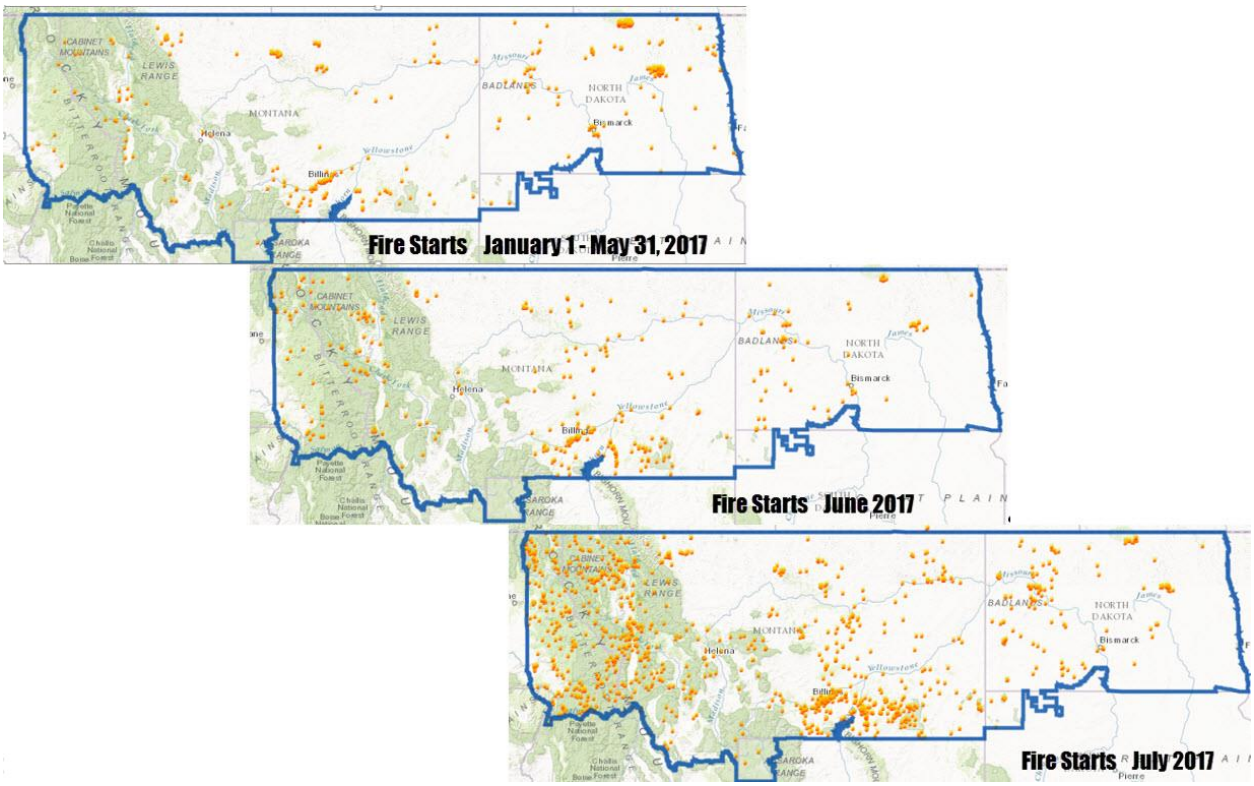
Northern Rockies Geographic Area

Fire Season Assessment

2017



August 5, 2017

Executive Summary

The Northern Rockies Geographic Area saw increased fire activity in July 2017 with an outlook for continued hot and dry conditions across the area. Therefore a team was established to complete a fire season assessment. For the period of June through October the team evaluated current and historical conditions, future fire potential, drought conditions, fire activity, fire danger, remote sensing of vegetative conditions and weather climatology. Due to the size of the Geographic Area and the disparity in fuels and conditions, the assessment was divided into two regions: northern Idaho/western Montana and eastern Montana/North Dakota.

After a wet fall of 2016 and slightly above average winter precipitation in 2017, the spring started as an average season in the western portions of the Geographic Area while the eastern area entered the season in drought. In western Montana/northern Idaho, snow cover was present in the high country as late as June 15 given the abundance of snow during the winter and spring; however, the above average temperatures, windy conditions, and negligible precipitation in June and July, has put fire season approximately two weeks ahead of normal. The eastern portions of the Geographic Area remain in drought. However, recent weather patterns with moisture and cooler conditions have brought temporary relief by moderating conditions. This assessment provides more detailed information about the current situation and potential season scenarios.

The following questions were asked and are addressed in the documents:

- What is the probability of an above average fire season and what are the anticipated impacts?
- Where are the critical locations based on values at risk and potential for large fire growth?
- What are the key fire environment indicators and thresholds which demonstrate above normal fire potential or indicate an increase in fire activity?
- What are the season ending or season slowing event probabilities?
- What are the probabilities of a frontal passage, red flag wind events, and the frequency?
- What is the probability of an August singularity type even and the timing of it?
- What is the probability of a late fire season extending into October?

This assessment was provided to the Forest Service Regional Office, the Northern Rockies Coordination Center, the Multi-agency Coordinating (MAC), and fire managers supporting incidents. A Story Map (digital version) of the "Northern Rockies – 2017 Fire Season Assessment" is located at http://arcg.is/2vtU7CN.

There are a number of notable past fire seasons (2000, 2003, 2007, 2012, and 2015) where there were more fire starts (for fires that grew larger than 100 acres) after August 1, suggesting that the fire season could continue with increased complexity into August.

Watch out situations as the season progresses are:

- Live fuel moistures decreasing with continued drying and become receptive to burning.
- North aspects start to burn readily
- Predicted cold front or back door cold front
- Predicted dry lightning or thunderstorms with isolated precipitation
- Humidity recovery at night is less than 30%

Considerations as the season progresses:

- Build strategies which account for increased winds and cold front passages through the remainder of the season
- Build strategies using fire history as indirect and point protection may be necessary due to fire activity, in order to manage exposure, and based on resource availability.
- Ensure staff is getting adequate rest for a long fire season, bringing in necessary re-enforcement as available.

Potential Season Scenarios:

The fire season is likely to continue for several more weeks or even months. Weather conditions are uncertain over this time period, so three likely scenarios were examined. Due to the current number of large fires and short-term predicted hot and dry weather, all three scenarios result in above-average area burned, but with different geographical distributions and magnitudes.

Scenario 1 – *Moderate likelihood scenario.* The fire season begins to trend toward **a typical August but weak "August Singularity"** materializes, damping fire danger only for a short period. This weather event is caused by the high pressure ridge breaking down, also bringing in the possibility of lightning episodes and more fire starts. Following the August moisture, the weather continues to be hot and dry with above-normal temperatures and windy conditions well into the fall, supporting days with large fire growth and new fire starts from lightning episodes. These weather events lead to above average acres burned and above average number of fire starts throughout the Geographic Area.

Scenario 2 – *Least likely scenario.* Weather season conditions **continue hot and dry until the "August Singularity" brings moisture to the area**. Fire season in eastern Montana and western North Dakota will be significantly slowed by mid-August with the western Montana and northern Idaho recovering back to above average conditions. A normal fall weather pattern arrives with moderating temperatures and moisture arriving to continue to dampen fire season. Large fires continue to grow under this scenario, lightning episodes will cause additional fires, overall acres burned and numbers off fire starts will be above average, especially in the western portion of the Geographic Area.

Scenario 3 – *Most likely scenario.* The fire season **continues into August and September under above average weather patterns which causes weather and fuel conditions already at the 90th and 97th percentile to set new maximums for dryness and fire danger.** No rain is received in mid-August and this trend continues in to the fall. Regular cold front passages occur producing windy conditions and high Haines index days but are dry and may or may not produce lightning. These weather conditions lead to continued large fire growth opportunities causing larger than average acres burned. Human-caused starts will be the primary ignition source with continued high pressure over the area limiting fire starts from lightning.

- Note: The "August singularity" as defined by Soule et al. 2008 is a "significant deviation from normal daily maximum temperatures that occur following the passage of a strong mid-latitude cyclone in mid- to late August in the northern Rocky Mountains." They also found that a 3-day singularity exists for August 24-26 and a single day negative maximum temperature exists for August 13th. This definition does NOT include precipitation, only reduced temperatures.
  https://geo.appstate.edu/sites/geo.appstate.edu/files/DoesanAugustSingularity.pdf

Contents

Executive Summary i
Potential Season Scenarios: ii
Analysis Findings and Recommendations 1
Expected outcomes 1
Indicators of increased fire behavior 1
Current Situation 1
What is a Typical Fire Season in the Northern Rockies? 1
How is the 2017 Fire Season Different from a Typical Fire Season? 2
Assessment of Current Situation Compared to History 6
Vegetation 9
Energy Release Component Graphs (ERC) 11
What are the probabilities of a frontal passage, red flag wind events, and the frequency? 13
Where are the critical locations based on values at risk and potential for large fire growth? 17
Possible Future Situations and Implications 19
What is the probability of an above average fire season and what are the anticipated impacts? 19
Analysis of Season Ending Events 22
Summary and Findings 23
Three Scenarios – What we might prepare for 24
Northern Rockies Fire Season Assessment Team Members 24
References 25
Appendices 25
Other Drought Metrics for July 2017 (for comparison above to the SPEI). 25
Wind Analysis 26

Analysis Findings and Recommendations

Expected outcomes

It is expected that this season will be an above average fire season. Extreme fire spread potential resulting from dry cold fronts in addition to no mitigation of fuel conditions can be expected as conditions likely continue to be hot and dry. Late August is forecasted to have the potential for widespread dry lightning. This expected outcome is supported throughout the document by assessing fire history and fires year-to-date, looking at fire danger indices and trends, assessing greenness, and evaluating winds while considering the weather forecast into October.

Indicators of increased fire behavior

Watch out situations as the season progresses are:

- Live fuel moistures decreasing with continued drying and become receptive to burning.
- North aspects start to burn readily
- Predicted cold front or back door cold front
- Predicted dry lightning or thunderstorms with isolated precipitation
- Humidity recovery at night is less than 30%

Humidity recovery at night is less than 30%Considerations as the season progresses:

- Build strategies expecting winds and cold front passages through the remainder of the season.
- Build strategies using fire history as indirect and point protection may be necessary due to fire activity, in order to manage exposure, and based on resource availability.
- Ensure staff is getting adequate rest for a long fire season, bringing in necessary re-enforcement as available.

Current Situation

What is a Typical Fire Season in the Northern Rockies?

EARLY SEASON: In May and June, low pressure systems can bring moisture from the Pacific which promotes the green-up of live fuels. The high pressure ridge becomes established over the Northern Rockies Geographic Area during late June to early July which begins a drying trend.

MID-SEASON: By late July to early August, the drying trend is moderated by occasional pulses of monsoon moisture from the south, which can bring lightning sometimes accompanied by moisture. Fires can become established during this period which can extend into late August. Fire growth can be retarded by occasional pulses of monsoon moisture.

LATE SEASON: Later in August and into September the passage of low pressure systems becomes more frequent. These systems can suppress or even break down the high pressure ridge, bringing periods of cooler temperatures, increased winds and occasionally enough moisture to retard or even suppress fire growth. Dry frontal passages associated with these low pressure systems can dramatically increase fire growth for short periods. Eventually the ridge gets pushed to the south and a west-to-east zonal flow becomes established. Low pressure systems riding this flow continue to bring periods of cooler temperatures, increased winds and occasional moisture until late October when seasonally decreasing temperatures and day length bring an end to the potential for fire growth.

How is the 2017 Fire Season Different from a Typical Fire Season?

The 2017 spring and summer season has been different -- both drier and warmer than typical seasons.

EARLY SEASON: Higher than normal temperatures and below average moisture was most notable in the month of July. The high pressure ridge became established early by mid-June and shut off the flow of Pacific moisture. More than a month has passed with no appreciable precipitation with parts of the Geographic Area poised to break records for the length of time with no precipitation.

MID-SEASON: Although an intrusion of monsoon moisture late in July moderated fire growth by cooling temperatures it was not accompanied by precipitation. The high pressure ridge" has been anomalously strong and has brought higher-than-normal temperatures to the western United States. Lack of moisture and anomalously high temperatures over the last six weeks have combined to produce drought conditions in the eastern part of the Geographic Area and critically low 100-hour and 1000-hour fuel moistures west of the Continental Divide.

Snow

The western portion of the Northern Rockies Geographic Area is dominated by mountainous terrain and receives appreciable snow during the winter. The timing of when that snow melts can influence fire behavior, with early spring snowmelt correlating with more area burned by wildfires (O'Leary et al. 2016). By June 1, 2017, many basins in the state of Montana were normal or above normal for snowpack, but in May the snowpack melted faster than normal due to higher-than-normal temperatures (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/mt/newsroom/releases/?cid=NRCSEPRD1331613). Those high temperatures continued during the months of June and July. A noticeable decrease in snowpack from June 15 to July 1 is evident (Figure 1). With diminished snowpack and limited snowcover, the higher elevation areas have fuels that dry earlier and faster than normal.

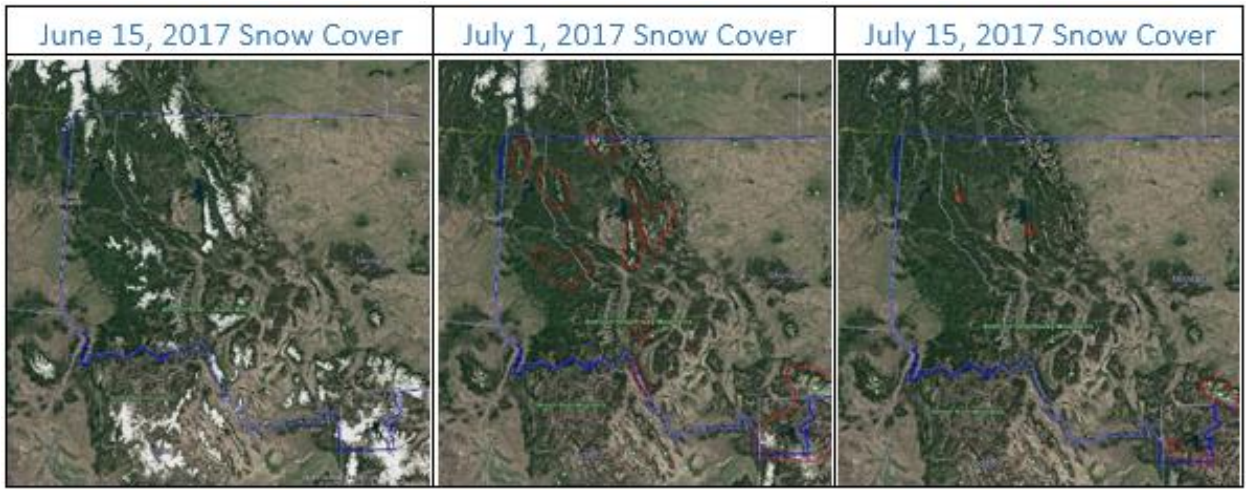


Figure 1 - NRCS snow cover maps for June 15, July 1, and July 15, 2017. Most of the snow pack was gone by July 15, 2017. Circled areas highlight remnant 1 X 1km pixels of remaining snow cover.

The departure from average temperature (Fig. 2a) suggest that as early by May 2017, higher temperatures were prevalent for a majority of the Northern Rockies Geographic Area. In May, much of western Montana and northern Idaho temperatures were approximately 2 to 4 degrees F higher than average, with a small portion of North Dakota also trending above average. By July, the departure from the 1981 – 2010 normal mean temperature was approximately 3-5 degrees F for most of the Geographic Area, except eastern North Dakota. This trend has continued to be most pronounced in central and western Montana and northern Idaho. Temperatures in North Dakota are currently moderating (Fig 2a).

Precipitation rankings when compared to historical data (1895 – 2010) suggest that much of the GACC is currently well below normal, with North Dakota displaying areas of below and above normal (Fig 3).The eastern portion of the Geographic Area (eastern Montana and western North Dakota) were showing up to a 25 percent departure from normal precipitation in May (Fig 2b). Parts of Northwest and eastern Montana and Western North Dakota were much below normal for the lack of precipitation compared to historical values (May 1895 – 2010). However, much of Western Montana was near normal for precipitation for May. July's weather produced a fairly dire situation for most of the Geographic Area. Northern Idaho and northwestern Montana received 5% of normal precipitation with most of the Geographic Area 50% or less compared to normal (compared to years 1981 – 2010). Western North Dakota showed some signs of recovery but still mostly below normal (Fig 2b).

For July, most of the Geographic Area had negligible precipitation (<0.01 in.) coupled with 20+ days of temperatures in excess of 90 degrees F (http://www.sercc.com/perspectivesmap?region=wrcc - Figure 2a and 2b). In summary, it's hot and dry and that has been the case especially for June and July.

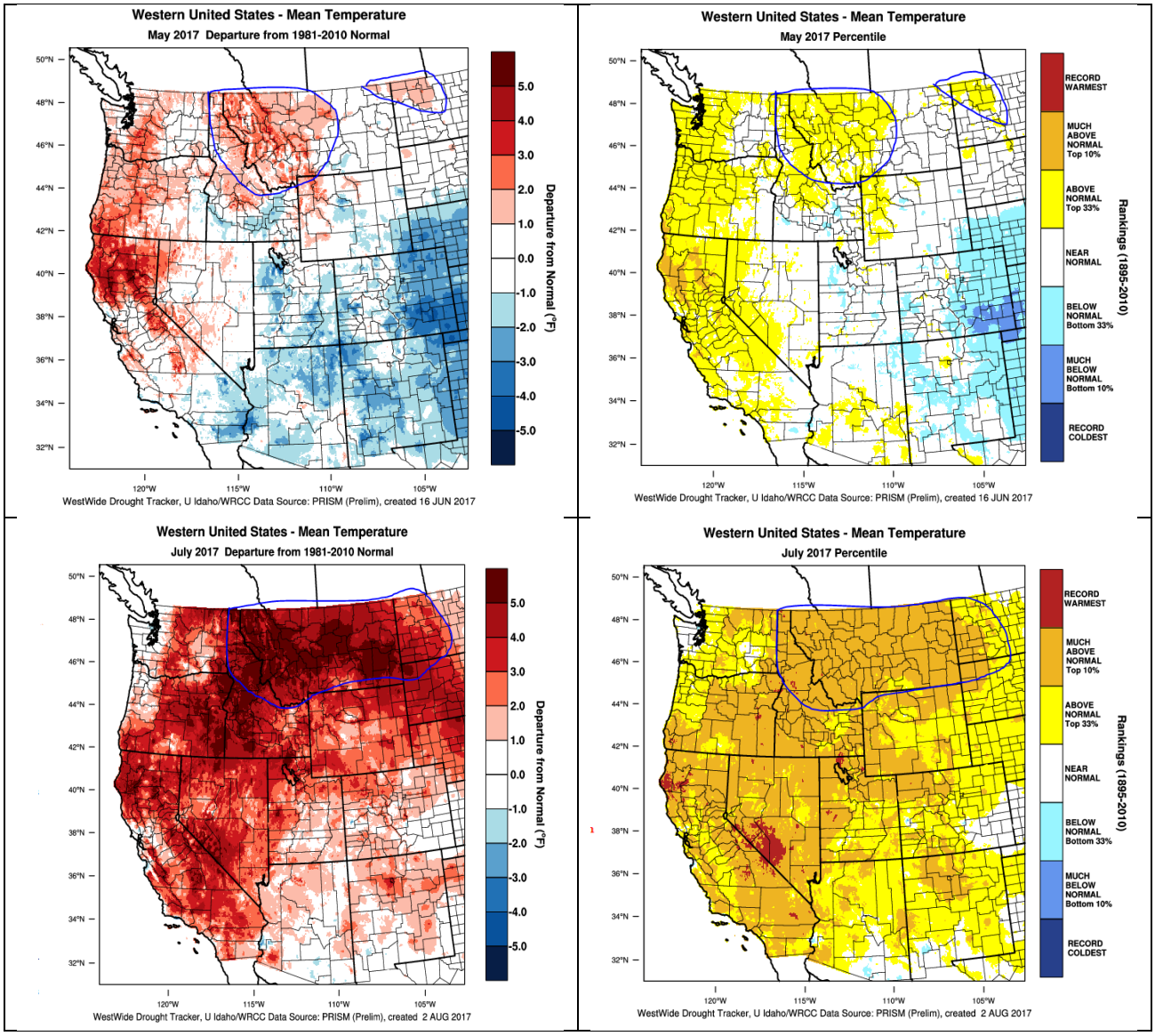


Figure 2a - Departure from Mean Temperature for April and July 2017 for actual temperatures (dg F) and percentile. Departure from normal was calculated using data from 1981 through 2010. Percentile rankings represent a given month based on the 1895 – 2010 data. Note the scale on the 'Departure from Normal' maps are different.

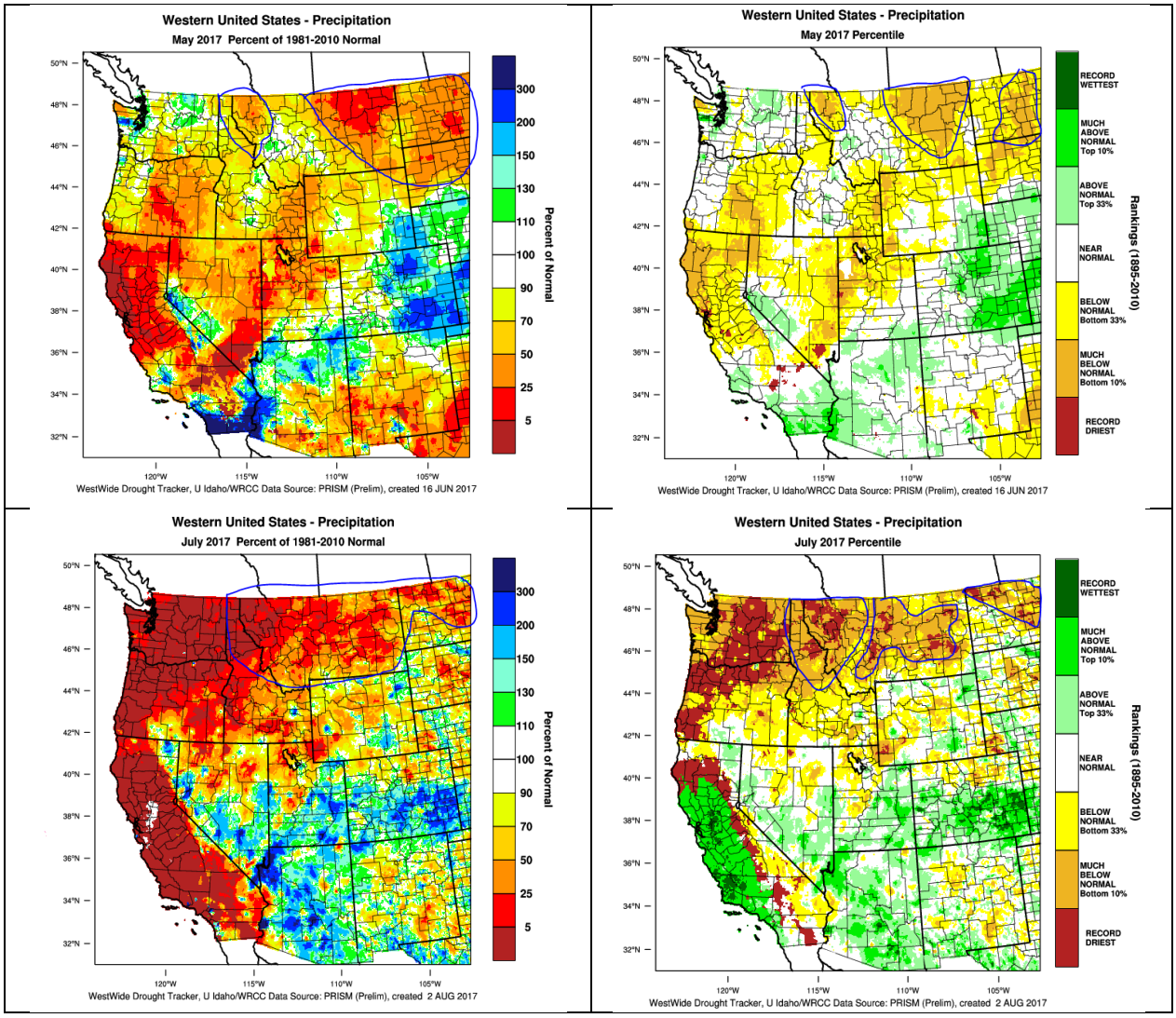
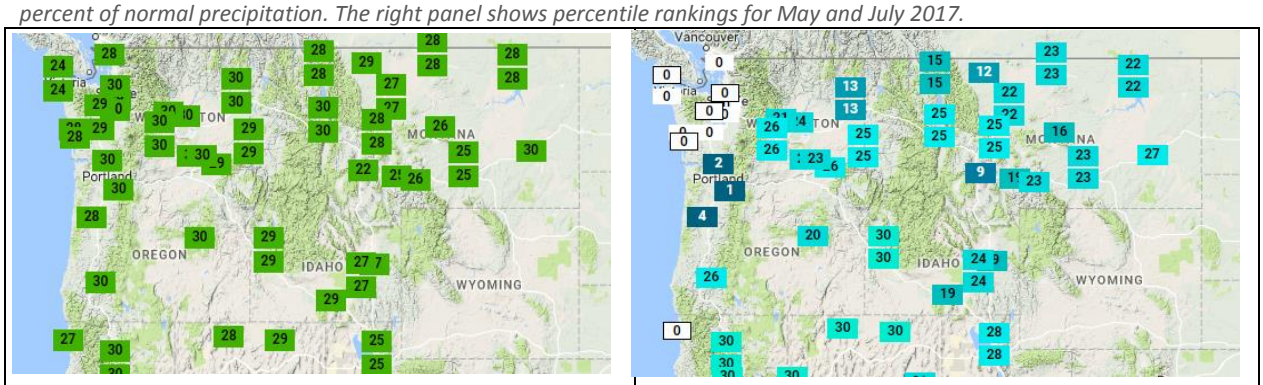


Figure 2b. Precipitation maps for the Western United States for May and July 2017. The left panel shows May and July as percent of normal precipitation. The right panel shows percentile rankings for May and July 2017.



Number of days in July where total precipitation was less than 0.01inch.	Number of days in July where maximum temperate was greater than or equal to 90 degrees F

Figure 3 - Western US Precipitation Images.

The graphics above show thresholds for precipitation and maximum temperature for the month of July. Most of the Geographic Area experienced more than 26 days without precipitation greater than 0.01 inches and 9 to 27 days where maximum temperature exceeded 90 degrees F.

Assessment of Current Situation Compared to History

2017 Fire Activity Compared to Historic

Data from the Fire Program Analysis Fire Occurrence Database (FPA FOD), spanning 1992-2015 (Short 2017) were incorporated with fire records from the Integrated Reporting of Wildland Fire Information (IRWIN) system for 2016 and 2017 and analyzed to gain an understanding of the current fire season activities compared to recent seasons. Given current and expected conditions, the analyses of analogue years suggest a likelihood of continued active fire spread for fires discovered after August 1, as well as those ignited prior to August that are still burning. Of these analogue years,

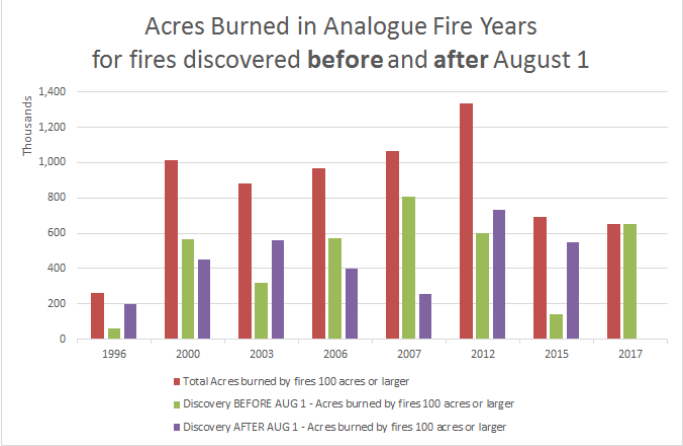


Figure 4 - Acres burned in analogue fire years for fires discovered before and after August 1.

- Three of these years showed fewer acres burned from fires discovered after August 1 compared to those discovered earlier.
- Four of the seven had more acres burned by fires that started after August 1 than from those fires discovered before August 1.

Only 2007 had more acres burned by fires ignited prior to August 1 than 2017:

- 806,900 acres burned by fires discovered prior to August 1 2007
- 654,271 acres burned prior to August 1, 2017 *(A disclaimer on these analyses: Many fires discovered prior to August 1 continue to burn after August 1 and reflect acres burned after August 1. These figures simply reflect the season-long impact of fires discovered either pre- and post- August 1.)* These analogue years in terms of fire activity and acres burned were selected by analyzing fire records from 1992 to the present fire season (up to August 1 2017). Fires 100 acres or larger were delineated by east/west and federal/non-federal status, by discovery month, and by pre- and post-August 1 discovery date.

Daily records of cumulative area burned in Montana suggest that by August 1, more than half of the acres burned usually occur during August, based on data from fire seasons 1999-2013 (Fig 5), suggesting that additional substantial large fire growth is likely during August this year.

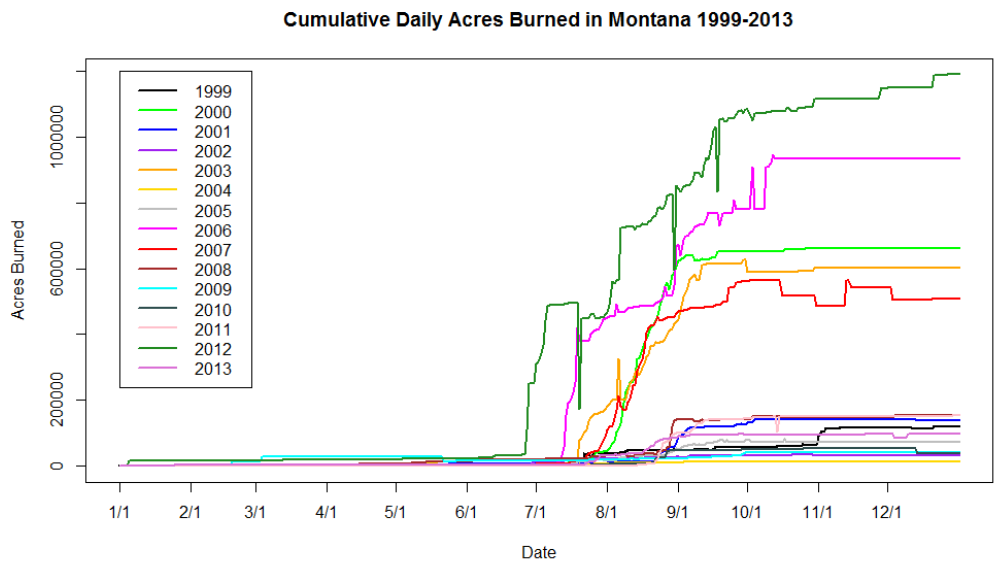


Figure 5 - Daily cumulative acres burned (based on daily SIT-209 reports).

Additional findings from the fire history analyses include:

- Based on number of fire ignitions, the fire season in the eastern area of the Geographic Area occurs during April-May and July-August-September. In the western area, fire activity is predominantly July through September. In both areas, August has the greatest number of large fire ignitions.
- When comparing current year acres burned to historical acres burned in a year, 2017 has seen the second highest acreage burned in the eastern/North Dakota area. The majority of acres burned in 2017 have been in this area of the Geographic Area.
- Acres burned in Western Montana and Northern Idaho prior to August 1st were not notable compared to history (however, many of the fires ignited during July are still active and could continue growing during August, augmenting the tally of acres burned). It is expected, based on weather predictions that the remainder of the season will be record setting or near record setting for acres burned.

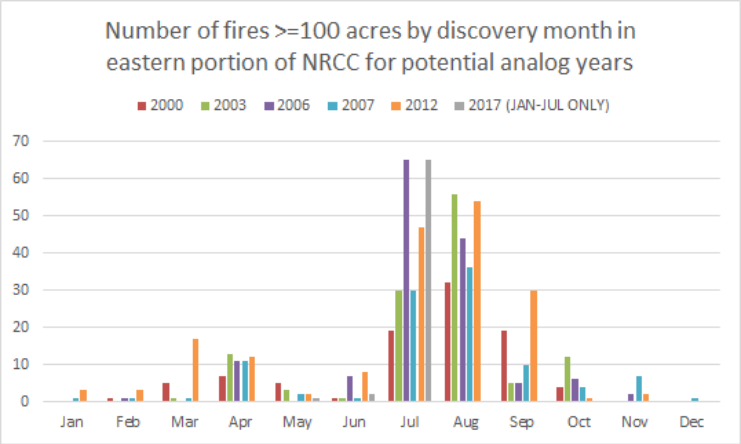


Figure 6 - Number of fires by discovery month for the eastern portion of the Geographic Area >= 100 acres

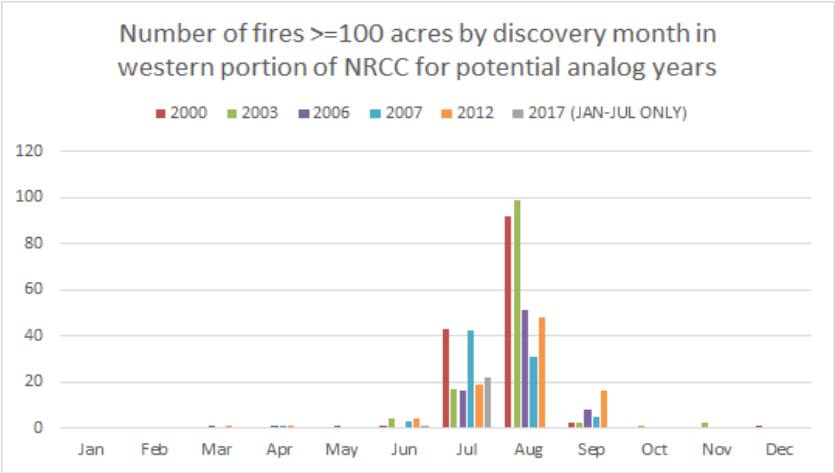


Figure 7 - Number of fires by discovery month for the western portion of the Geographic Area >= 100 acres

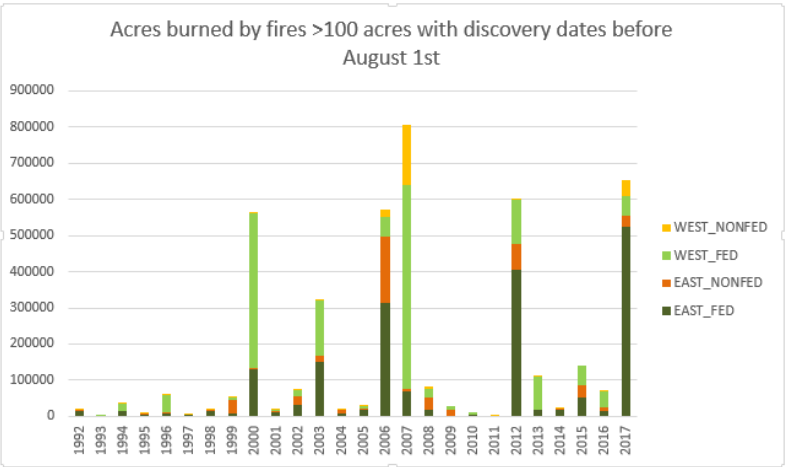


Figure 8 - Acres Burned prior to August 1 (fires >= 100 acres)

Acres burned in 2017 by fires with discovery dates before August 1 are already the second highest since 1992. Some fires are still active and will continue adding acreage during August.

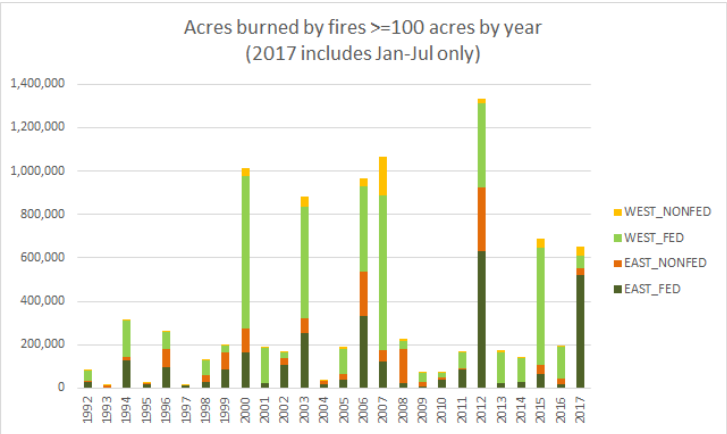


Figure 9 - Acres burned by year, including starts pre- and post- August 1.

Vegetation

In higher elevations, live fuels are still green enough to inhibit extreme fire spread, but vegetation continues to cure as the season progresses. Departure from Average Greenness is a remote sensing product produced Wildland Fire Assessment System (WFAS, http://www.wfas.net/). It shows how "green" each pixel is compared to the average greenness for the current week based on data from 1989 through 2003.

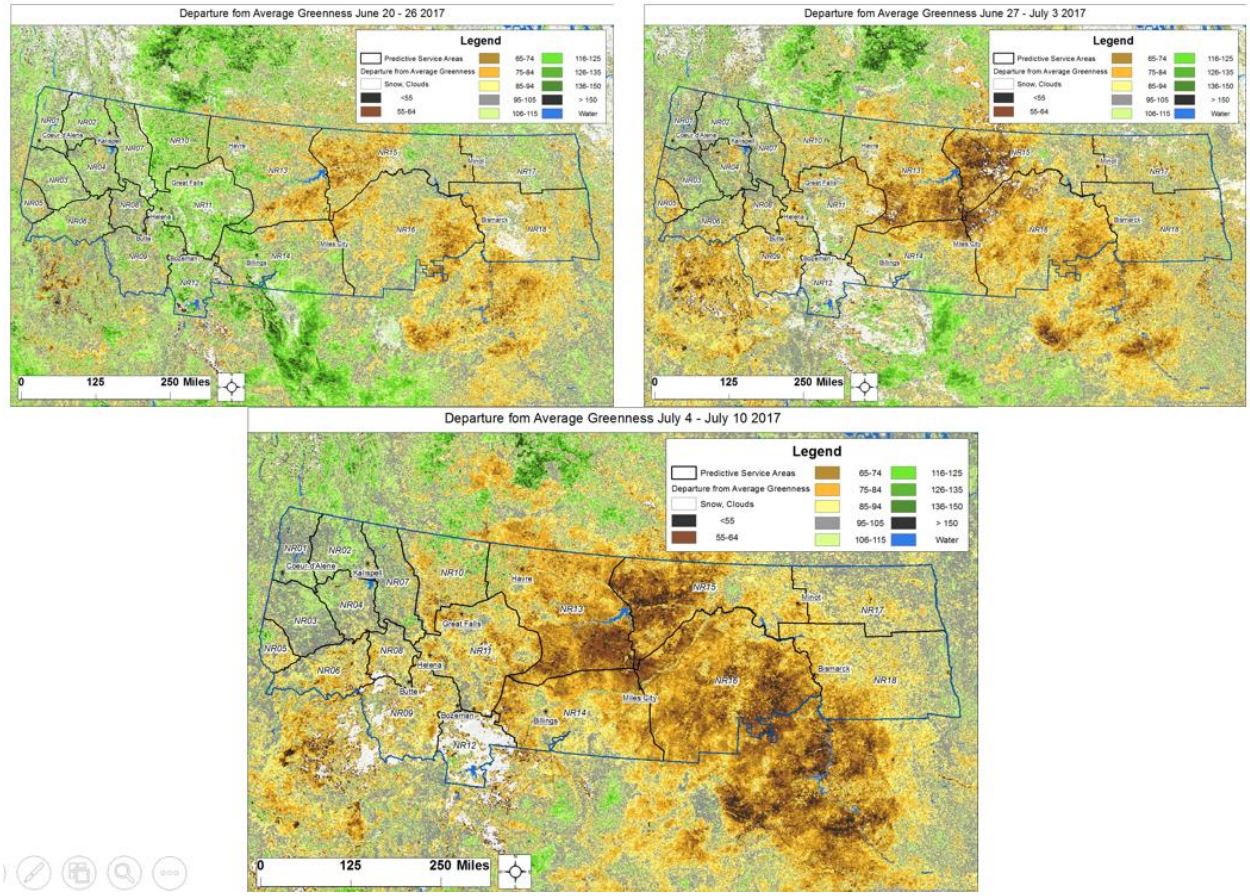


Figure 10 - Departure from Average Greenness for three 1- week periods (June 20 - June 26; June 27-July 3; and July 4-10, 2017)

Figure 10 shows that as recent as June 26th much of Western Montana had vegetation that was greener than average, suggesting that moisture deficits were experienced differently between the vegetation and the soil (as shown by the SPEI in Figure 11, which suggests very dry soil moisture). In early July the region shows decreasing values for departure from average greenness, suggesting that the vegetation is starting to cure, likely in response to the pervasive high temperatures and low precipitation in June and July.

Because temperatures have been above normal for much of the Northern Rockies region this summer, using a drought index such as the Standardized Precipitation Evaportranspiration Index (SPEI) which

takes into account the main impact of increased temperatures on water demand, seems appropriate. The SPEI uses monthly precipitation and average monthly temperature in its calculation and was developed to help overcome some limitations of the Standardized Precipitation Index (Vicente-Serrano et al., 2010).

The SPEI were calculated on August 2, 2017 (Abatzoglou et al. 2017, https://wrcc.dri.edu/wwdt/about.html) using data from 1895 to the present. Considering the last 12 months since July 2017, the SPEI maps show that eastern and southwestern Montana and western North Dakota were trending toward drier conditions. The 8-month SPEI continues to suggest worsening drought conditions for eastern Montana/western North Dakota and also shows the continued deficit in southwest Montana. The 5-month SPEI map is the first time that northwest Montana starts to show drier conditions. The 2-mo SPEI includes northern Idaho trending similar to northwestern Montana for developing drier conditions along with most of the region. Finally, the 1-mo SPEI suggests most of the region has worsened over the last month due to high temperatures and negligible precipitation. Southern Montana and portions of North Dakota appear to be dry but closer to normal. The SPEI has not been shown to be strongly related to large fire activity. While they give useful perspective on hydrologic drought conditions, longer timescales in drought indices (such as 6, 12, or 24-month) are not usually related to large fire activity. However, shorter-term indices on the 1-3 month scale are often strongly correlated with large fire activity (Riley et al 2012). Thus the 1 and 2 month SPEI may be indicative of elevated large fire potential over the entire GACC.

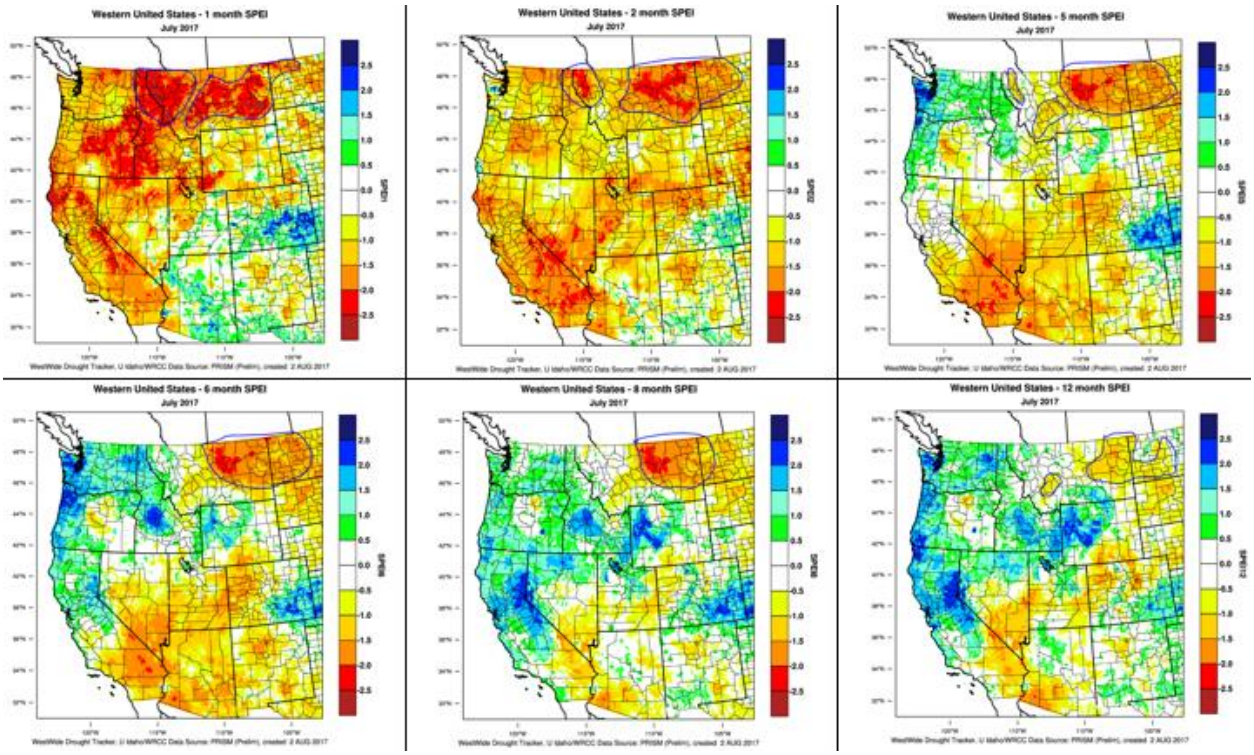


Figure 11 - Standardized Precipitation Evapotranspiration Index Graphs for July (1-month; 2 month; 5-month; 6-month; 8 month; and 12 month).

In sumary, the time series shows developing dryness in the Northern Rockies Geographic Area culminating to high values for the 1-month SPEI July 2017 (Fig 11).

Energy Release Component Graphs (ERC)

The energy release component (ERC) is a number related to the available energy (BTU) per unit area (square foot) within the flaming front at the head of a fire. Daily variations in ERC are due to changes in moisture content of the various fuels present, both live and dead. The ERC for fuel model G is often used in predictions of fire danger and large fire activity. The ERC-G has been shown to be strongly correlated with area burned in the western United States (Riley et al. 2013).

The Northern Rockies Geographic Area was broken into western and eastern areas, representing a climatic, vegetation, and topographic boundary as the mountainous terrain transitions to the plains. The Geographic Area is further divided into Predictive Service Areas (PSAs) whereby a group of 2-7 remotely automated weather stations (RAWS) are combined to monitor and predict fuels and fire danger. To remain consistent, all RAWS used a fuel model G (short-needle, heavy dead). This model is also used for all ERC graphs in the Wildland Fire Decision Support System (WFDSS).

Nine out of 10 PSAs in the western section show ERC values above the 97th percentile (the one exception is NR09 near Bozeman, MT, which near the 90th percentile). The years 2003 and 2007 were similar in their ERC values and are shown on the graphs as analogue years. Both those years were notable as far as number of starts and fire growth in the Northern Rockies (Fig 4). The ERC values for the east side of the Geographic Area (Fig 12)) are also above the 97th percentile (NR10, NR 11, NR 13). In the southern portion of the east-side Geographic Area, the ERC values become less dramatic and are hovering around the 90th percentile (NR 12, NR 14, NR 16). The eastern portion of the Geographic Area primarily in North Dakota has ERC values trending toward average or below average (NR 15, NR 17, NR 18).

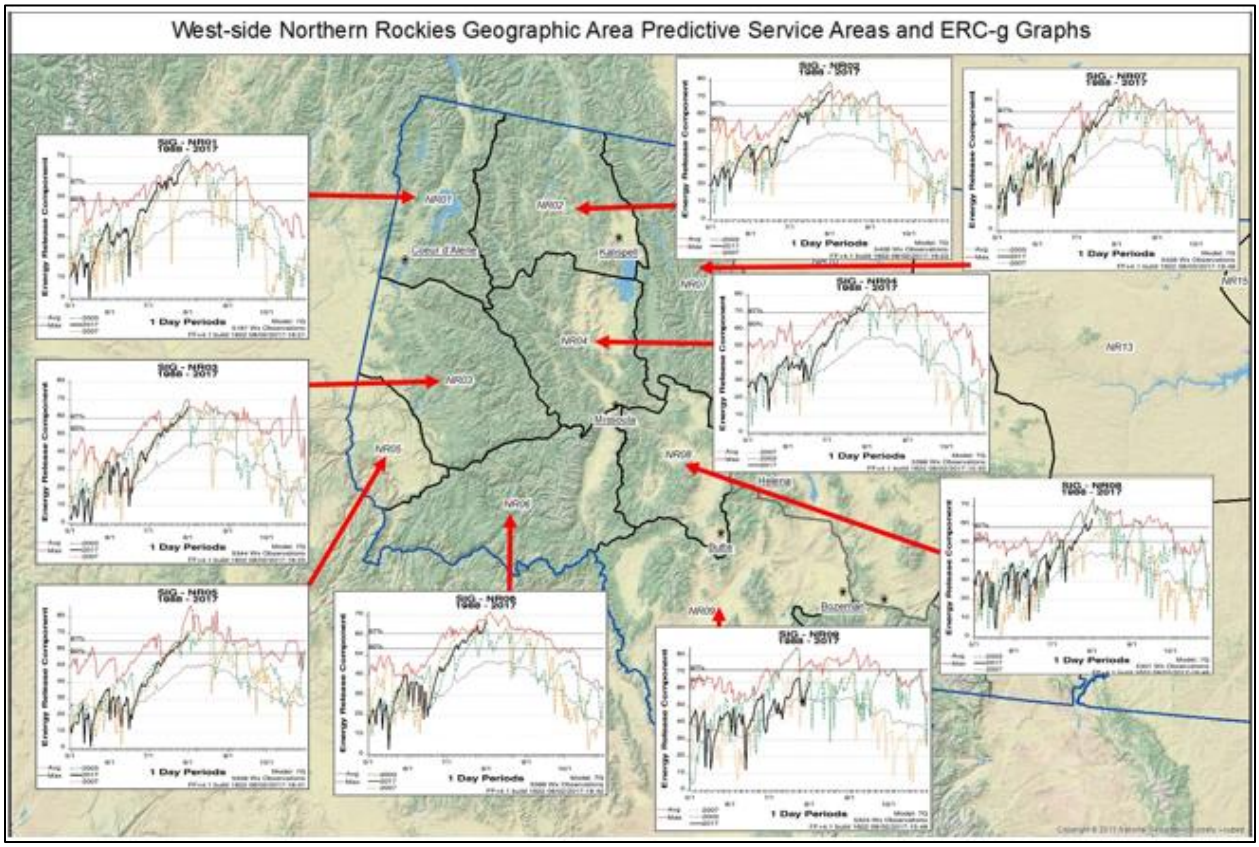


Figure 12 - Western Montana & northern Idaho ERC Graphs. The black lines show the ERC-G for 2017, while the gray shows the average and the red shows the maximum. The west side of the Northern Rockies Geographic Coorindation Area with associated Energy Release Component graphs. Similar years to what is currently being observed (dark black line) were 2003 (green dashed line) and 2007 (yellow dotted line). Each Predictive Service Area (PSA) has a series of Remote Automated Weather Stations (RAWS) that are used to show seasonal trends such as the ERC.

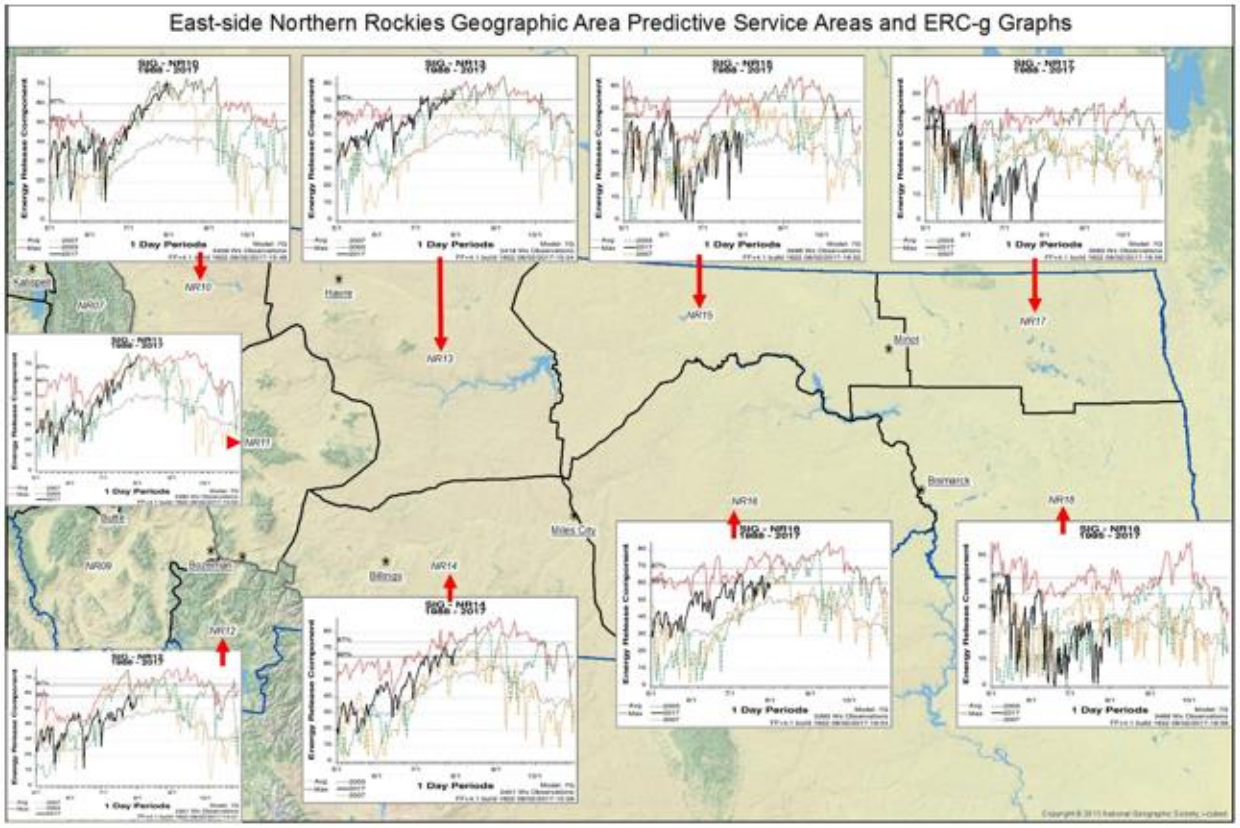


Figure 13- Eastern Montana and North Dakota ERC Graph. The black lines show the ERC-G for 2017, while the gray shows the average and the red shows the maximum. The east side of the Northern Rockies Geographic Coorindation Area with associated Energy Release Component graphs.Similar years to what is currently being observed (dark black line) were 2003 (green dashed line) and 2007 (yellow dotted line).Each Predictive Service Area (PSA) has a series of Remote Automated Weather Stations (RAWS) that are used to show seasonal trends such as the ERC.

What are the probabilities of a frontal passage, red flag wind events, and the frequency?

Analyses were conducted for cold front passages (roughly defined as a 15-25 deg drop in temperature accompanied by significant moisture over 2 days) and conditions at which high wind speeds may occur that would influence fire behavior. One analysis identified the first cold front passages through history for Missoula, with mid-August as the peak probability (57% occurrence) for the first strong frontal passage, with lesser rates before and after.

For this year, cold front passages are forecast for late August.

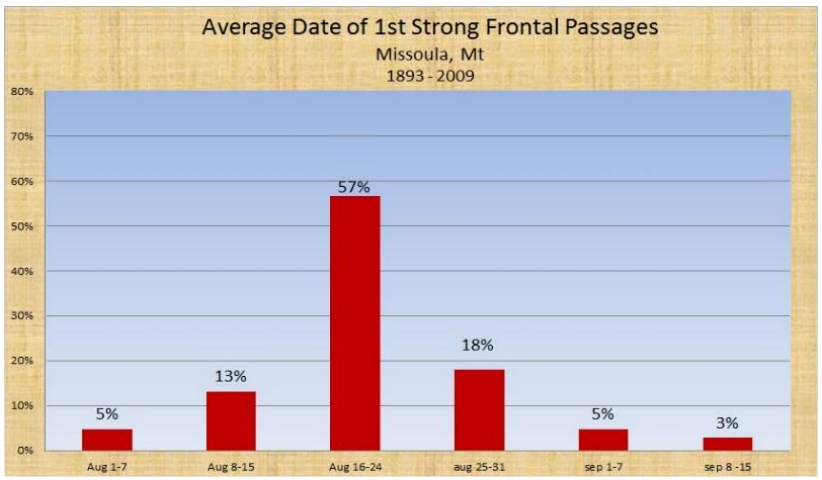


Figure 14 - Graph of Average Date of 1st Strong Cold Front Passage

Wind Gusts and Fire Spread Potential

An analysis of representative RAWS weather stations offers insights on critical wind thresholds for fire spread (Fig 15). Criteria for choosing weather stations were as follows:

- Predictive Services Key RAWS were used
- Longer periods of record were preferred
- More complete records were preferred (for example, a station that operates year-round would be chosen over a station that operates only during fire season, all else equal)
- RAWS on ridge tops were preferred. Wind roses and/or station photos were examined; stations where wind direction and speed were not dominated by topography were preferred where available.

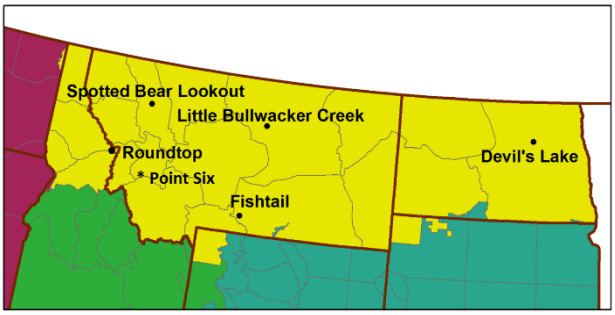


Figure 15 - Image of RAWS stations utilized for the wind analysis.

(See Appendix for additional notes and wind analyses methodology.)

The Thompson Creek Fire of 2003 was examined for thresholds in wind gusts that caused extreme fire growth. The Thompson Creek Fire made a run on 8/19/2003, going from 7,530 acres to 17,410 acres (based on the GeoMAC perimeter data). It appears that the fire may have traveled as much as 10.7 miles on that day. The high temperature was 95 degrees Fahrenheit at the nearby Pardee weather station and winds gusted up to 39 mph at the Roundtop weather station. From this case study, a determination was made to use gusts of 30 mph or greater as a threshold for identifying days prone to extreme fire spread. Additionally days with 20 and 10 mph winds were examined.

This analysis is unlikely to capture occurrence of thunderstorm downdraft winds as they may be localized some distance from the weather station. However, five of these sites display a signature of potential cold-front passage as higher and longer period winds may occur as the front approaches and passes the weather station.

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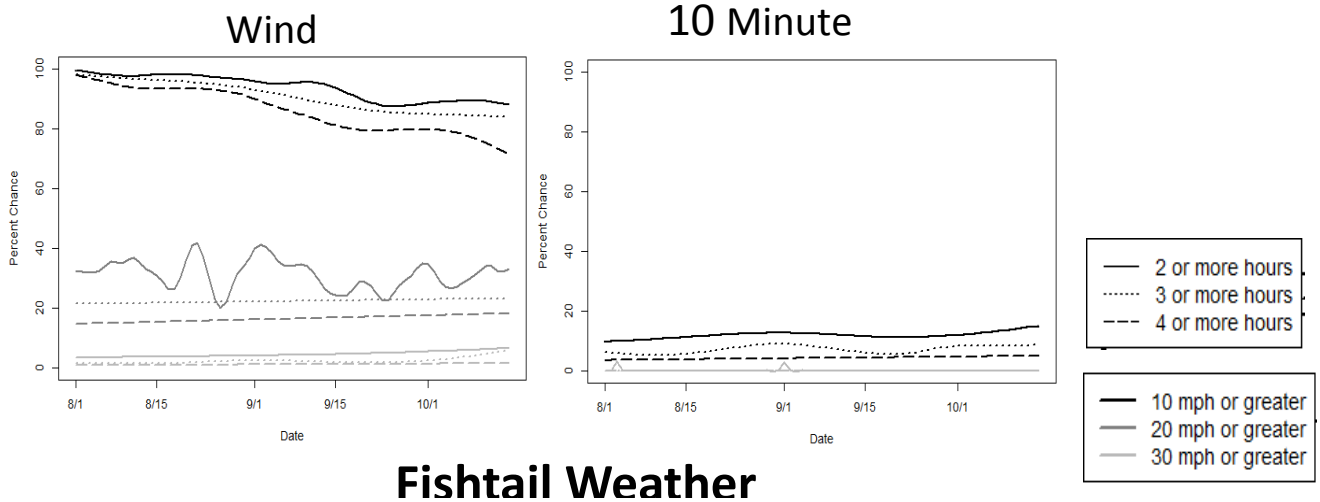
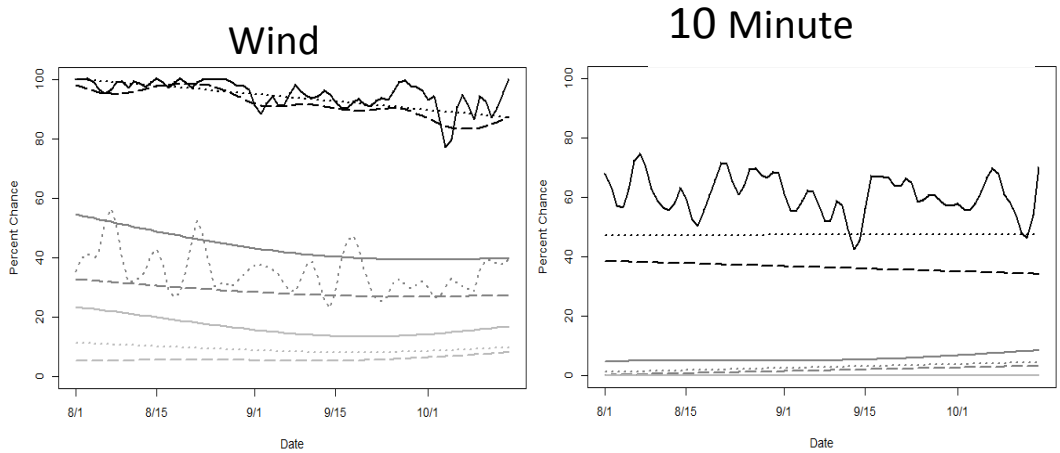
Eastern Montana / North Dakota

Little Bullwacker Hill



Fishtail Weather



Devil's Lake

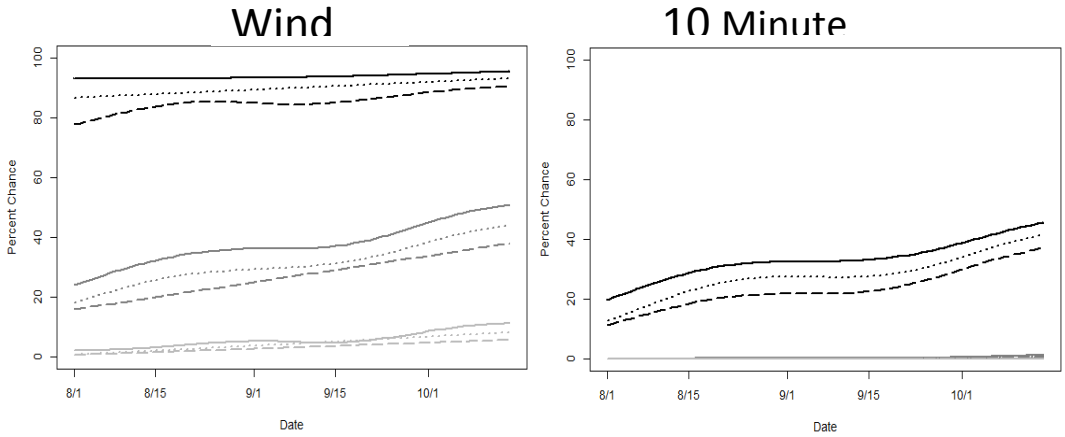
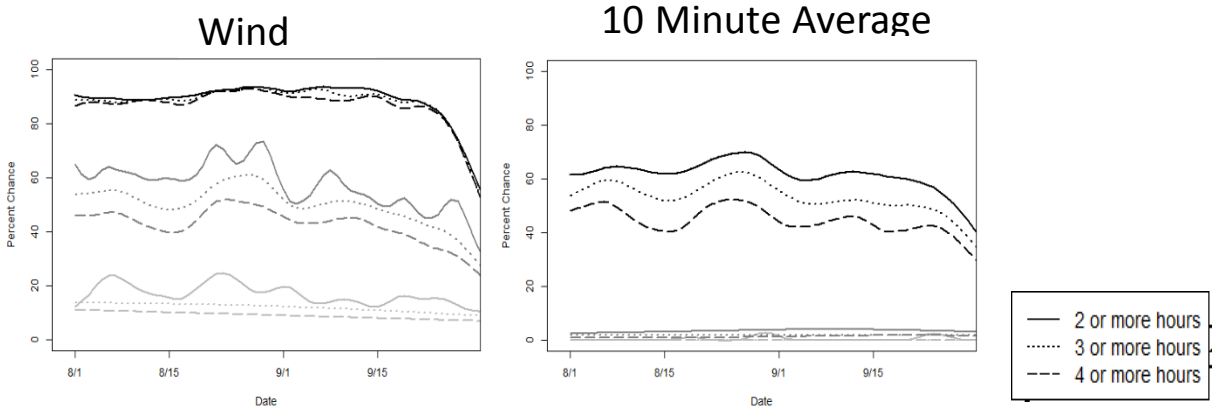


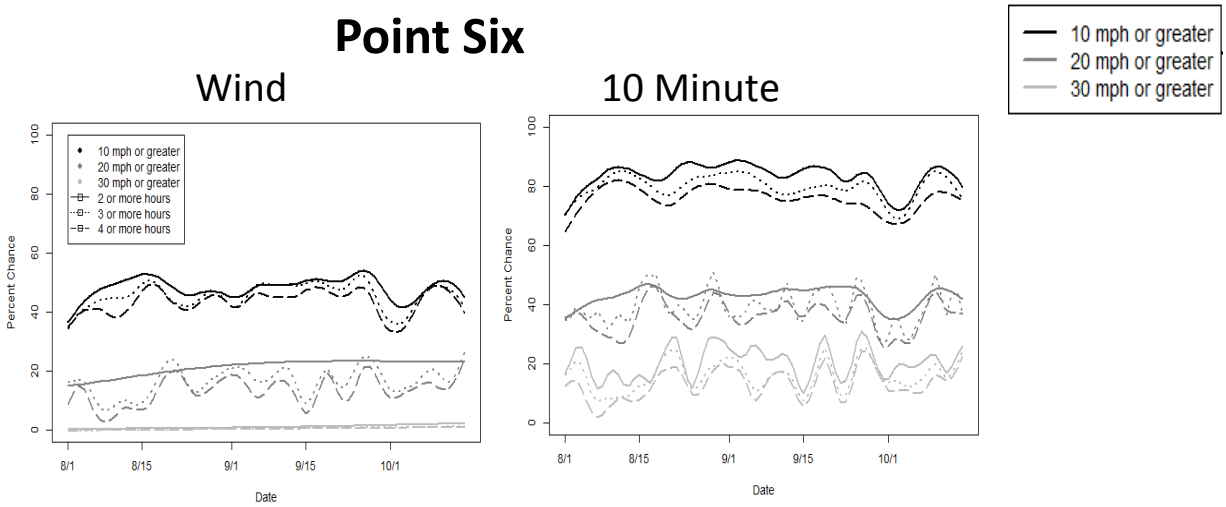
Figure 16 - Eastern Montana/North Dakota - Wind Analysis of 2 Representative RAWS stations. Daily probability of 10-minute average winds and wind gusts at or greater than 10, 20, and 30 mph over a period of 2, 3, and 4 hours.

Western Montana / Northern

Spotted Bear



Point Six



Roundtop

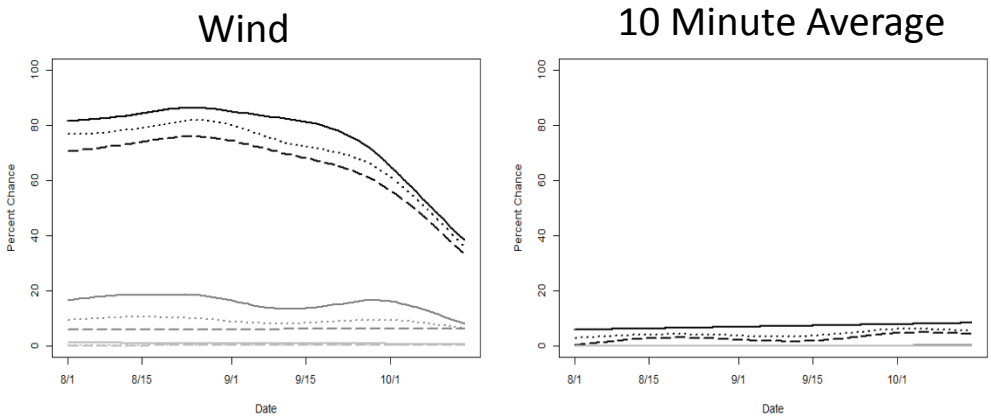


Figure 17 - Western Montana/Northern Idaho - Wind Analysis of 2 Representative RAWS stations. Daily probability of 10-minute average winds and wind gusts at or greater than 10, 20, and 30 mph over a period of 2, 3, and 4 hours.

Where are the critical locations based on values at risk and potential for large fire growth?

As the season continues, it will be difficult to identify critical locations as it is likely there will be times that the entire Geographic Area is experiencing severe fire weather conditions. Much of the potential will be based on fire start locations.

Fuels and Fire Behavior: Western Montana and Northern Idaho

The western portions of the region have a mix of open and closed canopy forests of Douglas fir, mountain hemlock, Ponderosa pine, western hemlock, Engelmann spruce, and lodgepole pine. These heavily wooded areas are intermixed with wet and dry open meadows.

Fire in these fuels are burning through heavy dead and down materials, spreading to ladder fuels and torching trees, with ember wash starting spot fires up to ½ mile from the ignition source. Crown runs are possible in windy conditions. As of early August fire was retarded on north slopes and at elevations where live fuel moistures are high. It is expected that this fire behavior will increase as conditions remain hot and dry and fuels begin to cure.

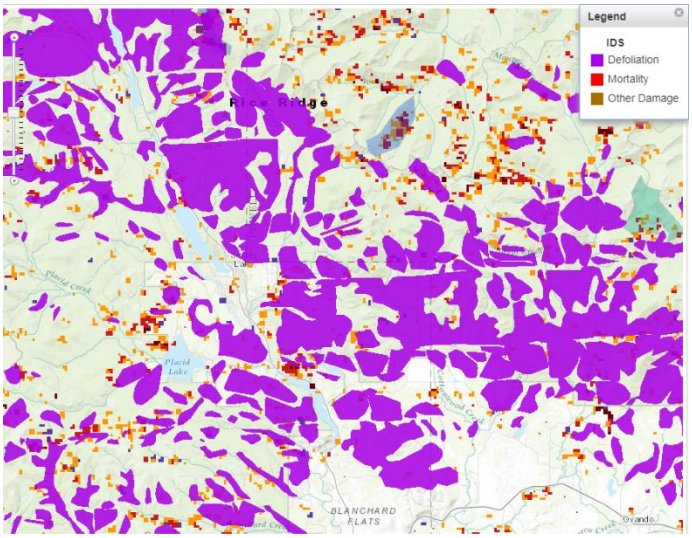


Figure 18 – Screenshot from USFS Forest Disturbance Monitor, focused on Seeley Lake and Rice Ridge Fire.

Forest disturbances from beetle kill ("bugkill") and other vectors are profuse throughout western Montana and Northern Idaho. Fire behavior changes should be expected in these areas, especially with the extended dry conditions. Recent bug killed areas will see little change in fire behavior but if the needles are red and fuel moistures are low one can expect torching trees and spotting. Gray standing trees with branches will burn readily but will be typically exhibit a slow to moderate rate of spread. Standing dead snags will see slow spread or will for the most part be ground-fuel dependent; some snags will ignite and loft embers to perpetuate fire growth. Landscape and local-scale evaluation of changing fuel risks is available at USFS Forest Disturbance Monitor (see Fig 18 and https://foresthealth.fs.usda.gov/FDM). This tool allows fire managers to export geo-referenced PDFs of forest disturbances to better prepare for potential changes in fire behavior.

Fuels and Fire Behavior: Eastern Montana and North Dakota

The eastern portion of the region is dominated primarily by prairies and grasslands. These areas are very dry due to drought conditions and will see fast moving, wind-driven fire spread. Moisture through frontal passages will dampen the fire behavior for short periods, but warm and windy weather will bring burning conditions back within a short timeframe. While fuels will likely remain available to fire spread throughout August and into September, these finer fuels respond more quickly in the fall to increased humidity as the days cool and burning periods are shorter. Typically, the season-slowing and ending events appear earlier in the east and move westward as fall conditions arrive.

Monitoring the Severe Fire Weather Potential, warnings for lighting and critical conditions will be important. Potential for large fire growth exists in any areas with high, very high or extreme indices. Priorities will need to be set based on values at risk and managing exposure of firefighters during the long term. Capitalizing on previous fire history for managing the fires will be critical in managing firefighter exposure and limited resources.

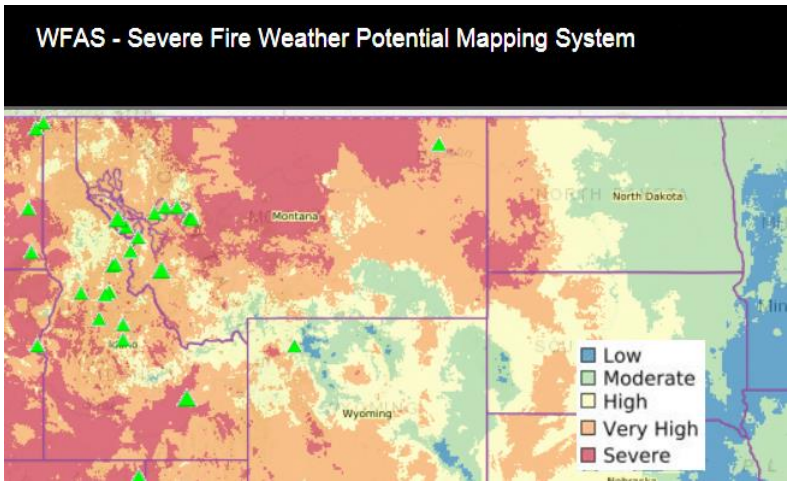


Figure 19 - Severe Fire Weather Potential Mapping System.

Another key tool to monitor is the Northern Rockies Fire Danger Portal (Fig 20) that can be monitored in near real time on the Story map associated with this document as well as on the Fire Behavior Outlook page on the NRCC website. PSA's can be selected to obtain the fire danger graphs and the fire danger indicator which represents the ERC graph in a simple linear format.

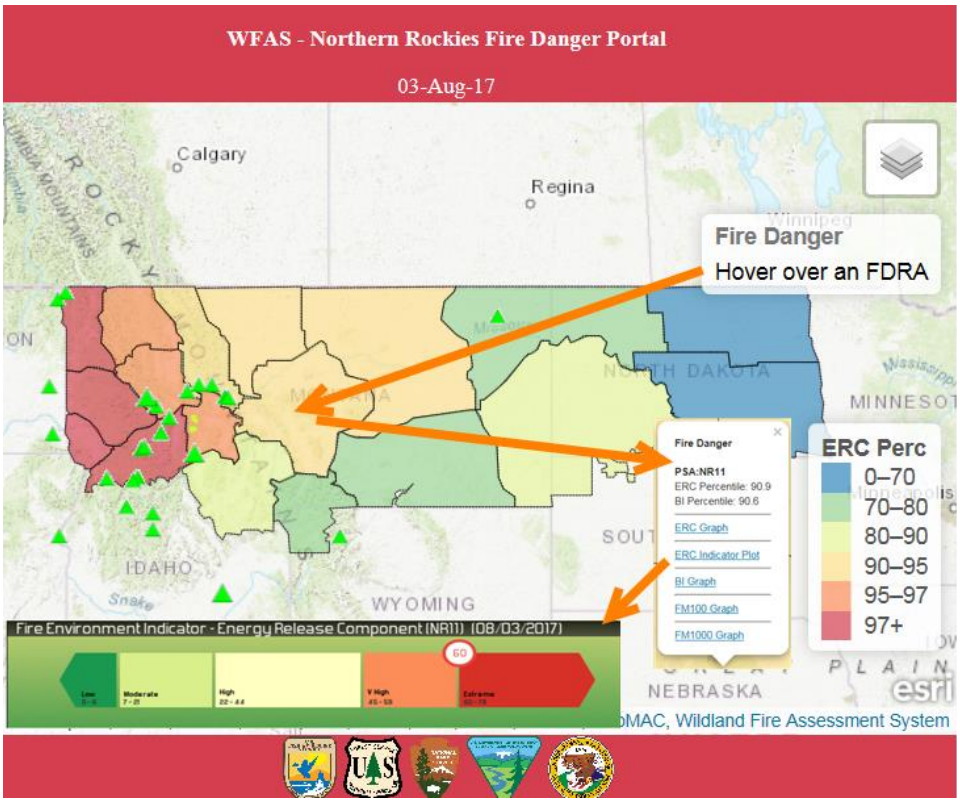


Figure 20 - Northern Rockies Fire Danger Portal

Possible Future Situations and Implications

What is the probability of an above average fire season and what are the anticipated impacts?

The weather outlook and current conditions indicate that the season will extend and the Northern Rockies Geographic Area will continue to experience large fire growth, potentially setting new records for acres burned. Impacts to communities, road corridors, and firefighting resources can be expected based on fire activity and smoky conditions.

Weather Outlook - August

A persistent period of weak flow with high-Haines environments are presently expected to characterize the fire-weather pattern for the early to middle parts of August. During August 5-10, multiple disorganized disturbances will gradually weaken the persistent mid-level ridging over the western United States. These disturbances will locally enhance thunderstorm potential, with lightning strikes outside of primary rain cores posing a risk for new ignitions given high ERCs and additional fuel drying related to the hot and dry surface conditions beneath the antecedent ridge. The better chance for thunderstorms may tend to focus across southern parts of the northern Rockies from disturbances crossing the Pacific Northwest and then developing toward the central Great Basin. However, a widespread ridge-breakdown event appears unlikely, with the related purely dry-thunderstorm risk somewhat limited and isolated. A general mix of dry and wet thunderstorms is expected with no widespread wetting rains expected. Terrain enhanced flows and weaker backdoor cold fronts may locally promote fire spread, though confidence in any large-scale strong wind events is currently low. Regardless, high-Haines scenarios with hot and dry surface conditions may enhance overall fire potential.

Going into mid-August, specifically August 11-15, there may be a brief lull in the overall thunderstorm potential as mid-level ridging reestablishes in the wake of the aforementioned waves. Continued high-Haines environments with perhaps a few wet storms may occur, but the overall strong wind and/or dry thunderstorm potential appear to have limited confidence in occurrence.

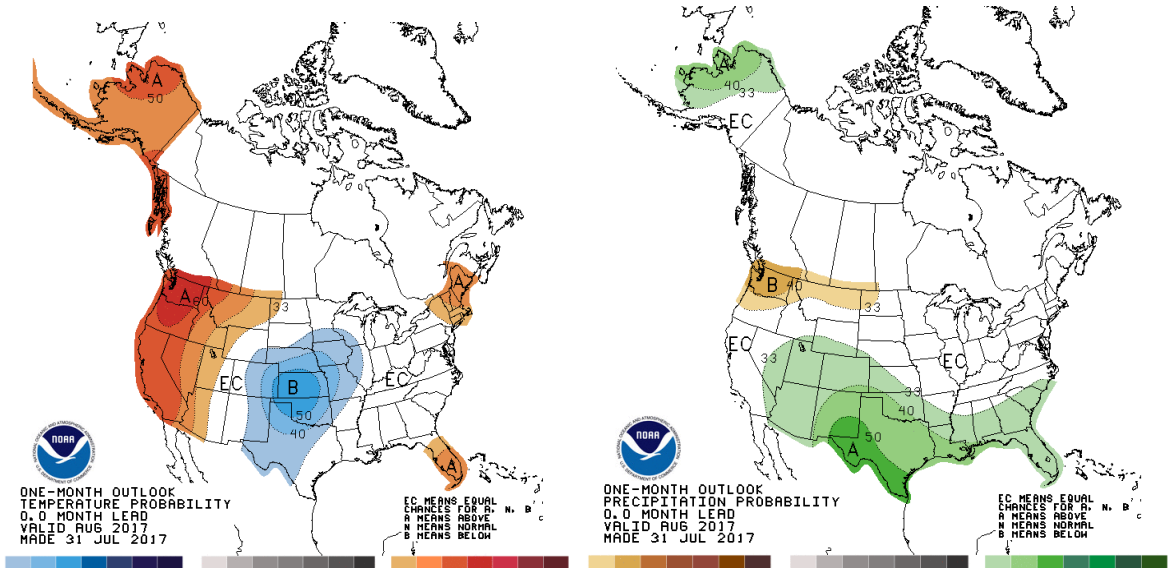


Figure 21 - One-Month Temperature and Precipitation Outlook *http://www.cpc.ncep.noaa.gov*

Going into latter parts of mid-August, a more active period may evolve during August 16-20, as extended range guidance indicates trough amplification off the Pacific Coast from Alaska to British Columbia and Pacific Northwest. A series of shortwave troughs -- which may trigger localized convection and thunderstorms -- may move across those areas and the northern Rockies, accompanied by episodic dry cold-frontal passages. Initially, as ascent spreads across resident monsoon-related moisture, dry thunderstorm potential may increase, with ignitions possible. Ignitions and fire spread would be exacerbated as winds increase and shift directions with dry cold-frontal passages as disturbances cross the area. With time, the influx of drier conditions will tend to limit the thunderstorm potential, but strong winds and wind-driven fires may be a concern. While confidence in these details are inherently low, this looks like a more active period.

Through the end of August, additional dry cold-frontal passages appear supported by model guidance as the overall pattern becomes more progressive. However, temperatures may trend cooler as individual disturbances lower heights aloft and move (advect) cooler air in the low levels, amidst a potentially short-wavelength pattern. Despite periodic episodes of strong winds, the general cooling trend and shallower vertical mixing could lessen fire-weather risk, though overall confidence is low. With dry fuels, these strong-wind episodes have the potential to increase spread rates, though eventually the boundary layer may become cool enough by the end of August to slow growth of large and emerging fires.

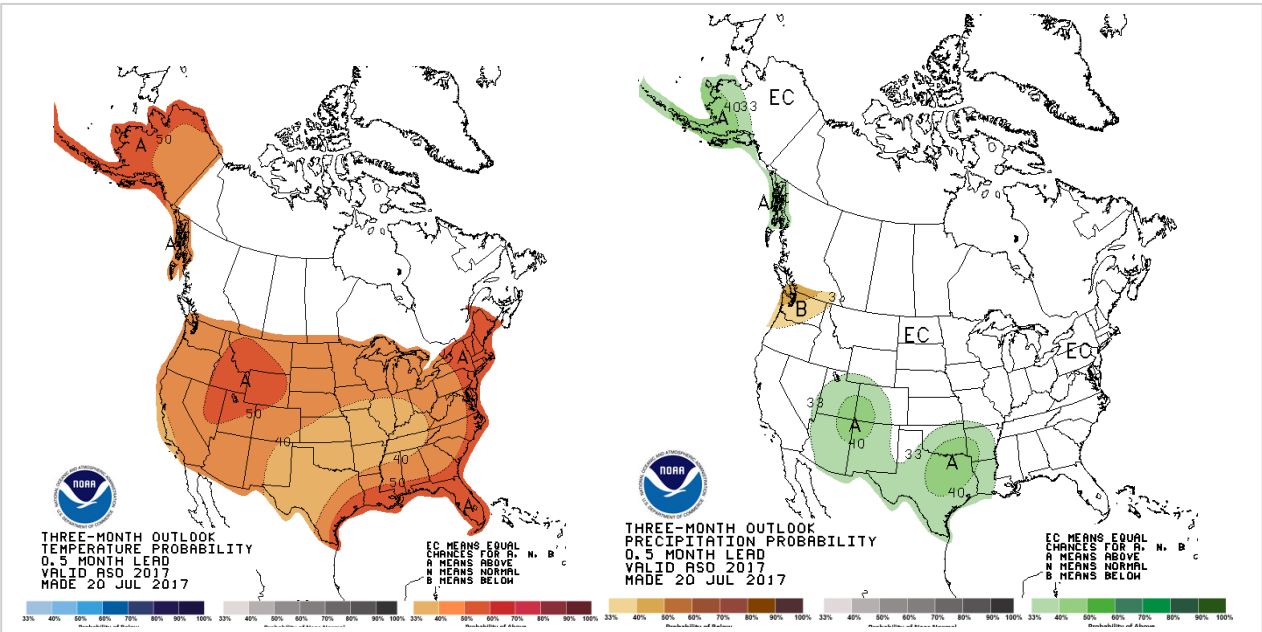


Figure 22- Three-Month Temperature and Precipitation Outlook *http://www.cpc.ncep.noaa.gov*

Longer Term

Longer term models do not indicate anomalous wet/dry conditions into September and through Fall with any sort of confidence for the northern Rockies. However, most long term guidance (models and CPC) are trending towards above average temperatures through September and possibly through Fall. This would indicate the possibility of an extended fire season before any season ending precipitation and cold air event occurs. Drought should continue to persist in eastern and northwest Montana and could expand if the above average temperatures persist with below to near normal precipitation. Thus 100 and 1000-hour fuels will continue to remain at elevated to critical levels and be receptive to ignition and fire spread through August and into September. New and existing large fire activity normally

declines rapidly during September and October. However, while critical fire weather conditions may subside (lower temperatures due to shortening of daylight and eventual transition back to an active polar jet stream across the CONUS), containment and control of large fires may be delayed due to projected above-average temperatures and the possibility of delayed season-ending precipitation event.

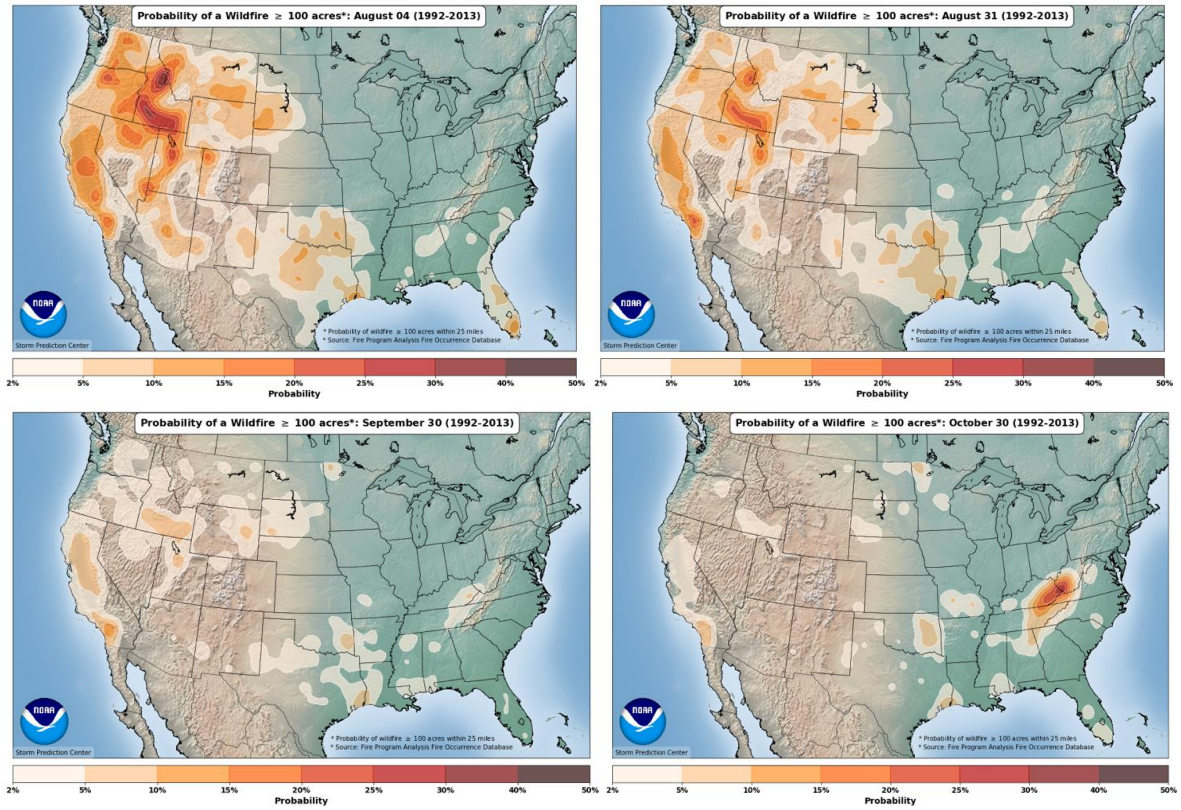


Figure 23 - Probability of Wildfires August-September http://www.spc/noaa.gov/new/FWclimo/climo.php?parm=100ac

Highlights

- Mid-August (specifically August 16-20) may be a period for substantial uptick in the fire-weather risk with thunderstorms followed by dry cold fronts
- No "season ending" precipitation event is expected in August. Guidance indicates persistence of current conditions to worsening fire weather conditions through mid-August
- Longer term model and CPC guidance indicate above average temperatures could continue into the Fall thus extending the fire season and active burning on large wildfires through September and into October

Disclaimer: Confidence in the aforementioned forecast details decrease going forward through the forecast periods.

Analysis of Season Ending Events

Assessing the history of season ending events provides an understanding of the fire season length based when fires no longer spread more than one burning period. Geospatial analysis was completed using a criteria of ERCs dropping below 60% and not recovering for 3 weeks. Figure 24 represents probabilities with corresponding dates of September 1, September 15, October 1, and October 15.

Although it is expected that season slowing events will be seen during this timeframe, season ending events as described above do not occur routinely until October 1 and more reliably by mid-October. Previous analysis of rain fall of 0.5 inches over multiple days also indicated an October timeframe for 90th percentile probability of season end for most of the Geographic Area. For an animated progression of season ending events: https://drive.google.com/file/d/0B3PL_lCXywLUZmRzU1hzZTdvajg/preview.

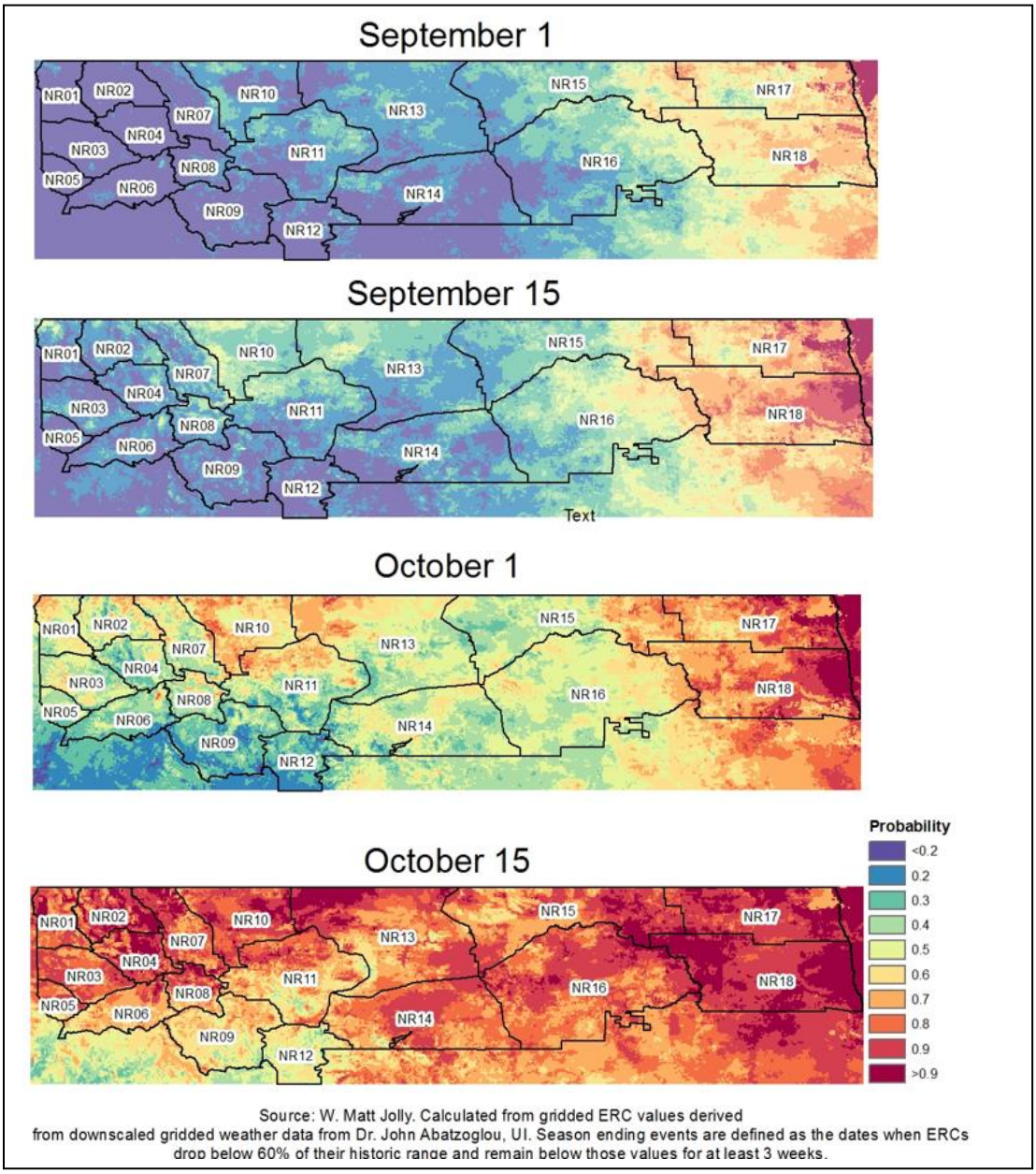


Figure 24 - Season Ending Event Probabilities

Research by Ann Hadlow examined the 90th percentile date for occurrence of a season slowing event (SSE) by extracting and analyzing data for 76 RAWS weather stations in Montana and Idaho (excluding North Dakota). SSE dates ranged from September 3 to November 28, with an average date of October 2 (Fig 25). Stations with significant autocorrelation for similar SSE dates were located in Montana near Anaconda, and along the Front and in central.

SSE was defined as more than 0.5 inches of precipitation that occurred over a 5-day period after August 11th.

Analysis indicates that "Season slowing events are occurring15 days later, on average, than they did in 1982, while summer rainfall is decreasing at 97% of stations, with clusters of significant change focused in the central Idaho mountains and in west-central Montana. The observed trends in precipitation paired with later season slowing events could result in more active fire seasons in the Northern Rockies and may explain some of the changes in fire season that have been previously attributed to earlier Spring snowmelt and warmer temperatures."

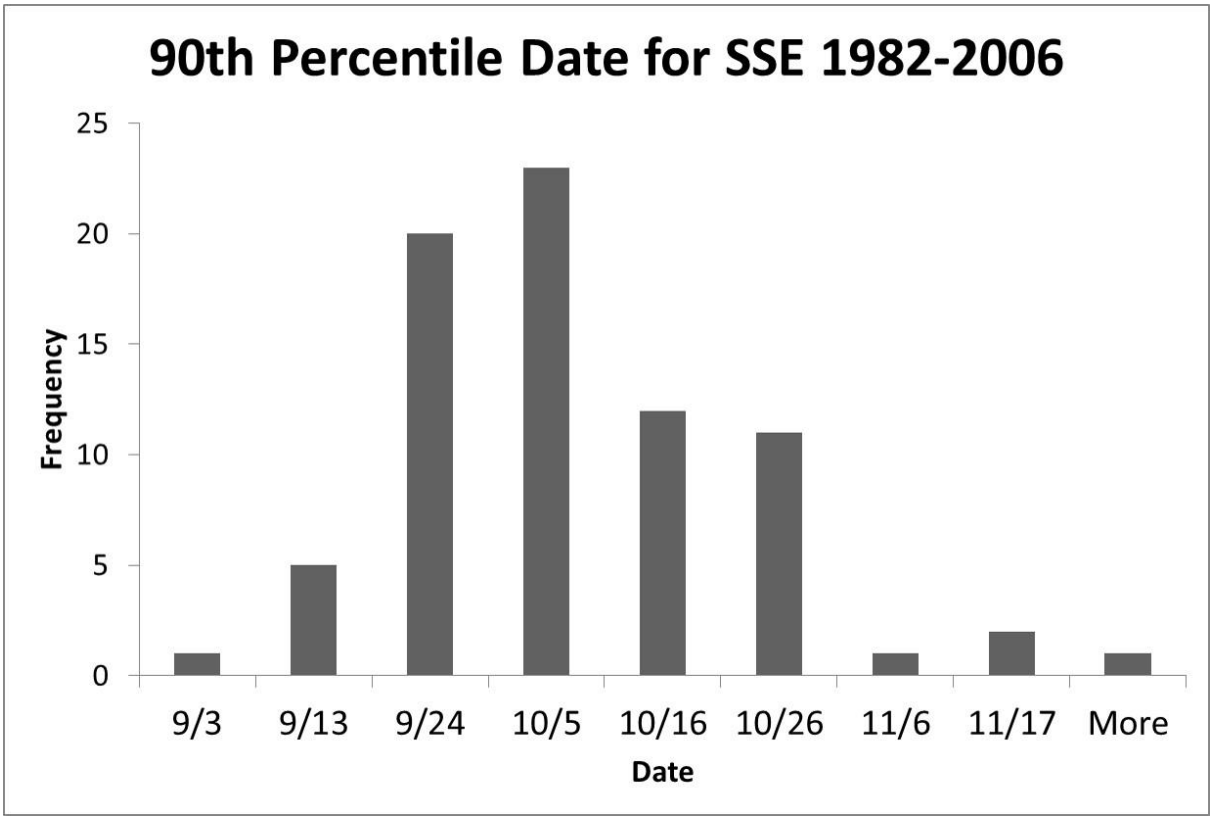


Figure 25 - 90th percentile for Season Slowing Event (SSE) for 76 RAWS stations in Montana and Idaho (excluding North Dakota).

Hadlow, Ann Marie, "CHANGES IN FIRE SEASON PRECIPITATION IN IDAHO AND MONTANA FROM 1982-2006 " (2009). University of Montana. *Theses, Dissertations, Professional Papers.* Paper 1282. http://scholarworks.umt.edu/etd/1282/

Summary and Findings

Three Scenarios – What we might prepare for

Based on current and expected weather, the Northern Rockies Geographic Area should prepare for a long and above average season. Expected weather patterns do not predict significant relief until fall patterns set up. Analyses regarding the seven key questions (prior sections), there are three potential scenarios to prepare for:

1. August Singularity – Mid- to Late August wet and cool period.
    - Least Likely. Based on current moisture deficit, fire frequency history, and meteorologists' outlooks.
2. Moderating Fire Activity – Humidity and fuel moisture moderate as the fire season transitions into longer nights and shorter burn periods. Thunderstorms are either wet or isolated.
    - Less Likely. Based on similar outlooks and analysis products listed above.
3. **Above Average Fire Activity** – Extreme fire spread potential resulting from dry cold fronts, no mitigation of fuel conditions, and potential for widespread dry lightning.
    - **Most Likely Scenario.** Supported by analogue years' analysis, fire history analysis, Energy Release Component (ERC) trends, and meteorologists' outlooks.

Northern Rockies Fire Season Assessment Team Members

The assessment team consisted of interagency specialists with various skills and experience in fire behavior, assessments, projections, and evaluation of the fire environment.

Bill Bunting	National Oceanic and Atmospheric Administration
Ariel Cohen	National Oceanic and Atmospheric Administration
Lisa Elenz	US Forest Service
Matt Jolly	US Forest Service
Chuck McHugh	US Forest Service
Nick Nauslar	National Oceanic and Atmospheric Administration
Bob Nester	National Weather Service
Erin Noonan-Wright	US Forest Service
Karin Riley	US Forest Service
Karen Short	US Forest Service
Ron Steffens	National Park Service

Thank you to all the individuals who provided input and expertise for this assessment.

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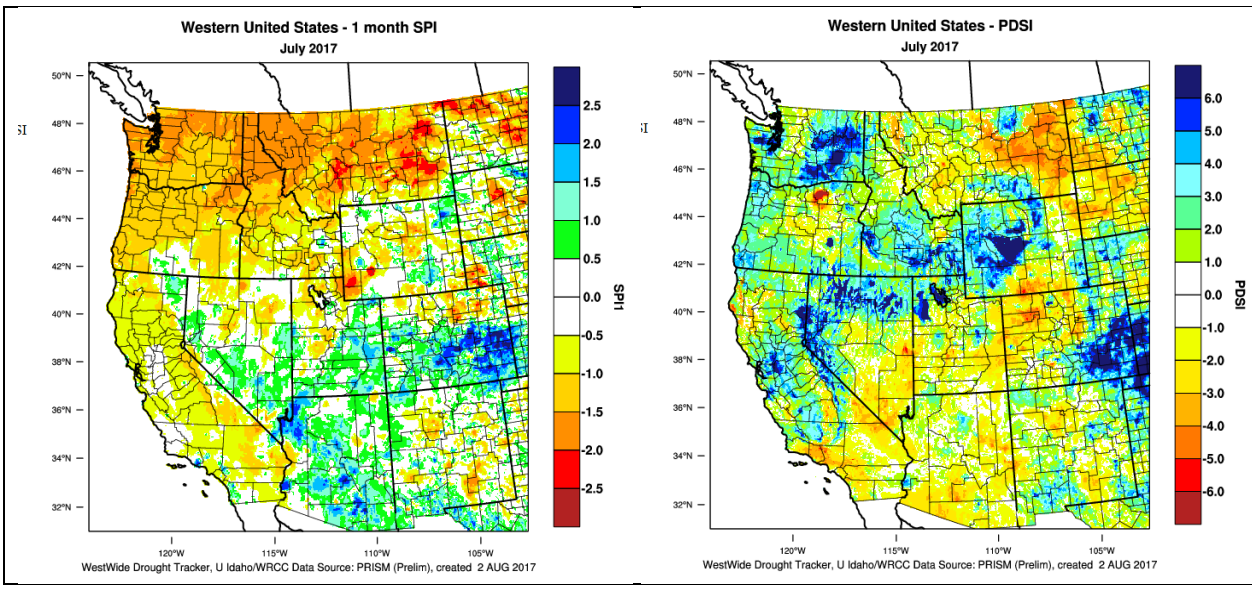
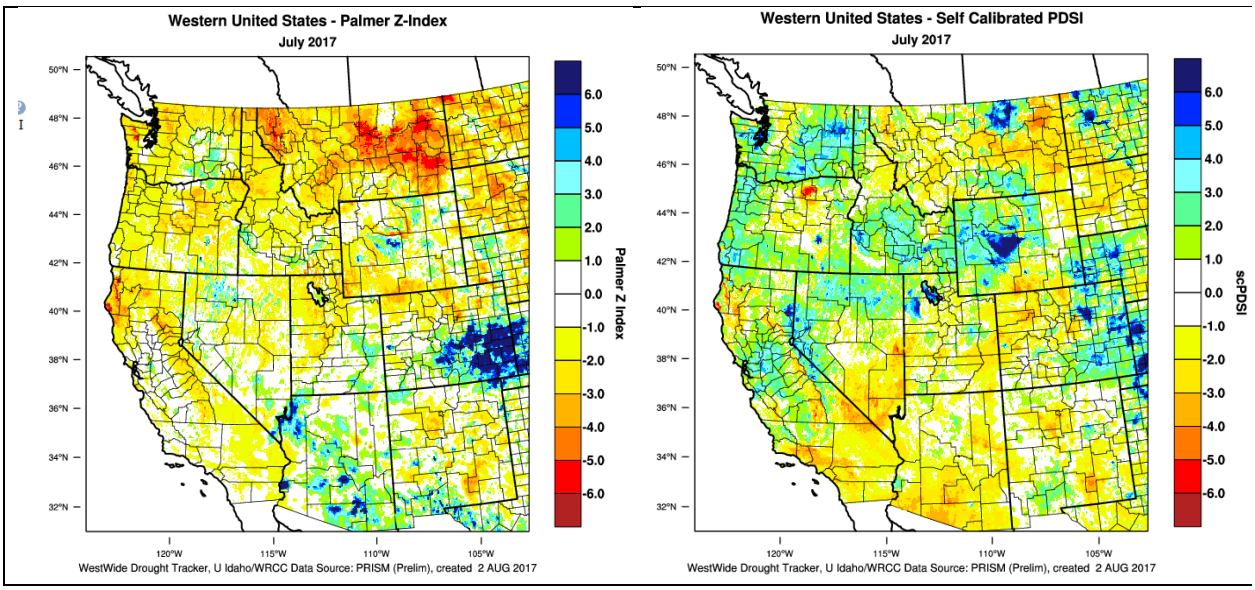
Vicente-Serrano, S. M., S. Beguería, and J. I. López-Moreno, 2010: A multiscalar drought index sensitive to global warming: the standardized precipitation evapotranspiration index. *J. Climate*, **23**, 1696-1718.

Riley, K.L., Abatzoglou, J.T., Grenfell, I.C., Klene, A.E. and F.A. Heinsch. The relationship of large fire occurrence with drought and fire danger indices in the western USA, 1984-2008: the role of temporal scale. *Intl J of Wildland Fire* 22: 894-909. http://dx.doi.org/10.1071/WF12149.

Appendices

Other Drought Metrics for July 2017 (for comparison above to the SPEI).





Wind Analysis

Appendix - Table 1. Weather stations selected for wind gust analysis and Predictive Services Area (PSA) in which they were located.

PSA code	PSA name	Wind station	Station duration
NR04	Western Montana	Point Six	Data to be updated
NR05	North Central Idaho and Bitterroot Mountain	Roundtop	1993-2017 (fire season only)
NR06	Glacier National Park and Wilderness	Spotted Bear LO	1999-2017 (year round since 2003)
NR12	Southern Plains Missouri Breaks	Fishtail	October 1992-current (year-round)
NR13	Northern Plains Missouri Breaks	Little Bullwacker Creek	1985-2017 (year-round)
NR16	Eastern North Dakota	Devil's Lake	1993-2017 (year-round)

At the representative weather stations used in this analysis, we found that the odds that at least one day during a month will have wind gusts in excess of 30 mph were high, ranging from a low of 46% in October at Roundtop weather station to a high of 100% at multiple stations in multiple months (Table 2). Odds were, of course, lower during two-week periods, ranging from a low of 17% at Roundtop weather station in the second half of October to a high of 100% at Fishtail weather station during multiple two-week periods.

Appendix - Table 2. Based on recent weather records, what are the chances of winds gusting to 30 mph or higher on at least one day during a month?

Weather station	Years in record	August	September	October
Roundtop	24	63%	63%	46%
Spotted Bear Lookout	26	100%	85%	Incomplete data
Little Bullwacker Creek	32	100%	100%	97%
Fishtail	24	100%	100%	100%
Devil's Lake	24	92%	96%	100%
Point Six		Data to be added		

Additional Notes on Wind Analysis

The Thompson Creek Fire of 2003 was examined for thresholds in wind gusts that caused extreme fire growth. The Thompson Creek Fire made a run on 8/19/2003, going from 7,530 acres to 17,410 acres (based on the GeoMAC perimeter data). It appears that the fire may have traveled as much as 10.7 miles on that day. The high temperature was 95 degrees Fahrenheit at the nearby Pardee weather station and winds gusted up to 39 mph at the Roundtop weather station. From this case study, a determination was made to use gusts of 30 mph or greater as a threshold for identifying days prone to extreme fire spread. Additionally days with 20 and 10 mph winds were examined.

Based on hourly wind records at the selected RAWS, the daily probability of winds was calculated at or greater than 10, 20, and 30 mph for durations at or greater than 2, 3, and 4 hours. These probabilities were calculated for both 10-minute average winds and wind gusts.

10-minute average winds are measured in the ten minutes prior to the weather being recorded and then averaged (for example, if the weather is recorded at 12:00, winds are measured from 11:50-12:00). Winds at a given station are likely to be different from the winds experienced on a fire, as winds can be quite variable across a landscape depending on topography, vegetation, and other factors. However, we expect that the winds measured at these exposed and/or ridgetop stations represent fairly well the frequency of wind speeds and durations that might be expected at exposed locations on the landscape. A spline function was applied to smooth the resulting curves.

This analysis is unlikely to capture occurrence of thunderstorm downdraft winds as they may be localized some distance from the weather station. However, three of these sites display a signature of potential cold-front passage as higher and longer period winds may occur as the front approaches and passes the weather station. Tracking wind gusts and shifts in wind direction (from southwest to southeast as the front approaches, and then clockwise to northwest as the front arrives and passes) can support early alerts for active fires. A weather station furthest to the west of the NRCC zones might be used to observe an approaching cold front prior to its impact on central and eastern zones, but time constraints prevented this analysis from being presented here.

Daily percent chance of wind gusts greater than or equal to 10 mph for a duration of 2 hours was as high as 100% at Fishtail RAWS. The chance of windy conditions declined as the fire season progressed at some stations, and increased at others. While the daily probability of wind gusts greater than 30 mph was low at some stations, fire managers might consider that if the daily chance is 3%/day over the

period of a week, the chance that windy conditions will occur on at least one day during the week is approximately 20%. At some stations, the daily chance of wind gusts in excess of 30 mph over a 2-hour period was as high as approximately 40%.

Chance of sustained winds at a given speed and duration was lower than chance of gusts for all five stations. At some stations, such as Roundtop, all estimated daily probabilities for 10-minute average winds were approximately 10% or lower. However, fires in this area have still experienced large daily growth, including the Thompson Fire of 2003, perhaps due to wind gusts. Daily chance of 10-minute average winds over a 2-hour period in excess of 10mph is near 70% at some stations such as Spotted Bear Lookout.

Of the stations, Little Bullwacker Creek Weather Station shows spikes in 20 mph winds in the third week of August and first week of September. Spotted Bear Weather Station shows three potential cold front passages between the third week of August and the early third of September. Fishtail Weather Station shows a different and more regular signature of wind spikes which may represent more local and regular wind events.

All sites except Roundtop Weather Station show a probability greater than 30% of 10 mph wind gusts into October. However, the 10 mph gusts may not be associated as clearly with active fire spread. Of the six sites, Fishtail, Spotted Bear and Point Six showed significant probability (40-60%) of 2-4 hour periods of 20+mph wind gusts, which may indicate a higher probability in such locations of active fire spread. As with other thresholds and watch-outs, these indicators should be adapted to local situations and watch-outs, these indicators should be adapted to local situations and observations, and adapted based on local knowledge and fire experience.