Wind Cave National Park
Headquarters West Prescribed Fire Report

Prepared by Valena Hofman
Great Plains Fire Management Office
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Burn Unit Summary

The 2009 Headquarters West prescribed fire is a 631-acre unit primarily consisting of ponderosa pine forest with native grass prairie and prairie dog town components. The entire Headquarters West unit (divided into four units) was burned in two operational periods. On September 3rd units 1-3 were burned (621 acres) and Loop A (11 acres) was burned on September 4th.

The unit is bounded by mowed-lines along the west line and a mix of mowed-lines and roads along the north, east and south lines. The east perimeter was adjacent to several park residences and structures. Significant work went into prepping the lines, primarily the west line; removal of pine seedling regeneration and heavy dead and down fuels as well as installation of hose lay. Loop A was bounded by mowed line along the east, south and west edges and by campground roads along the north line. Three monitoring plots were within the burn unit and burned over the course of the two days.

Fire along west line

Objectives

- Provide for firefighter and public safety while mimicking natural ecosystem fire-return intervals to prairie and ponderosa pine forest areas.
- Reduce the fuel loading in grass and light fuels by 70% and 100 hr and 1000 hr fuels by 20%.
- Achieve70-90% mortality of ponderosa pine seedlings regeneration (< 1" dbh).
- Achieve 40-60% mortality of pole sized (1-6" dbh) ponderosa pine trees.
- Achieve 10-30% mortality of overstory (> 8" dbh) ponderosa pine trees.
- Improve flow of water into the cave.
- Provide for training experience.

Personnel
Burn Boss: Jim McMahill, Jason Devcich (trainee)
Safety: JP Mattingly
Traffic Control: Jill Jaworski + 1
Public Information Officer: Mike Johnson
Firing Boss: Paul Mancuso
Finance/Check-In: Angie Nellen
Fire Monitors: Valena Hofman, Dan Swanson & Lindsey Barney (trainee)
Div. Supervisor: Eric Allen

Task Force 1 TLFD: Al Stover
Ignition: 1 squad
Holding: 4 Type 6 engines, 1 ATV, & 1 Squad
Task Force 2 TLFD: Scott Beacham, Andy Thorstenson (trainee)
Ignition: 1 squad
Holding Resources: 2 Type 6 engines, 1 ATV, 2 Type 2 crew

Additional Resources: 1 Water Tender
Personnel from: SD State (Wildland Fire, Custer State Park, DOC), USFS – Black Hills, Badlands NP, Wind Cave NP, Theodore Roosevelt NM, Knife River HS, NGP Fire Management & NPS MW Region

Weather conditions

The National Weather Service's spot forecasts from Rapid City, SD, predicted favorable conditions for both September 3rd and 4th; temperatures to be in the 80˚s F, mostly sunny, and predominantly light southeast winds. Mixing heights were forecasted to be 4200-5200' above ground level (AGL) on day one and 7300-8300' AGL on the 4th, minimum relative humidity (RH) was forecasted to be 25% and 30% respectively, with a 70% recovery overnight. Both spot forecasts were satisfactory in predicting temperature, general winds, clear skies and smoke lofting conditions, however the observed min RH was 10-22% higher than forecasted and terrain influenced winds from other directions were experienced.

Weather was collected on the hour the first day and near hourly during the second day; information was broadcasted to all burn personnel.

Notable weather observations during the 3rd include:

- Maximum temperature of 79˚F at 1400 hrs (6˚ lower than predicted).
- Minimum RH was 43%, 1400 hrs (22% higher than predicted).
- Wind shifts due to terrain influence, gusts to 13mph.


Ignitions along north line

Notable weather observations during the 4th include:

- Maximum recorded temperature of 80˚F at 1230 hrs (as predicted)
- Minimum recorded RH was 40% at 1610 hrs (10% above predicted).

No weather information was collected between 1230 and 1620 hours; higher max temps and/or lower RHs may have occurred during this time.

Table 1-A contains weather observations for September 3rd, while Table 1-B has September 4th observations.

Table 1-A. September 3rd Weather Observations

Date	Time	Temp	%RH	Wind Speed	Wind Direction	Comments
9/3/09	1000	70	54	3-5	ESE	
9/3/09	1100	72	55	2-5	NE - SE	
9/3/09	1200	75	50	2-4	ESE	Cumulus development
9/3/09	1300	75	50	2-3	ESE	Cumulus development
9/3/09	1400	79	43	4-6	E	Cumulus development N of unit
9/3/09	1500	75	50	4 (10)	SE	Altocumulus to W
9/3/09	1600	75	47	2-5	SE	10% cloud cover
9/3/09	1700	72	55	3 (8)	SE	50% smoke cover
9/3/09	1800	70	58	7-10	ENE	Up-canyon winds

Table 1-B. September 4th Weather Observations

Date	Time	Temp	%RH	Wind Speed	Wind Direction	Comments
9/4/09	0613	53	91	3 (5)	ESE	
9/4/09	0818	64	72	Calm	-	
9/4/09	0910	69	57	1-3	VAR	
9/4/09	1000	73	56	3-4	S	Taken center of unit
9/4/09	1100	75	50	5-7	SE	Loop A ignitions
9/4/09	1230	80	41	5-7	ESE	
9/4/09	1610	78	40	5-7	E	
9/4/09	1700	76	44	Calm	-	
9/4/09	1800	74	50	Calm	-	

Wind speed in miles per hour, Temperature in degrees Fahrenheit

Fire Behavior

Headquarters West unit is comprised primarily of ponderosa pine forest with native prairie and prairie dog town habitat. The unit has notable topography with rolling-to-steep hills and small canyons facing every aspect. The combination of fuels and topography influenced fire behavior, which was similar both days of the burn.

Primary fire carrier was litter within the ponderosa pine forest and grass in the open areas; the prairie dog town areas did not burn well due to lack of fuels. Fire behavior was predominantly driven by fuels with additional influences from winds and terrain. Behavior was consistent most of the day on September 3rd but activity decreased in the evening as temperatures dropped and RH rose.

The north, west and southern perimeters of the unit were burned with a mix of flanking and backing fires due to wind direction and desire to moderate fire intensity within ponderosa pine. Small strip head fires were used when needed to increase depth along the west and north line. Interior and east line ignitions produced head fires, predominantly in grass fuels. Flanking and backing fires consumed most fine and heavy fuels in both the woods and grasses while the head fires consumed most fine fuels and scorched shrubs

and pine seedlings. Late in the day the backing/flanking fire was still active in the open but only carried as a head/ flanking fire in the woodlands. Heavy fuels and some litter in the woods burned throughout the night and became active by late morning of the 4th.

Loop A was burned on the second day and exhibited limited fire behavior due to reduced fuels, having been burned in the Campground 2007 prescribed fire. Portions with grass understory carried flames and some larger woody fuels were consumed but fire did not carry well in areas with green understory. The open grass area in the northeast part of Loop A burned well and exhibited active fire behavior similar to the previous day's. Additional interior ignitions within the prairie dog town area proved to be slightly more active than the previous evening.

Fire behavior in heavy fuels along west line

Fire behavior in open grassland, Loop A

Fire in ponderosa pine had the following behavior: flanking fire, 1-10 chains/hours (c/h) with flame lengths (FL) of 0.5-10'; head fire, 3-20c/h with 1-15' FL (interior FL up to 30'); and backing, 0.75-1 c/h with 0.5-6' FL. Fire behavior in the prairie was observed along the north line; ranges are: flanking fire, 1.5 c/h with FL 0.5-4'; head fire, 10-50 c/h with FL 2-8'; and backing, 0.75-1.5c/h and FL of 1-3'.

Fire behavior in seedlings along south line

Flames interior of the unit and in pine regeneration were often observed at 10 and 15' heights. Torching and crowning was limited in larger sized trees and was regularly observed in seedlings and smaller pole trees associated with flanking and head fires. Fire laddering into trees was common, with flames sustained but not spreading readily in live needles. Several fire whirls were noted up to 10' in height, primarily in the woodlands along with an active fire front but also in the prairie. Spotting occurred along the west line during ignitions, with receptive fuels of punky logs and stumps within 50' of the line; spot fires were quickly contained.

The three monitoring plots were burned over the two days but only FFV3 was observed. Plot FFV1 burned on the first day; fire in the area was flanking/head fire and likely burned through the plot after 1700 hours. FFV2 burned on the 4th between 1000-1300 hours, likely with a flanking/head fire moving uphill. The third plot, FFV3 burned with backing, flanking and head fires between 1615 and 1645 hours on September 3rd.

Table 2. Fire Behavior Observations

Date	Time	Location	Fire Type	ROS	FL	Comments
9/3/09	1055	Test Fire	F	1.5	0.5-4’	Primary carrier grass
9/3/09	1125	Slope N of Test Fire	H	50	2-3’	Forbs/ grass and down dead fuels
9/3/09	1135	Slope N of Test Fire	B	0.75	1-3’	Forbs/ grass and down dead fuels
9/3/09	1205	0.20 mi S of DP 1	B	1	0.5-1’	Small fire whirls in pine seedlings; flare ups w/ 15’ FL
9/3/09	1230	0.10 mi N of DP 8	F	1-1.5	0.5-1’	2’ FL in woody debris, 100% scorch in seedlings < 4’
9/3/09	1300	3 Chains S of DP 8	B	0.5	0.5’	Spot fires occurring within 50’ of line
9/3/09	1315	Between DP 1 and DP 2	F/B	5	3’	Good consumption of 100 hrs, Large logs still present
9/3/09	1330	4 Chains S of DP 8	B	1	3-4’	Consumption in down 1000 Hrs
9/3/09	1330	Between DP 1 and DP 2	F	7	10’	3’ seedlings, 75%burned
9/3/09	1400	0.20 mi E of DP 1	H	15	1’	Flames laddering into trees; live needles holding flame but not spreading
9/3/09	1420	0.20 mi N of DP 7	H	4	1-3’	Variable winds gusty, 5 (9) out of ESE, fire whirls w/ wind gusts, Head strips
9/3/09	1504	S of DP 2 along water main corridor	B	1	0.5-1’	On slope shoulder, fire backing through pine seedlings, no consumption
9/3/09	1530	0.10 mi N of DP 7	B	1	0.5 -2’	Winds steady, cloud cover overhead, sun blocked
9/3/09	1540	DP 7	H	15	6-10’	2 big head fire swaths, FL 10’ in seedlings
9/3/09	1605	FFV 3	H	9	2’	Plot has variety of aspects & slopes, will be burned by a variety of flame fronts
9/3/09	1645	Bend East of DP 7	F/H	20	4-6’	Uphill runs w/wind
9/3/09	1713	Mid slope, 0.10 mi S of DP 3	B	1.5	1’	In grassland fuels
9/3/09	1745	E of DP 6	B	1	1-6’	Winds at 10, gusts to 13
9/3/09	1745	0.10 mi E of DP 3	H	20 -40	5-8’	
9/3/09	1930	4 chains E of FFV 2	H	<0.5	0.5-1’	Creeping in understory; needle cast & mixed herbaceous fuels
9/3/09	1930	4 chains E of FFV 2	B	0	<0.5’	Self extinguishing, not carrying; needle cast & mixed herbaceous

B=backing fire; F=flanking fire; H=head fire
ROS = rate of spread measured in chains per hour (1 chain = 66 feet or ≈ 20 meters)
FL = flame length

Smoke Monitoring

Mixing heights were forecasted to be 4200-5200' above ground level (AGL) the first day and increasing to 7300-8300' AGL on the 4th. Smoke observations were documented while burning on September 3rd and a few general observations made during the 4th.

On the 3rd smoke averaged a lofting height of 150-200' AGL with max heights near 400'. Southeast winds sent smoke to the northwest which, along with low smoke lofting conditions, caused the entire west line to be impacted by smoke for most of the day. Smoke color and density varied depending on fuel type and loading.

During the night following the burn, smoke settled in surrounding low areas, primarily Beaver Creek and Wind Cave Canyon and flowed to Buffalo Gap. A light volume of smoke moved down Cold Creek Canyon towards the town of Hot Springs. Smoke was also noted in Pringle and Argyle, west and northwest of the park.

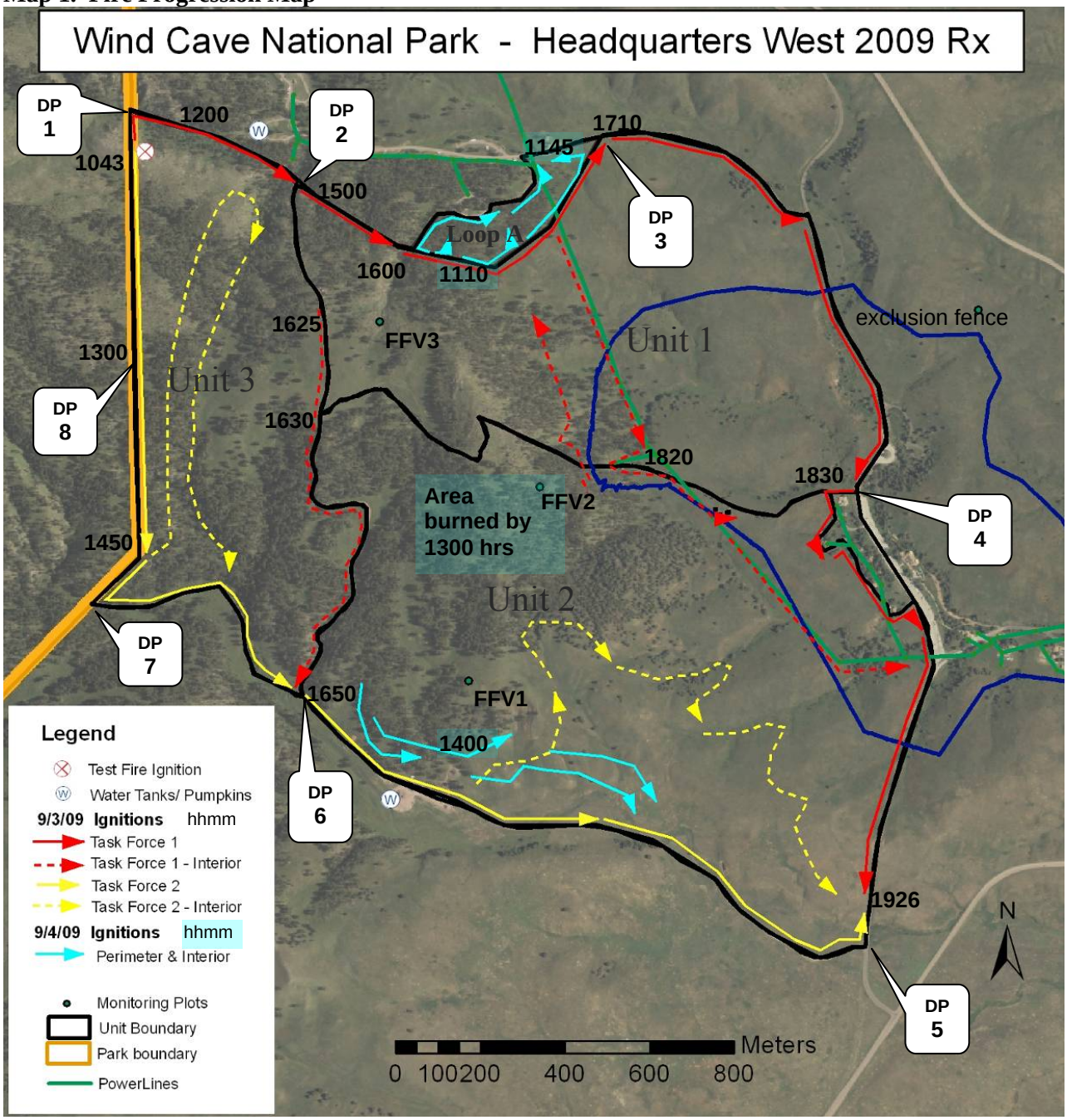
On the 4th the center of the unit, near FFV2, was unburned as of 1000 hours; the area was smoky and had little active fire behavior. Over the next several hours, smoke dispersal increased, with notable fire activity in the center of the unit as it completed burning out by 1300 hours.

Smoke continued to be produced from the interior of the burn for the next several days with one observation on September 5th indicating isolated smokes dispersing at or before tree height. Table 3 contains smoke observations from the 3rd.

Table 3. Smoke Monitoring

Date	Time	Location	Direction / Wind Speed	Elevation of smoke	Smoke Column Direction	Other Observations
9/3/09	1100	Test fire	ESE	150'	NW	
9/3/09	1130	0.1 mi S of DP 1	E	150'	W	White smoke; some black from heavies
9/3/09	1150	Between DP1 and test fire	NE (upslope) 6 (10)	30'	SW	Smoke from windrow fuels (heavies); upslope winds carrying smoke
9/3/09	1220	0.1 mi N of DP 8	SE	150'	NW	Light white smoke
9/3/09	1245	0.1 mi N of DP8	SE	250'	NW	Mostly light grey to white smoke; some dark grey smoke; dense smoke sustained
9/3/09	1250	DP 1	N (upslope) < 10	240'	S	White-brown smoke; wind & slope driven, laying down west of ignitions but starting to pull up
9/3/09	1345	Edge of canyon S of DP 8	E –SE	150-200'	NW	Light grey - white smoke
9/3/09	1430	0.2 mi N of DP 7	ESE 5 (9)	100-400'	W	Heavy white - light grey smoke
9/3/09	1515	0.1 mi N of DP 7	ESE 4 (8)	200'	WNW	Light grey, light density; shading from cumulus clouds
9/3/09	1630	0.2 mi E of DP 7				Heavy dark grey from interior and white above; heaviest smoke on west line
9/3/09	1730	DP 6	SE 3 (8)	420'	WNW	Dark heavy interior smoke and light grey in grass; heaviest smoke on west line

Map 1. Fire Progression Map



Fire Progression

Burning the unit occurred over two days with the majority, units 1-3, ignited on September 3rd as one continuous unit and firing of Loop A and supplemental interior ignition on the 4th. The unit was burned in a classic ring head-fire progression with two task forces heading in opposite directions, with Task Force 1 (TF1) responsible for the east and north lines and Task Force 2 (TF2) lighting and holding the west and south lines.

On September 3rd, the test fire was ignited at 1043 hours, on a ridge less than 0.1 mi south of DP 1. TF1 began moving down the south line while TF2 moved toward DP 1 and secured the corner. Firing along the west line proved to be smoky and hot with backing and flanking fires consuming piled slash (the heavy

fuels a result of the 1991 Shirttail Crown fire) and dense pine seedlings. Numerous spot fires occurred along the west line; all were suppressed quickly. Firing speed was controlled by TF2; by 1500 hours ignitions along the west line were near DP 7 while the north line ignitions reached DP 2. After the west and north lines were secured, perimeter ignitions continued at a greater speed, igniting prairie and prairie dog town fuels. TF1 used interior ignitions to secure power poles and the RAWS weather station and contended with burning around structures and propane tank as they proceeded south along the east line. The fire was rung at 1926 hours just north of the southeast corner of the unit. Additional interior ignition to increase fire spread occurred interior of the unit toward DP 6 at 1650 hours and later, north of the RAWs station as well as in the prairie dog town in the southeast corner of the unit.

The following day, on the 4th, Loop A was burned using a strip fire sequence. Ignition began in the southwest portion of the unit at 1110 hours, with the perimeter being lit clockwise around the unit and fire strips laid south-north connecting to the perimeter fire. The unit ignition was completed at 1145 hours along the north line.

Additional interior firing was used near the mixing circle and prairie dog town area where it had not burned well the evening in attempts to increase burned areas and target nearby pine regeneration. These ignitions were complete by 1500 hours.

Holding along west line

Fire Effects Monitoring

Three fire monitoring plots lay within the boundaries of the Headquarters West unit. Immediate post-fire monitoring was conducted the following week to assess fuel loading and burn severity.

Fuel Loading

Results show that the three plots vary greatly in fuel loading and type of fuels, each representing a different aspect of the unit. Two plots represent the fine fuels under pine overstory; FFV1 has the highest litter load and straddles the edge of pine and prairie, while FFV2 includes litter but close to no woody fuels. In contrast FFV3 is located within the

Monitoring plot FFV3 pre-burn

FFV3 post-burn

1991 Shirttail Crown fire and contains snags, scattered seedlings, shrubs and litter and a large amount of heavy fuel loading on the ground with no overstory.

Due to the differences between the plots and the changes in fuel loads the overall variability of the Headquarters West unit may be best illustrated by observing the individual and averaged plot results.

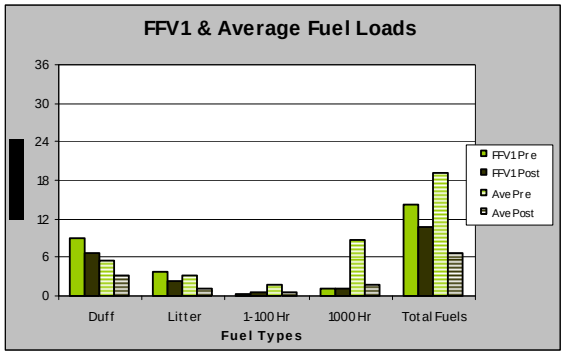
The average total fuel load was 19.2 tons/acre pre burn and 6.6 tons/acre post burn, a decrease of 65.8%. Overall, there was a decrease of 80.6% of 1000 hr fuels and 68.8% decrease of 1-100 hr fuels, both of which far exceed the goal of 20% reduction. The average reduction of litter was 60.9% and duff was reduced by 44.4%.

Plot FFV1 (See Graph 1) had the second highest total fuel load at 14.3 tons/acre but this plot had the least amount of fuel reduction during the burn, around 25% change with minimal consumption of woody fuels.

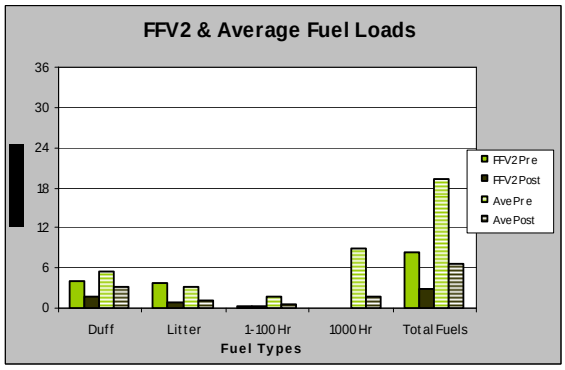
Although the fuel loading was lightest at plot FFV2 (Graph 2) the % reduction of fuels was average; over half comprised of duff with the remainder primarily litter and no 1000 hr fuels.

Differing from the previous two plots, FFV3 (Graph 3) had the highest total fuel load of all the plots. Two-thirds of the fuel loading consisted of 1000 hr fuels and the remaining third divided amongst duff, litter and 1-100 hrs. Fuel reduction was significant for all size classes (see photos on previous page).

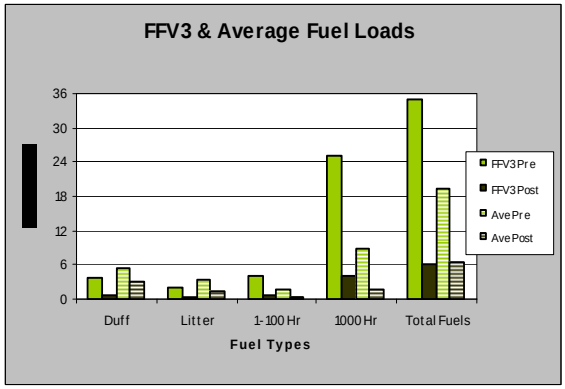
Graph 1. FFV1 Fuel Loads



Graph 2. FFV2 Fuel Loads



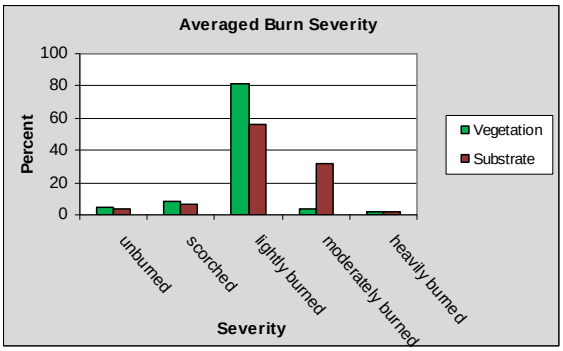
Graph 3. FFV3 Fuel Loads



Burn Severity

The burn severity of vegetation and substrate varied less so and is adequately represented by the unit average, depicted in Graph 4. Vegetation was at 81.7% lightly burned with the remaining vegetation ranging from unburned to heavily burned. Substrate burned slightly hotter, with 55.7% being lightly burned and 32.1% moderately burned, these numbers correlating to significant fuel reduction. Plots FFV1 and FFV2 were similar in their burn severity patterns with burn severity concentrated in the lightly burned category with some moderately burned, while FFV3 with higher dead and down fuel loading, contained more variability from unburned to heavily burned.

Graph 4. Burn Severity



Tree Mortality

The success in reducing ponderosa pine seedlings, pole and overstory trees by their respective amounts will be monitored over the next two years. Ocular estimation following

the burn suggests that objectives were likely met. Scattered canopy browning imply that up to 30% of the overstory was killed if not stressed. Observations along the west line suggest that 10' flames will likely lead to 100% mortality in seedlings 4-6'. Over 90% of the visible seedlings appear to be scorched, with a high mortality rate expected.

Biomass/ Soil Moisture

Biomass ranged from 1.23 – 14.83 tons/acre with an average of 6.24 tons/acre. Soil moisture averaged 7.86% with a range from 3.98-16.64%.

Conclusion

This burn was a prime example of successful reintroduction of fire within a Wildland-Urban Interface. Success was due to favorable weather, thorough planning and unit preparation, interagency cooperation and burning at the early end of the season. Headquarters West burn sets an excellent example of successful early fall burning in the Black Hills.

The weather and fuel conditions were favorable except for the heavy smoke impact along the west line; burning with south winds could mitigate this issue. Fire behavior throughout the day was active, yet variable depending on the fuel type, fuel structure and terrain. The longevity of the burn with ignitions continuing into the evening made for some lower fire behavior and required modified firing sequences. Fire activity interior of the unit on the second day proved successful in burning out unburned areas, including monitoring plot FFV2.

1000 hr fuel reduction along west line

The objectives of removing grass, fine dead and heavy fuels were successfully met. While the average fuel load reduction in litter (grass and fine fuels) was 60.9%, approximately 9% lower than desired, the actual reduction of prairie grasses was probably closer to 75% as indicated by plots FFV2 & 3 which burned more completely during favorable weather conditions. The reduction of large diameter woody debris was extremely successfully with approximately 80% decrease, 60% greater than desired. Mortality of seedlings, pole and overstory pine trees was likely achieved, with continued monitoring over the next two years to verify results. Water percolation into the cave should increase based on the reduction of the vegetation and will be monitored by Wind Cave natural resource division.

The burn also provided excellent training opportunities for numerous personnel and continued interagency collaboration.

Holding along west line