Assessing Daily Fire Severity

Step One – Developing a "Fuel Dryness Level"

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Introduction

A major purpose of **Predictive Services** at each Geographical Area Coordination Center is to make regional scale, scientific based, assessments of seasonal, monthly and daily fire severity across their region. This paper concerns itself with daily fire severity and, in particular, documents the development of the first component of our "Large Fire Potential Model"…the "Fuel Dryness Level" (DL).

Fire severity can be defined in numerous ways depending on one's perspective. From a regional and national level perspective, "large fire" occurrence is critical because it normally requires significant resource demands that extend beyond "local" boundaries.

Currently Predictive Services at NWCC measures daily fire severity in terms of potential for **new large fire occurrence** or **significant growth of existing large fires**. Both are potential drains on region-wide and national level resources.

The following outline will guide our on-going research effort at NWCC regarding daily potential for large fire activity.

Objective: Develop a "method" to assess, on any given day, the potential for either incurring a new "Large Fire" or for incurring significant growth on existing large fires. This potential should be forecastable out through 5 to 10 days, which is currently the extreme operational limit of medium resolution weather forecast models.

Premise: Large Fires are primarily a function of fuel dryness in combination with a weather event. Large Fire activity often tends to be "weather event" driven.

Strategy:
1. Develop a fuel dryness measure related to large fire occurrence and/or growth. (**Step One**)
2. Identify weather events related to large fire occurrence or growth and,
3. Analyze combinations of fuel dryness levels and intensities of various weather events and relate the combinations to the probability of incurring large fire activity. (**Step Two**)

Method: Statistical methods will be employed. Minimizing subjectivity is desired. "Probability of Detection" (POD) and "False Alarm Rate" (FAR) statistics will be a guiding consideration.

Deliverable: A combined graphic/text product to be issued daily that attempts to identify **"High Risk Days"** for large fire activity over the ensuing 5-10 days.

A few words concerning the above "Premise"…..

Weather and **fuel dryness** are leading contributors to large fire growth. However, other factors are also big contributors, particularly **resource availability** and **fire fighting strategy**. Currently only weather and fuel dryness is being investigated. Plans to try and incorporate resource considerations into the "model" are still down the road.

Definitions:

1. Large Fire Day (LFD) – a day when at least 1 "Large Fire" occurs.
2. Large Fire - 50 acres (100 acres east of Cascades) or the 95th percentile size (i.e. top 5%) of all "Daily Largest Fires", whichever is greater for a particular assessment zone (PSA).
3. High Risk Day – a day with a combination of "Fuel Dryness" and "Weather" that has historically resulted in either;
   a. a significantly above normal probability for occurrence of a new large fire or,
   b. high potential for significant new growth on an existing large fire

Step One – Developing the "Fuel Dryness Level"

It is well known that dryness of the fuel bed is a prerequisite for significant fire activity, especially large fires. However, the probability of large fire activity increases dramatically when certain weather events occur in conjunction with critically dry fuels. This combination of fuel dryness and "weather" defines the potential for large fire growth, at least from an environmental standpoint. One without the other often is often insufficient for large fire activity.

Think of fuel dryness as a "table setter" and, as such, is the logical first consideration when developing a "large fire potential" model.

Historically, the fire community has defined their fuel dryness in terms of percentile values of various National Fire Danger Rating System (NFDRS) outputs. One commonly used threshold has been either the 90th or the 97th percentile value of the Energy Release Component (ERC). Using percentile thresholds is a legitimate way of assessing fuel dryness. However, a particular percentile threshold such as the 90th or 97th may or may not actually have the best relationship with large fire activity. Thresholds should be determined that actually relate to increased probability of large fires. Also, it may well be that a determination of fuel dryness from a combination of different fuel moisture measures relates better to large fire occurrence than one single measure. Both of these possibilities were explored in developing our large fire potential model.

Without regard to whether or not a weather event was involved, LFD occurrence was statistically correlated to various fuel moisture measures as well as combinations of these measures. **Highest correlations between fuel dryness and large fire activity were found when fuel dryness was defined in terms of a combination of ERC and 100-hr fuel moisture (F100)**. By itself, F100 has a slightly higher correlation with large fire occurrence than ERC for most areas in the Pacific Northwest but, the combination of the two measures generally improved the correlation. This makes some sense. The ERC is a composite of all size classes of fuel moisture, both living and dead, but is heavily weighted toward the large 1000-hr FM and hence is a rather conservative measure, acting more slowly to daily fluctuations in air mass moisture. On the other hand, F100 is much more responsive to daily moisture fluctuations. The two measures used in conjunction more equally weigh both the longer term moisture levels (ERC) and the more volatile daily moisture levels (F100).

This combination of measures is the basis for the “Dryness Level” (DL) for each of the PSAs in the Pacific Northwest.

The following matrices were constructed for all 12 PSAs in the Pacific Northwest. They show the frequency of Fire Days (FD) as well LFDs for the various combinations of ERC vs. F100. Data covering the fire seasons 1994 through 2003 were used in development of the matrices.

PSA E4

ERC x F100 - **Fire Days** (July – September 1994 - 2003)

ERC (lower class limit)

F100	<40	40	45	50	55	60	65	70	75	80	85	Tot
4	-	-	-	-	-	-	-	-	-	-	1	1
5	-	-	-	-	-	-	1	3	7	25	4	26
6	-	-	-	-	0	8	13	21	35	14	1	85
7	-	-	-	2	3	17	37	34	15	3	-	109
8	-	-	0	9	16	24	23	21	3	-	-	96
9	-	1	3	9	26	13	15	5	-	-	-	72
10	2	7	5	12	17	19	11	-	-	-	-	73
11	4	9	6	14	10	9	3	-	-	-	-	55
12	6	5	8	9	4	0	-	-	-	-	-	32
13	11	5	5	6	0	-	-	-	-	-	-	27
>13	16	13	5	1	-	-	-	-	-	-	-	35
Tot	39	40	32	62	76	90	103	84	60	29	6	621

PSA E4

ERC x F100 - **Large Fire Days** (July – September 1994 - 2003)

Large Fire Day = Day with an occurrence of a 350+ acre fire

ERC (lower class limit)

F100	<40	40	45	50	55	60	65	70	75	80	85	Tot	LF/F
4	-	-	-	-	-	-	-	-	-	-	0	0	0%
5	-	-	-	-	-	0	0	0	1	4	0	5	14%
6	-	-	-	-	-	1	3	3	1	1	0	9	11%
7	-	-	-	0	0	0	3	4	1	0	-	8	7%
8	-	-	-	0	0	0	1	2	1	-	-	4	4%
9	-	0	0	0	3	0	0	0	-	-	-	3	4%
10	0	1	0	0	0	0	2	-	-	-	-	3	4%
11	0	0	0	0	0	0	0	-	-	-	-	0	0%
12	0	0	0	0	0	-	-	-	-	-	-	0	0%
13	0	0	0	0	-	-	-	-	-	-	-	0	0%
>13	0	0	0	0	-	-	-	-	-	-	-	0	0%
Tot	0	1	0	0	3	1	9	9	4	5	0	32	
LF/F	0%	3%	0%	0%	4%	1%	9%	11%	7%	17%	0%	5%	

The "historical" probability of a large fire is computed for each ERC/F100 combination (cell) by simply dividing the frequency of Large Fire Days for each ERC/F100 combination in the LFD matrix by the corresponding frequency of Fire Days from the same ERC/F100 combination in the FD matrix. This, at least from an historical sense, is the probability that given a day with ignitions at least one large fire will occur…In other words, for any given combination of ERC and F100, the probability that a FD will be a LFD. Upon examination of the cell probabilities one can partition the matrix into discrete sections that correspond to significantly different probabilities of large fire occurrence. The LFD matrix for each of our PSAs was partitioned into 3 areas that represent our **"Dryness Levels"** for that PSA.

1. Green – combinations of ERC and F100 that historically have resulted in little or no risk for large fires (i.e. most PSAs, below 1%)
2. Yellow – combinations of ERC and F100 that historically have resulted in a rather average risk for large fires (2%-7% range, given ignitions)
3. Red – combinations of ERC and F100 that historically have resulted in a significantly higher than average risk for large fires given ignitions (often above 10%)

Table 1 - Dryness Level Frequencies (June 15 – October 15 1999-2003)

	LFDs	Percent of All Days			% of Large Fire Days			% of Large Fires		
PSA		Green	Yellow	Red	Green	Yellow	Red	Green	Yellow	Red
W1	7	88%	7%	5%	28%	29%	43%	28%	29%	43%
W2	5	57%	29%	14%	0%	40%	60%	0%	33%	67%
W3	6	69%	28%	3%	17%	50%	33%	14%	57%	29%
W4	18	41%	31%	28%	0%	39%	61%	0%	30%	70%
C1	24	35%	46%	19%	4%	54%	42%	3%	49%	48%
C2	17	55%	32%	13%	6%	59%	35%	4%	61%	35%
C3	13	22%	52%	26%	0%	31%	69%	0%	29%	71%
E1	11	50%	40%	10%	9%	36%	64%	10%	40%	50%
E2	14	44%	43%	13%	0%	64%	36%	0%	53%	47%
E3	9	9%	66%	25%	0%	56%	44%	0%	56%	44%
E4	13	41%	21%	38%	0%	15%	85%	0%	12%	88%
E5	11	40%	25%	35%	0%	36%	64%	0%	31%	69%
Region	148	46%	35%	19%	4%	43%	53%	3%	41%	56%

- Statistics sample 1999-2003
- Region-wide: 201 large fires

The low frequency of large fires in PSAs W1, W2 and W3 for this sample makes statistics for these areas unreliable.

Table 2 – Large Fire Day Probabilities (June 15 – October 15 1999-2003)

	Frequency that FD=LFD			
PSA	All Days	Green	Yellow	Red
W1	2%	1%	6%	19%
W2	2%	0%	2%	5%
W3	2%	1%	4%	15%
W4	6%	0%	6%	12%
C1	6%	1%	7%	14%
C2	4%	0%	2%	10%
C3	3%	0%	2%	8%
E1	5%	1%	4%	30%
E2	4%	0%	9%	5%
E3	3%	0%	5%	4%
E4	4%	0%	2%	11%
E5	6%	0%	4%	7%
Region	4%	0%	4%	10%

* Statistics sample 1999-2003

These tables indicate some key points. Note from Table 1 that, on a region-wide level between 1999 and 2003, 53% of all large fire days and 56% or all large fires occur on only 19% of fire days ("red" fire days). That, of course, also means that 44% of large fires (47% of large fire days) occur at less severe fuel moisture levels (generally "yellow" levels). If we used "red" dryness as our sole predictor of large fire potential we would have a "probability of detection" (POD) of 56% for large fire occurrence. It is equally important to recognize that this method would result in a very high False Alarm Rate (FAR) of 90%! We often go days at a time with critically dry conditions without a large fire.

Also, table 2 shows that over the last 5 years (99-03) for PSAs E3 and E5, there appear to be little difference between "yellow" and "red" dryness levels as to the probability of large fire occurrence. It is interesting to note that these 2 PSAs are primarily grasslands as opposed to timberlands. This would suggest that for these fuel types a 2-tiered dryness system is more apropos than a 3-tiered system i.e. you are either dry enough to supports large fires or you are not… there is not much of a transition between the 2 regimes.

Even though for most of the PSAs, there appears to be good large fire probability separation between "green", "yellow" and "red" dryness levels, the probability of a large fire in the red is still on the average only about 10%. One concludes that, though dryness level is important, it is not the entire story! Fuel dryness only represents the first component of our large fire potential model. The second component to add to the model will be the effects that certain weather trigger events have when applied in conjunction with the dryness level. That will be the topic of Step Two documentation.