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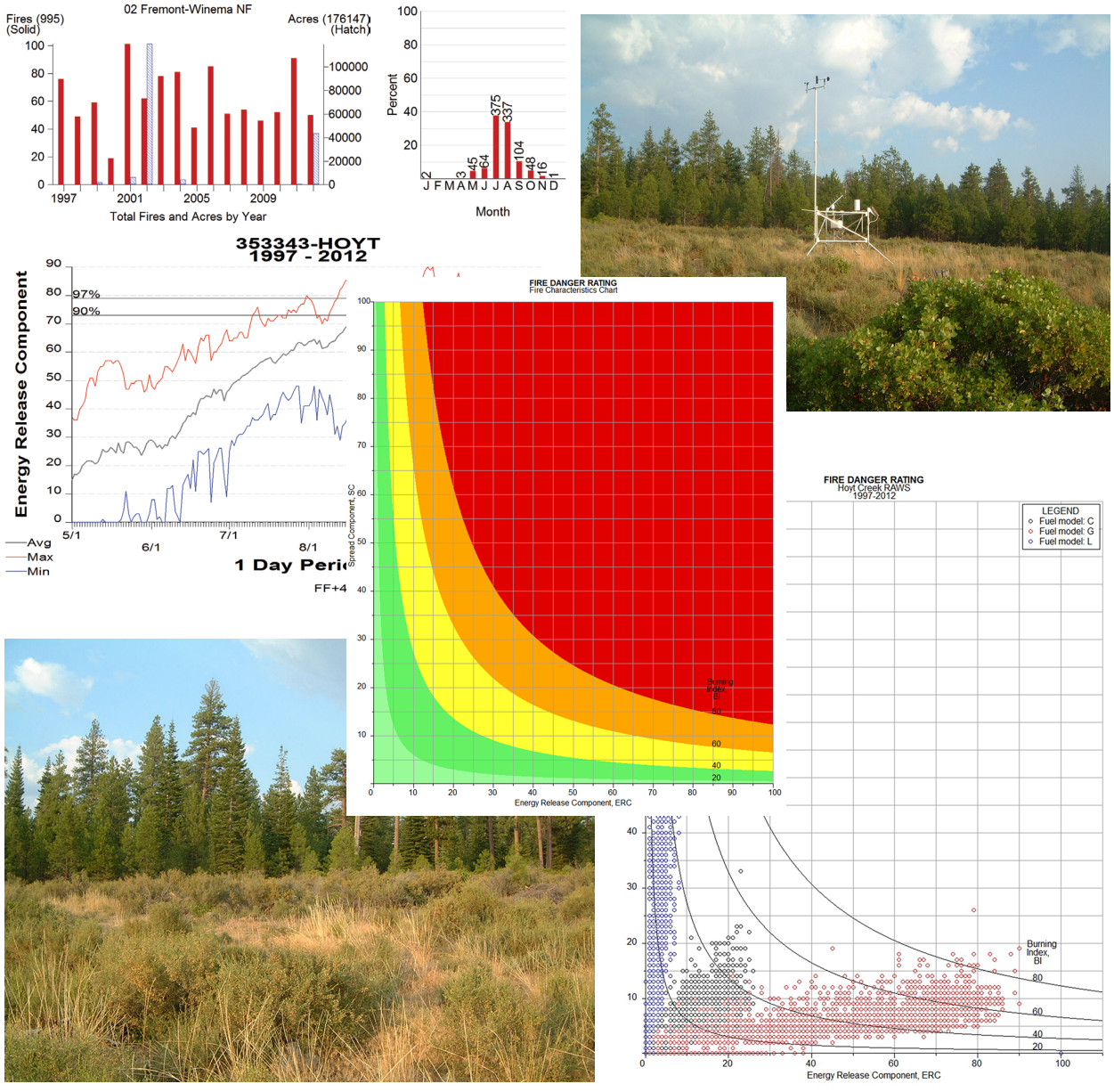
How to Generate and Interpret Fire Characteristics Charts for the U.S. Fire Danger Rating System

Faith Ann Heinsch, Patricia L. Andrews, and Deb Tirmenstein



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Abstract

The fire characteristics chart is a graphical method of presenting U.S. National Fire Danger Rating System (NFDRS) indexes and components as well as primary surface or crown fire behavior characteristics. Computer software has been developed to produce fire characteristics charts for both fire danger and fire behavior in a format suitable for inclusion in reports and presentations. Scales, colors, labels, and legends can be modified as needed. The fire characteristics chart for fire behavior has been described previously (Andrews et al. 2011). This report describes the fire characteristics chart for fire danger, which displays the relationships among the Spread Component, Energy Release Component, and Burning Index by plotting the three values as a single point. Indices calculated by using FireFamilyPlus can be imported into the fire danger characteristics chart software. Example applications of this software for comparing fire seasons, weather stations, and fire danger rating fuel models are presented.

Keywords: wildland fire, National Fire Danger Rating System, NFDRS, Energy Release Component, Spread Component, Burning Index, fire modeling, computer program

Cover Images (clockwise from upper left)**:** FireFamilyPlus graphs of fire occurrence on selected districts of the Fremont-Winema National Forest; Looking northeast toward the Hoyt Creek Remote Automated Weather Station (RAWS) on the Fremont-Winema National Forest; A fire danger characteristics chart; A fire danger characteristics chart showing three very different fuel models; Looking south from the Hoyt Creek RAWS (photos by U.S. Forest Service).

Available online at http://www.fs.fed.us/rm/pubs_series/rmrs/gtr/rmrs_gtr363.pdf

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Preface

The electronic version of this publication can be obtained through the U.S. Forest Service Treesearch website: http://www.treesearch.fs.fed.us/pubs/54597. Both the publication and Fire Characteristics Chart program can be downloaded from the BehavePlus section of the Fire Research and Management Exchange System (FRAMES) website: http://www.frames.gov/behaveplus.

Funding for development of the Fire Characteristics Chart software was provided by the U.S. Department of Agriculture, Forest Service, Fire and Aviation Management, Washington, DC, and the Rocky Mountain Research Station, Fire, Fuel, and Smoke Science Program. Programming was done through a contract with Systems for Environmental Management (SEM).

Information

Information about the Fire Characteristics Chart and the BehavePlus fire modeling system is available at http://www.frames.gov/behaveplus. Information about FireFamilyPlus is available at http://firelab.org/project/firefamilyplus.

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1. Introduction

A fire characteristics chart provides a graphical method to display primary characteristics of fire behavior and fire danger. It is designed to aid communication and interpretation of fire behavior variables related to fire spread and intensity and associated fire danger indexes and components. Software is available to produce charts for surface and crown fire behavior and for the U.S. National Fire Danger Rating System (NFDRS) indices and components. Fire behavior characteristics charts are described by Andrews et al. (2011). The fire danger characteristics chart is the focus of this report. We review the purpose and background of NFDRS and present example applications of the chart. We also describe details of program operation and available graph options.

The fire danger characteristics chart software described in this report is used to display fire danger rating indices obtained elsewhere. Fire danger rating indices can be calculated by using FireFamilyPlus (Bradshaw and McCormick 2000), and a file of historical NFDRS indexes and components can be imported. The Weather Information Management System (WIMS; NISG 2011) also calculates daily indices from observations or forecasts, which users can enter directly for comparison with historical values.

The U.S. NFDRS (Deeming et al. 1977) and operational fire behavior systems, such as BehavePlus, FlamMap, and FARSITE (Andrews 2014; Finney 2002, 2004, 2006), are based on the same mathematical fire models, which are used for core calculations. These fire model relationships make the fire characteristics chart possible. Two fire behavior variables—rate of spread and heat per unit area—are used to calculate flame length. Similarly, the NFDRS Spread Component (SC) and Energy Release Component (ERC) are used to calculate Burning Index (BI). There are, however, key differences between fire behavior and fire danger in details of the equations, interpretation of the results, and fire management applications. Differences between fire behavior and fire danger are apparent in the function and use of the appropriate fire characteristics chart.

Fire behavior modeling system results describe aspects of fire in absolute terms, such as rate of spread in chains (1 chain = 66 feet; 1 foot = 0.305 m) per hour or flame length in feet. Fire behavior charts are useful for understanding fire models, briefing personnel, providing documentation, and comparing fire behavior (Andrews et al. 2011). In addition to model results, observed values such as rate of spread and flame length can be plotted. The NFDRS, on the other hand, is not designed to model the behavior of specific fires, but rather to track changes in fire potential as the fire season progresses. Equations have been modified so that NFDRS calculations better reflect seasonal trends. Fire danger

rating produces relative indices, which are generally most meaningful when compared with the local climatology. Fire danger characteristics charts are intended to supplement seasonal plots of fire danger to aid in comparison of, for example, fuel models, seasons, and weather stations.

The fire behavior characteristics chart relationships were first used by Rothermel and Anderson (1966) to demonstrate the characteristics of fire behavior under changing wind speed. A fire danger characteristics chart was used to demonstrate the influence of suggested changes from the 1972 to the 1978 NFDRS (Rothermel 1974). Main and Haines (1983) used fire behavior characteristics charts to compare fire behavior fuel models with observed fire behavior in northeastern U.S. upland hardwood forests. The concept of using charts for both fire danger and surface fire behavior was developed for field application by Andrews and Rothermel (1982). Their report included paper versions of the two charts suitable for copying. Rothermel (1991) later developed a crown fire behavior characteristics chart. Versions of the fire behavior characteristics chart are found in BehavePlus version 5 and earlier (Andrews 2014), NEXUS (Scott 1999), and FARSITE (Finney 2004).

Fire behavior characteristics charts have also been developed for the Canadian Forest Fire Behavior Prediction (FBP) system (Alexander and Cole 1995; Cole and Alexander 1995). The FBP is based largely on empirical data, so each fuel type is represented by a different mathematical model. There is no simple relationship that allows all FBP fuel types to be included in this computer program; relationships between fire behavior and the fire danger characteristics chart must be developed independently for each FBP fuel type.

Many operational wildland firefighters are familiar with the fire behavior characteristics chart, also known as the "hauling chart" (haul in crews, haul in equipment, haul in aircraft, or haul everything out of there). The fire behavior characteristics chart is often used to demonstrate expected changes in fire behavior of an active wildfire. Fire danger characteristics charts, on the other hand, are designed for planning and analysis. As such, they are more useful in prefire applications. Following are examples of fire behavior and fire danger characteristics charts.

In figure 1, the fire characteristics of four fire behavior fuel models are compared under the same fuel moisture, wind speed, and slope conditions. The fire behavior characteristics charts for surface and crown fire behavior display rate of spread, heat per unit area, and flame length (as related to fireline intensity) as a single point. The character of the fire is represented by the location of the point on the chart. Fire behavior increases as the point moves away from the chart origin, either in terms of faster rate of spread (as in fuel model 1—short grass), higher heat per unit area (hotter fire; shown by fuel model 10—timber litter and understory), or both (for example, fuel model 4—chaparral). Under comparable environmental conditions, fuel models 1 and 10 have similar flame lengths; however, they have very different rates of spread and heat per unit area, in other words, different fire characteristics. Flame length curves can indicate suppression capacity, ranging from fires that can be attacked by firefighters with hand tools to fires for which control efforts would be ineffective (Rothermel 1983; Roussopoulos 1974).

Similarly, the fire danger characteristics chart illustrates the relationships among SC, ERC, and BI. In this case, the three indices reflect different characteristics of fire danger. The chart can provide a meaningful display regarding the level of fire danger

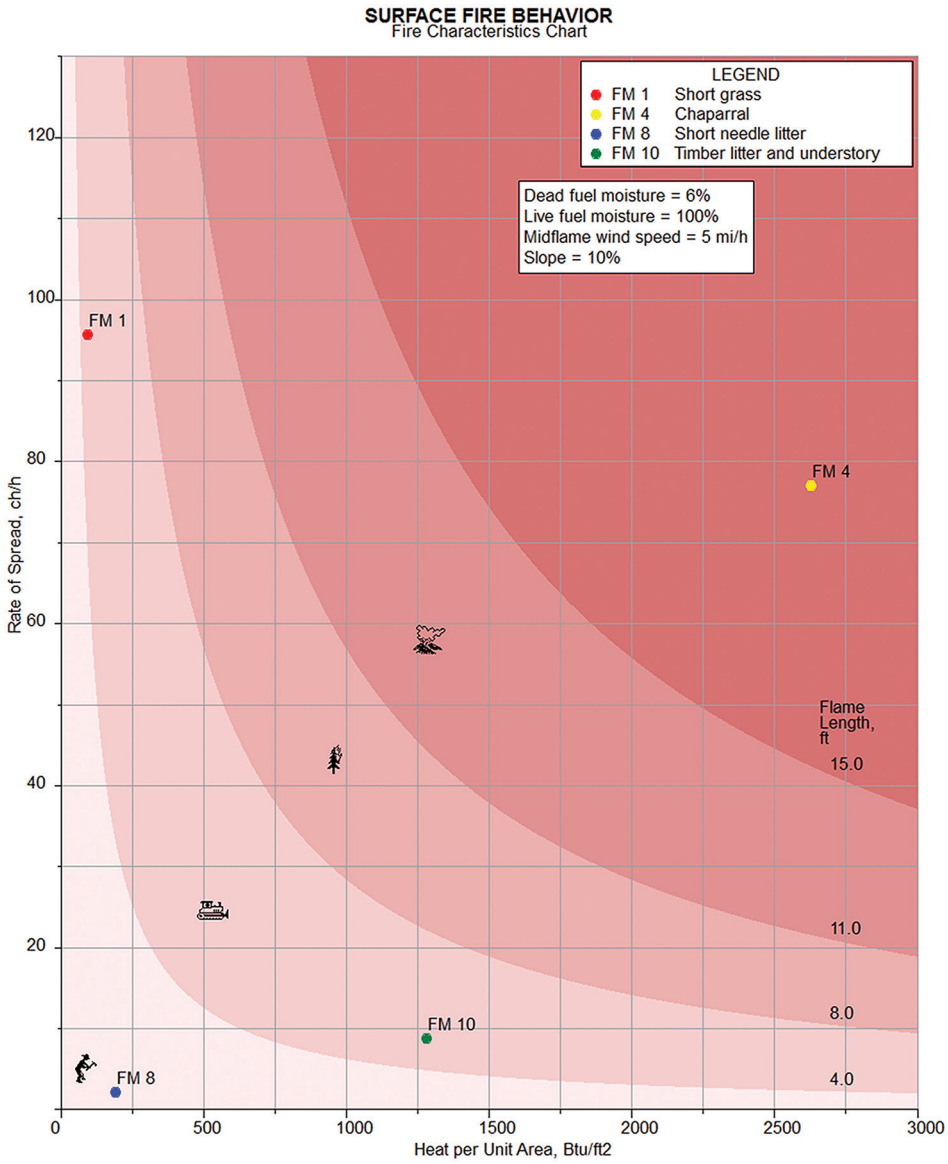


Figure 1—Surface fire behavior characteristics charts display primary fire behavior variables: rate of spread, heat per unit area, and flame length. Fire behavior increases as points move away from the origin. The difference in the fire characteristics is shown for four fuel models for the same moisture, wind, and slope conditions.

for an area. For example the chart can be used to facilitate a discussion of potential fire danger levels given several weather scenarios. Consider a hypothetical briefing to fire prevention specialists on June 20 to describe potential changes in fire danger, which can be used in determining prevention activities that might be required for the Fourth of July holiday. Figure 2 is a chart in which BI has been used to define fire danger levels for an area. Weather observations were used to plot recent indices (June 5–20). Three possible weather scenarios—persistent weather pattern, increasing hot and windy conditions, or light rain a few days before the U.S. holiday—were used to compare fire danger characteristics projected for July 4. As shown on the chart, each scenario results in a different level of fire danger, which provides meaningful input for fire management staff who must decide how to implement prevention and mitigation actions. The chart provides a non-technical display of possibilities; however, appropriate interpretation of the chart depends

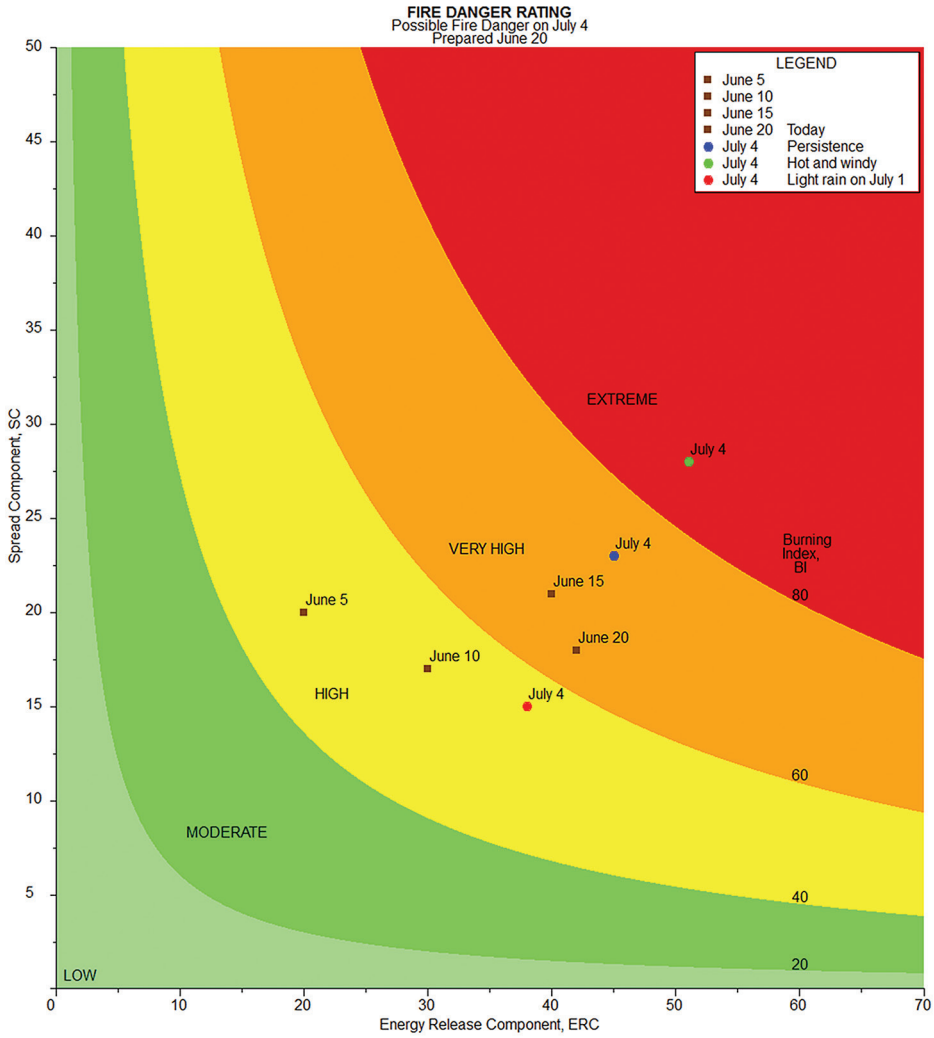


Figure 2—A fire danger characteristics chart containing actual and predicted fire danger can accompany a briefing to aid communication. Observed fire danger for June 5, 10, 15, and 20 is plotted. Three weather scenarios are used to calculate possible fire danger for July 4.

on knowledge of the technical details, assumptions, and calculations associated with estimating fire danger rating indices.

2. Fire Danger Rating

The U.S. National Fire Danger Rating System (NFDRS) is intended to be used for fire management applications prior to an initiating fire, such as fire preparedness, prevention, and suppression readiness. It consists of components and indices calculated from values representing topographic and vegetative conditions along with a steady stream of weather data. The system currently used in the United States is the 1978 NFDRS (Deeming et al. 1977) with options made available in 1988 (Burgan 1988). In this report we use the 1978 options.

The NFDRS is essentially a climatology system that integrates the effects of weather and fuels into various measures of potential fire danger. NFDRS is applied on a large scale, often to a fire danger rating area (FDRA). A fire danger rating area can range

from 10,000 to 100,000 acres (1 acre = 0.405 ha), and is defined as an area of relatively homogeneous climate, topography, and vegetation (Fosberg and Furman 1971, 1973; Schlobohm and Brain 2002). Point measurements taken at Remote Automated Weather Stations (RAWS) are assumed to be indicative of broad-scale weather across the FDRA. Because fire danger rating is designed for worst-case conditions, RAWS are often located mid-slope on south- or west-facing aspects. Potential fire danger for the FDRA is ascertained through use of several NFDRS components and indexes, which are unitless, relative, and dependent on weather data taken at the RAWS. Calculations are based on weather observations recorded during the afternoon, when fire danger is normally highest. The Weather Information Management System (WIMS; NISG 2011) uses weather observations to generate these indices on a daily basis. The National Weather Service provides daily weather forecasts, which are used to generate forecasted fire danger in WIMS. Indices are useful only when compared with historical climate data and NFDRS outputs from the same weather station (Deeming et al. 1977) using the same fuel model and other inputs. FireFamilyPlus (Bradshaw and McCormick 2000) is used to analyze the historical weather and NFDRS outputs needed for comparison. These outputs provide information about fire potential as it changes through the fire season.

Three commonly used NFDRS indices are the Spread Component (SC), Energy Release Component (ERC), and Burning Index (BI). Each one reflects a different effect of seasonal weather on fire potential. The fire danger characteristics chart, in conjunction with other tools, can help you understand what these indices represent and whether they are appropriate to support decisions in a given area.

A detailed diagram of the NFDRS relationships is shown in figure 3. Basic inputs include observed weather data and a site description with fuel model. Fuel moisture is calculated for four size classes of dead fuel as well as for live herbaceous and woody fuel. The fuel model defines the fuel load for each fuel class. For our purposes, it is important to note on the diagram that:

- BI is a function of SC and ERC,
- Wind is an input to SC but not to ERC, and
- The influence of fuel moisture by size class is different for SC and ERC.

The Spread Component (SC) uses the original weighting factors as defined by Rothermel (1972), emphasizing the fine fuels (1-h dead [<0.25 inch diameter; 1 inch = 2.54 cm]) that carry fire spread. Heavy fuels (1,000-h [3–8 inch diameter]) are not included in the SC calculation. Because of its dependence on fine fuel moisture and wind speed, SC can vary greatly from one day to the next.

The Energy Release Component (ERC) uses a weighting scheme developed for NFDRS that differs from Rothermel (1972). It primarily emphasizes the heavy fuels (100-h [1–3 inch diameter] and 1,000-h) to better reflect seasonal trends. Only those fuel classes that are included in the selected fuel model play a role. Fuel models lacking heavy fuels do not have the strong seasonal profile characteristic of fuel models containing such fuels.

The Burning Index (BI) integrates the fast response of SC to wind speed and fine fuel moisture with the slower response of the ERC to changes in large fuel moisture. The BI provides a measure of "the potential difficulty of fire containment as it relates to the flame length at the head of the fire" (NWCG 2012).

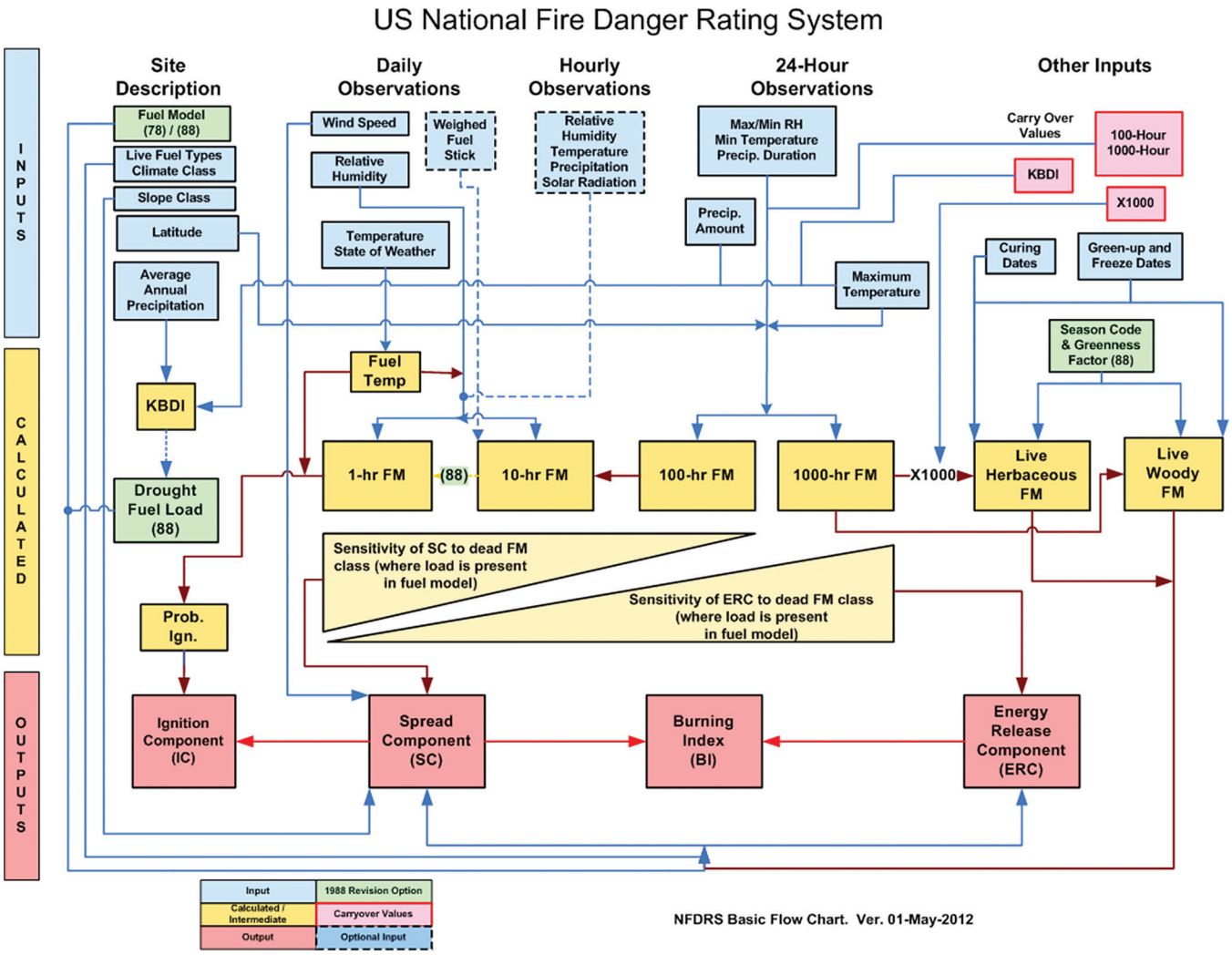


Figure 3—The NFDRS basic flow chart developed by Bradshaw and Jolly in 2012 is based on a simplified diagram from Andrews and Bradshaw (1991).

The fire danger characteristics chart uses SC and ERC values that have been calculated elsewhere (for example, in FireFamilyPlus or WIMS). The chart then combines the three fire danger rating indices using equation (1) (Andrews and Rothermel 1982; Cohen and Deeming 1985).

$$BI = \left[\frac{ERC \times SC}{0.091}\right]^{0.461} \quad (1)$$

FireFamilyPlus outputs can be imported directly into the chart program to produce clouds of points that show an envelope of fire danger. Individual points can then be added to the chart to emphasize, for example, the current day as compared to the current season, the forecasted fire danger for the next day or the next week, or conditions under which historical fires have occurred. Color can be added to the chart to highlight local climatological thresholds or fire business thresholds, using any of the three indices. Thresholds can be divided into 3, 5, or 9 classes and, when combined with seasonal and current fire danger rating values, provide a quick analysis of current fire danger in relation to previous years, months, or days. Finally, fire danger characteristics chart data and graphs can be exported into common file formats for documentation.

3. Application of the National Fire Danger Rating System Chart

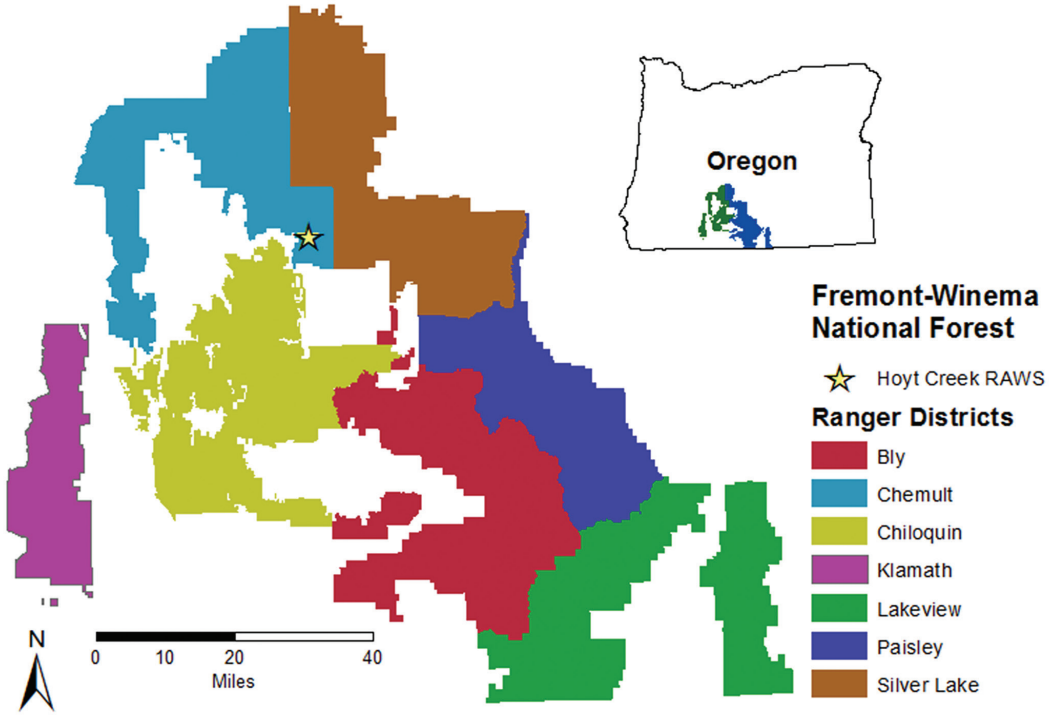
Interpretation of climatological breakpoints or fire business thresholds for fire danger rating indices is not general, as in the case of fire behavior charts, but rather specific to the current dataset. Using the fire danger characteristics chart to display quantitative fire danger rating values can be useful for many applications and provides a way to view many years of data in one graph. It clearly demonstrates the relationship among the Spread Component (SC), Energy Release Component (ERC), and Burning Index (BI) for a given fire danger rating area (FDRA). The chart can be used in conjunction with knowledge of fire danger rating during past fires of note as well as to help select a fuel model and index that best reflect local seasonal trends. We present examples of the fire danger rating characteristics chart for:

- Demonstrating the relationships among the three indices,
- Displaying thresholds based on each index,
- Comparing outputs with FireFamilyPlus season plots,
- Demonstrating interannual and seasonal variability,
- Comparing index values with past fires of note, and
- Comparing fire danger fuel models.

This section demonstrates use of the chart. Examples focus on application and interpretation rather than on how to produce charts. Section 4 covers basic program operation. Appendix A explains how to use data from FireFamilyPlus. Appendix B provides a brief summary of the steps necessary to produce each example chart. We used FireFamilyPlus version 4.1 in this report.

The same Remote Automated Weather Station (RAWS) is used in all examples: the Hoyt Creek RAWS (location: 42.98˚N, 121.42˚W; elevation: 5,445 feet), located on the Fremont-Winema National Forest in Klamath County, Oregon (fig. 4). Fire data associated with the RAWS station were obtained for five ranger districts: Bly, Chemult, Chiloquin, Paisley, and Silver Lake. The other two ranger districts (Klamath and Lakeview) were not associated with this RAWS because one or more factors (weather, topography, or vegetation) are too different from that represented by the RAWS. They could be different enough to be placed in a separate FDRA. Therefore, NFDRS indices calculated at the Hoyt Creek RAWS would not accurately indicate the fire danger on these two ranger districts. Weather and fire occurrence data for 1997 through 2012 were downloaded from the Fire and Aviation Management Web Applications website (https://fam.nwcg.gov/fam-web/).

The Fremont-Winema National Forest is an area of relatively low fire occurrence, with fewer than 1,000 fires during the 16-year period of analysis (fig. 5; five of seven districts). Most fires were less than 10 acres, as suppression actions are generally very successful on this forest. A fire season extending from May 1 through October 31 was selected on the basis of historical fire data (fig. 5). An ERC trace (average, maximum, and minimum ERC for the 16-year period) for the Hoyt Creek RAWS increases gradually, peaking in August and September, followed by a fairly rapid decline. Climatological breakpoints (five classes; table 1) for SC, ERC, and BI were developed based on calculations used in WIMS for Forest Service stations (97th percentile, 90th percentile, half of the value at the 90th percentile, half of that value [one-fourth of the value at the 90th percentile]).



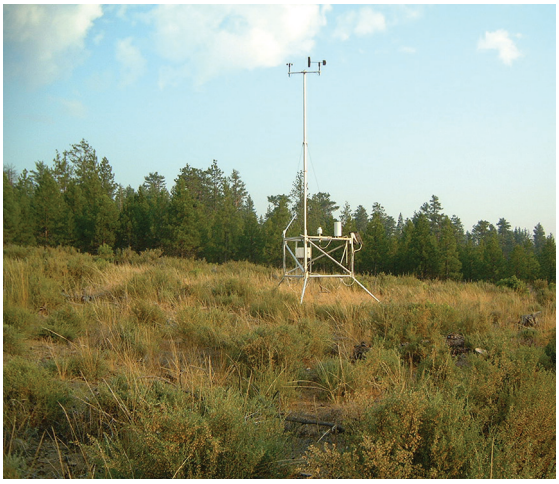


Figure 4—The Hoyt Creek RAWS, in southern Oregon, is used in all example applications. The Hoyt Creek RAWS is only representative of the weather on the Bly, Chemult, Chiloquin, Paisley, and Silver Lake Ranger Districts, so they are the only districts included in this analysis.

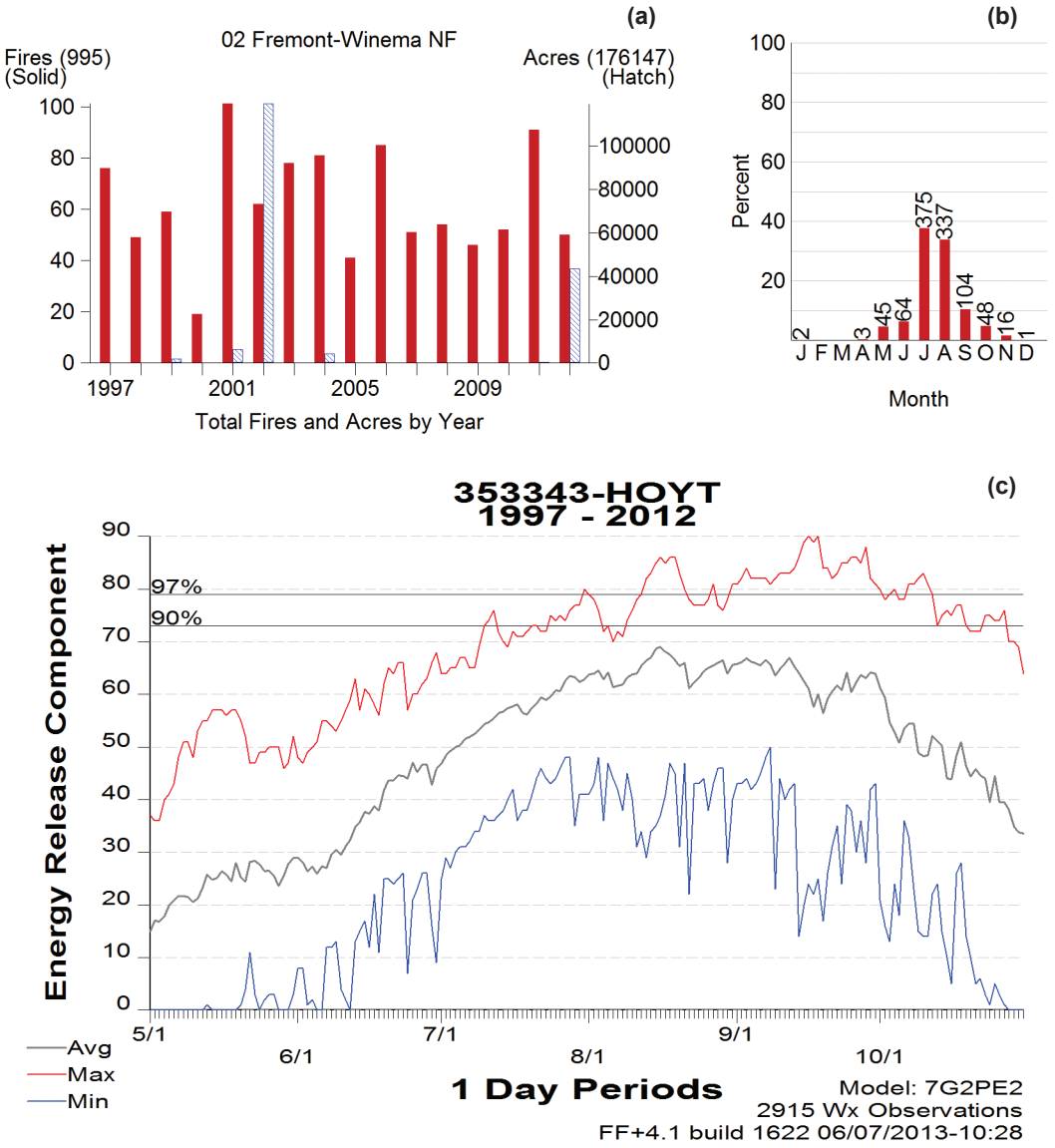


Figure 5—Fire occurrence by year (a) and by month (b) are presented for five of the seven districts of the Fremont-Winema National Forest that are represented by the Hoyt Creek RAWS. The ERC (Fuel Model G) graph summarizes seasonal average, maximum, and minimum fire danger for the Hoyt Creek RAWS for 1997–2012 (c).

Table 1—Climatological breakpoints and related fire danger classes are calculated for the Hoyt Creek RAWS based on fuel model G.

NFDRS index	Climatological breakpoints			
	¼ of 90th percentile	½ of 90th percentile	90th percentile	97th percentile
SC	2	5	10	13
ERC	18	36	73	79
BI	15	30	60	68

NFDRS index	Fire danger classes				
	Low	Moderate	High	Very high	Extreme
SC	<2	2-4	5-9	10-12	≥13
ERC	<18	18-35	36-72	73-78	≥79
BI	<15	15-29	30-59	60-67	≥68

3.1 Relationships Among Indices

The U.S. NFDRS is a tool that can be used for tracking fire season potential. The season plots produced by FireFamilyPlus are a primary means of displaying fire danger. The chart does not replace, but can supplement, these seasonal plots by showing the relationship among the indices, indicating the fire danger envelope of a selected fuel model, and improving understanding of the indices themselves.

Unless otherwise noted, we use five levels of fire danger rating in this report, based on four climatological breakpoints (table 1) using a climatological analysis of data from 1997 through 2012. Fire business thresholds, in which fire occurrence data are statistically compared with NFDRS indices, should be used in assessing fire danger thresholds, but such an analysis is beyond the scope of this document. As many as nine levels can be set within the fire danger characteristics chart, depending on individual needs. The fire danger characteristics chart offers the option of a defined colorway for 3, 5, and 9 classes based on the standard adjective danger rating levels (green, blue, yellow, orange, and red). Grey or red shading can be used for any number of classes.

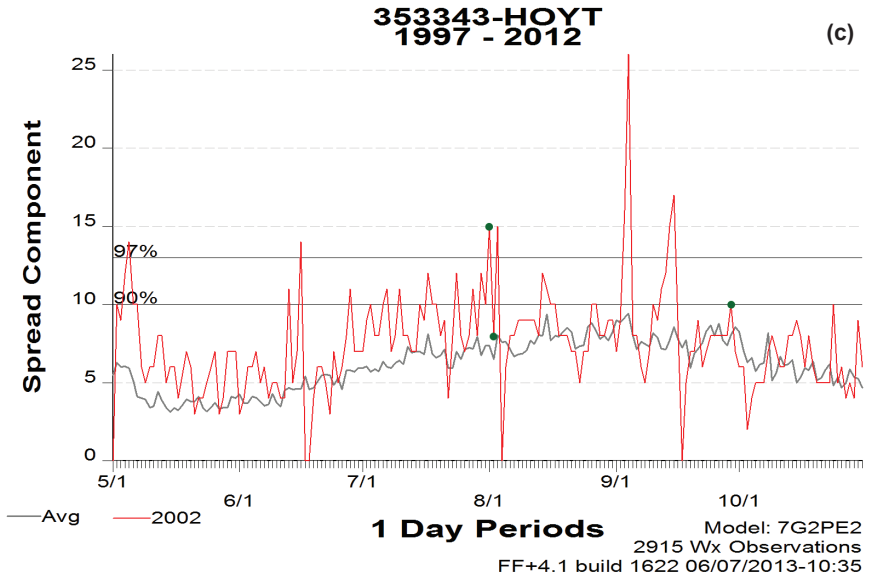
BI and especially SC can change radically from day to day depending on the wind speed at observation time; therefore, ERC is often used to set adjective rating levels. But BI is often used for staffing levels because of its rapid response. Depending on the intended use of the chart, breakpoints can be entered for any or all of the three variables. Note that the software default values of 20, 40, 60, and 80 do not represent either climatological breakpoints or fire business thresholds for this RAWS.

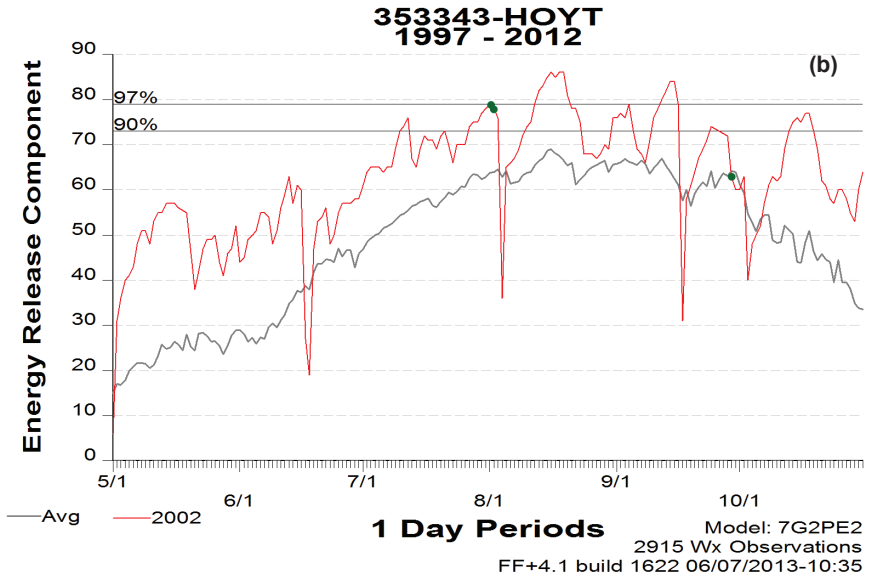
The year 2002 was a notable fire year for the Fremont-Winema National Forest; FireFamilyPlus season plots for SC, ERC, and BI indicate it was also a year with high fire danger (fig. 6). Three days (August 1, August 2, and September 29) are indicated on the plots and on a fire danger characteristics chart to show the relationship among them. The SC, ERC, and BI breakpoint lines on the seasonal plots correspond to those on the chart and are based on the climatological 90th and 97th percentiles for the site.

The chart allows you to determine at a glance the diverse effects of wind speed and seasonal drying on the potential fire danger for an area. On August 1 and 2, 2002, the ERC values are nearly equal, whereas SC on those days is quite different due to higher winds on August 1 (table 2). BI for those days is therefore also quite different and is categorized as extreme on August 1 and high on August 2. Conversely, the SC values on August 2 and September 29 are similar, whereas the ERC values differ. BI, however, is identical and is categorized as high.

3.2 Fire Season Examination

Season plots show how the three indices change throughout a single fire season, and this information can also be displayed on a fire danger characteristics chart. Data from FireFamilyPlus are plotted in figure 7 and represent the fire season for the Hoyt Creek RAWS during 2009. Data from FireFamilyPlus were separated by month and then imported into the chart program. Each file can be identified with a specific icon/color combination. Seasonal traces of SC, ERC, and BI were generated by using other software to incorporate corresponding colors (fig. 7). In 2009, the highest ERC values occurred during July–September, the months during which the height of the fire season





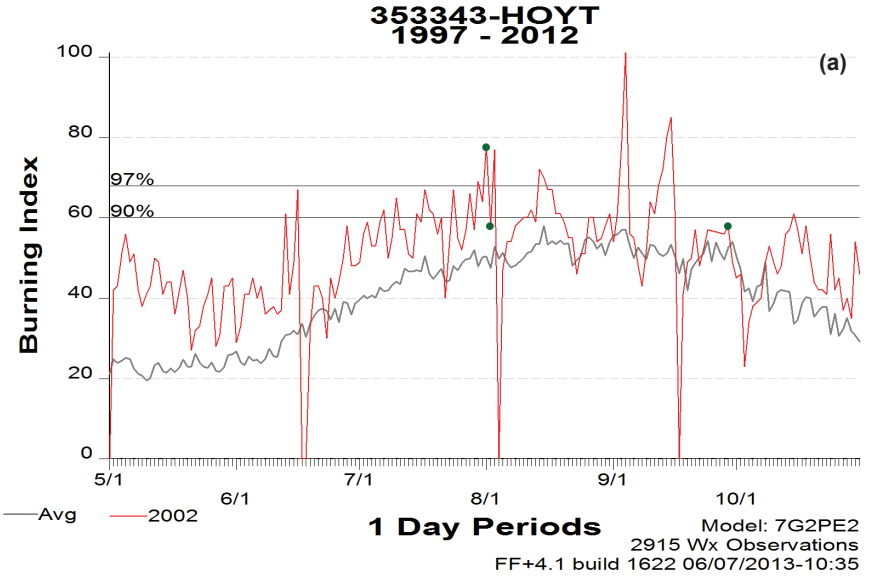


Figure 6—Season plots show how fire danger changes throughout a single fire season as shown by SC (a), ERC (b), and BI (c) for 2002 in southern Oregon highlighting the 3 days of fire danger from table 2. The 3 days indicated on the season plots are taken from table 2 and plotted on the fire characteristics chart (d) to demonstrate the relationship among them.

Figure 6—*Continued*.

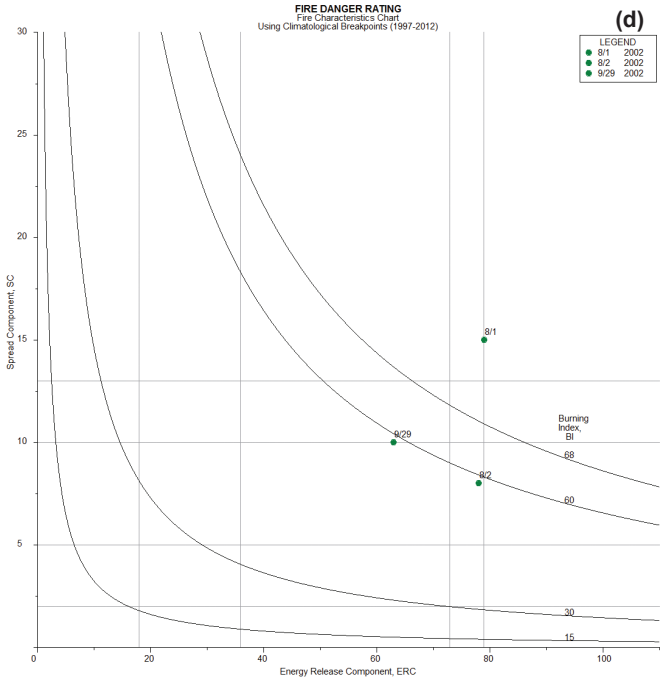


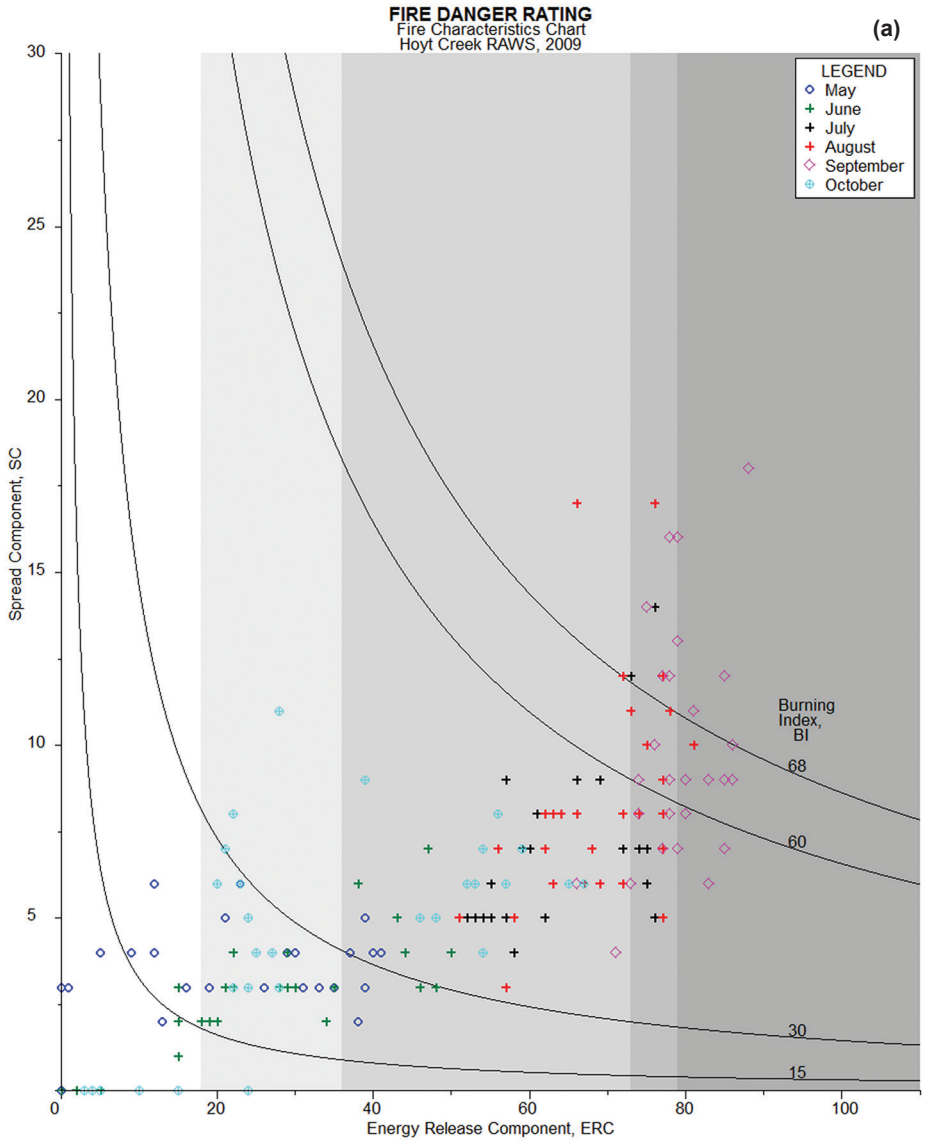
Table 2—Fire Danger Rating Index values for fuel model G are given for 3 days during 2002. Differences in wind speed led to changes in SC, while differences in ERC are based largely on changes in fuel moisture (E: extreme, VH: very high, H: high, based on climatological breakpoints calculated for table 1).

	NFDRS index		
Date	**SC**	**ERC**	**BI**
Aug. 1	15 (E)	79 (E)	79 (E)
Aug. 2	8 (H)	78 (VH)	59 (H)
Sept. 29	10 (VH)	63 (H)	59 (H)

often occurs in this National Forest. High values of SC in October are associated with the higher winds that can occur at this time, although ERC is lower during this period as fuels are typically wetter.

3.3 Fire Season Comparison

In addition to demonstrating the variation in fire danger rating indices during a single fire season, the chart can also show the variation in indices across multiple seasons. Seasonal plots from FireFamilyPlus for multiple indices and multiple years can be difficult to interpret. The fire danger characteristics chart provides a synopsis of how the indices vary among years. On the season graphs in figure 8, we selected 2 years of data (1998 and 2002) to show the difference in seasons and to compare with the 1972–2002 average. The 1997–2012 data are shown on the charts (fig. 9, brown circles) for reference along with the 1998 and 2002 data. Both the season plots and the fire danger characteristics charts show these differences for the full fire season (May–October). SC is fairly similar for the 2 years, whereas ERC is quite different. In fact, ERC was at or near maximum values for most of 2002 (fig. 8b). The difference is most apparent during July and August (fig. 9b), when there was almost no overlap in ERC values between the 2 years, resulting in BI values that were also higher during 2002.



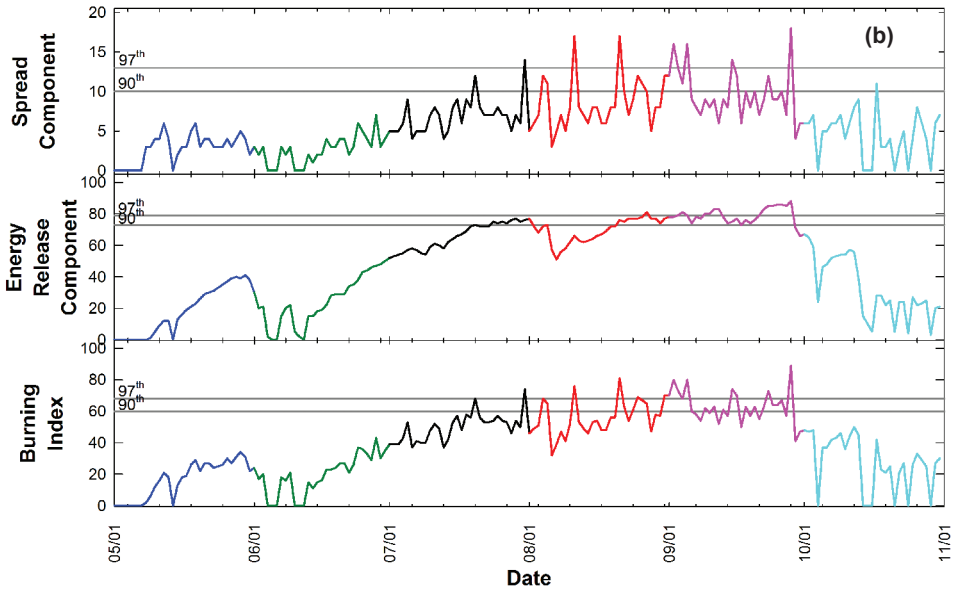
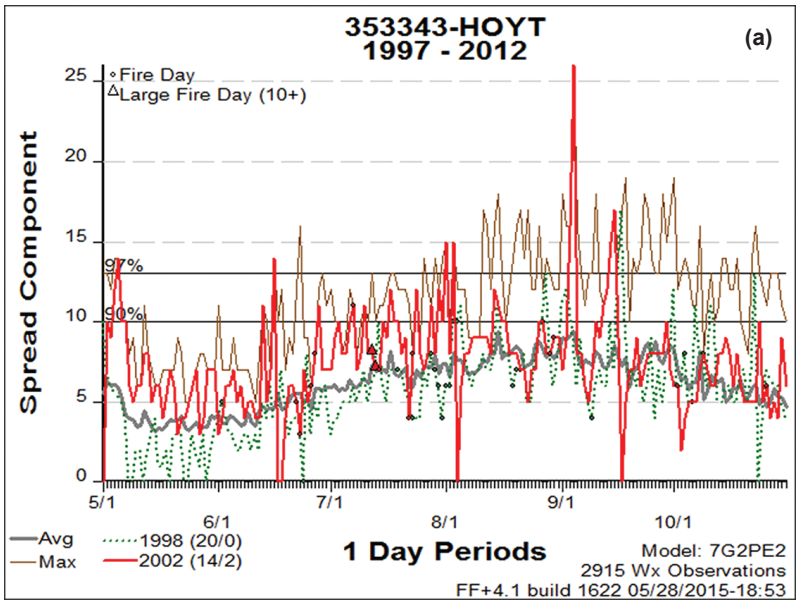
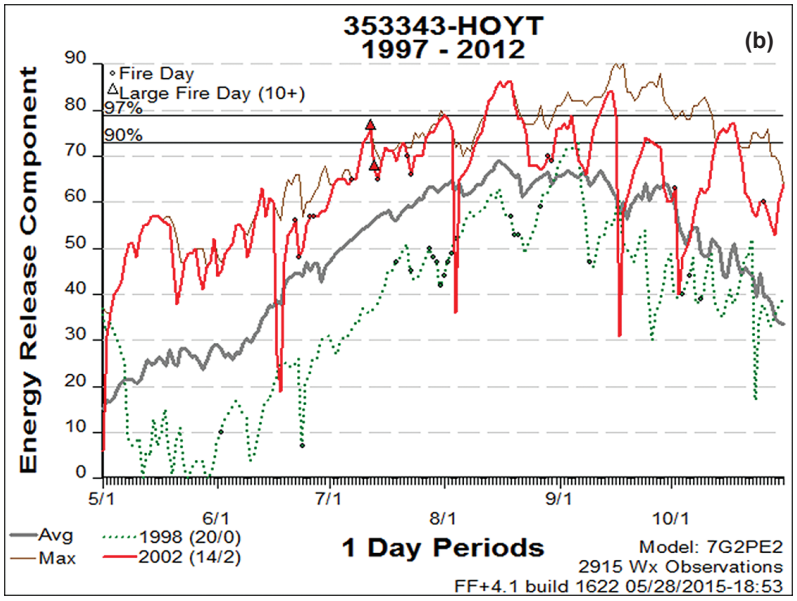


Figure 7—Fire danger characteristics chart (a) and corresponding seasonal traces (b) are provided for Hoyt Creek RAWS, demonstrating how fire danger changes throughout the fire season of May–October 2009. Colors represent months.





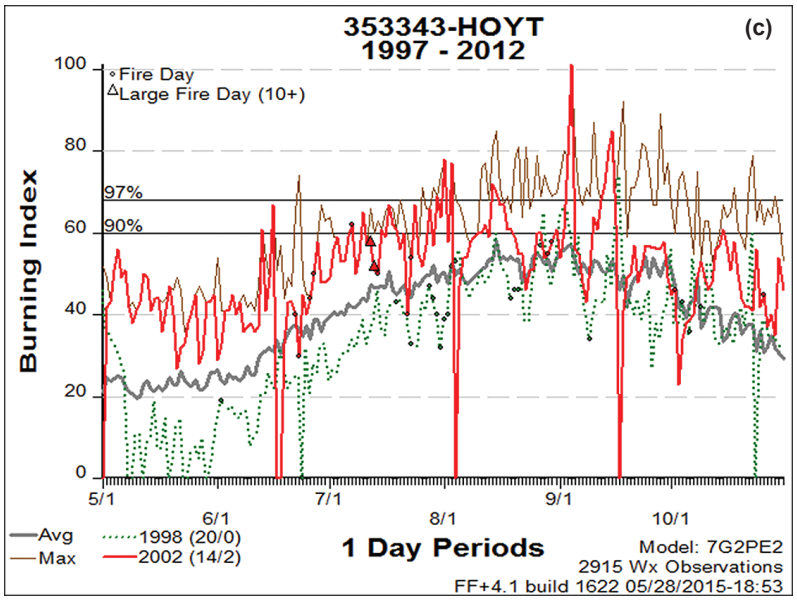


Figure 8—Interannual variability is demonstrated for a very dry year (2002) and a fairly wet year (1998) compared to 1997–2012 indices. FireFamilyPlus season graphs contain information about Spread Component (a), Energy Release Component (b), and Burning Index (c).

Interannual variability in weather can be significant, as shown in figures 8 and 9. We used FireFamilyPlus version 4.1 to associate fires with weather and NFDRS indices for each fire discovery day. All fires are indicated on the season plots (fig. 8); the three largest fires are marked by triangles. The NFDRS indices associated with the day these three fires were discovered are shown on the fire danger characteristics chart for the peak of fire season (fig. 9b). The two largest fires are represented by a single triangle because both started on July 12, 2002, during a year with above-average fire danger and area burned, but average fire occurrence (fig. 5). There were 43 fires during 2002, including the three largest fires (by an order of magnitude) of the entire 16-year period. The three largest fires were each greater than 20,000 acres, yet 97 percent of fires were 10 acres or less. In contrast, 1998 was a below-average year for fire danger and area burned (fig. 5) with 36 fires that burned less than 20 acres combined.

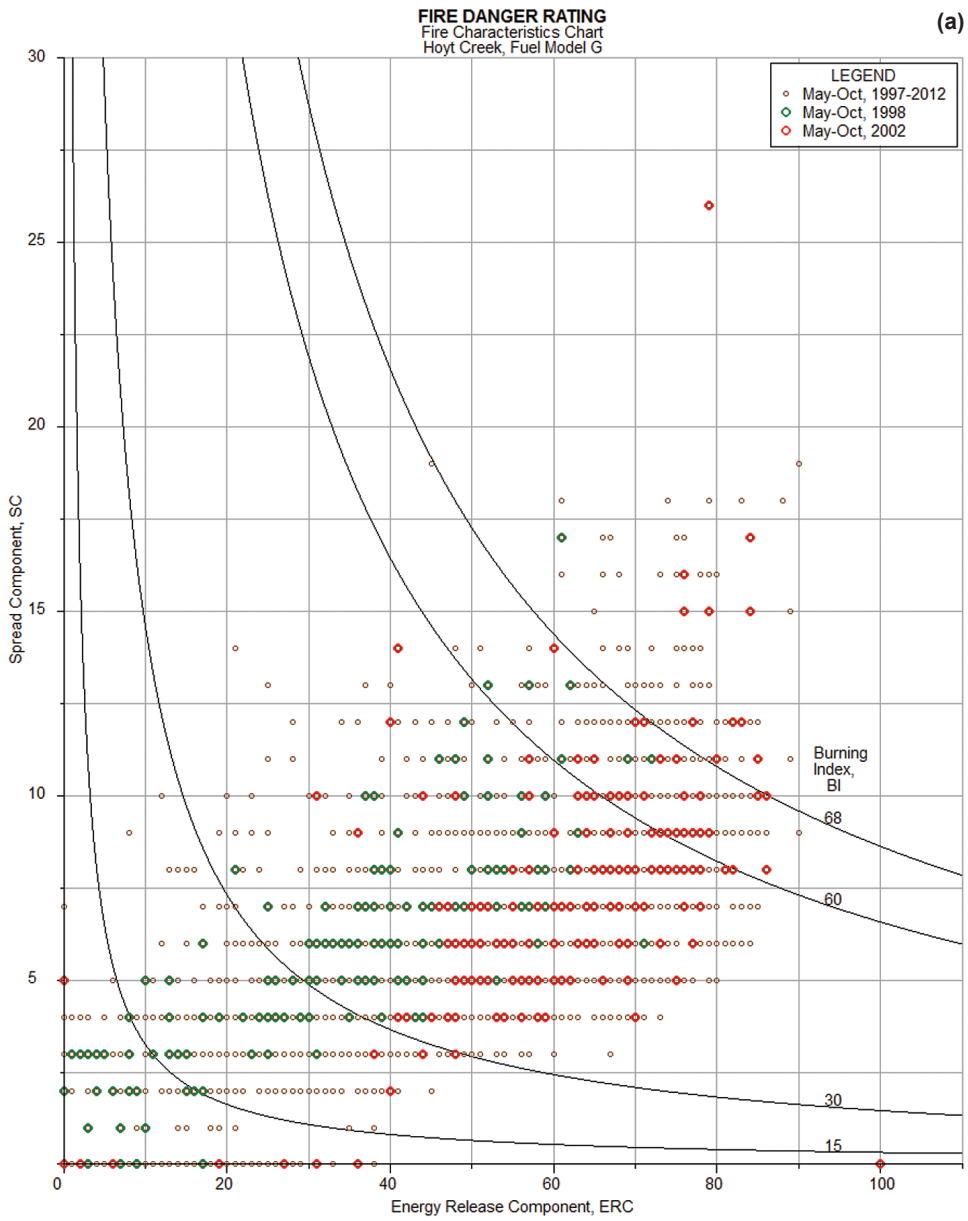


Figure 9—Clear differences in the ERC for the 2 years are evident in the fire danger characteristics charts for both May–October (a) and the peak of fire season (b) July–August. SC values are more similar, indicating that the increase in BI, driven by ERC, is moderated by the SC.

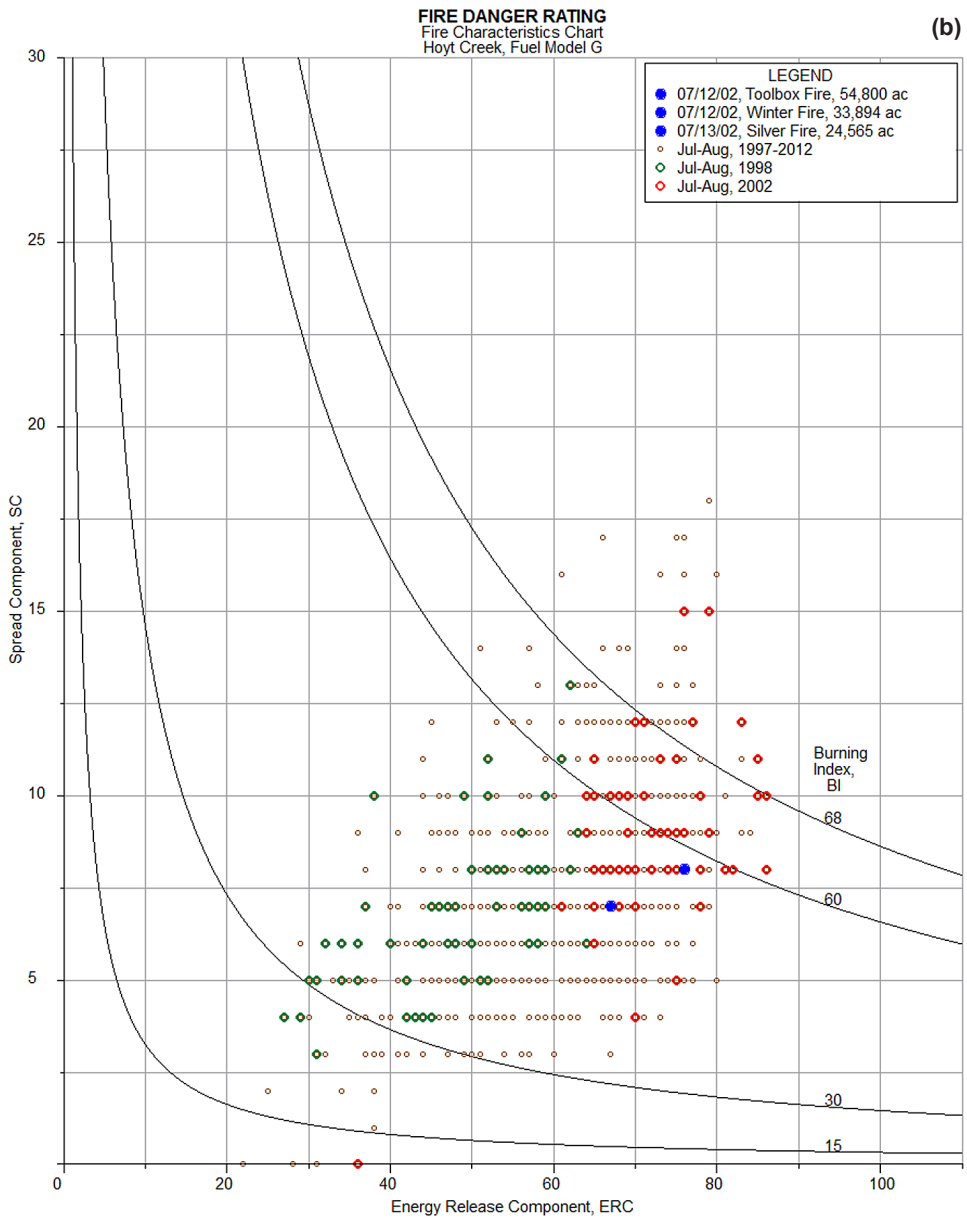


Figure 9—*Continued*.

3.4 Relationship of Indices to Historical Fires

Fire danger characteristics charts can be used as a visual tool to explore the relationship between NFDRS indices and fire activity. Although NFDRS does not predict the behavior of individual fires, higher indices should suggest higher levels of fire activity. Logistic regression methods (Andrews et al. 2003; Loftsgaarden and Andrews 1992) are incorporated into FireFamilyPlus to analyze the relationship between NFDRS indices and fire activity. Individual fires can be plotted on the season charts as shown in figure 9.

The Hoyt Creek RAWS indices on the discovery date of the fires greater than 10 acres were compared with NFDRS values from the RAWS for all days during 1997 through 2012. The resulting graph (fig. 10) indicates a relationship between large fires and high ERC values. The four largest fires were discovered on a day when ERC exceeded 55. Most large fires, identified in this analysis as being greater than 10 acres, occurred when BI was greater than 30.

3.5 Fire Danger and Climatological Breakpoints

Decisions such as staffing levels (used for internal staffing and management plans), and adjective fire danger rating levels (displayed on the familiar Smokey Bear sign for public information) may be based on classes or values derived from climatological breakpoints. These climatological breakpoints are often derived from climatologically based values, such as the 90th and 97th percentile levels for the U.S. Forest Service, U.S. Fish and Wildlife Service, and National Park Service, and the 80th and 95th percentiles for the Bureau of Land Management. Breakpoint values vary with the selection of weather station, fuel model, length of analysis period, and number of years of data. Therefore, any breakpoints derived from a given dataset and analysis apply only to that dataset. Breakpoints can be defined for any index (Heinsch et al. 2009).

Although a flame length of 5 feet has the same meaning no matter which fire behavior fuel model is selected, interpretation of an index value depends completely on the fire danger fuel model, weather station, and time period considered. An ERC of 50 has no meaning without reference to historic ERC values within a given dataset. Because the fire danger chart presented by Andrews and Rothermel (1982) was designed for paper, it had to use standardized BI curves rather than breakpoint-based curves. The fire danger characteristics chart software allows entry of breakpoints based on any (or all) of the three indices. You are responsible for defining appropriate climatological breakpoints or fire business thresholds for the area of interest.

In this example, data were analyzed for May–October, 1997–2012 using fuel models G and H. Data from 2004 were added to display seasonal variability in relation to average seasonal conditions. FireFamilyPlus season plots for the two fuel models look very similar to each other (fig. 11). However, the scales of the plots are quite different, with a range of ERC and BI values for fuel model H that are about 50 percent lower than the values for fuel model G (table 3). The highest ERC value in 2004 for fuel model G was 79, whereas it was 46 for fuel model H. It would be inappropriate to use the same breakpoints for both. However, entering climatological breakpoints separately in the software for each fuel model results in chart plots that look very similar to each other (fig. 12). If SC were not rounded to integers, the chart plots would be even more similar.

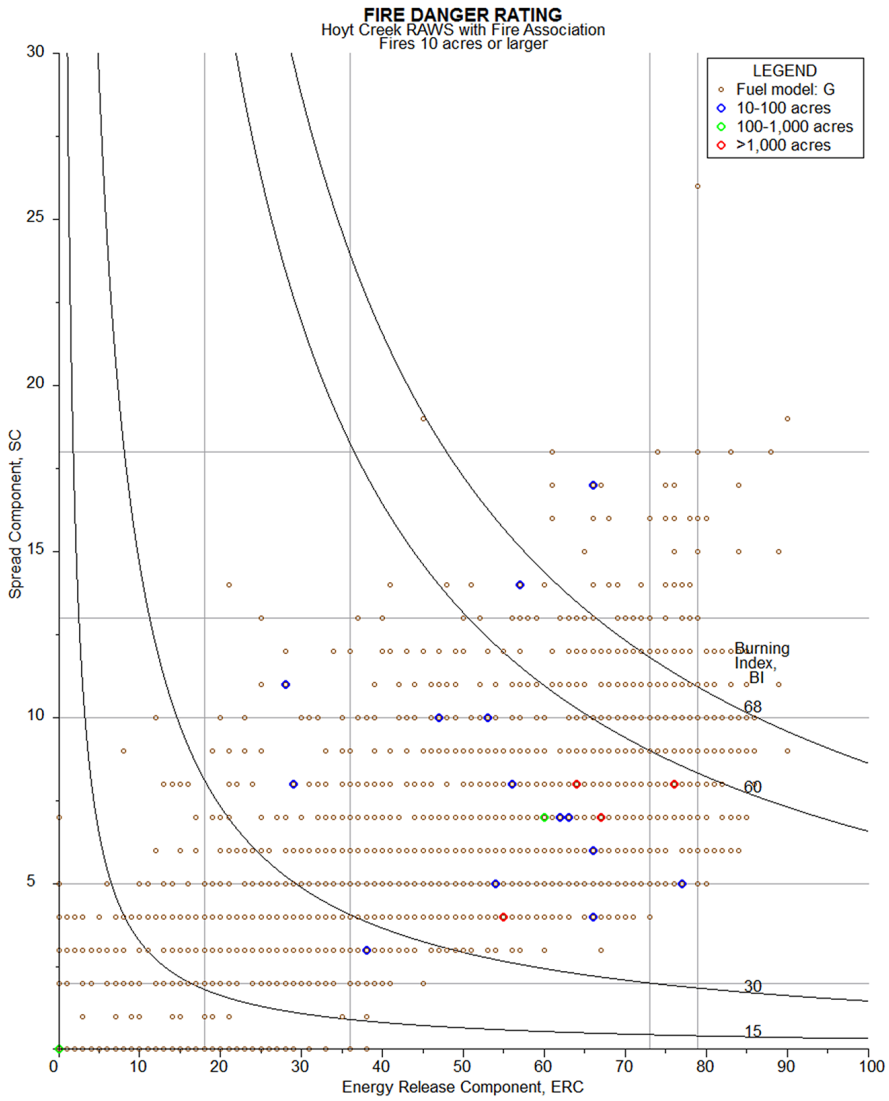


Figure 10—NFDRS indices from the Hoyt Creek RAWS for 1997–2012 are displayed on the fire danger characteristics chart. Fire danger rating indices on the day of discovery for fires greater than 10 acres on the Bly, Chemult, Chiloquin, Paisley, and Silver Lake Ranger Districts of the Fremont-Winema National Forest were also added to the chart to reveal when reportable fires are likely to occur.

3.6 Fuel Model Comparison

The same fuel type is clearly not present across an entire fire danger rating area (FDRA), even if the FDRA is defined in part by having relatively homogeneous vegetation. But the purpose of fire danger rating is not to predict fire behavior in a specific location, requiring a site-specific fuel model. Instead, selection of an NFDRS fuel model should be based on how well it reflects the fire season and fire potential in the FDRA, and on whether the fuels are dominated by grasses (light fuels), timber (heavy fuels), or shrubs (live fuels). Proper analysis combines a fuel model with an appropriate index to represent past fire activity in the FDRA, thereby providing information helpful for decision makers to predict future fire activity. A fuel model is merely a set of parameters used to calculate NFDRS indices. The actual name of the fuel model is not important. For example, it is quite possible the fuel model Q (Alaskan Black Spruce) would work well at sites in the lower 48 States.

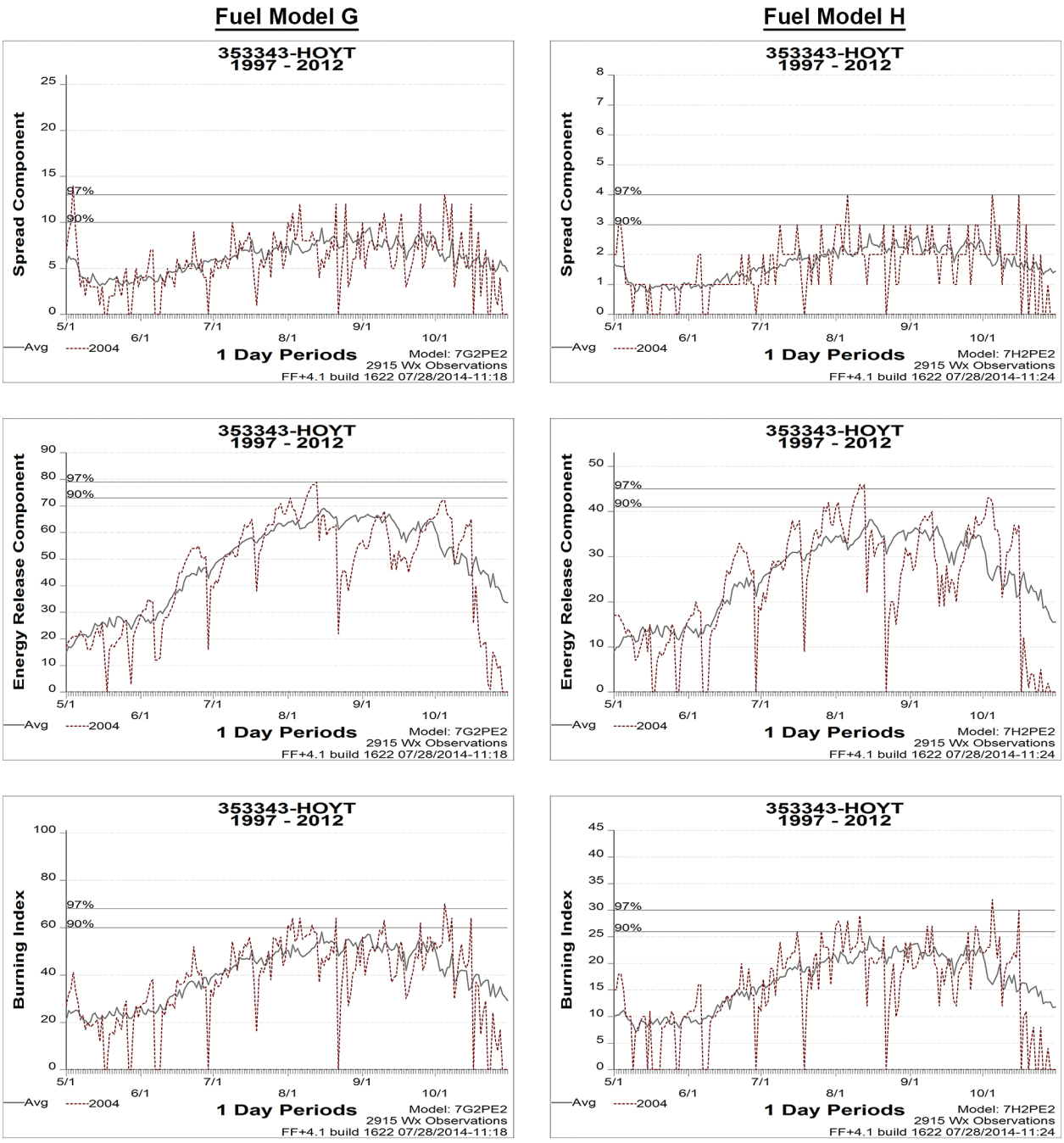


Figure 11—FireFamilyPlus season plots are shown for the NFDRS indices using fuel models G (left) and H (right) during 2004. Note the change in scale between fuel model G (left) and fuel model H (right), even though the seasonal traces are similar.

Table 3—Climatological breakpoints and related fire danger classes are calculated for the Hoyt Creek RAWS based on fuel models G and H. While the seasonal trends in the two models are quite similar (fig. 11), results for fuel model H are about 50% of those for fuel model G.

	Climatological breakpoints							
	Fuel model G				Fuel model H			
NFDRS index	¼ of 90th percentile	½ of 90th percentile	90th percentile	97th percentile	¼ of 90th percentile	½ of 90th percentile	90th percentile	97th percentile
SC	2	5	10	13	1	2	3	4
ERC	18	36	73	79	10	20	41	45
BI	15	30	60	68	6	13	26	30

NFDRS outputs can be plotted on a chart to show different results for different fuel models. Figures 11 and 12 demonstrate that despite the large difference in the SC values for two similar fuel models (G [range 0–25] and H [range 0–8]), the shape of the seasonal traces and the fire danger levels are very similar. Index values for very different fuel models can also be compared on the same chart. To demonstrate these differences, three very different fuel models (C, G, and L; table 4) are compared by plotting all data (1997–2012) on the same chart (fig. 13). Results for each fuel model are then plotted on separate charts, scaled with the associated climatological breakpoints for BI for each fuel model (table 5).

The differences can be attributed to fuel model parameters. Fuel models C and L are both grass fuel models, containing only light fuels (table 4). Fuel model L contains only fine 1-h (dead and live herbaceous) fuels. Fuel model C adds 10-h and live woody fuels. Fuel model G is a timber understory model, containing fuel in all major categories, with considerable heavy fuels.

Fuel model selection has a great impact on fire danger indices. Index values for the three fuel models are clearly different as illustrated when plotted on the same chart, using default breakpoints that load with the chart program (fig. 13). Fire activity in fuel model L is expected to consist of low intensity (low ERC), fast spreading (high SC) fires. Fires in fuel model G have higher intensity and low potential spread rates. Fuel model C lies between the two other models. However, an index value (such as a BI of 40) does not mean the same thing for the three fuel models. Using the climatological breakpoints specific to each model, a BI of 40 would be extreme for fuel model C, high for G, and very high for L (table 5).

SC, as mentioned previously, is largely influenced by the fine (1-h) fuel moisture. Therefore, a fuel model with a higher proportion of lighter fuels will have a higher SC, while 1,000-h fuels are not considered. For example, the SC for fuel model L (with only 1-h dead and live fuels) is much greater (ranging from 0 to 200) than the SC for fuel model G (which contains all six fuel size classes and ranges from 0 to 26) given the same weather conditions (fig. 13). Fuel model C has a moderate range of SC, from 0 to 33.

Conversely, ERC is weighted toward the larger (100-h and 1,000-h) fuels. Therefore, fuel models with a higher proportion of larger fuels also have a larger ERC. Fuel models containing no large fuels will have a narrow range of low ERC values. ERC values for fuel model G (containing a large proportion of 1,000-h fuels) range from 0 to 90 for this RAWS, whereas values for fuel model L range from 0 to 9. Again, fuel model C has a moderate ERC, ranging from 0 to 26.

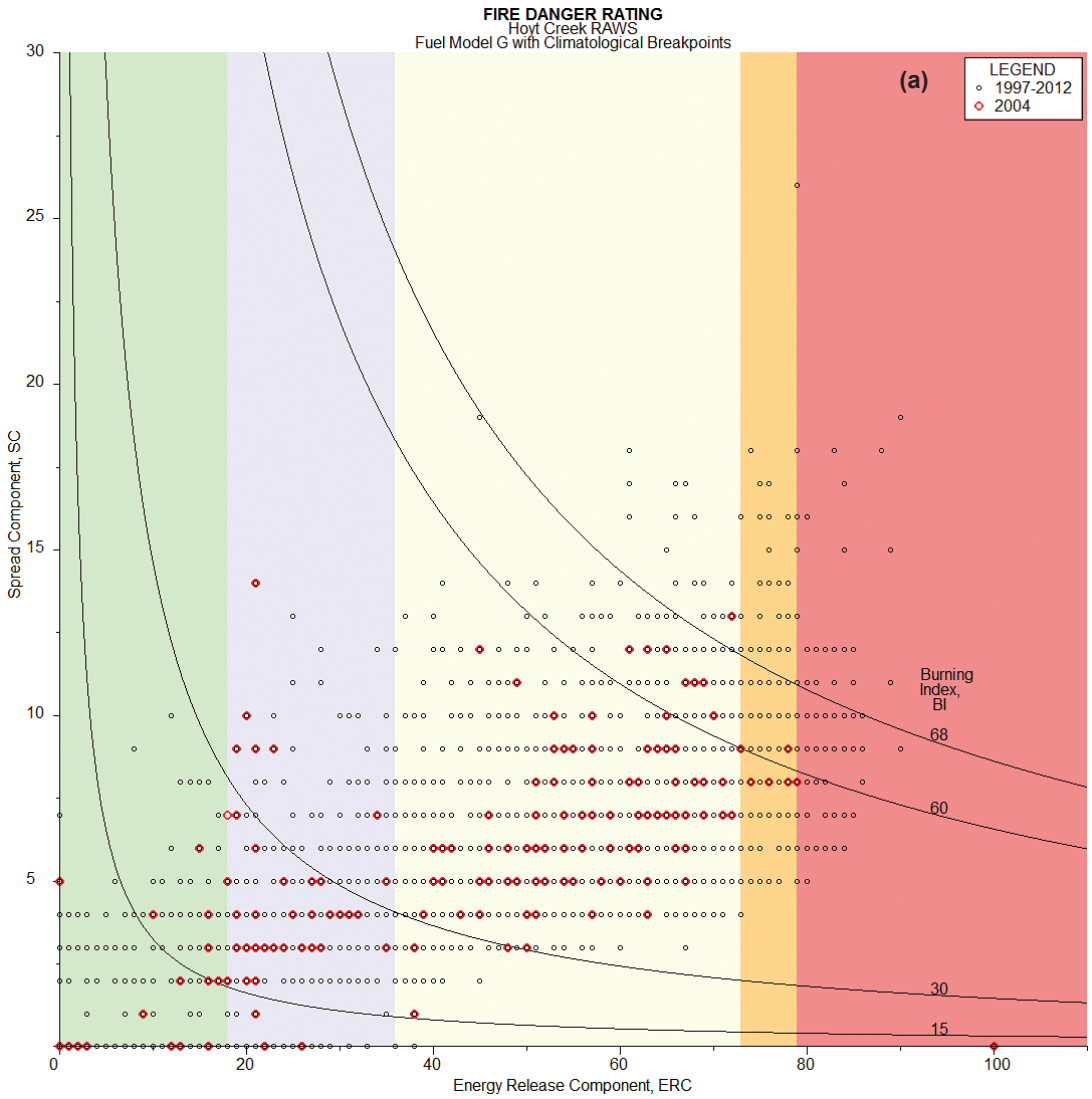


Figure 12—Fire danger characteristics charts for fuel models G (a) and H (b) during 2004. Data from 1997–2012 are provided as reference. Climatological breakpoints for ERC are displayed in color on the charts. The seasonal traces of ERC are similar, even though the actual values differ (see table 3).

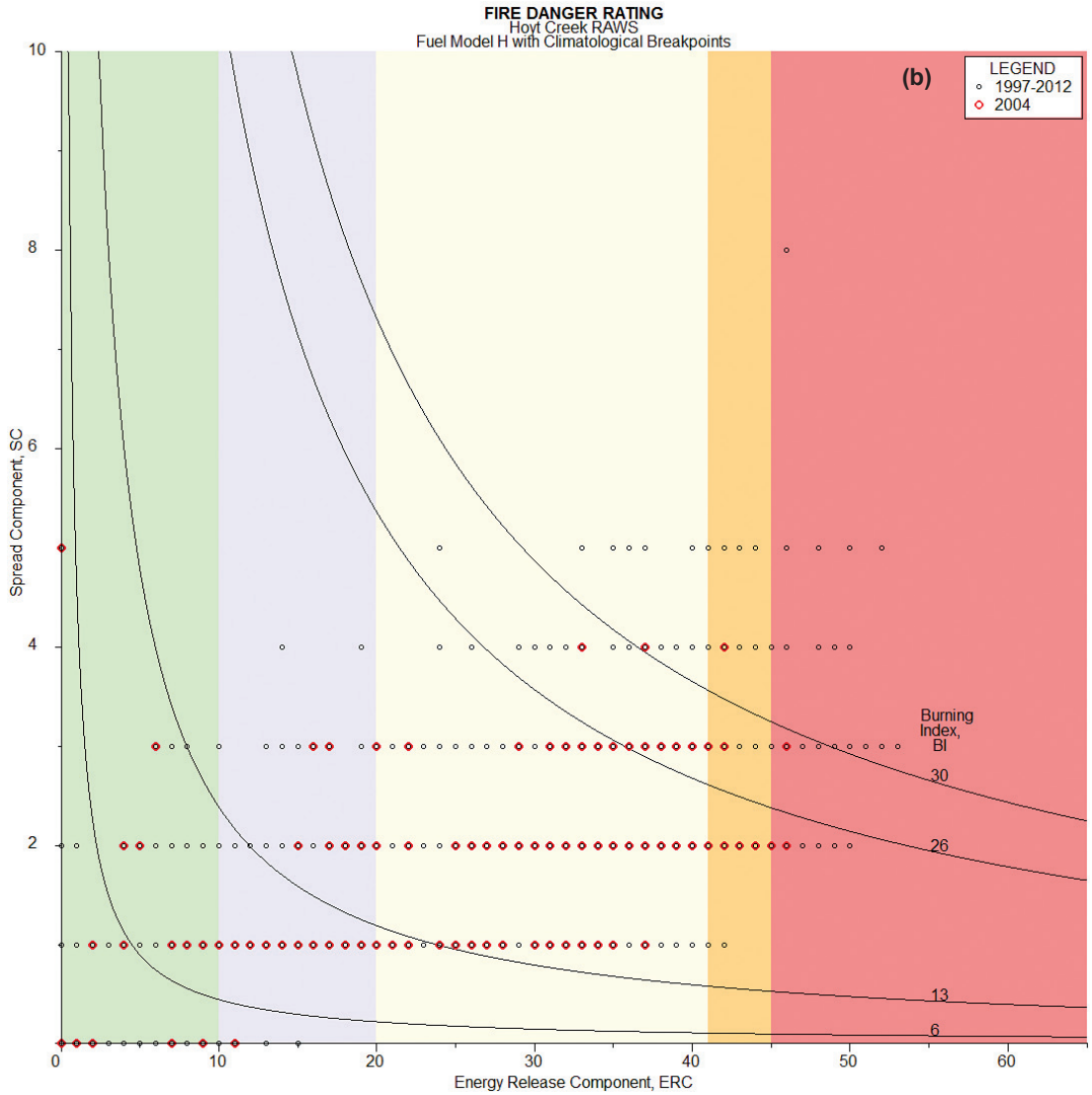


Figure 12—*Continued*.

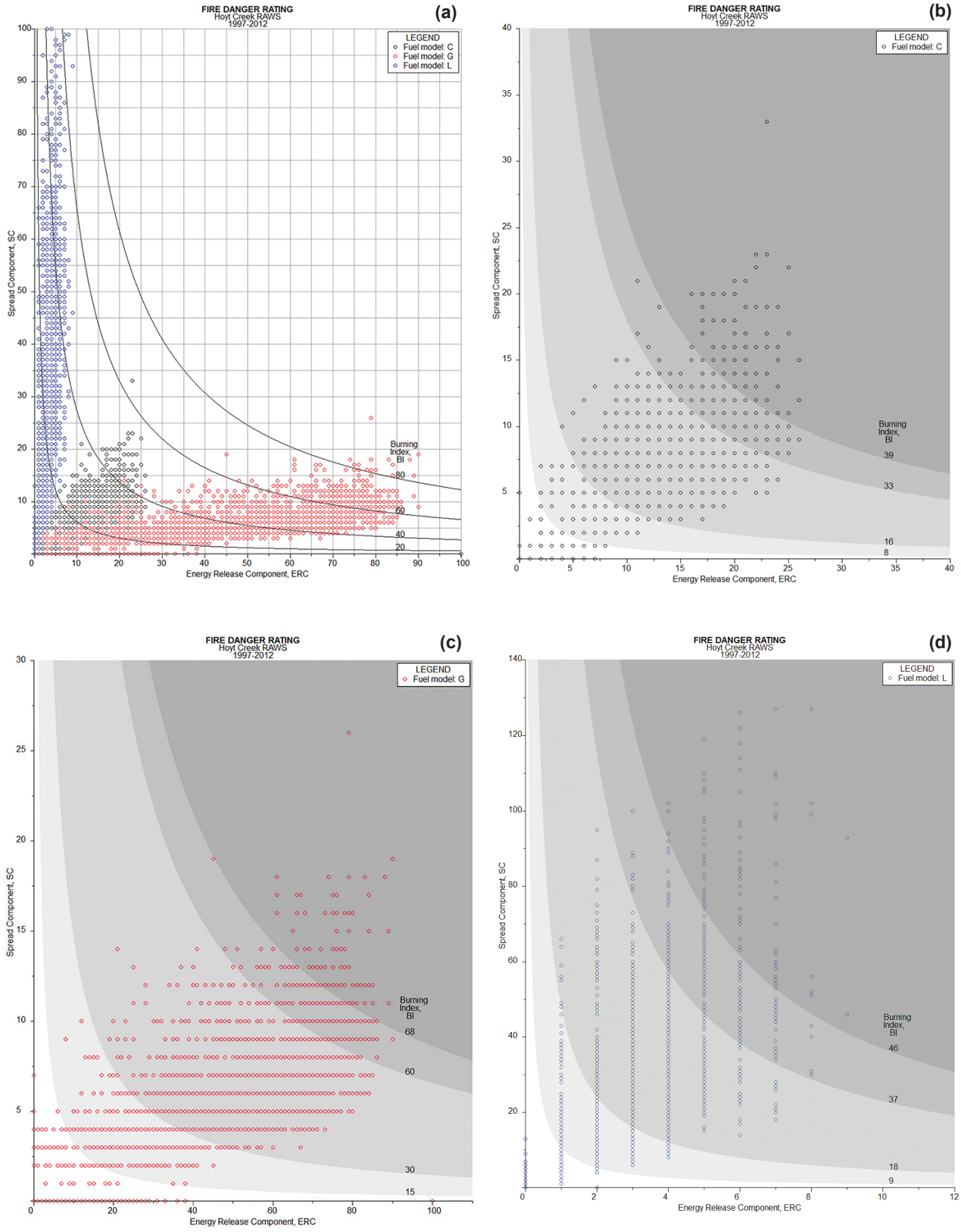


Figure 13—Fire danger is compared for three fuel models using the same weather data for the Hoyt Creek RAWS to demonstrate the effect of fuel model selection on fire danger. Fuel models are displayed on a single chart with default scales (a), and rescaled based on fuel model-specific climatological breakpoints for fuel model C (b), fuel model G (c), and fuel model L (d).

Table 4—Fuel parameters are provided for three NFDRS fuel models (C, G, and L), which are used in figure 13. Different fuel model parameters provide very different outputs within NFDRS.

Fuel model		Fuel load						Fuel bed depth	Dead fuel moisture of extinction
		1-h	10-h	100-h	1000-h	Live herb	Live woody		
		- - - - - - - - - - - - - - - - - tons/acre - - - - - - - - - - - - - - - - -						feet	%
C	Pine-grass savanna	0.40	1.00	0	0	0.80	0.50	0.75	20
G	Short needle (heavy dead)	2.50	2.00	5.00	12.00	0.50	0.50	1.00	25
L	Western grasses (perennial)	0.25	0	0	0	0.50	0	1.00	15

Table 5—Climatological breakpoints are calculated for fuel models C, G, and L for the Hoyt Creek RAWS to demonstrate differences in fuel model selection (see fig. 13).

Fuel model	NFDRS index	Climatological breakpoints			
		¼ of 90th percentile	½ of 90th percentile	90th percentile	97th percentile
C	SC	2	5	11	14
	ERC	4	9	19	22
	BI	8	16	33	39
G	SC	2	5	10	13
	ERC	18	36	73	79
	BI	15	30	60	68
L	SC	12	25	51	74
	ERC	1	2	5	6
	BI	9	18	37	46

3.7 Weather Station Comparison

When evaluating an FDRA, it is often advantageous to create a Special Interest Group (SIG) comprising several stations within the FDRA to ensure the weather of the area is properly captured (Fosberg and Furman 1971). Creating a SIG is described in the Advanced National Fire Danger Rating System course material, the FireFamilyPlus help system and User's Guide, and the WIMS User's Guide. When creating a SIG, selecting stations that "respond similarly to changes in the weather will create SIGs that have a more consistent signal of warming/drying or cool/moist conditions" (NAFRI 2011). You can use the fire danger characteristics chart to quickly compare indices from several stations to determine if the ranges of values are similar. You can then do further analysis to determine if the stations should be used to create a SIG.

In this example, two weather stations are compared to Hoyt Creek RAWS data: Cold Springs RAWS (location 44.35˚N, 120.13˚W; elevation 4,695 feet) and Calvert Peak RAWS (location 42.78˚N, 123.73˚W, elevation 3,822 feet). In a SIG, the fuel model, climate class, and slope class (in this example, G; 2 [subhumid]); and 2 [26–40 percent], respectively), must be identical for every station in the analysis; the only differing variables are site location and weather inputs. Data were analyzed for May–October, 1997–2012. Weather stations with similar climates (Hoyt Creek and Cold Springs RAWS) will have fairly similar NFDRS outputs and breakpoints, and values in the chart will overlap (fig. 14a, table 6). Conversely, weather stations with dissimilar climates (Hoyt Creek and Calvert Peak RAWS) are likely to show little overlap; and the SIG values will lie somewhere between those of the two RAWS (fig. 14b, table 6).

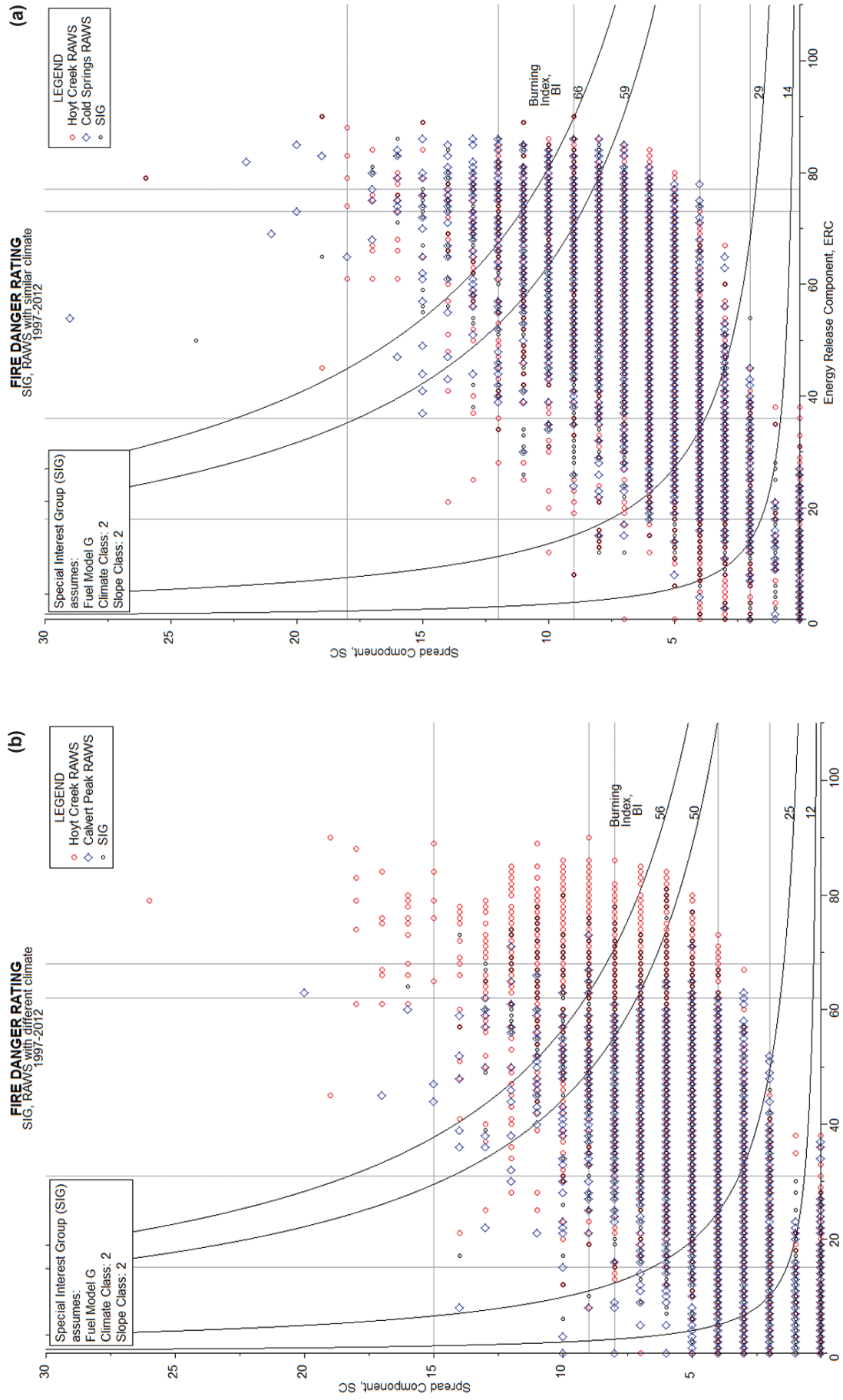


Figure 14—Chart for 1997–2012 for fuel model G was created to show the effect of using the Hoyt Creek RAWS in a Special Interest Group when combined with a similar (a) and a different (b) weather station. Climatological breakpoints shown in the graph are those for the SIG (table 6).

Table 6—Climatological breakpoints (fuel model G) are calculated for Hoyt Creek RAWS when combined in a Special Interest Group (SIG) with a similar (Cold Springs) and dissimilar (Calvert Peak) RAWS to demonstrate the importance of selecting the correct weather stations for use in a SIG demonstrated in figure 14.

	SC		ERC		BI	
Weather station	90th percentile	97th percentile	90th percentile	97th percentile	90th percentile	97th percentile
Similar RAWS						
Hoyt Creek	10	13	73	79	60	68
Cold Springs	10	13	74	80	60	69
SIG	9	12	73	77	59	66
Dissimilar RAWS						
Hoyt Creek	10	13	73	79	60	68
Calvert Peak	7	10	52	58	43	51
SIG	8	9	62	68	50	56

4. Program Operation

This section of the report provides a detailed description of program operation for the Fire Danger Rating tab of the Fire Characteristics Chart program, version 2.1. Information on the fire behavior characteristics charts is available through the program Help window and the report by Andrews et al. (2011). The program's Help window also provides a detailed and updated description of program operation for the Fire Danger Rating tab. The program's Help documents will be updated as needed to contain the most accurate information. You can use bookmarks to find an appropriate topic both in this report and in the Help documents.

The chart program offers several graphing options. The program opens with default settings, but you can open a saved file to use as a template. Data and chart format settings can be saved for later use. You can restore the initial settings for a fire characteristics chart without deleting data, and you can delete data without altering chart settings.

The following options are among many available for customizing the chart.

- Graph limits can be changed.
- Colors on the chart can be shades of red, rainbow colors, or shades of grey. Any of the three variables (SC, ERC, BI) can be selected for shading. Alternatively, lines can be drawn without color or shading.
- Font type and size can be changed.
- Point icons, labels, and the legend can be changed.
- Tabs allow you to define and label the BI, ERC, and SC curves.

Although the program offers many display options, it certainly does not meet all needs. Additional labels can be added to a basic chart using other software, as was done for many of the Application section figures in the fire behavior characteristics chart report by Andrews et al. (2011).

4.1 Overview

4.1.1 Installation

The Fire Characteristics Chart installation program (**FireChart.msi**) can be downloaded from the BehavePlus website (www.frames.gov/behaveplus). Once you have saved the program, double-click on **FireChart.exe** to install the executable and associated files. (Forest Service users will need to right-click on the file and select **Run Elevated**.) The Fire Characteristics Chart operates on computers running Microsoft® Windows 2000 or later, although this program must be run in desktop mode in Windows 8 and later. You will be prompted to install the program to the default folder **C:/BehavePlus/FireChart** or to select a different folder. Program files can be saved anywhere on your computer by simply changing the location at the prompt. However, we recommend that you not save the program to the folder **C:/Program Files** as administrative privileges associated with this folder may affect program operation.

4.1.2 Opening and Closing the Program

Each time the program opens, it opens the surface fire chart with the default settings. To use the NFDRS chart, click on the **Fire Danger Rating** tab (fig. 15). Saved (.xml) files can be opened from any tab (**File > Open Fire Characteristics Chart data file**); the program will automatically open the appropriate tab when the file is selected. Previously

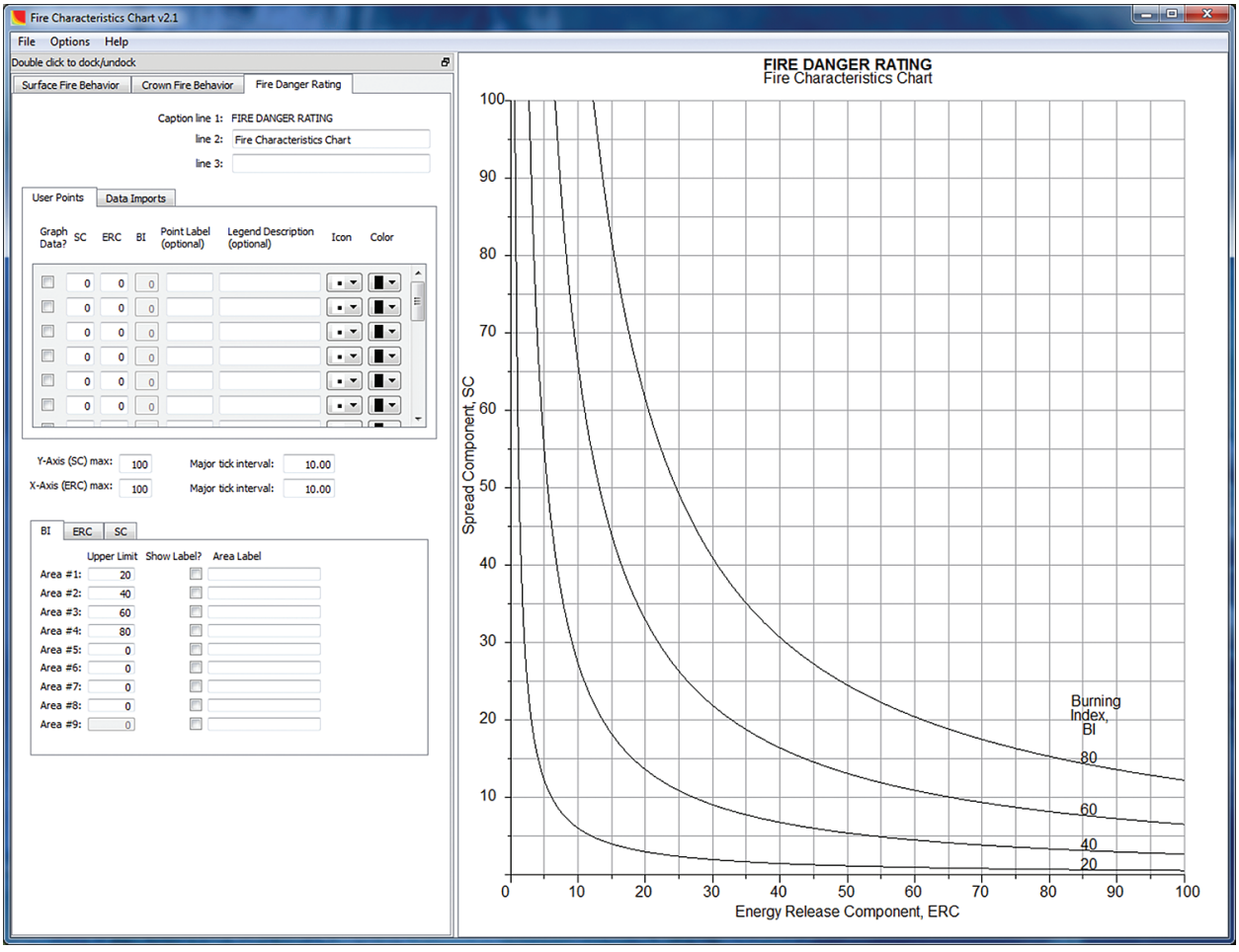


Figure 15—The Fire Characteristics Chart window contains **Surface Fire Behavior**, **Crown Fire Behavior**, and **Fire Danger Rating** worksheets (left-hand side) and a chart (right-hand side).

saved files with preferred settings can be used as a template. The command **File > Exit** allows you to exit the program; however, any data and settings that are not saved will be lost. For more information on saving data and settings, see Section 4.4.1.

4.1.3 The Fire Characteristics Chart Window

The header shows the program name and version number. Beneath the header are three menu items: **File, Options**, and **Help** (described in Section 4.1.6). The left-hand side of the program window is the worksheet; the right-hand side is the chart (fig. 15). You can switch between the three worksheets (Surface Fire Behavior, Crown Fire Behavior, and Fire Danger Rating) by clicking on the appropriate tab.

4.1.4 Worksheet

The worksheet is the form in which data are entered. Separate worksheets for surface and crown fire behavior, and fire danger rating are identified by separate tabs. Each worksheet contains three sections: Caption Lines, the Data Table, and Graph Definitions (fig. 16).

The Fire Danger Rating worksheet contains a **User Points** tab for entering individual fires or days, and a **Data Imports** tab for importing files created in other software. This latter tab allows you to plot hundreds of points using files generated by FireFamilyPlus

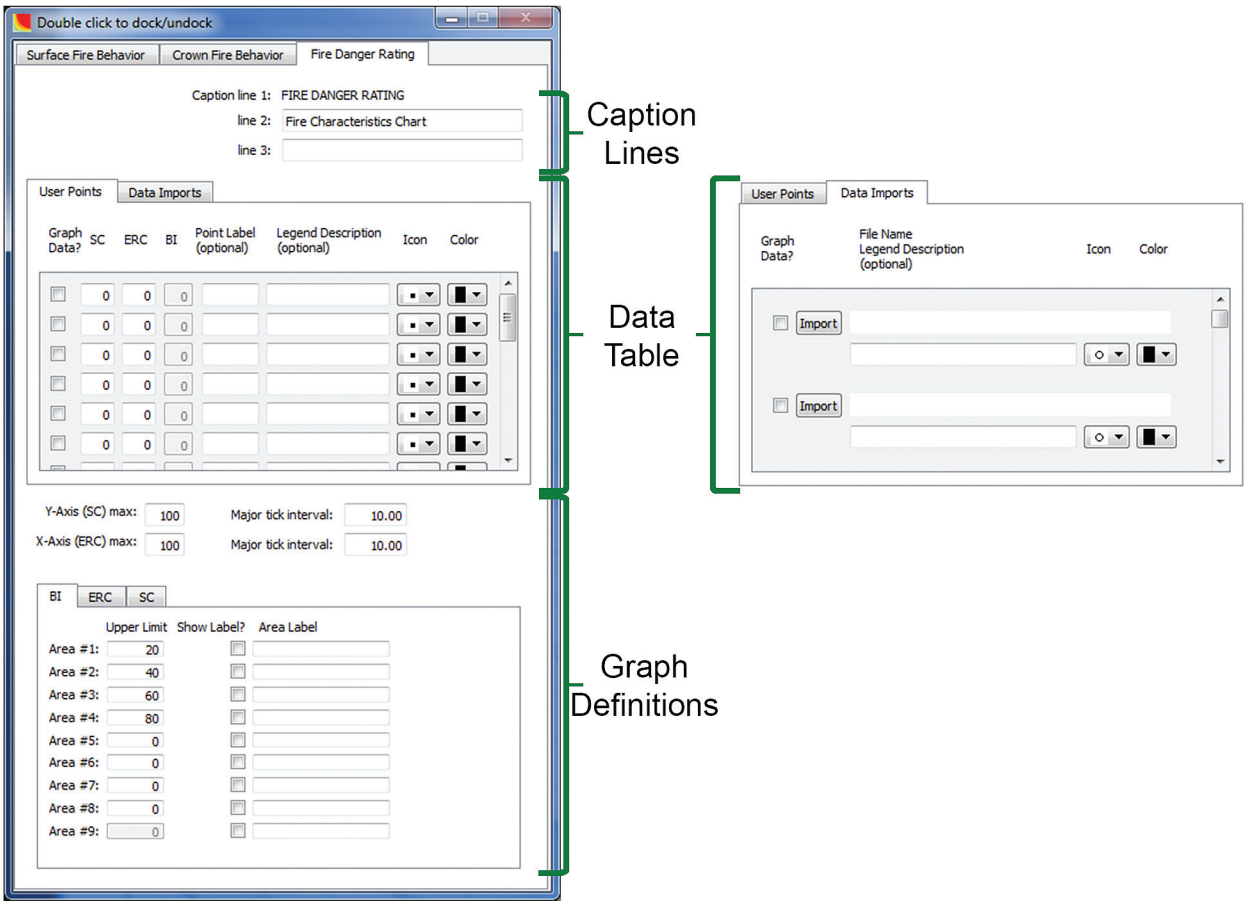


Figure 16—The Fire Characteristics Chart worksheet is divided into three sections: **Caption Lines, Data Table**, and **Graph Definitions**. The Data Table has two sections: **User Points** (left tab, shown) and **Data Imports** (right tab, details not shown). Caption Lines and Graph Definitions remain the same regardless of the type of input.

(Appendix A). In the worksheet, you can also specify maximum axis values and change tick intervals on the axes (Section 4.2.1).

4.1.5 Docking and Undocking the Worksheet

Graph size can be increased by removing the worksheet from the program window; click anywhere on the **Double click to dock/undock** menu bar (fig. 17). This option allows you to move the worksheet to a different area on the computer monitor or minimize it, thereby enlarging the graph. To reattach the worksheet, simply double-click on it; it will always attach to the left-hand side of the program window. If the worksheet is detached when the program is closed, the worksheet will return to the left-hand side of the program window when it is reopened.

4.1.6 Menu Items

The main menu items are **File**, **Options**, and **Help**. These items allow you to carry out relevant operations within the Fire Characteristics Chart. **File** offers a means of opening, saving, and printing files (fig. 18). Files that have been previously saved can be accessed by using the command **Open Fire Characteristics Chart data file**. To close the program use **File > Exit** (fig. 18) or click the red X in the upper right-hand corner.

Files can be saved in three ways:

- All data and settings (**Save data and settings to .xml file**)
- The chart itself (**Save image file…**)
- The worksheet, including all of the data (**Save data as HTML…**)

In addition, the program allows you to print just the chart (**Print Chart**) or the entire window, including both the worksheet and the chart (**Print Window**). Printing options can be modified by using the **Page setup…** command.

The **Options** menu (fig. 19) provides access to the **Graph options…**, where chart settings can be modified. A text box can now be added to the chart to display additional

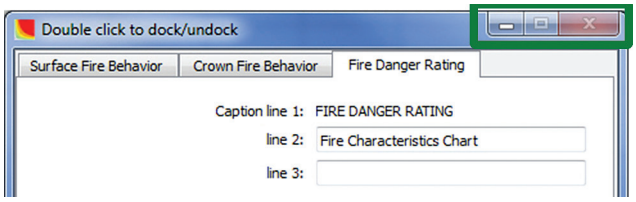


Figure 17—The worksheet can be removed from the graph by double-clicking anywhere on the **Double click to dock/undock** menu bar. Double-click on the menu bar again to return it to the program window. The window can be minimized by clicking on the **Minimize** button in the red box.

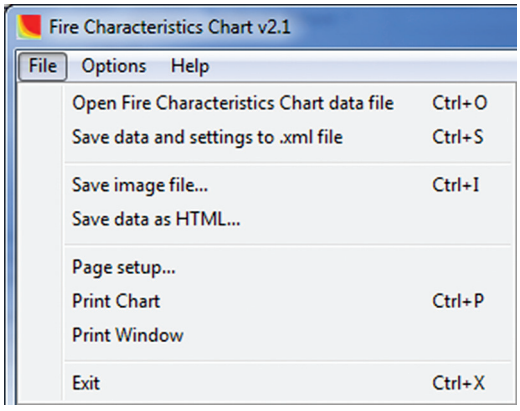


Figure 18—The **File** menu offers a means of opening, saving, and printing files.

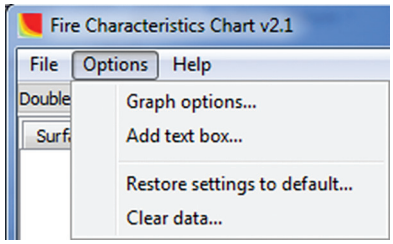


Figure 19—The **Options** menu provides access to graph options and settings.

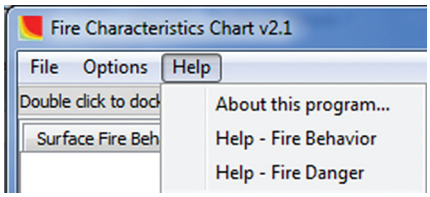


Figure 20—The **Help** menu gives information about the program and opens Help documents related to Fire Behavior and Fire Danger.

information by selecting **Add text box...**. To restore the chart to the default program settings without deleting data, select **Restore settings to default…**. To clear data from the worksheet without changing the defaults, choose **Clear data…**. To clear everything, select both options or exit the program and reopen it.

The **Help** menu (fig. 20) gives information about the program and links to help for fire danger (**Help > Help – Fire Danger**) and fire behavior (**Help > Help – Fire Behavior**).

4.2 Chart Format

Options for defining the fire danger rating chart formats are similar to those for surface and crown fire behavior and are found in two locations: (1) on the Graph Definitions portion of the worksheet and (2) under **Options > Graph options…**. In the worksheet's Graph Definitions section (fig. 16), you can select the graph scale, and tick mark intervals, as well as define BI, ERC, and SC curves. The **Graph options…** selection (fig. 21) allows you to show/hide gridlines, select a variable for shading, choose colors and

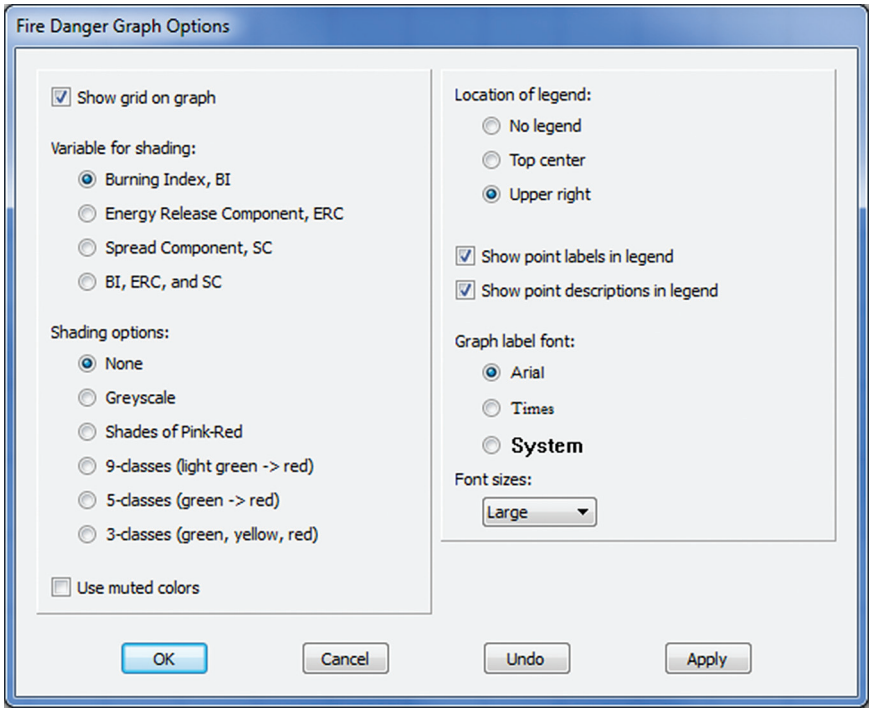


Figure 21—The **Graph Options** window controls the look of the chart.

shading options, use and format the legend, or change the font and font size. Changes affect only the graph in the active tab (Surface Fire Behavior, Crown Fire Behavior, or Fire Danger Rating). All chart format options described in this section are reset to default settings for the active tab by using **Options > Restore settings to default…**.

4.2.1 Graph Scale and Tick Marks

Graph scales are modified by setting the maximum values; minimum values are always zero. The y-axis represents SC, and the maximum value can be changed by typing a number into the **Y-Axis max** box (fig. 16). The upper limit for the Fire Danger Rating Y-Axis (SC) is 500. Similarly, the maximum value of the x-axis (**X-Axis max**; ERC) can be changed, and the upper limit is also 500. If you type in a value larger than 500 for either axis, the program will automatically replace it with 500.

The program will automatically estimate a tick mark interval, which, in most cases, is appropriate. The tick mark intervals can be changed by typing a new tick mark interval in the **Major tick interval** box on the worksheet (fig. 16). If the graph scale is later reset, the program will estimate a new tick mark interval. Gridlines can be removed by unchecking the **Show grid on graph** box in the **Graph Options** menu (Section 4.2.4).

4.2.2 Fire Danger Thresholds

BI, ERC, and SC can be used to set fire danger thresholds. Defining thresholds for any or all of the three indices can provide a quick visual assessment of how current fire danger compares to previous dates or to historical fire activity. The ERC and SC lines will not appear on the graph by default. The BI curves always appear on the graph. The shading represents fire danger levels, which you define. Unlike the flame length curves in the fire behavior characteristics charts, there are no set thresholds for BI. The interpretation of index values depends on many factors including fuel model, weather station, and fire occurrence.

As many as eight thresholds (nine areas) are available in the Graph Definitions section of the worksheet (fig. 16). Each threshold can be denoted by a line or a change in color on the graph. You can change the colorway by using the curve **Shading options** in the **Graph Options…** menu. Threshold values must appear sequentially from smallest to largest for the program to draw curves correctly. If you enter these values in a different order, the program will sort them automatically. Thresholds with a value of zero will be moved to the end of the list automatically and will not appear on the graph.

The default Fire Danger Rating chart setup contains four thresholds with upper limit values of 20, 40, 60, and 80 for BI, SC, and ERC. Selected area labels are associated with the areas below these limits. Although the chart can provide a quick, nontechnical visual display of fire danger, it is your responsibility to ensure that the use of the chart is based on technical knowledge of specific details and assumptions associated with estimating NFDRS indices.

4.2.3 Graph Options

Many of the graph appearance settings are made by using the **Options > Graph options…** window (fig. 21). Gridlines can be added to the graph, and changes can be made to curve shading, the legend, and graph fonts. Clicking on the **Apply** button will apply your changes to the graph without closing the **Graph Options** window. Applied changes can be undone by using the **Undo** button. **Cancel** will close the window

without making any changes that have not yet been applied. Click on **OK** to apply changes and close the **Graph Options** window. If you open a file that contains different graph options than those currently selected, the settings associated with the file will override the current graph options. Files can be saved and used as templates (Section 4.4.1).

4.2.4 Grid

Gridlines for both the x- and y-axes are visible by default. They can be removed (turned off) by removing the checkmark next to **Show grid on graph** in the **Graph Options** window (fig. 21). The tick mark interval is specified on the worksheet. This interval will be calculated automatically, but it can easily be changed (Section 4.2.1). You can override gridlines by entering upper limits for the ERC and SC curves in the Graph Definitions section of the worksheet and selecting the **Variable for shading** of BI, ERC, and SC.

4.2.5 Graph Color

Select the graph's colorway by selecting the variable for shading in the **Variable for shading** section of the **Graph Options** dialog box (fig. 21). Use the associated radio button to choose one of the four available options: Burning Index, BI; Energy Release Component, ERC; Spread Component, SC; or all three variables—BI, ERC, and SC.

Next select one of the **Shading options** (fig. 21). These options are: **None** (black lines on a white background), **Greyscale, Shades of Pink-Red, 9-classes** (light green to red), **5-classes** (green to red), or **3-classes** (green, yellow, red). Colors are associated with the area under the curve, not specific values. Colors in the Shades of Pink-Red, 9-classes, 5-classes or 3-classes colorways can be muted by checking the box next to **Use muted colors** so that points show up more clearly on the graph. Default selections are **BI** (Variable for shading) and **None** (Shading options).

4.2.6 Legend

A legend is available for identifying points on the graph. Labels are commonly used to describe fire danger rating classes (such as low, moderate, high, very high, extreme). Within the legend, there are options to show point labels and the point legend description. This may be helpful when the same point icon is used for more than one point (Sections 4.3.2.3 and 4.3.2.4).

The placement and format of the legend can be changed in **Options > Graph Options…**. The legend is placed inside the graph, either at the center (**Top center**) or in the upper right-hand corner (**Upper right**). You can also remove the legend by selecting **No legend**. At times, the legend may hide plotted data points. If this is a problem, change the axis scales to reveal the data point, remove the legend altogether, or add a legend later using other software.

4.2.7 Font

Graph fonts can be changed using **Options > Graph Options… > Graph label font**. There are three available fonts: **Arial, Times** (New Roman), and the default **System** font for the computer's operating system. You can select the font by using the radio dial buttons (fig. 21). Font size, with five options ranging from **Very Small** to **Very Large**, may be changed for **Arial** and **Times** (New Roman), by using a drop-down menu.

The computer's operating system sets the size for the **System** font. The default font is **Arial**, and the default font size is **Large**. Changes to the graph font will affect all text on the graph, including axis labels, point labels, and the legend.

4.2.8 Text Box

A text box can be added to supply more information to a graph by using **Options > Add text box…** (fig. 19). Text is entered in the box at the bottom of the **Text Box** window (fig. 22). A maximum of 210 characters can be entered. The text box is added by checking the **Show text box on graph** box in the upper left corner of the **Fire Danger Text Box** (fig. 22). The text box can initially be placed in the **Lower right** corner of the graph to the left of the BI curve values or in the **Upper left** corner of the graph below the title. You first select one of these options to place the text box on the graph. Then, you can move the box by the arrows associated with the command **Manually nudge** to place the box on the graph. At times, the text box may cover data points on the graph. To fix this, move the box or increase the x-axis or y-axis maximum value to allow more space on the graph.

4.2.9 Restore Settings to Default

To start over when customizing the graph format, select **Options > Restore settings to default…** (fig. 23). This action reverts to the default graph settings on the active tab for both the Graph Definition portion of the worksheet (fig. 16) and the **Options > Graph options…** window (fig. 21). Data are not deleted.

4.3 Entering Data

In the following sections, we describe entering data values and all other entries on the worksheet. All entries described in this section are cleared on the active tab by using **Options > Clear data…**. Clearing the data does not change the chart settings (Section 4.2.9).

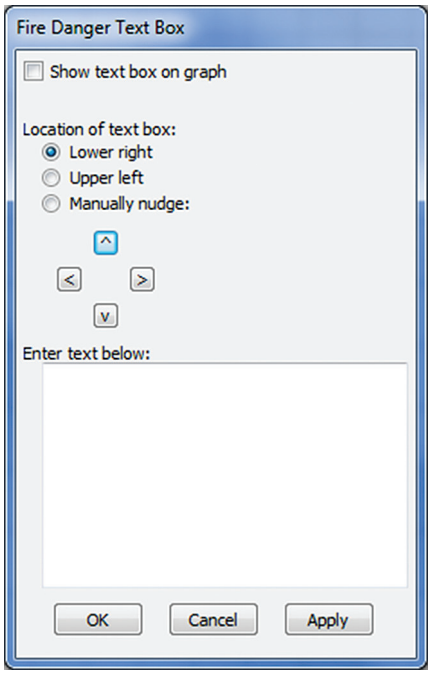


Figure 22—The **Fire Danger Text Box** window controls the location and content of a text box.

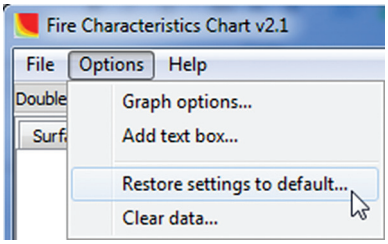


Figure 23—Choosing **Options > Restore settings to default...** will set the graph options to the default selections.

There are two methods for importing data: **User Points** and **Data Imports**. The **User Points** tab (Section 4.3.2) allows you to enter values directly for SC and ERC (fig. 16). The **Data Imports** tab (Section 4.3.3) allows you to import data as a FireFamilyPlus Daily Listing text file (.txt), tab-delimited text file (.txt), or comma-delimited text file (.csv). Both data entered individually (User Points) and data imported from FireFamilyPlus (Data Imports) can be entered on the same chart and saved.

4.3.1 Caption Lines

As many as three caption lines can be added to the graph for clarity (fig. 16). **Caption line 1** is generated automatically to properly identify the graph as a **FIRE DANGER RATING** Fire Characteristics Chart.

The second and third caption lines are optional and can be customized to provide more detailed information about the graph. For example, **Caption line 2** could consist of a location such as "*Station Name* RAWS" or a description such as "Current Fire Danger, *Date*." **Caption line 3** might be used to provide more specific information about a project, such as the date the worksheet was created or a fuel model. Caption lines are limited to 50 characters.

4.3.2 User Points

With the **User Points** tab enabled, you can enter values for SC and ERC directly into columns 2 and 3, respectively (fig. 24). The program automatically calculates the third fire danger index, BI, from the SC and ERC values entered as described in the paper by Heinsch and Andrews (2010). The program will *not* check for illogical values for SC, ERC, or BI. It is your responsibility to ensure that the values entered on the graph make sense. Zero is a valid input for all of the variables and will appear on the graph and in the legend if the **Graph Data?** box is checked. Entering values outside the plot scale limits is possible, but the points will not appear on the graph. However, the point will appear in the legend regardless of whether you entered a point label or point legend description for that value.

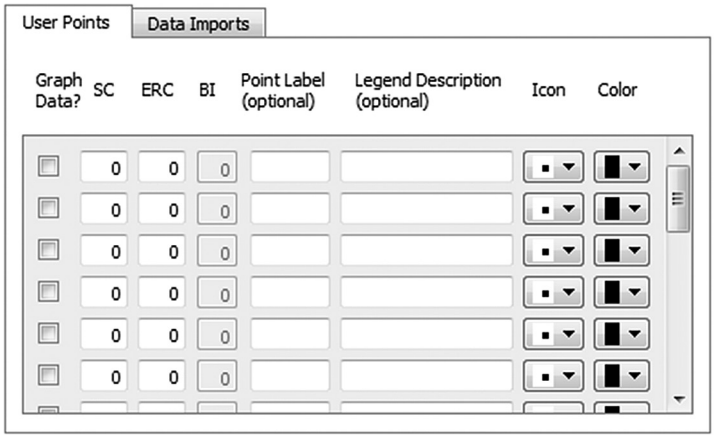


Figure 24—The second and third columns of the **Data Table** section of the worksheet are used to enter values for SC and ERC.

4.3.2.1 Graph Data

If the box in the **Graph Data?** column is checked, a point corresponding to the data in that row will be plotted on the graph, with or without a point label, *and* a point icon will appear in the legend with or without a point label or legend description. If the **Graph Data?** box is not checked, the data are ignored. However, these data will be saved in both Fire Characteristics Chart .xml files (Section 4.4.1) and HTML files (Section 4.4.4).

4.3.2.2 Point Icons

The icon and color for the plotted point are selected from drop-down menus for **Icon** and **Color**. There are 10 possible icons in column 7 that can be used to distinguish among data points and 10 possible colors in column 8 (fig. 25).

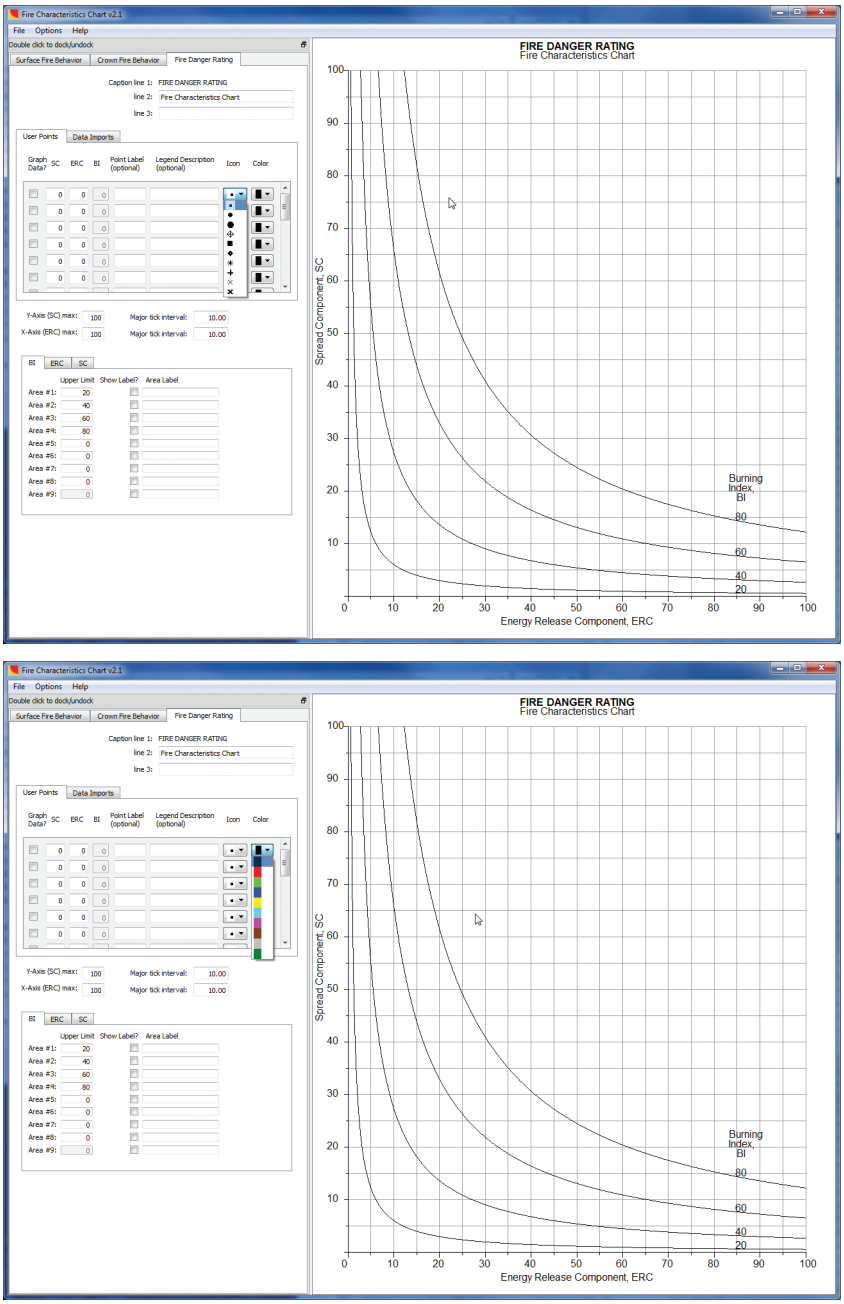


Figure 25—There are ten possible point icons and colors for use in the **User Points** portion of the fire danger characteristics chart.

4.3.2.3 Point Label

Up to eight characters can be entered in the optional **Point Label** column to label a point on the chart. If you leave this column blank, the point will appear on the graph, but there will be no label marking the point. The point will appear in the legend even without a **Point Label** or **Legend Description**. By default, the label will appear both on the graph and in the legend. Legend settings can be changed if desired (Section 4.2.6). At times, point labels may appear above the chart, interfering with the chart title. To fix this, simply increase the y-axis maximum value (Section 4.2.1).

4.3.2.4 Legend Description

A longer description, providing more detailed information, can be entered for each point in the optional **Legend Description** column (fig. 26). By default, this description appears at the end of the legend, although legend settings can be changed if desired (Section 4.2.6). The **Legend Description** can be up to 35 characters.

4.3.2.5 Upper Limit Values

You can set fire danger levels by entering upper limit values directly into the first column, in the **Upper Limit** boxes, at the bottom in the Graph Definitions section (fig. 27). Fire danger levels can be based on BI, ERC, or SC by selecting the appropriate tab. Associated area labels (of up to 12 characters), can be entered directly into the third column in the **Area Label** boxes. Commonly used descriptive labels include "Low" and "Moderate," or "L" and "M." Labels appear on the graph if the **Show Label?** box is checked. The default setup opens to the BI tab and displays four areas with upper limits of 20, 40, 60, and 80. However, these default values have little meaning if you do not use climatological information to set threshold values. For additional information, see Heinsch and Andrews (2010).

4.3.3 Data Import

Data can be imported from files generated elsewhere as FireFamilyPlus Daily Listing text files (.txt), tab-delimited (.txt), or comma-delimited (.csv) files. Specific formats must be used for data to be imported correctly. The **Data Import** tab allows you to plot hundreds of points at once by using files generated by FireFamilyPlus (Appendix A). You can click on the **Import** icon to import a single file, or multiple files of the appropriate format (fig. 16).

4.3.3.1 Import File Types

You can import files generated by FireFamilyPlus (Daily Listing .txt files), and properly formatted tab-delimited (.txt) or comma-delimited (.csv) files created in other software. In FireFamilyPlus, create a worksheet with the following outputs: date, SC, and ERC. You can include BI as a third variable for completeness, but it is not necessary as the Fire Characteristics Charts program generates BI values automatically. You can also include other variables in the file, but the program will ignore them. However, the first three columns must be date, SC, and ERC, in that order. A comma-delimited (.csv) file must contain at least three columns: date, SC, and ERC.

When you select the **Import** button (fig. 28), the file browser opens, allowing you to choose a single file or multiple files to import into the program. When multiple files are selected in the file browser window, the program inserts each file pathname into a line. You must choose **Graph Data?** individually for each file. More detailed information on

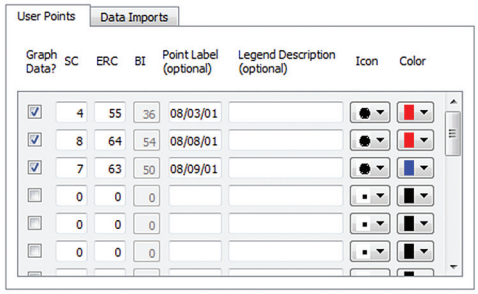
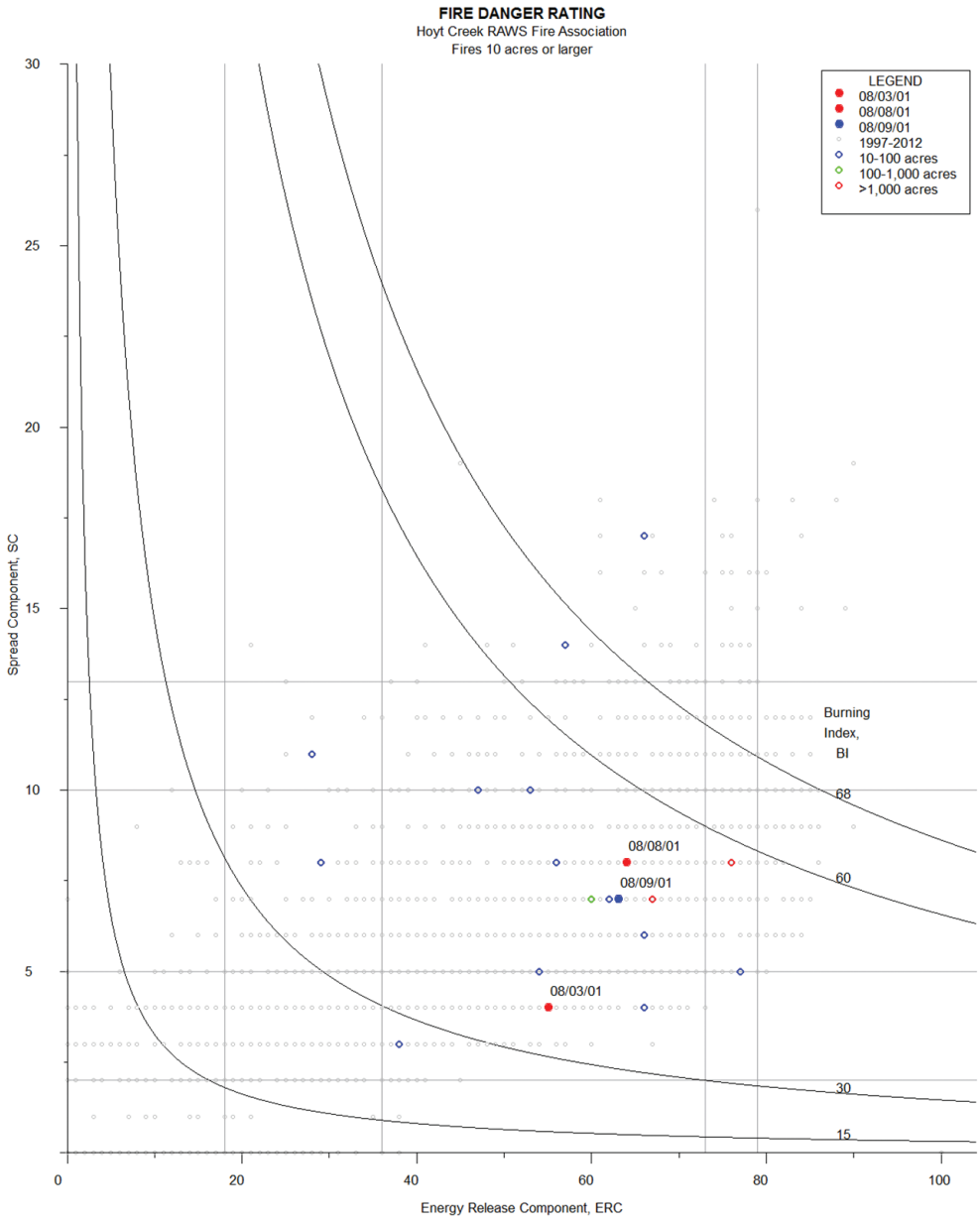


Figure 26—The **Point Label** from the data table is used to identify the points in the graph and/or legend. The point **Legend Description** from the data table can be used to identify points in the legend.



creating FireFamilyPlus files for import into the Fire Characteristics Chart is provided in Appendix A.

4.3.3.2 Graph Data

If the box in the **Graph Data?** column is checked (fig. 27), points corresponding to the data in the file will be plotted on the graph *and* a line will be created in the legend. If the

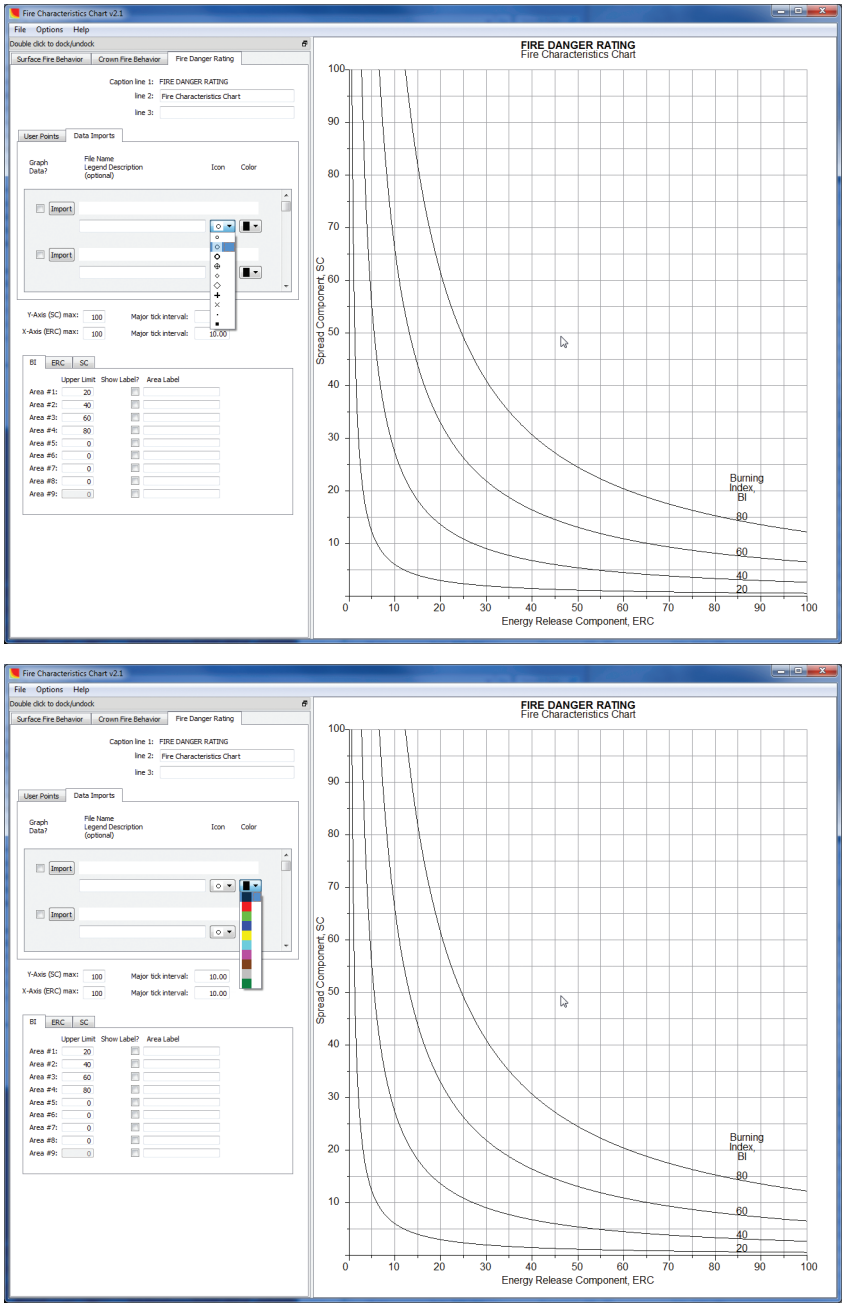


Figure 27—There are ten possible point icons (a) and colors (b) for use with imported data. All points in an imported file are given the same icon and color combination. The blank line to the right of the icons is the optional **Legend Description**.

Graph Data? box is not checked, the data are ignored. However, the names and locations of the data file will be saved in both Fire Characteristics Chart XML data files (Section 4.4.1) and HTML files (Section 4.4.4).

4.3.3.3 Point Icons

As with individual **User Points** data, the icon and color for the plotted points are selected from drop-down menus for **Icon** and **Color**. There are 10 possible icons that can be used to distinguish among data points and 10 possible colors (fig. 27). All points in the file are given the same icon and color combination.

4.3.3.4 File Name Legend Description

If a FireFamilyPlus report is imported and contains header information, the initial **Legend Description** is taken from the file's header for fuel model (fig. 28). If desired, you can replace the initial description with a more meaningful description of up to 35

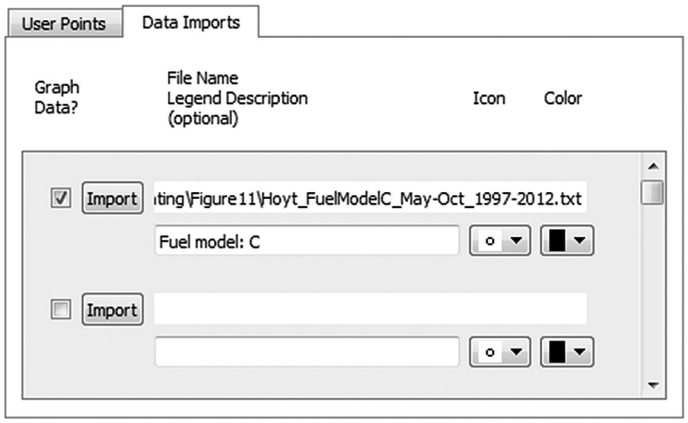


Figure 28—The **Data Imports** box is used to import files created elsewhere. If an imported FireFamilyPlus report contains header information, the initial **Legend Description** will be the fuel model.

characters. The **Legend Description** is optional, and the text can be deleted. Individual points are not labeled.

4.3.3.5 Upper Limit Values

You can set fire danger levels by entering upper limit values directly into the first column of the **Upper Limit** boxes at the bottom in the Graph Definitions section (fig.16). Fire danger levels can be based on BI, ERC, or SC by selecting the appropriate tab. Associated area labels of up to 12 characters can be entered directly into the third column in the **Area Label** boxes. Examples of commonly used descriptive labels are "Low" and "Moderate" and "L" and "M." Labels are shown if the **Show Label?** box is checked. The default setup opens to the BI tab and displays four areas with upper limit values of 20, 40, 60, and 80. However, these default values have little meaning if you do not set meaningful threshold values. For additional information, see Heinsch and Andrews (2010).

4.3.4 Clear Data

The menu selection **Options > Clear data…** (fig. 29) clears everything in the worksheet data table (fig. 16), including the data values, point labels, legend description, icon/color selections, and information/settings for any added text box. It will not, however, affect the graph settings (Section 4.2.9). This command applies only to data in the current, active tab.

4.4 Saving Files

The program opens with the default graph settings and a blank worksheet. Data and graph format settings can be saved or exported into common file formats for later use. Data values and the graph itself can be saved separately for documentation purposes. The default location for saving all files is the program folder, but files can be saved in any location on the computer.

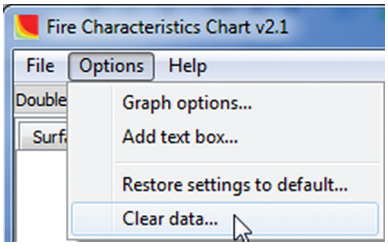


Figure 29—Selecting **Options > Clear data...** will delete all data in the active worksheet.

4.4.1 Saving a Fire Characteristics Chart File

Data and settings can be saved to XML file format by selecting **File > Save data and settings to .xml file** (fig. 18). These files contain *both* data values and graph settings for a given chart and can be opened only within the Fire Characteristics Chart program. You may wish to clear the data (**Options > Clear data…**) and save the graph settings as a personal template to use in place of default graph settings. Data and settings are saved only for the active worksheet; if there are data or settings in the other two tabs, they must be saved separately.

This file format was new with version 2 of the program. In version 1, files were saved as Fire Characteristics Chart data files (.fcd). The .fcd files could not be used if the program was updated, rendering previous files obsolete. With the switch to XML file format, the program can be made backwards-compatible, and older XML files can be used if the Fire Characteristics Chart program is modified.

4.4.2 Opening a Fire Characteristics Chart File

The **File > Open Fire Characteristics Chart data file** command (fig. 18) opens a Fire Characteristics Chart file that was previously saved by using version 2.0 or later. The Surface Fire Behavior, Crown Fire Behavior, and Fire Danger Rating worksheets operate independently, but the program opens the correct tab when a file is opened.

4.4.3 Save Image File

Graphs can be saved as images in the following formats: JPEG (.jpg), Windows bitmap (.bmp), TIFF (.tif), and Portable Network Graphics (.png). Once the graph is finished, click on **File > Save image file…** (fig. 18), select the desired location and file format, and save the graph. You can use this image for documentation or edit it with other software.

4.4.4 Saving Data as HTML

When you print a chart or save it as an image, document the data values and any other information needed to reproduce it. To assist in documentation, the worksheet can be exported as an HTML file that contains all of the data points and files, including those that do not appear on the screen (fig. 30). To save data values select **File > Save data as HTML…** (fig. 18). This file can be included in reports with the chart so that others can recreate your chart if desired.

4.5 Printing

The Fire Characteristics Chart graph can be printed by using the **File > Print Chart** command, and the graph and worksheet can be printed by using the **File > Print Window** command (fig. 18). The printer can be specified by using the **Select Printer** menu in the **Print** pop-up window. It is advisable to use caption lines (Section 4.3.1), a text box (Section 4.2.8), or both, to clearly describe the graph.

Use the **File > Page setup…** command to modify print settings for the program (fig. 31). Select the paper size, source, orientation (either Portrait or Landscape), and printer margins to customize print settings. Your printer sets the default printer margins. The printer can be selected by using **File > Print Chart** or **File > Print Window**, selecting a printer, and clicking the **Apply** button (fig. 32). Selecting **Cancel** will cancel any

FIRE DANGER RATING Hoyt Creek RAWS Fire Association Fires 10 acres or larger					
Graph Data?	**SC**	**ERC**	**BI**	**Point Label**	**Legend Description**
Yes	4	55	36	08/03/01	
Yes	8	64	54	08/08/01	
Yes	7	63	50	08/09/01	
	FFP Import File Name				
Yes	C:\Behave\FireChart\FireChart20\FireDangerRating\Figure9 \Hoyt_FuelModelG_May-Oct_1997-2012.txt				1997-2012
Yes	C:\Behave\FireChart\FireChart20\FireDangerRating\Figure9 \Fires_10-100ac.csv				10-100 acres
Yes	C:\Behave\FireChart\FireChart20\FireDangerRating\Figure9 \Fires_100-1000ac.csv				100-1,000 acres
Yes	C:\Behave\FireChart\FireChart20\FireDangerRating\Figure9 \Fires_GE_1000ac.csv				>1,000 acres

Y-Axis max	30	**Major Tick Interval**	5.000
X-Axis max	100	**Major Tick Interval**	10.00

BI	**Upper Limit**	**Show Label?**	**Label**
Area #1	15	No	
Area #2	30	No	
Area #3	60	No	
Area #4	68	No	
Area #5	0	No	

Figure 30—A worksheet can be saved as an HTML file for documenting the data used in creating the Fire Characteristics Chart.

changed selections and return to the main window. Printer settings are valid only for the current session of the Fire Characteristics Chart.

4.6 Adding Custom Labels

The Fire Characteristics Chart program may not meet all needs. In particular, you may want to emphasize certain portions of the graph by adding custom labels. To add custom labels, you can make a screen capture of the chart or save it as an image file (Section 4.4.3) and use other software to add additional lines, circles, or text to the graph.

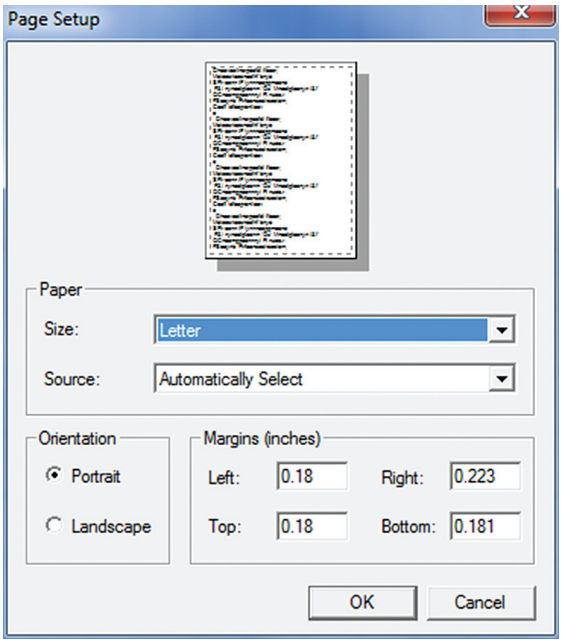


Figure 31—The **Page Setup** window allows you to define printer settings for the current session.

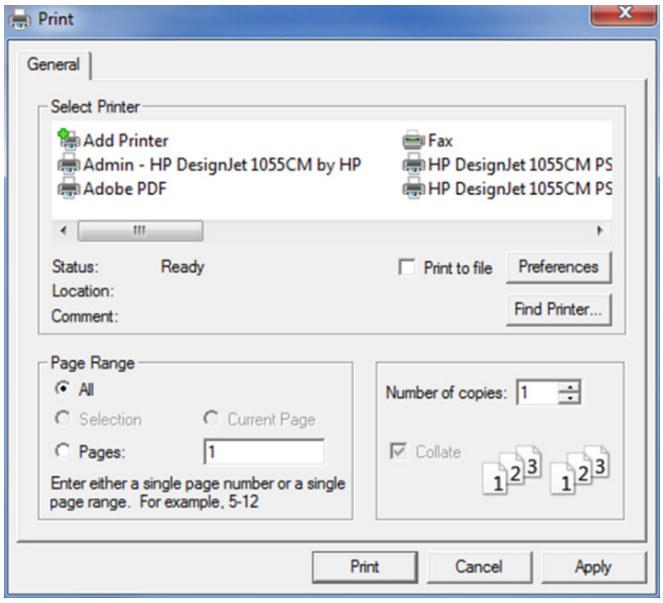


Figure 32—The **Print** window allows you to define the printer that will be used. If you are not ready to print, select Apply.

4.7 Help

The Help button on the Menu Bar (**Help > About this program…**) (fig. 20) provides information about the program, including the version number (fig. 33) and contact information for the developers.

Help for the Fire Danger Rating tab can be obtained by clicking on **Help > Help – Fire Danger**. Clicking on **Help > Help – Fire Behavior** (fig. 20) opens a similar document for fire behavior. You can navigate to the section of interest using the bookmarks in each document.

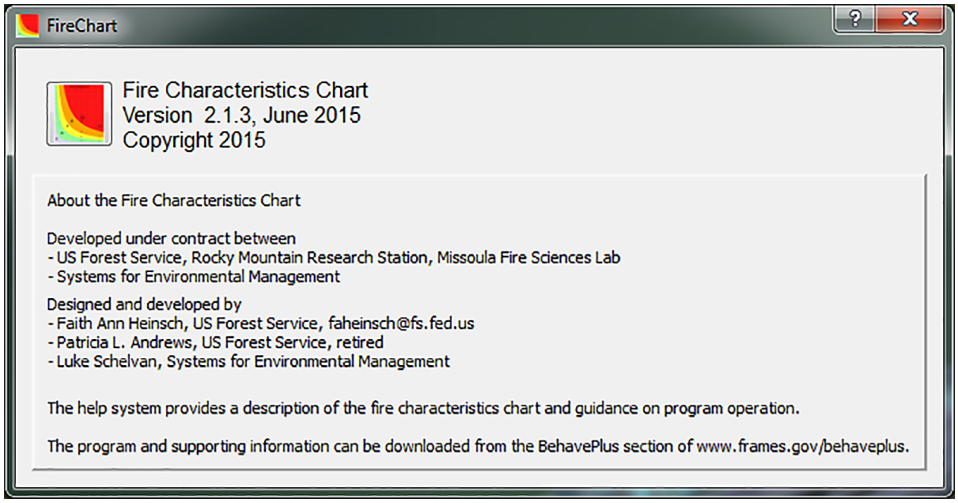


Figure 33—Information about this program can be found using **Help > About this program....**

5. Summary

Within the U.S. National Fire Danger Rating System, indices provide the most valuable information when viewed in relationship to historical climatology and fire occurrence. The fire danger characteristics chart provides a visual data summary and can supplement the seasonal plots, percentile analysis, and relationship to fire activity, currently available in FireFamilyPlus. The examples in this report are only a few of the analyses that can be performed. In addition, the charts can show current trends overlying the range of historical variability of the indices. Within the framework of a complete statistical analysis, fire danger characteristics charts can be used to display SC, ERC, and BI concurrently. This capability assists in delineating potential fire business thresholds, which associate seasonal indices with fire occurrence.

The Fire Characteristics Chart software is useful for interpretation of fire behavior values or fire danger rating indices. Charts can facilitate effective communication in briefings, presentations, and reports. Although features of the software may eventually be integrated into comprehensive systems, it now supplements BehavePlus and FireFamilyPlus.

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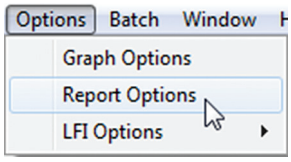
Appendix A—Creating a FireFamilyPlus Export File

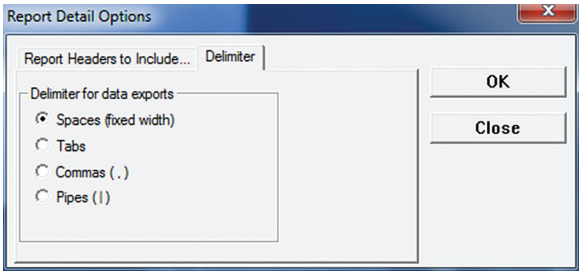
Hundreds of data points can be plotted by using files imported directly from FireFamilyPlus. National Fire Danger Rating System (NFDRS) indices are calculated in FireFamilyPlus by using historical weather data. Results can be exported into a space-delimited file that can then be imported into the Fire Characteristics Chart program. The following steps are required to export a file from FireFamilyPlus version 4.1.

1. "Space-delimited" is the default header selection, but to verify that the file will be exported in the required space-delimited format, click on **Options > Report Options**.



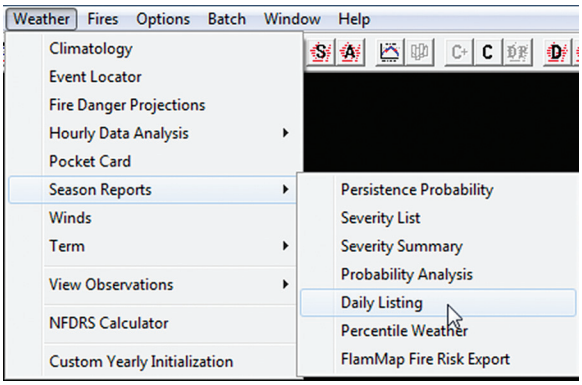
The **Report Detail Options** dialog box will open.

2. Click on the **Delimiter** tab and make sure that **Spaces (fixed width)** is the option selected.

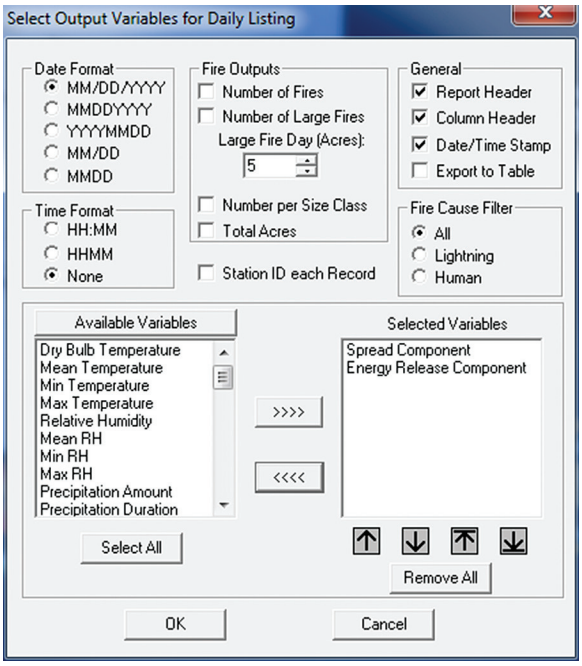


The **Daily Listing** feature of FireFamilyPlus consists of a simple interface used for selecting variables, defining date and time formats, making header selections, and adding selected fire occurrence data. You can use **Daily Listing** to generate a report listing all of the variables necessary for working with the Fire Characteristics Chart.

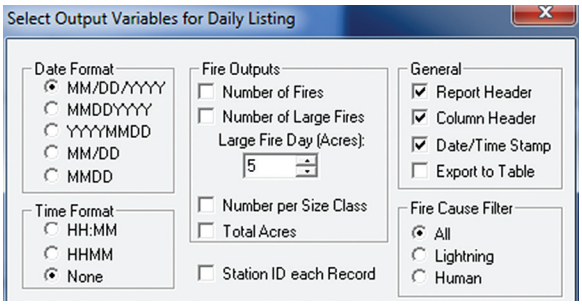
3. Open FireFamilyPlus and, in the Working Set, select the station, date filters of interest, green up date, and fuel model. Select **Weather > Season Reports > Daily Listing** or click on the shortcut icon "L" 



A dialog box opens (**Select Output Variables for Daily Listing**).



4. Select the following options in the upper section of the window.



a. **Date Format**: Format *must be* **MM/DD/YYYY**. Each row will begin with a date in this format.

b. **Time Format**: The value **None** *must be* selected.

c. **Fire Outputs:** Optional. These values will be ignored by the Fire Characteristics Chart.

i. **Number of Fires**: Number of fires burning on any given day.

ii. **Number of Large Fires**: Number of fires that meet the criteria for a Large Fire Day.

iii. **Large Fire Day (Acres)**: The fire size (acres) that constitutes a large fire.

iv. **Number per Size Class**: The number of fires occurring in each size class.

v. **Total Acres**: The total number of acres burned in all fires discovered on this day.

d. **Station ID each Record:** Do *not* check the **Station ID each Record** box.

e. **General:** Optional. If included, the fuel model in the Report Header will populate the fire characteristic chart File Name Legend Description (Data Imports Data Table).

i. Check **Report Header** or **Date/Time Stamp**, or both, if desired.

ii. Ensure **Column Header** is checked.

iii. Do *not* select the option **Export to Table**.

f. **Fire Cause Filter**: Optional

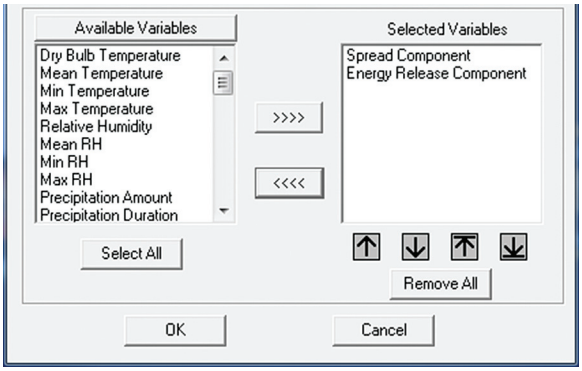
i. This radio dial button is used to select *all* fires, fires caused by lightning only, or just human-caused fires for analysis with **Fire Outputs**.

5. **Available Variables** (bottom of window)

a. If there are any variables in the **Selected Variables** box, click on **Remove All**.

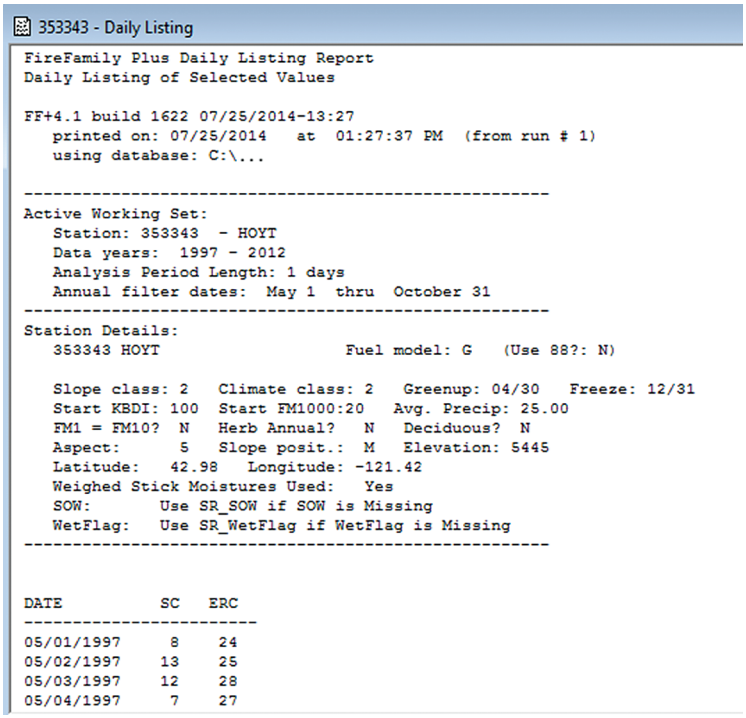
b. Select **Spread Component** (SC) and click on the >>>> box. *It must be listed first*.

c. Then select the **Energy Release Component** (ERC) and click on the >>>> box.

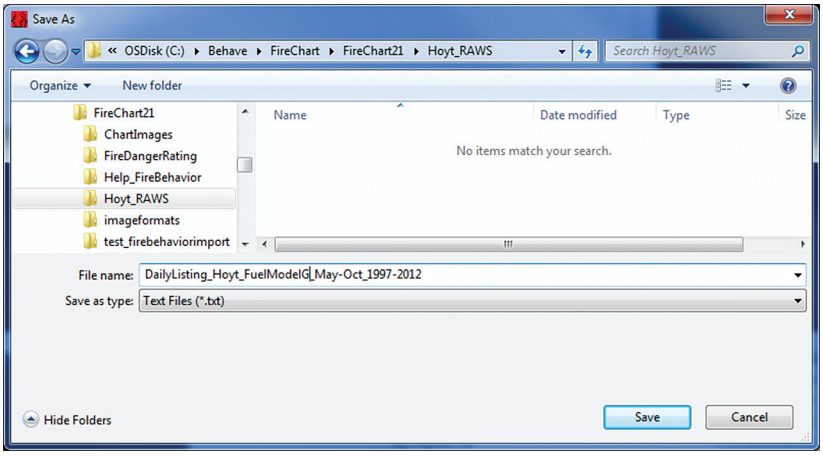


The variables *must be* in this order for the Fire Characteristics Chart to read them correctly. Additional variables, such as Burning Index (BI), can be added to the file, but they will be ignored by the Fire Characteristics Chart program.

6. Click **OK** and the **Daily Listing** report will be displayed in a separate window.



You can edit the results and save the data to your computer by using the command **File > Save As…** and saving as a text file (.txt).



Please note:

- FireFamilyPlus files saved in this manner can be imported into the Fire Characteristics Chart if they include the date, SC, and ERC. These are the only data that the program requires. Other variables, if selected, should follow SC and BI, but they will be ignored by the program.
- The resulting FireFamilyPlus Daily Listing text file (.txt) can be imported directly into the fire danger characteristics chart as described in Section 4.3.3.
- For additional information on exporting data, refer to the FireFamilyPlus Help Utility within the program or the User's Guide available in the FireFamilyPlus section of https://www.firelab.org under Apps & Products > Fire Danger Rating.

Appendix B—Summary of Steps Used to Produce Examples

Archived weather data for Remote Automated Weather Stations (RAWS) and relevant Forest Service fire occurrence data were obtained from the Fire and Aviation Management Web Applications website (http://fam.nwcg.gov/fam-web/). These data were then imported into FireFamilyPlus. The fire data were associated with the appropriate RAWS and analyzed. FireFamilyPlus version 4.1 was used to calculate indices and generate season plots with percentile values. The **Weather > Season Reports > Daily Listing** function was used to export Spread Component (SC) and Energy Release Component (ERC) values as described in Appendix A. The Burning Index (BI) was calculated by the Fire Characteristics Chart software by using equation (1) in Section 2 of this report.

B.1 FireFamilyPlus Analyses Used in Preparation of Report

The following steps were used in FireFamilyPlus version 4.1 to generate the data necessary for the figures shown in Section 3 of this report.

1. Download Weather and Fire data from the Fire and Aviation Management Fire and Weather Data page (http://fam.nwcg.gov/fam-web/weatherfirecd/) for the three weather stations and Fremont-Winema National Forests (NF) listed in Step 4.
2. Import the data into FireFamilyPlus. See FireFamilyPlus documentation for more details on importing data.
3. Set the Working Set for all stations (unless otherwise specified) to:
   a. Data Years: 1997–2012
   b. Annual Filter: May 1–October 31
   c. Green Up Date: April 30
4. Set associations for the Remote Automated Weather Station (RAWS).
   a. Hoyt Creek (353343)
      i. **Fire Associations** are
         1. Region: Pacific Northwest Region (R6)
         2. Units: Fremont NF
         3. Sub Units: Bly RD, Chemult RD, Chiloquin RD, Paisley RD, Silver Lake RD.
   b. Calvert Peak (352919)
   c. Cold Springs (352701)
   d. Create Special Interest Group (SIG) for Hoyt Creek and Calvert Peak with Fuel Model G, Climate Class 2, and Slope Class 2.
   e. Create SIG for Hoyt Creek and Cold Springs with Fuel Model G, Climate Class 2, and Slope Class 2.

5. Generate **Stats Graphs** for some figures. See FireFamilyPlus documentation for more details on generating these graphs.
6. Click on **Weather > Season Reports > Daily Listing**.
    a. Generate a **Daily Listing** of SC and ERC for Hoyt Creek for:
        i. May 1–October 31, 1997–2012
            1. Fuel Model C
            2. Fuel Model G
            3. Fuel Model H
            4. Fuel Model L
        ii. Fuel Model G
            1. May 1–October 31, 1998
            2. May 1–October 31, 2002
            3. May 1–October 31, 2004
            4. July 1–August 31, 1997–2012
            5. July 1–August 31, 1998
            6. July 1-August 31, 2002
        iii. Fuel Model G, May 1–October 31, 2009, separated into six monthly files: May, June, July, August, September, and October
            1. These monthly files can be generated individually in FireFamilyPlus, or they can be created by using a text editor from a larger May 1–October 31, 2009 file.
        iv. Fuel Model H
            1. May 1–October 31, 2004
    b. Generate a **Daily Listing** using fuel model G of SC and ERC for:
        i. May 1–October 31, 1997–2012
            1. Calvert Peak
            2. Cold Springs
            3. SIG for Hoyt Creek and Calvert Peak
            4. SIG for Hoyt Creek and Cold Springs
    c. Create FFP export files by selecting **File > Save As** and choosing **Text Files (*.txt)** for each file.
7. Using the Hoyt Creek RAWS, click on **Fire Associations > View Fires**.
    a. Click on the diskette () icon to save the file. Accept the defaults and select **Export text file**.

b. Open the file in spreadsheet software and sort by Total Acres. Note the Discovery Dates for fires in the following ranges: >1,000 acres, 100–1,000 acres; 10–100 acres. There should be 23 fires that are 10 acres or larger.

c. Look up the fire danger rating indices in the Hoyt Creek Fuel Model G text file for these Discovery Dates.

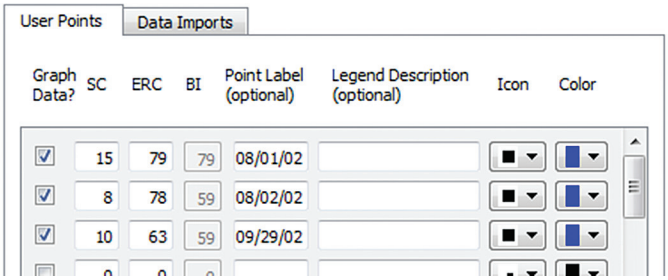
d. Create three individual comma-delimited (*.csv) files for these dates for each range of fire size. Each file should contain the date, SC, and ERC; use one header row.

B.2 Fire Danger Rating Characteristics Charts (By Figure Number)

The following steps were used in the Fire Characteristics Chart version 2 to create the figures shown in this report.

Figure 6. Comparing Points on FireFamilyPlus Stats Graph

1. Change **Caption line 3**.
2. Open **Fire Danger Rating > User Points**.
3. Enter information from the screenshot below for Hoyt Creek for 3 days in 2002.



4 Change **Icon** and **Color** as appropriate.

5. In **Options > Graph Options…**,

   a. Select **Variable for shading**: BI, ERC, and SC. By default, **Shading options** should be None, and **Show grid on graph** should be unchecked.

6. Axis maximum values are: **Y-Axis (SC) max**: 30; **X-Axis (ERC) max**: 110.
7. Change BI, ERC, and SC thresholds to appropriate climatological breakpoints.

	Climatological breakpoints			
NFDRS index	**¼ of 90th percentile**	**½ of 90th percentile**	**90th percentile**	**97th percentile**
SC	2	5	10	13
ERC	18	36	73	79
BI	15	30	60	68

Figure 7. Comparing Different Months

1. Change **Caption line 3**.
2. Open **Fire Danger Rating > Data Imports**.
3. Import the six monthly FFP text files for Hoyt Creek Fuel Model G for 2009.
4. Type a **Legend Description** in the boxes below file names.
5. Change **Icon**, **Color** as appropriate.
6. In **Options > Graph Options…**,
    a. Uncheck **Show grid on graph**.
    b. Select **Variable for shading**: Energy Release Component, ERC.
    c. Select **Shading options**: Greyscale.
7. Axis maximum values are: **Y-Axis (SC) max**: 30; **X-Axis (ERC) max**: 110.
8. Set ERC thresholds to appropriate climatological breakpoints.

Climatological breakpoints	¼ of 90th percentile	½ of 90th percentile	90th percentile	97th percentile
ERC	18	36	73	79

Figure 9. Comparing Different Years

Figures 9a. May–October

1. Change **Caption line 3**.
2. Open **Fire Danger Rating > Data Imports**.
3. Import the three FFP text files for Hoyt Creek for May–October:
    a. May–October, 1997–2012
    b. May–October, 1998
    c. May–October, 2002.
4. Type appropriate **Legend Description** in boxes below file names.
5. Change **Icon**, **Color** as appropriate.
6. Axis maximum values are:
    a. **Y-Axis (SC) max**: 30, **Major tick interval**: 5.
    b. **X-Axis (ERC) max**: 110, **Major tick interval**: 20.
7. In **Options > Graph Options…**,
    a. Select **Variable for shading**: BI.
    b. Select **Shading options**: None.
8. Change BI thresholds to appropriate climatological breakpoints. Use default values for ERC and SC.

Climatological breakpoints	¼ of 90th percentile	½ of 90th percentile	90th percentile	97th percentile
BI	15	30	61	68

Figure 9b: July–August.

1. Repeat steps 1 through 8 from figure 9a for July–August.
    a. July–August, 1997–2012
    b. July–August, 1998
    c. July–August, 2002.
2. Open **Fire Danger Rating > User Points**.
3. Enter the **SC**, **ERC**, and **Legend Description** for the three largest fires:

SC	ERC	Point label (optional)	Legend description (optional)
8	76		07/12/02, Toolbox Fire, 54,800 ac
8	76		07/12/02, Winter Fire, 33,894 ac
7	67		07/13/02, Silver Fire, 24,565 ac

4. Change **Icon**, **Color** as appropriate.

Figure 10. Comparing Fire Days to All Days

1. Change Caption line 2 and Caption line 3.
2. Open **Fire Danger Rating > Data Imports**.
3. Import FFP text file for Hoyt Creek Fuel Model G: May–October, 1997–2012.
4. Import the three FFP comma-delimited (*.csv) text files for Hoyt Creek Fuel Model G: Fires >10,000 acres; Fires 100–1,000 acres; and Fires 10–100 acres. *Note: If there are 20 or fewer data points, you could type them directly in the **User Points** tab. Each point would then show up separately in the legend.*
5. Type **Legend Description** in boxes below file names.
6. Change **Icon**, **Color** as appropriate.
7. In **Options > Graph Options…**, select **Variable for shading**: BI, ERC, and SC. By default, **Shading options**: should be None; and **Show grid on graph** should be unchecked.
8. Axis maximum values are: **Y-Axis (SC) max**: 30; **X-Axis (ERC) max**: 110.
9. Change BI, ERC, SC thresholds to appropriate climatological breakpoints.

NFDRS index	Climatological breakpoints			
	¼ of 90th percentile	½ of 90th percentile	90th percentile	97th percentile
SC	2	5	10	13
ERC	18	36	73	79
BI	15	30	60	68

Figure 12. Similar Fuel Models (G and H)

Figure 12a. Fuel Model G

1. Change caption lines 2 and 3.
2. Open **Fire Danger Rating > Data Imports**.
3. Import FFP text files for Hoyt Creek RAWS, Fuel Model G for May–October, 1997–2012, and May–October 2004.
4. Type **Legend Description** in box below file name.
5. Change **Icon**, **Color**.
6. In **Options > Graph Options…**,
    a. Uncheck **Show grid on graph**.
    b. Select **Variable for shading**: Energy Release Component, ERC.
    c. Select **Shading options**: 5-classes (green -> red); and
    d. Check **Use muted colors**.
7. Axis maximum values are: **Y-Axis (SC) max:** 30; **X-Axis (ERC) max**: 110.
8. Change ERC and BI thresholds to appropriate climatological breakpoints. Use default values for SC.

	Climatological breakpoints			
NFDRS index	**¼ of 90th percentile**	**½ of 90th percentile**	**90th percentile**	**97th percentile**
ERC	18	36	73	79
BI	15	30	60	68

Figure 12b. Fuel Model H

9. Repeat steps 1 through 7 from figure 12a for fuel model H.
10. Axis maximum values are: **Y-Axis (SC) max:** 10; **X-Axis (ERC) max:** 65.
11. Change ERC and BI thresholds to appropriate climatological breakpoints. Use default values for SC.

	Climatological breakpoints			
NFDRS index	**¼ of 90th percentile**	**½ of 90th percentile**	**90th percentile**	**97th percentile**
ERC	10	20	41	45
BI	6	13	26	30

Figure 13. Different Fuel Models

Figure 13a. Three Fuel Models

1. Change caption lines 2 and 3.
2. Open **Fire Danger Rating > Data Imports**.

3. Import FFP text files for Hoyt Creek RAWS Fuel Models C, G, and L for May–October 1997–2012.
4. Type **Legend Description** in box below file names.
5. Change **Icon**, **Color**.
6. Axis maximum values are: **Y-Axis (SC) max:** 100; **X-Axis (ERC) max:** 110.
7. BI, ERC, and SC thresholds are default values: 20, 40, 60, 80, 100.

Figure 13b–d. Separate Fuel Models

1. Change caption lines 2 and 3.
2. Open **Fire Danger Rating > Data Imports**.
3. Import FFP text files for Hoyt Creek RAWS Fuel Model C for May–October, 1997–2012.
4. Type **Legend Description** in box below file name.
5. Change **Icon**, **Color**.
6. In **Options > Graph Options…**, uncheck **Show grid on graph**; select **Variable for shading**: Burning Index, BI; select **Shading options**: Greyscale.
7. Axis maximum values are:
    a. Fuel Model C: **Y-Axis (SC) max**: 40; **X-Axis (ERC) max**: 40,
    b. Fuel Model G: **Y-Axis (SC) max**: 30; **X-Axis (ERC) max**: 110, and
    c. Fuel Model L: **Y-Axis (SC) max**: 140; **X-Axis (ERC) max**: 12.
8. Change BI thresholds to appropriate climatological breakpoints. Use default values for ERC and SC.

	Climatological breakpoints for BI			
Fuel model	**¼ of 90th percentile**	**½ of 90th percentile**	**90th percentile**	**97th percentile**
C	8	17	34	40
G	15	30	60	68
L	9	18	37	47

9. Repeat steps 1 through 8 for fuel models G and L.

Figure 14. SIG: Similar/Dissimilar RAWS

Figure 14a. Similar RAWS

1. Change caption lines 2 and 3.
2. Open **Fire Danger Rating > Data Imports**.
3. Import FFP text files for Hoyt Creek, Cold Springs, and their SIG (Fuel Model G: May–October, 1997–2012).
4. Type **Legend Description** in boxes below file names.

5. Change **Icon**, **Color**.
6. Axis maximum values are **Y-Axis (SC) max**: 30; **X-Axis (ERC) max**: 110.
7. Change BI, ERC, and SC thresholds to SIG climatological breakpoints.

NFDRS index	Climatological breakpoints			
	¼ of 90th percentile	½ of 90th percentile	90th percentile	97th percentile
SC	2	4	9	12
ERC	18	36	73	77
BI	14	29	59	66

8. Select **Add text box…** and type in the appropriate text.

Figure 14b. Dissimilar RAWS

1. Change caption lines 2 and 3.
2. Open **Fire Danger Rating > Data Imports**.
3. Import FFP text files for Hoyt Creek, Calvert Peak, and their SIG (Fuel Model G: May–October, 1997–2012).
4. Type **Legend Description** in boxes below file names.
5. Change **Icon**, **Color**.
6. Axis maximum values are **Y-Axis (SC) max**: 30; **X-Axis (ERC) max**: 110.
7. Change BI, ERC, and SC thresholds to SIG climatological breakpoints.

NFDRS index	Climatological breakpoints			
	¼ of 90th percentile	½ of 90th percentile	90th percentile	97th percentile
SC	2	4	8	9
ERC	15	31	62	68
BI	12	25	50	56

8. Select **Add text box…** and type in the appropriate text.

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