CS 176 Project

In [2]:
```
# load libraries
from matplotlib import pyplot as plt
import pandas as pd
import numpy as np
```

In [3]:
```
# states conversion dict that has all of the universal states
states = {'AK':'Alaska', 'AL':'Alabama', 'AR':'Arkansas', 'AZ':'Arizona', 'CA'

# read in the csv files
aqiDF = pd.read_csv('./data/annual_aqi_by_county_2021.csv')
copdDF = pd.read_csv('./data/County_COPD_prevalence.csv').rename(columns = {"S
popDF = pd.read_csv('./data/PopulationEstimates.csv', encoding="latin-1").rena

# cleaning all of the generic data for the us and states and only selecting th
popDF = popDF[(popDF.State != "US") & (popDF.State != popDF.County)]

# using a pivot table to restructure the dataset to include the attributes as
popDF = popDF.pivot(
    index=['FIPStxt', 'State', 'County'],
    columns='Attribute',
    values='Value'
).reset_index()


# remove all of the " country" or " parish" or similar from the end of the pop
popDF.County = popDF.County.map(lambda x: " ".join(x.split(" ")[:-1]))

# putting the aqi and copd into title case
aqiDF.State = aqiDF.State.str.title()
copdDF.State = copdDF.State.str.title()

# filtering for only the universal states in all of the dataframes
copdDF = copdDF[copdDF.State.isin(states.values())]
aqiDF = aqiDF[aqiDF.State.isin(states.values())]

# converting the popDF's state abbreviations into the full state names
popDF.State = popDF.State.map(states)
# only taking 2021 population estimates so that other years cann't be merged i
popDF_slim = popDF.loc[:, ["State", "County", "FIPStxt", "POP_ESTIMATE_2021"]]
```

In [4]:
```
# merge the dataframe using inner merges on the state county values
mergeTemp = pd.merge(aqiDF, popDF_slim, on=["State", "County"])
mergeFull = pd.merge(mergeTemp, copdDF, on=["State", "County"])

# merge just the copd values so that for COPD map missing AQI will not affect
COPDMerge = pd.merge(copdDF, popDF_slim, on=["State", "County"])

# mergeFull.head()
print(mergeFull.columns) # Print out all of the data columns that we have acce
```

```
print(len(mergeFull)) # Print total number of entries to see how many counties
```

```
Index(['State', 'County', 'Year', 'Days with AQI', 'Good Days',
       'Moderate Days', 'Unhealthy for Sensitive Groups Days',
       'Unhealthy Days', 'Very Unhealthy Days', 'Hazardous Days', 'Max AQI',
       '90th Percentile AQI', 'Median AQI', 'Days CO', 'Days NO2',
       'Days Ozone', 'Days PM2.5', 'Days PM10', 'FIPStxt', 'POP_ESTIMATE_2021',
       'FullGeoName', 'LocationID', 'Public_Health_Jurisdiction',
       'Percent_COPD', '95% Confidence Interval', 'Quartile'],
      dtype='object')
961
```

In [5]:
```
#this cell will sort the new data set by worst air quality meaning the highest
#this sorts so highest median aqi is first
worst_aqi = mergeFull.sort_values("Median AQI", ascending=False)
#this looks at the most important attributes of the 10 worst counties
worst_aqi.loc[:, ["State", "County", "Median AQI", "Percent_COPD", "POP_ESTIMA
```

Out[5]:

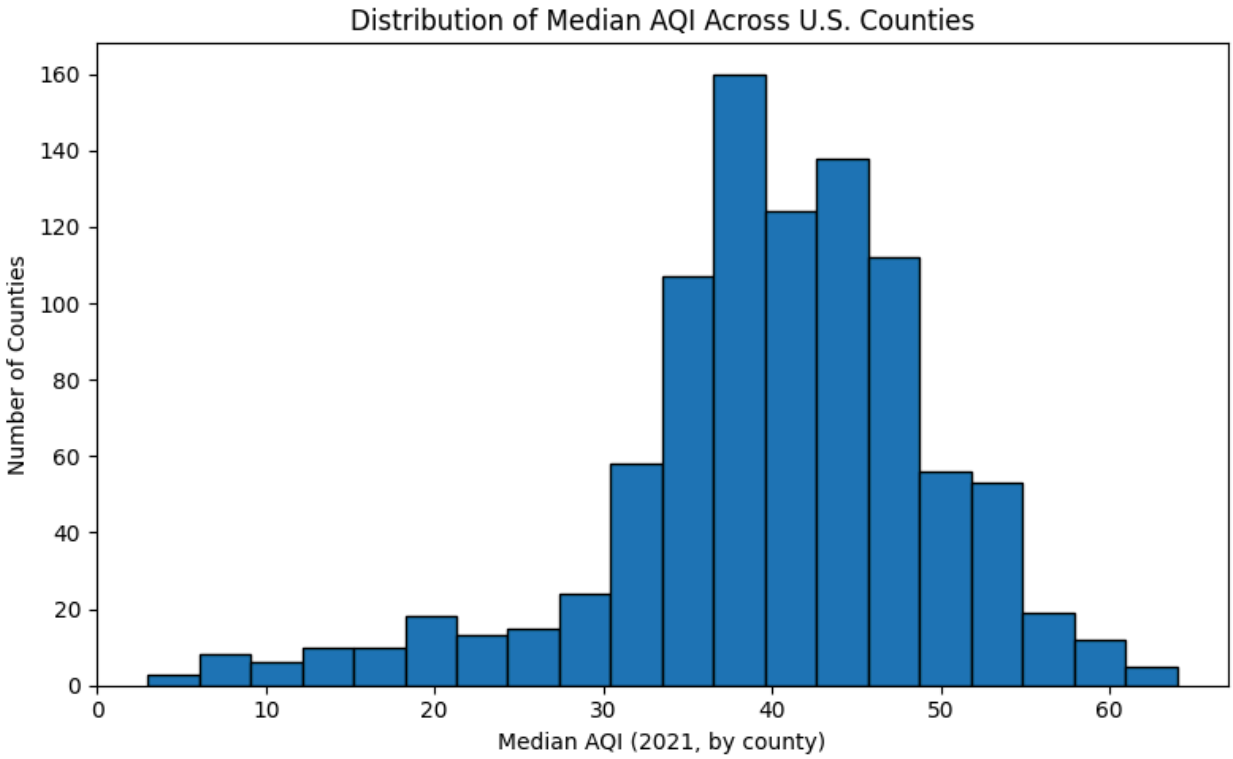
	State	County	Median AQI	Percent_COPD	POP_ESTIMATE_2021
20	Arizona	Maricopa	122	5.4	4499438.0
68	California	Riverside	89	5.3	2453399.0
71	California	San Bernardino	87	5.6	2193087.0
52	California	Kern	84	6.7	912709.0
88	California	Tulare	81	6.7	477176.0
55	California	Los Angeles	79	4.7	9809462.0
24	Arizona	Pinal	70	6.3	448993.0
47	California	Fresno	68	6.1	1013103.0
72	California	San Diego	67	4.7	3274432.0
67	California	Plumas	67	6.1	19958.0

In [6]:
```
# sorting the dataframe by the percentage of COPD residents
sorted_by_copd = mergeFull.sort_values("Percent_COPD", ascending=False)
#this looks at the most important attributes of the 10 worst counties
sorted_by_copd.loc[:, ["State", "County", "Median AQI", "Percent_COPD", "POP_E
```

Out[6]:

	State	County	Median AQI	Percent_COPD	POP_ESTIMATE_2021
306	Kentucky	Bell	52	13.3	23834.0
326	Kentucky	Pike	41	11.8	57416.0
311	Kentucky	Carter	35	11.7	26430.0
325	Kentucky	Perry	44	11.2	27927.0
323	Kentucky	Morgan	35	11.2	13689.0

In [7]:
```
aqi_vals = mergeFull["Median AQI"].dropna()
aqi_vals = aqi_vals[(aqi_vals >= 0) & (aqi_vals <= aqi_vals.quantile(0.99))]

plt.figure(figsize=(8,5))
plt.hist(aqi_vals, bins=20, edgecolor="black")
plt.xlabel("Median AQI (2021, by county)")
plt.ylabel("Number of Counties")
plt.title("Distribution of Median AQI Across U.S. Counties")
plt.tight_layout()
plt.show()
```



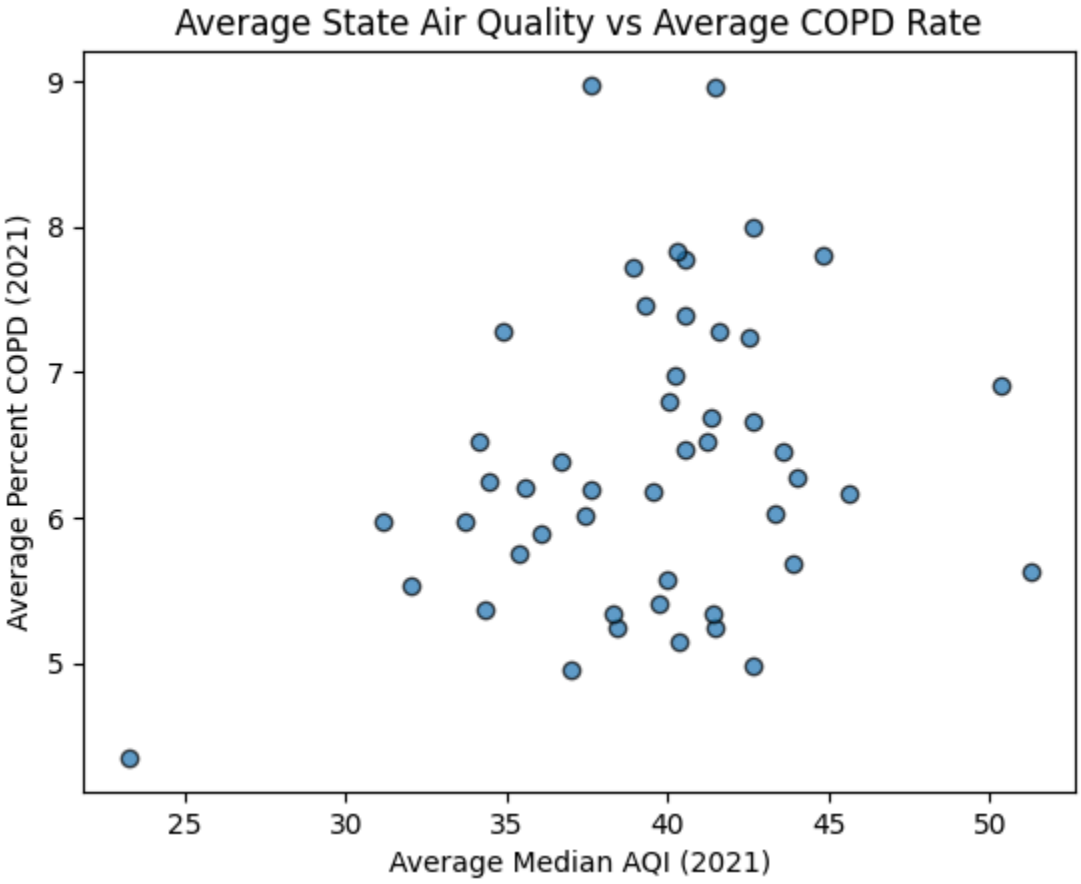
In [8]:
```
pivot_state = mergeFull.pivot_table(
    values=["Median AQI", "Percent_COPD"], #these are columns we want the aver
    index="State", #this will group the rows by state
    aggfunc="mean" #this will take the mean for each state
)
pivot_state.head()
```

Out[8]:

State	Median AQI	Percent_COPD
Alabama	40.533333	7.386667
Arizona	50.384615	6.907692
Arkansas	42.636364	8.000000
California	51.264151	5.630189
Colorado	39.709677	5.406452

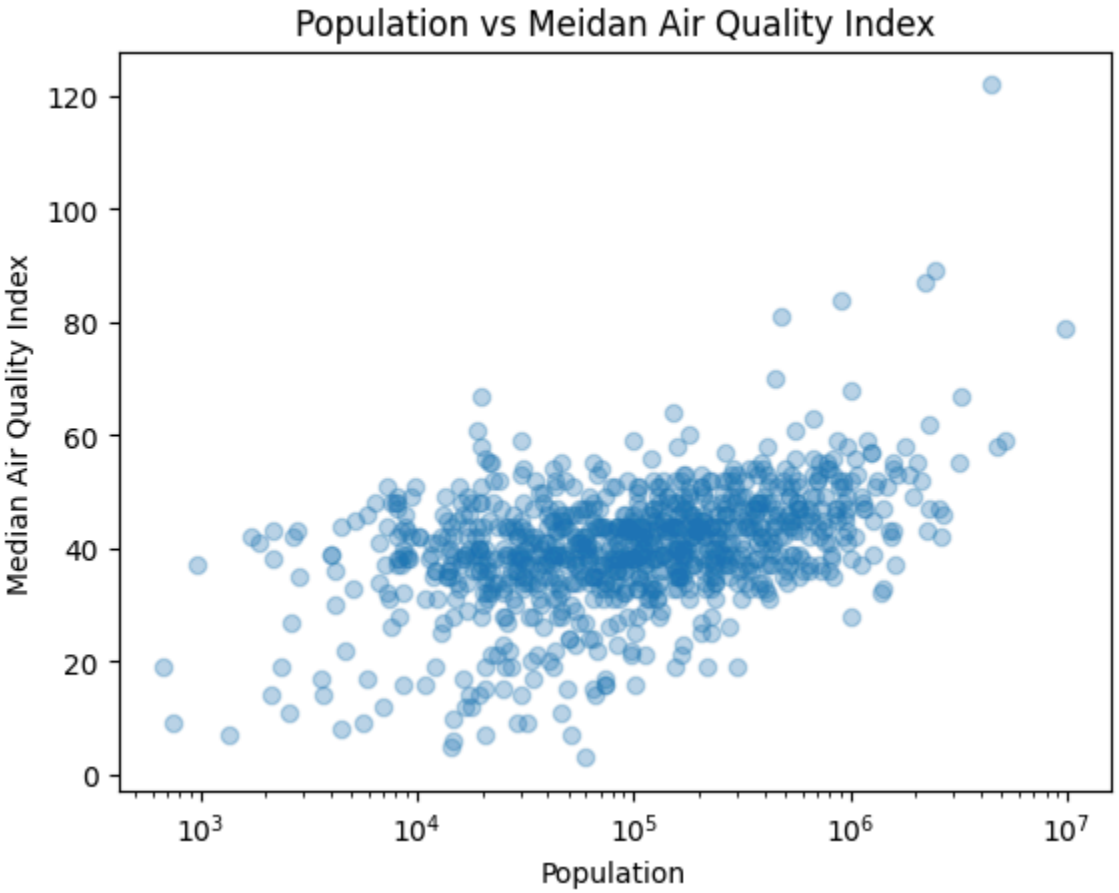
In [9]:

```
fig, ax = plt.subplots()

plt.scatter(
    pivot_state["Median AQI"],
    pivot_state["Percent_COPD"],
    alpha=0.7,
    edgecolor="black"
)
plt.title("Average State Air Quality vs Average COPD Rate")
plt.xlabel("Average Median AQI (2021)")
plt.ylabel("Average Percent COPD (2021)")
plt.show()
```



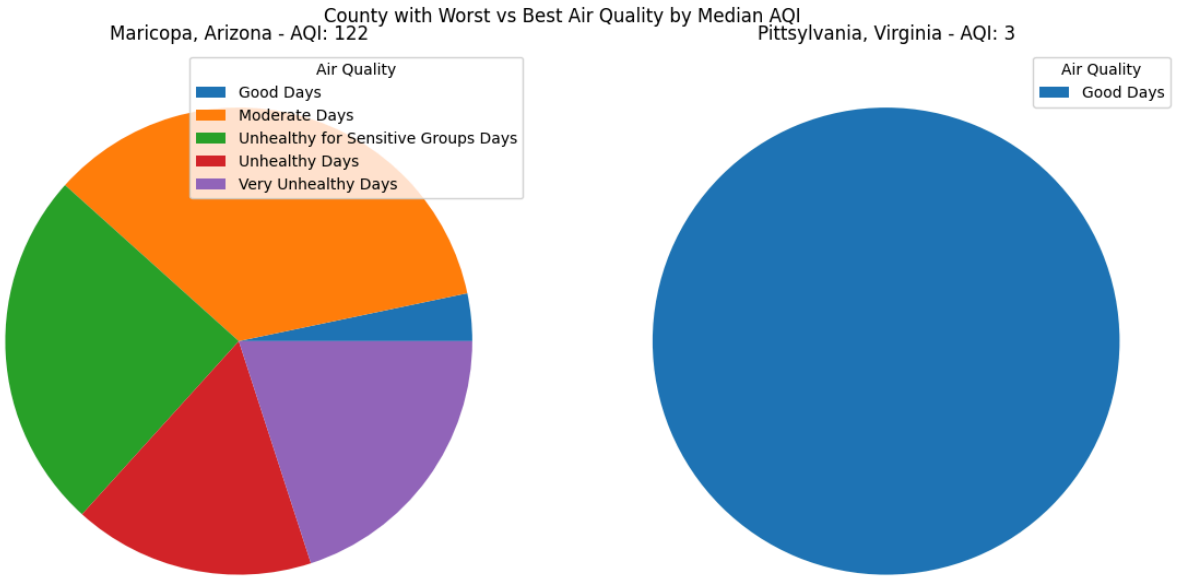
In [10]:
```
fig, ax = plt.subplots()
# creates a scatter plot of the 2021 population estimates against median aqi
ax.scatter(mergeFull["POP_ESTIMATE_2021"], mergeFull["Median AQI"], alpha=0.3)
ax.set_xscale("log")
ax.set_xlabel("Population")
ax.set_ylabel("Median Air Quality Index")
ax.set_title("Population vs Meidan Air Quality Index")
```

Out[10]: Text(0.5, 1.0, 'Population vs Meidan Air Quality Index')



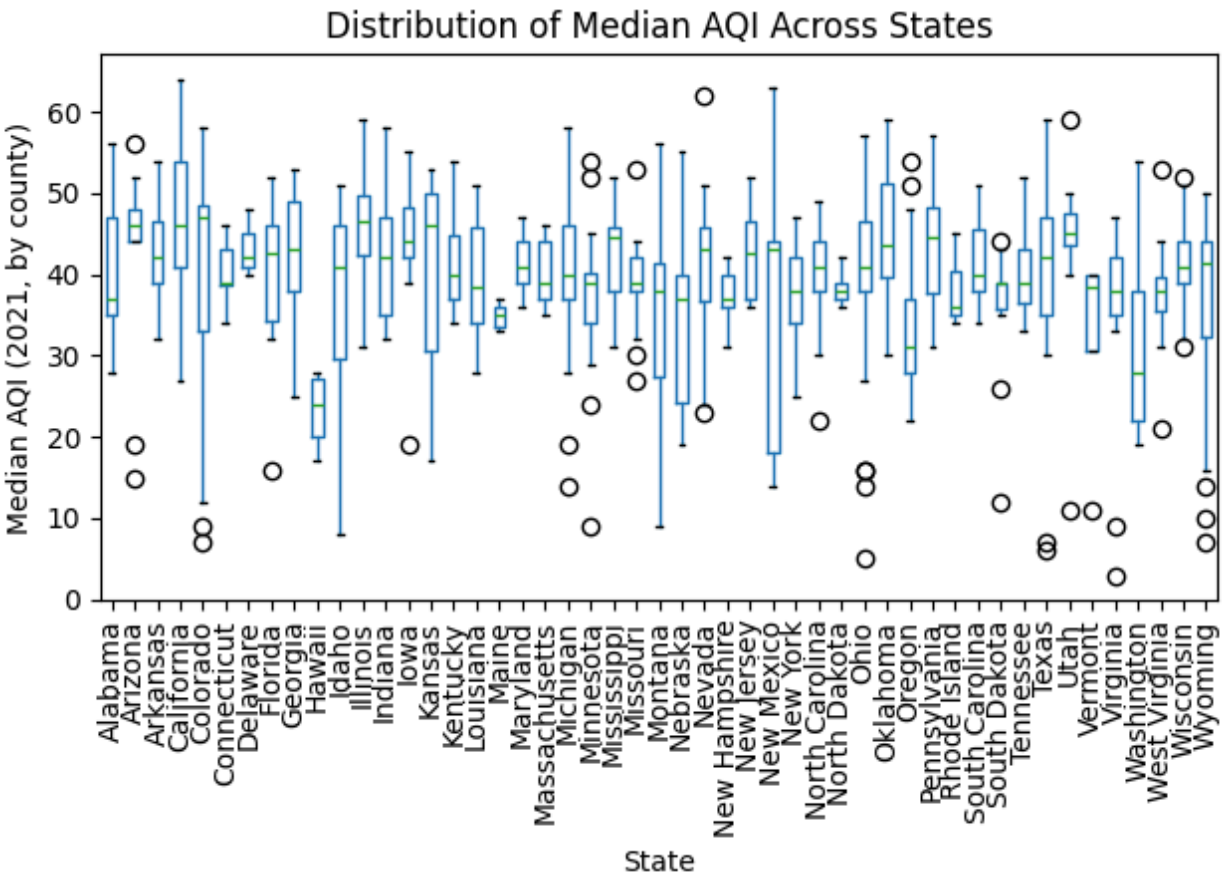
In [11]:
```
fig, ax = plt.subplots(1, 2, figsize=(12, 6))

# identify the days to plot
day_values = ['Good Days', 'Moderate Days', 'Unhealthy for Sensitive Groups Da

# filter and find just the best and worst counties in 2021 by median aqi
worst_county = mergeFull.loc[mergeFull['Median AQI'].idxmax(), :]
best_county = mergeFull.loc[mergeFull['Median AQI'].idxmin(), :]

# then get the column data values for the best and worst counties
worst_county_values = mergeFull.loc[mergeFull['Median AQI'].idxmax(), day_valu
best_county_values = mergeFull.loc[mergeFull['Median AQI'].idxmin(), day_value

# Create a pie chart with the best and worst values
worst_wedges, _ = ax[0].pie(worst_county_values)
best_wedges, _ = ax[1].pie(best_county_values)
```

```
# Create plot titles
fig.suptitle("County with Worst vs Best Air Quality by Median AQI")
ax[0].set_title(f"{worst_county.County}, {worst_county.State} - AQI: {worst_co
ax[1].set_title(f"{best_county.County}, {best_county.State} - AQI: {best_count

#create
ax[0].legend(worst_wedges, day_values[:-1], title="Air Quality", loc='best') #
ax[1].legend(best_wedges, day_values[:1], title="Air Quality", loc='best') # c

fig.tight_layout()
```



In [12]:
```
df_aqi = mergeFull[['State', 'Median AQI']].dropna()
df_aqi = df_aqi[df_aqi['Median AQI'] <= df_aqi['Median AQI'].quantile(0.99)]

plt.figure(figsize=(14,6))

df_aqi.boxplot(by='State', column='Median AQI', vert=True, grid=False)

plt.xticks(rotation=90)
plt.ylabel("Median AQI (2021, by county)")
plt.title("Distribution of Median AQI Across States")
plt.suptitle("")
plt.tight_layout()
plt.show()
```

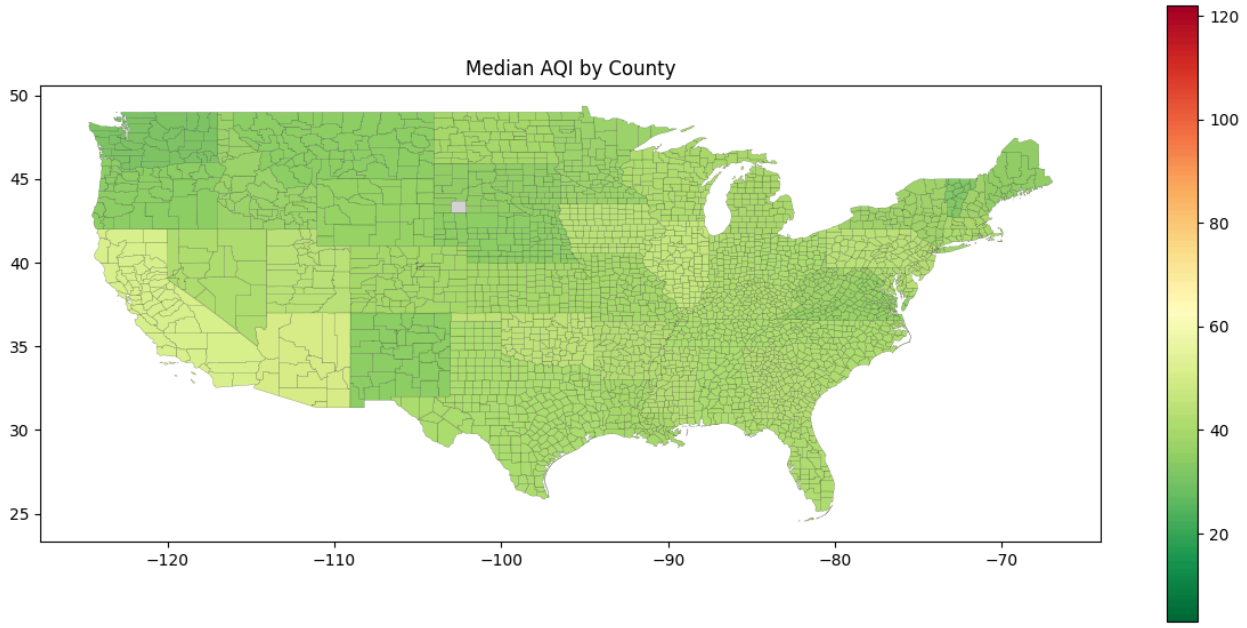
```
<Figure size 1400x600 with 0 Axes>
```



In [13]:
```
import json

with open("./data/geojson-counties-fips.json", 'r') as f:
    geojson = json.load(f)
```

In [14]:
```
from matplotlib.patches import Polygon
from matplotlib.collections import PatchCollection
from matplotlib.cm import ScalarMappable
from matplotlib.colors import Normalize

patches, colors = [], []

pivot_aqi_state = mergeFull.pivot_table(
    values=["Median AQI"], #these are columns we want the averages of
    index="State", #this will group the rows by state
    aggfunc="mean", #this will take the mean for each state
    dropna=True
).reset_index()

# find the min and max aqi so values can be scalled 0 to 1
min_aqi, max_aqi = mergeFull['Median AQI'].min(), mergeFull['Median AQI'].max(

# get the red yellow green color map and reverse it so that 'bad' ie a high AQ
cmap = plt.get_cmap('RdYlGn').reversed()

# for each county entry in the json's feature array
```

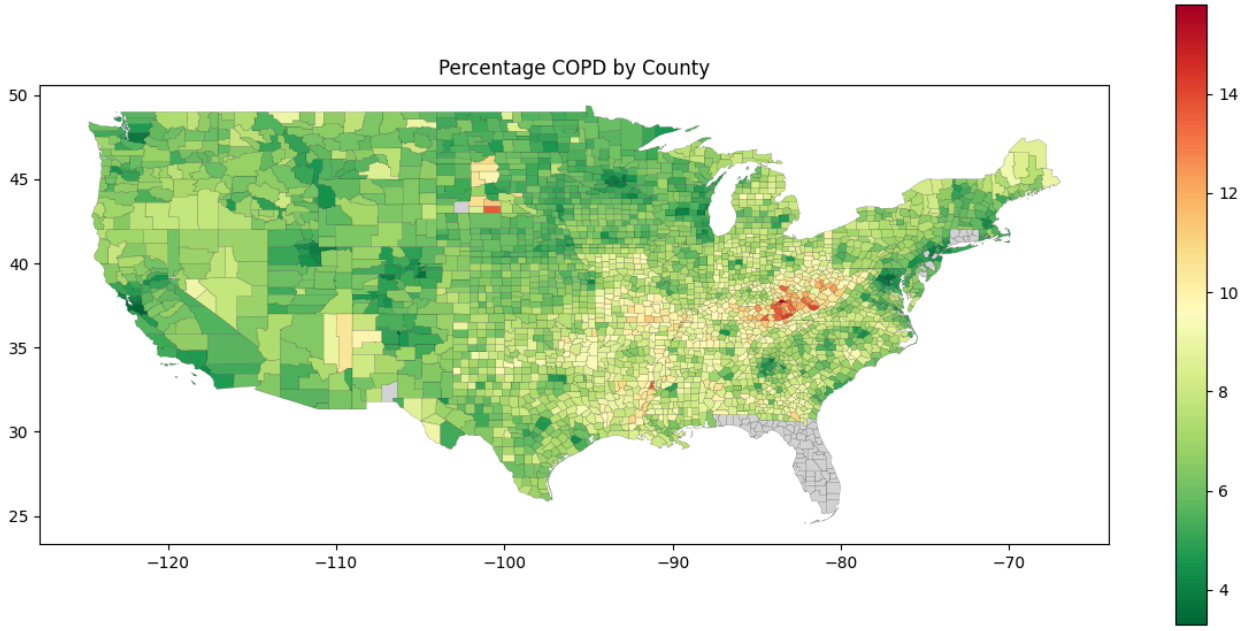
```
for feature in geojson['features']:
    #get the fips code which identifies the county
    fips = int(feature['id'])

    # get the aqi if it exists
    # median_aqi = mergeFull[mergeFull.FIPStxt == fips]['Median AQI'].values
    try:
        median_aqi = pivot_aqi_state[pivot_aqi_state.State == popDF[popDF.FIPS
    except:
        median_aqi = []
    # print(median_aqi)
    # color it either based on the pallete or gray if there is no data for the
    if len(median_aqi):
        color = cmap((median_aqi[0][1] - min_aqi) / (max_aqi - min_aqi))
    else:
        color = '#d3d3d3'

    # ignore Alaska, Hawaii, and Peurto Rico as they make the map tiny
    if feature['properties']['STATE'] in ['02', '15', '72']:
        continue

    # Handle either a polygon, or a multi-polygon for states with islands
    if feature['geometry']['type'] == 'Polygon':
        polys = [feature['geometry']['coordinates']]
    else:
        polys = feature['geometry']['coordinates']

    # append the matplotlib polygon to a list
    for poly in polys:
        patches.append(Polygon(poly[0], closed=True))
        colors.append(color)

# make plot
fig, ax = plt.subplots(figsize=(15, 7))
# add a color bar since I am just plotting patches, no actual plot
fig.colorbar(ScalarMappable(norm=Normalize(min_aqi, max_aqi), cmap=cmap), ax=a
# add all of the patches
ax.add_collection(PatchCollection(patches, facecolors=colors, edgecolor='black
# autoscale to show all of the patches
ax.autoscale()
ax.set_aspect('equal') # else it is very warped

ax.set_title("Median AQI by County")
plt.show()
```



In [15]:

```
from matplotlib.patches import Polygon
from matplotlib.collections import PatchCollection
from matplotlib.cm import ScalarMappable
from matplotlib.colors import Normalize

patches, colors = [], []

COPDMerge.dropna(inplace=True)

# find the min and max aqi so values can be scalled 0 to 1
min_aqi, max_aqi = COPDMerge['Percent_COPD'].min(), COPDMerge['Percent_COPD'].

# get the red yellow green color map and reverse it so that 'bad' ie a high AQ
cmap = plt.get_cmap('RdYlGn').reversed()

# for each county entry in the json's feature array
for feature in geojson['features']:
    #get the fips code which identifies the county
    fips = int(feature['id'])

    # get the aqi if it exists
    percent_copd = COPDMerge[COPDMerge.FIPStxt == fips]['Percent_COPD'].values

    # color it either based on the pallete or gray if there is no data for the
    if len(percent_copd):
        color = cmap((percent_copd[0] - min_aqi) / (max_aqi - min_aqi))
    else:
        color = '#d3d3d3'

    # ignore Alaska, Hawaii, and Peurto Rico as they make the map tiny
    if feature['properties']['STATE'] in ['02', '15', '72']:
        continue

    # Handle either a polygon, or a multi-polygon for states with islands
```

```
    if feature['geometry']['type'] == 'Polygon':
        polys = [feature['geometry']['coordinates']]
    else:
        polys = feature['geometry']['coordinates']

    # append the matplotlib polygon to a list
    for poly in polys:
        patches.append(Polygon(poly[0], closed=True))
        colors.append(color)

# make plot
fig, ax = plt.subplots(figsize=(15, 7))
# add a color bar since I am just plotting patches, no actual plot
fig.colorbar(ScalarMappable(norm=Normalize(min_aqi, max_aqi), cmap=cmap), ax=a
# add all of the patches
ax.add_collection(PatchCollection(patches, facecolors=colors, edgecolor='black
# autoscale to show all of the patches
ax.autoscale()
ax.set_aspect('equal') # else it is very warped

ax.set_title("Percentage COPD by County")
plt.show()
```



In [ ]: