APPLIED STATISTICS FOR FIREFAMILYPLUS

Contents

OBJECTIVE(S)

Upon completion of this lesson, participants will be able to:

1. Describe the statistics used in FireFamily to analyze NFDRS indices.
2. Use FireFamily to analyze NFDRS indices to select a final fuel model.

NARRATIVE

I. INTRODUCTION

FireFamilyPlus (FFP) is a computer software system that supports the spectrum of fire weather, fire danger, fire climate, and fire occurrence analysis tools required by fire managers to successfully use the National Fire Danger Rating System (NFDRS). History and downloads can be found at: https://www.firelab.org/project/firefamilyplus .

A. FFP can be used to compute indexes and components of the National Fire Danger Rating System (NFDRS), and the Canadian Forest Fire Danger Rating System from weather climatology data.

B. FFP can summarize weather climatology to produce climatological breakpoints for fire management decision making.

C. Combining fire occurrence record in the analysis displays the historical relationships between weather conditions and increasing fire occurrence which can be used to set fire business thresholds and track seasonal progression of Fire Danger.

II. WHY IS CLIMATOLOGY IMPORTANT?

A. Climate may be defined as the average course or condition of the weather at a specific place over a period of years as exhibited by temperature, humidity, wind velocity and precipitation. Fire Danger climatology further integrates (via the fire model) those basic meteorological parameters by inclusion of site descriptions (e.g. slope and fuel model), fuel moisture models, indexes and components.

B. Fire Danger Rating is based on climate; it is not a fire behavior prediction system. Fire management planning decisions may be made months before a fire season, and actions based on those decisions may be implemented over several years. And certainly, weather conditions affecting possible future fires are uncertain.

C. We use climatology (hindsight) as a proxy for prediction (foresight) to describe which weather conditions are likely, or unlikely, to occur in the face of uncertainty. Historical weather records provide the basis for this hindsight based on two assumptions:

1. Future weather patterns will not be greatly different from those in the past, and

2. Enough data have been archived to sample the variability in the weather of an area adequately. (10-15 years of data).

III. SUMMARIZING CLIMATOLOGICAL DATA USING OUTPUTS FROM FIREFAMILYPLUS

A. FireFamilyPlus has numerous outputs that are helpful when looking at climatological data. To interpret them, you need to know a few definitions regarding probability.

1. **Random Event**: any occurrence for which the outcome is uncertain.

2. **Probability**: the numerical chance that a random event will occur.

3. **Probability Distribution**: the pattern with which a random event can occur. We will deal mostly with graphic representations of probability distributions.

4. **Conditional Probability**: the probability of an event, GIVEN that some other event has already occurred

B. Probability outputs can be used for strategic fire management issues such as preparedness levels, staffing levels, and adjective fire rating. Conditional probability works well to inform more tactical decisions such as response (e.g., dispatch) levels.

IV. CHARACTERIZING NFDRS – FIRE BUSINESS RELATIONSHIPS

A. FireFamilyPlus has the capability to systematically associate fires from a specific area to a weather station or group of weather stations. This makes it quite easy to start evaluating the relationship of a weather variable, NFDRS index or component, or Canadian index with actual fire occurrence and size.

B. One way that FireFamilyPlus facilitates this is through seasonal graphs with overlays where each year's weather parameters and fires can be plotted. These overlays provide an informative, but subjective, perspective.

C. FireFamilyPlus allow you to perform a regression analysis between a weather index and what we refer to as a "Fire Business" variable. Because study after study has shown a poor relationship between almost any index and fire size, we look at fire occurrence as a dichotomous or binary event representing Fire Business.

1. Each day that has weather data is called a **Weather-Day**, sometimes called **All Days**. If there are no weather data, the day is not included in further analysis.

2. For each weather day, there is or is not a fire reported in the Fire Danger Rating Area. This is called a **Fire-Day**, recorded as either Yes (1) or No (0).

3. On a Fire-Day, a reported fire either exceeds a threshold fire size (acres) or not. This is called a **Large-Fire-Day**, again, Yes or No.

4. If more than one fire is discovered on a Fire-Day, the number of fires that day exceeds a threshold value or not. This is called a **Multi-Fire-Day** (Yes or No).

   Thus, Fire-Day, Large-Fire-Day, and Multi-Fire-Day are our Fire Business variables in FireFamilyPlus.

D. The regression analysis used in FireFamilyPlus is logistic regression, which has its roots in classical dose/response medical studies. The equation is as follows.

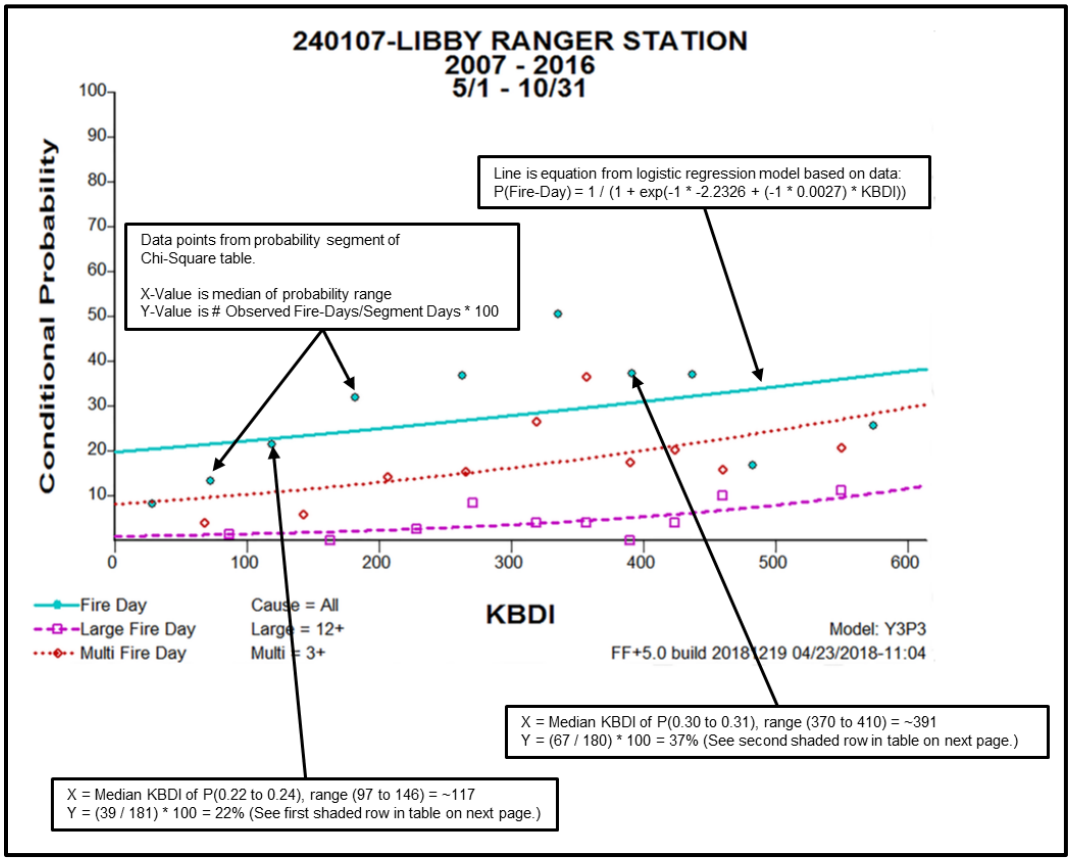
$$P(\text{Fire-Day}|\text{Index}) = 1 / (1 - \exp(a + b * \text{Index}))$$

This equation calculates the probability (0 to 1) of a Fire-Day for a given value of a predictor variable. It is well suited to:

1. displaying the relationship between weather parameters (dose) and different levels of fire business (response) and

2. objectively quantifying the ‘performance’ of an index’s ability to model expected to fire business.

Below is a graphical display of the relationship between a weather parameter (KBDI) and the three different levels of fire business (Fire-Day, Large-Fire-Day, Multiple-Fire-Day).



This is the accompanying tabular display of the relationship between a weather parameter (KBDI) and one of the levels of fire business (Fire-Day). Highlighted values are noted in the graph on the previous page.

FireFamily Plus Fires Analysis
240107-LIBBY RANGER STATION
Variable: KBDI

Model: Y3P3
 Time Frame: 5/1 - 10/31
 Data Years: 2007 - 2016
 Cause = All
 Large Fire Day (LFD)= 12 acres
 Multiple Fire Day (MFD)= 3 fires

 240107-LIBBY RANGER STATION - LIBBY RANGER STATION Model: Y3P3

**** Created data for 13 records with missing values. ****
  (Maximum of 5 consecutive missing days for replacement)
0 fires discarded due to no/missing weather.

Fire-Day:
    P(Fire-Day) = 1 / (1 + exp(-1 * -1.3959 + (-1 * 0.0015) * KBDI))
      Number of Weather-Days: 1802
      Number of Fire-Days: 503
Chi-Squared Goodness of Fit Tests for Fire-Day

			FD	FD		No-FD		
Prob. Range	KBDI Range	Days	Pct	Obs	Exp	Obs	Exp	Chi-Square
0.20 - 0.21	1 - 49	181	8	15	37	166	144	16.7
0.21 - 0.22	50 - 96	179	13	24	39	155	140	7.2
0.22 - 0.24	97 - 146	181	22	39	41	142	140	0.2
0.24 - 0.26	147 - 229	181	32	58	45	123	136	5.4
0.26 - 0.28	230 - 295	179	37	66	48	113	131	9.1
0.28 - 0.30	296 - 369	180	51	91	52	89	128	40.4
0.30 - 0.31	370 - 410	180	37	67	55	113	125	3.4
0.31 - 0.33	411 - 462	181	37	67	59	114	122	1.8
0.33 - 0.34	463 - 502	185	17	31	63	154	122	24.1
0.35 - 0.38	503 - 614	175	26	45	64	130	111	9.0
		1802	28	503	503	1299	1299	117.2

Chi Square	DF	P-Value	R(L)-Sq.
117.2	8	0.0000	0.17

E. While these statistics can help inform our decisions, how well do they represent the situation and how reliable are they? Let's consider the following:

1. The more fires you have the better the statistical fit. Thus, statistics may not be reliable for large fire days or multiple fire days.

2. If you have fewer than 20 fires, be cautious. You may only be able to consider fire days.

3. Do not change your large fire or multiple fire day definitions simply to improve the statistics. These definitions are based on local capacity.

When choosing an index to use, we can rate them by **Goodness-of-Fit** and **Probability and Predictor Variable Ranges** as summarized in the table below.

Summary of Statistics

Our goal is to rate models (indexes) by reviewing the following statistical results.

i. **Goodness-of-Fit**

a. Chi Square: Lower is better.
The following values apply only to the logistic regression used in FireFamilyPlus.

- 0 is a perfect fit,
- <13 is excellent,
- <20 is good,
- >26 is not so good.

2. Probability and Predictor Variable Ranges

a. A larger Probability Range is better:

- 0.1 to 0.9 is very good.

b) A large range of Predictor Variables is desirable because it allows more flexibility in setting levels for fire business.

V. SUMMARY

A. Statistics are not the only consideration. You do want the best possible statistics, but not necessarily the best numbers. Here's where the 'art' comes in. As you are thinking about indices to use along with the statistical relationships, consider the following:

1. Fires analysis - What questions are you trying to answer?

2. NFDRS indices – Response to changes; How do they relate to reportable fires? - If you want staffing levels that can respond rapidly, a great statistical relationship between ERC and a slash model may not help you. Perhaps a BI will provide better response times.

3. Vegetation type – Response to changes? - If your vegetation contains a lot of live fuel, and that live fuel changes throughout the fire season, then you should consider a fuel model that contains live fuel, even if the statistics are not the best. What is the implication if live fuel moisture changes, having a dramatic effect on fire danger, and a slash model is used to predict fire danger?

4. Decision space (range of index values) - Say that the index with the best statistical relationship (e.g., BI) has a decision space ranging from 1-10. How helpful is that in decision making?

These are hypothetical questions. You need to consider the vegetation, weather, NFDRS indices, and statistical relationships for your area.

VI. FIRES ANALYSIS (IN-CLASS EXERCISE)

A. **Step 1 (Lesson 11):** Set the initial Working Set.

Hint: Even if using Interactive Batch, it is easiest to set the Working Set in the main Working Set window before starting Interactive Batch. If you are in Interactive Batch, you can set the Working Set by clicking on the **Working Set** icon ( ).

B. **Step 2 (Lesson 11):** Determine the appropriate annual filter and fires analysis.

Hint: If you can't remember the fire size or cause class definitions, you can view them from the **Fire Summary** screen by going to **Options > View Class Definitions…**.

Hint: Change the large and multiple fire days in Interactive Batch using the **Fires Options** icon ( ).

C. **Step 3 (Lesson 11):** Screen the range of variables and indexes for the five NFDRS2016 fuel models.

D. **Step 4:** Determine the appropriate fuel model and variable to use with each management tool.

Now that you have selected the most appropriate Fire Business Candidates, you can consider which selection provides the best information for each management tool. Ultimately, you should assess the value of the better fuel model/index combinations for the following fire management tools: staffing levels, adjective rating, dispatch levels, preparedness, and pocket cards. Each tool can have a separate combination, or you can use the same combination for several tools, but keep in mind the increased workload associated with doing this.

Note: *The fuel model/index combination with the best statistics may not provide the information needed for your management decision. Use your best judgment to make your selection. The reasoning behind your selection is described in the Fire Danger Operating Plan.*

REVIEW OBJECTIVE(S)

Upon completion of this lesson, participants will be able to:

1. Describe the statistics used in FireFamilyPlus to analyze NFDRS indices.
2. Use FireFamilyPlus to analyze NFDRS indices to select a final fuel model.

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