FOREST MANAGEMENT AND WILDFIRE MITIGATION PLAN©

Roosevelt Ridge
Gilpin County, Colorado

October 2005

Prepared By:

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FOREST MANAGEMENT AND WILDFIRE MITIGATION PLAN©

Supporting Sustainable Management of Natural Resources

October 2005

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EXECUTIVE SUMMARY

The Roosevelt Ridge Forest Management and Wildfire Mitigation Plan has been created to meet long range resource planning goals for open space, to ensure ecosystem sustainability and to integrate directives with social goals. Specific project goals were to: restore forest health and reduce the risk of catastrophic wildfire; control noxious weeds; enhance and maintain native plant and animal species, their communities and the ecological processes that sustain them; develop an integrated management approach that encompasses all ecological communities represented at Roosevelt Ridge; and provide a tool to help residents of Roosevelt Ridge understand the complexity of the ecosystem and more effectively manage their property. These goals are applied to three distinct arenas: 1) *Forest Management and Wildfire Mitigation*, 2) *Noxious Weeds* and 3) *Wildlife*. An ecosystem management approach was utilized to integrate directives for these diverse communities.

Forest management is needed throughout the upper montane zone of the Front Range to return forests to an ecologically sustainable condition and to reduce the potential for catastrophic wildfire and insect epidemics. Forest conditions at Roosevelt Ridge were assessed and compared with historical parameters of composition, density and landscape distribution to establish restoration prescriptions. A comprehensive evaluation of wildfire hazard within Roosevelt Ridge was conducted; findings have been integrated into the restoration prescriptions here created. Project wide forest restoration treatments include the maintenance of forest openings, reductions in forest density primarily through low thinning, selective cutting to remove undesirable species and diseased trees, retention of mature trees, aspen enhancement and implementation of prescribed burning where feasible.

Aspen stands are a critical component of the Roosevelt Ridge ecosystem; they support a variety of herbaceous and shrubby vegetation and contribute to landscape diversity that is critical for numerous wildlife species. The health of these communities, however, is threatened by the proliferation of conifer trees and fire suppression.

Forests and rangelands were inventoried for the presence of noxious weeds. This assessment identified Canada thistle infestations along the primary access road. Additional weed species were not observed making the present time ideal to control the establishment and spread of noxious plants. Management recommendations include the implementation of weed control measures.

Large tracts of natural habitat in the Rocky Mountains support a variety of ecosystem types, each of which provides habitat for a unique set of wildlife species. A review of existing wildlife inventory data was conducted to identify species that could utilize the Roosevelt Ridge property. Habitat preservation and enhancement initiatives were integrated into the forest management prescriptions.

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The Roosevelt Ridge Forest Management and Wildfire Mitigation Plan was created to meet long-range resource planning goals for open space, to mitigate the risk of wildfire, to ensure that management activities are ecologically sustainable and to integrate these directives with social preferences. This plan provides specific management direction to ensure the sustainability of forests and serve as a management guide for open space and future development at Roosevelt Ridge.

Project Objectives

The four main objectives of the Roosevelt Ridge Forest Management and Wildfire Mitigation Plan are to:

1) Restore forest health and reduce the risk of catastrophic wildfire.
2) Control noxious weeds.
3) Enhance and maintain native plant and animal species, their communities and the ecological processes that sustain them.
4) Develop an integrated management approach that encompasses all ecological communities represented at Roosevelt Ridge.
5) Provide a tool for current and future residents of Roosevelt Ridge to understand the complexity of the local ecosystem so that they can more effectively manage their properties.

These objectives are applied to three distinct arenas: 1) *Forest Management and Wildfire Mitigation*, 2) *Noxious Weeds* and 3) *Wildlife.* Subsequent chapters of this report are organized accordingly with specific goals, background information, methods, results and management recommendations.

Background

Location

The approximately 567 acre property is located in the southwestern portion of Gilpin County near the Peak to Peak Highway 119 off of Feldspar road. The Locator Map in the Project Map Section shows the property in its regional setting; the General Reference Map provides greater detail of site resources.

Roosevelt Ridge Background

The Roosevelt Ridge property was homesteaded by the Howard family in the 1920s and has been held in the Howard-Dieker Family Trust for the past eighty years. The site is surrounded on three sides by Roosevelt National Forest and is heavily forested. The property begins at an elevation of 9,200' with gently sloping mixed conifer and aspen forest then rises in elevation through rock outcroppings to its peak at 9,808'.

The development approach essentially integrates the community into the natural setting of the existing landscape. To accomplish this, the development plan calls for approximately 20 acre lots with two acre building envelopes. In mountain environments such as Roosevelt Ridge, the natural condition is not highly tolerant of ground disturbance. By reducing the amount of land under the management of individual home owners to the two acre building envelope, the potential disturbance is minimized. Proposed building envelopes will utilize the surrounding forest to preserve an atmosphere of seclusion and privacy in addition to screening development from the Peak to Peak Scenic Highway.

With homes and outbuildings located in a small portion of each parcel, Roosevelt Ridge's residential community will be integrated into a permanently protected piece of the landscape. As a result, residences and access roads comprise less than 12% of the entire property. The rest will be protected as natural open space. To ensure smooth operation of the property, the land outside of the building envelope will be managed by the homeowners association for wildfire mitigation, forest health and sustainability, recreation and road maintenance. Roosevelt Ridge will also include a private trail system which will provide access to the open space.

Regional History

The first settlers came to the region in search of gold, which was first found in Gilpin County on May 6, 1859. On this date, John H. Gregory located, staked, and pre-empted the first mining claims in what became known as the "Richest Square Mile on Earth." The site was originally called Gregory's Diggings, but was later known as Mountain City, a ragged string of camp-like settlements. By the middle of July 1859, between 20,000 and 30,000 people lived in the area. After the decline of mining, the remaining settlements would be divided into the current communities of Black Hawk and Central City. (Retrieved on August 11, 2005 from Gilpin Historical Society http://www.coloradomuseums.org/our_history.html)

Gilpin County was officially established in 1861, along with sixteen other original counties of the Colorado Territory. Gilpin County was named for Colonel William Gilpin, the first territorial governor of Colorado.

State Highway 119, the Peak to Peak Highway, was named a scenic byway in 1918, and when the Colorado Scenic and Historic Byways program was created in 1989, the Peak to Peak was selected as one of the five initial designated routes. (Denver Post, March 5, 2005 by Nancy Muenker) The route originally went from Idaho Springs north to Central City and Black Hawk and northeast to Boulder until 1938 when it was shifted to its current route southeast of Black Hawk to US 6. (Colorado Highways: Routes 100 to 119, retrieved on August 11, 2005 from http://www.mesalek.com/colo/r100-119.html) Highway 119 travels through the 800,000 acre Roosevelt National Forest, originally part of the Medicine Bow Forest Reserve established in 1897, named for President Theodore Roosevelt, the person most responsible for its creation. (www.rooseveltridge.com)

Climate

Gilpin County has mountain climate; temperature and precipitation vary with altitude and aspect. Higher elevations are typically cooler and receive more moisture; northern aspects are cooler than southern aspects. Climatic data from the Nederland station are presented below.

Monthly Climate Summary for Nederland, Colorado

Period of Record: 4/13/1970 to 5/31/1988

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	34.9	37.8	41.8	49.2	57.5	69.1	75.2	73.3	65.3	55.2	43.1	37.1	53.3
Average Min. Temperature (F)	10.2	12.9	16.7	22.7	29.3	37.1	42.6	41.2	33.8	25.3	17.5	12.5	25.2
Average Total Precipitation (in.)	0.54	0.59	1.29	2.18	2.69	1.67	2.39	2.01	1.74	1.02	1.12	0.73	17.97
Average Total SnowFall (in.)	13.3	13.1	23.9	24.3	12.2	1.8	0.0	0.0	5.2	9.3	19.9	16.1	139.0
Average Snow Depth (in.)	2	1	2	2	1	0	0	0	0	1	2	2	1

Retrieved on July 14, 2005 from http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?conede.

FOREST MANAGEMENT AND WILDFIRE MITIGATION

Introduction

Statement of Needs

The Wildland Urban Interface, or Interface, is any area where structures are built close to or within natural terrain and vegetation which has high potential for wildland fires. During the past few decades, population growth in the Interface has increased dramatically. Subdivisions and other high density developments have created a situation where a wildland fire can put more buildings at risk than any amount of fire equipment could possibly protect. Exacerbating this problem is the accumulation of forest fuels which result from decades of fire suppression. As population in the Interface increases, so does the difficulty of protecting populations from wildland fires. Many fires which occurred in the Interface were suppressed and extinguished to prevent property loss and safety hazards; however, this practice has contributed to a decline in forest health because many western forest types require fire to maintain optimal health. Historically, fires thinned trees and brush while eliminating surface fuels. By suppressing fires to protect homes and populations, we have inadvertently disrupted ecosystem processes. In the absence of natural fire, fuel loads can increase to levels which support more destructive and dangerous fires. Management of the Interface today requires judicious management of forest conditions including species composition, structure and fuel loads to prevent the risk of catastrophic fire.

Forest Management and Wildfire Mitigation Objectives

1) Mitigate the risk of catastrophic, uncontrollable wildfires by thinning forests and enhancing aspen stands.
2) Promote a heterogeneous landscape of forested areas and clearings to mitigate wildfire risks and increase habitat diversity.
3) Selectively remove insect and disease damaged trees.
4) Increase the proportion of old-growth forest and decrease the proportion of closed canopy forest through selective thinning.
5) Reduce fuel loading on forest floor with mechanical treatments.
6) Minimize impacts to forest soils.

Background

Roosevelt Ridge Forest Communities

Forests at Roosevelt Ridge are typical of the upper montane zone of the Colorado Front Range. Lodgepole pine *(Pinus contorta*) is the dominant species which forms pure stands or mixes with other conifers including Douglas-fir (*Pseudotsuga menziesii),* Engleman spruce (*Picea englemannii*), blue spruce (*Picea pugens*) and limber pine (*Pinus flexilis*). Aspen (*Populus tremuloides*) occurs throughout the property either within mixed conifer forests or in stands which contain limited amounts of mixed conifer trees. Roosevelt Ridge also contains some riparian corridors and a few small meadows which are populated with grasses, forbs and shrubs (see the General Reference Map in the Project Maps Section).

Ecosystem Management

Ecosystem management is an evolving approach to natural resource management in which the primary goal is to sustain the integrity and diversity of an ecosystem and the human society that depends on it. This management paradigm differs from traditional concepts of natural resource management in that it takes greater steps to preserve the viability of ecological, social and economic systems. This ecological approach to management blends the needs of people with environmental values in a way that promotes diverse, healthy, productive and *sustainable* ecosystems (Christensen et al. 1996, Jensen et al. 1996, Jensen and Everett 1994). Achieving these goals requires that ecological conditions be incorporated into decision processes so that human needs are considered in relation to the sustainable capacity of the system (Kaufmann et al. 1994). A fundamental component of ecosystem management is knowledge of ecosystem conditions, natural disturbance patterns and processes and the productive capabilities of a landscape (Bourgeron and Jensen 1994, Grumbine 1997, Meyer and Swank 1996, Reichman and Pulliam 1996, Salwasser and Pfister 1993, Slocomb 1993).

A system's *historical range of variability* provides a window for understanding the conditions and processes that sustained ecosystems prior to significant human alteration (Swanson et al. 1994). These reference conditions serve as a guide for establishing future goals that will protect ecological systems and meet societal objectives (Kaufmann et al. 1994, Kaufmann et al. 1998, Landres et al. 1999, Moore et al. 1999, Morgan et al. 1994). Reference conditions serve as a guide for restoration of current landscape conditions to improve ecological sustainability and mitigate wildfire and post fire erosion hazards (Kaufmann et al. 2000a).

Together, reference conditions and current conditions are used to identify desired future conditions which are ecologically sustainable and congruent with desired land uses. Parameters that require evaluation include forest density, fuel load, fire return interval, species composition, landscape distribution, age distribution and habitat value. Monitoring and adaptive management are necessary to ensure that goals are met. Adaptive management is a critical component of ecological restoration because ecosystems are constantly changing in both time and space.

Lodgepole Pine

Lodgepole pine (*Pinus contorta*) grows on a wide range of sites, typically between 7,500 and 10,000 feet, in the Rocky Mountains and can occur in pure or mixed stands (Shepperd and Alexander 1983). In mixed stands at lower elevations, it can occur with Douglas-fir and ponderosa pine. At higher altitudes, mixed stands consist of Englemann spruce, subalpine fir and limber pine. Lodgepole is mostly shade intolerant and exists as a seral species where environmental change such as fire has occurred. Barring any disruptive event such as fire, lodgepole is typically succeeded by more shade tolerant species such as Douglas-fir, subalpine fir and Englemann spruce (Schmidt 1989). Stand replacing fires are natural in lodgepole pine; such fires set the seedbed for a new generation of trees. This species is susceptible to bark beetles, mistletoe, blow down and fire (Lotan 1964).

Lodgepole pine produces large seed crops every one to four years. Lodgepole pines produce two types of cones; serotonins and non-serotonins. Serotonins cones are adapted to fire; they open only after they have been heated by fire, producing a new generation of lodgepole. Non-serotonins cones open at maturity and sow seeds annually. Cone serotiny varies in stands and cones can exist as either serotonins or non-serotonins. In the Rocky Mountains, most lodgepole populations typically exist in serotonins, or closed cone form. However, in some areas, the cone habit is largely non-serotonins, or open.

Figure 1. Lodgepole pine is the dominant tree species at Roosevelt Ridge frequently forming closed canopy forests.

Lodgepole pine is an early seral species with remarkable ecological amplitude (Schmidt 1989). Lodgepole pine is insensitive to harsh conditions and can therefore regenerate in disturbed areas. In either case of serotiny, dispersed seeds survive long cold winters to germinate in spring or early summer following snowmelt. Dry periods in spring and early summer limit seedling survival, but usually do not kill seedlings except on severe sites. Fall moisture has less effect on seedling growth. Pines are usually considered to be well adapted to establishment in the open. However, light overstory shade does improve the survival and early growth of pines by lowering daytime temperatures, thereby reducing water losses from seedlings and soil (Alexander 1974).

Silvicultural prescriptions and management of lodgepole pine stands are complicated by the interrelationships of the above mentioned factors (Shepperd and Alexander 1983). Management recommendations are provided in Appendix I.

Aspen

Quaking aspen (*Populus tremuloides*) is the most widely distributed tree in North America. Density is greatest in Minnesota, Wisconsin, Michigan, Colorado and Alaska with each state containing at least two million acres of commercial aspen forests (FEIS 2002). Quaking aspen is a native deciduous tree, typically less than 48 feet in height and 16 inches in diameter at breast height (DBH). It grows on a variety of sites including moist upland woods, dry mountainsides, high plateaus and along riparian corridors. Climatic conditions vary widely throughout their range, but aspen generally occur in moist areas. In the Rocky Mountains, altitude plays an important role in its distribution. At higher elevations, quaking aspen is stunted and grows bent or prostrate. The species is not shade tolerant, and it does not tolerate long-term flooding or saturated soils (FEIS 2002). Aspen reproduces from seed, but ratooning is the most common mode of regeneration. Aspen form clones (left) that are connected by a common parental root system; this characteristic allows it to sprout vigorously after burning, cutting or other disturbances.

Figure 2. Aspen stands with productive understories of herbaceous vegetation occur through Roosevelt Ridge.

Aspen communities are recognized for numerous values including recreation, aesthetics, water yield, water quality, wood products and landscape diversity (Kilpatrick et al. 2003). Healthy stands also act as natural fuelbreaks which reduce fire intensity and severity providing managers with additional control options (Kilpatrick et al. 2003). Aspens are also unique in their ability to stabilize soils and provide habitat for many bird and mammal species. Aspen stands are important nesting and hiding grounds for grouse, doves, warblers and juncos. Deer and elk browse on aspen year-round, but they are especially dependent upon it during fall and winter when aspen protein levels are high relative to other browse species. Aspen communities are described as the major "deer-producing forest type". Severe browsing by large numbers of elk and deer can have a great impact on aspen communities. Management strategies should be developed to disperse elk and deer more by temporarily fencing portions of high-use areas or drawing the ungulates to areas of improved forage with prescribed fire or other means (Suzuki et al. 1999).

Recent research has shown a 50 to 96% decline in aspen in the western United States, with a 49% decline in Colorado (Bartos 2001). Factors contributing to aspen decline include fire suppression, livestock grazing and ungulate browsing. In the absence of periodic burning, aspen will succeed to conifers or other vegetative types (Jones et al. 1985). For these reasons, aspen restoration should be given top priority throughout the west (Bartos 2001). Management recommendations are provided in Appendix I.

Forest Insects and Diseases

Mixed conifer forests are damaged by a variety of agents. Lodgepole pine is most seriously affected by mountain pine beetle (*Dendroctonum ponderosae*) and dwarf mistletoe (*Arceuthobium vaginatum*). Mountain pine beetles damage trees by boring holes into the tree cambium where they lay their eggs. As these larvae mature they consume the cambium disrupting the flow of nutrients in the tree. Outbreaks can develop in areas of heavy blow down, fire damage, overcrowded stands and in concentrations of logging slash. Dwarf mistletoe is a leafless parasitic plant that propagates on branches and stems of lodgepole and ponderosa pine trees. While mistletoe rarely kills trees by itself, infestations can be fatal to trees when in combination with other stressors; mistletoe infestations are also unsightly. The spread of mistletoe can be halted by propagating resistant tree species, removing infected individuals and isolating large infestations. Lodgepole pine is also susceptible to windthrow as it has a shallow root system. Lodgepole pine trees support each other against windthrow in dense stands but become susceptible to blow down as forests are thinned. For this reason lodgepole pine is typically managed in phases which occur over the course of years; during each phase forest density is reduced incrementally while the residual trees develop wind firmness.

Other common damaging agents to mixed conifer forests include the western spruce budworm (*Choristoneura occidentalis*), the Douglas-fir beetle (*Dendroctonus pseudotsuqae*) and the Ips beetles (*Ips species*); these insects attack trees through similar mechanisms as the mountain pine beetle. The western spruce budworm (*Choristoneura occiddentalis*) is also common, typically infesting Douglas-fir and white fir but may also be found on Englemann spruce, blue spruce and subalpine fir where they consume new foliage. Of minor concern is western gall rust (*Endocronartium harknessii*), a canker forming fungus that occurs on lodgepole pine branches and trunks. Like most forest insects and diseases, western gall rust has limited distribution at Roosevelt Ridge.

Aspen is host to a number of insects and diseases. Although many diseases attack aspen, relatively few kill or seriously injure trees. Trunk cankers are the most obvious disease problem of cankers in the west. The two most common are Cytospora canker (*Cytospora chrysosperma*) and Black canker (*Ceratocystis fimbriata*). Among the insects common to aspen are tent caterpillars (*Malacosoma californicum*), leafminers (*Phyllocnistis populiella*) and aphids (*Chaitophorus populicola*). Damage can also result from environmental causes such as sunscald and snow load (DeByle 1985).

Forest insects and diseases can spread quickly in overly dense, stagnated or drought stressed forests. The ecological and social value of the land is diminished and left prone to wildfire. Treatment options do exist for infected trees, but the most effective defense against insects and disease damage involve alleviating stress and competition among trees prior to attack. The forest restoration prescriptions made herein will promote the health of individual trees and the forest thereby maximizing the forests' resistance to these stressors. Specific management techniques for the forest insects and diseases found at Roosevelt Ridge are provided in Appendix I.

Wildfire Behavior

Wildfire hazard is based on landscape characteristics including slope, aspect, elevation, fuel type and anticipated fire behavior. While southern aspects typically have lighter fuel loads, they have a higher probability of ignition. The interplay of fuel temperature, fuel moisture and aspect are illustrated below.

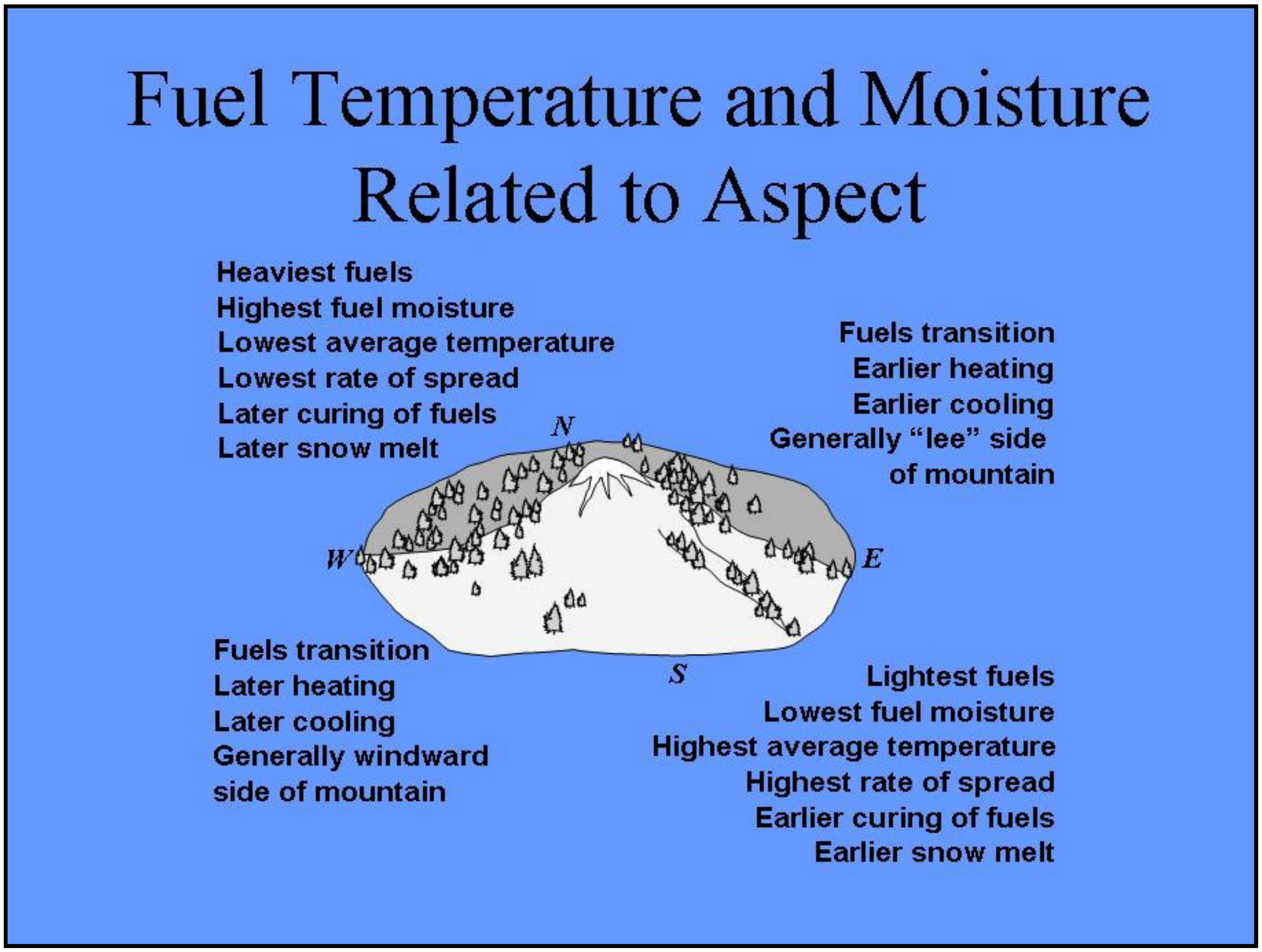


Figure 3. The interplay of fuel temperature and moisture as related to aspect.

Fire Suppression and Biological Processes

Fire is especially important in many western forest types; historically, fires regulated tree density and species composition, reduced the amount of dead biomass, maintained clearings and promoted nutrient cycling (Covington and Moore 1992, 1994, Covington and Sackett 1984, Covington and Sackett 1988, Fulé et al. 1997, Mast 1993, Swetnam and Betancour 1990). Fire suppression has caused major changes in the spatial pattern and ecological process of forested ecosystems. Thick organic layers on the forest floor and dense tree canopies have suppressed herbaceous vegetation in the understory (Sackett et al. 1993). Increased forest density decreased individual tree vigor resulting in greater mortality from insects, disease and drought. In the absence of fires, surface fuel loads and vertical fuel continuity increased to unprecedented levels creating ideal conditions for crown fires (Covington and Moore 1992, Covington and Sackett 1988, Fulé et al. 1997, Swetnam and Betancourt 1990). Prolific dead and down materials (fuel loading) increase fire line intensity and make forest fires difficult to extinguish. Many current forests have large fuel loads, are prone to insect outbreaks and are more susceptible to large catastrophic fires (Covington 1994, Covington and Moore 1992, Kaufmann et al. 1998, Rapport et al. 1998).

Prescribed Burns

Prescribed burns are generally the most effective means of reducing fire hazard, eliminating large numbers of understory trees, stimulating seral herbaceous and shrubby vegetation, creating receptive seedbeds and transforming nutrients into an available form (Arno and Harrington 1995, Fiedler et al. 1995). Prescribed burns are known to mitigate wildfire effects (Wagle and Eakle 1979) and can create landscape diversity that would be impossible to replicate by mechanical means alone. The structural diversity created by fire is also the best way to integrate management for varied ecological communities: there is no ecological substitute for burning. Current forest conditions, however, preclude the implementation of fire without mechanical treatments prior to prescription burns. A management scheme that incorporates both mechanical thinning and prescribed fire is therefore most likely to succeed.

The success of mechanical treatments used in conjunction with prescribed burns is illustrated by the Eldorado Fire in Boulder County (right). The background of this photo (green circle) received both thinning and prescribed fire in the fall of 1998 while the foreground (orange circle) received no treatment. A wildfire burned through both areas in September, 2000; a stand replacing "catastrophic" fire occurred in the orange circle while a low intensity surface fire occurred in the background (green circle).

Figure 4. The efficacy of fuels reductions projects when used in conjunction with prescribed fire are illustrated by the Eldorado Fire (above).

Fuel Treatments

The objectives of fuel treatment often incorporate ecosystem health and restoration. Fuel treatments include any manipulation of combustible materials (pre-commercial thinning and/or debris removal) and prescription burning. The effectiveness of fuel treatments is correlated with treatment intensity. There are several methods used to evaluate fuel treatment effectiveness. These assessments most frequently rely on retrospective (post fire) measurements of tree scorch height, canopy damage or depth of ground char (Omi and Martinson 2002). Fuel management techniques and their efficacy vary with forest type; the most useful measure of fire severity also differs across ecosystems (Omi and Martinson 2002). For these reasons and the lack of empirical data, this discussion is conceptual and based on findings from a variety of forest types. Treatment effects are variable in their significance but a cursory review of existing literature reveals several themes.

1) Surface fire intensity and continuity between fuel strata are critical factors in crown fire initiation. Likewise, crown fire propagation is dependent upon the abundance and horizontal continuity of canopy fuels; a reduction in crown fuels is therefore advisable (Omi and Martinson 2002).
2) Height of live crown typically determines crown fire initiation, but is also correlated with fire severity (Omi and Martinson 2002).
3) Tree density and average diameter are closely related to fire severity (Pollet and Omi 2002). Treatments that increase the average diameter of residual trees through the removal of the smallest stems appear to be most effective (Martinson and Omi 2003). Thus fuel treatments that reduce basal area or density from above (removal of the largest stems) are likely to be ineffective within the context of wildfire management.
4) Prescribed burning is an effective way to reduce fuel load (Wagle and Eakle 1979, Bastian 2000) and restore a critical ecosystem process (Arno and Harrington 1995, Fiedler et al. 1995).
5) Restoration treatments that incorporated low thinning, improvement cutting, and selection cutting were more effective at reducing the crowning index than diameter limit cuts were (Fiedler and Keegan 2003).
6) Areas that received some type of fuel treatment had 46% less crown volume scorch, reduced damage ratings and crown bulk density ratings below the threshold necessary for active crowning under extreme fire conditions (Omi and Martinson 2002).
7) Fuel management techniques need to be used in conjunction with prescribed burning to be most effective.

Fuel treatments provide options for landscape management that balance societal preferences with the unavoidable recurrence of wildland fire. In wildlands managed to include natural processes, fuel treatments can help to restore fire to its historic regime, either by restoring fuel profiles that facilitate safe management ignitions or by creating buffers between wildlands and values-at-risk or extensively managed areas where natural ignitions are allowed to burn themselves out (Martinson and Omi 2002). Recommendations are provided in Appendices I, II and III.

Methods

Forest Inventory

The property was inventoried with a stratified random sample design to quantify forest composition and density. The property was divided into four separate management units (Unit A, B, C and D) for the purpose of inventory and management. Two of these management units (Units B and D) were further subdivided into two separate stratifications on the basis of forest composition. These stratifications are named Unit B1, B2 and D1, D2. The management units are indicated on the Management Unit Map. The inventory was conducted with 42 variable plots (BAF 20). Field sampling evaluated forest characteristics including tree species, trees per acre, basal area, tree diameter, tree height, regeneration and incidence of disease. The site index, a measure of site productivity for a given species, was evaluated with increment bore readings. All inventory data were analyzed with **BIOCRUZ**; the Stand Visualization System (SVS) was utilized to create a graphical depiction of forest condition before and after treatment. While these depictions are based on forest inventory data, they do not present an *exact* replication of forest conditions. Forest stand tables and sample accuracy for all stratifications are presented in Appendix II.

Figure 5. Field measurements of tree diameter and site index were made with a diameter tape (orange) and increment borer (blue).

Fire Behavior Modeling

Fire behavior modeling provides a landscape level assessment of wildland fire hazards within the project area. Potential fire behavior was analyzed in order to determine which areas are most likely to burn and with what intensity. A **BEHAVE** simulation was run to compute potential fire behavior characteristics over the entire landscape for constant weather and moisture conditions. BEHAVE is a nationally recognized methodology for estimating a fire's intensity and rate of spread given topography, fuels and weather conditions. In order to model potential fire behavior across the project area, GIS data layers including elevation, slope, aspect, fuel models and canopy closure were utilized in FlamMap (Figure 6). This modeling procedure yields three maps: 1) *spread rate*, 2) *flame length* and 3) *crown fire activity*. These output maps illustrate the potential for fire behavior for the entire project area; they are used to prioritize treatment areas and guide fuel treatments. A detailed description of the wildfire modeling process and the input maps are provided in Appendix III; the output maps are presented in the Project Maps Section. Two fire scenarios were modeled for the property, one under *moderate conditions* and one under *extreme conditions*.

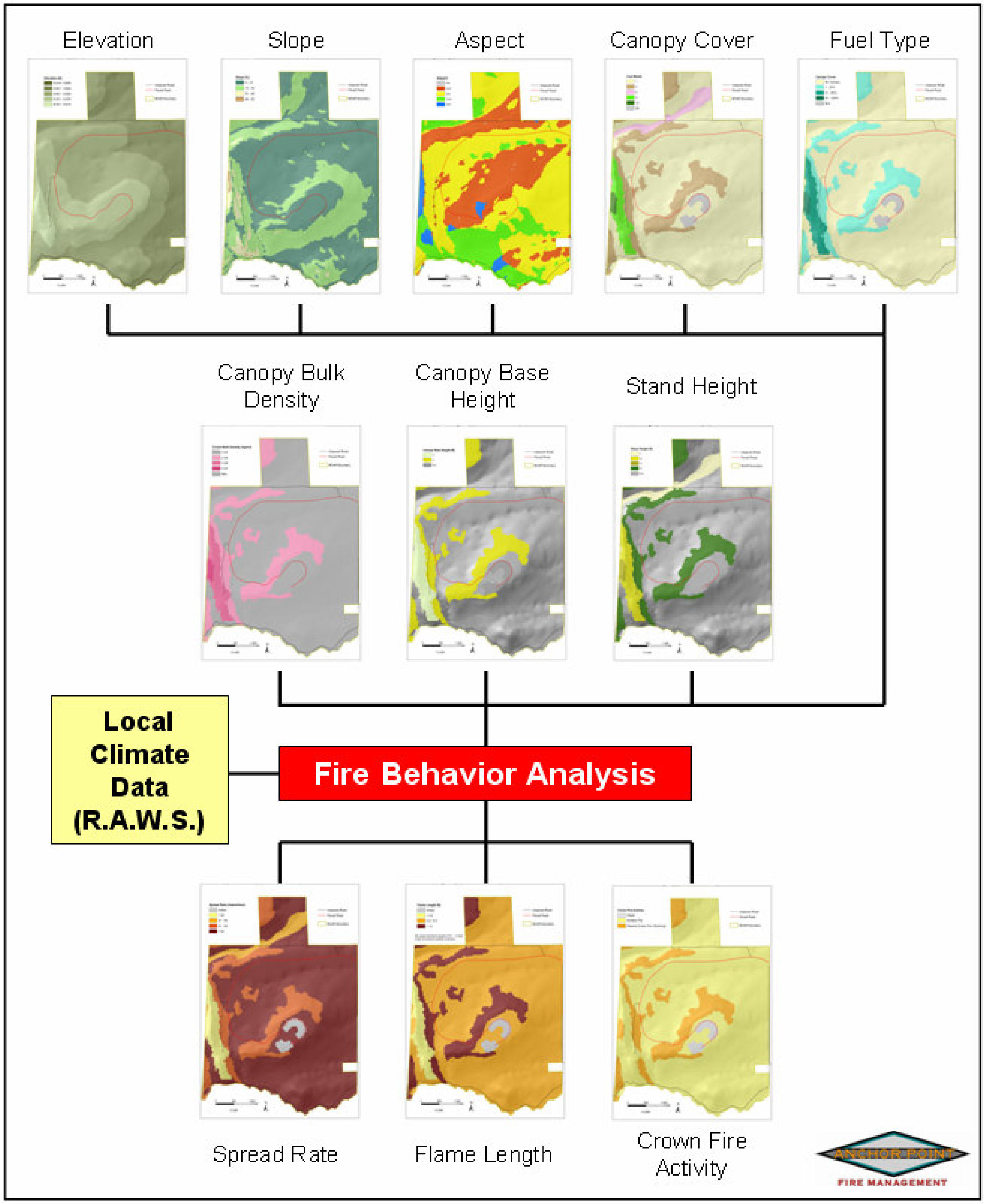


Figure 6. Fire behavior modeling utilizes geographic information layers including canopy closure, fuels, slope and aspect to produce maps of crown fire activity, rate of spread and flame length.

Results

Forest Inventory

The property has been divided into four separate management units (Unit A, B, C and D) for program implementation based on stand composition, location, density, wildfire hazard and topography (see the Management Unit Map in the Project Maps Section). Two of these management units were further subdivided as they contained aspen stands that were significantly different from the remainder of the unit. These sub stratifications are denoted as Unit B1, B2 and D1, D2. Management prescriptions for the forest management units are based on forest characteristics, inventory data and wildfire hazard. Discussions of forest inventory data and fire hazard analysis for all units and stratifications are provided below.

The photos and tables within these discussions are representative of the average condition but there may be significant variability surrounding these central tendencies. Basic stand data are summarized in tables that accompany each discussion. The Stand Visualization System (SVS) displays were included on adjoining pages to illustrate forest conditions within each management unit before and after treatment. The windthrow risk for all management units is assumed to be moderate based on slope, aspect, elevation and stand composition. Unit C is likely to have the greatest risk of windthrow; treatment in this area will be the least aggressive. Management prescriptions are described in the Appendix I.

Management Unit A

Description: The eastern portion of this unit supports an even aged stand of pure lodgepole pine with abundant mistletoe; the western portion of the unit supports multi storied (uneven aged) stands of mixed conifer trees (below). Aspen trees were common in the western portion of the unit comprising 10% of the total basal area. The understory of the western portion of Unit A was productive in contrast to the eastern portion which had little or no understory growth; the fuel load was low. A riparian corridor occurs on the northwestern portion of this unit. Several access roads are present. Thinning activities within this unit should include sanitation thinning, proportional cuts and patch cuts.

Figure 7. The western portion of Unit A supports a multi storied stand of mixed conifer and aspen trees.

Fire Hazard Analysis: Fires in this stand should be primarily low intensity surface fires. The deciduous ground cover is usually fire resistant and will not easily ignite or sustain fire. The primary concern in this area is fire propagation in mistletoe infested trees where small, dry twigs are abundant. The western portion also has mixed conifer with ladder fuels which present a crown fire hazard.

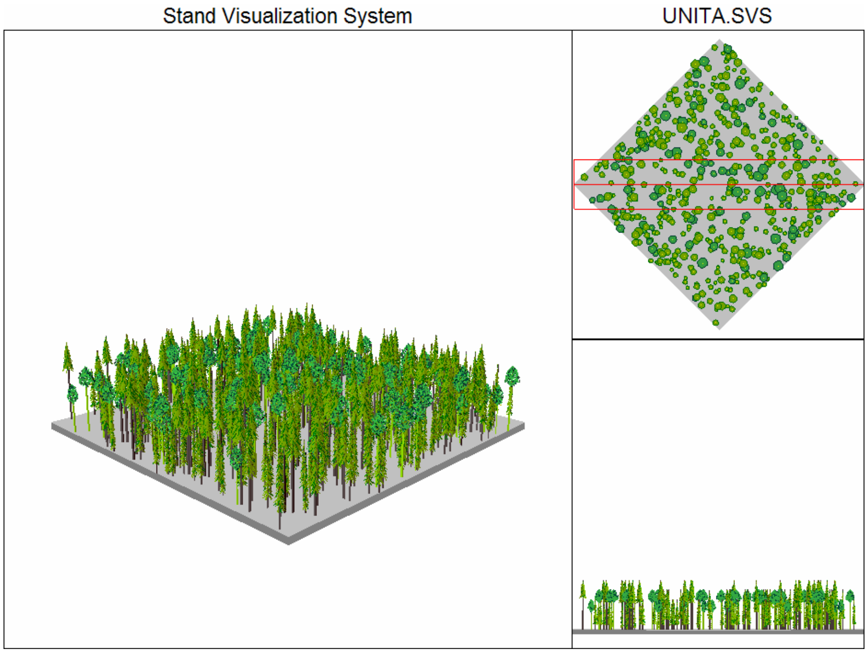
The FlamMap outputs show that under *moderate conditions* flame lengths in this area would be less than 4 feet, this low intensity fire could be readily extinguished with direct attack methods. The rate of spread would be less then 20 chains/hour or approximately ¼ mph. Such slow moving fires should not present significant problems to extinguish. Crown fire would not be anticipated under moderate conditions and few, if any trees would be involved. However, small diameter regeneration can act as ladder fuels which propagate torching or crown fire especially in the areas of fuel model 10 (FM 10).

Under *extreme conditions* a fire in the majority of this area would still have moderate fire behavior. The drainage in the northeast of the unit would be an exception because this area contains (FM 10); flame lengths would be would be 6 to 8 feet precluding direct attack methods. More importantly for this area is the potential for tree torching and crown fire development. The rate of spread stays the same because the density of the stands shelters the wind.

Table 1. Management Unit A summary.

Trees/Ac <1" DBH	BA Sq.'/Ac	Avg. Height'	Avg. Diameter"	Site Index	Fuel Models	Trees/ Acre	Total Acres
1404	153	42	6.8	59	8,10	602	116

BEFORE TREATMENT



AFTER TREATMENT

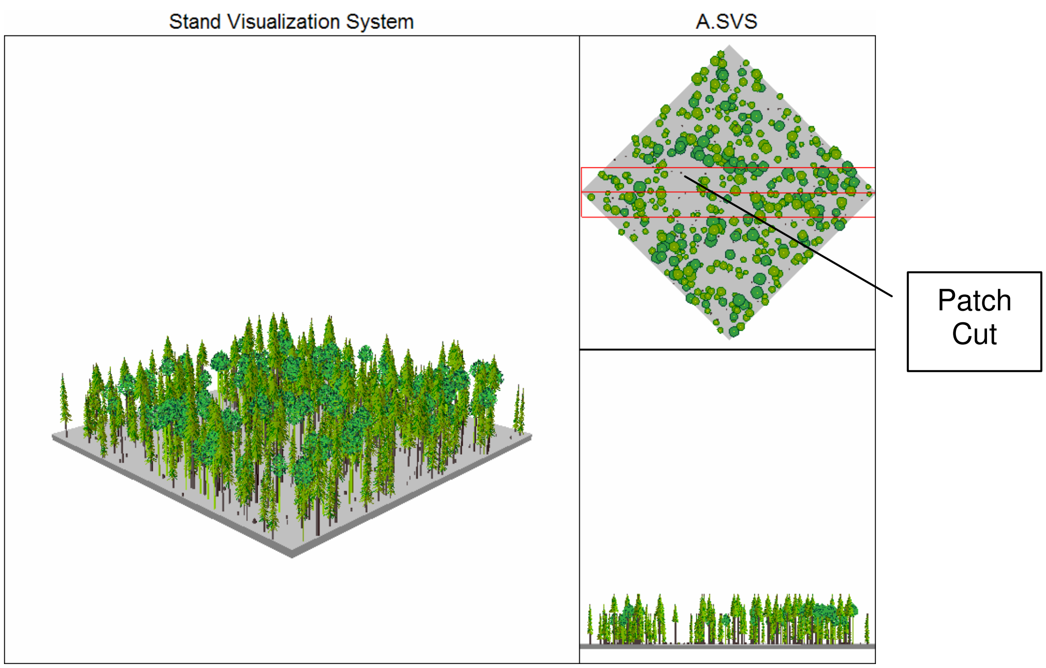


Figure 8. Current basal area within Unit A is 153 ft^2/acre (top); this density should be reduced by 25% to 115ft^2/acre. The recommended treatments within this unit include sanitation thinning, proportional cuts and patch cuts. Although the above simulation is based on inventory data, it is not an exact replica of forest structure.

Management Unit B1 (Mixed Conifer)

Description: This unit supports a multi storied mixed conifer forest with moderate amounts of fuels and a productive understory (below). Lodgepole pine is the dominant tree comprising 92% of the basal area with mixed conifer trees contributing the remaining portion. Several large Engelmann spruce were observed, some more than 70' tall. Aspen trees were also present but in small quantities. Mistletoe was observed in the central portion of this unit and there were many small areas of wet soil which contained more aspen trees than the remainder of the unit.

Fire Hazard Analysis: These stands have a slightly greater potential for severe wildfire as they are on steeper slopes and contain dense stands of mixed conifer trees with tight canopies (FM 10). These stands also have more dead and down materials which also contribute to intense fire behavior. The understory of small diameter "dog hair" trees can facilitate crown fire development. The proper conditions could result in a high intensity crown fire that would be more difficult to extinguish.

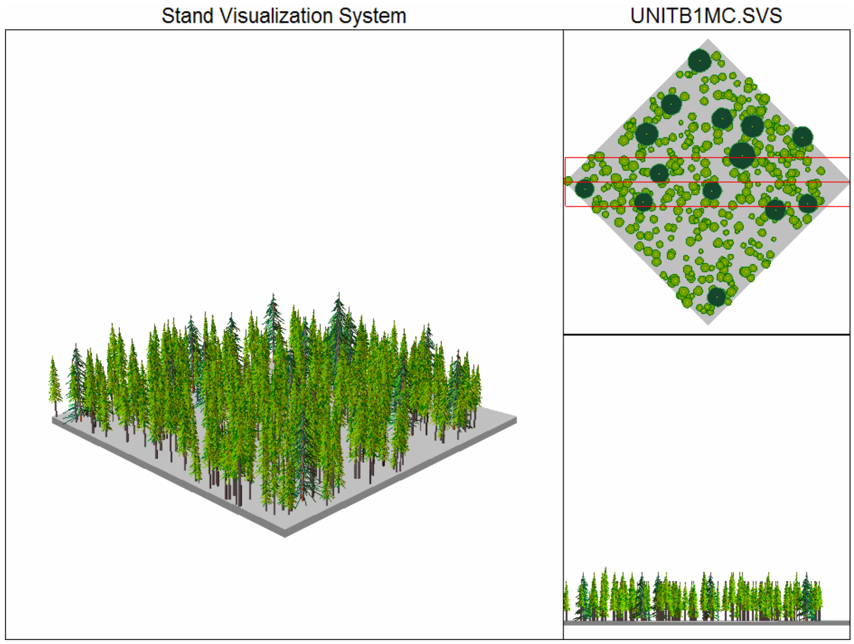
Under *moderate conditions* this unit has very similar fire behavior to Unit A. The rates of spread are fairly low (< 20 chains/hour) and the flame lengths would be up to 4 feet allowing the use of direct attack methods. Some pockets of trees would torch under these conditions with the possibility of crown fire on steeper slopes. Winds could spread embers up slope increasing the rate of spread.

Extreme conditions do not significantly increase the rate of spread of a surface fire; however, the FM 10 is a larger area and could generate significant heat intensity that would then ignite the crowns of the FM 8. The rate of spread would increase dramatically if the fire got into tree crowns where it would be exposed to the full force of the wind.

Table 2. Management Unit B1 summary.

Trees/Ac <1" DBH	BA Sq.'/Ac	Avg. Height'	Avg. Diameter"	Site Index	Fuel Models	Trees/ Acre	Total Acres
370	149	42	7.9	44	8, 10	433	142

BEFORE TREATMENT



AFTER TREATMENT

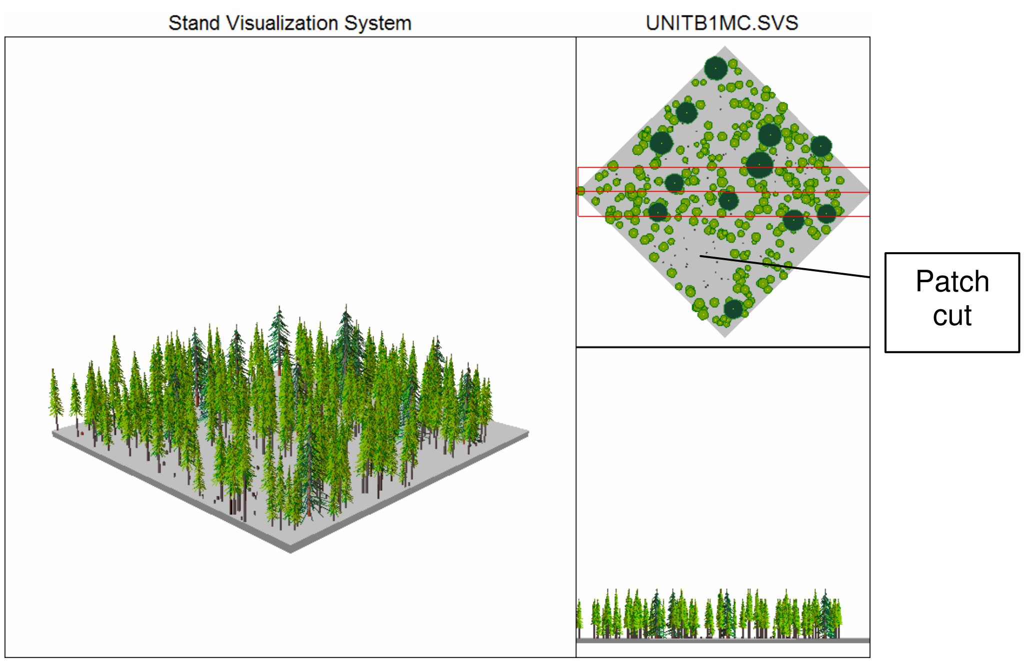


Figure 10. The current basal area within Unit B1 is approximately 149 ft^2/acre (top). This density should be reduced by 25% to 116ft^2/acre. The recommended treatments within this unit include a proportional cut, sanitation thinning and patch cuts. Although the above model simulation is based on forest inventory data, it is not an exact replica of forest structure before or after treatment.

Management Unit B2 (Aspen)

Description: The east central portion of this unit had little slope and moist soils. As a result it supported the best example of an aspen stand found on the property (below). Aspen contributed 86% of the basal area while Engelmann spruce Douglas-fir made up the remainder. Most conifer trees do not appear to pre-date the establishment of the aspen stand. The understory contained a robust mixture of grasses, forbs and sedges. The fuel load was moderate to low. This unit requires little active management apart from the removal of excessive fuels and small diameter encroachment where they occur.

Figure 11. Unit B2 supports a healthy aspen stand with a robust understory of herbaceous plants.

Fire Hazard Analysis: Fires in open aspen stands with grassy understories tend to be of very low intensity. The open canopy condition of these areas allows for good understory growth of fire resistant species. As the understory vegetation cures it is possible to get surface fire that might torch some of the conifers. The aspen overstory will not support crown fire. When the aspen is mixed in with Lodgepole pine it has a higher probability of burning because of the increased heat intensity from the pines.

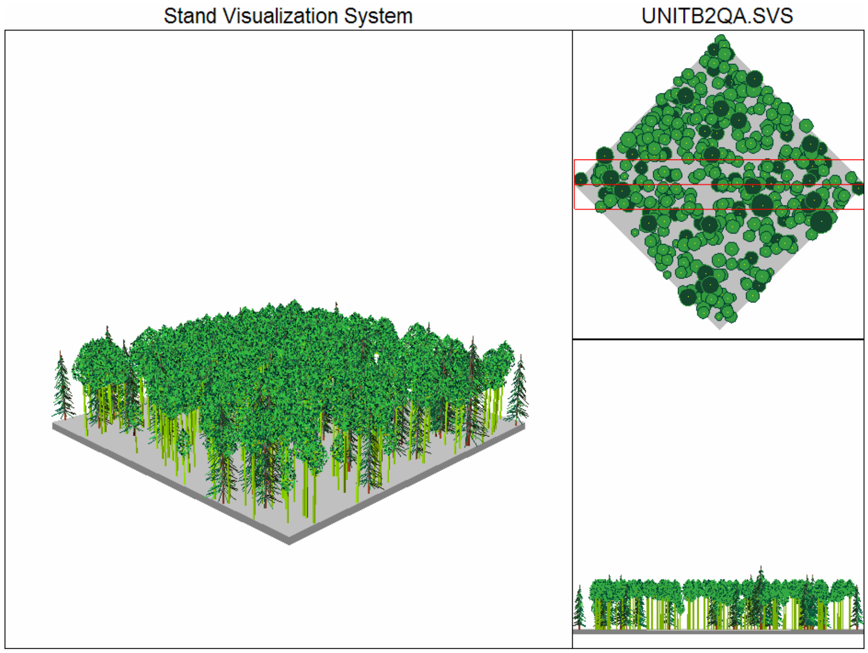
The FlamMap outputs show that under *moderate conditions* flame lengths in this area would be less than 4 feet; this low intensity fire that could be readily extinguished with direct attack methods. The rate of spread would be less then 20 chains/hour or approximately ¼ mph. This is considered a slow moving fire that should not present significant problems to extinguish. Crown fire would not be expected under these conditions and few, if any, trees would be involved.

Under *extreme conditions* fire behavior would still be very low. Flame lengths would still be less than 4 feet allowing for direct attack methods; the rate of spread would increase but not significantly. Under extreme drought conditions it is possible for aspens to burn because much of the understory vegetation would be dead and contribute to fire intensity.

Table 3. Management Unit B2 summary.

Trees/Ac <1" DBH	BA Sq.'/Ac	Avg. Height'	Avg. Diameter"	Site Index	Fuel Model	Trees/ Acre	Total Acres
288	187	47	8.8	N/A	Aspen	439	20

Before Treatment



After Treatment

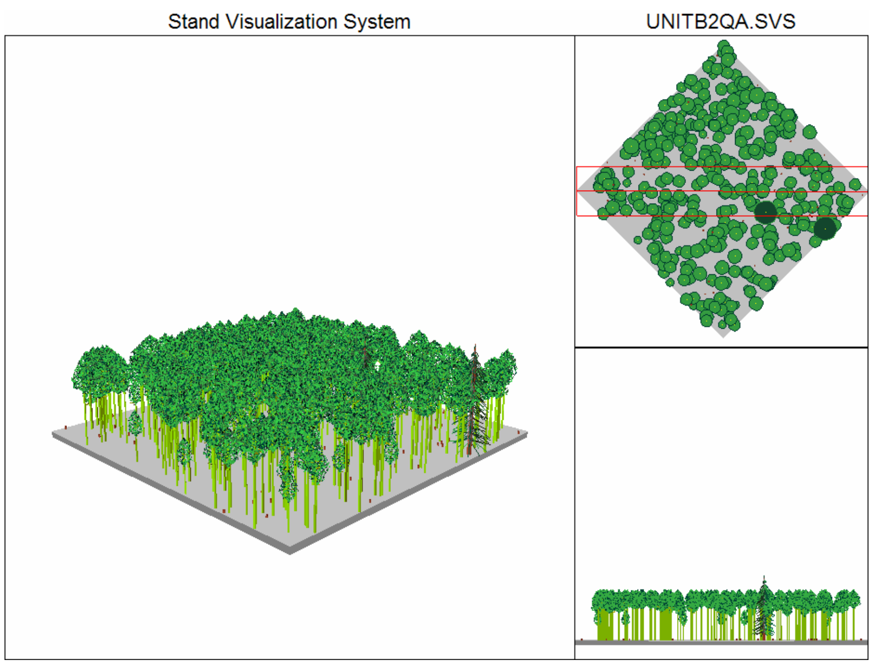


Figure 12. Current basal area within Unit B2 is approximately 187ft^2/acre (top); this density should be reduced by 10% to 168ft^2/acre (bottom). This treatment represents the removal or small diameter conifer regeneration. Although the above simulation is based on inventory data, it is not an exact replica of forest structure.

Management Unit C

Description: Conditions within this unit are extremely diverse. Lodgepole pine is the dominant tree contributing 82% of the basal area while aspen and other conifers contribute 11 and 7% of the basal area respectively. Multi storied uneven aged stands (left) were common but there are areas in the western portion of the unit that support pure stands of even aged lodgepole. There are also small aspen stands and wet meadows with robust herbaceous growth. The western portion of the unit has small areas with a western aspect where droughty conditions result in partial mortality and an open canopy. Mistletoe was observed in several locations and the fuel load was moderate. Thinning activities should include sanitation thinning, proportional cuts and patch cuts.

Figure 13. Unit C was extremely diverse with a multi storied uneven aged stand of mixed conifer trees.

Fire Hazard Analysis: Mixed conifer stands have the greatest potential for extreme fires as they have tight canopies with ladder fuels (FM 10) and occur on steeper slopes. Areas south of the property boundary have more dead and down materials (FM 11) which contribute to intense fire. These conditions could result in a high intensity crown fire that would be difficult to extinguish. The lodgepole areas would have lower fire intensity as there is little fuel to carry fire.

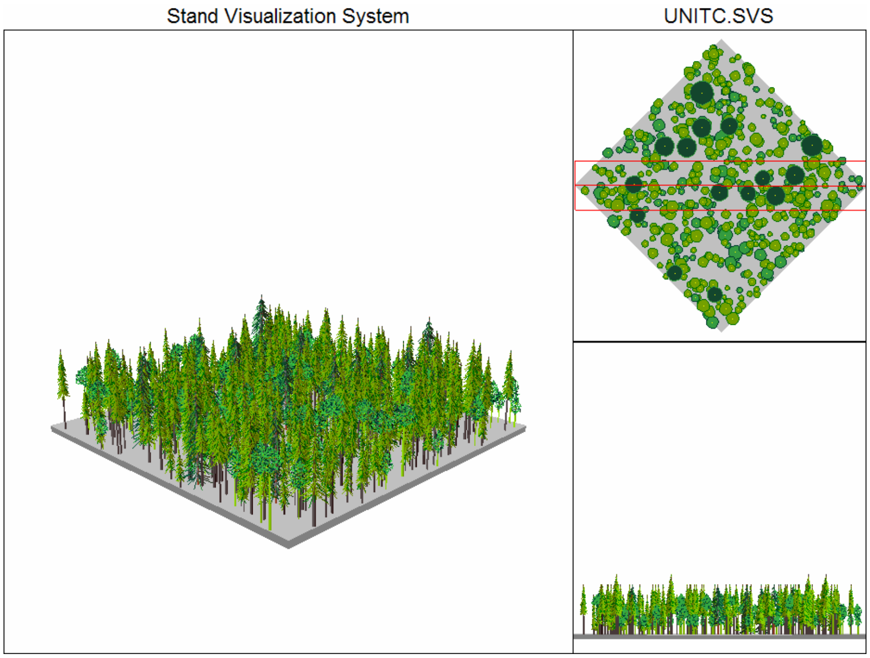
The FlamMap outputs show that under *moderate conditions* flame lengths in FM 8 and 10 would be less than 4 feet and the rate of spread in these areas would be less than 20 chains/hour or approximately ¼ mph; this low intensity fire could be readily extinguished with direct attack methods. Areas of FM 2 would have higher flame lengths and greater rates of spread because the open canopy condition would allow wind to fan the flames; this type of fire would be difficult to extinguish.

Under *extreme conditions* fire behavior would remain moderate due to wind sheltering by tree canopies. Steep slopes and areas of standing dead trees could cause torching and spotting. In areas of FM 2 flame lengths would be 8 to 12 feet which would create group torching and possibly crown fire; the rate of spread would double increasing fire size.

Table 4. Management Unit C summary.

Trees/Ac <1" DBH	BA Sq.'/Ac	Avg. Height'	Avg. Diameter"	Site Index	Fuel Model	Trees/ Acre	Total Acres
972	148	44	7.0	49	2, 8, 10	548	138

Before Treatment



After Treatment

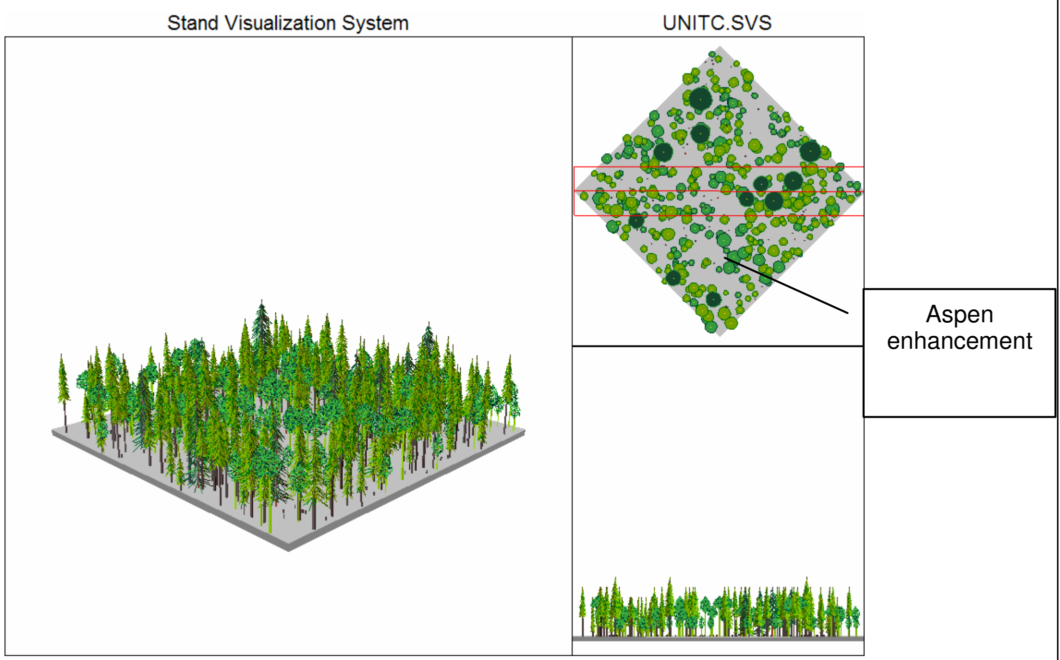


Figure 14. Current basal area within Unit C is approximately 148 ft^2/acre (top). This density should be reduced by 20 to 25% or approximately 112ft^2/acre. The recommended treatments within this unit include a proportional cut, patch cuts and sanitation thinning. Although the above simulation is based on inventory data, it is not an exact replica of forest structure.

Management Unit D1 (Mixed Conifer)

Description: This unit contains a multi storied uneven aged stand of mixed conifers (below). Lodgepole pine was the dominant tree contributing 81% of the basal area with aspen and other mixed conifers contributing 10 and 9% of the basal area respectively. Small pockets of pure aspen were common and lodgepole pine formed pure even aged stands in the eastern neck of this unit. The understory was productive due to an open canopy and the fuel load was moderate to high. Access exists in several places. Like Unit C, this unit had a west facing slope where conifers were in poor shape due to limited moisture. Thinning activities within this unit should include sanitation thinning, proportional cuts and patch cuts.

Figure 15. Unit D1 has an uneven aged stand of mixed conifers with the highest fuel loads found on the property.

Fire Hazard Analysis: These stands have greater potential for severe wildfire as they contain dense stands of mixed conifer trees with ladder fuels (FM 10). The large amount of dead and down fuel in conjunction with small diameter "dog hair" trees greatly increase the fire intensity and facilitate crown fire development. The proper conditions could result in a high intensity crown fire that would be difficult to extinguish.

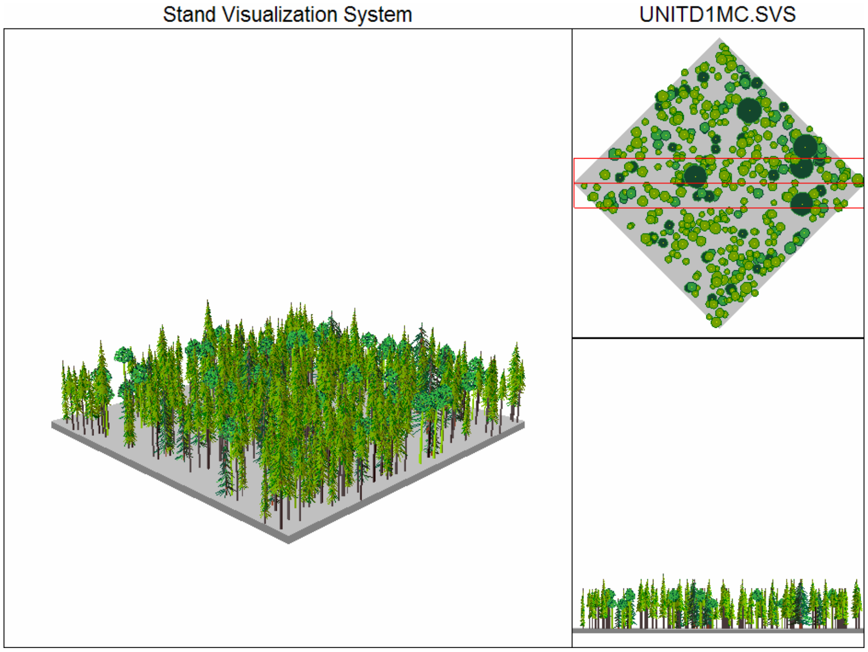
The FlamMap outputs show that under *moderate conditions* flame lengths in most of this area would be less than 4 feet, this low intensity fire that could be readily extinguished with direct attack methods. The rate of spread would be less than 20 chains/hour or approximately ¼ mph. This is considered a slow moving fire which should not present significant problems to extinguish. Torching is likely in areas of FM 10 where small diameter regeneration can act as ladder fuels.

Under *extreme conditions* fire behavior would still be fairly moderate, primarily due to wind sheltering. The areas with greater slopes or standing dead trees could cause group torching and spotting. Because large portions of this unit are prone to tree torching, crown fire development is likely. In this case the rate of spread would double thereby increasing fire size.

Table 5. Management Unit D1 summary.

Trees/Ac <1" DBH	BA Sq.'/Ac	Avg. Height'	Avg. Diameter"	Site Index	Fuel Model	Trees/ Acre	Total Acres
309	137	41	7.5	44	8, 10	444	109

BEFORE TREATMENT



AFTER TREATMENT

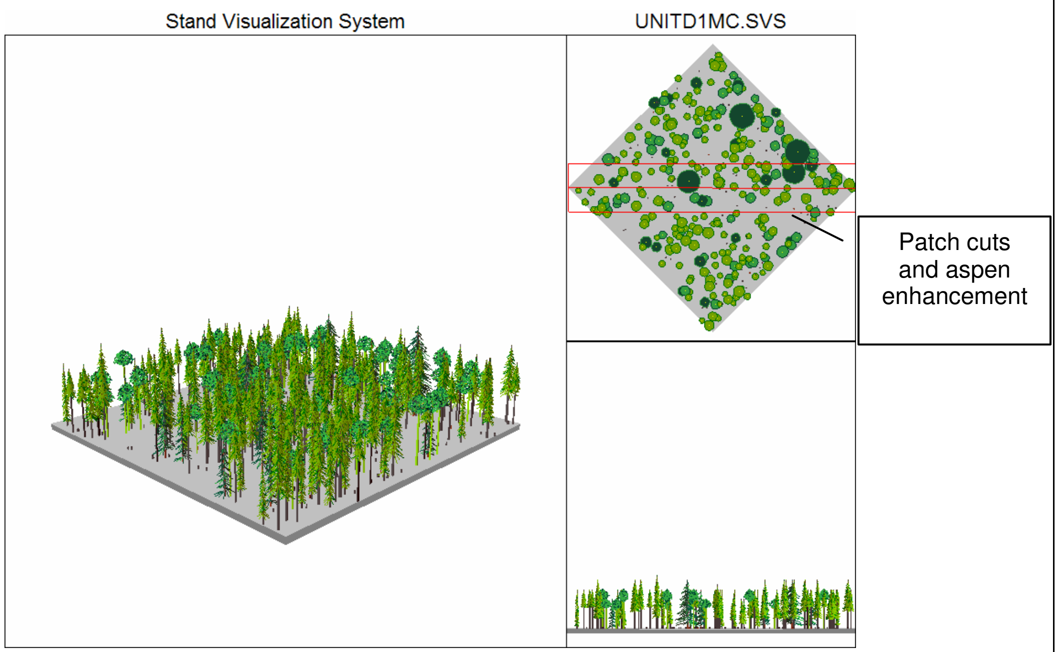


Figure 16. Current basal area within Unit D1 approximately 137 ft^2/acre (top). This density should be reduced by 30 to 35% or approximately 95ft^2/acre. The recommended treatments within this unit include a proportional cut, patch cuts and sanitation thinning. Although the above simulation is based on inventory data, it is not an exact replica of forest structure.

Management Unit D2 (Aspen)

Description: This unit supports the largest aspen stand on the property (below). Aspen dominated the community contributing 87% of the total basal area, small diameter lodgepole pine made up the remainder. Tree canopies are sparse resulting in a robust mixture of herbaceous growth; many forbs were in bloom at the time of sampling including paintbrush and columbine. The fuel load is low and there is access along existing roads and trails. Browse damage to aspen trees and other health problems were not prominent. This unit requires little active management apart from the removal of excessive fuels and small diameter encroachment where they occur.

Figure 17. Unit D2 supports a large aspen stand with a productive understory.

Fire Hazard Analysis: Fires in open aspen stands with grassy understories (FM 8) tend to be of very low intensity. The open canopy condition of these areas allows for abundant understory growth of herbaceous species that are fire resistant. In the event that this vegetation dries, it is possible that a surface fire could torch some conifer trees; however, the aspen overstory will not support crown fire.

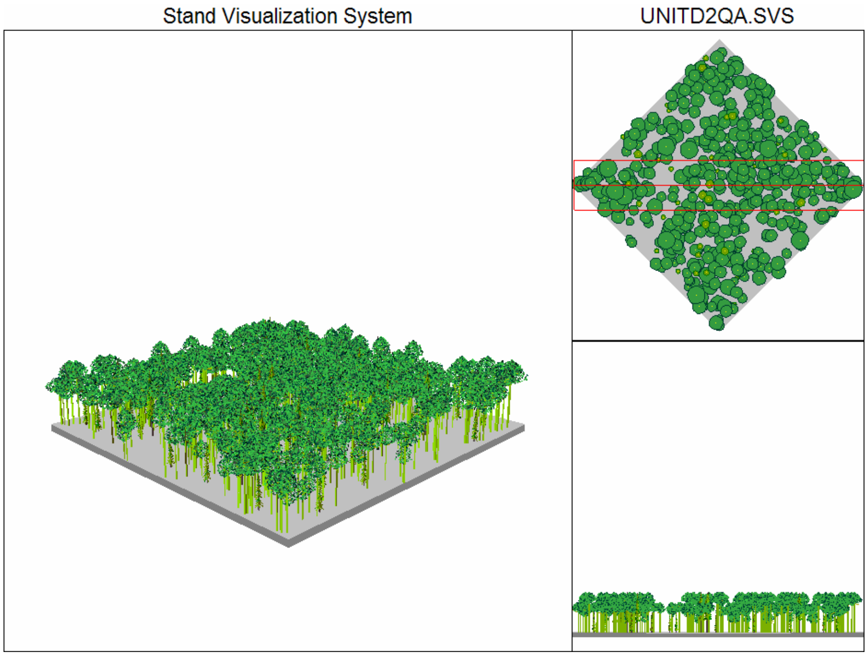
The FlamMap outputs show that under *moderate conditions* flame lengths in this area would be less than 4 feet, and the rate of spread would be less than 20 chains/hour or approximately ¼ mph. This type of low intensity and slow moving fire should not present significant problems to extinguish; direct attack methods could be utilized. Crown fire would not be expected under these conditions and few if any trees would be involved. However, small diameter conifer regeneration can act as ladder fuels which propagate crown fire.

Under *extreme conditions* fire behavior would remain very low. Flame lengths would still be less than 4 feet allowing for direct attack methods; the rate of spread would increase but not significantly. The aspen overstory could burn under extreme drought conditions when much of the understory vegetation would be dead, thereby increasing fire intensity.

Table 6. Management Unit D2 summary.

Trees/Ac <1″ DBH	BA Sq.′/Ac	Avg. Height′	Avg. Diameter″	Site Index	Fuel Model	Trees/ Acre	Total Acres
86	92	34	5.5	N/A	Aspen	551	42

BEFORE TREATMENT



AFTER TREATMENT

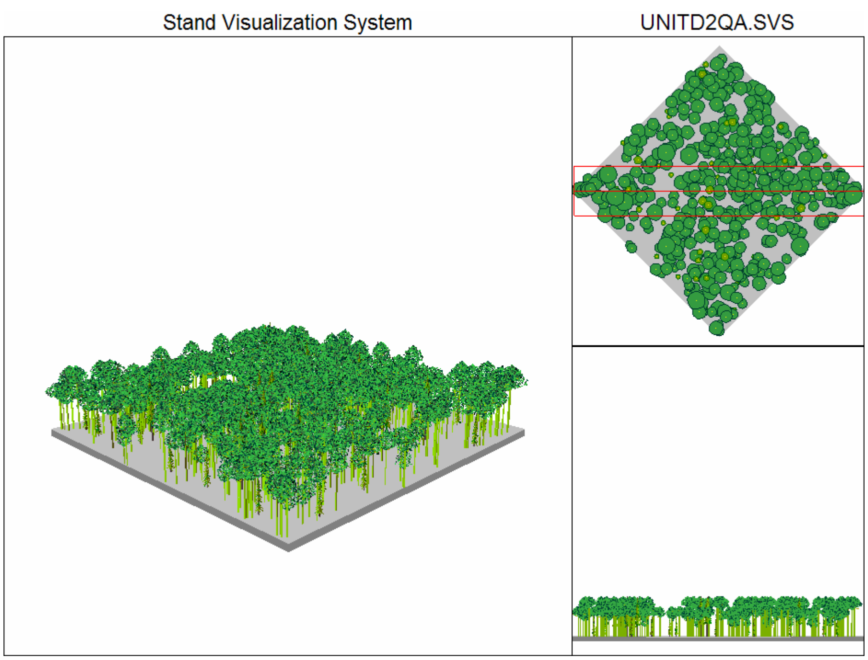


Figure 18. Current basal area within Unit D2 is approximately 92 ft^2/acre (top). This unit does not require a reduction in density; excessive fuels and small diameter conifer regeneration should be removed where they occur. Although the above simulation is based on inventory data, it is not an exact replica of forest structure.

Fire Behavior Modeling

The fire hazard analysis is based on model outputs that can be found in the Project Map Section. These map products include:

1) Crown Fire Activity Map (Average Conditions),
2) Crown Fire Activity Map (Extreme Conditions),
3) Flame Length Map (Average Conditions),
4) Flame Length Map (Extreme Conditions),
5) Spread Rate Map (Average Conditions) and
6) Spread Rate Map (Extreme Conditions).

Fire Behavior Analysis Outputs

Predictions of crown fire activity, rate of spread and flame length are derived from the fire behavior analysis. The output maps graphically display the outputs of **FlamMap** for both average and extreme weather conditions (output maps are presented in the Project Maps Section).

Crown Fire Activity: Crown fire activity values are generated by the **FlamMap** model and classified into 4 categories based on standard ranges: active, passive, surface and not applicable. In the surface fire category, little or no tree torching will be expected. During passive crown fire activity, isolated torching of trees or groups of trees will be observed and canopy runs will be limited to short distances. During active crown fire activity, sustained runs through the canopy will be observed that may be independent of surface fire activity.

Spread Rate: Spread rate values are generated by the **FlamMap** model and classified into four categories based on standard ranges: 0-20 CPH (chains/hour), 20.1-40 CPH, 40.1-60 CPH, and greater than 60 CPH. A chain is a logging measurement that is 66 feet. One mile equals 80 chains, 1 CPH equals approximately 1 foot/minute.

Flame Length: Flame length values are generated by the **FlamMap** model and classified in the four categories based on standard ranges: 0-4 feet, 4.1-8 feet, 8.1-12 feet and 12.1-60 feet. Flame lengths of 4 feet and less are acceptable for direct attack by hand crews. Flame lengths of 8 feet and less are suitable for direct attack by machinery. With flame lengths of greater than 8 feet, indirect and aerial attacks are the preferred methods.

Landscape Level Fire Hazard Analysis

Lodgepole pine is resistant to fire in most stages of its life. Typically, there are few ladder or ground fuels and fires smolder in the duff. Lodgepole stands are susceptible to high intensity crown fires when young regeneration is present, during its decline when there are ladder fuels present from encroachment by tree species or when large amounts of dead and down material have accumulated (right). The project area has stands in all of the life stages. Proper forest management of these areas is critical to prevent lodgepole communities from declining or being lost to catastrophic fire.

Figure 19. Excessive dead and down material contributes to high intensity fires.

Aspen is a fire resistant species, so much so, that it is frequently designated as a wildfire safety zone. Aspen stands can burn, but only under extreme conditions. Fires in aspen stands typically occur under droughty conditions or near other fuels, such as conifers, that are crowning or torching. Fires which enter aspen stands are moderated by moisture contained in aspen leaves and the herbaceous understory. Once leaves drop there is little possibility for fire to carry into the overstory. A low intensity surface fire is possible but should not present any problems to extinguish. Maintaining aspen stands and herbaceous meadows will greatly decrease the probability of wildfire. The aspen stands at Roosevelt Ridge will be excellent fuel breaks that prevent fires from moving into lodgepole pine stands once dead and down material and most conifer encroachment is removed. Aspen stands have been incorporated into the landscape level fuel break recommendations.

A major contributor to the fire hazard at Roosevelt Ridge is slope; because little can be done to reduce this portion of the hazard, fire prevention efforts need to shift towards strategic forest management and landscape level strategies as recommended in this document.

Implementation Considerations

There is an assortment of fuel treatment options available to land managers, include manual and mechanical methods. Wildfire mitigation planning will consider all options on a case-by-case basis. This mitigation plan has been developed from the landscape perspective and will be implemented to accommodate site specific project objectives including stand condition, financial constraints, accessibility, topography, aesthetics and political climate. Treatment costs can range between $1,000 to $2,000/acre. There are few temporal constraints on the implementation of these forest management activities.

Recommendations

Forest Management Recommendations

Forest management prescriptions outline actions that are designed to direct a forest towards a desired future condition. Management prescriptions were developed by identifying current conditions and comparing them with desired future conditions. Management goals are subsequently attained through the implementation of silviculture: the science and art of cultivating forests by controlling or manipulating the establishment, composition, and growth of trees. Management recommendations integrate forest health and wildfire mitigation.

Management activities are not a one time proposition; they must be integrated with a long-term plan for future treatments (Fiedler et al. 1995). Forest communities are not static over time, but rather are spatially and temporally dynamic as they are shaped by internal and external forces. Treatment interval will depend upon treatment intensity and method; a monitoring and adaptive management program is required to identify when an area needs to be revisited. Crown fire resistance achieved through restoration activities will deteriorate over time if maintenance thinning is not continued (Fulé et al. 2001). Treatment duration typically varies between 15 and 30 years; duration is dependent upon several factors including forest type, site productivity, fuel treatments, treatment intensity and anticipated wildfire behavior. Treatment duration will vary on a case-by-case basis. The management prescriptions should be reviewed and revised as necessary. Project prioritization is based on the wildfire hazard analysis and short range objectives of the development.

Special considerations in the management of lodgepole pine include the windthrow hazard and cone habit (serotonins vs. non-serotonins). Special provisions have been incorporated into this plan to minimize windthrow while achieving wildfire mitigation objectives. Thinning operations should be conducted over the course of 10 to 20 years so that the residual stand can develop wind firmness. If lodgepole regeneration is desired at some point in the future, steps must be taken to preserve a viable seed source. Reference conditions indicate that grassy meadows and aspen stands have been lost over the last century; rejuvenating these communities is compatible with Roosevelt land use objectives.

Management units may be sub-divided as necessary to accommodate changes in project funding, inaccessible terrain, variance in forest condition, ownership, or other unexpected circumstances. It is our intent to promote landscape diversity and fragment fuel profiles with a variety of forest prescriptions. Such variability will contribute to landscape diversity thereby creating more habitats and promoting resistance to wildfire, insect and disease epidemics. *Tree marking is the most critical phase of forest restoration and therefore should be conducted by qualified professional foresters familiar with mixed conifer forests and wildfire mitigation.* Additional assistance with project administration is strongly recommended. Management prescriptions are presented in Appendix I; this information should be used in conjunction with the Management Unit Map and Recommended Landscape Fuelbreak maps presented in the Project Maps Section. Descriptions of forest insects and diseases at Roosevelt Ridge and their management, and performance standards for forest operations are presented in Appendix II. Appendix III contains wildfire modeling methods and additional wildfire information.

NOXIOUS WEEDS

Introduction

Statement of Needs

Understory vegetation including grasses, forbs, sedges, succulents and shrubs are a critical component of a functioning forest community. The abundance and diversity of these plants directly influence the abundance and diversity of wildlife and are indicators of ecosystem condition. Herbaceous and shrubby plants provide structural diversity to the landscape and habitat for a multitude of wildlife species. The function of herbaceous communities, however, is frequently disrupted by noxious weeds. Noxious weeds are invasive plants that have been introduced to native ecosystems, intentionally or unintentionally, that are capable of displacing native vegetation thereby turning a productive ecosystem into a monoculture of undesirable plants (CWMA 2002).

Noxious weed invasions are an ecological catastrophe capable of drastically affecting plant and animal diversity, impoverishing native plant populations, damaging watersheds and lowering site productivity. In the absence of active management, noxious weed populations will proliferate, further diminishing the economic and biological value of the landscapes where they occur.

Noxious Weed Management Objectives

1) Reduce the abundance and prevent establishment of exotic species.
2) Maintain native plant species abundance and diversity.

Background

Exotic Species and Noxious Weeds

Exotic species adversely affect natural communities by changing native community structure, altering fire regimes, increasing water use in riparian areas and impacting wildlife habitat (Mack et al. 2000). The ecological damage of weed invasions is long lived and often worsens over time. Exotic species impact agricultural lands, rangelands and forests, alter ecosystem function and threaten native biodiversity important for economic, ecological and ethical reasons (Vitousek et al. 1997; Mack et al. 2000). In fact, exotic species cost the United States approximately $137 billion annually in the form of lost revenue and environmental damage (Pimentel et al. 2000). Nearly half of the nation's threatened and endangered species are listed due to competition with or predation by exotic species (Pimentel et al. 2000). Some exotic species are more disruptive to a system than others; the most disruptive plants are termed noxious. Noxious weed lists are maintained by federal, state and local management agencies. The Colorado Noxious Weed Act of 1990 requires landowners to manage noxious weeds if those weeds are likely to impact neighboring lands (CNAP 2002).

Methods

Noxious Weed Assessment

The composition of noxious weeds at Roosevelt Ridge was assessed during the forest inventory. Sampling efforts were conducted along the existing roads and throughout the forested areas as the inventory team traversed between inventory plots; noxious species were recorded.

Results

Roosevelt Ridge Noxious Weeds

Because the project area has not yet been significantly disturbed, the abundance and distribution of noxious plants is limited; only four species were found including oxeye daisy (*Chrysanthemum leucanthemum*), Canada thistle (*Cirsium arvense*), yellow toadflax (*Linaria vulgaris*) and musk thistle (*Carduus nutans*). All species were found adjacent to access roads (right). While the vegetative communities at Roosevelt Ridge are not yet seriously impacted by noxious species, the establishment and proliferation of undesirable plants will likely occur as the property is developed.

Figure 20. Canada thistle was found along roadsides.

Recommendations

Noxious Weed Management Recommendations

No single management technique is perfect for all weed control situations; several management activities are therefore required. Integrated Weed Management (IWM) is a process by which several management techniques (cultural, biological, mechanical and chemical) are applied in combination to control a particular species with minimal adverse impacts on non-target organisms. This approach is predicated on ecological principles and integrated multidisciplinary methodologies to develop strategies that are practical, economical and protective of environmental health. IWM is species specific, site specific and practical, with minimal impacts to other organisms (CNAP 2000). "An ounce of prevention is worth a pound of cure" is certainly appropriate for the management of noxious weeds. In order to control noxious weeds, management efforts should focus on:

1) reducing unnatural disturbance to native plant communities,
2) preventing the spread of additional weed populations,
    a. Incoming construction equipment should be pressure washed to help reduce the spread of weeds from outside sources.
    b. Through covenant control, mandate the use of only native plant species for landscaping.
    c. Through covenant control, mandate the eradication of any noxious weed populations after home site development and throughout ownership.
3) educating land owners and project managers about the effect of weeds,
4) inventorying weed populations,
5) containing, suppressing or eradicating populations when found and
6) monitor the status of weed populations and control efforts.

Depending on weed densities, available resources, political environment and the species in question, a variety of options are available for controlling the weeds at Roosevelt Ridge. The optimum combination of techniques may not be possible in every circumstance due to financial, geographic or political constraints.

Weed species in addition to those already identified are expected to occur in the project area as it is developed. *Because this area is not yet disturbed, this is an optimal time to control the establishment of undesirable plants.* We recommend that aggressive re-vegetation efforts be taken as soon as possible after disturbance, and that an annual weed inventory be conducted. These efforts should be used in conjunction with an integrated management plan that includes spatially explicit documentation of control efforts. Information about the life history, habitat requirements and control strategies for noxious species found at Roosevelt Ridge are provided in Appendix IV.

WILDLIFE

Introduction

Statement of Needs

Large tracts of natural habitat in the Rocky Mountains support a variety of ecosystems, each of which provides habitat for a unique set of wildlife species. Wildlife management techniques should be applied to enhance habitat types and ecosystems that are important to desirable species. As a part of any planning effort, a thorough assessment of the site should be completed. This assessment should include, but not be limited to, an inventory of habitat types present on the site, an inventory of plant species and wildlife species present on the site and identification of species that could utilize the habitats identified on the site. Special status plant and wildlife species that may require particular consideration under federal, state, or local regulations should also be identified. A number of federal, state and local laws and regulations determine how management and development may be applied to a specific property. These include: the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531-1544); the Clean Water Act (CWA), Section 404 (33 U.S.C. 1344); Environmental Protection Agency regulations; the Migratory Bird Treaty Act of 1918 (MBTA)(16 U.S.C. 703-712); the Bald and Golden Eagle Protection Acts (16 U.S.C. 668-668d); the Colorado Noxious Weed Act (§§ 35-5.5-101 through 119, C.R.S. [revised 2003]) and Colorado SB40 regulations (§§ 33-5-101, CRS 1973). In many instances, the application of these laws and regulations can be influenced by the type of ownership and sources of funding (federal, state, local or private) to be used for development or management.

Wildlife Management Objectives

1) Improve habitat diversity and quality for native wildlife species.
2) Maintain or increase native wildlife species diversity and richness.
3) Manage native wildlife population densities to conform to habitat limitations and desired habitat goals.
4) Protect critical habitat of special status species (threatened, endangered or species of concern).
5) Reduce and control exotic wildlife populations and noxious weeds.
6) Manage recreational use of the property to minimize habitat degradation, wildlife disturbance, sources of sedimentation and erosion.

Background

Roosevelt Ridge Wildlife

Wildlife species occurring at Roosevelt Ridge are generally associated with habitats that include dry mountains, rocky outcrops, steep terrain, cliffs, coniferous forests, cold mountain streams, mountain meadows, disturbed areas, road right-of-ways and forest openings. Vegetative communities covering most of the property can be characterized as homogeneous coniferous forest mixed with mature aspen stands and scattered mountain meadows. Several riparian corridors associated with small permanent and intermittent streams are also present in the southeast, southwest and northwest portions of the property.

Methods

Wildlife Assessment

A review of existing wildlife inventory data was conducted to identify species that could inhabit or utilize the Roosevelt Ridge property and its immediate vicinity. This review incorporated inventories of Gilpin County, Boulder County, the U.S. Fish and Wildlife Service and the Colorado Natural Heritage Inventory. A list of species that might be found on the site was determined by utilizing local data and by reviewing technical and popular publications (Robbins et al. 1966, Peterson 1990, Page and Burr 1991, Stebbins 1985, Burt and Grossenheider 1986, Lechleitner 1969, Armstrong 1972). Several agency personnel were also interviewed including the U.S. Fish and Wildlife Service (per. comm. Peter Page 2005), the Colorado Department of Wildlife (per. comm. Gary Skiba 2005), the Colorado Natural Heritage Program (per. comm. Michael Menefee 2005) and the Boulder County Parks and Open Space Department (per. comm. Rick Koopman 2003). The common name, scientific name, probability and seasonality of occurrence and habitat preference were recorded for all species. (These species lists are presented as tables on the Electronic Database in Appendix VIII).

In addition, literature relating to special status species in the project vicinity was reviewed. The U.S. Fish and Wildlife Service, the Colorado Natural Heritage Inventory and other pertinent data sources were utilized for additional information relating to federally listed and state listed special status species in the project area. (Findings are presented in Table 10, Appendix V.)

An onsite assessment was conducted by Steve C. Johnson, Senior Ecologist with Natural Resource Services, Inc. (NRSI) on August 11, 2005, to identify wildlife habitat types including unique habitats upon which special status species rely. Noxious weed species listed on the Colorado Noxious Weed List were also noted during the site visit. Findings, conclusions and recommendations were incorporated into this management plan.

Results

Roosevelt Ridge Habitat Description

Predominant plant species identified by NRSI on the property during the August 11, 2005 site visit included:

<u>Overstory</u>:

Lodgepole pine (*Pinus contorta*)
Engleman spruce (*Picea engelmannii*)
Douglas fir (*Pseudotsuga menziesii*)
Limber pine (*Pinus flexilis*)
Quaking aspen (*Populus tremuloides*)
American dwarf mistletoe (*Arceuthobium americanum*)

<u>Understory Shrub Layer</u>:

Aspen (*Populus tremuloides*)
Alder (*Alnus tenuifolia*)
Red elderberry (*Sambucus racemosa*)
Choke cherry (*Prunus virginiana*)
Wild plum (*Prunus americana*)
Common juniper (*Juniperus communis*)
Oregon grape (*Mahonia repens*)
Shrubby cinquefoil (*Pentaphylloides floribunda*)
Prickly rose (*Rosa acicularis*)
Wood's rose (*Rosa woodsii*)
Wild raspberry (*Rubus idaeus*)
Ninebark (*Physocarpus opulifolius*)

<u>Herbaceous Layer</u>:

Grasses:

Common timothy (*Phleum pratense*)
Reed canarygrass (*Phalaris arundinacea*) – not native
Tufted hairgrass (*Deschampsia caespitosa*)
Rocky Mountain trisetum (*Trisetum montanum*)
Smooth brome (*Bromus inermis*)
June grass (*Koeleria macrantha*)
Ticklegrass (*Agrostis scabra*)
Purple reedgrass (*Calamagrostis purpurasceus*)
Giant wildrye (*Leymus cinereus*)
Mountain brome (*Bromus carinatus*)
Spike trisetum (*Trisetum spicatum*)

Forbs:

Common yarrow (*Achillea lanulosa*)
Spreading Golden bean (*Thermopsis divaricarpa*)
Platte thistle (*Cirsium canescens*)
Pineappleweed (*Matricaria matricarioides*)
Dandelion (*Taraxacum officinale*) – not native
Silky crazyweed (*Oxytropis sericea*)
Prostrate knotweed (*Polygonum aviculare*) – not native
Fireweed (*Epilobium angustifolium*)
White cinquefoil (*Potentilla arguta*)
Sticky purple geranium (*Geranium viscosissimum*)
Silky scorpionweed (*Phacelia sericea*)
Willow dock (*Rumex salicifolius*)
Northern goldenrod (*Solidago multiradiata*)

The three minor riparian corridors identified within the Roosevelt Ridge property provide habitat for mammal, bird, reptile and amphibian species associated with moist woodlands and meadows. These corridors are associated with the headwaters of small unnamed perennial and intermittent streams which flow into the Beaver Creek watershed, part of the upper South Boulder Creek watershed. All of these corridors flow generally south to north.

Roosevelt Ridge Wildlife

Wildlife species that could potentially inhabit or utilize the Roosevelt Ridge property are listed in tables on the Electronic Database (Appendix VIII). A total of 128 bird species, 56 mammal species, 14 reptile and amphibian species, and 16 fish species were identified as possibly occurring within the Roosevelt Ridge site. As indicated in the tables, the area falls within the breeding range of 99 species of birds, within the wintering range of 61 species of birds and within the migration range of 113 species of birds.

The Roosevelt Ridge site also provides potential habitat for a number of wildlife species of special concern as shown in Table 10 (Appendix V). The data in the Table were developed from the Colorado Department of Wildlife Species of Concern List (revised April 2003) as well as from consultation with the Colorado Natural Heritage Program (per. comm. Michael Menefee 2005) and the U.S. Fish and Wildlife Service (per. comm. Peter Plage 2005) and the Boulder County Parks and Open Space Department (per. comm. Rick Koopman 2005). As with more common wildlife species, the probability of occurrence within the Roosevelt Ridge site was determined for each species after reviewing range and habitat data and verified occurrences on adjacent properties as provided in the literature. Table 10 also provides a key to the listing status of each species, i.e. federally and/or state listed as Threatened or Endangered and state listed as a Species of Concern. **<u>Note</u>: No wildlife species listed in Table 10 nor any listed plant species have been verified as occurring within the Roosevelt Ridge site, although some species have been verified on similar property located in Gilpin and Boulder counties.**

Discussion

Wildlife Discussion

The literature review and site visit resulted in the following observations:

1) At present, available wildlife habitat appears to be excellent for native species. Habitat diversity could be improved, however, by creating and enhancing meadows and by thinning and opening up homogeneous conifer stands to create more diversity and reduce wildfire danger.

2) A number of special status species and their critical habitats are known to occur in the vicinity of the Roosevelt Ridge property but none, to date, have been found on the site.

3) A large number of native wildlife species utilize the various habitats found on the Roosevelt Ridge property either as year round residents, migrant breeding populations, or as migrants through the area at some time of the year. A minimal number of exotic wildlife species also utilize the area.

4) Deer and elk populations appear to be in balance with the available browse supply. Excessive damage to vegetation due to over-browsing is not currently a problem.

5) Erosion and excessive sedimentation does not appear to be a major problem on the site at the present time, but erosion associated with new roads and timber harvest operations could develop if control measures are not implemented and maintained.

6) Exotic vegetation and noxious weeds (including species listed on the Colorado Noxious Weed List (§§ 35-5.5-101 through 119, C.R.S. [revised 2003])) have invaded some communities of native vegetation, primarily in the immediate vicinity of access roads. These weeds were probably introduced during road construction. Other areas within the property are relatively weed free. Identified noxious weed species include:

   a. Oxeye daisy (*Chrysanthemum leucanthemum*)
   b. Canada thistle (*Cirsium arvense*)
   c. Yellow toadflax (*Linaria vulgaris*)
   d. Musk thistle (*Carduus nutans*)

   Noxious weed control should be implemented over the entire site to prevent small infestations from becoming a major problem and degrading available habitat. See the Noxious Weed Section of this document.

Recommendations

Wildlife Management Recommendations

A residential development such as Roosevelt Ridge, which relies heavily on native ecosystems and healthy wildlife communities to enhance the aesthetic values of the properties, should give high priority to effectively managing those ecosystems to enhance aesthetics as well as habitat value for indigenous species. The forest management recommendations in this plan will enhance the habitats preferred by some wildlife species while altering habitats required by others. Forest thinning will reduce the spatial extent of dense forests while increasing the amount of open forests, thus enhancing wildlife habitat diversity by allowing more shrubby and herbaceous vegetation to become established. Habitat for wildlife species that prefer open forest will thereby be increased while habitat for species that prefer dense forest conditions will be decreased; each management practice has pros and cons which should be considered prior to plan implementation. We recommend the following steps be taken prior to initiating any management activities that may significantly alter existing habitats.

1) Identify existing critical habitats prior to the implementation of any management activities, infrastructure construction activities, etc. A thorough riparian and wetland assessment should be included in this inventory to identify areas that may be subject to regulatory requirements. Wildlife movement corridors should be identified and protected along with appropriate buffer areas. Protection of these areas will not only benefit the wildlife species which use them but will also protect aesthetic value of entire development, enhancing long-term property values.
2) Develop specific wildlife management objectives for the habitat types identified in the habitat inventory.
3) Prioritize any plant and animal species of concern that may utilize the site. Factors to be considered in developing priorities should include the preservation and/or enhancement of critical habitats in relation to anticipated forest management and wildfire mitigation activities, infrastructure development, recreational use, weed control and water quality protection. The management goals of adjacent properties should also be considered. Cooperation with adjacent landowners should be an integral part of any management process.
4) Develop a detailed wildlife management plan for Roosevelt Ridge that includes:
    a. The preservation, expansion and enhancement of key habitats for desirable species including special status or threatened and endangered species of plants and animals.
    b. The integration of wildlife management goals, such as critical habitat and movement corridors, with other management goals including forest restoration, wildfire mitigation, noxious weed control, water quality protection and recreational use.

c. Specific wildlife management objectives for each management unit on the property. This should include the identification and description of specific management practices to be implemented within each management unit.

d. A schedule for implementing management practices within each management unit and target dates for achieving management goals.

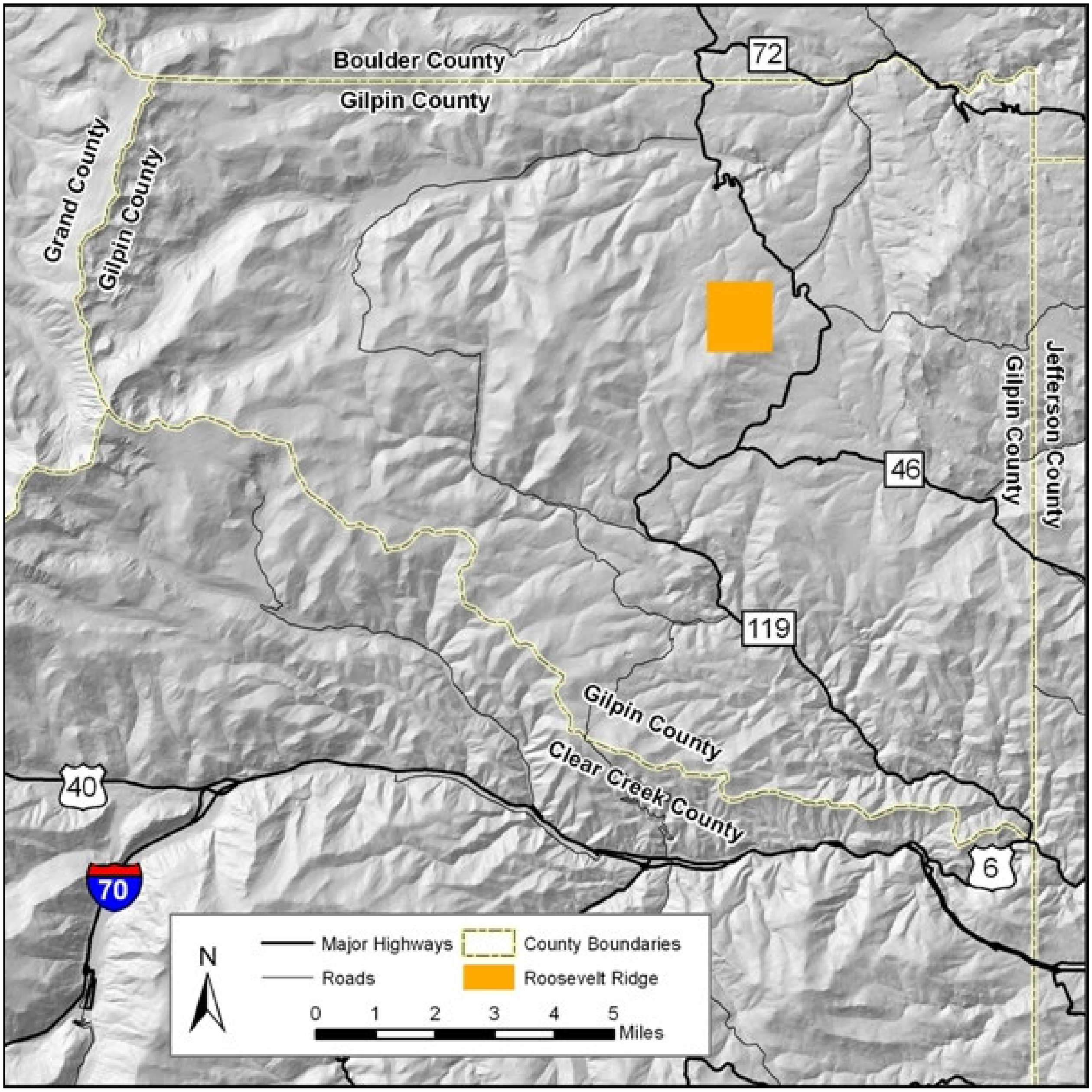
e. Proposed cost estimates and budgets for implementing management practices.

f. The creation of a monitoring and adaptive management program that will identify management issues early in the process of program implementation and allow for flexibility in addressing problems.

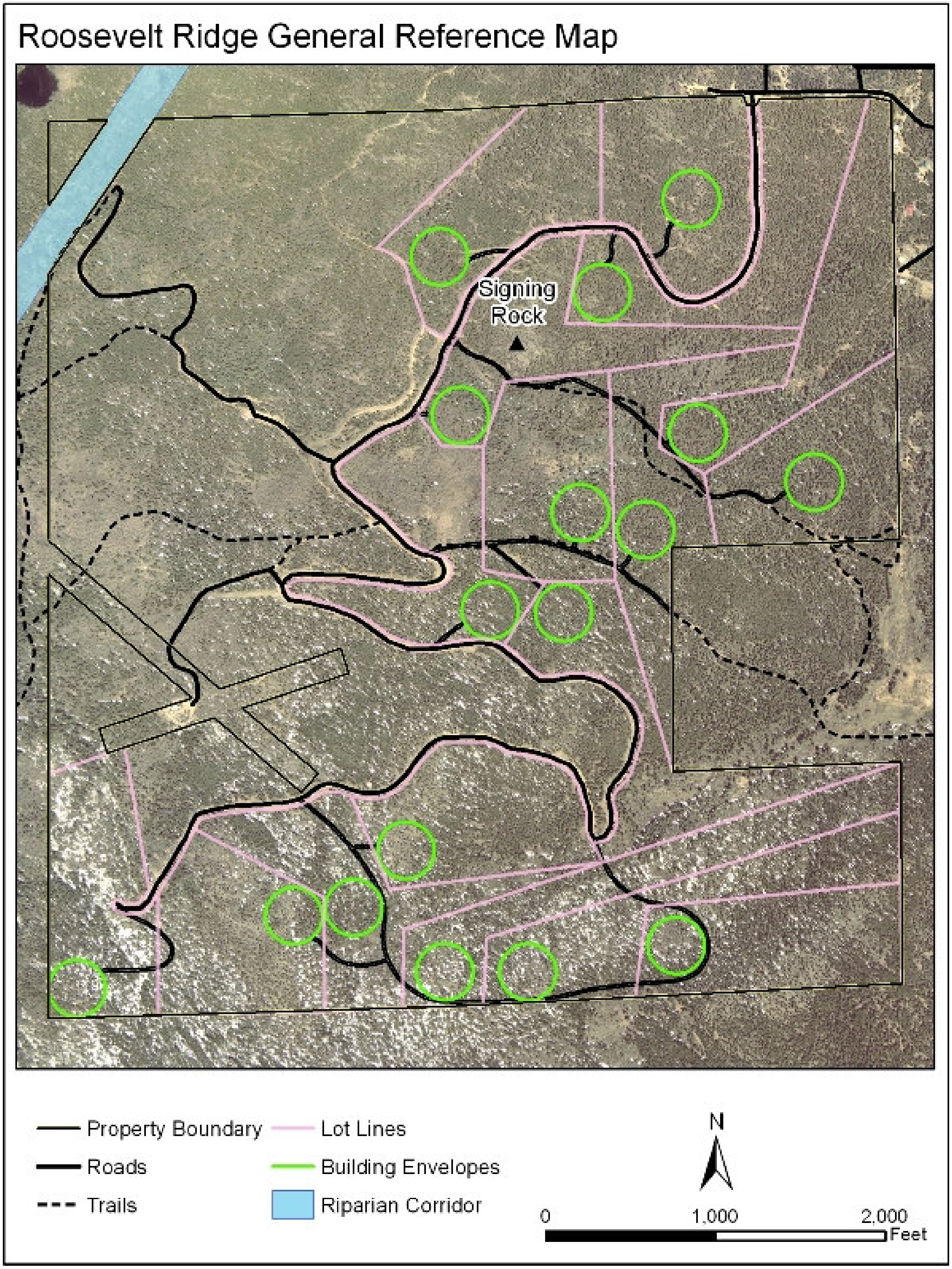
g. The integration of public education into the management process to inform landowners and recreational users about habitat management issues and reasons for implementation of various management practices. Attractive informational signage and printed materials should be considered as a means of providing information to individuals about wildlife species and habitats they may commonly see on the site.

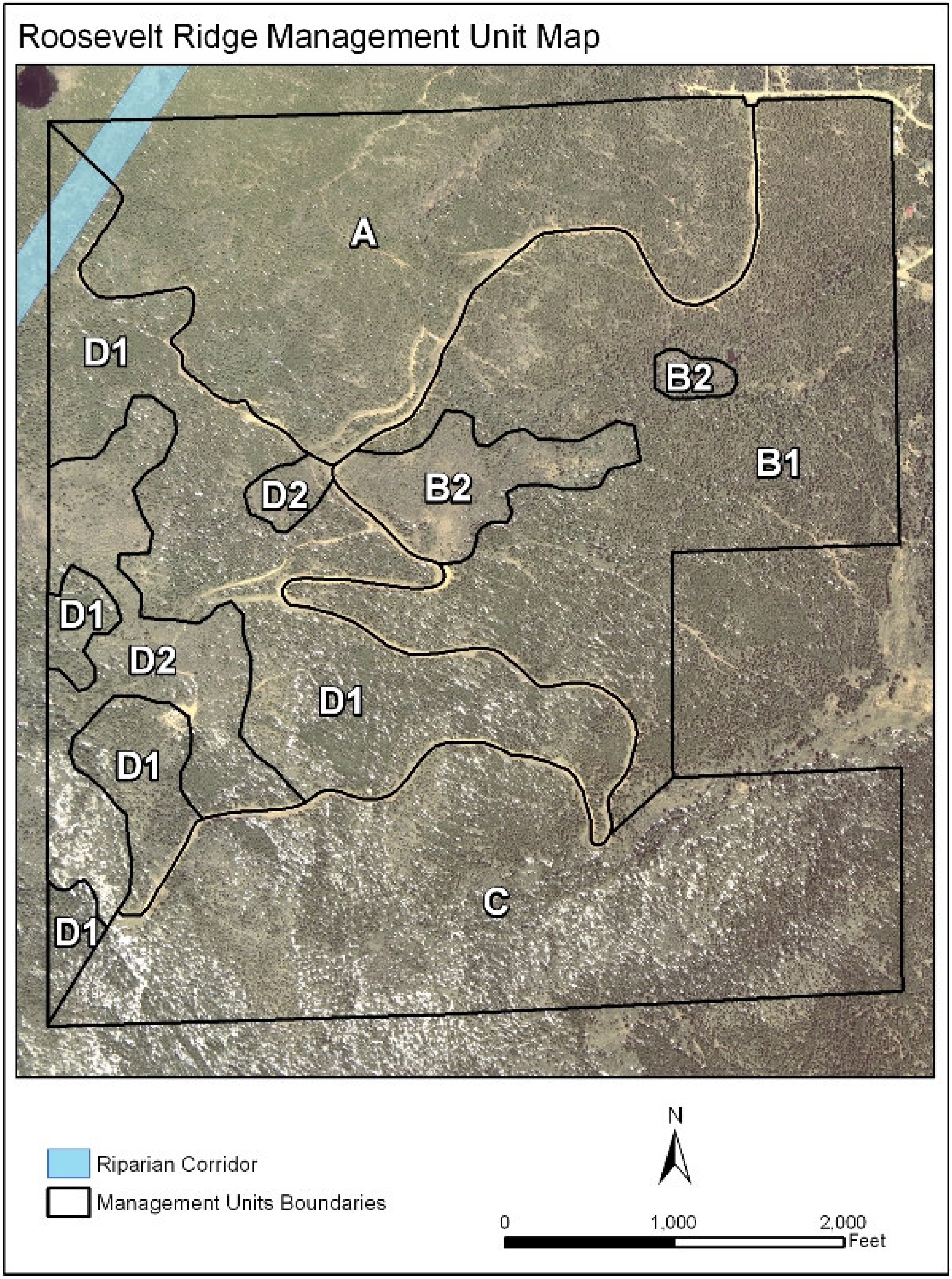
Implementing the procedures outlined above will ensure that any proposed management activities are well planned and that their consequences relating to wildlife populations and habitat have been considered prior to program implementation.

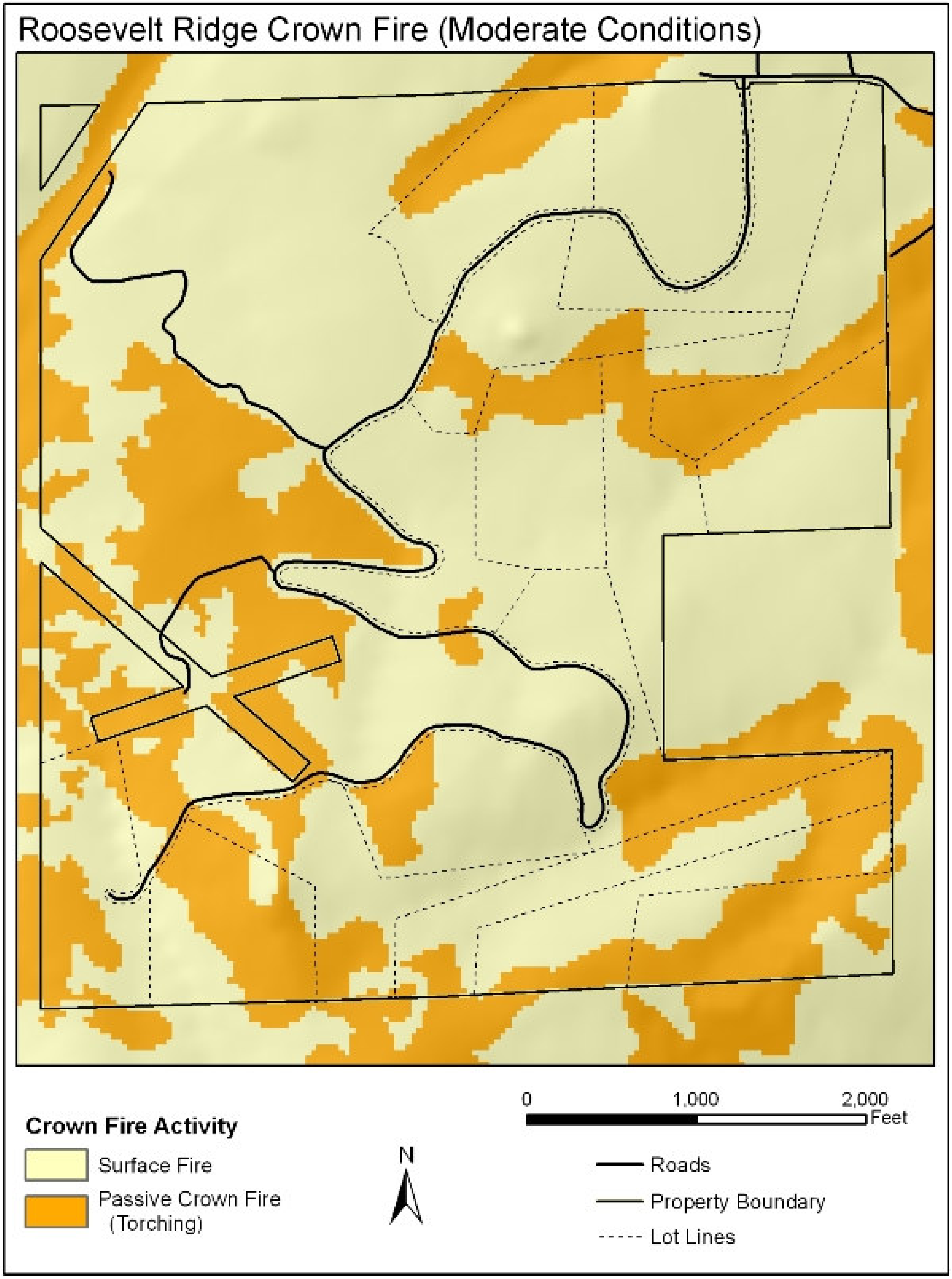
PROJECT MAPS

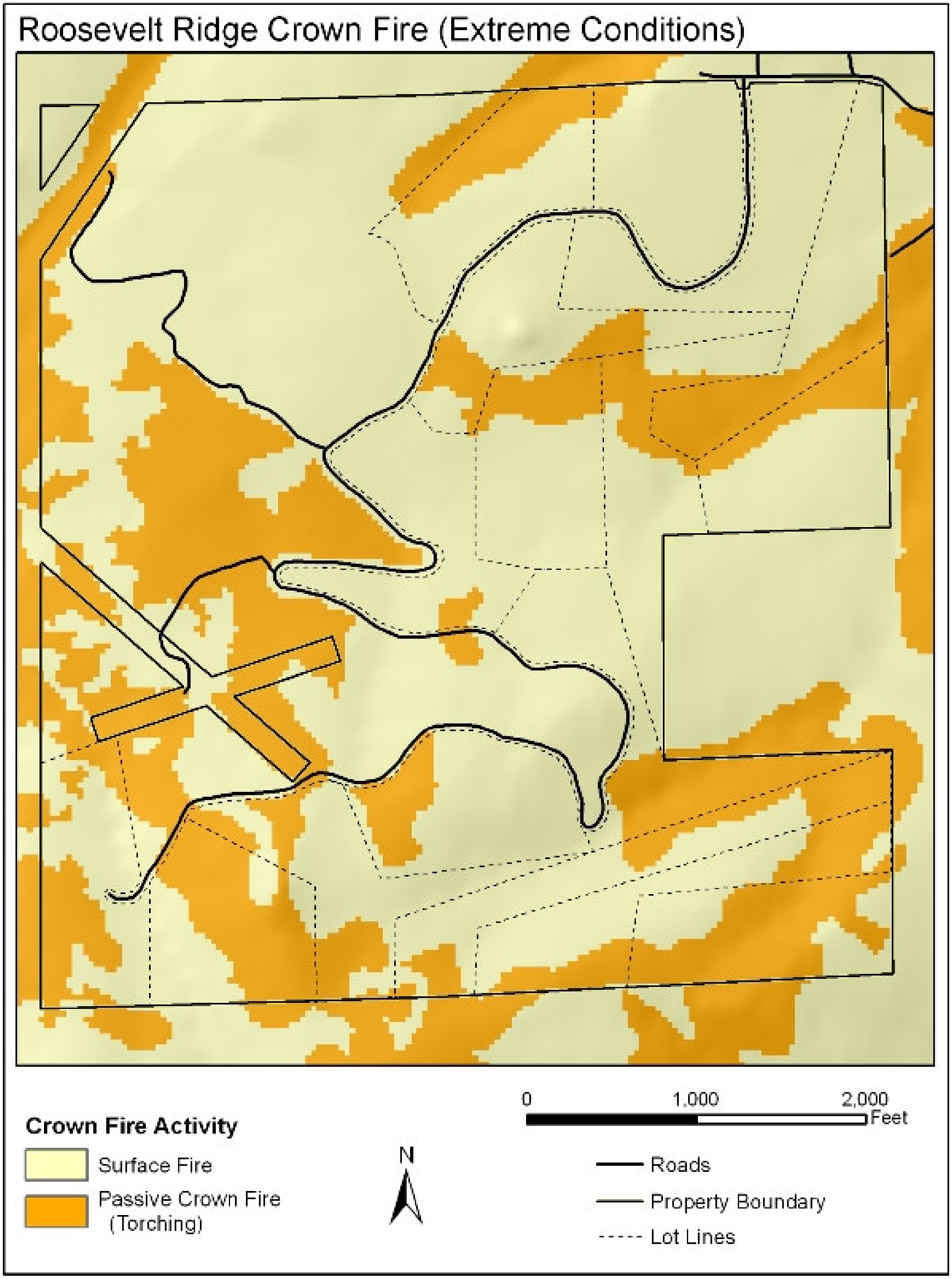


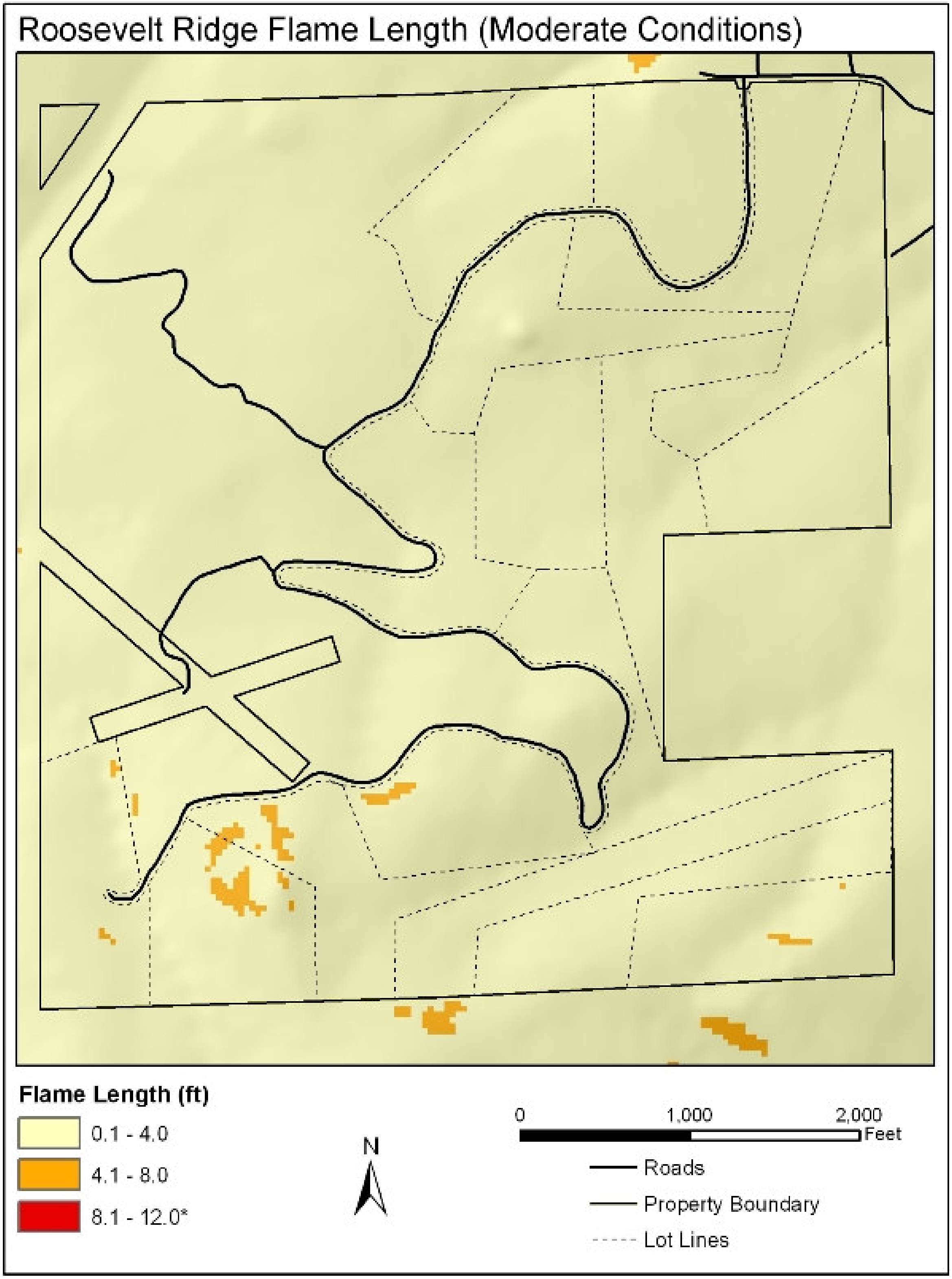
Boulder County
Gilpin County
72
Grand County
Gilpin County
Gilpin County
Jefferson County
46
119
Gilpin County
Clear Creek County
40
70
6
N
Major Highways
County Boundaries
Roads
Roosevelt Ridge
0 1 2 3 4 5
Miles

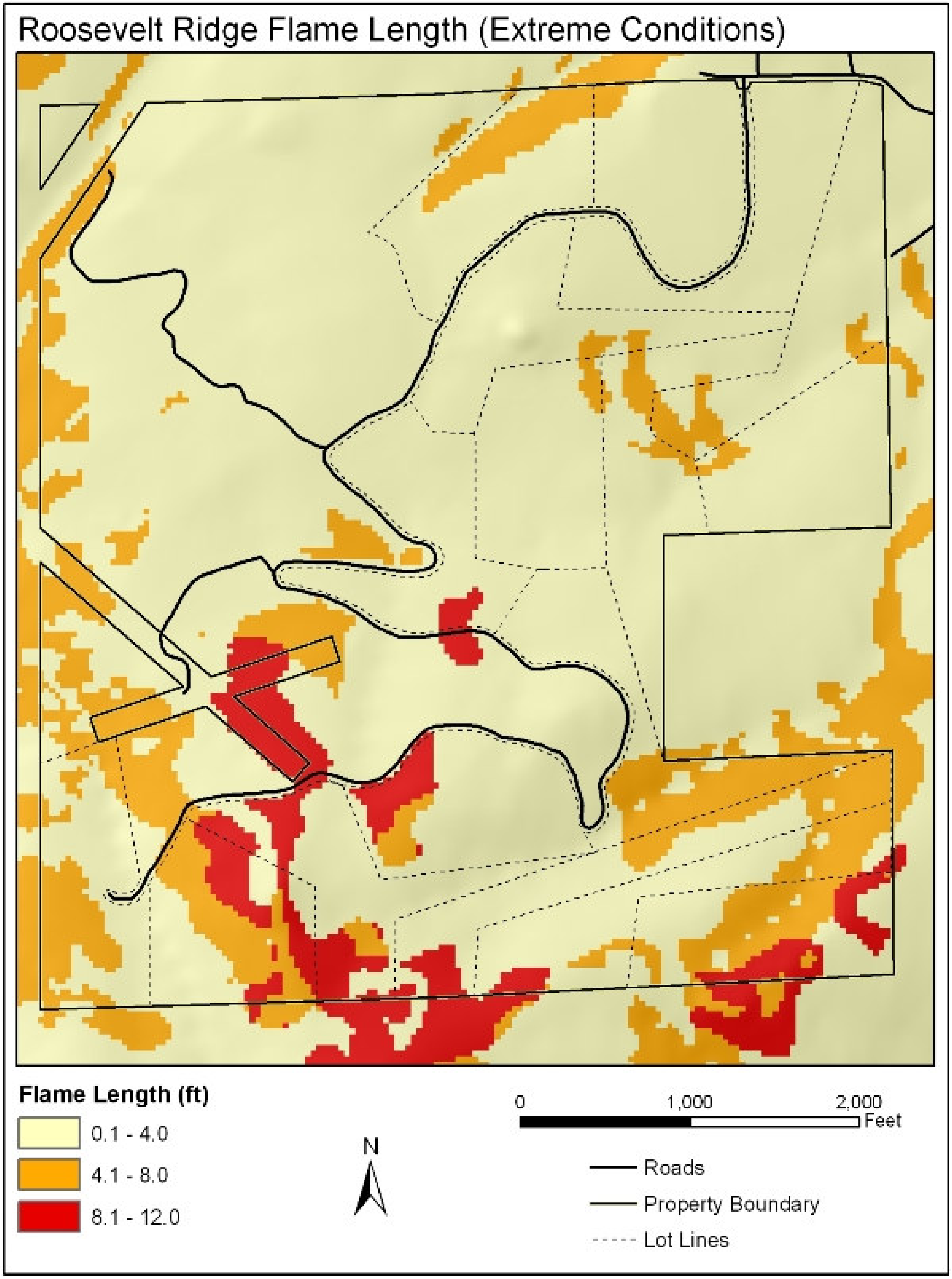

Roosevelt Ridge General Reference Map
Signing Rock
Property Boundary
Roads
Trails
Lot Lines
Building Envelopes
Riparian Corridor
N
0
1,000
2,000
Feet

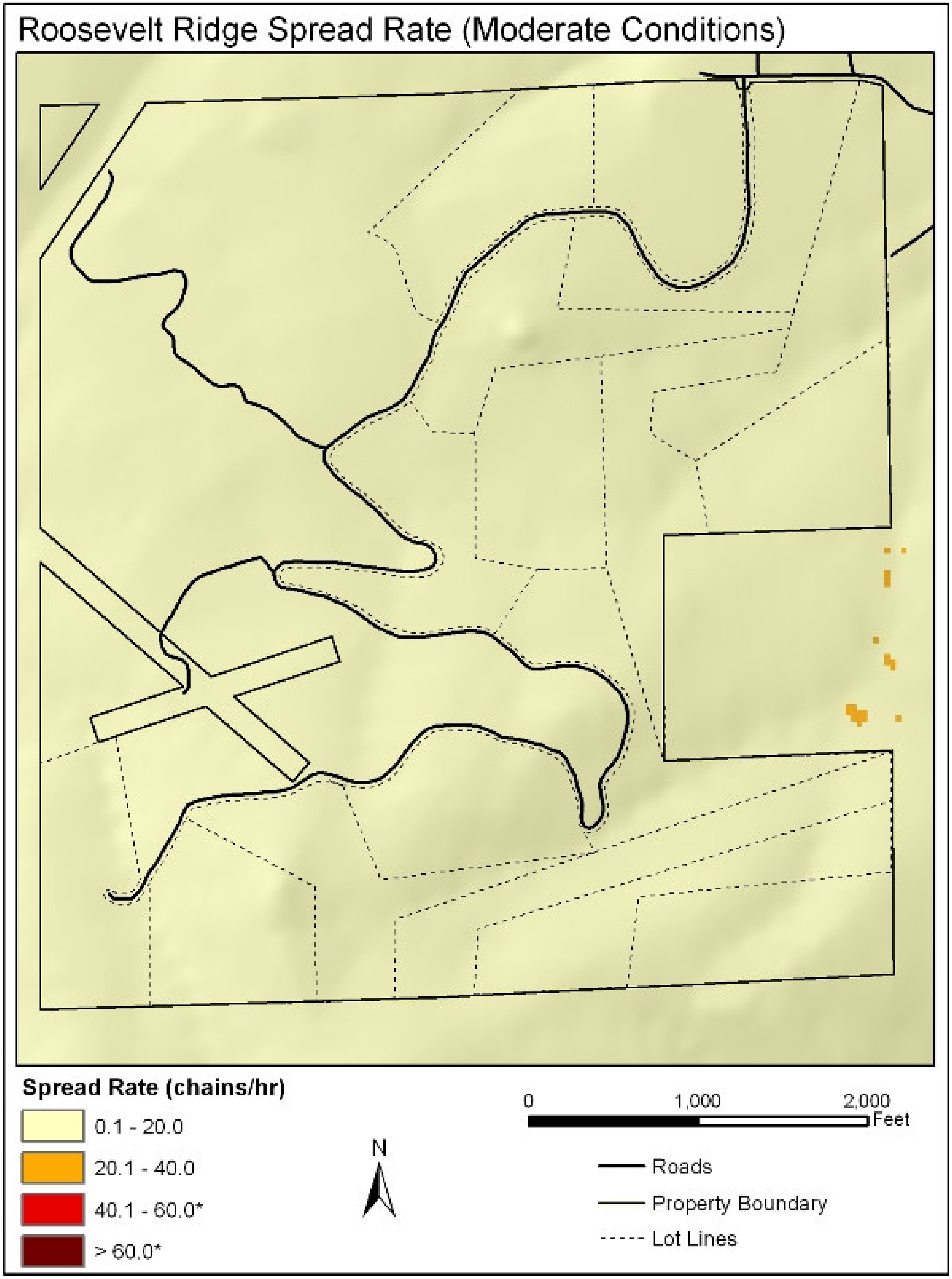

Roosevelt Ridge Management Unit Map
A
D1
B2
B1
D2
B2
D1
D2
D1
D1
C
D1
Riparian Corridor
Management Units Boundaries
N
0
1,000
2,000
Feet


Roosevelt Ridge Crown Fire (Moderate Conditions)
Crown Fire Activity
Surface Fire
Passive Crown Fire (Torching)
N
0
1,000
2,000
Feet
Roads
Property Boundary
Lot Lines

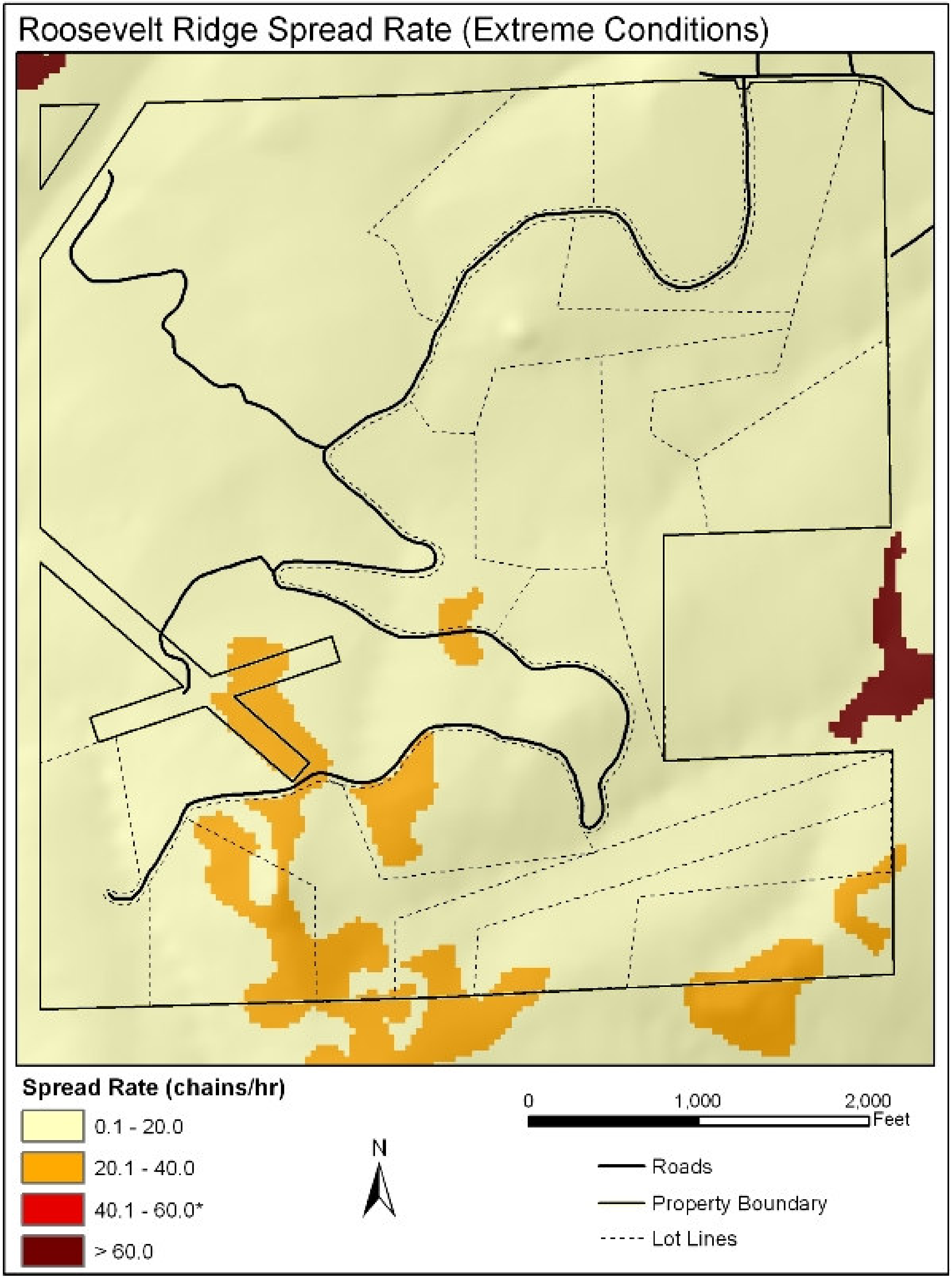

Roosevelt Ridge Crown Fire (Extreme Conditions)
Crown Fire Activity
Surface Fire
Passive Crown Fire
(Torching)
N
0
1,000
2,000
Feet
Roads
Property Boundary
Lot Lines

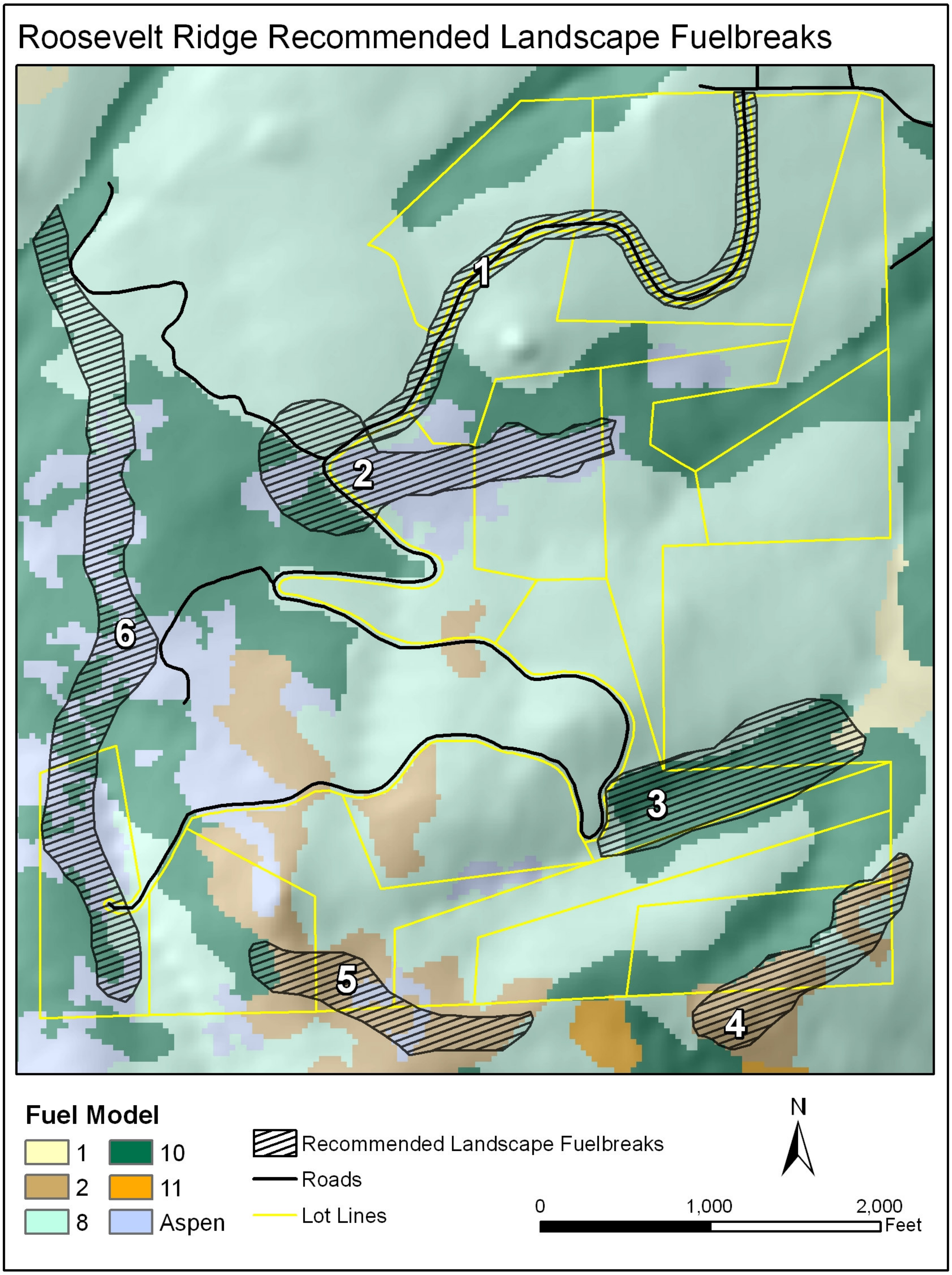

Roosevelt Ridge Flame Length (Moderate Conditions)
Flame Length (ft)
0.1 - 4.0
4.1 - 8.0
8.1 - 12.0*
N
0
1,000
2,000
Feet
Roads
Property Boundary
Lot Lines


Roosevelt Ridge Flame Length (Extreme Conditions)
Flame Length (ft)
0.1 - 4.0
4.1 - 8.0
8.1 - 12.0
N
0
1,000
2,000
Feet
Roads
Property Boundary
Lot Lines



Roosevelt Ridge Spread Rate (Moderate Conditions)
Spread Rate (chains/hr)
0.1 - 20.0
20.1 - 40.0
40.1 - 60.0*
> 60.0*
N
0
1,000
2,000
Feet
Roads
Property Boundary
Lot Lines


Roosevelt Ridge Spread Rate (Extreme Conditions)
Spread Rate (chains/hr)
0.1 - 20.0
20.1 - 40.0
40.1 - 60.0*
> 60.0
N
0
1,000
2,000
Feet
Roads
Property Boundary
Lot Lines



Roosevelt Ridge Recommended Landscape Fuelbreaks
1
2
3
4
5
6
Fuel Model
1
2
8
10
11
Aspen
Recommended Landscape Fuelbreaks
Roads
Lot Lines
N
0
1,000
2,000
Feet

APPENDIX I: MANAGEMENT PRESCRIPTIONS

Landscape Fuelbreaks

Treatment Area 1 (Very High Priority): Treatment Area 1 consists of 13.7 acres extending 4,150 linear feet along the main access road. This road represents the only way out for residents and the only way in for responding fire equipment. It is critical that this access and egress route be established with fuels reduction work to enhance safety during a fire. The minimum recommended fuel break width is 200 feet, split by the centerline of the road. Because the rate of fire spread and intensity increase with slope angle, the size of the fuel break should also be increased with an emphasis on the downhill side of the roadbed (see Table 9, Appendix III).

Treatment Area 2 (Very High Priority): Treatment Area 2 consists of 18.5 acres and has two distinct functions. First, the relatively round area at the junction of three roads will provide a staging ground and potential interior safety zone for arriving fire personnel once treated. The road base area should be maximized in this area to provide ad hock parking for fire apparatus. Second, fuels reduction will enhance the ability of fire apparatus to shelter itself if this area if overrun by fire. The elongated section of Treatment Area 2 is an aspen enhancement project that will provide a fuel break from a north/south perspective. This section is anchored by the road intersection on the west and an existing aspen stand on the east. The fuel break will help reduce potential southern/ uphill fire spread from a large continuous stand of Fuel Model 10.

Treatment Area 3 (High Priority): Treatment Area 3 consists of 16.5 acres and follows the drainage downhill, northeast of the "bird's beak" bend in the main road. The fuel break should be created with the drainage as the centerline of the project. This area has significant standing dead and down materials; however, the canopy is relatively open where the fuel break anchors into a grass meadow on the northeast side. A wildfire hazard analysis was recently completed for the Colorado Sierra Fire Department northeast of Roosevelt Ridge; it recommended the creation of a second means of access and egress for both Colorado Sierra and Roosevelt Ridge through Treatment Area 3. Blue Spruce Road and or Karlann Drive should be utilized.

Treatment Area 4 (Moderate Priority): Treatment Area 4 consists of 10.5 acres and is located on the ridge on the southeast portion of the development. The fuel break utilizes two areas of Fuel Model 2 broken by a short section of Fuel Model 8 and 10. "Linking" Fuel Model 2 meadows will create a fuel break to help reduce fire spread uphill from the southeast. The fuel break directly benefits two to three parcels in the area.

Treatment Area 5 (Moderate Priority): Treatment Area 5 consists of 9.5 acres and roughly follows the open meadows (Fuel Model 2) along the northeast ridge of Fairburn Mountain. This fuel break can be moved within the Fuel Model 2 areas to maximize protection for the lots in the area. Final evaluation for the specific location of this fuel break should be completed in relation to site specific home locations on these lots. Where feasible, this fuel break should tie into defensible space provided around homes in the area.

Treatment Area 6 (High Priority): This 28 acre treatment area begins roughly at the end of the main road and follows the riparian drainage due south. This treatment is intended to enhance the aspen and riparian drainage while providing a significant fuel break along the western edge of the development. Mountain View Drive, located west of the treatment area, and the high recreational use of U.S. Forest Service land adjacent to the treatment area pose significant threats to the Roosevelt Ridge development. Prevailing westerly winds make this fuel break critical.

Mixed Conifer Prescription: (Units A, B1, C and D1)

GENERAL PRESCRIPTION FOR ALL MIXED CONIFER UNITS:
All four mixed conifer management units (Unit A, B1, C and D1) are very similar in terms of structure and composition. For this reason one generic prescription is provided. Specific directions pertinent to individual units are presented subsequently.

1) Sanitation thinning
   (a) Remove trees containing dwarf mistletoe, create patch cuts in large infestations
   (b) Remove and treat trees infested with mountain pine beetle or other insects
   (c) Remove unhealthy, suppressed and poorly formed trees (whips, crooked stems, broken top, forked leader, poor site, etc.)
2) Thin from below, remove most small diameter regeneration that is less than 6 inches DBH; retain a limited amount of regeneration of all size classes.
3) Remove species in the following order: 1) Douglas-fir, 2) limber pine 3) blue spruce, 4) Englemann spruce 5) lodgepole pine
4) Remove most dead and down material, retain only 33 linear feet of down logs per acre, minimum of 8 inches in diameter
5) Create forest openings of irregular size and shape ranging in size from ¼ to 5 acres. Openings should be established in diseased or insect damaged areas; enlarge existing openings.
6) Retain most healthy dominant and co-dominant trees of all species
7) Retain or create 1-2 wildlife trees "snags" per acre > 8 inches DBH, favoring groupings
8) Retain 3-6 wildlife slash piles per acre (5' wide by 3' high)
9) Retain live trees that exhibit evidence of wildlife activity (cavities, borings, and caches)
10) Increase canopy spacing to 10' feet in lodgepole, 15' in mixed conifer
11) Prune lower branches from residual trees to 6' or 1/3 the height of the tree, whichever is less
12) Treat slash in accordance with methods described in Performance Standards (Appendix II)
13) Refer to aspen prescription when these trees are encountered (Appendix I)
14) Refer to mistletoe, pine beetle and gall rust prescriptions when encountered (Appendix I)

SPECIFIC PRESCRIPTIONS:
Unit A: Reduce density by 25% to 115 sq.ft./ac. Treat mistletoe infestation in eastern portion of unit and promote aspen growth in western portion of unit. Moderate fuel loads in the western portion of this unit require attention.

Unit B1: Reduce density by 25% to 116 sq.ft./ac. Treat diseased lodgepole in central portion of unit. Enhance existing aspen stands and abundant meadows by removing conifer encroachment, remove ladder fuels and dead and down material.

Unit C: Reduce density by 20 to 25% (112 sq.ft./ac.). Enhance existing aspen stands and abundant meadows by removing conifer encroachment, remove ladder fuels and dead and down material.

Unit D1: Reduce density by 30 to 35% (95 sq.ft./ac.). This stand can be treated more aggressively because it is lower on the slope (lower windthrow potential) and has a greater proportion of aspen and conifer trees. Heavy fuels loads on the northern portion of this unit require removal.

Aspen Prescription: (Units B2 and D2)

DESCRIPTION:
Aspen stands occur in various management units; these stands should be treated as follows when encountered.

MATURE STANDS:
Mature stands that exhibit low vigor, dieback, abundant down logs, conifer encroachment, poor form, lack of sprouts or an elevated canopy level due to extensive browsing may need to be rejuvenated.

1) In areas that can be burned:
   (a) Implement prescribed burns, high mortality is acceptable and desirable.
   (b) Protect regeneration with fencing to exclude wildlife until the stand becomes established.
2) In areas that cannot be burned:
   (a) Remove most conifer encroachment through selective cutting that allows gaps in the canopy for the shade-intolerant aspen. Retain conifer trees only that appear to pre-date the establishment of the aspen stand.
   (b) Aspen stands < 1 acre:
   Do not cut aspen trees, remove conifer encroachment and create a circular patch cut on the outer perimeter of the aspen stand that is 1 tree height wide where all conifers are removed.
   (c) Aspens stands > 1 acre:
   Create patch cuts in the aspen stands to stimulate ratoon growth, a basal area of 20 Ft^2/Ac is recommended to promote sprouting; remove conifers as above. Divide aspen stands into several equally sized units; rejuvenate one unit every other year.
   (d) Remove excessive dead and down material, retain only 50 to 100 linear feet of material >8" diameter pre acre

IMMATURE STANDS:
Stands that exhibit vigorous growth and abundant sprouting require little active management, if excessive browsing is evident, protect regeneration by temporarily fencing portions of high-use areas or by drawing the ungulates to areas of improved forage. Remove conifer competition from the stand interior and create a circular patch cut on the outer perimeter of the aspen stand that is 1 tree height wide where all conifers are removed.

NON-EXISTENT STANDS:
Where aspen stands are desirable and site conditions can support their existence (mesic areas), active management can facilitate stand establishment.

1) Cut existing overstory species to create a gap in the canopy.
2) Transplant aspen seedlings or vegetative cuttings onto the site.
3) Protect regeneration from browsing with fencing to exclude wildlife until the stand becomes established.

Forest Insects and Diseases: Dwarf Mistletoe

Dwarf mistletoe, (*Arceuthobium vaginatum*), is a leafless, parasitic flowering plant that typically infects ponderosa pine and lodgepole pine trees (Jacobi and Swift 1999). Mistletoes can kill their host plant by slowly robbing it of water and nutrients. Damage to trees includes a reduced growth rate, diminished wood quality, poor tree form, reduction in seed production, predisposition to insect and disease infestations and increased mortality due to drought. Mistletoes are spread by birds that consume seeds and by explosive discharge of seeds from the parent plant. Seeds stick to surfaces they strike and germinate on susceptible trees. Mistletoe seeds are dispersed in August and early September. Mistletoes spread slowly typically moving through a forest at 1 to 2 feet per year in dense stands. This rate can increase to 30 feet per year in open stands where seeds are able to travel further in the air. Dwarf mistletoe grows into the bark and phloem of an infected tree where root like "sinkers" become embedded in the wood. Dwarf mistletoes have a relatively long life cycle which takes 6 to 8 years between infection and seed production. This allows for the implementation of long term management strategies (Jacobi and Swift 1999).

Look for: The first symptom of infection is a slight swelling of the bark at the infection site. As the parasites' sinkers become more extensive, a distorted branching habit or witches broom becomes apparent. Infected trees will also display yellow foliage, reduced foliage, and branch mortality. The parasite forms green or yellow twig like structure at the site of infection (above).

Treatment: Because mistletoes spread slowly, (typically only several feet per year), long-term management options are effective. Management options include the pruning of infected branches, removal of infected trees, isolating pockets of heavy infestation with a 50' treeless buffer and propagating resistant tree species (Jacobi and Swift 1999).

Forest Insects and Diseases:
Mountain Pine Beetle

Mountain pine beetle, *Dendroctonus ponderosae,* is a native insect that typically attacks ponderosa pine and lodgepole pine trees. It's the most prolific insect pest in Colorado and often kills large numbers of trees during annual outbreaks (Leatherman and Cranshaw 1998). Female beetles lay approximately 75 eggs in stressed trees after tunneling under the bark. These larva then consume cambium tissue as they mature creating characteristic feeding galleries. Mature beetles emerge in late summer and form coordinated attacks on adjacent trees whereby several hundred beetles lay eggs in one tree. This coordinated effort allows the beetles to overwhelm the tree's defenses. These beetles also transmit bluestain fungi, further disrupting the trees ability to transport water.

Look for: Infected trees will display popcorn shaped masses of resin called "pitch tubes" at the site of beetle entry. Boring dust, "frass", may be in bark crevices and on the ground; woodpecker holes and yellowing foliage may also be apparent. Once the foliage has turned completely yellow, the tree is dead and the beetles have exited to attack an adjacent tree. Infected trees will display a blue discoloration on the outer portions of the cambial wood.

Treatment: Mountain pine beetles can be controlled by thinning forests to promote individual tree vigor thereby increasing the likelihood that healthy trees will be able to "pitch out" beetles. Infected logs need to be treated before beetle emergence to prevent further attacks. Infected logs can be burned, chipped, buried under eight inches of soil, or exposure to direct sunlight with rotation every three weeks. They may also be watered, wrapped in clear plastic and exposed to direct sunlight to elevate under bark temperatures to lethal levels. Infected trees can also be hauled to quarantine sites that are more than one mile from susceptible tree hosts. Photos from Leatherman and Cranshaw, for additional information see Leatherman and Cranshaw (1998).

Forest Insects and Diseases: Western Gall Rust

Western gall rust of pine (*Endocronartium harknessii*) is a fungus that spreads to uninfected trees by means of spores produced in the galls of infected trees. The spores require wet plant surfaces and cool temperatures to germinate; prolonged periods of cool, wet weather promote infection. Spores are produced in the spring and released when the gall surface ruptures; dispersal occurs in May and June. The windborne spores infect the current year's shoots where they initiate the formation of new galls. Galls form one year after infection, usually in the summer. Existing galls continue to produce spores every year. In the Rocky Mountain region the disease is common in stands of lodgepole and ponderosa pines. The disease seldom kills mature trees, though heavily infected trees generally become stunted or malformed, especially when galls are produced on main stems. A moderate number of branch galls does not significantly affect the health of the tree (Hiratsuka and Maruyama, 1991).

Look for: The appearance of spherical galls on the branches and limbs of pines of all ages. The galls are most visible in the spring when the surface ruptures to release bright orange spores. Galls are most commonly found on branches, but can be found on the main stem. As galls enlarge, they cause branch dieback and often cause the host to develop witches' brooms. Trunk or "hip" cankers are common on lodgepole pine where they do not look like a typical gall but a diamond-shaped canker (CSU 2000).

Treatment: This disease is very difficult to control because of its high rate of infection and the latency period between infection and expression of the symptoms. Removing infected trees has limited effect since latent infections from the previous year are invisible and therefore cannot be controlled (CSU 2000). The most practical and effective control of western gall rust is to cut the galls from infected trees. This will prevent infections from spreading to other parts of the tree or to nearby trees from spores produced by the galls (Hiratsuka and Maruyama, 1991). Galls may weaken the tree stem leaving it prone to breakage under heavy snow or in strong winds. Pruning branch galls and destroying trees with main stem galls should be avoided when the spores are being actively produced, because the control action itself can spread spores (CSU 2000).

APPENDIX II: FOREST MANAGEMENT

Roosevelt Ridge Forest Inventory

Per Acre Summary for all Species

Unit A

	DBH	HEIGHT CLASS 10	20	30	40	50	60	70	80	90	100	110	TOTAL
STEMS	4	0	0	127	0	0	0	0	0	0	0	0	127
CUVOL	4	0	0	108	0	0	0	0	0	0	0	0	108
SCRIB	4	0	0	0	0	0	0	0	0	0	0	0	0
STEMS	6	0	0	120	59	0	0	0	0	0	0	0	179
CUVOL	6	0	0	243	164	0	0	0	0	0	0	0	406
SCRIB	6	0	0	0	0	0	0	0	0	0	0	0	0
STEMS	8	0	0	69	81	23	0	0	0	0	0	0	172
CUVOL	8	0	0	244	436	180	0	0	0	0	0	0	860
SCRIB	8	0	0	635	1231	640	0	0	0	0	0	0	2506
STEMS	10	0	0	6	29	24	0	0	0	0	0	0	59
CUVOL	10	0	0	40	267	254	0	0	0	0	0	0	560
SCRIB	10	0	0	133	977	953	0	0	0	0	0	0	2062
STEMS	12	0	0	0	4	39	0	0	0	0	0	0	43
CUVOL	12	0	0	0	55	633	0	0	0	0	0	0	688
SCRIB	12	0	0	0	213	2499	0	0	0	0	0	0	2712
STEMS	14	0	0	0	0	14	0	0	0	0	0	0	14
CUVOL	14	0	0	0	0	322	0	0	0	0	0	0	322
SCRIB	14	0	0	0	0	1326	0	0	0	0	0	0	1326
STEMS	16	0	0	0	0	6	0	0	0	0	0	0	6
CUVOL	16	0	0	0	0	190	0	0	0	0	0	0	190
SCRIB	16	0	0	0	0	834	0	0	0	0	0	0	834
STEMS	18	0	0	0	0	2	0	0	0	0	0	0	2
CUVOL	18	0	0	0	0	62	0	0	0	0	0	0	62
SCRIB	18	0	0	0	0	282	0	0	0	0	0	0	282
TOTAL													
STEMS	0	0	0	322	173	107	0	0	0	0	0	0	602
CUVOL	0	0	0	634	922	1641	0	0	0	0	0	0	3196
SCRIB	0	0	0	768	2421	6535	0	0	0	0	0	0	9724

PER ACRE SUMMARY

STEMS	BA	DBH	HT
602	153	6.8	42

CRUISE SUMMARY

BAF USED= 20   POINTS SAMPLED= 8   AVG. # TREES/PT. = 7.6

LIMIT OF ERROR AT 1 STANDARD DEVIATION = 15%

Terms: See below.

Roosevelt Ridge Forest Inventory

Per Acre Summary for all Species

Unit B1 (Mixed Conifer)

	DBH	HEIGHT CLASS 10	20	30	40	50	60	70	80	90	100	110	TOTAL
STEMS	6	0	19	0	51	16	0	0	0	0	0	0	85
CUVOL	6	0	27	0	172	67	0	0	0	0	0	0	266
SCRIB	6	0	0	0	0	0	0	0	0	0	0	0	0
STEMS	8	0	0	98	75	0	0	0	0	0	0	0	173
CUVOL	8	0	0	439	401	0	0	0	0	0	0	0	840
SCRIB	8	0	0	1299	1276	0	0	0	0	0	0	0	2575
STEMS	10	0	0	0	96	37	0	0	0	0	0	0	133
CUVOL	10	0	0	0	854	430	0	0	0	0	0	0	1284
SCRIB	10	0	0	0	3104	1598	0	0	0	0	0	0	4702
STEMS	12	0	0	0	22	9	0	0	0	0	0	0	31
CUVOL	12	0	0	0	309	126	0	0	0	0	0	0	435
SCRIB	12	0	0	0	1204	467	0	0	0	0	0	0	1671
STEMS	14	0	0	0	0	7	3	0	0	0	0	0	10
CUVOL	14	0	0	0	0	131	81	0	0	0	0	0	212
SCRIB	14	0	0	0	0	513	339	0	0	0	0	0	853
STEMS	22	0	0	0	0	0	0	1	0	0	0	0	1
CUVOL	22	0	0	0	0	0	0	88	0	0	0	0	88
SCRIB	22	0	0	0	0	0	0	441	0	0	0	0	441
TOTAL													
STEMS	0	0	19	98	243	69	3	1	0	0	0	0	433
CUVOL	0	0	27	439	1735	755	81	88	0	0	0	0	3124
SCRIB	0	0	0	1299	5584	2578	339	441	0	0	0	0	10241

PER ACRE SUMMARY

STEMS	BA	DBH	HT
433	149	7.9	42

CRUISE SUMMARY

BAF USED= 20 POINTS SAMPLED= 7 AVG. # TREES/PT. = 7.4

LIMIT OF ERROR AT 1 STANDARD DEVIATION = 8%

Terms: See below.

Roosevelt Ridge Forest Inventory

Per Acre Summary for all Species
Unit B2 (Aspen)

	DBH	HEIGHT CLASS 10	20	30	40	50	60	70	80	90	100	110	TOTAL
STEMS	6	0	0	39	0	0	0	0	0	0	0	0	39
CUVOL	6	0	0	76	0	0	0	0	0	0	0	0	76
SCRIB	6	0	0	0	0	0	0	0	0	0	0	0	0
STEMS	8	0	0	0	73	0	0	0	0	0	0	0	73
CUVOL	8	0	0	0	371	0	0	0	0	0	0	0	371
SCRIB	8	0	0	0	537	0	0	0	0	0	0	0	537
STEMS	10	0	0	0	47	222	0	0	0	0	0	0	269
CUVOL	10	0	0	0	350	1855	0	0	0	0	0	0	2205
SCRIB	10	0	0	0	832	4977	0	0	0	0	0	0	5808
STEMS	12	0	0	0	11	42	0	0	0	0	0	0	53
CUVOL	12	0	0	0	122	534	0	0	0	0	0	0	656
SCRIB	12	0	0	0	399	1890	0	0	0	0	0	0	2290
STEMS	20	0	0	0	0	4	0	0	0	0	0	0	4
CUVOL	20	0	0	0	0	125	0	0	0	0	0	0	125
SCRIB	20	0	0	0	0	642	0	0	0	0	0	0	642
STEMS	26	0	0	0	0	0	2	0	0	0	0	0	2
CUVOL	26	0	0	0	0	0	174	0	0	0	0	0	174
SCRIB	26	0	0	0	0	0	899	0	0	0	0	0	899
TOTAL													
STEMS	0	0	0	39	131	267	2	0	0	0	0	0	439
CUVOL	0	0	0	76	843	2515	174	0	0	0	0	0	3609
SCRIB	0	0	0	0	1768	7509	899	0	0	0	0	0	10176

PER ACRE SUMMARY

STEMS	BA	DBH	HT
439	187	8.8	47

CRUISE SUMMARY
BAF USED= 20   POINTS SAMPLED= 3   AVG. # TREES/PT. = 9.3

LIMIT OF ERROR AT 1 STANDARD DEVIATION = 20%

Terms: See below.

Roosevelt Ridge Forest Inventory

Per Acre Summary for all Species

Unit C

HEIGHT CLASS

	DBH	10	20	30	40	50	60	70	80	90	100	110	TOTAL
STEMS	4	0	86	42	20	0	0	0	0	0	0	0	149
CUVOL	4	0	47	37	39	0	0	0	0	0	0	0	124
SCRIB	4	0	0	0	0	0	0	0	0	0	0	0	0
STEMS	6	0	14	0	76	10	0	0	0	0	0	0	100
CUVOL	6	0	17	0	193	39	0	0	0	0	0	0	250
SCRIB	6	0	0	0	0	0	0	0	0	0	0	0	0
STEMS	8	0	0	38	45	69	0	0	0	0	0	0	152
CUVOL	8	0	0	165	224	445	0	0	0	0	0	0	833
SCRIB	8	0	0	439	586	1464	0	0	0	0	0	0	2490
STEMS	10	0	0	13	31	36	0	0	0	0	0	0	80
CUVOL	10	0	0	82	284	413	0	0	0	0	0	0	779
SCRIB	10	0	0	237	1042	1546	0	0	0	0	0	0	2825
STEMS	12	0	0	3	16	32	0	0	0	0	0	0	51
CUVOL	12	0	0	30	214	506	0	0	0	0	0	0	750
SCRIB	12	0	0	112	828	1963	0	0	0	0	0	0	2903
STEMS	14	0	0	0	0	8	4	0	0	0	0	0	11
CUVOL	14	0	0	0	0	175	98	0	0	0	0	0	273
SCRIB	14	0	0	0	0	722	414	0	0	0	0	0	1136
STEMS	16	0	0	0	0	0	3	0	0	0	0	0	3
CUVOL	16	0	0	0	0	0	87	0	0	0	0	0	87
SCRIB	16	0	0	0	0	0	370	0	0	0	0	0	370
STEMS	18	0	0	0	0	2	0	0	0	0	0	0	2
CUVOL	18	0	0	0	0	77	0	0	0	0	0	0	77
SCRIB	18	0	0	0	0	348	0	0	0	0	0	0	348
STEMS	22	0	0	0	0	0	1	0	0	0	0	0	1
CUVOL	22	0	0	0	0	0	46	0	0	0	0	0	46
SCRIB	22	0	0	0	0	0	218	0	0	0	0	0	218
TOTAL													
STEMS	0	0	101	96	188	156	7	0	0	0	0	0	548
CUVOL	0	0	65	313	954	1654	231	0	0	0	0	0	3218
SCRIB	0	0	0	788	2456	6043	1002	0	0	0	0	0	10290

PER ACRE SUMMARY

STEMS	BA	DBH	HT
548	148	7.0	44

CRUISE SUMMARY

BAF USED= 20 POINTS SAMPLED = 12 AVG. # TREES/PT. = 7.4

LIMIT OF ERROR AT 1 STANDARD DEVIATION = 13%

Terms: See below.

Roosevelt Ridge Forest Inventory

Per Acre Summary for all Species
Unit D1 (Mixed Conifer)

		HEIGHT CLASS											
	DBH	10	20	30	40	50	60	70	80	90	100	110	TOTAL
STEMS	6	0	0	71	52	0	0	0	0	0	0	0	124
CUVOL	6	0	0	170	166	0	0	0	0	0	0	0	336
SCRIB	6	0	0	0	0	0	0	0	0	0	0	0	0
STEMS	8	0	0	22	170	9	0	0	0	0	0	0	200
CUVOL	8	0	0	86	830	69	0	0	0	0	0	0	984
SCRIB	8	0	0	212	2393	243	0	0	0	0	0	0	2848
STEMS	10	0	0	13	47	23	0	0	0	0	0	0	83
CUVOL	10	0	0	95	414	210	0	0	0	0	0	0	719
SCRIB	10	0	0	329	1462	769	0	0	0	0	0	0	2560
STEMS	12	0	0	0	0	19	0	0	0	0	0	0	19
CUVOL	12	0	0	0	0	289	0	0	0	0	0	0	289
SCRIB	12	0	0	0	0	1136	0	0	0	0	0	0	1136
STEMS	14	0	0	0	6	6	0	0	0	0	0	0	13
CUVOL	14	0	0	0	124	131	0	0	0	0	0	0	255
SCRIB	14	0	0	0	497	515	0	0	0	0	0	0	1011
STEMS	16	0	0	0	0	4	0	0	0	0	0	0	4
CUVOL	16	0	0	0	0	134	0	0	0	0	0	0	134
SCRIB	16	0	0	0	0	571	0	0	0	0	0	0	571
STEMS	18	0	0	0	0	0	2	0	0	0	0	0	2
CUVOL	18	0	0	0	0	0	75	0	0	0	0	0	75
SCRIB	18	0	0	0	0	0	349	0	0	0	0	0	349
TOTAL													
STEMS	0	0	0	106	276	61	2	0	0	0	0	0	444
CUVOL	0	0	0	351	1534	832	75	0	0	0	0	0	2792
SCRIB	0	0	0	541	4353	3233	349	0	0	0	0	0	8476

PER ACRE SUMMARY

STEMS	BA	DBH	HT
444	137	7.5	41

CRUISE SUMMARY
BAF USED= 20 POINTS SAMPLED= 7 AVG. # TREES/PT. = 6.9

LIMIT OF ERROR AT 1 STANDARD DEVIATION = 11%

Terms: See below.

Roosevelt Ridge Forest Inventory

Per Acre Summary for all Species

Unit D2 (Aspen)

	DBH	HEIGHT CLASS 10	20	30	40	50	60	70	80	90	100	110	TOTAL
STEMS	4	0	107	57	0	0	0	0	0	0	0	0	164
CUVOL	4	0	88	55	0	0	0	0	0	0	0	0	143
SCRIB	4	0	0	0	0	0	0	0	0	0	0	0	0
STEMS	6	0	0	109	121	0	0	0	0	0	0	0	230
CUVOL	6	0	0	203	239	0	0	0	0	0	0	0	443
SCRIB	6	0	0	0	0	0	0	0	0	0	0	0	0
STEMS	8	0	0	79	31	0	0	0	0	0	0	0	110
CUVOL	8	0	0	270	140	0	0	0	0	0	0	0	411
SCRIB	8	0	0	333	272	0	0	0	0	0	0	0	605
STEMS	10	0	0	28	20	0	0	0	0	0	0	0	48
CUVOL	10	0	0	161	146	0	0	0	0	0	0	0	307
SCRIB	10	0	0	289	420	0	0	0	0	0	0	0	708
TOTAL													
STEMS	0	0	107	273	172	0	0	0	0	0	0	0	551
CUVOL	0	0	88	690	526	0	0	0	0	0	0	0	1303
SCRIB	0	0	0	622	692	0	0	0	0	0	0	0	1314

PER ACRE SUMMARY

STEMS	BA	DBH	HT
551	92	5.5	34

CRUISE SUMMARY

BAF USED= 20   POINTS SAMPLED= 5   AVG. # TREES/PT. = 4.6

LIMIT OF ERROR AT 1 STANDARD DEVIATION = 21%

Terms: DBH is the Diameter at Breast Height of a tree, measured 4 ½ feet above the ground; diameter is presented in 2 inch classes above; Height Class is similarly presented in 10 foot intervals; STEMS are the number of trees per acre in each size class; CUVOL is the cubic feet of wood per acre; SCRIB is the Scribner log rule for measurement of sawn lumber (one board foot is 144 cubic inches, a board 2” thick, 6” wide and 12” long); BA is basal area, a measurement of tree density based on the cross sectional area of all tree stems 4 ½ feet above the ground/acre.

Performance Standards for Forestry Operations[1]

Temporary Road Management

1. The Contract Administrator shall approve the location and width of roads before operations begin. Skidding is prohibited along existing "social trails", landings must be 0.5 acres or smaller unless approved.
2. Where possible, existing roads should be utilized in place of creating new ones.
3. Skid road specifications:
    a. Maximum width of 10 feet
    b. Utilize existing openings where approved
    c. Minimize soil displacement
    d. Protect all streams, wetlands, and lakes by complete avoidance
    e. Stream crossings should be at right angles
    f. Keep road grades below 10%
    g. Roads and landings should be less than 15% of the total area
    h. The slope of the landing should be less than 8%
    i. Avoid sharp turns, intersections should be at 45 degree angles or less
    j. Reclaim skid trails after thinning activities are complete as designated by the Contract Administrator.

Motorized Equipment

Handheld equipment will be used to fell, buck, and limb trees. Other operational methods may be approved if agreed to by the Contractor and Contract Administrator. Yarding techniques must be in compliance with the specifications set forth in the "Mechanical Yarding" section of this document.

Mechanical Thinning Method

1. Trees shall be completely severed from the stump at a maximum of six inches above the ground, measured from the high side of the tree.
2. Trees shall be bucked to a three inch top and removed from the site with the exception of trees that are to remain on site as down woody material, or as specified in forest prescription.
3. Thinning operations should be conducted in such a manner as to protect the residual stand, designated trees, boundary trees, wildlife snags, and woody debris. A damaged tree is any tree damaged by Contractor's operations where the bark is removed for an area at least six inches high and one half the circumference of the tree, or where the top has been broken, or is uprooted, or is leaning more than 20 degrees or that will die for other operationally caused reasons. Trees that must be damaged in the course of normal operations (construction of approved roads, damaged while felling, etc.), as

[1] Adopted from the Colorado State Forest Service as modified by Tobler, 2002.

long as not considered to be excessive by the Contract Administrator, will be considered cut trees and must be treated as described herein.

4. Trees shall be felled away from riparian areas, wetlands, residual trees, social trails, and sensitive areas as designated on the ground or Project Map.
5. Fell and limb all trees as described in the Forest Stewardship Plan.
6. Project boundaries are identified by flagging and/or a blue vertical stripe.
7. Wildlife habitat trees are to be protected from operational damage.

Mechanical Yarding

1. Equipment used for yarding must be capable of meeting resource restrictions as stated in the "Protection of Natural and Developed Resources" section.
2. Equipment must be capable of suspending the leading edge of logs from the ground during yarding.
3. All skid roads must be pre-approved by the Contract Administrator and in compliance with standards set forth in the "Temporary Road Management" section.
4. Logs shall be skidded to pre-approved landings.
5. Low impact skidding techniques such as ATV skidding with a log arch or hoarse logging are strongly recommended. These practices minimize soil disturbance and aesthetic impacts. They are also suitable for steep terrain and inaccessible areas.

Slash Treatment Methods

The objective of slash treatment is to remove enough slash to reduce fuel buildup to an acceptable level, yet leave enough on site for future soil development, and to protect skid trails and disturbed areas. Performance criteria for the disposal of slash less than three inches in diameter are described below. Slash needs to be removed from the site or treated through pile burning or broadcast burning. Untreated slash will contribute to fire behavior.

1. Hand Piling
   a. Piles shall be located in clearings and away from residual trees.
   b. Piles shall not be greater than four feet high and ten feet wide.
   c. Piles shall be compact as possible so they do not topple.
   d. Piles shall be located at least ten feet away from residual trees and 50 feet from residences.
   e. Piles shall be constructed in a manner to prevent snow from entering the pile and to facilitate efficient combustion.
   f. Piles shall be a minimum of 30 feet from "social trails" and roads.
   g. Piles shall not be placed on rock outcrops, in ditches, near culverts, in streambeds, in riparian areas, on roads, or on downed woody material greater than eight inches in diameter.
2. Lop and Scatter
   a. Accumulations of slash shall not exceed 18 inches in depth, or cover more than 50% of the ground.
   b. Slash shall be scattered and discontinuous throughout the project site and not form piles or windrows.

c. Stems and tops shall be bucked so that stems/boles lie flush with the ground.
d. Unless agreed to in writing, except for handheld tools, the use of machinery is prohibited. If the contractor can demonstrate an equivalent to lop and scatter that meets the same project objective, use of alternative equipment may be authorized.
e. Slash shall not be scattered within 30 feet of social trails or roads.

3. Landing Slash
   a. Landing piles shall be compacted and free of dirt to facilitate efficient combustion.
   b. Piles shall not be larger than 15 feet tall and 50 feet wide.
   c. Piles shall be at least 50 feet from the residual stand.
   d. Approved log loading equipment may be used to construct landing piles.
4. Chipping
   a. Slash may be chipped and removed from the site.
   b. Extensive deposition of chips on the forest floor is not recommended because they will suppress rangeland growth and may alter the soil carbon/nitrogen ratio.

Wildlife Habitat Trees (Snags)

The management designated snags to be retained towards meeting the minimum criteria below:

1. Leave three or more snags per acre that are at least ten inches DBH.
2. Leave at least three declining or dying trees per acre as snag recruitment.
3. Snags shall be at least 25 feet tall where available.
4. Retain groups of two to six snags where they occur.
5. Retain most trees showing evidence of wildlife activity (cavities, boarings, and caches).
6. Retain all existing burned snags and stumps where possible.

Materials to be Removed

All felled trees to a top diameter of three inches shall be removed from the project site with the exception of down woody material and slash that is remaining on site as described herein. The Contract Administrator may make exceptions.

Down Woody Material

The Forest Stewardship Plan has specified down woody material to be retained on site in accordance with the below criterion.

1. Aspen forests: Retain 33 to 100 linear feet of down logs per acre, minimum of eight inches in diameter if available.
2. Ponderosa pine and mixed conifer: Retain 50 to 150 linear feet of down logs per acre, minimum of ten inches in diameter if available.

Protection of Natural and Developed Resources

1. Areas of eroded or compacted soils must be less than 15% of the project area.
2. Precautions shall be taken to prevent the release of any petroleum product, especially near any stream, wetland, or body of water. An "Oil Spill Plan" may be required for addressing equipment repairs, petroleum spills, refueling, etc., prior to the commencement of operations.
3. The project site must be clean and free of garbage.
4. A portable toilet will be required for five or more workers.
5. All logging equipment must be thoroughly cleaned prior to arrival at, and departure from the project site to minimize the spread of noxious weeds.
6. Restore all roads and skid trails to their pre-project condition. Restoration may include grading, installation of water bars, and addition of woody debris in disturbed areas, or tilling and seeding.
7. Forest thinning operations are restricted on slopes steeper than 30 degrees unless approved by the Contract Administrator.
8. Protect all streams, wetlands, riparian areas, and lakes by complete avoidance and a 100' buffer.

Operational and Seasonal Restrictions

1. All logging operations shall be suspended during periods of heavy rain as determined by the Contract Administrator.
2. Hauling operations are prohibited after nightfall, on weekends, and holidays unless otherwise approved.
3. Forest operations shall be suspended when fire hazard is high or extreme.
4. Operations will be restricted to times when the soil is protected by:
    a. Low moisture levels (low plasticity: soil cannot be compressed into a ball without breaking apart or crumbling), or
    b. Twelve inches of packed snow, or
    c. Two inches of frozen soil.

Safety

1. The Contract Administrator may require that informational signs be placed on roadways and social trails adjacent to all logging operations. The Contract Administrator shall approve the content of signs.
2. There shall be one fire tool with every person working on the site and one operational fire extinguisher in each vehicle, including skidders. All chainsaws shall have approved spark arrestors. Should a fire occur, all crewmembers will take immediate suppression activities; the contractor will be responsible for any fires if they, or an employee, are found to be negligent.

Wildfire Mitigation and Slash Pile Burning

Prescribed burning is a potentially risky and dangerous operation and should only be implemented by professionally trained and certified personnel.

Individuals should check with the local Colorado State Forest Service office or fire authority for the current requirements on open fires. One or more of the following steps may be required.

1. Complete and have an approved open burning permit from the local (county) Health Department.
2. Obtain authorization from the legally constituted fire authority for your area. This may be part of the health department permit process.
3. Land management agencies must complete and have approval of an open burning permit from the Colorado Department of Health – Air Pollution Control Division (303) 692-3157.

Copies of all permits should be available on-site during the burning operation. Burning activities should also include plans for safety, supplemental water sources, and extra assistance from the local fire authority or the landowner. The individual(s) planning the burning operation should notify the following entities on the day of a burn: the local fire authority; county sheriff's department; and adjacent landowners who may be affected by smoke. Notification should include the date, times, and location of the burn.

Slash pile burning must be conducted under suitable conditions. Periods of snow or light rain, with steady, light winds (for smoke dispersal), and sufficient snow cover (6 to 12 inches) are ideal. Do not burn during periods of high winds, low humidity or drying conditions, temperature inversions (especially "Red Air Quality" days in metropolitan areas), with a lack of snow cover, or if these conditions are expected to develop after starting the burn. Persons burning slash piles should have the following: leather gloves, shovel or pulaskis, suitable footwear, masks for covering the mouth and nose, and eye protection.

1. Defensible space standards: consult the Anchor Point Group or see F.C. Dennis 2003, Creating wildfire defensible space zones.
2. Fuelbreak standards: consult the Anchor Point Group.
3. Contact Anchor Point for assistance with implementation of prescribed fire.

APPENDIX III: WILDFIRE MITIGATION

Fire Behavior Potential Analysis Methodology

Purpose

The purpose of this appendix is to describe the methodology used to evaluate the threat represented by physical hazards, such as fuels, weather and topography, to values-at-risk in the study area by modeling their effects on fire behavior potential.

Model Description

The fire behavior potential analysis represents a relative ranking of locations based upon fire behavior predicted by the model. The model inputs include aspect, slope, elevation, canopy cover, fuel type, canopy bulk density, canopy base height and stand height. The model outputs are determined using FlamMap which combines surface fire predictions with the potential for crown fire development. Calculations for surface fire predictions (rate of spread and flame length) are based on the USDA Forest Service's BEHAVE model.

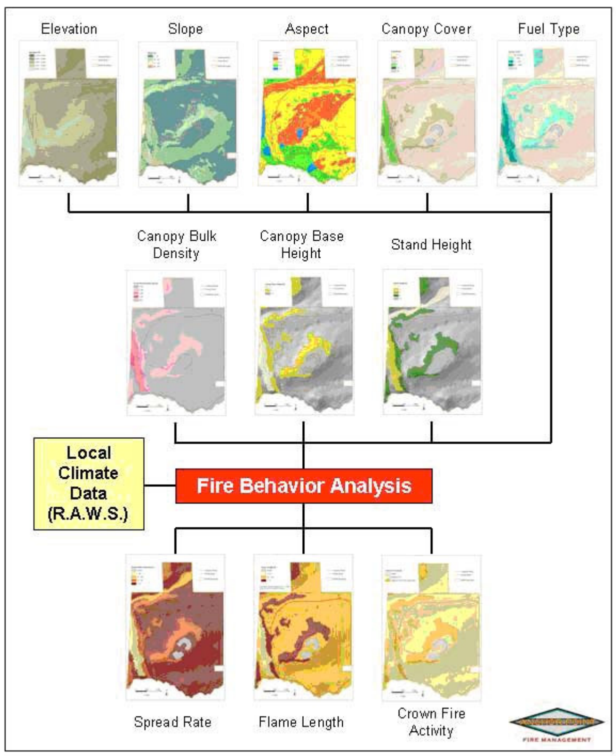


Figure 21. Modeling fire behavior potential

BEHAVE

The **BEHAVE** fire behavior prediction and fuel modeling system was utilized to determine surface fire behavior estimates for this study. **BEHAVE** is a nationally recognized set of calculations used to estimate a surface fire's intensity and rate of spread given certain conditions of topography, fuels (Anderson 1982) and weather. The **BEHAVE** modeling system has been used for a variety of applications including prediction of an ongoing fire, prescribed fire planning, fuel hazard assessment, initial attack dispatch and fire prevention planning and training. Predictions of wildland fire behavior are made for a single point in time and space given simple user-defined fuels, weather and topography. Requested values depend on the modeling choices made by the user. Assumptions of **BEHAVE:**

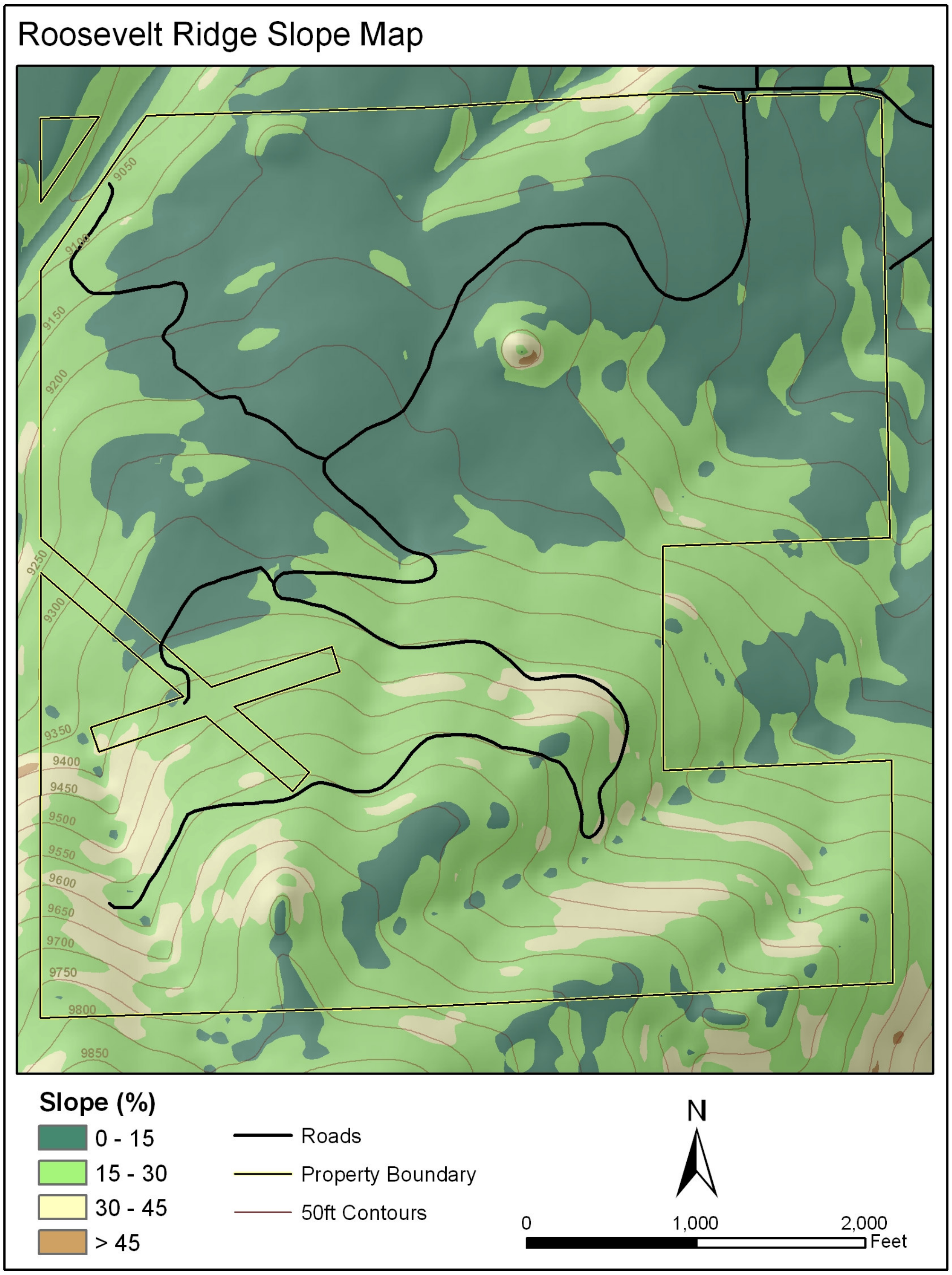
1) fire is predicted at the flame front,
2) fire is free burning,
3) behavior is heavily weighted towards the fine fuels,
4) fuels are continuous and uniform, and
5) surface fires.

FlamMap

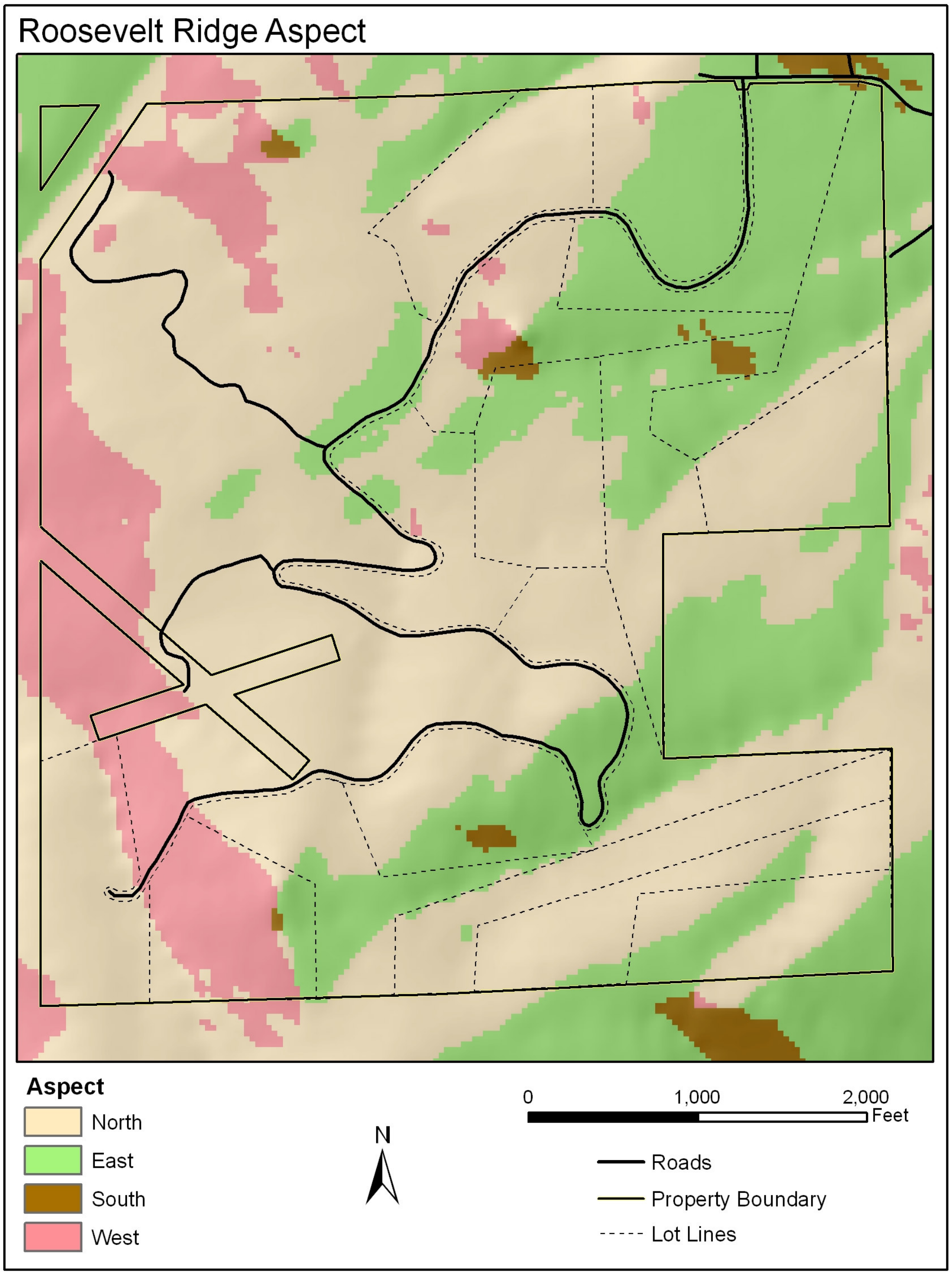
Anchor Point uses **FlamMap** to evaluate the potential fire conditions in the study area. The Roosevelt Ridge study area encompasses approximately 500 acres. This area, which includes a buffer of approximately 200 feet in all directions, is broken down into 10 meter (M) grids. Using existing vector and raster spatial data and field data, **ArcGIS** spatial analysis capabilities are utilized to calculate model inputs for each 10 meter square (MSq) grid. These values are input into **FlamMap,** along with reference weather and fuel moisture (long-term weather observations statistically calculated from the Pickle Gulch Remote Automated Weather Station information). The outputs of **FlamMap** include the estimated Rate of Spread (ROS) (from **BEHAVE**), Flame Length (FL) (from **BEHAVE**) and Crown Fire Activity for a fire in that 10 MSq grid. The model computes these values for each grid cell in the study area.

Fire Behavior Inputs

The major factors influencing fire behavior are aspect, slope, elevation, canopy cover and fuel type. The following pages contain a brief explanation of each.

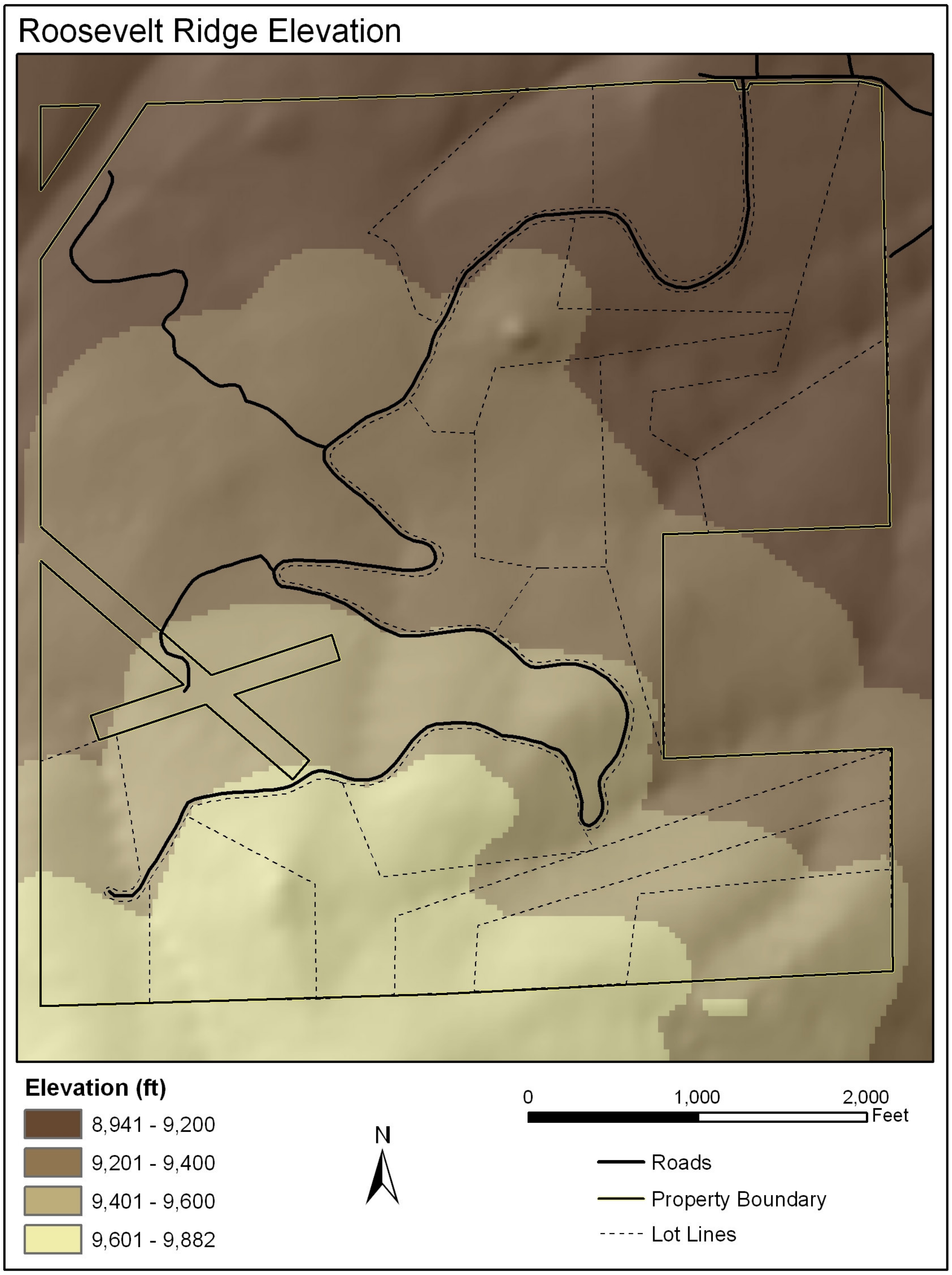


Slope: Steeper slopes intensify fire behavior and will contribute to a high wildfire hazard rating. Rates of spread for a slope of 30% are typically double those of flat terrain when all other influences are equal.



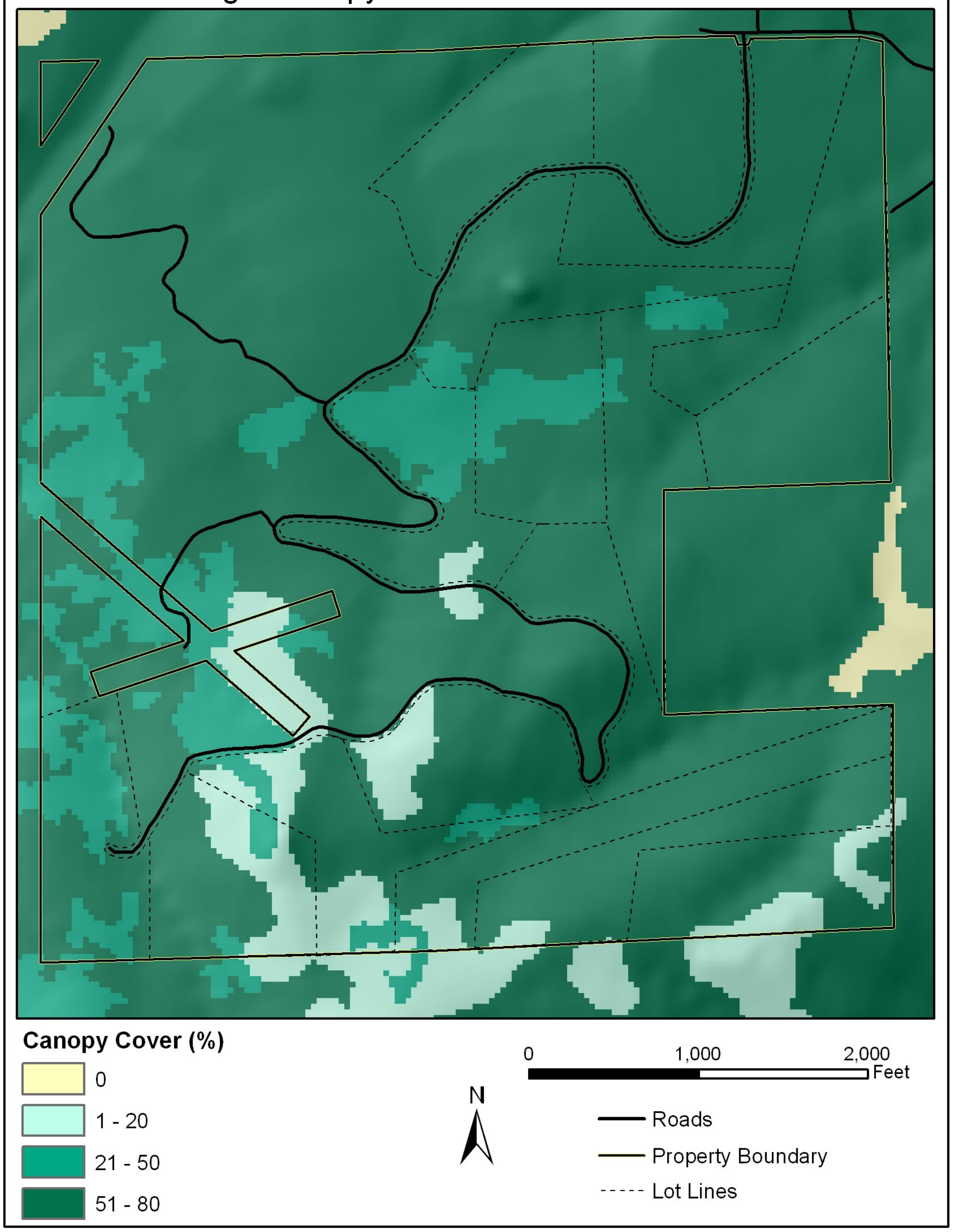
Aspect: Aspects are influential in the type and quantity of vegetative fuels. Fuels on south-facing slopes tend to be drier and more lightly loaded than fuels on north-facing slopes when all other influences are equal. Aspect also has an influence on plant species dominance.

Classification	North	East	South	West
Range	315-45	45-135	135-225	225-315

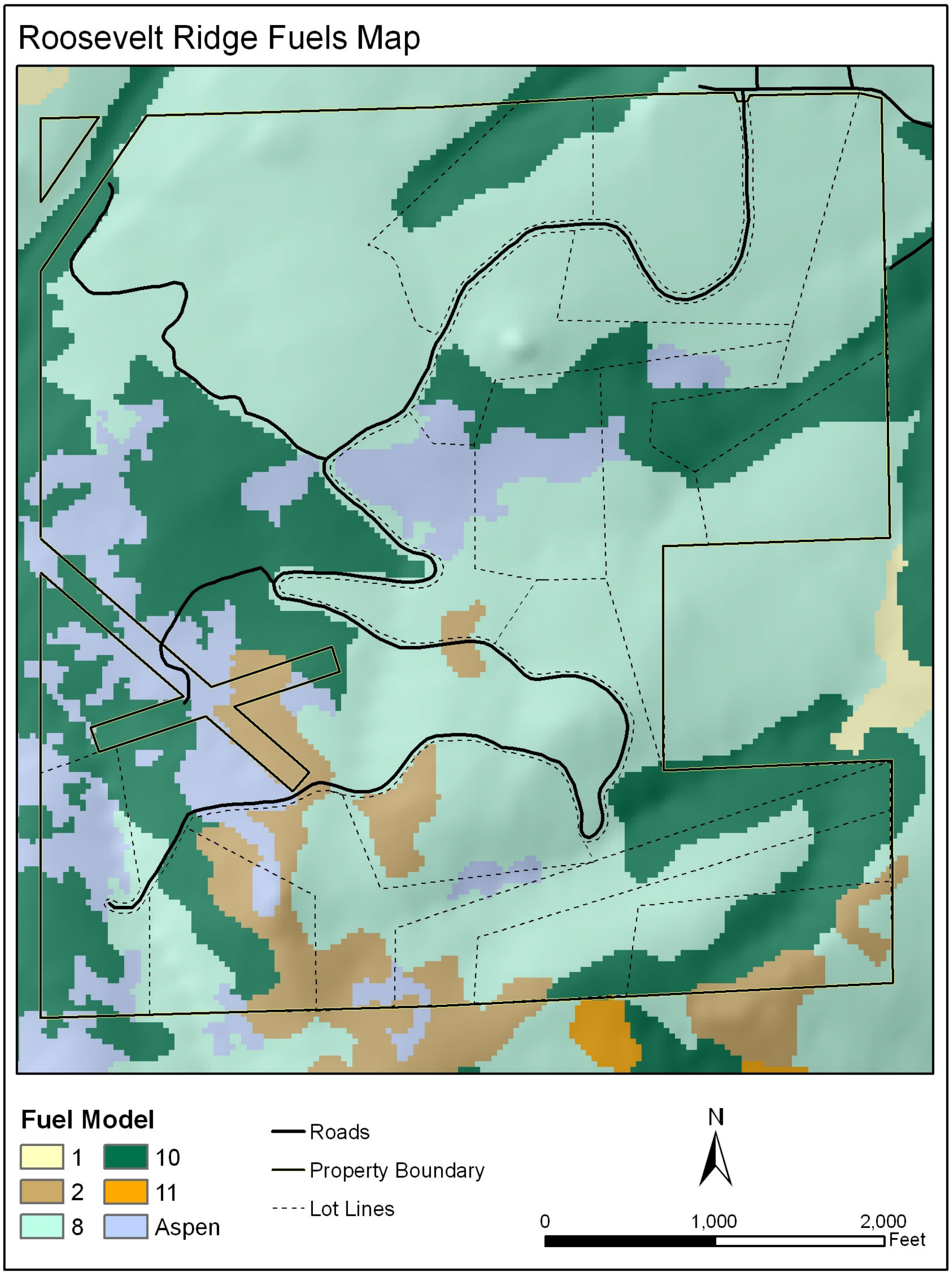


Elevation: As elevation increases, environmental conditions, fuel type and fuel characteristics change. Elevations within Roosevelt Ridge vary from 8,900 feet to approximately 9,880 feet.

Roosevelt Ridge Canopy Cover



Canopy cover: Canopy cover is the horizontal percentage of the ground surface that is covered by tree crowns. By shading other vegetation, canopy cover has a direct effect on the type and amount of surface fuels available for burning. Canopy cover is also a measure of the horizontal continuity of aerial fuels. Heavier canopy cover allows for an easier transmission of fire from crown to crown.



Fuel Models: Fuel models are sets of numbers that describe fuels in terms that a fire behavior model can use. There are seven characteristics that are used to categorize fuel models: 1) fuel loading, 2) size and shape, 3) compactness, 4) horizontal continuity, 5) vertical arrangement, 6) moisture content, and 7) chemical content. The study area is represented primarily by six fuel models (FM): FM 1, 2, 8, 10, 11 and 28 (a custom aspen fuel model). Other fuel models exist, but not in sufficient quantity to influence fire behavior. Each of these fuel types are further described below in tables which show a range of surface fire behavior based on the **BEHAVE** system.

Fuel Model 1

Characteristics: Grasslands and savanna are represented along with stubble, grass-tundra and grass-shrub combinations.

Common Types/Species: Annual and perennial grasses are included in this fuel model.

Fire Behavior: Fire spread is governed by the fine, very porous and continuous herbaceous fuels that have cured or are nearly cured. Fires in this fuel model are surface fires that move rapidly through the cured grass and associated material. Very little shrub or timber is present, generally less than one-third of the area.

Rate of spread in chains/hour (1 chain=66 ft)

		Mid-flame Wind Speed					
Fine Dead Fuel moisture %		2.0	4.0	6.0	8.0	10.0	12.0
	2.0	28.8	92.9	203.6	362.4	570.1	665.6
	4.0	22.0	71.1	155.7	277.0	345.1	345.1
	6.0	19.4	62.4	136.8	243.4	270.1	270.1
	8.0	16.7	53.9	118.1	198.7	198.7	198.7
	10.0	11.0	35.6	64.8	64.8	64.8	64.8

10 hr fuel=5%, 100 hr fuel=6%, herbaceous fuel moisture=100%, slope=10%

Flame Length in Feet

		Mid-flame Wind Speed					
Fine Dead Fuel moisture %		2.0	4.0	6.0	8.0	10.0	12.0
	2.0	3.0	5.1	7.3	9.6	11.8	12.7
	4.0	2.4	4.1	5.9	7.8	8.6	8.6
	6.0	2.2	3.8	5.5	7.1	7.5	7.5
	8.0	2.0	3.4	4.9	6.3	6.3	6.3
	10.0	1.4	2.4	3.2	3.2	3.2	3.2

10 hr fuel=5%, 100 hr fuel=6%, herbaceous fuel moisture=100%, slope=10%

Fuel Model 2

Characteristics: This type consists of open grown pine stands. Trees are widely spaced with few understory shrubs or regeneration. Ground cover consists of mountain grasses and/or needles and small woody litter. This model occurs in open-grown and mature ponderosa pine stands in the Foothill to Montane zones. Open shrub lands and pine stands or scrub oak stands that cover one-third to two-thirds of the area may generally fit this model; such stands may include clumps of fuels that generate higher intensities and that may produce firebrands. Scattered sage within grasslands and some pinyon-juniper may be in this model.

Common Types/Species: The dominant tree species is ponderosa pine; this type also includes some scattered Douglas-fir. Other tree and shrub species include common and Rocky Mountain juniper, buckbrush, sage, bitter brush, and mountain mahogany. Mountain grasses are also included.

Fire Behavior: Fire spread is primarily through the fine herbaceous fuels, either curing or dead. These are surface fires where the herbaceous material, in addition to litter and dead-down stem wood from the open shrub or timber overstory, contribute to the fire intensity.

Rate of spread in chains/hour (1 chain=66 ft)

		Mid-flame Wind Speed					
		2.0	4.0	6.0	8.0	10.0	12.0
Fine Dead Fuel moisture %	2.0	12.4	34.2	67.5	111.6	166.0	230.2
	4.0	10.2	28.0	55.3	91.4	135.9	188.5
	6.0	9.0	24.9	49.1	81.2	120.8	167.6
	8.0	8.3	22.9	45.3	74.9	111.3	154.4
	12.0	7.4	20.5	40.5	67.0	99.7	138.3

10 hr fuel=5%, 100 hr fuel=6%, herbaceous fuel moisture=100%, slope=10%

Flame Length in Feet

		Mid-flame Wind Speed					
		2.0	4.0	6.0	8.0	10.0	12.0
Fine Dead Fuel moisture %	2.0	4.3	6.9	9.4	11.8	14.2	16.5
	4.0	3.7	5.8	8.0	10.1	12.1	14.0
	6.0	3.4	5.4	7.3	9.2	11.1	12.9
	8.0	3.2	5.1	6.9	8.7	10.5	12.2
	10.0	2.9	4.7	6.4	8.1	9.7	11.2

10 hr fuel=5%, 100 hr fuel=6%, herbaceous fuel moisture=100%, slope=10%

Fuel Model 8

Characteristics: Closed canopy stands of short-needle conifers or hardwoods that have leafed out support fire in the compact litter layer. This layer is mainly needles, leaves, and occasionally twigs because little undergrowth is present in the stand. Amounts of needle and woody litter are also low. This fuel model occurs at higher elevations in the Montane zone.

Common Types/Species: Representative conifer types include white pine, lodgepole pine, spruce, fir, and larch but ponderosa pine can also be included. Closed stand of birch-aspen with leaf litter compacted and western hemlock stands are also representative; there are little or no understory plants.

Fire Behavior: Fires in this fuel model are slow burning, low intensity fires burning in surface fuels. Fuels are mainly needles and woody litter. Heavier fuel loadings can cause flare-ups. Heavier fuel loads have the potential to develop crown fires in extreme burning conditions.

Rate of spread in chains/hour (1 chain=66 ft)

		Mid-flame Wind Speed					
		2.0	4.0	6.0	8.0	10.0	12.0
Fine Dead Fuel moisture %	2.0	1.1	2.3	3.9	5.7	7.8	10.1
	4.0	0.9	1.9	3.2	4.7	6.4	6.9
	6.0	0.7	1.6	2.6	3.9	4.9	4.9
	8.0	0.6	1.4	2.3	3.4	3.8	3.8
	10.0	0.6	1.2	2.0	3.0	3.1	3.1
	12.0	0.5	1.1	1.8	2.7	2.7	2.7

10 hr fuel=5%, 100 hr fuel=6%, herbaceous fuel moisture=100%, slope=10%

Flame Length in Feet

		Mid-flame Wind Speed					
		2.0	4.0	6.0	8.0	10.0	12.0
Fine Dead Fuel moisture %	2.0	0.9	1.3	1.7	2.0	2.3	2.6
	4.0	0.8	1.1	1.4	1.7	2.0	2.0
	6.0	0.7	1.0	1.2	1.5	1.7	1.7
	8.0	0.6	0.9	1.1	1.3	1.4	1.4
	10.0	0.6	0.8	1.0	1.2	1.3	1.3
	12.0	0.6	0.8	1.0	1.2	1.3	1.3

10 hr fuel=5%, 100 hr fuel=6%, herbaceous fuel moisture=100%, slope=10%

Fuel Model 10

Characteristics: This model is represented by dense stands of over-mature ponderosa pine, lodgepole pine, mixed-conifer and continuous stands of Douglas-fir. In all stand types, heavy down material is present. There is also a large amount of dead, down woody fuels. Reproduction may be present, acting as ladder fuels. This model includes stands of budworm killed Douglas-fir, closed stands of ponderosa pine with large amounts of ladder and surface fuels and stands of lodgepole pine with heavy loadings of downed trees. This model can occur from the foothills through the sub-alpine zone.

Common Types/Species: All types of vegetation can occur in this model, but primary species are Douglas-fir, ponderosa pine and lodgepole pine.

Fire Behavior: Fire intensities can be moderate to extreme. Fire moves through dead, down woody material. Torching and spotting are more frequent. Crown fires are quite possible.

Rate of spread in chains/hour (1 chain=66 ft)

		Mid-flame Wind Speed					
		2.0	4.0	6.0	8.0	10.0	12.0
Fine Dead Fuel moisture %	2.0	3.8	8.2	13.7	20.1	27.3	35.1
	4.0	3.3	7.2	12.1	17.8	24.1	31.0
	6.0	3.0	6.6	11.0	16.1	21.8	28.0
	8.0	2.8	6.1	10.2	14.9	20.2	26.0
	10.0	2.6	5.7	9.6	14.1	19.1	24.5
	12.0	2.5	5.5	9.2	13.4	18.2	23.4

10 hr fuel 5%, 100= 6%, woody fuel moisture= 100%, slope 10%

Flame Length in Feet

		Mid-flame Wind Speed					
		2.0	4.0	6.0	8.0	10.0	12.0
Fine Dead Fuel moisture %	2.0	3.8	5.5	7.0	8.3	9.5	10.7
	4.0	3.5	5.0	6.3	7.5	8.6	9.7
	6.0	3.2	4.6	5.8	6.9	7.9	8.9
	8.0	3.0	4.3	5.5	6.5	7.5	8.4
	10.0	2.9	4.1	5.2	6.2	7.2	8.0
	12.0	2.8	4.0	5.1	6.0	6.9	7.8

10 hr fuel 5%, 100= 6%, woody fuel moisture= 100%, slope 10%

Fuel Model 11

Characteristics: This model is represented by light logging and partial cut slash residues. Clearcut operations generally produce more slash than represented here. The less-than-3-inch (7.6-cm) material load is less than 12 tons per acre (5.4 f/ha). The greater-than-3-inch (7.6-cm) is represented by not more than 10 pieces, 4 inches (10.2 cm) in diameter, along a 50-foot (15-m) transect.

Common Types/Species: Light partial cuts or thinning operations in mixed conifer stands, hardwood stands, and southern pine harvests are considered.

Fire Behavior: Fires are fairly active in the slash and herbaceous material intermixed with the slash. The spacing of the rather light fuel load, shading from overstory, or the aging of the fine fuels can contribute to limiting the fire potential.

Rate of spread in chains/hour (1 chain=66 ft)

		Mid-flame Wind Speed					
		2.0	4.0	6.0	8.0	10.0	12.0
Fine Dead Fuel moisture %	2.0	3.7	7	10.6	14.5	18.4	22.5
	4.0	3	5.7	8.7	11.8	15.1	18.4
	6.0	2.6	5	7.6	10.4	13.2	16.1
	8.0	2.4	4.6	7	9.5	12.1	14.7
	10.0	2.2	4.2	6.4	8.6	11	13.4
	12.0	1.9	3.6	5.5	7.5	9.6	11.7

10 hr fuel 5%, 100= 6%, herbaceous fuel moisture= 100%, slope 10%

Flame Length in Feet

		Mid-flame Wind Speed					
		2.0	4.0	6.0	8.0	10.0	12.0
Fine Dead Fuel moisture %	2.0	3	4.1	4.9	5.7	6.3	6.9
	4.0	2.6	3.5	4.2	4.9	5.4	6
	6.0	2.4	3.2	3.9	4.5	5	5.5
	8.0	2.2	3	3.7	4.2	4.7	5.2
	10.0	2.1	2.9	3.5	4	4.5	4.9
	12.0	1.9	2.6	3.1	3.6	4	4.4

10 hr fuel 5%, 100= 6%, woody fuel moisture= 100%, slope 10%

Fuel Model Aspen

Characteristics: Fuel model 28 (TU1 Light load dry climate timber-grass-shrub): the primary carrier of the fire is forest litter in combination with herbaceous or shrub fuels. This fuel model contains a live herbaceous load and is dynamic, meaning that the live herbaceous fuel load is allocated between live and dead as a function of live herbaceous moisture content.

Common Types/Species: Typical vegetation types are aspen stand and riparian areas. Fuel bed depth is about 0.5 feet.

Fire Behavior: The effect of live herbaceous moisture content on spread rate and intensity is strong and depends on the relative amount of grass and shrub load in the fuel model. Live herbaceous and shrub fuel strongly affect the fire behavior. Expect low spread rates and moderate flame lengths.

Rate of spread in chains/hour (1 chain=66 ft)

		Mid-flame Wind Speed					
Fine Dead Fuel moisture %		2.0	4.0	6.0	8.0	10.0	12.0
	2.0	0.9	2	3.3	4.8	6.4	8.1
	4.0	0.8	1.7	2.8	4.1	5.5	7
	6.0	0.6	1.4	2.3	3.3	4.4	5.3
	8.0	0.4	0.9	1.5	2	2	2
	10.0	0.3	0.6	0.9	0.9	0.9	0.9
	12.0	0.3	0.6	0.8	0.8	0.8	0.8

10 hr fuel 5%, 100= 6%, herbaceous fuel moisture= 100%, slope 10%

Flame Length in Feet

		Mid-flame Wind Speed					
Fine Dead Fuel moisture %		2.0	4.0	6.0	8.0	10.0	12.0
	2.0	1.1	1.5	1.9	2.3	2.6	2.9
	4.0	0.9	1.3	1.7	2	2.3	2.6
	6.0	0.8	1.1	1.4	1.6	1.9	2
	8.0	0.5	0.7	0.9	1.1	1.1	1.1
	10.0	0.4	0.5	0.6	0.6	0.6	0.6
	12.0	0.4	0.5	0.6	0.6	0.6	0.6

10 hr fuel 5%, 100= 6%, woody fuel moisture= 100%, slope 10%

Reference Weather Used in the Fire Behavior Potential Evaluation

The weather inputs for **FlamMap** were created by using weather data collected at Pickle Gulch.

Table 7. Pickle Gulch Site Information

Latitude (dd mm ss)	39 ° 52' 58 " N
Longitude (dd mm ss)	105 ° 30 ' 59 " W
Elevation (ft.)	9,380

Weather observations from the Pickle Gulch Remote Automated Weather Station (RAWS) were averaged for a ten-year period (May to October 1994-2004) to calculate these conditions. The average (moderate) conditions class (16th to 89th percentile) was calculated for each variable (1 hour, 10 hour, and 100 hour fuel moisture, woody fuel moisture, herbaceous fuel moisture, and wind speed) using Fire Family Plus. This weather condition class most closely represents an average fire season day.

The extreme conditions class was calculated using ninety-seventh percentile weather data. That is to say, the weather conditions existing on the four most severe fire weather days (sorted by Spread Component) in each season for the ten-year period were averaged together. It is reasonable to assume that similar conditions may exist for at least four days of the fire season during an average year. In fact, during extreme years such as 2000 and 2002, such conditions may exist for significantly longer periods. Even these calculations may be conservative compared to observed fire behavior. Drought conditions during the last few years have significantly changed the fire behavior in dense forest types such as mixed conifer. The current values underestimate fire behavior especially in the higher elevation fuels, because the extremely low fuel moistures are not represented in the averages. The following values were used in **FlamMap**:

Table 8. Moderate and extreme weather conditions

Moderate Conditions		**Extreme Conditions**	
Variable	Value	Variable	Value
Woody fuel moisture	117%	20 ft Wind speed up slope	11 mph
100 hr fuel moisture	11%	Herbaceous fuel moisture	50%
10 hr fuel moisture	7%	Woody fuel moisture	102%
1 hr fuel moisture	6%	100 hr fuel moisture	8%

Fire Behavior Interpretation and Limitations

This evaluation is a prediction of likely fire behavior given a standardized set of conditions and a single point source ignition at every point. It does not consider cumulative impacts of increased fire intensity over time and space. The model does not calculate the probability that a wildfire will occur. It assumes an ignition occurrence for every cell, a 10 x 10 meter area.

Weather conditions are extremely variable and not all combinations are accounted for. These outputs are best used for pre-planning and not as a stand alone product for tactical planning. It is recommended that whenever possible, fire behavior calculations be done with actual weather observations during the fire. It is also recommended that the most current ERC values be calculated and distributed during the fire season to be used as a guideline for fire behavior potential.

Landscape Scale Fuels Modifications

One of the most effective tools for modifying landscape fuels is the fuel break (sometimes referred to as "shaded fuel break"). A fuel break is preferably an easily accessible strip of land of varying width, depending on fuel and terrain, in which fuel density is reduced to improve fire control opportunities. Vegetation is thinned to remove diseased, fire-weakened and most standing dead trees; thinning should retain fire resistant species. Ladder fuels, such as low limbs and small diameter regeneration, brush, dead and down materials, logging slash and other heavy ground fuels are removed and disposed of to create an open, park-like stand. The use of fuel breaks under normal burning conditions can aid firefighters by limiting the uncontrolled spread of fire. Under extreme burning conditions, where spotting occurs for miles ahead of the main fire and the probability of ignition is high, even the best fuel breaks are not effective. However, fuel breaks have proven to be effective in limiting the spread of crown fires. Factors to be considered when determining the need for fuel breaks in mountain subdivisions include:

1) the presence and density of hazardous fuels,
2) slope and other hazardous topographic features,
3) crowning potential,
4) ignition sources,
5) wind direction and speed, and
6) the location and distribution of homes and building lots.

With the exception of aspen, all of Colorado's major timber types present a significant risk of wildfire. Aspen stands at Roosevelt Ridge, however, contain heavy fuel loads in places. In this circumstance, it is probable that down and dead material would be the primary carrier of fire under extreme burning conditions and aspen stands would not act as a significant fuel break.

Increasing slope causes fire to move from surface fuels to tree crowns more easily due to preheating. Compared to flat ground, a slope of 30% doubles the rate of spread of fire. Residential developments with homes located on or near summits and ridge tops are good candidates for fuel breaks. In Roosevelt Ridge, possible locations for fuel breaks are areas where active crown fires are likely to exist and where ignition sources (such as public lands and recreation areas that permit campfires) pose a threat.

Fuel breaks should always be connected to a good anchor point such as a rock outcropping, river, lake, road or less flammable fuel type. The classic location for a fuel break is along the top of a ridge to stop fires from backing down the other side or spotting into the next drainage. This is sometimes not practical because the structures firefighters are trying to protect are usually located at the tops of ridges or at mid-slope. The least desirable location for a fuel break is at mid-slope; however, it may be the most convenient location due to the proximity to defensible space work or existing roads and escape routes.

Fuel breaks are often easiest to locate along existing roadbeds (see the description of the fuels modification project for primary access corridors in this report). The minimum recommended fuel break width is 200 feet. As rate of spread and intensity increase with slope angle, the size of the fuel break should also be increased with an emphasis on the downhill side of the roadbed or centerline. The formulas for slope angles of 30% and greater are as follows (see also Table 3):

Distance below road = 100' + (1.5 x slope %)
Distance above road = 100' – slope %

For fuel breaks that pass through hazardous topographic features, these distances should be increased by 50%. Since fuel breaks can have an undesirable effect on the aesthetics of the area, crown separation should be emphasized over stand density levels. Isolating groupings rather than cutting for precise stem spacing will help mitigate the visual impact of the fuel break. Irregular cutting patterns that reduce canopy density and create islands with wide openings are also effective.

Another issue related to creating fuel breaks is the removal of cut materials. In Colorado's dry climate, slash decomposes very slowly. Failing to remove slash adds to the surface fuel loading, possibly making the area more hazardous than before treatment. It is imperative that all cut materials be disposed of by piling and burning, chipping, physical removal from the area or lopping and scattering. Lopping and scattering is the cheapest method but also the least effective since materials will contribute to the surface fuel load.

Fuel breaks must be maintained to be effective; thinning usually accelerates the process of regenerative growth. The effectiveness of the fuel breaks may be lost in as little as three to four years if ladder fuels and regeneration are not controlled.

Table 9. Recommended treatment distances for mid-slope roads

% Slope	Distance Above Road	Distance Below Road
30	70 feet	145 feet
35	65 feet	153 feet
40	60 feet	160 feet
45	55 feet	168 feet
50	50 feet	175 feet

Structure Protection from Wildfire

Construction in Roosevelt Ridge should be required to follow Ignition Resistant Constructing Class I standards as defined in the ICC Wildland Urban Interface Code. These construction techniques in combination with fuels reduction on both the landscape and home-site level should create a condition where developed property would have a low-to moderate impact from a moderate intensity wildfire. Additionally, there are other improvements that could be made to further ensure protection from fire. Some of these elements are detailed in these fact sheets from the Colorado State Forest Service:

http://www.ext.colostate.edu/pubs/natres/06302.html

- 6.302, *Creating Wildfire-Defensible Zones*;
- 6.303, *Fire-Resistant Landscaping*;
- 6.305, *FireWise Plant Materials*; and
- 6.306, *Grass Seed Mixes to Reduce Wildfire Hazard*.

Below is a maintenance checklist. Don't wait until a fire is approaching to perform these tasks. These should be done as conditions dictate, several times a year.

1) Thin tree and brush cover
2) Dispose of slash and debris left from thinning
3) Remove dead limbs and other litter
4) Maintain an irrigated greenbelt if possible, mow dry grasses and weeds regularly around structures out to 30 feet
5) Rake debris away from corners and culverts where they may accumulate
6) Prune branches 8 to 10 feet above the ground
7) Reduce forest density surrounding structures, beyond the established defensible space.
8) Keep flammable materials away from vegetation

APPENDIX IV: NOXIOUS WEEDS

Canada Thistle

Cirsium arvense is an exotic perennial forb that can spread by seed, but is more of a problem due to its ability to spread rapidly from vigorous rhizomes that can extend as far as 15 feet from the parent plant. Infestations often begin on disturbed sites such as ditches, overgrazed pastures, or waste areas (Beck 2000). Canada thistle is the greatest problem weed of riparian areas, but is also found occasionally in upland sites. Seeds can be blown long distances and are able to germinate within 8 to 10 days of pollination. Canada thistle begins growth in mid April through May as a rosette. It flowers in June, but produces seed sparingly, relying heavily on its extensive root system for spread. Seeds can remain viable in the soil for up to 20 years (Beck 2000). (Photo from Whitson et al. 1996)

Cultural control: Most cultural control measures for managing Canada thistle include increasing competition with Alfalfa and perennial grasses. However, this is not a viable option at Roosevelt Ridge due to the occurrence of healthy natural plant communities.

Biological control: The weevil *Ceutorhyncus litura* is currently being used in Colorado as a biocontrol agent (Beck 2000). The larvae of this weevil bore into the main leaf vein and down into the plant's crown. Large weevil populations can kill these plants; smaller populations will stress plants and decrease its vigor. Another biocontrol insect, *Urophora cardui*, has been used to control Canada thistle. The larvae of this insect burrow into the shoots and their feeding triggers large galls that stress the plant (Beck 2000). Biological control methods alone are not effective and must be used in conjunction with other practices.

Mechanical control: Mowing is a popular method of decreasing plant vigor and seed set. However, this may not be a viable option given the plants dispersal in riparian areas. Hand pulling is an effective means of control for small populations, but is not practical for large populations due to the robust, deep, and extensive network of underground rhizomes. When seed heads are encountered they should be clipped well below the apex, bagged, and disposed of in a dumpster.

Chemical control: Curtail at 2 to 3 quarts/Ac can be applied when the oldest Canada thistle plants are entering the bud growth stage and the youngest are in the rosette to bolting growth stages (Beck 2000). Transline can be applied at 2/3 to 1 pint/Ac when Canada thistle is in the rosette to bud growth stages. Transline at 1 pint/Ac is also effective when applied in the fall (Beck 2000). Caution should be used in selecting herbicides for this weed since it occurs near water where many pesticides can have detrimental effects on aquatic life.

Integrated Management Recommendations: Hand pull or clip seed heads, mow small populations where accessible in bud stage, apply chemical control around first frost; biocontrol options should also recommended.

Musk Thistle

Carduus nutans is an exotic winter annual or biennial that flowers from July to late September. It generally invades areas that are overgrazed or are experiencing poor perennial grass cover; establishment is favored by high levels of moisture and light. The average plant produces more than 10,000 seeds that are readily dispersed by the wind, thereby infesting large areas within two growing seasons (Lym and Zollinger, 2000). Control can be obtained by reducing seed set and depleting the seed bank. Photo from Whitson et al. (1996).

<u>Cultural control:</u> We recommend interseeding disturbed sites to prevent the spread of this plant. If competitive vegetation is not established, reinvasion will be likely.

<u>Biological control:</u> The musk thistle seed head weevil, *Rhinocyllus conicus*, has been used throughout Colorado to combat this weed (Beck 1997). The larvae of this weevil bore into the flower and destroy developing seeds thereby reducing seed production by 50%. Biological control is most effective when used in conjunction with mechanical or chemical methods.

<u>Mechanical control:</u> Mowing with a weed whip or scythe can be a useful mechanical control to reduce seed set. Mechanical control should be implemented when terminal flowers (e.g., tallest flowers which bloom first) are in the late-flowering stage, typically early July (Beck 1997). Mechanical control should be combined with biological methods.

<u>Chemical control:</u> Effective chemical control has been achieved in the past using Tordon at 0.5 to 1 pint/Ac, Curtail at 2 quarts/Ac, Banvel at 0.5 to 2 quarts/Ac, Telar at 1 ounce/Ac, and Ally-Escort at 0.5 ounces/Ac.

Oxeye Daisy

Oxeye daisy (*Chrysanthemum leucanthemum*) is identified by its daisy-like flowers. The flowers are approximately 2 inches in diameter, solitary at the end of braches and have white ray flowers and yellow, interior disc flowers. The plant is 10 to 24 inches tall, glabrous to sparsely hairy. The leaves are smaller in size upward on the stem; lower leaves are 2 to 5 inches long, lance-shaped to narrowly egg-shaped, and variously toothed. Oxeye daisy can be confused with the ornamental Shasta daisy (*Chrysanthemum maximum*), which is more robust with larger flowers. Flowering occurs from June through August. Oxeye daisy is a native of Eurasia; if given a chance, it can take over and modify natural areas, pasture and rangeland. It is widely distributed throughout the United States; in Colorado, oxeye daisy is usually found at higher elevations in meadows, along roadsides and in waste places. (Photo from Whitson et al. 1996)

Mechanical control: For small infestations, hand pulling or digging before seed head production is effective. However, it is important to remove as much of the underground part as possible to be successful (CNAP 2000).

Cultural control: Minimize disturbance and seed dispersal and eliminate seed production to prevent the establishment of new infestations. Sheep or goat grazing selectively impacts oxeye daisy without adversely affecting desirable species. Nitrogen fertilizer stimulates other vegetation, especially grasses that can out-compete oxeye daisy for nitrogen, grow taller and shade out the daisy (CNAP 2000).

Biological control: None known.

Chemical control: Herbicide is commonly used to control large infestations of oxeye daisy. Picloram (0.25 lb.), dicamba (1 lb. ai/acre), 2,4-D (1 lb. ai/acre) or glyphosate (1.5 lb. ai/acre) will control oxeye daisy. However, picloram can damage desirable forbs as well (CNAP 2000).

Integrated Management Recommendations: Hand pull or dig small infestations before seed heads are produced. Minimize the amount of bare soil exposed by land management practices and maintain a significant grass canopy to shade out oxeye daisy.

Yellow Toadflax

Yellow toadflax (*Linaria vulgaris*) is a perennial forb, 1 to 2 feet tall. It emerges in spring, around mid-April, depending on temperature; a few seedlings may emerge in the fall. It can be identified by its 1-inch long yellow flowers with bearded, orange throats that give it its common name of butter and eggs. Yellow toadflax has pale green, narrow leaves that are pointed at both ends. A similar species, dalmation toadflax, has leaves that are shorter, wider and have a broader base. Yellow toadflax was introduced to the United States from Eurasia as an ornamental in the mid-1800s. It establishes quickly in open sites, forming colonies through creeping root systems. The extensive roots systems make control of the plant difficult. (Photo from Whitson et al. 1996)

Mechanical control: Pulling toadflax by hand can be an effective method of control; however, it must be repeated as long as there are viable seeds in the soil (up to 10 years). Mowing yellow toadflax will not kill the plant but will reduce the current years' growth and seed dispersal. Burning is not recommended; the deep root systems protect the plant from fire. (CNAP 2000)

Cultural control: Intensive cultivation techniques are recommended for control on agricultural land. Minimum-till cultivation practices have contributed to the resurgence of yellow toadflax populations by failing to damage the root system of plants. (From the handout)

Biological control: One species, *Calophasis lunula*, may be available for biological control of yellow toadflax. The larvae of *C. lunula* feed on the leaves and flowers, severely damaging the plant. (CNAP 2000)

Chemical control: Yellow toadflax is hard to control with herbicides. Due to the high genetic variability of toadflax, the effectiveness of herbicides is highly variable. Chemicals should be applied during flowering, when carbohydrate reserves in the root of plants are at their lowest. Picloram (1 lb. ai/acre), dicamba (1 lb. ai/acre) or glyphosate (1.5 lb. ai/acre) will kill yellow toadflax in some situations. Picloram and 2,4-D (0.5 and 1.0 lb. ai/acre) applied together controlled 95 to 100 percent of yellow toadflax when applied for 1 to 3 consecutive years. (CNAP 2000)

Integrated Management Recommendations: Limit the vegetative spread of colonies (pull, cut, or spray) and destroy seedlings that emerge from the soil every year. To discourage other infestations, maintain a cover of native perennial plants.

APPENDIX V: WILDLIFE

Table 10. Special Status (Threatened and Endangered) species that could potentially occur at Roosevelt Ridge.

SCIENTIFIC NAME	COMMON NAME	STATUS[1]	PROBABILITY
Amphibians			
northern leopard frog	*Rana pipiens*	SC	High
Birds			
Mexican spotted owl	*Strix occidentalis lucida*	FT, ST	Low
western yellow-billed cuckoo	*Coccyzus americanus*	SC	Low
American peregrine falcon	*Falco peregrinus anatum*	SC	Low
northern goshawk	*Accipiter gentillis*	FC	Moderate
Fish			
greenback cutthroat trout	*Oncorthynchus clarki stomias*	FT, ST	Low
lake chub	*Couesius plumbeus*	SE	Low
suckermouth minnow	*Phenacobius mirabilis*	SE	Low
common shiner	*Luxilus cornutus*	ST	High
stonecat	*Noturus flavus*	SC	Moderate
Mammals			
wolverine	*Gulo gulo*	SE	Low
Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	FC, SC	Low
Botta's pocket gopher	*Thomomys talpoides rubidus*	SC	Moderate
northern pocket gopher	*Thomomys talpoides macrotis*	SC	High
Reptiles			
common garter snake	*Thamnophis sirtalis*	SC	High

[1]FE - Federally Listed as Endangered
FT - Federally Listed as Threatened
FC - Federal Candidate Species for Listing
Probability = Probability of occurrence

SE - Listed as Endangered in Colorado
ST - Listed as Threatened in Colorado
SC - Listed as a Species of Concern in Colorado

APPENDIX VI: LITERATURE CITED

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APPENDIX VII: GLOSSARY OF TERMS

Adaptive management – A process for implementing management decisions that requires monitoring of actions and adjustment of decisions based on results. Adaptive management applies scientific principles and methods to improve management decisions incrementally as experience is gained and in response to new scientific findings and societal changes.

Aspect – The compass direction of slope of the land.

Basal leaves – Produced at the ground level.

Basal area – The cross-sectional area of a tree stem measured at 4 ½ feet above the ground, expressed in square feet per acre.

Biological control – The use of plant's natural enemies in order to control the distribution of that plant.

Board foot – The amount of wood contained in a board 1 inch thick, 12 inches wide and 12 inches thick.

Broadcast burn – The implementation of prescribed fire to meet fuels reduction, or resource management goals.

Canopy cover– The percent foliar cover in a forest stand (may consist of one or several layers).

Catastrophic wildfire – A wildland fire outside of the historical range of variability both in terms of size and intensity.

Chemical control – The use of herbicides to reduce the incidence of undesirable plants.

Climax species – The final species to dominate a site by replacing early succession species through the mechanism of competition.

Community – An assembly of organisms that tend to occur together under similar environmental conditions; usually considered to be on a smaller spatial scale than an ecosystem.

Coniferous – Cone bearing.

Cultural control – The establishment of competing vegetation to suppress the incidence of undesirable plants.

DBH – Diameter at Breast Height, the standard measurement of tree diameter as measured 4 ½ feet above the ground.

Deciduous – Plants that shed their leaves seasonally

Disturbance – A discrete event, either natural or human induced, that causes change in the existing condition of an ecosystem.

Dog hair stands – Dense stands of small diameter trees found in forests where naturally occurring forests have been suppressed.

Downed fuels – The accumulation of dead woody material on the forest floor that has been severed from its source of growth; materials that serve as fuel for wildfires.

Ecosystem – Living organisms interacting with each other and their physical environment, usually described as an area that is meaningful to address these relationships.

Ecosystem function – The processes through which the constituent living and non-living elements of an ecosystem change and interact, including biogeochemical processes and succession.

Ecosystem management – A concept of natural resource management in which human activities are considered within the context of ecological, societal and economic interactions within a defined area over both the short term and long term. A major goal of ecosystem management is to sustain the ecosystem to meet ecological and human needs into the future: sustainability.

Ephemeral stream – A stream that flows in direct response to precipitation and whose channel is at all times above the water table. Ephemeral streams flow for less than 30 days a year.

Erosion – The wearing away of the land surface by detachment and movement of soil and rock fragments by water, wind, or other geological agents.

Even-aged – Forest stand composed of trees of the same or approximately the same age.

Exotic – Plants, animals, or materials that are not native to a site.

Fire interval – The amount of time between recurrent wildland fires.

Fire intensity – The rate of heat release/unit time/length of the fire front (in BTUs/second/foot). Fire intensity depends on the rate of spread, the heat of combustion, and the total amount of fuel consumed.

Fire suppression – A coordinated effort to control or extinguish wildland fires. A resource management policy initiated in the early 1900's by the U.S. Forest Service in response to widespread wildland fires burned hundreds of thousands of acres of public land. This policy, which was initiated to preserve forest lands, has been revised in recent decades as research has shown that fire is a necessary process in the maintenance of healthy forest ecosystems.

Fuelbreak – A natural or constructed discontinuity in a fuel profile utilized to isolate, stop, or reduce the spread of fire. Fuel breaks may also make retardant lines more effective and serve as control lines for fire suppression actions. Fuel breaks in the WUI are designed to limit the spread and intensity of crown fire activity.

Fuels – Plants and woody vegetation (live or dead) that are capable of supporting combustion.

Fuel load – The oven dry weight of fuels in a given area, usually expressed in tons/acre.

Habitat – Conditions essential for wildlife or fish including sufficient water, food, space, shelter and reproductive needs.

Herbaceous – Not woody.

Heterogeneity – Landscape diversity in the composition, size, shape and arrangement in time and space of landscape components that characterize ecological structure and function.

Historical range of variability – The range of spatial, structural, compositional and temporal characteristics of ecosystem elements during a period specified to represent "natural" conditions.

Intermittent stream – A stream that flows only at certain times of the year when it receives water from springs or from some surface source such as snow in mountainous areas. Intermittent streams flow continuously for at least 30 days a year.

Invasive – Alien species whose introduction and spread does or is likely to cause harm to the economy, the environment, or human health.

Ladder fuel – Any combustible material that enables flames to proceed from the ground into tree canopies; typical ladder fuels include tall grasses and shrubs, small trees, low hanging tree branches and deadfall.

Landing – A temporary storage area for accumulated logs removed from a forest stand during forestry operations.

Mechanical control – The use of physical practices to reduce the incidence of undesirable plants such as mowing, plowing or hand pulling.

Native – Plants, animals and materials that are indigenous to a site.

Noxious weed – A plant that is exotic to a particular environment that is capable of displacing native plant communities through aggressive competition for resources and prolific regeneration. A species that has a potential to cause significant ecological or economical damage.

Patch cut – A silvicultural method where all trees in a localized area are harvested. Patch size varies depending upon forest type and management goals but is typically 1 to 250 acres.

Perennial stream – A stream that flows continuously throughout the year. Perennial streams are generally associated with a water table in the locations through which they flow.

Prescribed burn - The controlled application of fire to wildland fuels to produce the fire behavior and characteristics required to attain resource management objectives.

Rangeland – Treeless or sparsely forested (<10% tree canopy cover) areas that are dominated by herbaceous or shrubby vegetation. These areas are also called forest "openings".

Ratoon – A sprout that grows from a root.

Reference conditions – Conditions that characterize ecosystem composition, structure, function and their variability.

Riparian – A type of wetland that is a transitional area between permanently saturated wetlands and upland sites. This transition area has vegetation or physical characteristics reflective of permanent surface or subsurface water influence.

Sanitation cutting – The removal of disease or insect infested trees from a stand.

Seral – A temporal and intermediate stage in the process of succession.

Silviculture – The science and of art of cultivating forests by controlling or manipulating the establishment, composition and growth of trees.

Site index – The average height of the dominant stand at a specified reference age (typically 100 years). This is a measure of site productivity for a given species.

Slash – Tree branches and woody material generated by forest thinning operations.

Snags – Standing dead trees. Snags provide valuable habitat to numerous wildlife species.

Spatially explicit – A set of resource management tools that may include a Geographic Information System (GIS), Geographic Positioning System (GPS), digital camera or video camera that are used to document management activities and summarize data in meaningful was. Spatially explicit technologies provide decision support to managers by integrating traditional forms of data capture into a GIS.

Stand – A community of trees sufficiently uniform in composition, age, spatial arrangement, or condition, to be distinguished from other plant communities and be treated as one entity for the purposes of management.

Succession – The directional and continuous pattern of colonization and extinction on a site by populations.

Thinning – The removal of undesirable trees for the purpose of improving forest growth and health.

Understory – The lower vegetation layers in a forest found beneath the forest canopy including grasses, forbs, sedges, succulents and shrubs; also referred to as rangeland vegetation.

Wildland urban interface – The area or zone where residential development or other structures meet or intermingle with undeveloped areas.

Woody debris – Dead woody vegetation that enters a riparian-wetland area that is large enough to remain in place for a period of time and operate as a hydrological modifier.

APPENDIX VIII. ELECTRONIC DATABASE