DC3: Exploratory Data Analysis
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The Missing Rose-Crested Blue Pipits in Mistford

Introduction:

The Boonsong Lekagul Nature Preserve is a great place for the local residents and tourists to visit and to embrace nature. On top of being a perfect hideaway and a potential transit area for the local bird, the Rose-Crested Blue Pipit, the preserve also hosts four factories. Given the factories' proximity to the preserve and the city, they were monitored closely to ensure that they do not pollute the environment with their chemical waste. Using the provided information and data, this report aims to potentially help Mitch Vogel understand what might have caused the declining local bird population and whether it has anything to do with factories being non-compliant with the recent years' environmental regulations. In particular, we hope to aid our analysis by reporting on possible sensor anomalies and vehicle activity patterns.

Hypothesis:

While considering the city Mistford, the nature preserve, and the four manufacturing companies, we hypothesize that the dropping population of the Rose-Crested Blue Pipit is due to the damaging actions of the companies. In June 2013, the Mistford Environmental Authority tightened emission standards for volatile organic compounds (VOCs), eliminating the need for Methylosmolene and other VOCs in the manufacturing processes from the companies in the region[1].

However, there is a high chance that before the regulations were implemented, damage has been done to the nature preserve with possible leakage from the nearby companies. Additionally, we believe that it is possible that at least one of the companies near the nature preserve has been sabotaging the sensors to ensure that the readings indicate that the emissions are well under control and under the limits. We also believe that the regulations may not be checked/implemented properly by those in charge. It is also highly suspected that the company, Radiance ColourTek, may be one of the main perpetrators of this sabotage. The metallic paint-based company would pose the greatest risk in having high amounts of VOCs due to paint emitting VOCs while drying. It is also unlikely that a company would have been able to completely change their paint formulas with the new and less harmful VOC, AGOC-3A, within a 5-year time frame. Therefore, there is a greater chance of chemical contamination/leakage from this company into the nature preserve of the unapproved VOCs either through winds or possible rain/run-off.

Methodology:

While considering the challenge, we recognized the need to understand who the companies that may be involved are, what daily patterns we can find in the sensors and traffic into the nature preserve, and how meteorological factors may be influencing the issues with the dropping population of nesting pairs of Pipits. The newsletters provided insight as to what the companies each did, the values they may hold, as well as any important events, such as the newly implemented environmental regulations. We were also provided financial context for all four companies near the preserve. In terms of the traffic, weather, and sensor data provided, we sought after general trends and looked for any unusual behaviors/data that may indicate suspicious activity/sabotage. From our investigation into the toxic chemicals' concentrations by observing totals and averages, we decided to disregard AGOC-3A even though it was detected more often and with more concentration due to being less harmful to the environment. This allowed us to see the trends and elevated concentrations of certain toxic chemicals compared to others. After analyzing each dataset, important trends were compared in order to better understand the events that may be surrounding the companies and the nature preserve.

Data Visualizations & Analysis:

Newsletter Context:

To start our investigation, we began sifting through the newsletters for any relevant information. Figure 1 charts each company's quarterly earnings per share over the time period of the newsletters.

The most outstanding trend in the chart is from the Kasios Office Furniture company. From June 2013 to December 2014, there's a gradual fall in the company's earnings. This could be due to expansion being costly[1] and their new product lines failing to turn a profit[2]. From December 2014 onward, their earnings dramatically increased, but the only context given is a new addition to the Kasios Board of Directors in the first half of 2016[3]. By investigating the data, more context may be obtained as to this sudden shift.

Taking a look at the Radiance ColourTek company, their stock prices remain relatively stable and high up until December 2014, where there is a substantial drop. The articles indicate that there was a stock split in 2015, thus primarily accounting for the fall[3]. Radiance also donated 2% of their 2015 second quarter revenue to the Pangera Ornithology Conservation Society after a year of developing new colors inspired by the local flora, fauna, and wildlife[4], hence the lack of an increase during this time period. The stock split was done to fund this new line of spray paint, and the company CFO indicated that investors would see a rise from 2016 onward, which aligns with the company's financial trend[3].

Kasios and Radiance co-sponsored a charity event in January 2016, indicating a potential partnership between the two companies[5]. It is also important to note that Radiance claims to

have the lowest VOCs in the industry[6], but further exploration into this new line of spray paint and the data may prove otherwise. Moreover, Radiance's communication specialist and MIP newsletter editor retired in 2016, but as to whether this indicates a change in company values or not is hard to gauge.

As for the Indigo Sol Boards company, their earnings follow a slightly-rising, oscillating trend. The initial drop in the first half of 2013 may be due to the shift from VOCs due to the tightened emission standards[1]. No other context is given from June 2013 to June 2015, but the rise in the second half of 2015 can be attributed to their new skateboard line[5]. The final drop going into 2016 could have occurred due to the company's expansion, similar to Kasios[3].

Finally, the Roadrunner Fitness Electronics company has a relatively stable chart, only rising in 2013. The only piece of relevant context is their partnership with the Mistford Public Parks Commission to open a fitness course in 2016[3]. Both Indigo and Roadrunner don't appear to have any suspicious activity in their financial trends, but further analysis of the traffic, meteorological, and sensor data may result in a different answer.

Traffic Trends:

Filtering out the unique car-id, most of the cars that the sensor picked up were Type 1 across the time frame (Figure 2).

In general, we found out three types of regular activities among those vehicles who entered the preserve based on how long they stayed in the preserve on each trip (Figure 3). The first group of vehicles, which is also the most common type, was just passing by; this is characterized by the short time interval (i.e., less than an hour) between gates that were picked up by the sensors. The second group of vehicles was considered as the one-day trippers, who visited sites at the preserve but didn't camp overnight. The third group was characterized as the overnight campers, who stayed in the preserve for several days.

After taking a closer look at the traffic data, there were two groups of suspicious activities taking place in the preserve. First of all, based on the entrance/exit record, there were 34 vehicles that entered the preserve but never came out. This was discovered based on the fact that these vehicles only have one entrance picked up by the sensor; their final whereabouts cannot be pinpointed after they were last seen at a camp location. Specifically, one car (car-id:20155705025759-63) had been staying inside the park for nearly a year and moved to different camping sites over time (Figure 4). In addition, we also observed that there was a group of 23 Type-4 vehicles passing Gates 3, 5, and 6, which were not open to the general public without a pass — only Type-2P vehicles were allowed to pass those gates. One thing to note was that all of the trespassing vehicles entered the preserve on different dates but had the same movement, moving from Entrance 3 to Gates 3, 5, and 6 and back to Entrance 3. One example of these vehicles' movement is visualized (car-id:-625; Figure 5). We cross-referenced these two groups of ids and found no overlap, therefore we concluded that these two groups

might be unrelated to each other. This latter group of unusual activities is particularly important given that both Gates 5 and 6 are close to the detectors and Entrance 3 is close to the companies. It is possible that this is related to the sabotaging of the chemical monitors or illicit disposal of wastes.

Meteorological Trends:

The meteorological trends of Mistford provided important insight into how potentially harmful emissions may have reached the Pipit populations in the nature preserves. Typically, manufacturing companies will produce waste in either the form of toxins/chemicals that have been used and released in a gaseous form, dumped in a liquid/solid form, or byproducts from machinery that can damage the environment. However, the wind data that we have been provided heavily relies on the possibility of gaseous waste from one or all the companies, especially Radiance.

As shown in Figure 6, we can see that while average wind speeds vary each day through the month (April, August, December), generally December has higher wind speeds. There are multiple apparent peaks reaching above an average of 5 meters/second in December, while almost no other month reaches those speeds. Additionally, with respect to wind direction in Figure 7, it was noted that throughout all three months, winds tended to blow towards the western side of the nature preserve. Specifically in April and December, it was noted that winds would often blow northwest while in August it was a mix of northwest and southwest. Additionally, we know that the northwest wind speeds in December were the strongest overall. This indicates potentially strong gusts of wind that can carry gaseous pollutants deeper into the nature preserve where the Pipits may reside. It is also possible that the Pipits may reside deeper in the nature preserve (North), away from the manufacturing companies, making it more likely that the Pipits may be interacting with pollutants leaked from the companies.

Sensor Trends:

The data gathered from the monitors allowed us to narrow down which chemicals have an increased presence and helped us understand what is happening in Mistford. Of the four chemicals being detected for, apart from AGOC-3A which is more environmentally friendly, there are elevated amounts of Methylosmolene, a toxic and heavily-regulated chemical that has side effects for invertebrates. In Figure 8, we visualized the mean amount of chemical per detection for the three most toxic chemicals being monitored throughout three months. It's clear that the Methylosmolene has higher concentrations per chemical detection than the other two chemicals throughout the month, with larger concentrations at the beginning of every month and becoming normal by the end. Looking at Figure 9, we can see that Methylosmolene is usually detected by the monitors less often than any of the other chemicals, yet it holds the largest concentrations. Methylosmolene also has much higher concentrations in the month of

December. The high concentration of Methylosmolene and its increases over the months could indicate a rise in toxicity to invertebrates from this chemical, which the birds could be feeding on and therefore injecting toxicity.

Unusual trends in Figure 9 representing the amount of times chemicals are detected per day per month and the lack of values in the hour and minute fields may indicate some sort of manipulation or mismanagement of the system. The consistent pattern of low amounts of detections around Day 8 for most of the chemicals and the mirrored pattern of AGOC-3A and Methylosmolene over Appluimonia and Chlorodine make us question if there is some sort of manipulation on the sensors. To further investigate this, we could look at production schedules of companies to see if they usually do not manufacture in the beginning of the month, but it is unlikely that all companies sync schedules. We would also want to know when these monitors are being monitored for compliance of the companies and if this happens to coincide with the lower detections.

Lastly, in Figure 10, which is a bar graph describing the total amount of chemicals detected by each monitor in each month, we can pay close attention to Monitor 4 and how it drastically changes throughout the months. From having low amounts of each chemical detected in April, Monitor 4 has the steepest increase in the total amount of chemicals detected every four months until in December, where it becomes the monitor with the largest amounts of chemicals detected in the system. As discussed in the Meteorological section, as the months increase so does the wind speeds with a northwest direction. Monitor 4 is in the northwest direction of two companies: Indigo, which is more to the east, and Radiance, which is closer to the northwest direction of Monitor 4. The increasing amounts of total chemicals detected throughout the months, the increasing wind speeds, and the fact that Radiance deals with paints which are often toxic and have had manufacturing issues in the past, leads us to believe there could be some chemical handling issue at the factory. That being said, we still do not discount Indigo's possible role in the environmental problem in Mistford and cannot definitively determine if Radiance is the main perpetrator, but both should be investigated further for additional answers.

Conclusion:

Overall, we have found that there are several instances of suspicious activity throughout the nature preserve in both the traffic patterns and the sensor data. There is one group of cars that only has one entrance data value each, thus lacking an exit point, and another group of cars that is unauthorized but passed through gates that are not open to the general public. The latter group of cars could illicitly facilitate companies to control sensors or dispose of waste. Through our investigation, we have pinpointed the companies Radiance ColourTek and Kasios Office Furniture as the possible perpetrators for the violation of the environmental regulations.

Data References:

1. Mistford Context & Information. https://jcrouser.github.io/CSC235/DC3.html
2. Newsletter Files
3. Sensor Data Files
4. Traffic Data Files

Citations:

1. Mistford Industrial Park Newsletter June 2013.pdf
2. Mistford Industrial Park Newsletter June 2014.pdf
3. Mistford Industrial Park Newsletter June 2016.pdf
4. Mistford Industrial Park Newsletter June 2015.pdf
5. Mistford Industrial Park Newsletter Dec 2015.pdf
6. Mistford Manufacturing Companies.docx

Appendix:

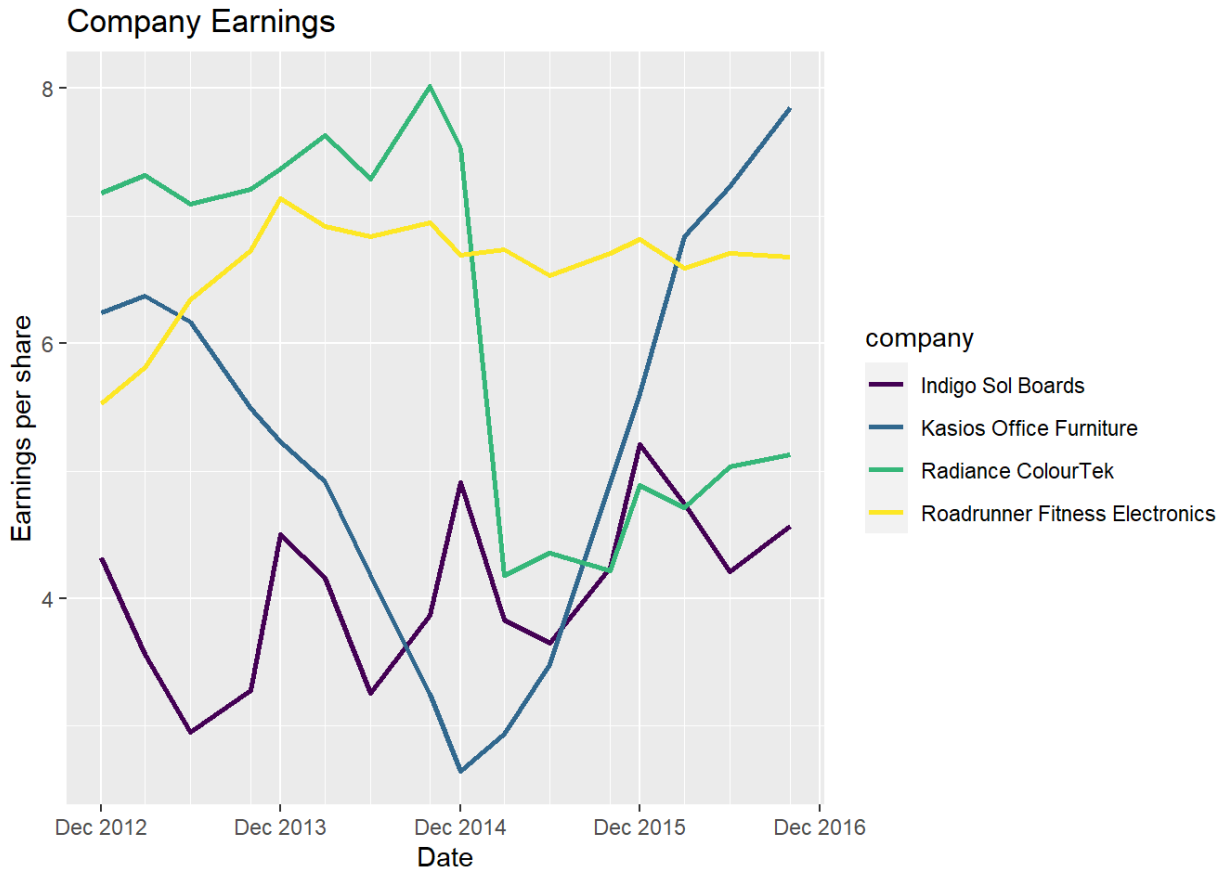

Figure 1. Company earnings

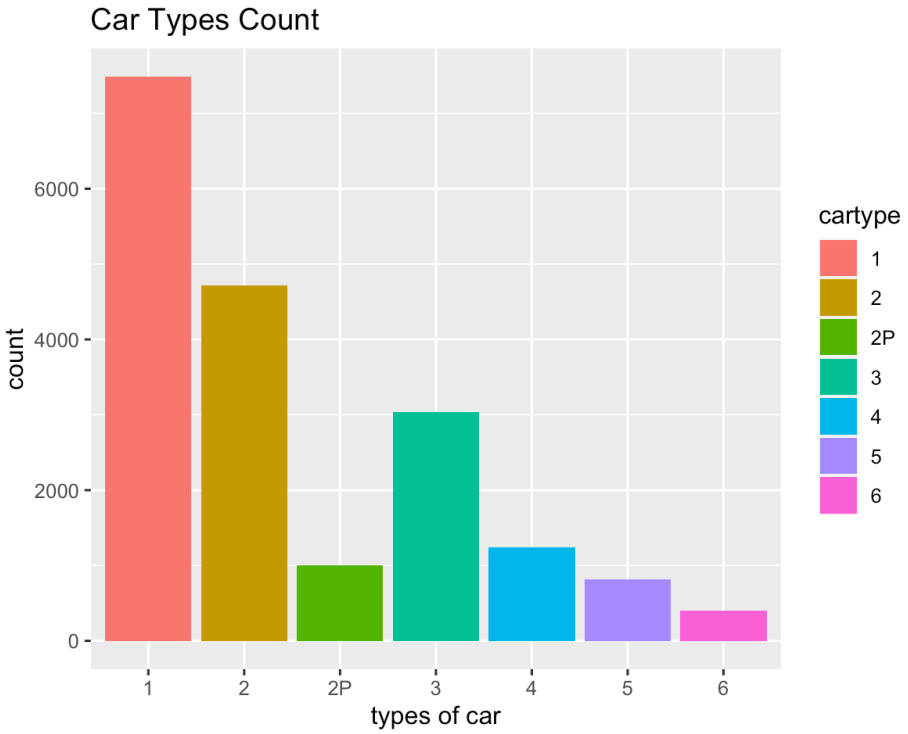

Figure 2. Car types count

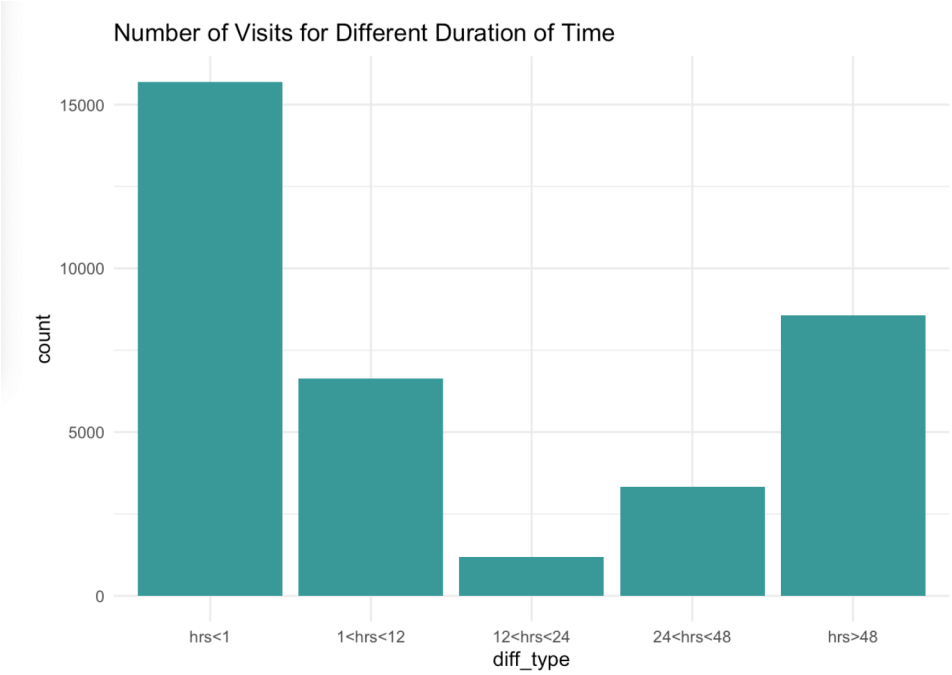

Figure 3. Number of visits for different duration of time

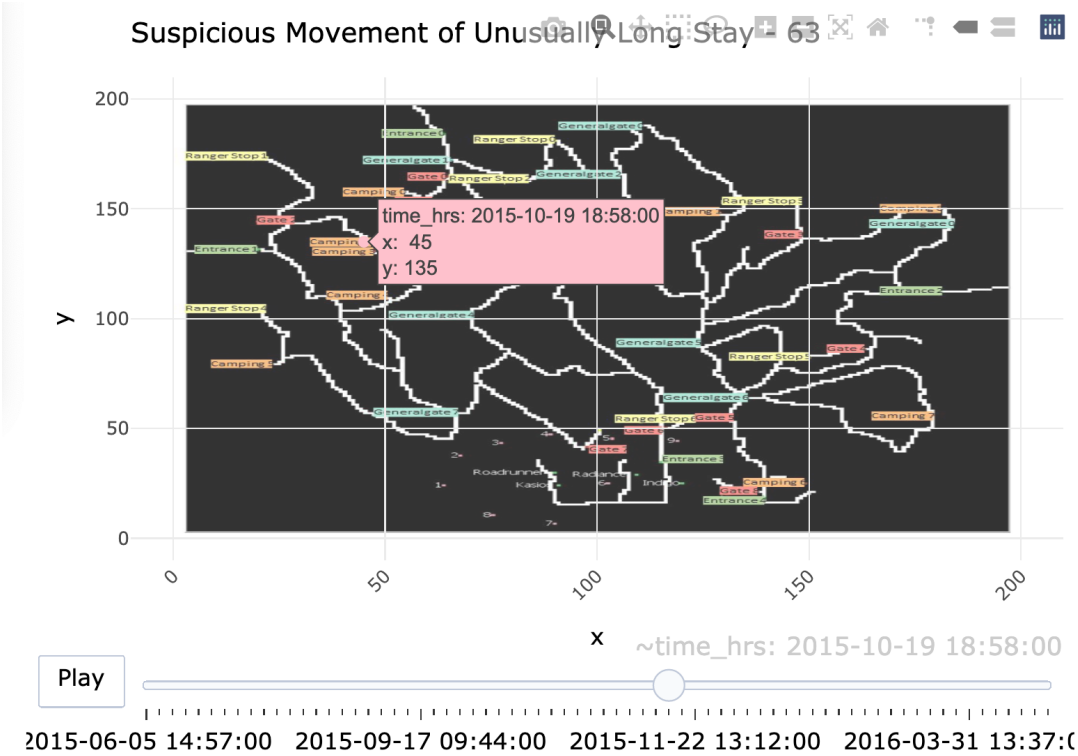

Figure 4. Snapshot of suspicious movement of unusually long stay (check html for interactive plot)

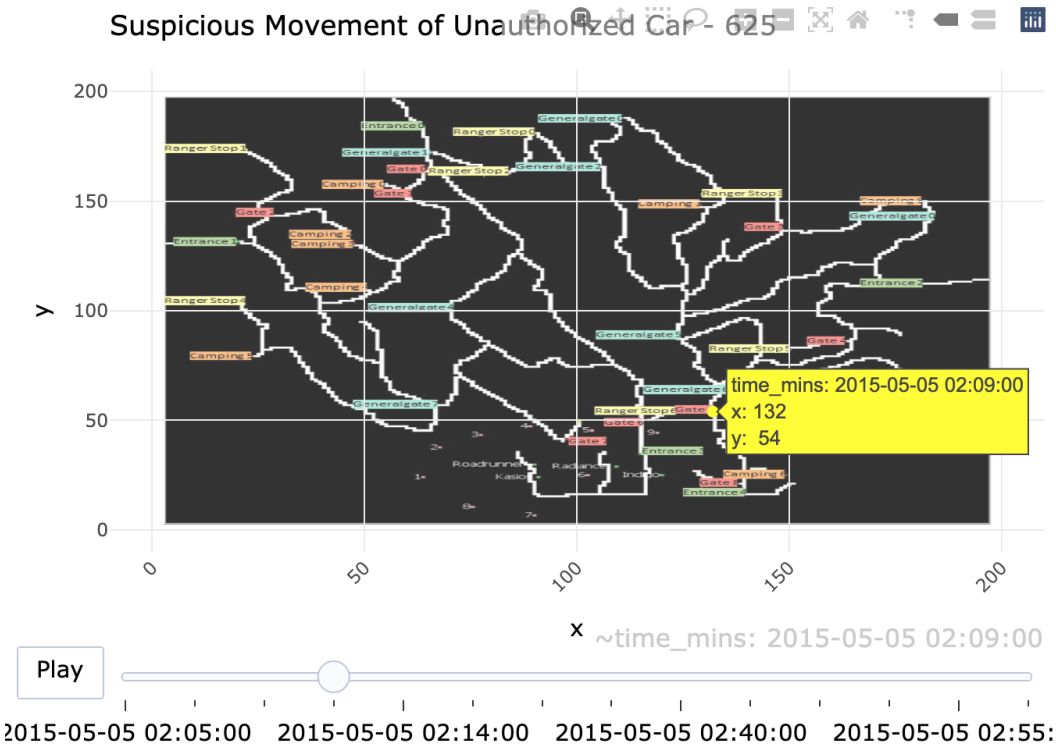

Figure 5. Snapshot of suspicious movement of unauthorized car (check html for interactive plot)

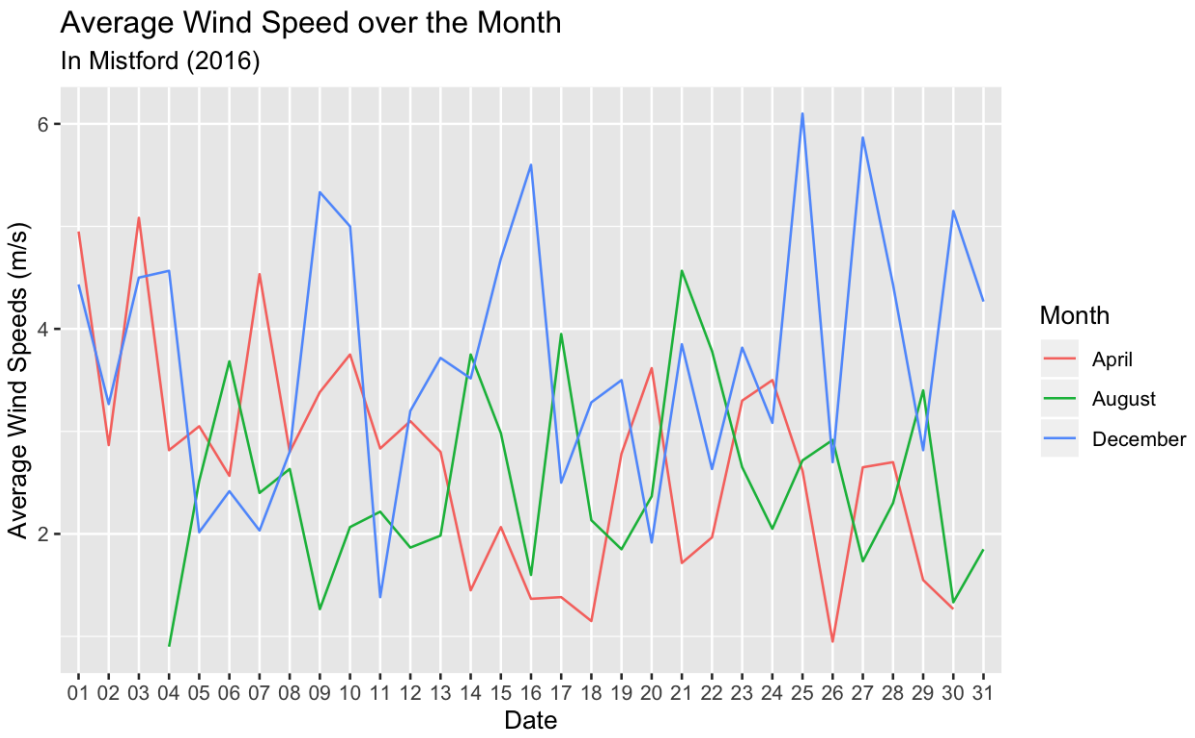

Figure 6. Average wind speed over the month

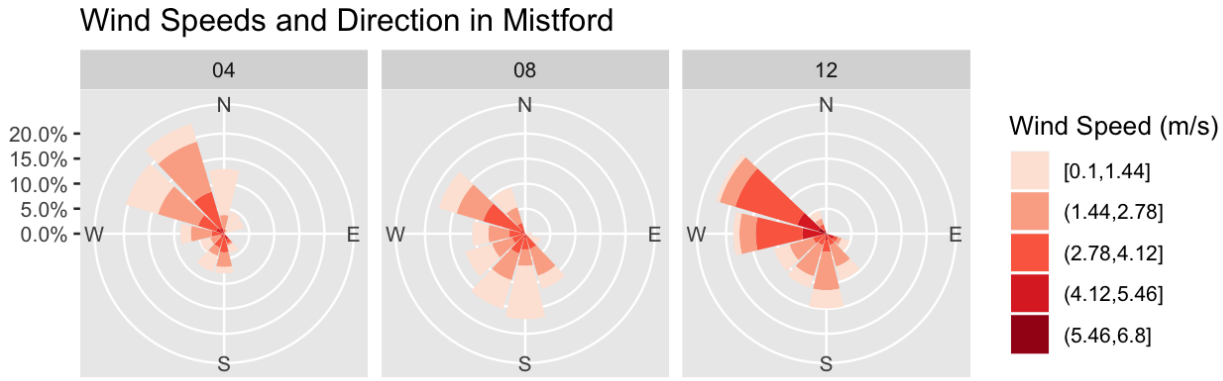

Figure 7. Wind speeds and direction in Mistford

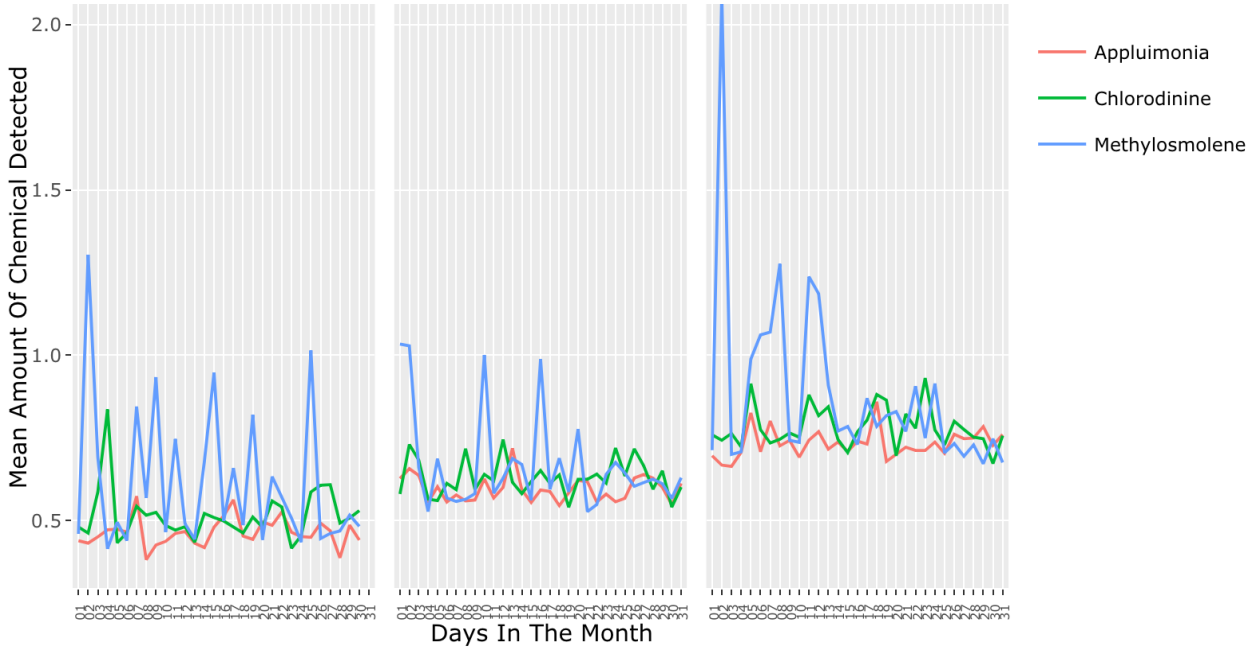

Figure 8. Mean amount of chemicals detected over the month

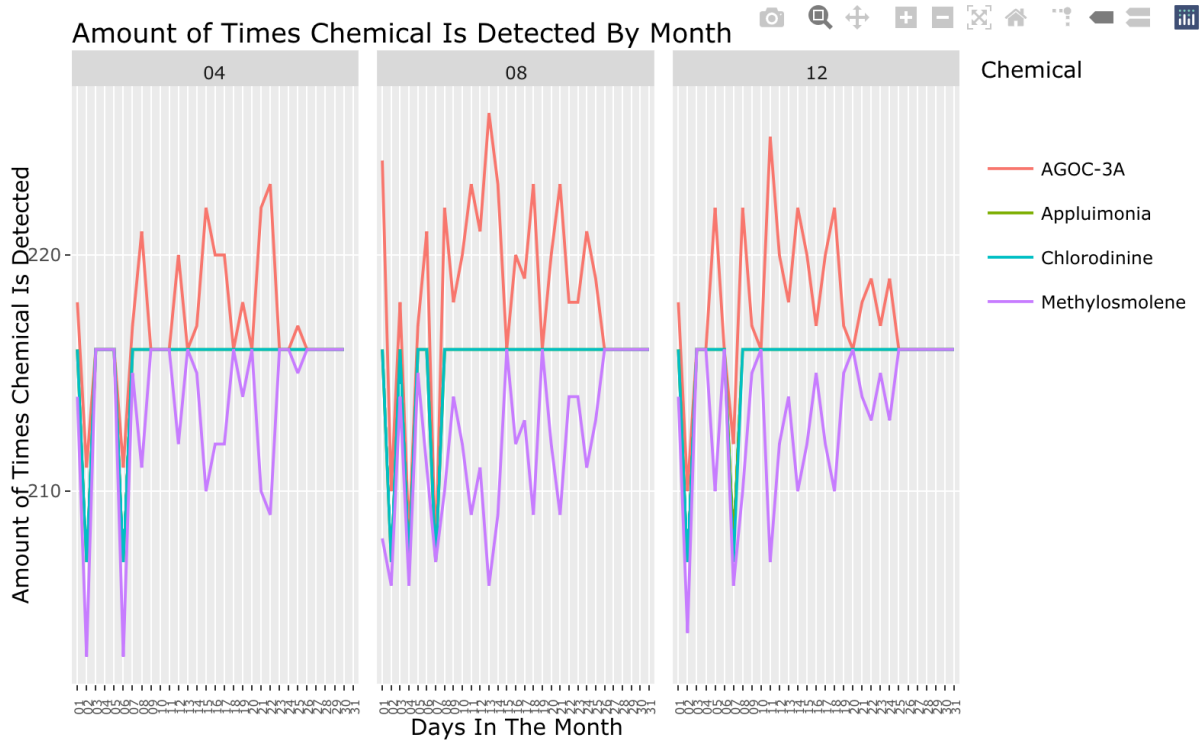

Figure 9. Total amount of times a chemical was detected over a month

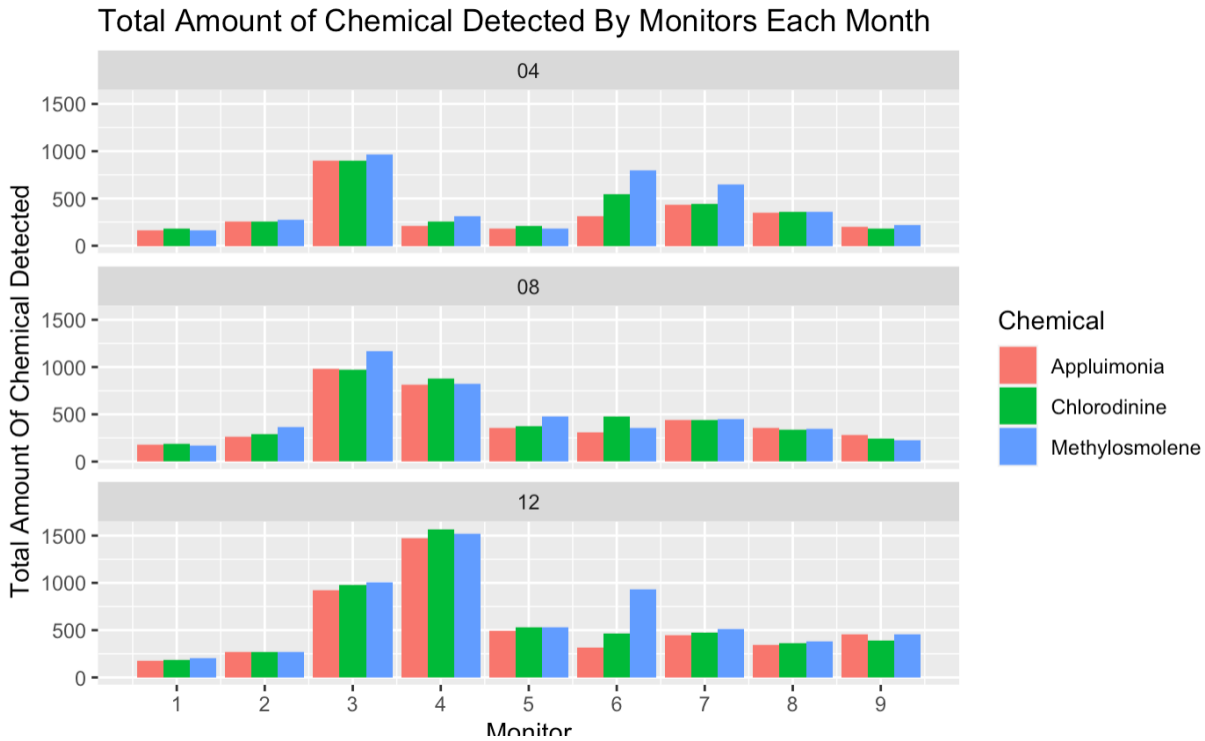

Figure 10. Total amount of chemicals detected by month