

There are no significant ethical or legal concerns with the contents of this notebook. Data protection and discrimination are not a concern. All data sourced is freely available.

## Importing Data & Cleaning

```
In [1]: import pandas as pd, re
import matplotlib.pyplot as plt
import matplotlib.ticker as mtick
import glob
import os
import numpy as np
import math
import seaborn as sb
import geocoder
import requests
import time
import folium
from folium.plugins import HeatMap, HeatMapWithTime
from geopy import distance
import sklearn
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import accuracy_score, mean_squared_error, r2_score, mean_absolute_error
```

Importing PSNI street crime data from 08-2015 to 05-2018 and displaying the first five rows

```
In [2]: src_dir = 'data/PSNI_StreetCrime_1Year'
psni_crime_data = pd.DataFrame()
list_ = []
i = 0
for root, dirs, files in os.walk(src_dir):
    allFiles = glob.glob(root + "/*.csv")
    for file in allFiles:
        year_df = pd.read_csv(file, index_col=None, header=0)
        list_.append(year_df)
        psni_crime_data = pd.concat(list_)
psni_crime_data.head()
```

Out[2]:

	Crime ID	Month	Reported by	Falls within	Longitude	Latitude	Location	LSOA code	LSOA name	Crime type	Last outcome category	Context
0	NaN	2015-08	Police Service of Northern Ireland	Police Service of Northern Ireland	-7.378949	54.717334	On or near Dublin Street	NaN	NaN	Anti-social behaviour	NaN	NaN
1	NaN	2015-08	Police Service of Northern Ireland	Police Service of Northern Ireland	-5.891082	54.222501	On or near Bracken Avenue	NaN	NaN	Anti-social behaviour	NaN	NaN
2	NaN	2015-08	Police Service of Northern Ireland	Police Service of Northern Ireland	-5.667276	54.663573	On or near High Street	NaN	NaN	Anti-social behaviour	NaN	NaN
3	NaN	2015-08	Police Service of Northern Ireland	Police Service of Northern Ireland	-5.962330	54.587243	On or near Rodney Parade	NaN	NaN	Anti-social behaviour	NaN	NaN
4	NaN	2015-08	Police Service of Northern Ireland	Police Service of Northern Ireland	-5.894063	54.590423	On or near Brenda Street	NaN	NaN	Anti-social behaviour	NaN	NaN

Let's look at the data frame from a high level and identify the data type and stored data in the columns

```
In [3]: psni_crime_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 445745 entries, 0 to 13728
Data columns (total 12 columns):
Crime ID          274726 non-null object
Month             445745 non-null object
Reported by       445745 non-null object
Falls within      445745 non-null object
Longitude         443370 non-null float64
Latitude          443370 non-null float64
Location          445745 non-null object
LSOA code         0 non-null float64
LSOA name         0 non-null float64
Crime type        445745 non-null object
Last outcome category 0 non-null float64
Context           0 non-null float64
dtypes: float64(6), object(6)
memory usage: 44.2+ MB
```

There are a number of columns that are redundant, containing all null values.

\*Last outcome category: "Missing outcome data. Neither the British Transport Police nor the Police Service of Northern Ireland provide the Home Office with outcome data. Although we are exploring the possibility of this with both forces, technical challenges mean that a solution remains some way off." - <https://data.police.uk/about/> (<https://data.police.uk/about/>)

\*LSOA code, name: "Lower Layer Super Output Areas are a geographic hierarchy designed to improve the reporting of small area statistics in England and Wales." - Not Northern Ireland,  
[https://www.datadictionary.nhs.uk/data\\_dictionary/nhs\\_business\\_definitions/l/lower\\_layer\\_super\\_output\\_area\\_de.asp?shownav=1](https://www.datadictionary.nhs.uk/data_dictionary/nhs_business_definitions/l/lower_layer_super_output_area_de.asp?shownav=1)  
([https://www.datadictionary.nhs.uk/data\\_dictionary/nhs\\_business\\_definitions/l/lower\\_layer\\_super\\_output\\_area\\_de.asp?shownav=1](https://www.datadictionary.nhs.uk/data_dictionary/nhs_business_definitions/l/lower_layer_super_output_area_de.asp?shownav=1))

\*Context: 'Currently, for newly added CSVs, this is always empty.'

Let's drop them from the table. <b>

```
In [4]: psni_crime_data = psni_crime_data.drop(['LSOA code', 'LSOA name', 'Last outcome category', 'Context'], axis=1)
```

```
In [5]: psni_crime_data.describe(include='all')
```

Out[5]:

	Crime ID	Month	Reported by	Falls within	Longitude	Latitude	Location	Crime type
count	274726	445745	445745	445745	443370.000000	443370.000000	445745	445745
unique	11728	34	1	1	NaN	NaN	14872	14
top	0039cf64d3190556005848fe28bf5e9efe71a59ac7a09c...	2015-10	Police Service of Northern Ireland	Police Service of Northern Ireland	NaN	NaN	On or near	Anti-social behaviour
freq	34	15444	445745	445745	NaN	NaN	61638	171019
mean	NaN	NaN	NaN	NaN	-6.268281	54.620995	NaN	NaN
std	NaN	NaN	NaN	NaN	0.527199	0.227856	NaN	NaN
min	NaN	NaN	NaN	NaN	-8.148313	54.026858	NaN	NaN
25%	NaN	NaN	NaN	NaN	-6.512727	54.511284	NaN	NaN
50%	NaN	NaN	NaN	NaN	-6.011100	54.597057	NaN	NaN
75%	NaN	NaN	NaN	NaN	-5.924801	54.697173	NaN	NaN
max	NaN	NaN	NaN	NaN	-5.434918	55.240074	NaN	NaN

Crime ID is not shared by all the rows. According to the official police API (<https://data.police.uk/docs/method/crime-street/>), this is used as an ID for the API and is not a police identifier. Let's investigate this ID further and decide whether it is valuable to have in the table.

```
In [6]: num_unique_crime_ids = psni_crime_data['Crime ID'].nunique()
print(f"Number of unique crime ids: {num_unique_crime_ids}")

psni_crime_data_crimetype = psni_crime_data.groupby('Crime type')['Crime ID'].count()
psni_crime_data_crimetype
```

Number of unique crime ids: 11728

```
Out[6]: Crime type
Anti-social behaviour          0
Bicycle theft                 2141
Burglary                       20368
Criminal damage and arson    52336
Drugs                          16483
Other crime                     7472
Other theft                     37313
Possession of weapons          2701
Public order                   3334
Robbery                        1732
Shoplifting                     17389
Theft from the person          1253
Vehicle crime                  11743
Violence and sexual offences   100461
Name: Crime ID, dtype: int64
```

Anti social behaviour does not have any Crime IDs associated with them. As Crime ID is not unique this makes me suspect there could be duplicates of the same crime in the table. I'm going to investigate this by finding rows with the same Crime ID, Month, Longitude, Latitude, Location and Crime Type

```
In [7]: grouped_psni_crime_data = psni_crime_data.fillna(-1).groupby(['Crime ID', 'Month', 'Longitude', 'Latitude', 'Location', 'Crime type']).size().reset_index(
    name='counts')

In [8]: num_duplicate_rows = grouped_psni_crime_data[grouped_psni_crime_data.counts > 1].counts.sum()
percent_duplicate_rows = "{:.1%}".format(num_duplicate_rows/len(psni_crime_data))
print(f"{percent_duplicate_rows}")
```

16.3%

16.3% of rows could be potentially duplicate. I will drop Crime ID as it is not an effective unique identifier for the rows and has no use interacting with the Police API.

Iain Dawson (Police.uk support)

Oct 30, 14:57 GMT

Hi James,

The 'Crime ID' field allows you to compare incidents against the outcomes CSVs and/or the [outcomes for a specific crime](#) API method.

It's not unique because it's derived from offence reference numbers, and forces include incidents with duplicate offence reference numbers in the data they provide. Forces may do this for various reasons; in some cases, there may be multiple crimes that are associated with the same report, or vice versa, or several suspects for a given reported incident.

Hope that helps,

Iain Dawson,

Police.uk support

```
In [9]: psni_crime_data = psni_crime_data.drop(['Crime ID'], axis=1)
```

'Reported by' and 'Falls within' columns can be dropped as in all entries they are both set to 'Police Service of Northern Ireland'

```
In [10]: print(psni_crime_data['Reported by'].nunique())
print(psni_crime_data['Falls within'].nunique())
psni_crime_data = psni_crime_data.drop(['Reported by', 'Falls within'], axis=1)

1
1
```

There are NaN float values in the longitude and latitude. Let's investigate this further.

```
In [11]: psni_crime_data[psni_crime_data['Longitude'].isnull() | psni_crime_data['Latitude'].isnull()].head()

Out[11]:
```

	Month	Longitude	Latitude	Location	Crime type
225	2015-08	NaN	NaN	No Location	Anti-social behaviour
3812	2015-08	NaN	NaN	No Location	Anti-social behaviour
5713	2015-08	NaN	NaN	No Location	Bicycle theft
5732	2015-08	NaN	NaN	No Location	Bicycle theft
6223	2015-08	NaN	NaN	No Location	Burglary

I'm going to verify that Location value is 'No Location' when Longitude and Latitude columns are null.

```
In [12]: psni_crime_data[(psni_crime_data['Location'] == 'No Location') & ~(psni_crime_data['Longitude'].isnull() & psni_crime_data['Latitude'].isnull())].head()

Out[12]:
```

Month	Longitude	Latitude	Location	Crime type
-------	-----------	----------	----------	------------

Let's add a binary column that is 1 if the location associated and 0 if it does not. This will make excluding these datasets more manageable when geographing the crimes.

```
In [13]: def has_location(row):
    if (math.isnan(row['Longitude']) or math.isnan(row['Latitude']) or row['Location'] == 'No Location'):
        return False
    else:
        return True

psni_crime_data['Has_Location'] = psni_crime_data.apply(lambda row: has_location (row),axis=1)
```

```
In [14]: psni_crime_data.dtypes
```

```
Out[14]: Month        object
          Longitude   float64
          Latitude    float64
          Location     object
          Crime type   object
          Has_Location bool
          dtype: object
```

The month column data is presented in the format yyyy-mm. This can be converted to datetime split up into more columns to allow for more information to be derived.

```
In [15]: psni_crime_data['Date'] = pd.to_datetime(psni_crime_data['Month'], format='%Y-%m')
psni_crime_data = psni_crime_data.drop(['Month'], axis=1)
```

The following add\_datepart algorithm is from fastai (<https://www.fast.ai/>).

```
In [16]: def add_datepart(df, fldname, drop=True, time=False):
    """add_datepart converts a column of df from a datetime64 to many columns containing
    the information from the date. This applies changes inplace.

    Parameters:
    -----
    df: A pandas data frame. df gain several new columns.
    fldname: A string that is the name of the date column you wish to expand.
        If it is not a datetime64 series, it will be converted to one with pd.to_datetime.
    drop: If true then the original date column will be removed.
    time: If true time features: Hour, Minute, Second will be added.

    Examples:
    -----
    >>> df = pd.DataFrame({ 'A' : pd.to_datetime(['3/11/2000', '3/12/2000', '3/13/2000'], infer_datetime_format=False) })
    >>> df
       A
    0  2000-03-11
    1  2000-03-12
    2  2000-03-13
    >>> add_datepart(df, 'A')
    >>> df
          AYear AMonth AWeek ADay ADayofweek ADayofyear AIS_month_end AIS_month_start AIS_quarter_end AIS_quarter_start AIS_year_end AIS_year_start AElast
    sed
    0  2000   3     10    11    5      71    False    False    False    False    False    False    False    95273
2800
    1  2000   3     10    12    6      72    False    False    False    False    False    False    False    95281
9200
    2  2000   3     11    13    0      73    False    False    False    False    False    False    False    95290
5600
    """
    fld = df[fldname]
    fld_dtype = fld.dtype
    if isinstance(fld_dtype, pd.core.dtypes.dtypes.DatetimeTZDtype):
        fld_dtype = np.datetime64

    if not np.issubdtype(fld_dtype, np.datetime64):
        df[fldname] = fld = pd.to_datetime(fld, infer_datetime_format=True)
    targ_pre = re.sub('[Dd]ate$', '', fldname)
    attr = ['Year', 'Month', 'Week', 'Quarter']
    for n in attr: df[targ_pre + n] = getattr(fld.dt, n.lower())
    if drop: df.drop(fldname, axis=1, inplace=True)
```

```
In [17]: add_datepart(psni_crime_data, 'Date')
```

```
In [18]: psni_crime_data.dtypes
```

```
Out[18]: Longitude      float64
Latitude       float64
Location        object
Crime type      object
Has_Location    bool
Year           int64
Month          int64
Week            int64
Quarter         int64
dtype: object
```

Location has the streets listed with 'On or near' preceding them. This can be formatted to remove 'On Or Near' to get a cleaner street name for use in geocoding the crimes to find more location information.

```
In [19]: def format_street(row):
    formattedstreet = row['Location']
    formattedstreet = formattedstreet.replace('On or near', '')
    formattedstreet = formattedstreet.strip()
    return formattedstreet.lower()
```

```
psni_crime_data['Location'] = psni_crime_data.apply(lambda row: format_street(row), axis=1)
```

```
In [20]: psni_crime_data[psni_crime_data['Location'] == 'dublin street'].head(5)
```

```
Out[20]:
```

	Longitude	Latitude	Location	Crime type	Has_Location	Year	Month	Week	Quarter
0	-7.378949	54.717334	dublin street	Anti-social behaviour	True	2015	8	31	3
3019	-7.378949	54.717334	dublin street	Anti-social behaviour	True	2015	8	31	3
6544	-7.378949	54.717334	dublin street	Criminal damage and arson	True	2015	8	31	3
2606	-7.380017	54.713413	dublin street	Anti-social behaviour	True	2015	9	36	3
877	-7.378949	54.717334	dublin street	Anti-social behaviour	True	2015	10	40	4

I'm going to categorise Location and Crime type as this will make the data splittable

```
In [21]: psni_crime_data.dtypes
psni_crime_data['Crime type'] = psni_crime_data['Crime type'].astype('category')
psni_crime_data['Location'] = psni_crime_data['Location'].astype('category')
```

```
In [22]: psni_crime_data.dtypes
```

```
Out[22]: Longitude      float64
          Latitude       float64
          Location        category
          Crime type     category
          Has_Location    bool
          Year            int64
          Month           int64
          Week            int64
          Quarter         int64
          dtype: object
```

I am now content the data has been cleaned.

## Visualising crime trends

I am going to create a chart showing the crimes per month and year to see if there is any general trend in crime year by year.

```
In [23]: psni_crime_data_grouped_month_year = psni_crime_data.groupby(['Month', 'Year']).size().reset_index(name='counts')
width = 0.27

fig = plt.figure(figsize=(15,6))
ax = fig.add_subplot(111)

yvals2015 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2015].counts
xvals2015 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2015].Month
rects2015 = ax.bar(xvals2015, yvals2015, width, color='#AED6F1')

yvals2016 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2016].counts
xvals2016 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2016].Month
rects2016 = ax.bar(xvals2016+width, yvals2016, width, color='#3498DB')

yvals2017 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2017].counts
xvals2017 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2017].Month
rects2017 = ax.bar(xvals2017+width*2, yvals2017, width, color='#2874A6')

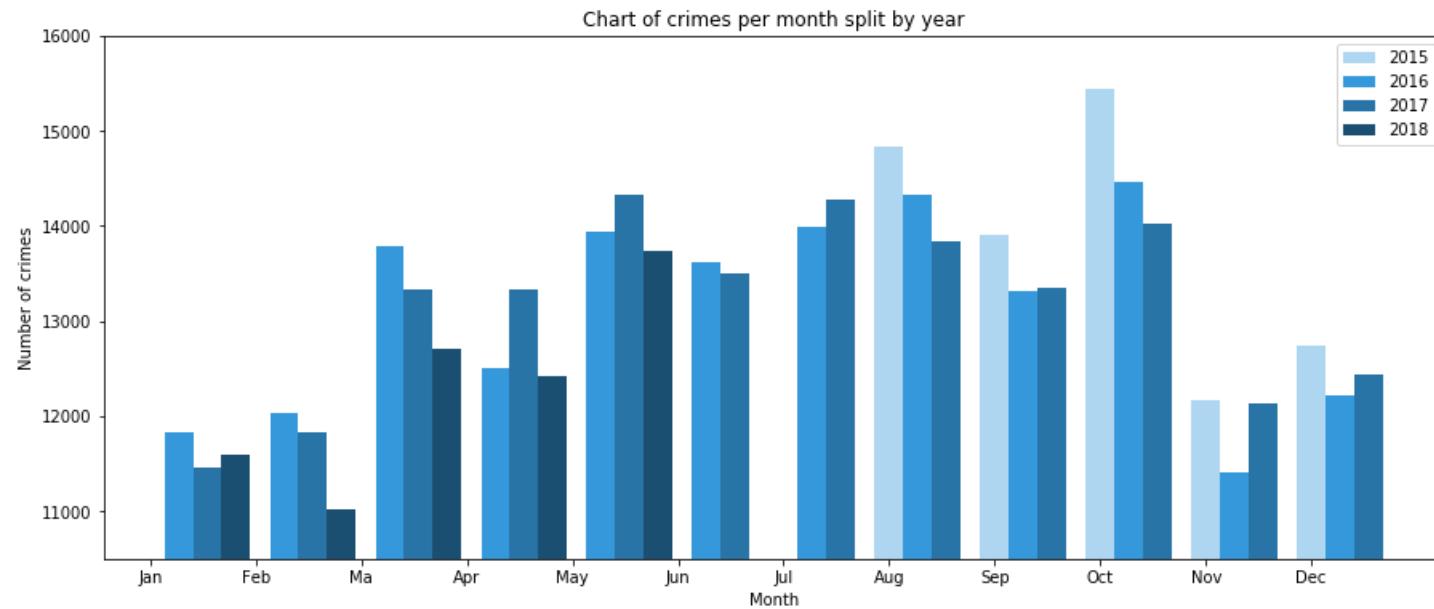
yvals2018 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2018].counts
xvals2018 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2018].Month
rects2018 = ax.bar(xvals2018+width*3, yvals2018, width, color='#1B4F72')

ax.set_ylabel('Number of crimes')
ax.set_xlabel('Month')
ax.set_xticks(np.arange(1, 13, step=1.0))
ax.set_xticklabels(['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'])
ax.legend([rects2015[0], rects2016[0], rects2017[0], rects2018[0]], ('2015', '2016', '2017', '2018'))

plt.title("Chart of crimes per month split by year")

plt.ylim(10500, 16000)

plt.show()
```



Across the 4 years there seems to be a general decrease in total crimes in the winter months (January, February) and a peak in October. There is crime total drops every year for the months February, March, August and October. July (albeit with less data than the other months) shows a rise.

I am going to group the time specific columns to see if there is any general observations I can gather from the month, year and quarter of crime. The data ranges from 2015-08 to 2018-05 so I am going to choose 2016-01 to 2017-12 as the range to avoid months disproportionately provided more crime totals when visualising graphs. I am going to visualise the difference in month crime totals 2016 vs 2017.

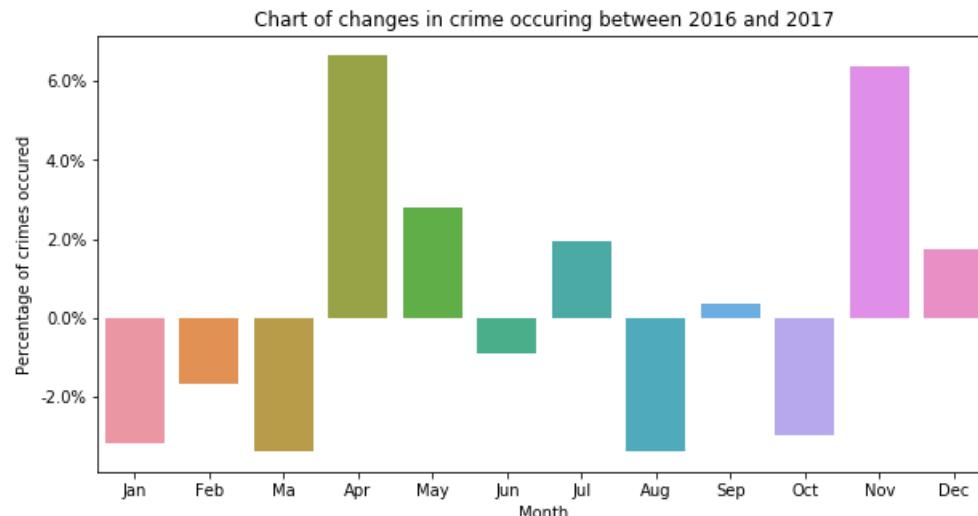
```
In [24]: plt.figure(figsize=(10,5))
counts_per_month_2017 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2017].reset_index()
counts_per_month_2016 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2016].reset_index()

dictMonth = {}
for index, row in counts_per_month_2017.iterrows():
    difference = (row['counts'] - counts_per_month_2016.iloc[index].counts)
    difference_percent = difference/(counts_per_month_2016.iloc[index].counts)*100
    dictMonth[str(index+1)] = difference_percent

difference_2016_2017 = pd.DataFrame.from_dict(dictMonth, orient='index')
difference_2016_2017.index = difference_2016_2017.index.astype(float)

ax = sb.barplot(difference_2016_2017.index, difference_2016_2017[0])
ax.set_ylabel('Percentage of crimes occurred')
ax.set_xlabel('Month')
ax.set_xticks(np.arange(0, 12, step=1.0))
ax.set_xticklabels(['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'])
ax.yaxis.set_major_formatter(mtick.PercentFormatter())
plt.title("Chart of changes in crime occurring between 2016 and 2017")

plt.subplots_adjust(hspace=0.5)
plt.subplots_adjust(wspace=0.5)
```



There is a considerable increase in crime in 2017 in the months April and November from 2016.

I'm going to look at a month and quarter level to see if there's any differences in times of the year and the number of crimes occurring in the period 2016-2017.

```
In [25]: psni_crime_data = psni_crime_data.reset_index()
psni_crime_data_ranged = psni_crime_data.drop(psni_crime_data[(psni_crime_data['Year'] == 2015) \
| ((psni_crime_data['Year'] == 2018))].index)
psni_crime_data_grouped_month = psni_crime_data_ranged.groupby('Month').size().reset_index(name='counts')
psni_crime_data_grouped_year = psni_crime_data_ranged.groupby('Year').size().reset_index(name='counts')
psni_crime_data_grouped_quarter = psni_crime_data_ranged.groupby('Quarter').size().reset_index(name='counts')

psni_crime_data_grouped_quarter_year = psni_crime_data.groupby(['Quarter', 'Year']).size().reset_index(name='counts')

counts_per_quarter_2017 = psni_crime_data_grouped_quarter_year[psni_crime_data_grouped_quarter_year.Year == 2017].reset_index()
counts_per_quarter_2016 = psni_crime_data_grouped_quarter_year[psni_crime_data_grouped_quarter_year.Year == 2016].reset_index()
```

```
In [26]: plt.figure(figsize=(15,10))

plt.subplot(2, 2, 1)
plt.pie(counts_per_month_2016['counts'], labels = ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'), \
         autopct='%.2f%%', shadow=False, startangle=90)
plt.axis('equal')
plt.title("2016: Chart of all crimes and anti-social behaviour occurring per month")

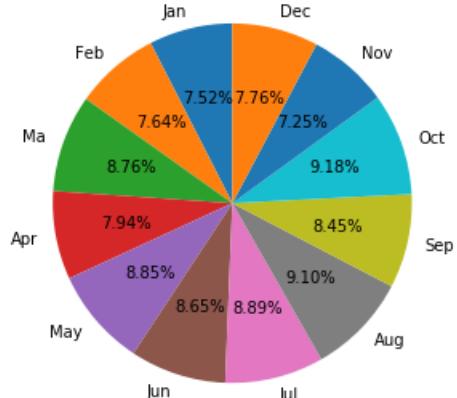
plt.subplot(2,2, 2)
plt.title("2016: Chart of all crimes and anti-social behaviour occurring per quarter")
plt.pie(counts_per_quarter_2016['counts'], labels = ('Quarter 1', 'Quarter 2', 'Quarter 3', 'Quarter 4'), autopct='%.1f%%', shadow=False, startangle=90)
plt.axis('equal')

plt.subplot(2, 2, 3)
plt.pie(counts_per_month_2017['counts'], labels = ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'), \
         autopct='%.2f%%', shadow=False, startangle=90)
plt.axis('equal')
plt.title("2017: Chart of all crimes and anti-social behaviour occurring per month")

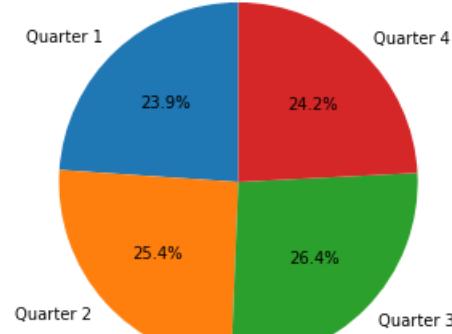
plt.subplot(2,2, 4)
plt.title("2017: Chart of all crimes and anti-social behaviour occurring per quarter")
plt.pie(counts_per_quarter_2017['counts'], labels = ('Quarter 1', 'Quarter 2', 'Quarter 3', 'Quarter 4'), autopct='%.1f%%', shadow=False, startangle=90)
plt.axis('equal')

plt.subplots_adjust(hspace=0.2)
plt.subplots_adjust(wspace=0.5)
```

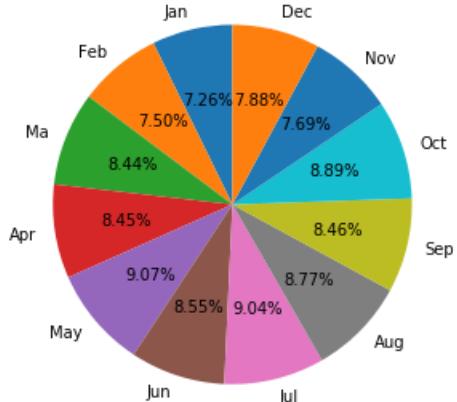
2016: Chart of all crimes and anti-social behaviour occuring per month



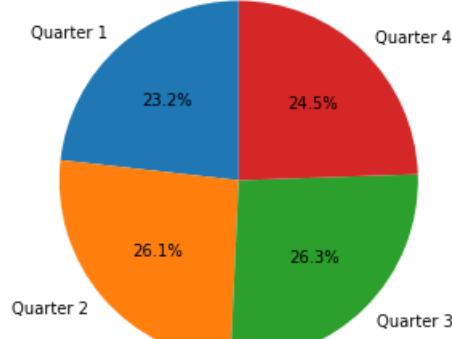
2016: Chart of all crimes and anti-social behaviour occuring per quarter



2017: Chart of all crimes and anti-social behaviour occuring per month



2017: Chart of all crimes and anti-social behaviour occuring per quarter

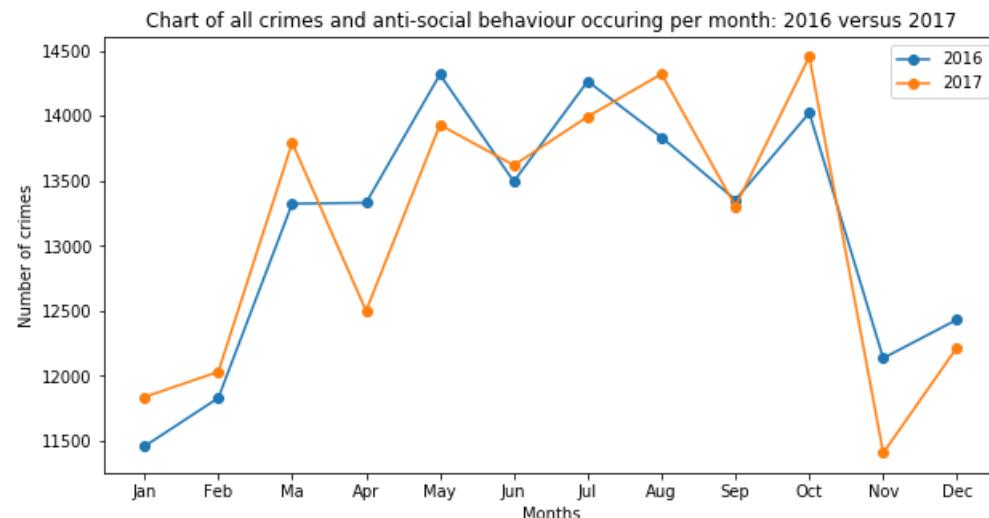


**2016: Most crimes in October and Quarter 3. Least crimes in month November and Quarter 1.** **2017: Most crimes in May and Quarter 3. Least crimes in January and Quarter 1.** Let's take a look at comparing 2016 and 2017 and see if there is a trend in those periods.

```
In [27]: plt.figure(figsize=(10,5))

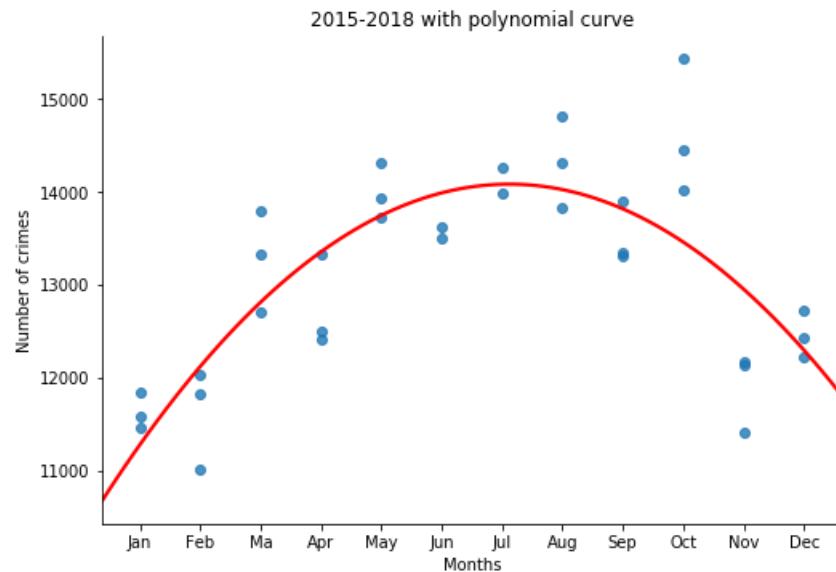
yvals2016 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2016].counts
xvals2016 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2016].Month
yvals2017 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2017].counts
xvals2017 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2017].Month
plt.plot(xvals2017, yvals2017, marker = 'o')
plt.plot(xvals2016, yvals2016, marker = 'o')
plt.xticks(np.arange(1, 13, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
plt.xlabel('Months')
plt.ylabel('Number of crimes')
plt.legend([2016, 2017])
plt.title("Chart of all crimes and anti-social behaviour occurring per month: 2016 versus 2017")
```

Out[27]: Text(0.5,1,'Chart of all crimes and anti-social behaviour occurring per month: 2016 versus 2017')



There appears to be a rise in crimes in the spring and summer months and a fall in the winter. I'm going to use numpy polyfit to estimate a polynomial curve to better visualise the yearly trend of number of crime. I'm going to include data from 2015 and 2018 as this is not directly comparing totals for each month and will provide more samples for the regressive curve.

```
In [28]: sb.lmplot('Month', 'counts', data=psni_crime_data_grouped_month_year[(psni_crime_data_grouped_month_year.Year >= 2015)], order=2, ci=None, height=5, aspect=1.5, line_kws={'color': 'red'})  
plt.xticks(np.arange(1, 13, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))  
plt.xlabel('Months')  
plt.ylabel('Number of crimes')  
plt.title("2015-2018 with polynomial curve")  
plt.show()
```



There is a higher occurrence of crimes in summer months (June, July, August) than in Winter Months (December, January, February). I am going to investigate the type of crimes being committed these months to see if there's a type of crime more or less prevalent in particular months. There could be crime types that are more prevalent in the summer causing the rise in the total of crime.

I'm going to take a look at first crime types in 2016 vs 2017 to see if there is any notable increases or decreases.

```
In [29]: psni_crime_data_grouped_crime_type = psni_crime_data_ranged.groupby(['Year', 'Crime type']).size().reset_index(name='counts')
psni_crime_data_grouped_crime_type
plt.figure(figsize=(20,5))
counts_per_month_2017 = psni_crime_data_grouped_crime_type[psni_crime_data_grouped_crime_type.Year == 2017].reset_index()
counts_per_month_2016 = psni_crime_data_grouped_crime_type[psni_crime_data_grouped_crime_type.Year == 2016].reset_index()

dictMonth = {}
dictDiffRaw = []
for index, row in counts_per_month_2017.iterrows():
    difference = (row['counts'] - counts_per_month_2016.iloc[index].counts)
    difference_percent = difference/(counts_per_month_2016.iloc[index].counts)*100
    dictMonth[row['Crime type']] = difference_percent
    dictDiffRaw.append(difference)

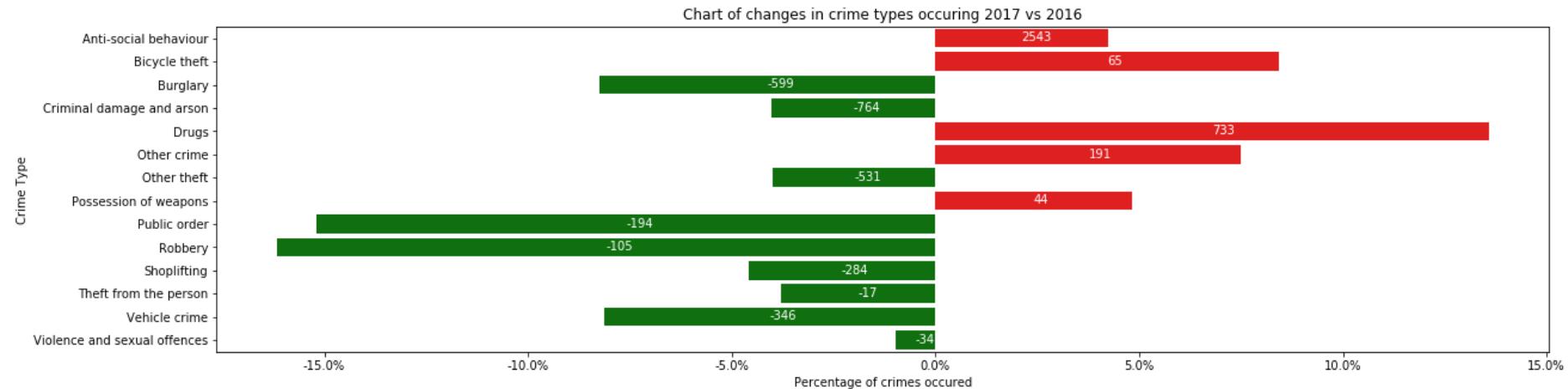
difference_2016_2017 = pd.DataFrame.from_dict(dictMonth, orient='index')
difference_2016_2017.index = difference_2016_2017.index.astype(str)

difference_2016_2017.head()
ax = sb.barplot(difference_2016_2017[0], difference_2016_2017.index, data=difference_2016_2017, palette=difference_2016_2017[0].apply(lambda x: 'r' if x>0 else 'g'))
ax.set_xlabel('Percentage of crimes occurred')
ax.set_ylabel('Crime Type')
ax.xaxis.set_major_formatter(mtick.PercentFormatter())
plt.title("Chart of changes in crime types occurring 2017 vs 2016")

plt.subplots_adjust(hspace=0.5)
plt.subplots_adjust(wspace=0.5)

total = float(len(difference_2016_2017))

i = 0
for p in ax.patches:
    width = p.get_width()
    height = p.get_height()
    ax.text(p.get_x()+width/2,
            p.get_y()+height/1.5,
            dictDiffRaw[i],
            color='white')
    i += 1
```



ASB sees an increase from 2016 to 2017. Drug crimes sees the largest % increase from 2016 to 2017. Robbery sees the largest % decrease from 2016 to 2017.

I've visualised crime type as yearly comparison, now let's look at it by month.

```
In [30]: psni_crime_data_grouped_crime_type = psni_crime_data_ranged.groupby(['Month', 'Crime type']).size().reset_index(name='counts')
psni_crime_data_grouped_crime_type.head()
```

Out[30]:

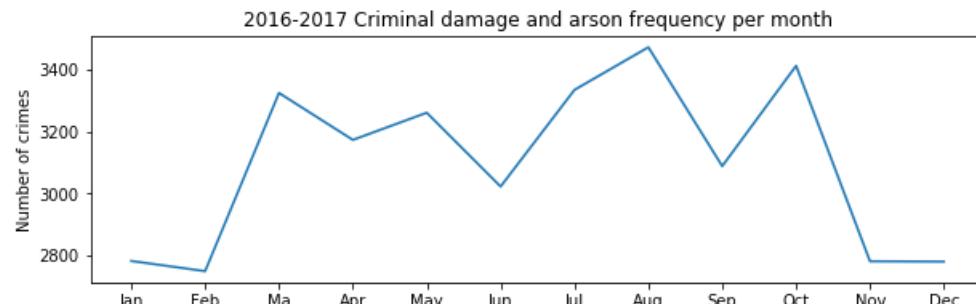
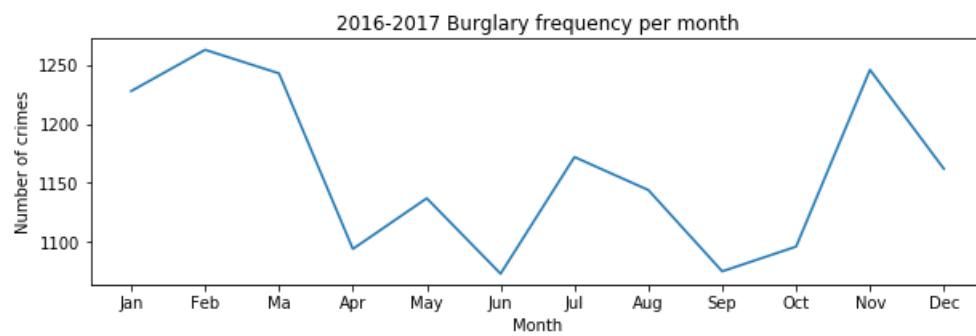
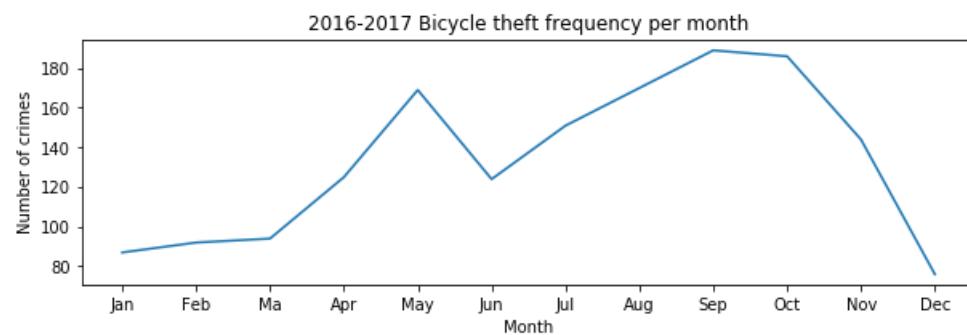
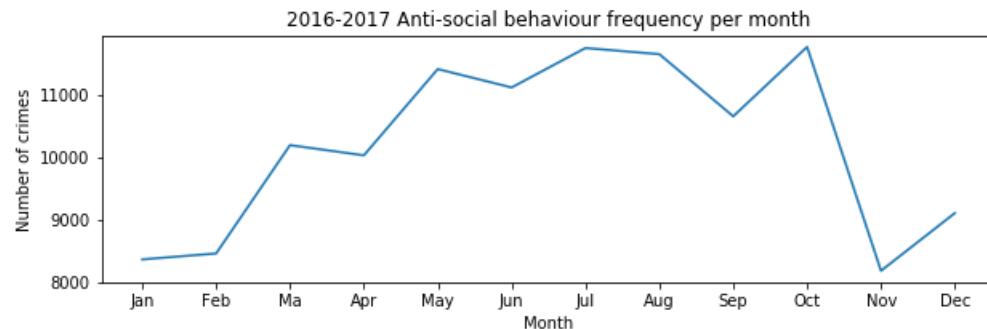
	Month	Crime type	counts
0	1	Anti-social behaviour	8366
1	1	Bicycle theft	87
2	1	Burglary	1228
3	1	Criminal damage and arson	2781
4	1	Drugs	890

```
In [31]: psni_crime_data_grouped_crime_type_pivot = psni_crime_data_grouped_crime_type.pivot('Month', 'Crime type', 'counts')
psni_crime_data_grouped_crime_type_pivot.head()
```

Out[31]:

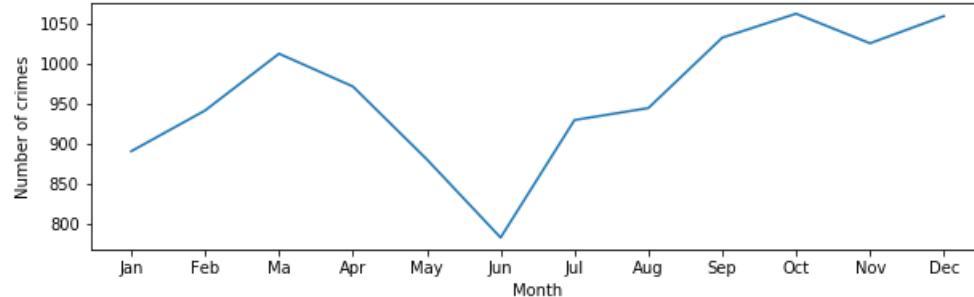
Crime type	Anti-social behaviour	Bicycle theft	Burglary	Criminal damage and arson	Drugs	Other crime	Other theft	Possession of weapons	Public order	Robbery	Shoplifting	Theft from the person	Vehicle crime	Violence and sexual offences
Month														
1	8366	87	1228	2781	890	392	2049	137	170	100	812	70	722	5491
2	8461	92	1263	2748	941	512	2193	126	215	98	1042	84	670	5416
3	10199	94	1243	3325	1012	525	2136	172	235	97	980	64	702	6334
4	10035	125	1094	3173	971	399	2144	164	191	103	1027	82	701	5622
5	11419	169	1137	3261	880	494	2275	178	217	84	1031	75	619	6410

```
In [32]: psni_crime_data_grouped_crime_type_pivot_hm = psni_crime_data_grouped_crime_type.pivot('Month', 'Crime type', 'counts')
plt.figure(figsize=(10,58))
i=1
for column in psni_crime_data_grouped_crime_type_pivot_hm.columns:
    if (column != 'Crime type'):
        ax = plt.subplot(len(psni_crime_data_grouped_crime_type_pivot_hm.columns),1,i)
        plt.xticks(np.arange(0, 12, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
        plt.title(f'2016-2017 {column} frequency per month')
        plt.xlabel('Month')
        sb.lineplot(np.arange(0, 12, step=1.0), psni_crime_data_grouped_crime_type_pivot_hm[column])
        plt.ylabel('Number of crimes')
    i += 1
plt.subplots_adjust(hspace=0.5)
```

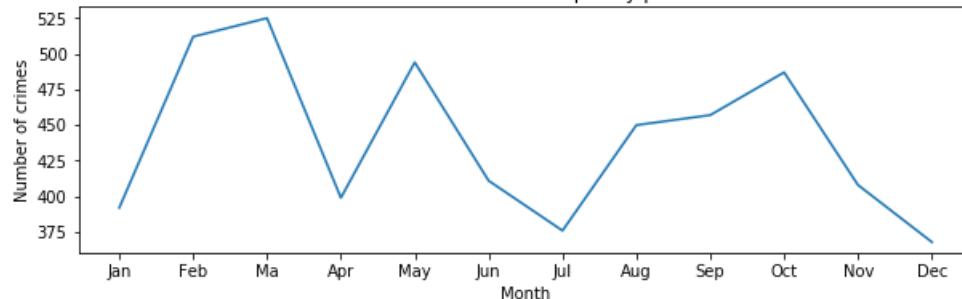


Month

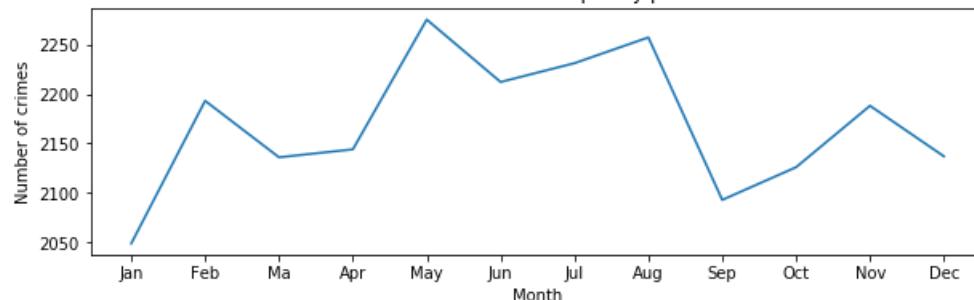
2016-2017 Drugs frequency per month



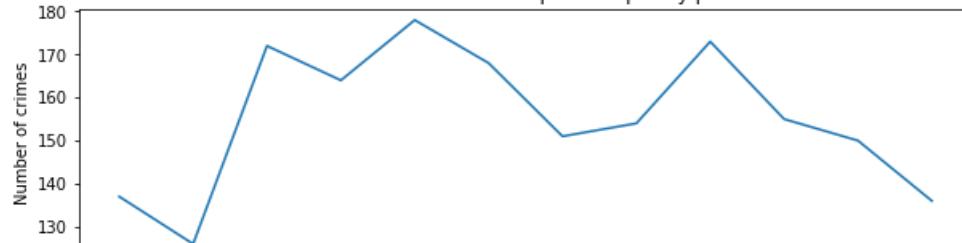
2016-2017 Other crime frequency per month

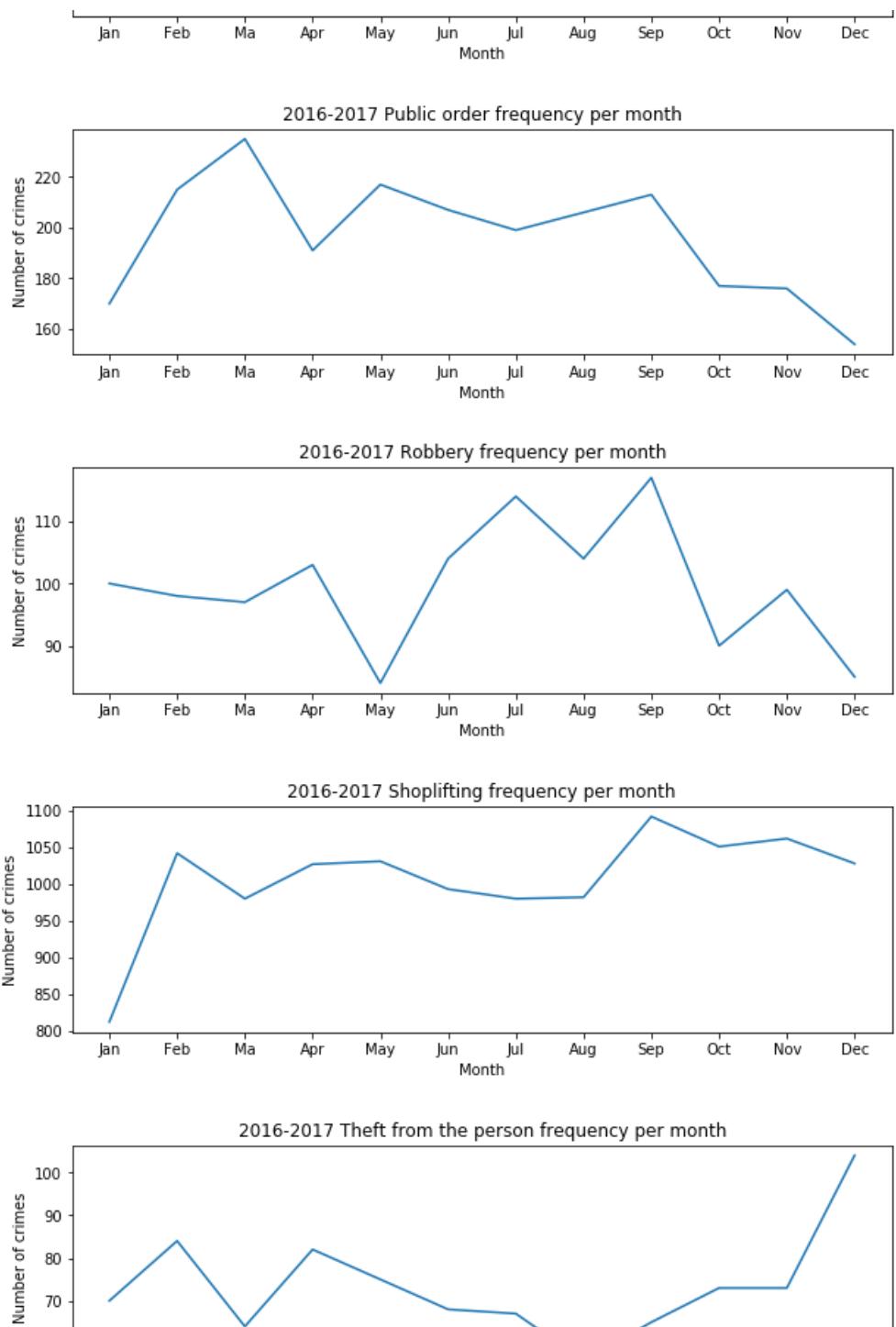


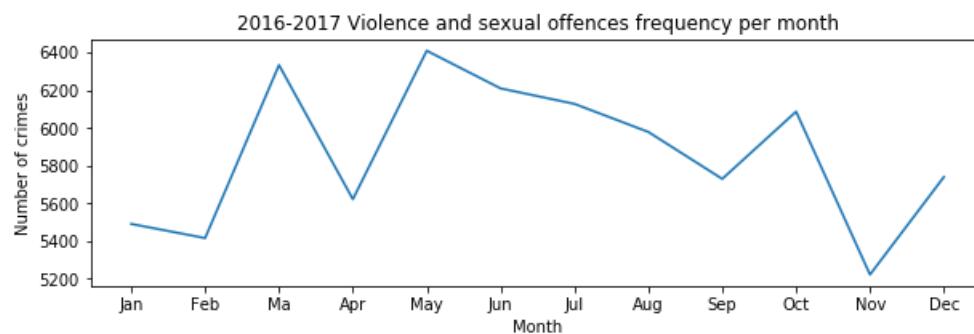
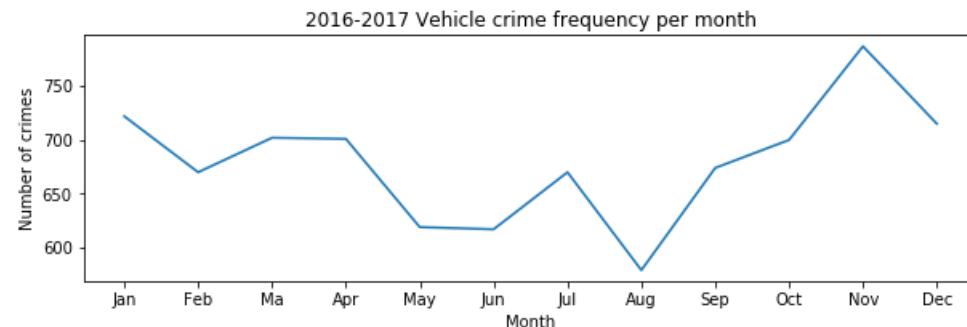
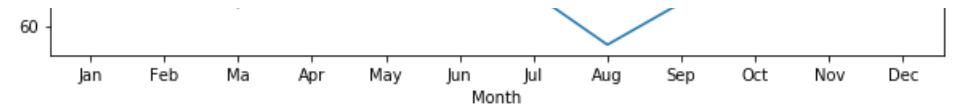
2016-2017 Other theft frequency per month



2016-2017 Possession of weapons frequency per month







Anti social behaviour: peaks in October, is prevalent in July and August and is least prevalent in November. There is a big drop between October and November.

Bicycle theft: Rise in June to peak in September, falls after to December.

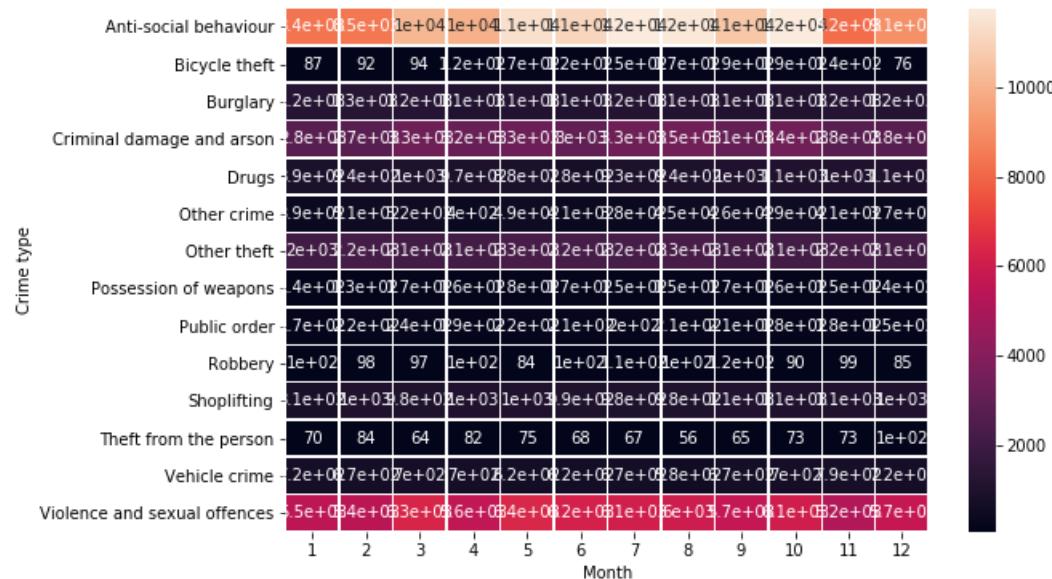
Drugs: peak in October, least prevalent in June.

Theft from the person frequency per month: Rise from August to peak in December.

From identifying a number of crimes above, I can observe different crime types have different prevalences across the year. I'm going to visualise this using a heatmap to see if I can gather any additional observations from a more direct comparison of totals across months. </b>

```
In [33]: psni_crime_data_grouped_crime_type_pivot_hm_transposed = psni_crime_data_grouped_crime_type_pivot_hm.transpose()
f, ax = plt.subplots(figsize=(9, 6))
sb.heatmap(psni_crime_data_grouped_crime_type_pivot_hm_transposed, annot=True, linewidths=.5, ax=ax)
```

Out[33]: <matplotlib.axes.\_subplots.AxesSubplot at 0x136f640ca90>



This heat map is not very informative, with high counts of particular crimes and anti social behaviour not providing an insight into minor crimes frequency per month. Let's normalize the data frame using standard normal distribution to better see the distribution of each crime type over a year.

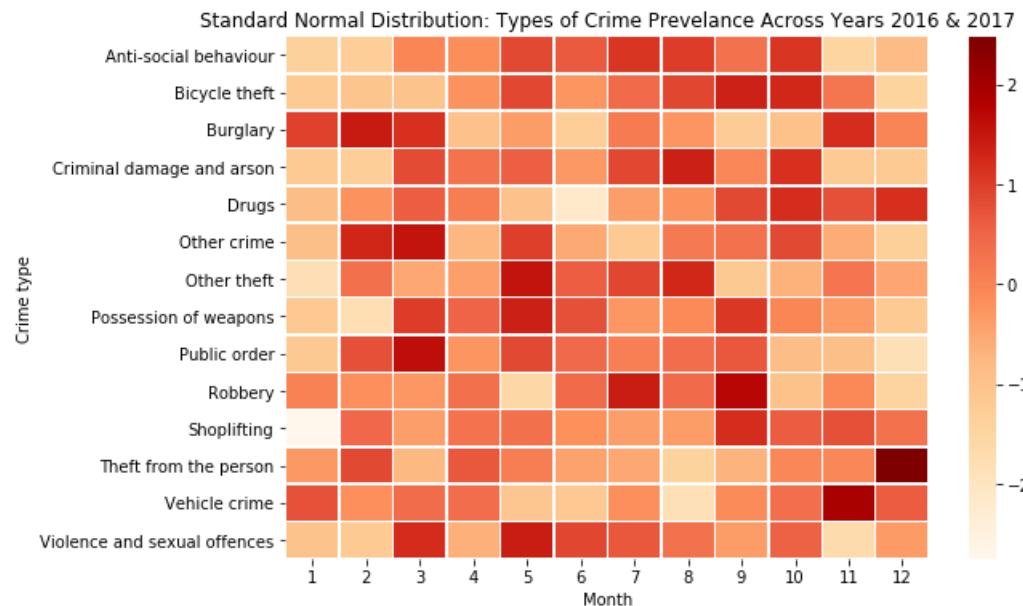
```
In [34]: psni_crime_data_grouped_crime_type_pivot_hm_normalised = psni_crime_data_grouped_crime_type.pivot('Month', 'Crime type', 'counts')
psni_crime_data_grouped_crime_type_pivot_hm_normalised =(psni_crime_data_grouped_crime_type_pivot_hm_normalised-psni_crime_data_grouped_crime_type_pivot_hm_normalised.mean(axis=0))/psni_crime_data_grouped_crime_type_pivot_hm_normalised.std(axis=0)
psni_crime_data_grouped_crime_type_pivot_hm_normalised_transpose = psni_crime_data_grouped_crime_type_pivot_hm_normalised.transpose()
psni_crime_data_grouped_crime_type_pivot_hm_normalised_transpose.head(5)
```

Out[34]:

Month	1	2	3	4	5	6	7	8	9	10	11	12
Crime type												
Anti-social behaviour	-1.340441	-1.272085	-0.021526	-0.139531	0.856311	0.644047	1.099516	1.028281	0.310901	1.112467	-1.472117	-0.805824
Bicycle theft	-1.167723	-1.043276	-0.993498	-0.221930	0.873199	-0.246819	0.425192	0.898089	1.370985	1.296317	0.250967	-1.441505
Burglary	0.957883	1.458893	1.172602	-0.960269	-0.344743	-1.260875	0.156267	-0.244541	-1.232246	-0.931640	1.215546	0.013122
Criminal damage and arson	-1.167728	-1.289226	0.835144	0.275518	0.599512	-0.280427	0.871961	1.380043	-0.037431	1.159138	-1.171410	-1.175092
Drugs	-0.843649	-0.234070	0.614559	0.124505	-0.963174	-2.134522	-0.377501	-0.198213	0.853610	1.212185	0.769942	1.176328

```
In [35]: f, ax = plt.subplots(figsize=(9, 6))
sb.heatmap(psni_crime_data_grouped_crime_type_pivot_hm_normalised_transpose, linewidths=.5, ax=ax, cmap="OrRd")
plt.title('Standard Normal Distribution: Types of Crime Prevelance Across Years 2016 & 2017')
```

Out[35]: Text(0.5,1,'Standard Normal Distribution: Types of Crime Prevelance Across Years 2016 &amp; 2017')



Burglary prevalent in January, February and March.

Bicycle theft prevalent in September and October.

Drugs prevalent October, November and December.

Vehicle crime prevalent in November.

Theft from the person prevalent in December.

Some crimes have blocks in which they are prevalent and less prevalent, there is not an even distribution across the year. Anti Social Behaviour has a 'cooling off' period between November and February in which the monthly total is lower than the rest of the year. As this is mainly an analysis on anti social behaviour let's compare which crimes are most similar to the distribution of anti social behaviour across the year.

</b>

## Comparing prevalence of different crime types with anti social behaviour

We can use correlation to find crimes that follow the same month trend with Anti social behaviour

```
In [36]: psni_crime_data_grouped_crime_type_pivot_hm_normalised.corr()
```

Out[36]:

Crime type	Anti-social behaviour	Bicycle theft	Burglary	Criminal damage and arson	Drugs	Other crime	Other theft	Possession of weapons	Public order	Robbery	Shoplifting	Theft from the person	Vehicle crime	Violence and sexual offences
Crime type														
Anti-social behaviour	1.000000	0.689546	-0.676137	0.891696	-0.171621	0.177150	0.454125	0.611439	0.374159	0.164878	0.190411	-0.472994	-0.687867	0.817012
Bicycle theft	0.689546	1.000000	-0.576943	0.624710	0.107058	0.201760	0.311338	0.540316	0.205160	0.276749	0.463775	-0.527865	-0.333636	0.289333
Burglary	-0.676137	-0.576943	1.000000	-0.437462	0.112229	0.164234	-0.054854	-0.562442	0.008333	-0.186391	-0.326067	0.096519	0.449031	-0.394611
Criminal damage and arson	0.891696	0.624710	-0.437462	1.000000	0.031076	0.327298	0.362878	0.597933	0.437968	0.130549	0.108549	-0.575198	-0.527493	0.740045
Drugs	-0.171621	0.107058	0.112229	0.031076	1.000000	0.107786	-0.406453	-0.141277	-0.307126	-0.146316	0.458527	0.292001	0.561364	-0.282991
Other crime	0.177150	0.201760	0.164234	0.327298	0.107786	1.000000	0.134346	0.282873	0.700746	-0.234718	0.285462	-0.282556	-0.259062	0.332807
Other theft	0.454125	0.311338	-0.054854	0.362878	-0.406453	0.134346	1.000000	0.203145	0.381119	-0.096394	0.279448	-0.170646	-0.597920	0.407261
Possession of weapons	0.611439	0.540316	-0.562442	0.597933	-0.141277	0.282873	0.203145	1.000000	0.552583	0.140516	0.280023	-0.472374	-0.328631	0.644527
Public order	0.374159	0.205160	0.008333	0.437968	-0.307126	0.700746	0.381119	0.552583	1.000000	0.288855	0.176711	-0.550579	-0.532474	0.499928
Robbery	0.164878	0.276749	-0.186391	0.130549	-0.146316	-0.234718	-0.096394	0.140516	0.288855	1.000000	-0.027205	-0.564146	-0.119956	-0.151520
Shoplifting	0.190411	0.463775	-0.326067	0.108549	0.458527	0.285462	0.279448	0.280023	0.176711	-0.027205	1.000000	0.215872	0.011282	-0.005729
Theft from the person	-0.472994	-0.527865	0.096519	-0.575198	0.292001	-0.282556	-0.170646	-0.472374	-0.550579	-0.564146	0.215872	1.000000	0.380251	-0.330628
Vehicle crime	-0.687867	-0.333636	0.449031	-0.527493	0.561364	-0.259062	-0.597920	-0.328631	-0.532474	-0.119956	0.011282	0.380251	1.000000	-0.611445
Violence and sexual offences	0.817012	0.289333	-0.394611	0.740045	-0.282991	0.332807	0.407261	0.644527	0.499928	-0.151520	-0.005729	-0.330628	-0.611445	1.000000

Criminal damage and arson and violence and sexual offences frequencies are most positively correlated to anti social behaviour frequency. Vehicle crime and burglary frequencies are the most negatively correlated to anti social behaviour frequency. I'm going to draw the graphs of each to compare their monthly prevalence with anti social behaviour.

```
In [37]: plt.figure(figsize=(20,10))

plt.subplot(2, 3, 1)
plt.title('Anti social behaviour 2016-17 normalized')
sb.lineplot(np.arange(0, 12, step=1.0), psni_crime_data_grouped_crime_type_pivot_hm_normalised['Anti-social behaviour'])
plt.xticks(np.arange(0, 12, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
plt.yticks(np.arange(-2, 2, step=0.5))
plt.ylabel('Standard score')
plt.xlabel('Month')

plt.subplot(2, 3, 2)
plt.title('Criminal damage and arson 2016-17 normalized')
sb.lineplot(np.arange(0, 12, step=1.0), psni_crime_data_grouped_crime_type_pivot_hm_normalised['Criminal damage and arson'])
plt.xticks(np.arange(0, 12, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
plt.yticks(np.arange(-2, 2, step=0.5))
plt.ylabel('Standard score')
plt.xlabel('Month')

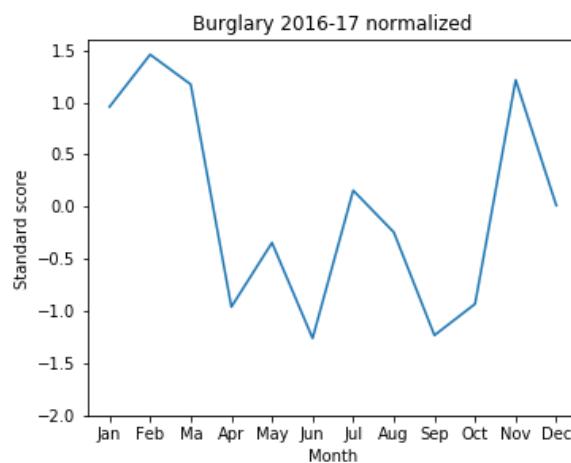
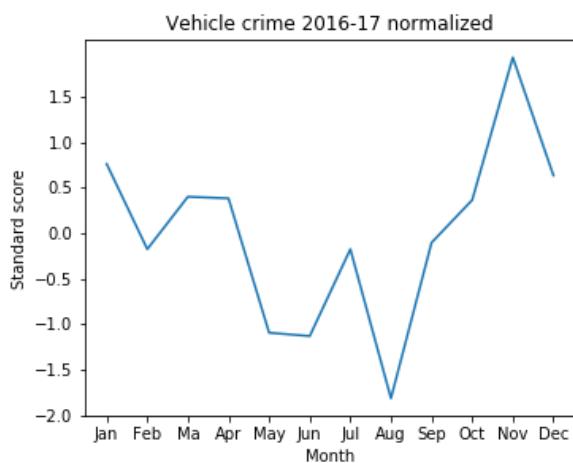
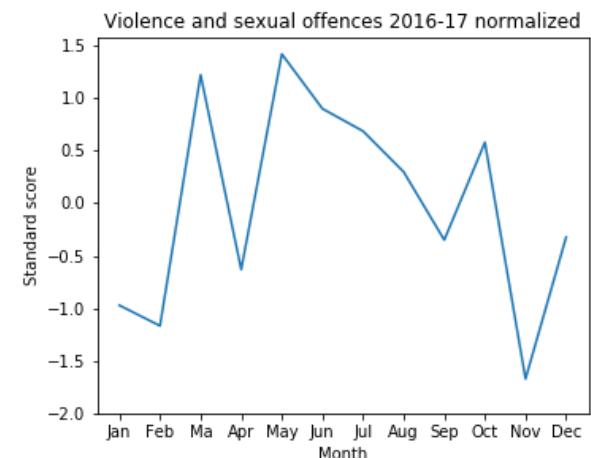
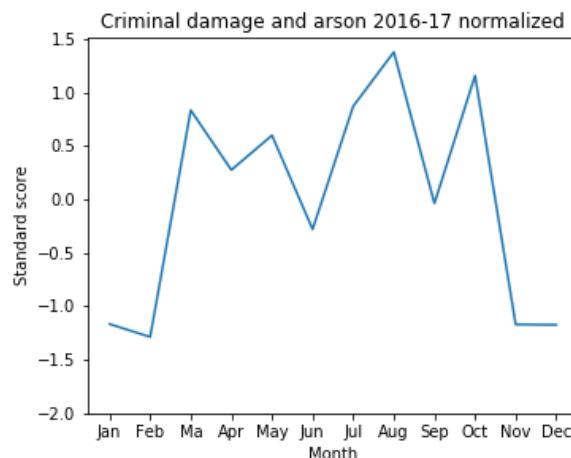
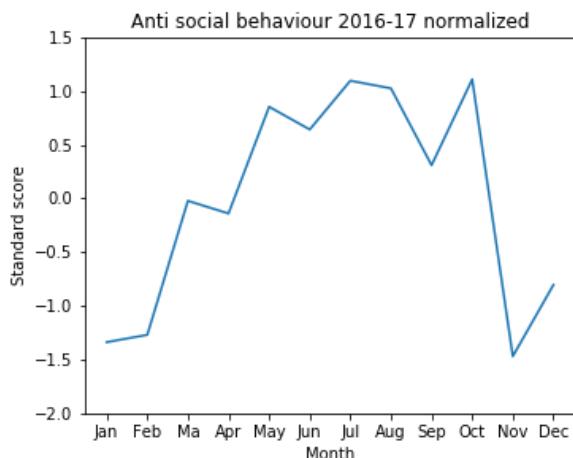
plt.subplot(2, 3, 3)
plt.title('Violence and sexual offences 2016-17 normalized')
sb.lineplot(np.arange(0, 12, step=1.0), psni_crime_data_grouped_crime_type_pivot_hm_normalised['Violence and sexual offences'])
plt.xticks(np.arange(0, 12, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
plt.yticks(np.arange(-2, 2, step=0.5))
plt.ylabel('Standard score')
plt.xlabel('Month')

plt.subplot(2, 3, 4)
plt.title('Vehicle crime 2016-17 normalized')
sb.lineplot(np.arange(0, 12, step=1.0), psni_crime_data_grouped_crime_type_pivot_hm_normalised['Vehicle crime'])
plt.xticks(np.arange(0, 12, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
plt.yticks(np.arange(-2, 2, step=0.5))
plt.ylabel('Standard score')
plt.xlabel('Month')

plt.subplot(2, 3, 5)
plt.title('Burglary 2016-17 normalized')
sb.lineplot(np.arange(0, 12, step=1.0), psni_crime_data_grouped_crime_type_pivot_hm_normalised['Burglary'])
plt.xticks(np.arange(0, 12, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
plt.yticks(np.arange(-2, 2, step=0.5))
plt.ylabel('Standard score')
plt.xlabel('Month')

plt.subplots_adjust(wspace=0.3)
plt.subplots_adjust(hspace=0.3)
```

## Crime EDA



**Positive correlation crimes:**

**Criminal damage and arson:** February to March considerable rise.

**Violence and sexual offences:** peak in May and fell in September. September to October rise. There's a noticeable rise from February to March and then a fall in April.

**ASB and Criminal Damage and Arson** are least prevalent in Winter. Violence and sexual offences do see a rise in December, but a sharp fall after in January in February.

**Negative correlation crimes:**

**Vehicle crime:** Fall January to August, least prevalent in August. Considerable rise from August to peak in November, falls after December.

**Burglary:** Peak in February fall to least prevalent in June, rise in July. Rise September to November.

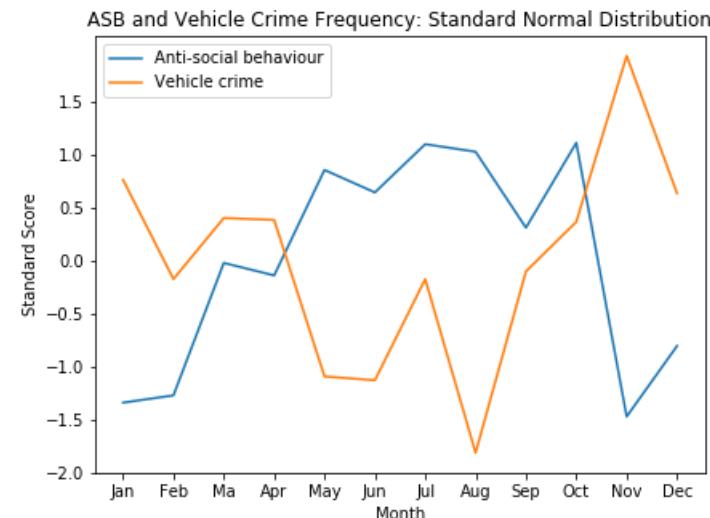
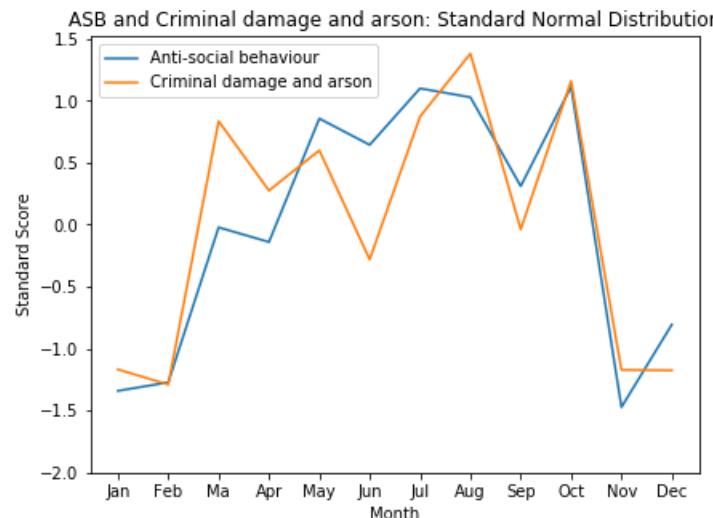
I'm going to compare the most correlated and least correlated by overlapping the ASB frequency.

```
In [38]: plt.figure(figsize=(15,5))

plt.subplot(1, 2, 1)
sb.lineplot(np.arange(0, 12, step=1.0), psni_crime_data_grouped_crime_type_pivot_hm_normalised['Anti-social behaviour'])
sb.lineplot(np.arange(0, 12, step=1.0), psni_crime_data_grouped_crime_type_pivot_hm_normalised['Criminal damage and arson'])
plt.xticks(np.arange(0, 12, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
plt.yticks(np.arange(-2, 2, step=0.5))
plt.ylabel('Standard Score')
plt.xlabel('Month')
plt.title('ASB and Criminal damage and arson: Standard Normal Distribution')
plt.legend(['Anti-social behaviour', 'Criminal damage and arson'])

plt.subplot(1, 2, 2)
sb.lineplot(np.arange(0, 12, step=1.0), psni_crime_data_grouped_crime_type_pivot_hm_normalised['Anti-social behaviour'])
sb.lineplot(np.arange(0, 12, step=1.0), psni_crime_data_grouped_crime_type_pivot_hm_normalised['Vehicle crime'])
plt.xticks(np.arange(0, 12, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
plt.yticks(np.arange(-2, 2, step=0.5))
plt.ylabel('Standard Score')
plt.xlabel('Month')
plt.title('ASB and Vehicle Crime Frequency: Standard Normal Distribution')
plt.legend(['Anti-social behaviour', 'Vehicle crime'])
```

Out[38]: <matplotlib.legend.Legend at 0x136f6cd8ac8>



The frequency of ASB and criminal damage and arson are visually similar in their frequency. ASB and Vehicle Crime do have an opposite trend in the months April-June. There is a rise from September to November while ASB has a decrease in that period.

## Seasonal Changes Investigation

I have found that some types of crimes are more prevalent in times of the year. Speculating, a crime such as vehicle crime could be because of shorter days in the winter months and therefore more cover of darkness to commit the crime. The rise of crimes such as ASB could be because of more outdoor activity in the summer, with parties leading to street drinking. To investigate this further, I am going to load in meteorological data from the Met Office (<https://www.metoffice.gov.uk/climate/uk/summaries/datasets>). I am going to use average sunshine per month and compare it with the number of crimes. 'Period during which direct solar irradiance exceeds a threshold value of 120 W/m<sup>2</sup>' is the hour value in the table.

```
In [39]: monthly_sunshine = pd.read_csv('data/MetOffice/Northern_Ireland_Sunshine.csv')
monthly_sunshine_4_years = monthly_sunshine[(monthly_sunshine.Year >= 2015)]
monthly_sunshine_4_years.head()
```

Out[39]:

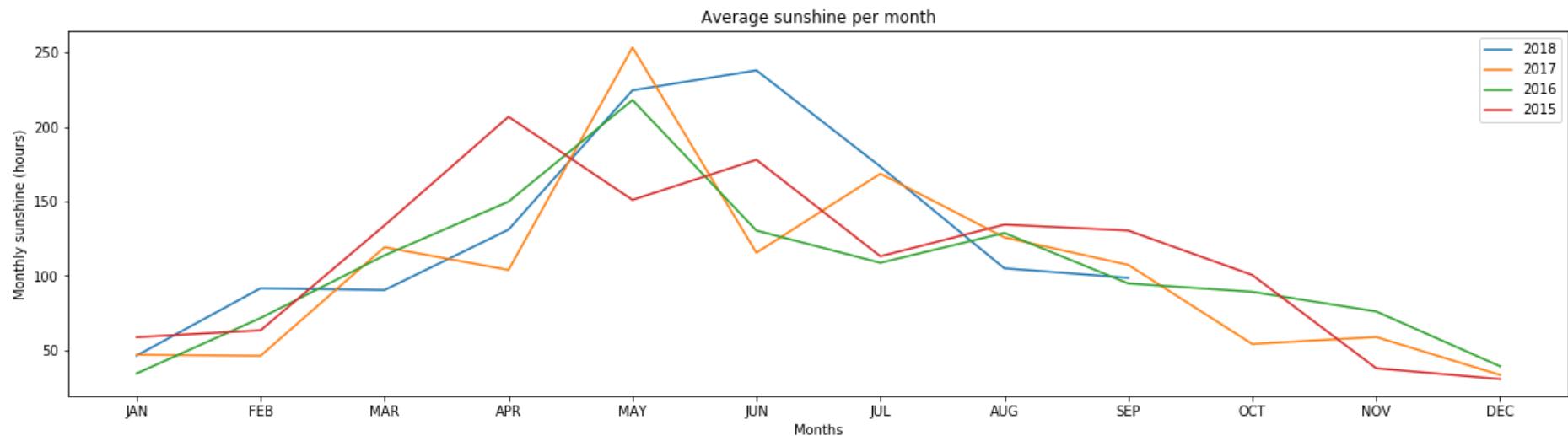
	Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	WIN	SPR	SUM	AUT	ANN
86	2015	58.7	63.3	133.9	206.9	151.0	178.0	113.1	134.4	130.4	100.5	37.8	30.5	166	491.9	425.4	268.7	1338.5
87	2016	34.3	71.6	113.7	149.8	218.1	130.4	108.7	128.8	94.8	89.2	76.0	39.1	136.4	481.6	367.9	260.0	1254.5
88	2017	46.9	46.2	119.2	103.9	253.5	115.5	168.6	125.8	107.3	54.1	58.8	33.3	132.2	476.6	409.9	220.1	1233.1
89	2018	46.3	91.6	90.4	131.0	224.7	238.1	173.4	105.0	98.6	NaN	NaN	NaN	171.3	446.1	516.5	NaN	NaN

Let's remove the season columns as this will be an analysis of frequency per month vs sunshine

```
In [40]: monthly_sunshine_4_years = monthly_sunshine_4_years.drop(['WIN', 'SPR', 'SUM', 'AUT', 'ANN'], axis=1)
```

```
In [41]: plt.figure(figsize=(20,5))
plt.plot(monthly_sunshine_4_years.drop('Year', axis=1).columns.tolist(), monthly_sunshine_4_years[monthly_sunshine_4_years['Year'] == 2018].drop('Year', axis=1).values.flatten().tolist())
plt.plot(monthly_sunshine_4_years.drop('Year', axis=1).columns.tolist(), monthly_sunshine_4_years[monthly_sunshine_4_years['Year'] == 2017].drop('Year', axis=1).values.flatten().tolist())
plt.plot(monthly_sunshine_4_years.drop('Year', axis=1).columns.tolist(), monthly_sunshine_4_years[monthly_sunshine_4_years['Year'] == 2016].drop('Year', axis=1).values.flatten().tolist())
plt.plot(monthly_sunshine_4_years.drop('Year', axis=1).columns.tolist(), monthly_sunshine_4_years[monthly_sunshine_4_years['Year'] == 2015].drop('Year', axis=1).values.flatten().tolist())
plt.xlabel('Months')
plt.ylabel('Monthly sunshine (hours)')
plt.title("Average sunshine per month")
plt.legend(['2018', '2017', '2016', '2015'])
```

Out[41]: <matplotlib.legend.Legend at 0x136f6959c50>



The spring and summer months have the most sunshine, while the autumn and winter have the least. This will provide a way to see if there is an influence of seasonal changes. I'm going to plot 2016 vs 2017 sunshine and crime frequency to see if there is any trend.

```
In [42]: plt.figure(figsize=(15,10))
plt.subplot(2, 1, 1)
ax = sb.lineplot(np.arange(0, 12, step=1.0), monthly_sunshine_4_years[monthly_sunshine_4_years['Year'] == 2016].drop('Year', axis=1).values.flatten().tolist(), color='orange')
ax2 = ax.twinx()

yvals2016 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2016].counts

ax2.set_xticks(np.arange(0, 12, step=1.0))
ax2.set_xticklabels(['Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'])

sb.lineplot((np.arange(0, 12, step=1.0)), yvals2016, ax=ax2)
ax.set_xlabel('Months')
ax.set_ylabel('Average sunshine')
ax2.set_ylabel('Number of crimes')

plt.title("Average sunshine vs Number of crimes per month in 2016")
ax.legend(['Sunshine'])
ax2.legend(['Crime'], bbox_to_anchor=(1,0.9), loc="upper right")

plt.subplot(2,1,2)
ax = sb.lineplot(np.arange(0, 12, step=1.0), monthly_sunshine_4_years[monthly_sunshine_4_years['Year'] == 2017].drop('Year', axis=1).values.flatten().tolist(), color='orange')
ax2 = ax.twinx()

yvals2016 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2017].counts

ax2.set_xticks(np.arange(0, 12, step=1.0))
ax2.set_xticklabels(['Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'])

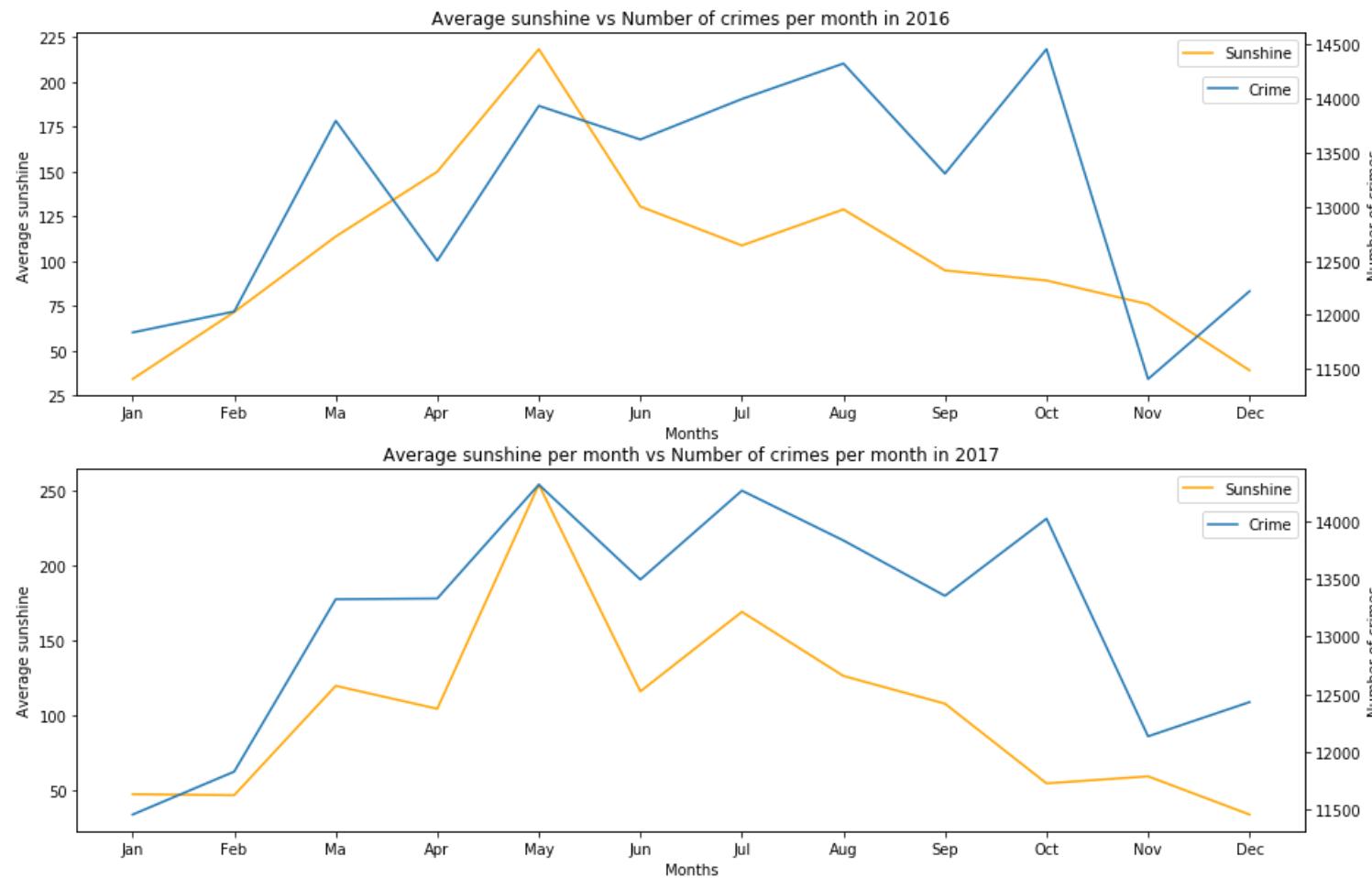
sb.lineplot((np.arange(0, 12, step=1.0)), yvals2016, ax=ax2)

ax.set_xlabel('Months')
ax.set_ylabel('Average sunshine')
ax2.set_ylabel('Number of crimes')

ax.legend(['Sunshine'])
ax2.legend(['Crime'], bbox_to_anchor=(1,0.9), loc="upper right")

plt.title("Average sunshine per month vs Number of crimes per month in 2017")
```

Out[42]: Text(0.5,1,'Average sunshine per month vs Number of crimes per month in 2017')



2016: The rise in sunshine in May appear to rise together with crime. The rise of sunshine in August and fall in September also occurs to the crime totals. However, the rise in crime in October is a fall in sunshine.

2017: The rise in sunshine in February to March rises together with crime. The peak of crimes and sunshine is May. The period from July to September sees a fall in both crime and sunshine.

Let's get a statistical figure for the correlation between monthly sunshine and monthly crime for 2015-2018

```
In [43]: #corr_sunshine_month_2016_2017 = monthly_sunshine_2016_2017.merge(psni_crime_data_grouped_month_year)

corr_sunshine_month_4_years = pd.DataFrame(columns=['counts', 'sunshine'])
months = ['JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC']
crimes_month_year_4_years = psni_crime_data_grouped_month_year[(psni_crime_data_grouped_month_year['Year'] >= 2015)].reset_index()
for index, row in crimes_month_year_4_years.iterrows():
    counts = row['counts']
    month = months[row['Month']-1]
    sunshine = monthly_sunshine_4_years[monthly_sunshine_4_years['Year'] == row['Year']].iloc[0][month]
    corr_sunshine_month_4_years = corr_sunshine_month_4_years.append({'counts': counts, 'sunshine': sunshine}, ignore_index=True)

corr_sunshine_month_4_years.head()
```

Out[43]:

	counts	sunshine
0	11837.0	34.3
1	11458.0	46.9
2	11585.0	46.3
3	12031.0	71.6
4	11830.0	46.2

```
In [44]: corr_sunshine_month_4_years.corr()
```

Out[44]:

	counts	sunshine
counts	1.000000	0.568879
sunshine	0.568879	1.000000

There is a moderate positive linear relationship between average monthly sunshine and the number of crimes per month. I'm going to take a look at another meteorological reading to see if there is stronger correlation. Some crimes could be caused by people participating in more outdoor activities whenever there is hot weather. Let's load in the mean temperature for each month, once again from the met office. The values are in celsius and are the temperature across the month, not the mean average high temperature.

```
In [45]: mean_monthly_temp = pd.read_csv('data/MetOffice/Northern_Ireland_Mean_Temp.csv')
mean_temp_4_years = mean_monthly_temp[(mean_monthly_temp.Year >= 2015)]
mean_temp_4_years.head()
```

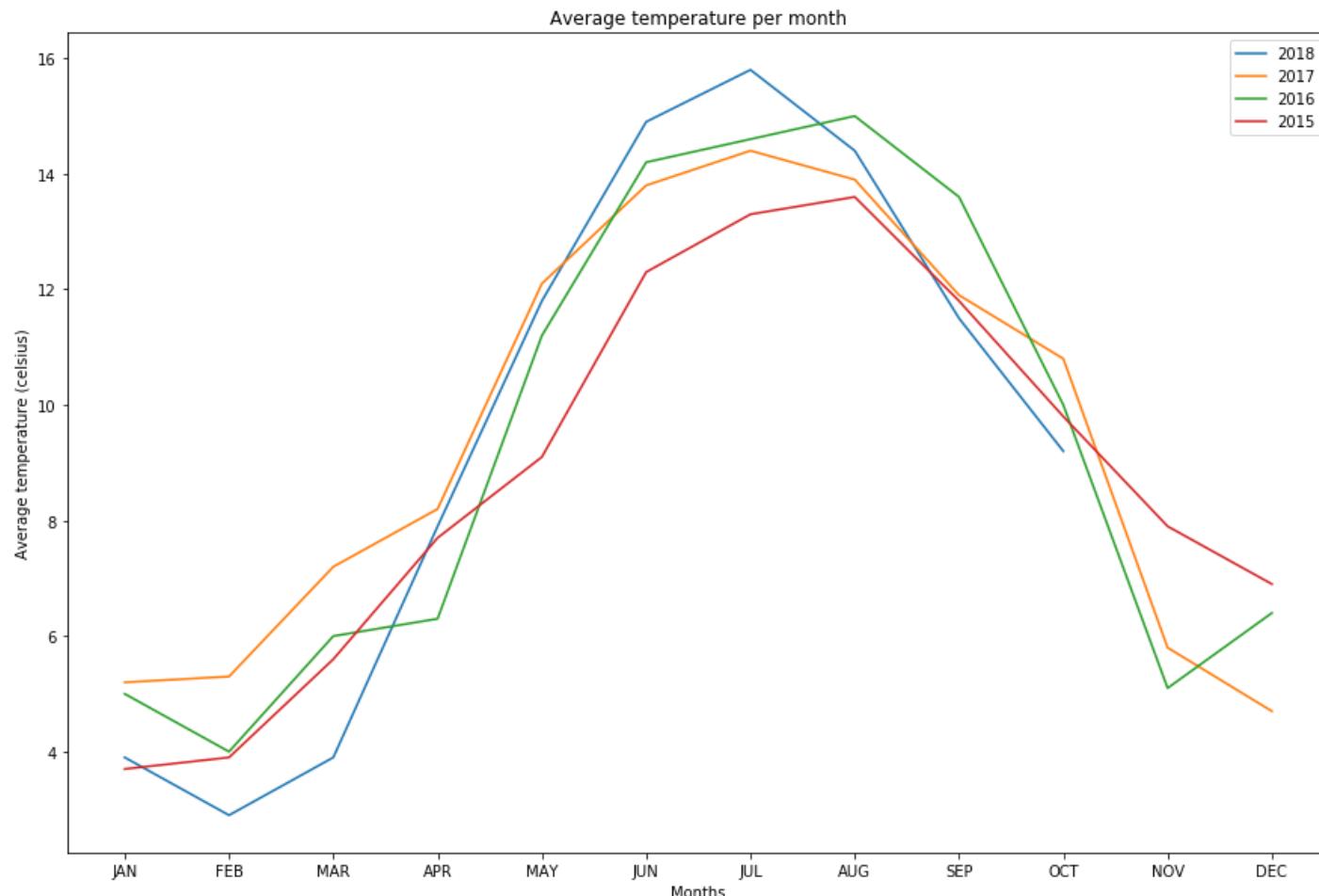
Out[45]:

	Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	WIN	SPR	SUM	AUT	ANN
105	2015	3.7	3.9	5.6	7.7	9.1	12.3	13.3	13.6	11.8	9.8	7.9	6.9	4.05	7.46	13.09	9.85	8.83
106	2016	5.0	4.0	6.0	6.3	11.2	14.2	14.6	15.0	13.6	10.0	5.1	6.4	5.35	7.87	14.61	9.57	9.32
107	2017	5.2	5.3	7.2	8.2	12.1	13.8	14.4	13.9	11.9	10.8	5.8	4.7	5.64	9.17	14.05	9.53	9.47
108	2018	3.9	2.9	3.9	7.9	11.8	14.9	15.8	14.4	11.5	9.2	NaN	NaN	3.88	7.89	15.02	NaN	NaN

```
In [46]: mean_temp_4_years = mean_temp_4_years.drop(['WIN', 'SPR', 'SUM', 'AUT', 'ANN'], axis=1)
```

```
In [130]: plt.figure(figsize=(15,10))
plt.plot(mean_temp_4_years.drop('Year', axis=1).columns.tolist(), mean_temp_4_years[mean_temp_4_years['Year'] == 2018].drop('Year', axis=1).values.flatten().tolist())
plt.plot(mean_temp_4_years.drop('Year', axis=1).columns.tolist(), mean_temp_4_years[mean_temp_4_years['Year'] == 2017].drop('Year', axis=1).values.flatten().tolist())
plt.plot(mean_temp_4_years.drop('Year', axis=1).columns.tolist(), mean_temp_4_years[mean_temp_4_years['Year'] == 2016].drop('Year', axis=1).values.flatten().tolist())
plt.plot(mean_temp_4_years.drop('Year', axis=1).columns.tolist(), mean_temp_4_years[mean_temp_4_years['Year'] == 2015].drop('Year', axis=1).values.flatten().tolist())
plt.xlabel('Months')
plt.ylabel('Average temperature (celsius)')
plt.title("Average temperature per month")
plt.legend(['2018', '2017', '2016', '2015'])
```

Out[130]: <matplotlib.legend.Legend at 0x136eda02cc0>



The summer months have the highest temperature celsius, while the spring and winter have the lowest temperature celsius. Like with sunshine, let's plot the frequency of crime in 2016 and 2017 months with the monthly temperature.

```
In [48]: plt.figure(figsize=(15,10))
plt.subplot(2, 1, 1)
ax = sb.lineplot(np.arange(0, 12, step=1.0), mean_temp_4_years[mean_temp_4_years['Year'] == 2016].drop('Year', axis=1).values.flatten().tolist(), color='orange')
ax2 = ax.twinx()

yvals2016 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2016].counts

ax2.set_xticks(np.arange(0, 12, step=1.0))
ax2.set_xticklabels(['Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'])

sb.lineplot((np.arange(0, 12, step=1.0)), yvals2016, ax=ax2)
ax.set_xlabel('Months')
ax.set_ylabel('Average temperature (celsius)')
ax2.set_ylabel('Number of crimes')

plt.title("Average temperature vs Number of crimes per month in 2016")
ax.legend(['Temperature'])
ax2.legend(['Crime'], bbox_to_anchor=(1,0.9), loc="upper right")

plt.subplot(2,1,2)
ax = sb.lineplot(np.arange(0, 12, step=1.0), mean_temp_4_years[mean_temp_4_years['Year'] == 2017].drop('Year', axis=1).values.flatten().tolist(), color='orange')
ax2 = ax.twinx()

yvals2016 = psni_crime_data_grouped_month_year[psni_crime_data_grouped_month_year.Year == 2017].counts

ax2.set_xticks(np.arange(0, 12, step=1.0))
ax2.set_xticklabels(['Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'])

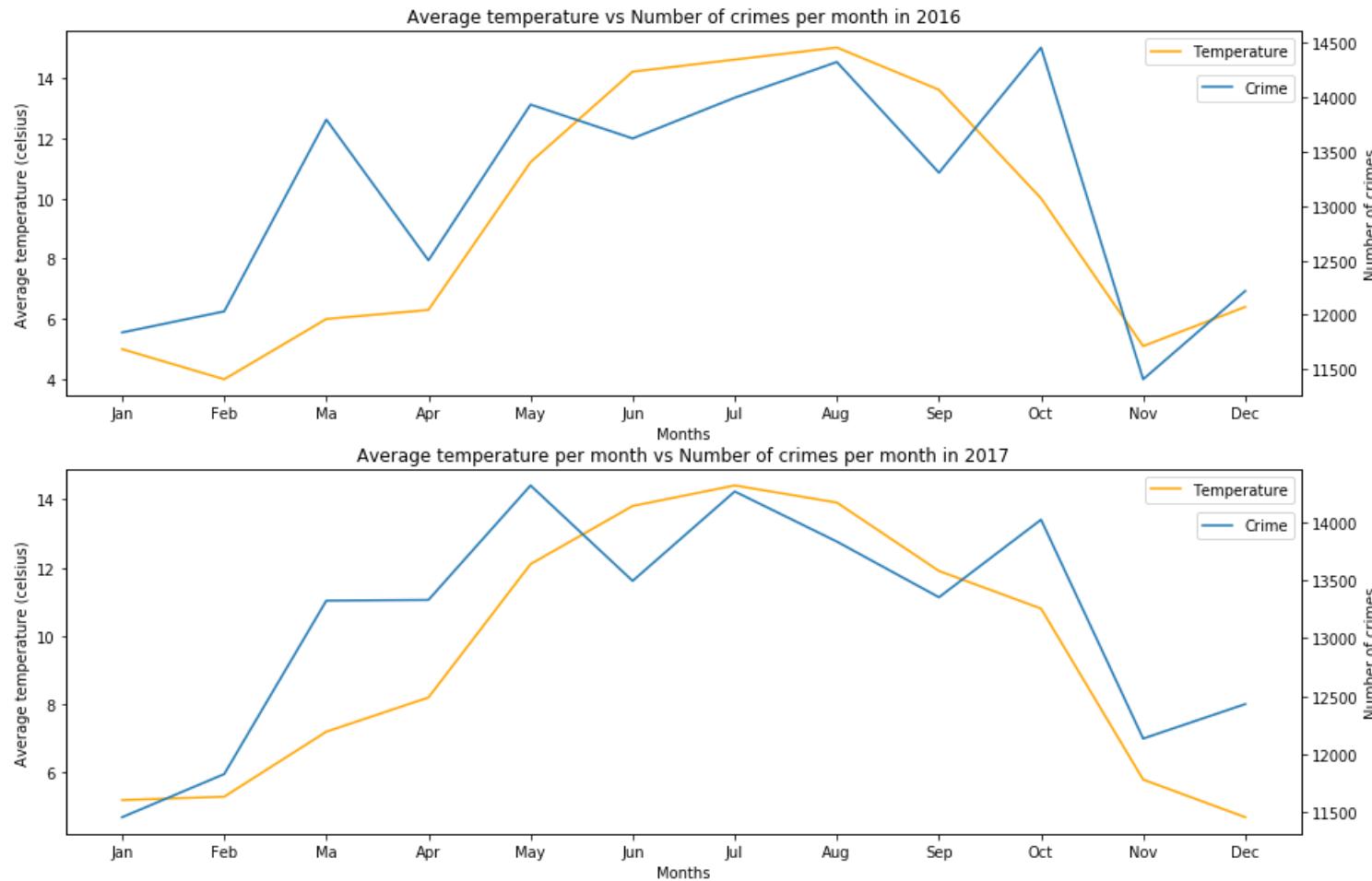
sb.lineplot((np.arange(0, 12, step=1.0)), yvals2016, ax=ax2)

ax.set_xlabel('Months')
ax.set_ylabel('Average temperature (celsius)')
ax2.set_ylabel('Number of crimes')

ax.legend(['Temperature'])
ax2.legend(['Crime'], bbox_to_anchor=(1,0.9), loc="upper right")

plt.title("Average temperature per month vs Number of crimes per month in 2017")
```

Out[48]: Text(0.5,1,'Average temperature per month vs Number of crimes per month in 2017')



2016: There is a slight rise in temperature accompanying the rise in crime in March, although the sharp drop from March to April is a slight rise in temperature. The peak of crimes in October is not temperature's, which peaks in August - although August does have a high frequency of crime.

2017: The peak of crimes in May accompanies the rise of temperature - the trend of temperature rising in the early months of the year and rise in crimes does seem apparent. The fall crime after October is joined by a sharp decrease in temperature.

October still remains an issue - it is the peak of crimes and neither sunshine nor temperature peak at that month.

Let's get a statistical figure for the correlation between monthly temperature and monthly crime. </b>

```
In [49]: corr_temperature_4_years = pd.DataFrame(columns=['counts', 'temperature'])
months = ['JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC']
crimes_month_year_4_years = psni_crime_data_grouped_month_year[(psni_crime_data_grouped_month_year['Year'] >= 2015)].reset_index()
for index, row in crimes_month_year_4_years.iterrows():
    counts = row['counts']
    month = months[row['Month']-1]
    temperature = mean_temp_4_years[mean_temp_4_years['Year'] == row['Year']].iloc[0][month]
    corr_temperature_4_years = corr_temperature_4_years.append({'counts': counts, 'temperature': temperature}, ignore_index=True)
corr_temperature_4_years.corr()
```

Out[49]:

	counts	temperature
counts	1.000000	0.787959
temperature	0.787959	1.000000

There is a strong positive correlation between month by month mean temperature and crime counts. Let's look at the correlation between mean monthly temperature and different crime types. It will be interesting to see whether ASB, which was identified as potentially season dependent, has strong correlation or not with temperature.

```
In [50]: psni_crime_data_grouped_crime_type.head()
```

Out[50]:

	Month	Crime type	counts
0	1	Anti-social behaviour	8366
1	1	Bicycle theft	87
2	1	Burglary	1228
3	1	Criminal damage and arson	2781
4	1	Drugs	890

```
In [51]: psni_crime_data_grouped_crime_type_month_year = psni_crime_data.groupby(['Year', 'Month', 'Crime type']).size().reset_index(name='counts')
psni_crime_data_grouped_crime_type_month_year['Temperature'] = None

months = ['JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC']
for index, row in psni_crime_data_grouped_crime_type_month_year.iterrows():
    month = months[row['Month']-1]
    temperature = mean_temp_4_years[mean_temp_4_years['Year'] == row['Year']].iloc[0][month]
    psni_crime_data_grouped_crime_type_month_year.at[index, 'Temperature'] = temperature

psni_crime_data_grouped_crime_type_month_year[['Temperature']] = psni_crime_data_grouped_crime_type_month_year[['Temperature']].apply(pd.to_numeric)
psni_crime_data_grouped_crime_type_month_year = psni_crime_data_grouped_crime_type_month_year.drop(['Year'], axis=1)
```

```
In [52]: unique_crimes = psni_crime_data['Crime type'].unique()
correlation_crime_type = pd.DataFrame(columns=['Crime type', 'Correlation'])
for crime in unique_crimes:
    crime_type_counts = psni_crime_data_grouped_crime_type_month_year[psni_crime_data_grouped_crime_type_month_year['Crime type'] == crime]
    crime_type_counts = crime_type_counts.drop(['Crime type', 'Month'], axis=1)
    correlation = crime_type_counts.corr()
    correlation_crime_type = correlation_crime_type.append({'Crime type': crime, 'Correlation': correlation.iloc[0]['Temperature']}, ignore_index=True)

correlation_crime_type.nlargest(5, ['Correlation']).head()
```

Out[52]:

	Crime type	Correlation
0	Anti-social behaviour	0.841309
1	Bicycle theft	0.707521
3	Criminal damage and arson	0.667986
12	Violence and sexual offences	0.566930
6	Possession of weapons	0.314003

```
In [53]: correlation_crime_type.nsmallest(5, ['Correlation']).head()
```

Out[53]:

	Crime type	Correlation
4	Drugs	-0.311053
2	Burglary	-0.098479
10	Theft from the person	-0.070984
13	Other crime	-0.018694
11	Vehicle crime	-0.002031

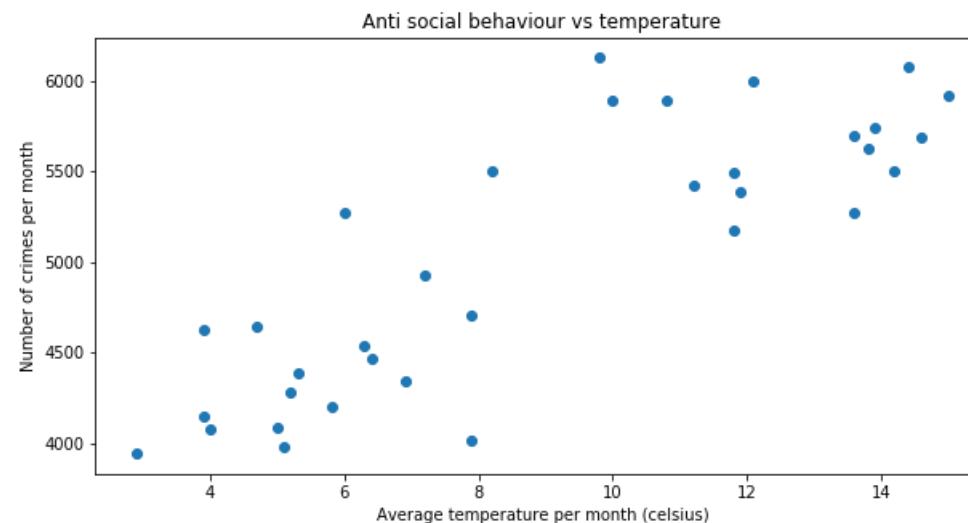
Monthly Anti-social behaviour counts have the strongest positive correlation to mean monthly temperature. Drugs has the strongest negative correlation to monthly temperature. As observed before, drug crime was more prevalent in October, November and December so this could be the reason why. I will visualise anti-social behaviour counts to mean monthly temperature to verify a positive relationship:

```
In [54]: plt.figure(figsize=(10,5))
anti_social_crime = psni_crime_data_grouped_crime_type_month_year[psni_crime_data_grouped_crime_type_month_year['Crime type'] == 'Anti-social behaviour'].reset_index(drop=True)
plt.scatter(anti_social_crime.Temperature, anti_social_crime.counts)

psni_crime_data_grouped_crime_type = psni_crime_data_ranged.groupby(['Month', 'Crime type']).size().reset_index(name='counts')

# numpyArrayX = anti_social_crime.Temperature.values
# numpyArrayY = anti_social_crime.counts.values
# sb.regplot(anti_social_crime.counts,anti_social_crime.Temperature);
plt.title("Anti social behaviour vs temperature")
plt.xlabel('Average temperature per month (celsius)')
plt.ylabel('Number of crimes per month')
```

Out[54]: Text(0,0.5, 'Number of crimes per month')



There is a positive trend between ASB and temperature. Let's use a linear regression model to better visualise this. I'm going to use 2015-2018 which will give me 34 samples, which is limited for a regression model. The goal of the model is knowing the mean temperature for a month, can you predict what the anti social behaviour count will be for that month?

```
In [55]: x = anti_social_crime[['Temperature']]
y = anti_social_crime['counts']

x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.4, random_state=0)

print(len(x_train))
print(len(y_train))
print(len(x_test))
print(len(y_test))

20
20
14
14
```

```
In [56]: regressor = LinearRegression()
```

```
In [57]: result = regressor.fit(x_train, y_train)
```

```
In [58]: y_pred = regressor.predict(x_test)
```

```
In [59]: def mean_absolute_percentage_error(y_true, y_pred):
    y_true, y_pred = np.array(y_true), np.array(y_pred)
    return np.mean(np.abs((y_true - y_pred) / y_true)) * 100

def min_error(y_true, y_pred):
    maxdiff = 0
    for i, j in zip(y_true, y_pred):
        difference = i - j
        if (difference > maxdiff):
            maxdiff = difference
    return maxdiff

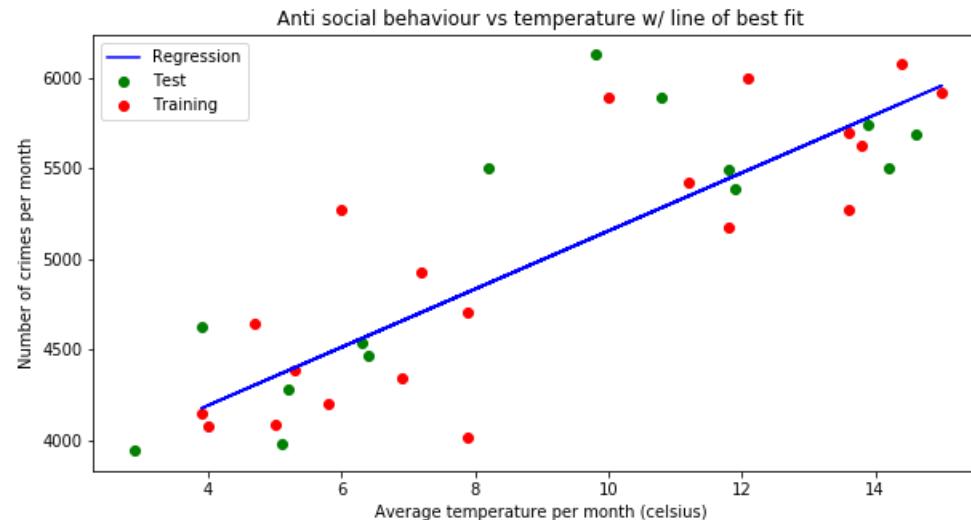
def max_error(y_true, y_pred):
    maxdiff = 0
    for i, j in zip(y_true, y_pred):
        difference = j - i
        if (difference > maxdiff):
            maxdiff = difference
    return maxdiff

print('Coefficients: \n', regressor.coef_)
print('Intercept: \n', regressor.intercept_)
print('Mean Absolute Percentage Error: %.2f' % mean_absolute_percentage_error(y_test, y_pred))
print('Mean Absolute Error: %.2f' % mean_absolute_error(y_test, y_pred))
print('Max Overforecasting Error: %.2f' % max_error(y_test, y_pred))
print('Max Underforecasting Error: %.2f' % min_error(y_test, y_pred))
```

```
Coefficients:
 [ 160.40946196]
Intercept:
 3549.36279509
Mean Absolute Percentage Error: 5.53
Mean Absolute Error: 292.16
Max Overforecasting Error: 384.45
Max Underforecasting Error: 1004.62
```

On average a 5.5% percentage error and a mean absolute error of 292 crimes per month. This model does perform quite well with the test data. However, it has a big problem with underforecasting the number of ASB for particular months (>1000 difference) in which the temperature is not particularly high but the crime total is high. The peak in October could be the reason for this.

```
In [60]: plt.figure(figsize=(10,5))
plt.scatter(x_test, y_test, color='green')
plt.scatter(x_train, y_train, color='red')
plt.plot(x_train, regressor.predict(x_train), color = 'blue')
plt.title("Anti social behaviour vs temperature w/ line of best fit")
plt.xlabel('Average temperature per month (celsius)')
plt.ylabel('Number of crimes per month')
plt.legend(['Regression', 'Test', 'Training'])
plt.show()
```



I'm going to investigate the outlier with over 6000 crimes and around 10 celsius temperature

```
In [61]: anti_social_crime[anti_social_crime['counts'] > 6000]
```

```
Out[61]:
```

	Month	Crime type	counts	Temperature
2	10	Anti-social behaviour	6126	9.8
23	7	Anti-social behaviour	6074	14.4

October for ASB is an outlier and does not fit the model well. The peak of ASB in October could be because of Halloween celebrations.

## ASB Location Crime Trends

I want to investigate anti social behaviour further and see where it is happening using the provided data longitudinal and latitudinal data.

```
In [62]: anti_social_crime = psni_crime_data[(psni_crime_data['Crime type'] == 'Anti-social behaviour') & (psni_crime_data['Has_Location'] == True)].reset_index  
(drop=True)  
anti_social_crime_sampled = anti_social_crime  
anti_social_crime_sampled.head()
```

Out[62]:

	index	Longitude	Latitude	Location	Crime type	Has_Location	Year	Month	Week	Quarter
0	0	-7.378949	54.717334	dublin street	Anti-social behaviour	True	2015	8	31	3
1	1	-5.891082	54.222501	bracken avenue	Anti-social behaviour	True	2015	8	31	3
2	2	-5.667276	54.663573	high street	Anti-social behaviour	True	2015	8	31	3
3	3	-5.962330	54.587243	rodney parade	Anti-social behaviour	True	2015	8	31	3
4	4	-5.894063	54.590423	brenda street	Anti-social behaviour	True	2015	8	31	3

```
In [63]: # anti_social_crime_sampled.to_csv('anti_social_crime.csv', index=False)
```

I did experiment with geocoding, however I felt I did not need to spend time getting properties like county and post code as none of my data I wanted to link used them as location properties.  
My investigation is below:

```
In [64]: osm = geocoder.osm([anti_social_crime.iloc[3].Latitude, anti_social_crime.iloc[3].Longitude], method='reverse')
```

```
In [65]: result = osm.json
```

```
In [66]: result
```

```
Out[66]: {'accuracy': 0.001,
  'address': 'Rodney Drive, Ballymurphy, Belfast, County Antrim, Northern Ireland, BT12 6HN, UK',
  'bbox': {'northeast': [54.5877489, -5.9623188],
  'southwest': [54.5872416, -5.9650519]},
  'city': 'Belfast',
  'confidence': 10,
  'country': 'UK',
  'country_code': 'gb',
  'county': 'County Antrim',
  'importance': 0.001,
  'lat': 54.5874972,
  'lng': -5.963674,
  'ok': True,
  'osm_id': '32932478',
  'osm_type': 'way',
  'place_id': '83608986',
  'place_rank': '26',
  'postal': 'BT12 6HN',
  'quality': 'residential',
  'raw': {'place_id': '83608986',
  'licence': 'Data © OpenStreetMap contributors, ODbL 1.0. https://osm.org/copyright',
  'osm_type': 'way',
  'osm_id': '32932478',
  'boundingbox': ['54.5872416', '54.5877489', '-5.9650519', '-5.9623188'],
  'lat': '54.5874972',
  'lon': '-5.963674',
  'display_name': 'Rodney Drive, Ballymurphy, Belfast, County Antrim, Northern Ireland, BT12 6HN, UK',
  'place_rank': '26',
  'category': 'highway',
  'type': 'residential',
  'importance': 0.001,
  'address': {'road': 'Rodney Drive',
  'locality': 'Ballymurphy',
  'city': 'Belfast',
  'county': 'County Antrim',
  'state': 'Northern Ireland',
  'postcode': 'BT12 6HN',
  'country': 'UK',
  'country_code': 'gb'}},
  'region': 'Northern Ireland',
  'state': 'Northern Ireland',
  'status': 'OK',
  'street': 'Rodney Drive',
  'type': 'residential'}
```

```
In [67]: osm = geocoder.bing([anti_social_crime.iloc[3].Latitude, anti_social_crime.iloc[3].Longitude], method='reverse', key='Aqi3VPnaoruTVcLa2v-o5gL_pwm7RnRDz0V6zzlGG3jgTUWT552Ud4gphny0jI1H')
```

In [68]: osm

Out[68]: &lt;[OK] Bing - Reverse [29 Rodney Parade, Belfast, BT12 6]&gt;

I've ran a script that links the latitude and longitude of the crime to what crime neighbourhood it took place in using the police API - Crime Neighbourhoods are part of an overall policing district and allow for Local Policing Teams (LPTs) and Neighbourhood Policing Teams (NPTs) to focus on crimes in the local area. This will allow me to categorise the crimes more meaningful and focus on a specific area in which ASB is prevalent.

```
In [69]: # anti_social_crime = pd.read_csv('anti_social_crime.csv')
# for index, row in anti_social_crime.iterrows():
#     Longitude = row['Longitude']
#     Latitude = row['Latitude']
#     url = f'https://data.police.uk/api/locate-neighbourhood?q={Latitude},{Longitude}'
#     response = requests.get(url)
#     neighbourhood = response.json()['neighbourhood']
#     anti_social_crime.at[index, 'Neighbourhood'] = neighbourhood
#     if (index % 1000 == 0):
#         print('Here')
#     anti_social_crime.to_csv('anti_social_crime.csv', index=False)

# anti_social_crime = pd.read_csv('anti_social_crime.csv')

anti_social_crime_sampled = pd.read_csv('anti_social_crime.csv')
anti_social_crime_sampled.head()
```

Out[69]:

	index	Longitude	Latitude	Location	Crime type	Has_Location	Year	Month	Week	Quarter	Neighbourhood
0	0	-7.378949	54.717334	dublin street	Anti-social behaviour	True	2015	8	31	3	Strabane
1	1	-5.891082	54.222501	bracken avenue	Anti-social behaviour	True	2015	8	31	3	Downpatrick
2	2	-5.667276	54.663573	high street	Anti-social behaviour	True	2015	8	31	3	Newtownards
3	3	-5.962330	54.587243	rodney parade	Anti-social behaviour	True	2015	8	31	3	Woodbourne
4	4	-5.894063	54.590423	brenda street	Anti-social behaviour	True	2015	8	31	3	Strandtown

```
In [70]: anti_social_crime_sampled.dtypes
```

```
Out[70]: index           int64
Longitude        float64
Latitude         float64
Location          object
Crime type        object
Has_Location      bool
Year              int64
Month             int64
Week              int64
Quarter            int64
Neighbourhood     object
dtype: object
```

```
In [71]: anti_social_crime_sampled.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 170910 entries, 0 to 170909
Data columns (total 11 columns):
index           170910 non-null int64
Longitude        170910 non-null float64
Latitude         170910 non-null float64
Location          147430 non-null object
Crime type        170910 non-null object
Has_Location      170910 non-null bool
Year              170910 non-null int64
Month             170910 non-null int64
Week              170910 non-null int64
Quarter            170910 non-null int64
Neighbourhood     170898 non-null object
dtypes: bool(1), float64(2), int64(5), object(3)
memory usage: 13.2+ MB
```

There are a few longitude and latitude inputs that did not provide a neighbourhood upon the API call. I will drop these as they are minimal (0.007% of the dataset)

```
In [72]: anti_social_crime_sampled = anti_social_crime_sampled[~anti_social_crime_sampled['Neighbourhood'].isnull()]
```

Neighbourhoods are part of policing districts. I manually mapped these using the information found in <https://www.psni.police.uk/my-area/all-districts/>. This can provide a more high level overview of ASB crimes happening in the different districts, and allow for more mapping of, for example census data with administrative geographies.

```
In [73]: neighbourhood_district = {
    'Newtownabbey': 'Antrim and Newtownabbey',
    'Antrim': 'Antrim and Newtownabbey',
    'Newtownards': 'Ards and North Down',
    'Armagh': 'Armagh City, Banbridge and Craigavon',
    'Lurgan': 'Armagh City, Banbridge and Craigavon',
    'Lisburn Road': 'Belfast City',
    'Strandtown': 'Belfast City',
    'Tennent Street': 'Belfast City',
    'Woodbourne': 'Belfast City',
    'Coleraine': 'Causeway Coast and Glens',
    'Limavady': 'Causeway Coast and Glens',
    'Strabane': 'Derry City & Strabane',
    'Strand Road': 'Derry City & Strabane',
    'Enniskillen': 'Fermanagh and Omagh',
    'Lisnaskea': 'Fermanagh and Omagh',
    'Omagh': 'Fermanagh and Omagh',
    'Lisburn': 'Lisburn and Castlereagh',
    'Castlereagh': 'Lisburn and Castlereagh',
    'Ballymena': 'Mid and East Antrim',
    'Larne': 'Mid and East Antrim',
    'Dungannon': 'Mid Ulster',
    'Magherafelt': 'Mid Ulster',
    'Crossmaglen': 'Newry, Mourne and Down',
    'Downpatrick': 'Newry, Mourne and Down',
    'Newry': 'Newry, Mourne and Down',
    'Newtownhamilton': 'Newry, Mourne and Down'
}

def map_neighbourhood_district(row):
    neighbourhood = row['Neighbourhood']
    district = neighbourhood_district[neighbourhood]
    return district
```

```
In [74]: anti_social_crime_sampled['Policing_District'] = anti_social_crime_sampled.apply(lambda row: map_neighbourhood_district (row),axis=1)
```

```
In [75]: anti_social_crime_sampled.head()
```

```
Out[75]:
```

	index	Longitude	Latitude	Location	Crime type	Has_Location	Year	Month	Week	Quarter	Neighbourhood	Policing_District
0	0	-7.378949	54.717334	dublin street	Anti-social behaviour	True	2015	8	31	3	Strabane	Derry City & Strabane
1	1	-5.891082	54.222501	bracken avenue	Anti-social behaviour	True	2015	8	31	3	Downpatrick	Newry, Mourne and Down
2	2	-5.667276	54.663573	high street	Anti-social behaviour	True	2015	8	31	3	Newtownards	Ards and North Down
3	3	-5.962330	54.587243	rodney parade	Anti-social behaviour	True	2015	8	31	3	Woodbourne	Belfast City
4	4	-5.894063	54.590423	brenda street	Anti-social behaviour	True	2015	8	31	3	Strandtown	Belfast City

## Using the Police API I was able to get the population for the policing neighbourhoods



Iain Dawson (Police.uk support)

Nov 20, 09:55 GMT

Hi James,

Team-level population data is provided to us by forces. If you have questions about a specific force's population data, I'd encourage you to [contact the force directly](#).

Kind regards,

Iain Dawson,  
Police.uk support

```
In [76]: # # neighbourhood_population = pd.DataFrame(columns=['Neighbourhood', 'Population'])

# # for key in neighbourhood_district:
# #     url = f'https://data.police.uk/api/northern-ireland/{key}'
# #     response = requests.get(url)
# #     population = response.json()['population']
# #     neighbourhood_population = neighbourhood_population.append({'Neighbourhood': key, 'Population': population}, ignore_index=True)
neighbourhood_population = pd.read_csv('neighbourhood_population.csv')
# # neighbourhood_population.to_csv('neighbourhood_population.csv', index=False)
```

I'm going to group the crimes by neighbourhood to see where ASB is most prevalent by population

```
In [77]: grouped_asb_neighbourhood = anti_social_crime_sampled.groupby('Neighbourhood').size().reset_index(name='count')
# grouped_asb_neighbourhood
```

```
In [78]: grouped_asb_neighbourhood = grouped_asb_neighbourhood.merge(neighbourhood_population, on='Neighbourhood')

def crime_per_population(row):
    population = row['Population']
    asb_count = row['count']
    return asb_count/population
grouped_asb_neighbourhood['ASB_per_population'] = grouped_asb_neighbourhood.apply(lambda row: crime_per_population(row), axis=1)
```

```
In [79]: grouped_asb_neighbourhood.sort_values(by=['ASB_per_population'], ascending=False).head(30)
```

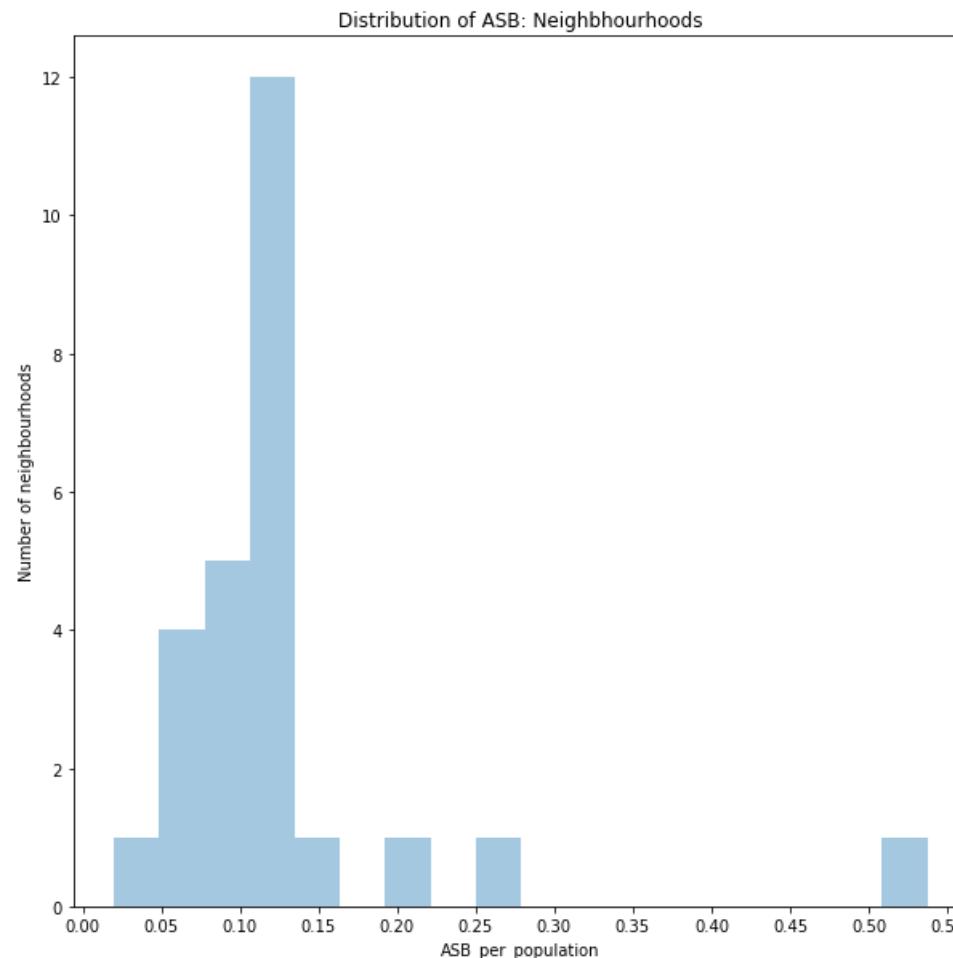
```
Out[79]:
```

	Neighbourhood	count	Population	ASB_per_population
12	Lisburn Road	18191	33859	0.537257
24	Tennent Street	13905	55389	0.251043
25	Woodbourne	10378	53759	0.193047
22	Strand Road	11465	74386	0.154128
16	Newry	6128	46596	0.131513
23	Strandtown	9573	73175	0.130823
0	Antrim	4785	36860	0.129816
14	Lurgan	12308	95413	0.128997
4	Coleraine	8022	62423	0.128510
7	Dungannon	5817	46499	0.125099
6	Downpatrick	6491	52145	0.124480
18	Newtownards	14258	115884	0.123037
17	Newtownabbey	6942	58666	0.118331
9	Larne	5859	50767	0.115410
2	Ballymena	5434	47550	0.114280
11	Lisburn	7389	66780	0.110647
8	Enniskillen	3709	35173	0.105450
1	Armagh	4984	50312	0.099062
10	Limavady	3159	35725	0.088425
20	Omagh	3137	37332	0.084030
21	Strabane	2446	29835	0.081984
3	Castlereagh	2168	30848	0.070280
19	Newtownhamilton	1054	20317	0.051878
15	Magherafelt	2616	51013	0.051281
13	Lisnaskea	624	12345	0.050547
5	Crossmaglen	56	2774	0.020187

There's clearly an uneven distribution in ASB per population in different neighbourhoods. Let's visualise this.

```
In [80]: plt.figure(figsize=(10,10))
sb.distplot(grouped_asb_neighbourhood['ASB_per_population'], kde=False)
plt.title('Distribution of ASB: Neighbourhoods')
plt.xticks(np.arange(0, 0.6, 0.05))
plt.ylabel('Number of neighbourhoods')
```

```
Out[80]: Text(0,0.5,'Number of neighbourhoods')
```



Lisburn road neighbourhood is an outlier. There's a large concentration between 0.10 and 0.15 asb crimes per population.

The top four neighbourhoods are in the Belfast Policing District. There could be a link between population and ASB\_per\_population.

In [81]: `grouped_asb_neighbourhood.corr()`

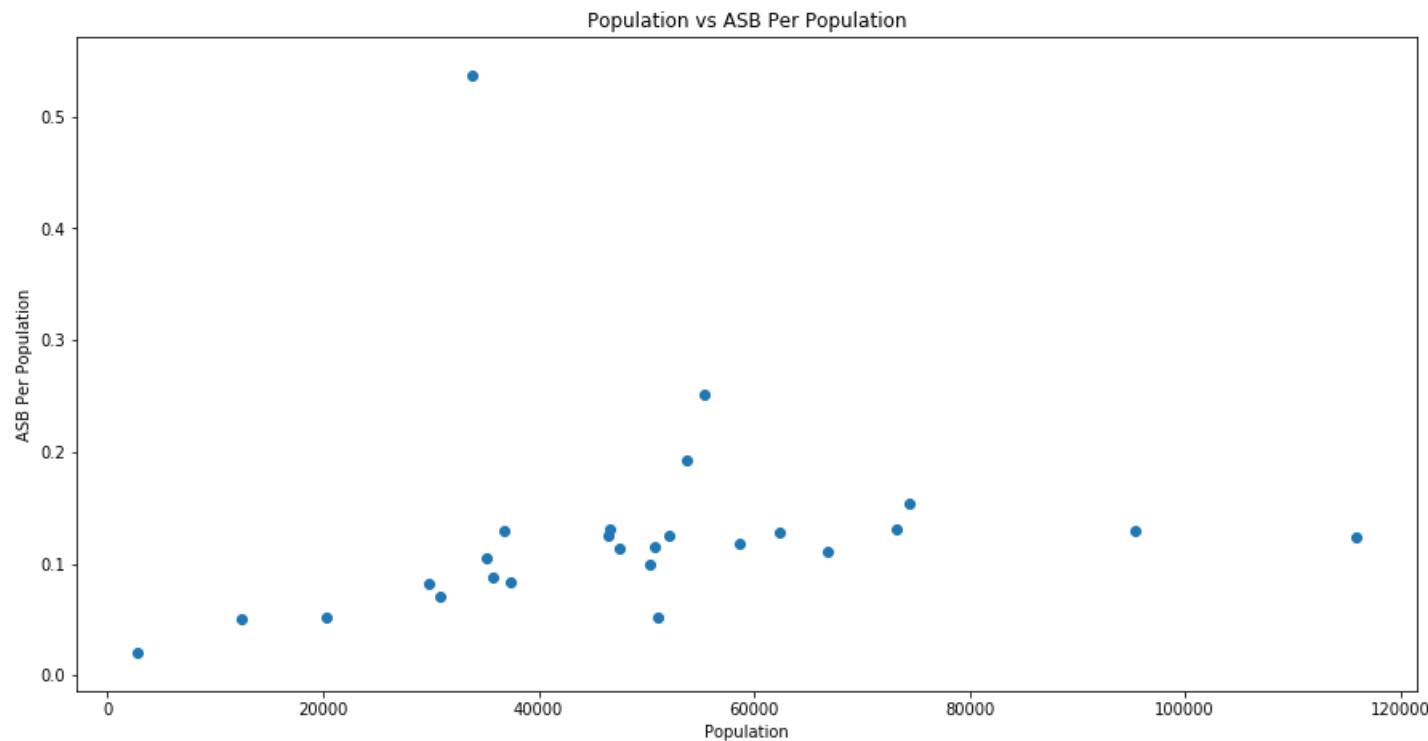
Out[81]:

	count	Population	ASB_per_population
count	1.000000	0.679060	0.794265
Population	0.679060	1.000000	0.139652
ASB_per_population	0.794265	0.139652	1.000000

There is a positive correlation between the number of ASB crimes being committed and number of people living in a neighbourhood. Let's draw a scatter graph to visualise this.

```
In [82]: plt.figure(figsize=(15,7.5))
plt.scatter(grouped_asb_neighbourhood['Population'], grouped_asb_neighbourhood['ASB_per_population'])
plt.title('Population vs ASB Per Population')
plt.xlabel('Population')
plt.ylabel('ASB Per Population')
```

```
Out[82]: Text(0,0.5,'ASB Per Population')
```



There is a moderate positive trend.

I'm going to compare the monthly distribution of ASB in Lisburn Road neighbourhoods with the other neighbourhoods 2016-2017. I want to see if the trend is different there, which is contributing to it being a outlier.

```
In [83]: lisburn_road = anti_social_crime_sampled[anti_social_crime_sampled.Neighbourhood == 'Lisburn Road']
lisburn_road = lisburn_road[(lisburn_road['Year'] == 2016) | (lisburn_road['Year'] == 2017)].reset_index()
lisburn_road_month = lisburn_road.groupby(['Month']).size().reset_index(name='counts')
lisburn_road_quarter = lisburn_road.groupby(['Quarter']).size().reset_index(name='counts')

plt.figure(figsize=(15,11))

plt.subplot(2, 2, 1)
plt.pie(lisburn_road_month['counts'], labels = ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'), \
         autopct='%1.2f%%', shadow=False, startangle=90)
plt.axis('equal')
plt.title("ASB occurring per month in Lisburn Road Neighbourhood")

plt.subplot(2,2, 2)
plt.title("Chart of all crimes and anti-social behaviour occurring per quarter")
plt.pie(lisburn_road_quarter['counts'], labels = ('Quarter 1', 'Quarter 2', 'Quarter 3', 'Quarter 4'), autopct='%1.1f%%', shadow=False, startangle=90)
plt.axis('equal')
plt.title("ASB Occuring per quarter in Lisburn Road Neighbourhood")

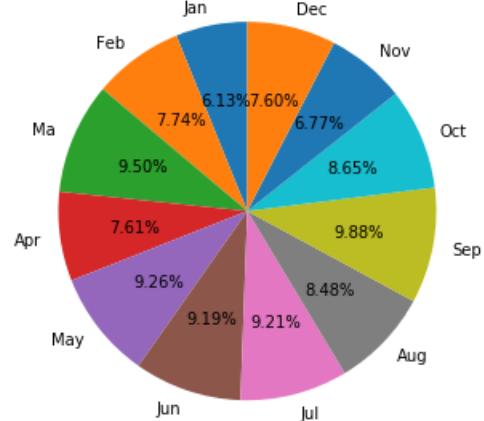
other_neighbourhoods = anti_social_crime_sampled[anti_social_crime_sampled.Neighbourhood != 'Lisburn Road']
other_neighbourhoods = other_neighbourhoods[(other_neighbourhoods['Year'] == 2016) | (other_neighbourhoods['Year'] == 2017)].reset_index()
other_neighbourhoods_months = other_neighbourhoods.groupby(['Month']).size().reset_index(name='counts')
other_neighbourhoods_quarters = other_neighbourhoods.groupby(['Quarter']).size().reset_index(name='counts')

plt.subplot(2, 2, 3)
plt.pie(other_neighbourhoods_months['counts'], labels = ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'), \
         autopct='%1.2f%%', shadow=False, startangle=90)
plt.axis('equal')
plt.title("ASB occurring per month in other Neighbourhoods")

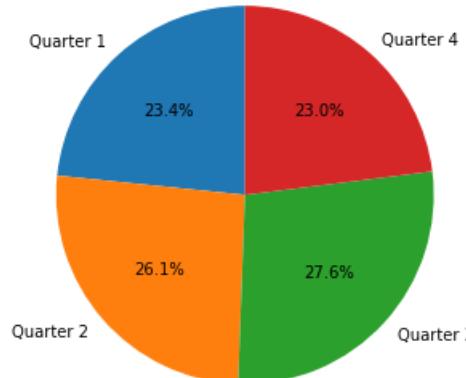
plt.subplot(2,2, 4)
plt.title("Chart of all crimes and anti-social behaviour occurring per quarter")
plt.pie(other_neighbourhoods_quarters['counts'], labels = ('Quarter 1', 'Quarter 2', 'Quarter 3', 'Quarter 4'), autopct='%1.1f%%', shadow=False, start \
angle=90)
plt.axis('equal')
plt.title("ASB Occuring per quarter in other Neighbourhoods")

plt.subplots_adjust(hspace=0.3)
plt.subplots_adjust(wspace=0.3)
```

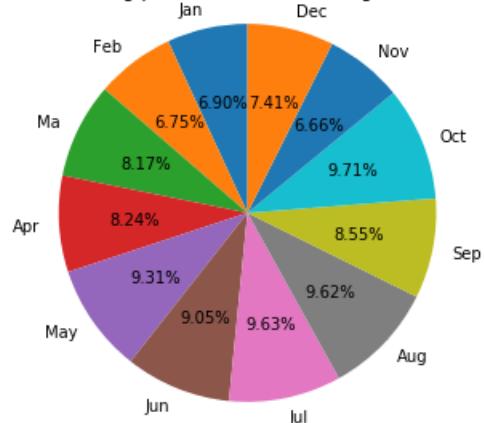
ASB occuring per month in Lisburn Road Neighbourhood



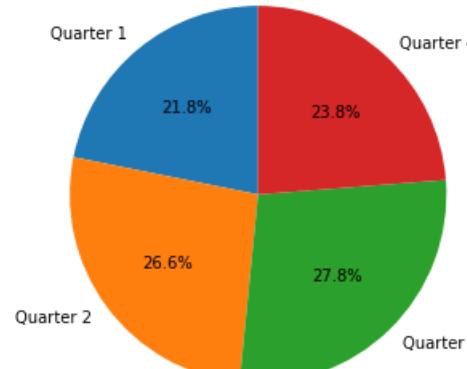
ASB Occuring per quarter in Lisburn Road Neighbourhood



ASB occurring per month in other Neighbourhoods



ASB Occuring per quarter in other Neighbourhoods



Lisburn Road: The highest number of ASB crimes occurred in 2016-17 in September. The summer months (Quarter 3) have high rates of ASB but in March there is a notable rise.

Other Neighbourhoods: The highest number of ASB crimes occurred in 2016-17 in October. The summer months (Quarter 3) have high rates of ASB. There is no notable rise like in Lisburn Road for March and September.

I'm going to take a look at March and September 2016 to find out where ASB on the Lisburn Road is happening in these peak months and if the pattern is different in least prevalent month of November.

```
In [84]: m = folium.Map(location=[54.5668, -5.95328], zoom_start=12)

lisburn_road_sampled = anti_social_crime_sampled[anti_social_crime_sampled.Neighbourhood == 'Lisburn Road']
lisburn_road_march_2016 = lisburn_road_sampled[(lisburn_road_sampled['Year'] == 2016) & (lisburn_road_sampled['Month'] == 3)].reset_index()

lisburn_road_november_2016 = lisburn_road_sampled[(lisburn_road_sampled['Year'] == 2016) & (lisburn_road_sampled['Month'] == 11)].reset_index()

lisburn_road_september_2016 = lisburn_road_sampled[(lisburn_road_sampled['Year'] == 2016) & (lisburn_road_sampled['Month'] == 9)].reset_index()

lisburn_road_september_2017 = lisburn_road_sampled[(lisburn_road_sampled['Year'] == 2017) & (lisburn_road_sampled['Month'] == 9)].reset_index()

asb_lisburn_road_coords_march_2016 = []

for index, row in lisburn_road_march_2016.iterrows():
    coords = (row['Latitude'], row['Longitude'])
    asb_lisburn_road_coords_march_2016.append(list(coords))

asb_lisburn_road_coords_november_2016 = []

for index, row in lisburn_road_november_2016.iterrows():
    coords = (row['Latitude'], row['Longitude'])
    asb_lisburn_road_coords_november_2016.append(list(coords))

asb_lisburn_road_coords_september_2016 = []

for index, row in lisburn_road_september_2016.iterrows():
    coords = (row['Latitude'], row['Longitude'])
    asb_lisburn_road_coords_september_2016.append(list(coords))

asb_lisburn_road_coords_september_2017 = []

for index, row in lisburn_road_september_2017.iterrows():
    coords = (row['Latitude'], row['Longitude'])
    asb_lisburn_road_coords_september_2017.append(list(coords))

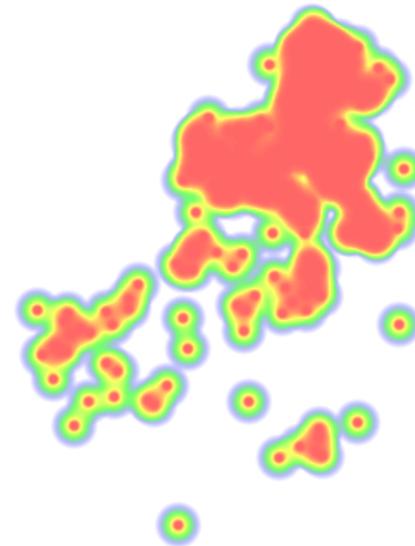
asb_lisburn_road_coords = []

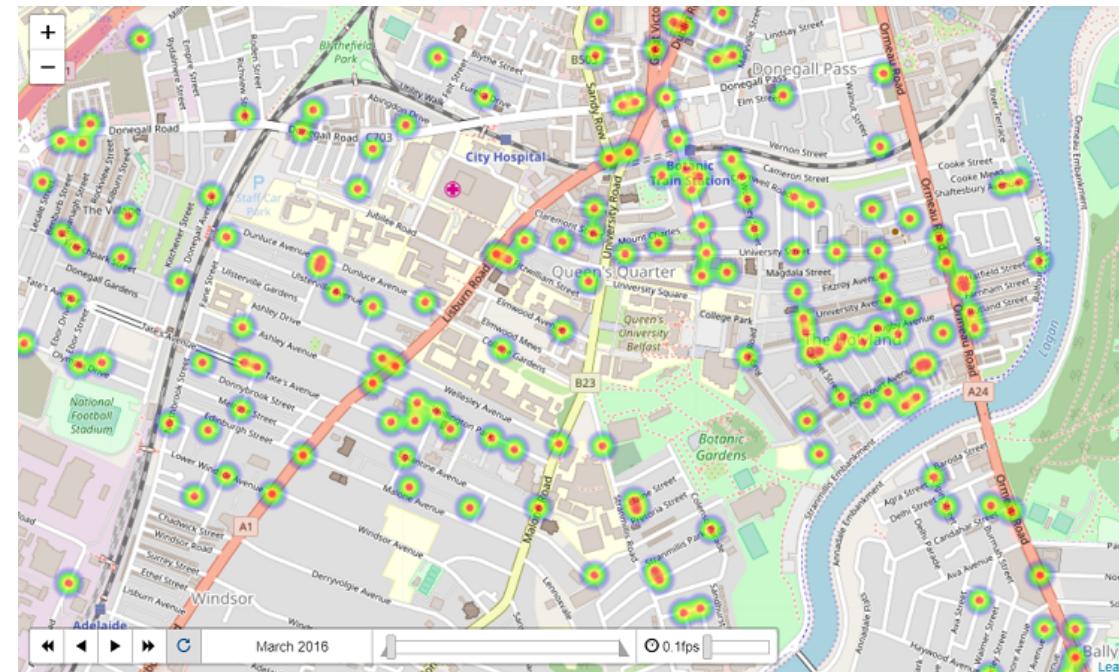
asb_lisburn_road_coords.append(asb_lisburn_road_coords_march_2016)
asb_lisburn_road_coords.append(asb_lisburn_road_coords_september_2016)
asb_lisburn_road_coords.append(asb_lisburn_road_coords_november_2016)
asb_lisburn_road_coords.append(asb_lisburn_road_coords_september_2017)

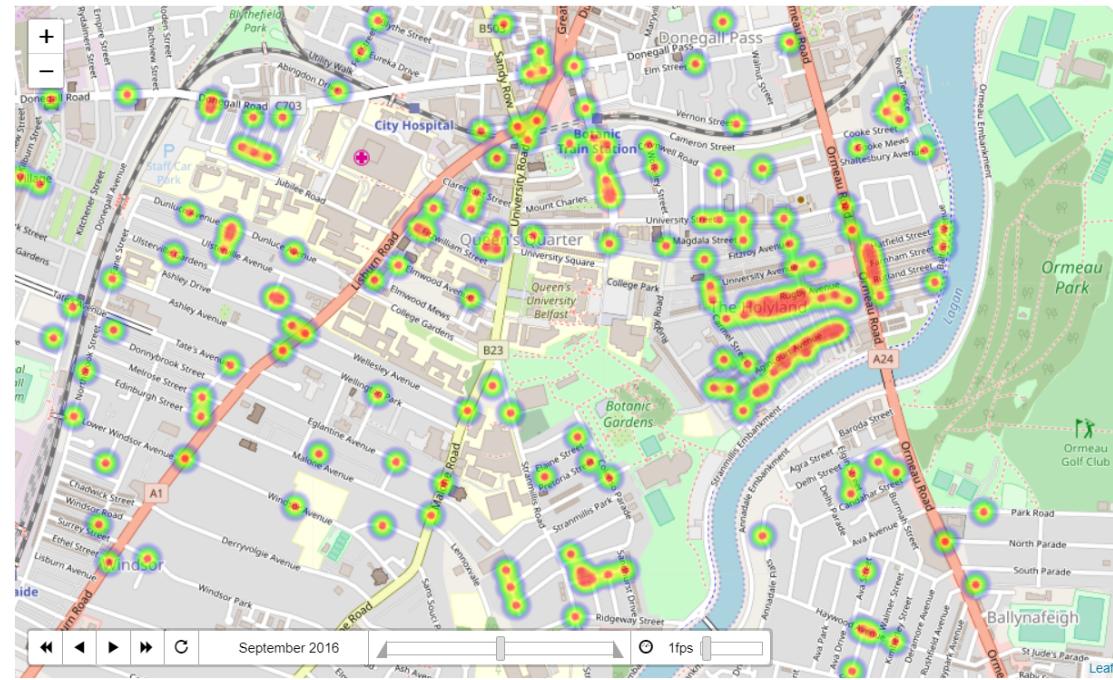
HeatMapWithTime(asb_lisburn_road_coords, index=['March 2016', 'September 2016', 'November 2016', 'September 2017']).add_to(m)
#m.add_child(HeatMap(asb_lisburn_road_coords_november_2016, gradient={0: 'blue', 0: 'lime', .4: 'red'}))

m
```

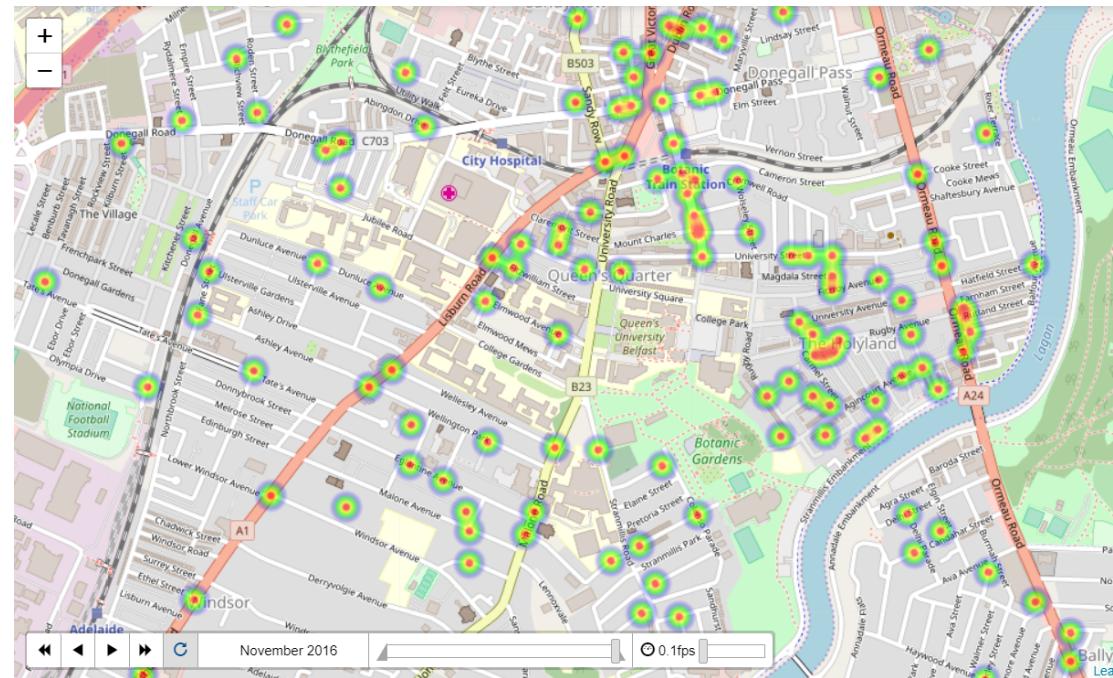
Out[84]:

Leaflet (<http://leafletjs.com>)

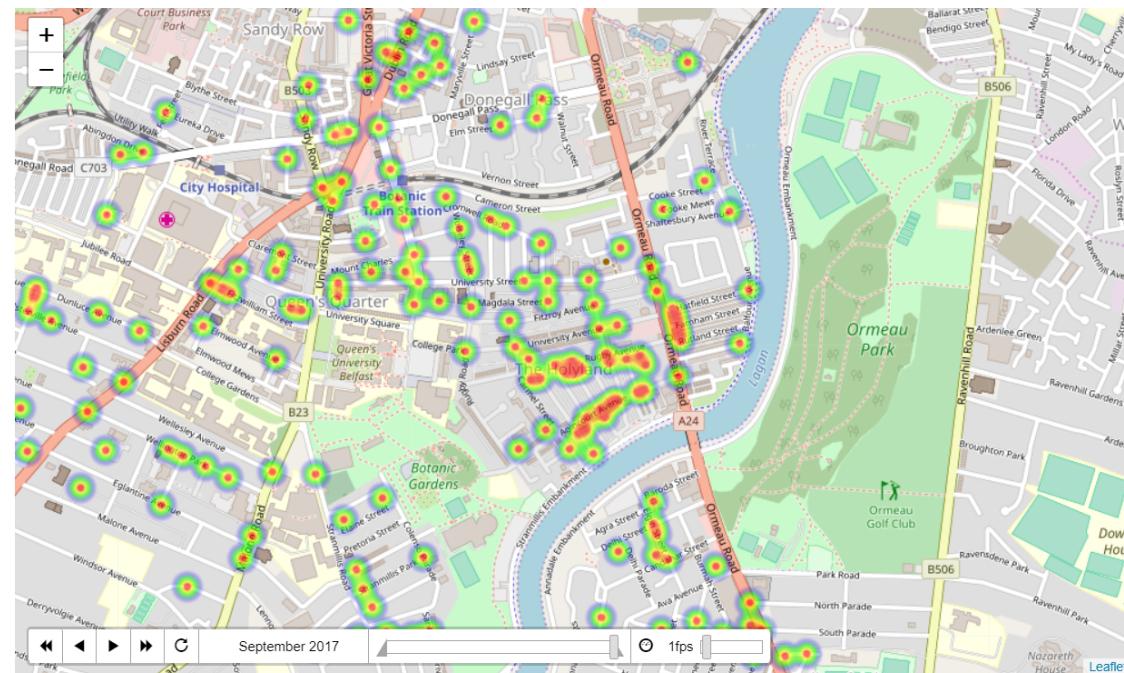
**Holylands March 2016****Holylands September 2016**



Holylands November 2016

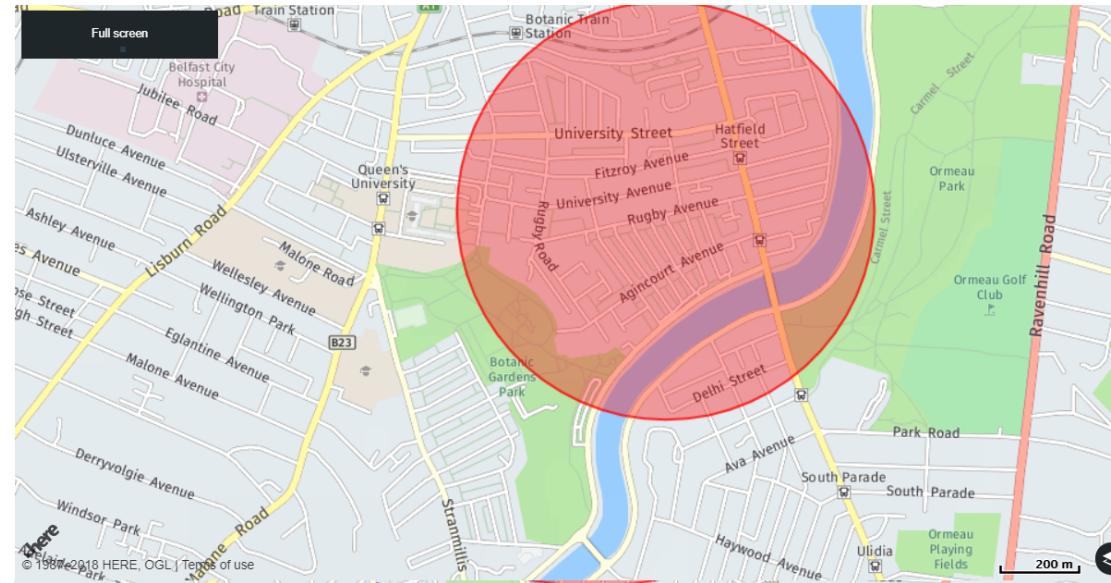


Holylands September 2017



Holylands Hotspot in Google Maps

Longitude Latitude: 54.584584, -5.925854



I've identified the Holylands as a hotspot for ASB in March and September. There's a considerable number of crime more in that area than any other area other than the city centre. Let's find crimes that are in a 0.5km radius of the centre of the hotspot. This could be because of St Patrick's Day in march and Fresher's Week in late September.

```
In [85]: crimes_within_distance = lisburn_road_sampled.copy()
crimes_within_distance = crimes_within_distance.iloc[0:0]
area_coord = ("54.584584", "-5.925854")
MAX_DISTANCE = 0.5

for index, row in lisburn_road_sampled.iterrows():
    coords = (row['Latitude'], row['Longitude'])
    d = distance.vincenty(area_coord, coords)
    if (d.km <= MAX_DISTANCE):
        crimes_within_distance = crimes_within_distance.append(row)
```

In [86]: `crimes_within_distance.describe()`

Out[86]:

	index	Longitude	Latitude	Year	Month	Week	Quarter
count	2888.000000	2888.000000	2888.000000	2888.000000	2888.000000	2888.000000	2888.000000
mean	2538.182133	-5.926044	54.584874	2016.504501	6.646468	27.163089	2.536011
std	1527.225280	0.002998	0.001621	0.925328	3.499322	15.253795	1.160225
min	2.000000	-5.933160	54.580268	2015.000000	1.000000	1.000000	1.000000
25%	1239.000000	-5.927597	54.583979	2016.000000	3.000000	13.000000	1.000000
50%	2449.000000	-5.925779	54.584756	2017.000000	7.000000	31.000000	3.000000
75%	3726.250000	-5.923939	54.586200	2017.000000	10.000000	39.000000	4.000000
max	6106.000000	-5.919741	54.588481	2018.000000	12.000000	53.000000	4.000000

There's 2888 crimes in that hotspot. Let's get what percentage that is of the total crimes in the Lisburn Road Neighbourhood

In [87]: `lisburn_road_sampled.describe()`

Out[87]:

	index	Longitude	Latitude	Year	Month	Week	Quarter
count	18191.000000	18191.000000	18191.000000	18191.000000	18191.000000	18191.000000	18191.000000
mean	2540.318949	-5.934584	54.587189	2016.518608	6.545819	26.766643	2.503161
std	1532.023971	0.013077	0.011245	0.902305	3.421495	15.015986	1.117691
min	0.000000	-5.995609	54.539587	2015.000000	1.000000	1.000000	1.000000
25%	1244.000000	-5.936264	54.583035	2016.000000	4.000000	13.000000	2.000000
50%	2469.000000	-5.932404	54.587985	2017.000000	7.000000	26.000000	3.000000
75%	3750.000000	-5.927162	54.595941	2017.000000	9.000000	39.000000	3.000000
max	6120.000000	-5.910017	54.602452	2018.000000	12.000000	53.000000	4.000000

2888/181191 (16%) of ASB crimes in Lisburn Road happened in this 0.5km radius. I'm going to look at the distribution of these crimes in 2016 vs 2017 to see if there's any interesting observations I can draw from them.

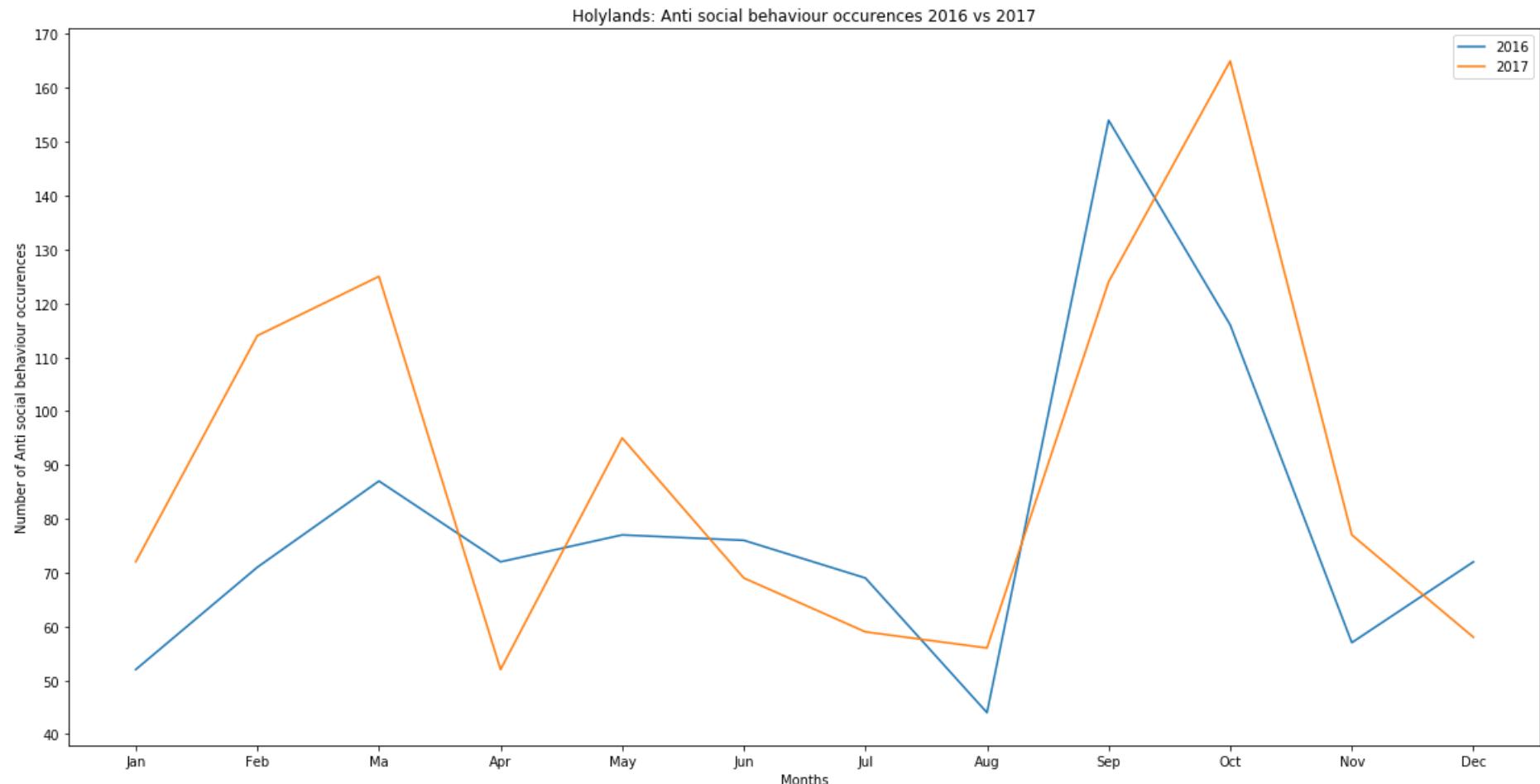
```
In [88]: crimes_within_distance_grouped = crimes_within_distance.groupby(['Month', 'Year']).size().reset_index(name='counts')
crimes_within_distance_grouped[crimes_within_distance_grouped.Year == 2016].head(13)
```

Out[88]:

	Month	Year	counts
0	1	2016	52
3	2	2016	71
6	3	2016	87
9	4	2016	72
12	5	2016	77
15	6	2016	76
17	7	2016	69
20	8	2016	44
23	9	2016	154
26	10	2016	116
29	11	2016	57
32	12	2016	72

```
In [89]: plt.figure(figsize=(20,10))
sb.lineplot(np.arange(0, 12, step=1.0), crimes_within_distance_grouped[crimes_within_distance_grouped.Year == 2016].counts)
plt.xticks(np.arange(0, 12, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
sb.lineplot(np.arange(0, 12, step=1.0), crimes_within_distance_grouped[crimes_within_distance_grouped.Year == 2017].counts)
plt.legend(['2016', '2017'])
plt.xlabel('Months')
plt.yticks(np.arange(40, 180, 10))
plt.ylabel('Number of Anti social behaviour occurences')
plt.title("Holylands: Anti social behaviour occurences 2016 vs 2017")
```

Out[89]: Text(0.5,1,'Holylands: Anti social behaviour occurences 2016 vs 2017')



2016: September most ASB crimes, august the least. 2017: October most asb crimes, April the least. March sees a notable rise in both years, as well as September. The low ASB crimes in august isn't consistent with the general pattern, this could be due to students leaving for home.

I want to see if there's a different monthly frequency of crimes other than ASB happening in March vs August. Other crimes rising could influence the rise in ASB.</b>

```
In [90]: crimes_within_distance = psni_crime_data_ranged.copy()
crimes_within_distance = crimes_within_distance.iloc[0:0]

area_coord = ("54.584584", "-5.925854")
MAX_DISTANCE = 0.5

not_asb_crimes = psni_crime_data_ranged[(psni_crime_data_ranged['Crime type'] != 'Anti-social behaviour') & (psni_crime_data_ranged['Has_Location'] == True)]
for index, row in not_asb_crimes.iterrows():
    coords = (row['Latitude'], row['Longitude'])
    d = distance.vincenty(area_coord, coords)
    if (d.km <= MAX_DISTANCE):
        crimes_within_distance = crimes_within_distance.append(row)

crimes_within_distance.head()
```

Out[90]:

	index	Longitude	Latitude	Location	Crime type	Has_Location	Year	Month	Week	Quarter
73170	4094	-5.932404	54.586753	botanic avenue	Bicycle theft	True	2016	1	53	1
73215	4139	-5.926404	54.583029	palestine street	Burglary	True	2016	1	53	1
73360	4284	-5.929958	54.586469		Burglary	True	2016	1	53	1
73393	4317	-5.925399	54.585151	university avenue	Burglary	True	2016	1	53	1
73410	4334	-5.923238	54.585967	ormeau road	Burglary	True	2016	1	53	1

```
In [91]: crimes_within_distance_grouped = crimes_within_distance.groupby(['Crime type', 'Month', 'Year']).size().reset_index(name='counts')
```

```
In [92]: crimes_within_distance_grouped_march = crimes_within_distance_grouped[(crimes_within_distance_grouped['Month'] == 3)]
crimes_within_distance_grouped_march = crimes_within_distance_grouped_march.groupby(['Crime type']).counts.sum().reset_index(name='counts')
crimes_within_distance_grouped_march.head(30)
```

Out[92]:

	Crime type	counts
0	Bicycle theft	6
1	Burglary	35
2	Criminal damage and arson	91
3	Drugs	19
4	Other crime	1
5	Other theft	41
6	Possession of weapons	4
7	Public order	2
8	Robbery	2
9	Shoplifting	7
10	Theft from the person	3
11	Vehicle crime	5
12	Violence and sexual offences	92

```
In [93]: crimes_within_distance_grouped_august = crimes_within_distance_grouped[(crimes_within_distance_grouped['Month'] == 8)]
crimes_within_distance_grouped_august = crimes_within_distance_grouped_august.groupby(['Crime type']).counts.sum().reset_index(name='counts')
crimes_within_distance_grouped_august.head(30)
```

Out[93]:

	Crime type	counts
0	Bicycle theft	3
1	Burglary	25
2	Criminal damage and arson	40
3	Drugs	12
4	Other crime	1
5	Other theft	24
6	Possession of weapons	3
7	Robbery	3
8	Shoplifting	6
9	Theft from the person	1
10	Vehicle crime	8
11	Violence and sexual offences	68

```
In [94]: plt.figure(figsize=(15,5))

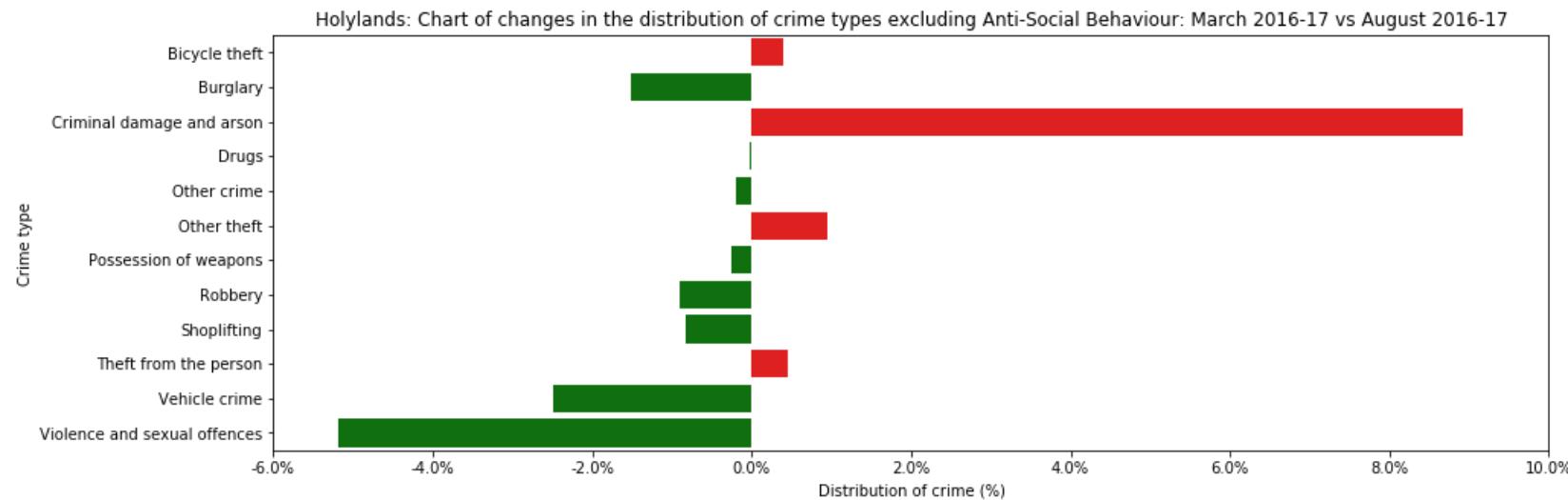
dictCrimeType = {}
total_august = crimes_within_distance_grouped_august['counts'].sum()
total_march = crimes_within_distance_grouped_march['counts'].sum()

for index, row in crimes_within_distance_grouped_august.iterrows():
    percent_august = row['counts']/float(total_august) * 100
    percent_march = crimes_within_distance_grouped_march[crimes_within_distance_grouped_march['Crime type'] == row['Crime type']].iloc[0]['counts']/float(total_march) * 100
    difference_percent = percent_march - percent_august
    dictCrimeType[row['Crime type']] = difference_percent

difference = pd.DataFrame.from_dict(dictCrimeType, orient='index')
difference.index = difference.index.astype(str)

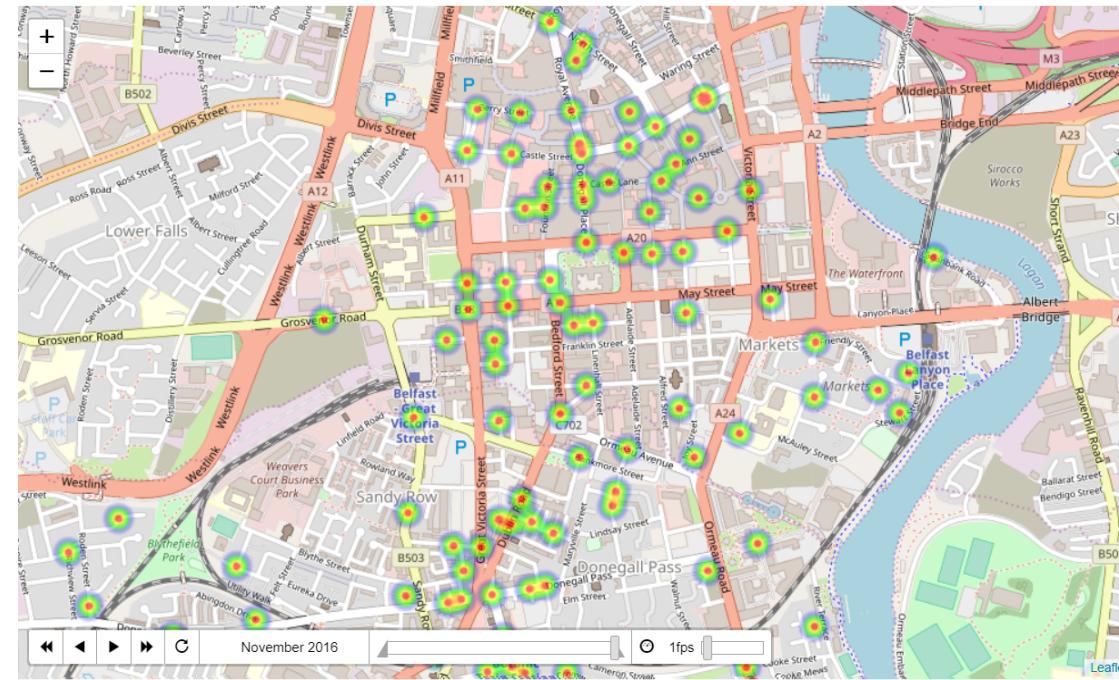
# ax = sb.barplot(difference.index, difference[0])
ax = sb.barplot(difference[0], difference.index, palette=difference[0].apply(lambda x: 'r' if x>0 else 'g'))
ax.set_xlabel('Distribution of crime (%)')
ax.set_ylabel('Crime type')
ax.xaxis.set_major_formatter(mtick.PercentFormatter())
ax.set_xlim(-6, 10)
plt.title("Holylands: Chart of changes in the distribution of crime types excluding Anti-Social Behaviour: March 2016-17 vs August 2016-17")

plt.show()
```



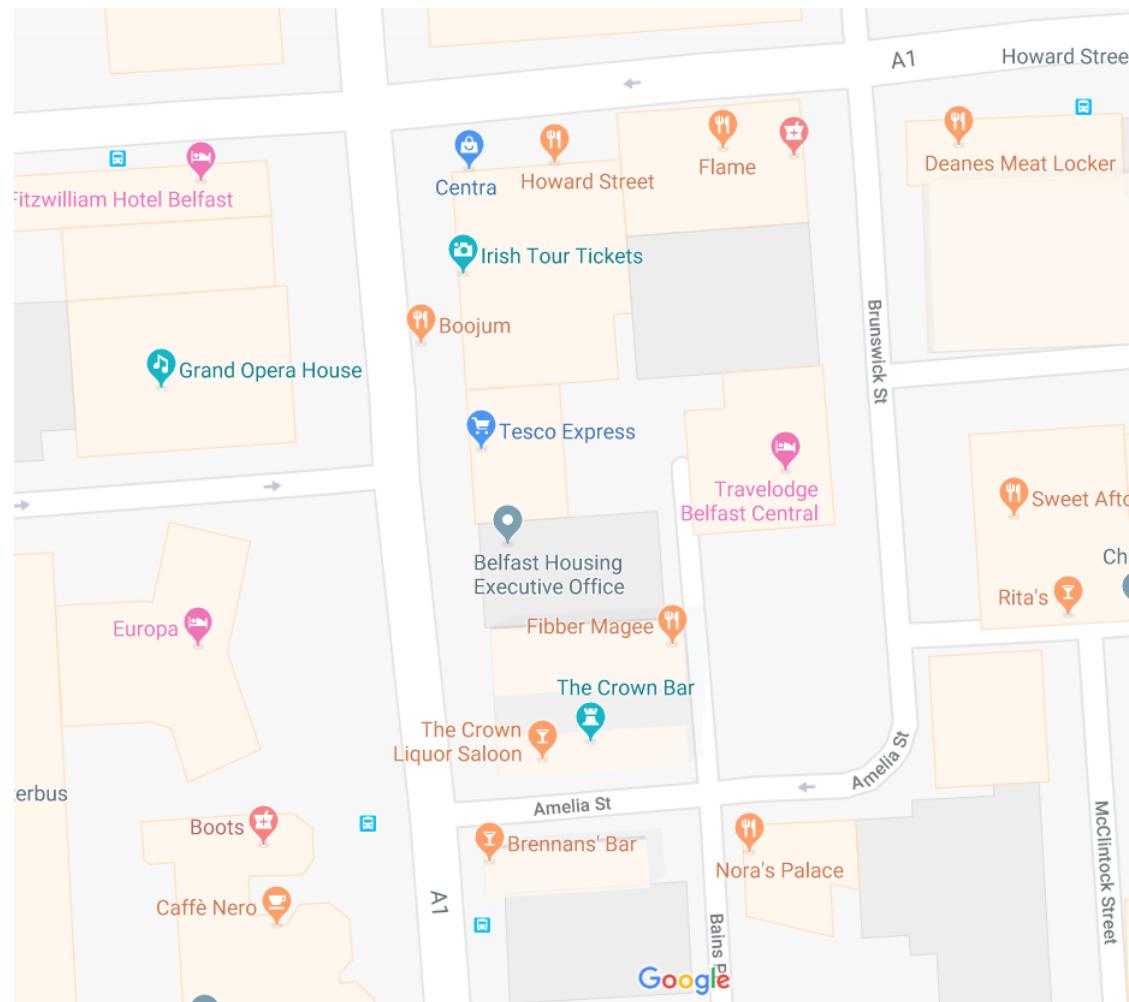
**Criminal damage and Arson** is considerably up in March compared to August. **Violence and sexual crimes** is considerably down in March compared to August. This suggests a relationship between ASB and Criminal Damage and Arson. Let's look at a different hotspot and see if this holds.

**City Centre March 2016****City Centre November 2016**



**City Centre Hotspot**

## Crime EDA



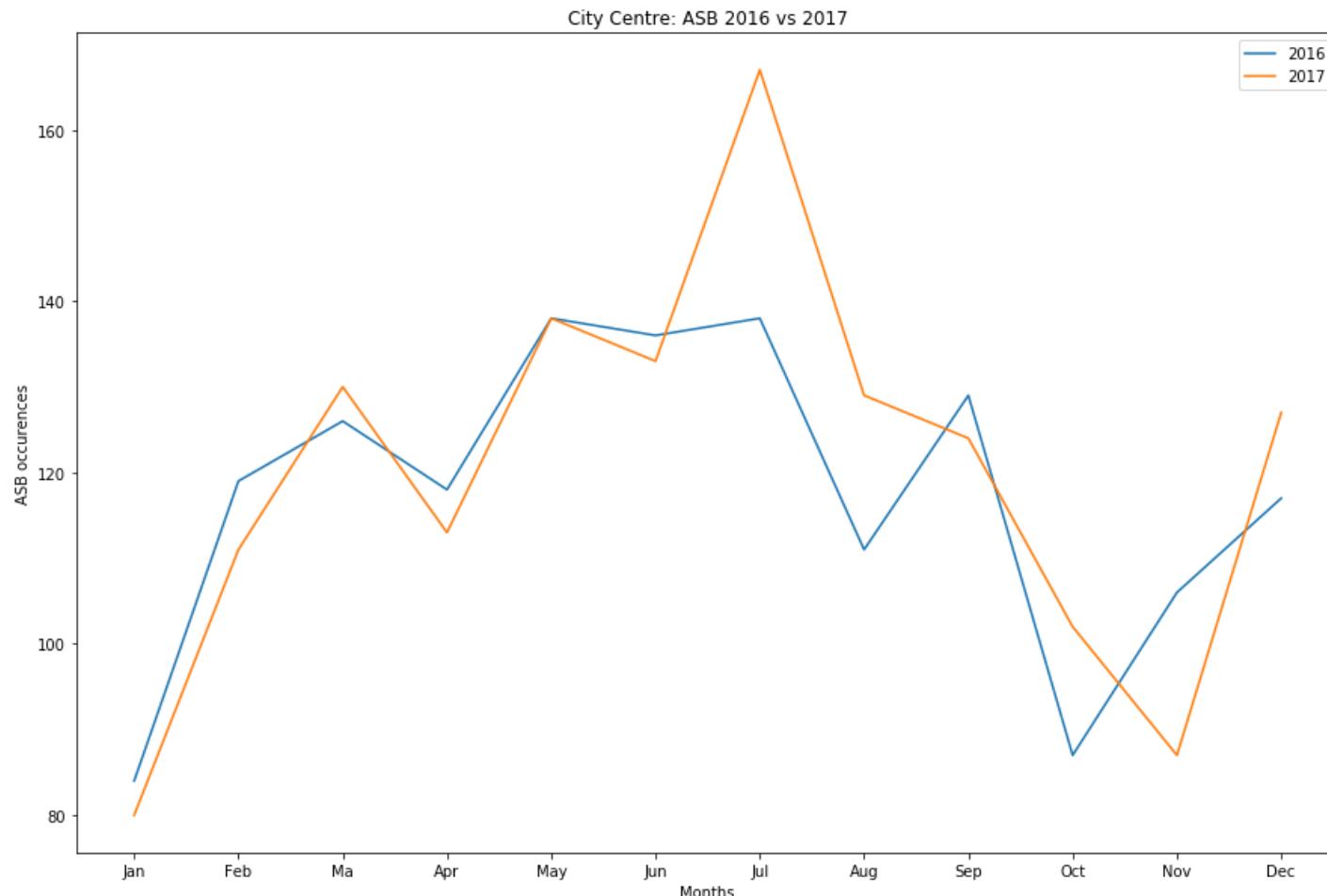
54.595016, -5.934491

```
In [95]: crimes_within_city_centre_distance = lisburn_road_sampled.copy()
crimes_within_city_centre_distance = crimes_within_city_centre_distance.iloc[0:0]
area_coord = ("54.595016", "-5.934491")
MAX_DISTANCE = 0.5
for index, row in lisburn_road_sampled.iterrows():
    coords = (row['Latitude'], row['Longitude'])
    d = distance.vincenty(area_coord, coords)
    if (d.km <= MAX_DISTANCE):
        crimes_within_city_centre_distance = crimes_within_city_centre_distance.append(row)
```

```
In [96]: crimes_within_distance_city_centre_grouped = crimes_within_city_centre_distance.groupby(['Month', 'Year']).size().reset_index(name='counts')
```

```
In [97]: plt.figure(figsize=(15,10))
sb.lineplot(np.arange(0, 12, step=1.0), crimes_within_distance_city_centre_grouped[crimes_within_distance_city_centre_grouped.Year == 2016].counts)
plt.xticks(np.arange(0, 12, step=1.0), ('Jan', 'Feb', 'Ma', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'))
sb.lineplot(np.arange(0, 12, step=1.0), crimes_within_distance_city_centre_grouped[crimes_within_distance_city_centre_grouped.Year == 2017].counts)
plt.legend(['2016', '2017'])
plt.xlabel('Months')
plt.ylabel('ASB occurrences')
plt.title("City Centre: ASB 2016 vs 2017")
```

```
Out[97]: Text(0.5,1,'City Centre: ASB 2016 vs 2017')
```



2016: Peak in summer months, low in January. Rise in January to February. 2017: Peak in July, low in January. Rise in December. Unlike the Holylands, August is not the lowest prevalence - January is. October is also not the peak. Let's take a look at the distribution of other crimes in July and January.

```
In [98]: crimes_within_distance_city_centre = psni_crime_data_ranged.copy()
crimes_within_distance_city_centre = crimes_within_distance_city_centre.iloc[0:0]

area_coord = ("54.595016", "-5.934491")
MAX_DISTANCE = 0.5

not_asb_crimes = psni_crime_data_ranged[(psni_crime_data_ranged['Crime type'] != 'Anti-social behaviour') & (psni_crime_data_ranged['Has_Location'] == True)]
for index, row in not_asb_crimes.iterrows():
    coords = (row['Latitude'], row['Longitude'])
    d = distance.vincenty(area_coord, coords)
    if (d.km <= MAX_DISTANCE):
        crimes_within_distance_city_centre = crimes_within_distance_city_centre.append(row)

crimes_within_distance_city_centre.head()
```

Out[98]:

	index	Longitude	Latitude	Location	Crime type	Has_Location	Year	Month	Week	Quarter
73169	4093	-5.929880	54.595012	franklin street	Bicycle theft	True	2016	1	53	1
73171	4095	-5.930439	54.592551	bankmore street	Bicycle theft	True	2016	1	53	1
73172	4096	-5.930154	54.597254	donegall square north	Bicycle theft	True	2016	1	53	1
73179	4103	-5.932499	54.598004	college street	Bicycle theft	True	2016	1	53	1
73181	4105	-5.933066	54.591086	dublin road	Bicycle theft	True	2016	1	53	1

```
In [99]: crimes_within_distance_city_centre_grouped = crimes_within_distance_city_centre.groupby(['Crime type', 'Month', 'Year']).size().reset_index(name='counts')
crimes_within_distance_grouped_january = crimes_within_distance_city_centre_grouped[(crimes_within_distance_city_centre_grouped['Month'] == 1)]
crimes_within_distance_grouped_january = crimes_within_distance_grouped_january.groupby(['Crime type']).counts.sum().reset_index(name='counts')
crimes_within_distance_grouped_january.head(30)
```

Out[99]:

	Crime type	counts
0	Bicycle theft	12
1	Burglary	17
2	Criminal damage and arson	37
3	Drugs	27
4	Other crime	2
5	Other theft	45
6	Possession of weapons	4
7	Public order	2
8	Robbery	5
9	Shoplifting	38
10	Theft from the person	9
11	Vehicle crime	20
12	Violence and sexual offences	142

```
In [100]: crimes_within_distance_city_centre_grouped = crimes_within_distance_city_centre.groupby(['Crime type', 'Month', 'Year']).size().reset_index(name='counts')
crimes_within_distance_grouped_july = crimes_within_distance_city_centre_grouped[(crimes_within_distance_city_centre_grouped['Month'] == 7)]
crimes_within_distance_grouped_july = crimes_within_distance_grouped_july.groupby(['Crime type']).counts.sum().reset_index(name='counts')
crimes_within_distance_grouped_july.head(30)
```

Out[100]:

	Crime type	counts
0	Bicycle theft	10
1	Burglary	18
2	Criminal damage and arson	45
3	Drugs	31
4	Other crime	4
5	Other theft	59
6	Possession of weapons	1
7	Public order	4
8	Robbery	3
9	Shoplifting	56
10	Theft from the person	10
11	Vehicle crime	35
12	Violence and sexual offences	138

```
In [101]: plt.figure(figsize=(20,5))

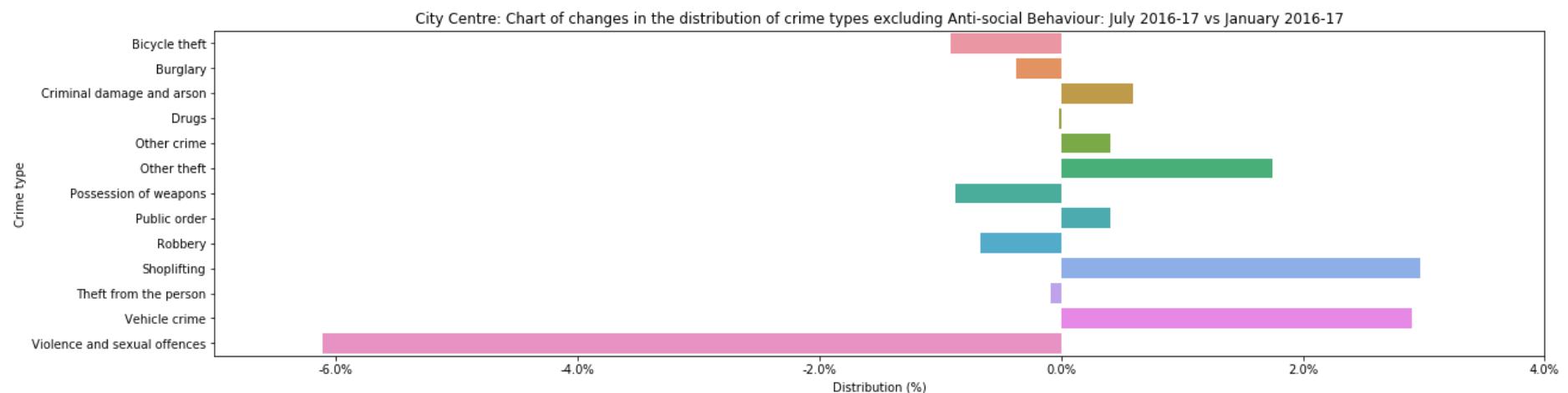
dictCrimeType = {}
total_january = crimes_within_distance_grouped_january['counts'].sum()
total_july = crimes_within_distance_grouped_july['counts'].sum()

for index, row in crimes_within_distance_grouped_january.iterrows():
    percent_january = row['counts']/float(total_january) * 100
    percent_july = crimes_within_distance_grouped_july[crimes_within_distance_grouped_july['Crime type'] == row['Crime type']].iloc[0]['counts']/float(total_july) * 100
    difference_percent = percent_july - percent_january
    dictCrimeType[row['Crime type']] = difference_percent

difference = pd.DataFrame.from_dict(dictCrimeType, orient='index')
difference.index = difference.index.astype(str)

ax = sb.barplot(difference[0], difference.index)
ax.set_ylabel('Crime type')
ax.set_xlabel('Distribution (%)')
ax.xaxis.set_major_formatter(mtick.PercentFormatter())
ax.set_xlim(-7, 4)
plt.title("City Centre: Chart of changes in the distribution of crime types excluding Anti-social Behaviour: July 2016-17 vs January 2016-17")

plt.show()
```



Like in the Holylands, Violence and sexual offences are down. However, Vehicle Crime and Shoplifting are up. This could be because the city centre being is a more affluent economic area than the Holylands. Shoplifting and other theft rising could be because there is more shops than the Holylands hotspot. Criminal damage and arson is up, although not as much as in the Holylands hotspot.

## Contribution to ASB: Perspectives

I want to investigate what people living in the Lisburn Road neighbourhood say are the biggest contributors to ASB in their local area to see if there is any link between other crimes occurring in the area and the findings previously are consistent with their perception of contributors. I'm going to load in the NICS dataset (<https://www.justice-ni.gov.uk/articles/northern-ireland-crime-survey>).

```
In [102]: asb_perception_districts_2016_2017 = pd.read_csv('data/Perceptions of Crime Findings/perceptions_asb_district_2016_2017.csv')
asb_perception_districts_2016_2017.columns
```

```
Out[102]: Index(['Policing District', 'LE Abandoned or burnt-out cars',
 'BE Abandoned or burnt-out cars', 'HE Abandoned or burnt-out cars',
 'LE Noisy neighbours or loud parties',
 'BE Noisy neighbours or loud parties',
 'HE Noisy neighbours or loud parties',
 'LE People being drunk or rowdy in public places',
 'BE People being drunk or rowdy in public places',
 'HE People being drunk or rowdy in public places',
 'LE People using or dealing drugs', 'BE People using or dealing drugs',
 'HE People using or dealing drugs',
 'LE Teenagers hanging around on streets',
 'BE Teenagers hanging around on streets',
 'HE Teenagers hanging around on streets',
 'LE Rubbish or litter lying around',
 'BE Rubbish or litter lying around',
 'HE Rubbish or litter lying around',
 'LE Vandalism, graffiti and other deliberate damage to property',
 'BE Vandalism, graffiti and other deliberate damage to property',
 'HE Vandalism, graffiti and other deliberate damage to property',
 'LE Perceived high level of ASB', 'BE Perceived high level of ASB',
 'HE Perceived high level of ASB', 'Unweighted base'],
 dtype='object')
```

NICS use their own algorithm (awarding points for responses to types of crime) to calculate perceived high level of ASB. I will drop this to perform my own analysis. I will also drop the LE and HE as they are for the 95% confidence interval. This will not be needed as I only want the mean figure (BE) to see if there's an ASB problem specific to Belfast.

```
In [103]: asb_perception_districts_2016_2017Focused = asb_perception_districts_2016_2017[['Policing District', 'BE Abandoned or burnt-out cars', 'BE Noisy neighbours or loud parties', 'BE People being drunk or rowdy in public places', 'BE People using or dealing drugs', 'BE Teenagers hanging around on streets', 'BE Rubbish or litter lying around', 'BE Vandalism, graffiti and other deliberate damage to property']].copy()
asb_perception_districts_2016_2017Focused.head(30)
```

Out[103]:

	Policing District	BE Abandoned or burnt-out cars	BE Noisy neighbours or loud parties	BE People being drunk or rowdy in public places	BE People using or dealing drugs	BE Teenagers hanging around on streets	BE Rubbish or litter lying around	BE Vandalism, graffiti and other deliberate damage to property
0	Antrim and Newtownabbey	4.065041	8.130081	11.065574	24.017467	15.040650	17.886179	13.414634
1	Ards and North Down	0.000000	5.483871	15.806452	18.493151	10.645161	24.193548	9.032258
2	Armagh City, Banbridge and Craigavon	2.356021	5.497382	13.350785	23.848238	13.350785	28.010471	11.518325
3	Belfast City	5.756579	10.708402	22.039474	36.619718	20.723684	33.059211	18.585526
4	Causeway Coast and Glens	1.048951	6.993007	16.783217	24.535316	10.139860	27.272727	10.139860
5	Derry City & Strabane	15.210356	11.326861	20.064725	24.221453	24.271845	23.948220	20.064725
6	Fermanagh and Omagh	4.602510	5.020921	10.878661	11.538462	7.949791	9.623431	5.439331
7	Lisburn and Castlereagh	1.709402	6.329114	7.203390	17.105263	12.236287	31.223629	13.502110
8	Mid and East Antrim	1.532567	3.831418	13.409962	27.343750	7.279693	29.118774	6.513410
9	Mid Ulster	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
10	Newry, Mourne and Down	3.858521	4.823151	7.073955	18.811881	5.787781	15.755627	3.858521

Dropping Mid Ulster as the sample size was too small (n<100) for a percentage perception to be recorded.

```
In [104]: asb_perception_districts_2016_2017Focused = asb_perception_districts_2016_2017Focused[asb_perception_districts_2016_2017Focused['Policing District'] != 'Mid Ulster']
```

Renaming columns to remove ('BE') from the start to make the visualisations more readable

```
In [105]: asb_perception_districts_2016_2017_focused = asb_perception_districts_2016_2017_focused.rename(columns=lambda x: re.sub('BE ','',x))
```

```
In [106]: asb_perception_districts_2016_2017_focused.info()
```

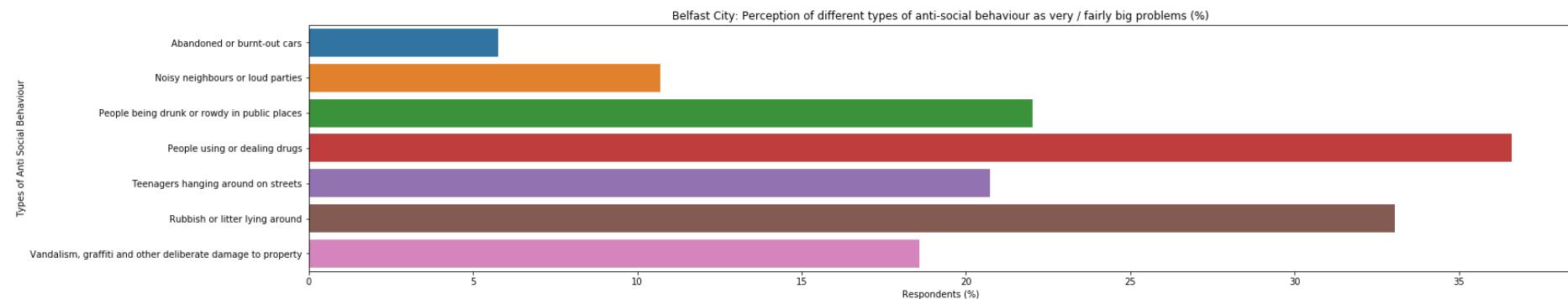
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 10 entries, 0 to 10
Data columns (total 8 columns):
Policing District          10 non-null object
Abandoned or burnt-out cars 10 non-null float64
Noisy neighbours or loud parties 10 non-null float64
People being drunk or rowdy in public places 10 non-null float64
People using or dealing drugs 10 non-null float64
Teenagers hanging around on streets 10 non-null float64
Rubbish or litter lying around 10 non-null float64
Vandalism, graffiti and other deliberate damage to property 10 non-null float64
dtypes: float64(7), object(1)
memory usage: 720.0+ bytes
```

The dataset has each policing district and percentage of people (sample size of each policing district > 100) living in those areas responding to each type of ASB as yes or no to it being a very/fairly big problem in their area. The values in the table are percentages of the sample size of that local area who responded yes.

Let's visualise Belfast City's ASB perceptions as Lisburn Road neighbourhood is in Belfast City neighbourhood.

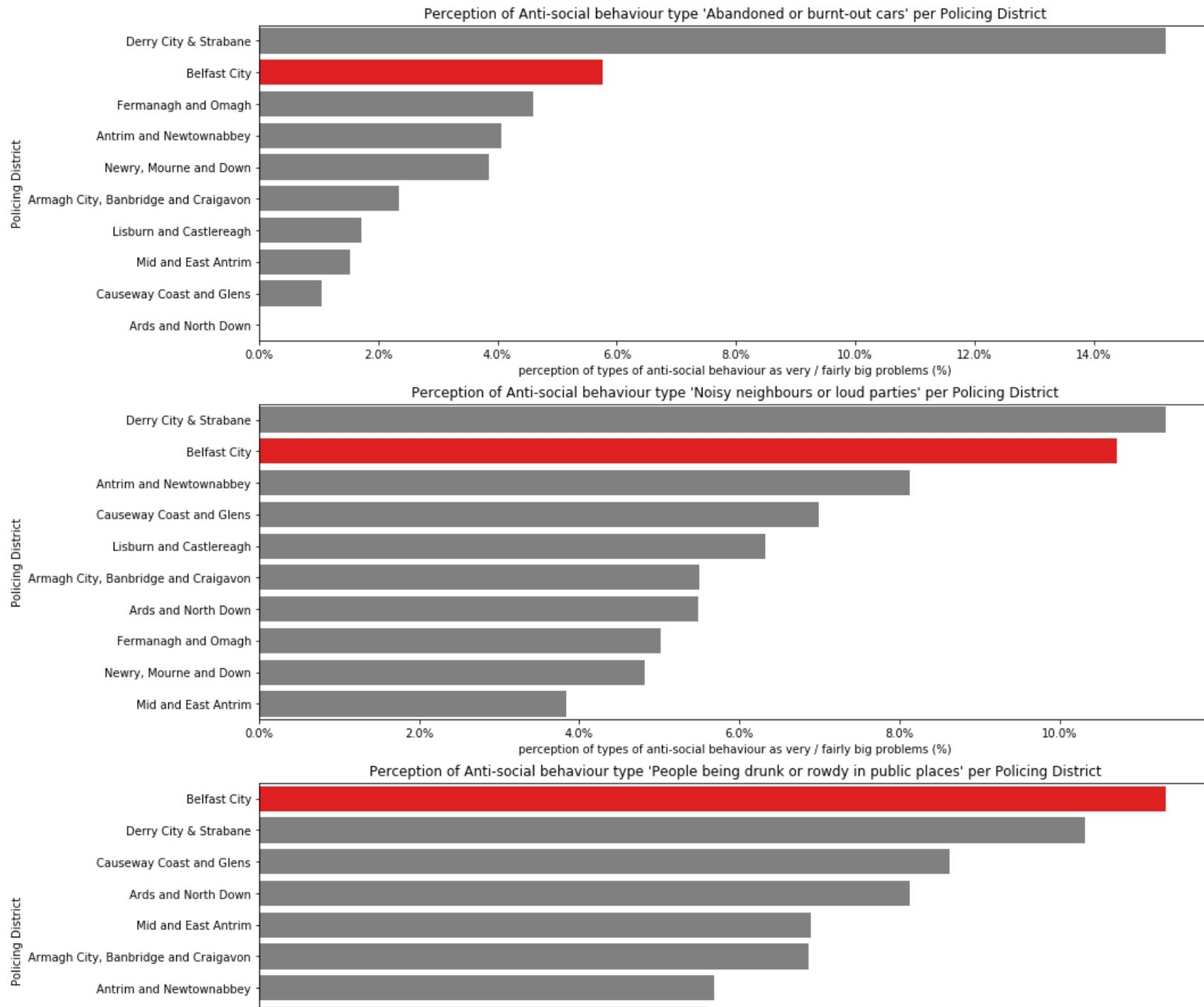
```
In [107]: asb_perception_districts_2016_2017_focused.set_index(['Policing District'])
belfastcity_perception = asb_perception_districts_2016_2017_focused[asb_perception_districts_2016_2017_focused['Policing District'] == 'Belfast City']
x = belfastcity_perception.columns
y = belfastcity_perception.iloc[0].tolist()
plt.figure(figsize=(25, 5))
sb.barplot(y[1:], x[1:])
plt.ylabel('Types of Anti Social Behaviour')
plt.xlabel('Respondents (%)')
ax.xaxis.set_major_formatter(mtick.PercentFormatter())
plt.title('Belfast City: Perception of different types of anti-social behaviour as very / fairly big problems (%)')
```

Out[107]: Text(0.5,1,'Belfast City: Perception of different types of anti-social behaviour as very / fairly big problems (%)')

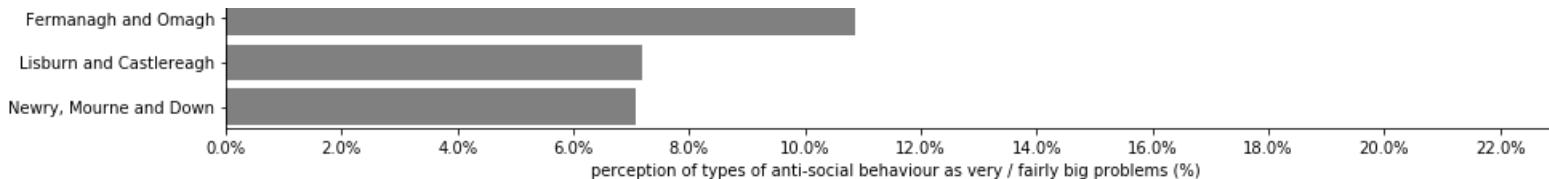


People using or dealing drugs and rubbish or litter lying around are the two perceived biggest ASB problems in Belfast City. Abandoned or burnt-out cars is viewed as the least significant ASB problem in Belfast City surveyed. Criminal damage which includes vandalism, graffiti and other deliberate damage to property (<https://www.police.uk/crime-prevention-advice/criminal-damage-arson/>) is 18.58%. Drug crime and criminal damage are both recorded separately from ASB, but minor crimes fitting their description could be recorded as anti social behaviour. Let's compare different types of ASB perceptions with the other districts, to compare crimes people in Belfast City view as being a very big problem and less so in other districts, and vice versa.

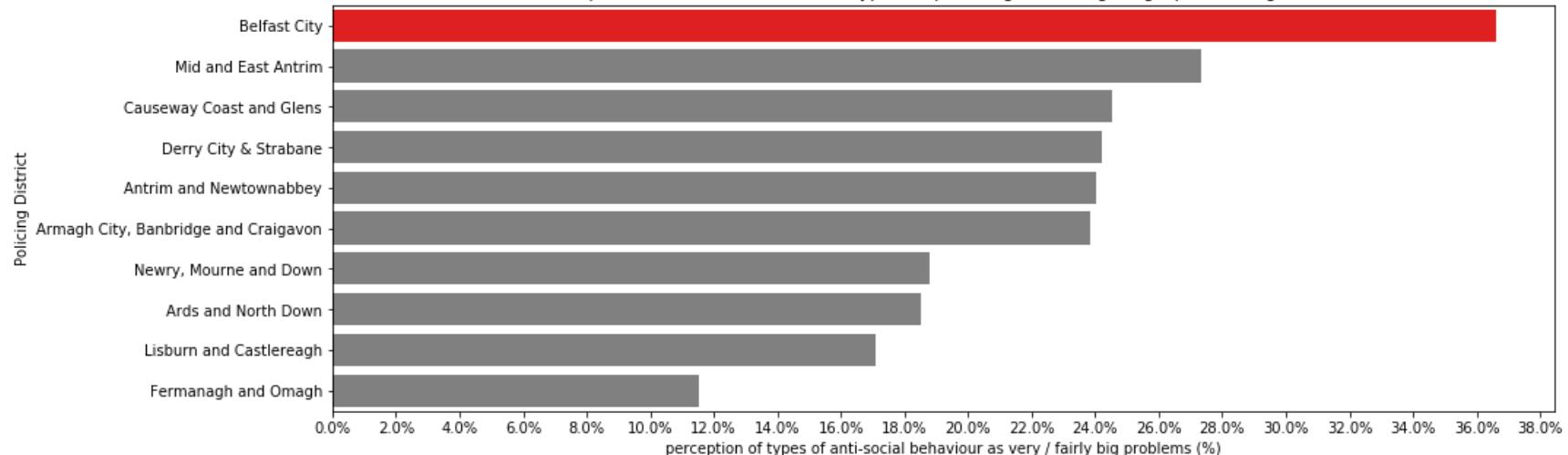
```
In [108]: i = 1
plt.figure(figsize=(15,48))
for column in asb_perception_districts_2016_2017_focused.columns:
    if (column != 'Policing District'):
        ax = plt.subplot(len(asb_perception_districts_2016_2017_focused.columns),1,i)
        ax.set_xticks(np.arange(0, 45, step=2))
        plt.title(f"Perception of Anti-social behaviour type '{column}' per Policing District")
        asb_perception_districts_2016_2017_focused_sorted = asb_perception_districts_2016_2017_focused.sort_values([column], ascending=False)
        sb.barplot(asb_perception_districts_2016_2017_focused_sorted[column], asb_perception_districts_2016_2017_focused_sorted['Policing District'], o
rient='h', palette=asb_perception_districts_2016_2017_focused_sorted['Policing District'].apply(lambda x: 'r' if x == 'Belfast City' else 'grey'))
        plt.xlabel("perception of types of anti-social behaviour as very / fairly big problems (%)")
        ax.xaxis.set_major_formatter(mtick.PercentFormatter())
    i += 1
```



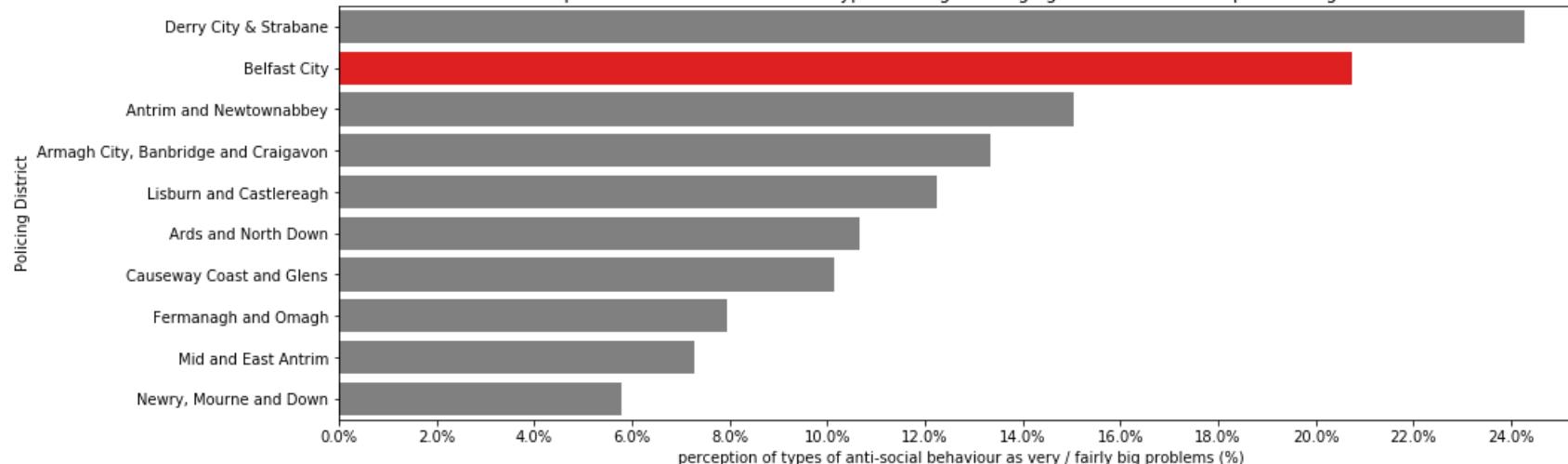
## Crime EDA



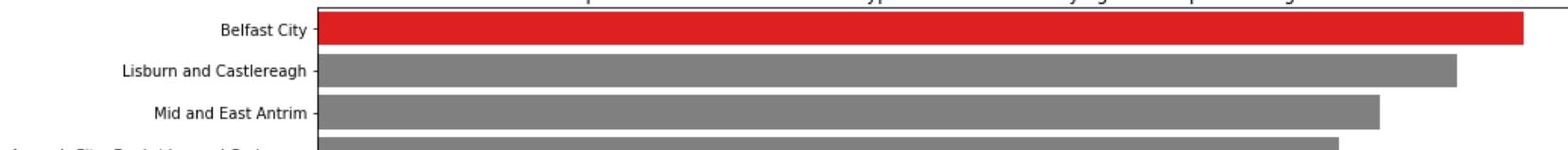
## Perception of Anti-social behaviour type 'People using or dealing drugs' per Policing District

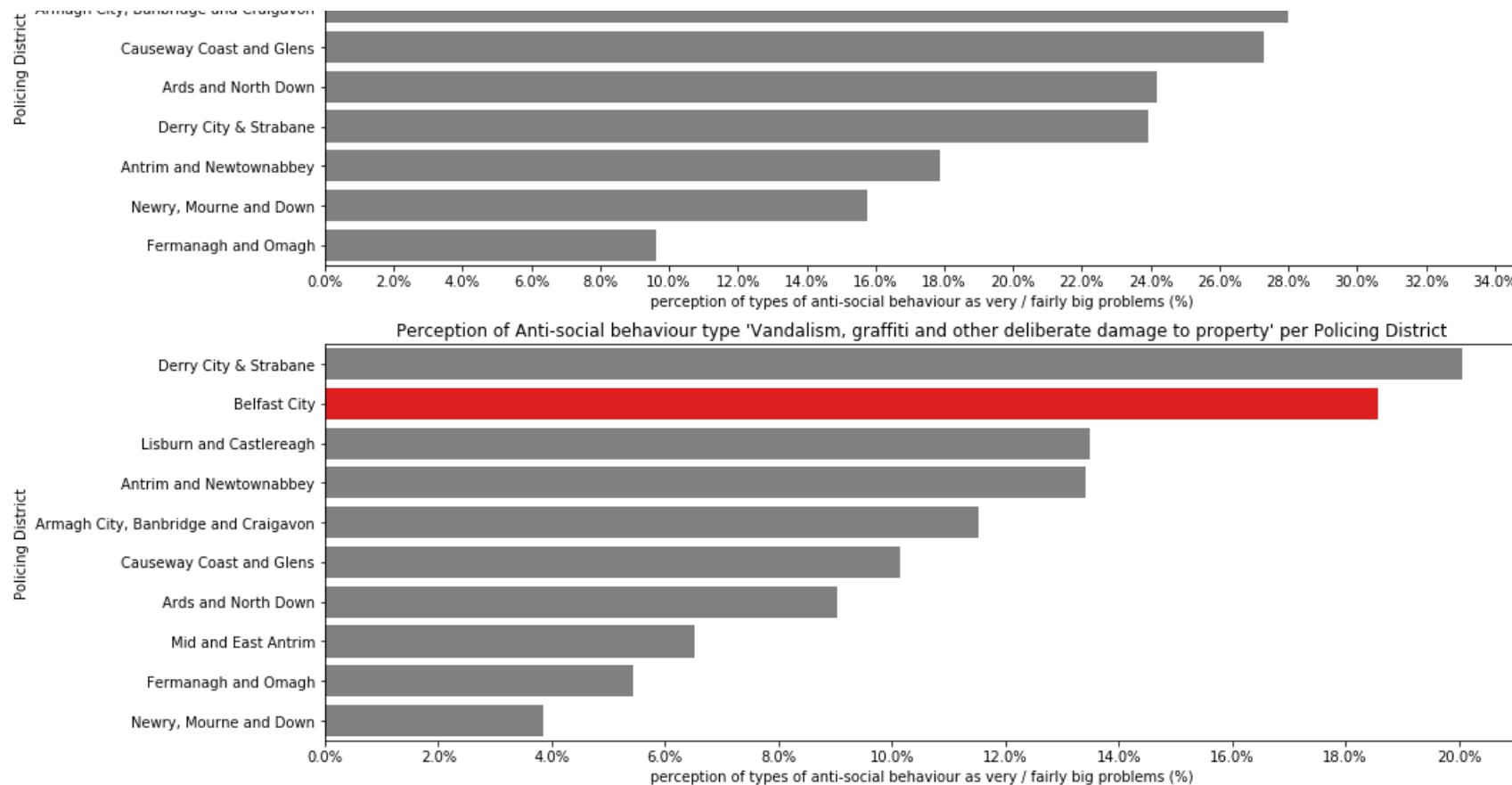


## Perception of Anti-social behaviour type 'Teenagers hanging around on streets' per Policing District



## Perception of Anti-social behaviour type 'Rubbish or litter lying around' per Policing District





People living in Belfast policing district perceive people using or dealing drugs as the biggest ASB problem in their area, the most of any policing district by approximately 10%. People being drunk or rowdy in public places and rubbish litter lying around is also perceived more by people living in Belfast City than in other districts. On a sidenote, people living in Derry City and Strabane perceive abandoned or burnt out cars as being an ASB problem in their local area disproportionately to other districts

## Investigating the link between Parks/Open Spaces: Drug Crime and ASB

Drugs may play a role in perpetuating other types of anti-social behaviour. Illicit drug users may occupy public spaces or amenities in order to use drugs. I want to investigate whether or not there's a concentration of crimes around parks, in particular drug crime and ASB. I'm going to load in a dataset from Belfast City Council that lists all the parks in Belfast and their location.

```
In [109]: parks_data = pd.read_csv('data/park/parksdata.csv')
```

In [110]: `parks_data.head(5)`

Out[110]:

	NAME	ADDRESS	POSTCODE	LONGITUDE	LATITUDE
0	Belfast City Hall	Donegall Square	BT1 5GS	-5.929895	54.596607
1	Gasworks	Ormeau Avenue	BT7 2JB	-5.922746	54.590815
2	Bridges Urban Skate Park	Corporation Street	BT1 3DE	-5.924104	54.604449
3	King William Park	Bradbury Place	BT7 1RS	-5.936026	54.587978
4	Dover Street Millennium Park	Shankill Road	BT13 2HQ	-5.942905	54.601582

As I am concentrating on the Lisburn Road neighbourhood for my analysis, I am going to include only parks that are within 0.5km of a crime in the lisburn road neighbourhood

```
In [111]: # parks_within_crime_distance = parks_data.copy()
# parks_within_crime_distance = parks_within_crime_distance.iloc[0:0]
# MAX_DISTANCE = 0.5

# for park_index, park_row in parks_data.iterrows():
#     longitude = park_row['LONGITUDE']
#     latitude = park_row['LATITUDE']
#     area_coord = (latitude, longitude)
#     for index, row in lisburn_road_sampled.iterrows():
#         coords = (row['Latitude'], row['Longitude'])
#         d = distance.vincenty(area_coord, coords)
#         if (d.km <= MAX_DISTANCE):
#             print(park_row['NAME'])
#             parks_within_crime_distance = parks_within_crime_distance.append(park_row)
#             break;
```

In [112]: `# parks_within_crime_distance.to_csv('parks_within_crime_distance.csv', index=False)`

```
In [113]: parks_within_crime_distance = pd.read_csv('parks_within_crime_distance.csv')
parks_within_crime_distance.head(20)
```

Out[113]:

	NAME	ADDRESS	POSTCODE	LONGITUDE	LATITUDE
0	Belfast City Hall	Donegall Square	BT1 5GS	-5.929895	54.596607
1	Gasworks	Ormeau Avenue	BT7 2JB	-5.922746	54.590815
2	Bridges Urban Skate Park	Corporation Street	BT1 3DE	-5.924104	54.604449
3	King William Park	Bradbury Place	BT7 1RS	-5.936026	54.587978
4	Ormeau Park	Ormeau Road	BT7 3GG	-5.916132	54.585517
5	Botanic Gardens	College Park Botanic Avenue	BT7 1LP	-5.932015	54.582249
6	Drumglass Park	Lisburn Road	BT9 6JF	-5.954841	54.574335
7	Lagan Meadows	Knightsbridge Park	BT9 5PB	-5.936648	54.561887
8	Grovelands	Stockman's Lane	BT9 7JB	-5.969532	54.569353
9	Musgrave Park	Stockman's Lane	BT9 7JB	-5.973881	54.569947
10	Clement Wilson Park	Newforge	BT9 5NX	-5.950436	54.555185
11	Wedderburn Park	Orpen Park	BT10 0BN	-5.987837	54.555355

Let's visualise the parks on a heat map with a high ASB count month (March 2016) to see if there's any concentration of ASB around parks

```
In [114]: m = folium.Map(location=[54.5668, -5.95328], zoom_start=12)

park_coords = []
crime_coords = []

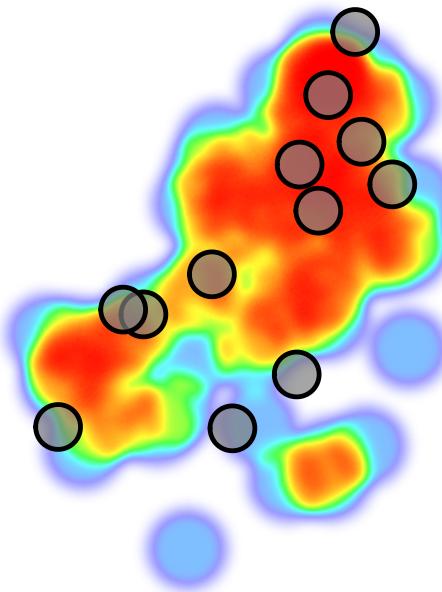
for index, row in parks_within_crime_distance.iterrows():
    coords = (row['LATITUDE'], row['LONGITUDE'])
    park_coords.append(list(coords))

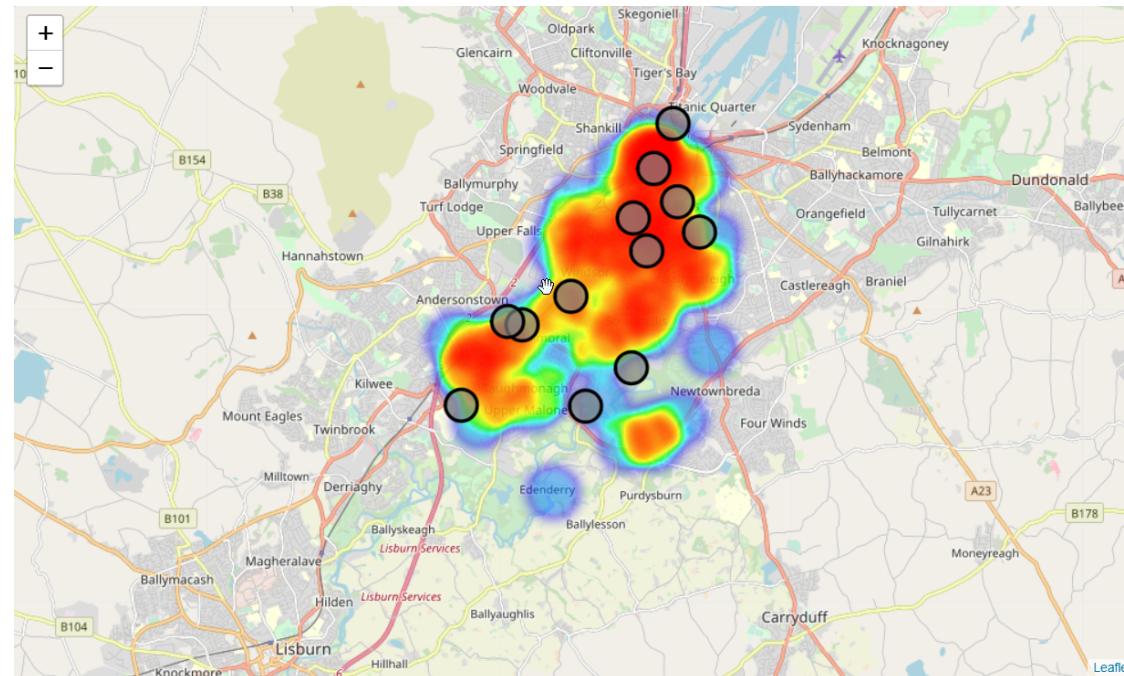
for index, row in lisburn_road_march_2016.iterrows():
    coords = (row['Latitude'], row['Longitude'])
    crime_coords.append(list(coords))

m.add_child(HeatMap(crime_coords))
for i, j in park_coords:
    folium.Circle([i,j], radius=300, fill_color='grey', fill_opacity=0.7, color='black').add_to(m)

m
```

Out[114]:

Leaflet (<http://leafletjs.com>)



Drumglass Park and Botanic Gardens a clear concentration. Botanic Gardens includes the Holylands hotspot in its radius. City Hall does encompass a lot more of a dense crime hotspot. Due to the inaccuracy in locations setting the longitude latitude to the nearest street, Belvoir Park Forest's crime radius may not include crimes happening within the forest. Overall, the shape of crime does not seem to concentrate itself close to parks in areas Stranmillis and Donegall Road. Let's get a count of the close crimes in the 0.3km radius of the parks to see if any park is a hotspot.

```
In [115]: crimes = psni_crime_data_ranged[psni_crime_data_ranged['Has_Location'] == True]
```

```
In [116]: # MAX_DISTANCE = 0.3

# for park_index, park_row in parks_within_crime_distance.iterrows():
#     count = 0
#     longitude = park_row['LONGITUDE']
#     latitude = park_row['LATITUDE']
#     area_coord = (latitude, longitude)
#     for index, row in crimes.iterrows():
#         coords = (row['Latitude'], row['Longitude'])
#         d = distance.vincenty(area_coord, coords)
#         if (d.km <= MAX_DISTANCE):
#             count += 1
#     parks_within_crime_distance.at[park_index, 'Close_Crimes_Count'] = count

parks_within_crime_distance = pd.read_csv('parks_within_crime_distance_count.csv')
```

```
In [117]: parks_within_crime_distance.sort_values('Close_Crimes_Count', ascending=False)
```

Out[117]:

	NAME	ADDRESS	POSTCODE	LONGITUDE	LATITUDE	Close_Crimes_Count
0	Belfast City Hall	Donegall Square	BT1 5GS	-5.929895	54.596607	4847.0
3	King William Park	Bradbury Place	BT7 1RS	-5.936026	54.587978	3330.0
2	Bridges Urban Skate Park	Corporation Street	BT1 3DE	-5.924104	54.604449	1156.0
5	Botanic Gardens	College Park Botanic Avenue	BT7 1LP	-5.932015	54.582249	465.0
1	Gasworks	Ormeau Avenue	BT7 2JB	-5.922746	54.590815	442.0
6	Drumglass Park	Lisburn Road	BT9 6JF	-5.954841	54.574335	294.0
8	Grovelands	Stockman's Lane	BT9 7JB	-5.969532	54.569353	186.0
4	Ormeau Park	Ormeau Road	BT7 3GG	-5.916132	54.585517	176.0
9	Musgrave Park	Stockman's Lane	BT9 7JB	-5.973881	54.569947	81.0
11	Wedderburn Park	Orpen Park	BT10 0BN	-5.987837	54.555355	31.0
10	Clement Wilson Park	Newforge	BT9 5NX	-5.950436	54.555185	10.0
7	Lagan Meadows	Knightsbridge Park	BT9 5PB	-5.936648	54.561887	0.0

Lagan Meadows having 0 close crimes is because of its longitude latitude radius being central in a forest area, as seen in the map above. Belfast City Hall has the highest crime count of any open space/park in Lisburn Road Neighbourhood. This could be because of its central location in the City Centre. King William Park also may have additional noise from being in a high footfall commercial area. I am going to drop these two parks from the table.

```
In [118]: park_coords = []
for index, row in parks_within_crime_distance[(parks_within_crime_distance['NAME'] != 'Belfast City Hall') & (parks_within_crime_distance['NAME'] != 'King William Park')].iterrows():
    coords = (row['LATITUDE'], row['LONGITUDE'])
    park_coords.append(list(coords))
```

```
In [119]: park_coords
```

```
Out[119]: [[54.59081464670145, -5.9227463040104285],
[54.60444946790272, -5.924104087169143],
[54.5855165230949, -5.916131805645338],
[54.582249006852685, -5.932014919679817],
[54.574334885713384, -5.954841146640687],
[54.561887223486956, -5.9366482628265365],
[54.56935316416344, -5.96953219998335],
[54.56994716540786, -5.973880524193518],
[54.555185254529285, -5.950435654808607],
[54.55535505750669, -5.9878366742481]]
```

Let's find crimes that are within the 0.3km radius of a park to compare with the overall crime type distribution of the total dataset.

```
In [120]: # crimes_within_parks_distance = psni_crime_data_ranged.copy()
# crimes_within_parks_distance = crimes_within_parks_distance.iloc[0:0]

# MAX_DISTANCE = 0.3

# for index, row in crimes.iterrows():
#     for i, j in park_coords:
#         coords = (row['Latitude'], row['Longitude'])
#         area_coords = (i, j)
#         d = distance.vincenty(area_coords, coords)
#         if (d.km <= MAX_DISTANCE):
#             crimes_within_parks_distance = crimes_within_parks_distance.append(row)
#             break;

# crimes_within_parks_distance.to_csv('crimes_park_distance.csv', index=False)
crimes_within_parks_distance = pd.read_csv('crimes_park_distance.csv')
```

In [121]: `crimes_within_parks_distance.head()`

Out[121]:

	index	Longitude	Latitude	Location	Crime type	Has_Location	Year	Month	Week	Quarter
0	14	-5.929275	54.582252	Nan	Anti-social behaviour	True	2016	1	53	1
1	131	-5.930676	54.583911	rugby road	Anti-social behaviour	True	2016	1	53	1
2	147	-5.927982	54.582122	Nan	Anti-social behaviour	True	2016	1	53	1
3	383	-5.955934	54.575958	marlborough court	Anti-social behaviour	True	2016	1	53	1
4	483	-5.921916	54.588541	cooke court	Anti-social behaviour	True	2016	1	53	1

In [122]: `crimes_within_parks_distance.info()`

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2760 entries, 0 to 2759
Data columns (total 10 columns):
index          2760 non-null int64
Longitude      2760 non-null float64
Latitude       2760 non-null float64
Location        2341 non-null object
Crime type     2760 non-null object
Has_Location    2760 non-null bool
Year            2760 non-null int64
Month           2760 non-null int64
Week            2760 non-null int64
Quarter         2760 non-null int64
dtypes: bool(1), float64(2), int64(5), object(2)
memory usage: 196.8+ KB
```

Let's group the crimes by crime type to compare the distribution of crime types.

In [123]: `within_range_parks_crime_type = crimes_within_parks_distance.groupby(['Crime type']).size().reset_index(name='counts')`  
`within_range_parks_crime_type.head()`

Out[123]:

	Crime type	counts
0	Anti-social behaviour	1094
1	Bicycle theft	79
2	Burglary	135
3	Criminal damage and arson	336
4	Drugs	124

Let's find the crimes that are not 0.3km from Lisburn Road parks

```
In [124]: not_within_range_parks_crime_type = crimes[~crimes.isin(within_range_parks_crime_type)].groupby(['Crime type']).size().reset_index(name='counts')
```

```
In [125]: not_within_range_parks_crime_type.head()
```

Out[125]:

	Crime type	counts
0	Anti-social behaviour	122656
1	Bicycle theft	1605
2	Burglary	13893
3	Criminal damage and arson	37054
4	Drugs	11190

Let's visualise the difference in crime type distribution between crimes within 0.3km of Lisburn Road parks and the rest of the PSNI dataset for 16-17

```
In [126]: dictCrimeType = {}

total_within_range = within_range_parks_crime_type['counts'].sum()
total_all = not_within_range_parks_crime_type['counts'].sum()

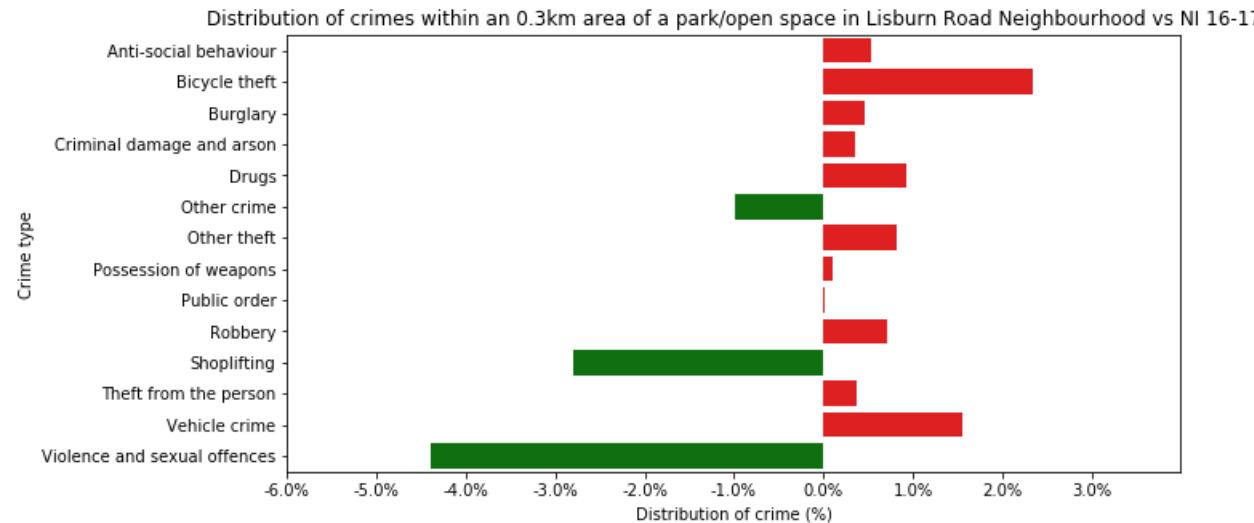
plt.figure(figsize=(10,5))

for index, row in not_within_range_parks_crime_type.iterrows():
    percent_all = row['counts']/float(total_all) * 100
    percent_within_range = within_range_parks_crime_type[within_range_parks_crime_type['Crime type'] == row['Crime type']].iloc[0]['counts']/float(total_within_range) * 100
    difference_percent = percent_within_range - percent_all
    dictCrimeType[row['Crime type']] = difference_percent

difference = pd.DataFrame.from_dict(dictCrimeType, orient='index')
difference.index = difference.index.astype(str)

ax = sb.barplot(difference[0], difference.index, palette=difference[0].apply(lambda x: 'r' if x>0 else 'g'))
ax.set_ylabel('Crime type')
ax.set_xlabel('Distribution of crime (%)')
ax.set_xticks(np.arange(-6, 4, 1))
ax.xaxis.set_major_formatter(mtick.PercentFormatter())
plt.title("Distribution of crimes within an 0.3km area of a park/open space in Lisburn Road Neighbourhood vs NI 16-17")
plt.xlim(-6, 4)

plt.show()
```



There's approx 0.5% anti social behaviour crimes in in a 0.3km radius arounds parks in Lisburn Road neighbourhood than the rest of Northern Ireland. Violence and sexual offences sees the biggest decrease by approx. 4.5%, while bicycle theft is the largest increase. Drug crime however does increase by 1%, meaning there could be a relationship with open spaces.