STA 141B Final Project

Fall 2018

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Problem: Is there a correlation between speeding and red light camera violations?

Case study: Chicago

Many people are likely to speed up as they approach an intersection when the traffic light turns yellow. It is dangerous and can sometimes lead to a fatal crash. The red light camera is intended to increase public safety by preventing people from running a red light, but is it really effective?

This common occurrence brought us to analyze the association between red light violations and speeding.

Data Extraction

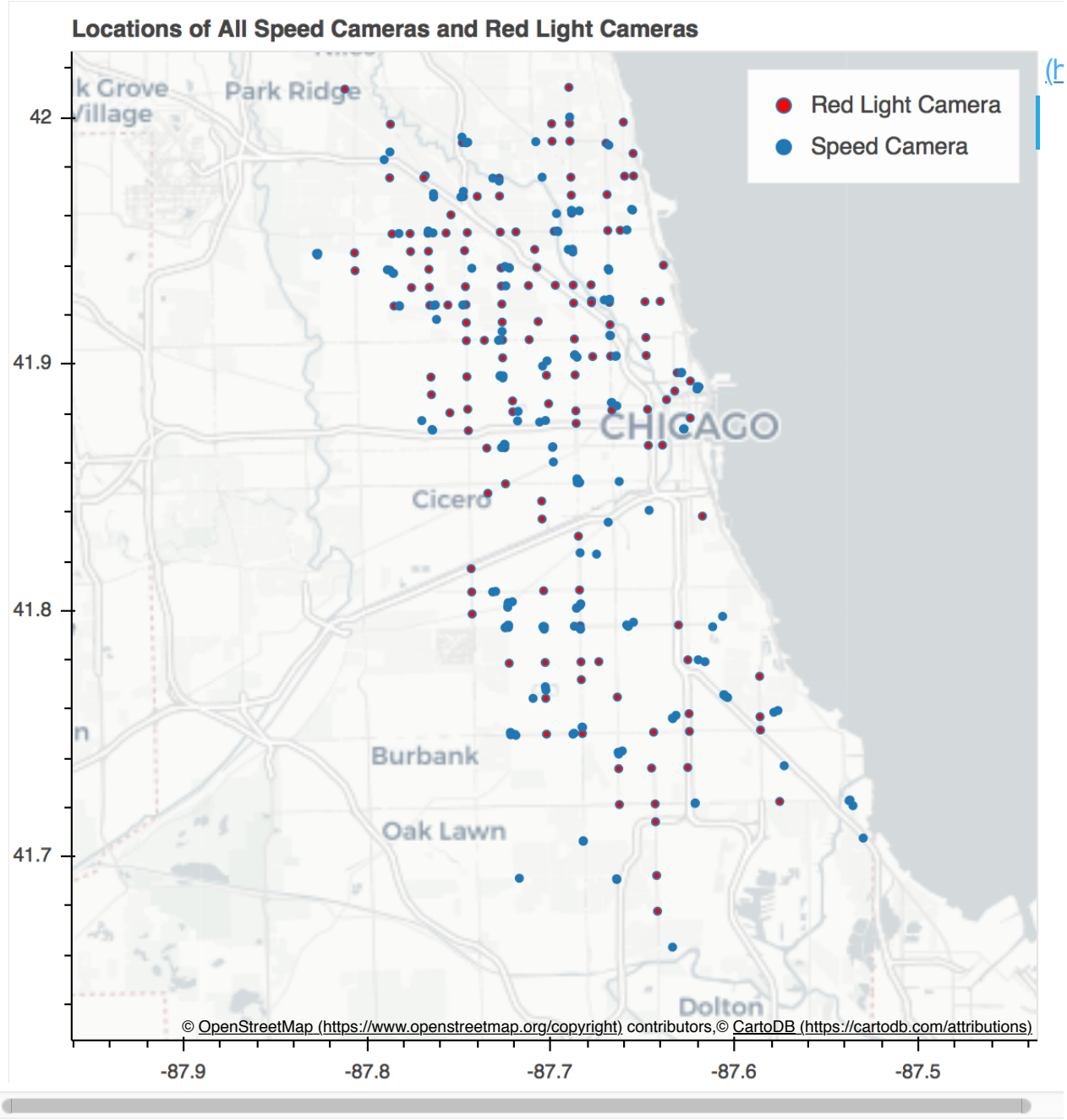
We obtained our data from the City of Chicago. There are four CSV files: red light camera locations, red light camera violations, speed camera locations, and speed camera violations (details of these data can be found at https://data.cityofchicago.org/browse?q=red+light+camera&sortBy=relevance (https://data.cityofchicago.org/browse?q=red+light+camera&sortBy=relevance)).

In [1]:
```
import os
import pandas as pd
import numpy as np
import math
from ast import literal_eval
from bokeh.plotting import figure, show, output_notebook
from bokeh.models.annotations import Title
from bokeh.tile_providers import CARTODBPOSITRON
import numpy
from scipy.stats import linregress
from scipy.stats import spearmanr
from plotnine import *
import warnings
warnings.filterwarnings('ignore')

redlight_loc = pd.read_csv('red-light-camera-locations.csv')
redlight_violations = pd.read_csv('red-light-camera-violations.csv')

speed_loc = pd.read_csv('speed-camera-locations.csv')
speed_violations = pd.read_csv('speed-camera-violations.csv')
```

`speed_loc` and `redlight_loc` have columns, latitude and longitude. We use Mercator projection to convert latitude and longitude into coordinates, and plot the locations of red light cameras and speed cameras.

In [2]:
```
# plot red light cameras and speed cameras locations
speed_loc["COORDINATES"] = '('+ speed_loc["LATITUDE"].astype(str) +','
+ speed_loc["LONGITUDE"].astype(str) + ')'
redlight_loc["COORDINATES"] = '('+ redlight_loc["LATITUDE"].astype(str
) +','+ redlight_loc["LONGITUDE"].astype(str) + ')'

def merc(Coords):
    Coordinates = literal_eval(Coords)
    lat = Coordinates[0]
    lon = Coordinates[1]

    r_major = 6378137.000
    x = r_major * math.radians(lon)
    scale = x/lon
    y = 180.0/math.pi * math.log(math.tan(math.pi/4.0 +
        lat * (math.pi/180.0)/2.0)) * scale
    return (x, y)

speed_loc['coords_x'] = speed_loc['COORDINATES'].apply(lambda x: merc(
x)[0])
speed_loc['coords_y'] = speed_loc['COORDINATES'].apply(lambda x: merc(
x)[1])

redlight_loc['coords_x'] = redlight_loc['COORDINATES'].apply(lambda x:
merc(x)[0])
redlight_loc['coords_y'] = redlight_loc['COORDINATES'].apply(lambda x:
merc(x)[1])

p = figure(x_range=(-9790000, -9735000), y_range=(5105000, 5165000),
           x_axis_type="mercator", y_axis_type="mercator")
p.add_tile(CARTODBPOSITRON)

p.circle(x = redlight_loc['coords_x'], y = redlight_loc['coords_y'], l
egend = "Red Light Camera", fill_color="#FF0000")
p.circle(x = speed_loc['coords_x'], y = speed_loc['coords_y'], legend
= "Speed Camera")

t = Title()
t.text = 'Locations of All Speed Cameras and Red Light Cameras'
p.title = t

p.legend.location = "top_right"
p.legend.click_policy="hide"

output_notebook()
show(p)
```

Loading BokehJS ...



In Chicago, 0.0001 latitude is about 111.2 meters when longitude is constant. When latitude is constant, 0.001 longitude is about 82.69 meters. link: https://www.movable-type.co.uk/scripts/latlong.html (https://www.movable-type.co.uk/scripts/latlong.html)

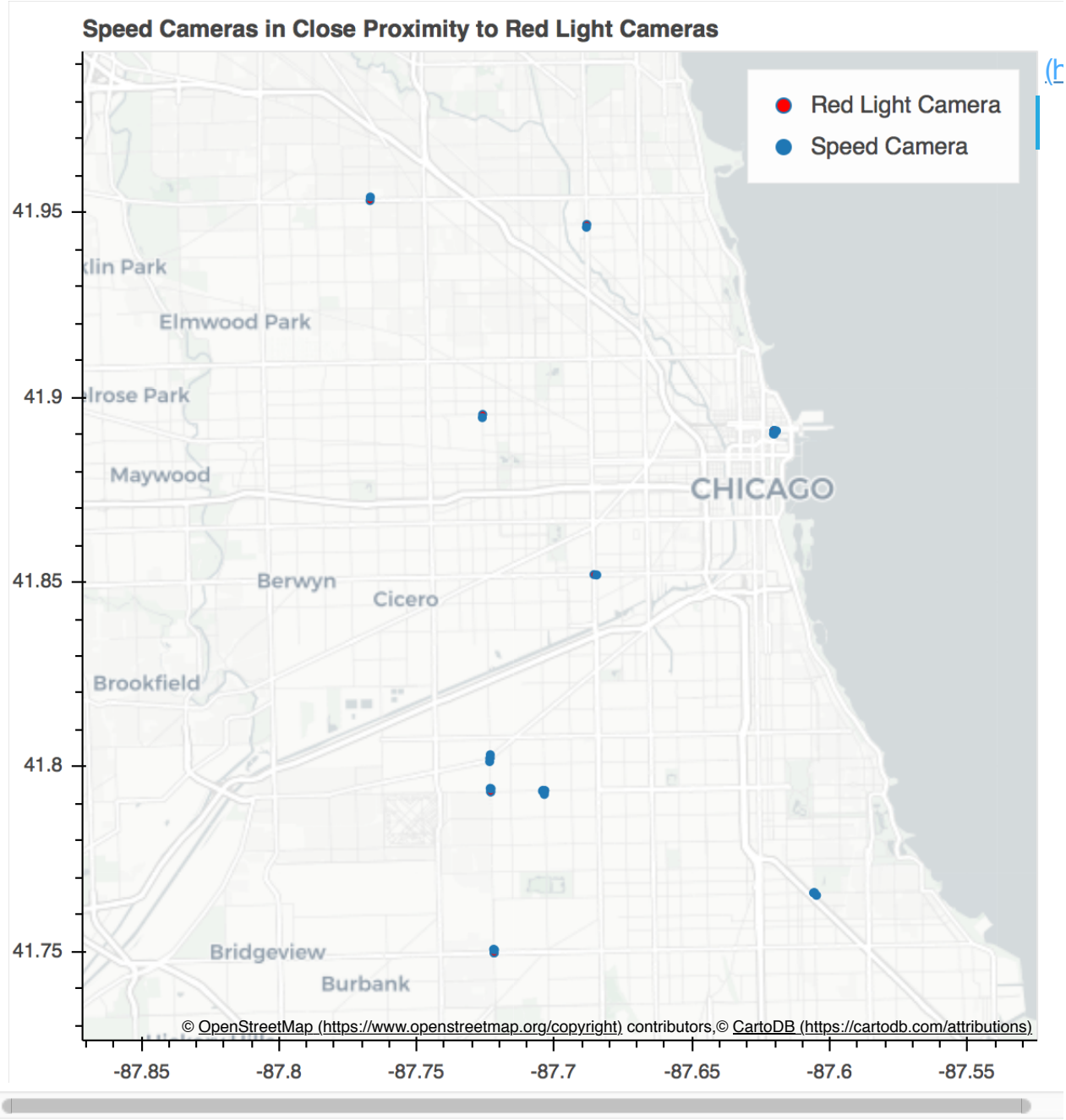
We subset the data by red light cameras and speed cameras that are near each other by 0.001 latitude and longitude.

In [3]:
```
# redlight_loc_copy is a subset of redlight_loc and contains the locat
ions of red light cameras near speed cameras
# speed_loc_copy is a subset of speed_loc and contains the locations o
f speed cameras near red light cameras
redlight_loc_copy = pd.DataFrame(columns = redlight_loc.columns.values
)
speed_loc_copy = pd.DataFrame(columns = speed_loc.columns.values)
pairs = pd.DataFrame(columns = ['speed', 'redlight'])

# find red light cameras near speed cameras
for i in range(0,speed_loc.shape[0]):
    for j in range(0,redlight_loc.shape[0]):
        if abs(speed_loc.iloc[i,4] - redlight_loc.iloc[j,5]) < 0.001 a
nd abs(speed_loc.iloc[i,5] - redlight_loc.iloc[j,6]) < 0.001:
            #if pd.to_datetime(speed_loc['GO-LIVE DATE']).dt.year[i] <
pd.to_datetime(redlight_loc['GO LIVE DATE']).dt.year[j]:
            redlight_loc_copy = redlight_loc_copy.append(redlight_loc.
iloc[j], ignore_index = True)
            speed_loc_copy = speed_loc_copy.append(speed_loc.iloc[i],
ignore_index = True)
            temp = pd.DataFrame({'speed': [speed_loc.iloc[i,0]], 'redl
ight': [redlight_loc.iloc[j,0]]})
            pairs = pairs.append(temp)
pairs = pairs.reset_index(drop = True)
```

In [4]:
```
# plot red light cameras near speed cameras
redlight_loc_copy["COORDINATES"] = '('+ redlight_loc_copy["LATITUDE"].
astype(str) +','+ redlight_loc_copy["LONGITUDE"].astype(str) + ')'
speed_loc_copy["COORDINATES"] = '('+ speed_loc_copy["LATITUDE"].astype
(str) +','+ speed_loc_copy["LONGITUDE"].astype(str) + ')'

speed_loc_copy['coords_x'] = speed_loc_copy['COORDINATES'].apply(lambd
a x: merc(x)[0])
speed_loc_copy['coords_y'] = speed_loc_copy['COORDINATES'].apply(lambd
a x: merc(x)[1])

redlight_loc_copy['coords_x'] = redlight_loc_copy['COORDINATES'].apply
(lambda x: merc(x)[0])
redlight_loc_copy['coords_y'] = redlight_loc_copy['COORDINATES'].apply
(lambda x: merc(x)[1])

p = figure(x_range=(-9780000, -9745000), y_range=(5120000, 5160000),
           x_axis_type="mercator", y_axis_type="mercator")
p.add_tile(CARTODBPOSITRON)

p.circle(x = redlight_loc_copy['coords_x'], y = redlight_loc_copy['coo
rds_y'], legend = "Red Light Camera", fill_color="#FF0000")
p.circle(x = speed_loc_copy['coords_x'], y = speed_loc_copy['coords_y'
], legend = "Speed Camera",)

t = Title()
t.text = 'Speed Cameras in Close Proximity to Red Light Cameras'
p.title = t

p.legend.location = "top_right"
p.legend.click_policy="hide"

output_notebook()
show(p)
```

(https://bokeh.pydata.org)

BokehJS 1.0.1 successfully loaded.



In [7]:
```
# change format of addresses in speed_loc_copy to match format of addr
esses in speed_violations
remove = ["(Speed", "Camera)", "Ave", "ST", "Rd", "St", "Blvd"]
for i in range(0, speed_loc_copy.shape[0]):
    speed_loc_copy.iloc[i,0] = " ".join([word for word in speed_loc_co
py.iloc[i,0].split() if word not in remove])

for i in range(0, pairs.shape[0]):
    pairs.iloc[i,0] = " ".join([word for word in pairs.iloc[i,0].split
() if word not in remove]).upper()
    pairs.iloc[i,1] = pairs.iloc[i,1].upper()

speed_violations_copy = pd.DataFrame(columns = speed_violations.column
s.values)

# subset speed violations where speed cameras are near red light camer
as
for i in range(0, speed_loc_copy.shape[0]):
    address = speed_violations[speed_violations['ADDRESS'].str.contain
s(speed_loc_copy.iloc[i,0].upper())]
    speed_violations_copy = speed_violations_copy.append(address, igno
re_index = True)
    if len(address.index) > 0:
        pairs.iloc[i,0] = address.iloc[0,0]
```

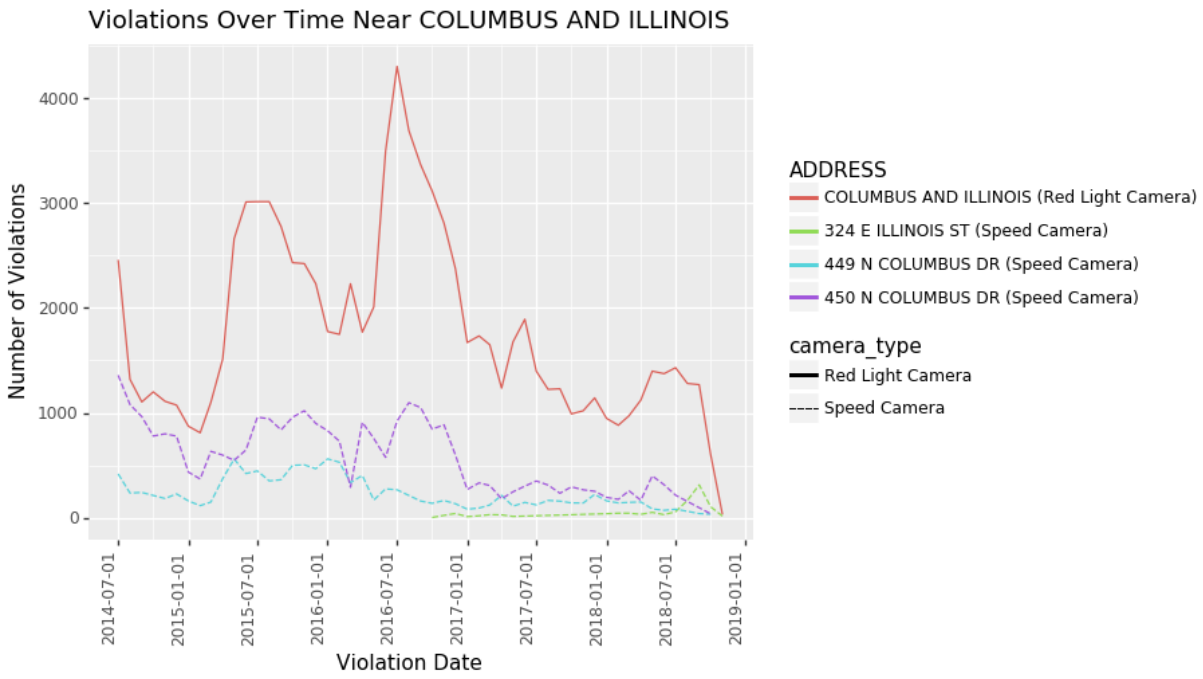
In [8]:
```
redlight_violations_copy = pd.DataFrame(columns = redlight_violations.
columns.values)

# subset red light violations where speed cameras are near red light c
ameras
# this will take a while
for i in range (0, redlight_violations.shape[0]):
    for j in range(0, redlight_loc_copy.shape[0]):
        intersection1 = redlight_violations.iloc[i,0].replace(' AND ',
'/').replace(' and ', '/').split('/')
        intersection2 = redlight_loc_copy.iloc[j,0].split('-')
        if len(intersection1) > 1 and len(intersection2) > 1:
            if intersection1[0] == intersection2[0].upper() or interse
ction1[0] == intersection2[1].upper():
                if intersection1[1] == intersection2[0].upper() or int
ersection1[1] == intersection2[1].upper():
                    redlight_violations_copy = redlight_violations_cop
y.append(redlight_violations.iloc[i], ignore_index = True)
                    pairs.iloc[j,1] = redlight_violations.iloc[i,0]
```

In [17]:
```
redlight = redlight_violations_copy.groupby('INTERSECTION')['VIOLATION
S'].sum().sort_values(ascending = False)
```

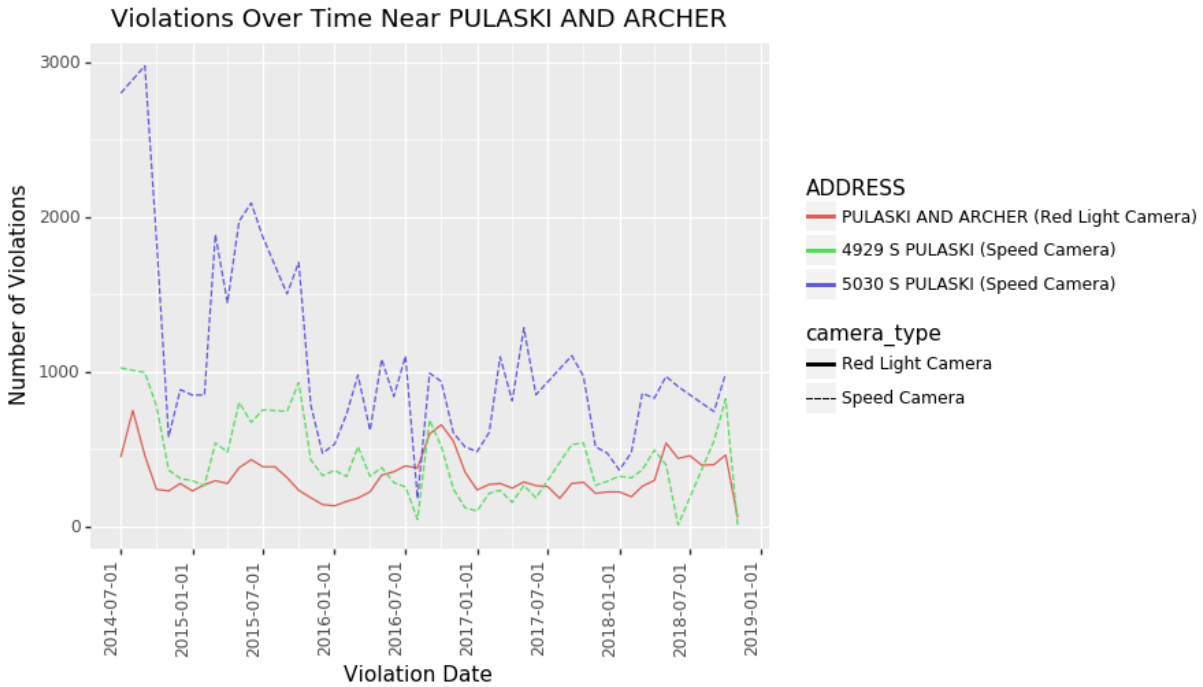
```
# output in order of most red light violations to least red light viol
ations
for i in range(0, len(redlight)):
    rlc_violation_intersection = redlight_violations_copy.loc[redlight
_violations_copy['INTERSECTION'].str.contains(redlight.axes[0][i])].re
set_index(drop = True)

    rlc_speed = pd.DataFrame()
    temp = pairs.loc[pairs['redlight'] == rlc_violation_intersection.i
loc[0,0]].reset_index(drop = True).iloc[:, 0].tolist()
    for j in range(0, len(temp)):
        rlc_speed = rlc_speed.append(speed_violations_copy.loc[speed_v
iolations_copy['ADDRESS'].str.contains(temp[j])].reset_index(drop = Tr
ue))

    temp1 = rlc_speed
    temp1['VIOLATION DATE'] = pd.to_datetime(temp1['VIOLATION DATE'])
    temp2 = rlc_violation_intersection
    temp2['VIOLATION DATE'] = pd.to_datetime(temp2['VIOLATION DATE'])

    for k in range(0, len(temp1['ADDRESS'].value_counts())):
        temp = temp1.loc[temp1['ADDRESS'] == temp1['ADDRESS'].value_co
unts().index[k]]
        x1 = pd.DataFrame()
        x2 = pd.DataFrame()
        for l in range(0, len(temp)):
            for m in range(0, len(temp2)):
                if(temp['VIOLATION DATE'][l] == temp2['VIOLATION DATE'
][m]):
                    x1 = x1.append(temp.iloc[l])
                    x2 = x2.append(temp2.iloc[m])
        #print('The Pearson correlation coefficient for speed violatio
ns at ', temp.iloc[0,0], ' and red light violations at ', x2.iloc[0,2]
, ' is ', numpy.corrcoef(x1['VIOLATIONS'], x2['VIOLATIONS'])[0,1], '.'
, sep = '')
        print('The Spearman correlation coefficient and p-value for sp
eed violations at ', temp.iloc[0,0], ' and red light violations at ',
x2.iloc[0,2], ' are ', spearmanr(x1['VIOLATIONS'], x2['VIOLATIONS'])[0
], ' and ', spearmanr(x1['VIOLATIONS'], x2['VIOLATIONS'])[1], ', respe
ctively.', sep = '')
        #print('R-squared for speed violations at ', temp.iloc[0,0], '
and red light violations at ', x2.iloc[0,2], ' is ', linregress(x1['VI
OLATIONS'], x2['VIOLATIONS'])[2] ** 2, '.', sep = '')

    rlc_speed['date'] = pd.to_datetime(rlc_speed['VIOLATION DATE']).ap
ply(lambda x: x.strftime('%Y-%m'))
    rlc_speed['date'] = pd.to_datetime(rlc_speed['date'])
    temp = rlc_speed.groupby(['ADDRESS', 'date'])['VIOLATIONS'].sum()
    plotdata_speed = pd.DataFrame({'ADDRESS': temp.index.get_level_val
ues('ADDRESS'), 'date': temp.index.get_level_values('date'),'count': t
```

```
emp.values})
    plotdata_speed['camera_type'] = 'Speed Camera'

    rlc_violation_intersection['date'] = pd.to_datetime(rlc_violation_
intersection['VIOLATION DATE']).apply(lambda x: x.strftime('%Y-%m'))
    rlc_violation_intersection['date'] = pd.to_datetime(rlc_violation_
intersection['date'])
    temp = rlc_violation_intersection.groupby('date')['VIOLATIONS'].su
m()
    plotdata_redlight = pd.DataFrame({'date': temp.index.get_level_val
ues('date'), 'count': temp.values,'ADDRESS': rlc_violation_intersectio
n.iloc[0,0]})
    plotdata_redlight['camera_type'] = 'Red Light Camera'

    plotdata_speed = plotdata_speed.loc[plotdata_speed['count'] != 0]
    plotdata_redlight = plotdata_redlight.loc[plotdata_redlight['count
'] != 0]

    plotdata_speed['ADDRESS'] += ' (Speed Camera)'
    plotdata_redlight['ADDRESS'] += ' (Red Light Camera)'

    print(ggplot(aes(x = 'date', y = 'count', color = 'ADDRESS', linet
ype = 'camera_type'), data = plotdata_redlight)
      + geom_line()
      + geom_line(aes(x = 'date', y = 'count', color = 'ADDRESS', line
type = 'camera_type'), data = plotdata_speed)
      + labs(x = 'Violation Date', y = 'Number of Violations')
      + theme(axis_text_x  = element_text(angle = 90, hjust = 1))
      + ggtitle('Violations Over Time Near ' + rlc_violation_intersect
ion.iloc[0,0]))
```

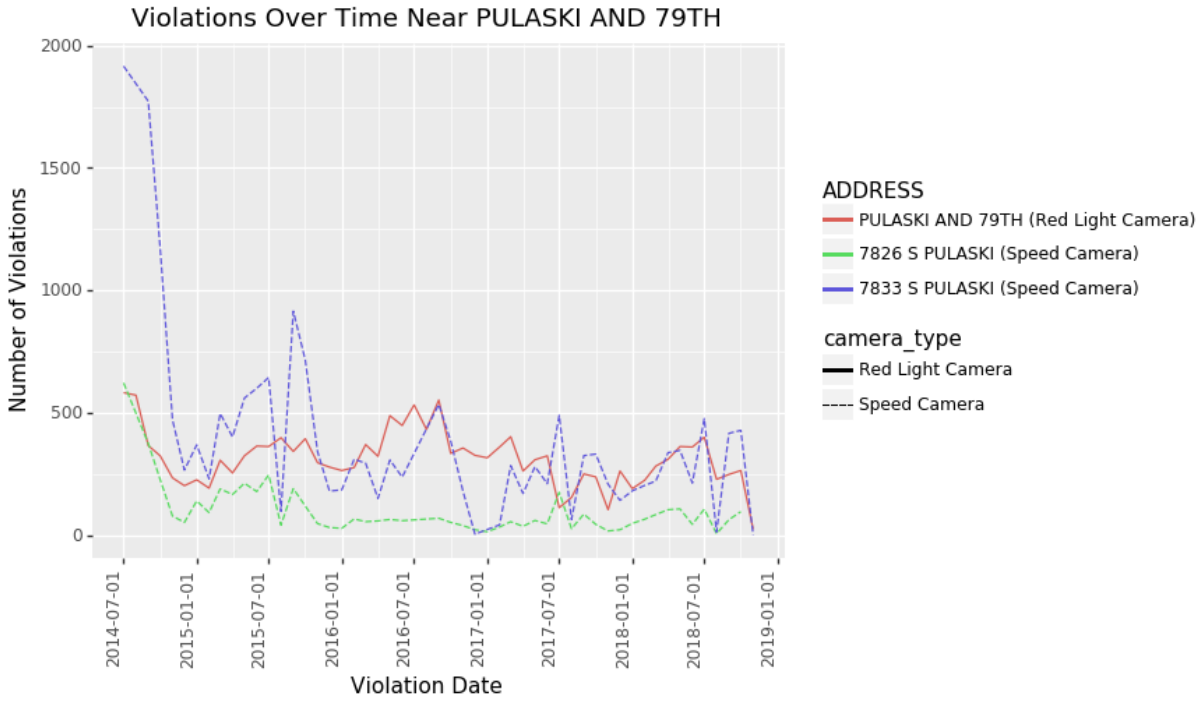
```
The Spearman correlation coefficient and p-value for speed violation
s at 449 N COLUMBUS DR and red light violations at COLUMBUS AND ILLI
NOIS are 0.162963453255 and 2.78044192069e-52, respectively.
The Spearman correlation coefficient and p-value for speed violation
s at 450 N COLUMBUS DR and red light violations at COLUMBUS AND ILLI
NOIS are 0.264360762275 and 2.79546990715e-134, respectively.
The Spearman correlation coefficient and p-value for speed violation
s at 324 E ILLINOIS ST and red light violations at COLUMBUS AND ILLI
NOIS are -0.0754133215296 and 0.00111370502749, respectively.
```



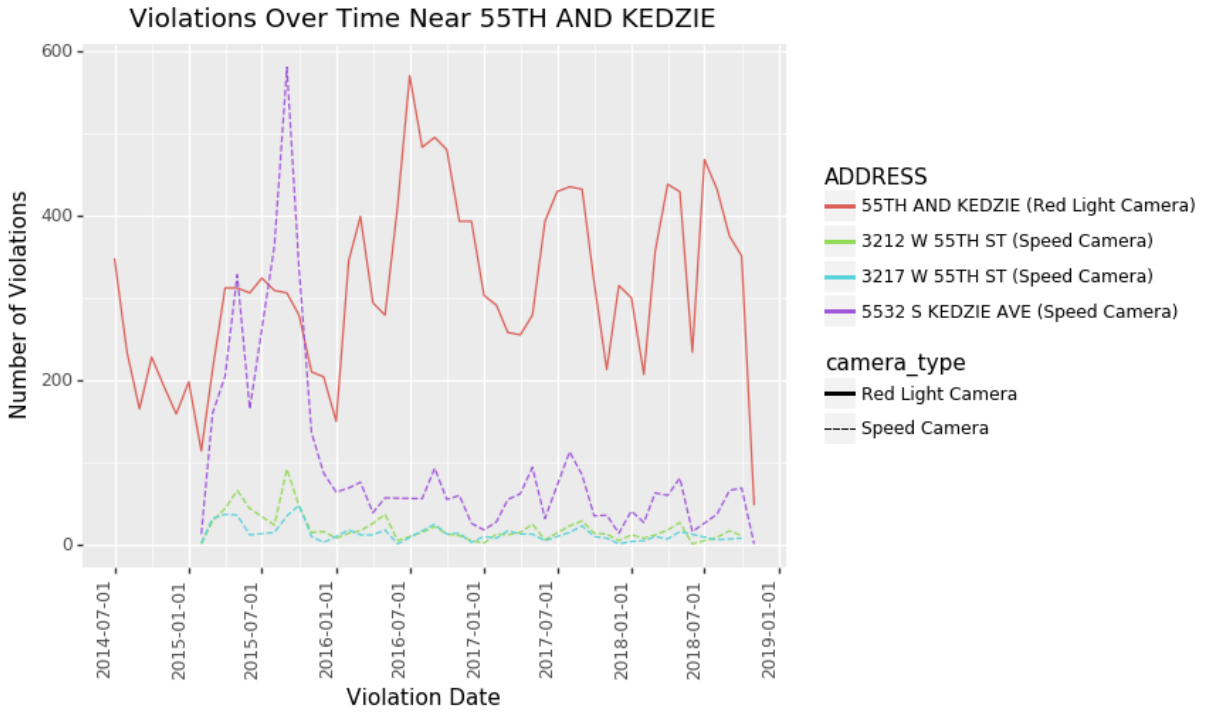
<ggplot: (-9223372036557937250)>
The Spearman correlation coefficient and p-value for speed violations at 5030 S PULASKI and red light violations at PULASKI AND ARCHER are 0.0858098835074 and 8.32305340821e-06, respectively.
The Spearman correlation coefficient and p-value for speed violations at 4929 S PULASKI and red light violations at PULASKI AND ARCHER are 0.0805567849214 and 3.18889544956e-05, respectively.



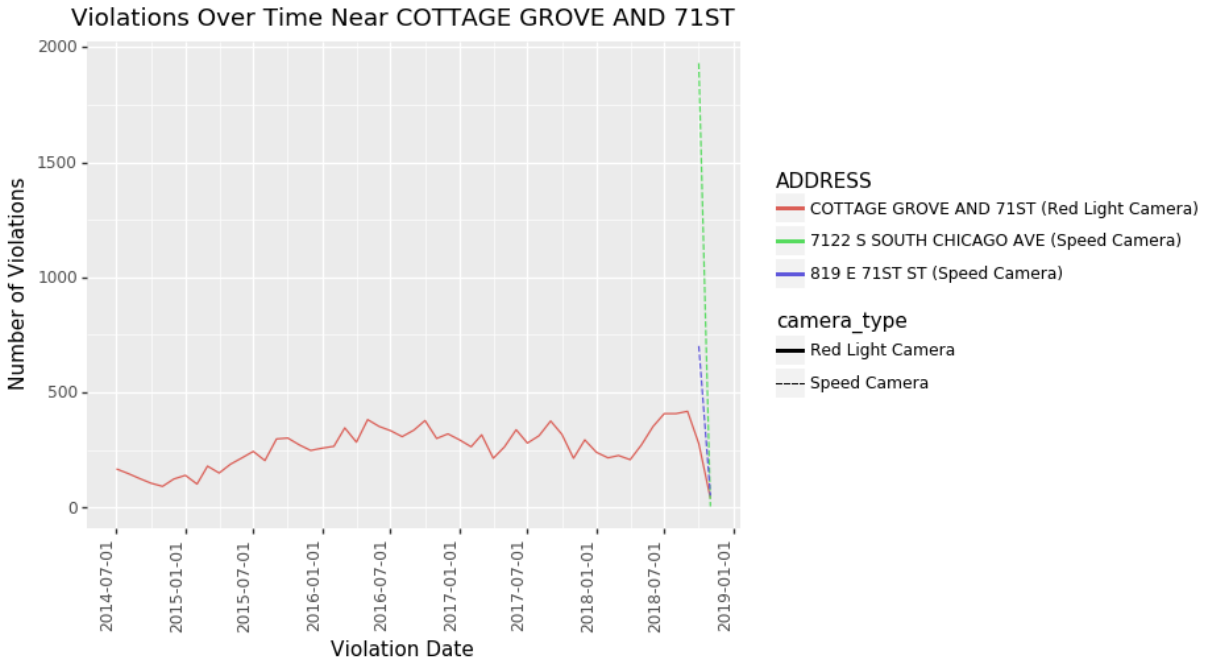
```
<ggplot: (-9223372036541700804)>
The Spearman correlation coefficient and p-value for speed violation
s at 7833 S PULASKI and red light violations at PULASKI AND 79TH are
0.0421715594408 and 0.0309514706502, respectively.
The Spearman correlation coefficient and p-value for speed violation
s at 7826 S PULASKI and red light violations at PULASKI AND 79TH are
0.0141353546134 and 0.468865265261, respectively.
```



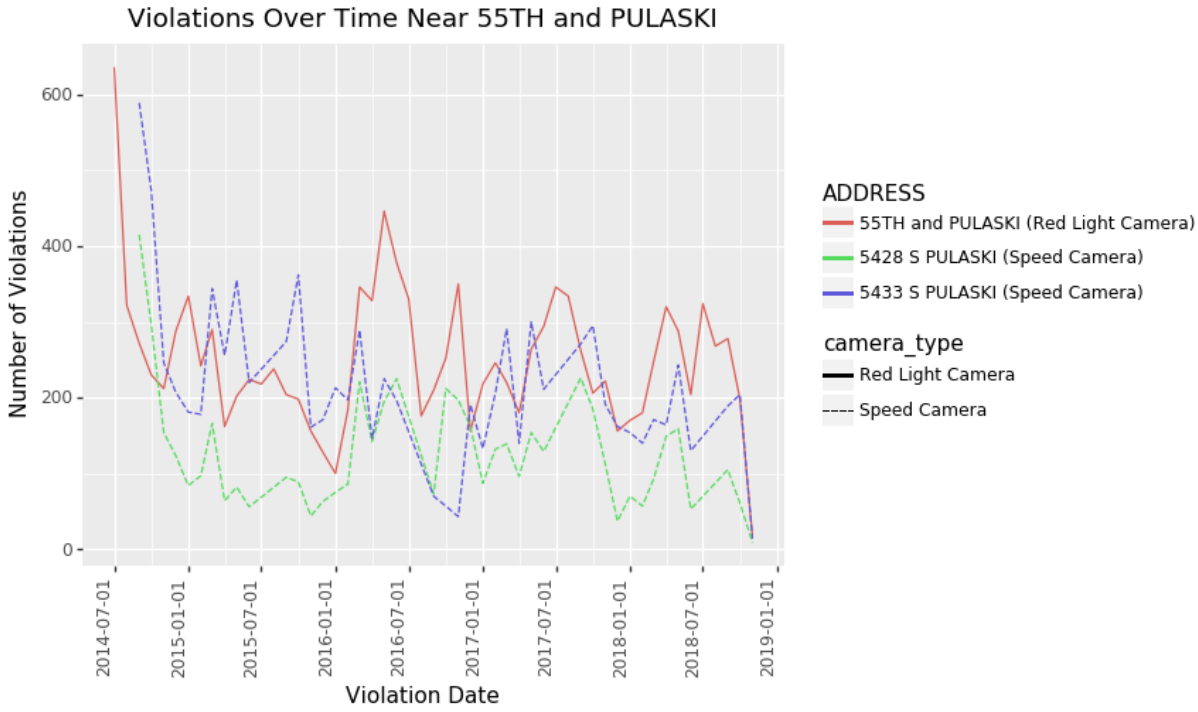

```
<ggplot: (296454415)>
The Spearman correlation coefficient and p-value for speed violation
s at 5532 S KEDZIE AVE and red light violations at 55TH AND KEDZIE a
re 0.0196416695613 and 0.30387986204, respectively.
The Spearman correlation coefficient and p-value for speed violation
s at 3212 W 55TH ST and red light violations at 55TH AND KEDZIE are
-0.0428981540587 and 0.065662139916, respectively.
The Spearman correlation coefficient and p-value for speed violation
s at 3217 W 55TH ST and red light violations at 55TH AND KEDZIE are
0.0192534438388 and 0.450386639939, respectively.
```



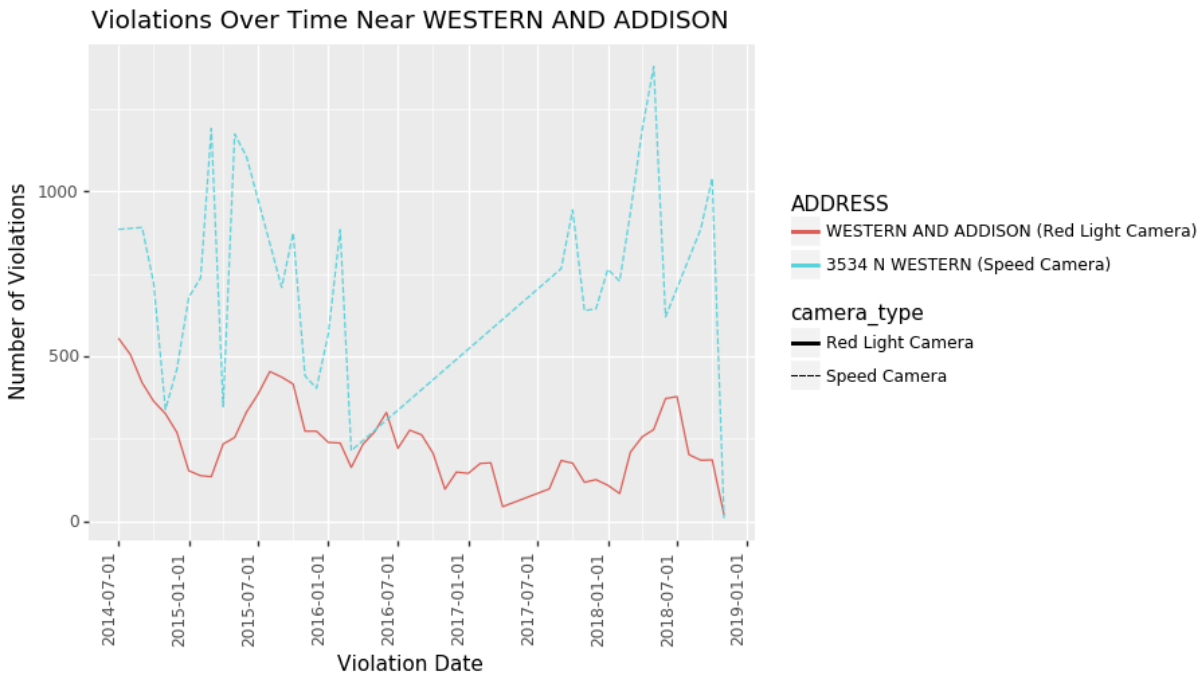
<ggplot: (296718095)>
The Spearman correlation coefficient and p-value for speed violations at 819 E 71ST ST and red light violations at COTTAGE GROVE AND 71ST are -0.298144378532 and 0.0121817373417, respectively.
The Spearman correlation coefficient and p-value for speed violations at 7122 S SOUTH CHICAGO AVE and red light violations at COTTAGE GROVE AND 71ST are -0.0650908855775 and 0.597942453407, respectively.



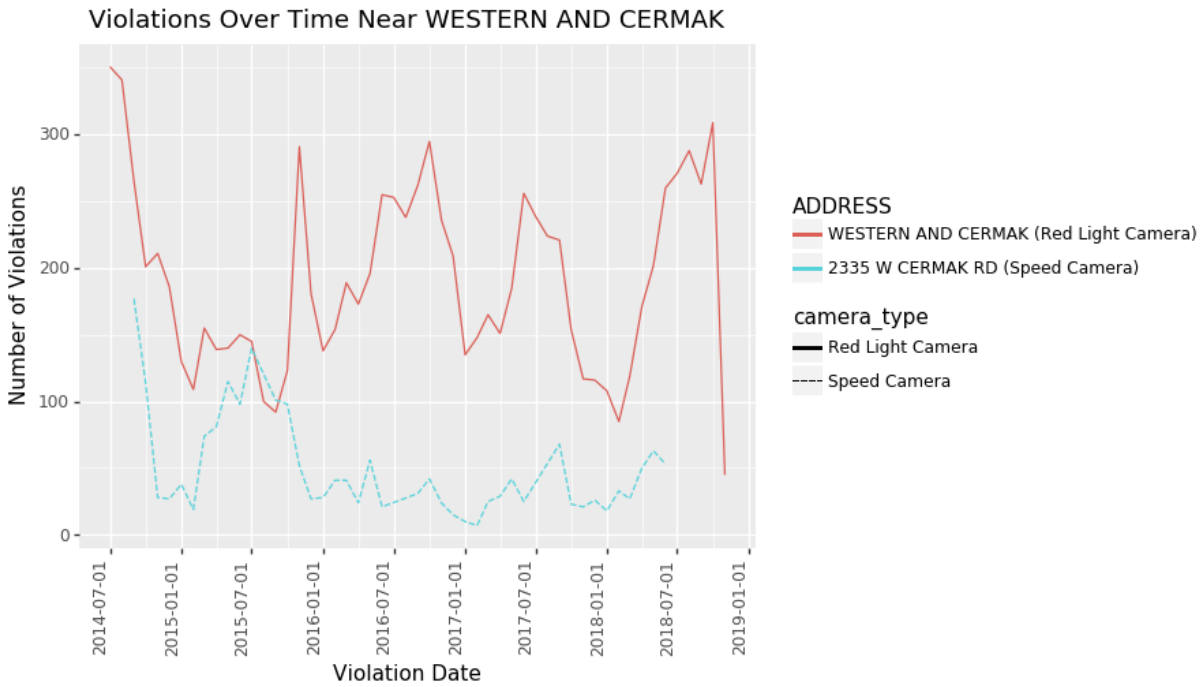
```
<ggplot: (-9223372036558081392)>
The Spearman correlation coefficient and p-value for speed violation
s at 5433 S PULASKI and red light violations at 55TH and PULASKI are
0.0513666664902 and 0.0130290766203, respectively.
The Spearman correlation coefficient and p-value for speed violation
s at 5428 S PULASKI and red light violations at 55TH and PULASKI are
0.126406090074 and 1.19662717129e-09, respectively.
```



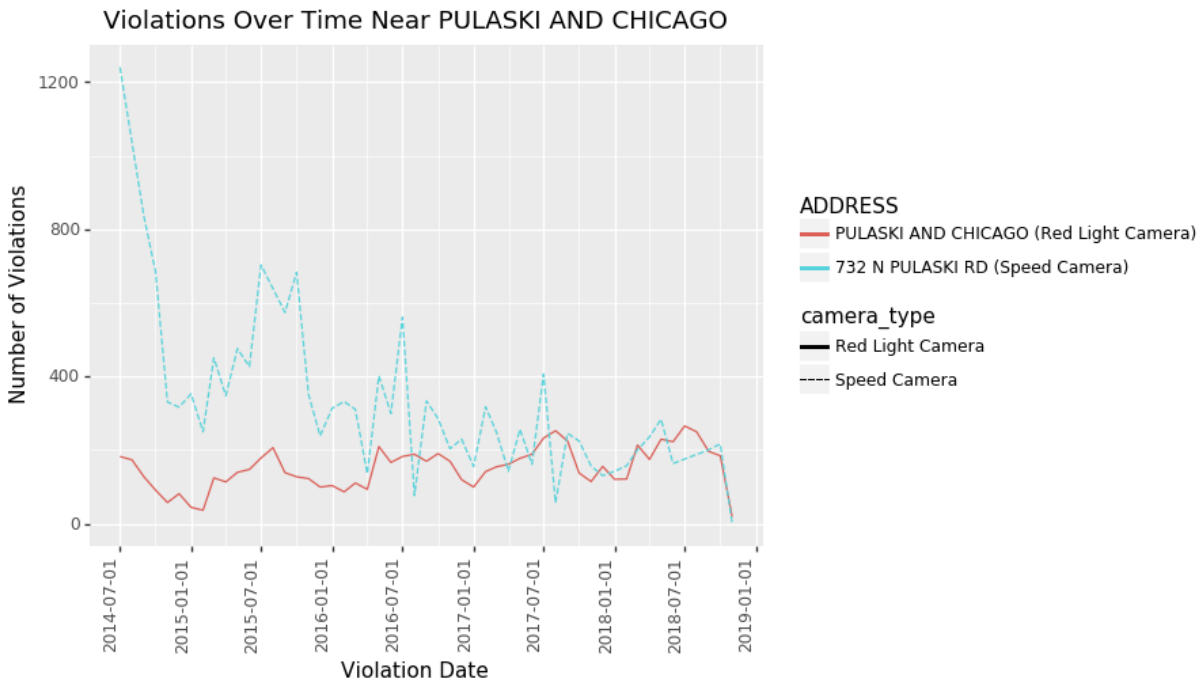

```
<ggplot: (-9223372036557143587)>
The Spearman correlation coefficient and p-value for speed violation
s at 3534 N WESTERN and red light violations at WESTERN AND ADDISON
are 0.0829683054404 and 0.0101969649149, respectively.
```



<ggplot: (296568475)>
The Spearman correlation coefficient and p-value for speed violations at 2335 W CERMAK RD and red light violations at WESTERN AND CERMAK are 0.0126478366504 and 0.693407633301, respectively.

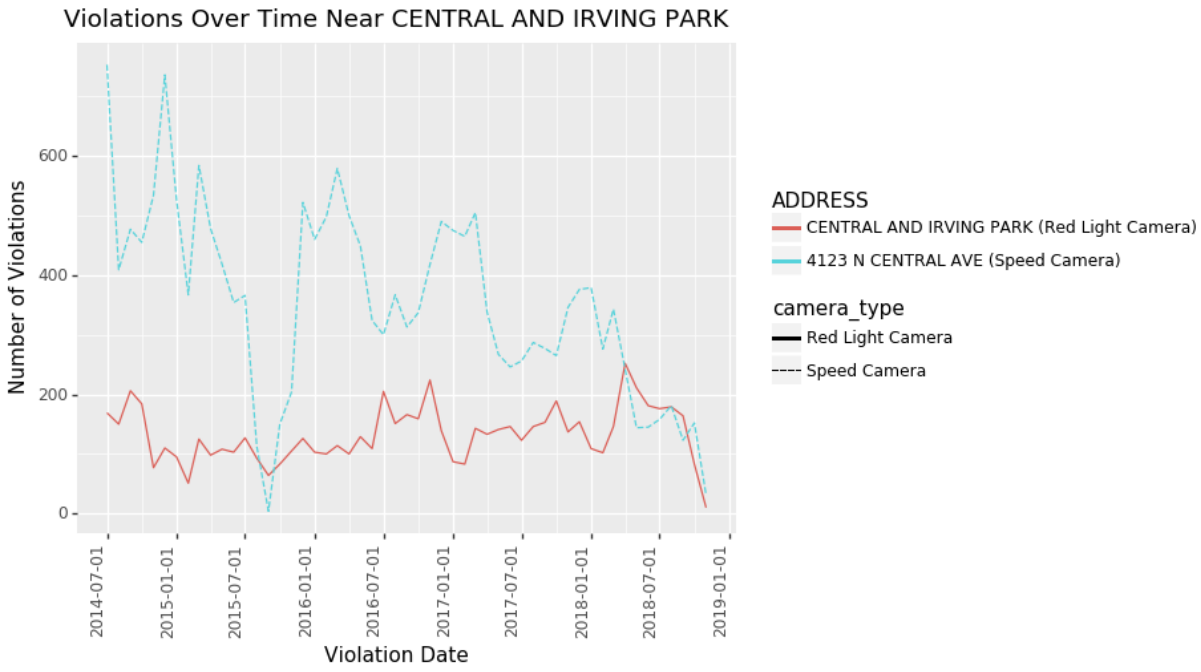


<ggplot: (294987605)>
The Spearman correlation coefficient and p-value for speed violations at 732 N PULASKI RD and red light violations at PULASKI AND CHICAGO are -0.0305480932393 and 0.274597466049, respectively.




```
<ggplot: (297608989)>
```

The Spearman correlation coefficient and p-value for speed violations at 4123 N CENTRAL AVE and red light violations at CENTRAL AND IRVING PARK are -0.0261146025436 and 0.198785140848, respectively.




```
<ggplot: (-9223372036557175566)>
```

In [ ]: