



2005

# Report on the Health of Colorado's Forests

Special Issue  
**Aspen Forests**







February 2006

The 2005 Report on the Health of Colorado's Forests highlights the ecology and management of the state's aspen forests and provides an expanded insect and disease update, with a particular focus on the mountain pine beetle and spruce bark beetle outbreaks currently spreading throughout Colorado's central mountains. Both sections of the Report underscore the need to address forest management in a proactive, rather than reactive, manner.

Many researchers and land managers attribute the size and intensity of current bark beetle activity, at least partially, to the lack of age diversity in lodgepole pine and some spruce and ponderosa pine forests. This condition leaves forests extremely vulnerable to bark beetle attack.

In the absence of natural cycles of wildfire or other disturbance, forest management treatments can increase age diversity, decrease competition and improve overall resilience among forest stands. But this action needs to occur prior to an insect epidemic in order to be most effective.

Once an insect outbreak has reached epidemic proportions, it is very difficult to slow its expansion. Ultimately, only freezing temperatures will stop the beetles' reproduction. Forest management actions taken in response to an ongoing epidemic should focus on public safety and the protection of homes and other critical infrastructure.

Unlike the mountain pine beetle situation, we still have the opportunity to be proactive in the management of Colorado's trademark aspen forests. Many of the state's aspen stands are reaching the end of their life cycle. In some areas, natural regeneration is not occurring. Strategic forest treatments can stimulate regeneration, but must occur before critical root systems decline beyond the point of recovery.

Colorado's aspen forests provide both residents and visitors with a tremendous range of values, including rich and diverse wildlife habitat, economic opportunities from recreation, tourism and timber harvest and unique cultural and scenic opportunities. If we wish to maintain these and other values, we must support forest management treatments that sustain aspen forests in their full range of natural diversity.

As members of Colorado's Forestry Advisory Board, we encourage all Coloradoans to better understand the natural processes and human decisions that influence the condition of our forests – and to support proactive treatments that improve that condition before negative impacts occur.

Sincerely,

Nancy M. Fishering  
Chairperson, Colorado Forestry Advisory Board

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# 2005 Report on the Health of Colorado's Forests

## Executive Summary

People enjoy and appreciate Colorado's forests, mountains, wildlife and weather. Although they often seem unchanging, each component of the state's beloved scenery is part of a constantly shifting natural system. Many forests, for example, are dependent on cycles of wildfire and native insects for renewal. The current mountain pine beetle epidemic in Colorado's north-central mountains is giving residents and visitors alike a vivid glimpse of this renewal process in action.

The combination of aging lodgepole pine forests and several years of severe drought has allowed the current mountain pine beetle epidemic to grow to a scale not previously recorded in Colorado. In 2005, over 425,000 acres of Colorado forests were infested with mountain pine beetle. Reducing wildfire hazard has become even more critical in mountain communities with beetle-killed forests.

Since the majority of Colorado's spruce forests have the mature, large-sized trees that are sought by another tree-killing insect, the spruce beetle, the state's spruce forests are also vulnerable to far-reaching change. Not only are spruce beetle outbreaks becoming more numerous, a recently observed shortening of the beetle's life cycle is enabling it to expand faster than previously seen.

Spruce forests are among Colorado's longest-lived, having life cycles of 300 or more years. The onset of widespread spruce beetle infestations could transform this high country scenery in the matter of a few decades. A major turnover of older spruce forests will affect people on



Skip Edell

many levels, dramatically changing the recreational and scenic experience of these special places.

Like lodgepole and spruce, Colorado's aspen also have far more old forests than young. The 2005 Report on the Health of Colorado's Forests continues a series begun in last year's report by providing a detailed look at the ecology, condition and management of aspen forests across the state.

In addition to its glorious fall colors, aspen is a tremendous asset to the state's economy, recreation, wildlife, and watersheds. There are more aspen forests in Colorado than any other state in the West.

*Mountain pine beetle trapped in pitch. Despite their small size, bark beetles are effecting major changes across the West.*







Although fire suppression is not the main cause of vulnerability in Colorado's spruce forests, it has had deleterious effects on the state's aspen and other lower-elevation forests. Continuing to severely restrict fire's role, without the addition of forest management, has serious long-term implications for the sustainability of aspen on the landscape.

Elk, cattle, and other animals pose another threat to aspen throughout the West. Where aspen sprouts are eradicated by browsing animals, young aspen suckers are prevented from

growing into trees. More research is being conducted on this serious management dilemma.

Coloradoans enjoy tremendous benefits from the state's forests and, in return, have a responsibility to be good stewards of the land. This may include bringing back disturbance to forests where vital natural processes, like wildfire, have been interrupted. Forest management, including tree cutting and prescribed fire, can play a critical role in keeping, and returning, Colorado's forests to good health.

*Although aspen will dominate the foreground of this photo for many decades, the distant hillside will soon be obscured by conifers in the absence of fires or other disturbances.*



Dan Wand





# 2005 Insect and Disease Activity Update

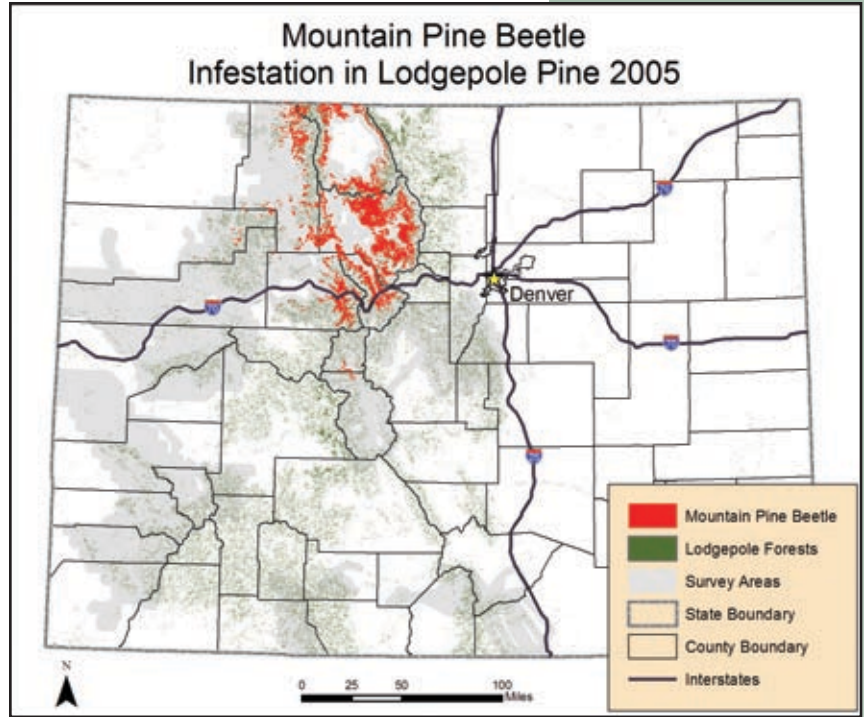
## Introduction

Insect and disease activity in 2005 provided a study in contrasts. Expanses of red beetle-killed trees drew tremendous public attention to the insect epidemic spreading through the state's north-central mountains. While in other areas, wetter weather actually reduced the dramatic insect activity seen in recent years.

Mountain pine beetle, an aggressive native insect, is the primary culprit in the death of millions of pines in Colorado and across the West. Like other bark beetles, mountain pine beetle plays a natural role in the life cycle of forest ecosystems, helping to precipitate the change from old stands to young.

The extent, severity and rate-of-spread that characterize the current outbreak may be outside the norms of this natural cycle due to a combination of drought impacts and the generally old, even-aged condition of many Colorado forests.

Colorado's aging spruce forests are poised to host the next big bark beetle epidemic, as spruce beetle populations continue to build in the state's high country. Spruce beetle is a primary agent of change in spruce forests, but researchers are concerned about a recent trend in the beetle's life cycle that has reduced its usual life span from two years to one. This adaptation allows the beetle to proliferate much more quickly, a reality that will likely bring vast changes to Colorado's spruce forests.



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*Colorado's current mountain pine beetle outbreak, which has been building for 10 years, has killed more trees than any previous epidemic in the state's recorded history.*



Ron Cousineau

*Mountain pine beetle infestation in Grand County, Colorado.*





CSFS



Colorado landowners have already spent millions of dollars to preventively spray trees and clear away dead trees from their properties. Even if logs are removed, piles of tree branches and tops can be expensive to chip or haul away and may create air quality impacts when burned.

In southwest Colorado, homeowners and land managers are beginning to see the recovery of piñon – juniper forests devastated by a drought-induced piñon ips outbreak in 2002 and 2003. Increased moisture has caused a corresponding decline in insect activity, while also promoting growth of remaining junipers.

A rise in precipitation throughout the state also lead to lush growth of grasses and forbs. Small rodent populations exploded in response to this abundant food source. During winter, voles and other rodents caused widespread damage by chewing the stems of junipers, aspens, small ornamentals and various shrubs.



Kent Grant

Damage to aspen from voles.

## Impacts to People from Widespread Beetle-Killed Trees

### Increased potential for wildfire which may result in:

- Loss of life and property
- Reduced real estate values
- Changes to tourism-based economies
- Long-term costs of water supply and reservoir clean-up
- Safety hazards from falling dead trees

### Potential impacts to recreation such as hiking, camping and skiing include:

- Scenery changes
- Reduced wind protection
- Safety hazards from falling dead trees

### Potential landowner impacts include:

- Property value reductions
- Erosion issues from increased water yields
- Wood and tree branch disposal challenges





## Aerial Survey: Art or Science?

Traveling at 100 miles per hour, 1,500 feet above the forest canopy, aerial surveyors have a challenging assignment. They are tasked with capturing the essence of insect activity, intensity and location by sketching their observations on maps. Turbulence, cloud shadows and physical discomfort can increase the job's complexity.

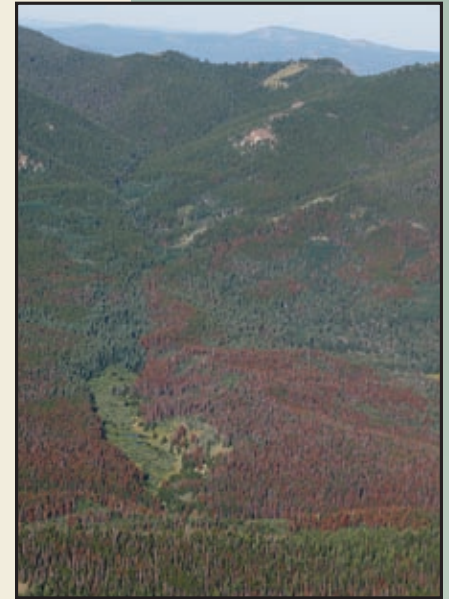
*“Patterns form that you can’t see from the ground,” said Crystal Tischler, a Colorado State Forest Service aerial surveyor. “Some insects move progressively through an area while others go from spot to spot.”*

A few insect signatures, like spruce beetle, are hard to distinguish from

the air. Validation, or ground truthing, of causal agent and location is critical.

Despite limitations of the data, aerial surveying is an invaluable tool for examining insect trends over time. Maps and numbers referenced in this report were derived from aerial surveys conducted in the summer of 2005.

Eventually, satellite imagery may replace aerial surveying, but currently the data is too expensive to purchase and interpret. Aerial surveying costs about a half a cent per acre.



Skip Ediel

## Mountain Pine Beetle

*(Dendroctonus ponderosae)*

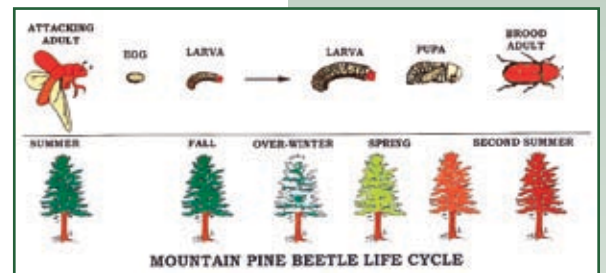
In Colorado, mountain pine beetles primarily attack ponderosa and lodgepole pines. The beetles carry a bluestain fungus that infects their chosen trees. The fungus spreads through and clogs the tree's water-transporting vessels while beetle larvae eat the tree's inner bark. The fungus and the larvae's activities interrupt the tree's nutritional system, causing the tree's death.

*Today, many of Colorado's high country forests are dense, mature, eight inches in diameter or larger lodgepole pine; this is precisely the habitat in which mountain pine beetle thrives.*

The current mountain pine beetle outbreak, which started in a few small areas in the 1990s, has affected over 425,000 acres in 2005, primarily in lodgepole pine forests of north-central Colorado.

Winter Park, Granby and Fraser in Grand County; Vail Valley in Eagle County; and parts of Summit, Jackson and Routt counties saw remarkable rates of mountain pine beetle expansion in 2005. Forest entomologists predict large-scale pine mortality from Vail to the Continental Divide.

Ponderosa pine forests in Colorado also experienced mountain pine beetle outbreaks in 2005. Population build-ups were detected near Salida and Buena Vista in eastern and central Chaffee County; outside Woodland Park in Northern Teller County; and southwest of Bailey in Park County.



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*Mountain pine beetle has a one-year life cycle in Colorado. In the summer, adults leave the dead trees where they developed.*



Unseasonably low temperatures during early fall (below 0° F), winter (below -34° F), or mid-spring (below 0° F) can retard outbreaks, but beetle survivors can re-start epidemics where overcrowded mature pine forests remain.

***Extreme weather or lack of remaining mature pines is the only means of stopping an epidemic of this intensity.***

Wildfires in the second half of the 19th century, including several in the dry year of 1851, were widespread in Colorado. Many lodgepole pine forests on the west side of Rocky Mountain National Park and east of Grand Lake regenerated after the 1851 fires. In the late 1800s and early 1900s, settlers harvested trees for mining, railroads and housing. The combination of wildfires and human settlement activity led to large sections of forest starting over at about the same time. These forests have since matured to a size susceptible to mountain pine beetle attack.

Lodgepole pines at about 80 years of age and older are susceptible to mountain pine beetle. Future landscapes will be vulnerable to another outbreak as widespread as this one if a more balanced distribution of ages is not reached.

***Less than a quarter of Colorado's lodgepole pine trees are small enough to be resistant to mountain pine beetle. Without forest management, future landscapes will be vulnerable to another widespread outbreak.***

Recent drought conditions weakened trees and enabled mountain pine beetle populations to swell to record levels.

Fires in some areas of these beetle-killed stands are likely during the next few years. Weather will be a primary influence on the timing, as well as the size, of fires in these areas.

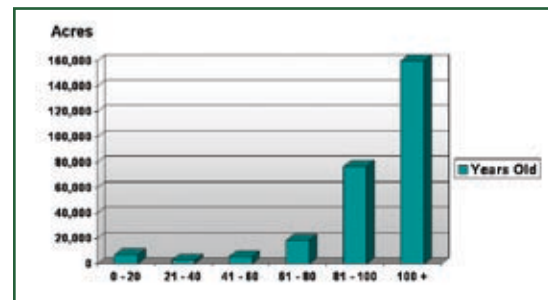
Fire danger increases during the first three to five years after beetles kill a forest, when needles are dry but remain



Ron Cousineau

*Young, small-diameter trees, as seen in the foreground, are not susceptible to mountain pine beetle.*

on the trees. Once needles fall off, wildfire hazard decreases for a period. Fire danger increases again in approximately 15 to 20 years when the trees rot and fall down, adding woody material to the young trees and other fine fuels growing on the forest floor. A fire in this arrangement is difficult to suppress and would pose safety hazards to firefighters. Severe wildfires have higher intensities and longer durations which can be very detrimental to plant communities, soils, and watersheds.



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*This graph from the Arapahoe Roosevelt National Forest (located in north-central Colorado) shows a typical age breakdown in Colorado's lodgepole forests.*



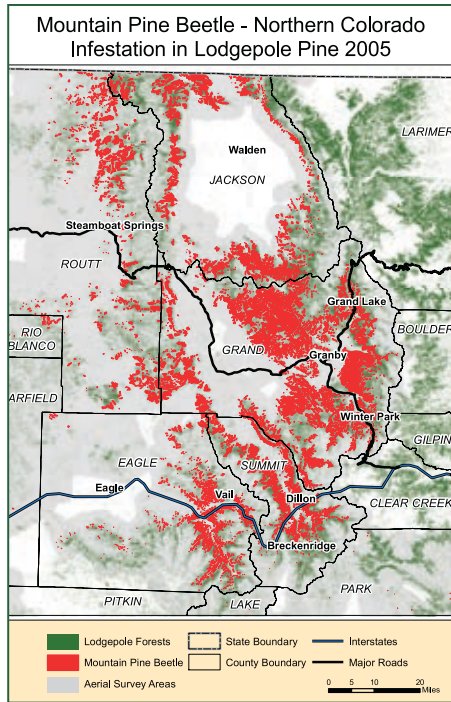


To lessen wildfire hazard, especially where homes are located in forests, it is critical to reduce the number of dead, dry trees. Removing this material can lower a fire's intensity and thus speed regeneration and recovery. Currently, timber removal is only occurring on a small percentage of lands affected by bark beetles, primarily in wildland urban interface areas.

***There is no practical way to stop a large-scale mountain pine beetle epidemic once it has begun.***

Management strategies may focus on removing standing dead trees (salvage), infested green trees (sanitation) and susceptible host material (thinning or clearcutting) or protecting high-value trees with preventive insecticide sprays. The latter strategy is not recommended for treating entire forests due to its expense and the difficulty of reaching vulnerable tree trunks. Aerial spraying of insecticides is not effective in preventing mountain pine beetles.

As with most insect and disease problems, the best way to reduce unwanted damage is to alleviate stress and extreme competition or otherwise improve forest conditions prior to attack. In bark beetle prone areas, the most effective approach may be a combination of salvage/sanitation harvesting, thinning of green stands and removing selected



*Red areas depict the presence of mountain pine beetle killed trees, and represent varying degrees of mortality. Foresters expect that most lodgepole pine forests in north-central Colorado will be impacted by this epidemic.*

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pine trees with diameters above eight inches. In lodgepole pine, clearcutting mimics natural processes and remains one of the best methods to create conditions conducive to regeneration.

Lodgepole pine's wood is typically too solid, whether infested with mountain pine beetle or not, to provide habitat to cavity-nesting birds found in large trees with heart rot. However, other animal populations, such as tree squirrels, pine martens, and woodpeckers, may experience population shifts that correspond

with changing habitats.

Because lodgepole pine is a direct competitor to aspen, in sunlit areas of pine mortality aspen should flourish if it is a component in those forests. Where lodgepole pine has been removed, ecologically beneficial stands of aspen will provide rich habitat to many wildlife species.

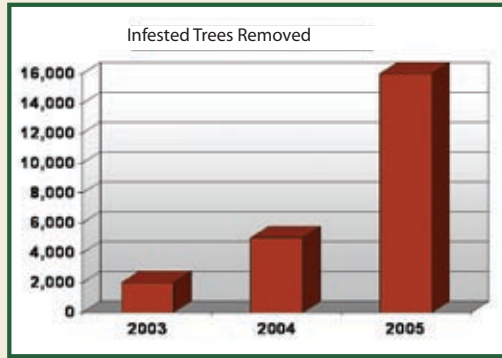
*The distinctive rusty-red needles on recently killed pine trees increase wildfire potential in the short term. Long-term risk is associated with accumulation of large amounts of deadfall.*



Jen Chase



### Community Impacts



Despite actively removing mountain pine beetle infested trees, residents in a subdivision near Granby Reservoir have seen increasing number of trees dying in their neighborhood.

CSFS

### Spruce Beetle (*Dendroctonus rufipennis*)

Spruce beetle is a primary ecological change agent that regenerates old spruce forests. A period of 250 years or more may pass between widespread epidemics. Intense wildfire is another disturbance in spruce forests; the moist, high-elevation sites where spruce/fir occur burn on a time scale of about 300-500 years.

Entomologists are concerned about an unusual recent change in the spruce beetle's typical life cycle, reducing the span from two years to one. This change enables the insects to proliferate at much faster rates than previously observed. Many attribute the life cycle change to milder temperatures and possible climate change influences.

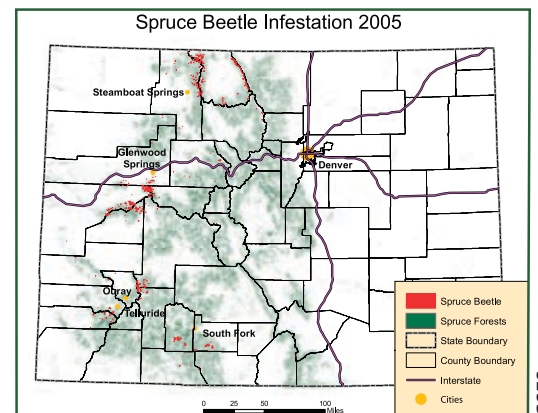
Many spruce beetle outbreaks are triggered by blowdown; others have causal events that are less obvious,

such as avalanches, temporary flooding by spring runoff, or root disease. The occurrence of spruce beetle epidemics across the West indicates the presence of large acreages of old, closely-spaced spruce trees as well as several triggering events.

*Unlike mountain pine beetle, which spends few hours outside of its host tree, this tree-killing insect usually takes a week to find a new host. With winds, spruce beetle can fly up to 30-40 miles.*

Many of Colorado's spruce forests are in remote locations that can be difficult to access. Several designated wilderness areas have growing spruce beetle populations.

Forest management efforts can reduce the impacts of spruce beetle by making spruce forests more diverse age-wise. Reintroducing fire in lower-elevation areas abutting spruce forests, and mimicking the effects of fire by cutting different areas over time are two available methods for increasing age diversity.



CSFS

*Red areas depict the presence of spruce beetle killed trees, and represent varying degrees of mortality. If current spruce beetle outbreaks continue to grow, Colorado's high country spruce forests may look very different in a few decades.*





## Piñon Ips

*(Ips confusus)*

Piñon ips beetle activity, which killed record numbers of piñon pine trees in 2002 and 2003, decreased for a second year in 2005. This corresponds with the improved winter and monsoon moisture over much of the state since mid-2004. The additional stress of twig beetle activity seen in 2003 and 2004 also decreased with the increased precipitation.

In Colorado, piñon ips beetles impacted over 800,000 acres in 2003 and over 500,000 acres in 2004. Rough estimates suggest that over 9,000,000 piñon trees were killed in this epidemic, mostly in the state's southwestern and southern forests.

The result has been a major shift in piñon-juniper forests in favor of juniper. Some piñons survived the outbreak and will provide the seed for a slow recovery of the species over the next hundred or more years.

## Douglas-fir Beetle

*(Dendroctonus pseudotsugae)*

Douglas-fir beetle increased on Colorado's Western Slope and decreased on the Front Range. Douglas-fir pole beetle and various engraver beetles associated with Douglas-fir beetle activity escalated somewhat as well. Some pockets of Douglas-fir beetle are associated with previous years' wildfires like the 2002 Million Fire outside of South Fork and the 2002 Missionary Ridge Fire near Durango. Douglas-fir beetle tends to populate areas that burned at high temperatures, but not hot enough to ruin the trees' inner bark layers.

## Subalpine Fir Decline

*(Dryocoetes confusus and Armillaria spp, Heterobasidion annosum, etc.)*

Mortality of subalpine fir, which is attributed to the western balsam bark beetle and/or root diseases, continued to be the most widespread forest health issue in Colorado in 2005. Because tree mortality is sporadic and because subalpine fir does not have a high commercial value, it does not draw much attention. This insect and disease combination killed over 600,000 subalpine fir trees in 2005.



USFS

*Spruce beetle populations that exploded after the 13,000-acre Routt Divide Blowdown in 1997 have killed most of the spruce type within many miles of the blowdown area.*



## Economics of Dead Trees

After a few months of infestation, a blue-stain fungus associated with mountain pine beetle turns the tree's wood light blue. This blue stain limits the products that can be made from the wood and reduces the wood's value.

Standing dead trees also lose value over time because the wood dries and cracks, making part of the wood unusable. To retain the most value, infested wood should be removed from the forest as soon as possible.



Hans Rinke

### Western Spruce Budworm (*Choristoneura occidentalis*)

Western spruce budworm is chronic throughout mountainous portions of Colorado, and it increased along the Front Range in 2005, particularly in Jefferson County. Thinning forests can promote tree vigor and may help trees better withstand repeated western spruce budworm attacks. Chemical spraying can be used to protect high-value trees from defoliation and associated damage.

### Douglas-fir Tussock Moth (*Orgyia pseudotsugata*)

The Douglas-fir tussock moth outbreak detected on the east slope of Doubleheader Mountain in 2004 spread slightly northward in 2005. Additional defoliation occurred near this area on the south side of U.S. Highway 285.

Although Douglas-fir tussock moth was rarely observed for most of the 1900s in Colorado, there have been increased outbreaks over

the past few decades. Without fire or active management, the fire sensitive Douglas-fir has proliferated beyond its historical territory, expanding even onto south-facing slopes. Recent Douglas-fir tussock moth outbreaks on these drier, atypical locations may be a result of fire suppression and may prove ecologically beneficial by removing Douglas-fir from inappropriate sites.

### Fir Engraver Beetle (*Scolytus ventralis*)

Fir engraver beetle typically attacks drought-stressed, pole-size and larger fir trees. A 2004 fir engraver beetle infestation in white fir along the eastern slopes of the Wet Mountains had no apparent new mortality in 2005. Improved moisture conditions likely caused the collapse of this insect population. Another notable fir engraver beetle population, also declining, continues in the area between Durango and Molas Divide.



## Dwarf Mistletoes

*(Arceuthobium spp.)*

Dwarf mistletoes, a group of parasitic plants, can reduce their host trees' growth and seed production, as well as increase susceptibility to insect attack, root disease and storm damage. Heavily infected trees show decline and mortality. Fire suppression in lower-elevation forests has reduced the number of openings that should serve as barriers to dwarf mistletoes' spread, favoring the development of denser understory stands beneath dwarf mistletoe infested trees.



Dave Leatherman

*An important strategy in bark beetle management, as with many forest insects and diseases, is the recognition and prevention of susceptible stand conditions that may lead to epidemics.*



CSFS

*Forest workers delimb beetle-killed trees on a run at Steamboat Ski Area.*

## Ski Area Battles Beetle

Intensive efforts to protect small pockets of infestation can be successful. The Steamboat Ski area has been gaining ground in areas affected by spruce beetle through persistent removal of infested trees. Although there is a high cost to aggressive sanitation, spruce beetle populations have abated for the third straight year in the ski area, while increasing on nearby lands.

## Other Forest Health Issues

- **Dutch elm disease** losses were much lower in 2005 than in previous years. Despite this positive trend, the value of large-leaved varieties of elms in Colorado's urban and community forests demands continued monitoring of this fungal disease and its two insect vectors, which are from Europe and Asia.

- Colorado State Forest Service set 1,578 **gypsy moth** traps statewide in 2005. No moths were detected. If imported, gypsy moth could threaten Colorado's urban, riparian, and orchard trees.

- Deciduous trees in southeast Colorado sustained **leaf and stem damage** from scales, plant bugs, leafhoppers, aphids, mites, and other sucking pests in 2005.

- The city of Aspen had a new outbreak of **willow scale** on about

100 aspen trees. City managers are effectively controlling the insect incidence with dormant oil treatments.

- **Spruce ips beetle** attacks in urban areas declined in northern Colorado, including Boulder.

- **Gambel oak borer** on oaks in the Denver metro area declined.

- Surveys for **emerald ash borer**, an Asian pest of ash species, will likely begin in a limited number of Colorado locations in 2006.

- **White pine blister rust**, a serious disease of limber and bristlecone pines, continues to spread into Colorado. Its impact and management options remain unknown.

- De-icing and dust control **salts** continued to cause discoloration of trees along Colorado's roadways.



Dave Leatherman



# Aspen Forests in Colorado

## Overview

Aspen (*Populus tremuloides*) is a hallmark of Colorado. Its stunning autumn colors, the rustling sound of its leaves “quaking” in the wind, and the unique quality of light filtering down through its open canopy have inspired generations of artists, musicians and outdoor adventurers. Its spectacular foliage draws thousands of visitors to forests throughout the state, resulting in a crucial economic boost to adjoining communities. And as Colorado’s primary deciduous tree, aspen provides valuable diversity to the state’s scenic and recreational experiences.

Aspen’s lush understory and nutritious shoots and buds also make it good forage for wildlife and cattle. The biodiversity found in aspen forests, as well as its characteristic soft wood, provide excellent habitat for many species, especially birds.

Prior to European settlement, periodic wildfires rejuvenated declining aspen stands by removing competing conifers and stimulating new growth. In the absence of these cyclic fires, Coloradans may see once golden slopes transformed into carpets of piney green.

***The two primary threats to aspen today are fire suppression and chronic animal browsing of young aspen shoots.***

Many of Colorado’s current aspen forests are reaching the end of their natural life cycle and being replaced by faster growing conifers. Because they have not been renewed by fire or other disturbance, aspen stands are also more vulnerable to extensive insect and disease problems and animal browsing.

Although it is unclear to what extent aspen existed on pre-settlement landscapes, researchers and land managers are exploring a variety of management techniques that may mimic natural disturbance cycles and revitalize



Terry Spivey

*Aspen’s majestic foliage brings millions of dollars to Colorado’s economy every fall.*

aging or otherwise declining aspen forests.

In Colorado, the question may not be one of aspen’s historic range, but rather where aspen stands are beneficial and what action is needed to ensure they are sustained.



Yvonne Lashmett



## Ecological Characteristics of Aspen

Aspen is the most widely distributed tree species in North America and the only major deciduous forest type in the Rocky Mountain region. Pure and mixed stands of aspen cover approximately 4 million acres in Colorado, making aspen the state's second most prevalent forest type after spruce-fir.

Researchers are unsure why Colorado has a relative abundance of aspen. Some cite past climate and disturbance history. Aspen is known to be an early invader of glaciated lands by seeding-in on the moist, bare soil left by receding glaciers. Aspen can grow on a variety of soils, but thrives on the deep clay soils found on the Colorado Plateau.

Aspen trees grow in clones that are made up of genetically identical stems. Each stem sprouts from a common ancestral root system through a process known as suckering. This unique ability gives aspen a distinct advantage over species that reproduce only from seed. The established root system provides young shoots, or suckers, with the water and nutrients needed to grow quickly. In ideal, moist conditions, aspen can grow about 10 feet tall in five years

as opposed to lodgepole pine, Colorado's fastest growing conifer species, which might only grow two feet in that time.

Aspen has been a component of Colorado's landscape since the last ice age, moving through cycles of establishment, replacement by conifers, and re-establishment after the conifers are removed through fire or other large-scale disturbance.

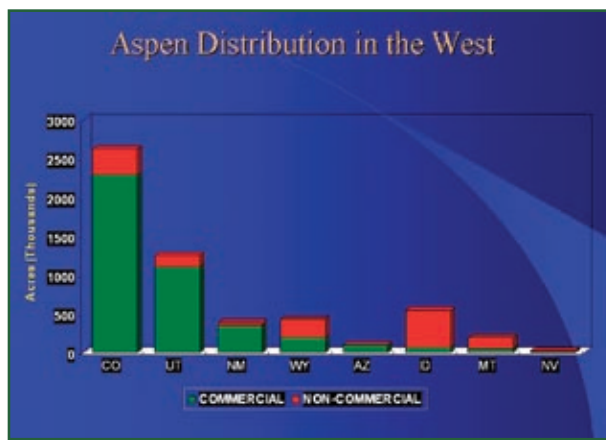
Aspen occurs in pure stands of one or more clones or in mixed stands with various species of conifers. Although aspen clones may

persist on a site for hundreds or even thousands of years, individual aspen trees are more ephemeral, living from 60 to 150 years of age.

Commonly known as "quaking aspen," the tree's individual leaves have a characteristic flutter which results from leaf stems that are flat in cross-section, rather than round. This adaptation gives the leaves strength while allowing them to twist flexibly in the wind.

Aspen's bark, which can be green or yellow in addition to the more common white, is a living layer, capable of photosynthesis. As a result, aspen displays wounds very clearly. Bark injuries, such as bear scratches, heal into black scars, recording the event. Historical aspen carvings by Basque shepherders from the late 1800s remain in many parts of Colorado and the West.

Aspen occurs at elevations from about 6,900 feet to timberline, approximately



USFS  
Although the majority of aspen forests are in Canada and the Lake States, Colorado has more aspen than any of its western neighbors.

A healthy, mature root system can put out 400,000 to a million shoots per acre. They thin themselves as they mature.



Jen Chase



10,500 feet. Aspen in the West can grow to about 30 to 70 feet tall, reaching diameters of one to two feet. The least shade tolerant of Colorado's native trees, aspen requires full sunlight to thrive.

Colorado's Western Slope has a much higher proportion of aspen than the Front Range. Extensive stands of pure aspen are located on the state's western mesas, which are outside the natural range of lodgepole pine, a frequent competitor with aspen.

The moisture regime on the Western Slope is also better suited for aspen. A large portion of the Front Range's moisture comes as rain in the summer, much of which is intercepted by the forest floor and subsequently lost to evaporation. The Western Slope receives the majority of its precipitation in the winter as snow. When the snowpack melts, a pulse of moisture saturates the soil, making it available to aspen's roots. The timing of the spring snowmelt precedes aspen's vital leaf-out period.



Hans Rinke

The bark of quaking aspen was used by pioneers and Native Americans as a fever remedy, as well as for scurvy. It contains salicin, which is similar to the active ingredient in aspirin.

## Biodiversity

In the West, aspen's plant and animal communities are second only to riparian areas in biodiversity richness. This tremendous biodiversity provides critical habitat for a wide variety of wildlife, especially birds. Aspen's tender bark and nutritious foliage also provide important wildlife forage.

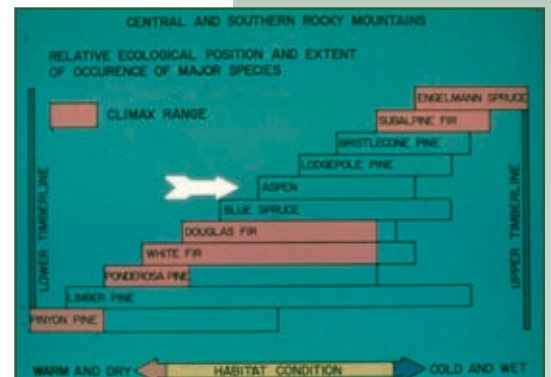
***Aspen is a valuable part of many western landscapes. In Colorado and Utah, aspen stands can be extensive and form a major habitat component for many species.***

Aspen forests can have several layers of vegetation. Plant communities associated with aspen include small trees such as chokecherry; shrubs such as snowberry, serviceberry, and common juniper; wildflowers; and grasses. Aspen is also found mixed with spruce/fir, Douglas-fir, lodgepole pine, ponderosa pine, Gambel oak, and sagebrush. Meadows and shrublands, which have decreased over much of Colorado in the last century, are sometimes neighboring communities associated with aspen.



Keith Wood

*Aspen clones can be easily distinguished from each other in the spring and fall, when they leaf out, change colors, and lose leaves simultaneously.*



Wayne Shepperd

*Aspen occurs in a wide variety of ecosystems and climatic regimes in mixed and pure forests.*



## Animals That Use Aspen Habitat

Animals that use aspen as habitat include deer, elk, moose, black bear, mountain lion, snowshoe hare, cottontail rabbit, beaver, porcupine, pocket gophers, bats, snails, insects and butterflies.

Many birds, including songbirds, cavity nesters, birds of prey, and gamebirds, benefit from aspen forests as well. Some avian species feed on aspen buds and seeds. Year-round residents in aspen communities include ruffed grouse, hairy woodpecker, mountain

chickadee, red-breastednuthatch and pine siskin. Bird species in old aspen stands are distinct from and more diverse than those of younger aspen stands.

Beaver, which is a keystone species in the West, depends on aspen for food and building materials. A keystone species significantly enriches ecosystem function relative to its abundance. Its removal initiates changes in

ecosystem structure and often loss of diversity.



Dave Leatherman

*Northern saw whet owl*



*Elk Calf*  
Dan Binkley

*Black Bear Cub*  
Terry Spivey

*Porcupine*  
Joseph O'Brien

*Beaver*  
Terry Spivey

## The Aspen Life Cycle

Aspen is considered a pioneer species, being the first to proliferate following fire or other disturbances. Conifers, which start growing more slowly, will out-compete aspen over time. Although conifers often succeed aspen, aspen can persist as a pure forest on sites where either a coniferous seed source is lacking or environmental conditions prevent the establishment of other trees.

Some aspen, called successional aspen, succeed to conifers within one generation without disturbance.

However, even when aspen trees have disappeared from the canopy, its root systems may persist for a long time, ready to re-sprout if a disturbance removes the conifer overstory. Successional aspen are dependant on change agents like wildfire or tree cutting to maintain a presence on the landscape. These aspen forests would eventually disappear in the absence of such disturbance.

Because of its rapid early growth and establishment, successional aspen may dominate a site for about 50 years. Aspen mortality typically begins at 60 to 80



years of age, when larger conifers begin to significantly shade aspen stems. Most aspen trees die between 80 and 100 years old. Conifers, such as lodgepole pine, may then dominate until the next fire or other large-scale disturbance. However, aspen are more likely to live to 150 years old or more in forests where conifers do not succeed aspen.

Data from a state-wide study indicate that the current average age of aspen trees in Colorado is 120 years, suggesting that many are approaching the end of their life cycle. The oldest recorded aspen in Colorado is 276 years old and is located outside of Paonia.

Although aspen is capable of reproducing from seed, it does not often occur. In order to germinate from seed, aspen needs full sunlight, a constant supply of moisture during the first growing season, and bare mineral soil. The climate in the central Rocky Mountains is typically too dry for aspen to grow from seed; therefore, most aspen propagation is from suckering. Genetic studies indicate that aspen has germinated from seed at least occasionally during the last several centuries; a few instances occurred after Colorado's 2002 wildfires.

***Unlike other western tree species, aspen will not readily regenerate from seed once lost from the intermountain west landscape.***

In select areas where aspen stems and root systems have fully disappeared from the landscape, re-introducing aspen will require planting. Insufficient moisture is a critical challenge to this approach and increases the importance of preventing declining aspen stands from dying altogether.



Dave Powell

*Abundant plant life responds to the sunlight that filters through the aspen canopy.*



Jen Chase

*Aspen and lodgepole pine often compete for the same sites. Aspen will flourish in many open areas created by the mountain pine beetle epidemic in north-central Colorado.*



## The Aspen Regeneration Triangle

Successful regeneration of aspen through root sprouting involves three components: hormonal stimulation, proper growth environment, and sucker protection.

**1.** Hormonal stimulation could be from any disturbance that interrupts the auxin/cytokinin hormone balance between the roots and stems. The hormone balance is responsible for suppressing or triggering new sucker growth from root buds. Auxin is produced by leaves and transferred to the roots where it suppresses cytokinin from stimulating the sucker buds. When the flow of auxin is interrupted, cytokinin causes buds to sprout.

**2.** The proper growth environment involves sun and water. The initiation of bud growth must be accompanied by sufficient sunlight and warmer temperatures at the forest floor for the new suckers to thrive.

If the clone and root system are healthy, new suckers will grow, but a weak root system may not regenerate. Inadequate carbohydrate reserves, damage from insects and diseases, as well as drought and climate conditions, could all limit the suckering response.

**3.** Protecting suckers from browsing may be necessary until the tender branch tips grow out of browsing animals' reach. Heavy browsing by herbivores can prevent suckers from maturing into overstory trees.

## Fire and Other Agents of Disturbance

Like many of Colorado's forests, aspen is a disturbance-driven species that developed in response to natural periodic fires and other landscape scale disturbance events. Prior to extensive human settlement, fire served as the primary agent of change in aspen forests. Fire maintains aspen stands on the landscape either by burning competing conifer stands, thereby allowing aspen to re-establish, or by burning the aspen stands themselves and stimulating regeneration.

Aspen's adaptations to fire include its preference for sunny sites, rapid early growth, prolific seed production and the ability to regenerate through suckers. Although individual trees easily succumb to fire, aspen forests usually contain more succulent, moist plants than conifer forests, making them harder to burn. Also in contrast to conifers, aspens lack resins and volatile compounds that burn easily.

In addition to fire, several secondary factors act as change agents that help regenerate aspen. These include: windthrow (blowdown), fungal diseases, tent caterpillars and other defoliating insects, burrowing animals, avalanches, snow damage, hail, and lightning. Cutting aspen trees or severing lateral roots from parent trees can also act as a regenerating disturbance.



Jen Chase

*The 2002 Million Fire that burned outside of South Fork is an example of how fire can maintain aspen on the landscape. Aspen will likely dominate parts of the burn area for the next 100 years because some conifer seed sources were consumed.*



Dave Powell

*Wind blew these trees down. Within a year, aspen suckers will abound in the opening.*



## Damaging Agents in Colorado's Aspen Forests in 2005

Aspen is renowned for being susceptible to damaging agents like diseases and defoliating insects. Its thin, living bark is a host to rot and canker disease organisms that can enter through even the smallest bark wounds and may rot or kill the tree.

- **Western Tent Caterpillar**

Western tent caterpillar was observed on the San Juan National Forest, between Durango and Durango Mountain Resort (formerly Purgatory Ski Area). On the west side of La Veta Pass, an infestation has the potential for significant expansion. Western tent caterpillar was also detected north of the Molas Divide, outside Silverton.

- **Foliage Disease of Aspen**

An orange discoloration of the foliage of aspen from leaf scorch was observed in South Park, outside Idaho Springs, and in the Waugh Mountain area.

- **Canker Fungi and Rots**

Canker fungi are present in almost all aspen stands over 100 years old. Many heart rots, root rots, and butt rots are also present.

- **Defoliators/Other**

In 2005, aerial surveyors detected about 20,000 acres of aspen defoliation in the Dolores Canyon area which was not observed in 2004. Whether a short-term defoliation from an insect occurred, or if the trees were killed, will be determined in the spring of 2006.

- **Aspen Decline**

A dieback of aspen, including mortality of overstory trees, is widespread in the northern Front Range. In 2005, most of these affected stands appeared to have a dense and healthy understory of aspen regeneration, indicating that new aspen will replace the trees that died.

*Western Tent Caterpillar Defoliation*



CK Morey



Hans Rinke

*Heart-rot*



Jen Chase

Prior to human settlement aspen stands re-burned on a scale ranging from decades to centuries.

## Consequences of Change

The extent to which aspen covered past landscapes is a current topic of debate and research. Fire suppression, herbivore damage and climate change are three influences that may have altered aspen from its cyclical coverage on the landscape. Although forests can be returned to an aspen-dominated condition, action will likely be needed to bring about this change.

### Fire Suppression

Unlike ponderosa pine, which can live through several fires and record each disturbance in its growth rings, aspen trees either do not burn or are consumed in the fire, leaving no discernable record. This makes fire history in aspen very difficult to determine. The fire history evidence that does exist suggests that frequent, patchy fires occurred on aspen landscapes in western Colorado in the latter half of the 19<sup>th</sup> century.

While research continues into the extent of fire's role in other parts of the state, it is clear that Colorado's current aspen stands are declining due to lack of disturbance.

Fire suppression over the last century has undoubtedly prevented some Colorado landscapes from returning to aspen-dominated forests. Continuing to severely restrict fire's role has serious long-term implications to aspen sustainability.



Bob Sturtevant

While aspen's presence is still widespread in Colorado's forests, some researchers estimate that aspen-dominated stands in other parts of the West have decreased between 50-96%.

Many researchers also attribute aspen's current high proportion of older *age classes* to fire suppression. These mature forests (as with all stages of forests) play an important ecological role, but with a majority of Colorado's aspen stands in older age classes, many landscapes are not providing the full range of benefits - from recreation opportunities to wildlife forage - that would be available from a forest with a more diverse mix of ages.

### Herbivore Damage

Since older aspen forests produce less forage than young ones do, many of Colorado's aging stands are at heightened vulnerability to animal browsing. A few aspen stands may even face potential eradication in heavily impacted areas.



Dave Powell

Elk Damage to Aspen

When aspen suckers are repeatedly browsed, they are not able to grow into trees. An aspen forest with greater age diversity would have an increased number of sprouts and would be less at risk from the impacts of elk, cattle and other browsing animals.

Although there is a lush understory in many aspen stands, elk prefer aspen's nutritious twigs, leaves, and bark. Elk have historically browsed aspen, but chronic, intense browsing is a relatively recent threat. Over the past several decades, some aspen areas in Colorado have been severely impacted by animal browsing. These impacts coincide with an increase





Dan Binkley

*There are still many elk in Yellowstone, but the threat of re-introduced wolves has changed their browsing habits and aspen suckers now have a chance to grow into trees. Despite the unhealthy appearance of the parent stems, this Lamar Valley photo shows a functioning system with aspen sprouting. The aspen sprouts have not been browsed, indicating a significant improvement in the area's aspen's prospects.*

in elk populations and a decrease in natural predators.

While natural predators can reduce elk populations through mortality, it is the return to natural travel patterns that improves young aspen survival. Elk behavior has changed significantly in the absence of its major predators. Rather than moving from one location to another, elk have become increasingly stationary. This concentrates browsing, allows less time for aspen stands to recover, and reduces survival of aspen suckers. In the ten years since wolves were re-introduced in Yellowstone National Park, aspen sucker survival has visibly improved in the area.

### Climate Change

Many current aspen clones are believed to have established from seed during cooler and wetter times. Aspen will be at a disadvantage in a warming climate because it cannot change its range with seed production, except during rare establishment periods. If temperatures become warmer, researchers expect aspen

to decline at its lower elevation limits, particularly in areas of shrubland such North Park and South Park in Colorado.

### Management Options

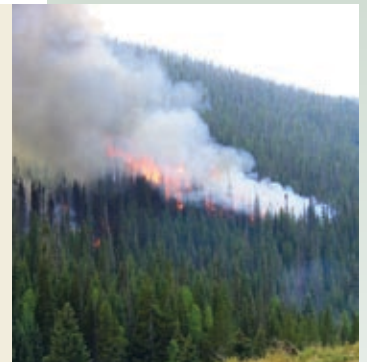
Various management options can be employed to maintain or re-establish aspen on the landscape for ecological, commercial, and aesthetic reasons. Fencing can eliminate animal browsing and allow suckers to grow into trees. Cutting trees or conducting prescribed fire in areas that are large enough to disperse herbivores can also help some aspen suckers survive. Experience in Colorado has shown that harvesting several 15- to 20-acre clearcut units at one time in a landscape can result in successful aspen regeneration, even if large numbers of browsing animals are present.

***Forest management can alter the succession of aspen forests to coniferous forests just as wildfire did naturally.***

Due to numerous pathologic, biotic, and environmental factors, active monitoring is key to aspen management, especially for the first five years after stand establishment.

### Wildfire Use

Wildfires have had ecological benefits, such as re-establishing aspen, for millennia. Wildfire Use is a type of management that allows wildfire to fulfill its vital role in rejuvenating ecosystems. This important tool can be employed on some lightning-started fires. The benefits of Wildfire Use are increasingly apparent. Its use can be very complex near populated areas.



Jen Chase





## Common Aspen Management Techniques

### 1. No Action

Not taking action is a form of management. In aspen stands that are able to regenerate themselves without disturbance, no action may still result in the retention of aspen on the landscape. Such stands are prevalent on the Western Slope, but are less common in the Front Range. Even if aspen clones are in decline, they may still be able to regenerate successfully.

### 2. Release from Competition

Removing conifers can slow or set back the shift from aspen-dominated to conifer-dominated forests. Removing small conifers is less expensive and can result in less injury to aspen stems than cutting full-sized conifers. Although removing competing conifers does not directly stimulate sucker production, it

does allow sunlight to reach the forest floor. Resulting warmth may encourage the natural sucker production that is already occurring in declining clones.

### 3. Protection from Herbivory

Where browsing animals are present, protecting new suckers

may be the key technique needed to achieve successful aspen regeneration. Fencing is the only proven means of directly protecting aspen sprouts from herbivory. It also reduces the risk of herbivores injuring aspen. However, game-proof fencing is costly, labor intensive, and time consuming to construct and maintain.

Stems need to be larger than one and a half inches in diameter and about

15 feet tall to survive under extreme elk browsing pressure. In most cases, eight to 10 years of normal growth are necessary for suckers to attain these sizes.

### 4. Prescribed Fire

Prescribed fire can provide ideal growing conditions for aspen suckers. Fire removes competing vegetation and blackens the soil surface, which absorbs the sunlight's warmth, encouraging sucker production. Prescribed fire can also improve forage quality and small mammal habitat.

Prescribed fires that burn the periphery of aspen stands will stimulate new aspen suckering along clone boundaries, even if the overstory aspen are not killed. This can create a diverse landscape in which some areas will be covered by new suckers while others will have some surviving overstory trees.

When fire regenerates aspen, the clone not only grows back, it expands from one to one and a half times a tree height out from the area previously occupied, because aspen roots extend that far away from trees.

In remote mixed conifer/aspen stands, prescribed crown fire can promote aspen regeneration or development. Crown fire not only rejuvenates aspen and resets vegetation succession, it can also increase understory plant diversity, forage production, and water yields, as well as improve habitat for many wildlife species.

In these cases, conifers carry the crown fire through the forest, killing all the aspen as well as the conifers. If conducted when soil moisture is high, such burns can avoid excessive damage to aspen roots.

Combining fire with other aspen management techniques can greatly benefit aspen regeneration and maximize suckering. Blending this technique with others mimics natural fire disturbance cycles in mixed aspen/conifer ecosystems.



USFS

*Fencing must be kept functional long enough to allow aspen to outgrow their most susceptible stage to elk damage.*



## 5. Mechanical Treatments

Harvesting can establish groups of aspen at different ages in otherwise large, single-aged landscapes. Removing all of the aspen in patches, including understory stems if present, will stimulate dense suckering.

An advantage of harvesting aspen is the treatment of black canker. If an infected stand is clearcut, the new suckers



*The Dixie forest in southern Utah used prescribed crown fire in mixed conifer/aspen forests.*

will be free of the canker. However, removing all stems in small stands near elk populations may result in loss of overstory trees as well as the root system if protection from elk is not provided.

Severing lateral roots is another form of mechanical treatment that regenerates aspen. It relies on the wide-spreading root habit of aspen to establish suckers at the edge of aspen stands where they will receive direct sunlight.

A single pass with a ripper along the edge of a clone can effectively stimulate suckering by cutting roots to a depth of about eight inches. To be effective, the roots only need to be separated from parent trees. Multiple passes, or use of discs or rototillers, is not recommended because they cause too much injury to lateral roots.

## Areas of Aspen Management

Because it is a very desirable species, there are many efforts to return aspen to the landscape. The following projects highlight some aspen management efforts in Colorado.

### U.S. Forest Service Fraser Experimental Forest

At the Fraser Experimental Forest, managers are working to enhance aspen in conjunction with mountain pine beetle salvage efforts. While removing dead and infested lodgepole pine trees, they also cut areas of competing conifers surrounding aspen trees, which stimulates aspen suckering.

### West Side Project, Salida

In a cooperative effort called the West Side Project, the U.S. Forest Service, Bureau of Land Management, Colorado State Forest Service, and local landowners are working across property boundaries to reduce mountain pine beetle impacts and mitigate wildfire hazard.

Because of its fire-resistant properties, encouraging aspen is a primary goal.

Thousands of acres have been treated in the few short years since the West Side project started. Thinning and patch-cutting in this landscape-scale effort is changing an unnaturally dense forest to one that favors aspen and increases age class diversity. Specific aspen improvement measures include removing old aspen and cutting conifers in mixed aspen/conifer forests.



*Clearcutting small patches of aspen increases valuable edge habitat, which gives wildlife cover and access to food that is available in meadows and young forests.*

USFS

Doug Page



### San Juan National Forest

In Montezuma and Dolores Counties, foresters have been actively managing aspen for several decades. By harvesting, they mimic how wildfire historically re-set succession. This regenerates older, declining stands and increases the number of younger aspen forests in an area where most are old.

Land managers target areas of mature aspen trees with extensive insect and disease problems. They then design harvest units to break up the forest canopy. Cutting all of the aspen within the five- to 40-acre units allows warm sunlight to reach the ground and maximizes aspen suckering.

Although the smaller material remaining from harvest activities decomposes relatively quickly, large woody debris breaks down slowly and provides habitat for small animals. For this reason, some logs are left on site, distributed

through the cutting areas. This can also help protect aspen regeneration, making some sprouts less visible and accessible to elk and cattle.

The harvested wood is put to many uses. One local mill makes tongue and groove aspen paneling, used for interior walls and ceilings. Another local mill shreds the wood to make erosion control mats, which help stabilize soil and allow plants to establish.

Because mill work is one of the better paying local jobs, the communities of Mancos and Dolores benefit from the mills' employment

opportunities and revenue. However, when wood supply decreases, mills struggle. These mills receive about 20 to 50% of their aspen wood from federal timber sales, about 40 to 50% from private land, and up to 40% from state lands.

The 387-acre Upper Lost Timber Sale, planned for 2006, contains about five million board feet of aspen. U.S. Forest Service plans to continue these ecologically and economically beneficial aspen management activities in future years.

### Uncompahgre National Forest and Grand Mesa National Forest

Management efforts in the Uncompahgre and Grand Mesa National Forests help retain the area's aspen stands. When aspen stands are excessively diseased in these National Forests, south and east of Grand Junction, respectively, foresters consider them for harvesting.

Wildlife habitat factors help determine the size and shape of the cutting units. Land managers use patterns that will enhance wildlife habitat over the long term, ensuring that future aspen areas have some mature stands. Currently most aspen stands in the area are nearing the end of their life cycle. If all of these areas were to regenerate at about the same time, there would be vast expanses of young stands with little or no mature cover to provide security for wildlife.

Local markets also benefit from aspen management. Products made locally from aspen timber include paneling, palettes, mine props and commodities from shredded wood. Between the Uncompahgre and Grand Mesa National Forests, about 200 acres of aspen are harvested annually.



Doug Page

Long term site productivity is enhanced by leaving some logs and tree branches on the ground.



## References and Additional Reading

Baker, F. S. 1925. Aspen in the central Rocky Mountain Region. USDA Department Bulletin Number 1291.

Barnes, B. V. 1966. The clonal growth habit of American aspens. *Ecology* 47:439-447.

Bartos, Dale L. 2001. Landscape Dynamics of Aspen and Conifer Forests. In: Sustaining aspen in western landscapes: Symposium Proceedings; 13 - 15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Bartos, D. L. and R.B. Campbell, Jr. 1998b. Water depletion and other ecosystem values forfeited when conifer forests displace aspen communities. In: D. F. Potts (ed), 1998 Proceedings of AWRA Specialty Conference, Rangeland Management and Water Resources. American Water Resource Association. Herndon, Virginia. TPS-98-1. 474 p.

Chong, G.W., S.E. Simonson, T.J. Stohlgren and M.A. Kalkhan. 2001. Biodiversity: aspen stands have the lead, but will nonnative species take over? In: Sustaining aspen in western landscapes: Symposium Proceedings; 13 - 15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Cottam, W.P. 1954. Prevernal leafing of aspen in Utah mountains. *Journal of the Arnold Arboretum* 35:239-250.

DeByle, N.V. 1985. Wildlife. In: N.V. DeByle and R.P. Winokur, editors. Aspen: ecology and management in the Western United States. General Technical Report RM-119. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

DeByle, N.V. and R.P. Winokur, editors. 1985. Aspen: ecology and management in the Western United States, General Technical Report RM-119. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.



Jones, J.R. and N.V. DeByle. 1985. Morphology. In: N.V. DeByle and R.P. Winokur, editors. *Aspen: ecology and management in the Western United States*. General Technical Report RM-119. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Kaye, C.E. 1997. Is aspen doomed? *Journal of Forestry*. 95:4-11.

Mueggler, W.F. 1985. Vegetation associations. In: N.V. DeByle and R.P. Winokur, editors. *Aspen: ecology and management in the Western United States*. General Technical Report RM-119. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 45-55.

Romme, W. H., L. Floyd-Hanna, D.D. Hanna, and E. Bartlett. 2001. Aspen's ecological role in the West. In: *Sustaining aspen in western landscapes: Symposium Proceedings; 13 - 15 June 2000; Grand Junction, CO*. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Shepperd, Wayne D.; Binkley, Dan; Bartos, Dale L.; Stohlgren, Thomas J.; and Eskew, Lane G., compilers. 2001. In: *Sustaining aspen in western landscapes: Symposium Proceedings; 13 - 15 June 2000; Grand Junction, CO*. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 p.

Shepperd, W. D. and J. R. Jones. 1985. Nurse crop. In: N.V. DeByle and R.P. Winokur, editors. *Aspen: ecology and management in the Western United States*. General Technical Report RM-119. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.



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