Long Term Risk Assessment for the Black Hills Complex

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Introduction

Two different storms started the Black Hills and Fish Lakes Fires on the Tetlin NWR. The Black Hills fire was started by lightning on July 16th. The Fish Lake Fire was first sighted on July 29th, probably resulting from lighting on July 21st. These two fires were authorized for Wildland Fire Use, and named the Black Hills Complex. The Black Hills fire was approximately 42,000 acres on August 18th making it the largest fire ever to burn on the Tetlin National Wildlife Refuge. Tetlin NWR and Wrangell St. Elias National Park and Preserve managers agreed to a joint Maximum Manageable Area of 998,857 acres (Figure 1). The fire crossed on to the Preserve on August 20, 2003. This document will summarize activities taken on the complex relative to fire behavior and the Fire Behavior Group, including an assessment of existing fuels, seasonal severity, observed burning conditions, and the probability of fire spread to various points of concern associated with individual fires.

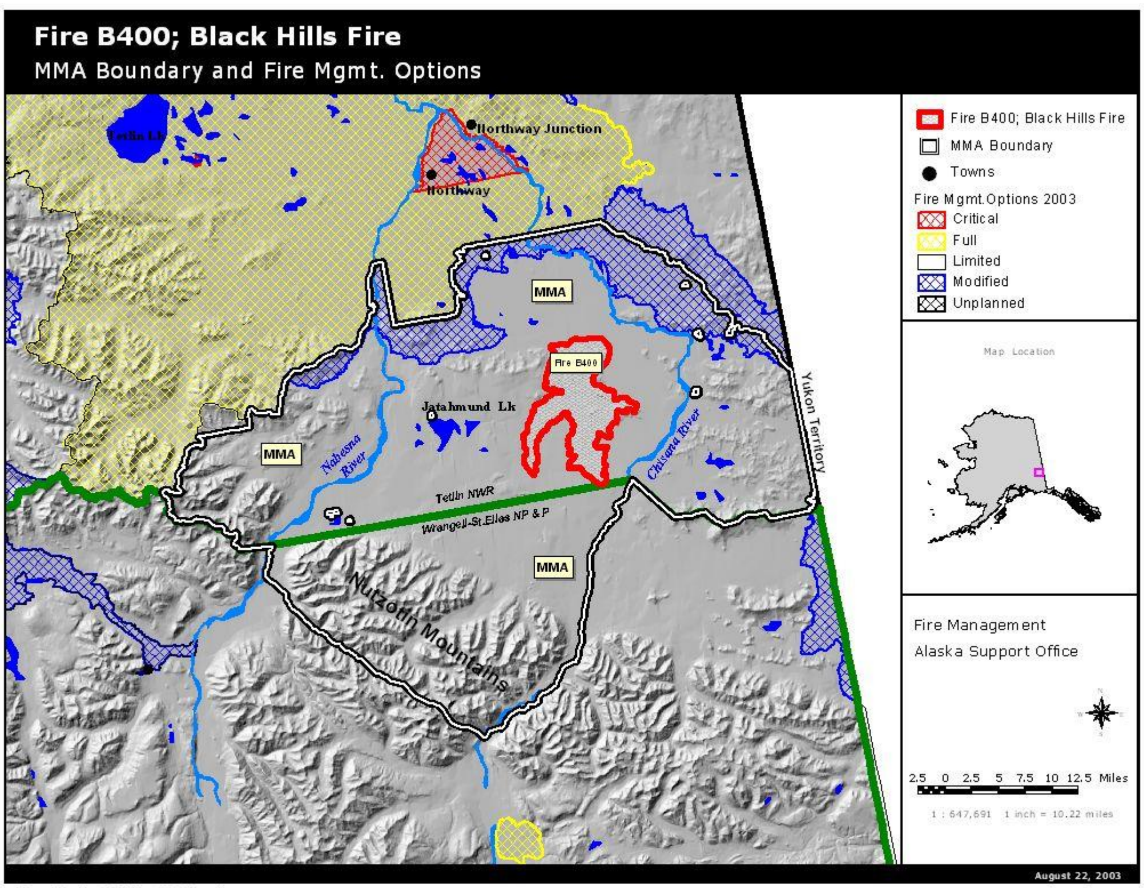


Figure 1 - Maximum Manageable Area for the Black Hills Complex

Seasonal Severity

Regional weather and drought indicators show that Interior Southeast Alaska is drier than normal (Figure 2). Canadian Forest Fire Weather Indices for the weather stations surrounding the fires are trending above average to extreme for the last couple of weeks.

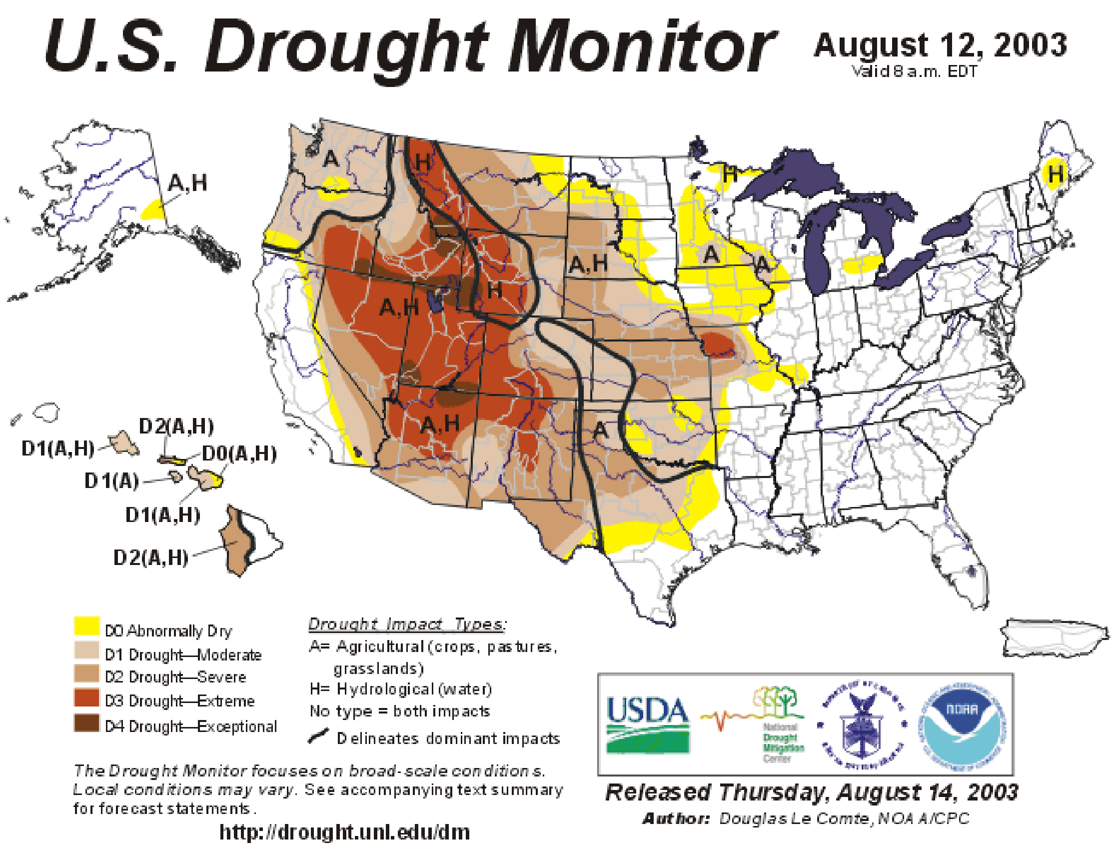


Figure 2 - Current Drought Monitor including Alaska

Canadian Forest Fire Weather Indices

The Canadian Forest Fire Weather Indices track the effect of temperature, rain fall, relative humidity and wind speed on forest fuels. Charts for The Drought Code (DC - Figure 3) and the Duff Moisture Code (DMC – Figure 4) at Northway weather station reflect medium and long term drying of Duff Layers. The Build Up Index (BUI - Figure 5) represents the total fuel available for combustion and seems to track fire activity fairly well. Drought Code, Duff Moisture Code and Build Up Index have all been near or setting new record maximums in late July and early August. Some care should be taken when applying this information on the landscape, as localized conditions vary based on physiographic characteristics, such as elevation and aspect. Precipitation at the Northway station has been below average from most of the fire season (Figure 6). Large fire spread events on August, 9, 10, 16 and 17 reflect these trends.

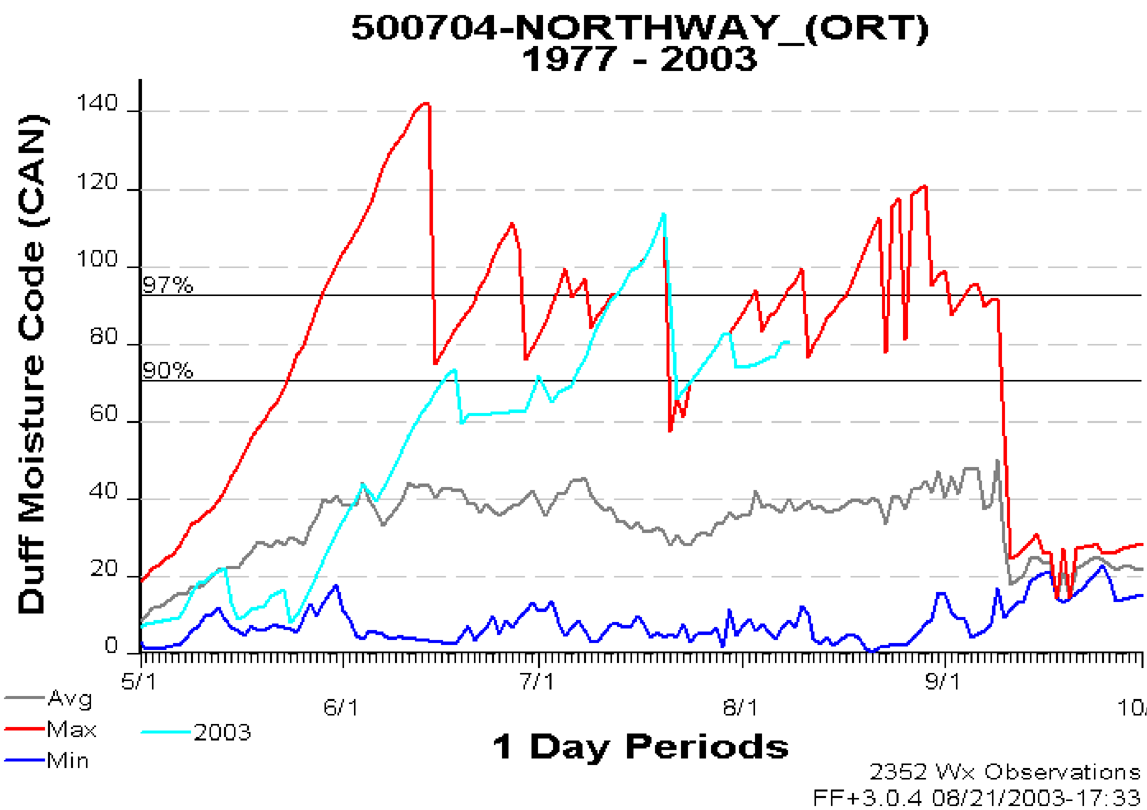


Figure 3 -Duff Moisture – Northway Weather Station

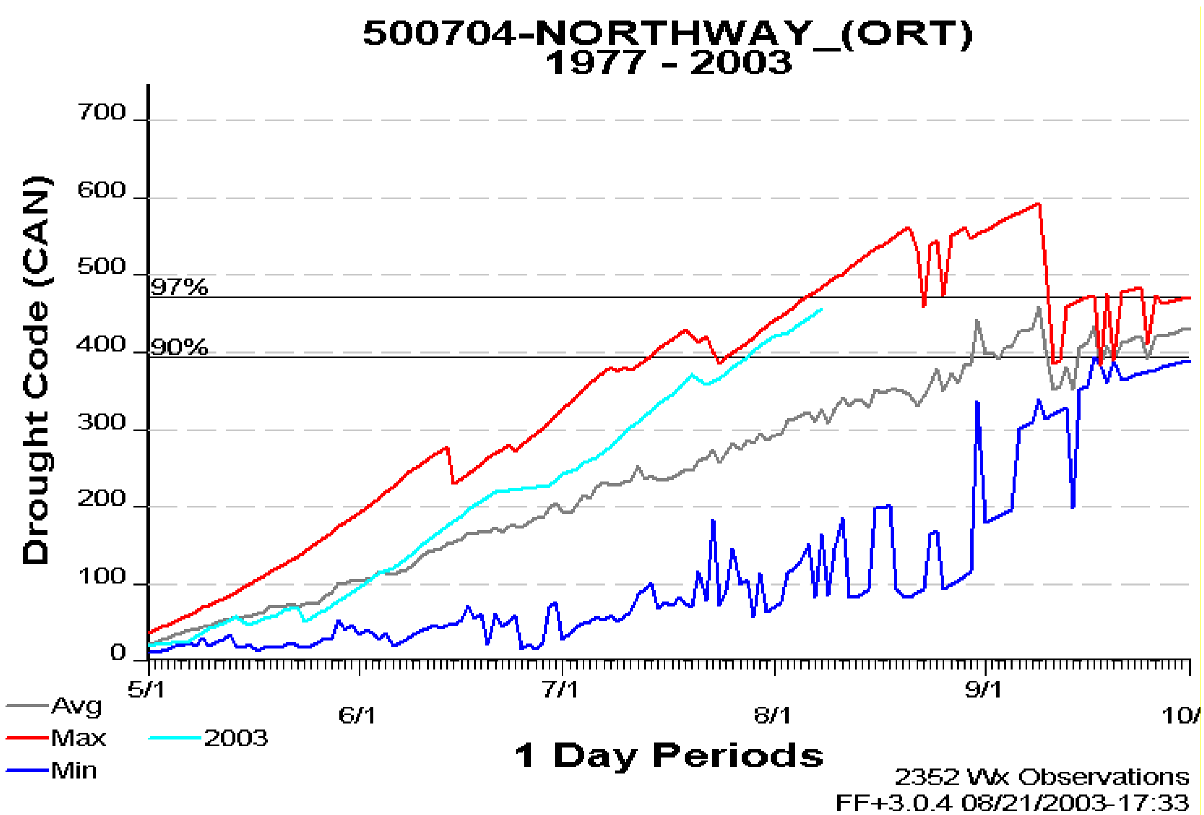


Figure 4 - Drought Code – Northway Weather Station

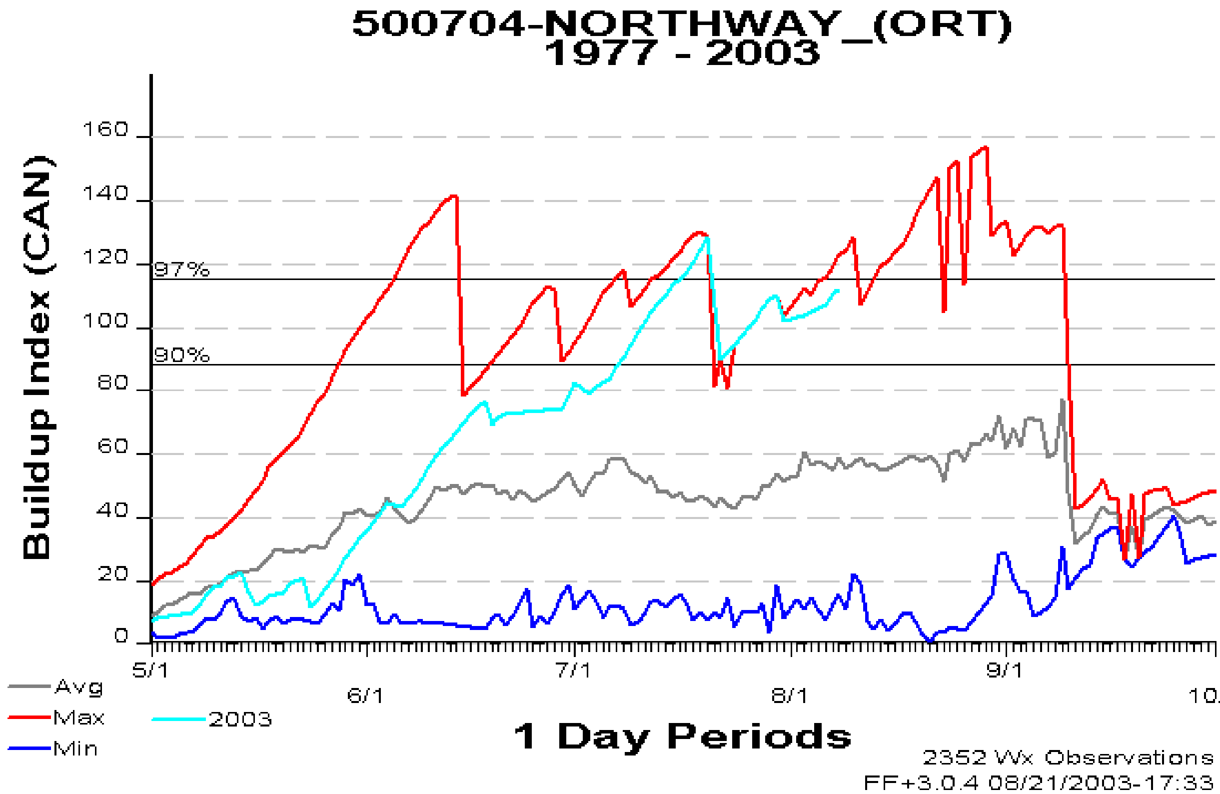


Figure 5 - Buildup Index – Northway Weather Station

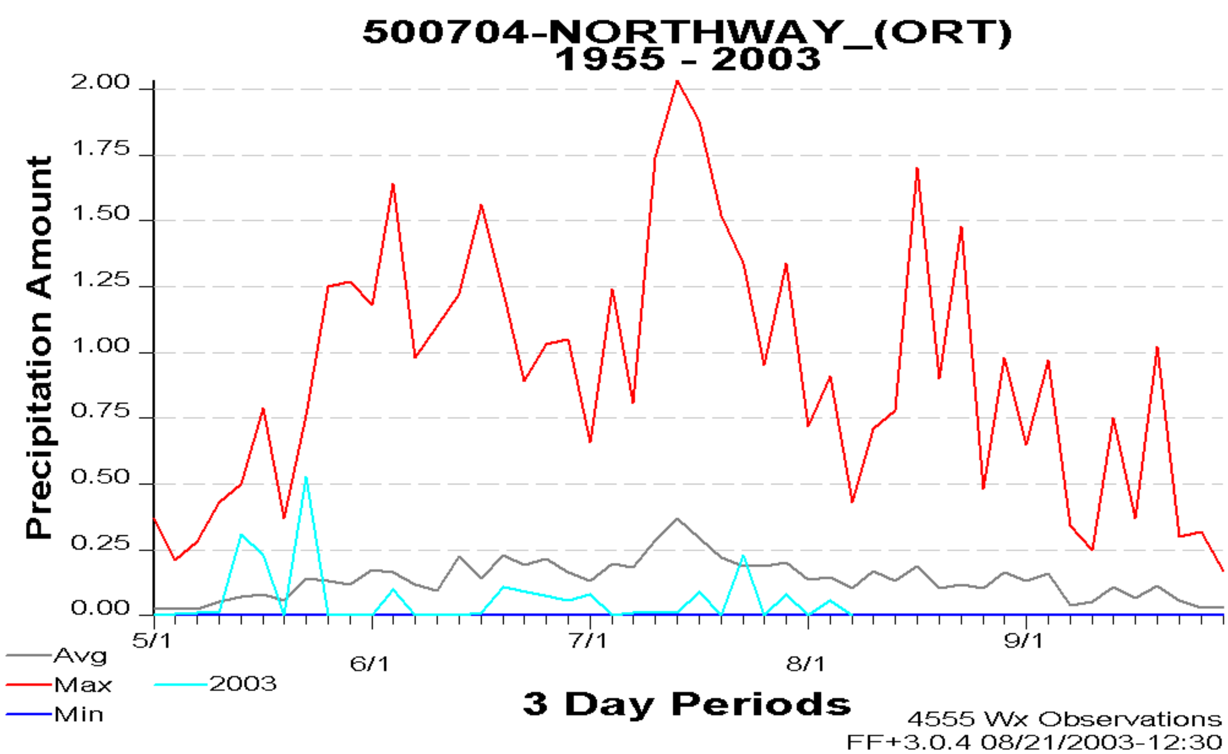


Figure 6 - Precipitation at the Northway Weather Station

Vegetative Greenness Imagery Analysis

Satellite observations can be used to assess vegetation greenness (Burgan and Hartford, 1993) and interpreted to assess relative fire danger. Relative Greenness and Departure from Average Greenness are most useful for this application. Greenness data are typically displayed as maps. Relative greenness maps represent how green the vegetation is compared to the range of greenness observed since 1989 when data of this type became available. Departure from Average Greenness maps are not currently available for Alaska. Greenness imagery was incomplete and the data was inconclusive in helping assess the fire situation at this time.

Fuel Moistures

The general area Fine Fuel Moisture Code (Figure 7), Duff Moisture Codes (Figure 3) and Drought Codes (Figure 4) are all relatively high, although an overall trend is harder to see in the Fine Fuel Moisture Code due to daily fluctuations.

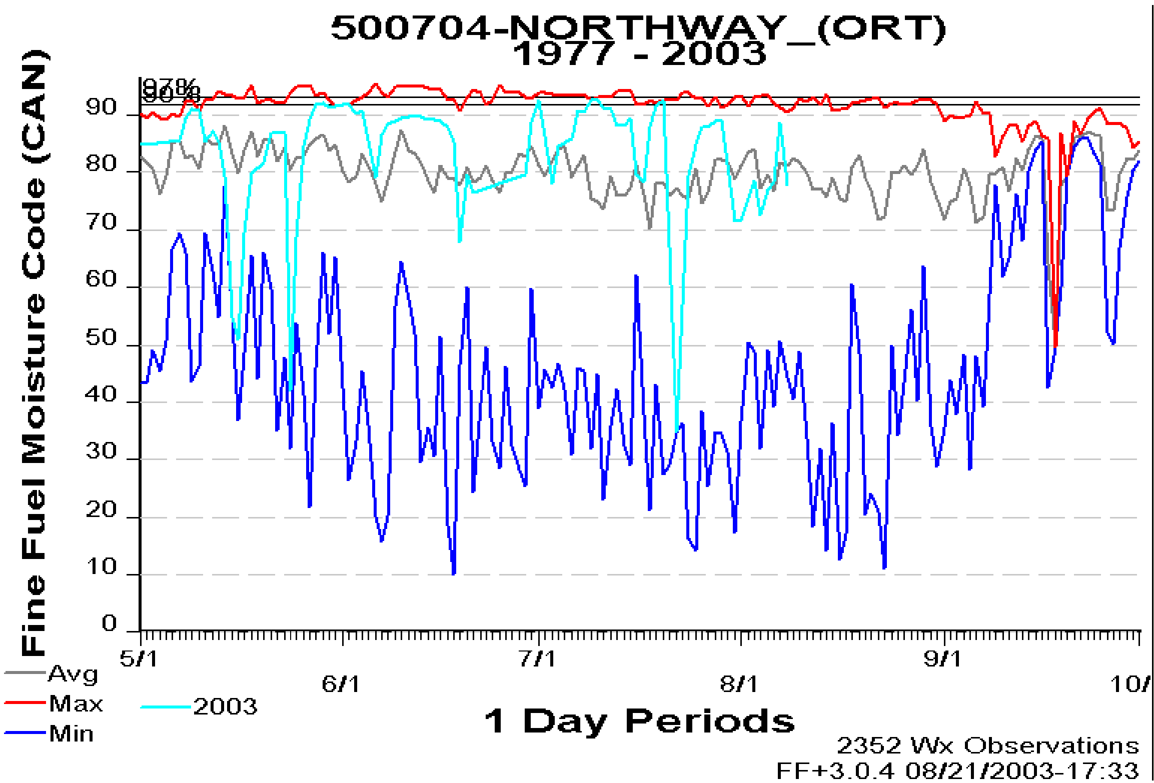


Figure 7 - Fine Fuel Moisture Code from Northway Weather Station

Fuels and Vegetation

A GIS landcover dataset from the Copper River Landcover Mapping Program was used to determine vegetation and fuel types in the vicinity of the fire. The landcover dataset was derived using Landsat Multi-Spectral Scanner (MSS) Imagery by the USGS EROS Data Center in 1984. A 1997 landcover layer of Wrangell St. Elias did not cover the area included in the MMA. Vegetation in the proximity of the fire can be loosely classified into 4 types. Closed Black Spruce Forest (CNF), Open Black Spruce Forest (ONF), Black Spruce Woodland (WNF) and Dwarf Shrub Sedge Bog (DSSB). Nearly all of the vegetation within the perimeter of the Black Hills fire was classified as either Woodland Needleleaf Forest (76%), Dwarf Shrub – Sedge Bog (11%), Open Needleleaf Forest

(9%), or Closed Needleleaf Forest (3%). Black Spruce Woodland dominates the MMA with small patches of Closed and Open Black Spruce Forest and Dwarf Shrub Sedge Bog intermingled.

Fuels Data

The vegetation and fire fuels data layer mentioned above was used to determine what fuels were on the different projection lines for Rare Events Risk Analysis (RERAP). Using the Alaska Handy Dandy, Tetlin NWR Fire Management Plan and local knowledge the vegetation types were used as the fuel models and shadings found in Table 1. Wind Sheltering and Shading are for flat ground only and were adjusted accordingly for slope and aspect. These do not necessarily reflect the true stand conditions, but made the BEHAVE model give Rate of Spread (ROS) outputs that reflected observed fire spread rates in these types.

Table 1 – Vegetation and Fuel Models used in BEHAVE

Vegetation Code	NFFL Fuel Model	Wind Sheltering	Shading	Notes
CNF	9	Partial	Unshaded	
ONF and WNF	9	Unsheltered	Unshaded	
DSSG	6	Unsheltered	Unshaded	
Water or Sparse Vegetation	1	Unsheltered	Unshaded	No spread except at Extreme Conditions

Fire History

The Tetlin and Wrangell St. Elias fire history databases have data starting in the 1950s with improved accuracy beginning in the 1970's. The management response to fires in this area over the years has ranged from full suppression to monitoring. The Black Hills fire has burned through a portion of the 1982 Kennebec fire, 31,430 acres (Figure 8). That fire was actively suppressed as a Type 1 Incident. This was the largest fire in Refuge history before the Black Hills Fire. The Fish Lake Fire is partially burning in an area burned in 1986. Historic fire spread patterns are generally to the South and East.

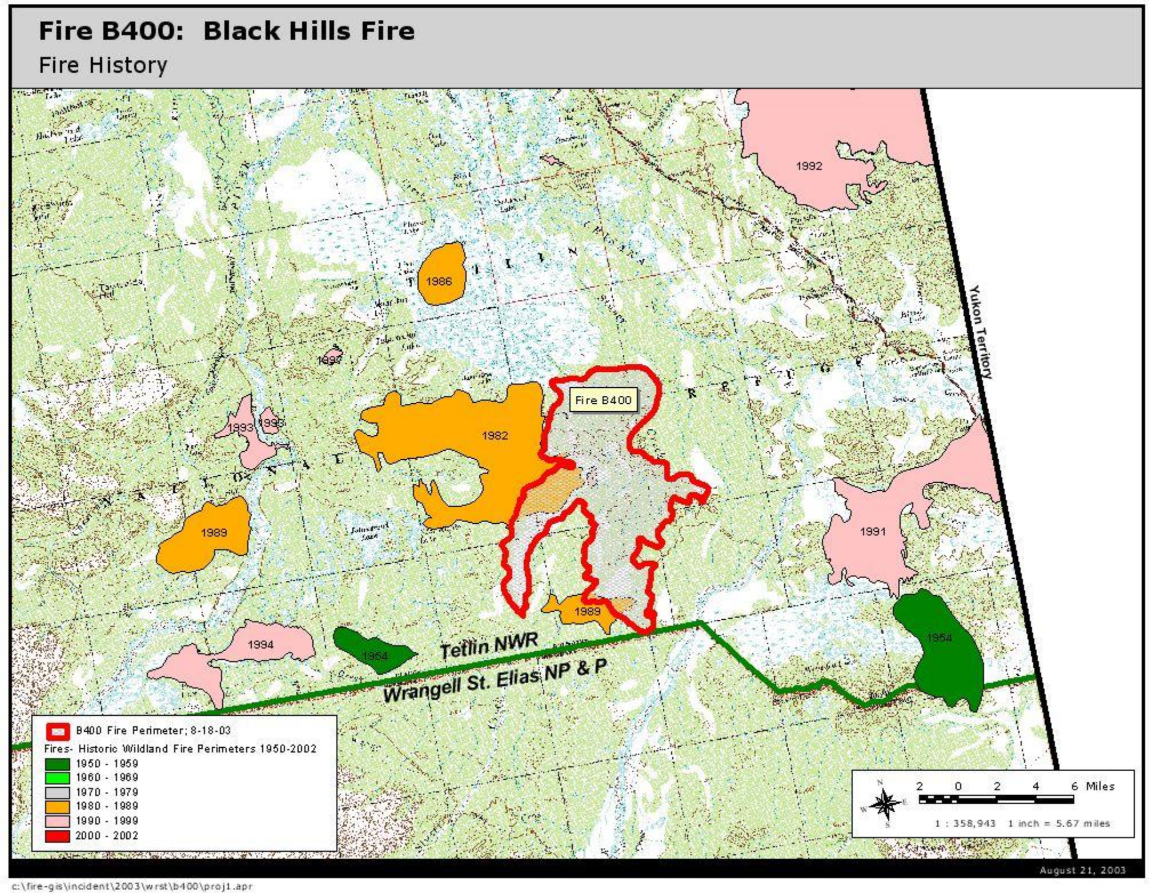


Figure 8 - Fire History of the general fire area

Fire occurrence data was available from KCFAST for both the refuge and the park. The refuge had data from 1980 to present, 42 fires. The park had data from 1955 to present, 78 fires. Both areas have had mostly small fires. Tetlin NWR has had more large fires than Wrangell St. Elias NPP (Figure 9 and 10). The largest fire at Wrangell St. Elias was 18,571 acres, Wilson Cam in 1981. At Wrangell St. Elias humans started the majority of fires. At Tetlin lightning started the majority of its fires.

The fire files from both the refuge and park were examined in relationship to a number of different indices, DMC, DC, BUI, Max Temp, Wind Speed and SC. The only significant relationship between fire and any of these variables was with maximum temperature. FireFamily+ associates all the acres from a fire with the start date. I believe with fires that are spreading over a period of weeks or even months that this is problematic because you are not looking at the indices on the large growth or spread days. It would be best to used the current association with fires only as an indicator of ability of fires to start, not necessarily as an indicator of ability to spread.

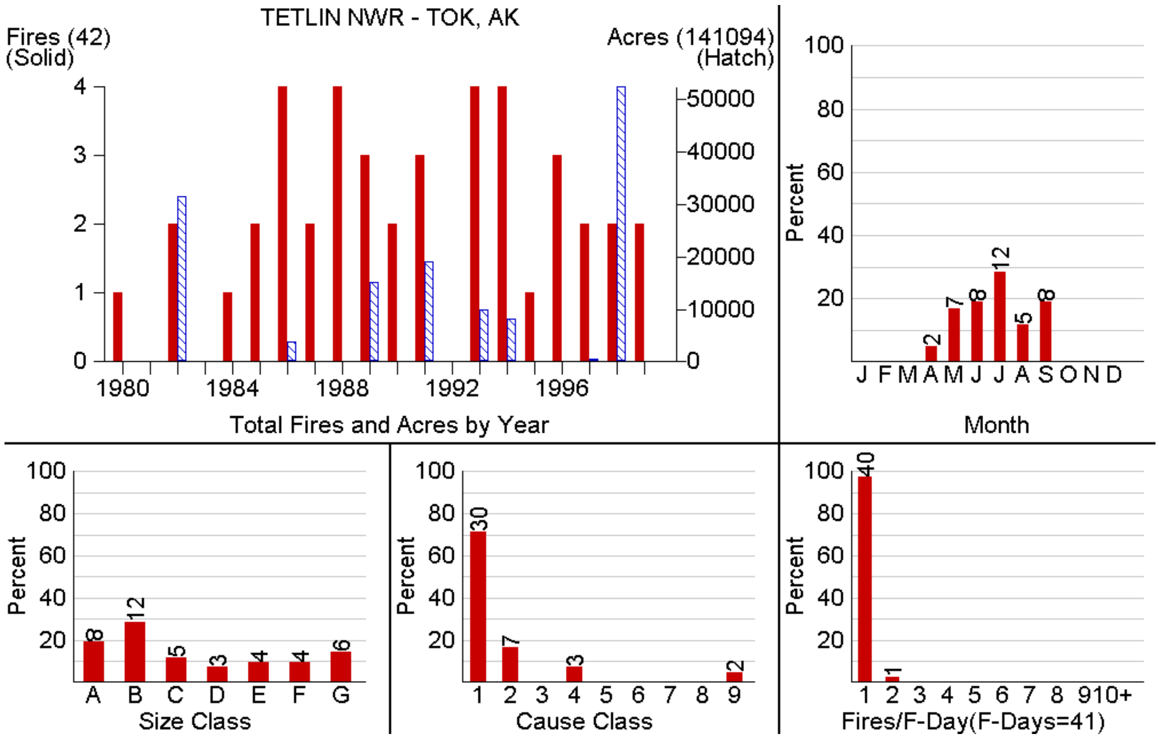


Figure 9 – Tetlin NWR Fire Summary from 1980-present

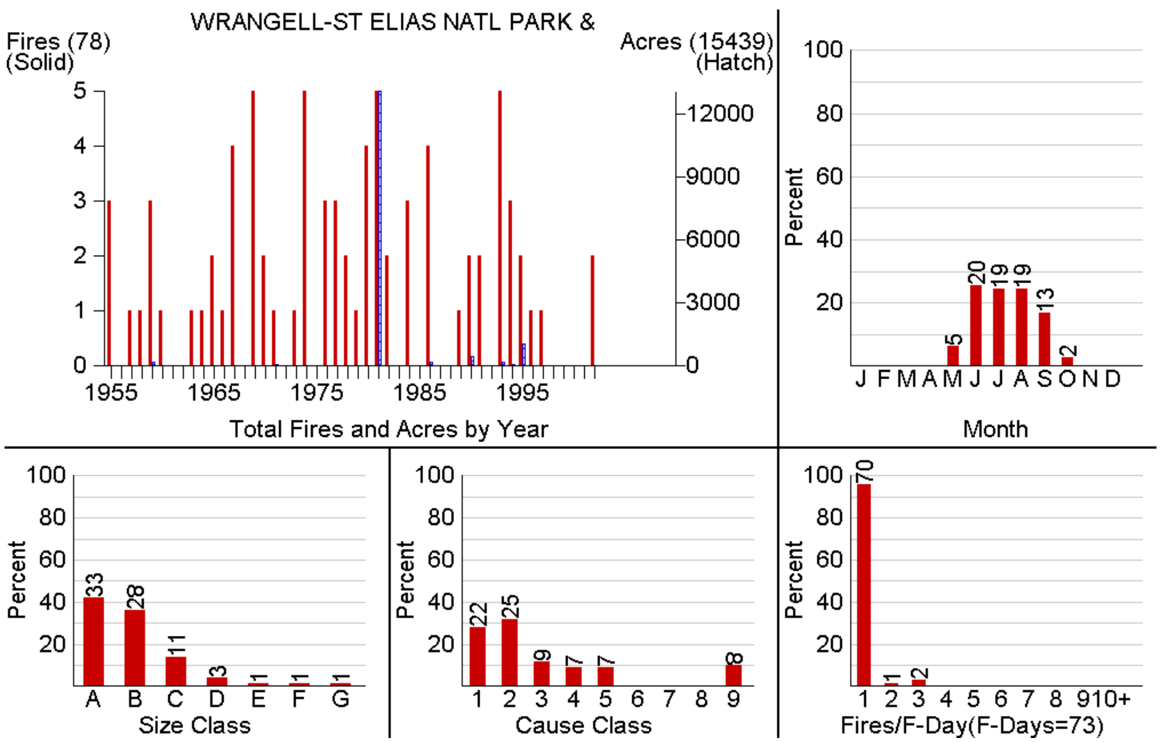


Figure 10 – Wrangell St. Elias NPP Fire Summary from 1955-present

Summary of Observed Weather and Fire Behavior

Lightning ignited all fires in the complex. The area is much drier than normal. Some moisture has fallen on west side of the fire on 18 August.

A generally normal spring and dry early and late summer have allowed the fire to spread and move up to a mile a day. The largest fire spread was over 3 miles per day occurring on three different occasions. Fire activity has generally increased the more days the area has gone without measurable precipitation. The Black Hills Fire has increased in size as shown in Table 2.

Date	Acreage	Growth (acres)
7/18/03	31	31
7/19/03	550	519
7/22/03	7,011	6,461
7/28/03	7,260	249
8/1/03	8,025	765
8/5/03	8,040	15
8/13/03	28,000	19,960
8/15/03	32,072	4,072
8/17/03	38,000	5,928
8/18/03	41,500	3,500
8/24/03	42,800	1,300
8/26/03	42,600	0

Table 2. Black Hills Fire Growth

The Fish Lake fire has been limited in growth because of lakes, sparse fuels, or limited available fuels and the recent burn. High temperatures on the Black Hills Fire have generally been in the upper 70’s to low 80’s since the fire began. Low relative humidities have been in the upper 20’s to mid 40’s. Winds have been variable in direction and speed throughout the period and generally light (2-5 mph). Winds during the larger acreage gains were from 12-19 mph from the northeast, northwest and west.

Fire spread has generally been by head fires, with a little backing observed in the spruce and bog areas due to the dryness of the fuels. Large fire growth days were associated with moderate wind speeds, generally 5-10 mph. Spotting of up to a mile in front of the fire has been observed.

Since rain showers around the starting on August 18, the fire has exhibited very little growth (less than 1,300 acres). But small head fire runs have been observed with predominate winds if there was active fire in the area.

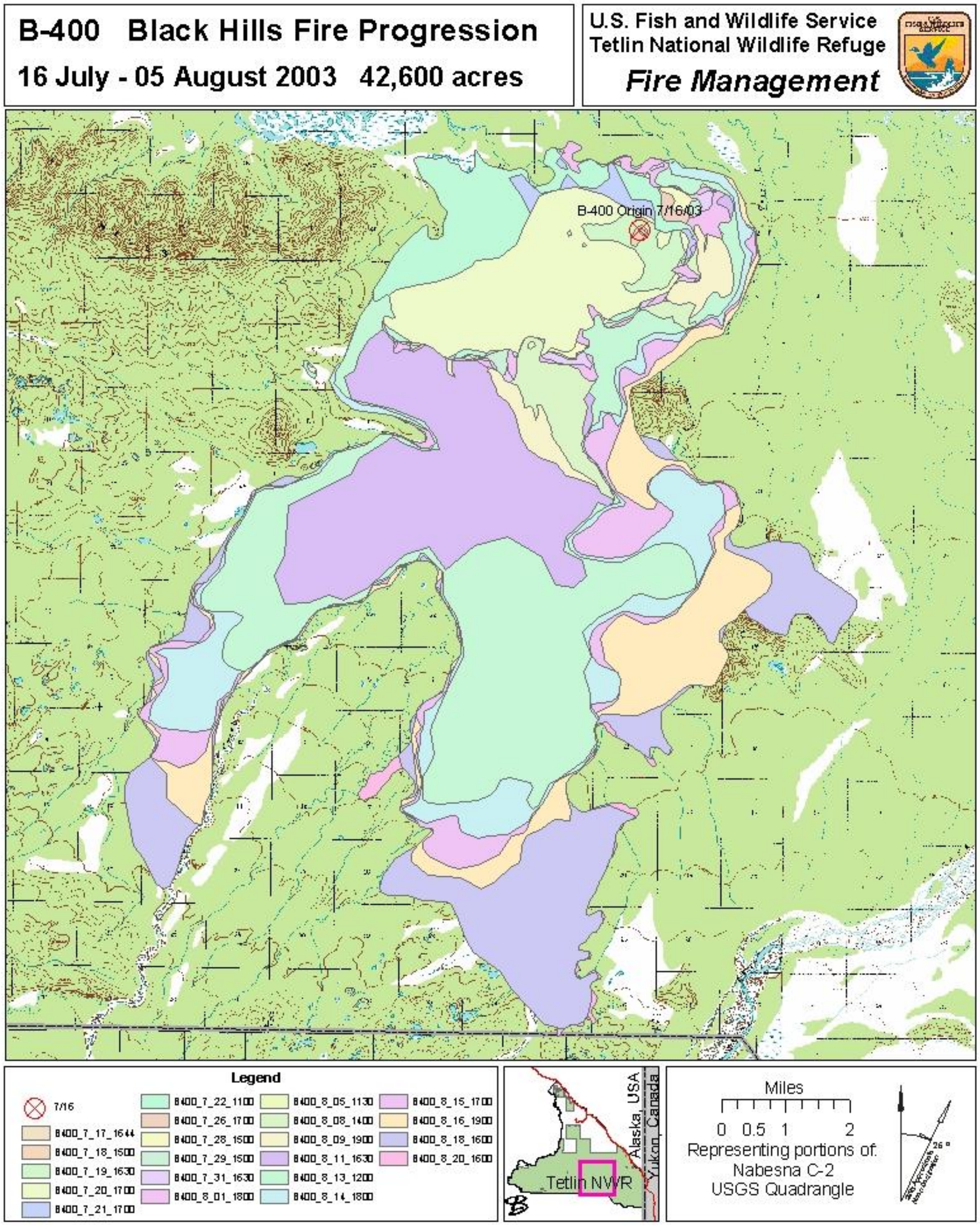


Figure 11 – Fire Progression map for the Black Hills fire as of August 20, 2003

Over the next week, August 24-30, a westerly flow aloft will develop. This will bring in mostly cloudy weather, cooler temperatures and a more stable air mass. Fire growth will continue to be small, unless temperatures rise, relative humidities drop and winds increase.

Weather Outlook

The long lead outlook calls for an equal chance of slightly above normal, normal or slightly below normal temperatures and precipitation for the month of August and through October.

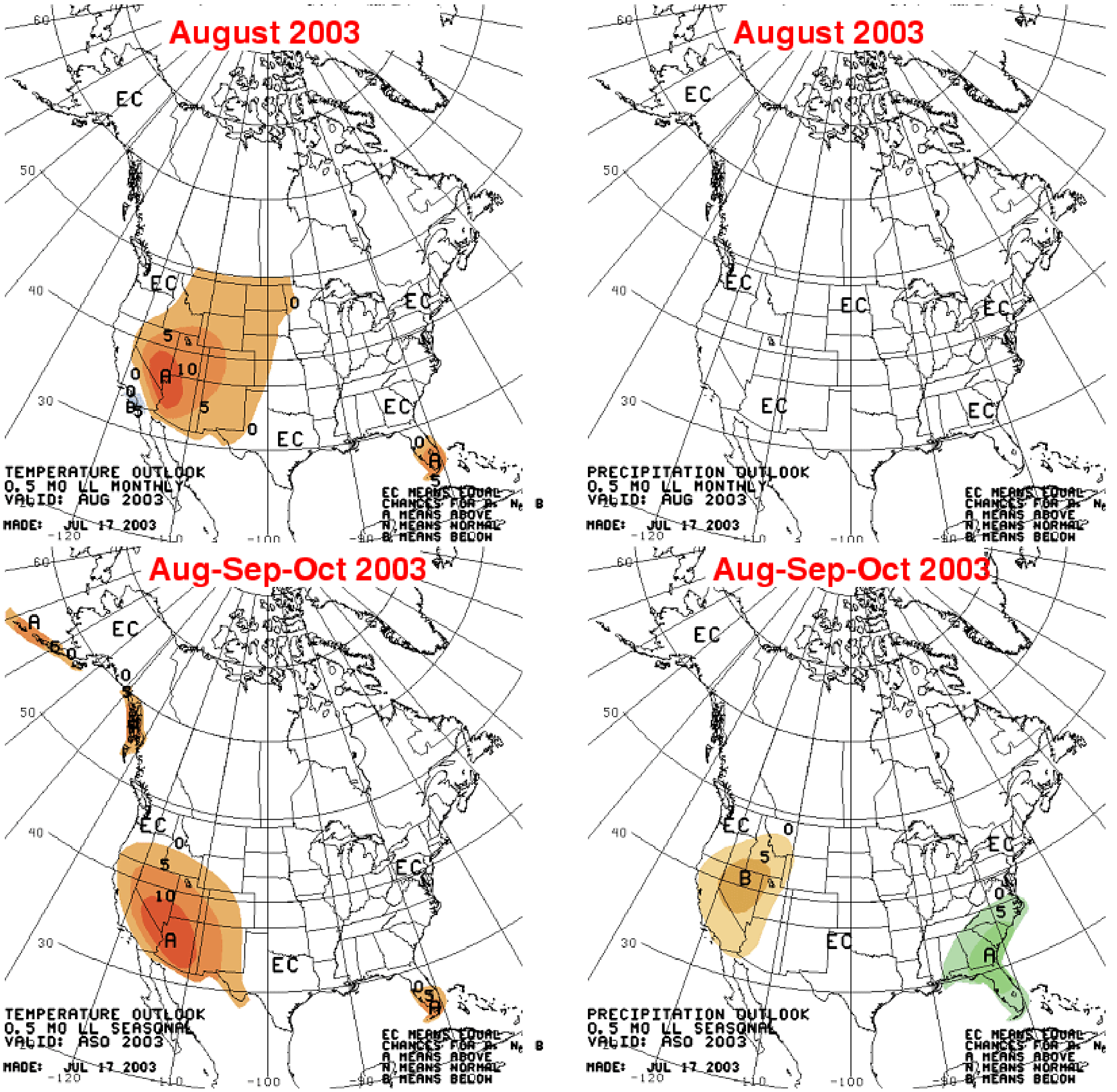


Figure 12 - Long Lead Outlook Maps of Precipitation and Temperature

Based on historical data from the Northway weather station, mean weather conditions for the months of August and September with the number years of observations out of a total of 25 years examined are as follows:

	August	Years of observations	September	Years of observations
Maximum Temperature, °f	54-80	23	45-64	10
Minimum Relative Humidity, %	34 – 41	18	35 - 48	6
Wind Speed, mph	2-9	23	2-10	10
Wind Direction	W, NW, E	NA	E, NW, W	NA
Precipitation Amount, in	.3 - .75	14	.96	1
Precipitation Duration, hrs	.3 – 6.0	23	0 – 6	10

Table 3. Historic weather from the Northway Weather Station

Rare Event Risk Assessment Process: Probability of Long Term Fire Spread

The Rare Event Risk Assessment Process (RERAP) is a stochastic model utilized to assess the risk of fire spreading to points of concern within, along and beyond the Maximum Manageable Area (MMA). In this case, locations in the Black Hills Complex's MMA were assessed.

RERAP incorporates several computer software programs that allow the fire manager to quantify risk associated with rare, but significant weather events (primarily wind) and the uncertainty related to the length of the fire season. Estimates were developed for specific periods of time and for given directions.

Historic weather data is prepared and analyzed using Fire Family Plus, which uses National Interagency Fire Management Information Database (NFMID) weather data files to compute NFDRS and CFFDRS Indices and classify individual weather components relative to low, moderate, high, and extreme severity levels to determine fire spread potential. Please look at the documents, Developing Long Term Assessment for the Black Hills Complex and Acquiring data for the Black Hills Complex Assessment for more information on that process.

Three program modules are used in RERAP to estimate fire spread distances, season ending event probabilities and the probability that a fire will reach an area of interest before a season ending event.

Climatological weather is used as opposed to the short-range weather forecasts that are used in developing fire behavior predictions. The use of historical weather data is more appropriate for statistical analysis when evaluating weather event probabilities, as a number of weather data samples are available for any given single date. The Northway weather station (500704) was used to conduct probable weather scenarios in RERAP. This data set represents 25 years of weather data. The station is 20 miles northwest of the fire area and is in an area of black spruce which is similar in elevation and slope to much of the area in Black Hills Complex.

No criteria for defining a season ending event had been developed for Tetlin NWR or Wrangell St. Elias NPP. Larry Vanderlin, retired Fish and Wildlife FBAN and Brian Sorbel, NPS Regional GIS specialist were consulted to help develop criteria for a season ending event. The final term file used for the Black Hills Fire Use Complex has season ending dates established with this term file with the following criteria:

- The DMC of less than 40 and at least one half inch of precipitation falls over a three day period OR

- DMC of less than 35 and at least three quarters of an inch of precipitation over a five day period OR
- A sliding scale of the moisture needed to cause a season ending event over 7 days,
    - 1.5 inches of rain or more in June
    - 1-1.5 inches of rain in July
    - 0.5-1 inches of rain in August
    - 0.2-0.5 inches of rain in September

Dates for 16 years were obtained – 9 years had no season ending criteria before the data records ended (Table 4). Some year show less than the rain amounts above because of the way the days were combined (3 or 5 days groups vs. 7 day totals).

Year	Date	Total Precipitation over previous 7 days (inches)	Days With Rain	DMC
1978	7/14	1.24	3	26
1979	7/12	0.52	4	31
1980	8/12	0.42	3	33
1981	7/16	0.18	2	32
1983	8/15	0.23	5	33
1984	7/25	0.74	3	29
1985	8/23	1.62	7	3
1989	8/4	0.71	2	38
1990	7/19	2.03	1	43
1991	7/7	1.76	4	10
1992	8/9	0.52	2	19
1994	7/4	0.22	4	40
1997	7/30	0.56	3	13
1999	8/14	0.39	2	27
2000	6/18	1.55	5	6
2002	8/19	0.16 - missing data	2	4

Table 4. Term file dates with total precipitation, days with rain and duff moisture code.

Local knowledge thought that there would be season ending events in September, but due to the lack of data in this period, no dates were found. Season ending dates were entered into the RERAP model and a cumulative distribution developed for determining the probability of a season ending event over a given waiting period was developed (Figure 14).

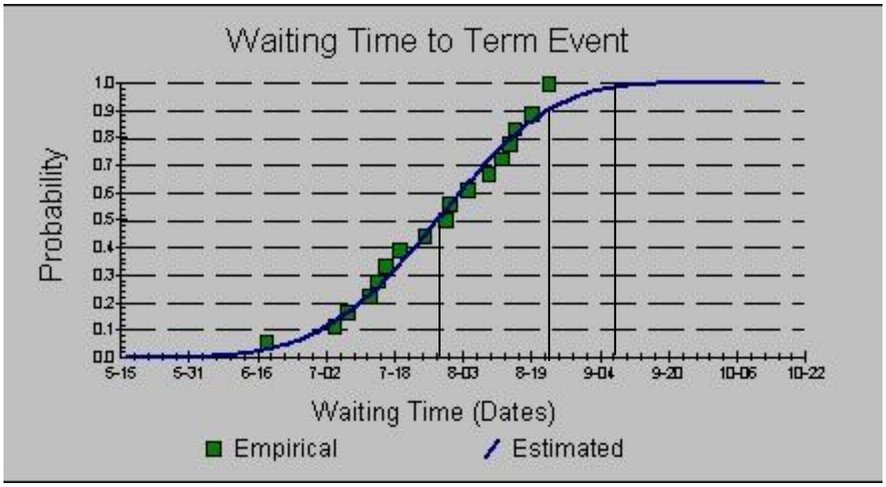


Figure 14. Waiting Time to a Season Ending Event

Based on this distribution, there is,

- a 50% probability of a season ending event around August 1^{st}.
- a 90% probability of a season ending event around August 24^{th}
- a 99% probability of a season ending event around September 7^{th}

Due to the unusually dry 2003 fire season, combined with weather forecasts for warm, dry weather into September, the ‘season ending curve derived from historical weather data may not adequately describe the waiting time for a season ending event in 2003. To allow for modeling of an outlier fire season, Climatalogical probabilities were adjusted as suggested in a paper by Robert Zeil. These adjusted climatological probabilities were used for the ‘normal’ and worst case runs. A term file with 1 month added to all dates was used to simulate a longer fire season and was used for the worst case runs.

Projections were completed to determine the probability of the Black Hills Fire reaching several points of concern. One projection was made for the Fish Lake fire (Figure 15).

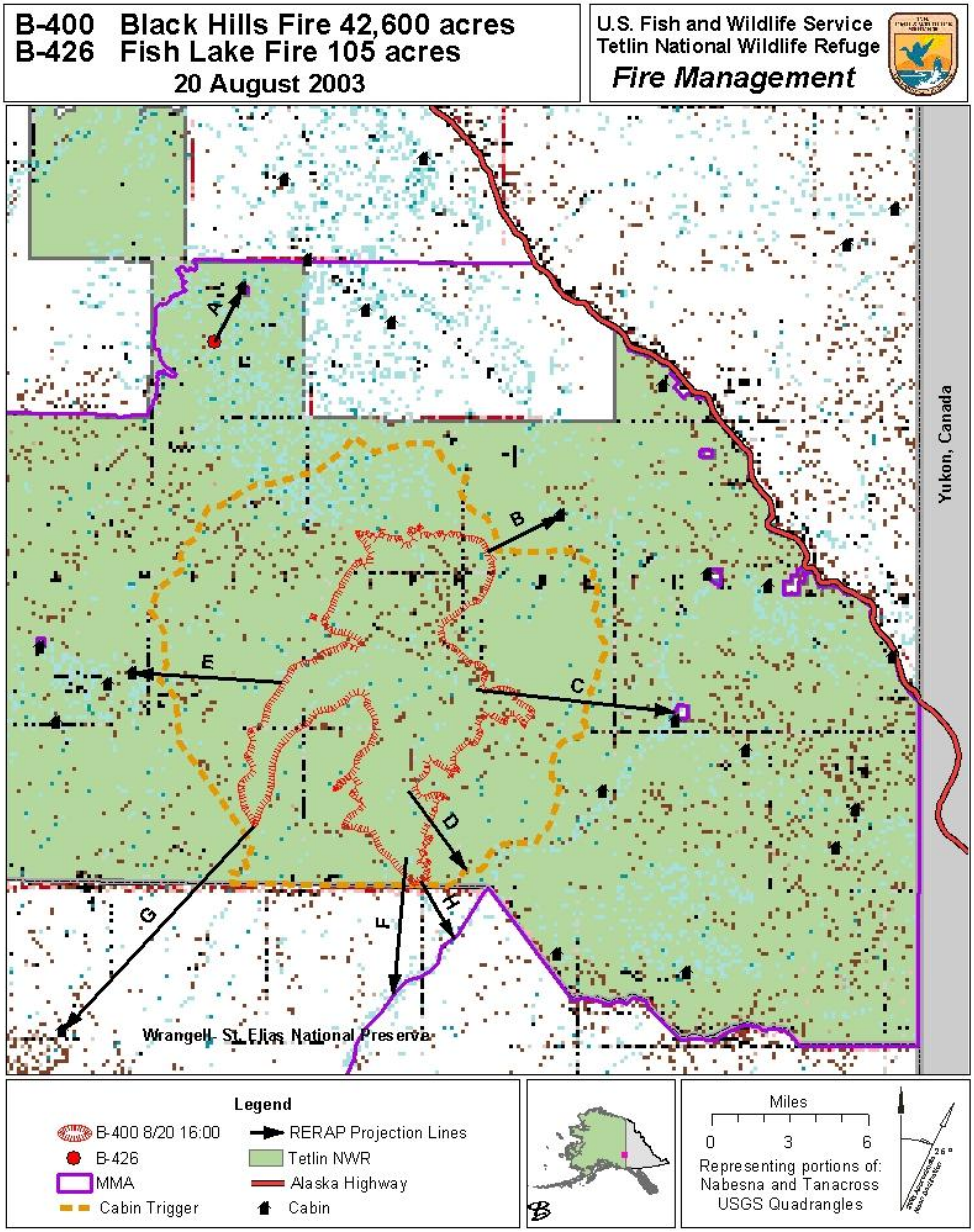


Figure 15 – Projection Lines for RERAP analysis

Four lines had probabilities higher than 0.3 %. These are shown below and were run both with the normal term file and the fire season extended one month as the worst case scenario. Table 5 exhibits the calculated probabilities for these lines.

Direction	Probability	Worst Case Scenario	Point of Concern	Method Rare/ Significant Events
Segment H – SE flank to MMA Boundary across Chisana River	5 % by 9/15	18 % by 9/15	MMA Boundary	Rare Event
Segment D – SE flank to Management Action Point on west side of Chisana River	3% by 9/15	14% by 9/15	MAP and MMA Boundary	Rare Event
Segment A – Fish Lake fire to allotment near Northway	3% by 9/15	8% by 9/15	Allotment and Northway	Rare Event

Table 5. Probabilities of the Black Hills and Fish Lake Fires Reaching Points of Concern

The next highest probability was 1% for Segment B – from the Northeast Flank of the fire to a cabin and allotment to the east.

The risk probabilities listed above are subject to change as conditions evolve. As the fire season progresses, the decision environment will be different which may invalidate the underlying assumptions, thus invalidating the previous risk estimates. Therefore, periodic revalidation of the assumptions underlying the risk estimates and recalculation of the probabilities is may be needed.

It is also important to keep in mind that this process is only a tool for supporting the decision making process. It should be only one of the decision elements used. Local expertise and knowledge as well as fire behavior variables observed on the fire line are equally important decision elements.

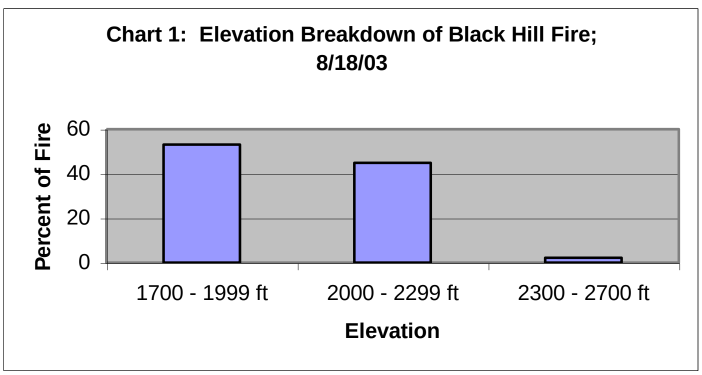
Elevation Analysis

Brian Sorbel did additional analysis on the relationship between fire size and elevation. This analysis was used to give Wrangell St. Elias additional information about potential risk to cabins to the south of the fire. Fire occurrence and fire behavior in many areas of Alaska are highly dependent upon elevation. During the period 1950 – 2002, seventy-eight fires occurred in Wrangell-St. Elias National Park and Preserve. For these 78 fires, fire ignitions occurred between elevations of 650 feet and 5905 feet. Of this total, 17 fires have attained a size of 10 acres or greater. Based on an analysis of historical data, ignition locations for fires greater than 10 acres within Wrangell-St. Elias are confined to an elevation spectrum from 600 feet to 3800 feet. Within Wrangell-St. Elias, six fires have grown larger than 100 acres. Ignition locations for fires greater than 100 acres occur within an elevation spectrum of 600 to 3200 feet. Four fires have grown larger than 1000 acres. Ignition locations for fires greater than 1000 acres are limited to an elevation spectrum of 600 to 2300 feet. Finally, two fires have grown larger than 10,000 acres. The elevation spectrum for ignition locations of fires greater than 10,000 acres lies between 600 and 2100 feet. The predicted maximum fire size for fires in Wrangell-St. Elias based on elevation at the point of origin is displayed in Table 1.

Table 1: Wrangell St. Elias National Park and Preserve Fire-Elevation Spectrum

Elevation (ft)	Fire Size Criteria
0 - 600	No fires
600 - 2100	Fires can be larger than 10,000 acres
2100 - 2300	Max Fire Size = 10,000 acres
2300 - 3200	Max Fire Size = 1,000 acres
3200 - 3800	Max Fire Size = 100 acres
3800 - 5900	Max Fire Size = 10 acres
5900 - 18000	No fires

On August 18, the Black Hills fire occupied a spectrum of elevation values ranging from 1778 ft to 2649 ft. Overall, the fire occupies an elevation range of approximately 900 feet. However, the vast majority of the Black Hills fire occupies only the lower two thirds (1700 – 2300 ft) of this elevation spectrum. Approximately 53.1% of the Black Hills fire occurs between 1700 and 2000 ft. elevation. Approximately 44.8% of the fire occurs between 2000 and 2300 ft. Only 2.1% lies between 2300 and 2700 ft. elevation (Chart 1).



Five structures are located approximately 12 – 15 miles southwest of the Black Hills fire in Wrangell St. Elias. Table 2 summarizes the distance from the structures, the elevation of the structures and the elevation difference between the structures and the fire.

Table 2

	Distance to Fire (miles)	Elevation (ft)	Elevation Difference (ft)
Structure 1	**12**	**3447**	**758**
Structure 2	**10.5**	**2986**	**297**
Structure 3	**13**	**3284**	**595**
Structure 4	**14**	**2590**	**0**
Structure 5	**17**	**3581**	**892**

These five structures appear to lie in terrain where elevation begins to constrain fire size. Structure 2 and 4 are in an elevation range where historically, fire ignitions are limited to a size of 1000 acres. Structures 1, 3 and 5 are at an elevation where fire ignitions appear to be limited to a size of 100 acres.

One would expect that continued spread of the Black Hills fire into Wrangell St. Elias will be hindered in part by increasing elevation and the corresponding changes in vegetation, temperature and moisture which have hindered historical fire spread at higher elevations.