Meetup 5: Visualizing Geospatial Data

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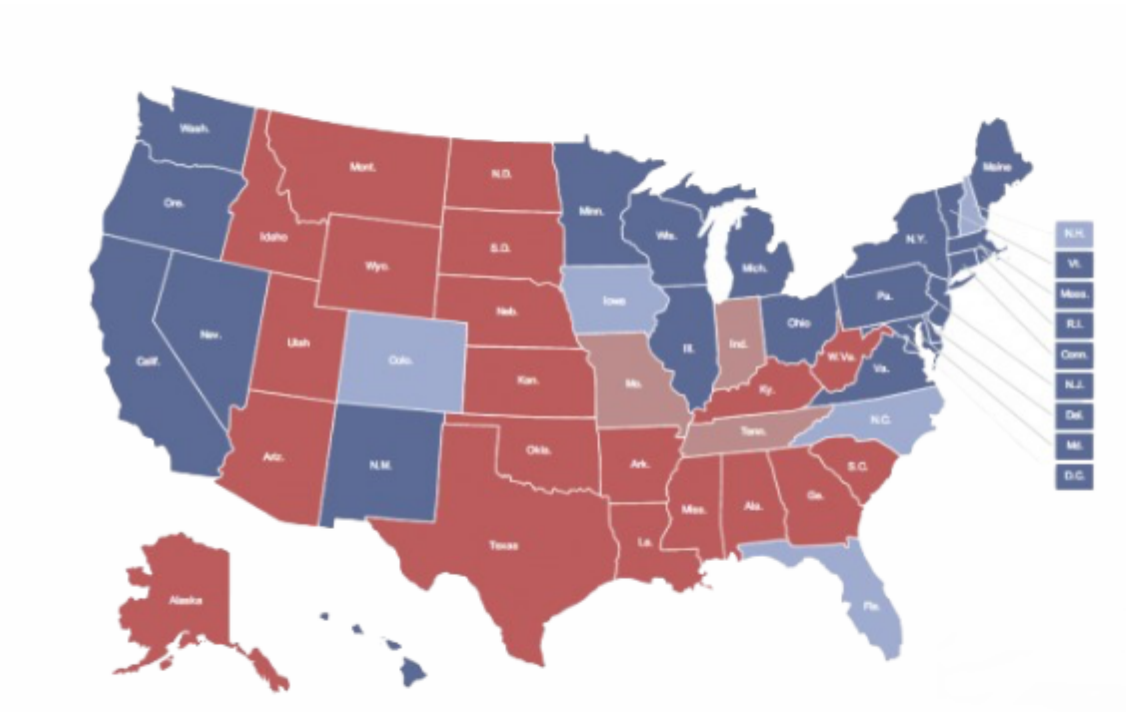
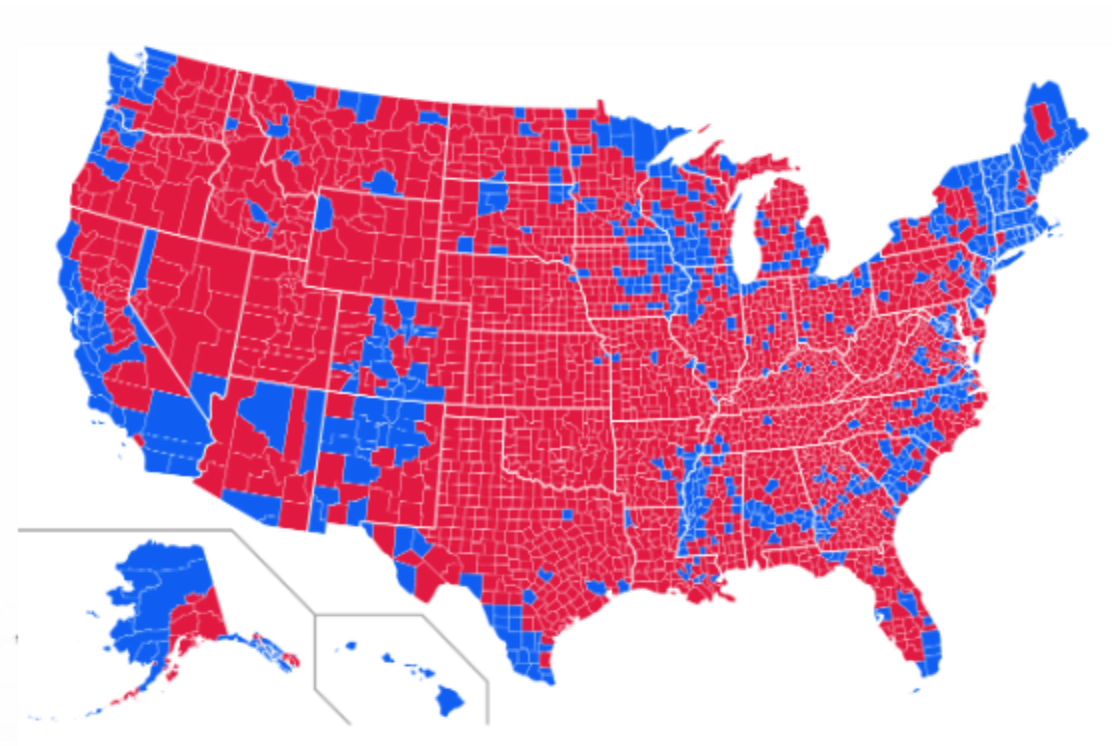
Many Ways to Map the Same Data

- Results of 2016 US Election



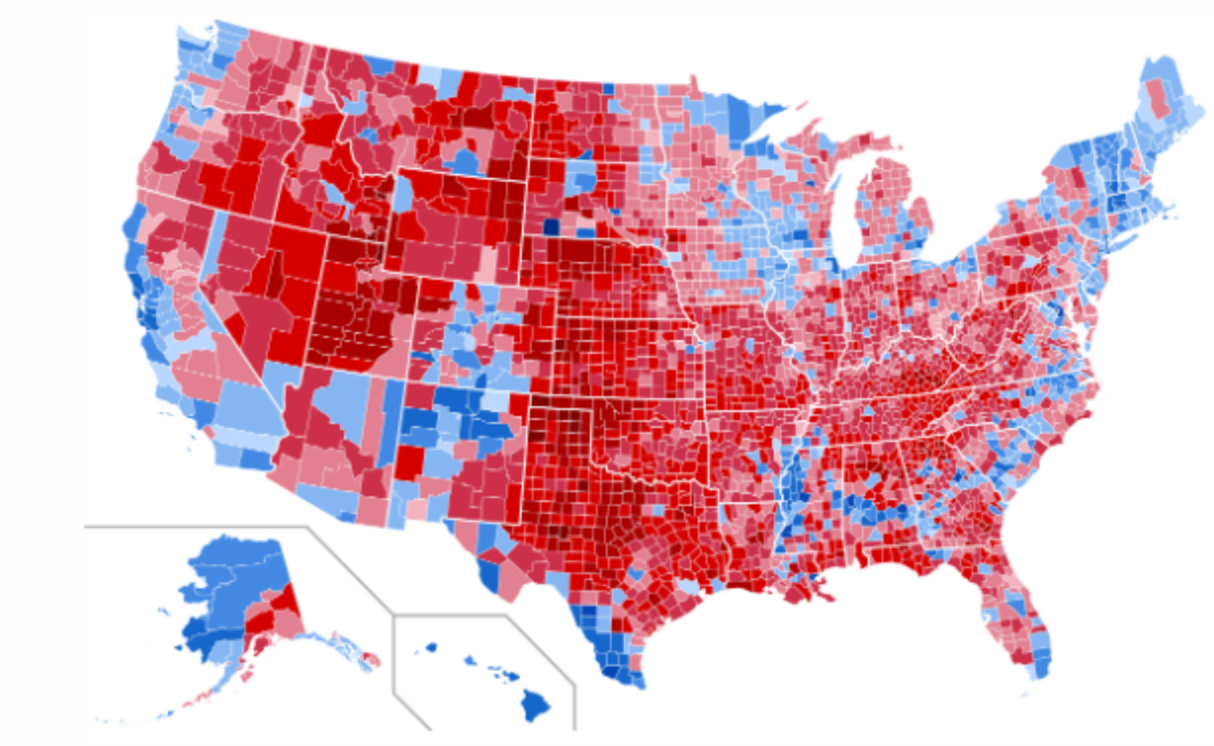
Many Ways to Map the Same Data

- Results of 2016 US Election



Many Ways to Map the Same Data

- Results of 2016 US Election



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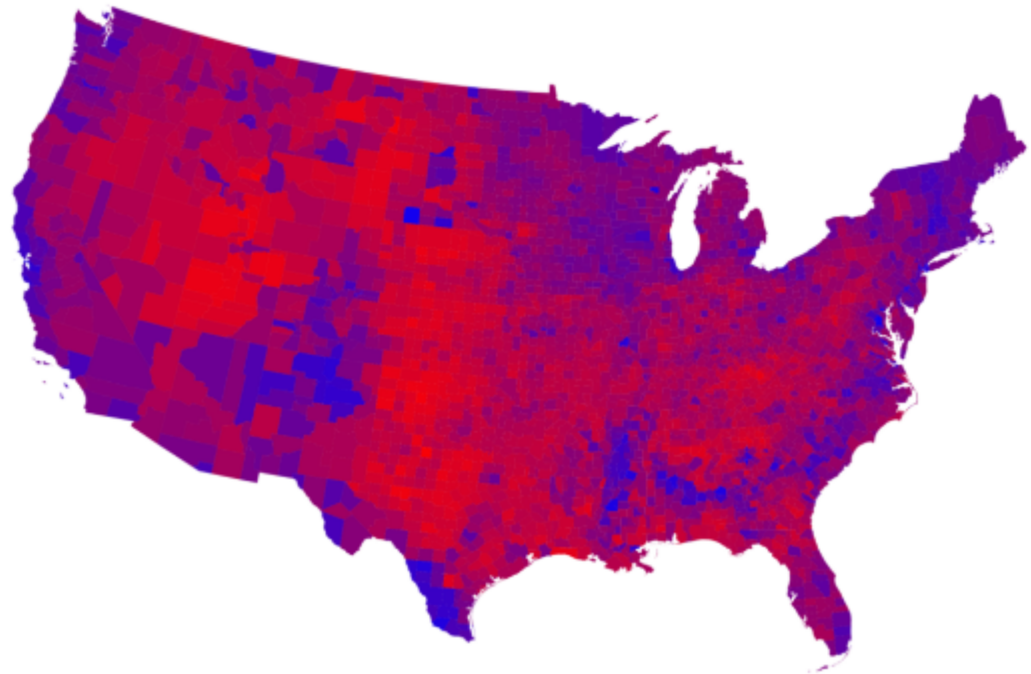

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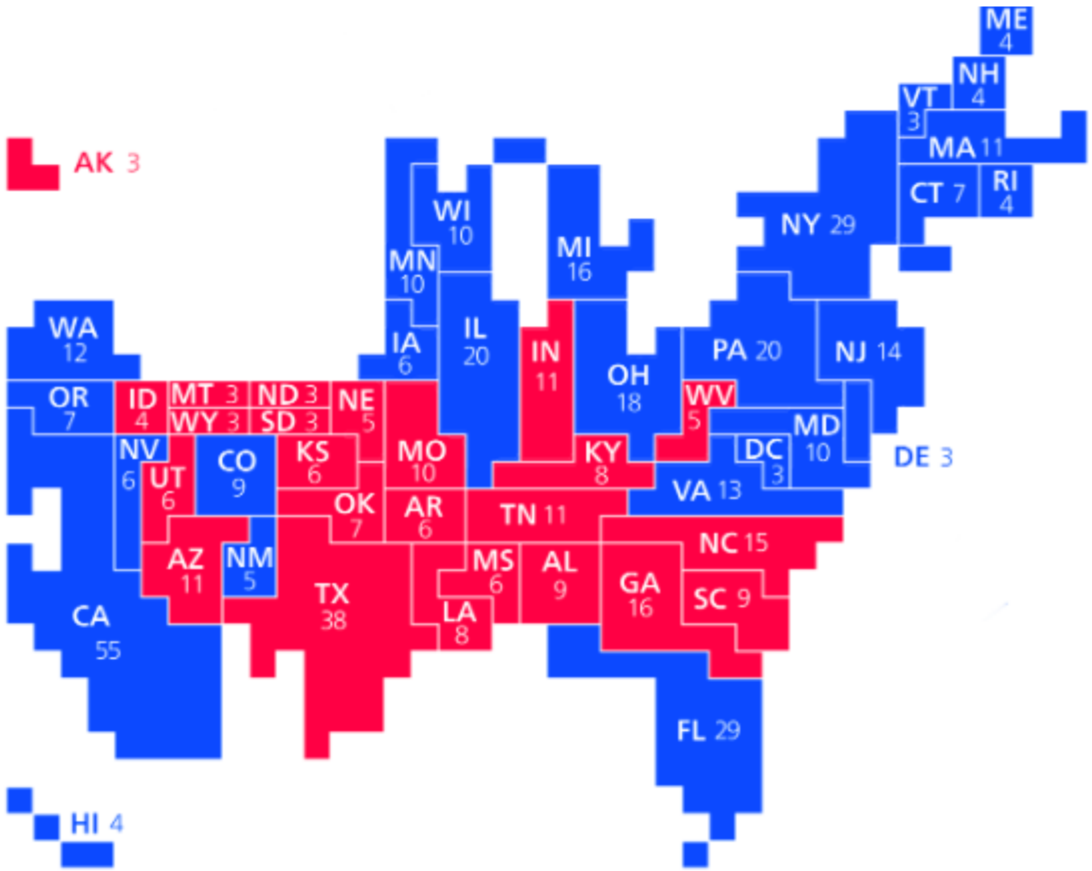
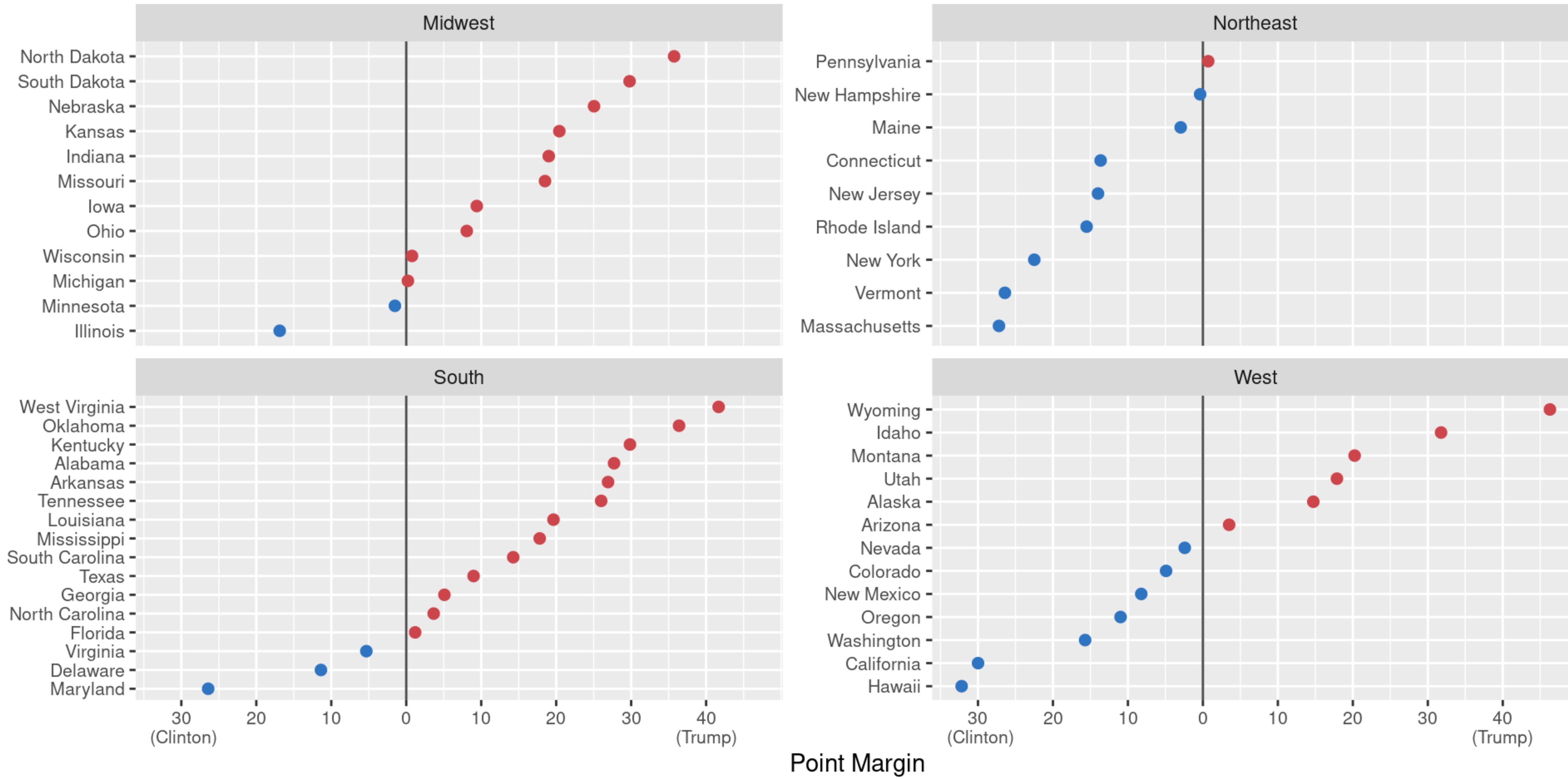


Many Ways to "Map" the Same Data



Several Differences

- Areas of different regions vary by a lot
- Number of people vary by a lot
- Different resolution shows different patterns
- Pattern of votes vs. Meaningful outcome
- For numbers, the dot-plot is better

Week Summary

- Reading for the week:
  - Chapter 15 of Wilkie
  - Chapter 7 of Healy (especially if R user)
  - Cartopy Tutorial (for pythonistas)
  - Ecological Fallacy Section
- Discussion: Find a lying map
- New Lab Available

How Does R Draw Maps?

- Let’s Look at the data available in a map:

```
library(maps)
us_counties = map_data("county") |> as_tibble()
head(us_counties)
```

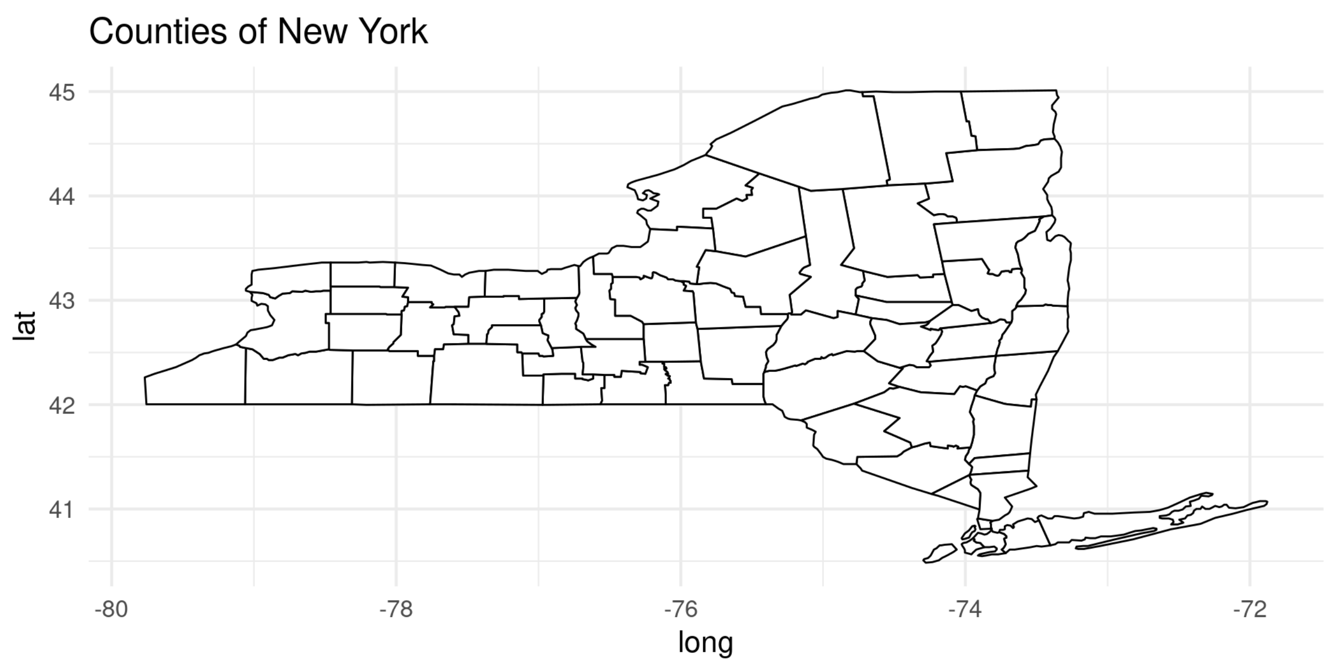
```
# A tibble: 6 × 6
   long   lat group order region  subregion
  <dbl> <dbl> <dbl> <int> <chr>   <chr>
1 -86.5  32.3     1     1 alabama autauga
2 -86.5  32.4     1     2 alabama autauga
3 -86.5  32.4     1     3 alabama autauga
4 -86.6  32.4     1     4 alabama autauga
5 -86.6  32.4     1     5 alabama autauga
6 -86.6  32.4     1     6 alabama autauga
```

- Each unit is a polygon with coordinates and ordering

Draw Some Polygons

- Use `geom_polygon` to see how it works

```
us_counties |> filter(region == "new york") |>  ggplot(aes(x=long,y=lat,gro
  geom_polygon(fill="white",color="black") +
  theme_minimal(base_size=16) +
  labs(title="Counties of New York")
```



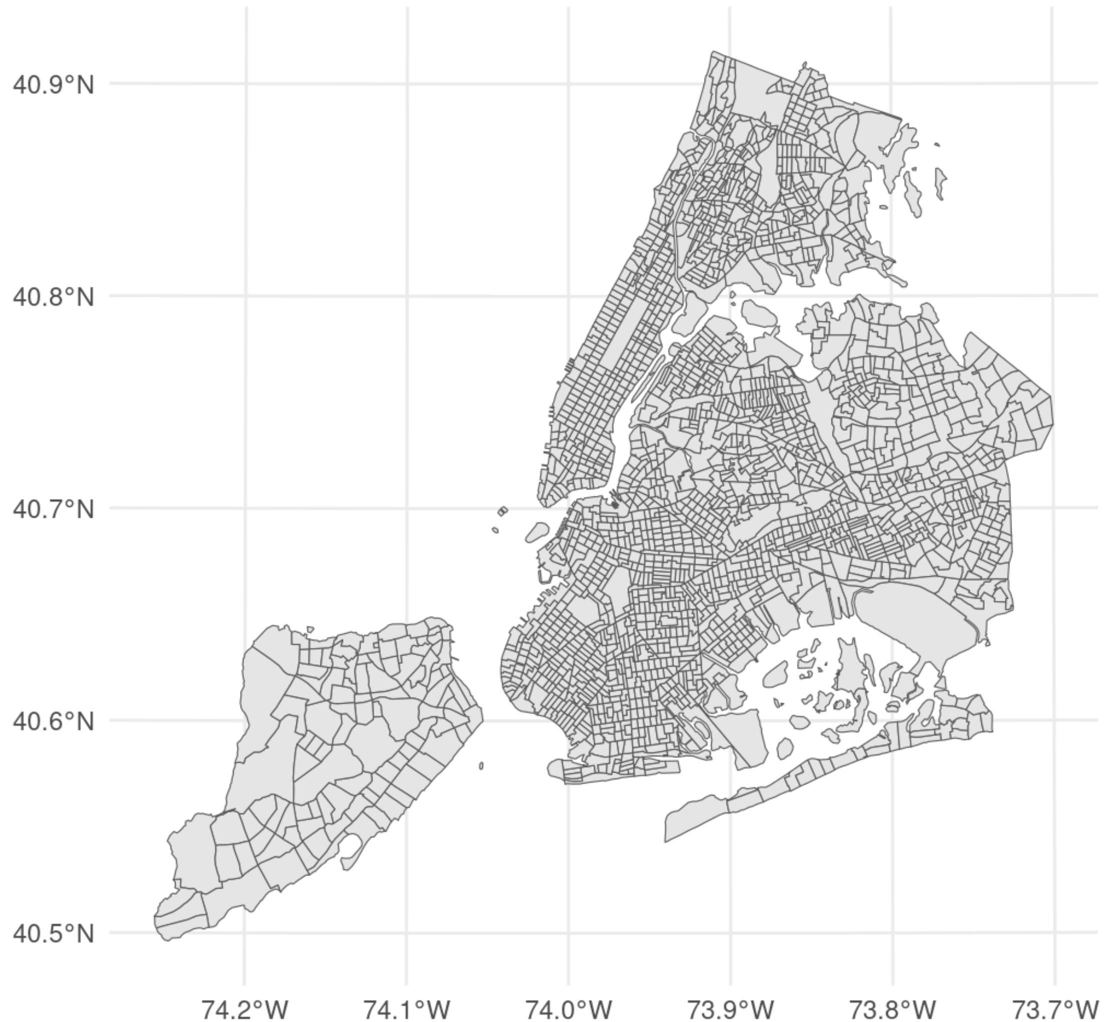
Mapping Libraries

- There are several tools which are better at making maps:
  - `sf` or `simple features`
  - `tmap` or `tidy maps`
- These bring full suit of GIS (Geographic Information Systems Tools)
- Projections,

Mapping NYC

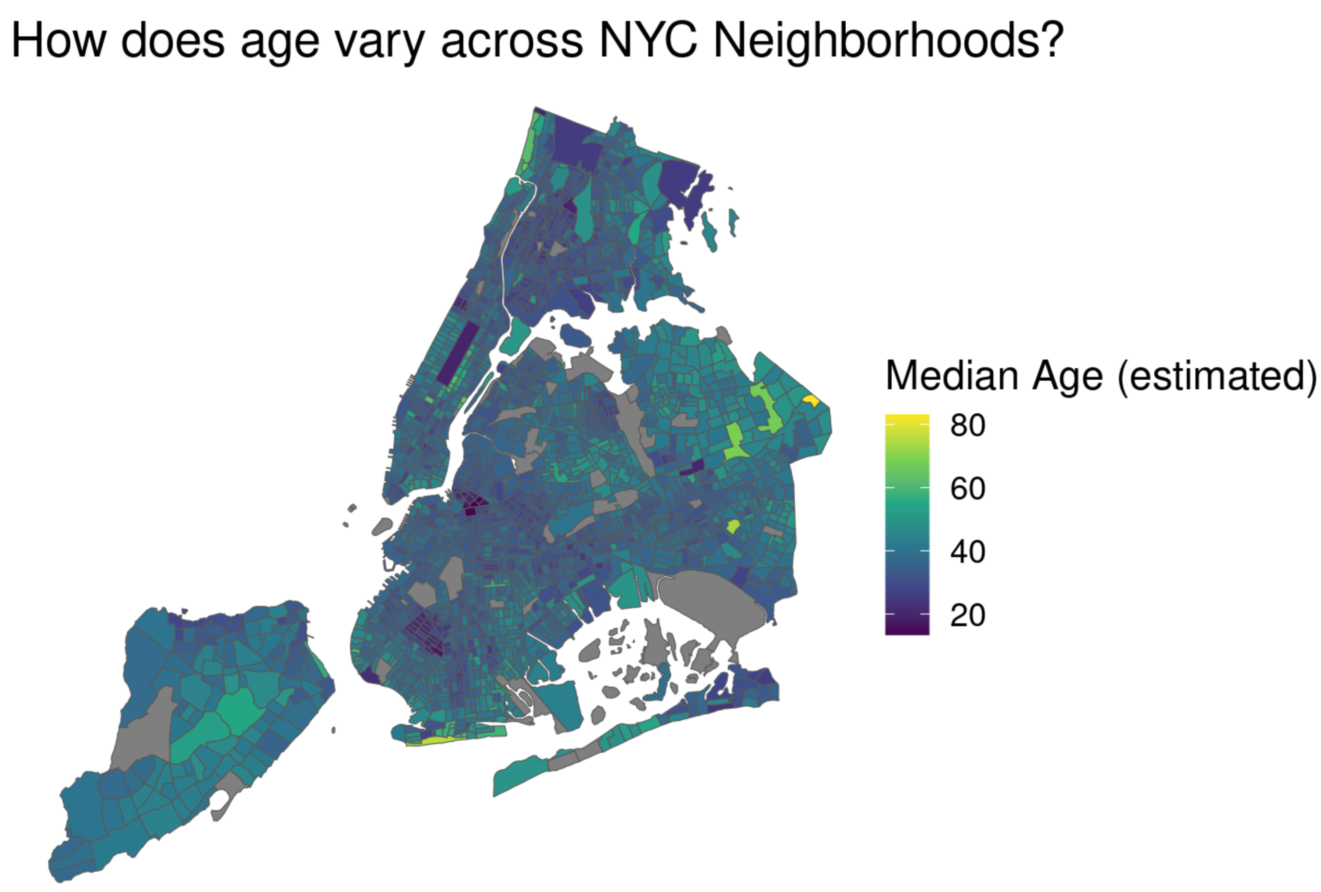
```
Simple feature collection with 2166 features and 12 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: 913180.2 ymin: 120131.4 xmax: 1067382 ymax: 272798.5
Projected CRS: NAD83 / New York Long Island (ftUS)
# A tibble: 2,166 × 13
   geoid       borough_tract_id state_fips county_fips tract_id county_name
   <chr>       <chr>            <chr>      <chr>       <chr>    <chr>
 1 36061000100 1000100          36         061         000100   New York
 2 36061000201 1000201          36         061         000201   New York
 3 36061000202 1000202          36         061         000202   New York
 4 36061000500 1000500          36         061         000500   New York
 5 36061000600 1000600          36         061         000600   New York
 6 36061000700 1000700          36         061         000700   New York
 7 36061000800 1000800          36         061         000800   New York
 8 36061000900 1000900          36         061         000900   New York
 9 36061001001 1001001          36         061         001001   New York
10 36061001002 1001002          36         061         001002   New York
# ℹ 2,156 more rows
# ℹ 7 more variables: borough_name <chr>, borough_id <chr>, nta_id <chr>,
#   nta_name <chr>, puma_id <chr>, puma_name <chr>,
```

Mapping NYC



Mapping NYC

- Let’s get some data



Mapping NYC

- Let's get some data

```
tract_acs_data |> select(pop_total_est:med_age_est) |> head(10)
```

```
# A tibble: 10 × 3
   pop_total_est pop_total_moe med_age_est
           <dbl>         <dbl>       <dbl>
 1          1382           132        48.4
 2          8881           973        30.2
 3          1674           217        33.6
 4          8604          1004        42.4
 5          8811          1035        45.8
 6         15149          1399        35.8
 7          4920           415        39.7
 8          5621           616        38.7
 9             0            11        NA  
10          3990           331        39.9
```

Mapping NYC

- Let's get some data

```
nyc_boundaries(geography = "tract")
```

```
Simple feature collection with 2166 features and 12 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: 913180.2 ymin: 120131.4 xmax: 1067382 ymax: 272798.5
Projected CRS: NAD83 / New York Long Island (ftUS)
# A tibble: 2,166 × 13
   geoid       borough_tract_id state_fips county_fips tract_id county_name
   <chr>       <chr>            <chr>      <chr>       <chr>    <chr>
 1 36061000100 1000100          36         061         000100   New York
 2 36061000201 1000201          36         061         000201   New York
 3 36061000202 1000202          36         061         000202   New York
 4 36061000500 1000500          36         061         000500   New York
 5 36061000600 1000600          36         061         000600   New York
 6 36061000700 1000700          36         061         000700   New York
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 9 36061001001 1001001          36         061         001001   New York
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```

```
# ℹ 2,156 more rows
# ℹ 7 more variables: borough_name <chr>, borough_id <chr>, nta_id <chr>,
#   nta_name <chr>, puma_id <chr>, puma_name <chr>,
```

Mapping NYC

- Let's get some data

```
tract_age = tract_acs_data |> select(med_age_est,geoid)

nyc_boundaries(geography = "tract") %>%
  left_join(tract_age, by = c("geoid" = "geoid")) %>%
  ggplot() +
  geom_sf(aes(fill = med_age_est)) +
  scale_fill_viridis_c(name = "Median Age (estimated)") +
  theme_void() +
  theme(panel.grid = element_line(color = "transparent")) +
  labs(title = "How does age vary across NYC Neighborhoods?")
```

Projections

- Mapping involves transforming from a spherical surface to a 2D plane
- Many Choices

Default: WGS-84

Projections

- Mapping involves transforming from a spherical surface to a 2D plane
- Control with `coord_sf`

```
library(rnaturalearth)
sf_world <- ne_countries(returnclass='sf')
ggplot(sf_world) + geom_sf() +
  theme_minimal(base_size=16) +
  labs(title="Default: WGS-84") +
  coord_sf(crs = st_crs("ESRI:54009"))
```

Projections

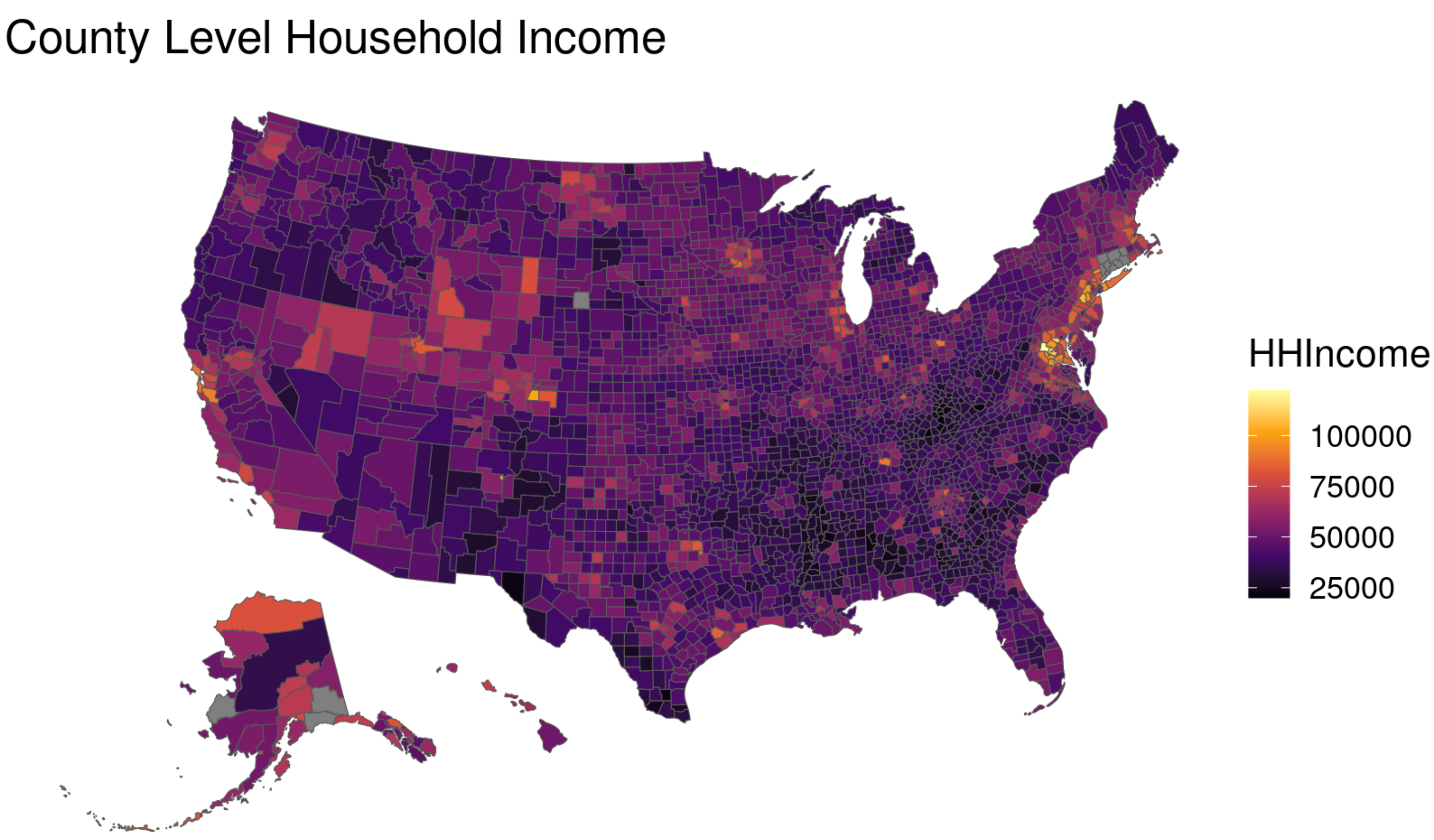
- Mapping involves transforming from a spherical surface to a 2D plane
- Control with `coord_sf`

Projections

- Mapping involves transforming from a spherical surface to a 2D plane
- Control with `coord_sf`

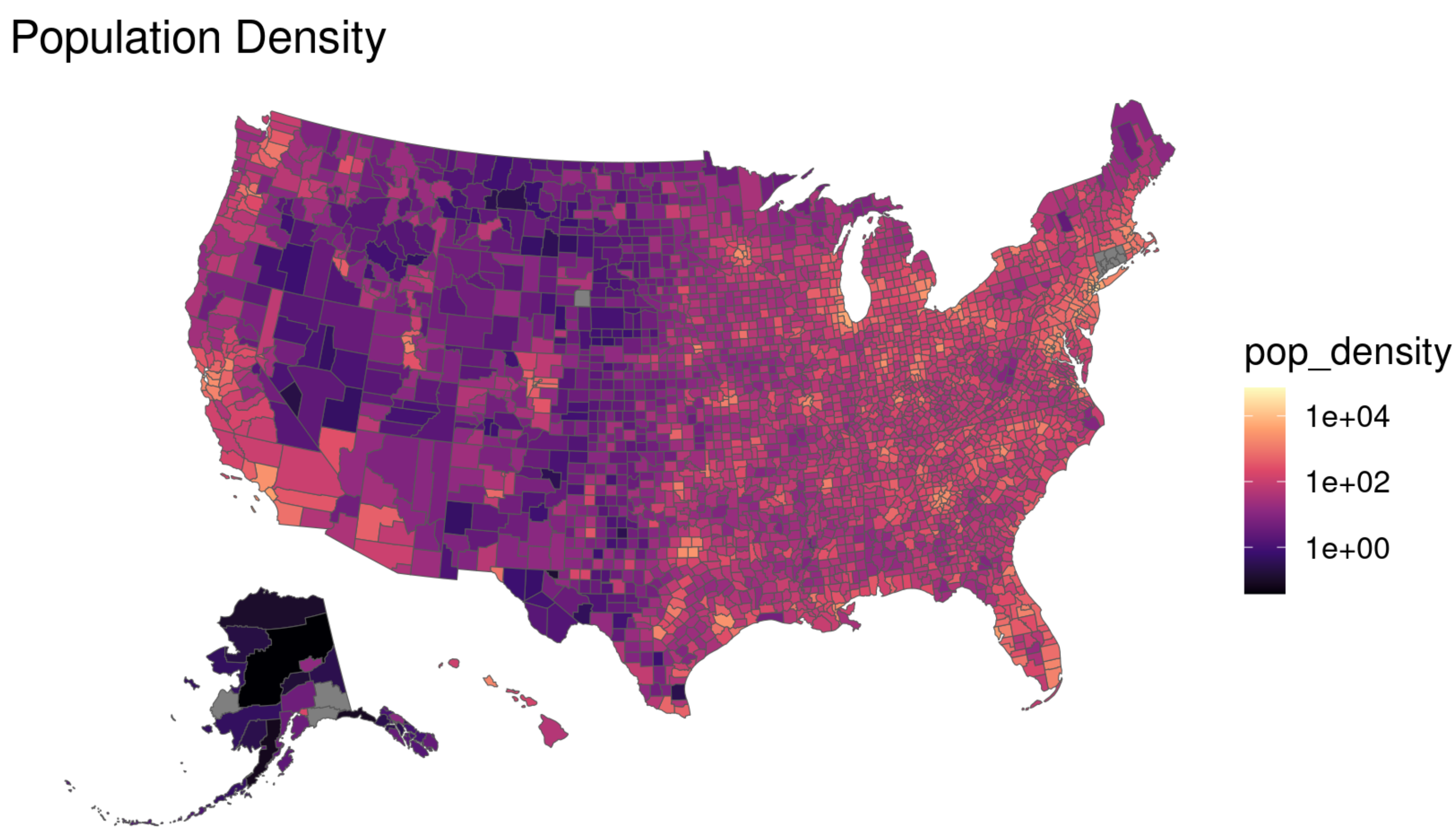
Choropleth Maps

- Maps that color regions based on data



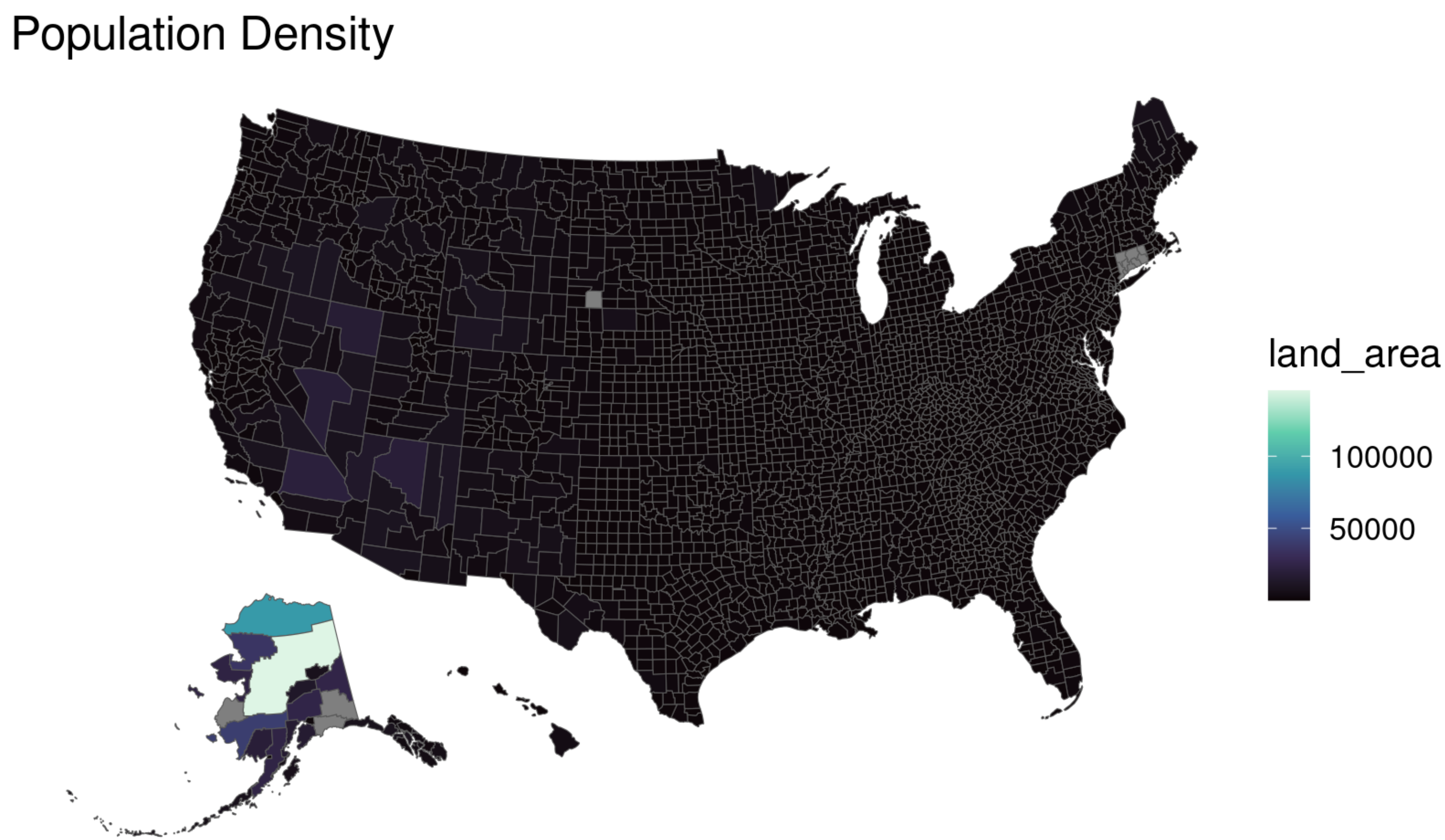
Problems With Choropleths

- Population distribution very heterogeneous



Problems with Choropleths

- Geographic definitions also heterogeneous



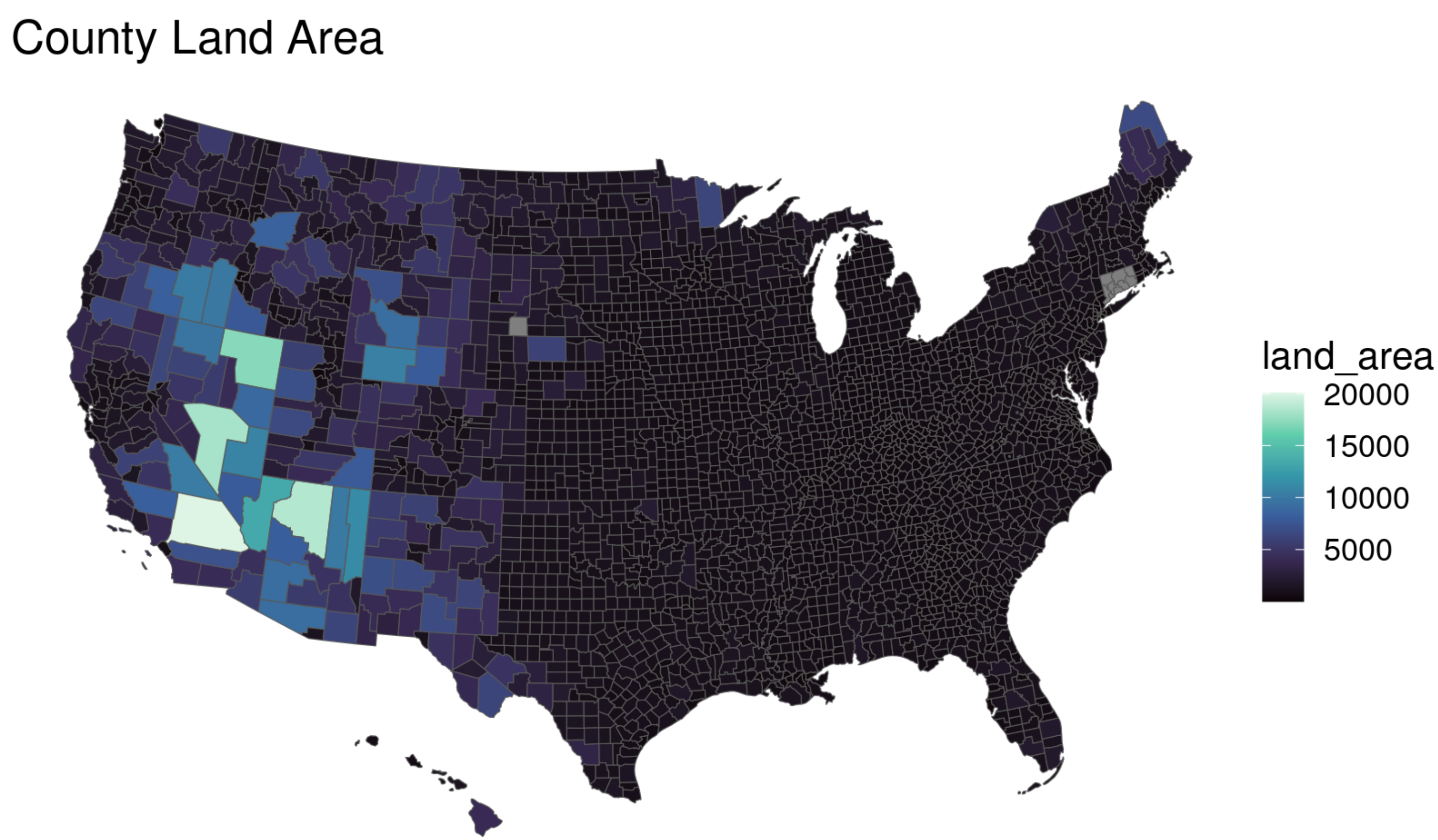
Problems with Choropleths

- Geographic definitions also heterogeneous

```r
county_full |>
  filter(abbr != "AK")
ggplot(aes(fill = land_area)) +
  geom_sf() +
  scale_fill_viridis_c(option="G") +
  theme_void(base_size=16) +
  theme(panel.grid = element_line(color = "transparent")) +
  labs(title = "Population Density")
```

Problems with Choropleths

- Geographic definitions also heterogeneous

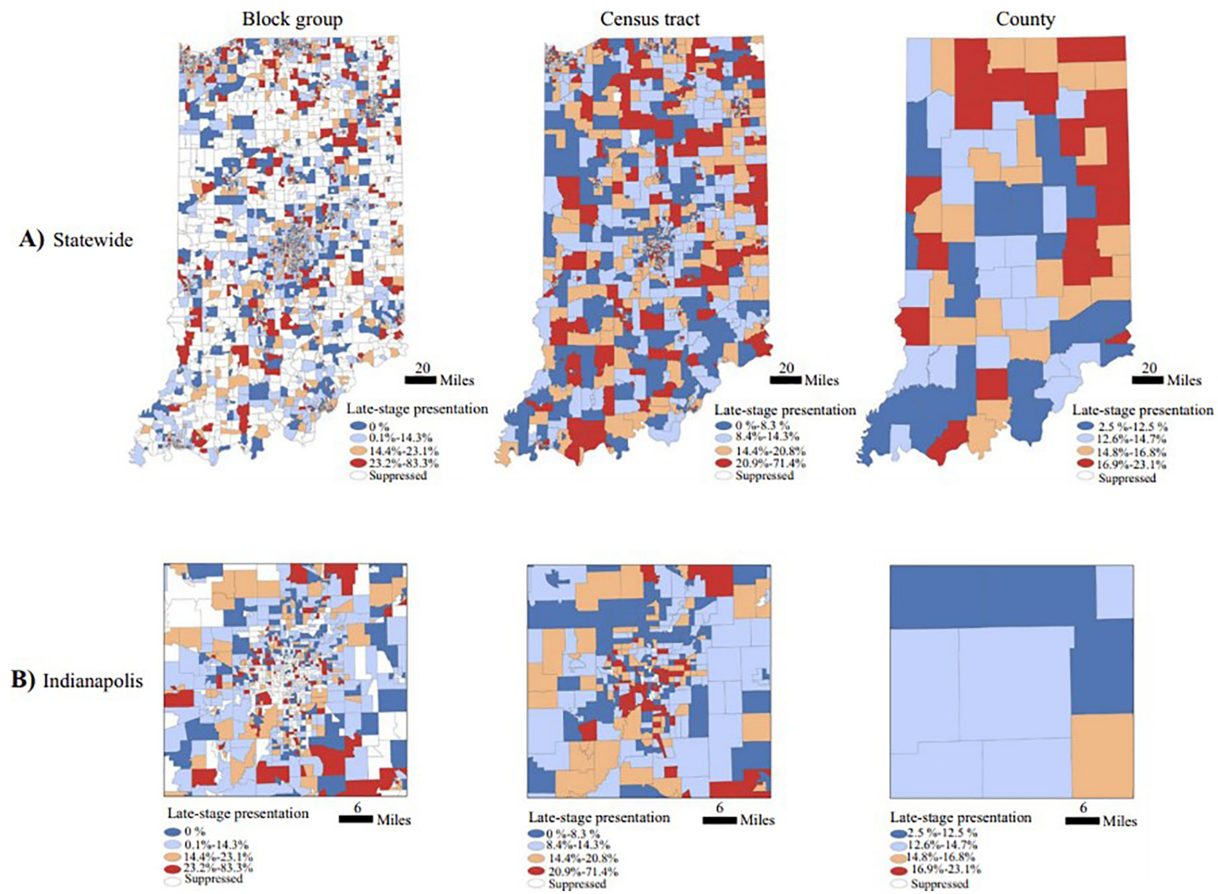


Ecological Fallacy

- Properties of individuals may not correspond to mean properties of the group
- Modifiable Areal Units Problem
  - Different areas may show different story

Ecological Fallacy

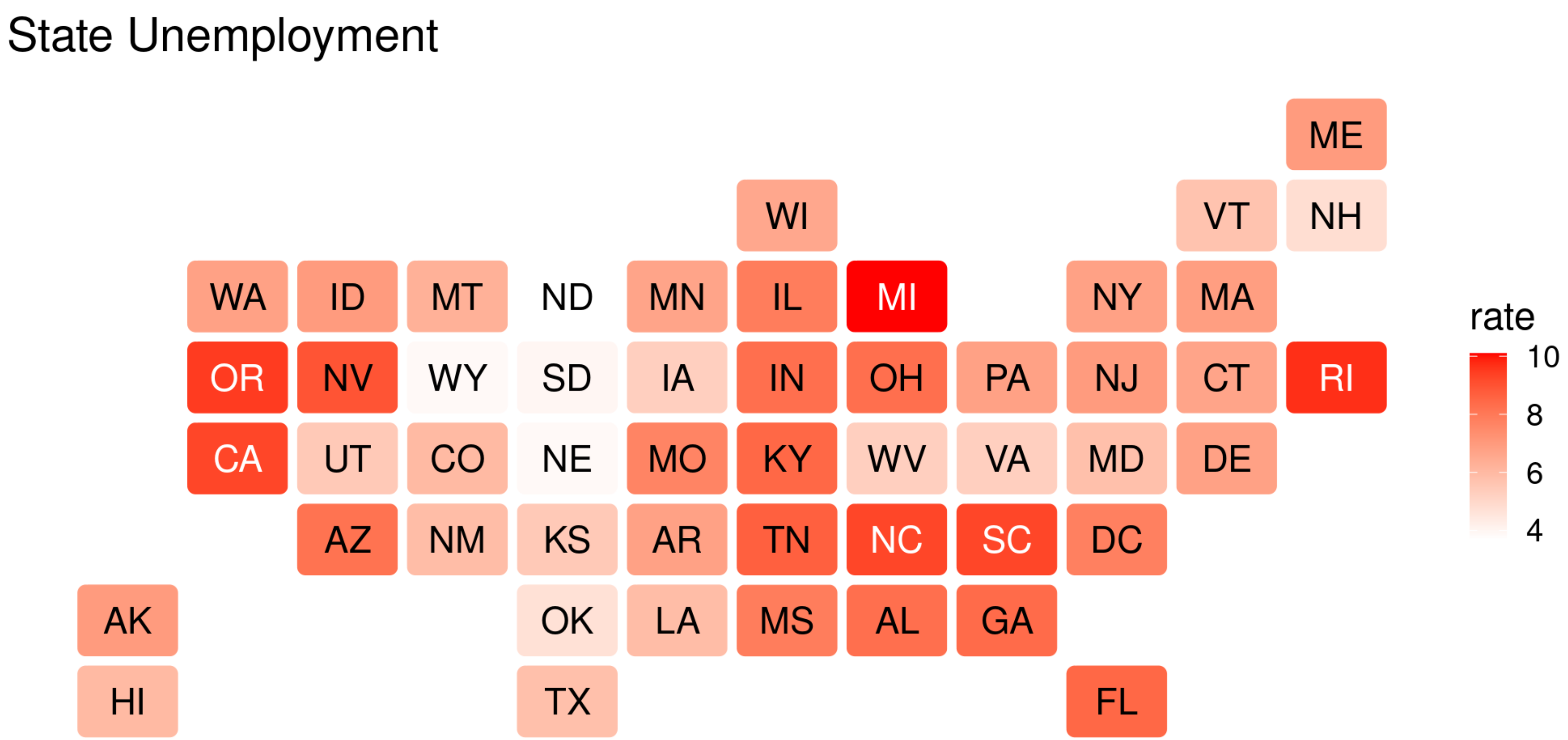
- Geographical disparities in cancer stage at diagnosis



Fontanet et al 2024

Cartogram

- Cartogram is a technique to equalize areas while retaining geography



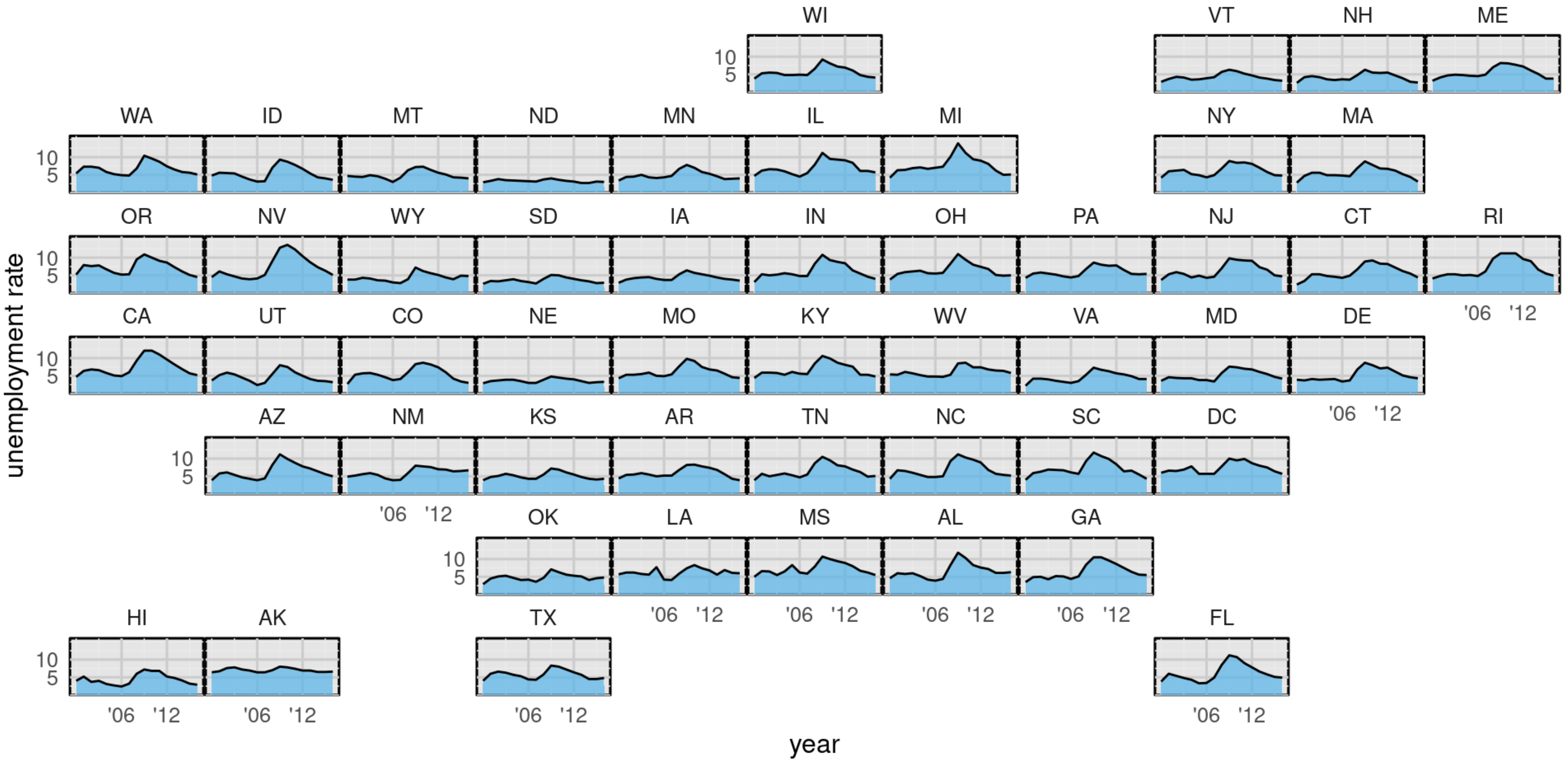
`statebins` library

- `geom_statebins`

```r
library(geofacet)
library(statebins)
state_unemp |> as_tibble() |> filter(year==2008) |> ggplot(aes(fill=rate,st
  scale_fill_gradient(low="white",high="red") +
  theme_void(base_size=18) +
  labs(title="State Unemployment")
```

```
# A tibble: 867 × 3
    year  rate state
   <int> <dbl> <chr>
 1  2000   4.6 AL
 2  2001   6   AL
 3  2002   5.8 AL
 4  2003   6   AL
 5  2004   5.2 AL
 6  2005   4.2 AL
 7  2006   3.9 AL
 8  2007   4.4 AL
 9  2008   8.3 AL
10  2009  11.8 AL
# ℹ 857 more rows
```

Time Series in Each Bin

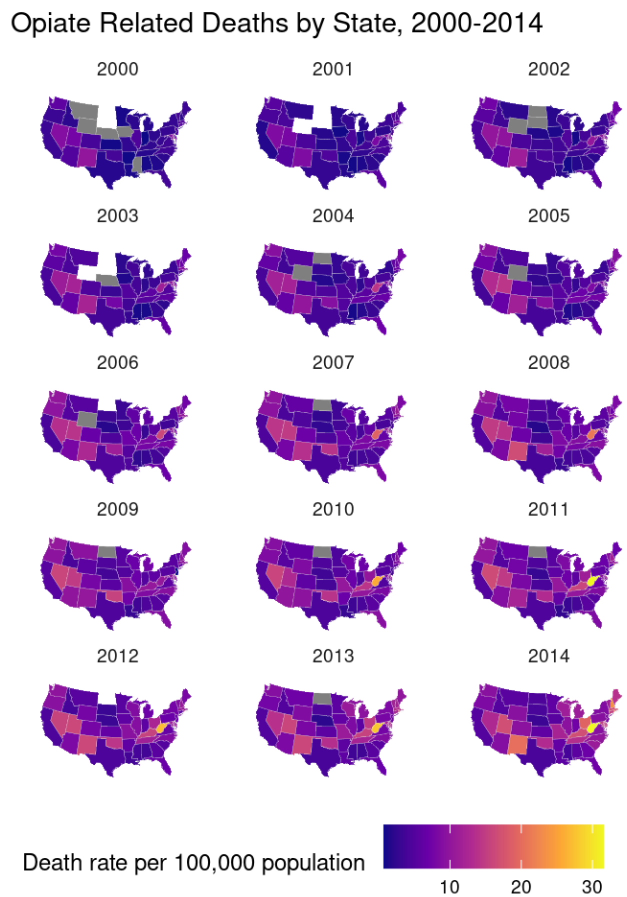


Time Series in Each Bin

```
state_unemp %>%
  ggplot(aes(year, rate)) +
  geom_area(fill = "#56B4E9", alpha = 0.7) +
  geom_line() +
  scale_y_continuous(
    name = "unemployment rate",
    limits = c(0, 16), expand = c(0, 0),
    breaks = c(5, 10),
    labels = c( "5", "10")
  ) +
  scale_x_continuous(breaks = c(2006, 2012),
    labels = c("\'06", "\'12")) +
  coord_cartesian(clip = "off") +
  facet_geo(~state, grid = "us_state_grid1") +
  theme_minimal(base_size=12) +
  theme(
    axis.line.x = element_blank(),
    panel.spacing.x = grid::unit(1, "pt"),
    panel.spacing.y = grid::unit(1, "pt")
```

Small Multiples

- Facet by time

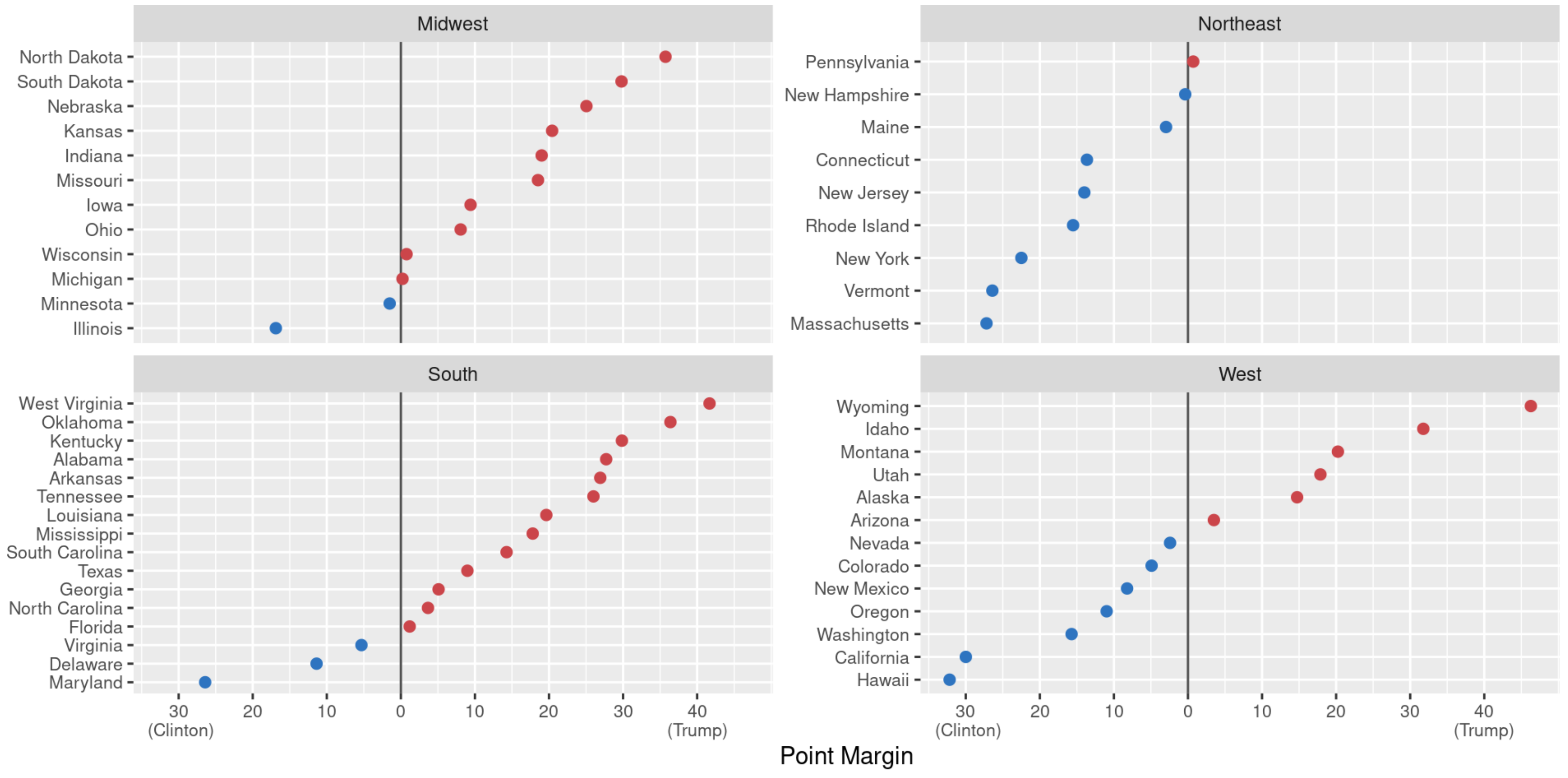


Small Multiples

```
opiates$region <- tolower(opiates$state)
opiates_map <- left_join(us_states, opiates)

p0 <- ggplot(data = subset(opiates_map, year > 1999),
             mapping = aes(x = long, y = lat,
                           group = group,
                           fill = adjusted))

p1 <- p0 + geom_polygon(color = "gray90", size = 0.05) +
    coord_map(projection = "albers", lat0 = 39, lat1 = 45)

p2 <- p1 + scale_fill_viridis_c(option = "plasma")

p2 + theme_map() + facet_wrap(~ year, ncol = 3) +
    theme(legend.position = "bottom",
          strip.background = element_blank()) +
    labs(fill = "Death rate per 100,000 population ",
         title = "Opiate Related Deaths by State, 2000-2014")
```

Non-Spatial Plots

- Direct numerical visualization more precise than colors



Non-Spatial Plots

- Direct numerical visualization more precise than colors

```
election |> filter(state != "DC") |> ggplot(
  aes(x = r_points, y = reorder(state, r_points),
                              color = party)) + geom_vline(xintercept = 0, col
   geom_point(size = 2) + scale_color_manual(values = party_colors) + scal
                                                    "10", "20", "30", "40\n(Trump)"))
  facet_wrap(~ census, scales="free_y",ncol=2) +
   guides(color=FALSE) + labs(x = "Point Margin", y = NULL) +
   theme(axis.text=element_text(size=8))
```

Thanks

References

- Kieran Healy Data Visualization and Github