**Project Report**

**Toronto Fire Incidents and Weather**

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1. **Introduction**

According to the Government of Canada, in 2021, 59 people died from fire related incidents in Canada. (<https://www150.statcan.gc.ca>)1 In Toronto, Canada's sprawling urban landscape, the interplay between environmental factors and fire incidents presents a complex and critical issue for public safety. This project aims to explore the correlation between Toronto's fire incidents and key meteorological variables: wind speed, temperature, and sea level pressure. Wind speed can significantly influence fire spread, with higher speeds potentially exacerbating fires and complicating containment efforts. Temperature also plays a pivotal role, as higher readings often align with drier conditions, increasing fire risks. Additionally, variations in sea level pressure can indicate broader weather patterns, possibly impacting fire behavior. By analyzing historical data, this project seeks to uncover patterns and correlations, providing insights into how these environmental factors may influence the frequency and severity of fire incidents in Toronto. This understanding is crucial for enhancing fire prevention strategies and emergency response planning, ultimately aiming to bolster the city's resilience against fire-related hazards.

1. **Data**

This project focuses on two primary sources of data: Fire Incidents dataset from Kaggle and weather data from Toronto weather stats.

* 1. *Fire Incidents*

I collected this data set from Kaggle2 and it provides data on different fire incidents in Toronto, Canada from 2011 and 2018 and features like date, location, costs, and causes.

Fire Incidents consists of 11,214 different fire incidents and 29 different features. I cut this down to 9 features including the date, casualties, costs, material ignition, and station. I decided to break this data set down due to difficulty of scraping the weather data and focused only on fire incidents in 2015. This brought the number of fire incidents down to 1,254. I removed columns and broke down the data in the *project\_cleaning.R* file.

This dataset didn’t really need much cleaning done to it. There was a column in the dataset of the time and date when emergency services were called so I converted that to a date value and change the column name to year. The only other thing I had to do was remove columns that weren’t needed. All of this work is in the *project\_cleaning.R* file.

* 1. Toronto Weather

I collected this data from Toronto Weather Stats3 , and it provided daily weather statistics in the three weather variables I am focusing on: temperature, wind Speed, and sea level pressure. I was unable to scrape this website so I used Power Automate to get the data into an excel spreadsheet. I was able to get all 365 days of 2015 for the averages of temperature, wind speed, and sea level pressure. Each one of the variables had three different flows and spreadsheets due to the data being on different pages. The temperature is measured in degrees celsius, wind speed is measured in kilometers per hour, and sea level is measured in kilopascals.

This data required a lot of cleaning before I was able to merge it with the Fire Incidents data frame. I had to first make column names for each of the excel files and I matched the *year* column so I could merge it with the fire incidents data frame. The second issue was the data types with each of the values. They were all characters, so I had to convert it to numeric type. The celsius, km/h, and kPa were included in the values so I removed them. There was also a white space before or after the value, so I removed that as well. I was then able to convert it to a numeric value.

* 1. Combining Data Frames

By converting and matching the structures the same it was relatively simple to combine these together. I merged them together to match the *year* column or the date of the weather averages and the fire incident. The first thing that I had to do was merge the three different data frames from the weather variables. I created the winds, temps, and pressures data frames. Since a fire incident may not have occurred during a day in 2015, I merged them so it would only include the daily weather averages if a fire incident occurred that day. All of this work is provided in the project\_combining.R file. The final data frame is incidents\_with\_weather with 1,254 observations and 12 variables.

*Data Dictionary*

|  |  |  |  |
| --- | --- | --- | --- |
| **Column** | **Data Type** | **Description** | **Source** |
| Area\_of\_Origin | Text | Area of Origin code and description | Fire Incidents |
| Civilian\_Casualties | Numeric | Civilian casualties observed at scene | Fire Incidents |
| Estimated\_Dollar\_Loss | Numeric | Estimated Dollar Loss | Fire Incidents |
| Ignition\_Source | Text | Ignition Source code and description | Fire Incidents |
| Incident\_Station\_Area | Text | TFS Station area where the incident occurred | Fire Incidents |
| Latitude | Numeric | Latitude of nearest major or minor intersection in the ward of the incident | Fire Incidents |
| Longitude | Numeric | Longitude of nearest major or minor intersection in the ward of the incident | Fire Incidents |
| Material\_First\_Ignited | Text | Material First Ignited code and description | Fire Incidents |
| year | DateTime | Date when the incident occurred | Fire Incidents |
| degreesC | Numeric | Average temperature for the day (in degrees Fahrenheit) | Toronto Weather Stats |
| km/h | Numeric | Average wind speed recorded for the day (in mph) | Toronto Weather Stats |
| kPa | Numeric | Average Sea level pressure for the day (kPa) | Toronto Weather Stats |

1. **Analysis**
   1. *Fire Incidents and Wind Speed*

When thinking about fires incidents occurring and possible causes, wind speed is a top thought. Wind could possibly spread fires faster and make them less manageable. For running this analysis from 2015 fire incidents in Toronto, Canada, I decided to count the number of fire incidents that occurred each day and matched the days to their average wind speed.

*A graph of a number of incident

Description automatically generated*

Figure 1: Scatterplot of the number of incidents per day depending on the wind speed

The results from this analysis and graph showed that there was a very small correlation between fire incidents and wind speed. From the initial thought of higher winds would cause more fires due to difficulty to manage, the results were contradictory. More days that a fire occurred happened when the wind was slower. Although there wasn’t much correlation, this is an interesting variable to test against from the other years or on other locations.

* 1. *Fire Incidents and Temperatures*

Temperature is one of the first things that come to mind when you think of fires happening. Many forest fires occur during the summer when temperatures are high. A good prediction is that more urban fires will also occur when temperatures are higher. For the analysis, I counted the number of fire incidents that occurred on each day in 2015 and match them to average temperatures.

*A graph of a number of incident

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Figure 2: Scatterplot of the number of incidents per day depending on the temperature

The results of this test weren’t as correlated as I thought but closer to as we predicted. There were more days that had a fire incident when the temperature was higher. A result that contradicts our prediction is that the days that had the most fires occurred when the temperature was below 0 degrees Celsius.

* 1. *Fire Incidents and Sea Level Pressure*

*I decided to throw a weather variable in that wouldn’t be thought of as a reason for fire incidents to occur. Changing in sea level pressures could possibly predict a change in weather patterns and possibly have correlation on fires igniting. For this analysis, I counted the number of fire incidents on different days and linked them to their average sea level pressure.*

*A graph of a number of incident indicators

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Figure 3: Scatterplot of the number of incidents per day depending on sea level pressure

As for the results, our prediction held true. For just throwing in a random weather variable that could possibly have a chance to be correlated, there was no correlation between them. The most days that had a fire incident occurred right at the average sea level average. One thing that I could take from this test is the second highest sea level pressure day in 2015 held the most fires. This is most likely a coincidence but could be tested on the other years or other locations to prove.

* 1. *Location of Fire Incidents*

To put aside the weather variables, I thought it would be interesting to run analysis on the location of the fire incidents since they included the longitude and latitude. I decided to use qplot and make a map with all of the fire incidents in 2015. One thing we could possibly correlate with the location of the fires is population density.

*A graph with black dots

Description automatically generated*A map of canada with numbers and numbers

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Figure 4 (left) : Map of fire incidents in Toronto, Canada based in Longitude and Latitude

4Figure 5 (right) : Real map of Toronto, Canada that shows population density

This was the most accurate analysis that this project resulted in. In the map of the fires I made, most fires occurred around 43.65 latitude and -79.4 longitude. I then put it up against the population density map of Toronto, Canada and the maps line up. I can confidently confirm that population density has a positive correlation to fire incidents.

1. **Conclusion**

In this project, I analyzed three different weather variables: wind speed, temperature, and sea level pressure and their influence on fire incidents. From these analysis questions presented, I found the following results:

1. *Is there a strong correlation between fire incidents and wind speed? If winds are high for a day, is there a higher chance of a fire incident occurring?*

There wasn’t much correlation between fire incidents and wind speed. The slight correlation what was presented was the opposite of what could be inferenced. More days with fire incidents occurred when the wind speed was less than 20 km/h.

1. *Is there a strong correlation between fire incidents and temperature? Will higher temperature cause more fires due to dryness?*

The was a slight positive correlation between fire incidents and temperature. In regard to the number of fire incidents in one day, temperature didn’t affect that, but there was in increase in days that a fire incident occurred in high temperatures.

1. *Is there a strong correlation between fire incidents and sea level pressure? Do different weather patterns increase the probability of a fire incident?*

This analysis has the least correlation out of the weather variables. Most of the days that had a fire instance were when sea level pressure was at its average. One thing that could be further examined is that the day with the highest sea level had 11 fires.

1. *Where in the Toronto area did most fire incidents occur? Were these more populated areas?*

This analysis was the most beneficial of the analysis questions. More fire incidents occurred in the more populated areas and similarly matches the population density map of Toronto. There is a positive correlation between population density and fire incidents.

This project didn’t perform as well as I would have liked. I thought that these weather variables would show more correlation to fire incidents. This topic can still be further examined by including the other years from the data set or testing more weather variables to see if they have more correlation. This project has some limitations including location. This only provided fire incidents in Toronto, Canada where the temperature doesn’t get too warm to possible affect dryness and fire incidents.

Works Cited

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