PS6_AndrewYu

August 3, 2023

[13]:
```
from google.colab import drive

drive.mount('/content/drive')
FOLDERNAME = "Stanford Summer Session/SOC 128D"

import pandas as pd
import matplotlib.pyplot as mplt
import seaborn as sb
import plotnine as pn
import numpy as np

mplt.style.use("ggplot")
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call
drive.mount("/content/drive", force_remount=True).
```

1. Read the North Carolina shapefile into R using the process described in section 6.1. Then plot the data using ggplot2. Use a variable other than AREA to fill the shapes, and try using one of the scale_fill_ arguments to create a red color scale. See these notes on color scales with ggplot for some theory and ideas here.

[2]:
```
# Python doesn't have an R exact equivalent of simple features, so I downloaded␣
↪North Carolina's shapefiles from that library: https://github.com/r-spatial/
↪sf/tree/main/inst/shape
import geopandas as gpd

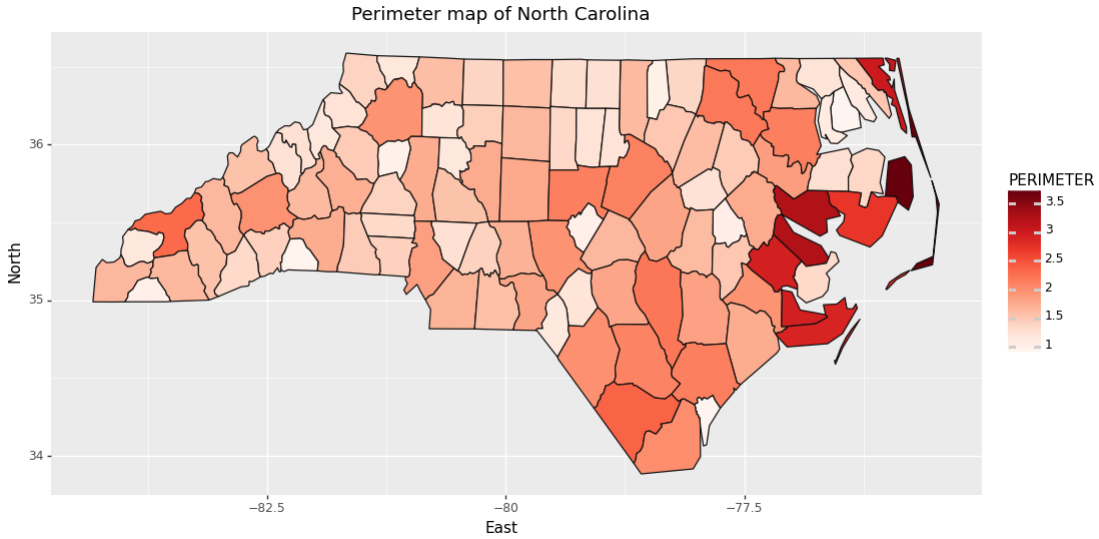
nc_data = gpd.read_file(f"drive/My Drive/{FOLDERNAME}/data/nc.shp")

plot = (
    pn.ggplot(nc_data)+
    pn.geom_map(pn.aes(fill="PERIMETER"))+
    pn.scale_fill_cmap(cmap_name='Reds') +
    pn.theme(figure_size=(12, 6)) +
    pn.labs(title="Perimeter map of North Carolina", x="East", y="North")
  )

print(plot)
```

```
/usr/local/lib/python3.10/dist-packages/plotnine/mapping/evaluation.py:216:
```

```
FutureWarning: You are adding a column named 'geometry' to a GeoDataFrame
constructed without an active geometry column. Currently, this automatically
sets the active geometry column to 'geometry' but in the future that will no
longer happen. Instead, either provide geometry to the GeoDataFrame constructor
(GeoDataFrame(… geometry=GeoSeries()) or use `set_geometry('geometry')` to
explicitly set the active geometry column.
```



2. Read in the CDP hazards data and cities location data from Canvas ("cdp_hazards.csv" and "CDP-Cities-geographical-coordinates.csv"), and plot the cities according to at least one of the hazards. Discuss your graph and what conclusions you might draw about the geographies of risk.

[3]:
```
from shapely.geometry import Point

hazards_df = pd.read_csv(f"drive/My Drive/{FOLDERNAME}/data/cdp_hazards.csv")
coords_df = pd.read_csv(f"drive/My Drive/{FOLDERNAME}/data/
 ↪CDP-Cities-geographical-coordinates.csv", usecols=["Account.Number", "lat",␣
 ↪"long"])
hazards_df = pd.merge(hazards_df, coords_df, left_on=["Account Number"],␣
 ↪right_on=["Account.Number"], how="left").drop(columns=["Account.Number",␣
 ↪"Column Number"])
hazards_gdf = gpd.GeoDataFrame(hazards_df, geometry=[Point(lon, lat) for lon,␣
 ↪lat in zip(hazards_df["long"], hazards_df["lat"])]).dropna(subset=["hazard"])
hazards_gdf = hazards_gdf[hazards_gdf["hazard"].isin([" Vector-borne disease",␣
 ↪" Water-borne disease", " Air-borne disease"])]
world_gdf = gpd.read_file(gpd.datasets.get_path('naturalearth_lowres'))
# Ensuring same CRS
hazards_gdf.crs = world_gdf.crs
```

```
hazard_plot = (
    pn.ggplot(hazards_gdf) +
    pn.geom_map(world_gdf, color="black", size=0.1, fill="lightgrey") +
    pn.geom_map(pn.aes(color="hazard")) +
    pn.theme_minimal() +
    pn.theme(figure_size=(12, 8)) +
    pn.labs(title="CDP Hazards", x="East", y="North")
)
print(hazard_plot)
```

```
<ipython-input-3-d45c83378440>:8: FutureWarning: The geopandas.dataset module is
deprecated and will be removed in GeoPandas 1.0. You can get the original
'naturalearth_lowres' data from
https://www.naturalearthdata.com/downloads/110m-cultural-vectors/.
/usr/local/lib/python3.10/dist-packages/plotnine/mapping/evaluation.py:216:
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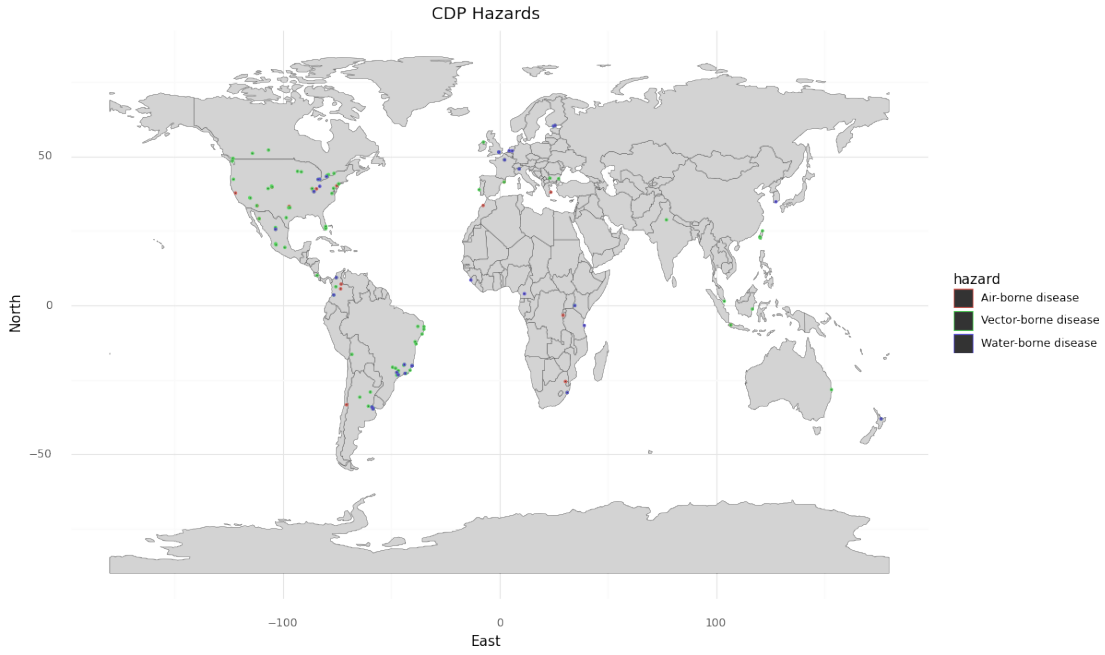
```



[4]:
```
hazards_gdf[(hazards_gdf["hazard"].isin([" Water-borne disease"])) &␣
↪(hazards_gdf["CDP Region"] == "North America")].head(20)
```

[4]:

	Questionnaire	Year Reported to CDP	Account Number	Organization	Country	CDP Region	Parent Section	Section	Question Number
1501	Cities 2020	2020	50578	City of Windsor	Canada	North America	Climate Hazards and Vulnerability	Climate Hazards	2.1
1546	Cities 2020	2020	50555	City of Hamilton	Canada	North America	Climate Hazards and Vulnerability	Climate Hazards	2.1
1865	Cities 2020	2020	49333	City of Louisville, KY	United States of America	North America	Climate Hazards and Vulnerability	Climate Hazards	2.1
2183	Cities 2020	2020	54092	City of Ann Arbor	United States of America	North America	Climate Hazards and Vulnerability	Climate Hazards	2.1
2298	Cities 2020	2020	43910	City of Columbus	United States of America	North America	Climate Hazards and Vulnerability	Climate Hazards	2.1

```
                                          Question Name      Column Name  \
1501  Please list the most significant climate hazar…  Climate Hazards
1546  Please list the most significant climate hazar…  Climate Hazards
1865  Please list the most significant climate hazar…  Climate Hazards
2183  Please list the most significant climate hazar…  Climate Hazards
2298  Please list the most significant climate hazar…  Climate Hazards

                              Response Answer Comments  File Name  \
1501  Biological hazards > Water-borne disease      NaN        NaN
1546  Biological hazards > Water-borne disease      NaN        NaN
1865  Biological hazards > Water-borne disease      NaN        NaN
2183  Biological hazards > Water-borne disease      NaN        NaN
2298  Biological hazards > Water-borne disease      NaN        NaN

                Last update                hazard      lat     long  \
1501  09/07/2020 09:45:36 AM   Water-borne disease  42.3149 -83.0364
1546  09/07/2020 09:45:36 AM   Water-borne disease  43.2500 -79.8661
1865  09/07/2020 09:45:36 AM   Water-borne disease  38.1960 -85.6784
2183  09/07/2020 09:45:36 AM   Water-borne disease  42.2808 -83.7430
2298  09/07/2020 09:45:36 AM   Water-borne disease  39.9612 -82.9988

                       geometry
1501  POINT (-83.03640 42.31490)
1546  POINT (-79.86610 43.25000)
1865  POINT (-85.67840 38.19600)
2183  POINT (-83.74300 42.28080)
2298  POINT (-82.99880 39.96120)
```

I was interested in the distribution of risk of diseases, and how they might relate to geographical distribution.

The graph illustrates that the risk of Vector-borne diseases are the most reported, in North and Latin America. Most of these are also near the water body areas. It could be because of the summer season during the period of data collection, where insects like mosquitoes and thrive in warm and humid climates.

Water-borne disease risks are the second most reported, with some in North and Latin America, but also prominent in Europe. Interestingly, those in North America are not near obvious water bodies, unlike the other areas. Upon further investigation through Google Maps however, Ohio River runs down Louisville, KY, Scioto River down Columbus, Huron River down Ann Arbor, Detroit River down Windsor and Hamilton is near the bay. It is interesting then, that this disease did not spread further downstream. Perhaps these areas are generally poorer/less accessible/affordable healthcare?

Finally, air-borne diease risks are very sparse and there is generally not a pattern or clustering.

3. Now do the same thing, but for the CDP actions data ("cdp_actions.csv"). Do you notice any differences between the cities facing hazards and those that are taking actions?

[5]:
```
actions_df = pd.read_csv(f"drive/My Drive/{FOLDERNAME}/data/cdp_actions.csv")
actions_df = pd.merge(actions_df, coords_df, left_on=["Account Number"],␣
 ↪right_on=["Account.Number"], how="left").drop(columns=["Account.Number",␣
 ↪"Column Number"])
actions_gdf = gpd.GeoDataFrame(actions_df, geometry=[Point(lon, lat) for lon,␣
 ↪lat in zip(actions_df["long"], actions_df["lat"])])
actions_gdf = actions_gdf[actions_gdf["action"].isin([" Vector-borne disease",␣
 ↪" Water-borne disease", " Air-borne disease"])].dropna(subset=["action"])
actions_gdf.crs = world_gdf.crs

action_plot = (
    pn.ggplot(actions_gdf) +
    pn.geom_map(world_gdf, color="black", size=0.1, fill="lightgrey") +
    pn.geom_map(pn.aes(color="action")) +
    pn.theme_minimal() +
    pn.theme(figure_size=(12, 8)) +
    pn.labs(title="CDP Actions", x="East", y="North")
)
print(hazard_plot)
print(action_plot)
```

```
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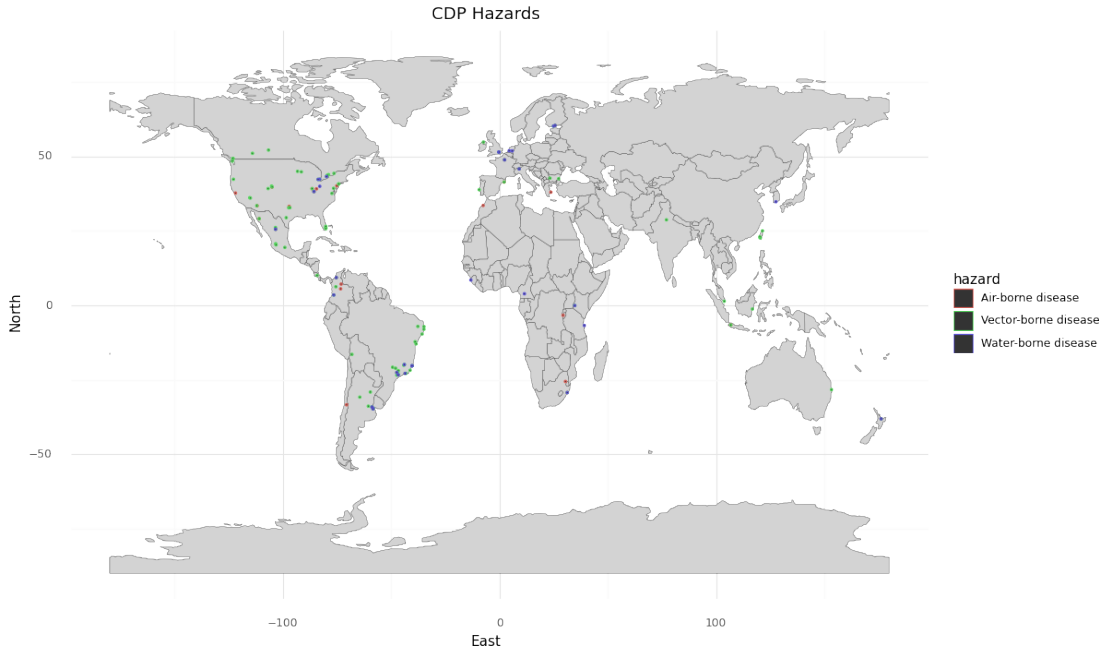
explicitly set the active geometry column.
```




```
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/usr/local/lib/python3.10/dist-packages/plotnine/mapping/evaluation.py:216:
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sets the active geometry column to 'geometry' but in the future that will no
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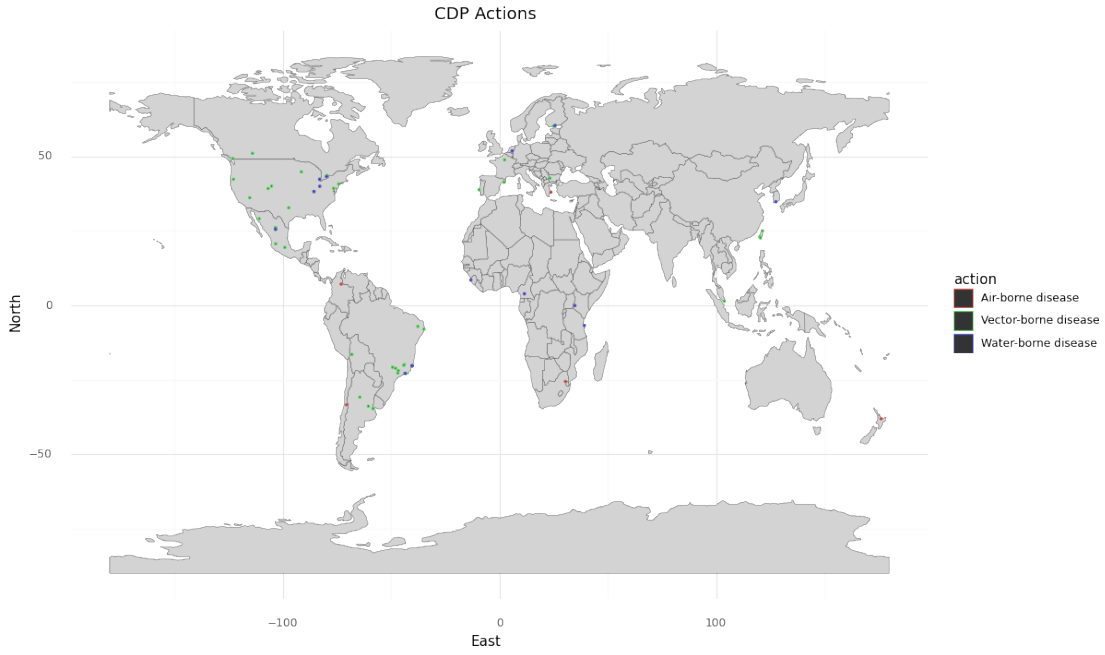
explicitly set the active geometry column.
```



[6]:
```
not_solved_gdf = pd.merge(actions_gdf, hazards_gdf[["Account Number",␣
↪"hazard"]], left_on=["Account Number"], right_on=["Account Number"],␣
↪how="right").dropna(subset=["Questionnaire"])
not_solved_gdf
```

[6]:

	Questionnaire	Year Reported to CDP	Account Number	\
1	Cities 2020	2020.0	42388	
4	Cities 2020	2020.0	50549	
9	Cities 2020	2020.0	60142	
10	Cities 2020	2020.0	60142	
11	Cities 2020	2020.0	63601	
..	…	…	…	
179	Cities 2020	2020.0	50381	
180	Cities 2020	2020.0	50381	
181	Cities 2020	2020.0	50381	
185	Cities 2020	2020.0	35853	
186	Cities 2020	2020.0	31172	

	Organization	Country	CDP Region	\
1	Intendencia de Montevideo	Uruguay	Latin America	
4	City of Fort Worth	United States of America	North America	
9	City of Kisumu	Kenya	Africa	
10	City of Kisumu	Kenya	Africa	
11	Township of Maplewood, NJ	United States of America	North America	

```
..                          …                          …            …
179       Municipio de Torreón                     Mexico  Latin America
180       Municipio de Torreón                     Mexico  Latin America
181       Municipio de Torreón                     Mexico  Latin America
185          City of Baltimore  United States of America  North America
186                Mexico City                     Mexico  Latin America

    Parent Section             Section  Question Number  \
1       Adaptation  Adaptation Actions              3.0
4       Adaptation  Adaptation Actions              3.0
9       Adaptation  Adaptation Actions              3.0
10      Adaptation  Adaptation Actions              3.0
11      Adaptation  Adaptation Actions              3.0
..             …                  …               …
179     Adaptation  Adaptation Actions              3.0
180     Adaptation  Adaptation Actions              3.0
181     Adaptation  Adaptation Actions              3.0
185     Adaptation  Adaptation Actions              3.0
186     Adaptation  Adaptation Actions              3.0

                                        Question Name      Column Name  \
1    Please describe the main actions you are takin…  Climate hazards
4    Please describe the main actions you are takin…  Climate hazards
9    Please describe the main actions you are takin…  Climate hazards
10   Please describe the main actions you are takin…  Climate hazards
11   Please describe the main actions you are takin…  Climate hazards
..                                               …              …
179  Please describe the main actions you are takin…  Climate hazards
180  Please describe the main actions you are takin…  Climate hazards
181  Please describe the main actions you are takin…  Climate hazards
185  Please describe the main actions you are takin…  Climate hazards
186  Please describe the main actions you are takin…  Climate hazards

                             Response Answer  Comments  File Name  \
1    Biological hazards > Vector-borne disease       NaN        NaN
4    Biological hazards > Vector-borne disease       NaN        NaN
9     Biological hazards > Water-borne disease       NaN        NaN
10   Biological hazards > Vector-borne disease       NaN        NaN
11   Biological hazards > Vector-borne disease       NaN        NaN
..                                         …       …         …
179    Biological hazards  > Air-borne disease       NaN        NaN
180   Biological hazards > Water-borne disease       NaN        NaN
181  Biological hazards > Vector-borne disease       NaN        NaN
185  Biological hazards > Vector-borne disease       NaN        NaN
186  Biological hazards > Vector-borne disease       NaN        NaN

               Last update                 action      lat      long  \
```

```
1    09/07/2020 09:45:36 AM   Vector-borne disease -34.7112  -58.2987
4    09/07/2020 09:45:36 AM   Vector-borne disease  32.7555  -97.3308
9    09/07/2020 09:45:36 AM    Water-borne disease  -0.0917   34.7679
10   09/07/2020 09:45:36 AM   Vector-borne disease  -0.0917   34.7679
11   09/07/2020 09:45:36 AM   Vector-borne disease  40.7300  -74.2700
..                      …                    …       …       …
179  09/07/2020 09:45:36 AM      Air-borne disease  25.5428 -103.4070
180  09/07/2020 09:45:36 AM    Water-borne disease  25.5428 -103.4070
181  09/07/2020 09:45:36 AM   Vector-borne disease  25.5428 -103.4070
185  09/07/2020 09:45:36 AM   Vector-borne disease  39.2904  -76.6122
186  09/07/2020 09:45:36 AM   Vector-borne disease  19.4326  -99.1332

                        geometry                 hazard
1    POINT (-58.29870 -34.71120)   Vector-borne disease
4     POINT (-97.33080 32.75550)   Vector-borne disease
9      POINT (34.76790 -0.09170)   Vector-borne disease
10     POINT (34.76790 -0.09170)   Vector-borne disease
11    POINT (-74.27000 40.73000)   Vector-borne disease
..                           …                    …
179  POINT (-103.40700 25.54280)   Vector-borne disease
180  POINT (-103.40700 25.54280)   Vector-borne disease
181  POINT (-103.40700 25.54280)   Vector-borne disease
185   POINT (-76.61220 39.29040)   Vector-borne disease
186   POINT (-99.13320 19.43260)   Vector-borne disease

[110 rows x 20 columns]
```

In general, a lot less actions are taken than there are reports of hazards.

Vector-borne diseases are the most mitigated, however, water-borne diseases are the least mitigated, despite being the 2nd most reported hazard.

There are some cities that take action against the exact reported hazard, which is great. But in not_solved_gdp, there are many cities which did not manage to address the reported issue. Most of them do seem to be in poorer areas, like rural Latin America and Mexico, etc.

4. Use the tigris function to download shapefiles of your choice. Plot the data using ggplot().

[7]:
```
# !pip install pygris
import pygris

ca_df = pygris.counties(state="CA", year="2022", cb=True)
ca_gdf = gpd.GeoDataFrame(ca_df)
ca_plot = (
    pn.ggplot(ca_gdf) +
    pn.geom_map( color="black", size=0.1, fill="lightgrey") +
    pn.theme(figure_size=(12, 8)) +
    pn.labs(title="California Counties", x="East", y="North")
)
```

```
print(ca_plot)
```

```
Using FIPS code '06' for input 'CA'
```

```
/usr/local/lib/python3.10/dist-packages/plotnine/mapping/evaluation.py:216:
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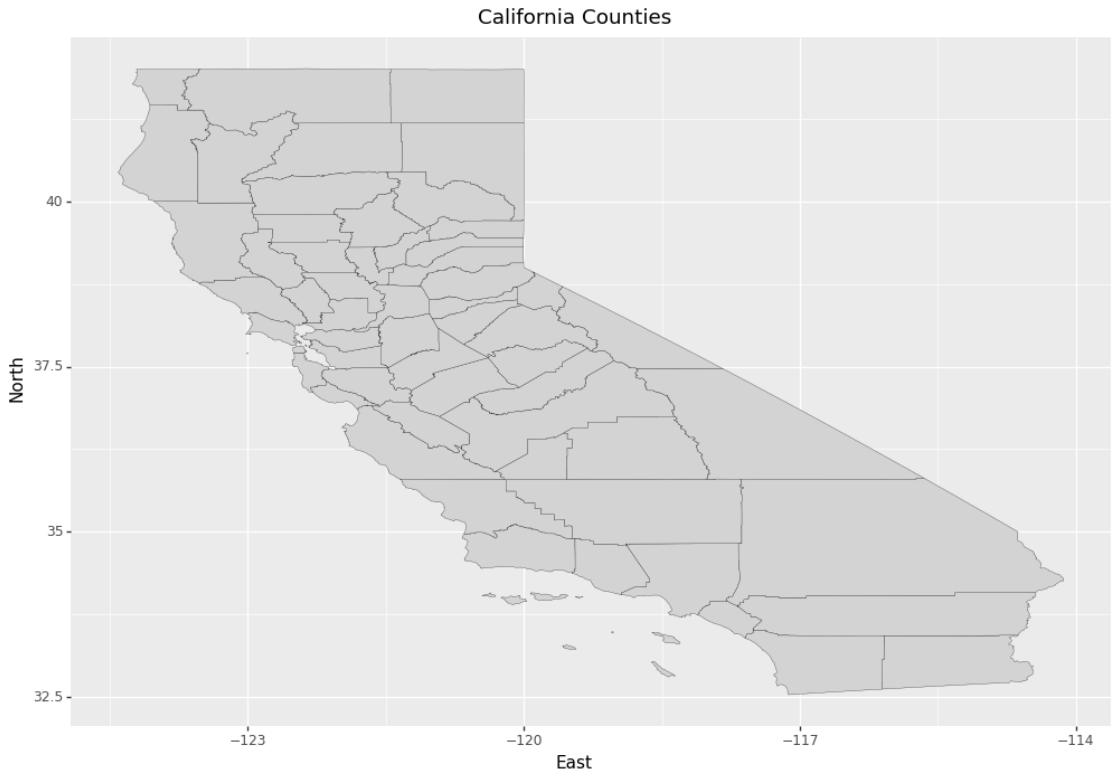
```



5. Download one of the clean AQI monitor datasets from Canvas ("aqi22_clean_us.csv" or "aqi22_clean_ca.csv") and plot these inside the boundaries that you have downloaded from tigris. Then, calculate the average PM2.5 levels in each of the geographical units, and plot your geographies again according to these levels (as we did in section 6.5). Which areas had the best (and worst) air quality in 2022? What are the implications?

[8]:
```
aqi_df = pd.read_csv(f"drive/My Drive/{FOLDERNAME}/data/aqi22_clean_ca.csv",␣
↪usecols=lambda col: col not in ["State Code", "County Code", "Site Num",␣
↪"Parameter Code"])
```

```
aqi_gdf = gpd.GeoDataFrame(aqi_df, geometry=[Point(lon, lat) for lon, lat in␣
 ↪aqi_df["geometry"].str.strip("c()").str.split(",")])
# Changing CRS of aqi to that of ca
aqi_gdf.crs = ca_gdf.crs

pm_plot = (
    pn.ggplot(aqi_gdf) +
    pn.geom_map(ca_gdf, color="black", size=0.1, fill="lightgrey") +
    pn.geom_map(pn.aes(color="Arithmetic Mean"), size=1.6) +
    pn.scale_color_cmap(cmap_name='magma_r') +
    pn.theme(figure_size=(12, 8)) +
    pn.labs(title="California Counties PM", x="East", y="North", color="PM2.5␣
 ↪Avg")
)
print(pm_plot)
```

```
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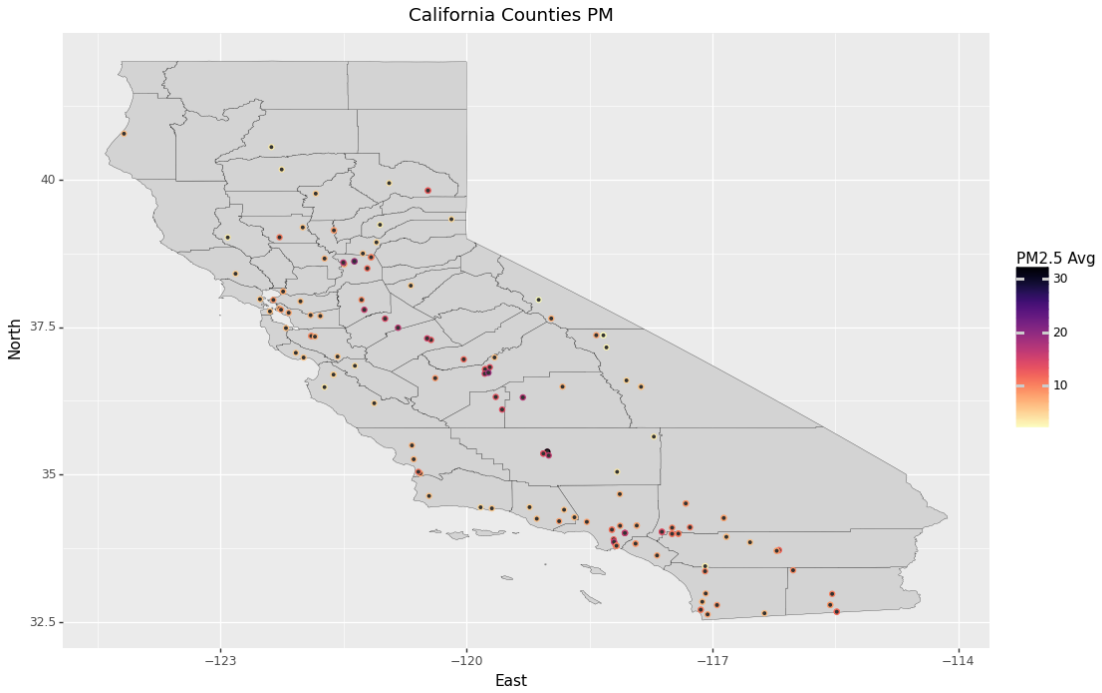
```



[9]:
```
aqi_df = pd.read_csv(f"drive/My Drive/{FOLDERNAME}/data/aqi22_clean_ca.csv",␣
 ↪usecols=lambda col: col not in ["State Code", "County Code", "Site Num",␣
 ↪"Parameter Code"])
mean_aqi = aqi_df.groupby("County Name").agg({
    "Arithmetic Mean": "mean",
    "State Name": "first",
    "City Name": "first",
    "geometry": "first"

})
mean_aqi_df = pd.DataFrame(mean_aqi).reset_index().rename(columns={"Arithmetic␣
 ↪Mean": "Mean AQI"})
mean_aqi_gdf = gpd.GeoDataFrame(mean_aqi_df, geometry=[Point(lon, lat) for lon,␣
 ↪lat in mean_aqi_df["geometry"].str.strip("c()").str.split(",")])
# Changing CRS of aqi to that of ca
mean_aqi_gdf.crs = ca_gdf.crs

pm_plot = (
    pn.ggplot(mean_aqi_gdf) +
    pn.geom_map(ca_gdf, color="black", size=0.1, fill="lightgrey") +
    pn.geom_map(pn.aes(color="Mean AQI"), size=1.6) +
    pn.scale_color_cmap(cmap_name='magma_r') +
```

```
    pn.theme(figure_size=(12, 8)) +
    pn.labs(title="California Counties PM", x="East", y="North", color="PM2.5␣
 ↪Avg")
)
print(pm_plot)
```

```
/usr/local/lib/python3.10/dist-packages/plotnine/mapping/evaluation.py:216:
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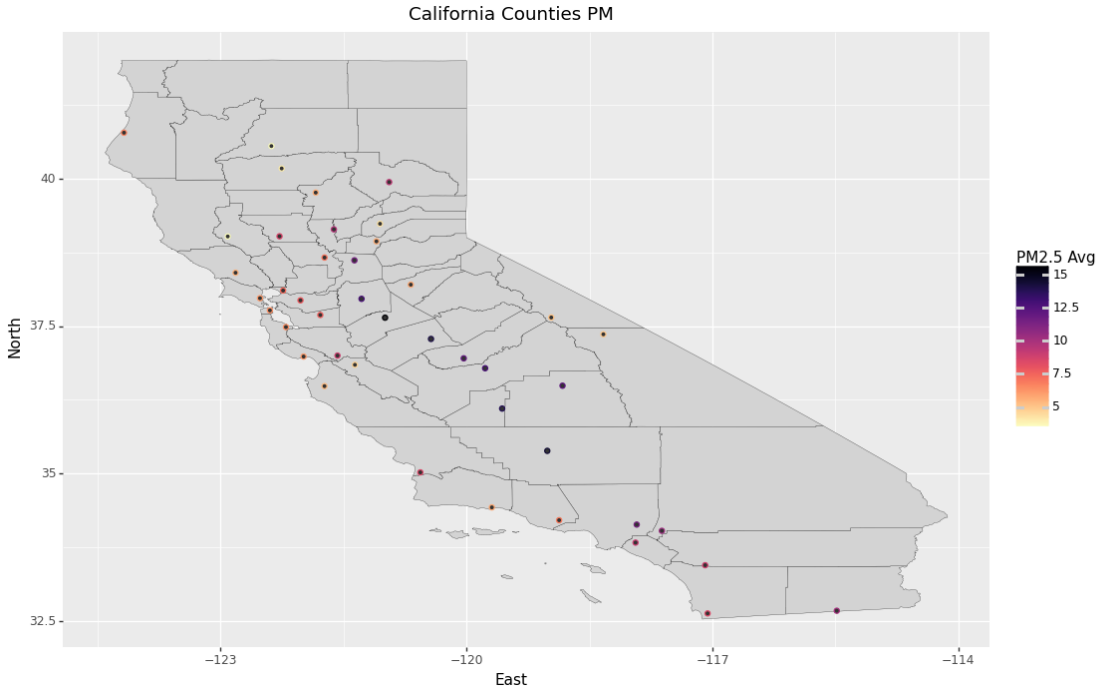

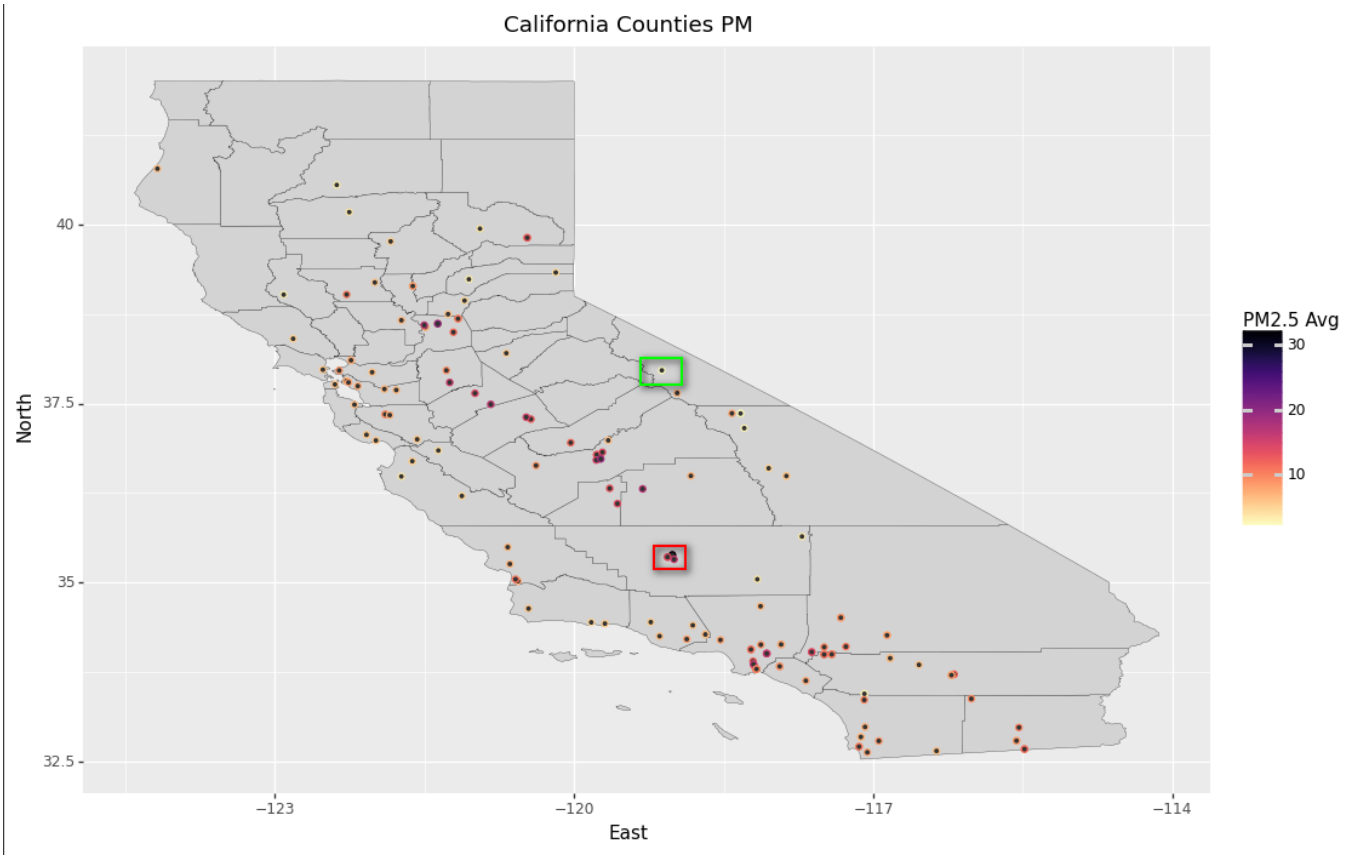

I wasn't sure which to plot, based on the question, so I plotted both since they are quite similar.

As highlighted in green, the area with the best air quality seems to be the county of Mono.

As highlighted in red, the area with the worst air quality seems to be the county of Kern, in the city of Bakersfield.

Interestingly, a common trend is that usually areas with poor air quality are usually clustered together, while those with good air quality are not. Of course, since this dataset concerns air quality monitors, it is likely that more monitors are placed in areas with concerning air quality than those without. It could also be that air in areas with poor air quality often spreads to surrounding areas, worsening overall air quality in the vicinity.