**Summary**

**Objective:** To understand the relationships and patterns between various fire weather indices and environmental factors of Canada over a 10-year period.

**Dataset:** Wildfire incident point locations, along with associated fire weather indices and environmental factors, recorded annually over a 10-year period across the USA and Canada. Raw dataset consists of 39 variables and 7,464,062 rows.

**Methodology**

**Dataset Cleaning:** Cleaned data sets consist of 3,865,712 rows and 27 columns. Variables that are not part of analysis, inconsistent with the 10-yr records and data from outside of Canada were removed from the data sets. For the computation of average values, nulls were dropped to avoid skewness in the analysis and model.

**EDA:** Time series plots for Fire Weather Index (FWI), Buildup Index (BUI), Initial Spread Index (ISI) and other variables to show trends per month over 10 years to check any seasonal trends.

Scatter plots were used to explore relationships between pairs of variables, including BUI vs Fine fuel moisture code (FFMC), Drought code (DC) vs Duff Moisture Code (DMC), FWI vs Temperature, Relative Humidity, Precipitation, and ISI vs Wind Speed, FFMC, Relative Humidity, and Precipitation.

**Conclusions**

* Overall BUI, ISI and FWI indicate seasonal patterns. Higher risk of large fires occurred during their peaks in late summer/ early fall and reduced risk during winter/ early spring.
* BUI is influenced by FFMC, DMC and DC. Calculating their correlation with BUI showed that DMC has strong positive linear correlation (R = 0.99), DC has moderate linear positive correlation (R = 0.72) and FFMC has moderate positive exponential correlation (R = 0.66), This suggests that monitoring DMC is the key in predicting large fires.
* ISI is estimated by combining FFMC and WS values. While the correlation of WS with ISI demonstrated variability and weak relationship (R = 0.38), calculating the effective wind speed will give a better insight of its influence with the rate of fire spread.
* FWI and Temperature have positive strong correlation (R = 0.89) with linear relationship for temperature above 5°C. FWI shows a strong negative correlation (R = -0.79) with RH, and moderate negative correlation (R = -0.48) with Precipitation.

## Appendix – Dataset description

* year – year of detection
* month – month of detection
* year-month – year month of detection
* rep\_date – date and time of detection
* source – data source
* sensor – satellite sensor
* satellite – satellite name
* agency – province/territory in which hotspot is located
* temp – noon temperature (in degrees) at hotspot location
* rh – local noon relative humidity (%) at hotspot location
* ws – local noon wind speed (km/h) at hotspot location
* wd – local noon wind direction (degrees) at hotspot location
* pcp – local noon 24–hour precipitation (mm) at hotspot location
* ffmc – Fine Fuel Moisture Code at hotspot location
* dmc – Duff Moisture Code at hotspot location
* dc – Drought Code at hotspot location
* isi – Initial Spread Index at hotspot location
* bui – Buildup Index at hotspot location
* fwi – Fire Weather Index at hotspot location
* fuel – FBP fuel type at hotspot location
* ros – Rate of Spread (m/min) at hotspot location (modelled)
* sfc – Surface Fuel Consumption (kg/m²) at hotspot location (modelled)
* tfc – Total Fuel Consumption (kg/m²) at hotspot location (modelled)
* hfi – Head Fire Intensity (kW/m) at hotspot location (modelled)
* cfb – Crown Fraction Burned (%) at hotspot location (modelled)
* pcuring – Percentage Curing
* greenup - Green-Up - The period of vegetation growth or greening

## Appendix - Graphs

Figure . Scatter plot of Buildup Index (BUI) versus Duff Moisture Code (DMC), Drought Code (DC), Fine Fuel Moisture Code (FFMC), Relative Humidity (RH), Temperature and Precipitation (PCP)

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Figure 2. Time series plot for Buildup Index (2014-2023)

A graph with blue lines and red dots

Description automatically generated

Figure . Time series plot for Initial Spread Index (2014-2023)

A graph showing the number of spreadsheets

Description automatically generated

Figure . Time series plot for Initial Spread Index (ISI) and Fine Fuel Moisture Code (FFMC), Wind Speed (WS), Relative Humidity (RH) and Precipitation (PCP).

A graph of a number of different colored lines

Description automatically generated with medium confidence

Figure . Scatter plot of Initial Spread Index (ISI) versus Fine Fuel Moisture Code (FFMC), Wind Speed (WS), Relative Humidity (RH) and Precipitation (PCP)

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Figure 6. Scatter plot of Fine Fuel Moisture Code (FFMC) vs Relative Humidity (RH) and Precipitation (PCP)

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Figure 7. Time series plot for Fire Weather Index (2014-2023)

**A graph of a graph showing the average fire weather index

Description automatically generated**

Figure 8. Time series plot of Temperature

**A graph showing the temperature of the year

Description automatically generated**

Figure 9. Time series plot of Fire Weather Index and Temperature

**A graph of a graph showing the temperature of a few months

Description automatically generated with medium confidence**

Figure 10. Time series plot of Relative Humidity

**A graph of a graph showing the temperature of the year

Description automatically generated with medium confidence**

Figure 11. Time series plot of Precipitation

**A graph with green lines and red dots

Description automatically generated**

Figure 12. Scatter plot of Fire Weather Index (FWI) versus Temperature, Relative Humidity (RH) and Precipitation (PCP)

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## Appendix – R Codes

setwd("/Users/khulanj/Documents/project2/Cleaned/")

# Install packages

install.packages("ggplot2")

install.packages("lubridate")

install.packages("data.table")

install.packages("pheatmap")

install.packages("corrplot")

install.packages("tidyverse")

# Load necessary library

library(dplyr)

library(readxl)

library(ggplot2)

library(lubridate)

library(data.table)

library(pheatmap)

library(corrplot)

data\_2023 <- read.csv("2023\_hotspots\_cleaned.csv")

data\_2022 <- read.csv("2022\_hotspots\_cleaned.csv")

data\_2021 <- read.csv("2021\_hotspots\_cleaned.csv")

data\_2020 <- read.csv("2020\_hotspots\_cleaned.csv")

data\_2019 <- read.csv("2019\_hotspots\_cleaned.csv")

data\_2018 <- read.csv("2018\_hotspots\_cleaned.csv")

data\_2017 <- read.csv("2017\_hotspots\_cleaned.csv")

data\_2016 <- read.csv("2016\_hotspots\_cleaned.csv")

data\_2015 <- read.csv("2015\_hotspots\_cleaned.csv")

data\_2014 <- read.csv("2014\_hotspots\_cleaned.csv")

datasets <- list(data\_2023, data\_2022, data\_2021, data\_2020, data\_2019, data\_2018, data\_2017, data\_2016, data\_2015, data\_2014)

datasets <- lapply(datasets, function(df) {

colnames(df) <- tolower(colnames(df)) # Convert column names to lowercase

return(df)

})

full\_data <- bind\_rows(datasets)

# Converting year-month to date format

date\_parsed <- ym(full\_data$year.month)

year\_month <- format(date\_parsed, "%Y-%m")

# Creating pivot table based on year-month

setDT(full\_data)

pivot\_table\_ave\_year\_month <- full\_data[, .(

average\_temp = mean(temp, na.rm = TRUE),

average\_rh = mean(rh, na.rm = TRUE),

average\_ws = mean(ws, na.rm = TRUE),

average\_wd = mean(wd, na.rm = TRUE),

average\_pcp = mean(pcp, na.rm = TRUE),

average\_ffmc = mean(ffmc, na.rm = TRUE),

average\_dmc = mean(dmc, na.rm = TRUE),

average\_dc = mean(dc, na.rm = TRUE),

average\_isi = mean(isi, na.rm = TRUE),

average\_bui = mean(bui, na.rm = TRUE),

average\_fwi = mean(fwi, na.rm = TRUE),

average\_ros = mean(ros, na.rm = TRUE),

average\_sfc = mean(sfc, na.rm = TRUE),

average\_tfc = mean(tfc, na.rm = TRUE),

average\_hfi = mean(hfi, na.rm = TRUE),

average\_cfb = mean(cfb, na.rm = TRUE),

average\_pcuring = mean(pcuring, na.rm = TRUE)),

by = .(year\_month)]

print(pivot\_table\_ave\_year\_month)

# ---------------------------------BUI------------------------------------------

# PLOTTING - BUI

# TIME-SERIES (LINE PLOT)

# Create the time-series BUI \_WHOLE 10-YR PERIOD\_WHOLE CANADA

pivot\_table\_ave\_year\_month[, year\_month := as.Date(paste0(year\_month, "-01"), format = "%Y-%m-%d")]

ggplot(pivot\_table\_ave\_year\_month, aes(x = year\_month, y = average\_bui)) +

geom\_line(color = "blue3", size = 1, alpha = 0.7) +

geom\_point(color = "blue3", size = 2, shape = 16) +

labs(

title = "Average Monthly Buildup Index (2014 to 2023)",

x = "Month",

y = "Average BUI"

) +

theme\_minimal() +

scale\_x\_date(date\_labels = "%b %Y", date\_breaks = "6 months") +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_bui), by = 20)

) +

geom\_hline(yintercept = 90, linetype = "dashed", color = "red", size = 1) +

theme(

plot.title = element\_text(size = 18, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 16, face = "bold"),

axis.title.y = element\_text(size = 16, face = "bold"),

axis.text.x = element\_text(size = 10, angle = 45, hjust = 1),

axis.text.y = element\_text(size = 12)

)

#Correlation coefficient BUI vs FFMC per year-month

cor\_bui\_ffmc <- cor(pivot\_table\_ave\_year\_month$average\_bui, pivot\_table\_ave\_year\_month$average\_ffmc)

# Scatter plot BUI vs FFMC per year-month

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_ffmc, y = average\_bui)) +

geom\_point(color = "blue",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of BUI vs FFMC") +

xlab("Fine Fuel Moisture Code") +

ylab("Buildup Index") +

theme\_minimal() +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_bui), by = 20)

) +

annotate("text", x = min(pivot\_table\_ave\_year\_month$average\_ffmc) \* 0.9,

y = max(pivot\_table\_ave\_year\_month$average\_bui) \* 0.8,

label = paste("R =", round(cor\_bui\_ffmc, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

#Correlation coefficient BUI vs FFMC per year-month

cor\_bui\_dc <- cor(pivot\_table\_ave\_year\_month$average\_bui, pivot\_table\_ave\_year\_month$average\_dc)

# Scatter plot BUI vs DC per year-month

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_dc, y = average\_bui)) +

geom\_point(color = "blue",size = 4,alpha = 0.7) +

ggtitle("Scatter Plot of BUI vs DC") +

xlab("Drought Code") +

ylab("Buildup Index") +

theme\_minimal() +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_bui), by = 20)

) +

annotate("text", x = min(pivot\_table\_ave\_year\_month$average\_dc) \* 0.9,

y = max(pivot\_table\_ave\_year\_month$average\_bui) \* 0.8,

label = paste("R =", round(cor\_bui\_dc, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

#Correlation coefficient BUI vs DMC per year-month

cor\_bui\_dmc <- cor(pivot\_table\_ave\_year\_month$average\_bui, pivot\_table\_ave\_year\_month$average\_dmc)

# Scatter plot BUI vs DMC per year-month

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_dmc, y = average\_bui)) +

geom\_point(color = "blue",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of BUI vs DMC") +

xlab("Duff Moisture Code") +

ylab("Buildup Index") +

theme\_minimal() +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_bui), by = 20)

) +

annotate("text", x = min(pivot\_table\_ave\_year\_month$average\_dmc) \* 0.9,

y = max(pivot\_table\_ave\_year\_month$average\_bui) \* 0.8,

label = paste("R =", round(cor\_bui\_dmc, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

#Correlation coefficient BUI vs TEMP per year-month

cor\_bui\_temp <- cor(pivot\_table\_ave\_year\_month$average\_bui, pivot\_table\_ave\_year\_month$average\_temp)

# Scatter plot BUI vs temp per year-month

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_temp, y = average\_bui)) +

geom\_point(color = "blue", size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of BUI vs Temperature") +

xlab("Temperature (°C)") +

ylab("Buildup Index") +

theme\_minimal() +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_bui), by = 20)

) +

annotate("text", x = min(pivot\_table\_ave\_year\_month$average\_temp) \* 0.9,

y = max(pivot\_table\_ave\_year\_month$average\_bui) \* 0.8,

label = paste("R =", round(cor\_bui\_temp, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

#Correlation coefficient BUI vs pcp per year-month

cor\_bui\_pcp <- cor(pivot\_table\_ave\_year\_month$average\_bui, pivot\_table\_ave\_year\_month$average\_pcp)

# Scatter plot BUI vs pcp per year-month

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_pcp, y = average\_bui)) +

geom\_point(color = "blue", size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of BUI vs Precipitation") +

xlab("Precipitation (mm)") +

ylab("Buildup Index") +

theme\_minimal() +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_bui), by = 20)

) +

annotate("text", x = max(pivot\_table\_ave\_year\_month$average\_pcp) \* 0.8,

y = max(pivot\_table\_ave\_year\_month$average\_bui) \* 0.8,

label = paste("R =", round(cor\_bui\_pcp, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

#Correlation coefficient BUI vs rh per year-month

cor\_bui\_rh <- cor(pivot\_table\_ave\_year\_month$average\_bui, pivot\_table\_ave\_year\_month$average\_rh)

# Scatter plot BUI vs rh per year-month

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_rh, y = average\_bui)) +

geom\_point(color = "blue", size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of BUI vs Relative Humidity") +

xlab("Relative Humidity (%)") +

ylab("Buildup Index") +

theme\_minimal() +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_bui), by = 20)

) +

annotate("text", x = max(pivot\_table\_ave\_year\_month$average\_rh) \* 0.8,

y = max(pivot\_table\_ave\_year\_month$average\_bui) \* 0.8,

label = paste("R =", round(cor\_bui\_rh, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

# -----------------------------------FWI----------------------------------------

# PLOTTING - FWI

# Time series for fwi

pivot\_table\_ave\_year\_month[, year\_month := as.Date(paste0(year\_month, "-01"), format = "%Y-%m-%d")]

ggplot(pivot\_table\_ave\_year\_month, aes(x = year\_month, y = average\_fwi)) +

geom\_line(color = "blue3", size = 1, alpha = 0.7) +

geom\_point(color = "blue3", size = 2, shape = 16) +

labs(

title = "Average Monthly Fire Weather Index (2014 to 2023)",

x = "Month",

y = "Fire Weather Index"

) +

theme\_minimal() +

scale\_x\_date(date\_labels = "%b %Y", date\_breaks = "6 months") +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_fwi), by = 10)

) +

geom\_hline(yintercept = 20, linetype = "dashed", color = "red", size = 1) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 16, face = "bold"),

axis.title.y = element\_text(size = 16, face = "bold"),

axis.text.x = element\_text(size = 10, angle = 45, hjust = 1),

axis.text.y = element\_text(size = 12)

)

# Timer series for temp

pivot\_table\_ave\_year\_month[, year\_month := as.Date(paste0(year\_month, "-01"), format = "%Y-%m-%d")]

ggplot(pivot\_table\_ave\_year\_month, aes(x = year\_month, y = average\_temp)) +

geom\_line(color = "red", size = 1, alpha = 0.7) +

geom\_point(color = "red", size = 2, shape = 16) +

labs(

title = "Average Monthly Temperature (2014 to 2023)",

x = "Month",

y = "Temperature (°C)"

) +

theme\_minimal() +

scale\_x\_date(date\_labels = "%b %Y", date\_breaks = "6 months") +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_temp), by = 10)

) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 16, face = "bold"),

axis.title.y = element\_text(size = 16, face = "bold"),

axis.text.x = element\_text(size = 10, angle = 45, hjust = 1),

axis.text.y = element\_text(size = 12)

)

# time series for fwi and temp

pivot\_table\_ave\_year\_month[, year\_month := as.Date(paste0(year\_month, "-01"), format = "%Y-%m-%d")]

# Plotting both FWI and temperature on the same graph with two y-axes

ggplot(pivot\_table\_ave\_year\_month, aes(x = year\_month)) +

# Plot the first line (average FWI)

geom\_line(aes(y = average\_fwi, color = "Fire Weather Index"), size = 1, alpha = 0.7) +

geom\_point(aes(y = average\_fwi, color = "Fire Weather Index"), size = 2, shape = 16) +

# Plot the second line (average temperature)

geom\_line(aes(y = average\_temp \* (max(pivot\_table\_ave\_year\_month$average\_fwi) / max(pivot\_table\_ave\_year\_month$average\_temp)), color = "Temperature"), size = 1, alpha = 0.7) +

geom\_point(aes(y = average\_temp \* (max(pivot\_table\_ave\_year\_month$average\_fwi) / max(pivot\_table\_ave\_year\_month$average\_temp)), color = "Temperature"), size = 2, shape = 16) +

# Add title and axis labels

labs(

title = "Average Monthly Fire Weather Index and Temperature (2014 to 2023)",

x = "Month",

y = "Fire Weather Index",

color = "Variable" # Title for the legend

) +

# Customize the x-axis and y-axis

scale\_x\_date(date\_labels = "%b %Y", date\_breaks = "6 months") +

scale\_y\_continuous(

name = "Fire Weather Index",

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_fwi), by = 10)

) +

scale\_y\_continuous(

sec.axis = sec\_axis(

trans = ~ . \* (max(pivot\_table\_ave\_year\_month$average\_temp) / max(pivot\_table\_ave\_year\_month$average\_fwi)),

name = "Temperature (°C)",

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_temp), by = 10)

)

) +

# Customize the colors for the lines

scale\_color\_manual(

values = c("Fire Weather Index" = "blue3", "Temperature" = "red")

) +

# Customize the plot's appearance

theme\_minimal() +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 16, face = "bold"),

axis.title.y = element\_text(size = 16, face = "bold"),

axis.text.x = element\_text(size = 10, angle = 45, hjust = 1),

axis.text.y = element\_text(size = 12),

axis.text.y.right = element\_text(size = 12)

)

# scatterplot of fwi vs temp

cor\_fwi\_temp = cor(pivot\_table\_ave\_year\_month$average\_fwi, pivot\_table\_ave\_year\_month$average\_temp)

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_temp, y = average\_fwi)) +

geom\_point(color = "red",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of FWI vs Temperature") +

xlab("Temperature (°C)") +

ylab("Fire Weather Index") +

theme\_minimal() +

annotate("text", x = min(pivot\_table\_ave\_year\_month$average\_temp) \* 0.9,

y = max(pivot\_table\_ave\_year\_month$average\_fwi) \* 0.8,

label = paste("R =", round(cor\_fwi\_temp, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

# Time series for rh

pivot\_table\_ave\_year\_month[, year\_month := as.Date(paste0(year\_month, "-01"), format = "%Y-%m-%d")]

ggplot(pivot\_table\_ave\_year\_month, aes(x = year\_month, y = average\_rh)) +

geom\_line(color = "red", size = 1, alpha = 0.7) +

geom\_point(color = "red", size = 2, shape = 16) +

labs(

title = "Average Monthly Relative Humidity (2014 to 2023)",

x = "Month",

y = "Relative Humidity (%)"

) +

theme\_minimal() +

scale\_x\_date(date\_labels = "%b %Y", date\_breaks = "6 months") +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_rh), by = 10)

) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 16, face = "bold"),

axis.title.y = element\_text(size = 16, face = "bold"),

axis.text.x = element\_text(size = 10, angle = 45, hjust = 1),

axis.text.y = element\_text(size = 12)

)

# scatterplot of fwi vs rh

cor\_fwi\_rh = cor(pivot\_table\_ave\_year\_month$average\_fwi, pivot\_table\_ave\_year\_month$average\_rh)

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_rh, y = average\_fwi)) +

geom\_point(color = "red",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of FWI vs Relative Humidity") +

xlab("Relative Humidity (%)") +

ylab("Fire Weather Index") +

theme\_minimal() +

annotate("text", x = max(pivot\_table\_ave\_year\_month$average\_rh) \* 0.9,

y = max(pivot\_table\_ave\_year\_month$average\_fwi) \* 0.8,

label = paste("R =", round(cor\_fwi\_rh, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

# Time series for pcp

pivot\_table\_ave\_year\_month[, year\_month := as.Date(paste0(year\_month, "-01"), format = "%Y-%m-%d")]

ggplot(pivot\_table\_ave\_year\_month, aes(x = year\_month, y = average\_pcp)) +

geom\_line(color = "green2", size = 1, alpha = 0.7) +

geom\_point(color = "green2", size = 2, shape = 16) +

labs(

title = "Average Monthly Precipitation (2014 to 2023)",

x = "Month",

y = "Precipitation (mm)"

) +

geom\_hline(yintercept = 2.5, linetype = "dashed", color = "red", size = 1) +

theme\_minimal() +

scale\_x\_date(date\_labels = "%b %Y", date\_breaks = "6 months") +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_pcp), by = 1)

) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 16, face = "bold"),

axis.title.y = element\_text(size = 16, face = "bold"),

axis.text.x = element\_text(size = 10, angle = 45, hjust = 1),

axis.text.y = element\_text(size = 12)

)

# scatterplot of fwi vs pcp

cor\_fwi\_pcp = cor(pivot\_table\_ave\_year\_month$average\_fwi, pivot\_table\_ave\_year\_month$average\_pcp)

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_pcp, y = average\_fwi)) +

geom\_point(color = "red",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of FWI vs Precipitation") +

xlab("Precipitation (mm)") +

ylab("Fire Weather Index") +

theme\_minimal() +

annotate("text", x = min(pivot\_table\_ave\_year\_month$average\_pcp) \* 0.9,

y = max(pivot\_table\_ave\_year\_month$average\_fwi) \* 0.8,

label = paste("R =", round(cor\_fwi\_pcp, 2)),

color = "black", size = 6, hjust = -4) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

# ---------------------------------ISI------------------------------------------

# PLOTTING - ISI

# Time-series (Initial Spread Index) \_Average per MONTH per YEAR

pivot\_table\_ave\_year\_month[, year\_month := as.Date(paste0(year\_month, "-01"), format = "%Y-%m-%d")]

ggplot(pivot\_table\_ave\_year\_month, aes(x = year\_month, y = average\_isi)) +

geom\_line(color = "blue3", size = 1, alpha = 0.7) +

geom\_point(color = "blue3", size = 2, shape = 16) +

labs(

title = "Average Monthly Initial Spread Index (2014 to 2023)",

x = "Month",

y = "Initial Spread Index"

) +

theme\_minimal() +

scale\_x\_date(date\_labels = "%b %Y", date\_breaks = "6 months") +

scale\_y\_continuous(

breaks = seq(0, max(pivot\_table\_ave\_year\_month$average\_isi), by = 10)

) +

geom\_hline(yintercept = 10, linetype = "dashed", color = "red", size = 1) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 16, face = "bold"),

axis.title.y = element\_text(size = 16, face = "bold"),

axis.text.x = element\_text(size = 10, angle = 45, hjust = 1),

axis.text.y = element\_text(size = 12)

)

# Time-series(MULTIPLE VARIABLES\_ISI, FFMC, WS) \_Average per MONTH per YEAR

pivot\_table\_long <- melt(pivot\_table\_ave\_year\_month,

id.vars = "year\_month",

measure.vars = c("average\_isi", "average\_ffmc", "average\_ws"),

variable.name = "Variable",

value.name = "Value")

ggplot(pivot\_table\_long, aes(x = year\_month, y = Value, color = Variable)) +

geom\_line(linewidth = 1) +

geom\_point(size = 2) +

scale\_y\_continuous(

name = "Average ISI and Average FFMC",

sec.axis = sec\_axis(~ . \* 0.5, name = "Average WS (scaled)")

) +

scale\_x\_date(date\_labels = "%Y-%m", date\_breaks = "6 months") +

labs(

title = "Average Monthly ISI, FFMC, and WS",

x = "Month",

y = "Values",

color = "Variable"

) +

theme\_minimal() +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.text.x = element\_text(angle = 45, hjust = 1),

axis.title.x = element\_text(size = 13, face = "bold"),

axis.title.y = element\_text(size = 13, face = "bold"),

legend.title = element\_text(size = 12, face = "bold")

) +

scale\_color\_manual(values = c("average\_isi" = "blue", "average\_ffmc" = "forestgreen", "average\_ws" = "red"))

# SCATTER PLOTS

# Scatter Plot (ISI and FFMC) \_Average per MONTH per YEAR

cor\_isi\_ffmc <-cor(pivot\_table\_ave\_year\_month$average\_ffmc,pivot\_table\_ave\_year\_month$average\_isi)

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_ffmc, y = average\_isi)) +

geom\_point(color = "blue",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of FFMC vs ISI") +

xlab("Fine Fuel Moisture Code") +

ylab("Initial Spread Index") +

theme\_minimal() +

annotate("text",

x = min(pivot\_table\_ave\_year\_month$average\_ffmc) \* 0.9,

y = max(pivot\_table\_ave\_year\_month$average\_isi) \* 0.8,

label = paste("R =", round(cor\_isi\_ffmc, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

cor\_isi\_ws <-cor(pivot\_table\_ave\_year\_month$average\_ws,pivot\_table\_ave\_year\_month$average\_isi)

# Scatter Plot (ISI and WS) \_Average per MONTH per YEAR

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_ws, y = average\_isi)) +

geom\_point(color = "blue",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of WS vs ISI") +

xlab("Wind Speed (km/h)") +

ylab("Initial Spread Index") +

theme\_minimal() +

annotate("text",

x = min(pivot\_table\_ave\_year\_month$average\_ws) \* 0.9,

y = max(pivot\_table\_ave\_year\_month$average\_isi) \* 0.8,

label = paste("R =", round(cor\_isi\_ws, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

cor\_isi\_rh <-cor(pivot\_table\_ave\_year\_month$average\_rh,pivot\_table\_ave\_year\_month$average\_isi)

# Scatter Plot (ISI and RH) \_Average per MONTH per YEAR

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_rh, y = average\_isi)) +

geom\_point(color = "blue",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of RH vs ISI") +

xlab("Relative Humidity (%)") +

ylab("Initial Spread Index") +

theme\_minimal() +

annotate("text",

x = min(pivot\_table\_ave\_year\_month$average\_rh) \* 2.5,

y = max(pivot\_table\_ave\_year\_month$average\_isi) \* 0.8,

label = paste("R =", round(cor\_isi\_rh, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

cor\_isi\_pcp <-cor(pivot\_table\_ave\_year\_month$average\_pcp,pivot\_table\_ave\_year\_month$average\_isi)

# Scatter Plot (ISI and PCP) \_Average per MONTH per YEAR

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_pcp, y = average\_isi)) +

geom\_point(color = "blue",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of PCP vs ISI") +

xlab("Precipitation (mm)") +

ylab("Initial Spread Index") +

theme\_minimal() +

annotate("text",

x = min(pivot\_table\_ave\_year\_month$average\_pcp) \* 150,

y = max(pivot\_table\_ave\_year\_month$average\_isi) \* 0.8,

label = paste("R =", round(cor\_isi\_pcp, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

cor\_ffmc\_rh <-cor(pivot\_table\_ave\_year\_month$average\_ffmc,pivot\_table\_ave\_year\_month$average\_rh)

# Scatter Plot (FFMC and RH) \_Average per MONTH per YEAR

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_rh, y = average\_ffmc)) +

geom\_point(color = "blue",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of RH vs FFMC") +

xlab("Relative Humidity (%)") +

ylab("Fine Fuel Moisture Code") +

theme\_minimal() +

annotate("text",

x = min(pivot\_table\_ave\_year\_month$average\_rh) \* 1,

y = max(pivot\_table\_ave\_year\_month$average\_ffmc) \* 0.8,

label = paste("R =", round(cor\_ffmc\_rh, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)

cor\_ffmc\_pcp <-cor(pivot\_table\_ave\_year\_month$average\_ffmc,pivot\_table\_ave\_year\_month$average\_pcp)

# Scatter Plot (FFMC and RH) \_Average per MONTH per YEAR

ggplot(pivot\_table\_ave\_year\_month, aes(x = average\_pcp, y = average\_ffmc)) +

geom\_point(color = "blue",size = 4, alpha = 0.7) +

ggtitle("Scatter Plot of PCP vs FFMC") +

xlab("Precipitation (mm)") +

ylab("Fine Fuel Moisture Code") +

theme\_minimal() +

annotate("text",

x = min(pivot\_table\_ave\_year\_month$average\_pcp) \* 100,

y = max(pivot\_table\_ave\_year\_month$average\_ffmc) \* 0.8,

label = paste("R =", round(cor\_ffmc\_pcp, 2)),

color = "black", size = 6, hjust = 0) +

theme(

plot.title = element\_text(size = 20, face = "bold", hjust = 0.5),

axis.title.x = element\_text(size = 14, face = "bold"),

axis.title.y = element\_text(size = 14, face = "bold"),

axis.text.x = element\_text(size = 13),

axis.text.y = element\_text(size = 13)

)