WILDLAND FIRE IN THE BLACK HILLS

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1. INTRODUCTION

Over 125 years ago, the Custer expedition marched through the Black Hills region reporting abundant timber, minerals, and other natural resources. Not surprisingly, the gleam of these reports attracted settlers and the landscape, ecosystem structure, and fire regime, were changed forever. Today, the Black Hills National Forest (BHNF) attracts nearly 4 million people annually and is in a rugged and scenic area approximately 125 miles long and 65 miles wide in western South Dakota and eastern Wyoming. There is a significant amount of privately owned land in the Black Hills and there is an extraordinary road network. The local community has become very concerned about fire and there is anxiety both about the potential for catastrophic wildfire as well as the growing use of prescribed fire.

The Lakota people called this sacred and mountainous region "paha sapa," meaning "hills that are black." When viewed from a distance the trees covering the Black Hills appear black in color portraying the dense concentrations of ponderosa pine (*Pinus ponderosa*), white spruce (*Picea glauca*), aspen (*Populous tremuloides*), bur oak (*Quercus macrocarpa*), and paper birch (*Betula papyrifera)* amongst the vastness of the Great Plains. Tree densities have increased over the years (McAdams 1995) since the Custer expedition and have contributed to an unhealthy forest characterized by insect infestations, changes in native plant species, and larger fires. The South Dakota climate is characterized by precipitation generally around 14 inches on the western prairies (except in the Black Hills where precipitation is as high as 28 inches annually) to the eastern plains where precipitation averages nearly 25 inches per year. Summers are typically hot and winters cold.

There are multiple concerns facing the fire community in the Black Hills region. Upon considering the wildland-urban interface problem, rising tourism, state of the fuels, trends in recent fire behavior, and the threat of future drought, we suggest current management strategies to mitigate the problems of wildfire in the Black Hills.

2. THE WILDLAND-URBAN INTERFACE PROBLEM

The three main counties (Pennington, Custer and Lawrence) in the Black Hills of South Dakota have seen an average increase in population from 1990-2000 of about 11% (U.S. Census Bureau). There are approximately 125,000 people living in the Black Hills on an annual basis, but the area receives about 4 million tourists annually to visit sites such as the Crazy Horse Memorial, Mt. Rushmore, the Black Hills National Forest, Wind Cave National Park, Badlands National Park, Custer State Park and the Sturgis, South Dakota annual motorcycle rally. The number of visitors to Mt. Rushmore National Memorial has increased nearly 16% since the year 2000 (personal communication, South Dakota Department of Tourism) and the rise is typical of other areas in the State that attract tourists.

Approximately 46% of the land in the Black Hills ecoregion is of private ownership, which in a relative sense ranks 11th out of the 95 national forests west of the Missouri River in the United States for raw acres of private land (United States Department of Agriculture Forest Service). With such a large private sector presence in the BHNF, the wildland-urban interface problem becomes an instant concern for any wildfire occurring in the forest.

The Black Hills are carved by nearly 8,000 miles of forest roads, compared to only 1,500 miles of roads in the similarly sized Bighorn National Forest, 200 miles to the west in Wyoming (Nachison 1993). Numerous roads that zigzag across the Black Hills are mostly the relics of logging practices of years past in a forest that has been almost completely harvested at least twice during the past century (Alexander 1987). Regions with high rates of timber harvesting require more access roads and have more extensive fires according to a recent report (Congressional Research Service 2000). This study suggests a contradiction to the theory that forest thinning reduces the risk of large wildfires. Timber harvesting removes large diameter wood but leaves behind small fuels including twigs and needles on the forest floor that increase the rate of spread of wildfires (Martin and Brackebusch 1974).

To prevent wildfire from physically jumping from crown to crown, trees must be widely spaced or drastically thinned to effectively reduce threats to structures (Agee 1996). However, current thinning projects underway in the BHNF and the lingering effects of previous logging practices, may allow additional factors to contribute to increased fire risk for the local community including the following: the mechanical removal of large trees allows more sunlight and wind into the forest allowing for higher rates of evaporation and increased flammability; thinning opens up the forest, which promotes the increase of brushy, and potentially flammable

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undergrowth that may act as ladder fuels in the future; and the compaction of soil from logging vehicles and equipment may encourage more surface rainfall runoff and not allow for moisture to filter into the soil (Lawrence 2001).

3. FUELS CHARACTERIZATION

The Black Hills has a long history of environmental exploitation that dates back to around the turn of the century when the first commercial timber sale in the United States occurred near present day Nemo, South Dakota. Timber harvesting practices have changed significantly since early times when logging the forest was purely an entrepreneurial pursuit. By the early 1970s environmental awareness began to increase and now forest managers work to minimize the destructive impacts of logging by attempting to replicate conditions in the forest that existed in pre-settlement times. This is done through meticulously planned prescribed fires and carefully controlled timber harvests. Timber is collected through selective tree cutting, which leaves a more open-canopied forest that more closely imitates forest conditions when low severity wildfires accomplished the same task during the previous century (Arno and Bunnell 2002).

The sawtimber (nine inch and greater) populations of trees in the BHNF have seen a dramatic increase (personal communication, USDA Forest Service Mystic Ranger Station) since the time of the Custer expedition, comprising about 20% of the forested area in 1875 to filling about 70% of the same area today (Fig. 1). According to the vegetation classification scheme from Hoffman and Alexander (1987), ponderosa pine is the most dominant tree species in the Black Hills and it occurs at all elevations, on all soil types, and on all aspects.

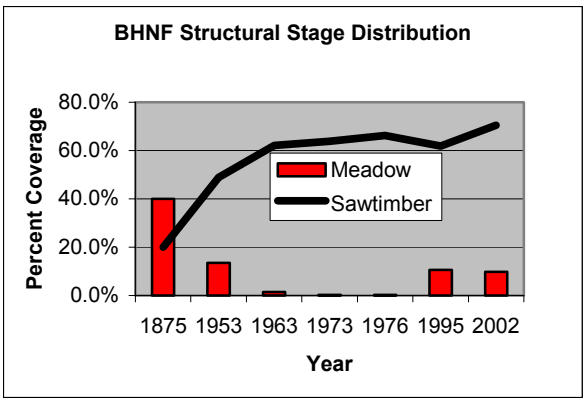

Fig. 1: Comparison of the sawtimber (9 in. or greater) estimated coverage compared to the estimated meadow coverage.

Insect infestations caused by greater numbers of weakened ponderosa pine and white spruce have been increasing recently in the BHNF (South Dakota Forest Health Highlights 2002). Studies indicate that the infestation of mountain pine and pine engraver beetles will continue to increase over the next five years, which will contribute more hazardous fuels available for wildfire combustion (Resource Conservation and Forestry 2003).

The United States Forest Service (USFS) assessment of current forest conditions indicate that fire is an important disturbance that has been limited during the last century due to aggressive fire suppression. This lack of fire has created an unhealthy forest with abnormal amounts of fuels that have led to the decline of many western mountain ecosystems. Fire exclusion has made it more dangerous for those living in and near mountain forests, and for those that fight fire in the forests of the Western U.S (Keane *et al.* 2002).

4. FIRE HISTORY

Historically, ponderosa pine has adapted from the presence of fire. Thick bark has enabled it to withstand damage from fires that consumed small seedlings and pruned lower branches from the more mature trees, thus discouraging fires from spreading throughout large stands of trees. The result was the much sought after mosaic effect with clumps of forest mixed with smaller burned areas. If and when large fires did occur, they probably did not burn large areas or stands of trees without leaving some unburned areas available for seeding and recolonization (Shepperd and Battaglia 2002). Evidence now suggests that there may have been large, catastrophic fires prior to settlement of the Black Hills during the period from 1730 to 1852 (Shinneman and Baker 1997). Clearly, with the dawn of fire suppression in the Black Hills, forests have become denser and the prairies have dwindled (Fisher *et al.* 1987). Consequently, recent fires have exhibited a trend toward more extreme fire behavior, resulting in larger areas of ecosystem-damaging stand replacement fires.

Fisher *et al.* (1987) found average pre-settlement or pre-Custer expedition mean fire intervals (MFI's) prior to the late 1800s of 14-27 years at a site near the western edge of the Black Hills at Devil's Tower National Monument in eastern Wyoming. Brown and Sieg (1996) have shown MFI's taken from areas in the southern BHNF to be on average 16 years although the results indicated high variability and large standard deviations amongst the four sites included in the study. The last area-wide fire for the northern portions of the Black Hills was reported to be in 1937 (Fisher *et al.* 1987) near Devils Tower National Monument and in 1879 (Wienk 2001) for an area just to the south. The last area-wide fire for the central Black Hills occurred in 1890 (Brown and Smith 2000). During the last century, however, fire return intervals have become much larger.

Recently, there has been an escalation in the number of large wildland fires (Fig. 2) occurring in the Black Hills region of South Dakota. The total number of acres burned (Fig. 2) by both lightning and human-caused fires over the last three years accounts for 77% of the total number of acres burned over the last 11 years. There have been 10 fires over 7,000 acres in the last 11

years (personal communication, Northern Great Plains Interagency Dispatch Center, 2003) and all of them except one occurred in the last three years (Table 1). The largest of these recent fires was the Jasper fire that began with extreme environmental conditions including near record low fuel moisture, drought conditions, and high temperatures. This fire initially spread at an average rate of more than 7 acres per minute (Jasper Fire Rapid Assessment 2002).

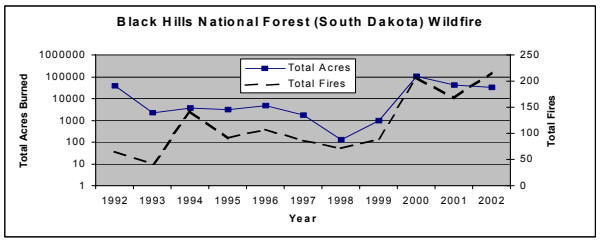

Fig. 2. Total Acres Burned (left axis) and Total Fires (right axis).

Table 1. Fires over 7,000 acres in BHNF of South Dakota. Courtesy of Northern Great Plains Dispatch.

Date	Fire Name	Acres
10/22/1992	NEW UNDERWOOD FIRE	33000
8/12/2000	FLAGPOLE	7385
8/24/2000	JASPER	83500
9/17/2000	CAMP CROOK COMPLEX-GOEHRING	11840
7/30/2001	ELK MT. COMPLEX	14990
7/30/2001	ROGERS SHACK (HELL CANYON)	11770
9/26/2001	WEST HELL	10547
6/29/2002	GRIZZLY GULCH	10771
8/16/2002	BATTLE CREEK	11300
7/21/2003	RED POINT	17950

Source: NGP Fire Dispatch

5. CLIMATE AND WEATHER

The climate of the Black Hills differs from that of the surrounding plains due mainly to their elevation and to the lifting effect provided by the local terrain. The Black Hills climate is Continental type, cold in winter and hot in summer (Johnson 1949).

The increased elevation of the Black Hills increases precipitation in favored locations and decreases temperature. Areas in the northern Black Hills average near 30 inches per year, while locations in the southern Black Hills average just over 15 inches per year where upslope flow is less common. The last three years have averaged less than the 30-year (1971-2000) average (16.3 inches) at Rapid City Regional Airport, contributing to drought conditions and an increase in fire occurrence. Periods of drought have affected the Black Hills over the last century, particularly in the Dust Bowl period during the 1930s and again, but less significantly, during the period from 2000-2002 as severe drought conditions occurred.

Mean surface temperatures for the Black Hills climate division have averaged nearly 2 degrees Fahrenheit greater than the 30-year June through August average over the last three years, also contributing to the latest surge of wildfire activity. Precipitation and temperature anomalies are critical in determining the extent of the wildfire season in the Black Hills (Figs. 3, 4).

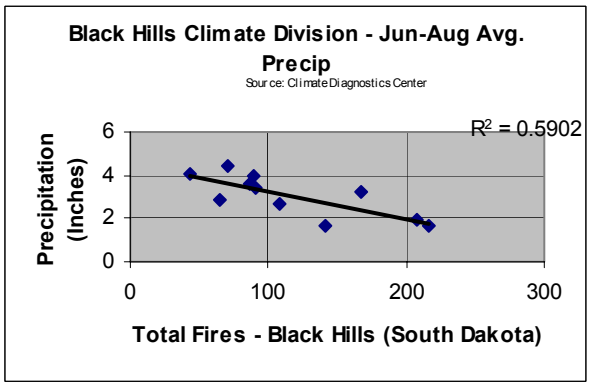

Fig. 3

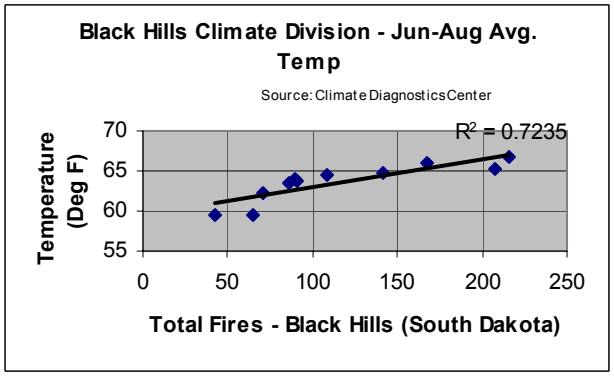

Fig. 4

Fuel moisture levels of 10, 100 and 1000 hr fuels at the Nemo RAWS (Remote Automated Weather Station) location in the Central Black Hills on the initial days of the largest fires over the last three years show large departures from normal values (Table 2). These fires occurred during the normal fire season in the Black Hills (late June through September) as climatic and meteorological forces acted together to increase fire behavior.

Scientists at both the University of Washington and NASA's Jet Propulsion Laboratory believe a marked shift in long-term ocean temperatures has taken place in the Pacific Ocean as of late (D'Aleo 2001). The fluctuating phenomenon referred to as the Pacific Decadal Oscillation (PDO) may be entering a cool phase whereby ocean temperatures in the Pacific Ocean average cooler than normal over the span of 20 to 30 years and have a

Table 2. Fuel moisture on fire start days at Nemo, South Dakota.						
	10hr	**Mean**	**100hr**	**Mean**	**1000hr**	**Mean**
8/12/2000	6.2	*9.5*	14	*14.9*	16.7	*17.4*
8/24/2000	3.7	*9.5*	11	*14.9*	14.3	*17.4*
9/17/2000	5.1	*10.4*	11.3	*16.4*	12.8	*17.4*
7/31/2001	15.5	*10.6*	15.5	*15.1*	18.2	*18.3*
9/26/2001	6.6	*10.4*	16.3	*16.4*	16.6	*17.6*
6/29/2002	3.1	*11.8*	12.6	*16.4*	12.6	*21.2*
8/16/2002	4.1	*9.5*	11.6	*14.9*	14	*17.4*
7/21/2003	11.9	*10.6*	11.9	*15.1*	15.1	*18.3*
Daily minus 10 year mean (1993-2002)						

Table 3. Cool phase of the PDO during the period from 1950-1975.

Years	ENSO	QBO	Temp. Dep.	Pcp. Dep.	Avg. PDSI
1956, 1959, 1960, 1970, 1974	Neutral/La Nina	East	1.5	-0.5	-0.6
1955, 1962, 1964, 1967, 1971, 1973, 1975	Neutral/La Nina	West	-0.1	0.1	1.4
1963, 1965, 1972	El Nino	Transition/East	-0.2	1.0	4.2

PDO data courtesy of University of Washington. Sea surface temperature anomaly data in the region Nino 3.4 and QBO data courtesy of Climate Prediction Center. Temperature and precipitation departures for the Black Hills climate division were calculated using the 1950-1995 mean. Temperature, precipitation, and Palmer Drought Severity Index (PDSI) data courtesy of Climate Diagnostics Center.

direct impact on climate. Simply put, changes in sea surface temperatures influence jet stream patterns that affect temperature and precipitation. As a result, fishing, agriculture, and even wildfire activity are affected by changes in the PDO. Assuming we have entered a cool phase of the PDO resembling conditions similar to the period 1950-1975, La Nina's (cooler than normal sea surface temperatures (SST's) in the equatorial Pacific) are more favored than El Nino's (warmer than normal SST's in the equatorial Pacific). La Nina summers are typically dry in the Northern Plains (Livezey). Another phenomenon impacting Western U.S. climate is the Quasi-Biennial Oscillation (QBO). This an alternation of winds in the equatorial stratosphere that change in direction about every 2 years that correlates negatively with temperatures in the Northern Rockies and Pacific Northwest during the summer season. An increased understanding of this oscillation may help seasonal fire weather forecasting in adjacent areas of South Dakota and Wyoming. A combination of more frequent cooler than normal Pacific SST's favoring increased La Nina events, and an easterly or negative phase of the QBO, typically favor hot, dry summers (Fig. 7) and a greater potential for increased wildfire activity in the Black Hills.

6. MANAGEMENT

With the significant wildfire activity over the last three years and stagnated court battles regarding how to manage a key hazardous fuel area infested by pine beetles known as Beaver Park, Senators Tom Daschle and Tim Johnson pushed legislation last year designed to thin 5,000 acres of this area in the northern Black Hills. As a result, free firewood is now available and commercial loggers are busy working to thin stands to reduce areas of overgrown forests suffering the effects of fire exclusion.

A multi-agency Type 3 fire management team has been assembled in the Black Hills that includes utilizing wildfire management and suppression resources from the State of South Dakota, USDA Forest Service, National Park Service, U.S. Fish and Wildlife Service, U.S. Bureau of Land Management, Bureau of Indian Affairs, the State of Wyoming, and county and local volunteer fire departments. This group was used recently in the 17,950 acre Red Point fire of July, 2003.

Real time monitoring of fire weather conditions in the Black Hills region will be increasing in the future. During the year 2003, a RAWS operating plan for South Dakota has been developed that highlights maintenance and calibration of all existing and future National Fire Danger Rating System (NFDRS) RAWS stations in the state of South Dakota.

Additional human resources have been added to meet the escalating wildfire occurrence in the Black Hills. A state wildland fire coordinator and state incident meteorologist now work with existing state and federal agencies in the event of wildfires in the BHNF.

Public outreach activities have increased as well. To increase public awareness of the effects of wildfire and to address what property owners can do to prevent wildfires on private land, a state wildland fire prevention month has been declared by the governor.

To improve predictive services regarding the forecasting of fire weather conditions, future research is planned in the following areas: identifying historical weather patterns that have led to large wildfires, analyzing lightning potential in thunderstorms to increase the accuracy of Lightning Activity Level (LAL) forecasts, improving predictions of the potential for dry lightning, and identifying at-risk fuels for potential wildfire starts in the Black Hills.

7. SUMMARY

The size of the human footprint left by man on the Black Hills ecosystem has been enormous. Post-settlement activities including mining, logging, and tourism have created a landscape carved by numerous roads and a complex intermingling of public and private land in a fire regime that is becoming increasingly dangerous to the local community.

Recent wildfires covering more area and burning in higher concentrations of fuels as a result of a century of fire suppression have led to more aggressive management strategies. Recent changes in large-scale climate oscillations such as the PDO may support more frequent La Nina's favoring potentially higher than normal summer temperatures, more frequent drought conditions, and possibly more wildfires.

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