Predictive Analytics Project: Manitoba Wildfire Prediction

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AGENDA

❑Introduction

❑CRISP-DM Methodology

➤ Business Understanding

➤ Data Understanding

➤ Data Preparation

➤ Modeling

➤ Evaluation

➤ Deployment

❑Conclusion

❑References

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INTRODUCTION

Project Overview:

Develop a predictive model to forecast the occurrence and severity of wildfires, particularly forest fires using the Canadian Forest Fire Weather Index (FWI) System.

Importance of the Project:

o To gain deeper understanding of main causes of wildfire here in Canada and the severity of each fire.

o Enhance early detection and resource allocation to mitigate wildfire impacts.

Photo Link

BUSINESS UNDERSTANDING

Problem Understanding: Research and identify the Canadian Wildfire Weather System, its background information, and historical wildfire information.

Goal: Predict the Fire Weather Index (FWI) to identify fire intensity and high-risk areas.
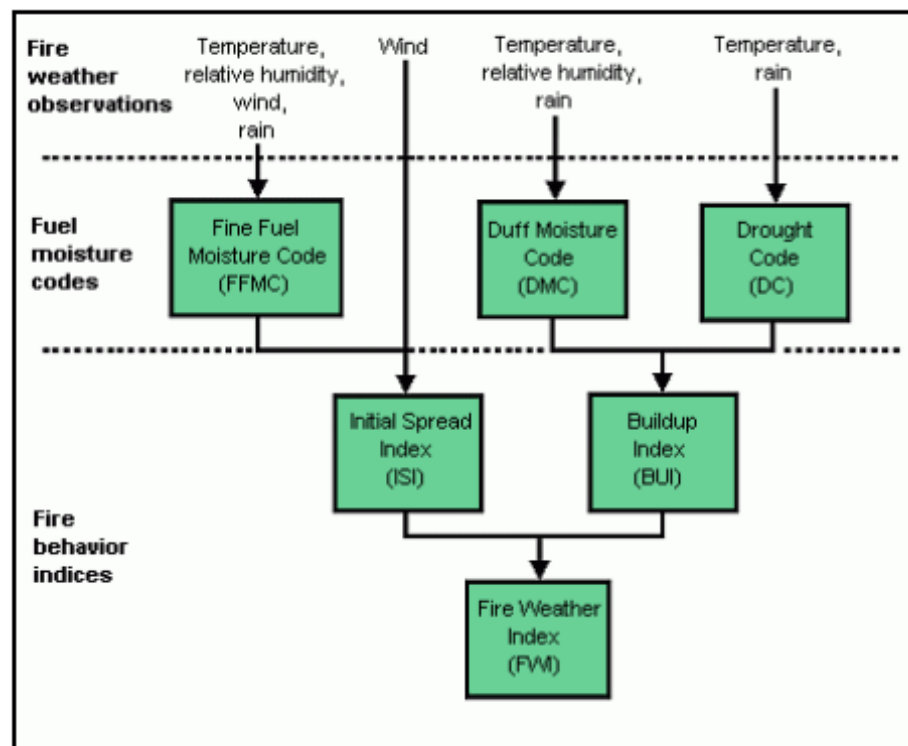
Questions to Answer:
o What factors contribute to wildfire occurrences?
o What model gives the highest accuracy and takes less time?

Photo Link

BUSINESS UNDERSTANDING

Structure of the FWI System

https://cwfis.cfs.nrcan.gc.ca/background/summary/fwi

Site Map Contact Government

Manitoba

Search for programs and online services SEARCH

| RESIDENT AND ONLINE SERVICES | BUSINESS | GOVERNMENT | VISITORS |

Economic Development, Investment, Trade and Natural Resources

Manitoba.ca > Economic Development, Investment, Trade and Natural Resources > Wildfire Service

Weather Calculations Report

OBSERVED WEATHER
2024-08-26

STATION	TEMP	RH	WD	WS	RAIN	FFMC	DMC	DC	ISI	BUI	FWI	DSR
ATIK LAKE	17.3	51.0	358.0	7.4	0.0	88.6	44.7	416.0	5.0	70.4	16.1	3.7
BEAUSEJOUR AG	21.1	56.0	327.0	18.1	0.6	83.8	31.6	391.1	4.4	52.6	12.4	2.4
BERENS RIVER (WCF)	18.2	65.0	295.0	21.0	0.2	59.1	5.2	111.5	1.1	9.3	0.6	0.0
BIRCH RIVER AG	21.5	40.0	297.0	15.4	0.0	89.0	70.7	544.7	8.0	106.7	28.0	9.9
BISSETT	22.9	55.0	295.0	5.6	0.0	58.5	8.7	140.4	0.5	15.0	0.4	0.0
BRANDON (YBR)	18.3	54.0	330.0	11.0	0.0	82.7	32.1	412.5	2.7	53.7	8.3	1.1
BURNTWOOD LAKE	17.1	42.0	324.0	22.4	0.0	88.3	56.3	461.2	10.3	86.3	29.9	11.1
CACHE LAKE	18.7	50.0	245.0	10.9	0.0	77.0	8.2	212.9	1.5	14.9	1.5	0.1
CARBERRY (WZE)	18.4	57.0	315.0	13.0	0.0	85.4	36.6	389.8	4.2	59.3	12.8	2.5
CARMAN (WNK)	19.7	62.0	327.0	14.0	0.0	84.7	18.3	346.3	4.1	32.3	8.7	1.3
CHURCHILL (YYQ)	15.9	96.0	322.0	44.0	18.6	26.0	5.3	221.9	0.0	10.0	0.0	0.0
COLLINS BAY SK (WWC)	15.4	47.0	332.0	17.0	0.0	85.6	37.4	375.7	5.4	59.9	15.5	3.5
CREIGHTON (SK)	17.7	48.0	310.0	7.9	0.0	86.5	22.4	252.8	3.9	36.7	9.0	1.3
CYPRESS RIVER (POY)	19.7	51.0	332.0	17.0	0.0	86.3	23.5	367.8	5.9	40.5	13.5	2.7

https://www.gov.mb.ca/conservation_fire/Wx-Report/2024/20240826-obs-wxrep.html

DATA UNDERSTANDING

Data Collection:

Gathered historical and current fire weather reports, fire occurrences, and FWI components (Fine Fuel Moisture Code, Duff Moisture Code, Drought Code, Initial Spread Index, Buildup Index, and Fire Weather Index) from Manitoba Natural Resources and Northern Development website.

Features	Description
STATION	Station name
TEMP	Temperature (°C)
RH	Relative Humidity
WD	Wind Direction
WS	Wind Speed (km/h)
RAIN	Rain (24-hour precipitation)
FFMC	Fine Fuel Moisture Code

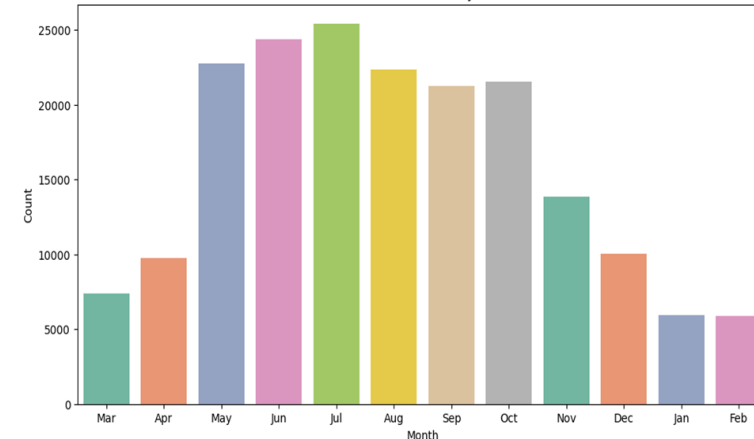| Features	Description
DMC	Duff Moisture Code
DC	Drought Code
ISI	Initial Spread Index
BUI	Buildup Index
FWI	Fire Weather Index
DSR	Daily Severity Rating
DATE	Date (Jan 2015 – Jul 2024)

DATA UNDERSTANDING (Exploratory Analysis)

Feature Correlation MB Fire Weather Dataset
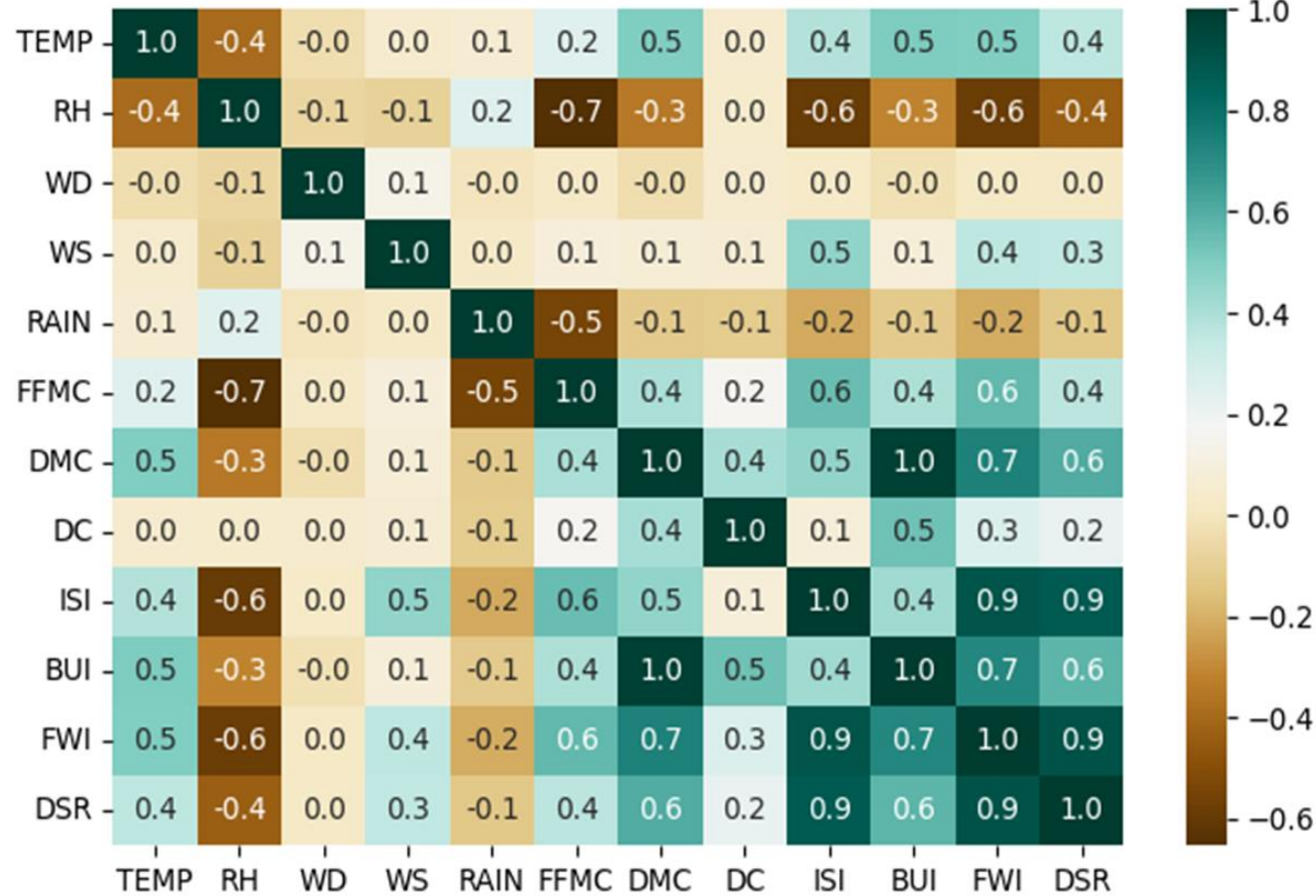
Observations by Year from 2015 to 2024
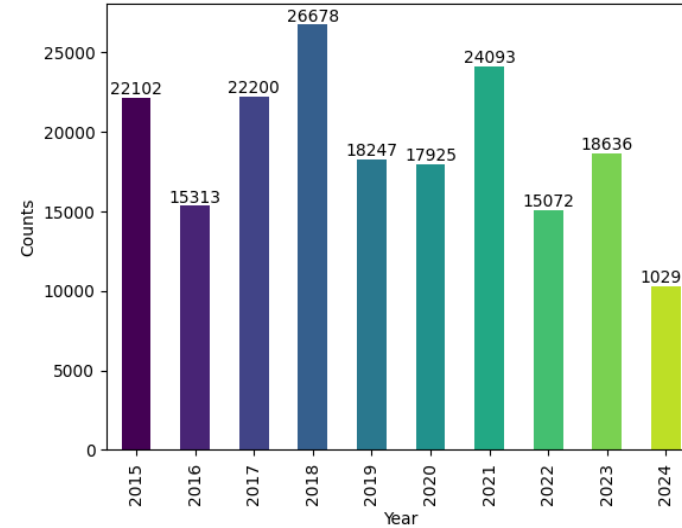
Count of Forest Fires by Month

DATA PREPARATION

Data Cleaning:

Normalized station names, due to updates on some station names through time.

Handling Missing Values:
- Removed rows with 90% incomplete data.
- Applied Imputation Method (K-Nearest Neighbors (KNN) Imputation): Use KNN to fill missing values based on similar data points.

Top 20 Stations with More Frequency
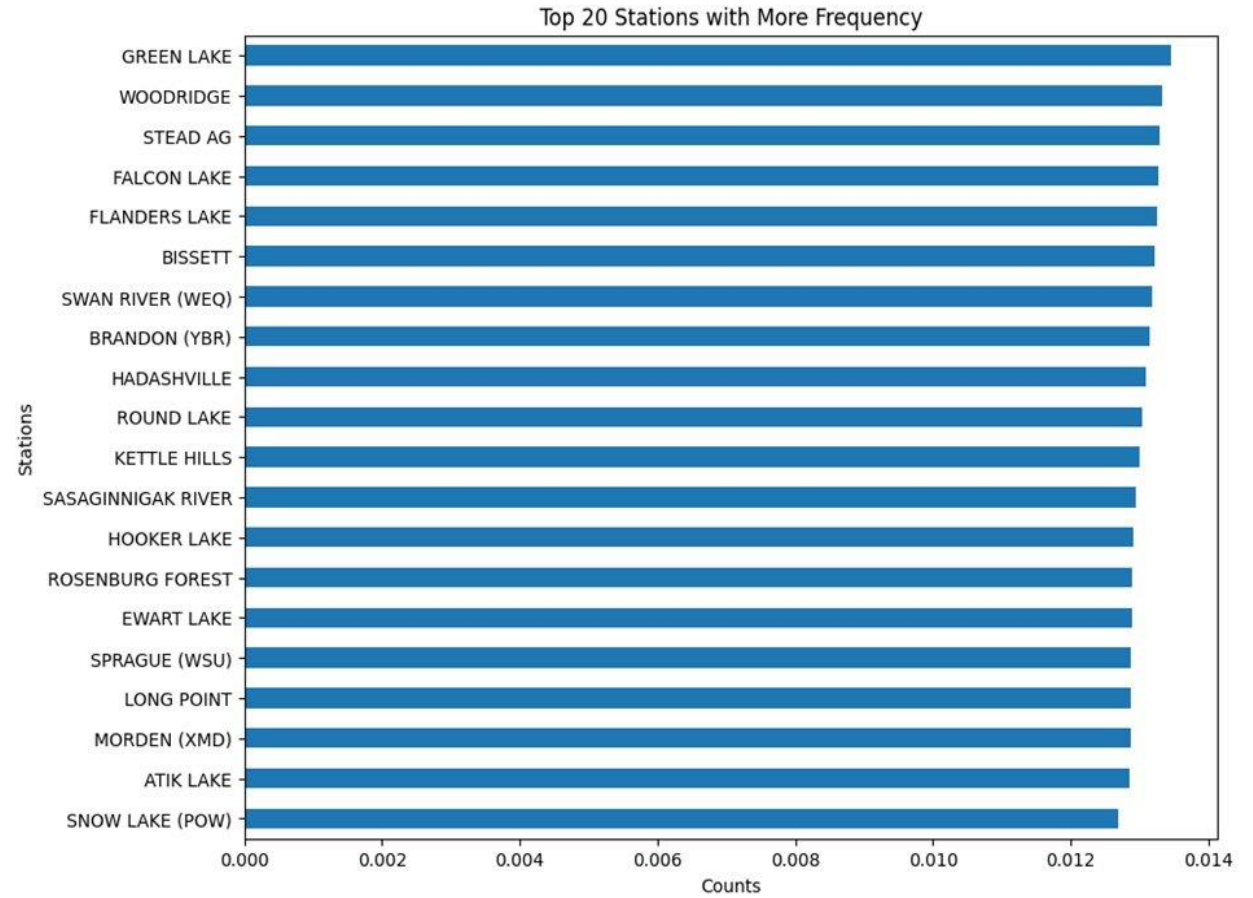
MODELING

Model Development:

Built and validated machine learning regression models to predict wildfire occurrence and severity, and fine-tuned predictive models for fire outbreaks. Complemented by classification to categorize the risk level based on the estimated FWI.


Photo Link

EVALUATION

Models	R-squared (R²)	Mean Squared Error (MSE)	Root Mean Squared Error (RMSE)	Mean Absolute Error (MAE)	Training Time	Testing Time
Random Forest Regressor	0.998	0.140	0.46	0.06	91.734 sec	2.240 sec
Gradient Boosting Regressor	0.998	0.140	0.22	0.07	84.173 sec	0.594 sec
Decision Tree Regressor	0.996	0.276	0.67	0.09	1.319 sec	0.030 sec
KNN Regressor	0.995	0.393	1.15	0.54	20.875 sec	6.742 sec
Multivariable Regression	0.964	2.612	2.26	1.39	0.291 sec	0.020 sec
Polynomial Regression	**0.994**	**0.543**	**0.76**	**0.41**	**0.184 sec**	**0.02 sec**

EVALUATION

Regression Model Comparison: FWI Actual vs Predicted

Actual vs Predicted (Polynomial Regression)
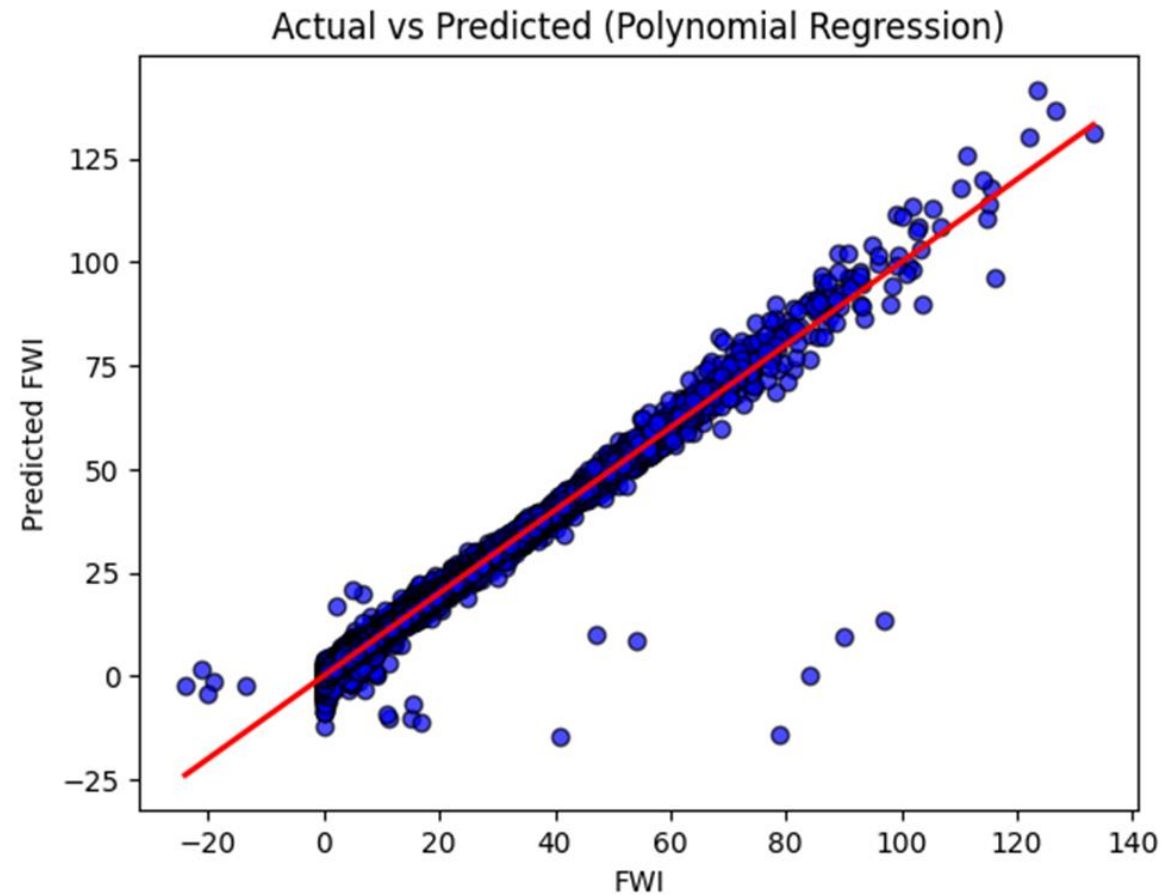
FWI	DSR	Predicted Fire Weather Index (FWI)	FWI Levels
16.8	4	16.56200584	High
18.7	4.9	18.44921279	High
5.6	0.6	5.390683358	Moderate
26.9	9.2	26.83955504	Very High
5.4	0.5	5.0718327	Moderate
22.5	6.7	22.05331347	Very High
26.2	8.8	26.00503468	Very High
5.8	0.6	5.508083279	Moderate
27.7	9.7	27.25526749	Very High
13.4	2.7	13.14791733	High
14	2.9	13.55125528	High
11.5	2	11.47935505	High
10.5	1.7	10.3453414	High
21.4	6.1	20.82983119	Very High
11.8	2.1	11.51721944	High
6.3	0.7	6.015195824	Moderate
13.8	2.8	13.3983693	High
8.1	1.1	7.817369957	Moderate
13.2	2.6	12.77886276	High
4.8	0.4	4.602686665	Low
10.1	1.6	9.814556515	Moderate
18.8	4.9	18.51562628	High
17.6	4.4	17.15070916	High

DASHBOARD DEPLOYMENT
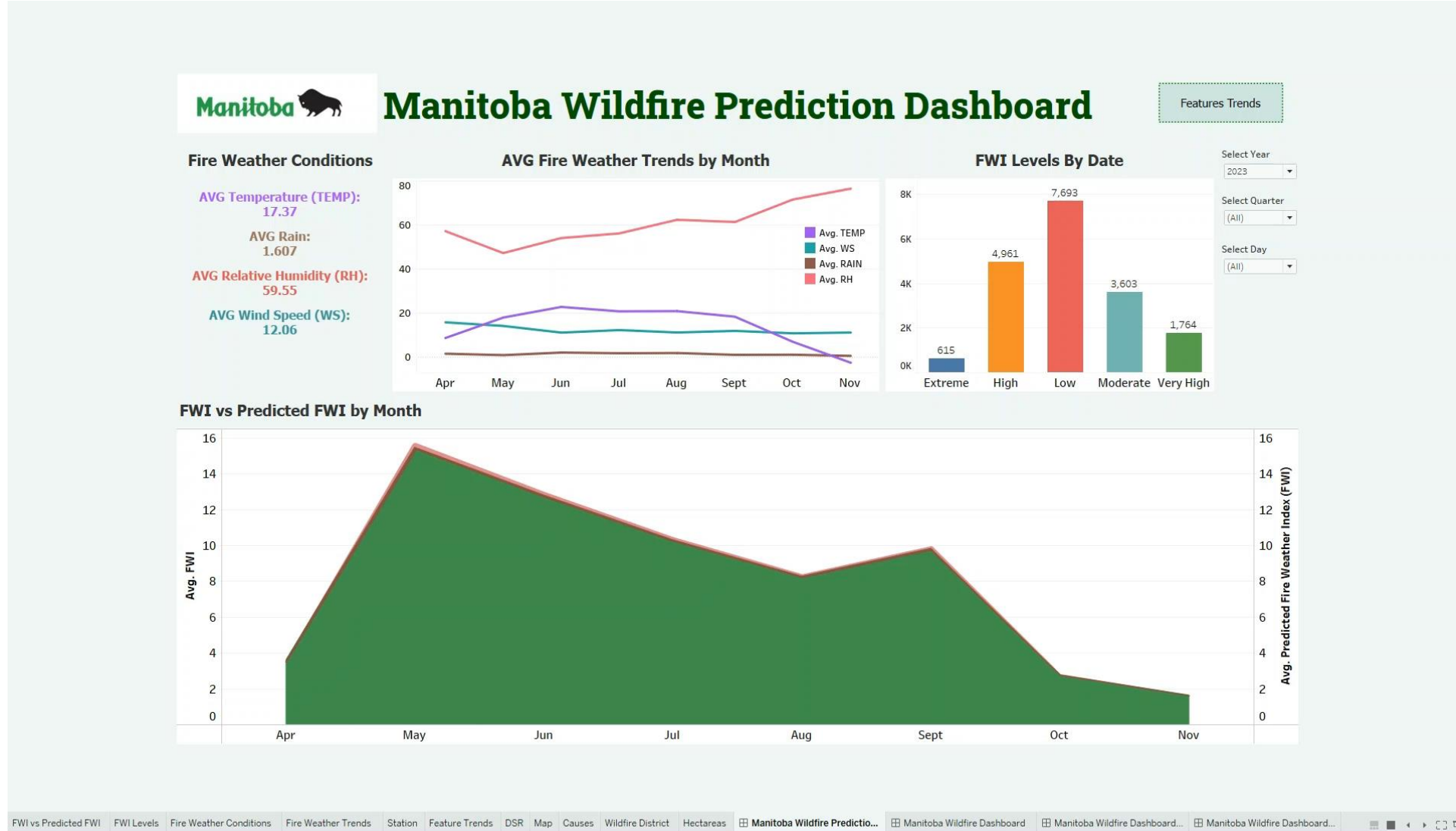
CONCLUSION

Questions Answered

Factors that contribute to wildfire occurrences:
- Human
- Nature
- Temperature
- Relative Humidity
- Wind Speed
- Precipitation (Rain)

Best Model:
Polynomial regression model was the best performing model after evaluation and test run on real data.

REFERENCES

Canada, N. R. (n.d.). *National wildland fire situation report*. Canadian Wildland Fire Information System.
https://cwfis.cfs.nrcan.gc.ca/report
https://cwfis.cfs.nrcan.gc.ca/background/summary/fwi

Canadian Forest Index – Fire Research. Fire Research and Management Exchange System - Government of Canada. https://www.frames.gov/documents/alaska/c5/files/FWI-history.pdf

National Forestry Database, Forest Fires. http://nfdp.ccfm.org/en/data/fires.php#tab313

Manitoba Government. (n.d.). *Province of Manitoba: Natural resources and northern development*. Province of Manitoba - Natural Resources and Northern Development.
https://www.gov.mb.ca/conservation_fire/Wx-Report/index.html

Shmuel, A., & Heifetz, E. (2023, August 16). *A machine-learning approach to predicting daily wildfire expansion rate*. MDPI. https://www.mdpi.com/2571-6255/6/8/319#B39-fire-06-00319

Weather Guide for Canadian Forest Fire. BD Lawson,. Natural Resources Canada. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://cfs.nrcan.gc.ca/pubwarehouse/pdfs/29152.pdf

THANK YOU!!!