Geographical Data Visualization (15 points)

In this homework, you will visualize bike trip data as a heat map with pandas and geopandas. Feel free to make ready use of online resources to familiarize yourself either Python packages.

You will be working with 3 datasets:

Bike trip data for July 2020: datasets\202007-divvy-tripdata.csv

Bike station locations: datasets\station-locations.csv

Community areas from the city of Chicago: datasets\chicago-community-areas.geojson

Data Pre-Processing (3/15 points)

Some of the data in these datasets are not in the format we want and may be missing important data points. We're going to change that by pre-processing each dataset to ensure that they're in the proper format. Complete the tasks below:

1. Bike trip Pre-Processing (1 point): Within the bike trip data that we loaded (trips_df), get rid of missing (NaN) start and end station IDs, and convert those columns to integer columns. Make sure the modified dataframe is referenced as trips_pr_df.
2. Community Areas Pre-processing (1 point): Within the geojson data for the Chicago community areas (community_df), rename the column area_numbe to area_number, and convert that column to an integer column. Make sure to reference the modified geojson data as community_pr_df.
3. Stations Pre-processing (1 point): Within the bike station location data (stations_df), convert it to a GeoDataFrame and set its geometry to the point specified by the longitude and latitude pair. Make sure to reference the modified data as stations_pr_df.

Hint: use the geopandas.points_from_xy() method to construct longitudinal and latitudinal points and specify the geometry arg when constructing the GeoDataFrame. Grading Metric: We'll run your code to generate trips_pr_df, community_pr_df, and stations_pr_df. Points are assigned based on how accurately the implementation follows the instructions. We'll use a code implementation of our own to test whether the changes have been appropriately made to each dataframe.

In [1]:
```
pip install geopandas
```

```
Requirement already satisfied: geopandas in d:\annaconda\lib\site-packages
(0.14.3)
Requirement already satisfied: fiona>=1.8.21 in d:\annaconda\lib\site-package
s (from geopandas) (1.9.6)
Requirement already satisfied: packaging in d:\annaconda\lib\site-packages (f
rom geopandas) (23.1)
Requirement already satisfied: pandas>=1.4.0 in d:\annaconda\lib\site-package
s (from geopandas) (2.0.3)
Requirement already satisfied: pyproj>=3.3.0 in d:\annaconda\lib\site-package
s (from geopandas) (3.6.1)
Requirement already satisfied: shapely>=1.8.0 in d:\annaconda\lib\site-packag
es (from geopandas) (2.0.3)
Requirement already satisfied: attrs>=19.2.0 in d:\annaconda\lib\site-package
s (from fiona>=1.8.21->geopandas) (22.1.0)
Requirement already satisfied: certifi in d:\annaconda\lib\site-packages (fro
m fiona>=1.8.21->geopandas) (2023.7.22)
Requirement already satisfied: click~=8.0 in d:\annaconda\lib\site-packages
(from fiona>=1.8.21->geopandas) (8.0.4)
Requirement already satisfied: click-plugins>=1.0 in d:\annaconda\lib\site-pa
ckages (from fiona>=1.8.21->geopandas) (1.1.1)
Requirement already satisfied: cligj>=0.5 in d:\annaconda\lib\site-packages
(from fiona>=1.8.21->geopandas) (0.7.2)
Requirement already satisfied: six in d:\annaconda\lib\site-packages (from fi
ona>=1.8.21->geopandas) (1.16.0)
Requirement already satisfied: python-dateutil>=2.8.2 in d:\annaconda\lib\sit
e-packages (from pandas>=1.4.0->geopandas) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in d:\annaconda\lib\site-packages
(from pandas>=1.4.0->geopandas) (2023.3.post1)
Requirement already satisfied: tzdata>=2022.1 in d:\annaconda\lib\site-packag
es (from pandas>=1.4.0->geopandas) (2023.3)
Requirement already satisfied: numpy>=1.21.0 in d:\annaconda\lib\site-package
s (from pandas>=1.4.0->geopandas) (1.24.3)
Requirement already satisfied: colorama in d:\annaconda\lib\site-packages (fr
om click~=8.0->fiona>=1.8.21->geopandas) (0.4.6)
Note: you may need to restart the kernel to use updated packages.
```

In [2]:
```
import pandas as pd
import geopandas as gpd
from shapely.geometry import Point
```

In [3]:
```
# Load the bike trip data
trips_df = pd.read_csv('202007-divvy-tripdata.csv')
```

In [4]:
```
trips_df.head()
```

Out[4]:

	ride_id	rideable_type	started_at	ended_at	start_station_name	start_st
0	762198876D69004D	docked_bike	2020-07-09 15:22:02	2020-07-09 15:25:52	Ritchie Ct & Banks St	
1	BEC9C9FBA0D4CF1B	docked_bike	2020-07-24 23:56:30	2020-07-25 00:20:17	Halsted St & Roscoe St	
2	D2FD8EA432C77EC1	docked_bike	2020-07-08 19:49:07	2020-07-08 19:56:22	Lake Shore Dr & Diversey Pkwy	
3	54AE594E20B35881	docked_bike	2020-07-17 19:06:42	2020-07-17 19:27:38	LaSalle St & Illinois St	
4	54025FDC7440B56F	docked_bike	2020-07-04 10:39:57	2020-07-04 10:45:05	Lake Shore Dr & North Blvd	

In [5]:
```
# Pre-processing the bike trip data
# Remove rows where start or end station IDs are missing
trips_df.dropna(subset=['start_station_id', 'end_station_id'], inplace=True)

# Convert start and end station IDs to integer
trips_df['start_station_id'] = trips_df['start_station_id'].astype(int)
trips_df['end_station_id'] = trips_df['end_station_id'].astype(int)

# Renaming the modified dataframe as requested
trips_pr_df = trips_df

# Display the first few rows to verify the changes
trips_pr_df.head()
```

Out[5]:

	ride_id	rideable_type	started_at	ended_at	start_station_name	start_st
0	762198876D69004D	docked_bike	2020-07-09 15:22:02	2020-07-09 15:25:52	Ritchie Ct & Banks St	
1	BEC9C9FBA0D4CF1B	docked_bike	2020-07-24 23:56:30	2020-07-25 00:20:17	Halsted St & Roscoe St	
2	D2FD8EA432C77EC1	docked_bike	2020-07-08 19:49:07	2020-07-08 19:56:22	Lake Shore Dr & Diversey Pkwy	
3	54AE594E20B35881	docked_bike	2020-07-17 19:06:42	2020-07-17 19:27:38	LaSalle St & Illinois St	
4	54025FDC7440B56F	docked_bike	2020-07-04 10:39:57	2020-07-04 10:45:05	Lake Shore Dr & North Blvd	

In [6]:
```
# Load the Chicago community areas GeoJSON data
community_df = gpd.read_file('chicago-community-areas.geojson')
```

In [7]:
```
community_df.head()
```

Out[7]:

	community	area	shape_area	perimeter	area_num_1	area_numbe	comarea_id
0	DOUGLAS	0	46004621.1581	0	35	35	0
1	OAKLAND	0	16913961.0408	0	36	36	0
2	FULLER PARK	0	19916704.8692	0	37	37	0
3	GRAND BOULEVARD	0	48492503.1554	0	38	38	0
4	KENWOOD	0	29071741.9283	0	39	39	0

In [8]:
```
# Pre-processing the community areas data
# Rename the column 'area_numbe' to 'area_number'
community_df.rename(columns={'area_numbe': 'area_number'}, inplace=True)

# Convert the 'area_number' column to an integer
community_df['area_number'] = community_df['area_number'].astype(int)

# Renaming the modified GeoDataFrame as requested
community_pr_df = community_df

# Display the first few rows to verify the changes
community_pr_df.head()
```

Out[8]:

	community	area	shape_area	perimeter	area_num_1	area_number	comarea_id
0	DOUGLAS	0	46004621.1581	0	35	35	0
1	OAKLAND	0	16913961.0408	0	36	36	0
2	FULLER PARK	0	19916704.8692	0	37	37	0
3	GRAND BOULEVARD	0	48492503.1554	0	38	38	0
4	KENWOOD	0	29071741.9283	0	39	39	0

In [9]:
```
# Load the bike station locations data from the specified CSV file
stations_df = pd.read_csv('station-locations.csv')
```

In [10]:
```
stations_df.head()
```

Out[10]:

	has_kiosk	lat	lon	external_id	rental_uris	s
0	True	41.876511	-87.620548	a3a36d9e-a135-11e9-9cda-0a87ae2ba916	{'ios': 'https://chi.lft.to/lastmile_qr_scan',...	
1	True	41.867226	-87.615355	a3a37378-a135-11e9-9cda-0a87ae2ba916	{'ios': 'https://chi.lft.to/lastmile_qr_scan',...	
2	True	41.856268	-87.613348	a3a378ca-a135-11e9-9cda-0a87ae2ba916	{'ios': 'https://chi.lft.to/lastmile_qr_scan',...	
3	True	41.874053	-87.627716	a3a37e26-a135-11e9-9cda-0a87ae2ba916	{'ios': 'https://chi.lft.to/lastmile_qr_scan',...	
4	True	41.886976	-87.612813	a3a38363-a135-11e9-9cda-0a87ae2ba916	{'ios': 'https://chi.lft.to/lastmile_qr_scan',...	KA1

5 rows × 21 columns

In [11]:
```
# Convert the stations DataFrame to a GeoDataFrame
# Creating a geometry column from the longitude and latitude pairs

stations_pr_df = gpd.GeoDataFrame(
    stations_df,
    geometry=gpd.points_from_xy(stations_df['lon'], stations_df['lat'])
)

# Display the first few rows of the stations_pr_df to verify the conversion
stations_pr_df.head()
```

Out[11]:

	has_kiosk	lat	lon	external_id	rental_uris	s
0	True	41.876511	-87.620548	a3a36d9e-a135-11e9-9cda-0a87ae2ba916	{'ios': 'https://chi.lft.to/lastmile_qr_scan',...	
1	True	41.867226	-87.615355	a3a37378-a135-11e9-9cda-0a87ae2ba916	{'ios': 'https://chi.lft.to/lastmile_qr_scan',...	
2	True	41.856268	-87.613348	a3a378ca-a135-11e9-9cda-0a87ae2ba916	{'ios': 'https://chi.lft.to/lastmile_qr_scan',...	
3	True	41.874053	-87.627716	a3a37e26-a135-11e9-9cda-0a87ae2ba916	{'ios': 'https://chi.lft.to/lastmile_qr_scan',...	
4	True	41.886976	-87.612813	a3a38363-a135-11e9-9cda-0a87ae2ba916	{'ios': 'https://chi.lft.to/lastmile_qr_scan',...	KA1

5 rows × 22 columns

Geographical Visualization (12/15 points)

We will now analyze the relationship between community area, trips, and station location. Some of these tasks involve merging DataFrames and GeoDataFrames in a manner similar to SQL table joins. We will also visualize one of these relationships as a spatial heat map.

1. Spatial Join (2 points): Given points from station locations, we want to find out which community areas those points are in. This can be accomplished using a sjoin in geopandas. After joining the two datasets, you should be able to find the area_number for each station_id. Save your joined results as station_community_df. Hint: If you see an error about CRS of frames not matching, you can set the crs parameter of the GeoDataFrame to the same as the community areas.

In [12]:
```
# Ensure both GeoDataFrames have the same CRS
stations_pr_df.set_crs(community_pr_df.crs, inplace=True)

# Perform the spatial join
station_community_df = gpd.sjoin(stations_pr_df, community_pr_df, how="left",

# This will add the area_number from the community areas to each station recor
# Display the first few rows to verify the join
station_community_df.head()
```

1	True	41.867226	-87.615355	a3a37378-a135-11e9-9cda-0a87ae2ba916	{'ios' 'https://chi.lft.to/lastmile_qr_scan',..
2	True	41.856268	-87.613348	a3a378ca-a135-11e9-9cda-0a87ae2ba916	{'ios' 'https://chi.lft.to/lastmile_qr_scan',..
3	True	41.874053	-87.627716	a3a37e26-a135-11e9-9cda-0a87ae2ba916	{'ios' 'https://chi.lft.to/lastmile_qr_scan',..
4	True	41.886976	-87.612813	a3a38363-a135-11e9-9cda-0a87ae2ba916	{'ios' 'https://chi.lft.to/lastmile_qr_scan',..

5 rows × 32 columns

2. Add Community Areas to Trips (4 points): Use the updated dataframe from the previous part with the bike trip dataset to add columns specifying the start and end community area numbers (start_ca_num and end_ca_num) for each trip. Remove any entries in your final results that have NaN values for either start_ca_num or end_ca_num. Save your results in trips_community_df. Hint: Use the start_station_name and end_station_name and the joined dataframe from the previous part to set these. You could try to use two normal pandas merges (one for start and one for end) as opposed to the sjoin method.

In [13]:
```
# Ensure that station_community_df contains a unique mapping of station_id to a
station_community_df_unique = station_community_df[['station_id', 'area_number

# Merge for Start Community Area
trips_with_start_ca = pd.merge(
    trips_pr_df,
    station_community_df_unique,
    left_on='start_station_id',
    right_on='station_id',
    how='left'
)
trips_with_start_ca.rename(columns={'area_number': 'start_ca_num'}, inplace=Tr
```

In [14]:
```
trips_with_start_ca.head()
```

Out[14]:

	ride_id	rideable_type	started_at	ended_at	start_station_name	start_st
0	762198876D69004D	docked_bike	2020-07-09 15:22:02	2020-07-09 15:25:52	Ritchie Ct & Banks St	
1	BEC9C9FBA0D4CF1B	docked_bike	2020-07-24 23:56:30	2020-07-25 00:20:17	Halsted St & Roscoe St	
2	D2FD8EA432C77EC1	docked_bike	2020-07-08 19:49:07	2020-07-08 19:56:22	Lake Shore Dr & Diversey Pkwy	
3	54AE594E20B35881	docked_bike	2020-07-17 19:06:42	2020-07-17 19:27:38	LaSalle St & Illinois St	
4	54025FDC7440B56F	docked_bike	2020-07-04 10:39:57	2020-07-04 10:45:05	Lake Shore Dr & North Blvd	

In [15]:
```
# Merge for End Community Area
trips_with_end_ca = pd.merge(
    trips_with_start_ca,
    station_community_df_unique,
    left_on='end_station_id',
    right_on='station_id',
    how='left'
)
trips_with_end_ca.rename(columns={'area_number': 'end_ca_num'}, inplace=True)
```

In [16]:
```
trips_with_start_ca.head()
```

Out[16]:

	ride_id	rideable_type	started_at	ended_at	start_station_name	start_st
0	762198876D69004D	docked_bike	2020-07-09 15:22:02	2020-07-09 15:25:52	Ritchie Ct & Banks St	
1	BEC9C9FBA0D4CF1B	docked_bike	2020-07-24 23:56:30	2020-07-25 00:20:17	Halsted St & Roscoe St	
2	D2FD8EA432C77EC1	docked_bike	2020-07-08 19:49:07	2020-07-08 19:56:22	Lake Shore Dr & Diversey Pkwy	
3	54AE594E20B35881	docked_bike	2020-07-17 19:06:42	2020-07-17 19:27:38	LaSalle St & Illinois St	
4	54025FDC7440B56F	docked_bike	2020-07-04 10:39:57	2020-07-04 10:45:05	Lake Shore Dr & North Blvd	

In [17]:
```
# Cleanup: Remove rows with NaN in start_ca_num or end_ca_num
trips_community_df = trips_with_end_ca.dropna(subset=['start_ca_num', 'end_ca_

# Drop extra station_id columns resulting from merges
trips_community_df.drop(columns=['station_id_x', 'station_id_y'], inplace=True

# Display the first few rows to verify the result
trips_community_df.head()
```

```
C:\Users\gxy\AppData\Local\Temp\ipykernel_16564\3847885979.py:5: SettingWithC
opyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy (https://panda
s.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-ver
sus-a-copy)
  trips_community_df.drop(columns=['station_id_x', 'station_id_y'], inplace=T
rue)
```

Out[17]:

	ride_id	rideable_type	started_at	ended_at	start_station_name	start_st
0	762198876D69004D	docked_bike	2020-07-09 15:22:02	2020-07-09 15:25:52	Ritchie Ct & Banks St	
1	BEC9C9FBA0D4CF1B	docked_bike	2020-07-24 23:56:30	2020-07-25 00:20:17	Halsted St & Roscoe St	
2	D2FD8EA432C77EC1	docked_bike	2020-07-08 19:49:07	2020-07-08 19:56:22	Lake Shore Dr & Diversey Pkwy	
3	54AE594E20B35881	docked_bike	2020-07-17 19:06:42	2020-07-17 19:27:38	LaSalle St & Illinois St	
4	54025FDC7440B56F	docked_bike	2020-07-04 10:39:57	2020-07-04 10:45:05	Lake Shore Dr & North Blvd	

3. Explaining the Joins (2 points): In a short (no more than a paragraph) description, please briefly answer the following inquiries. You can write either in Markdown or in code comments in the space provided in the notebook file.
   A. For each join conducted in steps 1 and 2, what was your rationale for using these particular join types?
   B. Did your final trips_community_df end up a different size from the original trips_pr_df dataframe? If so, what do you think caused this difference in size?

Answer for A: For Step 1, the spatial join was chosen because it is uniquely suited to geographic data, as it allows for the identification of which geographic area (a polygon) contains each point, a task that traditional dataframe merges cannot accomplish. This method ensures each station is accurately mapped to a community area based on its spatial coordinates, essential for any geographic analysis. For Step 2, traditional pandas merge operations were used instead of a spatial join because the task only asks simply to linki data based on common identifiers (station IDs and their associated community area

numbers). Each bike trip, characterized by start and end stations, needed to be augmented with the community area information obtained from Step 1. Using merge is effective in

Answer for B: Yes, the final trips_community_df likely ended up a different size compared to the original trips_pr_df dataframe due to the removal of entries that lacked start or end community area numbers (start_ca_num or end_ca_num). This discrepancy arises because some bike trips might start or end at stations that couldn't be matched with a community area, possibly due to missing or incorrect station location data, stations being located outside the defined community areas, or inaccuracies in the spatial join process. Additionally, the data cleaning step, which involves dropping rows with NaN values in the new community area columns, further filters out trips that cannot be accurately analyzed within the spatial context of Chicago's community areas. This filtering is crucial for maintaining the integrity and reliability of spatial analyses conducted with the dataset.

In [ ]:

4. Visualize Station Distribution (4 points): We want to understand which community areas have bike stations. Using geopandas, generate a plot of the number of stations per community area. This can be accomplished by aggregating the stations by community area. Then use the plot() command to generate a chloropleth map. Examples of possible chloropleth maps are provided below. You are allowed to define a colormap for your chloropleth map via the cmap parameter.

Hint(s): If you end up using groupby, you should recreate the GeoDataFrame before plotting. If your plot appears less like a geographic map and more like a collection of dots, make sure check that the geometry of your GeoDataFrame uses MultiPolygon rather than Point; this will depend largely on how you joined the stations_community_df.

In [18]:
```
import matplotlib.pyplot as plt

# Step 1: Aggregate stations by community area
station_counts = station_community_df.groupby('area_number').size().reset_inde
```

In [19]:
```
# Step 2: Use .dropna() to remove rows with any NaN values
community_stations = community_pr_df.merge(station_counts, on='area_number', h
```

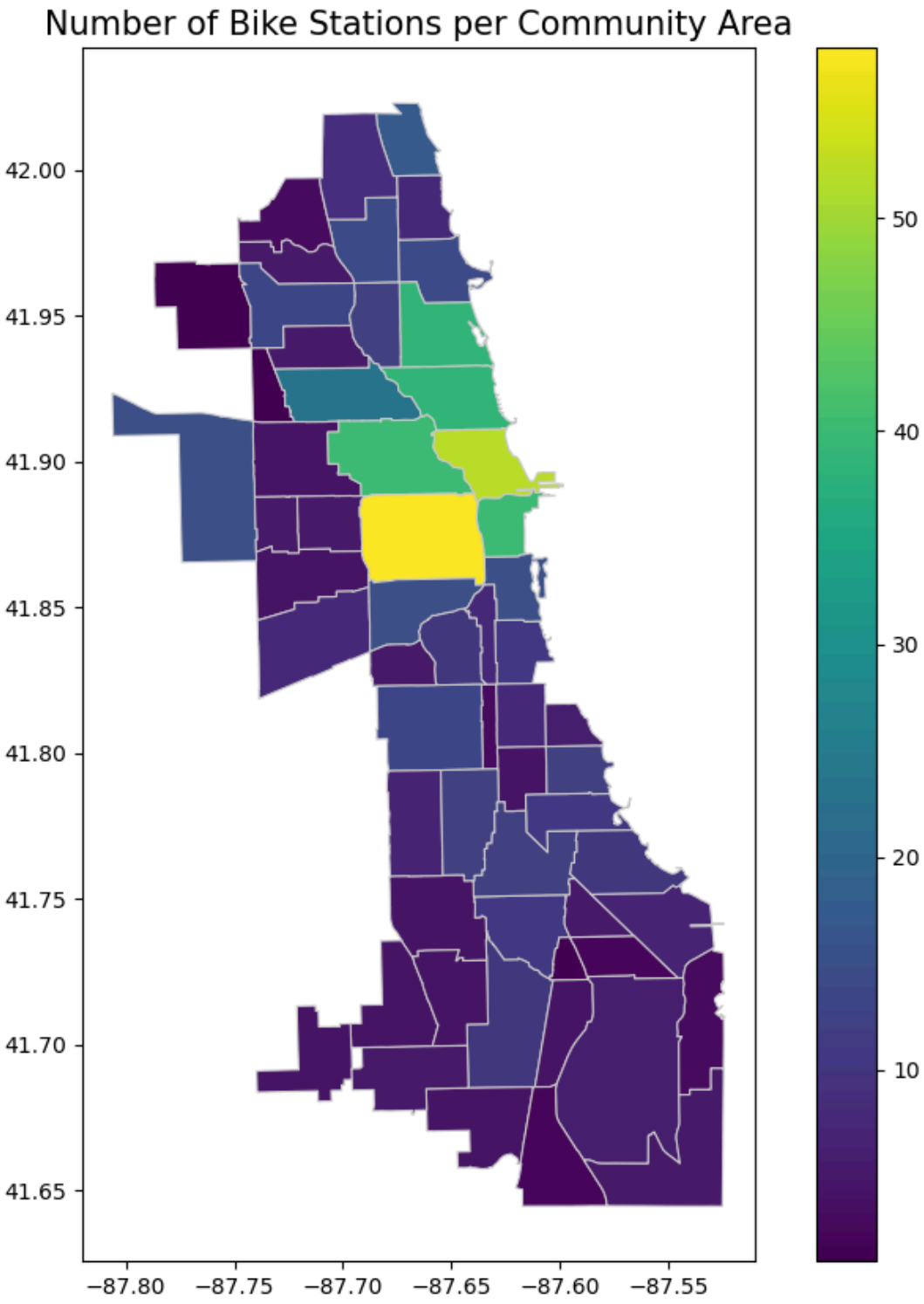
In [20]:

```
# Step 3: Plotting
fig, ax = plt.subplots(1, 1, figsize=(10, 10))
community_stations.plot(column='station_count', legend=True, linewidth=0.8, a

# Customize title and turn off axis
ax.set_title('Number of Bike Stations per Community Area', fontdict={'fontsize

# Instead of turning off the axis, adjust ticks for a cleaner look
ax.tick_params(axis='both', which='both', bottom=True, left=True, labelbotton

plt.show()
```



In [ ]:

In [ ]: