

Mapping in R

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Just for fun!

Today

- Maps in `ggplot` (one way).
- Animations in R (using `maps`)

Maps in R

There are several packages that let you do maps in R. Let us use one called `maps`.

```
#install.packages("maps")  # Install this if you don't already have it!
library(maps)
```

```
## Warning: package 'maps' was built under R version 4.3.3
```

```
library(tidyverse)
```

```
## Warning: package 'ggplot2' was built under R version 4.3.3
```

```
## Warning: package 'purrr' was built under R version 4.3.3
```

```
## Warning: package 'stringr' was built under R version 4.3.3
```

```
## — Attaching core tidyverse packages ————— tidyverse 2.0.0 —
## ✓ dplyr      1.1.2      ✓ readr      2.1.4
## ✓ forcats    1.0.0      ✓ stringr    1.5.1
## ✓ ggplot2    3.5.0      ✓ tibble     3.2.1
## ✓ lubridate  1.9.2      ✓ tidyr      1.3.0
## ✓ purrr      1.0.2
## — Conflicts ————— tidyverse_conflicts() —
## ✗ dplyr::filter() masks stats::filter()
## ✗ dplyr::lag()    masks stats::lag()
## ✗ purrr::map()    masks maps::map()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
#install.packages("magick")
library(magick)
```

```
## Warning: package 'magick' was built under R version 4.3.3
```

```
## Linking to ImageMagick 6.9.12.98
## Enabled features: cairo, freetype, fftw, ghostscript, heic, lcms, pango, raw, rsvg, webp
## Disabled features: fontconfig, x11
```

- This package contains the data needed to produce a map that we extract using the function `map_data`.
- The dimensions of `states48` are large because this is an object that contains the points of latitude and longitude needed to draw the map.

```
states48 <- map_data("state")
dim(states48)
```

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

```
states48[1,]
```

```
##      long      lat group order  region subregion
## 1 -87.46201 30.38968     1     1 alabama      <NA>
```

```
counties48 <- map_data("county")
dim(counties48)
```

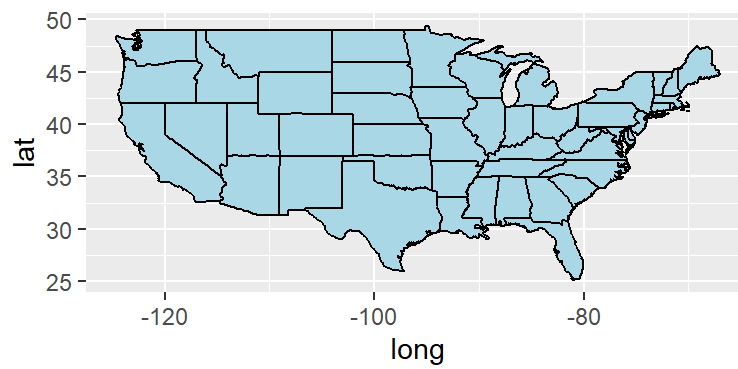
```
## [1] 87949      6
```

```
worldpac <- map_data("world")
dim(worldpac)
```

```
## [1] 99338      6
```

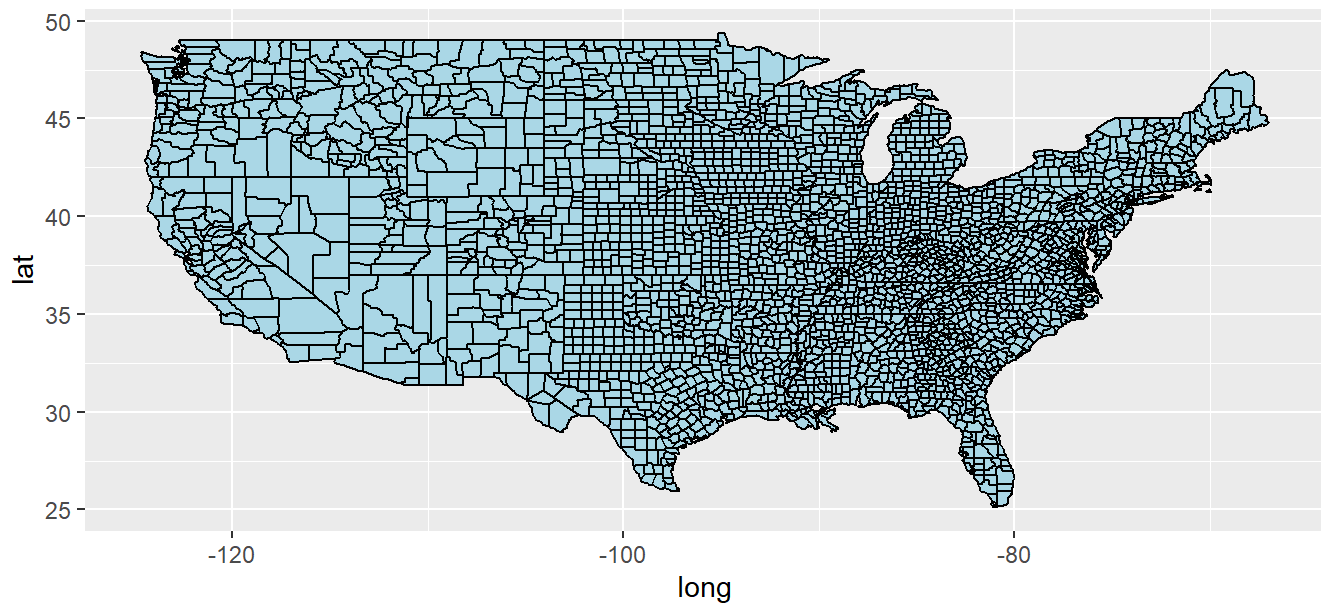
Now let's plot. Notice I have changed some things when defining the R chunk.

```
states48 %>%
  ggplot() +
  geom_polygon(aes(x=long, y=lat, group=group),
               color="black",
               fill="lightblue") +
  coord_fixed()
```



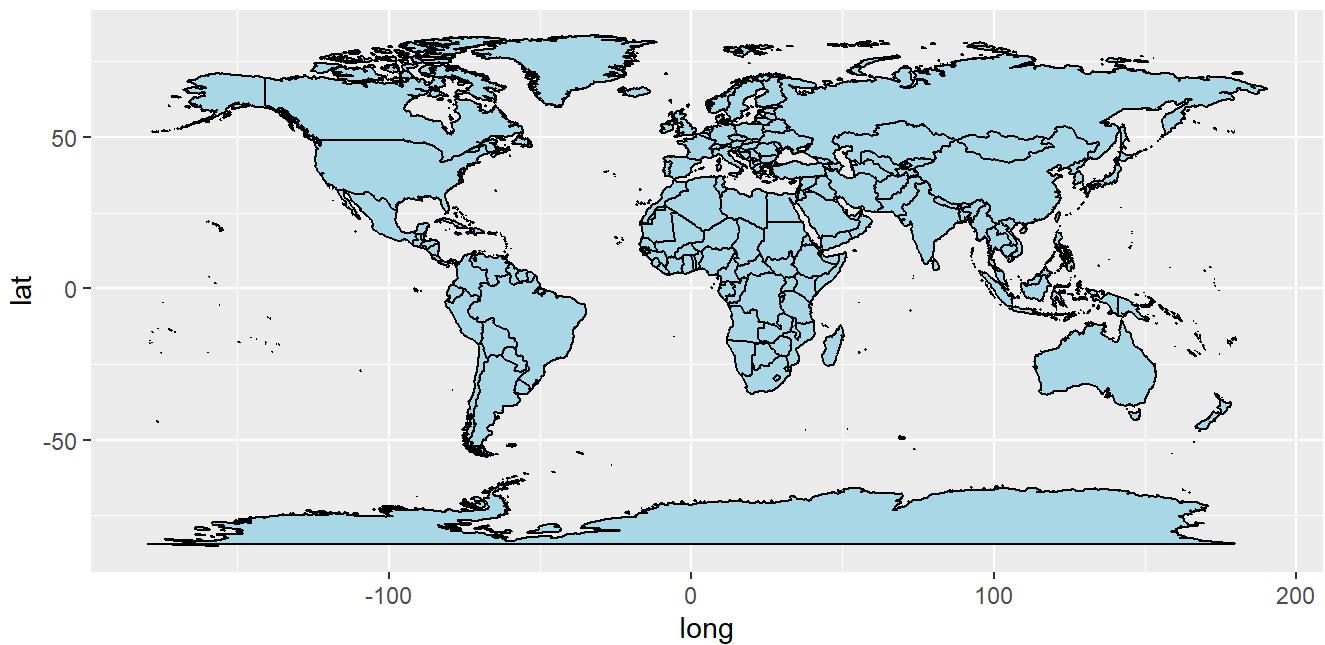
Quick Exercise Produce a map of US Counties

```
counties48 %>%  
  ggplot() +  
  geom_polygon(aes(x=long, y=lat, group=group),  
               color="black",  
               fill="lightblue") +  
  coord_fixed()
```



We can also plot the entire world.

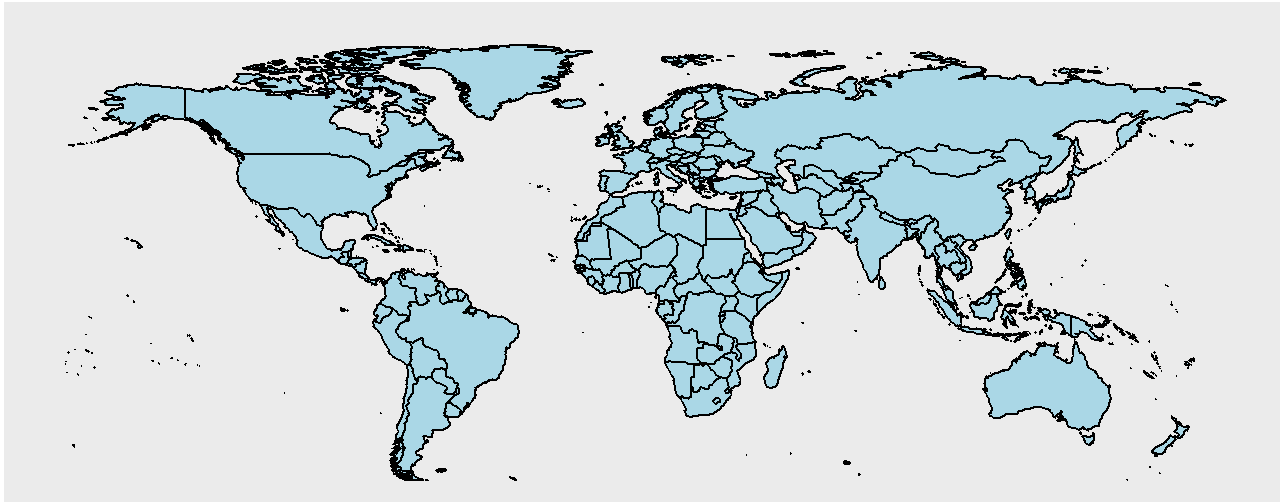
```
worldpac %>%  
  ggplot() +  
  geom_polygon(aes(x=long, y=lat, group=group),  
               color="black",  
               fill="lightblue") +  
  coord_fixed()
```



Note that all of our `ggplot` tools still apply. So we can set limits and breaks. So if we want to exclude Antarctica and remove the axes labels

```
worldpac %>%  
  ggplot() +  
  geom_polygon(aes(x=long, y=lat, group=group),  
               color="black",  
               fill="lightblue") +  
  coord_fixed() +  
  labs(x="", y="", title = "World Map") +  
  scale_y_continuous(limits=c(-55,90), labels=NULL, breaks=NULL) +  
  scale_x_continuous(labels=NULL, breaks=NULL)
```

World Map



Can use limits to focus your attention. Try changing the limits yourself and see how things change. If you exclude points included in an object being plotted by your choice of limits, things can look weird. To see this, make the limits used below smaller and see what happens.

```
worldpac %>%  
  ggplot() +  
    geom_polygon(aes(x=long, y=lat, group=group),  
                 color="black",  
                 fill=NA) +  
    coord_fixed() +  
    labs(x="", y="", title = "Africa") +  
    scale_y_continuous(limits=c(-35,41), labels=NULL, breaks=NULL) +  
    scale_x_continuous(limits=c(-20,52), labels=NULL, breaks=NULL)
```

Africa



But this is not ideal. Better would be to use our wrangling skills to select the states we wish to plot.

```
mystates <- states48 %>%
  filter(region=="new york" | region=="new jersey" | region=="california" | region ==
"tennessee")
```

```
mystates %>%
  ggplot() +
  geom_polygon(aes(x=long, y=lat, group=group),
    color="black",
    fill="lightblue" ) +
  labs(y = "",x = "",title="States I have lived in") +
  scale_x_continuous(breaks=NULL, labels=NULL) +
  scale_y_continuous(breaks=NULL, labels=NULL) +
  coord_fixed() +
  theme(
    panel.border = element_blank(),
    panel.background = element_blank(),
    panel.grid.major = element_blank(),
    panel.grid.minor = element_blank()
  )
```

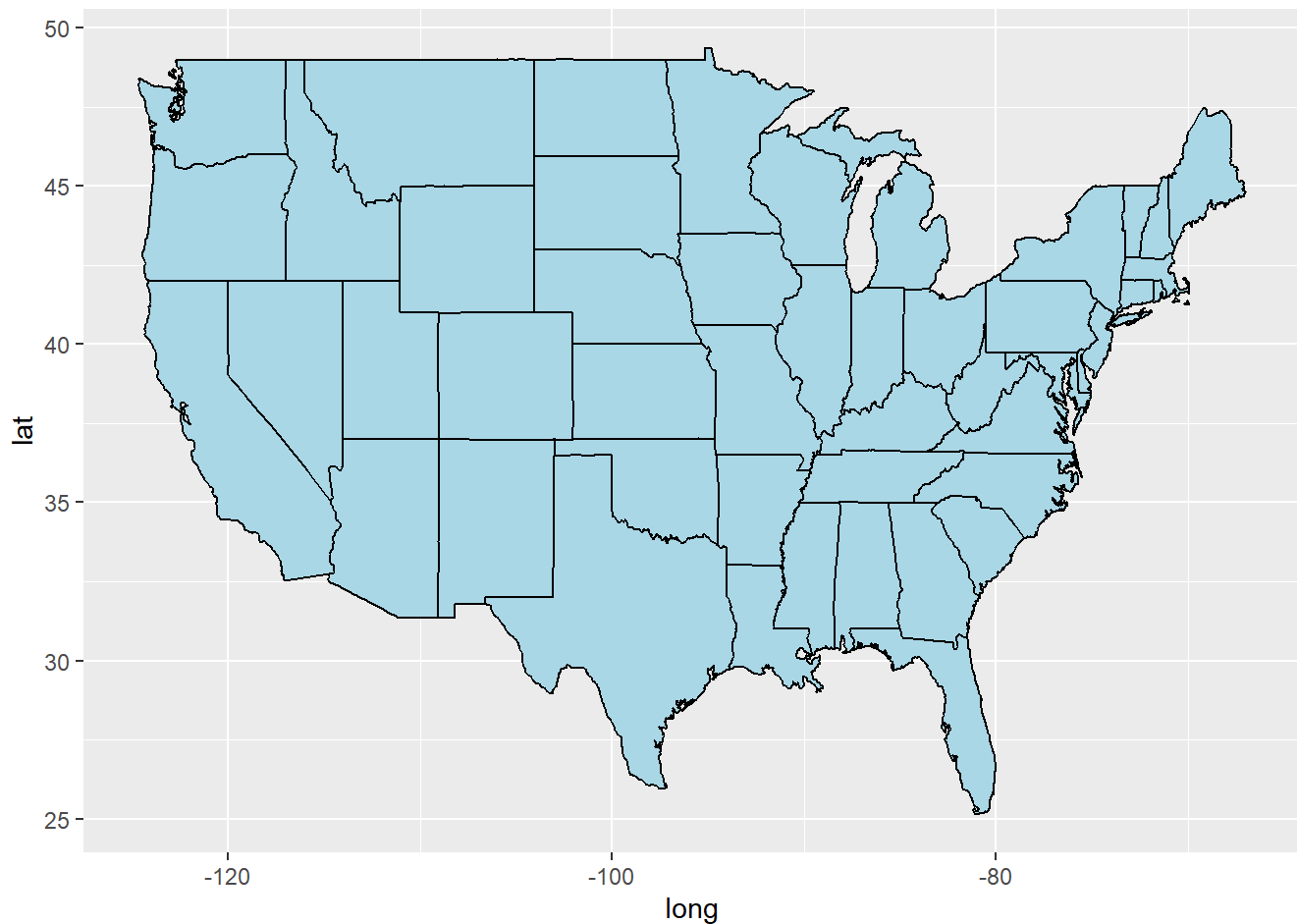
States I have lived in



Creating the canvas

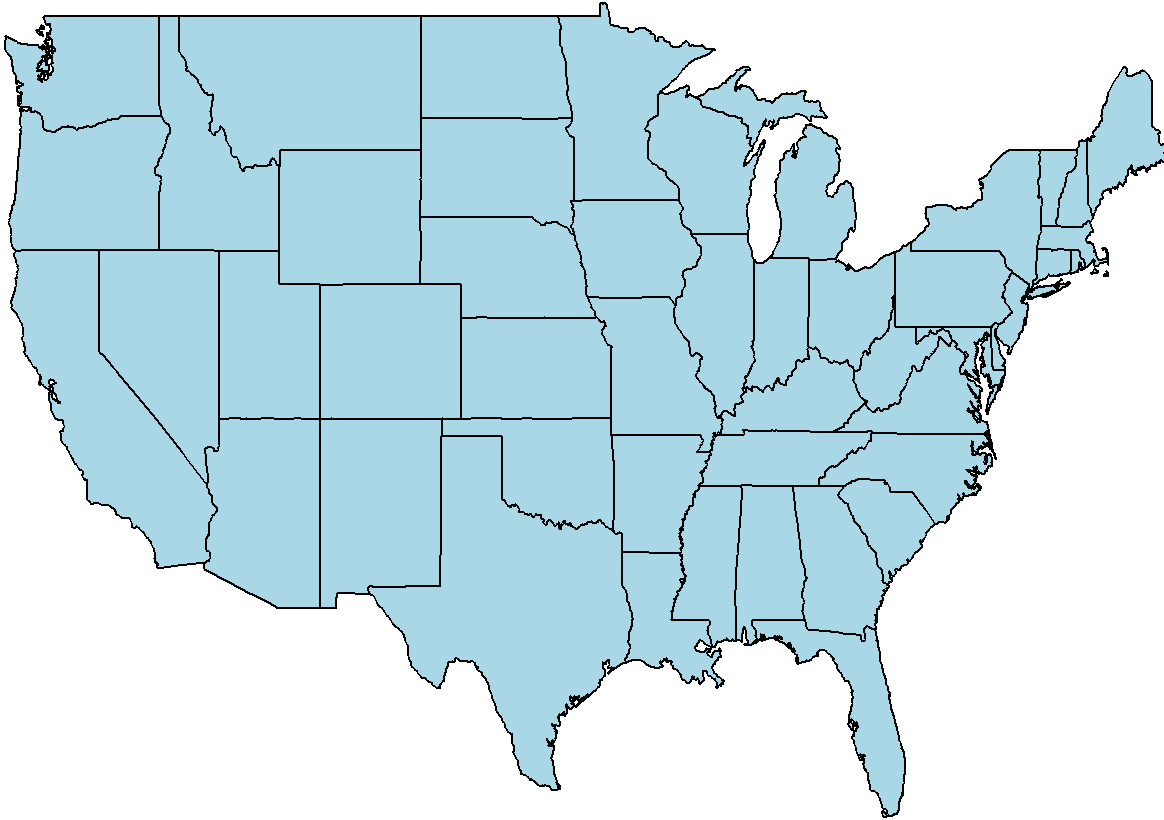
- The map is drawn using `geom_polygon` which uses the `long` and `lat` to draw the points in `ggplot`.
- Note that the default is pretty ugly (and distracting)

```
states48 %>%  
  ggplot() +  
  geom_polygon(aes(x=long, y=lat, group=group),  
               color="black",  
               fill="lightblue" )
```

Let's clean it up and save it as an object to be used later. (Note that we can create a custom theme to apply to a ggplot)

```
plotmap <- states48 %>%  
  ggplot() +  
  geom_polygon(aes(x=long, y=lat, group=group),  
               color="black",  
               fill="lightblue" ) +  
  labs(y = "") +  
  labs(x = "") + scale_x_continuous(breaks=NULL, labels=NULL) +  
  scale_y_continuous(breaks=NULL, labels=NULL) +  
  theme(  
    panel.border = element_blank(),  
    panel.background = element_blank(),  
    panel.grid.major = element_blank(),  
    panel.grid.minor = element_blank()  
  )  
  
plotmap
```



Get Some Data!

Load in our data

```
PollDat <- read_rds(file="https://github.com/jbisbee1/DS1000_S2024/raw/main/data/PresStatePolls04to20.Rds") %>%  
  rename(region=state.name)
```

Now mutate it and group it to have the observation be a state-year.

```
PollDat <- PollDat %>%  
  group_by(year,region) %>%  
    summarize(DemPct = mean(dem.poll, na.rm = TRUE),  
              RepPct = mean(rep.poll, na.rm = TRUE),  
              DemVote = first(dem.vote),  
              RepVote = first(rep.vote),  
              region = first(region))
```

```
## `summarise()` has grouped output by 'year'. You can override using the  
## `.groups` argument.
```

Now pull out 2020 vote to start

```
polls2020 <- PollDat %>%
  filter(year == 2020)
```

First, some wrangling.

- `inner_join()` merge dataframes if common in both (must have same name)
- `full_join()` merge dataframes if in either

(There is also a `left_join` (all observations from the 1st tibble), a `right_join` (all observations from second tibble), an `anti_join` (all unmatched observations))

```
inner.join <- inner_join(states48,polls2020)
```

```
## Joining with `by = join_by(region)`
```

```
glimpse(inner.join)
```

```
## Rows: 15,527
## Columns: 11
## $ long      <dbl> -87.46201, -87.48493, -87.52503, -87.53076, -87.57087, -87.5...
## $ lat       <dbl> 30.38968, 30.37249, 30.37249, 30.33239, 30.32665, 30.32665, ...
## $ group     <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, ...
## $ order     <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 1...
## $ region    <chr> "alabama", "alabama", "alabama", "alabama", "alabama", "alab...
## $ subregion <chr> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, ...
## $ year      <dbl> 2020, 2020, 2020, 2020, 2020, 2020, 2020, 2020, 2020, 2020, 2020, ...
## $ DemPct    <dbl> 38.92857, 38.92857, 38.92857, 38.92857, 38.92857, 38.92857, ...
## $ RepPct    <dbl> 56.78571, 56.78571, 56.78571, 56.78571, 56.78571, 56.78571, ...
## $ DemVote   <dbl> 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, ...
## $ RepVote   <dbl> 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, ...
```

```
full.join <- full_join(states48,polls2020)
```

```
## Joining with `by = join_by(region)`
```

```
glimpse(full.join)
```

```
## Rows: 15,539
## Columns: 11
## $ long      <dbl> -87.46201, -87.48493, -87.52503, -87.53076, -87.57087, -87.5...
## $ lat       <dbl> 30.38968, 30.37249, 30.37249, 30.33239, 30.32665, 30.32665, ...
## $ group     <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, ...
## $ order     <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 1...
## $ region    <chr> "alabama", "alabama", "alabama", "alabama", "alabama", "alab...
## $ subregion <chr> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, ...
## $ year      <dbl> 2020, 2020, 2020, 2020, 2020, 2020, 2020, 2020, 2020, 2020, ...
## $ DemPct    <dbl> 38.92857, 38.92857, 38.92857, 38.92857, 38.92857, 38.92857, ...
## $ RepPct    <dbl> 56.78571, 56.78571, 56.78571, 56.78571, 56.78571, 56.78571, ...
## $ DemVote   <dbl> 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, ...
## $ RepVote   <dbl> 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, ...
```

So let's actually do the tibble we want?

```
states48.join <- inner_join(states48,polls2020)
```

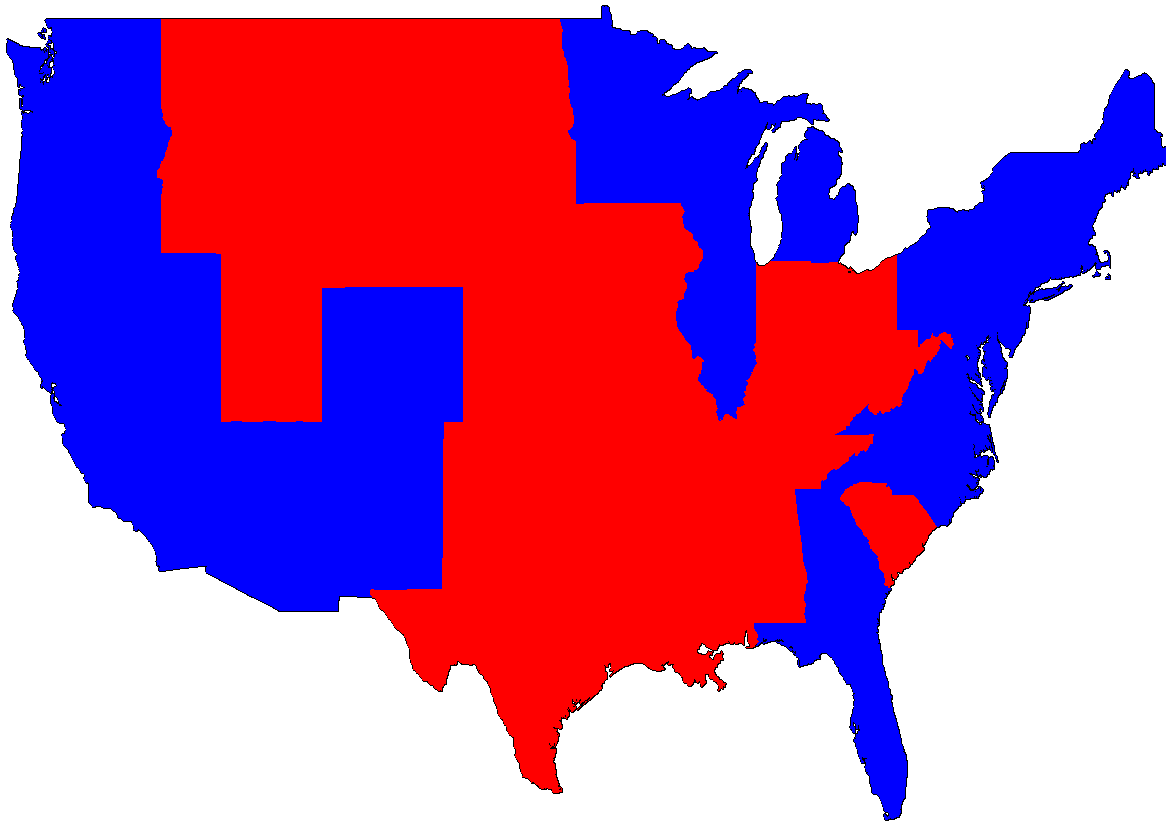
```
## Joining with `by = join_by(region)`
```

```
glimpse(states48.join)
```

```
## Rows: 15,527
## Columns: 11
## $ long      <dbl> -87.46201, -87.48493, -87.52503, -87.53076, -87.57087, -87.5...
## $ lat       <dbl> 30.38968, 30.37249, 30.37249, 30.33239, 30.32665, 30.32665, ...
## $ group     <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, ...
## $ order     <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 1...
## $ region    <chr> "alabama", "alabama", "alabama", "alabama", "alabama", "alab...
## $ subregion <chr> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, ...
## $ year      <dbl> 2020, 2020, 2020, 2020, 2020, 2020, 2020, 2020, 2020, 2020, ...
## $ DemPct    <dbl> 38.92857, 38.92857, 38.92857, 38.92857, 38.92857, 38.92857, ...
## $ RepPct    <dbl> 56.78571, 56.78571, 56.78571, 56.78571, 56.78571, 56.78571, ...
## $ DemVote   <dbl> 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, 37, ...
## $ RepVote   <dbl> 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, 62, ...
```

First, Produce a map that indicates predicted winners depending on the average polling done in each state using different polygons.

```
plotmap +
  geom_polygon(data=states48.join,
               aes(x=long, y=lat, group=group)) +
  geom_polygon(data=filter(states48.join, DemPct > RepPct),
               aes(x=long, y=lat, group=group), fill="Blue") +
  geom_polygon(data=filter(states48.join, DemPct < RepPct),
               aes(x=long, y=lat, group=group), fill="Red")
```

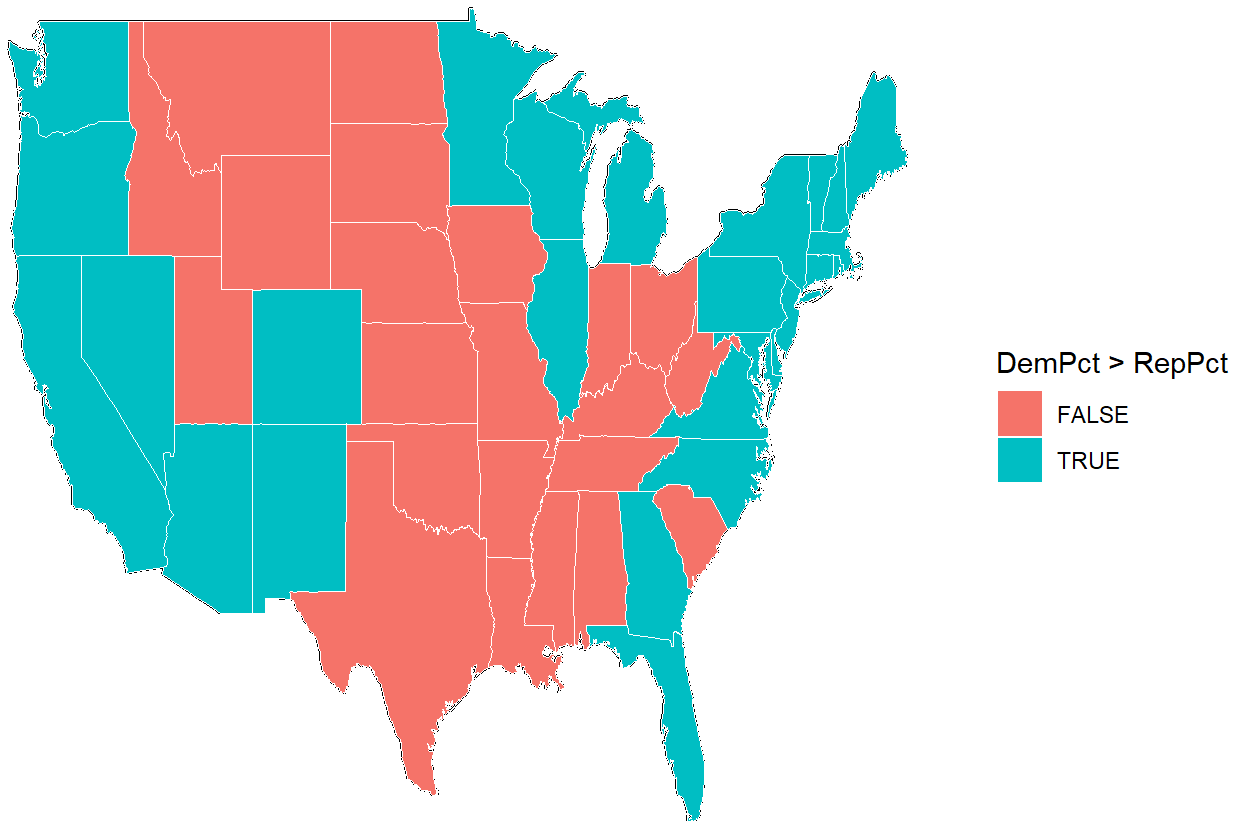


But we can do the same thing using `fill` – here defined to be which candidate is larger.

```
statewinner <- plotmap +  
  geom_polygon(data=states48.join,  
              aes(x=long, y=lat, group=group,  
                  fill=DemPct > RepPct),  
              color="white", size = .1)
```

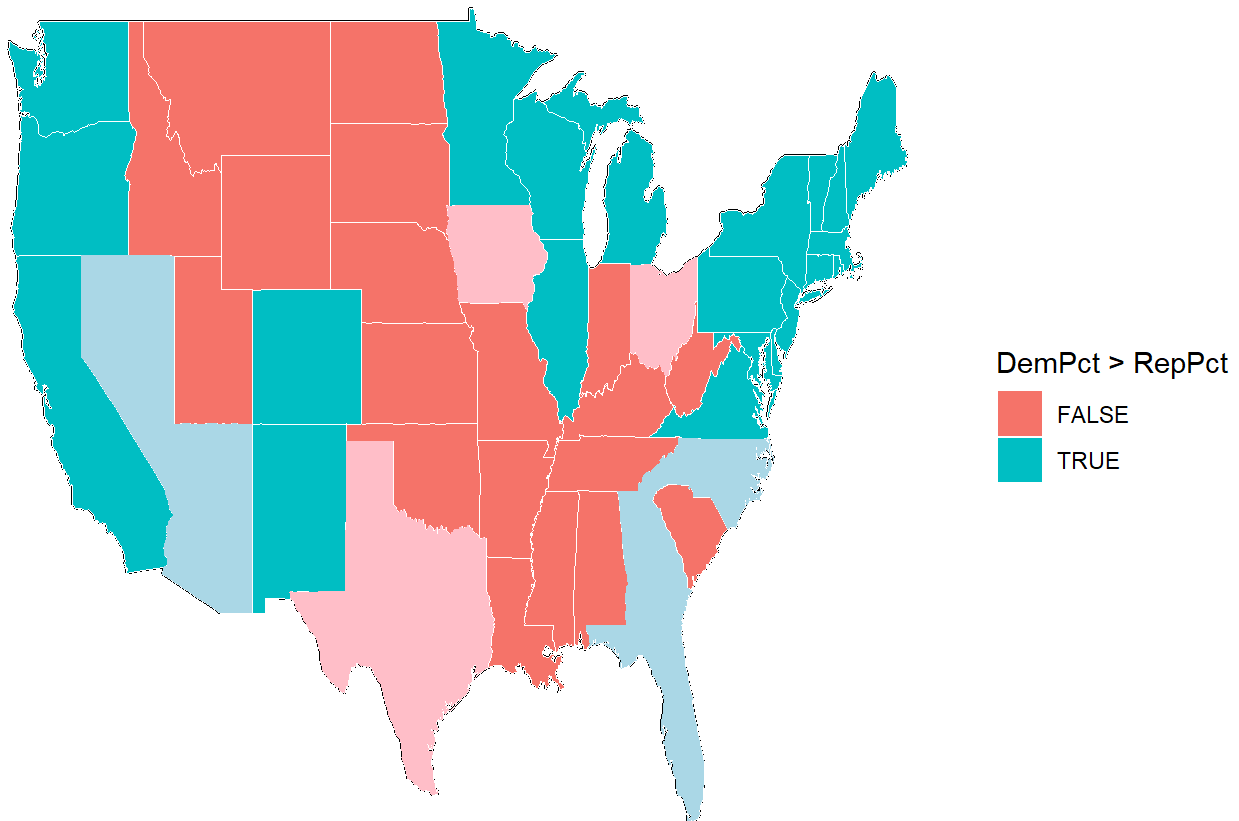
```
## Warning: Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.  
## i Please use `linewidth` instead.  
## This warning is displayed once every 8 hours.  
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was  
## generated.
```

```
statewinner
```



- We can also add more nuanced information by denoting the location of states where the predicted margin is less than 5 – i.e., very close.
- Because we are adding on top of the canvass we are just “repainting” the impacted states.

```
statewinner +
  geom_polygon(data=filter(states48.join,
    DemPct > RepPct & DemPct - RepPct < 5),
    aes(x=long, y=lat, group=group),
    fill="light blue") +
  geom_polygon(data=filter(states48.join,
    DemPct < RepPct & RepPct - DemPct < 5),
    aes(x=long, y=lat, group=group),
    fill="pink")
```



Quick Exercise Can you plot the location of “Blow out” states using a different color? How do you define “blow-out” states?

```
# INSERT CODE HERE
```

Note that we could also use this to define a subset of the states to be plotted!

Quick Exercise Can you plot *just* the close states? HINT: first filter based on closeness, then plot.

```
# INSERT CODE HERE
```

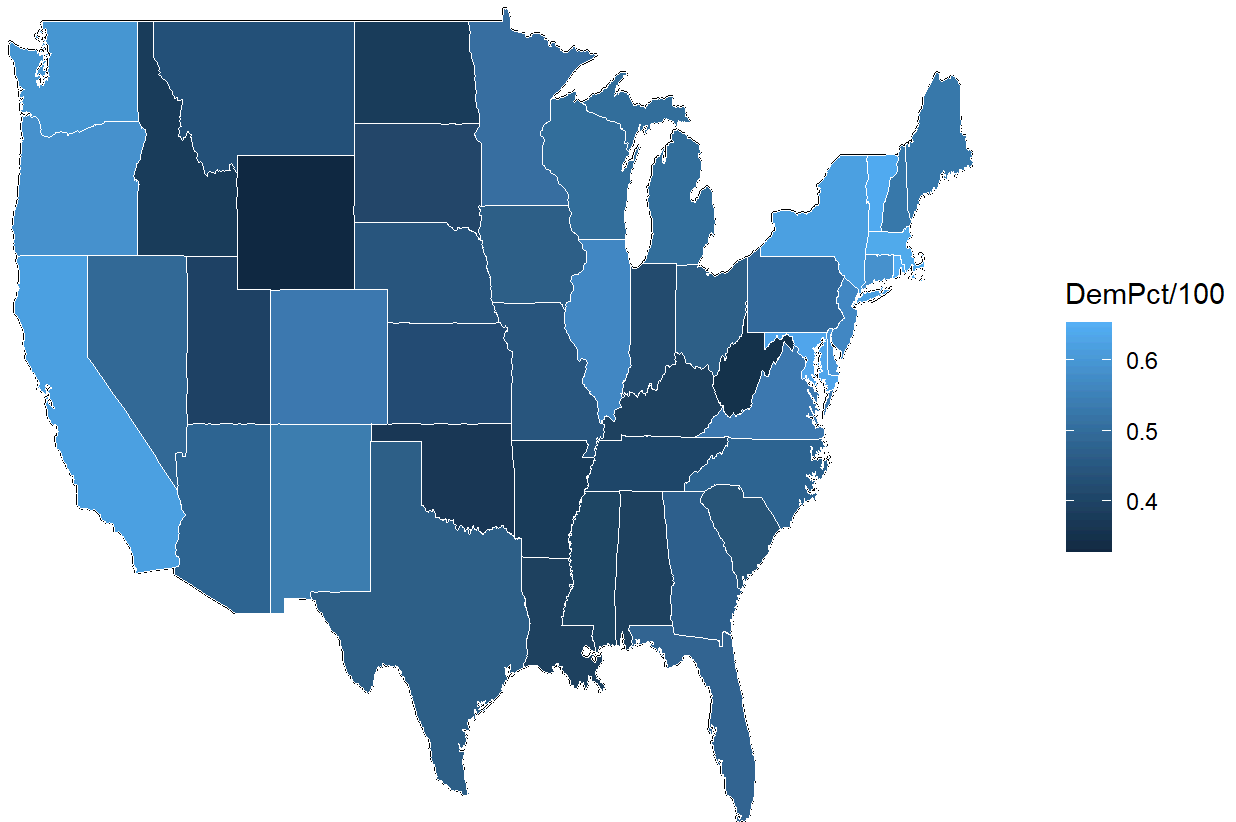
Using Fill as a variable

- Instead of using different colors to define categories of difference we can also use the `fill` to try to convey information about the variation of continuous differences – e.g., the level of support.

NOTE THAT `fill` is an aesthetic (and included in `aes`) when it varies!

```
plot1 <- plotmap +  
  geom_polygon(data=states48.join,  
    aes(x=long, y=lat, group=group,  
      fill=DemPct/100),  
    color="WHITE", size = .1)
```

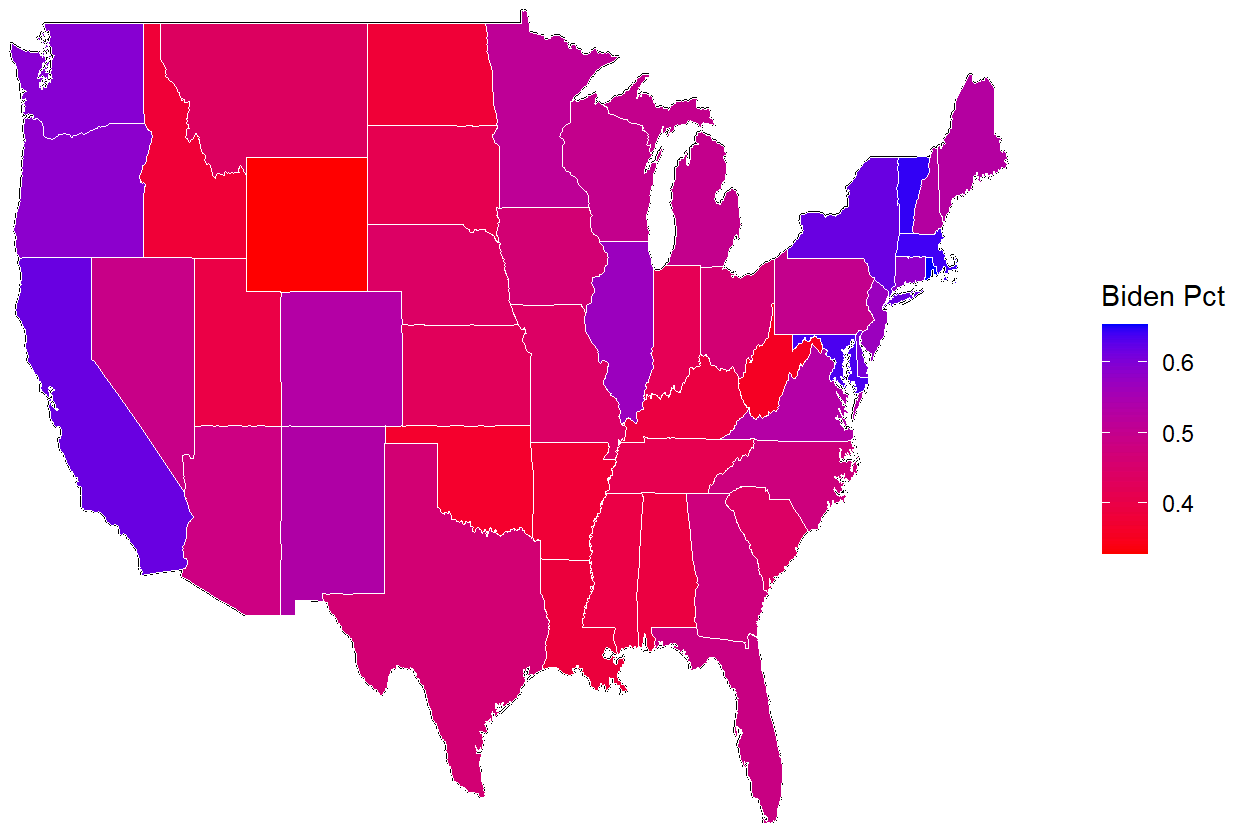
plot1



This is the default. Ugly.

And we can also define the scale in terms of the color associated with the min and max values.

```
plot1 + scale_fill_continuous(name="Biden Pct",  
  low = "Red", high = "Blue")
```

Changing the Geography: plotting counties

OPTIONAL Here is some code that I used to create the `countycovid.Rds` file we are using. We are not going to cover it in class, but I wanted to show you what I did – and what you could also do – using the tools we have talked about (and a slight extension using the `stringr` library to parse a string variable and separate it into 2 string variables).

Let's grab the data from our plotting assignment that had votes and pandemic information at the county level. Need to change the county fips code (a standard unique identifier used by the US Government to identify counties) to numeric.

```
covidvote <- read_rds(file="https://github.com/jbisbee1/DS1000_S2024/raw/main/data/COVID.Death.Voting.Rds")
covidvote <- covidvote %>%
  mutate(fips = as.numeric(fips.code))
```

Now join `covidvote` with a dataset in `maps` that connects the county name to the fips code for merging. Then parse this and break it apart.

```
covidvote <- inner_join(covidvote, county.fips)
library(stringr)
covidvote <- covidvote %>%
  mutate(region = word(polynome, 1, sep=", "),
         subregion = word(polynome, 2, sep=", "))

countycovid <- inner_join(covidvote, counties48)
```

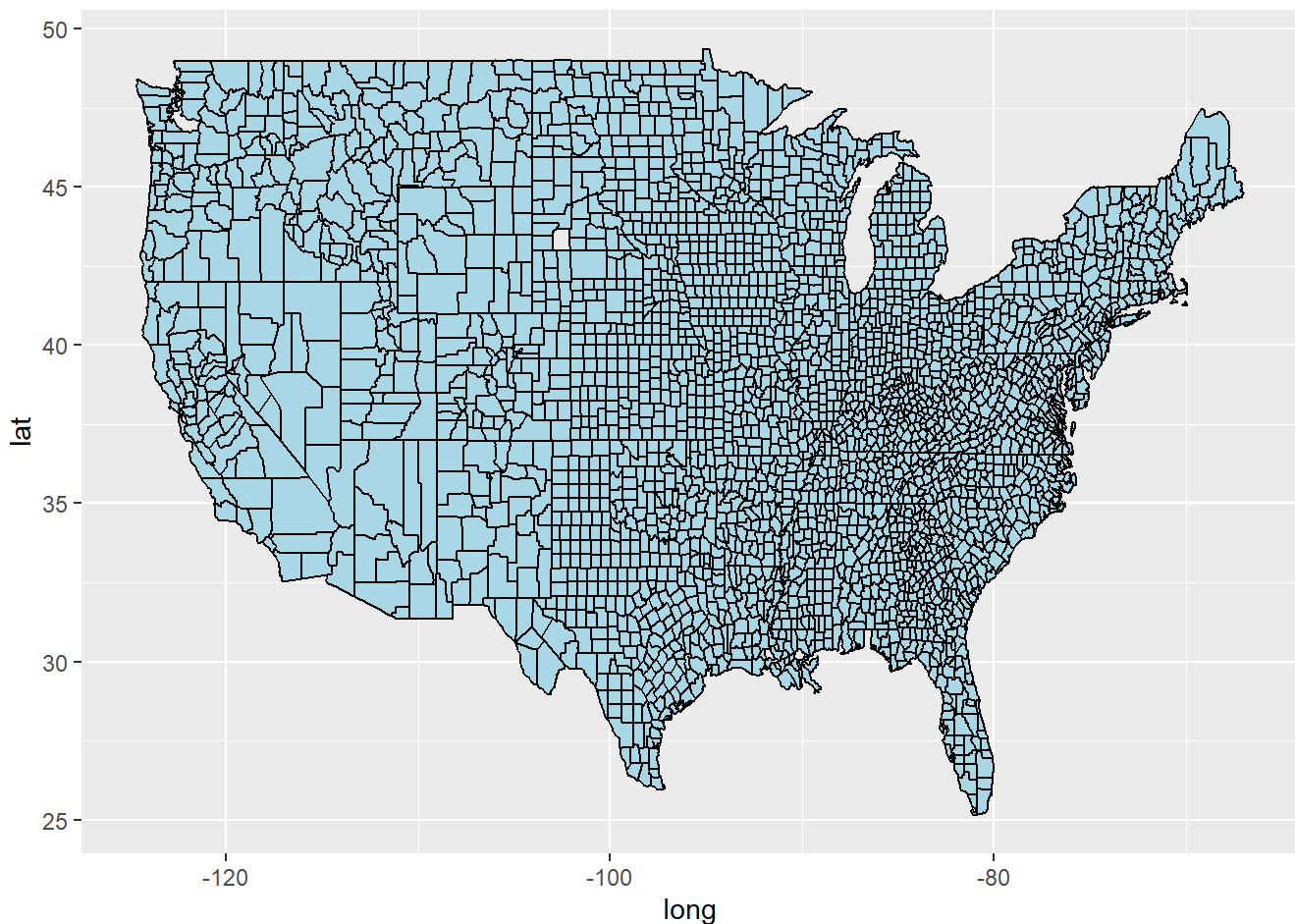
LECTURE COVERAGE STARTS HERE:

Load in the data!

```
countycovid <- read_rds(file="https://github.com/jbisbee1/DS1000_S2024/raw/main/data/countycovid.Rds")
```

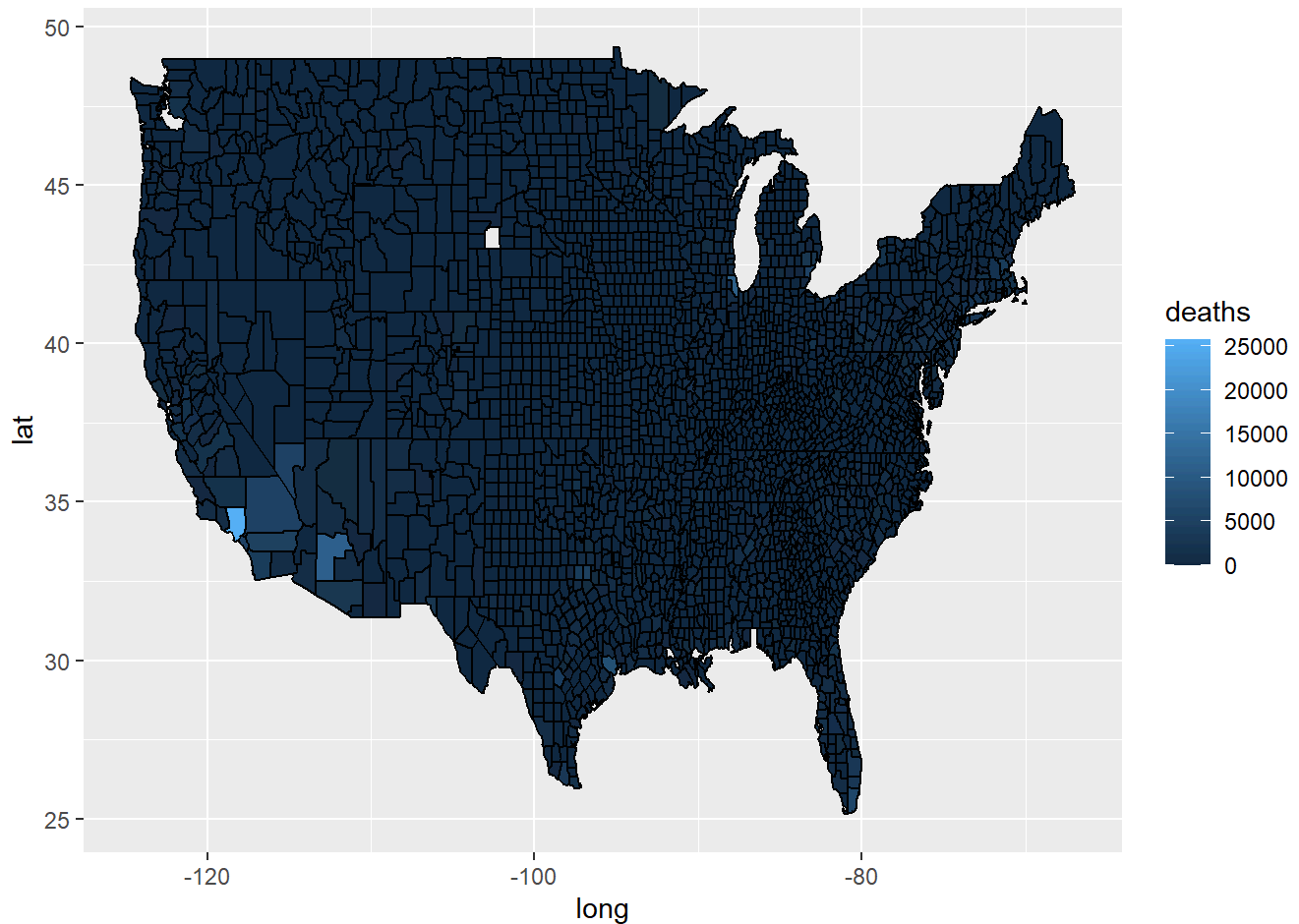
Now lets just see what happens if we plot.

```
countycovid %>%
  ggplot() +
    geom_polygon(aes(x=long, y=lat, group=group),
                color="black",
                fill="lightblue" )
```



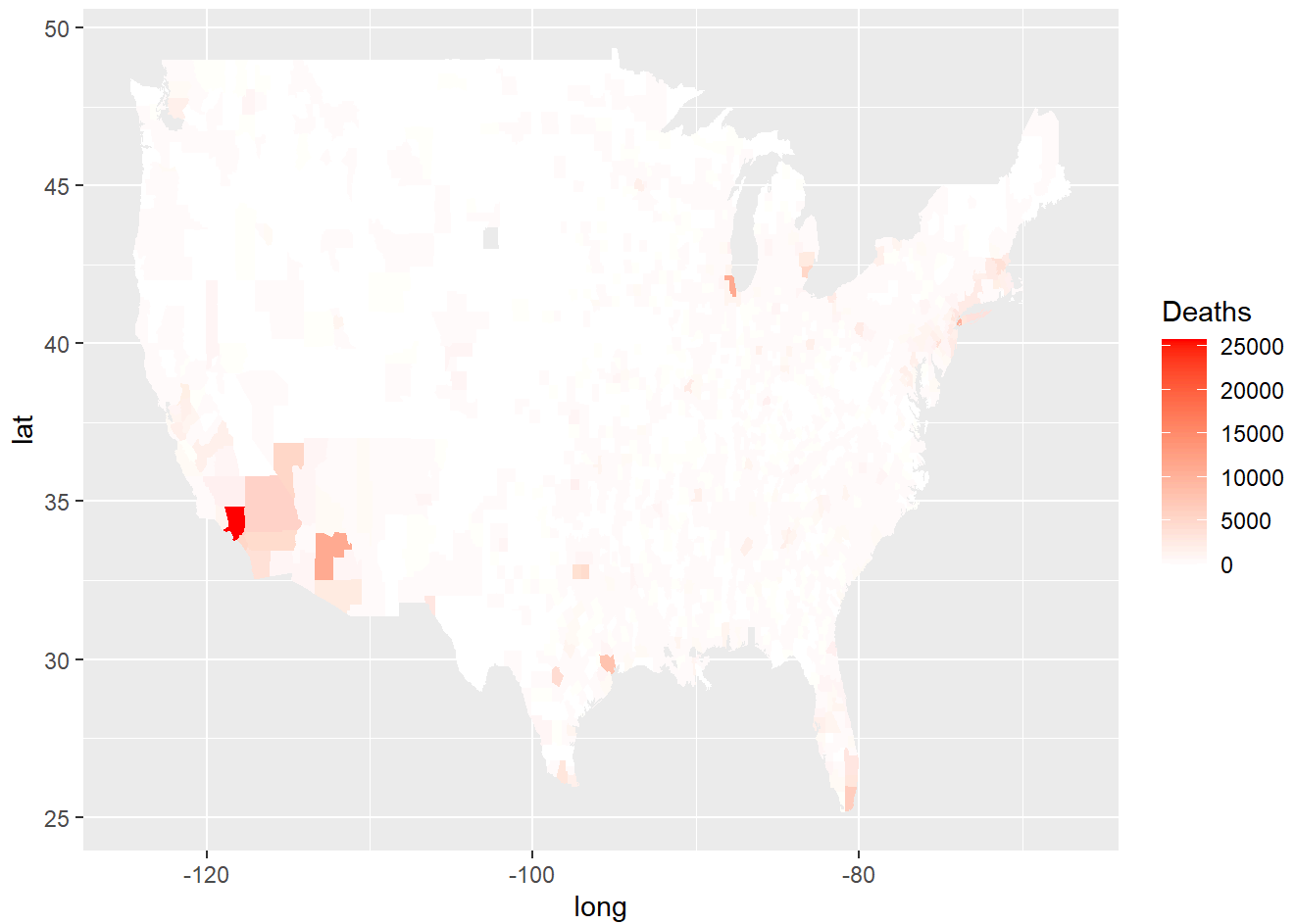
Let's plot the number of deaths in each county using `deaths` as the `fill`. Note we are using `scale_fill_continuous` to refine the default colors being using.

```
countycovid %>%  
  ggplot() +  
    geom_polygon(aes(x=long, y=lat, group=group,  
                     fill=deaths),  
                 color="black")
```



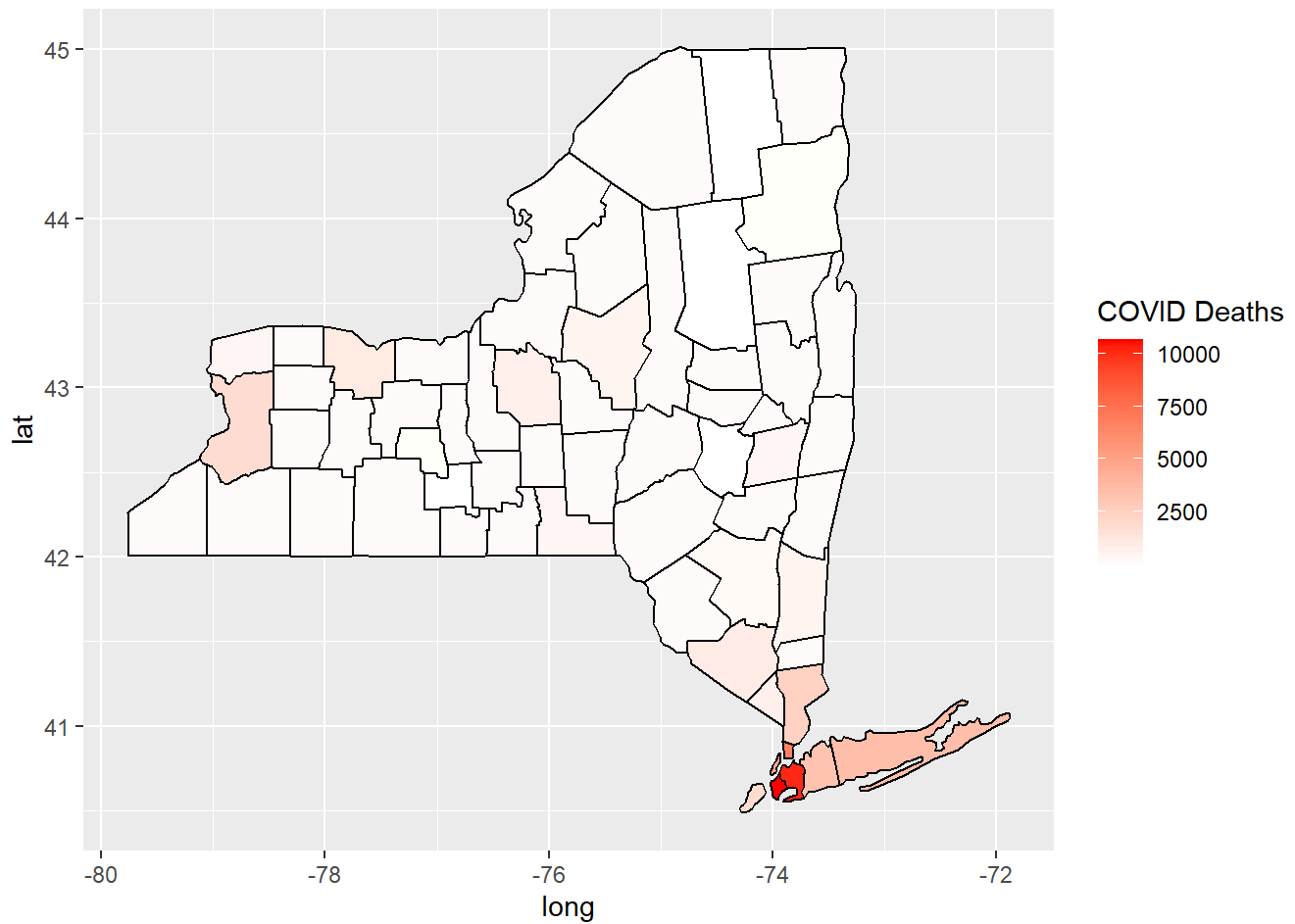
Maybe we should remove the county boundaries as they take up so much of the graphic.

```
countycovid %>%  
  ggplot() +  
    geom_polygon(aes(x=long, y=lat, group=group,  
                     fill=deaths)) +  
    scale_fill_continuous(name="Deaths",  
                          low = "white", high = "red")
```



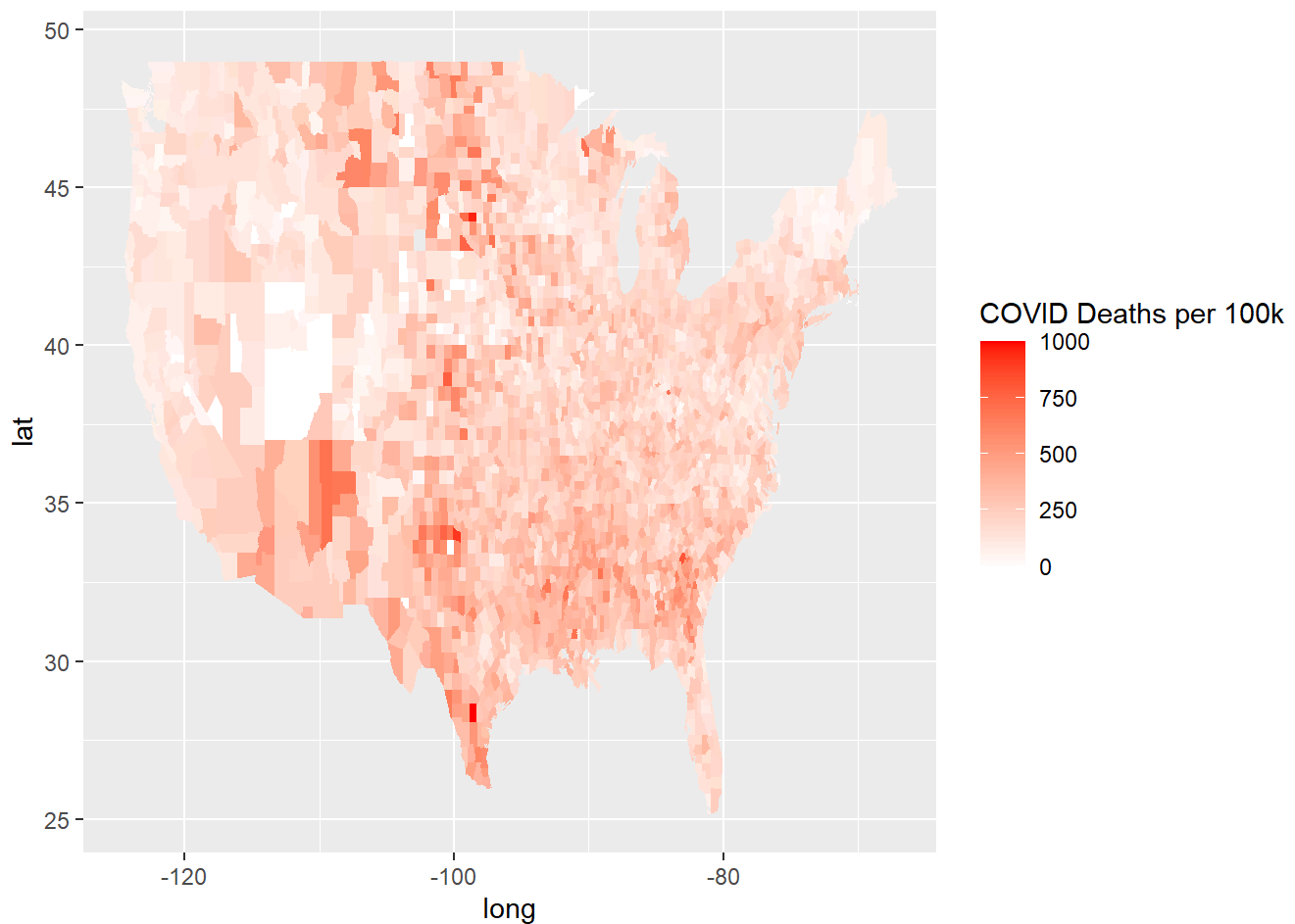
If we want to focus on a particular state, recall that we can filter!

```
countycovid %>%  
  filter(region == "new york") %>%  
  ggplot() +  
    geom_polygon(aes(x=long, y=lat, group=group,  
                     fill=deaths),  
                 color="black") +  
    scale_fill_continuous(name="COVID Deaths",  
                           low = "white", high = "red")
```



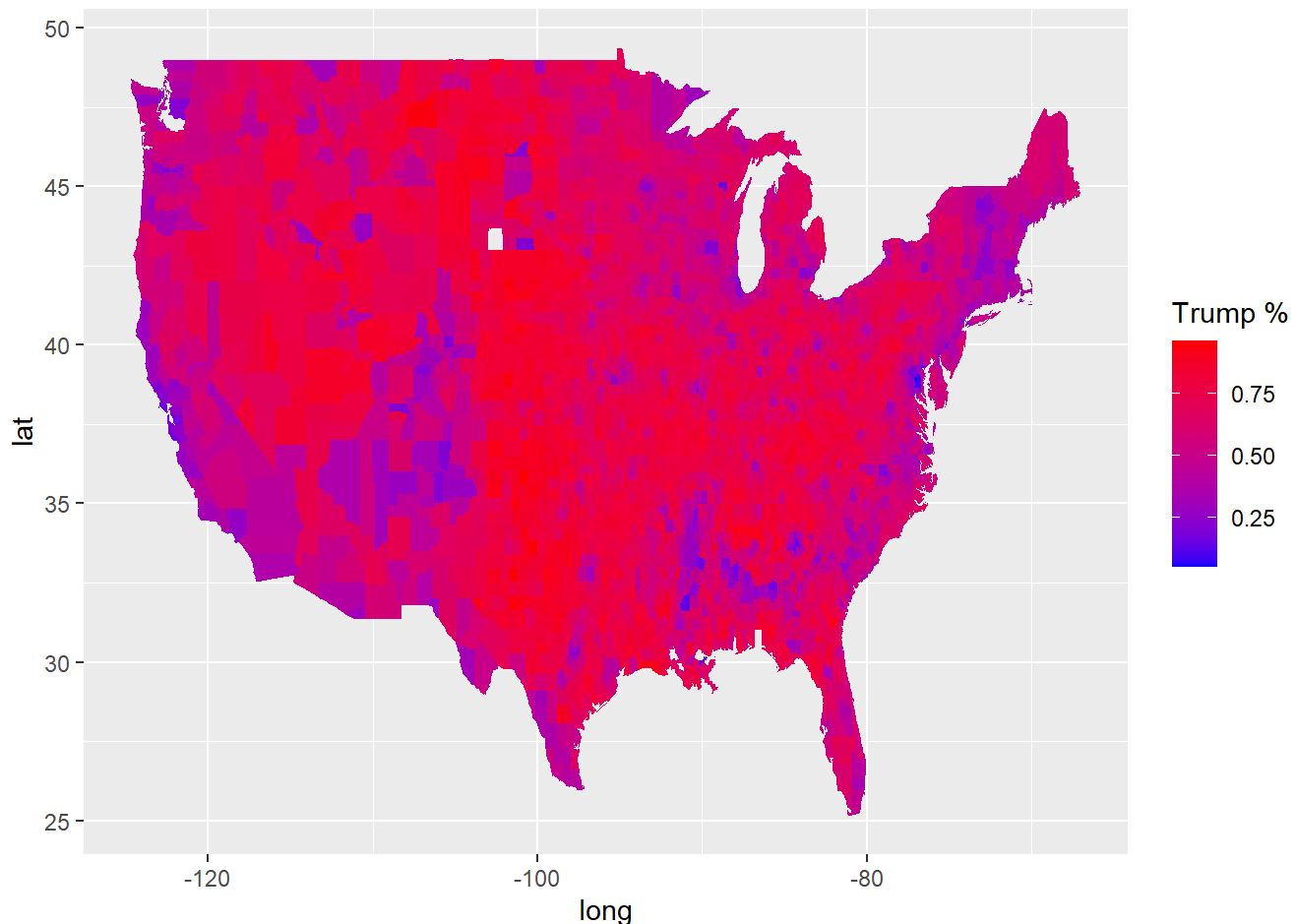
If we want to make the fill a different function – say the number of deaths per 100k in the population all we need to do is to first mutate, then plot!

```
countycovid %>%
  mutate(death100k = 100000*(deaths/population)) %>%
  ggplot() +
    geom_polygon(aes(x=long, y=lat, group=group,
                     fill=death100k)) +
    scale_fill_continuous(name="COVID Deaths per 100k",
                          low = "white", high = "red")
```



We can also change the variables. If we want to avoid the pandemic and instead plot the percentage of votes Trump received in each county we can mutate and plot!

```
countycovid %>%  
  mutate(TrumpPct = trump.votes/turnout.2020) %>%  
  ggplot() +  
    geom_polygon(aes(x=long, y=lat, group=group,  
                     fill=TrumpPct)) +  
    scale_fill_continuous(name="Trump %",  
                          low = "blue", high = "red")
```



Quick Exercise Can you plot the county-level vote for just the states of Georgia, North Carolina, and Virginia?

INSERT CODE HERE

Now let's do this over time!

```
PollDat <- read_rds(file="https://github.com/jbisbee1/DS1000_S2024/raw/main/data/PresStatePolls04to20.Rds") %>%
  rename(region=state.name)
```

```
PollDat <- PollDat %>%
  group_by(year,region) %>%
  summarize(DemPct = mean(dem.poll, na.rm = TRUE),
            RepPct = mean(rep.poll, na.rm = TRUE))
```

```
## `summarise()` has grouped output by 'year'. You can override using the
## `.groups` argument.
```

```
states48.join.hist <- inner_join(states48,PollDat)
```

```
## Joining with `by = join_by(region)`
```

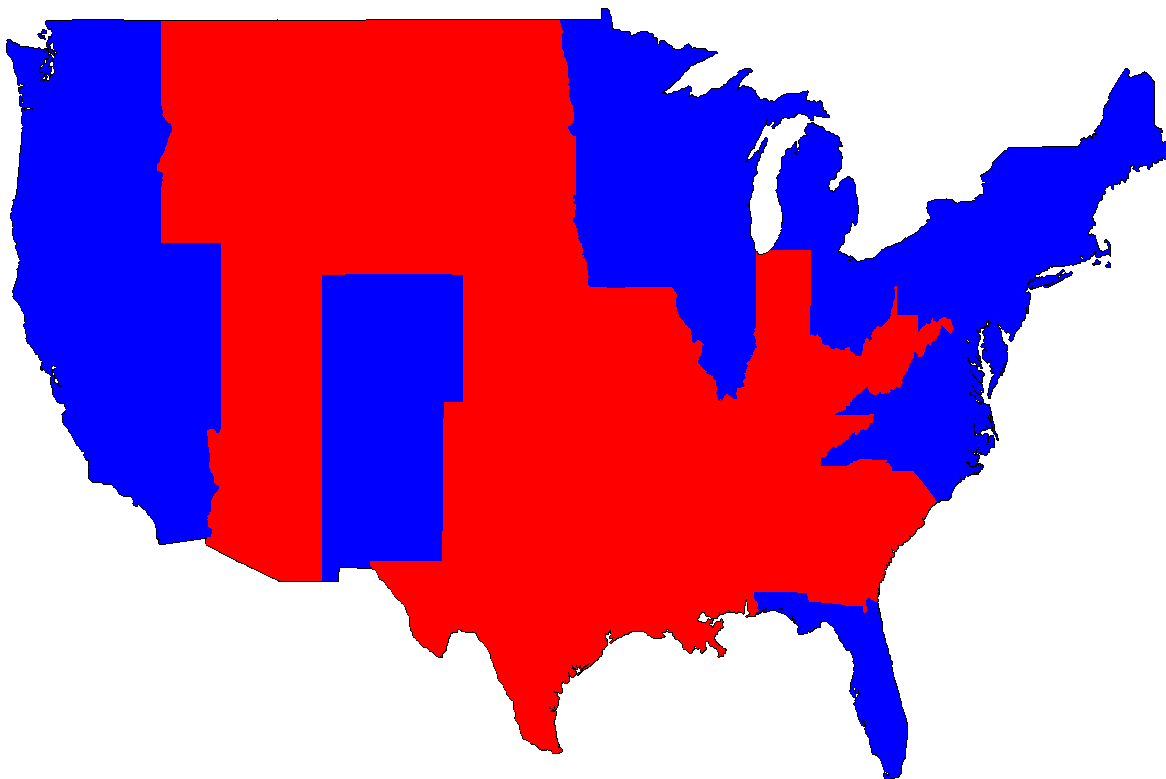
```
## Warning in inner_join(states48, PollDat): Detected an unexpected many-to-many relationship between `x` and `y`.
## i Row 1 of `x` matches multiple rows in `y`.
## i Row 1 of `y` matches multiple rows in `x`.
## i If a many-to-many relationship is expected, set `relationship =`
##   "many-to-many" to silence this warning.
```

```
states48.join.hist[1,]
```

```
##      long      lat group order  region subregion year DemPct RepPct
## 1 -87.46201 30.38968    1     1 alabama    <NA> 2004    39    57
```

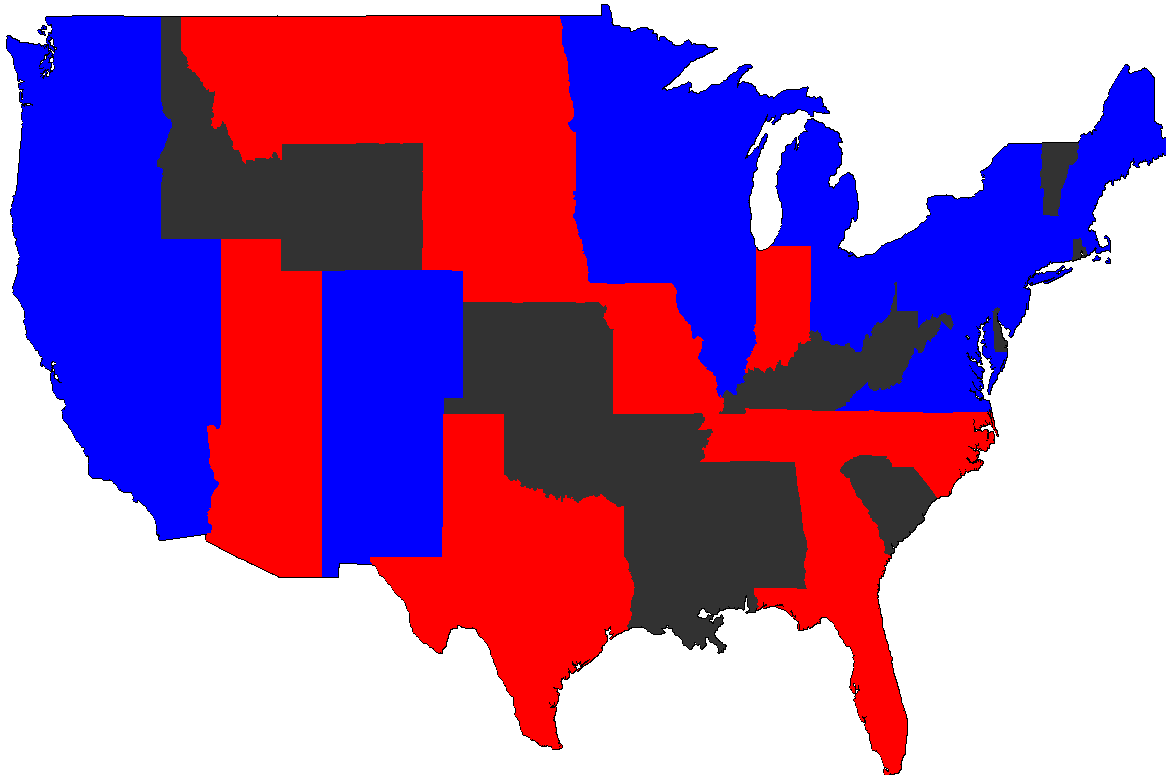
```
plotmap +
  geom_polygon(data=filter(states48.join.hist),
               aes(x=long, y=lat, group=group)) +
  geom_polygon(data=filter(states48.join.hist, year==2008 & (DemPct > RepPct)),
               aes(x=long, y=lat, group=group), fill="Blue") +
  geom_polygon(data=filter(states48.join.hist, year==2008 & (DemPct < RepPct)),
               aes(x=long, y=lat, group=group), fill="Red") +
  labs(title = "2008 Election")
```

2008 Election




```
plotmap +
  geom_polygon(data=filter(states48.join.hist),
               aes(x=long, y=lat, group=group)) +
  geom_polygon(data=filter(states48.join.hist,year==2012 & (DemPct > RepPct)),
               aes(x=long, y=lat, group=group),fill="Blue") +
  geom_polygon(data=filter(states48.join.hist,year==2012 & (DemPct < RepPct)),
               aes(x=long, y=lat, group=group),fill="Red") +
  labs(title = "2012 Election")
```

2012 Election



Let's create an animated GIF! We are going to do a map of the elections over time

```
e2004 <- plotmap +
  geom_polygon(data=filter(states48.join.hist),
               aes(x=long, y=lat, group=group)) +
  geom_polygon(data=filter(states48.join.hist,year==2004 & (DemPct > RepPct)),
               aes(x=long, y=lat, group=group),fill="Blue") +
  geom_polygon(data=filter(states48.join.hist,year==2004 & (DemPct < RepPct)),
               aes(x=long, y=lat, group=group),fill="Red") +
  labs(title = "2004 Election")
ggsave(filename = "e2004.png", plot=e2004,width=5,height=5,units="in",scale=1)
p2004 <- image_read("e2004.png")
```

Now get the rest of the years

```
e2008 <- plotmap +
  geom_polygon(data=filter(states48.join.hist),
    aes(x=long, y=lat, group=group)) +
  geom_polygon(data=filter(states48.join.hist,year==2008 & (DemPct > RepPct)),
    aes(x=long, y=lat, group=group),fill="Blue") +
  geom_polygon(data=filter(states48.join.hist,year==2008 & (DemPct < RepPct)),
    aes(x=long, y=lat, group=group),fill="Red") +
  labs(title = "2008 Election")
ggsave(filename = "e2008.png", plot=e2008,width=5,height=5,units="in",scale=1)
p2008 <- image_read("e2008.png")

e2012 <- plotmap +
  geom_polygon(data=filter(states48.join.hist),
    aes(x=long, y=lat, group=group)) +
  geom_polygon(data=filter(states48.join.hist,year==2012 & (DemPct > RepPct)),
    aes(x=long, y=lat, group=group),fill="Blue") +
  geom_polygon(data=filter(states48.join.hist,year==2012 & (DemPct < RepPct)),
    aes(x=long, y=lat, group=group),fill="Red") +
  labs(title = "2012 Election")
ggsave(filename = "e2012.png", plot=e2012,width=5,height=5,units="in",scale=1)
p2012 <- image_read("e2012.png")

e2016 <- plotmap +
  geom_polygon(data=filter(states48.join.hist),
    aes(x=long, y=lat, group=group)) +
  geom_polygon(data=filter(states48.join.hist,year==2016 & (DemPct > RepPct)),
    aes(x=long, y=lat, group=group),fill="Blue") +
  geom_polygon(data=filter(states48.join.hist,year==2016 & (DemPct < RepPct)),
    aes(x=long, y=lat, group=group),fill="Red") +
  labs(title = "2016 Election")
ggsave(filename = "e2016.png", plot=e2016,width=5,height=5,units="in",scale=1)
p2016 <- image_read("e2016.png")

e2020 <- plotmap +
  geom_polygon(data=filter(states48.join.hist),
    aes(x=long, y=lat, group=group)) +
  geom_polygon(data=filter(states48.join.hist,year==2020 & (DemPct > RepPct)),
    aes(x=long, y=lat, group=group),fill="Blue") +
  geom_polygon(data=filter(states48.join.hist,year==2020 & (DemPct < RepPct)),
    aes(x=long, y=lat, group=group),fill="Red") +
  labs(title = "2020 Election")
ggsave(filename = "e2020.png", plot=e2020,width=5,height=5,units="in",scale=1)
p2020 <- image_read("e2020.png")
```

Now let's put the plots together and save as a GIF. We then want to open the GIF in a browser to see what we got.

```
img <- c(p2004,p2008,p2012,p2016,p2020)
image_append(image_scale(img, "x100"))
```



```
my.animation<-image_animate(image_scale(img, "600x600"), fps = 1, dispose = "previous")
image_write(my.animation, "PollingPredictions.gif")
```

Quick Exercise The data also has information on the actual votes that were received: `rep.vote` and `dem.vote` for the states in which a poll was recorded. Can you use that to create a map of what actually happened?

```
# INSERT CODE HERE
```

Quick Exercise The data also has information on the actual votes that were received: `rep.vote` and `dem.vote` for the states in which a poll was recorded. Can you use that to create a map of state-level polling error?

```
# INSERT CODE HERE
```

Do we need/want a map?

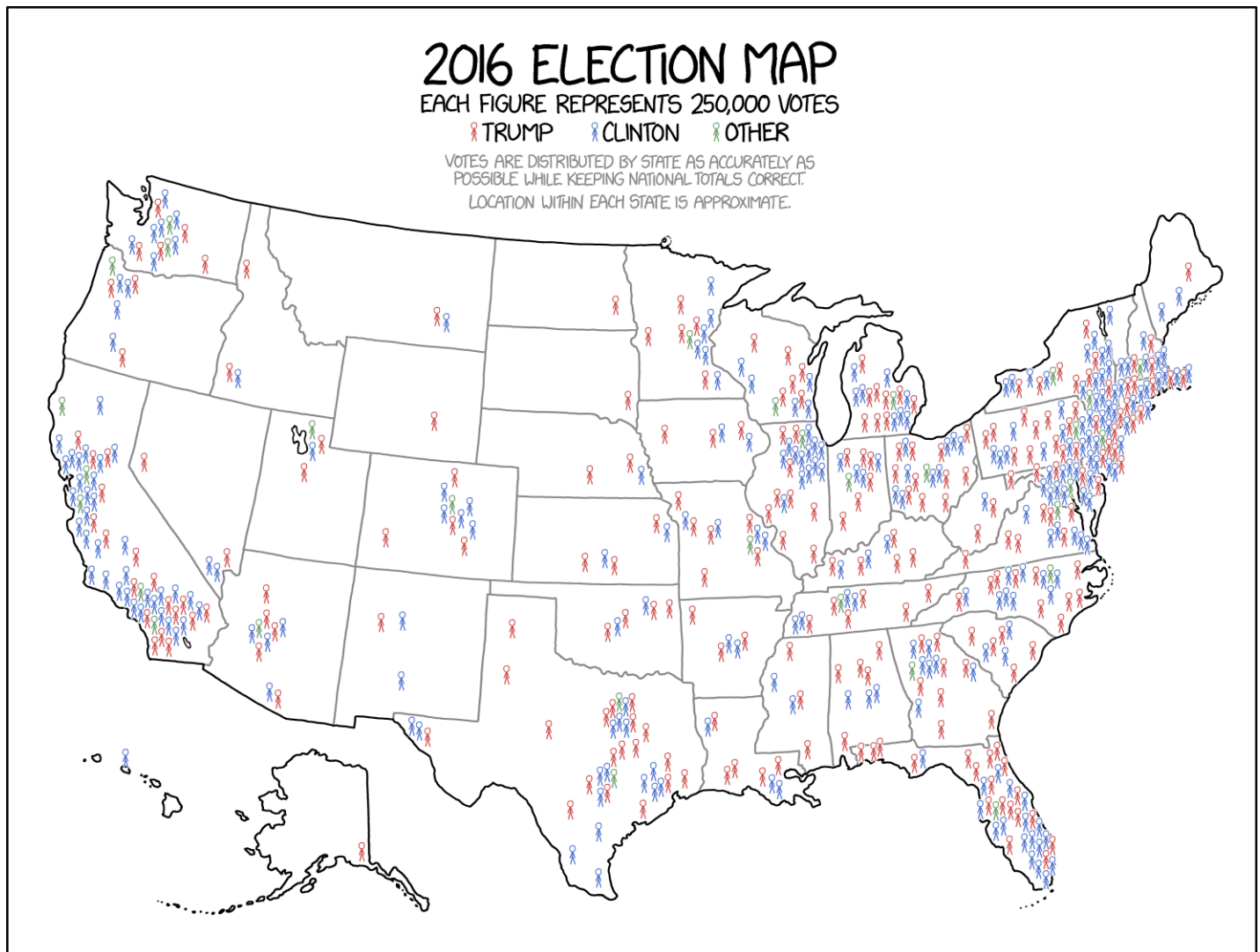


Donald J. Trump ✓
@realDonaldTrump



♡ 80K 6:05 AM - Oct 1, 2019





- But how much better is this than a histogram? Does the geography really matter here?
- Why a histogram and not a barplot? What would a barplot look like?

2020 Biden Overall Polling Average Across States

