Explanation of Parts I, II and III of the Forest Ecosystem Management Plan

While the forest inventory on Open Space lands was completed in 1996, 1997, and 1998 inventory efforts on Mountain Parks lands have been completed only recently and data analysis is still underway. In order to accommodate these differences and continue with forest planning, the Plan has been divided into several parts. The intent throughout the planning process is to make the separate Plan components compatible through interagency review, collaboration, and public participation.

Part I of the Plan establishes the framework for forest ecosystem management on City lands and includes general policy guidelines and management direction. It also includes specific management prescriptions (primarily thinning and the use of prescribed fire) for Open Space forest stands along the urban/wildland interface. Part II of the Plan will include management prescriptions for low-elevation forest stands along the Mountain Parks/urban interface. Part III of the Plan will include management prescriptions for Mountain Parks high-elevation forest stands.

Organization of Part I of the Forest Ecosystem Management Plan

Chapter 1. The introduction to the City of Boulder's Forest Ecosystem Management Plan describes the purpose and need for the Plan, along with general goals for management of City forests. The introduction also outlines the planning context and ecological concepts that provide the basic framework for the Plan's development.

Chapter 2. The second chapter of the Plan summarizes what is known about historical and recent ecological processes and interactions that have influenced and sustained the composition, structure, and function of forested montane ecosystems across multiple scales in both space and time. This summary describes what is known about the historical range of variability of disturbance processes, forest structure, and understory patterns.

Chapter 3. In the third chapter staff summarizes current low-elevation forest conditions using forest inventory data collected in 1996, 1997, and 1998 by City of Boulder Open Space. Complete details on the methodology and results of the Open Space inventory are compiled in four technical reports (City of Boulder 1998a, 1998b, and 1998c; Murphy 1998). Mountain Parks inventory data will be summarized in Part II (low-elevation forest stands) and Part III (high-elevation forest stands) of the Plan. Inventory data were compiled and summarized to contrast present-day with historical ecosystem conditions.

Chapter 4. The fourth chapter of the report outlines a long-range plan for forest ecosystem management that is designed to restore the structure and function of these ecosystems. Restoring natural fire regimes will reduce the risk of catastrophic wildfire and help maintain more natural forest conditions. Coarse-scale and fine-scale implementation plans are presented that will help achieve desired future conditions. This chapter also discusses understory plant and wildlife management considerations to evaluate during implementation.

Chapter 5. A key component of this Plan is monitoring the effects of management actions to assess whether the goals of the Plan are being met. Chapter 5 outlines monitoring objectives and methods. Monitoring is critical in order to document successful management actions, to allow staff to determine corrective action in the event Plan goals are not being achieved, and to refine and improve management actions as new information and ecological models become available.

EXECUTIVE SUMMARY
CITY OF BOULDER
FOREST ECOSYSTEM MANAGEMENT PLAN

This Forest Ecosystem Management Plan takes a holistic approach to restoring and nurturing essential natural forest ecosystem components and processes and to reducing the risk of catastrophic wildfire. In addition, the Plan is comprehensive, grounded on the best available science, long-term in focus, and geared to managing across ownership and agency boundaries.

Given how far existing forest conditions have diverged from natural presettlement conditions, the proposed Forest Ecosystem Management Plan is essentially an ecological restoration program. Major restoration objectives include:

- Restoring forest structure and function.
- Restoring the diversity of plant and animal habitats and communities.
- Restoring a natural fire regime, which involves frequent low-intensity surface fires. Restoring a natural fire regime will reduce the risk of catastrophic wildfire and help maintain more natural forest ecosystem conditions.

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.

BACKGROUND

The City of Boulder manages approximately 8,000 acres of forested land. These forests form part of the easternmost area of the lower foothills of the Front Range. The City of Boulder, a growing urban area with a population of over 100,000, is situated just to the east of the foothills forest, at the edge of the Great Plains.

Biological diversity is high in low-elevation montane areas along the Front Range. Several sensitive plant communities have been documented here, including foothill prairies, riparian shrublands, ponderosa pine-scrub woodlands, and ponderosa pine savannas. In addition, wildlife diversity is greater in low-elevation montane forests than in the forests found at higher elevations.

To assess current conditions in the forest ecosystem and develop management plans for these lands both Open Space and Mountain Parks have over the past 3 years completed extensive forest inventories. Open Space recently completed a forest inventory in 56 of 60 designated stands in their management area. Complete details on the methodology and results of the Open Space forest inventory are compiled in four technical reports (City of Boulder 1998a, City of Boulder 1998b, City of Boulder 1998c, and Murphy 1998) that are supporting documents to the Forest Ecosystem Management Plan. Mountain Parks staff recently completed a similar detailed inventory of forests stands in their land base, and are in the process of analyzing the inventory data and preparing a report that summarizes their findings.

Current interest in revised management of ponderosa pine forest ecosystems can be attributed to two factors. In recent decades ecologists and land managers have developed a new understanding of the role that fire plays in the maintenance of healthy low-elevation montane forests throughout the West. The fire suppression policy that was initiated in the early 1900s has been replaced by the use of prescribed fire as a management tool that can help to prevent catastrophic wildfires. Secondly, many of these low-elevation montane forests are near growing population centers where increasing use of forest lands for homes and recreation has added a sense of urgency to reducing wildfire risks along the urban/wildland interface.

Statement of Purpose, Need and Goals

The purpose of the Forest Ecosystem Management Plan is to provide specific management direction to ensure the ecological sustainability of Boulder's forests.

The Forest Ecosystem Management Plan is needed to meet long-range resource planning goals and objectives for Open Space and Mountain Parks. The Plan also is needed to ensure that management activities are compatible with sustainable forest ecosystems and to balance environmental and social values.

Specific goals for this Plan are drawn from the mission statement of the Boulder County Interagency Forest Ecosystem Management Initiative and are intended to promote natural ecosystem processes and patterns in City of Boulder forests. The ecosystem management approach is an effort to anticipate resource needs in a long-term integrative context. The goals outlined here are flexible but provide both specific and general management direction for what City of Boulder staff can expect to accomplish under this management Plan:

GOAL 1. Maintain or enhance native plant and animal species, their communities, and the ecological processes that sustain them.

GOAL 2. Reduce the wildfire risk to forest and human communities.

The Ecosystem Management Approach

Ecosystem management is an evolving approach to natural resource management in which the primary goals are to sustain the integrity and diversity of ecosystems and the human societies that depend on them. Ecosystem management differs from more traditional concepts of natural resources management in that the entire complex of biotic, abiotic, and societal components present in a given area is considered in a holistic manner, rather than as separate components, such as timber, wildlife, soils, or hydrology. Persistence of natural ecosystems is a major focus, and both long-term and short-term perspectives are crucial for perpetuating ecosystems into the future. Goals in ecosystem management generally are not specified as deliverable goods and services, such as board feet of timber or numbers of visitor days, but are stated in terms of desired future conditions or desired ecosystem behavior.

There is also explicit recognition of the complexity of ecosystem behavior, and the integral role of scale when attempting to manage dynamic systems. Management cannot attempt to "freeze" ecosystems in a particular state or condition because the factors and interactions that drive ecosystem behavior are constantly changing through time and across space. Management must be flexible and adaptive to accommodate both ever-changing conditions within ecosystems and new scientific knowledge and models of how ecosystems function.

Adaptive Ecosystem Management

Two central concepts of an ecosystem management approach are: (1) ecosystems are constantly changing in both time and space, and (2) there is often a great deal of uncertainty when attempts are made to define the direction or magnitude of ecosystem changes that may take place. Ecosystems are inherently dynamic and changes within them occur across spatial scales ranging from individual plants to landscapes and time scales ranging from days to centuries. Uncertainty arises because it usually is not known how system components interact at these multiple scales to produce the rich variety of conditions that are often seen in natural systems.

These two key features of ecosystems mean that management actions must be flexible to adapt to new data and new theories that further understanding of how ecosystems work. The basis for an adaptive management approach is that since it is not always known what will happen when a treatment is applied to an area, staff must monitor ecosystem response and assess whether goals were in fact met by the treatment or whether unforseen circumstances altered the response. The assumptions and predictions that guide management actions also are reassessed as new information becomes available. In this manner, future management treatments can be refined by evaluating past results.

VEGETATION

Overstory

Present-day ponderosa pine forests are well outside of their historical range of natural conditions. Logging, grazing, and fire suppression have all resulted in ecosystem changes. The most profound changes In ponderosa pine forests over the past century have been caused by the suppression of frequent, episodic surface fires. This has led to an increase in the homogeneity of forest landscapes and an increase in densities of small- and medium-diameter trees. Logging has led to a concurrent decrease in large-diameter trees. Changes in forest overstories also have reduced understory diversity and changed productivity and successional pattems.

From the early 1970s to the early 1980s, Boulder's forested ecosystems experienced extensive tree mortality from an epidemic of mountain pine beetles. A plan for thinning and harvesting these trees was outlined in the final Project Greenslope report (Colorado State Forest Service 1982). This plan was designed to treat not just the symptoms but what was widely perceived as the underlying cause of the epidemic, namely dense, overstocked stands of trees that not only favored the mountain pine beetle but also increased the risk of catastrophic wildfires. However, recommendations made during Project Greenslope for follow-up treatment of forests stands were not implemented for a variety of reasons, and tree regeneration since the early 1980s has resulted in stand conditions in some areas that are similar to those that existed prior to Project Greenslope. Also, new forested areas have been added to the City's land base; these areas were not inventoried until the recent forest inventories were undertaken.

Repeat photography and analyses of tree age structure have documented the effects of 19th century non-Native American settlement on forest structure and landscape patterns in the Boulder area. These studies show that the ponderosa pine forest was heavily impacted by early settlement in the Boulder area. The recent City of Boulder forest inventory documented that local forests consist largely of middle-aged trees that matured after unrestricted use of the forest was curtailed by early land management efforts that began in the early part of this century.

Understory

Although forests are defined primarily by trees, most of the plant species that grow in forests are found in the understory, which is the layer of shrubs, wildflowers, and grasses beneath the forest canopy. The abundance and diversity of understory plants directly influence the abundance and diversity of forest wildlife and are indicators of the ecological condition of the forest. Understory vegetation also influences important ecological processes, by contributing to soil fertility and soil stabilization, altering pine seedling growth and mortality rates, and affecting the intensity and spread of fires.

Invasive non-native plant species (also known as aliens, exotics, or weeds) commonly threaten native plant communities by displacing native species, and impact natural areas by reducing native species diversity, affecting natural processes, raising the cost of land management, and diminishing aesthetic and recreational values. Non-native plant species comprise 20% of the plant species documented during the Open Space understory inventory and 18% of the cover of herbaceous plant species.

Forest-wide objectives for vegetation:

- Maintain or increase the number of native plant species.
- Maintain or increase the existing number of rare and uncommon plant species.
- Maintain or increase the existing number of occurrences of rare and uncommon plant species.
- Maintain or increase the density or population size in each occurrence of a rare or uncommon plant species.
- Reduce the abundance of invasive non-native species present on City lands.
- Prevent the establishment and spread of species of invasive non-native species that have not been previously encountered on City lands whenever possible.
- Maintain or increase the existing number and types of plant associations dominated by native plants on Open Space and Mountain Parks lands.
- Maintain or increase the vegetation quality for each plant association or for any associations identified in the future.
- Reduce the density and increase the size of trees so stand averages of tree density and size fall within the historical range of variability of the region for the different forest types.
- Increase the proportion of stand initiation and old-growth forest and decrease the proportion of stem-exclusion, closed canopy forest.
- Maintain or increase the cover of native vegetation and reduce the cover of bare ground and litter on the soil surface.
- Maintain or increase the areal extent of shrublands.
- Maintain or increase the areal extent of riparian areas.
- Maintain or increase the areal extent of existing wetlands.

WILDLIFE

In addition to the impacts of historical logging, grazing and fire suppression, forest wildlife species on City lands more recently have been affected by increased urban and suburban development. Increasing human populations around the City's forests have resulted in a number of consequences including further fragmentation of forest ecosystems, changes in vegetation (e.g., increases in non-native plants), decreased local hunting pressure, and increased numbers of domestic animals. These influences impact wildlife in different ways depending on the species.

According to the Colorado Division of Wildlife, 228 species of wildlife use ponderosa-pine forest ecosystems for some part of their life cycle. Other research suggests that there are some 98 wildlife species that regularly occur in the ponderosa-pine forests of Boulder County. While Open Space and Mountain Parks have collected some information through various efforts, the information relative to wildlife occurring in the forest is limited. 1998 inventory efforts on Open Space identified 61 bird species and three species of small mammals. In addition, 11 species of bats have been documented in the forested landscapes of Boulder.

A primary emphasis of this Plan is to increase the knowledge of wildlife needs in forested landscapes and to continue data collection and monitoring to ensure objectives are being met. However, there are simply too many wildlife species that live on City of Boulder lands to attempt to manage each one individually. Single-species approaches at the forest stand level (where management actions occur) cannot provide a comprehensive and holistic management strategy. Therefore, staff has adopted the approach of assuming that a relatively complete array of habitat types in the local forests will harbor the vast majority of local wildlife species. While it is not possible to manage for each individual species, it is desirable to protect species of special interest at both the community and species levels.

Forest-wide objectives for wildlife:

- Maintain or increase native wildlife species richness.
- Maintain or increase the densities of breeding bird species.
- Maintain or increase the number of nesting and roosting sites of raptor and bat species (especially sensitive species).
- Maintain or increase the existing avian species of special interest.
- Maintain or increase the existing mammalian species of special interest.
- Maintain or increase the existing reptilian species of special interest.
- Maintain or increase the population density of each avian, mammalian, and reptilian wildlife species of special interest.
- Maintain existing tree snags and create additional large snags.

ABIOTIC RESOURCES

Ecosystems are composed of both living (biotic) and nonliving (abiotic) components. Water and soils are the essential abiotic components of the ecosystem; they significantly influence individual plant species, as well as plant communities and their related wildlife habitat types. Management of the forest through thinning and prescribed fire will influence the amount of water found in riparian and wetland areas, as well as the duration of flow of streams.

Soils--their composition, texture, aggregation, water-holding capacity, and potential for erosion and compaction--greatly influence vegetation patterns. One of the management objectives of the Plan is to minimize impacts to grassland and forest soils that would reduce their ability to support native plant species and plant associations.

Forest-wide objectives for abiotic resources:

- Maintain or increase the duration and volume of base flow of intermittent streams that arise on Open Space and Mountain Park lands.
- Minimize soil erosion and compaction in treated forest stands.
- Maintain soil fertility in treated forest stands.

WILDFIRE RISK

In addition to ecosystem considerations, recent changes in stand structure and tree density in ponderosa pine forests have direct implications for human values and safety. Fire control has been the great paradox of land management efforts over the past century. The effectiveness of fire suppression in recent decades has increased the extent and intensity of fire when wildfires do occur. Predominately low-intensity surface fires have been replaced by high-intensity crown fires that can devastate large areas of forests and cost money, resources, and, all too often, human lives to control. Furthermore, increases in the landscape homogeneity of stands can result in more extensive wildfires, especially those that are stand destroying. Landscape changes that have increased the risk, frequency and intensity of extensive wildfires are especially critical considerations in the wildland-urban interface of cities like Boulder, where houses are often located in or on the margins of forested areas. Increased homogeneity of forest conditions also may have contributed to more extensive and devastating outbreaks of pathogens in recent years, such as the mountain pine beetle outbreak in City of Boulder forests in the late 1970s and early 1980s.

While wildfire mitigation is one of the main objectives of the Plan, it must be noted that management actions planned for the forest will not eliminate the fire hazard in City of Boulder forests and along the urban/wildland interface. Weather conditions in the western U.S., like severe storms, frequent lightning strikes, high winds, and drought, will continue to set the stage for both local and regional wildfires, some of which will be uncontrollable. Staff does anticipate, however, that the wildfire mitigation measures will help to decrease the intensity and severity of local wildfires.

Forest-wide objectives for wildfire mitigation:

- Thin forests to levels that reduce the risk of large-scale, uncontrollable wildfires.
- Reduce fuel loading on the forest floor.
- Create and improve fuel breaks along the wildland/urban interface.
- Maintain existing fire access roads.
- Selectively remove insect- and disease-damaged trees.
- Determine fire conditions during prescribed bums in order to track impacts of fire on biotic and abiotic resources.

MONITORING

Monitoring ecological resources is conducted primarily for two purposes: (1) to detect biologically significant changes in resource abundance and/or condition and/or population structure, and (2) to understand the effects of management on population or community dynamics. The Forest Ecosystem Management Plan has incorporated long-term monitoring as an essential component. Monitoring objectives are tied directly to management objectives in order to determine whether management objectives are being met and to change management direction if they are not, which is the essence of adaptive management.

Monitoring protocols for vegetation will focus on detecting changes in the overall composition, structure, and function of forested areas following the implementation of management objectives, as well as changes in sensitive plant populations, uncommon plant communities, and non-native plant populations. The initial emphasis for wildlife monitoring will be to detect changes in rare species densities and distributions, and in bird and small mammal diversity. As inventory data on reptiles, amphibians, and invertebrates become available, additional monitoring protocols will be developed. Abiotic elements addressed in the current monitoring guidelines include hydrologic and soil attributes, as well as fire behavior and fire weather.

Monitoring will achieve several overall objectives that support the Plan goals. Results of monitoring will be used to assess the success of, and to provide feedback on, management decisions and actions. Monitoring will be designed to track and anticipate ecological changes (changes in resource abundance and/or condition and/or population structure). Knowledge gained from long-term monitoring should increase understanding of the processes that shape forest ecosystems in the Boulder area.

Forest-wide objectives for monitoring:

- Determine the extent to which desired future conditions for the forests are being achieved.
- Determine the effects of prescribed fire on the composition, structure, and function of the forest ecosystem.
- Identify undesirable conditions that will alert staff that the results of management actions are different from those anticipated, and that modification of management strategies needs to be considered.
- Establish reference (control) areas for each plant community and key wildlife habitat types within the forest ecosystem.

IMPLEMENTATION

The Plan defines different areas of the forest that require different types and levels of management intervention. Moving forest ecosystem conditions closer to the historical range of variability will require major efforts to thin and open up the forest by selectively cutting trees and conducting prescribed burns on an ongoing basis. These principal tools will be complemented with many other kinds of management actions such as wildlife habitat enhancement, weed control, erosion control, reintroduction of native species, and management of visitor use.

The initial phase of implementation of the Plan is expected to begin in the spring of 1999. This initial effort will strive to restore forest ecosystem conditions to within the historical range of variability. The immediate priority for Open Space and Mountain Parks staff and the wildfire mitigation crew of the Boulder Fire Department is to implement management prescriptions along the wildland/urban interface. During this time improvements to the Plan will be made based on information gathered during additional inventory work, monitoring activities and feedback from the public. Once the forest is returned to more natural conditions, ongoing management will then be needed to maintain desired forest conditions. This will require a significant long-term commitment of time and money by the City. While staff does not currently have a detailed budget for implementing the plan, a budget for the program will be developed in 1999 that details costs associated with various management activities. Some of the unknown variables at this time include the availability of contractors and the economics of the wood products market.

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1. INTRODUCTION

As early as 1890, Boulder's leaders and other citizens realized the special beauty and natural values of the foothills and mountains west of town. In 1898, largely through the efforts of the Boulder Improvement Society, the Chautauqua site and 80 acres on the east side of Flagstaff Mountain were purchased and preserved as park lands.

The following year, in response to Boulder's request, Congress granted a gift of 1,800 acres "from the top of Flagstaff west to the mouth of Four-Mile Canyon, to Sunshine Canyon then south to Green Mountain." Land was acquired from the State of Colorado and other private landowners to prevent the Flatirons from being marred by rock quarries that were being developed at the time. Over the next few decades, many other properties along the mountain backdrop were purchased or gifted to the City.

After World War II the City of Boulder began to experience rapid population growth. From 1950 to 1980 the population increased from 20,000 to over 78,000. This period of rapid expansion prompted the passing of a blue line ordinance in 1959 that limited growth in the mountain areas west of Boulder by limiting City water service to areas below approximately 5700 feet in elevation.

Even with efforts such as this, development pressure on Boulder's mountains continued. In 1967 Boulder citizens approved an ordinance that created a financing mechanism for the purchase of greenbelt areas in and around the City.

Today, the City of Boulder Open Space Department and Boulder Mountain Parks Division own and manage about 8,000 acres (3,240 hectares) of forested lands. These **montane forests**[1] are part of the easternmost area of the lower foothills of the Front Range. The City's forest **ecosystems** are managed primarily to conserve and promote **biological diversity** and **sustainable ecosystems**, as well as to provide compatible recreational opportunities and protect scenic **landscapes** adjacent to the urban environment of the City of Boulder.

This Plan outlines a long-range management program for the forested ecosystems owned and managed by the City of Boulder. The Plan is based on the concepts of **ecosystem management**, **adaptive management**, and what is known about the **historical range of variability** (HRV) in **ecosystem processes and patterns** in montane forests of the Front Range of Colorado. It is also

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[1]See the glossary for definitions of terms in boldface.

consistent with the policy guidance provided by Boulder City and County planning documents (see Appendix 1.1 for more detail).

Ecosystem management is based on and attempts to promote the integrity of natural ecosystem processes and patterns, while accommodating human use of the landscape. A central tenet of ecosystem management is that humans are part of the **natural environment** and cannot be excluded from the management process (Kaufmann et al. 1994, Christensen et al. 1996). On the other hand, management planning also must recognize that human impacts on ecosystems during the period of rapid population growth of the last 150 years often have been profound and pervasive. These impacts may have compromised the **sustainability** of some western forest ecosystems (e.g., Vitousek 1994, Holling and Meffe 1996, Vitousek et al. 1997).

In recent decades ecologists and land managers have developed a better understanding of the role that episodic, low-intensity **surface fire** plays in the maintenance of healthy montane forests. The **fire suppression** policy that was initiated in the early 1900s to protect forest lands in the western U.S. created conditions that in recent decades actually have increased the size and intensity of **wildfires**. **Prescribed fire** is now a widely-used management tool that can help to prevent large-scale **catastrophic wildfires**. Many low-elevation montane forests are near growing population centers, where increasing use of forest lands for homes and recreation has added a sense of urgency to reducing wildfire risks along the **urban/wildland interface**.

1.1 Recent History of City of Boulder Forest Management

Montane forests in Boulder are composed primarily of ponderosa pine (*Pinus ponderosa scopulorum*), Douglas-fir (*Pseudotsuga menziesii*), and mixed ponderosa pine-Douglas-fir forests. In the early 1970s local forests experienced extensive tree mortality related to the mountain pine beetle. In 1977 a City Forester was hired to assist in control of the mountain pine beetle epidemic. Also in 1977 a cooperative forest management program was initiated to manage forests to withstand beetle attacks and reduce wildfire hazards. Pesticides and commercial tree **thinning** were the primary tools used.

By 1978, after a period of chemical treatment, the City sought a means to address the causes rather than the symptoms of poor **forest health**. The trees were crowded and competed for a limited supply of light, soil nutrients and water. As a result, trees were stressed and susceptible to outbreaks of mountain pine beetles and various diseases. Each additional year of fire suppression increased the risk of catastrophic wildfire as beetle-killed trees and other **fuels** continued to accumulate. In 1979 the City of Boulder and the Colorado State Forest Service signed a cooperative agreement to manage the City's forests.

The new management initiative was dubbed "Project Greenslope" (Colorado State Forest Service 1982) and the City Council approved $348,000 from the City's general fund and Open Space revenues for the three-year project. The project included a long-range forest management plan published by the Colorado State Forest Service in 1982. However, by 1988 the implementation of the plan had been abandoned largely because of changes in attitudes about tree-cutting and chemical usage and the declining local market for forest products.

Forest health and wildfire hazard questions persisted but remained unaddressed. In March of 1992 the City of Boulder began to bring Boulder County land management agencies together for renewed discussions about forest management. After several meetings, this coalition agreed upon a mission statement, and outlined the goals and objectives of the Boulder County Interagency Forest Ecosystem Management Initiative.

The mission statement of the Boulder County Interagency Forest Ecosystem Management Initiative is to "cooperate toward sound management of forest ecosystems in Boulder County." The specific goals include maintaining **native** plant and animal communities and ecological processes, using or mimicking natural processes to maintain, protect or enhance **ecosystem health**, reducing wildfire hazard, and providing opportunities for education and public input.

1.2 Purpose and Need for the Forest Ecosystem Management Plan

The purpose of the . Forest Ecosystem Management Plan is to provide specific management direction to ensure the ecological sustainability of Boulder's forests.

Ecosystem sustainability refers to the ability of an ecosystem to sustain health, biological diversity, and **productivity** over long time periods. Abundant evidence suggests that today montane forests in Colorado and throughout the western U.S. are well outside of the historical or natural range of variability because of changes brought about by intensive land use during the last 150 years (Figure 1.1). Logging, grazing, and the cessation of frequent, low-intensity surface fires are often-cited causes of changes in forest patterns.

Logging practices over the past century, especially logger's choice, where the largest trees were harvested first, have resulted in fewer **forest stands** that contain older trees and forest stands with **age classes** and **size classes** that are less diverse than they were in the past. Removal of older trees also may have reduced the genetic potential of ponderosa pine trees and compromised their ability to withstand attacks by pathogens (e.g., Linhart et al. 1994).

Widespread and intensive livestock grazing contributed to ponderosa pine **regeneration** by selective removal of **herbaceous** (non-woody) vegetation like grasses that compete with woody plants (e.g., Archer 1994). Grazing also contributed to the loss of **understory** plant diversity and abundance and to the expansion of **non-native species** in many areas.

However, the most profound changes in montane forests over the past century have been the result of the cessation of frequent, episodic surface fires

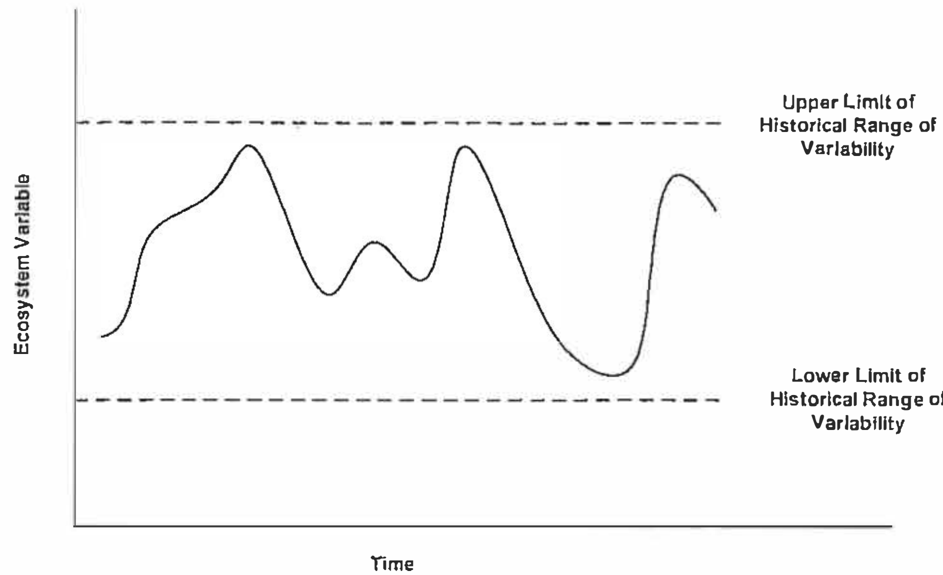

Figure 1.1: Historical Range of Variability. HRV encompasses the boundariesof natural ecosystem fluctuations prior to extensive human influence (after Morgan et al. 1994).

(Cooper 1960, White 1985, Savage 1991, Mutch et al. 1993, Covington and Moore 1992, 1994, Agee 1994, Arno et al. 1995, Swetnam and Baisan 1996, Fulé et al. 1997). Fire is a natural ecosystem process that directly or indirectly controls or influences many other ecosystem components (Holling 1992).

Fire influences animal **habitats** by leaving **snags** and other **coarse woody debris** and by creating a **mosaic** of different types of **wildlife habitat**. Mortality of living **biomass** affects forest **overstory** and understory productivity and vegetation patterns. Fire affects nutrient cycling by rapid chemical and physical turnover of carbon and nutrients stored in both living and dead biomass. Fires influence **riparian** productivity and diversity by removal of upstream living biomass that results in changes in streamflow and deposition in stream channels. Increases in upstream forest stand densities after fire exclusion have led to reduced flows and shorter flows in **ephemeral streams** that, in turn, have reduced the extent of highly diverse riparian and stream channel communities. Extirpation of species has likely occurred in many riparian areas as a result (Covington and Moore 1994).

In addition, historical **fire regimes** produced distinctive frequencies in temporal components and distinctive clusters in spatial components of ecosystems (Holling 1992). Low-intensity surface fires tend to create finer-scale **patches** in forest architecture (e.g., a greater variety of **patch types**, smaller patch size, and more widely dispersed patches) than **crown fires**. Locations or periods with frequent surface fires produce a more open overstory because of mortality of tree **seedlings**. Locations or periods with fewer surface fires tend to show both increased **overstory recruitment** and more extensive patches of dense forest overstory.

Furthermore, increases in the **landscape homogeneity** of forests (an increase in densities of small- and medium-diameter trees and a decrease in large-diameter trees) can result in more extensive fires, especially those that are **stand destroying** (Swetnam 1990, Covington and Moore 1992). Increased homogeneity of forest conditions also may have contributed to more extensive and devastating outbreaks of pathogens in recent years (e.g., Swetnam and Lynch 1993, Schmid and Mata 1996), such as the mountain pine beetle outbreak in City of Boulder forests and along the entire Front Range in the 1970s (Colorado State Forest Service 1982).

These shifts from historical patterns have led some people to question whether ponderosa pine forests will be sustainable in the future under these altered **disturbance regimes** (e.g., Covington et al. 1994). There are currently many research projects and management plans underway in ponderosa pine forests that are designed to both restore and promote historical patterns in ponderosa pine forests to assure that they remain sustainable and productive in the future (e.g., Mutch et al. 1993, Arno et al. 1995, Covington et al. 1997). All of these projects use some combination of forest treatments (including prescribed fire and tree thinning) to achieve long-term goals. These research and management efforts are models for what this Forest Ecosystem Management Plan proposes to accomplish in forests of the City of Boulder.

In addition to ecosystem considerations, recent changes in forest stand structure and tree density in montane forests have direct implications for human values and safety. Changes in **fuel loads** and landscape patterns of forest stands are especially critical considerations along the urban-wildland interface of cities like Boulder, where houses are often located in or on the margins of forested areas. Fire control has been the great paradox of land management efforts over the past century. The effectiveness of fire suppression in recent decades has actually increased the scale and intensity of fire when fires do occur. Predominantly low-intensity surface fires have been replaced in many areas by high-intensity crown fires that can devastate large areas of forests and cost money, resources, and, all too often, human lives, to control. (See "Wakeup call for forest management" at the end of this chapter).

While wildfire mitigation is one of the main objectives of the Plan, it must be noted that management actions planned for the forest will not eliminate the fire hazard in City of Boulder forests and along the urban/wildland interface. Weather conditions in the western U.S., like severe storms, frequent lightning strikes, high winds, and drought, will continue to set the stage for both local and regional wildfires, some of which will be uncontrollable. Staff does anticipate, however, that the wildfire mitigation measures will help to decrease the intensity and severity of local wildfires.

This Plan proposes methods to sustain the future integrity of montane forests managed by the City of Boulder by promoting or restoring historical patterns in forest ecosystem **function**, **structure**, and **composition**, especially surface fire regimes (see Figure 1.2). To this end, the Plan summarizes what is known about historical ecosystem processes that controlled and influenced the formation of ecosystem patterns during periods before intensive human impacts began in the

LANDSCAPE STRUCTURE AND FUNCTION

LANDSCAPE STRUCTURE AND FUNCTION are interrelated. Changes to the structure (e.g., thinning forest patches) can alter landscape function (e.g., reducing likelihood of catastrophic fire or insect infestation).

STRUCTURE

~~Physical, tangible landsc~~ape elements (living and nonliving). Examples include individual trees, stands of trees, water, soil, flowering plants, grasslands, individual animals, and communities of animals.

These structural elements occur in patterns over the landscape. For example, a specific stand of trees can be thought of as one patch in the landscape that may be connected to another, larger patch via a corridor that facilitiates the movement of species and resources between the patches.

FUNCTION

Functions (or processes) alter and maintain a dynamic landscape. Stuctural landscape elements and patterns change over time due to functions such as disturbance, succession (change in species over time), extinction of species, and migration.

Figure 1.2: Description of Landscape Structure and Function.

middle to late 1800s. HRV is central to the development of this Plan, as **historical conditions** provide staff with benchmarks to compare to present-day ecosystem components and to guide **restoration** of ecosystem components in areas and situations where human impacts may have compromised ecosystem sustainability (Swanson et al. 1993, Morgan et al. 1994, Kaufmann et al. 1994).

1.3 GOALS AND OBJECTIVES

The Forest Ecosystem Management Plan is needed to meet long-range resource planning goals and objectives for Open Space and Mountain Parks forest lands. The Plan also is needed to ensure that management activities are compatible with maintaining sustainable forest ecosystems and to balance environmental and social values.

An ecosystem management approach is an effort to address natural resource protection in a long-term, integrative context. The two goals for this Forest Ecosystem Management Plan are consistent with the mission statement of the Boulder County Interagency Forest Ecosystem Management Initiative and are intended to promote natural ecosystem processes and patterns in City of Boulder forested landscapes. The goals outlined here are flexible but provide general management direction for what City of Boulder staff can expect to accomplish under this management Plan.

Goal #1. *Maintain or enhance native plant and animal species, their communities, and the ecological processes that sustain them.*

Goal #2. *Reduce the wildfire risk to forest and human communities.*

Plan goals will be implemented through the development of specific management objectives. Under goal number one, management objectives include (1) maintaining or enhancing individual native plant and animal species and communities, (2) reducing the threats to native plant and animal populations from introduced, non-native plants and animals, and (3) changing the structure of the forest by increasing the proportion of **stand initiation** and **old-growth forests** and decreasing the proportion of stands with dense, small-diameter trees. In addition, areas that are high in biological diversity, including shrublands, **wetlands**, and riparian corridors, will be maintained or enhanced.

Under goal number two, management objectives include (1) thinning forest stands and reducing forest fuels to reduce the risk of catastrophic wildfires, (2) maintaining or improving **fuelbreaks** and fire access roads to enhance control of natural and prescribed fires, and (3) tracking fire conditions during prescribed burns to monitor the impacts of fire on biotic and abiotic resources. Management objectives are discussed in relation to **monitoring** goals and objectives in Chapter 5 of the Plan.

1.4 Ecological Framework for the Plan

In this section, specific ecological principles and conservation ideas that were used to develop this Forest Ecosystem Management Plan are outlined. These principles also guided the development of specific **management prescriptions** outlined in Chapter 4 and Appendix 1.2.

1.4.1 Ecosystem Management

__Ecosystem management__ is management driven by explicit goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function. (Christensen et al. 1996)

Ecosystem management is an evolving approach to natural resource management in which the primary goals are to sustain both the integrity and diversity of ecosystems and the human societies that depend on them (Jensen and Bourgeron 1994, Kaufmann et al. 1994, Christensen et al. 1996). Ecosystem management differs from more traditional concepts of natural resource management in that the entire complex of **biotic**, **abiotic**, and societal components present in a given area is considered in a **holistic** manner, rather than as separate components, such as timber, wildlife, soils, recreation, and **hydrology**. The persistence of sustainable natural ecosystems over time is a major focus.

Goals in ecosystem management generally are not specified as deliverable goods and services, such as board feet of timber or numbers of visitor days, but stated in terms of **desired future conditions** or desired ecosystem behavior (Christensen et al. 1996). There is explicit recognition of the complexity of ecosystem behavior and the integral role of scale when attempting to manage dynamic systems. Management cannot attempt to "freeze" ecosystems in a particular state or condition, because the factors and interactions that drive ecosystem behavior are constantly changing through time and across space. Management must be flexible and adaptive to accommodate both ever-changing conditions within ecosystems and new scientific knowledge and models of how ecosystems function.

Ecosystem management is an emerging paradigm (Alpert 1995). In an effort to provide operational guidelines for ecosystem management, Brunner and Clark (1997) describe the advantages and disadvantages of different approaches to ecosystem management. The first of these approaches is to clarify goals for management actions. However, Brunner and Clark (1997) suggest that premature definition of goals that are too specific may reduce the flexibility of ecosystem management as an adaptive process. Tightly framed goals may restrict management actions unnecessarily to specific courses of action. Each problem encountered in ecosystem management requires a judgement to be made within its own context, and goals that are too explicit may limit management unnecessarily.

The second approach Brunner and Clark discuss is the development of better and more complete scientific foundations for ecosystem management actions. Basic science and theories that clarify relationships among ecosystem components are necessary foundations for management actions. Basic data and ecosystem models must be further integrated with applied scientific knowledge that is specific to particular contexts. However, context and contingencies are inherent in every decision that needs to be made, especially those of societal origin. Brunner and Clark conclude that:

> Because context matters, ecosystem managers and other practitioners cannot avoid interpretations and judgements, regardless of the objectivity of basic science.

Brunner and Clark also describe a scale of inquiry that they refer to as prototyping that falls between smaller controlled experiments and full-scale management interventions as a viable model for practical application of ecosystem management. Prototypes are innovative, small-scale actions that begin with guiding goals but are flexible enough to respond to unexpected problems or opportunities as they arise. The small scale of the prototype makes it less subject to political considerations and more easily terminated if unsuccessful. Prototyping uses innovative, bottom-up management actions that may eventually be applied at a larger scale if they prove successful and useful.

Ecosystem Health

> *Clearer general goals and a better scientific foundation are means for improving decisions on behalf of ecosystem integrity, but they are not ends in themselves or substitutes for practice-based improvements. Practice provides a reality check on the considerations integrated into decisions, the best opportunity for learning from experience, and the only reliable gauge of progress in ecosystem management.* (Brunner and Clark 1997)

The first dictum for management of ecosystems should be the same as that of the medical profession: "do no harm." In medicine, there are often no well-bounded, explicitly-defined problems that can be easily solved by simple cause-and-effect types of treatments. Any action taken on behalf of a patient must be considered in light of historical precedent, the patient's current health and condition, and some desired future condition that takes into account all known or hypothesized side-effects of the action. Any action is further coupled with monitoring of the patient to judge both effectiveness of the treatment and whether follow-up treatments need to be considered and implemented. Uncertainty is often an overriding characteristic of the problem and possible treatments, and adaptive assessments after an initial treatment are used to refine prescriptions in the future. Most important, any treatment considered should first and foremost be conservative, resulting in no change to functions and processes that are healthy and productive in the patient.

Development and implementation of a management plan for ecosystems should follow a similar formula. Historical processes and patterns, current conditions, and desired future conditions must be integrated to provide both short-term and long-term goals for management actions. Management should be wholly conservative, causing minimal disruption to existing components that are stable and productive (Holling and Meffe 1996).

Ecosystem Sustainability

Another goal for ecosystem management--and the one that is a primary foundation for this Plan--is to provide for and promote sustainable ecosystems (Covington and DeBano 1993). To sustain montane forests into the future, forests must be managed with an understanding of the ecosystem processes that control and influence ponderosa pine and Douglas-fir life cycles and community relationships. A process-based approach is the basis for sustainable management practices. Long-term success is determined by whether or not ponderosa pine and Douglas-fir forests, in fact, persist into the future in a productive and functional manner. Data from monitoring programs will be used to assess objectively both structural and functional ecosystem characteristics and to refine directions for future management actions.

ECOSYSTEM RESILIENCE

Ecologists are increasingly recognizing that equilibrium or stability is rarely achieved in natural systems (e.g., Reice 1994). Change is ubiquitous in all natural ecosystems, and change occurs at all scales in both time and space. Holling and Meffe (1996) in a recent paper argue that past natural resource management practices often resulted in a loss in the natural variability in ecosystem processes and components. This in turn has led to reductions in **ecosystem resilience**, or the ability of an ecosystem to persist in response to major shifts in **driving factors** or system processes.

Human-generated changes must be constrained because nature has ***functional, historical,*** *and* ***evolutionary*** *limits. Nature has a range of ways to be, but there is a limit to those ways, and therefore, human changes must be within those limits.* (Pickett et al. 1992; authors' emphases)

This concept emphasizes system dynamics that are inherently unpredictable and may only become apparent in larger systems over longer time periods. The focus here for natural resource management is to identify actions that adversely impact ecosystem structure or function through changes in the variables and processes that control ecosystem behavior. As long as a range of variability in system behavior is retained, Holling and Meffe (1996) argue that ecosystem resiliency is maximized and ecological crises or unanticipated changes can be minimized. This concept also is embodied in the guiding principles for ecosystem management set out by Kaufmann et al. (1994) and in the concepts of natural or historical range of variability of Swanson et al. (1993) and Morgan et al. (1994).

1.4.2 ADAPTIVE MANAGEMENT

Two central concepts of an ecosystem management approach are:
(1) ecosystems are constantly changing at multiple scales in both space and time, and (2) and there is often a great deal of uncertainty when attempts are made to define the direction or magnitude of ecosystem changes that may take place (Kaufmann et al. 1994, Christensen et al. 1996). Ecosystems are inherently dynamic and changes within them occur across spatial scales ranging from individual plants to landscapes and across time scales ranging from days to centuries. Uncertainty arises because it is usually not known how system components interact at these multiple scales to produce the rich variety of behavior that is often seen in natural systems.

These two key features of ecosystems mean that management actions must be flexible to adapt to new data and new theories that further understanding of how nature works. The basis for an adaptive management approach is that since it is not always known what will happen when a treatment is applied to an area, staff must monitor ecosystem response and assess whether goals were, in fact, met by the treatment or if unforseen circumstances altered the response. The assumption's and predictions that guide management actions are also reassessed as new information becomes available. In this manner, future treatments can be refined by past results (Holling 1978).

Because uncertainty is often an overriding feature of management decisions, managers and practitioners must make judgments, interpretations, and inferences that are based on multiple factors that include general goals, scientific knowledge, practical prudence, and context-specific information. Adaptive management is a type of practice-based approach that adapts basic science and general goals to practical realities.

1.4.3 The Ecosystem Management Planning Process

The ecosystem management planning process consists of three stages (see Figure 1.3). The first stage is the description of what is known about historical ecological conditions in the management area. The second stage is the description of current ecological conditions, including ecosystem composition, structure, and function. Current conditions can then be contrasted with historical conditions to assess the nature and degree of departure from conditions that existed prior to extensive human influence. The third stage is the description of desired future conditions, or conditions that resource managers hope to achieve by targeted management and monitoring programs.

Historical Conditions

Ecosystems function best under conditions to which they have adapted over long periods.

While natural ecosystems are highly variable and are always undergoing fluctuations and change, there are certain observable ecosystem patterns. Natural ecosystems generally experience a characteristic range of variability in specific ecosystem conditions and processes (such as the mix of species, size and density of populations, and frequency of disturbances like fire and insect epidemics). These ecosystem patterns result in observable limits in the magnitude and rate of change. Prior to significant human modification of the natural environment, ecosystem conditions and processes fell within an upper limit and a lower limit in an historical range of variability (Morgan et al., 1994, see Figure 1.1).

The importance of the concept of historical range of variability lies in two important facts. First, ecosystem dysfunction and loss of biological diversity are often observed where ecosystem conditions and processes have been altered significantly from the historical range of variability. Second, communities of plants and animals within ecosystems are incredibly diverse, but have evolved to survive within certain environmental gradients or tolerances reflected in an historical range of variability. Consequently, their survival can be threatened when environmental conditions are pushed outside of the historical range of variability, whether due to synoptic events like climate change or human alteration of the landscape (Kaufmann et al., 1994, Morgan et al., 1994, Swanson et al., 1993). Because of the dynamic nature of ecosystems and the need for sustainable resource management over long time frames, historical range of variability analysis has become an important tool for managing ecosystems.

Morgan et al. (1994), Swanson et al. (1993), and others (e.g., Kaufmann et al. 1994, Leslie et al. 1996, Holling and Meffe 1996) have proposed that managers use measures of the historical or natural range of variability in ecosystem structure and function as models for defining conditions that promote sustainable ecosystem behavior over long time-scales. The central premise is that ecosystems function best under conditions to which they have adapted over long periods (Swanson et al. 1993, Covington et al. 1997).

Many people may have the sense that historical conditions refer to a "snapshot" of conditions in the past, and use some central tendency in conditions or a single point in time as a management goal. However, historical range of variability

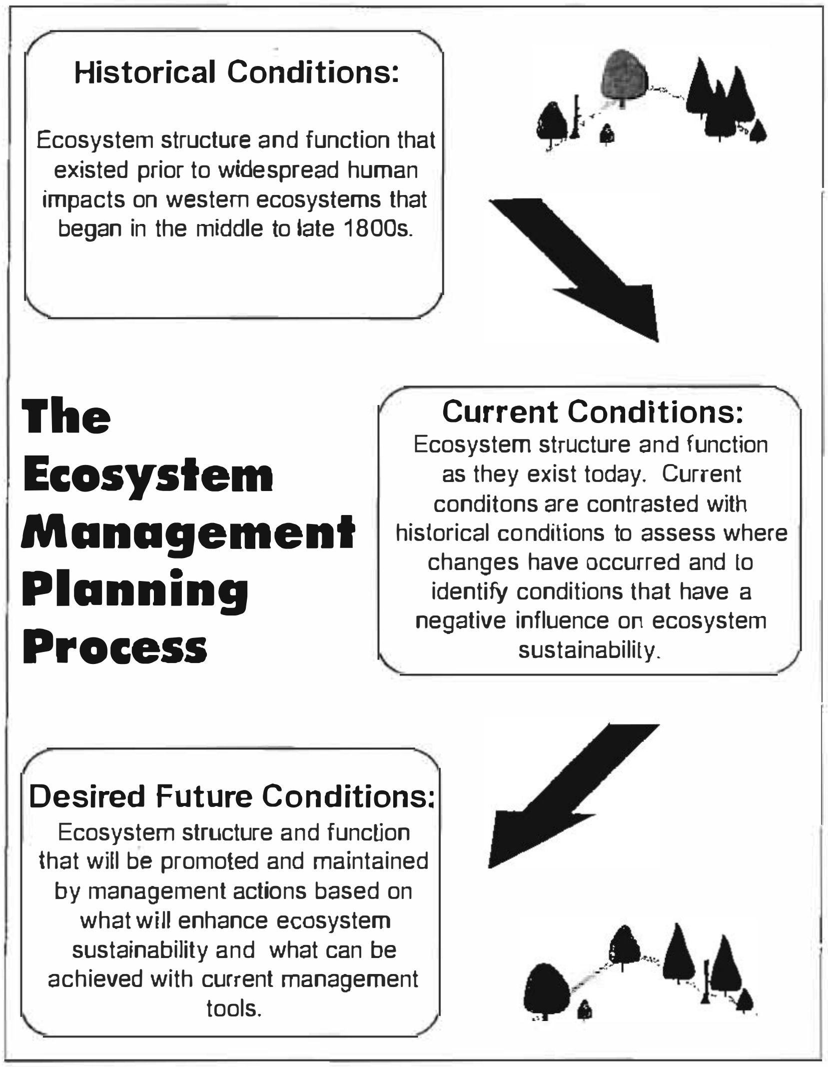

Figure 1.3: Diagram of Ecosystem Management Planning Process.

explicitly refers to the dispersion of conditions through time and space, including their transient responses to possible driving factors, such as climate change. For example, variability in fire frequency and extent in the southwestern U.S. has been related to long-term changes in precipitation patterns (e.g., Swetnam and Betancourt, 1999). Definition of HRVs in ecosystem components also permits greater operational flexibility and adaptability in management goals, since the ranges of possible outcomes to specific management actions can be expanded.

In some cases a return to historical variability in ecosystem processes may be impractical or impossible given present-day ecosystem structure. For example, in forests where surface fire predominated prior to the 1900s, fire exclusion during this century often has resulted in historically unprecedented fuel loads and fuel arrangements, especially the creation of **ladder fuels** that allow surface fires to migrate into forest canopies. There are also societal and safety constraints on the use of fire as a management tool, especially along the urban-wildland interface that comprises much of the City of Boulder management area. The result is that in many areas resource managers cannot simply reintroduce historical patterns of surface fires because of changes in fuels and crown structure. Resource managers must first restore forest structure to fall more within the bounds of the historical range of variability before surface fire can be reintroduced as an ecosystem process. The historical range of variability for montane forests in the Southern Rocky Mountains is described in detail in Chapter 2.

CURRENT CONDITIONS

The second stage in the ecosystem management planning process is the description of current ecological conditions, including ecosystem composition, structure, and function. The recent biological inventories conducted by Open Space and Mountain Parks were undertaken to gather information about the current condition of City of Boulder forests. The results of these inventories are presented in Chapter 3 of this Plan. **Landscape analysis**, which is described in Section 1.5 below, also is used to define existing conditions. Once current conditions are known, they can then be contrasted with historical conditions to assess the nature and degree of departure from conditions that existed prior to extensive human influence.

DESIRED FUTURE CONDITIONS

The third stage in the ecosystem management planning process is the description of desired future conditions, or conditions that resource managers hope to achieve by targeted management and monitoring programs. Desired future conditions are based on what is known about both historical and current conditions. Desired future conditions for City of Boulder forests are outlined in Chapter 4 of this Plan.

1.5 LANDSCAPE ANALYSIS AND DESIGN

Landscapes are composed of multiple, interacting ecosystems that are repeated across the land as a result of the interaction of plants, animals, humans, and physical factors, such as bedrock geology, landform, hydrology, soils, and climate. Landscapes range in size from a thousand acres to a quarter of a million acres.

Landscape analysis is a process that helps to define current and desired future conditions--ecological, social, and economic—at a landscape scale. The City of Boulder's forest lands are part of a larger landscape encompassing forest, grasslands, riparian, and urban ecosystems. Landscape analysis for the Forest Ecosystem Management Plan provides a broader geographical context for understanding how current and desired future conditions on the City's forested areas are influenced by both public and private lands in a larger landscape. Forest treatments often focus on **forest stands**, which are a type of landscape patch formed by clusters of trees. Landscape analysis provides a broader multi-stand and multi-ecosystem perspective, which is important to ensure that the various pieces of the forests fit together in a holistic framework.

Paradoxically, as fire exclusion escalates, wildfires fight back with increasing ferocity. In the absence of fire, ground fuel accumulates and crowded forests become more susceptible to disease and insect damage. So when lightning inevitably strikes, the odds are much higher that it will flare up faster, burn hotter and higher, crown into the big trees and decimate entire forests in what professionals call a "stand replacing fire." These intense, densely-fueled wildfires are also increasingly expensive, and unpredictable, to fight. The only way to break this vicious cycle is to put controlled fire back onto the land.
Bruce Babbitt, Secretary of the Interior, 1995

Landscape analysis focuses on understanding the big picture, which is a mosaic of different types of patches on the land, how these patches change over time, and the natural and human processes that influence their characteristics. An important part of landscape analysis is understanding how different communities of plants and animals change as a result of natural and human-induced disturbances and **succession**. Landscape analysis is also concerned with understanding the movements across landscapes of plants, animals, people, water, wind, fire, soil, weeds, insects, and much more. These movements both respond to and create fluctuations and changes in ecosystem conditions and processes.

Landscape design involves mapping the various landscape patches, flows, and connections, assessing how well they function, and identifying desired future conditions; identifying management actions needed to achieve these desired future conditions; and setting up a program to monitor ecosystem changes--natural changes, human-caused changes, and the effects of management actions.

Landscape analysis and design help resource managers to identify the constraints and opportunities for achieving desired future conditions and to refine stand-level treatment prescriptions for forested areas. They also aid the identification of management actions that need to be implemented in concert by the City of Boulder and other public and private landowners. Landscape analysis specifically provides insight into the way different pieces of the forest mosaic need to vary in order to produce spatial **heterogeneity** among and within patches and stands, which is critical to maintaining the quality and diversity of habitat and other natural characteristics.

1.6 IMPLEMENTATION OF THE PLAN

The Forest Ecosystem Management Plan defines different areas of the forest that require different types and levels of management intervention. Moving forest ecosystem conditions closer to the natural range of variability will require major efforts to thin and open up the forest by selectively cutting trees and conducting **prescribed burns** on an ongoing basis. These principal tools will be complemented with many other kinds of management actions, such as wildlife habitat enhancement, weed control, erosion control, restoration of hydrologic flows, reintroduction of **native species**, and management of visitor use.

The initial phase of implementation of the Plan is expected to begin in the spring of 1999. This initial effort will strive to restore forest ecosystem conditions to within the historical range of variability. The immediate priority for Open Space and

Mountain Parks staff and the wildfire mitigation crew of the Boulder Fire Department is to implement management prescriptions along the urban/wildland interface. During this initial implementation phase improvements to the Plan will be made based on information gathered during additional inventory and monitoring activities, as well as feedback from the public. Once the forest is returned to more natural conditions, ongoing management, including episodic prescribes fires, will then be needed to maintain desired forest conditions.

1.7 Public Participation

1.7.1 Citizen Involvement during Forest Plan Development

Ecosystem management is the overall goal of the Forest Ecosystem Management Plan. Ecosystem management recognizes that humans are an integral part of the natural environment and affirms that people cannot be excluded from either the development or the implementation of management plans for their public lands. In keeping with this philosophy, the development of this Plan included extensive public involvement. Over the past year, citizens have learned about the Plan and contributed to its development in a variety of ways. The result is a collaborative planning effort between land management staff and the citizens of Boulder, resulting in a better, more comprehensive Plan for Boulder's forested lands.

Information on the Plan was communicated to citizens through diverse media. The intent was to share information about the Plan, as well as to elicit response from the public on the development of the Plan. Communication with the public has included:

- Open Space and Mountain Parks web site information
- Utility bill inserts
- Newsletter mailings and placement of notices at trail heads and in other locations around the community
- Articles in the Open Space newsletter
- Public meetings
- Family and adult educational programming and field trips
- City of Boulder Channel 8 cable television programming
- Presentations to neighborhood groups, homeowner associations, and community groups
- Information booths at community festivals

1.7.2 Citizen Involvement during Forest Plan Implementation

Communication with the public will also be an essential element of successful Plan implementation. A *Citizens' Guide to the Forest Ecosystem Management Plan* was recently distributed, and will be a primary tool for informing the public about the purpose and goals of the Plan, as well as for answering commonly asked questions about Plan implementation. Diverse methods for working with the public during the implementation phase will be employed, including:

- Incorporating the goals and management actions of the Plan into community environmental education programs offered by Open Space, Mountain Parks and Fire Department staff

- Publicizing information on Plan implementation at railhead information boards
- Using appropriate signage and interpretive specialists on trails when management actions are underway
- Providing information on Plan implementation on Open Space and Mountain Parks web sites
- Working closely with neighborhoods near forested City lands to communicate information about management actions and to answer questions about the Plan

City of Boulder Forest Ecosystem Management Plan project leaders and planners have been available to answer public questions and incorporate public comment throughout the development of the Plan, and will continue to be accessible to citizens as the Plan is implemented.

Wakeup call for forest management

By Chad Oliver

GUEST COMMENTARY

Over the past several decades, dramatic changes have occurred in our forests. For many reasons, including fire suppression, forests that were once relatively open have become dense with trees and brush.

Forests are always changing. However, the current state of many Western forests is the result of well-meaning but misguided assumptions and actions. The idea that forests will thrive if left alone already has produced catastrophic results in the form of diseased trees, overcrowded forests, threatened species and wildfires. Some fires were destructive, so we prevented all fires. Some logging was inappropriate, so we extensively curtailed logging and now are harvesting about two-thirds as much wood as we grow. Instead of harvesting our own forests, we import wood and use more steel and concrete. Production of these substitutes adds carbon dioxide to the atmosphere, as does the burning of unhealthy trees in our crowded forests. As intense forest fires burn, they destroy old-growth habitats and watersheds.

I am reminded of a typical "I Love Lucy" episode in which Lucy made an incredible blunder, tried to fix it with another blunder and then went on to make a series of increasingly silly bloopers to justify earlier ones. All the players look foolish because they expend energy on justifying the past rather than resolving the issue. The show ends with the recognition that everyone is a little right and a little wrong.

Wildfire is, of course, never funny, but our handling of issues critical to good management of natural resources is little different from Lucy's approach. Today's wildfires are hotter, bigger and more destructive than since we began controlling fire almost 100 years ago. Our fire-exclusion policy has allowed trees to fill in stands once characterized by widely spaced, fire-resistant trees. Forest floors have become dense with debris, providing fuel for fires that now reach to the crowns of trees. The low-intensity, more frequent fires that once cleaned and revitalized some forests are largely a thing of the past. At the same time, the open forest that once harbored birds, butterflies and plants has dramatically diminished.

All sides of the debate are inching toward the same solution, but, like Lucy, often look silly trying to defend past actions. The solution includes thinning, planting, selective harvesting and pruning, prescribed fire and other strategies to improve the balance of the forest. The goal is to return our forests to a mixture of openings, savannas, old growth and dense conditions. In the process, timber would be removed and used, dangerous conditions would be prevented, homes for fish and wildlife would be provided and high-quality wood would grow for future generations. This wood would help to offset the costs of the operations.

But there are challenges to implementing this integrated approach. Increased federal regulation and policies make active forest management on federal lands very difficult. Our forests grow more wood and occupy more acres than they did in 1918. There is no timber shortage. But we are in danger of a shortage of high-quality trees for timber and old-growth habitat. Overcrowded trees do not grow large because they must compete for sunlight, nutrients and water. Our old growth, which is not being replaced, will be burned in the extreme fires.

We need to abandon our "management by sound-bites" style. This becomes a challenge to the media, advocates, professionals, scientists and policy-makers of all perspectives. Accurate information about complex issues must be available to the public, though it is more difficult to communicate than the "us vs. them" story. The temptation to broadcast rhetoric that only polarizes people must be resisted in the pursuit of accuracy. In the same vein, professionals and scientists need to make information understandable to the press.

Heavy rains of the extended winter have helped create ideal conditions for massive, destructive wildfires. This, coupled with the build-up of decades of diseased and dead trees on the forest floor, could combine to become a wake-up call of historic proportions. One hopes we will awaken on our own and reach consensus about the critical need for intelligent forest management.

Chad Oliver is professor of Silviculture and Forest Ecology at the University of Washington College of Forest Resources. He has written more than 80 scientific and technical publications and one book. He has been active at local, regional, national and international forest-policy levels.

Denver Post, November 15, 1998

2. Historical Range of Variability in Ponderosa Pine and Douglas-Fir Forests

In this chapter, key elements of the historical range of variability (HRV) in ponderosa pine (*Pinus ponderosa scopulorum*) and Douglas-fir (*Pseudotsuga menziesii*) forests are reviewed, both generally in the western U.S. and specifically on City of Boulder Open Space and Mountain Parks lands. This review will provide an historical context with which to assess current forest conditions and disturbance processes, as described in Chapter 3, and an ecological basis for development of specific recommendations and management prescriptions for Open Space and Mountain Parks forest stands, as described in Chapter 4.

2.1 Montane Forests

Throughout western North America montane forests are dominated by ponderosa pine and Douglas-fir. At lower elevations these forests are usually bordered by grasslands, shrublands, or woodlands, and at upper elevations they intergrade with subalpine forests. Ponderosa pine and Douglas-fir forests across Colorado and the western U.S. vary in terms of geology, climate, fire regimes, understory plant composition, and wildlife species.

In Colorado montane forests are found along the eastern and western slopes of the Southern Rocky Mountains on a variety of geological substrates and soils. In Boulder County lower montane forests form part of the easternmost area of the foothills of the Front Range at elevations from 5400 feet (1800 meters) to 6800 feet (2600 meters) along the **ecotone**, or transitional area, with the grasslands of the Great Plains. The upper montane forest type, at elevations from 6800 to 8800 feet (2260 to 2900 meters), is cooler and moister, with a predominance of Douglas-fir and the addition of other trees not usually found in the lower montane, including limber pine (*Pinus flexilis*), lodgepole pine (*Pinus contorta latifolia*), and aspen (*Populus tremuloides*). The discussion below focuses on the lower montane forests. Upper montane forests will be described in more detail in Part III of the Forest Ecosystem Management Plan.

Most early descriptions of ponderosa pine forests in the southwestern U.S. depict presettlement forests as open and "park-like," with widely spaced mature trees and abundant grass and other herbaceous (or nonwoody) understory vegetation (e.g., Biswell et al. 1973, Cooper 1960). While abundant evidence supports the generalization that presettlement forests were open and park-like for the most part, denser stands also were present and contributed to diverse landscape mosaics (Woolsey 1911). Landscape diversity in vegetation patterns is related to a large extent to local environmental variability. Unmanaged ponderosa pine forests at Cheesman Lake on the Front Range (Kaufmann et al. in revision and unpublished data) show a large range of variation in both numbers of trees and **tree basal area** (area of tree stem over total stand area) that corresponds to differences in **aspect** and topographic position of forest stands.

Spatial diversity in stand structure in ponderosa pine forests also is related to patterns of tree regeneration through time. Ponderosa pine regeneration tends to be very episodic in response to optimal climatic events (Pearson 1923, Swetnam and Brown 1992, Savage et al. 1996, Brown and Kaufmann unpublished data). Regeneration events often result in abundant seedlings (Pearson 1931) that, if they survive and become established in the overstory, influence forest structure for centuries (Swetnam and Brown 1992, Savage et al. 1996). After pulses of regeneration in the past, most tree seedlings were killed by episodic surface fires. Occasional individuals would survive repeated fires until their bark was thick enough to protect growth tissues and their crowns were high enough to escape scorching. These trees would eventually become part of the overstory. Longer intervals between fires result in increased tree density and more trees which have a chance to reach overstory status. Furthermore, there is evidence that regeneration pulses occur during cooler and wetter periods that have fewer and smaller fires.

2.2 History of Forest Disturbance

Disturbances are temporally and spatially discreet events that remove existing biomass and create both space for plant and animal colonization and resources for surviving individuals. Disturbances also damage or kill individual plants and animals and sometimes destroy or degrade resources, at least in the short term. Characteristics of disturbance regimes include the size of an area impacted by a disturbance, disturbance frequency, season of disturbance, and disturbance magnitude or severity (Pickett and White 1985). Greater variability in spatial and temporal components of disturbance regimes results in greater heterogeneity of habitats and resources for organisms. Heterogeneity in habitats contributes greatly to natural species diversity at scales from populations to regions (e.g., Ricklefs 1987). Disturbances that affect montane forests include **natural disturbances**, like fire and insect outbreaks, and human disturbances, like fire suppression and livestock grazing.

2.2.1 Natural Disturbance Patterns

Vegetation patterns across landscapes are created by the relationships between biotic processes and interactions (e.g., competition and **herbivory**), abiotic environmental constraints (e.g., soils and topography), and disturbance regimes (e.g., Urban et al. 1987, Urban 1994). The most significant natural disturbances that have influenced the montane forests of the Boulder area are fire and insects and other pathogens.

Fire

Fire has been an especially ubiquitous disturbance in western forests where rates of biomass accumulation are greater than rates of decomposition and where fuel conditions conducive to fire ignition and spread are common during long dry periods. Fire serves multiple roles in ecosystems, as discussed earlier. Heterogeneity in fire timing, area burned, and fire intensity contributes to heterogeneity of both plant and animal habitats at multiple spatial scales ranging from individual plants to landscapes, and therefore contributes to the maintenance and promotion of biological diversity in these ecosystems. Fire also contributes to the formation of snags and other coarse woody debris that serve multiple roles in forests (e.g., Harmon et al. 1986).

Episodic surface fires have been a common disturbance in montane forests of the western U.S. in general and the Boulder area in particular during the past several centuries (e.g., Cooper 1960, Amo 1976, Barrett and Amo 1982, Dieterich and Swetnam 1984, Fisher et al. 1987, Savage 1991, Goldblum and Veblen 1992, Mutch et al. 1993, Amo et al. 1995, Touchan et al. 1995, Grissino-Mayer 1995, Brown and Sieg 1996, Swetnam and Baisan 1996, Veblen et al. 1996, Fulé et al. 1997). Ponderosa pine trees are well-adapted to low-intensity surface fires. Ponderosa pine trees have thick bark that protects active growth layers (cambium) from lethal temperatures and high crowns in mature trees that decrease the degree of crown scorch. Mature ponderosa pine trees are rarely killed by surface fires, except where local fuel loads are high or windy or dry conditions cause fire to migrate from surface fuels to tree crowns. Mortality of overstory trees occurs when either the cambium is completely killed around a tree's circumference or enough of the crown is scorched or consumed so that photosynthetic capacity is compromised. Mutch (1970) suggests that, through natural selection, ponderosa pine has evolved mechanisms that both protect individuals from lethal fire effects and enhance fuel conditions that promote surface fires in ponderosa pine stands.

A number of studies have reconstructed historical patterns in fire regimes in ponderosa pine forests of the Front Range and Boulder areas (Table 2.1). These studies used **fire scars** recorded within tree ring series as records of past fire occurrences. Fire scars result when surface fire kills a portion of a tree's growing circumference, forming a characteristic lesion visible in the tree rings. Dates of fires and fire frequency are determined either by ring counts on living trees or by dendrochronological methods. Some fires leave no fire scars, so fire frequency numbers based on fire scar data may underestimate true fire frequency. However, this data is still useful as it provides an approximation of historical fire frequencies. **Dendrochronology** is preferable, since it provides absolute dates for fire events, allowing comparison of fire years between sites and of annual climate variability and fire-climate relationships. Fire frequency is the variable of a fire regime most commonly reconstructed in ponderosa pine forests, although some studies also have reconstructed other components of fire regimes, including spatial patterning, seasonality, and **fire intensity** (Brown et al. in press, Veblen et al. in review).

Two recent studies of historical patterns of surface fires in forests of Boulder County, funded in part by City of Boulder Open Space, have been used to reconstruct fire frequency in the montane forests of Boulder County. Goldblum and Veblen (1992) and Veblen et al. (1996) reconstructed fire histories at over 40 locations in the montane forests of Boulder County and on the southern fringes of Rocky Mountain National Park (Table 2.1). They found highly variable fire frequencies that are related to the period and location examined and to the size of the area where fire scar samples were collected.

In general, Veblen et al. (1996) found the highest fire frequency in the lowest elevation stands, especially those on the ecotone with the Great Plains grasslands. In the lowest elevation stands, Veblen et al. (1996) reconstructed presettlement **mean fire intervals** (MFI) of around 8 to 14 years (Table 2.1). At

Table 2.1: Historical Fire Frequency in Ponderosa Pine Stands of the Front Range of Colorado.

Study, Site Names, and Periods of Analysis	Type of Analysis [1]	No. of Intervals	Mean Fire Intervals ± SD [2]	Range of Intervals (in years)
Laven et al. 1980, Wintersteen Park, Cache la Poudre River:				
full chronology (1708 to 1973)	unknown	-	45.8	3 to 161
pre-settlement (pre-1840)	"	-	66.0	5 to 157
settlement era (1840 to 1905)	"	-	17.8	3 to 161
suppression era (post-1905)	"	-	27.3	8 to 146
Skinner and Laven 1983, Rocky Mountain National Park:				
full chronology (1703 to 1968)	all fires	24	11.0 ± 11.7	1 to 51
pre-settlement (1703 to 1840)	"	6	21.5 ± 18.2	5 to 51
settlement era (1840 to 1905)	"	9	7.0 ± 6.1	1 to 18
suppression era (1905 to 1968)	"	8	7.8 ± 6.7	1 to 19
Goldblum and Veblen 1992, Fourmile Canyon [3]:				
full chronology (1721 to 1949)	all fires	14	16.3 ± 15.4	2 to 49
pre-settlement (1721 to 1840)	"	3	30.3 ± 24.2	3 to 49
settlement era (1840 to 1905)	"	6	8.7 ± 5.6	2 to 17
suppression era (1905 to 1949)	"	9	9.1 ± 8.0	4 to 28
Veblen et al. 1996, Boulder County clusters of sites:				
Losobo (1703 to 1995)	≥2 trees with scars	-	11.2 ± 8.4	1 to 29
Midsob (1654 to 1995)	"	-	23.4 ± 28.3	1 to 73
Lomidb (1684 to 1995)	"	-	19.0 ± 26.6	1 to 102
Fourmi (1581 to 1995)	"	-	16.9 ± 23.0	1 to 63
Uplh (1624 to 1995)	"	-	19.5 ± 44.0	1 to 162
Jamsal (1567 to 1995)	"	-	11.7 ± 13.2	2 to 34
Sosv (1595 to 1995)	"	-	19.9 ± 16.2	2 to 53
Norths (1696 to 1995)	"	-	19.9 ± 14.7	3 to 38
Veblen et al. 1996, Boulder County individual sites[4]:				
Site 11 (1684 to 1902)	all fires	4	54.3 ± 33.5	28 to 101
Site 12 (1707 to 1880)	"	4	43.3 ± 38.0	7 to 79
Site 13 (1597 to 1860)	"	6	43.8 ± 24.7	9 to 65
Site 14 (1763 to 1916)	"	11	13.9 ± 9.0	6 to 29
Site 15 (1680 to 1916)	"	28	8.4 ± 6.3	2 to 29
Brown et al., unpublished data (site locations in Figure 2.1) [5]:				
Lone Pine, LPI (1568 to 1887)	all fires	5	63.8 ± 49.2	10 to 122
Wet Gulch Burn, WGB (1593 to 1908)	"	8	39.4 ± 27.4	8 to 79
M. Kaufmann's Cabin, MKC (1609 to 1916)	"	15	20.5 ± 12.8	3 to 50
Parachute Hill, PAF (1654 to 1871)	"	7	31.0 ± 15.8	12 to 57
Mica Mine, MMF (1524 to 1885)	"	14	25.8 ± 13.8	4 to 52
Lefthand Canyon, LEF (1531 to 1911)	"	13	29.2 ± 15.1	11 to 69

[1] All fires recorded at a site or a subset of fire years. [2] Mean fire interval ± 1 standard deviation in years. [3] Numbers calculated by Swetnam (1997). [4] Sites 11 to 13 are west of Boulder Mountain Park and sites 14 and 15 are at the mouth of Eldorado Canyon. Fire frequency data for these sites were calculated for this report. [5] Data for these sites are reported in three unpublished reports (Swetnam et al. 1992, Swetnam 1997, and Brown 1997).

higher elevations, fire frequency was lower, with MFIs increasing to 20 to 30 years in clusters of sites and even less frequently at individual sites that averaged up to 40 to 50 years between fires. Veblen et al. (1996) suggest that crown fires were more common in higher elevation forests than in lower elevation forests of the ponderosa pine-Douglas-fir zone. The occurrence of crown fires tends to increase with increasing elevation because higher elevation forests are more productive and intervals between fires are longer (Veblen et al. 1996).

In addition to Veblen et al.'s work, Brown et al. (unpublished data) recently completed a network of fire chronologies from multiple sites along a latitudinal transect in the southern Rocky Mountains extending from the San Luis Valley in the south to the Laramie Peak area of Wyoming in the north (Figure 2.1). This network consists of well-dated, well-replicated chronologies of fire events developed from fire-scarred trees collected from sites no more than about 123 acres (50 hectares) in size (e.g., Brown and Sieg 1996, Swetnam and Baisan 1996). Fire chronologies from the Southwest and the Black Hills in South Dakota were collected using comparable methodology. This extensive, absolutely-dated network of fire dates and spatial patterns will be used to examine variability in fire regimes, fire timing, and fire/climate relationships in ponderosa pine forests from the Southwest to the northern Rocky Mountains.

Brown et al.'s unpublished data suggest that fire frequency was highly variable in ponderosa pine forests in the Front Range, but that recognizable patterns were present along gradients in elevation and latitude. The fire chronologies shown in Figure 2.1 are consistent with presettlement fire frequencies along elevation gradients found by other studies in the Front Range near Boulder (see Table 2.1). Mean fire intervals are highly sensitive to the size of the area sampled. Mean fire intervals are highly sensitive to the size of the area sampled. Smaller sites tend to have lower fire frequencies than larger areas (Brown and Swetnam 1994). Veblen et al.'s lower sites (number 14 and 15) recorded fires an average of every 11.2 years, while trees at MKC near Fort Collins recorded fires an average of every 20.5 years.

None of the fire chronologies that Brown et al. have developed from the Boulder area or from the Front Range in general document any increase in fire frequency in the middle to late 1800s, suggesting that the increased fire frequency during the settlement era found by other studies may have been localized to areas of either heavy mining activity or railroad activity. However, in all areas in the Front Range surface fires ceased for the most part by the late 1800s, a pattern seen in virtually every fire history study in ponderosa pine forests in the western U.S. (e.g., Swetnam and Baisan 1996). Although there is abundant research that documents that frequent surface fires were the typical disturbance regime in ponderosa pine forests throughout its range in all areas of the western U.S., stand-replacing fires also occurred, especially in the higher elevation montane forests.

Many of the same fire years were recorded at sites up and down the Front Range and can be related to variations in the regional climate (Veblen et al. 1996). Veblen et al. and Brown et al. document several widespread fire years in the past several centuries, including 1654, 1685, 1723, 1781, 1812, 1842, 1851, 1861, and 1880. The influence of annual climate variability and the El Niño/Southern Oscillation (ENSO) on past fire occurrence is currently being investigated (Veblen

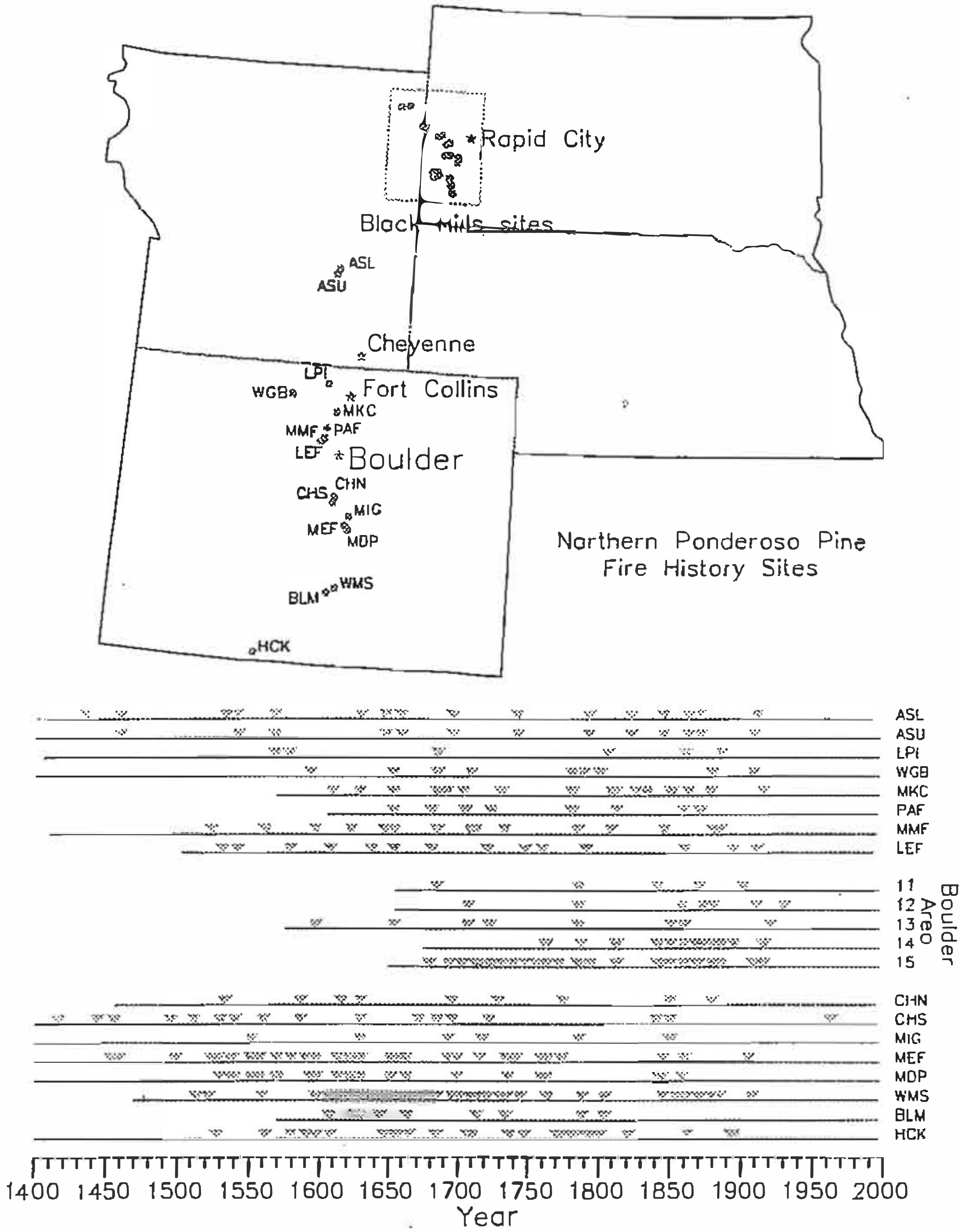

Figure 2.1: Selected Locations and Chronologies of Surface Fire Histories from Ponderosa Pine and Ponderosa Pine - Douglas-Fir Forests in the Front Range of Colorado and Vicinity. Location of fire history sites collected by Brown et al. (unpublished data) are shown on the map. Fire chronologies are shown in the graph below the map. Time spans of fire chronologies are indicated by horizontal lines with fire dates at each site indicated by inverted triangles. Five fire chronologies collected by Veblen et al. (1996) in the Boulder area (sites 11 to 15) are also shown. Note the almost complete absence of fire after 1920 due to policy of fire suppression implemented by the U.S. Forest Service and other land management agencies.

et al. 1996, Brown et al. unpublished data). Data analyzed so far indicate that there was a strong relationship between ENSO and historical fire occurrences, with a significant decrease in fire occurrences during, and a marked increase in widespread fire occurrences 3 to 4 years following, El Niño events (Veblen et al. 1996). This pattern is similar to fire-climate relationships seen in southwestern ponderosa pine ecosystems (Swetnam and Betancourt 1990, Swetnam and Baisan 1996). Increased precipitation during El Niño events results in higher fuel moisture than can limit fire occurrence, but in subsequent years increased growth of grasses and other herbaceous fuels can support fire (Swetnam and Betancourt 1990).

Finally, another recent fire history study completed at Cheesman Lake on the South Platte River in the Front Range reconstructed fire frequency, spatial patterning, fire intensity, and fire seasonality over the past several centuries across the ponderosa pine landscape of this area (Brown et al. in press). The Cheesman study area is a ponderosa pine forest surrounding Cheesman Lake on the South Platte River (Kaufmann et al. 1997). The Cheesman Lake landscape is unique on the Front Range in that it has had few management impacts during the 1900s. Cheesman Lake was created by the construction of a dam on the South Platte River in 1905 and the landscape has remained virtually untouched by human land use since that time. Livestock grazing was eliminated by construction of a fence around the property at the time of dam construction and the area has never been logged, although some trees were cut during the region-wide mountain pine beetle outbreak in the 1970s. Recreational use of the area has been restricted to protect the watershed immediately surrounding the reservoir.

Fire regime parameters (spatial extent of burned areas, fire frequency, fire severities, and season of fire occurrences) were reconstructed across a 15 square mile (40 square kilometers) study landscape at Cheesman Lake to assess the long-term stability of fire regimes in this area. From the fire record developed at Cheesman Lake, Brown et al. (1999) infer that the area burned during fire years, the length of time between fires, the intensity or severity of individual fire events, and the season of occurrence of fires varied considerably across this landscape and over the period covered by the fire chronology from 1197 to the present. Fire sizes ranged from the scale of individual trees or small clusters of two or three trees to fires that covered the entire landscape. Intervals between fire years ranged from 1 to 29 years across the entire landscape to 3 to 58 years at one stand, to up to 155 years at other stands.

Fire severity also varied, with evidence of both surface fire and crown fire in the ponderosa pine forest at Cheesman Lake. A widespread fire during 1851 was apparently a crown fire across large areas of the landscape and was most likely related to both crown and understory conditions that resulted from optimal climate conditions in the early 1800s (Kaufmann et al. in revision, Brown et al. in press).

The seasonal position of fire scars within tree ring series also suggest that fires burned at all times of the summer and during late spring and early fall during different years, with no set season of fire occurrence. The overall fire history from Cheesman Lake prior to fire suppression documents a great deal of heterogeneity in the fire regime over the past several centuries in this area. Brown et al. (in press) conclude by suggesting that since there has been little stability in parameters of the fire regime, vegetation patterns across the landscape also have been variable at multiple scales.

Other Natural Disturbances

In addition to fire, other major natural disturbances in ponderosa pine and Douglas-fir forests include insects and pathogens, such as species of bark beetles, defoliators, dwarf mistletoes, and root pathogens (Wilson and Tkacz 1996). Although there is generally limited information on the historical range of variability of these disturbance agents, the majority of these species are natives and have co-evolved with their hosts for millennia. For further information on forest insects and diseases see the *Forest Inventory Handbook* (City of Boulder 1998a).

Bark Beetles

Numerous species of bark beetles affect ponderosa pine forests. The mountain pine beetle (*Dendroctonus ponderosae)* is the most common and often the most devastating (Pearson 1950). During recent mountain pine beetle epidemics, nearly 100% of overstory trees were killed over large areas (Schmid and Mata 1996). Little historical data exist for mountain pine beetle outbreaks prior to the 1900s (Wilson and Tkacz 1994), especially from Front Range ponderosa pine forests. Roe and Amman (1970) document major outbreaks from Colorado to Idaho in the late 1800s and early 1900s. Recent outbreaks--notably the outbreak during the late 1970s and early 1980s that occurred in many areas of the western U.S. including the Front Range (Wilson and Tkacz 1994)--have been more widespread in extent and more severe in terms of numbers of trees killed. At least part of the increasing severity and extent of outbreaks has been attributed to increases in tree density and landscape homogeneity of stands during the 1900s as a result of fire suppression (Roe and Amman 1970, Wilson and Tkacz 1994, Schmid and Mata 1996).

The Douglas-fir bark beetle (*Dendroctonus pseudotsugae*) is a major pathogen on Douglas-fir in the Front Range and can cause extensive mortality, especially in conjunction with western spruce budworm (Hadley and Veblen 1993, Schmid and Mata 1996). Recent outbreaks have occurred every 15 to 35 years, and epidemic conditions have lasted from 5 to over 15 years (Hadley and Veblen 1993, Schmid and Mata 1996). Outbreaks of Douglas-fir beetles occurred simultaneously in several locations in Colorado during the 1930s (Schmid and Mata 1996), again suggesting that landscape homogeneity of forest conditions may be leading to more extensive epidemics.

Mistletoe

Other major pathogens in montane forests of the Front Range are the highly specialized dwarf mistletoes in the genus *Arceuthobium* (Hepting 1971, Hawksworth and Shaw 1984, Hawksworth and Weins 1996). The southwestern dwarf mistletoe (*A. vaginatum* subsp. *cryptopodum*) causes the most significant damage to ponderosa pine (Wilson and Tkacz 1994). The Douglas-fir dwarf mistletoe (*A. douglasii*) can be common in Douglas-fir stands. The spread and intensity of infection by dwarf mistletoe are related to tree, stand, and environmental factors. Dwarf mistletoes affect wildlife habitat by providing food, nesting and foraging sites for many species of passerine birds. Although there is little historical information on dwarf mistletoes, they were most likely well established in southwestern forests prior to early settlement. Based on present understanding of mistletoe ecology and structural changes in southwestern forests, Dahms and Geils (1997) infer that mistletoe abundance may have increased during the post-settlement period.

Budworms

A major defoliator affecting Douglas-fir stands is the western spruce budworm (*Choristoneura occidentalis*), and long histories of its effects on forest structure and tree growth in New Mexico and the Front Range are available from tree-ring data (Hadley and Veblen 1993, Swetnam and Lynch 1989, 1993). Hadley and Veblen (1993) show that impacts from spruce budworm are related to stand structure and tree ages. Young stands were minimally impacted by defoliation from spruce budworm, while multi-aged, dense stands were more heavily affected. Historical outbreaks in the Front Range tended to be asynchronous between stands, with localized heavy impacts on tree growth and stand structure. Swetnam and Lynch (1987, 1993) documented nine regional outbreaks from 1690 to 1989 in northern New Mexico. One stand of trees showed that budworm and Douglas-fir may coexist at the same stand for up to 700 years. However, Swetnam and Lynch (1993) conclude that changes in the recent century have led to more widespread and intense mortality when outbreaks occur. Mixed-conifer forests have greatly expanded in extent and density during the post-settlement fire suppression period (Swetnam and Lynch 1989, Johnson 1995) and increases in landscape homogeneity have resulted in larger landscape-scale outbreaks.

Root Diseases

Other disturbances in ponderosa pine and Douglas-fir stands are root diseases, especially species of *Armillaria* in ponderosa pine forests, and *Heterobasidion annosum* in Douglas-fir. These pathogens may cause extensive local mortality (Lundquist 1995, Wilson and Tkacz 1994), although generally not on the spatial scale of the mountain pine beetle or some other pathogens. *Armillaria* is present in Front Range forests, although it historically has not resulted in the extensive mortality, as it has in the Black Hills (e.g., Lundquist 1995). Douglas-fir is more prone to root diseases than ponderosa pine and shifts in species composition in ponderosa pine-Douglas-fir forests, where Douglas-fir replaces ponderosa pine, may result in an increased abundance of susceptible hosts and a higher incidence of mortality (e.g., Hagle and Goheen 1988, Swetnam and Lynch 1989).

2.2.2 Impacts of Human Disturbance

Ponderosa pine and Douglas-fir forests throughout the West have been heavily utilized for logging, grazing, and recreation during the last 150 years. Much of the presettlement forest east of the Continental Divide, including the Boulder area, was logged in the middle to late 1800s for timber for mines and ties for the early railroads. Between 1870 and 1960, about 40% of all the timber harvested in Colorado was ponderosa pine (Miller and Choate 1964). Uncontrolled fires started by miners or trains also took their toll, with large areas of the foothills and mountains denuded of trees by the late 1800s or early 1900s (Veblen and Lorenz 1986, 1991).

CHANGES IN FOREST OVERSTORY STRUCTURE

Dramatic shifts in the structure and tree density of ponderosa pine forests over the past 100 years have been documented for many areas of the western U.S. Many studies show that low-density, open-canopy ponderosa pine forests composed primarily of mid- to large-diameter overstory trees have changed over the past century to forests composed of smaller-diameter, usually suppressed trees, often to the competitive detriment of any older overstory component that may be left in a stand (Biondi 1996). In mixed-conifer stands in the southwest, studies have also documented shifts in species dominance, with shade-tolerant and fire-intolerant species like Douglas-fir replacing pine species (e.g., Swetnam and Lynch 1989, Fulé et al. 1997).

Several studies have reconstructed presettlement forest stand age and size structures in ponderosa pine forests, making it possible to quantify the HRV of these forest components (Covington and Moore 1992, 1994, McAdams 1995, Arno et al. 1995, Edminster and Olsen 1996, Fielder et al. 1997, Covington et al. 1997, Fulé et al. 1997, Brown et al. unpublished data). These studies show significant increases in densities of smaller and middle diameter trees and decreases in larger diameter trees due to logging of stands (e.g., Arno et al. 1995, Covington et al. 1997, Fulé et al. 1997) or to increased competition with subcanopy trees (e.g., Biondi 1996). Logging also had a large impact on landscape patterns in ponderosa pine forests because of selective removal of most, if not all, forest stands that were in old-growth status (Covington and Moore 1992, Fulé et al. 1997).

Episodic regeneration of trees is evident in the age structure of forest stands at Cheesman Lake, with pulses of establishment during the late 1600s, 1720s, 1780s to 1790s, 1830s to 1850s, and the 1880s to 1890s (Kaufmann et al. in revision). The 1830s to 1850s and 1880s to 1890s pulses were especially pronounced and most living trees at Cheesman date to these regeneration events. There is tentative evidence that these regeneration events were related to cooler and wetter climate conditions and therefore may have been regional events in the Front Range (Swetnam and Brown 1992, Savage et al. 1996, Swetnam and Betancourt 1999; Brown and Kaufmann unpublished data).

Repeat photography (Veblen and Lorenz 1991) and analyses of tree age structure (Veblen and Lorenz 1986) have documented the effects of nineteenth century **non-Native American settlement** on forest structure and landscape patterns in the Boulder area. These studies show that ponderosa pine forests were heavily impacted by early settlement in the Boulder area. Present-day forests consist of relatively young trees that matured after unbridled use of the forest was curtailed by land management efforts that began in the early 1900s. Mast et al. (1997) also document the expansion of ponderosa pine forest in the foothills during the 1900s using repeat sequences of aerial photographs. This expansion occurred both in areas that were occupied by ponderosa pine forest prior to an increase in logging and fires in the middle 1800s and in areas that were once either forest **savannas** or prairie grasslands.

Goldblum and Veblen (1992) and Veblen et al. (1996) defined three distinct fire regime periods in the Boulder area that correspond to increasing human use of the landscape. The first is the Native American period from the 1600s to 1840, which was characterized by episodic, moderately-frequent, surface fires. It is impossible to know what percentage of these fires may have been started by humans or lightning, but most likely at least some of these fires were started by Native Americans. There are numerous historical records of Native American setting fires in the western U.S., including the central Great Plains (e.g., Higgins 1986). On the other hand, recognizable relationships between fire and climate variability are evident in the fire scar records, and suggest that regional climate variability influenced fire occurrence and spread by affecting both fuel loading and seasonal patterns of fuel moisture (Veblen et al. 1996, Brown et al. unpublished data).

The second period in the fire histories is the non-Native American settlement period from 1840 up to 1905. This period was characterized at most sites in the Boulder County area by higher fire frequency than in the previous period. Laven et al. (1980) and Skinner and Laven (1983) also found higher fire frequency during the period of early non-Native American settlement at other locations in the Front Range (see Table 2.1). Increased fire frequency during this period may have been related to the increased sources of ignition that came with settlement, especially during the mining boom that began in the 1850s (Goldblum and Veblen 1992). For example, prospectors were reported to have set fires to reveal geological features, and early wood-burning trains in the foothills often started fires (Goldblum and Veblen 1992).

The third phase is the fire suppression period that began in earnest after the devastating fires of 1910 in the northern Rockies (Plummer 1912) and the subsequent designation of the Forest Service's **"10 A.M." policy** of total fire suppression which attempted to put all wildfires out by 10 A.M. of the next day (Pyne 1982). This period is characterized in most areas by much reduced fire frequency (see Table 2.1).

In addition to active fire suppression by land management agencies, grazing by large numbers of livestock often is cited as a reason for the decrease in surface fires beginning in the middle to late 1800s (Savage 1991, Touchan et al. 1995, Swetnam and Balsan 1996, Brown and Sieg 1996). Intensive grazing during that time reduced the **cover** of grasses and other fine fuels necessary for fire propagation. Geographical **fragmentation** of landscapes caused by road and fence construction also tends to reduce the amount of area burned during any fire event and most likely contributed to reduced fire frequencies at individual locations (e.g., McPherson 1997).

CHANGES IN FOREST UNDERSTORY STRUCTURE

Recent shifts in forest structure have led to a series of known or hypothesized changes in other components of ponderosa pine and ponderosa pine-Douglas-fir forests, including decreased understory diversity, extirpation of species, reduced **nutrient cycling**, reduction in surface and subsurface hydrology, and increased risk of crown fires owing to increased fuel loads and the presence of ladder fuels (e.g., Covington and Moore 1994).

Use of the concept of historical range of variability has focused on disturbance regimes and forest stand structure because fire scars and tree rings can be used to establish relatively complete records that extend several centuries into the past. However, the concept of HRV also applies to other ecosystem characteristics. For example, large animal herbivory is a process that is known to influence the structure and species composition of grasslands and understory vegetation of woodlands and forests. Unfortunately, data that can be used to estimate the historical range of variability of other processes or structural elements of ponderosa pine and Douglas-fir on City of Boulder lands do not appear to be available.

However, inferences may be made about other ecosystem components based upon data available from present-day ecosystems. Several studies have related changes in understory production and diversity to changes in overstory tree density in ponderosa pine forests (Pearson 1933, Pearson 1942, Pase 1958, Clary et al. 1975, 1976, Kooiman and Linhart 1986, Covington and Moore 1994). These studies show that the number of understory species and the amount of biomass decrease with both increases in canopy coverage and accumulation of duff layers and needle litter on the forest floor. Available light reaching the forest floor decreases with increases in canopy coverage. Increased tree biomass also results in greater capture of nutrients and water in the forest environment. Increased duff and litter layers reduce openings for understory plants that require mineral soils for germination. Cooper (1960) and Covington and Moore (1994) suggest that the high understory biomass of presettlement forests was most likely the result of high nutrient cycling from frequent surface fires and less competition from overstory trees (see also Amo et al. 1995, Covington et al. 1997).

Additional understory data for Front Range ponderosa pine forests will eventually be available from future City of Boulder studies, as well as studies such as one currently underway at Cheesman Lake (Kaufmann et al. 1997 and unpublished data). These data will be useful for refinement of management directions in City of Boulder forests as they become available in the near future.

In summary, research on the historical range of variability in ponderosa pine-Douglas-fir forests has shown that:

- Disturbance (biotic and abiotic) is a major factor in shaping the structure and function of the montane forest ecosystem.
- Greater variability in spatial and temporal components of disturbance regimes results in greater heterogeneity of habitats (and, as a consequence, greater species diversity).
- Ponderosa pine and other species are well-adapted to low-intensity surface fires-
- Fire frequency is highly variable in ponderosa pine forests in the Front Range. The highest fire frequency is found in the lowest elevation stands, especially those that fringe the ecotone with the Great Plains grasslands.
- Over the last 100 to 150 years, human activities have profoundly altered the structure and function of the montane forest ecosystem.

Information on the recent forest understory and overstory inventories completed by Open Space and Mountain Parks is presented in the next chapter of the Plan, which describes current conditions on City of Boulder forests.

3. RECENT AND CURRENT CONDITIONS IN CITY OF BOULDER FOREST ECOSYSTEMS

3.1 CITY OF BOULDER FORESTS

City of Boulder forest lands are part of the Front Range of the Southern Rocky Mountains, the easternmost mountain range in Colorado, which extends for 185 miles from central Colorado to southern Wyoming. The Front Range is about 40 miles (64 kilometers) wide, but the foothills section is only 2 to 4 miles wide (3 to 6.5 kilometers), forming a narrow band of montane forests, meadows, and rocky escarpments dissected by numerous mountain streams (Hess and Alexander 1986). This ecotonal forest, where the Great Plains and the Southern Rocky Mountains meet, is a linear vegetation zone which contains unique assemblages of plants and animals (Marr 1964, Weber 1995).

Lower montane forests, found in this area between 5400 and 6800 feet (1800 to 2300 meters), are dominated by ponderosa pine (*Pinus ponderosa scopulorum*) and are bounded on the east by the grasslands of the Great Plains and on the west by the more mesic forests of the upper montane zone. Ponderosa pines grow here in a mosaic of grasslands, savannas (open forest-grasslands), woodlands, and closed-canopy forests. Douglas-fir (*Pseudotsuga menziesii*) occurs both in mixed stands with ponderosa pine and in pure stands in cooler, more mesic areas. Rocky Mountain juniper (*Sabina scopulorum*) and limber pine (*Pinus flexilis*) occur regularly, but with lower frequency. Many species of native shrubs occur in the forest understory, including the abundant three-leaf sumac (*Rhus aromatica trilobata*) and wax currant (*Ribes cereum*). The herbaceous (or nonwoody) vegetation consists of a diverse mix of **forbs**, grasses, and dryland sedges.

Upper montane forests at elevations from 6800 to 8500 feet (2300 to 2800 meters) are cooler and more humid than lower elevation forests and have a shorter growing season. Ponderosa pine and Douglas-fir are still the dominant trees, but tree density is typically higher and Douglas-fir is usually more abundant than ponderosa pine. In addition, limber pine (*Pinus flexilis*), lodgepole pine (*Pinus contorta latifolia*), and aspen (*Populus tremuloides*) form stand-types that are not typically found in the lower montane forests. Analysis of data collected in the upper montane forests will be included in Part III of the Forest Ecosystem Management Plan.

Biological diversity is high in montane areas along the Front Range (Peet 1981, Weber 1995, Hogan 1994, Schroeder 1996), due to the variety of habitats that occur as a result of steep environmental gradients (elevation, slope, aspect, soils, and moisture availability). Montane vegetation on the Front Range is better developed on the east slope than on the west slope (Marr 1964). Several sensitive **plant communities** that may require special management and/or protection have been documented here, including foothill prairies, riparian shrublands, and ponderosa pine savannas (Mullen et al. 1992, Colorado Natural Heritage Program 1999). In addition, wildlife diversity is greater in lower montane forests than in the forests found at higher elevations (Schroeder 1996).

The climate in Boulder County is semiarid and continental, with an average annual precipitation of 18 inches, and large daily and seasonal temperature ranges. Humidity and precipitation are both low, but precipitation is concentrated in March, April and May, the beginning of the growing season. Summer droughts are not uncommon, but in recent years precipitation in Boulder County has been above average. Although average annual snowfall is 75 inches, some winter months can also be dry, causing significant winter drying of soils and plants. Drying down slope winds are common and extremely high winds (occasionally over 100 miles an hour) also occur. Hailstorms can be locally devastating to vegetation, stripping trees and other plants of their foliage. Lightning strikes are common during summer thunderstonns (Callahan 1986).

3.2 Project Greenslope

The first inventory of the natural resources on forest lands owned and managed by the City of Boulder was completed in the mid-1970s by the Colorado State Forest Service (McNair 1975). This inventory was designed to provide City staff with specific site recommendations for protection and preservation of natural resources on Mountain Parks and Open Space lands. Abiotic resources, such as soils, and biotic resources, including forest and grassland vegetation, were inventoried to provide guidelines for management actions on individual management units.

Beginning in the early 1970s and extending through the early 1980s, the areas that then comprised the City of Boulder's forested ecosystems experienced extensive tree mortality from an epidemic of mountain pine beetles that killed large numbers of ponderosa pine trees along the Front Range (Pirnak 1979, Colorado State Forest Service 1982). In 1977 a City Forester was hired to help coordinate a mountain pine beetle control program that included harvesting and chemical treatments of trees infested with mountain pine beetle. However, given the high tree mortality caused by the mountain pine beetle epidemic, it was soon apparent that greater management intervention was needed and Project Greenslope was initiated (Colorado State Forest Service 1982). Project Greenslope was designed to treat not just the symptoms, but what was widely perceived as the underlying cause of the epidemic, namely, dense, overstocked stands of trees that not only favored mountain pine beetles but also increased the risk of catastrophic fires (Colorado State Forest Service 1982).

During Project Greenslope, forest stands were identified and prioritized for treatments. Treatments often involved heavy thinning of smaller-diameter ponderosa pine and Douglas-fir trees. Other activities during Project Greenslope included rehabilitation of hiking trails and fire access roads, as well as wildlife habitat improvements, including snag creation. A long-term plan for thinning and harvest treatments was outlined in the final Project Greenslope report (Colorado State Forest Service 1982). This plan was designed to maintain open stand conditions and thereby reduce the fire danger and possible incidence of mountain pine beetles in the future. Project Greenslope was an early effort at ecosystem management, since long-term ecosystem integrity, including human use of the ecosystem, was central to development of the plan. However, recommendations made during Project Greenslope for follow-up treatment of stands were never implemented, and tree regeneration since the early 1980s has resulted in stand

.conditions in some areas that are similar to those that existed prior to Project Greenslope.

3.3 Recent City of Boulder Forest Inventory

To assess current conditions in the forested ecosystems managed by the City of Boulder, both Open Space and Mountain Parks recently completed extensive forest overstory and understory inventories. Different methodologies were used to characterize the overstory and understory components of the forest. These methodologies are described in detail in the *Forest Inventory Handbook* (City of Boulder 1998a). For the most part, Open Space and Mountain Parks used the same methodologies to collect inventory data. In some instances, however, the methodologies were different, as explained below.

3.4 Mountain Parks Forest Inventory

Mountain Parks data are currently being analyzed and will be presented in Part II and Part III of the Forest Ecosystem Management Plan. Desired future conditions, management objectives, and monitoring protocols will be developed for Mountain Park lands following data analysis. The current status of the forest inventory on Mountain Park lands is described below.

3.4.1 Design Elements

The Forest Ecosystem Management Plan was designed to look at the unusual diversity of forest types occurring from 5400 to 8500 feet (1800 to 2800 meters) elevation on City lands. It is central to the design of the Plan to develop the ecosystem model at a landscape scale, as discussed in Chapter 1. The Mountain Parks landscape includes outflow mesas, colorful meadows, lush drainages, seeps and springs, thickets of shrubbery, rock and talus, and mountain peaks. Forests of ponderosa pine (*Pinus ponderosa scopulorum*), Douglas-fir (*Pseudotsuga menziesii*), limber pine (*Pinus flexilis*), lodgepole pine (*Pinus contorta latifolia*), aspen (*Populus tremuloides*), and Rocky Mountain juniper (*Sabina scopulorum*) cover this diverse landscape. How do the pieces fit together? How does staff focus in on project areas for thinning, prescribed burning, and improving wildlife habitat and at the same time see the system as a whole?

A **Geographic Information System** (GIS) is being used to map Mountain Parks forest species and canopy densities, as well as other types of land cover, such as grasslands and shrublands. Forest stand maps show forests by **age classes**, canopy cover, and tree heights to show the size of forest patches and how they exist three dimensionally on the landscape. The study of understory patterns related to tree age classes provides the basis for monitoring native **species richness** in the forest landscape and specific changes related to management actions. Forest measurements, such as basal area, when related to structural stages, provide a quantitative tool for shaping tree age and size groups when designing prescriptions for management actions.

Forest types are being correlated with the environmental elements of slope, aspect, elevation, soils, and geology to show similar and contrasting patterns on the landscape, which can be identified as ecological units. Ecological units offer a powerful technique for clustering management techniques related to environmental gradients and predicting successional patterns through time. The GIS database will be invaluable for tracking and mapping changes in the forest through time, especially as these changes are related to management practices and desired future conditions.

Data from a riparian survey and hydrologic study conducted during 1997 and 1998 are being incorporated in the GIS database and are integral to the Forest Ecosystem Management Plan. The interrelationships among topography, forest cover, soil movement, and stream flow are central to ecosystem function. The riparian studies are providing information on plant communities in rich riparian corridors that are important to wildlife and to the unusually high numbers of sensitive plant species found in Mountain Parks.

The recent inventory of Mountain Parks forest stands represents a sample of current forest types. Despite the constraints of budget and staff, the sample is generally representative of the rich diversity of forest types. While not a full inventory, the GIS database provides a framework and versatile tool for storing information, defining management actions, and conducting long-term planning. Although information varies in depth and completeness, new information will continually be added to the feedback loop for adaptive management.

3.4.2 Project Status

Forest Overstory Inventory

Field work and vegetation mapping to support the Forest Ecosystem Management Plan began in Mountain Parks in late 1996. During the 1997 field season, Mountain Parks contracted with the Colorado State Forest Service for overstory sampling. A five-cluster plot method was used. In addition, Mountain Parks Staff, using the cruise line method, sampled five stands on Enchanted Mesa. In 1998, Mountain Parks staff conducted cruise line sampling using a methodology similar to the one used by Open Space. Representative forest stands were chosen on the basis of tree species, canopy cover, aspect, and elevation.

Forest Understory Inventory

Understory sampling followed methodology used by the U.S. Forest Service in conducting Integrated Resource Inventories. This methodology differed from the cover point method used by Open Space. The Forest Service circular plot was used by Mountain Parks because it produces comparative data in highly varied terrain and allows sampling in stands too steep for use of the cover-point device used by Open Space. The types of plots used during the Mountain Parks inventory are summarized in Table 3.1.

Table 3.1: Summary of Mountain Parks Inventory Plots			
Type of Plot	Number of Clusters/Stand	Number of Overstory Plots	Number of Understory Plots
Five-Point Cluster	34	170	17
Cruise Line Stands	35	360	88
Totals	69	530	105

Riparian Wetland Study

Fifty-four hydrologic function and vegetation plots were established in 1997 and 1998. Nineteen hydrologic stations were installed to monitor water flow and physical characteristics of water. Three stations were sampled in cooperation with the Water Quality Department to monitor cumulative aspects of water chemistry.

Global Positioning System Locations

Precise Global Positioning System location data for all permanently-monumented understory and riparian plots are being completed. Global Positioning System locations are important for correlating the GIS database with locations in the landscape, and offer an invaluable tool for mapping and analysis. Precise locations are critical for long-term monitoring.

Data Analysis

All 1997 and 1998 data from forest and riparian plots are currently being analyzed. The data analysis has been divided into two parts. Analysis of stands and clusters along the eastern and northern edges of Mountain Parks, and stands which are most contiguous to Open Space stands designated for thinning or prescribed fire, will be presented in Part II of the Plan. These areas include Enchanted Mesa and Anemone Hill. Data will be fully integrated with Open Space inventory data.

In Part III of the Plan stands that typically include higher elevation areas with very diverse forest types will be analyzed. This analysis will look comprehensively at forests, meadows, shrublands, and riparian areas, as well as a variety of management actions in addition to thinning and prescribed fire. Data will help provide an assessment of current landscape conditions and characterization of forest stands by age-class structure and existing understory. Areas not yet sampled will be characterized in 1999 at a coarse scale by forest age and structural classes to assist long-term planning. Analysis of completeness of representative stands may indicate the need for detailed sampling of additional stands in the future.

3.5 Forest Stand Structure and Overstory Conditions on Open Space Forests

During 1996 to 1998 Open Space completed a detailed forest overstory inventory in 56 of 60 designated stands in their management area. The main goal of the Open Space forest overstory inventory was to provide baseline information about forest stand structure in order to assess the wildfire hazard and to guide the development of management prescriptions for the forest stands.

Forest stands were delineated on the basis of observed canopy cover using aerial photography. Stand boundaries were drawn where forest canopy or species composition changed dramatically (e.g., along creeks, roads, and property boundaries). Riparian areas were excluded for the most part from these forest stands, and will be inventoried in the near future. Most of the Open Space stands are located on the foothills of the mountains adjacent to the Great Plains (Figure 3.1), mainly in areas with east- and northeast-facing aspects with relatively gentle slopes (usually less than 40%). Many of the forest stands are the same as those identified during Project Greenslope.

Table 3.2 outlines the number of forest inventory stands and plots established on Open Space forest lands during the baseline inventory conducted during 1996 to 1998. A subset of the plots was permanently-monumented (every first, fifth, and each multiple of five thereafter). All plots were surveyed in each of the stands sampled during the overstory inventory, but only the permanently-monumented plots were sampled during the understory inventory. The stands and plots are listed in Table 3.3.

Table 3.2: Summary of Open Space Inventory Stands and Plots (1996-1998)

Open Space Forest Inventory Stands and Plots	Total Plots Established	Total Plots Sampled overstory/understory
Forest Stands	60	56/37
Forest Plots within Stands	817	817/133
Permanently-Monumented Forest Plots	196	196/133*

*During the understory inventory frequency data was collected on 133 plots. Cover data was collected on 123 plots (10 plots were too steep to collect cover data with the use of the cover-point ocular device).

During the overstory inventory 1/10-acre circular plots were established for data collection on understory regeneration, plant coverage, and species composition. Variable radius plots (basal area equal to 20 square feet per acre) were established to document **overstory stocking** and other stand conditions.

Complete details on the methodology, data analysis, and results of the Open Space forest overstory inventory are compiled in two technical reports (City of Boulder 1998a and City of Boulder 1998b). A map of the location of Open Space

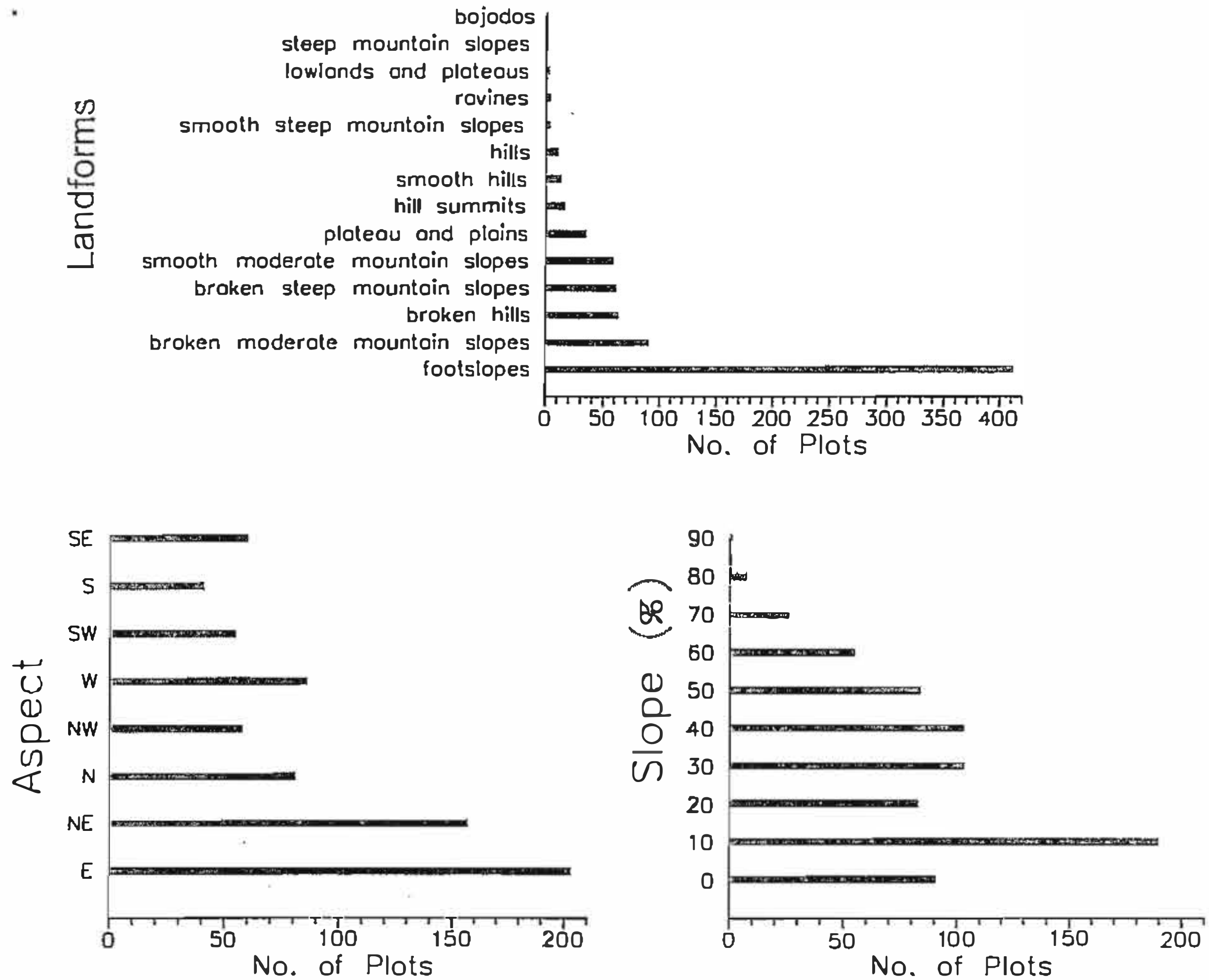

Figure 3.1: Landform, Aspect, and Slope for Open Space Forest Inventory Plots.

Table 3.3: Stands and Plots in Open Space Forest Inventory. All stands listed (with the exception of those in italics) were included in the overstory inventory. Stands in boldface were included in the understory inventory. Stands marked with an asterisk were designated during Project Greenslope.

Map Display	Stand Name	Abbre-viation	# of Plots	# of Perm. Plots	Acres	Hectares
North	**DAKOTA RIDGE**	**DAKR**	**10**	**3**	**11.92**	**4.82**
North	N. BOULDER VALLEY-N	NBV-N	9	2	97.67	39.53
North	N. BOULDER VALLEY-S	NBV-S	5	2	37.02	14.98
North	**PINEBROOK**	**PNBRK**	**11**	**3**	**9.32**	**3.77**
North	**SUNSHINE**		**8**	**2**	**18.59**	**7.52**
North	**WITTEMYER-E**	**WITT-E**	**10**	**3**	**33.40**	**13.52**
North	**WITTEMYER-NE**	**WIIT-NE**	**30**	**7**	**55.12**	**22.31**
North	**WITTEMYER-NW**	**WITT-NW**	**21**	**5**	**27.66**	**11.19**
North	**WITTEMYER-S**	**WITT-S**	**14**	**3**	**23.64**	**9.57**
North	**WITTEMYER-W**	**WITT-W**	**14**	**3**	**43.16**	**17.47**
Central	BARUT-NE		12	3	18.34	7.42
Central	*BARUT-S*		*NA*	*NA*	*12.25*	*4.96*
Central	BONNIE-SCHNELL	BS	19	4	32.91	13.32
Central	*BONNIE SCHNELL-N*	*BS-N*	*10*	*3*	*31.19*	*12.62*
Central	*CAMPBELL*	*CBELL*	*12*	*3*	*33.53*	*13.57*
Central	**DUNN-1/81***	**D-1/81**	**8**	**2**	**11.21**	**4.54**
Central	**DUNN-1***	**D-1**	**13**	**3**	**11.63**	**4.71**
Central	**DUNN-2***	**D-2**	**13**	**3**	**25.46**	**10.30**
Central	**DUNN-3/ DUNN-4***	**D-3/D-4**	**34**	**7**	**73.77**	**29.85**
Central	FOX-E	FOX-E	6	2	18.53	7.50
Central	FOX-W	FOX-W	7	2	11.24	4.55
Central	KASSLER	KSLR	14	3	13.77	5.57
Central	**LOWER SHANAHAN***		**10**	**3**	**81.05**	**32.80**
Central	MASSEY/QUARTER CIRCLE	MQC	5	2	9.92	4.01
Central	MASSEY/QUARTER CIRCLE-W	MQC-W	12	3	29.84	12.08
Central	MCCANN/ CULBERSON/DUNN	MCCD	34	7	44.88	18.16
Central	**POWERLINE***		**27**	**6**	**23.79**	**9.63**
Central	**SHANAHAN-3***	**S-3**	**28**	**6**	**94.57**	**38.27**
Central	**SHANAHAN-4***	**S-4**	**11**	**3**	**19.42**	**7.86**
Central	**SHANAHAN-5***	**S-5**	**14**	**3**	**45.98**	**18.61**
Central	**SHANAHAN-9***	**S-9**	**14**	**3**	**28.74**	**11.63**
Central	**SHANAHAN-10***	**S-10**	**13**	**3**	**24.53**	**9.93**
Central	**STENGEL-I-1***	**ST-1**	**18**	**4**	**13.05**	**5.28**
Central	**STENGEL-I-3***	**ST-3**	**11**	**3**	**24.35**	**9.85**

Table 3.3: Stands and Plots in Open Space Forest Inventory. All stands listed (with the exception of those in italics) were included in the overstory inventory. Stands in boldface were included in the understory inventory. Stands marked with an asterisk were designated during Project Greenslope.

Map Display	Stand Name	Abbre-viation	# of Plots	# of Perm. Plots	Acres	Hectares
Central	**STENGEL-I-5***	**ST-5**	**8**	**2**	**6.63**	**2.68**
Central	**STENGEL-I-6***	**ST-6**	**19**	**4**	**28.38**	**11.49**
Central	**STENGEL-I-7***	**ST-7**	**7**	**2**	**9.86**	**3.99**
Central	**STENGEL-I-8***	**ST-8**	**5**	**2**	**14.94**	**6.05**
Central	**STENGEL-I-9***	**ST-9**	**7**	**2**	**12.99**	**5.26**
Central	**STENGEL-I-10***	**ST-10**	**7**	**2**	**11.70**	**4.73**
Central	**WATERTANK***		**22**	**5**	**122.49**	**49.57**
South	**ELDORADO-NW**	**ELDO-NW**	**5**	**2**	**10.20**	**4.13**
South	**ELDORADO-C**	**ELDO-C**	**5**	**2**	**4.98**	**2.02**
South	**ELDORADO-E**	**ELDO-E**	**18**	**4**	**15.97**	**6.46**
South	**ELDORADO-N**	**ELDO-N**	**18**	**4**	**21.69**	**8.78**
South	**ELDORADO-S**	**ELDO-S**	**10**	**3**	**31.71**	**12.83**
South	***ELDORADO-SW***	***ELDO-SW***	***17***	***4***	***24.65***	***9.98***
South	**ELDORADO-T**	**ELDO-T**	**5**	**2**	**18.15**	**7.35**
South	**ELDORADO-W**	**ELDO-W**	**19**	**4**	**48.83**	**19.76**
South	**LINDSAY-JEFFCO-NE**	**LJC-NE**	**11**	**3**	**54.17**	**21.92**
South	**LINDSAY-JEFFCO-NW**	**LJC-NW**	**18**	**4**	**50.08**	**20.27**
South	**LINDSAY-JEFFCO-SE**	**LJC-SE**	**21**	**5**	**44.92**	**18.18**
South	**LINDSAY-JEFFCO-SW**	**LJC-SW**	**14**	**3**	**24.90**	**10.08**
South	**LINDSAY-N**	**LIND-N**	**10**	**3**	**97.05**	**39.28**
South	**LINDSAY-S**	**LIND-S**	**18**	**4**	**52.56**	**21.27**
South	**MOORE-ROBINSON-LINDSAY**	**MRL**	**23**	**5**	**69.75**	**28.23**
South	SCHNEIDER GIFT-N	SG-N	10	3	41.00	16.59
South	SCHNEIDER GIFT-S	SG-S	10	3	18.06	7.31
South	**STENGEL-II**	**STGL-II**	**22**	**5**	**151.65**	**61.37**
TOTAL			817	196	2094	847

forest stands is attached in Appendix 3.1. Data collected during the recent forest overstory inventory are summarized below to provide information on current forest composition and structure.

3.5.1 Age Structure

Current tree age and diameter distributions in the Open Space forest stands reflect impacts from two post-settlement factors. Both extensive logging and uncontrolled fires in the early non-Native-American settlement period caused widespread mortality of trees and dramatically reduced the landscape extent of forests, especially old-growth stands (Veblen and Lorenz 1991, Goldblum and Veblen 1992). The impacts of logging and fires were especially pronounced in the readily accessible foothills and other low-elevation areas that comprise much of the Open Space landscape.

Most tree establishment that began in the 1880s to 1890s in Open Space stands corresponds to establishment during this same period in other Front Range ponderosa pine forests. Age structure data from forests at both Cheesman Lake (Kaufmann et al. in revision) and Manitou Experimental Forest (Brown et al. unpublished data) show pronounced pulses of tree recruitment during the 1880s to 1890s. However, age data from Cheesman and Manitou suggest that the 1880s to 1890s pulse was very pronounced but relatively short-lived, with fewer trees established in these areas during the rest of this century. Age data from Open Space stands show more or less continuous recruitment from 1900 to 1950. Trees surveyed in Open Space forest plots tend to have small diameters, with a majority less than about 18 inches in **diameter at breast height** (Figure 3.2), and are generally young, with the majority less than 120 years old (Figure 3.3).

Some of the differences in patterns of tree establishment found by these studies are likely related to differences in methodology for determining tree ages. Age data from Cheesman and Manitou were determined from increment cores taken at 12 to 14 inches (30 to 35 centimeters) height on tree stems. Cores were dendrochronologically cross-dated to provide absolute tree ages. In contrast, ages from the Open Space areas were determined from cores taken at breast height (4.5 feet or 1.5 meters from the base of the tree) and ring counted in the field. Ring counts do not account for missing or false rings in the ring series and may miss smaller rings in the count. Furthermore, it can take up to several decades for trees in dense stands in stressed growing conditions to reach breast height.

To compare actual ages determined by dendrochronological methods to ages determined from field counts, over 250 increment cores from trees in Open Space stands were cross-dated. These cores were randomly-selected from those collected for the forest inventory. The results of this comparison show that field-counted tree ages generally underestimated true ages, and that this error was larger with older trees. When true ages are underestimated, patterns of establishment are shifted to later dates. In Figure 3.4 more of the Open Space trees were dated to the 1880s to 1890s period after cross-dating. However, there is still a large amount of spread in dates from the Open Space stands. This spread may be related to the time it takes for trees to reach breast height in these plots.

3.5.2 Tree Densities and Stand Structure

Tree stocking levels (stems/acre) by two-inch diameter **size classes** were determined for each Open Space stand based upon **tally tree** data from variable radius plots (see City of Boulder 1998a for methodology). Although there is usually only a weak relationship between tree establishment age and DBH for

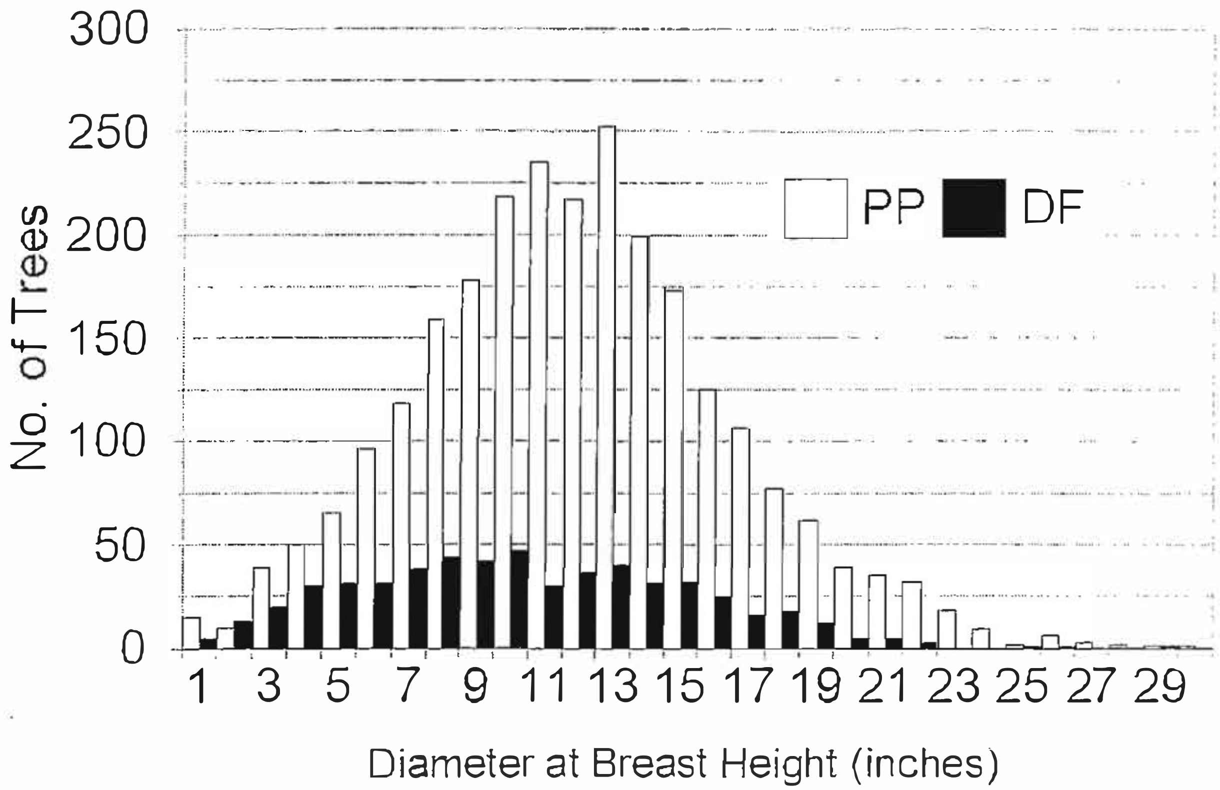

Figure 3.2: Diameter at Breast Height of Ponderosa Pine and Douglas-Fir Trees on Open Space Inventory Plots (n=3153). Size and age data are for trees taller than breast height and do not include data on trees counted and measured in 1/100-acre regeneration plots.

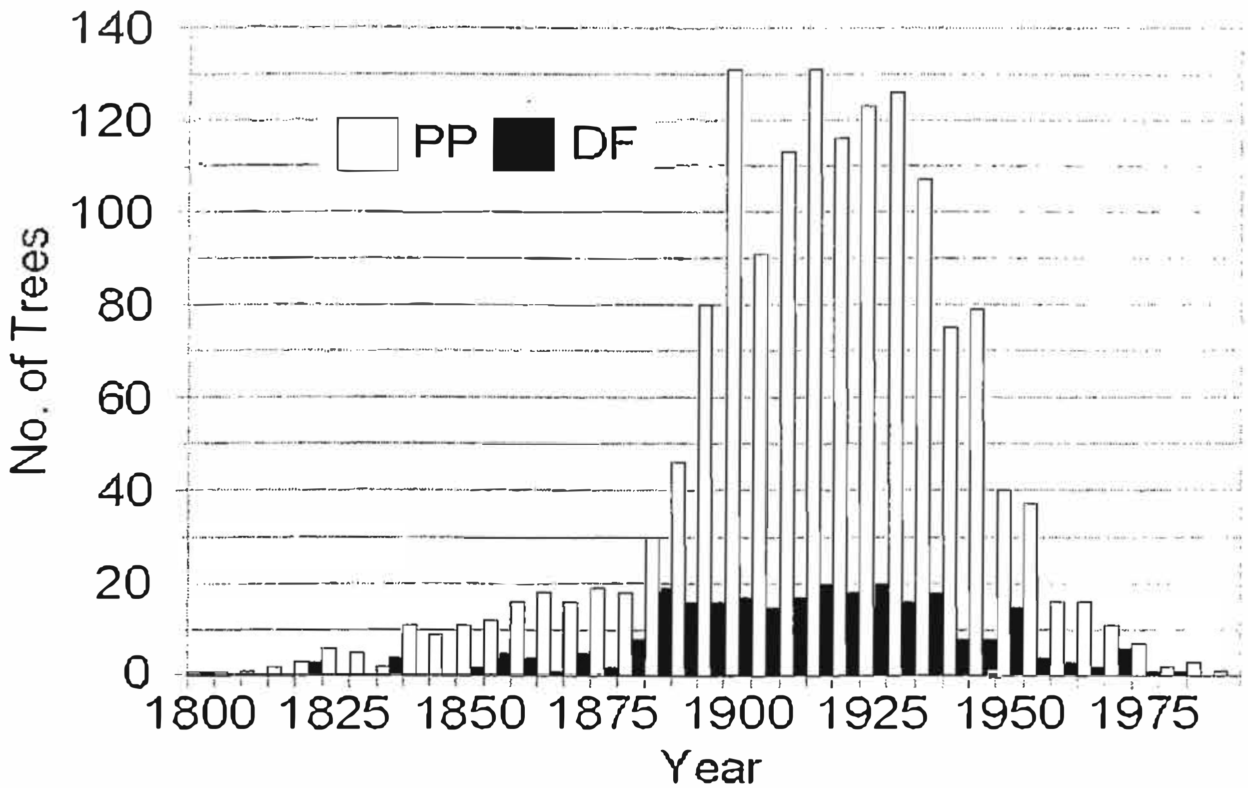

Figure 3.3: Ring-Counted Center Dates of Ponderosa Pine and Douglas-Fir Trees on Open Space Inventory Plots. Total trees: 1848. Size and age data are for trees that are taller than breast height and do not include data on trees counted and measured in 1/100-acre regeneration plots.

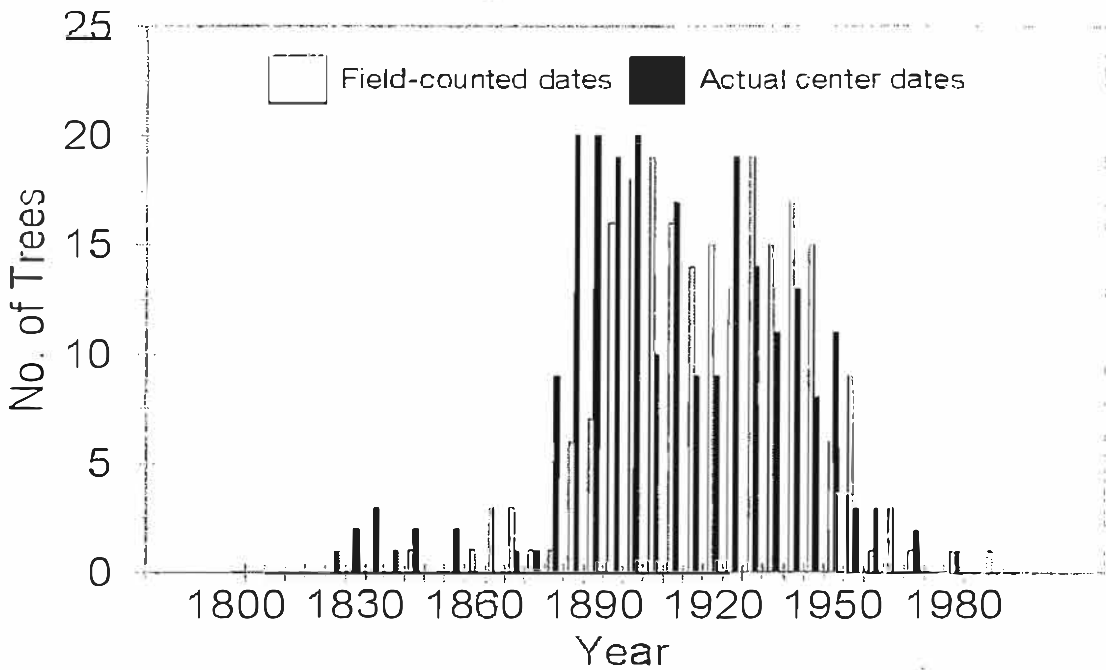

Figure 3.4: Actual and Field-Counted Center Dates from Dendrochronologically Cros's-dated Cores from Open Space Forest Inventory Plots. See text for explanation.

ponderosa pine (Figure 3.5), patterns of tree diameter distributions in forest stands often have been used as indicators of tree establishment and growth through time. Diameter distributions are also critical data for examining possible future stand dynamics.

The number of stems per acre by diameter class in each of the Open Space stands was determined using the equation:

(BAF/BA)/# of plots = Stems/Acre

where BAF is the basal area factor used for variable radius plot (all plots in the Open Space inventory were BA = 20) and BA is basal area in square feet for each size class (determined as N(DBH^2 * 0.0054542), where N is the number of tally trees by diameter class for all plots within a stand; Shepperd 1980). Stems of different species were not separated for the calculation of stocking levels since the intent was to determine overall tree density in each stand. The percentage of Douglas-fir increased with stand elevation, with a sharp change from predominantly ponderosa pine to predominantly Douglas-fir at around 6,700 feet (Figure 3.6).

Numbers of trees by diameter classes in the Open Space stands are summarized in Table 3.4. Stocking levels also were converted to basal areas (BA) to examine relative contributions of different diameter classes to stand densities. These results are summarized in Table 3.5.

Diameter classes below approximately 4 inches are not well represented when 20 BA prisms are used for variable radius plots because of the difficulty in determining when smaller trees are within plot boundaries (W.D. Shepperd and F.W. Smith, personal communication). Therefore, stocking levels for the smallest diameter classes should be considered as conservative in Tables 3.4 and 3.5. However, many of the stands had abundant **seedlings** (trees over 6 inches in height and less than 1 inch DBH) and **saplings** (trees 1 to 4.9 inches DBH) that were recorded in 1/100 acre **regeneration plots**, although several stands had few to no seedlings in regeneration plots.

Extrapolating these smaller diameter classes to the future suggests that, in the absence of heavy mortality of seedlings and smaller sized trees, many of the Open Space stands will continue to increase in tree basal areas and stand densities. Size distributions in several stands that originally were inventoried during Project Greenslope in the late 1970s and early 1980s exhibit distinct patterns that can be related to Project Greenslope treatments. In several of these stands, the impacts of **thinning from below** are evident with few or no trees in the under eight-inch size classes. Thinning from below involved removal of all trees under a specific DBH. Project Greenslope stands that exhibit a pattern of thinning from below include D-1, D-2, D-1/181, Lower Shanahan, Powerline, S-9, S-10, ST-6, ST-7, Stengel-II, and Watertank. Several of these stands also have large numbers of seedlings that have become established in the stand since treatment during Project Greenslope (see Table 3.4).

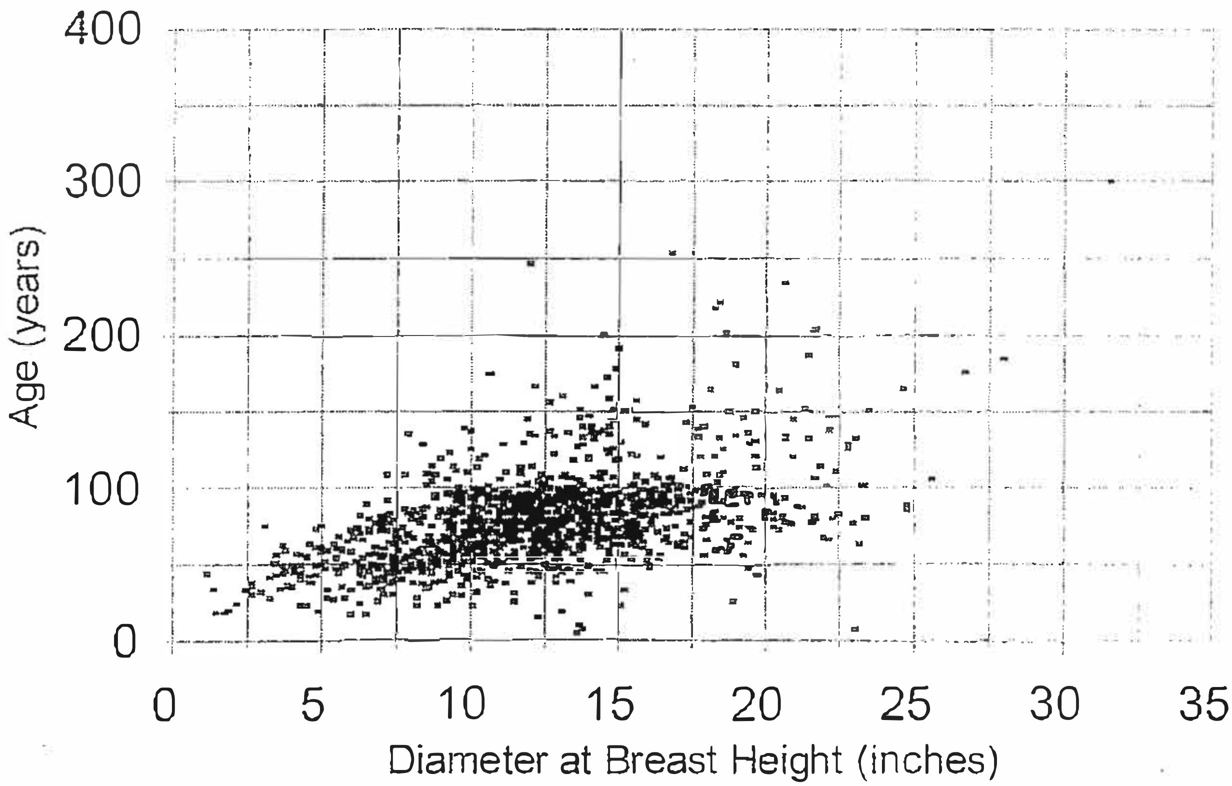

Figure 3.5: Age as a Function of Diameter at Breast Height in Open Space Forest Inventory Plots. Most of the trees sampled are small in diameter (less than 18 inches) and relatively young (less than 120 years old).

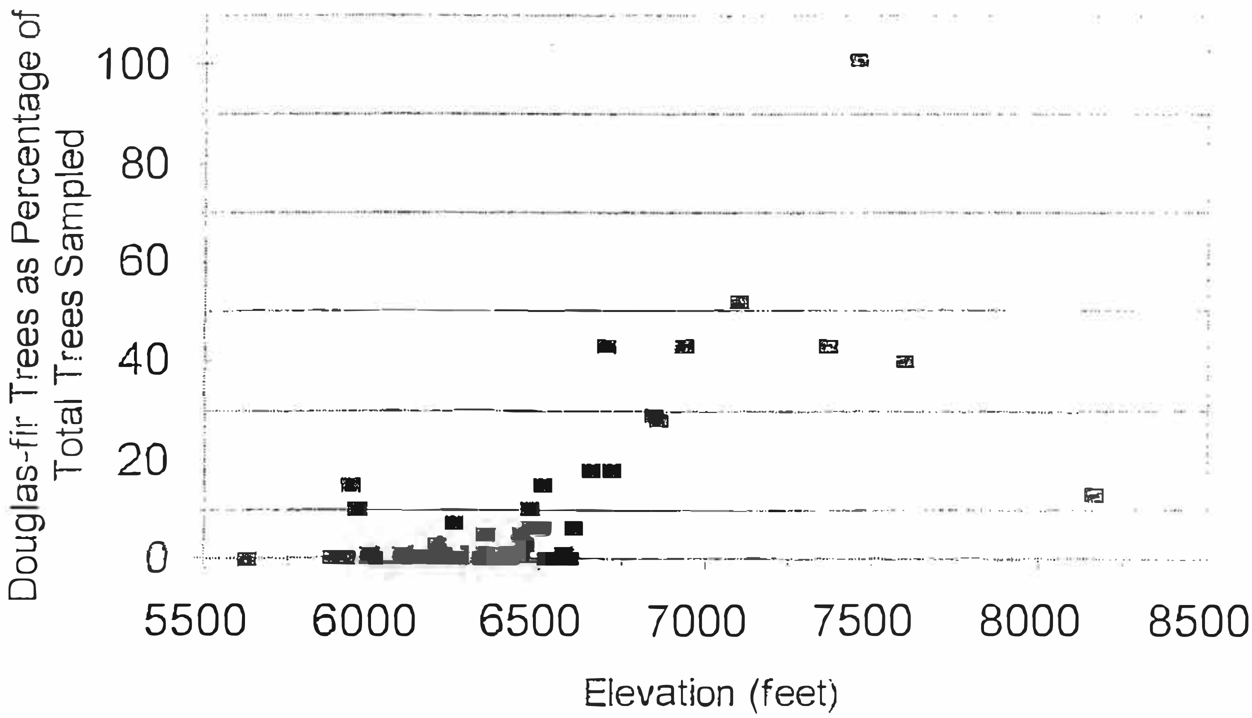

Figure 3.6; Douglas-Fir Trees as Percentage of Total Trees Sampled on Open Space Forest Inventory Plots as a Function of Elevation. The percentage of Douglas-fir in forest stands increases with increasing elevation.

Table 3.4: Tree Density for Open Space Forest Inventory Stands. Tree density is shown in stems/acre by two-inch diameter classes. Stands are grouped in three classes based upon the management prescriptions recommended in Chapter 4.

	Stems/Ac by Diameter Class (in) = Tree Density																
Stand	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**32**	**Total**
NBV-N	0.0	0.0	0.0	0.0	4.6	6.4	4.7	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	16.4
D-1/81	0.0	0.0	0.0	0.0	18.3	3.2	7.0	5.4	4.2	2.3	0.9	2.4	0.0	0.0	0.0	0.0	43.8
D-2	0.0	0.0	0.0	4.4	8.5	5.9	5.8	3.3	10.4	4.2	0.6	0.5	0.0	0.4	0.0	0.3	44.2
LOWER SHANAHAN	0.0	0.0	10.2	0.0	7.3	5.1	9.4	12.9	2.3	3.7	3.0	0.0	0.0	0.0	0.0	0.0	53.8
STGL-II	0.0	0.0	9.3	7.8	13.3	15.0	6.8	3.9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.2
S-9	0.0	0.0	0.0	8.2	7.9	16.4	16.0	9.2	0.8	0.7	1.1	0.5	0.0	0.0	0.0	0.0	60.7
D-1	0.0	0.0	15.7	4.4	8.5	15.7	10.1	9.9	3.5	2.1	1.2	0.0	0.0	0.0	0.0	0.0	71.0
FOX-E	0.0	0.0	17.0	9.5	24.4	8.5	3.1	4.8	0.0	3.1	0.0	1.1	0.0	0.0	0.0	0.0	71.5
WATERTANK	0.0	10.4	0.0	5.2	13.3	8.1	11.1	13.0	3.6	4.6	1.0	1.4	0.2	0.2	0.0	0.0	72.3
BS	48.2	0.0	0.0	3.0	7.7	4.0	4.9	2.3	3.6	1.4	2.4	0.0	0.0	0.2	0.0	0.0	77.8
S-10	0.0	0.0	7.8	0.0	11.3	21.5	28.8	8.8	4.4	1.4	0.0	0.5	0.0	0.0	0.0	0.0	84.5
POWERLINE	0.0	8.5	0.0	10.6	14.9	18.9	22.9	10.6	6.7	4.4	1.1	0.0	0.0	0.0	0.0	0.0	98.6
ST-6	0.0	0.0	10.7	3.0	19.3	20.1	25.6	14.3	4.8	1.0	0.8	0.7	0.0	0.0	0.0	0.0	100.3
S-5	0.0	32.7	0.0	8.2	21.0	16.4	14.7	6.1	1.6	1.3	1.6	0.5	0.0	0.0	0.0	0.0	104.1
LJC-SW	0.0	0.0	0.0	16.4	13.1	29.1	22.7	14.3	4.9	1.3	1.6	0.5	0.4	0.0	0.0	0.0	104.2
PNBRK	0.0	20.8	9.3	15.8	26.7	9.3	22.1	5.2	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	109.8
ST-8	0.0	45.6	20.4	0.0	14.7	10.2	11.2	8.6	2.3	3.7	0.0	0.0	0.0	0.0	0.0	0.0	116.8
D-3 AND D-4	27.0	33.7	15.0	10.1	8.6	4.5	7.2	3.4	2.7	1.6	2.0	0.9	0.3	0.0	0.0	0.0	116.9
ST-7	0.0	0.0	29.1	16.4	15.7	25.5	18.7	14.3	3.2	2.6	0.0	0.9	0.0	0.0	0.0	0.0	126.4
ST-10	0.0	32.7	29.1	24.6	31.4	7.3	2.7	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	133.9
LJC-SE	43.7	21.8	0.0	2.7	17.5	13.3	18.7	8.9	6.5	1.7	1.4	0.0	0.0	0.0	0.0	0.0	136.2
DAKR	0.0	45.8	30.6	40.1	14.7	12.7	5.6	2.9	1.1	0.9	1.5	0.0	0.0	0.0	0.0	0.0	155.9
NBV-S	0.0	45.8	61.1	11.5	0.0	20.4	11.2	5.7	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	157.3
SUNSHINE	0.0	28.6	38.2	28.6	13.8	15.9	14.0	12.5	4.2	2.3	0.0	0.0	0.0	0.0	0.0	0.0	158.3
MCCD	27.0	27.0	27.0	32.0	20.5	15.7	6.1	2.9	3.0	1.3	0.7	0.0	0.0	0.0	0.0	0.1	163.2
WITT-NW	43.7	21.8	24.3	21.8	12.2	12.1	14.3	8.9	4.9	0.4	1.4	0.0	0.0	0.0	0.0	0.0	165.6
S-4	0.0	20.6	27.6	41.7	26.7	27.6	23.8	5.2	5.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	179.7
KSLR	65.5	0.0	29.1	32.7	21.0	20.0	13.4	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	189.8
WITT-NE	30.6	22.9	40.7	40.1	23.2	27.2	8.7	4.8	1.8	0.3	0.3	0.0	0.2	0.0	0.0	0.0	200.8
ST-9	131.0	0.0	14.6	16.4	10.5	14.8	8.0	8.2	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	206.0
ST-1	101.9	25.5	5.7	31.8	24.4	35.4	12.5	6.4	1.9	0.0	0.4	0.0	0.0	0.0	0.0	0.0	245.8
LIND-S	50.9	12.7	39.6	38.2	34.6	45.3	16.7	8.0	5.0	1.5	0.4	0.0	0.0	0.0	0.0	0.0	255.0
ELDO-C	0.0	45.8	101.9	11.5	0.0	20.4	18.7	2.9	0.0	0.0	0.0	0.0	1.1	0.0	0.8	0.0	203.0
LJC-NE	0.0	20.8	27.8	67.7	43.3	37.0	17.0	6.5	0.0	1.7	2.1	0.0	0.0	0.0	0.0	0.0	224.0
S-3	32.7	40.9	32.7	32.7	57.8	24.6	13.4	4.6	1.2	0.0	0.8	0.0	0.0	0.0	0.0	0.0	241.3
WITT-W	65.5	49.1	58.2	24.6	18.3	16.2	13.4	6.1	3.2	1.3	1.1	0.0	0.0	0.0	0.0	0.0	259.0
MRL	39.9	109.6	62.0	37.4	14.3	6.6	7.3	2.5	2.0	0.0	0.3	0.0	0.0	0.2	0.0	0.0	262.1
ELDO-E	50.9	63.7	45.3	44.6	32.8	26.9	14.6	7.2	3.8	0.5	0.4	0.0	0.0	0.0	0.0	0.0	290.3
LIND-N	0.0	68.8	50.9	68.8	44.0	48.4	13.1	4.3	1.1	1.8	0.0	0.0	0.5	0.0	0.8	0.4	302.9
ST-5	114.6	57.3	50.9	50.1	27.5	22.3	2.3	5.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	331.9
WITT-E	91.7	114.6	30.6	74.5	51.3	15.3	3.7	2.9	3.4	2.8	0.0	0.0	0.0	0.0	0.0	0.0	390.7
LJC-NW	152.8	101.9	62.2	44.6	48.9	21.2	12.5	4.0	2.5	1.5	0.6	0.4	0.0	0.0	0.0	0.0	453.3
MRSL	250.0	62.5	74.1	46.9	23.3	6.9	10.2	0.0	2.1	0.8	0.0	0.0	0.0	0.0	0.0	0.0	476.9
WITT-S	196.4	131.0	36.4	40.9	28.8	21.8	13.4	9.2	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	481.1
FOX-W	261.9	163.7	43.7	32.7	26.2	3.6	5.3	2.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	540.1
ST-3	333.4	125.0	18.5	15.6	16.7	13.9	8.5	9.1	2.1	2.5	0.7	0.0	0.0	0.0	0.0	0.0	545.9
ELDO-S	0.0	0.0	20.4	11.5	36.7	22.9	15.0	8.6	1.1	1.8	0.8	0.0	0.0	0.0	0.0	0.0	118.7
ELDO-N	101.9	25.5	34.0	25.5	8.1	4.2	8.3	3.2	5.0	2.5	0.8	0.0	0.0	0.0	0.0	0.0	219.0
SG-N	0.0	45.8	40.7	63.0	47.7	25.5	9.4	1.4	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	235.8
MOC-W	76.4	38.2	67.9	57.3	18.3	14.9	6.2	7.2	2.8	0.8	0.6	1.1	0.0	0.0	0.0	0.0	291.7
MOC	183.3	0.0	0.0	34.4	51.3	20.4	33.7	11.5	13.6	1.8	1.5	0.0	1.1	0.0	0.0	0.0	352.6
BARUT-NE	229.2	19.1	17.0	43.0	18.3	17.0	7.8	10.7	4.7	3.1	1.3	0.0	0.5	0.0	0.0	0.0	371.6
ELDO-NW	183.3	137.5	61.1	11.5	14.7	15.3	15.0	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	444.1
ELDO-W	96.5	168.9	96.5	66.3	42.5	21.4	14.8	9.0	6.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	523.0
SG-S	183.3	160.4	122.2	57.3	36.7	10.2	11.2	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	582.5
ELDO-T	386.7	91.7	20.4	34.4	44.0	10.2	11.2	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	584.3

Table 3.5: Basal Area/Acre for Two-inch Diameter Classes in Open Space Forest Inventory Stands. Stands are grouped in three classes based upon the management prescriptions recommended in Chapter 4.

	Basal Areas (square feet) by Diameter Class (in inches)																
Stand	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**32**	**Total**
NBV-N	0.0	0.0	0.0	0.0	2.5	5.0	5.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	15
D-1/81	0.0	0.0	0.0	0.0	10.0	2.5	7.5	7.5	7.5	5.0	2.5	7.5	0.0	0.0	0.0	0.0	50
D-2	0.0	0.0	0.0	1.5	4.6	4.6	6.2	4.6	18.5	9.2	1.5	1.5	0.0	1.5	0.0	1.6	55
LOWER SHANAHAN	0.0	0.0	2.0	0.0	4.0	4.0	10.0	18.0	4.0	6.0	8.0	0.0	0.0	0.0	0.0	0.0	58
STGL-II	0.0	0.0	1.8	2.7	7.3	11.8	7.3	5.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36
S-9	0.0	0.0	0.0	2.9	4.3	12.9	17.1	12.9	1.4	1.4	2.9	1.4	0.0	0.0	0.0	0.0	57
D-1	0.0	0.0	3.1	1.5	4.6	12.3	10.8	13.8	6.2	4.6	3.1	0.0	0.0	0.0	0.0	0.0	60
FOX-E	0.0	0.0	3.3	3.3	13.3	6.7	3.3	6.7	0.0	6.7	0.0	3.3	0.0	0.0	0.0	0.0	47
WATERTANK	0.0	0.9	0.0	1.6	7.3	6.4	11.8	18.2	6.4	10.0	2.7	4.5	0.9	0.9	0.0	0.0	72
BS	1.1	0.0	0.0	1.1	4.2	3.2	5.3	3.2	6.3	3.2	6.3	0.0	0.0	1.1	0.0	0.0	34
S-10	0.0	0.0	1.5	0.0	6.2	16.9	30.8	12.3	7.7	3.1	0.0	1.5	0.0	0.0	0.0	0.0	80
POWERLINE	0.0	0.7	0.0	3.7	8.1	14.8	24.4	14.8	11.9	9.6	3.0	0.0	0.0	0.0	0.0	0.0	91
ST-6	0.0	0.0	2.1	1.1	10.5	15.8	27.4	20.0	8.4	2.1	2.1	2.1	0.0	0.0	0.0	0.0	92
S-5	0.0	2.9	0.0	2.9	11.4	12.9	15.7	8.6	2.9	2.9	4.3	1.4	0.0	0.0	0.0	0.0	66
LJC-SW	0.0	0.0	0.0	5.7	7.1	22.9	24.3	20.0	8.6	2.9	4.3	1.4	1.4	0.0	0.0	0.0	99
PNBRK	0.0	1.8	1.8	5.5	14.5	7.3	23.6	7.3	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	64
ST-8	0.0	4.0	4.0	0.0	8.0	8.0	12.0	12.0	4.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	60
D-3 AND D-4	0.6	2.9	2.9	3.5	4.7	3.5	7.6	4.7	4.7	3.5	5.3	2.9	1.2	0.0	0.0	0.0	48
ST-7	0.0	0.0	5.7	5.7	8.6	20.0	20.0	20.0	5.7	5.7	0.0	2.9	0.0	0.0	0.0	0.0	94
ST-10	0.0	2.9	5.7	8.6	17.1	5.7	2.9	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51
LJC-SE	1.0	1.9	0.0	1.0	9.5	10.5	20.0	12.4	11.4	3.8	3.8	0.0	0.0	0.0	0.0	0.0	74
OAKR	0.0	4.0	6.0	14.0	6.0	10.0	6.0	4.0	2.0	2.0	4.0	0.0	0.0	0.0	0.0	0.0	60
NBV-S	0.0	4.0	12.0	4.0	0.0	16.0	12.0	8.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	60
SUNSHINE	0.0	2.5	7.5	10.0	7.5	12.5	15.0	17.5	7.5	5.0	0.0	0.0	0.0	0.0	0.0	0.0	85
MCCD	0.6	2.4	5.3	11.2	11.2	12.4	6.5	4.1	5.3	2.9	1.8	0.0	0.0	0.0	0.0	0.6	64
WITT-NW	1.0	1.9	4.8	7.6	6.7	9.5	15.2	12.4	8.6	1.0	3.8	0.0	0.0	0.0	0.0	0.0	71
S-4	0.0	1.8	5.5	14.5	14.5	21.8	25.5	7.3	9.1	1.6	0.0	0.0	0.0	0.0	0.0	0.0	102
KSLR	1.4	0.0	5.7	11.4	11.4	15.7	14.3	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70
WITT-NE	0.7	2.0	8.0	14.0	12.7	21.3	9.3	6.7	3.3	0.7	0.7	0.0	0.7	0.0	0.0	0.0	79
ST-9	2.9	0.0	2.9	5.7	5.7	11.4	8.6	11.4	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54
ST-1	2.2	2.2	1.1	11.1	13.3	27.8	13.3	8.9	3.3	0.0	1.1	0.0	0.0	0.0	0.0	0.0	82
LIND-S	1.1	1.1	7.8	13.3	18.9	35.6	20.0	11.1	8.9	3.3	1.1	0.0	0.0	0.0	0.0	0.0	121
ELDO-C	0.0	4.0	20.0	4.0	0.0	16.0	20.0	4.0	0.0	0.0	0.0	0.0	4.0	0.0	4.0	0.0	76
LJC-NE	0.0	1.8	5.5	23.8	23.6	29.1	18.2	9.1	0.0	3.6	5.5	0.0	0.0	0.0	0.0	0.0	120
S-3	0.7	3.6	6.4	11.4	31.4	19.3	14.3	6.4	2.1	0.0	2.1	0.0	0.0	0.0	0.0	0.0	97
WITT-W	1.4	4.3	11.4	8.6	10.0	14.3	14.3	8.6	5.7	2.9	2.9	0.0	0.0	0.0	0.0	0.0	63
MRL	0.9	9.6	12.2	13.0	7.8	5.2	7.8	3.5	3.5	0.0	0.9	0.0	0.0	0.9	0.0	0.0	64
ELDO-E	1.1	5.6	8.9	15.6	17.8	21.1	15.6	10.0	6.7	1.1	1.1	0.0	0.0	0.0	0.0	0.0	103
LIND-N	0.0	6.0	10.0	24.0	24.0	38.0	14.0	6.0	2.0	4.0	0.0	0.0	2.0	0.0	4.0	2.0	136
ST-5	2.5	5.0	10.0	17.5	15.0	17.5	2.5	7.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
WITT-E	2.0	10.0	6.0	26.0	28.0	12.0	4.0	4.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	102
LJC-NW	3.3	8.9	12.2	15.6	26.7	16.7	13.3	5.6	4.4	3.3	2.2	1.1	0.0	0.0	0.0	0.0	110
MRSL	5.5	5.5	14.5	16.4	12.7	5.5	10.9	0.0	3.6	1.8	0.0	0.0	0.0	0.0	0.0	0.0	71
WITT-S	4.3	11.4	7.1	14.3	15.7	17.1	14.3	12.9	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99
FOX-W	5.7	14.3	8.6	11.4	14.3	2.9	5.7	2.9	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	63
ST-3	7.3	10.9	3.6	5.5	9.1	10.9	9.1	12.7	3.6	5.5	1.8	0.0	0.0	0.0	0.0	0.0	73
ELDO-S	0.0	0.0	4.0	4.0	20.0	18.0	16.0	12.0	2.0	4.0	2.0	0.0	0.0	0.0	0.0	0.0	82
ELDO-N	2.2	2.2	6.7	8.9	4.4	3.3	8.9	4.4	8.9	5.6	2.2	0.0	0.0	0.0	0.0	0.0	56
SG-N	0.0	4.0	8.0	22.0	26.0	20.0	10.0	2.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	96
MOC-W	1.7	3.3	13.3	20.0	10.0	11.7	6.7	10.0	5.0	1.7	1.7	3.3	0.0	0.0	0.0	0.0	87
MOC	4.0	0.0	0.0	12.0	28.0	18.0	36.0	16.0	24.0	4.0	4.0	0.0	4.0	0.0	0.0	0.0	144
BARUT-NE	5.0	1.7	3.3	15.0	10.0	13.3	8.3	15.0	8.3	6.7	3.3	0.0	1.7	0.0	0.0	0.0	07
ELDO-NW	4.0	12.0	12.0	4.0	8.0	12.0	16.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72
ELDO-W	2.1	14.7	18.9	23.2	23.2	16.8	15.8	12.6	11.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	138
SG-S	4.0	14.0	24.0	20.0	20.0	8.0	12.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
ELDO-T	8.0	8.0	4.0	12.0	24.0	8.0	12.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76

Finally, the most recent 10-year radial growth increments were measured on each core collected for age structure. Ten-year radial increments were converted to **basal area increments** (BAI) to provide estimates of average tree growth rates in stands. Multiple factors can affect average growth rates, including environmental conditions (e.g., soils, aspect, and elevation), climate variability, and competition with surrounding trees. However, overall trends in growth rates in Open Space stands follow trends similar to those seen at Manitou Experimental Forest (Brown et al. unpublished data), with smaller growth increments recorded in plots with more trees (Figure 3.7).

Average radial growth increments in stands also are inversely related to both total tree basal area/acre (Figure 3.8) and average percent stand canopy cover (Figure 3.9). Stands shown in Figures 3.8 and 3.9 are only those located primarily in foothill landscape positions where environmental variations, such as elevation or differences in soils, should minimally affect comparison of average growth rates. Stands that were not treated during Project Greenslope tend to have the highest canopy coverage and tree basal areas and the slowest average tree growth rates, while Project Greenslope treated stands tend to have less canopy cover, lower basal area/acre, and faster growth rates in individual trees.

In summary, analysis of Open Space forest overstory inventory data shows that the structure of local forests has changed dramatically over the last 150 years. Today forest stands are characterized by:

- A high percentage of young trees, with the majority less than 120 years old, and no old-growth forests.
- A high percentage of crowded, small diameter (less than 18 inches) trees with slow growth rates.

Tree basal area and stand density will continue to increase on Open Space stands in the absence either of ecosystem management directed at restoring the structure of the forest to conditions that prevailed historically or of a large scale fire or insect epidemic that would dramatically change the structure of the forest.

3.6 FOREST UNDERSTORY VEGETATION

A forest is much, much more than a collection of trees.
Pielou 1988

Although forests are defined primarily by trees, most of the plant species that grow in forests are found in the understory, which is the layer of shrubs, wildflowers, and grasses beneath the forest canopy. The abundance and diversity of understory plants directly influence the abundance and diversity of forest wildlife and are indicators of the ecological condition of the forest. Understory vegetation also influences important ecological processes, such as contributing to soil fertility and soil stabilization, altering pine seedling growth and mortality rates, and affecting the intensity and spread of ground and surface fires (Marschner 1997).

The Open Space understory inventory was conducted in 1997. During the overstory inventory some plots were permanently-monumented (plot 1, plot 5, plot 10, etc., in each stand). Understory plots (20 meters square) were established

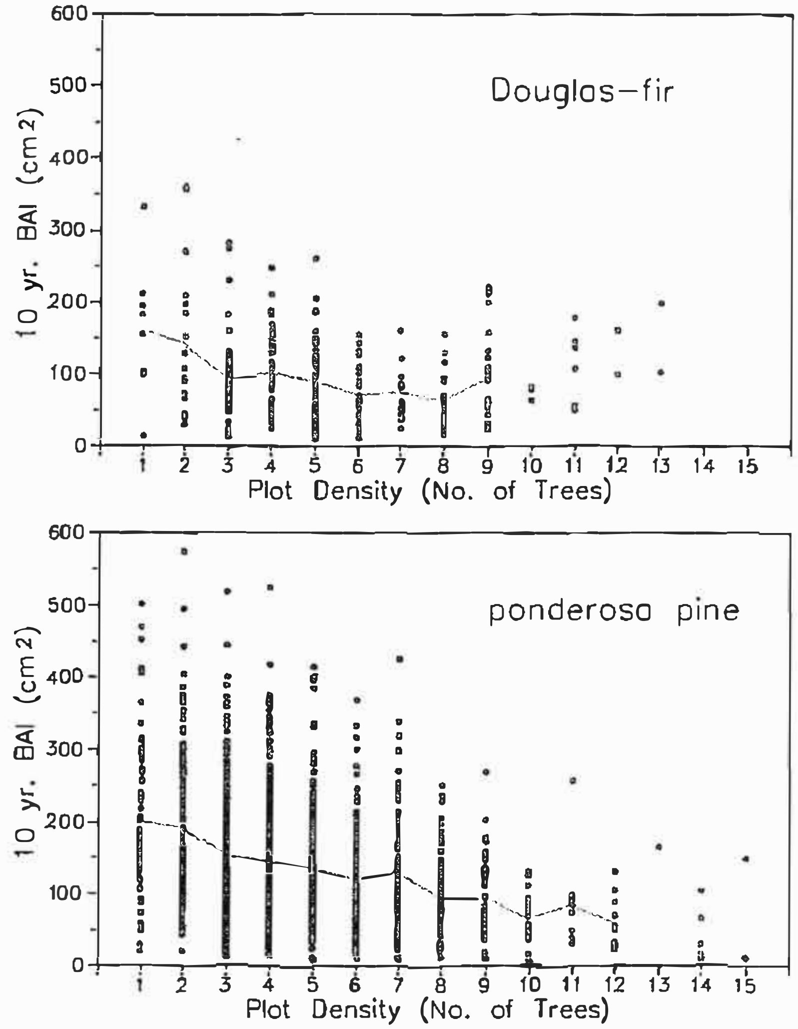

Figure 3.7: Ten-Year Basal Area Increments for Ponderosa Pine and Douglas-Fir Trees on Open Space Forest Inventory Plots as a Function of Plot Density (Number of Trees per Plot). As plot density increases, the basal area increment decreases.

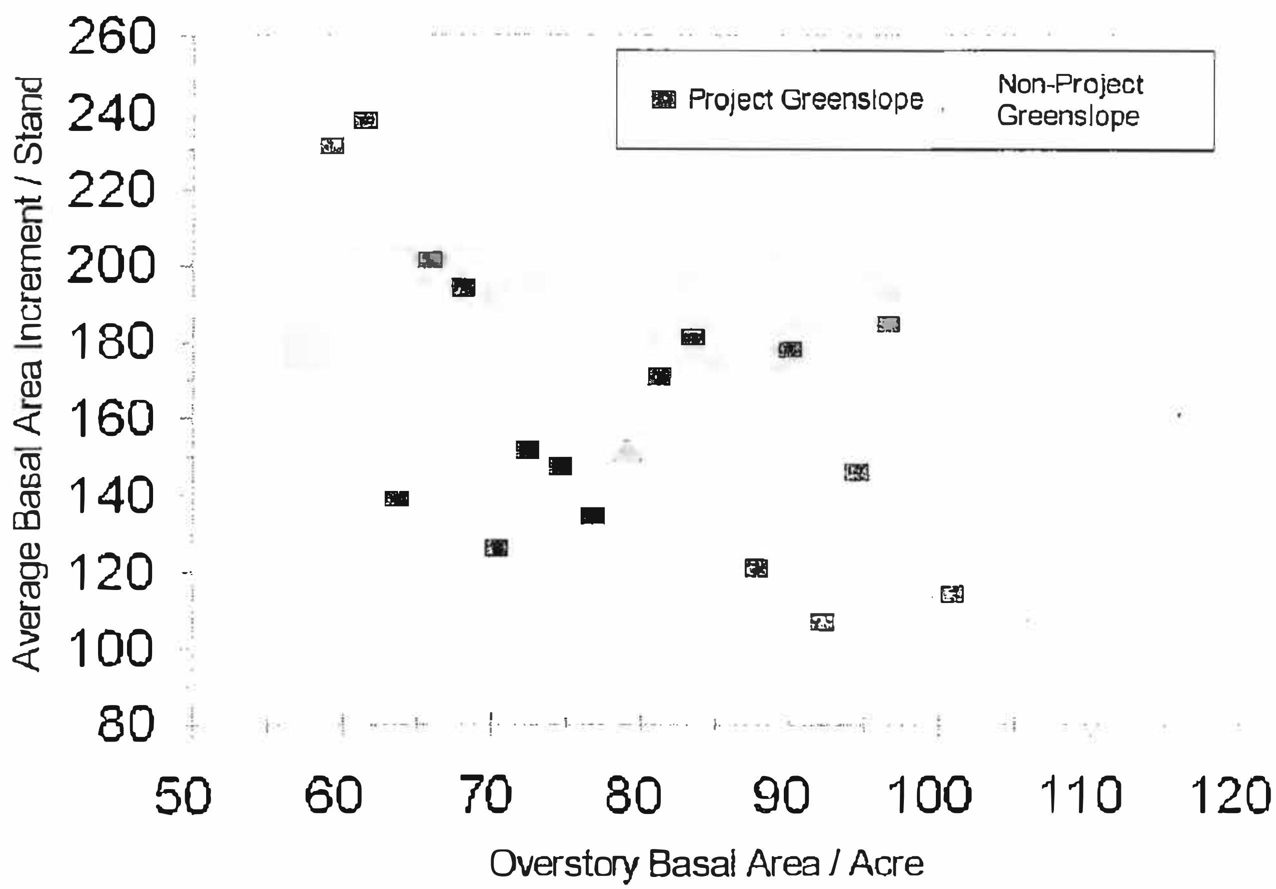

Figure 3.8: Average 10-year Basal Area Increments for Selected Open Space Forest Stands as a Function of Average Overstory Basal Area per Acre. Stands shown are from low-elevation areas on footslopes or the plains-foothills ecotone. Project Greenslope stands were those thinned during the late 1970s to early 1980s. As the basal area per acre increases, the basal area increment decreases.

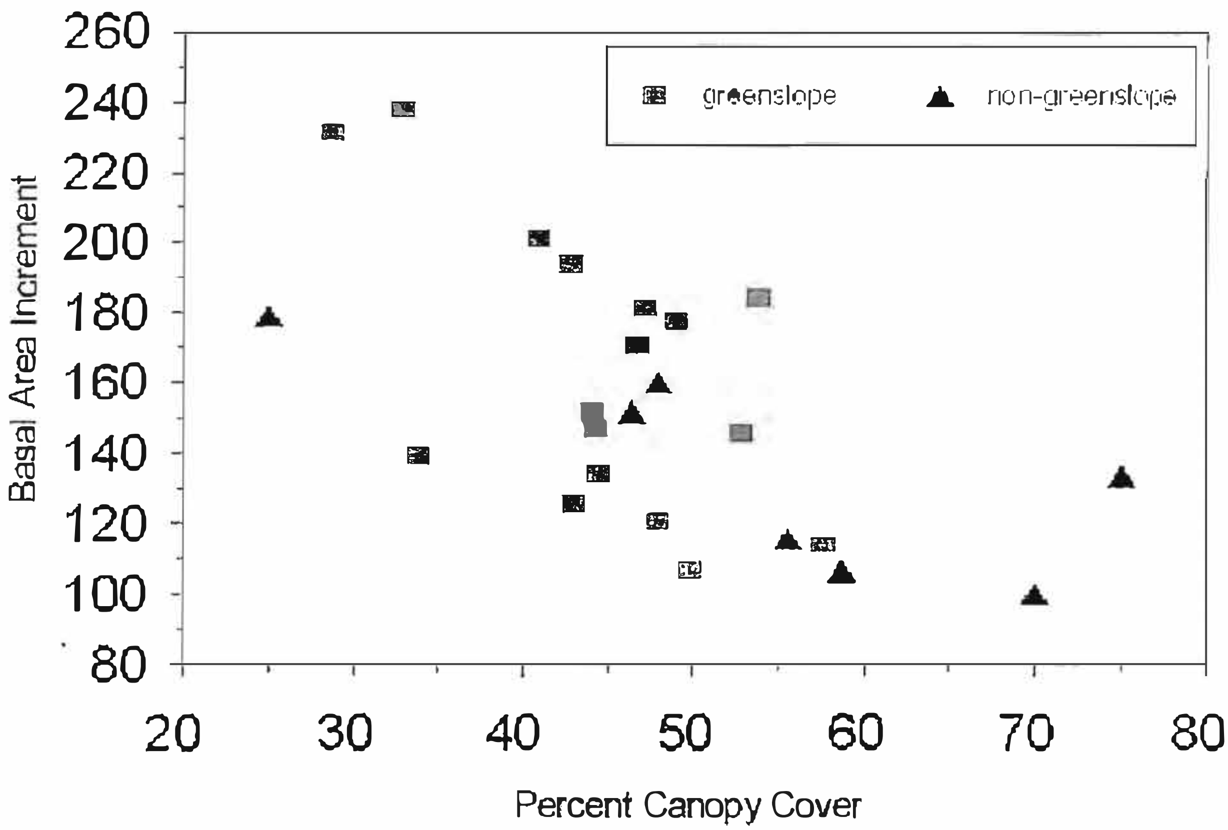

Figure 3.9: Average 10-year Basal Area Increments for Selected Open Space Forest Stands as a Function of Percent Canopy Cover. Stands shown are from low-elevation areas on footslopes or the plains-foothills ecotone. Project Greenslope stands were those thinned during the late 1970s to early 1980s. As canopy cover increases, average basal area increments decrease.

only on these permanent plots in 37 of the 60 Open Space stands (see Table 3.6). Three technical reports provide complete details on the methodology, data analysis, and results of the forest understory inventory (City of Boulder 1998a, City of Boulder 1998c, and Murphy 1998). The results of the understory inventory are summarized below and in Table 3.6.

Table 3.6: Floristic Summary of Open Space Forest Understory Inventory Plots

SPECIES	330	
GENERA	232	
FAMILIES	79	
FAMILIES WITH THE HIGHEST NUMBERS OF SPECIES:		
ASTERACEAE	Sunflower Family	65 species
POACEAE	Grass Family	56 species
FABACEAE	Pea Family	17 species
BRASSICACEAE	Mustard Family	16 species
ROSACEAE	Rose Family	15 species

3.6.1 Open Space Forest Understory Inventory

The main goals of the Open Space understory inventory were (1) to describe the composition and structure of the forest vegetation, (2) to analyze the current condition of the understory on forested Open Space lands, and (3) to provide baseline data for future management and monitoring projects.

A previous study funded by City of Boulder Open Space found that the plant communities most in need of study were ponderosa pine forests and mountain shrublands (Bunin 1985). The 1997 Open Space understory inventory is one of a series of studies funded by Open Space and Boulder Mountain Parks (see Bunin 1985, Cooper 1984, D'Amico et al. 1998, Hogan 1989, 1993a, 1993b, 1994, 1995, Kettler et al. 1993) with the aim of increasing the understanding of the plant species and plant communities which form the basis of the biological wealth and beauty of this area.

Floristic Summary

One-hundred and thirty-three plots on 37 Open Space forest stands were sampled during the 1997 field season (May through August). These 37 forest stands are predominantly low-elevation ponderosa pine forests. Many of the forest stands which are dominated by Douglas-fir were not included in the understory inventory during 1997 due to both time constraints and the difficulty of using the cover-point optical device in dense forests and on steep slopes (see City of Boulder 1998a and 1998c for details on methodology). Nonvascular plants (lichens and mosses) were not documented during this study. The forest stands for the most part exclude riparian and wetland areas, but in some cases are adjacent to them.

Three hundred and thirty species of vascular plants were documented during the 1997 understory inventory in 79 families and 232 genera (Table 3.6). This represents 21% of the species, 35% of the genera, and 59% of the families found in Boulder County. Weber (1995) reports 1538 species of vascular plants in Boulder County in 135 families and 666 genera. A list of all plants found in the understory inventory plots during the 1997 field season is appended to the *Open Space Understory Inventory Report* (City of Boulder 1998c).

PLANT GEOGRAPHY

The location of the study area near the meeting place of the Great Plains and the Rocky Mountains is a significant factor in the composition and distribution of the plant species found here. As Mutel and Emerick (1992) note, "the transition between the Great Plains and the Southern Rocky Mountains is particularly abrupt along the eastern slope of the Front Range near Boulder, where the high peaks along the Continental Divide are less than twenty miles from the edge of the grasslands." Weber (1965, 1995) points out that this area has been influenced botanically by the northern and southern Great Plains, the eastern woodlands of the U.S., the north/south Rocky Mountain corridor, and even Asia. Peet (1981) notes that the Front Range is adjacent to a large area of semi-arid vegetation to the south and east, but disjunct from larger areas of cool or mesic vegetation.

Weber (1995) lists the following understory species as distinctive to the transitional, or ecotonal, area between the high plains and ponderosa pine woodland: leadplant (*Amorpha nana*), buckbrush (*Ceanothus herbaceus*), western spring beauty (*Claytonia rosea*), needlegrass (*Hesperostipa spartea*), marbleseed (*Onosmodium molle occidentale*), prairie dropseed (*Sporobolus heterolepis*), and birdfoot violet (*Viola pedatifida*). All of these species were documented during the understory inventory, but two (leadplant and birdfoot violet) were infrequent in the understory inventory plots and have been classified as imperiled in the state of Colorado (Colorado Natural Heritage Program 1999).

ENDEMICS AND DISJUNCTS

Other special elements of the **flora** of this area include **endemics** (species with a range confined to a limited area) and **disjuncts** (species occurring in two or more widely separated geographic areas). Some endemics are confined to a large area, like the Southern Rocky Mountains, and others are confined to smaller areas. Regional endemics are important elements of the flora, as they are especially sensitive to disturbance.

Below is a list of some of the endemic and disjunct species that occur in the study area with notes about their distribution in the Open Space forest stands and in Boulder County (the latter taken from Weber 1995):

- Mountain caraway (*Aletes acaulis*) is a member of a small genus limited to the southwestern U.S. Very common in Boulder County on cliffs in the foothill canyons, but only one record in the understory inventory plots.
- Whiskbroom parsley (*Harbouria trachypleura*) represents a monotypic genus (only one species in the genus) restricted to the montane zone of the Front

Range. Common in the understory inventory plots and widely distributed in Boulder County on open, dry slopes throughout the foothills.

- Colorado sunflower (*Helianthus pumilis)* is an endemic sunflower. Uncommon in the understory inventory plots, but common in Boulder County in the foothills.

- Waxflower (*Jamesia americana)* is a monotypic genus limited to only three principal areas in the western U.S. Only two records in the understory inventory plots, and uncommon in Boulder County in the lower montane forests, but common on higher-elevation stands sampled during the overstory inventory.

- Spike fescue *(Leucopoa kingii*) is a disjunct, the only American species of a small Asiatic genus. Fairly common in the understory inventory plots, and very common in Boulder County in the open ponderosa pine forests of the outer foothills.

- Boulder raspberry *(Oreobatus deliciosus)* is a monotypic genus limited to the American southwest. Common in the understory inventory plots and in Boulder County in the outer foothill canyons.

- Bluemist penstemon (*Penstemon virens)* is endemic to the middle altitudes of the Front Range. One of the most common plants in the understory inventory plots, and very abundant in Boulder County in the outer foothills.

- Blue-bottle gentian (*Pneumonanthe bigelovii*) is an endemic restricted to the Eastern Slope of the Front Range below 8000 feet. Common in the understory inventory plots and in Boulder County from the outer foothills to the upper montane in dry forests and grasslands.

Eastern Woodland-Prairie Element

Weber (1995) describes the eastern woodland-prairie element of the flora as remnants from an earlier, milder era when the eastern woodlands stretched across the present area of the Great Plains. As the climate became drier and the vegetation shifted to grasslands over the last several thousand years, some eastern species survived in more mesic areas in the foothills. These species include:

- Leadplant *(Amorpha nana)* is uncommon in Boulder County and in the understory inventory plots (four records).

- Sunsedge (*Carex pensylvanica heliophila)* is the most common sedge in the foothills and in the understory plots.

- Buckbrush (*Ceanothus herbaceus*) was found on one understory inventory plot.

- Pin cherry (*Cerasus pensylvanica*) occurred on one understory inventory plot.

- Hazelnut (*Corylus cornuta*) occurred on only one understory inventory plot, but is more common in riparian areas.

- Frostweed (*Crocanthemum bicknellii*) was found on one understory inventory plot.

- Birdsfoot violet (*Viola pedatifida*) was documented on three forest stands, but was not found in any of the understory inventory plots.

The grasses below are prominent in the tallgrass prairie of the eastern Great Plains and also occur in some grassland areas in Boulder County and intermixed with other species in the open pine forests:

- Big bluestem (*Andropogon gerardii*) is one of the most common grasses found in the understory inventory plots.

- Porcupine grass (*Hesperostipa spartea)* is fairly common in the understory inventory plots.

- Little bluestem (*Schizachyrium scoparium)* is common in the understory inventory plots.

- Indiangrass (*Sorghastrum avenaceum*) is fairly common in the understory plots.

- Prairie dropseed *(Sporobolus heterolepis*) is uncommon in the understory plots.

Plant Species Composition

Plant ecologists have developed a number of methods for assessing species composition in a given area, including measurements of species **frequency**, species cover, and species richness, as well as proportions of endemic, non-native, and threatened or **endangered species** (see Noss and Cooperrider, 1994).

Plant Species Frequency

Species frequency is the percentage of sampling units (or plots, in the case of the inventory) in which a given plant species occurs. Species frequency in the understory inventory is based on the species lists which were compiled for each of the 133 one-tenth-acre plots sampled. Frequency is a useful measure for comparing different plant communities and for monitoring change over time, and also provides a view of the distribution of species throughout the study area. A list of all the species documented during the 1997 field season in their order of frequency is included in the *Open Space Forest Understory Inventory Report* (City of Boulder 1998c).

Species frequency in the study area ranged from 99% (132 out of 133 plots) for ponderosa pine to 0.75% for many species which were recorded in only one plot. The 22 most frequent species occurred in over 50% of the plots. The 70 most frequent species occurred in over 20% of the plots. Most species occurred in less than 10% of the plots. Table 3.7 lists all of the species found in the top eight frequency classes. These are the most common species in the forest stands. What these species indicate about the condition of the forest is discussed in more detail in Section 3.6.2.

Trees

The only coniferous trees found in the forest stands sampled during the Open Space understory inventory were ponderosa pine *(Pinus ponderosa scopulorum,* all plots except one), Douglas-fir (*Pseudotsuga menziesii,* 30% of the plots), limber pine (*Pinus flexilus,* not recorded in any understory plots, but documented in the overstory inventory), and Rocky Mountain juniper (*Sabina scopulorum*, 24% of the 133 plots).

Deciduous trees are uncommon in the ponderosa pine forest outside of riparian areas, which were mostly outside the boundaries of the forest stands. Eleven species of deciduous trees were documented during the understory inventory. Five of the 11 were recorded with low frequency in the study plots: Rocky Mountain maple (*Acer glabrum*), serviceberry (*Amelanchier alnifolia*), hackberry (*Celtis reticulata*), hawthorn (*Crataegus* species), and oak (*Quercus* species), all of them native except for the oak, which is native to the south and west of the study area but not to Boulder County (Weber 1995). Hackberry (*Celtis reticulata*) is a native tree of limited abundance locally. The other six species were recorded within the forest stands but not in any of the understory plots and are uncommon on dry sites (see Table 3.8).

Shrubs

The only coniferous shrub found in the study area is common juniper (*Juniperus communis alpina*). It is a regular constituent of the ponderosa pine forest, but occurs infrequently (10% of the plots). Other evergreen shrubs include kinnickinnick (*Arcostaphylos uva-ursi*), which was seldom found within the study area (7% of the plots), but is common at higher elevations.

Unlike deciduous trees, deciduous shrubs are a major component of the understory vegetation of the low-elevation ponderosa pine forest. Trees generally require a more mesic environment, while many shrubs have a slower growth rate and can survive under more xeric conditions (Mozingo 1987)). Twenty-three species of shrubs were documented in the study area, nine of them common (see Table 3.8). The two with the highest frequency (77%) are skunkbrush (*Rhus aromatica trilobata)* and wax currant (*Ribes cereum)*. The other common shrubs in order of frequency are holly-grape (*Mahonia repens)* 50%, chokecherry *(Padus virginiana)* 49%, wild rose (*Rosa woodsii/R. sayii)* 47%, boulder raspberry (*Oreobatus deliciosus)* 42%, buckbrush (*Ceanothus fendleri)* 36%, and mountain-mahogany (*Cercocarpus montanus)* 12%.

The 14 uncommon shrub species include leadplant (*Amorpha nana*), a rare shrub found on only four understory plots, bladder senna (*Colutea arborescens*), a non-native shrub that escaped from cultivation and is established in a limited part of the study area, as well as shrubs that are more common either on mesic sites--wild plum (*Prunus americana),* golden currant (*Ribes aureum),* and common gooseberry (*Ribes inerme*)--or at higher elevations--oceanspray (*Holodiscus discolor*) and waxflower (*Jamesia americana*).

Table 3.7: Plant Species in Frequency Classes for Open Space Forest Understory Inventory Plots.
Frequency classes show the percentage of 133 plots in which the species was found. Plots were 1/10 of an acre (400 square meters). Native species are in boldface. Some species were difficult to distinguish in the field and are listed as pairs (e.g., *Heterotheca villosa/H. foliosa*).

Frequency Class	Species in Frequency Class	Common Name
90 to 100	***Pinus ponderosa scopulorum***	Ponderosa pine
80 to 89	***Artemisia ludoviciana*** ***Carex pensylvanica heliophila***	Prairie sage Sunsedge
70 to 79	***Achillea lanulosa*** ***Grindelia squarrosa/G. subalpina*** ***Opuntia macrohiza*** ***Penstemon virens*** ***Ribes cereum***	Western yarrow Gumweed Prickly-pear cactus Bluemist penstemon Wax currant
60 to 69	***Andropogon gerardii*** ***Campanula rotundifolia*** ***Drymocallis fissa*** *Poa compressa* ***Poa agassizensis*** *Tragopogon dubius major*	Big bluestem Harebell Cinquefoil *Canada bluegrass* Mountain bluegrass *Salsify*
50 to 59	***Ambrosia psilostachya*** var. ***coronopifolia*** ***Cerastium strictum*** ***Elymus elymoides/E. longifolius*** ***Harbouria trachypleura*** ***Heterotheca villosa/H. foliosa*** ***Muhlenbergia montana*** ***Rhus aromatica trilobata*** *Verbascum thapsus*	Western ragweed Mouse ear Squirreltail Whiskbroom parsley Hairy golden aster Mountain muhly Three-leaf sumac *Mullein*
40 to 49	***Achnatherum nelsonii*** ***Allium cernuum*** *Anisantha tectorum* ***Antennaria*** species ***Artemisia frigida*** *Bromus japonicus,* *Carduus nutans macrolepis* ***Danthonia spicata pinetorum*** ***Hesperostipa comata*** ***Koeleria macrantha*** ***Liatris punctata*** ***Mahonia repens*** ***Oreobatus deliciosus*** ***Padus virginiana melanocarpa*** ***Phacelia heterophylla*** ***Rosa woodsii/R. sayi*** ***Schizachyrium scoparium*** ***Symphoricarpos albus/S. occidentalis***	Needlegrass Wild onion *Cheatgrass* Pussytoes Fringed sage *Japanese brome* *Musk thistle* Poverty oatgrass Needle-and-thread grass Junegrass Gayfeather Holly-grape Boulder raspberry Chokecherry Scorpionweed Wild rose Little bluestem Snowberry

Table 3.7: Plant Species in Frequency Classes for Open Space Forest Understory Inventory Plots.
Frequency classes show the percentage of 133 plots in which the species was found. Plots were 1/10 of an acre (400 square meters). Native species are in boldface. Some species were difficult to distinguish in the field and are listed as pairs (e.g., *Heterotheca* ***villosa/H. foliosa***).

Frequency Class	Species in Frequency Class	Common Name
30 to 39	***Aster porteri***	Porter aster
	Ceanothus fendleri	Buckbrush
	Gaillardia aristata	Blanket flower
	Geranium caespitosum atropurpureum,	Wild Geranium
	Hypericum perforatum	*St. Johnswort*
	Lathyrus leucanthus	Peavine
	Pseudotsuga menziesii	Douglas-fir
	Psoralidium tenuiflorum	Wild alfalfa
	Pulsatilla patens multifida	Pasqueflower
	Taraxacum officinale	*Dandelion*
20 to 29	***Allium*** species	Wild onion
	Arnica fulgens	Meadow arnica
	Breea arvensis	*Canada thistle*
	Bromopsis lanatipes	Woolly brome
	Bromus briziformis	*Rattlesnake brome*
	Cirsium ochrocentrum	Wavyleaf thistle
	Cynoglossum officinale	*Houndstongue*
	Cystopteris fragilis	Brittlefern
	Eremogone fendleri	Desert sandwort
	Erigeron species	Fleabane
	Eriogonum flavum	Wild buckwheat
	Eriogonum umbellatum var. ***umbellatum***	Wild buckwheat
	Lactuca serriola	*Wild lettuce*
	Leucopoa kingii	Spike fescue
	Mertensia lanceolata	Bluebells
	Monarda fistuloa methifolia/M. pectinata	Horsemint
	Phleum pratense	*Timothy*
	Sabina scopulorum	Rocky Mountain Juniper
	Solidago species	Goldenrod
	Yucca glauca	Spanish bayonet

Table 3.8: Frequency for Trees and Shrubs in Open Space Forest Understory Inventory Plots					
0 = occurred in stands only (not documented in any understory inventory plots)					
			% Frequency		
Location of Plots		South	Central	North	ALL
		36 plots	68 plots	29 plots	133 plots
TREES: CONIFERS					
Pinus flexilus	Limber pine	0	0	0	0
Pinus ponderosa scopulorum	Ponderosa pine	100	100	100	100
Pseudotsuga menziesii	Douglas-fir	14	49	7	30
Sabino scopulorum	Rocky Mountain juniper	22	29	14	24
TREES: DECIDUOUS					
Acer glabrum	Rocky Mountain maple	8	7	7	8
Amelanchier alnifolia	Serviceberry	3	1	0	2
Celtis reticulata	Hackberry	8	4	0	5
Corylus cornuta	Hazelnut	0	0	0	0
Crataegus sp.	Hawthorn	3	0	14	4
Ligustrum vulgare	Privet	0	0	0	0
Negundo aceroides interius	Box-Elder	0	0	0	0
Populus sp.	Cottonwood	0	0	0	0
Populus tremuloides	Aspen	0	0	0	0
Quercus sp.	Oak	0	1	0	1
Salix scouleriana	Scouler's willow	0	0	0	0
EVERGREEN SHRUBS					
Arcostaphylos uva-ursi	Kinnickinnick	8	6	7	7
Juniperus communis	Common juniper	11	10	10	10
DECIDUOUS SHRUBS-COMMON					
Ceanothus fendleri	Buckbrush	11	40	59	36
Cercocarpus montanus	Mountain-mahogany	28	1	17	12
Mahonia repens	Holly-grape	56	53	34	50
Oreobatus deliciosus	Boulder raspberry	61	34	38	42
Padus virginiana	Chokecherry	56	41	59	49
Rhus aromatica trilobata	Skunkbrush	72	78	80	77
Ribes cereum	Wax currant	72	78	80	77
Rosa woodsii/R. sayii	Wild rose	36	54	41	47
Symphoricarpos sp.	Snowberry	56	34	34	40
DECIDUOUS SHRUBS-UNCOMMON					
Amorpha nana	Leadplant	0	3	0	1
Ceanothus herbaceous	Buckbrush	1	0	0	0
Cerasus pensylvanica	Pin cherry	0	1	0	0
Chrysothamnus nauseosus	Rabbitbrush	0	1	0	0
Colutea arborescens	Bladder senna	0	0	17	4
Holodiscus discolor	Oceanspray	3	0	0	1
Jamesia americana	Waxflower	0	3	3	2

Table 3.8: Frequency for Trees and Shrubs in Open Space Forest Understory Inventory Plots					
0 = occurred in stands only (not documented in any understory inventory plots)					
			% Frequency		
Location of Plots		South	Central	North	ALL
Physocarpus sp.	Ninebark	6	1	3	3
Prunus americana	Wild plum	3	4	3	4
Rhus glabra	Smooth sumac	8	4	0	5
Ribes aureum	Golden currant	0	0	0	0
Ribes inerme	Common gooseberry	3	0	10	3
Rubus idaeus melanolasius	Wild raspberry	3	16	3	3
Salix exigua	Sandbar willow	0	0	0	0
TOTALS		652	653	640	647

Forbs
Two-hundred and twenty-two forb species were recorded in the study area. The species with highest frequency are prairie sage (*Artemisia ludoviciana*) 88%, bluemist penstemon (*Penstemon virens*, 79%, and western yarrow (*Achillea lanulosa*) 78%. Forbs are discussed in more detail below in Section 3.6.2.

Graminoids (Grasses, Sedges, and Rushes)
Sixty-eight graminoid species were recorded during the field season. The species with highest frequency are sunsedge (*Carex pensylvanica heliophila*) 95%, mountain bluegrass (*Poa agassizensis)* 70%, and Canada bluegrass (*Poa compressa* 68%. Graminoids are discussed in more detail below in Section 3.6.2.

PLANT SPECIES COVER
Species cover, the percent of ground surface covered by a given plant species, is a measure of the dominance of different species in a plant community. Data on the nonvegetation components of cover of the understory (litter, bare rock, bare soil, gravel, and trails) were also collected. Cover data were collected during the field season following **point-intercept** methodology, using a cover-point ocular device designed by David Buckner of ESCO Associates (see City of Boulder 1998a). Two hundred cover points were recorded for each plot. Not all species in a plot have cover values, only those intercepted on the transects. Ten of the 133 plots sampled have no quantitative cover values since they were located on terrain too steep or too densely forested to sample with the cover-point ocular device. A table that lists cover values for all species in all plots by vegetation layer is included in the *Open Space Forest Understory Inventory Report* (City of Boulder 1998c).

As can be seen in Figure 3.10, total nonvegetation cover values in the understory inventory plots exceed total vegetation cover values. This is partly a reflection of the low natural productivity of the land in a semiarid climate with a complex surface geology and partly a result of human influences on the landscape. For example, fire suppression and grazing have been shown to decrease the productivity of understory vegetation in ponderosa pine forests.

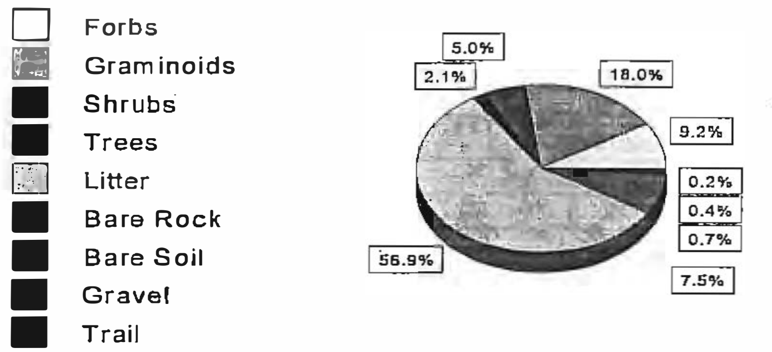

Figure 3.10: Total Vegetation and Nonvegetation Cover for Open Space Forest Understory Inventory Plots.

Litter accounts for almost 87% of the total nonvegetation cover, and bare rock for 11%. The range of litter cover in the plots is quite broad, from 20% to 90%. In some areas the litter was a thick layer of slowly decomposing pine needles, in other areas a shallow layer of pine needles, and in grassy areas a mat of decomposing herbaceous vegetation.

Figure 3.11 shows the total vegetation cover in the understory inventory plots. Graminoids account for over half the total vegetative cover, forbs for over one-

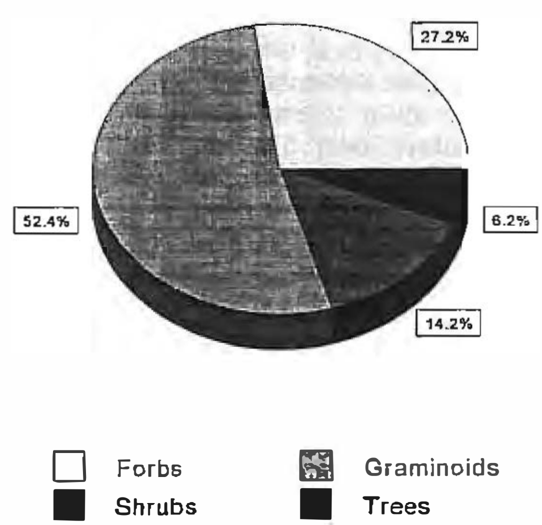

Figure 3.11: Vegetation Cover by Plant Layer for Open Space Understory Inventory Plots.

quarter, shrubs for 14% and trees for 6%. Note that tree cover as measured with the cover-point device accounts for only tree branches within 4 to 5 feet of the **forest floor** (the height of the device) and tree trunks intercepted during sampling. Tree canopy cover measurements were taken during the Open Space overstory inventory.

PLANT SPECIES RICHNESS

Species richness is a count of the number of plant species in a plot, area, or community (Kent and Coker 1992). Species richness in the understory inventory plots ranged from 18 species per plot to 80 species per plot, with an average of 48 species per plot. The southern stands had the highest average species richness with the northern stands a close second. The central stands had the lowest species richness, but the greatest range in the number of species/plot (see Table 3.9). Overall there was no major difference in species richness in the southern, central, and northern stands.

Table 3.9: Species Richness for Southern, Central, and Northern Open Space Forest Understory Inventory Stands.

	Southern Stands	Central Stands	Northern Stands	ALL PLOTS
Average Species Richness	50	45	49	48
Range of Species Richness	28 to 69	18 to 73	31 to 80	18 to 80

Peet (1981) notes that species richness varies independently for different plant groups within a plant community. Table 3.10 shows the total number of species for each plant group and the percent of total species richness in each group.

Table 3.10: Species Richness for Different Plant Groups on Open Space Forest Stands.

Species Richness	Trees	Shrubs	Forbs	Graminoids
Species richness/plant group	9	32	263	68
Percent of total species richness/plant group	2%	10%	67%	21%

Forbs account for 67% of the total species richness found in the understory inventory plots, while graminoids account for 21%. Trees and shrubs account for much less of the species richness, but are the so-called dominant plants in the forest due to their larger size and their large influence on the plants that grow beneath them.

Table 3.11 shows a comparison of percent of total cover and percent of total species richness for each plant group. Graminoids, which account for 52% of total vegetation cover, account for only 21% of total species richness, while forbs, which account for only 27% of total cover, account for 67% of total species richness.

Table 3.11: Percent of Total Cover and Percent of Total Species Richness/Plant Group.

Plant Group	Percent of Total Cover	Percent of Total Species Richness
Forbs	27	67
Graminoids	52	21
Shrubs	14	10
Trees	6	2

Note that tree cover in Table 3.11 only reflects a small percentage of total tree cover, since only the stems and tree trunks along the transects were measured with the cover-point ocular device.

SPECIES OF SPECIAL INTEREST

Rare and Uncommon Plants

During the 1997 field season the Open Space understory inventory crew documented all occurrences of plants listed as rare and imperiled in Boulder County by the Colorado Natural Heritage Program (1999), as well as species that are uncommon on Open Space land but not classified as rare by Colorado Natural Heritage Program. Table 3.12 lists the species that were documented in the understory plots and stands and their locations (by stand and plot or by stand only if the species did not occur within any of the plots within that stand).

Rare and imperiled species found in Boulder County, but not yet documented on Open Space are:

- Rocky Mountain sedge *(Carex saximontana)*, which is very rare in Boulder County (two records), is found on dry slopes of foothills canyons.

- Torrey sedge *(Carex torreyi)* has been found only once at the mouth of Gregory Canyon and Bear Canyon.

- Scarlet gaura *(Gaura neomexicana coloradensis)* is very rare on the outwash fans in Boulder County (one record).

Field personnel will continue to search for these species during future inventory and monitoring work.

There are not sufficient data from this one field season to determine whether there are any areas with high concentrations of plants of special concern in the study area. The limited available data shows that most of the rare species documented during 1997 were found in the southern (three occurrences) and central (six occurrences) forest stands, with only one occurrence in the northern

Table 3.12: Rare and Uncommon Plants on Open Space Forest Stands. Ranking codes are based on Colorado Natural Heritage Program (1999) designations.*

Species	Ranking Code	Location In Open Space Forests	Habitat, Boulder County (Weber 1995)
Amorpha nana, Leadplant	G5, S2	D-2 Stand, Lower Shanahan Stand, Powerline #5, S-3 #25, Watertank #15 and #20	Locally common on mesas.
Asplenium septentrionale, Grass-fern	NA	Not documented during the inventory, but previously documented on Lindsay and Eldorado Mountain.	Frequent in crevices, Flatirons.
Cheilanthes fendleri, Lipfern	NA	Witt-W #10	Locally frequent on seams of granite outcrops.
Crocanthemum bicknellii, Frostweed	NA	S-9#10, Lindsay South Stand	Rare, on hogbacks.
Linaria canadensis texane, Blue toadflax	NA	Not documented during the inventory, but previously documented on Lindsay and Shanahan.	Infrequent on the outwash fans and sandy sites in grasslands, piedmont valleys.
Penstemon gracilis, Slender penstemon	NA	LJC-NE Stand	Infrequent on the outwash fans.
Piperia unalascensis, Alaskan orchis	NA	LJC-NW Stand	Rare, outer foothills.
Smilax lasioneuron, Carrion-flower	NA	Not documented during the inventory, but previously documented on Lindsay and Lindsay-JeffCo.	Infrequent in gulches of the outwash fans.
Viola pedatifida, Birdsfoot violet	G5, S2	Lower Shanahan Stand, Watertank #1, LJC-NE Stand	Uncommon on outwash fans and grassy openings in pine groves.

*G for Global Rank, based on range-wide status of species;
G5 is "demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery";
S2 is "imperiled in state because of rarity (6 to 20 occurrences) or because of other factors demonstrably making it very vulnerable to extirpation from the state";
S3 is "vulnerable in state (21 to 100 occurrences)" (Spackman et al.1997).
NA indicates that the species is not sufficiently imperiled to merit a ranking by the Colorado Natural Heritage Program, but is a species of limited occurrence and is being monitored on Open Space lands.

forest stands. Additional rare plant survey work will provide a better evaluation of the status of rare plants on Open Space lands.

Non-native Plant Species

Invasive non-native plant species (also known as aliens, exotics, or weeds) commonly threaten native plant communities by displacing native species, and impact natural areas by reducing native species diversity, affecting natural processes, raising the cost of land management, and diminishing aesthetic and recreational values. Non-native plant species account for 20% of the plant species documented during the understory inventory and 18 percent of the total understory cover.

The overall importance values of the non-native species in the understory inventory plots are listed in Table 3.13. The importance values are a combination of cover and frequency values (expressed as percentages), and provide an indication of the importance of the plant species within a particular area (see Murphy 1998). Note that these importance values reflect only the data collected for the understory inventory plots, and while they are representative of the forest stands, more detailed weed mapping is needed to accurately assess which species represent the greatest threat in this area. Also the importance values for individual species do not reflect the potential these species have for displacing native species or the difficulty of controlling them. Diffuse knapweed (*Acosta diffusa*), for instance, has a much greater potential to disrupt local ecosystems than other non-native species which have higher importance values for this inventory.

Table 3.13: Overall Importance Values for Non-native Plant Species from Open Space Forest Understory Inventory Plots.

A = annual; B = biennial; all other species are perennials
CS = cool season; PF = postfire; PG = postgrazing
IV = importance value
top 10 list = top 10 weeds in state of Colorado
noxious = on the noxious weed list for Colorado

Species	Common Name	IV		Notes
Poa compressa	Canada bluegrass	76		CS, increaser
Tragopogon dubius major	Salsify	39	B	
Bromus japonicus	Japanese brome	34	A	CS, Increaser PG
Anisantha tectorum	Cheatgrass	33	A	noxious; CS, increaser PF/PG
Verbascum thapsus	Mullein	31	B	noxious; increaser PF/PG
Carduus nutans macrolepis	Musk thistle	29	A/B	top 10 list; increaser PG
Hypericum perforatum	St. Johnswort	26		top 10 list; increaser PF/PG
Taraxacum officinale	Dandelion	21		increaser PF/PG
Phleum pratense	Timothy	20		CS
Breea arvensis	Canada thistle	16		top 10 list
Cynoglossum officinale	Hound's tongue	15	B	noxious; toxic to livestock, horses
Anisantha/Bromus spp.	Cheatgrass/Brome species	14	A	CS, Increaser PF/PG
Bromus briziformis	Rattlesnake brome	14	A	CS
Lactuca serriola	Prickly lettuce	13	A/B	increaser PF/PG
Neolepia campestre	Fieldcress	11		
Bromopsis inermis	Smooth brome	10		CS

Table 3.13: Overall Importance Values for Non-native Plant Species from Open Space Forest Understory Inventory Plots.

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IV = importance value
top 10 list = top 10 weeds in state of Colorado
noxious = on the noxious weed list for Colorado

Species	Common Name	IV		Notes
Alyssum alyssoides	Alyssum	9	A	increaser PG
Silene antirrhina	Sleepy catchfly	8		
Camelina microcarpa	False flax	8	A	spread by horses
Elytrigia repens	Quackgrass	8		noxious; WS
Potentilla recta	Sulfur cinquefoil	6		noxious;
Acosta diffusa	Diffuse knapweed	4		top 10 list
Fallopia convolvulus	Black bindweed	4		
Alyssum spp.	Alyssum	3	A	Increaser PG
Dactylis glomerata	Orchard grass	3		
Acetosella vulgaris	Sheep sorrel	3		increaser PF/PG
Thinopyrum intermedium	Intermediate wheatgrass	3		CS
Galium aparine	Bedstraw	2	A	
Alyssum parviflorum	Alyssum	2	A	increaser PG
Convolvulus arvensis	Field bindweed	2		top 10 list
Nepeta cataria	Catnip	2		
Rumex crispus	Curly dock	2		
Turritis glabra	Tower mustard	2		
Linaria vulgaris	Toadflax	2		top 10 list
Colutea arborescens	Bladder senna	2		
Pseudognaphalium canescens	Cudweed	2		
Agropyron cristatum desertorum	Crested wheatgrass	2		CS
Thlaspi arvense	Pennycress	1	A	
Agrostis gigantea	Redop	1		CS
Saponaria officinalis	Bouncing bet	1		noxious
Arrhenatherum elatius	Tall oatgrass	1		
Bassia sieversiana	Ironweed, Kochia	1		
Cirsium vulgare	Bull thistle	1	B	noxious
Poa pratensis	Kentucky bluegrass	1		
Silene dichotoma	Catchfly	1		
Tithymalus spathulatus	Spurge	1		
Pseudognaphalium viscosum	Cudweed	1		
Acosta maculosa	Spotted knapweed	<1		top 10 list
Asparagus officinalis	Wild asparagus	<1		

Table 3.13: Overall Importance Values for Non-native Plant Species from Open Space Forest Understory Inventory Plots.

A = annual; B = biennial; all other species are perennials
CS = cool season; PF = postfire; PG = postgrazing
IV = importance value
top 10 list = top 10 weeds in state of Colorado
noxious = on the noxious weed list for Colorado

Species	Common Name	IV		Notes
Bromus commutatus	Brome	<1	A	CS
Dianthus armeria	Deptford pink	<1		
Stenactus strigosa	Daisy fleabane	<1		
Tithymalus myrsinites	Myrtle spurge	<1		noxious
Triodanis perfoliata	Venus' looking glass	<1	A	
Trifolium pratense	Red clover	<1		
Verbena bracteata	Bigbract verbena	<1	A	
Non-native Plant Species With No Importance Values				
Anisantha sterilis	Poverty brome		A	
Capsella bursa-pastoris	Shepherd's purse		A	
Carderia chalapensis	Whitetop			
Chenopodium berlandieri	Netseed lambsquarters		A	
Chlorispora tenella	Blue mustard		A	noxious
Cichorium intybus	Chicory			noxious
Erodium cicutarium	Filaree			noxious
Iris sp.	Cultivated iris			
Linaria genistifolia dalmatica	Common toadflax			noxious
Poa bulbosa	Bulbous bluegrass		A	CS
Quercus species	Oak			
Sisymbrium altissimum	Jim Hill mustard		A	

The following non-native species were documented during the inventory and are on the top ten weed list for the state of Colorado: musk thistle (*Carduus nutans macrolepis*), St. Johnswort (*Hypericum perforatum*), Canada thistle (*Breea arvensis*), diffuse knapweed (*Acosta diffusa*), field bindweed (*Convolvulus arvensis*), toadflax (*Linaria vulgaris)*, and spotted knapweed (*Acosta maculosa*), but only the first three have relatively high importance values in the understory inventory plots. In addition, several species are on the noxious weed list for the state of Colorado: cheatgrass (*Anisantha tectorum*), mullein (*Verbascum thapsus*), houndstongue *(Cynoglossum officinale*), species with relatively high importance values in the Open Space inventory, and quackgrass (*Elytrigia repens*), sulfur cinquefoil (*Potenilla recta*), bouncing bet (*Saponaria officinale*), bull thistle (*Cirsium vulgare*), myrtle spurge (*Tithymalus myrsinites*), chicory (*Chichorium intybus*), blue mustard (*Chlorospora tenella*), filaree (*Erodium cicutarium*), and common toadflax (*Linaria genistifolia dalmatica*), species with low importance values in the Open Space inventory. Management concerns for non-native species are discussed in more detail in Chapter 5.

3.6.2 Open Space Forest Plant Associations

In addition to analyzing the plant composition of the forest as a whole, plant ecologists consider the larger landscape patterns created by plant assemblages. The plant association is currently considered to be the basic unit for vegetation classification in North America. It is defined as "a plant community type of definite floristic composition, uniform habitat conditions, and uniform physiognomy" (Grossman et al. 1998). The Ponderosa pine/Sunsedge *(Pinus ponderosa scopulorum/Carex pensylvanica heliophila*) Plant Association is the single plant association delineated by an analysis of the 1997 understory inventory data (see Murphy 1998 for complete details of the analysis). Five plant subassociations (PSAs) within this plant association were also delineated. As additional data are collected on Open Space and Mountain Parks forests, the plant association analysis will be repeated, and the structure of some of these plant subassociations may change, or new plant associations and subassociations may be added.

Since this plant association and the five subassociations that occur within it on Open Space forest lands have been influenced by natural and human disturbances, these disturbances will be briefly described below, and then the plant associations themselves will be described.

The Influence of Disturbance on Plant Succession

Plant communities and associations change over time as environmental conditions change. These sequential changes in the vegetation on a given site are known as plant succession, a process which is influenced by the reproductive and competitive strategies of individual species, and by natural and human disturbance. Although succession is usually described as species turnover or replacement, it also affects ecosystem structure and function (Dahms and Geils 1997). In fact, plant communities and associations are often more sensitive to disturbances than the larger landscape is. One of the challenges of ecosystem management is to determine, to the extent possible, how ecosystems change over time in response to natural and human disturbances.

Both natural and human disturbances have had, and will continue to have, a profound influence on the plant species and communities found within a given area and on the structure of the plant community (that is, the role of trees, shrubs, forbs, and graminoids, their distribution and population structure, and associated habitat variables). As discussed earlier in the Plan, human activities have influenced the plant communities of this area for hundreds of years, but most notably since the middle 1800s. In fact, the development and composition of forest plant associations throughout the West have been influenced by four primary factors over the last 150 years, namely, logging, intensive grazing of livestock, fire suppression, and the introduction of non-native plants.

Logging
Open Space forests have been cut periodically since the 1860s. Early settlers cut trees for building homes, bridges, mines, and railroads, and to clear the land for agricultural and mining enterprises. In more recent decades, the forests have been logged to reduce the impact of mountain bark beetle and other infestations, as was done during the late 1970s and early 1980s during Project Greenslope. Today, following the paradigm of ecosystem management, land managers are cutting trees to open the canopy and restore conditions that prevailed before the policy of fire suppression was initiated and to prepare stands for prescribed fire.

Grazing
Plants respond to grazing pressure in different ways. Some plants are relished by cattle and some are avoided. Some are resistant to grazing and some are not. Research findings over the past several decades (U.S. Department of Agriculture 1937, Costello and Schwan 1946, Weaver 1968, Stubbendieck et al. 1986, Holechek et al. 1989, Fleischner 1994) have shown that certain plants are indicators of overgrazing, either because they are not palatable to livestock (increasers), or are extremely sensitive to grazing (decreasers), or invade disturbed areas where plant cover has been diminished (invaders).

Wildfire and Fire Suppression
Western forests have coevolved with fire and many species have developed adaptations like thick bark and fire-adapted seed that allow them to survive repeated burning. As discussed earlier, fires of all sizes and intensities have been a regular feature of these forests throughout their history. These periodic fires favor fire-resistant species in the forests over species that are vulnerable to fire.

The growth-forms of plants affect their ability to survive fire and other disturbances, especially in relation to the position of the "perennating tissue" (or growth tissue) that is inactive during cold and/or dry seasons. Plants with their growth tissues close to the ground or underground are more protected from disturbances like **ground fire** and grazing.

Although fires were intentionally and unintentionally set by Native Americans and early non-Native-American settlers, fire suppression has been the rule during the last 100 years. Fire suppression also affects the abundance of certain plant species, especially those that are least resistant to fire. In areas where fire suppression has been in effect for many decades, for instance, these plants may be much more abundant than they would be under an historical fire regime. Wax currant (*Ribes cereum*), for example, is one of the most common shrubs in Open Space forests. Since it is vulnerable to fire, it may decrease in abundance where prescribed fires burn through the understory vegetation.

Introduction of Non-native Plant Species
Non-native species have gained ground in recent decades as more and more land has been subjected to various kinds of disturbance. Intensive grazing increases the spread and establishment of non-native species, as cattle disperse seed, open up habitat for non-natives, and decrease competition from native species that are good forage plants (Fleischner 1994). Logging, roads, and recreational trails have also provided avenues for the introduction of non-native plants.

In the following section, the impacts of natural and human disturbances on the plant associations found in Open Space forests will be discussed in greater detail.

DESCRIPTION OF PLANT ASSOCIATIONS AND SUBASSOCIATIONS ON OPEN SPACE FORESTS

The Ponderosa pine/Sunsedge (*Pinus ponderosa scopulorum/Carex pensylvanica heliophila*) Plant Association and the five subassociations within it are described and discussed below in relation to their location, environmental factors, composition, condition, and management implications. Figure 3.12 is a diagram of the **indicator species** for the plant associations and subassociations. Indicator species are those species that show a high degree of fidelity to a particular plant group, but are not necessarily abundant. Figure 3.13 shows species with highest importance values for each plant subassociation. Importance values are based on both total percent cover and frequency values for each species and provide a measure of the relative importance (or dominance) of each species in a particular plant association (see Murphy 1998).

Ponderosa pine/Sunsedge Plant Association

(*Pinus ponderosa/Carex pensylvanica* Plant Association)

This plant association has been described in several studies in the central Rocky Mountain region (Alexander 1985, Anderson et al. 1998, Baker 1984, Bunin 1985, Grossman et al. 1998, Hess and Alexander 1986, Johnson 1987, Peet 1978 and 1981). Ponderosa pine forests in the Rocky Mountains are usually characterized by either a grass or a shrub understory. Along the Eastern Slope of the Front Range low-elevation ponderosa pine forests are commonly associated with Douglas-fir, Rocky Mountain juniper and common juniper, and are noted for the diversity of the understory (Weber 1995, Marr 1961).

Plots: The Ponderosa pine/Sunsedge Plant Association is based on the cover data collected on 123 of the 133 understory inventory plots in 37 forest stands. The following ten plots were not assigned to a PSA due to lack of cover data, since they were on slopes too steep or in stands too dense for sampling with the cover-point ocular device: Dakota Ridge (1, 5), MRL (5, 20), S-4 (10), ST-3 (1), Witt-E (1), Witt-NW (5, 10), Witt-W (10).

Current Condition: Table 3.14 lists the indicator species for the Ponderosa pine/Sunsedge Plant Association, as well as species with high importance values for the plant association. A review of Table 3.14 indicates that only three of the 18 species listed are non-native: cheatgrass (*Anisantha tectorum*), Japanese brome (*Bromus japonicus*), and salsify (*Tragopogon dubius*). However, nine of the native species listed are known to increase in areas that have been intensively grazed, and are indicators of prior landscape disturbance. Three additional species are decreasers: Nelson's needlegrass (*Acnatherum nelsonii*), mountain muhly (*Muhlenbergia montana*), and wax currant (*Ribes cereum*), plants that decrease in areas that have been intensively grazed. The fact that these three species have high importance values probably indicates that the ecosystem has recovered to some degree from previous grazing impacts. Fire suppression in recent decades may also be a factor in the abundance of wax currant and needlegrass, as these species are relatively vulnerable to fire.

OPEN SPACE PLANT ASSOCIATIONS AND SUBASSOCIATIONS
Pinus ponderosa scopulorum/Carex pensylvanica heliophila Plant Association
123 samples

Pinus ponderosa
Carex pensylvanica heliophila
Artemisia ludoviciana
Penstemon virens
Achillea lanulosa
Cerastium strictum
Drymocallis fissa
Achnatherum nelsonii
Ribes cereum
Opuntia macrorhiza & *Muhlenbergia montana* (sparse but wide spread)

†+clay,+graz,-slope | †+timb,+litt,+burn

61 plots
☛*Hypericuim perforatum*
☛ ((*Poa compressa*))
Rhus aromatica

†+graz,+north,-slope | †+SE/SW,+slope

24 plots | 37 plots

Poa compressa/Arnica fulgens PSA
☛*Arnica fulgens*
Senecio integerimus
Galium species
Lomatium orientale
Neolopia campestris
((Taraxacum officinalis))
((Eremogone fendleri))
((Aster porteri))
((Antennaria species))
((Symphoricarpos species))

☛*Hesperostipa comata*
((Schizachyrium scoparium))

3 plots | *17 plots* | *17 plots*
†+NW,+slope | †+litter,+sand, -elev, -regen | †+clay, +elev

Physocarpus monogynus/Elymus lanceolatus PSA
☛*Oxytropis sericea*
Elymus lanceolatus
Leymus ambiguus
Packera cana
Nepeta cataria
Physocarpus monogynus
Adenolinum lewisii

Carex pensylvanica helophila/Danthonia spicata PSA
((Symphortcarpos species))
[(Danthonia spicata)]
Leymus ambiguus

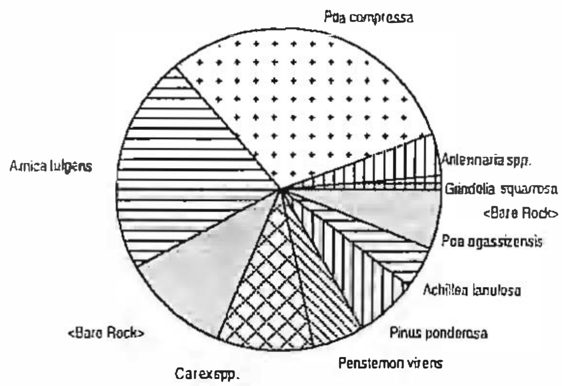
Andropodon gerardii/Psoralidium tenuiflorum PSA
☛ *(Andropogon gerardii)*
☛*Psoralidium tenuiflorum*
((Poa agassizensis))
Dalea purpura
Sorghastrum avenaceum
Ratibida columnifera
(*Bouteloua curtipendula*)
(*Yucca glauca*)

62 plots
Ceanothus fendleri/Danthonia spicata
☛*Danthonia spicata*
☛*Harbouria trachypleura*
☛*Ceanothus fendleri*
☛*Pseudotsuga menzesii*
((*Mahonia repens*))

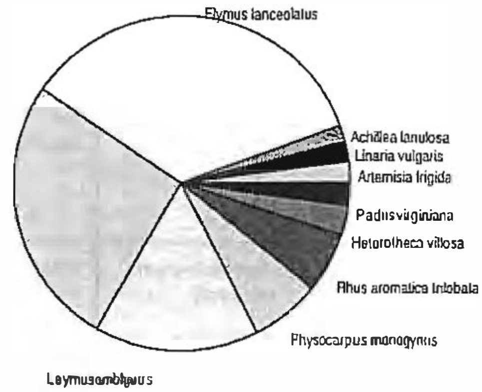
☛ This symbol is used to mark the indicator species identified by TWINSPAN
The number of samples in each division is at the top of each column.
Single parenthesis = (xxxxx) = center in a moderately wide distribution
Double parenthesis = ((xxxxx)) = center in a broad distribution
Bracketed parenthesis = [(xxxxx)] = secondary center in moderate distribution
† This symbol identifies the environmental factors that the DISCRIM program identified as correlated with the TWINSPAN division.

FIGURE 3.12: Plant Associations and Subassociations based on Twinspan Analysis of 1997Open Space Forest Understory Inventory Cover Data (Adapted from Murphy 1998)

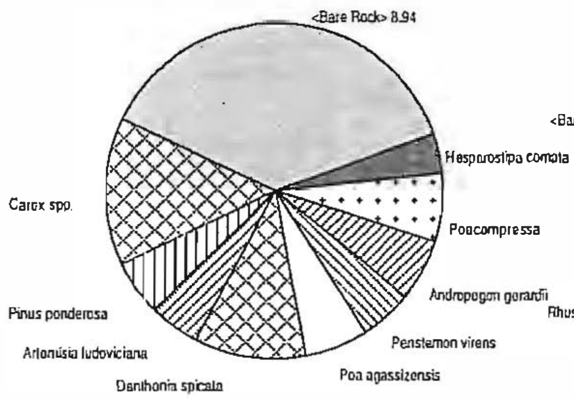
Canada bluegrass/Meadow arnica Plant Subassociation (*Poa compressa/Arnica fulgens*)



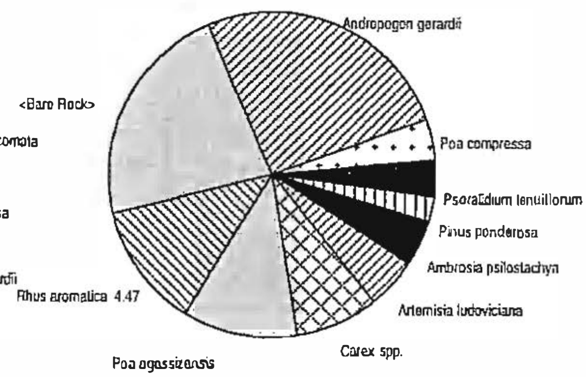
Ninebark/Thickspike wheatgrass Plant Subassociation (*Physocarpus monogynous/Elymus lanceolatus*)



Sunsedge/Poverty oatgrass Plant Subassociation *(Carex pensylvanica heliophila/Danthonia spicata)*



Big bluestem/Wild alfalfa Plant Subassociation (*Andropogan gerardii/Psoralidium tenuiflorum*)



Buckbrush/Poverty oatgrass Plant Subassociation (*Ceanothus fendleri/Danthonia spicata)*

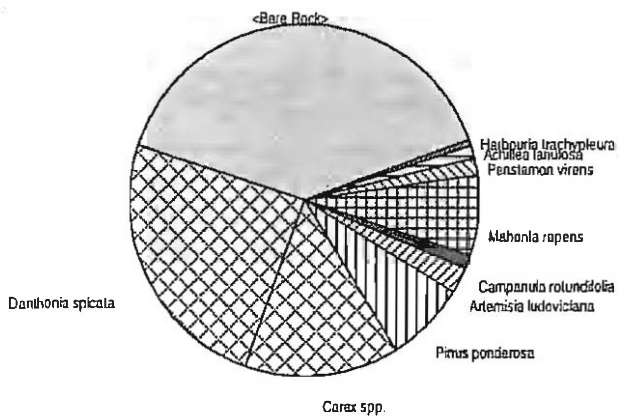


Figure 3.13. Open Space Forest Plant Subassociations in the Ponderosa pine/Sunsedge Plant Association. Pie-charts show species with highest importance values in each plant subassociation. (Murphy 1998)

Table 3.14: Indicator and Dominant Species for the Ponderosa Pine/Sunsedge Plant Association. Native species are in boldface.

Species	Common Name	Fire Effects	Grazing Effects	Indicator Species	High Importance Values
Achillea lanulosa	Western yarrow	cover and frequency generally increase	increaser	X	
Achnatherum nelsonii	Nelson's needlegrass	cool season grass; detrimental early summer; recovers slowly	decreaser	X	
Ambrosia psilostachya coronopifolia	Western ragweed	fire resistant; may increase	increaser		X
Anisantha tectorum	Cheatgrass	early spring harms; late summer favors	invader		X
Artemisia ludoviciana	Sagewort	moderately resistant; may increase	increaser	X	
Bromus japonicus	Japanese brome	fire tends to reduce, except in wet years	invader		X
Campanula rotundifolia	Harebell				X
Carex pensylvanica heliophila	Sunsedge	summer favors	increaser?	X	
Cerastium strictum	Mouse-ear		increaser?	X	
Drymocallis fissa	Cinquefoil		increaser	X	
Grindelia species	Gumweed	increaser?	increaser		X
Muhlenbergia montana	Mountain muhly	takes several years to recover; warm season grass	decreases	X	
Opuntia macrorhiza	Prickly-pear	decreaser?	increaser	X	
Padus virginiana	Chokecherry	top-killed but sprouts vigorously; may increase			X
Penstemon virens	Blue-mist penstemon		increaser	X	

Table 3.14: Indicator and Dominant Species for the Ponderosa Pine/Sunsedge Plant Association. Native species are in boldface.

Species	Common Name	Fire Effects	Grazing Effects	Indicator Species	High Importance Values
Pinus ponderosa scopulorum	Ponderosa pine	extremely well-adapted beyond the pole stage		X	
Ribes cereum	Wax currant	most plants killed; reestablished by seed	decreaser	X	
Tragopogon dubius major	Salsify		invader		X

PLANT SUBASSOCIATIONS WITHIN THE PONDEROSA PINE/SUNSEDGE PLANT ASSOCIATION

Groups of plants are often distinguished by their preferred habitats as they relate to soils, moisture, aspect, elevation, and microclimates. Plant groups can thus indicate fine-scale environmental differences between sites. Ponderosa pine is found across a wide range of soil and moisture conditions and therefore forms a more heterogeneous plant community than species which grow within a narrower range of environmental conditions (Marr 1964). This heterogeneity is reflected in the five plant subassociations which are described below (see Murphy 1998 for additional detail).

Table 3.15 shows the relationships of the five plant subassociations with the environmental variables of location, aspect, slope, and soils. The Canada bluegrass/Meadow arnica (*Poa compressa/Arnica fulgens)* PSA is the only one linked exclusively to southern stands and to Nederland very coarse sandy loam soil. The Big bluestem/Wild alfalfa (*Andropogon gerardii/Psoralidium tenuiflorum*) PSA is the only one linked to moist, fertile, colluvial soils. The Buckbrush/Poverty oatgrass (*Mahonia repens/Danothonia spicata*) PSA is the only one linked to mostly southwest-facing areas over 15 degrees in slope and on mostly Goldvale-Rocky outcrop complex soils.

The plant subassociations should also show some correlations with forest canopy cover. Because of problems with the methodology used to collect forest canopy cover, however, such correlations are difficult to determine at this time. Once adequate canopy cover data are collected, the relationship between canopy cover and plant subassociations will be analyzed.

Table 3.15: Open Space Forest Plant Subassociations and Their Relationships to Environmental Variables.

Plant subassociation and number of plots	**Location and management area**	**Aspect**	**Slope**	**Soils (based on Soil Conservation Service 1971)**
Buckbrush/Poverty oatgrass *Ceanothus fendleri/Danthonia spicata* 62 plots	mostly in the central and northern stands	mostly SW-facing	>15%	mostly Goldvale-Rocky outcrop complex (moderately permeable soils; available water capacity is high), with some Nederland very coarse sandy loam, Baller stony sandy loam, and Juget-Rock outcrop complex
Canada bluegrass/Meadow arnica *Poa compressa/Arnica fulgens* 24 plots	southern stands;	mostly NW-SE-facing	<15%	Nederland very coarse sandy loam (moderately permeable soils; available water capacity is moderate)
Big bluestem/Wild alfalfa *Andropogon gerardii/Psoralidium tenuiflorum* 17 plots	mostly in central stands	mostly NW-SE-facing	<15%	moist, fertile soils; mostly Colluvial, with some Nederland very coarse sandy loam and Baller stony sandy loam
Sunsedge/Poverty oatgrass *Carex pensylvanica/Danthonia spicata* 17 plots	southern, central, and northern stands	mostly NW-SE-facing	<15%	Baller stony sandy loam (rapid permeability; available water capacity is low), Nederland very cobbly sandy loam, Goldvale-Rock outcrop complex, Juget-Rock outcrop complex (rapid permeability soils; available water capacity is low)
Ninebark/Thickspike wheatgrass *Physocarpus monogynous/Elymus lanceolatus* 3 plots	a single northern stand	NW-facing	>15%	unknown

Buckbrush/Poverty oatgrass Plant Subassociation
(*Ceanothus fendleri/Danthonia spicata* Plant Subassociation)

Plots: 62 plots, mostly in the central and northern stands: D2 (1), D3D4 (5, 30), Eldo-E (10), Lindsay-N (1), Lindsay/Jeffco-NW (1), MRL (15), Powerline (1, 5, 10, 15, 20, 25), S-10 (1, 5), S-3 (1, 5, 10, 15, 20, 25), ST-3 (5, 10), ST-5 (1, 5), ST-6 (1, 5, 10, 15), ST-7 (1, 5), ST-8 (1, 5), ST-9 (1, 5), Witt-E (5, 10), Witt-NE (1, 5, 15, 20, 25, 30), Witt-NW (15, 20), Witt-S (5), Witt-W (5)

Aspect and Slope: Only PSA that is mostly southwest-facing and on greater than 15% slopes.

Soils: Mostly Goldvale-Rocky outcrop complex (available water capacity is high) with some Nederland very coarse sandy loam, Baller stony sandy loam, and Juget-Rock outcrop complex.

Current condition: The Buckbrush/Poverty oatgrass PSA, with over half of all the understory inventory plots, represents the beginning of the true lower montane ponderosa pine/Douglas-fir forest (Table 3.16). It is the only PSA with consistent cover of Douglas-fir. This PSA has the highest cover of litter and the lowest total vegetation cover of any of the PSAs. It ranks lowest in species richness, with an average of 40 species/plot, but has the highest shrub species richness (11 species) of any of the PSAs, including the highest importance values for holly-grape, buckbrush, common juniper, and wild raspberry. Poverty oatgrass, which does well on poor, infertile soils, has its highest importance value in this PSA.

Table 3.16: Indicator and Dominant Species for Buckbrush/Poverty oatgrass (*Ceanothus fendleri/Danthonia spicata*) Plant Subassociation. Native species are in boldface.

Species	Common Name	Indicator Species	High Importance Values
Achillea lanulosa	Western yarrow		X
Artemesia ludoviciana	Prairie sage		X
Campanula rotundifolia	Common harebell		X
Carex pensylvania heliophila	Sunsedge		X
Ceanothus fendleria	Buckbrush	X	
Danthonia spicata	Poverty oatgrass	X	X
Harbouria trachypleura	Whiskbroom parsley	X	X
Mahonia repens	Holly-grape	X	
Penstemon virens	Bluemist penstemon		X
Pinus ponderosa scopulorum	Ponderosa pine		X
Pseudotsuga menziesii	Douglas-fir	X	

Canada bluegrass/Meadow arnica Plant Subassociation
(*Poa compressa/Arnica fulgens* Plant Subassociation)

Plots: 24 plots, all in southern stands: Eldo-E (1, 5, 15), Lindsay-N (5, 10), Lindsay-S (1, 5, 10, 15), Lindsay/Jeffco-NE (1, 5, 10), Lindsay/Jeffco-SE (1, 5, 10, 15, 20), Lindsay/Jeffco-SW (5, 10), Stengel II (1, 5, 10, 15, 20)

Aspect and slope: Mostly NW-SE aspect and less than 15% slopes.

Soils: Nederland very coarse sandy loam (available water capacity is moderate).

Current condition: The Canada bluegrass/Meadow arnica PSA is characterized by a long history of disturbance, including intensive livestock grazing (cattle and sheep), and by an open canopy and relatively flat terrain. This PSA is defined by 13 species, including four non-native plants which invade disturbed areas (Canada bluegrass, St. Johnswort, fieldcress, and dandelion) and three native species which increase in intensively grazed areas (meadow arnica, pussytoes, and desert sandwort) (Table 3.17). It has the highest cover of non-native annual grasses and the highest importance values of any of the PSAs for several non-native species (cheatgrass, false flax, cinquefoil, and sheep sorrel), but it also has the highest average cover of native perennial forbs of any of the PSAs.

The Canada bluegrass/Meadow arnica PSA ranks second in total vegetation cover of the four main PSAs and third in species richness, with an average of 44 species per plot. Overall this PSA has the lowest shrub cover of the four main PSAs, but high shrub cover on MRL and Eldo-E forest stands provide food and shelter for wildlife. Wildlife sightings are frequent in this area, including bear, mountain lion, and wild turkey. Recreational use is relatively low, but horseback riding, jogging, hiking, and birding were observed on the roads and on social trails in the forest.

Table 3.17: Indicator and Dominant Species for Canada bluegrass/Meadow arnica (*Poa compressa/Arnica fulgens*) Plant Subassociation. Native species are in boldface.

Species	Common Name	Indicator Species	High Importance Value
Achillea lanulosa	Western yarrow		X
Antennaria species	Pussytoes	X	X
Arnica fulgens	Meadow arnica	X	X
Aster porteri	Porter's aster	X	
Carex pensylvanica heliophila	Sunsedge		X
Eremogone fendleri	Desert sandwort	X	
Galium species	Bedstraw	X	
Grindelia squarosa	Gumweed		X

Table 3.17: Indicator and Dominant Species for Canada bluegrass/Meadow arnica (*Poa compressa/Arnica fulgens*) Plant Subassociation. Native species are in boldface.

Species	Common Name	Indicator Species	High Importance Value
Hypericum perforatum	St. Johnswort	X	
Lomatium orientale	Salt-and-pepper	X	
Neolepia campestris	Fieldcress	X	
Penstemon virens	Bluemist penstemon		X
Pinus ponderosa scopulorum	Ponderosa pine		X
Poa agassizensis	Mountain bluegrass		X
Poa compressa	Canada bluegrass	X	X
Rhus aromatica trilobata	Three-leaf sumac	X	
Senecio integerrimus	Spring senecio	X	
Symphoricarpos species	Snowberry	X	
Taraxacum officinalis	Dandelion	X	

Big bluestem/Wild Alfalfa Plant Subassociation
(*Andropogon gerardii/Psoralidium tenuiflorum* Plant Subassociation)

Plots: 17 plots, mostly in the central stands: D181 (1), D1 (1, 5, 10), D2 (5, 10), D3D4 (1, 5, 10, 15, 20, 25), Dakota Ridge (10), Lindsay/Jeffco-NW (15), Lower Shanahan (1), Watertank (1, 15, 20).

Slope and Aspect: Mostly NW-SE aspect and less than 15% slope.

Soils: Moist, fertile soils; mostly Colluvial, with some Nederland very coarse sandy loam and Baller stony sandy loam.

Current condition: This plant subassociation is characterized by an increase in elevation relative to the grassland/forest ecotone, as well as by moist, fertile soils and an abundance of native prairie plants. It is the only PSA with high cover of both warm and cool season grasses, ranking first in cover for warm season native grasses (and having the highest importance values for big bluestem, mountain bluegrass, spike muhly, and Indiangrass) of the four main PSAs (Table 3.18). It is highest in total vegetation cover and lowest in average cover for litter of the four main PSAs and ranks first in species richness, with an average of 51 species per plot.

Table 3.18: Indicator and Dominant Species for Big bluestem/Wild alfalfa (*Andropogon gerardii/Psoralidium tenuiflorum*) Plant Subassociation.

Species	Common Name	Indicator Species	High Importance Values
Ambrosia psilostachya coronopifolia	Western ragweed		X
Andropogon gerardii	Big bluestem	X	X
Artemisia ludoviciana	Prairie sage		X
Bouteloua curtipendula	Sideoats grama	X	
Carex pensylvanica heliophila	Sunsedge		X
Dalea purpurea	Purple prairie clover	X	
Hesperostipa comata	Needle-and-thread	X	
Hypericum perforatum	St. Johnswort	X	
Pinus ponderosa scopulorum	Ponderosa pine		X
Poa agassizensis	Mountain bluegrass	X	X
Poa compressa	Canada bluegrass	X	X
Psoralidium tenuiflorum	Wild alfalfa	X	X
Ratibida columnifera	Prairie coneflower	X	
Rhus aromatica	Three-leaf sumac	X	X
Schizachyrium scoparium	Little bluestem	X	
Sorghastrum avenaceum	Indiangrass	X	
Yucca glauca	Soapweed yucca	X	

Sunsedge/Poverty Oatgrass Plant Subassociation
(*Carex pensylvanica/Danthonia spicata* Plant Subassociation)

Plots: 17 plots, scattered across the southern, central, and northern stands: Lindsay/Jeffco-NW (5, 10), Lindsay/Jeffco-SW (1), Lower Shanahan (5, 10), MRL (1, 10), S-10 (10), S-5 (1), S-9 (1), Witt-NE (10), Witt-NW (1), Witt-S (1, 10), Witt-W (1), Watertank (5, 10)

Aspect and slope: Mostly NW-SE aspect and less than 15% slope.

Soils: Baller stony sandy loam, Nederland very cobbly sandy loam, Goldvale-Rock outcrop complex, and Juget-Rock outcrop complex.

Current condition: This PSA appears to be transitional or successional, as indicated by the fact that all of the species which define it are shared by other PSAs (Table 3.19). It is characterized by high litter, sandy soils, and low tree regeneration. Indicators of previous landscape disturbance are native poverty oatgrass and sunsedge and non-native Canada bluegrass, all of which increase in intensively grazed areas, and non-native St. Johnswort, which invades disturbed areas.

The Sunsedge/Poverty oatgrass PSA ranks third in total vegetation cover of the four main PSAs, and second in species richness, with an average of 47 species per plot. This is the only PSA with recorded cover for mountain mahogany (it ranked 22 in importance value for this PSA) and it is second only to the Buckbrush/Poverty oatgrass PSA in species richness for trees and shrubs.

Table 3.19: Indicator and Dominant Species for Sunsedge/Poverty oatgrass (*Carex pensylvanica/Danthonia spicata*) Plant Subassociation.

Species	Common Name	Indicator Species	High Importance Values
Andropogon gerardii	Big bluestem		X
Artemisia ludoviciana	Prairie sage		X
Carex pensylvanica heliophila	Sunsedge		X
Danthonia spicata	Poverty oatgrass	X	X
Elymus lanceolatus	Thickspike wheatgrass	X	
Hesperostipa comata	Needle-and-thread	X	X
Hypericum perforatum	St. Johnswort	X	
Leymus ambiguus	Colorado wild rye	X	
Penstemon virens	Bluemist penstemon		X
Pinus ponderosa scopulorum	Ponderosa pine		X

Table 3.19: Indicator and Dominant Species for Sunsedge/Poverty oatgrass (*Carex pensylvanica/Danthonia spicata*) Plant Subassociation.			
Species	**Common Name**	**Indicator Species**	**High Importance Values**
Poa agassizensis	Mountain bluegrass		X
Poa compressa	Canada bluegrass	X	X
Rhus aromatica	Three-leaf sumac	X	
Schizachyrium scoparium	Little bluestem	X	
Symphoricarpos species	Snowberry	X	

Ninebark/Thickspike wheatgrass Plant Subassociation
(*Physocarpus monogynous/Elymus lanceolatus* Plant Subassociation)

Plots: 3 plots, all in northern stands in the Sunshine/Dakota Ridge Management Area: Pinebrook (1, 5, 10)

Aspect and slope: Northwest aspect and >15% slope

Soils: Unknown at this time.

Current Condition: The Ninebark/Thickspike wheatgrass PSA (Table 3.20) is limited to one stand, which has a NW-facing aspect, the only stand with this aspect that was sampled during the 1997 Open Space understory inventory. Additional plots may be assigned to this PSA once the Open Space understory inventory is completed on the 22 forest stands that were not surveyed during 1997. Some Mountain Park plots may also be assigned to this PSA once their inventory data is analyzed. Alternatively, these plots may be reassigned to a different PSA once all the inventory data are analyzed.

This PSA is defined by two native shrubs (three-leaf sumac and ninebark), two cool-season native grasses (thickspike wheatgrass, Colorado wild rye) and one cool-season non-native grass (Canada bluegrass), as well as two native warm season grasses (needle-and-thread grass and little bluestem).

Table 3.20: Indicator and Dominant Species for Ninebark/Thickspike wheatgrass (*Physocarpus monogynous/Elymus lanceolatus*) Plant Subassociation			
Species	**Common Name**	**Indicator Species**	**High Importance Value**
Achillea lanulosa	Western yarrow		X
Adenolinum lewisii	Blue flax	X	
Artemisia frigida	Silver sage		X

Table 3.20: Indicator and Dominant Species for Ninebark/Thickspike wheatgrass (*Physocarpus monogynous/Elymus lanceolatus*) Plant Subassociation

Species	Common Name	Indicator Species	High Importance Value
Elymus lanceolatus	Thickspike wheatgrass	X	X
Heterotheca villosa	Golden aster		X
Hesperostipa comata	Needle-and-thread	X	
Hypericum perforatum	St. Johnswort	X	
Leymus ambiguus	Colorado wild rye	X	X
Linaria vulgaris	Toadflax		X
Nepeta cataria	Catnip	X	
Oxytropis sericea	Locoweed	X	
Packera cana	Groundsel	X	
Padus virginiana melanocarpa	Chokecherry		X
Physocarpus monogynus	Ninebark	X	X
Poa compressa	Canada bluegrass	X	
Rhus aromatica trilobata	Three-leaf sumac	X	X
Schizachyrium scoparium	Little bluestem	X	

Management considerations for each of the above plant associations are outlined in Chapter 4.

PLANT COMMUNITIES OF SPECIAL INTEREST

Plant communities, like individual plant species, may be rare or imperiled. Table 3.21 lists the plant communities in foothills and forests considered to be rare or imperiled in Boulder County (Colorado Natural Heritage Program 1999). The indicator species for each of these plant communities occur together on Open Space forests, but additional field work and mapping need to be undertaken in order to determine whether good examples of these communities exist on Open Space and/or Mountain Parks forests and their relationship to the plant associations and subassociations described earlier.

In summary, the analysis of the Open Space understory inventory data shows that although the ecosystem has been altered by human disturbance, the understory vegetation appears to be relatively natural and in some degree of recovery from past disturbance.

Table 3.21: Rare and Imperiled Plant Communities in Boulder County Foothills and Forests, Excluding Riparian Areas. (Based on Colorado Natural Heritage Program 1999.)
This table is based on the latest study completed by the Colorado Natural Heritage Program (1999). Each community is assigned a rank which indicates its status globally and in Colorado.* Additional analysis will be conducted to determine whether these communities exist in Open Space forest stands.

Plant Community	Rank	Open Space Understory Inventory Data
Mountain mahogany-Three-leaf sumac/Big bluestem *Cercocarpus montanus-Rhus aromatica/Andropogon gerardii* Mixed Foothill Shrubland	G2G3, S2S3	All three species occur on 5 of 133 plots: D-1/81 5; LJC-NE 5; LJC-NW 10, 15; MRL20
Mountain mahogany/Needlegrass *Cercocarpus montanus/Hesperostipa comata* Mixed Foothill Shrubland	G2, S2	Both species occur on 14 of 133 plots: D-1/81; LJC-NW 1, 5, 10, 15; LJC-SW 1; MRL 5, 10, 20; Sunshine 1; Witt-NW 1, 5, 20; Witt-S 5
Mountain mahogany/New Mexico feathergrass *Cercocarpus montanus/Hesperostipa neomexicana* Foothills Shrubland	G2G3, S2S3	Feathergrass not found in inventory plots, but occurs on NBV-N and NBV-S.
Mountain mahogany/Scribner's needlegrass *Cercocarpus montanus/Achnatherum scribneri* Foothills Shrubland	G3, S3	Both species occur on 8 of 133 plots: MRL 20, Witt-NE 1, 15, 20, 30; Witt-S 5, Witt-E 1, ST-10 5
Rocky Mountain juniper/Mountain mahogany *Sabina scopulorum/Cercocarpus montanus* Foothills Juniper Woodlands/Scarp Woodlands	G2, S2	Both species occur on 6 of 133 plots: D-1/81 5; LJC-NW 1, 5; LJC-SW 1; MRL 5, 10
Ponderosa pine/Mountain mahogany/Big bluestem *Pinus ponderosa/Cercocarpus montanus/Andropogon gerardii* Foothills Ponderosa Pine Scrub Woodlands	G2, S2?	All three species occur on 9 out of 133 plots: D1/81 5; LJC-NW 1, 5, 10, 15; MRL 5, 20; Witt-NW 1, 15
Ponderosa pine/Spike fescue *Pinus ponderosa/Leucopoa kingii* Foothills Ponderosa Pine Savannas	G3, S3	Both species occur on 33 of 133 plots: 69% of plots in the northern forest stands, mostly in the Wittemyer stands; 19% in central forest stands, especially S-10, ST-3, ST-10
Douglas-fir/Waxflower *Pseudotsuga menziesii/Jamesia americana* Lower Montane Forest	G3G4, S3	Waxflower was not documented during the understory inventory, but was found in higher elevation stands during the overstory inventory.

*G2 = Imperiled globally because of rarity (6 to 20 occurrences), or because of other factors demonstrably making it very vulnerable to extinction throughout its range.
G3 = Vulnerable throughout its range or found locally in a restricted range (21 to 100 occurrences).
G4 = Apparently secure globally, though it might be quite rare in parts of its range, especially at the periphery. S2 = Imperiled in state because of rarity (6 to 20 occurrences), or because of other factors demonstrably making it very vulnerable to extirpation from the state.
S3 = Vulnerable in state (21 to 100 occurrences).
MA = management area; see Appendix 3.1 for location of forest stands.

On the one hand, there is a lot of evidence that the area has been altered by human activities:

- Twenty percent of the herbaceous (nonwoody) plant species in the inventory plots are non-native to this area. These non-native species account for 18% of the cover of herbaceous plants.
- Some native species that are known to increase in disturbed areas have high cover values.
- As a result of the increase in non-natives and of native species tolerant of disturbance, some native species have probably decreased in abundance.
- Some native species may have been eliminated completely from this area.

On the other hand, there is also evidence that native vegetation has recovered to some degree from previous disturbances:

- Some species that typically decrease in disturbed areas, such as big bluestem, have relatively high cover values in some areas of the forest.

3.7 WILDLIFE

Since non-Native American settlement of the Boulder area began over 150 years ago, the local forests have changed dramatically, as is discussed elsewhere in this Plan. These changes have undoubtedly had major effects on wildlife[2] species, although staff does not have adequate baseline data to understand exactly what these changes have meant for the vast majority of wildlife species. Thompson and Strauch, Jr. (1986), for instance, report that red-headed woodpeckers (*Melanerpes erthyrocephalus*) and Lewis' (*M. lewis*) woodpeckers were once common in Boulder County but are now rare. While there are other similar references, current understanding of wildlife in the past is based largely on anecdotal accounts, past studies, and conjectures.

We can make informed guesses regarding the changes in wildlife that have occurred in the past one and one-half centuries based on the changes that have been documented in forest *vegetation* structure. There is compelling evidence that today's forests have: (1) more trees, (2) younger and smaller trees, (3) more closed tree canopies, and (4) less understory vegetation cover than historical forests. On a landscape level, there is evidence that today's forests are more homogeneous, more fragmented and less diverse structurally than historical forests. These changes are due mostly to the combined effects of fire suppression, timber harvesting and livestock grazing.

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[2] Wildlife has often been defined and interpreted to mean animals and the habitats (for the most part plant communities) that support them. However, for the purposes of this section, wildlife refers to native animal species and animal communities. The distinction is made simply to illustrate and clarify how implementation of the Plan influences native animals. It is fully recognized that while promoting native animal communities (wildlife) is a central consideration of this Plan, it cannot be accomplished without the efforts (outlined elsewhere in the Plan) that are designed to promote native plant communities.

In addition to the impacts of historical logging, grazing and fire suppression, forest wildlife species on City lands and in Boulder County in general, have more recently been affected by increased urban and suburban development.

Increasing human populations around the City's forests have resulted in further fragmentation of forest ecosystems, changes in vegetation, such as increases non-native plants, decreased local hunting pressure, and increased numbers of domestic animals. These influences impact wildlife in different ways depending on the species.

According to the Colorado Division of Wildlife (cited in Trails and Wildlife Task Force et al. 1998), 228 species of wildlife use ponderosa pine forest ecosystems for some part of their life cycle. Schroeder (1996) suggests that there are some 98 wildlife species that regularly occur in the ponderosa-pine forests of Boulder County. While Open Space has collected some information through recent inventory and research efforts, the information relative to wildlife occurring in the forested portions of Open Space properties is limited. 1998 inventory efforts identified 61 bird species and three species of small mammals in Open Space forests. These species are listed in Table 3.22. Meadow vole (*Microtus pennsylvanicus*) and Hispid pocket mouse (*Chaetodipus hispidus*) were also trapped in 1998 during other forest research projects. Adams and Thibault (1998) report 11 species of bats utilizing the forested landscapes of Boulder. Larger mammals, reptiles, and invertebrates were not included in the 1998 inventory, but will be inventoried and monitored in coming years.

A primary emphasis of this Plan is to increase the knowledge of wildlife and in City of Boulder forests and to continue data collection and monitoring to ensure management objectives are being met. However, there are simply too many wildlife species that live on City of Boulder lands to attempt to manage each one individually. Single-species approaches at the forest stand level (where management actions occur) cannot provide a comprehensive and holistic management strategy (Thompson et al. 1995). Therefore, staff has adopted the approach of assuming that a relatively complete array of habitat types in the local foothills forests will harbor the vast majority of local wildlife species (Hunter et al. 1988). While it is not possible to manage for each individual species, it is desirable to protect **species of special interest** at both community and species levels.

Table 3.22: Bird and Small Mammal Species Observed in Open Space Forest Stand Point Counts During 1998 Inventory.

Common Name	Scientific Name	Common Name	Scientific Name
American crow	*Corvus brachyrhynchos*	Mountain chickadee	*Parus gambeli*
American goldfinch	*Carduelis tristis*	Mourning dove	*Zenaida macroura*
American kestrel	*Falco sparverius*	Northern flicker	*Colaptes auratus*
American robin	*Turdus migratorius*	Peregrine falcon	*Falco peregrinus*
Black-billed magpie	*Pica pica*	Pine siskin	*Carduelis pinus*
Black-capped chickadee	*Parus atricapillus*	Plumbeous vireo	*Vireo plumbeous*
Black-headed grosbeak	*Pheucticus melanocephalus*	Prairie falcon	*Falco mexicanus*
Blue-gray gnatcatcher	*Polioptila caerulea*	Pygmy nuthatch	*Sitta pygmaea*
Broad-tailed hummingbird	*Selasphorus platycercus*	Red crossbill	*Loxia curvirostra*
Brown creeper	*Certhia americana*	Red-breasted nuthatch	*Sitta canadensis*
Brown-headed cowbird	*Molothrus ater*	Red-winged blackbird	*Agelaius phoeniceus*
Canyon wren	*Catherpes mexicanus*	Ruby-crowned kinglet	*Regulus calendula*
Cedar waxwing	*Bombycilla cedrorum*	Scrub jay	*Aphelocoma coerulescens*
Chipping sparrow	*Spizella passerina*	Sharp-shinned hawk	*Accipiter striatus*
Common raven	*Corvus corax*	Spotted towhee	*Pipilo maculatus*
Cordilleran flycatcher	*Empidonax occidentalis*	Steller's jay	*Cyanocitta stelleri*
Dark-eyed junco	*Junco hyemalis*	Townsend's solitaire	*Myadestes townsendi*
Downy woodpecker	*Picoides pubescens*	Tree swallow	*Tachycineta bicolor*
Dusky flycatcher	*Empidonax oberholseri*	Vesper sparrow	*Pooecetes gramineus*
Great blue heron	*Ardea herodias*	Violet-green swallow	*Tachycineta thalassina*
Great horned owl	*Bubo virginianus*	Virginia's warbler	*Vermivora virginiae*
Green-tailed towhee	*Pipilo chlorurus*	Warbling vireo	*Vireo gilvus*
Hairy woodpecker	*Picoides villosus*	Western meadowlark	*Sturnella neglecta*
Hammond's flycatcher	*Empidonax hammondii*	Western tanager	*Piranga ludoviciana*
House finch	*Carpodacus mexicanus*	Western wood-pewee	*Contopus sordidulus*
House wren	*Troglodytes aedon*	White-breasted nuthatch	*Sitta carolinensis*
Killdeer	*Charadrius vociferus*	White-throated swift	*Aeronautes saxatalis*
Lark sparrow	*Chondestes grammacus*	Willow flycatcher	*Empidonax traillii*
Lazuli bunting	*Passerina amoena*	Yellow-breasted chat	*Icteria virens*
Lesser goldfinch	*Carduelis psaltria*	Yellow-rumped warbler	*Dendroica coronata*
MacGillivray's warbler	*Oporomis tomiei*		
Deer mouse	*Peromyscus maniculatus*	Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*

Schroeder (1996) used information from the scientific literature, museum collections, Colorado Division of Wildlife Latilong Distribution data and the opinions of local experts to develop a list of vulnerable wildlife species in Front Range ponderosa pine forests. He identified eight vertebrate species which are of concern due to declining populations, special habitat needs or some other factor and which are most closely associated with ponderosa pine forests in this area. These species are the band-tailed pigeon, flammulated owl, common poorwill, Williamson's sapsucker, pygmy nuthatch, western bluebird, fringed myotis bat, and Abert's squirrel. Unfortunately, similar information is not available for foothills Douglas-fir or mixed-conifer forests. Interestingly, Schroeder states that all of these species except one (Abert's squirrel) would be promoted by increasing the abundance of open, mature forest with an abundance of snags and with well-developed grass and shrub understories. This type of forest will become more abundant under the Forest Ecosystem Management Plan and a number of the species referenced in Schroeder will be used to measure achievement of forest management objectives, as detailed in Chapter 5.

Increasing the number of snags is of particular importance in the implementation of this Plan. A number of biologists and researchers (e.g., Jones, undated and Thompson and Strauch, Jr. 1986, 1987) have not only illustrated the importance of snags to forest dwelling wildlife, but have specifically recommended that the City's forest management include restoring snag densities to functional levels. While recommended snag densities range anywhere from 12.8 snags per acre (5.2 per hectare) (Cunningham et al., 1980) to 148 snags per acre (60 per hectare) (Marzluff and Lyon, 1983), 1997 inventory data indicate current snag densities on Open Space forest stands at just under 10 per acre. However, the majority of these are less than 12 inches in diameter and therefore have no functional value as snags (rather, they are classified simply as dead saplings or poles). Furthermore, Scott et al. (1980) report that cavity nesting birds typically comprise 30% to 45% of forest breeding bird populations. However, Thompson and Strauch, Jr. (1986) found cavity nesting birds to represent only 10% of the forest breeding bird population on Open Space forests. Specific objectives related to creating and maintaining snags are outlined in Chapter 5.

4. Desired Future Conditions and Management Direction

In order to sustain the integrity and function of forested ecosystems into the future and to protect the safety of neighbors and users of City of Boulder forests, this Plan develops a methodology designed to shift forest structure and processes closer to the historical range of variability. The Plan proposes to use a combination of **silvicultural** and prescribed fire treatments to achieve this goal.

This chapter outlines both general and specific management actions for City of Boulder forested ecosystems. General management prescriptions will be applied to both Mountain Parks and Open Space areas. Specific management prescriptions are detailed for 16 Open Space forest stands in Appendix 1.2; the remainder of the prescriptions for Open Space stands will be detailed in an addendum to this Plan in April of 1999. Management prescriptions for Mountain Parks stands will be described in Part II and Part III of the Plan.

4.1 Plan Implementation: Overview

Coarse-scale management protocols for the forested ecosystems managed by the City of Boulder are described in this section. These protocols make use of two primary treatment options for both short-tenn and long-tenn management of forest stands. First, because of abundant regeneration over the past century and high tree densities in many stands, ponderosa pine forest structure must be restored to a more historical condition before surface fires can be reintroduced. Silvicultural methods will be used to thin trees to reduce **fuel loads** and **ladder fuels** that promote crown fires. Second, prescribed fire will be used both to further reduce tree seedling numbers in stands and to restore fire as a key ecosystem process. Prescribed fire is currently recognized as the best tool available for restoration and management of ponderosa pine ecosystems in the western U.S. (e.g., Arno et al. 1995, Hardy and Arno 1996, Covington and Wagner 1996, Covington et al. 1997).

While the treatments and options outlined in this Plan are both ecologically and operationally sound, there are two major factors that must be considered before application of the recommended treatments. The first of these is the possible response of Boulder citizens to thinning and prescribed fires in Open Space and Mountain Park areas. Logging and fires have been very limited in these forests in the recent past, and may be upsetting for people to see in what they perceive to be relatively healthy forest ecosystems. Public education regarding elements of the Plan presented here will, therefore, be critical to its successful implementation.

Societal perspectives that all fires are bad fires are changing through education and better scientific information about historical fire processes in forest ecosystems. For example, much of the public sentiment over the past few years has changed to support prescribed fire as a management tool. A recent survey of

Boulder residents found that 72% would support the use of prescribed fire as a management option to enhance ecological values and to help reduce the hazards associated with wildfires (City of Boulder 1996). Continued efforts will be needed to make sure that citizens of Boulder know and understand the need for and goals of forest management actions that are proposed with this Plan.

A second major consideration related to the use of prescribed fire in the Front Range will be current regulations concerning air quality. Smoke management is a major concern for all efforts to restore historical fire processes to western forests (e.g., Ottmar et al. 1995) and may ultimately limit the ability of forest managers to use fire as a management tool. Any fire event has the potential to temporarily degrade air quality, impair visibility, and expose the public to pollutants (Ottmar et al. 1995). Current regulations concerning particle emissions from fires are based on the Environmental Protection Agency's **"PM10 standard,"** which is the grams of particulate matter 10 micrometers or smaller in diameter per ton of fuel consumed. Periods of burning for specific treatment units will need to be based upon when the PM10 standard can be met or when wind conditions will limit smoke over more heavily populated areas of the Front Range. Such conditions also will need to be coordinated with other weather and fuel prescriptions for burning. A major consequence of these prescription constraints is that prescribed burn windows will need to be highly flexible and defined by qualified prescribed fire and smoke management specialists. There may be greater flexibility in the amount of particulate emissions allowed from prescribed fires in coming years (Babbitt 1996).

4.2 Plan Implementation: Coarse Scale

Three primary treatments to guide overall management efforts in the forest ecosystems of the City of Boulder have been identified. These treatments are assigned to forest stands based on both landscape characteristics and current forest conditions. These coarse-scale treatments will be modified by specific stand-level management prescriptions for forest stands (see Section 4.3 and Appendix 1.2). The three treatment classifications are based both on level of management intervention needed and level of management intervention possible in different areas. The treatments are: (A) thinning followed by prescribed fire in areas with dense stands of small- to medium-diameter trees, (B) prescribed fire in areas that include more open stands with lower tree density that can be burned without extensive prior thinning, and (C) less-intensive management in areas that include inaccessible areas on the mountain front.

4.2.1 Thinning Followed by Prescribed Fire

The first treatment covers stands that will need forest structure restored to a more historical condition before prescribed fire can be implemented. Treatments in these areas will rely on application of **uneven-aged tree selection** to thin stands (e.g., O'Hara 1998, Long 1998). Uneven-aged treatments are used to maintain ponderosa pine regeneration in stands, but at lower levels than at present. **Q-curves** will be used to quantify ratios between **size classes** in stands (Alexander and Edminster 1977). A lower Q-ratio produces a more unifonn distribution of size classes of trees after thinning.

Few trees with a diameter at breast height (DBH) larger than 12 inches will be cut during these silvicultural operations. Larger-diameter trees (approximately 20 inches DBH) are generally absent from City of Boulder forest ecosystems, as noted earlier. Most trees larger than 12 inches will be left to grow into dominant overstory trees in the future. Larger-diameter trees left in Open Space stands should facilitate conversion of some stands to old-growth forest conditions. At present, old-growth forests are under-represented components of the City of Boulder forest landscape. In addition, Douglas-fir will be removed from stands in preference to ponderosa pine where ponderosa pine was the dominant tree historically. This will be done to promote ponderosa pine in stand canopies. Douglas-fir is less fire-tolerant than ponderosa pine (e.g., Wright and Bailey 1982) and most likely was not as abundant in pre-settlement low-elevation forests as it is today, except in areas where steep north-facing slopes favor this species over ponderosa pine.

4.2.2 PRESCRIBED FIRE

The second treatment for City of Boulder forests is in areas amenable to immediate treatment with prescribed fires. These areas have lower stand densities and fewer trees in small-diameter classes. Many of the stands that were thinned during Project Greenslope fall into this classification. Prescribed fires will maintain and promote open stands through mortality of seedlings, saplings, and other smaller diameter trees. Occasional small crown fires in the overstory also will create openings in the canopy. Prescribed fires are critical components for ecosystem management in these areas, since they will restore and reinvigorate related ecosystem processes and promote more diversity in landscape pattems. Prescribed fires on the margins of the forest-grassland ecotone also will be used to maintain forest and grassland community patterns across the landscape.

Variability in historical fire frequencies and spatial pattems, as discussed in Chapter 2, will guide application of prescribed fires in stands. The best fire history data near the forest-grassland ecotone suggest a range of **fire intervals** from 3 to 20 years for these areas (Veblen et al. 1996). Higher elevation stands can be burned on a range of 10 to 35 years (Veblen et al. 1996, Brown et al. unpublished data). In addition, monitoring of prescribed fires will provide feedback for the detennination of how frequently given areas will be scheduled for future prescribed fires. In addition, monitoring of prescribed fires will provide feedback for the detennination of how frequently given areas will be scheduled for prescribed fires. The use of the concept of historical range of variability in fire patterns will allow managers flexibility in annual bum plans, since the range of intervals between fires will be a target for burning and not the mean fire intervals or other central tendencies seen in fire histories. Variation in stand structure resulting from differences in fire behavior will mimic past landscape diversity. Staff expects that in areas with dense patches of trees, some canopy will burn, increasing the heterogeneity of forest stands. For example, a 1995 prescribed bum in the Lindsay-South forest stand crowned and killed about an acre of trees (Laven and Gallup 1997).

4.2.3 Less-Intensive Management Areas

A less-intensive management alternative will be used in some of the forested areas managed by the City of Boulder. These areas, especially those managed by Mountains Parks, are found on the steep slopes of the Flatirons. These forested ecosystems include the most scenic and visible landscapes in the Boulder area, where intensive management treatments would be difficult to implement. The steep areas are not conducive to low-impact silvicultural operations, nor will it be easy to apply prescribed fire treatments in some of the most inaccessible areas.

However, a longer-term solution for these areas is to eventually manage them as a **prescribed natural fire** management zone, where naturally-ignited wildfires will be allowed to bum under prescribed conditions. A prescribed natural fire zone would be established in these areas only after treatments of other stands on its periphery have been completed. Treated areas on the margins of the prescribed natural fire zone will act as buffers for control of wildfires that ignite naturally in the prescribed natural fire zone area in the future. After a lightning ignition in this area, and as long as prescribed weather and fuel conditions persist, natural fires (including crown fires) would be allowed to bum.

4.3 Plan Implementation: Individual Stands

This section of the Plan summarizes specific recommendations for individual forest stands that make up most of the Open Space forested area. Overall recommendations for each stand will be given and summarized by acreage. Specific management prescriptions for 16 Open Space forest stands are attached in Appendix 1.2.

While overall recommendations will be made based upon average overstoiy conditions within stands, there is usually variability in forest structure within stands. For example, stands on the foothills grade from very open savanna forests nearer the forest-grassland ecotone to more closed canopy conditions next to the mountain front. Gradients in overstory conditions from the foothills to the plains are likely related to eastward expansion of ponderosa pine forest in these areas during this century (Archer 1994, Mast et al. 1997). In these and other stands, treatment prescriptions will likely need to be modified before any treatment implementation. For example, overall stand condition as averaged from all plots within a stand may suggest an open forest with low tree density and few small diameter trees that would need to be thinned before a prescribed fire treatment. However, local patches in the stand may have closed canopies with high tree densities that could increase the possibility of crown fires during prescribed fire treatments. In these cases, management staff may want to thin trees in these areas before application of prescribed fire treatments. These decisions will, of course, need to be made by foresters and prescribed fire specialists in charge of treatment implementations. Relatively localized crown fires must be anticipated as part of the heterogeneity of the fire regime that will be restored in these forest ecosystems.

OPEN SPACE FOREST STAND PRESCRIPTIONS

Recommended treatments for all Open Space forest stands are listed in Table 4.1. The first group of forest stands includes those that need to be thinned, both to remove excessive biomass and ladder fuels and to restore forest structure to an historical range of variability before application of prescribed fires. Fourteen Open Space stands have been identified for this treatment. Silvicultural treatments for stands will be based on uneven-aged tree-selection that is designed to maintain ponderosa pine regeneration in stands and landscape heterogeneity in forest structure (e.g., Edminster and Olsen 1996, O'Hara 1998).

Table 4.1: Management Prescriptions for Open Space Forest Stands.

Thinning Followed by Prescribed Fire		Prescribed Fire		No Thinning or Prescribed Fire at this Time	
Stand Name	**Acres**	**Stand Name**	**Acres**	**Stand Name**	**Acres**
ELDO-C	4.98	BS	32.91	BARUT-NE	18.3
ELDO-E	15.97	D-1/81	11.21	ELDO-N	21.7
FOX-W	11.24	D-1	11.63	ELDO-NW	10.2
LIND-N	97.05	D-2	25.46	ELDO-S	31.7
LJC-NE	54.17	D-3AND D-4	73.77	ELDO-T	18.2
LJC-NW	50.08	DAKR	11.92	ELDO-W	48.8
MRL	69.75	FOX-E	18.52	MQC	9.9
MRSL	14.82	KSLR	13.77	MQC-W	29.8
S-3	94.57	LIND-S	52.56	SG-N	41.0
ST-3	24.35	LJC-SE	44.92	SG-S	18.1
ST-5	6.63	LJC-SW	24.90	**Total Acres**	**247.7**
WITT-E	33.40	LOWER SHANAHAN	81.05		
WITT-S	23.63	MCCD	44.88		
WITT-W	43.16	NBV-N	97.67		
		NBV-S	37.00		
Total Acres	**543.8**	PINEBROOK	9.32		
		POWERLINE	23.79		
		S-10	24.53		
		S-4	19.42		
		S-5	45.98		
		S-9	28.74		
		ST-1	13.05		
		ST-10	11.70		
		ST-6	28.38		
		ST-7	9.86		
		ST-8	14.94		

Table 4.1: Management Prescriptions for Open Space Forest Stands.					
Thinning Followed by Prescribed Fire		Prescribed Fire		No Thinning or Prescribed Fire at this Time	
Stand Name	Acres	Stand Name	Acres	Stand Name	Acres
		ST-9	12.99		
		STGL-II	151.65		
		SUNSHINE	18.59		
		WATERTANK	122.49		
		WITT-NE	55.12		
		WITT-NW	27.65		
		Total Acres	**1200.4**		

The second group of stands will be treated with prescribed fire. These stands are within the historical range of variability in forest structure and tree density. These stands are less vulnerable to crown fire and escaped fire situations owing to lower tree density and fewer ladder fuels. Thirty-two Open Space stands, the majority of them on the foothills and at the forest-grassland ecotone, have been identified as amenable to prescribed fire treatments as soon as operationally feasible.

These stands also tend to have a greater range of variability in crown conditions, so that if a high-intensity fire started during prescribed fire operations, there is a greater probability that crown fire would remain localized and not burn throughout the stand. However, as stated above, some of these stands have denser areas within them and some local thinning may be needed. In these cases, thinning-from-below silvicultural methods will be used, such that all of the small diameter trees below a specified size class are removed from the stand. These small-diameter trees also are generally the shorter trees in a cluster, and would therefore tend to act as ladder fuels that would support crown fires. The larger, more dominant trees in a cluster of trees will be retained.

Based upon the numbers of medium-diameter trees that are to be removed from Open Space stands, commercial sales of trees and removal by contract loggers will be considered during implementation of the Plan. While the overriding goal for the Plan is to promote natural ecosystem processes, timber will be considered a by-product of restoration of ecosystem structure. Timber sales also can be used to help offset costs of promoting and maintaining a sustainable forest ecosystem (e.g., Willits et al. 1996, Fielder et al. 1997, Koch 1998). Harvesting contracts should require removal or piling of all small-diameter trees from the stand during site preparation prior to burning by City staff. Small-scale thinning operations sometimes use innovative methods for tree removal and marketing. For example, several mechanized systems are currently being promoted for thinning ponderosa pine forests in a cost-effective manner (Willits et al. 1996, Hartsough et al. 1997). Also, removal of trees using horse or tractor logging methods (e.g., Mannon 1997, Smith 1997) may be feasible, if a contractor can be found in the Boulder area. Both of these methods are low-impact techniques for removal of logs from forest stands where damage to the understory needs to be kept to a minimum. Horse logging in particular is more aesthetically appealing in stands where hiking and other recreational activities occur. Horse logging was used as a low-impact method for tree harvesting during Project Greenslope (Colorado State Forest Service 1982) and its application to the goals of this Plan will be explored.

The last stands considered are those that are not amenable to prescribed fire or thinning because of slope steepness and/or difficulty of access for application of management prescriptions. The ten Open Space stands recommended for no prescribed fire or thinning at this time are in the Eldorado Canyon area in the southwest corner of Open Space lands (see map in Appendix 3.1). Most of these stands are in more isolated areas of Open Space that are surrounded on two or more sides by private landowners, especially stands on the south side of Eldorado Canyon. While coordination and cooperation with surrounding land owners and management agencies will be crucial during the implementation of any of the prescriptions presented in this Plan, coordination will most likely be more difficult in these steeper, more rugged stands of Eldorado Canyon. During the implementation of management prescriptions like prescribed fire and thinning consideration will be given to conditions that exist in different areas of the forest, as outlined below for understory vegetation and wildlife.

4.4 UNDERSTORY VEGETATION MANAGEMENT CONSIDERATIONS

4.4.1 PONDEROSA PINE/SUNSEDGE PLANT ASSOCIATION

(*Pinus ponderosa/Carex pensylvanica* Plant Association)

Systemwide management considerations and information gaps:

- Rare plant mapping has not been completed for Open Space forest stands and is a high priority for pretreatment evaluation of stands where management actions will be implemented.
- The introduction of non-native species in recent decades presents a major challenge when planning for prescribed bums. These species (most often forbs and grasses) can displace native species and can greatly impact the structure and function of native ecosystems. Completion of ongoing mapping of non-native species is a high priority, as is monitoring of (1) the success of the integrated pest management strategies used to reduce non-native species, (2) the impacts of fire on non-native plants, and (3) the effectiveness of **best management practices** in preventing the further introduction and/or spread of non-native species.
- Shrublands along the Front Range have been shown to be extremely valuable components of wildlife habitat, providing food and cover for a large percentage of wildlife species. Additional study and mapping of these shrublands is required for a complete evaluation of their value to wildlife and their ability to recover after fire.
- Impacts of changes in recent decades in the abundance of wildlife species (especially large mammals like deer and elk) on the condition and structure of native plant associations have not been evaluated yet.
- An inventory of the understory of riparian and wetland areas within Open Space forests has not been completed. Such an inventory is a high priority

and will provide the data necessary to evaluate the extent and condition of riparian and wetland areas, as well as their significance to area wildlife.

- Fire suppression is thought to be a factor in ponderosa pine encroachment onto grasslands. Reintroduction of fire into the ecosystem should result in a gradual shift, over time, in the forest/grassland boundary.
- The 1997 Open Space understory inventory sampled only 37 of the 60 forest stands. Stands that were not sampled during 1997 that are scheduled for thinning or prescribed fire will require the collection of baseline understory data.
- Nonvascular plants (mosses and lichens) have not been inventoried on Open Space forests. These plants will be inventoried in the near future.

4.4.2 BUCKBRUSH/POVERTY OATGRASS PLANT SUBASSOCIATION

(*Ceanothus fendleri/Danthonia spicata* Plant Subassociation)

Management considerations:

- Douglas-fir (*Pseudotsuga menziesii*) is less resistant to fire than ponderosa pine (*Pinus ponderosa scopulorum*) and will decrease in areas designated for prescribed fire. This is the only plant subassociation in Open Space stands in which Douglas-fir occurs consistently.
- Dry, southwest-facing, steep slopes are especially prevalent in this PSA and will need to be monitored for soil erosion after implementation of prescribed burns.
- The release of nutrients and decrease in litter after prescribed burning should be followed by an increase in the understory cover of forbs and graminoids, if soil erosion is not a problem.
- Bladder senna (*Colutea arborescens*), a non-native shrub, has become established in the understory of this PSA in the Wittemyer and Dakota Ridge stands. Treatment to reduce the populations of this shrub was initiated in 1997 (cutting and herbicide applications) and continued in 1998. Fire effects on this species are unknown.
- Eleven plots--Witt-E (10), Witt-NE (1, 5, 10, 15, 20, 25, 30), and Witt-S (1, 5, 10)--have some ground area covered with small fragments of granite gravel. All of these plots have high nonvegetation cover and may be especially susceptible to erosion.
- Prescribed burning may cause a decrease in the abundance of the some species which are not resistant to fire, including Rocky Mountain juniper (*Sabina scopulorum*) and common juniper (*Juniperus communis alpina*).
- Rare and uncommon species documented in this PSA are leadplant (*Amorpha nana*), lipfern (*Cheilanthes fendleri*), and frostweed (*Crocanthemum bicknellii*).

4.4.3 CANADA BLUEGRASS/MEADOW ARNICA PLANT SUBASSOCIATION

(*Poa compressa/Arnica fulgens* Plant Subassociation)

Management considerations:

- This PSA is dominated by Canada bluegrass (*Poa compressa*), a non-native cool season grass which decreases when burned in the spring. Spring burning also has the potential to release some of the native warm season grasses in these stands and to decrease common dandelion (*Taraxacum officinale*) and St. Johnswort (*Hypericum perforatum*), two non-native cool season forbs. Native pussytoes (*Antennaria* species) and meadow arnica (*Arnica fulgens*) may also decrease after spring burning.

- Four non-native species are among the indicator species for this PSA: St. Johnswort, fieldcress (*Neolepia campestris*), Canada bluegrass, and dandelion. These species should be carefully monitored after burning, as they are all invaders of disturbed areas. Timing of prescribed burns, as indicated above, should help to control the spread of these species.
- Current grazing leases allow summer grazing in some of these stands, which adversely impacts native warm season grasses. Once summer grazing is discontinued, native warm season grasses should increase in cover.
- Foothills shrublands provide important habitat for neotropical migrant birds, and may be highly significant to other wildlife species as well. Shrublands on MRL and Eldo-E should be evaluated for their value in providing cover and food for wildlife and for their ability to recover after fire. Mountain lions and bear have been sighted in these areas repeatedly.
- Many rare and uncommon species have been documented in this area, including birdfoot violet (*Viola pedatifida*), leadplant (*Amorpha nana*), Alaskan orchis (*Piperia unalascensis*), grass fern (*Asplenium septentrionale*), blue toadflax (*Linaria canadensis*), and carrion flower (*Smilax lasioneuron*). Mapping and monitoring of these species is a high priority.

4.4.4 SUNSEDGE/POVERTY OATGRASS PLANT SUBASSOCIATION

(*Carex pensylvanica/Danthonia spicata* Plant Subassociation)

<u>Management considerations:</u>

- Spring burning should favor native warm season grasses, like big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and sand dropseed (*Sporobolus cryptandrus*) over St. Johnswort (*Hypericum perforatum*), Canada bluegrass (*Poa compressa*), and sunsedge (*Carex pensylvanic heliophila*), but it could adversely impact the native cool season grasses, such as needle-and-thread grass (*Hesperostipa comata*), thickspike wheatgrass (*Elymus lanceolatus*), and Colorado wild rye (*Leymus ambiguus*). Colorado wild rye grows only in Colorado and New Mexico and is a climax indicator on montane grassland communities in Colorado.
- This PSA has the highest importance value for mountain mahogany (*Cercocarpus montanus*). The areal extent of this species needs to be mapped and its importance to wildlife evaluated before prescribed fire is implemented in these shrublands. Although mountain mahogany can sprout readily from the crown after fire, older stands may burn more intensely and are subject to greater damage.
- Shrub cover is especially high on MRL, Lindsay/Jeffco, and Watertank. The shrubs with highest importance values in this PSA should also be assessed for value to wildlife and sensitivity to fire. Wax currant (*Ribes cereum*) will only survive low-intensity fires. Snowberry (*Symphoricarpos* species) is sensitive to frequent burning. Chokecherry (*Padus virginiana melanocarpa*) is fire resistant. Rare and uncommon species documented in this area are leadplant (*Amorpha nana*) and birdfoot violet (*Viola pedatifida*). Mapping and monitoring of these species is a high priority.

4.4.5 Big bluestem/Wild alfalfa Plant Subassociation
(*Andropogon gerardii/Psoralidium tenuiflorum* Plant Subassociation)

Management considerations:

- In order to preserve the native warm season grasses (big bluestem, Indiangrass, sideoats grama, and spike muhly), prescribed bums should be implemented in the spring, but spring burning may decrease native cool season grasses (like needle-and-thread grass and porcupine grass). Spring burning also has the potential to decrease the non-native cool season Canada bluegrass, Japanese brome, and St. Johnswort.
- Rocky Mountain juniper, which is sensitive to fire, has its highest average cover in this PSA. Until the areal extent of this species is mapped throughout the forest stands, prescribed fire should be implemented with care. Surface fires conducted in the spring, when vegetation and soils are usually still moist from winter snows and spring rains, might do minimal damage to mature junipers.
- Three-leaf sumac and wild rose have their highest importance values in this PSA. Three-leaf sumac is rarely killed by fire and typically increases after fire, but wild rose is usually favored only by low-intensity fire.
- Rare and uncommon species documented in this area are leadplant (*Amorpha nana*) and birdfoot violet (*Viola pedatifida*). Mapping and monitoring of these species is a high priority

4.4.6 Ninebark/Thickspike wheatgrass Plant Subassociation
(*Physocarpus monogynous/Elymus lanceolatus* Plant Subassociation)

Management Considerations:

- This is the only PSA with high importance value for ninebark (*Physocarpus monogynous*), a shrub that tends to grow on northwest-facing hillsides.
- Spring burning has the potential to decrease the cover of non-native St. Johnswort (*Hypericum perforatum*), but it could also decrease cool-season native grasses like needle-and-thread (*Hesperostipa comata*), thickspike wheatgrass (*Elymus lanceolatus*), and Colorado wild rye (*Leymus ambiguus*). Colorado wild rye is found only in Colorado and New Mexico and is a climax indicator on montane grassland communities in Colorado (McMurry 1987).

4.5 Wildlife Management Considerations

One of the main goals of this Plan is to maintain or enhance native plant and animal species and communities. Therefore, ensuring that wildlife species, communities and habitats are maintained or enhanced is a fundamental consideration for implementation of the Plan.

There is abundant evidence that wildlife species respond individually to changes in their environment (Hejl et al. 1995, Raphael et al. 1988). Different wildlife species have different habitat needs. Any change in a forest stand will benefit some species and disadvantage others. To deal with this dilemma, Hejl et al. (1995) suggest maintaining a sufficient variety of habitats so that all native wildlife species can survive in a landscape. For birds, Hejl et al. are particularly concerned with the loss of early-successional habitat, old-growth forest, snags and burned areas. These are the types of habitat that are generally least abundant in today's western forests, including City of Boulder lands.

Wildlife generally would benefit from the existence of a variety of habitats and by increasing the abundance of those habitats and habitat structural elements that are relatively scarce, i.e., early-successional habitat, old-growth forest, snags and burned areas. This is precisely what the Forest Ecosystem Management Plan is attempting to accomplish via prescribed burning and thinning trees in certain portions of City of Boulder forests.

Management actions like thinning and burning will increase the variability of disturbance, temporally and spatially, which will increase habitat heterogeneity and therefore wildlife diversity. Untreated reference areas will not only serve as a basis for comparison with treated areas, but will increase habitat heterogeneity as well.

Prescribed fire generates long-term benefits for many wildlife species by producing greater habitat and forage diversity, increasing forage abundance and elevating forage nutrient content. Also, it is expected that burning will result in increased levels of stress to trees, thereby increasing the number and diversity of insects available for insectivorous wildlife species. Burning should also help meet the objective of establishing greater snag density.

Prescribed fires can also have negative impacts on certain species and individuals. Fire may result in direct losses to individuals, as well as localized decreases in food and cover and increased fragmentation. On a large scale, this can result in starvation, increased vulnerability to predators, decreased reproductive success, and decimation from exposure (Patton, 1992). Also, the potential indirect impacts to aquatic wildlife (such as increased potential for soil runoff into streams and locally decreased shading) should not be ignored. However, given the scale proposed here, effects on individuals and populations are expected to be negligible and short term. The long-term benefits of creating greater habitat and forage diversity, increasing forage abundance, and elevating forage nutrient content outweigh the potential negative impacts. Furthermore, the negative effects can be managed by manipulating prescribed fire timing, intensity, and frequency.

As mentioned above, the stand prescriptions are designed to create open stands of older, larger trees, within the historical range of variability related to tree age and size classes overall, therefore benefiting the wildlife species typical of ponderosa pine forests, including the vulnerable wildlife species identified by Schroeder (1996) and listed in Table 4.1. Open stands tend to support greater numbers and diversity of wildlife. For example, Jones (undated) found greater numbers of breeding birds (individuals and species) on open canopy plots than on plots with closed canopies. Furthermore, management activities related to tree thinning (e.g., soil scarification) can have positive influences on wildlife, similar to those described for prescribed burning.

Thinning forest stands can also have negative impacts to wildlife similar to those of prescribed fire. Falling trees occupied by nesting birds or other wildlife species can result in direct losses of individuals. Thinning large areas (several hundreds of acres) can result in decreased food and cover for some species and thus the potential for increased vulnerability to predator and weather exposure. However, these impacts are expected to be negligible and minimized through preharvest walk throughs and small-scale thinning.

Stands that are not burned or thinned will help to maintain historical range of variability related to wildlife habitat and ensure systemwide habitat diversity. Species that rely on climax ponderosa pine forest ecosystem conditions will therefore ultimately be conserved. Also, because of the slope, aspect and other characteristics of many of these untreated areas, these stands should also provide habitat for those species that prefer Douglas-fir and mixed-conifer forests.

Note that staff cannot say with absolute certainty that implementation of the Plan will provide sufficient habitat for every wildlife species on City lands. However, as pointed out early on, this Plan is designed to, at a very minimum, "do no harm". Therefore, staff believes that the vast majority of these species, including the vulnerable species, will continue to live in City of Boulder forests. Staff believes the monitoring data that will be collected, coupled with adaptive management responses to these data, will tell staff when wildlife are not being served by on-going forest management and what changes in land management might be necessary. Wildlife monitoring programs are discussed in Chapter 5.

4.6 Timeframe for Plan Implementation

The Plan defines different areas of the forest that require different types and levels of management intervention. Moving forest ecosystem conditions closer to the natural range of variability will require major efforts to thin and open up the forest by selectively cutting trees and conducting prescribed burns on an on-going basis. These principal tools will be complemented with many other kinds of management actions such as wildlife habitat enhancement, weed control, erosion control, restoration of hydrologic flows, reintroduction of native species, and management of visitor use.

The initial phase of implementation of the Plan is expected to begin in the spring of 1999 and to continue for several years. This initial effort will strive to restore forest ecosystem conditions to within the natural range of variability. The immediate priority for Open Space and Mountain Parks staff and the wildfire mitigation crew of the Boulder Fire Department is to implement management prescriptions along the urban/wildland interface. During this time improvements to the Plan will be made based on information gathered during additional inventory work, monitoring activities, and feedback from the public.

Once the forest is returned to more natural conditions, ongoing management will then be needed to maintain desired forest conditions. Prescribed fires will be used episodically to maintain open stand conditions and promote related ecosystem processes. At such time, historical patterns in fire regimes will guide timing and spatial patterns of prescribed fires. Surface fires in the stands should be done at intervals that range from 3 to 20 years (i.e., the range of historical fire intervals for the Boulder area from Table 2.1). Likewise, variability in the amount of area burned during different years will promote greater heterogeneity in landscape patterns of forest structure. Prescribed fires should occur at a range of sizes, from small patchy fires to large fires that ultimately should burn across entire hillsides and across multiple stands during the same year (e.g., Brown et al. in press).

These historical patterns also will provide greater operational flexibility in the future by allowing variability in annual goals for acreage treated. While both the coarse-scale and individual stand recommendations in this Plan concentrate on the general responses of forested ecosystems to management actions, staff also recognizes that more specific ecosystem and community responses must be taken into consideration when applying treatments to stands. Removal of living tree biomass from the forests of the City of Boulder should enhance some wildlife habitats by creating greater structural diversity in forest ecosystems. Creation of snags and logs during silvicultural operations and prescribed fires should further enhance habitats for certain mammals and cavity nesting birds. On the other hand, opening of stands may result in lessening of habitats for other species that prefer closed canopy forests.

Opening of stands and creating greater diversity in landscape patterns in forests also should help to mitigate the impacts of mountain pine beetle outbreaks or other pathogens in the future. Mountain pine beetles and other pathogens are components of the historical range of variability of these stands and should be expected in the future. However, greater diversity in stand characteristics should reduce the potential for widespread and intensive mortality (Schmid and Mata 1996). Opening of stands will increase the vigor of individual trees and therefore their ability to withstand mountain pine beetle attacks. Stand opening should also decrease the incidence of dwarf mistletoes in the stands by decreasing the possibility of mistletoe spread. Finally, opening of stands also should enhance the visual qualities of the landscape and possibly the visitor enjoyment of Open Space and Mountain Park areas.

However, these are all inferences that staff is making at the start of what will be a long-term process. All of these inferences can be stated in terms of hypotheses that can be tested during application of treatments to individual stands. One of the key tenets of an adaptive management approach is to test assumptions and predictions regularly and to revise management approaches based on the results of these tests.

There are six principle areas where the concept of adaptive management is particularly appropriate for this Plan. These topics are overstory vegetation, understory vegetation, non-native species, wildlife, soils, and hydrology. Staff has proposed a number of predictions about treatment response that can be tested in an adaptive mode during the life of this Plan. These predictions are posed as management objectives which are presented in the next chapter on monitoring.

5. MONITORING

Monitoring is . . . the cornerstone of adaptive management; without monitoring we cannot learn and cannot adapt.
Noss and Cooperrider 1994

Monitoring ecological resources is conducted primarily for two purposes: (1) to detect biologically significant changes in resource abundance, resource conditions and population structures, and (2) to understand the effects of management on population or community dynamics (The Nature Conservancy 1996). The Forest Ecosystem Management Plan incorporates long-term monitoring as an essential component. Monitoring objectives are tied directly to management objectives, to determine whether, in fact, management objectives are being met and to change management direction if they are not, which is the essence of adaptive management.

This chapter of the Plan identifies monitoring objectives and describes monitoring plans for overstory and understory vegetation, wildlife, fire behavior, soils, and hydrologic properties of riparian areas, with an initial focus on the first 5 years of monitoring. In addition, best management practices (BMPs) are being developed and the implementation and effectiveness of those practices will be monitored. Once the monitoring program has been in place for 5 years, the City will conduct a reassessment of monitoring protocols to evaluate what has been accomplished and whether modifications need to be made in the monitoring program. Stands in the low-elevation ponderosa pine savanna, woodland, and forest communities inventoried by Open Space and Mountain Parks staff from 1996 to 1998 are the primary focus of the monitoring plans which are described below. Plans for monitoring higher elevation vegetation types (e.g., mixed conifer and Douglas-fir forests) and their associated wildlife species will be outlined in an Part III of this Plan, to be prepared by Mountain Parks and Open Space upon the completion and analysis of the higher elevation stand inventories.

5.1 GENERAL MONITORING OBJECTIVES

Monitoring will achieve several overall objectives that support the Plan goals. Results of monitoring will be used to assess the success of, and to provide feedback on, management decisions and actions. Monitoring will be designed to track and anticipate ecological changes (changes in resource abundance, resource conditions and population structures). Knowledge gained from long-term monitoring should increase understanding of the processes that shape forest ecosystems in the Boulder area.

Key general objectives for vegetation and wildlife monitoring are to:

- Determine the extent to which desired future conditions for the forest, as outlined in Section 4, are being achieved.
- Determine the effects of prescribed fire on the composition, structure, and function of the forest ecosystem. Fire effects monitoring is critical and needs to include post-fire vegetation succession with frequent monitoring during the first 5 to 10 years after fire.
- Identify undesirable conditions that will alert staff that the results of management actions are different than those anticipated, and that modification of management strategies needs to be considered.

- Establish reference (control) areas for each plant subassociation and key wildlife habitat type within the forest ecosystem.

Monitoring protocols for vegetation will focus on detecting changes in the overall composition, structure, and function of forested areas following the implementation of management prescriptions, as well as changes in sensitive plant populations, uncommon plant communities, and non-native plant populations. A system-wide wildlife inventory has not yet been completed. However, 19 forest stands were censused in 1998 for birds and small mammals. Therefore, the initial emphasis for wildlife monitoring will be to detect changes in bird and small mammal diversity, and in densities and distributions of rare species. As inventory data on large mammals, reptiles, amphibians, and invertebrates are collected, those monitoring protocols may be revised. Abiotic elements addressed in the current monitoring guidelines include hydrologic and soil attributes, as well as fire behavior and weather conditions during prescribed burns.

5.2 Vegetation Monitoring

5.2.1 Recommended Monitoring Methods: Design and Layout

Monitoring protocols for forest management are based on a model developed by The Nature Conservancy (1996). The design and implementation of the Open Space/Mountain Parks monitoring program incorporates the model by including the basic elements of formulating management and monitoring objectives, reviewing existing information, developing and implementing a monitoring plan, analyzing and reporting on data, and adjusting the management or monitoring plans as necessary. A flow diagram depicts this monitoring process (see Figure 5.1).

During 1996 and 1997 forest inventory plots were established on City of Boulder Open Space forest stands. The methodology used for defining forest stands and establishing plots is described in the *Forest Inventory Handbook* (City of Boulder 1998a). The overall layout of stands and sampling plots is based on overstory characteristics. Eight hundred forest inventory plots, approximately 1/10 acre in size, were established in 56 forest stands to provide sites for collection of baseline data and for future monitoring of change caused by both natural and human factors. In each forest stand the first plot, the fifth plot, and each multiple of five thereafter were permanently-monumented. The initial inventory plots are not sufficient, however, to meet every monitoring need, and additional monitoring plots will be established in the forest stands, as discussed in more detail below. Also, additional permanently-monumented inventory plots may be needed in some stands. A forest database was designed to enable staff to input and analyze the data collected on these plots (see City of Boulder 1998a).

Monitoring methods will take into account (1) efficiency in data collection and analysis, (2) the potential for data-sharing with other land management agencies, (3) the selection of appropriate methodologies to monitor the effects of management actions and the progress toward meeting objectives, and (4) the utility of establishing reference (control) areas within each plant association and

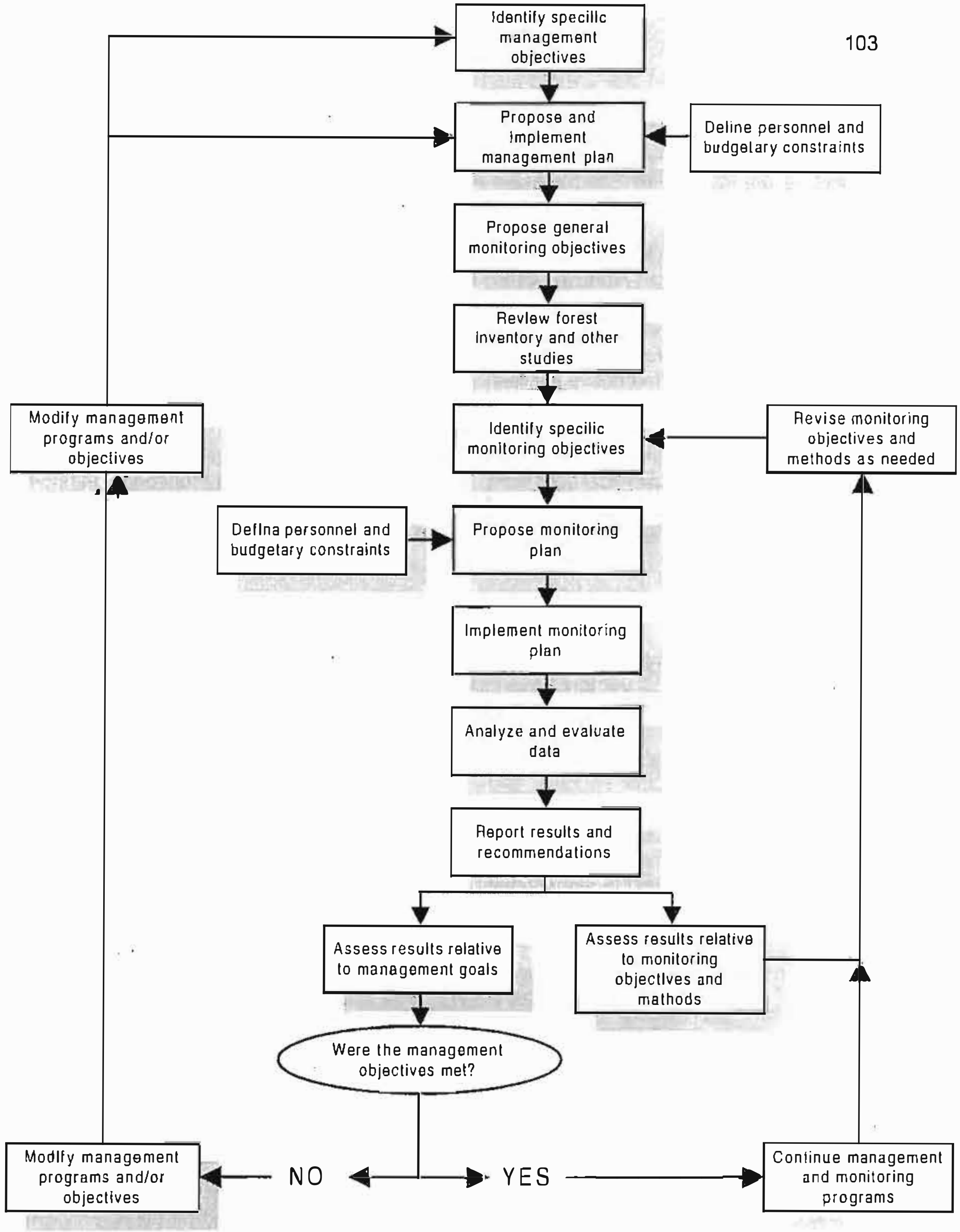

Figure 5.1: Management and monitoring program flow diagram. Stages in the development and implementation of an adaptive management and monitoring program are outlined. Adapted from The Nature Conservancy 1996.

across geographic gradients for comparison with areas in the forest that are targeted for treatment (including thinning and prescribed burns). The fact that abiotic and biotic resources exist at a variety of scales (in time and space) influences forest management, and should be reflected in management prescriptions and monitoring protocols.

In addition to the results of the initial forest inventory, knowledge of the forest ecosystem in general and the forest stands delineated for management in particular, will be enhanced by conducting pre-treatment, screening walk throughs and by collecting key information from literature and other sources. Some information is not available at this time (e.g., fire effects on certain rare plants and other native species). Management prescriptions will be based on the best available information and may be modified as new information is acquired.

Sampling design will be tailored to fit specific monitoring objectives and specific ecological conditions. Objectives and methods for monitoring understory vegetation at the individual species and plant subassociation levels, and vegetation types (e.g., overstory and shrubland) are outlined below.

5.2.2 Monitoring Individual Plant Species

The overall objectives of monitoring individual species are to determine changes in cover and frequency of native species, rare plants, and non-native species, including changes in individual plant populations.

Native Plant Species Richness

Preserving native plant species is one of the goals of the Forest Ecosystem Management Plan. Native species are indicators of good forest condition and provide food, shelter, and other habitat requirements for wildlife. The box below lists the management and monitoring objectives that relate to native plant species richness (which is the total number of native plants documented in a given area).

Management Objective 1.1. Maintain or increase the number of native plant species (i.e., native plant species richness).
***Rationale*:** Maintaining or increasing the number of native plant species is one aspect of the long-term conservation of these species.

Monitoring objective: Determine at 5-year (or more frequent) intervals the number of native plant species in the forest stands and inventory plots.

> **Adaptive Management Response:** Reassess treatment program to determine whether management actions (burning, thinning or fire suppression) are reducing the number of native plant species.

Recommended Monitoring Methods

Floristic composition: All species will be listed in all understory plots and in each stand where understory species are monitored. This data will be collected every 5 years by listing all species in each permanent understory plot (at the same time that cover data is collected), and by listing all species encountered during a systematic walk through of each stand. The walk throughs will be conducted relatively rapidly over entire stands, and will therefore represent a less intense search for species than the searches conducted in the understory plots. Additional species lists will be generated when other monitoring plots are established. For instance, modified-Whittaker plots (Stohlgren et al. 1995, Stohlgren et al. 1996) may be established in each plant subassociation in treated and untreated areas (see discussion below on monitoring plant subassociations).

Photographic monitoring: Photo documentation and repeat photography will be used in combination with other methods to meet numerous monitoring objectives in the Plan. During the Open Space forest overstory inventory, four photos were taken, one in each cardinal direction, at each permanent inventory plot. This photographic record provides a baseline to use to document changes in the appearance and condition of populations and vegetation.

Although individual species may be not be identifiable in general study plot photographs, the condition of a species' habitat may be discerned. The procedure used during the inventory of taking four photos at each monumented plot will be repeated during subsequent monitoring of those plots.

In summary:
Systemwide: Every 5 years, collect frequency data, compile stand-level species lists, and photograph permanent inventory plots.

Treated/reference stands: Collect frequency data, compile stand-level species lists, and photograph inventory plots in years 1, 2, 4, 7, and 10 after treatment.

Rare and Uncommon Plants

The preservation and sound management of rare species and their habitat is a goal of the Forest Ecosystem Management Plan. Forest management, which covers treated and untreated portions of the forest ecosystem, aims to maintain or improve conditions for plant species of special interest. The rare and uncommon plant species documented on Open Space forests are listed in Table 5.1. Open Space species listed by the Colorado Natural Heritage Program (1999) (CNHP) will be monitored more intensively than species that are not listed by CNHP. Currently, the CNHP-listed plants known from Open Space forests are leadplant (*Amorpha nana*) and birdsfoot violet (*Viola pedatifida*). Several additional species that occur in Mountain Parks are listed by the CNHP. These species will be discussed in Parts II and III of the Plan. The CNHP-listed species will be censused as well as mapped during pre- and post-treatment monitoring. All other rare and uncommon species will be mapped.

Table 5.1: Rare and Uncommon Plants Documented on Open Space, with Recommended Monitoring Methods.

SPECIES	LOCATION ON OPEN SPACE	HABITAT, BOULDER COUNTY (Weber 1995)	RECOMMENDED MONITORING METHODS
Species listed by the Colorado Natural Heritage Program			
Amorpha nana, Leadplant	D-2 Stand, Lower Shanahan Stand, Powerline #5, S-3 #25, Watertank #15 and #20	Locally common on mesas.	Census and map *A. nana* in treated stands and reference areas.
Viola pedatifida, Birdsfoot violet	Lower Shanahan Stand, LJC-NE Stand, Watertank #1	Uncommon on outwash fans and grassy openings in pine groves.	Census and map *V. pedatifida* in treated and reference areas.
Other Rare and Uncommon Species			
Asplenium septentrionale, Grass-fem	Documented on Lindsay and Eldorado Mountain prior to understory inventory.	Frequent in crevices in granite and in Fountain Sandstone.	Survey and map each species in treated stands and reference areas according to walk-through protocol.
Cheilanthes fendleri, Lipfem	Witt-W #10	Locally frequent on seams of granite outcrops and Lyons sandstone.	Survey and map each species in treated stands and reference areas according to walk-through protocol.
Crocanthemum bicknellii, Frostweed	S-9#10, Lindsay South Stand	Rare, on hogbacks.	Survey and map each species in treated stands and reference areas according to walk-through protocol.
Linaria canadensis, Blue toadflax	Documented on Lindsay and Shanahan prior to inventory.	Infrequent on the outwash fans and sandy sites in grasslands, piedmont valley.	Survey and map each species in treated stands and reference areas according to walk-through protocol.
Penstemon gracilis, Slender penstemon	LJC-NE Stand	Infrequent on the outwash fans.	Survey and map each species in treated stands and reference areas according to walk-through protocol.
Piperia unalascensis, Alaskan orchis	LJC-NW Stand	Rare, outer foothills.	Survey and map each species in treated stands and reference areas according to walk-through protocol.
Smilax lasioneuron, Carrion-flower	Documented on Lindsay and Lindsay-JeffCo prior to inventory.	Infrequent in gulches of the outwash fans.	Survey and map each species in treated stands and reference areas according to walk-through protocol.

Rare species that have been documented locally, but not yet in Open Space forests, are *Carex saximontana*, Rocky Mountain sedge, which is very rare in Boulder County (two records), and is found on dry slopes of foothills canyons, and *Gaura neomexicana coloradensis*, scarlet gaura, which is very rare on the outwash fans in Boulder County (one record).

There is not sufficient data from one field season of forest inventory to determine whether there are any areas with high concentrations of rare or uncommon plants in the study area. The limited data available show that most of the rare and uncommon species documented during 1997 were found in the southern (four species and four occurrences) and central (four species and nine occurrences) forest stands, with only one species and one occurrence in the northern forest stands.

Existing rare plant inventory and mapping data, information from the CNHP database, pertinent literature, and the forest understory inventory results constitute to the current state of knowledge. Additional rare plant survey work will provide the basis for a better evaluation of the status of rare and uncommon plants on City of Boulder forested lands.

Monitoring objectives for rare and uncommon plants emphasize the detection of change in densities of individuals, numbers of occurrences, and numbers of species (see discussion below). Management prescriptions are based on staff's current knowledge of rare and uncommon plants in the entire forest area, and are designed to avoid negative impacts to these species. If negative impacts are detected that may affect the long-term survival of a species, and may be related to forest management practices (i.e., the impacts are within staff's sphere of influence), adjustments will be made.

Documented occurrences of individual species listed by the CNHP will be monitored in reference and treated areas. Repeat monitoring will be conducted on a post-treatment schedule (years 1, 2, 4, 7, and 10) in treated and reference areas. CNHP-listed species occurring outside of treated or reference areas will be monitored at 5-year or more frequent intervals. All species listed in Table 5.1 will be mapped when encountered during walk throughs. Species-specific monitoring methods and schedules have been developed and are outlined later in this chapter in Table 5.5.

Rare plant monitoring and inventory protocols that have been previously developed by Open Space and Mountain Parks will continue to be implemented on untreated stands and for rare and uncommon species not listed by the CNHP. Rare plant inventory and monitoring protocols vary by species. Documentation of methods and results are filed with Mountain Parks and Open Space plant ecologists.

MANAGEMENT OBJECTIVE 1.2. Maintain or increase the existing number of rare and uncommon plant species (currently nine species on Open Space).

Rationale: Rare and uncommon plant species are species that are unusually sensitive to human disturbance and/or grow in unusual habitats. Maintaining these species is part of the overall goal of maintaining native plant species.

Monitoring objective: Determine the status of each known rare or uncommon plant species and any newly-documented rare or uncommon species by surveying known and potential habitat in treated and reference stands on a post-treatment schedule (years 1, 2, 4, 7, and 10). Determine the status of species occurring outside of treated and reference stands on a 5-year (or more frequent) interval.

> **Adaptive Management Response:** Reassess treatment program to determine whether management actions (burning, thinning or fire suppression) are eliminating rare or uncommon plant species. Assess success of weed management to determine whether weed proliferation could be eliminating plant species of special interest.

Recommended Monitoring Methods

Mapping: Update current maps of species occurrences during pre-treatment stand walk throughs and any subsequent walk throughs.

Stand walk throughs: Both pre- and post-treatment stand walk throughs will include surveys for each rare species that is known or expected in the Forest Ecosystem Management Plan area. Potential habitat and documented occurrences for each species will be surveyed during pre-treatment walk throughs and post-treatment monitoring. CNHP-listed species will be mapped and censused, and occurrences of other species will be mapped.

Information collection/data gaps:

- Determine abundance/protection status for each species; compile baseline information; update regularly with monitoring results and CNHP listings.
- Compile and synthesize response/adaptations of **sensitive species** to fire; update as new information becomes available.
- Detect factors threatening rare and endemic plant species; known potential threats from treatments will be covered in management prescriptions and in best management practices; monitoring results should reveal unanticipated impacts.
- Determine important aspects of population structure for individual sensitive species; compile background information (available for some species and not

for others) for designing stand-level management prescriptions, landscape-level patch treatment configuration (in space and time) and monitoring protocols.

- Develop habitat descriptions for each rare species to guide field surveyors.

In summary:
Systemwide: Continue to search for rare and uncommon plant species during walk throughs and all other monitoring, mapping, and inventory field work in the forest. Continue to implement established Open Space and Mountain Parks rare plant monitoring and inventory protocols on untreated stands.

Treated/reference stands: Visit each known occurrence of each rare plant species in years 1, 2, 4, 7, and 10 after treatment. Map, census, and photo-document occurrences of CNHP-listed species. Map all other rare and uncommon species.

MANAGEMENT OBJECTIVE 1.3. Maintain or increase the existing number of occurrences of rare and uncommon plant species. An occurrence is a distinct location for a species, where the criteria defining 'distinct location' are species-specific. Individual occurrences are typically separated by a specified minimum distance, and/or by a geographical, ecological, or human feature on the landscape.
Rationale: Occurrences of these species are generally small in area and/or contain relatively few individual plants. Thus, an entire occurrence could easily disappear. Maintaining all known occurrences of plant species of special concern is a way of reducing the risk that a species would disappear entirely from City lands.

Monitoring objective: Determine the number of occurrences for each species of concern in treated and reference stands on a post-treatment schedule (years 1, 2, 4, 7, and 10). Monitor all other forest occurrences on a 5-year (or more frequent) interval.

> **Adaptive Management Response:** Reassess treatment program to determine whether management actions (burning, thinning or fire suppression) are eliminating occurrences of plant species of special concern. Assess success of weed management to determine whether weed proliferation could be reducing plant occurrences of plant species of special concern.

Recommended Monitoring Methods

Systemwide: Continue to search for occurrences of rare plants during walk throughs and all other monitoring, mapping, and inventory field work in the forest.

Continue to implement established Open Space and Mountain Parks rare plant monitoring and inventory protocols for untreated stands.

Treated/reference stands: Visit each known occurrence of a plant species of special concern in years 1, 2, 4, 7, and 10 after treatment; count number of special plant species occurrences present and photo-document.

MANAGEMENT OBJECTIVE 1.4. Maintain or increase the density or population size (pick appropriate measure for each species) in each occurrence of a CNHP-listed rare or uncommon plant species. Note: It may be desirable to collect qualitative data for a subset of these plant species because some species may not be amenable to quantitative study and because some species may not face any demonstrable threat to their existence on City lands.

Rationale: Even if the number of occurrences of special species remains the same, population sizes could shrink. Given the typically small size of occurrences of these plant species, declines in population size of any occurrence would be very detrimental to the long-term likelihood of the continuation of an occurrence.

Monitoring objective: For each occurrence in years 1, 2, 4, 7, and 10 after treatment, detect a 20% change in plant density or population size. Staff wants to be 80% certain of detecting this change, and will accept a 20% chance of concluding that a 20% change occurred when it really did not.

> **Adaptive Management Response:** Reassess treatment program to determine whether management actions (burning, thinning or fire suppression) are decreasing the density or population size of each occurrence. Assess success of weed management to determine whether weed proliferation is decreasing the density or population size of each occurrence.

Recommended Monitoring Methods

Systemwide: Continue to implement established Open Space and Mountain Parks rare plant monitoring and inventory protocols for untreated stands and species not listed by CNHP.

Treated/reference stands: Census and/or sub-sample to measure density in each CNHP-listed rare plant occurrence in years 1, 2, 4, 7, and 10 after treatment. Photo-document all CNHP-listed rare plant occurrences in all treated and reference stands.

NON-NATIVE PLANTS

Invasive non-native plant species (also known as aliens, exotics, or weeds) commonly threaten native plant communities by displacing native species, and impact natural areas by reducing native species diversity, affecting natural processes, raising the cost of land management, and diminishing aesthetic and recreational values. Non-native herbaceous (nonwoody) plant species comprise 20% of the plant species and 18% of the vegetation cover recorded during the Open Space understory inventory.

The overall importance values of the non-native species in the understory inventory plots are listed in Table 5.2. The importance values are a combination of cover and frequency values, and provide an indication of the importance of the plant species within a particular area. Note that these importance values reflect only the data collected for the Open Space understory inventory plots, and while they are representative of the forest stands, more detailed weed mapping is needed to accurately assess which species represent the greatest threats in these forests. Also the importance values for individual species do not reflect either the potential the species have for displacing native species or the difficulty of management. Diffuse knapweed, for instance, has a much greater potential to disrupt local ecosystems than other species with higher importance values.

Six non-native species documented during the Open Space inventory are on the top ten weed list for Colorado (the species that are the most widespread and cause the greatest economic impact in the state): musk thistle (*Carduus nutans macrolepis*), Canada thistle (*Breea arvensis*), diffuse knapweed (*Acosta diffusa*), field bindweed (*Convolvulus arvensis*), toadflax (*Linaria vulgaris*), and spotted knapweed (*Acosta maculosa*), but only the first two have relatively high importance values in the understory inventory plots.

In addition, 14 species are on the noxious weed list for the state of Colorado: cheatgrass (*Anisantha tectorum*), mullein (*Verbascum thapsus*), St. Johnswort (*Hypericum perforatum*), houndstongue (*Cynoglossum officinale*), species with relatively high importance values in the inventory plots, and quackgrass (*Elytrigia repens*), sulfur cinquefoil (*Potentilla recta*), bouncing bet (*Saponaria officinalis*), tall oatgrass (*Arrhenatherum elatius*), bull thistle (*Cirsium vulgare*), myrtle spurge (*Tithymalus myrsinites*), chicory (*Cichorium intybus*), blue mustard (*Chlorispora tenella*), filaree (*Erodium cicutarium*), and common toadflax (*Linaria genistifolia dalmatica*), species with low importance values in the inventory plots. Non-native species that have high importance values in the inventory plots, but are not on the state lists, include Canada bluegrass (*Poa compressa*) and Japanese brome (*Poa japonicus*). Some non-native species, like mullein and houndstongue, are common in the forest, but are not high-priority species, because they are not as invasive or do not threaten to displace native species or communities to the degree that high priority non-natives do.

In summary, the high-priority non-native species requiring management actions based on the Open Space understory inventory data are listed in Table 5.2. Many of the non-native species in Table 5.2 are cool season species, which begin their growth in the winter or early spring. Canada bluegrass (*Poa compressa*), cheatgrass (*Anisantha tectorum*), and other cool-season non-native species have probably displaced native cool-season species in the forest understory.

Table 5.2: High-priority Non-native Plants Based on the Open Space Forest Inventory.

SPECIES	LOCATIONS	ECOLOGICAL NOTES
Acosta diffusa, Diffuse knapweed	Uncommon in inventory plots (8 out of 123 plots), all in central forest stands.	A highly invasive biennial species with high seed production and long-term seed viability. Knapweed seed disperses effectively as the dried plant tumbles with prevailing winds. Knapweed can be introduced in road and trail building materials. Invasion and spread occurs in both disturbed and relatively undisturbed habitat.
Anisantha tectorum, Cheatgrass	Ranks fourth in overall importance value for non-native plants on the Open Space inventory plots. Most important in the Canada bluegrass/Meadow arnica, Sunsedge/Poverty oatgrass, and Buckbrush/Poverty oatgrass PSAs.	Competes aggressively with native species by using early season moisture before many natives are growing, and by producing large amounts of seed that can germinate in the fall or spring. Cheatgrass can affect fire regimes, and is an early successional species after fire.
Breea arvensis, Canada thistle	Ranks tenth in overall importance value for non-native plants on the Open Space inventory plots. Importance values only in Sunsedge/Poverty oatgrass and Buckbrush/Poverty oatgrass PSAs.	A perennial species with an extensive root system. Seeds are viable in the soil for decades. Replaces native species, and degrades the quality of wildlife habitat. Canada thistle is a common early successional plant after fire.
Bromus japonicus, Japanese brome	Ranks third in overall importance value for non-native plants on the Open Space inventory plots. Most important in Sunsedge/Poverty oatgrass and Big bluestem/Wild alfalfa PSAs.	An aggressive annual species similar to cheatgrass, but does not germinate well after plant litter is removed by fire.
Carduus nutans macrolepis, Musk thistle	Ranks sixth in overall importance value for non-native plants on the Open Space inventory plots. Occurs throughout the forest stands with generally low cover, but frequency on the inventory plots was 52%.	A biennial species that can dominate areas after disturbance (early successional).
Hypericum perforatum, St. Johnswort	Ranks seventh in overall importance value of non-native plants on the Open Space inventory plots. Most important in Canada bluegrass/ Meadow arnica and Big bluestem/ Wild alfalfa PSAs.	Spreads aggressively and replaces native species due to high seed production, long-lived seeds, highly effective seed dispersal, and extensive root system.
Linaria vulgaris, Yellow toadflax	Uncommon in inventory plots (2 out of 123 plots), but encountered more frequently in forest stands.	A highly invasive, difficult-to-control perennial species that displaces native plants.
Poa compressa, Canada bluegrass	Ranks first in overall importance value of non-native plants on the Open Space inventory plots. Especially important in the Canada bluegrass/Meadow arnica PSA.	*P. compressa* is a perennial grass that increases with livestock grazing, spreads by seed and roots, and is able to grow in poor, dry soils. *P. compressa* stabilizes soils. Fall fires may stimulate vegetative growth, and late spring fires may negatively impact the species. This cool season species has probably replaced native cool season species in the forest understory.

MANAGEMENT OBJECTIVE 1.5. Focus first on reducing abundance and occurrences of high-priority invasive non-native species present on City lands. Reduce the frequency and cover of low-priority non-native species whenever possible.
Rationale: Invasive non-native species have been shown to create significant undesirable changes in ecosystem structure and function, e.g., eliminating certain native plant species. Some non-native species are much more threatening than others. Thus, control efforts need to be concentrated on those species that are most likely to cause problems locally and which are most susceptible to control efforts.

<u>**Monitoring objective:**</u> Detect changes in the density of mapped occurrences of high-priority non-native species. Detect a 20% change in frequency and cover of high- and low-priority non-natives in forest understory inventory plots by collecting data every 5 years in all inventory plots, or more frequently in treated and reference stands. Staff wants to be 80% certain of detecting these changes, and will accept a 20% chance of concluding that a 20% change occurred when it really did not.

> **Adaptive Management Response**: Incorporate monitoring results into ongoing integrated weed management planning. Reassess treatment program to determine whether management actions (burning, thinning or fire suppression) could be altered to reduce noxious weed abundance. Reassess the effectiveness of forest management best management practices, and the weed management program.

Recommended Monitoring Methods

Integrated pest management (IPM) protocols continue to be developed for Open Space non-native species, and are implemented as outlined in Open Space IPM policies (document in preparation), and as described in area management plans. IPM treatment effects on specific non-native species will also be tracked.

<u>*Mapping*</u>: Map selected non-native species (in progress); update current maps during pre-treatment stand walk throughs and any subsequent walk throughs.

<u>*Photographic monitoring*</u>: Establish photo-points for photo-documenting significant infestations of high-priority weed species; track change over time. Collect Global Positioning System data for selected photo-points.

Stand walk throughs: Collect additional information on occurrences of non-native species and localities, and rank species priorities in each stand for IPM treatment.

Best Management Practices (BMPs): Establish best management practices to limit inadvertent spread of non-natives during implementation of management prescriptions. Assess the effectiveness of BMPs.

Information collection/data gaps: Compile and synthesize response and adaptations of non-native species to fire; update as new information becomes available.

FIRE EFFECTS ON NON-NATIVE SPECIES

The introduction of non-native species in recent decades presents a major challenge when planning for prescribed burns. These species can displace native species and can significantly impact the structure and function of native ecosystems. Several non-natives, including Canada thistle, St. Johnswort, mullein and cheatgrass, are known to increase (at least initially) after fire. Competition from native species can help reduce the densities of some non-natives during post-fire succession.

In summary:
Systemwide: Every 5 years, collect cover and frequency data on all permanent inventory plots. Continue to map non-native species and apply integrated pest management practices developed by Open Space and Mountain Parks. Continue to search for non-native populations during walk throughs, mapping, monitoring, and inventory field work. Monitor effectiveness of IPM methods on different non-native plant species through repeat mapping and density estimates of priority species. Additional methods for assessing the effects of treatments on native and non-native species are being developed.

Treated/reference stands: In years 0, 1, 2, 4, 7, and 10 after treatment collect cover and frequency data on permanent plots for low-priority weeds. Treat high-priority weeds, if possible, as soon as they are detected.

MANAGEMENT OBJECTIVE 1.6. Whenever possible, prevent the establishment and spread of invasive non-native species that have not been previously encountered on City lands.
Rationale: Preventing problem non-native species from becoming established has been shown to be far more cost-effective than controlling species that are already established. An ounce of prevention is worth a pound of cure. Control efforts will be focused on non-native species that would likely cause serious problems if they became established on City lands. Special attention will be paid to forest areas adjacent to the urban edge, where garden plants can escape and become naturalized, and to spread of non-native species through on-trail and off-trail recreational activities.

<u>Monitoring objective: Detect</u> any new invasive non-native species in the forest ecosystem.

> **Adaptive Management Response:** Reassess effectiveness of weed management. Assess the need for new measures to prevent new weed species establishment, the impact of recreational and management activities on establishment and spread of non-native species, and the effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Systemwide: Detect, map, and photo document occurrences of new invasive non-native species by walking the length of every Open Space and Mountain Parks trail at least once each growing season. Ideally, trailside monitoring would occur in May, June and August to detect spring, summer, and last summer non-native species, if staff and/or volunteer time is available.

Treated/Reference Stands: In years 1, 2, 4, 7, and 10 after fire, detect and photo-document occurrences of new invasive non-native species during stand walk throughs. Track the implementation of best management practices to determine whether they are preventing the dissemination and spread of weeds during forest treatments.

5.2.3 MONITORING PLANT SUBASSOCIATIONS AND VEGETATION TYPES

In addition to monitoring individual plant species as outlined above, individual plant subassociations and vegetation types (namely, riparian areas, wetlands, and shrublands) will be monitored, as described below.

Changes in the diversity, areal extent, and distribution of plant associations, plant subassociations, and vegetation types can be a result of plant succession, of environmental changes at a given site, or of invasion by non-native species (The Nature Conservancy 1996). Monitoring changes in the plant subassociations and vegetation types will provide feedback on how management actions (prescribed fire, in particular) are affecting the nature and distribution of these plant assemblages and the wildlife species that depend on them.

MANAGEMENT OBJECTIVE 1.7. Maintain or increase the existing number and types of plant associations dominated by native plants on Open Space and Mountain Parks lands (currently one plant association and five subassociations on Open Space forests).
***Rationale*:** Maintaining or increasing the number of native plant communities is one aspect of maintaining these communities generally. In addition, native plant associations capture a significant portion of the biological diversity of an area; therefore, maintaining plant communities will simultaneously maintain many plant and animal species.

Monitoring objective: Determine the number and types of native plant associations in treated and reference areas every 5 years.

> **Adaptive Management Response:** Reassess treatment program to determine whether management actions (burning, thinning or fire suppression) are eliminating plant communities.

Recommended Monitoring Methods

Systemwide: Every 5 years, collect cover and frequency data from all permanent inventory plots and other plots in each plant association and analyze using multivariate analysis to determine the number and types of plant communities.

Floristic composition: Complete lists of all plant species found in each plant association/subassociation will be compiled from all monitoring and inventory fieldwork completed in the forest. Visits to stands will be made, over time, during every season to document spring, summer, and fall species. Every 5 years all understory plots will be revisited to collect cover and frequency data. This data will then be analyzed using multivariate analysis to track the number and types of plant associations and subassociations present. Outstanding areas of common plant associations and subassociations will be identified.

Where additional cover and frequency data are needed in a stand, the modified-Whittaker point-intercept method, or other appropriate method, will be used.

Mapping: Identify limits of each plant association and subassociation and map on aerial photos. The plant subassociation boundaries and patches will be mapped in order to identify expansion or shrinkage over time. Map rare plant communities, if present. (See discussion of rare plant communities in Section 3.6.2.)

Photographic monitoring: A system of photographic monitoring locations for the plant associations and subassociations will be established.

Information collection/data gaps:
- Continue to compile information on forest succession for the relevant plant associations.
- Determine abundance/protection status of rare plant associations and subassociations in this region. Compile baseline information and update regularly.
- Continue to compile and synthesize response/adaptations to fire of rare plant communities; update as new information becomes available.
- Detect factors threatening rare plant communities; known potential threats from treatments will be covered in prescriptions and in best management practices; monitoring results should reveal unanticipated impacts.

MANAGEMENT OBJECTIVE 1.8. Maintain or increase the vegetation quality for each of the above plant associations and for any associations identified in the future. Note: Vegetation quality will be estimated using a floristic quality index which is computed using both a floristic value for each species present and the total number of plant species present (see Taft et al. 1997).
Rationale: High-condition plant associations are more valuable than degraded plant communities because they contain a higher proportion of native plant species. The Taft et al. (1997) approach to assessing the floristic quality of plant associations has worked well in the upper Midwest, and staff proposes to apply it here.

Monitoring objective: Determine the vegetation quality of each treated and reference area every 5 years.

> **Adaptive Management Response:** Reassess treatment program to determine whether management actions (burning, thinning or fire suppression) are eliminating native plant species with high floristic values. Assess success of weed management to determine whether weed proliferation is reducing floristic quality.

Recommended Monitoring Methods

Floristic quality assessment: A floristic quality index will be adopted for forest monitoring purposes. Each species documented by forest inventory and monitoring will be assigned a value within the index. Floristic quality assessments can then be completed at the plot, stand, and forest levels using species lists generated from repeat monitoring of permanent inventory plots and other plots and from stand-level walk throughs (Taft et al. 1997)).

Systemwide: Every 5 years, calculate the floristic quality for each plant association using frequency data from the permanent inventory plots.

Treated/reference stands: Calculate the floristic quality for each stand in years 1, 2, 4, 7, and 10 after treatment.

CHANGES IN THE FOREST CANOPY AND FOREST UNDERSTORY

One of the major management objectives of the Plan is to return City of Boulder forests to their historical range of variability, primarily by opening up the canopy of the ponderosa pine forests, increasing old-growth ponderosa pine forests, and decreasing the cover of ponderosa pine/Douglas-fir forests and the cover of high density, young ponderosa pine trees. These changes will affect the types of understory plants that grow beneath the canopy, and thereby influence the plant associations and subassociations present. Monitoring these changes will provide the information needed to evaluate whether management actions are achieving desired future conditions within the forest.

MANAGEMENT OBJECTIVE 1.9. Reduce the density and increase the size of trees so stand averages of tree density and size fall within the historical range of variability of the region for the different forest types. ***Rationale***: Fire suppression has led to many forest stands that are characterized by high densities of relatively small trees. The goal is to reverse this trend and to manage for forests that fall within the historical range of variation in terms of tree density and size structure.

Monitoring objective: Determine the average tree density and average tree size by collecting canopy cover data on all permanent inventory plots every 5 years.

> **Adaptive Management Response**: Reassess burning and thinning program to determine whether additional burning or thinning is necessary to achieve management objectives. Assess effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Systemwide: Every 5 years collect canopy cover data on all permanent inventory plots.

Treated/Reference Stands: Every 5 years, determine the average tree density and average tree size (diameter at breast height), with 90% confidence intervals no wider than 15% of the estimated true average tree density and tree size using data from permanent plots. Photo-document canopy cover.

MANAGEMENT OBJECTIVE 1.10: Increase the proportion of stand initiation and old-growth forests and decrease the proportion of stem-exclusion, closed canopy forest. Stand initiation refers to forest stands dominated by tree seedlings. Old-growth refers to forests that are characterized by widely spaced old trees, some of which have broken tops; large standing dead trees (snags) and fallen trees are present. Stem-exclusion refers to forest stands that are heavily stocked with relatively small trees with sparse understory, a consequence of little light reaching the forest floor.
Rationale: Stand data from City lands show that old-growth forests are absent and stand initiation forests are relatively uncommon, while stem-exclusion, closed canopy forests are the most abundant and are greatly over-represented today compared to historical conditions.

Monitoring objective: Every 5 years, characterize each permanent inventory plot in treated and reference stands as one of three forest types (stand initiation, stem- exclusion, or old growth) by measuring tree density and size.

> **Adaptive Management Response:** Reassess the validity and implementation of stand prescriptions. Assess effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Treated/Reference Stands: Every 5 years, assign each permanent inventory plot in treated and reference stands to one of the three forest types (old-growth, stand initiation, and stem-exclusion), using tree density and size data. Quantitative definitions of the three forest categories will be developed.

Mapping: Map targeted potential old-growth areas. Map current stand-initiation areas and new stand-initiation areas as they develop.

Photographic monitoring: Establish photo-points for repeat photography of potential old-growth forests and stand-initiation forests.

Management Objective 1.11. Maintain or increase the cover of native understory vegetation and reduce the cover of bare ground and litter on the soil surface.
Rationale: Forests that pre-dated fire suppression had more ground-layer vegetation and less bare soil and litter due to higher light levels that reached the forest floor and frequent low-intensity burns that reduced litter and released nutrients. In addition, higher vegetation cover and less bare ground reduce soil erosion.
Note: Site factors, such as soils, will limit the amount of plant cover in some areas. Increasing understory cover will occur most readily in areas where the forest canopy is opened up by thinning and burning.

Monitoring objective:

Every 5 years, detect a 20% change in cover of native perennial plant species in aggregate and bare ground, respectively. Staff wants to be 80% confident of detecting a 20% change, and will accept a 20% false-change error rate, using data from permanent understory vegetation plots.

Adaptive Management Response: Reassess burning and thinning program to determine whether additional burning or thinning is needed to increase sunlight on the forest floor and reduce litter.

Recommended Monitoring Methods
See methods under Management Objectives 1.1 and 1.7

Understory species cover data: Cover data will be collected in all understory plots using the point-intercept method and the cover point optical device. In selected stands, the modified-Whittaker method may be used to quantify understory cover. Methodology for estimating cover in sites that are steep, rocky or in some other way difficult to monitor has been developed and used in the Mountain Parks forest inventory. The same or similar methodology will be used for understory inventories and monitoring in higher elevation Open Space stands. Understory cover data will be collected every 5 years in each permanent understory plot, and during years 1, 2, 4, 7, and 10 in understory plots located in treated and reference stands.

Photographic monitoring: Photo documentation and repeat photography will be used in combination with other methods to meet numerous monitoring objectives in the Plan. Although individual species may be not be identifiable in plot photographs, the condition of a species' habitat may be discerned. The procedure used during the inventory of taking four photos at each monumented plot will be repeated during subsequent monitoring of those plots.

In summary:
Systemwide: Every 5 years, collect cover data and photograph permanent inventory plots.

Treated/reference stands: Collect cover data and photograph inventory plots in years 1, 2, 4, 7, and 10 after treatment.

SHRUBLANDS

Shrub vegetation types within the ponderosa pine ecosystem are of particular concern due to their contribution to native plant diversity and to the structural diversity of the forest, as well as their importance in providing food and cover for wildlife. Information is lacking on foothills shrubland communities in this area. This section addresses the need to better characterize foothills shrublands both inside and outside of delineated forest stands.

There are two overall reasons for mapping and monitoring shrublands:

- Foothill shrubland communities may be influenced directly or indirectly by forest treatments, or by no-treatment prescriptions. Prescribed fire will be the most influential treatment on species composition and frequency of shrublands in the forest.
- Shrubland communities associated with the ecotone between the plains and foothills in this area are not well-documented, and that creates a significant data gap for wildlife management and local ecosystem-level management planning.

MANAGEMENT OBJECTIVE 1.12 Maintain or increase the number of shrubland community types. Avoid negative impacts to uncommon shrubland species or communities.

Monitoring objective: Detect changes in the composition and cover of shrubland communities within the forest ecosystem in treated and reference areas by monitoring selected shrubland patches pre- and post-treatment. Detect a 20% change with an 80% confidence level.

> **Adaptive Management Response:** Use results to assess trends in the status of shrubland communities in treated and untreated areas. Adjust treatment prescriptions if a shrubland community type is in decline on a forest-wide level, or an uncommon shrubland community is in decline on the individual occurrence level. Prescriptions may be altered based on new treatment effects (e.g., fire effects) information resulting from research conducted in forests locally and/or regionally.

Recommended Monitoring Methods

Floristic Composition: Identify common shrubland types, unusual types, and the fire ecology of key shrubland species. Establish a monitoring protocol and select shrubland patches to monitor (inside and outside of delineated forest stands).

Mapping: Using remote-sensing imagery, map lower elevation shrublands both inside and outside of forest inventory stands. Ground-truth the remote imagery mapping.

Photographic Monitoring: Establish a system of photographic monitoring locations for the shrub communities and shrub vegetation types.

RIPARIAN AND WETLAND AREAS

Riparian and wetland areas within the lower elevation forests were not surveyed during the 1996 to 1998 Open Space forest inventory, as they were mostly outside of the boundaries of the established forest stands. However, these areas provide habitat for a great diversity of plant and wildlife species, and have important hydrological functions as well. Additional management and monitoring objectives will be developed for these areas once inventories have been completed.

MANAGEMENT OBJECTIVE 1.13. Maintain or increase the areal extent of riparian areas.
Rationale: Riparian areas are perhaps the single most important habitat type in the semi-arid west, including Open Space and Mountain Parks lands, because of the exceptional wildlife habitat they provide. In addition, they are very appealing to urban recreationists.

Monitoring objective: Detect changes in the areal extent of riparian areas within the forest ecosystem by using remotely-sensed imagery to estimate the cover of riparian vegetation every 5 to 10 years.

> **Adaptive Management Response:** Reassess burning and thinning program to determine whether it is reducing the size of riparian areas.

Recommended Monitoring Methods

Systemwide: Every 5 to 10 years, estimate the areal extent of riparian vegetation, with a precision of 20%, using a supervised classification of remotely sensed false-color infrared data in a GIS environment followed by field truthing.

MANAGEMENT OBJECTIVE 1.14. Maintain or increase the areal extent of existing wetlands.
Rationale: Like riparian areas, wetland are critical in a semi-arid environment like the Front Range. Wetlands are protected by local ordinances and federal statutes.

Monitoring objective: Detect changes in the areal extent of wetlands within the forest ecosystem by using remotely sensed imagery to estimate the cover of wetland vegetation every 5 years.

> **Adaptive Management Response:** Reassess burning and thinning program to determine whether it is reducing the size of wetlands.

Recommended Monitoring Methods

Systemwide: Every 5 years, estimate the areal extent of wetlands, with a precision of 20%, using a supervised classification of remotely sensed false-color infrared imagery in a GIS environment, followed by field truthing.

5.3 MONITORING WILDLIFE

The following section discusses the wildlife management and monitoring objectives for this Plan. Sampling design is tailored to fit specific monitoring objectives and specific ecological conditions. Monitoring methodology will be discussed for (1) group monitoring and (2) individual species of special interest monitoring.

5.3.1 NATIVE SPECIES

One of the goals of the Plan is to maintain or enhance native plant and animal species and communities and the ecological processes that sustain them. Therefore, promoting native wildlife species, as indicators of good forest condition, is a central concern of the Plan.

MANAGEMENT OBJECTIVE 1.15. Maintain or increase native wildlife species richness.

Rationale: This statement follows directly from the first Plan goal. Species richness is perhaps the most basic expression of native animal species biological diversity.

Monitoring objectives:

In years 1, 2, 4, 7, and 10 post-treatment, analyze field inventory and anecdotal data collected for small mammals since the year of the last analysis, and prepare a list of small mammal species encountered or reliably reported during that time period.

Every 5 years post-treatment, analyze field inventory and anecdotal data collected for large mammals since the year of the last analysis, and prepare a list of large mammal species encountered or reliably reported during the five-year period.

In years 1, 2, 4, 7, and 10 post-treatment, analyze field inventory and anecdotal data collected for birds since the year of the last analysis, and prepare a list of bird species encountered or reliably reported during that time period.

Every 5 years post-treatment, analyze field inventory and anecdotal data collected for reptiles since the year of the last analysis, and prepare a list of reptile species encountered or reliably reported during the five-year period.

Every 5 years post-treatment, analyze field inventory and anecdotal data collected for amphibians since the year of the last analysis, and prepare a list of amphibian species encountered or reliably reported during the five-year period.

Every 5 years post-treatment, analyze field inventory and anecdotal data collected for invertebrates, censusing butterflies as an indicator species, since the year of the last analysis, and prepare a list of invertebrate species encountered or reliably reported during the five-year period.

> **Adaptive Management Response:** If a species that was previously documented is not encountered or is not otherwise reliably reported during the subsequent time period, prepare a brief memo that lists and outlines plausible explanations for its presumed disappearance from Open Space and Mountain Parks and discusses possible changes in land management that would promote recolonization of the species. In particular, reassess the burning and thinning program to determine whether burning or thinning could be eliminating any wildlife species.

Recommended Monitoring Methods

Small Mammals

In years 1, 2, 4, 7, and 10 post-treatment, trap for small mammals at plot 5 (or plot 10, if necessary) of each forest stand. Sherman live-traps will be placed in a 5 x 5 meter grid (traps 5 meters apart), for a total of 25 traps, with the southwest corner of the grid oriented at the permanent plot marker. The traps will be placed on the grid opening to the north. Traps will be baited with sweet mix and a handful of polyester batting. The traps will not be pre-baited. Trapping will occur on four consecutive nights for a total of 100 trap-nights and checked each morning within an half-hour of sunrise. Data on species, including sex, weight, reproductive condition, and recapture rate, will be collected.

Large Mammals
Every 5 years post-treatment, conduct wildlife transects through each forest stand. These transects will be conducted quarterly in those years and will be designed to capture data relevant to all wildlife. Therefore, all observations or signs (tracks, scat, dens, nests, etc.) of birds, mammals, reptiles, amphibians, and invertebrates are to be recorded during this walking transect.

Birds
On years 1, 2, 4, 7, and 10 post-treatment, conduct point counts at permanent plots in each forest stand that are at least 200 meters apart. Point counts are conducted within a 100-meter radius from the permanent plot marker. The point count circle is subdivided into a 50-meter radius, as well. All birds seen or heard will be recorded within these radii for 10 minutes. Point counts can be conducted from sunrise to 10:00 am. Three replicates are done, starting in May and ending before July 15th.

Reptiles
Record observations or signs of reptiles during wildlife transects described under *Large Mammals*.

Amphibians
Every 5 years post-treatment, conduct amphibian transects as designed for Area Management Plan inventories. These walking transects are set up along riparian areas and are designed to capture observations and signs of amphibians. In addition, data on amphibians will be recorded during wildlife transects described under *Large Mammals*.

Invertebrates
Every 5 years post-treatment, conduct butterfly transects in each forest stand. Because the resources are currently lacking to do a comprehensive invertebrate census, butterflies are singled out as indicator species of forest health for invertebrates. Walking transects will be conducted on which all butterfly species seen will be identified and recorded (see Pineda et al. 1997).

When collected, the data from the above methods will be compared to baseline data and all monitoring for each of these forest stands. For those species not observed in the above projects, other sources of information will be searched (wildlife sightings database, research projects, Breeding Bird Surveys, National Audubon Society including Christmas Bird Counts, Boulder County Nature Association, Sierra Club, etc.) to determine whether they continue to be present. If additional information is still not found, a brief report will be written that gives plausible explanations for the failure to detect those species. Specific projects for individual species of special interest may then be implemented to determine their status on Open Space and Mountain Parks lands. Changes in land management may result.

MANAGEMENT OBJECTIVE 1.16. Maintain or increase the densities of breeding bird species.
Rationale: If breeding bird species are declining, this knowledge will motivate reassessment of the forest management program before any birds species disappear locally.

Monitoring objective: Determine trends in population densities for breeding passerine birds every 5 years, using a confidence level of 0.1 for the slope of the regression line. Determine the population trends for breeding passerine birds every 5 years.

> **Adaptive Management Response:** Assess Open Space/ Mountain Parks forest management activities, especially the burning and thinning program, to determine whether changes are needed to reverse declining trends in bird species. Initiate a nest search program for declining species if evidence suggests that reduced nesting success may be contributing to the species' decline.

Recommended Monitoring Methods

Based on data collected from bird point counts, determine the population trends for breeding passerine birds on Open Space/Mountain Parks forests every 5 years. Because trends in breeding bird populations may decline for reasons unrelated to local forest stand management, both treated and reference stands will be sampled and the calculated trends will be compared to national Breeding Bird Survey trends.

MANAGEMENT OBJECTIVE 1.17. Maintain or increase the number of nesting and roosting sites of raptor and bat species (especially sensitive species).
***Rationale*:** Nesting and roosting sites support resident populations of raptors and bats, and the availability of nest sites can limit their populations.

Monitoring objective: Detect changes in the number of nesting and roosting sites of raptor and bat species by annually monitoring all known forest sites.

> **Adaptive Management Response:** Assess Open Space /Mountain Parks land management activities, especially the burning and thinning program, to determine whether any activities could be reducing the use of nest or roost sites.

Recommended Monitoring Methods

Preserving historic and active nesting and roosting sites of native wildlife species, especially those of special interest (see Table 5.3), is an important step in maintaining those populations. Locating and monitoring these sites will be accomplished through the wildlife sightings database, literature searches, pre-treatment walk throughs, wildlife transects and special projects, when necessary.

Check known nests of raptor species (especially sensitive species) annually to detennine if they are successful, i.e., if they produce at least one fledgling. Sensitive raptors include northern goshawk, sharp-shinned hawk, peregrine falcon, prairie falcon, Cooper's hawk, golden eagle, long-eared owl, and flammulated owl.

Check known bat species (especially sensitive species) roosting sites annually to detennine if bats are using them. Sensitive bat species include Townsend's big-eared bat and fringed myotis.

5.3.2 WILDLIFE SPECIES OF SPECIAL INTEREST

Species of special interest are those species that are either listed, whether federally or locally, or those whose status is unknown on Open Space/Mountain Parks lands.

MANAGEMENT OBJECTIVE 1.18. Maintain or increase the existing number of each avian species of special interest listed in Table 5.3 (northern goshawk, sharp-shinned hawk, peregrine falcon, prairie falcon, Cooper's hawk, golden eagle, long-eared owl, flammulated owl, hairy woodpecker, Lewis' woodpecker, band-tailed pigeon, common poorwill, Williamson's sapsucker, pygmy nuthatch, and western bluebird). This list is subject to revision as new information becomes available.

Rationale: Open Space/Mountain Parks forest lands provide important habitat for species that are declining, are locally rare, or whose local status is unknown.

Monitoring objective: Determine the number of avian species of special concern present in the forest ecosystem through annual inventories.

> **Adaptive Management Response:** Assess Open Space/Mountain Parks land management activities, especially the burning and thinning program, to determine whether any activities could be reducing the population density or degrading habitat for any of these species.

Recommended Monitoring Methods

The above monitoring objective will be met, in part, by the monitoring methods already discussed in this chapter for native wildlife. For those avian species of special interest not observed during the point counts or wildlife transects, other sources of information will be searched (wildlife sightings database, research projects, Breeding Bird Surveys, National Audubon Society including Christmas Bird Counts, Boulder County Nature Association, Sierra Club, etc.). Annual inventory projects specifically designed for each species or groups of species with similar habitat requirements may be implemented to determine whether they continue to be present. If additional information is still not found, a memo will be written that gives plausible explanations for the failure to detect those species. Changes in land management may result.

Table 5.3: Wildlife Species of Special Interest in Open Space Forests.

AVIAN SPECIES	RANKING*					HABITAT
	Federal	State Status	CNHP	USFS Reg. 2	BCNA	
Accipiter cooperii, Cooper's hawk			G4, S3S4B, S4N			usually deciduous, occasionally coniferous, forest, woodland, esp. riparian
Accipiter gentilis, Northern goshawk	C2		G5, S3B, S4N	S	4,5	mixed, often mostly coniferous, forest, open woodland
Accipiter striatus, Sharp-shinned hawk			G5, S3S4B, S4N			woodland, mountainous coniferous/deciduous forest
Aquila chrysaetos, Golden eagle			G5, S3S4B, S4N		4	open habitats, esp. in mountains and hills
Asio otus, Long-eared owl			G5, S3S4B, SZN		1	coniferous and mixed coniferous-deciduous forest, esp. near water, occasionally deciduous forest
Columba fasciata, Band-tailed pigeon						oak forest and woodland, coniferous forest
Falco mexicanus, Prairie falcon			G4G5, S3S4B, S4N		4	open habitat in mountainous regions
Falco peregrinus, Peregrine falcon	LE	T	G4T4, S2B, SZN		3, 4	open habitats from tundra, savanna, and seacoasts to high mountains, also open forest
Melanerpes, lewis, Lewis' woodpecker				S	2, 4	open woodland and forest, often logged or burned, including oak, coniferous forest, riparian woodland
Otus flammeolus, Flammulated owl				S	4	montane forest, esp. ponderosa pine forest
Phalaenoptilus nuttallii, Common poorwill						scrub, brush, prairie, rocky canyon, open woodland

Table 5.3: Wildlife Species of Special Interest in Open Space Forests.						
	RANKING*					
AVIAN SPECIES	Federal	State Status	CNHP	USFS Reg. 2	BCNA	HABITAT
Picoides villosus, Hairy woodpecker						deciduous or coniferous forest, wooded swamps, orchards, woodland
Sialia mexicana, Western bluebird						open, riparian, burned, or cutover woodlands, other open country with scattered trees
Sitta pygmaea, Pygmy nuthatch				S	4	pine forests (esp. ponderosa, piñon-juniper woodland
Sphyrapicus thyroideus, Williamson's sapsucker						montane coniferous forest, esp. fir, lodgepole pine, also aspen groves
MAMMALIAN SPECIES						
Corynorhinus townsendii, Townsend's big-eared bat	C2		G4T4, S3			piñon-juniper woodlands and open montane forests
Erthizon dorsatum, Common porcupine						conifers in montane and subalpine forests and piñon-juniper woodlands
Myotis thysanodes, Fringed myotis	C2		G5, S3S4	S		ponderosa pine woodlands
Sciurus aberti, Abert's squirrel				S		open ponderosa pine forest
Urocyon cinereoargenteus, Gray fox						rough, broken terrain in montane shrublands, piñon-juniper and riparian woodlands
REPTILIAN SPECIES						
Opheodrys vernalis, Smooth green snake			G5, S3S4			lush growths of herbaceous vegetation along mountain and foothill streams

*	**Federal Status: USFS Reg. 2** ***U.S. Fish and Wildlife Service (58 Federal Register 51147, 1993) and (61 Federal Register 7598, 1996)***
LE	Endangered; taxa formally listed as endangered
E (S/A)	Endangered due to similarity of appearance with listed species.
LT	Threatened; taxa formally listed as threatened.
P	Proposed E or T; taxa formally proposed for listing as endangered or threatened.
C	Candidate: taxa for which the Service has on file sufficient information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened.
(C1)	FORMERLY: Notice of Review, Category 1: taxa for which substantial biological information exists on file to support proposing to list as endangered or threatened.
(C2)	FORMERLY: Notice of Review, Category 2: taxa for which current information indicates that proposing to list as endangered or threatened is possible, but appropriate or substantial biological information is not on file to support an immediate rulemaking.
(C2*)	FORMERLY: Taxa believed to be possibly extirpated in the wild.
(3A)	FORMERLY: Taxa for which the USFWS has persuasive evidence of extinction.
(3B)	FORMERLY: Names that based on current taxonomic knowledge do not represent taxa meeting the Endangered Species Act's definition of a species.
(3C)	FORMERLY: Notice of Review, Category 3C: taxa that have proven to be more abundant or widespread than was previously believed, and/or those that are not subject to any identifiable threat.
FS	*U.S. Forest Service (Forest Service Manual 2670.5) (noted by the Forest Service as "S")* Sensitive: those plant and animal species identified by the Regional Forester for which population viability is a concern as evidenced by: a. Significant current or predicted downward trends in population numbers or density. b. Significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.
BLM	*Bureau of Land Management (BLM Manual 6840.06D) (noted by BLM as "S")* Sensitive: those species found on public lands, designated by a State Director, that could easily become endangered or extinct in a state. The protection provided for sensitive species is the same as that provided for C (candidate) species.
	State Status: State, Colorado Natural Heritage Program (CNHP)
	Colorado Division of Wildlife
E	Endangered
T	Threatened
S	Sensitive
SC	Special Concern
	Colorado Natural Heritage Program Codes:
G4	Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G5	Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
S2	Imperiled in state because of rarity (6 to 20 occurrences), or because of other factors demonstrably making it very vulnerable to extirpation from the state.
S3	Rare in state (21 to 100 occurrences).
S3S4	Watchlisted; specific occurrence data are collected and periodically analyzed to determine whether more active tracking is needed.
B	Breeding season imperilment, summer-resident species.
T	Colorado Division of Wildlife, state threatened.

	Boulder County Status: Boulder County Nature Association (BCNA)
	Boulder County Nature Association Code
1	Rare and declining.
2	Declining (but not yet rare).
3	Rare and stable.
4	Isolated or restricted populations (species that are found only at certain locations and/or have narrow habitat niches).
5	Status undetermined.
6	Extirpated.
W	Winter.

MANAGEMENT OBJECTIVE 1.19. Maintain or increase the existing number of each mammalian species of special interest listed in Table 5.3 (Abert's squirrel, Townsend's big-eared bat, fringed myotis, gray fox, and porcupine). This list is subject to revision as new information becomes available.

Rationale: Open Space/Mountain Parks forest lands provide important habitat for species that are declining, are locally rare, or whose local status is unknown.

Monitoring objective: Determine the number of mammalian species of special concern present in the forest ecosystem through annual inventories.

Adaptive Management Response: Assess Open Space/Mountain Parks land management activities, especially the burning and thinning program, to determine whether any activities could be reducing the population density or degrading habitat for any of these species.

Recommended Monitoring Methods

The above monitoring objective will be met, in part, by the monitoring methods already discussed in this chapter for native wildlife. For those mammalian species of special interest not observed during the small mammal trapping or wildlife transects, other sources of information will be searched (wildlife sightings database, research projects, Boulder County Nature Association, Sierra Club, etc.). Annual inventory projects specifically designed for each species or groups of species with similar habitat requirements may be implemented to determine whether they continue to be present. If additional information is still not found, a memo will be written that gives plausible explanations for the failure to detect those species. Changes in land management may result.

MANAGEMENT OBJECTIVE 1.20. Maintain or increase the existing number of each reptilian species of special interest listed in Table 5.3 (smooth green snake). This list is subject to revision as new information becomes available.
Rationale: Open Space/Mountain Parks forest lands provide important habitat for species that are declining, are locally rare, or whose local status is unknown.

Monitoring objective: Determine the number of reptilian species of special concern present in the forest ecosystem through inventories every 5 years.

> **Adaptive Management Response:** Assess Open Space/Mountain Parks land management activities, especially the burning and thinning program, to determine whether any activities could be reducing the population density or degrading habitat for any of these species.

Recommended Monitoring Methods

The above monitoring objective will be met, in part, by the monitoring methods already discussed in this chapter for native wildlife. For those reptilian species of special interest not observed during the wildlife transects, other sources of information will be searched (wildlife sightings database, research projects, Boulder County Nature Association, Sierra Club, etc.). Annual inventory projects specifically designed for each species or groups of species with similar habitat requirements may be implemented to determine whether they continue to be present. If additional information is still not found, a memo will be written that gives plausible explanations for the failure to detect those species. Changes in land management may result.

MANAGEMENT OBJECTIVE 1.21. Maintain or increase the population density of each avian, mammalian, and reptilian wildlife species of special interest listed in Table 5.3.
Rationale: It is important to determine the population densities of these special species so changes in land management can be initiated before any special species declines further or goes extinct locally.

Monitoring objective: Detect changes in population densities of each avian, mammalian, and reptilian wildlife species of special interest in the forest by sampling in all treated and reference stands every 5 years.

> **Adaptive Management Response:** Assess Open Space/Mountain Parks land management activities, especially the burning and thinning program, to determine whether any activities could be reducing the population density of any species which appear to be declining.

Recommended Monitoring Methods

Every 5 years, estimate the population density or an index of abundance of each species. Calculations will be made from existing data, and/or other sources of information (wildlife sightings database, research projects, Breeding Bird Surveys, National Audubon Society including Christmas Bird Counts, Boulder County Nature Association, Sierra Club, etc.). Each estimate shall be within 25% of its true value with a confidence level of 90%. Specific projects for individual species of special interest may be implemented to determine their abundance on Open Space and Mountain Parks lands.

5.3.3 SNAGS (STANDING DEAD TREES)

Snags provide nesting, roosting, and denning sites for a large number of wildlife species. Primary cavity nesting birds create cavities in snags (the wood is softer and easier to drill than in live trees), and these cavities are used by secondary cavity nesting birds, small squirrels, chipmunks, and bats (e.g., maternal colonies of bats sometimes occur in bird cavities).

Jones (undated) found an average of 1.1 snags/hectare (2.47 acres) in nine Eldorado Mountain area study plots (range 0 to 5 snags/plot), although the quality of the existing snags was relatively high.

Jones (undated) makes the following recommendations:
1. Maintain snag densities of at least 10 snags/hectare, over 25 centimeters (10 inches) diameter at breast height (DBH)
2. Retain all snags containing nest cavities

3. Retain all snags over 35 centimeters (14 inches) DBH
4. Retain broken top snags over 25 centimeters (10 inches) DBH and with at least 40% bark cover
5. Create snags as necessary to provide nesting habitat for rare or endangered populations of cavity-nesting birds (see Table 5.4)

These recommendations will be adopted as a minimum effort.

MANAGEMENT OBJECTIVE 1.22. Maintain existing snags and create additional large snags. Large snags are defined here as those trees with a DBH over 25 centimeters (10 inches), total height over 6 meters (19 feet) and bark cover over 40%.
Rationale: Snags are known to have high value for wildlife, mainly as a source of nesting sites for birds. Large snags are much more valuable for wildlife than small snags.

Monitoring objective: Determine the density and sizes of snags in each treated and reference stand every 5 years.

> **Adaptive Management Response:** Reassess burning and thinning program to determine whether burning and thinning are destroying snags or are failing to create new snags. Determine whether efforts to create new large snags are successful.

Recommended Monitoring Methods

Every 5 years, estimate the density of large snags in each stand. The estimate will fall within 20% of the true density with 90% confidence level. Patchy snag distribution in forests with at least 10 snags/ hectare (2.47 acres) is recommended, as it may benefit wildlife with differing habitat requirements (Jones undated). One of the methods listed in Table 5.4 may be used to create snags, as needed.

When feasible, girdling and burning individual trees will be used to meet the desired snag density. Using additional methods may be necessary. If there are not enough large trees, nest boxes may be added until additional large snags can be created.

Table 5.4: Methods for Creating Snags (Jones undated).				
Method	**Instructions**	**Time to create**	**Time until usable**	**Comments**
Girdling	cut two parallel rings 4 to 6 inches apart with a chain saw, and then chip off the bark between the rings with a polaski	about 15 minutes/tree	rot and die slowly	may be toppled in high winds
Burning Individual Trees	pile slash 3 to 5 feet high around base of tree and ignite; scorch tree at base but leave crown intact	about 1 hour/tree	may see use within 1 year	
Injection of Heart Rot Fungus	insert hollow pine dowels infected with the fungus into drill holes in the trees at a height of 3 meters (9 feet)	time consuming	about 8 to 12 years	low success rate
Prescribed Bums	moderate intensity bum	variable	within 2 to 5 years	mimics natural processes but destroys many snags
Topping	top with a chain saw at least 10 meters (30 feet) above the ground	time consuming	variable	broken top snags are generally preferred; method is dangerous
Nest Boxes	erect nest boxes, especially for locally endangered or threatened species	variable	variable	not a long-tenn solution

5.4 Monitoring Abiotic Resources

Ecosystems are composed of both living (biotic) and nonliving (abiotic) components. Water and soils are the essential abiotic components of the ecosystem that are considered here, as they significantly influence individual plant species, as well as plant communities and their related wildlife habitat types.

5.4.1 Water

Management of the forest through thinning and prescribed fire will influence the amount of water found in riparian and wetland areas, as well as the duration of flow of streams.

MANAGEMENT OBJECTIVE 1.23. Maintain or increase the duration and volume of base flow of intermittent streams that arise on Open Space and Mountain Parks forest lands.
Rationale: Evidence from the old-growth ponderosa pine forests surrounding Cheesman Reservoir suggests that fire suppression has reduced the surface flows of intermittent streams due to the increased density of trees that transpire water. Removing trees in the uplands via fire or thinning should increase the base flow (during periods of dry weather) of intermittent streams.

Monitoring objective: Detect changes in the duration and base flow of two representative intermittent streams in the forest ecosystem by annually measuring the average base flows in those streams.

> **Adaptive Management Response:** Reassess burning and thinning program to determine whether burning and thinning are influencing the duration and volume of base flow of streams.

Recommended Monitoring Methods

Each year, determine the average base flows of intermittent streams, including Shadow and Long Canyons, with 90% confidence intervals no wider than plus 10% of the respective estimated true average base flows. Flow will be determined by establishing "gaging stations" and monitoring flows with continuous streamflow recording devices.

5.4.2 SOILS

Soils–their composition, texture, aggregation, water-holding capacity, and potential for erosion and compaction–significantly influence vegetation patterns. One of the management objectives of the Plan is to minimize impacts to grassland and forest soils that would reduce their ability to support native plant species and plant associations.

MANAGEMENT OBJECTIVE 1.24. Minimize soil erosion and compaction in treated forest stands.
Rationale: Loss of soil (especially topsoil) is usually associated with a decline in soil fertility and in total biomass of vegetation. Some species may be unable to survive a decline in soil fertility, resulting in a loss of species richness. Loss of plant species that are capable of fixing nitrogen in the soil could decrease soil fertility. Compaction of soil reduces poor spaces, reducing capacity of soil to hold water, air, and nutrients.

Monitoring objective: Determine the degree of soil erosion and compaction in treated and reference stands by measuring soil loss, soil fertility, and soil compaction in years 1, 2, 4, 7, and 10 post-treatment.

> **Adaptive Management Response:** Reassess burning and thinning program to determine whether program is effectively limiting soil erosion and soil compaction. Assess effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Mapping: Add soils data to vegetation maps. Use current information (Soil Conservation Service 1971) and work toward acquiring more detailed soils mapping of state-of-the-art quality.

Information collection/data gaps: Collect data on soil fertility (organic matter, fertility, water-holding capacity); select key sites (representative of each sub-association type, and each soil type) where this information can be collected by either staff or contractors.

Systemwide: Detect loss of soil from untreated reference stands as a baseline of comparison with treated stands.

Treated/Reference Stands: Detect loss of soil from stands in years 1, 2, 4, 7, and 10 after treatment. Compare the effects of severe, moderate, and low intensity fires on soil erosion. Detect degree of soil compaction caused by thinning and prescribed burns. Identify significant nitrogen-fixing plants and monitor changes in their frequency and cover in years 1, 2, 4, 7, and 10 after treatment. Track the implementation of best management practices to determine whether they are minimizing adverse impacts to the forest.

MANAGEMENT OBJECTIVE 1.25. Maintain soil fertility in treated forest stands.
Rationale: Soil fertility determines the productivity of vegetation. Reductions in soil fertility could decrease species richness and species cover, and could increase non-native plants that do well on infertile soils. Increases in soil fertility that can occur after fire can also increase some non-native species (e.g., knapweed and Canada thistle).

Monitoring objective: Detect changes in soil fertility by sampling nutrient levels in reference and treated areas in years 0 (baseline), 1, 2, 4, 7, and 10 post-treatment.

Adaptive Management Response: Reassess burning and thinning program to determine whether program is maintaining soil fertility. Assess effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Systemwide: Measure soil fertility in each plant subassociation as a baseline of comparison with treated stands.

Treated/Reference Stands: Detect changes in amounts of basic nutrients and availability of nutrients to plants. Detect impacts of changes on individual plant species of concern. Compare the effects of severe, moderate, and low intensity fires on soil fertility.

5.5 MONITORING WILDFIRE AND WILDFIRE MITIGATION EFFECTS

One of the overall goals of the Plan is to reduce wildfire risks to human and forest communities.

5.5.1 REDUCING WILDFIRE RISKS TO HUMAN COMMUNITIES

Management objectives that will assist in reducing wildfire risk to human communities include thinning the forest in areas where trees are overly crowded, reducing fuel loading on the forest floor, creating and improving fuel breaks near housing developments, and maintaining forest access roads.

MANAGEMENT OBJECTIVE 2.1. Thin forests to levels that reduce the risk of large-scale, uncontrollable wildfires, while meeting science-based ecosystem management goals and objectives. (See Management Objective 1.10).

Rationale: By creating better spacing between trees a fire will stay on the surface where it has a positive effect on the understory. "Dog hair" stands are jackpots of fuel that increase the intensity of a fire. They also are more damaging to the site as they tend to burn hotter and to sterilize soils.

Monitoring objective: Determine and observe changes in tree densities and forest canopy structure by sampling and photographing all established inventory plots in years 0, 1, 2, 4, 7, and 10 pre- and post treatment.

> **Adaptive Management Response:** Reassess thinning and burning program to determine whether thinning is achieving desired future condition. Assess effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Treated/Reference Stands: Photo-document treated stands in years 0, 1, 2, 4, 7, and 10. Measure canopy cover in all established inventory plots in years 0, 1, 2, 4, 7, and 10.

MANAGEMENT OBJECTIVE 2.2. Reduce fuel loading on the forest floor.

Rationale: Fire intensity is related to available fuels. By consuming or removing surface fuels (woody debris) in a controlled manner, a wildfire will not be as intense and therefore as harmful to the forest community. This can be achieved by prescribed fire, chipping (mechanically breaking up wood into smaller pieces with a portable machine), and piling and burning.

Monitoring objective: Detect changes in the fuel loading on the forest floor by measuring cover and photographing all treated stands on a schedule of years 0, 1, 2, 4, 7, and 10 pre- and post-treatment.

> **Adaptive Management Response**: Reassess burning and chipping program to determine whether reduction of forest fuel loading is achieving desired future condition. Assess effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Treated/Reference Stands: Photo-document treated stands in years 0, 1, 2, 4, 7, and 10. Measure cover of fuel on the forest floor in years 0, 1, 2, 4, 7, and 10 after treatment. Track the implementation of best management practices to determine whether they are minimizing adverse impacts to the forest.

Compare the effects of prescribed fire, chipping, and piling and burning on nutrient availability and plant succession. Develop methods and select analytical tools to compare treatment effects using cover and frequency data collected in permanent inventory plots.

MANAGEMENT OBJECTIVE 2.3. Create and improve fuel breaks in the wildland/urban interface.
Rationale: By creating an area of reduced fuels between the forest and nearby subdivisions it is possible to reduce the risk of fire moving into residential areas. It will also make it safer for the firefighters who are protecting the homes.

Monitoring objective: Determine the number, quality, and distribution of fuel breaks by photo-documenting treated stands before and after treatment in years 0, 1, 2, 4, 7, and 10.

> **Adaptive Management Response:** Reassess thinning program to determine whether program is achieving desired future condition. Assess effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Treated/Reference Stands: Map all fuel breaks in forest stands to serve as a baseline of information for treatment planning and for comparison with subsequent mapping. Establish permanent photo points to document and monitor a selection of representative fuel breaks. Take photographs at permanent points in years 0, 1, 2, 4, 7, and 10.

MANAGEMENT OBJECTIVE 2.4. Maintain existing fire access roads.
Rationale: Good access is critical to fire control. Other emergency situations will also benefit from improved access.

Monitoring objective: Determine the condition of all fire access roads in the forest by conducting an inventory and assessment every 5 years.

> **Adaptive Management Response:** Assess effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Systemwide: Conduct a baseline mapping and assessment of all fire roads, and reevaluate fire road condition every 5 years.

5.5.2 Reducing Wildfire Risks to Forest Communities

Wildfire risks to forest communities will be reduced by management objectives that call for removing some percentage of insect- and disease-damaged trees and by determining fire conditions during prescribed burns so that fire effects on vegetation and wildlife can be evaluated.

Management Objective 2.5. Selectively remove insect- and disease-damaged trees.
Rationale: These trees tend to have large amounts of dead limbs and needles that are more flammable than those on healthy trees.

Monitoring objective: Detect changes in the percentage of insect- and disease-damaged trees in treated and reference stands by re-sampling all established inventory plots every 5 years, and by photographing treated stands before treatment and on a schedule of years 1, 2, 4, 7, and 10 post-treatment.

> **Adaptive Management Response:** Reassess removal of insect and disease damaged trees to determine whether program is achieving desired future condition. Assess effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Treated/Reference Stands: Photo-document treated stands before and after treatment.

MANAGEMENT OBJECTIVE 2.6. Determine fire conditions during prescribed burns in order to track impacts of fire on biotic and abiotic resources.
Rationale: Different fire intensities (severe, moderate, low) will have different impacts on biotic and abiotic resources. Fires tend to be variable in intensity, even within small areas.

Monitoring objective: Document weather and fire behavior attributes during prescribed burns.

> **Adaptive Management Response**: Reassess prescribed fire program to determine whether program needs to be modified to reduce impacts on biotic or abiotic resources. Assess effectiveness of best management practices in minimizing adverse impacts to the forest.

Recommended Monitoring Methods

Treated/Reference Stands: During prescribed burns, measure fire intensity by following standard federal fire behavior monitoring guidelines. Determine impacts of severe, moderate, and low intensity fires on selected native and non-native plant species and on plant subassociations.

Continue annual monitoring of 1995 Lindsay/Stengel II prescribed burn to track impacts on biotic and abiotic resources; this burn will continue to provide information on plant succession after fire.

5.6 Summary of Monitoring Methods

The monitoring of treatment effects and ecosystem characteristics in Boulder's forest ecosystem is complex in design. In order to clarify the design of the monitoring program for vegetation, wildlife, soils, and hydrology, summary information is presented in Tables 5.5 and 5.6.

Several aspects of the plans for monitoring and evaluating forest ecosystem management will be completed or refined during the initial years of forest plan implementation. For example, the location and establishment of reference areas, the evaluation of sample size adequacy, and the refinement of the monitoring schedule need to be accomplished. In addition, pre-treatment stand walk throughs may reveal the need to establish additional sample points to monitor important or sensitive habitat not included in the permanent inventory plots. Methodology for the additional sampling will be selected once monitoring objectives are established. The initial years of monitoring, therefore, will serve as a pilot program during which the proposed monitoring scheme will be tested, evaluated, and refined.

Table 5.5: Summary of Vegetation, Soils, and Hydrology Monitoring Methods for the Forest Ecosystem Management Plan

NAME	DESCRIPTION	MANAGEMENT OBJECTIVES (see text for complete details
1. Cover and frequency data collection on permanent forest inventory plots	Data collected during the forest inventory (1996-1998) on 20 x 20 meter plots provides baseline data. All permanently-monumented plots (plots numbered 1, 5, 10, 15, etc.) will be revisited every 5 years system wide, and more frequently on treated and reference stands (years 1, 2, 4, 7, and 10). Tree canopy cover, using the cover-point optical device, was not recorded during the forest inventory; it will be added to the inventory methodology.	1.1 maintain/increase number of native species 1.5 control non-native species 1.7 maintain/increase plant communities 1.8 maintain/increase floristic quality 1.11 increase understory cover 1.12 maintain/increase shrubland community types 2.1 thin forests
2. Point-intercept cover data transects	50-meter transects for collecting cover data, with 100 square meter plot for collecting frequency data. Used to obtain a baseline characterization of understory plant subassociations, and will be used to monitor understory trends in cover and species composition.	1.1 maintain/increase native species 1.5 control non-native species 1.7 maintain/increase plant communities 1.8 maintain/increase floristic quality 1.11 increase understory cover 2.1 thin forests
3. Modified-Whittaker plots	20 x 50 meter plots may be established in the major plant subassociations, including treated/reference stands.	1.1 maintain/increase native species 1.5 control non-native species 1.7 maintain/increase plant communities 1.8 maintain/increase floristic quality 1.11 increase understory cover 2.1 thin forests
4. Census and/or sub-sample plant populations	Measure density and/or population size for rare plants and high priority non-native species.	1.4 maintain/increase density/populations of rare plants 1.5 control non-native species
5. Floristic quality assessment	Every 5 years calculate the floristic quality for each plant association using frequency data from the permanent inventory plots.	1.8 maintain/increase vegetation quality
6. Tree measurements	Measure average tree density and average tree height every 5 years. Measure basal area and size classes in treated and reference stands every 5 years.	1.9 Reduce density and increase size of trees 1.10 increase stand-initiation and old-growth forests; decrease stem-exclusion, closed canopy forests

Table 5.5: Summary of Vegetation, Soils, and Hydrology Monitoring Methods for the Forest Ecosystem Management Plan

NAME	DESCRIPTION	MANAGEMENT OBJECTIVES (see text for complete details
7. Stand walk throughs (pre-treatment and post-treatment) and species of special concem site visits	Stand species lists will be compiled; qualitative evaluations of vegetation and wildlife habitat; mapping of rare plants, non-natives, plant subassociations, etc.	1.1 maintain/increase native species 1.7 maintain/increase plant communities 1.8 maintain/increase floristic quality 1.2 maintain/increase existing rare plants 1.3 maintain/increase existing occurrences of rare plants 1.4 maintain/increase density/populations of rare plants 1.6 detect new non-native species
8. Photo documentation	All permanently-monumented forest inventory plots were photographed from plot center in four cardinal directions. Photo documentation will be implemented on treated and reference stands in years 1, 2, 4, 7, and 10 after treatment and system wide every 5 years on all permanent plots.	1.1 maintain/increase native species 1.2 maintain/increase existing rare plants 1.3 maintain/increase existing occurrences of rare plants 1.4 maintain/increase density/populations of rare plants 1.5 control non-native species 1.6 detect new non-native species 1.7 maintain/increase plant communities 1.9 reduce density and increase size of trees 1.10 increase stand initiation and old-growth forest and decrease stem-exclusion, closed canopy forest 1.11 increase understory cover 2.1 thin forests 2.2 reduce forest fuel loading 2.3 create and improve fuel breaks 2.4 maintain existing fire roads 2.5 remove insect and diseased trees

Table 5.5: Summary of Vegetation, Soils, and Hydrology Monitoring Methods for the Forest Ecosystem Management Plan

NAME	DESCRIPTION	MANAGEMENT OBJECTIVES (see text for complete details
9. *Mapping (including GIS)*	Vegetation types, plant subassociations and wildlife habitat maps will be continually updated to track changes across the ecosystem.	1.2 maintain/increase existing rare plants 1.3 maintain/increase existing occurrences of rare plants 1.4 maintain/increase density/populations of rare plants 1.5 control non-native species 1.6 detect new non-native species 1.7 maintain/increase plant communities 1.10 increase stand initiation and old-growth forest and decrease stem-exclusion, closed canopy forest 1.12 maintain shrubland community types 1.13 maintain areal extent of riparian areas 1.14 maintain areal extent of wetlands
10. *Trail Walks*	Non-native species will be qualitatively monitored along all trails during mid-summer.	1.6 detect new non-native species
11. *Soils: soil fertility, soil structure, soil loss, nutrient availability, and fire intensity impacts on soils*	Sample soil fertility, soil structure, soil loss, nutrient availability, and fire intensity in treated and reference stands (years 1, 2, 4, 7, and 10). Methods to be developed.	1.24 minimize soil erosion and compaction 1.25 maintain soil fertility 2.6 determine fire conditions and impacts of fire intensity
12. *Water: base flow*	Establish "gaging stations" and monitor flow with continuous streamflow recording devices in drainages in treated and reference stands.	1.23 maintain/increase duration and volume of base flow of intermittent streams
13. *Tree measurements*	Measure average tree density and average tree height every 5 years. Measure basal area and size classes in treated and reference stands every 5 years.	1.9 Reduce density and increase size of trees 1.10 increase stand-initiation and old-growth forests; decrease stem-exclusion, closed canopy forests

Table 5.6: Summary of Wildlife Monitoring Methods for the Forest Ecosystem Management Plan		
CATEGORY	**DESCRIPTION**	**MANAGEMENT OBJECTIVES**
1. Native wildlife species	Inventory started in 1998. Permanent plots will be revisited on years 1, 2, 4, 7, and 10 for small mammals (at least one plot per stand, trapping in a 5 x 5 meter grid) and birds (100 meter radius point counts at all permanent plots at least 200 meters apart). Every 5 years wildlife transects (quarterly in those years) will capture data on all wildlife (mammals, birds, herpetiles, invertebrates), and additional amphibian censusing (riparian transects) will be conducted. Every five years, determine population trends from point counts and compare to national Breeding Bird Surveys. Locate and monitor nesting/roosting sites of native wildlife species (especially species of special interest) to determine whether they continue to be used successfully.	1.15 maintain/increase native species 1.16 maintain/increase breeding birds 1.17 maintain/increase nesting and roosting sites
2. Wildlife species of special interest	For those species of special interest (see Table 5.3) not detected in the point counts, small mammal trapping, or wildlife transects, other sources of information will be searched to determine whether they continue to be present. If necessary, specific projects for individual species of special interest may then be implemented to determine their status. Every five years, estimate the population density or an index of abundance of each species of special interest. Calculations will be made from inventory data, external sources, or specific projects may be implemented.	1.18 maintain/increase avian species of special interest 1.19 maintain/increase mammalian species of special interest 1.20 maintain/increase reptilian species of special interest 1.21 maintain/increase population density of species of special interest
3. Snags	Every five years, estimate the density of large snags (dbh > 25 cm, height > 6 meters, and > 40% bark cover). Create snags as needed (preferably by girdling, burning individual trees, and topping).	1.22 maintain/create snags

5.7 Annual Monitoring Tasks

Each year of monitoring entails many tasks, which are briefly described below.

Assess Staff Needs and Resources

Staff will prepare an annual budget, as well as a budget for project needs for the next 5 years. Work plans will be written by permanent staff, seasonal staff, and volunteers. Time for all monitoring protocols, including planning, fieldwork, data entry, data analysis, report writing, staff meetings, and staff coordination, will be incorporated into work plans. Monitoring priorities will be established for the coming year. Research projects related to the forest ecosystem will be coordinated with volunteers and local schools and universities.

Report Results and Recommendations

At the end of each field season staff will prepare an annual forest monitoring program report, detailing program goals and objectives for the year, monitoring methods, and results. After data is collected each season, it will be entered into the forestry database. Results will be assessed relative to management goals and monitoring objectives and reported to staff.

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City of Boulder Open Space/Real Estate Department, Mountain Parks Division (Parks and Recreation Department), and Wildland Fire Division (Boulder Fire Department)

Dianne Andrews, Natural Resource Specialist (Open Space)--understory methodology, data collection, inventory analysis, and monitoring.

Steve Armstead, Ranger/Naturalist (Mountain Parks)--wildlife and understory data collection.

Ann Armstrong, Plant Ecologist (Mountain Parks)--coordination of vegetation inventory methods, data collection, and data analysis for Mountain Parks.

John Armstrong, GIS Staff (Mountain Parks)--maps and data analysis.

Matt Claussen, Ranger/Naturalist (Mountain Parks)--Global Positioning System and understory inventory.

Chip Clouse, Natural Resource Specialist (formerly with Open Space, Mountain Parks)--overstory methodology, data collection, and data analysis; wildlife data collection for Open Space.

Brandy Collins, Natural Resource Specialist (formerly with Open Space, Mountain Parks)-- overstory data collection.

Don D'Amico, Natural Resource Planner (Open Space)--project manager and coordinator of Forest Ecosystem Management Plan for Open Space.

Justin Dombrowski, Wildland Fire Management Officer (Boulder Fire Department)--review of fire management sections of the Plan.

Ann FitzSimmons, Administrative Assistant (Open Space)--editing and formatting Plan documents.

Mark Gershman, Natural Resource Planner (formerly with Open Space)--original project manager and coordinator of Forest Ecosystem Management Plan for Open Space.

Todd Kipfer, Technical Research Assistant (Open Space)--maps, data development.

Leda Kobziar, Natural Resource Specialist (formerly with Open Space, Mountain Parks)--overstory data collection.

Dave Kuntz, Planning Supervisor (Open Space)--planning context, coordination with administrative staff and Open Space Board of Trustees, integrating project into Open Space Program's work schedule.

Dick Lyman, Coordinator of Field Operations (Mountain Parks)--wildfire and forest insects.

Joe Mantione, Environmental Planner (Mountain Parks)--coordination of landscape analysis, forest ecosystem planning and management for Mountain Parks.

Maria Mayer, Ranger/Naturalist (Mountain Parks)--understory data collection.

Rod Moraga, Forest Ecologist (Open Space)--overstory inventory methods and data analysis for Open Space, development of forest prescriptions for Open Space.

Gary Norton, Natural Resource Specialist (formerly with Open Space)--understory inventory methodology and data collection.

Ellen O'Callaghan, Natural Resource Specialist (Mountain Parks)--understory data collection and analysis.

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Bryan Pritchett, Natural Resources Supervisor (Open Space)--coordination of Forest Ecosystem Management Plan within the Resource Conservation Division; wildlife analysis.

Lynn Riedel, Plant Ecologist (Open Space)--coordination of understory vegetation inventory methodology and analysis for Open Space.

Ann Roberts, Education/Outreach Specialist (formerly with Open Space)--education and outreach, overstory methodology and data collection.

Anne Ruggles, Ranger/Naturalist (formerly with Mountain Parks)--understory data collection.

Colleen Scanlan-Lyons, Resource Planner (Open Space)--coordination of public process for the Forest Ecosystem Management Plan for Open Space.

Jeanne Scholl, Coordinator of Ranger Services (Mountain Parks)--natural resources management and supervision.

Kjerstin Skov, Natural Resource Specialist (formerly with Open Space, Mountain Parks)--overstory data collection.

Peter Smith, Natural Resource Specialist (Mountain Parks)--data analysis for Mountain Parks.

Burton Stoner, Ranger/Naturalist (Mountain Parks)--project manager for Mountain Parks forest inventory.

Lynne Sullivan, Ranger/Naturalist (Mountain Parks)--understory data collection.

David Sutherland, Natural Resource Specialist (Mountain Parks)--coordination of public process for the Forest Ecosystem Management Plan for Mountain Parks.

Greg Toll, Wildland Fire Mitigation Supervisor (Boulder Fire Department)--coordination of prescribed fires on City of Boulder lands.

Kerri Vierling, Wildlife Biologist (formerly with Open Space--wildlife methodology, inventory, and data analysis.

Kelly Walsh, Ranger Naturalist (Mountain Parks)--understory data collection.

Ann Wichmann, Park Manager (Mountain Parks)--administration of Forest Ecosystem Management Plan for Mountain Parks.

Contract Consultants

Peter Brown, Rocky Mountain Tree-Ring Research, Inc., Ft. Collins, Colorado (Open Space and Mountain Parks)--assistance with development of the Forest Ecosystem Management Plan.

Alan Carpenter, Land Stewardship Consulting, Boulder, Colorado (Open Space and Mountain Parks)--assistance with development of the Forest Ecosystem Management Plan.

Cam Marshall, Marshall Information Service, Boulder, Colorado (Open Space)--development of forest inventory database.

Pat Murphy, Ecotone Corporation, Boulder, Colorado (Open Space and Mountain Parks)--assistance with developing inventory methods; plant community analysis.

Doug Stevenson, Colorado State Forest Service (Mountain Parks)–overstory data collection.

Other Inventory Contributors

Tom Andrews, Plant Ecologist (U.S. Forest Service)--assistance with developing Open Space understory inventory methods.

Dave Buckner, Plant Ecologist (Consultant)--assistance with developing Open Space inventory methods.

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Nancy Neupert, Botanist (Open Space)–data collection, plant identification, data entry, and editing of Biota Table.

Randy Pair, Volunteer--overstory data collection and mapping for Mountain Parks.

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GLOSSARY

Abiotic: Non-living component of an ecosystem, such as climate.

Adaptive management: A process for implementing management decisions that requires monitoring of management actions and adjustment of decisions based on past and present knowledge. 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.

Age class: An age grouping of trees according to an interval of years, usually 20 years. A single age class would have trees that are within 20 years of the same age, such as 1 to 20 years or 21 to 40 years.

Aspect: The direction a slope faces.

Basal area (or tree basal area): The cross sectional area of a tree, measured at breast height (4.5 feet above the ground) by use of a wedge prism or calculated from the diameter. Often used to describe the collective basal area of trees, expressed in either square feet/acre or square meters/hectare.

Basal area increment (BAI): Increase in tree basal area during a specified period, usually over 1 year or 10 years. BAI may be calculated on a per-tree or per-acre or hectare basis.

Best Management Practices (BMPs): Resource management practices that are designed to prevent or reduce undesirable side-effects of implementation of management actions.

Biogeochemical cycles: The dynamics of nutrient and carbon flows and pools between biotic and abiotic elements in an ecosystem. Pools and flows between them include biotic, geological, atmospheric, oceanic, and/or cryotic components.

Biological diversity (Biodiversity): The number and abundance of species found within a common environment. Includes the variety in genes, species, and ecosystems, and the ecological processes that connect everything within a common environment.

Biomass: The amount and type of organic matter that is contained within a given area; the total weight of all living organisms in a biological community.

Biotic: Living components of ecosystems.

Cambium: Layer of growing cells underneath tree bark.

Canopy (tree canopy, forest canopy): The part of any stand of trees represented by the tree crowns. It usually refers to the uppermost layer of foliage, but it can be used to describe lower layers in a multi-storied forest.

Catastrophic wildfire: An especially intense and widespread fire that usually, but not always, occurs in forests that are outside the historical range of variability in terms of forest structure and forest fuels due to fire suppression.

Coarse filter management: Land management that addresses the needs of all associated species, communities, environments, and ecological processes in a land area (see fine filter management).

Coarse woody debris: Woody biomass that consists of snags (standing dead trees), logs, and larger diameter branches (≥2.5 cm) on the forest floor.

Corridor: Elements of the landscape that connect similar areas, such as a riparian area connecting meadows.

Cover: In vegetation science, the vertical projection of vegetation from the ground as viewed from above. The percentage of the ground obscured by vegetation is canopy (or aerial) cover. Basal cover is the percentage of the ground covered by the base or trunk of the plant.

Crown fire: A fire that burns in the forest canopy. "Passive" crown fires are those that are supported by surface fires with occasional burning of overstory trees, while "active" crown fires are those that burn through overstory trees with no associated surface fire.

Dendrochronology: The science of dating tree rings. Dendrochronology relies upon cross dating, the process of cross-matching in-common patterns of variability in ring features that are controlled by climate variability to discover calender dates for individual growth rings.

Desired future condition: A desired state for an ecosystem or ecosystem component that is based on its relationship with other interacting components. Usually implies a long-term goal for management.

Diameter at breast height (DBH): Tree diameter at a standard height of 4.5 ft (1.37 meters) above the ground surface on the uphill side of the tree.

Disjunct: Species that occur in two or more widely separated geographic areas.

Disturbance: A discrete event or process, either natural or human induced, that causes a change in the existing conditions of an ecological system. As used here, disturbances are primarily internal to an ecosystem, established by and influencing principally local ecosystem components (e.g., fire, pathogen outbreaks). Contrast this usage with perturbation, which is an event or process that affects biotic components but that originates outside of the system (e.g., land use changes).

Disturbance regime: The temporal and spatial patterns of disturbance characteristic of a particular place. Disturbances that affect montane forests include natural disturbances, like fire and insect outbreaks, and human disturbances, like fire suppression and livestock grazing. Characteristics of disturbance regimes include the size of an area impacted by a disturbance, disturbance frequency, season of disturbance, and disturbance magnitude or severity.

Dog-hair stands: Dense stands of small-diameter trees generally found in forests where naturally-occurring fires have been suppressed.

Driving factor: Independent variables that influence ecosystem functions but that originate outside of the ecosystem itself. Jenny (1961) recognized at least six principal driving factors (or state factors) of ecosystem behavior: climate, parent material, topography, regional species availability, humans, and time.

Duff: Tree and understory plant leaves that constitute forest floor litter and detritus. Duff includes all soil organic horizons from undecomposed litter to very decomposed organic matter on top of mineral soil.

Ecosystem: The dynamic complex of organisms and their environment contained within a specified area during a specified time. Systemic elements include interactions and feedbacks between components. Note that all ecosystems are open systems, with energy flows and material cycles to and from the system. Hence, spatial and temporal scales of ecosystems must be defined for analysis or management.

Ecosystem function: The processes by which the biotic and abiotic components of an ecosystem interact and change through time and space, such as succession, the food chain, fire, weather, and the hydrologic cycle. The term ecosystem function is often used in reference to the specific contribution of an ecosystem component to system behavior.

Ecosystem health: A condition in which an ecosystem has the capacity for renewal, for recovery from a wide range of perturbations, and for retention of ecosystem resiliency.

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

Ecosystem patterns: The arrangement of ecosystem components across space and through time.

Ecosystem processes (Ecological processes): The actions or events that link organisms (including humans) and their environment, such as disturbance, successional development, nutrient cycling, productivity, and decay. The mechanisms by which ecosystem components interact and change across space and through time.

Ecosystem resilience: The ability for an ecosystem to restore or maintain biodiversity, ecosystem functions, and ecological structure and processes after a perturbation. Ecosystem resilience implies a return to some stable trajectory or stable rate or type of system *dynamics* after system perturbation.

Ecosystem structure: The living and nonliving elements of an ecosystem and their spatial arrangement.

Ecosystem sustainability (Ecological sustainability): The ability to sustain diversity, productivity, resilience to stress, health, renewability, and/or yield of desired values, resource uses, products, or services from an ecosystem, while maintaining the integrity of the ecosystem over time.

Ecotone: The transition zone between two biotic communities, such as between a ponderosa pine forest and a grassland.

Ephemeral streams: Streams that flow only as the direct result of rainfall or snowmelt. They have no permanent flow.

Endangered species: A plant or animal that is in danger of extinction throughout all or a significant portion of its range. Endangered species are identified by the Secretary of the Interior in accordance with the Endangered Species Act of 1973.

Endemic: Refers to plants or animals that occur naturally in a certain region and whose distribution is relatively limited geographically.

Feedback: An interaction between ecosystem components in which variability in or amount of one component is influenced by the effect that it has on another ecosystem component. Feedback interactions may be positive (variability or amount of the first component is increased by the interaction) or negative (variability or amount is decreased by the interaction).

Fine filter management: Management that focuses on the welfare of a single or only a few species rather than the broader habitat or ecosystem (see coarse filter management).

Firebreak: A natural or constructed discontinuity that is utilized to segregate, stop, and control the spread of fire or to provide a control line from which to suppress a fire.

Fire intensity: The rate of heat release/unit time/length of 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 intensity accounts for the convective heat that move up from the surface and determines fire effects on the overstory.

Fire interval: The average time between fires in a given area.

Fire regime: The complex of temporal and spatial patterns of fires that occur over specified periods for a given area. Parameters of fire regimes include fire frequency, the amount of area burned, season of fire occurrences, fire intensity, fire predictability, and relations with driving factors, such as climate and human activities.

Fire scars: Fire scars result when surface fire kills a portion of a tree's growing circumference, forming a characteristic lesion visible in the tree rings.

Fire severity: The amount of conductive and radiant heat that goes down. Fire severity depends on the moisture content of the duff and the amount of fuel on the forest floor. Indicators of fire severity are the amount of duff consumption and the depth of char. Fire severeness largely determines fire effects on the understory.

Fire suppression: A coordinated effort to control or put out a fire. Also, a resource management policy initiated in the early 1900s by the U.S. Forest Service after widespread, naturally-occurring wildfires burned hundreds of thousands of acres of public forest lands. Subsequently, this policy was adapted by many other land management agencies. This policy, which was initiated in order 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 and as catastrophic wildfires have increased in frequency. Prescribed fire and allowing natural fires to burn when conditions are suitable are now widely-used management methods.

Forb: A broadleaf plant that has little or no woody material in it.

Forest floor: The surface and ground layer beneath the forest canopy.

Forest health: A measure of the robustness of forest ecosystems. Aspects of forest health include biological diversity, natural disturbances, and the capacity of the forest to provide a sustainable flow of goods and services.

Forest savanna: An open grassland forest with scattered trees; often forms a broad ecotone between true grassland and true forest.

Forest Stand: A group of trees that occupies a specific area and is similar in species, age, and condition.

Fragmentation: In landscape analysis the loss of continuity in either space or time. The splitting or isolating of patches of similar habitat, typically forest cover, but including other types of habitat. Habitat can be fragmented naturally and by certain types of management and land use.

Frequency: In vegetation science, the percentage of plots occupied by a given species.

Fuelbreak: A wide strip or block of land on which the native or preexisting vegetation has been permanently modified so that fires burning into it can be more readily extinguished.

Fuel loads: The ovendry weight of fuels in a given area, usually expressed in tons/acre.

Fuels: Plants and woody vegetation, both living and dead, that are capable of burning.

GIS (geographic information systems): GIS is both a database designed to handle geographic data, as well as a set of computer operations that can be used to analyze the data.

Ground fire: Fire that burns in fuels on the forest floor, such as litter, grasses and other nonwoody plants, as well as organic material in the soil layer. Propagates largely by creeping along the ground.

Ground litter: The top layer of the forest floor composed of loose debris (dead branches and twigs and recently fallen leaves or needles) little altered by decomposition.

Habitat: The area where a plant or anima lives and grows under natural conditions.

Healthy ecosystem: An ecosystem in which structure and functions allow the maintenance of the desired conditions of biological diversity, biotic integrity, and ecological processes over time.

Herbivory: Refers to animals that feed on plants and the impacts on this activity on the environment.

Heterogeneity: In landscape analysis refers to diversity in the composition, size, shape, and arrangement in time and space that characterize landscape structures and dynamics. See "homogeneity".

Historical conditions (range of historical variation): Range of the spatial, structural, compositional, and temporal characteristics of ecosystem elements during a period specified to represent "natural" conditions.

Historical range of variability (HRV): A means to define the boundaries of ecosystem behavior and patterns that have remained relatively consistent over long periods. HRV is usually defined for centuries to millennia before the period of widespread human population increase and associated ecosystem changes that began in roughly the early to middle 1800s for many regions of western North America.

Holistic: The integration of components of an ecosystem in some scale of ecological inquiry. In a holistic perspective, one ecosystem component cannot be isolated without reference to how it affects and is affected by other components in the system.

Homogeneity: In landscape analysis, refers to a lack of diversity in the composition, size, shape, and arrangement in time and space that characterize landscape structures and dynamics . See "heterogeneity".

Hydrological regimes: The spatial and temporal dynamics of water flow and associated fluvial processes in an ecosystem.

Hydrology: Science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

Indicator species: A species, the presence or absence of which is indicative of a particular habitat, community, or set of environmental conditions.

Ladder fuels: Vegetation, located below the crown level of forest trees, that can carry fire from the forest floor to tree crowns. Ladder fuels may be low-growing tree branches, shrubs, or smaller trees. Fire can move from surface fuels by convection into the crowns with relative ease.

Landscape: A generally heterogeneous composition of multiple land units that may contain multiple interacting ecosystems. Landscapes are usually defined for large areas, typically from 1000 to 100,000 hectares in size.

Litter (forest litter): The freshly fallen on only slightly decomposed plant material on the forest floor. This layer includes foliage, bark fragments, twigs, flowers, and fruit.

Logger's choice: Also called high-grading. The selective harvesting of the largest, most commercially valuable trees in a stand.

Lopping and scattering: Cutting branches, topes, and small trees after felling into lengths such that resultant slash will eventually lie close to the ground. Spreading the slash more or less evenly over the ground.

Management prescription: Management actions and treatments that are implemented under specific environmental conditions to achieve specific desired results.

Matrix: The vegetation type that is most continuous over a landscape.

Mineral soil: Soil that consists mainly of inorganic material, such as weathered rock, rather than organic matter.

Monitoring: The periodic evaluation of management activities to determine how well objectives are being met and whether management practices should be adjusted. See "adaptive management."

Mosaic: In landscape analysis refers to areas with a variety of plant communities, such as trees, shrublands, and meadows.

Native species: Plant and animal species that naturally occur in a specific area. Also known as indigenous species.

Natural disturbance: Periodic impact of natural events such as fire, severe drought, insect or disease attack, or wind.

Natural environment: The complex of biotic and abiotic factors that acts on an organism or a community in the absence of significant human intervention.

Non-Native American settlement: Extensive and widespread settlement in the western U.S. that began in response to the Homestead Act and other legislation that promoted migration to western lands in the middle to late nineteenth century. Often referred to as Euro-American settlement, but also included large numbers of African-Americans after the Civil War, Asian-Americans from the West Coast, and Hispanic-Americans from the New World.

Non-native species: Also called alien, invasive, and weed species, these species have been introduced, by various means, into areas where they were not originally found.

Nutrient cycling: The transformation of chemical elements from inorganic form in the environment to organic form in organisms and via decomposition back to inorganic form.

Old growth forests: Old forests which often contain several canopy layers, variety in tree sizes and species, decadent old trees, and standing and fallen dead woody material.

Organic soil: Soil at least partly derived from living matter, such as decayed plant material. See "mineral soil".

Overstory: The upper tree canopy layer; the plants below comprise the understory. Tree species and their structural patterns in a forest.

Patch: In landscape analysis an area of vegetation with homogeneous structure and composition.

Patch cut: Silvicultural method where all trees in a localized area are harvested. Patch size varies depending upon the forest type and management goals but is typically 1 to 100 hectares in scale.

Perimeter: The exterior boundary of a fire area.

Perturbation: An event or shift in ecosystem properties that causes major disruption to or mortality of ecosystem components. Perturbation as used in this report is similar to the use of disturbance in other descriptions of ecosystem management plans. However, *disturbance* as used in this report refers to processes that are endemic to the system itself (e.g., fire), while *perturbation* implies that the event originates outside of the system (e.g., climate change).

Plant communities: Assemblages of plants that grow together in space and time and are usually tied to environmental features, such as elevation, slope, and soils.

PM10 standards: Standards set by the U.S. Environmental Protection Agency to control the amount of particulate matter in the atmosphere that is less than or equal to 10 micrometers in diameter.

Point intercept: In vegetation science, a method for measuring plant cover. Cover is measured based on the number of "hits" on the target species out of the total number of points measured.

Prescribed fire: Management-ignited fire that is set and allowed to burn under prescribed weather and fuel conditions.

Prescribed natural fire: Naturally-ignited wildfire that is allowed to burn under prescribed weather and fuel conditions in prescribed management areas.

Prescribed thinning: The use of mechanical treatments to remove trees from forest stands.

Productivity: The amount of biomass produced in an ecosystem or specific subsystems of an ecosystem (e.g., understory productivity) over a given period.

Q-curves: The ratio of one size class in a distribution of tree diameters to the next smallest tree diameter size class.

Raptor: A bird of prey, such as an eagle or hawk.

Reference conditions: Conditions characterizing ecosystem composition, structure, and function and their variability.

Regeneration: The renewal of a tree crop by either natural or artificial means. The term is also used to refer to the young crop itself.

Resilience: The ability of an ecosystem to restore or maintain biodiversity, ecosystem functions, and ecological structure and processes after a perturbation.

Restoration: The process of returning ecosystem patterns or processes to an historical range of variability or other defined reference condition.

Riparian areas: Areas along streams and rivers, including related plant and animal communities.

Roosting site: A place where avian species or bats spend the night.

Sampling: Measuring a subset of a population; the subset data is used to estimate values for the entire population.

Sapling: a young tree, usually not over 4 inches in diameter at breast height.

Seedlings: A young plant; a tree smaller than a sapling.

Seed tree cut: Removal of the mature timber crop from an area in one cut, except for a certain number of trees left singly, in small groups, or in narrow strips, as a source of seed for natural regeneration.

Sensitive species: Plant or animal species which are more vulnerable to habitat changes or impacts from various kinds of disturbance.

Silviculture: The art and science that promotes the growth of single trees and the forest as a biological unit.

Size class: One of the three intervals of tree stem diameters used to classify timber. The size classes are: seedling/sapling (less than 5 inches in diameter), pole timber (5 to 7 inches in diameter), and saw timber (greater than 7 inches in diameter).

Snags: Standing dead trees which provide important wildlife habitat, especially for cavity-nesting birds.

Species of special interest: Native and non-native species of plants and animals (e.g., rare and threatened species; invasive weeds) that require special management and monitoring actions.

Stand (or forest stand): A group of trees that occupies a specific area and is similar in species, age, and condition.

Stocking level: The number of trees in an area as compared to the desirable number of trees for best growth and management.

Structure: How the parts of ecosystems are arranged, both horizontally and vertically. Structure usually reflects a pattern or mosaic of vegetation types.

Succession: A compositional change in an ecosystem as the available organisms modify and respond to changes in the environment, resulting in changes in the dominant plant and animal species and communities.

Surface fire: Fire that spreads through ground fuels with a flaming front.

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

Sustainable ecosystem: An ecosystem with a balance of processes and components that promote ecosystem resilience and permit the ecosystem to persist into the future in a functional and productive manner.

Thinning: Use of mechanical treatments to remove tree biomass from forest stands.

Thinning from below: Removal of all trees from a stand below a certain diameter to favor larger trees in the stand.

Understory: The lower vegetation layers in a forest found beneath the forest canopy, including shrubs, grasses and grass-like plants, and forbs.

Uneven-aged tree selection: Forest stands created or maintained that include three or more distinctly different age classes.

Urban/wildland interface: That line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland.

Wildfire: A fire occurring on wildland that has been started by natural agents like lightning.

Wildlife: Native animal species as well as native animal communities.

Wildlife habitat: The place or type of site where a plant or animal naturally or normally lives and grows.

Wildlife habitat diversity: The distribution and abundance of different plant and animal communities and species within a specific area.

Windthrow: Trees uprooted by wind.

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APPENDICES

APPENDIX 1.1: PLANNING CONTEXT

Lands owned and/or managed by the City of Boulder Open Space Department and the Mountain Parks Division of the Parks and Recreation Department overlap many jurisdictions. Although owned by the City of Boulder and subject to the City's charter, code and comprehensive plan, much of the City-owned forested land lies outside of the city limits. Boulder County and the City have both adopted documents which include specific language that addresses environmental protection and preservation. These documents include goals and policies which guide the management of natural resources in the Boulder Valley. This Plan has been drafted to be as consistent as possible with City and County land use documents and attempts to balance competing values when governing policies conflict.

Specific policy guidance that governs this Plan is provided in the *Boulder County Comprehensive Plan* (Boulder County 1997), *Boulder Valley Comprehensive Plan* (City of Boulder 1996), City of Boulder Charter and *Open Space Long Range Management Policies* (City of Boulder 1995).

BOULDER COUNTY COMPREHENSIVE PLAN

The *Boulder County Comprehensive Plan* was first adopted in 1978 and has been reviewed and updated many times since then. The following selected goals are the most relevant to management of forests on City lands (Boulder County 1997).

Environmental Management

B.1 Unique or distinctive natural features and ecosystems and cultural features and sites should be conserved and preserved in recognition of the irreplaceable character of such resources and their importance to the quality of life in Boulder County. Natural resources should be managed in a manner which is consistent with sound conservation practices and ecological principles.

B.3 Critical wildlife habitats should be conserved and preserved in order to avoid the depletion of wildlife and to perpetuate and encourage a diversity of species in the County.

B.4 Significant natural communities including significant riparian communities) and rare plant sites should be conserved and preserved to retain living examples of natural ecosystems, furnish a baseline of ecological processes and function, and enhance and maintain the biodiversity of the region.

B.6 Unique or critical environmental resources identified pursuant to Goals B.1, B.3, B.4 and B.5 shall be conserved and preserved in a manner which assures their protection from adverse impacts, with the private sector, non-county agencies, and other governmental jurisdictions being encouraged to participate.

B.8 Environmental Conservation Areas (ECAs) should be conserved and preserved in order to perpetuate those species, biological communities, and ecological processes that function over large geographic areas and require a high degree of naturalness.

A set of implementation policies accompanies the *Boulder County Comprehensive Plan* goals. Most of the policies instruct the Boulder County government to take various actions. Several of the policies involve municipalities, but usually only to direct the County to offer them technical assistance as appropriate. The following policy statements from the *Boulder County Comprehensive Plan* provide relevant direction to the City of Boulder for the management of forested ecosystems:

Environmental Resources

Environmental Conservation Areas

ER 8.01 The County shall encourage the removal of development rights from Environmental Conservation Areas through transfer, donation, acquisition or trade.

ER 8.02 Development within Environmental Conservation Areas shall be located and designed to minimize impacts on the flora and fauna of the area.

ER 8.03 Development outside of Environmental Conservation Areas shall be located and designed to minimize impacts on Environmental Conservation Areas and connectivity between Environmental Conservation Areas.

ER 8.04 The County will encourage and participate with the various public and private owners in the development of coordinated management plans to conserve, protect or restore the values of Environmental Conservation Areas.

ER 8.05 Management of Environmental Conservation Areas shall encourage use or mimicry of natural processes, maintenance or reintroduction of native species, restoration of degraded plant communities, elimination of undesirable exotic species, minimizing human impacts, and development of long-term ecological monitoring programs.

ER 8.06 The County will work towards protecting critical elk range and migration routes through reducing development potential and by working with landowners and management agencies to minimize human disturbance and provide seasonal habitat needs.

ER 8.07 The County will work with appropriate management agencies and property owners to protect or restore riparian areas.

ER 8.08 The County shall work toward minimizing human impacts to riparian ecosystems from development, roads, and trails.

ER 8.09 The County will work with appropriate entities to ensure suitable minimum and maximum stream flows that maintain channel morphology, support hydrologically connected wetlands, and perpetuate species, both plant and animal, dependent on riparian ecosystems.

ER 8.10 Land use proposals which could have adverse impacts to riparian ecosystems must submit a report and site plan detailing such impacts. Although examined on a case-by-case basis, the County will encourage avoidance of riparian ecosystems. Where impacts are unavoidable, the County shall require appropriate mitigation.

ER 8.11 Management of riparian areas shall encourage use or mimicry of natural processes, maintenance or reintroduction of native species, restoration of degraded plant communities, elimination of undesirable exotic species, minimizing human impacts, and development of long-term ecological monitoring programs.

Open Space Policies

Resource Management

OS 2.01 The County shall identify and work to assure the preservation of Environmental Conservation Areas, critical wildlife habitats and corridors, Natural Areas, Natural Landmarks, significant areas identified in the Boulder Valley Natural Ecosystems Map, historic and archaeological sites, and significant agricultural land.

While these policies are not directed specifically at the City of Boulder, the management of City-owned land has significant implications for the ability of the County to achieve these goals. It is intended that this Plan will be consistent with the environmental preservation goals and implementation policies of the *Boulder County Comprehensive Plan.*

BOULDER VALLEY COMPREHENSIVE PLAN

Coordination of comprehensive planning issues between the City and County is articulated in the *Boulder Valley Comprehensive Plan* (City of Boulder 1996). The Boulder Valley is a Community Service Area within Boulder County where the City and County have agreed upon a set of land use and management policies to implement their joint planning objectives.

Like the *Boulder County Comprehensive Plan*, the *Boulder Valley Comprehensive Plan* has in the past concentrated upon general direction to protect isolated patches of special habitat. The recent (1996) revisions include increased emphasis upon:

- the maintenance of ecological processes
- the preservation of connections and buffers associated with important natural ecosystems
- regional outreach and environmental education, and
- programs for monitoring and evaluation

The following selected policies are most relevant to the City of Boulder's management of forest ecosystems.

4.06 Natural Ecosystems.
The City and the County shall protect and restore significant ecosystems and habitats for native plant and animal species on public and private lands through acquisition, land use planning, development review, and public land management practices. Promotion of biological diversity and protection of endangered species and their associated habitat will be emphasized. Degraded habitat may be restored and selected extirpated species may be reintroduced as a means of enhancing native flora and fauna in the Boulder Valley. Natural areas (as designated in the Boulder County Comprehensive Plan) that are within the Boulder Valley, shall be managed in a manner that is consistent with the Natural Area Goals and Policies of the Boulder County Comprehensive Plan.

4.07 Ecosystem Connections and Buffers.
The City and the County recognize the biological importance of preserving large areas of unfragmented habitat. The City and County will work together to preserve, enhance, and restore undeveloped lands critical for providing ecosystem connections and buffers for joining significant ecosystems. These areas are important for sustaining biological diversity and viable habitats for native species and for minimizing impacts from developed lands.

4.08 Maintain and Restore Ecological Processes.
Recognizing that ecological change is an integral part of the functioning of natural systems, the City and the County shall work to ensure that, when appropriate precautions have been taken for human safety and welfare, natural processes will be utilized or mimicked to sustain, protect, and enhance native ecosystems.

4.18 Wildfire Protection and Management.
The City and the County will require on-site and off-site measures to guard against the danger of fire in developments adjacent to forests or grasslands. Recognizing that fire is a widely accepted means of managing ecosystems, the City and the County will integrate ecosystem management principles with wildfire hazard mitigation planning and urban design.

4.33 Resource Planning.
The City and the County shall seek to incorporate short- and long-term environmental costs into resource planning decisions, to maximize the efficiency of resource use in the Boulder Valley and to encourage the use of renewable resources.

4.43 Integrated Pest Management.
The City and the County shall encourage efforts, both public and private, to reduce the use of chemical herbicides, pesticides, and fungicides. In its own practices, the City commits to use of integrated pest management, which emphasizes the selection of the most environmentally-sound approach to pest management, with the overall goal of reducing, and where possible eliminating, the dependence on chemical pest control strategies.

City of Boulder Charter - Open Space Goals

Open space planning and management are guided by the purposes of Open Space contained in the City Charter. The City Charter lists the following purposes of Open Space which are most relevant to this plan.

- Preservation or restoration of natural areas characterized by or including terrain, geologic formations, flora, or fauna that is unusual, spectacular, historically important, scientifically valuable, or unique, or that represent outstanding or rare examples of native species;

- Preservation of water resources in their natural or traditional state, scenic areas or vistas, wildlife habitats, or fragile ecosystems;

- Preservation of land for its aesthetic or passive recreational value and its contribution to the quality of life of the community.

Open Space Long-Range Management Policies

In March of 1995, the City Council approved the *Long Range Management Policies* for the Open Space Department. These policies emphasize a broad approach to natural resource management and direct staff to consider plant and animal communities, the processes which sustain them, and the mosaic of habitats associated with any ecosystem type.

Ecosystem Approach
Natural resources shall be managed to maintain fundamental ecological processes, as well as for individual species and features. Open Space resource managers ordinarily will not focus on the preservation of individual species, except threatened or endangered species, or individual natural processes; rather, managers will attempt to balance all the elements and processes of naturally evolving ecosystems, including the natural abundance, diversity, and ecological integrity of the plants and animals.

Interdisciplinary Planning
An interdisciplinary team of Open Space personnel will develop and periodically update resource management plans. In these plans the staff will identify, define, and recommend implementation techniques to accomplish the monitoring, inventory, research, mitigation, and enforcement actions required to protect Open Space natural resources and natural processes, achieve the Open Space program goals, and regulate Open Space use.

Landscapes and Plants
The Department will seek to perpetuate native plants as part of natural ecosystems. Landscapes and plants may be manipulated only when necessary to accomplish approved management goals. Landscapes and plants may be manipulated to maintain habitat for native plants with preference given to threatened or endangered species. Manipulation of existing plants will be carried out in a manner designed to restore or enhance the functioning of the native plant and animal communities.

Fire Management
Fire is a natural process which can be used as a tool to achieve land management goals by approximating natural processes. Open Space fire management programs will be designed around resource management and community objectives subject to the limitations of equipment, personnel, and safety considerations.

Division of Mountain Parks Mission Statement

The mission of the Mountain Parks Division is to ensure the long-term protection of the Park's natural resources and functions while providing for appropriate visitor access for education, enjoyment, and low-impact recreational opportunities consistent with resource protection goals.

The goals of the Division of Mountain Parks which pertain most directly to the Forest Ecosystem Management Plan are:

Develop and implement a management system which recognizes the constantly changing balance between increasing human use and finite resources. Develop a zone management plan which minimizes habitat fragmentation and maximizes the biodiversity and genetic integrity of ecosystems.

Promote a thorough understanding of the Mountain Parks and resource issues through appropriate biological and sociological studies and cooperative involvement in community affairs.

REFERENCES

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Appendix 1.2: Management Prescriptions for Open Space Forest Stands

This appendix provides management prescriptions for Open Space stands along the wildland/urban interface. Each prescription includes a management objective specific to that stand, as well as a description of the treatment recommendation and special considerations that must be evaluated prior to implementation. Special considerations include wildlife habitat, recreational use, soils, slope, visibility, understory vegetation, smoke management, and access. Each of these parameters will be evaluated more fully during pre-treatment surveys by City staff.

Group I stands require thinning to reduce fuel loads in the stands and provide for safer conditions prior to the reintroduction of prescribed fire. Each prescription shows basal area (BA) for the stand, as well as tree densities by size classes as they currently exist and also after thinning. The corresponding bar graph summarizes the data and shows the thinning levels by size class; all trees above the horizontal line are proposed to be removed.

Each prescription also displays a computer generated visualization of what the stand looks like before thinning and generally what it will look like after thinning. Oblique, overhead, and horizontal perspectives are provided.

Group II stands are amenable to the reintroduction of prescribed fire without significant thinning beforehand. These stands generally have larger, more widely spaced trees with few ladder fuels. The same general information is provided for these stands. However, because it is not possible to predict exact mortality by size class when conducting prescribed burns, post-treatment data are not provided. Except for occasional torching of a small number of medium to large trees, seedling and saplings, fire will remain in the understory.

Group I Forest Stands

These stands require thinning to reduce fuel loads and provide for safer conditions prior to the reintroduction of prescribed fire.

Eldorado-C (ELDO-C) Acres: 5.0

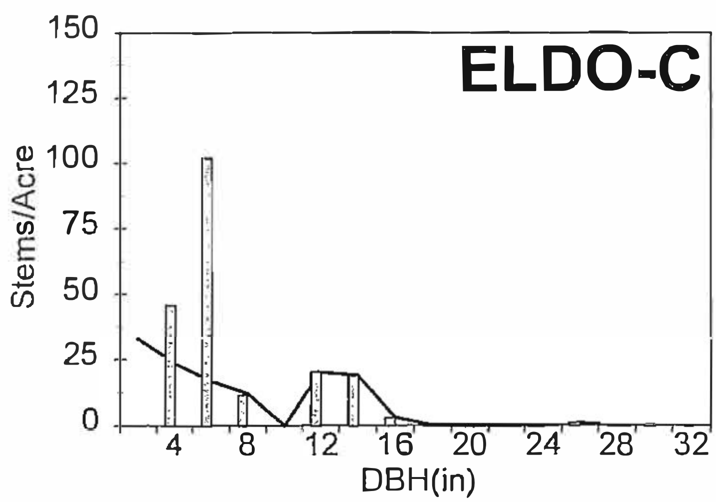
Specific Stand Objectives: Thin trees in 4" to 6" size classes to reduce BA and trees/ac; maintain open conditions and restore ecosystem processes with prescribed fires

Treatment Recommendations: Thin from 88-53 BA. Large numbers of trees in 4" and 6" size classes will need to be reduced from this otherwise open stand on the south side of El Dorado Canyon. Most of the trees in these size classes are Douglas-fir that should be selectively removed during thinning. This stand and ELDO-E are the most open units in the Eldorado Canyon area. ELDO-C has a large number of trees in larger size classes and continue to develop into healthy climax stage once the unit is opened by thinning and prescribed fires. Episodic prescribed fires will be used to maintain open conditions in the future.

Special Considerations:
Native vegetation: An understory vegetation inventory needs to be completed for this stand.
Wildlife: Three snags were noted during stand inventory. More could be recruited from the larger numbers of larger diameter trees in this unit.
Other: Treatment of this stand will be important to create a open buffer from un-treated units in Eldorado Canyon area. There are grassland and savanna areas adjacent to the unit that could be treated at the same time.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	0.0	45.8	101.	11.5	0.0	20.4	18.7	2.9	0.0	0.0	0.0	0.0	1.1	0.0	0.8	0.0	**203.1**
BA	0.0	4.0	20.0	4.0	0.0	16.0	20.0	4.0	0.0	0.0	0.0	0.0	4.1	0.0	3.9	0.0	**76.1**
Prescription:																	
Stems/Ac	32.9	23.5	16.8	12.0	0.0	20.0	19.0	3.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	**129.2**
BA	0.7	2.1	3.3	4.2	0.0	15.7	20.3	4.2	0.0	0.0	0.0	0.0	3.7	0.0	4.9	0.0	**59.1**
Difference:																	
Stems/Ac	(0.0)	22.3	85.1	0.0	0.0												
BA	(0.0)	1.9	16.7	0.0	0.0												



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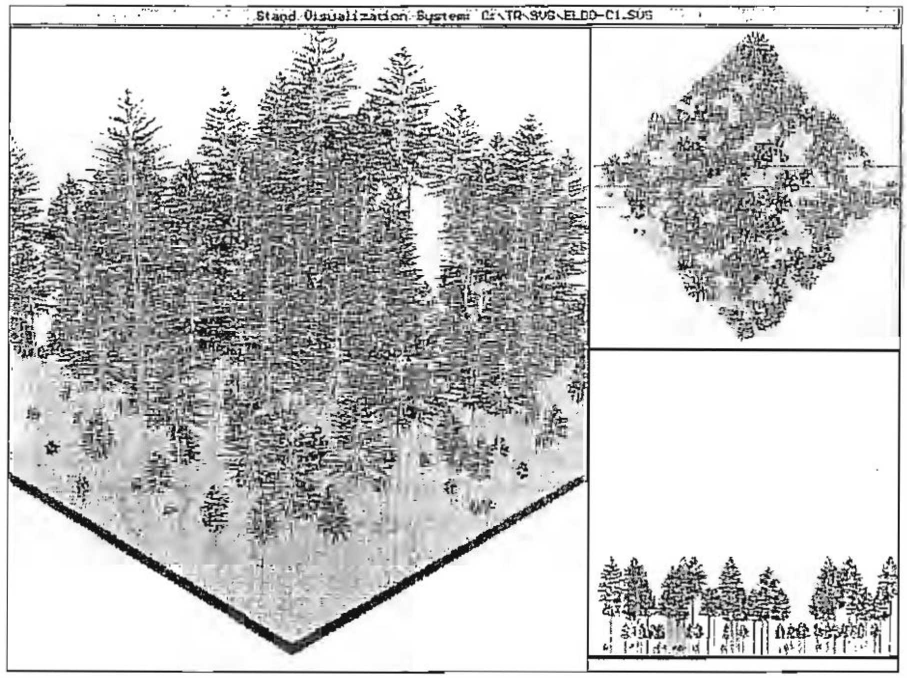

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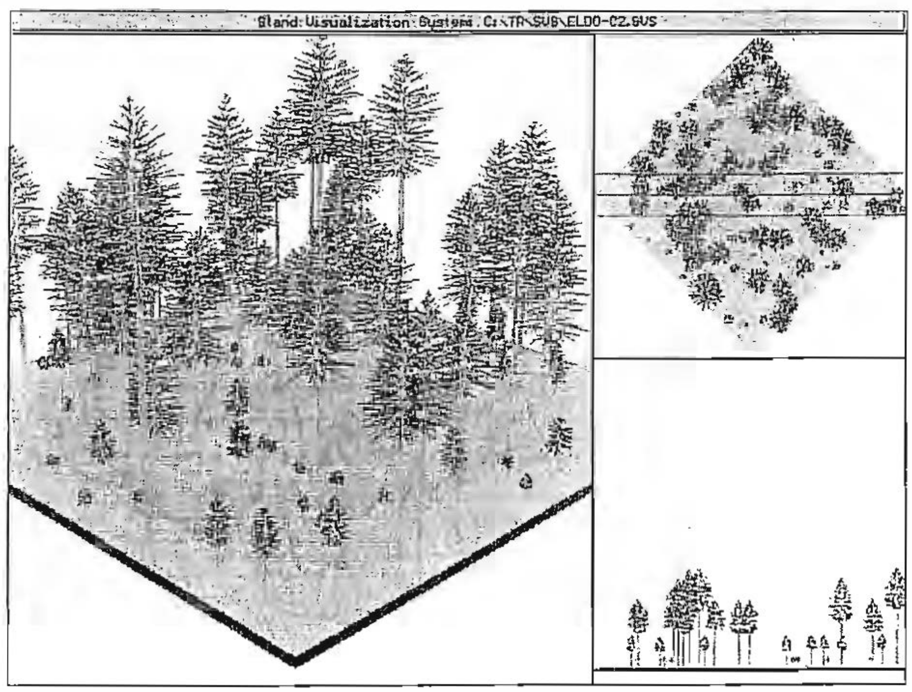


Eldorado-E (ELDO-E) Acres: 16.0

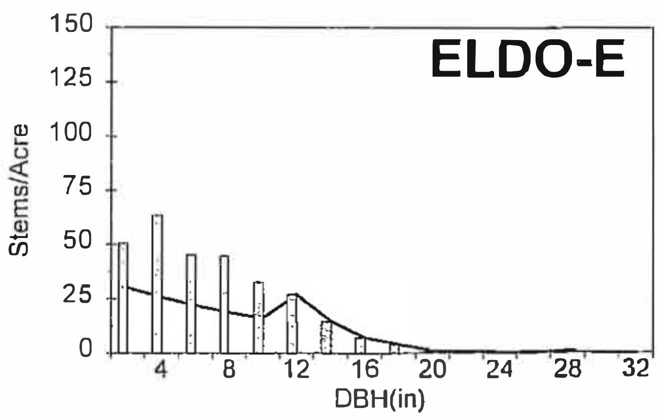
Specific Stand Objectives: Reduce basal area in all size classes below 12" with thinning and reintroduce episodic fires.

Treatment Recommendations: Thin from 121-40 BA. This may be done in a series of treatments. Much of BA is in larger diameter classes (12"+) and stand will still be relatively closed after treatment. However, treatment of this unit is needed to create open conditions in this area of Eldorado Canyon. Many smaller diameter trees in the stand can be removed to reduce ladder fuels and create a modified fuel break for wildfires from the west.

Special Considerations:
Native vegetation: Relatively high shrub species diversity, but generally low cover. Grasses and sedges predominantly cool-season species that may be adversely impacted by spring burning.
Nonnative plant species: Cheatgrass and Canada bluegrass have the highest cover.
Wildlife: Game trails were noted in 7 of 18 plots from this unit. Only 1 snag was seen during inventory and many more should be recruited from the large numbers of larger trees in the stand.
Other: There are grassland and savanna areas adjacent to the unit that could be treated at the same time.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	50.9	63.7	45.3	44.6	32.6	26.9	14.6	7.2	3.8	0.5	0.4	0.0	0.0	0.0	0.0	0.0	290.5
BA	1.1	5.6	8.9	15.6	17.8	21.1	15.6	10.1	6.7	1.1	1.1	0.0	0.0	0.0	0.0	0.0	104.6
Prescription:																	
Stems/Ac	30.0	25.6	21.9	18.7	16.0	27.0	15.0	7.0	4.0	1.0	1.0	0.0	0.0	1.0	0.0	0.0	168.2
BA	0.7	2.2	4.3	6.5	8.7	21.2	16.0	9.8	7.1	2.2	2.6	0.0	0.0	4.3	0.0	0.0	85.6
Difference:																	
Stems/Ac	20.9	38.1	23.4	25.9	16.6												
BA	0.5	3.3	4.6	9.0	9.1												



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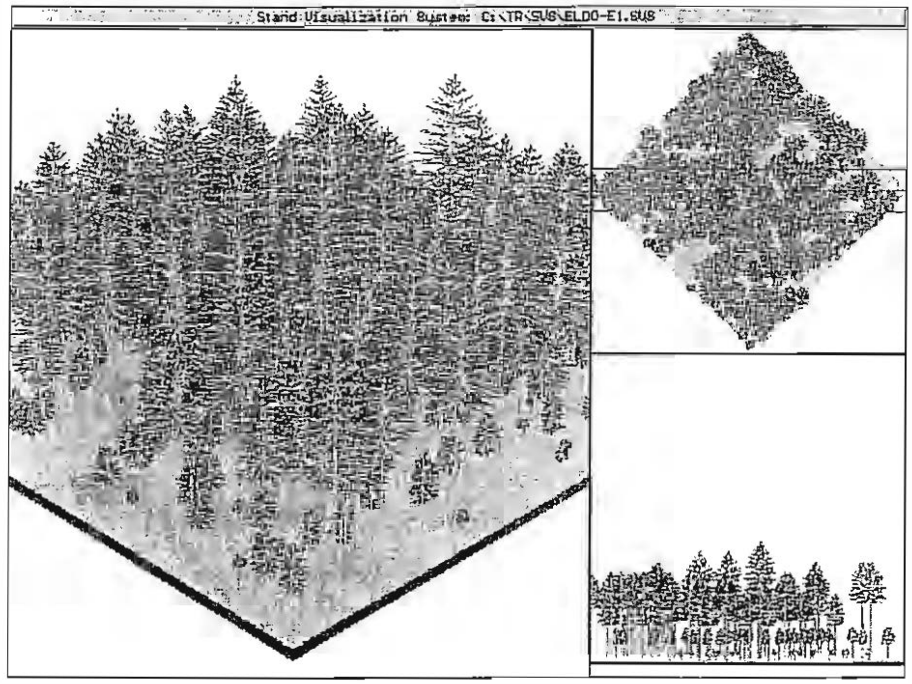

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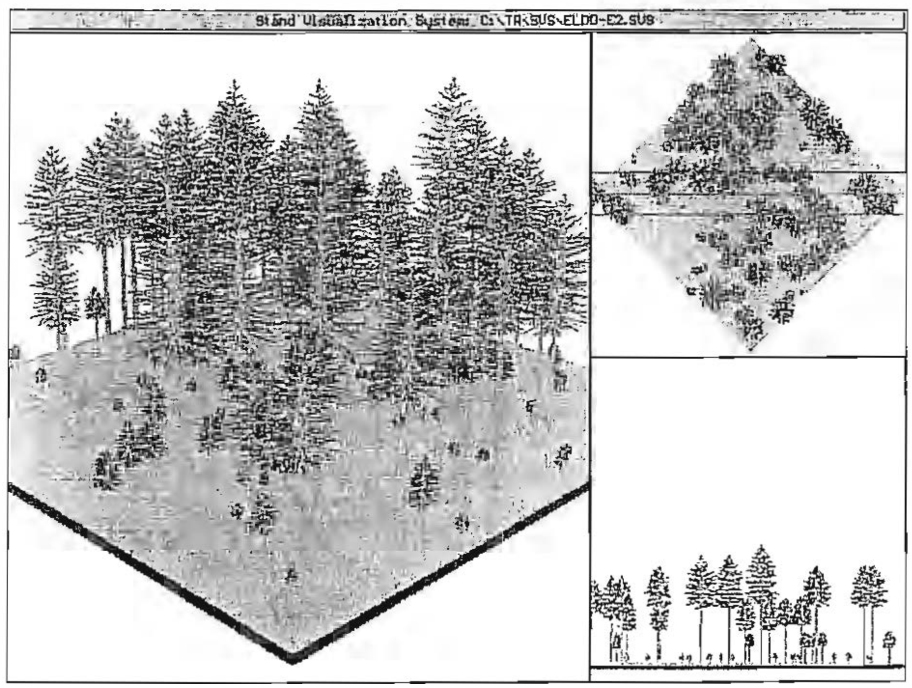


Fox-W Acres: 18.5

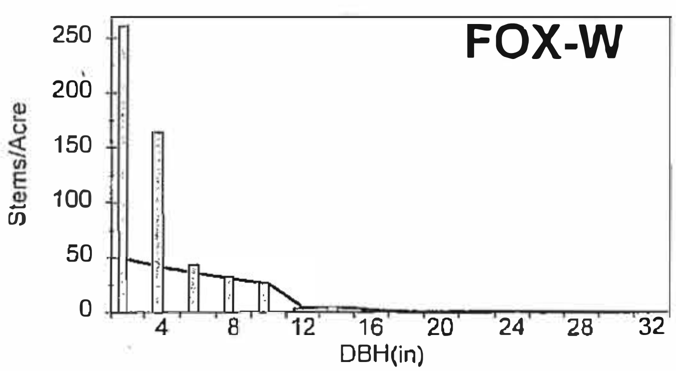
Specific Stand Objective: Significantly reduce smaller size classes and regeneration in stand.

Treatment recommendations: Thin from 46 to 30 BA. This stand contains abundant regeneration and a large numbers of trees < 12" DBH. Much of the regeneration is Douglas-fir that should be selectively removed to promote ponderosa pine in the unit. This area is on the south side of Boulder Creek and access should be good for thinning treatments.

Special Considerations:
Native vegetation: An understory vegetation inventory needs to be completed for this stand.
Wildlife: Only one snag was noted during inventory. However, lack of trees in larger size classes may limit possible recruitment of more. Wildlife use of this area is likely high just above Boulder Creek.
Other: Private land adjoins the unit on the south and west.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	261.9	163.7	43.7	32.7	26.2	3.6	5.3	2.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	540.0
BA	5.7	14.3	8.6	11.4	14.3	2.8	5.7	2.8	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	68.4
Prescription:																	
Stems/Ac	48.7	41.6	35.6	30.4	26.0	4.0	5.0	2.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	194.4
BA	1.1	3.6	7.0	10.6	14.2	3.1	5.3	2.8	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	50.9
Difference:																	
Stems/Ac	213.2	122.1	8.1	2.3	0.2												
BA	4.7	10.7	1.6	0.8	0.1												



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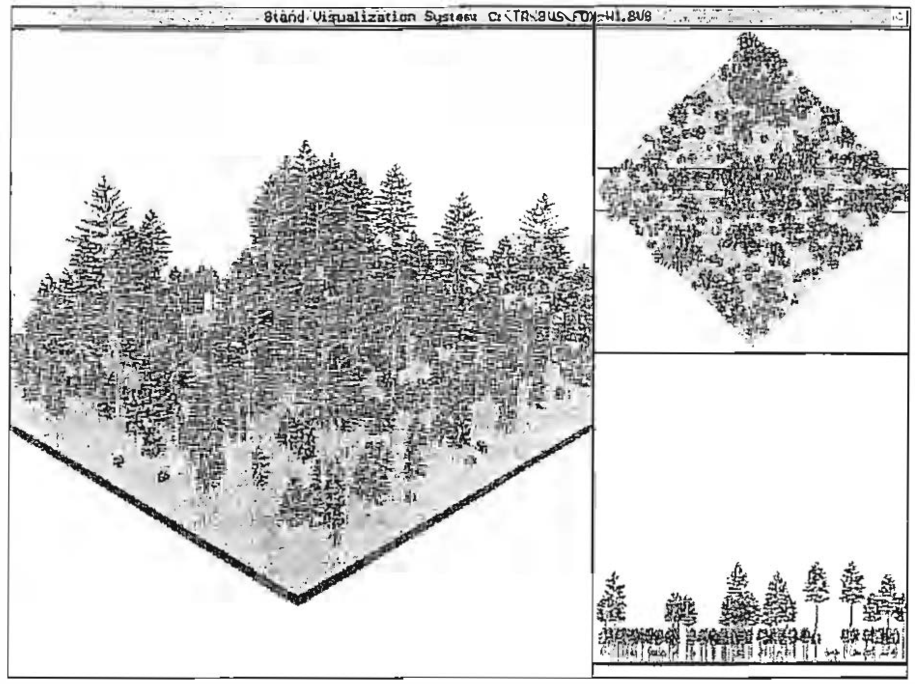

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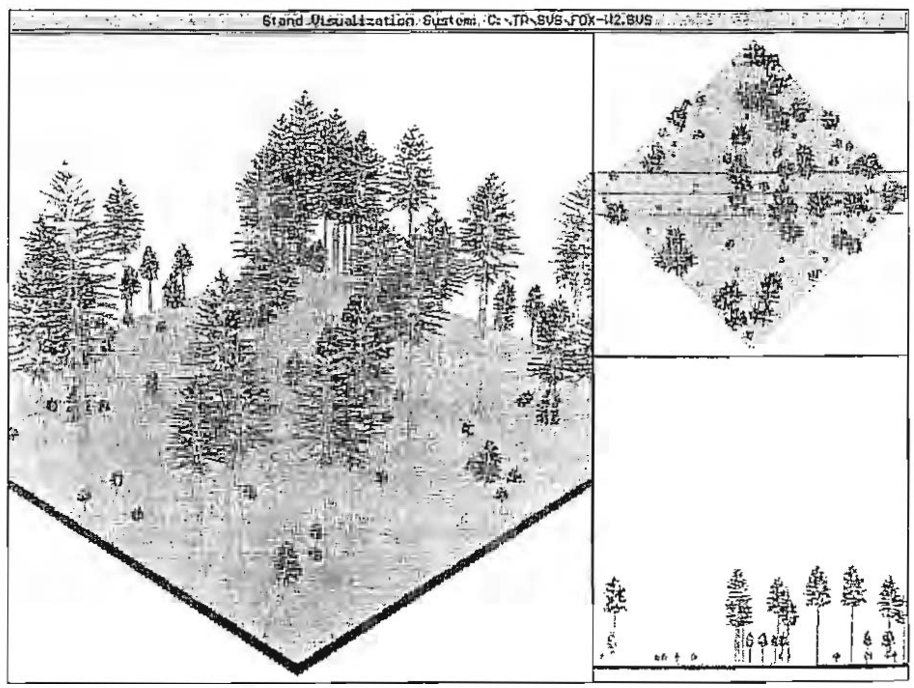


Lindsay-N (LIND-N) Acres: 97.0

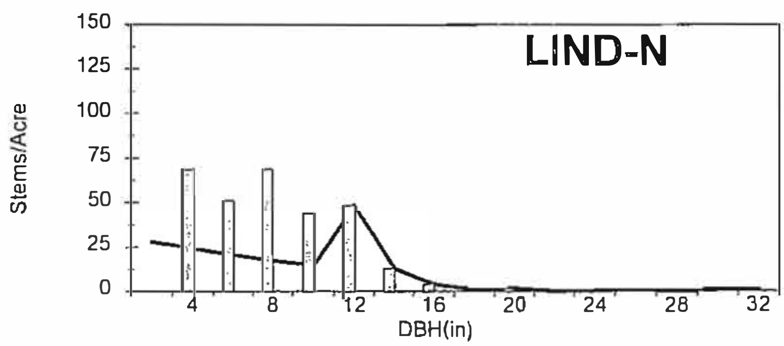
Specific Stand Objective: Maintain open conditions and restore ecosystem processes with prescribed fires.

Treatment Recommendation: Thin from 136 to 99 BA. Mechanically thin 4" to 10" size classes to open stand canopy. Overstory conditions in the stand grade from open savanna areas on the prairie margins to very closed conditions at the south end near the canal. Much of the basal area is in the small diameter classes, although the stand also has large numbers of trees in larger diameter classes with some of the largest trees recorded during stand inventory. This stand should continue into a healthy climax stage once smaller trees are reduced in number. Parts of the stand will need heavy thinning and access for equipment is good from the road along the canal. Burning in local patches of overstory will promote further opening of the existing canopy and this should be encouraged during prescribed fire operations. Other areas closer to the prairie margins are more open and amenable to burning at the present time before thinning of other areas.

Special Considerations:
Native vegetation: Shrub species richness is high (14 species), but cover is patchy. Ephemeral stream areas should be monitored for fire effects; they should also be evaluated for wildlife habitat. Rocky Mountain juniper, common juniper, and Douglas-fir occur in this stand; they are vulnerable to fire.
Nonnative plant species: Species with highest cover are Canada bluegrass, cheatgrass, and St. Johnswort, all cool-season species that may be adversely impacted by spring burning. A small area of whitetop (*Cardaria chalepensis*) has invaded the large meadow on the east side of the stand.
Wildlife: No snags were recorded during inventory; however, large numbers of trees in larger size classes suggest that snags should be recruited in this unit. Deer are frequently sighted in this stand.
Recreation: Visitor use is limited to hikers and horseback riders.
Other: There are forested areas to the west of the unit that could be treated at the same time. These areas have significant regeneration from construction disturbance. This area, especially the more open areas in the north and east, could be burned at the same time as adjoining grassland areas to the north and east.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	0.0	68.8	50.9	68.8	44.0	48.4	13.1	4.3	1.1	1.8	0.0	0.0	0.5	0.0	0.8	0.4	302.9
BA	0.0	6.0	10.0	24.0	24.0	38.0	14.0	6.0	1.9	3.9	0.0	0.0	1.8	0.0	3.9	2.2	135.9
Prescription:																	
Stems/Ac	0.0	24.0	20.5	17.6	15.0	48.0	13.0	4.0	1.0	2.0	0.0	0.0	0.5	0.0	0.8	0.4	176.2
BA	0.0	2.1	4.0	6.1	8.2	37.7	13.9	5.6	1.8	3.9	0.0	0.0	1.8	0.0	3.9	2.2	98.5
Difference:																	
Stems/Ac	(0.0)	44.8	30.4	51.3	29.0												
BA		3.9	6.0	17.9	15.8												



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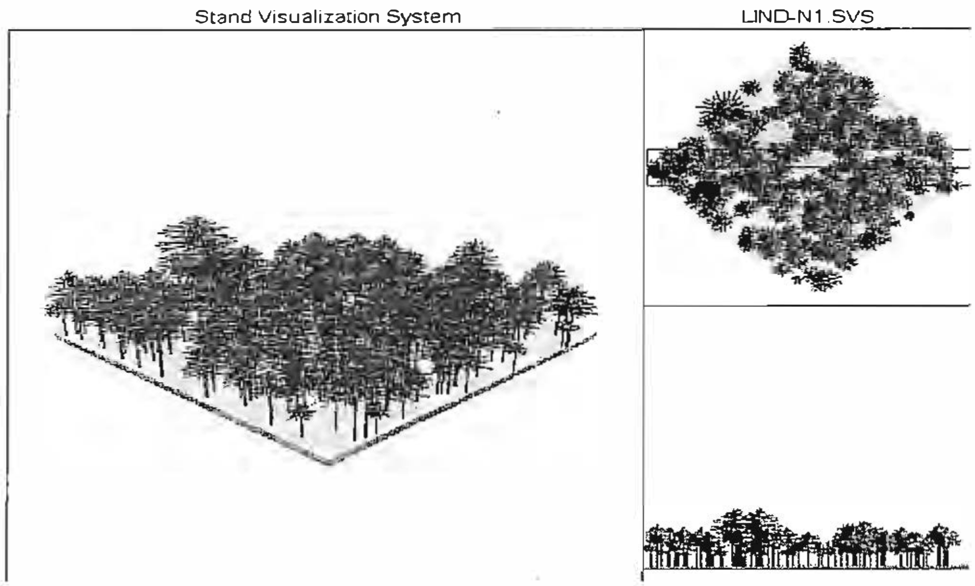

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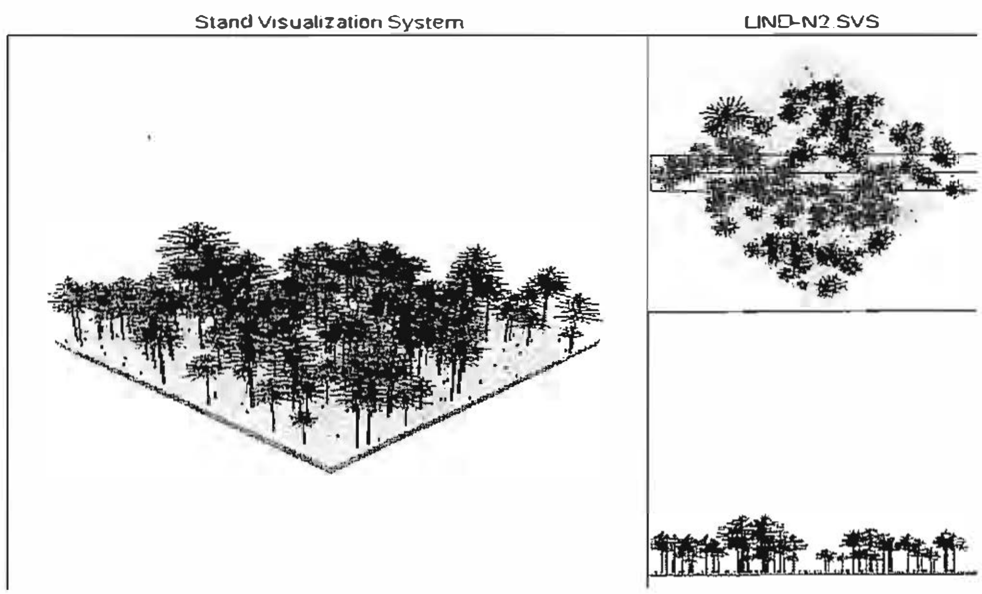


Lindsay-Jeffco-NE (LJC-NE) Acres: 54.2

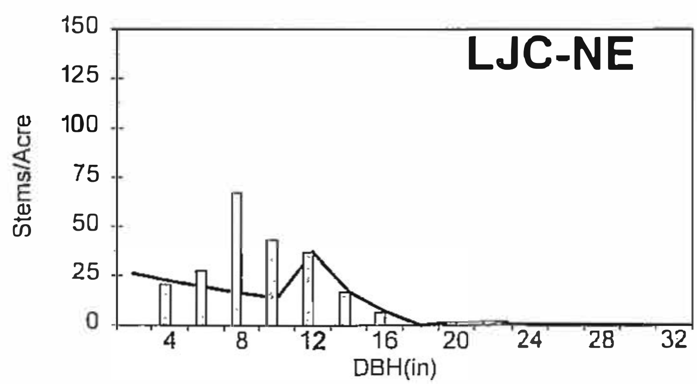
Specific Stand Objective: Maintain open conditions and restore ecosystem processes with prescribed fire.

Treatment Recommendation: Thin from 120 to 86 BA, specifically trees in 6" to 10" size classes. Large numbers of trees, especially in the 8" size class, will need to be thinned before application of prescribed fire. Twelve-inch diameter and larger trees will still be common after treatments and beetle attack will be something to watch for in the future. There is little regeneration in this otherwise open, flat stand, and thinning operations should be relatively easy in this unit. Episodic prescribed fires will maintain open conditions.

Special Considerations:
Native vegetation: A rare plant community–mountain mahogany-threeleaf sumac/big bluestem (*Cercocarpus montanus-Rhus aromatica/Andropogon gerardii*)--may be present. Additional fieldwork is needed to verify the presence of this community. The rare birdsfoot violet (*Viola pedatifida*) occurs on this stand and will be carefully monitored. Lilac penstemon (*Penstemon gracilis*) occurs on this stand; it is uncommon in local lower montane ponderosa pine forests and will be monitored for fire effects.
Nonnative plant species: Species with highest cover are Japanese brome, Canada bluegrass, cheatgrass, and rattlesnake grass. These species should decrease with spring burning.
Wildlife: No snags were seen during inventory; they can be promoted from the large numbers of trees in larger size classes in this unit.
Other: There are open meadows between this stand and LJC-NW and LIND-S that could be burned as part of this unit. Grass and shrub areas east of the unit in Dowdy Draw should also be considered for treatment with this stand.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	0.0	20.8	27.8	67.7	43.3	37.0	17.0	6.5	0.0	1.7	2.1	0.0	0.0	0.0	0.0	0.0	223.9
BA	0.0	1.8	5.5	23.6	23.6	29.1	18.2	9.1	0.0	3.7	5.5	0.0	0.0	0.0	0.0	0.0	120.1
Prescription:																	
Stems/Ac	0.0	20.8	19.2	16.4	14.0	37.0	17.0	6.5	0.0	1.7	2.1	0.0	0.0	0.0	0.0	0.0	134.7
BA	0.0	1.8	3.8	5.7	7.6	29.1	18.2	9.1	0.0	3.7	5.5	0.0	0.0	0.0	0.0	0.0	84.5
Difference:																	
Stems/Ac	(0.0)	(0.0)	8.6	51.3	29.3												
BA	(0.0)	(0.0)	1.7														



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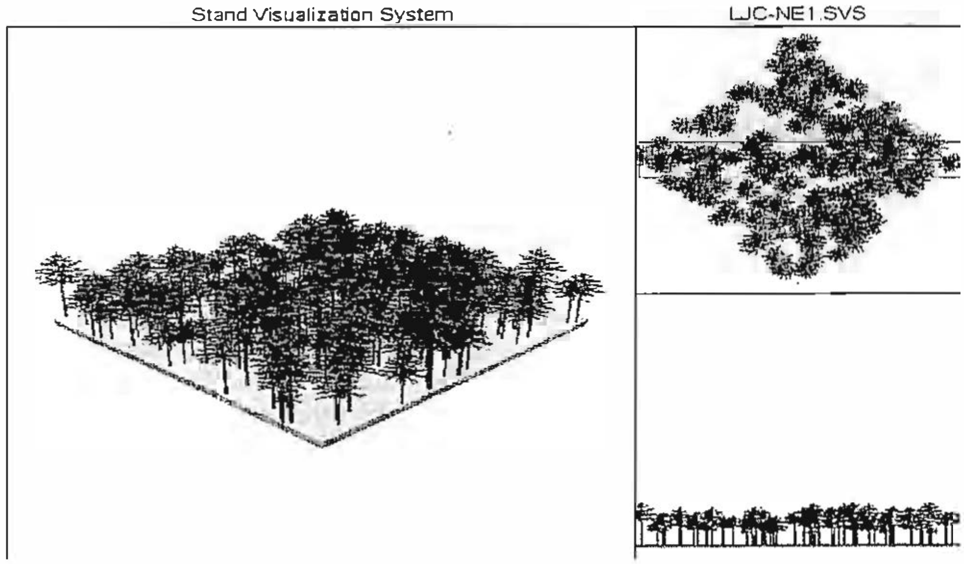

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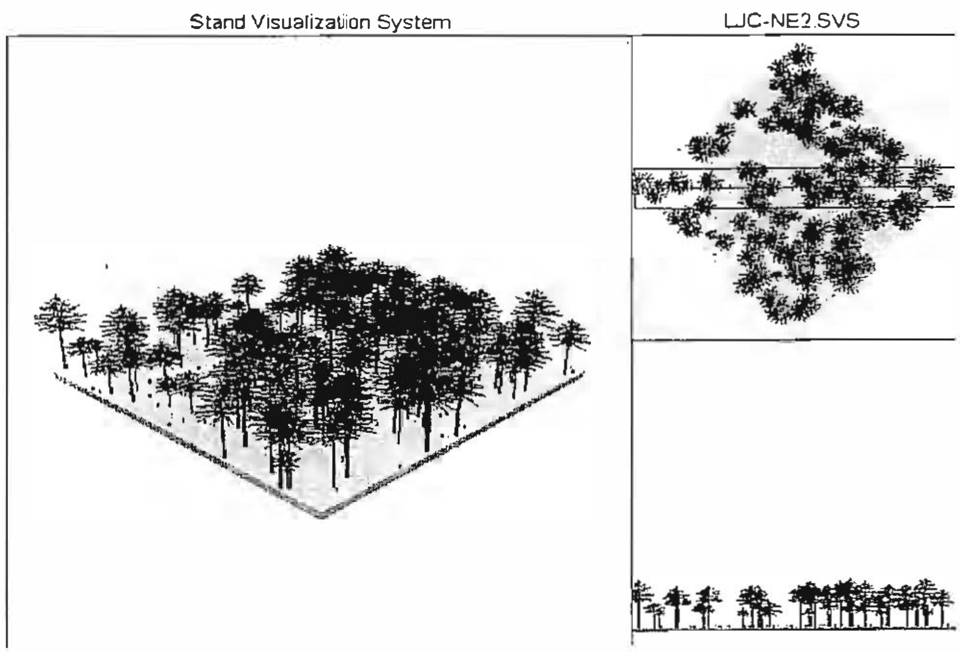


Lindsay-Jeffco-NW (LJC-NW) Acres: 50.1

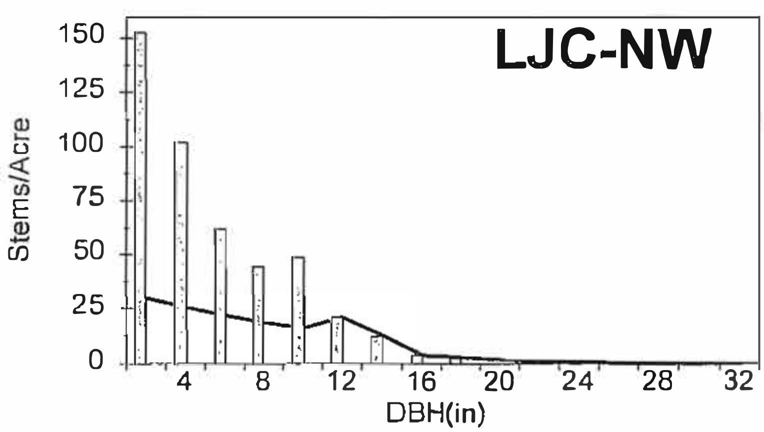
Specific Stand Objective: Promote and maintain open stand conditions through prescribed fire. Reduce regeneration and abundant smaller diameter trees.

Treatment Recommendation: Thin stand from 113 to 74 basal area. This stand will need heavy mechanical thinning of 2" to 10" size classes. The unit is on the east side of the hogback and backs up to private land on the west. The area is rocky and steep, and thinning operations in this area may be difficult. Episodic prescribed fires in this unit in the future will maintain open conditions and restore ecosystem processes.

Special Considerations:
Native vegetation: A small population of uncommon Alaskan orchis (*Piperia unalascensis*) occurs on this stand and will be carefully monitored. Colorado wildrye (*Leymus ambiguus*) is also present and has a limited distribution along the east slope of the mountains in Colorado and New Mexico. Fire effects for this species are unknown and should be carefully monitored. High shrub cover in this stand, with some areas with high cover of mountain mahogany. Four rare plant communities may occur on this stand--mountain mahogany-threeleaf sumac/big bluestem (*Cercocarpus montanus-Rhus aromatica/Andropogon gerardii*), mountain mahogany/needlegrass (*Cercocarpus montanus/Hesperostipa comata*), Rocky Mountain juniper/mountain mahogany (*Sabina scopulorum/Cercocarpus montanus*), and ponderosa pine/mountain mahogany/big bluestem (*Pinus ponderosa/Cercocarpus montanus/Andropogon gerardii*). Additional fieldwork is needed to verify the presence of these communities.
Nonnative vegetation: Canada bluegrass is the species with highest cover.
Wildlife: Two snags were seen during the inventory and more should be promoted.
Other: There is an open meadow area on the north end of this stand and south of stand MRL that could be treated by fire in conjunction with this or other stands.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	152.8	101.9	62.2	44.6	48.9	21.2	12.5	4.0	2.5	1.5	0.8	0.4	0.0	0.0	0.0	0.0	453.3
BA	3.3	8.9	12.2	15.6	26.7	16.7	13.4	5.6	4.4	3.3	2.1	1.3	0.0	0.0	0.0	0.0	113.3
Prescription:																	
Stems/Ac	30.0	25.6	21.9	18.7	16.0	21.0	12.5	4.0	2.5	1.5	0.8	0.4	0.0	0.0	0.0	0.0	157.2
BA		2.2	4.3	6.5	8.7	16.5	13.4	5.6	4.4	3.3	2.1	1.3	0.0	0.0	0.0	0.0	73.9
Difference:																	
Stems/Ac																	
BA																	



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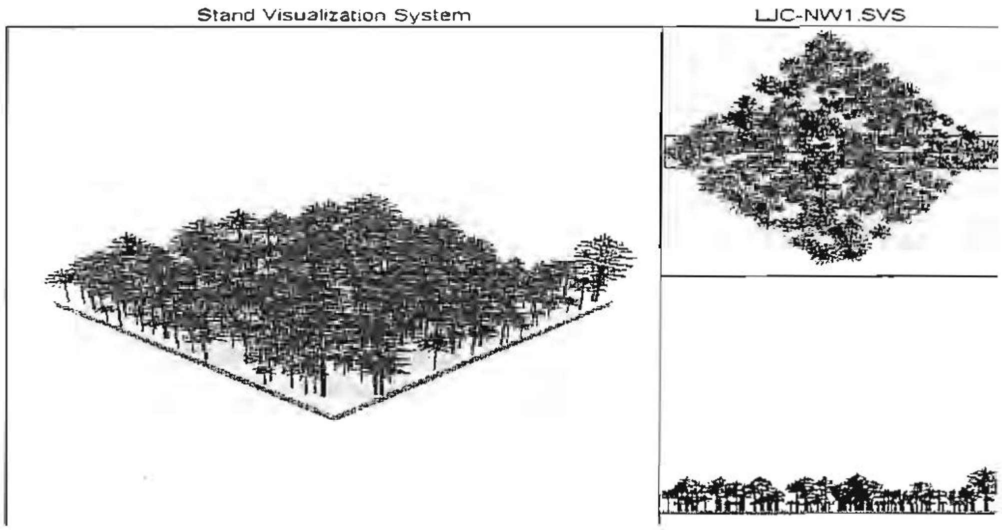

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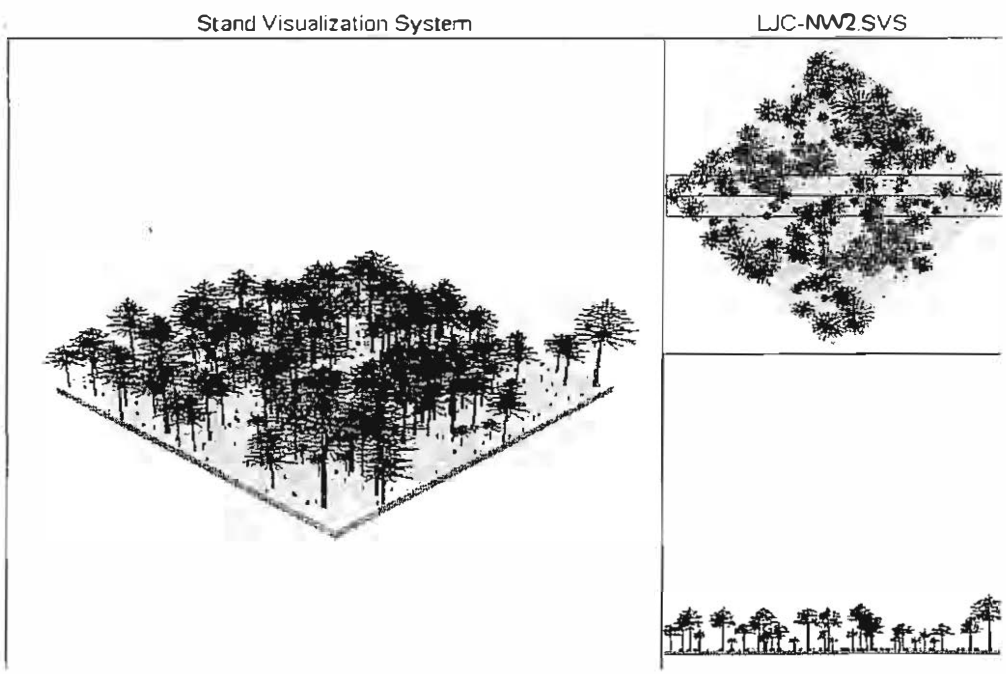


Moore-Robinson-Lindsay (MRL) Acres: 69.8

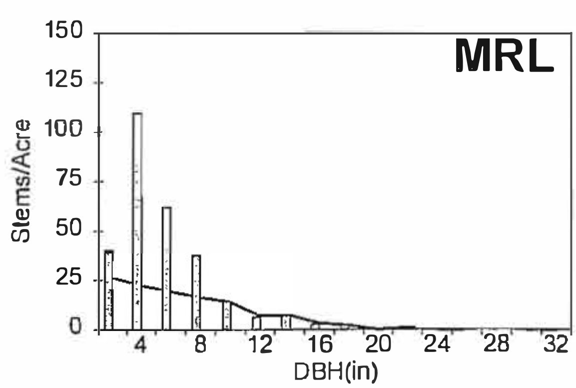
Specific Stand Objective: Maintain open forest conditions and reduce regeneration of seedling and saplings.

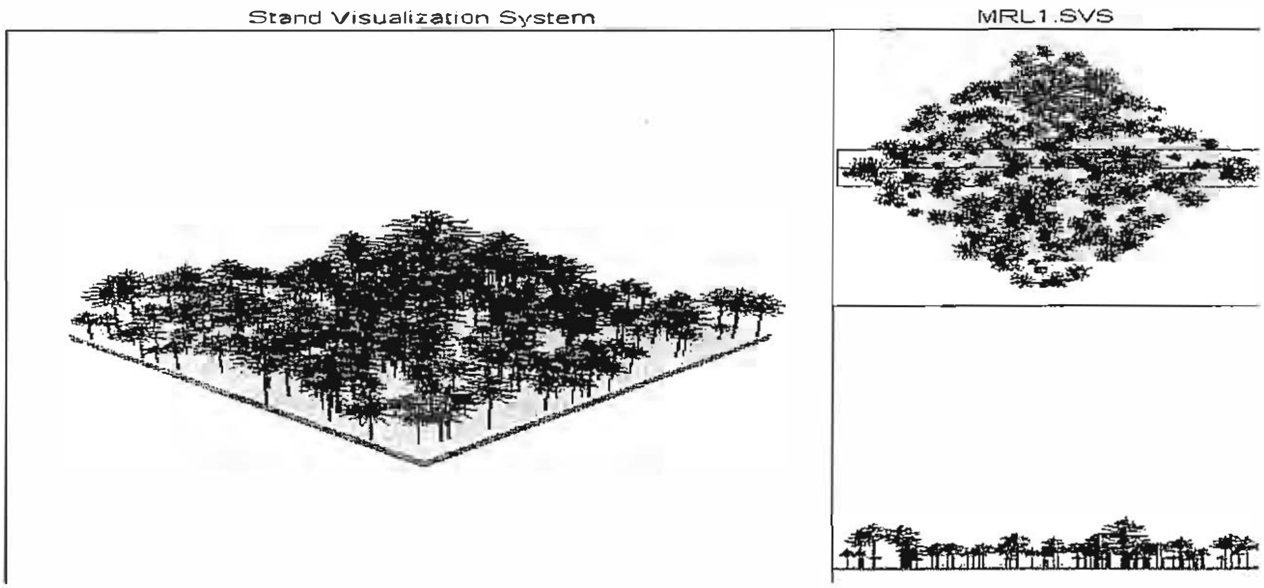
Treatment Recommendations: Thin from 65 to 47 BA. Understory bum after mechanical treatment. Heavy mechanical removal of seedlings and 1" diameter trees. Roadside regeneration should be completely removed as it is a result of road disturbance. Much of this material can be chipped and scattered. Trees in the 3" and 7" diameter size classes should also have significant removal. There is a considerable amount of mistletoe on the north side of the stand which has led to deformed and topped trees. These trees should be removed first. Removal will be to the road and most material to 6 inches can be chipped.

Special Considerations:
Native vegetation: Shrub cover is very high on this stand, as well as shrub species diversity (14 species). Douglas-fir, Rocky Mountain juniper and common juniper are vulnerable to fire. Five rare plant communities may be present: mountain mahogany-threeleaf sumac/big bluestem, mountain mahogany/needlegrass, mountain mahogany/Scribner's needlegrass, Rocky Mountain juniper/mountain mahogany, and ponderosa pine/mountain mahogany/big bluestem. Additional fieldwork is needed to verify which of these communities are present. Colorado wildrye (*Leymus ambiguus*), which occurs only along the east slope of the mountains in Colorado and New Mexico, also occurs here and should be monitored for fire effects.
Nonnative plant species: Species with highest cover are cheatgrass and cinquefoil (*Potentilla recta*).
Wildlife: Bear and mountain lion have been sighted on this stand. There is the potential to create some snags and all existing snags that qualify should be kept.
Soils: The slope is over 40% in some areas and we will need to be sensitive to how we remove material in these areas. Late spring burning should encourage understory growth which is critical in the steeper areas where signs of erosion are visible.
Recreation: Visitor use is limited to low numbers of hikers.
Other: This stand is in the mid-seral stage and should continue to develop into a healthy climax stage with this treatment. Thinning first will minimize the potential for torching of the larger trees that we want to promote. Existing roads will be used for hauling.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	39.9	109.6	62.0	37.4	14.3	6.6	7.3	2.5	2.0	0.0	0.3	0.0	0.0	0.2	0.0	0.0	282.1
BA	0.9	9.6	12.2	13.1	7.8	5.2	7.8	3.5	3.5	0.0	0.8	0.0	0.0	0.9	0.0	0.0	65.1
Prescription:																	
Stems/Ac	26.2	22.4	19.2	16.4	14.0	6.6	7.0	2.5	2.0	0.0	0.3	0.0	0.0	0.2	0.0	0.0	119.2
BA	0.6	2.0	3.8	5.7	7.6	5.2	7.5	3.5	3.5	0.0	0.8	0.0	0.0	0.9	0.0	0.0	47.3
Difference:																	
Stems/Ac	13.7	87.2	42.8	21.0	(0.0)												
BA	0.3	7.6	8.4	7.3	(0.0)												





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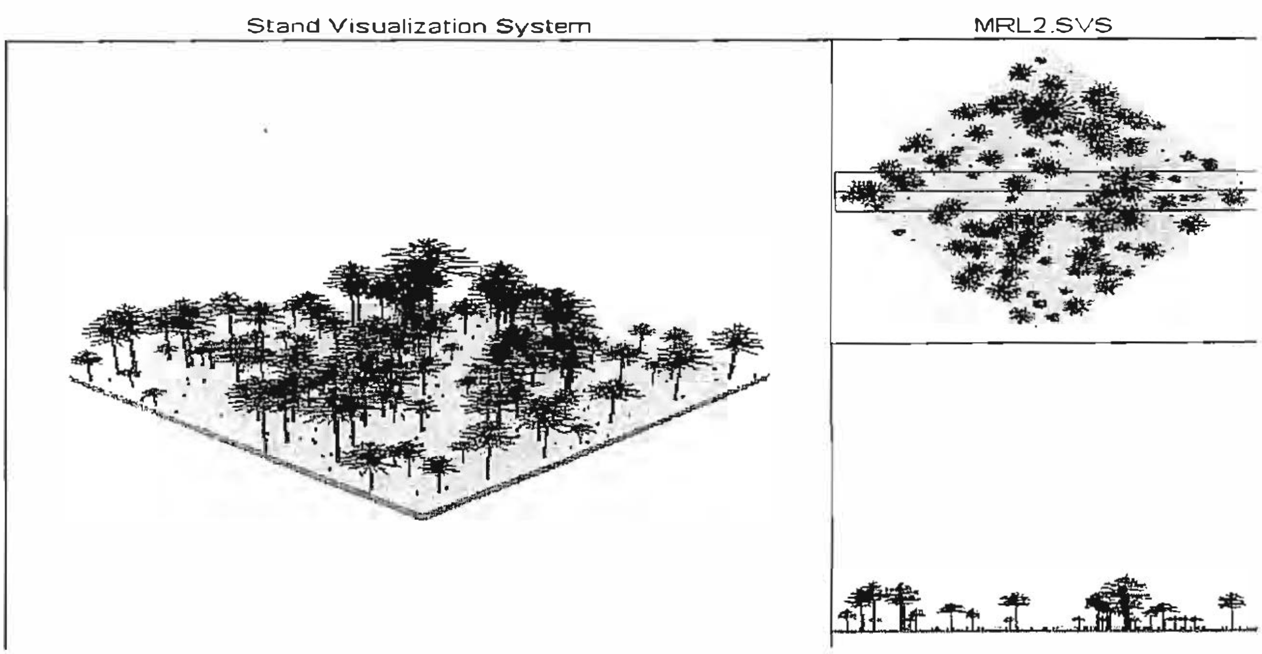


Marshall Mesa (MRSL) Acres: 14.8

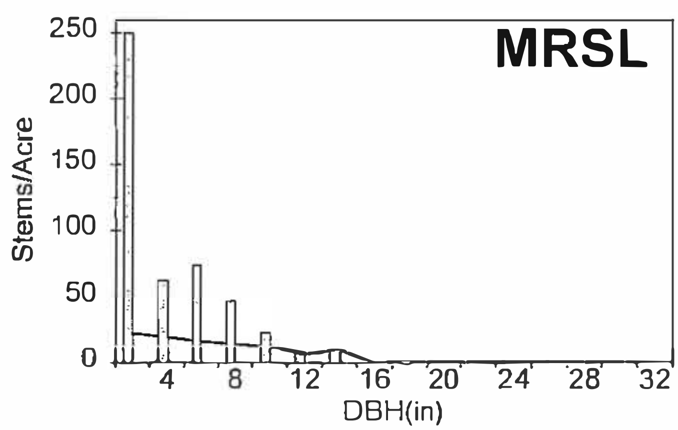
Specific Stand Objective: Reduce abundant regeneration in the stand by mechanical thinning; reduce BA of trees, especially the 4" to 8" size classes.

Treatment Recommendation: Thin from 57 to 32 BA. This unit is the farthest out on the prairie margins of any on Open Space property. Abundant ponderosa pine regeneration on the stand margins should be reduced to maintain savanna-grassland ecotone at its present location. The stand is bordered by grassland areas on all sides and access for thinning treatments is good.

Special Considerations:
Native vegetation: An understory vegetation inventory needs to be completed for this stand.
Wildlife: No snags were noted during inventory; however, location of the stand on the prairie landscape may preclude use by many forest species and snag recruitment is not recommended. Wildlife trails were seen in all inventory plots and this area appears to be heavily used by deer and other wildlife in this area.
Other: Visibility from the stand is high and smoke management will be critical because of nearby highways and roads.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	250.0	62.5	74.1	46.9	23.3	6.9	10.2	0.0	2.1	0.8	0.0	0.0	0.0	0.0	0.0	0.0	476.8
BA	5.5	5.5	14.5	16.4	12.7	5.4	10.9	0.0	3.7	1.7	0.0	0.0	0.0	0.0	0.0	0.0	76.3
Prescription:																	
Stems/Ac	22.5	19.2	16.4	14.0	12.0	7.0	10.0	0.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	104.2
BA	0.5	1.7	3.2	4.9	6.5	5.5	10.7	0.0	3.5	2.2	0.0	0.0	0.0	0.0	0.0	0.0	38.7
Difference:																	
Stems/Ac	227.5	43.3	57.7	32.9	11.3												
BA	5.0	3.8	11.3	11.5	6.2												



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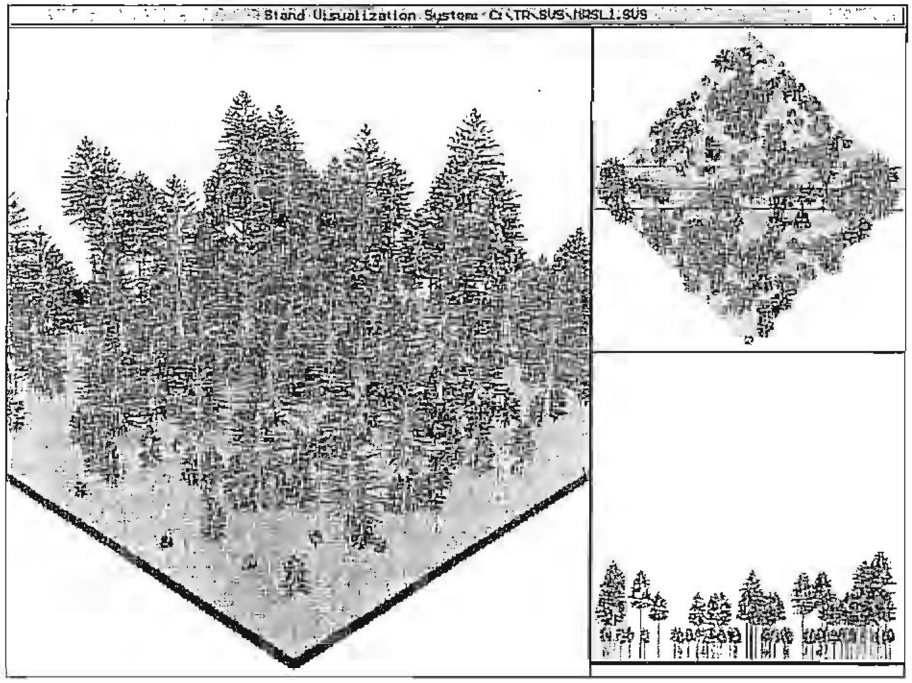

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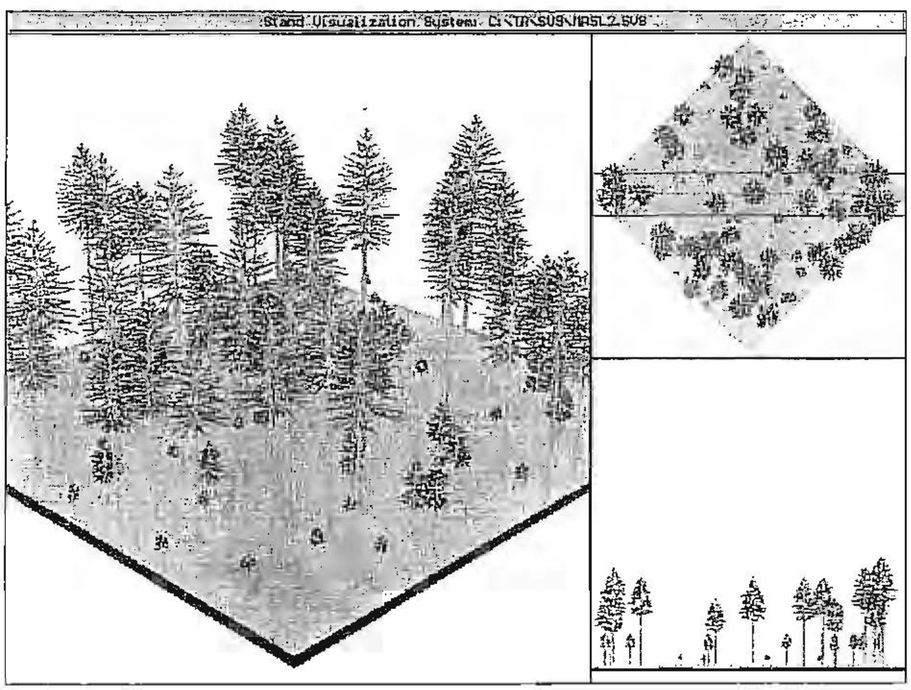


Shanahan-3 (S-3) Acres: 94.6

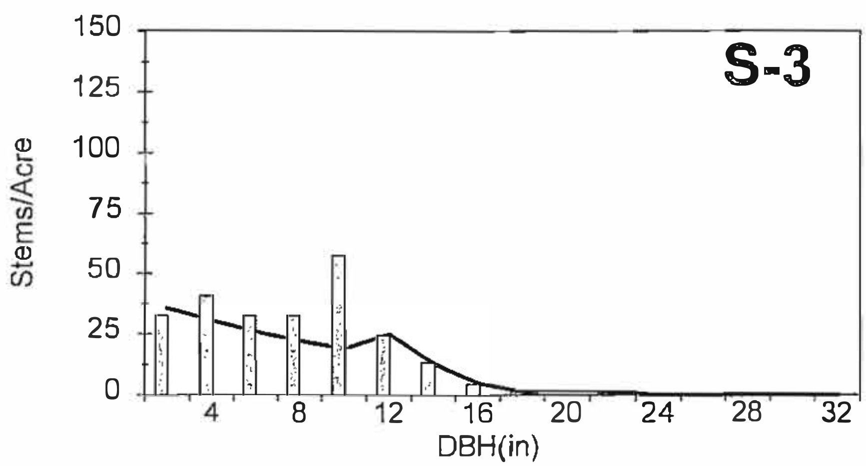
Specific Stand Objective: Maintain open conditions with prescribed fire.

Treatment Recommendation: Thin from 97 to 76 Basal area. Many of the trees to be removed are in the 10" size class. Thin trees in 4" to 10" size classes to reduce BA and trees/acre. Many of the trees to be left after mechanical thinning in 2" to 8" classes may need to be thinned again in the near future; it is recommended this be accomplished using a series of prescribed fires on short intervals. Passive torching should be encouraged to further thin the overstory in this unit and to create landscape diversity of stand structure in the S- and ST- stands in this area. Access to the unit for thinning treatments is available from roads in the unit.

Special Considerations:
Native vegetation: Douglas-fir is vulnerable to fire. Leadplant (*Amorpha nana*), a rare species in the lower montane ponderosa pine forest, occurs in plot 25 and will be carefully monitored. Grass cover is dominated by poverty oatgrass (*Danthonia spicata*), a native cool season grass that is tolerant of fire.
Nonnative plant species: Japanese brome and Canada thistle are the species with highest cover.
Wildlife: One snag was noted during inventory and more should be recruited from trees in 14" diameter classes.
Recreation: Several recreation trails are in this area. Efforts to sign and advise public of work in the area will be critical.
Other: There are large areas of savanna and grasslands on the south and southeast sides of the unit that could be burned at the same time as this unit.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	32.7	40.9	32.7	32.7	57.6	24.6	13.4	4.6	1.2	0.0	0.8	0.0	0.0	0.0	0.0	0.0	241.2
BA	0.7	3.6	6.4	11.4	31.4	19.3	14.3	6.4	2.1	0.0	2.1	0.0	0.0	0.0	0.0	0.0	97.8
Prescription:																	
Stems/Ac	32.7	30.4	26.0	22.2	19.0	24.6	13.0	4.6	1.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	180.3
BA	0.7	2.7	5.1	7.8	10.4	19.3	13.9	6.4	1.8	0.0	2.1	0.0	0.0	0.0	0.0	0.0	75.9
Difference:																	
Stems/Ac		10.5	6.7	10.5	38.6												
BA																	



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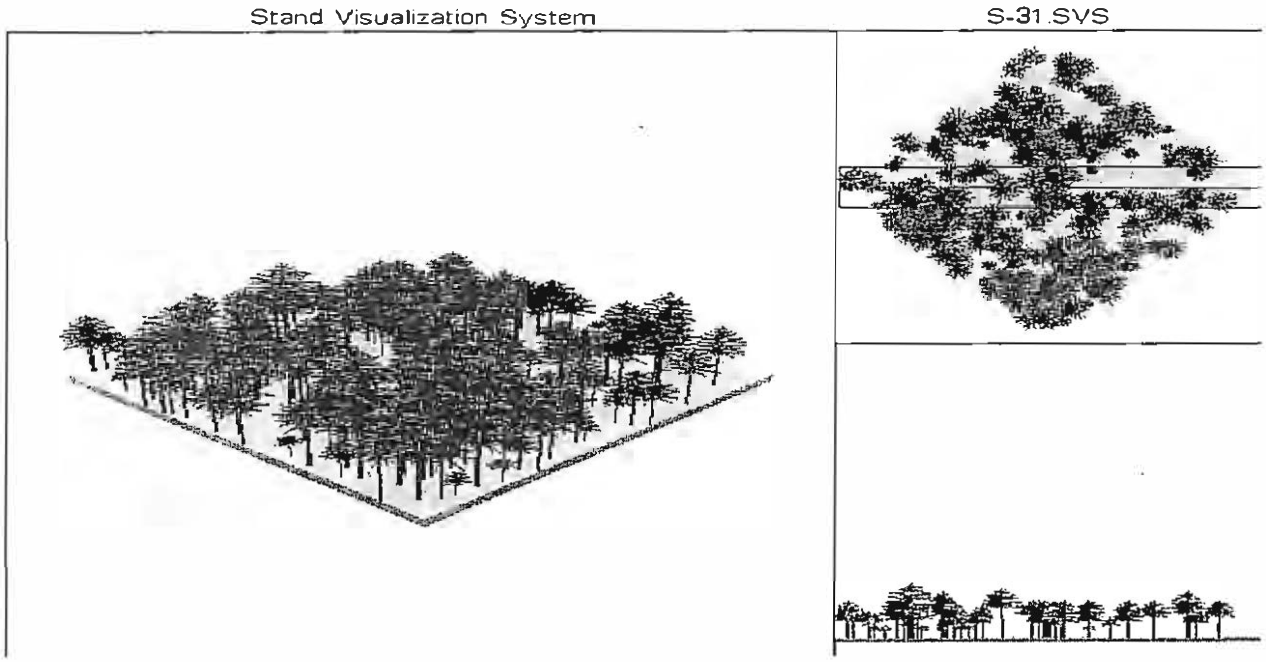

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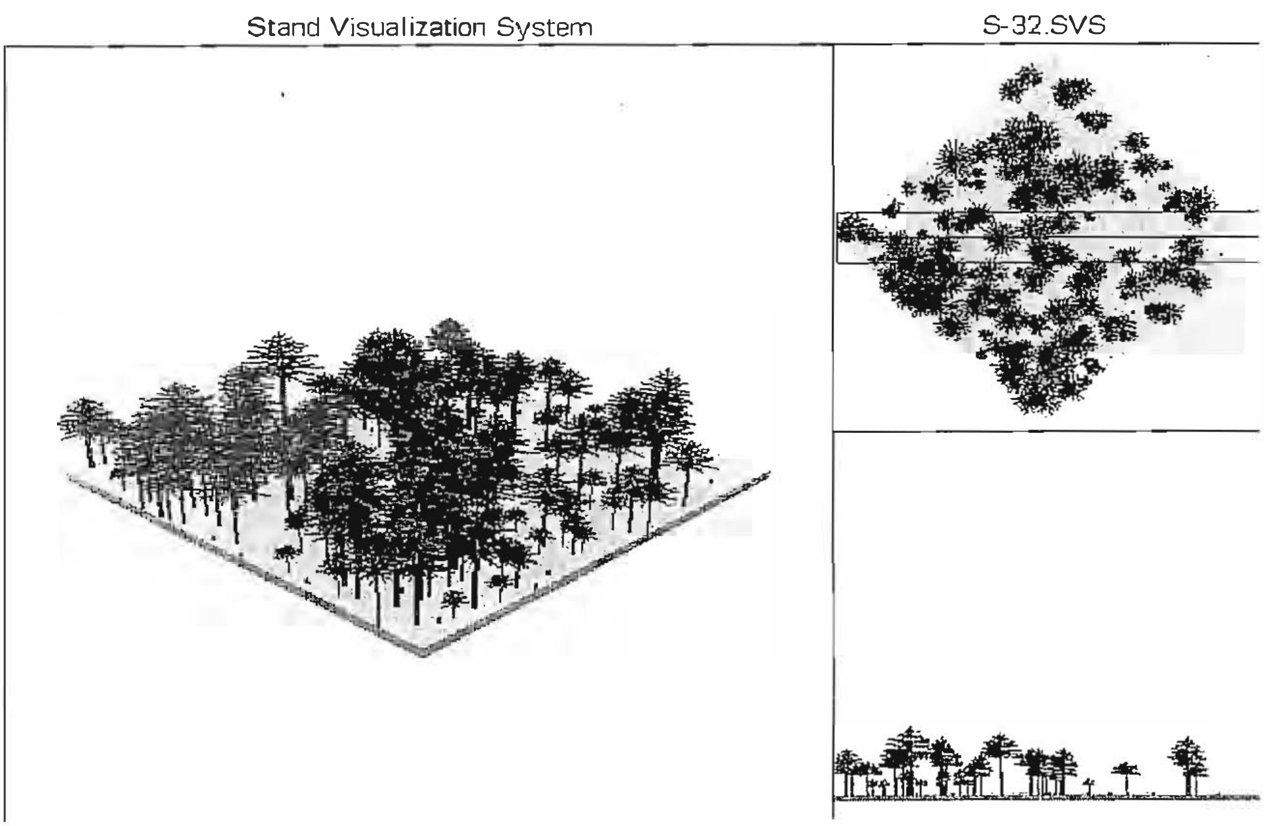


Stengel I-3 (ST-3) Acres: 24.4

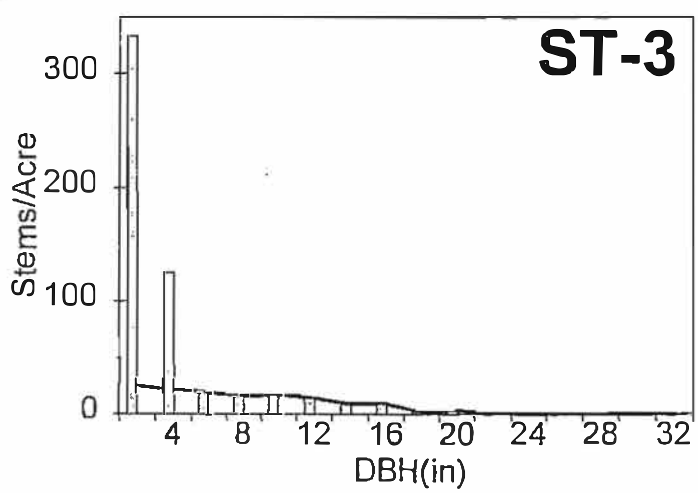
Specific Stand Objective: Heavily thin regeneration in stand to reduce trees per acre. Maintain open conditions with prescribed fire.

Treatment Recommendation: Thin from 38 to 30 BA. Much of BA to be removed is in the smaller size classes. Douglas-fir should be selectively removed from the stand. Large numbers of trees in larger diameter classes in this unit suggest this area will continue into a healthy climax stage. Local overstory burning should be encouraged to further reduce BA in this unit, and to create landscape diversity of stand structure in the S- and ST- stands in this area. Access to unit is limited because of steeper slopes in this area.

Special Considerations:
Native vegetation: Douglas-fir, Rocky Mountain juniper, and common juniper are vulnerable to fire. Relatively high shrub species diversity for such a small stand. Grasses are predominately cool season species that would be adversely impacted by spring burning. A rare plant community–ponderosa pine/spike fescue (*Pinus ponderosa/Leucopoa kingii*)--may occur on this stand. Additional fieldwork is needed to verify the presence of this community.
Nonnative plant species: Canada thistle has the highest cover.
Wildlife: No snags were noted during inventory. Large numbers of trees in larger diameter classes suggest that many could be recruited in this area.
Other: Recreation trails are present in this area.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	333.4	125.0	18.5	15.6	16.7	13.9	8.5	9.1	2.1	2.5	0.7	0.0	0.0	0.0	0.0	0.0	546.0
BA	7.3	10.9	3.6	5.4	9.1	10.9	9.1	12.7	3.7	5.5	1.8	0.0	0.0	0.0	0.0	0.0	80.1
Prescription:																	
Stems/Ac	25.6	21.9	18.7	16.0	17.0	14.0	9.0	9.0	2.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	137.2
BA	0.6	1.9	3.7	5.6	9.3	11.0	9.6	12.6	3.5	6.5	2.6	0.0	0.0	0.0	0.0	0.0	66.9
Difference:																	
Stems/Ac	307																
BA	6.7																



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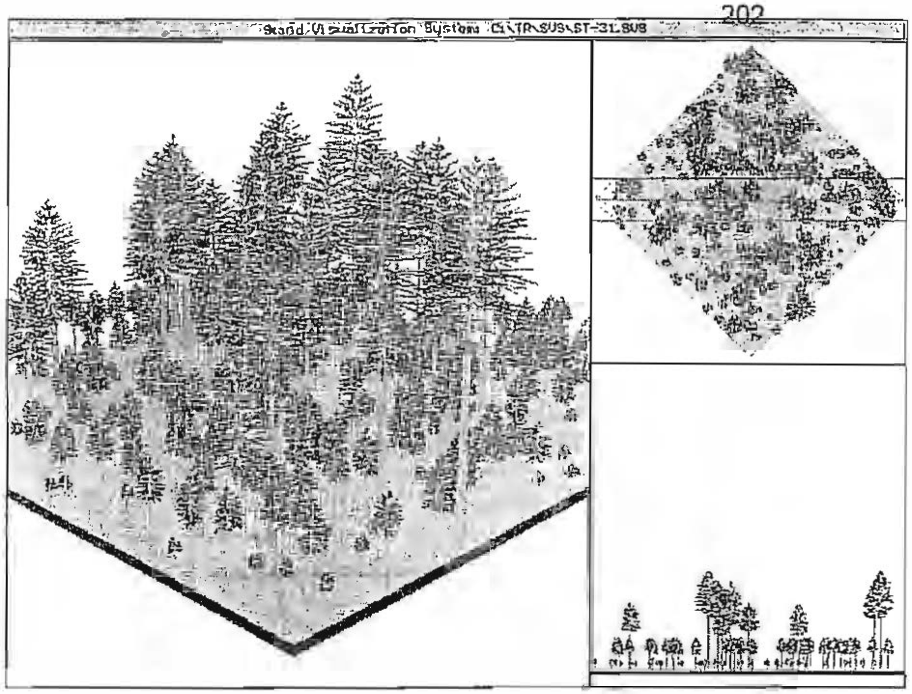

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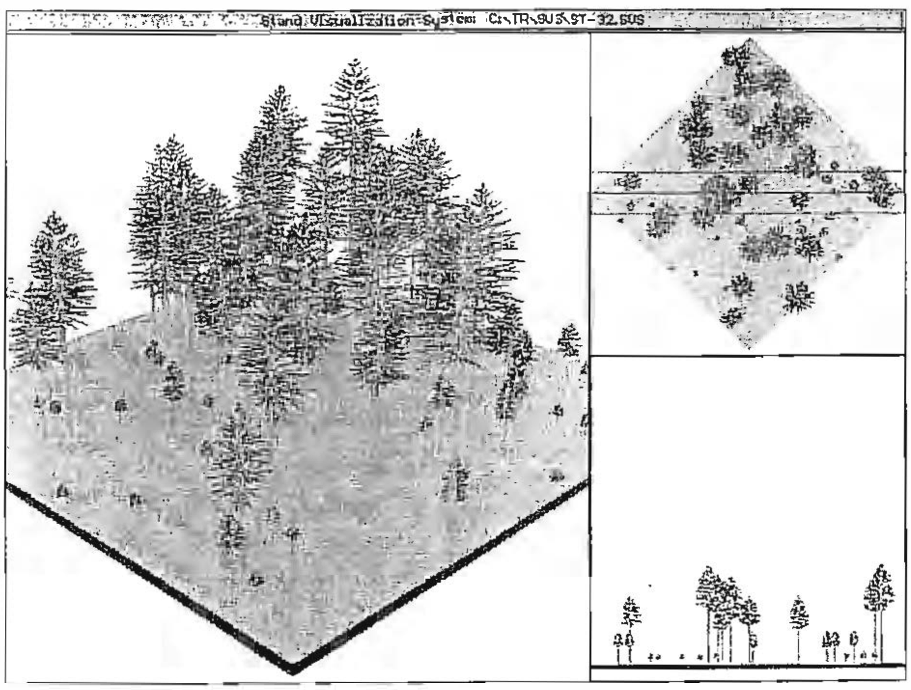


Stengel I-5 (ST-5) Acres: 6.6

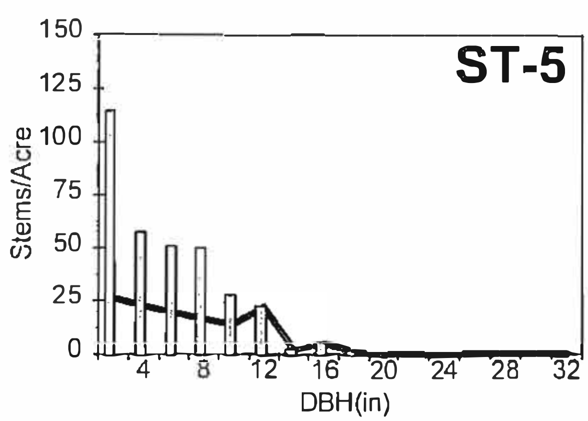
Specific Stand Objective: Thin trees in 4" to 10" size classes to reduce BA and trees per acre. Maintain open conditions with prescribed fire.

Treatment Recommendation: Thin from 97 to 32 BA. Much of BA to be removed is in the 10" size class. Trees left after thinning in 2" to 8" classes may need to be thinned again in the near future; it is recommended this be accomplished using a series of prescribed fires after initial thinning treatment. Local overstory burning should be encouraged to further reduce BA in this unit, and to increase diversity of stand structure.

Special Considerations:
Native vegetation: Douglas-fir is vulnerable to fire. High cover of holly-grape in this stand. Understory vegetation cover under 20 percent.
Wildlife: No snags were noted during inventory. Large numbers of trees in larger diameter classes suggest that many could be recruited in this area.
Other: Recreation trails are present in this area and educational signing will be crucial.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	114.6	57.3	50.9	50.1	27.5	22.3	2.3	5.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	331.8
BA	2.5	5.0	10.0	17.5	15.0	17.5	2.5	7.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.0
Prescription:																	
Stems/Ac	26.2	22.4	19.2	16.4	14.0	22.0	2.0	5.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	128.2
BA	0.6	2.0	3.8	5.7	7.6	17.3	2.1	7.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.8
Difference:																	
Stems/Ac	88.4	34.9	31.7	33.7	13.5												
BA	1.9	3.0	6.2	11.8	7.4												



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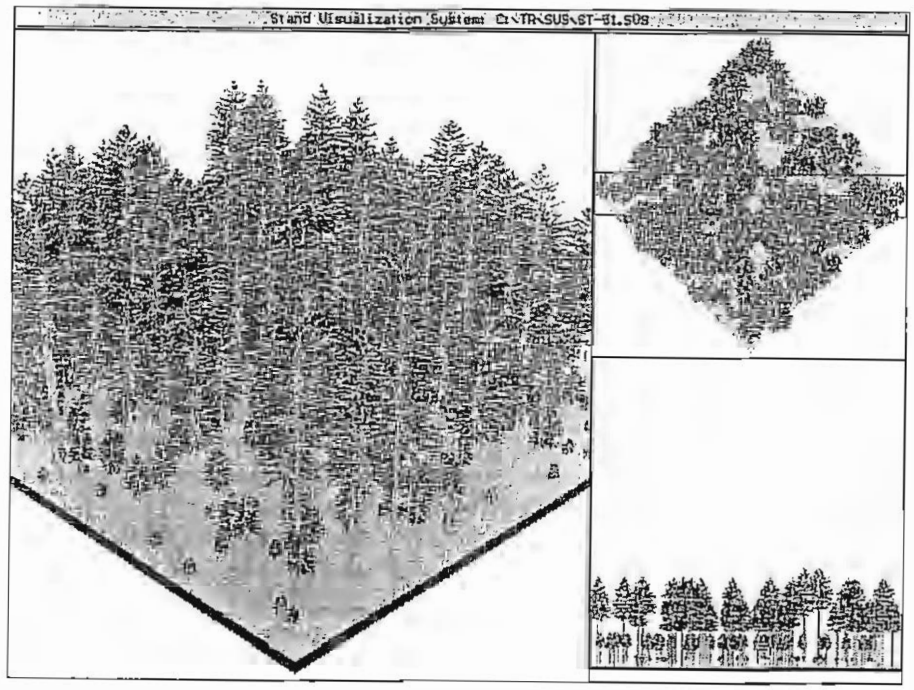

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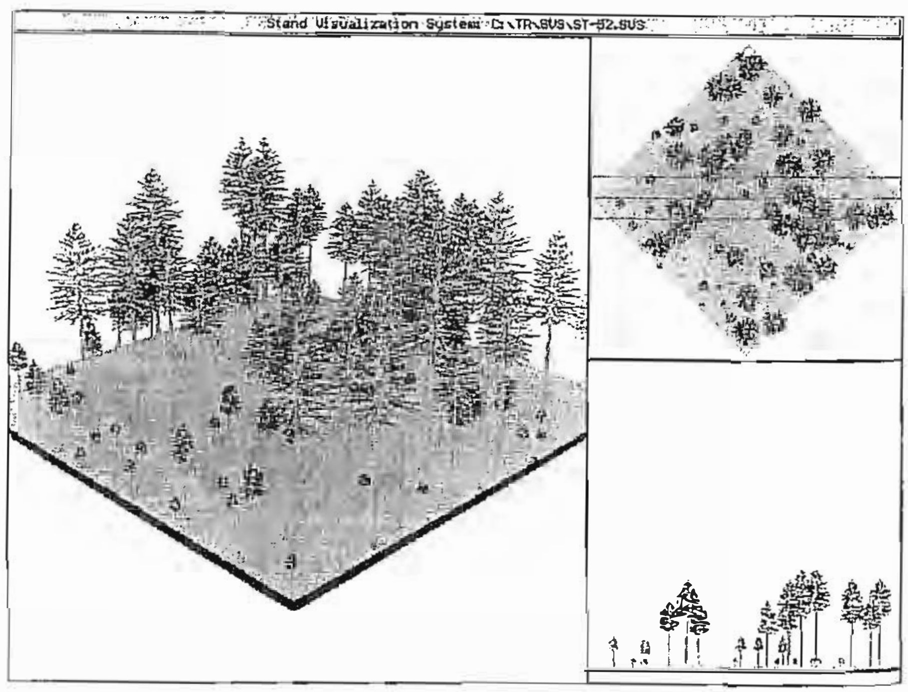


Wittemyer-E (WITT-E) Acres: 33.4

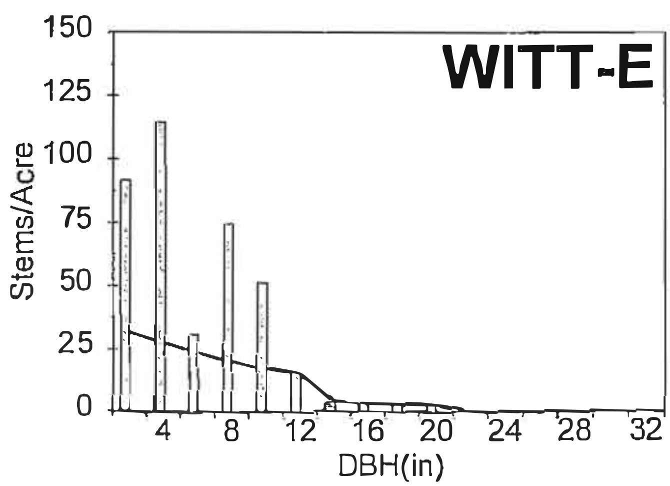
Specific Stand Objective: Thin trees in 4" to 10" size classes. Maintain open conditions with prescribed fire.

Treatment Recommendation: Thin from 86 to 40 BA. Much of BA to be removed is in the 10" size class. There are many trees in larger size classes and this stand should continue to develop into a mature stage. There are areas between the inventoried WITT stands that should be treated along with these units. Most of these areas are more open savanna forest areas.

Special Considerations:
Native vegetation: Holly-grape has high cover in this stand. Two rare plant communities–mountain mahogany/Scribner's needlegrass (*Cercocarpus montanus/Acnatherum scribneri*) and ponderosa pine/spike fescus (*Pinus ponderosa/Leucopoa kingii*)--may be present. Additional fieldwork is needed to verify the presence of these communities.
Nonnative plant species: Japanese brome has the highest cover.
Wildlife: Five snags were noted during inventory. Large numbers of trees in larger diameter classes suggest that many could be recruited in this area.
Other: This stand is located above north Boulder and private subdivisions are above and below the unit.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	91.7	114.6	30.6	74.5	51.3	15.3	3.7	2.9	3.4	2.8	0.0	0.0	0.0	0.0	0.0	0.0	390.8
BA	2.0	10.0	6.0	26.0	28.0	12.0	4.0	4.0	6.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	104.1
Prescription:																	
Stems/Ac	31.9	27.2	23.3	19.9	17.0	15.0	4.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	147.2
BA	0.7	2.4	4.6	6.9	9.3	11.8	4.3	4.2	5.3	6.5	0.0	0.0	0.0	0.0	0.0	0.0	55.9
Difference:																	
Stems/Ac	59.8	87															
BA	1.3	7.															



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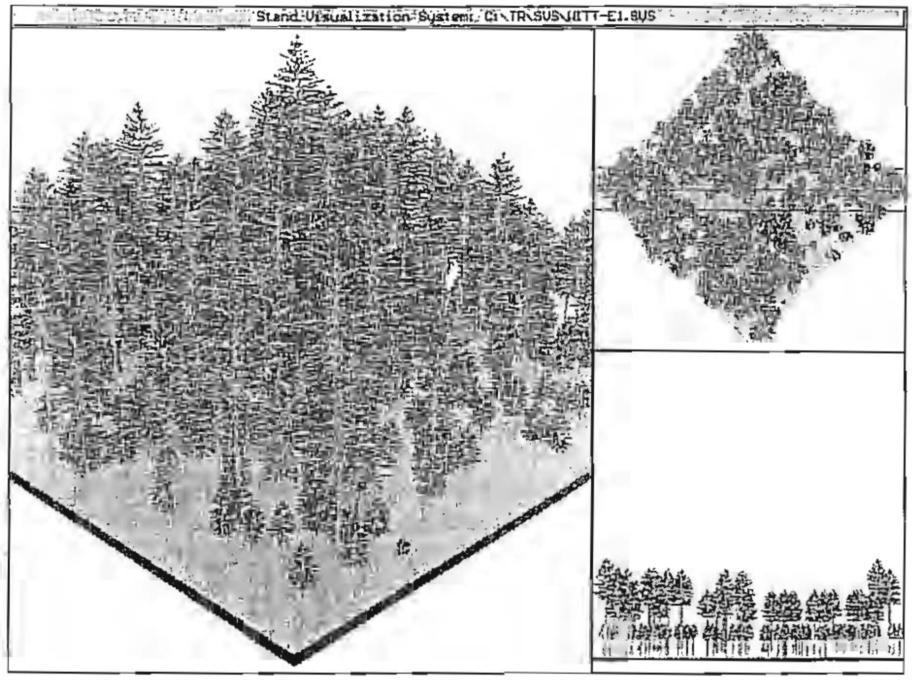

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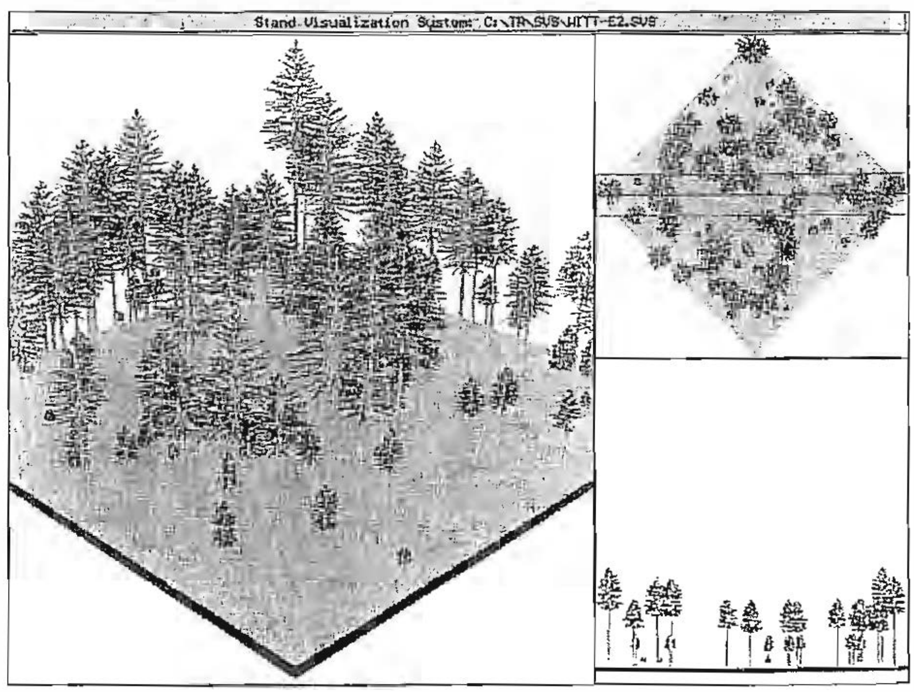


Wittemyer-S (WITT-S) Acres: 23.6

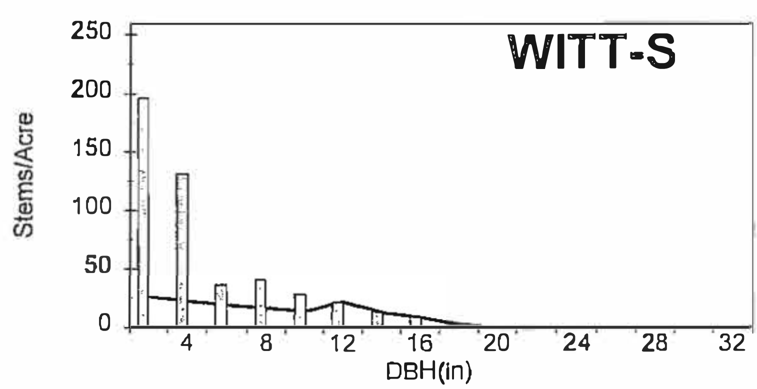
Specific Stand Objective: Heavily reduce regeneration in stand. Thin trees in 4" to 10" size classes to remove BA and trees/ac. Maintain open conditions with prescribed fire.

Treatment Recommendation: Thin from 62-40 BA. Abundant regeneration in the stand is the biggest treatment problem. Access to unit appears to be limited at this time. There are areas between the inventoried WITT stands that should be treated along with these units. Most of these areas appear to be more open savanna forest areas.

Special Considerations:
Native vegetation: Three rare plant communities--mountain mahogany/Scribner's needlegrass (*Cercocarpus montanus/Acnatherum scribneri*), mountain mahogany/needlegrass (*Cercocarpus montanus/Hesperostipa comata*), and ponderosa pine/spike fescue (*Pinus ponderosa/Leucopoa kingii*)--may be present. Additional fieldwork is needed to verify the presence of these communities.
Nonnative plant species: Bladder senna (*Colutea arborescens*), a nonnative shrub, has become established in the understory. Fire effects are unknown. Bladder senna (*Colutea arborescens*) has become established in the understory. Fire effects on this species are unknown.
Nonnative plant species: Cheatgrass has the highest cover.
Wildlife: No snags were noted during inventory. Large numbers of trees in larger diameter classes suggest that many could be recruited in this area.
Other: This unit is right above north Boulder and private subdivisions are above and below the unit.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	196.4	131.0	36.4	40.9	28.8	21.8	13.4	9.2	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	481.1
BA	4.3	11.4	7.1	14.3	15.7	17.1	14.3	12.8	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	102.8
Prescription:																	
Stems/Ac	26.2	22.4	19.2	16.4	14.0	22.0	13.0	9.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	145.2
BA	0.6	2.0	3.8	5.7	7.6	17.3	13.9	12.6	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	68.7
Difference:																	
Stems/Ac	170.2	108.6	17.2	24.5	14.8												
BA	3.7	9.5	3.4	8.6	8.1												



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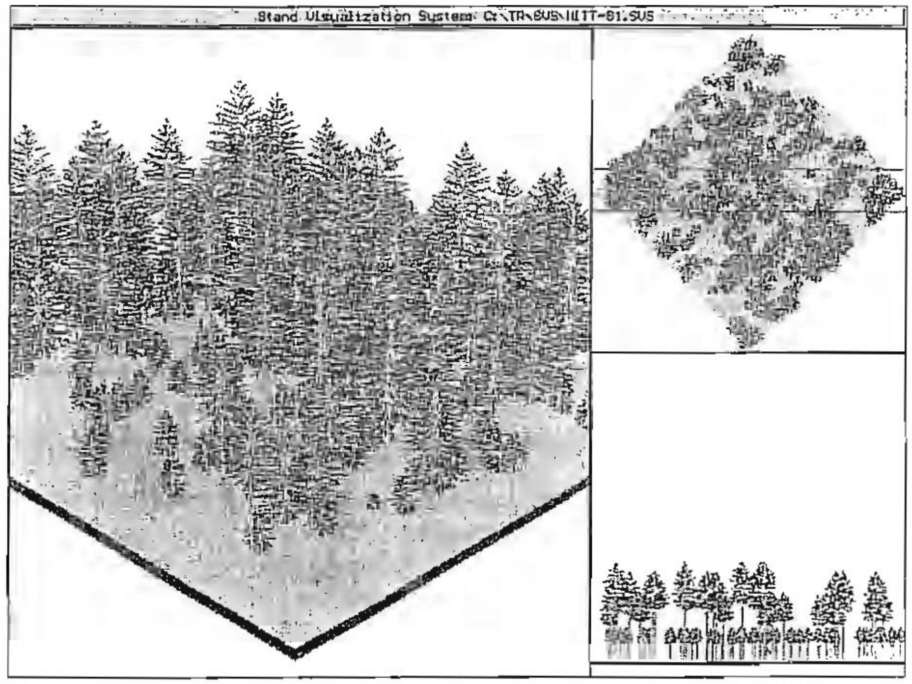

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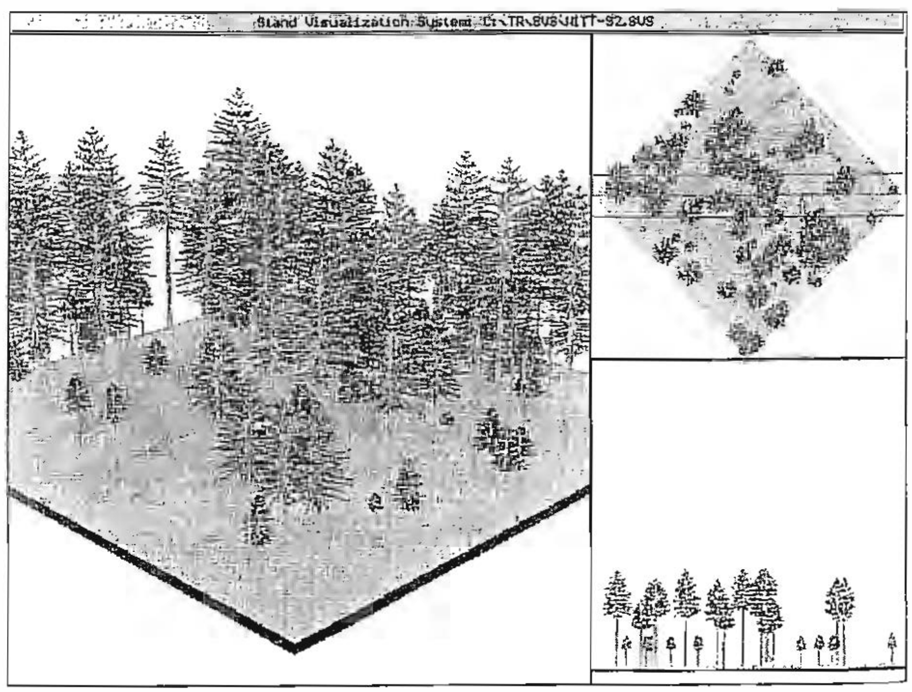


Wittemyer-W (WITT-W) Acres:43.2

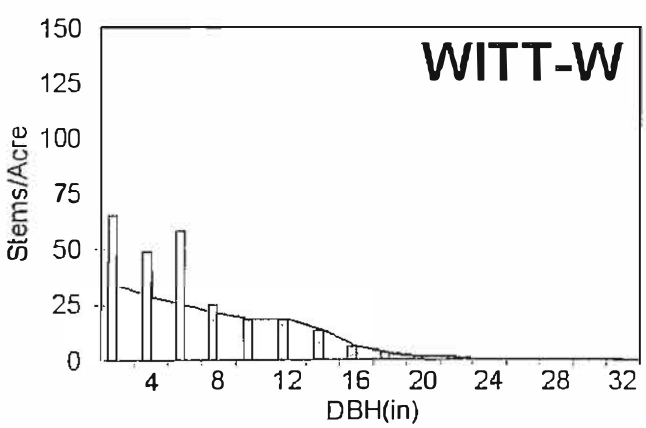
Specific Stand Objective: Maintain open conditions and promote ecosystem processes using prescribed fire.

Treatment Recommendation: Thin stand from 84 to 72 Basal area. Heavy thinning is needed in the 2" to 6" size classes to reduce numbers of trees in the unit. Heavy regeneration will also need to be removed from the unit with prescribed fire. Some trees in 8" size classes should also be removed during thinning operations.

Special Considerations:
Native vegetation: A rare plant community--ponderosa pine/spike fescue (*Pinus ponderosa/Leucopoa kingii*)--may be present. Additional fieldwork is needed to verify the presence of this community.
Nonnative plant species: Bladder senna (*Colutea arborescens*), a nonnative shrub, has become established in the understory. Fire effects are unknown.
Nonnative species: Bladder senna (*Colutea arborescens*), a nonnative shrub, has become established in the understory. Fire effects on this species are unknown.
Wildlife: One snag was noted during inventory. Large numbers of trees in larger diameter classes suggest that many could be recruited in this area.
Other: This stand has been treated in the past. This unit is right above north Boulder and private subdivisions are above and below the unit.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Totals
Current:																	
Stems/Ac	65.5	49.1	58.2	24.6	18.3	18.2	13.4	6.1	3.2	1.3	1.1	0.0	0.0	0.0	0.0	0.0	259.0
BA	1.4	4.3	11.4	8.6	10.0	14.3	14.3	8.5	5.7	2.8	2.9	0.0	0.0	0.0	0.0	0.0	84.2
Prescription:																	
Stems/Ac	33.7	28.8	24.6	21.1	18.0	18.0	13.0	6.0	3.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	168.3
BA	0.7	2.5	4.8	7.4	9.8	14.1	13.9	8.4	5.3	2.2	2.6	0.0	0.0	0.0	0.0	0.0	71.8
Difference:																	
Stems/Ac	31.8	20.3	33.6	3.5	(0.0)												
BA	0.7	1.8	6.6	1.2	(0.0)												



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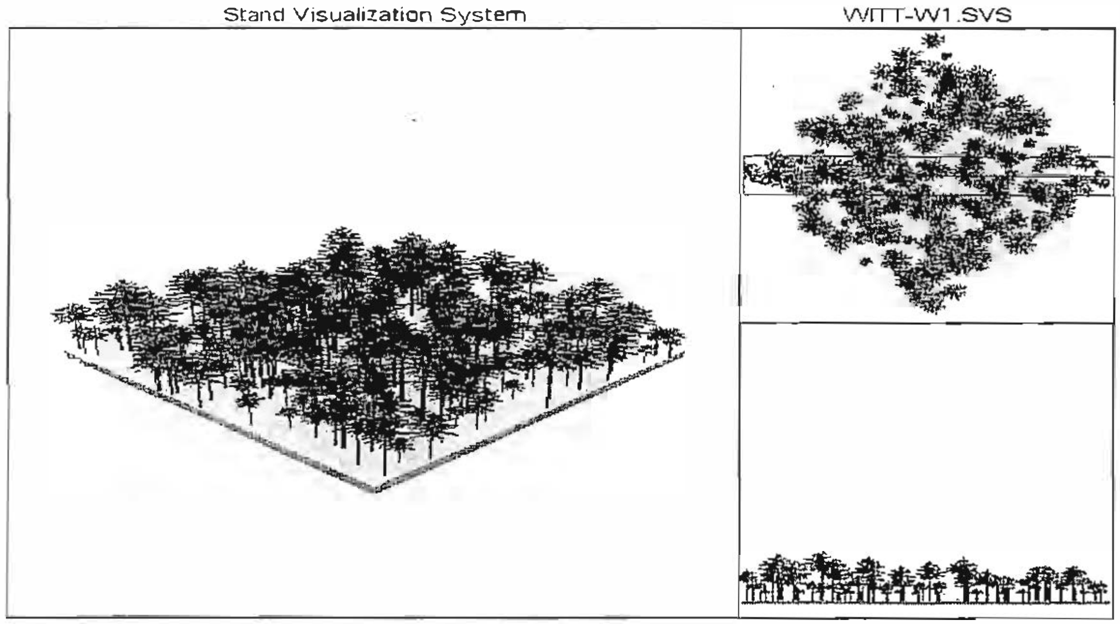

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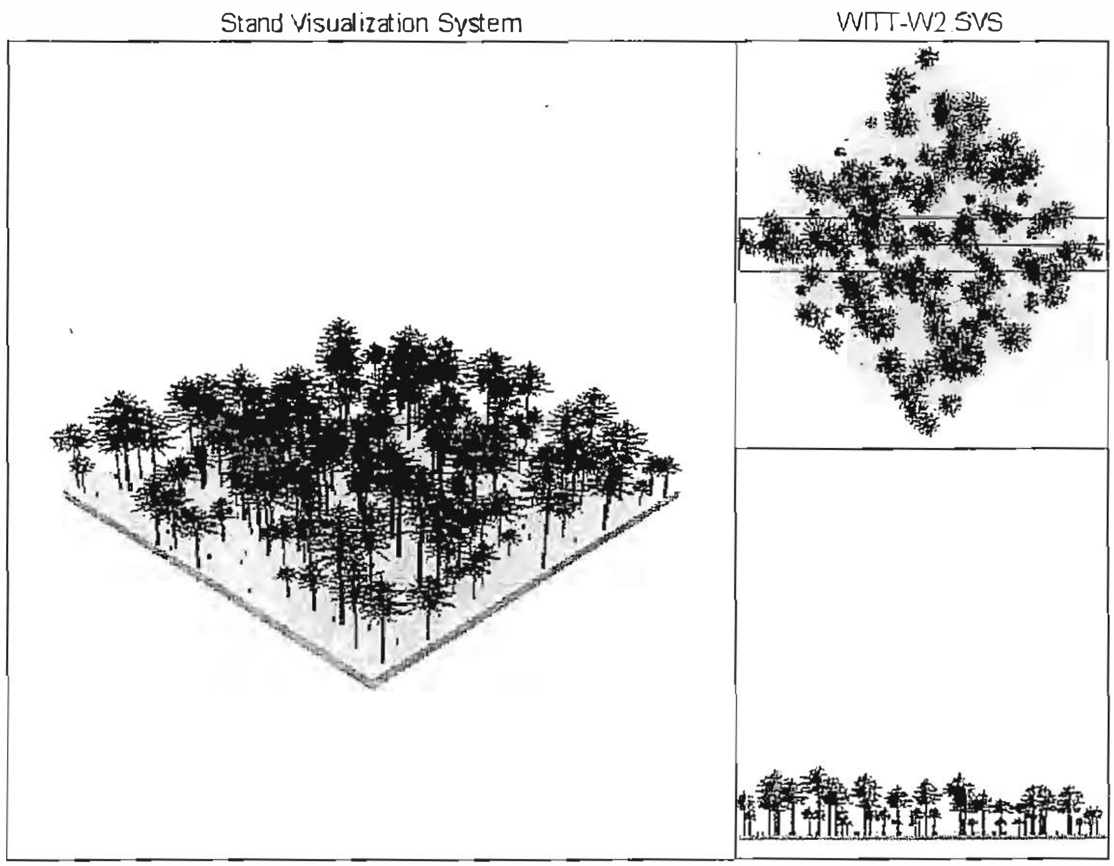


Group II Forest Stands

These stands are amenable to the reintroduction of prescribed fire without significant thinning beforehand.

Bonnie S-Schnell (BS) Acres: 32.9

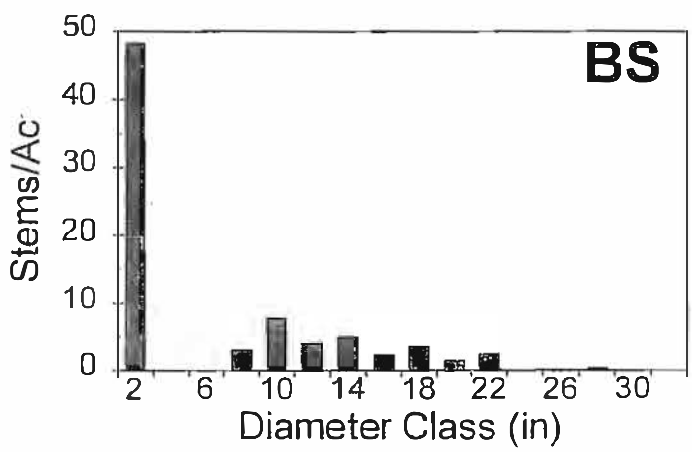
Specific Stand Objective: Maintain open forest conditions and reduce heavy regeneration, especially Douglas-fir seedlings and saplings.

Treatment Recommendations: Moderate intensity understory burn. The unit is on a south-facing slope above Boulder Creek with a low BA of 35 and a canopy cover of 28%. Open conditions are coupled with some of the larger trees in Open Space. There is heavy regeneration in the unit (21 seedlings/ac and 53 saplings/ac), primarily Douglas Fir. Mechanical lop and scatter techniques will be needed to remove ladder fuels prior to burning. Raking of duff layers around larger trees also is recommended to reduce possibility of moisture stress caused by burning.

Special Considerations:
Native vegetation: An understory vegetation inventory needs to be completed on this stand.
Wildlife: No snags were recorded in forest inventory and should be promoted in the stand.
Soils: This unit is located on a steep slope of 38% and soil erosion after burning should be expected, but can be minimized by burning in late spring or fall.
Recreation: The Tenderfoot Trail runs through the middle of the unit.
Other: Private land adjoins the northwest side of the unit. Treatment of this unit could be coupled with treatments on adjoining Mountain Parks units to the southwest, south, and east. After initial prescribed fire treatment, stand will need episodic prescribed fires to maintain current open conditions and restore ecosystem processes. Existing road can be used for access.

Diameter class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	48.2	0.0	0.0	3.0	7.7	4.0	4.9	2.3	3.6	1.4	2.4	0.0	0.0	0.2	0.0	0.0	77.8
BA	1.1	0.0	0.0	1.1	4.2	3.2	5.3	3.2	6.3	3.2	6.3	0.0	0.0	1.1	0.0	0.0	34



Dunn-1/81 (D-1/81) Acres: 11.2

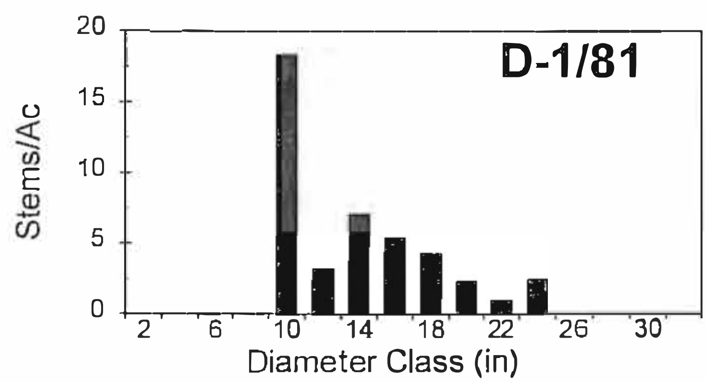
Specific Stand Objective: Maintain open stand conditions.

Treatment Recommendations: Understory burn. This is, in general, an open stand with many trees greater than 8" DBH. However, inventory data recorded heavy regeneration in the unit (50 seedlings/acre, 38 saplings/acre) and pre-treatment by **lopping and scattering** may be needed in areas of the unit.

Special Considerations:
Native vegetation: Douglas-fir, Rocky Mountain juniper, and common juniper are vulnerable to fire.. High shrub species diversity for such a small stand. Both cool- and warm-season native grasses are present. Four rare plant communities--mountain mahogany-threeleaf sumac/big bluestem (*Cercocarpus montanus-Rhus aromatica/Andropogon gerardii*), mountain mahogany/needlegrass (*Cercocarpus montanus-Hesperostipa comata*), Rocky Mountain juniper/mountain mahogany (*Sabina scopulorum/Cercocarpus montanus*), and ponderosa pine/mountain mahogany/big bluestem (*Pinus ponderosa/Cercocarpus montanus/Andropogon gerardii*)—may be present. Additional fieldwork is needed to verify the presence of these communities.
Nonnative plant species: Species with highest cover are Japanese brome, musk thistle, St. Johnswort, and prickly lettuce.
Wildlife: No snags were recorded during inventory. However, overall tree density in the unit is second lowest in Open Space stands and conversion of living trees should be limited.
Recreation: The Mesa Trail is at the bottom (east) of the unit. Informational signing will be necessary.
Soils: The unit is located on steeper slopes at the base of the Flatirons and soil erosion after burning may be a problem.
Other: There is high visibility from El Dorado Canyon and south Boulder. Smoke management during burns will be critical. There are adjoining forested areas to the east that were not incorporated in stand inventories and could be burned in conjunction with this or other stands in the area.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	0.0	0.0	18.3	3.2	7.0	5.4	4.2	2.3	0.9	2.4	0.0	0.0	0.0	0.0	43.8
BA	0.0	0.0	0.0	0.0	10.0	2.5	7.5	7.5	7.5	5.0	2.5	7.5	0.0	0.0	0.0	0.0	50



Dunn-1 (D-1): Acres: 11.6

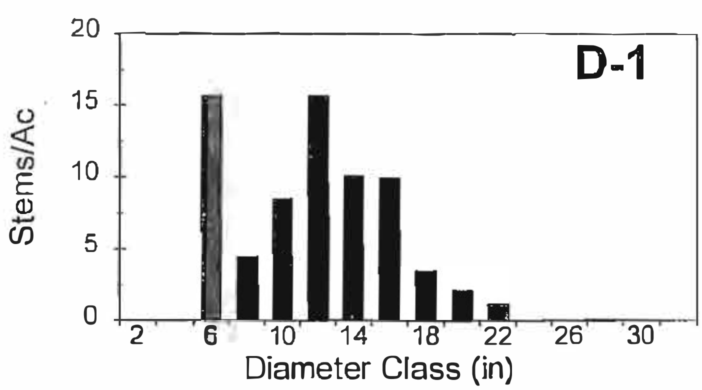
Specific Stand Objective: Maintain open stand conditions and promote wildlife habitat with snag creation.

Treatment Recommendations: Understory burn. This is an open unit with low density and canopy cover, no regeneration recorded in forest inventory, and large numbers of 20"+ DBH trees. After initial prescribed fire treatment, stand will need episodic prescribed fire to maintain current open conditions and restore ecosystem processes.

Special Considerations:
Native vegetation: Leadplant (*Amorpha nana*), a rare plant in local lower ponderosa pine forests, will be carefully monitored in this stand. Relatively high cover of both cool- and warm-season native grasses and sedges.
Nonnative plant species: Species with the highest cover are Japanese brome, Canada bluegrass, and St. Johnswort. Spring burning could decrease cover of these species, but could also impact native cool-season grasses like needlegrass and junegrass.
Wildlife: Two snags were recorded in the forest inventory. However, many trees in 18" to 22" size classes suggest that snags could be recruited from this population.
Recreation: Mesa Trail and Big Bluestem Trail are near the stand. Informational signing will be necessary.
Other: There is high visibility from El Dorado Canyon and south Boulder. Smoke management during burns will be critical. There are adjoining grassland areas that could be burned in conjunction with this stand.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	15.7	4.4	8.5	15.7	10.1	9.9	3.5	2.1	1.2	0.0	0.0	0.0	0.0	0.0	71.0
BA	0.0	0.0	3.1	1.5	4.6	12.3	10.8	13.8	6.2	4.6	3.1	0.0	0.0	0.0	0.0	0.0	60



Dunn-2 (D-2) Acres: 25.5

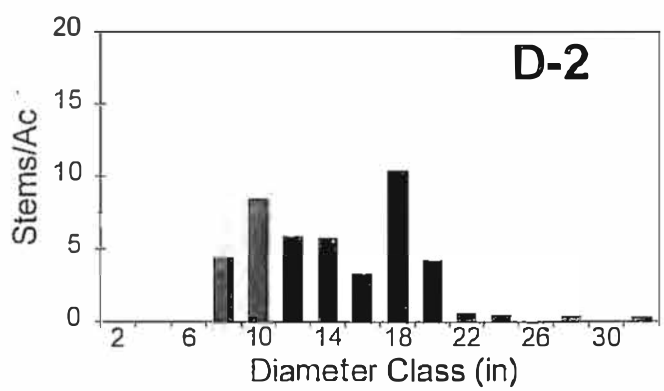
Specific Stand Objective: Maintain open stand conditions.

Treatment Recommendations: Understory burn. This is an open unit with low tree density and canopy cover and large numbers of 20"+ diameter trees, including one of the largest trees recorded during the Open Space inventory. There are areas of regeneration with 15 seedlings/acre. Lop-and-scatter may be needed for pre-treatment in some areas. Raking of duff layers around larger trees also is recommended to remove possibility of moisture stress caused by burning. After initial prescribed fire treatment, stand will need episodic prescribed fires to maintain current open conditions and restore ecosystem processes.

Special Considerations:
Native vegetation: Rocky Mountain juniper is vulnerable to fire. Native warm season grasses, including big bluestem, Indian grass, and switchgrass, are abundant in and adjacent to this stand. Warm season grasses tend to be favored by spring burning and may be harmed by summer burning.
Nonnative plant species: Species with the highest cover are Canada bluegrass, cheatgrass, and Japanese brome, all cool-season grasses that could decrease with spring burns. However, spring burns could also impact native cool season grasses like needlegrass and junegrass.
Wildlife: No snags were recorded in the forest inventory. However, many trees in 18"+ size classes suggest that snags could be recruited from this population.
Recreation: Several established hiking trails are in the vicinity of the unit. Informational signing will be necessary.
Other: The unit is right above housing and recreational areas in El Dorado Canyon. Smoke management during bums will be critical. There are adjoining grassland areas that could be burned in conjunction with this stand. Cultural resources needed to be protected.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	0.0	4.4	8.5	5.9	5.8	3.3	10.4	4.2	0.6	0.5	0.0	0.4	0.0	0.3	44.2
BA	0.0	0.0	0.0	1.5	4.6	4.6	6.2	4.6	18.5	9.2	1.5	1.5	0.0	1.5	0.0	1.6	55



Dunn-3 and Dunn-4 (D-3 and D-4) Acres: 73.8

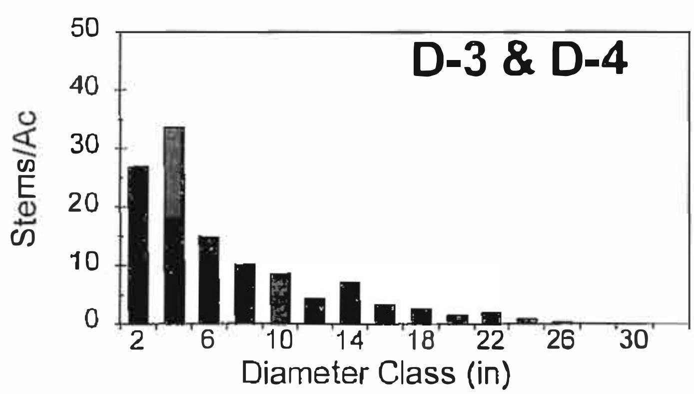
Specific Stand Objective: Reduce heavy regeneration and maintain open stand conditions.

Treatment Recommendations: Understory burn. Abundant regeneration in this stand will likely need lopping and scattering pre-treatment. Otherwise, stand overstory is open and many larger-diameter trees suggest this stand should continue into a healthy climax stage. Raking of duff layers around larger trees also is recommended to remove possibility of moisture stress caused by burning. After initial prescribed fire treatment, stand will need episodic prescribed fires to maintain current open conditions and restore ecosystem processes.

Special Considerations:
Native vegetation: Rocky Mountain juniper and Douglas-fir are vulnerable to fire. High cover of native warm season grasses, espeically big bluestem, which may be adversely impacted by summer burning.
Nonnative plant species: Canada bluegrass and St. Johnswort are species with highest cover. These species could decrease with spring burning, but native cool-season grasses could be adversely impacted. Diffuse knapweed found in plot 25.
Wildlife: Only one snag was recorded in the forest inventory. However, many trees in 18"+ size classes suggest that snags could be recruited from this population.
Recreation: Several hiking trails are in or in the vicinity of the unit. Informational signing will be necessary.
Other: The unit is near housing and recreation areas in El Dorado Canyon and visibility from south Boulder is high. Smoke management during burns will be critical. There are adjoining grassland areas to the east of the unit that could be burned in conjunction with this stand.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	27.0	33.7	15.0	10.1	8.6	4.5	7.2	3.4	2.7	1.6	2.0	0.9	0.3	0.0	0.0	0.0	116.9
BA	0.6	2.9	2.9	3.5	4.7	3.5	7.6	4.7	4.7	3.5	5.3	2.9	1.2	0.0	0.0	0.0	48



Dakota Ridge (DAKR) Acres: 11.9

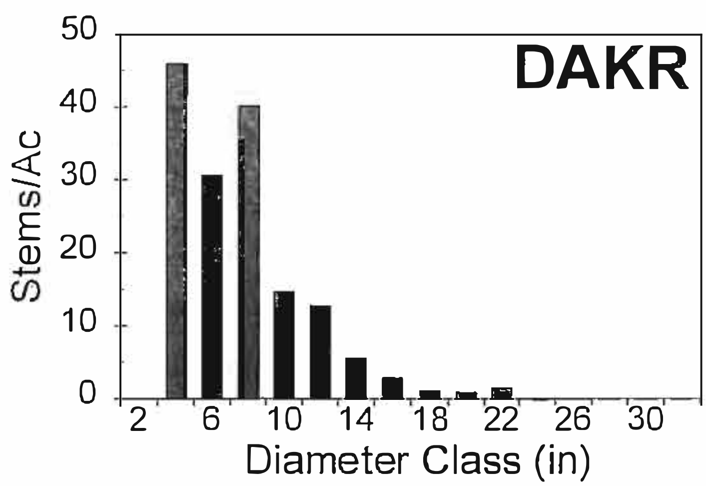
Specific Stand Objective: Maintain open savanna conditions.

Treatment Recommendations: Understory burn. This is an open savanna stand on the hogback just west of north Boulder with a BA of 60. There is some regeneration (20 seedlings/ac, 30 saplings/ac) to be reduced during burning or with pre-treatment lop-and-scatter. After initial prescribed fire treatment, stand will need episodic prescribed fires to maintain current open conditions and restore ecosystem processes.

Special Considerations:
Native vegetation: Hackberry trees present on all understory plots; fire effects on this uncommon tree are unknown.
Nonnative plant species: Cheatgrass and Canada bluegrass have the highest cover.
Wildlife: No snags were recorded in the forest inventory.
Recreation: A hiking trail exists in the stand.
Other: The unit is very close to housing areas in north Boulder. Smoke management during burns will be critical. There are adjoining grassland areas on all sides of the unit that could be burned in conjunction with this stand.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	45.8	30.6	40.1	14.7	12.7	5.6	2.9	1.1	0.9	1.5	0.0	0.0	0.0	0.0	0.0	155.9
BA	0.0	4.0	6.0	14.0	8.0	10.0	6.0	4.0	2.0	2.0	4.0	0.0	0.0	0.0	0.0	0.0	60



Fox-E Acres: 18.5

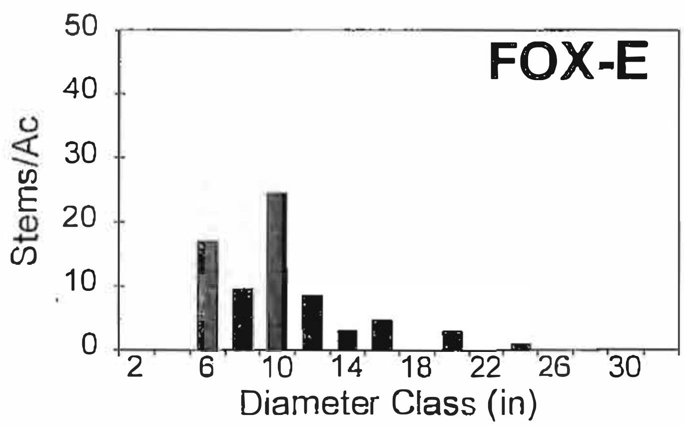
Specific Stand Objective: Reduce abundant regeneration, especially Douglas-fir; maintain open stand conditions.

Treatment Recommendations: Low intensity understory burn. This is an open stand with a low BA of 47. However, abundant regeneration of mostly Douglas-fir in the understory will need to be removed by fire or likely by lop-and-scatter pre-treatment in some locations. The stand is on steep slopes on the south side of Boulder Canyon, and removal of regeneration by fire may be more difficult than in footslope areas.

Special Considerations:
Native vegetation: An understory vegetation inventory needs to be completed for this stand.
Wildlife: This stand is probably heavily used by wildlife to reach the riparian corridor below. No snags were seen in inventory plots and should be promoted in the future stand.
Other: Private land to the south and west sides of this unit may make access difficult. This unit could be burned in conjunction with Mountain Parks stands to the west that are also on the south side of Boulder Canyon.

Diameter class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	17.0	9.5	24.4	8.5	3.1	4.8	0.0	3.1	0.0	1.1	0.0	0.0	0.0	0.0	71.5
BA	0.0	0.0	3.3	3.3	13.3	6.7	3.3	6.7	0.0	6.7	0.0	3.3	0.0	0.0	0.0	0.0	47



Kassler (KSLR) Acres: 13.8

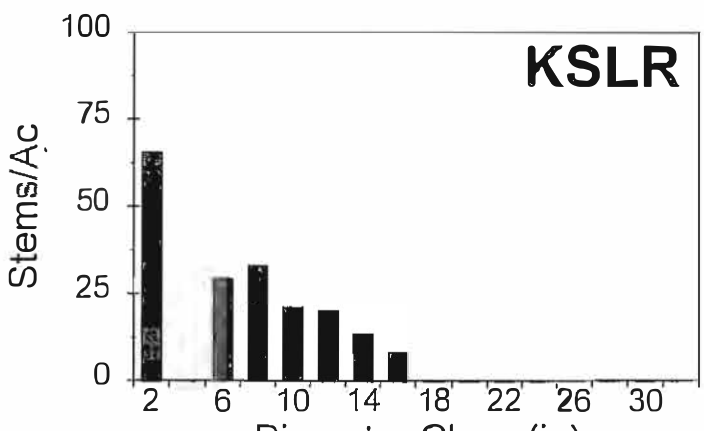
Specific Stand Objective: Reduce abundant small diameter trees and maintain open overstory conditions.

Treatment recommendations: Understory burn. This stand has a BA of 71. Abundant seedlings and saplings (86 seedlings and 64 saplings/acre) will need to be lopped-and-scattered during stand pre-treatment. Much of the regeneration is Douglas-fir that should be cut preferentially. This stand is located at the mouth of Boulder Canyon near housing areas in west Boulder, with Mountain Parks stands on the west and south. The stand is on a steep slope with high erosion potential.

Special Considerations:
Native vegetation: An understory vegetation inventory needs to be completed for this stand.
Wildlife: This stand is probably heavily used by wildlife to reach the riparian corridor below. Only one snag was noted in inventory. However, there are few larger-diameter trees in the unit and possibility for snag recruitment may be limited.
Other: Because of the unit's location close to housing areas, smoke management during prescribed fires will be critical. This area could be burned in conjunction with adjoining areas of Mountain Parks to the south and west and savanna areas of Open Space to the east.

Diameter Class: (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	65.5	0.0	29.1	32.7	21.0	20.0	13.4	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	189.8
BA	1.4	0.0	5.7	11.4	11.4	15.7	14.3	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70



Lindsay-S (LIND-S) Acres: 52.6

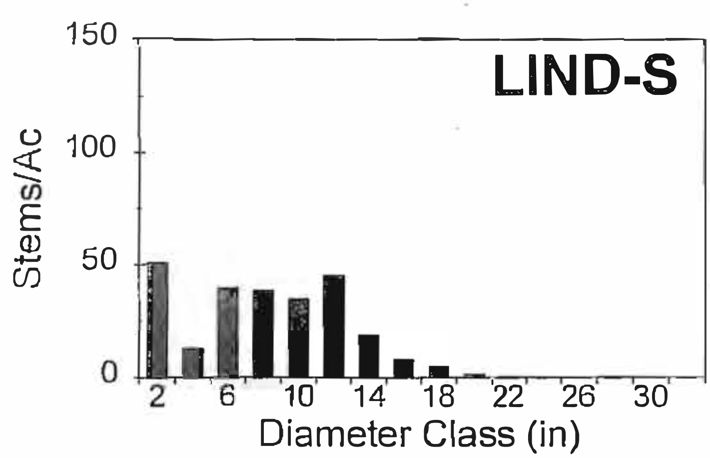
Specific Stand Objective: Reduce regeneration and overall basal area to create more open stand conditions.

Treatment Recommendation: Understory burn with passive torching to encourage tree mortality. This is the most dense stand recommended for burn-only treatment under this plan, and this area may need mechanical thinning of size classes up to 10 inches depending upon successful implementation of prescribed fire treatments in other units. Overstory conditions in this stand are similar to those in LIND-N, although greater tree density is in smaller diameter classes that may be thinned successfully with fire only. Basal area in the stand is high with large numbers of mid-sized trees. Passive torching is to be expected during burning. The recent prescribed fire in this stand (1995) caused an area of significant tree mortality and this pattern is to be encouraged as a means of creating stand heterogeneity and increasing snags and coarse woody debris in the ecosystem. The stand is more open on the south near the LJC stands, and there are areas of open savanna forests and grasslands to the north that could be treated in conjunction with this unit.

Special Considerations:
Native vegetation: Rocky Mountain juniper and common juniper are vulnerable to fire.
Nonnative plant species: Species with highest cover are Canada bluegrass, cheatgrass, and St. Johnswort, all of which could be reduced by spring bums. Several nonnative species occur in patches in the 1995 bum area, including musk thistle, prickly lettuce, mullein, timothy, and Canada thistle. These species will be monitored annually.
Wildlife: Fifteen snags were noted during the inventory and were likely created during the recent prescribed fire in this unit. More snags could be recruited from the living tree population to help reduce total stand BA.
Other: The stand is next to the canal road which is used by hikers and horseback riders. This area has low visibility from Boulder.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	50.9	12.7	39.6	38.2	34.6	45.3	18.7	8.0	5.0	1.5	0.4	0.0	0.0	0.0	0.0	0.0	255.0
BA	1.1	1.1	7.8	13.3	18.9	35.6	20.0	11.1	8.9	3.3	1.1	0.0	0.0	0.0	0.0	0.0	121



Lindsay-Jeffco-SE (LJC-SE) Acres: 44.9

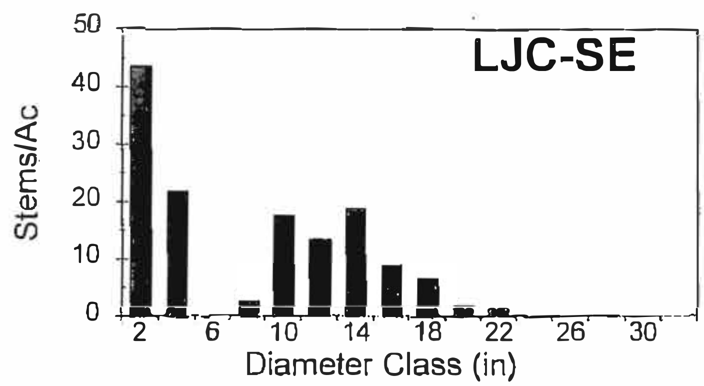
Specific Stand Objective: Reduce understory regeneration and maintain open stand conditions.

Treatment Recommendation: Understory burn. Heavy regeneration in this unit will likely need lop-and-scatter pre-treatment before implementation of prescribed fire. Unit is for the most part relatively level on the footslope and application of fire should be easier than in some of the denser stands. Many smaller diameter trees in the stand may be thinned by fire. Much of BA is in larger diameter trees and the stand should develop into a healthy climax stage. This stand and LJC-SW could be treated as one unit. In addition, areas of savanna and grassland to the east could be burned in conjunction with this stand. Episodic prescribed fires in the south end of this unit will maintain open stand conditions and ecosystem processes in this area.

Special Considerations:
Native vegetation: Meadow arnica (*Arnica fulgens*) cover is high. This species may be sensitive to spring burning, but unaffected by summer burning since it is summer dormant.
Nonnative plant species: Species with highest cover are Canada bluegrass, cheatgrass, and St. Johnswort, which could all decrease with spring burns.
Wildlife: Only two snags were inventoried in 21 plots from this stand and they will need to be promoted in the future. Many trees in the 14" to 18" size classes could be used to create snags. Elk have been sighted in this stand.
Other: The unit is at the south end of Open Space in an area of low visibility from Boulder, although visibility from Highway 93 is high.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	43.7	21.8	0.0	2.7	17.5	13.3	18.7	8.9	6.5	1.7	1.4	0.0	0.0	0.0	0.0	0.0	136.2
BA	1.0	1.9	0.0	1.0	9.5	10.5	20.0	12.4	11.4	3.8	3.8	0.0	0.0	0.0	0.0	0.0	74



Lindsay-Jeffco-SW (LJC-SW) Acres: 24.9

Specific Stand Objective: Maintain open stand conditions, reduce basal area of larger diameter trees and promote cavity nesting bird habitat by creating snags.

Treatment Recommendations: Understory burn with passive torching. Pretreatment in LJC-SW may be needed in some areas of denser overstory, although regeneration is low (5 seedlings/acre, 7 saplings/acre) and ladder fuels less likely. Patches of local overstory mortality are to be encouraged. Episodic prescribed fires will maintain open stand conditions and ecosystem processes.

Special considerations:
Native vegetation: Rocky Mountain juniper and Douglas-fir are vulnerable to fire. Two rare plant communities--Rocky Mountain juniper/mountain mahogany (*Sabina scopulorum/Cercocarpus montanus*) and mountain mahogany/needlegrass (*Cercocarpus montanus/Hesperostipa comata*)--may be present. Additional fieldwork is needed to verify the presence of these communities.
Nonnative plant species: Canada bluegrass and cinquefoil (*Potentilla recta*) are the species with highest cover. Canada bluegrass could be decreased by spring burns. Fire effects on cinquefoil are unknown.
Wildlife: No snags were recorded during the stand inventory and these should be promoted in the stand. Because of high numbers of trees in the 14" to 18" size classes, some should be converted to snags.
Other: This stand and LJC-SE are recommended to be burned together. Both are on the south end of Open Space property in an area with low visual impacts from Boulder, although visibility from Highway 93 will be high during stand treatments.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	Total
Stem/Ac	0.0	0.0	0.0	16.4	13.1	29.1	22.7	14.3	4.9	1.3	1.6	0.5	0.4	104.2
BA	0.0	0.0	0.0	5.7	7.1	22.9	24.3	20.0	8.6	2.9	4.3	1.4	1.4	99

Lower Shanahan Acres: 81.0

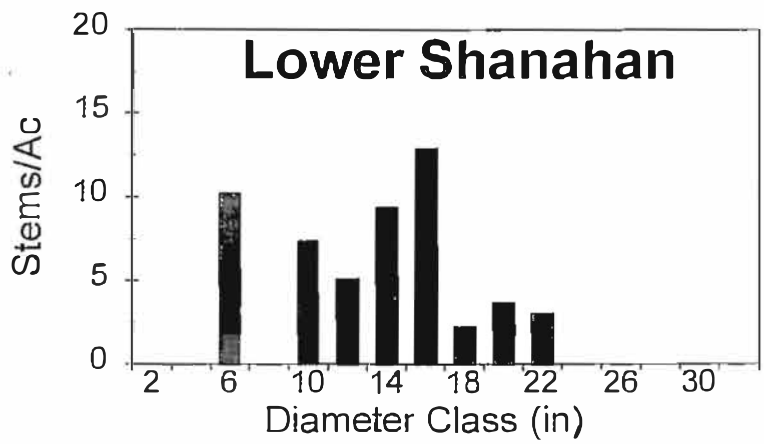
Specific Stand Objective: Maintain open savanna conditions and the grassland ecotone in this area.

Treatment Recommendation: Understory burn. This is one of the most open savanna stands on Open Space, although overstory conditions grade from very open in the east on the grassland ecotone to more closed nearer the foothills. Regeneration is higher than inventory suggests (only 10 seedlings/acre recorded in regeneration plots from stand) and pre-treatment lopping and scattering should be performed. This is a very large unit with good control points offered by numerous trails in the unit. Much of the BA is in larger diameter trees suggesting the stand should develop into a healthy climax stage.

Special Considerations:
Native vegetation: Both leadplant (*Amorpha nana*) and birdfoot violet (*Viola pedititfida*), the two rare plants that occur in the lower ponderosa pine forests, will be carefully monitored in this stand. Both warm and cool-season grasses and sedges are well represented.
Nonnative plant species: Species with highest cover are Canada bluegrass and Japanese brome. Diffuse knapweed occurs on plots 1 and 10.
Wildlife: No snags were recorded during inventory. However, large numbers of trees 14 inches in diameter and larger suggest that snags should be promoted from this population.
Recreation: This unit is one of the most heavily used on Open Space and several trails run through the stand. Public education prior to and during treatment implementation will be critical in this and surrounding stands in the area.
Other: Many of the other stands in this area could be treated concurrently. In addition, savanna and grasslands to the east and south should be burned in conjunction with this unit, both to reintroduce fire processes and to help maintain the ponderosa pine/grassland boundary where it is today.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	10.2	0.0	7.3	5.1	9.4	12.9	2.3	3.7	3.0	0.0	0.0	0.0	0.0	0.0	53.8
BA	0.0	0.0	2.0	0.0	4.0	4.0	10.0	18.0	4.0	8.0	8.0	0.0	0.0	0.0	0.0	0.0	58



McCann/Culberson/Dunn (MCCD) Acres: 44.9

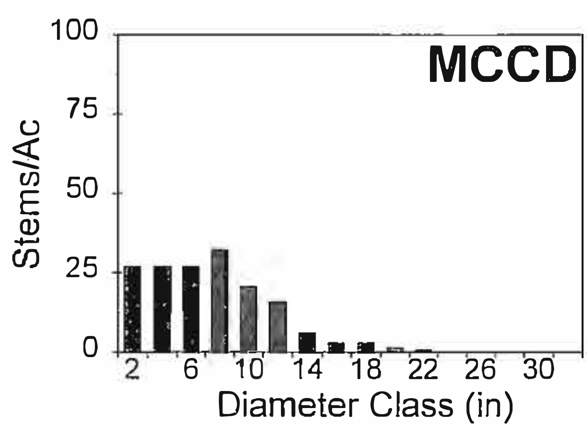
Specific Stand Objective: Reduce regeneration, especially Douglas-fir, and maintain open stand conditions.

Treatment Recommendation: Understory burn. This stand has a BA of 64. This unit is located on a steep hogback on the north slope above Eldorado Canyon and access will be more difficult than most other stands in Open Space. The stand has a wide distribution of size classes, including one of the largest trees recorded during stand inventories. There is abundant regeneration in the unit that may need lop-and-scatter pre-treatment thinning. Raking of duff layers from around the bases of larger trees will also reduce moisture stress after burning for these valuable older trees. There are grasslands with scattered savanna trees to both the east and west that could be burned in conjunction with this stand.

Special Considerations:
Native vegetation: An understory vegetation inventory needs to be completed on this stand.
Wildlife: Only two snags were noted during the inventory but more could be recruited from a population of 14"+ trees in the stand.
Recreation: Homestead, Towhee, and Mesa trails run through the north end of the unit.
Other: Grassland areas between MCCD and D-1 and D-2 should be considered for burning in conjunction with these stands. There are shrub communities on the west side that need to be considered during burning.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	27.0	27.0	27.0	32.0	20.5	15.7	6.1	2.9	3.0	1.3	0.7	0.0	0.0	0.0	0.0	0.1	163.2
BA	0.6	2.4	5.3	11.2	11.2	12.4	6.5	4.1	5.3	2.9	1.8	0.0	0.0	0.0	0.0	0.6	64



North Boulder Valley- North (NBV-N) Acres: 97.7

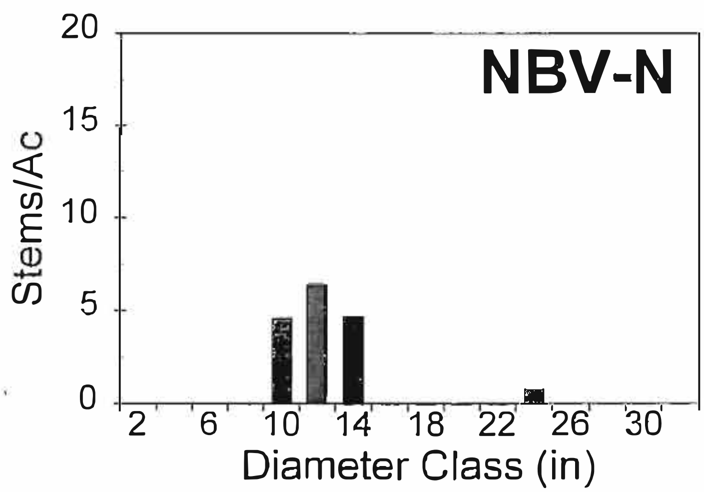
Specific Stand Objective: Maintain open savanna conditions.

Treatment Recommendation: This is the most open stand in Open Space with very little tree regeneration and a BA of 15. The stand will require episodic fires to maintain savanna conditions and the grassland margin.

Special Considerations:
Native vegetation: An understory inventory needs to be completed for this stand. A rare plant community--mountain mahogany/New Mexico feathergrass--may occur on this stand. Additional fieldwork is needed to verify the presence of this community.
Wildlife: No snags were recorded during the inventory; however, there were many potential snags created during the Old Stage fire in 1990.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	0.0	0.0	4.6	6.4	4.7	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	16.4
BA	0.0	0.0	0.0	0.0	2.5	5.0	5.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	15



North Boulder Valley-South (NBV-S) Acres: 37.0

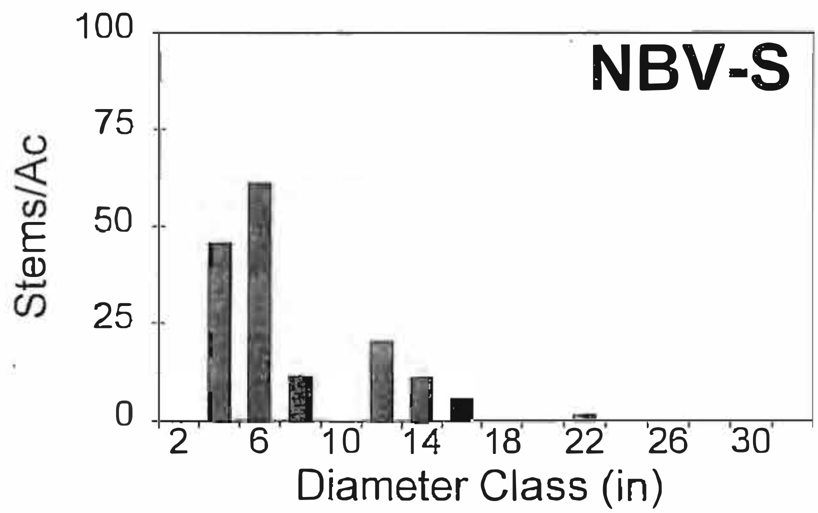
Specific Stand Objective: Reduce 4" and 6" trees and maintain open stand conditions.

Treatment Recommendation: Understory burn. This stand has a BA of 60. There are large numbers of 4" and 6" trees in the stand that will need to be thinned by lop-and-scatter before application of prescribed fire. The stand is on the east side of the hogback and is bordered by private land to the west.

Special Considerations:
Native vegetation: An understory inventory needs to be completed for this stand. A rare plant community--mountain mahogany/New Mexico feathergrass--may occur on this stand. Additional field is needed to verify the presence of this community.
Wildlife: No snags were seen during inventory but some could be promoted from high numbers of trees in 12" size class.
Other: The unit should be burned in conjunction with grassland and savanna areas to the east.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	45.8	61.1	11.5	0.0	20.4	11.2	5.7	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	157.3
BA	0.0	4.0	12.0	4.0	0.0	16.0	12.0	8.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	60



Pinebrook (PNBRK) Acres: 9.3

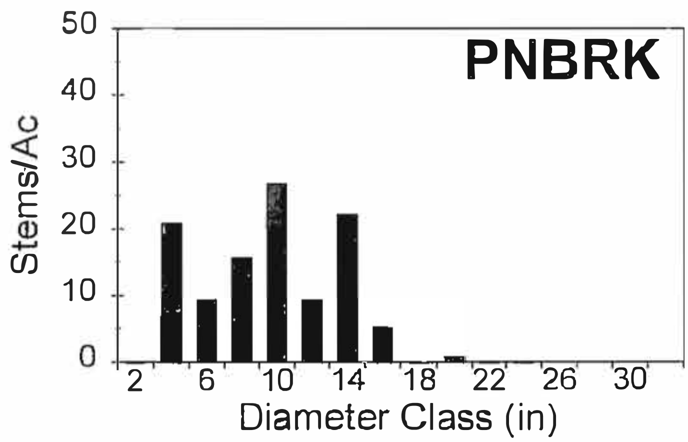
Specific Stand Objective: Maintain open stand conditions.

Treatment Recommendation: Understory bum. This stand has a BA of 64. There is little to no regeneration in this very open area. The west side of the unit borders on a subdivision and a fuel break will be needed in the overstory to reduce threat of overstory fire in this area. High visibility from north Boulder.

Special Considerations:
Native vegetation: Ninebark, a shrub which is typically found on north-facing slopes, has relatively high cover here. It will be monitored for fire effects. Native cool season grasses, especially thickspike wheatgrass (*Elymus lanceolatus)* and Colorado wild rye (*Leymus ambiguus*), are predominant; they may be adversely impacted by spring burning.
Nonnative plant species: Toadflax (*Linaria vulgaris*) occurs on this stand. Cheatgrass and Canada bluegrass have highest cover.
Wildlife: No snags were seen during inventory but they could be promoted from large numbers of 14" trees.
Other: Smoke management in this unit which is close to Boulder will be critical during precribed fire implementation.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	20.8	9.3	15.6	26.7	9.3	22.1	5.2	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	109.8
BA	0.0	1.8	1.8	5.5	14.5	7.3	23.6	7.3	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	64



Powerline Acres: 23.8

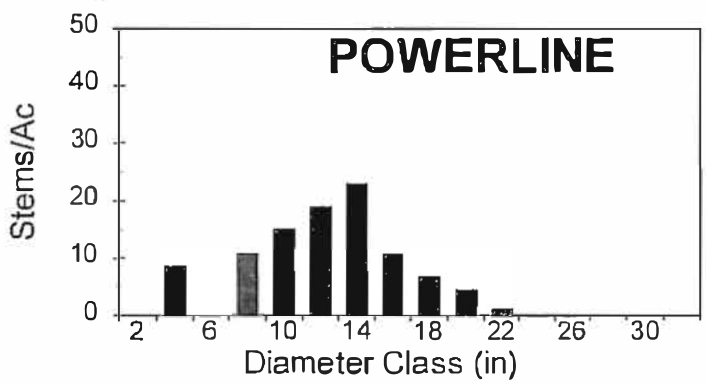
Specific Stand Objective: Reduce regeneration and promote open stand and old-growth conditions.

Treatment Recommendation: Understory burn to reduce seedling numbers in stand and promote open conditions. Stand has a large number of trees in 12"+ size classes and should develop into a healthy climax stage. The stand grades from more open areas to the east to more closed conditions, although still relatively open canopies, in the west.

Special Considerations:
Native vegetation: Douglas-fir is vulnerable to fire and will decrease in abundance with burning. Leadplant (*Amorpha nana*), a rare species, occurs in this stand and will be carefully monitored. Colorado wildrye (*Leymus ambiguus*), which is restricted to the eastern slope of Colorado and New Mexico, occurs on this stand and will be monitored for fire effects. Shrub species diversity is high in this stand and shrub cover is high in plots 1 and 25. Fire effects on shrubs need to be carefully monitored; buckbrush (*Ceanothus fendleri*) may increase with prescribed burning.
Nonnative plant species: The species with the highest cover are Japanese brome, timothy, Canada thistle, musk thistle, and myrtle spurge. Toadflax also occurs on this stand.
Wildlife: Five snags were noted during inventory and this stand has one of the highest densities of snags of any Open Space unit. However, greater snag density in this area could be promoted from large numbers of trees in 14" and larger size classes.
Recreation: Numerous hiking trails accessible from south Boulder run through this and adjacent units in this area. Public education and informational signing will be necessary.
Other: Openings between stands in this area should be treated in conjunction with surrounding units.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	8.5	0.0	10.6	14.9	18.9	22.9	10.6	6.7	4.4	1.1	0.0	0.0	0.0	0.0	0.0	98.6
BA	0.0	0.7	0.0	3.7	8.1	14.8	24.4	14.8	11.9	9.6	3.0	0.0	0.0	0.0	0.0	0.0	91



Shanahan-4 (S-4) Acres: 19.4

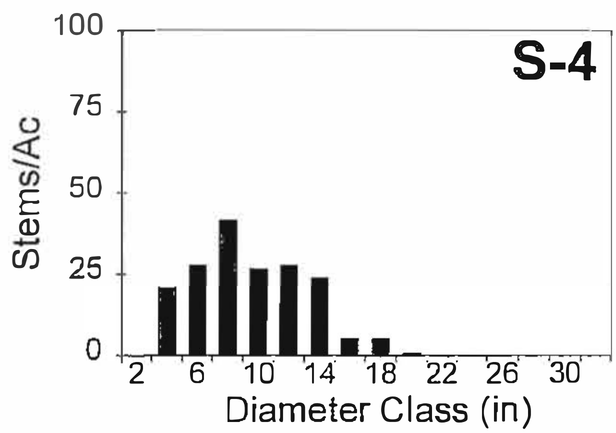
Specific Stand Objective: Reduce regeneration in stand, open canopy with local crowning fires, and maintain open stand conditions.

Treatment Recommendation: Understory burn with passive torching. This stand has a BA of 102. This stand, while generally open with a majority of the BA in larger diameter trees, does have a large number of trees in 4" to 14" size classes that could be thinned by passive torching to open up the canopy. This stand will need minor pretreatment to thin regeneration (46 seedlings/acre, 27 saplings/acre) that has come in since the Greenslope project.

Special Considerations:
Native vegetation: Understory vegetation cover very low and litter cover high.
Wildlife: One snag was recorded during stand inventory. Larger diameter trees in this stand suggest that snags can be recruited from this population.
Recreation: Numerous, often heavily used, trails are in this area and public education during application of prescribed fires in this area will be crucial.
Riparian communities: Several exist within the stand.
Other: There are open grasslands or savannas between many of the units in this area that should be treated at the same time as adjacent units.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	20.8	27.8	41.7	26.7	27.8	23.8	5.2	5.1	0.8	0.0	0.0	0.0	0.0	0.0	0.0	179.7
BA	0.0	1.8	5.5	14.5	14.5	21.8	25.5	7.3	9.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	102



Shanahan-5 (S-5) Acres: 46.0

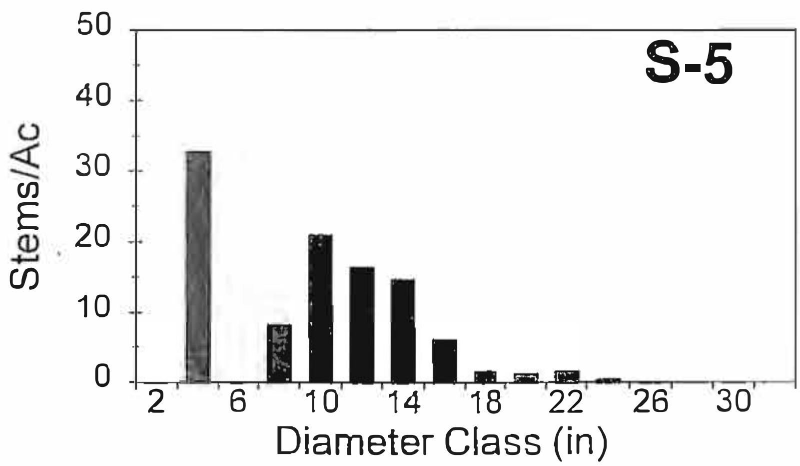
Specific Stand Objective: Maintain open stand conditions.

Treatment Recommendation: Understory burn. This stand has a BA of 65. This stand is very open with a majority of the BA in larger diameter trees. This stand will need pretreatment by lop-and-scatter to thin regeneration (50 seedlings/acre) that has come in since the Greenslope project.

Special Considerations:
Native vegetation: Understory plant cover is low (20 to 30 percent). Rocky Mountain juniper and common juniper are both vulnerable to fire.
Nonnative plant species: Canada bluegrass has the highest cover.
Wildlife: No snags were recorded during stand inventory. Larger diameter trees in this stand suggest that snags can be recruited from this population.
Recreation: Numerous, often heavily used, trails are in this area and public education during application of prescribed fires in this area will be crucial.
Other: There are open grasslands or savannas between many of the units in this area that should be treated at the same time as adjacent units.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	32.7	0.0	8.2	21.0	16.4	14.7	6.1	1.6	1.3	1.6	0.5	0.0	0.0	0.0	0.0	104.1
BA	0.0	2.9	0.0	2.9	11.4	12.9	15.7	8.6	2.9	2.9	4.3	1.4	0.0	0.0	0.0	0.0	66



Shanahan-9 (S-9) Acres: 28.7

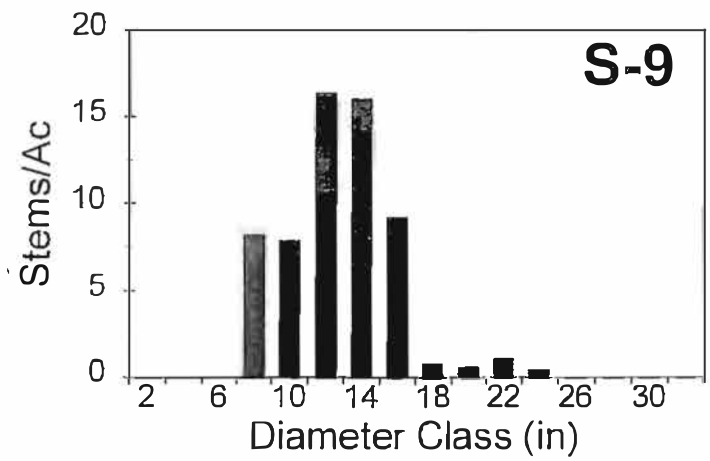
Specific Stand Objective: Maintain open stand conditions.

Treatment Recommendation: Understory bum. This stand has a BA of 84 and is the most open in the Shanahan area. This stand will need minor pre-treatment to thin regeneration (71 seedlings/acre) that has come in since the Greenslope project.

Special Considerations:
Native vegetation: Relatively high shrub species diversity for such a small stand with high shrub cover in some areas. Rocky Mountain juniper is vulnerable to fire.
Nonnative plant species: Cheatgrass and Canada bluegrass, both cool season grasses, have the highest cover.
Wildlife: Five snags were recorded during stand inventory. Because of open conditions and fewer larger diameter trees in this stand, snag recruitment should be limited here.
Recreation: Numerous, often heavily used, trails are in this area and public education during application of prescribed fires in this area will be crucial.

Diameter class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	0.0	8.2	7.9	16.4	16.0	9.2	0.8	0.7	1.1	0.5	0.0	0.0	0.0	0.0	60.7
BA	0.0	0.0	0.0	2.9	4.3	12.9	17.1	12.9	1.4	1.4	2.9	1.4	0.0	0.0	0.0	0.0	57



Shanahan-10 (S-10) Acres: 24.5

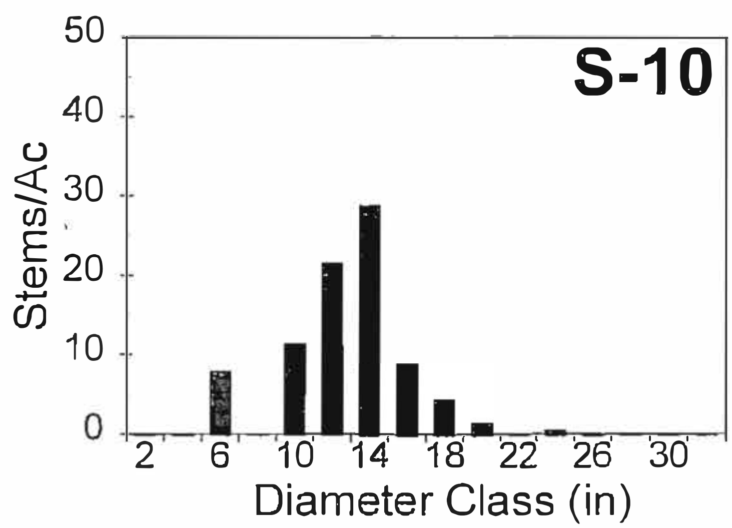
Specific Stand Objective: Maintain open stand conditions.

Treatment Recommendation: Understory burn. This stand has a BA of 57. This stand will need minor pre-treatment to thin regeneration (39 seedlings/acre) that has come up since the Greenslope project.

Special Considerations:
Native vegetation: Douglas-fir is vulnerable to fire. Cool-season grasses and sedges are predominant. A rare plant community--ponderosa pine/spike fescue (*Pinus ponderosa/Leucopoa kingii*)–may occur on this stand. Additional fieldwork is needed to verify the presence of this community.
Nonnative plant species: Cheatgrass, Japanese brome, timothy, and Canada bluegrass, all cool-season grasses, have the highest cover. These species may decrease with spring burning.
Wildlife: No snags were recorded during stand inventory. Larger diameter trees in this stand suggest that snags can be recruited from this population. A substantial population of Abert's squirrel exists in this stand. Raking the duff away from the nest trees will be critical.
Recreation: Numerous, often heavily used trails are in this area and public education during application of prescribed fires in this area will be crucial.
Other: There are open grasslands and savannas between many of the stands in this area that should be treated at the same time as adjacent stands.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	7.8	0.0	11.3	21.5	28.8	8.8	4.4	1.4	0.0	0.5	0.0	0.0	0.0	0.0	84.5
BA	0.0	0.0	1.5	0.0	6.2	16.9	30.8	12.3	7.7	3.1	0.0	1.5	0.0	0.0	0.0	0.0	80



Stengel I-1 (ST-1) Acres: 13.1

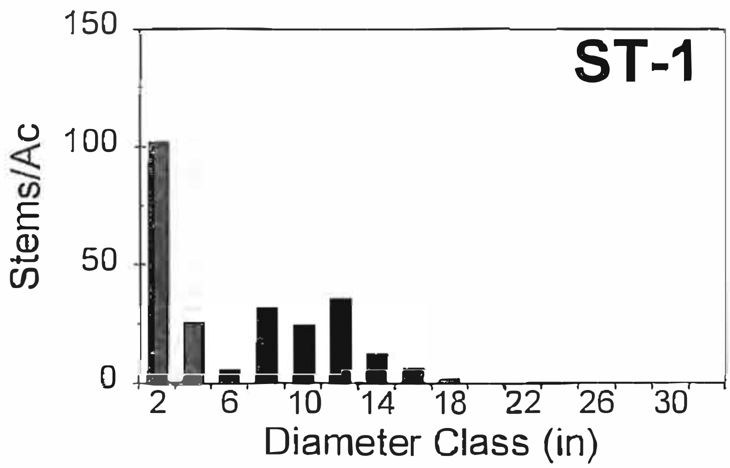
Specific Stand Objective: Reduce abundant tree regeneration in stand to promote open conditions.

Treatment Recommendation: Understory burn. This stand has a BA of 84. This stand will need major pretreatment to thin abundant regeneration that has come in since the Greenslope project in the late 1970s. The stand is on steeper slopes above the footslope areas. Much of regeneration may be removed by prescribed fire treatment.

Special Considerations:
Native vegetation: Douglas-fir, Rocky Mountain juniper, and common juniper are vulnerable to fire. Relatively high shrub cover on this stand.
Nonnative plant species: Canada thistle, cheatgrass, Canada bluegrass, and timothy have the highest cover.
Wildlife: No snags were recorded during stand inventory. Larger diameter trees in the 10" and 12" diameter classes in this stand suggest that snags can be recruited from this population.
Recreation: Numerous, often heavily used, trails are in this area and public education during application of prescribed fires in this area will be crucial.
Other: There are open grasslands or savannas between many of the units in this area that should be treated at the same time as adjacent units.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	101.9	25.5	5.7	31.8	24.4	35.4	12.5	6.4	1.9	0.0	0.4	0.0	0.0	0.0	0.0	0.0	245.8
BA	2.2	2.2	1.1	11.1	13.3	27.8	13.3	8.9	3.3	0.0	1.1	0.0	0.0	0.0	0.0	0.0	82



Stengel I-6 (ST-6) Acres: 28.4

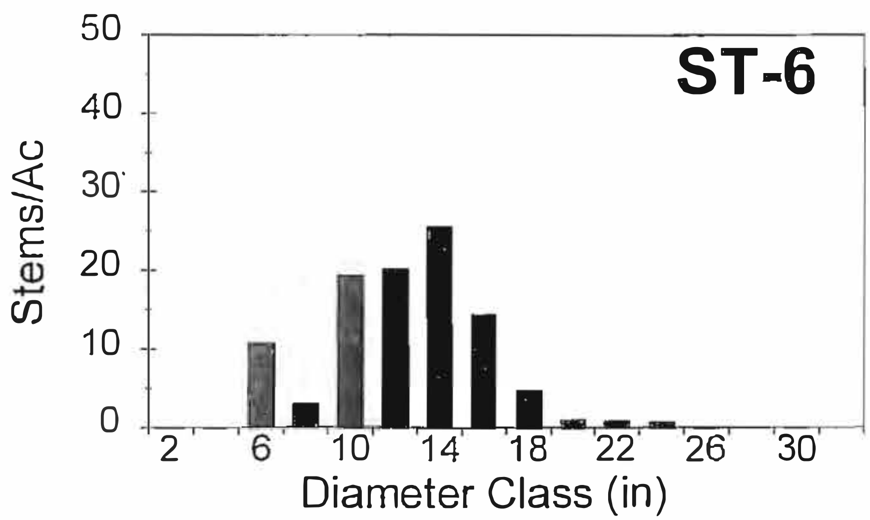
Specific Stand Objective: Maintain open stand conditions.

Treatment Recommendation: Understory burn. This stand is relatively open with a BA of 92, mostly in larger diameter trees. This stand likely will need minor pretreatment to thin regeneration (53 seedlings/acre) that has come in since the Greenslope project.

Special Considerations:
Native vegetation: Douglas-fir and Rocky Mountain juniper are vulnerable to fire. Grasses and sedgesare predominantly cool-season species--mostly poverty oatgrass (*Danthonia spicata*) and sunsedge (*Carex pensylvanica*)–that may be adversely impacted by spring burning.
Nonnative plant species: Canada bluegrass has the highest cover.
Wildlife: No snags were recorded during stand inventory. Large numbers of larger diameter trees in this stand suggest that snags can be recruited from this population.
Recreation: Numerous, often heavily used, trails are in this area and public education during application of prescribed fires in this area will be crucial.
Other: There are open grasslands or savannas between many of the stands in this area that should be treated at the same time as adjacent stands.

Diameter class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	10.7	3.0	19.3	20.1	25.6	14.3	4.8	1.0	0.8	0.7	0.0	0.0	0.0	0.0	100.3
BA	0.0	0.0	2.1	1.1	10.5	15.8	27.4	20.0	8.4	2.1	2.1	2.1	0.0	0.0	0.0	0.0	92



Stengel I-7 (ST-7) Acres: 9.9

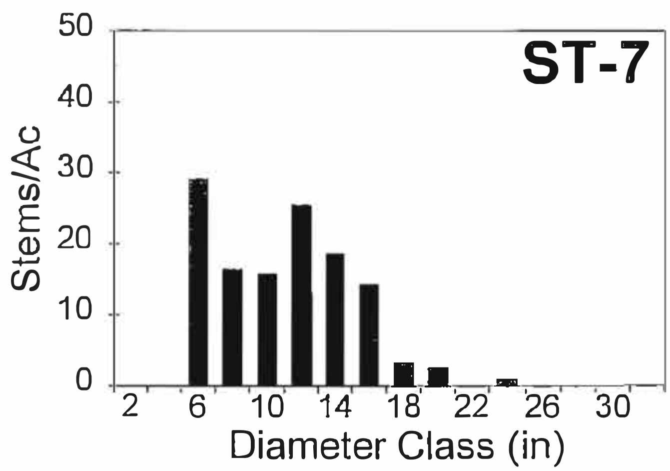
Specific Stand Objective: Maintain open stand conditions.

Treatment Recommendation: Understory burn. This stand has a BA of 94. This stand is relatively open with a majority of tree BA in larger diameter trees. This stand will need lop-and-scatter pretreatment to thin regeneration (129 seedlings/acre) that has come in since the Greenslope project.

Special Considerations:
Native vegetation: Douglas-fir and Rocky Mountain juniper are vulnerable to fire. High shrub species diversity for such a small stand. Grasses and sedges are predominantly cool-season species (poverty oatgrass has the highest cover) that may be adversely impacted by spring burning.
Nonnative plant species: Canada bluegrass and timothy have the highest cover.
Wildlife: No snags were recorded during stand inventory. Large numbers of larger diameter trees in this stand suggest that snags can be recruited from this population.
Recreation: Numerous, often heavily used, trails are in this area and public education during application of prescribed fires in this area will be crucial.
Riparian communities: Stream communities, both permanent and ephemeral, were noted in the unit during inventory.
Other: There are open grasslands or savannas between many of the stands in this area that should be treated at the same time as adjacent stands.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	29.1	16.4	15.7	25.5	18.7	14.3	3.2	2.6	0.0	0.9	0.0	0.0	0.0	0.0	126.4
BA	0.0	0.0	5.7	5.7	8.6	20.0	20.0	20.0	5.7	5.7	0.0	2.9	0.0	0.0	0.0	0.0	94



Stengel I-8 (ST-8) Acres: 14.9

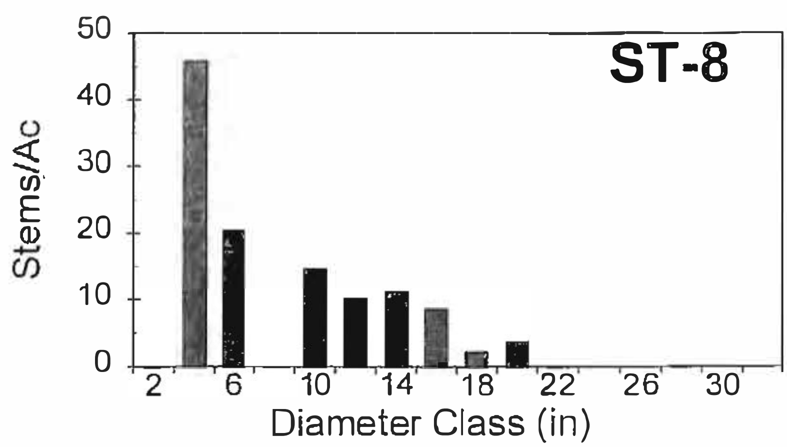
Specific Stand Objective: Maintain open stand conditions.

Treatment Recommendation: Understory burn. This stand has a BA of 60 and is very open with a majority of the BA in larger diameter trees. This stand will need minor pretreatment to thin regeneration (40 seedlings/acre) that has come in since the Greenslope project.

Special Considerations:
Native vegetation: Douglas-fir, Rocky Mountain juniper, and common juniper are vulnerable to fire. High shrub species diversity for such a small stand. High cover of holly-grape. Grasses and sedges are predominantly cool-season species that may be adversely impacted by spring burning.
Nonnative plant species: Canada bluegrass has the highest cover.
Wildlife: No snags were recorded during stand inventory. Large numbers of larger diameter trees in this stand suggest that snags can be recruited from this population.
Recreation: Numerous, often heavily used, trails are in this area and public education during application of prescribed fires in this area will be crucial.
Other: There are open grasslands or savannas between many of the units in this area that should be treated at the same time as adjacent units.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	45.8	20.4	0.0	14.7	10.2	11.2	8.6	2.3	3.7	0.0	0.0	0.0	0.0	0.0	0.0	116.8
BA	0.0	4.0	4.0	0.0	8.0	8.0	12.0	12.0	4.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	60



Stengel I-9 (ST-9) Acres: 13.0

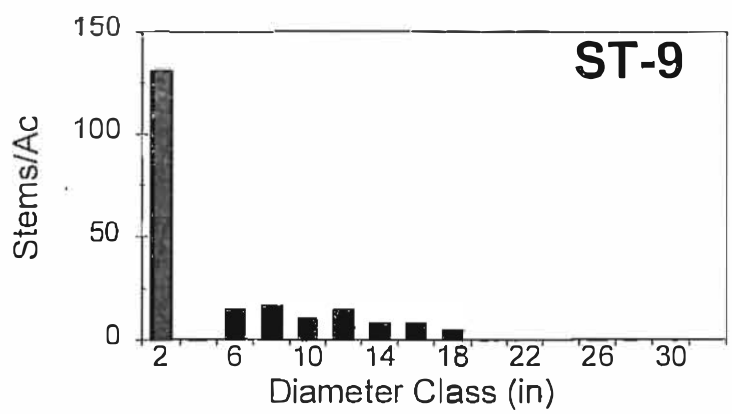
Specific Stand Objective: Reduce abundant regeneration in the unit and promote more open conditions.

Treatment Recommendation: Understory burn. This stand has a BA of 57. This stand is very open with a majority of the BA in larger diameter trees. However, there is abundant regeneration in the stand that has come in since the Greenslope project that will need to be removed either with lop-and-scatter pretreatment or through application of prescribed fire.

Special Considerations:
Native vegetation: Douglas-fir and Rocky Mountain juniper are vulnerable to fire. Relatively high shrub species diversity for such a small stand. High cover of holly-grape (*Mahonia repens*) and buckbrush (*Ceanothus fendleri*). Grasses and sedges are predominantly cool-season species that may be adversely impacted by spring burning.
Nonnative plant species: Canada bluegrass and timothy have the highest cover.
Wildlife: No snags were recorded during stand inventory. Large numbers of larger diameter trees in this stand suggest that snags can be recruited from this population.
Recreation: Numerous, often heavily used, trails are in this area and public education during application of prescribed fires in this area will be crucial.
Other: There are open grasslands or savannas between many of the stands in this area that should be treated at the same time as adjacent stands.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	131.0	0.0	14.6	16.4	10.5	14.6	8.0	8.2	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	208.0
BA	2.9	0.0	2.9	5.7	5.7	11.4	8.6	11.4	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54



Stengel I-10 (ST-10) Acres: 11.7

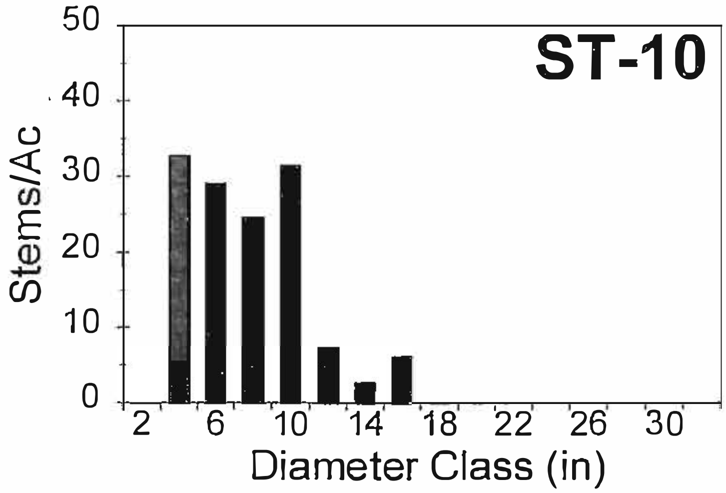
Specific Stand Objective: Promote open stand conditions by reducing stand regeneration.

Treatment Recommendation: Understory burn. This stand has a BA of 51. It will need lop-and-scatter pretreatment to thin regeneration (43 seedlings/acre, 71 saplings/acre) that has come in since the Greenslope project. Stand has very few larger diameter trees, and much of 6" to 10" diameter class should be retained for legacy trees.

Special Considerations:
Native vegetation: Douglas-fir and Rocky Mountain juniper are vulnerable to fire. Relatively high shrub species diversity for such a small stand. Two rare plant communities--Mountain mahogany/Scribner's needlegrass (*Cercocarpus montanus/Achnatherum scribneri*) and ponderosa pine/spike fescue (*Pinus ponderosa/Leucopoa kingii*)--may occur on this stand. Additional fieldwork is needed to verify the presence of this community.
Wildlife: No snags were recorded during stand inventory. However, because of few larger diameter trees in this stand, snag recruitment should be limited here.
Recreation: Numerous, often heavily used, trails are in this area and public education during application of prescribed fires in this area will be crucial.
Other: A wet meadow area and side slope seeps were noted in the unit and should be protected during treatment implementation. There are open grasslands or savannas between many of the stands in this area that should be treated at the same time as adjacent stands.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	32.7	29.1	24.6	31.4	7.3	2.7	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	133.9
BA	0.0	2.9	5.7	8.6	17.1	5.7	2.9	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51



Stengel II (STGL-II) Acres: 151.7

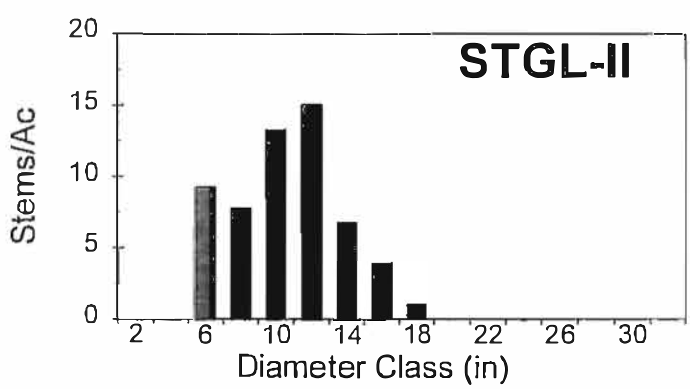
Specific Stand Objective: Maintain open savanna conditions and the savanna margin on the edge of the grassland.

Treatment Recommendations: Understory burn with occasional passive torching. The unit grades from very open ponderosa pine savanna areas on the edge of the grassland to the east and south to more dense areas in the west. There is very little regeneration in the stand (9.1 seedlings/acre, 4.5 saplings/acre) and pretreatment of the stand should be minimal. However, many trees in the stand are young (average age of tally trees is 50.6 years) with low canopies. For this reason, the potential for individual tree mortality during burning is high. A secondary objective of burning will be to raise crown heights such that trees will be better able to survive future fires in this area. After initial prescribed fire treatment, the stand will need episodic prescribed fires to maintain current open conditions and restore ecosystem processes.

Special Considerations:
Native vegetation: Shrub cover and diversity is low. Grass and sedge cover is relatively high (over 30 percent), but a good part of the cover is accounted for by nonnative species, mainly Canada bluegrass (*Poa compressa*).
Nonnative plant species: Species with highest cover are Canada bluegrass, cheatgrass, salsify, and cinquefoil (*Potentilla recta*). Spring burns could reduce cover of some of these species.
Wildlife: Maintenance of open savanna conditions in this area will promote wildlife species that prefer savanna areas.
Recreation: The Doudy Draw Trail runs through the middle of the unit. Public education and informational signing will be necessary.
Other: Visibility from Highway 93 is high and there is potential for smoke on the highway. The unit could be burned in conjunction with grasslands to the east and north and there are large areas of savanna to the east, northeast, and south that should be treated as one unit. There are also shrub communities to the northwest on the side of Doudy Draw that could be burned along with the unit. This will promote shrub regeneration in this area. Livestock grazing on the unit should be curtailed 1 to 2 years before burning to allow for fine fuel buildup to carry fire.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	0.0	9.3	7.8	13.3	15.0	6.8	3.9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.2
BA	0.0	0.0	1.8	2.7	7.3	11.8	7.3	5.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38



Sunshine Acres: 18.6

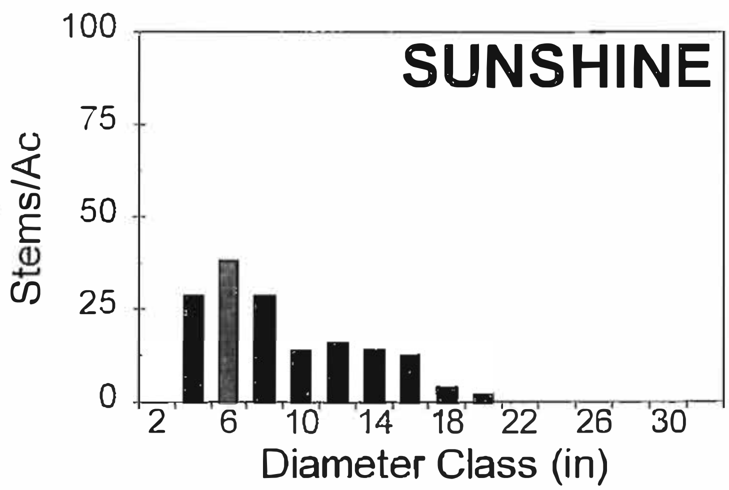
Specific Stand Objective: Promote more open stand conditions and reduce regeneration.

Treatment Recommendation: Understory burn. This stand has a BA of 85. This stand is located on the south side of Sunshine Drive on a steeper slope. Regeneration is heavy in the stand (100 seedlings/acre), mostly Douglas-fir. This area will need lop-and-scatter pretreatment and application of prescribed fire to reduce understory trees. Much of stand BA is in larger diameter trees.

Special Considerations:
Native vegetation: High shrub species diversity for such a small stand. A rare plant community--mountain mahogany/needlegrass (*Cercocarpus montanus/Hesperostipa comata*)--may occur on this stand. Additional fieldwork is needed to verify the presence of this community.
Wildlife: Numerous wildlife trails were noted in the stand during inventory. Only one snag was noted during inventory, and the presence of large numbers of larger diameter trees suggest that many could be recruited from this population.
Soils: Due to the steep slopes, erosion control measures will need to be considered.
Other: The unit is bordered to the west by private land. The unit is also bordered to the east and south by savanna areas and forests on Mountain Parks that could be treated in conjunction with this area.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	28.6	38.2	28.6	13.8	15.9	14.0	12.5	4.2	2.3	0.0	0.0	0.0	0.0	0.0	0.0	158.3
BA	0.0	2.5	7.5	10.0	7.5	12.5	15.0	17.5	7.5	5.0	0.0	0.0	0.0	0.0	0.0	0.0	85



Watertank Acres: 122.5

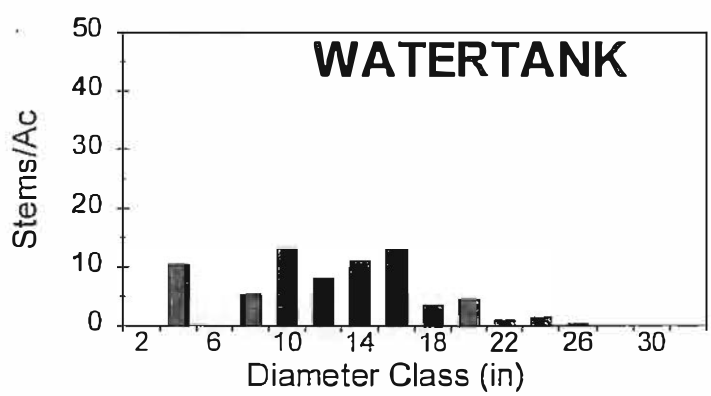
Specific Stand Objective: Maintain open conditions and promote old-growth in this area.

Treatment Recommendation: Understory bum. This stand is the most structurally diverse on Open Space, with low density of a wide range of diameter classes and very little tree regeneration. This is a large stand that should develop into a healthy climax stage and could serve as a model for the rest of low elevation Open Space stands to be treated under this plan. Prescribed fire treatments will maintain open conditions by removing what little regeneration there is in the unit and return ecosystem processes to the area. Raking of litter from around larger overstory trees is the only pretreatment recommended in this area to reduce moisture stress during treatment.

Special Considerations:
Native vegetation: Two rare plants–leadplant (*Amorpha nana*) and birdsfoot violet (*Viola pedatifida*)–occur in this stand and will be carefully monitored. High cover of big bluestem, a warm-season species, and sunsedge, a cool-season species.
Nonnative plant species: Canada bluegrass, Japanese brome, and cheatgrass are the species with highest cover. They could all decrease with spring burns, but native cool season grasses like needlegrass could also be affected.
Wildlife: No snags were recorded during the inventory. The presence of many larger diameter trees suggests that this area would be ideal to create more snags.
Other: There are open grasslands and savannas between many of the units in this area that should be treated at the same time as adjacent units. Many of the stands on the footslopes could either be treated together or stands could be broken into smaller units based upon presence of trails as control points.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	0.0	10.4	0.0	5.2	13.3	8.1	11.1	13.0	3.6	4.6	1.0	1.4	0.2	0.2	0.0	0.0	72.3
BA	0.0	0.9	0.0	1.8	7.3	6.4	11.8	18.2	6.4	10.0	2.7	4.5	0.9	0.9	0.0	0.0	72



Wittemyer-NE (WITT-NE) Acres: 55.1

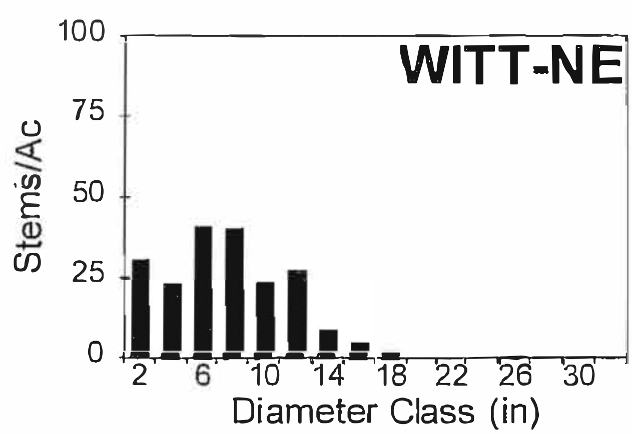
Specific Stand Objective: Reduce stand basal area and regeneration; promote open stand conditions.

Treatment Recommendation: Understory burn. This stand has a BA of 80. This and the other WITT stands are located in relatively steep areas bordered by private lands. This stand has abundant regeneration coupled with many larger-diameter trees. Pre-treatment of many areas of the stand will be needed because of the abundant regeneration, almost all of which is ponderosa pine.

Special Considerations:
Native vegetation: Two rare plant communities--ponderosa pine/spike fescue (*Pinus ponderosa/Leucopoa kingii*) and mountain mahogany/Scribner's needlegrass (*Cercocarpus montanus/Achnatherum scribneri*)--may be present. Additional fieldwork is needed to verify the presence of these communities. Buckbrush (*Ceanothus fendleri*) occurs in all the understory plots in this stand and may increase after prescribed fire.
Nonnative plant species: Bladder senna (*Colutea arborescens*), a nonnative shrub, has become established in the understory. Fire effects are unknown.
Wildlife: Snags were seen in 2 plots, and can be converted from living trees in other areas.
Soils: Due to the steep slopes, erosion control measures will need to be considered.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	30.6	22.9	40.7	40.1	23.2	27.2	8.7	4.8	1.9	0.3	0.3	0.0	0.2	0.0	0.0	0.0	200.8
BA	0.7	2.0	8.0	14.0	12.7	21.3	9.3	6.7	3.3	0.7	0.7	0.0	0.7	0.0	0.0	0.0	79



Wittemyer-NW (WITT-NW) Acres: 27.2

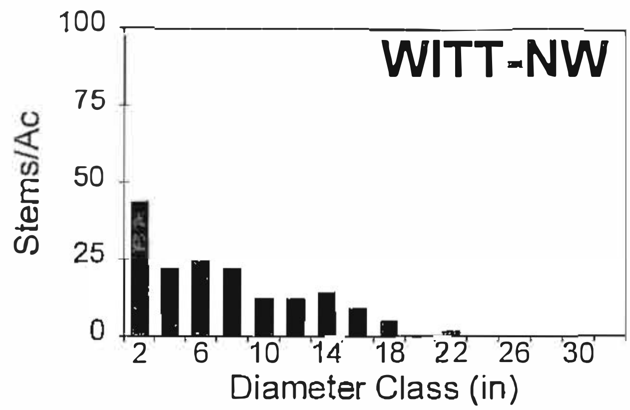
Specific Stand Objective: Reduce regeneration and promote more open stand.

Treatment Recommendation: Understory burn. This stand has a BA of 72. This stand has abundant regeneration coupled with many larger-diameter trees. Pre-treatment of many areas of the stand will be needed because of the abundant regeneration, almost all of which is ponderosa pine.

Special Considerations:
Native vegetation: Grasses and sedges are predominantly cool season species that may be adversely impacted by spring burning. Three rare plant communities--mountain mahogany/needlegrass (*Cercocarpus montanus/Hesperostipa comata*), ponderosa pine/mountain mahogany/big bluestem (*Pinus ponderosa/Cercocarpus montanus/Andropogon gerardii*), and ponderosa pine/spike fescue (*Pinus ponderosa/Leucopoa kingii*)--may be present. Additional fieldwork is needed to verify the presence of these communities.
Nonnative plant species: Bladder senna (*Colutea arborescens*), a nonnative shrub, has become established in the understory. Fire effects are unknown.
Wildlife: One snag was recorded during inventory and more should be converted from living trees in other areas of the unit.
Soils: Due to the steep slopes, erosion control measures will need to be considered.

Diameter Class (in.)

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	Total
Stem/Ac	43.7	21.8	24.3	21.8	12.2	12.1	14.3	8.9	4.9	0.4	1.4	0.0	0.0	0.0	0.0	0.0	165.8
BA	1.0	1.9	4.8	7.6	6.7	9.5	15.2	12.4	8.6	1.0	3.8	0.0	0.0	0.0	0.0	0.0	71



APPENDIX 3.1: MAP OF FOREST STANDS SHOWING GENERAL MANAGEMENT PRESCRIPTIONS FOR OPEN SPACE STANDS

City of Boulder Forest Plan: Stand Treatments