Black Hills Resilient Landscapes Project

Black Hills National Forest

Fire & Fuels
Specialist Report

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Introduction

The Black Hills Resilient Landscapes project area includes approximately 1,098,000 acres of National Forest System Lands. These lands are managed by the Black Hills National Forest (BKF) within the areas designated by the Secretary of Agriculture under the amended Healthy Forests Restoration Act (HFRA, 16 U.S.C. 6591), excluding Inventoried Roadless Areas and certain management areas.

The project area includes the following management areas (MAs).

MA	Emphasis	Acres*	Proposed activities
3.31	Backcountry motorized recreation	6,870	Fuels/hazard trees
3.32	Backcountry non-motorized recreation	8,948	Fuels/hazard trees
3.7	Late succession landscapes	18,484	Fuels/hazard trees
4.1	Limited motorized use and forest products	41,374	All
5.1	Resource production	558,520	All
5.1A	Southern Hills forest and grassland	27,845	Fuels/hazard trees
5.2A	Fort Meade VA Hospital watershed	3,299	Fuels/hazard trees
5.4	Big game winter range	388,950	All
5.43	Big game and resource production	10,083	All
5.6	Forest products, recreation, and big game	34,043	All
*MA acres in project area	Total	1,098,425	

Ponderosa pine is the primary tree species in the Black Hills, however there are also some white spruce and hardwood communities scattered throughout. The BKF has been experiencing a mountain pine beetle epidemic since 1997. The epidemic is slowing and has left behind many dead and dying trees across the landscape. As these trees die they fall and pile up on the existing surface fuels creating uncharacteristically high fuel loadings. Due to the amount of private property, homes, businesses and critical infrastructure that exist within the Forest boundary as well as adjacent to the Forest, there are major concerns with respect to the wildland urban interface (WUI) and at-risk communities, specifically relating to public safety.

This project is proposing treatments to move landscape-level vegetation conditions in the project area toward objectives identified in the 1997 Revised Land and Resource Management Plan for the Black Hills National Forest as Amended by the 2005 Phase II Amendment (Forest Plan). This will increase ecosystem resilience to insect infestation and other natural disturbances, contribute to public safety and the local economy, and reduce the risk of wildfire to landscapes and communities. These treatments are also in alignment with the three goals of the National Cohesive Wildland Fire Management Strategy which; Restore and Maintain Landscapes, Fire-Adapted Communities, and Safe and Effective Wildfire Response. Proposed treatment activities would begin in approximately 2018 and continue for about 10 years.

Summary of Proposed Activities:

Table 1: Proposed and Connected Activities

Fuel and hazard tree treatments	
Mechanical and manual fuel treatments *(shaded fuel break construction; thin, pile, and burn fuels; scatter, shred, or chip fuels; cut, lop, and scatter fuels); includes up to 4,000 acres of shaded fuel breaks with commercial removal*	70,000 acres (7,000 acres per year)
Prescribed fire	100,000 acres (10,000 acres per year)
Hazard tree treatments	As needed and funded
Enhancement of non-pine vegetation and within-stand diversity	
Removal of pine/spruce from aspen stands	6,000 acres
Regeneration of aspen stands	4,000 acres
Removal of pine/spruce from aspen inclusions (possibly commercial)	22,500 acres
Removal of pine/spruce from aspen inclusions (non-commercial)	8,400 acres
Removal of encroaching pine from oak stands	5,400 acres
Removal of encroaching pine from grasslands	14,200 acres
Uneven-age individual tree selection or group selection	As stand conditions allow (max. 10,000 acres, out of the 185,210 acres below)
Pine structural stage modification	
Overstory removal *By management area:* *MA 4.1: Approximately 7,670 acres* *MA 5.1: Approximately 129,890 acres* *MA 5.4: Approximately 41,210 acres* *MA 5.43: Approximately 250 acres* *MA 5.6: Approximately 6,190 acres*	185,210 acres
Precommercial and/or POL thin	250,000 acres (25,000 acres per year)
Patch cut *By management area:* *MA 4.1: 1,300 acres* *MA 5.6: 600 acres*	1,900 acres
Tree planting *(MAs 5.1, 5.4, and 5.43)*	5,000 acres
Mechanical site preparation	4,000 acres
Connected actions	
Road construction – Specified	18 miles
Road construction – Temporary	39 miles
Temporary roads on existing templates	182 miles
Road conversion (unclassified to system)	20 miles (part of 182 miles above)
Road maintenance	2,500 miles (estimated)
Road reconstruction	375 miles (estimated)

*Maximum activity acres and miles are displayed. The amount implemented may be less.

Affected Environment

The recent mountain pine beetle epidemic has left approximately 215,000 acres of beetle killed trees across the Forest. In some areas that were first hit by beetles, numerous trees have already fallen to the ground or broken off creating large accumulations of hazardous surface fuels. Stands that were more recently hit are beginning to experience this as well. There are many remaining impacted trees that will continue to die, decompose and fall creating an uncharacteristically high surface fuel loading for years to come. This surface fuel loading is characterized by what is described as coarse woody debris (CWD), standing or down woody material generally greater than 3 inches in diameter, and the presence of smaller surface fuels. In stands that were heavily affected by the beetles, the newly open canopy is and will continue to create an opportunity for pine seedlings to become established and prolific regeneration of pine to occur within and around the large accumulations of CWD further increasing fire hazard (photos below). In areas of the Forest that were not heavily impacted by beetles there remain moderately stocked to well stocked stands of ponderosa pine.

Photo A

Photo B

Photo C

Photo D

Vegetation

The ponderosa pine cover type dominates the landscape. Also interspersed throughout the project area are Quaking Aspen, Bur Oak, Paper Birch, and White Spruce. As a result of fire exclusion and past management activities, ponderosa pine has encroached on the non-forested communities, contributing to the reduction in size of the hardwood cover type and meadows. This also created dense, closed canopy ponderosa pine stands, prior to the mountain pine beetle epidemic. In light of the recent mountain pine beetle activity within and adjacent to the project area, changes have been seen in the fuels profile. Impacted trees are losing their needles, decomposing, and breaking off or falling to the ground increasing the surface fuel loading. Surface fuels include duff, small woody debris, dead down logs and long needle litter. Isolated areas of storm damage, and slash from past management activities also exist within the project area.

Mountain pine beetle damage will continue to alter several stand characteristics including canopy fuels, down woody fuels, duff, ladder fuels, herbaceous fuels, and microclimate, in turn altering the fire hazard and potential fire behavior. The potential for crown fire will be reduced without as many closed canopy stands, but as a result of the increased surface fuel loading, more of the Black Hills is available for, and may potentially be affected by, large, intense wildland fires.

Vegetation Species Distribution:

Table 2: Dominant vegetation – all management areas combined

Dominant vegetation	Acres	Percent
Meadow	4,269	0.39%
Grassland	71,038	6.47%
Shrubs	4,662	0.42%
Quaking aspen	39,963	3.64%
Bur oak	13,212	1.20%
Ponderosa pine	848,322	77.23%
Mixed pine and aspen	56,512	5.14%
Mixed pine and oak	28,049	2.55%
Paper birch	4,248	0.39%
White spruce	24,289	2.21%
Other	3,861	0.35%
Total	1,098,425	100.00%

Fire Regime and Condition Class

Historically, fires burned more frequently and were less severe, with ignitions caused by both lightning and humans. This promoted fire tolerant species of vegetation and controlled regeneration of those species, maintained an open forest structure, reduced biomass, decreased the impacts of insects and disease, and maintained wildlife habitats for many species that utilize open stand structures (Graham, McCaffrey, & Jain, 2004). However, during the early 1900s the focus became aggressive fire suppression and prevention. Fire suppression, grazing, and intensive forest management have trended the forest outside historic ranges, creating uniformly stocked landscapes with numerous even aged stands, many of which are densely stocked or contain dense understories of regeneration (Hunter et al., 2007). This has lead to wildfires of increased severity and higher susceptibility of stands to mountain pine beetle outbreaks.

Fire regimes characterize the role fire plays in an ecosystem in the absence of modern human intervention but take into account possible influence from aboriginal fire use (Barrett et al., 2010). Descriptions of fire regimes are done at a coarse scale because of the enormous variability of fire over time and space. Currently, there are three general types of fire regimes in the Black Hills (USDA Forest Service, 2005). Condition class describes the degree to which the composition and structure of vegetation has departed from historical fire regimes. Fire regimes have 3 condition classes which describe current vegetation conditions within the fire regime groups. The risk of loss of key ecosystem components from wildfires increases from condition class 1 (low) to condition class 3 (high). The fire regime condition class rating can be used to describe the degree of departure from the historic fire regime (reference conditions), possibly resulting in changes to key ecosystem components such as vegetation characteristics, fuel composition, fire frequency, severity, pattern, and other associated disturbances, such as insect and disease mortality, grazing, and drought (Barrett et al., 2010). Table 3 below describes each fire regime followed by a typical stand structure for each condition class.

Table 3: Fire Regimes in the Black Hills (FEIS)

	General Characteristics	Major Controlling Variables	Distribution
Frequent, Low-Severity Fire Regimes	Fires recur within any stand at relatively short intervals (10 - 50 years), burning at low severity in the canopy and soil, and variable severity in the understory	***Weather*** (fires occur during dry periods), ***Climate*** (extensive fires tend to occur in dry years that follow 1- 3 wet years), and ***Fuels*** (fuels gradually accumulate during the intervals between successive fires)	Evidence of surface fire in ponderosa pine forests throughout the Black Hills, most frequent at the Prairie-Forest ecotone and less frequent in interior forests at mid to high elevations (Fisher et al. 1987, Brown and Sieg 1996, Brown and Sieg 1999, Brown et al. 2000, Wienk 2001, Brown 2003, Wienk et al. 2004).
Infrequent, High-Severity Fire Regimes	Fires recur within any stand at long intervals (100 – 500+ years), burning at high severity in the canopy and understory, and at variable severity to the soil	***Weather*** and ***Climate*** are the primary controllers (most ignitions extinguish by themselves because of wet conditions; extensive fires occur only in very dry summers; variability in fuels usually has little influence on fire frequency, extent, or severity)	Large areas of even-aged and dense forest and of closed canopy, mature or old-growth forest at the time of settlement are evidence of stand-replacing disturbance (Graves 1899, Shinneman and Baker 1997).
Mixed Severity Fire Regimes	These fire regimes are intermediate between the Frequent, Low- Severity and the Infrequent, High- Severity Fire Regimes. Fires occur at variable intervals (10 - >100 years), and burn at variable severity (patches of high severity intermingled with patches of low or intermediate severity)	***Weather***, ***Climate***, and ***Fuels*** all influence fire frequency, extent, and severity, in complex ways that are not well understood, with enormous variability over time and space	Proposed as the dominant model for fire regimes in ponderosa pine forests of the Black Hills. Under this model, surface fire forms the background process creating forest structure and landscape pattern. However, fires sometimes burn with mixed severity, with both a surface fire and a stand-replacing fire component, and may sometimes create large areas of high severity burns. Forest patches are variable in size and within patch structure (Lentile et al. in press)

The coarse scale national data characterizes the Black Hills as primarily condition class III (Schmit, Menakis, Hardy, Hann, & Bunnell, 2002), high relative risk of significantly altering or losing key components of the ponderosa pine forest system. These conditions significantly increase the probability of a surface fire transitioning to a crown fire with increased burn severity and tree mortality. Evidence of past fires shows the potential for large, high intensity surface fires, and, given the right conditions, stand-replacing fires. Recent examples include the Jasper, Elk Mountain II, Battle Creek, Grizzly Gulch, West Hell Canyon, Ricco, Alabaugh, Whoopup, Coal Canyon, and White Draw wildland fires.

Table 4: Fire Regime Condition Class (FRCC) rating descriptions (Barrett et al., 2010).

Fire Regime Condition Class	Description
FRCC1 Low Departure (<33%) from the *central tendency of the historic fire regime.	• Fire regimes are within the historical range. • Risk of losing key ecosystem components is low. • Vegetative attributes are intact and functioning within the historical range.
FRCC2 Moderate Departure (33-66%) from the *central tendency of the historic fire regime.	• Fire regimes are moderately altered from their historical range. • Risk of losing key ecosystem components is moderate. • Vegetation attributes have been moderately altered from their historical range. • Fire frequencies have departed from natural frequencies by one or more return intervals, resulting in changes to fire size, intensity, severity, and landscape patterns.
FRCC3 High Departure (>66%) from the *central tendency of the historic fire regime.	• Fire regimes are significantly altered from their historical range. • The risk of losing key ecosystem components is high. • Vegetation attributes have been significantly altered from their historical range. • Fire frequencies have departed from historical frequencies by multiple return intervals, resulting in dramatic changes to fire size, intensity, severity, and landscape patterns.

- Central tendency refers to a composite estimate of vegetation characteristics including: species composition, structural stages, stand age, canopy closure, and mosaic pattern; fuel composition; fire frequency, severity, and pattern; and other associated natural disturbances.

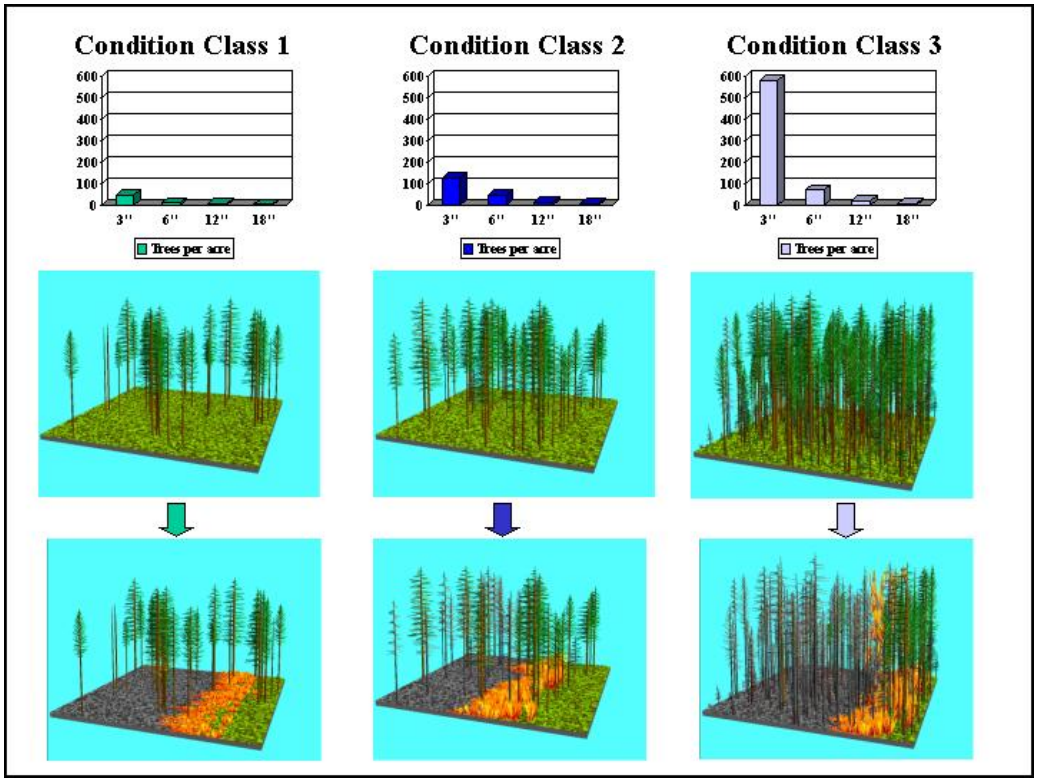


Figure 1: Typical stand structure for each Fire Regime Condition Class (FRCC)

Fire Risk

Fire risk applies to the probability of an ignition occurring as determined from historical fire record data. Fire history occurrence of both large and point fires were analyzed using the entire 1.2 million acres of the Black Hills since the proposed project area spans most of the Forest. The fire history data includes fires occurring from 1970 to present. Of the 5,738 fires that occurred, 4,038 were lightning-caused, 158 equipment-caused, 626 campfire-caused, 121 smoking-caused, 140 debris burning-caused, 75 railroad-caused, 147 arson-caused, 114 children-caused and 315 miscellaneous. Both historical fire occurrence data and large fire history (those fires exceeding 100 acres), in and around the project area are depicted. In addition, the percent of the project area impacted by large fires (greater than 100 acres) is displayed. (Figure 2, Table 5)

Table 5: Fire history occurrence and the size of the fires from 1970 to present

Fire Size Class	Fire Size (acres)	Number of Fires
A	0 – ¼	3,541
B	¼ to 9	1,978
C	10-99	149
D	100 – 299	22
E	300-999	17
F	1000-4999	15
G	5000 +	16

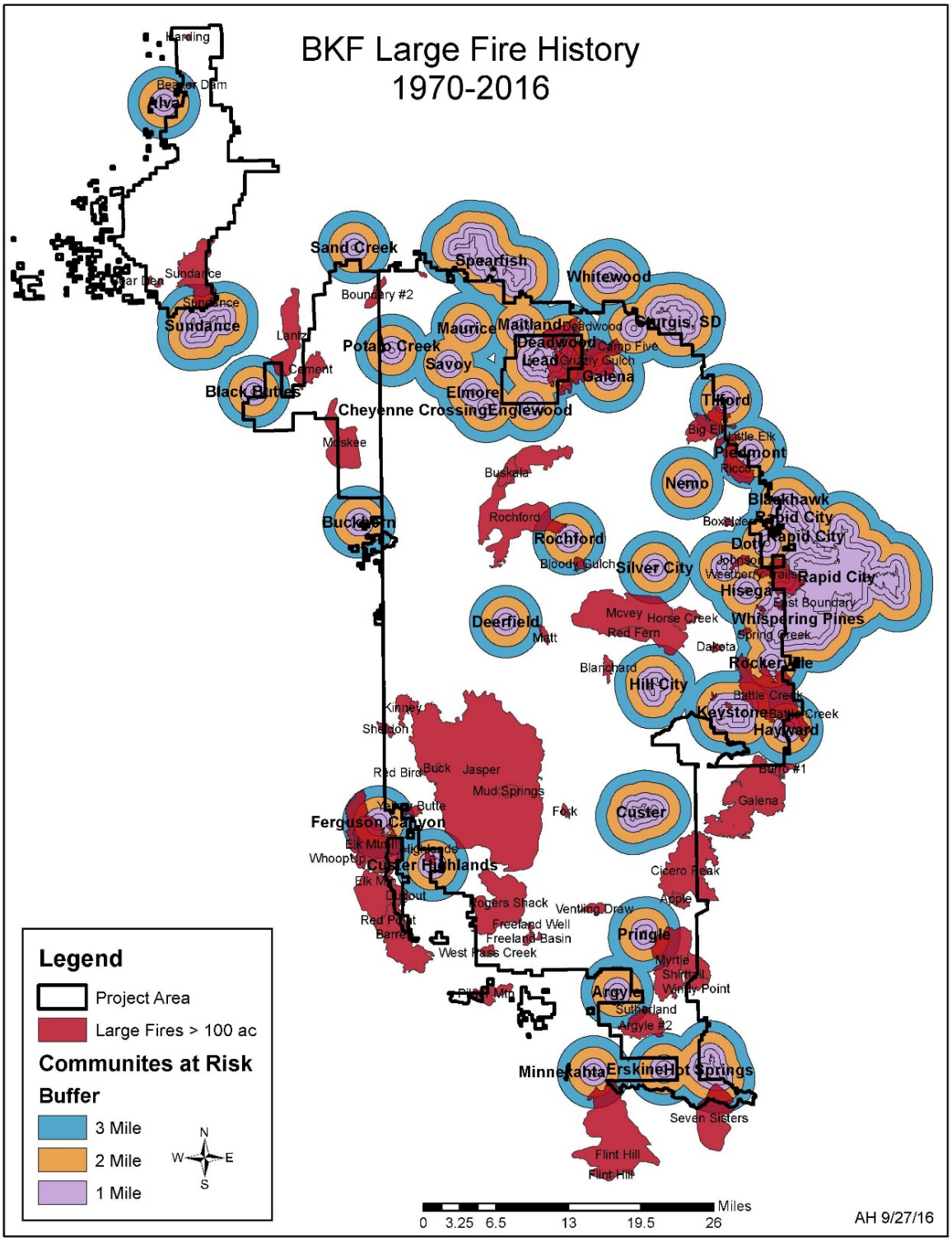


Figure 2: Large Fire History within the project area (100 acres or larger)

Table 6: Area of each large fire (1970-2016) falling within the project area

Number of Large Fires	Large Fire Acres	Percent of Project Area Impacted by Previous Large Fires	Percent of Project Area Not Impacted by Previous Large Fires
70	241,064	22%	78%

The number of fires on the entire Black Hills National Forest system lands averages 123 per year, which remains fairly constant. The number of fires that have escaped initial attack has also remained constant. However, these escaped fires have become larger and more difficult to control with an average large fire size increasing from under 1,000 acres per fire in the early 1900's to nearly 10,000 acres per year in the last 20 years, having burned approximately 267,000 acres since 1986. This may be due largely, to drought conditions experienced from 2000-2007. Given severe fire weather conditions the average size of fires may be expected to increase due to the increased risk to firefighting personnel and limited tactical options for engaging fires in standing bug killed timber stands as well as in bug killed stands where the dead trees have fallen and significantly increased the surface fuel loading. This increased fuel loading results in increased resistance to control and makes direct attack with handtools extremely slow and difficult.

Values at Risk

Values are defined in the Forest Plan EIS (Appendix E-80) as any or all natural resource improvements, or other values that may be jeopardized if a fire occurs. There are 56 at-risk communities located within or adjacent to the Black Hills Resilient Landscapes project area. To further assess the level of wildfire risk for each community, buffer zones were created at distances of one half, one, two, and three miles around each community and supported through Community Wildfire Protections Plans. Based on county structure data from Crook, Weston, Lawrence, Pennington, Custer and Fall River Counties (Figure 3) there are approximately 29,335 structures within 3 miles of the project area. Other values at risk include commercial timber stands, public water supplies, powerlines, communication sites (cell towers, radio towers, etc), recreational sites/facilities, range improvements, investments in timber stand improvement and reforestation, wildlife habitat, including snags, forage, riparian areas, security cover, and mid to late seral ponderosa pine stands, sensitive species, as well as water, air and visual quality.

The Healthy Forests Restoration Act contains two key items relating to community wildfire preparedness. They are the definition of the elements of an *at-risk community* and the establishment of the composition of a Community Wildfire Protection Plan. All seven counties containing portions of Black Hills NFS lands currently have approved Community Wildfire Protection Plans, including Crook, Weston, Lawrence, Meade, Pennington, Custer and Fall River counties.

1. *At-Risk Community (ARC)* means an area that meets the following conditions:
    - the definition of a wildland urban interface community
    - includes an environment that is conductive of a large-scale wildland fire
    - involves a significant threat to human life or property as the result of a wildland fire

2. Community Wildfire Protection Plan is a collaborative plan for at-risk communities that:

- meets specific standards developed by Wildland Fire Leadership Council and agreed to by applicable Federal, State and local government agencies affected by its composition
- identifies and prioritizes areas for hazardous fuel reduction treatments; recommends the types and methods of treatment on Federal and non-Federal land; and includes actions that will protect 1 or more at-risk communities and essential infrastructure, and
- includes recommendations to reduce structural ignitability of public and private property throughout the at-risk community.

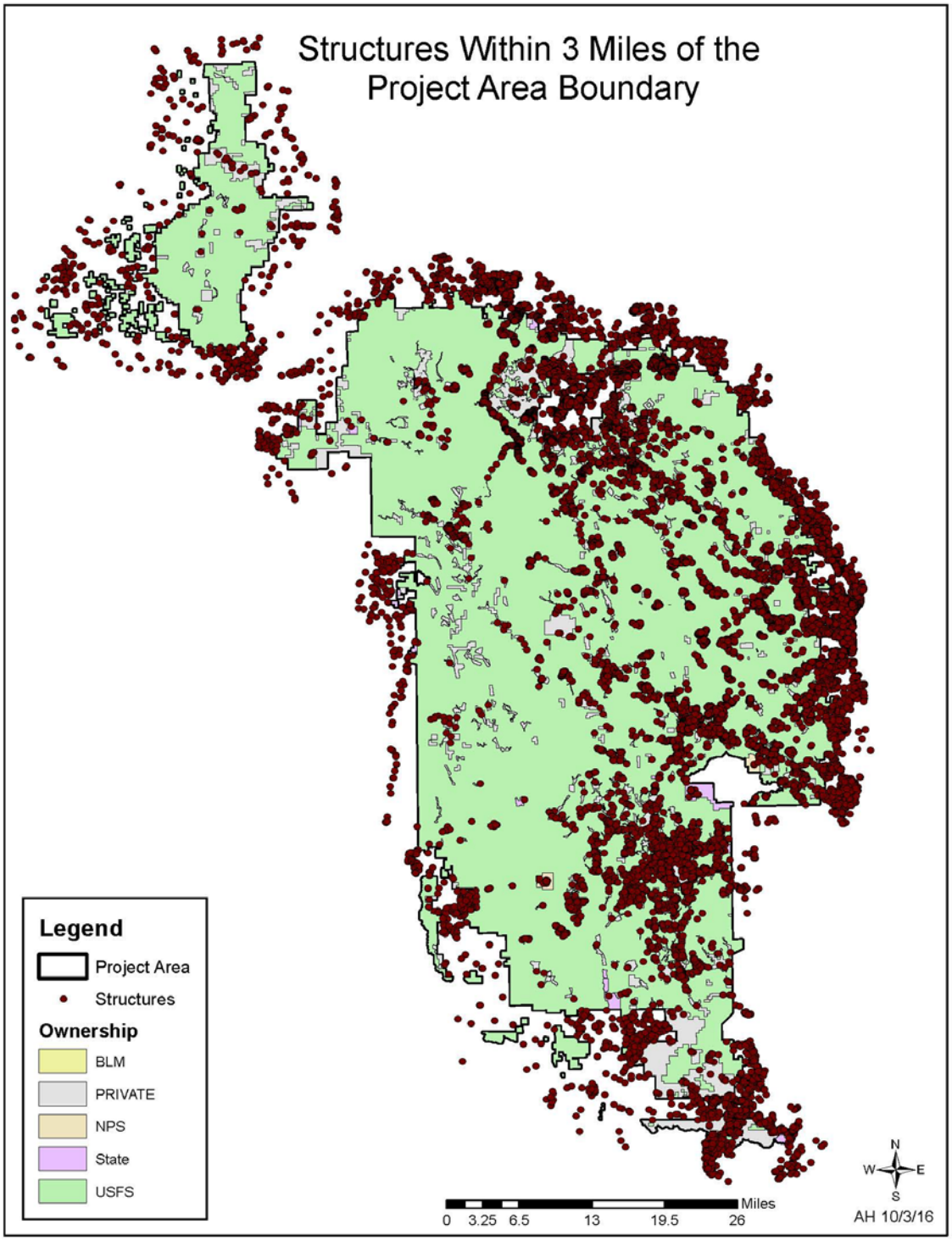


Figure 3: Structures Within 3 Miles of the Project Area

Fire Hazard

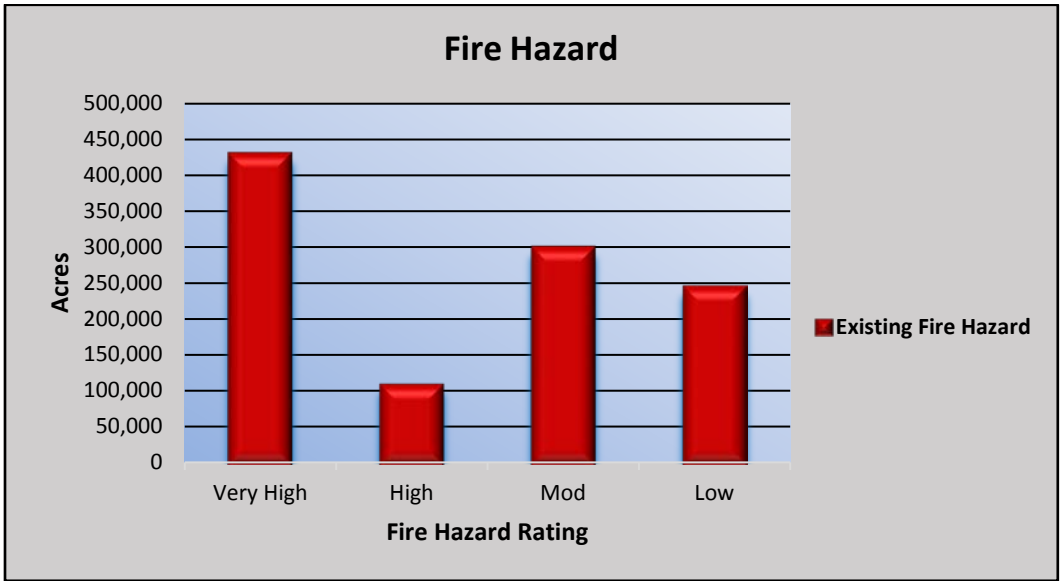
Fire hazard is defined as a fuel complex that determines the ease of ignition and the resistance to control. It is an expression of what kind of fire may potentially occur and how it affects human values. Although it's commonly thought of in terms of torching and crowning, it is also determined by rate-of-spread, intensity, spotting, resistance to control, and fire persistence. The fire hazard rating increases as the amount and continuity of surface and canopy fuels increases. As the amount of fuel on a given landscape increases and fuel profiles become more horizontally and vertically continuous, the intensity of a wildfire in that landscape is expected to increase. Areas with a high fire hazard rating have the potential to exhibit more extreme fire behavior with more severe effects than those with a low hazard rating.

The Phase II Amendment quantifies fire hazard in terms of structural stage. The structural stage gives an indication of the current fire hazard and is a stand level rating of torching and crowning susceptibility. The mountain pine beetle epidemic has altered the fuels profile across the landscape. Crown fire hazard will no longer be a concern in many stands due to lack of mature trees, however fire hazard in terms of surface fuels is a growing concern due to the large accumulation of dead, falling trees, especially in the wildland urban interface and along access and egress routes.

Table 7: Existing Fire Hazard Ratings Based on Structure Stage Data

Structural Stage	Fire Hazard Rating	Approximate Acres	% of Project Area
1 – Grass/Forb,	Low	78,567	7
2 – Shrub/Seedling	Moderate	54,640	5
3A – Sapling-pole, <40% canopy closure, 1-9" diameter	Moderate	66,009	6
3B – Sapling-pole, 40-70% canopy closure, 1-9" diameter	High	42,681	4
3C – Sapling-pole, >70% canopy closure, 1-9" diameter	Very High	23,993	2
4A – Mature, <40% canopy closure, >9" avg. diameter	Moderate	178,400	16
4A – Mature, <40% canopy closure, <9" avg. diameter	Very High	244,988	23
4A-Mature, <40%canopy closure, < or > 9" avg. diameter	High	12,290	1
4B – Mature, 40-70% canopy closure, >9" avg. diameter	High	53,070	5
4B – Mature, 40-70% canopy closure, <9" avg. diameter	Very High	92,571	9
4B – Mature, 40-70% canopy closure, < or 9" avg. diameter	Very High	6,833	1
4C – Mature, < or >70% canopy closure, < or >9" avg. diameter	Very High	56,187	5
5 – Late Successional, 16"+ diameter	Very High	4,089	1
Non-Conifer	Low	165,623	15

Graph 1: Existing Fire Hazard



Continuous aerial fuels, combined with steep and broken terrain, create the environment for a potentially fast moving stand replacing fire. Local experience has shown that continuous stands of ponderosa pine can easily support sustained runs of crown fire, either day or night, given the correct weather conditions. High fire severity is a significant threat to the existing forest resources but the real danger is to life safety. Rapidly moving fire can easily cut off escape routes for the public and emergency services. Continuous surface fuels in the form of coarse woody debris (CWD), also attribute to fire hazard. As CWD decays, the probability of a reburn is more likely due to the high fire persistence associated with it caused by smoldering. Large amounts of decaying CWD are also prone to spotting from log to log, which would result in high probabilities of ignition, even in the absence of torching trees, adding to an increased difficulty in controlling a fire. Also, with large woody fuel accumulation there is a greater chance of torching, crowning, and spotting due to the increased amount of energy released during a fire, similar to that of heavy slash burning. It's assumed that high to extreme fire hazard potential exists when downed CWD exceeds 30 to 40 tons per acre (Brown, Reinhardt, & Kramer, 2003).

Few studies have been done on fire effects in timber stands exhibiting MPB mortality. Consequently, we do not have a firm research basis on which to draw conclusions. Anecdotal evidence as well as field experience and observations are currently the best way to draw conclusions. Insect hazard closely correlates with fire hazard ratings and structural stages. As has been seen on the forest, one year post infestation, a ponderosa pine's needles will begin to fade and ultimately turn rust red by season's end (Hopkins 1905). A fading (dying) or "red top" (dead) ponderosa pine might more easily support the transition from a surface fire to the crowns due to the lack of foliar moisture present within the needles (given the correct weather conditions). The potential for crown fire may increase for this relatively short time while the needles are still attached to the tree. Needles fall from the dead tree in as little as six months or as long as two years depending on weather factors. The fire hazard, as defined by structural stage, will decrease dramatically due to the lack of crowns. With less vegetative cover, sites

become dryer due to increased solar insolation and surface winds. Grasses and forbs soon begin to be the dominant vegetation. These fine fuels would then become the primary carrier of fire depending on weather conditions, potentially increasing rates of spread. Within five years, 70-95% of the dead trees fall to the ground (Schmid, Mata, & Schaupp, 2009). The fuel profile is being changed dramatically. The potential for crown fire is disappearing in areas severely affected by the MPB. However, with the additional accumulation of fine fuels and CWD from the falling dead trees, surface fire hazard is increasing. Fuel loadings on the forest floor are increasing from the typical 5 tons/acre seen in ponderosa pine stands to up to 50-100 tons/acre in previously dense stands that were highly impacted by beetles. A fire passing through this fuel model would be resistant to control due to higher fireline intensities, flamelengths exceeding four feet (flamelengths greater than four feet require mechanized equipment) and spotting from fire brands. Resulting damage to residual trees, regeneration, and soils would most likely be severe. Photo B, shown above, is an example of CWD resulting from MPB mortality. Three 50 foot transects taken in this location revealed an average of 82 tons per acre in the stand. The optimum CWD for an acceptable fire hazard that also provides benefits to soil and wildlife in ponderosa pine stands is 5 to 20 tons per acre (Brown, Reinhardt, & Kramer, 2003). With increased sunlight and less competition, natural pine regeneration will begin to take hold, changing the fuel model once again (Photos C & D). Embers falling into the crowns of beetle attacked and killed trees or the needle litter below these trees, have a high probability of independent ignition with no additional heat source. Transition in these stands from surface to active crown fire can be extremely rapid with little change of weather and atmospheric conditions (Hoyt & Jolly, 2012).

Air Quality

Air quality within the Black Hills National Forest is addressed in the Final Environmental Impact Statement for the 1997 Revised Forest Plan. Overall, air quality within the Black Hills National Forest is very good. Air quality is better than national ambient air quality standards (NAAQS) for all pollutants.

There are two Class 1 airsheds in South Dakota, Wind Cave and Badlands National Parks. These Class 1 airsheds are also those in closest proximity to the project area. Wind Cave is located adjacent to the Black Hills National Forest to the southeast, and Badlands is located approximately 50 miles east/southeast of the project area.

A solid working relationship exists between the Black Hills National Forest and the South Dakota Department of Environment and Natural Resources. There have been few problems identified and communicated to the Black Hills National Forest regarding negative impacts to air quality relating to prescribed fire activity on the Black Hills National Forest in the last 10 years. The only case of known impacts was a short term event that lasted less than two hours.

The Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for six pollutants, called criteria pollutants, in compliance with the Clean Air Act. NAAQS include primary standards, which were established to protect public health; and secondary standards that protect public welfare. Of the “criteria” pollutants identified, one, particulate matter less than 2.5 microns in size ($PM_{2.5}$) is a primary component of smoke

emissions from wildland fires and prescribed fires. The EPA issued two standards developed for $PM_{2.5}$; an annual standard of 12 micrograms/cubic meter of air ($\mu g/m^3$), which was revised from the previous standard of 15 $\mu g/m^3$ in 2013, and a 24 hour standard of 35 $\mu g/m^{3.}$ This means that the 3-year average of the weighted annual mean concentration measured at established monitoring stations must not exceed this level. EPA established the secondary standard as equal to the primary standard.

Data from four monitoring stations in the South Dakota portion of the Black Hills are reported for $PM_{2.5}$ on EPA's Airtrends website (https://www.epa.gov/air-trends/). One of these sites meets minimum trends completeness criteria. This site is located in Jackson County, near Badlands National Monument, some 90 miles east of the town of Custer. The other three sites record data but do not meet the minimum trends completeness criteria.

South Dakota's ambient air quality monitoring network for $PM_{2.5}$ has continuously demonstrated attainment with the $PM_{2.5}$ standards. Between 2007 and 2016, monitoring stations in Custer, and Jackson, and Pennington Counties in South Dakota showed $PM_{2.5}$ concentrations averaging 4.01 $\mu g/m^3$ for the Jackson station, 3.97 for Custer station, and 6.62 for the Pennington station, based on seasonally-weighted annual averages. These measurements are well below the national average for $PM_{2.5}$ concentrations, and are also well below the primary and secondary standards for this criteria pollutant. See Appendix B for graphs of average and highest PM 2.5 concentration levels.

Air pollution in the form of PM_{10}, particulate matter smaller than 10 microns diameter, was at one time an issue in the Rapid City area. The 1996 Forest Plan EIS notes that the Rapid City area had been classified as an area not attaining the NAAQS for PM_{10} particulates. In September 2005, the State of South Dakota, Department of Environment and Natural Resources, petitioned the U.S. Environmental Protection Agency (EPA) requesting that the Rapid City area be re-designated from unclassifiable to attainment status for the PM_{10} standard. EPA published a proposed rule in the Federal Register on December 9, 2005, soliciting public comment on the proposal (70FR73183). On March 6, 2006, the EPA published a final rule approving the request from the State of South Dakota (71FR11162). The approval was based on the State's demonstration that the Rapid City area was in attainment of the PM_{10} national standard, and commitment to continuation of fugitive dust controls. The Rapid City area was officially re-designated from unclassified to attainment status for PM_{10} effective April 5, 2006.

The project area is in the vicinity of two Class 1 airsheds; Badlands National Park and Wind Cave National Park and several communities at risk (Figure 2). The project area is designated as a Class II area allowing higher concentrations of pollutants than the Class I airsheds. Smoke generated by wildfire is usually greater and cannot be mitigated; however, smoke generated under the controlled conditions, such as during a prescribed fire, can be mitigated using the following means:

- Limit treatment area size
- Specify wind directions and speed
- Specify minimum mixing heights
- Stagger ignitions

- Different lighting patterns

These design criteria techniques in addition to other control methods for smoke management minimize the impacts of smoke to visibility and human health. Smoke management and air quality is one of the required elements of the prescribed fire planning and implementation process. Prior to ignition, the Prescribed Fire Burn Boss must review the weather forecast and evaluate test fire observations to ensure the smoke emission will be in full compliance with the NAAQS.

Desired Conditions

The desired condition in the Black Hills Resilient Landscapes Project emphasizes moving landscape-scale vegetation conditions toward Forest Plan objectives in order to reduce risk of wildfire to landscapes and communities, increase ecosystem resilience to insect infestation and other natural disturbances, and contribute to public safety and the local economy. Crown fire hazard is a key component of fire hazard, especially in WUI areas. In addition, the correlation between beetle hazard and crown fire hazard is strong, with stands that have a high crown fire hazard in most cases also having a high risk for MPB activity. High levels of surface fuel loadings also are a contributor to fire hazard causing higher fire severity and greater resistance to control during fire suppression efforts. The project design would use a combination of treatments to reduce hazardous fuels thus reducing current fire hazard ratings consistent with Land and Resource Management Plan (LRMP) Objective 10-01 (to manage for 50%-75% moderate to low fire hazard within the wildland urban interface). Fuels are to be treated around all non-National Forest lands to meet standards set by National Fire Protection Association (NFPA) 1144: Protection of Life and Property from Wildfire. This is consistent with Goal 10, LRMP, Phase II.

Fuels treatments would be designed to protect values identified above. The treatments would be arranged to break up the continuity of both the surface fuel loading and vertical structure thus creating a mosaic pattern. This pattern will be especially critical in reducing the threat of a large scale stand replacement fire to communities and other values at risk. Residual crown spacing should provide open space between trees thus reducing the likelihood of a crown fire's ability to sustain itself. Treatments resulting in denser tree spacing should be isolated by stands of thinner trees to limit crown fire potential. Treatments should also be placed adjacent to natural barriers such as meadows and nonconiferous stands to maximize the effectiveness of barriers and allow for increased tactical fire management opportunities. Fuels treatments will primarily be focused on areas in the WUI, near at-risk communities and non-NFS lands, critical infrastructure, and adjacent to roads and trails, focusing first on egress routes, although they may occur in other areas following timber sales.

Environmental Consequences

Alternative A (Proposed Action)

Alternative A is designed to increase ecosystem resilience to insect infestation and other natural disturbances, contribute to public safety and the local economy, and reduce risk of wildfire to

landscapes and communities. It would move structure stages toward Forest Plan structural stage objectives which would help reduce current and potential future insect and fire hazards. Activities would also maintain and perpetuate aspen, oak, and grasslands. Activities include commercial and non-commercial treatments, mechanical fuels treatments, hazard tree removal, and prescribed burning.

Proposed fuels treatment includes mechanical fuels treatment on up to 7,000 acres per year, prescribed fire of up to 10,000 acres per year, and hazard tree removal. Mechanical fuels treatment includes fuel break construction, thinning, piling, burning piles, scattering, shredding (masticating), or chipping fuels, or lopping and scattering of activity fuels. Priority criteria for treatment include wildland-urban interface (specifically, within one-half mile of at-risk communities and within 300 feet of other private property) and areas adjacent to egress roads and critical infrastructure. Treatments in these areas would increase firefighter and public safety, create tactical fire suppression opportunities enabling more successful protection of values at risk, and provide safer egress routes in the event public evacuations were necessary.

Proposed timber treatments include overstory removal on up to 187,000 acres of SS 4A stands, precommercial and/or POL thinning on up to 25,000 acres per year to increase SS 3A and 3B to promote growth toward 4B, patch clearcuts on up to 1,300 acres in MA 4.1 and 600 acres in MA 5.6, and planting of ponderosa pine seedlings on up to 5,000 acres where large wildfires have recently occurred. Mechanical site preparation would occur in open, mature pine stands on up to 4,000 acres.

Pine and spruce removal from aspen stands would take place on up to 6,000 acres. On up to 30,900 acres of pine stands, pine and spruce would be removed from aspen inclusions. Regeneration of declining aspen stands would occur on up to 4,000 acres. Pine removal from oak stands would take place on up to 5,400 acres. Pine would be cut from encroached grasslands on up to 14,200 acres. Uneven-age management would occur on up to 10,000 acres of SS 4A stands.

Direct and Indirect Effects

The treatments proposed in Alternative A would have a significant effect on the fuels profile and potential fire behavior across the landscape. Overstory removal, uneven-age individual tree selection, precommercial thinning, POL thinning, patch cuts and pine encroachment treatment would all break up the horizontal and vertical continuity of the fuels in both ladder fuels and the canopy. This would reduce the likelihood for crown fire initiation and spread by creating openings in the canopy as well as reducing the canopy bulk density of the stand, decreasing the fire hazard associated with torching and crowning. Following thinning, there are two primary options for managing the remaining activity fuels, whole tree yarding and lopping and scattering. Whole tree yarding removes the entire tree, with the tops piled and burned when there is adequate snow cover. When lop and scatter is the method utilized, the boles are removed and the activity fuels are left and scattered across the forest floor adding to the surface fuel loading. Of the two methods, whole tree yarding contributes to reduction of surface fuels in addition to decreasing crown fire hazard, therefore this method is preferred when dealing with activity fuels.

Proposed mechanical and manual fuels treatments include fuel break construction, thinning,

piling, and pile burning, scattering, shredding or chipping fuels, and prescribed burning (broadcast). In areas that were thinned, residual slash would be piled and burned at a later date. This would break up vertical continuity, and reduce surface fuel loadings which would decrease torching, crowning and spotting potential, reduce flamelengths, fireline intensity, and resistance to control in the event a wildfire occurred. Shredding and scattering surface fuels with a masticator, or chipping fuels, modifies the vertical and horizontal distribution of fuels. It compacts fuels and makes it more difficult for a fire to move from the surface into the crowns of trees. It would reduce rates of spread, spotting potential, flamelength, fireline intensities, duration, crown fire potential, and resistance to control. These types of treatments would move the CWD toward the optimum range of 5-20 tons per acre, which would represent moderate to low fire hazard. Broadcast burning would also reduce surface fuel loadings and CWD. It would raise canopy base heights, reduce seedling and sapling densities, and help mature trees become more resilient to future fires. While thinning will decrease the likelihood of crown initiation, thinning that is not followed by reduction of surface fuels, such as whole tree yarding, prescribed burning, or both won't be as effective at decreasing potential fire intensity or severity.

Post treatment fire behavior is expected to be low to mixed severity surface fire with isolated pockets of group torching, especially in areas that have been whole tree harvested or where thinning was followed by prescribed burning. This would create more strategic and tactical firefighting opportunities resulting in greater success during initial attack, increased firefighter and public safety, reduced wildfire risk to communities, wildland urban interface (WUI), and natural resources, as well as lower suppression costs. In addition a change in FRCC can be expected moving from a FRCC 3 to a FRCC 2. Where multiple treatments are occurring, such as thinning followed by prescribed burning, a FRCC 1 may be the result. This would create a landscape that is more resilient to future disturbance events such as wildfire or insects.

Table 8: Principles of Fire-Resilient Forests (Graham, McCaffrey, & Jain, 2004)

Objective	Effect	Advantage	Concerns
Reduce surface and ladder fuels	Reduces potential flame length	Fire control easier, less torching	Surface disturbance less with fire than other techniques
Increase canopy base height	Requires longer flame length to ignite tree crowns	Less torching	Opens understory, may allow surface wind to increase
Decrease crown density	Makes independent crown fire less probable	Reduces crown fire propagation	Surface wind may increase, surface fuels may be drier
Increase proportion of mature fire-resilient tree species	Thicker bark, taller crowns, higher canopy base height	Increases survivability of trees	Removing smaller trees is sometimes problematic

Road construction and maintenance, associated with timber sales, would create better access for fire suppression activities in the event a wildfire occurs in that area. Hazard tree reduction is a proposed treatment in areas with heavy beetle infestation, where the dead standing trees are threatening structures, private property, critical infrastructure, or open roads or trails. This treatment will reduce the threat of falling trees to the public and private landowners.

In the grass fuel model, fires will still have the potential for high rates of spread due to less canopy cover resulting from MPB caused mortality and thinning. Grass production will increase as well as the potential for higher winds moving across the landscape through open stands. The reduced canopy cover will also enable fuels on the surface to receive more sunlight and become drier.

Post treatment fuel models will be best represented by GR4, TL8, and SB1. Fuel model GR4 is a moderate load, dry climate grass fuel model. TL8 is moderate load long-needle pine litter. SB1 is light dead and down activity fuel.

Table 9: Alternative A-Fire Behavior Outputs (Behave Plus 5.0.5)

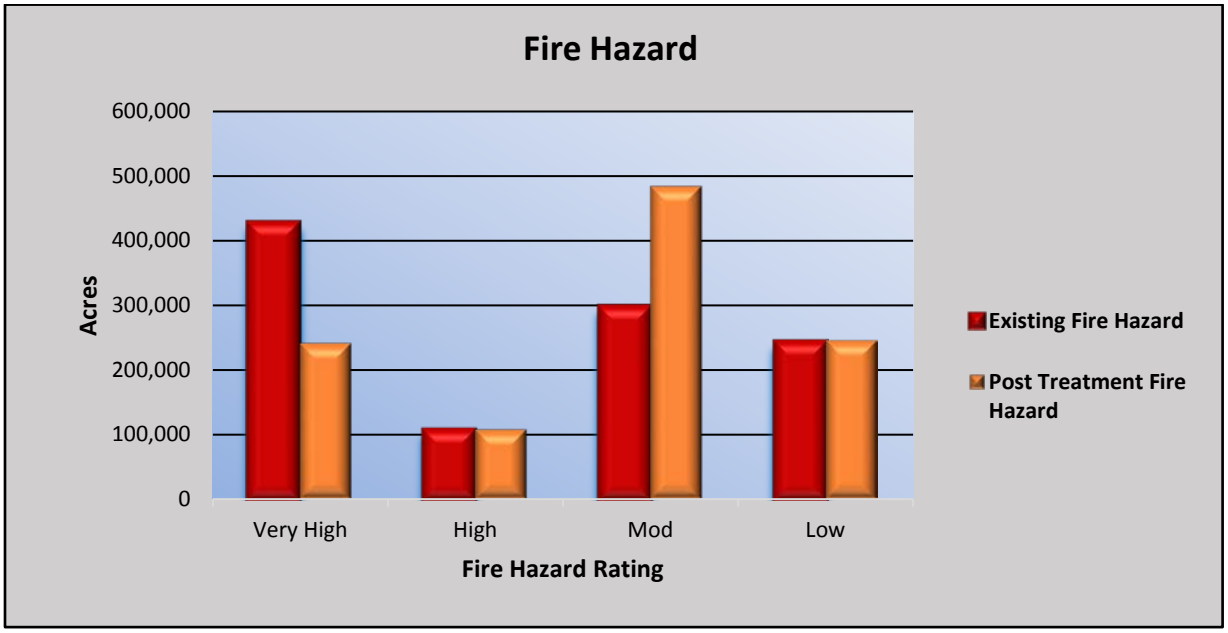
Pre-treatment Fuel Model	Flamelength (ft)	Fireline Intensity (btu/ft/sec)	Post-treatment Fuel Model	Flamelength (ft)	Fireline Intensity (btu/ft/sec)
SB3	9.6	774	SB1	3.2	73
SH5	16.1	2373	TL8	3.6	91
GR4	9.8	819	GR4	9.8	819

*Based on 90th percentile weather data from Fire Family Plus 4.1

Table 10: Existing and Post Treatment Fire Hazard Ratings

Fire Hazard Rating	Existing Acres (Approximate)	% of Project Area	Post-treatment Acres (Approximate)	% of Project Area
Very High	428,661	40	167,974	22
High	108,041	10	104,821	10
Moderate	299,190	28	355,817	45
Low	244,190	23	469,729	23

Graph 2: Alternative A-Fire Hazard Rating



Prescribed burning, regardless of whether pile burning or broadcast burning, would affect air quality. The main pollutants that would be emitted include: $PM_{2.5}$, PM_{10}, carbon monoxide and volatile organic compounds. PM_{10} emissions may also be present resulting from logging operations, log hauling and road construction/reconstruction or rehabilitation. Dust may also be generated through timber harvest activities adding fine particulate emissions locally.

Smoke generated from prescribed burning may affect visibility and air quality, and may be noticed by nearby residents, recreational users, adjacent communities, and perhaps in sensitive areas such as the Class 1 airsheds in Wind Cave or Badlands National Parks depending on transport wind direction and mixing heights. Of the six criteria air pollutants identified by the EPA, particulate matter with diameters less than 2.5 microns ($PM_{2.5}$) is the pollutant of greatest concern. Most of the mass of wildfire smoke (80-90%) falls into the $PM_{2.5}$ classification. A 1997 amendment to the Clean Air Act established a national goal of prevention of any future and remedying of any existing impairment of visibility in mandatory Class 1 federal areas where impairments result from human caused pollution.

Fire intensities and fuel consumption are expected to be lower during prescribed fire than during a high intensity wildfire because a significant amount of biomass will be utilized as part of commercial harvest activities. This results in short-term emissions to the atmosphere, with generally low concentrations of pollutants that dissipate fairly quickly.

Any prescribed burning is subject to prescriptive elements as defined in an approved Prescribed Fire Plan. These prescriptive elements may include mixing height, transport windspeed and direction as well as the adjective smoke dispersal forecast. Monitoring of potential smoke impacts occurs at different levels during prescribed burning activities and may include on-site air monitoring stations, ocular estimation of visual smoke impacts or referencing of air monitoring

sites at Wind Cave or Badlands National Parks or the monitoring site in Rapid City, SD. Secondly, the prescribed burn planning process itself incorporates the Interagency Prescribed Fire Planning and Implementation Procedures Guide (April 2014) and undergoes technical review prior to Line Officer review and approval. Potential short-term effects would be minimized by project design criteria and by following applicable smoke permit conditions identified in the appropriate State Implementation plans. Public notification procedures prior to initiating a prescribed fire project would be specified in the approved burn plan. Weather forecasts are requested through the National Weather Service and are one of the primary factors when making the decision to proceed with ignition.

Effects of treatment would be visible for approximately 10 years. Beyond that, resistance to control would increase as the pine regeneration grows more quickly filling in the open areas where the canopy has been opened up as well as where mechanical site preparation occurred. Surface fuels would also once again accumulate. If wildfire occurred in the next 10 years, mortality in the regeneration could be high, but later in the life of the stand, the effects of a fire would be less as the fire resistance of pine regeneration increases (Battaglia, Smith, & Shepperd, 2008). Consecutive treatments would maintain treatment effectiveness characterized by an FRCC close to historical conditions with low intensity mixed severity wildfires. Without consecutive treatments, in 20 years, fire behavior would increase due to an increase in ladder fuels enabling torching and crown fire initiation to contribute to fire spread.

Alternative A would meet the Forest Plan Goal 10 by establishing and maintaining a mosaic of vegetative conditions to reduce occurrences of large-scale, high intensity fire, insect, and disease events, and facilitate insect and disease management and firefighting capabilities. It will also meet Goal 11 by enhancing or maintaining the natural rate of recovery after significant fire or other natural events while maintaining a mosaic of fuel-loading conditions to facilitate future fire suppression activities. In addition, it would meet the intent of Standard 4103 by utilizing prescribed fire to achieve management objectives for specific management areas and 4105 by using broadcast burning to dispose of slash in order to return the inorganic and organic chemicals in the foliage and small woody material to the soil, to reduce fire hazard, and to provide seedbeds for natural regeneration.

This alternative would meet the intent of the National Cohesive Wildland Fire Management Strategy by helping to restore and maintain landscapes so they are resilient to fire-related disturbances, creating fire adapted communities, and making wildfire response safer, more effective and more efficient. It would also meet objectives of CWPPs.

Alternative B (No Action)

The no action alternative assumes that none of the vegetation management proposed in this analysis would take place within the project area, however other ongoing and planned activities would still occur. Fire suppression would continue to be practiced. The only other changes that would occur on the landscape would be those changes that occur as a result of natural occurrences including Mountain Pine Beetle activity, wildland fire or those resulting from other project decisions.

Direct and Indirect Effects

Change towards desired conditions as outlined in the Forest Plan (USDA Forest Service 2006a) would not occur. Fuels would not be altered in order to move the landscape toward being more resilient to future disturbance. The wildfire hazard to at-risk communities, WUI, and natural resources would not be reduced. Objectives presented by the Healthy Forests Restoration Act, National Fire Plan, and the affected Community Wildfire Protection Plans would not be met. Fire exclusion would continue, furthering the departure from historic fire return intervals.

The current mountain pine beetle outbreak is expected to run its course by 2019. Crown fire potential could increase in the short term as needles go from green to the red stage in newly impacted stands. In a laboratory study done by the Rocky Mountain Research Station, it was determined that ignition rates were faster for the red needles than healthy green needles due to their lower foliar moisture (Jolly et al., 2012). Within 3-5 years following beetle caused mortality, 70%-90% of a stand is expected to be on the ground (Schmid et al., 2009). In many stands this has already taken place. In others it will continue as newly infested trees die. Without treatment, surface fuel accumulation will increase greatly due to the additional CWD from broken and fallen trees as well as fine fuels from the trees during the early stages of mortality (fuel model SB3). In stands hit heavily by MPB the resulting fuel loadings may be 50-100 tons per acre. Due to the reduction in overstory, grass production will increase (fuel model GR4) followed later by prolific regeneration of pine seedlings. When ponderosa pine regenerates itself in the Black Hills, it often grows like “dog hair” (overstocked with saplings) and can burn like a shrub (fuel model SH5). Fire hazard in terms of torching and crowning as well as surface fire hazard determined by rate-of-spread, fireline intensity, spotting, resistance to control, and fire persistence would increase across the project area. If a fire burns through the heavy dead and down fuel, the high resistance to control would be due to high fireline intensities, flamelengths greater than 4 feet, and log to log spotting from firebrands. With the open canopy, windspeeds are likely to increase throughout the forest. The complex fuels arrangements will create an environment conducive to fast moving, high intensity, long duration wildfires that would result in a greater likelihood of increased risk of loss to private property, communities, natural forest resources, and threaten firefighter and public safety. Residual trees, regeneration, and soils would be greatly impacted as well. Refer to Appendix A, for Forest Vegetation Simulator images of wildfire in 3C, 4A, and 4C stands, and prescribed fire.

In areas of the forest, with little to no MPB mortality, tree densities and canopy cover would continue to increase, as would ladder fuels, leading to an increased torching and crowning hazard. The ultimate result in many areas would be even-aged, dense stands of ponderosa pine creating an environment conducive to large severe fires and MPB outbreaks. When untreated stands are impacted by MPB and deteriorate to where the surface fuel loading may be in excess of 40-50 tons per acre, coupled with future prolific regeneration, increased fire potential may exist well into the future.

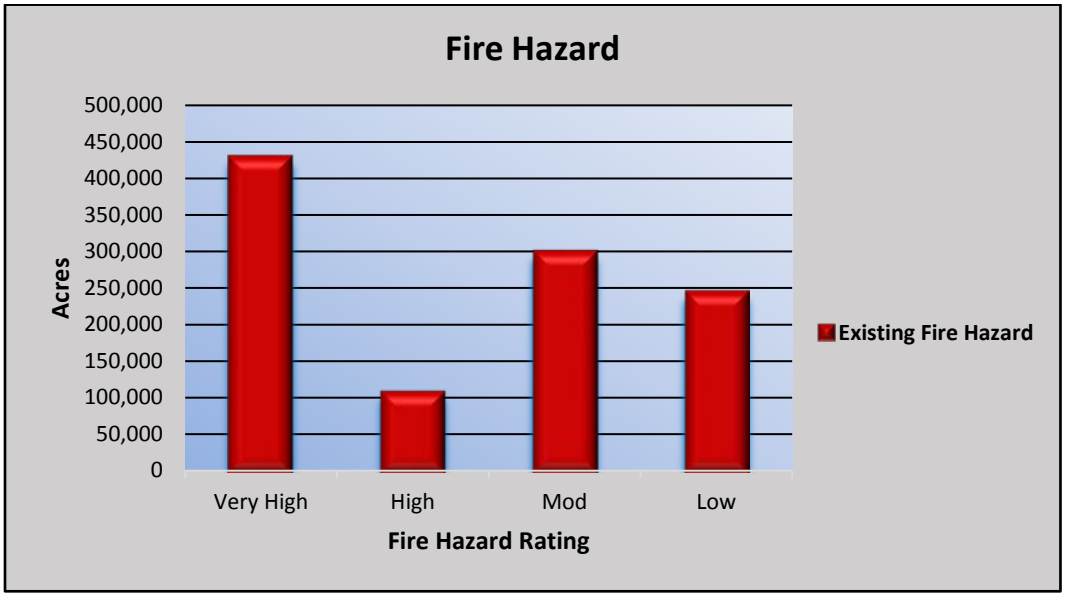
Representative fuel models would be GR4, SH5, and SB3. Fuel model GR4 is a moderate load, dry climate grass fuel model. SH5 is high load, dry climate shrub (representative of pine regeneration 4-6 feet tall). SB3 is heavy dead and down activity fuel or moderate blowdown (representative of CWD).

Table 11: Alternative B Fire Behavior Outputs (Behave Plus 5.0.5)

Fuel Model	Flamelength (ft)	Fireline Intensity (btu/ft/sec)
GR4	9.8	819
SH5	16.1	2,373
SB3	9.6	774

*Based on 90th percentile weather data from Fire Family Plus 4.1

Graph 3: Alternative B-Fire Hazard Rating



Fire risk would increase with more people and resulting infrastructure moving into the WUI. As fire hazard and risk increase, the potential for a large stand replacing fire event would become more likely. Continuous stands of ponderosa pine would become denser and surface fuel loadings high creating the opportunity for human caused wildfires to increase. Damage to forest resources would correspond with fire size, intensity, and severity. Values-at-risk in the WUI would also be threatened to a higher degree. The threat to life safety of the public and emergency services personnel would become more of an issue. The ability to safely engage a fire during high fire danger would become more difficult as time passes.

Although air quality would not be directly impacted under the no action alternative, there would not be any control over the timing or amount of emissions released into adjacent airsheds in the event of a wildfire. A large wildfire has the potential to make a much greater impact on adjacent communities and Class 1 airsheds. The EPA addresses smoke from wildland fire under their natural events policy at https://www.epa.gov/natural-disasters.

Cumulative Effects

In the Black Hills Resilient Landscapes Project area past, present and reasonably foreseeable future actions as well as the MPB, past drought effects, and wildfires contributed to changes in fuel conditions and profiles. Past management activities may have created situations that could have increased and/or decreased the risk of large scale high intensity wildland fires. For example, wildfire suppression can lead to an accumulation in down and dead fuels, increased stocking levels and an increase in ladder fuels, which all lead to an increase in fire hazard. Had fires been allowed to spread across the landscape unchecked, instead of being aggressively suppressed over the last 100 years, stands would have burned at more frequent intervals with expected lower intensities resulting in fire adapted ecosystems. This, however, has not been possible due to fractured ownership patterns that include interspersed private lands and at-risk communities. In addition to fire exclusion, the recent MPB epidemic has added an even greater complexity to the fuels arrangement across the forest. There are trees in varying stages of mortality, with some just becoming red needled and others broken off and fallen to the ground. The end result of impacted stands is a heavy dead and down accumulation of surface fuels. As is already evident, in areas that were hit by MPB, the canopy becomes more open, allowing for grass production to increase and greater windspeeds to flow through the stands. Fuel conditions of today are conducive to more severe wildfires that exhibit greater resistance to control than in the past.

There are numerous examples of past, present and foreseeable management activities across the forest and adjacent to the project area that have helped to reduce the fire hazard. These include the Prairie Project, Mountain Pine Beetle Response Project, Bugtown, Vestal, Elmo, Thrall, Lightning, Rifle Pit, Doghouse, and Burner timber sales, as well as many others. Prescribed fire projects include Martin, Bitter, Picnic, Fossil, Bullock, Prairie, Lemming, Sundance, Rifle Pit, Bitter, Medicine, and Needles, as well as others. The most effective treatments with the greatest longevity are different types of thinning followed by broadcast burning. Vegetative treatments identified on state and private lands within the cumulative effects area may serve to reduce fire hazard from both crown fire and surface fire. In areas not being treated, the potential for sustained crown fire and expected fireline intensities can reasonably be expected to increase.

Wildfires will continue to occur in the future and add to the cumulative effect of any management actions that are implemented. The severity and duration of fires can be expected to increase due to accumulation of heavy down and dead surface fuels. These fuel conditions and expected fire behavior may result in forest fire suppression not being able to be achieved under certain weather conditions.

Wildland fires occurring outside of the project area and proposed treatment areas may also affect the project area when conditions allow. There are examples of fires making sustained, high intensity crown fire runs, some of which are estimated at nearly 12 miles (Jasper 2000). Although rare and requiring extreme conditions, a large scale, high intensity fire is more likely if no treatment is implemented. A fire starting in the project area under the right conditions, would not only damage or destroy improvements within a given stand, but could have the potential to burn into or affect one of the 56 at-risk communities or private property within a fairly short timeframe. A high intensity wildfire brings with it numerous risks and effects. Homes in the

path of a wildfire are perhaps the most immediately recognized value at risk, however, numerous other important values include: critical infrastructure, fish and wildlife habitat, firefighter and public health and safety, soil productivity, clean air, and functional fire-adapted ecosystems (Graham et al., 2004). Some of these values are also threatened by the secondary effects of wildfire, such as soil erosion, and the spread of exotic species (Graham et al., 2004).

The action alternative is expected to have positive long term cumulative effects to both overstory and surface fuel loadings and potential fire behavior. The proposed treatments combined with monitoring, past projects and foreseeable future projects would decrease the potential of large-scale, high intensity damage of wildfire as well as decrease fuel loadings moving the project area to a more desirable condition and a resilient fire adapted ecosystem. The proposed treatments would reduce stand density, canopy closure, and surface fuels bringing the forest back to a more historical type condition, improving condition class. Fire managers would have greater opportunities to conduct suppression activities and have a safer environment to work in. Public safety would be enhanced and communities and values easier to protect. The possibility of losing key ecosystem components would be minimized. Adjacent area projects would also have a beneficial impact on fire hazard. This would move conditions toward meeting Forest Plan Goal 10, Objective 10-01, and Objective 10-04. Treatment impacts would be evident for approximately 10 years, until regeneration has filled in under the open canopies and once again created a higher fire hazard, but at a lower rate than if no treatment had taken place. In order to maintain treatment effectiveness over time, maintenance treatments would be necessary.

The no action alternative would not reduce the buildup of fuels or return the forest structure to reference conditions. Fire hazard would increase. The condition class would not see improvement and the ecosystem would move away from becoming resilient and fire adapted. This is in conflict with Forest Plan Goal 10, Objective 10-01, and Objective 10-04.

The smoke and other emissions that may be generated by activities planned under the selected alternative may contribute to local and regional pollutant loading. The cumulative effect of pile burning activities, broadcast burning, or other planned land management activities would be short-lived and once smoke and/or dust has dissipated, the impact is over and will have no further overlap in time or space with other pollutants that are generated by non-Forest Service activities. As a result, planned land management activities (including prescribed burning) are not expected to have long term or significant impacts to National Ambient Air Quality Standards and should not contribute to significant future impairments of visibility in Class 1 airsheds.

Approved burn plans for prescribed burning use design criteria. These design criteria have proven effective over the last ten years in maintaining smoke emissions at acceptable levels, as demonstrated by State monitoring which has shown only two temporary violations of $PM_{2.5}$ standards at the monitoring site in Rapid City that may have resulted from prescribed fire activity on the Black Hills National Forest. The design criteria that have been shown to be effective in the past can be expected to be effective under the action alternative for this project as well.

Summary of Effects

Forest vegetative and fuels conditions in the Black Hills Resilient Landscapes project area would continue to deviate from their historic range under Alternative B (No Action). With the MPB epidemic, large amounts of dead, dry fuels have been and will continue to be added to an already uncharacteristic hazardous fuels condition. Wildfire hazard in the project area will continue to increase if no action is taken to modify or treat the fuels. The end result could be high intensity wildfire over much of the project area that would remove a large amount of the existing forest cover. This could cause significant negative effects to the ecosystem, area infrastructure, public and private lands, and threaten the lives of residents and firefighters.

Treatments planned in Alternative A would decrease the potential for a large-scale, high intensity wildfire by reducing fuel loadings or breaking up the continuity of existing fuels, moving the forest closer to a Condition Class 1 or 2, conditions more closely approaching the natural (historical) range of variability of vegetation characteristics relative to fuel composition, wildfire frequency, severity and pattern, and other associated disturbances. It would also create a greater diversity of stand conditions and cover types, create more strategic and tactical firefighting opportunities resulting in greater success during initial attack, increased firefighter and public safety, reduced wildfire risk to communities, wildland urban interface (WUI), and natural resources, as well as lower suppression costs. This alternative would result in a landscape that is more resilient to future disturbance events such as wildfire or insects.

Treatments would be implemented on a landscape basis and designed so that they would complement existing or natural fuel break features such as hardwood stands, meadows, private land pastures, and moister habitats.

Fire Hazard is expected to be reduced significantly with Alternative A, but conditions change quickly in a fire regime 1 forest, and fire hazard will eventually escalate post-treatment as the vegetation grows and fuels once again accumulate. However, the fire hazard in twenty years is expected to be much lower with Alternative A than the no action alternative.

Table 12: Fire Hazard Rating Summary

Fire Hazard Rating	Alternative A (proposed) Approximate Acres	Alternative B (no action) Approximate Acres
Low	246,090	244,190
Moderate	484,266	299,049
High	108,041	108,041
Very High	241,544	428,661

The action alternative would meet Forest Plan Goal 10, establishing and maintaining a mosaic of vegetative conditions to reduce occurrences of catastrophic fire, insect, and disease events, and facilitate insect and disease management and firefighting capabilities, and Standard 4103, utilizing prescribed fire to achieve management objectives. The no action alternative would not reduce the buildup of fuels or return the forest structure to reference conditions. The condition class would not see improvement and the ecosystem would move away from becoming resilient and fire adapted. This is in conflict with Forest Plan Goal 10.

Air quality would be affected by Alternative A. Smoke generated by prescribed burning can be mitigated using the methods identified in Alternative A. Smoke generated by wildfire is usually greater and cannot be mitigated.

It is important to understand that fuel treatments would not prevent wildland fires from occurring. However, with fuel treatments, the risk of an extreme wildfire event would be greatly decreased and establish breaks in fuel arrangement that provide opportunities to attack the fire, enabling firefighters to conduct effective suppression activities in a safer environment. Fuel treatments would also need to occur in adjacent planning areas in order for treatments to be more effective at the landscape scale.

Design Criteria

- Prescribed burn treatments which include burning of piled material and broadcast burning will meet with the provisions of the Clean Air Act. District personnel would monitor burn conditions, and the SASEM (Smoke Model) or equivalent program would be used to assure provisions are met. The impacts of burning on metropolitan areas such as Rapid City would be assessed at the time of burning.

  Smoke impacts would be minimized utilizing the following design criteria and are incorporated into the burn plan as appropriate:
  - Limit treatment area size
  - Specify wind directions and speed
  - Specify minimum mixing heights to ensure dispersal of emissions
  - Stagger ignitions

- Revegetation of prescribed burned areas will be promoted by:
  a) If piled and burned fuel creates ash piles deeper than three inches, scatter the ash, scarify and mix it with mineral soil, or bury it. **Guideline 4106**

- Prescribed burn plans (which includes the Forest Level III Programmatic Burn Plan for Pile Burning) will identify acceptable levels of tree mortality for seedlings/saplings, poles and sawtimber; burning prescriptions will be estimated to meet these levels. **Guideline 4108**

- Slash piles that are scheduled for burning will be located outside of meadows that contribute to Waters of the United States. Use a buffer distance designed to keep sediment, ash and debris out of channels. **Guideline 4111**

- Activity fuels will be treated along forest collector roads and forest development trails to meet the adopted Scenic Integrity Objectives (SIO). Along arterial roads, remove 70-90 percent of activity fuels up to 300 feet from roads edge. Debris piles will be burned as soon as practical after remaining on-site for at least 2 years. Where mechanical treatment and prescribed burning of piled material is proposed within the same site, mechanical treatments will be completed prior to burning.

- Reduce or otherwise treat all fuels adjacent to non-forest lands so the potential fireline intensity does not exceed 200 BTUs/second/foot on 90 percent of the days when fires occur,

or break up continuous fuel concentrations exceeding the above intensity into units 30 to 40 acres maximum size, surrounded by fuel breaks. Deadfall treatments are included in all treated sites adjacent to all non-National Forest lands.

Regulatory Framework

Land and Resource Management Plan Phase II Amendment Direction

Forest-wide goals/objectives and standards/guidelines identified for fire and fuels management in the Phase II Amendment of the Land and Resource Management Plan include Goal 2 objective 234 and Goal 10 objectives 10.01 – 10.08, Goal 11; as well as standards/guidelines 4101 - 4112. The objective of fuels treatment is to reduce fuel levels and/or redistribute it to reduce fire behavior and the risk of catastrophic, stand-replacing fire. Fuel characteristics include amount (tons per acre), size, arrangement, continuity, and moisture content. The amount of fuels remaining after treatment would vary depending on stand structure prior to treatment and what level of cutting takes place. Protecting resource values, including water quality, timber, and wildlife habitat are also included.

Goals and Objectives:

Goal 2: *Provide for a variety of life through management of biologically diverse ecosystems.*

Objective 234. *NEW. Create or maintain a moderate-to-low crown-fire hazard adjacent to occurrences of R2 sensitive [species] and species of local concern; [and] plants and botanical areas bordered by continuous, dense conifer stands where long-term persistence is at risk from a single high-intensity fire.

Goal 10: *Establish and maintain a mosaic of vegetation conditions to reduce occurrences of catastrophic fire, insect, and disease events, and facilitate insect and disease management and firefighting capability.*

Objective 10-01. *NEW Manage for 50- to 75-percent moderate-to-low fire hazard in the wild land-urban interface and reduce fire hazard within proximity of structures to current NFPA standards except in Management Area (MA) 1.1 Black Elk Wilderness, MA 2.2 Research Natural Areas, MA 3.1 Botanical Areas, MA 4.2B Peter Norbeck Scenic Byway, and MA 5.4A Norbeck Wildlife Preserve. Manage the remainder of the Forest for 50 percent moderate-to-low fire hazard except in MA 1.1 Black Elk Wilderness, MA 2.2 Research Natural Areas, MA 3.1 Botanical Areas, MA 3.7 Late-successional Forest Landscapes, MA 4.2B Peter Norbeck Scenic Byway, and MA 5.4A Norbeck Wildlife Preserve.

Objective 10-02. *NEW. The scenic integrity objectives (SIO) within the wildland-urban interface will be moderate to low for 2 to 4 years after management activities have been completed.

Objective 10-03. *NEW . Within 5 years of a formal research natural area (RNA) designation, manage for a moderate-to-low fire hazard between RNAs and at-risk communities (ARCs) and

other resources as needed where the topography, wind conditions, and fuels could create the potential for high-intensity crown-fire spread to the ARCs or resources (e.g., sensitive plants, heritage resources), except those designated in Management Area 1.1 Black Elk Wilderness.

Objective 10-04. **MOVED FROM OBJECTIVE 224**. Reduce or otherwise treat fuels commensurate with risks (fire occurrence), hazard (fuel flammability), and land and resource values common to the area, using the criteria in Forest-wide Guideline 4110.

Objective 10-05. **MOVED FROM OBJECTIVE 225**. Manage wildfires using the appropriate response based on management area emphasis, existing values, risk of ignition, and fuel hazards within a given area.

Objective 10-06. **MOVED FROM OBJECTIVE 226**. Develop fuel management and protection strategies for intermixed land ownerships in partnership with private, state, and other federal agencies.

Objective 10-07. **MOVED FROM OBJECTIVE 228**. Where outbreaks of mountain pine beetle could present risks to management objectives for ponderosa pine, reduce acreage of ponderosa pine stands that are in medium or high risk for infestation.

Objective 10-08. **MOVED FROM OBJECTIVE 229**. Using analyses of insect-and-disease occurrences prioritize suppression strategies to meet management objectives and minimize value loss of tree vegetation affected by outbreaks of insect-and-disease pests.

Standards and Guidelines:

Standard 2301. Retain all snags greater than 20-inch dbh unless a safety hazard. If snag densities within a project area are below Objective 211, retain all snags unless they are a safety hazard. If large snags (>14 in DBH) are not available, retain snags in the largest size class available. This standard does not apply to areas salvaged under Objective 11-03.

Standard 2308. During vegetation management activities on ponderosa pine forested sites, retain an average of at least 50 linear feet per acre of coarse woody debris with a minimum diameter of 10 inches. On white spruce forested sites retain an average of at least 100 linear feet per acre of coarse woody debris with a minimum diameter of 10 inches.

Standard 4101. Use the appropriate suppression response for each management area as shown in the fire management direction summary table in Chapter 2 on pages 42 and 43.

Standard 4102. Protect heritage resources, R2 sensitive species and plant species of local concern (SOLC), botanical areas (BAs), research natural areas (RNAs), streams, stream banks, shorelines, lakes and associated vegetation from degradation by wildfire suppression efforts.

a. Avoid the use of earth-moving equipment within national register eligible heritage resource sites, known locations of R2 sensitive species and SOLC plants, BAs, RNAs, or in stream channels, except at designated points and with proper mitigation. Prohibit this use in the Wilderness.

b. Discourage the application of fire-retardant chemicals over riparian areas, wetlands and open waters. Avoid applications in these areas in the Wilderness and RNAs.
c. To prevent soil erosion, re-vegetate burned areas that will not naturally re-vegetate quickly. See Management Area 1.1A for re-vegetation in the Wilderness. No re-vegetation efforts will occur within designated RNAs.

Standard 4103. Utilize prescribed fire through planned and natural ignitions to achieve management objectives for each management area as shown in the fire management direction summary table 3-46.

Standard 4104. Visual effects of prescribed fire will comply with the approved scenic integrity objective of the area.

Guideline 4105. When feasible and appropriate use broadcast burning to dispose of slash in order to return the inorganic and organic chemicals in the foliage and small woody material to the soil, to reduce fire hazard, and to provide seed beds for natural regeneration. (Amended Regional Guide Silviculture Guideline)

Guideline 4106. Promote revegetation of prescribed burned areas.
b. If piled and burned fuel creates ash piles deeper than three inches, scatter the ash, scarify and mix it with mineral soil, or bury it.

Guideline 4108. Prescribed burn plans will identify acceptable levels of tree mortality for seedling/saplings, poles, and sawtimber; burning prescriptions will be established to meet these levels. In planning prescribed burns, consider how the potential loss of trees is offset by the beneficial effects of fire in terms of overall stand health and wood fiber production. Consider value recovery if tree mortality exceeds project objectives.

Guideline 4109. Utilize the Black Hills National Forest Fire Protection Assessment (FPA) for purposes of identifying and prioritizing fire management program activities.

Guideline 4110. Base activity and natural fuel treatment on area matrix values within the Black Hills National Forest FPA in accordance with the following treatment options.
a. In areas identified as having high ratings for risk, hazard or value:
(1) Reduce or otherwise treat all fuels (activity fuels within three years of cutting) so the potential fireline intensity does not exceed 200 BTUs/second/foot on 90 percent of the days when fires occur, or break up continuous fuel concentrations exceeding the above intensity into units 30 to 40 acres maximum size, surrounded by fuel breaks.
(2) Interim activity fuel treatment will be accomplished by requiring all slash to be lopped to 18 inches or less at the time of cutting.
b. In areas identified as having moderate ratings for risk, hazard or value:
(1) Reduce or otherwise treat all fuels (activity fuels within three years of cutting) so the potential fireline intensity does not exceed 300 BTUs/second/foot on 90 percent of the days when fires occur, or break up continuous fuel concentrations exceeding the above intensity into units 40 to 50 acres maximum size, surrounded by fuel breaks.

(2) Interim activity fuel treatment will be accomplished by requiring all slash to be lopped to 18 inches or less at the time of cutting.

c. In areas identified as having low ratings for risk, hazard or value:

(1) Reduce or otherwise treat all fuels (activity fuels within three years of cutting) so the potential fireline intensity does not exceed 400 BTUs/second/foot on 90 percent of the days when fires occur, or break up continuous fuel concentrations exceeding the above intensity into units 40 to 50 acres maximum size, surrounded by fuel breaks.

(2) Interim activity fuel treatment will be accomplished by requiring all slash to be lopped to 24 inches or less at the time of cutting.

Guideline 4111. Locate slash piles that are scheduled for burning out of meadows that contribute to Waters of the United States. Use a buffer distance designed to keep sediment, ash and debris out of channels. See Appendix J.

Guideline 4112. Treat activity fuels adjacent to roads and trails as follows:

a. For Forest Development Roads classified as collectors, and Forest Development Trails, manage activity fuels to meet adopted SIO.

b. For federal, state, county and Forest Development Roads classified as arterials, remove 70 to 90 percent of the activity fuels seen from the road's edge up to a maximum distance of 300 feet. Treat debris within one year of harvest completion.

Guideline 8401. Keep natural and activity fuels to a minimum in timber stands to reduce the threat of wildfire to the public and to reduce potential fire damage to facilities.

National Fire Plan (2001)

The National Fire Plan provides fire management long term goals:

- Reduce the threat of severe, destructive fires
- Provide for safer living conditions
- Restore fire-adapted communities
- Improve the health, resilience, and sustainability of forests and grassland
- Conserve priority watersheds, species, and biodiversity
- Reduce overall wildland fire management costs

The National Cohesive Wildland Fire Management Strategy (2012)

The National Cohesive Wildland Fire Management Strategy is a strategic framework designed to coordinate multiple agency and homeowner efforts toward three goals:

1. Restore and maintain resilient landscapes
2. Create fire adapted communities
3. Ensure safe and effective wildfire response

It provides guidance for vegetation and fuels treatments and supports management options of prescribed fire, managing wildfire for resource objectives, and fuel treatment using mechanical, biological, or other non-fire methods.

- Where wildfires are unwanted or threaten communities and homes, design and prioritize fuel treatments to reduce fire intensity, structure ignition and extent.
- Where allowed and feasible, manage wildfire resources objectives and ecological purposes to restore and maintain fire-adapted ecosystems and achieve fire-resilient landscapes.
- Use and expand fuel treatments involving mechanical, biological, or chemical methods where economically feasible and sustainable, and where they align with landowner objectives.

Healthy Forests Restoration Act Title 16-Conservation 6501 (2003)

The purposes of this chapter are—

(1) to reduce wildfire risk to communities, municipal water supplies, and other at-risk Federal land through a collaborative process of planning, prioritizing, and implementing hazardous fuel reduction projects;

(2) to authorize grant programs to improve the commercial value of forest biomass (that otherwise contributes to the risk of catastrophic fire or insect or disease infestation) for producing electric energy, useful heat, transportation fuel, and petroleum-based product substitutes, and for other commercial purposes;

(3) to enhance efforts to protect watersheds and address threats to forest and rangeland health, including catastrophic wildfire, across the landscape;

(4) to promote systematic gathering of information to address the impact of insect and disease infestations and other damaging agents on forest and rangeland health;

(5) to improve the capacity to detect insect and disease infestations at an early stage, particularly with respect to hardwood forests; and

(6) to protect, restore, and enhance forest ecosystem components—

(A) to promote the recovery of threatened and endangered species;

(B) to improve biological diversity; and

(C) to enhance productivity and carbon sequestration.

Limitations and Assumptions

- All figures are approximate.
- Actual acres/miles implemented will depend on weather, funding, priorities, and other factors.
- Mapped stand boundary locations are approximate. Stand structure determinations are preliminary. Stand delineation and structure are subject to corrections based on field review.
- Fire hazard rating acre estimates under Alternative A are based on all treatments being implemented.
- Assumptions were made regarding number of treatment acres for 4A stands that fall in the moderate versus very high fire hazard categories (>9” dbh vs <9’ dbh) as well as fuel treatment location based priority areas listed above.
- The BehavePlus 5.0.5 model uses site-specific input data to predict fire behavior for a point in time and space, using weather and fuels inputs for that specific time. It predicts free burning fire at the flaming front, assuming fuels are uniform.
- Fire behavior calculations are based 90th percentile weather data from Fire Family Plus 4.1

Works Cited

Barrett, S., Havlina, D., Jones, J., Hann, W., Frame, C., Hamilton, D., Schon, K., Demeo, T., Hutter, L., and Menakis, J. 2010. Interagency Fire Regime Condition Class Guidebook. Version 3.0 [Homepage of the Interagency Fire Regime Condition Class website, USDA Forest Service, US Department of the Interior, and The Nature Conservancy]. [Online], Available: https://www.frames.gov/frcc

Battaglia, Mike A.; Smith, Frederick W.; Shepperd, Wayne D. 2008. Can prescribed fire be used to maintain fuel treatment effectiveness over time in Black Hills ponderosa pine forests? Forest Ecology and Management. 256 (12): 2029-2038.

Brown, James K.; Reinhardt, Elizabeth D.; Kramer, Kylie A. 2003. Coarse Woody Debris: Managing Benefits and Fire Hazard in the Recovering Forest. USDA Forest Service, General Technical Report RMRS-GTR-105, Rocky Mountain Research Station, Fort Collins, CO.

Graham, R.; McCaffrey, S.; and Jain, T. 2004. Science Basis for Changing Forest Structure to Modify Wildfire Behavior and Severity. USDA Forest Service, General Technical Report RMRSGTR-120, Rocky Mountain Research Station, Ft. Collins, CO.

Healthy Forests Restoration Act. 2003.

Hopkins, A.D., 1905. The Black Hills Beetle. USDA, Bureau of Entomology, Bulletin No. 56, Washington.

Hoyt, Stu, and Jolly Matt. Probability of Ignition of Mountain Pine Beetle Affected Trees. 2012

Hunter, M.E.; Shepperd, W.D.; Lentile, J.E.; Lundquist, J.E.; Andreu, M.G.; Butler, J.L.; Smith, F.W. 2007. A comprehensive guide to fuels treatment practices for ponderosa pine in the Black Hills, Colorado Front Range, and Southwest. USDA Forest Service, General Technical Report RMRS-GTR-198, Rocky Mountain Research Station. Fort Collins, CO.

Jolly, W. Matt; Parsons, Russell A.; Hadlow, Ann M.; Cohn, Greg M.; McAllister, Sara S.; Popp, John B.; Hubbard, Robert M.; Negron, Jose F. 2012. Relationships between moisture, chemistry, and ignition of Pinus contorta needles during the early stages of mountain pine beetle attack. Forest Ecology and Management. 269: 52-59.

Parsons, Russ; Jolly, Matt; Langowski, Paul; Matonis, Megan; Miller, Sue. 2014. Post-epidemic fire risk and behavior [Chapter 3]. In: Matonis, M.; Hubbard, R.; Gebert, K.; Hahn, B.; Miller, S.; Regan, C. Future Forests Webinar Series, Webinar Proceedings and Summary: Ongoing Research and Management Responses to the Mountain Pine Beetle Outbreak. Proceedings RMRS-P-70. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 19-28.

Photo Series for Quantifying Forest Residues in the Black Hills Ponderosa Pine Type and Spruce Type. 1990. USDA Forest Service. Rocky Mountain Region.

NWCG. 1998 Fireline Handbook, NWCG Handbook 3, PMS 410-1.

Scott, Joe H, and Burgan, Robert E. 2005. Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Mode. USDA Forest Service, General Technical Report RMRS-GTR-153, Rocky Mountain Research Station. Fort Collins, CO.

Scott, Joe H.: Reinhardt, Elizabeth D. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. USDA Forest Service, RMRS-RP-29, Rocky Mountain Research Station. Fort Collins, CO.

Schmid, J. M.; Mata, S. A.; Schaupp, W. C., Jr. 2009. Mountain Pine Beetle-Killed Trees as Snags in Black Hills Ponderosa Pine Stands. USDA Forest Service, Research Note RMRS-RN-40, Rocky Mountain Research Station. Fort Collins, CO.

Schmidt, Kirsten M.; Menakis, James P.; Hardy, Colin C.; Hann, Wendall J.; Bunnell, David L. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. USDA Forest Service, Gen. Tech. Rep. RMRS-GTR-87, Rocky Mountain Research Station. Fort Collins, CO.

USDA-Forest Service 2012, Calumet Environmental Impact Statement, US Department of Agriculture-Forest Service Black Hills National Forest, Custer South Dakota.

USDA Forest Service. 2006. 1997 Revised Land and Resource Management Plan for the Black Hills National Forest, as Amended by the Phase 2 Amendment. US Department of Agriculture-Forest Service, Black Hills National Forest. Custer, South Dakota. March, 2006. Available on-line at
http://www.fs.usda.gov/detail/blackhills/landmanagement/planning/?cid=STELPRDB5112303

USDA Forest Service. 2005. Final Environmental Impact Statement for the Phase 2 Amendment to the 1997 Revised Land and Resource Management Plan for the Black Hills National Forest. US Department of Agriculture-Forest Service, Black Hills National Forest. Custer, South Dakota. October, 2005. Available on-line at
http://www.fs.usda.gov/detail/blackhills/landmanagement/planning/?cid=STELPRDB5112303

USDA Forest Service. 2005. Record of Decision for the Phase 2 Amendment to the 1997 Revised Land and Resource Management Plan for the Black Hills National Forest. US Department of Agriculture-Forest Service, Black Hills National Forest. Custer, South Dakota. October, 2005. Available on-line at
http://www.fs.usda.gov/detail/blackhills/landmanagement/planning/?cid=STELPRDB5112303

USDA Forest Service. 1996. Final Environmental Impact Statement for the Revised Land and Resource Management Plan for the Black Hills National Forest. US Department of Agriculture-Forest Service, Black Hills National Forest. Custer, South Dakota. December, 1996. Available on-line at
http://www.fs.usda.gov/detail/blackhills/landmanagement/planning/?cid=STELPRDB5112303

USDA Forest Service; US Department of the Interior. 2001. National Fire Plan. A report to the President in response to the wildfires of 2000, Sept. 8, 2000: managing the impact of wildfires on communities and the environment. Washington, DC.

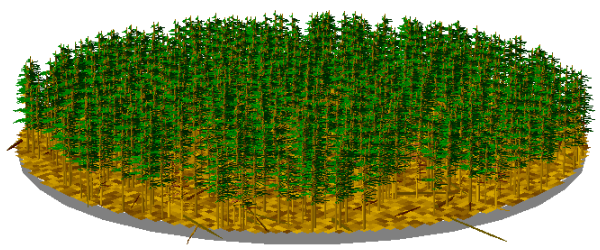
USDA-Forest Service 2011, Vestal Environmental Impact Statement, US Department of Agriculture-Forest Service Black Hills National Forest, Custer South Dakota.

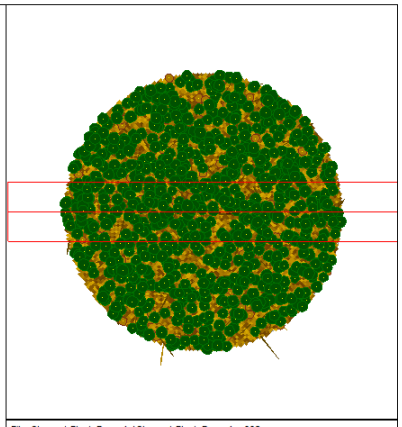
Wildland Fire Leadership Council. 2012. A National Cohesive Wildland Fire Management Strategy. Available on-line at https://www.forestsandrangelands.gov/strategy/index.shtml

Appendix A-Forest Vegetation Simulator (FVS) runs

3C stand-preburn, during wildfire, postburn, and 10 years postburn:

Stand=0203060908020027 Year=2050 Beginning of cycle Clearcut-Plant_Burn_1a_006.svs





File: Clearcut-Plant_Burn_1a\Clearcut-Plant_Burn_1a_006.svs

Summary is for all species

Tree list summary:

Origin: (0.0,0.0)
Size: 235.5 by 235.5 (1.00 acres)
Units: ENGLISH

Total objects: 1071 (1071 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	5.6	0.5	3.8	6.8
ht	26.7	1.1	22.0	29.0

Basal area: 147.8 (147.8 per acre)
Number of trees: 842 (842 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	3.9	0.9	0.6	5.0
ht	16.7	4.0	2.0	19.0

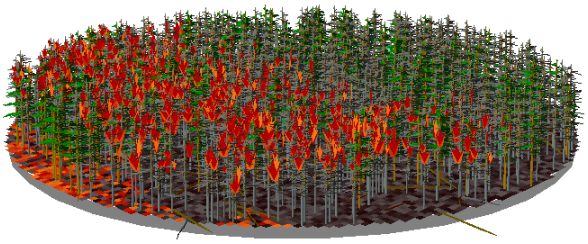
Basal area: 9.7 (9.7 per acre)
Number of trees: 109 (109 per acre)

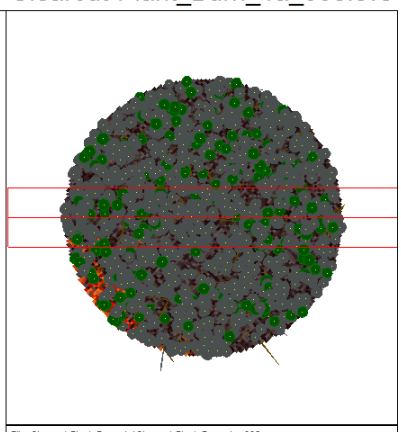
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	5.4	3.4	0.9	12.0
length	15.4	6.3	4.0	24.0

Number of logs: 120 (120 per acre)

Stand=0203060908020027 Year=2050 During the fire (02/03) Clearcut-Plant_Burn_1a_008.svs





File: Clearcut-Plant_Burn_1a\Clearcut-Plant_Burn_1a_008.svs

Summary is for all species

Tree list summary:

Origin: (0.0,0.0)
Size: 235.5 by 235.5 (1.00 acres)
Units: ENGLISH

Total objects: 1713 (1713 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	5.7	0.6	4.1	6.6
ht	26.7	1.1	22.0	29.0

Basal area: 28.9 (28.9 per acre)
Number of trees: 164 (164 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	5.4	0.8	0.6	6.8
ht	25.3	3.9	2.0	28.0

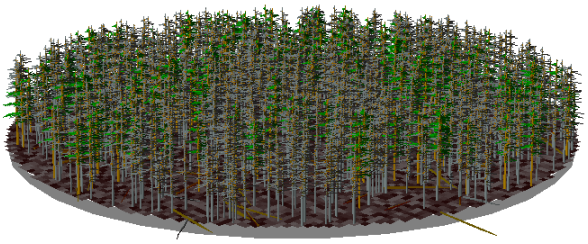
Basal area: 128.5 (128.5 per acre)
Number of trees: 787 (787 per acre)

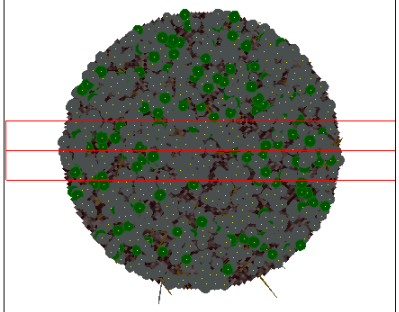
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	4.9	3.0	0.9	12.0
length	15.7	6.5	4.0	24.0

Number of logs: 107 (107 per acre)

Stand=0203060908020027 Year=2050 After the fire (03/03) Clearcut-Plant_Burn_1a_009.svs





File: Clearcut-Plant_Burn_1a\Clearcut-Plant_Burn_1a_009.svs

Summary is for all species

Tree list summary:

Origin: (0.0,0.0)
Size: 235.5 by 235.5 (1.00 acres)
Units: ENGLISH

Total objects: 1058 (1058 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	5.7	0.6	4.1	6.6
ht	26.7	1.1	22.0	29.0

Basal area: 28.1 (28.1 per acre)
Number of trees: 159 (159 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	5.4	0.8	0.6	6.8
ht	25.3	3.9	2.0	28.0

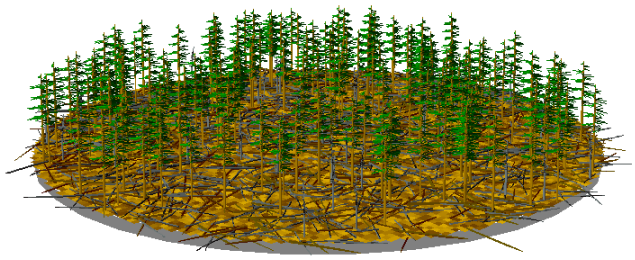
Basal area: 129.4 (129.4 per acre)
Number of trees: 792 (792 per acre)

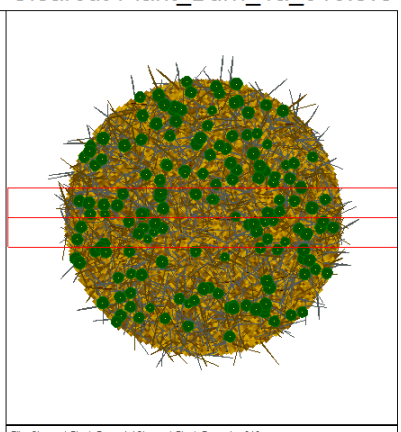
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	4.9	3.0	0.9	12.0
length	15.7	6.5	4.0	24.0

Number of logs: 107 (107 per acre)

Stand=0203060908020027 Year=2060 Beginning of cycle Clearcut-Plant_Burn_1a_010.svs





File: Clearcut-Plant_Burn_1a\Clearcut-Plant_Burn_1a_010.svs

Summary is for all species

Tree list summary:

Origin:	(0.0,0.0)
Size:	235.5 by 235.5 (1.00 acres)
Units:	ENGLISH

Total objects: 1647 (1647 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	6.5	0.7	4.4	7.7
ht	34.2	1.7	29.0	37.0

Basal area: 37.2 (37.2 per acre)
Number of trees: 159 (159 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	5.4	0.7	2.1	6.8
ht	20.6	3.1	3.0	23.0

Basal area: 7.9 (7.9 per acre)
Number of trees: 48 (48 per acre)

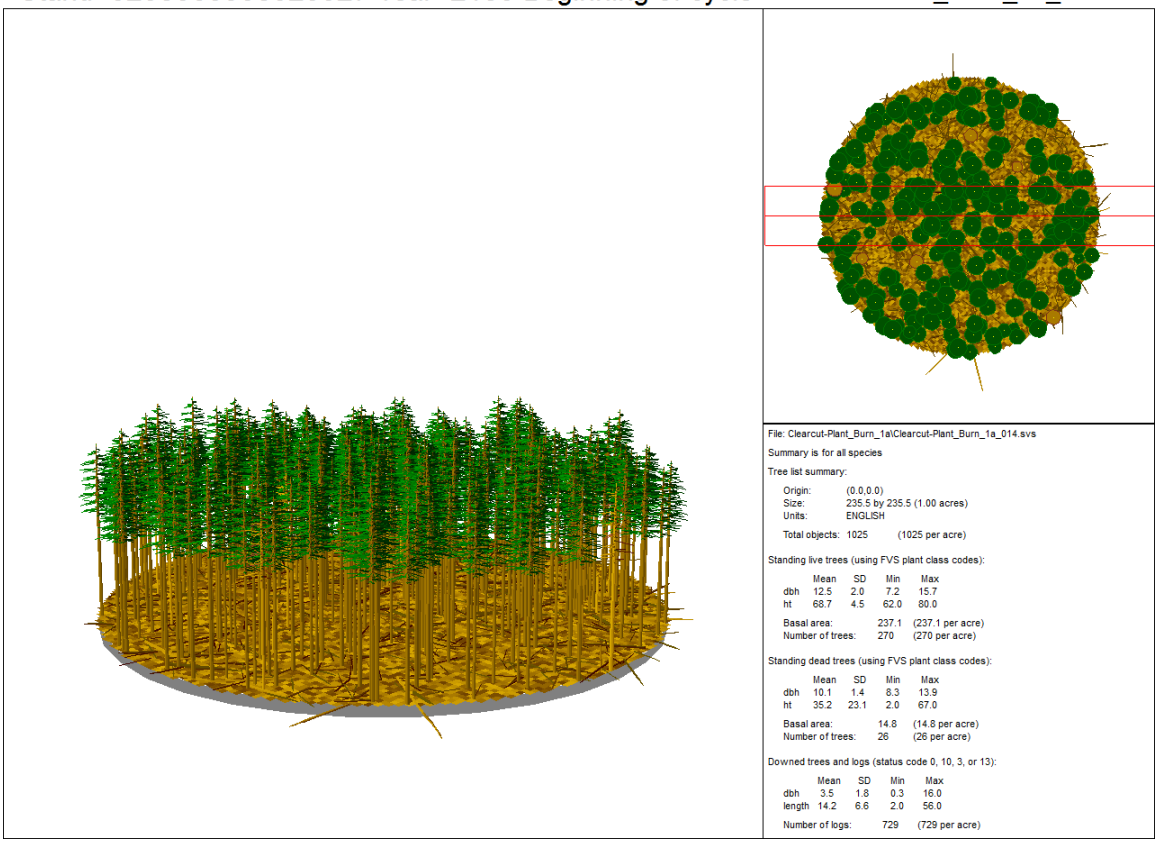
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	4.2	1.5	0.0	12.0
length	17.9	5.3	0.0	24.0

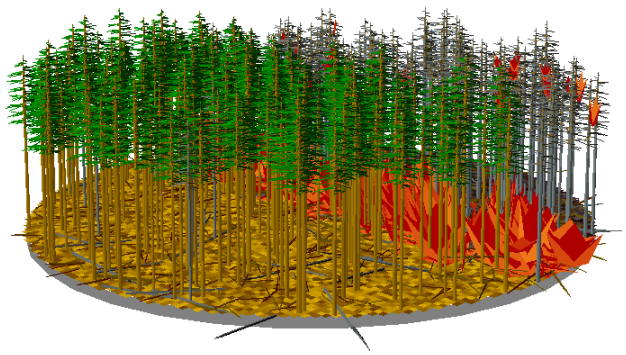
Number of logs: 1440 (1440 per acre)

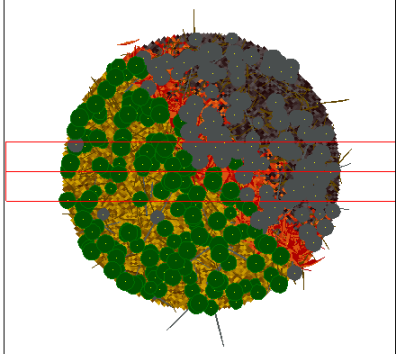
4C stand-preburn, during high intensity fire, postburn, and 20 years postburn:

Stand=0203060908020027 Year=2130 Beginning of cycle Clearcut-Plant_Burn_1a_014.svs



Stand=0203060908020027 Year=2130 During the fire (02/05) Clearcut-Plant_Burn_1a_016.svs





File: Clearcut-Plant_Burn_1a\Clearcut-Plant_Burn_1a_016.svs

Summary is for all species

Tree list summary:

Origin: (0.0,0.0)
Size: 235.5 by 235.5 (1.00 acres)
Units: ENGLISH

Total objects: 1207 (1207 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	12.6	2.0	8.0	15.7
ht	68.9	4.6	62.0	80.0

Basal area: 139.2 (139.2 per acre)
Number of trees: 158 (158 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	12.1	2.1	7.2	15.5
ht	62.1	16.8	2.0	79.0

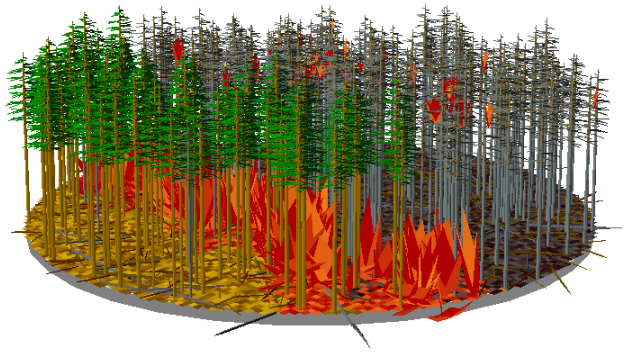
Basal area: 112.6 (112.6 per acre)
Number of trees: 138 (138 per acre)

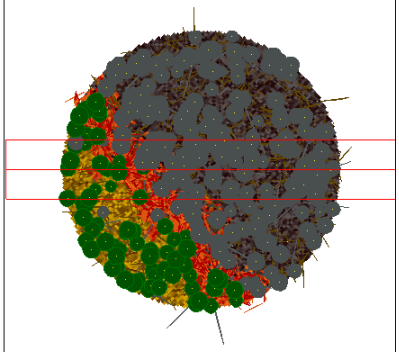
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	3.5	1.7	0.3	12.0
length	14.3	6.9	2.0	56.0

Number of logs: 640 (640 per acre)

Stand=0203060908020027 Year=2130 During the fire (03/05) Clearcut-Plant_Burn_1a_017.svs





File: Clearcut-Plant_Burn_1a\Clearcut-Plant_Burn_1a_017.svs

Summary is for all species

Tree list summary:

Origin: (0.0,0.0)
Size: 235.5 by 235.5 (1.00 acres)
Units: ENGLISH

Total objects: 1226 (1226 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	12.6	1.9	8.3	15.5
ht	68.8	4.7	62.0	80.0

Basal area: 64.5 (64.5 per acre)
Number of trees: 73 (73 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	12.2	2.1	7.2	15.7
ht	64.7	13.9	2.0	80.0

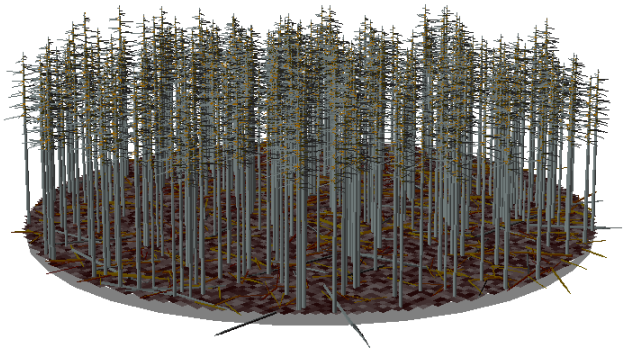
Basal area: 187.3 (187.4 per acre)
Number of trees: 223 (223 per acre)

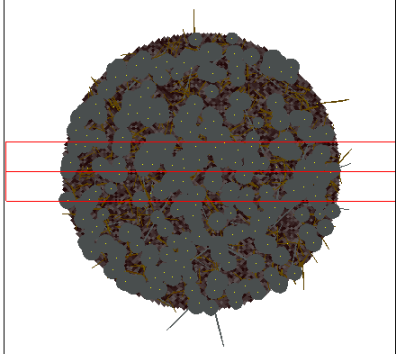
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	3.5	1.7	0.3	12.0
length	14.3	6.9	2.0	56.0

Number of logs: 640 (640 per acre)

Stand=0203060908020027 Year=2130 After the fire (05/05) Clearcut-Plant_Burn_1a_019.svs





File: Clearcut-Plant_Burn_1a\Clearcut-Plant_Burn_1a_019.svs

Summary is for all species

Tree list summary:

Origin: (0.0,0.0)
Size: 235.5 by 235.5 (1.00 acres)
Units: ENGLISH

Total objects: 936 (936 per acre)

Standing live trees (using FVS plant class codes):

No FVS standing live trees to summarize

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	12.3	2.1	7.2	15.7
ht	65.7	12.4	2.0	80.0

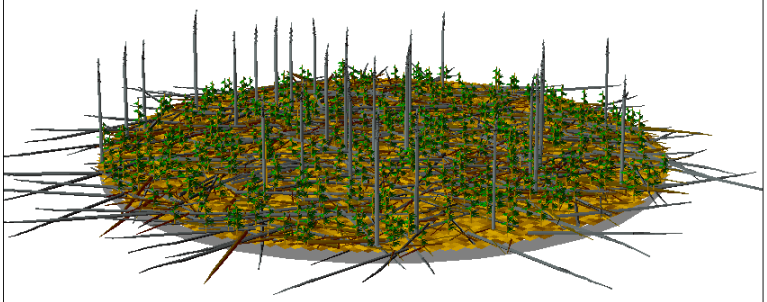
Basal area: 251.8 (251.8 per acre)
Number of trees: 296 (296 per acre)

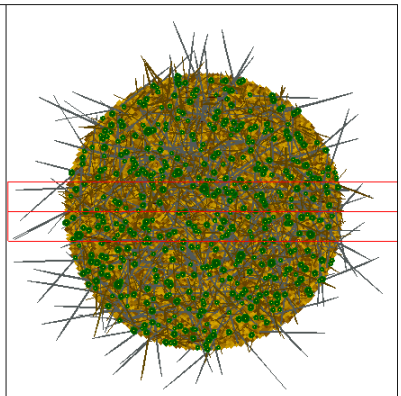
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	3.5	1.7	0.3	12.0
length	14.3	6.9	2.0	56.0

Number of logs: 640 (640 per acre)

Stand=0203060908020027 Year=2150 Beginning of cycle Clearcut-Plant_Burn_1a_021.svs





File: Clearcut-Plant_Burn_1a\Clearcut-Plant_Burn_1a_021.svs

Summary is for all species

Tree list summary:

Origin: (0.0,0.0)
Size: 235.5 by 235.5 (1.00 acres)
Units: ENGLISH

Total objects: 1849 (1849 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	1.7	0.5	1.0	3.7
ht	9.0	1.4	7.0	14.0

Basal area: 8.4 (8.4 per acre)
Number of trees: 490 (490 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	10.4	5.9	0.1	15.5
ht	34.8	17.9	3.0	51.0

Basal area: 29.5 (29.5 per acre)
Number of trees: 38 (38 per acre)

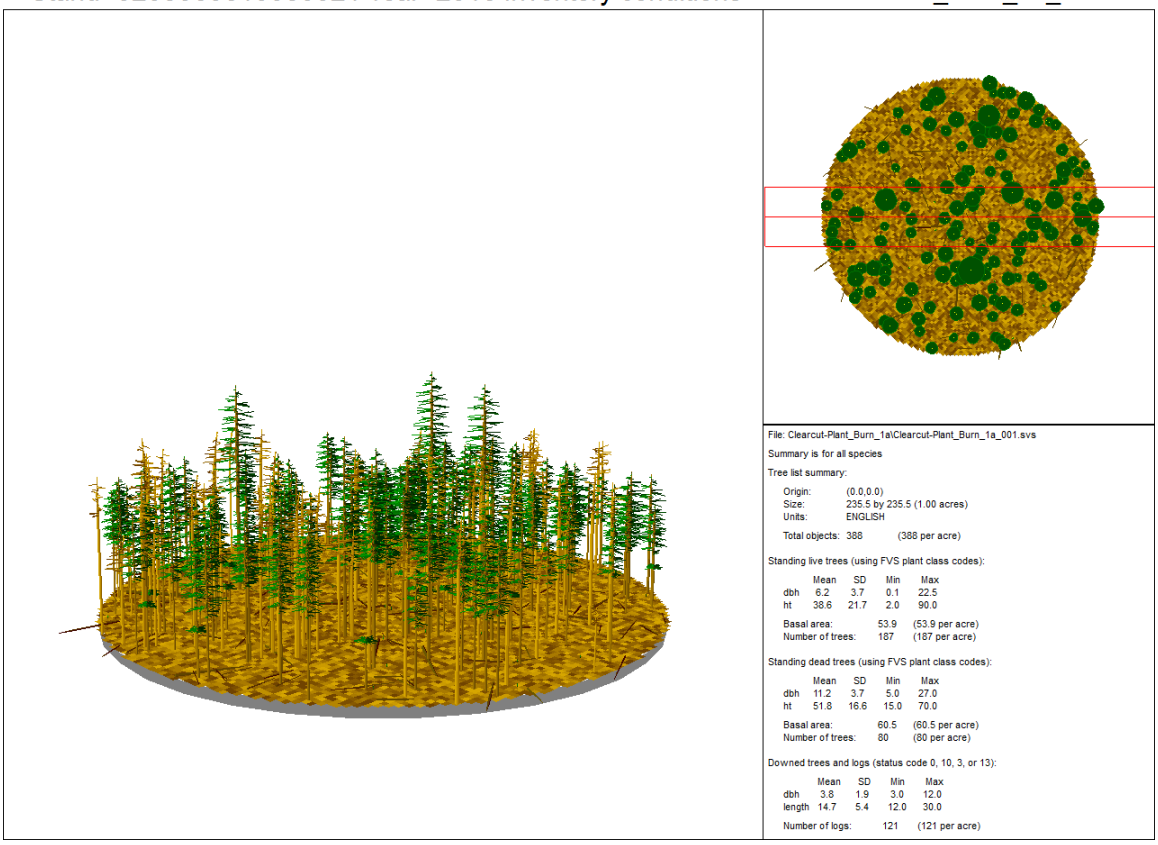
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	5.0	3.6	0.0	16.0
length	22.0	17.6	0.0	69.0

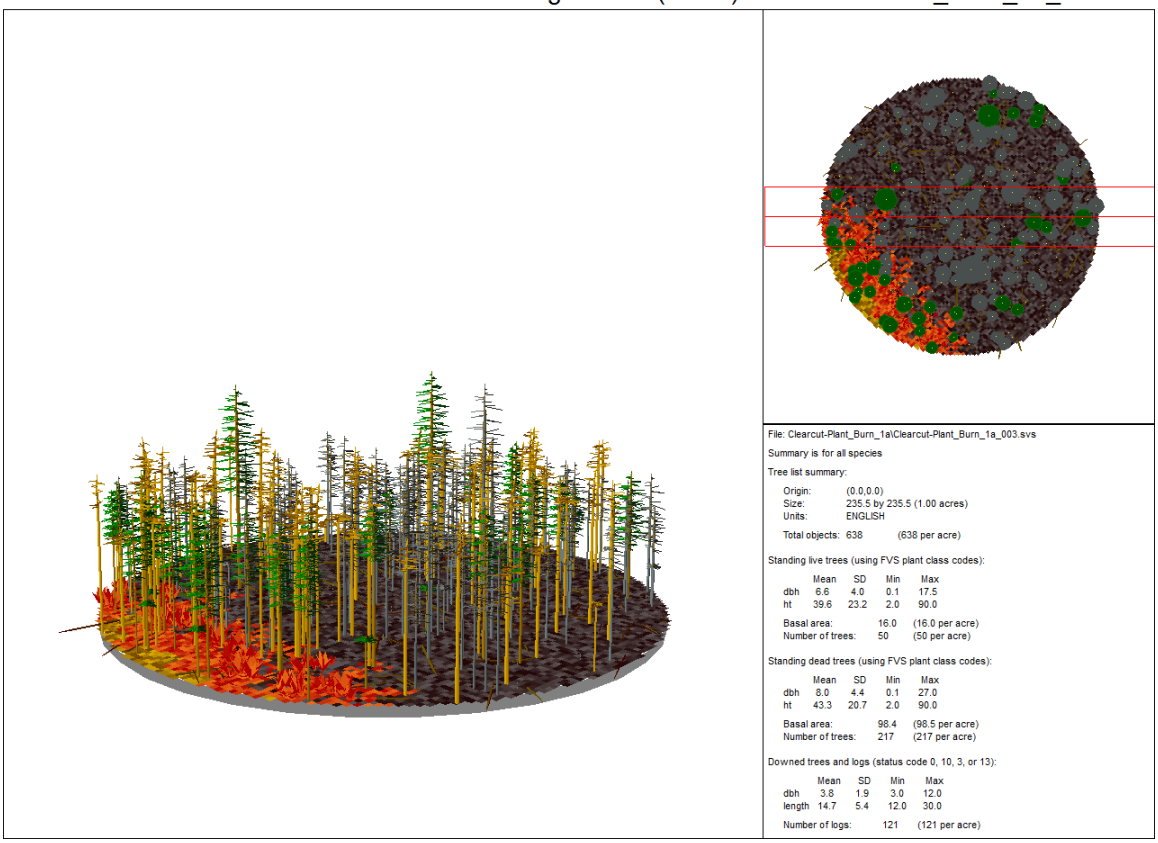
Number of logs: 1321 (1321 per acre)

4A stand with MPB-snags preburn, during wildfire, postburn, and 10 years postburn:

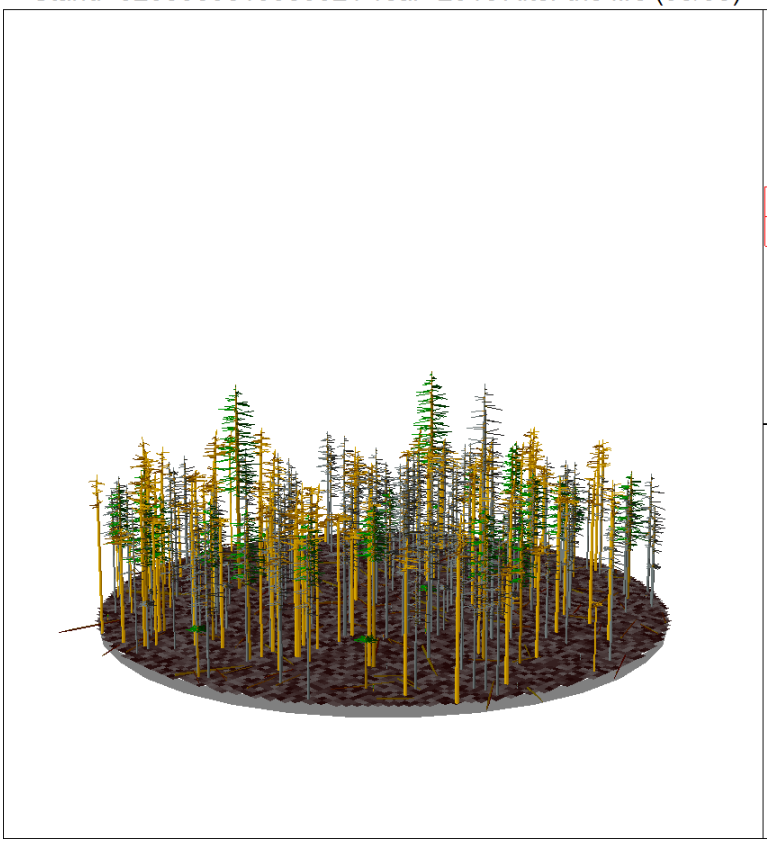
Stand=0203060610030021 Year=2016 Inventory conditions Clearcut-Plant_Burn_1a_001.svs

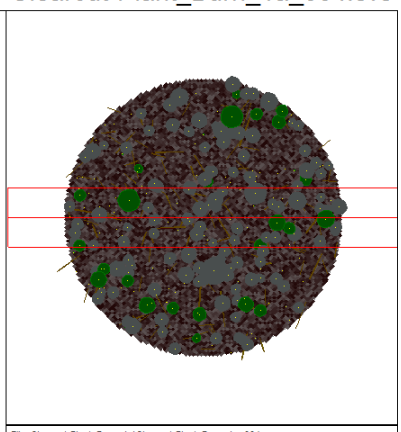


Stand=0203060610030021 Year=2016 During the fire (02/03) Clearcut-Plant_Burn_1a_003.svs



Stand=0203060610030021 Year=2016 After the fire (03/03) Clearcut-Plant_Burn_1a_004.svs





File: Clearcut-Plant_Burn_1a\Clearcut-Plant_Burn_1a_004.svs

Summary is for all species

Tree list summary:

Origin: (0.0,0.0)
Size: 235.5 by 235.5 (1.00 acres)
Units: ENGLISH

Total objects: 388 (388 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	6.3	4.6	0.1	17.5
ht	36.4	26.1	2.0	90.0

Basal area: 11.6 (11.6 per acre)
Number of trees: 35 (35 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	7.9	4.3	0.1	27.0
ht	43.5	20.2	2.0	90.0

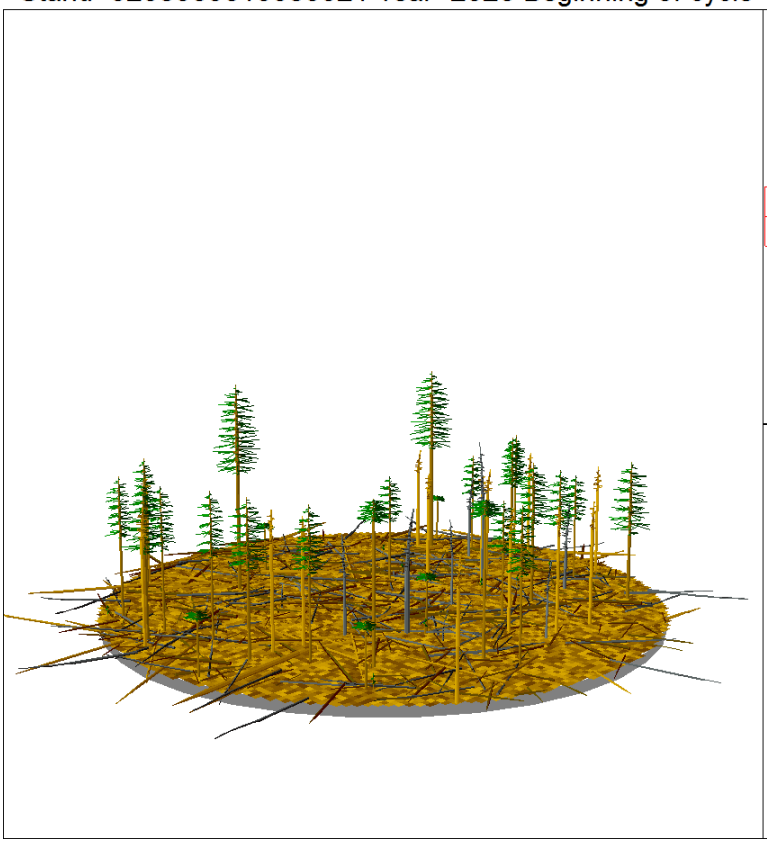
Basal area: 102.9 (102.9 per acre)
Number of trees: 232 (232 per acre)

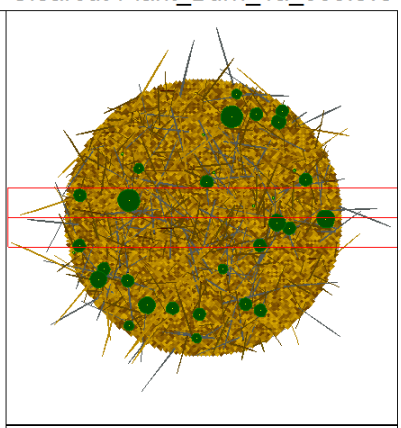
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	3.8	1.9	3.0	12.0
length	14.7	5.4	12.0	30.0

Number of logs: 121 (121 per acre)

Stand=0203060610030021 Year=2026 Beginning of cycle Clearcut-Plant_Burn_1a_005.svs





File: Clearcut-Plant_Burn_1a\Clearcut-Plant_Burn_1a_005.svs

Summary is for all species

Tree list summary:

Origin: (0.0,0.0)
Size: 235.5 by 235.5 (1.00 acres)
Units: ENGLISH

Total objects: 571 (571 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	7.3	4.9	0.6	18.8
ht	40.1	25.3	6.0	90.0

Basal area: 14.6 (14.6 per acre)
Number of trees: 35 (35 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	12.5	4.2	0.1	22.5
ht	48.9	12.7	2.0	72.0

Basal area: 20.8 (20.8 per acre)
Number of trees: 22 (22 per acre)

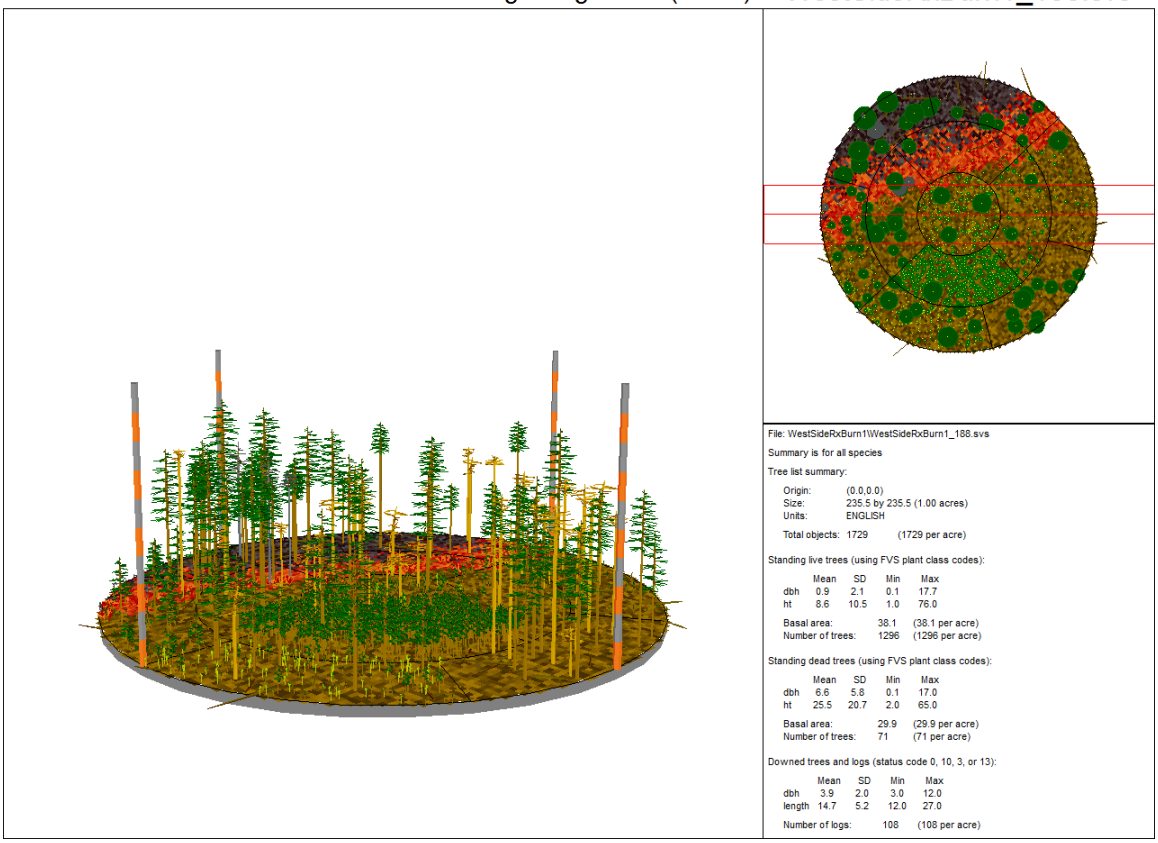
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	5.7	3.3	3.0	25.1
length	26.3	15.8	12.0	63.0

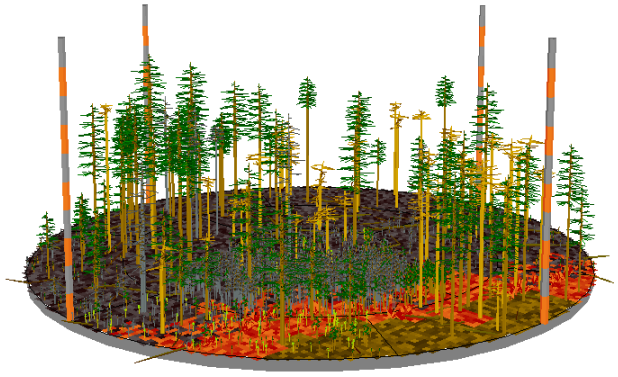
Number of logs: 514 (514 per acre)

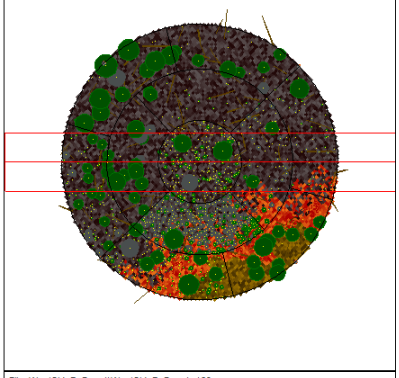
Prescribed burn with regeneration-during burn, postburn, and 10 years postburn

Stand=0203060608080019 Year=2016 Beginning of fire (01/03) WestSideRxBurn1_188.svs



Stand=0203060608080019 Year=2016 During the fire (02/03) WestSideRxBurn1_189.svs





File: WestSideRxBurn1\WestSideRxBurn1_189.svs

Summary is for all species

Tree list summary:

Origin:	(0.0,0.0)
Size:	235.5 by 235.5 (1.00 acres)
Units:	ENGLISH

Total objects: 1701 (1701 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	1.6	3.2	0.1	17.7
ht	11.2	15.5	1.0	76.0

Basal area:	33.4	(33.4 per acre)
Number of trees:	477	(477 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	1.1	2.5	0.1	17.0
ht	8.6	9.2	2.0	65.0

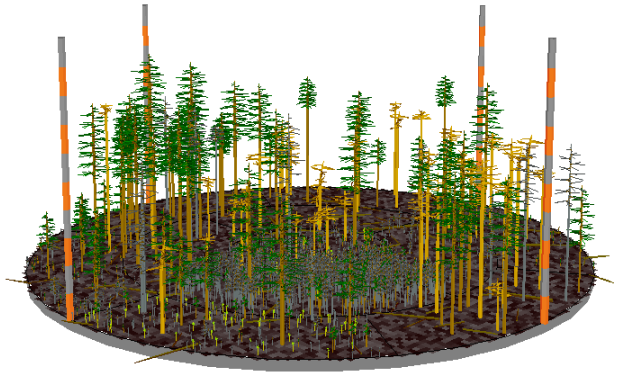
Basal area:	34.6	(34.6 per acre)
Number of trees:	890	(890 per acre)

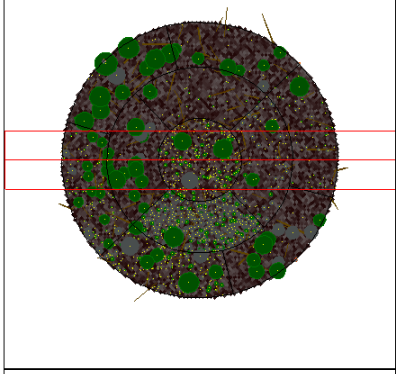
Downed trees and logs (status code 0, 10, 3, or 13):

	Mean	SD	Min	Max
dbh	3.9	2.0	3.0	12.0
length	14.7	5.2	12.0	27.0

Number of logs: 108 (108 per acre)

Stand=0203060608080019 Year=2016 After the fire (03/03) WestSideRxBurn1_190.svs





File: WestSideRxBurn1\WestSideRxBurn1_190.svs

Summary is for all species

Tree list summary:

Origin:	(0.0,0.0)
Size:	235.5 by 235.5 (1.00 acres)
Units:	ENGLISH

Total objects: 1479 (1479 per acre)

Standing live trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	1.8	3.5	0.1	17.7
ht	12.0	16.9	1.0	76.0

Basal area:	31.4	(31.4 per acre)
Number of trees:	367	(367 per acre)

Standing dead trees (using FVS plant class codes):

	Mean	SD	Min	Max
dbh	1.0	2.4	0.1	17.0
ht	8.6	9.2	2.0	65.0

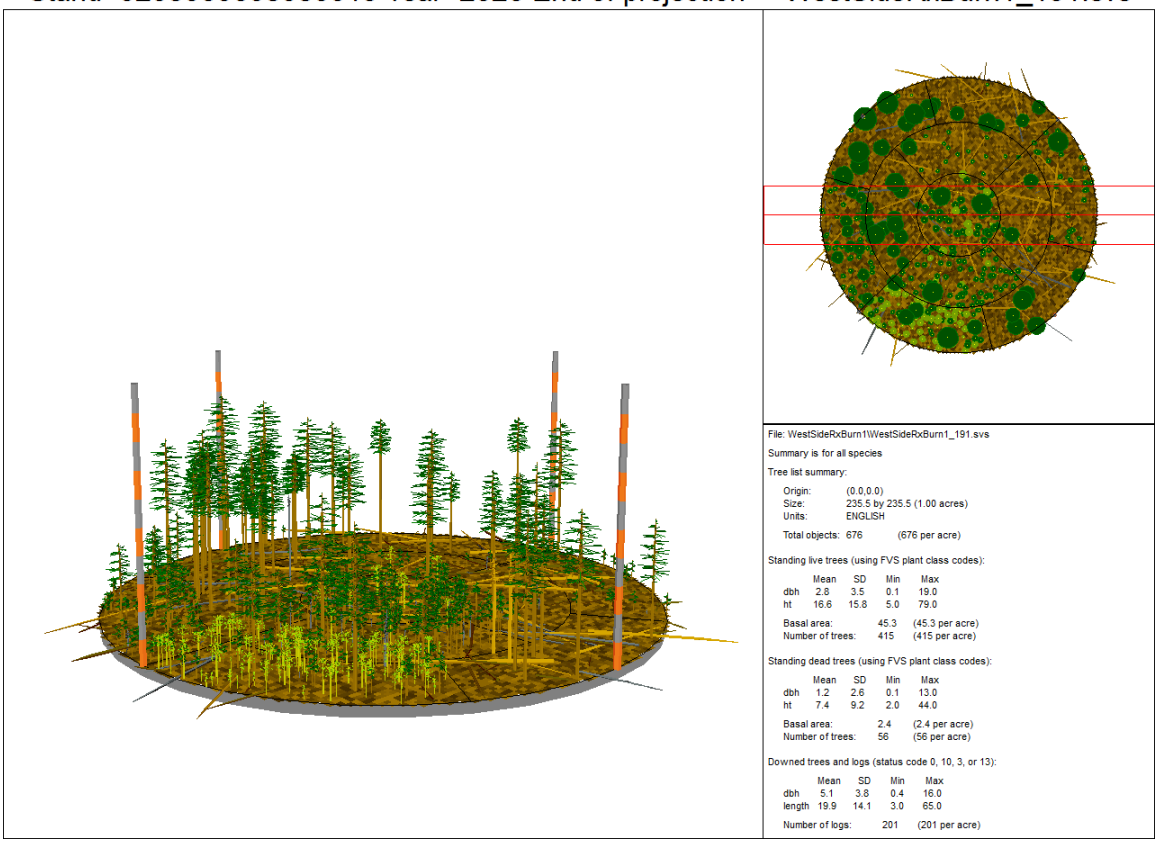
Basal area:	36.5	(36.5 per acre)
Number of trees:	1000	(1000 per acre)

Downed trees and logs (status code 0, 10, 3, or 13):

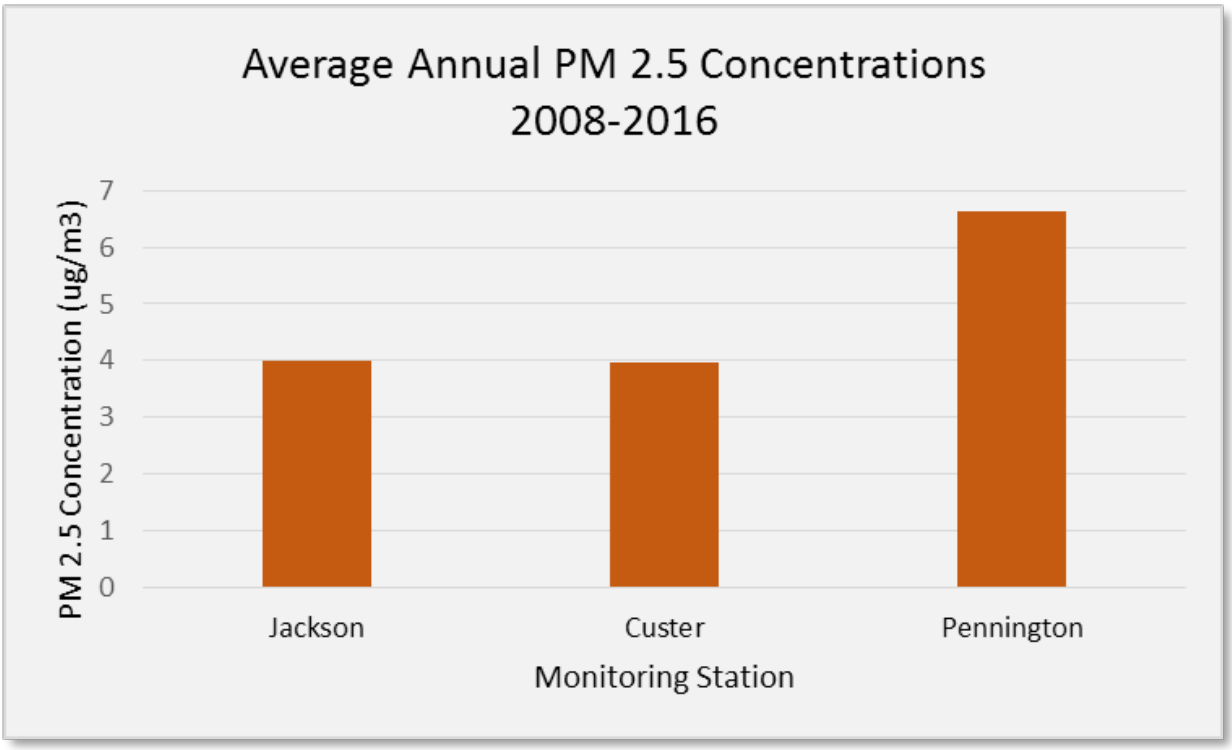
	Mean	SD	Min	Max
dbh	3.9	2.0	3.0	12.0
length	14.7	5.2	12.0	27.0

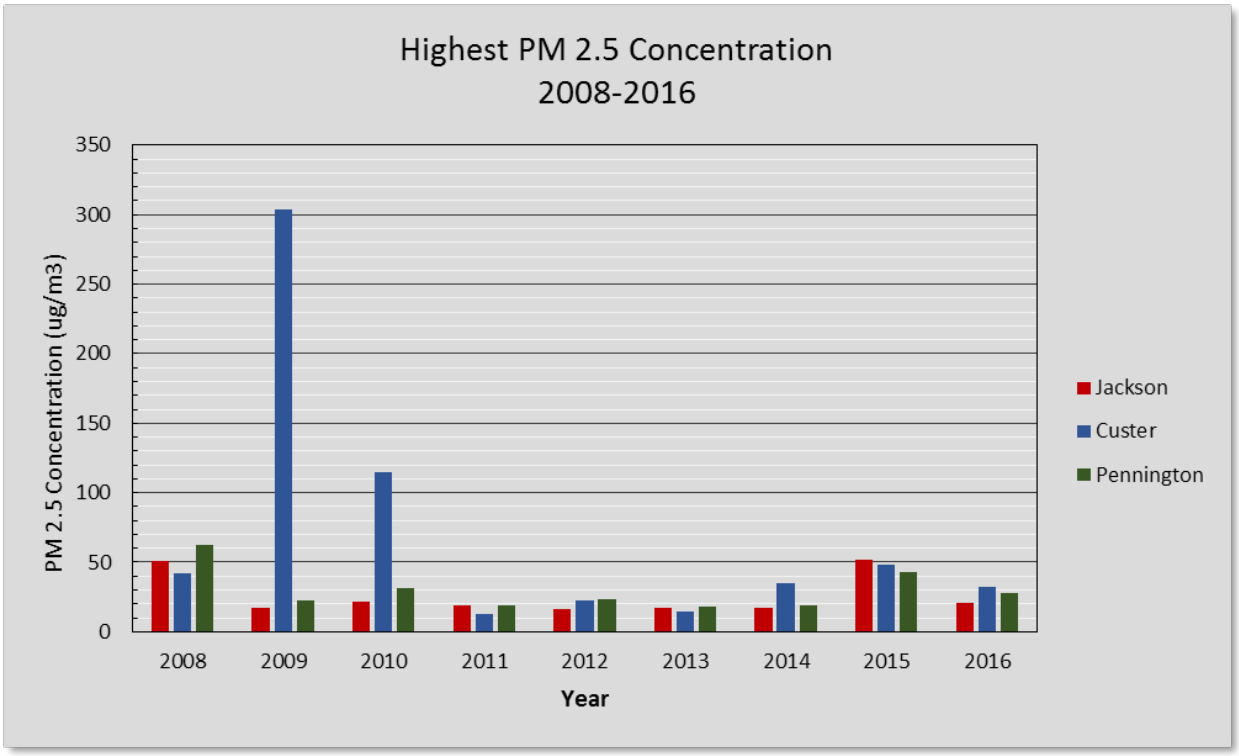
Number of logs: 108 (108 per acre)

Stand=0203060608080019 Year=2026 End of projection WestSideRxBurn1_191.svs



Appendix B


Average Annual PM 2.5 Concentrations
2008-2016
PM 2.5 Concentration (ug/m3)
0
1
2
3
4
5
6
7
Jackson
Custer
Pennington
Monitoring Station


Highest PM 2.5 Concentration
2008-2016
PM 2.5 Concentration (ug/m3)
0
50
100
150
200
250
300
350
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year
Jackson
Custer
Pennington