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_lo
c["LONGITUDE"].astype(str) + ')'
redlight_loc["COORDINATES"] = '('+ redlight_loc["LATITUDE"].astype(str) +','+ re
dlight_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'], legend = "R
ed Light Camera", fill_color="#FF0000")
p.circle(x = speed_loc['coords_x'], y = speed_loc['coords_y'], legend = "Speed C
amera")

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 ...

(https://github.com/pydata/pandas)

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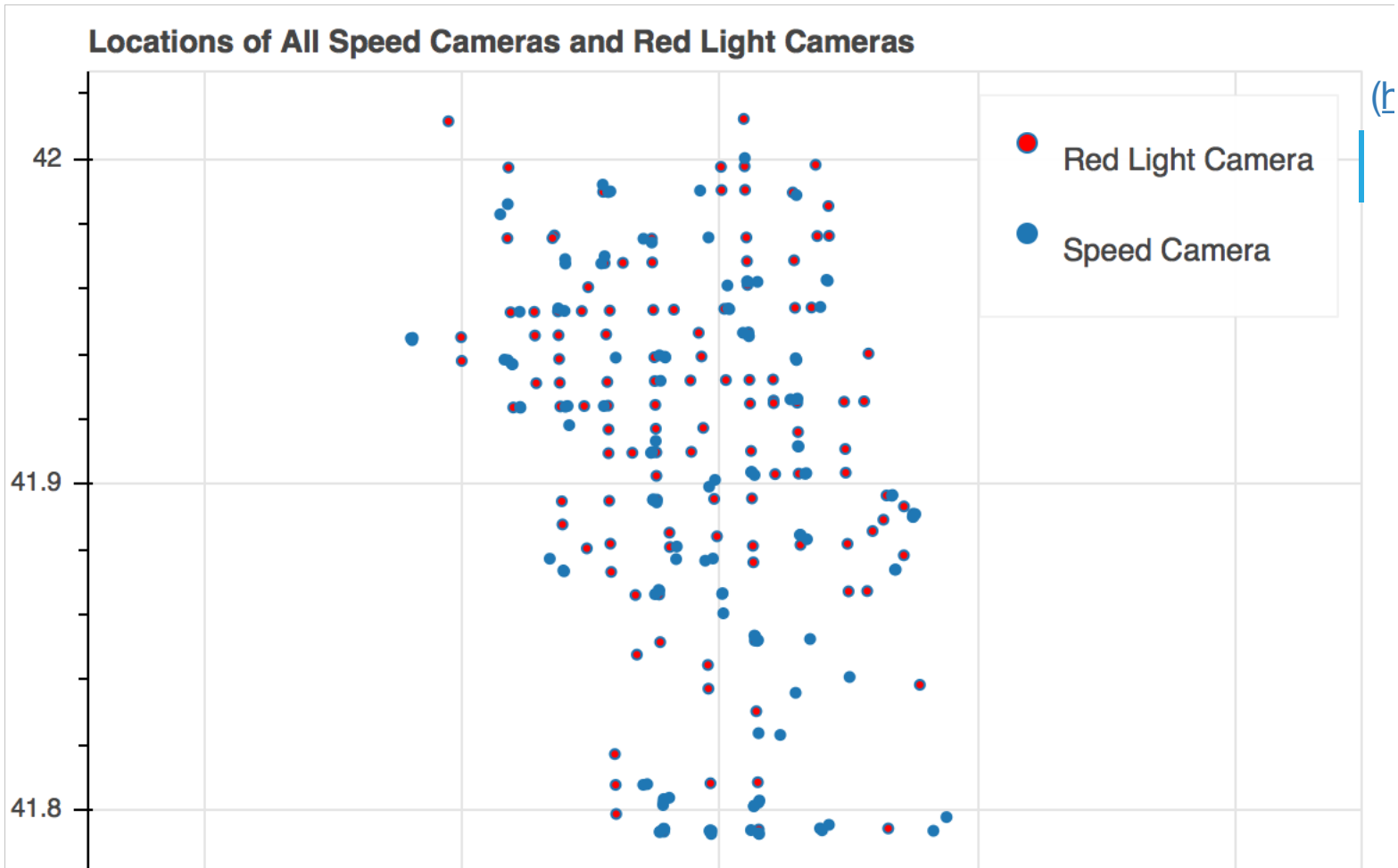

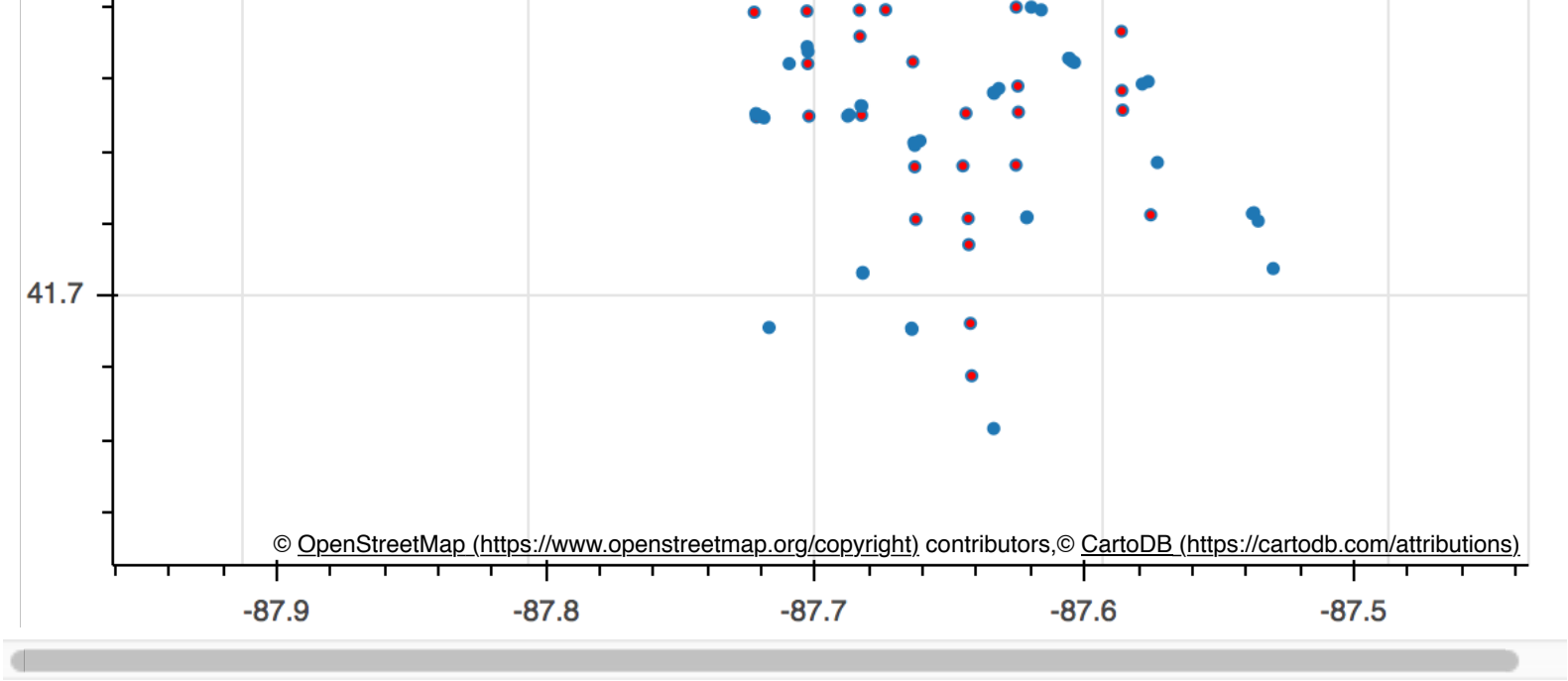

In Chicago, 0.0001 latitude is about 111.2 meters when longitude is constant. When latitude is constant, 0.001 longitude is about 82.69 meters. link: https://www.movable-type.co.uk/scripts/latlong.html (https://www.movable-type.co.uk/scripts/latlong.html)

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 locations of re
d light cameras near speed cameras
# speed_loc_copy is a subset of speed_loc and contains the locations of speed ca
meras 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 and abs(spe
ed_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_dat
etime(redlight_loc['GO LIVE DATE']).dt.year[j]:
            redlight_loc_copy = redlight_loc_copy.append(redlight_loc.iloc[j], i
gnore_index = True)
            speed_loc_copy = speed_loc_copy.append(speed_loc.iloc[i], ignore_ind
ex = True)
            temp = pd.DataFrame({'speed': [speed_loc.iloc[i,0]], 'redlight': [re
dlight_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(lambda x: merc(
x)[0])
speed_loc_copy['coords_y'] = speed_loc_copy['COORDINATES'].apply(lambda 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['coords_y'], l
egend = "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)

Bokeh 1.0.1 successfully loaded.

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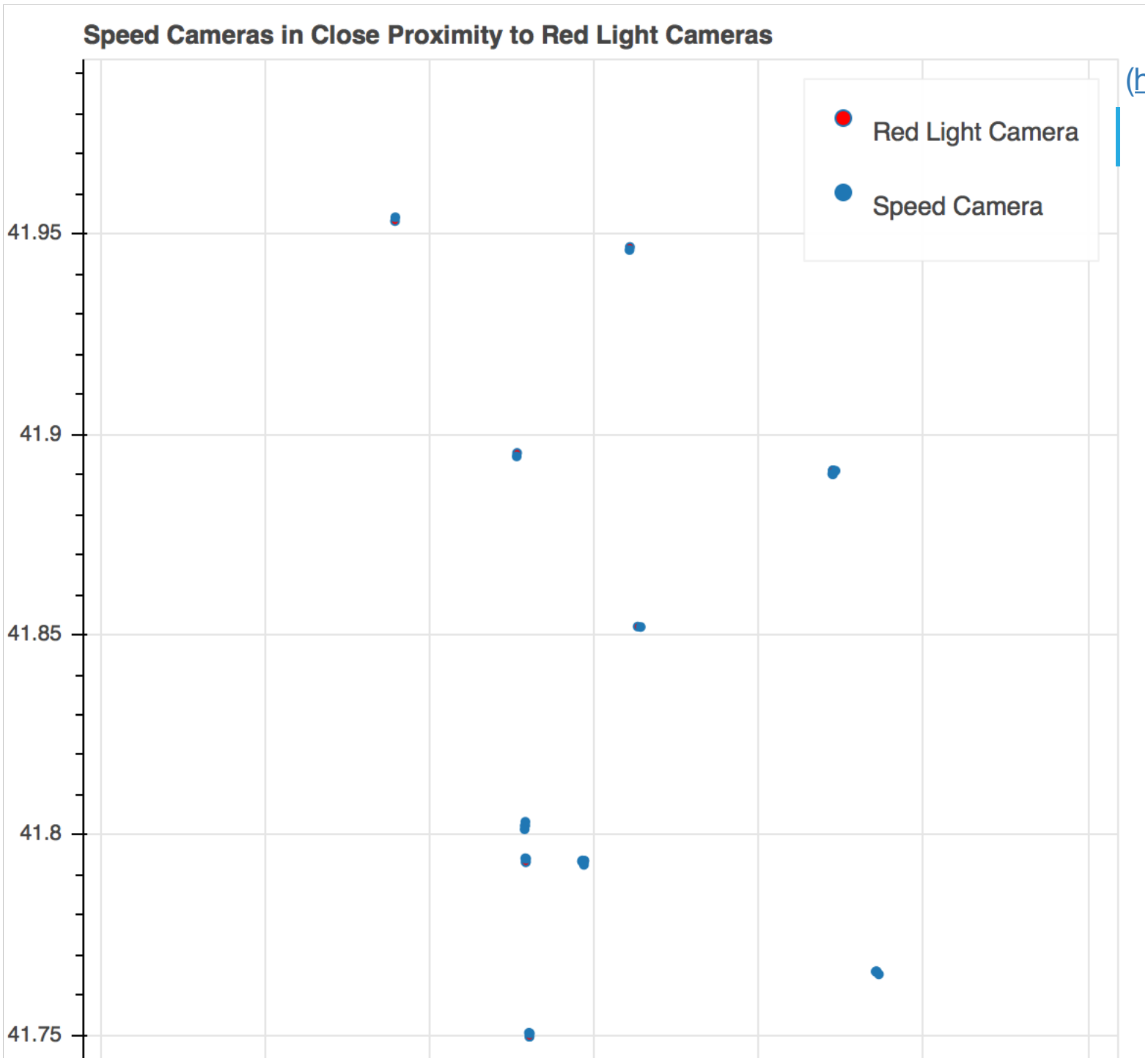
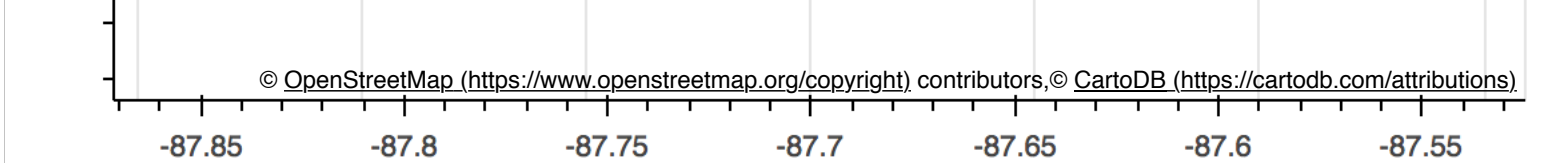




In [7]:

```
# change format of addresses in speed_loc_copy to match format of addresses in s
peed_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_copy.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.columns.values)

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

In [8]:

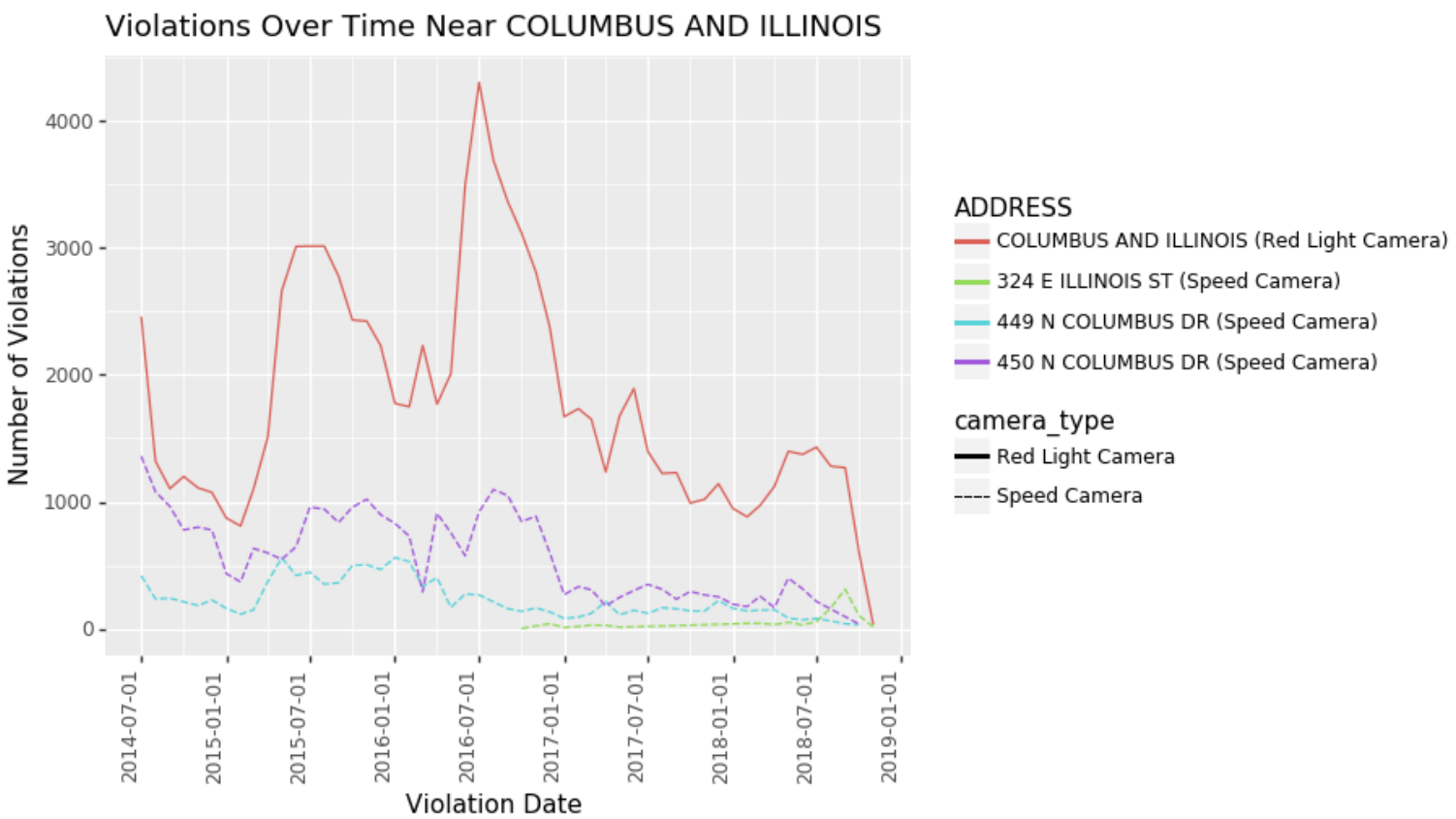
```
redlight_violations_copy = pd.DataFrame(columns = redlight_violations.columns.va
lues)

# subset red light violations where speed cameras are near red light cameras
# 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 ', '/').repl
ace(' 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 intersection1[0]
== intersection2[1].upper():
                if intersection1[1] == intersection2[0].upper() or intersection1
[1] == intersection2[1].upper():
                    redlight_violations_copy = redlight_violations_copy.append(r
edlight_violations.iloc[i], ignore_index = True)
                    pairs.iloc[j,1] = redlight_violations.iloc[i,0]
```

In [17]:

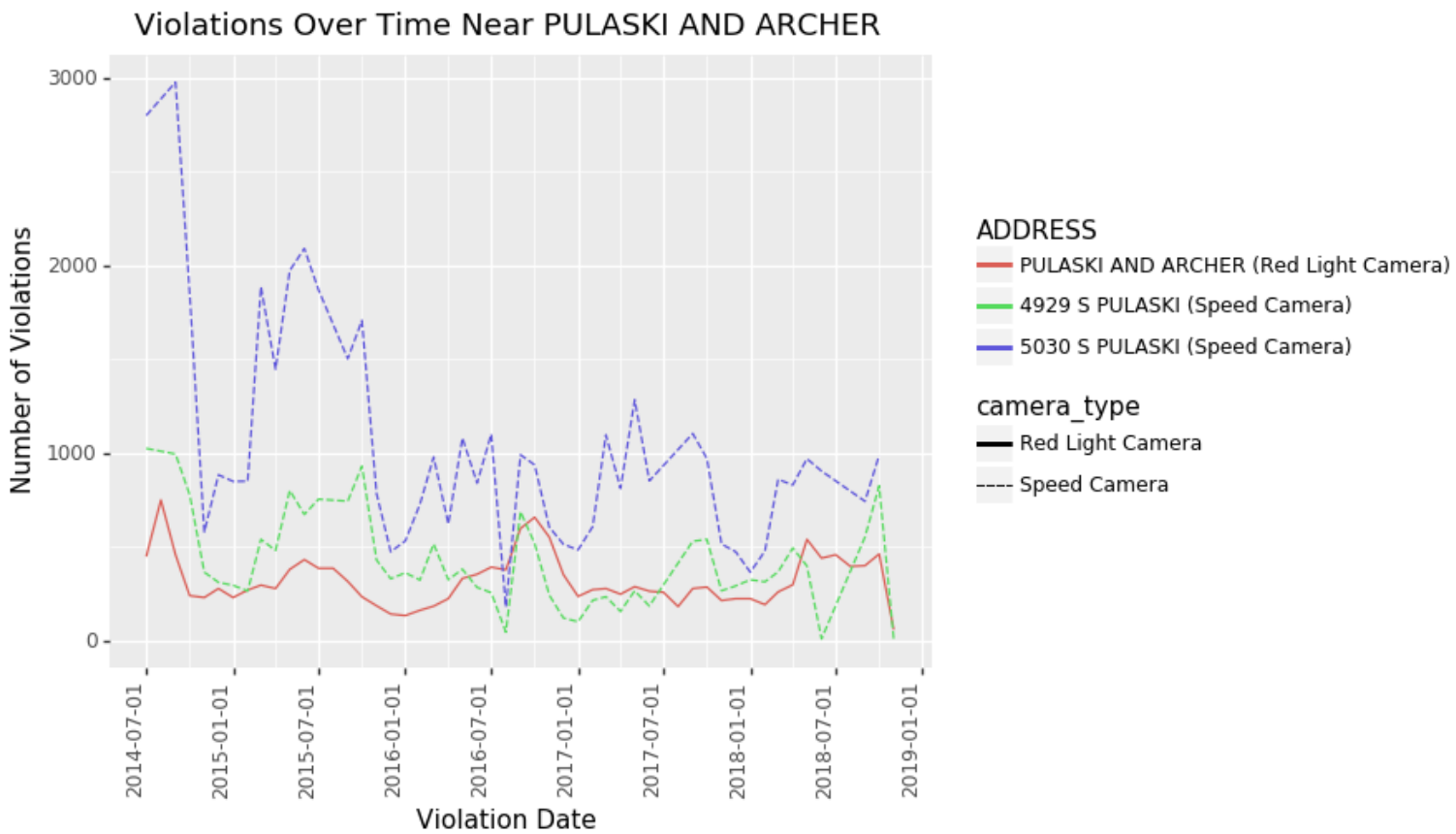
```
redlight = redlight_violations_copy.groupby('INTERSECTION')['VIOLATIONS'].sum().
sort_values(ascending = False)

# output in order of most red light violations to least red light violations
for i in range(0, len(redlight)):
    rlc_violation_intersection = redlight_violations_copy.loc[redlight_violation
s_copy['INTERSECTION'].str.contains(redlight.axes[0][i])].reset_index(drop = Tru
e)

    rlc_speed = pd.DataFrame()
    temp = pairs.loc[pairs['redlight'] == rlc_violation_intersection.iloc[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_violations_
copy['ADDRESS'].str.contains(temp[j])].reset_index(drop = True))

    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_counts().ind
ex[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 violations at ', t
emp.iloc[0,0], ' and red light violations at ', x2.iloc[0,2], ' is ', numpy.corr
coef(x1['VIOLATIONS'], x2['VIOLATIONS'])[0,1], '.', sep = '')
        print('The Spearman correlation coefficient and p-value for speed violat
ions at ', temp.iloc[0,0], ' and red light violations at ', x2.iloc[0,2], ' are
', spearmanr(x1['VIOLATIONS'], x2['VIOLATIONS'])[0], ' and ', spearmanr(x1['VIOL
ATIONS'], x2['VIOLATIONS'])[1], ', respectively.', sep = '')
        #print('R-squared for speed violations at ', temp.iloc[0,0], ' and red l
ight violations at ', x2.iloc[0,2], ' is ', linregress(x1['VIOLATIONS'], x2['VIO
LATIONS'])[2] ** 2, '.', sep = '')

    rlc_speed['date'] = pd.to_datetime(rlc_speed['VIOLATION DATE']).apply(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_values('ADDRE
SS'), 'date': temp.index.get_level_values('date'),'count': temp.values})
    plotdata_speed['camera_type'] = 'Speed Camera'

    rlc_violation_intersection['date'] = pd.to_datetime(rlc_violation_intersecti
on['VIOLATION DATE']).apply(lambda x: x.strftime('%Y-%m'))
    rlc_violation_intersection['date'] = pd.to_datetime(rlc_violation_intersecti
```

```
on['date'])

    temp = rlc_violation_intersection.groupby('date')['VIOLATIONS'].sum()
    plotdata_redlight = pd.DataFrame({'date': temp.index.get_level_values('date'
), 'count': temp.values,'ADDRESS': rlc_violation_intersection.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', linetype = 'cam
era_type'), data = plotdata_redlight)
      + geom_line()
      + geom_line(aes(x = 'date', y = 'count', color = 'ADDRESS', linetype = 'ca
mera_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_intersection.iloc[0
,0]))
```

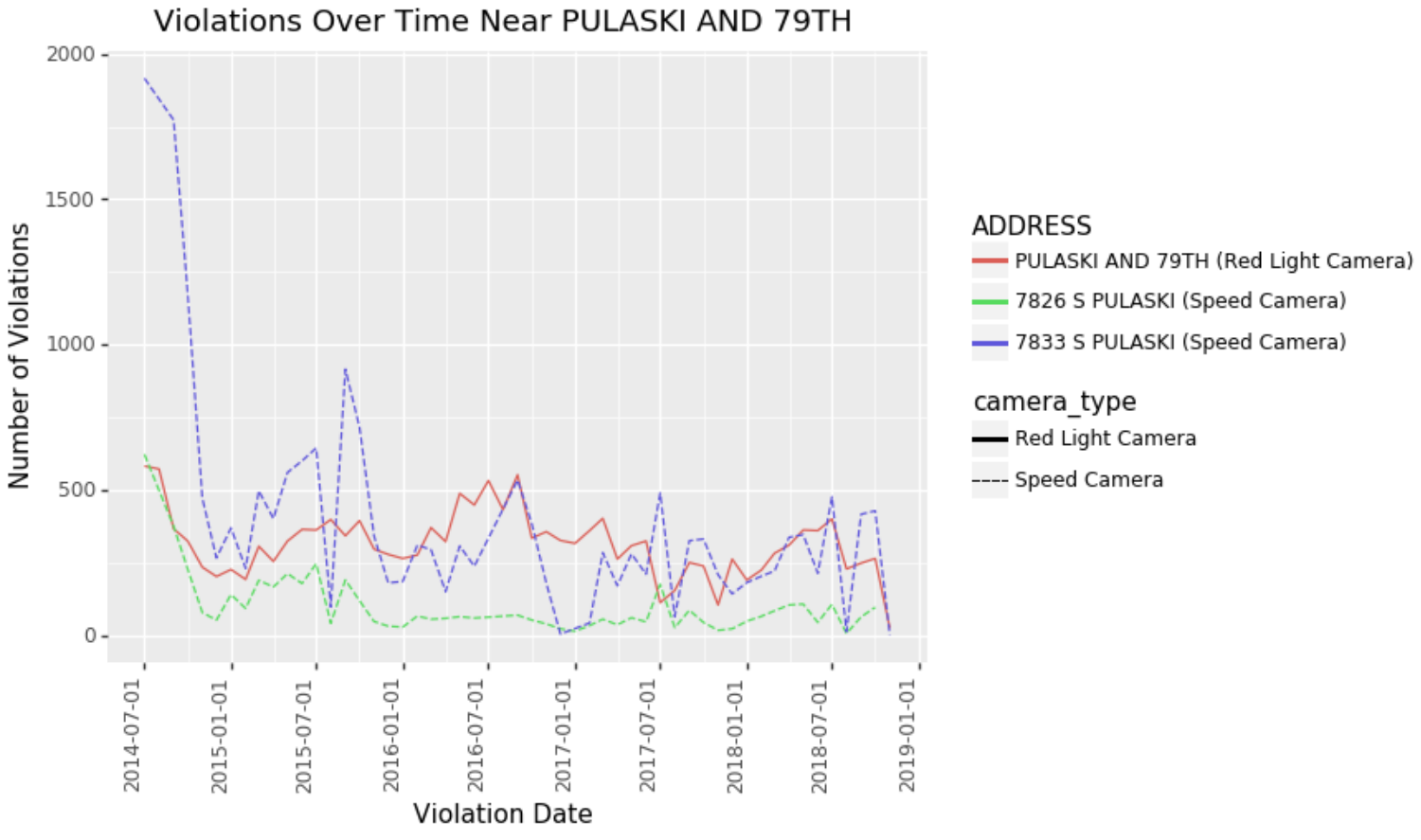
```
The Spearman correlation coefficient and p-value for speed violation
s at 449 N COLUMBUS DR and red light violations at COLUMBUS AND ILLI
NOIS are 0.162963453255 and 2.78044192069e-52, respectively.
The Spearman correlation coefficient and p-value for speed violation
s at 450 N COLUMBUS DR and red 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.
```



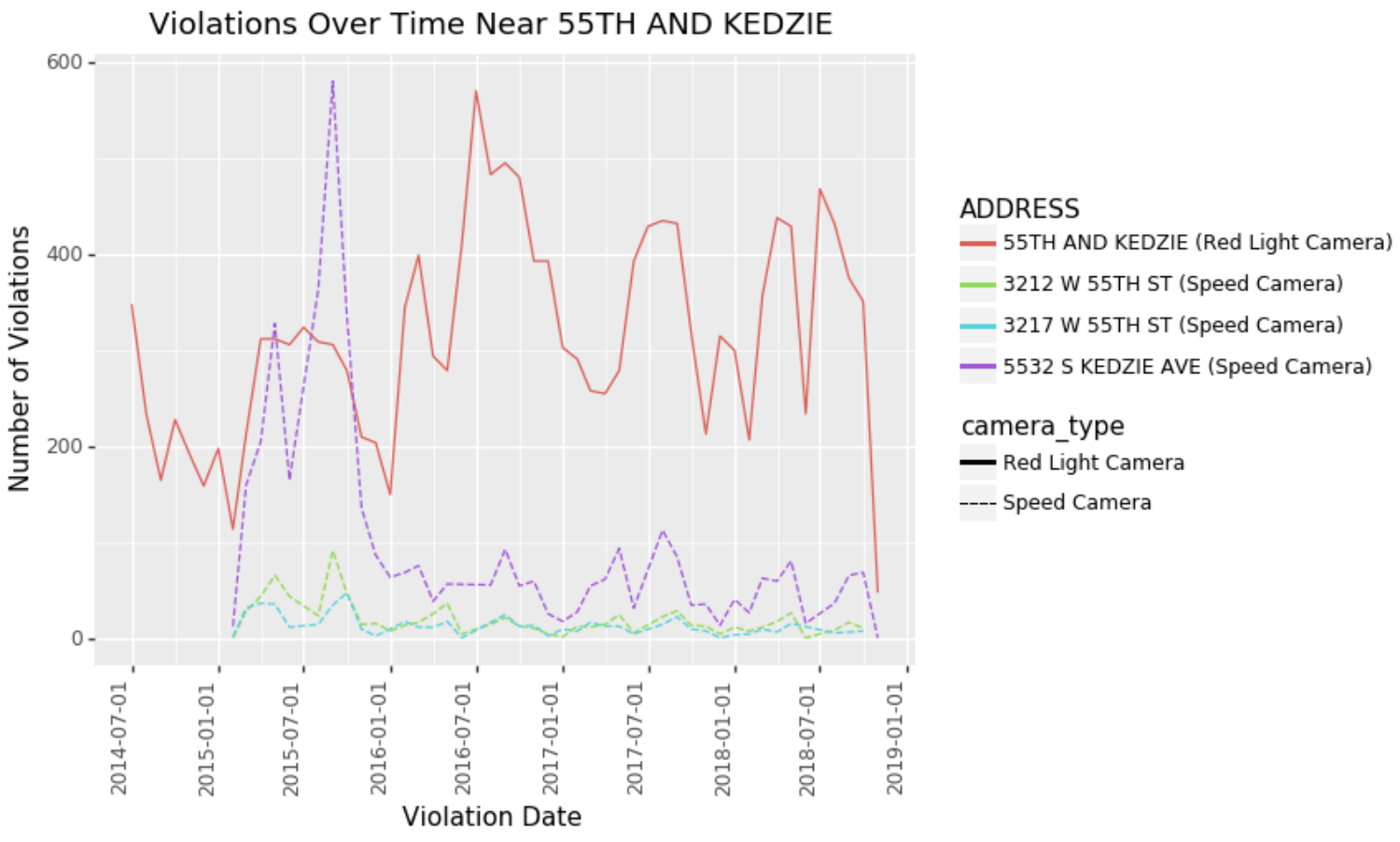
<ggplot: (-9223372036557937250)>
The Spearman correlation coefficient and p-value for speed violations at 5030 S PULASKI and red light violations at PULASKI AND ARCHER are 0.0858098835074 and 8.32305340821e-06, respectively.
The Spearman correlation coefficient and p-value for speed violations at 4929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



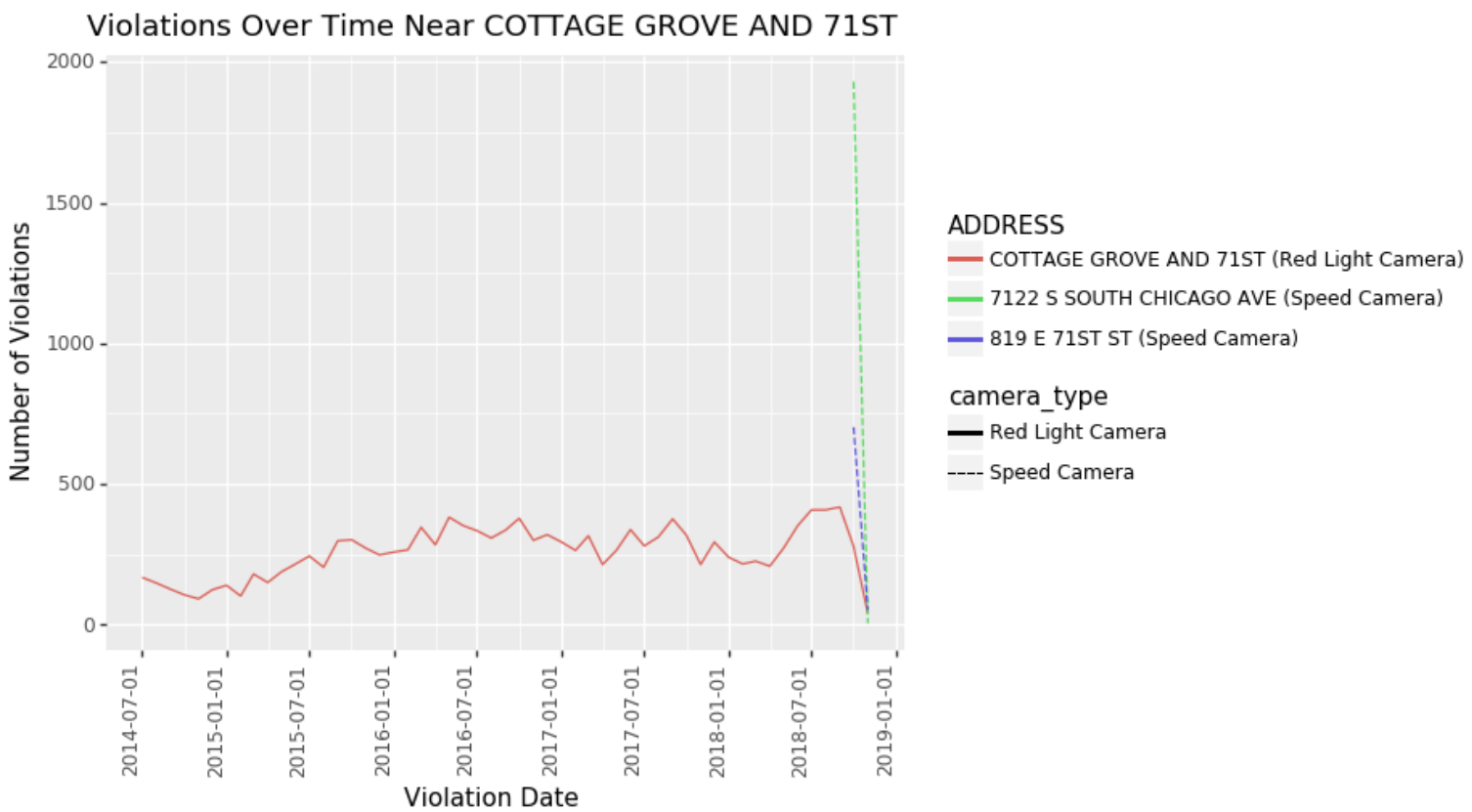
<ggplot: (-9223372036541700804)>
The Spearman correlation coefficient and p-value for speed violations at 7833 S PULASKI and red light violations at PULASKI AND 79TH are 0.0421715594408 and 0.0309514706502, respectively.
The Spearman correlation coefficient and p-value for speed violations at 7826 S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



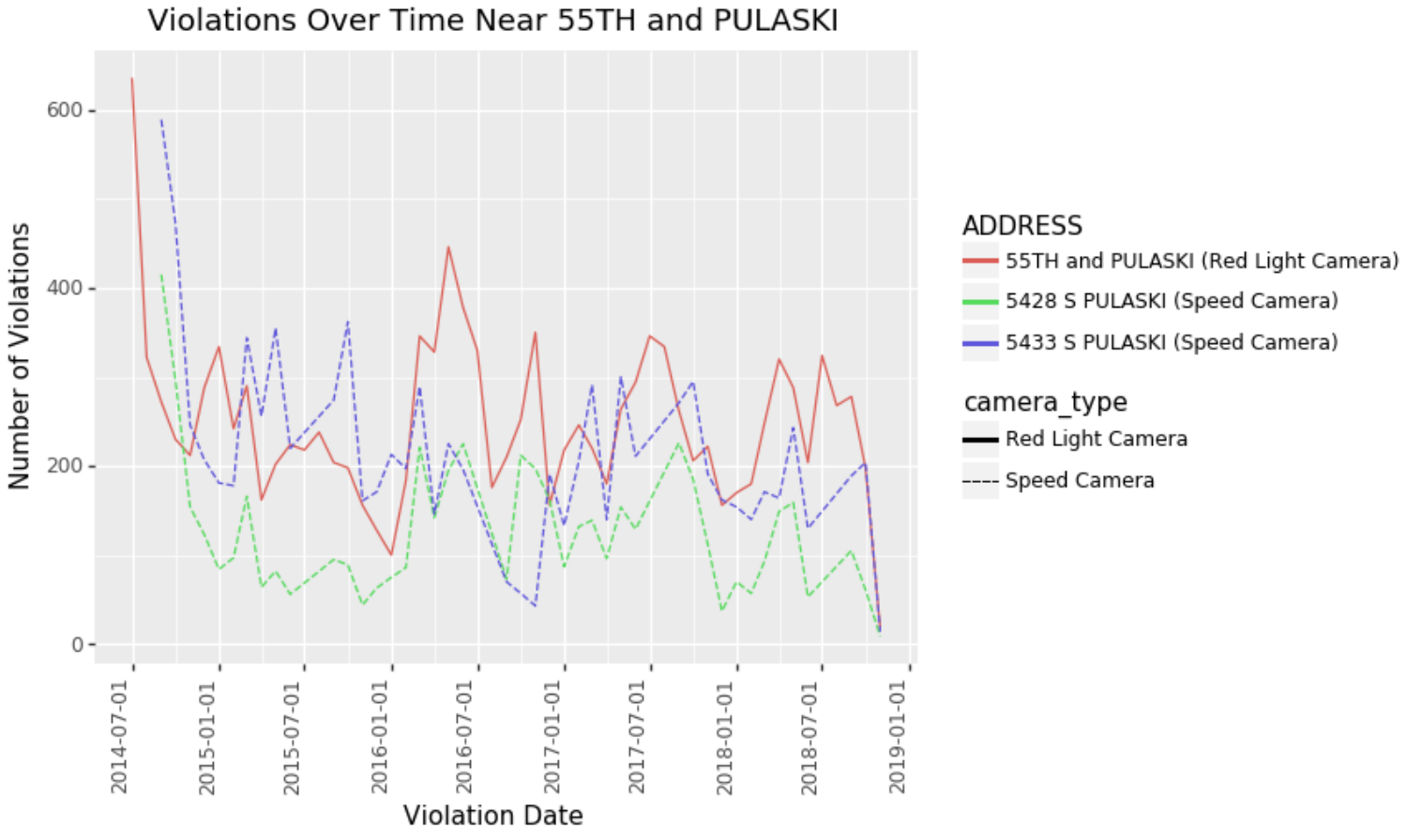
<ggplot: (296454415)>
The Spearman correlation coefficient and p-value for speed violations at 5532 S KEDZIE AVE and red light violations at 55TH AND KEDZIE are 0.0196416695613 and 0.30387986204, respectively.
The Spearman correlation coefficient and p-value for speed violations at 3212 W 55TH ST and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



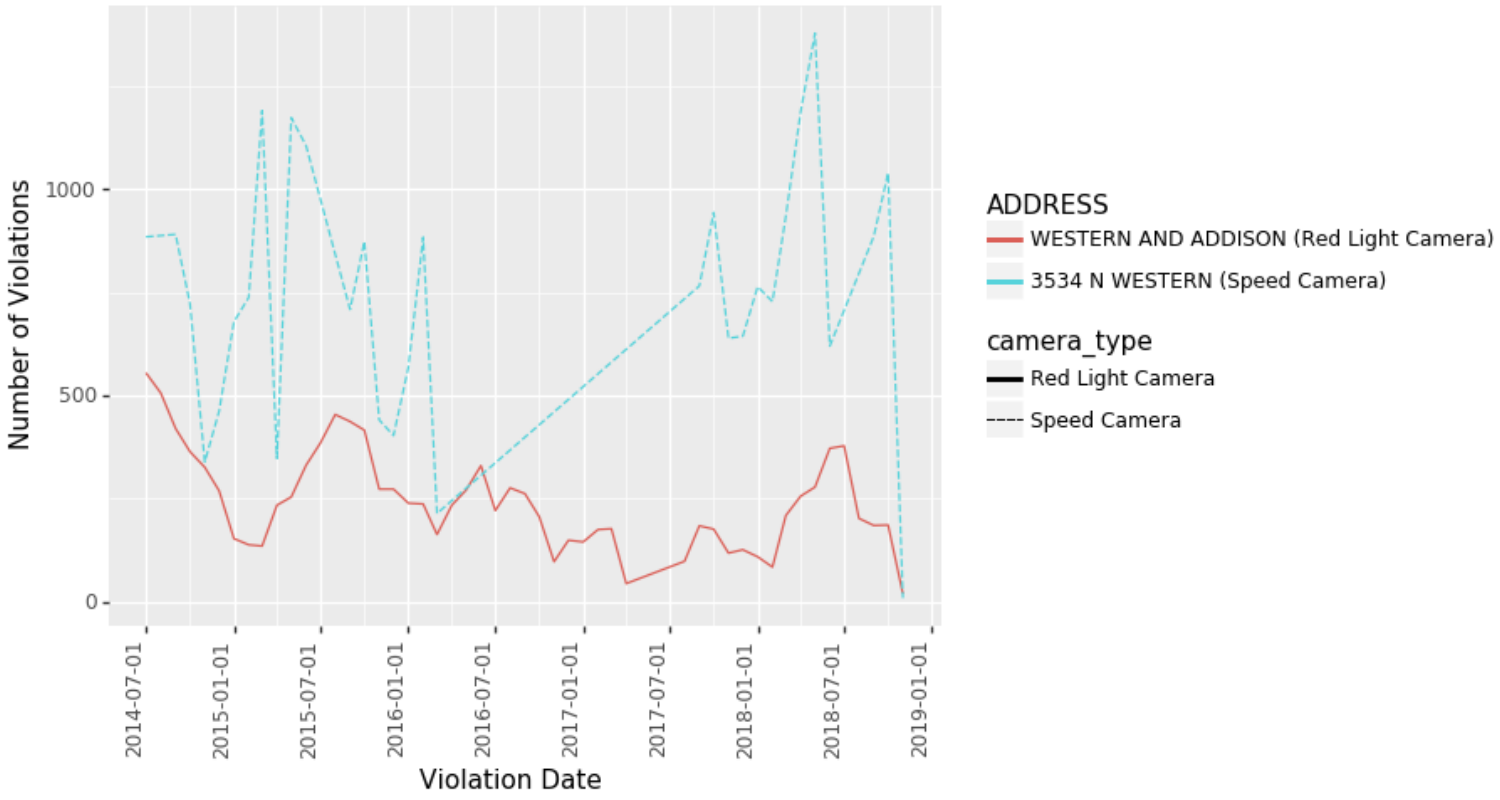
<ggplot: (296718095)>
The Spearman correlation coefficient and p-value for speed violations at 819 E 71ST ST and red light violations at COTTAGE GROVE AND 71ST are -0.298144378532 and 0.0121817373417, respectively.
The Spearman correlation coefficient and p-value for speed violations at 7122 S SOUTH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



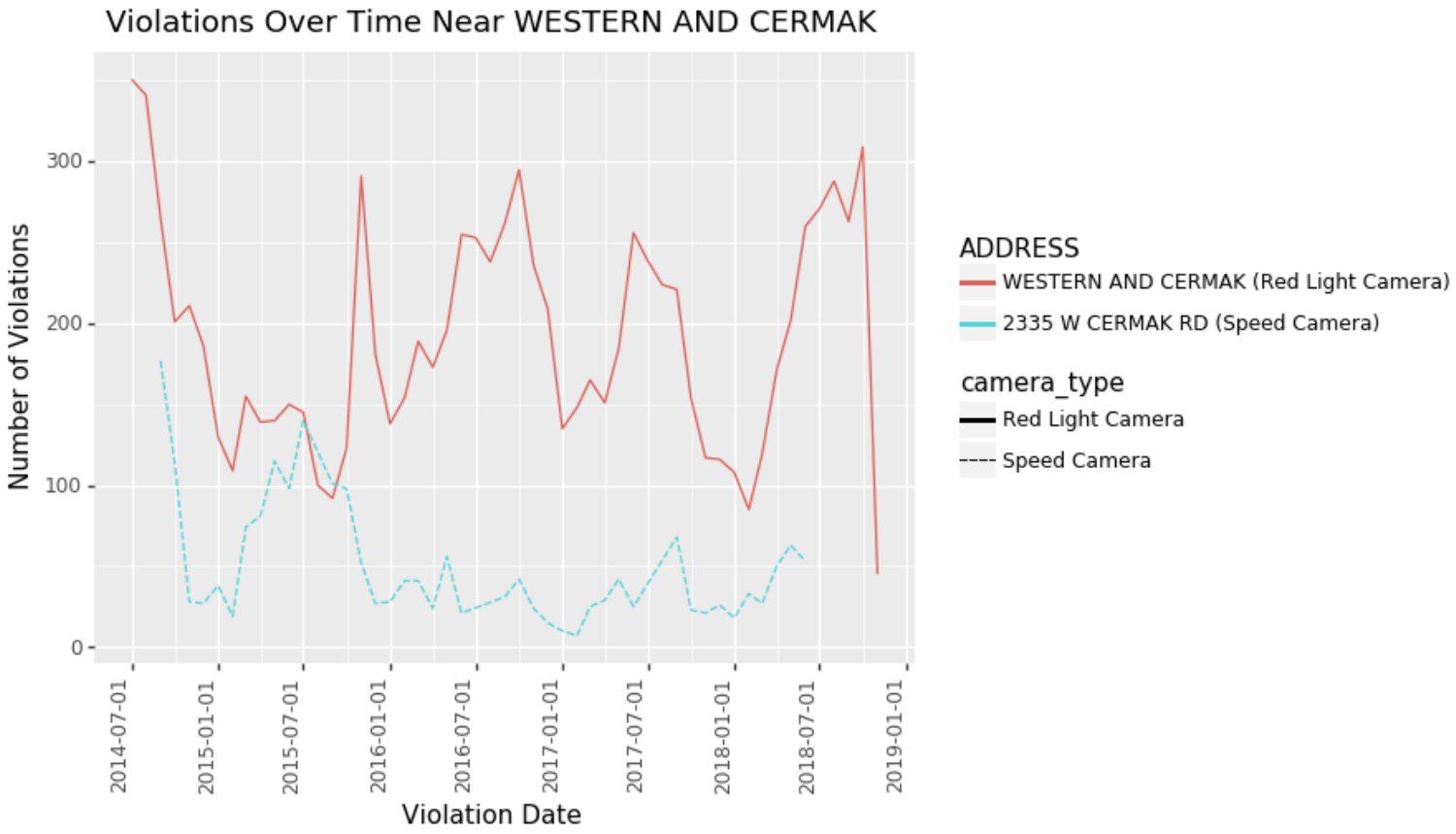
<ggplot: (-9223372036558081392)>
The Spearman correlation coefficient and p-value for speed violations at 5433 S PULASKI and red light violations at 55TH and PULASKI are 0.0513666664902 and 0.0130290766203, respectively.
The Spearman correlation coefficient and p-value for speed violations at 5428 S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



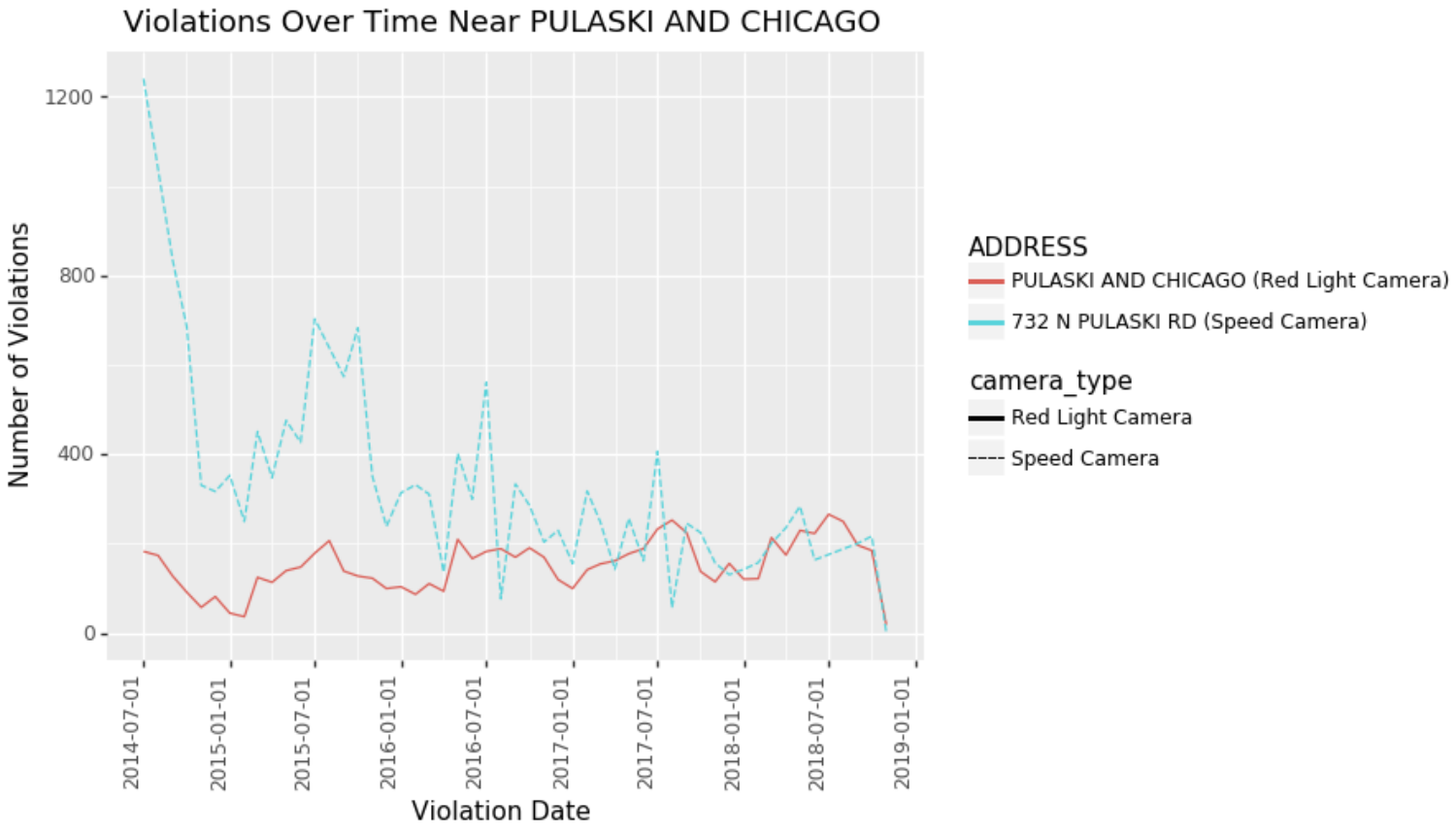
<ggplot: (-9223372036557143587)>
The Spearman correlation coefficient and p-value for speed violation
s at 3534 N WESTERN and red light violations at WESTERN AND ADDISON
are 0.0829683054404 and 0.0101969649149, respectively.



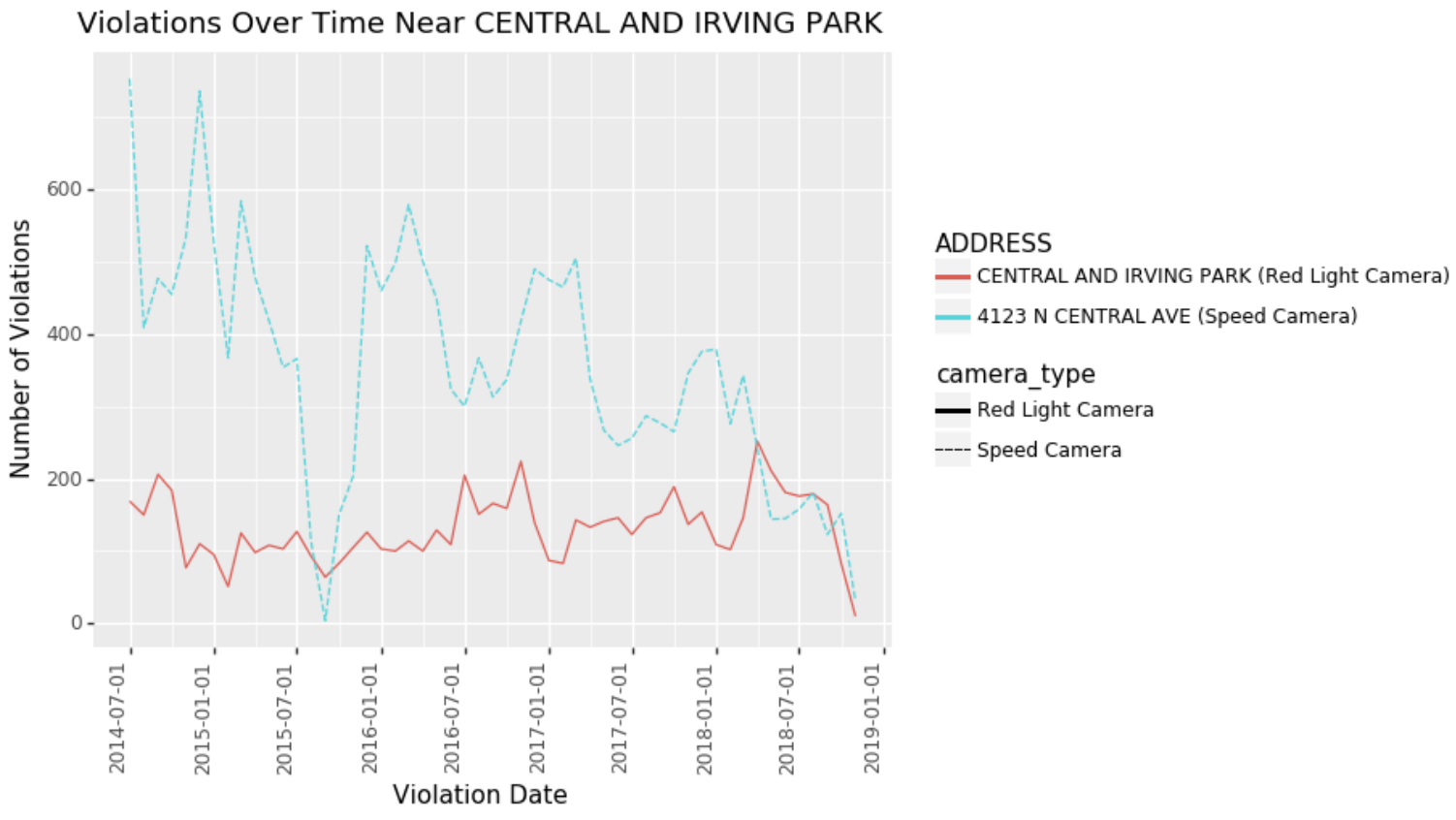
<ggplot: (296568475)>
The Spearman correlation coefficient and p-value for speed violation
s at 2335 W CERMAK RD and red light violations at WESTERN AND CERMAK
are 0.0126478366504 and 0.693407633301, respectively.



<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 [ ]: