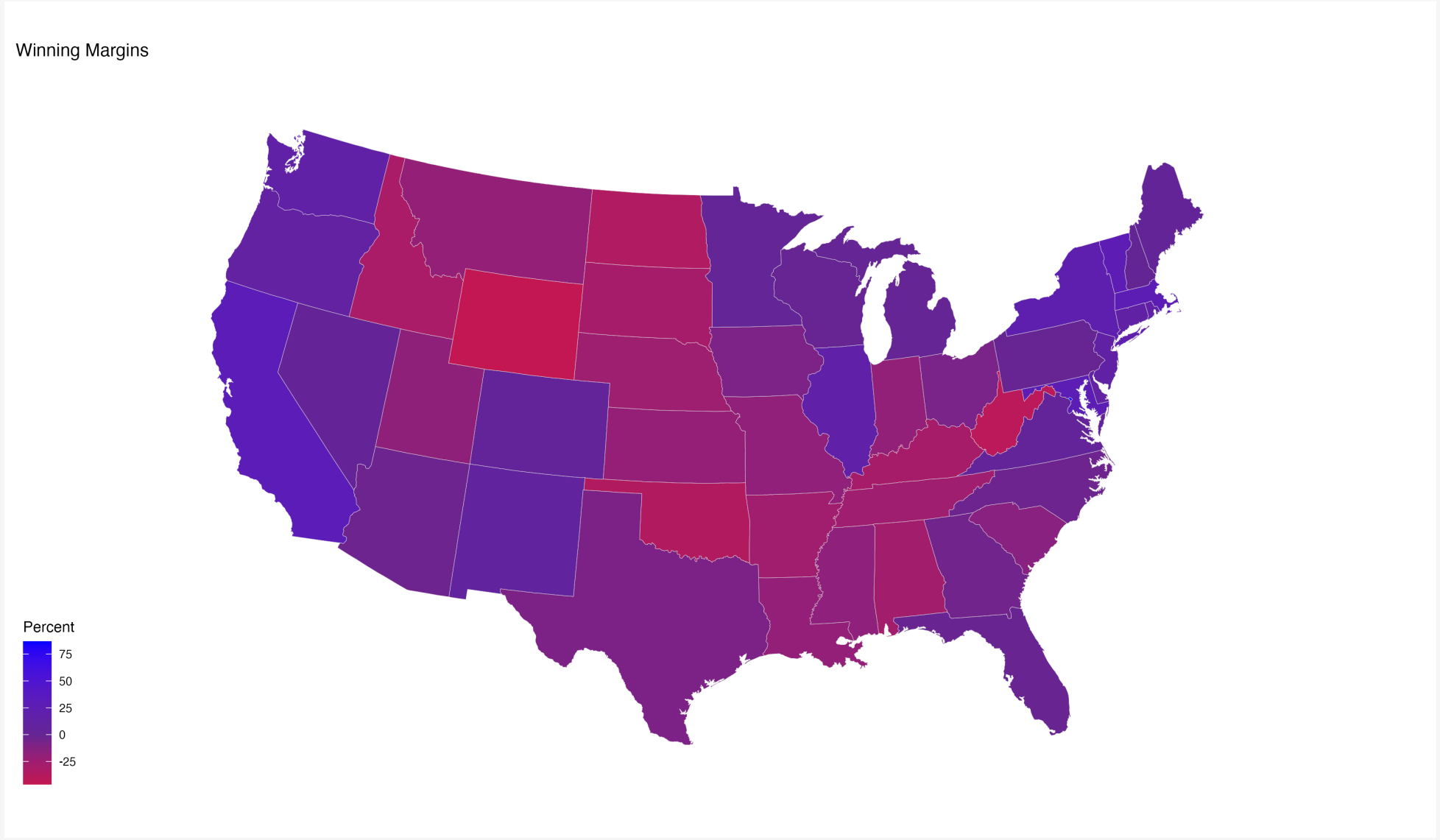
```
us_states_elec ▷
  ggplot(mapping = aes(x = long,
                       y = lat,
                       fill = d_points,
                       group = group)) +
  geom_polygon(color = "gray90",
               size = 0.1) +
  scale_fill_gradient2() +
  coord_map(projection = "albers",
         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



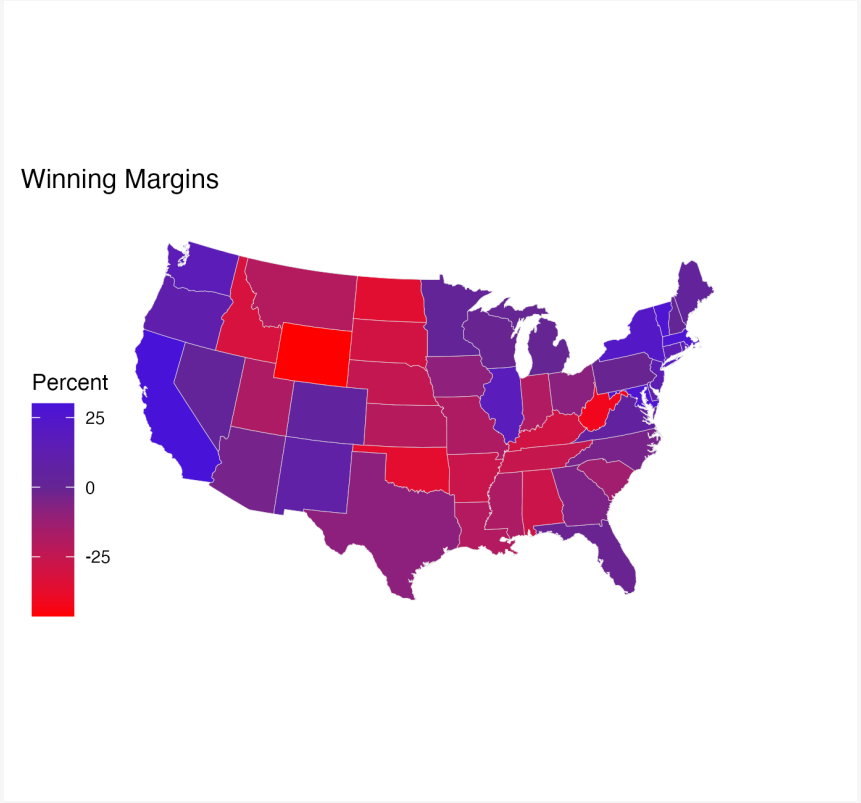


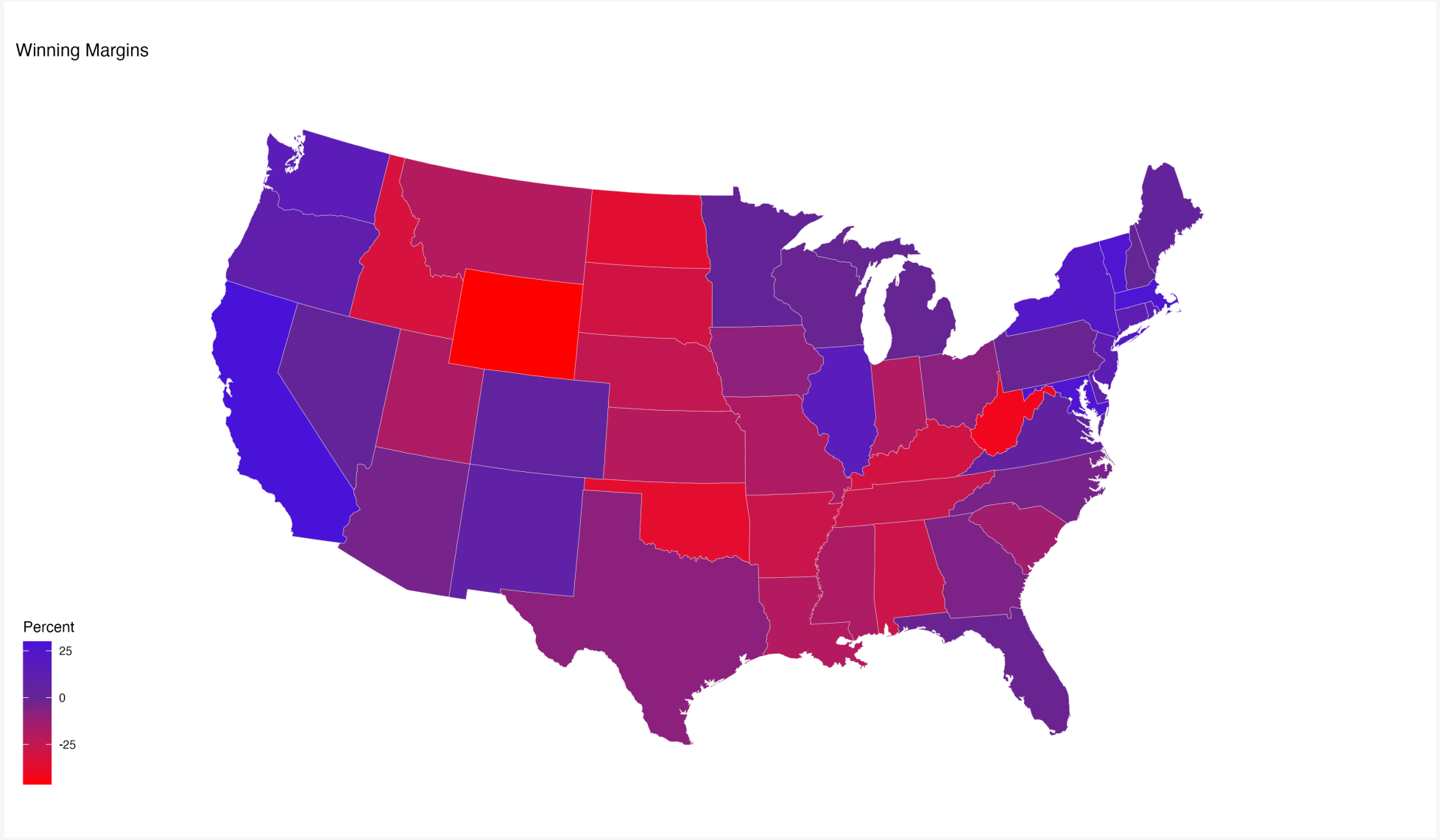
Take a closer look at this, though.

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 39121 Noble County         OH    [   10,   50) [ 2.0, 5.0)
 2 26047 Emmet County         MI    [   50,  100) [ 0.0, 2.0)
 3 40151 Woods County         OK    [    0,   10) [ 2.0, 5.0)
 4 17161 Rock Island County   IL    [  100,  500) [ 5.0,10.0)
 5 56031 Platte County        WY    [    0,   10) [ 0.0, 2.0)
 6 12009 Brevard County       FL    [  500, 1000) [10.0,15.0)
 7 05103 Ouachita County      AR    [   10,   50) [25.0,50.0)
 8 19135 Monroe County        IA    [   10,   50) [ 0.0, 2.0)
 9 37097 Iredell County       NC    [  100,  500) [10.0,15.0)
10 53007 Chelan County        WA    [   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 = "i
```

County Population Density

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

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
```

County Population Density

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


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 = "i

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 = "i


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 = "i


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 = "i


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

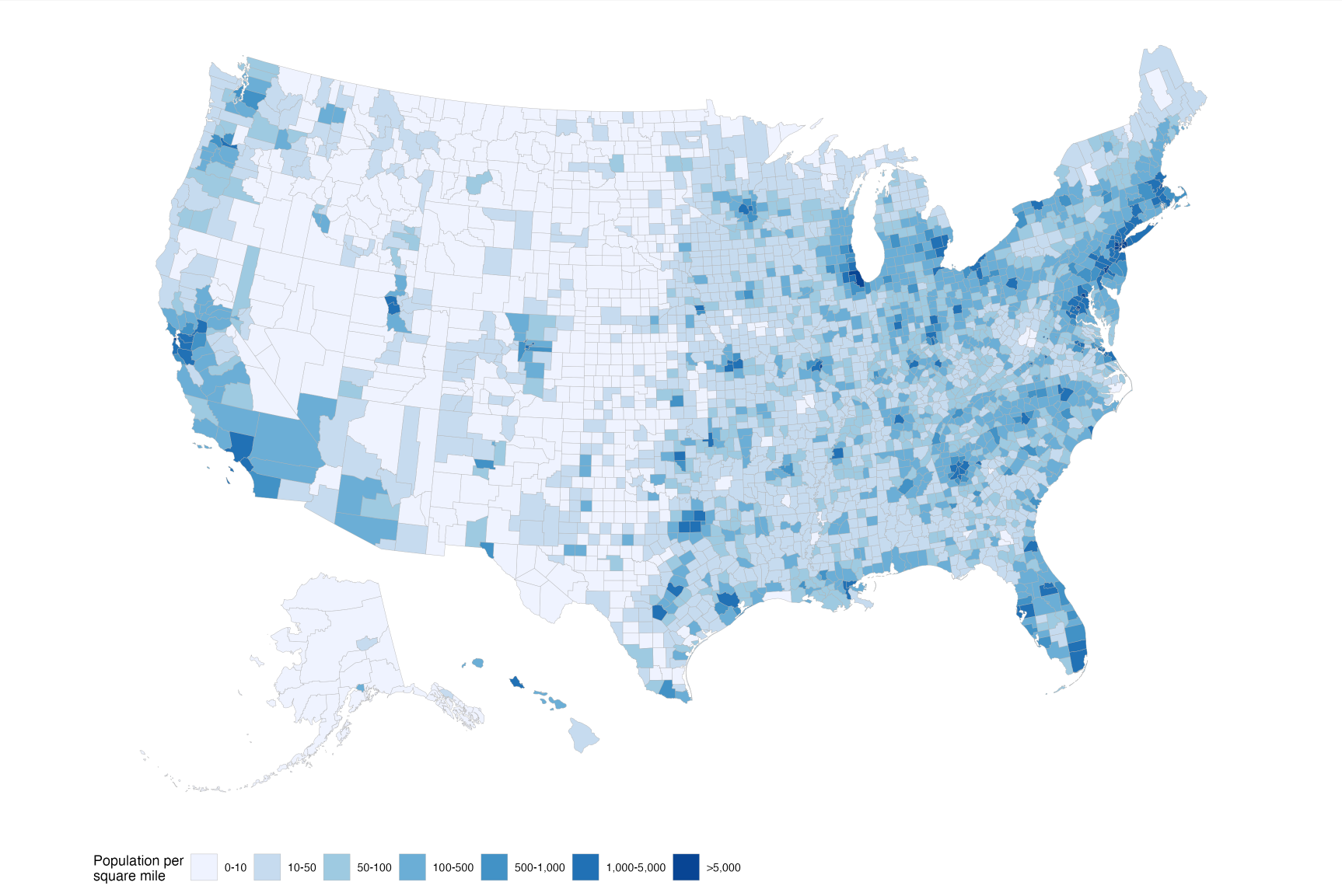
```
county_full ← as_tibble(left_join(county_map, county_data, by = "i


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 = "i


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 = "i


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 = "i
```

Same again for Percent Black

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

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
```

Same again for Percent Black

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

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 = "i

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 = "i

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 = "i

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 = "i

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

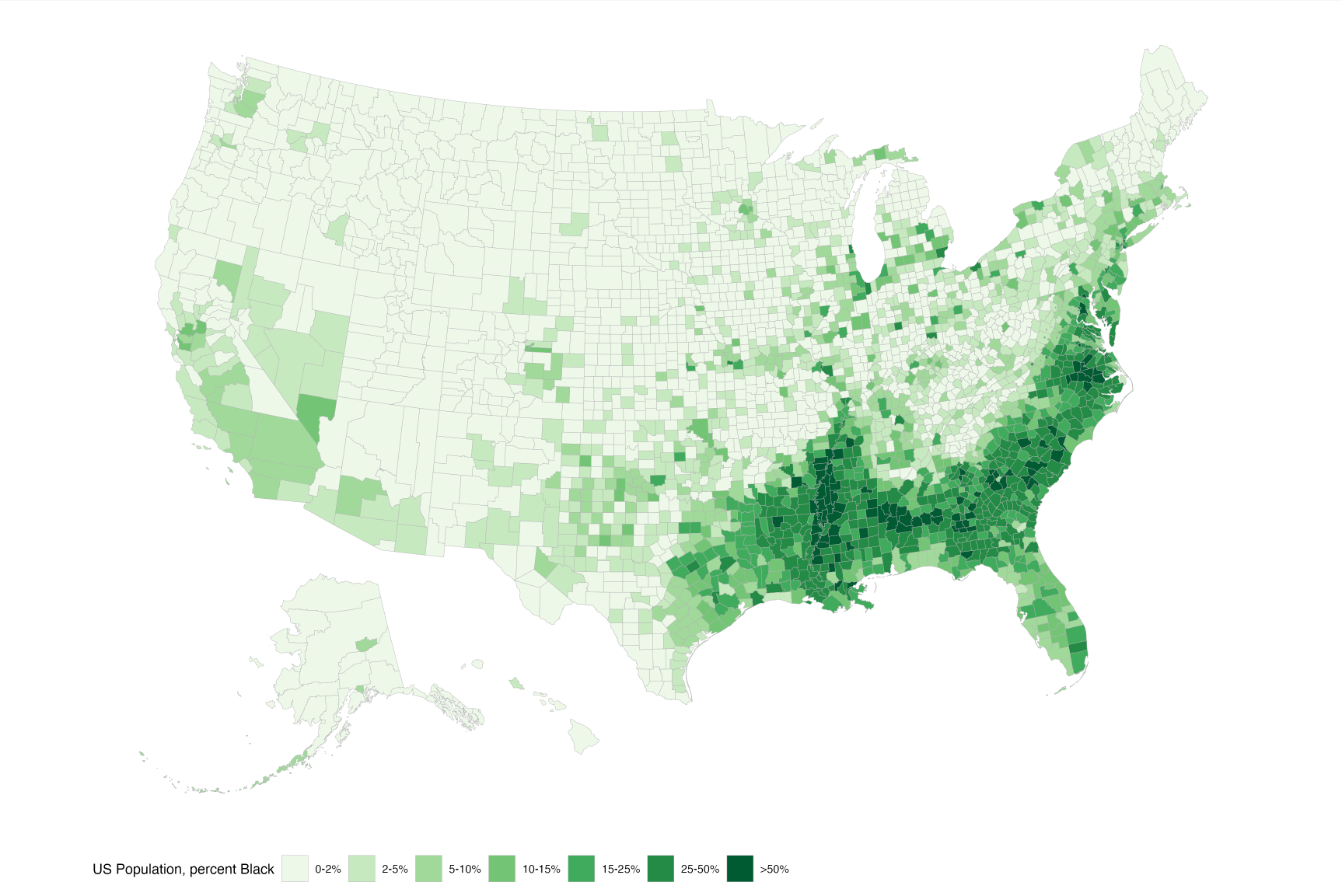
```
county_full ← as_tibble(left_join(county_map, county_data, by = "i

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 = "i

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 = "i

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

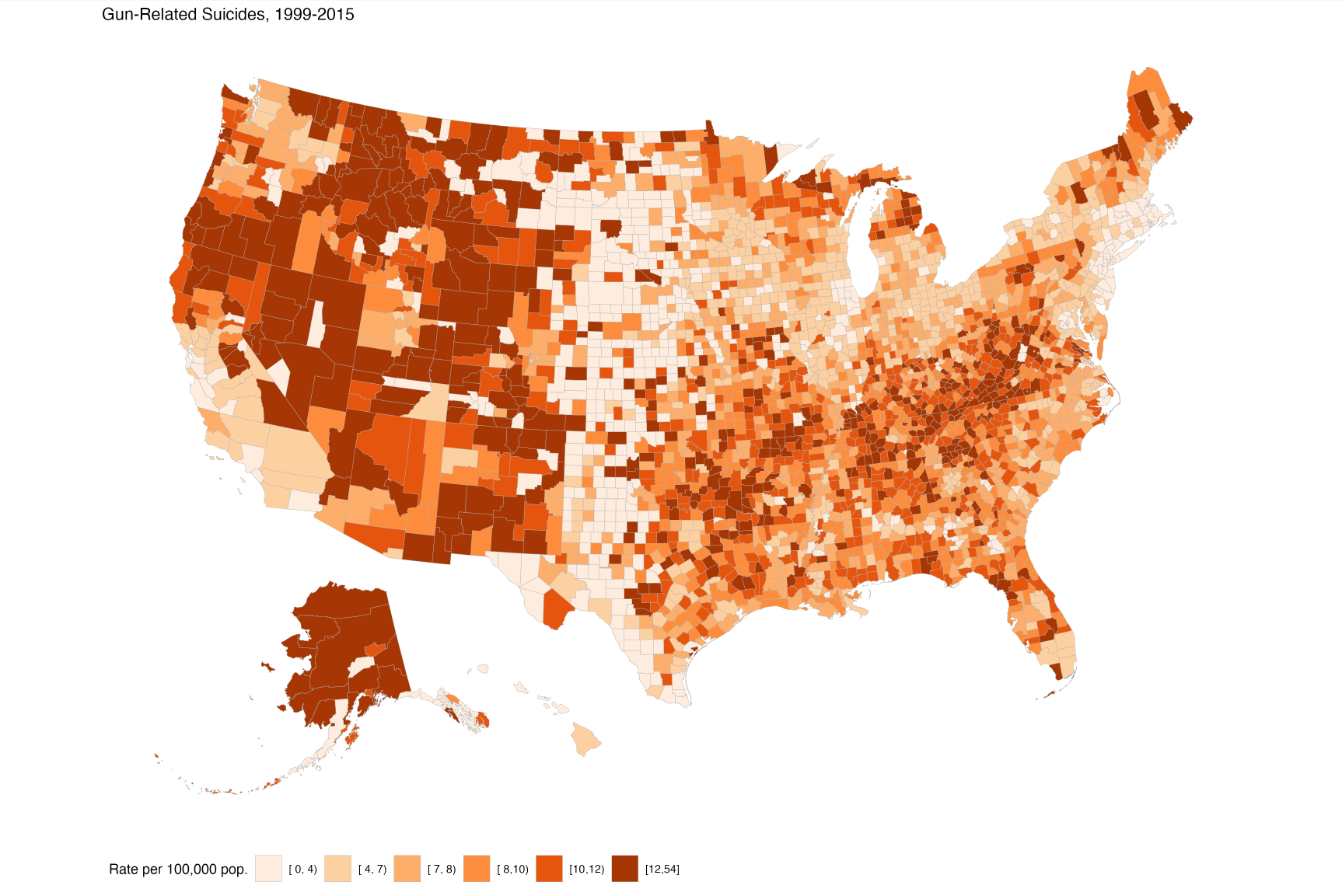
Code | Reverse

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

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

Build a plot

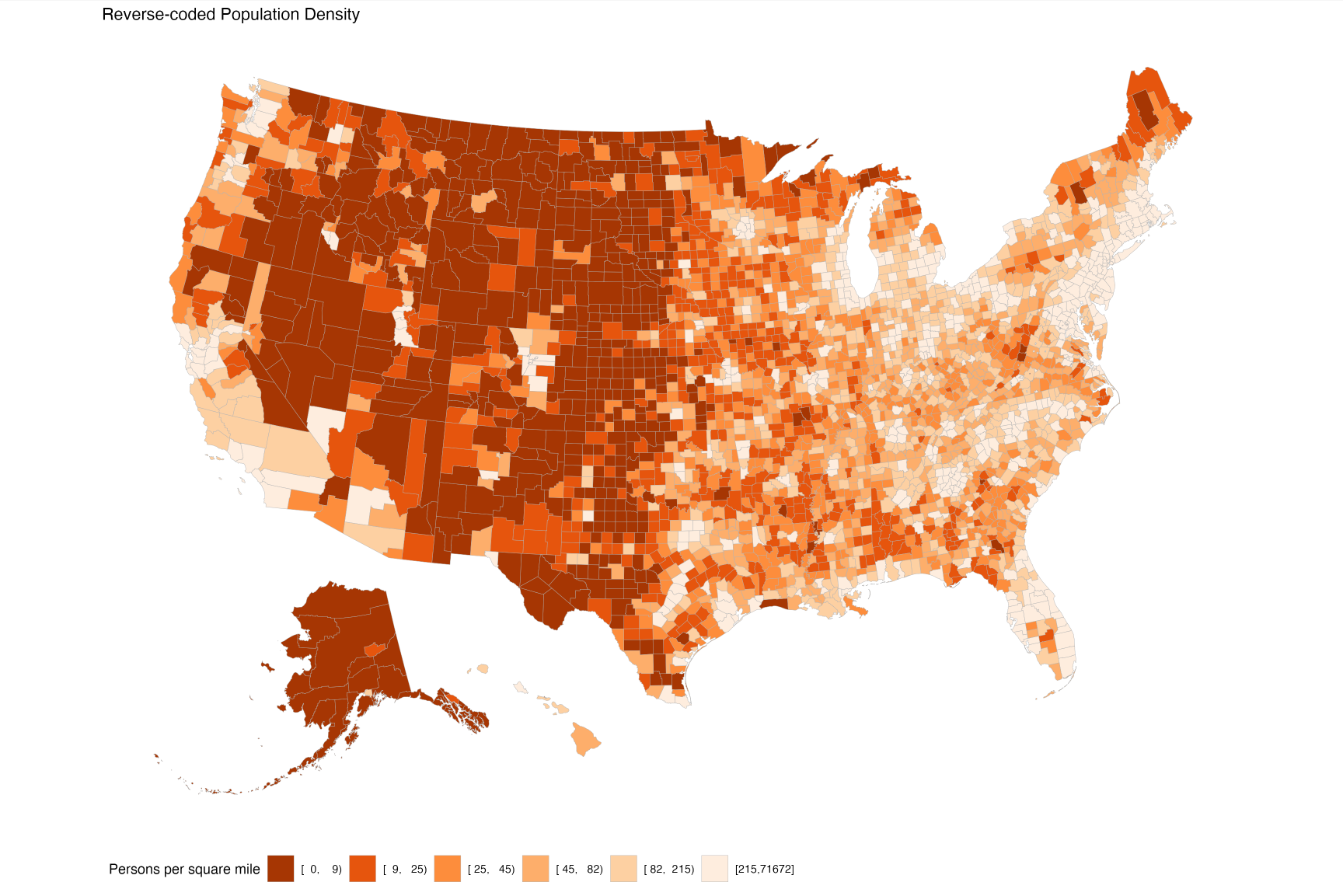
```
p_g1 ← county_full ▷
  ggplot(mapping = aes(x = long, y = lat,
                       fill = su_gun6,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_manual(values = orange_pal) +
  labs(title = "Gun-Related Suicides,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



Regular palette

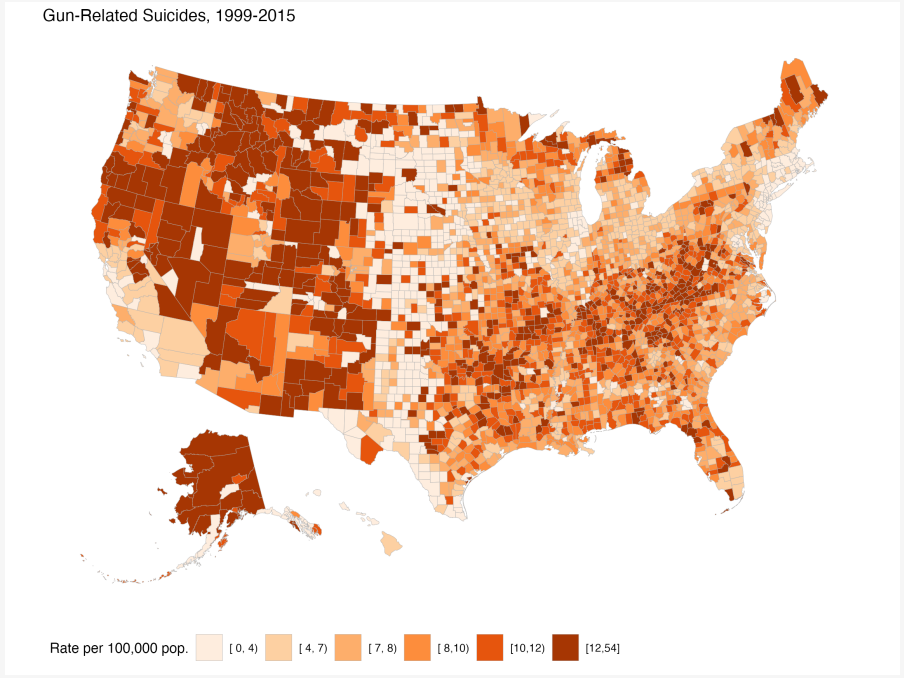
And another

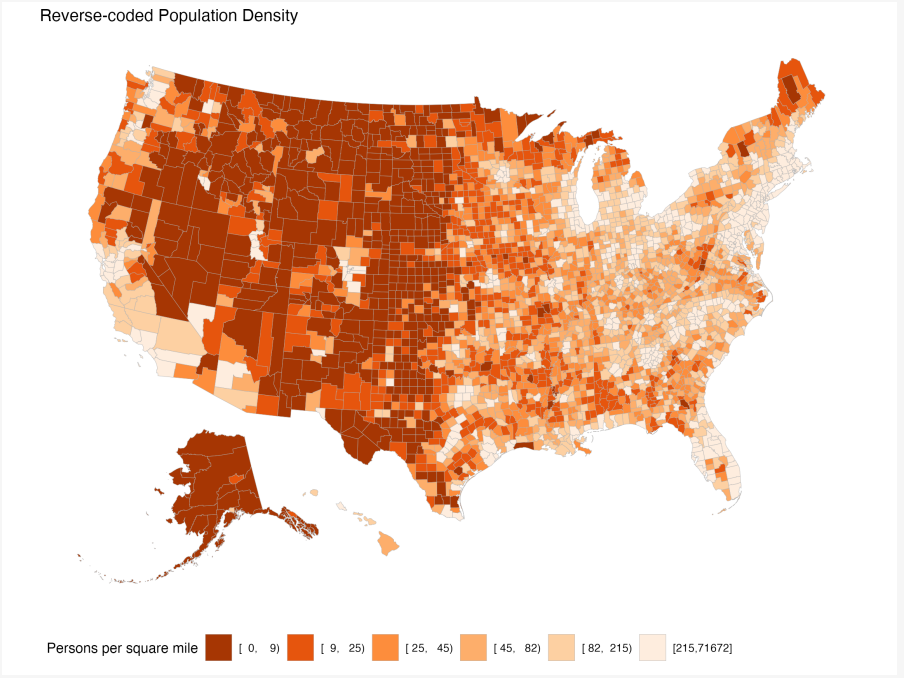
```
p_g2 ← county_full ▷
  ggplot(mapping = aes(x = long, y = lat,
                       fill = pop_dens6,
                       group = group)) +
  geom_polygon(color = "gray70",
               size = 0.1) +
  coord_fixed() +
  scale_fill_manual(values = orange_rev) +
  labs(title = "Reverse-coded 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

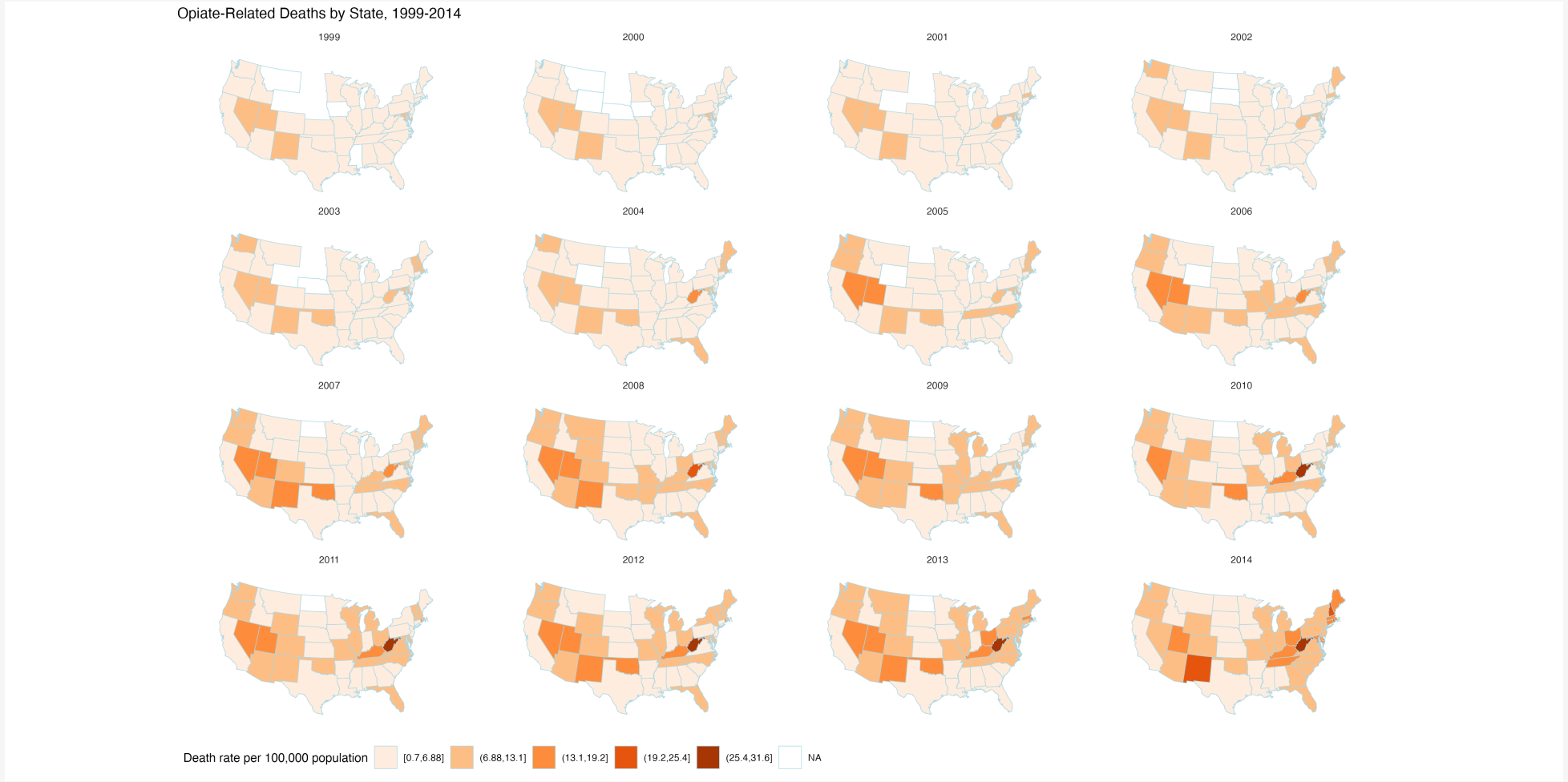
Opiate-related Mortality, 1999-2014

```
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
# 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
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
# 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
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
# 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
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
# 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

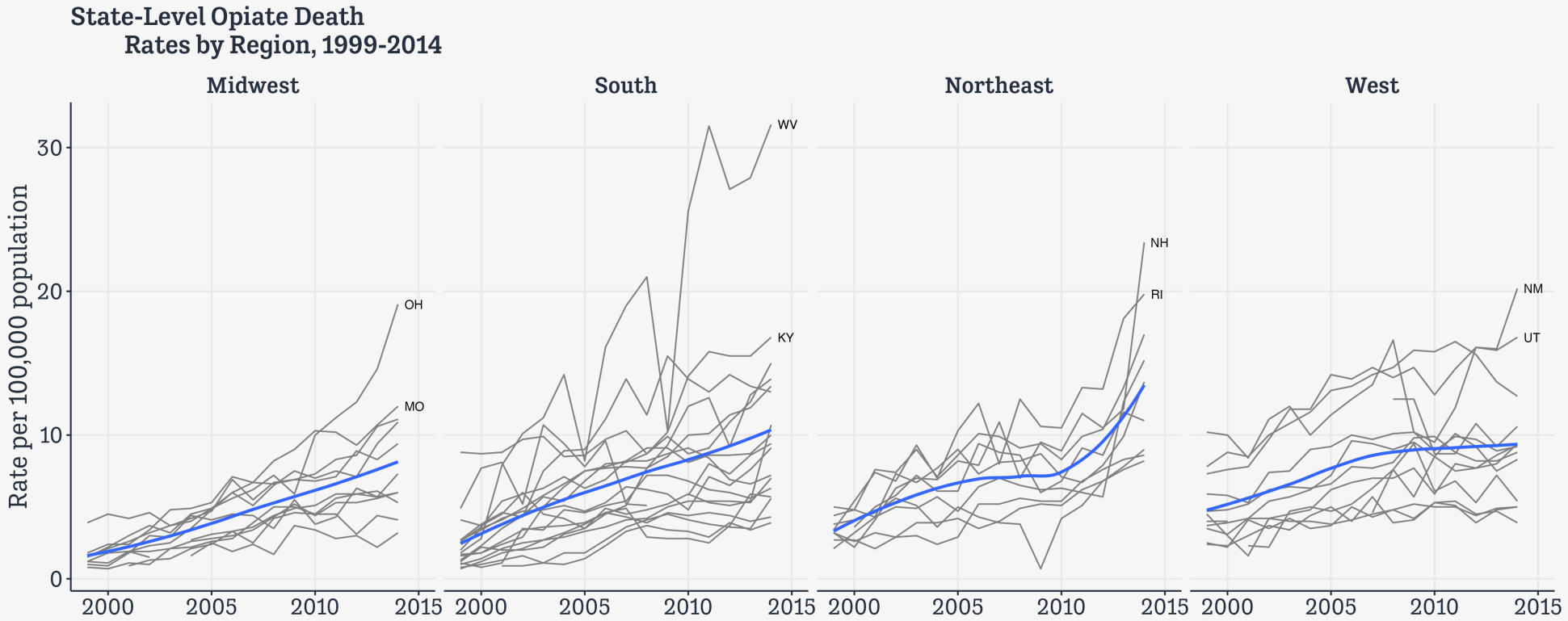
```
st_top ← opiates ▷  filter(year == max(year), abbr ≠ "DC") ▷
  group_by(region) ▷
  slice_max(order_by = adjusted, n = 2)

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)
```



Regional trends in opiate-related mortality.