ECOSYSTEM MANAGEMENT PLAN

University Corporation for Atmospheric Research, Boulder County, Colorado

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ECOSYSTEM MANAGEMENT PLAN

Supporting Sustainable Management of Natural Resources

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EXECUTIVE SUMMARY

The NCAR Ecosystem Management 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 to the forest and region; control noxious weeds and improve rangeland health; 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 NCAR and provide a tool for UCAR management, National Science Foundation, local users of the site and other concerned parties to understand the complexity of the NCAR ecosystem. These goals are applied to three distinct arenas: 1) Forest Restoration and Wildfire Mitigation, 2) Rangelands and Noxious Weeds and 3) Wildlife. An ecosystem management approach was utilized to integrate directives for these diverse communities.

Ponderosa pine restoration is needed throughout 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 NCAR were assessed and compared with historical parameters of composition, density and landscape distribution to establish restoration prescriptions. A comprehensive evaluation of wildfire hazard within NCAR 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 and implementation of prescribed burning.

Rangelands are a critical component of the NCAR 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 noxious weeds. Forests and rangelands were inventoried with a landscape level assessment and a focused inventory of noxious weeds. These assessments have provided a complete picture of vegetative composition, documented baseline condition and produced a master species list including identified noxious weed populations. Management recommendations include forest thinning to preserve rangelands and implementation of the integrated weed management plan.

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 NCAR property. Habitat preservation and enhancement initiatives were integrated into the forest and rangeland management prescriptions. The diverse initiatives of the forest restoration, wildfire mitigation, rangeland management, noxious weed control and wildlife habitat preservation have been integrated in this document. Findings are illustrated with discussions, data tables, figures and project maps; recommendations are supported by current ecological research.
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INTRODUCTION

Introduction

Statement of Needs

The NCAR Ecosystem Management Plan was created is to meet long-range resource planning goals for open space, to ensure that management activities are ecologically sustainable, and to integrate these directives with social goals. This plan provides specific management direction to ensure the sustainability of the ponderosa pine ecosystem and serves as a management guide for open space at NCAR.

Project Objectives

Considering previous management activities and desired future conditions, the four main objectives of the NCAR Ecosystem Management Plan are to:

1) Enhance and maintain native plant and animal species, their communities, and the ecological processes that sustain them.
2) Restore forest health and reduce the risk of catastrophic wildfire to the forest and community.
3) Develop an integrated management approach that encompasses all ecological communities represented at NCAR.
4) Provide a tool for UCAR management, National Science Foundation, local users of the site and other concerned parties to understand the complexity of the NCAR ecosystem.

These objectives are applied to three distinct arenas: 1) Forest Restoration and Wildfire Mitigation, 2) Rangelands and 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 450 acre property is located in the southwestern portion of Boulder County on Table Mesa approximately 1.5 miles west of US Route 36. 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.

NCAR Background

“The National Center for Atmospheric Research (NCAR) was designed by a small group of innovative scientists (most of them university faculty members) as a creative response to major challenges that faced the nation in the years between the 1930s and late 1950s. Departments of Meteorology had been established at the Massachusetts Institute of Technology, the University of Chicago, and other U.S. universities in the 1930s. Their goal was to scientifically investigate the physical principles that were thought to define the behavior of the atmosphere. Within a decade, military operations of World War II (unlike those of any previous wars) massive land, sea, and air assaults were highly dependent on weather conditions over vast regions from the North Atlantic to the South Pacific and from the poles to the tropics.

"University meteorology departments grew rapidly as the military services sent weather officers to learn the fundamentals of meteorology. These officers' assignments ranged from daily weather forecasting to strategic planning for large military operations such as the D-Day invasion in Normandy. The military services also supported meteorological research to improve understanding of weather and climate. Military pilots on long-range bombing missions discovered the fast-moving, high-altitude rivers of air that came to be known as jet streams, now recognized as key elements in the large-scale circulation of the atmosphere.

"Despite the impressive training programs of the 1940s, the field of atmospheric science lost ground in the postwar years, becoming a poor cousin to many other branches of science. Approximately 90% of American meteorologists in mid-century were employed by the federal government, mainly in weather forecasting rather than engaging in basic research on the fundamental problems posed by the atmosphere. The number of new people entering the field
was woefully low. At the same time, meteorology boasted the smallest percentage of doctoral degrees of any scientific discipline.

“In 1956, the National Academy of Sciences convened a committee of distinguished scientists to investigate the state of meteorology. Noting the size and complexity of atmospheric problems and the inadequate resources for solving them, the committee recommended an exponential increase in support for basic research. Coupled with new funding, the committee planned to establish a national institute (later called a national center) for atmospheric research to be operated by a consortium of universities with support from the National Science Foundation.

“In 1960, NCAR began operations in Boulder, Colorado, as a program of the National Science Foundation (NSF) managed by the nonprofit University Corporation for Atmospheric Research (UCAR). At the time it funded the creation of NCAR, NSF itself had been in existence only ten years. NSF is now celebrating its 50th anniversary.

“Today, NCAR provides the university research and teaching community with tools such as aircraft and radar to observe the atmosphere and with the technology and assistance to interpret and use these observations, including supercomputer access, computer models, and user support. NCAR and university scientists work together on research topics in atmospheric chemistry, climate, cloud physics and storms, weather hazards to aviation, and interactions between the sun and earth. In all of these areas, scientists are looking closely at the role of humans in both creating climate change and responding to severe weather occurrences.

“Site consulting engineers recommended Table Mesa as the home of NCAR and the UCAR boards of trustees unanimously chose Boulder as the site of NCAR in 1960. The state of Colorado purchased the land for the NCAR laboratory and, in 1961 Boulder Colorado citizens approved the site for NCAR in a 4-1 vote. Renowned architect I.M. Pei was chosen to design the new laboratory on Table Mesa and construction of NCAR’s new home was completed in 1967. For more information about UCAR, NCAR, and UOP, please see the web site at http://www.ucar.edu.” Obtained from (http://www.eo.ucar.edu/what/hist1.html).

Other sources of information regarding the natural history of the NCAR site and surrounding area include “Natural Features of the NCAR Site” by J. Chronic, “Natural History of the Boulder Area” by H. Rodeck and “Natural History Inventory of Colorado” by Tim Hogan.

Soils

Of special concern to the management of the NCAR property is the erodability and productivity of soil groups found in the area. Soil is a dynamic natural body composed of mineral and organic materials and organisms in which plants grow (Brady 1984). The chemical, physical and biological properties of soil determine its suitability for various uses. Soils within Boulder County were mapped by the USDA Soil Conservation Service in 1975. A brief discussion of the six soil types found at NCAR is provided below; these soil units are also indicated on the Soil Unit Map. Additional information regarding these soils can be found in the soil survey (USDA 1975). None of these soils are listed as hydric on the State of Colorado Comprehensive Hydric Soils list (State of Colorado Comprehensive Hydric Soils List. (n.d.). Retrieved May 7, 2005 from ftp://ftp-
The locations of the soil types discussed below are indicated on the Soil Map provided in the Project Maps Section.

**Baller stony sandy loam (BaF):** This soil is found on east slopes in the western part of the county. Large amounts of stone are included throughout this profile. Included within this mapping unit are small areas near the bottom of slopes that have a sandy loam surface and sandy clay loam subsoil. Also included are areas of Rock outcrop. The included soils and Rock outcrop make up approximately 20% of this unit. Runoff is rapid and the erosion hazard is high (USDA 1975).

**Colluvial Land (Cu):** Colluvial land is in long narrow valleys and varies widely in depth, texture, color, reaction and stoniness. Lime content ranges from strongly calcareous to noncalcareous and reaction ranges from moderately alkaline to neutral. Colluvial land receives runoff from adjacent land; erosion hazard is high. Most areas with this soil are used for range (USDA 1975).

**Goldvale-Rock outcrop complex (Grf):** This complex is comprised of about 55% Goldvale coarse sandy loam and about 30% Rock outcrop. This complex is found on long mountain spurs and ridges in the western portion of the county. Included in this complex are minor amounts of shallow soils on ridge tops and alluvial soils along the edges of streams. Included soils are approximately 15% of the mapping unit. Runoff is rapid and the erosion hazard is high. These soils are used for range, timber recreation and home sites (USDA 1975).

**Nederland very cobbly sandy loam (NdD):** This soil is on outwash fans and on the uplands in the central part of the county. These areas have many stones and cobbles on the surface. Included within this soil unit are some soils that lack a sandy clay loam subsoil and that are very stony within cobbly sandy loam throughout the profile. Also included are some areas of Valmont cobbly clay loam on 1 to 5% slopes. The included soils make up about 20% of the mapping unit. Runoff is slow to medium and the erosion potential is slight on this soil. In most places this soil is used for range or home sites (USDA 1975).

**Sixmile stony loam (SmF):** This soil is on the uplands on the western side of steep ridges in the western portion of the county. Included with this soil in mapping are narrow bands of Rock outcrop and escarpments. Near the base of slopes are small areas of Colluvial land. Included soils make up approximately 20% of this mapping unit. Runoff is rapid and erosion hazard in high (USDA 1975).

**Terrace Escarpments (Te):** Terrace escarpments are found on side slopes of old outwash fans and terraces. These areas consist of undifferentiated shallow soils that have many cobbles and stones on the surface. Runoff is rapid and the erosion hazard is high. Terrace escarpments absorb water slowly, only limited moisture is available for plants because these undifferentiated soils are shallow. These soils are not suitable for cultivation and are frequently used for range (USDA 1975).
FOREST RESTORATION AND WILDFIRE MITIGATION

Introduction

Statement of Needs

Ponderosa pine restoration is needed to return forests to an ecologically sustainable condition and to reduce the potential for catastrophic wildfire and insect epidemics (Kaufmann et al. 2003). Restoration efforts should be guided by the historical range of variability and current ecological conditions.

Ponderosa pine forests all along the Front Range of Colorado have changed dramatically over the past 100 years. Since European settlement, activities such as logging, grazing, construction and fire suppression have resulted in forests typically composed of dense timber with numerous small diameter trees, thick layers of litter and ladder fuels, and lack of rangeland vegetation. The absence of periodic fire has left a legacy of weak, slow growing trees that compete for limited soil moisture, minerals and sunlight. Contemporary forests are more susceptible to widespread disease, insect outbreaks, historically uncommon devastating wildfires, and are less able to support as wide a variety of plant or animal life as they had in the past.

“If restoration of more natural forest conditions is not achieved, the risk of catastrophic wildfire will become even more extreme, forest habitat quality is likely to continue to decline and additional ecosystem components could be lost.” (City of Boulder Open Space Dept. 1999)

Forest Restoration and Wildfire Mitigation Objectives

1) Restore forest composition, structure and landscape distribution to within the bounds of the historical range of variability by implementing restoration prescriptions.
2) Mitigate the risk of catastrophic, uncontrollable wildfires by thinning forests.
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 prescribed burns.
6) Minimize impacts to forest soils.
Background

NCAR Forest Communities

Forests at NCAR are typical of xeric (arid), open ponderosa pine/Douglas-fir forests of the lower montane zone of the Colorado Front Range as described by Peet (1981). Ponderosa pine (*Pinus ponderosa*) is the dominant overstory species and typically forms pure stands on south facing slopes. Northern slopes support denser stands of ponderosa pine mixed with Douglas-fir (*Pseudotsuga menziesii*) trees. Understories in both areas are populated with grasses, forbs and shrubs. There are also abundant rangelands and several intermittent streams (see the General Reference Map in the Project Maps Section). Evidence of previous forest fires was observed west of the NCAR facility.

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 process, 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).

Ecologically based management of ponderosa pine ecosystems within the Colorado Front Range also requires knowledge of ecosystem structure and function prior to Euro-American settlement that began in the mid to late 1800s. 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 that are ecologically sustainable and to guide restoration treatments (Figure 2). 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. A further discussion of relevant information regarding ponderosa pine forests is provided below to detail the reference conditions that were used to guide restoration efforts at NCAR.
Ecologically based management of ponderosa pine ecosystems requires knowledge of ecosystem structure and function prior to significant human alteration. **Reference conditions** are compared with **current conditions** to develop **restoration prescriptions**.

**Historical forests** were mosaics of forested areas and clearings. Fire created complex and dynamic landscapes of low density forest patches and transient clearings. Fire also removed excessive ingrowth, regulated tree composition and consumed fuels.

**Current forests** typically lack landscape diversity; trees have colonized clearings that were maintained by fire, and species composition has been altered. Forest density has increased substantially resulting in decreased tree vigor, increased incidence of insect and disease epidemics and the accumulation of fuels.

**Desired forests** are significantly less dense than many current forests and contain clearings that moderate fire behavior. Individual tree vigor is increased resulting in greater resistance to forest pathogens. The mosaic of forests and clearings also increases habitat diversity.

Figure 2. The Ecosystem Management Framework® illustrates the process of forest management where restoration ecology is a management directive. Photos from Veblen and Lorenz 1991 (top), Kaufmann et al. 2000a (middle) and Tobler 2003 (bottom).
Ponderosa Pine Forests

**A brief comparison of southwestern and Front Range ponderosa pine forests:** Southwestern ponderosa pine forests and Front Range ponderosa pine forests are frequently considered to be similar; however, these forests differ markedly both in terms of structure and function. Historical fire behavior in southwestern ponderosa pine forests was dominated by *low-intensity* surface fires that maintained an open forest structure and a grassy rangeland (Covington et al. 1997, Covington and Moore 1994). *Low-intensity* surface fires that recurred every 2 to 20 years were typical in presettlement ponderosa pine ecosystems of southwestern areas. Because frequent surface fires consumed dead fuels, crown fires were uncommon; none were reported in Arizona prior to 1900 (Cooper 1960). In contrast, a *mixed-severity* fire behavior pattern, having both a *stand replacing component* and a *surface fire component*, dominated ponderosa pine forests in the Colorado Front Range (Brown et al. 1999, Kaufmann et al. 2000). This *mixed-severity* fire regime had fire return intervals ranging from 1 to 100 years. The mixed-severity fire regime is represented at NCAR.

**Post settlement changes that have occurred in both areas:** Historically fires regulated tree density, species composition, reduced the amount of dead biomass, maintained clearings, and promoted nutrient cycling (Covington and Moore 1992, 1994, Covington and Sackett 1984, 1988, Fulé et al. 1997, Mast 1993, Swetnam and Betancour 1990). Fire suppression and cattle grazing, introduced by Euro-American settlement in the late 1800s, have caused major changes in the spatial pattern and ecological processes of ponderosa pine ecosystems. These changes have increased tree density and reduced the frequency of natural fires (Covington 1994, Weaver 1961). As a result, trees are colonizing clearings normally maintained by fire and new clearings are not being created. Open savannas of high herbaceous content have changed into dense forests with closed canopies and reduced nutrient cycling rates (Covington and Moore 1992, Covington and Sackett 1988, Fulé et al. 1997, Swetnam and Betancourt 1990). Fire suppression and grazing facilitated a significant increase in the amount of Douglas-fir trees (Kaufmann et al. 2000). Grazing contributed to increased tree densities by reducing herbaceous cover and breaking fuel continuity on the forest floor. Tree seedlings proliferated in the absence of fire and competition from grasses (Harrington and Sackett 1992). Thick organic layers on the forest floor and dense pine canopies have suppressed herbaceous vegetation in the rangeland (Sackett et al. 1993). Increased pine 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. These changes have caused deterioration in forest ecosystem integrity (Dahams and Geils 1997).

Current ponderosa pine forests (including those present at NCAR) 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). Forests have also been affected by increased urban and suburban development. The consequences of increasing human populations around the forests include further fragmentation of forest ecosystems and increased problems with invasive weeds. The loss of landscape diversity has diminished wildlife habitat.
value. Nearly all ponderosa pine forests have been altered significantly by human activities, and current forest structures often bear little resemblance to historical forests (Fulé et al. 1997). Current fire behavior is beyond historical norms in terms of frequency, severity and size. The Hayman Fire, for example, burned with complete tree mortality on about 95% of the landscape. Tree age data from this area indicate that the size of area burned with complete mortality was unprecedented over the last five centuries (Huckaby et al. 2001). Large scale stand replacing fires can result in erosion, sedimentation, and flooding that impact watersheds and threaten human health (Bruggink et al. 1998) as is evident from the 2003 fire season in California.

**Front Range ponderosa pine forests:** Ponderosa pine forests in the central Rocky Mountains have a *mixed-severity* fire pattern. This fire pattern is similar to the *moderate-severity* fire regime described by Agee (1998) and the *mixed and variable* fire regime described by Brown (1995). Brown et al. (1999) constructed a fire history near Cheesman Lake; fire scar records and inferences from forest stand ages were used to reconstruct the fire frequency, fire severity, seasonality, and spatial extent of fires during the last 800 years. These fire histories record greater variability in fire interval and intensity than was common in southern areas. This *mixed-severity* fire regime had fire intervals ranging from 1 to 100 years and high intensity crown fires were more common (Brown et al. 1999) than in southern areas. The presettlement fire regime was a spatial and temporal mixture of surface fire and stand replacing fire; this regime maintained open stands of trees interspersed with clearings that remained for decades (Huckaby et al. 2001). Research conducted by Goldblum and Veblen (1992) and Laven et al. (1980) also identified a longer mean fire interval in the central Rocky Mountains than in other areas. Shorter growing seasons, poorer soils and erratic summer rainfall in the central Rocky Mountains make the overstory and rangeland of these forests less productive. The longer fire intervals and limited fine fuel conditions have created different effects on forest structure in these landscapes than where fire intervals were short (Kaufmann 2000a). The variable fire intensity of these areas further contributes to structurally diverse forests.

Veblen and Lorenz (1991) used *repeat photography* to assess changes in vegetation structure and composition of the Colorado Front Range during the last 50 to 100 years. Comparisons of photos of the same landscape taken many years apart revealed an increase in forest fires caused by settlement activities in the 1920s. Subsequent fire suppression resulted in an increase in ponderosa pine stand density, loss of natural clearings and an increase in Douglas-fir. Fornwalt et al. (2002a) used the Forest Vegetation Simulator to predict historical forest density and diameter distributions. While it is difficult to make definitive predictions of these parameters and equate findings to other areas of varying productivity, it is clear that tree densities have increased substantially over the last 100 years. Two examples of repeat photography from the NCAR property are provided in the Results portion of this section.
Landscape Diversity and Disturbance

Historically, ponderosa pine forests were a mosaic of forested areas and clearings (Peet 1988), unlike the homogenous forests common today (Figure 3). Hadley and Veblen (1993) suggested human disturbances and fire suppression have decreased landscape diversity and mean stand ages. It is hypothesized by Kaufmann (personal communication) that homogeneous ponderosa pine forests are more vulnerable to catastrophic fire than heterogeneous forests with clearings.

Disturbance affects landscape diversity by creating different successional stages within a landscape. At any given time an ecosystem may contain an array of irregular patches composed of vegetation of different ages, composition and structure. Landscape patterns are the product of spatial coincidences of factors controlling vegetative distribution including climate, soils, topography and time since disturbance (Bailey 1996). Disturbances operate unpredictably in time and space to create a mosaic of successional communities within a landscape (Kaufmann et al. 1994, Turner et al. 1993, White 1979). The proportion of various seral stages present within an ecosystem remains constant while individual plots change over time creating a steady state shifting mosaic (Borman and Likens 1979).

In a study of seedling recruitment and fire history in the Cheesman landscape, Kaufmann et al. (2000b) determined that many patches of trees were uneven aged with a distinct age cap, suggesting that seedling establishment occurs in pulses following stand replacing fires. Both surface and localized crown fires maintained a complex and dynamic landscape of low density forest patches and transient openings from less than 1 to more than 250 acres (Brown et al. 1999, Kaufmann et al. 2000). These openings contained rangeland species but lacked a tree canopy, apparently because of fire caused mortality followed by very slow reforestation (Kaufmann et al. 2003). Fire disturbance and variable timing of tree recruitment into openings was determined to

Figure 3. Landscape diversity, or heterogeneity, is illustrated by the photo of the Cheesman Lake watershed at left. Landscape homogeneity is illustrated by the photo at right also from the South Platte Basin. Photos from Kaufmann et al. 2000a.
be the primary influence effecting landscape diversity. Landscape diversity can be replicated with restoration treatments (Figure 4).

Aspect was implicated as an important regulator of tree distribution in the Colorado Front Range by Mast et al. (1993) and Tobler (2000). In both studies, tree invasion into rangelands and tree densities were greater on northern slopes while southern slopes remained non-forested in many areas. These differences were attributed to arid conditions on southern slopes. Landscape diversity in ponderosa pine forests of the Colorado Front Range frequently result from stand replacing fires and the subsequent difficulty of tree recruitment on harsh southern slopes.

The interactions of landscape components are illustrated in Figures 5 and 6. These models reflect the interplay of four major forest components through time. Figure 5 is based on historical conditions of ponderosa pine forests that occurred in the South Platte Basin, but is also appropriate for other portions of the Front Range having similar fire regimes and relatively coarse textured soils, including NCAR. The distribution of canopy classes should be considered as central tendencies, recognizing there is temporal and spatial variation around these classes (Kaufmann et al. 2003). Post settlement changes to Front Range ponderosa pine forests include: loss of old-growth forests, loss of forest openings, increased forest density, and wide scale conversion to a crown fire system. The effects of human activities homogenized the landscape, forest regeneration following widespread logging and human caused fires created large areas where trees are even aged (Huckaby et al. 2003b). Trees 300 to 500 years old were common in ecological reference areas. Mature trees can be distinguished from younger trees by their yellow bark, parasol top, and needle die back (see Huckaby et al. 2003a, 2003b).
Figure 5. Estimated proportions of the four canopy classes of the ponderosa pine/Douglas-fir landscape in the Front Range of Colorado. The period of time between Historical and Settlement reflects the interplay of forest components prior to the late 1860s. Subsequent to Settlement logging and grazing increased resulting in a reduction of forest density in all classes. Current forests have responded to fire suppression with an expansion of dense ponderosa pine/Douglas-fir forest. The period of time between Current and Restored reflects landscape changes that might occur under a restoration scenario (from Kaufmann et al. 2000). Note that the ponderosa pine, mixed ponderosa pine and Douglas-fir and openings are divided into canopy classes in Figure 6, all of which may contain persistent old growth.
Figure 6. Forest succession and periodic fire. This model illustrates the interrelationships among openings, patches of ponderosa pine and patches of mixed conifer trees within the South Platte Basin of Colorado. Green arrows represent tree recruitment and the orange arrows represent fires which reduce ingrowth or create forest openings. Note that all canopy classes may contain persistent old growth as is represented in Figure 5. (From Kaufmann et al. 2000)
Forest Insects and Diseases

Several insects and diseases attack Front Range forests including dwarf mistletoe (*Arceuthobium vaginatum*), mountain pine beetle (*Dendroctonum ponderosae*), western spruce budworm (*Choristoneura occidentalis*), and the Douglas-fir beetle (*Dendroctonus pseudotsuqae*). Forest insects and diseases can spread quickly in overly dense, stagnated, or drought stressed forests. The ecological 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 would promote the health of individual trees and the forest community maximizing the forests’ resistance to these stressors. Specific management techniques for the forest insects and diseases found at NCAR are provided in Appendix I.
A Case for Restoring Fire (Part I)

Fire suppression over the last century has had profound effects on ecosystems where natural fire was a keystone ecological process. Prescribed burns should be implemented in these areas to mimic natural processes. Prescribed burns are generally the most effective means of reducing future fire hazard, eliminating rangeland 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. Fire creates structural diversity and is the best way to integrate management for varied ecological communities. Fire was a historical component of the NCAR ecosystem (Figure 7) and there is no ecological substitute for burning. Current forest condition, however, precludes the implementation of fire without mechanical treatments prior to prescribed burns. A management scheme that incorporates both mechanical thinning and prescribed fire is therefore most likely to succeed.

The efficacy of mechanical treatments used in conjunction with prescribed burns is illustrated by the Eldorado Fire in Boulder County (Figure 8). The area circled in green at left received a thinning treatment and prescribed burn in the fall of 1998 while the foreground (orange circle) received no treatment. A subsequent wildfire in 2000 resulted in a stand replacement crown fire in untreated areas (orange circle) and a low intensity surface fire with minimal tree mortality in the treatment area (green circle). The Polhemus prescribed burn likewise moderated the behavior of the Hayman fire (Graham et al. 2003). 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).

Previous research efforts unanimously indicate that fuel treatments mitigate wildfire behavior and the associated effects (Martinson and Omi 2003, Omi et al. 2005a).

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 play themselves out (Omi and Martinson 2002).
Ponderosa Pine Restoration

Ponderosa pine restoration is needed in many places in the western U.S. to return forests to an ecologically sustainable condition and reduce the hazard of catastrophic crown fires and insect epidemics (Kaufmann et al. 2003). The soundest way to mitigate the risk of catastrophic fire is to return the forest to a structure similar to what existed before Euro-American settlement (Huckaby et al. 2003b). Restoration goals aimed toward ecological sustainability depend upon historical fire behavior and tree recruitment patterns. Restoration plans must also incorporate factors affecting landscape diversity. Findings reported by Kaufmann et al. (2000, 2003, 2000a) on ponderosa pine forests having a historically mixed-severity fire regime suggest several specific restoration goals for forests in the Colorado Front Range and South Platte Basin. These goals include:

1) Openings ranging in size from 1 to 250 acres, amounting to 15 to 25% of the landscape. Openings should be interspersed with patches of low density forest and managed to persist for decades.

2) Major reductions in tree density, especially in smaller diameter classes (< 5”), resulting in canopy covers of 10 to 30% over most of the landscape. Forest density should be reduced through a combination of mechanical thinning and prescribed fire.

3) Most Douglas-fir should be removed, thinned on northern aspects.

4) Mature trees (200 years or older) should be retained as they provide an important component of the historical age structure.

5) Fire should be reintroduced to minimize in-growth of new trees, maintain low forest density and to thin out Douglas-fir.

Restoration treatments that incorporate low thinning to remove most small trees, improvement cutting to remove undesirable species and selective cutting to reduce stand density provide the best protection from current and future crown fire hazards (Fiedler and Keegan 2003). 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 at reducing fire behavior (Martinson and Omi 2003). There are many benefits associated with forest restoration including reducing the risk of catastrophic wildfires while improving the likelihood of ecological sustainability (Kaufmann et al. 2000a). Restoration treatments mandate retention of most trees older than 200 years, substantial reductions in forest density, and the creation of forest openings (Kaufmann 2003). Even-aged forests need to be set on an uneven-aged trajectory and regeneration should be controlled. Restoration treatments require a combination of silvicultural treatments and prescribed fire where possible. Restoration efforts can reduce the risk that wildfires pose to the safety of people living at the wildland/urban interface and the costly impact fires have on reservoir systems. Reduced forest densities would also benefit wildlife species that favor an open forest condition. Alleviating stress and competition between trees by reducing forest density will increase trees' resistance to insect epidemics. Fire mitigation promotes sustainable ponderosa pine ecosystems by restoring them to a historical condition (Kaufmann 2003, personal communication). Persistence of the natural ecosystem, along with its dynamism, should be a major focus.
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 in Figure 9.

![Fuel Temperature and Moisture Related to Aspect](image_url)

Figure 9. The interplay of fuel temperature and moisture as related to aspect.
Methods

Forest Inventory

The property was inventoried with a stratified random sample design to quantify forest composition and density. The property was divided into two separate stratifications on the basis of landform and forest composition. Management unit 1 contains three subdivisions, unit 1A, unit 1B and unit 1C. Although management units 1A, 1B and 1C are discontinuous, they have similar structure and are therefore considered as one stratification. All stratifications are indicated on the Management Unit Map. The inventory was conducted with 15 variable plots (BAF 10). Field sampling evaluated forest characteristics including tree species, trees per acre, basal area, tree diameter and height, regeneration and incidence of disease for all trees within the sample plots. 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, a program developed by Dr. Sheppard of the Rocky Mountain Forest and Range Experiment Station in Ft. Collins, Colorado. 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 both stratifications are presented in Appendix A. Figure 19 in the Rangeland and Noxious Weed Section is a comprehensive flowchart that depicts all levels of analysis utilized at NCAR. This flowchart includes the forest inventory, its stratifications and the analysis procedures that were used in relation to other assessments.

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 10). This modeling procedure yields three maps: 1) rate of spread, 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 which in turn reduce fire intensity. Two fire scenarios were modeled for the property, one under moderate conditions and one under extreme conditions. This analysis is illustrated in relation to the other assessments conducted at NCAR in Figure 18 in the Rangeland and Noxious Weed Section.
Figure 10. 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

Management Units

The property has been divided into two separate management units (Unit 1 and Unit 2) for program implementation based on stand location, density, wildfire hazard and topography (see the Management Unit Map). Management Unit 1 was subdivided because this forest type occurs in three separate locations on the property (Units 1A, 1B and 1C). Management prescriptions for the forest management units are based on forest characteristics and inventory data. Discussions of forest inventory data and fire hazard analysis for both stratifications are provided below.

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

1) Slope Map,
2) Elevation Map,
3) Anderson’s Fuel Model Map,
4) Crown Fire Activity Map (Average Conditions),
5) Crown Fire Activity Map (Extreme Conditions),
6) Flame Length Map (Average Conditions),
7) Flame Length Map (Extreme Conditions),
8) Fire Rate of Spread Map (Average Conditions) and
9) Fire Rate of Spread Map (Extreme Conditions).
Management Units 1A, 1B and 1C

Description: These units support ponderosa pine woodlands (10 to 30% canopy closure) with a heterogeneous landscape structure of forested areas and clearings and a productive understory of grasses, forbs and shrubs (Figure 11). Ponderosa pine is the dominant tree in this community but there are also some Douglas-fir and Rocky Mountain juniper (*Juniperus scopulorum*) trees. The photo at left and the stand table below are representative of the average condition but there is significant variability surrounding this central tendency ranging from open meadows to dense thickets of secondary growth less than 4.5 feet tall. There is evidence of previous harvest and some trees exhibit old-growth characteristics. Douglas-fir ingrowth is minimal, small diameter regeneration is undesirably high especially in the northern portion of Unit 1A. This unit faces north and east with slopes that range between 20 and 40%. The basal area is approximately 101 square-feet per acre and the average tree diameter is relatively large, 11.8 inches. The site index, a measure of site productivity for a given species, is 59 on a scale of 20 to 70, indicating good conditions for ponderosa pine. Minimal amounts of dwarf mistletoe, mountain pine beetle and ponderosa pine needle miner (*Coleotechnites ponderosa*) were observed; there was little dead and down material. The preponderance of small diameter regeneration in this unit provides clear documentation of the changes that have occurred in Front Range forests in the absence of fire and is an excellent opportunity for forest restoration today. Forest openings or “clearings” such as the one pictured above are a critical and underrepresented component of Front Range ecosystems; these areas were a prominent feature of historical landscapes. Thinning activities within this unit should focus on the removal of small diameter regeneration, forest insect and disease control and maintenance of the forest/grassland mosaic; details are described in the prescriptions section. Basic stand data are summarized in Table 1. The Stand Visualization System (SVS) was utilized to illustrate forest conditions within this management unit before and after treatment (Figure 12).

![Figure 11. Unit 1 has a heterogeneous structure of forested areas and openings.](image)

Table 1. Management Unit 1A, 1B and 1C summary.

<table>
<thead>
<tr>
<th>Slope %</th>
<th>BA Sq./Ac</th>
<th>Avg. Height’</th>
<th>Avg. Diameter”</th>
<th>Site Index</th>
<th>Fuel Model</th>
<th>Trees/ Acre</th>
<th>Total Acres</th>
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<td>11.8</td>
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<td>48</td>
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Figure 12. Current basal area within Units 1A, 1B and 1C is approximately 101 ft²/acre (top). This density should be reduced by 30% to 71 ft²/acre. The recommended treatments within this unit include a proportional cut, patch cuts and sanitation thinning and prescribed burning. Although the above model simulation is based on forest inventory data, it is not an exact replica of forest structure before or after treatment.
**Unit 1 Fire Hazard Analysis:** Fires in open ponderosa stands with grassy understories (fuel model 2) tend to be of lower intensity but very fast moving. The open canopy condition of these areas exposes them to the full force of the wind which promotes rapid rates of spread. Embers from trees are likely to ignite dry grasses creating spot fires ahead of the main fire. Juniper trees present an additional fire hazard as these trees contain volatile oils which can ignite adjacent tree crowns.

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 by firefighters. The rate of spread would be less than 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. However, small diameter regeneration can act as ladder fuels which propagate crown fire.

Under *extreme conditions* a fire in this area would be much more difficult and dangerous to extinguish. Flame lengths would be greater than 12 feet precluding direct attack methods. The anticipated rate of spread would double which increases the likelihood of a larger fire. Indirect attack techniques and aerial resources are commonly utilized on this type of fire. The most significant factor in this scenario is the potential for tree torching and crown fire development. This hazard is minimal in the majority of Unit 1A due to an open canopy condition but there are some dense pockets especially near the Fleischmann building. Steep slopes also add to the probability of tree torching and crowning. Grasses would be very dry under these conditions increasing the rate of fire spread through embers and spot fires.
Management Unit 2

Description: This unit is found on the western portion of the property and supports a ponderosa pine forest with greater than 30% canopy closure; in most areas the tree canopy is too dense to support herbaceous or shrubby vegetation (Figure 13). Ponderosa pine is the dominant tree in this community but there are also some Douglas-fir and Rocky Mountain juniper trees. While this stand has a similar basal area to Unit 1, there is a significant difference in forest structure as this area has a larger contribution to the total basal area from smaller diameter trees. This forest has two distinct strata, that of mature ponderosa with a very low basal area per acre, and that of excessive small diameter regeneration populating intermediate crown positions. Several trees exhibiting old-growth characteristics were observed. Douglas-fir ingrowth is moderate and small diameter regeneration is undesirably high in places. The stand primarily faces east and has slopes that range between 30 and 55%. The basal area is approximately 103 square-feet per acre and the average tree diameter is 6.7 inches. The site index, a measure of site productivity for a given species, is 35 on a scale of 20 to 70, indicating poor conditions for ponderosa pine. The low site index in this area is a result of soil conditions; the Soil Type Map in the Project Map Section indicates that this unit has abundant rock outcrops and a shallow depth to bedrock. Dwarf mistletoe was observed north of the water tank; mountain pine beetle distribution was limited. There was little dead and down material. An aggregated forest structure is no longer apparent. Thinning activities within this unit should focus on the removal of small diameter regeneration, restoration of a landscape mosaic and sanitation thinning; details are described in the prescriptions section. Basic stand data are summarized in Table 2. The Stand Visualization System (SVS) was utilized to illustrate forest conditions within this management unit before and after treatment (Figure 14).

<table>
<thead>
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<th>Slope %</th>
<th>BA Sq./Ac</th>
<th>Avg. Height’</th>
<th>Avg. Diameter”</th>
<th>Site Index</th>
<th>Fuel Model</th>
<th>Trees/Acre</th>
<th>Total Acres</th>
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<td>30-55</td>
<td>103</td>
<td>32</td>
<td>6.7</td>
<td>35</td>
<td>9, 10</td>
<td>421</td>
<td>28</td>
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</table>
Figure 14. The current basal area within Unit 2 is approximately 103 ft²/acre (top). This density should be reduced by 35% to 67 ft²/acre. The recommended treatments within this unit include a proportional cut and sanitation thinning. Although the above model simulation is based on forest inventory data, it is not an exact replica of forest structure before or after treatment.
**Unit 2 Fire Hazard Analysis:** These stands have the greatest potential for severe wildfire as they are on steep slopes and contain dense stands of mixed conifer trees with tight canopies (fuel model 9 and 10). The predominant winds in the area align with the slopes and contribute to higher intensity fire behavior. 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 a greater potential for intense fire than Unit 1. The rates of spread are fairly low (<20 chains/hour) but the flame lengths would be 4 to 8 feet precluding 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 model does not calculate the spread rate of a crown fire. 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. Combustion of trees at the base of the ridge would pre-heat and dry the trees above them resulting in a crown fire on steep slopes. Flame lengths >12 feet can’t be fought directly, aerial resources would be recommended. The presence of mistletoe and unhealthy conditions within this unit, combined with the presence of more flammable species such as Douglas-fir on the west side of the unit, would make this area much more likely to have an intense fire.
Repeat Photography

Historical photographs of the NCAR area document forest change over the last 100 years. A review of historical photos available in the Carnegie Branch of the Boulder Public Library yielded two images of the area from the turn of the century (Figures 15 and 16). These photo locations were re-visited and photographed during our analysis to document forest change. In both cases a dramatic increase in forest density is apparent. The photo locations are indicated on the General Reference Map in the Project Map section.
Figure 15. This set of repeat photographs illustrates the increase in forest density over the last 105 years. Looking southwest into Ponderosa Pine Unit 1B in 1900 (top), and today (middle and at right). Top photo from Carnegie Branch Library for Local History, Boulder Historical Society Collection. From photo location 1 on the General Reference Map.
Figure 16. This set of repeat photographs illustrates the increase in forest density over the last 102 years. Looking north into Ponderosa Pine Unit 2 in 1903 (top), and today (middle and at right). Top photo from Carnegie Branch Library for Local History, Boulder Historical Society Collection. From photo location 2 on the General Reference Map.
Discussion

Forest Discussion

The comparison of historical conditions with current conditions and ecological research present four lines of justification for reductions in forest density including: 1) tree density, 2) landscape distribution, 3) diameter distribution, and 4) species composition.

**Tree Density:** Basal area estimations indicate an overly dense forest condition in many areas. Tree densities need to be reduced by 15 to 45% dependent upon management unit and aspect. The basal area of Unit 1A should be reduced from current levels to 30 to 50 square feet per acre. Basal area on other northern slopes should be reduced from current levels to 50 to 80 square feet per acre. Eastern and western slopes are also in need of similar treatment. While the optimal numbers of trees per acre for Front Range ponderosa pine forests have not yet been established, research conducted by Kaufmann and Covington indicates that many ponderosa pine forests require substantial reductions in the number of trees per acre to return to a historical and healthy condition. Such reductions are needed at NCAR.

Prolific and rapid growth of tree seedlings on favorable sites further contribute to undesirable forest conditions in the absence of periodic burning (Figure 17). Tree seedlings eventually form closed canopy stands which compete with each other for site resources. Competition will decrease individual tree vigor and increase the risk of catastrophic wildfire. Repeat photography also documents substantial increases in forest density. While some logging and fuel wood cutting likely occurred on site during the 1800s and 1900s, the location of forested areas remains constant indicating that anthropogenic impacts may have been minimal in relation to the affect of landscape level processes and site conditions.

**Landscape Distribution:** Comparison of current canopy density with the model developed by Kaufmann et al. (2003) for historical South Platte Basin ponderosa pine forests indicates that the proportion of clearings (0 to 10% canopy closure) within the NCAR landscape resembles historical distributions; therefore, large openings do not need to be created. The proportion of closed canopy forest, however, (>30% canopy closure) needs to be decreased substantially. The NCAR landscape appears to have two primary components, that of rangelands (1 to 10% canopy closure) and that of dense forest (>30% canopy closure). Woodlands (10 to 30% canopy closure) are under represented within the NCAR landscape. Further, if the current trend of prolific
regeneration is allowed to continue unchecked, woodlands will be lost within this landscape. The woodland within Unit 1 needs to be maintained by thinning this community into patches of irregular size and varying density with the above specifications as targets. Repeat photography also documents the expansion of forests into historically unforest areas. Rangelands and small forest openings need to be maintained by reducing regeneration with fire, mechanical means, or both.

**Diameter Distribution:** Many large and mature trees are present throughout the property, but the average tree diameter remains relatively low due to the abundance of small diameter regeneration. This trend becomes apparent when basal area estimations are compared with average tree diameter and stems per acre. Unit 2, for example, has a basal area similar to that of Unit 1 but with significantly more stems per acre and a smaller average diameter. Abundant mature trees stand over a large influx of young regeneration that has been established in the absence of fire. This competition reduces overall forest productivity and stresses individual trees limiting their ability to resist insect and disease epidemics. Forests with a low average diameter are also more prone to increased fire severity and post fire site colonization by invasive plants. Omi et al. (2005a) determined that fire severity decreased with increased mean tree diameter and/or decreased stand density.

**Species Composition:** The species composition of overstory trees resembles historical distributions in most places: ponderosa pine trees dominate southern slopes and mix with Douglas-fir on northern slope. Douglas-fir should be thinned aggressively when it occurs on southern, western or eastern slopes. Junipers are present on all aspects and need to be thinned. Reduced fire frequency is a major contributor to the expansion of juniper woodlands into rangelands, forests and aspen stands. Prior to fire suppression, juniper may have been restricted to sites that burned infrequently such as rocky sites (FEIS 2003). Historically, these trees would have been consumed by fire. Junipers are extremely flammable due to volatile oils in their foliage.

**Landscape Fire Hazard Analysis**

Conditions leading up to the current unhealthy ecological state of ponderosa pine forests along the Front Range go hand-in-hand with the ever-increasing rate of catastrophic, difficult to control crown fires as opposed to natural, restorative surface fires. Fuel characteristics and other findings from the Wildfire Hazard analysis have been integrated into the restoration prescriptions made herein. This property contains fuel conditions (fuel models, see Appendix I) that are typical of Front Range forests. Current forest densities, in conjunction with the preponderance of flashy fuels (grasses) and steep slopes, (see the Slope Map in the Project Map Section) are contributors to increased fire behavior.
Recommendations

Forest Management Recommendations

The forests at NCAR are poised for restoration. Restoration prescriptions created for individual compartments outline the steps that need to be taken to return forests at NCAR to within their historical range of variability. Ecological principles such as group selection, tree species densities, old-growth retention, uneven age selection, snag trees, coarse woody debris, shrubland rejuvenation, aspen rejuvenation, wildfire mitigation and special riparian treatments are incorporated. These prescriptions meet the demands of forest restoration and wildfire mitigation.

Restoration activities are not a one time proposition; they must be integrated with a long-term plan for future treatments (Fiedler et al. 1995). 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 burning or thinning are 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.

Management prescriptions presented here are a "best case" scenario in which restoration efforts are not impeded by financial constraints, accessibility, public will, or the ability to implement prescribed burns. It is anticipated that NCAR management will make minor modifications to these prescriptions on a case-by-case basis as they become more familiar with each individual unit. It is unlikely that the implementation of prescribed burns will be feasible in all management compartments due to environmental or sociological constraints. Treatment options are also likely to vary depending on financial resources, stand conditions and other variables. Project prioritization is based on the wildfire hazard analysis completed separately.

Management compartments may be sub-divided as necessary to accommodate changes in project funding, inaccessible terrain, variance in forest condition, or other unexpected circumstances. It is our intent to promote landscape diversity with a variety of forest prescriptions. Variability in prescription implementation will further 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 foresters who are familiar with Front Range ponderosa pine, landscape ecology and wildfire mitigation. Additional assistance with project administration is strongly recommended. Contractor performance should be evaluated in relation to the performance standards and prescription directives to ensure that project objectives are being met and that resource damage is minimized.

Management prescriptions for each management unit are presented in Appendix I. The Management Unit Map presents the number and location of each compartment; a Slope Map is also provided. A description of forest insects and diseases at NCAR and their management is presented in Appendix I as are performance standards for forestry operations. Refer to Appendix I for additional information as necessary; treat Unit 1A first, then Unit 2, then Unit 1B and 1C.
RANGELANDS AND NOXIOUS WEEDS

Introduction

Statement of Needs

Rangelands are treeless (or sparsely forested) communities that support herbaceous and woody vegetation including grasses, forbs, sedges, succulents and shrubs. The abundance and diversity of these plants directly influence the abundance and diversity of wildlife and are indicators of ecosystem condition. Rangelands provide structural diversity to the landscape and habitat for a multitude of wildlife species. The structure and function of these areas, however, are 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.

Rangelands and Noxious Weed Management Objectives

1) Reduce the abundance and prevent establishment of exotic species.

2) Maintain or increase the number of native plant species.

3) Maintain or increase the vegetation quality and diversity.

4) Maintain or increase the cover of native vegetation and reduce the cover of bare ground and litter.

5) Minimize impacts to forest and grassland soils.

6) Reduce fuel loading in grasslands using prescribed burns.

7) Minimize impacts to rangeland soils.
Background

NCAR Rangelands

Rangelands at NCAR support a variety of shrubs, grasses, forbs and sedges that are a critical component of the ecosystem (see the General Reference Map in the Project Maps Section). These rangelands contribute to landscape diversity and provide habitat for a variety of wildlife species. There are, however, a host of exotic species that are seriously impacting native plant communities, thereby reducing the wildlife values in those communities. The most important management directive within the rangelands is the control of noxious weeds.

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, or 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).
A Case for Restoring Fire (Part II)

Fire suppression has changed open savannas with high herbaceous content into dense forests with closed tree canopies and reduced nutrient cycling rates (Covington and Moore 1992, Covington and Sackett 1988, Fulé et al. 1997, Swetnam and Betancourt 1990). Conditions in historical forests and rangelands are documented in accounts by early settlers; E.F. Beale made the following observation in Arizona in 1858 as quoted by Cooper (1960):

“We came to a glorious forest of lofty pines, through which we have traveled ten miles. The country was beautifully undulating, and although we usually associate the idea of barrenness with pine regions, it was not so in this instance; every foot being covered with the finest grasses, and beautiful broad grassy vales extended in every direction. The forest was perfectly open and unencumbered with brush wood so the traveling was excellent” (Beale 1858)

Prescribed burns can be used to reduce the duff layer and the dead and down materials which increase fire intensity and make natural fires difficult to extinguish. In rangelands, fire rejuvenates stagnated plants and prepares the ground for new growth by increasing nutrient cycling rates. Prescribed burns can enhance the production, quality and diversity of herbaceous forage favored by ungulates and other herbivores (Arno and Harrington 1995) while reducing the risk of catastrophic wildfire (Vallentine 1989). Repeat photography of prescribed burns conducted in Colorado (below) document the rejuvenating effect of fire.

![Prescribed burns conducted in Colorado (below)](image)

Figure 18. Prescribed fires have a rejuvenating effect on grasslands which typically “green-up” just several weeks after prescribed burns.

There are also several advantages of prescribed burning over other noxious plant control methods. Except for erosion hazards on highly erodible sites, fire is applicable regardless of rockiness of soil, steepness of slope, or irregularity of terrain (providing there is sufficient ground fuel to carry the fire). Compared to mechanical treatments, prescribed burns can be a low-cost alternative for the manipulation of vegetation. Season of burning and plant growth stage directly affect vegetative responses to burning (Vallentine 1989). Because each plant species responds somewhat differently, special considerations must be made when constructing the burn plan. Under ideal conditions, grassland diversity is maintained by a fire interval of 3 to 5 years.
Methods

Rangeland Assessment

Rangeland condition was inventoried with an iterative procedure that included a *landscape level assessment* and a *focused inventory of noxious weeds*. The landscape level assessment utilized Modified-Whittaker Intensive plots to quantify the species composition and frequency of all rangeland plants including native and exotic species. Plots were stratified by community composition and include forested areas and rangelands (non forested or sparsely forested areas). The focused inventory evaluated the distribution of noxious weeds throughout known corridors of weed migration. A detailed explanation of these sampling methods is provided below. Sampling was conducted in late May and early June of 2005. Results from both of these sampling efforts were combined in this chapter to develop a comprehensive assessment of rangeland condition at NCAR.

Landscape Level Assessment

*Sample plot distribution:* Sample plots were distributed with Project Envelope in order to efficiently capture site diversity at NCAR. Project Envelope is an ESRI ArcMap 8.0 extension which creates a map of the study area with identified areas of interest based on selected environmental layers and unsampled regions. The property was divided into 4 separate vegetative stratifications based on community type; there are two forest stratifications (ponderosa pine 10 – 30% canopy closure and ponderosa pine >30% canopy closure) and 2 rangeland stratifications (short grass prairie and wet meadow). Community types were determined by evaluating the Boulder County Vegetation Type Map, the Natural Resource Conservation Service Soil Type Map, aerial photographs and field reconnaissance. Twenty of the 30 sample sites were then randomly located within these 4 stratifications. Project Envelope was then used to locate the remaining 10 sample points onto unsampled regions by query of geographic layers including slope, aspect and elevation. Sample plots were located in the field by reviewing aerial photographs annotated with the sample locations and compass triangulation. Plots that fell on or adjacent to roads, trails, rock outcrops, or disturbed sites were relocated within the same topographic class 25 meters away. The process of rangeland stratification, plot distribution and data analysis are depicted in Figure 19; this flowchart also illustrates all other types of analysis utilized at NCAR. The Management Unit Map in the Project Map Section indicates the location of the rangeland stratifications.

*Sample plot type:* A multi scale plot design was selected for the inventory of rangeland conditions to improve species area calculations and our understanding of native and exotic plant diversity patterns (Barnett and Stohlgren 2003, Stohlgren and Chong et al. 1997). The Modified Whittaker Intensive plot is a multi scale plot that utilizes four 1m$^2$ subplots and one 10m$^2$ plot that are nested within a 100m$^2$ plot (Figure 20). The frequency and percent cover of species present and the percent cover by ground variables (soil, rock, duff, wood, water, moss) were made in the 1m$^2$ subplots. Percent cover was based on ocular estimates. A search for additional species was conducted in the 10m$^2$ and 100m$^2$ rectangle. Data from the Modified Whittaker Intensive plots document the percent cover and composition of exotic species on the landscape scale. Rangeland data analysis was conducted in EcoNab, a Microsoft Access 2000 program designed by Rick Shory of Natural Resource Ecology Laboratory at Colorado State University. Nomenclature corresponds to Weber (2002) and the Natural Resource Conservation Service PLANTS website.
Focused Inventory of Noxious Weeds

The composition, abundance and location of noxious weeds at NCAR were also assessed with a focused sampling procedure. (This analysis is illustrated in relation to other assessments in Figure 19). Focused sampling efforts were concentrated in known corridors of weed migration including roads, trails, riparian areas, utility corridors and disturbed sites. State and county lists of noxious species were consulted prior to sampling. Weed infestations were identified and mapped in accordance with North American Invasive Plant Mapping Standards. This process entails species identification, an ocular estimation of the infestation size and density, and its Universal Transvers Mercator (UTM) location; the Noxious Weed Inventory Form is provided in Appendix II. Forest and rangeland stratifications were also surveyed for noxious weeds as the study team traversed between sample plots.
Figure 19. Flow chart detailing the assessment procedures utilized at NCAR.
Figure 20. The Modified-Whittaker Intensive plot was used for the landscape level assessment to quantify vegetative composition, origin, duration and growth form.
Results

NCAR Rangelands

*Landscape Level Assessment:* The landscape level assessment provides a comprehensive picture of rangeland health. These data document baseline condition and will be instrumental in evaluating future management activities within the vegetative communities represented at NCAR. Brief descriptions of noteworthy data are provided below. Additional rangeland data and other species lists are available on electronic database (Appendix IV). In this format any number of queries can be made of the vegetative dataset.

1) A master species list was created for all plants found in the landscape level assessment. This list includes the origin (native, exotic, naturalized), duration (annual, biennial, perennial), growth form (grass, forb, sedge, subshrub, shrub, tree, succulent) and location (stratifications where found) of all plants identified in the landscape level analysis. Data available on the electronic database (Appendix IV).

2) The 10 most abundant plants found in forests and rangelands are presented in Table 1. The 5 most abundant noxious plants found in forests and rangelands are presented in Table 2.

3) Information available on the electronic database (Appendix IV):
   a. Species lists by plot
   b. Species lists by stratification
   c. Percent cover and frequency for species by stratification, substratification and plot
   d. Most abundant native, exotic and noxious species
   e. Species sorted by origin, duration, growth form
   f. Species sorted by location
   g. Cover by abiotic factors
   h. Jaccard’s coefficient of vegetative similarity between or within any plot grouping
   i. Ecological diversity indexes (Margalef, Menhinick, Simpson, Shannon, Pielou, Heip)
   j. Species area trends
The landscape level analysis yielded a master species list with a total of 179 plant species. There were 136 native species, 25 exotic species, 4 naturalized species, and 14 plants that were identified to genus or unknown. The master species list can be found in the electronic database in Appendix IV. The 10 most abundant species in forested areas and rangelands are presented in Table 3 (descending order abundance as ranked by frequency). The 5 most abundant noxious species that were encountered in these areas during the landscape level assessment are presented in Table 4. These findings reflect the time of sampling and therefore contain a greater percentage of warm season plants. Many types of plants were in bloom during field sampling (Figure 21).
Table 3. The 10 most abundant plants in forests and rangelands at NCAR as ranked by frequency of occurrence in Modified-Whittaker plots. Scientific name is on the left, common name is on the right.

<table>
<thead>
<tr>
<th>FORESTS</th>
<th>RANGELANDS</th>
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<tbody>
<tr>
<td><em>Artemisia ludoviciana</em></td>
<td><em>Poa pratensis</em></td>
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<tr>
<td><em>Arrhenatherum elatius</em></td>
<td><em>Tragopogon dubius</em></td>
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<tr>
<td><em>Achillea millefolium</em></td>
<td><em>Agropyron smithii</em></td>
</tr>
<tr>
<td><em>Penstemon virens</em></td>
<td><em>Artemisia ludoviciana</em></td>
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<tr>
<td><em>Drymocallis fissa</em></td>
<td><em>Lithospermum multiflorum</em></td>
</tr>
<tr>
<td><em>Poa pratensis</em></td>
<td><em>Opuntia polyacantha</em></td>
</tr>
<tr>
<td><em>Cerastium arvense</em></td>
<td><em>Psoralidium tenuiflorum</em></td>
</tr>
<tr>
<td><em>Galium aparine</em></td>
<td><em>Bidens bigelovii</em></td>
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<tr>
<td><em>Grindelia squarrosa</em></td>
<td><em>Arnica fulgens</em></td>
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<tr>
<td><em>Taraxacum officinale</em></td>
<td><em>Grindelia squarrosa</em></td>
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<thead>
<tr>
<th>FORESTS</th>
<th>RANGELANDS</th>
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<tbody>
<tr>
<td><em>Cynoglossum officinale</em></td>
<td><em>Bromus tectorum</em></td>
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<tr>
<td><em>Bromus tectorum</em></td>
<td><em>Cardaria draba</em></td>
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<tr>
<td><em>Hypericum perforatum</em></td>
<td><em>Euphorbia esula</em></td>
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<tr>
<td><em>Verbascum thapsus</em></td>
<td><em>Hypericum perforatum</em></td>
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<tr>
<td><em>Cirsium arvense,</em></td>
<td><em>Cirsium arvense</em></td>
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<tr>
<td><em>Cirsium arvense,</em></td>
<td><em>Canada thistle</em></td>
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<td></td>
<td><em>Canada thistle</em></td>
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</tbody>
</table>

Table 4. The 5 most abundant noxious plants in forests and rangelands at NCAR as ranked by frequency of occurrence in Modified-Whittaker plots. Scientific name is on the left, common on right.

<table>
<thead>
<tr>
<th>FORESTS</th>
<th>RANGELANDS</th>
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<tbody>
<tr>
<td><em>Cynoglossum officinale</em></td>
<td><em>Bromus tectorum</em></td>
</tr>
<tr>
<td><em>Bromus tectorum</em></td>
<td><em>Cardaria draba</em></td>
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<tr>
<td><em>Hypericum perforatum</em></td>
<td><em>Euphorbia esula</em></td>
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<tr>
<td><em>Verbascum thapsus</em></td>
<td><em>Hypericum perforatum</em></td>
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<tr>
<td><em>Cirsium arvense,</em></td>
<td><em>Cirsium arvense</em></td>
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<tr>
<td><em>Cirsium arvense,</em></td>
<td><em>Canada thistle</em></td>
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<td></td>
<td><em>Canada thistle</em></td>
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</table>
Focused Inventory of Noxious Weeds: The focused inventory of noxious weeds identified 14 species in 76 populations at NCAR. These species are indicated in Table 3 and on the Noxious Weed Map. As anticipated, most populations were adjacent to roads and trails or in riparian corridors and disturbed sites. Cheatgrass, houndstongue, Canada thistle, mullein and dalmatian toadflax were the most common noxious species at the landscape scale; these species were found in all stratifications. Canada thistle, houndstongue and teasel were common in the central portion of the wet meadow stratification. Dalmatian toadflax (Figure 22) was broadly distributed in the south facing portion of the short grass prairie stratification. Only isolated pockets of St. Johnswort, myrtle spurge, Russian olive, white top, and field bindweed were observed. Populations of white top were found adjacent to the main parking lot and along the fire road on the western portion of the property; it was also encountered as isolated plants in the landscape level analysis. Field bindweed was found in riparian corridors, adjacent to parking lots and along the eastern property boundary. Jointed goatgrass was found on trails in the southern portion of the property, along the fire road on the eastern property boundary and in the Skunk Creek riparian corridor. Poison hemlock was restricted to riparian areas and moist sites such as seeps. The Skunk Creek riparian corridor, the wet meadow and adjacent areas on the northern portion of the property were the most heavily infested. Musk thistle and Scotch thistle occurred as isolated plants. The knapweed and sulfur cinquefoil identified in the 1999 survey were not apparent during this field effort perhaps because of previous suppression efforts and survey timing in relation to plant phenology. No populations of leafy spurge were found but isolated plants were encountered in the landscape level analysis. The Noxious Weed Map indicates the composition, location, size and cover class and treatment priority of all weed populations.

All noxious species found at the NCAR site are presented in Table 5; these species are prioritized based on their ability to disrupt native plant communities and the difficulty of their control (as ranked in the Colorado Noxious Weed Act (http://www.ag.state.co.us/CSD/Weeds/statutes/weedrules.pdf). The Noxious Weed Map is presented in the Project Maps Section; all populations identified in the focused inventory of noxious weeds are also presented in the Noxious Weed Table (Table 6, Appendix II). The Noxious Weed Table should be used in conjunction with the Noxious Weed Map during suppression activities.

Figure 22. Noxious weed populations, such as the toadflax pictured above (yellow flowers) were mapped and are indicated on the Weed Management Map.
Table 5. Prioritized noxious weed species found at NCAR. Scientific name is on the left, common name is on the right.

<table>
<thead>
<tr>
<th>A LISTED SPECIES: HIGH PRIORITY</th>
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<tbody>
<tr>
<td><em>Euphorbia myrsinites</em></td>
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<tr>
<td>myrtle spurge</td>
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</table>

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<tr>
<th>B LISTED SPECIES: MEDIUM PRIORITY</th>
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<tbody>
<tr>
<td><em>Acosta diffusa</em></td>
</tr>
<tr>
<td><em>Elaeagnus angustifolia</em></td>
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<tr>
<td><em>Euphorbia esula</em></td>
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<tr>
<td><em>Cardaria draba</em></td>
</tr>
<tr>
<td><em>Carduus nutans</em></td>
</tr>
<tr>
<td><em>Cirsium arvense</em></td>
</tr>
<tr>
<td><em>Cynoglossum officinale</em></td>
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<tr>
<td><em>Dipsacus fullonum</em></td>
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<tr>
<td><em>Linaria dalmatica</em></td>
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<tr>
<td><em>Onopordum acanthium</em></td>
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<tr>
<td><em>Potentilla recta</em></td>
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<tr>
<td>knapweed</td>
</tr>
<tr>
<td>Russian olive</td>
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<tr>
<td>leafy spurge</td>
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<tr>
<td>white top</td>
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<tr>
<td>musk thistle</td>
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<tr>
<td>Canada thistle</td>
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<tr>
<td>houndstongue</td>
</tr>
<tr>
<td>teasel</td>
</tr>
<tr>
<td>dalmatian toadflax</td>
</tr>
<tr>
<td>Scotch thistle</td>
</tr>
<tr>
<td>sulfur cinquefoil</td>
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<thead>
<tr>
<th>C LISTED SPECIES: LOW PRIORITY</th>
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<tbody>
<tr>
<td><em>Aegilops cylindrica</em></td>
</tr>
<tr>
<td><em>Bromus tectorum</em></td>
</tr>
<tr>
<td><em>Conium macaulatum</em></td>
</tr>
<tr>
<td><em>Convolvulus arvensis</em></td>
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<tr>
<td><em>Hypericum perforatum</em></td>
</tr>
<tr>
<td><em>Verbascum thapsus</em></td>
</tr>
<tr>
<td>jointed goatgrass</td>
</tr>
<tr>
<td>cheatgrass</td>
</tr>
<tr>
<td>poison hemlock</td>
</tr>
<tr>
<td>field bindweed</td>
</tr>
<tr>
<td>St. Johnswort</td>
</tr>
<tr>
<td>common mullein</td>
</tr>
</tbody>
</table>

The species priority indicated in Table 5 was used in conjunction with population characteristics to establish treatment priority. Priority populations are small populations of high priority species, species that can be easily eradicated, populations that pose a significant threat to site values and populations of species uncommon on the property. Accessible areas and stratifications that are relatively free of weeds are also a high priority. The above table also includes species of weeds that were identified in the 1999 inventory.

Refer to Appendix II (Table 6) for a complete list of weeds encountered during sampling, their location, density, distribution and treatment priority. The locations of these populations are also presented on the Noxious Weed Map. North American invasive plant mapping standards supplemental information is provided in Appendix II (Table 7). The data form is provided in Appendix II for use in future inventories.
Discussion

Rangeland Discussion

A total of 134 species were found in forested areas, 117 were found in rangelands. A Jaccard’s similarity index was calculated indicating that these areas have 74 species in common and are 41.8% similar. The landscape level analysis indicated that the combined rangeland stratifications had greater noxious species diversity and higher noxious species relative cover. This trend has been documented by Stohlgren et al. (1999) and Fornwalt et al. (2002b) who determined that exotic species cover was positively correlated with total foliar cover. Rangelands with high species richness, foliar cover, or soil fertility are more likely to be invaded by exotic species. This trend may be more closely related to the degree of resource availability in plant communities and independent of species richness. Similarly, fertile soil and frequent disturbance make riparian areas prone to invasion; these areas may further serve as havens, corridors and sources of exotic plant invasions for adjacent upland sites (Stohlgren et al. 1998). The Skunk Creek riparian corridor at NCAR is heavily impacted with several noxious species; the intermittent drainage in the wet meadow and the Bear Creek Canyon riparian corridor were also impacted but not as heavily as Skunk Creek. Management efforts in the Skunk Creek area will focus on containment while smaller high priority populations will be controlled more aggressively.

Fire severity was a consistent predictor of high exotic species cover in 3 studies conducted by Omi et al. (2005a). Areas that burn with high severity had a higher relative cover of invasive plants subsequent to the fire. Preliminary results from a study conducted by Omi et al. (2005b) in the Cero Grande Fire in Los Alamos, New Mexico suggest that fuel treatments which incorporate both mechanical thinning and prescribed burning may mitigate the spread and cover of invasive plants by suppressing subsequent wildfire severity.

The effect of logging, grazing and similar disturbances on exotic species establishment and distribution in managed and protected ponderosa pine/Douglas-fir forests of the Colorado Front Range was evaluated by Fornwalt et al. (2002b). Results indicated that forest management activities had less of an impact on exotic species establishment and distribution than topographic position did. Therefore, forest management activities at NCAR should not have a significant impact on the incidence of exotic plants at NCAR.
No single management technique is perfect for all weed control situations. Several management activities are typically required for effective control. 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 in developing 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,
3) educating recreational users and land managers about the effect of weeds,
4) inventorying weed populations,
5) containing, suppressing or eradicating populations when found, and
6) monitoring 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 NCAR. The optimum combination of techniques may not be possible in every circumstance due to financial, geographic or political constraints. Often, weed populations are most easily managed within the first few years of their establishment. For older weed populations, management shifts from prevention to active control.

The study team sought to identify most weed species but was not able to map every population. Weed populations in addition to those already mapped may exist and can be documented during the first round of weed suppression activities. Suppression efforts should always include a search for additional populations in the area. Continual weed mapping efforts are required to identify new infestations. Monitoring is necessary to track the status of known weed populations and evaluate treatment efficacy. All identified weed populations have a unique tracking number to document management activities and plant responses. Future monitoring and management activities should integrate spatially explicit documentation of site activities.

Effective weed control plans also require species specific knowledge of the abundance and distribution of each weed, their life history, habitat requirements, reproductive biology, and mode of dispersal. This information, a photograph, and control strategies are provided for all noxious species found at NCAR in Appendix II. A grassland management prescription and additional weed management resources are also provided in Appendix II. Refer to the Noxious Weed Map and the Noxious Weed Table for treatment prioritization.
WILDLIFE

Introduction

Statement of Needs

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. Wildlife management techniques should be applied to enhance habitat types and ecosystems which are important to desirable species. A thorough assessment of the site should be completed as part of the planning effort. This assessment should include, but not be limited to, an inventory of habitat types present on the site. This inventory should also include an inventory of plant species and wildlife species present and those which could utilize the habitats identified on the site. Special status plant and wildlife species which may require special consideration by federal, state, or local regulations should also be identified. A number of federal, state and local laws and regulations, such as the National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321-4347); the Endangered Species Act of 1973 (16 U.S.C. 1531-1544); the Clean Water Act, 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. [2003]) and Colorado SB40 regulations (§§ 33-5-101, CRS 1973) regulate how management and development may be applied to a specific property. In many instances, the application of many of these laws can be influenced by the type of ownership and sources of funding (federal, state, local, or private) to be used for development or management. On federal property, or where federal funding is utilized, NEPA regulations generally require an initial environmental assessment and an accompanying discussion of alternative management scenarios.

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 species population densities to conform to habitat limitations and desired habitat goals.
4) Protect special status (threatened, endangered, species of concern) species critical habitats.
5) Reduce and control exotic species populations and noxious weeds.
6) Manage recreational use of the property to reduce habitat degradation, wildlife disturbance, sources of sedimentation and erosion.
Background

NCAR Wildlife

Wildlife species occurring at NCAR are generally associated with habitats which include dry mountains, rocky outcrops, steep terrain, cliffs, coniferous forests, cold mountain streams, rangelands and forest openings (Figure 23). Rangelands at NCAR occur on most of the property and include a short grass prairie and meadows. There are also low density woodlands in the central portion of the property and dense forests to the west. The Flatirons and Eldorado Mountain lie to the west of NCAR. Much of these areas are owned and managed by the City of Boulder Mountain Parks and Boulder County Open Space. These public lands are protected from development by the city and county and contain significant areas of unique habitats inhabited by many rare and unique species of plants and animals. Much of the area is closed to public use during certain portions of each year to protect breeding populations of golden eagles (*Aquila chrysaetos*), peregrin falcons (*Falco peregrinus*) and other species of birds.

Three significant riparian corridors also exist within the NCAR property which provide habitat for mammal, bird, reptile, and amphibian species associated with moist areas. These corridors include the Bear Creek riparian corridor (Figure 24) on the south boundary of the property, the Skunk Creek riparian corridor on the north side of the property, and an unnamed intermittent riparian corridor found in the center of the property (see the General Reference Map); all of these corridors flow west to east. The Bear Creek and Skunk Creek corridors maintain a permanent flow in wet years. The federally threatened Preble’s meadow jumping mouse (*Zapus hudsonius preblei*) has been verified along the Bear Creek corridor (Ruggles et. al 2000).

Figure 23. The NCAR landscape and surrounding mountains provides a variety of habitat to wildlife.

Figure 24. Bear Canyon Creek was full with spring runoff in May of 2005.
Methods

Wildlife Assessment

A review of existing wildlife inventory data was conducted to identify species that could inhabit or utilize the NCAR property and its immediate vicinity. This review was completed to include inventories of Boulder County, City of Boulder Mountain Parks, State of Colorado, U.S. Fish and Wildlife Service and other data sources. A list of species that could 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 IV.)

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 8, Appendix III.)

An onsite assessment was also conducted by Natural Resource Services, Inc. on May 4, 2005 and June 8, 2005 to identify wildlife habitat types, including unique habitats upon which special status species rely. Figure 17 in the Rangelands and Noxious Weed section illustrates how the wildlife assessment relates to other types of analysis conducted at NCAR. Findings, conclusions and recommendations were incorporated into this management plan.

Results

NCAR Wildlife

Wildlife species that could inhabit or utilize the NCAR property are listed on the electronic database (Microsoft Excel format) in Appendix IV. A total of 204 bird species, 93 mammal species, 26 reptile and amphibian species, and 18 fish species were identified as possibly occurring within the NCAR site. As indicated on the electronic database, the area falls within the breeding range of 159 species of birds, within the wintering range of 93 species of birds and within the migration range of 176 species of birds.

The NCAR site also provides potential habitat for a number of wildlife species of special concern as shown in Table 8 (Appendix III). The data in Table 8 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),
As with more common wildlife species, the probability of occurrence within the NCAR site was determined for each species after reviewing range and habitat data and verified occurrences on adjacent properties as provided in the literature. Table 8 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. Some species listed in Table 8 have not been verified as occurring within the NCAR Table Mesa site but have been verified on adjacent property. A number of listed plant species of special concern are also found within the vicinity of the NCAR site.

**Discussion**

**Wildlife Discussion**

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

1) A number of special status species and their critical habitats have been verified to occur on or immediately adjacent to the property. The City of Boulder Open Space and Mountain Parks and Boulder County Open Space jointly close these areas on an annual basis to protect breeding areas and critical habitat for these species.

2) Excessive browsing by deer is occurring throughout NCAR and adjacent properties resulting in noticeable browse lines and damage to native vegetation.

3) Excessive human and ungulate use of existing trails on the property is causing significant erosion and siltation of streams in some portions of the property (Figure 24).

4) Exotic vegetation and noxious weeds, including species listed on the Colorado Noxious Weed List have invaded communities of native vegetation at a number of locations.
Recommendations

Wildlife Management Recommendations

The forest management recommendations in this ecosystem 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. Habitat for wildlife species which 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 critical habitats which may exist prior to the implementation of management activities. A thorough riparian and wetland assessment should be included in this inventory. We also recommend that several browse exclosures be constructed at various locations within the property to monitor ungulate pressure on native vegetation.

2) Analyze the results of the habitat assessment to identify plant and animal species which may utilize existing habitats.

3) Develop wildlife management objectives for the habitat types that were identified in the habitat assessment.

4) Prioritize plant and animal species of concern. 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 the management process.

5) Develop a detailed wildlife management plan for NCAR which 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 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 recreational users about habitat management issues and reasons for implementation of various management practices. Appropriate signage and printed materials should be considered. An ecological theme that emphasized wildfire, wildlife and weather may be appropriate for the NCAR site.

Implementing the procedures outlined above will ensure that proposed management activities are well planned and that their consequences have been considered prior to program implementation.
PROJECT MAPS
Remove this page and insert the NCAR General Reference Map here
Remove this page and insert the NCAR Soil Unit Map Here
Remove this page and insert the NCAR Management Unit Map here
Remove this page and insert the NCAR Slope Map here
Remove this page and insert the NCAR Elevation Map here
NCAR Anderson’s Fuel Model Map
NCAR Crown Fire Activity Map (Average Conditions)
NCAR Crown Fire Activity Map (Extreme Conditions)
NCAR Flame Length Map (Average Conditions)
NCAR Flame Length Map (Extreme Conditions)
NCAR Fire Rate of Spread Map (Average Conditions)
NCAR Fire Rate of Spread Map (Extreme Conditions)
NCAR Noxious Weed Map
LITERATURE CITED


Colorado Weed Management Association (CWMA). 2002. PO Box 1910, Grandby, CO 80446-1910, Phone: 970-887-1228, e-mail: CWMA@rkymtnhi.com


USDA, Soil Conservation Service. 1975. Boulder County Area, Colorado. USDA Soil Conservation Service in cooperation with the Colorado Agricultural Experiment Station.


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.

Advanced ecological status – A biotic community with a high coefficient of similarity to a defined or perceived potential natural community from an ecological site, usually late seral or potential natural community ecological status.

Alternate leaves – Having one leaf arising at each node, having members of one whorl attached between the members of the next outer or inner whorl.

Annual – Living through only one growing season.

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.

Best management practice (BMP) – Resource management practices that are designed to prevent or reduce undesirable side-effects of implementation of management actions.

Biennial – A plant that lives for two years.

Biodiversity – The number of species, the amount of genetic variation or the number of community types present in an area.

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

Biotechnical slope protection – The use of structural and vegetative elements to stabilize a slope.

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

Bract – A small, leaf like structure below a flower.

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

Browse – The part of shrubs, woody vines, and trees suitable for animal consumption.

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.
Channel – A noticeable natural or artificial waterway featuring periodic or continuous running water.

Channel confinement – The restriction of a channel of water by natural or artificial features.

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.

Compound leaves – Divided into a number of similar parts.

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.

Dendrochronology – The science of precisely dating tree rings based on patterns of annual ring width.

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.

Ecological process – The actions or events that link organisms and their environment such as disturbance, succession, nutrient cycling, carbon sequestration, productivity and decay.

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.

Fine fuels – Fuels that are less than ¼ inch in diameter such as grass, leaves, pine needles etc, that when dry ignite readily and are consumed rapidly.

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 that 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.

Forage – Browse and herbage that is available for grazing animals.

Forb – Herbaceous plants other than grasses and grass like plants.

Fuelbreak – A strip of land in which fuel density is reduced thus improving fire control opportunities.

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.

Fuel model – A set of numbers that define fuel input to the fire spread model.

Geographic Information Systems (GIS) – GIS is a database and analytical tool designed to analyze geographic data.

Grass – Monocotyledonous herbaceous plants.

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

Headcutting – An erosional process moving upstream or upslope from the location of origin.

Herbaceous – Not woody; dying back to the ground each year.

Herbivory – The consumption of plants by herbivores.

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

**Infiltration** – The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers.

**Interruption 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.

**Landscape distribution** – The relative proportion of various ecological communities within a given geographic area.

**Litter** – Deadfall from plants that accumulates on the ground typically comprised of leaves, needles, bark, dead grass, etc.

**Lobed** – Cut into shallow segments.

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

**Montane** – The middle elevations of the Colorado Front Range occurring between 6,000 and 9,000 feet.

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

**Natural regeneration** – The natural re-growth of tree species from seeding or other reproductive means (suckering, layering or sprouting).

**Naturalized** – An exotic plant that is now considered an acceptable part of a community. To come into conformity with nature.

**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.

**Opposite leaves** – Arranged on the same node at the opposite side of the stem.

**Obligate wetland species** – Plant species that occur almost always (estimated 99% probability) under natural conditions in a wetland.

**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.
Permeability – The quality of the soil that enables water to move downward through the profile. Permeability is measured in inches per hour.

- Slow – 0.06 to 0.2 inches per hour
- Moderate – 0.6 to 2.0 inches per hour
- Moderately rapid – 2.0 to 6.0 inches per hour
- Rapid – 6.0 to 20 inches per hour

Potential natural community – The biological community an area could support given adequate time for succession, the climax community.

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.

Repeat photography – Photographs of the same subject separated by some period of time, usually used to evaluate change.

Restoration – The process of returning ecosystem patterns or processes to within the historical range of variability or other defined reference condition.

Rhizome – An underground stem with nodes, scale-like leaves, and internodes.

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.

Rock outlet protection – A section of rocks placed at the outlet end of culverts, conduits or channels. Rock outlet protection is to reduce the depth, velocity and energy such that the flow will not erode the receiving downstream reach.

Rosette – Compact cluster of leaves radiating at ground level, often in a circle.

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

Sedge – Grass like herbaceous plants lacking nodes on the stem.

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.

Slope – The steepness of a parcel of land expressed in percent: rise over run.

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 ways. 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.

**Stocking level** – The number of trees in a stand relative to the optimal level of trees for that area.

**Subsurface water status** – The depth and amount of water below the surface of the ground.

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

**Sustainability** – The ability of an ecosystem to maintain ecological processes and functions, biological diversity, and productivity over time.

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

**Tiller** – A shoot or adventitious bud at the base of a plant.

**Tree core** – A cylindrical extraction of a tree’s cross section; tree cores are about the size of a pencil and are taken to measure a tree’s age.

**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.

**Uneven-aged** – Forest stand composed of an intermingling of trees that differ markedly in age.

**UTM** – Universal Transverse Mercator: A Cartesian coordinate georeferencing system used for mapping purposes.

**Visitor Use Day** – One visitor day represent an aggregate of 12 visitor hours at a site or area.

**Watershed** – An area of land with a characteristic drainage network that contributes surface or ground water to the flow at a given point; a drainage basin or major subdivision of a drainage basin.

**Wetland** – Lands transitional between terrestrial and aquatic systems where the water table is at or near the surface, or the land is covered by shallow water. For purposes of classification, wetlands must have at least one of the following attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time of the growing season of each year (FWS). Wetlands include: riparian lands, wet meadows, marshes and peatlands.

**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 I: FOREST RESTORATION AND WILDFIRE MITIGATION
## NCAR Forest Inventory
### Per Acre Summary for all Species, Units 1A, 1B and 1C

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| SCRIB | 8 | 0 | 35 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 71 |

| STEMS | 10 | 0 | 0 | 7 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 27 |
| CUVAL | 10 | 0 | 0 | 35 | 148 | 0 | 0 | 0 | 0 | 0 | 0 | 183 |
| SCRIB | 10 | 0 | 0 | 58 | 280 | 0 | 0 | 0 | 0 | 0 | 0 | 339 |

| STEMS | 12 | 0 | 0 | 14 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 16 |
| CUVAL | 12 | 0 | 0 | 170 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 198 |
| SCRIB | 12 | 0 | 0 | 514 | 92 | 0 | 0 | 0 | 0 | 0 | 0 | 606 |

| STEMS | 14 | 0 | 0 | 2 | 4 | 11 | 0 | 0 | 0 | 0 | 0 | 16 |
| CUVAL | 14 | 0 | 0 | 17 | 51 | 198 | 0 | 0 | 0 | 0 | 0 | 266 |
| SCRIB | 14 | 0 | 0 | 45 | 175 | 741 | 0 | 0 | 0 | 0 | 0 | 961 |

| STEMS | 16 | 0 | 0 | 0 | 6 | 12 | 0 | 0 | 0 | 0 | 0 | 18 |
| CUVAL | 16 | 0 | 0 | 0 | 125 | 299 | 0 | 0 | 0 | 0 | 0 | 424 |
| SCRIB | 16 | 0 | 0 | 0 | 499 | 1220 | 0 | 0 | 0 | 0 | 0 | 1719 |

| STEMS | 18 | 0 | 0 | 0 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 7 |
| CUVAL | 18 | 0 | 0 | 0 | 0 | 182 | 34 | 0 | 0 | 0 | 0 | 216 |
| SCRIB | 18 | 0 | 0 | 0 | 0 | 789 | 148 | 0 | 0 | 0 | 0 | 937 |

| STEMS | 20 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 3 |
| CUVAL | 20 | 0 | 0 | 0 | 27 | 92 | 0 | 0 | 0 | 0 | 0 | 118 |
| SCRIB | 20 | 0 | 0 | 0 | 119 | 410 | 0 | 0 | 0 | 0 | 0 | 529 |

| STEMS | 22 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 |
| CUVAL | 22 | 0 | 0 | 0 | 0 | 59 | 34 | 0 | 0 | 0 | 0 | 92 |
| SCRIB | 22 | 0 | 0 | 0 | 0 | 268 | 156 | 0 | 0 | 0 | 0 | 425 |

| STEMS | 24 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| CUVAL | 24 | 0 | 0 | 0 | 51 | 59 | 0 | 0 | 0 | 0 | 0 | 111 |
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| SCRIB | 26 | 0 | 0 | 0 | 104 | 138 | 0 | 0 | 0 | 0 | 0 | 242 |

| STEMS | 28 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CUVAL | 28 | 0 | 0 | 0 | 51 | 0 | 0 | 0 | 0 | 0 | 0 | 51 |
| SCRIB | 28 | 0 | 0 | 0 | 243 | 0 | 0 | 0 | 0 | 0 | 0 | 243 |

| STEMS | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CUVAL | 30 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 27 |
| SCRIB | 30 | 0 | 0 | 0 | 128 | 0 | 0 | 0 | 0 | 0 | 0 | 128 |

| STEMS | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CUVAL | 36 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 27 |
| SCRIB | 36 | 0 | 0 | 0 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 130 |

| TOTAL | STEMS | 0 | 14 | 10 | 19 | 52 | 36 | 2 | 0 | 0 | 0 | 0 | 133 |
| CUVAL | 0 | 8 | 22 | 86 | 723 | 945 | 67 | 0 | 0 | 0 | 0 | 1852 |
| SCRIB | 0 | 35 | 138 | 2431 | 3934 | 304 | 0 | 0 | 0 | 0 | 0 | 6843 |

### Per Acre Summary

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LIMIT OF ERROR AT 1 SD = 13%
### NCAR Forest Inventory

**Per Acre Summary for all Species, Unit 2**

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### 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.
Prescriptions Units 1A, 1B, & 1C 48 ACRES

Conditions within this unit require treatment of small diameter regeneration and wildfire mitigation thinning. A proportional cut, sanitation thinning and patch cuts are required to remove undesirable trees and increase tree spacing. Tree density should be reduced from 101 square feet/acre to approximately 71 square feet/acre. A 30% reduction in basal area is recommended to accomplish these ends. See formula below:

Current forest volume (all size classes) = 1852 cubic feet/acre
Desired reduction in volume = 30% (proportional)

1852 cubic feet/acre X .3 = 555.6 cubic feet/acre reduction

1) Implement and maintain defensible spaces around all structures within Unit 1A (see Structure Protection form Wildfire recommendations)
2) Sanitation thinning
   (a) Remove trees containing dwarf mistletoe. If infestation is larger than several acres, isolate with a linear clearing that is at least 50 feet wide.
   (b) Remove and treat trees infested with mountain pine beetle and ponderosa pine needle miner. See appendices for treatment guidelines.
   (c) Remove unhealthy, suppressed and poorly formed trees (whips, crooked stems, broken top, forked leader, poor site, etc.)
3) Reduce basal area to 60 to 80 Ft²/.Ac.; target canopy closure density is 10 to 30 % closure.
4) Remove most (8 in 10) of the Douglas-fir trees in favor of ponderosa pine.
5) Remove most juniper trees, especially where they are ladder fuels.
6) Thin from below, remove most small diameter regeneration that is less than 3 inches DBH. Retain a limited amount of regeneration of all size classes.
7) Retain mature trees of all species: look for large diameter, yellow bark, fire pruning, parasol top, reduced foliage, cavities, etc.
8) Create several openings of irregular size and shape ranging in size from ¼ to 5 acres. Openings should be established in diseased or insect damaged areas. Existing clearings may be enlarged to contribute to this tally.
9) Retain or create 3 wildlife trees “snags” per acre that are greater than 10 inches DBH, favoring groupings. Girdle trees if necessary.
10) Retain most trees showing evidence of wildlife activity (cavities, borings, and caches).
11) Retain 150 linear feet of downed woody/acre that is at least 10 inches in diameter.
12) Increase canopy spacing to 15 to 20 feet, retain groupings and promote a forested mosaic.
13) Prune lower branches from residual trees as they may facilitate crown fire development.
14) Lop and scatter slash or utilize other methods described in Performance Standards; use careful consideration with hand or machine plies as they may promote weeds.
15) Rake litter and duff away from the base of mature trees prior to the prescribed fire.
16) Broadcast burn after treatments to remove dead and down material and to stimulate rangeland growth.
Prescriptions Unit 2  

28 ACRES

Conditions within this unit require treatment of diseases and wildfire mitigation thinning. A proportional cut and sanitation thinning are required to remove undesirable trees and increase tree spacing. Tree density should be reduced from 103 square feet/acre to approximately 67 square feet/acre. A 35% reduction in basal area is recommended to accomplish these ends. See formula below:

\[
\text{Current forest volume (all size classes)} = 1380 \text{ cubic feet/acre} \\
\text{Desired reduction in volume} = 35\% \text{ (proportional)} \\
1380 \text{ cubic feet/acre} \times 0.35 = 483.0 \text{ cubic feet/acre reduction}
\]

1) Sanitation thinning
   (a) Remove trees containing dwarf mistletoe. If infestation is larger than several acres, isolate with a linear clearing that is at least 50 feet wide.
   (b) Remove and treat trees infested with mountain pine beetle or other insects. See appendices for treatment guidelines.
   (c) Remove unhealthy, suppressed and poorly formed trees (whips, crooked stems, broken top, forked leader, poor site, etc.)

2) Reduce basal area to 60 to 80 Ft\(^2\)/Ac; there may be considerable variability in tree density.

3) Remove some of the Douglas-fir trees in favor of ponderosa pine.

4) Remove most juniper trees, especially where they are ladder fuels.

5) 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.

6) Retain mature trees of all species: look for large diameter, yellow bark, fire pruning, parasol top, reduced foliage, cavities, etc.

7) Retain or create 3 wildlife trees “snags” per acre > 10 inches DBH, favoring groupings.

8) Retain most trees showing evidence of wildlife activity (cavities, borings, and caches).

9) Increase canopy spacing to 15 to 20 feet, retain groupings and promote a forested mosaic.

10) Target canopy density for this unit is 30 to 50 % closure.

11) Prune lower branches from residual trees as they may facilitate crown fire development.

12) Lop and scatter slash or utilize other methods described in Performance Standards; use careful consideration with hand or machine plies as they may promote weeds.

13) Broadcast burning may be considered after final treatments to remove dead and down material and to stimulate understory growth.
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.

**Look for:** The first symptom of infection is a slight swelling of the bark at the infection site. As the parasite’s sinkers (roots) become more extensive, a distorted branching habit or witches broom becomes apparent. Infected trees will also display yellow foliage, reduced foliage, and branch mortality.

**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 exposed 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. For additional information see Leatherman and Cranshaw (1998).
Forest Insects and Diseases:
Ponderosa Pine Needle Miner

Ponderosa pine needle miner, Coleotechnites ponderosae, is a tiny dark gray moth that bores into young pine needles where it develops to maturity often causing needle tip die-back. Adult needle miners emerge in late summer to mate and lay eggs, typically in previously mined needles. Eggs hatch and the larvae move to green needles to feed. Development continues slowly through the winter and accelerates with the onset of spring (Rewerts 2000). The larvae will complete their development by midsummer. Although needle miner feeding is not typically a forest health problem, it does diminish aesthetics near homes or in urban settings (Stevens et al. 1996).

Look for: Browning foliage is evidence of injury and closer inspection may reveal hollowed-out needles which typically remain green at the base. Affected needles will have holes in them such that light can shine through them. Needle miner damage differs in appearance from pine beetle damage in that only portions of the tree may be effected and the inner portions of the needle may remain green (Stevens et al. 1996).

Treatment: Numerous natural controls limit needle miner populations. Acephate foliar sprays (Orthene) or injections (Acecap), applied to individual trees prior to egg hatch can provide control (Rewerts 2000). Pruning branches or removing trees is also effective.
Structure Protection from Wildfire

The buildings in the study area have a low threat from wildfire, due primarily to the construction materials used and the paths and driveways that surround them. All materials are fire resistant and are in areas of low fuel loading; however, there are some improvements that could be made to further ensure protection from fire. Some of these recommendations 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 in a 100’ radius
7) Reduce forest density surrounding structures
8) Keep flammable materials away from vegetation
Performance Standards for Forestry Operations¹

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, 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.
Fuel Model 1

Characteristics
This type consists of short grasses one foot tall or less. The area has very few shrubs or trees, any that are present are widely scattered. This type occurs on the plains, the first hogbacks of the foothills and mountain meadows.

Common Types/Species
Included in this fuel type are: prairie and mountain grasses, shrubs such as Currant, Buckbrush, Bitterbrush and Mountain Mahogany, and trees such as Ponderosa pine.

Fire Behavior
Surface fires that spread rapidly. Fire is carried by the fine herbaceous fuels that are cured or nearly cured.

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

<table>
<thead>
<tr>
<th>Fine Dead</th>
<th>Mid-flame Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>2.0</td>
<td>28.8</td>
</tr>
<tr>
<td>4.0</td>
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<tr>
<td>6.0</td>
<td>19.4</td>
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<td>8.0</td>
<td>16.7</td>
</tr>
<tr>
<td>10.0</td>
<td>11.0</td>
</tr>
</tbody>
</table>

Slope 10%

Flame Length in Feet

<table>
<thead>
<tr>
<th>Fine Dead</th>
<th>Mid-flame Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>4.0</td>
<td>2.4</td>
</tr>
<tr>
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<td>2.2</td>
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<tr>
<td>8.0</td>
<td>2.0</td>
</tr>
<tr>
<td>10.0</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Fuel model charts are general descriptions of Fuel Models found in the study area. These tables show a range of outputs for flame lengths and rate of spread as windspeed and fine dead fuel moisture change. It reacts to changes in relative humidity quickly. The tables are a quick reference to understand the effects of wind and relative humidity on fire behavior with all other parameters being equal.

2 descriptions from Fuel models for Colorado by CSFS  All inputs created with Behave by Remsoft v. 97.2

130
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 zone.

**Common Species/Species**
The predominate tree species is Ponderosa pine. This type may include some scattered Douglas fir. Other tree and shrub species include Common and Rocky Mountain Juniper, Buckbrush, Bitter brush, and Mountain Mahogany. Mountain grasses are included in this model.

**Fire Behavior**
Surface fires that spread easily. Clumps of fuel may generate higher fire intensities. Fire is carried by grasses and/or woody litter.

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

<table>
<thead>
<tr>
<th>Fine Fuel</th>
<th>2.0</th>
<th>4.0</th>
<th>6.0</th>
<th>8.0</th>
<th>10.0</th>
<th>12.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>12.4</td>
<td>34.2</td>
<td>67.5</td>
<td>111.6</td>
<td>166.0</td>
<td>230.2</td>
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<tr>
<td>4.0</td>
<td>10.2</td>
<td>28.0</td>
<td>55.3</td>
<td>91.4</td>
<td>135.9</td>
<td>188.5</td>
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<td>6.0</td>
<td>9.0</td>
<td>24.9</td>
<td>49.1</td>
<td>81.2</td>
<td>120.8</td>
<td>167.6</td>
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<tr>
<td>8.0</td>
<td>8.3</td>
<td>22.9</td>
<td>45.3</td>
<td>74.9</td>
<td>111.3</td>
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<tr>
<td>10.0</td>
<td>7.4</td>
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<td>40.5</td>
<td>67.0</td>
<td>99.7</td>
<td>138.3</td>
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<td>12.0</td>
<td>5.9</td>
<td>16.3</td>
<td>32.3</td>
<td>53.3</td>
<td>79.3</td>
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</tr>
</tbody>
</table>

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

### Flame Length in Feet

<table>
<thead>
<tr>
<th>Fine Fuel</th>
<th>2.0</th>
<th>4.0</th>
<th>6.0</th>
<th>8.0</th>
<th>10.0</th>
<th>12.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>4.3</td>
<td>6.9</td>
<td>9.4</td>
<td>11.8</td>
<td>14.2</td>
<td>16.5</td>
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<tr>
<td>4.0</td>
<td>3.7</td>
<td>5.8</td>
<td>8.0</td>
<td>10.1</td>
<td>12.1</td>
<td>14.0</td>
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<td>3.4</td>
<td>5.4</td>
<td>7.3</td>
<td>9.2</td>
<td>11.1</td>
<td>12.9</td>
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<tr>
<td>8.0</td>
<td>3.2</td>
<td>5.1</td>
<td>6.9</td>
<td>8.7</td>
<td>10.5</td>
<td>12.2</td>
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<tr>
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<td>2.9</td>
<td>4.7</td>
<td>6.4</td>
<td>8.1</td>
<td>9.7</td>
<td>11.2</td>
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<tr>
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<td>2.4</td>
<td>3.9</td>
<td>5.3</td>
<td>6.7</td>
<td>8.0</td>
<td>9.3</td>
</tr>
</tbody>
</table>

3 descriptions from Fuel models for Colorado by CSFS
Fuel Model 9

Characteristics
This stand is represented by closed canopy stands of Ponderosa pine and mixed conifer. Understory may consist of small trees and shrubs, grasses, and moderate concentrations of down, dead woody litter. High amounts of needle litter may be present. This model can exist from foothills to sub-alpine.

Common Types/Species
This model can include Ponderosa pine, Lodgepole pine, and a mixture of Douglas-fir spruce and pine. Some mountain shrubs and grasses are present.

Fire Behavior
Fires run through surface litter, torching of individual trees is possible. Under high burning conditions, crown fires can be encountered.

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

<table>
<thead>
<tr>
<th>Fine Fuel</th>
<th>Mid-flame Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>4.0 9.8 18.1 28.7 41.5 56.2</td>
</tr>
<tr>
<td>4.0</td>
<td>3.2 7.7 14.3 22.7 32.7 44.4</td>
</tr>
<tr>
<td>6.0</td>
<td>2.6 6.4 11.8 18.8 27.1 36.7</td>
</tr>
<tr>
<td>8.0</td>
<td>2.3 5.5 10.2 16.3 23.5 31.8</td>
</tr>
<tr>
<td>10.0</td>
<td>2.0 5.0 9.2 14.7 21.2 28.7</td>
</tr>
<tr>
<td>12.0</td>
<td>1.9 4.6 8.5 13.5 19.5 26.5</td>
</tr>
</tbody>
</table>

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

Flame Length in Feet

<table>
<thead>
<tr>
<th>Fine Dead Fuel</th>
<th>Mid-flame Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>2.3 3.5 4.7 5.8 6.8 7.9</td>
</tr>
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<td>4.0</td>
<td>1.9 2.9 3.9 4.8 5.7 6.6</td>
</tr>
<tr>
<td>6.0</td>
<td>1.7 2.5 3.4 4.2 5.0 5.7</td>
</tr>
<tr>
<td>8.0</td>
<td>1.5 2.3 3.1 3.8 4.5 5.2</td>
</tr>
<tr>
<td>10.0</td>
<td>1.4 2.2 2.9 3.5 4.2 4.8</td>
</tr>
<tr>
<td>12.0</td>
<td>1.4 2.1 2.7 3.4 4.0 4.6</td>
</tr>
</tbody>
</table>

4 descriptions from Fuel models for Colorado by CSFS
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, 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)**

<table>
<thead>
<tr>
<th>Fine Dead Fuel</th>
<th>2.0</th>
<th>4.0</th>
<th>6.0</th>
<th>8.0</th>
<th>10.0</th>
<th>12.0</th>
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</thead>
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<td>7.2</td>
<td>12.1</td>
<td>17.8</td>
<td>24.1</td>
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</tr>
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<td>3.0</td>
<td>6.6</td>
<td>11.0</td>
<td>16.1</td>
<td>21.8</td>
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<td>6.1</td>
<td>10.2</td>
<td>14.9</td>
<td>20.2</td>
<td>26.0</td>
</tr>
<tr>
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<td>2.6</td>
<td>5.7</td>
<td>9.6</td>
<td>14.1</td>
<td>19.1</td>
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<td>5.5</td>
<td>9.2</td>
<td>13.4</td>
<td>18.2</td>
<td>23.4</td>
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</table>

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

**Flame Length in Feet**

<table>
<thead>
<tr>
<th>Fine Dead Fuel</th>
<th>2.0</th>
<th>4.0</th>
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<th>8.0</th>
<th>10.0</th>
<th>12.0</th>
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</thead>
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<tr>
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<td>5.5</td>
<td>7.0</td>
<td>8.3</td>
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<td>10.7</td>
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<td>6.3</td>
<td>7.5</td>
<td>8.6</td>
<td>9.7</td>
</tr>
<tr>
<td>6.0</td>
<td>3.2</td>
<td>4.6</td>
<td>5.8</td>
<td>6.9</td>
<td>7.9</td>
<td>8.9</td>
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<td>5.5</td>
<td>6.5</td>
<td>7.5</td>
<td>8.4</td>
</tr>
<tr>
<td>10.0</td>
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<td>4.1</td>
<td>5.2</td>
<td>6.2</td>
<td>7.2</td>
<td>8.0</td>
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<td>4.0</td>
<td>5.1</td>
<td>6.0</td>
<td>6.9</td>
<td>7.8</td>
</tr>
</tbody>
</table>

---

5. descriptions from Fuel models for Colorado by CSFS
APPENDIX II: RANGELANDS AND NOXIOUS WEEDS
Table 6. Noxious Weed Table.

<table>
<thead>
<tr>
<th>Point</th>
<th>Priority</th>
<th>Species</th>
<th>Acres</th>
<th>% Cover</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>CIAR4</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>Near intermittent drainage with populations of field bindweed, yellow salsify, mullein, teasel and musk thistle</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>COAR4</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>In intermittent drainage with other noxious species, bindweed is common</td>
</tr>
<tr>
<td>3</td>
<td>L</td>
<td>VETH</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>In intermittent drainage with other noxious species</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>DIFU2</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>In intermittent drainage with other noxious species</td>
</tr>
<tr>
<td>5</td>
<td>L</td>
<td>DIFU2</td>
<td>&gt; 5</td>
<td>1 - 25</td>
<td>Broadly distributed in wet meadow, seed source is at top of hill. Recommend cutting seed heads. Polygon</td>
</tr>
<tr>
<td>6</td>
<td>L</td>
<td>BRTE</td>
<td>&lt; 1</td>
<td>51 - 75</td>
<td>Small population along trail, priority due to limited distribution</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>COMA2</td>
<td>&lt; .1</td>
<td>1 - 25</td>
<td>Individual plants found throughout Bear Creek and Skunk Creek riparian corridors</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>COMA2</td>
<td>&lt; .1</td>
<td>1 - 25</td>
<td>Individual plants found throughout Bear Creek and Skunk Creek riparian corridors</td>
</tr>
<tr>
<td>9</td>
<td>H</td>
<td>CANU4</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Found on bench along riparian corridor with houndstongue and mullein</td>
</tr>
<tr>
<td>10</td>
<td>H</td>
<td>CYOF</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Found on bench along riparian corridor with musk thistle and mullein</td>
</tr>
<tr>
<td>11</td>
<td>L</td>
<td>VETH</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Found on bench along riparian corridor with musk thistle and houndstongue</td>
</tr>
<tr>
<td>12</td>
<td>H</td>
<td>LIDA</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Population is on Boulder County land but is a management priority due to its limited size.</td>
</tr>
<tr>
<td>13</td>
<td>L</td>
<td>VETH</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Found with poison hemlock, sparse population</td>
</tr>
<tr>
<td>14</td>
<td>H</td>
<td>COMA2</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Found with mullein, sparse population</td>
</tr>
<tr>
<td>15</td>
<td>M</td>
<td>CANU4</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>Found with musk thistle, houndstongue, teasel, mullein; on hillside north of main road, high priority</td>
</tr>
<tr>
<td>16</td>
<td>M</td>
<td>CYOF</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>Found with musk thistle, houndstongue, teasel, mullein; on hillside north of main road, high priority</td>
</tr>
<tr>
<td>17</td>
<td>M</td>
<td>DIFU2</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>Found with musk thistle, houndstongue, teasel, mullein; on hillside north of main road, high priority</td>
</tr>
<tr>
<td>18</td>
<td>M</td>
<td>VETH</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>Found with musk thistle, houndstongue, teasel, mullein; on hillside north of main road, high priority</td>
</tr>
<tr>
<td>19</td>
<td>M</td>
<td>CADR</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Near trails and subdivision road, site is disturbed, occurs with white top, houndstongue, cheatgrass and mullein</td>
</tr>
<tr>
<td>20</td>
<td>M</td>
<td>CYOF</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Near trails and subdivision road, site is disturbed, occurs with white top, houndstongue, cheatgrass and mullein</td>
</tr>
<tr>
<td>21</td>
<td>L</td>
<td>BRTE</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Near trails and subdivision road, site is disturbed, occurs with white top, houndstongue, cheatgrass and mullein</td>
</tr>
<tr>
<td>22</td>
<td>L</td>
<td>VETH</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Near trails and subdivision road, site is disturbed, occurs with white top, houndstongue, cheatgrass and mullein</td>
</tr>
<tr>
<td>23</td>
<td>L</td>
<td>COMA2</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>Near trail and riparian corridor, with poison hemlock, musk thistle, mullein, houndstongue &amp; Canada thistle</td>
</tr>
<tr>
<td>24</td>
<td>L</td>
<td>CANU4</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>Near trail and riparian corridor, with poison hemlock, musk thistle, mullein, houndstongue and Canada thistle</td>
</tr>
<tr>
<td>25</td>
<td>L</td>
<td>VETH</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>Near trail and riparian corridor, with poison hemlock, musk thistle, mullein, houndstongue and Canada thistle</td>
</tr>
<tr>
<td>26</td>
<td>L</td>
<td>CYOF</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>Near trail and riparian corridor, with poison hemlock, musk thistle, mullein, houndstongue and Canada thistle</td>
</tr>
<tr>
<td>27</td>
<td>L</td>
<td>CIAR4</td>
<td>1 - 5</td>
<td>1 - 25</td>
<td>Near trail and riparian corridor, with poison hemlock, musk thistle, mullein, houndstongue and Canada thistle</td>
</tr>
<tr>
<td>28</td>
<td>H</td>
<td>EUMY2</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Small population near spring, high priority due to limited distribution</td>
</tr>
<tr>
<td>29</td>
<td>L</td>
<td>VETH</td>
<td>&lt; .1</td>
<td>1 - 25</td>
<td>Found in riparian area</td>
</tr>
<tr>
<td>30</td>
<td>M</td>
<td>VETH</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Mullein and Canada thistle growing in drainage ditch below substation</td>
</tr>
<tr>
<td>31</td>
<td>H</td>
<td>CIAR4</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Mullein and Canada thistle growing in drainage ditch below substation</td>
</tr>
<tr>
<td>Point</td>
<td>Priority</td>
<td>Species</td>
<td>Acres</td>
<td>% Cover</td>
<td>Comments</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>---------</td>
<td>-------</td>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>32 H</td>
<td>ELAN</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Russian olive, houndstongue and teasel occurring along train on near northeastern property boundary</td>
<td></td>
</tr>
<tr>
<td>33 H</td>
<td>CYOF</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Russian olive, houndstongue and teasel occurring along train on near northeastern property boundary</td>
<td></td>
</tr>
<tr>
<td>34 H</td>
<td>DIFU2</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Russian olive, houndstongue and teasel occurring along train on near northeastern property boundary</td>
<td></td>
</tr>
<tr>
<td>35 L</td>
<td>BRTE</td>
<td>.1 - 1</td>
<td>76 - 100</td>
<td>Cheatgrass, mullein, poison hemlock, houndstongue in riparian area along trail</td>
<td></td>
</tr>
<tr>
<td>36 L</td>
<td>VETH</td>
<td>.1 - 1</td>
<td>76 - 100</td>
<td>Cheatgrass, mullein, poison hemlock, houndstongue in riparian area along trail</td>
<td></td>
</tr>
<tr>
<td>37 L</td>
<td>COMA2</td>
<td>.1 - 1</td>
<td>76 - 100</td>
<td>Cheatgrass, mullein, poison hemlock, houndstongue in riparian area along trail</td>
<td></td>
</tr>
<tr>
<td>38 L</td>
<td>CYOF</td>
<td>.1 - 1</td>
<td>76 - 100</td>
<td>Cheatgrass, mullein, poison hemlock, houndstongue in riparian area along trail</td>
<td></td>
</tr>
<tr>
<td>39 H</td>
<td>CYOF</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Houndstongue and cheatgrass, trace quantity</td>
<td></td>
</tr>
<tr>
<td>40 H</td>
<td>BRTE</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Houndstongue and cheatgrass, trace quantity</td>
<td></td>
</tr>
<tr>
<td>41 M</td>
<td>BRTE</td>
<td>.1 - 1</td>
<td>51 - 75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42 H</td>
<td>LIDA</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Small population on top of hill near trail, some myrtle spurge and cheatgrass in area</td>
<td></td>
</tr>
<tr>
<td>43 H</td>
<td>AECY</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>On fire road with other weeds</td>
<td></td>
</tr>
<tr>
<td>44 H</td>
<td>EUMY2</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Occurs with myrtle spurge, goat grass and cheatgrass; near houses and trail</td>
<td></td>
</tr>
<tr>
<td>45 H</td>
<td>AECY</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Occurs with myrtle spurge, goat grass and cheatgrass; near houses and trail</td>
<td></td>
</tr>
<tr>
<td>46 H</td>
<td>BRTE</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Occurs with myrtle spurge, goat grass and cheatgrass; near houses and trail</td>
<td></td>
</tr>
<tr>
<td>47 H</td>
<td>LIDA</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48 H</td>
<td>CIAR4</td>
<td>.1 - 1</td>
<td>26 - 50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49 H</td>
<td>CYOF</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 M</td>
<td>CIAR4</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Canada thistle and houndstongue</td>
<td></td>
</tr>
<tr>
<td>51 M</td>
<td>CYOF</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Canada thistle and houndstongue</td>
<td></td>
</tr>
<tr>
<td>52 L</td>
<td>VETH</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Mullein, Canada thistle and cheatgrass occurring in gulley resulting from parking lot drainage</td>
<td></td>
</tr>
<tr>
<td>53 M</td>
<td>CIAR4</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Mullein, Canada thistle and cheatgrass occurring in gulley resulting from parking lot drainage</td>
<td></td>
</tr>
<tr>
<td>54 L</td>
<td>BRTE</td>
<td>&lt;.1</td>
<td>26 - 50</td>
<td>Mullein, Canada thistle and cheatgrass occurring in gulley resulting from parking lot drainage</td>
<td></td>
</tr>
<tr>
<td>55 H</td>
<td>CIAR4</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Canada thistle and curly dock occurring east of parking lot</td>
<td></td>
</tr>
<tr>
<td>56 H</td>
<td>CADR</td>
<td>&lt;.1</td>
<td>76 - 100</td>
<td>Occurring east of parking lot</td>
<td></td>
</tr>
<tr>
<td>57 M</td>
<td>LIDA</td>
<td>&gt; 5</td>
<td>1 - 25</td>
<td>On hill side south of NCAR, large disperse population</td>
<td></td>
</tr>
<tr>
<td>58 H</td>
<td>LIDA</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Small population south of NCAR</td>
<td></td>
</tr>
<tr>
<td>59 H</td>
<td>CADR</td>
<td>&lt;.1</td>
<td>76 - 100</td>
<td>White top, mullein and curly dock occurring on north side of NCAR</td>
<td></td>
</tr>
<tr>
<td>60 L</td>
<td>VETH</td>
<td>&lt;.1</td>
<td>76 - 100</td>
<td>White top, mullein and curly dock occurring on north side of NCAR</td>
<td></td>
</tr>
<tr>
<td>61 H</td>
<td>LIDA</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Small population near road, no other toadflax in found in area</td>
<td></td>
</tr>
<tr>
<td>62 L</td>
<td>CIAR4</td>
<td>&gt; 5</td>
<td>1 - 25</td>
<td>Occurring in wet meadow with Canada thistle, teasel and houndstongue</td>
<td></td>
</tr>
<tr>
<td>63 L</td>
<td>CYOF</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Occurring in wet meadow with Canada thistle, teasel and houndstongue</td>
<td></td>
</tr>
<tr>
<td>64 L</td>
<td>DIFU2</td>
<td>&gt; 5</td>
<td>1 - 25</td>
<td>Occurring in wet meadow with Canada thistle, teasel and houndstongue</td>
<td></td>
</tr>
<tr>
<td>Point</td>
<td>Priority</td>
<td>Species</td>
<td>Acres</td>
<td>% Cover</td>
<td>Comments</td>
</tr>
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<td>-------</td>
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<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>65</td>
<td>H</td>
<td>CIAR4</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Small population of Canada thistle, houndstongue and mullein; top priority due to small size and accessibility</td>
</tr>
<tr>
<td>66</td>
<td>H</td>
<td>CYOF</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Small population of Canada thistle, houndstongue and mullein; top priority due to small size and accessibility</td>
</tr>
<tr>
<td>67</td>
<td>L</td>
<td>VETH</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Small population of Canada thistle, houndstongue and mullein; top priority due to small size and accessibility</td>
</tr>
<tr>
<td>68</td>
<td>H</td>
<td>CIAR4</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Canada thistle &amp; houndstongue occurring in uninfested area, good access, search both sides of the fire road</td>
</tr>
<tr>
<td>69</td>
<td>H</td>
<td>CYOF</td>
<td>.1 - 1</td>
<td>1 - 25</td>
<td>Canada thistle &amp; houndstongue occurring in uninfested area, good access, search both sides of the fire road</td>
</tr>
<tr>
<td>70</td>
<td>L</td>
<td>HYPE</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Small population heavily infested with beetles, recommend using biocontrol on all HYPE populations</td>
</tr>
<tr>
<td>71</td>
<td>L</td>
<td>BRTE</td>
<td>.1 - 1</td>
<td>26 - 50</td>
<td>Low priority population occurring with S. Johnswort</td>
</tr>
<tr>
<td>72</td>
<td>H</td>
<td>CADA</td>
<td>&lt;.1</td>
<td>26 - 50</td>
<td>Small population along fire road to water tank, no other white top found in area</td>
</tr>
<tr>
<td>73</td>
<td>H</td>
<td>COAR4</td>
<td>&lt;.1</td>
<td>26 - 50</td>
<td>Field bindweed found along parking lot in small patches, survey remaining perimeter of parking lot</td>
</tr>
<tr>
<td>74</td>
<td>H</td>
<td>AECY</td>
<td>.1 - 1</td>
<td>51 - 75</td>
<td>Jointed Goatgrass along recreation trail extending west.</td>
</tr>
<tr>
<td>75</td>
<td>H</td>
<td>AECY</td>
<td>.1 - 1</td>
<td>51 - 75</td>
<td>Jointed Goatgrass along recreation trail extending east. Survey and treat remainder of trail.</td>
</tr>
<tr>
<td>76</td>
<td>L</td>
<td>AECY</td>
<td>.1 - 1</td>
<td>51 - 75</td>
<td>Jointed Goatgrass occurs with numerous weeds in Skunk Creek riparian zone.</td>
</tr>
<tr>
<td>65</td>
<td>H</td>
<td>CIAR4</td>
<td>&lt;.1</td>
<td>1 - 25</td>
<td>Small population of Canada thistle, houndstongue and mullein; top priority due to small size and accessibility</td>
</tr>
</tbody>
</table>

**Note:** 1) The point number corresponds to the Noxious Weed Map population number. 2) Priority: H = High, M = Medium, L = Low 3) Species “NRCS” code are identified on the Noxious Weed Map 4) Acres and percent cover are based on ocular estimations.
Table 7. North American invasive plant mapping supplemental information.

<table>
<thead>
<tr>
<th>NORTH AMERICAN INVASIVE PLANT MAPPING SUPPLEMENTAL INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>State: Colorado</td>
</tr>
<tr>
<td>County: Boulder</td>
</tr>
<tr>
<td>Site: NCAR, Table Mesa</td>
</tr>
<tr>
<td>Examiner: Matt Tobler, Steve Johnson, Amy Randell</td>
</tr>
<tr>
<td>Collection Date: 5/04/2005 to 6/3/2005</td>
</tr>
<tr>
<td>Source of Data: Field, ocular estimations of % cover and area</td>
</tr>
<tr>
<td>UTM Datum: WGS 84, Zone 13s</td>
</tr>
<tr>
<td>Nomenclature: Webber, 2002 and PLANTS National Database</td>
</tr>
</tbody>
</table>
Rangeland Prescriptions 334 Acres

DESCRIPTION:
Rangelands are treeless (or sparsely forested) communities that support herbaceous and woody vegetation including grasses, forbs, sedges, succulents and shrubs. Rangelands are broadly distributed throughout NCAR and frequently intermingle with forested areas. In some areas rangelands support sparse populations (0 – 10% canopy closure) of ponderosa pine or Rocky Mountain juniper trees.

PRESCRIPTION:

1) Remove most small diameter conifer encroachment to reduce the risk of catastrophic wildfire and to preserve the landscape mosaic of forested areas and rangelands.

2) Limb the residual trees to a height of 6 to 12 feet.

3) Remove all Russian olive and Siberian elm trees.

4) Follow prescriptions for forested areas and sparsely forested areas when encountered (Appendix I).

6) Follow noxious weed management prescriptions for weed populations when encountered.

7) Use prescribed burns to reintroduce a keystone ecological process which will limit forest ingrowth, reduce fuels and stimulate herbaceous growth. Implement prescribed burns where possible to rejuvenate rangelands. The prescribed burn interval will vary between 1 to 3 years for the first 2 cycles and then could be backed off to 3 to 5 years. Special care must be taken to evaluate the vegetative composition of rangelands prior to any prescribed burn activity because fire can have a stimulating effect on many noxious weed species if it is implemented at the wrong time of year. The decision to utilize prescribed fire must be made on a case-by-case basis. (A specific burn plan must be done by qualified individuals before implementing any prescribed burns.)

8) Establish a community of native plants in disturbed sites to prevent the proliferation of noxious species.

9) Conduct a survey for warm season plants in July, August or September to identify and locate species that were not apparent during the spring inventory.

10) Organize two “Clip and Pull” weed management days each year utilizing volunteer labor. Contact the Anchor Point Group to discuss what species and populations should be targeted at the time year the field day is conducted.

11) Create a spatially explicit monitoring program to evaluate treatment efficacy.

12) Update this weed inventory every three years.
Canada Thistle
B List

*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 NCAR due to the occurrence of healthy natural plant communities.

**Biological control:** The weevil *Ceutorhynccus 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 their 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 are also recommended.
Cheatgrass

A List

*Bromus tectorum* is an exotic winter annual grass that is one of the most widely distributed weeds in the western U.S. Cheatgrass has been shown to significantly alter the fire regime of ecosystems (D'Antonio and Vitousek 1992). It germinates in the fall or early spring and sets seed in May and June. Cheatgrass flourishes in moderately and highly disturbed upland sites such as roadways, overgrazed areas, revegetated areas, and waste sites; it gains a competitive edge over native species by initiating early spring growth, and by aggressive utilization of deep soil resources. Seeds are dispersed by animals and recreationists who unknowingly have the seeds stuck in their fur, socks, boots, muddy tires, etc. Because seeds remain viable for up to five years, control measures that reduce seed set can reduce the spread of this plant. (Photo from Whitson et al. 1996)

**Cultural control:** Due to the broad distribution of this plant, tilling and seeding operations would be impractical and costly. However, in areas where historic revegetation efforts have not produced a healthy stand of perennial grass cover, interseeding these areas with native perennial grasses, following cheatgrass control, can be effective. Fire has also been known to effectively control cheatgrass when prescribed in the early spring before seed set. Burning for 5 years will be required and therefore may not be practical. Since burning during other times of the year can increase the abundance of cheatgrass, every effort should be made to coordinate prescribed fire with the life stage of this weed.

**Biological control:** Grazing is a possible control strategy. Cattle find cheatgrass highly palatable in early spring before seed set occurs. Where infestations are large and dense, prescribed spring grazing repeated for 3 to 5 years by cattle and sheep can be effective, and indeed may be the only option in some areas where it is difficult or impractical to implement other prescriptions.

**Mechanical control:** Given the life history patterns of cheatgrass, mechanical control efforts are not recommend unless they are followed by an aggressive revegetation and chemical control program. When mowing is used, it should be done in early spring before seed heads are fully developed (early to mid- May) and repeated for at least 5 years.

**Chemical control:** Given the ubiquitous occurrence of this weed in NCAR, and the topographical challenges where it occurs, herbicide treatment may be impractical. Fall application of Plateau 1.5 ounces/acre has been effective in some experimental plots. Application must be made in fall, before plants become too mature to be affected (Smith 2003).

**Integrated Management Recommendations:** Cheatgrass should be a high management priority because it is extremely difficult and costly to control and it has a limited distribution within this landscape. Populations should be monitored to determine their rate of spread and invasion into new areas. Additional consultation is recommended to develop an effective control program.
**Common Mullein**

A List

*Verbascum thapsus* also known as flannel leaf, fleawort or Jacob's staff, is a biennial forb that can easily be identified by its yellow flowers grouped in a "corn cob" shaped flowering raceme. The leaves are light green and densely wooly. Mature plants have a single, erect stem that can grow 6 to 8 feet in height. Seeds germinate in the early spring, forming a rosette that continues to grow into late autumn and over winter; a tall stem topped with the flowering raceme is produced the following spring.

Common mullein can be hard to control due its prolific seed production. The seeds can germinate after lying dormant for several decades. If seeds are not present when an area is disturbed or a field is abandoned, the limited dispersal ability of the seeds will probably not enable mullein seeds to arrive and establish while bareground is still available. Mullein is easily outcompeted in areas with a densely vegetated ground cover but readily grows in disturbed sites. Mullein prefers dry, gravelly to sandy, coarse-textured soils, and is commonly found throughout Colorado in pastures, meadows, fencerows, waste areas, and along river bottoms. It was probably introduced to America from Eurasia as a medicinal herb used to remedy coughs and stomach ailments (CNAP 2000).

**Cultural control:** Minimize disturbance and seed dispersal, eliminate seed production and maintain healthy native communities. Mullin is often an early invader of burned areas.

**Biological control:** Weevils (*Gymnetron tetrum*) that feed on the seeds have been found effective in reducing seed production (Denver County Cooperative Extension. (n.d.) *Gardening and Horticulture: Weeds*. Retrieved August 12, 2004 from http://www.colostate.edu/Depts/CoopExt/4DMG/Weed/mullein.htm)

**Mechanical control:** Mullein plants have shallow tap roots and are easily hand-pulled. They should be pulled as soon as they are large enough to grasp but before they produce seeds. Mullein stems can be cut or mowed to prevent flower and seed production, but stems must be cut below the root crown or rosettes will re-bolt (CNAP 2000).

**Chemical control:** Herbicide application is most effective during the rosette stage. Due to the wooly nature of the leaves, herbicides should be mixed with a surfactant to facilitate uptake. Effective herbicides include metsulfuron at 0.6 oz. ai/acre, tebuthiuron at 4-6 lb. ai/acre (CNAP 2000).

**Integrated Management Recommendations:** Remove seed heads by hand and dispose of off site, apply herbicides where possible.
Dalmatian Toadflax

A List

*Linaria dalmatica* is an exotic perennial forb that easily invades natural ecosystems, thereby displacing native vegetation. Dalmatian toadflax begins flowering in May and June and given sufficient moisture, can continue flowering into the fall (Beck 2001). By initiating early top growth from underground roots (which can reach a depth of 6 feet or more), it effectively competes with native plants for light, soil moisture and other nutrients. It spreads efficiently from seed as well as from root buds that can travel underground up to 10 feet. In wet years, these plants reproduce abundantly from seed. However, since seedling root development is slow, this represents a life stage vulnerable to control (Beck 2001). (Photo from Whitson et al. 1996)

Cultural control: There are no proven cultural controls effective against this weed in Colorado.

Biological control: Several biocontrol agents have been used to control toadflax but the success of these agents has not been sufficiently documented (Beck 2001). A defoliating moth (*Calophasia lunula*), an ovary-feeding beetle (*Brachypterolus pulicarius*), and two seed capsule-feeding weevils (*Gymnaetron antirrhini* and *G. netum*) have been used in the U.S. and Canada. Population density of this plant may not be adequate to support biological control agents. If biological control is desired, many of these agents can be obtained from the Colorado Department of Agriculture Insectary in Palisade.

Mechanical control: Hand pulling has been an effective control measure, but requires five to six years of successive treatment to deplete root reserves (Lajeunesse et al. 2000). Hand pulling should be done at the bud development stage in early summer.

Chemical control: Tordon 22K at 2 pints/acre sprayed at the time of flowering or in the fall has proven successful in Colorado (Beck 2001).

Integrated Management Recommendation: Because this plant has limited distribution within this landscape it should be treated aggressively where it occurs. Hand pulling and monitoring of populations is recommended.
Field Bindweed

_B List_

*Convolvulus arvensis*, also known as morning glory or creeping jenny, is a perennial forb identifiable by its leaves, which are the shape of arrowheads, and its white to pink funnel-shaped flowers. The scientific name *convolvulus* comes from the same root word as convulsion and refers to the manner in which the plant climbs by writhing and wrapping itself around any plant or object nearby. Flowers appear from June to September, and seeds mature within 2 weeks after pollination during hot summer days. Germination can occur in the fall or spring, over a wide range of temperatures.

Field bindweed can be a serious threat to native plant communities because of its high capacity for regeneration. Its seeds can easily live for 50 years in the soil, and its tremendous root system and rhizomes have the potential to produce large numbers of new shoots. Finally, its broad range of environmental tolerances make it highly competitive in most areas. However, field bindweed cannot tolerate shade, and it is unlikely that it would persist in later stages of community succession (CNAP 2000). (Photo from Whitson et al. 1996)

**Cultural control:** Maintain a healthy cover of perennial plants to discourage field bindweed establishment.

**Biological control:** No insects are available that effectively control this weed. Livestock will graze bindweed as a nutritious feed; however, horses can develop intestinal problems when eating primarily bindweed. Overall, because of its low growth habit, bindweed tends not to be grazed intensely enough to cause the necessary plant stress. (Adams County Weed & Pest. (n.d.) Management of Field Bindweed. Retrieved August 12, 2004, from http://www.colostate.edu/Depts/CoopExt/Adams/weed/bindweed_mgt.html)

**Mechanical control:** Plants should be cut below the surface in the early seedling stage. Mechanical control of field bindweed is difficult because of its low growth habit. Mowing generally has little or no effect (CNAP 2000). Hoeing or grubbing are more effective.

**Chemical control:** Foliar applications of glyphosate at 1.5 lb. ai/acre or picloram at 0.25-0.5 lb. ai/acre, dicamba or 2,4-D at 1 lb. ai/acre can provide good control. Herbicides are best most effective when applied during early flowering and when soil moisture is low. Repeated applications are advised for long-term control. High rates of application can result in substantial damage to desirable plants (CNAP 2000).

**Integrated Management Recommendations:** Utilize chemical control.
Houndstongue

A List

*Cynoglossum officinale* is a biennial that grows 1 to 4 feet tall and reproduces solely by seed. Leaves are alternate 1 to 12 inches long 1 to 3 inches wide, rough, hairy and smooth. The fruit is composed of 4 prickly nutlets each about 1/3 inch long (Whitson et al. 1996). Houndstongue forms a rosette the first year and a flowerstalk the second year. This plant is an early successional species typically found in pastures, along roadsides and in disturbed areas. The seeds break apart at maturity and cling to clothing or animals. Houndstongue was introduced from Europe as a contaminant in agricultural seed; it is toxic to livestock (Whitson et al. 1996).

**Cultural control:** Minimize disturbance and maintain healthy native communities. Houndstongue requires areas with more than 10% bare ground for establishment.

**Biological control:** None

**Mechanical control:** Mowing second year plants during flowering but before seed maturation reduces seed production and may kill the plant (CNAP 2000).

**Chemical control:** Picloram at 0.25 to 0.5 lb, 2,4-D, or dicamba at 1.0 lb., or metsulfuron at 0.6 oz. ai/acre applied in the spring provides control of houndstongue. Spring treatments with picloram, dicamba or metsulfuron are more effective than fall treatments. Chlorsulfuron applied 0.5 ai/ac gives complete control when applied any time beginning with the rosette stage until the bolted plant has attained 10 inches in height (CNAP 2000).

**Integrated Management Recommendation:** Maintain a community of native perennials, treat first year plants with herbicides and mow bolted plants before seed set where possible.
Jointed Goatgrass

B List

*Aegilops cylindrica* in a winter annual grass that is 15 to 30 inches tall at maturity with one or several erect stems or tillers. Leaves are alternate, simple, with auricles at the base and leaf blade 1/8 to 1/4 inch wide with hairs. The spike is cylindrical and contains 2 to 12 spikelets that fit the contour of the rachis. Glumes are several-ribbed with a keel on one side extending into a single awn or beard. Jointed goatgrass is found mostly in winter wheat growing areas but is also survives along roadsides, in waste areas, fields and pastures. Flowering and seed production occur from May to July (Whitson et al. 1996). Jointed goatgrass has a short fibrous root system and reproduces solely by seed (CNAP 2000). Jointed goatgrass is a significant problem in winter wheat fields where it exists as a seed contaminant. Both plants are genetically similar making control difficult in agricultural areas. (Photo from Whitson et al. 1996)

**Cultural control:** Prevent the establishment of new populations by depleting soil seed bank in agricultural areas. Winter or spring burning is an effective way to kill seeds on the surface of the soil (CNAP 2000).

**Biological control:** None

**Mechanical control:** Mowing can be effective when conducted after goatgrass flowers and before seeds mature (CNAP 2000).

**Chemical control:** Glyphosate at 1.5 lb. ai/acre will control goatgrass (CNAP 2000).

**Integrated Management Recommendation:** Prevent the establishment of new populations by depleting the soil seed bank. Use mechanical and chemical methods on small infestations.
Knapweed

B List

*Acosta diffusa* (*Centaurea diffusa*) is an exotic biennial (sometimes annual or short-lived perennial) forb that often invades both disturbed and relatively undisturbed upland sites. Knapweed reproduces from seeds that germinate in the spring or fall. It survives in a rosette stage for its first year and bolts in the second year setting seed in June and July (Beck 1997). Mature plants often break off at ground level; they can be dispersed to new sites by blowing in the wind, or by transport on the undercarriage of vehicles. (Photo from Whitson et al. 1996)

**Cultural control:** Timely tilling is one effective means of controlling this weed where populations are very dense, and occur in an agricultural setting. However, tilling is not recommended where this weed occurs in native ecosystems, due to the high level of soil disturbance caused by tilling. Tilling may also propagate other weeds.

**Biological control:** The seed head flies *Urophora affinis* and *Urophora quadrificasciata* have been released in Colorado to cause plants to produce fewer viable seeds and abort terminal or lateral flowers (Beck 1997). Larvae of the diffuse knapweed root beetle (*Sphenoptera jugoslavica*) and yellow winged knapweed moth feed in the roots of this weed. Sheep, goats and cattle will also consume knapweed. This strategy is most effective if used before seed set in early spring (May).

**Mechanical control:** Hand pulling or mowing before seed set has proven to be an effective control strategy within Boulder County. We suggest hand pulling where small infestations occur. Mowing or hand pulling should be conducted when the plants are in the bud growth stage (early summer, mid to late June) to decrease seed set. Plants should be mowed as close to the ground as possible. Mechanical treatments need to be followed by revegetation in areas that lack native cover. Seed heads should be clipped well below the apex, bagged, and disposed of in sealed dumpsters.

**Chemical control:** Research indicates that dicamba (Banvel) at 0.5 to 1.0 lb active ingredient per acre (a.i./Ac) and picloram (Tordon) at 0.25 to 0.5 lb a.i./Ac control knapweed (Beck 1997). However, where occurrence is due to lack of perennial grass cover in revegetated areas, control methods must be followed by restoration efforts in order to prevent future reinfestations.

**Integrated Management Recommendations:** Utilize mechanical and chemical control methods.
Leafy Spurge
B List

*Euphorbia esula* is an aggressive, long-lived perennial weed that displaces native plants in many habitats (Biesboer 1998). Leafy spurge produces a large number of seeds and has extensive lateral root systems with which it can reproduce vegetatively. These two reproductive strategies allow this plant to rapidly form monocultures. Large nutrient reserves in root systems allow this plant to re-establish in treated areas; it also produces an allelopathic compound that inhibits growth of other plants (Butterfield et al. 1996). Spurge can grow in a wide variety of habitats, but is best adapted to semi-arid settings. It typically occurs in untilled rangelands and is most abundant on coarse textured soils. Leafy spurge emerges early in the spring (mid April to late May), flowering ends in June to mid July. (Photo from Whitson et al. 1996)

**Cultural control:** Long-term control requires the establishment of competing vegetation. Seed mixtures should contain plants with early, mid and late growth as well as shallow, intermediate and deep roots.

**Biological control:** The Division of Plant Industry’s Biological Pest Control Section has released eight species to control leafy spurge. The most effective biological control agents are six species of root and foliage feeding beetles in the genus *Aphthona*, and a stem and root boring beetle *Obera erythrocephala* (Lajeunese et al. 1999).

**Mechanical control:** Tillage is not practical in many areas, mowing can increase plant density and may not be effective when combined with herbicide. Hand pulling is ineffective due to extensive root systems. Burning is moderately effective when it is combined with herbicide application after five weeks.

**Chemical control:** Herbicide applications can be successful but successive treatments are required due to the extensive root systems of this plant. A combination of picloram and 2,4-D (1-1.5 pints of picloram with 1-1.5 quarts of 2,4-D) has shown to provide best control when applied in the spring when flowers emerge (Beck 1996). Picloram at 1 quart/acre for two to three consecutive years is also effective, but costly. An annual combination of dicamba plus 2,4-D (4-8 ounces with 0.5 to 1 quart per acre) also provided good control (Beck 1996). Glycoghosate is most effective when applied sequentially at 1 quart/acre at one month intervals, coupled with fall grass seeding (Beck 1996).

**Integrated Management Recommendation:** Leafy spurge is extremely difficult to control by chemical means and almost impossible to control with cultural or mechanical means. Therefore a management scheme that combines control methods over four to five years is recommended (Beck 1996).
Musk Thistle

B List

*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)

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

**Biological control:** The musk thistle seed head weevil, *Rhinocyllus conicus*, has been used throughout Colorado to combat this weed (Beck 2000). 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.

**Mechanical control:** 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 2000). Mechanical control should be combined with biological methods.

**Chemical control:** Effective chemical control has been achieved in the past using Tordon at 0.5 to 1 pint/acre, Curtail at 2 quarts/acre, Banvel at 0.5 to 2 quarts/acre, Telar at 1 ounce/acre, and Ally-Escort at 0.5 ounces/acre (Beck 2000).

**Integrated Management Recommendations:** Utilize mechanical and chemical control means; biocontrol agents may be suitable for large or inaccessible infestations.
Myrtle Spurge

C List

*Euphorbia myrsinites* is a perennial forb which can grow to 4 to 6 inches in height and spread up to 18 inches. Myrtle spurge has yellow green flower like bracts that appear in the early spring and trailing stems of fleshy blue-green alternate leaves. This plant contains a milky white latex in its stems that can irritate the skin; it reproduces solely by seed. Livestock and wildlife generally avoid myrtle spurge and large infestations diminish rangeland value. Myrtle spurge is not a particularly aggressive invader and is not typically found in agricultural areas because it does not tolerate frequent cultivation. This plant prefers dry to moist, well drained soils and will tolerate partial shade to full sunlight. Myrtle spurge is native to Eurasia and is common throughout Colorado particularly near residential areas where it has escaped cultivation as an ornamental species. Because this species is not yet widespread in Colorado, it should be a priority for immediate eradication where found (CNAP 2000).

**Cultural control:** Prevent the establishment of new populations by minimizing disturbance and maintaining a healthy community of native perennials (CNAP 2000).

**Biological control:** None

**Mechanical control:** Small populations can be dug or hand pulled depending on the size of the infestation (CNAP 2000).

**Chemical control:** Several chemicals can be used to control myrtle spurge including 2,4-D at 1 lb. ai/acre glycophosphate at 1.5 lb. ai/acre. Picloram at 0.5 ai/acre can also be used; apply herbicides with a wick to avoid damaging native plants. Apply herbicides during the seedling stage for best results (CNAP 2000).

**Integrated Management Recommendation:** Myrtle spurge can be controlled by eliminating seed sources and a combination of mechanical and cultural practices. Hand pulling may be cost effective for small populations.
Poison Hemlock

A List

*Conium maculatum* is a biennial forb that grows 4 to 10 feet tall. Stems are erect, extensively branched and covered in purple spots (CNAP 2000). Leaves are shiny, green, finely pinnately divided 3 or 4 times; leaflets are segmented and 1/8 to 1/4 inch long. Lower leaves clasp the stem, upper leaves have shorter stalks. The foliage has a strong musty order and white flowers are borne in many umbrella shaped clusters, each supported by an individual stalk. Seeds are paired, 1/8 inch long, light brown, ribbed and concave (Whitson et al. 1996). Seed dispersal occurs for an extended period of time beginning in July and continuing into winter; poison hemlock reproduces only by seed (CNAP 2000). Plants typically bolt in the second year. Poison hemlock typically grows near streams or ditch banks; it is also found near pastures and cropland. All parts of the plant are poisonous (Whitson et al. 1996).

**Cultural control:** Prevent the establishment of new populations by eliminating seed production and maintaining a healthy community of native perennials (CNAP 2000).

**Biological control:** The European palearctic moth (*Agonopterix alstroemeriana*) was introduced to the United States and feeds on poison hemlock. It is found in Colorado and is a biocontrol agent in Idaho, Oregon and Washington (CNAP 2000).

**Mechanical control:** Poison hemlock can be controlled by digging, repeated mowing, pulling or by spring/winter burns (CNAP 2000).

**Chemical control:** Tebuthuron can provide excellent pre-emergent control of this species. Chlorsulfuron and metsulfuron provide pre-emergent and foliar control (CNAP 2000). Picloram, dicamba 2,4-D at 1 lb. ai/acre, or glyphosate at 1.5 ai/acre can be used to provide control of this species. Apply foliar herbicides during the rosette stage with a wick to minimize damage to native communities, cut any stems that grow after treatment. Repeat treatment for several years until the seed bank is completed (CNAP 2000).

**Integrated Management Recommendation:** Restrict herbicide use in riparian areas. Remove seed heads and dispose to exhaust seed bank; use gloves when dealing with this plant (CNAP 2000).
Russian Olive

A List

*Elaeagnus angustifolia* is a fast growing tree, normally reaching heights of 10 to 25 feet. Trunks and branches are armed with 1 to 2 inch woody thorns. Leaves are narrow, 2 to 3 inches long and covered with minute scales which give the foliage a distinctive silvery appearance. Scales are usually more abundant on the underside of the leaf. Flowers are yellow and arranged in clusters. Fruits are shaped like small olives, are silvery when immature or brown at maturity. Russian olive was imported from Europe and is common as a landscape plant (Whitson et al. 1996). Once Russian olive is allowed to become established in unwanted areas, it is difficult to control and almost impossible to eradicate because of its habit of forming root shoots and suckers. Efforts at control have included mowing of seedlings and sprouts, cutting or girdling of stems, burning and herbicide application (IEPC 2004). (Photo from Whitson et al. 1996)

**Cultural control:** Prevent the establishment of escaped ornamentals.

**Biological control:** None

**Mechanical control:** Cut to the ground and remove, remove shoots and sprouts.

**Chemical control:** Apply 2, 4-D or 2, 4, 5-T to the stump within 1 minute of tree cutting (FEIS).

**Integrated Management Recommendation:** Cut existing trees and prevent future establishment.
Scotch Thistle
A List

*Onopordum acanthium* is a biennial forb that can grow up to 12 feet tall (CNAP 2000). Stems have broad, spiny wings; leaves are large, spiny and covered with fine dense hair creating a greyish appearance. Upper leaves are alternate, coarsely lobed and irregular; basal leaves may be up to 2 feet long and 1 foot wide. Flower heads are numerous, 1 to 2 inches in diameter, bracts are spine-tipped. Flowers are violet to reddish; fruits are approximately 3/16 inches long and tipped with slender bristles (Whitson et al. 1996). Flowering occurs from mid-June to September. Scotch thistle is commonly found along roadsides, irrigation ditches, waste areas and on rangelands. The seeds contain a water soluble inhibitor so this species is especially successful in moist areas that are adjacent riparian areas or bottomlands. Scotch thistle reproduces by seeds which are dispersed by clinging to animal fur or clothing. Scotch thistle is an aggressive plant that can form dense stands that are impenetrable (CNAP 2000). (Photo from Whitson et al. 1996)

**Cultural control:** No information available

**Biological control:** None

**Mechanical control:** Mowing or hand cutting are effective when used in conjunction with other methods. Sever tap root 1 to 2 inches below the ground surface and remove the plant from the site for disposal (CNAP 2000). Cut and remove seed heads from site.

**Chemical control:** Picloram at 0.25 lb, dicamba at 0.5 lb., or 2,4D at 1 lb. ai/acre or a combination in spring before Scotch thistle bolts or in the fall to rosettes. Herbicide rates vary depending upon stand density and environmental conditions (CNAP 2000).

**Integrated Management Recommendation:** Scotch thistle is best controlled in the rosette stage; it can also be controlled by severing its tap root 1 to 2 inches below the surface of the ground. Control efficacy is enhanced with follow-up applications of herbicides to surviving rosette (CNAP 2000).
St. Johnswort

A List

*Hypericum perforatum* is a perennial forb that grows to 1 to 3 feet with numerous erect branches that are rust colored and woody at their base. Leaves are opposite, sessile, entire, elliptic to oblong, less than 1 inch long and covered with transparent dots. Flowers are 3/4 inch in diameter, bright yellow numerous in flat-topped cymes, with 5 separate petals. St. Johnswort is often found on sandy or gravely soils. It is commonly found on rangelands, pastures, along roadsides and in waste areas. It is an aggressive invader of disturbed lands. St. Johnswort reproduces by seed and from rizomes which spread laterally to form new buds. This plant contains a toxic substance which affects white-haired animals (Whitson et al. 1996). Originally from Europe, St. Johnswort is widely used as a medicinal herb to treat depression (CNAP 2000). (Photo from Whitson et al. 1996)

Cultural control: Maintain a closed canopy of native perennials (CNAP 2000).

Biological control: There are several biocontrol agents that can be used to suppress this weed. Two beetles (*Chrysolina hyperici* and *Chrysolina quadrigemina*) have been released and are established in California, Oregon and other western states. The control of St. Johnswort with beetles is perhaps the most successful example for biocontrol in the United States (CNAP 2000).

Mechanical control: Readily controlled by tillage in agricultural areas (CNAP 2000).

Chemical control: St. Johnswort is commonly controlled with combinations of 2,4-D and picloram or 2,4-D and glyphosate (CNAP 2000).

Integrated Management Recommendation: St. Johnswort is not yet common in Colorado and therefore should be a high management priority. Maintain healthy stands of native perennials and control with herbicides. Two stands of St. Johnswort at NCAR were heavily infested with defoliating beetles indicating that biocontrol is a strong consideration for controlling this plant.
Sulfur Cinquefoil

Potentilla recta is a long lived perennial forb that grows to 1 to 1.5 feet tall with well developed roots. Leaves are palmately compound with 5 to 7 toothed leaflets on each leaf. Leaves are sparsely hairy and appear green on the underside rather than silvery as do many other Potentilla species. Flowers are light yellow with 5 petals, each flower producing numerous single seeded achenes; flowering occurs from May to July. Sulfur cinquefoil is frequently found in disturbed areas such as roadsides and pastures (Whitson et al. 1996). It is a competitive early successional species that exists until woody cover is present. Sulfur cinquefoil reproduces by seed and vegetatively (CNAP 2000). (Photo from Whitson et al. 1996)

Cultural control: Frequent plowing is effective in agricultural areas (CNAP 2000).

Biological control: Acceptable biocontrol agents are difficult to find as damaging insects also consume strawberries (Fragaria species) which are similar to sulfur cinquefoil. Cattle, horses and sheep will not eat this plant but goats will (CNAP 2000).

Mechanical control: Small populations can be controlled by hand digging; sulfur cinquefoil cannot be controlled by mowing because this type of disturbance causes the plant to develop bulky spreading roots (CNAP 2000).

Chemical control: Picloram is the most consistently effective and cheapest herbicide for the rosette stage through fall. Picloram (0.25 acid equivalent/ac) applied in the fall or spring up to the late bud stage will provide control. A combination of 2,4-D and picloram can also be used (CNAP 2000).

Integrated Management Recommendation: Sulfur cinquefoil is a competitive weed that can out-compete other noxious species. Because this species is not yet widespread in Colorado, it should be a high management priority. Small infestations can be hand pulled; larger populations will require suppression with herbicides (CNAP 2000).
Teasel
A List

*Dipsacus fullonum* is a stout, taprooted biennial which can grow to 6 feet in height. Stems are striate-angled with several rows of downward facing thorns. Leaves are conspicuously veined with small thorns on the lower midrib. The basal rosette typically dies early in the second season. Stem leaves are lanceolate up to 10 inches long, opposite leaves have fused bases which trap rainwater. Purple flowers are borne in dense heads, each flower subtended by spine like bracts. Fruits are 4-angled with a single seed (Whitson et al. 1996). Teasel flowers from July to August and reproduces only by seed. Teasel can be an aggressive competitor in disturbed sites; massive seed production and high germination rates enable this plant to invade an area and outcompete other plants. Teasel grows in open sunny areas that range from wet to dry and is frequently found along irrigation ditches, abandoned fields, pastures, waste areas and forests (CNAP 2000). (Photo from Whitson et al. 1996)

**Cultural control:** Prevent the establishment of new populations by minimizing disturbance and seed dispersal and by maintaining a healthy community of native perennials (CNAP 2000).

**Biological control:** None

**Mechanical control:** Small populations can be dug or hand pulled depending on the size of the infestation (CNAP 2000).

**Chemical control:** Metsulfuron at 0.3 oz. ai/acre or dicamba at a rate of 0.25-0.5 lb. ai/acre can be applied to teasel rosettes. For larger rosettes increase to 0.5 to 1.0 lb. ai/acre or 1.0 to 1.5 lb. ai/acre when plants are bolting (CNAP 2000). Redeem or 2,4-D also provide effective control.

**Integrated Management Recommendation:** Teasel can be controlled by eliminating seed production and exhausting the seed bank. Cut stems of flowering plants, bag and remove seed heads from site for disposal.
White Top

B List

Cardaria draba is an exotic perennial forb which, in the absence of competition, can spread over an area of 12 feet in diameter in a single year (CNAP 2000). Clusters of white flowers spread across large patches in mid spring making this plant easy to identify. This plant is unpalatable to cattle and may also be unpalatable to wildlife. This weed spreads mainly by its highly persistent roots. It crowds out native vegetation and becomes a monoculture in open, disturbed ground (CNAP 2000). This weed can also spread by seeds that can remain viable for up to three years in the soil. Effective control is achieved by exhausting the root reserves and establishing competing perennial vegetation. (Photo from Whitson et al. 1996)

Cultural control: Cultivation can control white top when tillage begins at the flower bud stage and is repeated every ten days throughout the growing season (CNAP 2000). Tilling may promote the establishment of other weeds. Fire may favor rapid growth of white top from its rhizomes and seed germination (FEIS 1996). Fire may hasten the spread of white top if conducted in a time of year that eliminates competing vegetation. However, fire can be an effective tool if implemented at the correct time of year.

Biological control: There is little research to support the use of biological agents to control white top. Sheep grazing may be successful, but must be managed appropriately to avoid grazing of desirable vegetation.

Mechanical control: Mowing for three consecutive years may help to reduce the spread of white top, but this practice is used mostly in conjunction with herbicide use for effective control.

Chemical control: White top is most commonly controlled by herbicides (CNAP 2000), with the most effective control achieved when spraying is done prior to flowering in May. Multiple applications are often needed for lasting control and should be followed up by an effective revegetation program to lessen the threat of reinvasion. Metsulfuron and chlorsulfuron are the most effective herbicides. If using these herbicides, it is important to use a non-ionic surfactant. Glyphosate at 1.5 lb. a.i./A applied during the flower stage will provide good control of white top. Picloram does not control white top (CNAP 2000).

Integrated Management Recommendation: Given the aggressive nature of this weed and its current limited distribution, white top should be a high management priority at NCAR. Unfortunately, this is a very difficult weed to control with mechanical, cultural, or biological methods. We therefore recommend that this weed be controlled with glyphosate at 1.5 lb. a.i./acre applied prior to the flower stage (mid May) following spring mowing. Treatment should be done for a minimum of three years. An effective revegetation program to establish competing perennial vegetation should follow control efforts.
Additional Weed Management Resources

**BIOCONTROL AGENTS**  
Many biological control agents can be obtained from the Colorado Department of Agriculture Insectary in Palisade.

**LOCAL GOVERNMENT AGENCIES**  
Boulder County Weed Supervisor: Cindy Owsley. County Fairgrounds, 9595 Nelson Road, Longmont, CO 80501  
Phone: 303-441-3131 x 6110. cxopa@co.boulder.co.us

Colorado Weed Management Association (CWMA). PO Box 1910, Grandby, CO 80446-1910, Phone: 970-887-1228, e-mail: CWMA@rkmtnhi.com. Website: www.fortnet.org/CWMA

**WEED MANAGEMENT**  
Colorado State University Weed Management Site:  
www.colostate.edu/Depts/IPM/nipm/agwee.html.

Control of Invasive Exotic Plants in the Great Plains:  
http://www.npsc.nbs.gov/resource/literatr/exotic/exotic.htm

Colorado’s 10 most wanted weeds:  
http://www.ag.state.co.us/commish/press/1999/weedweek.html

Agricultural Resource Service Exotic and Invasive Weeds Unit;  
http://wric.ucdavis.edu/exotic/exotic.htm

**WEED IDENTIFICATION:**  

Weed Identification Web Site:  
http://www.uwyo.edu/plants/weeds/id/

http://www.plants.usda.gov
NOXIOUS WEED INVENTORY FORM

General Information

Site Name ___________ Collection Date (Yyyymmdd) __ __ __ __ __ __ __
Examiner Name: Last ___________________ First: ________________
Country ____ State or Province: ____________
County ____ National Ownership __ __ __ __
Local Ownership __ __ __ __ Source of Data ________

Location Information

UTM: _______________ UTM Datum Zone __ __ __ UTM Year __ __ __
UTM Easting __ __ __ __ __ __ __ __ __ __ UTM Northing __ __ __ __ __ __ __ __
Top row of numbers on unit, only 7 digits. Bottom row of numbers on unit.

Plant Information

GENUS ___________________________ SPECIES ___________________________
Common Name __________________________
PLANT CODE __ __ __ __ __
Infested Area ____________ Unit of Measure ______
(Actual infested area of weeds.)
Gross Area ____________ Unit of Measure ______
Canopy Cover (How dense are the weeds. Check the appropriate box)
☐ 1 - 10%  □ 11 - 20%  □ 21 - 30%  □ 31 - 40%  □ 41 - 50%  □ 51 - 60%  □ 61 - 70%  □ 71 - 80%  □ 81 - 90%  □ 91 - 100%

COMMENTS

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Table 8. Special Status (Threatened and Endangered) species that could potentially occur at NCAR.

<table>
<thead>
<tr>
<th>SCIENTIFIC NAME</th>
<th>COMMON NAME</th>
<th>STATUS ¹</th>
<th>PROBABILITY</th>
</tr>
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<tbody>
<tr>
<td><strong>Amphibians</strong></td>
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<tr>
<td>northern leopard frog</td>
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<td><strong>Birds</strong></td>
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<td><em>Gulo gulo</em></td>
<td>SE</td>
<td>Low</td>
</tr>
<tr>
<td>river otter</td>
<td><em>Lutra canadensis</em></td>
<td>SE</td>
<td>Low</td>
</tr>
<tr>
<td>Townsend’s big-eared bat</td>
<td><em>Corynorhinus townsendii pallescens</em></td>
<td>FC, SC</td>
<td>Moderate</td>
</tr>
<tr>
<td>black-tailed prairie dog</td>
<td><em>Cynomys ludovicianus</em></td>
<td>SC</td>
<td>High</td>
</tr>
<tr>
<td>Botta’s pocket gopher</td>
<td><em>Thomomys talpoides rubidus</em></td>
<td>SC</td>
<td>Moderate</td>
</tr>
<tr>
<td>northern pocket gopher</td>
<td><em>Thomomys talpoides macrotis</em></td>
<td>SC</td>
<td>High</td>
</tr>
<tr>
<td><strong>Mollusks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rocky Mountain capshell</td>
<td><em>Acroloxus coloradensis</em></td>
<td>SC</td>
<td>Moderate</td>
</tr>
<tr>
<td>cylindrical papershell</td>
<td><em>Anodontoides ferussacianus</em></td>
<td>SC</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Reptiles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>common garter snake</td>
<td><em>Thamnophis sirtalis</em></td>
<td>SC</td>
<td>High</td>
</tr>
</tbody>
</table>

¹FE - 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 IV: ELECTRONIC DATABASE