

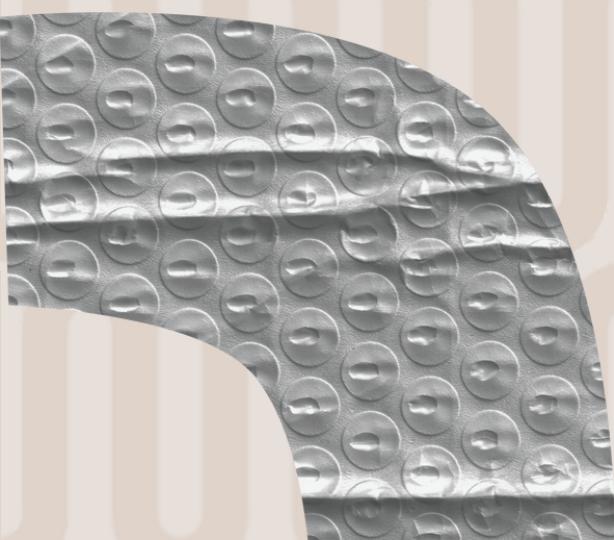


Team Project

ANALYSIS OF BC WILDFIRE



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AGENDA

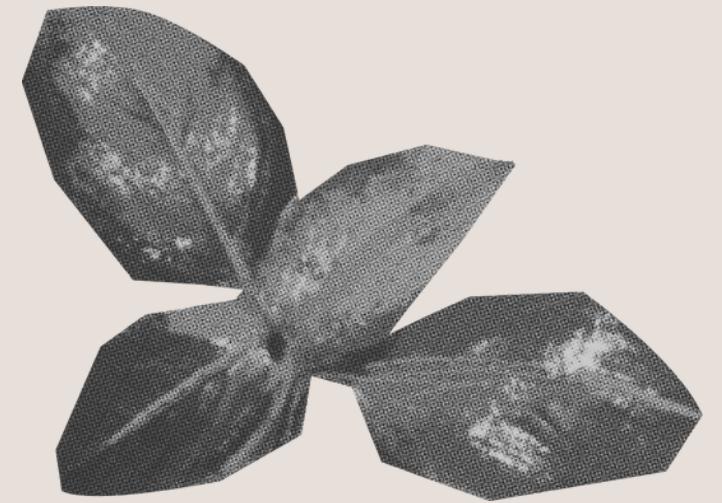
1 EDA PROCESS

2 CLUSTERING FIRE EVENT

3 EXPLORATION OF VARIABLES

4 TREND ANALYSIS

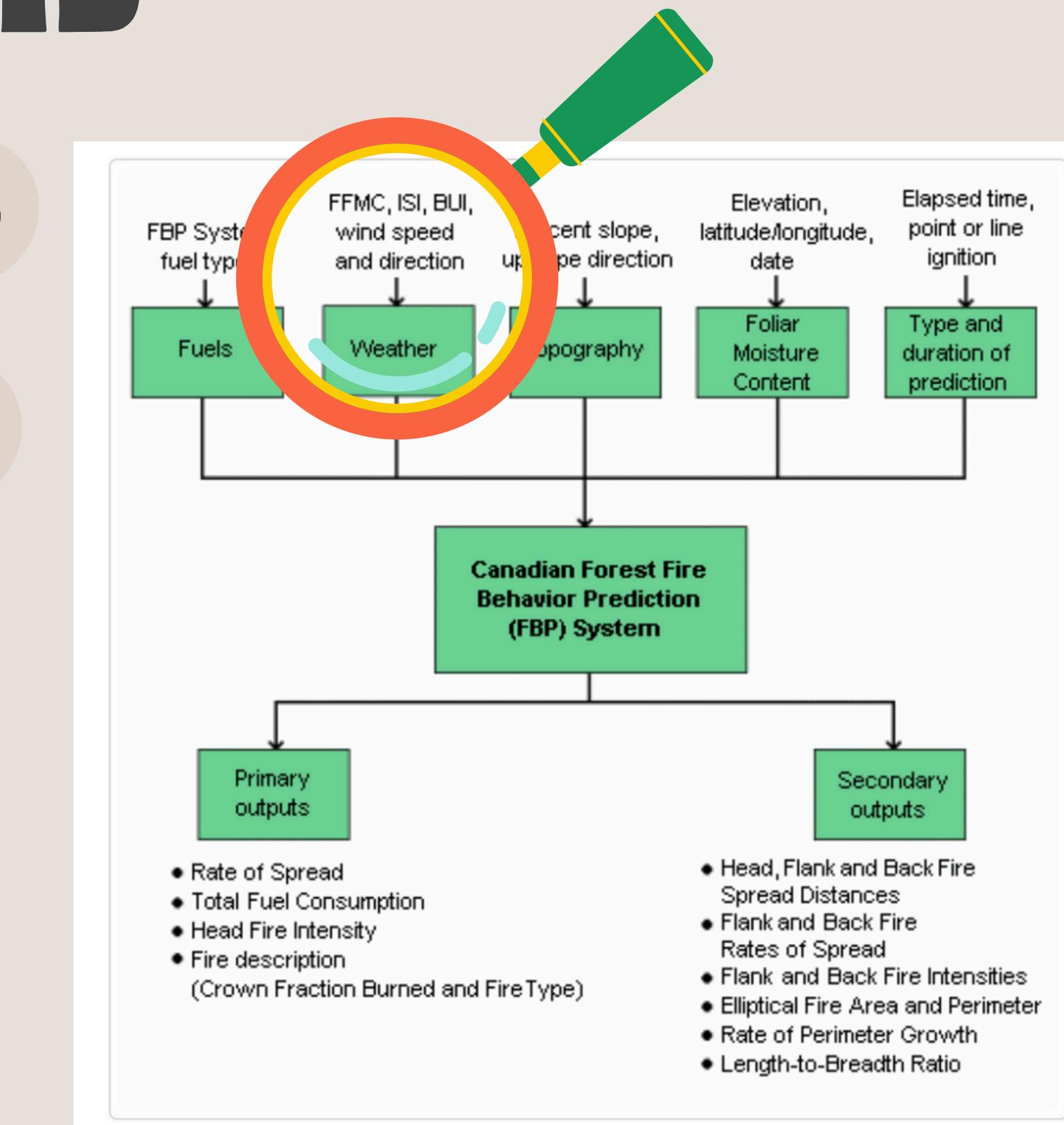
5 T-TEST AND MODEL



SCOPE OF ANALYSIS

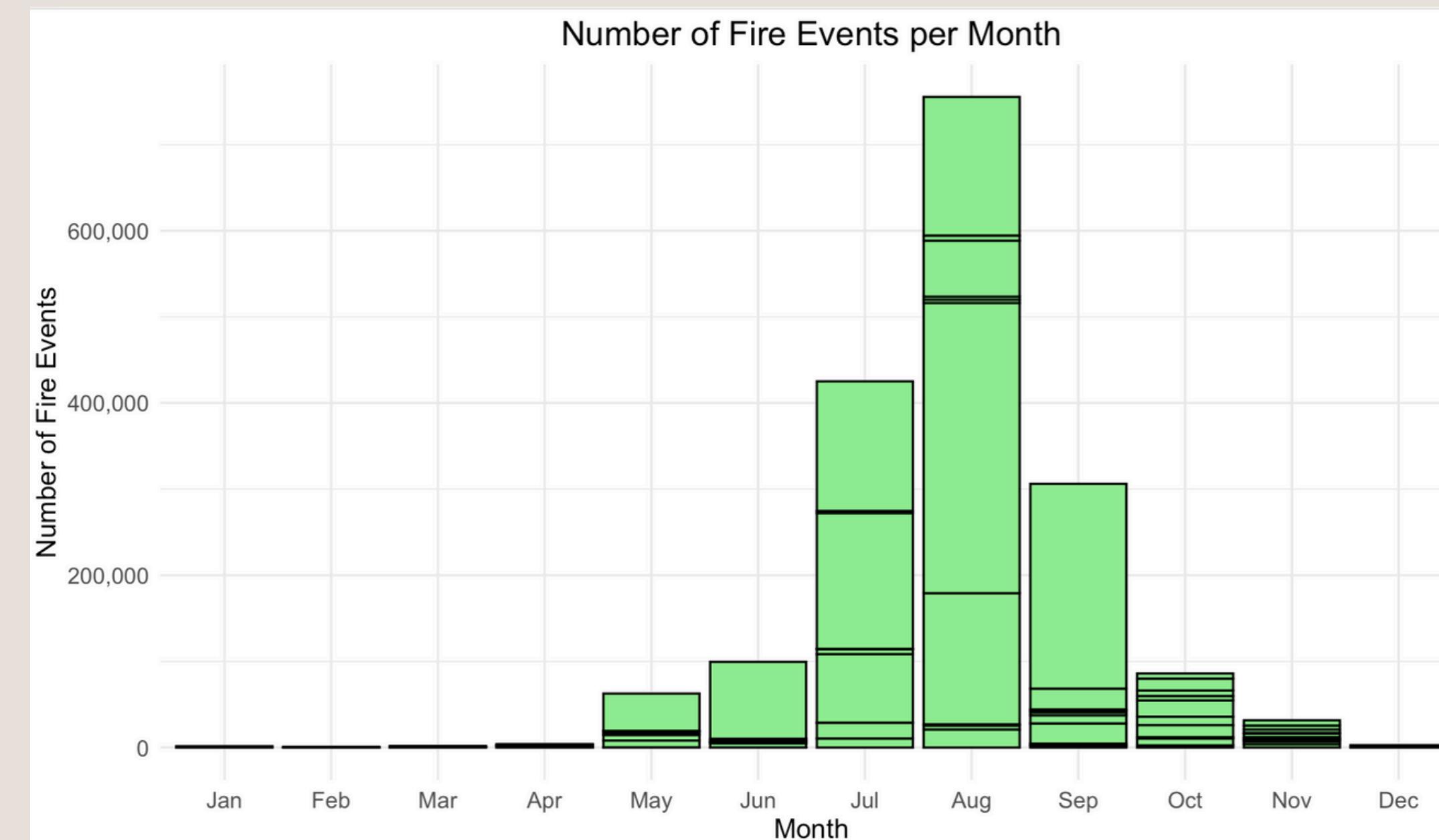
HOTSPOT AND WEATHER DATA FROM 2014 - 2023

FIRE INDEX VARIABLES USE ON CANADIAN FOREST FIRE BEHAVIOR PREDICTION SYSTEM



SCOPE OF ANALYSIS

DATA CONCENTRATION FROM MAY - OCTOBER OR “PEAK”



HOTSPOT

DIMENSION :
1781.266 ROWS
41 VARIABLES

| | hotspots_2013 | hotspots_2014 | hotspots_2015 | hotspots_2016 | hotspots_2017 | hotspots_2018 | hotspots_2019 | hotspots_2020 | hotspots_2021 | hotspots_2022 | hotspots_2023 |
|-----------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| lat | TRUE |
| lon | TRUE |
| rep_date | TRUE |
| uid | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | TRUE | FALSE | FALSE | FALSE |
| source | TRUE |
| sensor | TRUE |
| satellite | TRUE |
| agency | TRUE |
| temp | TRUE |
| rh | TRUE |
| ws | TRUE |
| wd | TRUE |
| pcp | TRUE |
| ffmc | TRUE |
| dmc | TRUE |
| dc | TRUE |
| isi | TRUE |
| bui | TRUE |
| fwi | TRUE |
| fuel | TRUE |
| ros | TRUE |
| sfc | TRUE |
| tfc | TRUE |
| bfc | TRUE |
| hfi | TRUE |
| cfb | TRUE |
| age | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | FALSE | FALSE | FALSE | FALSE |
| estarea | TRUE |
| polyid | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | FALSE | FALSE | FALSE | FALSE |
| pcuring | TRUE |
| cfactor | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE | FALSE | FALSE | FALSE | FALSE | FALSE |
| greenup | TRUE |
| elev | TRUE |
| cfl | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | TRUE | TRUE | TRUE | TRUE | TRUE |
| tfc0 | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | TRUE | TRUE | TRUE | TRUE | TRUE |
| sfl | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | TRUE | TRUE | TRUE | TRUE | TRUE |
| ecozone | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | TRUE | TRUE | TRUE | TRUE | TRUE |
| sfc0 | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | TRUE | TRUE | TRUE | TRUE | TRUE |
| cbh | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | TRUE | TRUE | TRUE | TRUE | TRUE |

WEATHER

DIMENSION :
1000.928 ROWS
38 VARIABLES

| Year | 2023 | 2022 | 2021 | 2020 | 2019 | 2018 | 2017 | 2016 | 2015 | 2014 |
|---------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| <i>max_temp</i> | | | | | | | | | | |
| Missing Value | 6670 | 7149 | 8591 | 8962 | 9320 | 10235 | 8789 | 10075 | 9586 | 9020 |
| NA % | 16% | 16% | 18% | 19% | 19% | 22% | 18% | 20% | 18% | 17% |
| <i>mean_temp</i> | | | | | | | | | | |
| Missing Value | 7020 | 7369 | 8855 | 9185 | 9551 | 10642 | 9236 | 10551 | 10088 | 9442 |
| NA % | 16% | 17% | 19% | 19% | 20% | 23% | 19% | 21% | 19% | 18% |
| <i>spd_max_gust</i> | | | | | | | | | | |
| Missing Value | 32844 | 34322 | 35838 | 38213 | 38981 | 37826 | 40160 | 42021 | 43731 | 45134 |
| NA % | 76% | 77% | 77% | 80% | 81% | 82% | 82% | 82% | 83% | 84% |
| <i>total_rain</i> | | | | | | | | | | |
| Missing Value | 26355 | 27208 | 28068 | 28513 | 28437 | 25821 | 24786 | 26182 | 24827 | 24030 |
| NA % | 61% | 61% | 60% | 60% | 59% | 56% | 50% | 51% | 47% | 45% |
| <i>total_precip</i> | | | | | | | | | | |
| Missing Value | 9594 | 10842 | 11987 | 13263 | 13553 | 10434 | 8895 | 10033 | 9077 | 8559 |
| NA % | 22% | 24% | 26% | 28% | 28% | 23% | 18% | 20% | 17% | 16% |

CLUSTERING FIRE EVENTS

APPLY DBSCAN (DENSITY-BASED SPATIAL CLUSTERING AND APPLICATION WITH NOISE)
AND VISUALIZE IT ON MAP

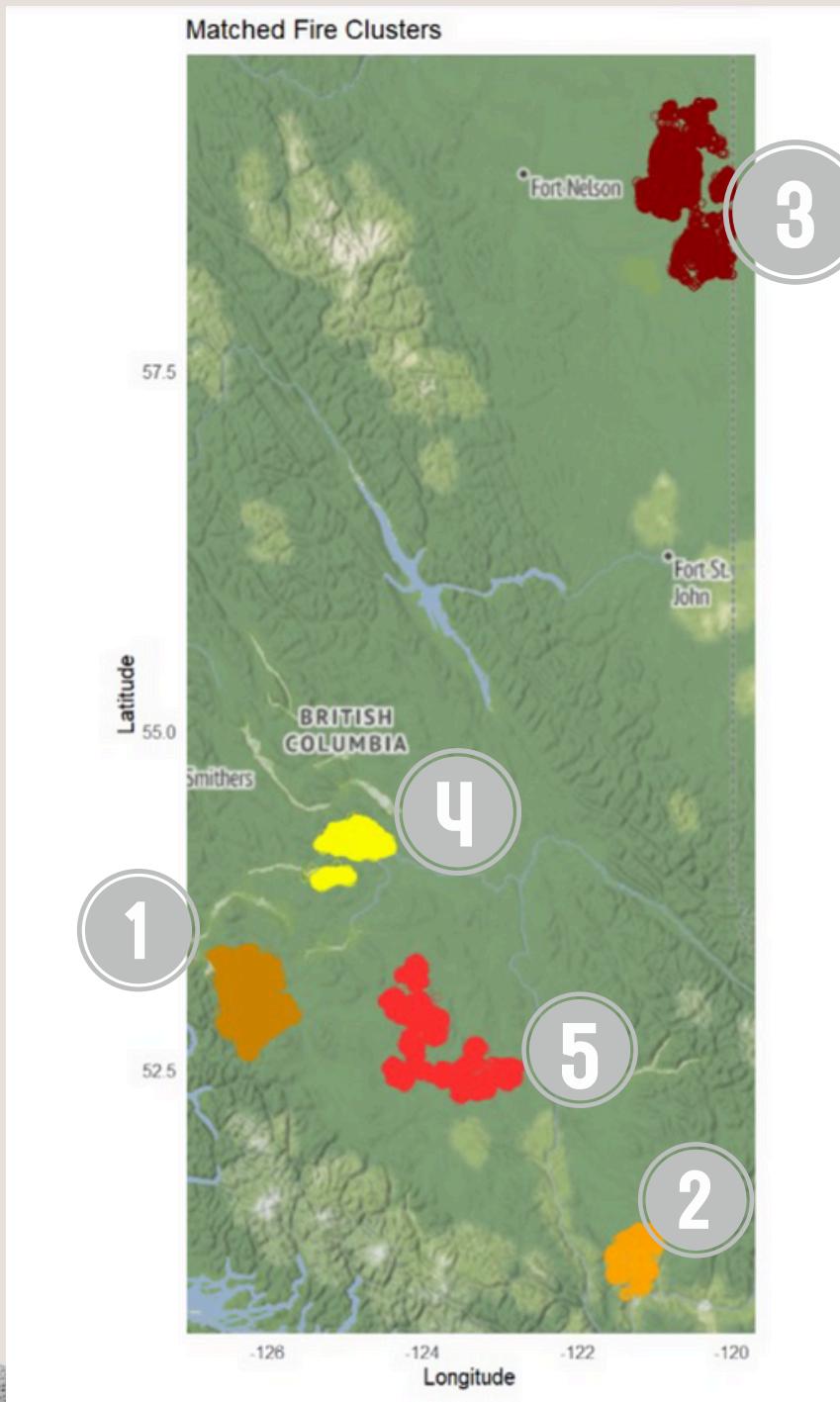
Using Iteration to find suitable radius
and clustered into 15.026 fire events
without noise, which is the closest to
the BC official records of fire for 10
years (15.095)*

```
Console Terminal × Render × Background Jobs ×
R 4.4.1 · ~/ ↵
eps = 7 , minPts = 4 : Number of clusters = 23676 , Number of noise points = 23666
eps = 7 , minPts = 5 : Number of clusters = 21399 , Number of noise points = 33194
eps = 8 , minPts = 1 : Number of clusters = 30883 , Number of noise points = 0
eps = 8 , minPts = 2 : Number of clusters = 24282 , Number of noise points = 6602
eps = 8 , minPts = 3 : Number of clusters = 20783 , Number of noise points = 13600
eps = 8 , minPts = 4 : Number of clusters = 18453 , Number of noise points = 20776
eps = 8 , minPts = 5 : Number of clusters = 16463 , Number of noise points = 29116
eps = 9 , minPts = 1 : Number of clusters = 25243 , Number of noise points = 0
eps = 9 , minPts = 2 : Number of clusters = 19353 , Number of noise points = 5891
eps = 9 , minPts = 3 : Number of clusters = 16434 , Number of noise points = 11729
eps = 9 , minPts = 4 : Number of clusters = 14527 , Number of noise points = 17675
eps = 9 , minPts = 5 : Number of clusters = 12961 , Number of noise points = 24379
eps = 10 , minPts = 1 : Number of clusters = 20894 , Number of noise points = 0
eps = 10 , minPts = 2 : Number of clusters = 15957 , Number of noise points = 4938
eps = 10 , minPts = 3 : Number of clusters = 13684 , Number of noise points = 9484
eps = 10 , minPts = 4 : Number of clusters = 12270 , Number of noise points = 13880
eps = 10 , minPts = 5 : Number of clusters = 11097 , Number of noise points = 18934
eps = 11 , minPts = 1 : Number of clusters = 19395 , Number of noise points = 0
eps = 11 , minPts = 2 : Number of clusters = 15026 , Number of noise points = 4370
eps = 11 , minPts = 3 : Number of clusters = 13015 , Number of noise points = 8392
eps = 11 , minPts = 4 : Number of clusters = 11721 , Number of noise points = 12361
eps = 11 , minPts = 5 : Number of clusters = 10650 , Number of noise points = 16780
eps = 12 , minPts = 1 : Number of clusters = 17398 , Number of noise points = 0
eps = 12 , minPts = 2 : Number of clusters = 13383 , Number of noise points = 4016
eps = 12 , minPts = 3 : Number of clusters = 11554 , Number of noise points = 7674
eps = 12 , minPts = 4 : Number of clusters = 10402 , Number of noise points = 11195
eps = 12 , minPts = 5 : Number of clusters = 9437 , Number of noise points = 15221
eps = 13 , minPts = 1 : Number of clusters = 15189 , Number of noise points = 0
eps = 13 , minPts = 2 : Number of clusters = 11496 , Number of noise points = 3694
eps = 13 , minPts = 3 : Number of clusters = 9923 , Number of noise points = 6840
eps = 13 , minPts = 4 : Number of clusters = 8962 , Number of noise points = 9824
eps = 13 , minPts = 5 : Number of clusters = 8163 , Number of noise points = 13201
```

*<https://www2.gov.bc.ca/gov/content/safety/wildfire-status/about-bcws/wildfire-statistics/wildfire-averages>

CLUSTERING FIRE EVENTS

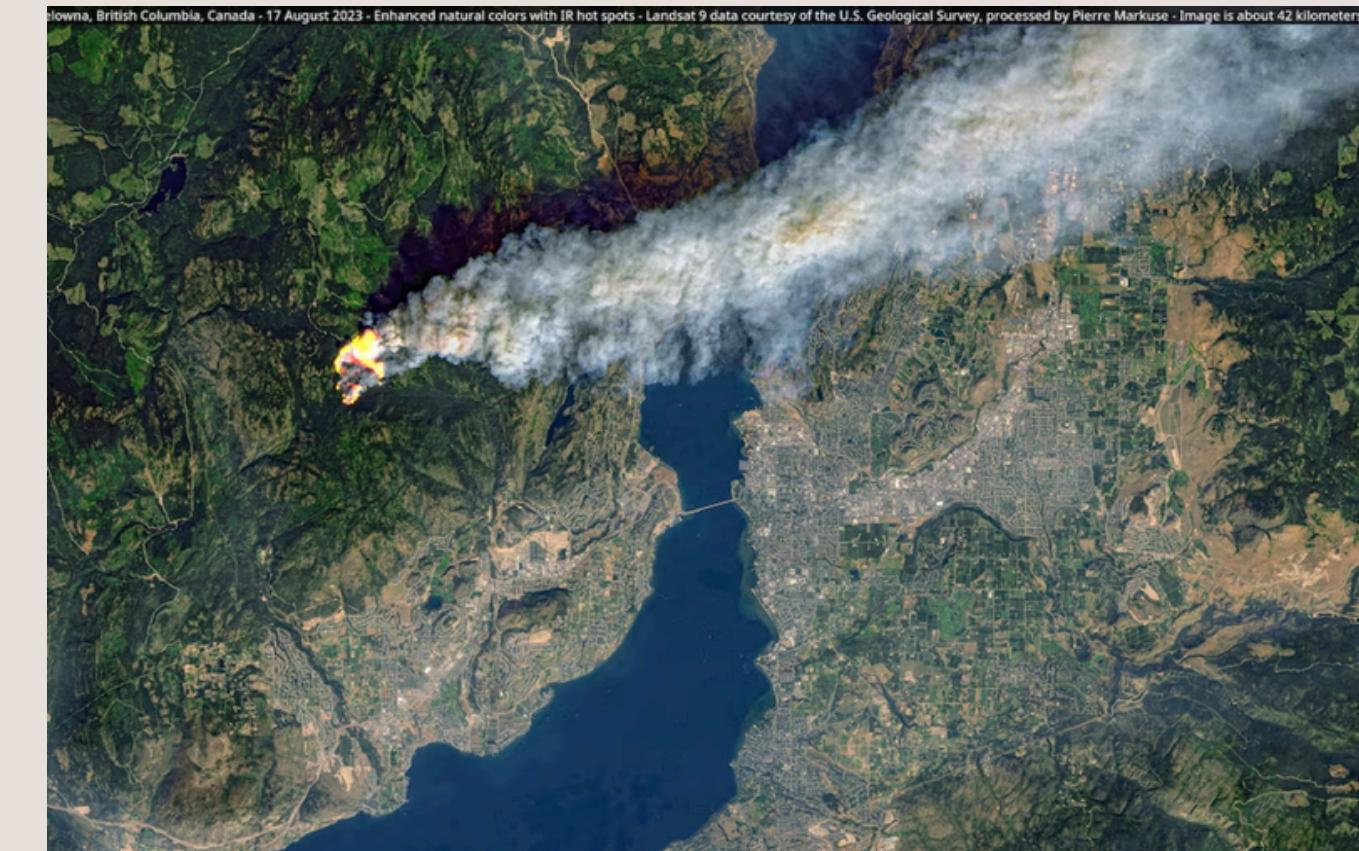
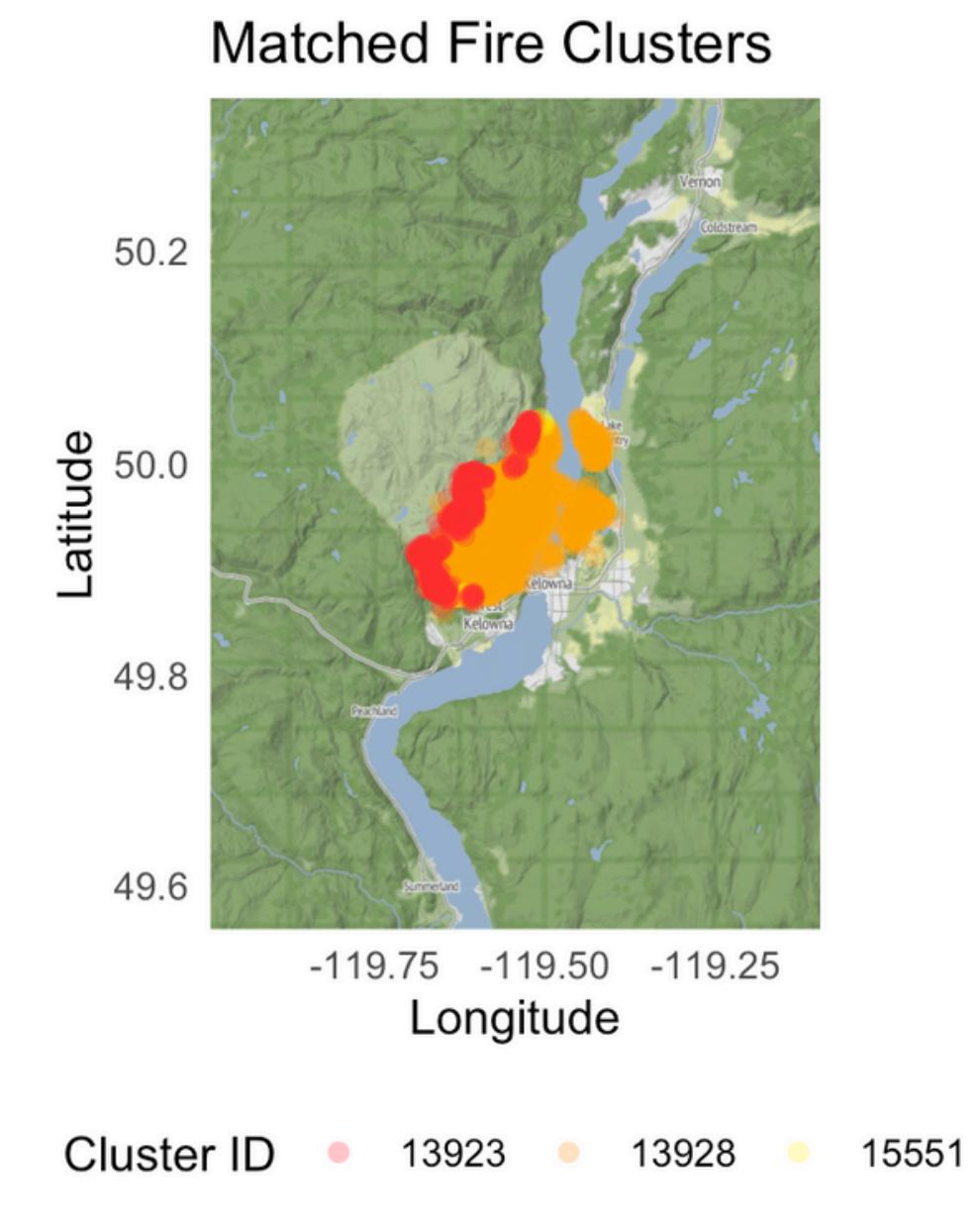
TOP 5 CLUSTER BY NUMBER OF EVENT



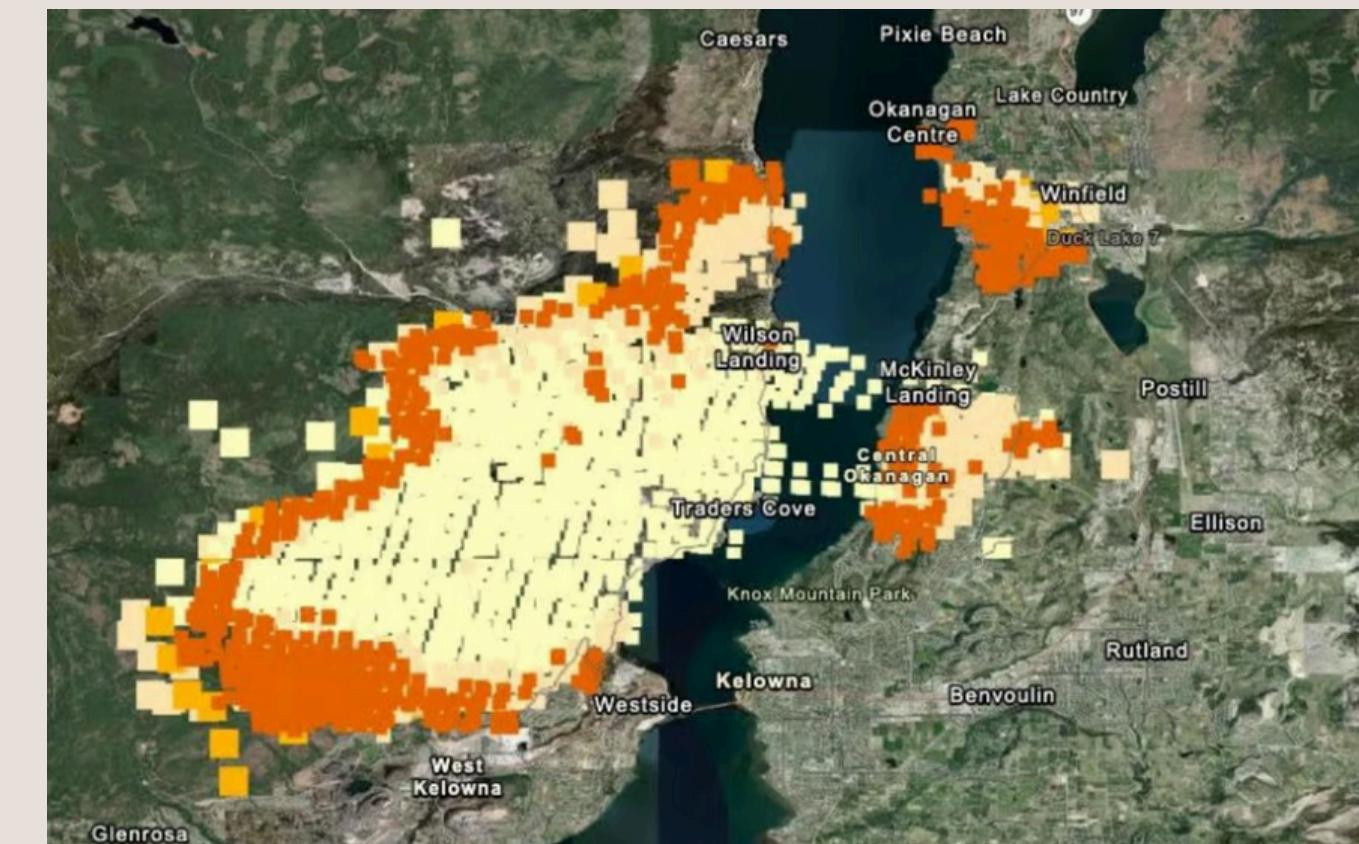
| No. | Date | Num of events | Fire Name |
|-----|----------------------|---------------|-----------------------------|
| 1 | 04 Aug - 25 Aug 2018 | 62103 | Tweedsmuir Complex Fire |
| 2 | 28 Jul - 13 Aug 2017 | 61622 | Elephant Hill Fire |
| 3 | 14 Sep - 24 Sep 2023 | 55183 | Fort Nelson Fire |
| 4 | 05 Aug - 22 Aug 2018 | 30660 | Shovel Lake Fire |
| 5 | 23 Jul - 13 Aug 2017 | 30152 | Hanceville-Riske Creek Fire |

UNIQUE FIRE EVENT

KELOWNA FIRE IN 2023 or McDougall Creek Fire



Satellite image



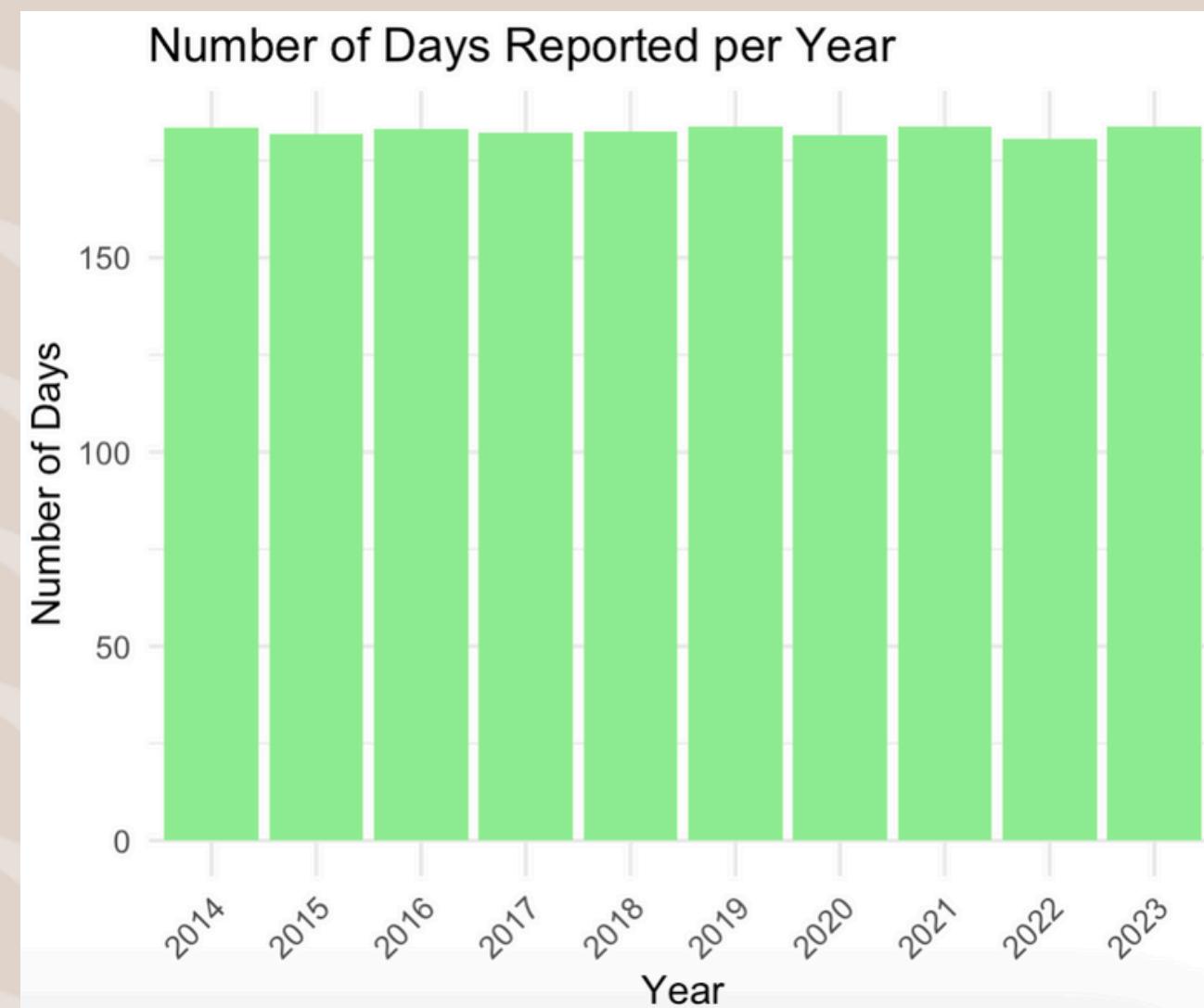
Thermal imaging photo from NASA



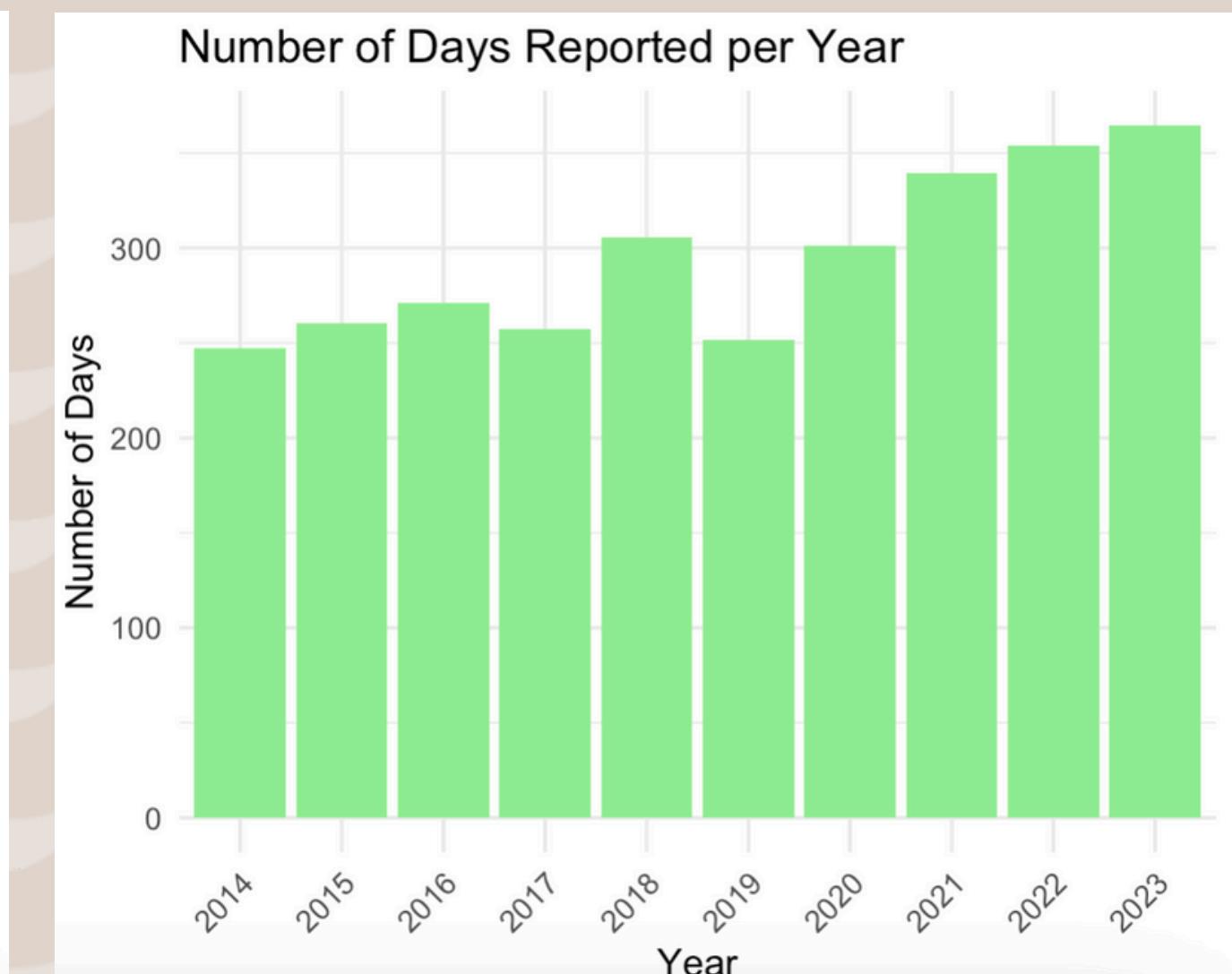
EXPLORATION OF VARIABLES

From fire dataset it shows the number of days reported every year.

Data collection shows improvement in the recent years.



*raw hotspot dataset

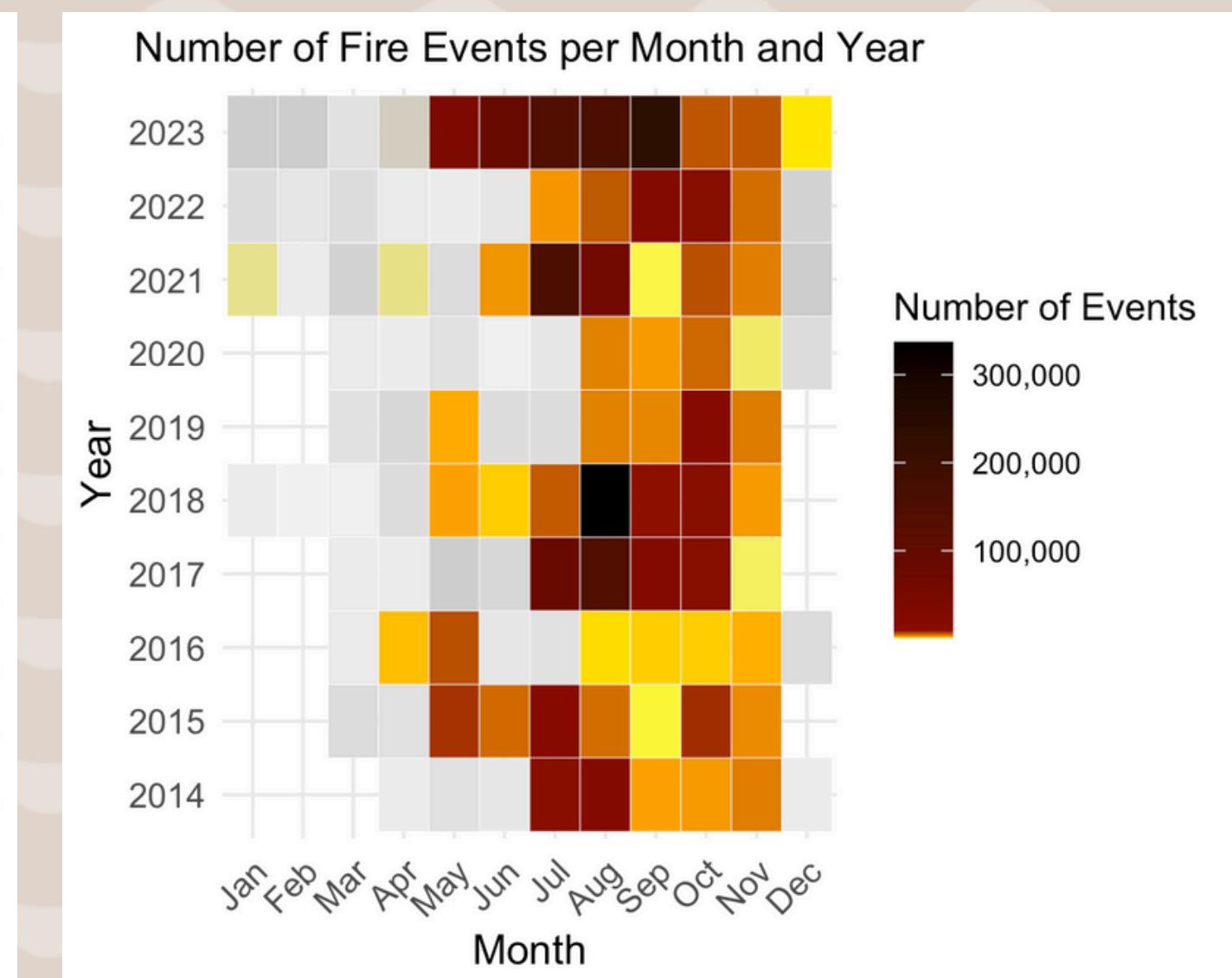
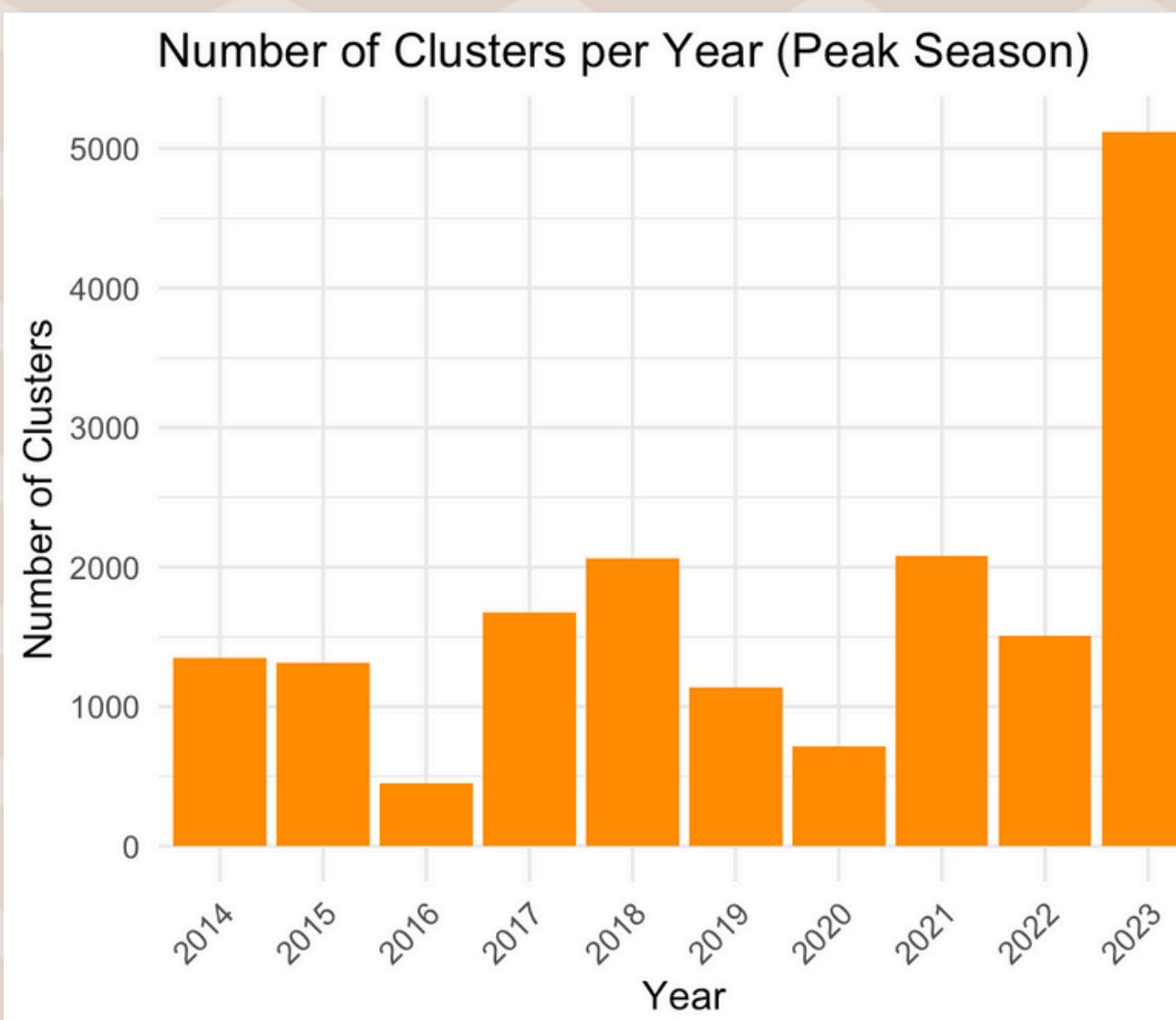


*peak hotspot dataset



EXPLORATION OF VARIABLES

**Number of cluster per year
in the peak season
and the background of
decision to concentrate
during period of May – Oct**

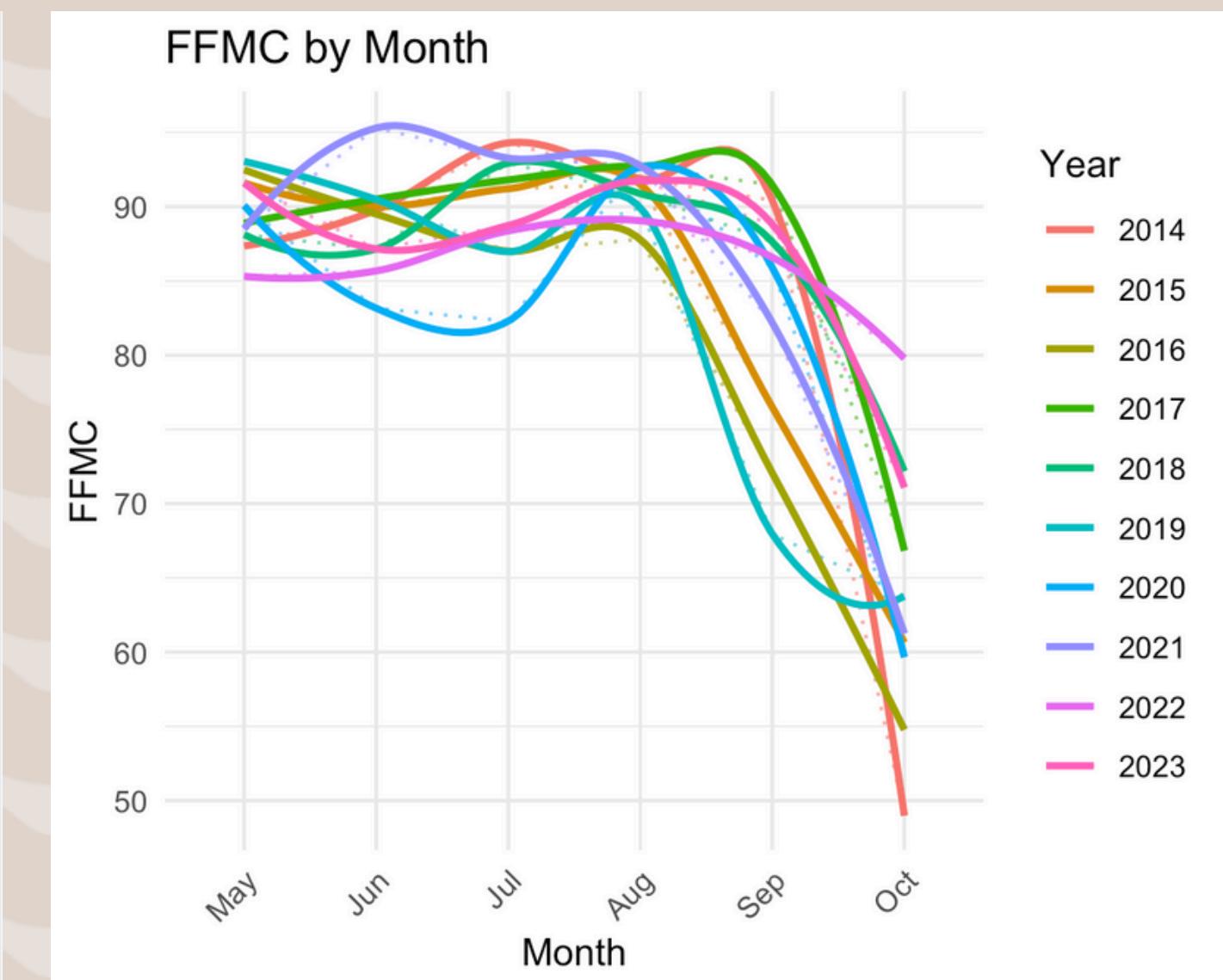
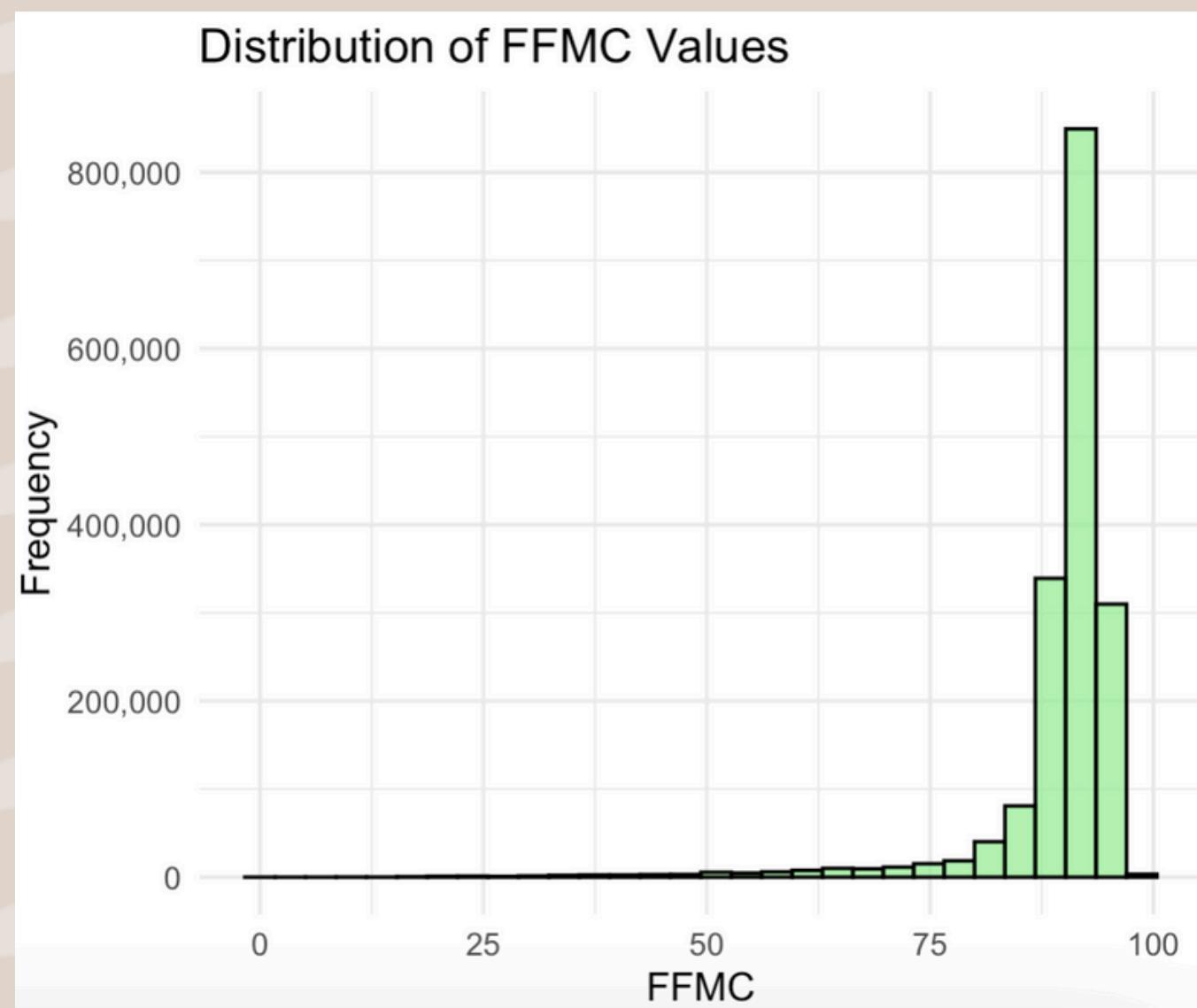




EXPLORATION OF VARIABLES

FIRE INDEX VARIABLE : FFMC, DMC, DC (MOISTURE CONTENT)

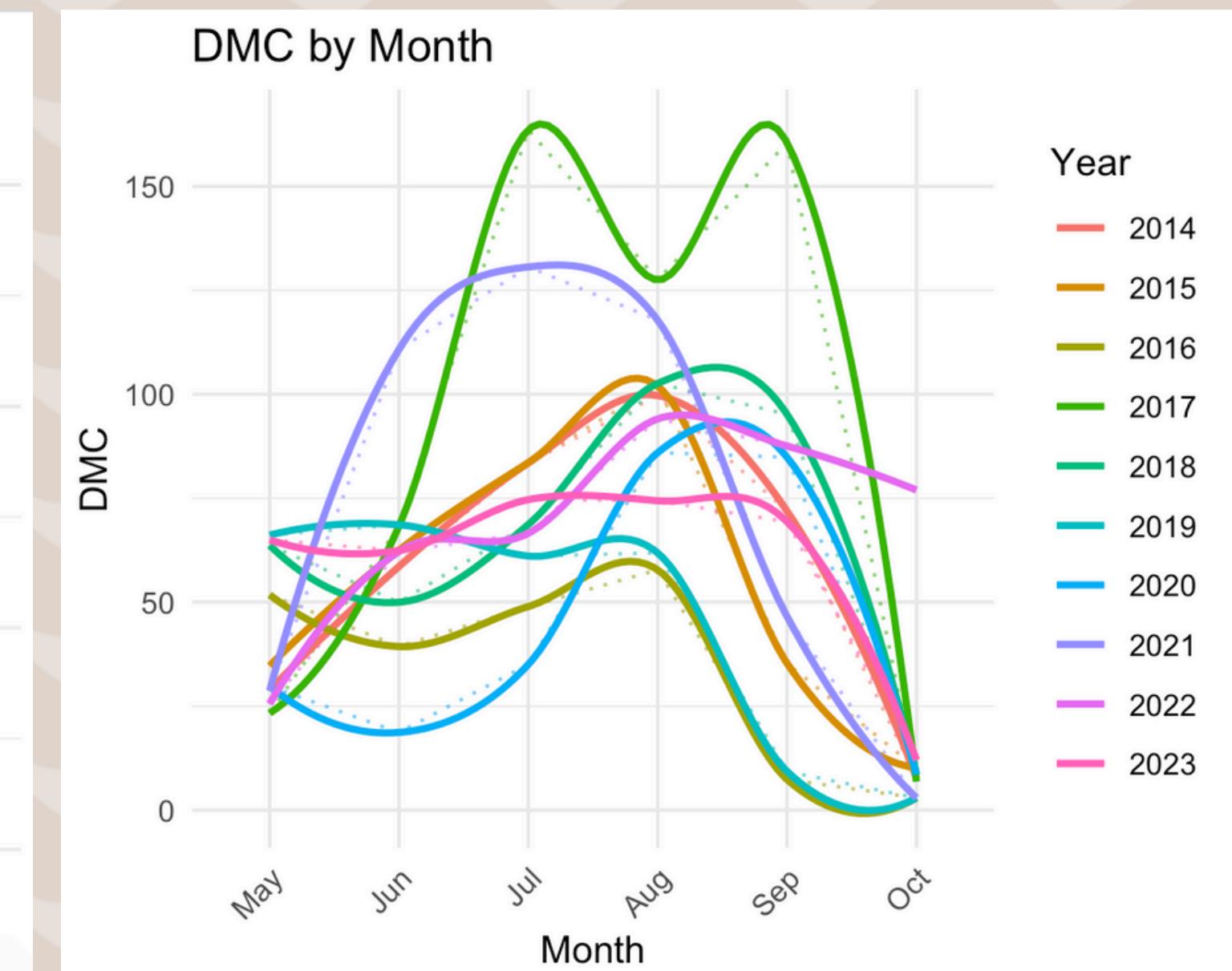
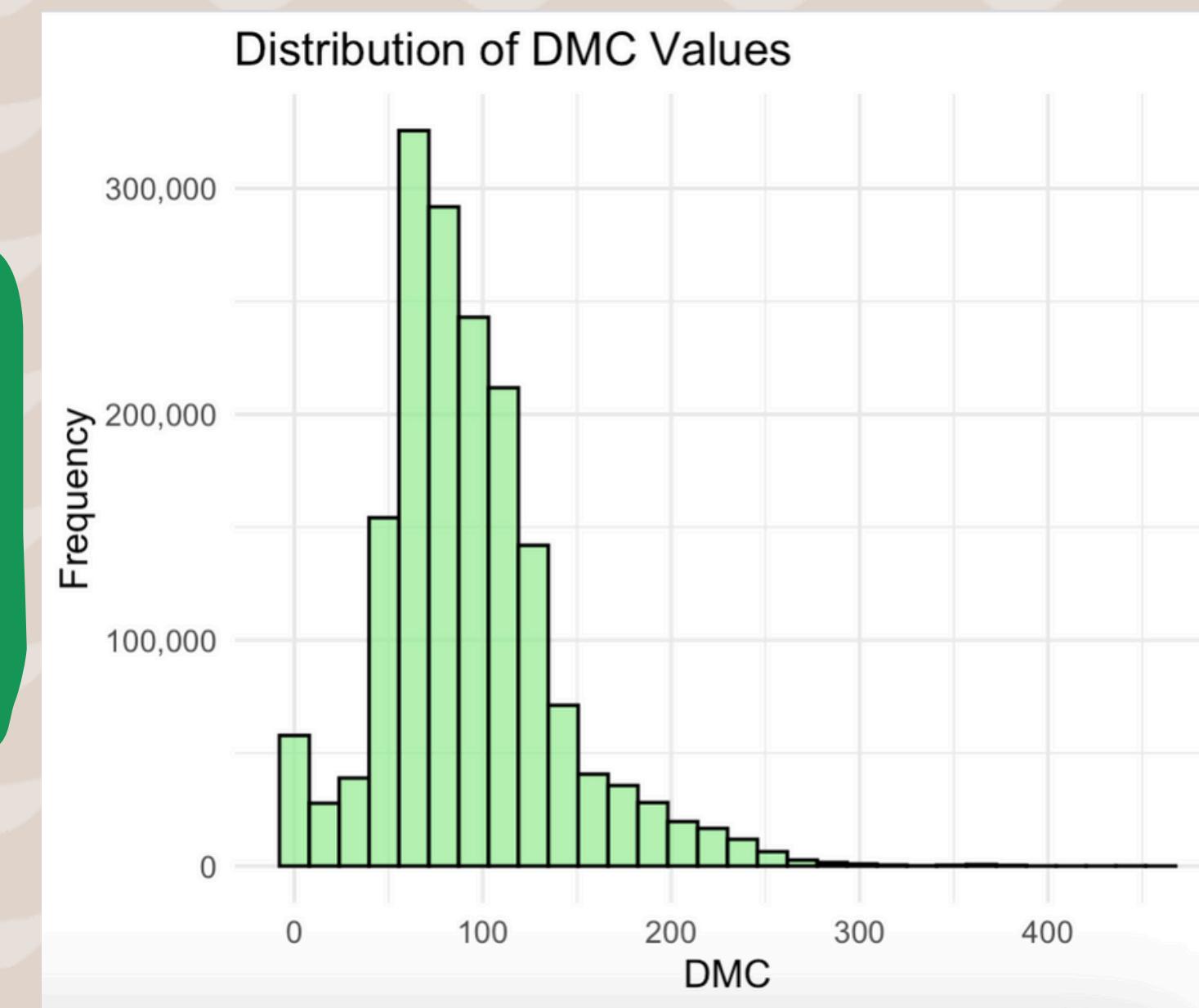
FFMC (Fine Fuel Moisture Code) -
indicator of relatively ease of ignition & the flammability.
e.g small twigs, fallen leaves



EXPLORATION OF VARIABLES

FIRE INDEX VARIABLE : FFMC, DMC, DC (MOISTURE CONTENT)

DMC (Duff Moisture Code) – average moisture content of loosely compacted organic layers of moderate depth.

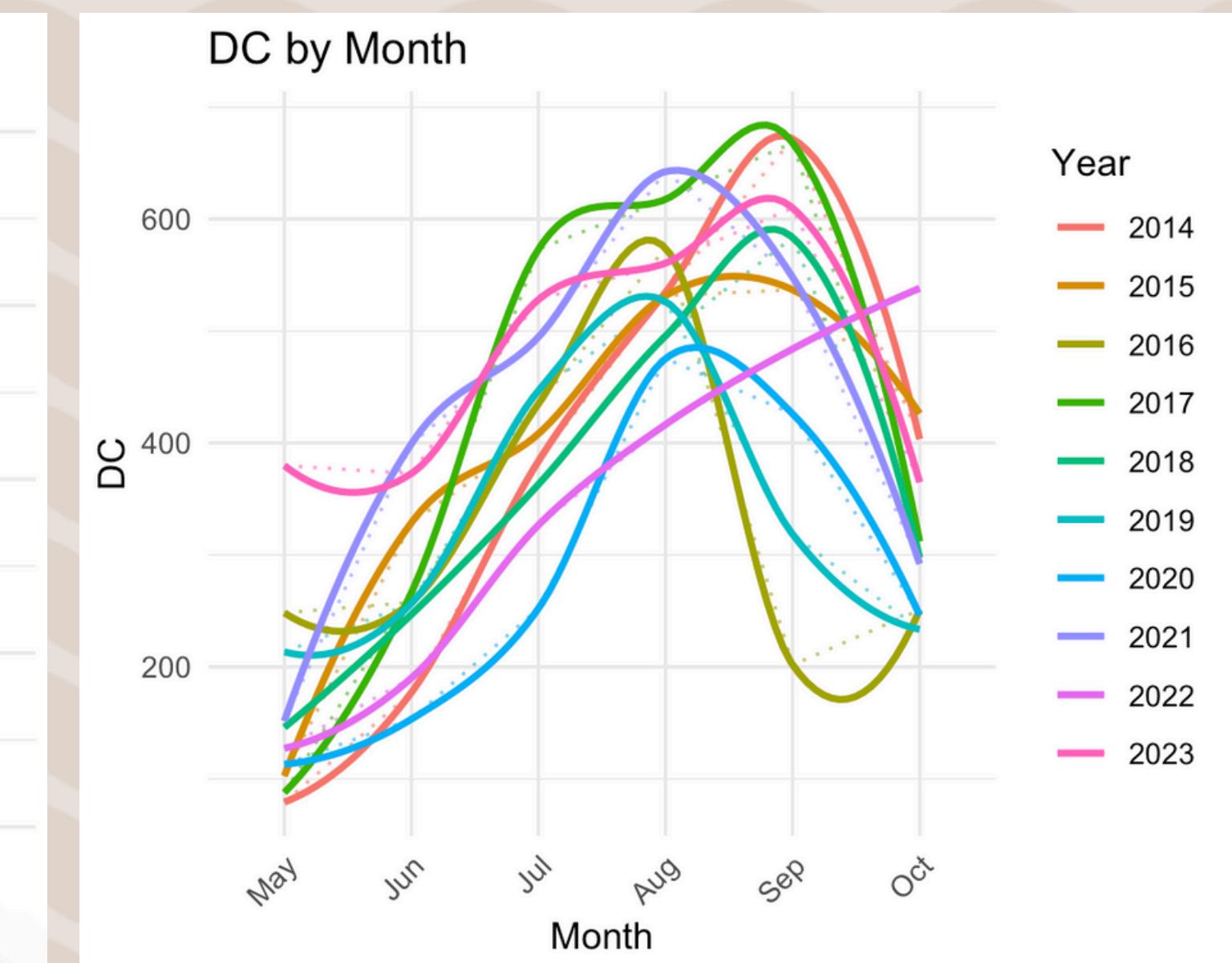
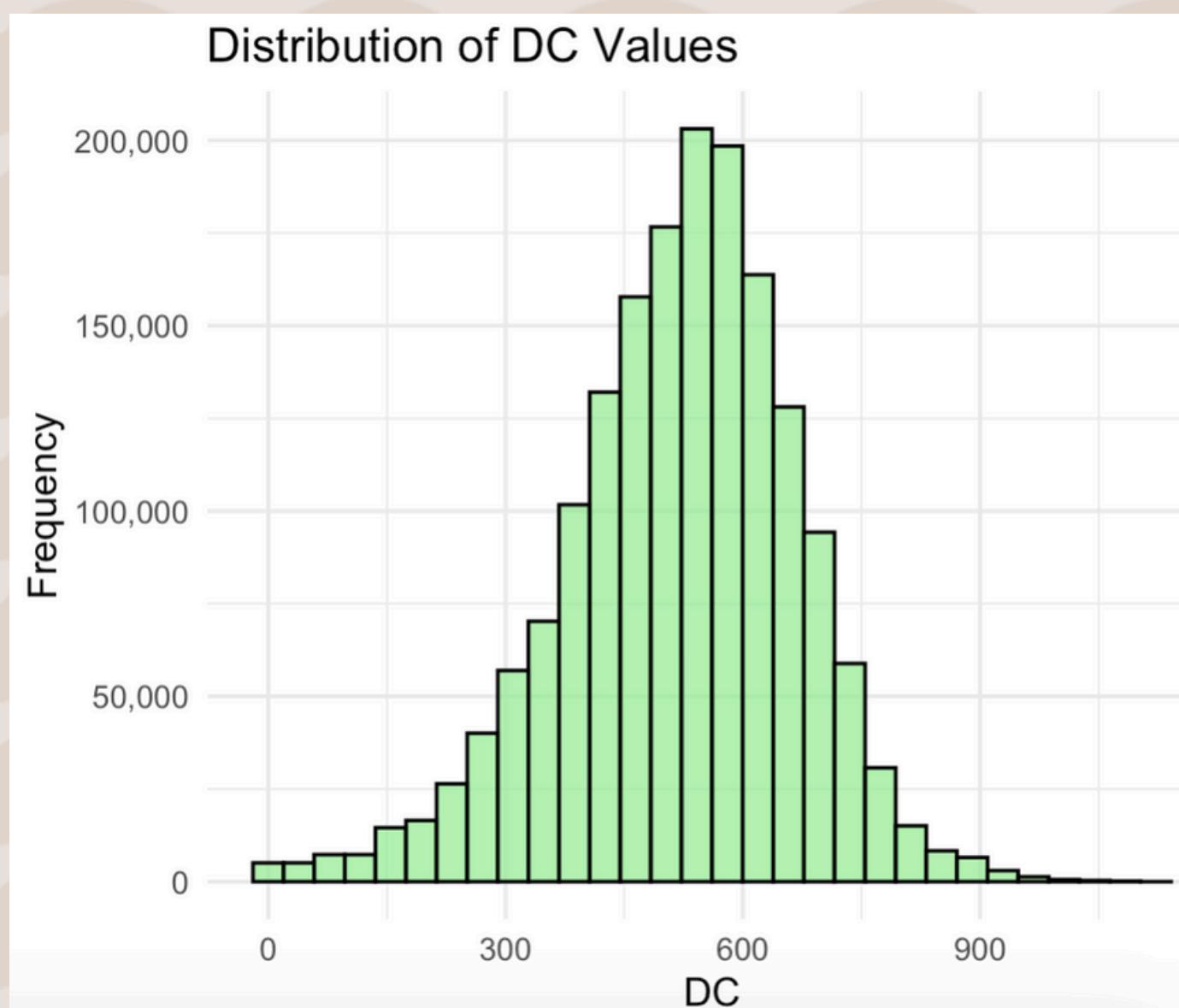




EXPLORATION OF VARIABLES

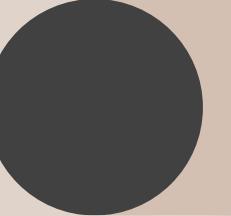
FIRE INDEX VARIABLE : FFMC, DMC, DC (MOISTURE CONTENT)

**DC (Drought Code) -
average moisture
content of deep,
compact organic layer**



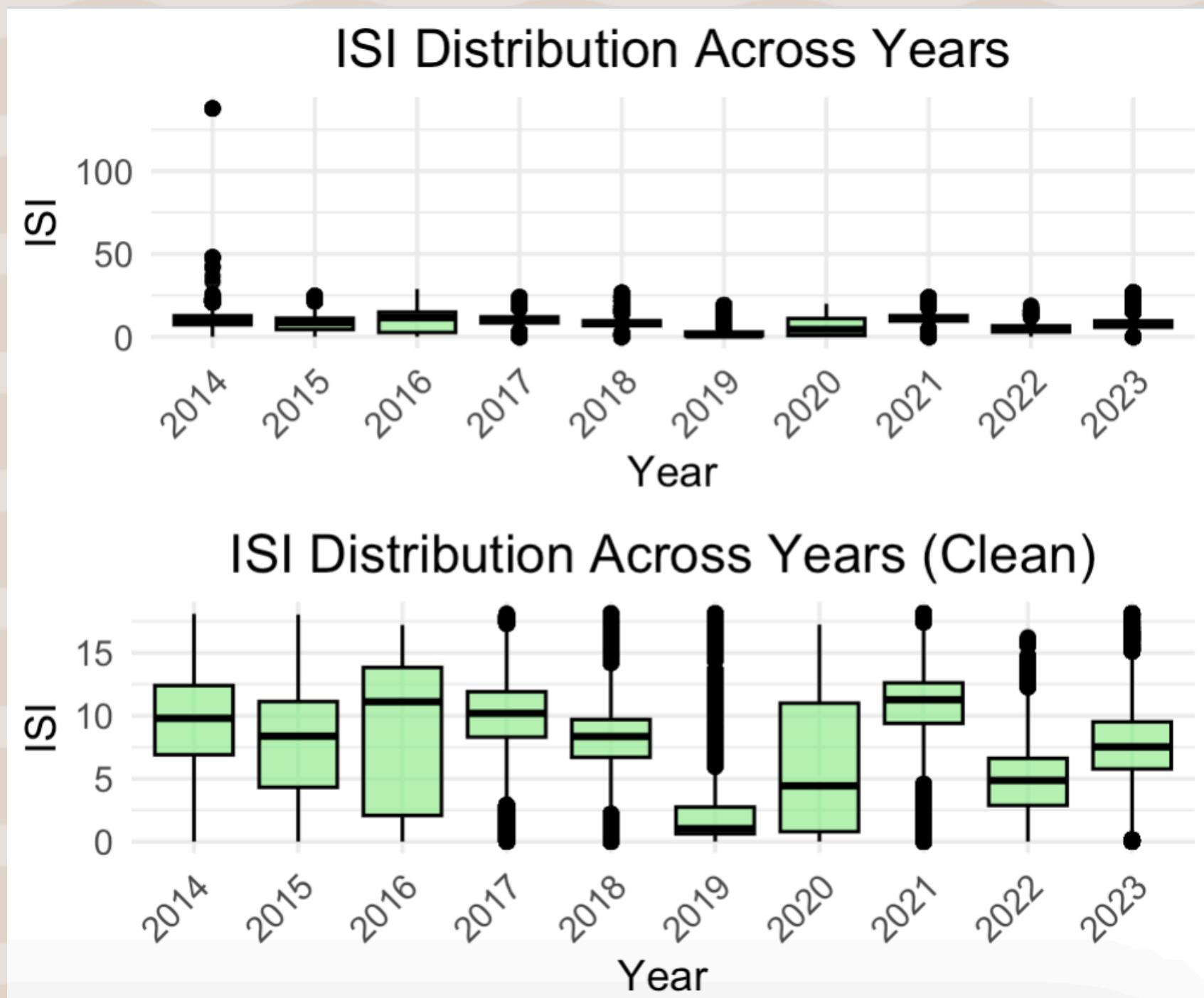


EXPLORATION OF VARIABLES



FIRE INDEX VARIABLE : ISI, BUI, FWI (FIRE BEHAVIOUR)

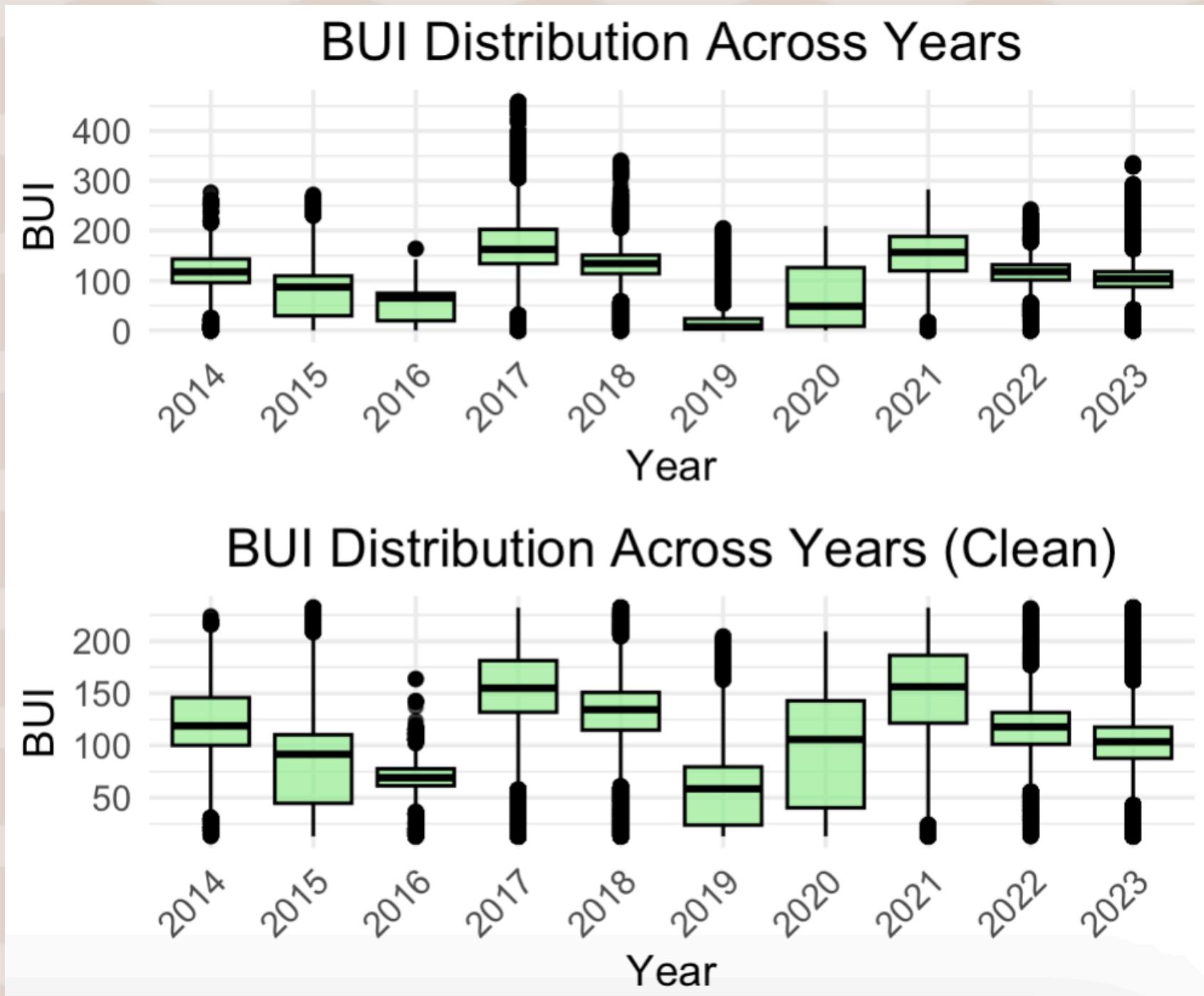
ISI (Initial Spread Index) - expected rate of fire spread



EXPLORATION OF VARIABLES

FIRE INDEX VARIABLE : ISI, BUI, FWI (FIRE BEHAVIOUR)

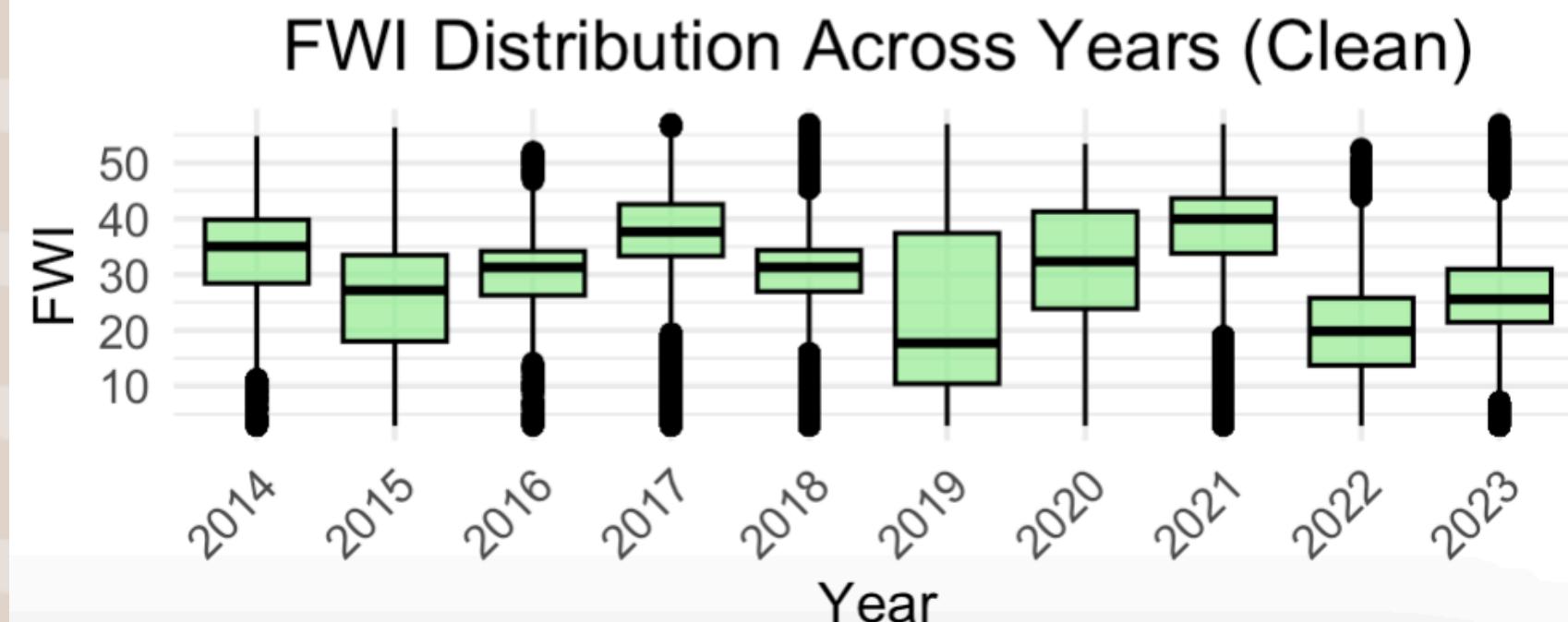
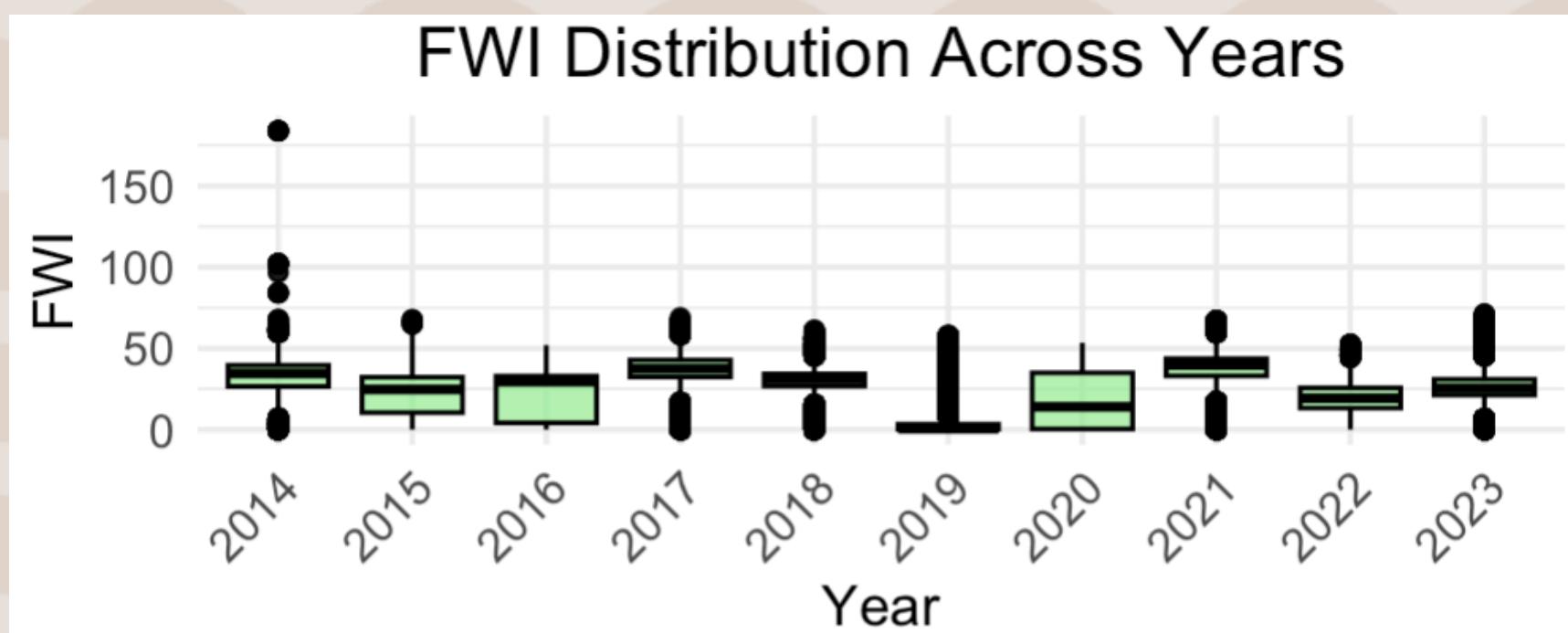
BUI (Buildup Index) -
total amount of fuel
available for
combustion on the
landscape



EXPLORATION OF VARIABLES

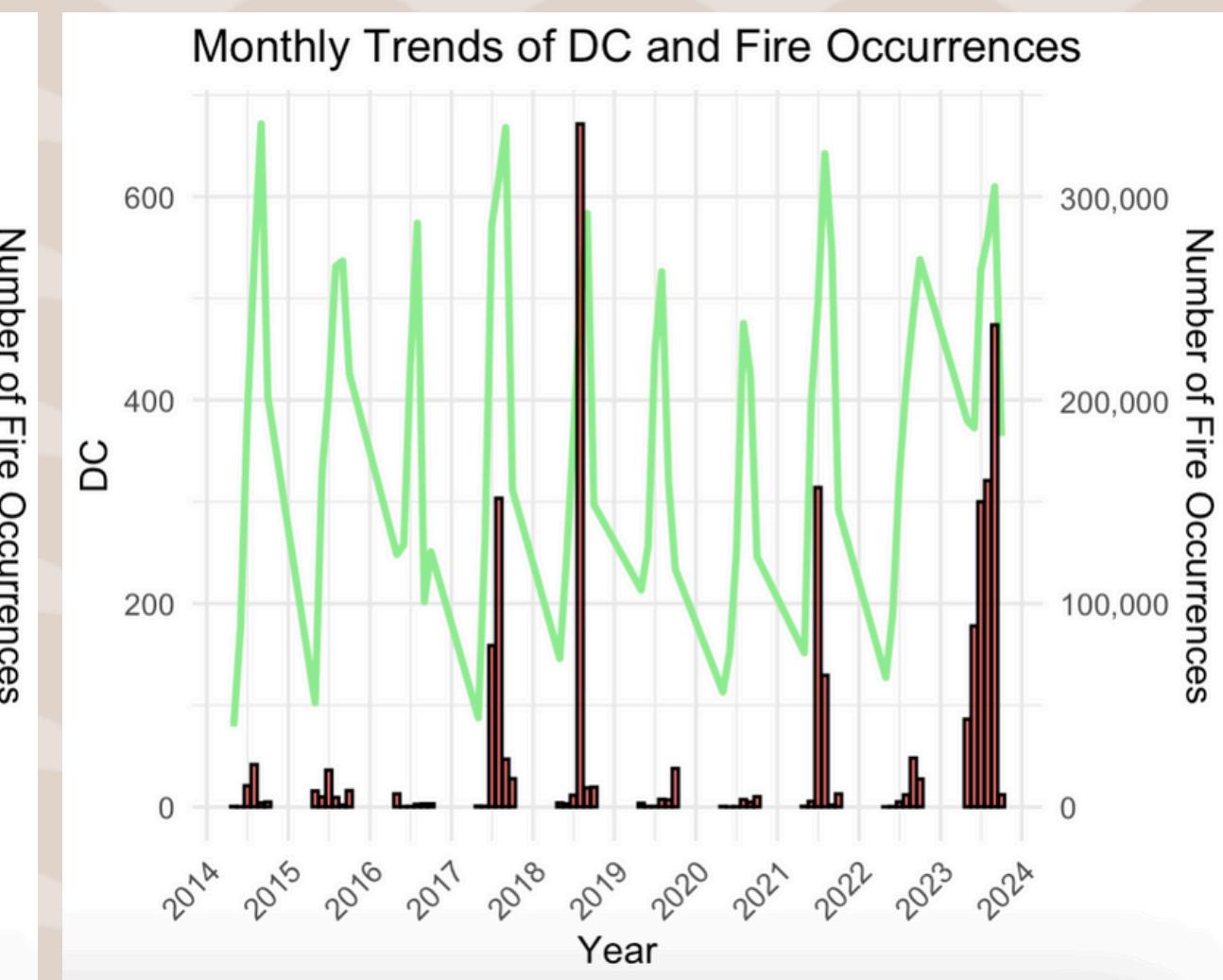
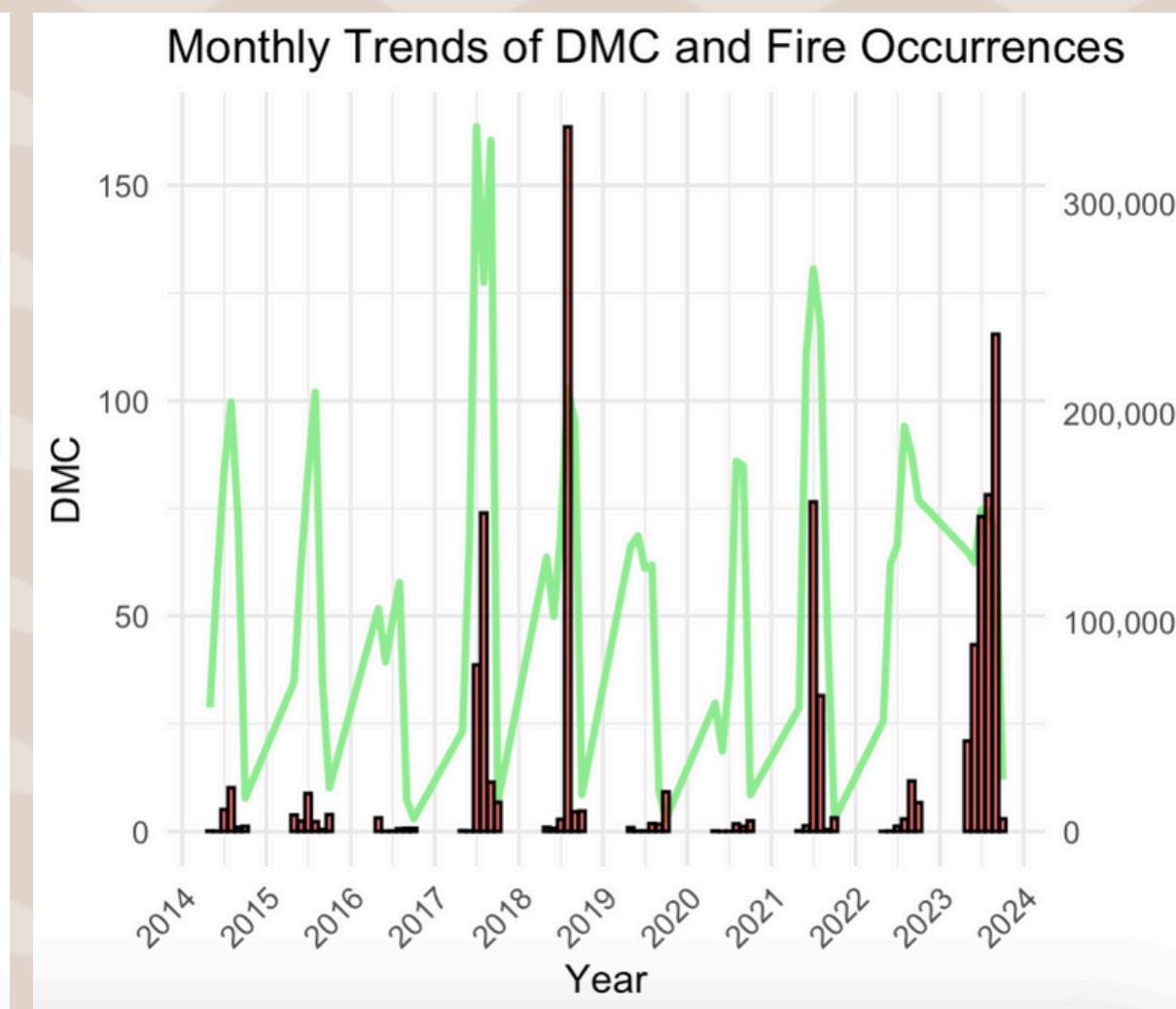
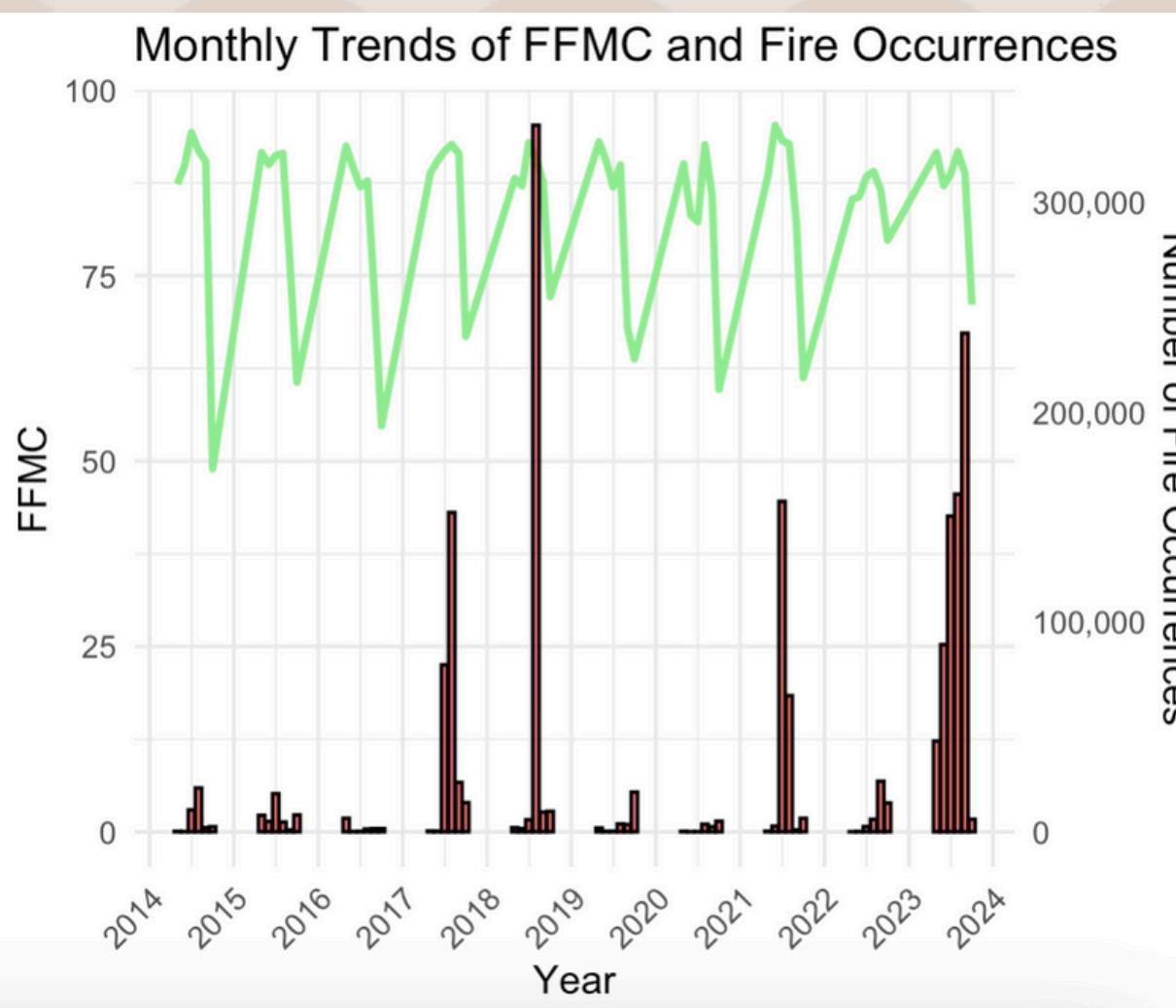
FIRE INDEX VARIABLE : ISI, BUI, FWI (FIRE BEHAVIOUR)

FWI (Fire Weather Index) – numeric rating of fire intensity



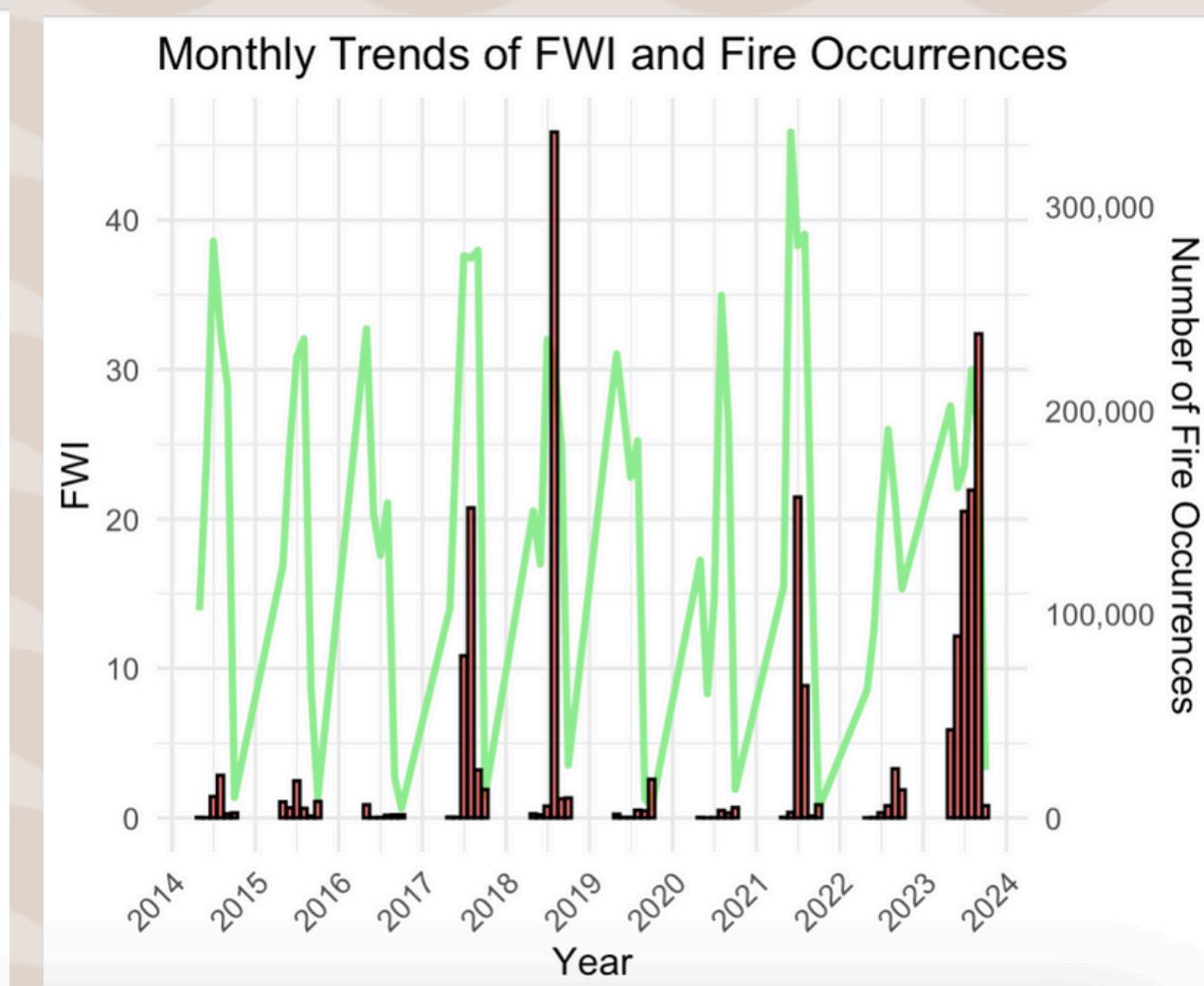
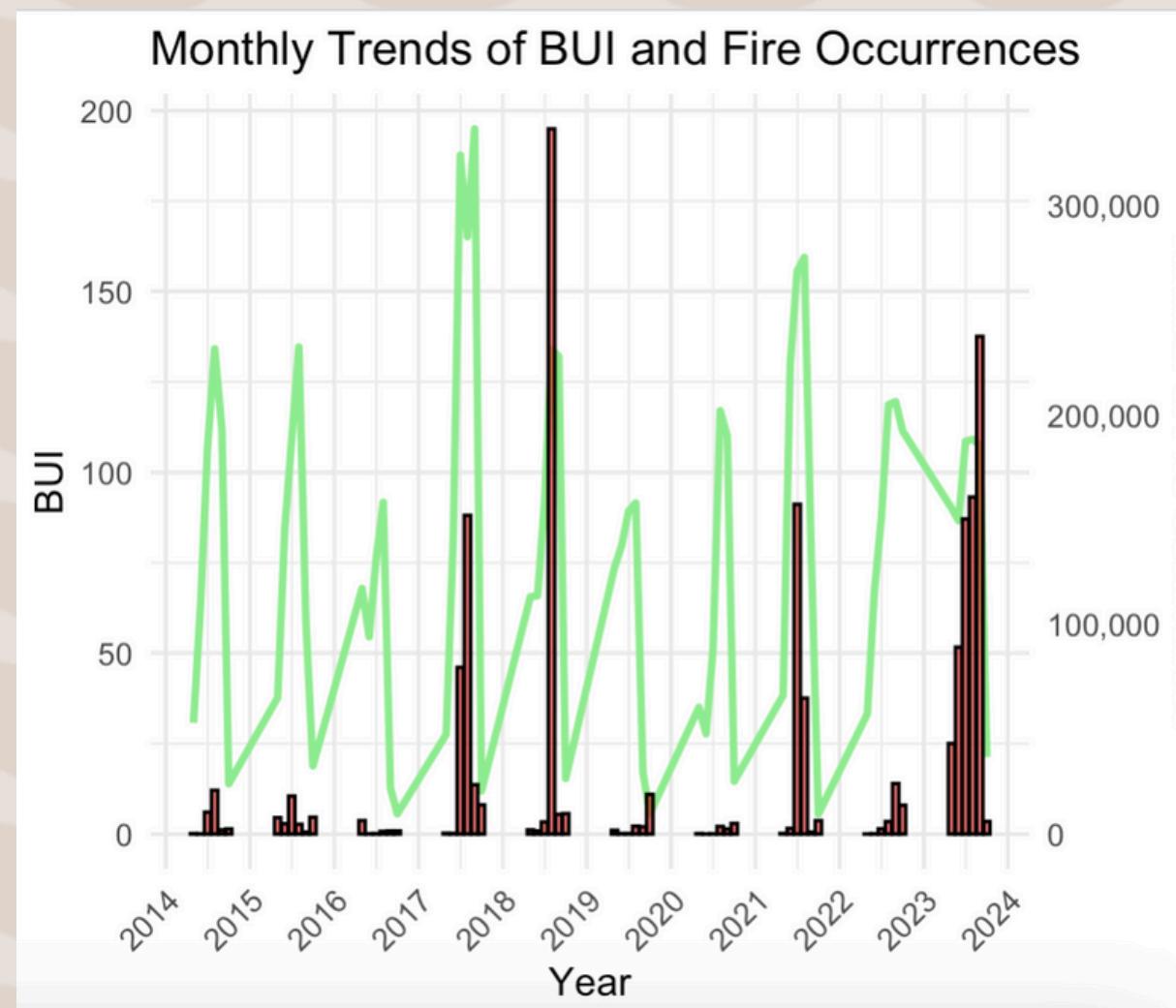
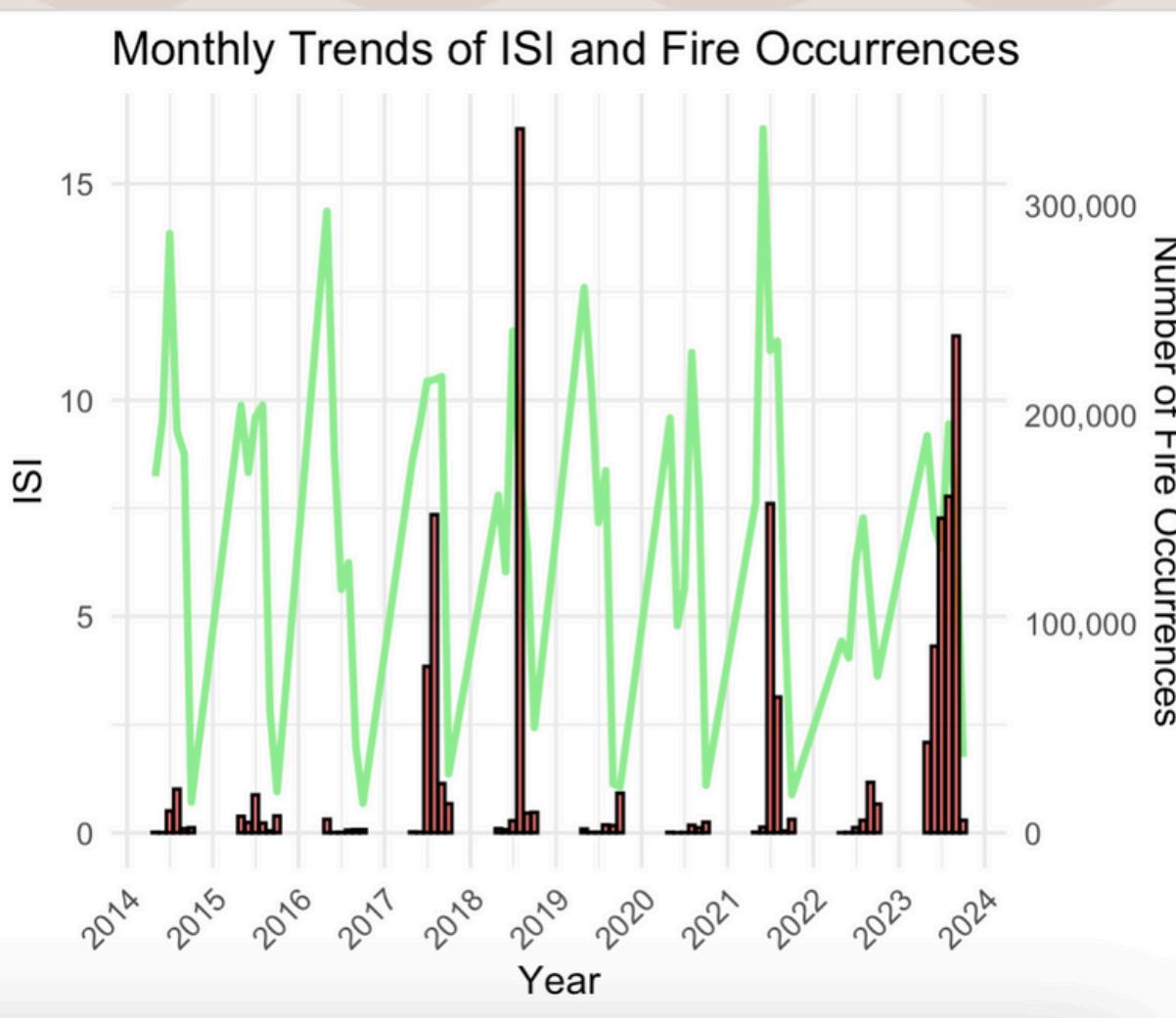
TREND ANALYSIS

TREND ANALYSIS BETWEEN FIRE INDEX AND FIRE EVENTS



TREND ANALYSIS

TREND ANALYSIS BETWEEN FIRE INDEX AND FIRE EVENTS



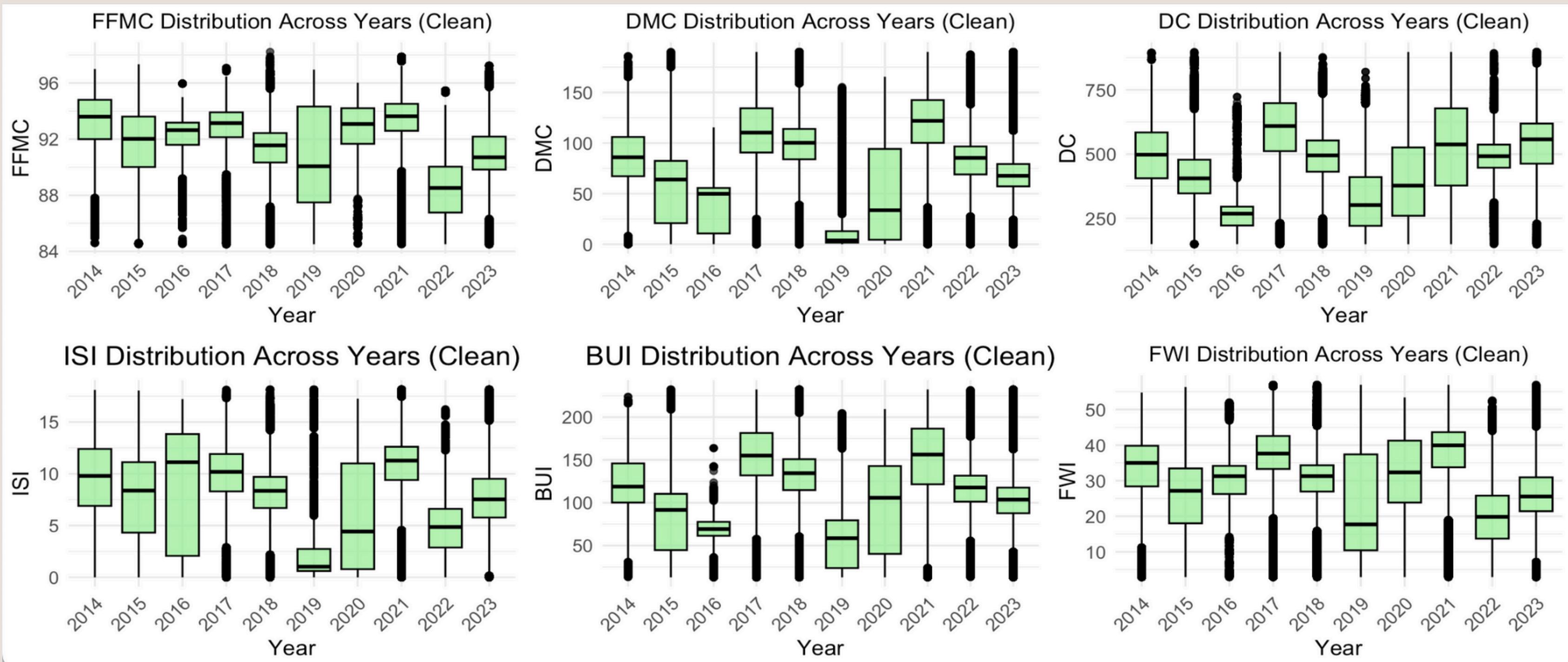
T-TEST AND MODEL

- Subset to focus on numerical variables
- Number of sample
- Exclude outliers and check NA Value
- Run Appropriate T-test

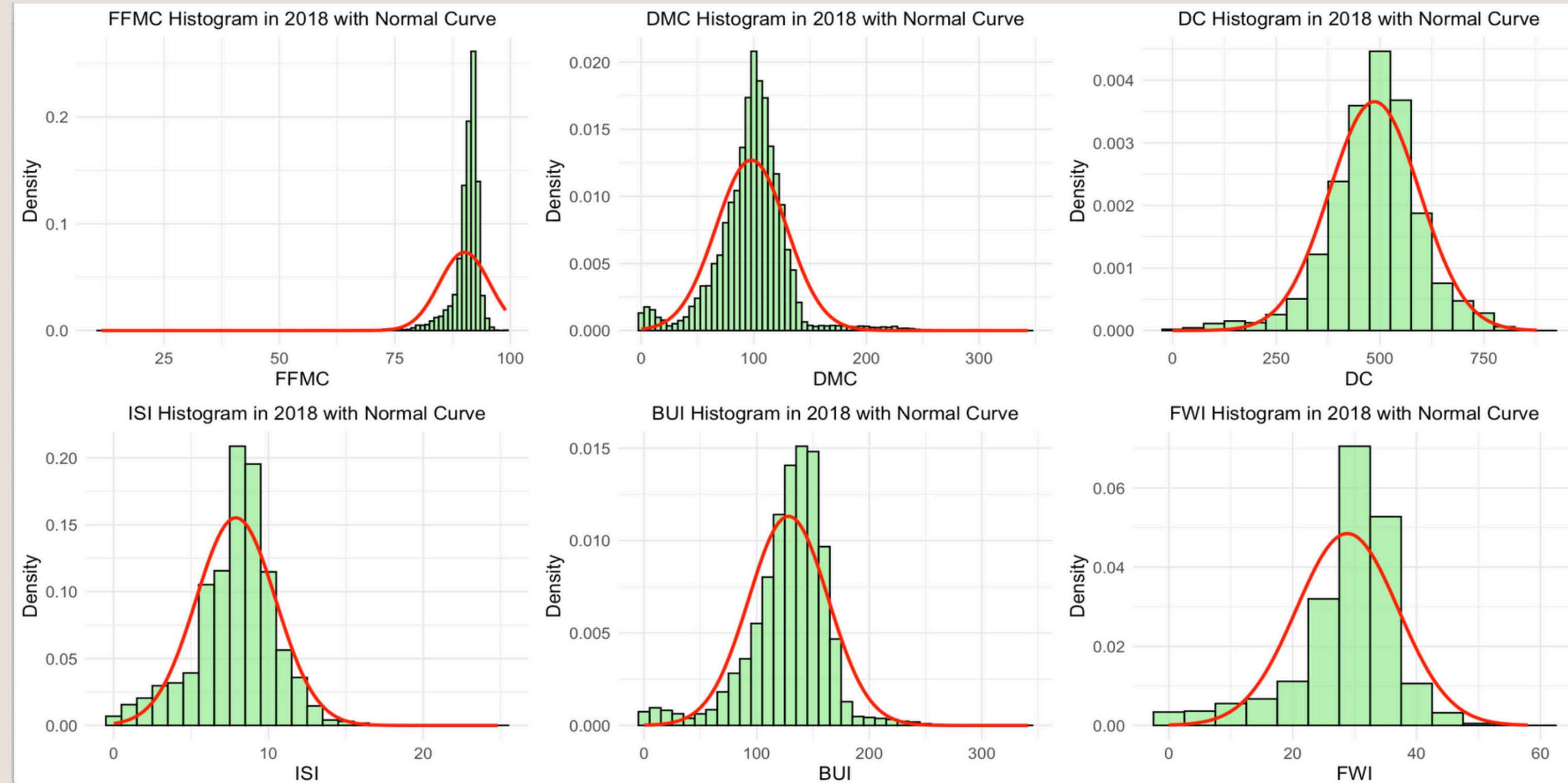
- Plot to see the normal distribution
- Run Wilcoxon Test

- Check correlations and choose predictors for linear regression model
- Testing the Model

TESTING PROCEDURE

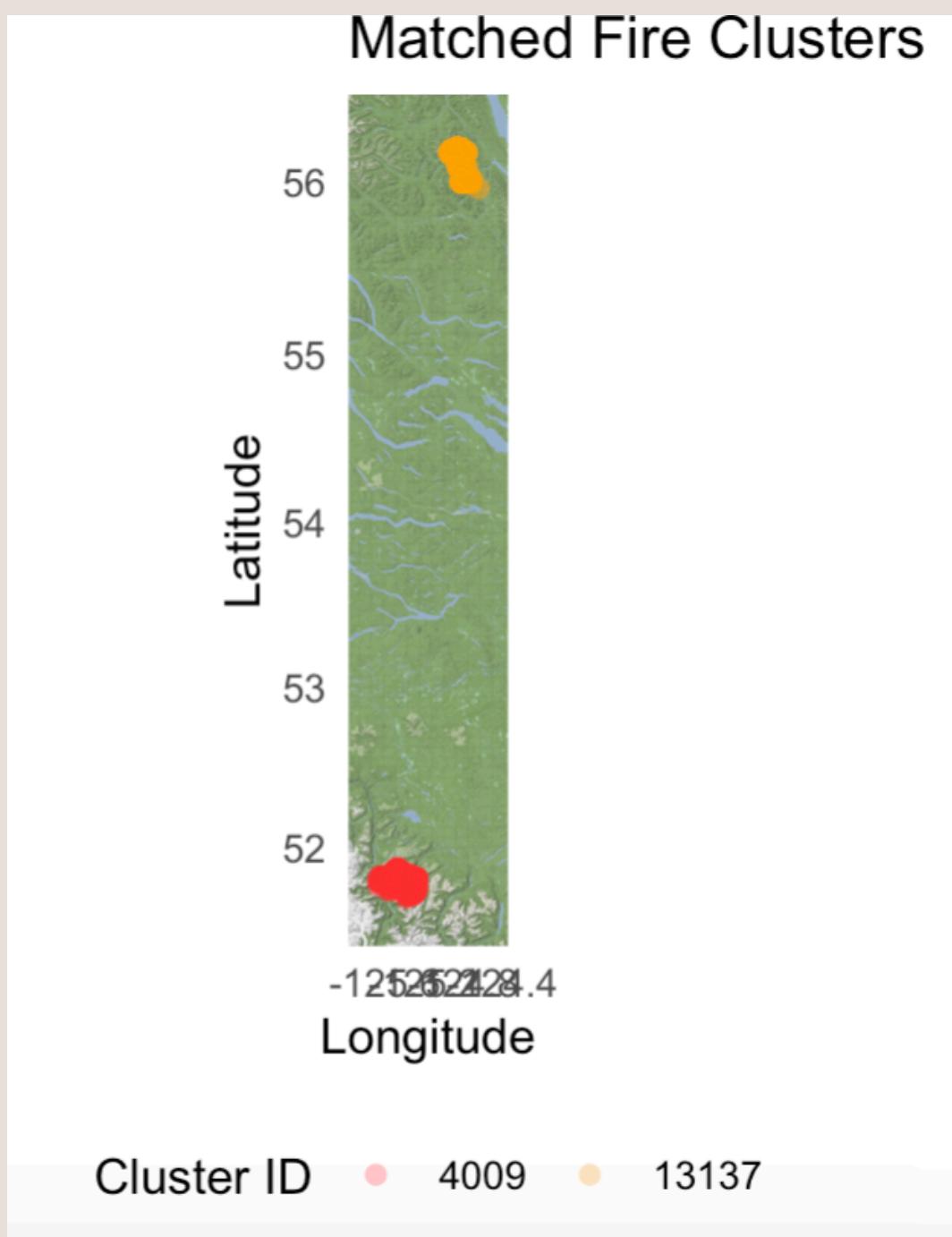


TESTING PROCEDURE

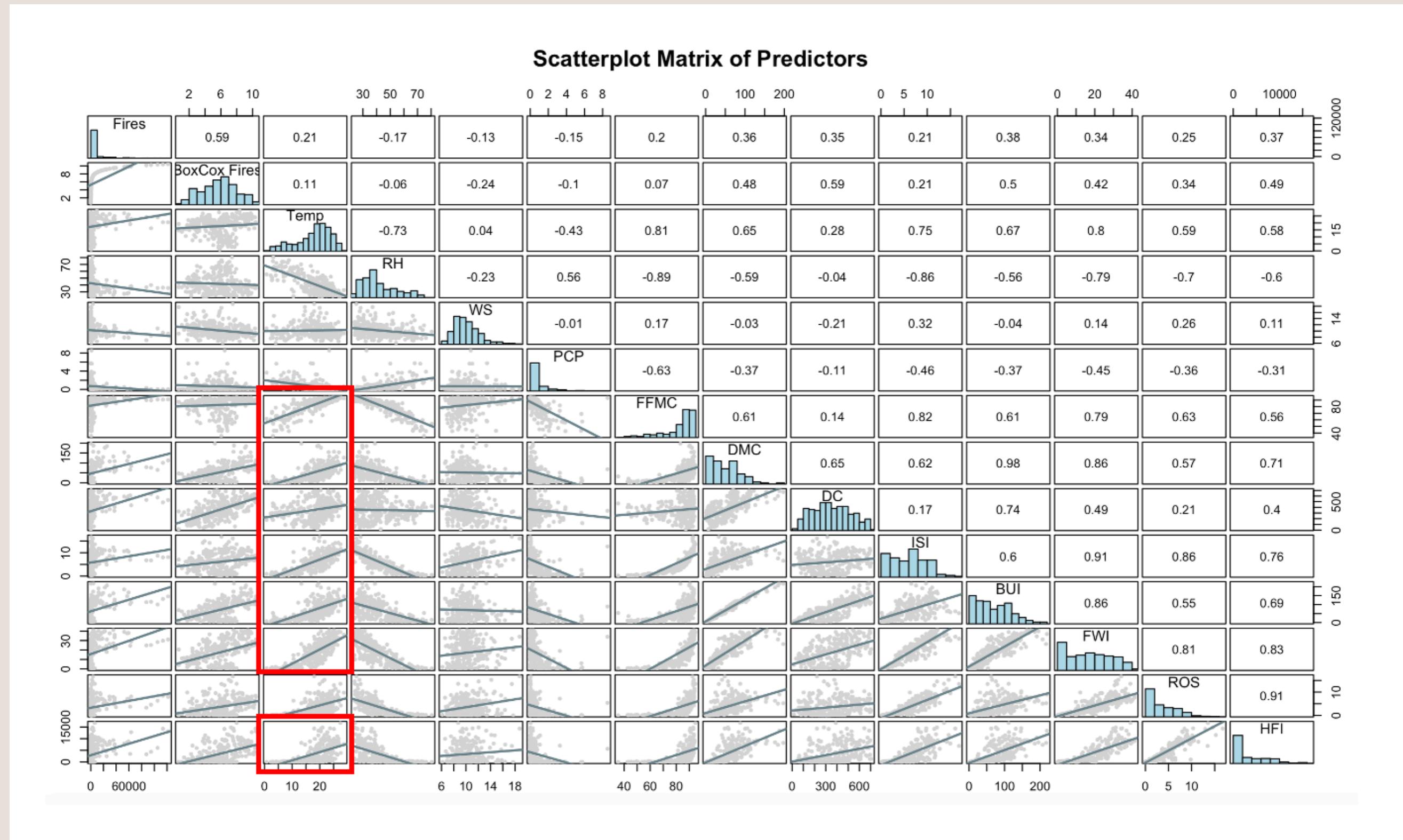


TESTING PROCEDURE

- Found cluster which has similarity in terms of the 6 fire index

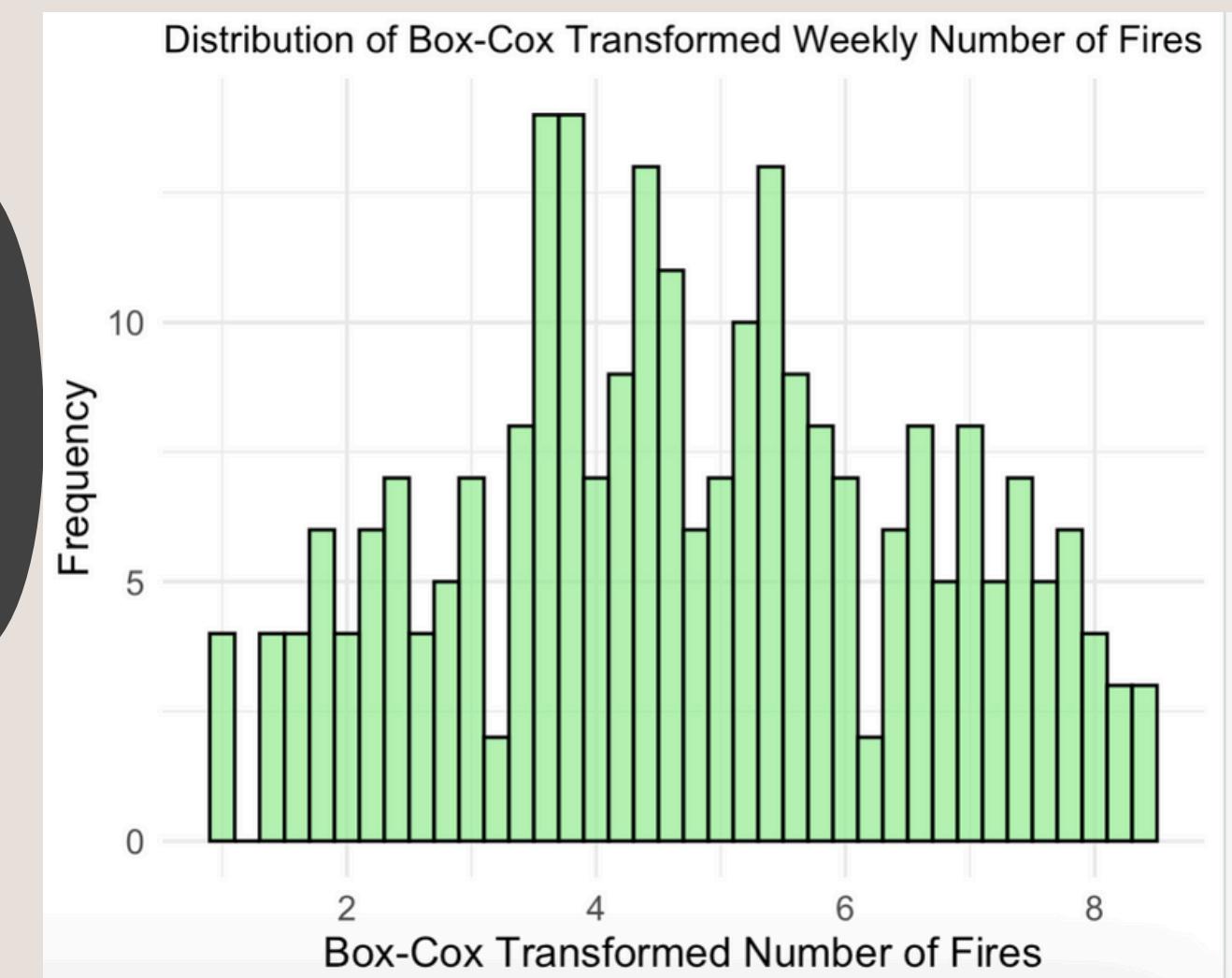
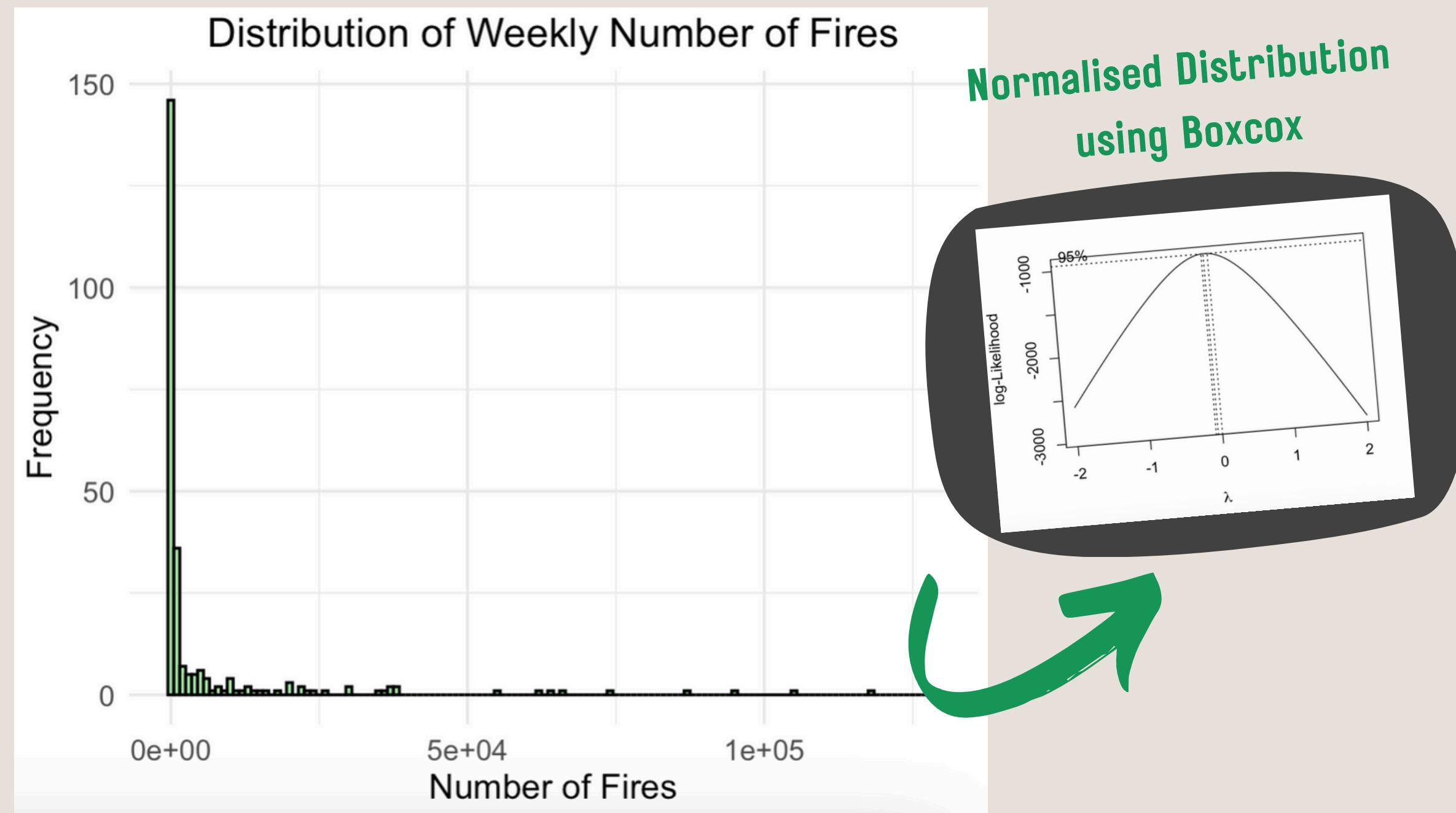


LINEAR REGRESSION



MODEL

- Transform number of fire event and fire index average in weekly basis



MODEL

- Test model started from 6 fire index , then check multicollinearity and rework to achieve appropriate model

1

```
Call:
lm(formula = boxcox_fires ~ dmc + dc + bui + fwi + hfi + ffmc +
    isi, data = weekly_summary)
```

Residuals:

| Min | 1Q | Median | 3Q | Max |
|---------|---------|--------|--------|--------|
| -3.3806 | -0.8998 | 0.0634 | 0.8441 | 3.7086 |

Coefficients:

| | Estimate | Std. Error | t value | Pr(> t) |
|-------------|------------|------------|---------|--------------|
| (Intercept) | -7.661e+00 | 3.139e+00 | -2.441 | 0.015360 * |
| dmc | 4.531e-03 | 1.803e-02 | 0.251 | 0.801776 |
| dc | 3.879e-03 | 1.076e-03 | 3.607 | 0.000376 *** |
| bui | -3.460e-03 | 1.981e-02 | -0.175 | 0.861517 |
| fwi | 4.936e-02 | 5.372e-02 | 0.919 | 0.359049 |
| hfi | 1.079e-04 | 3.261e-05 | 3.307 | 0.001085 ** |
| ffmc | 1.227e-01 | 3.798e-02 | 3.231 | 0.001404 ** |
| isi | -1.849e-01 | 9.973e-02 | -1.853 | 0.065028 . |

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.282 on 243 degrees of freedom

Multiple R-squared: 0.5339, Adjusted R-squared: 0.5205

F-statistic: 39.77 on 7 and 243 DF, p-value: < 2.2e-16

> vif(model_1)

| dmc | dc | bui | fwi | hfi | ffmc | isi |
|-----------|----------|------------|-----------|----------|----------|-----------|
| 71.646154 | 5.402068 | 126.267107 | 50.437070 | 3.711512 | 4.887781 | 17.218502 |

2

```
Call:
lm(formula = boxcox_fires ~ dmc + dc + fwi + hfi + ffmc + isi,
    data = weekly_summary)
```

Residuals:

| Min | 1Q | Median | 3Q | Max |
|---------|---------|--------|--------|--------|
| -3.3678 | -0.9068 | 0.0508 | 0.8667 | 3.6864 |

Coefficients:

| | Estimate | Std. Error | t value | Pr(> t) |
|-------------|------------|------------|---------|--------------|
| (Intercept) | -7.782e+00 | 3.055e+00 | -2.548 | 0.011464 * |
| dmc | 1.537e-03 | 5.568e-03 | 0.276 | 0.782707 |
| dc | 3.744e-03 | 7.459e-04 | 5.020 | 9.96e-07 *** |
| fwi | 4.369e-02 | 4.272e-02 | 1.023 | 0.307394 |
| hfi | 1.092e-04 | 3.158e-05 | 3.459 | 0.000640 *** |
| ffmc | 1.241e-01 | 3.702e-02 | 3.353 | 0.000928 *** |
| isi | -1.769e-01 | 8.849e-02 | -1.999 | 0.046735 * |
| --- | | | | |

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.28 on 244 degrees of freedom

Multiple R-squared: 0.5339, Adjusted R-squared: 0.5224

F-statistic: 46.58 on 6 and 244 DF, p-value: < 2.2e-16

> vif(model_no_bui)

| dmc | dc | fwi | hfi | ffmc | isi |
|----------|----------|-----------|----------|----------|-----------|
| 6.860335 | 2.608283 | 32.023793 | 3.494464 | 4.663975 | 13.609199 |

FINAL MODEL

- Test model started from 6 fire index , then check multicollinearity and rework to achieve appropriate model

3

```
Call:
lm(formula = boxcox_fires ~ dmc + dc + hfi + ffmc + isi, data = weekly_summary)

Residuals:
    Min      1Q  Median      3Q     Max 
-3.9542 -0.9217  0.0803  0.8811  3.4199 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) -9.1725060  2.7361807 -3.352 0.000928 ***
dmc          0.0059544  0.0035151  1.694 0.091547 .  
dc           0.0041543  0.0006291  6.603 2.48e-10 ***
hfi          0.0001176  0.0000305  3.857 0.000147 *** 
ffmc         0.1390352  0.0340308  4.086 5.96e-05 *** 
isi          -0.1063571  0.0554752 -1.917 0.056375 .  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Residual standard error: 1.28 on 245 degrees of freedom
 Multiple R-squared: 0.5319, Adjusted R-squared: 0.5223
 F-statistic: 55.68 on 5 and 245 DF, p-value: < 2.2e-16

```
> vif(model_no_fwi)
   dmc      dc      hfi      ffmc      isi
2.733665 1.855307 3.258580 3.940046 5.347517
```



```
Call:
lm(formula = boxcox_fires ~ dc + hfi + ffmc, data = weekly_summary)

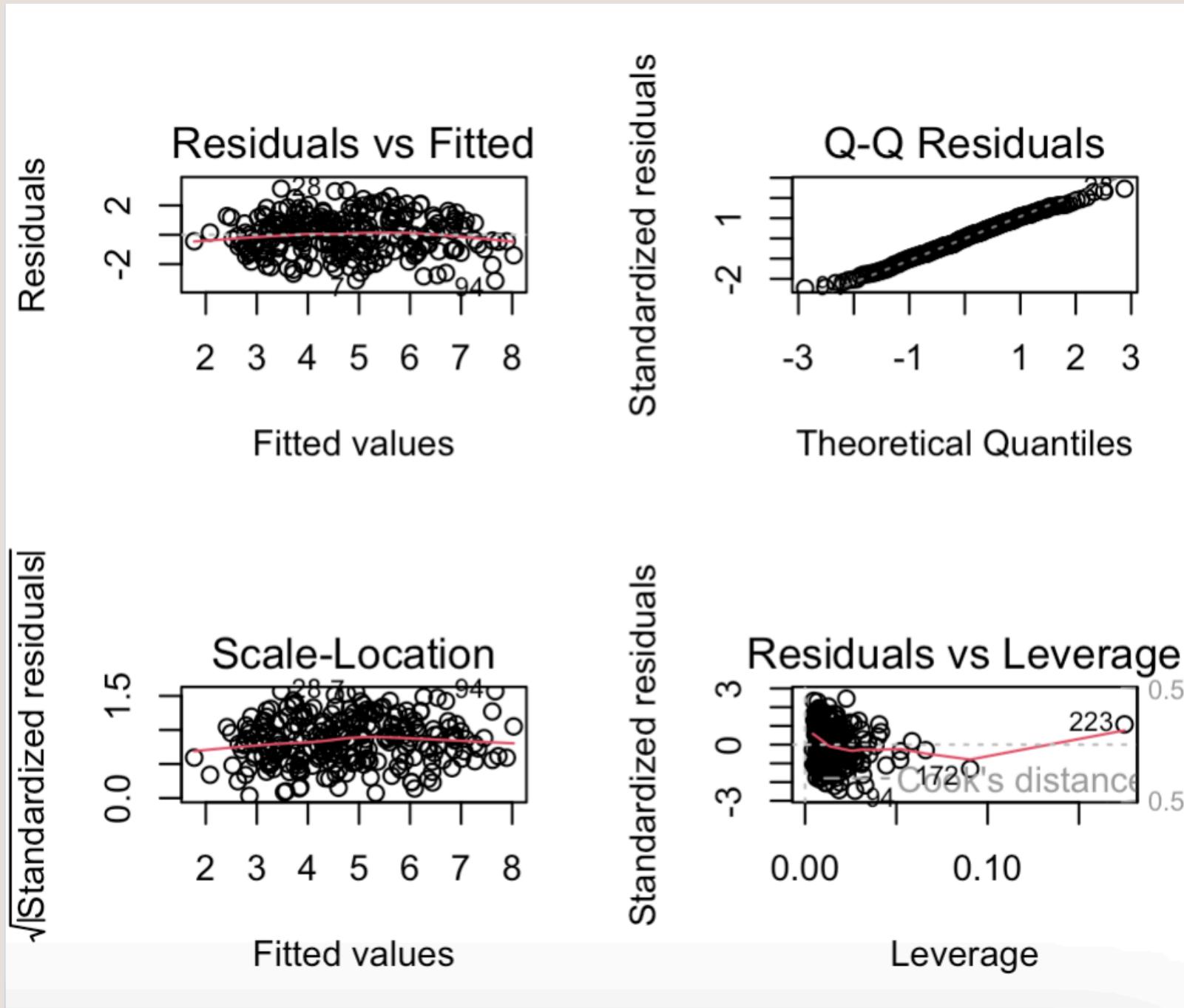
Residuals:
    Min      1Q  Median      3Q     Max 
-3.13574 -0.94013  0.00977  0.93856  3.14025 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) -6.8627267  2.0448755 -3.356 0.000915 ***
dc           0.0050003  0.0005140  9.728 < 2e-16 ***
hfi          0.0001067  0.0000238  4.484 1.12e-05 *** 
ffmc         0.1049715  0.0232203  4.521 9.57e-06 *** 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Residual standard error: 1.292 on 247 degrees of freedom
 Multiple R-squared: 0.519, Adjusted R-squared: 0.5131
 F-statistic: 88.83 on 3 and 247 DF, p-value: < 2.2e-16

```
> vif(model_final)
   dc      hfi      ffmc
1.21514 1.94711 1.79975
```

FINAL MODEL



Kelowna Fire (2023)

| DC | HFI | FFMC | Predicted fire |
|-----|------|------|----------------|
| 867 | 3389 | 91.6 | 20114 |
| 929 | 6282 | 93.4 | 94072 |
| 920 | 1010 | 86.5 | 7941 |

| DC | HFI | FFMC | DMC | ISI | BUI | FWI | Predicted fires |
|-----|------|------|------|-------|-----|------|-----------------|
| 867 | 3389 | 91.6 | 98.9 | 8.14 | 154 | 32 | 15269 |
| 929 | 6282 | 93.4 | 176 | 14.00 | 239 | 48 | 41011 |
| 920 | 1010 | 86.5 | 170 | 4.68 | 233 | 23.4 | 7397 |



THANK YOU!