Maps Mini Project: Gerrymandering

```
#install and load the necessary packages
library(tidyverse)
```

```
-- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
v dplyr     1.1.4     v readr     2.1.5
v forcats   1.0.0     v stringr   1.5.1
v ggplot2   3.4.4     v tibble    3.2.1
v lubridate 1.9.3     v tidyr     1.3.1
v purrr     1.0.2
-- Conflicts ------------------------------------------ tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to becor
```

```
library(sf)
```

```
Linking to GEOS 3.11.0, GDAL 3.5.3, PROJ 9.1.0; sf_use_s2() is TRUE
```

```
library(mapproj)
```

```
Loading required package: maps

Attaching package: 'maps'

The following object is masked from 'package:purrr':

    map
```

```
library(maps)
library(ggspatial)
library(prettymapr)
devtools::install_github("baumer-lab/fec12")
```

```
Skipping install of 'fec12' from a github remote, the SHA1 (aa02bfc1) has not changed since l
  Use `force = TRUE` to force installation
```

```
library(fec12)
library(leaflet)
library(mdsr)
```

Introduction

We are interested in seeing the difference in Democratic and Republican votes. The use of geospatial data will be useful in helping us understand. We are emulating our analysis of potential gerrymandering in Wisconsin. Our analysis focuses on the Federal Election Commission, specifically for the state of Wisconsin in the 2012 Presidential Election. This dataset, `results_house`, comes from the Federal Election Commission library. `Results_house` includes information on the the number of districts a particular state has, whether a candidate from that district is from the Republican or Democratic Party, the general number of votes in the election. We begin with determining how many congressional candidates there are for each district in the United States.

```
print(results_house, width = Inf)
```

```
# A tibble: 2,343 x 13
   state district_id cand_id   incumbent party primary_votes primary_percent
   <chr> <chr>       <chr>     <lgl>     <chr>         <dbl>           <dbl>
 1 AL    01          H2AL01077 TRUE      R             48702           0.555
 2 AL    01          H2AL01176 FALSE     R             21308           0.243
 3 AL    01          H2AL01184 FALSE     R             13809           0.158
 4 AL    01          H0AL01030 FALSE     R              3854           0.0440
 5 AL    02          H0AL02087 TRUE      R                NA          NA
 6 AL    02          H2AL02141 FALSE     D                NA          NA
 7 AL    03          H2AL03032 TRUE      R                NA          NA
 8 AL    03          H2AL03099 FALSE     D                NA          NA
 9 AL    04          H6AL04098 TRUE      R                NA          NA
10 AL    04          H2AL04055 FALSE     D             10971           0.514
```

```
   runoff_votes runoff_percent general_votes general_percent won   footnotes
          <dbl>           <dbl>         <dbl>           <dbl> <lgl> <chr>
 1           NA              NA        196374           0.979 TRUE  <NA>
 2           NA              NA            NA          NA     FALSE <NA>
 3           NA              NA            NA          NA     FALSE <NA>
 4           NA              NA            NA          NA     FALSE <NA>
 5           NA              NA        180591           0.636 TRUE  <NA>
 6           NA              NA        103092           0.363 FALSE <NA>
 7           NA              NA        175306           0.640 TRUE  <NA>
 8           NA              NA         98141           0.358 FALSE <NA>
 9           NA              NA        199071           0.740 TRUE  <NA>
10           NA              NA         69706           0.259 FALSE <NA>
# i 2,333 more rows
```

```
results_house |>
  group_by(state, district_id) |>
  summarize(N = n())
```

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

# A tibble: 445 x 3
# Groups:   state [56]
   state district_id     N
   <chr> <chr>       <int>
 1 AK    00             10
 2 AL    01              4
 3 AL    02              2
 4 AL    03              2
 5 AL    04              3
 6 AL    05              3
 7 AL    06              6
 8 AL    07              3
 9 AR    01              6
10 AR    02              4
# i 435 more rows
```

Note that there are 435 Representatives in the US House, but there are 445 state and district combinations in our data because the `fec12` dataset includes the US Territories of: Guam, Puerto Rico, American Somoa, Northern Mariana Islands, District of Columbia, the Virgin Island.

However, we are only interested in the eight congressional districts in Wisconsin.

Analyzing Votes by District in Wisconsin

```
# summary of the 8 congressional WI districts and the 2012 voting results
district_elections <- results_house |>
  mutate(district = parse_number(district_id)) |>
  group_by(state, district) |>
  summarize(
    N = n(),
    total_votes = sum(general_votes, na.rm = TRUE),
    d_votes = sum(ifelse(party == "D", general_votes, 0), na.rm = TRUE),
    r_votes = sum(ifelse(party == "R", general_votes, 0), na.rm = TRUE),
    .groups = "drop"
  ) |>
  mutate(
    other_votes = total_votes - d_votes - r_votes,
    r_prop = r_votes / total_votes,
    winner = ifelse(r_votes > d_votes, "Republican", "Democrat")
  )
wi_results <- district_elections |>
  filter(state == "WI")
wi_results |>
  select(-state)
```

```
# A tibble: 8 x 8
  district     N total_votes d_votes r_votes other_votes r_prop winner
     <dbl> <int>       <dbl>   <dbl>   <dbl>       <dbl>  <dbl> <chr>
1        1     3      364891  158414  200423        6054  0.549 Republican
2        2     6      390111  265422  124683           6  0.320 Democrat
3        3     2      339425  217712  121713           0  0.359 Democrat
4        4     3      325321  235257   80787        9277  0.248 Democrat
5        5     2      368813  118478  250335           0  0.679 Republican
6        6     3      359381  135921  223460           0  0.622 Republican
7        7     3      359264  157524  201720          20  0.561 Republican
8        8     2      355161  156287  198874           0  0.560 Republican
```

Here, we are summing up all the `general_votes` for the Democratic and Republican Party for the state of Wisconsin. Notice that we are not super interested in any Third Party candidates, but we are interested in knowing the proportion of Democratic and Republican votes.

Proportion of Republican and Democratic Votes

```
# distribution of total number of votes is narrow by design
wi_results |>
  skim(total_votes) |>
  select(-na)
```

Variable type: numeric

var	n	mean	sd	p0	p25	p50	p75	p100
total_votes	8	357795.9	19345.37	325321	351227	359322.5	365871.5	390111

```
# compare total Dem and Rep votes across WI in 2012
wi_results |>
  summarize(
    N = n(),
    state_votes = sum(total_votes),
    state_d = sum(d_votes),
    state_r = sum(r_votes)
  ) |>
  mutate(
    d_prop = state_d / state_votes,
    r_prop = state_r / state_votes
  )
```

```
# A tibble: 1 x 6
      N state_votes state_d state_r d_prop r_prop
  <int>       <dbl>   <dbl>   <dbl>  <dbl>  <dbl>
1     8     2862367 1445015 1401995  0.505  0.490
```

First, we are interested in the mean of the total votes across all 8 congressional districts. Aproximately 357796 individuals from each congressional district voted, with a standard deviation of 19345. With that information, we are able to calculate the total amount of Republican and Democratic votes, and the proportion of Democratic and Republican votes for the entire state of Wisconsin.

Winner of Each District

```
# Proportion of Rep votes by district
wi_results |>
  select(district, r_prop, winner) |>
  arrange(desc(r_prop))
```

```
# A tibble: 8 x 3
  district r_prop winner
     <dbl>  <dbl> <chr>
1        5  0.679 Republican
2        6  0.622 Republican
3        7  0.561 Republican
4        8  0.560 Republican
5        1  0.549 Republican
6        3  0.359 Democrat
7        2  0.320 Democrat
8        4  0.248 Democrat
```

Now, we are able to analyze the proportion of Republican voters, in addition, to the party that won in that congressional district. Notice, a bigger difference from 0.50 the better. For the state of Wisconsin, the Republican Party seems to have won in a majority of the congressional districts. However, notice that the Republican Party wins by a slight margin, whereas the Democratic Party won by a much alrger margin. In other words, there is a more significant difference between the Democratic and Republican votes. Now that we have the numbers, let us visualize the data.

Visualization of Potential Gerrymandering in Wisconsin

```
#first, let us download the fec12 dataset from UCLA

src <- "http://cdmaps.polisci.ucla.edu/shp/districts113.zip"
lcl_zip <- fs::path(tempdir(), "districts113.zip")
download.file(src, destfile = lcl_zip)
lcl_districts <- fs::path(tempdir(), "districts113")
unzip(lcl_zip, exdir = lcl_districts)
dsn_districts <- fs::path(lcl_districts, "districtShapes")

# read shapefiles into R as an sf object
st_layers(dsn_districts)
```

```
Driver: ESRI Shapefile
Available layers:
    layer_name geometry_type features fields crs_name
1 districts113       Polygon      436     15    NAD83
```

```
# be able to read as a data frame as well
districts <- st_read(dsn_districts, layer = "districts113") |>
  mutate(DISTRICT = parse_number(as.character(DISTRICT)))
```

```
Reading layer `districts113' from data source
  `/private/var/folders/38/j8rsrqzs2b1_d3b742694ty80000gp/T/Rtmpkrl4Jh/districts113/district
  using driver `ESRI Shapefile'
Simple feature collection with 436 features and 15 fields (with 1 geometry empty)
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -179.1473 ymin: 18.91383 xmax: 179.7785 ymax: 71.35256
Geodetic CRS:  NAD83
```

```
head(districts, width = Inf)
```

```
Simple feature collection with 6 features and 15 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -91.82307 ymin: 29.41135 xmax: -66.94983 ymax: 47.45969
Geodetic CRS:  NAD83
  STATENAME           ID DISTRICT STARTCONG ENDCONG DISTRICTSI COUNTY PAGE  LAW
1 Louisiana 022113114006        6       113     114       <NA>   <NA> <NA> <NA>
2     Maine 023113114001        1       113     114       <NA>   <NA> <NA> <NA>
3     Maine 023113114002        2       113     114       <NA>   <NA> <NA> <NA>
4  Maryland 024113114001        1       113     114       <NA>   <NA> <NA> <NA>
5  Maryland 024113114002        2       113     114       <NA>   <NA> <NA> <NA>
6  Maryland 024113114003        3       113     114       <NA>   <NA> <NA> <NA>
  NOTE BESTDEC                  FINALNOTE RNOTE                 LASTCHANGE
1 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
2 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
3 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
4 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
5 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
6 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
  FROMCOUNTY                       geometry
```

```
1          F MULTIPOLYGON (((-91.82288 3...
2          F MULTIPOLYGON (((-70.98905 4...
3          F MULTIPOLYGON (((-71.08216 4...
4          F MULTIPOLYGON (((-77.31156 3...
5          F MULTIPOLYGON (((-76.8763 39...
6          F MULTIPOLYGON (((-77.15622 3...
```

```r
class(districts)
```

```
[1] "sf"         "data.frame"
```

```r
#Append election results to geospatial data
wi_merged <- districts |>
  filter(STATENAME == "Wisconsin") |>
  st_transform(4326) |>
  inner_join(wi_results, by = c("DISTRICT" = "district"))
head(wi_merged, width = Inf)
```

```
Simple feature collection with 6 features and 23 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -92.808 ymin: 42.49198 xmax: -87.50719 ymax: 45.20957
Geodetic CRS:  WGS 84
  STATENAME           ID DISTRICT STARTCONG ENDCONG DISTRICTSI COUNTY PAGE  LAW
1 Wisconsin 055113114001        1       113     114       <NA>   <NA> <NA> <NA>
2 Wisconsin 055113114002        2       113     114       <NA>   <NA> <NA> <NA>
3 Wisconsin 055113114003        3       113     114       <NA>   <NA> <NA> <NA>
4 Wisconsin 055113114004        4       113     114       <NA>   <NA> <NA> <NA>
5 Wisconsin 055113114005        5       113     114       <NA>   <NA> <NA> <NA>
6 Wisconsin 055113114006        6       113     114       <NA>   <NA> <NA> <NA>
  NOTE BESTDEC                  FINALNOTE RNOTE                 LASTCHANGE
1 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
2 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
3 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
4 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
5 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
6 <NA>    <NA> {"From US Census website"}  <NA> 2016-05-29 16:44:10.857626
  FROMCOUNTY state N total_votes d_votes r_votes other_votes    r_prop
1          F    WI 3      364891  158414  200423        6054 0.5492681
2          F    WI 6      390111  265422  124683           6 0.3196090
```

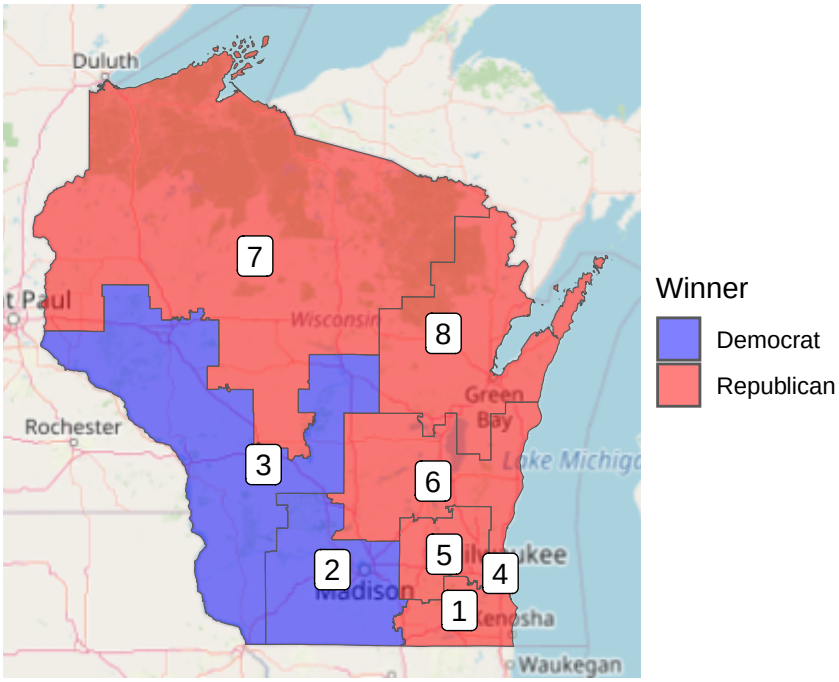
```
3          F    WI 2      339425  217712  121713           0 0.3585858
4          F    WI 3      325321  235257   80787        9277 0.2483301
5          F    WI 2      368813  118478  250335           0 0.6787586
6          F    WI 3      359381  135921  223460           0 0.6217914
      winner                       geometry
1 Republican MULTIPOLYGON (((-89.08072 4...
2   Democrat MULTIPOLYGON (((-90.43 43.1...
3   Democrat MULTIPOLYGON (((-91.3984 44...
4   Democrat MULTIPOLYGON (((-88.06601 4...
5 Republican MULTIPOLYGON (((-89.01359 4...
6 Republican MULTIPOLYGON (((-89.78555 4...
```

```r
# Color based on winning party; shows the 8 congressional districts

wi <- ggplot(data = wi_merged, aes(fill = winner)) +
  annotation_map_tile(zoom = 6, type = "osm", progress = "none") +
  geom_sf(alpha = 0.5) +
  scale_fill_manual("Winner", values = c("blue", "red")) +
  geom_sf_label(aes(label = DISTRICT), fill = "white") +
  theme_void()
wi
```

```
Warning in st_point_on_surface.sfc(sf::st_zm(x)): st_point_on_surface may not
give correct results for longitude/latitude data
```

```
Loading required namespace: raster
```



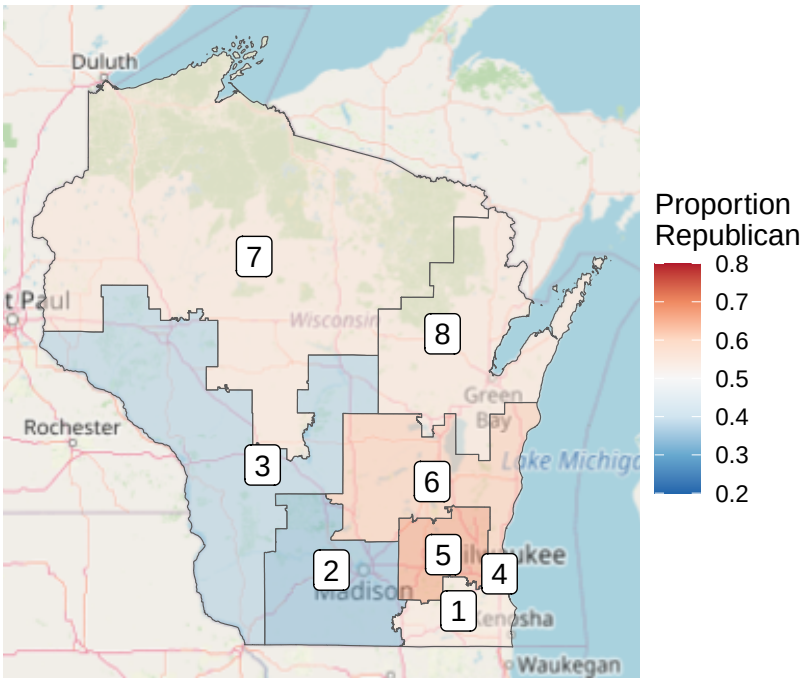
This map shows the potential gerrymandering of the eight total congressional districts in the state of Wisconsin. Note that the map is color coded such that it matches the results we found above. There are 3 congressional districts where the Democratic Party won, and 5 congressional districts where the Republican Party won. From this map, I wanted to create a choropleth map which allows us to visualize the proportion of Republican and Democratic votes in each district.

Another visualization of our potential gerrymandering

```
# Color based on proportion Rep.
wi +
  aes(fill = r_prop) +
  scale_fill_distiller(
    "Proportion\nRepublican",
    palette = "RdBu",
    limits = c(0.2, 0.8)
  )
```

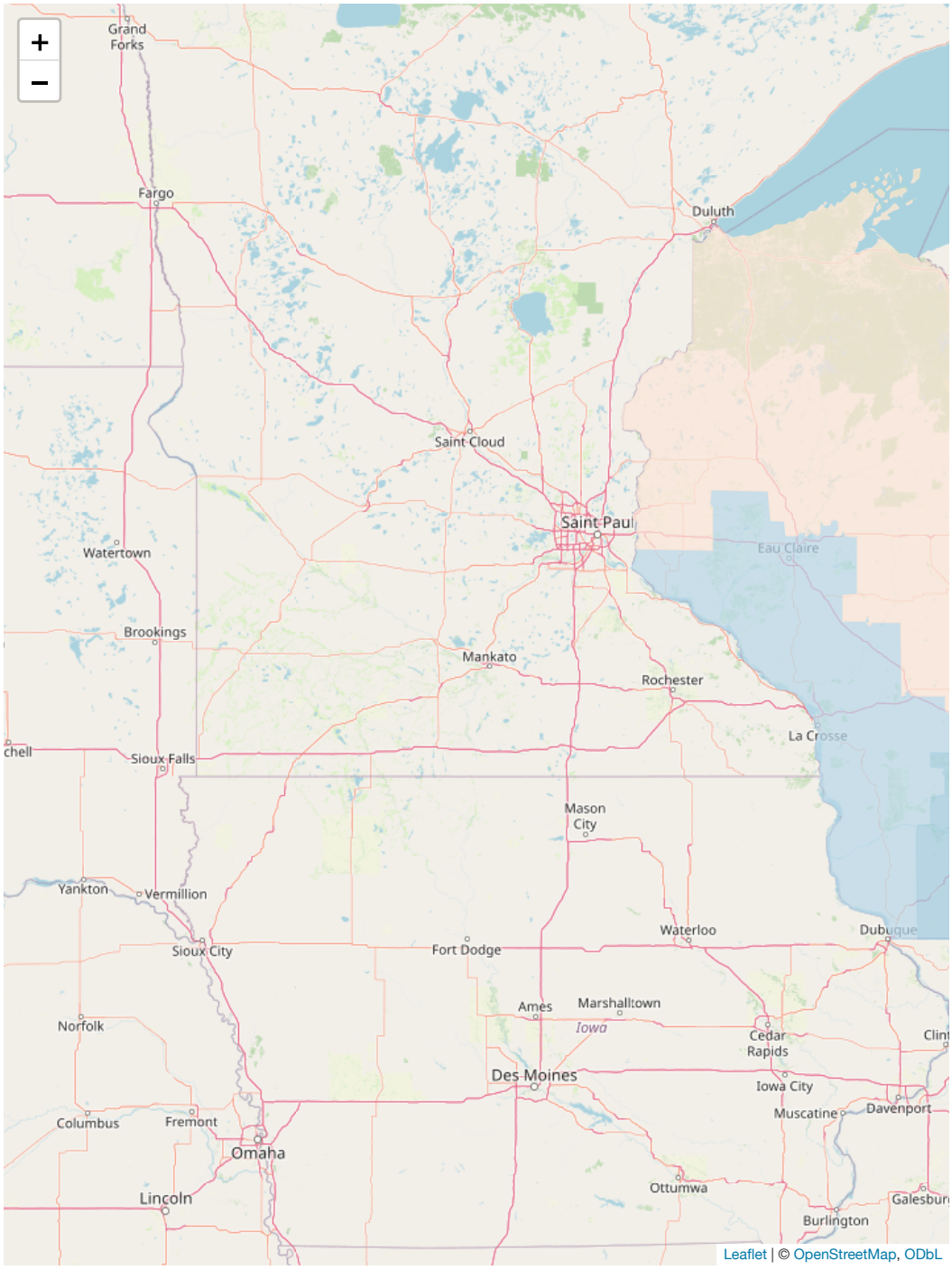
```
Scale for fill is already present.
Adding another scale for fill, which will replace the existing scale.
```

```
Warning in st_point_on_surface.sfc(sf::st_zm(x)): st_point_on_surface may not
give correct results for longitude/latitude data
```




```
# A leaflet map can allow us to zoom in and see where major cities fit, etc.
library(leaflet)
pal <- colorNumeric(palette = "RdBu", domain = c(0, 1))

leaflet_wi <- leaflet(wi_merged) |>
  addTiles() |>
  addPolygons(
    weight = 1, fillOpacity = 0.7,
    color = ~pal(1 - r_prop),    # so red association with Reps
    popup = ~paste("District", DISTRICT, "</br>", round(r_prop, 4))
  ) |>                           # popups show prop Republican
  setView(lng = -89, lat = 44, zoom = 7)
leaflet_wi
```


Grand Forks
Fargo
Duluth
Saint Cloud
Saint Paul
Watertown
Eau Claire
Brookings
Mankato
Rochester
La Crosse
Sioux Falls
Mason City
Yankton
Vermillion
Waterloo
Dubuque
Sioux City
Fort Dodge
Ames
Marshalltown
Iowa
Norfolk
Cedar Rapids
Des Moines
Iowa City
Columbus
Fremont
Muscatine
Davenport
Omaha
Lincoln
Ottumwa
Burlington
Leaflet | © OpenStreetMap, ODbL

Note, this is a choropleth map, where meaningful shading relates to the proportion of Democratic and Republican votes by congressional districts. Similar to the map above, the color blue represents the Democratic Party, while the color red represents the Republican Party. Notice, this map illustrates the same information as the map above. However, in this chorpleth map, we can how much each party won, by congressional districts. We can tell the proportion of Democratic and Republican votes by how opaic the colors are on the map. If we hover our mouse over a particular place on the map, it tells us what district it is, and the proportion of votes they received.

Conclusion

It was quite interesting to explore the congressional districts data of Wisconsin. Knowing the results from the Presidential Election, I learned a lot about how the majority of the winning congressional districts does not translate to which party won in that particular state due to the electoral college. By analyzing potential gerrymandering data, we can learn more about each congressional district, and how the proportion of votes affect which party wins.

Citations

Federal Election Commission: