P1.5 IMPLICATIONS OF USING PERCENTILES TO DEFINE FIRE DANGER LEVELS

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1. INTRODUCTION

The National Fire Danger Rating System (NDFRS) uses daily weather data to calculate indices that reflect seasonal changes. Indices, including Energy Release Component (ERC) and Burning Index (BI), describe relative fire danger as opposed to observable fire behavior values (Deeming et al., 1977). Index values are interpreted differently for individual regions and for different fuel models in the same region. Interpretation of indices is based on climatology, using selected years and months. Climatology-based percentile levels are used to define the average and extreme conditions for an area.

Indices are often expressed in relative terms as percentiles (e.g., 90th and 97th percentiles). Percentiles place indices in the same context for use in class definitions, which are used for many applications including public information (e.g., Smokey Bear signs), firefighter pocket cards (Andrews et al., 1998: Schlobohm, 2000), and Wildland Fire Assessment System (WFAS) maps (Jolly et al., 2005). Fire behavior modelers may use fire danger percentiles to define fuel moisture values for programs such as FARSITE and FlamMap (Finney, 1998; Finney, 2006).

Research use of NFDRS includes evaluating indices, examining fuel models, and modeling the impacts of climate change on fire danger. Research in these areas improves our understanding and informs future development of fire danger rating. We summarize common methods for using percentiles to define fire danger levels, examine issues and deficiencies of current approaches, and suggest the need for additional analysis and improved methods.

2. METHODS

For the examples in this paper, several Remote Automated Weather Stations (RAWS) were selected that (1) represent a range of climatological conditions and (2) have relatively complete weather data, thereby minimizing problems related to missing data (Table 1). Station catalogs and weather data were downloaded from Kansas City Fire Access Software (KCFAST). Fire danger rating calculations were performed using FireFamilyPlus version 4.0 (Bradshaw and Tirmenstein, in prep.).

The method of defining a five-class staffing level is described by Helfman et al. (1987), and is used by the Weather Information Management System (WIMS; National Information Systems Group, 2009) and the FireFamilyPlus program. An index is calculated using historic weather data and the resulting distribution is converted to percentiles. Cutoff values for the two upper classes are based on percentile levels. Cutoff values for the three lower classes are calculated from the value at the 90th or 10th percentile, and are not affected by the data distribution (Table 2).

3. RESULTS AND DISCUSSION

3.1 Defining Fire Danger Levels

In March 1974, standards were developed for specifying the level of fire danger for public information (Helfman et al., 1987). The U.S. Forest Service (USFS) specified that staffing levels (then called manning classes) be based on the 90th and 97th percentile Burning Index (BI); the Bureau of Land Management (BLM) specified using the 80th and 95th percentiles of the BI (Helfman et al., 1975). While these climatological breakpoints are still predetermined by agency directive (Standards for Fire and Fire Aviation Operations Task Group, 2009), the 90th and 97th percentiles are most commonly used today and are applied to all indices, not only BI. The weather station manager specifies the top two breakpoints. While these breakpoints may be documented in the local fire management plan, there is no formal documentation in the station catalog of the data (years, months) used to set those breakpoints.

Not using data distribution to set lower levels can be problematic in certain situations. For example, fire danger levels are compared for Black Creek, Mississippi (MS) and Missoula, Montana (MT) because they have similar index values at the 90th and 97th percentile levels but very different climates and fire seasons. Most fires in southern MS occur during October-April, while fires in western MT occur primarily during June-September. Figure 1a shows the distribution of ERC, fuel model D [ERC(D)] for Black Creek, MS and ERC(G) for Missoula, MT. The distributions are quite different. The most common ERC for MS is 20, while the most frequent value for MT is 39. The corresponding cumulative curves with the similar index values at the 90th and 97th percentile levels are shown in Figure 1b. For both sites, by definition, 7% and 3% of the days are in the “Very High” and “Extreme” classes, respectively. Recall that the breakpoints for the lower classes are not based on data, but on the index value at the 90th percentile. The 90th percentile ERC value for both sites is 53. While the breakpoints for the lower classes are the same (13 and 27), the percent of days in the classes are quite different (Fig. 1c; Table 3). The “High” class includes 40% of the days for MS and 64% for MT, a difference of 24%.

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Table 1. Weather Stations used in the analysis.

Station ID	Site Name	State	Climate Division (Bailey 1995)	Latitude	Longitude	Elevation (ft)	Years of Data Used
045709	Mt. Laguna	CA	Mediterranean	32.880°N	116.420°W	5760	1970-2008
086704	Chekika	FL	Humid tropical	25.625°N	80.580°W	5	1999-2008
203802	Baldwin	MI	Hot Continental	43.5°N	85.5°W	832	1999-2008
227802	Black Creek	MS	Humid subtropical	30.849°N	89.034°W	275	1978-2008
241513	Missoula	MT	Temperate steppe	46.82°N	114.1°W	3200	1970-2008
261705	Red Rock	NV	Tropical/Subtropical Desert	36.135°N	115.427°W	3760	1999-2008
290801	Tower	NM	Temperate steppe	35.779°N	106.626°W	6500	2003-2008
415109	Conroe	TX	Humid subtropical	30.236°N	95.4823°W	120	1999-2008

Table 2. Calculation of fire danger class thresholds for a five-class staffing level, after Helfman (1987).

Fire Danger Class	Lower limit of the class for indices for which *higher* values indicate higher fire danger (e.g., ERC, BI, Maximum Temperature)	Upper limit of the class for indices for which *lower* values indicate higher fire danger (e.g., 1000-h Fuel Moisture, Relative Humidity)
E–Extreme	97th percentile value	3rd percentile value
VH–Very High	90th percentile value	10th percentile value
H–High	½ of the value at the 90th percentile	½ of the difference between the maximum value and the 10th percentile value
M–Moderate	¼ of the value at the 90th percentile	¾ of the difference between the maximum value and the 10th percentile value
L–Low	Zero	Maximum value

When fire danger rating was used primarily for determining conditions under which fire potential was “Extreme”, climatology breakpoints at the lower levels were less important. As the use of fire danger rating has broadened to include a range of applications (e.g., prescribed fire), more attention should be paid to proper definition of the lower classes.

There can be distinct differences in the number of days in a fire danger rating class between the 90th/97th and the 80th/95th percentile standards. The percentile levels used to define the upper two classes are specified by the station manager. The difference between the 90th/97th standard and the 80th/95th standard was examined for a single weather station (Missoula, MT). Figure 2a shows those percentile levels on seasonal plots of the mean and maximum ERC(G) for 1999-2008 and the ERC(G) values calculated for the year 2000. The “Very High” class, by definition, includes 7% or 15% of the historic data used in the analysis. Depending on the standard used to set the classes, there would have been either 27 or 56 days in the “Very High” class in 2000, a difference of 29 days (Fig. 2b). Analysts comparing the number of days with fire danger in the highest classes should be aware of the method used to set the levels.

3.2 Using Percentiles to Interpret Indices

NFDRS is a complex system that includes the fire danger indices of Spread Component (SC), Energy Release Component (ERC), Burning Index (BI), Ignition Component (IC), and Keetch-Byram Drought Index (KBDI) (Burgan, 1988: Deeming et al., 1977), as well as intermediate values (e.g., 1000-h fuel moisture) that can serve as indices. A number of input options can be customized in the Station catalog, including Slope Class, Climate Class, and Green Up Date. Additionally, the user selects from 20 fuel models from the 1978 NFDRS as well as 20 fuel models from the 1988 update.

Of primary consideration is the fact that NFDRS produces relative indices, not absolute fire behavior values. The Burning Index (BI) is an index whose calculation is based on a model for flame length. However, BI is *not* a prediction of flame length – proper interpretation of index values requires analysis of historical climate data to ascertain the relative significance of a given value. Fire managers can use a percentile analysis to compare indices based on various options and fuel models to assess differences and guide selection.

Fuel model selection is also an important consideration. As an example, fuel models G and H are compared for weather stations in both western Montana and eastern Texas. Fuel model G is labeled “Closed,

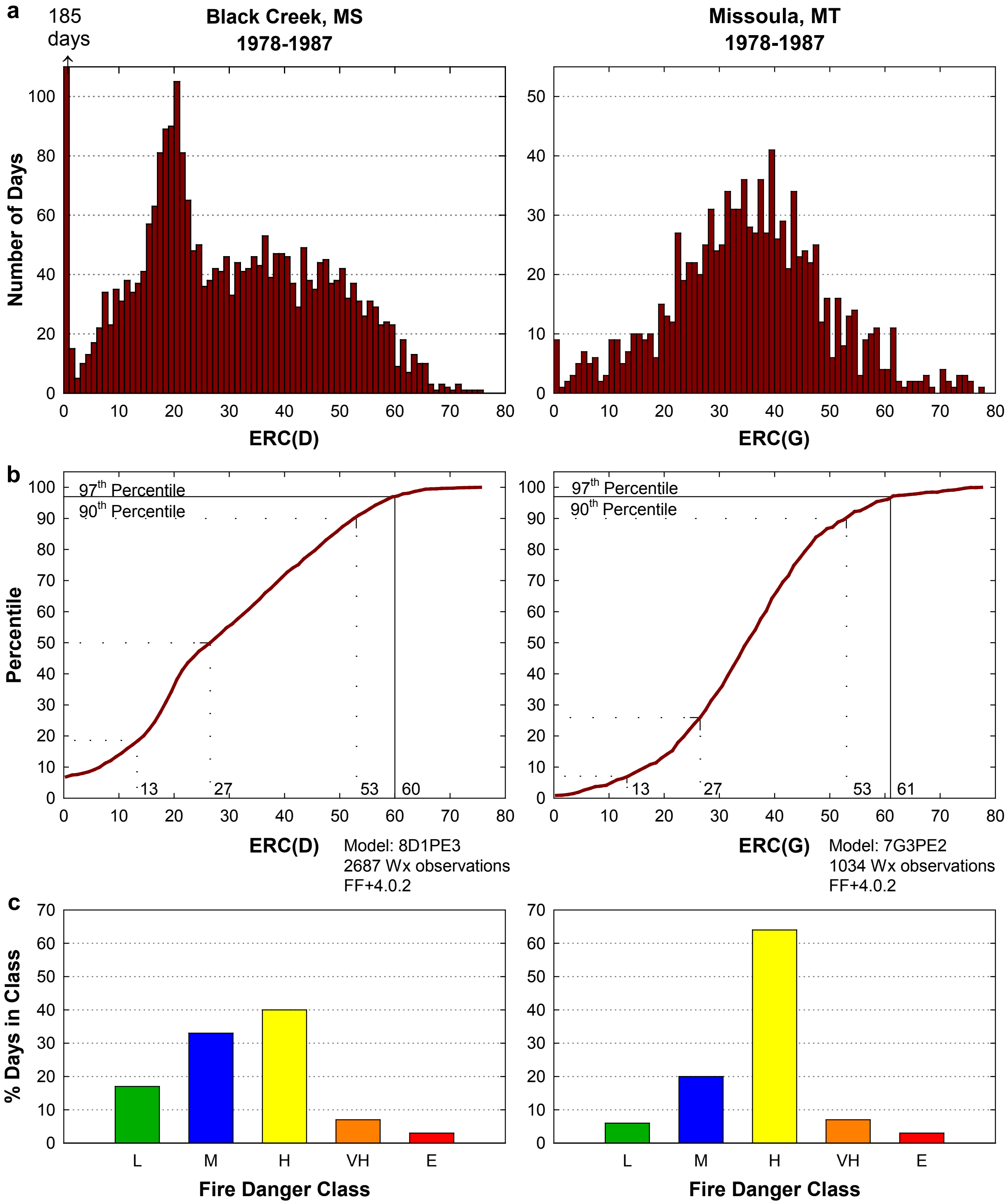

Figure 1. Comparison of two sites with very different fire weather, but with similar index values at the 90th and 97th percentile levels. (a) Number of days at a given ERC value. (b) Cumulative distribution of the ERC. (c) Percent of days in each fire danger rating class.

short-needle conifer (heavy dead)," while fuel model H is labeled "Closed, short-needle conifer (normal dead)." Some users understandably select a fuel model through its name and description in an attempt to best match their fuel type. The more appropriate basis for fire danger rating is how a fuel model responds to site weather data to produce an index that correctly tracks the fire season.

Table 3. Fire danger classes, based on ERC(D) for Black Creek, MS, and ERC(G) for Missoula, MT. Percent days is plotted in Figure 1c.

Fire Danger Class	ERC (MS and MT)	%Days	
		MS	MT
E	61	3%	3%
VH	53	7%	7%
H	27	40%	64%
M	13	33%	20%
L	0	17%	6%

To illustrate the relationship between fuel models, values are calculated for ERC(G) and ERC(H) at Missoula, Montana (MT) and for BI(G) and BI(H) at Conroe, Texas (TX). The 2008 season plots show a similar trend for fuel models G and H for both stations and indices (Fig. 3a), and scatter plots of data from 1999-2008 illustrate the strong relationship between the two fuel models (Fig. 3b). The difference in magnitude for fuel models G and H is reflected in the percentile curves (Fig. 3c). The 97th percentile for MT is 69 for ERC(G) and 39 for ERC(H), while the 97th percentile for TX is 42 for BI(G) and 18 for BI(H). When the indices are interpreted as fire danger levels based on percentiles, a similar number of days fall in each class (Fig. 3d). As a relative indicator of fire danger, there is essentially no benefit of using fuel model H over fuel model G. However, the expanded range of the results from fuel model G may provide additional information hidden when using fuel model H.

Although not specifically designed as indices, weather variables and intermediate fuel moisture calculations can be used as such. A comparison of the 1000-h fuel moisture for a wet site, Chekika, Florida (FL) and an arid site, Red Rock, Nevada (NV) shows large differences (Fig. 4). The maximum value for 1000-h fuel moisture at Red Rock, NV, rarely reaches the minimum value found at Chekika, FL. This does not imply that fire danger is always low in Florida and always high in Nevada. In this example, “High” fire danger would be found at 1000-h fuel moisture values of 18-25% for FL and 5-12% for NV (Table 4).

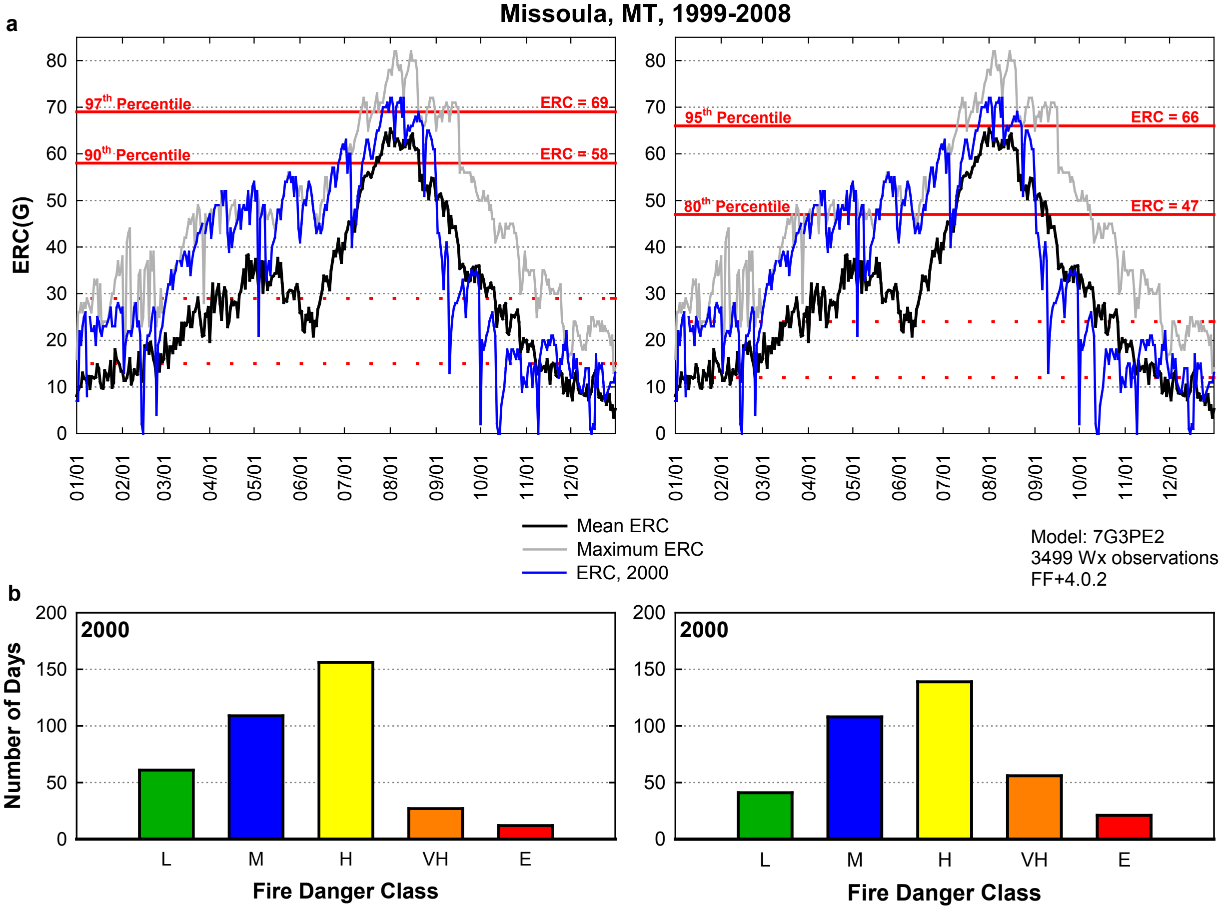

Figure 2. Comparison of (a) breakpoints based on 90th and 97th and on 80th and 95th percentile standard (b) number of days in each class for the year 2000.

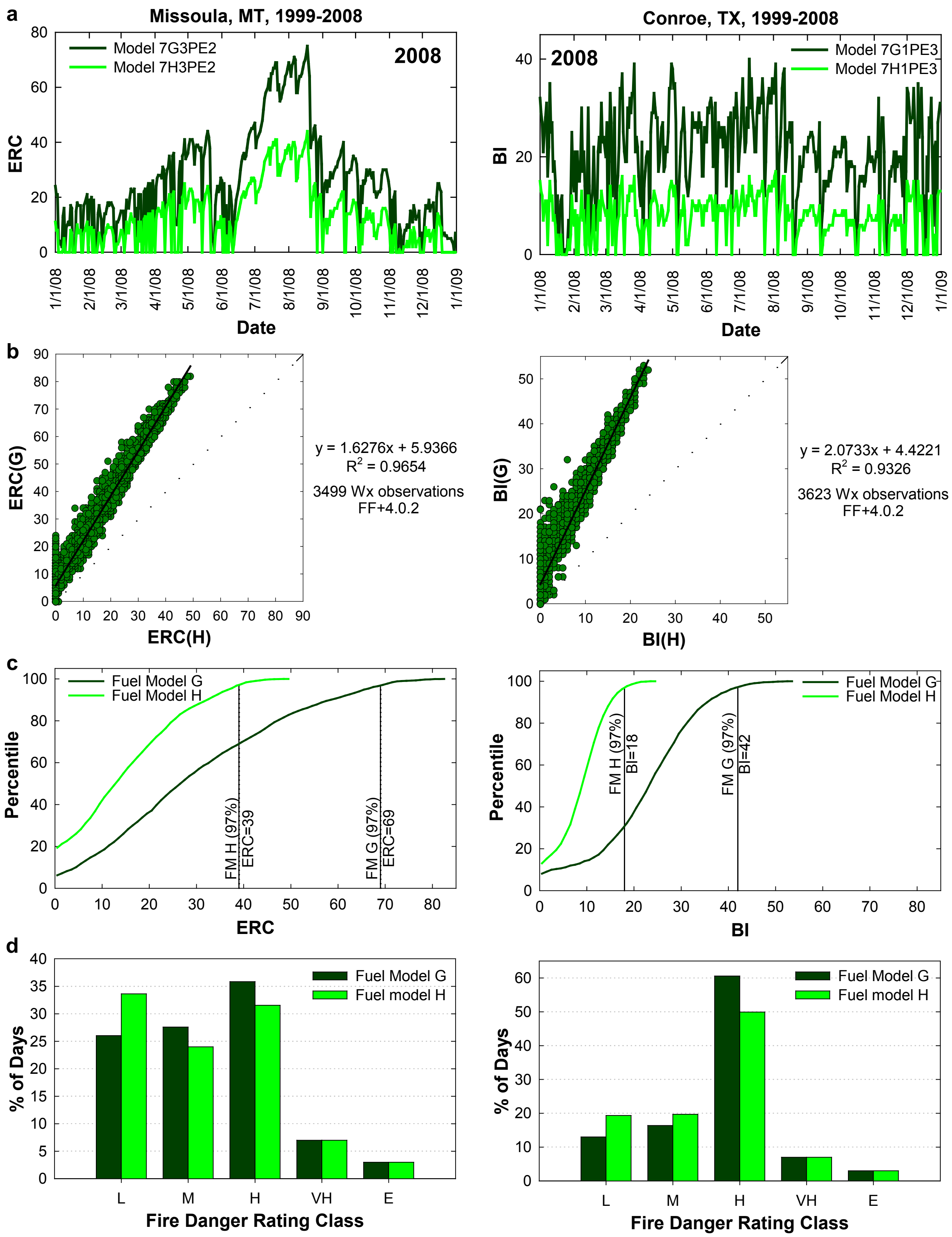

Figure 3. Comparison of Fuel Models G and H for ERC at Missoula, MT (241513) and BI at Conroe, TX (415109), 1999-2008. (a) Season plots for 2008 show similar daily variation. (b) Plots of the daily values for 1999-2008 display strong relationships. (c) Percentile curves for ERC and BI for the two fuel models show the difference in magnitude at the two sites. (d) The number of days in each fire danger class is similar.

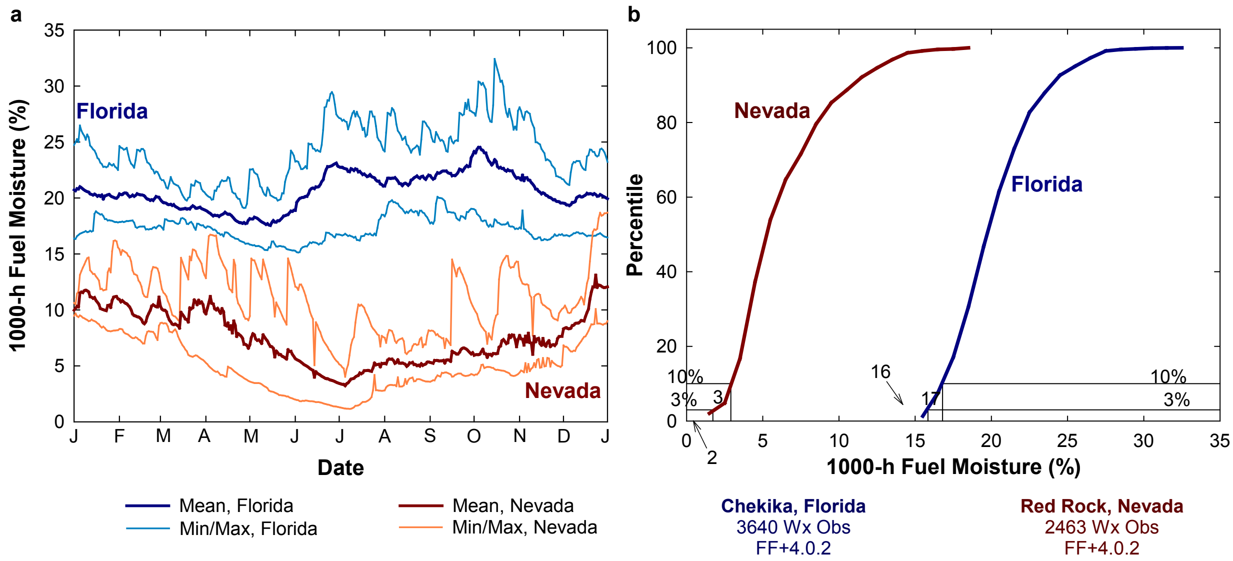

Figure 4. (a) 1000-h fuel moisture values for Chekika, FL, a wet site, and Red Rock, NV, a dry site for 1999-2008. (b) Cumulative distributions of the fuel moisture values. Since lower fuel moisture values are more extreme, the 3rd and 10th percentiles are used instead of the 97th and 90th percentiles.

Table 4. Class values for 1000-h Fuel Moisture from Figure 4.

Fire Danger Class	1000-h Fuel Moisture (%)	
	Chekika, Florida	Red Rock, Nevada
E	≤16%	≤3%
VH	17%	4%
H	18-25%	5-12%
M	26-28%	13-15%
L	29-32%	16-19%

3.3 Using Seasonal vs. Annual Climatological Data for Setting Fire Danger Levels

Some analysts use annual weather data to determine class breakpoints, while others use only data taken during the local fire season. The ERC values at two sites experiencing summer fire seasons are analyzed using both annual and seasonal weather data: (1) ERC(U) at Tower, New Mexico (NM), Bandolier National Monument, and (2) ERC(G) at Missoula, Montana (MT), Lolo National Forest (Fig. 5). The annual values for the 90th and 97th percentiles reflect colder winter months in MT, which can also be seen in the seasonal variation of the ERC(G) (Fig. 5b). Differences in the 90th and 97th percentile levels using annual and fire season data are more pronounced for MT than for NM (Fig. 5). The “Extreme” class in MT has ERC ≥ 70 based on weather data (2003-2008) taken during the fire season, and ERC ≥ 66 based on year-round data, resulting in 14 more days in the “Extreme” class when using seasonal data (Table 5). The “Very High” class contains 30 more days using annual data because of the lower calculated threshold value. The results at NM are less extreme, with the number of days in the “Extreme” and “Very High” classes differing by 6 and 12 days, respectively, because of the differing threshold levels for annual and seasonal data.

Caution should be used in using annual data, unless an area has year-round fire activity. The “Very High” and “Extreme” danger rating thresholds may be lower than warranted when including non-fire season months with low fire danger index values. If annual data are used, annual data should be available for every year in the selected date range to avoid hidden biases. In addition, use of fire season data can be biased without a consistent definition of the “fire season.” Additionally, the length of the fire season may be increasing; the definition of a “fire season” should be sensitive to such changes.

3.4 Length of the Climatological Record for Setting Fire Danger Levels

In addition to deciding which months to use in setting fire danger levels, the number of years of data used, which years are used, and how often results should be updated must be determined. Climate change and missing data are important considerations as well. There are not yet agreed-upon answers. These examples illustrate the potential impacts of dataset selection.

Data availability is an issue. Longer-term datasets provide more information on a site’s historic climatology, but many fire weather stations did not begin consistent year-round data collection until the 1990s. Determining which data are available ensures that results are not skewed by months of missing data.

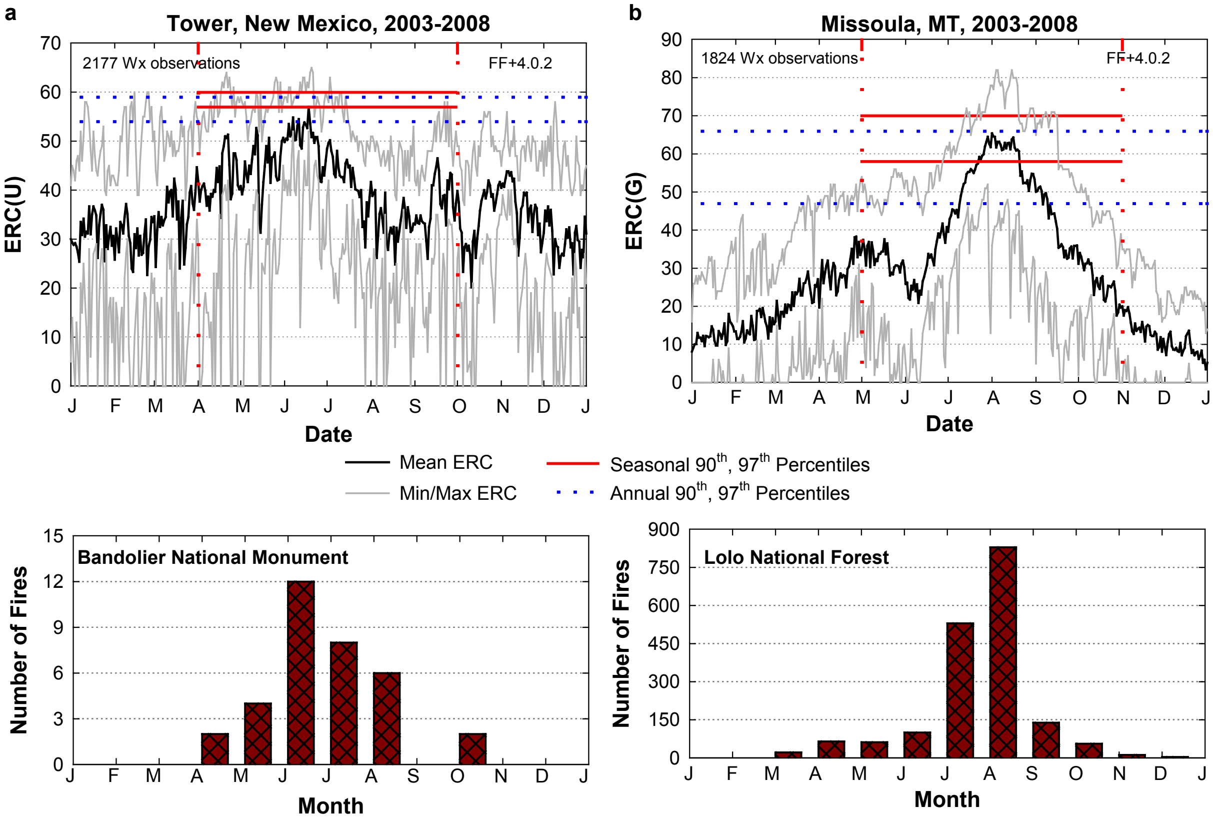

Figure 5. The difference between seasonally (red) calculated "Very High" ERC values and annual (blue) ERC values can be (a) quite small, as in Tower, NM, or (b) quite large, as in Missoula, MT. Both sites experience a summer fire season. Values are shown in Table 5.

Table 5. The number of days in the "Very High" and "Extreme" fire danger rating classes can be quite different in a given fire season when using seasonal or annual data (2003-2008) to determine levels for two different sites with summer fire seasons: (a) Tower, New Mexico and (b) Missoula, Montana. Values are from plots in Figure 5.

Tower, New Mexico, ERC(U)

a Fire Danger Rating Class	Class Lower Limit (Apr-Sep, 2003-2008)	Number of Days in Class (Apr-Sep, 2004)	Class Lower Limit (Jan-Dec, 2003-2008)	Number of Days in Class (Apr-Sep, 2004)
VH	57	14	54	26
E	66	4	59	10

Missoula, Montana, ERC(G)

Fire Danger Rating Class	Class Lower Limit (May-Oct, 2003-2008)	Number of Days in Class (May-Oct, 2000)	Class Lower Limit (Jan-Dec, 2003-2008)	Number of Days in Class (May-Oct, 2000)
VH	58	45	47	75
E	70	12	66	26

Cumulative distributions (Fig. 6) and the values at the 90th and 97th percentiles (Table 6) are calculated for BI(B) at Mt. Laguna, California (CA) and ERC(G) for Missoula, Montana (MT). Year-round data are used for CA and MT, and then for comparison, only June-August data are used for MT. In each case a percentile curve is plotted for 10, 20, 25, 30, and 39 years of weather data, all ending in 2008, illustrating that the number of years of data used can impact results. There is a large difference in the results for CA (Fig. 6a). The results for the last 30 years (1989-2008) and the last ten years (1999-2008) form the extremes, with 90th percentile values of 119 and 129, respectively. The MT curves, on the other hand, appear quite similar for each time period when year-round data are used. The results are different when only June-August data (Fig. 6c) are used because in the early record, data exist primarily during June-August, suggesting that missing data may be masking changes in weather conditions during the fire season.

It is worthwhile for a weather station manager to perform a periodic analysis of the threshold values in the Station Catalog. This is not to suggest that

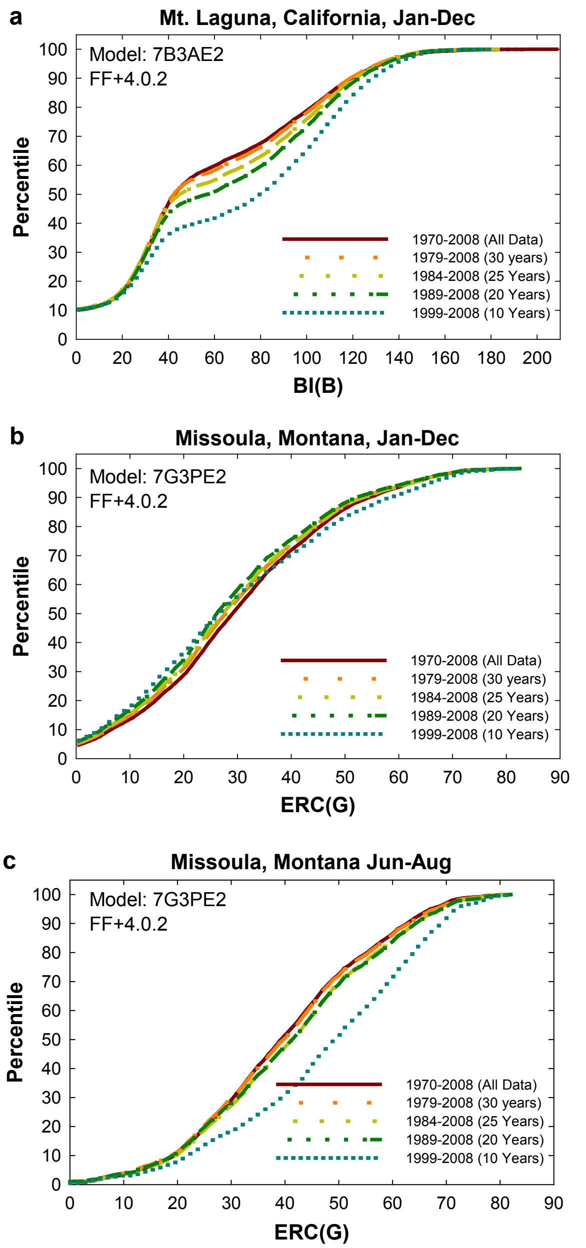

Figure 6. Effect of the number of years of data on the annual calculation of (a) BI(B) in Mt. Laguna, CA and (b) ERC()G) in Missoula, MT. The amount of data in the record can also affect results. Most of the early data in Missoula, MT was limited to (c) Jun-Aug, showing a difference in the results when compared with the annual data (b).

previously calculated values are invalid, merely that conditions that used to be rare (3% of the time) may now be more common, especially as the effects of climate change increase. An analysis of changes in the 97th percentile, for example, could aid in identifying the cause. A comment in the Station Catalog on how thresholds were established (method and dataset used) helps others better interpret results at a given station.

Analysis of NFDRS indices can provide information on changing weather conditions (McHugh, 2009). Effects of climate change on fire weather station data, however, may be masked if data are missing in the long-term data (e.g., Fig. 6c). Two sites with reasonably complete weather data for the fire season were selected and data analyzed to identify potential climate change signals using a series of overlapping 10-year periods. Percentile curves for BI(B) for CA and ERC(G) for MT are shown in Figure 7. The corresponding 90th and 97th percentile values are given in Table 7. Notice that for the CA site, index values have been increasing since the 1979-1988 period. More research is needed to distinguish recent climate change signals from those caused by climate oscillations such as the El Niño-Southern Oscillation (ENSO).

3.5 Using Fire Danger Percentile Levels to Define Fire Behavior Fuel Moisture Values

Fuel moisture values calculated in FireFamilyPlus are sometimes used as inputs to fire behavior models (e.g., FARSITE and FlamMap). Two methods are commonly used to determine the moisture values:

a) Calculate the X-percentile (e.g., 3rd percentile) of *each individual moisture value*.
b) Select the X-percentile (e.g., 97th percentile) of *an index* [e.g., ERC(G)], and calculate the associated average fuel moisture values using the Percentile Weather function in FireFamilyPlus.

Both methods are, of course, influenced by the years and months of weather data used in the analysis.

Fuel moistures associated with the 97th percentile ERC(G) and determined independently at the 3rd percentile at four sites with a range of climates are shown in Figure 8 and Table 8. "Extreme" (3rd percentile) fuel moisture values are always lower (drier) when calculated individually than when they are determined from an index. The range of fuel moisture values at the 97th percentile ERC(G) can be large, especially for the live fuel moistures.

The large differences in live fuel moistures (Fig. 8; Table 8) are due to the method used to model live fuel moisture in NFDRS. Modeling the transfer of fuel from live herbaceous to dead fuel results in the reporting of impossibly low values for live herbaceous moisture (Fuel with <30% moisture content is dead fuel.). Because of this issue, analysts generally do not use the live fuel moisture values obtained in this way.

The "Extreme" and "Very High" class ranges may not occur concurrently when dead fuel moistures are based on a percentile of each *individual* moisture value (1-h, 10-h, and 100-h; Table 9). Although by definition, 3% of the fuel moisture data fall in the "Extreme" class, the percentage of days during which all three moisture values occurred together ranged from 0.3% for Chekika, Florida to 1.4% for Missoula, Montana. Similarly, 7% of the fuel moisture data fall in the "Very High" class by definition, but the percentage of days during which all three fuel moisture values occurred together ranged from 0.6% for MI to 2.3% for MT.

Table 6. The 90th and 97th percentiles from the analysis in Figure 6. Values from the Station Catalog are shown for comparison.

a

Mt. Laguna California BI(B) , Jan-Dec	Years	90th Percentile	97th Percentile
All Data	1970-2008	120	141
30 Years	1979-2008	119	138
25 Years	1984-2008	122	140
20 Years	1989-2008	123	140
10 Years	1999-2008	129	145
Station Catalog		114	148

Missoula, Montana ERC(G) , Jan-Dec	Years	90th Percentile	97th Percentile
All Data	1970-2008	54	66
30 Years	1979-2008	53	66
25 Years	1984-2008	53	66
20 Years	1989-2008	52	66
10 Years	1999-2008	58	69
Station Catalog		55	62

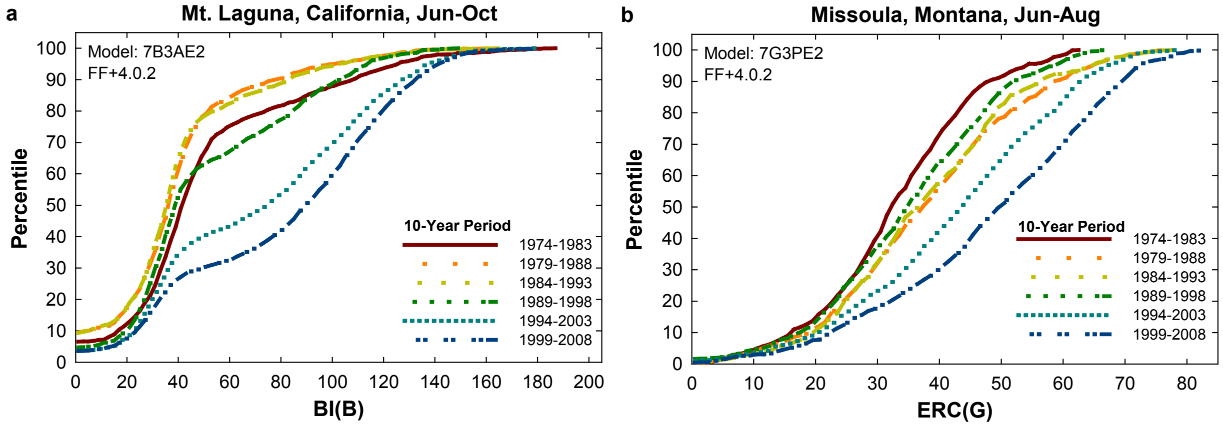

Figure 7. Effect of the time frame used on the seasonal calculation of (a) BI(B) in Mt. Laguna, California and (b) ERC(G) in Missoula, Montana. These months were chosen as they contained the most complete weather data in the 1974-2008 record.

Using historic weather and NFDRS calculations in FireFamilyPlus to determine fuel moisture values for fire behavior modeling provides a method for characterizing various moisture conditions for a site. An analyst should seriously examine and fully document the method used. Stating that “the 97th percentile weather was used,” for example, is not an adequate description

4. CONCLUSIONS

Use of climatology is required for proper interpretation of fire danger indices and for development of fire danger classes. Percentiles normalize indices across broad geographic areas, allowing intercomparison of indices, fuel models, and model inputs (e.g., Slope Class).

A commonly used standard for defining extreme fire danger is the 97th percentile. However, this standard is not necessarily correlated with fire occurrence or size. The value associated with the 97th percentile varies depending on the years and months of data included in the analysis. The results of using annual data may be much different than those using fire season data. Missing data can have a large, sometimes hidden, impact on results.

Table 7. Comparison of 90th and 97th percentiles from the analysis in Figure 7 for 10-year overlapping periods of selected months, chosen for maximum data availability. Values from the Station Catalog are shown for comparison.

a

Mt. Laguna California BI(B) , Jun-Oct	90th Percentile	97th Percentile
1974-1983	111	140
1979-1988	86	120
1984-1993	88	119
1989-1998	103	122
1994-2003	124	142
1999-2008	129	145
Station Catalog	114	148

b

Missoula, Montana ERC(G) , Jun-Aug	90th Percentile	97th Percentile
1974-1983	41	52
1979-1988	47	63
1984-1993	44	58
1989-1998	38	50
1994-2003	45	59
1999-2008	47	66
Station Catalog	55	62

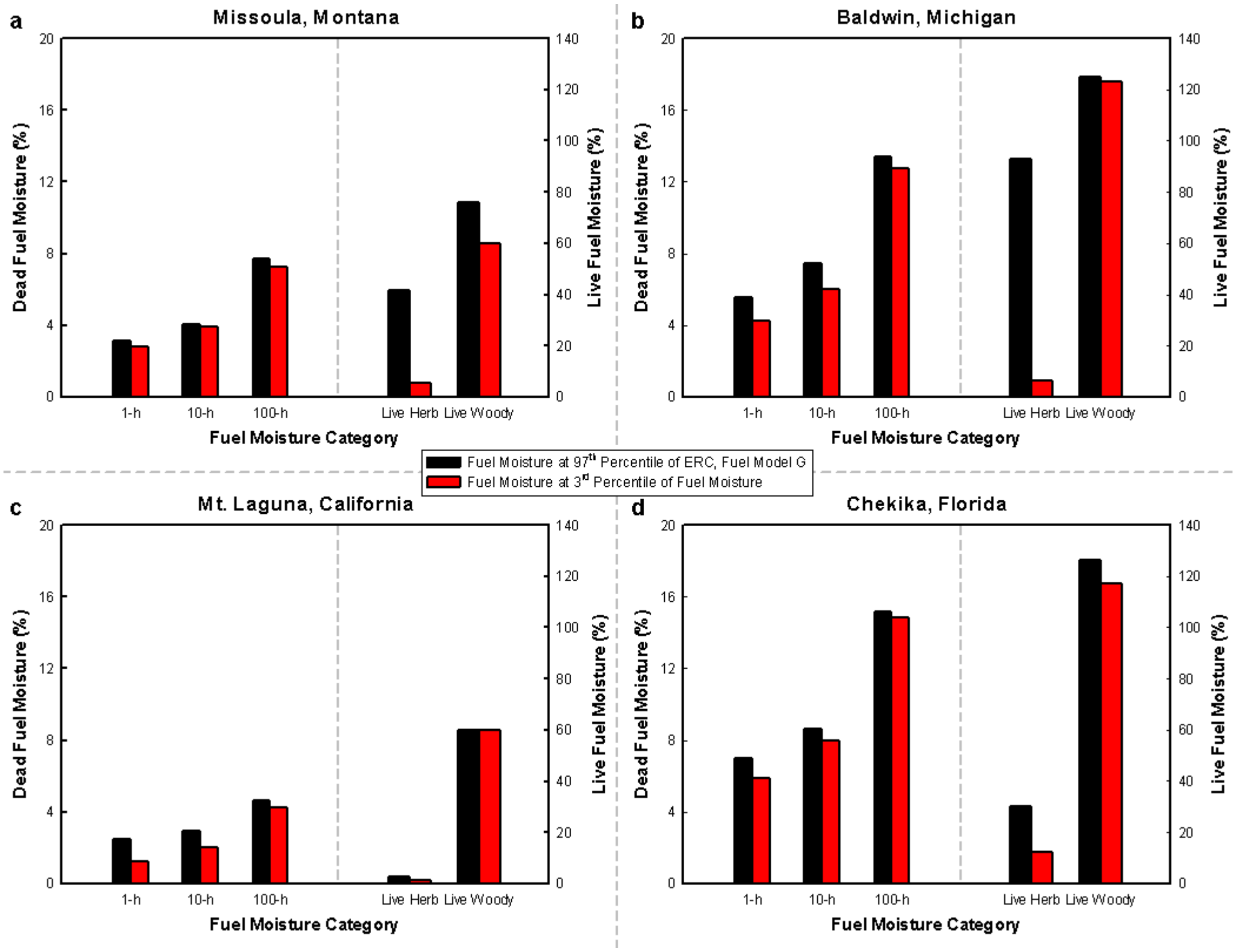

Figure 8. Fuel moisture values determined from the 97th percentile of ERC(G) (black bars) compared to the 3rd percentile of each fuel moisture (red bars) for four sites: (a) Missoula, MT [MT; temperate steppe]; (b) Baldwin, MI [MI; hot continental]; (c) Mt. Laguna, CA [CA; Mediterranean]; and (d) Chekika, FL [FL; humid tropical]. Data from Jan-Dec, 1999-2008, were used for all sites.

For stations in areas with increasing temperatures, the 97th percentile value can be lower for a prior 10-year period than for the most recent 10-year period. Rather than updating fire danger thresholds, it may be important to recognize that, under current conditions, more than 3% of days should now be classified as "Extreme."

Complete documentation will aid application and communication of fire danger. The method and dataset used to set levels could be added to the Station Catalog. Publications and reports that use fuel moisture from fire danger calculations should include a complete description of the method used.

In addition to using historical data to interpret fire danger indices, there is great benefit in also using fire data. Methods for relating fire occurrence and final size to the fire danger index on the day of discovery have been developed and are available in FireFamilyPlus (Andrews et al., 2003). There are, however, not firm guidelines comparable to the 90th and 97th percentile standards. Among unanswered questions is the size of the area associated with indices from a fire weather station (e.g., National Forest or District). Moreover, the index on discovery day may not accurately describe the fire danger associated with that fire on days of major fire growth.

In this paper, we have presented examples of the influence of several factors on using percentiles to define fire danger levels. Relating fire danger indices to fire occurrence as well as determining percentile thresholds may be more informative than using standard class definitions. Additional work on the topic will aid research assessment of the fire danger rating system itself and of modeling climate change impacts. Improved guidelines will lead to better information in support of fire management decisions. Application of fire danger rating has expanded since the early days of assessing conditions for fire suppression readiness. Indices and fuel moisture values are used for prescribed fire planning, fuel hazard assessment, and long-range modeling of ongoing fires.

Table 8. Fuel moisture values calculated at the 97th percentile of ERC using Fuel Model G and the 97th percentile of fuel moisture for the four sites in Figure 8. Data from January-December, 1999-2008, were used for all sites.

Station	Fuel Moisture Class	Fuel Moisture Value at 97th Percentile ERC(G) (%) Range	Average	3rd Percentile Fuel Moisture Value (%)
Baldwin, Michigan 1999-2008 Jan-Dec (2563 days)	1-h	3 – 10	5.6	4.2
	10-h	4 – 11	7.4	6.0
	100-h	9 – 16	13.4	12.8
	Live Herbaceous	3 – 171	93.1	6.5
	Live Woody	108 – 142	125.1	123.1
Chekika, Florida 1999-2008 Jan-Dec (3640 days)	1-h	4 – 10	7.0	5.9
	10-h	6 – 11	8.6	8.0
	100-h	12 – 16	15.2	14.8
	Live Herbaceous	30 – 30	30.0	12.1
	Live Woody	112 – 133	126.2	117.0
Missoula, Montana 1999-2008 Jan-Dec (3499 days)	1-h	2 – 8	3.1	2.8
	10-h	2 – 8	4.0	3.9
	100-h	5 – 9	7.7	7.3
	Live Herbaceous	30 – 53	41.7	5.7
	Live Woody	60 – 81	76.1	60.0
Mt. Laguna, California 1999-2008 Jan-Dec (3484 days)	1-h	0 – 5	2.5	1.2
	10-h	1 – 5	2.9	2.0
	100-h	3 – 6	4.7	4.3
	Live Herbaceous	0 – 5	2.5	1.2
	Live Woody	60 – 60	60.0	60.0

Table 9. Percent of days during which the three dead fuel moisture categories occurred together in the "Very High" and "Extreme" fire danger rating classes for the four sites in Figure 8. Data from January-December, 1999-2008, were used for all sites.

Station	Fire Danger Class	Fuel moisture (%) 1-h	10-h	100-h	% Days Using Fuel Moisture Values	% Days Using ERC(G)
Baldwin, Michigan	VH	4.3 – 5.4	6.1 – 7.0	12.9 – 14.1	0.6	7.0
	E	≤ 4.2	≤ 6.0	≤ 12.8	0.8	3.0
Chekika, Florida	VH	6.0 – 7.0	8.1 – 8.9	14.9 – 15.7	1.4	7.0
	E	≤ 5.9	≤ 8.0	≤ 14.8	0.3	3.0
Missoula, Montana	VH	2.9 – 3.6	4.0 – 4.9	7.4 – 9.1	2.3	7.0
	E	≤ 2.8	≤ 3.9	≤ 7.3	1.4	3.0
Mt. Laguna, California	VH	1.3 – 1.9	2.1 – 2.8	4.4 – 5.3	1.4	7.0
	E	≤ 1.2	≤ 2.0	≤ 4.3	0.8	3.0

There is a need for specific methods using fire data in conjunction with climatology to define fire danger levels. Guidelines are needed for how many years of data to use and how often to update thresholds. An assessment is needed to guide fire managers in using fire danger to assess climate change impacts.

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