SOUTH DAKOTA GAME, FISH AND PARKS

Custer State Park Resource Management Plan

2010-2025

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A plan leading natural resource management in Custer State Park

Custer State Park

Resource Management Plan

2010-2025

Acknowledgements:

The development of this plan used facilitated focus group meetings of invited stakeholder groups. The facilitator was Wyss Associates, Inc. of Rapid City. Two meetings were held; one prior to plan development presented the group with the current landscape description and solicited comment and direction from the group. The second meeting presented the group with the planning direction and solicited feedback on the management direction.

This plan represents a significant contribution from a number of CSP resource staff members, some of whom are no longer with the Department. The plan was prepared by:

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Additional thanks go to Jake Davis and Chelsey Pasbrig, fisheries biologists with the Division of Wildlife, for their contributions to the fisheries sections of the document.

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INTRODUCTION

Custer State Park (CSP) encompasses 70,750 acres of forestland and grasslands in the Black Hills of South Dakota. The park is located approximately 17 miles south and west of Rapid City. Geography varies from steep granitic spires in the northwest part of the park, forested hill land in the main body and grading eventually into grasslands on the eastern and southern boundaries. Elevation ranges from 3,760 to 6,700 feet above sea level. Vegetation is dominated by white spruce ponderosa pine mix on north slopes at higher elevations, by ponderosa pine interspersed with hardwoods on most forestlands and by mid-grass prairie plants on grasslands.

Developments in Custer State Park include 4 resort complexes, 4 man-made lakes, 10 campgrounds, the Black Hills Playhouse for Performing Arts, the STAR Academy East, a shop complex, Park employee housing, and a system of roadways.

Custer State Park visitation numbers approximately 1.8 million people per year. Most visitation occurs June through August.

Administratively, Custer State Park is under the Division of Parks and Recreation within the Department of Game, Fish and Parks. The park operation consists of four programs: Administration, Visitor Services, Maintenance, and Resource Management. The Resource Management Program is responsible for management and conservation of the forestlands and rangelands in the Park. This includes managing rangeland and forestland utilization by wildlife and bison, fire management, forest health and fire suppression. There are six full time positions assigned to the Resource Management Program. Additionally, a Division of Wildlife Senior Wildlife Biologist and Division of Wildland Fire Suppression Fire Management Officer work within the Resource Management Program.

Past program activity has been guided by the "Custer State Park Resource Management Plan 1995-2010”. The 1995 plan was a holistic approach to resource management in Custer State Park. This plan is patterned after and a continuation of the 1995 plan and is also holistic in nature. This plan like its predecessor was prefaced by a series of focus group meetings. These meetings were facilitated by Wyss and Associates. The focus group was composed of members of the following stakeholder groups:
Black Hills Sportsman
Neiman Timber Co.
SD Grassland Coalition
Black Hills, Badlands, and Lakes Association
A Custer County Landowner
Custer County Director of Emergency Services
Custer Commissioner
Black Hills Group Sierra Club
Black Hills Forest Resource Association

SD Wildlife Federation
Intermountain Forest Association
The Nature Conservancy
Alliance of Tribal Tourism Advocates
Custer County Chamber of Commerce

Planning and management flexibility are necessary to enable correct responses to new information, changing climatic conditions, and other changing situations that are unknown but to be expected. This plan of necessity lays claim to the right of flexibility.

Mission Statements

Custer State Park Mission

1. Manage and protect the park's natural, cultural, and geological resources.

2. Provide for public use of the park in a manner that is consistent with current standards and compatible with the perpetuation of the park's resources.

3. Develop and promote the park to its potential as a tourism destination for South Dakota.

4. Provide an adequate funding base to enable continued park operations.

Resource Management Program Mission: The Mission Statement for resource management in CSP was developed by the focus group in 1995 and is holistic in nature with 3 parts; Quality of Life, Production, and Future Landscapes.

1. Quality of Life - Custer State Park will be a place for both people and nature, a place where visitors can see and experience much of the natural and cultural heritage of western South Dakota, a place where the character of the natural systems predominate and where activities of both management and visitors are in harmony with that character.

2. Production - The natural systems of Custer State Park produce forage, wildlife, wood fiber, and surface water. The Resource Management Program seeks to maintain and/or move these natural systems toward a high level of productivity and biodiversity to assure system health, viability, and profitability. The program also seeks to preserve and protect the cultural and geologic resources on park landscapes, and to preserve and expose the aesthetic qualities of those landscapes.

3. Future Landscapes - The Custer State Park landscapes, to be inherited by future generations of South Dakotans, should be characterized by:

   mixed grass prairies dominated by healthy native grasses and relatively free of exotic plant species, where native woody shrubs frequent drainage bottoms, and where native wildlife populations can abound within the capacity of the habitats to sustain them;

forestlands where vegetative diversity is present on appropriate sites, where native forest floor vegetation is commonly present and is relatively free from exotic plant species, where fuel loadings approximate that of areas periodically adjusted by fire occurrences, where large old pine are well distributed and easily seen by park visitors, where major forested watersheds enable perennial stream flows, where wildlife populations native to southern Black Hills forests can prosper; and fire disturbed areas (i.e. Galena and Cicero Peak Fire Areas) that are soil stable and are progressing toward a returning forest condition, and where an appropriate mix of cover essential to complete habitats exits;

surface water systems that enjoy either perennial flows or continuous open water wherever possible and ephemeral sources where continuous flows are not possible; that are protected by diverse native vegetation, that are relatively free from exotic plant species and degrading erosion, and that enable widespread use of park landscapes by resident wildlife.

CURRENT LANDSCAPE DESCRIPTION

MIXED GRASSLAND ECOSYSTEM

VEGETATION

Analysis of grassland vegetation

Analysis of rangeland soils for vegetation type was conducted through overlay analysis using Geographic Information System (GIS) software. Rangeland soils encompass 17,860 ac. These soil types have been classified to Ecological Sites based on NRCS categorization (Table 1). Keller (2011) determined condition ratings for each Rangeland Ecological Site (Figure 1). According to Keller (2011) condition is rated as excellent on 14% of the range, good on 85% and fair on < 1%. No Ecological Sites are in poor condition.

Table 1. ArcGIS analysis of Ecological Sites determined from soil type.

Ecological Site Classification	Area (%)	Area (ac)
Loamy	16.09	2874
Overflow	15.20	2715
Savannah	6.64	1185
Stony Hills	48.32	8629
Shallow	5.62	1004
Clayee	7.88	1408
Thin Upland	0.25	45
Total	100.00	17860

ArcGIS analysis indicated that 2995 ac of pine forest occur on rangeland soils (Figure 2). These stands were classified as timber, not rangeland, and therefore represent pine encroachment on Ecological Sites. Indications are that, in the absence of fire, this encroachment is continuing. There are 1890 ac of woody vegetation excluding pine and spruce parkwide (Table 2, Figure 3) and 746 ac occurring on rangeland soils (Table 3). Total hardwood vegetation including aspen, oak and other hardwood trees on rangeland soils are 514 ac. A significant amount of these hardwoods occur on overflow soils (a range soil type) within the forestland system (see Figure 2). Woody species along riparian corridors are, primarily deciduous shrub and woody draws, are limited.

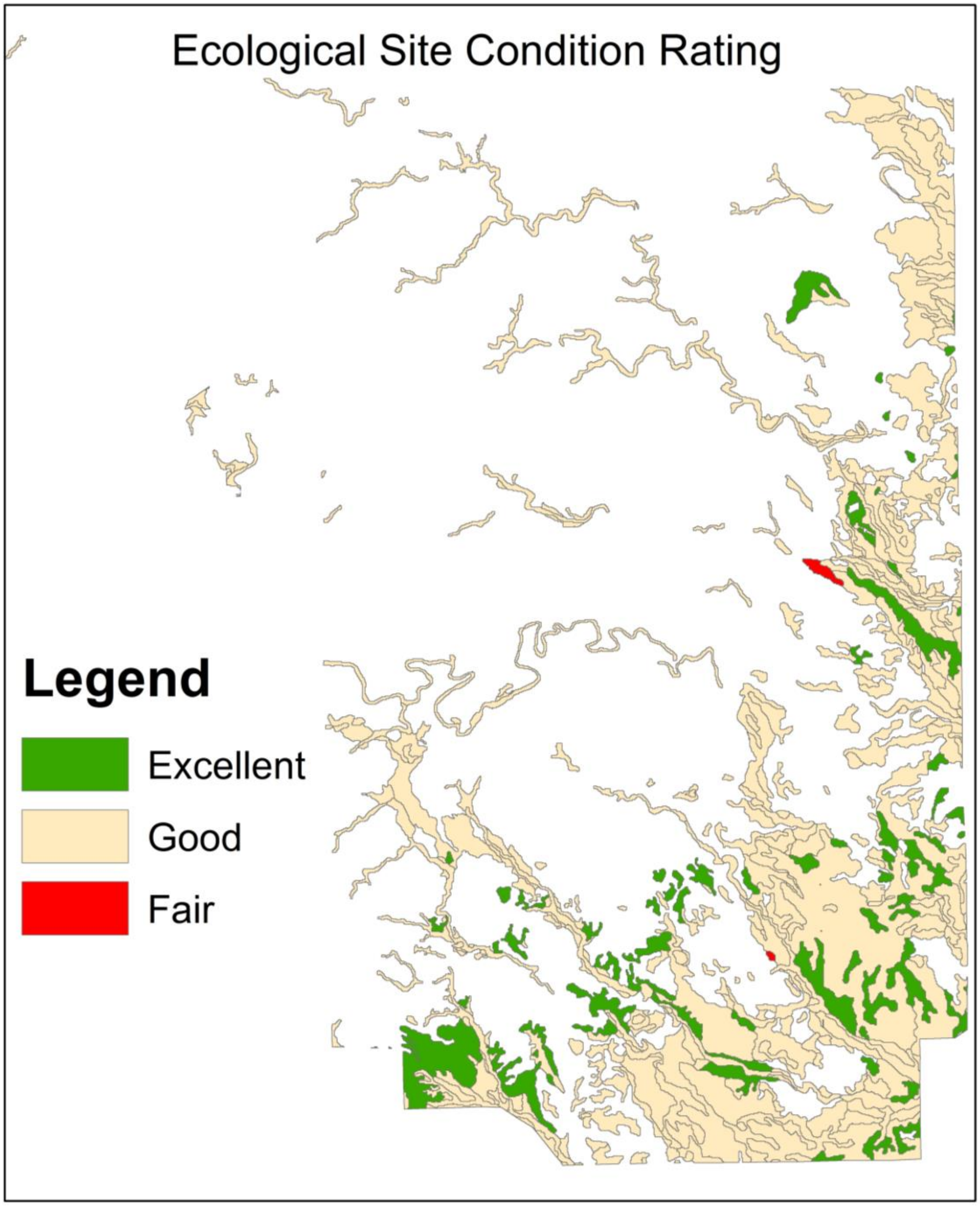

Figure 1. Ecological Sites classified from soil type. Savannah and Clayey sites (green) rated excellent. Stony Hills, Loamy, Overflow and Shallow sites (tan) rated good. Thin Upland sites (red) rated fair.

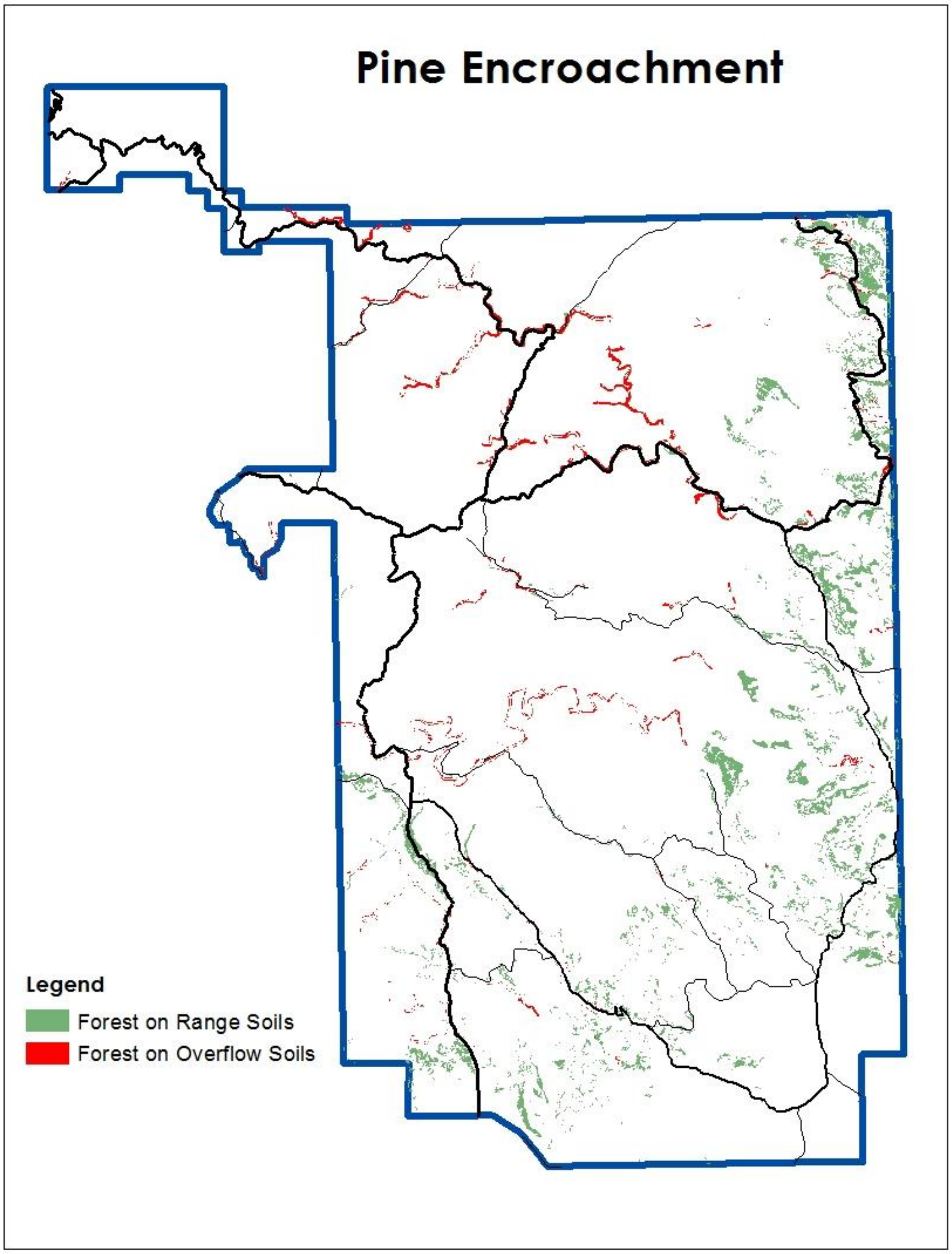

Figure 2. Pine encroachment on rangeland ecological sites.

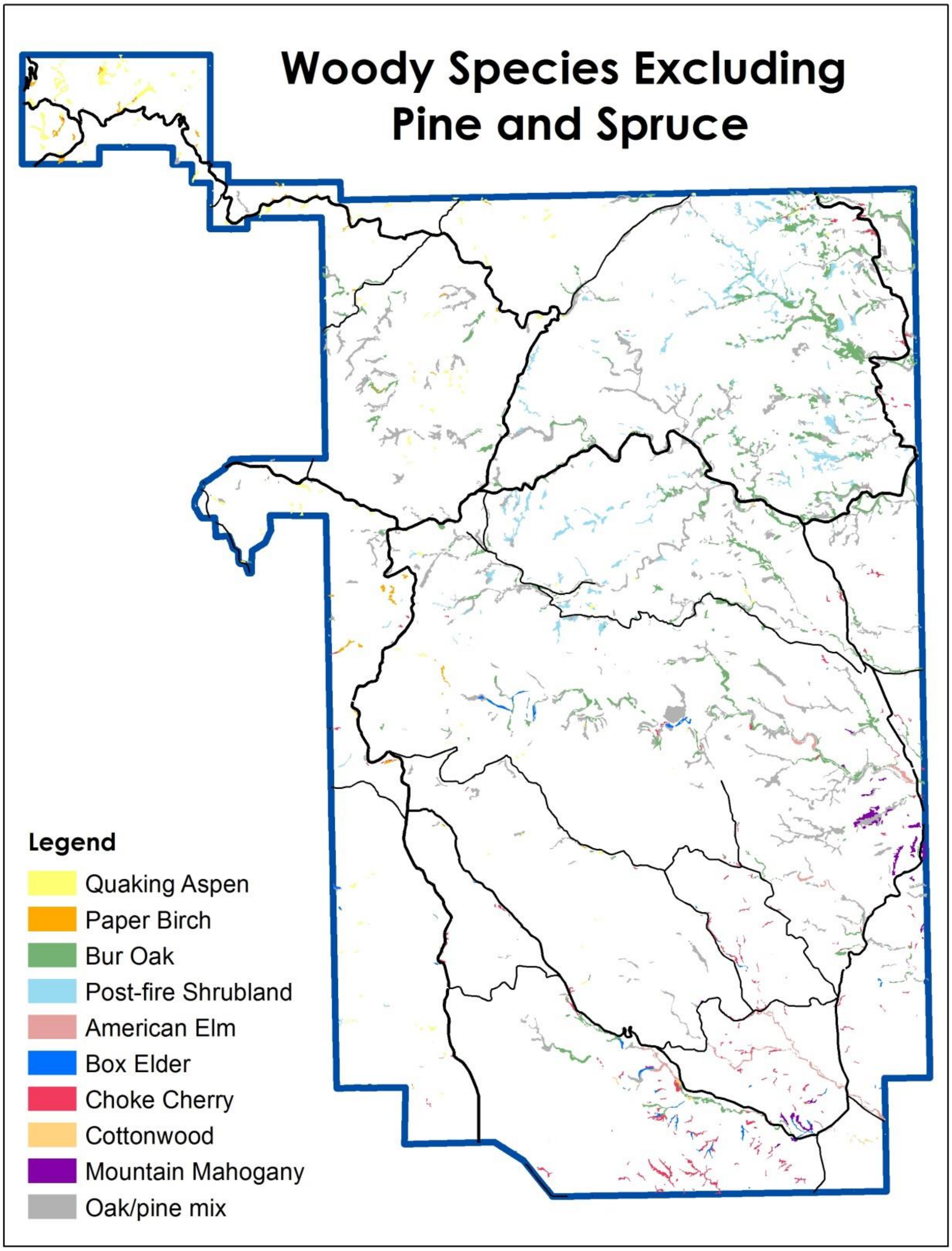

Figure 3. Woody vegetation other than pine and spruce.

Table 2. ArcGIS analysis of woody species excluding pine and spruce.

Species	Area (%)	Area (ac)
Quaking Aspen	5.1	203
Bur Oak	26.4	1043
Paper birch	2.0	78
Cottonwood	0.3	13
Mountain Mahogany	1.9	77
Oak/pine mix	44.4	1758
American Elm	2.4	94
Box Elder	1.6	63
Choke Cherry	5.5	218
Post-fire Shrubland	10.4	411
Total	100.00	3958

Table 3. ArcGIS analysis of woody vegetation excluding pine and spruce on rangeland ecological sites.

Species	Area (%)	Area (ac)
Quaking Aspen	4.76	35
Bur Oak	7.75	58
Deciduous Shrub	29.34	219
Other Hardwood	45.14	337
Mountain Mahogany	1.40	10
Oak/pine mix	11.23	84
Juniper	0.38	3
Total	100.00	746

System Function

Fire In The Grassland/Savanna Ecosystem

Historic Fire

Fire has been an integral disturbance mechanism in the northern mixed grass prairie and pine-grassland ecosystem of the southern Black Hills. Fires often raged across vast acreages of the plains, driven by wind, topography, and fuel continuity. Sieg (1998) estimates a fire return interval of 5-10 years in the northern mixed grass prairie. A study of historical variability of fire in the pine savannas of Wind Cave National Park (WICA) indicate that mean fire intervals were 10 to 12 years and occurred twice as often as interior forest sites of the Black Hills (Brown and Sieg 1999). This study suggests the 10-12 year fire return interval closely reflects the fire regime of the surrounding mixed grass prairie than of the interior ponderosa pine forest of the Black Hills.

The cause of these frequent fires pre-European settlement was the result of Native American ignitions, and lightning (less frequent). Bragg (1995) claims that lightning ignitions were historically common in late summer and early fall. Fire intervals studied at WICA(potentially both natural and man-caused) were also found to be late in the growing or dormant season (Brown and Sieg 1999). It is thought that Native American's used fire to manage trees and brush, improve vegetation quality, establish camp sites, and attract and move game (Lewis 1982). The arrival of non-native settlers during the mid to late 1800s led to fire suppression policies and, in many areas, a shift in the timing of fires (Sieg 1998). Roads, changes in grazing, and other cultural factors were thought to further influence the behavior and extent of wildfires after European settlement (Higgens 1984).

Fire Exclusion

The impacts of fire suppression are evident in the rangelands of Custer State Park today. Without the ecological functions of fire these grassland/savanna species have adapted to, areas of Custer State Park are showing degradation. Degradation on rangeland sites due to fire exclusion can include: un-naturally high litter and duff accumulations, encroachment of woody species (ponderosa pine), limited nutrient cycling, decreased forage quality, a change in species composition and invasion of non-native species that do not have a natural reduction mechanism.

Fire Effects On The Northern Mixed Grass Prairie

Effects on plant reproduction and composition

Most perennial grasses and forbs are capable of vegetative reproduction. This trait gives them a competitive advantage and helps grassland species to survive fire. Subterranean buds, rhizomes, bulbs, corms, and other specialized structures provide opportunities for plants to renew top growth following a fire. The timing and frequency of a fire, particularly prescribed burning, can be critical in some grasslands. Usually spring burns (depending on the stage of development of the cool season grasses) serves to promote warm season grasses by burning the foliage critical for root production in cool season plants – leaving the warm season plants untouched (Howe 1994). Conversely, burning towards the end of the growing season consumes the reproductive parts of the warm season grasses, and leaves the cool season species intact (as they are done growing at this point). Timing of prescribed burning can be used to set back grassland invaders. There has been some success in burning smooth brome and Kentucky bluegrass when they are emerging, but prior to when the native cool season grasses emerge. There has also been success using spring burning for smooth brome and Kentucky bluegrass reduction when a pre-existing population of warm season grasses can increase dominance on the site in place of these non-native invasive species. Timing can also play an important role in nutritional quality of grassland plants. Aldous (1934) found that late spring burning of big bluestem grasslands increased protein content, whereas burning in other seasons decreased it.

Grassland fire can create disturbed sites or pioneer conditions which allow invasion by opportunistic species - annuals, short-lived perennials, and other weedy species. Disturbance by fire and other factors guarantee a mix of invaders, opportunistic pioneers, annuals, and stable perennials (Stewart 1956). If disturbance is taken away, grassland species numbers soon decline.

Woody draws are also an important component to the Northern Great Plains grassland ecosystem. While the effects of fire in maintaining these woodland draws are unclear, it is likely that these areas burned periodically, as did the surrounding grasslands (Sieg 1996). It is believed that fire played and still plays an important role in stimulating hardwood sprouting while discouraging ponderosa pine encroachment. Fire suppression has been attributed to the increase and encroachment of woody species such as ponderosa pine on grassland sites (Wakimoto and Willard 2004). Fires promote grasses and herbaceous plants by killing woody plants before they can establish and exclude understory individuals through shading (Sieg 1999). In a study by Bock and Bock (1983), cool season and dormant season burns were successful at significantly reducing immature pines, while other shrubs were unaffected. This possibly proves the hardwood's resilience to the frequent burning that historically was thought to occur. In general, bur oak (*Quercus macrocarpa*), raspberry (*Rubus idaeus*), chokecherry (*Prunus virginiana*), American plum (*Prunus americana*), mountain mahogany (*Cercocarpus montanus*), leadplant (*Amorpha canescens*), and white coralberry (*Symphoricarpos albus*) respond well immediately or soon after (within a month) fire. Generally American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), and boxelder (*Acer negundo*) are more susceptible to fire, as they have thin bark. Post-fire regeneration for American elm and green ash can include sprouting from the base or root collar if top-killed by fire (Coladanto, 1992, Gucker 2005). Off-site seeding is the common post-fire regeneration strategy common to all three species. More specific information on the fire effects of these species can be found in the FEIS database: http://www.feis-crs.org/beta/.

Nutrient Cycling and Forage Quality

Fire's main role in ecosystem nutrient cycling is through the thermal decomposition of organic fuels (USDA – RMRS 2005). Normal biological decomposition is long-term, however fire's thermal decomposition of these same fuels is instantaneous. A summary on the effects of fire on nutrient cycling are perfectly summed up in *Wildland Fire in Ecosystems – Effects of Fire on Soil and Water* (USDA – RMRS 2005 pg. 71).

> *Soil organic matter plays a key role in nutrient cycling, cation exchange, and water retention in soils. When organic matter is combusted, the stored nutrients are either volatilized or are changed into highly available forms that can be taken up readily by microbial organisms and vegetation. Those available nutrients not immobilized are easily lost by leaching or surface runoff and erosion. Nitrogen is the most important nutrient affected by fire, and it is easily volatilized and lost from the site at relatively low temperatures. The amount of change in organic matter and N is directly related to the magnitude of soil heating and the severity of the fire. Cations (Ca, Mg, Na, K, and NH4) are not easily volatilized and usually remain on the site in a highly available form. An abundance of cations can be found in the thick ash layers remaining on the soil surface following high-severity fires.*

Nutrient levels, particularly available soil nitrogen (as compared to total soil nitrogen) have been documented to increase post-fire. Available soil nitrogen increases as nitrogen is release through thermal decomposition of litter duff and soil organic matter. However, total soil nitrogen decreases as a portion of the total nitrogen is volatilized during combustion (DeBanos et al. 1998, Christensen 1973, DeBano et al. 1979). How significant the nitrogen losses are depends on the proportion of nitrogen lost in each ecosystem and the regeneration of nitrogen fixing plants (such as lead plant, scurf peas and clovers here in Custer State Park). Mineral salts of Ca, P, K, and Mg generally increase with burning (Metz et al. 1961). Since these are water soluble they are readily taken up by plants and soil organisms (Tomanek 1948). The accumulation of litter can produce a mantle that inhibits growth by depriving plants of space and light. Conversion by fire of standing plants and litter to ash and charcoal blackens the soil surface and acts to stimulate earlier, denser growth by creating warmer surface temperatures (Ehrenreich and Aikman 1963) extending the growing season. Not only is the post-fire grass growth lush and free of the previous year's litter that normally masks it, it can also be nutritionally superior to un-burned grasslands.

Daubenmire (1968) found that most plants are often higher in crude protein, ether extract, nitrogen free extract, digestible energy, phosphorus, nitrogen, and potassium post fire In a study by Hobbs and Spowart (1984), it was found that prescribed burning improves the nutritional quality of the diets of mule deer and mountain sheep through increases in protein concentration and in vitro digestible organic matter.

Grazing Ecology

Role of ungulate grazers

Material cycling is a vital part of an ecosystem's function. Once the inputs of sunlight and materials are converted to carbohydrates by plants, the cycling of these nutrients, water, carbon, nitrogen, and minerals are essential to ecosystem vitality.

Productivity is determined by "the rate at which matter is recycled through the system" (Owensby 1992). Herbivores and decomposers are the two primary drivers of total energy flow in the rangeland ecosystem. In arid and semiarid rangeland areas such as western South Dakota, the activity of decomposers is limited by the environment. Decomposers are not able to adequately recycle material through the ecosystem process by themselves. Thus, the activity of grazers becomes vital to the long term functioning of the system.

Grazing animals, however, can both upgrade and degrade a rangeland system. Therefore, range management has focused on manipulating vegetation and soils by controlling the grazing animal (Holechek et al 2004). "Range systems are circular casual systems. The herbivore eats the plant and is affected by it, but the herbivore eating has also affected the plant" (Owensby 1992). Periodic herbage removal can stimulate grass plants into using expendable carbohydrate reserves for foliage production, thereby increasing productivity. Increased, sustained herbage removal decreases plant vigor, resulting in reduced productivity. At the same time, the grazer's physical and biochemical activity on the rangeland enable adequate material cycling, which increases energy flow through the system resulting in increased productivity. Continued herbage removal of some specific plants and plant species over time can cause that plant or plant species to lose vigor and population size. Thus, overgrazing occurs when grazers stay too long or come back too often to remove herbage from their favorite plant. Conversely, the non-removal and non-displacement of herbage from plants and plant species result in tying up materials and subjecting them to an extremely slow cycling process, especially in the more arid climates. Over time, plant vigor is degraded and certain plant populations are reduced. In both cases, the relative populations of various species can shift, resulting in reduced rangeland productivity.

The challenges of managing rangeland and savanna ecosystems in Custer State Park include maximizing grazing's upbuilding effects and minimizing grazing’s degrading effects. Rangeland and savanna ecosystems are continuously changing. It is important for the range manager to understand these changes and which ones influence management decisions (Holechek et al 2004). To assist range managers state-and-transition models are being developed for each Ecological Site listed in Table 1. Palatable plants increase and unpalatable plants declined under light grazing intensities. CSP has chosen to utilize a light grazing intensity to allow climax and desirable plants species to recover. According to (Keller 2011) rangeland soils produce about 70% potential and forested soils produce about 80% potential vegetation from 2005-2008. Light grazing intensity will allow climax species to recover, CSP’s goal is to have both rangeland and woodland soils producing 90% or better of vegetation potential.

<u>Role of Prairie Dogs</u>

Black-tailed prairie dogs (*Cynomys ludovicianus*) are native to South Dakota and the Great Plains region. Prairie dogs are often referred to as a "keystone" species for their pivotal role in providing food and shelter for other species (Higgins et al. 2000). Prairie dog colonies provide important habitats for burrowing owls (*Athene cunicularia*) and prairie rattlesnakes (*Crotalus viridis*). They provide food for numerous predators such as coyotes (*Canis latrans*), badgers (*Taxidea taxus*), foxes and raptors. Prairie dog towns compared to adjacent grasslands show an increased density of small mammals, such as deer mice (*Peromyscus maniculatus*) and grasshopper mice (*Onochomys leucogaster*); however, species richness of small mammals was greater in areas without prairie dog towns (Agnew et al. 1986). Density and species richness of birds were significantly greater on prairie dog towns. Horned larks (*Eremophila alpestris*) were most common on prairie dog towns, whereas western meadowlarks (*Sturnella neglecta*) were most common on mixed-grass prairie without prairie dog towns (Agnew et al. 1986). Prairie dog towns also provide habitat for 5 classes and over 13 orders and 39 families of invertebrates (Deisch et al. 1989).

The burrowing activity of prairie dogs changes soil structure and promotes soil formation. Prairie dog activity decreases soil compaction, opens hard soils, and increases water percolation and aeration. Soils in prairie dog colonies are richer in nitrogen, phosphorus, and organics than adjacent grasslands (Sharps and Uresk 1990).

In western South Dakota near Conata Basin, plant production of 43 plant species was evaluated for three treatments after poisoning black-tailed prairie dogs on rangelands in western South Dakota (Uresk 1985). The three pre-poison treatments were ungrazed (no cattle or prairie dogs), prairie dogs only, and cattle plus prairie dogs. Results of the Uresk (1985) study indicated western wheatgrass (*Pascopyrum smithii*) had lower production on the prairie dog, and cattle-prairie dog treatments 4 years after prairie dog control, when compared with no grazing. Buffalograss (*Buchloe dactyloides*) showed a decrease in production on the cattle plus prairie dog grazing treatment, when compared to no grazing. Needleleaf sedge (*Carex eleocharis*) was lower on the cattle-prairie dog treatment, when compared to the prairie dog treatment. No other significant differences were observed over the 4-year period among the three treatments for all other species, including grass and forb categories. Prairie dog poisoning did not increase plant production over a 4-year period. Additional time with reduced livestock grazing may be required to increase forage production (Uresk 1985).

In a different study conducted by Cid et al. (1991) it was found that combined grazing by black-tailed prairie dogs and bison (*Bison bison*) produces and maintains a series of changes in the vegetation of prairie dog colonies. However, because their grazing patterns differ in frequency and intensity through time, their individual impacts maybe different. The objective of this study was to determine the individual and combined influences of these 2 herbivores in maintaining selected vegetation characteristics of a prairie dog colony in a mixed-grass prairie at Wind Cave National Park. Results indicated prairie dogs and bison had similar and independent (i .e. additive) effects in maintaining plant community structure. Total above-ground biomass increased 32-36% within 2 years of removal of each species primarily as a result of increases in accumulation of graminoid biomass. Plant species diversity, equitability, and dominance concentration were similar in all treatments both years, although there were slight decreases in relative abundance of forbs and increases in relative abundance of graminoids in the second year after removal of grazers. Mean graminoid leaf nitrogen concentration (May to September) declined slightly but significantly after removal of prairie dogs (1.49 to 1.38%) in 1985, and after bison exclusion (1.64 to 1.50%) in 1986. Cid et al. (1991) suggest that rate of vegetation change following removal of grazers depends upon weather conditions, plant species composition, and prior intensity and duration of grazing.

Large grazers such as cattle can have a profound impact on rangeland ecosystems and prairie dog density and expansion. Prairie dog colonies and densities have been shown to expand on areas intensively grazed because of cover removal (Uresk et al. 1982). The exclusion of cattle grazing increases cool season grass density and height and prevented the expansion of prairie dogs on mid- and short-grass rangelands. A review of the literature and available information does not justify holding distribution and numbers of prairie dogs at a level that is too low to perform their “keystone” ecological function (Miller et al. 2007). Research provides evidence that indicates that it is especially important that prairie dogs be sufficiently abundant on public lands to perform their “keystone” functions (Miller et al. 2007).

Prairie dogs can increase ecosystem diversity. Prairie dog towns break up contiguous areas of grassland communities allowing species usually in lower abundance in grasslands to increase. An example of this diversity was exhibited by resource selection for pronghorn antelope (*Antilocapra americana*) in Custer State Park. Lehman et al. (2009) found pronghorn fawns selected bed sites on the periphery of prairie dog towns. The diversity of grasses and forbs provided along the edges of prairie dog towns and upland native prairie was utilized by pronghorn fawns in Custer State Park.

<u>Role of Precipitation</u>

Precipitation plays a critical role in the functioning of the rangeland ecosystem. According to records kept at Wind Cave National Park, the average annual precipitation on their north boundary (CSP's south boundary) is 16.5 inches. Records have been kept at a USGS weather station by the park's Wildlife Station Visitor Center since 1984 (Table 4).

The distribution of rainfall on the southeast pasture in CSP is skewed to the second half of the water year. Over 75% of the moisture occurs between April and September with April-June receiving just almost half the annual rainfall. May is the wettest month. Keller (2011) modeled forage production in CSP. Top model to predict forage production included rangeland and woodland ecological site (15 categories), current year spring precipitation, previous year spring precipitation, ordinal day of last spring frost, a pseudo-threshold form of canopy closure, a quadratic form of elevation, a binary (on / off) prairie dog colony variable, and slope. When evaluating the 3 climatic factors, total current-year spring (1 April – 30 June) precipitation, total previous-year spring precipitation, and the date of the last spring frost on forage production with all other variables in the model held constant the current year spring precipitation is the most influential climate variable. The date of last spring frost was negatively related to forage production, but the relationship was not as strong as either precipitation variable.

Table 4. Cumulative precipitation Wildlife Station Visitor Center 1984 to 2013.

Month	Ave. Monthly Precipitation (inches)	Ave. Cumulative Precipitation (inches)	% of total by quarter
October	1.27	1.27	1st quarter 12.4%
November	0.69	1.95	
December	0.30	2.25	
January	0.31	2.56	2nd quarter 9.7%
February	0.55	3.11	
March	0.89	4.00	
April	2.13	6.13	3rd quarter 45.5%
May	3.21	9.34	
June	2.91	12.25	
July	2.75	14.99	4th quarter 32.4%
August	1.75	16.74	
September	1.39	18.13	

Historic Management

Wildlife stocking-rate decisions are critical to the long-range stability of rangeland ecosystems and depend on accurate estimates of forage production. Forage production models are important to land managers where climate is variable and drives forage production. Natural Resource Conservation Service (NRCS) production tables are an important resource because they estimate forage production by ecological site. Annual forage production dictates wildlife and bison stocking rates. The park has used a model that incorporates NRCS estimates modified with a moving-two-year mean of annual precipitation (see Bison – current status, historic management: balance production and consumption). This model projected production in the following growing season, allowing adjustment of stocking levels through fall management activities (i.e. bison auction and hunting seasons).

Species-specific biomass, as well as woody twig and foliage biomass data was collected from 2005-2008. Clipping and weighing and visual obstruction techniques were used to measure forage biomass (Keller 2011). Keller (2011) also developed models of resource use and forage utilization. Models provide insight into forage utilization, grazing interactions and spatial distribution of grazing pressure (see Future Management Direction: Approach for Balancing Production and Consumption).

CSP has used fire in several areas (see Figure 27) to improve forage production and quality as well as reduce exotics. Production of forbs was significantly higher on burned sites and utilization of forage was also higher on burned sites in CSP (Easterly and Jenkins 1992). Spring burning also reduces cool-season grasses and enhances warm-season grasses. Additionally, fire has been used to control encroaching pine on rangeland ecological sites. Timber activities over the past 20 years have included the removal of timber from rangeland ecological sites. These practices have been directed at returning rangeland ecological sites to areas that have been encroached through the exclusion of fire from the system.

WILDLIFE

Overview of wildlife presence on Custer State Park rangelands

Wildlife management on rangelands under the Custer State Park Resource Management Plan 1995-2010 was based primarily on forage production and allocation. Primary species of consideration on rangelands were bison (*Bison bison*), elk (*Cervus elaphus*), pronghorn (*Antilocapra americana*), deer (*Odocoileus spp.*), and black-tailed prairie dogs (*Cynomys ludovicianus*). Bison were the primary emphasis species because of their importance in terms of economics, ecology, and visitor expectations. However, changes in the market of bison and changes in park administration have reduced their importance economically.

Elk are native to the Black Hills and adjacent areas but were extirpated in the early 1900's. Custer State Park received 3 introductions of Rocky Mountain elk (*C. e. nelsoni*) in 1914, 1915, and 1916 (Custer State Park Historical Data, unpublished). Elk are very susceptible to human disturbance and generally avoid human interaction by utilizing forest cover and avoiding roads. Elk do extensively use the forest-range ecotone, especially for night grazing (Millspaugh et al. 2000, Millspaugh, 1999).

Pronghorn are very important as a viewable wildlife species in CSP. Using minimum counts pronghorn have varied from at least 100 animals to a high of just over 350 in 2009. Pronghorn fawns select bed sites near prairie dog towns based on a study from 2008-2009 (Lehman et al. 2009). Pronghorn were not hunted from 1986-2008, but were hunted again starting in 2009 due to increased density.

Mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*) are also native ungulates on CSP rangelands. A deer study was conducted in the early 2000s which quantified CSP deer demographics and densities (Woeck 2003). White-tailed deer were estimated at 853 animals (95% CI = 670-1162) and mule deer were estimated at 321 animals (95% CI = 152-998) in 2002 (Woeck 2003). Deer are important as watchable wildlife in the park with trophy class bucks available to the viewing public. In past seasons a limited draw for any deer and any white-tailed deer has occurred annually with tags being available to the South Dakota residents.

Prairie dogs have a significant effect on rangelands in CSP. Their presence on rangelands increases biological diversity at several scales. Prairie dog colonies are distributed across CSP rangelands and are also an important viewing species. Prairie dogs are managed primarily through chemical control.

Black-footed ferrets (*Mustela nigripes*) are an endangered species that were reintroduced into Wind Cave National Park by special permit under the Endangered Species Act. Ferrets have expanded their range and occur in the southern portions of Custer State Park. They use prairie ecosystems and forage primarily on prairie dogs. The presence of black-footed ferrets increases species richness. Further, the presence of black-footed ferrets returns a natural predator and mammal to the ecosystem and returning healthy system function. Finally, this predator would be a natural biological process in which to potentially control prairie dog populations.

Burros (*Equus asinus*), a non-native species, inhabit the park in one primary herd by the corrals. These animals originated from the Harney Peak trail rides and/or area miners. These animals are a visitor attraction because of their approachability and viewability. Burro numbers are controlled through a surplus auction conducted in conjunction with the annual bison auction.

Coyotes (*Canis latrans*) are found throughout CSP, including the open rangelands. Little is known about coyote ecology or population trends in the park. Past studies in the Black Hills indicate that deer can be an important food resource, especially in the winter (MacCracken and Uresk 1984). Predation has been postulated as a population limiting factor for both deer and pronghorn in CSP. These predator/prey relationships need investigation.

Several small game, game bird, and non-game species exist on CSP rangelands. More obvious species in addition to prairie dogs are cottontail rabbits (*Sylvilagus* spp.), sharp-tail grouse (*Tympanuchus phasianellus*), and various raptors. This group also includes species with federal or state protected status (eg. raptors and eagles, swift fox [*Vulpes velox* – historic records], migratory songbirds, and rattle snakes [*Crotalus viridis*]). The primary sources of information on non-game species in CSP are field guides, and the South Dakota Ornithological Union breeding bird survey. Also, inventories of non-game species were conducted for birds (Schickel 2007) and small mammals (Ellis et al. 2008). Documentation of presence/absence and status of non-game is very limited to nonexistent for most groups; especially reptiles and amphibians.

Bison – current status, historic management

The Bison Program had 4 goals: 1) Provide for public viewing, 2) ensure a balance between forage production and the consumptive demand of the bison population and other wildlife species, 3) maintain a high quality, disease free herd and continue that herd as a viable economic enterprise, and 4) manage to conserve the diverse genome present in the CSP herd.

Provide for public viewing

Tourism continues to expand in the park. A $7.8 million concession development plan initiated in the early 1990's stated the intent of making Custer State Park a tourism destination. An additional $12 million concession development program was initiated in the mid 2000's. Visitation rose from 1,272,000 in 1987 to 1,800,000 in 2010 (+41.5%). The park continues to develop the spring and fall "shoulder seasons". The annual buffalo roundup is an important fall event for the park.

Management events are open to public viewing and in some cases, limited public participation. Promotion of the park's fall roundup has resulted in crowds growing from 2,000 in 1993 to over 14,000 spectators in 2010. Managing the viewing public has become a major part of the fall roundup management event.

Participation by volunteer horsemen in the park's fall roundup has been historic; however, since 1988 it has become more rigidly controlled. In 1993, three teams of ten riders each were used in the roundup. That number has grown to three teams of twenty riders. Each team leader is radio equipped and works in concert with a vehicle team during the roundup. Each team is comprised of a core group, an invited group, and a draw group. The core group is experienced riders with experience around buffalo. The invite group is comprised of dignitaries and other figures invited by the governor's office and has experienced and inexperienced riders. The draw riders are interested public riders drawn annually from application. All riders are required to sign waivers of park liability prior to participating.

The public has full access to the buffalo herd. Fortunately, the park has had few gorings and only one fatality. The park continues to rely on signing, "Buffalo are dangerous - do not approach", to communicate the importance of caution to park visitors.

Balance production and consumption

Several factors determine rangeland production allocation. These factors include economic impacts of the bison herd, expectations of park visitors, legislative requirements, Department and Division goals and rangeland ecology. Available production estimates were based on the level of grazing that will not result in a deterioration of the condition class of the Ecological site.

CSP bases production on rangeland and woodland ecological site estimates modified by factors such as rangeland production, forest canopy closure and percent normal rainfall (NRCS 2003). The park model uses 25% of predicted production as available for grazing consumption. Since 1988, the park has used this predictive methodology in planning annual reductions and resultant overwintering populations to attempt to match demand with expected rangeland production for upcoming summer. Because populations are adjusted in the fall, a predictive model must be employed. This model uses a weighted 2-year mean of 25% of the previous water year precipitation and 75% of the current water year precipitation to predict the percent normal precipitation the following growing season. Production is predicted to be the weighted mean percent of normal production and populations are adjusted up or down accordingly. A research study was conducted in 2005-2009 to validate the production and utilization variables used in this calculation (Keller 2011). Allocations for target populations under normal rainfall conditions for 1995 to 2010 are shown in Table 5. Table 6 represents actual production/allocation present in 2010.

Table 5. Production/allocation 1995-2010 under normal rainfall conditions. Population numbers represent overwinter population goals. Percent represents allocation to species in range, forest or the overlap ecotone.

Species	**Range****	**Overlap****	**Forest****
Bison 11,108 AUM (967 head)	70.4% 8,331 AUM	45% 1,594 AUM	15% 1,183 AUM
Elk 6,480 AUM (900 head)	16.4% 1,944 AUM	55% 1,944 AUM	33% 2,592 AUM
Other* 1,536 AUM (586 head)	4.4% 516 AUM		13% 1,020 AUM
Un-used 4,115 AUM	8.8% 1,043 AUM		39% 3,072 AUM
TOTAL 23,239 AUM	11,834 AUM	3,538 AUM	7,867 AUM

*	300 Deer	720 AUM
	125 Pronghorn	300 AUM
	36 Burros	216 AUM
	125 Bighorn Sheep	300 AUM
	586 head	1,536 AUM

** Represents usable forage or 25% of estimated total production.

A major interior division fence was completed in 1991 and used for the first time in 1992. The southwest division fence enables grazing control in the SW section of the park. Its first use was for late season deferment of the SW pasture (repeated through 1995), the intent being to increase carbohydrate reserves in big bluestem (*Andropogon scoparius*).

Table 6. Production/allocation 2010 under 2 year moving mean rainfall conditions (111%). Population numbers represent overwinter population levels. Percent represents estimated utilization by species in range, forest or the overlap ecotone.

Species	**Range****	**Overlap****	**Forest****
Bison 9,310 AUM (804 head)	75% 6,983 AUM	15% 1,396 AUM	10% 931 AUM
Elk 1,512 AUM (210 head)	20% 302 AUM	30% 454 AUM	50% 756 AUM
Deer 2,400 AUM (1000 head)	12.5% 300 AUM	12.5% 300 AUM	75% 1,800 AUM
Pronghorn 780 AUM (325 head)	75% 585 AUM	15% 117 AUM	10% 78 AUM
Bighorn 91 AUM (38 head)			100% 91 AUM
Burro 180 AUM (30 head)	67% 120 AUM	33% 60 AUM	
Un-used 11,522 AUM	42% 4,846 AUM	14% 1,600 AUM	44% 5,076 AUM
TOTAL 25,795 AUM	13,136 AUM	3,927 AUM	8,732 AUM

Problems with grazing distribution persist (Keller 2011). Forage production/allocation models and target numbers assume distribution of animals uniformly across range, forest and overlap areas as noted on tables by species. Certain areas of the park receive disproportionate use while other areas remain underutilized. The park has maintained the SW division fence and periodically defers the SW pasture primarily for warm season grass release. The RD (named for Recreation Demonstration Area) fence continues to provide a late growing season deferment from bison. Additionally, permanent water sources and mineral sites have been developed across CSP ranges.

<u>Maintain a high quality, disease free herd and continue that herd as a viable economic enterprise</u>

Custer State Park (CSP) was an operationally self-supporting unit of South Dakota state government until 2005. Bison were an important part of that revenue stream. However, dramatic fluctuations in the bison market from 1995 to 2005 made budgeting tentative and impacted CSP operations (Figure 4). A merger of the Division of Custer State Park and the Division of Parks and

Recreation made additional funding sources available and consequently reduced the park's reliance on maximizing revenue through the exploitation of natural resources including bison. However, the sale of surplus bison remains an important revenue basis for CSP and the Division.

Over the previous planning period, CSP diversified its marketing of bison surpluses. Marketing venues have included; the annual live production auction since February of 1966, a Trophy bull hunt annually since 1962, and a sealed bid offering of contract calves and yearlings beginning in 1984. From 1988 – 2002 CSP participated in the National Bison Association's video auction during the National Western Stock Show, in Denver, Colorado. The park transitioned to a phone/fax auction format from 2003 – 2006 which lead to the current Internet auction beginning in 2007. CSP also marketed cull cows to Custer State Park Resort Company for use in the Park's restaurants from 2001 – 2006. A Non-Trophy Hunt of cull cows and 30 month old bulls was initiated in 2004. The annual live auction accounts for approximately 75% of the surplus annually depending on the current herd numbers. From 1995 – 2010, inclusive, CSP marketed 4,655 head of bison through the annual live auction. In addition to live auction sales, CSP has sold surpluses of 2,312 head through the other venues during this time period.

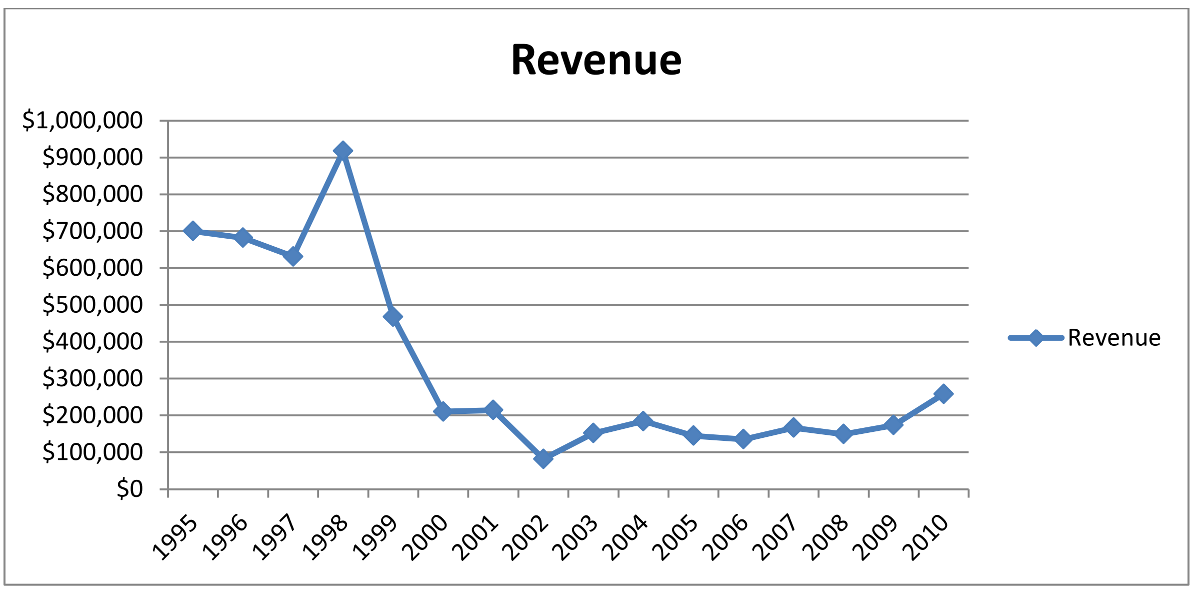

Figure 4. Revenue generated from bison live auction sales 1995-2005.

Custer State Park's past bison program goals placed a heavy emphasis on herd productivity. CSP has made several changes from the previous plan that shifted those objectives. The labor and direct overhead costs of this emphasis on productivity was reduced to where a slight decline in productivity is still acceptable. Those changes implemented are:

1. Pregnancy testing breeding age cows had occurred sporadically over the years. In February of 2002 annual pregnancy testing all breeding age cows began. Emphasis on fertility was the main reason to pregnancy test. Culling the unproductive cows for the current season was initiated rather than an age based removal of ten years old cows. Coinciding with this decision was allowing the cow herd to age. Fertility and age of the cows as this herd aging progresses will be closely monitored. Research indicates that fertility may decline at approximately 16 – 17 years of age. At this same time a random group of 15 cows were marked with dangle tags to begin observation as the social/family structure of the herd re-establishes. Of this group only 3 cows of the same age continued to remain in close proximity with each other as anticipated. The current herd structure was based on age cohorts which was very observable. The pregnancy testing was moved from February to October when the "winter round up" was discontinued after February of 2006. Beginning in February of 2003 only the surplus calves are weaned, the remaining herd calves are returned to the cow to allow her to naturally wean the calf. This has allowed the social/family structure of the herd to re-establish. No significant decline in productivity was experienced. It has varied slightly more than in previous years but not substantially.

2. Supplemental feeding of the cow herd was discontinued the winter of 2003. Due to the social structure of bison it was not accomplishing the objective of supplementing the cows that were in lower body condition. The dominant cows were consuming the majority of the supplement. The only feasible way to accomplish the intended objective would have been to segregate the lower condition cows and feed separately, this would have been labor intensive and not in the nature of natural management of bison. Supplemental feeding of the weaned sale calves continued; however, the source was changed in 2005 to a dehydrated alfalfa pellet instead of a grain based feed.

3. Free choice mineral is offered on a year round basis.

4. The practice of the annual "winter round up" was discontinued after February of 2006. The objective of the winter roundup was weaning the herd calves and sorting spring delivery contract animals. Eliminating the stress of an additional handling was the primary reason for discontinuing the winter roundup. The handling of the herd went to a true annual basis where all surpluses for the season including contract animals are sorted off during the fall round up and handling. The "contract" bison, typically calves, are held throughout the winter in the small "trap" paddocks near the corral area and supplemented with natural protein lick tubs and alfalfa pellets. Another main event that was discontinued after the fall of 2006 was the Sunday "push" of the annual round up. Again the main reasoning was to reduce the stress on the bison. The herd is now opportunistically captured in the east RD pasture several days prior to the round up. Any stragglers are gathered if needed just prior to the corralling event.

The park pursues the qualitative aspects of its third management objective through several management techniques. Disease testing is done annually in conjunction with the sales program. Routine testing deals with brucellosis and tuberculosis. Vaccinations for calves include female official calf hood brucellosis vaccination, and those things pertinent to the stress of handling and weaning of sale stock. These include pinkeye, parasites, IBR and PI3, and the blackleg complex. CSP will deal with other disease problems that occasionally arise. Replacement breeding bulls are selected with care. Through 1992, the primary emphasis had been strictly phenotypic. From 1992 until 2002, blood group alleles were considered. Additional factors have included fertility and weight. Currently, replacement bulls are selected based on weight (must be a minimum of 1000 lbs.) and fertility (must pass a standard fertility examination). Bulls meeting these minimums are randomly sorted to sale as certified breeding bulls or to the herd as replacement breeding bulls. Fifteen 2-year-old class bulls are returned to the herd annually since 2006.

Manage to conserve the diverse genome present in the CSP herd

Discussions on bison genetics occurred at the 1987 Public Bison Herds Symposium at Missoula Montana. CSP began a cautious approach to genetic management due to the inconclusive nature of those discussions on the role of public herds in bison conservation genetics. CSP conducted two genetic surveys using blood typing of the bison herd, one in 1984 and the other in 1992, by Stormont Labs, of Woodland, California. The intent of these surveys was to make an initial determination as to whether any genetic movement could be detected with the Custer State Park herd. The change in the heterozygosity index for Custer State Park offspring from 3.4 in 1984 to 3.1 in 1992, the differences between males versus females, and the 1984 males versus 1992 males were statistically significant. Thus, it appeared that the genetic base of Custer State Park had undergone some erosion. A greater depression of the heterozygosity index in males over females led to suspicions that the method of bull selection may have had an erosive effect on the herd's genetic base.

Custer State Park developed the goal of maintaining the genetic diversity of the CSP herd based on 8 blood group loci, the CA locus, and hemoglobin polymorphism. The goal was to restore the heterozygosity index of the Custer State Park herd to 4.0 by the year 2000 using only the inherent genetic material in the herd by selecting for rare alleles in replacement breeding bulls. This goal assumed that the heterozygosity exhibited among the known blood group systems was reflective of the broad, but unknown, genetic basis of the population. This method of breeding bull selection occurred until 2000.

Microsatellite testing as well as mitochondrial DNA (mtDNA) testing was conducted by the University of Calgary in 1992. Results indicated a high level of genetic variability at 11 microsatellite loci in CSP bison (Wilson and Strobeck 1999). Results from Strobeck's lab also revealed the presence of cattle mtDNA in a small percentage of animals (Ploziehn et al. 1995).

Additional testing using discriminatory microsatellite testing conducted by Texas A&M reveals that the CSP herd has a very diverse genome. However, there is some level of cattle genetic introgression at both the mitochondrial and nuclear levels (Ward et al. 1999, Schnabel et al. 2000). CSP sampled the entire herd (excluding mature bulls) in 2004. Blood samples were sent to the University of Missouri where they were genetically screened for the discriminatory microsatellite loci and mtDNA (Schnabel, unpublished data). Again, results demonstrated the very diverse genome of the bison herd and quantified the level of cattle introgression as low but significant at both the nuclear and mtDNA levels.

Additional samples have been extracted on replacement breeding animals. These samples have not been screened. All DNA samples are currently housed at Black Hills State University. The park is working with Dr. Shane Sarver's lab at BHSU to develop a genetic management strategy.

Prairie dogs - current status, historic management

Prairie dogs occur in 26 different towns in CSP, and in 2010 actively occupied 875 acres (Table 7, Figure 5). There were 8 acres of colonies that were previously occupied but were currently inactive as of 2010. Staff used a subjective ocular estimate based on numbers of prairie dog mounds to estimate density as high, moderate, or low density (Table 7). Most of the colonies were estimated as moderately dense. Most of the acreage occurs in three towns (Lame Johnny, Cow Camp, and Hay Flats towns; 677 acres). When the colonies exceed population goals and expand their areas, population control (primarily zinc phosphide poisoning) is implemented. Control on the Cow Camp town was conducted periodically in concert with prairie dog control in WICA. However, WICA ceased control of prairie dogs and has introduced black-footed ferrets. Control on the Cow Camp town is currently limited to the north and east perimeters to prevent further expansion. Other colonies which become established through dispersal from these existing colonies or from colonies in WICA are eliminated through chemical means or through controlled shooting.

Table 7. Prairie dog colonies that are active/inactive and density estimates (High, Moderate, Low) in acres for Custer State Park, updated 2010.

Active/Inactive and Density (High, Moderate, Low)	Acres
Active	875
Inactive	8
High	97
Moderate	626
Low	152

Current Grassland/Savanna Restoration

Currently Custer State Park has 2,995 acres of pine encroachment on rangeland soils (Figure 2). Encroachment areas were accessed by overlaying forested areas from the vegetation map with the soils layer in ArcGIS. Areas where rangeland soils exist with a pine condition indicate encroachment.

Range Improvement

The park has initiated numerous projects over the past planning period to enhance rangeland and woodland understory ecological sites. Projects include:

- Riparian trees planted along North and South Fork of Lame Johnny Creek;
- Prescribed fires including: Boundary, Red Valley, Swint Well, Hurst, Haystack Butte, Stony Hills, Tea Kettle, Old Buffalo Pasture, Elk Run, and South Fork in part to control smooth brome *(Bromus inermis)*;
- Prescribe fire to enhance ecosystem health: See Figure 27 for prescribed fire history 1995-2010;
- Use of chemical and biological control as part of an integrated approach to control invasive plant species;
- Control or removal of startup prairie dog towns including adjacent to Schleck's property;
- Treated the following prairie dog towns: Red Valley, Cow Camp near Baker Gate, Hay Flats, and South Viewing;
- No-till drilled native grass, forb, and shrub seed in degraded areas after red valley prairie dog town was treated in 2012;
- Rehabbed logging slash piles after burning;
- Treated noxious weeds and planted native grass seed in the Barnes Canyon prescribed fire area to keep soil on site;
- Constructed approximately 30 aspen exclosures to prevent browsing and allow regeneration;
- Water improvements, drilled three solar powered wells: old buffalo pasture, East R & D, and five gates. Installed 2 new water troughs off the Game Lodge water system. The first trough is south of volunteer village and the second trough is east of the Wildlife Loop Road in the old buffalo pasture. The following ponds were dredged from 1995-2010: North Farm, Robbers Roost, Swint, Norbeck, and Kill pasture;
- New 7ft. tall boundary fence built between Wind Cave National Park (WICA) and CSP constructed by WICA 2010-2012.

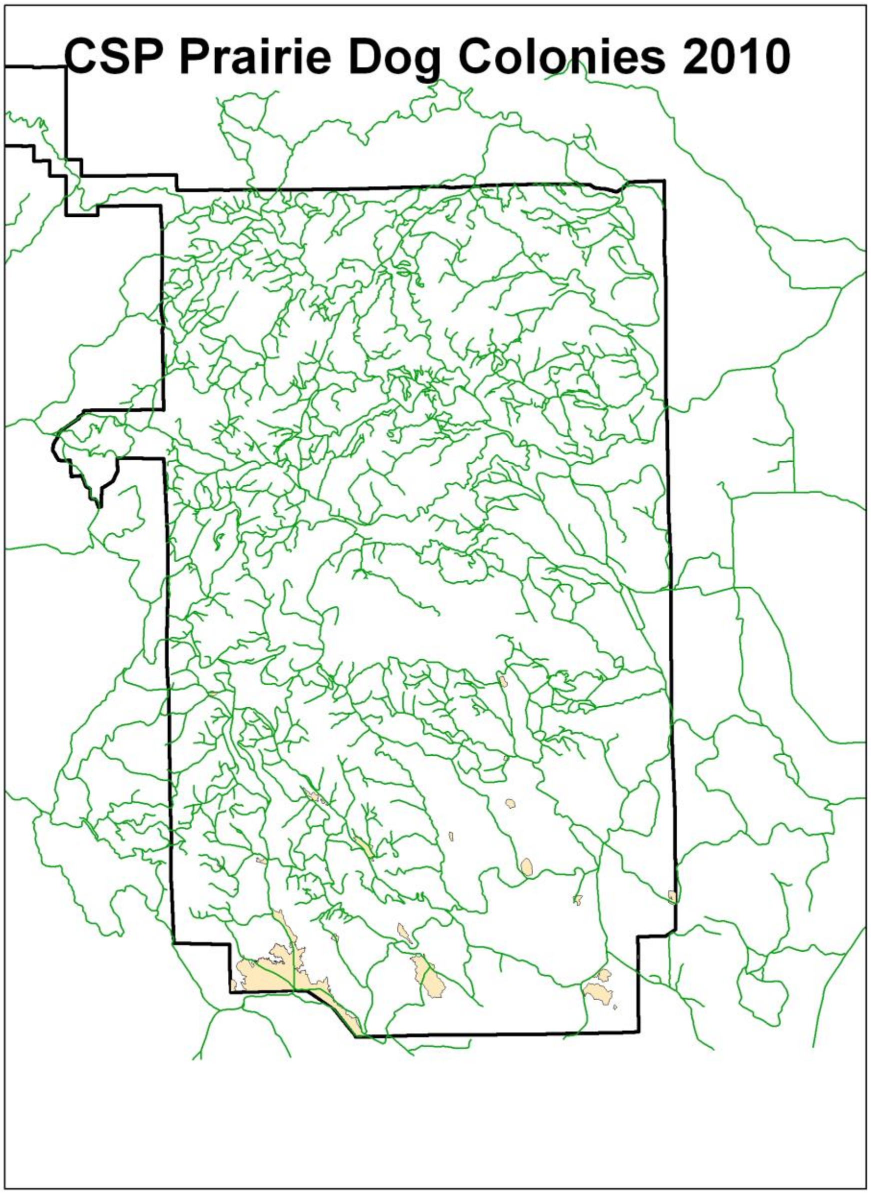

Figure 5. Locations of active prairie dog colonies (beige polygons) in Custer State Park for 2010.

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FOREST ECOSYSTEM

VEGETATION

Analysis of Vegetation in the Forestland System

Custer State Park's vegetation was mapped by the Remote Sensing and GIS Group, Bureau of Reclamation, based on color infrared aerial photography taken mid-summer 2000. Vegetation typing used the National Vegetation Classification System (NVCS). An inventory of the Black Hills was completed in 2000 and documented a comprehensive list of the NVCS plant associations found in the Black Hills. Most of Custer State Park's vegetation map units fell into existing NVCS associations. However 8 unique associations were created specifically for Custer State Park to represent recently disturbed areas, areas of sparse vegetation, and special associations smaller than the minimum mapping unit of 0.5 ha. There were a total of 50 mapping units broken into nine categories; 1) Modified Vegetation, 2) Sparse Vegetation, 3) Post-fire Vegetation, 4) Riparian/Wetland Herbaceous Vegetation, 5) Grasslands and Forblands, 6) Shrublands, 7) Deciduous Woodlands and Forest, 8) Coniferous Woodlands and Forest and 9) Land Use. Prior to writing this plan, color infrared aerial photography from 2005 and true color aerial photography from 2008 was used to update the original mapping project. Timber sales, thinning activity, and fires significantly altered the vegetation from 2000 to 2010. No forest inventory was completed on non-coniferous vegetation types. All analyses with these types are based on spatial data from photo typing. In the analysis of coniferous data; size, density, and species estimated from photo typing were used to calculate current stand characteristics. The size classes are: (1) Seedling = 0-1" diameter at breast height (dbh), (2) Sapling = 1-5" average dbh, (3) Medium = 5-9" average dbh, and (4) Large = 9+" average dbh. The density classes are: (A) Low = 10-40% crown closure, (B) Medium = 40-60% crown closure and (C) High = 60+% crown closure. The species are ponderosa pine (PP), white spruce (SP), and Oak/Pine, (OP). Due to the low number of stands on the forest and the limited inventory for oak/pine and spruce stands, they were not subdivided by size or density and were given a code of OP00 and SP00 respectively (Table 8). It should be noted that these size and density types were made for each stand from an aerial photograph and may not represent the exact conditions of the stand. Thirty-three percent of the conifer stands were field inventoried prior to writing this plan. A process called phototype expansion was used to assign characteristics of inventoried stands to the remaining uninventoried stands (Arney 1992). A database used for the current landscape description and future growth predictions was built using the stand specific data and attributes assigned to the uninventoried stands.

Custer State Park's forestland system contains tree vegetation dominated by ponderosa pine (*Pinus ponderosa*), white spruce (*Picea glauca*) or deciduous hardwoods. Forest inventory data indicates that areas typed as white spruce are in fact a mix of spruce and pine and are usually dominated by pine. Hardwood species that dominate forest stands in CSP are bur oak (*Quercus macrocarpa*), paper birch (*Betula papyrifera)*, and quaking aspen (*Populus tremuloides*). Many of the hardwood stands dominated by the above tree species are actually composed of a mix of these species and may also contain other hardwoods including American elm (*Ulmus americana*), green ash (*Fraxinius pennsylvanica*) and box elder (*Acer negundo*). See *Hardwoods – Historic Management and Current Status* below for further hardwood

Table 8. Photo typing classification breakdown

Classification	Area (%)	Area (acres)
PP01	0.2	68
PP2A	1.4	504
PP2B	0.7	271
PP2C	5.5	2,039
PP3A	10.3	3,814
PP3B	24.8	9,193
PP3C	15.2	5,644
PP4A	9.7	3,612
PP4B	12.8	4,762
PP4C	13.5	5,010
OP00	4.7	1,758
SP00	1.2	461
	100.0	37,134

analysis. The forestland system also contains large areas that were significantly impacted by large wildfires. Galena and Cicero Peak fires in 1988 and 1990, respectively, consumed 12,686 acres of timber and the Four Mile fire in 2007 consumed 1,129 acres of timber, resulting in large areas with post-fire range and shrub conditions. In the 1995-2010 Resource Management Plan the forest system was broken into two categories: fire disturbed and non-fire disturbed. In this plan both categories will be considered together as the forestland system. However, for certain analyses and discussion only the live forestland will be considered (stands that contain live ponderosa pine, white spruce, or a pine/oak mix.)

Ponderosa Pine, P. Pine/Oak Mix, and White Spruce/P. Pine Mix

There are 34,915 acres of Custer State Park that are dominated by ponderosa pine, 1,758 acres that contain a mix of ponderosa pine and bur oak, and 461 acres dominated by white spruce. A portion of the pine dominated forest encroaches on 2,995 acres of ranges soils, of which 739 acres are on overflow soils (Figure 2). Overflow soils are predominately in draw bottoms, compared to other rangeland soil types that are predominately upland meadows. The current state of this forest is a direct result of the 1981 Vegetative Management Plan directives which imposed a forest regulation schedule beginning in the same year. The 1995-2010 Resource Management Plan continued those directives and guided the completion of forest regulation. During the regulation period (1981 to 2009) 23,876 acres of conifer vegetation were managed through timber sales and non-commercial thinning. Figure 6 indicates those areas that have been managed during the regulation period by five year intervals. The areas prioritized for treatment were managed according to goals established in the 1981 Vegetative Management Plan. Generally speaking, these goals were to bring the forest into a regulated condition by harvesting overmature timber and thinning (commercially and non-commercially) overstocked and stagnated forest stands while maintaining the unique diversity and aesthetics of the travel corridors. The goal of non-management was continued for the French Creek Natural Area and the Grace Coolidge Walk-In Fishing Area.

Results of the regulation period history on the forestland system can be seen in Figures 7-9 and Tables 9-12 which display the distribution of conifer density, diameter size classes, and age classes. Density of conifer stocking can be directly linked to forest management activity. Low density stocking areas for the most part have been recently harvested and/or thinned to improve forest health and growth. Understocked areas were thinned heavily to release hardwoods. Stands that were treated once, early in the regulation period have since grown and are generally medium stocked. High; overstocked areas are generally unmanaged areas that have not recently had significant natural disturbance.

Due to the prolific regeneration recorded in inventory plots, quadratic mean diameter (QMD) by itself is not a very useful statistic for many of the stands in Custer State Park. Most forest stands (85%) have a QMD less than 4 inches. Looking at QMD in size classes is much more useful. There are multiple ways to look at size classes. It should be noted that these are measured from inventory plots and are not the same size classes as the aerial photograph typing. QMD of the largest 200 trees/acre in the stand is more representative of where the majority of the overstory stocking is. Using this method 90% of park stands are in the 6-8" class (48%) and the 8-10" class (42%). Another classification based on where the majority of the stocking is, measured in terms of basal area, indicates that the majority of the forestland is in a large size class, nearly 30,000 acres (Table 13). In the 1995-2010 Resource Management Plan a goal of maintaining at least two percent of the live forest classed as "Very Large" was set. In 2010 6% of all forestland (all woodland soils – including fire killed areas) and 11% of live forestland was classified as "Very Large." It is also worth noting that nearly 30% of the forestland remains unstocked, mainly due to fires, but also to forestland meadows (see Forestland Meadows and Shrubs below).

Age class distribution across the live forestland system also tracks with management. Two thirds of the live forestland is 60-100 years old (25%) or 100-120 years old (42%), and is generally in managed stands. One third of the live forestland is 120 years old or older, and is generally in areas in travel corridors where large old trees have been preserved, inoperable areas, the French Creek Natural Area, and the Walk-In Fishing Area. The age class distribution also reveals how little of the live forestland (6.6%) is in a young age class (< 80 years). This is partly due to smaller trees being in higher age classes, but also reveals the lack of young seedlings and saplings dominating a stand across the live forestland.

Table 9. Conifer density (crown competition factor - CCF), live forestland.

Classification	Area (%)	Area (acres)
Under Stocked - <50	0.5	170
Low - 50-200	32.9	12,224
Medium - 200-300	47.3	17,571
High; Over stocked - >300	19.3	7,169
		37,134

Table 10. Size class (QMD of largest 200 trees/acre); live forestland.

Classification	Area (%)	Area (acres)
2 - 4" DBH	2.2	822
4 - 6" DBH	5.0	1,858
6 - 8" DBH	47.8	17,749
8 - 10" DBH	41.7	15,495
10 - 12" DBH	2.6	974
12" + DBH	0.6	236
		37,134

Table 11. Conifer age classes in the live forestland.

Classification	Area (%)	Area (acres)
15 - 60 yrs	0.2	75
60 - 80 yrs	4.4	1,650
80 - 100 yrs	20.2	7,507
100 - 120 yrs	42.2	15,685
120 - 150 yrs	16.8	6,232
150 yrs plus	16.1	5,985
		37,134

Table 12. Conifer timber size classes (majority of basal area) in all forestland system

Classification	Area (%)	Area (acres)
Non-stocked (fire killed or meadows)	29	15,834
Seedling - 3" tall-1" DBH	3	1,614
Small - Major Stocking 1-4.9"	2	842
Medium - Major stocking 5-8.9"	6	3,039
Large - Major stocking 9-15.9"	55	29,846
Very Large - stocking >16"DBH	6	3,404
		54,580

*Includes conifer stands on rangeland soil

Aside from age and size characteristics of the forest it is also useful to look at structural characteristics and their diversity across the forest. Aerial photography revealed that 9,304 acres (25% of 37,134 live forested acres) are in a multi-strata classification (Figure 10). This is somewhat short of the goal of having 35% of live conifer forests in a multi-storied condition by 2010 set forth in the 1995-2010 Resource Management Plan. Of the 9,304 acres of multi-strata stands, 44% or 4,082 acres occur on inoperable ground and 9% or 1,025 acres occur in the French Creek Natural Area. This indicates that over half of the multi-strata stands occur on managed acres, likely in the travel recreation zone.

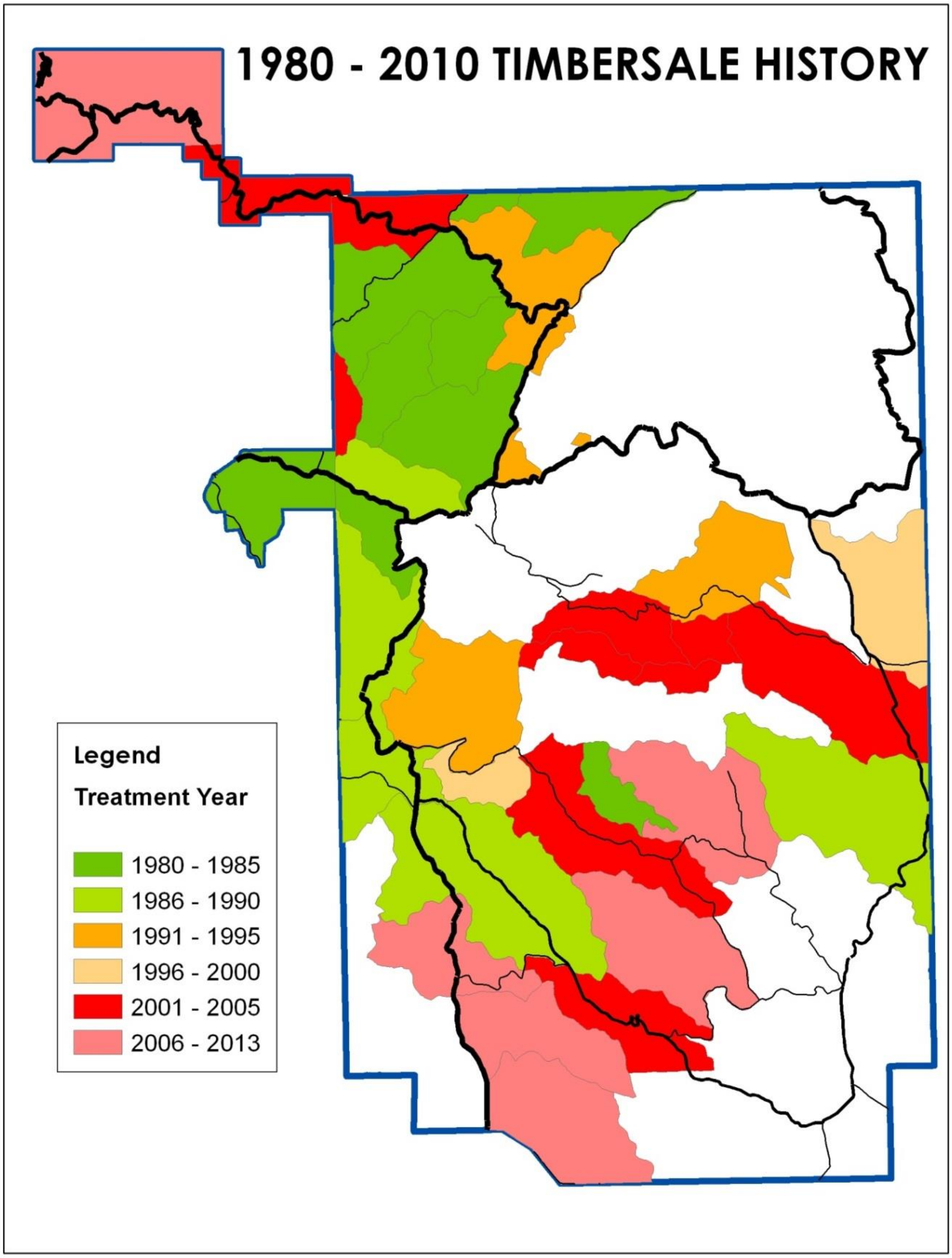

Figure 6. 1980 to 2013 Timbersale History.

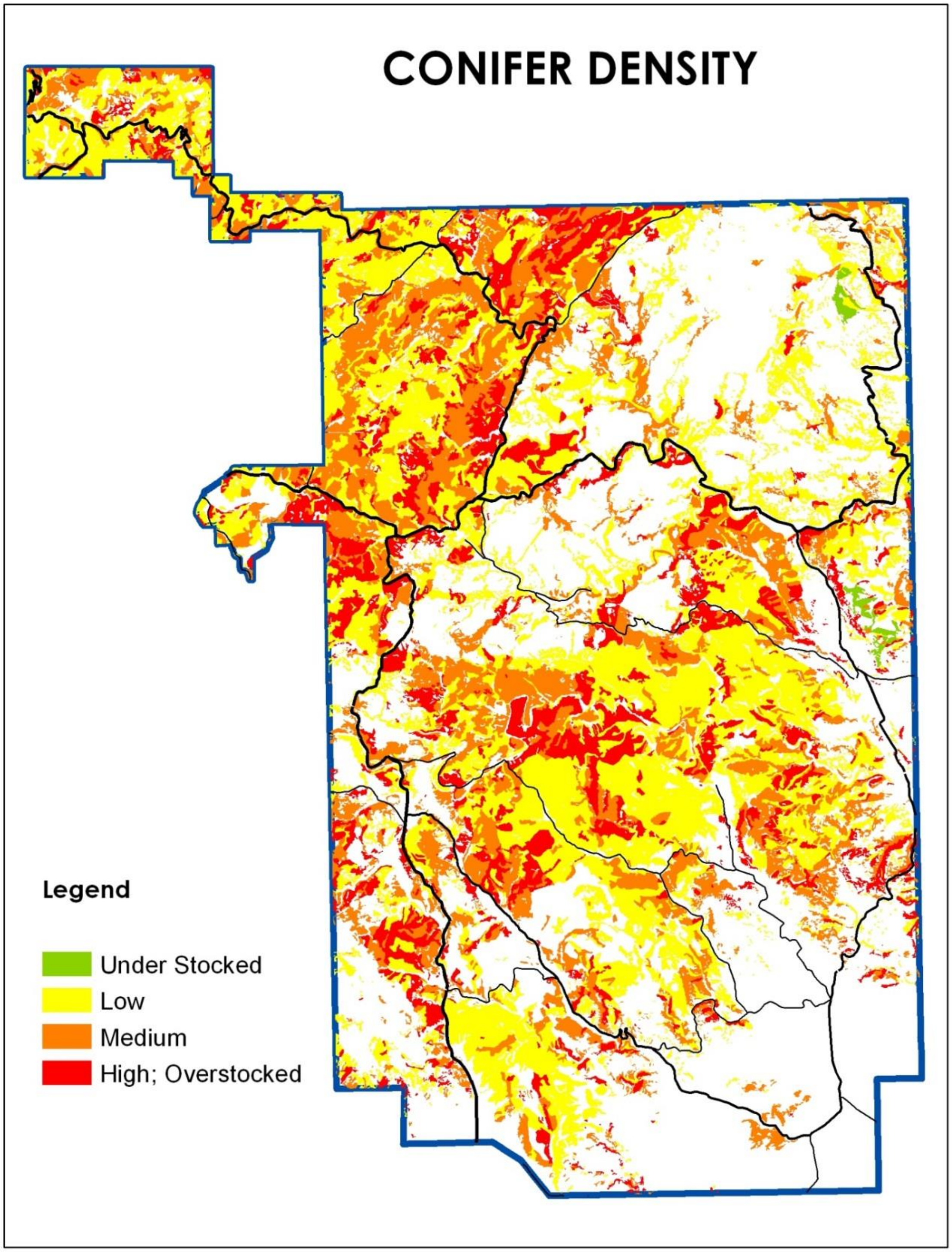

Figure 7. Conifer density, live forestland.

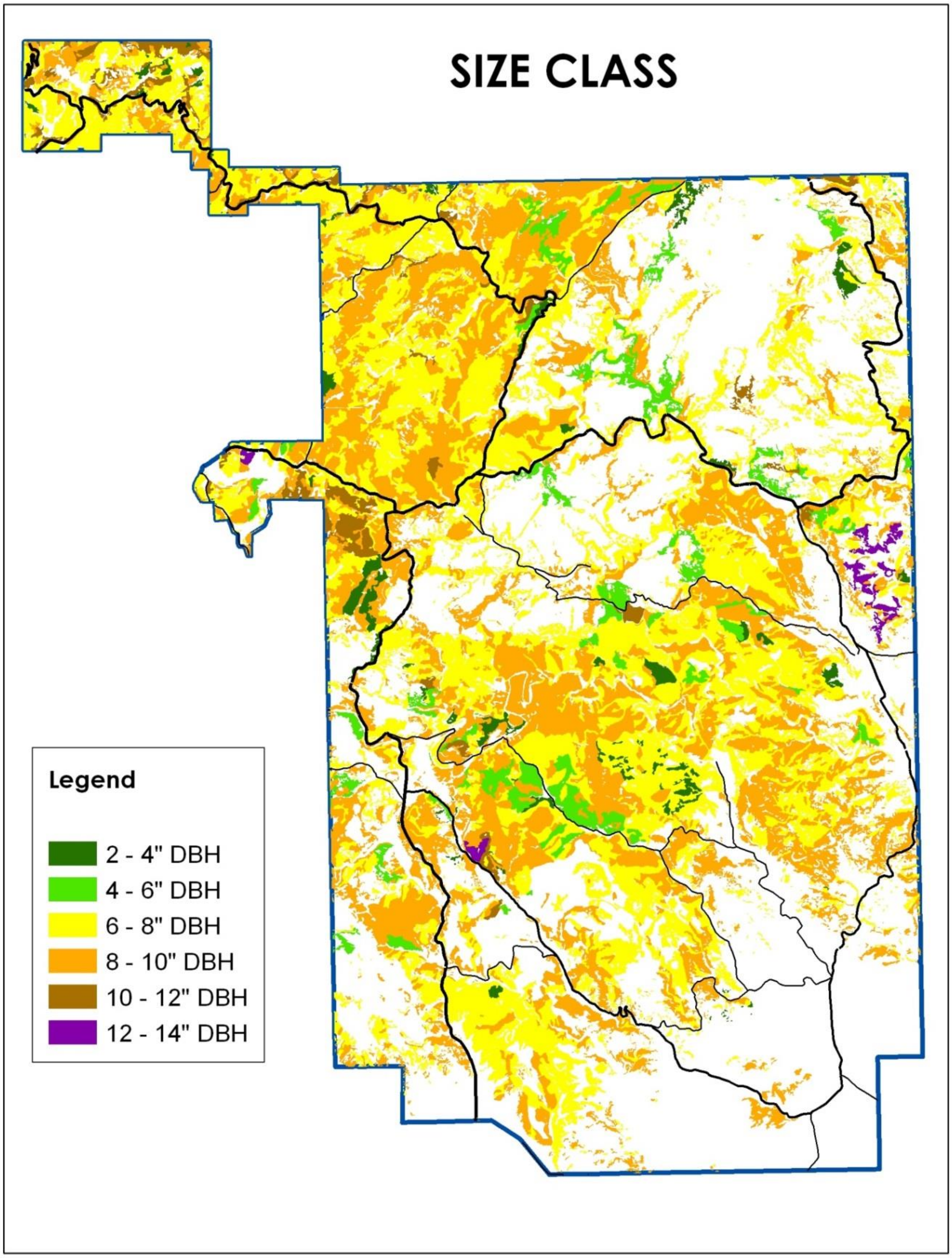

Figure 8. Conifer size classes (QMD of largest 200 trees per acre), live forestland.

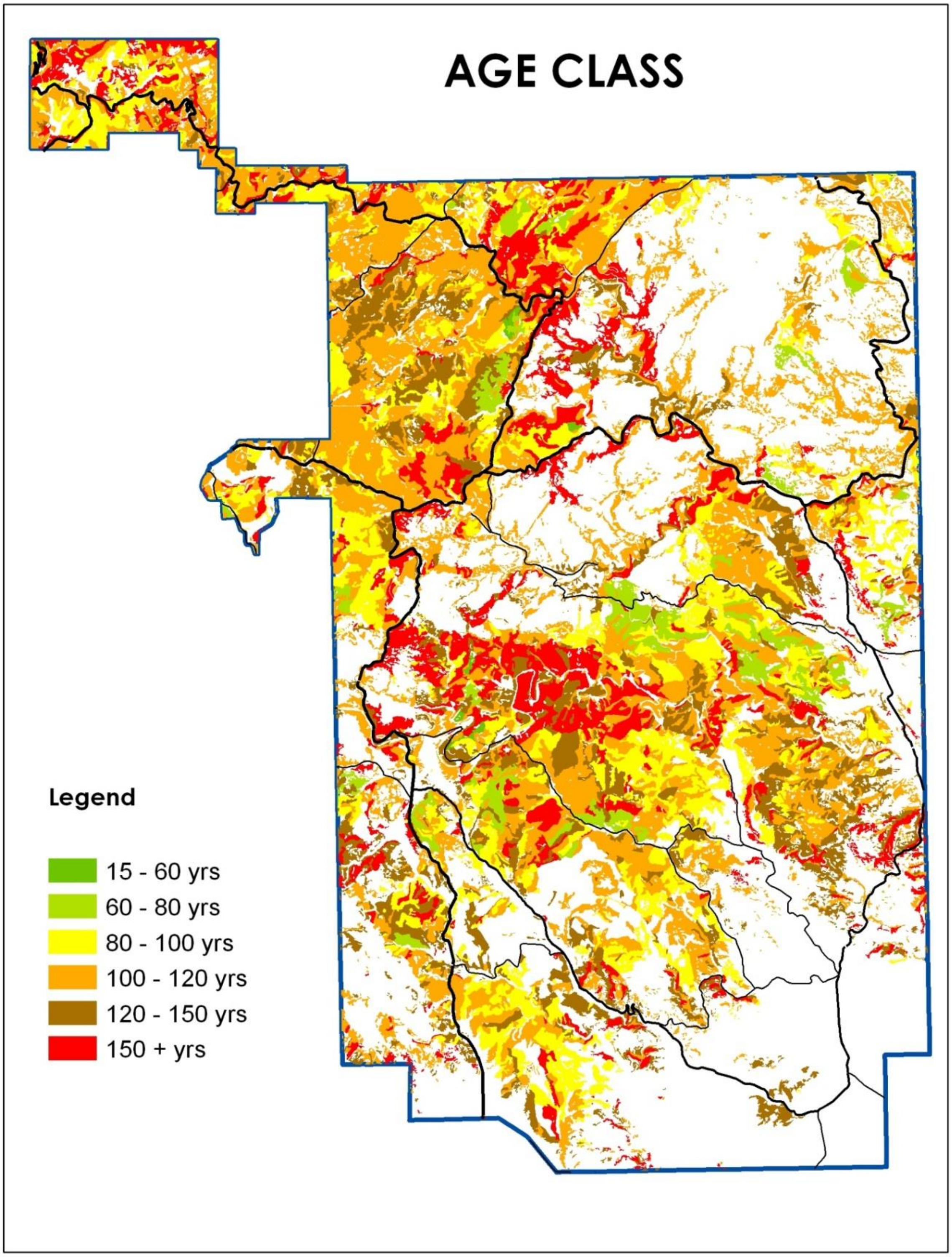

Figure 9. Conifer age classes, live forestland.

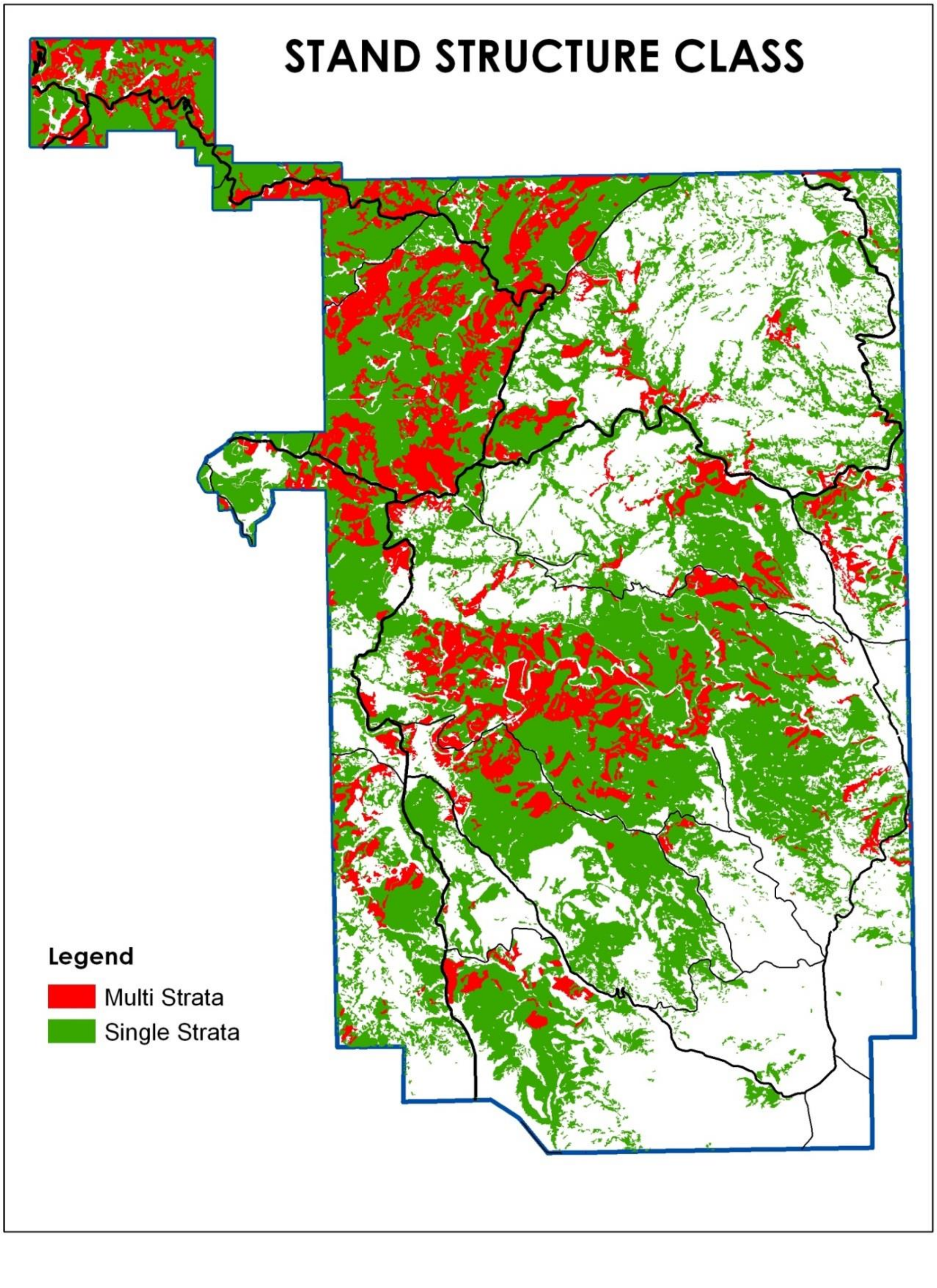

Figure 10. Stand Structure Class, live forestland.

Table 13 shows the total gross merchantable volume in the forest system by product class (this is not the same as size class). Thousand board feet (MBF) was calculated to a 6" top and does not include product other than logs (POL). By including POL in the calculation of cubic feet volume (hundred cubic feet – CCF) it alters the distribution of volume between size classes when compared to MBF, because the total CCF volume is greater by including the POL size class. It is worth noting that nearly 10% of the total cubic foot volume is in 5-8 inch product class, representing a significant amount of volume. Table 14 and Figure 11 indicate that nearly 30% of the live forestland acres and standing volume exist on inoperable ground or in the French Creek Natural area. This is a very significant amount of volume and reduces the timber base, thus reducing the amount of available timber that can be harvested on an annual basis. It also represents a significant portion of CSP that is generally unmanaged. The major exception to this would be the Sylvan Lake area, where thinning and mountain pine beetle treatments took place on inoperable ground.

Table 13. Gross merchantable growing stock volumes by timber product class.

PRODUCT CLASS	MBF TO 6" TOP	% TOTAL
8 - 15" Sawtimber	130,026	53
15" + Large Sawtimber	115,321	47
TOTAL	245,347	

PRODUCT CLASS	CCF - TO 4" TOP	% TOTAL
5 - 8" POL	48,461	9
8 - 15" Sawtimber	301,985	53
15" + Large Sawtimber	219,370	38
TOTAL	569,816	

MBF = thousand board feet
CCF = hundred cubic feet
POL = Products other than logs

Table 14. Inoperable ground/French Creek Natural Area acres and volume

CLASS	CCF - TO 4" TOP	ACRES
Operable	401,182	27,081
Inoperable/Protected Areas	168,634	10,050
% Inoperable	30	27
	569,816	37,134

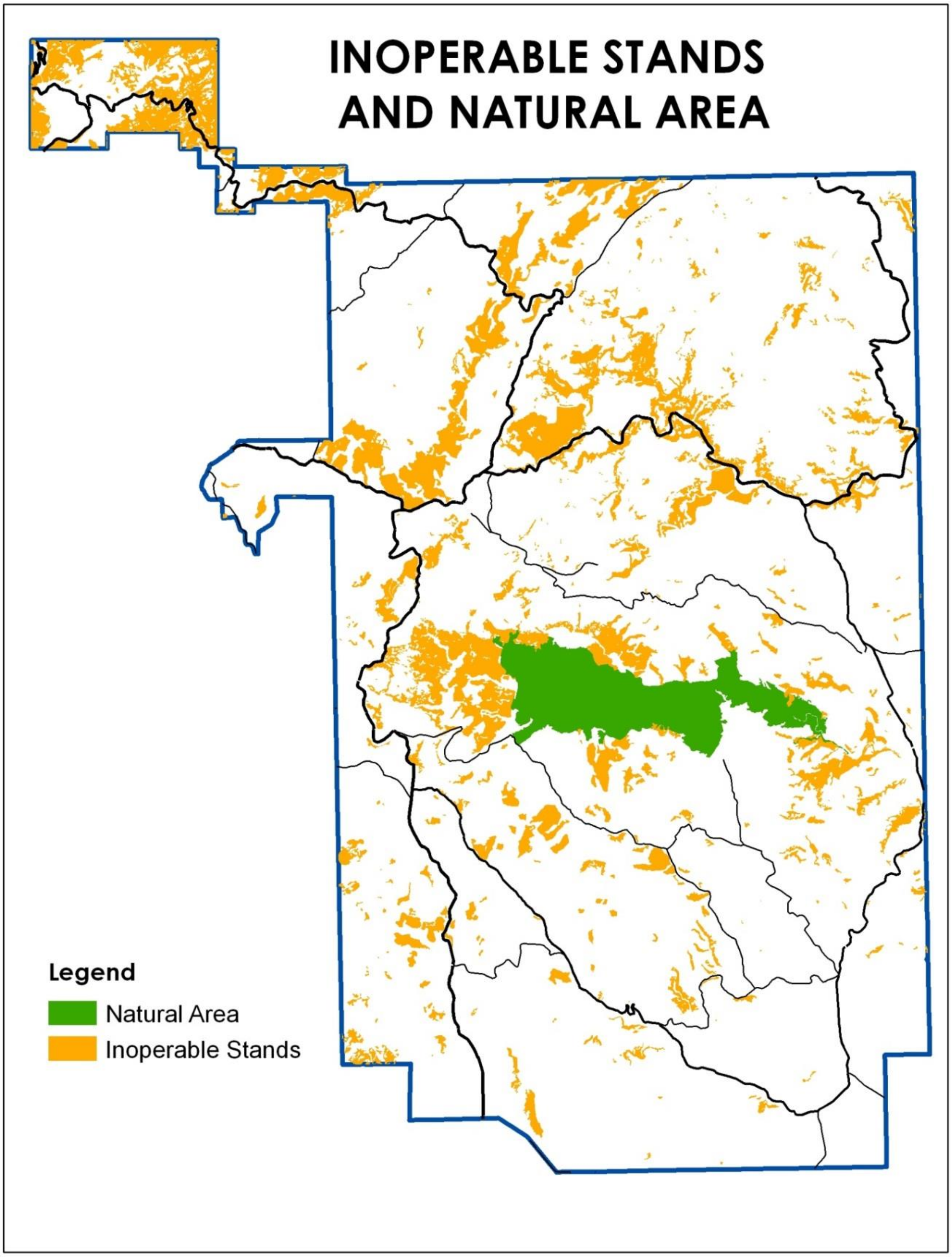

Figure 11. Inoperable Acres and French Creek Natural Area.

Hardwoods

The ecological importance of hardwoods was recognized as early as the 1951 Management Plan. The greatest value of hardwoods in the 1951 plan was seen in their indirect benefits to wildlife, watershed protection, and in breaking up the continuity of the pine types for insect and disease protection. Even though the 1951 plan discussed the importance of the hardwood types, it is evident that there were no actions taken to propagate or enhance these stands.

The Timber Management Plan of 1970 concentrated its efforts strictly on the management of ponderosa pine as a commercial timber producing species. The hardwoods were identified as individual types in the forest inventory leading to that plan but were not given any consideration in the management recommendations.

The Vegetative Management Plan of 1981 again recognized the ecological importance of hardwoods and set broad goals for hardwood acreages. These goals included increasing hardwood acreages wherever possible to 10% of the Park's forested acres and to improve the condition of existing stands so that they are vigorous and adequately stocked.

To achieve these goals the following treatments were implemented:

1. Remove merchantable pine from within and surrounding (up to 66 feet) established hardwood stands during commercial timber sales.
2. During non-commercial thinning operations pine is cut in a 30 foot radius from healthy individual hardwood trees.

Cutting of hardwoods to stimulate regeneration and planting hardwood trees were recommended in 1981. These measures were carried out on a limited basis but did not have a significant impact on the hardwood acreages.

Inventory from the 1995 Resource Management Plan indicated there were a total of 1,514 acres of hardwood stands in Custer State Park (4% of the total 38,155 acres forested in 1995). Current inventory indicates that there are 3,256 acres of hardwood stands in Custer State Park (8.4% of the total 38,624 acres forested in 2010) (Figure 12). Much of the hardwood acreage is dominated by bur oak or is a mix of bur oak and ponderosa pine (Tables 15, 16). One of the reasons for the large increase in hardwood acreage between 1995 and 2010 may be that photo typing in 2000 attempted to delineate as much of the hardwood stands as possible, even if they were a small size (less than 1 acre). Hardwood expansion and enhancement has continued to be done almost exclusively within the forestland system. Expansion tactics used from 1995-2010 were similar to those established in the 1981 plan. It involved clearing around established hardwood clumps in pre-commercial thinnings (30 foot expansion) and commercial timbersales (60 foot expansion). Additionally, 30 individual aspen clones were fenced or otherwise protected from ungulate browsing.

There has been no major effort to improve hardwood stands in the grassland system. The exceptions to this would be the removal of pine encroachment off of rangeland soils that contain hardwood stems and a tree planting project along Lame Johnny Creek. It appears that a significant portion of hardwood stands were lost in the Galena and Cicero fires. However, many of those lost hardwood stands have sprouted with little competition from ponderosa pine.

Table 15. GIS analysis of hardwood species.

Species	Area (%)	Area (ac)
Quaking aspen	6.2	203
Bur Oak	32.0	1,043
Oak/pine mix	54.0	1,758
Paper birch	2.4	78
Other hardwoods	5.3	174
Total	100.0	3,256

Table 16. GIS analysis of hardwood species on woodland soils.

Species	Area (%)	Area (ac)
Quaking aspen	8.0	190
Bur Oak	28.5	681
Oak/pine mix	58.5	1,395
Paper birch	2.7	65
Other hardwoods	2.3	56
Total	100.0	2,387

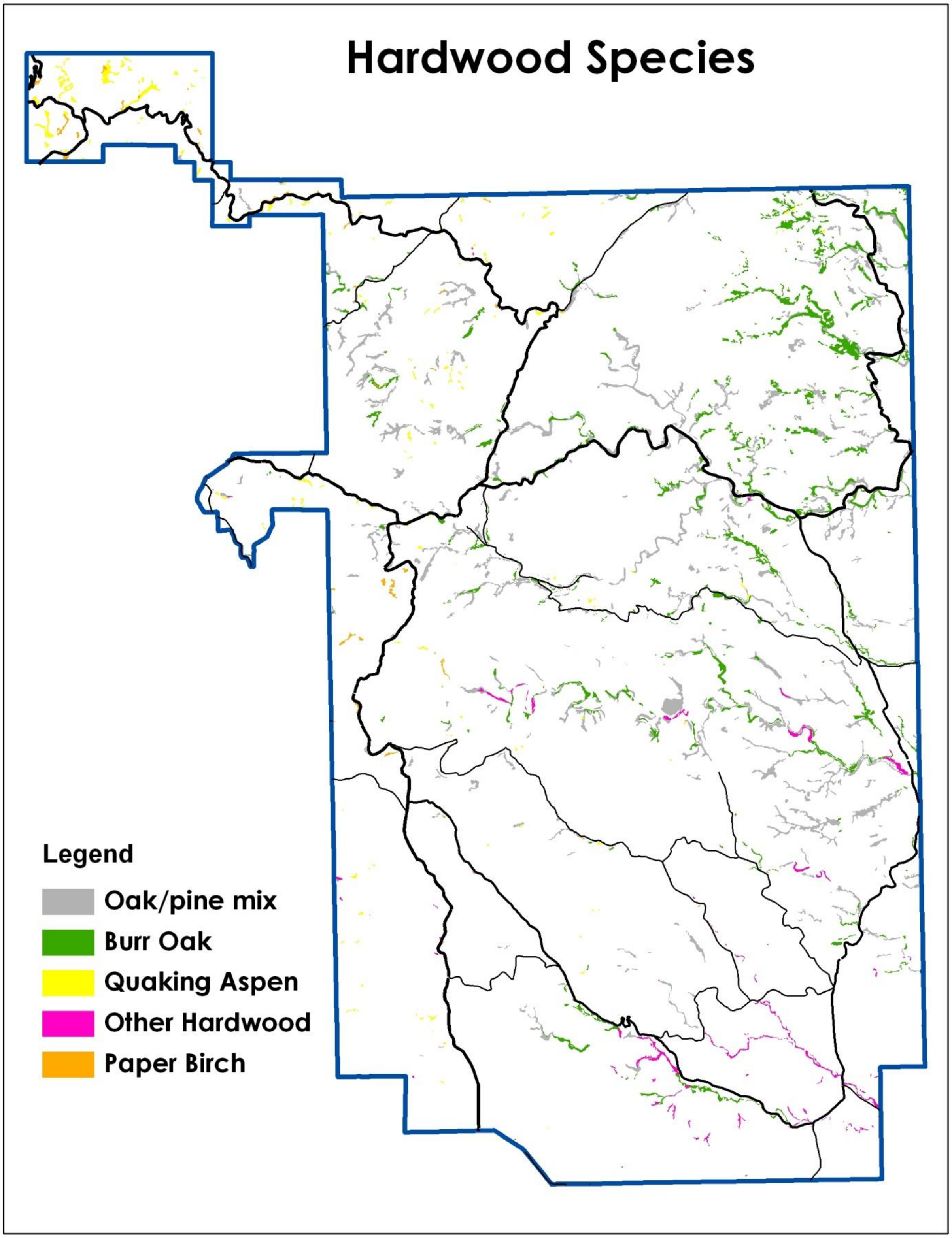

Figure 12. Hardwood species.

Forestland Meadows and Shrublands

Forestland meadows have been treated similarly to hardwood stands. With timber sales, non-commercial thinning contracts and prescribed fires, ponderosa pine has been selectively removed from the meadows. Without significant disturbance in the ecosystem, ponderosa pine gradually has and continues to encroach on forestland meadows and rangelands. The use of the above mentioned management tools has allowed for the preservation and expansion of this unique habitat and also aids in the diversity of the overall forest habitat. In 1995 there were 3,933 acres of meadow/rangeland on non-fire disturbed forestland and a total of 16,619 acres of non-timbered sites that occurred on woodland soils (includes fire killed acres). Current GIS data indicates there are 5,490 acres of meadow/rangeland on non-fire disturbed forestland and a total of 17, 448 acres of non-timbered sites that occur on woodland soils. 671 of these acres are dominated by shrubs. Of the 17,448 acres not timbered, 10,828 acres are a result of the Galena and Cicero Peak fires in 1988 and 1990 and 1,130 acres are a result of the Four-mile fire in 2007 (Figure 13). This figure was calculated using GIS analysis by overlaying non-timbered and shrubland sites on woodland soils as classed by the Natural Resource Conservation Service.

Four Mile Fire

The Four Mile Fire was started by an arsonist in June of 2007. The burn was approximately 2,300 acres (Figure 13). Fire behavior was classified as extreme and observed fire behavior included crown runs, group torching and active surface spread. Long-term drought and extreme weather conditions were major contributing factors to its size and intensity. In September of 2007 Richard Sparks, a past CSP Fire Management Forester, wrote a comprehensive Rehabilitation Plan. One of the major results of the plan was the identification of burn severity; high – 401 acres, moderate – 843 acres and low – 1056 acres (see Four Mile Rehabilitation Plan for more detailed information). High severity was characterized by complete consumption of both canopy and ground fuels resulting in nearly 100% mortality of trees. Moderate severity was characterized by partial consumption of canopy and ground fuels; however little to no tree survival was expected. Low severity was characterized by incomplete combustion of both canopy and ground fuels. Partial to complete overstory survival was anticipated. This equates to 1,244 acres having nearly 100% mortality of trees. This is close to the 1,130 acres photo typed as fire killed using aerial photography from 2008. The plan also identified areas in need of vegetation and soil rehabilitation. His main recommendations were seeding yellow sweet clover at a rate of 1.5 lbs/acre on high burn severity upland slopes and annual rye grass at 10-12 lbs/acre in drainage bottoms and cross felling standing dead trees on 164 acres of severely burned sites to reduce water velocity and break up concentrated flow in severely burned drainages. These activities were completed in early 2008.

Timber salvage was also an important component to the rehabilitation and succession of the post-fire vegetation. Contractors were required to use harvesting methods that left limbs and tops on the ground on slopes greater than 20% to act as a barrier to overland flow and reduce rain drop impact and soil movement. On slopes less than 20% whole tree harvest was acceptable. Approximately 8,000 tons were removed during salvage on 843 acres.

Galena and Cicero Peak Fires

Custer State Park experienced two large wildfires (Galena in 1988 and Cicero Peak in 1990, Figure 13). The gross area of these two fires was 20,952 acres. In 1995 it was estimated that 12,686 acres of mainly ponderosa pine forest was destroyed and 6,091 acres survived the fires. Much of the surviving forested acres had some level of mortality and their spatial location was very fragmented. A regeneration survey was conducted on the Galena Fire in 2001. The goal of the survey was to create a predictive model to estimate what the regeneration potential was based on a variety of spatial and topographic variables. A good model was not created and it was concluded that distance to seed source was the only reliable variable to estimate the likelihood of regeneration.

There has not been a significant landscape scale change to the tree component in these two fires areas since the 1995 Resource Management Plan. The majority of the mature timber stands in or directly surrounding the fire perimeters were not treated in order to maintain some cover in what are otherwise very open landscapes. Stands phototyped in 2000 revealed that there were a total of 6,825 acres of ponderosa pine stands with trees larger than seedling size and 524 acres of hardwood stands. When the Bureau of Reclamation phototyped stands in the burn areas they identified fire killed stands that had a presence of ponderosa pine seedlings. It was estimated that 1,614 acres had a significant seedling component. While the regeneration survey and recent photo typing may not be very accurate tools for estimating the amount of pine regeneration in the burn areas, it is evident that pine regeneration is occurring slowly and the majority of the burn area is still in a grass or shrub condition. Also, hardwoods that stump sprouted continue to grow without much pine competition.

Travel Recreation Zone

Custer State Park has managed the areas near the main travel routes in CSP in a unique manner. The ultimate goal throughout the park's history has been to maintain the aesthetic quality in the Travel Recreation Zone (TRZ) (See the 1995-2010 Resource Management Plan). In the 1981 Vegetative Management Plan, the TRZ was defined as the land within 500 feet of the road edge (designated travel corridors) or line of sight, whichever is least. The area of the TRZ was estimated at 9,997 acres. However, the actual management of the TRZ has been almost always on a "viewshed" basis making it near impossible to estimate acres that have been treated. The broad management goals of the TRZ in the 1981 plan were:

1. Provide for a healthy forest environment while utilizing each unit's capability for diversity.
2. Manage for approximately 1/3 of the TRZ pine acreage in "old growth pine."

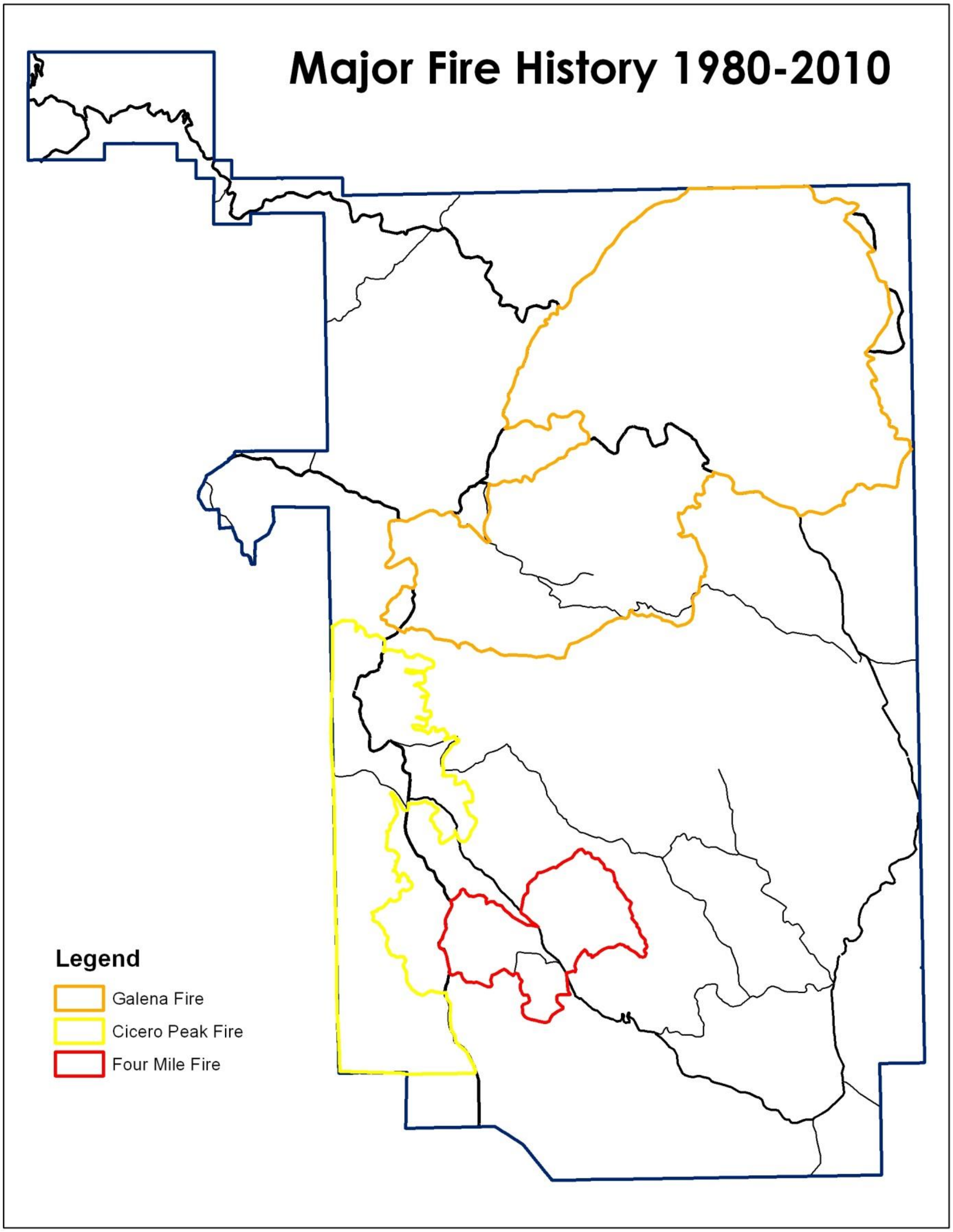

Figure 13. Major fires since 1980.

From 1995-2010 these broad management goals were employed when managing areas in the Travel Recreation Zone. In general the prescriptions in the TRZ left up to 80 square feet of basal area in "healthy" old growth wherever possible, hardwood stands were expanded where applicable, and dense stands of small trees were thinned to promote future old growth trees and produce a multi-aged stand. Areas within the TRZ are regularly treated when the adjacent general forest zone receives treatment. The forest management prescriptions specific to the TRZ have created areas diverse in vegetation type, tree size and appearance.

Old Growth

The 1995 RMP states "Custer State Park believes that the conditions commonly associated with the "old growth" forest of other regions – a stabile state condition of large areas of dense old trees, multistructured canopy, and an abundance of down material on the forest floor – rarely existed in the Black Hills due to the fire cycle of 15 – 20 years." Today as in 1995 there is not a well-defined definition of "old growth" in the Black Hills nor is there agreement as to how much, if any has ever existed. Currently, as in 1995, CSP recognizes that large, relatively old, ponderosa pine trees offer unique values and contribute to the diversity of the local ecosystem. In 1995 this led to goals of maintaining at least 2% of the live forestland in stands classified as "very large" and 35% or more of the live forestland in a multi-storied condition. As of 2010 6% of the forestland is in a "Very Large" size class and 25% is in a multi-storied condition.

Natural Areas

The French Creek Natural Area (FCNA) has similar conditions today as it did at the writing of the 1995 Resource Management Plan. Much of the FCNA, which is 2209 acres, remains unmanaged and has experienced little disturbance during 1995-2010. With the exception of small fires, there have been no major disturbances and fires have been actively suppressed. In 1995 inventory analysis indicated that 61% of the FCNA was overstocked, and that much of the area was very dense and stagnated. The 2010 inventory indicates that 41% of the FCNA is overstocked and 44% is moderately stocked. However, much of the moderately stocked area is in the upper end of the medium stocking category. Its primary use continues to be for the purpose of science, recreation, and education. The 1995 RMP aimed to conduct a large burn on the western half of the FCNA to enhance bighorn sheep habitat. This burn was never completed and has only had some minor planning to date.

The Grace Coolidge Walk-In Fishing Area has been managed under the same auspices as French Creek except that an official boundary has never been delineated. In 1988 this area was burned over by the Galena Fire. It continues to be a prime recreation area frequented by many park visitors.

System Function

<u>Fire Ecology In Black Hills Ponderosa Pine</u>

The forestlands of the Black Hills were typically modified by several disturbance agents. Historically, fire was a keystone ecological process that shaped the composition and structure of plant communities in the Black Hills (Shepperd and Battaglia, 2002). Ponderosa pine is adapted to fire through thick, insulating, fire resistant bark, self-pruning of lower limbs, and fire resistant foliage (see fire effects section for more information on other Black Hills species). Historic fires were thought to consist mostly of low intensity surface fires which maintained open, park-like stands of ponderosa pine. These frequent, low-intensity surface fires consumed pine seedlings (limiting the amount and distribution of "doghair" thickets), pruned lower limbs of the pines through scorch kill, and by consuming surface fuel buildups (limbs, needle-cast, duff). Less frequent, high intensity crown/stand replacing fires also occurred. Historical accounts, as reported by Shinneman and Baker (1997), concluded that stand-replacing fires may have ranged in size from 7,500 to 22,000 acres. As a result of the mixed fire severities and frequencies, the Black Hills interior pine forests hosted an array of forest structures, from dense forests, to moderately stocked forests, to tree-less openings (M.E. Hunger et al, 2007).

Fire was found to be twice as frequent in ponderosa pine savanna sites at Wind Cave National Park than those of interior ponderosa pine forests at Jewel Cave National Monument. The mean fire return interval for savanna sites in the SE Black Hills was found to be 10-12 years, meaning that the fire return interval for interior ponderosa pine forests was likely over 20 years (Brown and Sieg, 1999). The highest elevations of the Black Hills (Sylvan Lake and Cathedral Spires areas in CSP) host ponderosa pine, white spruce, and aspen and are thought to have a mean fire return interval of 22-23 years (with a range of 11-74 years). Like the surrounding Northern Great Plains mixed grass prairie lands, lightening and Native American fire use are thought to be the main agents of wildfire in the interior ponderosa pine forests of the Black Hills. Most historic lightening caused fires occurred during the months of July and August (Higgins, 1984).

Fire suppression of the past 120 years has dramatically altered the Black Hills forest landscape. Ponderosa pine regional density is much higher today as compared to pre-European conditions (Grafe and Horsted, 2002). The forests of the Black Hills are also typically managed with an even-aged shelterwood sylviculture system. As a result of intensive forest management, ponderosa pine, on average, are smaller in diameter than pre-European conditions, and old growth conditions are rare. Timber management practices have changed fuel loadings through the process of pre-commercial and commercial thinning, as well as through lop and scatter logging methods. As a result of the increased tree densities and fuel loadings, the Black Hills fire regime has changed more towards less-frequent, large, stand-replacing fires (M.E. Hunter et al, 2007). The Galena, Cicero Peak, and Four Mile fires are evidence of this altered fire regime in Custer State Park.

The results of this altered fire regime can be striking impacting tree density, hydrology and soil quality. Increased tree density lowers the water yield of watersheds through increased evapotranspiration and canopy interception (M. E. Hunter et. al., 2007). Increased hydrologic throughput has been observed in the Bear Gulch and Grace Coolidge watersheds as a result of the Galena fire (Whitesides 1989). Increased surface water has been observed in the Four Mile fire area. High intensity wildfire, as a result of the altered fire regime, can have catastrophic effects on soils. Severe wildfires can strip a landscape vegetative cover, resulting in mass soil and water movement and associated reductions in site fertility, water quality, and stream community health (DeBano, 1991). High intensity fires can also cause soils to become hydrophobic which can have effects on water absorption, erosion, and plant growth. The highly disturbed soils resulting from high intensity wildfire promote the establishment of invasive plants, which can potentially lead to reductions in biodiversity if these plants become well-established (M.E. Hunter et al, 2007).

Fire suppression and the altered fire regime can noticeably change forest relationships with insects and disease. Fire suppression has removed one of the forest's methods to naturally thin stands. Fire historically "thinned" understories, keeping individual trees healthy, vigorous, and more capable of defending themselves against insect and disease. Conversely, high intensity fires resulting from the altered fire regime are likely to wound trees. Wounded trees are more susceptible to bark beetles infestations and/or pathogens attack (M.E. Hunter et al, 2007).

Finally, the impacts of fire suppression, increased tree density and associated canopy cover, as well as the presence of activity fuels, hinder the forage production and understory diversity of many ponderosa pine sites in the Black Hills. By some estimates the increase in ponderosa pine forest density in Arizona has led to as much as a 92% reduction in forage production (M.E. Hunter et al, 2007). While similar studies have not been completed, current estimates for the Black Hills also reflect lower productivity in similar sites.

In order to mitigate the negative effects of fire suppression and intensive logging residues, fuels treatments are used frequently in the Black Hills. Fuels treatments, such as fuel breaks, can act as a defense against catastrophic wildfire by removing fuels that are adjacent to unmanaged stands, areas of high fuel loading, or sensitive areas (houses, roads, etc). Treatments can include whole tree logging, thinning and hand-piling, and/or mastication/chipping and can be effective against potential wildfire spread because they break up the fuel continuity, whether it is aerial crown fuels or surface activity fuels or both. However, Battaglia et al (2008) found that fuel treatments in ponderosa pine forests will lose their effectiveness within 10-20 years if regeneration densities are not controlled. Prescribed fire is sufficient in maintaining low densities of ponderosa pine regeneration and fuel treatment effectiveness if applied every 10 years. If prescribed burning in these fuel treatments exceeds 15 years, the ability to achieve desired maintenance results (mortality in sapling sized trees) can be almost impossible under typical weather and operational conditions. When ponderosa pine regeneration becomes 15 years old or older, fuel loadings, fuel moistures, and weather conditions will have to be adjusted in order to achieve desired results. However, using higher fuel loadings or lower fuel moistures to achieve the heat required for scorch mortality poses holding risks and mortality risks to the residual trees. Therefore frequent (10-15 year) burning intervals in fuel treatment areas are recommended as the best all-around solution to maintaining fuel treatment effectiveness.

Fire Effects On Common CSP Tree Species

The following information was summarized from the USDA Forest Service FEIS (Fire Effects Information System) website: http://www.feis-crs.org/beta/.

- ***Ponderosa pine (Pinus ponderosa):*** Ponderosa pine is highly resistant to fire.

Adaptations include: thick bark, self-pruning limbs, thick bud scales, high foliar moisture, and deep rooting habits. Seedlings can be killed through complete consumption (if the flames are at least ¾ the height or more of the seedling) or through heat girdling. Fire prepared mineral soil seedbeds are favorable for pine regeneration.

- ***Limber pine (Pinus flexilis):*** This species is susceptible the effects of fire because of thin bark, but larger trees with thicker bark may be able to withstand low intensity surface fires. Seedlings/saplings are readily killed by scorch. Limber pine regenerate on fire prepared mineral soils through the caching and seed dispersal of Clark's Nutcrackers.
- ***Black Hills spruce (Picea glauca):*** Black Hills spruce is easily killed by fire because of its shallow roots, thin bark, and low, sometimes flammable foliage. Black Hills spruce will colonize quickly in fire-prepared mineral soil through wind dispersed seeds. Seeding into large fire burned areas by BH spruce is dependent upon the availability of spruce remnants as seed trees and the proximity of these seed trees to the fire areas.
- ***Quaking aspen (Populus tremuloides):*** Quaking aspen becomes more resistant to fire as average bole diameter increases beyond 6 inches. Damage to aspen through top kill or scarring can promote the onslaught of wood-decay fungi, killing the tree years after the fire incident. Aspen roots near the soil surface may be killed by moderate to high fire intensity, but the availability of carbohydrate reserves in deep roots may be able to facilitate suckering post fire. Generally, quaking aspen sprouts vigorously from the roots after fire, and will colonize fire prepared mineral soil by seed dispersal.
- ***Plains cottonwood (Populus deltoids):*** Plains cottonwood is highly susceptible to fire, but may be able to sprout from the root collar, roots, or bole if scarred or top-killed by fire. Sprouting response is poor, especially if water availability is limiting. Plains cottonwood is especially susceptible to late summer and fall burns.
- ***Peachleaf willow (Salix amygdaloides:*** Fire usually kills aboveground tissues, but if the heat and consumption of the upper soil layers and associated organic matter layers is low, the willow will be able to basally sprout. Peachleaf willow is also able to colonize fire prepared mineral soil through seed dispersal.
- ***Paper birch (Betula papyrifera):*** Paper birch is very susceptible to fire – the bark is thin and peels back from the bole in flammable sheets creating a fuel source that can easily girdle the tree. Birch sprout vigorously after fire, and can re-establish on mineral soil quickly after fire if there are seed trees nearby.
- ***Bur oak (Quercus macrocarpa):*** Bur oak is resistant to the effects of fire by having thick, corky (insulating) bark. Bur oak seedlings/saplings are usually killed by surface fires in savanna areas, but mature trees are resilient to fire even in some high intensity fire situations. Bur oak is able to sprout back from stumps or root collars if top killed by fire. It has been shown in the Black Hills that bur oak sprouts compete well with pine seedlings in burned areas.
- ***Green ash (Fraxinus pennsylvanica):*** Generally green ash is susceptible to fire because of thin bark, but it can be fire tolerant in the dormant season with low severity fire. Top killed or fire damaged green ash will sprout prolifically from the root collar. The "ecological tolerance" of ash seedlings makes colonization on burned sites likely for this species.
- ***American elm (Ulmus americana):*** American elm trees up to sapling size may be top

killed by fire, and mature trees may be wounded. Generally American elm is susceptible to the effects of fire. Young elm trees have been observed to sprout from the base after fire.

- ***Chokecherry (Prunus virginiana):*** Chokecherry stems and foliage can be killed by fire, but this shrub quickly sprouts within a few months or a year after the fire. In the Black Hills, chokecherry within 2 months post-burn had double the sprouts pre-burn, of an early May burn.
- ***American plum (Prunus americana):*** Tree sized American plum is usually more resistant to the effects of fire (having thicker bark) than shrub sized plum (which may be top-killed by fire). The deep rooting systems of American plum allow the plant to sprout from these tissues, even after being top killed. American plum is also able to re-establish on fire prepared sites through seed dispersal by animals or through the pre-existing seed bank in the soil. American plum has been shown to increase in density after fire in the woody draws of the Northern Great Plains.
- ***Box elder (Acer negundo):*** Susceptible to fire due to thin bark, would likely sprout back vigorously if top-killed, re-establishes after fire mostly by seed.
- ***Serviceberry (Amalanchier alnifolia):*** Generally increases after fire, sprouts back after fire from root collar or deep rhizomes depending upon the fire severity.
- ***Ironwood (Ostrya virginiana):*** Ironwood will stump-sprout if top-killed, however most ironwood in CSP are seedling/sapling size. It is likely that average prescribed burning conditions (light-moderate intensity) would set back or kill ironwood of these sizes.
- ***Skunkbush sumac (Rhus aromatica):*** Skunkbush sumac is top killed by fire, but readily sprouts back from the root collar post-fire.
- ***Juniper spp. (Juniperus scopulorum, J. horizontalis, J. communis):*** Fire readily kills the listed juniper species (low fire intensity may leave some foliage/branches intact to keep the tree alive). This species depends primarily on seed dispersion by animals to burned sites for colonization.
- ***Mountain mahogany (Cercocarpus montanus):*** Mountain mahogany is typically top killed by fire. Light surface fire can be enough to top kill through consumption or heat kill the tissues through scorch. Depending upon site conditions, mountain mahogany may be able to sprout back from the root collar or rhizomes.
- ***White Coralberry/Western Snowberry (Symphoricarpos albus, S. occidentalis)*** Both shrubs are typically top killed by fire, but are able to sprout from deeply rooted rhizomes.

Influence of fire on wildlife distribution

Environmental disturbance is an important process in all ecosystems because it alters habitats and available resources. Throughout the west, wildfire is a recurring disturbance that has influenced floral and faunal communities (Habeck and Mutch 1973, Arno and Allison-Bunnel 2002). Wildfire creates a mosaic of vegetation communities when severity, extent, and frequency vary over time and space, and this resulting landscape is important in influencing species diversity (Brawn et al. 2001, Turner et al. 2003, Smucker et al. 2005). Furthermore, studies conducted in burned forests indicate that many species respond positively to fire. Bird assemblages in forests that have experienced high-severity wildfire are unique compared with those in unburned forests, and several species are considered primarily restricted to burned forest conditions (Taylor and Barmore 1980, Hutto 1995, Kotliar et al. 2002). One bird that could be considered a burn obligate (Hutto 1995) is the black-backed woodpecker (*Picoides arcticus*) which is a species of concern and an important indicator of the positive and regenerative role that wildfire can play in western forests. Optimal habitats for some species can be provided by implementing an extensive prescribed fire program.

Burning in ponderosa pine forests enhanced vertebrate biomass for deer mice (*Peromyscus maniculatus*) (Converse et al. 2006a). Mechanical thinning is not ecologically equivalent to fire with respect to populations of individual small-mammal taxa (Converse et al. 2006b). Responses of small mammals to fuel reduction treatments are likely determined by responses of critical habitat components, including shrub and herbaceous vegetation and coarse woody debris. Understory vegetation, which provides a source of cover, as well as vegetation and seed food sources (Ahlgren 1966, Wilson and Carey 2000), and coarse woody debris, which provides nesting and travel cover and insect and fungal food sources (Hayes and Cross 1987, Carey and Harrington 2001), strongly influence small-mammal populations, and these components of small-mammal habitat may have quite different responses to thinning and prescribed fire. Thinning is expected to increase coarse woody debris through slash deposits, while prescribed fire leads to short-term declines in coarse woody debris (Arno et al. 1995). Combined thinning/ prescribed-fire treatments have been shown to result in increased herbaceous vegetation and decreased coarse woody debris (Converse et al. 2006b). Least chipmunks (*Tamias minimus*) responded positively to timber harvest treatments and remained similar in density following prescribed fire (Converse et al. 2006b).

Fire affects vegetation community composition, structure, and function (Wright and Bailey 1982, Briggs and Knapp 2001), and can lead to short-term increases in net primary productivity, particularly in grasslands or shrublands (Blair 1997, Johnson and Matchett 2001). Thus, managers often prescribe fire to sites where increased production might benefit wild or domestic herbivores. Investigators have documented increased use of burned sites by grazing ungulates such as bison (*Bison bison*) (Vinton et al. 1992, Biondini et al. 1999) and elk (*Cervus elaphus*) (Pearson et al. 1995, Singer and Harter 1996, Van Dyne and Darragh 2007). A study in Montana indicated that elk resource selection closely tracked changes in production and nutritional quality of plants (Van Dyne and Darragh 2007). The investigators concluded that increases in quantity and quality of forage were the primary cause for increased use of burned sites by elk. Van Dyne and Darragh (2007) describe that managers can expect only short-term responses from elk following burning but longer-term increases in plant diversity and persistence of grass-forb communities on burned sites for > 10 years that may be important to elk and other grazing ungulates.

Research indicates the importance of open terrain for bighorn sheep use. Both ewe and ram groups select against dense ponderosa pine stands (Brundige 1985, Layne 1987) and prescribed fires and timber management could enhance habitats for bighorns. Dense tree stands can act as significant barriers to dispersal and range expansion (Geist 1971). Disturbance through prescribed fire will enhance bighorn sheep habitats by increasing sight distance. Bighorn sheep will move further from escape terrain when visibility is high. The mosaic pattern of the burned habitat from the Jasper Fire in the Black Hills was beneficial at the intestinal mucosal level for white-tailed and mule deer within 3 years postfire (Zimmerman et al. 2006).

Disturbance such as fire can kill and remove late successional tree species and rejuvenate early successional species such as aspen (*Populus tremuloides*) (Erwin et al. 2001). Increasing aspen in the western United States could enhance ruffed grouse (*Bonasa umbellus*) populations (Boag and Sumanik 1969, Rusch and Keith 1971, Stauffer and Peterson 1985, Hansen 2009). Researchers in the Black Hills found aspen was critical for ruffed grouse occupancy (Hansen 2009). Ruffed grouse occupancy estimates in the Black Hills National Forest (BHNF) (2007 = 0.13, 2008 = 0.11) were primarily influenced by the amount of aspen and spruce surrounding a site. However, increasing the amount of aspen had the largest positive effect on occupancy. The average colonization probability was 0.005 and positively influenced by the amount of aspen while the average local extinction probability was 0.20 and negatively influenced by the amount of aspen. Hansen's 2009 results suggested that ruffed grouse occupancy in the BHNF was low and the highest occupancy was associated with increasing amounts of aspen surrounding a site. Thus, to improve ruffed grouse occupancy in the BHNF, management to increase the size and extent of aspen communities should continue (Hansen 2009).

Based on the previous review of the literature given above, it is quite apparent that fire is an important disturbance needed in the Black Hills ecosystem because of its positive influence on floral and faunal communities. Fire burned habitat creates a mosaic of vegetation communities allowing for a diversity of wildlife species.

Role of wildlife on current system function

Domestic animals and wildlife at higher populations than the landscape can support can have deleterious effects on vegetation (Wilson and MacLeod 1991, Holechek et al. 2001). Overgrazing occurs when animals change the vegetation community to a point where there is consequent loss of animal production or productive potential (Wilson and MacLeod 1991). Over utilization of forage, if sustained, leads to loss of palatable forages and an increase in undesirable vegetation (Holechek et al. 2001, Holechek 2002). Browsing by overpopulated deer in the eastern United States has been shown to have profound effects on the establishment of re-generation, species composition, and density of hard-wood seedlings (Marquis 1974, Robinson et al. 1980, and Stromayer and Warren 1997).

A study of elk and cattle competition in relation to available herbaceous biomass provided some insight into the foraging ecology of large ungulates and their effects on vegetation (Hobbs et al. 1996). Hobbs et al. (1996) discovered that when total herbaceous biomass available to cattle (residual dead + live produced) fell below 400 lb/ac (45 g/m2), cattle body mass at the end of spring declined as forage biomass declined. However, when forage biomass available to cattle exceeded 400 lb/ac, cattle body mass was largely insensitive to changes in biomass. High levels of biomass were negatively correlated with the digestible energy concentration of that biomass as a result of the diluting influence of standing dead crop (Hobbs et al. 1996). Hobbs concluded that elk grazing can harm production by cattle, despite temporal separation in their use of rangelands. However, Hobbs et al. (1996) stress that the magnitude of the effects of elk on cattle production are not proportionate to elk population density. Results show that elk populations can be managed to minimize competition with cattle by assuring that forage available to cattle during the spring grazing season exceeds threshold levels (Hobbs et al. 1996).

A different study evaluating herbivory by elk and vegetation response was conducted in Oregon. Stewart et al. (2006) hypothesized that if herbivore optimization occurred with increasing density of elk, there should be a concordant increase in plant production, followed by a decline in productivity as grazing intensity continued to increase (i.e., herbivore optimization). Net aboveground primary productivity (NAPP) increased from no herbivory to herbivory by elk at moderate density and then declined as herbivory by elk continued to increase in areas with high NAPP (mesic and logged forests) but not in areas with low NAPP (xeric forests and grasslands). Management implications from this study did not support maintaining large densities of ungulates on western rangelands to obtain peak production of NAPP.
They recommend maintaining low to moderate densities of large herbivores in ecosystems if goals are to maximize NAPP and forage quality or to maximize body condition and reproduction of ungulates (Stewart 2006).

The direct and indirect influences of large herbivores on ecosystems are various. Including consumption of herbaceous biomass, they affect the ecosystems by trampling, urinating, defecating, and trashing (Skarpe 1991, Walker 1987). Depending on feeding habits, but also on mouth morphology, stomach structure and digestive physiology the herbivores have been classified into four groups: concentrate selectors (browsers), roughage feeders (grazers), and intermediate feeders being either preferential browsers or preferential grazers (Hofmann 1989). Based on morphology, bison should be bulk-feeding grazers, elk intermediate adaptive-selective grazers, mule deer and pronghorn selective concentrate selectors, and white-tailed deer opportunistic adaptable concentrate selectors (Hanley 1982, Hofmann 1985). Plants respond to herbivory by changes in chemical composition, biomass produced, and in morphology, thus promoting or deterring further herbivory (Skarpe 1991). Vegetation responds to effects of herbivory by changes in species composition and physiognomy. Grasses and forbs on overgrazed range are of lesser heights and lower densities (Madany and West 1983). Prairie dogs increase with increased grazing (see system function, role of prairie dogs).

Poisonous plant availability is closely associated with grazing intensity. In North America, livestock death losses to poisonous plants average about 2.0% under moderate grazing compared with 4.8% under heavy grazing intensities (Holecheck 2002). Overstocked ungulate populations can cause a decline in palatable forage plants and an increase in unpalatable poisonous plants (Holecheck 2002). Additionally, heavy use of browse by ungulates can limit or eliminate regeneration of forage species such as aspen (*Populus tremuloides*) (White et al. 1998, Kashian et al. 2007). In Yellowstone National Park, aspen stands regenerate well in areas of low elk density and in some areas of moderate elk density; however, in areas of high and very high elk density, aspen stands do not regenerate (White et al. 1998). To restore aspen, it is recommended that National Parks restore carnivores to control elk density, use fire in areas of low elk density, and control human uses that displace carnivores (White et al. 1998). Efforts to regenerate aspen in CSP are most effective when sites are fenced, eliminating pressure on regenerating stock. Areas outside exclosures exhibit little or no regeneration. Increased use of prescribed fire, or disturbance from mountain pine beetles may also increase aspen in CSP.

Wildlife also has a significant impact on soil dynamics. Burrowing animals (i.e. prairie dogs, gophers, other small mammals, foxes, coyotes) move and mix soil and introduce organic material. Ground squirrels and gophers alone were estimated to move from 59,952-79,936 lbs/ac of subsoil to the surface (Thorp 1949). Interactions between above ground and below ground systems also exist. Gophers were estimated to move 720 lbs/ac of soil to the surface. The soil moved increased to 14,153 lbs/ac on overgrazed range (Buechner 1942).

Invertebrate animals also move and mix significant amounts of soil. Earthworm casts equaled about 21,400 lbs/ac in undisturbed Texas prairie (Dyksterhuis and Schmutz 1947). The production of this high nutrient soil builder was impaired on disturbed rangeland.

Large amounts of organic material from hair, molted feathers, and carcasses are also produced by animals. It was estimated that 2.1 million rabbits and rodents lived on 49,900 ac of Arizona desert grassland. This equals about 438,500 lbs of animal (Taylor 1935). This limited segment of the animal population contributes roughly 9 lbs/ac of organic material with each population turnover. Another contribution of wildlife to the soil is droppings. Jackrabbit droppings averaged about 80 lbs/ac on rangeland, 30 times the weight of the jackrabbits (Vorhies and Taylor 1933). Additional organic material is incorporated from food caches and nests.

Physical ecosystem engineering by organisms such as beavers (*Castor canadensis*) which create or modify habitat structure has been postulated to be an important mechanism generating landscape-level heterogeneity and thus high species richness (Jones et al. 1997, Wright et al. 2002). When ponds are abandoned and the associated dams are breached, extensive meadows form that can persist over the long-term (Ives 1942). Beaver create meadows by building dams that trap nutrient-rich sediment and by directly and indirectly killing woody vegetation through their disturbance (Wright et al. 2002).

In addition to foraging, impacts of bison and elk hoof action can influence plant biomass, productivity, and diversity (Pastor and Naiman 1992, Olff and Ritchie 1998), as well as soil properties (Augustine and Frank 2001, Bardgett and Wardle 2003). Dispersed use has little impact, but areas of concentrated use (around water holes or salt) show decreases in ground cover and soil porosity, with increased erosion. Wildlife may impact fire spread by the maintenance of trails which act as fire breaks. Extinction of grizzly bears (*Ursus arctos*) and wolves (*Canis lupus*) by humans from 95-99% of the contiguous USA and Mexico has resulted in dramatically altered and expanded prey communities (Berger 1999). Such ecological change has occurred in the Black Hills of South Dakota. With the loss of some apex predators, some prey species populations have over-exploited their habitats and landscapes have been altered. An example of this would be less aspen occurring across the landscape than previously existed before the altered predator and prey communities (Kashian et al. 2007).

Historic Management of Pine

Timber sales and Non-commercial thinning

Early management of Custer State Park's pine forest was unregulated (1917-1927) and disorganized (1927-1980) (see 1995-2010 Resource Management Plan for full description). In 1981 the Vegetative Management Plan set an aggressive schedule to regulate the pine forest condition by the year 2004. One of the primary goals was to produce a non-declining sustained yield of forest products. To achieve these goals, the 1981 Timber Management Plan estimated that sawtimber harvest should be 3.3 million board feet per year and 10,559 total acres would require non-commercial thinning, all to be accomplished during the regulation period. The majority of acres intended to be managed during the regulation period were treated between 1981 and 2010. Tables 17 and 18 are a summary of what was treated from 1995-2010.

During the entire regulation period (1981-2010), 23,876 acres were treated by non-salvage timber sales and 11,663 acres were treated with non-commercial thinning. 1,135 acres of miscellaneous, smaller units were not treated. From 1981-2010 approximately 66 million board feet of timber was harvested on non-salvage timber sales and approximately 26 million board feet was harvested on fire salvage timber sales (Galena, Cicero Peak, and Four-mile). The average annual harvest during the 29 year regulation period was approximately 3.2 million board feet (this includes fire salvage sales).

Mountain Pine Beetle

Mountain pine beetle (MPB) pressure from the Black Elk Wilderness along with a beetle population in Custer State Park prompted a variety of management and treatment techniques (Table 19 and Figure 14). Early MPB control work (2005) focused on detection and treatment of a portion of the infested trees. As beetle populations increased and the number of infested trees increased, a concerted effort began in the fall of 2007 to identify all the infested trees and treat them. From 2005-2008, under the direction of the current Forest Health Specialist John Ball, treatment included felling and bucking infested trees into two foot sections. Trees were identified after peak flight in Mid-September through the winter. Since trees were generally in inaccessible areas, the majority of infested trees could not be removed in the Sylvan Lake area. Dr. Ball used a sequential sampling method to estimate that beetle mortality was approximately 75-80% in chunked trees. After the trees were chunked the bark begins to dry and separate, and the beetles essentially starve to death and cannot complete their life cycle. Mold growth underneath drying bark is also a significant factor in beetle mortality. It is thought that the 20-25% survival is beetles on the underside of the chunks that are flush with the ground and receive little sunlight and drying. It appears that this tactic has worked to slow the spread of MPB. A subjective observation of the Black Elk Wilderness, where no MPB control was employed, indicates that beetle spread was more rapid then in CSP. Even though this tactic appears to have stabilized the MPB population it cannot and will not stop the epidemic, it is a holding tactic.

Table 17. Non-commercial thinning history; 1995 - 2010.

Fiscal Year	Acres	Cost
1995	289	$30,020
1996	310	$39,875
1997	651	$76,142
1998	244	$37,164
1999	--------	--------
2000	--------	--------
2001	895	$113,306
2002	--------	--------
2003	249	$26,388
2004	74	$9,250
2005	359	$50,505
2006	516	$74,494
2007	338	$51,889
2008	277	$42,367
2009	335	$57,579
TOTALS	4,537	$312,472

TOTAL THINNING EXPENDITURE: $312,472

Table 18. Non-salvage timber sale history; 1995 - 2010.

Fiscal Year	Volume - CCF	Volume - MBF	Revenue
1995	--------	--------	--------
1996	2,117	1,059	$182,590
1997	3,425	1,712	$182,149
1998	5,774	2,887	$249,706
1999	2,365	1,183	$113,530
2000	5,483	2,742	$351,214
2001	4,507	2,253	$200,555
2002	2,450	1,225	$114,856
2003	--------	--------	--------
2004	13,562	6,781	$578,853
2005	--------	--------	--------
2006	9,032	4,516	$466,051
2007	788	394	$22,080
2008	7,946	3,973	$202,623
2009	--------	--------	--------
2010	7,361	3,681	$19,005
TOTALS	64,810	32,405	$2,683,211

TOTAL POL REMOVED 1,642 CCF

TOTAL NET AREA TREATED BY NON-SALVAGE TIMBER SALES = 10,258 acres

NOTE: MBF = Thousand board feet
CCF = 100 cubic feet
POL = Products other than logs (posts, poles, firewood, etc.)

With growing concerns of the fuel build-up caused by felling and chunking infested trees for 5 years an alternative approach was used in 2009. A helicopter was used to remove merchantable infested trees and the timber was utilized for sawtimber and post and poles. While the results of this are yet to be seen, it is anticipated that this will result in fewer infested trees in 2010 as compared to felling and chunking. Also, since only tops and branches were left on site the long-term fuel risk is reduced. The 7,345 tons of sawtimber and post and pole material from this thinning operation was utilized for product production.

Table 19. Summary of MPB control activities and expenditures FY 2005-2010

		Cost - $		
Fiscal Year	Activity	CSP	Dept. of Agriculture	Total
2005	Blue Star Highway Salvage	2,625	2,625	5,250
2006	MPB Control (3,014 trees)	54,252	54,252	108,504
2007	MPB Control (3,827 trees)	38,270	38,270	76,540
2008	MPB Control (11,967 trees)	42,885	159,770	202,655
2008	Special Appropriation Buffer Thinning (450 ac)		185,187	185,187
2009	MPB Control (20,082 trees)	176,030	312,735	488,765
2010	MPB Control Helicopter Removal (20,000 trees)	147,500	172,050	319,550
2010	MPB Control Helicopter Thinning (90 acres)		85,000	85,000
2010	Sylvan timbersale and Helicopter clean-up	22,500	32,950	55,450
	TOTALS	484,062	1,042,839	1,526,901

TOTAL NON-CONVENTIONAL THINNING ACRES: 530 ACRES
TOTAL NUMBER MPB CONTROL TREES: 58,890 TREES

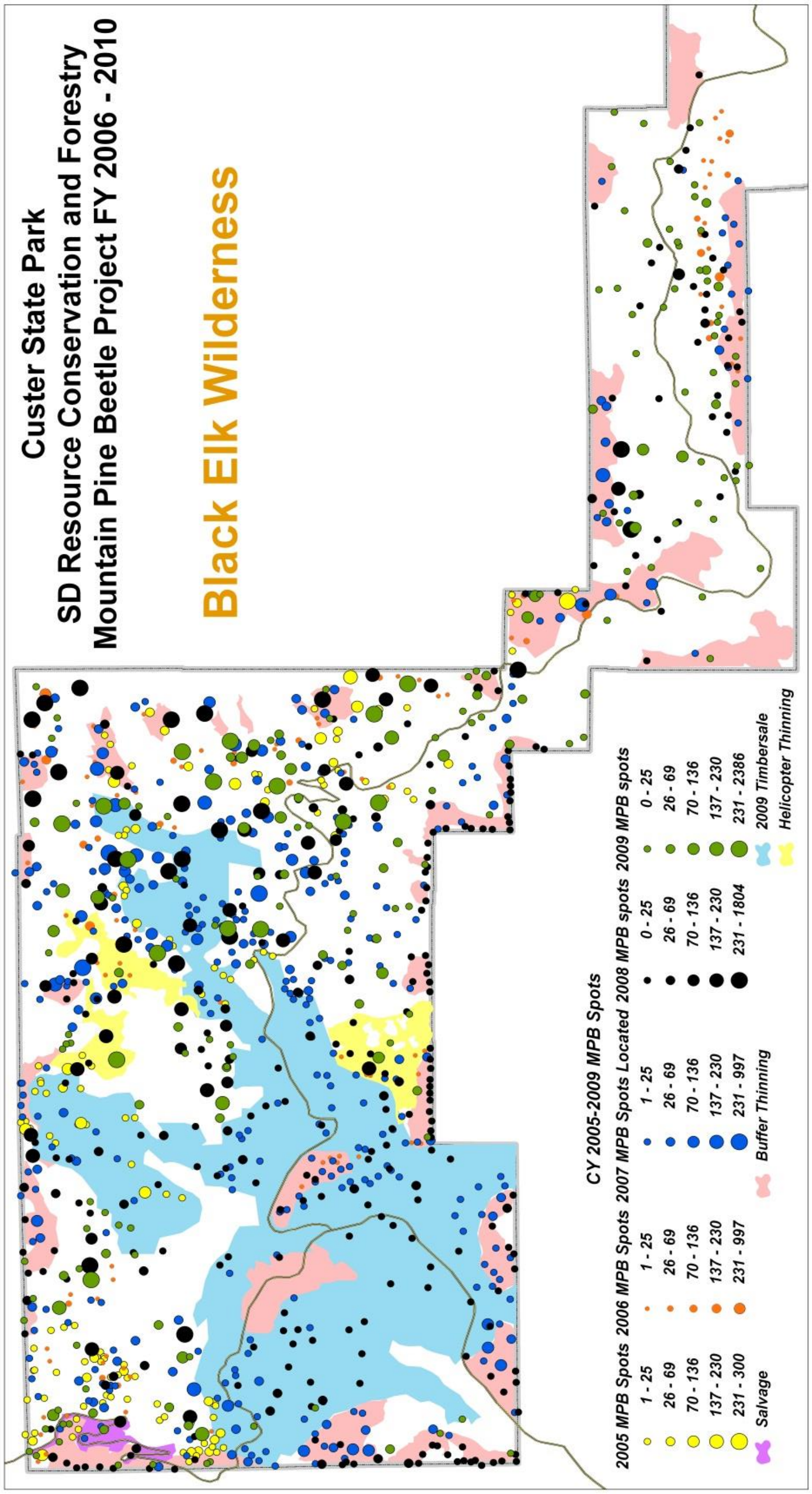

Figure 14. MPB control activities FY 2005-2010.

Thinning has been experimentally demonstrated to reduce risk of MPB infestations (Schmid et al., 2007). Thinning treatments were employed on 450 acres of primarily inoperable ground around the park boundary to act as a buffer between CSP and the Black Elk Wilderness and Norbeck Wildlife Preserve (Figure 14). The prescription was to thin from below to a Growing Stock Level (GSL) 60. Except for a few accessible areas where logs were salvaged the majority of the trees were lopped and scattered. To date the majority of the 450 acres are intact with little MPB caused mortality after two flight seasons at relatively high pressure. Only thinning areas with extreme pressure suffered significant beetle mortality. Also, nearly 700 acres were thinned with conventional methods around highly visible areas near Sylvan Lake, Little Devil's Tower and along Highways 89 and 87 corridors. The general prescription was a shelterwood cut to a GSL 30-40. Hardwood releases were used where a significant hardwood component existed and the visual corridor and trails were left at a GSL 50-60. This area had been treated in 1998 under the guidance of the 1995 Resource Management Plan, but was re-entered sooner than originally planned because of beetle pressure. While it was not seen as a direct control measure 313 acres were treated along Needles highway in 2004. The prescription was to thin from below to a GSL 60 and employ hardwood release where applicable. This area has experienced little mortality from MPB.

Anti-aggregate pheromone (verbenone) has also been used to limit MPB caused mortality on limber pine. Verbenone is similar to one pheromone released by MPB to deter additional attacks on a tree that has been successfully mass attacked, preventing over infestation. Verbenone pouches have been placed on or close to nearly all the limber pine growing near Cathedral Spires. The pouches are placed on the trees in late July to early August. The pouches are assumed to have an effective range of 50-60 feet, so pouches are placed 60 feet or less apart. Research indicates that verbenone can reduce attacks, particularly at endemic levels, but is not highly effective at preventing tree mortality, particularly at epidemic levels (Amman et al., 1989). Bentz et al. (1989) did not see a significant treatment difference in effectiveness of using various levels of verbenone to prevent attack. Despite these indications, virtually 100% of limber pines within 30 feet of verbenone pouches have survived the current epidemic. However, during 2008, four limber pine trees without verbenone pouches were killed despite being within 30 feet to limber pine with pouches. Additionally ponderosa pine trees within close proximity to limber pine with pouches were killed, but the limber pine were not attacked. Verbenone pouches appear to be quite successful on limber pine, but not on ponderosa pine in the Black Hills.

Figure 15 and Table 20 reveal that the majority of CSP is at a low to moderate risk for mountain pine beetle attack, and only 7 percent is at a high risk. It should be noted that 67% of CSP stands contain extrapolated data from like stands. All of the summarized stands extrapolated were in the low or medium category.

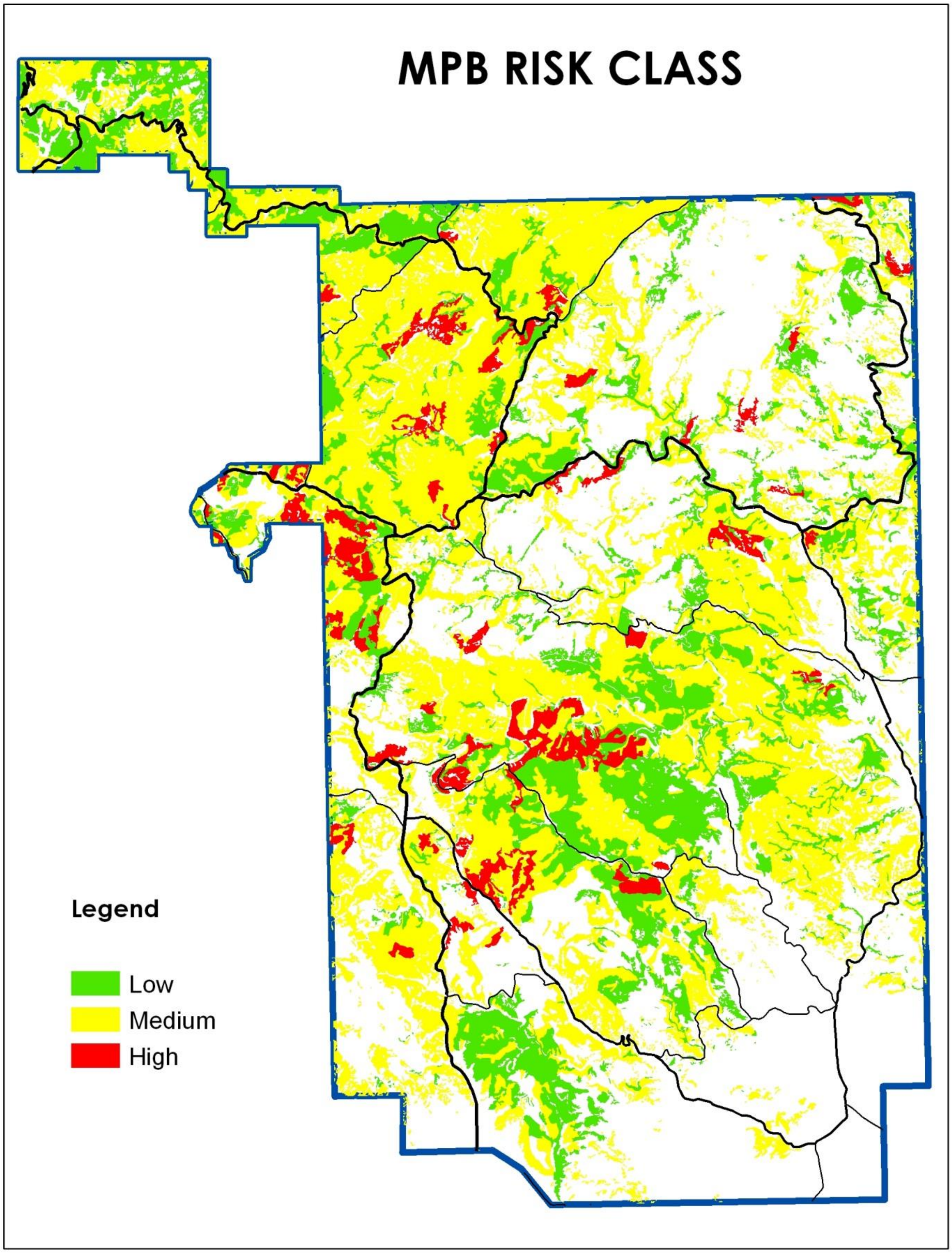

Figure 15. Mountain Pine Beetle Risk class rating.

Table 20. Mountain Pine Beetle Risk Class Rating.

Risk Class	Area (%)	Area (acres)
Low	28	10,320
Medium	66	24,384
High	7	2,430
		37,134

Forest Fuels

Fuel is all vegetative biomass, living or dead that can be ignited by natural or man-made causes. Fuels are often quantified by their individual components and aggregated into a total weight, expressed as tons per acre. Tons per acre (TPA) measures and estimates give resource managers a good idea of the fuel model and the associated fire behavior expected across the area of interest.

Fuels are divided into several classes based on size and their associated ability to equalize their internal moisture content with that of the surrounding environment. The rate at which fuels adjust to the atmospheric moisture is referred to as the *timelag*. Fuel Timelags are categorized into 1 hr, 10 hr, 100 hr, and 1000 hr fuels based on surface to volume ratio. For instance, it takes a pine needle with a large surface to volume ratio(a 1 hour timelag fuel) approximately 1 hour to equilibrate to the atmospheric moisture, where it takes a large log (1000 hour timelag fuel) over a month to adjust because of the small surface area to volume). In addition, the sum weights of all these fuels classes (as sampled by a Brown's line/transect) is used to calculate the total tons per acre of biomass or slash on a particular site. The following are the descriptions of the timelag fuels classes as well as other fuels of importance for fire behavior planning in the park:

- **1 HOUR FUELS:** wood, debris, or litter < 0.25" in diameter (cured grass, pine needles, small twigs)
- **10 HOUR FUELS:** woody debris or litter 0.26"-1.0" diameter (small branches, pinecones)
- **100 HOUR FUELS:** woody debris 1.0"-3.0"diameter (larger branches, smaller course woody debris)
- **1000 HOUR FUELS:** course woody debris > 3.0" diameter (old logs, larger branches, thinning debris or logging residues)
- **LITTER:** Forest debris, mostly consisting of 1 hour fuels, that is still recognizable in its original form and is not decomposed
- **DUFF:** Forest litter that has decomposed to the point where litter components are not recognizable as their original form. Duff is a spongy material that lies above the soil surface, and does not include any soil particles.

- **LIVE HERBACEOUS:** Any non-woody living vegetation in the forest floor (grasses, forbs). Fuel moisture can be as much as 300% in the peak of the growing season, and as low as 30% when dormant and cured in the fall/winter.
- **LIVE WOODY HERBACEOUS:** The living leaf component of the woody vegetation in the forestland system. In Custer State Park live woody herbaceous is sampled as foliar moisture in ponderosa pine and common juniper.

In describing fuels, it is important to distinguish whether they are living or dead and in what strata they occur. The following are 3 recognized fuel strata in forestland systems:

1. Ground fuels - includes burnable material below the loose surface litter such as duff, tree roots, decomposing wood, and peat. Duff, the partially decomposed organic material that lies beneath the freshly fallen twigs, needles, and leaves, is the most important component of ground fuels.

2. Surface fuels - includes the forest floor litter layers composed of loose debris such as recently fallen leaves or needles, and various sizes of downed woody material. This material has not begun to decompose. Surface fuels also include a live component of grasses, forbs, low shrubs and seedlings. Surface fuels can be subdivided into two categories at Custer State Park; natural and activity fuels. *Natural* fuels are litter items that are deposited on the forest floor continually through the natural ecosystem function of the forest. *Activity* fuels consist of the same components as natural fuels, but are deposited on the forest floor as a result of human caused activities (i.e. timber sales, thinnings, fuels modifications, etc).

3. Aerial or Crown fuels – include combustible materials above the surface fuel stratum. These fuels include overstory trees, large shrubs, suspended moss, and snags. This stratum of fuels is important to quantify on a stand basis because crown spacing, crown bulk density, and canopy base height are key factors in determining wind effects at the surface level, as well as the potential for crown fire (expressed in later analysis as Crowning Index and Torching Index).

Fuels are broken up into different fuel models to help fire managers predict the fire's behavior in different vegetation systems. Generally these models differ in their respective fuel loadings (weight in tons per acre) and the distribution of the fuel classes in these fuel loadings. Fire managers currently use 2 different sets of fuel models. The first set, and probably most well-known, are the 13 Anderson (1982) fuel models, broken up in terms of primary carrier of fire (grass, shrub, forest understory, slash). The new set of models by Scott and Burgan (2005) is grouped by the "fire-carrying" fuel type. These types are Non-burnable (NB), Grass (GR), Grass-shrub (GS), Shrub (SH), Timber-understory (TU), Timber litter (TL), and Slash-blowdown (SB). The fuel models common to Custer State Park, and relative to the fuel loading analysis described later, are:

ANDERSON 13: (Anderson 1982)

- FM1: Short grass – found in most of the dry range areas in the east and southeast portions of the park
- FM2: Timber (grass and understory) – found in more open woodlands and timber lands

with a grass understory – this would include a majority of the forested areas in Custer State Park

- FM4: Chaparral – found in pockets of “dog-hair” ponderosa pine regeneration. These areas are common in meadows where pine encroachment exists, or in post-harvest timber sale areas where an overstory removal occurred.
- FM9: Hardwood litter – Contrary to the name, this fuel model is found under closed canopy stands of ponderosa pine. The main carrier of fire is surface litter, not vegetation (like FM2).
- FM10: Timber – Litter and understory: This forest type consists of greater quantities of 1000 hr fuels than FM9 and would include the wind-thrown/storm damaged areas of the park, and areas where old thinning slash still resides.
- FM 11, 12, 13 – Light – medium – heavy- logging slash. These fuel models are represented in different areas of the park. Light pre-commercial thinnings would represent FM11, heavy pre-commercial thinnings or the buffer thinning units at Sylvan Lake would represent FM 12, and pockets of FM 13 exist at Sylvan Lake where mountain pine beetle sanitation cutting (chunking) has occurred.

Historic Fuels Treatment and Generation

It is important to understand the historic fuels treatments and/or logging activities and how they contribute to the distribution and loading of activity fuels throughout Custer State Park.

LOP AND SCATTER (CONVENTIONAL LOGGING): This method of logging leaves unmerchantable tree tops and other residues “lopped” or cut into smaller pieces and scattered over the forest floor. This method is generally performed by hand-crews, and is used in terrain inoperable to tracked logging machinery (feller-bunchers) or where higher fuel loadings are desired for prescribed burning or other resource management objectives. This method is also used for pre-commercial thinning operations. Activity fuels resulting from this activity can range in the Black Hills from 5 to 50 tons per acre depending on the size distribution of slash and the amount of stems cut per acre. While the slash does temporarily inhibit understory vegetative growth, the coarse woody debris resulting from the logging activities are important for nutrient and ecosystem cycling, as well as erosion control. Lop and scatter treatments are usually deemed as a less desirable treatment because of the potentially high amounts of resulting activity fuels and the associated probability for increased fire behavior.

WHOLE TREE LOGGING: Under the direction of the 1995 CSP Resource Management Plan, whole-tree logging was to be used wherever possible. Whole tree logging involves using a tracked feller-buncher to cut the merchantable trees and set them in whole-tree bunches for skidding to a landing. At the landing, a delimbing machine cuts the merchantable trees to length and stacks the unmerchantable tops in a pile for later disposal. In the Black Hills, disposal usually means waiting for sufficient snow and prolonged cold weather to burn the piles. Whole tree logging leaves little residue in the woods, and is desirable for quickly releasing the site to understory vegetation development and pine seedling establishment. This method is also desirable because it dramatically reduces the potential fire behavior in the stand if wildfire should occur. The disadvantages of whole-tree logging are: disposal of the top piles, and the nutrient cycling and benefits of course woody debris on the forest floor. Table 21 displays a comparison of the effects of lop and scatter logging verses whole tree logging on selected forest system elements.

Table 21. Comparison of the effects of common CSP logging methods on selected forest system attributes.

LOGGING EFFECTS ON:	LOP & SCATTER	WHOLE TREE
Soil Compaction and Erosion	Compaction is possible through the skidding process. However, in theory impacts are less severe because machinery traverse a particular area is considerably fewer times. In addition, woody debris left in place displaces the pressure and disruption of the machinery on the soil surface. This material also helps to control erosion through slowing the water's force as in travels downhill.	Significant compaction was found on mechanically thinned plots (Parker et. Al 2007). The impacts of compaction are likely more severe on fine textured soils with more organic matter. Overflow soils in draw bottoms are particularly sensitive to increased compaction caused by WT logging. These draw areas tend to hold moisture better than upland sites, making compaction more likely through rutting and erosion. In addition, tracks formed by machinery can channel water downhill, causing erosion, if not properly rehabbed with slash. Leaving a scattering of some slash on site would help mitigate these problems (as well as operating in frozen winter months, or dry summer months)
Nutrient Cycling and Organic Matter	Losses of forest floor and mineral soil organic matter after stand harvesting lowers soil moisture retention, cation-exchange capacity, and subsequent tree growth in coarse-textured soils (Ginter et al. 1979). Logging debris left in place after lop and scatter method mitigates this issue. Logging debris will decompose creating organic matter additions to the soil system. However, substantial logging residues or thinning slash can cause nitrogen (a limiting nutrient) to be immobilized in microbial biomass until the residues	Whole tree harvest removes all the merchantable biomass and associated tops from the site. Branches, twigs, and foliage contain high concentrations of most nutrients. This litter in a natural system would decompose to organic matter critical for nutrient cycling, water retention, and microbial activity. Sites sensitive to nutrient depletion as a result of full tree harvesting include those with medium to coarse textured soils and little humus, and sites with shallow soils. This could include a lot of CSP's high elevation, granitic derived soils. A report by Wiensczyk (1992) suggests that a coarse textured soil can recover the lost nutrients (N, P, K, Ca, Mg) within 31

	are decayed (Powers, 1989). Nitrogen is needed in large quantities for the microbial decomposition process to occur.	years post whole-tree harvest. While CSP soils can probably regenerate essential nutrients through weathering and atmospheric deposition, it is important to consider the effects on organic matter – especially for site moisture and microbial function.
Water Holding Capacity/Soil Temperature	The slash layer following lop and scatter logging treatments allow the soil surface to be shaded and in turn hold more soil moisture. The slash itself will also hold moisture, later available to plants and microbes as decay progresses.	The soil surface is more exposed to sunlight in the short term (until vegetation response) because of the lack of shading. Whole tree logged areas are likely drier than lop and scatter units of the same type. The lack of shading, and associated increases in soil temperature, are also thought to increase the rate of organic matter decomposition.
Understory Vegetation	Logging residues or thinning slash prevent sunlight from reaching the soil surface in lop and scatter treatment areas. Vegetation will start to re-establish the site once a majority of the fine debris (blocking the light) decompose.	Due to the immediate availability of light to the forest floor following WT activity, site establishment of understory vegetation is relatively quick (1-5 years).
Weeds	The risk of weeds is less than whole-tree logging because the amount of light reaching the forest floor post-harvest is less with the slash covering the ground. The slash inhibits a lot of vegetative growth, including desirable native vegetation.	Cover of non-native plants has been found to increase following mechanical treatments where a great deal of basal area is removed from the site in ponderosa pine forests (M.E. Hunter et. al., 2007). The increase in light to the forest floor and disturbance through machinery of the forest floor provide instant conditions for exotics to establish.
Fire Risk	Surface fire risk is significantly increased in the short term. High amounts of red-needled surface fuel loading can facilitate fast moving, intense wildfire. This fire risk subsides with time.	Surface fire risk is immediately reduced after whole-tree harvest. However, there is fire risk associated with the top piles if they are not disposed of properly.

Prescribed Fire implementation	Prescribed fire can be more difficult to implement in the short term – high fuel loadings associated with lop and scatter treatments usually promote high intensity surface fires with undesirable fire effects on residual living trees and soil resources. Fire may be used successfully with cooler, wetter conditions, or after the needles on the slash have decomposed (around 3-5 years post-thinning) (M.E. Hunter et. al., 2007)	Prescribed fire is usually easy to implement following whole tree harvest, providing there is sufficient vegetation and purpose to carry and use fire in the system. Usually, whole tree harvest takes the place of prescribed burning, through the removal of surface fuels. This comes at a cost however. Disposing of the top piles resulting from whole-tree harvest is a cost and challenge that most forest and fire managers face in the Black Hills. Snow conditions may be hard to come by for pile burning, and/or recipients or markets for woodchips are poor to nonexistent at times.

POTENTIAL CONSIDERATIONS FOR WHOLE TREE LOGGING**:**
What are the resource objectives for the management unit/timber sale area? With this in mind, consider the following questions:

- Do any of the following or combination of the following make one logging method more suitable than another: soil texture, slope percentage, residual vegetation, and vegetation of concern (aspen/hardwood areas)?
- Do landing locations or potential top pile footprints make a particular type of logging more feasible than another?
- Is top pile disposal of some form going to be possible in a majority of environmental conditions and/or will there be cost-effective methods to dispose of those piles?
- Does the location of the logging unit in proximity to developments or other improvements create a need to consider aesthetics and/or fuels reduction?
- Does one method of logging make the sale more attractive to potential bidders than another form?
- If pre-commercial thinning is performed at the same time as the commercial harvest, what sizes or amounts of residues, if any, should be left on site?

Current Fuels Modifications

CSP has been constructing fuel breaks to facilitate protection of infrastructure and resources (Figure 16). This fuel break system is designed to provide points of attack and anchor points in the event of wildfire. Additional fuel breaks will be designed and implemented to provide a network defining areas where appropriate fire management can be accomplished. This would include prescribed fire as well as indirect wildfire management.

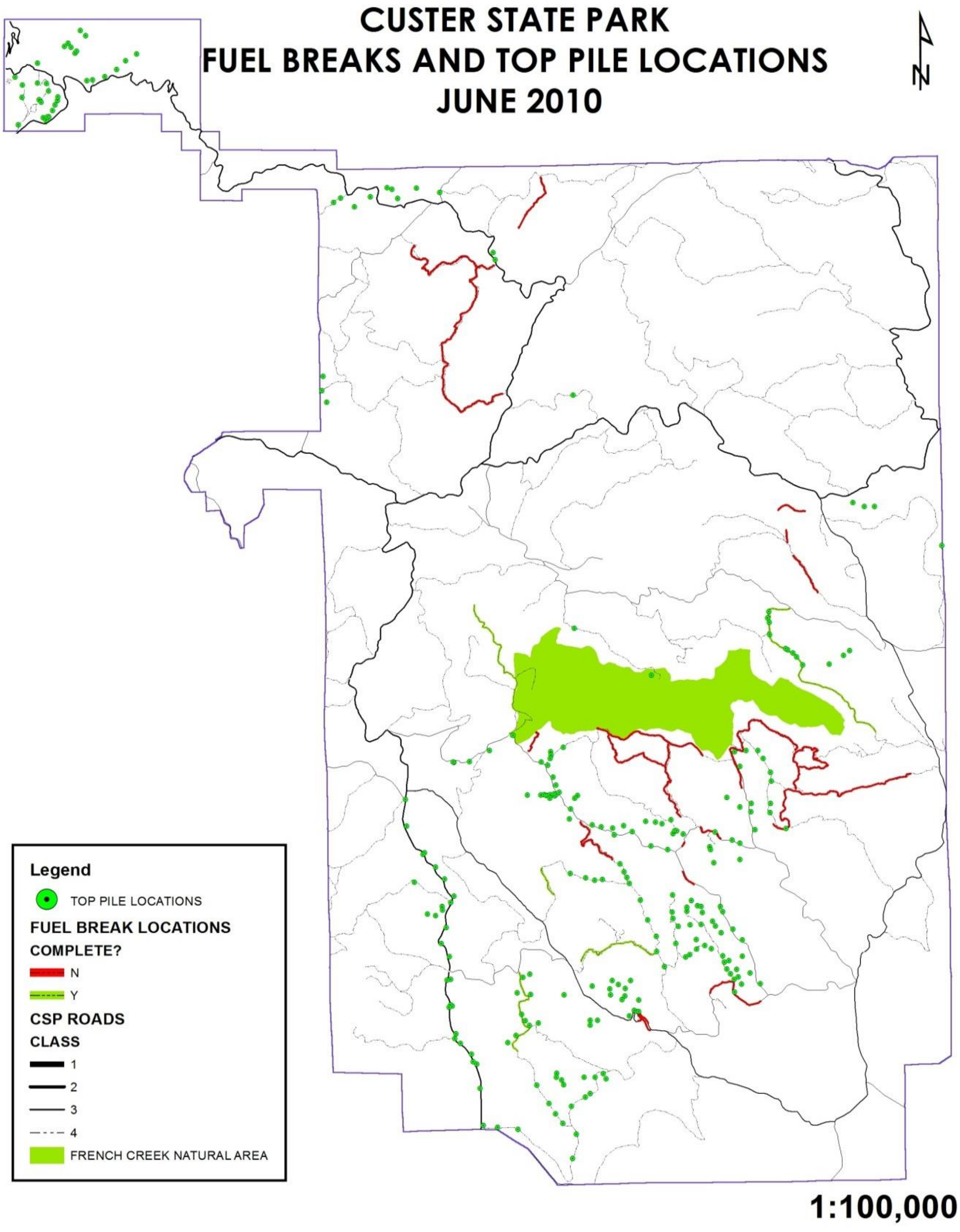

Figure 16. Fuel break and top pile locations in CSP June 2010.

Current Fuels Assessment

Fuel Modeling

Several products have been created to describe fuels and fire behavior in Custer State Park. The first assessment and probably the most important to fire managers is the surface fuel analysis. Different Scott and Burgan (2005) fuel models were used to describe actual surface fuels found throughout Custer State Park (Figures 17-22). The method for assessing the varying fuel models found throughout Custer State Park was coarse, but efficient. Based on discussions with the Rocky Mountain Research Station and other land managers large scale fuel mapping should incorporate some type of assessment with a forest stand-based inventory. However, budget and time constraints necessitated using the following process to create the CSP fuel model map (Figure 23):

1. All management units (and associated logging and/or inoperable units) were digitized on ArcGIS. In addition, all pre-commercial thinning boundaries back to the year 2000 were also digitized on the map (for purposes of mapping activity fuels)
2. Larger management units were broken down by logging units as well as by units that were not treated (inoperable units). Usually timber sales are harvested by either lop and scatter or whole-tree methods on a unit by unit basis. Therefore, the general assumption for creating this fuels map was that the mapping unit of a continuous fuel model should be the logging unit. Units that were not treated or were inoperable in a timber sale were made into their own mapping units and sampled as such.
3. All logging units and a majority of non-treated units were assigned fuel models which most represent the entire logging unit by the fire management forester. These ocular assignments were completed either from close proximity roads or by hiking through the unit. Only the fire management forester made the fuel model assignments, to streamline the evaluation.
4. A majority of rangeland and large fire areas (Galena and Cicero Peak fires) were assigned fuel models based on an aerial photo and/or the vegetative photo typing. Fuels in these areas are very uniform, so remotely-sensed fuel model assignments were a practical method for describing the rest of Custer State Park.
5. Field data was taken during the month of August 2010, and the surface fuel model map was generated in September of 2010.

Figure 17: TU1 (Timber Understory 1). Characterized in CSP by continuous vegetation at least 1 ft tall, including small amounts of pine litter. TU1 may include pine seedlings as well.

Figures 18A and 18B: TU5 - Timber Understory 5 - characterized in CSP by continuous non-woody vegetation mixed with continuous or patchy woody vegetation (pine saplings to small poles) under a forest canopy. This model is common in type conversions without non-commercial treatment (bottom photo) and in overstory removal situations.

Figure 19: SB1 - Slash Blowdown 1 - Characterized in CSP by small diameter thinning slash or lop & scatter residues. Needles must still be present to be considered a slash model.

Figure 20: SB2 - Slash blowdown 2 - characterized in CSP by heavier precommercial or light commercial thinnings. Needles must still be present to be considered a slash model.

Figure 21: TL8 - Timber Litter 8 - Long Needle Litter - Characterized by continuous needlecast and light to moderate forest litter or old logging debris. This model may include a small amount of living vegetation, but less than TU1. This model is common in mature forests with moderate to canopy closure.

Figure 22A and 22B: TL8LF - Timber litter 8 - ladder fuels: This is not an actual model, but a designation made to differentiate areas of straight timber litter from areas with timber litter and substantial ladder fuels (dog hair pine regeneration, pre-thinned stands, etc). The above photosdisplay common examples of this fuel designation.

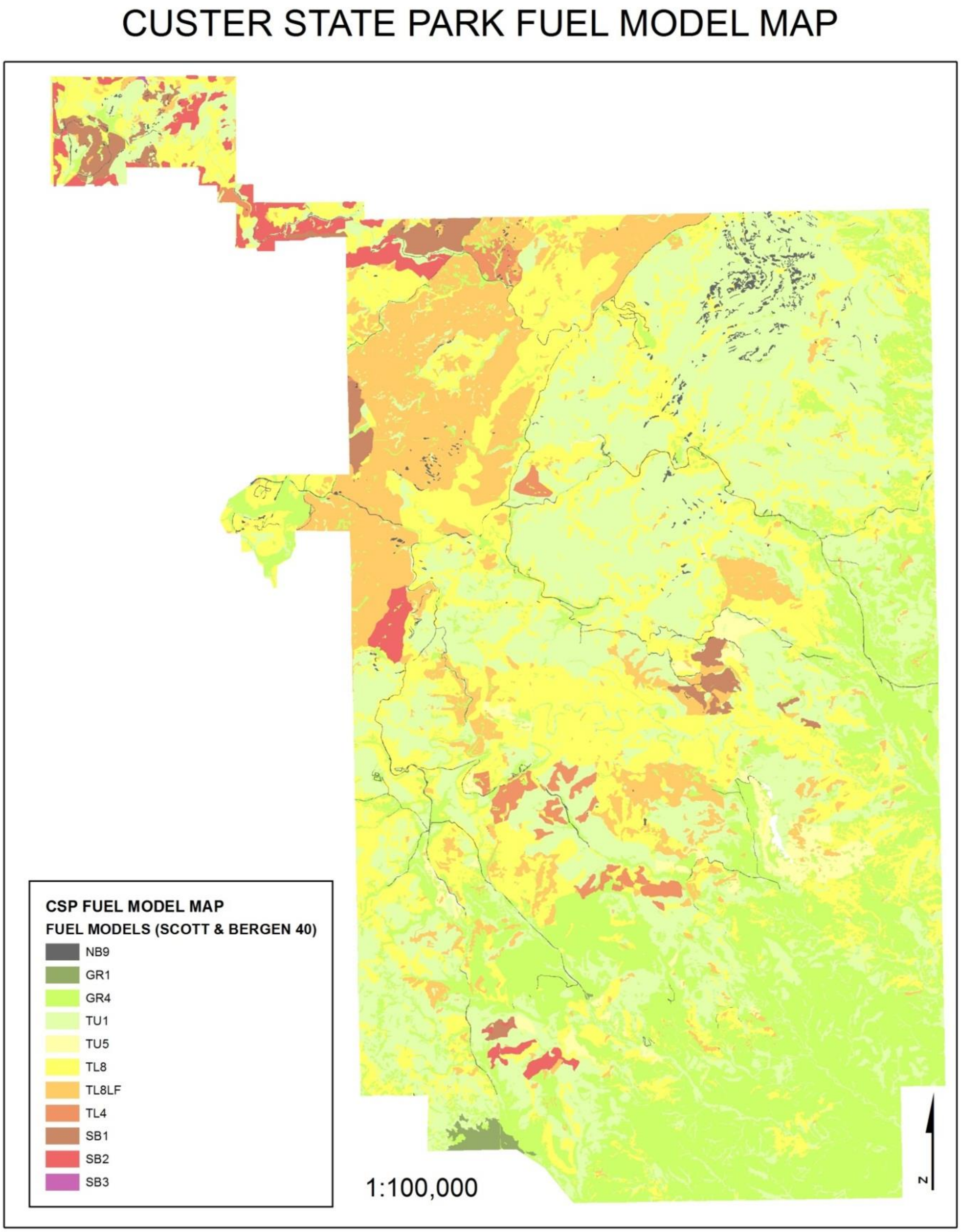

Figure 23. Fuel model status Custer State Park.

Aerial Fuels

To assess aerial fuels, torching index and crowning index are used and can be calculated through Forest Vegetation Simulator – Fire and Fuels Extension based on current stand inventory data. *Torching Index (TI)* is the 20-foot windspeed at which a passive crown (torching) fire could occur (Figure 24). Torching Index is a function of surface fuel characteristics (fuel model), surface fuel moisture contents, foliar moisture content, canopy base height (height to bottom average live forest canopy from the ground), slope steepness, and wind reduction by the canopy. The *Crowning Index (CI)* is the 20-foot windspeed at which an active crown fire is possible (Figure 25). Crowning Index is a function of canopy bulk density (mass per unit volume of combustible crown biomass: including foliage, twigs, and branches), slope steepness, and surface fuel moisture content (Scott Stephens 2009, pers comm).

Fire Regime Condition Class

Fire regime is a classification of the role fire would play in a landscape without the intervention of modern human mechanization. It does, however, take into account the role that aboriginal burning played in landscape development (Agee 1993, Brown 1995). Fire regime condition class (FRCC) classifies how far a landscape has departed from the natural regime (Hann and Bunnell 2001). How far a landscape has departed is a relative measure based on changes to a variety of ecological components including changes in species composition, stand age, structural stage of a stand, fire frequency, fire severity and other disturbances such as insect and disease. Hardy et al. (2001) and Schmidt et al. (2001) have developed three course scale classes for FRCC use by land managers. These condition class departures describe the departure and define potential risks to the ecosystem. The level or departure, or FRCC, can have implications for management based on the significance of the departure (Figure 26, Table 22).

Prescribed Fire History

Prescribed fire is a tool used to accomplish a number of objectives. Fire has been used to improve rangeland condition, reduce fuel loadings, reduce encroachment, thin pine regeneration, recycle nutrients, improve vegetation health, enhance wildlife habitat and protect infrastructure. Prescribed fires accomplished from 1995-2010 include Boundary, Old Buffalo Pasture, Tea Kettle, Hurst, Swint Well, Hurst, Haystack, Red Valley, Elk Run, and Antelope Flats (Figure 27).

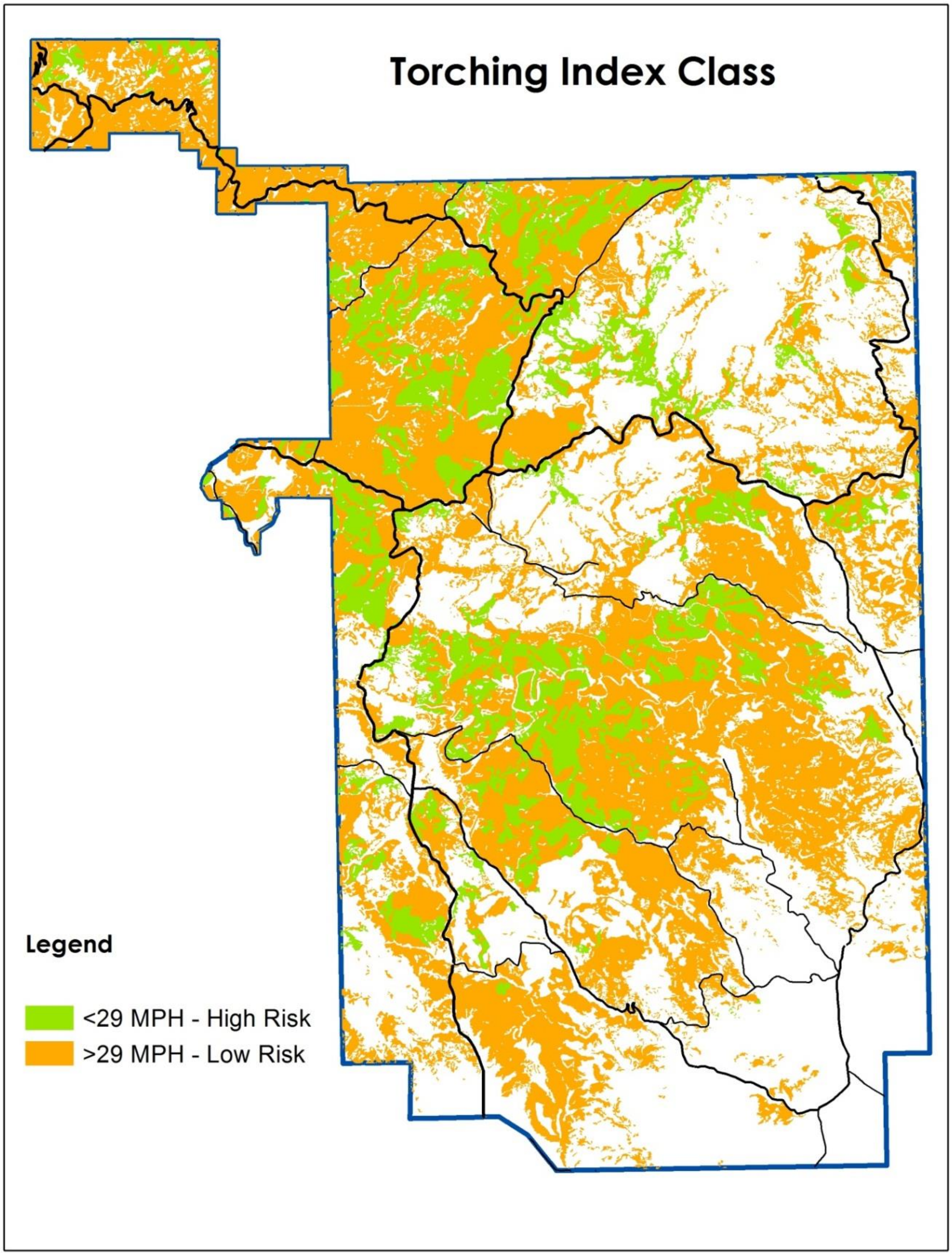

Figure 24. Torching index class.

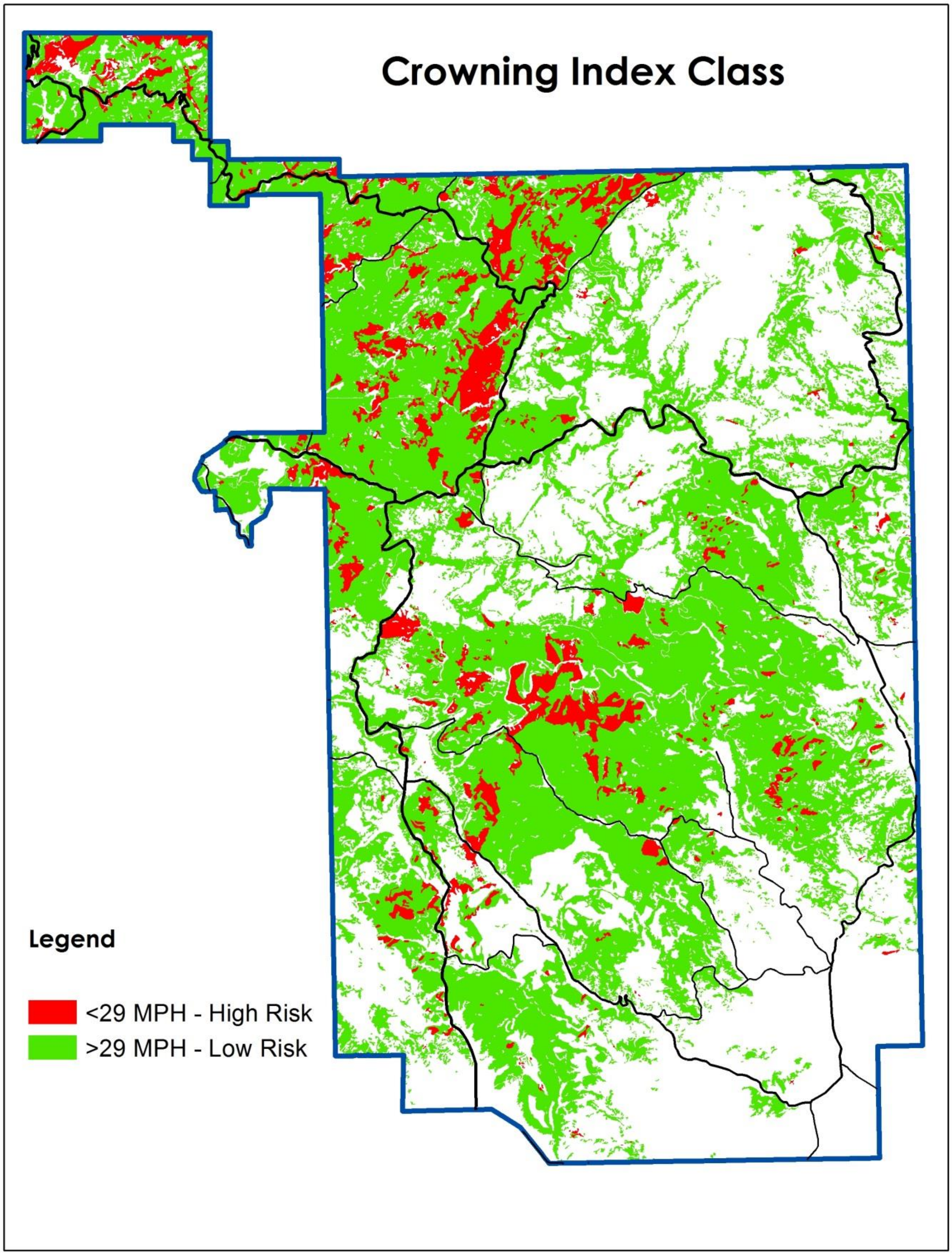

Figure 25. Crowning index class.

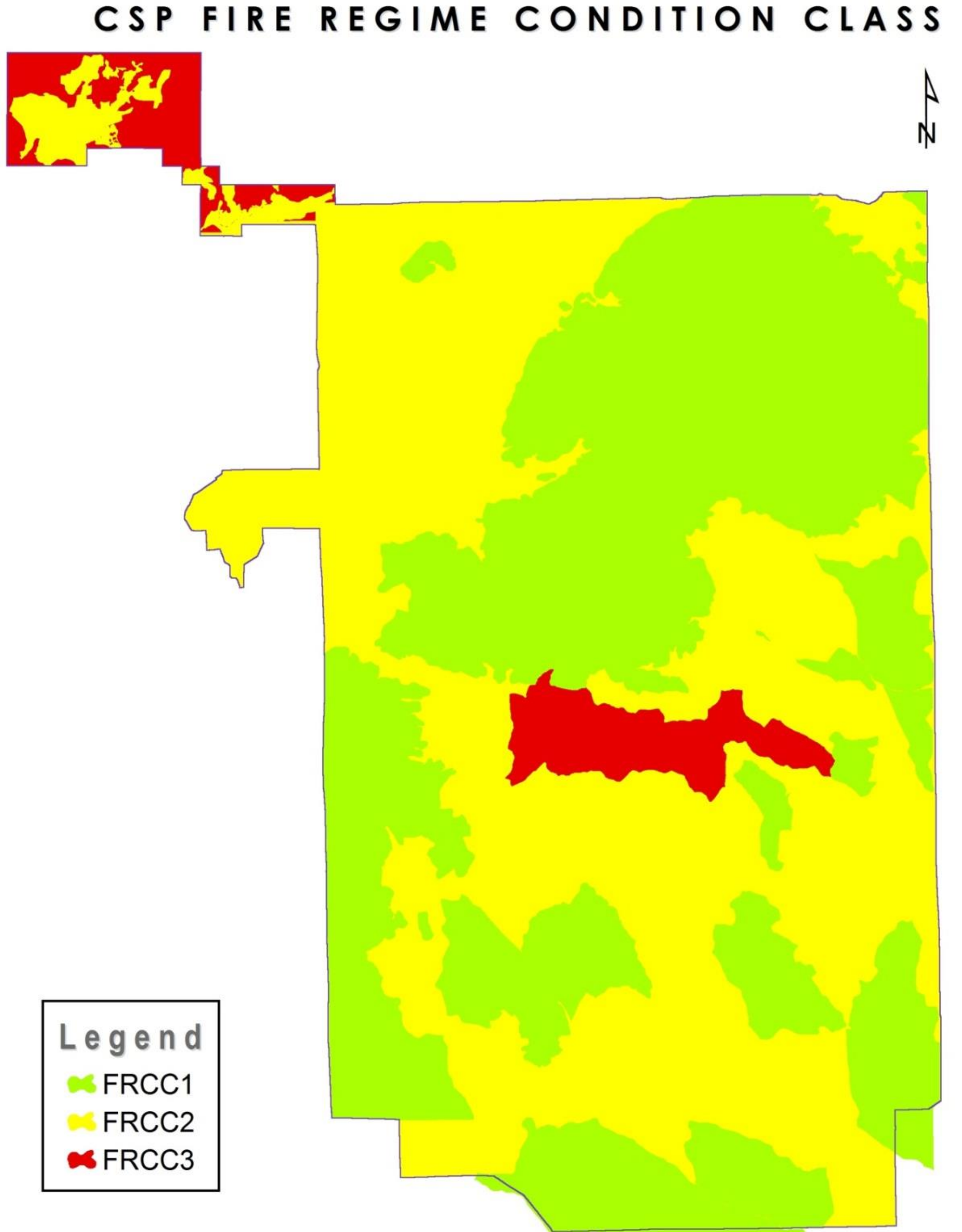

Figure 26. Fire regime condition class.

Table 22. Fire Regime Condition Class.

Condition Class	**Fire Regime**	**Example Management Options**	**Examples of Key Ecosystem Component Susceptibility to Changing Fire Regime Condition Classes**			
			Species composition and structure	**Invasion by nonnative species**	**Smoke production, hydrology, and Soils**	**Insects and disease**
Condition Class 1 (Low)	Fire regimes are within the natural (historical) range, and the risk of losing key ecosystem components is low. Vegetation attributes (species composition, structure, and pattern) are intact and functioning within the natural (historical) range.	Where appropriate, these areas can be maintained within the natural (historical) fire regime by treatments such as fire use.	Species composition and structure are functioning within their natural (historical) range at both patch and landscape scales.	Non-native species are currently not present or present in limited extent. Through time or following disturbance sites are potential vulnerable to invasion by non-native species.	Functioning within their natural (historic) range.	Insect and disease populations functioning within their natural (historical) range.
Condition Class 2 (Moderate)	Fire regimes have been moderately altered from their natural (historical) range. Risk of losing key ecosystem components is moderate. Fire frequencies have departed from natural frequencies by one or more return intervals (either increased or decreased). This result in moderate changes to one or more of the following: fire size, intensity and severity, and landscape patterns. Vegetation and fuel attributes have been moderately altered from their natural (historical) range.	Where appropriate, these areas may need moderate levels of restoration treatments, such as fire use and hand or mechanical treatments, to be restored to the natural fire regime.	Species composition and structure have been moderately altered from their historical range at patch and landscape scales. For example: Grasslands – Moderate encroachment of shrubs and trees and/or invasive exotic species. Shrublands – Moderate encroachment of trees, increased shrubs, or invasive exotic species. Forestland/Woodland – Moderate increases in density, encroachment of shade tolerant tree species, or moderate loss of shade intolerant tree species caused by fire exclusion, logging, or exotic insects or disease. Replacement of surface shrub/grass with woody fuels and litter.	Populations of nonnative invasive species may have increased, thereby increasing the potential risk for these populations to expand following disturbances, such as wildfires.	Have been moderately altered from their natural (historical) range. Water flow typically less. Smoke and soil erosion following fire typically greater.	Insect and Disease populations have been moderately altered from their natural (historical) range.
Condition Class 3 (High)	Fire regimes have been substantially altered from their natural (historical) range. The risk of losing key ecosystem components is high. Fire frequencies have departed from natural frequencies by multiple return intervals. Dramatic changes occur to one or more of the following: fire size, intensity, severity, and landscape patterns. Vegetation attributes have been substantially altered from their natural (historical) range.	Where appropriate, these areas may need high levels of restoration treatments, such as hand or mechanical treatments, before fire can be used to restore the natural fire regime.	Species composition and structure have been substantially altered from their historical range at patch and landscape scales. For example: Grasslands – High encroachment and establishment of shrubs, trees, or invasive exotic species. Shrublands – High encroachment and establishment of trees, increased shrubs, or invasive exotic species. Forestland/Woodland – High increases in density, encroachment of shade tolerant tree species, or high loss of shade intolerant tree species caused by fire exclusion, logging, or exotic insects or disease.	Invasive species may be common and in some cases the dominant species on the landscape. Any disturbance will likely increase both the dominance and geographic extent of these invasive species.	Have been substantially altered from their historical range.	Insect and disease population have been substantially altered from their natural (historical) range. Typically higher mortality or defoliation.

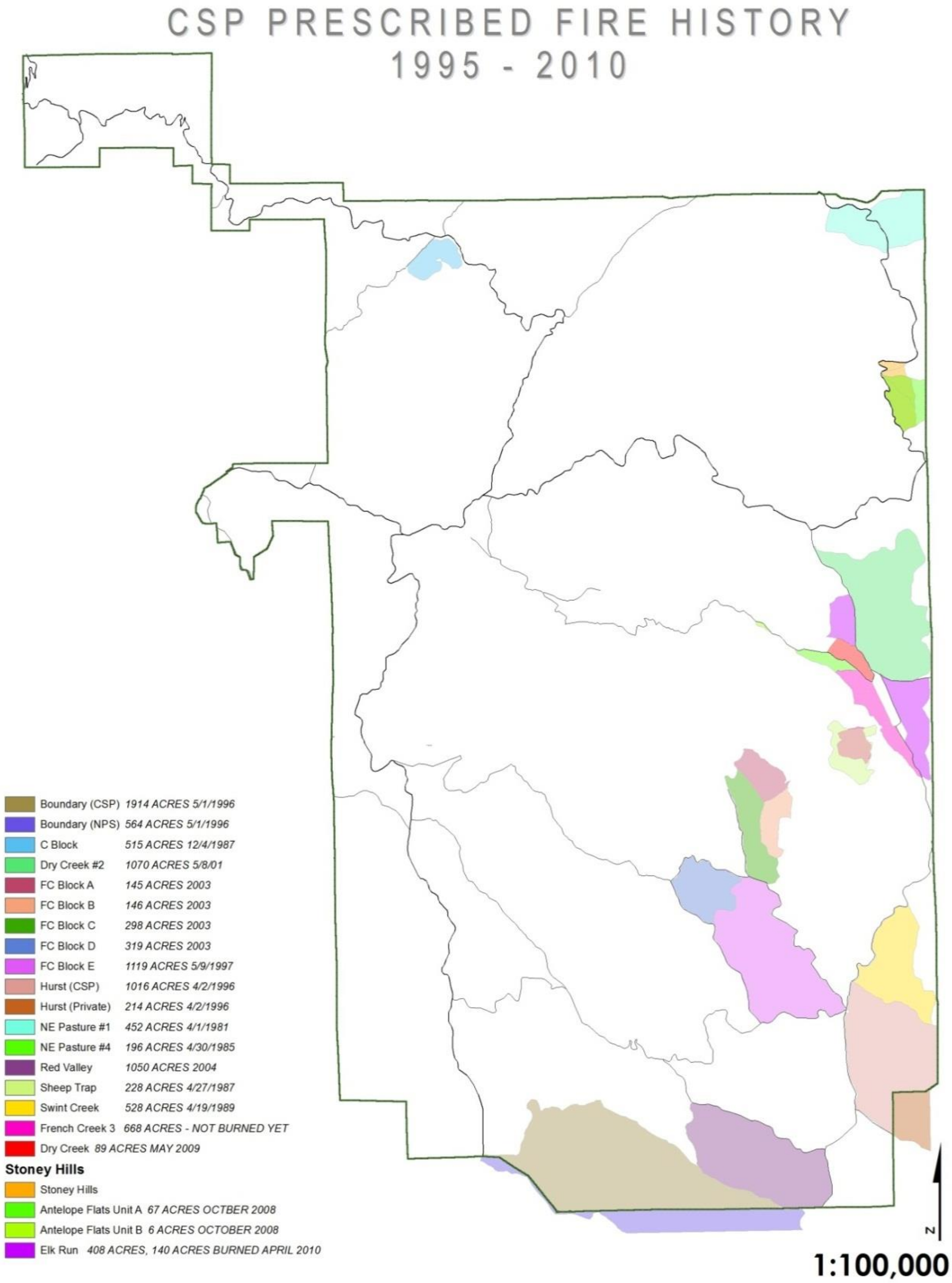

Figure 27. Prescribed fire history 1995-2010.

Understory Vegetation

Under the 1995-2010 Resource Management Plan (Walker et al. 1995) Soil Conservation Service (SCS now NRCS) production estimate tables were used to predict production based on woodland soils and estimated canopy closure from stand inventories (Table 23). SCS tables also indicate primary species composition expected on these soils under various canopy closures. These SCS estimates are only given for soils considered to be grazable woodland soils on slopes <40% (see Soil Survey of Custer and Pennington Counties, Black Hills Parts, South Dakota, USDA SCS). Therefore not all woodland soils have estimates. Estimates for the figures were derived from conservative interpolation of soils occurring on slopes >40%. These production figures represent potential production from estimates taken during the soil survey. Actual production may vary due to several site variables. A conservative measure of production was utilized based on the assumption forest understories were in good condition overall. Based on SCS guidelines, production estimates are 75% potential for sites in good condition.

A study conducted from 2005-2008 to validate the production model used in CSP (Keller 2011) indicated production was underestimated. To determine understory production, grazing-exclusion cages were randomly located throughout woodland grazable sites. A 0.25 m^2 hoop was clipped of all vegetation within each cage. Clipped plants were separated by species to determine species-specific production at each site. Shrub production was also clipped at each site within a 25 m^2 plot around each cage. All shrubs and tree browse within 1.83 m of the ground were clipped. After 4 years of vegetation clipping, understory production was determined to be 80% or 32,411,360 lbs of potential (40,620,057 lbs). Goal for understory production is ≥ 90% or 36,558,051 lbs) of potential production. It is important to remember CSP allocates 25% of the understory vegetative production to be utilized by ungulate grazers. With 80% understory production, 25% or 8,102,840 lbs of forage is available for consumption by wildlife. Understory production should increase with the use of deferred grazing, prescribed fire, and timber management. Once elk numbers recover to our objective of 800; elk will utilize more woodland grazable vegetation then all the other ungulates in CSP combined. It will be important to manage the elk population so woodland grazable sites are not over utilized.

To determine if potential production of woodland grazable sites is increasing toward our goal of ≥ 90% potential, grazing-exclusion cages will be clipped as done by Keller (2011) every 10 years. This will allow the Range Ecologist to determine if understory production is increasing or if changes need to occur. An increase in potential production is important; it allows managers to increase the elk population, which allows for more viewing and hunting opportunities (see chapter 1, Keller 2011).

Table 23. Woodland understory potential production during a normal year.

Production (lbs/ac)	Area (%)	Area (acres)	Forage (lbs)
125	1.75	913.1	114132
150	2.57	1343.3	201490
170	0.13	68.7	11678
200	2.27	1187.8	237567
210	4.62	2419.4	508076
255	7.66	4009.7	1022493
300	20.16	10544.9	3163491
340	0.16	81.1	27557
400	0.98	512.7	205097
500	0.38	196.9	98471
510	2.06	1075.6	548581
560	1.62	848.1	474917
600	0.41	213.0	127803
680	2.43	1271.4	864522
700	1.58	828.8	580154
765	0.78	409.5	313232
800	14.61	7641.7	6113384
900	2.19	1146.1	1031466
1000	3.16	1651.9	1651899
1120	4.38	2292.6	2567760

1360	8.70	4550.7	6188939
1600	17.40	9104.6	14567350
TOTAL	100.00	52311.7	40620057

WILDLIFE

Overview of wildlife presence on Custer State Park forestlands

Past wildlife management focused on emphasizing forest species such as elk, bighorn sheep, and specific cavity nesters. Elk are an important species because of their intrinsic value. Elk were hunted in CSP from 1919 to 1921 by Elks Lodges. Elk hunting was discontinued and by the 1940's overpopulation was leading to resource damage through overgrazing. Surplus elk were slaughtered and processed in CSP and sold to retail and wholesale outlets. Elk hunting was again authorized in 1962 and archery seasons began in 1966. Initially these were guided hunts until 1976. Tags ranged up to as many as 180 tags for rifle elk and 62 for archery. Elk populations in CSP have exhibited potential for substantial population growth. Overpopulation of elk and bison led to the opening of a meat processing plant in CSP. From 1940 to 1976 elk were slaughtered at the locker plant.

Elk population estimates in CSP are based on winter aerial surveys and surveys from 2011-2013 used a Poisson-log Normal Mark-Resight model and matrix projections for future abundance estimates. Future aerial survey methodology will use the same sightability model that has been used outside of CSP (see SDGFP Elk Management Plan 2015). Elk populations have fluctuated greatly. Estimates in the mid-1980s ranged from 400-700 animals with an estimate of approximately 550 in 1989. The population increased in the early 1990s to 800-900 animals and maintained near or above 1000 animals through the early 2000s. An antlerless elk season was initiated in 1994 as a population control measure. The population estimates peaked from 1997 through 2003 with the population estimated at 1183 animals in 2003. Antlerless seasons were liberalized in the early 2000s and the population has decreased significantly. Additionally, poor calf recruitment and elk movement out of CSP have contributed to further declines. Facilitated movement of elk out of Wind Cave National Park into CSP occurred from 2012 to 2014. A total of 442 elk were moved into the southern end of CSP (381 cows and calves and 61 bulls); based on telemetry data roughly 160-170 elk escaped back into Wind Cave National Park after the initial movement. The population estimate in winter of 2015 was 525 elk (95% CI = 479-556) based on a matrix projection model and initial abundance estimates using a mark-resight model.

Bighorn sheep are also an important management species in CSP. Audubon's bighorn sheep (*O. c. auduboni*), the subspecies native to the Black Hills, was extirpated from the area by about 1920 and became extinct by 1924 due to market hunting and introduced disease. Eight Rocky Mountain bighorn sheep (*O. c. canadensis*) from Alberta were released in CSP in 1922 to replace the extinct subspecies. The initial population grew to approximately 150 animals where it stabilized. An all-age die off in 1959 decimated the population. In 1964 a second reintroduction of 22 Rocky Mountain bighorn sheep from Wyoming was made. The population increased to approximately 150 by 1995 and peaked at around 200 animals in 2003-04. Another all-age die off occurred in 2004 which reduced the population down to roughly 40-50 animals in 2005. Lack of lamb recruitment and loss of older adult ewes and rams has led to a population estimate of approximately 30 animals in 2015. Past hunting seasons were conducted in 1970 through fall of 2004 (except 1971 and 1974) with tags numbering from 2-6 and 100% success. Hunting has not occurred since the last season in 2004. Bighorn sheep inhabit steep terrain, typically devoid of dense forest. Bighorn sheep became established in 3 ewe/lamb subherds in the park. One group inhabited the Grace Coolidge drainage and providing substantial viewing opportunity. The other 2 groups inhabited the east and west ends of French Creek canyon. An additional group was established in Bear Gulch from the 1999 Alberta transplant. This group's range included part of the Grace Coolidge drainage and these groups interacted on occasion. Rams segregated into 3 subgroups; the southeast, southwest and northern groups, and ranged widely during the non-rutting seasons (Layne 1987). Traditional lambing, ewe, and ram areas are provided in Figure 28.

Historically, white-tailed deer (*Odocoileus virginianus*) were not restocked in CSP. Based on survey work and population simulations, white-tailed deer were estimated at 853 animals (95% CI = 670-1162) in 2002 using a mark-resight model (Woeck 2003). Historically, deer have been hunted on and off since CSP began. The season was closed in 1991 due to the poor recruitment and resultant several weak age classes in the population (Custer State Park, unpublished data). The season was reopened in 1998 and in 2015 there were 10 any white-tailed deer tags available to South Dakota residents. Antlerless white-tailed deer tags have been offered to control deer numbers when necessary. White-tailed deer are important watchable wildlife in CSP. Mule deer, also never restocked, occur in the forestlands as well as the rangelands. Mule deer (*O. hemionus*) were estimated at 321 animals (95% CI = 152-998) using a mark-resight model in 2002 (Woeck 2003). Similar to white-tails, the season was reopened in 1998 but tag numbers were limited to 2 any mule deer tags available to South Dakota residents. In 2015, there were no "any" deer tags (allowing the take of mule deer) available. Mule deer also provide viewing opportunities for the public particularly when they are close to roads in the more open prairie landscapes.

Records indicate 49 Merriam's turkeys (*Meleagris gallopavo merriami*) were stocked into CSP from 1948 to 1951. The first hunting season occurred in 1969. Primary determinants of turkey numbers are predation, winter weather on survival, and spring weather on reproduction. Recent research has shed some light on factors associated with survival and reproduction of Merriam's turkeys (Lehman et al. 2007, Lehman et al. 2008, Lehman et al. 2008). Turkeys provide excellent viewing opportunities because of their diurnal nature and use of many vegetation communities in the Park.

Coyotes (*Canis latrans*) occur throughout CSP and they are ecologically important as a predator. Coyote numbers in CSP vary widely. Mange outbreaks have had significant impacts on coyote numbers in the past. Oftentimes, coyotes are suspected and/or blamed for the poor population performance of some game species in the park. Unfortunately, there is little information on predator/prey dynamics to substantiate or refute these claims.

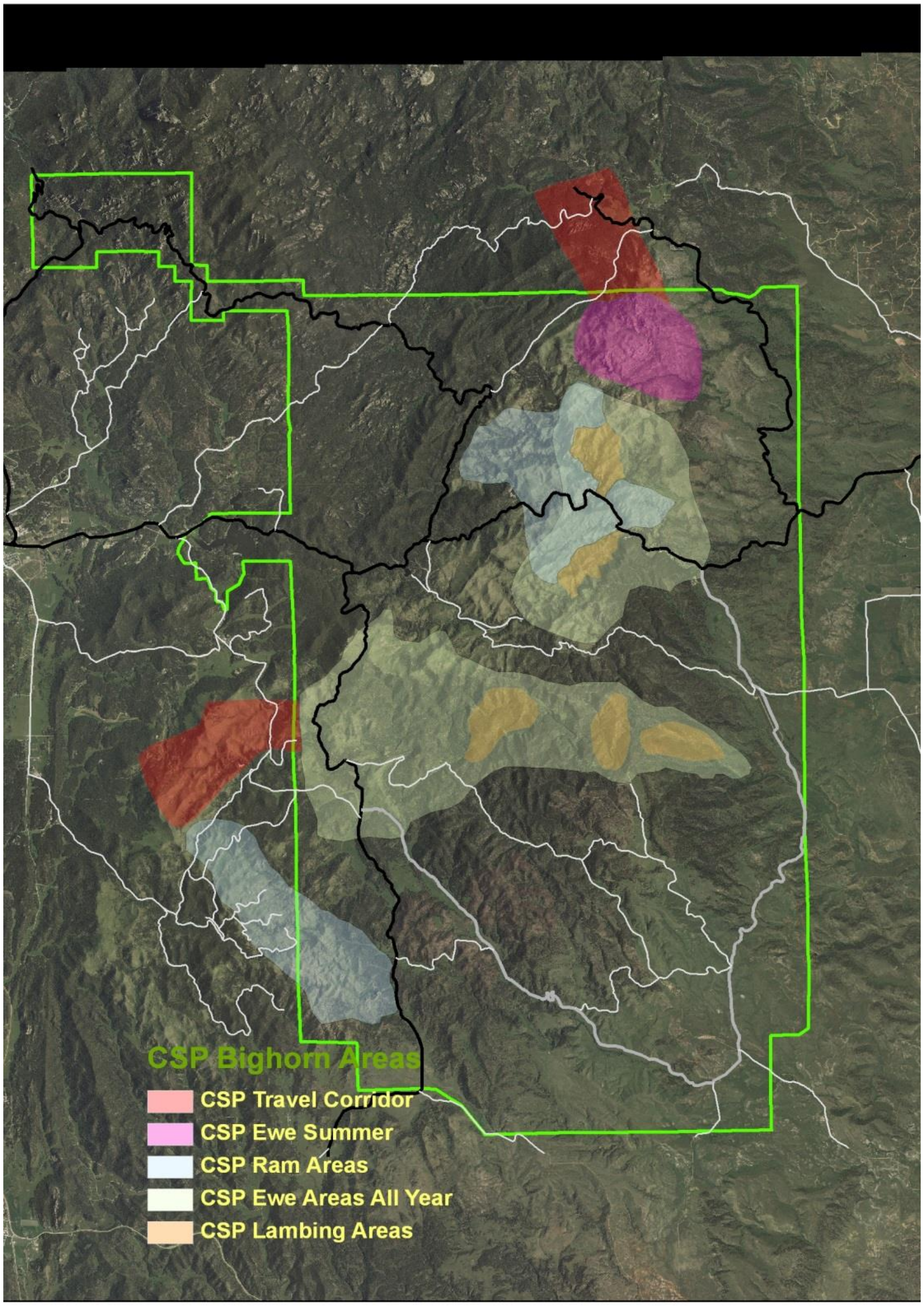

Figure 28. Traditional lambing, ewe, and ram areas in Custer State Park.

Mountain lions (*Puma concolor*) occur throughout CSP and they are ecologically important as an apex predator. Extensive research was conducted on lions within CSP from 2007-2009. Additionally, food habitats were studied on puma in a bighorn sheep area from the central Black Hills. Based on data collected from GPS collared mountain lions, mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*) comprise the majority of mountain lion diets, but other large ungulates such as elk (*Cervus elaphus*) and bighorn sheep (*Ovis canadensis*) are also consumed (Smith 2014). Although mountain lions primarily subsist on large ungulates, small mammals including raccoons (*Procyon lotor*), lagomorphs, ground squirrels (*Spermophilus* spp.), and mink (*Mustela vison*) may also supplement mountain lion diets. Research on elk calf survival indicated ≤27% annual calf survival with most of the mortality being attributed to mountain lion predation in Custer State Park (Lehman 2015).

Based on data collected by South Dakota State University, radiotelemetry data indicates that all the acreage of CSP is occupied by at least one mountain lion. There appears to be much home range overlap among females (Jansen 2011). In 2009, 22 lions (including cubs) had been radiomarked in the park. During the 2009 lion hunting season, 12 of those were located exclusively within the unhunted portion of CSP, and 3 were located exclusively outside of CSP (B. Jansen, personal communication). For the remaining 7 cats, the average time spent outside of Custer State Park during the hunting season was 36%. Based on research data, it was estimated that CSP has an average of 18 lions at any given time during the years of 2009-2011 (mean = 18, SE = 2, 95% CI = 13–23) (B. Jansen, personal communication).

Mountain lion hunting began inside CSP in 2011. In order to control disturbance on other wildlife, hunters were required to apply for and receive a special permit to be able to hunt within the confined of the fenced portion of the park. The use of dogs was initiated in 2013 in order to increase the take.

The black-backed woodpecker (*Picoides arcticus*) is a species of concern and an important indicator of the positive and regenerative role that wildfire and pine beetle epidemics can play in western forests. Research occurred from 2008-2011 and the objectives included:

1) Determine whether black-backed woodpeckers exhibit unique movement probabilities when moving to and from burned forest and beetle infestations.
2) Assess factors affecting movement probabilities of black-backed woodpeckers. Specifically, I will identify factors affecting the probability that a woodpecker will emigrate from a site and immigrate to a site.
3) Estimate habitat-specific survival and reproductive rates.
4) Evaluate source sink dynamics of black-backed woodpeckers based on habitat –specific vital rates.
5) Determine how sensitive source-sink dynamics are to variation in vital rates.
6) Assess how woodpecker space-use is affected by the spatial distribution of resources.
7) Correlate prey density with specific vegetation.
8) Determine individual variation in resource selection.
9) Understand how resources use changes with increasing time since disturbance.

Black-backed woodpeckers as well as other woodpeckers such as hairy (*Picoides villosus*), downy (*Picoides pubescens*), red-naped sapsuckers (*Sphyrapicus nuchalis*), and three-toed woodpeckers (*Picoides tridactylus*) provide nesting cavities for secondary cavity nesters. Previous management for cavity nesting birds such as woodpeckers was designed to retain a minimum of 3 cavity-bearing trees (dead or dying tree >15 ft high with dbh >8 in) per acre within the general forest zone. Timber sales were marked to retain an average of 3-5 trees from the largest diameter class of the stand to provide replacement snags. Retaining a few snag trees in a forest management program will provide some low quality habitat for woodpeckers but optimal habitats will be provided by implementing an extensive prescribed fire program. A fire program that includes a mixed-severity fire mosaic would benefit woodpeckers as well as other secondary cavity nesting bird species (Keyser et al. 2006, Bagne et al. 2008, Pierson et al. 2009, Russell et al. 2009). Black-backs that reside in habitats provided by spring and summer wildfires have increased survival and reproduction than black-backs that reside in mountain pine beetle infested areas or fires that occurred during fall (Rota et al. 2014).

Inventory work had been conducted and still continues for northern goshawks (*Accipiter gentilis*) to identify nesting territories. An understanding of how forest management effects goshawk survival and reproduction is important in developing conservation plans that guide resource management and conservation of this species. The combined designation of the goshawk as a sensitive species and a management indicator species by the U.S. Forest Service, and a species of greatest conservation need by the state of South Dakota, has resulted in a need for information on the status and trend of goshawk populations and habitats in the Black Hills. Initial data analysis revealed goshawks are selecting nesting sites with greater large tree (≥15.24" average diameter at breast height [DBH]) density, greater average DBH of trees, and greater overstory canopy cover than found at paired reference sites (C. Lehman, SDGFP, unpublished data).

General inventory data has been collected on small mammal populations (Ellis et al. 2008). This study caught 871 small mammals belonging to 11 different species in 18 different vegetation alliances. Of the 11 species caught, 92% of the individuals captured were of 4 species: the meadow vole (*Microtus pennsylvanicus*), the least chipmunk (*Tamias minimus*), the white-footed mouse (*Peromyscus leucopus*), and the deer mouse (*P. maniculatus*). Small mammal species richness ranged from 2 to 7 with a mean of 5 species per vegetation alliance (Ellis et al. 2008).

General inventory data has been collected on passerine songbird populations in CSP (Schickel 2007). This study found white spruce (*Picea glauca*) dominated forests had higher species richness when compared to ponderosa pine dominated forests. Additionally, Shannon diversity index values were greater for contiguous coniferous forests when compared to wildfire burned and grassland vegetation communities. For forest species, the highest densities included chipping sparrow (*Spizella passerina*), American robin (*Turdus migratorius*), yellow-rumped warbler (*Dendroica coronata*), white-winged junco (*Junco hyemalis*), red crossbill (*Loxia curvirostra*), western tanager (*Piranga ludoviciana*), black-capped chickadee (*Poecile atricapillus*), red-breasted nuthatch (*Sitta canadensis*), and plumbeous vireo (*Vireo plumbeus*) (Schickel 2007).

Little information is available for amphibians and reptiles. Some initial survey work has been conducted for snakes and results were not available at the time of this planning process.

Analysis of resource needs for selected species

We selected elk, northern goshawks, and black-backed woodpecker species based on their importance in terms of economics and/or intrinsic values. Additionally, we selected these species because of their unique resource needs in forested environments. Elk are found in many different structural stage categories of forested landscapes, depending on the activity and time period, and use disturbed and undisturbed forests for habitat selection. We selected elk to represent game species and their importance as a trophy game species to residents of South Dakota. We also selected 2 non-game species. We selected northern goshawks and black-backed woodpeckers because of their importance as sensitive species and species of greatest conservation need. Northern goshawks primarily use undisturbed (green) forests for nesting and have specific requirements for mature forest when using nesting territories. In contrast, black-backed woodpeckers use resources in disturbed environments such as mountain pine beetle areas or wildfire burned areas. We used some data collected in CSP and some data collected elsewhere in developing resource descriptions and maps for these selected species.

Elk

Resource selection at parturition sites for female elk was investigated and at coarse scales in forests and grasslands, female elk selected sites in areas with greater proportions of vegetation communities that provided forage (56–74% of area) and more rugged topography (194–248 m) than found at random (Lehman et al. 2015). At coarse scales in grasslands, elk selected sites in areas with lower road densities (≤1.24 km/plot). At the fine scale in forests and grasslands, female elk selected sites in areas with intermediate slope (19%), closer to water (355–610 m), and far from roads (541–791 m). Further, elk in forests and grasslands selected sites with intermediate security cover (50–88 m). We hypothesize elk selected for intermediate rugged terrain at larger scales for security from high road densities and human disturbance, but these areas may have placed elk in riskier environments for puma predation. Forest management that maintains open-canopied vegetation communities in less rugged areas and prevents ponderosa pine encroachment of meadows to provide forage may be beneficial for elk. Further, elk parturition sites occurred close to roads, particularly on public lands, and agencies should consider road-use restrictions and vegetation buffers beside roads in areas with less rugged terrain, which may provide favorable calving habitat (Lehman et al. 2015).

Northern Goshawks

The conservation of northern goshawk (*Accipiter gentiles*) habitat and the effects of forest management on this habitat have been the focus of much research in western ponderosa pine ecosystems (Reynolds et al. 1992, Boyce et al. 2006). It has been hypothesized that harvesting mature pine forests causes declines in goshawk populations by changing the structure of its nesting habitat, changing its prey base in foraging habitat, and by influencing the numbers of its predators and competitors (Reynolds and Joy 2006, Reynolds et al. 2006). Nesting areas in southwestern ponderosa pine forests typically have a relatively high density of mature trees, greater canopy cover, and an open understory (Squires and Reynolds 1997). Additionally, greater tree density and canopy closure within a nest area have been associated with increased territory occupancy and nesting rates (Keane 1999, Finn et al. 2002).

An understanding of how forest management effects goshawk survival and reproduction is important in developing conservation plans that guide resource management and conservation of species. The previous Custer State Park Resource Management Plan includes forest management for species of special concern and for management that maintains species diversity (Custer State Park Resource Management Plan 1995-2010). The combined designation of the goshawk as both a sensitive species and a management indicator species by the U.S. Forest Service has resulted in a need for information on the status and trend of goshawk populations and habitats throughout its range

During the past decade, managers began to turn their focus away from individual species needs to address emerging concerns about managing ecosystems, and more recently to concerns about forest health. Increased forest health concerns were related to the increased number and size of devastating wildfires that have destroyed much of the remaining old forests (Graham et. al. 2004). Also, greater tree densities can lead to more insect outbreaks and the Black Hills are more susceptible to mountain pine beetle infestations. In the Black Hills, mountain pine beetles have been historically prevalent, with an epidemic occurring on average every other decade and lasting 8 to 13 years (Blackman 1931, Allen 2005). The primary management tool to improve forest health is tree-thinning (Graham et al. 1999). However, as forests are thinned, managers have become concerned about forest-dependent species that may be affected by these treatments, including the northern goshawk. Data collected in CSP and adjacent areas at goshawk nests were summarized and compared with paired reference sites (Figure 29). Our initial analysis with a small sample size of 6 indicates goshawk nest resources have more large trees, fewer small trees, and greater herbaceous understory cover in the form of more grass and forb cover (Table 24). Management implications include protecting goshawk nest areas by providing a 20-30 acre buffer around nest territories where the buffer area is centered on the nest structure. Large trees and canopy overstory within buffers should be maintained. Additional areas of large trees with greater overstory canopy cover adjacent to nest territories should also be protected (Reynolds et al. 1992). In CSP this has included inoperable areas. Using ArcGIS, a map was developed using the covariates greater canopy cover associated with greater tree density (≥ 290 Stand Density Index) and larger structural stage ponderosa pine/spruce (≥ 20 cm average dbh) to provide spatial data where goshawks may have a higher probability of nesting in Custer State Park (Figure 30).

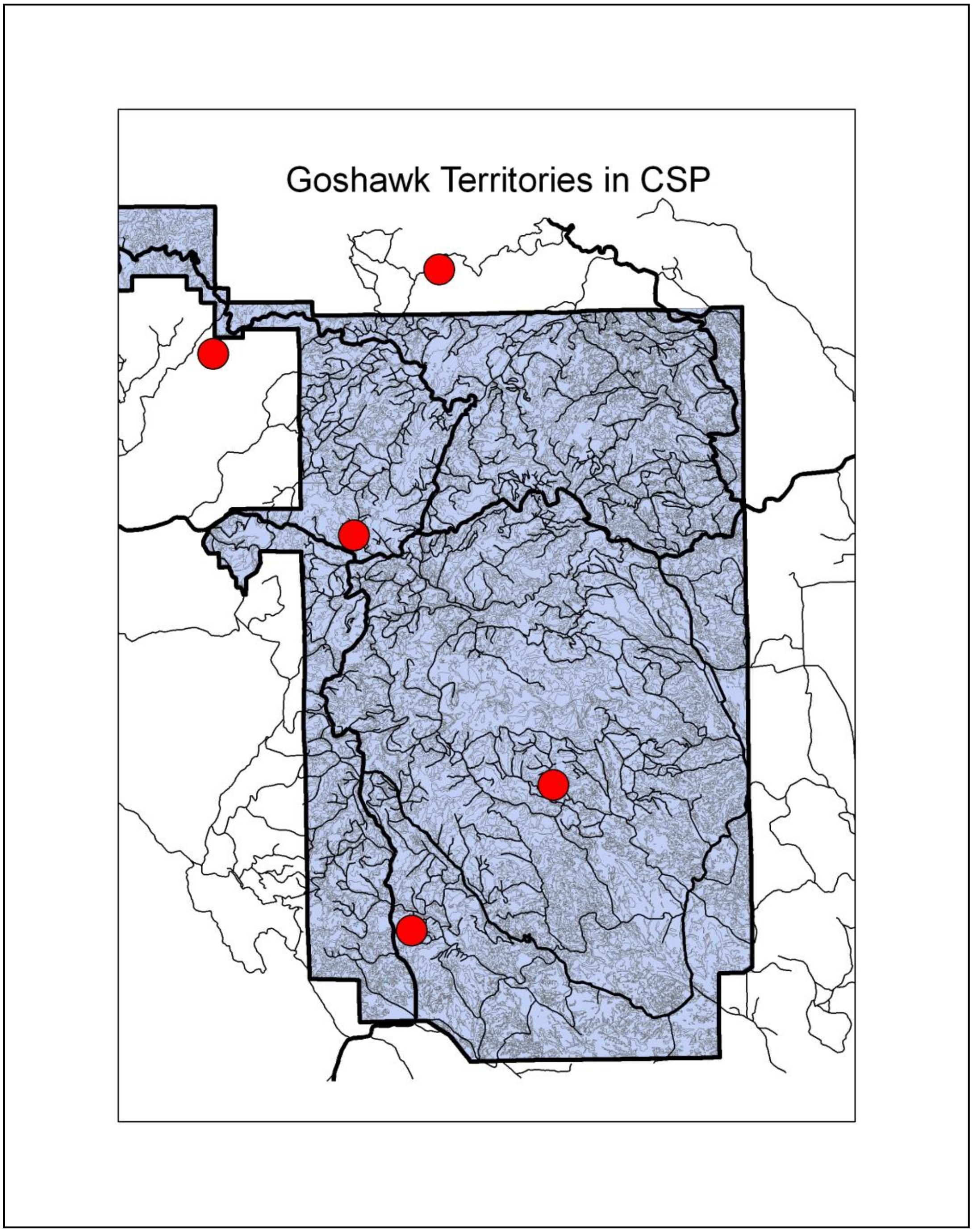

Figure 29. Location of goshawk territories in and adjacent to Custer State Park, South Dakota 2007-2015.

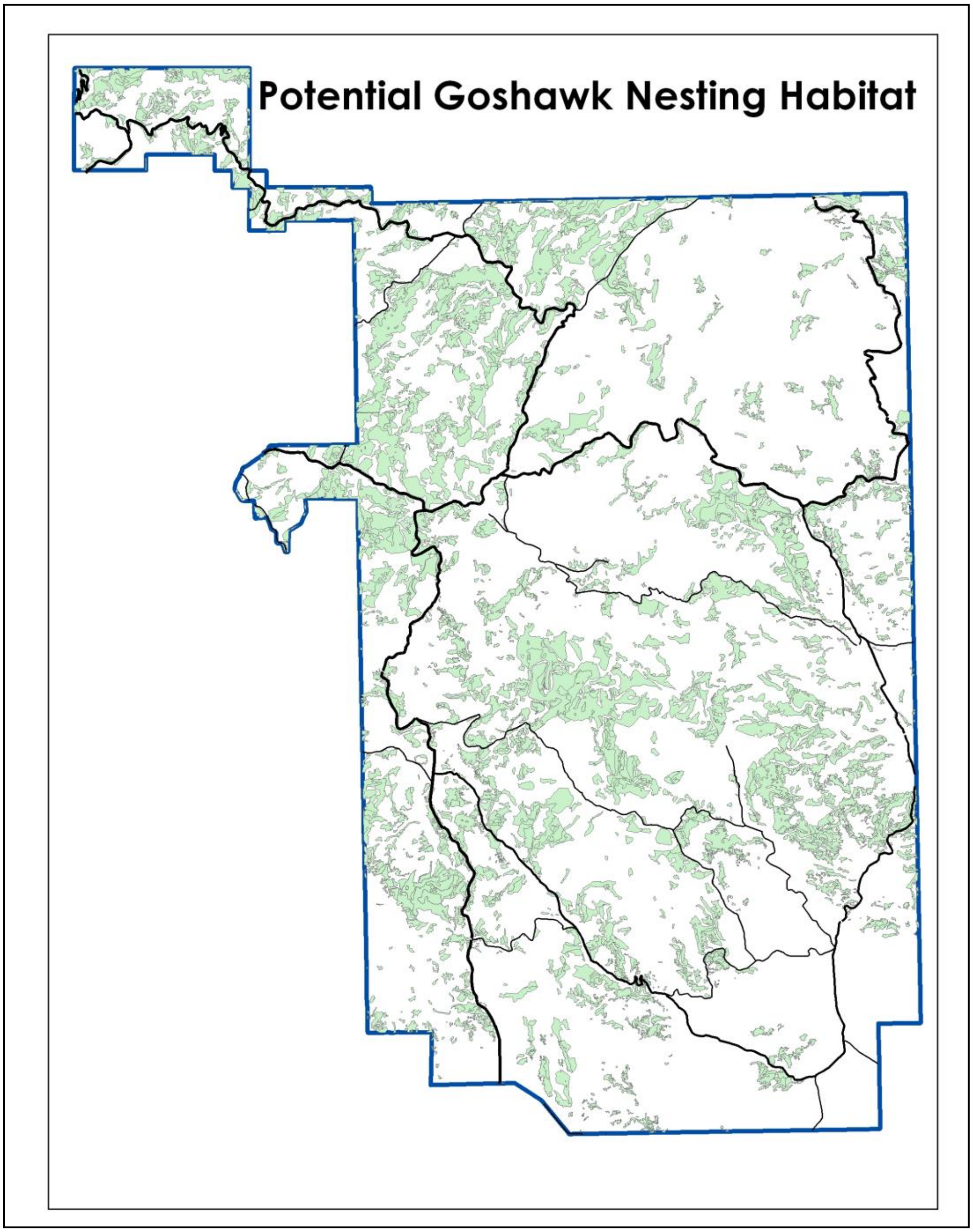

Figure 30. Areas in Custer State Park with greater canopy cover associated with greater tree density (≥ 290 Stand Density Index) and larger structural stage ponderosa pine/spruce (8 in average dbh) where goshawks may have a higher probability of nesting.

Table 24. Means (SE) and comparisons of covariates measured for nest sites (n = 6) and paired reference sites (n = 6) for northern goshawks in Custer State Park, South Dakota, 2007–2008.

	Nest site		Reference site		Comparison[b]	
Covariate	$\bar{x}$	SE	$\bar{x}$	SE	z-test	P-value
North aspect (316-45°)[a]	1.0		2.0			
West aspect (226-315°)[a]	2.0		1.0			
South aspect (136-225°)[a]	1.0		0.0			
East aspect (46-135°)[a]	2.0		3.0			
Overstory canopy cover	60.0	5.2	54.0	8.9	–0.52	0.60
Basal area (m^2/ha)	27.2	4.1	22.0	2.2	–0.73	0.50
Large tree (≥15.23 cm) dbh (cm)	38.0	1.4	30.0	1.2	–2.20	0.03
Small tree (<15.23 in) density	537.9	223.5	2186.8	904.2	–2.20	0.03
Small tree dbh (cm)	6.9	1.6	7.3	0.5	–0.11	0.92
Total herbaceous cover (%)	55.1	6.1	19.2	7.4	–2.20	0.03
Grass cover (%)	31.0	5.3	5.5	2.1	–2.20	0.03
Forb cover (%)	10.0	2.7	0.3	0.2	–2.20	0.03
Shrub cover (%)	21.0	7.4	12.9	7.1	–0.52	0.60
Visual obstruction (cm)	8.2	2.6	5.8	1.8	–0.14	0.89
Slope (%)	12.0	1.7	15.3	3.5	–0.52	0.60

[a]Total no. instead of means (SE) for nest sites and reference sites in each categorical variable.

[b]We used Wilcoxon signed rank z-tests to compare continuous covariates.

Black-backed woodpeckers

The black-backed woodpecker (*Picoides arcticus*) has received considerable attention by avian research scientists because of its importance as a disturbance dependent species (Bock and Lynch 1970, Hutto 1995, Dixon and Saab 2000, Bonnot et al. 2008). This species can be irruptive and is typically found in greater numbers in areas with insect outbreaks or fire disturbance (Goggans et al. 1989, Hutto 2008, Bonnot et al. 2009). However, fire suppression activity and lack of insect disturbance can contribute to its rarity in montane forests of the west, and black-backed woodpeckers have been given special status. In 2010 there were 2 primary foraging and nesting areas of importance for black-backed woodpeckers in Custer State Park (Figure 31). They are considered a Sensitive Species by Region 2 of the United States Forest Service and a Species of Greatest Conservation Need by the state of South Dakota (South Dakota Department of Game, Fish, and Parks 2006). Because of their importance, it is essential that resource management agencies receive essential research information through radio-telemetry studies and consider their management needs when developing plans.

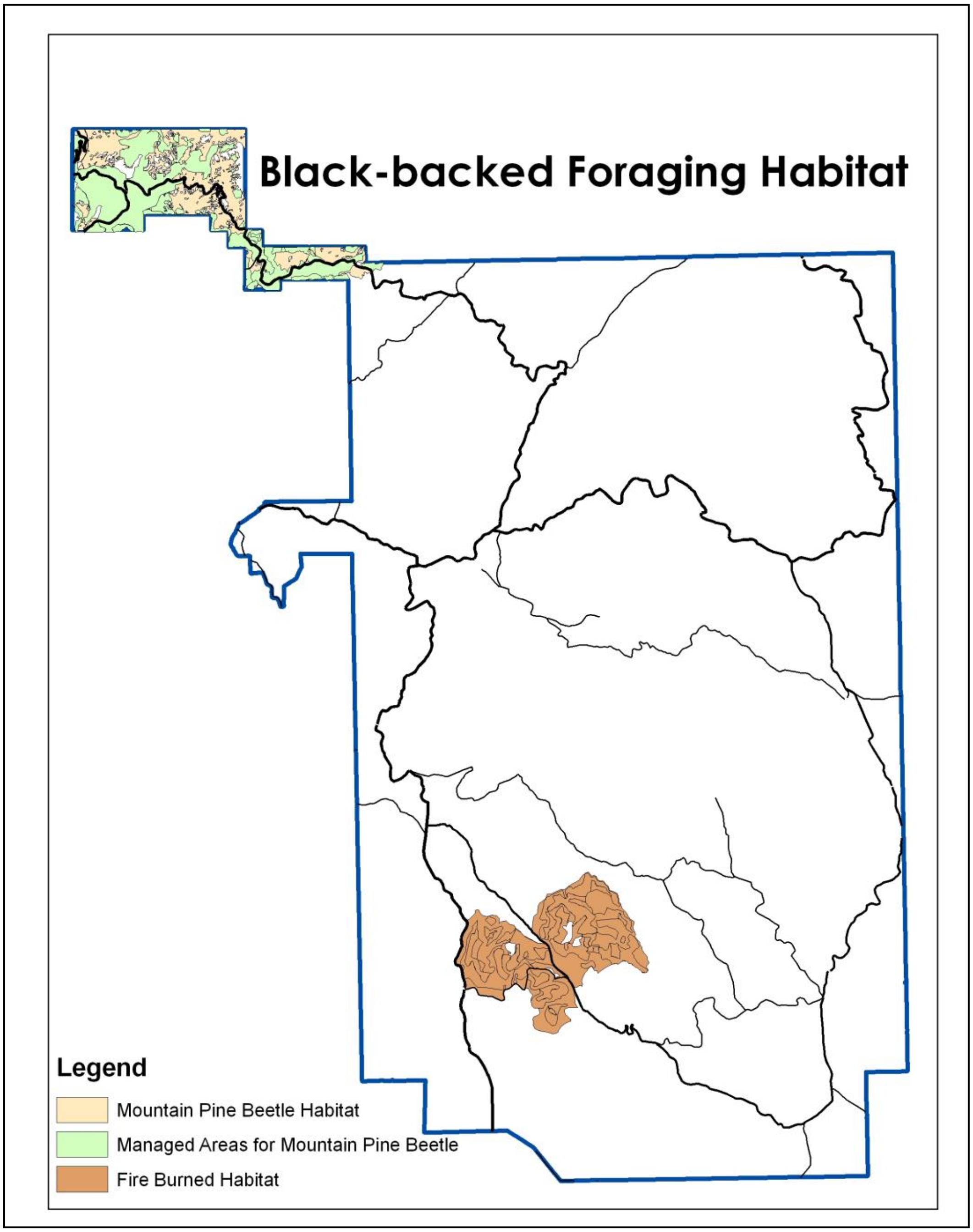

Figure 31. Primary foraging and nesting areas for black-backed woodpeckers in Custer State Park; map includes areas of ephemeral disturbance such as mountain pine beetle infestations and fire burned areas that provide invertebrate foraging for woodpeckers in Custer State Park.

Recent research in the Black Hills indicates the importance of food resources available to black-backed woodpecker for nesting areas but creates a challenge for forest managers that want to manage beetle outbreaks and avoid the negative impacts to black-backed woodpeckers (Bonnot et al. 2009). Reduction of beetle populations in forests with mountain pine beetle outbreaks could negatively affect the suitability of those areas for nesting. Therefore, Bonnot et al. (2009) advise against use of silvicultural treatments such as salvage logging in small outbreaks <20 ha, which is based on their territory scale analysis. For recently killed forests >20 ha Bonnot et al. (2009) advise against silvicultural treatments during the black-backed woodpecker breeding season of May 15 through July 31 which would reduce direct impacts to food resources during nesting. When prescribing silvicultural treatments in outbreaks larger than 20 ha, Bonnot et al. (2009) suggest managers retain areas containing suitable distributions of food and nest sites. Patches of mountain pine beetles or wood borers interspersed at intermediate distances of 50–100 m with areas containing increased densities of aspens and 3–5-year-old pine snags should be considered for retention (Bonnot et al. 2009).

Little information exists on black-backed woodpecker nesting in mountain pine beetle outbreaks in the Black Hills. However, a recent study estimated nest density and found nest densities were slightly greater than what was recently reported for burned forest in the region (0.1 nests per 40 ha; Bonnot et al. 2008, Vierling et al. 2008). Furthermore, the Bonnot et al. (2008) study found young were fledged at rates comparable to those in burned forests. Given the infrequency of large-scale, stand-replacing fires in the Black Hills, further work is needed to understand the importance of beetle-killed forests in the maintenance of black-backed woodpecker populations in this region. Rota et al. (2014) found beetle killed areas had negative population growth for black-backs.

For fire disturbed areas, conditions providing nesting habitat for black backs typically have higher snag densities (mean of 275–316 snags [≥9 in dbh] per ha) (Saab et al. 2009). Consequently, post-fire management practices that promote retention of clumps of large standing dead trees (≥ 23 cm dbh), particularly ponderosa pine with areas of high pre-fire crown closure will likely be most successful at maintaining populations of cavity-nesting birds (Saab et al. 2009). Research in the Black Hills indicates nest-site selection in a recently burned forest included greater distances to unburned patches, a higher proportion of moderate- to high-severity effects in the landscape, and larger snags (Vierling et al. 2008). Although fire planning that encourages low-severity fires is important, Vierling et al. (2008) recommends that fire planning provide for opportunities where mixed-severity fires can occur (i.e., encourage a mosaic of fire effects including patches of dead trees, as well as live trees and forest openings). Large snags and trees (that will eventually become snags) are found at low densities in the Black Hills (Spiering and Knight 2005). Vierling et al. (2008) recommends that post-fire snags ≥9 in dbh be retained.

Historical effects of management on wildlife species

<u>Timber management</u>

Timber production in CSP is maintained as a viable commercial operation. However, timber management practices are reviewed and modified to retain or enhance wildlife values. Modifications may reduce the direct economic return from the sale of timber but CSP must also be concerned with production of wildlife resources.

The initial management of timber in CSP began in the early 1900's. This "management" was primarily highgrading and clearcutting of all merchantable pine. Management was suspended in the 1920's and resumed again in the 1940's as mostly overstory removal. This type of management, in concert with the prevention of fire led to dense regeneration of ponderosa pine stands. This management regime led to a significant change in forest structure and resource availability.

In 1980 CSP began a comprehensive timber management program. This program was designed to improve the timber resource as well as improve wildlife habitat values. Harvest of commercial value timber may be modified to preserve particularly important components or interspersions of wildlife habitat. "Old growth" generally exists either as a roadside stand intensively managed for aesthetics (TRZ), or as a stand which was deemed inoperable by conventional logging methods. An additional 2,209 acres along the French Creek canyon and a smaller area around the Grace Coolidge walk in fishing area are maintained as "wilderness" (See Natural Areas section). Commercial and non-commercial thinning of stands in CSP are designed to improve timber stand conditions as well as improve forage production. Several projects treated during the regulation period were modified by the wildlife biologist to retain cover for elk.

During 1995-2010 timber prescriptions were often modified from traditional prescriptions. Prior to 1995 almost all immature stands were managed to a 60 growing stock level (GSL). Since then pine stands have been managed at a variety of densities based on stand structure and productivity. Horizontal diversity was also enhanced by retaining stands >120 GSL for wildlife cover and on inoperable lands. Diversity was also increased by the removal of pine encroachment from meadows, riparian areas, and hardwood stands. Fuel breaks constructed during the project also provided additional diversity, edge and travel corridors for some wildlife. Understory development was also enhanced by the use of whole tree logging.

Prescribed fire is used to improve wildlife habitat in CSP. Between 2001 and 2010 there have been 8 prescribed fires and 1 major wildfire that have provided wildlife habitat. Prescribed fires have burned roughly 4850 acres and the four-mile wildfire burned 2300 acres in CSP. Objectives of fire include rangeland improvement, reduction of pine encroachment and reduction of slash. Research in CSP indicates that production of forbs was significantly higher on burned sites and utilization of forage was also higher on burned sites (Easterly and Jenkins 1992). Additionally, a spring burn reduced cool-season grasses and enhanced warm-season grasses. Fire obligates such as black-backed woodpeckers and other woodpecker species will benefit from fire burned habitats (see selected species section for more detail).

Disease management and research

Wildlife disease surveys have been conducted in Custer State Park from 1995-2015. Disease information was primarily collected on bighorn sheep and elk. Bighorn sheep disease analysis results from 1997-2015 are presented in Table 26. Testing conducted on 139 animals revealed antibodies or past exposure to bovine respiratory syncytial virus (BRSV), *Mycoplasma ovipneumoniae* (MO), and parainfluenza 3 (PI3). Recent testing in 2015 indicates MO is still present with 2 chronic shedders in the herd (Table 25).

Table 25. Results of disease testing on bighorn sheep in Custer State Park, 1997-2015.

Date	**Samples**	**Number**	**Age**	**Sex**	**Results**
1997-1998	Blood	106	Adult	M and F	6% positive BRSV[a], 32% positive MO[b], 20% positive PI3[c]
2007	Organs/blood	1	Adult	F	*Pasteurella trehalosi* cause of death; however, predisposing factors include BRSV, PI3 and *Mycoplasma*
2008	Swab/blood	4	Adult	F	Swabs detected *Mycoplasma ovipneumoiae* in 2 of 4 (50%)
2008	Organs/swab/ blood	1	Adult	M	Ram was healthy but serum had elevated titers to BRSV, PI3, and *Mycoplasma ovipneumonia*
2008	Swab/blood	1	Adult	F	Ewe had low titers to BRSV, PI3, and no detection of *Mycoplasma ovipneumonia*
2008	Organs/swab/ blood	1	Lamb	M	Bronchopneumonia cause of death, predisposing factors included *Mycoplasma ovipneumonia*
2009	Organs/swab/ blood	1	Lamb	F	Bacterial bronchopneumonia due to infection with *Moraxella spp*. was cause of death. No predisposing agents were identified.
2015	Organs/swab/ blood/wash	24	Varied	M and F	13% positive MO[b]

[a]Indicates positive antibody present to due exposure, vaccination, or passive transfer for bovine respiratory syncytial virus (BRSV).

[b]Antibody detected at levels consistent with exposure or infection with *Mycoplasma ovipneumoiae* (MO). In 2015, this is the percentage of sheep shedding MO into the environment.

[c]Indicates positive antibody present to due exposure, vaccination, or passive transfer for parainfluenza 3 (PI3).

Twenty-eight elk (*n* = 10 bulls, *n* = 18 cows) were paneled for disease in 2009 and evaluated for the prevalence of antibodies to *B. abortus*, type I and II bovine viral diarrhea (BVD), *Mycobacterium paratuberculosis* (Johne's disease), and epizootic hemorrhagic disease (EHD) virus serotypes. Serologic evidence of exposure to EHD virus occurred in 3 samples of cow elk.

This finding was interpreted as evidence of past exposure, and not a current carrier state. In 2009, testing in CSP revealed 27 elk all tested negative for Type I and Type II BVD. In 2011, more testing of 40 elk revealed that all 40 tested positive for BVD Type I, and 38 of 40 tested positive for Type II BVD. These seropositive results indicate that wild elk have been exposed to related *pestiviruses* and may only serve as a host to BVD virus. However, it is not known in most cases if wild species serve as a reservoir for BVD or whether infections occur due to contact with cattle (Van Campen et al. 2001). There is no evidence that persistently infected wild elk occur in South Dakota. The most significant vector of BVD virus for range cattle is a persistently infected bovine carrier within a herd, and not wild ruminants (Williams 1999).

Chronic wasting disease (CWD) is a fatal brain disease of deer and elk that is believed to be caused by an abnormal protein called a prion. Animals infected with CWD show progressive loss of weight and body condition, behavioral changes, loss of muscle control and eventual death. Testing of hunter harvested animals from 2001 to 2009 provided 973 samples in Custer State Park. There were 781 elk tested (181 bulls, 600 cows) and 192 deer. For deer, the majority of testing was for white-tailed deer since very few mule deer were harvested by hunters in CSP. Positive samples include 4 elk (3 cows and 1 bull) and 1 deer (white-tail doe) and annual prevalence rates varied from 0% to 3.6% from 2001-2009 (Table 26). From 2010-2015 42 deer (0 positives) and 52 elk (9 positives) were tested for CWD. Additionally, during a research project where 42 female elk were radio-marked and studied for survival in CSP from 2011-2013, it was documented that none of those animals died from CWD.

<u>Population controls</u>

Management of game populations in Custer State Park is conducted through hunter harvest. In 2014, CSP had hunting seasons for elk, white-tailed deer, mountain lion, pronghorn, and Merriam's turkey. We provide data of licenses issued and harvest metrics for elk, deer, pronghorn, and wild turkey (Table 27). Custer State Park strives to provide a unique quality hunting experience by limiting the number of hunters and providing mature males for bighorn, deer, elk, pronghorn, and wild turkey. When populations need control female harvests are implemented when appropriate. When populations cannot sustain hunting mortality, hunting seasons are closed. Bighorn sheep, which experienced a population die-off in 2004, have not been hunted since closure in 2005.

Table 26. Annual prevalence rates for chronic wasting disease of elk and deer in Custer State Park, 2001-2009.

Date	Species	Number Sampled	Number Positive	Sex	Prevalence Rate[a]
2001	Elk	74	0	-	0.00%
2001	Deer	1	0	-	0.00%
2002	Elk	95	0	-	0.00%
2002	Deer	3	0	-	0.00%
2003	Elk	111	0	-	0.00%
2003	Deer	17	0	-	0.00%
2004	Elk	145	1	F	0.70%
2004	Deer	21	0	-	0.00%
2005	Elk	110	0	-	0.00%
2005	Deer	19	0	-	0.00%
2006	Elk	105	2	2 F	1.90%
2006	Deer	34	0	-	0.00%
2007	Elk	53	0	-	0.00%
2007	Deer[b]	28	1	F	3.60%
2008	Elk	47	0	-	0.00%
2008	Deer	32	0	-	0.00%
2009	Elk	41	1	M	2.44%
2009	Deer	37	0	-	0.00%

[a]Prevalence rates were computed as a percentage of positives divided by total sampled.

[b]Positive sample was a white-tailed deer.

Table 27. Number of applicants, number of licenses, harvest success, and mean number of hunter recreation days for hunters in Custer State Park (Mean rec), South Dakota, 2014-2015. Data for ungulates was collected during the 2014 season and data for turkeys was collected in 2015.

Species and tag type	Applicants[a]	Licenses	Harvest success	Mean rec
Elk Early Archery	3,023	4	100%	8.8
Elk Rifle	8,084	4	100%	1.0
Any White-tail	1,662	10	80%	2.2
White-tail Antlerless	93	20	65%	2.2
Any Pronghorn	1086	3	100%	2.00
Merriam's Turkey Male	563	135	37%	2.56

[a]Does not include ZZ applicants for preference points only.

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WATER AND RIPARIAN ECOSYSTEM

VEGETATION

Analysis of developed, ephemeral and live waters

Custer State Park has a total of 236 linear miles of stream habitat in the main body of the Park. This includes 88 miles of permanent streams and 148 miles of ephemeral streams (Figure 32). An additional 42 ponds or impoundments exist. These are primarily along Grace Coolidge Creek or on rangelands. Numerous springs occur throughout the park. For the most part, these are not mapped. Additional springs and seeps have developed within the burn areas.

<u>Status of riparian vegetation</u>

No riparian vegetation sampling occurred during the 1995-2010 resource planning period. Riparian conditions are unknown at this time. Highland Creek has an exclosure erected around the riparian area to exclude bison. An exclosure exists on the South Fork of Lame Johnny Creek in the Bachelor Draw area. No other exclosure areas exist on CSP waters. Exclusion of bison from these riparian corridors resulted in recovery of the vegetation and stabilization of the stream banks in these 2 areas. Removing half Lame Johnny exclosure has led to a slow degradation of streamside woody vegetation in the opened area. Other riparian sites exhibit very limited regeneration of riparian vegetation and decadent overstory vegetation. Removal of pine encroachment from mesic hardwood vegetation has provided varied results in hardwood response.

<u>Watershed analysis and historic management of open water systems</u>

The only long term flow records in CSP come from a gauging station on Grace Coolidge Creek downstream about 3/4 mile from the Game Lodge. Although bothered by sink holes (moved in 1976 because of them), the USGS gauging station has recorded streamflow on Grace Coolidge Creek since 1967. The total watershed area is 25.2 square miles (16,128 ac), most of which is in the park. Watershed efficiency ranges widely with figures as low as 5% during drought and as high as 15% after the Galena Fire. Figures are intermediate during years of normal precipitation and vegetative cover. This demonstrates the effects of vegetation and soil moisture throughout the watershed on water entering the riparian system. CSP has parts of 13 watersheds excluding the Sylvan extension (Table 28). CSP acreage in watersheds ranges from 474 ac to 12,925 ac. All watersheds encounter the limestones along the eastern side of CSP and generally disappear underground prior to exiting the park. However, some watersheds have significant acreage upstream outside CSP, most notably French Creek, Iron Creek and Flynn Creek.

Table 28. Watershed acres associated with permanent streams along with miles of permanent stream in CSP.

WATERSHED	Acres in CSP	Miles of permanent stream in CSP
French Creek	13753	19.6
Grace Coolidge Creek	13031	21.9
Lame Johnny Creek	11668	8.5
Galena Creek	5234	7.7
Swint Creek	4392	0.0
Flynn Creek	3553	6.8
Dry Creek	3275	0.0
Bear Gulch	3237	6.7
Highland Creek	3098	1.2
Spokane Creek	2844	1.1
Whiskey Gulch	1719	0.0
Blacktail Creek	1530	0.0
Iron Creek	1239	2.2
Spring Creek	1043	2.4
Willow Creek	941	0.9
Total	70558	79.1

Treatments on a watershed level have occurred by timber harvest, non-commercial thinning, and stand replacing fires (see Forest Management). Additional treatments through grazing deferments have taken place beginning in the 1980's. The southernmost portions of CSP (south of the RD fence) have been deferred by bison during the growing season from approximately early-July through mid-September. In spite of the mortality of American elm from Dutch elm disease, the hardwood vegetation along Lame Johnny Creek appears to have remained vigorous. Additional deferments have occurred in the SW pasture (SW of the North Fork Lame Johnny Creek) from 1992 until 1995.

WILDLIFE

Fisheries and Fishery habitat analysis of open water resources

Custer State Park contains parts of 5 watersheds providing fishing opportunity; French Creek, Grace Coolidge Creek, Spring Creek, Galena Creek, and Highland Creek. Contained within these watersheds are 4 man-made lakes; Stockade (130 ac), Center (25 ac), Sylvan (18 ac), and Legion (9 ac). Aeration systems have been deployed on Stockade Lake and Sylvan Lake. An air pump and grid system pumps air through a series of hoses into Stockade Lake oxygenating the water column. A Solar Bee system circulates water throughout the water column of Sylvan Lake to mix oxygenated water for better aeration. These systems provide additional suitable fish habitat but also oxygenate the lakebed sediments to reduce the movement of nutrients into the water column.

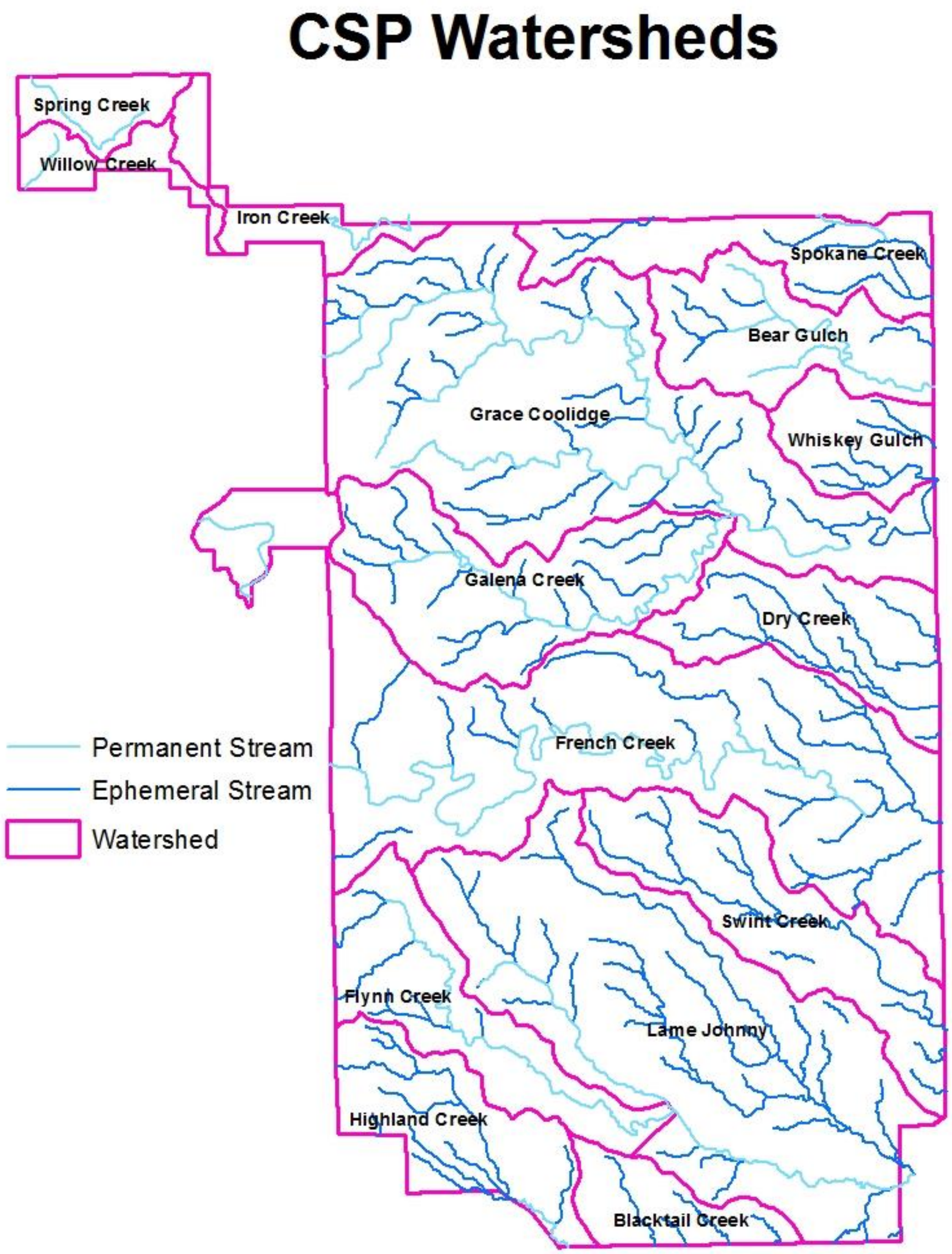

Figure 32. Live water resources in CSP.

The park watershed with the largest upstream area is the French Creek watershed. French Creek provides 2 stream fishing opportunities within Custer State Park. The first is a 6 mile stream reach from the west perimeter fence to horse camp. This reach exhibits problems associated with stream degradation. Prior uses of the area, reductions in water yield, stream channelization, road construction, and improper in-stream structures have led to a stream channel which is too wide and shallow for existing stream flows. This resulted in a reduced capacity to manage this reach for trout habitat and angling opportunity.

The riparian zone of this upstream reach of French Creek is limited primarily to grass/forb vegetation. Lack of woody stream side vegetation limits overhead stream cover and shading, thereby limiting stream quality for trout. This reach of French Creek has received a great deal of pool development from man-made rock dam structures. While initially providing fish holding areas, these pools have accumulated large amounts of silt. These sites support white suckers (*Catostomus commersoni*), as well as mountain sucker (*Catostomus platyrhynchus*) a SGCN, longnose dace (*Rhinichthys cataractae*), creek chub (*Semotilus atromaculatus*), and fathead minnow (*Pimephales promelas*)(Bucholz and Wilhite 2010). Historically, French Creek supported populations of Lake Chub (*Couesius* plumbeus) and Longnose Sucker (*Catostomus catostomus*) both listed as SGCN and Longnose sucker state threatened. Lake chub, possibly extirpated, were last sampled in French Creek in the early 1930s, shortly after Stockade Dam and lake was constructed. It is presumed that the impoundment and associated stream fragmentation along with trout introductions lead to their decline and ultimate extirpation. Longnose Sucker was last reported for French Creek in the 1960s. An instream fisheries habitat improvement project created plunge pools and narrowed the stream channel in some stretches. This had a marginal impact on improvement of the fishing opportunity in this reach of the stream. Water conditions, primarily increased temperature and reduced flows, have precluded stocking during latter parts of the summer. As a result, SDGFP does not stock brown trout on an annual basis, but rather when suitable conditions allow.

The second reach of French Creek supporting a sport fishery is from horse camp to the sink holes at the east end of French Creek canyon. Brown trout (*Salmo trutta*) were stocked in the middle of French Creek below Fisherman's Flats in 2008 and 2015. This section of stream runs through the French Creek canyon. The stream gradient through the canyon is steeper, leading to increased velocity. . The natural formation of deep holes occurs here. Springs provide additional stream volume in this section and contribute to maintenance of lower water temperatures. Riparian vegetation includes a moderately well-developed woody component. This streamside overstory, together with the shading due to canyon walls, also helps to maintain lower water temperature, enhancing trout habitat. Several gradient changes provide diversity of in-stream habitats and, as with the upstream reach, habitat for native fishes is provided by several riffle areas with moderate velocities and in-stream vegetation cover.

The second watershed providing stream fishing opportunity is the Grace Coolidge drainage. This stream consists of 3 main components: the upstream reach from Center Lake to the headwaters (7 mi), the lowhead dams of the walk-in fishing area (3 mi), and the downstream reach from Grace Coolidge campground to the sinkholes (3 mi). The stream flows in Grace Coolidge are much lower than French Creek.

The upstream reach supports a naturally reproducing population of brook trout (*Salvelinus fontinalis*)(Bucholz and Wilhite 2010). This upstream reach has limited fishing opportunity due to the small stream size and volume and the limited size of fish.

The 3-mile walk-in fishing area contains 6 lowhead dams. Impoundments behind these dams provide holding and rearing areas for trout. This area runs through a canyon, and riparian vegetation is fairly well developed. Stream segments between impoundments have limited flows but provide habitat for small-bodied fishes and crayfish in addition to some suitable trout habitat. Movement by fish is restricted by dams in this section. This area received heavy siltation from runoff after the Galena fire, with the silt load being heaviest downstream. Silt loading of impoundments has decreased water volume and quality and the lifespan of the lowhead dams.

The lower 3 mile segment of Grace Coolidge received large amounts of silt and ash with runoff after the Galena burn. This segment also contains 12 dam structures, some of which contain sewer lines. These structures accumulated large amounts of silt. Additionally, these dam structures restrict or prohibit fish movement among stream segments. Riparian woody vegetation is moderately well developed and provides good overhead cover. All impoundments along Grace Coolidge had silt removed in 2000.

The third watershed supporting a sport fishery is the Highland Creek watershed. This creek originates from springs in the southwest portion of CSP and flows approximately 1/2 mi before entering Wind Cave National Park. This stream segment has been fenced to exclude buffalo and allow recovery of the stream banks and riparian vegetation. Stream flows are low but consistent. The stream is narrow and the bottom gravelly. Two to 3 pools provide rearing habitat for the naturally reproducing brook trout population. Most fish in Highland Creek do not reach "catchable"(279-381-mm) size because of the small stream size. However, this creek is very productive and serves as a source for stocking other waters including some CSP ponds. Streamside vegetation is primarily grass/forb with some stands of shrubs. Highland Creek becomes choked with aquatic vegetation during the summer and fisherman access is extremely limited.

Other creeks in CSP are generally too small or too erratic in flow to support sport fisheries. Little Squaw Creek does support a limited number of brook trout; however adult pool habitat is lacking. Similarly, Galena Creek also supports a population of brook trout, but like Little Squaw Creek, low water volume limits fish size. Bear Gulch achieved steady flows after the Galena fire and the creek channel developed with high flow events As a result, brook trout were stocked in fall 1992. However, the stream returned to intermittent flows in many reaches with drought conditions during the mid-2000s. The permanent reaches support limited fish populations.

The park also has 19 stock dams and impoundments. Periodic stocking provides some limited fishing opportunity. These ponds vary in size and depth. Severe winters occasionally lead to winterkill.

The park also has 4 man-made lakes. The largest lake is Stockade Lake, located on French Creek, with a surface area of 130 ac. . Nutrient loading, siltation, and low water flows reduce water quality of Stockade Lake. Algae blooms have caused fish kills in the past. An active aeration system installed on Stockade Lake has improved water quality and improved fish habitat. Stockade Lake supports fishable populations yellow perch (*Perca flavescens*), black crappie (*Pomoxis nigromaculatus*), black bullhead (*Ameiurus melas*), northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*) and both largemouth bass (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*)(Miller et al. 2013) .

Center Lake is the second largest lake in the park. Center Lake is 25 surface acres in size. The primary fishery in the lake is rainbow trout. However, tiger trout (*Salmo trutta* X *Salvelinus fontinalis*) which is a hybrid cross between brown trout and brook trout were stocked into Center Lake in 2008 and provide additional sport fishing.

Sylvan Lake is 18 acres and is located in the northwest extension of the park. Sylvan is fed by a series of springs in the draws surrounding the lake. Sediments in Sylvan Lake contain phosphates from the surrounding geology. These phosphates came into solution under anaerobic conditions created during stratification during the summer. Lake turnover lead to a eutrophic state and algal blooms. Sylvan occasionally experienced summer kills. Sylvan Lake had a Solar Bee circulator installed. This unit intake is set at 23 feet and mixes the lake volume breaking stratification. Oxygenated water prevents phosphates from coming into solution over approximately 80% of the lakebed, improving water quality and improving the fishery. This lake supports a rainbow trout fishery (Miller et al. 2009).

Legion Lake is the only fishing resource in the Galena drainage. Legion is the smallest lake in CSP at 9 acres but does receive heavy fishing pressure on its rainbow trout fishery.

Management of Custer State Park fisheries

Fisheries management in CSP originated with the management of the Black Hills as a fishery, which began in 1886 with the stocking of Brook Trout at Cleghorn Springs (Barnes 2007). By 1910 over 15 million trout and char had been stocked in South Dakota. Fishing regulations began as early as 1887, with a daily limit of 15 trout established in 1912 (Brown 2007). Since that time, stocking, regulations, and other management practices have changed in response to changing angler expectations.

Currently, management of fisheries within CSP falls under the SDGFP Black Hills Fisheries Management Plan (SDGFP 2014b), in which, specific aquatic systems are managed based on their biological characteristics. Additionally, the Black Hills supports a diverse angling public (Longmire 2015) and social considerations need to be taken into account when determining proper management strategies. As a result, different systems often require varying management strategies to help accomplish specific management objectives. Because of this, separate management plans were created for reservoirs and streams. Management of individual reservoirs within CSP can be found in the Reservoir Management Index, with a specific management plan included for Stockade Lake (SDGFP 2015a). Similarly, management of specific streams within CSP can be found in the Streams Management Index, located in the Black Hills Streams Management Plan (SDGFP 2015b). These plans were adopted in 2015, with the goal that they will be updated on a five year schedule.

Overview of riparian influences on wildlife

Riparian areas are those terrestrial zones in close association with aquatic ecosystems. These areas are characterized by the presence of trees, shrubs, or herbaceous vegetation in moist conditions. This discussion will include the aquatic ecosystem.

Riparian ecosystems make up a minor portion of the overall area, but are generally more productive in terms of biomass, both plant and animal, then the surrounding vegetation communities; the riparian ecosystem is a critical source of biodiversity within rangelands (Thomas et al. 1979, Dosskey 1998, Rumble and Gobeille 1998, Sanders and Edge 1998).

Riparian systems improve habitat for more numerous at-risk aquatic and terrestrial species (Krueper 1996). Riparian vegetation stabilize stream banks, reduce pollutant runoff, and provide habitat for fish and wildlife, particularly in overgrazed or highly fragmented landscapes (Schultz et al. 1995, Dosskey 1998). Riparian systems in the Great Plains are often under duress from traditional grazing management that has reduced vegetation cover and altered plant communities along many of the region's streams, contributing to erosion and degradation of terrestrial and aquatic habitat (Boldt et al. 1979, Chaney et al. 1990). Riparian restoration through special grazing management planning and tactics can reverse these problems (Boldt et al. 1979, Kinch 1989, Chaney et al. 1990).

Several conditions specific to riparian zones contribute to the special characteristics of riparian ecosystems. The presence of water is characteristic to the riparian habitats. Several species are closely affiliated with water during all or a part of their life cycle. Large ungulates such as elk, bighorn sheep, and bison utilize these important water resources, and are particularly important during hot dry periods where ephemeral water sources may be scarce. Some species depend almost exclusively on the riparian zone and associated aquatic ecosystem (e.g. amphibians, belted kingfisher [*Ceryle alcyon*], American dipper [*Cinclus mexicanus*], and mink [*Mustela vison*] are some examples).

Riparian habitats have very high edge-to-area ratios. These ecotones, or interfaces, provide a diversity of habitats in very close proximity and demonstrate "edge effect". These riparian ecotones are typically more productive, in terms of both species diversity and density of species than the adjacent uplands (Naiman and Decamps 1997, Rumble and Gobeille 1998, Sanders and Edge 1998).

Vegetation also plays an important role in regulating the micro climate. Micro climate is moderated in the riparian zone by the influence of water and vegetation, primarily deciduous. Riparian vegetation exhibits higher rates of evapotranspiration, together with direct evaporation from open water, leading to higher humidity levels (Naiman and Decamps 1997). Additionally, the more luxuriant vegetation reduces solar irradiation. These conditions provide thermal protection, prevent desiccation or overheating of reptiles and amphibians, create conditions for insects and other invertebrates which in turn provide food for many terrestrial and aquatic species. Natural riparian zones are some of the most diverse, dynamic, and complex biophysical habitats on the terrestrial portion of the planet (Naiman and Decamps 1997).

The riparian vegetation also significantly impacts the associated aquatic system. These stream side "buffers" serve to mitigate impacts from activities in surrounding areas. Riparian vegetation serves to stabilize stream banks, maintaining channel integrity. They also reduce sedimentation while providing organic influx to the aquatic ecosystem. This material is primarily deciduous in nature, which is more readily decomposed. This influx of organics and the shading by the overhead canopy serve to regulate primary production in the aquatic system. Overhead canopy also serves to insulate streams and helps maintain desirable stream temperatures (Naiman and Decamps 1997).

Riparian habitats are in various states of quality and ecological stage in CSP. The lack of disturbance has led some sites to become decadent. The increased area of ponderosa pine and pine encroachment has led to decreased water running through the watershed and some creeks have dried up or become ephemeral in nature. These factors have led to a reduction in both the quantity and the quality of riparian habitat. Some cottonwood and green ash vegetation communities are late seral stage with little recruitment. Resource personnel have planted some trees along the Lame Johnny riparian zone to supplement low recruitment. Also, several roads follow creek courses and these riparian zones are heavily impacted by the physical presence of vehicle traffic. Visitation may also impact riparian zones without roadways. Visitor traffic is relatively heavy along some hiking and horseback trails without visitor accessible roads. This human use reduces the quality of the habitat for some species.

SYSTEM FUNCTION

Role of Fire or Lack of Fire in Current Watershed Productivity

Fire occurs rarely in the riparian zones of humid regions where most vegetation cannot withstand even mild fires but plays a significant role in drier regions such as the west (Agee 1993, Naiman and Decamps 1997). Following fire, halophytic shrubs recover faster than mesophytic trees (Busch 1995). Complex interactions among the variables hydrology, geomorphology, light, temperature, and fire influence the ecology, dynamics, and structure of riparian zones (Brinson 1990, Naiman and Decamps 1997). Hydrologic processes that may be affected by fire include: infiltration, soil moisture storage, overland flow, and erosion (Naiman and Decamps 1997).

Water quantity

Hydrologic cycles and water quantity have been modified in more densely forested watersheds, likely decreasing total streamflows, peak flows, and base flows (Ffolliott et al. 1989, Allen et al. 2002). However, large scale catastrophic fires can present some problems because the aftermath of such fires includes short-term amplification of erosion and flooding (Agee 1993, White 1996). Water yield increases because retention by litter and debris, and transpiration both decrease after a fire (Ffolliott et al. 1989). This effect (increased water yield) can be reduced as vegetation and litter return and increased evaporation from the soil surface compensates for reduced transpiration.

Increased accumulations of snow may occur following fires that remove tree cover which decreases interception of snow by the canopy (Ffolliott et al. 1989, Baker and Ffolliott. 2002). Thus, spring runoff may be increased. Although, as the size of the fire increases, snow accumulation may decrease due to wind scour (Haupt 1979).

Water quality

Fires can mobilize and transport materials such as sediments, but there have been few studies documenting the impacts of wildfires on nutrient loadings to surface waters (Wright 1976, McColl and Grigal 1977, Tiedemann et al. 1978, Schindler et al. 1980); none of these studies collected data during and immediately after the fire passed the area. Large quantities of particulates and volatile compounds may be released into the atmosphere during wildfires, and the potential impact of this material on nutrient loadings to surface waters would be overlooked by studies initiated after the fires were extinguished (Spencer and Hauer 1991). Fires can mobilize and discharge large amounts of phosphorus and nitrogen concentrations into streamwaters (Tiedemann et al. 1979, Spencer and Hauer 1991). Additional changes can include increases in bicarbonates, ammonium, and organic nitrogen (Chandler et al. 1983).

Conclusion

Although effects of fire on water resources vary widely, there are some common elements that are worthy of emphasis:

1. Fire increases sensitivity of the landscape to eroding forces and to reduced land stability. Erosion responses to fire are a function of: amount of protective cover removed; steepness of the slope; degree of soil moisture levels; climate; and speed of vegetation recovery.

2. Fire causes rapid mineralization and mobilization of nutrient elements such as phosphorous and nitrogen. However, studies indicate that these additional nutrients do not impair the quality of surface waters.

Current disruptions to hydrologic channel maintenance of Custer State Park streams

Of the 1,200 potential miles of trout streams in the Black Hills 100+ years ago, only approximately 375 miles remain. Several factors led to the loss of the majority of these potential trout streams. These factors include: water diversions, hydropower, road and railway construction, timber harvesting, mining, channelization, improper riparian management, and domestic uses. Most of these factors have impacted Custer State Park streams.

The 2 most impacted streams in CSP are Grace Coolidge Creek and French Creek. Grace Coolidge Creek has Center Lake dividing its upper reach, a relatively small feeder stream, from the lower reach which sustains higher flows. However, the lower reach has approximately 18 dam structures. These structures serve to restrict flow, flood the existing channel, and reduce peak flow events. Therefore, water force acting on the stream channel is limited. With the exception of the large lakes, other streams in CSP do not have these types of control structures.

One "structure" that has greatly impacted stream channels in CSP is the construction of numerous small rock "dams". These have been built by several individuals and groups over the years. These activities have slowed the water and allowed sediments to accumulate in the artificial pools. Under some circumstances these dams have led to additional bank erosion when water forces itself around the dam and erodes the unarmored bank. This leads to a wide, shallow stream channel.

The construction of roads has impacted several streams in CSP. Roads, both primary and secondary as well as logging and fire trails, are generally constructed in draw bottoms. This construction has led to channelization in some cases, but generally impacts streams by direct elimination of riparian vegetation and damage to stream banks at crossings.

The reduction of riparian vegetation caused by road building and apparent overgrazing in the past limits stream overhead cover. However, in the context of channel maintenance, the lack of runoff interception and controlled releases to streams limits control of peak flows and flooding. High water events exceed stream banks and this flooding causes additional bank erosion, further increasing channel width.

The lack of fire and adequate forest management in the past has led to a dramatic increase in the forest density. Thus causing reduced water flow in streams in many CSP watersheds. The lack of sufficient stream flows reduces any natural channel scouring except during peak flows, when bank channels are exceeded.

The sum of these influences has led to excessively broad, shallow channels. Insufficient flows are maintained for natural channel maintenance or development. High water events continue to erode banks, widening channels and exacerbating the problem. A stream improvement project was conducted on French Creek in the late 1990s to address problems with the stream channel. The project consisted of narrowing the channel by creating bank structures, reestablishing the stream in old narrow channel beds and the creation of plunge pools. This improved some reaches, but the existing rocky stream bed limited the ability to establish deep pools. Additionally, the reach from the Stockade dam to the park boundary near Blue Bell is heavily impacted on private and Forest Service land leading to degraded water quality upstream from improvements. The lowhead dams along Grace Coolidge Creek have been dredged to improve the fishery. These ponds continue to accumulate sediments that will need periodic removal.

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CULTURAL

Custer State Park has its origin through the efforts of Peter Norbeck. In the early part of the 20th Century, Norbeck consolidated state School lands dispersed through the Black Hills National Forest in a block east of Custer City. The original block was 8 miles wide and 12 miles north to south. Included within the area were some private inholdings. In 1912 this area became Custer State Forest. A year later game preserve status was added and elk and buffalo were stocked into the sanctuary over the next few years. To provide additional protection, Custer State Forest and Game Preserve became the state's first state park in 1919. Additional wildlife stocking into CSP included pronghorn and bighorn sheep between 1919 and 1922. During the 1920s-1930s in addition to managing the state park, the Custer State Park Board also managed federal resources exclusive of timber on areas north of CSP in Black Hills National Forest and south of CSP in the Recreation Demonstration area. The area managed by the Board was approximately 128,000 acres. Parts of the federal areas later became the Norbeck Wildlife Preserve or were added to Custer State Park and Wind Cave National Park. Inholdings were added to CSP and today all area within the park boundary is state park land. Today Custer State Park includes approximately 71,000 acres.

Four resort areas have been developed inside Custer State Park; Sylvan Lake, Legion Lake, Game Lodge and Blue Bell Lodge. These resorts are spread over CSP and each has a long and unique history. Two, Sylvan Lake and Legion Lake are associated with created reservoirs. These resort complexes are managed by private industry under a concession agreement. In addition, CSP has approximately 400 buildings including pump houses, administrative offices, a shop complex and Visitor Centers. Several buildings including the Peter Norbeck and Wildlife Station Visitor Centers, and the Mt Coolidge Fire Tower were constructed by the CCC and some buildings such as the Game Lodge and Peter Norbeck Visitor Center are on the National Historic Register. Additionally, a number of visitor park facilities have been developed including; Stockade N and S, Legion Lake, and Sylvan Lake, Center Lake, Grace Coolidge, Blue Bell Campgrounds; the French Creek Horse Camp, as well as several day-use areas Visitor Center and Game Lodge.

Some mining occurred in the late 1800s and early 1900s. Mines still on maps include the Copper Queen in the French Creek area and the Ivanhoe off the Needles Highway. Several exploratory pits can be found around the park, and a number of shallow horizontal shafts. The early history of CSP also included several homesteads from the late 1800's and small town called Bakerville near the SW corner of CSP. Additionally, an effort was made early to include some private cabins. These cabins soon reverted to long leases of cabins on state property due to expire in 2029.

Logging has a varied history in CSP with the first sale occurring in 1916. 45MMBF of timber were removed from CSP before the State Legislature limited the cut to 500,000 BF/year. This effectively ending commercial harvest until a timber management plan in 1950 again allowed for the removal of timber. For additional information on early activities in CSP see Sundstrom (1994).

The four lakes in CSP are all man-made. Sylvan Lake was built in the late 1800s, while the remaining lakes were built in the 1930s. A pipeline was constructed in the 1950s to transport French Creek water past the sinkholes and allow continued flows out the east side of the park. It was used for only a short time, but was never removed. Seven impoundments on Grace Coolidge Creek in the walk-in fishing area as well as six low head dams on lower Grace Coolidge Creek, were built during the 1930s.

The Game Lodge concession operates “Buffalo Safari Jeep Rides” which tour park visitors on wildlife and back country viewing excursions, notably to see bison. The concession uses roads open to the public as well as a number of administrative use roads. The Blue Bell Lodge concession also operates an evening chuck wagon cookout to Parker Canyon. Blue Bell also operates a horseback ride concession and pastures about 100 trail ride horses seasonally on a pasture south of the lodge.

Wildlife are enjoyed from both a non-consumptive (wildlife viewing) and a consumptive (seasonal sport hunting) basis. Interpretive/educational efforts are directed through the park’s Naturalist Program as well as through a number of interpretive sites throughout the park.

Geology

The majority of CSP occurs primarily on metamorphic and igneous type formations, both of Precambrian age. These formations include granites, pegmatites, quartzes, and schists. The granite outcrops such as the Cathedral Spires, Little Devils Tower, and the Needles all occur in the igneous formations around Sylvan Lake (Figures 33 - 35).

Along the eastern and southeastern edges of the park, a variety of formations are exposed as is typical of the fringes of the Black Hills uplift. Figures 34-36 display lithology, geologic age, and geologic units within CSP boundaries.

The exposed limestone formations along the eastern edge of CSP are important as potential cave areas and as areas of sinkholes for the streams flowing out of the park. These sinkholes supply the Madison aquifer. A significant cave has been discovered along the Grace Coolidge stream channel. This cave is unique in being formed by active water flows.

Archaeology

Based on records at the South Dakota State Archaeological Research Center, very little of CSP has been received professional archaeological survey (4,320 acres or 6%). Of 121 archaeological sites recorded, 60 are prehistoric. Eight of those 60 recorded prehistoric sites were lone artifacts that did not occur in the context of a larger site (isolates).

Small block surveys have taken place in forested terrain along Grace Coolidge Creek, Dry Creek, and Lame Johnny Creek, as well as between the north and south forks of Lame Johnny Creek.

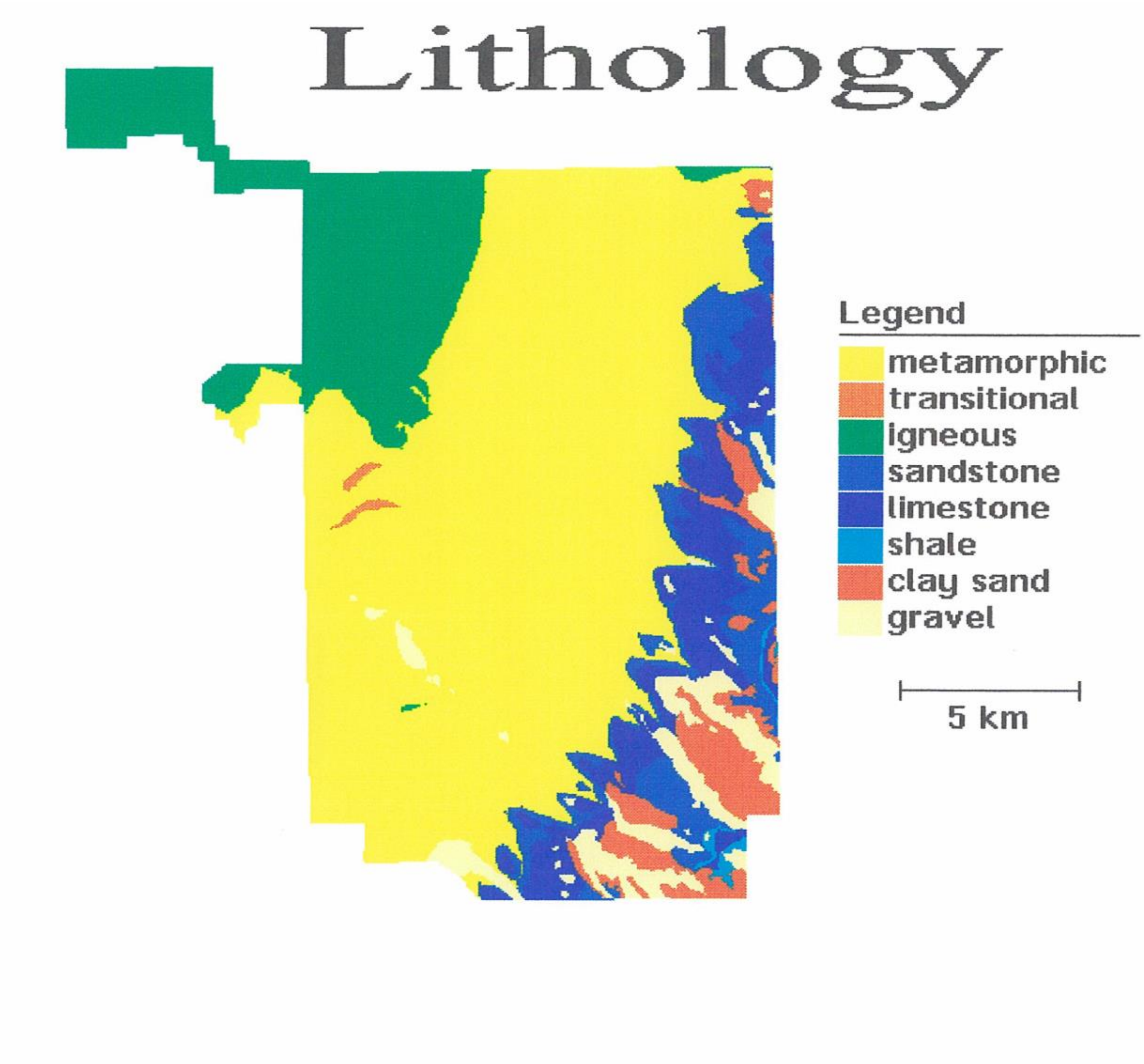

Figure 33. Lithology of Custer State Park.

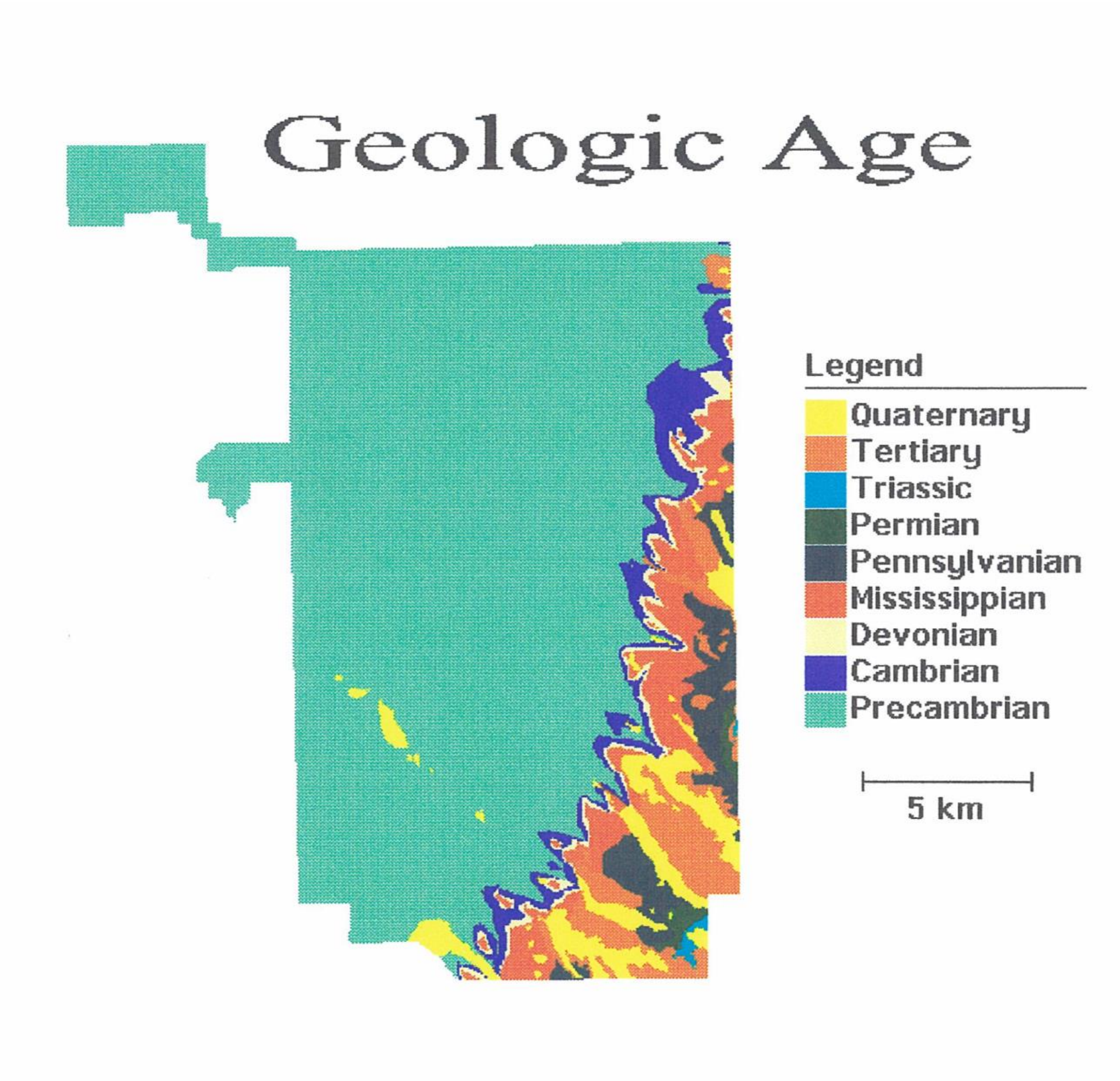

Figure 34. Geologic age of Custer State Park.

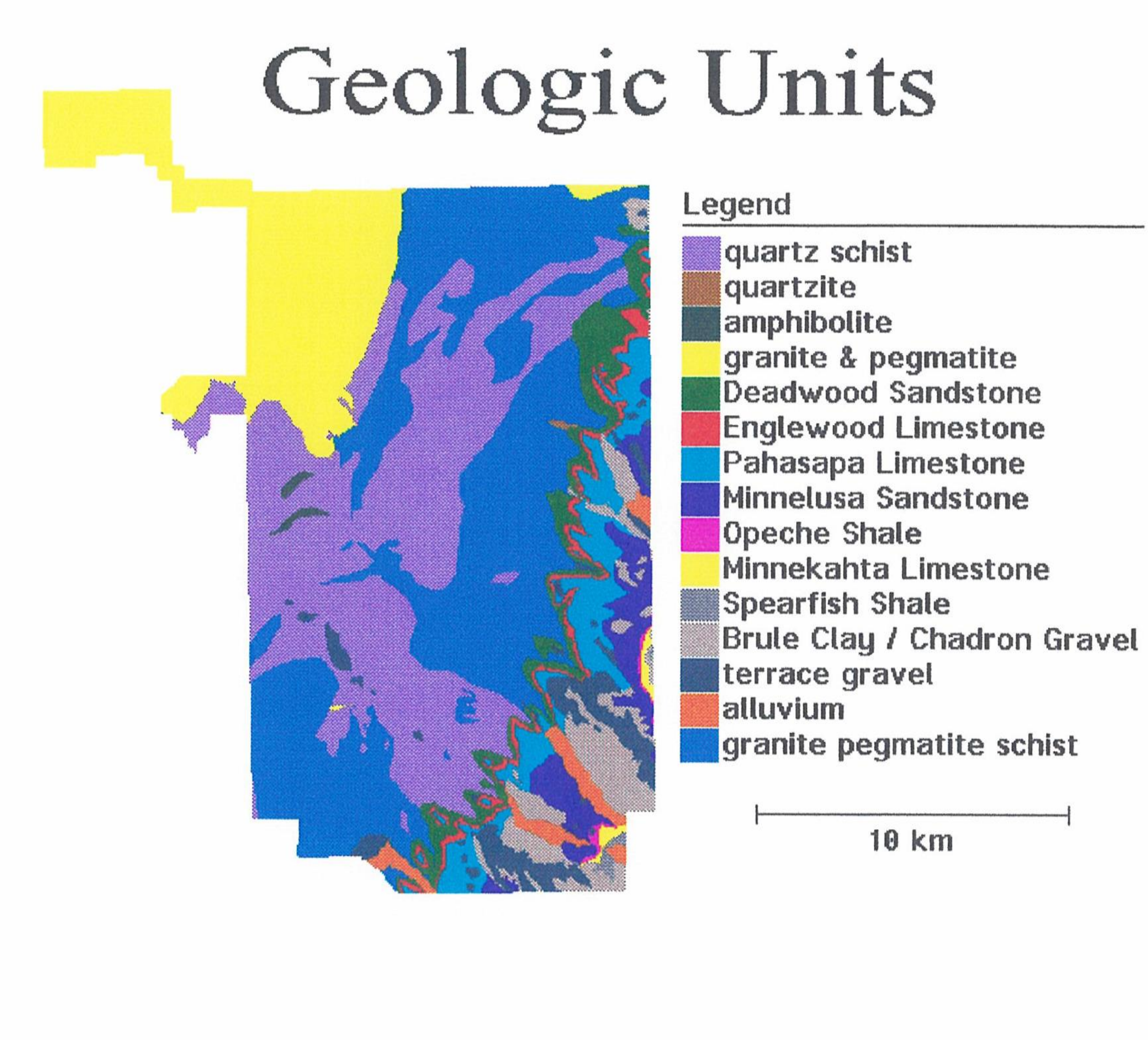

Figure 35. Geologic units within Custer State Park.

Linear surveys have generally followed existing highways, roads, and trails or have followed secondary drainages upstream from permanent streams into high, forested terrain.

A rock shelter cave was discovered in the sandstone ridge along Lame Johnny Creek. Test pits were excavated to determine the significance of the site. Numerous artifacts were unearthed and indications of multiple occupations. Artifacts and hearth dated from the lowest levels excavated show occupation 2,500 BP by the Avonlea culture. Indications are the time line may extend farther into the past. The significance of the site lies in the probability of documenting the transition from atlatl culture to bow-and-arrow. The site has been covered and further excavations have not occurred.

Roads

The park has developed a significant system of roads and trails. The current role of the Custer State Park road system is to provide for the movement of people and resources in and out of the park. The road system provides access for recreationists to reach trail heads, view wildlife, and to open water for boating and fishing. Roads also furnish access for resource management, fire protection, maintenance of park facilities and emergency services.

Road development originated from a number of activities and recreation, forest management and fire control needs have played a large role in determining the location and number of roads constructed. Over time some roads were incorporated into the US and state highway system. Other roads were developed for visitor services, were incorporated into the administrative access network or have been abandoned. Public access has been limited to roads that provide for recreational needs and the remaining roads are used for ongoing park management operations.

Custer State Park roads have been mapped using U. S. Geological Survey 7.5 minute quad maps, aerial photos and GPS units and incorporated in the Park's GIS system. A total of 492 miles of road exist in CSP. Roads have been divided into seven classes and a mileage for each class determined. Road classes were assigned based on type of road (hard surface or gravel), public access needs, park management requirements, fire control and emergency service needs (Table 29, Figure 36).

Sixty-four miles of asphalt roadways exist in CSP (class 1 and class 2). Class 1 roads are highways (US 16A and SD 87) and comprise 46 of the system miles (9%). These two-lane paved roads can handle relatively unrestricted traffic at moderate speeds. The wildlife loop road is 18 miles (4%) and is the only class 2 road. While also 2 lanes and paved, this road often has significant traffic congestion due to visitors and wildlife viewing. Class 3 roads branch from state highways and the wildlife loop road and are medium-standard roads (gravel surface). Class 3 roads comprise 41 miles (8%) and are open to the general public for access and wildlife viewing. They carry a mix of management and recreation traffic so are generally wide enough to allow vehicles meeting each other to pass. CSP numbered roads are usually stable enough for most traffic during the normal season of use; however, some may see seasonal closure to prevent damage.

Table 29. Custer State Park Road Classes.

CLASS	MILES	DESCRIPTION	MAINTENANCE	PUBLIC VEHICLE ACCESS
1	46	South Dakota Highways	Yes	Yes
2	18.0	Wildlife Loop Road	Yes	Yes
3	41	Custer State Park Named Roads	Yes	Yes
4	153	Resource Management Roads	Yes	No
5	142	Unmaintained Trails (accessible)	No	No
6	83	Unmaintained Trails (not accessible)	No	No
99	9	Other access open to public	Yes	Yes
total	492			

The small single lane resource management roads (class 4) are found near the end of the system and make up 153 miles (31%) of CSP roads. These are minimum-standard roads (native surface) and provide access for specific purposes such as resource management, maintenance of park facilities, fire control and emergency services into the back country. They allow limited passing and road conditions require that vehicles move slowly. Class 4 roads are closed to public vehicle access but are used by the public for hiking, horseback riding, hunting and other recreational uses. The surfaces of these roads may not be stable under all traffic or weather conditions. These roads are maintained for resource management and fire control access.

The remaining class 5 (142 miles, 29%) and class 6 (83 miles, 17%) roads are unmaintained and make up approximately 46% of the road system. They are at the end of the system and are often dead end roads. Some are passable, many are not. They are generally used for very specific purposes. No maintenance is provided to these roads other than to prevent serious erosion problems. In most cases they have begun to revert back to pre-trail conditions. As management activities take place a class 5 or 6 road may be up-graded to resource management road status. Class 5 and 6 roads are closed to the public for vehicle use but may be used for recreating.

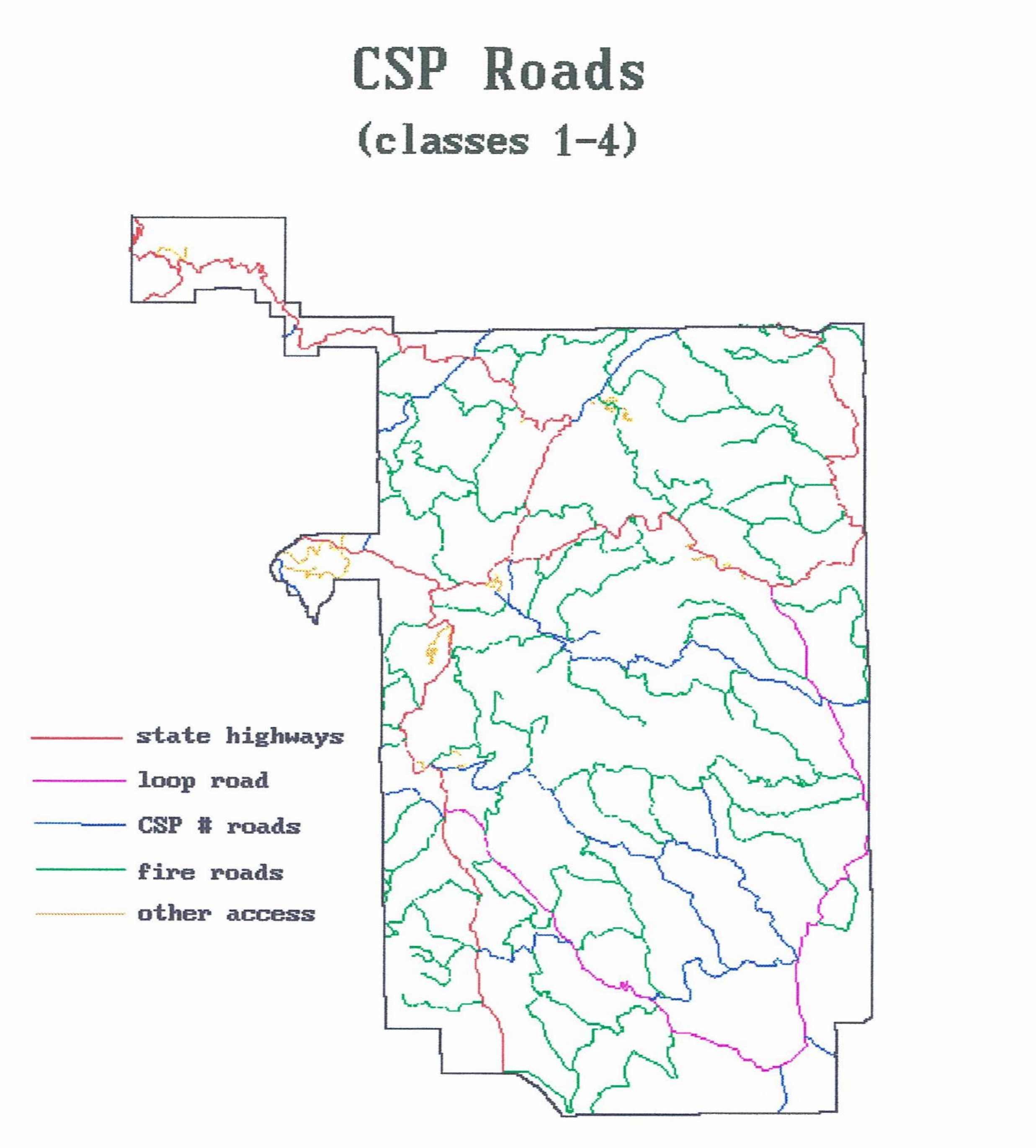

Figure 36. CSP roads by class.

Class 99 roads make up less than 2% of the road system. Class 99 roads are generally paved and open to the public for vehicle access to camp ground loops, lake shore roads and access to other park facilities.

Trails

Custer State Park offers recreational uses such as foot travel, horseback travel, and mountain bike travel on a number of trails. A total of 62 miles of trail are designated for use by foot or mountain bike (Table 30), by use of foot, mountain bike and horse (Table 31), or horse only (Table 32). However, all users may use all park trails and roads and backcountry. The only exceptions are horses are not permitted in the Sunday Gulch watershed in the Sylvan Lake area nor in the Walk-In Fishing area along Grace Coolidge Creek.

Table 30. Foot and mountain bike trails.

TRAIL	MILEAGE
Creekside	1.9
Lovers Leap	3.8
Walk-Fishing Area	2.4
Prairie	2.1
Sylvan Lakeshore	0.7
Badger Clark	0.6
Sunday Gulch #6	2.8
Harney Peak #9	1.7
Cathedral Spires #4	2.2
Legion Lake	1.1
Stockade Lake	1.5
TOTAL	20.8

Table 31. Foot, mountain bike and horse trails.

TRAIL	MILEAGE
Centennial-South boundary to Horse Camp	8.6
Centennial-Horse Camp to 16A Trailhead	5.0
16A Trailhead to North Boundary	7.7
TOTAL	21.3

Table 32. Horse trails; Off road portions.

TRAIL	MILEAGE
#1 French Creek-Caulkins Draw	5.2
#2 Robber's Roost	4.4
#3 Parker Canyon	3.4
#4 Mt.Coolidge,Sawmill Draw, Heddy Draw	6.9
TOTAL	19.9

FUTURE MANAGEMENT DIRECTION

RANGE MANAGEMENT ACTIVITY

GOALS

Improve rangeland condition on each Ecological Site listed in Table 1. Special emphasis will be placed on achieving a full component in hardwood communities native to the various Ecological Sites. The maintenance of a balance between consumptive demands of wildlife and the precipitation qualified rangeland production will be a continuing goal. There are five management strategies that will be employed in achieving range management goals.

Goals

1. Continue the use of deferments with the bison herd over the three unit capability.
2. Treat rangelands impacted with pine encroachment with logging and fire. Current forested areas will be reduced by up to 2,995 acres due to the removal of pine.
3. Control noxious weeds with herbicide and/or biocontrol agents. Noxious weeds in areas accessible with ATV or UTV will be treated with herbicide. Biological control will be primary means of back country noxious weed control. Currently there are three insects introduced to control Canada thistle, two insects introduced to control leafy spurge, two insects introduced to control spotted knapweed, one insect introduced to control yellow toadflax, and one insect introduced to control common mullein.
4. Balance forage demand against forage production. To accurately determine production 0.25 m^2 hoops will be clipped according to Keller (2011) to determine production. Clipping will occur every 10 years. Usable forage equals approximately 25% of the total forage production.
5. Monitor 3-6 Designated Monitoring Areas (DMA) so each DMA is read every 5 years to determine riparian health. The DMA is the location on the stream where all monitoring procedures described in this protocol occur (BLM 2011).

Deferments:

Deferments will continue to be an important range management tool to improve rangeland condition. Figure 1 shows rangeland condition ratings in 2008. The function of a deferment is to remove grazing pressure during the time desirable plants are actively growing and storing carbohydrate reserves. This time will vary depending on the grass species targeted. All ecological sites lack desired percentage of warm season grasses. Potential to do deferments on three different gazing units includes: East, Southwest, and R & D (Figure 37). The scheduling of deferments will also need to compliment handling requirements of the bison herd.

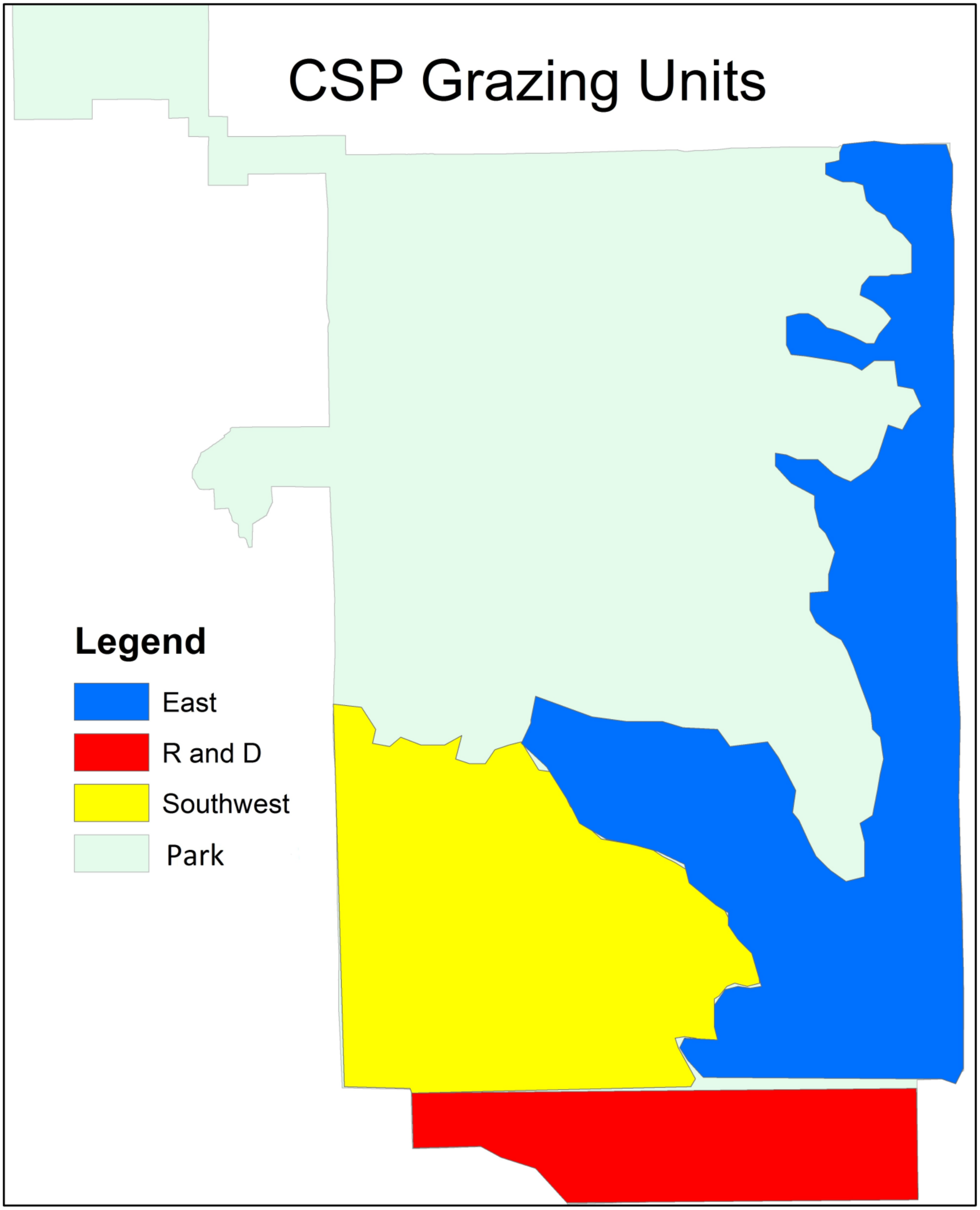

Figure 37. CSP Grazing Units

Pine Encroachment:

Pine encroachment has increased from 2200 acres in 1995 to 2995 acres in 2010 (Figure 2). Pine encroachment onto rangeland ecological sites will be removed via timber sales or with the use of prescribed fire. Pine encroachment not controlled by fire or timber sales can be controlled with the Fecon mastication head.

Noxious Weeds:

South Dakota statute requires landowners to control noxious weeds on their own land. CSP is bound by the same law as all other landowners.

A weed must possess the following characteristics to be declared noxious statewide:

- The weed is perennial.
- The weed has unique capability to spread rapidly.
- The weed is not controllable without special prevention or management.
- The weed is capable of decreasing the value of land.
- The weed is capable of materially reducing the production of crops or livestock.
- The weed is not native to South Dakota.

State Noxious weeds known to occur in CSP: Canada thistle (*Cirsium arvense*), and leafy spurge (*Euphorbia esula*).

Weeds may be designated locally noxious upon request from counties and approval from the South Dakota Weed and Pest Control Commission.

Locally noxious weeds have the following characteristics:

- Is biennial, perennial, or a pernicious annual.
- Is capable of spreading rapidly.
- Is not controllable without special preventative or management practices.
- Is capable of materially reducing production of crops and livestock.
- Is capable of decreasing the value of the land.

Locally noxious weeds in CSP: spotted knapweed (*Centaurea stoebe*), yellow toadflax (*Linaria vulgaris*), hound's tongue (*Cynoglossum officinale*), common mullein (*Verbascum thapsus*), St. Johnswort (*Hypericum perforatum*), black henbane (*Hyoscyamus niger*), absinth wormwood (*Artemisia absinthium*), and common burdock (*Arctum minus*).

Noxious weeds in areas accessible with ATV or UTV will be treated with herbicide. Herbicides used will vary by noxious weed(s) or the area being treated. Herbicides can also change depending on research and products available. Biological control will be primary means of back country noxious weed control. Currently there are three insects introduced to control Canada thistle they are stem mining weevil (*Hadroplontus litura*), stem gall fly (*Urophora cardui*), and seed eating weevil (*Larinus planus*). Three insects introduced to control leafy spurge are spurge stem and crown mining weevil (*Oberea erythrocephala*), spurge gall tip midge (*Spurgia esulae*) and root mining weevil (*Aphthona* species mix). Two insects introduced to control spotted knapweed are seed head weevil (*Larinus obtusus*), and root boring weevil (*Cyphocleonus achates*). One insect introduced to control yellow toadflax, stem boring weevil (*Mecinus janthinus*). One insect introduced to control common mullein, seed eating weevil (*Gymnetron tetrum*).

Figures 38-43 show the location of these insectary attempts. Monitoring the success of these sites need to occur at 3 to 5 year intervals. Average release site requires 5 years before a decline in the noxious weed occurs (Mark Hendrix personal observation). The acquisition of additional biocontrol agents will depend on need. Once successful insectaries are established in CSP bioagents will be collected and distributed as needed.

Balance Forage Demand:

Available forage biomass is the main determinant of stocking rates and carrying capacity estimates for domesticated and wild herbivores, and is a function of both abiotic (e.g., precipitation, temperature, elevation) and biotic (e.g., organic matter, canopy cover, grazing history) factors (Wight and Hanks 1981, Wight et al. 1984, Milchunas et al. 1994, Keller 2011).

Managers must also predict forage production for soil types that are not included in the rangeland and woodland ecological sites in the NRCS production tables. For example, the woodland site steep rocky side slope makes up 22% of the park, yet NRCS estimates do not provide data on forage production for this site because the slopes are steeper than what domestic cattle typically graze. Wild ungulates, however, utilize steeper slopes than domestic livestock (Stewart et al. 2002), managers must make gross estimates of forage production on these steeper sites from available data for production on rocky side slope (Keller 2011).

There are 12 rangeland and woodland grazable ecological sites in CSP (Figure 44): rocky side slope (226.80 km^2; 46.1% of CSP), stony hills (52.00 km^2; 10.6%), overflow (23.80 km^2; 4.8%), loamy (14.90 km^2; 3.0%), cool slope (12.10 km^2; 2.5%), warm slope (12.10 km^2; 2.5%), shallow ridge (8.10 km^2; 1.6%), clayey (7.40 km^2; 1.5%), shallow (7.20 km^2; 1.4%), savannah (5.50 km^2; 1.1%), silty footslope (0.90 km^2; 0.2%), and thin upland (0.20 km^2; <0.1%). Park managers created 3 woodland grazable sites that were not included in NRCS production tables due to the steepness of slope: steep rocky side slope (107.10 km^2; 21.7% of CSP), steep cool slope (0.23 km^2; 0.5%), and steep warm slope (12.00 km^2; 2.4%) (Keller 2011). Natural Resource Conservation Service (NRCS) provides descriptions of rangeland and woodland ecological sites.

Woodland understory communities in CSP are dominated by Kentucky bluegrass (*Poa pratensis*), poverty oatgrass (*Danthonia spicata*), sedges (*Carex* spp.), bearberry (*Arctostaphylos uva-ursi*), wild raspberry (*Rubus ideaus*), and western snowberry (*Symphoicarpus occidentalis*); (Custer State Park, unpublished data).

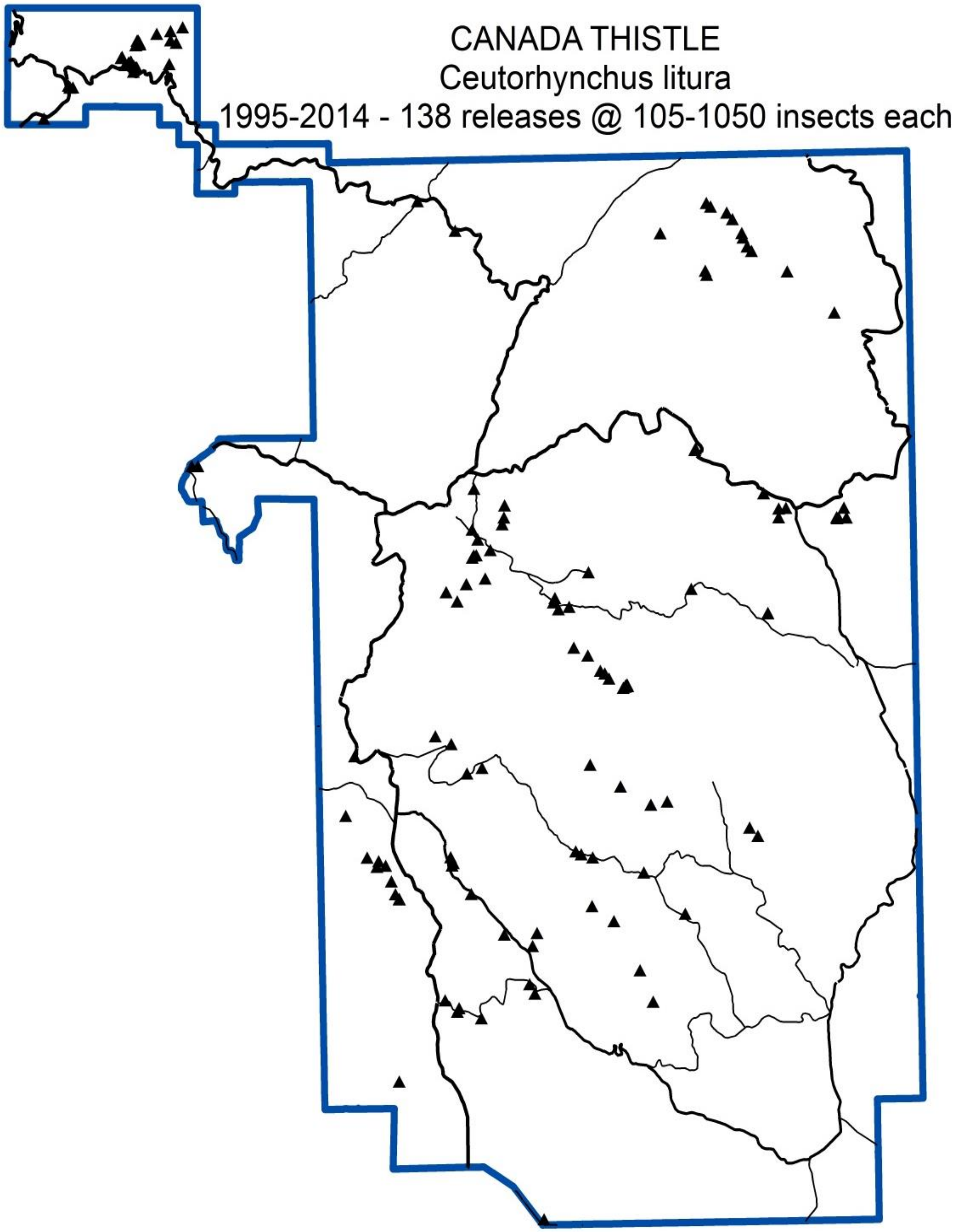

Figure 38. Ceutorhynchus litura release locations.

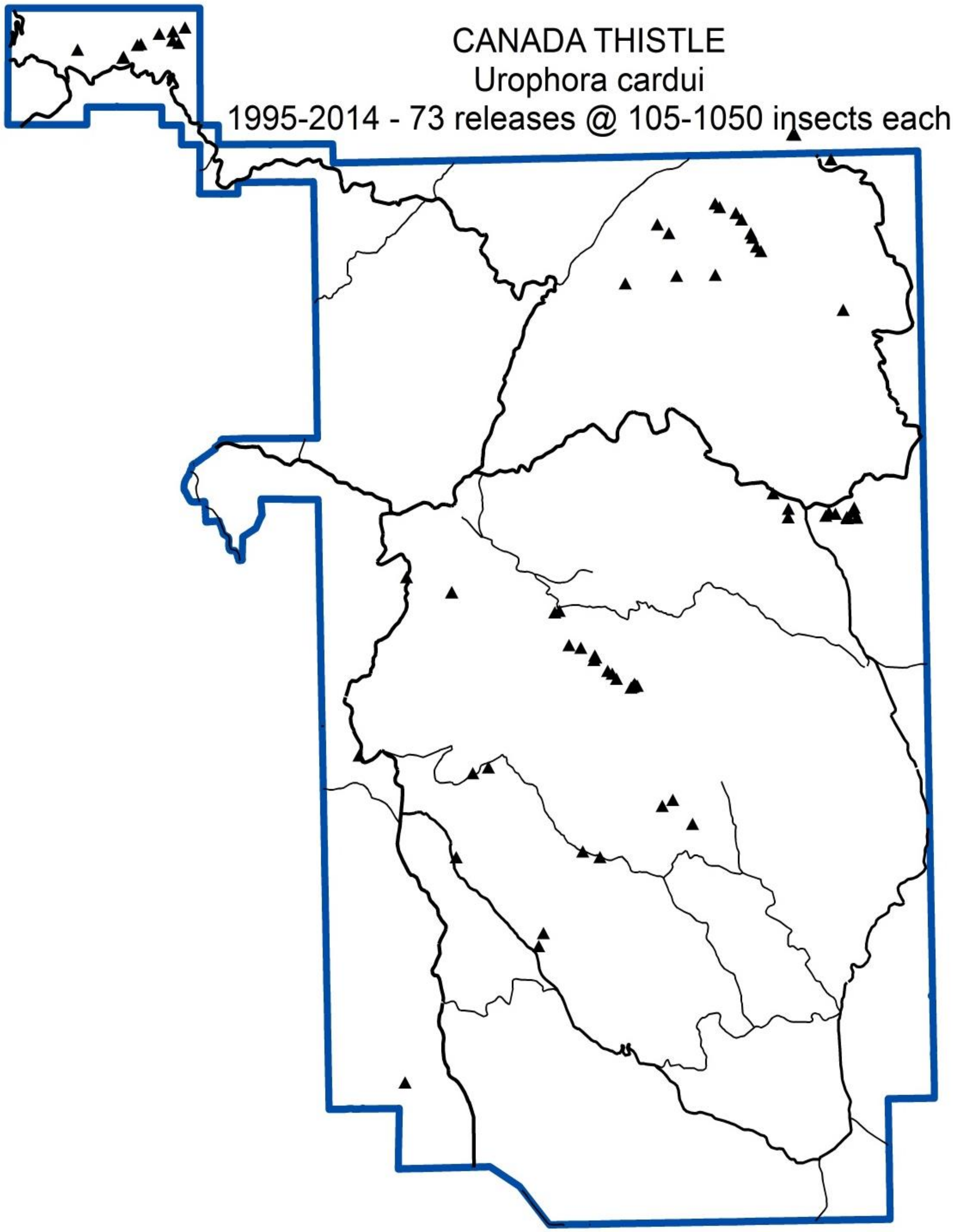

Figure 39. Urophora cardui release locations.

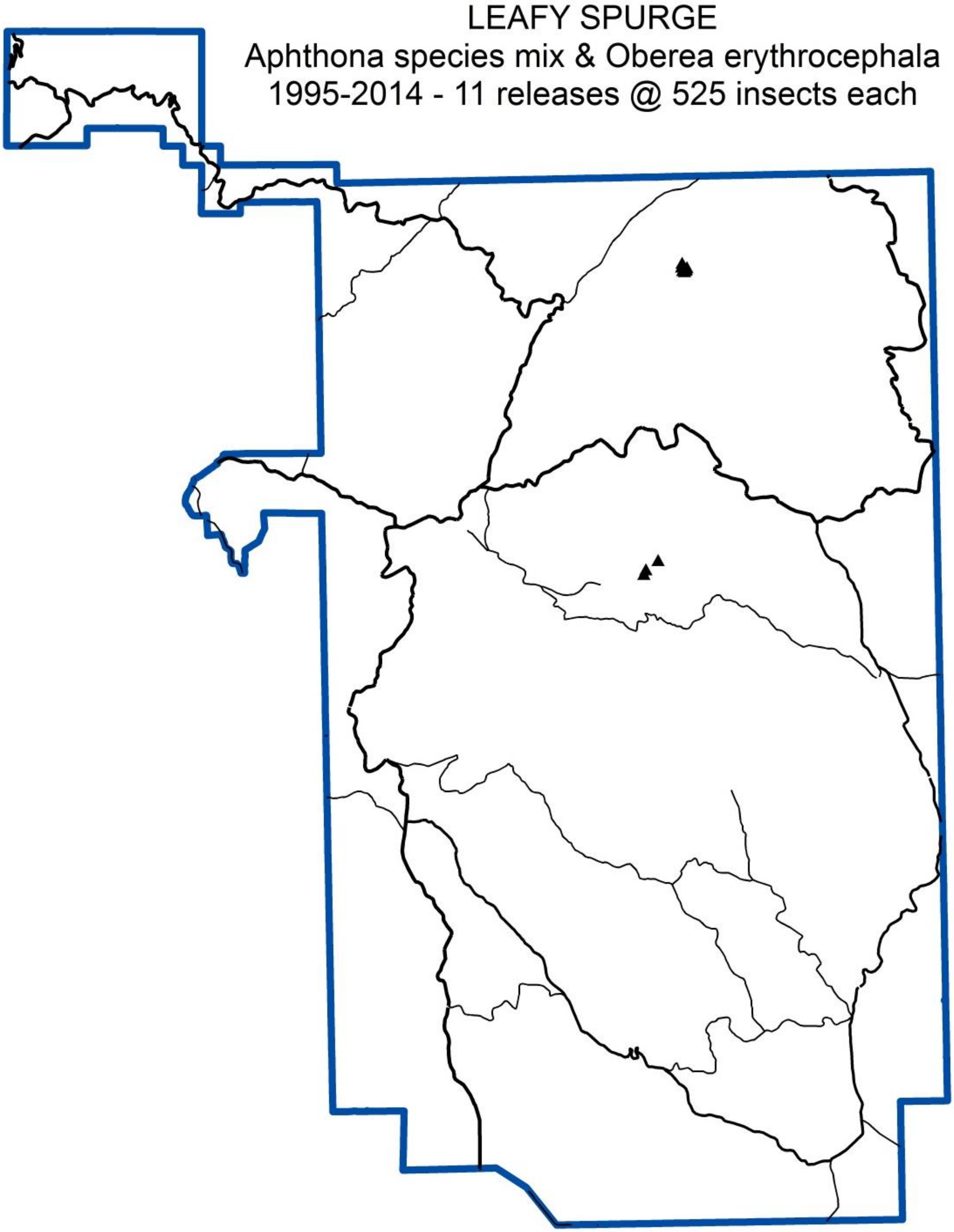

Figure 40. Aphthona species mix and Oberea erythrocephala release locations.

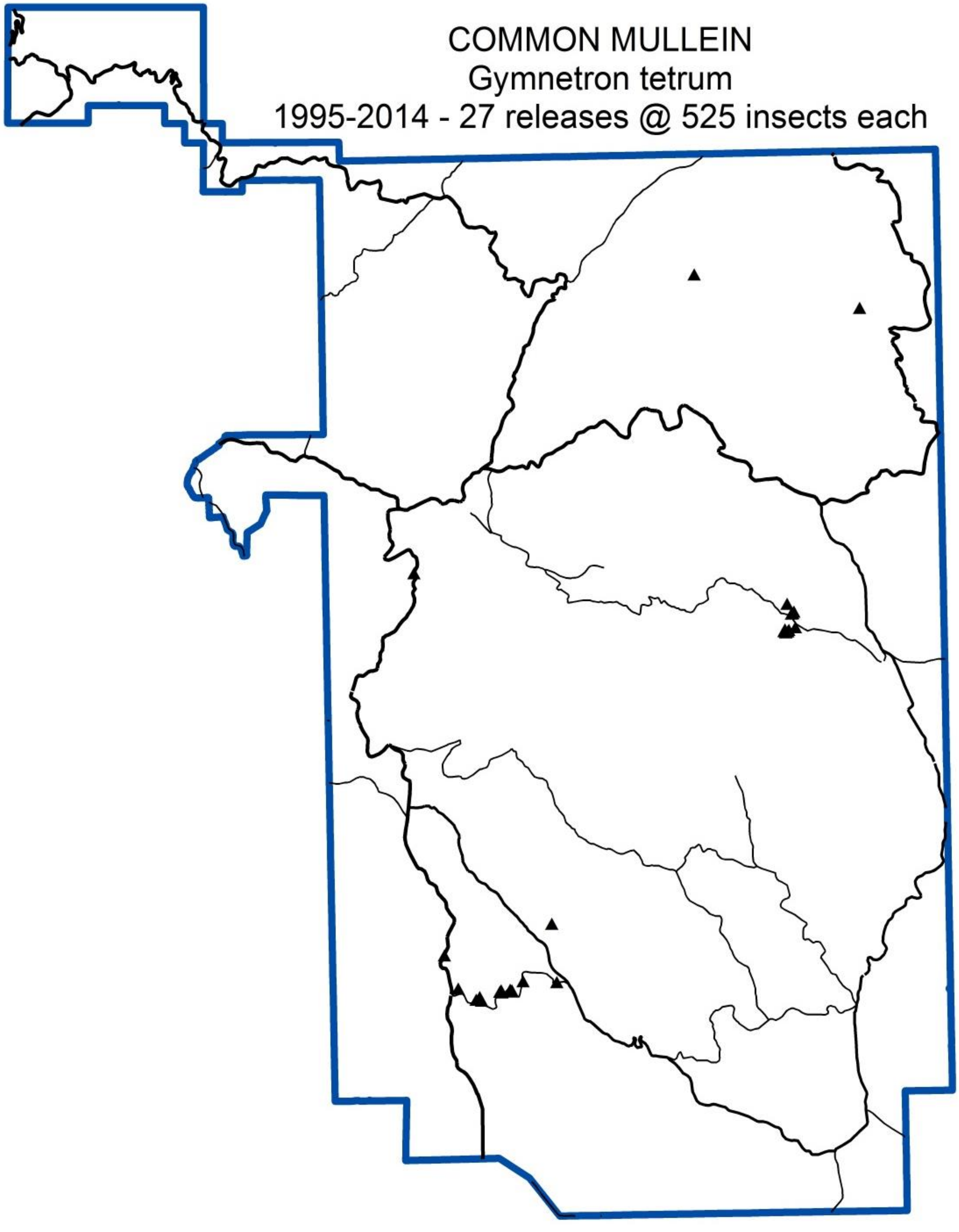

Figure 41. Gymnetron tetrum release locations.

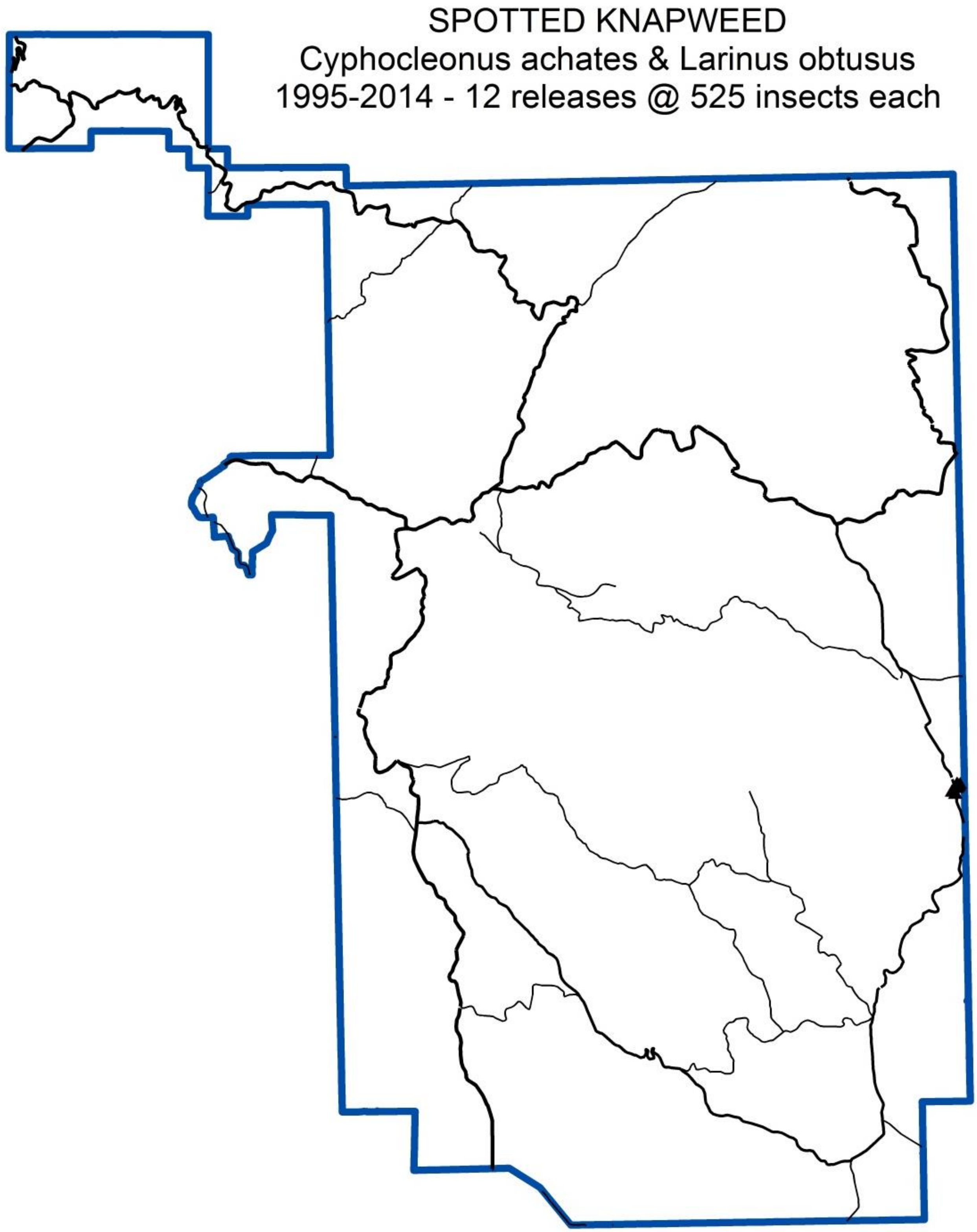

Figure 42. Cypaocleonus achates & Larinus obtusus release locations.

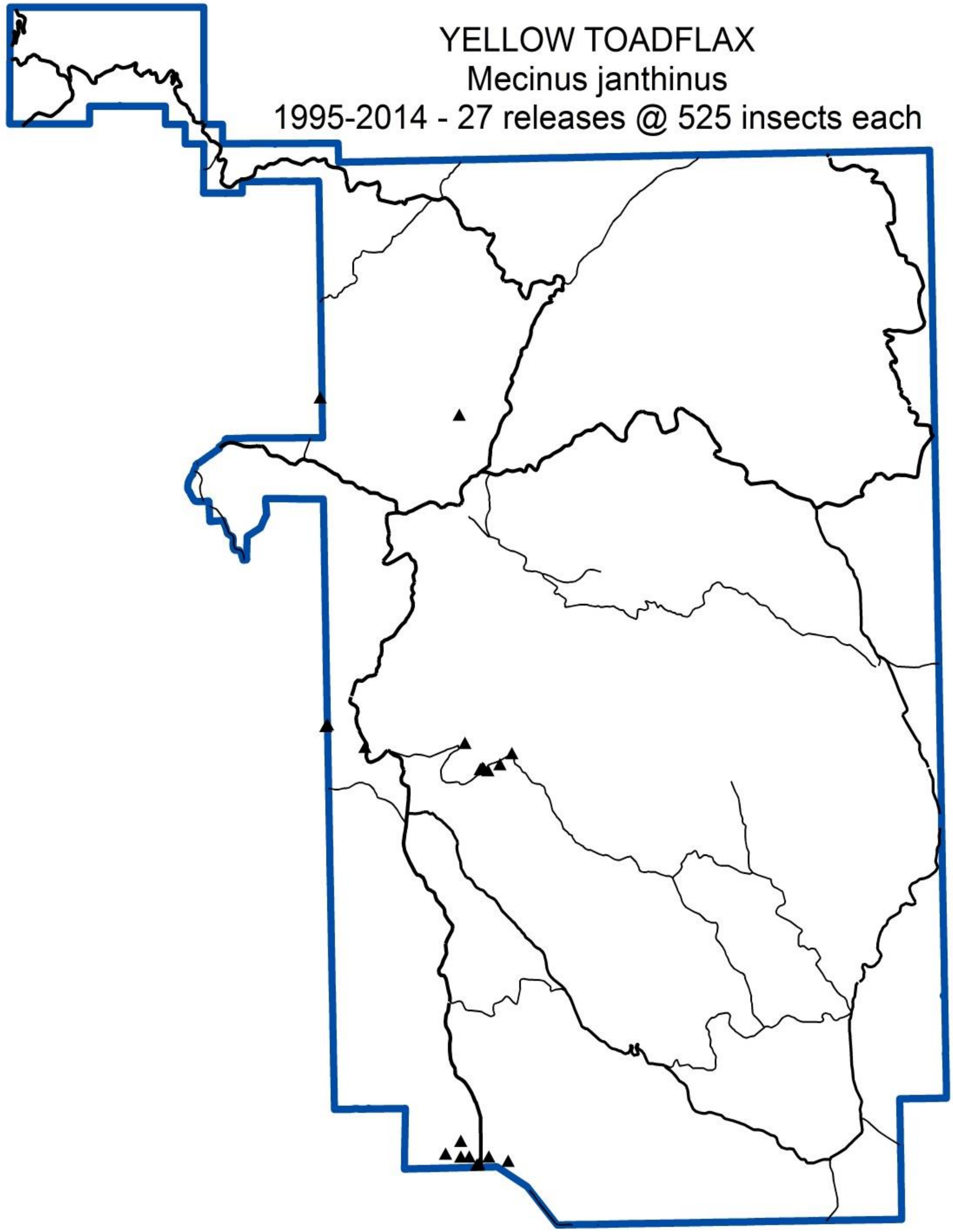

Figure 43. Mecinus janthinus release locations.

Rangelands are dominated by Kentucky bluegrass, big bluestem (*Andropogen gerardi*), little bluestem (*Schizachyrium scoparium*), western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), and sideoats grama (*Bouteloua curtipendula*). Common shrub species include leadplant (*Amorpha canscens*), western snowberry, wild raspberry, and wild rose (*Rosa* spp.); (Custer State Park, unpublished data).

<u>Sampling</u>

Clipping and Weighing

Clipping and weighing technique was used to estimate forage production throughout CSP (Keller 2011). This technique is generally considered the most accurate technique for biomass estimation (Higgins et al. 1994, Olenicki and Irby 2005). We stratified our sampling based on rangeland and woodland ecological sites (Figure 44). An ecological site is a “distinctive kind of land with specific physical characteristics (climate, soil, topography) that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation” (NRCS 2003). Generally, soil units that produce similar plant communities are grouped into ecological sites or woodland ecological sites when forest is the present or potential land use (NRCS 2003).

Grazing-exclusion cages that were 4ft wide by 4ft tall, constructed of circular welded wire fencing panels, were placed at each sampling site to prevent the removal of biomass by grazing ungulates. Studies of forage production in the northern mixed-grass prairie report that peak standing biomass occurs between early June and mid-July (Heitschmidt et al. 1995). It is important to vary the area and ecological sites we visited day-to-day so that all sampling sites of one ecological site were not clipped early in the sampling period, to avoid biasing biomass estimates (Keller 2011).

A 0.25 m^2 plot was clipped of all vegetation within each cage (Figure 45). We separated plants by species during clipping to determine species-specific production at each site. After clipping, we moved the grazing-exclusion cage adjacent to the clipped site to avoid the effects of clipping on the forage production estimate for the next field season. We moved the cage approximately 4ft, in a different direction each field season so our browse measurement plots did not overlap among seasons. We dried clippings in an oven at 90° Celsius for 48 hours and weighed each species to the nearest 0.1 g (Keller 2011).

Shrub production

At each clipping site, we also clipped any new twig or leaf growth on any shrub species (Larson and Johnson 1999) occurring within a 25 m^2 or 6.25 m^2 plot placed around each cage (Figure 45). A larger plot is needed to estimate browse biomass since browse production occurs at a larger scale than understory herbage production (Higgins et al. 1994). We clipped all shrub and tree browse within 1.83 m of the ground. In sites that contained very dense, uniformly distributed browse species (i.e., grassland sites with uniform low-growing rose and leadplant patches) we used a 6.25 m^2 sampling area. At all other sites we used 25 m^2. We alternated the position of the browse plot each field season (see above), so overlap did not occur among field seasons.

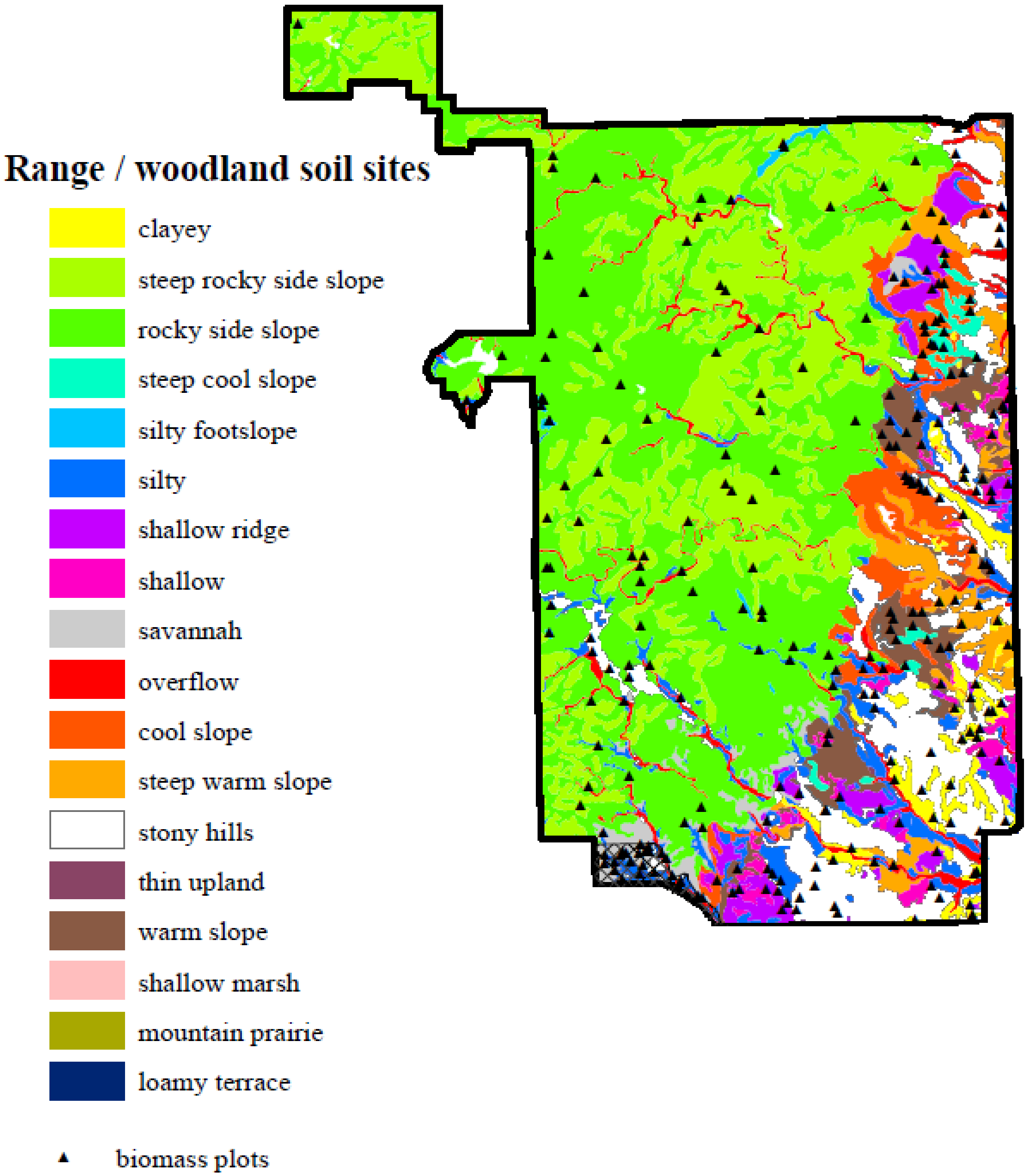

Figure 44. Rangeland and Woodland ecological site locations for biomass sampling.

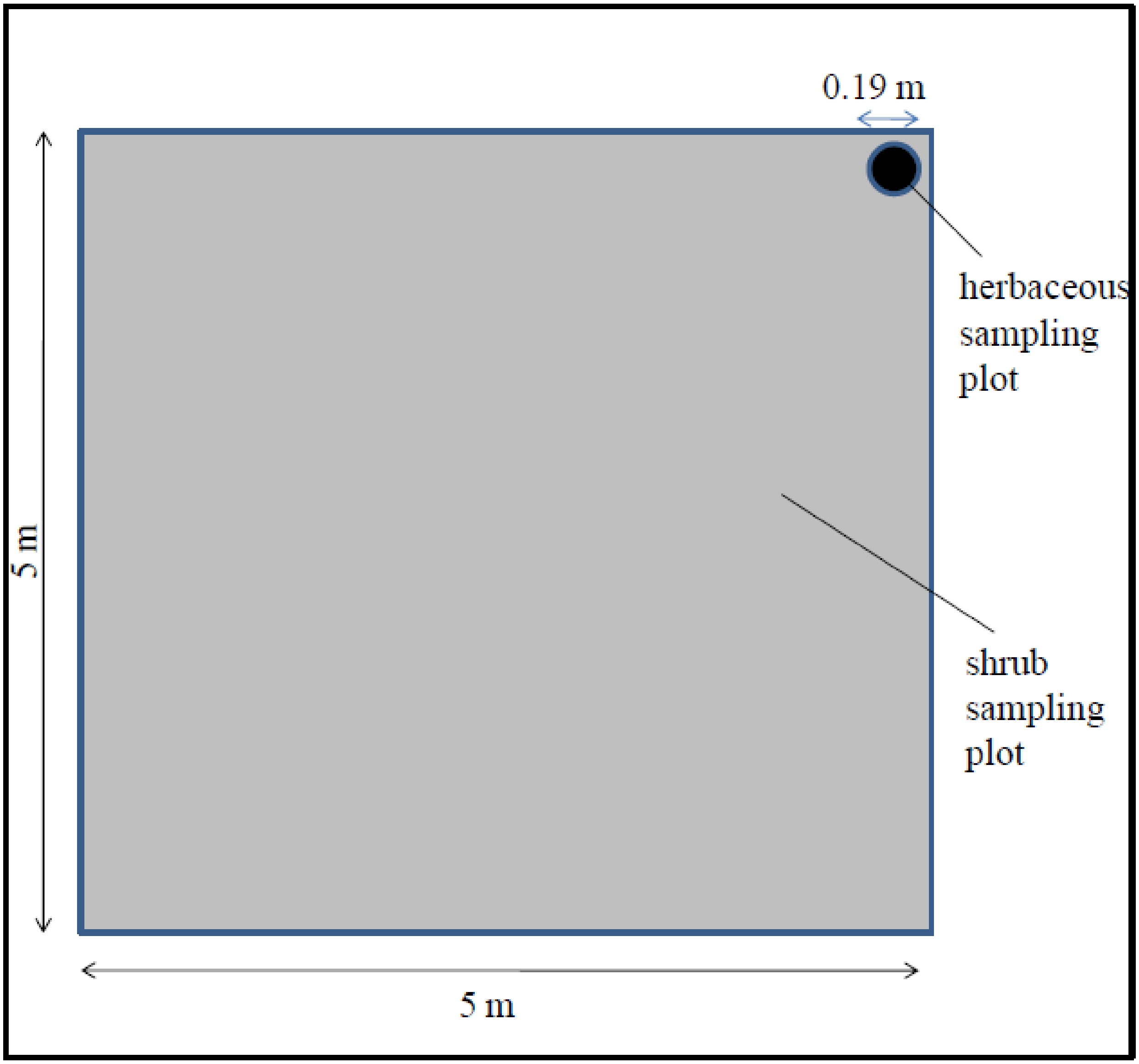

Figure 45. Location of shrub sampling plot in relation to herbaceous sampling plot.

We separated leaves and twigs for weighing. We dried browse biomass in an oven at 90°Celsius for 48 hours and recorded the weight to the nearest 0.1 g. We used a double-sampling procedure to improve sampling efficiency of shrub production. In 2005, 2006 and 2008 a percent coverage ocular estimate of each browse species was made before the plot was clipped. Although we used the larger sampling plot specifically for shrub production, we also clipped any shrub or woody species present in the smaller herbaceous plot (Keller 2011).

The forage species composition in CSP indicates that native, warm-season grasses such as big bluestem and little bluestem may be decreasing as Kentucky bluegrass, western wheatgrass, sedges and forbs increase in CSP, despite climate conditions that favor warm-season grass production. Spring droughts in the northern mixed-grass prairie typically result in a shift from cool-season to warm-season grass production (Heitschmidt et al. 2005). Although spring precipitation was below average in CSP from 2004–2007, cool-season grasses, particularly western wheatgrass and Kentucky bluegrass, dominated most rangeland and woodland ecological sites. Dominance by these cool-season grasses is considered undesirable for some ecological sites, even though both grasses are utilized by grazing animals (Larson and Johnson 1999). Managers may consider management actions that increase warm-season production, such as a reduction of stocking rates or spring burning (Herbel and Anderson 1959, Hover and Bragg 1981, Gillen et al. 1987, Vinton et al. 1993) given that many of the ecological sites were dominated by plant species considered to be indicative of heavy grazing, and forb and shrub cover in many ecological sites was higher than expected by NRCS estimates.

Stream Monitoring:

Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation will be used to inventory the 13 watersheds either completely or partially within the park. Goal is for each of the 13 watersheds in CSP to be dominated by late seral plants, a Greenline Ecological Status Rating of “late”. Two enclosures along riparian areas provide insight to potential riparian vegetative development in the park. Each year 3-6 DMAs need to be sampled. All DMA areas need to be resampled every 5 years.

The MIM protocol is designed to be objective, efficient, and effective for monitoring streambanks, stream channels, and streamside riparian vegetation. Indicators and procedures in this protocol were selected and developed primarily to determine and monitor impacts of livestock and other large herbivores on wadable streams (usually less than 10 m wide). The MIM protocol integrates annual grazing use and long-term trend indicators allowing for evaluation of wildlife grazing management. Because MIM protocol includes procedures for documenting stream condition and trend, users will also find that the long-term indicators described in this protocol are useful for monitoring changes that occur on the streambank and in the channel as a result of management activities other than grazing. The MIM protocol was developed and tested on relatively low-gradient (less than 4 percent), perennial snowmelt-dominated and spring-fed streams in the Western United States and is most applicable to those systems for stabilizing physical stream processes and functions that influence stream bank stability and channel geometry (BLM 2011).

The MIM protocol combines observations of up to 10 indicators along the same stream reach into one protocol, using mostly simple adaptations of existing procedures. Location of monitoring sites is a critical component for obtaining useful monitoring data; the MIM protocol addresses stratifying riparian vegetation complexes and stream segments and locating designated monitoring areas (DMAs). The DMA is the location on the stream where all monitoring procedures described in this protocol occur.

This protocol includes procedures for monitoring 10 indicators. Three indicators provide data for which short-term wildlife use information can be derived:

1. Stubble height

2. Streambank alteration
3. Woody species use

Short-term indicators provide information necessary to help determine whether the current season's wildlife grazing is meeting grazing use criteria. They can be used as early warning indicators that current grazing impacts may prevent the achievement of management objectives and can also be used to help explain changes in riparian vegetation and channel conditions over time.

Seven indicators provide data from which long-term resource condition information can be derived.

1. Greenline composition
2. Woody species height class
3. Streambank stability and cover
4. Woody species age class
5. Greenline-to-greenline width
6. Substrate
7. Residual pool depth and pool frequency

Long-term indicators provide data to assess the current condition and trend of streambanks, channels, and streamside vegetation. They help determine if grazing management strategies and other land management actions are making progress toward achieving the long-term goals and objectives for streamside riparian vegetation and aquatic resources.

In addition to providing procedures for monitoring the 10 indicators described above, the MIM protocol suggests establishing permanent photo points. Photo points provide visual records of long-term streambank and riparian vegetation condition and trend.

There are three types of DMAs:
Representative DMA – A monitoring site in a riparian complex that is representative of a larger area. Representative DMAs should be located within a single riparian complex. When more than one riparian complex occurs in a management unit, the DMA should be placed in the complex that is most sensitive to management influence. The premise is that if the DMA is placed in the most sensitive complex and that complex is being monitored and managed to achieve desired conditions, then other less sensitive complexes will also be managed appropriately.

Critical DMA – A reach that is not representative of a larger area but is important enough that specific information is needed at that particular site. Critical DMAs are monitored for highly localized purposes and to address site-specific questions. Extrapolating data from a critical DMA to a larger area may not be appropriate.

Reference DMA – A reach chosen to obtain reference data useful for identifying potential condition and establishing initial desired condition objectives for a similar riparian complex. A common example is a grazing exclosure where large herbivore access to the stream is restricted. Reference DMAs meet many of the same criteria as representative DMAs.

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BISON MANAGEMENT IN CUSTER STATE PARK

The bison herd will continue to be managed as a high visibility, high quality herd. Goals for bison management will be to continue to provide for public viewing, to manage the bison within the capacity of the range to support them, and to maintain a healthy, high quality herd. We will continue to manage for a more natural ecological functioning of the herd by allowing the continued development of the social structure and the development of family groups. This will have implications for annual bison management activities and strategies will change as the social system develops. Monitoring will continue on the genetic issues and CSP will begin working with Black Hills State University on a genetics management plan.

Several significant changes have occurred in the bison program since the previous plan was written. Most significant were the decisions to discontinue the forced weaning of all calves that remain in CSP and also allowing the cow herd to age past ten years of age. The previous plan placed a heavy emphasis on herd productivity to generate maximum revenue for Park operations. The bison herd is still an important revenue base for Park operations; however, with the merger between CSP and P&R that heavy economic emphasis is not as crucial today.

The herd had been capped at ten years of age for decades. The productive life span of a bison cow is upwards of 15-20 years. Selling the cows at age 10 was right in the middle of their productive life span. The decision was made in 2002 to allow the cow herd to age and to resume pregnancy testing cows and cull based on fertility instead of age. The age structure of the herd will be closely monitored. Some infertile cows will be allowed to remain in the herd. Studies have shown that there is social value to these older unproductive cows in the matriarchal social system of bison (Green et al. 1989).

Another emphasized practice in the previous plan was force weaning all calves by February each year. This weaning practice was breaking the mother/daughter bond leading to a herd social structure based on age cohorts instead of a natural matriarchal family order. The practice was reviewed and was discontinued in 2006. Allowing the cows to age and not weaning calves has led to a more natural herd structure. These two practices combined have been monitored through identifying a random group of cows in February of 2002. This group of varying age cows was randomly marked prior to working the herd. They were then tagged and attempts have been made each season prior to the annual round up to identify and then tag all female offspring from these cows. These female calves are then returned to the herd to “mother up” with the cows and remain in the herd as replacements. Observations on these tagged females have been recorded to see if, and how long the mother/daughter relationship carries. To date it appears that this family/social structure is establishing within the herd. The herd dynamic seems to be fracturing with smaller groups of animals distributed more widely over the Park. We will continue to closely monitor the progression of family/social restructuring of the herd in general.

The genetic conservation concerns of today’s bison population have significantly increased in the past several years. Much of this has been brought about due to the advancement of technology in genetic studies. The previous plan referenced the goal of conservation genetics. At that time, the technology was blood type based. Today it has advanced to DNA technology and continues to advance at a rapid rate. The previous genetic goal was based on conservation of genetic diversity. The concern today focuses on that diversity and the issue of cattle introgression in the bison genetics. In 2005 a genetic sampling of the entire herd was conducted. It was found that the herd has genetic introgression of both nuclear and mitochondrial sites. To date it has not been demonstrated that the introgression is expressed. We have and will continue to monitor the progression of the technology and advancement in conservation genetic planning.

The bison genome is being mapped, and the completion of that will allow the development of a genetic management plan. This plan will be developed with Dr. Shane Sarver’s genetics lab at Black Hills State University. CSP has genetic origins in at least 3 of the founding herds. Previous studies (Halbert et al. 2005, Schnabel, R. University of Missouri unpublished data) have demonstrated the CSP herd has a diverse genome. The goal of the genetic management effort will be the preservation of the diverse genetic base inherent in the CSP while addressing any issues with cattle introgression of genetic material. Initial plans will be to address the mtDNA introgression.

APPROACH FOR BALANCING PRODUCTION AND CONSUMPTION

1995 model

The Resource Management Plan 1995-2010 based forage production on a model utilizing rangeland/woodland ecological site condition and a weighted 2-year moving mean of average rainfall (see Current Landscape Description – production/allocation). Condition was estimated as good (75% potential) on all woodland sites. Condition was rated as excellent over most rangeland sites (98% potential). Twenty-five percent of projected production was allocated across primary grazers based on a predicted use pattern on rangeland sites, woodland sites and the ecotone between. The overlap was defined as the forested area considered as primary bison range by NRCS specialists in the 1980's and the range area within 300 ft of suitable elk cover (Table 5).

Under the 1995 model, conditions for rangeland production utilization in 2010 are illustrated in Table 6. Populations were below targets for bison, elk and bighorn. Significant underutilization even at 25% allocation occurred on both rangeland and woodland ecological sites. However, significant overestimation of production on rangeland ecological sites occurred in the 1995 model. When production numbers from Keller (2011) are used, all sites were still underutilized, but only slightly for range sites (Table 33).

Table 33. Actual modelled production/utilization based on measured production (Keller 2011) for CSP rangeland and woodland ecological sites using CSP population estimates for 2010. Production estimates in parenthesis are for modified 1995 soil potential (Walker et al. 1995) modified by 2-year moving mean of rainfall (111%) in 2010.

Spp and #	**R% - F%**	**Range**	**Forest**
Total available 20,137 (25,795) AUM	48% - 52% (59% - 41%)	9,750 (15,099)	10,388 (10,696)
Bison – 866 9,872 AUM	75% - 25%	7,404	2,468
Elk – 228 1,642 AUM	25% - 75%	411	1,231
Pronghorn – 302 725 AUM	80% - 20%	580	145
Mule deer – 200 480 AUM	60% - 40%	288	192
White-tail – 800 1920 AUM	15% - 85%	288	1,632
Bighorn – 25 60 AUM	10% - 90%	6	54
Current use = 14,706 - 73% (57%)		8,977 - 92% (59%)	5,722 – 55% (53%)

Research conducted from 2005 – 2009 to assess the forage production model and the resource selection and diet of the large ungulate assemblage in CSP produced an accurate estimate of production by rangeland and woodland ecological site (Keller 2011, Table 34). Production estimates from 1995 were overestimating the production on rangeland ecological sites (71% vs 98%) and underestimating production on woodland ecological sites (79% vs 75%).

Table 34. Production estimates in pounds for soils potential (NRCS 1988), adjusted for condition 1995 (CSP RMP 1995) and measured 2006-2009 (Keller 2011).

	Normal Potential soils	Estimated Potential 1995 (% normal)	Measured Production Potential (% normal)
Range	43,007,842	42,040,638 (98%)	30,418,656 (71%)
Forest	40,620,057	30,465,042 (75%)	32,411,360 (79%)
Total	83,627,899	72,505,680 (87%)	62,830,016 (75%)
AUM 25% total	26,804 AUM	23,239 AUM	20,137 AUM

The production model developed by Keller (2011) utilizes 3 climatic factors, total current-year spring (1 April – 30 June) precipitation, total previous-year spring precipitation, and the date of the last spring frost to estimate forage production over the current year. With all other variables in the model held constant the current year spring precipitation is the most influential climate variable. The modified NRCS model used by CSP provided estimates that were in general lower (~9.5%) than the Keller model. Both models outperform the unmodified NRCS model. The Keller model has better predictive ability in a majority of the rangeland and woodland ecological sites and requires less sampling. The CSP model tends to underestimate production in most situations, providing a more conservative estimate. However the climatic variables used in the CSP model are available by Oct. 1 of the year prior to the growing season allowing Fall adjustments to stocking levels. Climatic data for the Keller model is not available until July 1 of the current year negating any opportunity to adjust stocking levels for the current growing season.

Keller (2011) also investigated resource selection and diets of the ungulate assemblage in CSP. Together with the spatially explicit forage production model she was able to perform optimization modelling of ungulate forage interactions in CSP. This modelling indicated that some forages are being utilized above the 25% allocation, but most forages were not utilized at over 50% which is still considered a conservative utilization. Often a population(s) was constrained due to the overutilization of a single or few plant species in an area of overlap. Seasonal variations in resource selection and in diets lead to dramatic changes in carrying capacity. Carrying capacity for elk ranged for a low of 212 in Summer to a high of 699 in Spring with a 25% allowable allocation. Bison were constrained in the model to 500 and carrying capacity ranged from 500 to 659. The model demonstrates the interactions of species and the impacts of changing numbers on other wildlife populations as well as vegetation. The spatial component will allow managers to monitor specific areas and forage species.

Utilizing the data presented in Keller (2011) we will allocate forage based on her estimation of production for a normal year as the basis for population levels (Table 35). Utilization will be based on the daily intake rates referenced in Keller (2011, pgs 342-346) and herd compositions calculated for a stabile herd. Forage is divided into either rangeland or woodland ecological sites and utilization partitioned by species based on empirical data or subjective analysis of resource utilization patterns.

Table 35. Utilization/Allocation of rangeland and woodland forage for Custer State Park during a normal precipitation year with 25% forage production allocated to these grazers. Utilization based on daily intake rates and herd sex/age composition. Populations represent overwinter herd size after reductions.

	lbs dry forage	Range	Forest	Total
		30,418,656	32,411,360	62,830,016
	25% Allocation	7,604,664	8,102,840	15,707,504
	Species	Objective	lb/day equivalent	lbs consumed annual
	Bison	960	22.4	7,837,092
	Elk	800	12.3	3,590,647
	White-tail	800	3.1	918,740
	Mule deer	200	3.6	260,508
	Pronghorn	350	2.2	284,824
	Bighorn	200	5.2	381,257
	Spp and #	R% - F%	Range	Forest
Available	15,707,504	48%-52%	7,604,664	8,102,840
Bison	7,837,092	75%-25%	5,877,819	1,959,273
Elk	3,590,647	21%-79%	754,036	2,839,611
Pronghorn	918,740	80%-20%	734,992	183,748
Mule Deer	260,508	60%-40%	156,305	104,203
White-tail	284,824	15%-85%	42,724	242,100
Bighorn	381,257	10%-90%	38,126	343,131
Consumed	13,273,068		7,604,001	5,669,067
% used	85%		100%	70%

Forage production will be predicted using the modified NRCS model (2-year moving mean of precipitation) and populations will be adjusted to that percent normal population level. The forage production prediction will be checked using the Keller model. Bison target numbers will be based on the modified NRCS models current water year prediction. Annual target numbers for populations adjusted through fall hunting seasons will be based on the modified NRCS model and the empirical model from the year prior to season setting. This will lead to a 1 year lag in response to changing forage conditions for populations other than bison.

Production estimates indicate rangeland and woodland ecological sites are in good condition on average, producing from 70-80% of potential. Results of the forage allocation optimization will be used to target specific areas and species of concern for management action. Additional range management activities (see Range Management) will be utilized to move forage condition parkwide with a goal of achieving 90%+ potential production. Achieving 90% potential production would allow increased stocking of grazing species, with the biggest gain on rangelands allowing for an increase in species on rangeland and increased viewing opportunity (Table 36). Again, forage optimization modelling (Keller 2011) would be used to determine plant species and locations to monitor for overutilization.

Other Findings

- Production/condition by Ecological Site.
- Habitat use (Ecological Site, woodland site) and spatial overlap – what areas are going to see additional pressure.
- Dietary overlap – what plant species may be receiving additional pressure.

Conclusions

- Current research indicates rangelands and understories are producing 71-79% potential.
- Current ungulate grazers are below carrying capacity based on production but overutilizing ecological sites and areas of mutual selection. However, ungulate grazers are not utilizing over 35% of estimated production, still a conservative allocation level.
- Adjusted population targets will increase demand to supply, or slightly over on rangelands.

To Do

- Determine rangeland and understory condition by site.
- Improve rangeland and understory condition (fire, noxious weed control, plantings…).
- Use research results to determine areas of overutilization. Given the relatively high diversity of concentrate selectors in the park, monitoring of forage species that occur to a moderate extent in all 3 diets, 196.
- Including wild raspberry, wild rose, western snowberry, fringed sagewort, and cudweed sagewort, may be prudent to prevent overutilization.
- Adjust stocking targets to match production and utilize other tools to protect/enhance high use areas.
- Continue to monitor utilization and wildlife/bison use patterns.

Table 36. Utilization/Allocation of rangeland and woodland forage for Custer State Park with rangeland and woodland producing 90% potential forage. Production for a normal precipitation year with 25% forage production allocated to these grazers. Utilization based on daily intake rates and herd sex/age composition. Populations represent overwinter herd size after reductions.

	lbs dry forage	Range	Forest	Total
	Potential	43,007,842	40,620,057	83,627,899
	90% potential	38,707,058	36,558,051	75,265,109
	25% Allocation	9,676,764	9,139,513	18,816,277
	Species	Objective	lb/day equivalent	lbs consumed annual
	Bison	1,200	22.4	9,796,365
	Elk	900	12.3	4,039,478
	White-tail	800	3.1	918,740
	Mule deer	700	3.6	911,777
	Pronghorn	500	2.2	406,891
	Bighorn	250	5.2	476,571
	Spp and #	R% - F%	Range	Forest
Available	18,816,277	48%-52%	9,676,764	9,139,513
Bison	9,796,365	75%-25%	7,347,274	2,449,091
Elk	4,034,478	21%-79%	848,290	3,191,187
Pronghorn	918,740	80%-20%	734,992	183,748
Mule Deer	911,777	60%-40%	547,066	364,711
White-tail	406,891	15%-85%	61,034	345,857
Bighorn	476,571	10%-90%	47,657	428,914
Consumed	16,549,822		9,586,313	6,963,509
% used	88%		99%	76%

FOREST MANAGEMENT ACTIVITY

INTRODUCTION

The park's forest management activities, in conjunction with the park's fire management activities, will provide the vehicle of disturbance needed to maintain ecosystem health. When forestry tools are used in Custer State Park, they will be used to enhance productivity, diversity, and simulate the effects of natural disturbance, including fire.

Goals

The goal of forest management activities is to provide diverse and healthy conifer and hardwood vegetation communities. The goal of this process is to actively manage forests to maintain and improve system health, enhance ecosystem functions, and provide a variety of usable wood products. The use of prescribed fire will be integrated with traditional forest management treatments to accomplish forest management objectives (see Fire Management section).

Objectives (forest diversity):

1. Increase the use of uneven-aged silviculture practices in ponderosa pine stands;
2. Maintain current white spruce acreage and limit white spruce removal;
3. Increase the vigor and acreage of hardwood stands to 10% of the forest system;
4. Continue preservation efforts to protect and enhance limber pine;
5. Provide healthy forest communities along the travel/visual corridors to enhance viewing opportunities for the public;
6. Use natural disturbances such as insect and fire to enhance forest communities;
7. Enhance and expand existing forest meadows on non-fire disturbed sites;
8. Continue to exclude timber harvesting in the French Creek Natural Area and Walk In Fishing Area;

Objectives (system health and productivity):

1. Avoidance of abnormal or excessive soil erosion through adherence to "Best Management Practices for Water Quality Protection on Timber Harvest and Other Silvicultural Activities in South Dakota", and through an upgraded and maintained trails system in the park;
2. Prevention of noxious weed infestations;
3. Protect and enhance riparian systems;
4. Minimize damage to conifer forests by fire, insect, and disease;
5. Allow natural succession to occur on woodland soils in areas impacted by large wildfires.

Approaches and Desirable Outcomes

Diversity

Ponderosa pine forest

To maintain ecosystem health, the 36,641 acres of ponderosa pine (*Pinus ponderosa*) forest will be managed for biological diversity while producing multiple products.

To achieve the goals of diversity in the ponderosa pine forest, there must be diversity within stands and between stands. As areas are planned for management and prescriptions are written, each individual stand should be analyzed for its contribution to diversity in the forest. To increase the diversity within stands the use uneven-aged silvicultural treatments should increase and be expanded outside of the travel recreation zone. In general uneven-aged silvicultural treatments will be used in stands where multiple age classes already exist, in management units where wildlife objectives warrant the use of uneven-aged treatments, and where vertical diversity is lacking. Stands that receive uneven-aged treatments will be mapped and documented. It is likely that these stands will require multiple entries to obtain desired uneven-aged conditions.

Growing stock levels (GSL) should vary between and within stands to increase diversity in even-aged ponderosa pine stands. During non-commercial treatments, within stand densities will vary by leaving higher densities on the best growing sites, such as draw bottoms, moderate densities on average growing sites, such as mid-slope and upper slopes on north aspects, and lower densities on below average sites, such as ridge tops and areas with shallow soils. Depending on stand structure and productivity all possible stand densities should now be considered. Stands densities of 40 – 80 GSL should be considered for all intermediate treatments. Horizontal diversity will be enhanced through varied GSL as well as the retention of stands >120 GSL for wildlife cover and on inoperable lands. Diversity within stands can be further created by clearing pine hardwoods and clearcutting pine in small patches.

Diversity within the Custer State Park forest can also be enhanced through the use of a variety of logging methods and tools. During a timber sale in the park, conventional logging methods (chainsaws and log skidders) preclude areas over about 40% slope from treatment, and leaves limbs and tops (fuel) in the forest.

As units are planned for harvest, cable logging, horse logging, helicopter logging, and whole tree logging should be considered as alternative logging methods. Consideration of a variety of logging methods will enable access to a greater portion of the forest to manage for diversity.

The desirable outcome of these practices will be pine stands with a broad mix of densities, age and size classes, and vertical structures.

White spruce/P. pine mix

Pure white spruce (*Picea glauca*) and mixed spruce/pine stands are rare in CSP (1.4% of the total conifer forest). It should be noted that the majority of these stands contain a significant pine component. These stands provide excellent diversity within the generally pure ponderosa pine forest. Stands typed as white spruce/pine mix should have their present integrity preserved. The current stands should be maintained in the locations shown on Figure 46.

Diversity goals for the spruce/pine stands can be met by continuing with the practice of cutting minimal amounts of white spruce during a timber sale or non-commercial thinning. During treatment preparations, stocking levels for spruce/pine mixed stands should be set at a minimum of 80 GSL. Whenever possible, spruce should not be cut during a management entry. When pure spruce stands are encountered, the occasional pine and possibly some white spruce should be removed in small group selection cuts. The only exception to this would be the removal of all conifer vegetation to enhance a hardwood community where desirable.

Hardwoods

Deciduous trees classified as hardwoods are a rare vegetation community and offer unique opportunities for diversity in the park's forest. The bur oak (*Quercus macrocarpa*), quaking aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*) stands also provide a break in the pure ponderosa pine forest. The goal for hardwood forests in Custer State Park will be to achieve vigorous stands and trees on currently mapped hardwood stands and to have continued dominance of hardwoods on at least 10% of the forestland.

To increase the percentage of hardwoods on potential areas three practices should be used: 1. Remove competing pine from true hardwood sites. If there are 3-9 hardwood trees spaced 15 feet or less, all pine within a 10 foot radius of the group should be cut. If there are 10 + hardwoods spaced less than 15 feet, all pine within a 30 foot radius of the group should be cut. Hardwood trees should be ten feet tall to be considered established (unless aspen clonal suckering). Also, areas that have potential for hardwood expansion but hardwood stems do not exist should have pine trees removed (example – adjacent aspen clone or riparian areas). 2. Cut decadent hardwood trees to encourage sprouting. This practice should be done in conjunction with prescribed fire. 3. Plant native hardwoods on proper sites. 4. Use prescribed fire or mechanical methods to scarify soil to facilitate regeneration. 5. Consider the use of "hinging" where appropriate to expand hardwood stands and limit ungulate browsing. 6. Use exclosures where appropriate and when funding is available to prohibit ungulate browsing.

A desirable outcome of these practices is to increase the hardwood acreage to a minimum of 10% (5,000 acres) of the forestland. Currently there are 3,256 acres of mapped hardwoods.

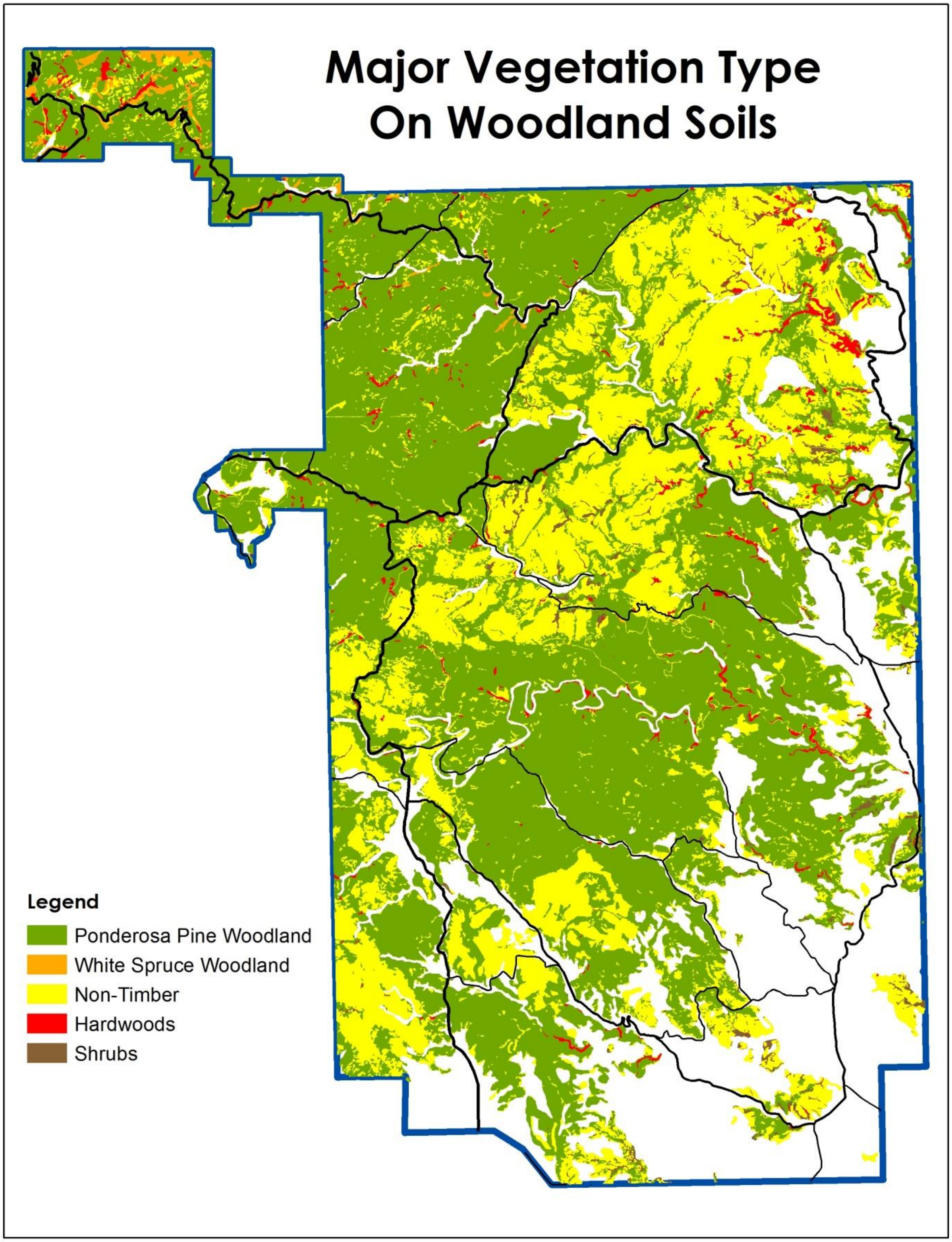

Figure 46. Major vegetation type on woodland soils.

Limber pine

Limber pine (*Pinus flexilis*) is located in the Sylvan Lake area of Custer State Park. This species ranges only as far east as the eastern slope of the Rocky Mountains except for this group of about 200 trees found in CSP and a limited number found on adjacent USFS lands. In the 1995 Resource Plan it was recommended that the rare limber pine stand in the Sylvan Lake area should be excluded from any logging activities. However, due to the recent mountain pine beetle epidemic this area was thinned and piled. No limber pine were cut and the residual density was left high enough to limit understory development, due to the potential for white pine blister rust to infect trees if the alternate host species *Ribes* established and expanded.

These trees and the area where they are found should be preserved. This area should continue to be monitored for mountain pine beetle and white pine blister rust. Also, CSP will continue to work with the South Dakota Division of Resource Conservation and Forestry in placing verbenone pouches on limber pine to repel attack by mountain pine beetle until such time as it is determined protection is no longer necessary. Other management options include planting limber as replacement trees in the event mountain pine beetle kills the majority of the overstory trees or to expand the acreage occupied by limber pine. Herbicides may also have to be used on *Ribes* plants if white pine blister rust is detected.

The desirable outcome of these practices is to maintain all live limber pine trees and ensure their survival in the future.

Visual Corridors

Visual corridors were formerly known as the Travel Recreation Zone (TRZ), a defined and mapped unit. Although the TRZ had defined boundaries it has always been physically managed on a "viewshed basis". Viewsheds and corridor viewsheds are a series of views along a road, trail, or waterway and are special places for visitors and residents (Bacon, 1995).

Areas within the visual corridors will be managed to provide for a healthy forest environment while utilizing each area's capability for diversity. When visual corridors are entered for management, their special characteristics should be identified. Characteristics such as scenic vistas, geologic formations, hardwood stands, meadows, and developed areas should be enhanced and protected.

Stands in the visual corridor will be managed primarily to maximize the opportunity of park visitors to view large old trees, and to create open park like stands that are aesthetically pleasing. In general healthy large trees will be maintained in the visual corridor. Stands in the visual corridor will be entered when the particular management unit surrounding it is entered (see Harvest Areas map). When stands are entered trees should be evaluated on an individual tree basis. Residual stocking will vary between stands, but it generally should not be greater than 80 GSL. Multiple age classes are desired in the visual corridor, not only to have a diverse canopy layer, but also to maintain younger trees to provide future large trees. It should be noted that visual corridors have been and should continue to be managed on a subjective, intensive "on the ground" basis. Every individual area treated should have its unique characteristics analyzed and managed for. Blind adherence to stocking targets would be a mistake in the visual corridors. Also, small openings (1/4 to 1/2 acre) should be made where a group of low vigor large trees can be removed to release younger trees. Exceptions to the above guidelines would be: during mountain pine beetle outbreaks, residual densities may need to be lower to prevent the loss of all the larger old trees in the visual corridor and the removal of all trees to release hardwoods and meadows or enhance a scenic view.

To accomplish the goals for the visual corridors, very selective timber harvesting and non-commercial thinning should be used. Individual tree marking in the corridors should be done by trained Custer State Park personnel. Unit boundaries, roads, skid trails, and advanced regeneration should all be considered carefully during timber sale planning so as to best accomplish the goals for these areas. In general, logging slash should be hand piled or whole tree harvesting techniques used to remove slash in the visual corridor. As the visual corridors are established on a viewshed basis they will be mapped as individual stands.

Natural Disturbances

Natural disturbances such as wildfires, insect, disease, and weather events can have drastic impacts on the forest system. Natural disturbances will be viewed as a way to enhance diversity across the forest. Every natural disturbance event will be evaluated and a management strategy determined following the event. Current or potential damages from a natural disturbance will be weighed with wildlife management goals to determine a course of action. However, damages from wildfires and mountain pine beetle will not be left un-checked or un-managed, but mitigation strategies will incorporate a wide variety of goals and objectives.

Large wildfires have the greatest possibility to alter the structure of the forest at a landscape scale. Large swaths of forest, both overstory and understory, can be killed in a very short time period. Large fires can also result in very open habitats with low possibility of future regeneration. Large fires will also likely result in a mosaic in the condition of surviving stands. Other results of large fires are large areas with numerous dead trees that will become snags and eventually course woody debris inputs. Given the benefits of snags and course woody debris to some wildlife species, the extent of salvage logging in these burn areas will be weighed with these benefits in mind.

Other than wildfires mountain pine beetle (*Dendroctonus ponderosae*) has the greatest potential to alter the structure of the forest at a large scale. Mountain pine beetles are insects that feed and carry out their life cycles in pine trees of the Black Hills. Their activities can kill large numbers of trees and are a natural process of thinning landscapes that have higher than normal carrying capacities of trees. Changes in landscapes from the current mountain pine beetle epidemic can benefit some wildlife species by enhancing their habitats. Dead trees also provide coarse woody debris inputs. In addition, canopy gaps are created across the forest leading to a patch work of tree size and density across the landscape. However, high beetle populations can create large areas of beetle-killed trees creating a more open habitat at a larger scale. Given the benefits of beetle-killed trees and the change in forest structure created by beetle-killed trees to some wildlife species, beetle mitigation strategies will be developed with these benefits in mind.

Mountain pine beetle strategy – Given the current mountain pine beetle epidemic in the Black Hills a park wide management and mitigation strategy was devised. The strategy is a multi-pronged approach and will require the use of a variety of practices working simultaneously to be effective.

Mitigation Goals and Priorities – The goal of mountain pine beetle mitigation efforts are 1) preserve large contiguous areas of live ponderosa pine trees, 2) minimize the number of dead and dying trees caused by mountain pine beetle in the visual corridor and visitor use areas, and 3) to protect a portion of the existing multistoried, mature ponderosa pine stands dominated by large diameter trees.

Management strategies include:

1. Prevention – The majority of our efforts to minimize damage to conifer forest by mountain pine beetle will focus on treating stands before they become infested in order to lower the risk of attack. Mountain pine beetle risk should be maintained where the rating of "High" includes 25% or less of the ponderosa pine forest. To this aim management units falling under treatment order 1, 2, 3, and 4 (see Harvest Areas 2010 – 2025) should occur as fast as possible. Also, as management units are entered, all inoperable ground should be evaluated for any possible method of treatment, as thinning is always preferred to direct suppression. Also, as each management unit is entered a portion of the operable ground outside of the visual corridor should focus on the retention of large old trees and stands in multi-storied condition.
2. Direct Suppression –The number of infested trees in CSP and the budget for the fiscal year can vary greatly. Since nearly 1/3 of the Park's forest is on inoperable ground (generally the area with greatest risk), treating every tree infested by beetles in these areas is generally very costly. Therefore, a mitigation plan for direct suppression will be developed on an annual basis. In order to meet parkwide diversity goals, the following 2 MPB treatment strategies which deal with the treatment of currently infested trees will be implemented:
    - I. 100% treatment of infested trees – This strategy should focus in and around the visual corridor and visitor use areas, stands with large old trees which are desired to be maintained in their current condition, and large contiguous stands that are susceptible to becoming large infestations. This treatment will generally take place when the possibility of endemic population levels is threatening to increase to epidemic population levels. The direct suppression of infested trees should take place while populations are still low and spot sizes are generally still small. The goal will be to avoid major expansion of individual pockets at a large scale. The implementation of this treatment will have to take place on an annual basis in the same general area, when beetle populations are building to be successful.
    - II. Monitor infestation levels and potential expansion – This strategy should be

employed in low risk areas, where the potential for large scale expansion is unlikely, where preventative measures can easily be employed, and where some losses from mountain pine beetle is acceptable.

3. Chemical Treatment – Preventative chemical treatments may be used in high visitor use areas, such as campgrounds in order to protect high value trees from being attacked.
4. Inventory and Monitoring – Forest inventory and aerial photography will be used to monitor stand risk and the location of current infestations.

Forest Meadows

Forest meadows that are not a result of large wildfire activity are scattered across the park's forest. They are generally small and are found on forest edges, draw bottoms, and where small-scale disturbances occurred. When a management unit is entered existing meadows should be identified as well as areas with opportunities for expansion or creation. Management practices should include removal of 95-100% of conifer vegetation in existing meadows and where applicable meadows should be expanded along the perimeter.

The desirable outcomes from these practices is the maintenance of existing forest meadows and increased acreage of forest meadows outside of areas affected by large wildfires.

French Creek Natural Area

The French Creek Natural Area should remain a permanently designated natural area used for scientific research, education, and recreation. Research and education should focus on the natural area's long term undisturbed condition, the progress of forest succession, and consequences of inaction. Because of the lack of disturbance and loss of diversity, natural processes should be returned to the Natural Area through the use of prescribed fire. The removal of insect and disease infested trees should not occur.

The desirable outcomes from these practices are an area that will maintain some level of old growth characteristics and allow for natural disturbances and prescribed fire to be the main disturbance agents.

<u>System Health and Productivity</u>

Erosion

Practices on Custer State Park forestland must be conducted in such a manner that abnormal or excessive soil erosion is avoided. Soil movement is part of the natural dynamic processes in the forest ecosystem and activities used to simulate natural disturbance will affect the degree of erosion. To avoid detrimental erosion, CSP will adhere to goals established in "Best Management Practices for Water Quality Protection on Timber Harvests and Other Silvicultural Activities in South Dakota" prepared by the South Dakota Division of Resource Conservation and Forestry.

Noxious Weeds and Exotic Plants

Control of noxious weeds on forestland and fire disturbed areas will be administrated through the noxious weed control program as described in the Management Strategies section of the Range Management Program. Weed establishment and expansion can be mitigated during forest management activities by seeding native grasses and/or stabilization "nurse" plants on areas of high impact such as skid trails and landings immediately after activity is completed.

Riparian areas

Riparian areas, although not well defined at this time, are also unique communities in CSP and provide an important component of the ecosystem. When riparian areas are identified, the goal should be to preserve the unique community to the extent of its boundaries. At a minimum, riparian areas need to be maintained as they are now found. The preservation and maintenance of riparian areas can be accomplished through timber harvesting, non-commercial thinning and prescribed fire. Encroachment of pine should be checked by cutting 95-100% of existing pine from a defined riparian area during a management entry. Logging equipment should only be used in riparian areas during winter months to avoid damage to the generally wet environment. Often times, large groups of hardwood trees exist in riparian areas. The removal of pine from these areas benefits the riparian condition as well as improving hardwood stands. Prescribed fire should be considered in conjunction with cutting or as a stand-alone tool for the management of riparian areas. Planting native species suited to the riparian environment and building exclosures to limit browsing of desired woody species will also be considered.

Minimize damage to conifer forest

Damages to conifer forest by wildfire, insects, disease, and weather events are naturally processes in the ecosystem. Our actions or inactions will affect the extent of the damages by these agents. The main tool used to minimize the damage to conifer forest by wildfire, insect, disease, and weather events will be commercial timbersales and thinning. Residual densities on the majority of forest management treatments should be reduced to levels that are considered at a low to moderate risk of damage by wildfire, insect, and disease not only post treatment, but until the next treatment is implemented. Exceptions to this would be when wildlife objectives call for leaving a stand at a higher density. See Natural Disturbances – Mountain pine beetle strategy

Natural Succession in large fire areas

Two effects of large wildfires are:

1. Fragmentation of the forest into scattered stands of trees.

2. Creation of large treeless expanses.

The park will not artificially regenerate or plant trees in the pine forest within post-fire areas. Natural regeneration of trees within post-fire areas will act as areas of future timber productivity.

Diseases

Custer State Park manages to preserve "old growth" trees and forest stands therefore maintaining a relatively high level of red ray rot and shoestring root rot. The goal for managing these two diseases will be to remove obviously infected trees during management entries. Western gall rust, present in most younger stands, should also be managed for reduction whenever possible.

Understory Development

A variety of native grasses, forbs and shrubs in the forest understory contribute to the diversity of the forest ecosystem. Production of native understory plants should be encouraged on all forestland while maintaining tree cover that is consistent with other resource goals. Production of forest understory plants should be at a minimum of 75% of potential in a normal year as measured in pounds per acre (see Table 36). Understory composition should approximate that described in the NRCS technical guide "Woodland Understory Vegetation in Custer and Pennington Counties" as modified for steep slopes (see Range section above).

Fiber Production

Fiber production of ponderosa pine for commodity use should be considered equally and balanced with the objectives for forest health and diversity.

On the majority of forestland other than Visual Corridors, wood fiber will be efficiently produced. To meet the goals for productivity in the ponderosa pine forest as well as balancing other goals for the forest, stands best suited for fiber production will have residual stocking levels between 50 - 80 GSL during intermediate treatments. Regeneration harvests will have residual stocking levels between 10- 40 GSL. Stands on woodland soils with a Site Index of 55 or greater will be classified as primarily suited for fiber production. Exceptions to this directive are riparian areas and wildlife foraging areas that may be cleared of pine to achieve diversity goals.

The majority of the park's forestland available for commercial harvest has been entered and the forest at a landscape scale has been regulated. Stands that were treated at the beginning of the regulation period (early 80's) will be treated first during the next entry schedule. Treatment of forested stands in the Galena and Cicero fire has not occurred since prior to the burns. The surviving stands were considered for entry during this planning cycle.

For even-aged stands the rotation age will be considered 120 years. Forest stands that are greater than 120 years old and have received a preparation cut during the regulation period will be eligible for a regeneration cut. The target residual stocking in these stands will be 10-40 GSL.

Other methods to promote a productive forest in Custer State Park include:

1. Selection of phenotypically superior trees for reserve during timber sales and thinning process.

2. Select against disease and insect infested trees during timber sales and thinning.

3. Adhere to the best forest management practices possible to avoid site and tree damage.

Methods and Processes

<u>Forest Administration</u>

When Custer State Park wrote its first timber management plan in 1947 the park was divided into "logging units". Over time they have become known as "management units". Their boundaries have been the basis for the administration of forest management activities; timber sales, non-commercial thinning and prescribed burning. The boundaries will continue to be used, however they have been consolidated into 36 larger units. Figure 47 shows the location of the management units within CSP and Table 37 lists the Custer State Park management unit names and their status and entry year in regards to forest management since the base year 1980. Through this planning period, these units will be used for administration and categorizing projected growth and yield from the forest.

Forest management prescriptions directing management activities will have the following content and format:

I. Site Data
  a. Geology and landform
  b. Soils
  c. Climate
  d. Hydrology/ watershed
  e. Potential vegetation
  f. Site quality/productivity
  g. Cultural features
II. Stand Data
  a. Timber stand resources (from forest inventory)
  b. Wildlife and fisheries habitat
  c. Rangeland resources
  d. Visual and recreation resources
  e. Protection and fuels treatment
III. Evaluation of Data/Projections
  a. Forest management objectives
  b. Prescriptions on a stand basis
  c. Describe results
  d. Growth and yield projections
  e. Economic analysis
IV. Specific timber marking and timber sale layout guidelines
V. Stewardship activities and layout guidelines

A draft forest management prescription should be circulated among the Custer State Park staff for comment. The final revision of the prescription should receive approval from the Resource Program Manager and ultimately the park superintendent.

Entry schedule and harvest predictions

Based on the goals and directions set forth, the following is the predicted harvest over the next 15 years (Figure 48, Table 38,). Growth and yield projections were made using the U.S. Forest Services' public domain software, Forest Vegetation Simulator (FVS) Central Rockies Variant for Black Hills ponderosa pine.   Additional forest management needs during this period include non-commercial thinning. Projected harvests assume that mortality from insect, fire, disease, snow, and wind are minimal throughout the planning period. If there is a large amount of mortality from fire, insects, or other weather event, then the current goals and objectives, treatment schedule, and harvest projections will have to be re-assessed and modified. There are no years attached to the treatment order. All areas are planned to be treated by 2025. However, at least one treatment area should be prepared and put under contract a year. If time permits it is desirable to do the first four treatments as soon as possible given the location and extent of the current MPB outbreak

<u>Analysis of future condition</u>

The future condition of all forested stands is summarized in Tables 39-41. This includes all acres that were managed during the initial regulation period from 1981 to 2010, as well as forested acres managed from 2010 to 2025, and inoperable acres. The results seem to indicate that at the end of the planning period there will be conditions that are dominated by an even-aged structure growing mostly at low to moderate density. The vegetative structural stages results indicate that nearly 85% of the forested acres are in structural stage 4. It also indicates that almost 50% of the acres are in structural stage 4C. The results shown above are likely a result of prolific regeneration that is growing underneath the overstory. As the growth of forested stands is modeled forward, regeneration will drive up canopy closure and density class, but will drive down average stand diameter. The treatment of regeneration in these stands, or the actual survival and recruitment of this regeneration will play a major factor in the future conditions in many forested acres in the Park.

<u>Future direction for planning period 2025 – 2040</u>

Currently CSP is using a 30 year cutting cycle. The initial regulation period was from 1981 to 2010. Roughly all the operable forested acres were treated during this time period. All stands entered during this planning period will be a second entry. Management units that are entered in 2025 to 2040 will generally be ones that were entered from 1995 to 2010 (Figure 6).

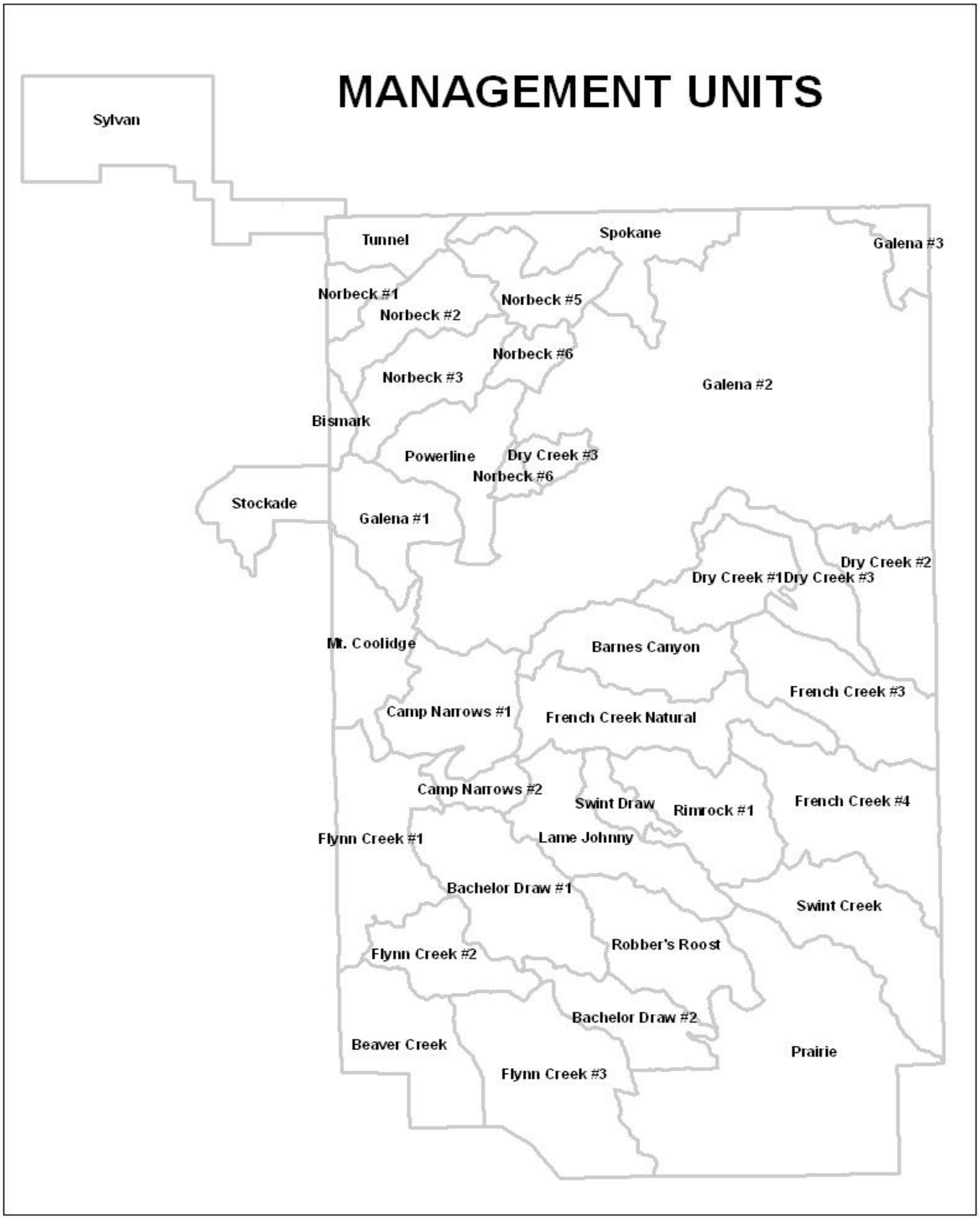

Figure 47. Management Units.

Table 37. Management Unit Summary

MANAGEMENT UNIT	STATUS	ENTRY YEAR
Bismark	Entered	2005
Galena #1	Entered	1987
Galena #2	Mostly Burned	N/A
Galena #3	Not Entered	N/A
Tunnel	Entered	2005
Barnes Canyon	Entered	2003
Dry Creek #1	Entered	1993
Dry Creek #2	Entered	1997
Dry Creek #3	Not Entered	N/A
Flynn Creek #1	Entered	1988
Flynn Creek #2	Entered	2013
Flynn Creek #3	Entered	2006
Mt. Coolidge	Entered	1988
Lame Johnny	Entered	2004
French Creek Natural Area	Not Entered	N/A
Spokane	Entered	1981
Stockade	Entered	1985
Sylvan	Entered	2009
Swint Creek	Not Entered	N/A
Swint Draw	Entered	1982
Rimrock #1	Entered	2011
Robber's Roost	Entered	2008
Norbeck #1	PCT	1985
Norbeck #2	Partial Entry, Mostly PCT	1983
Norbeck #3	PCT	1985
Norbeck #5	Entered	1992
Norbeck #6	Entered	1994
Beaver Creek	Prairie	N/A
Bachelor Draw #1	Entered	1986
Bachelor Draw #2	Entered	2002
French Creek #3	Entered	2004
French Creek #4	Entered	1986
Camp Narrows #1	Entered	1992
Camp Narrows #2	Entered	1997
Powerline	Entered	1985
Prairie	Prairie	N/A

*PCT = Pre-commercial thin

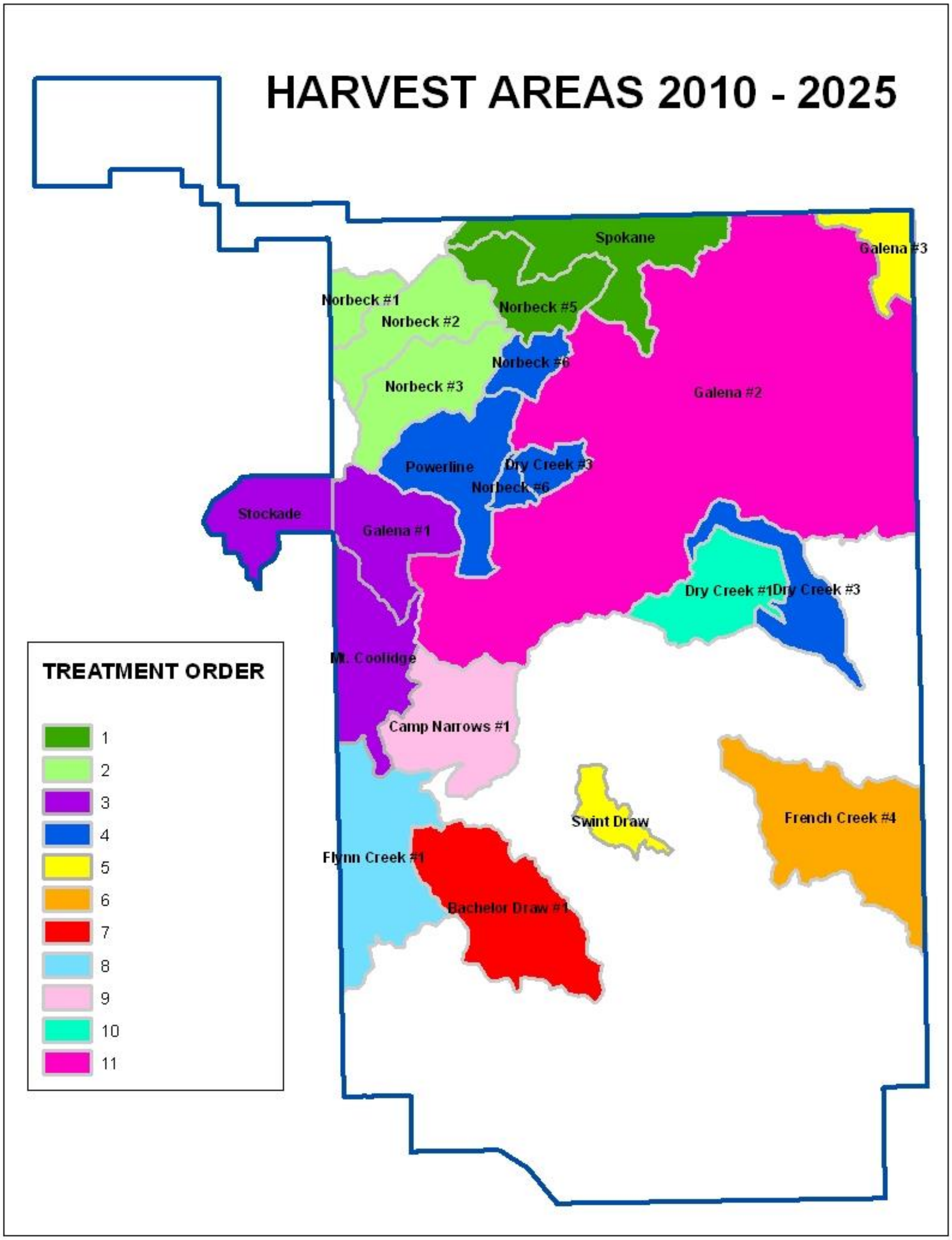

Figure 48. Commercial harvest schedule.

Table 38. Commercial harvest during the planning period.

TREATMENT ORDER	MANAGEMENT UNIT	TREATED ACRES	VOLUME (BD. FT.)	VOLUME (CU. FT.)
1	Spokane			
	Norbeck 5			
Total		**1,230**	**5,091,307**	**1,102,685**
2	Norbeck 1			
	Norbeck 2			
	Norbeck 3			
Total		**2,099**	**6,749,523**	**1,482,544**
3	Stockade			
	Galena #1			
	Mt. Coolidge			
Total		**1,488**	**6,481,591**	**1,405,073**
4	Norbeck #6			
	Powerline			
	Dry Creek #3			
Total		**1,531**	**6,132,998**	**1,365,995**
5	Swint Draw			
	Galena #3			
Total		**419**	**2,091,830**	**455,312**
6	French Creek #4	**1,075**	**4,524,030**	**972,752**
7	Bachelor Draw #1	**908**	**3,950,696**	**841,444**
8	Flynn Creek #1	**774**	**4,000,610**	**853,710**
9	Camp Narrows #1	**282**	**1,569,295**	**338,214**
10	Dry Creek #1	**734**	**3,659,255**	**786,083**
11	Galena #2	**1,265**	**5,675,901**	**1,210,677**
Grand Total		**11,805**	**49,927,036**	**10,814,489**

Table 39. Mean stand diameter in two inch classes - 2025

Classification	ACRES	% TOTAL
2 - 4" DBH	6,439	18
4 - 6" DBH	23,242	65
6 - 8" DBH	2,148	6
8"+ DBH	3,693	10
TOTAL	35,522	

Table 40. Conifer density classes (% Stand Density Index) – 2025

Classification	ACRES	% TOTAL
Low - 0-30%	9,140	26
Medium - 30-55%	19,253	54
High; Over stocked - 55%+	7,129	20
TOTAL	35,522	

Table 41. Vegetative structural stages – 2025

Classification	ACRES	% TOTAL
2	645	2
3A	3,066	9
3B	32	0
3C	849	2
4A	5,572	16
4B	8,089	23
4C	17,269	49
TOTAL	35,522	

Non-commercial thinning

Non-commercial thinning will be primarily used as a follow up treatment in timbersales where young trees were released and are over stocked. The non-commercial thinning needs over the next 15 years are as follows:

15-Year Planning Period: 6,000 ACRES

Annual Thinning Objective: 400 ACRES

Fuels Treatment

As outlined under "Scope and contents of prescriptions", planning of forest management activities will involve the fire management forester's input. Forest fuels generated from forestry activity will be minimized using a variety of methods. At a minimum fuels from thinning and harvesting operations will be manipulated so that the slash lies within 18 inches of the ground. Large concentrations of slash, such as log landing areas, will have slash piled so that it can be burned. Additional measures to treat fuels are fuel breaks, and whole tree logging. Fuel breaks consist of piling and burning strips of fuels, usually along roads or other defensible points. Whole tree logging involves the skidding of severed trees with all limbs and tops attached to them to a central location whereupon the limbs and tops are cut from the trees and piled for burning. This effectively removes most of the dangerous fuels from the forest stands. Whole tree logging should be prescribed whenever feasible because of the tremendous impact it has on reducing fire danger.

General Forest Health

Inventory and monitoring

Forest stand inventory

To better manage the forest resource in Custer State Park a complete stand inventory should be maintained at all times. At this writing approximately 33% of the conifer stands have been inventoried. To maintain a complete stand inventory 100% of the stands should be inventoried within 10 years of the completion of this plan. This will entail contracting approximately 24,880 acres of inventory while conducting "in house" inventory on those lands that receive treatment during this period and their attributes change. This will commonly occur after a non-commercial thinning, timber sale, or prescribed burn. Inventory should be conducted under the guidelines of the U.S.D.A. Forest Service Stand Examination Specifications for the Rocky Mountain Region. Adjustments to the specifications should be made to suit the needs of Custer State Park. Cost of completing an inventory in conifer stands is estimated at $75,000. Since uneven-aged conditions are desired at a landscape scale, inventory protocol should incorporate the best means to measure and distinguish horizontal diversity between and within stands.

A regeneration survey of the Galena and Cicero fire areas was completed in 2000. An updated survey and mapping of regeneration should take place after the majority of the area has been treated with prescribed burning. The purpose of the surveys will be to determine where natural regeneration is occurring and can coincide with pre and post burn monitoring. Also, young pine stands both in the Galena and Cicero fire are scheduled for non-commercial thinning. These units will be mapped as forested stands and inventoried post thinning.

As the park's landscape changes, the aerial photography crucial to planning in CSP will become obsolete. Therefore, color-infrared aerial photography or other remote sensing imagery should be obtained in 2015 and 2025 so that planning efforts remain current.

To better understand the growth of timber stands in Custer State Park an effort should be made to remeasure the permanent inventory plots that were established in 1970.

Information from this inventory will allow for calibration of growth and yield models for the park. Permanent inventory plots should be measured in 2011 and 2021, ten and twenty years after the last measurement.

Each year as changes take place due to management or environmental affects, polygon boundaries in the GIS base map must be updated. The boundaries of new or updated polygons should be surveyed with GPS technology so as to provide accurate geo-referencing of new boundaries. The database of forest attributes must also be updated in conjunction with polygon updates.

Insect and disease monitoring

The GIS technology used to prepare this plan is a powerful tool to analyze vegetative conditions. As forest stands change in density, size classes, and age the GIS can predict the susceptibility to insect and disease outbreaks (see Role of Insects and Disease on Current System Function). Conditions of forest pest populations should be monitored using observation, the GIS for risk analysis, and current pest inventories done by the South Dakota Division of Resource Conservation and Forestry and USFS.

FIRE MANAGEMENT ACTIVITY

INTRODUCTION

In Custer State Park fire is a necessary component of a healthy, ecologically diverse ecosystem. Exclusion of fire over the past 120 years has modified forestland and rangeland conditions. Fire management is not an end unto itself; it is programmatically dependent on all resource areas. The fire management program within Custer State Park will use two primary methods, prescribed fire and appropriate management response (AMR) to wildland fire, to accomplish integrated land management strategies from wildlife, range, and forest management to successfully return fire to the landscape.

Prescribed fire allows land managers to use fire under specific conditions to achieve management objectives. These will be implemented under specific weather, fuel, and seasonal conditions in pre-planned locations and will require a “team effort” by all resource areas involved to achieve success. Protection of life and property, public and firefighter safety, and cost will be weighed against achieving resource objectives when determining when and where the use of prescribed fire is appropriate.

The use of appropriate management response (AMR) in response to wildland fires allows agency administrators and incident commanders to choose from a full spectrum of fire suppression actions. While suppression action is necessary on all wildland fires within CSP, not all wildfires need to be suppressed with the same level of intensity. The CSP interdisciplinary resource management team, made up of resource, fire, and agency

administrators, recommends that suppression action, whether aggressive, high intensity or low intensity, be based on the preplanned analysis and land management.
The fire management program has many interrelated goals. The overarching objective is to allow fire to take a more natural role in ecosystem management and provide for opportunities returning fire more closely to its historic return intervals.

THE GOAL OF THE FIRE MANAGEMENT PROGRAM

- Provide fire managers with appropriate pre-suppression planning and management actions that will provide opportunities for returning fire to the fire-adapted ecosystem in order to improve forestland and rangeland health.
- Use prescribed fire and appropriate management response to wildland fires to reach Custer State Park's annual objectives for fire disturbance on the landscape.

Objectives

- Apply fire (prescribed or AMR) to 3770 acres per year.
    - Forestland 2270 acres
    - Rangeland 1500 acres
- Develop and maintain a network of fuel breaks to assist with wildland fire management.
- Use fire to assist in achieving management objectives for range, timber and wildlife resources.
- Dispose of 70-90% of activity fuels visible from roads, up to 150 ft, within 2 years of completion.
- Apply fire/fuels treatments to 5% of lands (based on soil type) to promote prairie/rangeland restoration and reduce pine encroachment.
- Apply fire/fuels treatments to 5% of hardwood / riparian areas annually to promote suckering and reduce pine encroachment.
- Re-vegetate burn areas that do not re-vegetate quickly.

<u>ANNUAL OBJECTIVES</u>

- Forestland 2270 acres
- Rangeland 1500 acres

PRESCRIBED FIRE

Prescribed fire in Custer State Park will be used to accomplish interrelated program strategies. The following descriptions identify four general areas in which prescribed fire will be used.

Forestland

Objective: Forestland maintenance

Prescribed burning within the forestland will be used to reduce fuel loading, manage ponderosa pine seedling densities and improve wildlife habitat. The seasonality of the prescribed fires will depend on objectives, weather and fuel parameters. Additional benefits of forestland burning will include:

- Increased nutrient cycling
- Improved aesthetics
- Reduced tree density
- Regeneration of certain hardwood tree species
- Habitat manipulation for wildlife
- Reduced forest fuels

Rangeland

Objective: Rangeland maintenance and restoration

Systematic burning in the rangeland and savanna will be used to prevent decadence, improve productivity and reduce ponderosa pine encroachment on prairie soil types. The seasonality of rangeland prescribed fires will be timed to best meet objectives. Prescribed burn plans will address specific objectives regarding species mix desired following the burn.

General guidelines that will be followed for range burning are:

- Timing of the burn should address specific site objectives.
- Burn when there is a breeze to move the fire along quickly to dissipate heat.
- Plan for grazing deferment after burning to allow plant stocks to establish food reserves.

Additional benefits of rangeland burning will include:

- Restoration of native mid-grass prairies
- Reduction of invasive species
- Increased nutrient cycling
- Restoration of riparian areas
- Wildlife habitat manipulation
- Improved forage production and quality
- Reduced pine encroachment

<u>Rangeland Fire Frequency</u>

Studies indicate that the historic fire frequency in mixed grass prairies and savannas in the Great Plains to occur every 10-12 years. There are currently 17,860 acres typed as rangeland within the park. Our objective will be to applying fire to the rangeland on a 12 year cycle (Figure 49). The burning schedule will be as follows:

Total rangeland	:	17,860 Acres
Yearly Burn Objective (Rangeland)	:	1500 Acres
15 Year Burn Objective (Rangeland)	:	22,500 Acres

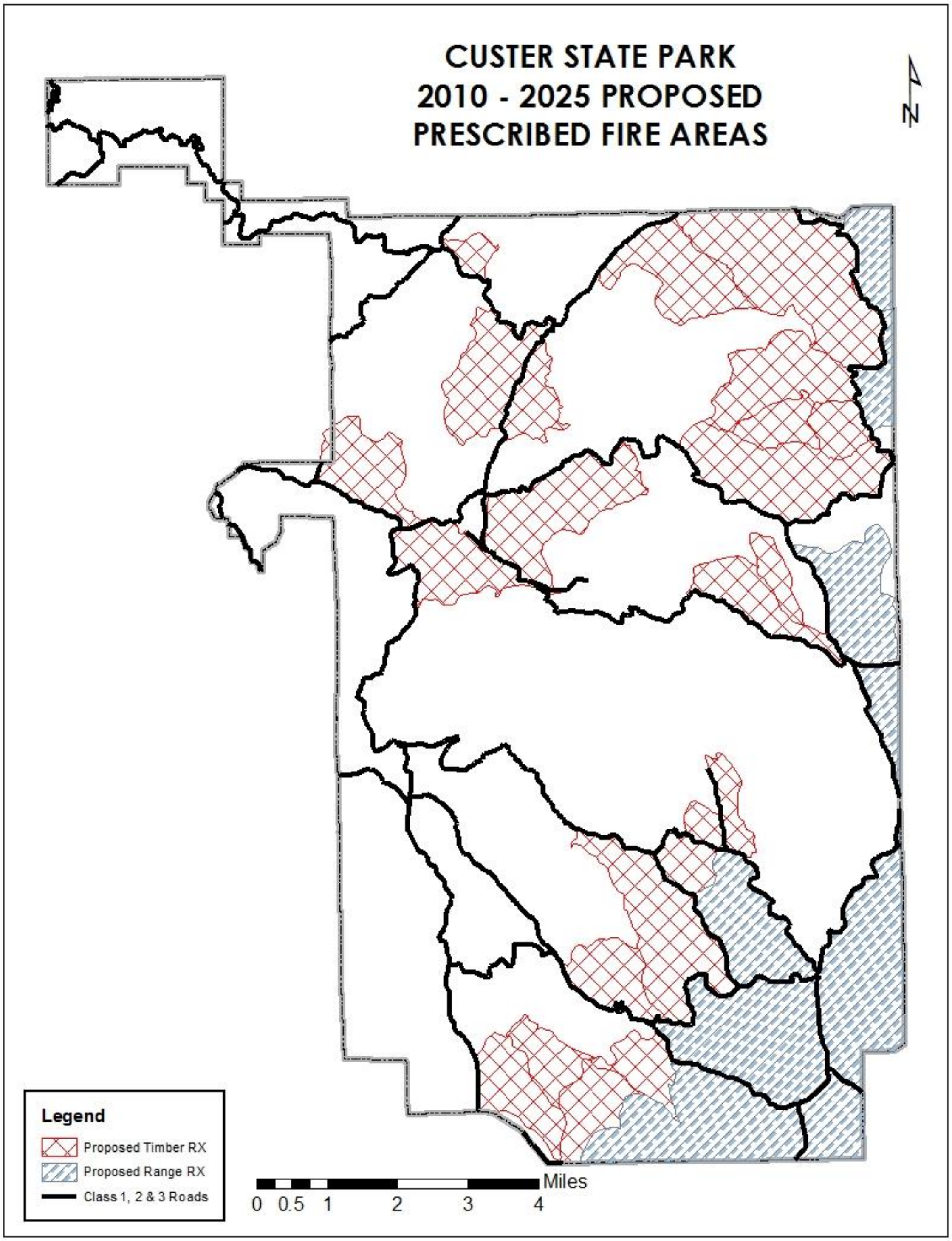

Figure 49. Proposed rangeland and timber prescribed fire locations, 2010-2025.**Error! Bookmark not defined.**

Wildlife Habitat

Objective: Habitat manipulation

Prescribed burning for wildlife will focus on habitat manipulation which invariably involves efforts to alter plant succession. As succession is altered within plant communities' habitat the structure changes. Structure deals with the form or appearance of a stand, the arrangement of the canopy, and the volume of vegetation in tiers or layers. Research indicates that wildlife species tend to select habitat on the basis of structure rather than plant species composition.

Emphasis will be directed initially toward the forestland system specifically in the French Creek Natural Area. Here prescribed burning will be used to improve bighorn sheep habitat by reducing the forest density (stand structure) primarily on the north facing slopes. The objective will be to apply fire to approximately 25 % of the forested acres within the French Creek Natural Area.

- ♦ Total forested acres French Creek Natural Area : 2035 Acres

- ➢ Burn Objective (Sheep Habitat Improvement) : 500 Acres

To allow for fire within the French Creek Natural Area a great deal of site preparation will be required. Control line preparation may take more than one season.

Across CSP all fires, prescribed or wildfire, will indirectly benefit wildlife through habitat manipulation. Although a particular prescribed fire may have other objectives, such as fuel reduction, there will be wildlife benefits such as increased grass and forb production.

Additional objectives include:
- Improve and enhance habitat for disturbance obligate species
- Improve forage production and quality for large ungulates
- Habitat manipulation

Hardwoods

Objective: Regeneration (Oak, Aspen and Birch)

Fire plays an important role in the regeneration of hardwood stands, particularly oak and aspen. Application of prescribed fire encourages re-establishment through suckering, sprouting root crowns or sprouting roots. Hardwood regeneration may also be accomplished concurrently with other types of fire. Additional benefits from burning hardwood stands include:

- Grass and forb production

- Improved wildlife habitat
- Reduced fuel loading
- Nutrient cycling
- Improved aesthetics (more fall color)
- Promote hardwood regeneration
- Aspen suckering
- Woody shrubs

APPROPRIATE MANAGEMENT RESPONSE

The use of appropriate management response (AMR) to manage wildland fires allows agency administrators and incident commanders to choose from a full spectrum of fire suppression actions. While suppression action is necessary on all wildland fires within Custer State Park (CSP), not all need to be suppressed with the same level of intensity. The CSP interdisciplinary resource management team, made up of resource, fire, and agency administrators, recommends that suppression action, whether aggressive, high intensity or low intensity, be based on the preplanned analysis and land management objectives outlined in the CSP Resource Management Plan.

The Resource Management Plan and preplanned analysis seek to minimize suppression costs and negative impacts to resources, including the threat to life and property, and to return fire to a more natural role in ecosystem management with Custer State Park. Preplanned analysis criteria has been identified through the planning process in which the interdisciplinary team classified Custer State Park lands into the two different management categories listed as follows (Figure 50):

Category 1

Lands where wildland fire should be excluded. Only prescribed fire or non-fire treatment techniques should be used to achieve the desired resource conditions or management of the area. The appropriate management response for these lands will be full suppression. In multiple fire situations, with fires occurring in both Categories 1 and 2, suppression priorities will be given to those fires burning within Category A land. When multiple fires occur within Category 1, suppression priorities will be based on the threat or potential threat to public safety, structures, private property, and improvements.

Criteria used to determine Category 1 land include:

- Protecting public safety;
- Threats to private, state or federal property;
- Protecting capital improvements;
- Protecting administrative/recreational sites;
- Protecting Federal and Private lands identified under fire protection agreements

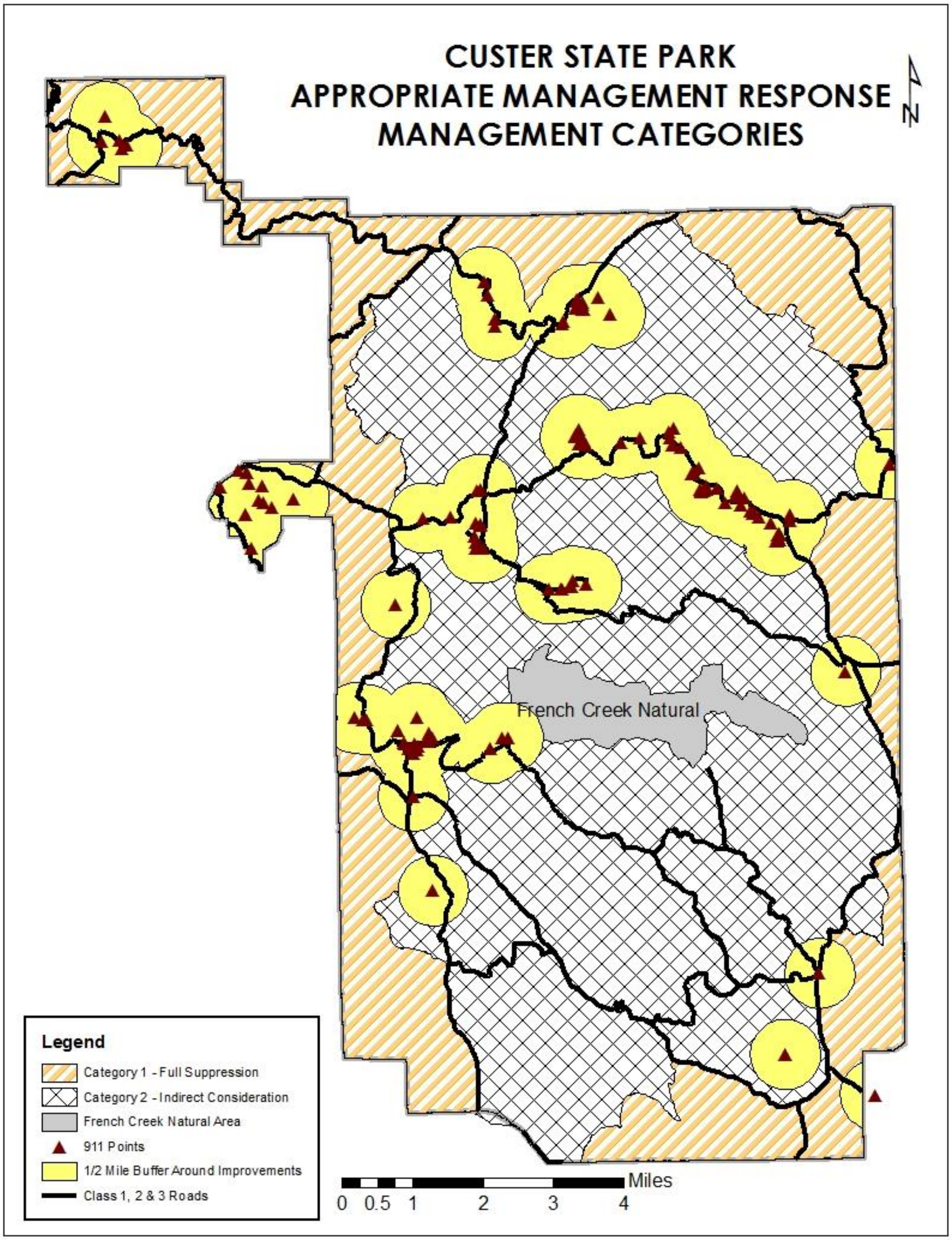

Figure 50. Appropriate Management Response zones and structure buffers.

Category 2

Lands where wildland fire could be used in addition to prescribed fire to meet desired resource conditions or management. Under this category the appropriate management response could vary based on predetermined fire and resource criteria (see criteria below) for land in and adjacent to the fire location. In multiple fire situations, Category 1 land will, with the exception of threat to life, receive higher priority for suppression actions than will Category 2 land.

While all wildland fires will receive a suppression response, under the appropriate condition that response will not always be aggressive, direct suppression. Less than full suppression responses will depend on seasonal weather trends, current weather and fuel conditions, or in multiple fire situations when suppression forces are not adequate to respond to all going fires. With multiple fires burning, suppression actions will occur in order of priority, with lower priority fires receiving suppression action as forces become available. All other fires receiving less than full suppression actions must meet the following fire criteria thresholds:

- Fire located within Category 2 land;
- Observed and predicted fire behavior will continue to meet resource management objectives;
- No threat to public safety;
- Not a threat to private or Federal land (unless those lands are under a signed mutual agreement with the landowner or agency for less than full suppression actions);
- Fire's ignition is not suspected to be arson;
- Actions are in accordance with the "Preparedness Level 3" or less of the local unit (this level is based on the number of fire suppression resources that are committed to ongoing fire suppression activities, as more resources are committed the level raises).

If any of these criteria are exceeded the appropriate management response becomes that of full suppression, unless other suppression tactics, as determined by the incident commander, line officer and agency administrators, are necessary to manage the threat to life and property or during a multiple fire situation where suppression actions are based on priority.

Within Category 2, land resource considerations will be addressed and updated annually to reflect appropriate changes in the values to be protected. Resource criteria has been identified as to those criteria which may lead to full suppression actions and those criteria which may lead to less than full suppression actions, those criteria include but are not limited to the following.

Resource criteria that may lead to full suppression action include but are not limited to:

- Burning vegetation resources with commodity values
- Burning within the perimeter of an area burned within the last 10 years
- Burning within the perimeter of a fire rehabilitation area
- Burning within sensitive vegetation types/habitat (key winter range, annual grasslands, or shrub/annual grassland)

Resource criteria that may lead to less than full suppression actions include but are not limited to:

- Burning within the French Creek Natural Area
- Burning within riparian areas
- Burning within given vegetation types (oak, aspen/birch);
- Burning within an area that has a prescribed fire plan in place

The authorized officer has the authority to modify fire and resource criteria for either category of land based on site-specific resource management objectives identified through the adaptive management process.

FUELS MANAGEMENT

Fuel Treatment Standards

Custer State Park is divided into three fuel management zones with separate fuel treatment standards. Fuel treatment standards are based on land use, presence of structures, resource management objectives and the risk of fire occurrence. Fuels are defined as vegetative debris from natural and logging activities.

Following is a description of each of the three zones and the fuel treatment standards for each:

<u>Zone One</u>

Zone One consists of the visual corridors. CSP numbered roads, priority fuel breaks and capital development areas (lodges, campgrounds/picnic areas, historic and administrative sites) are included within Zone One.

Fuel treatment standards for Zone One will be to treat all fuels so the potential fireline intensity does not exceed 100 BTU's/second/foot on 90% of the days when a fire could occur.

Fuel treatments will consist of piling and burning, chipping or removal of activity fuel. Activity fuel will be cleared at least 150 feet either side of visual corridors and maximum fuel loading will not exceed 5 tons/acre. Additional thinning and pruning of trees may be used around structures and developed sites to reduce fire hazard.

Zone Two

Zone Two is the forest and rangeland of Custer State Park managed for biological diversity. This area consists of 43,606 acres of forest and 17,860 acres of rangeland.

Fuel treatment standards for Zone Two will be treat all fuels so potential fireline intensity does not exceed 400 BTU's/sec/foot on 90% of the days when a fire could occur.

Fuels treatments will consist of a combination of prescribed fire, and mechanical treatments such as whole tree harvest, and piling. A minimum treatment such as lopping slash to 18 inches must be used on all activity fuel generated.

Zone Three

Zone Three consists of park backcountry with little to no access. These areas are characteristically rough and rocky with slopes generally exceeding 40%. The areas included in Zone Three are the French Creek Natural Area and the areas inoperable to mechanized forestry in Zone Two. There are approximately 9,126 acres that comprise Zone Three.

Very little activity fuel will be produced in Zone Three. Fuel hazards include dense, overstocked stand of pine and a concurrent build-up of downed, woody debris and litter on the forest floor. Fuel treatment options in this zone are limited. Treatments in this zone will be directed toward reducing tree density and cleaning up the forest floor.

Treating fuels in Zone Three will be difficult due to the challenges presented by the terrain. However, that doesn't mean that these areas are exempt from treatment. Because of the current cost per acre of hand or mechanical treatments and the deviation of these areas from historic fire regime the best option for fuels treatments in this zone is the application of fire. Incorporating these areas as their own prescribed fire burn units will present safety and holding issues. Instead of applying fuel treatments or prescribed fire directly to these areas, best management practices for Zone Three will be directed towards strengthening control lines (which lie within Zones One or Two) to support the use of prescribed fire or indirect suppression in the event of a wildland fire.

Cultural

ARCHEOLOGY

Several physiographic zones in Custer State Park remain unexplored archaeologically. These include large tracts in the southeastern portion of the CSP, high peaks and meadows throughout the Park, and the wide, unforested valleys and canyons along creeks throughout the park. Several factors influence the distribution of prehistoric archaeological sites. The suitability of a locale for habitation, proximity to resources such as water, game herds, plant foods, or tool-stone are important factors. Shelter is a factor in locating camps and villages. If military defense was a factor in site location is unknown, but peoples located in the Black Hills were known to have linkage to peoples along the Missouri River where this was an important factor. Several Paleoindian and Early Archaic sites were probably destroyed through erosion-deposition events, making remaining sites more important.

Archaeological reconnaissance of a large, diverse geographic area such as Custer State Park can be accomplished most efficiently by focusing first on areas that are poorly known but likely to contain archaeological sites. As funding is/becomes available, CSP should work with the State Archeological Research Center (SARC) to systematically inventory these identified sites. Specific places targeted for this initial survey are: watergaps, exposed cliffs, rockshelters, and ridge tops in the Hogback physiographic zone (including Red Canyon); rockshelters along streams; stream terraces along the lower reaches of two branches of Lame Johnny Creek; areas of Quaternary terrace deposits north of the North Fork and south of the South Fork of Lame Johnny Creek; and Racetrack Butte. These areas were chosen because they contain physical features that either are atypical of the Black Hills or tend not to occur on federal lands where most archaeological surveys take place.

ROADS

Class 4 road maintenance

Class 4 roads are small single lane, minimum-standard, backcountry roads. Maintenance of Class 4 roads will be a necessary part of managing the transportation system in Custer State Park. Resource management activities (ie. fire and resource management, maintenance of park facilities, and emergency services) are dependent upon access provided by Class 4 roads. Class 4 roads are not open to the public for vehicle access. Class 4, 5 and 6 roads will remain closed to motor vehicle traffic. Exceptions will be for park administrative activities. A set of roads will be made available for use by the Buffalo Safari Jeep Rides. A meeting will be held annually preseason between Resort Company staff and CSP to cover restrictions of use.

There are currently 161 miles of Class 4 roads identified and mapped on the park GIS. The goal is to maintain all 161 miles over the current planning period. Special problem areas will be addressed on an as needed basis. Timber sales will include road maintenance and construction as contract items. Roads will be moved from undesirable locations (e.g. drainage bottom) during scheduled maintenance or timber sale activity.

Maintenance activities will:

- maintain a minimum 8 foot road width
- establish or maintain water bars
- repair or establish stream crossings

- repair road bed
- clear downed trees
- relocate road if necessary

The park is divided into 7 maintenance areas (Figure 51). Maintenance will be concentrated in one area before moving on to the next. Areas are based on:

- assumption that all groups have roughly the same level of maintenance needs
- locational relationship of roads to one another
- topographical features
- ease of moving maintenance equipment within the group
- approximately 20 miles of road within area

TRAILS

Trail maintenance and development in CSP is managed through the engineering section. However, trails have been demonstrated to have a significant impact on wildlife. The resource section will continue to review any proposed new trails and provide input on mitigation. Some areas of CSP are unsuitable for the development of trails and those areas will be maintained as dispersed use areas.

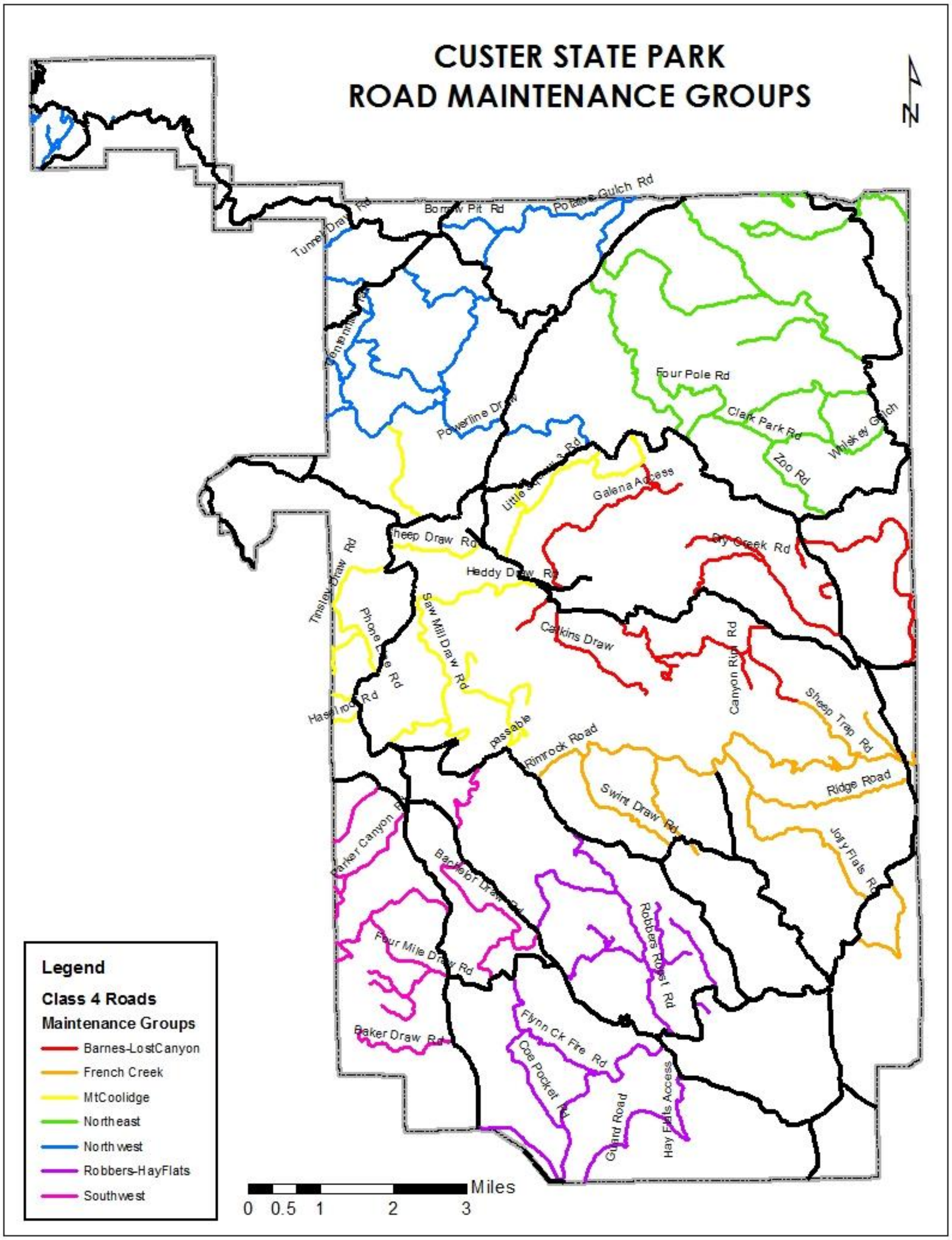

Figure 51. Administrative road maintenance areas.

WILDLIFE MANAGEMENT ACTIVITY

INTRODUCTION

Management of wildlife in Custer State Park, under the 1995-2010 Wildlife Management Plan, was an emphasis on maintenance and enhancement of ecological functioning and maintaining ecosystem diversity would ensure resources would be available to wildlife species who reside in those ecosystems. It is therefore the intent of the wildlife program to maintain the ecosystem maintenance and enhancement philosophy for the 2010-2025 management plan.

Goals

The goal of wildlife management activities is to provide for a maximum of wildlife species diversity and species richness. The goal of this process will be the enrichment, reestablishment and preservation of complete ecosystem processes and functions.

Objectives

1. Restore native species, where appropriate, to the Black Hills ecosystem.

2. Provide for viable wildlife populations and habitats.

3. Manage habitats, through the use of fire, timber management, and other appropriate tools to enhance habitat diversity and to mimic natural processes which maintained those conditions.

4. Manage habitats to achieve population goals for rare and sensitive species, or species of greatest conservation need as outlined in the South Dakota Comprehensive Wildlife Conservation Plan.

5. Manage the human/wildlife interface to provide for maximal recreation without jeopardizing ecosystem integrity and function.

MANAGEMENT FOR WILDLIFE DIVERSITY

Selected Species Based Upon Resource Needs and Habitats Occupied

We selected prairie dogs (*Cynomys ludovicianus*), black-footed ferrets (*Mustela nigripes*), pronghorn (*Antilocapra americana*), sharp-tailed grouse (*Tympanuchus phasianellus*), and grasshopper sparrows (*Ammodramus savannarum*) as prairie ecosystem representatives. We selected these species because of their unique resource needs in prairie environments. Prairie dogs and black-footed ferrets use primarily short grass prairies and ferrets are an endangered species of importance. Pronghorn utilize many different vegetation communities on the prairie and are a unique species occurring in the northern Great Plains. Grouse were selected because they can inhabit various vegetation communities. They primarily select for short grass, mid grass, and shrub steppe prairies of the Great Plains and Rocky Mountain West (Aldrich 1963; Johnsgard 1973; Johnsgard 2002, Flake et al. 2010). Data in the North American Breeding Bird Survey (Sauer et al. 2005) indicate that grasshopper sparrow populations are declining at a rate of 3.8% annually throughout their range in North America. Grasshopper sparrows select for short to mid grass prairie and avoid shrub cover (Ahlering et al. 2009).

We selected elk (*Cervus elaphus*), bighorn sheep (*Ovis canadensis*), northern goshawks (*Accipiter gentilis*), and black-backed woodpecker (*Picoides arcticus*) species as forest representatives based on their importance in terms of intrinsic values. Additionally, we selected these species because of their unique resource needs in forested environments. Elk are found in many different structural stage categories of forested landscapes, depending on the activity and time period, and use disturbed and undisturbed forests for habitat selection. Bighorn sheep in the Black Hills represent mammals that typically need habitats influenced by disturbance and typically use open areas following fire. We also selected 2 non-game species. We selected northern goshawks and black-backed woodpeckers because of their importance as sensitive species and species of greatest conservation need. Northern goshawks primarily use undisturbed (green) forests for nesting and have specific requirements for mature forest when using nesting territories. In contrast, black-backed woodpeckers use resources in disturbed environments such as mountain pine beetle areas or wildfire burned areas.

<u>Prairie Dogs</u>

Prairie dogs are often referred to as a “keystone” species for their pivotal role in providing food and shelter for other species (Higgins et al. 2000). Prairie dog colonies provide important habitats for burrowing owls (*Athene cunicularia*) and prairie rattlesnakes (*Crotalus viridis*). They provide food for numerous predators such as black-footed ferrets, coyotes (*Canis latrans*), badgers (*Taxidea taxus*), and raptors. Prairie dogs can be associated with diversity of grassland characteristics in rangeland ecosystems. The presence of prairie dogs on rangeland increases diversity of both plant and animal communities on local and landscape scales. Prairie dogs are native to the mixed grass system of Custer State Park and act as ecosystem regulators providing for increased soil, plant, invertebrate and animal diversity.

Strategy

Prairie dog towns will be dispersed over the rangelands to provide maximal interspersion. Total acreage included in prairie dog towns will be limited to approximately 5% of the total rangeland acreage (900 acres). When total town acreage is met, measures will be initiated to limit town growth. Cow Camp town south of Baker Gate will not be controlled since that area is the primary prairie dog and ferret area.

Because the benefits derived from prairie dog towns diminishes over time, conditions on prairie dog towns will be inventoried every 5 years. Develop a sampling protocol to determine when conditions deteriorate below a diversity threshold and control actions need to be initiated. Towns determined to be below the threshold will be eradicated if possible. A system of introduction and eradication of prairie dogs will be developed. A rotation system for prairie dogs on range will be updated using GIS and information on town condition, Ecological Site condition, and soil characteristics.

Black-footed Ferrets

Black-footed ferrets are an endangered species and having this species in Custer State Park contributes to increased species richness for CSP and the Black Hills ecoregion. Black-footed ferrets occur in the southern portions of Custer State Park. They use prairie ecosystems and forage primarily on prairie dogs. The presence of black-footed ferrets returns a natural predator and mammal to the ecosystem, in turn returning healthy system function. This predator would be a natural biological process in which to potentially control prairie dog populations.

Strategy

Black-footed ferrets will be monitored to determine density and location across Custer State Park. Activities such as poisoning prairie dogs or other potential activities which could be detrimental to ferrets will be mitigated to protect ferrets. These activities may include trapping and moving ferrets, eliminating or modifying poisoning or other prairie dog controls. Prairie dogs will not be controlled using gas or aluminum phosphide due to potential non-target impacts. Maintaining prairie dog towns at higher acreage (roughly 900 acres) will ensure some keystone prey and habitats for black-footed ferrets will be available.

Pronghorn

Pronghorn are very important as a viewable wildlife species in CSP. Pronghorn, along with bison are the primary larger species viewable during hot summer days. During the hiding phase pronghorn fawns selected dry prairie-seminatural mixed grassland at the course-scale level; group phase fawns selected prairie dog dominated grasslands and dry prairie-seminatural mixed grassland at the course-scale (Lehman et al. 2009). Evaluation at the fine-scale indicated fawns during the group phase period selected bed sites that had greater forb cover and overstory canopy cover of ponderosa pine trees compared to random sites. Management activities that promote a dynamic grassland ecosystem with patches of forb cover may enhance resources selected as bedding habitat by pronghorn fawns during the group phase period (Lehman et al. 2009). Pronghorn were not hunted from 1986-2008, but were hunted again starting in 2009 due to increased density.

Strategy

Pronghorn hunting of females when implemented will be used as a management tool to maintain stable populations. For males, hunting recreation provides a unique opportunity to harvest some mature animals for a quality hunt. Management for a diversity of grasses and forbs will maintain fawn bedding habitat necessary for survival. Fawn bed site selection was greatest on the edges of prairie dog towns and upland native prairie. The periphery of prairie dog towns typically is lower in prairie dog density than in the center, and experiences less foraging activity by prairie dogs allowing relatively taller vegetation on the periphery versus the center of the prairie dog town. Differences in vegetation height along periphery are also due to a change in soil type. Forested soils have more rock than rangeland soils so prairie dogs avoid digging burrows in the forested soils that surround most prairie dog towns. This may support the maintenance of towns to be dynamic, or of relatively young age and smaller size for a greater edge to area ratio and avoiding management for stagnant prairie dog colonies. Management activities will provide for a diversity of grassland habitats and areas of grassland habitat that are dominated by a single species such as smooth brome (*Bromus inermis*) will be avoided.

Sharp-tailed Grouse

Sharp-tailed grouse are a native upland bird in Custer State Park and South Dakota. Populations vary annually depending upon upland rangeland conditions and precipitation patterns. Typically, nest success and adult survival is enhanced with greater grass and forb cover on the upland prairies (Flake et al. 2009). Brood rearing habitats of sharp-tailed grouse have many characteristics including: shrubby vegetation for concealment, short vegetation nearby for feeding, and high amounts of forbs present (Hamerstrom 1963; Flake et al. 2010).

Strategy

Management for a diversity of grasses and forbs will maintain nesting habitat. Management of a healthy grassland ecosystem dominated by grasses and forbs will ensure adequate nest and brood-rearing cover necessary for reproduction and survival (Flake et al. 2010).

Grasshopper Sparrow

Although spring habitat characteristics may be associated with summer characteristics, the strength and reliability of this association typically depends on the annual stability of climatic conditions. Also, grasslands are disturbance-dependent ecosystems characterized by high annual climatic variability (Bragg 1995), which creates a highly variable (spatially and temporally) mosaic of available resources. Grassland birds have adapted to this annual variability by exhibiting nomadic tendencies (Cody 1985, Winter et al. 2005). Grasshopper sparrows typically select for a diversity of grasses and forbs of mixed height categories in the short to mid grass prairie (Ahlering et al. 2009). Grasshopper sparrows typically avoid woody cover and research indicates a negative relationship between woody cover and bird density (Ahlering et al. 2009). Use of areas with fewer woody perches could be a mechanism to reduce the opportunity for brood parasitism by Brown-headed cowbirds (*Molothrus ater*) (Ahlering et al. 2009).

Strategy

Management for a diversity of grasses and forbs will maintain habitat required throughout their life cycle. Maintaining a healthy grassland ecosystem dominated by grasses and forbs will provide the necessary habitat needed by grasshopper sparrows.

Management which ensures adequate grassland habitat should reduce the opportunity for brood parasitism by Brown-headed cowbirds.

Elk

Elk populations have fluctuated greatly and in the mid-1980s there were approximately 400-700 animals. The population increased in the early to mid-1990s to roughly 800-900 animals and maintained near or above 1000 animals through the early 2000s. In 2003 the population was at roughly 1200 animals. Since liberal antlerless seasons were initiated in the early 2000s, the population has decreased significantly. Additionally, poor calf recruitment and elk movement out of CSP have contributed to further declines. The population estimate in winter of 2015 was 525 elk (95% CI = 479-556). Resource selection at parturition was investigated and at coarse scales in forests and grasslands, female elk selected sites in areas with greater proportions of vegetation communities that provided forage (56–74% of area) and more rugged topography (194–248 m) than found at random (Lehman et al. 2015). At coarse scales in grasslands, elk selected sites in areas with lower road densities (≤1.24 km/plot). At the fine scale in forests and grasslands, female elk selected sites in areas with intermediate slope (19%), closer to water (355–610 m), and far from roads (541–791 m). Further, elk in forests and grasslands selected sites with intermediate security cover (50–88 m). We hypothesize elk selected for intermediate rugged terrain at larger scales for security from high road densities and human disturbance, but these areas may have placed elk in riskier environments for puma predation. Forest management that maintains open-canopied vegetation communities in less rugged areas and prevents ponderosa pine encroachment of meadows to provide forage may be beneficial for elk. Further, elk parturition sites occurred close to roads, particularly on public lands, and agencies should consider road-use restrictions and vegetation buffers beside roads in areas with less rugged terrain, which may provide favorable calving habitat (Lehman et al. 2015).

For foraging habitat, elk select areas recently disturbed by fire (Pearson et al. 1995, Singer and Harter 1996, Van Dyne and Darragh 2007). A study in Montana indicated that elk resource selection closely tracked changes in production and nutritional quality of plants (Van Dyne and Darragh 2007). The investigators concluded that increases in quantity and quality of forage were the primary cause for increased use of burned sites by elk. Van Dyne and Darragh (2007) describe that managers can expect only short-term responses from elk following burning but longer-term increases in plant diversity and persistence of grass-forb communities on burned sites for > 10 years that may be important to elk and other grazing ungulates.

Strategy

Hunting of females when implemented will be used as a management tool to maintain stable populations. Hunting of males will provide a unique opportunity to harvest some mature animals for a quality hunt. Prescribed fire and mechanical thinning will be tools used to disturb the ecosystem to enhance foraging habitats. Such management will provide for a diversity of high quality grasses and forbs. Water resources will be developed and provided by artificial creation, or with ecosystem disturbance. Also, travel management and road development will be restricted and managed to mitigate disturbance by visitors and employees. Research will provide necessary data required to make sound management decisions.

Bighorn Sheep

Bighorn sheep in CSP number approximately 30 and have remained very low due to the negative effects of the pneumonia die-off from 2004-2005. Reproduction has been limited and evidence indicates only one lamb was recruited in CSP from 2004-2010. Limited genetic variability exists as a result of the founder effect and from genetic drift and inbreeding due to small population size. Supplemental transplants have been suggested as a means of increasing genetic diversity and thereby increasing herd vigor in small bighorn sheep herds. Increases in genetic variability may lead to an increase in herd productivity and an increase in ram horn volume. Research indicates the importance of open terrain for bighorn sheep use. Both ewe and ram groups select against dense ponderosa pine stands (Brundige 1985, Layne 1987). Dense tree stands can act as significant barriers to dispersal and range expansion (Geist 1971). Bighorn sheep will move further from escape terrain when visibility is high.

Strategy

Once there is evidence the pneumonia epidemic from 2004-05 subsides and the herd tests clean of the pneumonia causing microorganisms, a program to supplement the herd will be initiated. Research will be implemented in 2015 where the results from the study can be implemented to facilitate the removal of diseased individuals which may allow the herd to recover for future sheep reintroductions. Staff will acquire ewes and rams from another herd for transplant into CSP. The herd of preference would be the northeastern Montana herd near Charles M. Russell National Refuge. Ewes for the transplant should optimally be adults (2+ years) and rams should range from subadult through subdominant (2-6 years). Trap and transplant should occur in mid-winter. This will increase the probability of success with ewes remaining on the site to lamb. Once the population rebounds to adequate levels, the preferred management tool would be transplanting surplus ewes to supplement or establish new herds. If other areas or entities cannot be located, hunting will be used as a management tool to maintain a stable population. Prescribed fire and timber management will be tools used to enhance habitats for bighorns. Disturbance through prescribed fire will enhance bighorn sheep habitats by increasing sight distance.

Northern Goshawks

Northern goshawks have been classified as both a species of conservation need and a sensitive species (U.S. Forest Service, South Dakota Department of Game, Fish, and Parks). Nesting areas in southwestern ponderosa pine forests typically have a relatively high density of live (green) mature trees, greater canopy cover, and an open understory (Squires and Reynolds 1997). Additionally, greater tree density and canopy closure within a nest area have been associated with increased territory occupancy and nesting rates (Keane 1999, Finn et al. 2002). Data collected in CSP indicates goshawk nest resources have more large trees, fewer small trees, and greater herbaceous understory cover in the form of more grass and forb cover.

Strategy

More information will continue to be collected as more goshawk nests are found in CSP. Management will include protecting goshawk nest areas by providing a 20-30 acre buffer around nest territories where the buffer area is centered on the nest structure. Large trees and canopy overstory within buffers should be maintained and not harvested. Additional areas of large trees with greater overstory canopy cover adjacent to nest territories will also be protected (Reynolds et al. 1992) and this may include inoperable areas.

<u>Black-backed Woodpeckers</u>

The black-backed woodpecker is a species of conservation need and a sensitive species (U.S. Forest Service, South Dakota Department of Game, Fish, and Parks). This species is an important indicator of the positive and regenerative role that wildfire and pine beetle epidemics can play in western forests. In the Black Hills this species is primarily found in areas disturbed by wildfire or mountain pine beetle colonizations (Vierling et al. 2008, Bonnot et al. 2009). Reduction of beetle populations in forests with mountain pine beetle outbreaks could negatively affect the suitability of those areas for nesting. Therefore, Bonnot et al. (2009) advise against use of silvicultural treatments such as salvage logging in small outbreaks <20 ha, which is based on their territory scale analysis. For recently killed forests >20 ha, Bonnot et al. (2009) advise against silvicultural treatments during the black-backed woodpecker breeding season of May 15 through July 31 which would reduce direct impacts to food resources during nesting. When prescribing silvicultural treatments in outbreaks larger than 20 ha, Bonnot et al. (2009) suggest managers retain areas containing suitable distributions of food and nest sites. Patches of mountain pine beetles or wood borers interspersed at intermediate distances of 50–100 m with areas containing increased densities of aspens and 3–5-year-old pine snags should be considered for retention (Bonnot et al. 2009). For fire disturbed areas, conditions providing nesting habitat for black backs typically have higher snag densities (mean of 275–316 snags [≥23 cm dbh] per ha) (Saab et al. 2009). Consequently, post-fire management practices that promote retention of clumps of large standing dead trees (≥ 23 cm dbh), particularly ponderosa pine with areas of high pre-fire crown closure will likely be most successful at maintaining populations of cavity-nesting birds (Saab et al. 2009). Research in the Black Hills indicates nest-site selection in a recently burned forest included greater distances to unburned patches, a higher proportion of moderate- to high-severity effects in the landscape, and larger snags (Vierling et al. 2008). Although fire planning that encourages low-severity fires is important, Vierling et al. (2008) recommends that fire planning provide for opportunities where mixed-severity fires can occur (i.e., encourage a mosaic of fire effects including patches of dead trees, as well as live trees and forest openings). Large snags and trees (that will eventually become snags) are found at low densities in the Black Hills (Spiering and Knight 2005). Vierling et al. (2008) recommends that post-fire snags ≥26 cm dbh be retained. Research indicated spring and summer wildfires provided habitat where black-backed woodpeckers had positive population growth rates, whereas fall prescribed fire and mountain pine beetle areas provided habitats where black-backed woodpeckers had negative growth rates (Rota et al. 2014).

Strategy

Salvage logging will not occur during the black-backed woodpecker breeding season of May 15 through July 31 which would reduce direct impacts to food resources during nesting. During periods when MPB are at endemic levels, areas with small outbreaks of MPB will not be salvage logged. In larger outbreak areas (> 50 ac), when consistent with MPB management strategies, management will retain areas containing suitable distributions of food and nest sites. Patches of mountain pine beetles or wood borers interspersed at intermediate distances of 50–100 m with areas containing increased densities of aspens and 3–5-year-old pine snags will be retained.

Prescribed fire and natural fires will be used to provide black-backed woodpecker habitat. Post-fire management practices will promote retention of clumps of large standing dead trees. Fire planning will include management where mixed-severity fires can occur (i.e., encourage a mosaic of fire effects including patches of dead trees, as well as live trees and forest openings). Spring prescribed fire will provide habitat for positive growth of black-backs, whereas fall prescribed fire may not provide optimal conditions. Allowing for natural wildfires during summer will also provide optimal habitats for black-backs.

<u>Other Species</u>

Habitats and species complexes have changed in the Black Hills and Custer State Park over the past 120 years. Several conspicuous species are absent, notably the bears (*Ursus arctos*, *U. americanus*) and wolves (*Canis lupus*). Other species have increased in abundance, primarily forest interior species. Habitats have been created such as lakes (reservoirs) and associated species such as ospreys have colonized these habitats. Efforts to increase wildlife species diversity by matching wildlife species to habitats should be pursued.

Strategy

Identify potential species additions where appropriate habitats exist. Investigate social, political, and ecological consequences of introducing these to the complex. Where appropriate, pursue introduction. Evaluate species with limited occurrence in distribution or numbers. Pursue population supplementation if such species would benefit.

Inventory

<u>Endangered, Threatened, and Rare Species</u>

Species listed as endangered and threatened must be protected by law. Current occurrences of these species, as well as rare or sensitive species and species of greatest conservation need, are documented only through incidental observation. These species are generally specialists, requiring very specific habitat components. Therefore, they serve as good indicators of ecological limitations and may demonstrate ways to increase ecological diversity.

Strategy

Investigate and catalogue all reported sightings of endangered, threatened or SGCN in CSP. Inventories will be conducted on proposed developments or management activities prior to action to ensure endangered or threatened species will not be negatively impacted. Species found to occur will be further investigated to determine population status and habitat associations and needs. Appropriate action will be taken to protect required habitats and investigate methods to improve population status. Investigations into resource selection, survival, and reproduction will provide needed knowledge of such species. Goals outlined within the Fisheries and Aquatic Resources Statewide Strategic Management Plan include conserving, maintaining, and restoring native aquatic plant and animal communities for their long-term health, and for the benefit of the general public (SDGFP 2014b). Objectives and strategies will work to standardize survey programs to reduce knowledge gaps by updating information on aquatic communities and watersheds while supporting research and monitoring projects and working collaboratively with state and non-governmental conservation partners (SDGFP 2014c).

<u>Riparian Wildlife</u>

Riparian habitats support much greater species diversity than surrounding upland landscapes. Microclimate conditions in riparian areas provide unique niches unavailable in associated landscapes. Some species, such as some amphibians, belted kingfishers (*Ceryle alcyon*), and mink (*Neovison vison*), are obligate riparian inhabitants and cannot live elsewhere. Other species are facultative riparian inhabitants, using these habitats when available but not dependent on them.

Strategy

Inventory wildlife species using riparian habitats. Conduct these inventories in conjunction with riparian status inventories. Inventories conducted in enclosure areas will serve as models of potential.

<u>Water Resources</u>

Water resources have a direct impact on species distributions and habitat availability. Water can be used as one tool to distribute resource pressure. Available free water is dependent on numerous variables including precipitation, soil hydrology, and vegetative cover. Water resources such as springs and seeps have developed in CSP as a result of extensive fire. Additional water resources are available as permanent and ephemeral streams and man-made reservoirs. Status and distribution of these resources is only partially documented.

Strategy

Inventories of existing water resources will be conducted. Occurrence will be documented and mapped using several techniques. Document existing free water during management activities, systematic inventories, and remote sensing. Information will be incorporated into the park GIS and water resources mapped. Satellite imagery will be modeled and potential water resources field verified. Identified water resources will be visited at least biannually, spring and fall, to determine permanence. Additionally, biennial inspections will be made to correlate site specifics with water year. Holding capacity of springs and seeps discovered in areas lacking free water will be developed.

Aquatic Wildlife

<u>Lakes and Ponds</u>

Lakes in CSP provide unique habitats for some species. Some associated terrestrial wildlife includes bald eagles (*Haliaeetus leucocephalus*) and osprey (*Pandion haliaetus*), both species listed as SGCN and osprey as state threatened. Great blue herons (*Ardea herodias*) use Stockade Lake as summer residents. Waterfowl such as mallards (*Anas platyrhynchos*) also use lakes for breeding and brood-rearing habitats. Several mammal species also use lake areas.

Lakes also provide important and unique opportunities for recreation including fishing. All lakes in CSP support fishable trout populations, primarily through scheduled stocking. Stockade Lake also supports a substantial warm water fishery, primarily large-mouth bass (*Micropterus salmoides*), northern pike (*Esox lucius*), black crappie (*Pomoxis nigromaculatus*), and yellow perch (*Perca flavescens*).

Strategy

Inventory and catalogue lake use by terrestrial vertebrates. Investigate methods to enhance lake area suitability for associate terrestrial species.

Continue current stocking schedules for CSP lakes to support sport fisheries. Continue to develop the warm water fishery in Stockade Lake through cooperative projects with Division of Wildlife fisheries biologists. Continue to develop the cold water fishery in lakes throughout CSP through cooperative projects with Division of Wildlife fisheries biologists.

Streams

Streams, in addition to associated terrestrial wildlife previously discussed, support limited fisheries. Several permanent streams support limited brook trout (*Salvelinus fontinalis*) populations as well as native non-game fish populations. French Creek and Grace Coolidge Creek are the primary stream fisheries in the park. These streams are stocked with catchable size trout on a put-and-take basis.

Strategy

Continue put-and-take stocking on French Creek and Grace Coolidge Creek to support sport fishing. Investigate additional instream fishery habitat improvement projects on park streams, with emphasis on improvements along Grace Coolidge Creek from the walk in fishing area downstream to the sinkholes. Investigate and identify streams and refuge areas which can be managed for non-game and native fish populations as well as trap and transfer stocking techniques as a potential management tool for supplementation and management of non-game fish populations (SDGFP 2014c).

Population Management

Manage Populations Within Carrying Capacity

Populations within CSP need to be maintained within the limits of the habitat to sustain those populations without degradation to that habitat. Several methods are available to both control populations and protect habitat from overuse.

Productivity goals of various species will require managing those populations at different levels along the production curve in relation to carrying capacity. Care must be taken to match control efforts to desired population goals. Those species which are managed for production (sale or harvest) will be managed at densities intermediate on the production curve between maximum sustained yield and carrying capacity. Other species managed to provide other recreational opportunity, or to reach diversity goals, may be managed closer to carrying capacity, realizing the tradeoff in poorer condition and increased mortality from disease, starvation, etc. Population management in CSP will have to balance recreational demand, diversity goals, visitor expectations, and interspecific interactions (competition, predation, symbiosis - see Approach for Balancing Production and Consumption).

Hunting Strategy

Hunting will be the primary population control tool for big game species in CSP. The antlerless elk season will be used to stabilize herd population growth by removing a portion of the breeding females. Required harvest (tags offered) will vary based on research results, population inventories, and population modeling.

Antlerless deer (*Odocoileus virginianus*, *O. hemionus*) and female pronghorn seasons will be implemented on an as needed basis. When inventory information indicates that populations are reaching the limits of habitat, female seasons will provide herd reduction and demographic controls. Other species which are suitable for implementation of these types of seasons will also be investigated if population control becomes necessary.

Prairie Dogs

Strategy

Prairie dogs will play an increasing role in prairie ecosystem dynamics. An increase in prairie dog abundance will require an increase in required control efforts. Prairie dog poisoning will be used as necessary to maintain prairie dogs within the confines of designated areas. Control actions will not be implemented on towns which remain within the confines defined as prairie dog colony areas. Care will be taken to ensure that non-target species are minimally impacted.

Other control methods for prairie dogs, or other nuisance or problem populations, will be investigated. These may include, but should not be limited to, sterilants, predation, or other biocontrol. Any prairie dog shooting determined to be necessary will be accomplished by park personnel, not through a hunting season offered to the public. Control methods deemed to be both effective and economical will be implemented when necessary.

Black-footed Ferrets

Strategy

Black-footed ferrets will be monitored to determine density and location across Custer State Park. Activities such as poisoning prairie dogs or other potential activities which could be detrimental to ferrets will be closely monitored as to not kill or harm ferrets. Mitigating tactics such as trap and transplant, adjustments in areas poisoned will be used to protect ferrets. Fumigants will not be used for prairie dog control to eliminate threat to fetters and other non-target species. Additionally, the Cow Camp town from Baker Gate south will not receive control actions on prairie dogs. Maintaining prairie dog towns at higher acreages (roughly 900 acres) will ensure adequate prey densities and habitats for black-footed ferrets.

Recreation

Recreation is one very important aspect of the wildlife in CSP. Recreational opportunities exist as both consumptive and non-consumptive uses. Obvious consumptive uses include recreational hunting; however, less obvious consumptive uses include disturbance activities such as hiking and touring. These activities can displace sensitive species from preferred habitats, leading to reduced population performance. Integration of human uses with wildlife use is an important part of the resource program.

<u>Viewability Strategy</u>

Hunting has been shown to reduce the viewability of some wildlife species; therefore, when hunting is implemented whether to control population numbers through female harvest, or when providing a limited mature male harvest, it will be mitigated in a manner to maintain viewability. Measures such as providing short season length and limiting number of licenses will maintain the viewability of some wildlife species that are hunted. Further, in 2015 a 200-yard road buffer was put in place around all public roads where hunting cannot occur to help reduce potential visitor and hunter interactions.

Bighorn Sheep

Strategy

Since the 2004 die-off sheep recovery has been slow. Research will be initiated in 2015 testing the hypothesis that the *Mycoplasma ovipneumoniae* (MO) pathogen is shed by some individuals in the herd contributing to prolonged pneumonia die-offs. A potential result of the research may be to implement a strategy for recovering this population by disease testing and removing “shedding sheep”. If a sheep tests positive for shedding MO, it will be removed and placed into a research facility. This protocol will continue to test for “shedding sheep” and once all known sheep are testing negative for shedding, CSP will be evaluated for a re-introduction of sheep from a transplant.

Interpretative/Educational Sites

Strategy

Wildlife interpretative (viewing) sites will be developed when needed. Such sites will complement the existing forestry and wildland fire interpretative sites. This strategy will provide visitors an opportunity to learn about ecosystem function and the role of management.

Wildlife/Human Interface

Strategy

CSP has many miles of roads open to the public (see Cultural, Travel Management). Vehicle traffic can be heavy on highways, especially during the tourist season. Hazards exist from wildlife on the roadway, or from visitors stopping in the roadway to observe the wildlife. Signage will be erected at the entrances, intersections, and areas of high wildlife use indicating wildlife in the roadway. Additional speed limit signs and enforcement should reduce collision hazards.

An additional hazard exists from visitors feeding wildlife. This should be discouraged through visitor education. This education effort will include information on the potential hazards to humans and of the health hazards to the wildlife. This educational effort will include an informational article in the *Tatanka* as well as a posting at both visitor centers.

Off-road activities such as hiking, biking, and horseback riding may have a significant impact on some wildlife species. Previous research conducted in CSP indicates some activities may displace elk from preferred habitats. In order to prevent additional potential detrimental impacts from dispersed visitor use, a moratorium on new trail development in CSP will remain in effect until full impacts are elucidated and mitigation procedures determined.

Any additional developments will be restricted to already developed areas. As additional information on the impacts of human use patterns on wildlife use in CSP becomes available, these restrictions may be modified. Modifications might include opening some non-critical areas, seasonal restrictions on critical areas, or limitations on visitor densities, or times of use.

Recreational Hunting

Strategy

CSP offers several hunting seasons. These hunting seasons are recreational in nature, provide an excellent high quality hunting opportunity, and generate revenue. License allocations for each hunting season will take into account number of applicants, population density based on surveys, visitor viewability, and results of research studies. Adjustments in the seasons will be made such as providing short season length and limiting number of licenses to maintain the viewability of some wildlife species that are hunted. Further, in 2015 a 200 yard road buffer was put in place around all public roads where hunting cannot occur to help reduce potential visitor and hunter interactions.

For elk, the harvest quota will be based on population survey data, research results, and modeling of survey and research data. The harvest rate will not exceed 20% of the estimated bull population (excluding bull calves). Additionally, management will provide an available age structure where there is a minimum of 45% mature bulls (6+ years or older) available for viewing and hunting opportunities. This objective falls within what is outlined in the South Dakota Department of Game, Fish, and Parks elk management plan for a minimum of 60% bulls 4+ years or older, but still ensures mature animals are available for viewing and hunting recreation.

Elk hunting opportunities will be allocated at 25% of “any elk” licenses as archery licenses, with the remainder (75%) issued as firearm licenses. Antlerless management will be conducted using firearm hunters.

Harvest of bighorn sheep on a limited trophy basis will be allowed after population recovery. Tags available will be based on current population status. Harvest levels will be determined based on the estimated number of rams exceeding 8 1/2 years age. Bighorn sheep are relatively easy to approach, and hunters have the opportunity to carefully select the animal to harvest.

Recreational harvest of deer (white tailed and mule deer) and pronghorn will be based on estimated number of mature bucks available and impacts to viewability. Seasons will include no-hunt zones of 200 yards around all public roads and visitor areas to reduce impacts of viewing opportunity.

Other recreational hunts will be offered as appropriate. Consideration will be given to impacts on viewability and plans will be developed to mitigate impacts from additional hunting opportunities.

Wildlife Survey and Inventory

Winter helicopter surveys will be conducted for elk at 3-5 year intervals. The park will evaluate the potential for conducting annual winter flights of elk in CSP. Additional ground surveys will be conducted annually during fall for white-tailed deer, mule deer, and elk. A spring ground survey will be conducted annually for pronghorn. Additionally, research investigations will provide information on other species.

Habitat Management

<u>Enhancement</u>

Timber Prescriptions

Timber management can have a profound impact on wildlife habitat, in both positive and negative directions. Wildlife management goals for timber management will strive to enhance forest understory forage production and to provide for maximal habitat diversity. Habitat diversity will be scaled to provide essential habitat components for maximum species richness and should consider both horizontal and vertical components.

Strategy

Review timber management prescriptions. Modify prescriptions to protect critical cover areas or unique habitats. Use results of research studies to develop management strategies of cover and forage.

Schedule timber harvest and thinning so that activities do not incorporate adjacent drainages simultaneously; continue to release hardwood stands from pine encroachment. Create irregular activity boundaries both for increased edge effect (increased diversity) and to enhance aesthetics. Investigate methods to increase vertical diversity. Provide cover through the retention of slash pockets in areas lacking sufficient understory cover.

Investigate alternative logging methods to harvest timber from areas inoperable to conventional methods. These areas represent unique habitats in CSP and are on steeper, rugged areas. Retain some of these stands in mature forest but enhance diversity by managing some stands. Additionally, some less severe terrain should be allowed to develop without harvest. Maintaining old growth stands will provide habitats for some sensitive species and species of concern.

Prescribed Fire

Wildlife species evolved in fire disturbance environments in the Black Hills. Fire frequencies have been reduced in the Black Hills and Custer State Park. This has led to a reduction in some habitat types; park like stands and aspen/birch (*Betula paprifyra*) for instance, and an increase in others, most prominently dense ponderosa pine. These changes have led to a reduction in habitat and carrying capacity for some species. Habitat quality has been greatly reduced for disturbance dependent or early successional species such as ruffed grouse (*Bonasa umbellus*), black-backed woodpeckers, elk, and bighorn sheep.

Fire historically was an integral part of the ecosystem dynamics of the Black Hills. Prescribed fire is one tool available to reintroduce the regulatory role of fire into the ecosystem in a controlled and directed manner. This plan calls for the use of fire to restore ecosystem function.

Strategy

Provide objectives and review prescribed fire prescriptions. Modify prescriptions to protect critical cover areas or unique habitats and to create new important habitats for fire obligate species. Each fire management should strive to achieve high, moderate, and low fire intensity habitats to create a diversity of habitats. Proportions of area of fire intensity may vary depending upon habitat objectives.

Range Improvement

Strategy

Use fire to enhance cool season or warm season grasses on a site-by-site basis. Fire can also increase the abundance of forbs and to reduce or eliminate exotics, thereby enhancing rangeland diversity. The burning of Ecological Sites to accomplish these goals will follow guidelines outlined in the range and fire management programs. Prescribed fire will be used to check encroachment on rangeland ecotypes.

Riparian

Strategy

Fire will be used in conjunction with mechanical treatments and plantings to restore damaged or decadent riparian sites. The use of fire will be evaluated on specific riparian zones scheduled for restoration. Fire may be used to prepare a site for plantings, to disturb existing vegetation, set succession back, reduce ground slash, remove decadent vegetation, or other appropriate use on a site-by-site basis.

Hardwoods

Strategy

Hardwood stands, primarily aspen/birch will be treated with mechanical thinning. Prescribed fire will be used to remove competing trees and enhance suckering. Hinging treatments can be implemented for protecting young suckers from browsing. Where practical, large blocks will be treated which will reduce the relative damage from browsing and reduce the necessity for protection. Isolated stands treated will be protected from browsing.

Understory

Strategy

Forest understories and meadow inclusions will be evaluated for potential prescribed fire. Slash will be treated when surrounding stands have developed to the point where fire will not cause unacceptable damage to the standing timber.

The Galena and Cicero Peak fire areas will be evaluated for site specific prescribed fire. Potential prescribed fire benefits in the old burns include reduction of exotics, reduction of ground litter and slash, and meadow maintenance for high quality forage.

Other Projects

Special habitat enhancement projects will be conducted when opportunity and need arise. Information gathered during other activities or from research projects may provide opportunity for species specific habitat enhancements that are in concert with program goals. Habitat enhancement projects will be conducted in cooperation with other agencies or organizations whenever possible.

Needs Identification

Several of the items outlined in wildlife management program will require information which is currently unavailable. In order to effectively implement this program, several information gaps need to be filled. Where information is lacking, and action is prescribed, conventional wisdom will be used. However, as information needs are identified, data collection studies will be developed, prioritized, and implemented. Information on current and proposed research will be exchanged with the Division of Wildlife on a biannual basis through scheduled meetings.

Some information needs have been identified and are outlined in strategies. Additional research needs include:

1) Research on forage quality in relation to population levels of large ungulates.

2) Resource selection information is lacking on habitat use patterns for several species in CSP. Literature review will provide some baseline data for species of interest. However, due to the interactions of the wildlife complex and the high visitor volume in CSP, information on habitat use in relation to visitor use remains a need. Resource selection in relation to habitat management is needed.

3) CSP entertains over 1.8 million visitors a year. Interactions of human uses and wildlife uses of park ecosystems needs to be elucidated. These interactions may

determine the success or failure of specific projects.

4) Wildlife disease is a concern for several species in the park. Immediate concerns include the pneumonia complex in bighorn sheep, the potential for plague in prairie dogs and associated threat to ferrets, and CWD in elk and deer. Efforts will be made to monitor and cooperate in investigations related to these and other disease outbreaks.

Anticipated Program Effect on Current Landscape Description

The implementation of these activities will result in a more diverse system, in both land and wildlife terms. Ecological Sites will host a greater complex of wildlife species as a result of the diversifying effect of increased prairie dog acreage. An upgrade in condition of riparian sites will likewise increase species diversity.

Fire will be used to enhance habitats for many species. Fire disturbed areas will provide more open habitats with increased forage quantity and quality. Such disturbance will enhance habitats for bighorn sheep, elk, deer, wild turkey, and some non-game species such as black-backed woodpeckers, American Three-toed Woodpeckers (*Picoides dorsalis*), and Hairy Woodpeckers (*Picoides villosus*). Fire, together with controlled timber harvest, will also be used to improve habitat diversity and understory forage production, resulting in increased wildlife diversity and carrying capacity. Retention of non-disturbed forest cover will benefit elk, turkey and interior species such as the northern goshawk.

Recreational opportunity will also be diversified. Viewability and watchability of wildlife, a major tourist draw, should be enhanced by this program. Increases in population numbers and species diversity will provide increased viewing opportunity. Limiting hunting of some species to population control only will increase their viewability while retaining limited recreational hunting on others will continue to provide a quality hunting experience.

The accomplishment of inventory and research projects will provide the requisite information to continue to refine wildlife management in CSP. Information gathered will allow modification of existing programs, development of additional programs, and management of the human/wildlife interface.

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