Long-Term Risk Assessment
Columbia Complex – X September 2006

Summary

Introduction

This long-term risk assessment intends to meet x objectives.

1.

Three remote automated weather stations (RAWS) were used to complete this assessment with Alder (453803) used as the primary station. Eden (351518) and Black Mountain (351317) provided supplemental and comparative information. Alder RAWS is located at 4500 ft elevation, Eden at 4200 ft and Black Mountain at 5425 ft. Black Mountain is considered sheltered from winds by local fire personnel and located several miles southwest of the fire area.

Observed Fire Behavior and Weather

Seasonal Severity

This fire season has been unusually severe. May was warmer and drier than average, June was about average and conditions since late June-early July have been much warmer and drier than average at all three stations examined. The energy release component graph (ERC) for Alder is very typical of all three stations (figure x). All three stations have recorded maximum temperatures frequently above average since late June. Minimum relative humidity trends have been more variable between the three stations. Eden and Alder recorded minimum relative humidity mostly below average since mid-July. Black Mountain's minimum relative humidity did not drop below seasonal norms on a regular basis until early August.

Perhaps even more telling are this season's trends in maximum relative humidity. These have frequently been below seasonal norms since late June, with the trend more pronounced at Alder and Eden than at Black Mountain. Humidity recovery trends have been most severe at Alder. Maximum relative humidity last reached 100% on July 15 at that station. Between July 16 and September 5 (52 days), 26 days have had humidity recovery of less than 30% and only 10 days have had humidity recovery above 50%. Eden and Black Mountain have also seen a number of days with very poor humidity recovery, but not to the extent seen at Alder.

Precipitation has also been below average for July and August at all three stations, although May and June were above average at Alder and Black Mountain. Black Mountain last recorded precipitation on June 15. July precipitation was 24% of average at Alder and 21% of average at Eden. August precipitation was 45% of average at Alder and 75% of average at Eden. The differences in August appear to represent isolated or scattered thunderstorms.

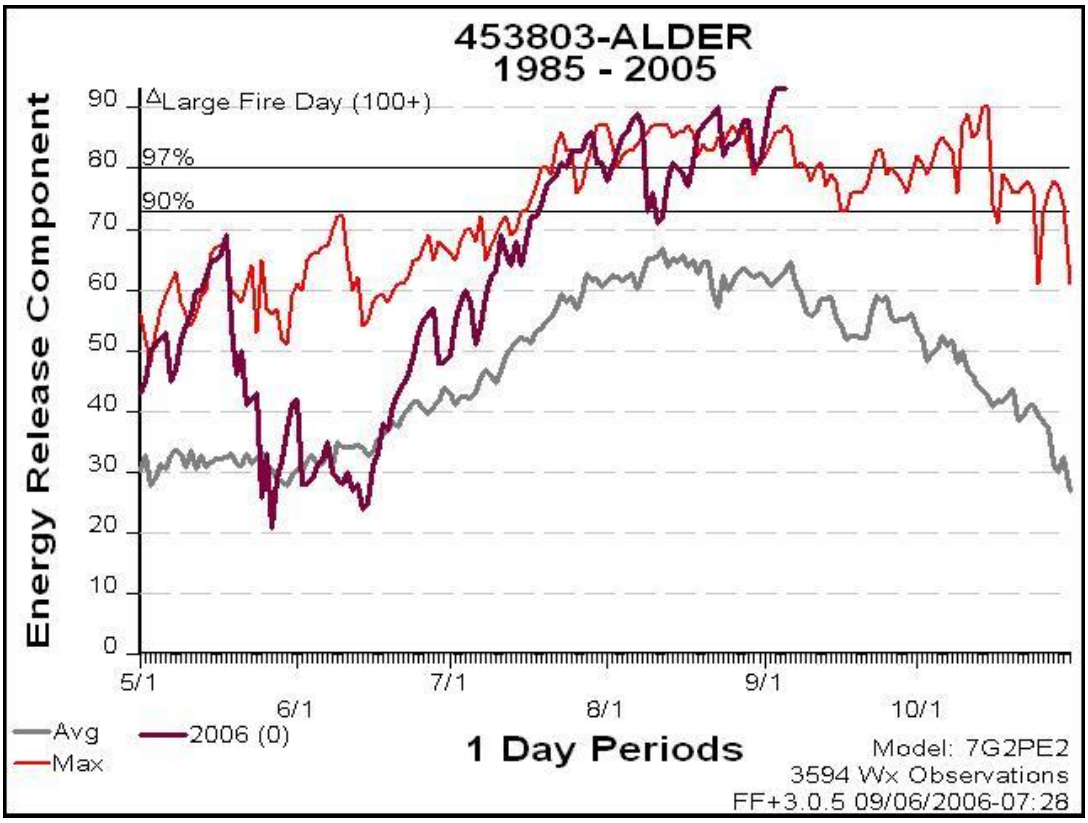

Figure x. Alder has been setting new maximum ERC values regularly since mid-July, a trend echoed at Eden and Black Mountain.

Although the Pacific Northwest moved out of drought conditions this past winter, summer conditions have resulted in a return of abnormally dry conditions in Washington (figure x). Long-term outlooks indicate that September and the September through November period should see temperatures above average and precipitation below average. Mid-term forecasts through September 19 support the 30-day outlook for September. Drought conditions are expected to develop across much of the Pacific Northwest over the next three months as well.

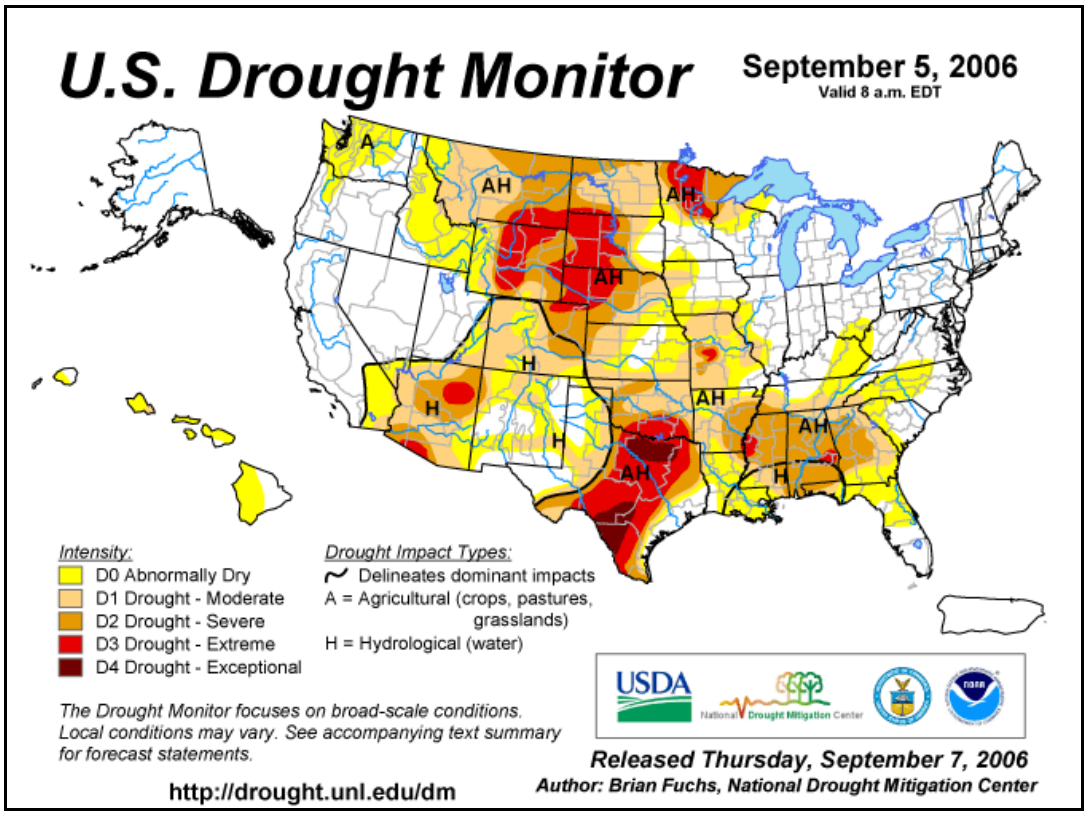

Figure x. Abnormally dry conditions developed in much of Washington and the northern Oregon Cascades. These conditions could continue to expand and intensify over the next few weeks based on the medium and long-range forecasts.

Since Alder had the longest period of record in weather, we compared this year's ERC pattern with previous years to determine if other years had a similar pattern and, if so, how the remainder of the season played out. Fire season 2000 had a similar pattern but a rain event dropped ERC values back down to seasonal averages at the end of August, an event that did not occur this year. Previous seasons did not contain a year that had ERC values above seasonal norms throughout summer and fall. Years with higher than average ERCs earlier in the year, such as 2000 and 2004, usually dropped back to seasonal averages sometime in late August. Years with higher than average ERCs in September and October, such as 1987, 1991 and 1999, usually began the year with lower than average ERCs. Fire season 2005 frequently had above average ERCs from late July until late September, but began the year with below average values. Fire season 2003 began with above-average ERCs in early June, dropped below average in early September and then popped back above average in mid-September until late September.

The long-term outlook suggests that a late season similar to 2005 or 2003 may be the most likely with significant season slowing sometime after mid-September. The lowest precipitation on record for September is 0.00 inches at both Alder and Eden and 0.01 inches at Black Mountain and for October is 0.00, 0.64, and 1.21 inches at Alder, Eden, and Black Mountain, respectively. Higher than average temperatures could mean maximum temperatures 6-10 degrees above seasonal averages through October with some days as much as 15 degrees above average. At Alder, high temperatures may range from the 80s to low 90s through mid-September, upper 70s to low 80s from mid-September through mid-October and low 70s to upper 60s through the remainder of October. Maximum

temperatures at Eden typically range 5-10 degrees above those at Alder through the same period and 5-10 degrees lower at Black Mountain.

Critical Spread Events

Critical spread events tend to occur when conditions are warm and dry along with another weather trigger, such as dry cold front passage, thunderstorm passage, or Haines Index of 5 or 6. Since Haines Index and other measures of instability are not archived, we used temperature and relative humidity as indicators of precursor conditions that could support critical spread if Haines Index 5 or 6 was also present.

Temperature and Relative Humidity

Late in the season, we assumed fuels were dry enough to support critical spread events if weather triggers were present. We used the 90^{th} percentile maximum temperature and 10^{th} percentile minimum relative humidity as indicators that a weather trigger was present (table y). All three stations indicate at least one event should be expected in September with none in October with an overall 4% chance on any given day in September. However, statistical averages appear to be a poor fit for this fire season in this characteristic, with a higher probability on any given day, more than one event likely, and events of longer duration likely. Conditions are most likely to be present in the first half of September in runs of 2-5 days. An unstable atmosphere coupled with these temperature and relative humidity values and poor humidity recovery the previous evening indicate conditions are present to support extreme fire behavior.

Table y. Critical values for temperature and relative humidity that indicate conditions for a critical spread event may be present.

	Maximum Temperature	Minimum Relative Humidity
Alder	$\geq 82^{\circ}$F	$\leq$18%
Eden	$\geq 91^{\circ}$F	$\leq$15%
Black Mountain	$\geq 79^{\circ}$F	$\leq$18%

Winds

We used wind speeds of 18 mph or greater as indicative of cold front passage or thunderstorm downdrafts. Through mid-September, the more likely scenario for a critical spread event would be a thunderstorm downdraft; after mid-September it would be a dry cold front. High winds can result in critical spread events at cooler temperatures and higher relative humidity than those listed in table y. We compiled wind rose data using hourly wind observations from Alder RAWS through the Desert Resource Institute at the Western Regional Climate Center.

Alder RAWS has consistently recorded higher winds than either Eden or Black Mountain, particularly from the southwest (figures x and x). We believe these represent cold front winds. We examined the probability of high winds during a 24-hour period and during the burning period for September and October. Calm winds (winds $\leq$1.3 mph) occur about 13% of the time over a 24-hour period but only 3% of the time during the September burning period (1000-2000) and 6% of the October burning period (1000-1900).

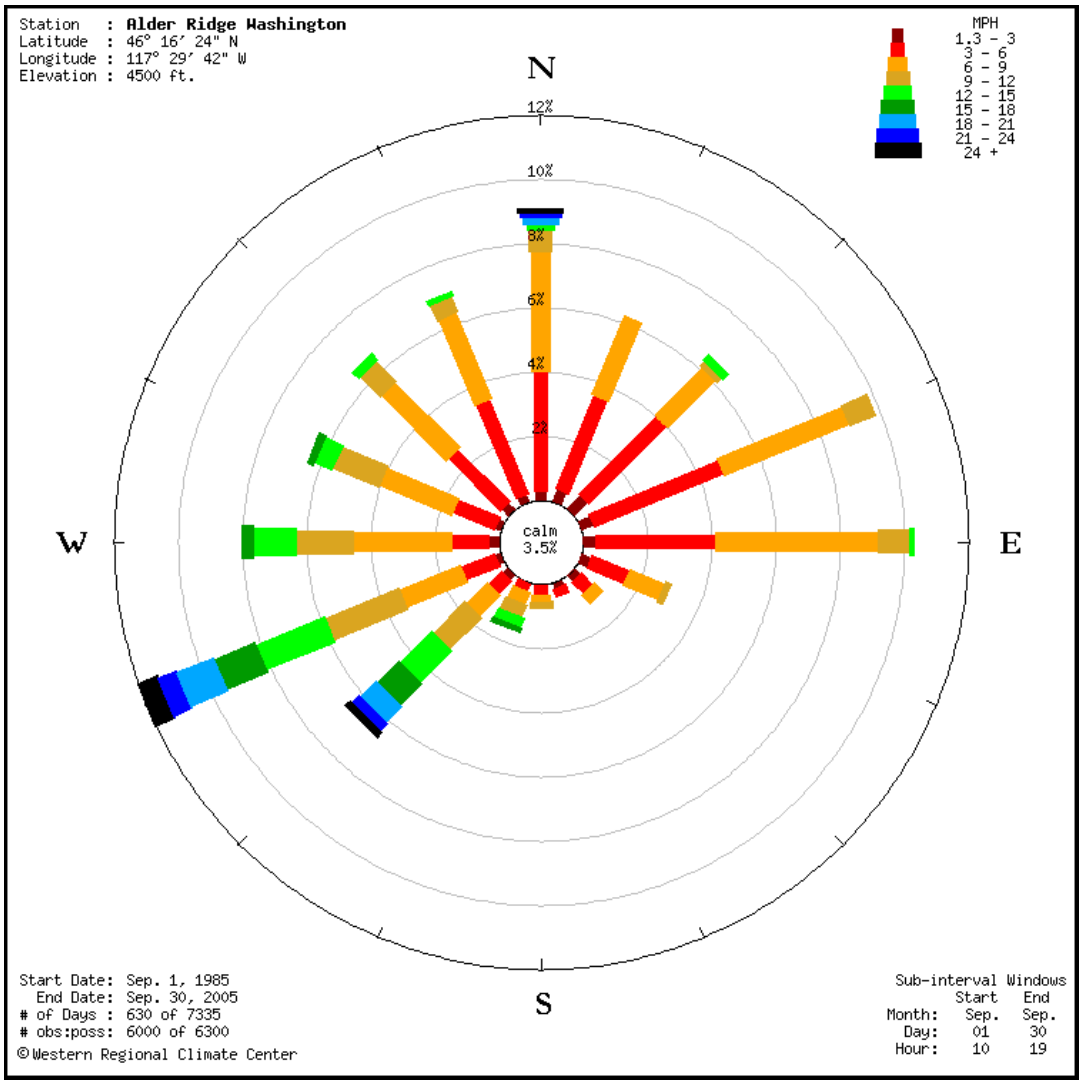

Figure x. September burning period wind rose for Alder RAWS indicates the strongest winds are out of the southwest and north with south and southeast winds light and uncommon.

During the September burning period the strongest winds are out of the southwest, averaging 12 mph. Winds are 18 mph and greater almost 5% of the time, predominately out of the southwest (3.7%) and to a much lesser degree out of the north, south, west and northwest (<0.5% each direction). Most commonly, winds range from 3-12 mph (77% of the time). Winds are only rarely recorded out of the southeast and south.

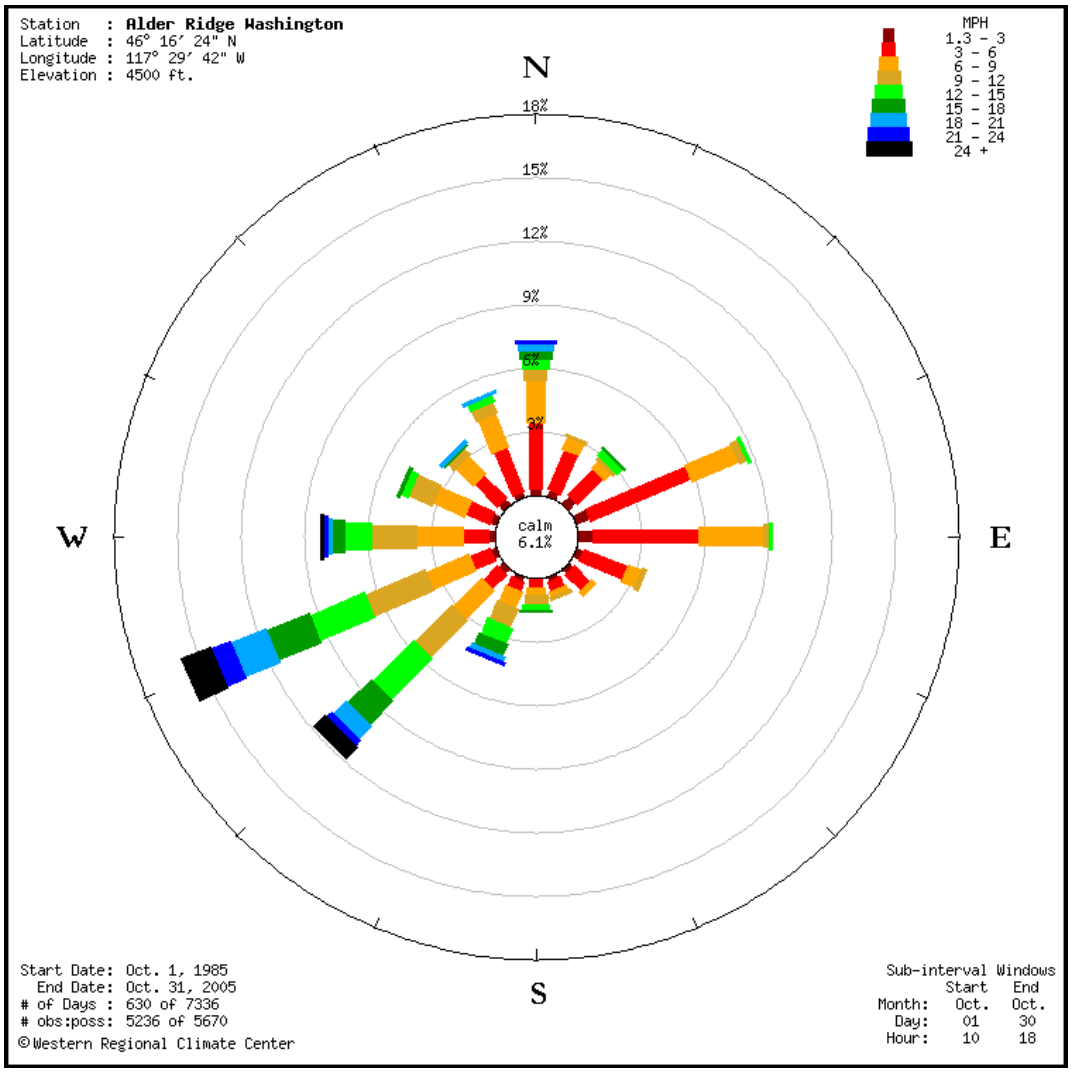

Figure x. The October burning period wind rose is similar to September but with a much greater proportion of winds out of the southwest.

October burning winds are even more common out of the southwest, probably reflecting more common cold front passage. Winds are also slightly stronger with the average wind speed out of the southwest at 13 mph. Winds of 18 mph and greater occur 8.7% of the time, still predominately out of the southwest (6.1%) but also more frequently out of the north, west and northwest than in September. Most commonly, winds continue to range from 3-12 mph (64.5%) with southeast and south winds still relatively rare.

Eden RAWS tends to have much lighter winds and predominantly out of the south rather than southwest. Hourly wind speeds at this station rarely exceed 12 mph in September and 9 mph in October with most winds less than 9 mph. Black Mountain RAWS ….

These 10-minute average wind speeds recorded at RAWS and other weather stations can hide much higher gusts. Generally, the higher the average wind speed, the gustier the winds due to increased surface turbulence. Wind gusts tend to promote the more problematic fire behavior such as erratic spread, initiation of torching and crowning, and longer-range spotting. Crosby and Chandler researched wind gusts that can 'hide' within both the 10-minute average wind speeds taken at weather stations. Their original paper

was reprinted in the Winter 2004 issue of Fire Management Today and partially shown in table y.

Table y. Wind gust estimating table reproduced in part from Crosby and Chandler 2004.

Standard 10-minute Average (mph)	Probable Maximum 1-minute Speed (mph)	Probable Momentary Gust	
		Average (mph)	Maximum (mph)
5	9	15	18
10	14	22	26
15	20	29	33
20	25	35	40
25	30	41	47
30	35	47	54

Fire Slowing Events

Two types of fire slowing events are commonly recognized in the western United States. A rain event of 0.10-0.25 inches often provides enough moisture to slow fire spread for 1-3 days. A rain event of 0.25-0.50 inches will often slow a fire for 3-6 days. We examined precipitation records at all three stations using the Event Locator tool in Fire Family Plus to determine the overall probability of each type of event on any given day, the number of events that might be expected and the probability for each month (table y). These were single day event searches; a multi-day event search could yield different probabilities.

Table y. Probabilities and number of different fire slowing events from data at three RAWS near the Columbia Complex.

	Slow Fires 1-3 days			Slow Fires 3-6 days		
Station	Daily Probability	Monthly Probability	Number of Events	Daily Probability	Monthly Probability	Number of Events
Alder	5%	67% - Sep 86% - Oct	1-2 – Sep, Oct	2%	38% - Sep 57% - Oct	½ - Sep 1 – Oct
Eden	6%	50% - Sep 81% - Oct	1-2 – Sep 2 - Oct	4%	56% - Sep 75% - Oct	1 – Sep 1-2 – Oct
Black Mountain	6%	81% - Sep 91% - Oct	1 – Sep 2-3 - Oct	6%	82% - Sep 91% - Oct	1-2 – Sep, Oct

The chance of a fire-slowing event of 1-3 days duration is about 67% in September with one or possibly two events possible. Most likely, this event will occur in the second half of the month. The probability is much higher on Black Mountain due to its higher elevation. A likely scenario is rain on the higher elevations (above 5000 feet) with clouds, cooler temperatures and high relative humidity below 5000 feet. The chance of this event increases in October to at least 80%, with two events most likely.

The chance of a fire-slowing event of 3-6 days duration showed much more variability between the three stations. The probability in September for the larger event was lower at Alder than for the smaller event, and about the same at Black Mountain, which is what we expected. However, the probability is slightly higher at Eden, a lower elevation station than both Alder and Black Mountain, which we did not expect. The larger rain event occurs only every other year on average at Alder in September. One event may be possible on the eastern part of the fire, given its location in mountainous terrain where orographic uplift can

trigger a rain event. As expected, the probability of this event increases in October with at least one event likely.

These results are somewhat borne out when compared with precipitation probabilities at National Weather Service cooperative network stations. The closest such station is in Dayton, Washington with 75 years of data (figure x). We compared precipitation probabilities for 0.25 inches and 0.5 inches over a 3- and 5-day period. Both curves were similar with lower probabilities of the larger event, not surprising at a location where the average annual precipitation is only 19 inches. These graphs indicate about a 20-30% chance of a precipitation event near mid-September, in late September and in early October. After mid-October, the chances of precipitation move up significantly. The RAWS data indicated the September event was more likely later in the month than shown in figure x. Also of note is the 15-20% probability of a precipitation event about the 3rd week of August; known as the August singularity, this event did not occur in 2006.

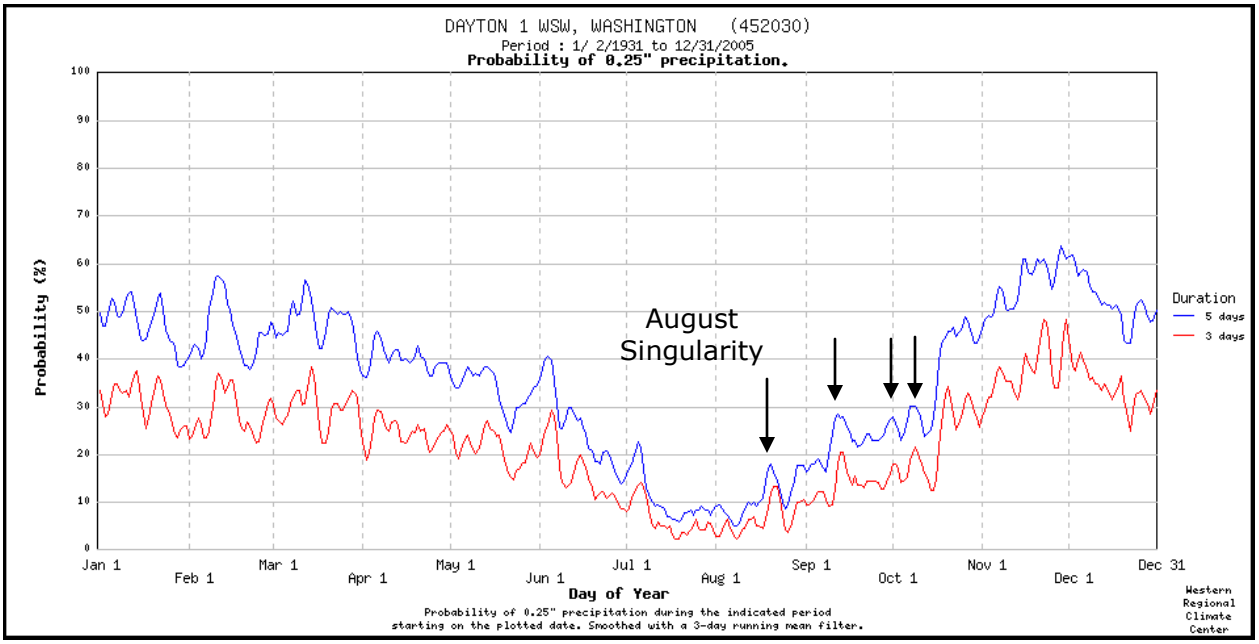

Figure x. The chances of precipitation begin increasing in September with a spikes (arrows) occurring in the 3rd week of August, near the middle of September, at the end of September and in early October.

Along with fire-slowing events, the overall season has begun to slow as well, although current burning conditions mask some of this effect. Day length is shortening and sun angle declining enough to affect fuel pre-heating in the morning and cooling at night. Fuel moistures are so low, however, that much of this effect is not readily noticeable as compared to moister years. As of September 5, Dayton, Washington experienced 13 hours and 6 minutes of daylight. By October 15, the amount of daylight will drop to 10 hours and 56 minutes with an estimated loss of 3.25 minutes of daylight per day. At the same time, the maximum sun angle will decrease from 50.3° to 34.8° for a loss of 0.4° per day.

The combination of the shortening days and decreasing sun angles means cooling begins sooner and occurs more rapidly after sunset and fuel heating takes longer after sunrise, particularly on north and east aspects. North aspects will have less direct sunlight all day and east aspects will become shaded earlier in the day. Even a light rain will noticeably affect potential fire spread on north aspects and the lower 1/3 of the slope, particularly after September 15 and in deep, narrow drainages that are oriented east-west.

Season End

Another key piece of information is when might the fire season end. There is no single clear definition to use for season end. In the past, a rain event of a certain amount was frequently used, but this type of definition has proven unreliable in many areas. Season end is frequently associated with some sort of precipitation event, but the amount can vary widely, depending on the circumstances of a given year. Further, some seasons have ended without a clear precipitation event as changing day lengths, sun angles, temperatures and relative humidity result in conditions that do not support large fires in the absence of a major wind event. For the purposes of this assessment, season end refers to conditions that may continue to support fire spread but do not support large growth events.

For that reason, one criterion used was the date at which ERC dropped below the 75th percentile value and did not recover. We selected the last date at which this occurred, built term files for all three RAWS and then compared the dates to determine how much difference there was between the stations (table y). The drawback to this criterion is that season end cannot be easily recognized at the time since ERC can drop below the 75th percentile and then recover above it later.

Table y. Comparison of season ending dates between Alder, Eden and Black Mountain RAWS.

	Alder	**Eden**	**Black Mountain**
R^2	0.97	0.97	0.98
50th Percentile Date	Sep 28	Sep 26	Sep 23
80th Percentile Date	Oct 16	Oct 11	Oct 8
90th Percentile Date	Oct 24	Oct 18	Oct 15

Given its higher elevation and generally cooler conditions, it is not surprising that Black Mountain produces season ending chances 1-2 weeks earlier than Alder and Eden. We had hoped that Alder and Eden would produce dates closer together, but as the season progress, the difference between the two stations gradually widens. One use of this type of result is to use Alder's results in drier than average seasons, Eden's results in average seasons and Black Mountain's results in wetter than average seasons. While all three stations suggest the possibility of season end in late September, the long-range forecast indicates a mid-October or later season end is more likely (figure y).

We also prepared a term file using Black Mountain's data to determine the possibility of freeze-dried fuels occurring before the season end at the higher elevations of the fire. Freeze-drying of fuels occurs when hard freezes kill herbaceous vegetation and leaves on deciduous species before a rain event. A hard freeze can occur at 32°F, but requires that temperature be present for several hours. As temperature drops, the time needed to have a hard freeze decreases. At 28°F, a hard freeze occurs in just a few minutes. The RAWS data cannot tell us how long the station was at the minimum temperature, so we used the Event Locator to find the first date at which minimum temperature was 28°F or less. These results indicate that freeze drying of fuels is unlikely to be an issue as the necessary temperatures are reached 2-3 weeks after the season end criterion is typically reached.

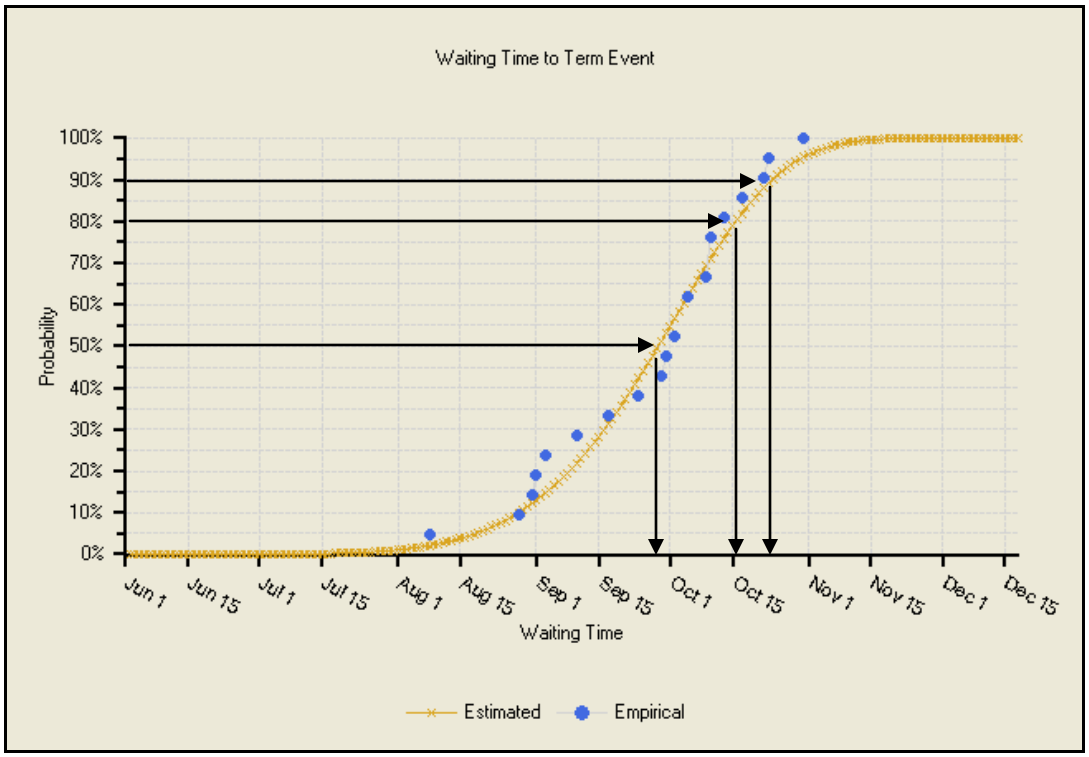

Figure x. Alder RAWS produces later season-end dates than Eden and Black Mountain and may be more representative of 2006, given medium- and long-term forecasts.

Risk Assessment

Management Considerations