



2001
Report
on the
Condition
of
Colorado's
Forests



January 21, 2002

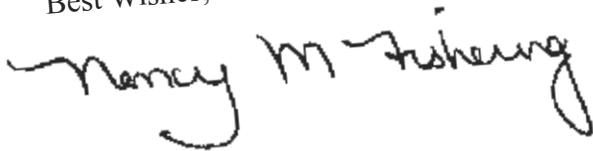
As Chairperson of Colorado's newly created Forestry Advisory Board, I would like to thank you for taking the time to consider this 2001 Report on the Condition of Colorado's Forests. This report is the first of what will be an annual investigation of critical forest health issues, including the identification of priority areas across the state where current forest conditions demand timely action.

We rely on our rich forest resource for a wide variety of benefits and services, such as improved air and water quality, wildlife habitat, wood products and recreation. A number of natural and human-induced forces impact the ability of our forests to sustain this productivity over the long-term. In many regions of the state, current forest health conditions threaten this lasting sustainability.

Ownership of Colorado's forests lies in the hands of a diverse group of federal, state, local, tribal, private and non-profit entities. But in a larger sense, we are all accountable for promoting the responsible stewardship of this valuable natural resource. In order to effectively redeem this stewardship responsibility, land managers, government leaders and the public should better understand the variety of interactions that led to our current forest conditions and what options we have in the future.

This first annual report provides a sound basis from which to begin a public dialogue on the future management of Colorado's forests. I encourage you to read it and to get involved in the prioritization and decision-making processes to follow.

Best Wishes,



Nancy Fishering

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Report on the Condition of Colorado's Forests

Executive Summary

Colorado's forests are expansive, diverse and beautiful. They provide vital shelter for both people and wildlife, improve the quality of our water, filter pollutants from the air, enrich our outdoor experiences and furnish products and jobs that strengthen local economies. A number of natural and human-induced forces influence the ability of Colorado's forests to sustain this diversity and productivity over the long-term. In many regions of the state, current forest conditions threaten this lasting sustainability.

Forest condition, or health, can be defined by the interaction between three components: first, a forest's resilience to disturbance; second, its ability to sustain a natural range of biological diversity; and third, its ability to meet the current and future needs of people in terms of values, products and services.

A number of issues and influences contribute to the current condition of Colorado's forest resources. Those of primary concern are: trends in forest cover change; insect and disease cycles; expansion of the wildland-urban interface; and watershed health. Additional issues of note include threats to the health of the state's urban and riparian forests and the implications of Colorado's air quality for future forest conditions.

A lack of large-scale disturbance is the culprit behind many of the state's forest health challenges. The majority of Colorado's forested landscapes are considered disturbance driven, meaning they evolved with natural cycles of wildfire, insect and disease infestations, flooding, avalanches or windstorms. Changes in human values and the resulting shift in land management practices interrupted these disturbance cycles, primarily through aggressive fire suppression and reduced harvesting activity on public lands.

Without these disturbances to periodically rejuvenate forest stands and ensure a variety of forest types, ages and densities, many of Colorado's forests have become unnaturally crowded and concentrated in older age classes. This lack of diversity, along with intense competition for resources such as water and light, has left many forest stands vulnerable to insect and disease attack, catastrophic wildfire and other types of damage at an inordinately vast scale.

In recent decades, scientists and land managers have begun to re-emphasize the importance of fire and disturbance in many of Colorado's forests. But restoring fire as a functioning, natural component of these ecosystems poses a number of challenges. Tools such as prescribed fire must be used appropriately and with attention to fuel loads and smoke management. Thinning of forest stands is often needed in advance of prescribed fire and to restore proper spacing and



Figure 1: The mix of aspen and conifers displayed here is an annual highlight of autumn in Colorado.



Figure 2: Pinion-juniper forests such as this one are found throughout western and south-central Colorado.

distribution across the landscape, but thinning of small-diameter trees can be expensive and currently offers little economic return. The rapid growth of homes and other development in the wildland-urban interface (WUI) poses the additional challenge of trying to manage natural resources while also providing for the protection of lives and property.

Management decisions regarding forest health issues are necessarily subjective and require a balance of public and private values. In order to make these decisions in an informed, effective manner, land managers, government leaders and the public must better understand how the interactions between natural and human forces shape our forests and influence their ability to sustainably provide a variety of benefits.

This first annual Report on the Condition of Colorado's Forests is intended to provide a credible, scientifically-sound basis from which to launch a public dialogue regarding the future of Colorado's forests. It is in this public arena where the needs and values of our forests will be evaluated and decisions made regarding future management and investment of resources.

Future editions of this annual report will provide greater detail regarding individual forest health issues in Colorado and will highlight priority areas where conditions merit specific attention and timely action.

I. Colorado's Forest Resource

Colorado's forested landscape is, perhaps, the most complex of any in the Intermountain West, with a diverse mix of coniferous and deciduous species. The basis for this vegetative mosaic is a physical landscape that ranges from flat plains and high plateaus to steep mountains, deep canyons and sloping foothills. A wide range of topographic, soil and growing conditions further influence this variety and contribute to the state's multi-faceted forest resource.

Ecoregions

Issues and events that influence forest condition often occur across forest types, ownerships and political boundaries. As a result, scientists, researchers and land managers must also find a way to assess and treat these issues in a boundary-less way. *Ecoregions* are often used as a non-political land division to help researchers study forest condition. An ecoregion is a large landscape area that has relatively consistent patterns of topography, geology, soils, vegetation, climate and natural processes (Shinneman and others 2000). Many smaller *ecosystems* may reside within an ecoregion.

Colorado contains parts of six major ecoregions (Bailey 1995), with the most prominent being the Southern Rockies, which occupies most of the state's central and western portions and the Great Plains-Palouse Dry Steppe in the eastern half of the state. Other ecoregions include the Intermountain Semi-Desert and Desert, the Nevada-Utah Mountains and the Colorado Plateau. Forests are found in all ecoregions of the state, but the Southern Rockies contain the most forested area and the greatest variety of forest types.

Forest Types

Forest type, or forest cover, refers to the dominant tree species in the overstory of a given site. The distribution of forest types across the landscape is determined by factors such as climate, soil, elevation, aspect and disturbance history (Rogers and others 2000). A number of Colorado's forests are characterized as *disturbance driven*. The life history of these forest types evolved with a cycle of natural disturbance such as wildfire, insect infestations, flooding, avalanches, windstorms or disease infections. These disturbances served to periodically rejuvenate forests, ensuring a variety of forest types, age classes and densities across the landscape. Due to lack of disturbance, the majority of Colorado's forests are concentrated in older age classes, with virtually no significant forest in the zero to 20-year age classes.

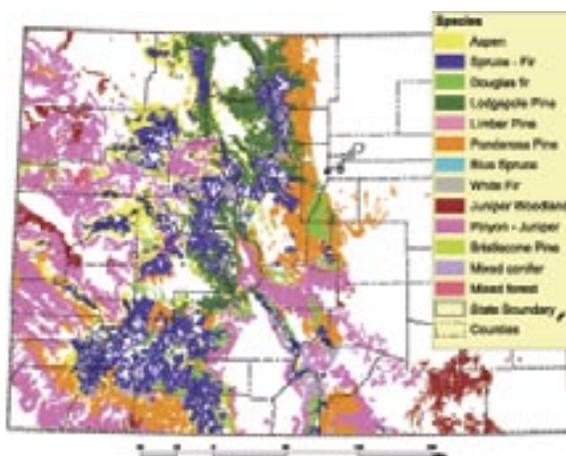


Figure 3: A number of forest types exist throughout Colorado.

Colorado blue spruce and the cottonwood-willow combination found in many riparian areas.

- **Spruce-Fir**

The slow-growing Engelmann spruce (*Picea engelmannii*), in association with the smaller, narrow-crowned subalpine fir (*Abies lasiocarpa*), forms the vast green vistas so typical of Colorado's high country or subalpine zone. The spruce-fir combination often results in a climax-type forest at high elevations, despite the existence of many uneven-aged stands. This is because both species are shade tolerant and tend to quickly repopulate shaded gaps in the forest. At lower elevations, Engelmann spruce forests can contain more moisture than any other stand type in the state. Snow packs may exist well into summer and water yield from these forests is very important. The return interval for naturally-occurring fires within the spruce-fir forest may be 300 years or longer. Thin bark and the persistence of dead lower limbs increases the spruce's susceptibility to fire as well as the likelihood of intense crown fires and tree mortality. In the case of a stand-replacing fire, it may be as many as 300 years before a spruce-fir forest again occupies the site. Spruce-fir is the most extensive type in the state and also the most publicly owned (Benson and Green 1987).

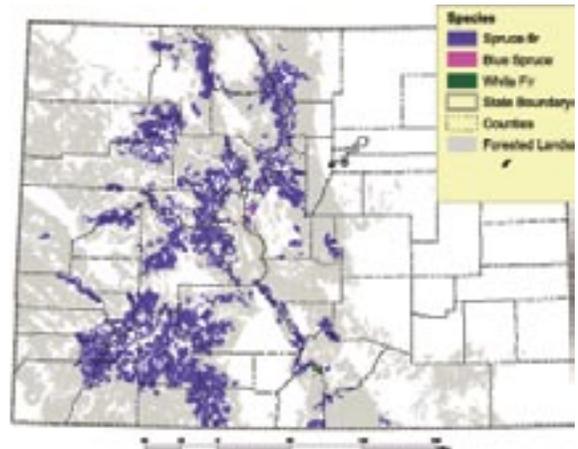


Figure 4: The spruce-fir forest type is the most extensive in the state.

- **Ponderosa Pine**

The ponderosa pine (*Pinus ponderosae scopulorum*) is the most widely distributed pine in North America and occupies a vast area in the West. It is well adapted to high temperatures and low moisture and is highly resistant to low-intensity fire. Ponderosa pine is generally the dominant lower timberline species in Colorado's *montane zone*, particularly at elevations from 5,800 to 9,800 feet. A long taproot helps the drought-resistant pine obtain adequate moisture and also decreases its chances of being uprooted by strong winds. Ponderosa pine generally evolved with a natural cycle of frequent, low-intensity fire which eliminated competing conifer seedlings but allowed mature pines to survive. Because it is more accessible than other species, and largely in private ownership, ponderosa pine has been an important source of lumber and other wood products (Benson and Green 1987). The advent of aggressive fire suppression has resulted in increased encroachment of shade-tolerant Douglas-fir (*Pseudotsuga menziesii*) in the understory of ponderosa pine stands. When fire occurs in these mixed forests, the understory Douglas-fir tend to carry fire in ladder fashion into the pine crowns, making the fire much more likely to reach unnatural, stand replacement proportions. Forest monitoring data indicates that ponderosa pine acreage in Colorado may be declining due to fire suppression practices that allow encroachment of Douglas-fir.

Figure 5: Ponderosa pine is Colorado's dominant lower timberline species and an important source of wood products.

- **Lodgepole Pine**

Lodgepole pine (*Pinus contorta*) is a familiar species in the montane and subalpine forests of Colorado's northern Rocky Mountains. It tolerates a wide variety of climatic and soil conditions, but achieves its best growth on gentle slopes and in basins with well-drained, slightly acidic, sandy or gravelling loams. Lodgepole pine is intolerant to shade and thrives in the aftermath of fire. Many lodgepole produce *serotinous* cones, which open in response to extreme heat and release an abundance of seeds. These long-lived cones may remain viable for decades, waiting for a fire to release their seeds. Natural lodgepole regeneration in open, sunny areas often produces very dense stands of 20,000 or more trees per acre. Lodgepole pine is the third most extensive commercial forest type in the Rocky Mountains and is used in Colorado for products such as fenceposts, corral rails, utility poles, paneling, railroad ties and pulpwood. Mountain pine beetle (mpb) and dwarf mistletoe are the most damaging agents of lodgepole pine.

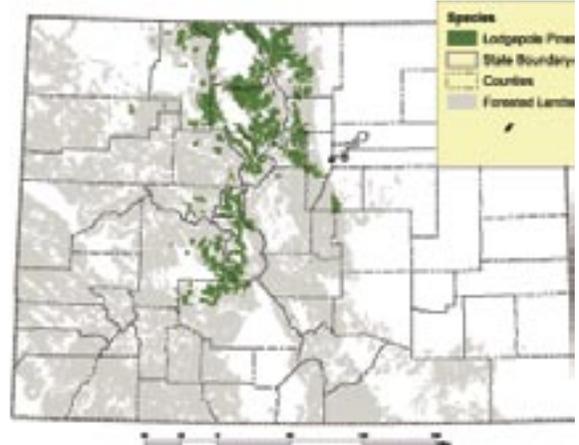


Figure 6: Lodgepole pine is an important high-elevation species in the state's northern Rocky Mountain region.

- **Aspen**

The aspen's (*Populus tremuloides*) delicate leaves and vibrant fall color are often displayed as a symbol of Colorado, itself. Aspen represents the state's only widespread, native deciduous tree and is most commonly found in the western two-thirds of the state. Aspen can occur over a wide variety of sites ranging from dry, high-elevation grasslands to poorly drained meadow sites. The sun-loving aspen regenerates through sprouts or suckers that are produced by its roots in response to increased soil or root temperatures. Because of this sprouting response, aspen is often first to colonizes forest clearings, burns or other disturbed sites. As stands grow, and shade on the site increases, conifer species begin to invade and may eventually replace the aspen. The open canopy and high light levels of aspen stands lead to a more lush understory than that of neighboring conifers. Drier groves generally consist of grasses, with some wildflowers and medium-sized shrubs such as ninebark or cinquefoil. Wetter forests have an abundance of wildflowers, including meadow rue, arnica, lupine, and paintbrush, and sometimes a thicker shrub layer consisting commonly of snowberry or wild rose. Combined with dead and down material, this ground layer provides cover for small rodents and a source of food for birds. Throughout its lifecycle, aspen also provides critical habitat for wildlife such as cavity-nesting birds and those, like the warbling vireo, who are dependent on deciduous trees for breeding (Kingery 1998).

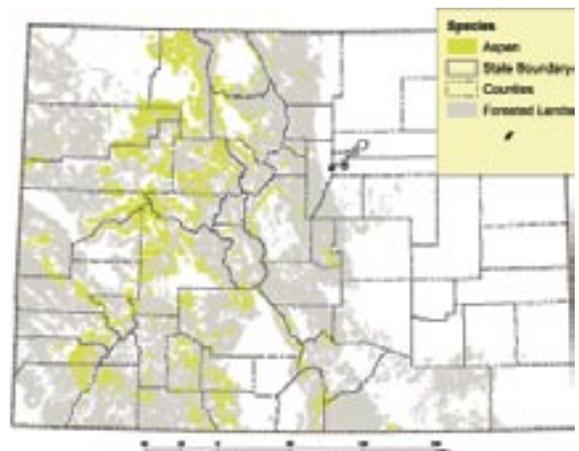


Figure 7: Aspen represents the state's only widespread, native deciduous tree.

- **Pinion-Juniper**

Pinion pine and juniper woodlands are widespread in the lower elevations of Colorado's West Slope. While the U.S. Forest Service distinguishes 32 pinion and 23 juniper plant communities, Colorado pinion pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) are the most common species. Annual precipitation is typically from 10 to about 15 inches in pinion-juniper or "P-J" woodlands, and tree species in these communities have developed resistance to both drought and cold. Juniper tends to grow at lower elevations and in more arid areas as its scaled foliage allows it to conserve water more effectively than pinion pine. Juniper-dominated woodlands tend to include open savannas of scattered trees without a significant shrub component, except in areas where big sagebrush has become dominant as a consequence of grazing. Woodland communities have expanded considerably over the course of this century in many parts of the Colorado Plateau, including New Mexico, Arizona and Utah. Tree densities have increased in some areas to the point that larger proportions of pinion-juniper woodland now support damaging crown fires.

Figure 8: Pine nuts and juniper berries provide an important source of winter food for wildlife in Colorado's pinion-juniper woodlands.

Land Ownership Patterns

Decisions regarding the management, use and condition of Colorado's forests are complicated by a montage of public and private ownerships ranging in size from a single acre to more than a million acres.

Each landowning entity brings with it a unique set of philosophies, directives and regulations that further influence the decisions made about their particular part of the forest and, often, the decisions available to surrounding landowners, as well.

Nearly 68 percent of Colorado's 22.6 million acres of forestland is in federal ownership, with the primary landholder being the U.S. Forest Service (USFS) at 49 percent. The U.S. Bureau of Land Management (BLM) oversees 19 percent of the state's forests, primarily in lower elevations. An estimated 200,000 private landowners control 6.2 million acres, or 28 percent, of the state's forested landscape, with no significant portion being held by forest industry. The remaining four percent is held by a combination of municipalities, state and other non-federal entities. The Colorado State Land Board owns approximately 370,000 acres of forest land throughout the state, the largest parcel being the Colorado State Forest near Walden.

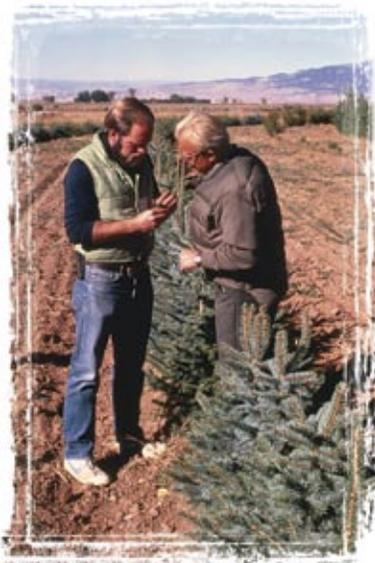


Figure 9: Field foresters from the Colorado State Forest Service help private forest landowners like this one with the stewardship of their resources.

Management History

The majority of Colorado's forests have been influenced by human actions and decisions, whether deliberate or unintentional. Human interaction with the region's forests most likely began with early Native American inhabitants who gathered firewood for domestic use

and may have set periodic fires to drive game (Shinneman and others 2000). The extent and intensity of this activity in relation to that of lightning-caused fires is unknown.

Documented expeditions of Spanish, French and American explorers traveled through Colorado in the late 18th and early 19th centuries, but sustained settlement did not begin until after the 1859 gold rush. Although Colorado's generally dry, slow-growing forest conditions and steep topography have kept logging from developing into a major state industry, early settlers found a number of uses for the surrounding forest resource.



Figure 10: An early tie-hack peels logs to prepare them for use as railroad ties.

Miners harvested local forests for mine timbers and other building materials needed by nearby towns and villages. They also deliberately set forest fires to expose rock faces and sometimes, often inadvertently, launched large-scale fire across the landscape (Shinneman and others 2000). The expansion of the railroad followed closely on the heels of the gold rush and resulted in extensive logging for railroad ties.

The advent of public forestland in Colorado came in 1893 when President Benjamin Harrison established five forest reserves in Colorado: the White River Plateau, Pikes Peak, Plum Creek, South Platte and Battlement Mesa. These, and future reserves, were managed according to principles of "sustained yield" for maximum long-term timber production. Following the disas-

trous wildfires of 1910, management directives also included aggressive suppression of all fire starts.

Sale of timber off federal land increased rapidly in the 1940s in response to war needs, and reached a high point in the post-war "baby boom" era when economic growth and massive housing starts fueled the timber industry. Harvest on Colorado's Rio Grande National Forest grew from less than 5 million board feet in 1948 to 31 million board feet in 1967 (Shinneman and others 2000).

The passage of the 1960 *Multiple Use-Sustained Yield Act*, which placed equal importance on the values of outdoor recreation, range, timber, watersheds and wildlife on National Forests, signaled a change in public expectations regarding forests. Increased public interest in environmental protection, outdoor recreation and public involvement in government decision-making resulted in the passage of several more laws over the following decades which drastically changed the public land management milieu. Those laws include the 1964 *Wilderness Act*, 1968 *Wild and Scenic Rivers Act*, 1969 *National Environmental Policy Act*, 1973 *Endangered Species Act*, 1976 *National Forest Management Act*, and the 1976 *Federal Land Policy and Management Act*.

Beginning in the 1980s, activity on federal forests was increasingly governed by the philosophy of *ecosystem management*, which emphasized biological diversity, adaptive management and the integration of human and natural values. In 1997, a newly appointed Forest Service Chief further refined the agency's agenda to emphasize: 1) watershed health and restoration, 2) sustainable forest management, 3) management of forest roads and 4) recreation.



Figure 11: Cattle provided a popular means of transporting logs harvested from Colorado's lower-elevation forests.

Sustaining Resources and Communities in Southwest Colorado Case Study I

Early photos of the Gunnison River's Lake Fork drainage show a forest primarily composed of large, widely spaced ponderosa pine. Douglas fir were also present, but limited to a few scattered trees with an occasional dense pocket. Periodic wildfire kept Douglas fir from becoming overly dense because any fire on the area's steep hillsides was likely to kill young fir, while leaving the more fire resistant ponderosa pine.

Nineteenth century prospectors traveled the Lake Fork area in southwest Colorado in search of valuable minerals. Boomtowns such as Lake City rose up around this influx of people and wealth and quickly began harvesting surrounding timber for homes, railroad ties and mine timbers. Cattle and sheep were introduced to feed the community and strict wildfire suppression efforts were initiated. Over the next century, these land management actions resulted in visible changes to the forest.

Today, the forest in the Lake Fork drainage is much different from the one found by early miners. Without regular, low-intensity fires, Douglas fir has become the predominate tree in the landscape, often reaching densities of over 600 trees per acre. Forests in this kind of stressed condition are susceptible to insect and disease outbreaks and catastrophic wildfire.

Western Spruce Budworm (WSBW) is a defoliating insect, which in the larval stage, travels from tree to tree on a silken thread. The Lake Fork's crowded forests make it very easy for the budworm to consume large amounts of foliage. After several years of heavy defoliation, many trees in the area have died.

A short-term solution to controlling WSBW damage is to aerial spray the forest with insecticide. This has been done around Lake City several times since the 1980's. A better long-term solution is to thin the forest, which increases residual tree vigor, makes it more difficult for the budworm to feed, and reduces wildfire hazard.

The current economy of Lake City and surrounding communities is dependant on tourism and seasonal residents. Local citizens and community leaders have recognized that the health and natural beauty of the surrounding forest is vital to their economic health.

In 1999, the Hinsdale County Spruce Budworm Task Force (HCSBTF) was formed to address forest health issues. This group is comprised of landowners, as well as local, state and federal partners. Delineation of forest conditions and mapping of priority thinning areas was completed in 2000. A demonstration thinning project was prepared in 2001 and a local contractor will complete the project in early 2002. The Bureau of Land Management, which owns much of the land immediately adjacent to private property, will begin planning efforts in 2002.

Much work remains. Steep slopes limit where machinery can operate and the majority of trees needing to be removed are small diameter and have no current commercial market. But a continued long-term effort across land ownerships is the most likely way to improve and sustain healthy forests and healthy communities in the Lake Fork area.

Although they are not subject to the same directives and regulations, managers of non-federal forestlands in Colorado have been strongly influenced by the dominant presence of federal ownership in the state. The condition and management of Colorado's non-federal forests often reflects that of its federal neighbors, particularly the USFS. Of the 5.9 million acres of private forestland in Colorado, 40 percent is within one mile of federal land and 60 percent is within two miles.

Along with the influence of federal ownership, rapid urban growth is the primary factor shaping private forestland management in Colorado. While the ratio of public to private lands has remained relatively constant in the state since the turn of the century, the ownership structure of private forestland has changed dramatically.

In the last decade, alone, the number of private landowners with at least one forested acre has grown from 46,300 in 1990 to an estimated 200,000 in 2000. Since private land acreage has remained the same, these numbers indicate that private forests are being fragmented into smaller and smaller parcels, the majority of which are managed for recreation, wildlife and scenic benefits.

Inventory and Analysis of Forest Condition

The majority of Colorado's forest inventory, monitoring and analysis information is produced through two cooperative federal / state programs: the Forest Inventory and Analysis Program (FIA) and the Forest Health Monitoring Program (FHM). These programs are funded and administered nationally by the U.S. Forest Service and are implemented in partnership with State Forestry agencies.

The FIA program has been in operation since 1930 and is often labeled "the nation's forest census." The FIA plot system is distributed across the landscape with approximately one sample location every 6,000 acres. During a state's survey cycle, each plot location is visited by state and/or federal field crews who collect a variety of forest ecosystem data.

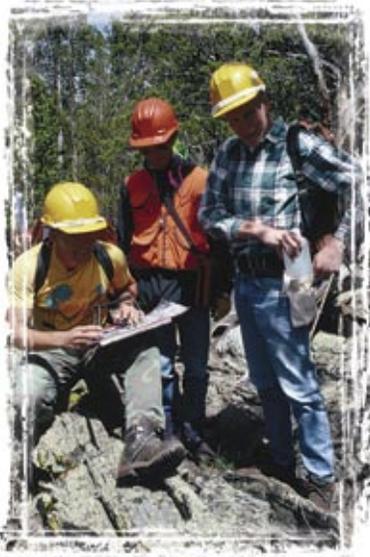


Figure 12: A forest inventory crew maps a course to their next sample plot.

Subsequent FIA reports contain information on changes in the area and location of forests; trends in the species distribution and size of trees; total tree growth mortality and removals through harvest; wood production and utilization rates; and forest land ownership. Colorado's last FIA survey was completed in 1983.

In 1992, the Colorado State Forest Service worked cooperatively with the U.S. Forest Service to establish a complementary system of permanent statewide plots for the new Forest Health Monitoring program. Each FHM plot covers about 2.5 acres and involves readings on complete vegetative diversity, soils, coarse woody debris, crown conditions and lichen communities as well as FIA's more traditional readings on tree species, diameter and height and tree damage.

The annual collection of FHM plot data, in combination with aerial detection surveys, provides a framework for baseline and long-term monitoring of forest change. This coordinated network of ground-based sample plots and air-borne surveys can detect abnormal rates of change in forest conditions before they reach epidemic proportions. If unexplained changes are detected, federal and state scientists can quickly move into an Evaluation Monitoring status to determine the extent and severity of changes and plan an appropriate course of action.

In 1999, the plot component of the national FHM program was merged with the FIA program. This new combined effort, often referred to as Enhanced FIA, is intended to meet the national demand for more timely, consistent and reliable forest inventory and monitoring information. Enhanced FIA also involves a shift from periodic to annualized data collection in every state. Under this annual approach data will be collected on a subset of plots in all states every year. Implementation of Enhanced FIA in Colorado will begin in Spring 2002.

Additional forest-related data is obtained through smaller scale or project-specific research conducted by local, state and federal entities as well as non-profit research organizations.

II. Current Issues

Existing data regarding the trends and condition of Colorado's forests highlights several areas of concern. From high-elevation spruce-fir forests to urban areas and riparian corridors, the long-term sustainability of our forested landscapes is being challenged by a variety of natural and human-induced influences. Issues and areas that merit further investigation are described below.

Forest Cover Change

Forest cover change occurs when the dominant vegetation type, or combination of types, shifts in response to an interruption in the forest's natural disturbance cycle. Because forests are not static, some fluctuation in cover type is expected in response to forces such as climate change, weather events or lightning strikes. Scientists focus on the rate of such change and whether or not the change is within the "range of natural variability" for a given forest type. If forest conditions reflect unnaturally large swings, it may be cause for concern.

Fire exclusion has been the primary driver of forest change in Colorado. While a conclusive study of this change would require more long-term data than is now available, the current trend in aspen decline should help illustrate this issue:

- **Aspen Decline**

Forest monitoring data collected over the past decade appears to show a decline in aspen cover throughout the Interior West (Rogers and others 1998). Scientists believe the chief cause of this decline is the lack of natural and human-caused forest fires. Aspen is one of a few tree species that readily regenerates after a fire burns through a forest. Because aspen regenerate primarily by suckering from underground root stock, they maintain an advantage over other species whose reproductive parts (cones and seeds) are often consumed in the fire or take longer to establish.

The absence of fire or other large-scale disturbance inhibits the regeneration of new aspen stands and allows mature stands (80-150 years) to be replaced by competing conifers growing up through the shaded understory. This basic formula, in combination with other factors, such as browsing pressures on seedlings, appears to be causing a large-scale decline of aspen in Colorado.

Aspen forests support a unique range of understory plants and lichens and provide valuable habitat for a number of wildlife species, including elk, beaver, mountain bluebird, northern goshawk and warbling vireo (Hoover and Wills 1984). The loss of aspen as a dominant cover type would have far reaching affects on biodiversity in Colorado and on the remaining forest's susceptibility to fire, insects and/or disease.

Insect and Disease Disturbance

A number of insects and diseases impact the condition of Colorado's forests. Some are native and part of a natural cycle of species interaction, while others are not. Little is known about the long-term human impacts on insect and disease disturbances, but research does show that both management activities and climate play important roles (Rogers and others 2001).

Forests in Colorado and much of the Intermountain West experience frequent short-term advances and declines in insect and disease outbreaks. Some of these events help maintain healthy forest functions and species diversity over time. Changes in disturbance patterns, such as fire exclusion, can accelerate these

cycles, making them larger in scope and faster moving across the landscape. Reduced genetic, age or species diversity and changes in the population of natural control agents can also increase forest susceptibility.

Insect and disease outbreaks generally draw public attention when the resulting damage threatens something of public value such as commercial timber, scenic and recreational areas or the safety of homes and property. Insect and disease events near developed areas may provoke secondary disturbances such as hazard tree damage or high-intensity wildfire that can place nearby homes or structures at risk.

Some of the forest insects and diseases of primary concern in Colorado are described below.

- **Mountain Pine Beetle**

The mountain pine beetle (*Dendroctonus ponderosae*) is the most important damaging insect of Colorado's pine forests. Trees that are not growing vigorously due to old age, poor growing conditions, drought, fire, mechanical damage and other causes are most likely to be attacked. The mountain pine beetle (mpb) particularly favors older, dense stands of ponderosa, lodgepole and limber pines. It has reached epidemic proportions on roughly 10-20 year cycles in Colorado, with outbreaks being equally evident in wilderness areas, mountain subdivisions and back yards. In both ponderosa and lodgepole pine stands, mpb is in the sixth year of an increasing epidemic. Aerial surveys conducted over 22 million acres of Colorado in 2000 counted 275,000 recently killed trees, a dramatic increase from the 13,000 killed trees identified in 1996. Worst-hit ponderosa pine areas in the state include the Upper Arkansas Valley near Buena Vista in Chaffee County, the US 285 corridor from Morrison to Grant in Jefferson and Park Counties and from Rustic to Red Feather Lakes in Larimer County. In lodgepole pine, mpb is epidemic in the Vail Valley and large areas of Grand County.

- **Spruce Beetle**

Spruce beetle (*Dendroctonus rufipennis*) typically has a two-year life cycle and is capable of causing widespread spruce mortality. It generally builds up on the underside of large-diameter windthrown or otherwise downed trees and spreads to standing spruce. In Colorado, factors found to increase the risk of spruce beetle attack include: well-drained creek bottom growing sites; stands with an average diameter of 16 inches or greater and a density of 110 trees per acre; and stands with an overstory made up of at least 65 percent spruce. While management efforts can locally mitigate spruce beetle impacts to varying degrees, stopping a landscape-level spruce beetle epidemic once it has begun is almost impossible. Developing epidemics may be controlled if proper suppression and prevention activities are initiated before these epidemics reach landscape proportions. Management strategies include rapid salvage and removal of fresh windthrown trees and/or infested windthrow; creation and removal of trap trees, which are intentionally made available to



Figure 13: Damage from a mountain pine beetle infestation turned this Front Range ponderosa pine stand from a healthy green to a dry red.



Figure 14: Bark beetles create galleries like these when the adult beetle bores in to lay its eggs and again when the hatched larvae make their exit.

Joining Forces to Battle Vail's Beetle Invasion Case Study II

The Vail Valley is home to two world-class ski resorts, numerous year-round recreational opportunities and some of the most valuable real estate in the nation. Among Vail's natural treasures are the vast expanses of lodge-pole pine that form a breathtaking backdrop to the Vail experience.

In 1996, forest scientists and area residents began noticing more and more red, dried-up trees on the forested hillsides. A subsequent assessment by the U.S. Forest Service revealed 200 acres of existing mountain pine beetle (MPB) activity and another 34,000 acres at moderate to high risk for beetle infestation.

Land managers and local officials quickly realized that an infestation of this size could tremendously increase the wildfire threat to area residents and would dramatically impact the aesthetic beauty that is key to the region's tourist-based economy.

Although MPB is a native insect to Colorado, it reaches epidemic proportions every few decades. The chances of a large-scale beetle infestation are increased in lodgepole pine forests because they tend to grow in dense, even-aged stands with little diversity to compensate for insect or disease damage.

Although it is virtually impossible to stop a MPB epidemic once it's underway, it is possible to take action to promote public safety and protect community resources. And that is exactly what Vail area homeowners began asking federal, state and local officials to do.

In 1997, the White River National Forest, the Town of Vail and private landowners began conducting thinning and related tree removal projects to reduce the rate of spread from beetle infested areas. Forest managers also began annual aerial and ground surveys of beetle-impacted areas, selective use of insecticide sprays, and beetle baiting through release of pheromones on trees that were later removed.

In 2000, the U.S. Forest Service, Vail Resorts, the Colorado State Forest Service, the Gunnison Service Center and the Vail Town Council entered into a memorandum of understanding to develop and implement both a short and long-term plan for dealing with the beetle problem in the area.

Among the challenges facing this partnership are: increased wildfire and avalanche hazard; steep, inaccessible terrain; likely degradation of aesthetic resources; and vast expanses of roadless lands immediately adjacent to the wildland-urban interface. But the Mayor of Vail, the local Forest Service District Ranger and other partners agree that the priority is to protect public safety and, if possible, homes and structures through strategic on-the-ground mitigation efforts.

beetles, colonized and then removed; solar or fire treatment of infested logs; use of pheromones and application of pesticides. Colorado experienced a major wind event encompassing approximately 20,000 acres on the Routt National Forest north of Steamboat Springs on October 25, 1997. The U.S. Forest Service found spruce beetle activity in 85 percent of sampled windthrown trees in 1999. The beetles began moving into standing trees in 2000. The age and size of most of Colorado's spruce make the potential for increased beetle attack a cause for statewide concern. Spruce forests in north central Colorado are at particular risk due to the Routt and similar blowdown events.



Figure 15: Several acres of windthrown trees like this one paved the way for a spruce beetle epidemic in the Routt blowdown area near Steamboat Springs.

- **Western Spruce Budworm**

The western spruce budworm (*Choristoneura occidentalis*) is the most widely distributed and destructive forest defoliator in western North America. Several outbreaks have occurred in Colorado, the largest exceeding two million acres. Favored hosts are Douglas-fir, white fir and Engelmann spruce with the most activity occurring in dense stands that have been stressed either by competition or external factors. Budworm females lay masses of eggs on the undersides of needles. In spring, the hatched larvae migrate to new foliage where they feed on developing buds. Budworms are significant because they can eat all the new growth produced by host trees. The needles are most important in producing food for the tree, so the immediate effect of defoliation is a reduction in growth. Budworm outbreaks in Colorado last an average of 11 years, with the last outbreak occurring from 1972-1985. Defoliation detected in 2000 was 20,650 acres. This is below the 1999 level of 40,060 acres but is well above the level detected in the previous years.

- **Dwarf Mistletoe**

In the western U.S., disease from dwarf mistletoe (*Arceuthobium americanum*) is estimated to cause 400 billion cubic feet of growth loss per year, one-quarter of which is in ponderosa pine. According to the USFS, about 855,000 cubic feet are lost on an annual basis in Colorado. Dwarf mistletoe is the most important health factor for lodgepole pine. Historically, the extent and spread of this parasitic plant has been limited by large, stand-replacing fires. With the advent of intense fire suppression, the range and severity of mistletoe infection in lodgepole pine has increased westwide. Typical impacts of mistletoe in both ponderosa and lodgepole pine include formation of "witches brooms" in crowns and branches; reduction in diameter, height and volume growth; reduced seed production; increased susceptibility to insect attack, root diseases and storm damage; and loss of wood quality. Dwarf mistletoe is also an important factor when evaluating hazard trees in recreation areas such as campgrounds. Lodgepole dwarf mistletoe currently infects 31 percent of the state's lodgepole pine resource.

- **Armillaria Root Rot**

Armillaria Root Rot (*Armillaria* spp.) and similar root diseases cause significant conifer mortality in localized areas of Colorado, particularly in the southwestern part of the state. The crowns of Armillaria infected trees generally begin to thin and change to a red or brown color. Further symptoms of root disease include resin blisters on stems and branches, decayed wood with a water-soaked appearance, and heavy resin flow from the tree base. Reduced resistance to Armillaria can

occur if a tree is not receiving enough water, light or soil nutrients, or has been exposed to temperature extremes, pollution, or insect attack. In Colorado, subalpine and Douglas-fir are the most susceptible to *Armillaria*. Trees are infected with *Armillaria* through rhizomorphs, black shoe-string-like structures which grow out through the soil from an established infection and penetrate directly into the root surface of uninfected trees. When roots from a healthy tree touch an infected root or stump, a new infection results. *Armillaria* is a significant predisposing factor for bark beetle attack – a connection which has been demonstrated throughout Colorado’s stands of subalpine fir, most noticeably around many of the state’s ski resorts. The most important control measure for *Armillaria* is to manage for reduced tree stress.

Wildland Urban Interface

The rapid expansion of urban development into previously wildland areas of Colorado raises both forest sustainability and public safety concerns. A century of aggressive fire suppression, combined with cycles of drought and changing land management practices, has left many of Colorado’s lower and mid elevation forests unnaturally dense and susceptible to damage from insects, disease and fire. These forested

Protecting Lives and Property Along the Front Range Case Study III

The forested home sites in the Douglass Ranch subdivision are typical of many new developments popping up in previously wildland areas along Colorado’s Front Range. The Douglass Ranch Homeowners Association realized early on that locating their homes in a wooded, fire-prone “interface” zone brought with it some risks. In 1999, the Association began working with the Elk Creek Fire Protection District and Colorado State Forest Service (CSFS) to determine what homeowners could do to mitigate their wildfire risk.

The reality of fire in the wildland-urban interface came home to Douglass Ranch in 2000 when the Hi Meadow Fire swept through western Jefferson County forcing the evacuation of the entire subdivision. Following the fire, the CSFS increased its conversations with residents of Douglass Ranch and other developments in the Lower Elk Creek watershed about creating defensible space around their homes and property.

Several homeowners implemented risk reduction plans in May and June of 2001 that included thinning dense stands of trees and clearing ladder fuels that can quickly transport fire into the crowns of trees and onto flammable roofs and decks.

With new funding available through the National Fire Plan, the CSFS has continued to provide technical and financial assistance to homeowners throughout Lower Elk Creek. In addition, large-scale, multi-ownership fuel breaks are being created in the area and a GIS assessment of wildfire hazard and community risk is underway. Monthly forestry articles in local newspapers and a specially designed website for area homeowners help keep neighbors up to date.

Action in this watershed is critical to future public and firefighter safety. But it will also contribute to the protection of critical drinking water resources provided by the larger Upper South Platte Basin, of which Lower Elk Creek is a part. Area wildlife seem to approve of the change: Wild turkeys, which have not been seen regularly in the area for quite some time, now visit Douglass Ranch almost daily, spending most of their time on properties thinned for defensible space.

landscapes are also the preferred scenic backdrop for many city dwellers moving from urban and suburban neighborhoods into the mountains.

The Colorado State Forest Service estimates that nearly one million people currently live within the Red Zone, an area characterized by more than six million acres of forest land at high risk for large-scale wildfire. Fires in these wildland-urban interface zones (WUI) pose a tremendous threat to the lives and property of area residents, and are particularly dangerous to the firefighters sent in to suppress the blaze.

Human presence in the forest also increases the risk of human-caused fires. While abandoned campfires and carelessly discarded cigarettes are well-known fire hazards, homes and structures also represent a tremendous fuel source. Flammable building materials, the presence of hazardous household chemicals and fuel tanks, and dense vegetation, both natural and planted, in the surrounding landscape can increase the intensity of an oncoming fire.

Ironically, development in the WUI often limits land managers' ability to reduce wildfire hazard through tools such as landscape-scale fuel reduction or prescribed burning. Thinning of forest fuels is complicated in the interface by the difficulty of coordinating projects across a number of small ownerships. Application of prescribed fire can also be seen as too risky in areas with large numbers of homes and/or residents. These challenges are being met in Colorado through the development of several multi-ownership projects designed to treat hazardous fuels on a landscape or watershed scale.



Figure 17: A typical home in Colorado's wildland-urban interface.

Increased WUI development in pinion-juniper landscapes has drawn greater public attention to the issue in recent years.

Watershed Health

The headwaters for most of Colorado's rivers are located in forests. The condition of those high elevation forests, along with lower elevation riparian areas, plays a critical role in determining the quantity and quality of the water that supplies the state's natural systems, agricultural production and municipal water supplies.

Stream flow in forested landscapes is primarily influenced by forest structure and disturbance. These factors regulate groundwater recharge and the amount of precipitation that reaches streams as runoff. Since the majority of Colorado's runoff results from snowmelt rather than summer rain, forest influence on snowpack is critical. Increased forest density means more snow intercepted in the canopy where it

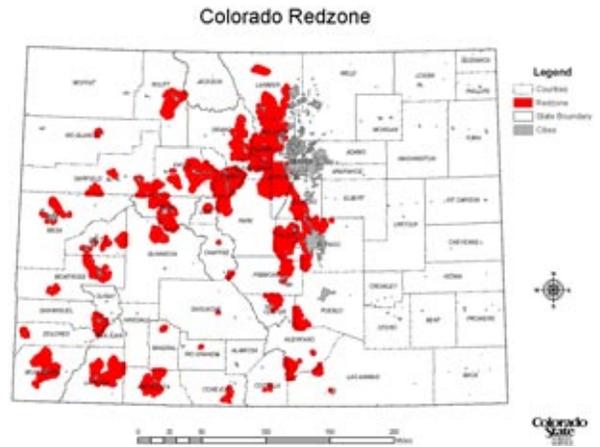


Figure 16: This map of Colorado's Red Zone identifies areas in the state where forests with high wildfire hazard coincide with significant human development.

evaporates before reaching the ground. As forests shift from a more open-canopy to a closed-canopy structure there is a proportional loss of runoff. In addition, increased tree density results in higher evapotranspiration rates, which further reduce the amount of water available for stream flows.

As the density of Colorado's upland forests continues to increase, so does the threat of catastrophic disturbances to Colorado's streams and rivers. High intensity wildfires, fed by accumulated ground fuels and dense understory and canopy vegetation, often lead to intensified soil erosion and increased stream sedimentation. Such sedimentation has both short and long term impacts on streams and watershed function. Soil disturbance is most prevalent following rapid snowmelt or heavy rain events in the months following a wildfire.

One recent example of this looming threat was seen in the 1996 Buffalo Creek Fire. In less than six hours, this wind-driven fire consumed more than 12,000 acres of federal and private forest as well as 10 dwellings in the upper South Platte watershed of Jefferson County. Less than two months later, a high intensity thunder storm dumped approximately 2.5 inches of rain on the burned area causing severe flooding, which resulted in the washout of Jefferson County Highway 126 and the destruction of the City of Buffalo Creek's potable water and telephone facilities. The storm resulted in the deposition of hundreds of thousands of tons of sediment into Strontia Springs Reservoir, an amount equal to the previous 13-year sediment load. Strontia Springs is a major distribution facility for Denver's water supply.



Figure 18: A forested stream near Cameron Pass on the Colorado State Forest.



Figure 19: Altered stream flows have caused many of the state's native cottonwood-willow stands to be replaced by non-native invasives such as tamarisk and Russian olive.

The fire suppression costs combined with the costs of the first flood were in excess of \$17,000,000 – more than \$1,400 dollars per acre burned. Subsequent rainstorms have delivered many more thousand cubic yards of sediment into Strontia Springs. It is estimated that the accumulated costs to date are in excess of \$25,000,000.

Riparian Forests

In the arid West, *riparian* or streamside ecosystems provide essential habitat for a large number of wildlife species, help maintain water quality and quantity and aid in stream bank stabilization. Colorado's rivers and streams support diverse riparian landscapes that range from mosses, grasses and a few small flowering plants to more complex systems of forests, woodlands and marshes. This diversity was revealed in a recent survey by the Colorado Natural Heritage Program that identified 150 native plant associations in the state's riparian ecosystems (Pague 2001).

The condition of Colorado's riparian forests has been significantly altered over the past century by water development and flood control, with additional impacts attributable to urban development, intensive agriculture and grazing, timber harvest, land clearing, rural and urban pollution and fire (Pague 2001). Altered stream flows and other human-induced hydrologic changes have caused many of the state's

native cottonwood-willow stands to be replaced by non-native woody species such as Russian olive (*Elaeagnus angustifolia*) and tamarisk (*Tamarix ramosissima*).

The conversion of native cottonwood-willow stands has been particularly noticeable in Colorado's lower elevation riparian areas and on larger rivers where human impacts are more concentrated. A recent assessment of the aquatic systems in Colorado's Southern Rocky Mountains confirmed that while higher elevation riparian zones are more likely to exhibit good site integrity, the state's lower elevation systems are in relatively poor condition. Other statewide assessments have found Colorado's low elevation riparian zones too degraded to adequately represent native riparian vegetation (Pague 2001).

Non-native species generally out-compete native riparian species through greater tolerance for water stress and salinity and better recovery from disturbances such as fire. The conversion of riparian vegetation from native to non-native species can alter entire ecosystem properties with profound implications for wildlife diversity and survivability. Bird species richness and density, for example is dramatically higher in native riparian vegetation.

Urban Forests

Colorado's rich urban forests include hundreds of thousands of trees lining neighborhood streets, beautifying public open spaces, shading homes and businesses and improving urban wildlife habitat throughout the state.

The density of the state's urban forests follows that of the population itself, with the greatest concentration of trees occurring along the eastern flank of the Rockies. The composition of this forest is typified by tree species adapted to the plains or eastern United States, which thrive under proper care in urban areas. Common examples include: American and Siberian elms; green ash; honey locust; lindens; bur and northern red oaks; several fruit tree varieties; Colorado blue spruce; ponderosa, Austrian, and pinion pines; and various junipers.

Urban forests are susceptible to a large number of insects and diseases, particularly introduced or "exotic" pests. Dutch elm disease (DED) provided a dramatic example of this vulnerability when it eliminated large areas of native and planted elms in the eastern United States. During the 1970s, the Colorado State Forest Service launched an aggressive program to detect and eradicate infected elms during this outbreak to help the state avoid similar devastation. The State's DED initiative grew into a more holistic program of total urban tree management called "community forestry."

Gypsy moths are currently the state's most threatening exotic pest. This insect "hitchhikes" into Colorado in the form of egg masses on objects such as vehicles and nursery stock. To date it has been detected in over 60 locations in the state, with the greatest concentration along the Front Range. The Colorado State Forest Service, in cooperation with the U.S. Department of Agriculture, tracks the progress of gypsy moth through an extensive trapping program that places approximately 2000 traps annually within all cities and towns in the state.

Other exotics of concern to Colorado are the Asian long-horned beetle from China and the pineshoot beetle from Europe. To date, neither has been detected, but introductions are expected. Various state and federal agencies maintain detection programs for these and other potential biotic threats.



Figure 20: Tree plantings and other urban forestry activities help city dwellers learn about and appreciate the natural environment.

Air Quality

The effects of air borne pollutants on Colorado's forest environments are unclear (Rogers and others 2001). However, research has revealed that in areas of consistently poor air quality, certain plants are negatively impacted. Ponderosa pine, for example, displays foliage damage or dieback in response to pollution.

Field crews monitoring forest health pay particular attention to lichen species in forests because lichens' intolerance to poor air quality makes them a useful indicator species for pollution damage. In addition to gauging air quality, lichens add significantly to forest diversity, enhance nutrient cycling and are a critical food source for wildlife.

Preliminary analysis suggests that lichen communities along the Front Range, near Steamboat Springs, in the Yampa Valley and in the Four Corners area have been altered significantly. Pollution intolerant lichen species are disappearing from these regions at a notable rate.

The effects of air quality on forest condition can also be measured through visual evaluation of tree foliage and crown conditions. Such observations have not yet revealed significant ozone damage in Colorado's forests, but high ozone levels have dramatically affected plant and tree health in the eastern United States and southern California for decades.

Trees weakened by ozone damage may be predisposed to damage by other disturbances, such as fire, insects, disease and wind storms. Future inventories and assessments of Colorado's forest condition will continue and intensify lichen sampling and visual evaluations of foliage and crown damage, so that emerging problems related to poor air quality can be quickly detected and remedied, if possible.

III. Conclusion

Existing data regarding the trends and condition of Colorado's forests highlights several areas of concern. From high-elevation spruce-fir forests to urban areas and riparian corridors, the long-term sustainability of our forested landscapes is being challenged by a variety of natural and human-induced influences.

As revealed in this report, issues and areas that merit particular concern include:

- The decline of ponderosa pine throughout its range due to mountain pine beetle, altered fire regimes and lack of management. Particular attention is warranted in the upper Arkansas Valley.
- Aspen decline throughout its range due to fire exclusion and changed management activities.
- Damage from spruce bark beetle in north-central Colorado as a result of the Routt blowdown and subsequent build up of beetle populations.
- Pinion pine decline in south-central and southwest Colorado due to environmental pressures and increased interface development.
- Subalpine fir mortality throughout its range due to bark beetle and root rot damage. Particular attention is needed adjacent to ski areas along the I-70 corridor and in the vicinity of Telluride.
- Statewide impacts as a result of land conversion and species loss in the wildland-urban interface.
- The extent and threat of exotic pests in Colorado's urban forests.
- The impact of poor air quality on forests along the Front Range, the Yampa Valley and in the Four Corners region.
- The conversion of native cottonwood-willow stands throughout Colorado's low-elevation riparian forests.

In the spring of 2002, the Colorado State Forest Service and the USDA Forest Service will begin an inventory of Colorado's forests that will be more comprehensive than any in nearly 20 years. During the first year of this new cycle, federal field crews will inventory all plots located on lands managed by the USDA Forest Service. Combined state and federal crews will begin a similar process across all forest ownerships as part of Colorado's transition to an annualized forest inventory. Analysis of the data collected in 2002 will begin within the year, with raw data available shortly thereafter. A comprehensive report on the data collected from all ownerships will likely be published within five years, with similar reports published on a five-year cycle.

The advent of this activity offers the state an opportunity to invest in intensified data collection and/or analysis in areas of particular concern. More importantly, it will provide land managers, decision-makers and the general public with valuable, up-to-date information regarding the issues outlined above.

It is hoped that this report, along with continued research and data collection, will provide a credible, scientifically sound basis from which to launch a public dialogue regarding the future of Colorado's forest resources. It is in this public arena where the needs and values of our forests will be determined along with decisions regarding future management and investment of resources.

Future editions of this annual report will provide greater detail regarding individual forest health issues in Colorado and will highlight priority areas where conditions merit specific attention and timely action.

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