MEASURING NUANCES OF INITIAL ATTACK SUCCESS

PREPARED FOR:

AVIATION, FOREST FIRE AND EMERGENCY SERVICES

MINISTRY OF NORTHERN DEVELOPMENT, MINES, NATURAL RESOURCES AND FORESTRY

MDA9144B DATA ANALYTICS CONSULTING

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EXECUTIVE SUMMARY

The Aviation, Forest Fires and Emergency Services (AFFES) reports the initial attack success on a fire in an aggregate way using a threshold of 4 hectares of fire size or using the time it takes for the fire to be declared as being held. Success is defined by the fire size being less than or equal to 4 hectares and the fire being declared as held by noon on the day after the first report.

While this definition has been a successful risk reduction strategy, the AFFES wishes to understand the underlying nuances of Initial Attach (IA) successes. The scope of our project entails finding potential features and the way that they impact IA success, the variation revolving around IA success, whether it can be predicted, and if there might be alternative ways to define IA success and the impact this may have on our inferences.

1. INTRODUCTION

The Ministry of Northern Development, Mines, Natural Resources and Forestry is a government entity that is responsible for Ontario's provincial parks, forests, fisheries, wildlife, mineral aggregates, and the Crown lands and waters that make up 87% of the Canadian province of Ontario .

The Ministry of Northern Development, Mines, Natural Resources and Forestry (MNDMNRF) manages wildland fires (grass, brush and forest fires) in Ontario through planning, preparation and continually providing emergency services as needed[1]. This is a massive undertaking as the Fire Region of Ontario spans approximately 91.9 million hectares[2].

While fire plays a significant role in renewing forests and creating a healthy natural habitat, the vastness of fire prone lands, and their proximity to residential dwellings, infrastructure and industries makes it necessary to have a plan of action in place to minimize life and revenue loss.

This process of planning and carrying out activities to correctly balance preventing and managing fires to protect people and property is a vital role performed by the MNDMNRF. As the process is centralized and resources are expensive and limited, the right strategy must be built to spread out the resources, aircraft, equipment and people to correctly respond to a fire. In Ontario, each wildland fire is assessed and is dealt with in one of the following manners depending on the situation and most effective use of resources:

a. Quick response to fires posing an immediate threat to high values, such as communities or infrastructure. This action taken to halt the spread or potential spread of a fire by the first fire fighting force to arrive at the fire is called the initial attack (IA).

b. Managing less threatening fires to limit negative impacts and costs. These may be fires that could have a positive impact on the ecological system

The department of Aviation, Forest Fire and Emergency Services at the Ministry of Northern Development, Mines, Natural Resources and Forestry wishes to understand the nuances surrounding the success of Initial Attacks as asserted by the incident commander, the sector response officer, the duty officer and various stakeholders. This metric has, so far, been a successful risk reduction strategy and they wish to expand its scope to effectively deal with future challenges. Our analysis aims to identify factors important to IA success, how IA success varies, whether it can be predicted using the collected data and there may be better ways to define IA success to make it more effective.

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[1] *Forest Fire Management*. ontario.ca. (n.d.). Retrieved April 13, 2022, from https://www.ontario.ca/page/forest-fire-management

[2] How to reference the client slides?

2. DATASET

The dataset provided by the MNDMNRF contains 69 columns describing all the features collected for fires that occurred between 1993 and 2010. There are a total of 1328 observations, with each one corresponding to a single fire. Each fire has been assigned a unique identifier and some of the features collected for each fire include:

- Date of fire occurrence
- Region and subregion of the fire
- Fuel moisture code
- Fire weather index
- Fuel type
- Estimated size of the fire at various times
- Start date of Initial Attack
- Initial Spread Index collected over 5 days
- Fire Weather Index collected over 5 days
- Probability of spread event based on the Initial Spread Index
- Probability of spread event based on the Fire Weather Index

Our first action with regards to this dataset is to review the contents and gauge the completeness of information. We will perform removal of incomplete data or imputation of features, where necessary to ensure that we have a dataset that can be used to perform accurate analysis on the definition of Initial Attack Success as well as find relevant features that may potentially be impactful in explaining it.

3. DATA PREPARATION

On an initial review of the dataset, we find that the following fields have missing information:

a. WX_STATION - The weather station used for fire weather variables
b. LOC_ATTACK - Location of attack
c. START_DATE - Start date of fire
d. DISC_DATE - The date the fire was discovered
e. F_REP_DATE - The date the fire was first reported
f. S_REP_DATE - The date the fire was reported a second time
g. GETAWAY_DATE - The date the IA resources left to fight the fire
h. ATTACK_DATE - The date the IA resources began fighting the fire
i. BHE_DATE - The date the fire was declared as "Being Held"
j. UCO_DATE - The date the fire was declared as "Under Control"
k. OUT_DATE - The date the fire was declared as being "Out"

As our analysis is concerned with the success of Initial Attack, we consider only the observations where the objective of the Ministry was "Suppression", i.e., FSUP. In doing so, we reduced the number of observations to 1219 from the initial size of 1328. Additionally, we converted all dates into the proper format to help perform trend and seasonality analysis on our data.

What did we do here? - output did not seem to change - Drop rows where F_REP_DATE is NULL

Commented [1]: Out of all the FSUP records, we removed the ones that had nulls in First reported Date or being held date. there were 3 such records

Once we successfully accounted for the missing values and generated the final dataset, we were now ready to proceed with creating our response variable, i.e. Initial Attack Success. Here, we had to meet two criteria:

a. A threshold of fire size of 4 hectares or less We should consider size at the time of being held, correct?
b. The fire should reach the state of being held no later than noon on the day after the first report of the fire.

Commented [2]: Question- as I got a bit confused now. If the size is less than 4 hect, but the time taken was longer than noon next day- it is still considered success, right? because if it;s not, we will need to change the code a bit.

Using the above, we classified each fire into two categories as follows:
a. Initial Attack successful - 1
b. Initial Attack unsuccessful - 0

4. **EXPLORATORY DATA ANALYSIS**

We began our analysis by first exploring the various features captured in our dataset. Before making any conclusions about Initial Attach success, we decided to investigate the fires and their trends based on time of year, weather conditions, causes, fuel and other features that we have access to in our dataset.

4.1 Seasonality and causes of fire

From our analysis, we see that over the period of data collection, the highest number of fires were observed in 1995, as seen in Figure. Upon examining the causes of the fires monthly, we find that the highest number of fires occur in August, with the cause of almost 300 of these fires being lightning. The second most common cause of fires is human, specifically recreational fires. These trends have been summarized in Figure and Figure.

Commented [DS3]: Run this part of the code and rename the y axis of the plot to 'Number of fires'

Change the monthly seasonality to use same color scheme for all bars

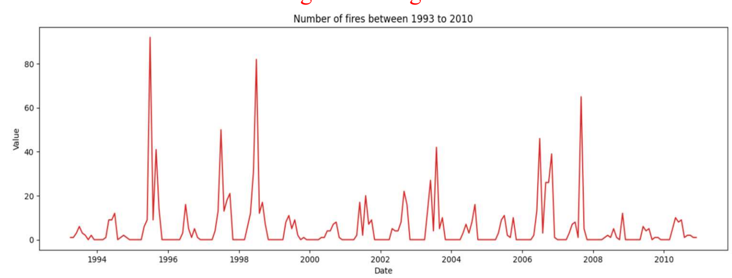


Figure 1

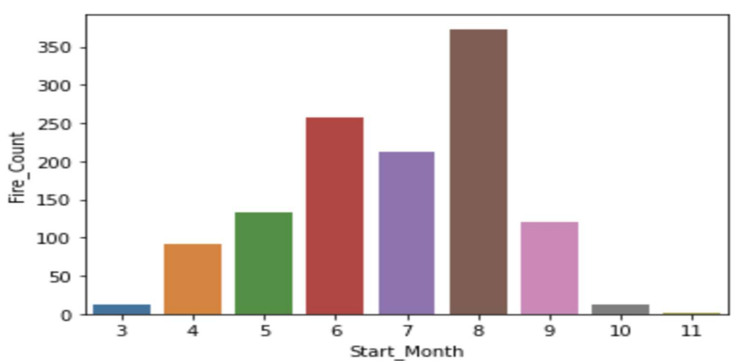
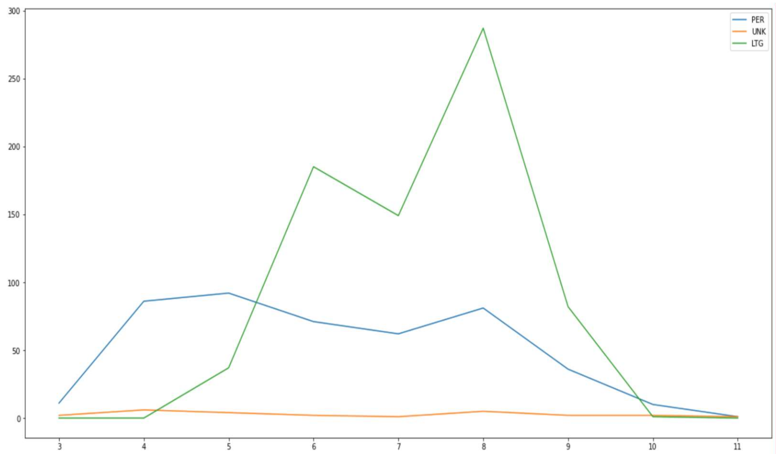


Figure 2



Commented [DS4]: Perhaps this plot is not required? We have a similar one below

Figure 3 shows us that, after lightning (LTG), the next most prominent cause of fire is recreational (REC), the highest number of which occurs in August. This is followed by miscellaneous (MIS) and residential (RES) although, these numbers are far lower than that of lightning and recreational. This trend in fire caused by human intervention has also been highlighted in Figure 5.

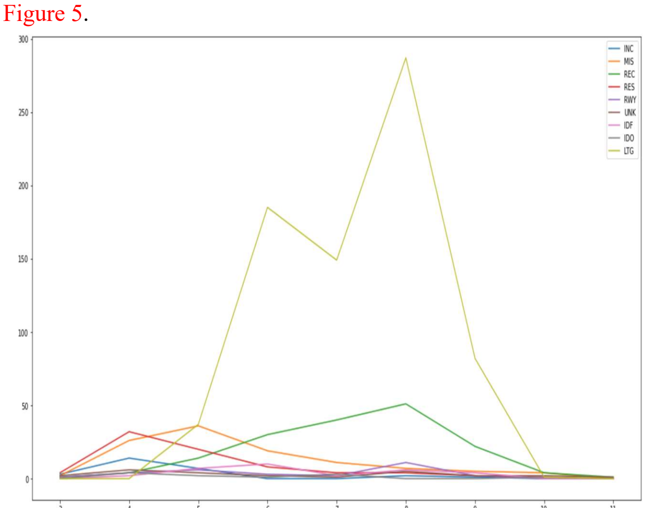
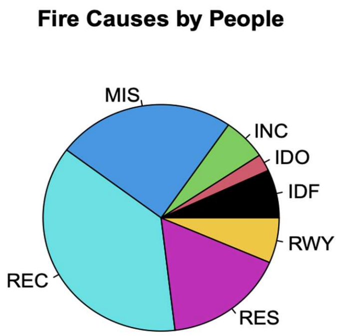


Figure 4

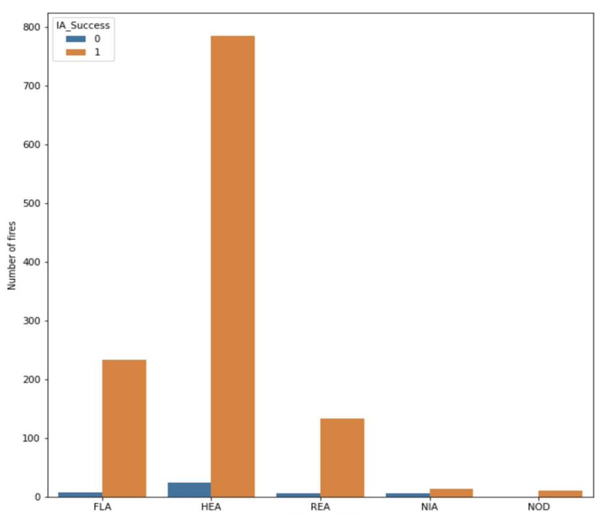


REC	Recreational
MIS	Miscellaneous
RES	Resident(s)
IDO	Other non forestry incendiary
IDF	Industrial forestry operations
RWY	Railway

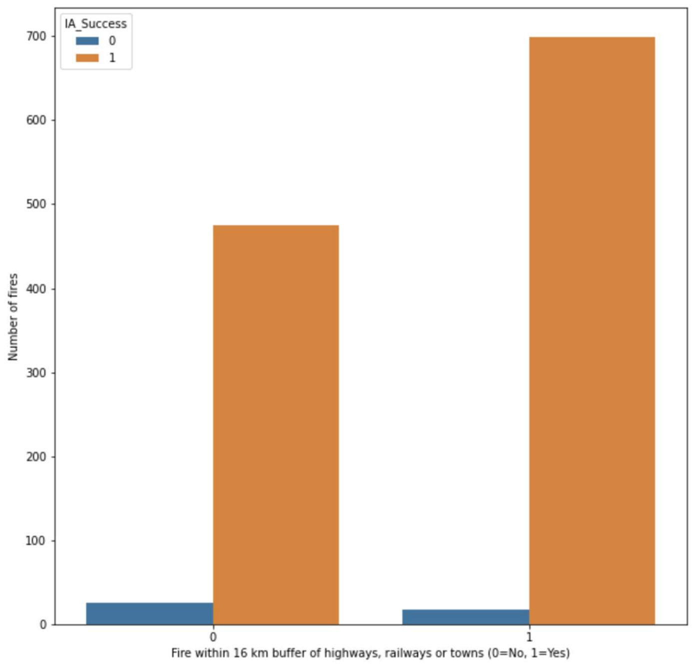
4.2 Trends in Initial Attack (IA) Success

From Fi

In this section, we will analyze the trends we see in the newly created IA success variable, which acts as the focal point of our project. We wish to understand how various affect the success of an initial attack and we start by visually investigating trends.

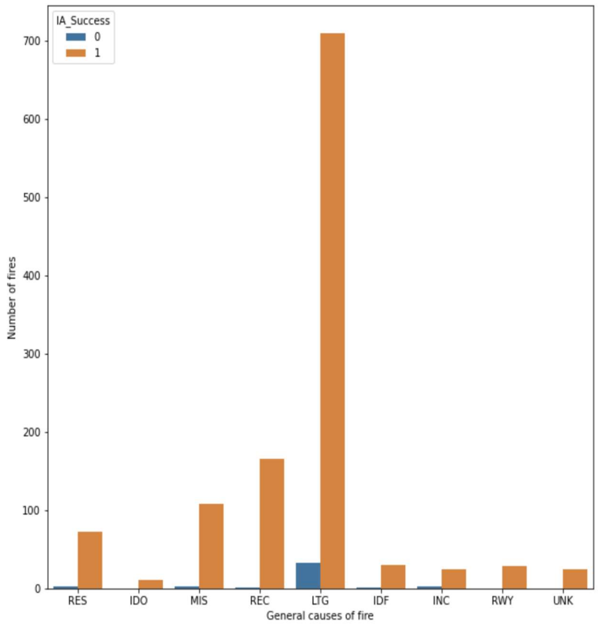


We see an interesting trend in Figure. While the total number of fires are higher in areas closer to highways, railways and towns, the proportion of successful initial attack success is lower than fires in far away regions. We would generally assume that being close to major infrastructure would mean that there is better reach to fight the fire. However, we find that this is not the case.



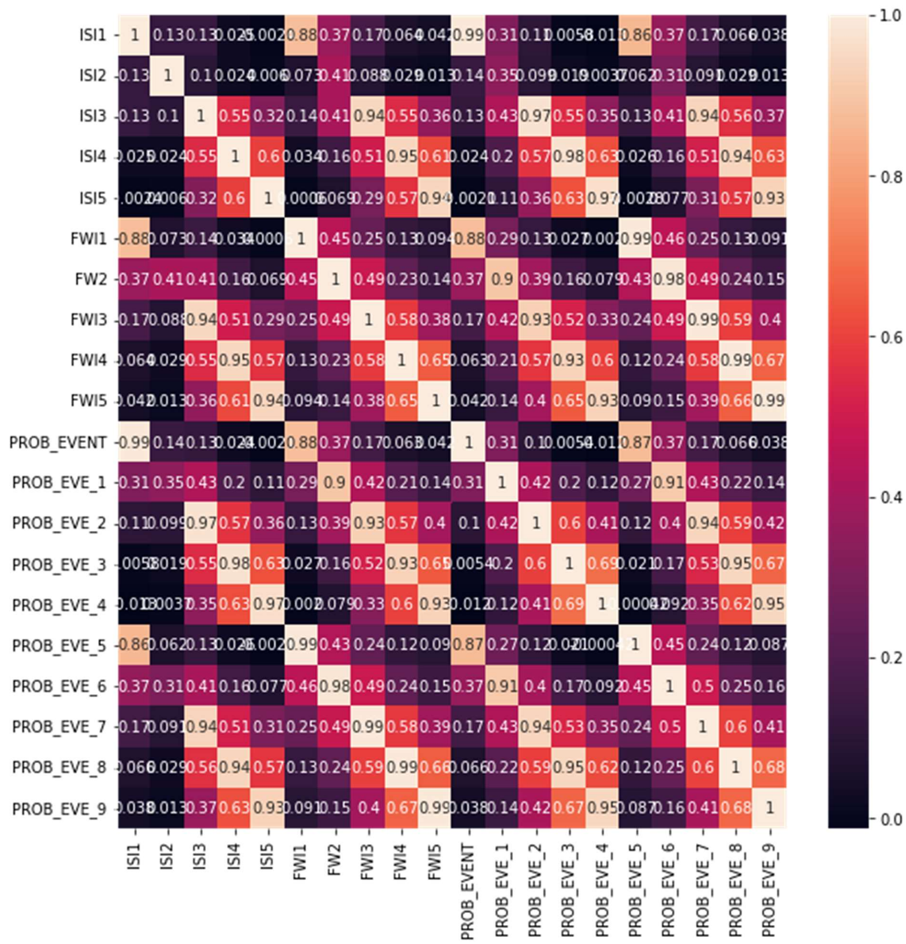
Following the results above, we also see the trend in initial attack success in terms of the causes of fire as recreational and residential fires which are the most common non-natural causes of fire would occur closer to communities.

Figure shows us that while we do see some initial attack successes in fires caused by lightning, recreational activities and residential fires, railway fires and unclassified fires have had no initial attack successes.



REC	Recreational
MIS	Miscellaneous
RES	Resident(s)
IDO	Other non forest incendiary
IDF	Industrial forestry operations
RWY	Railway
LTG	Lightning
INC	Incendiary
UNK	Unknown

Removing correlated variables

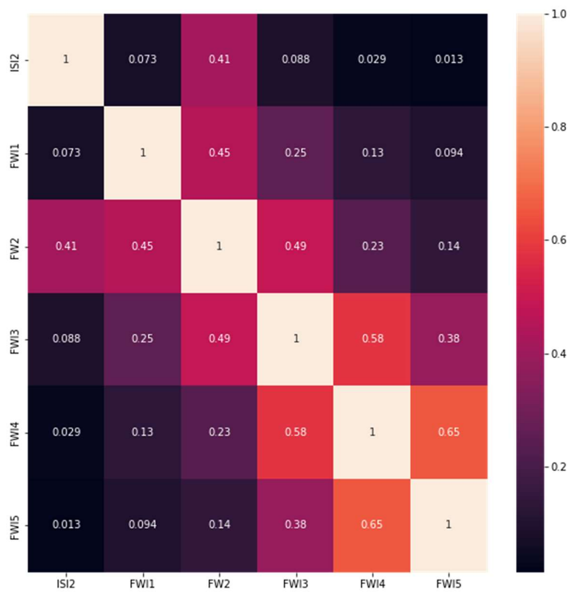


From the above correlation plot between the Initial Spread indices, Fire Weather indices and the Probability of event using ISI and FWI, it has been observed that day-wise high correlation occurs between ISI and FWI, ISI and PROB_EVENT using ISI and ISI and PROB_EVENT using FWI.

For better analysis and identifying the significant variables, we remove the redundant variables and keep the Fire Weather indices only as they are based on initial spread indices and represent the probability of events using absolute values.

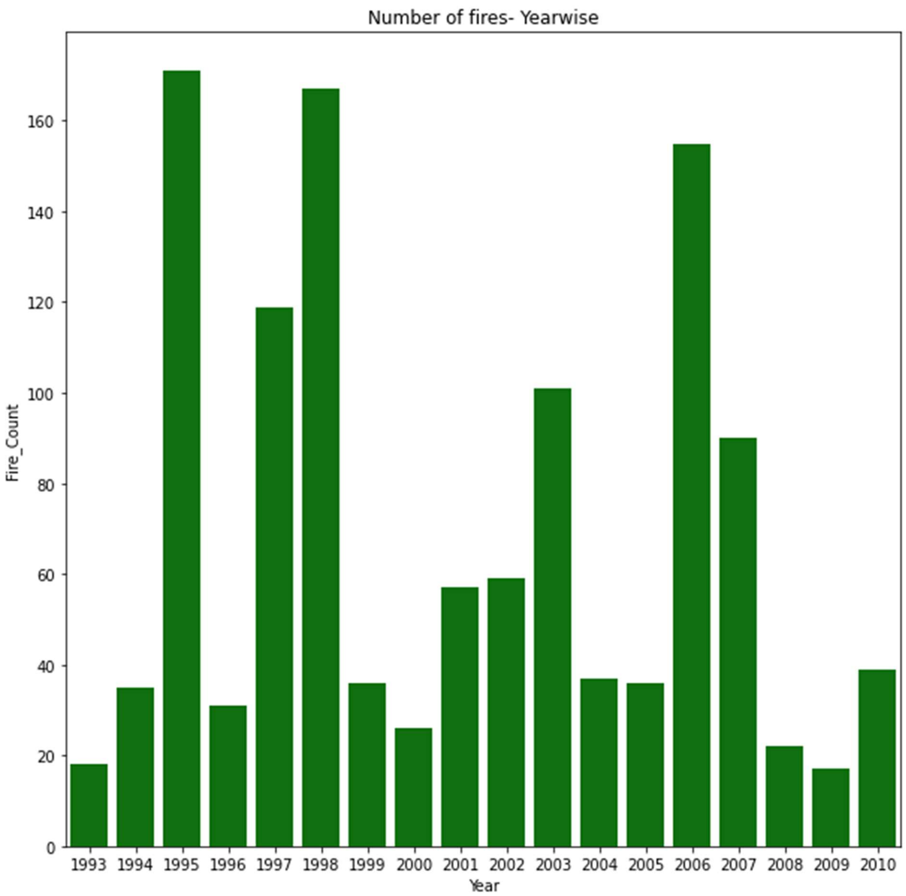
We observe that ISI2 is not highly correlated with FW2, so we continue to consider it for further analysis in identifying the nuances of IA successes.

Commented [5]: I wonder if we should remove all ISIs and not just a few to be consistent? I know that we're keeping this due to lack of high correlation but 0.33 is still not too low? Thoughts?

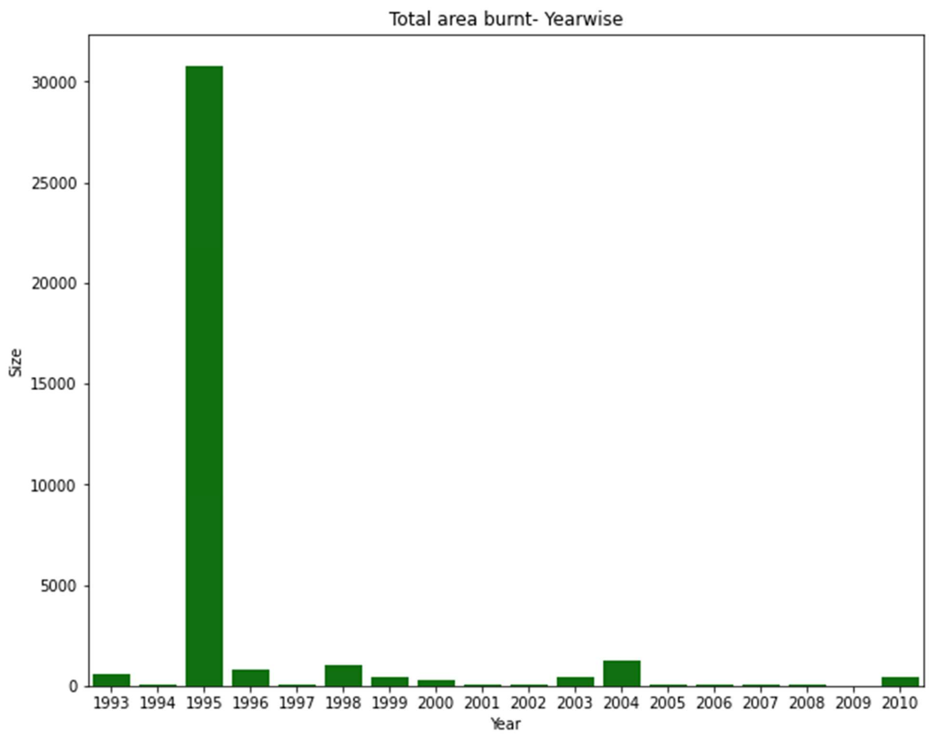


Number of fires breaking out each year and total amount of area burnt:

The trend of number of fire counts is as follows:



The trend of total area burnt is as follows:



We see that the number of fires breaking out in 1995 was the highest, so was the total area burnt(sum of final area). However, we see that in the years 2006 and 2007, the number of fires that broke out was quite huge, but the area burnt was very small in comparison. What changes? Number of staff??

TREND OF INITIAL ATTACK SUCCESS

PREDICTIVE MODELING

RESULTS OF ANALYSIS

CONCLUSIONS AND RECOMMENDATIONS