The Health of Colorado's Forests

Special Issue:
Threats to Colorado's Current and Future Forest Resources

2009 Report

Acknowledgements

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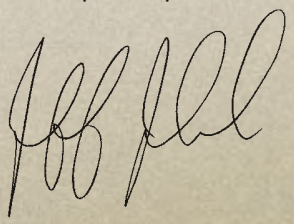
The *2009 Report on the Health of Colorado's Forests: Threats to Current and Future Forest Resources* provides an overview of insect and disease conditions in all of the state's forests. It also includes sections on urban forests, piñon-juniper woodlands, aspen forests and urban forests. In addition, this report introduces the Statewide Forest Resource Assessment, a new initiative mandated by an amendment to the Federal Cooperative Forestry Assistance Act. Interactions between forests, wildfire, insects, diseases and humans also are reviewed, as is the role forests play in protecting Colorado's watersheds.

This report is the ninth in a series developed by the Colorado State Forest Service (CSFS) on the condition of Colorado's forests. Much of the information contained in this report is derived from the annual forest health aerial survey, a cooperative project between the CSFS and the Rocky Mountain Region of the USDA Forest Service (USFS) that covers all land ownerships. In addition, the 17 CSFS district offices conduct forest insect and disease assessments and provide technical assistance to private forest landowners. These activities supplement the information in this report.

The CSFS, in conjunction with cooperators and stakeholders, is working to minimize the ecological, social and economic impacts of these events, primarily through long-term forest management such as thinning, prescribed burning and timely harvesting of mature forests. These activities are designed to maintain the vigor and health of all of Colorado's forests.

I hope you will find the information contained in this report to be informative and helpful. I invite you to contact your nearest CSFS office to learn more about our forests and what you, as a citizen/landowner, can do to help manage and protect this valuable resource.

Thank you for your interest in Colorado's forests.



Jeff Jahnke
State Forester and Director
Colorado State Forest Service

Executive Summary

The purpose of the annual forest health report is to provide a credible, scientifically sound basis from which to engage in public dialogue regarding the future of Colorado's forests. It is in this public arena that the needs and values of Colorado's forests will be evaluated so decisions can be made regarding future management and investment of resources. Each annual forest health report investigates critical forest health issues, including the identification of priority areas across the state where current forest conditions demand timely action. The information contained in this report builds on the foundation laid in previous reports by updating readers on issues of current concern and providing additional details for public dialogue. Coloradans can use these documents to better understand how the interactions between natural and human forces shape our forests and how informed citizens can contribute to the decisions made regarding future forest management. To view past issues of the annual forest health report, visit http://csfs.colostate.edu/pages/pub-csfs2.html.

It is important to note that while this year's report provides a broad overview of the numerous insect and disease issues challenging our state, the mountain pine beetle epidemic continues to be the predominant issue due to the threats it presents to human safety, communities, critical infrastructure, recreation and tourism, wildlife habitat, watersheds and water supplies, and Colorado's economy. We anticipate that the impacts of the MPB epidemic will be our primary focus for the next several years, and we will continue to engage in public dialogue to determine how to most effectively mitigate its impacts and create a future forest that is more resilient to catastrophic insect and disease epidemics.

MPB infestations encompassed 1.02 million acres of the state's 1.5 million areas of lodgepole pine forests. Infestations continued to intensify along portions of the Front Range and as far south as Fairplay. Lodgepole forests west of the Continental Divide have suffered heavy losses from MPB since 1998, and the outbreak has run its course in many areas because most of the susceptible trees have been killed. Evidence suggests that infestations are building in ponderosa pine forests along the Front Range. Increased attacks were seen in ponderosa pines where ponderosa and lodgepole pine forests adjoin. In early 2009, an outbreak was detected in ponderosa pine forests located in northern Larimer County near the Wyoming border.

Spruce beetle infestations continued in high-elevation Engelmann spruce forests in several areas of the state, with a total area of 114,000 acres of active infestations detected in 2009. Tree mortality caused by a combination of western balsam bark beetle and root disease-causing fungi continued in many high-elevation forests, but at a significantly reduced rate from past years. Localized infestations of Douglas-fir beetle occurred in portions of the Rampart Range between Denver and Colorado Springs, and in several other areas of the state.

In 2009, western spruce budworm defoliation of Douglas-fir, white fir and Engelmann spruce increased and intensified to a total of 382,000 acres. Defoliated areas included portions of the Culebra, Flat Top, Sangre de Cristo, San Juan and Rampart ranges.

Special surveys again were conducted for early detection of gypsy moth and emerald ash borer, both exotic pests. Three male gypsy moths were trapped in two locations in Colorado in 2009. Additional cases of thousand cankers disease of black walnut, which is caused by multiple fungi spread by the walnut twig beetle, a native insect that has recently expanded its range, were detected in several Colorado communities.

Aspen decline continues to be a concern, especially at the lower-elevation limits of its natural range. However, after two seasons of normal or above normal moisture, there are indications that the rate of aspen decline has at least stabilized and may be decreasing. In 2009, 342,000 acres of aspen decline and mortality were mapped, compared to 542,000 acres in 2008.

Although insect and disease outbreaks are normal and contribute to the dynamics of Colorado's forests, they can affect scenic values, alter water quality

Above: Mountain pine beetle-killed lodgepole pine trees at Michigan Reservoir. *Photo: Ingrid Aguayo*

and quantity, interrupt the availability of forest products and endanger the lives of people working or recreating in these forests. The CSFS and its cooperators and stakeholders are working to minimize the adverse impacts of these agents.

Colorado's Forest Resource Assessment

In response to an amendment to the Federal Cooperative Forestry Assistance Act of 1978 (CFAA), enacted as part of the 2008 Farm Bill, Colorado has embarked on a statewide assessment of its forest resources. This assessment will guide the development of a long-term forest resource strategy for Colorado. The purpose of the assessment and strategy is to ensure that federal and state resources are focused on important landscape areas — those that provide the greatest opportunities to address shared management priorities and achieve measurable benefits.

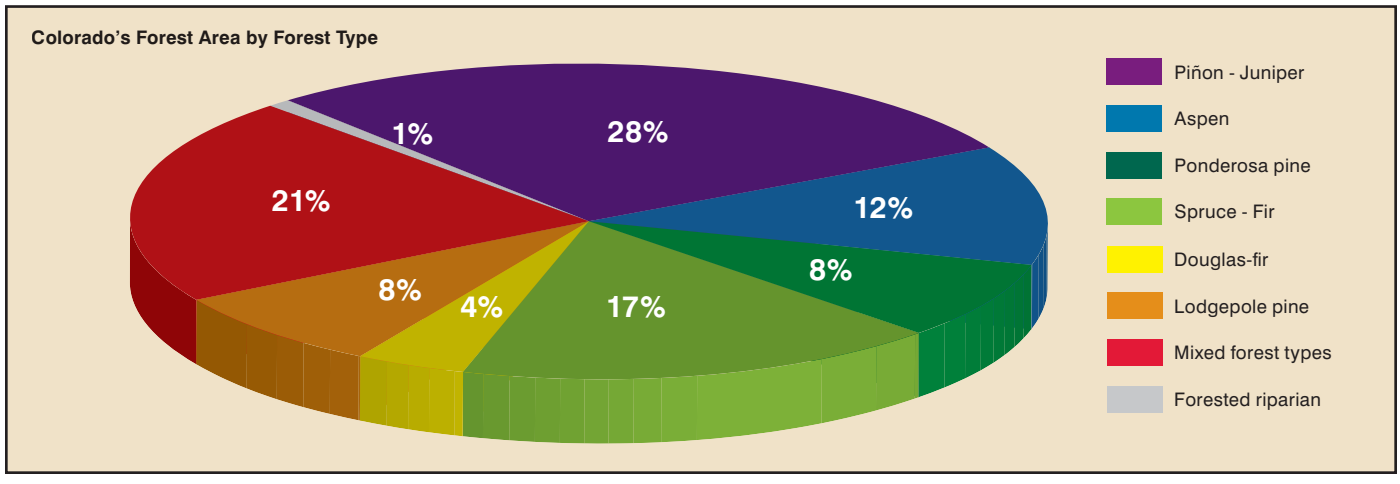
Colorado's Statewide Forest Resource Assessment identifies important forest landscapes across the state's nearly 19 million acres of forests and woodlands according to three national themes:

- Conserving working forest landscapes
- Protecting forests from harm
- Enhancing public benefits from trees and forests

Above: A forest vista from the summit of Mt. Margaret, Larimer County.

The Colorado State Forest Service (CSFS) is leading the assessment, with significant assistance from The Nature Conservancy, in partnership with representatives of other land management agencies and stakeholders including indigenous tribes, USFS, State Forest Stewardship Coordinating Committee, State Technical Committee of the Natural Resources Conservation Service and the State Wildlife Committee. All forested lands, regardless of ownership, are included in the assessment.

The overall approach to the assessment is to develop a series of thematic maps based on spatial data from



Left: Bighorn ram, Big Thompson Canyon. **Below:** Fritillary butterflies on thistle. **Bottom:** Cones of Douglas-fir, *Pseudotsuga menziesii*.

a variety of sources using a geographic information system (GIS). These include:

Conserving Working Forest Landscapes

Forest Legacy Areas
Private lands are identified that could be set aside to protect environmentally sensitive forests as authorized by a 1990 Farm Bill amendment to the Cooperative Forestry Assistance Act of 1978.

Spatial Analysis Project
Identifies non-federal land with high stewardship potential.

Change in Degree of Human Modification
Identifies lands with a high susceptibility to undergo modification.

Protecting Forests from Harm

Wildfire Susceptibility and Intensity
Data on vegetation type and fuel conditions are combined with topographic information to identify the probability of wildfire occurrence and the amount of resource damage a wildfire can cause. These data will be used to identify priority areas for wildfire protection.

Insect and Disease Mitigation Potential
Cumulative tree mortality caused by insects and disease between 2004 and 2008 based on annual forest health aerial surveys and stand basal area from the Forest Inventory and Analysis (FIA) are combined to identify areas with relatively low cumulative tree mortality but high potential for future damage.

Enhancing Public Benefits from Trees and Forests

Critical Watersheds for Drinking Water
Data on soil types, slope, existence of water diversions and fire susceptibility are combined to identify areas at high risk of events that could threaten the availability and quality of domestic water supplies.

Wildland-Urban Interface Zones
Housing density data are used to define community edges, identify areas where forest management is needed to reduce wildfire risk, and develop evacuation plans in the event of wildfire.

Wildlife Habitat
Areas that provide critical habitat for both economically important and imperiled species are identified.

Recreation Opportunities
Forest lands are scored by their ability to provide opportunities for biking, camping, fishing, hiking, hunting, skiing, snow shoeing and water sports.

The Colorado Statewide Forest Resource Assessment was initiated in June 2008 and completed in December 2009. The next phase is development of a strategy on how to address treatment of the high-priority landscapes identified in the assessment. This is being accomplished via a series of discussion sessions in several locations across Colorado to solicit public input. The Colorado Forest Restoration Institute is facilitating the sessions. The institute is based at Colorado State University and was chartered in response to the Federal Southwestern Forest Health and Wildfire Prevention Act of 2004. The objective of the institute is to help restore the health of Colorado's forests and reduce catastrophic wildfires by providing forest landowners with the best available science in forest ecology, restoration and management. The statewide assessment will culminate with the development and implementation of the strategy. The

strategy will describe how Colorado proposes to invest both competitive and non-competitive federal funding, along with other available resources, to address national and regional priorities, as well as those identified in the assessment. Forest management programs will be further refined and focused to address the management of Colorado's valuable and diverse forest resources, and provide tangible benefits to all Coloradans.

Right: Logs harvested from areas damaged by mountain pine beetle will be processed into a variety of wood products. *Photo: Dan Bihn.* **Below:** A hiker takes in a mountain vista. **Bottom:** Biking is a popular recreation activity in Colorado's forests. *Photo: Pat Ciesla.*

Colorado Forest Insect and Disease Update

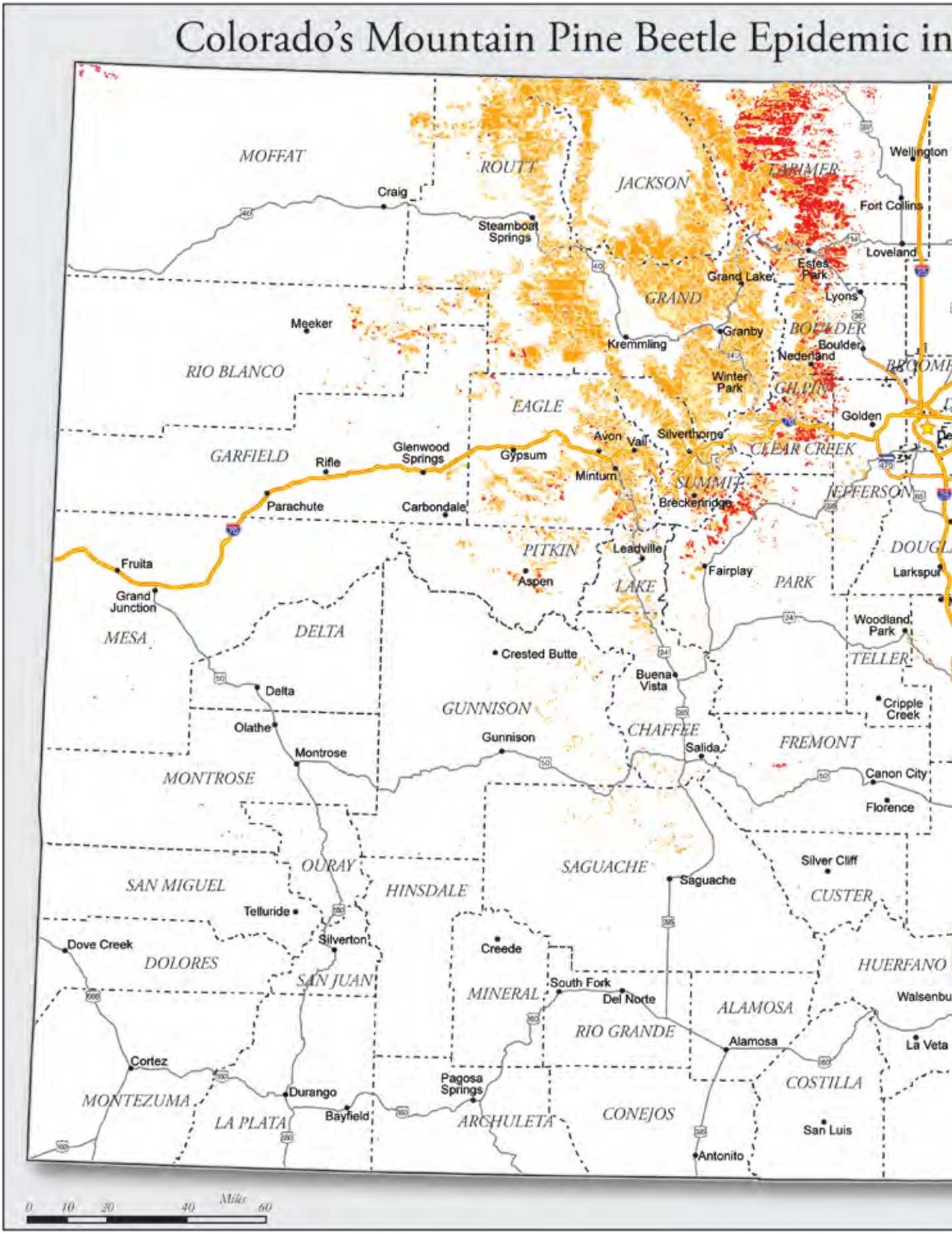
This section highlights the status of important insect and disease pests in Colorado's forests. Data were derived from several sources, including the Colorado forest health aerial survey, which is conducted through a partnership between the USFS and the CSFS. In 2009, more than 90 percent of Colorado's forests (exclusive of piñon-juniper woodlands) were surveyed over the course of more than 300 hours in a high-wing aircraft. Maps that show the location of pest outbreaks can be accessed on the web at www.fs.fed.us/r2/resources/fhm/aerialsurvey/. In addition, personnel in the 17 CSFS district offices conduct evaluations of forest pest activity on a regular basis and provide advice to forest landowners on how to reduce losses. The information they collect is included in this report.

Bark Beetles

Mountain Pine Beetle
(Dendroctonus ponderosae)

In 2009, MPB continued to be the dominant forest pest in Colorado. Active infestations continued on 1.02 million acres of the state's 1.5 million acres of lodgepole/limber pine forests. The intensity of infestations again increased in forests east of the Continental Divide, with many stands suffering attack rates of at least 10 trees per acre. Infestations in portions of Grand and Summit counties, where the outbreak began during the late 1990s, have declined due to the death of the most susceptible trees (those over age 60 with diameters of at least 6 inches). In some areas east of the Continental Divide, such as portions of North Park, the northern Rawah Range in northwestern Larimer County and Berthoud Pass, many susceptible lodgepole pines have been killed and infestations also are declining. Most areas in which the MPB outbreak has run its course still have young lodgepole pine stands. These stands are less

Top: Mountain pine beetle outbreaks now cover vast areas of Colorado's landscape.
Above: Mountain pine beetle adult.


Colorado's Mountain Pine Beetle Epidemic in
MOFFAT
ROUTT
JACKSON
LARIMER
Wellington
Craig
Fort Collins
Steamboat Springs
Loveland
Estes Park
Grand Lake
GRAND
Lyons
Meeker
BOULDER
Granby
Kremmling
Boulder
Nederland
RIO BLANCO
Winter Park
GILPIN
EAGLE
Golden
Avon
Vail
Silverthorne
CLEAR CREEK
GARFIELD
Rifle
Glenwood Springs
Gypsum
Minturn
SUMMIT
JEFFERSON
Parachute
Carbondale
Breckenridge
PITKIN
Leadville
Fruita
Fairplay
Larkspur
Aspen
LAKE
PARK
Grand Junction
Woodland Park
MESA
DELTA
Crested Butte
TELLER
Buena Vista
Delta
Cripple Creek
GUNNISON
Olathe
CHAFFEE
FREMONT
Gunnison
Salida
Montrose
Canon City
MONTROSE
Florence
Silver Cliff
OURAY
SAGUACHE
SAN MIGUEL
HINSDALE
Saguache
CUSTER
Telluride
Dove Creek
Silverton
Creede
DOLORES
HUERFANO
SAN JUAN
South Fork
MINERAL
Del Norte
Walsenbu
ALAMOSA
RIO GRANDE
Alamosa
La Veta
Cortez
COSTILLA
Pagosa Springs
MONTEZUMA
Durango
Bayfield
LA PLATA
ARCHULETA
CONEJOS
San Luis
Antonito
0 10 20 40 Miles 60

Lodgepole Pine 1996 - 2009

Mountain Pine Beetle
(New Acres in 2009)

Mountain Pine Beetle
(Previously Affected Acres
1996 - 2009)

Interstate

US Highway

County

Cities

Mountain Pine Beetle

Tree mortality from the current mountain pine beetle infestation is unprecedented in Colorado's recorded history. Since the infestation began in 1996, approximately 1.5 million acres of lodgepole pine have been infested in Colorado.

Beetle epidemics are a natural part of forest ecosystems, but the old age of many of the state's lodgepole pine forests makes them susceptible to large-scale epidemics. Old forests, drought, warm temperatures all have had a role in fueling this epidemic.

At current rates of spread and intensification, it is likely that MPB will kill the majority of Colorado's mature lodgepole pine forests within the next 3-5 years. However, younger lodgepole pines will survive and seedlings will regenerate naturally.

During the first few years following infestation, needles turn red on infested trees and the trees die. Fifteen to 20 years later, the dead trees fall over. Wildfire is a real threat to life and property in beetle-killed areas whether trees are red and dead or years later when they fall over and litter the ground.

Aerial Survey Data

Due to the nature of aerial surveys, the data on this map will only provide rough estimates of location, intensity and the resulting trend information for agents detectable from the air. Many of the most destructive diseases are not represented on this map because these agents are not detectable from aerial surveys. The data presented on this map should only be used as a partial indicator of insect and disease activity, and should be validated on the ground for actual location and causal agent. Shaded areas show locations where tree mortality or defoliation were apparent from the air. Intensity of damage is variable and not all trees in shaded areas are dead or defoliated.

The insect and disease data represented on this map are available digitally from the USDA Forest Service, Region Two Forest Health Management group. The cooperators reserve the right to correct, update, modify or replace GIS products. Using this map for purposes other than those for which it was intended may yield inaccurate or misleading results.

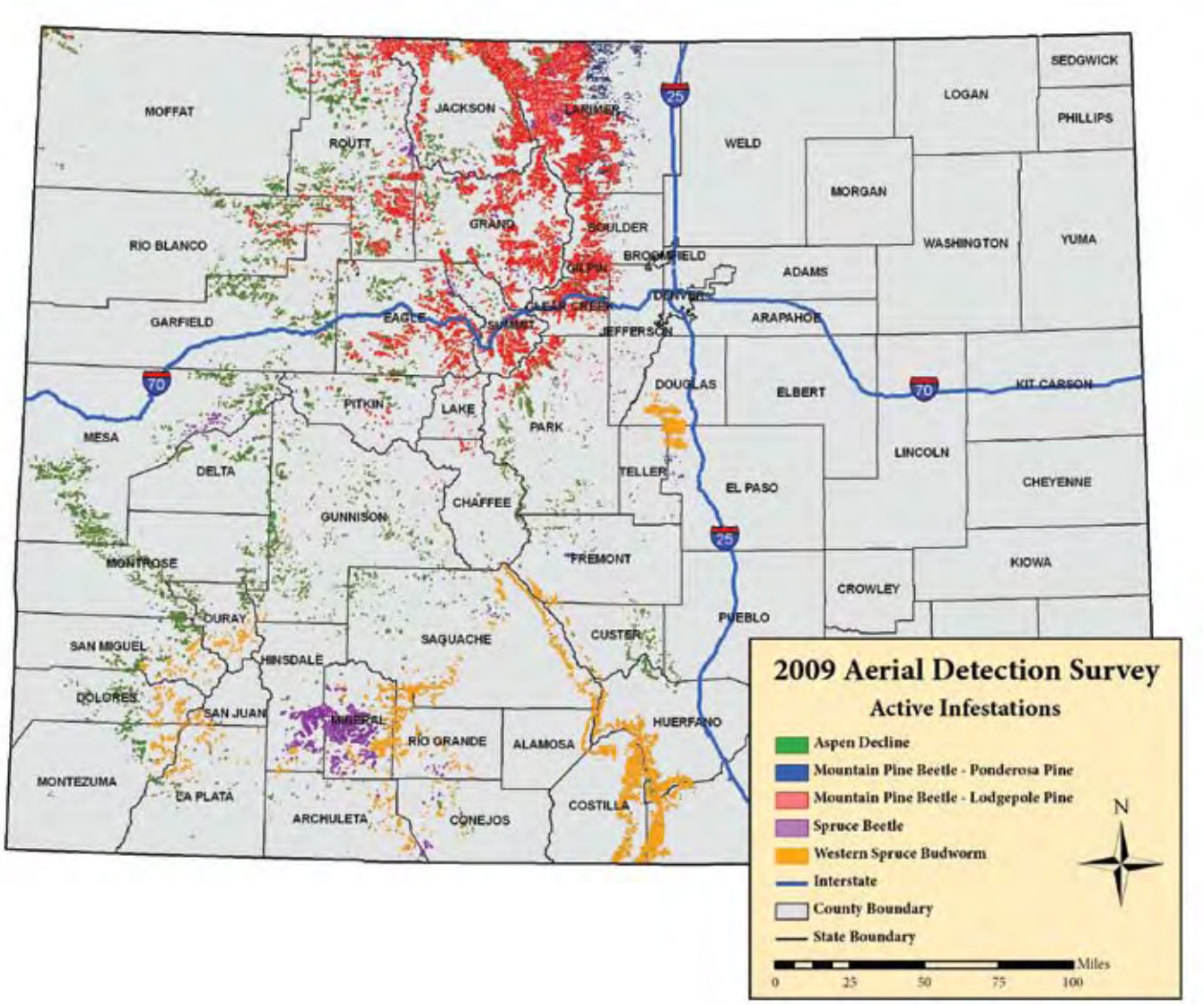
Map created January 2010
For more information:
http://csfs.colostate.edu/

susceptible to attack, although some trees have died. Young, small-diameter lodgepole pines are too small to produce large numbers of next-generation beetles. In addition, a few larger trees also have survived the outbreak.

An interesting aspect of MPB infestations in 2009 is that the foliage of trees attacked in 2008 did not fade to their typical red-orange color until late summer. Throughout most of the summer, many lodgepole pines dying from MPB attack were a sickly yellow color, which made aerial detection of trees attacked in 2008 more challenging. This phenomenon was probably due to the cool, wet summer of 2009, which delayed fading.

In some areas of Colorado, lodgepole pines were attacked by three species of bark beetles. In addition to MPB, the pine engraver (*Ips pini*) killed primarily small-diameter trees of 5 inches or less. High levels of engraver beetle activity were detected from Meeker Park south to Central City, and in portions of Larimer, Boulder and Gilpin counties. A third species, identified as *Pityogenes plagiatus knechteli*, also attacked lodgepole pines. This insect is considered a common "secondary" invader of lodgepole pines but was seen attacking trees in large numbers at numerous locations. In a few cases, all three bark beetles were invading the same trees.

Many people are concerned that the current outbreak in lodgepole pine will spread to ponderosa pine forests, especially along the Front Range where MPB historically has been a pest in ponderosa pine forests. Evidence suggests that the potential is high for an MPB outbreak in ponderosa pine as beetles move into forests in which ponderosa and MPB-infested lodgepole pine adjoin. This condition is occurring near Estes Park, parts of Rocky Mountain National Park in Larimer County, near Eldora in Boulder County, and near Empire, Georgetown and Idaho Springs. In addition, CSFS foresters discovered an MPB outbreak in ponderosa pine forests near Virginia Dale in northern Larimer County in early 2009. This outbreak is believed to have originated from infestations in lodgepole pine



Left: Lodgepole pines killed by mountain pine beetle. **Below:** The pine engraver beetle, *Ips pini*, is frequently associated with mountain pine beetle in lodgepole pine and can be found killing young trees.

forests immediately west of this area and now extends into Wyoming. Currently, the size of the average infestation in this area is about 50 trees.

In recent years, the demand and availability of markets for forest products has declined. However, continuing efforts are being made to harvest trees killed by MPB to reduce fuels, remove hazard trees and improve aesthetics. Much of this work is occurring near homes, road and power line rights-of-way, and developed recreation sites. Salvaged trees are used for a variety of wood products, including lumber, house logs, furniture, wood pellets for fuel, and bark chips and mulch for landscaping. Blue-stain, a discoloration of wood caused by a fungus associated with bark beetles, produces attractive wood that has become popular for furniture and paneling in homes and offices. Blue-stain pine also is popular for production of wooden bowls, candlesticks and other novelty items.

The CSFS manages state forest trust lands, including the Colorado State Forest, where a major MPB outbreak is underway. The CSFS has increased management activities on the state forest over the last several years to address this epidemic. The CSFS also is involved in local initiatives with organizations such as the Colorado Bark Beetle Cooperative and the Northern Front Range MPB Working Group to identify high-risk areas and implement treatments to reduce the threat of wildfire. CSFS district personnel have advised forest landowners affected by the outbreak about various forest management options available to reduce losses. They also have provided information on available markets for bark beetle-killed trees. In addition, the CSFS is working closely with Colorado State Parks to improve the health of forest land under its jurisdiction through long-term forest management. This cooperative work demonstrates that forest management is compatible with extensive recreation use.

Spruce Beetle
(Dendroctonus rufipennis)

Spruce beetle affecting high-elevation Engelmann spruce forests has increased throughout the state. A total of 114,000 acres of active spruce beetle infestations were mapped in 2009, compared to

64,000 acres in 2008. Most mature spruce forests on the crest of the Rawah Range in northern Colorado and in the San Juan Mountains near the headwaters of the Rio Grande River have been severely impacted by the outbreak; nearly 100-percent mortality of large-diameter trees has occurred in these areas. In addition, spruce beetle activity was detected in the high mountains south of Wolf Creek Pass, in the vicinity of Crown Point in the Never Summer Range and on the Grand Mesa.

Pure or nearly pure Engelmann spruce forests occur at high elevations. Most of these forests are inaccessible by road and/or are classified as wilderness areas. These factors limit options for pest management or salvage of dead trees. However, in some portions of the northern San Juan Range where mature spruce was harvested about 40 years ago, vigorous young stands of spruce have re-established themselves.

In June 2007, a high-wind event in the Wet Mountains caused patches of blowdown in Engelmann spruce forests. Spruce beetles readily invade wind-thrown trees where they reach outbreak levels and can attack standing trees. The potential for a spruce beetle outbreak in this area is high. On Sept. 12, 2009, another blowdown occurred in forests dominated by Engelmann spruce on the slopes of Del Norte Peak in Rio Grande County. This blowdown also could cause spruce beetle populations to spike.

Top: This area of spruce blowdown occurred on the slopes of Del Norte Peak in Rio Grande County in September 2009. *Photo: Courtesy of the Rio Grande National Forest.* **Above:** Spruce beetle outbreaks in portions of the San Juan Range have killed most of the mature Engelmann spruce.

Western Balsam Bark Beetle/ Root Disease Complex

Subalpine fir continued to die in high-elevation forests throughout the state. Tree death is caused by western balsam bark beetle (*Dryocoetes confusus*) infestations, in combination with two fungi that cause root disease (*Armellaria spp. and Heterobasidium annosum*). This condition often is referred to as "subalpine fir decline." In 2009, subalpine fir decline was detected on 184,000 acres of high-elevation forests, a substantial decrease from the 346,000 acres detected in 2008. The decrease may be the result of two seasons of heavy snowpack and normal or above normal precipitation.

Tennessee Mountain

Chronology of a Mountain Pine Beetle Outbreak

This tiny hut with a bright green roof, a shelter used by skiers, is located in a small meadow surrounded by forest on the eastern slope of Tennessee Mountain near Nederland in Boulder County. The site has been photographed each of the past five years as part of the annual forest health aerial survey and shows the progress of the MPB outbreak over time.

In the early stages of the outbreak, MPB attacks were confined primarily to limber pine (*Pinus flexilis*) growing at the edge of the meadow; very few lodgepole pine were affected. Limber and lodgepole pine can be easily distinguished by the broader crowns of limber pine.

The following year, a scattering of lodgepole pine faded due to attacks that occurred in 2005. In 2007, the outbreak increased in intensity and a large number of additional lodgepole pine faded due to MPB attacks in 2006.

In 2008, additional lodgepole pine died and many of the trees attacked in previous years began to lose their needles. Fewer trees faded in 2009, but now a high proportion of the older lodgepole pine in the area are dead. MPB prefers to attack older, large-diameter lodgepole pine. These trees have relatively thick bark and can produce large numbers of next-generation beetles.

2005

2006

2008

2009

Other Bark Beetles

Other important bark beetles include Douglas-fir beetle (*Dendroctonus pseudtsugae*), fir engraver beetle (*Scolytus ventralis*) and several species of ips engraver beetles (*Ips spp.*).

In 2009, an overall reduction occurred in the area affected by Douglas-fir beetle. However, tree mortality increased in portions of the Rampart Range between Denver and Colorado Springs. Several drainages contained stands of 100 or more trees with the red foliage characteristic of trees dying from bark beetle attack. (Local residents were concerned that the MPB had reached epidemic proportions in their area.) Douglas-fir beetle activity also was observed south of Paonia. Statewide, tree mortality caused by the Douglas-fir beetle was detected on 23,000 acres in 2009.

A localized outbreak of a twig beetle, identified as *Pityophthorus boycei,* was detected in a bristlecone pine (*Pinus aristata*) forest near the summit of Thirty-Nine Mile Mountain in southeastern Park County. Approximately 75 percent of the new tree shoots were killed in the most heavily infested areas.

Above: Douglas-fir beetle galleries. **Left:** Twig beetle adults, *Pityophthorus boycei*, in twigs of bristlecone pine.

Defoliators

Western Spruce Budworm *(Choristoneura occidentalis)*

Western spruce budworm (WSBW) is a major pest of Douglas-fir, white fir, Engelmann spruce and other conifers throughout western North America. Larvae first bore into the buds of these conifers and later feed on the foliage of new shoots. During outbreaks, WSBW defoliate millions of acres of trees. For over a decade, WSBW has caused tree defoliation in southern Colorado and adjoining areas of New Mexico. In 2009, WSBW defoliation in Colorado more than doubled. Approximately

Left: Aerial view of the defoliation of Douglas-fir and white fir caused by western spruce budworm in the Culebra Range. **Below Left:** Mature western spruce budworm larva. **Center:** Pine sawfly larva feeding on needles of ponderosa pine in Elbert County. **Bottom:** Gypsy moth detection trap. *Photo: Ingrid Aguayo.*

382,000 acres of defoliation visible from the air were mapped, compared to 155,000 acres in 2008. In 2009, defoliation occurred in portions of the Culebra, Flat Top, Sangre de Cristo, San Juan and Rampart ranges. Damaged forests have an overall brown cast, and years of successive defoliation causes growth loss, top kill and tree death.

Pine Sawfly
(Neodiprion autumnalis)

An outbreak of pine sawfly has been underway in the eastern-most fringes of ponderosa pine forests in Elbert County. This sawfly, identified as *Neodiprion autumnalis,* feeds in colonies on the needles of ponderosa pine and has been active in this area for approximately 8 years. The adult wasp lays eggs inside pine needles during the fall. Winter is spent in the egg stage and the larvae hatch the following spring. Numerous landowners in the area have sprayed their pines with insecticides to reduce defoliation.

Ponderosa Pine Needle Miner
(Coleotechnites ponderosae)

For the second year, yellow discoloration of ponderosa pine needles caused by ponderosa pine needle miner was detected in several areas along the eastern edge of ponderosa pine forests. The larvae of this insect feed inside pine needles and cause them to turn yellow and die.

Exotic Pests

Gypsy Moth
(Lymantria dispar)

This significant defoliator of broadleaf trees and forests was introduced into the eastern United States during the late 1800s. Every year, gypsy moth defoliate large areas of oaks and other broadleaf trees in portions of the northeastern and north central United States, and south into the Appalachian Mountains. Gypsy moth moves easily from place to place because the larvae will pupate almost anywhere — including the hubcaps of cars — and female moths can lay eggs on almost any surface. Spot infestations have appeared in a number of locations in the western United States, including Colorado. If gypsy moth were to become established in the state, many species of broadleaf trees in urban areas would be threatened. In addition, native forests composed of Gambel oak, aspen and other broadleaf trees could experience extensive defoliation.

The CSFS, in partnership with the USDA Animal Plant Health Inspection Service (APHIS) and USFS, uses a network of traps baited with an attractant chemical known as Disparlure that attracts male gypsy moths. Entomologists use traps to determine if and where gypsy moth exist. In 2009, two male gypsy moths were trapped in Adams County and one in Pueblo County. More intensive trapping will occur in these areas in 2010, and will

help define infestation boundaries and the need for follow-up action.

Emerald Ash Borer
(Agrilus planipennis)

In 2002, emerald ash borer, native to Asia, was discovered in southeastern Michigan where it was killing ash trees. Foresters believe it may have arrived in the United States via infested wood products from China. This insect killed millions of ash trees in Michigan and since has spread to several other states, including Ohio, Indiana, Illinois, West Virginia, Missouri and Pennsylvania. In 2009, infestations were discovered

Above: Emerald ash borer. *Photo: David Cappaert.*

for the first time in Minnesota and western New York. Adult ash borers can fly up to a mile, but long-distance spread generally occurs via interstate transport of infested ash firewood or nursery stock. The insect is of concern to Colorado because several cultivars of green and white ash are popular shade and ornamental trees throughout the state's urban forests. Single leaf ash (*Fraxinus anomala*), native to southwestern Colorado, also is a potential host of this insect.

To facilitate early detection of emerald ash borer, the CSFS, in cooperation with the Colorado Department of Agriculture and APHIS, conducts an annual survey that involves use of intentionally stressed ash trap sites in approximately 140 locations across the state. To date, no infestations of this damaging insect have been found in Colorado.

Marketing Beetle-Killed Trees

Development of viable markets for wood products from trees killed by bark beetles is an important aspect of managing these forest insects. Today, more than 90 percent of all wood used in Colorado is imported, either from other states, Canada or Mexico. Therefore, many opportunities exist to promote Colorado wood products and several initiatives are underway. For example, the CSFS Colorado Wood Utilization and Marketing Program (CoWood) facilitates retention, expansion and recruitment of forest and wood products businesses. CoWood responsibilities include research, technical and business assistance, and education and outreach. (http://csfs.colostate.edu/cowood/index.html). Colorado Forest Products (http://csfs.colostate.edu/cowood/cfp.html) is a consumer awareness/product branding program funded by the CSFS for marketing wood products from forest restoration and fuels reduction efforts in Colorado forests. The Colorado Forest Products logo can be used by businesses that obtain at least 50 percent of the wood for their products from Colorado forests. The Peak to Peak Wood Program (http://www.peaktopeakwood.org) was created to move wood generated from forest management projects on public and private land in Boulder, Clear Creek, Gilpin, Jefferson and Larimer counties into private markets. The program recently was expanded to help salvage MPB-killed timber. Peak to Peak operates several public wood collection and sort yards where infested logs can be delivered. Revenues obtained from sale of bark beetle killed trees currently are tax exempt.

Top: Cabinets made from blue-stained wood. *Photo: Dan Bihn.* **Above:** the wood of logs from trees infested by mountain pine beetle and other bark beetles is discolored by blue-stain fungi. The stained wood can be used to produce a variety of colorful wood products.

COLORADO FOREST PRODUCTS

Peak to Peak WOOD
Elevating Front Range Sustainability

Protecting Colorado's Watersheds

Water is a critical resource for drinking, irrigation, industry and recreation. In Colorado, where the average yearly precipitation is about 17 inches, water is scarce and perhaps is our most critical resource. Two successive years of above-average snowpack, combined with a wet spring and early summer in 2009, turned our hills emerald green and helped fill the state's reservoirs. Early in 2009, reservoir storage volumes were at 116 percent of capacity — the highest storage volume since 1999. However, just a few years ago, our reservoirs were far below capacity, resulting in restricted water use for many Colorado communities. Water is a resource that must be carefully managed to meet the needs of Colorado's residents, as well as those who live in neighboring states.

High-elevation forested watersheds are the source of most of Colorado's water. They form the headwaters of four of America's major rivers — the Arkansas, Colorado, Platte and Rio Grande. These rivers provide water to 18 states, in addition to Colorado. Most of our precipitation arrives during winter as snow and is stored on mountain slopes as snowpack. With the arrival of warm weather in spring, the snow melts and flows downstream into a network of reservoirs that store water for domestic, agricultural and industrial uses. If warm temperatures arrive too quickly, the snowpack melts too fast. As a result, streams become swollen and may flood their banks with resultant damage to property and infrastructure. Forest cover is critical for protection of water quality and quantity. Forests provide shade that slows the rate of spring snow melt, and the roots of trees, shrubs and grasses bind the soil to help prevent erosion, which can significantly reduce water quality.

Protecting forests from damaging agents such as fire, and insect and disease outbreaks will help maintain and enhance water quality and yield. The 2002 Hayman Fire burned more than 138,000 acres in the South Platte River Basin. Burned surface vegetation and the formation of hydrophobic soils caused increased surface runoff, which transported sediment during heavy rains causing severe soil erosion. This, in turn, caused siltation and reduced the drinking water quality of Cheesman and Strontia Springs reservoirs, important sources of domestic water for the greater Denver area. Heavy soil erosion and mudslides in the Hayman burn area have affected the dynamics of the landscape. In July 2009, for example, heavy rains over sections of the burned area caused severe mudslides in the vicinity of Deckers and temporarily blocked State Highway 67. This followed flooding in previous years that caused severe damage to the highway, kept it closed for months and cost $11,000,000 to repair.

The massive MPB outbreak currently underway in lodgepole pine forests of northern Colorado also could affect water quantity and quality. As trees die and fall, forest cover becomes less dense, allowing greater exposure of snowpack to solar radiation, causing faster runoff and increased soil erosion. Grand Lake, west of Rocky Mountain National Park, is at the epicenter of the current MPB outbreak. It also is the source of water for heavily populated areas on the northern Front Range. Water from Grand Lake is carried eastward via a network of tunnels under Rocky Mountain National Park and national forest lands, and eventually reaches Horsetooth Reservoir west of Fort Collins. The long-term effect of the MPB outbreak on the quality and quantity of domestic water is not yet fully understood.

Effective management and protection of Colorado's forests, based on sound science, is integral to the protection of the state's watersheds and water supplies. These practices will help ensure a sustainable supply of water to meet present and future needs.

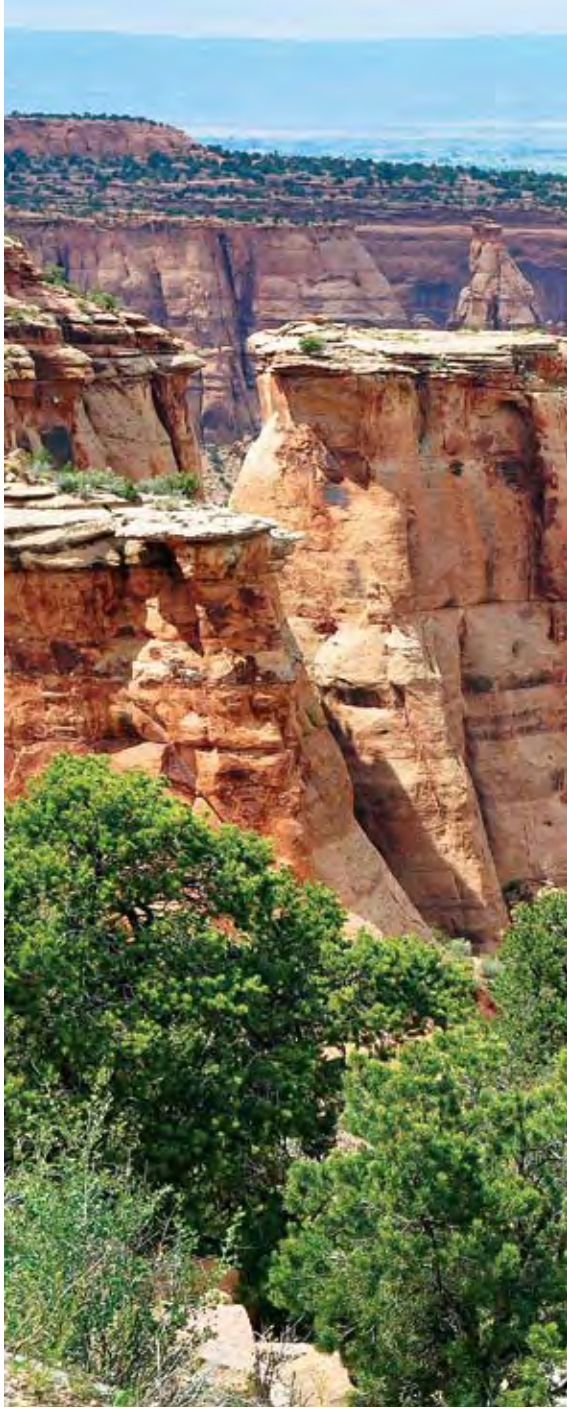
Above: In addition to providing water, reservoirs provide opportunities for recreation including boating and water skiing. **Left:** Areas burned by the 2002 Hayman Fire are still subject to soil erosion, as this photo indicates. *Photo: Meg Halford.*

Piñon-Juniper Woodlands: A Unique Ecosystem

Covering a total land area of more than 48 million acres, the piñon–juniper (PJ) woodland of the Southwest is the most extensive forest cover type in the western United States. Colorado has approximately 5.3 million acres of PJ woodlands, which comprise roughly 28 percent of the state's total forest area. PJ woodlands consist of short, scrubby, often multi-stemmed trees that may appear inhospitable — this is far from accurate. These woodlands provide essential habitat for mule deer, a variety of smaller mammals and many species of birds, reptiles and insects. They also are home to many flowering plants such as the prickly pear cactus with its brilliant red, pink and yellow spring and early summer blossoms. In addition, piñon pine nuts once were a staple food of indigenous tribes that lived in the Southwest. Today, they are considered a delicacy and are an ingredient in many popular regional dishes.

In Colorado, PJ woodlands are found from just south of Colorado Springs, south and west to the Four Corners region. PJ woodland also is a major forest type in the lower elevations of the Western Slope. They occupy low-elevation sites that are too dry for larger trees such as ponderosa pine and Douglas-fir. One species of piñon, the New Mexico piñon (*Pinus edulis*), and three species of junipers constitute Colorado's PJ woodlands. In the eastern-most areas, Rocky Mountain juniper (*Juniperus scopulorum*) and one-seed juniper (*Juniperus monosperma*) are the dominant junipers. Utah juniper (*Juniperus osteosperma*) with its characteristic dark green foliage is the dominant juniper of PJ woodlands on the Western Slope. In addition, Gambel oak (*Quercus gambelii*) often is found in these woodlands.

Piñon-juniper woodlands are a major component of several of the state's crown jewels, including the Colorado National



Above: Piñon-juniper woodlands are the dominant vegetation in the Colorado National Monument. **Left:** The collard lizard, *Crotophytus collaris*, is one of the many residents of Colorado's piñon-juniper woodlands. **Above Left:** Prickly pear cactus, with its bright blossoms and many colors, is a common plant in piñon-juniper woodlands.

Monument, Mesa Verde National Park, and the Great Sand Dunes National Park and Preserve. These woodlands also have become popular homesites for people who wish to live in a rural setting.

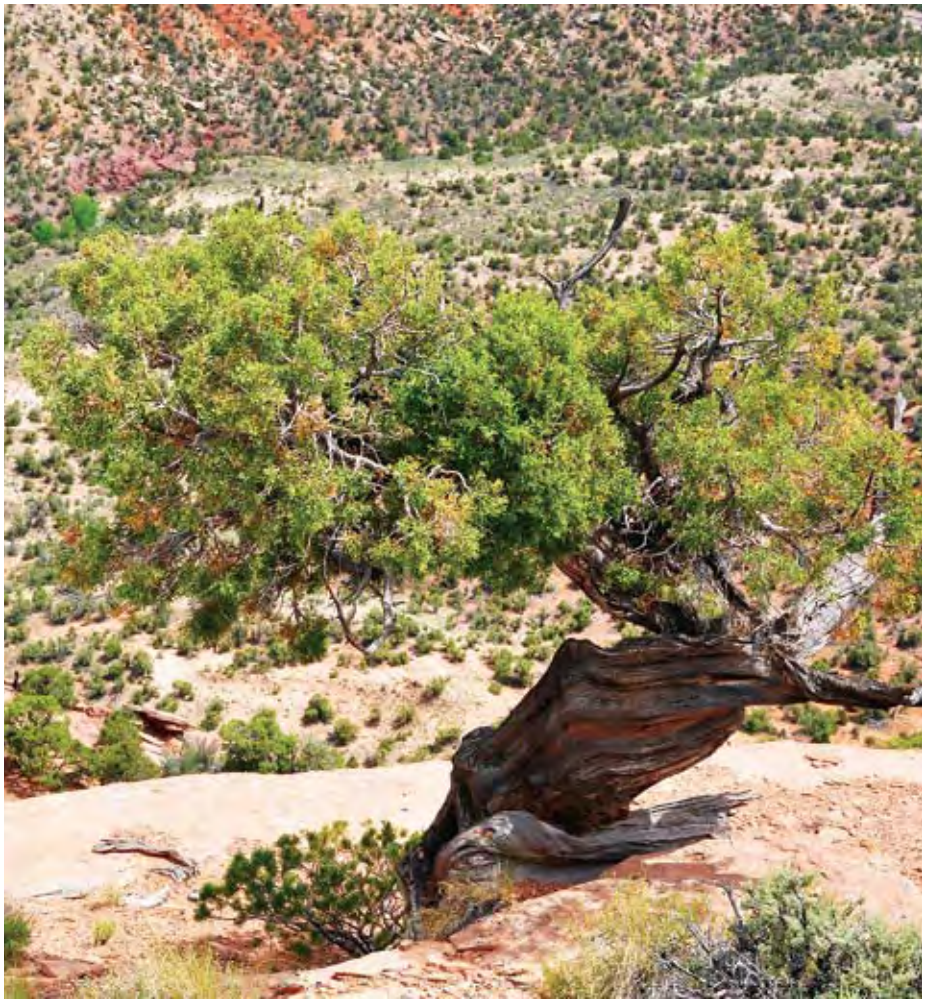
Like all of Colorado's forests, PJ woodlands are dynamic and subject to disturbances caused by fire, insects and disease. Wildfire is integral to the dynamics of these woodlands. For example, since Mesa Verde National Park was established in 1906, 80 percent of the park's forests have burned. In 2000, wildfires burned more than 20,000 acres of the park's PJ and Gambel oak woodlands. An outbreak of the piñon ips (*Ips confusus*) bark beetle killed large numbers of piñons between 2002 and 2003. The following sections highlight some of the key pests of PJ woodlands.

Pests of Piñon-Juniper Woodlands

Piñon Ips
(Ips confusus)

This bark beetle, a relative of the MPB, breeds under piñon bark and kills the tree. Attacks occur in weakened trees and outbreaks usually follow periods of below-normal rainfall. During the dry years of 2001-2003, this insect killed millions of piñon in southwestern Colorado and adjoining states. At the peak of the outbreak in 2003, aerial surveys indicated that 4.2 million piñon were killed on approximately 937,000 acres. In southwestern Colorado, many woodlands lost 90 percent of the mature piñon. The heaviest infestations occurred near Durango, Cortez and Dolores. Further north, infestations were more scattered with some areas of localized tree mortality. The outbreak has subsided in recent years as higher levels of precipitation have occurred.

Right: A lone juniper clings to a rock face at the Colorado National Monument. **Below:** A piñon shoot killed by a twig beetle. **Bottom Left:** The sawfly, *Zadiprion rowheri*, is one of two sawflies known to defoliate piñon pine. **Bottom Right:** Galleries of a juniper bark beetle, *Phloeosinus sp*.



Twig Beetles
(Pityopthorus spp.)

Twig beetles are bark beetles that breed in and feed on the stems and twigs of trees. Several species of twig beetles attack piñon pine and damage often is seen in areas where piñon ips beetle is active. Twig beetles usually do not kill entire trees, but the crown may sustain significant damage during periods of heavy infestation.

Piñon Needle Scale
(Matsucoccus acalyptus)

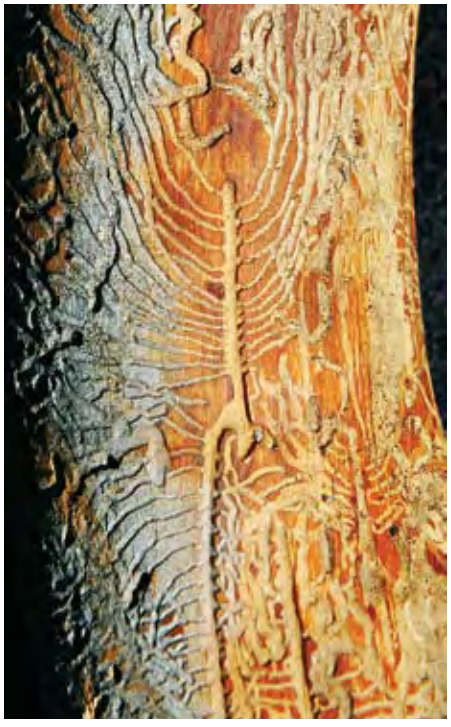
Nymphs and adults of piñon needle scale feed on the tender shoots and one-year old needles of piñons. The damage causes loss of older foliage, weakens trees and makes them susceptible to attack by piñon ips. During 2009, piñon scale infestations were reported in Huerfano County.

Sawflies
(Neodiprion edulicolis and Zapdiprion rowheri)

The larval stage of a sawfly is similar to a caterpillar, but the adult is a small wasp. Two of these species feed on the needles of piñon pine and occasionally reach epidemic levels. Large numbers of larvae strip the trees of their foliage. In 2007, one of these sawflies, *Zadiprion rohweri*, defoliated piñon in Mesa Verde National Park and other areas of southwestern Colorado.

Juniper Bark Beetles
(Phloeosinus spp.)

Several bark beetles attack junipers, breed under the bark and kill the trees. They usually confine their attacks to recently cut or weakened juniper and may kill healthy trees during extended dry periods.



Left: Ammons Hall in the summer on the Colorado State University campus oval. Many trees on campus are now over 100 years old. *Photo: Bill Cotton.*

Colorado's Urban Forests

Trees are essential to our quality of life. They add beauty and harmony to what otherwise would be a harsh, cold landscape. Trees planted along streets, parks and greenbelts provide welcome shade from the summer sun and peaceful places to walk or simply relax. They filter the noise of heavy traffic and fragment "heat islands" created when the sun's radiation is absorbed by tall buildings. Trees help reduce levels of carbon dioxide and other greenhouse gases in the earth's atmosphere that can contribute to global climate change.

In Colorado, urban forest ecosystems are composed almost entirely of exotic trees. Many of our most popular shade and ornamental trees such as linden, white and green ash, honey locust, and Norway and silver maples are native to the eastern United States or Europe. Even our own quaking aspen, a Colorado native, occurs naturally at elevations that are higher than most of our urban forest communities. Many of Colorado's urban forests occupy what once was the short grass prairie, an ecosystem totally devoid of trees except for the occasional cottonwood along stream bottoms.

The health and vitality of urban forests requires vigilance, care and regular maintenance. Colorado's semi-arid climate requires that urban trees be watered regularly, including during winter months when prolonged dry periods may occur. A variety of biotic and abiotic agents can damage our urban forests.

Because many trees planted in Colorado's urban forests are exotic, most of the pests that damage these trees also are exotic. These trees and pests typically come from the eastern United States and Canada, Europe or Asia. Fortunately, much of the damage these agents cause, such as leaf deformities and galls by insects and mites, is cosmetic; however, significant exceptions do exist. (One such exception is Dutch elm disease. Caused by the fungus *Ophiostoma ulmi*, which was introduced into the eastern United States during the 1930s, Dutch elm disease since has killed thousands of elm trees.) Several recent pest introductions, including the Asian longhorn beetle (*Anoplophora glabripennis*) and the emerald ash borer (*Agrilus planipennis*) have caused significant damage in parts of the eastern United States and Canada, and pose a significant threat to Colorado's urban forests.

An effective long-term strategy to minimize the impacts of damaging urban tree and shrub pests is to plant as great a variety of species as local conditions will allow. Because biotic pests (insects, mites, fungi, etc.) are relatively host specific, only a portion of the trees would be susceptible should a new pest appear. Many communities learned this lesson firsthand when Dutch elm disease established itself in North America. Prior to the introduction of this devastating disease and its principal insect vector, the smaller European elm bark beetle (*Scolytus multistriatus*), many communities in the central United States relied heavily on the stately American elm (*Ulmus americana*) as a shade tree. Once the disease began to spread, these communities lost all of their shade trees within just a few years.

Damaging or not, urban tree pests are of concern to many homeowners. The CSFS, in partnership with Colorado State University Extension and city foresters, provides technical assistance to communities to identify and manage tree pests. The following section provides brief descriptions of some of Colorado's more common urban tree pests.

Thousand Cankers Disease of Black Walnut

Thousand cankers disease was recently discovered in Colorado. This potentially significant disease of black walnut has been killing trees in Colorado and other parts of the western United States. The disease is likely caused by multiple fungi (*Geosmithia spp.*) and is spread by a walnut twig beetle (*Pityophthorus juglandis*). The beetle is native to Mexico, Arizona, a small area in southern California and New Mexico where it causes minor damage to Arizona walnut. The range of the disease currently is expanding in California,

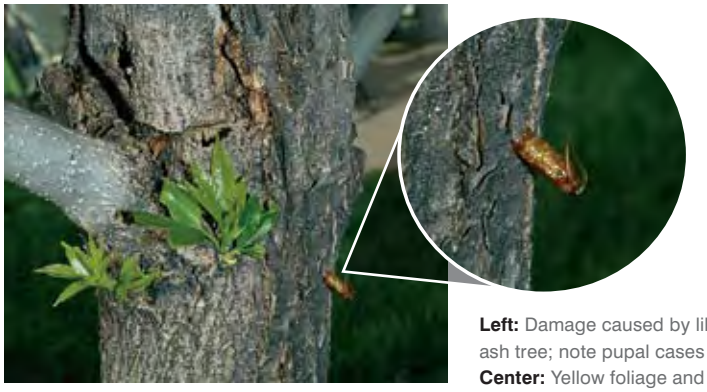
and now has reached Colorado, Idaho, Oregon, Utah and Washington where it is attacking the ornamental black walnut tree (*Juglans nigra*), a new host. The beetle is more aggressive on black walnut, has developed an association with the *Geosmithia* fungus and carries the fungus from tree to tree. The fungus causes cankers, which restrict the flow of nutrients and can kill trees within a year. This insect/fungus association has killed many black walnut trees in Boulder and Colorado Springs. If this insect spreads east into the natural range of black walnut, where lumber produced from this tree is widely used for furniture, gunstocks and other specialty products, losses could be devastating.

In 2009, new infestations were detected in the Denver Metro area including Arvada, Aurora, Brighton, Denver proper, Golden, Westminster and Wheat Ridge. The disease also has been confirmed in Berthoud, Erie and Longmont. It has been present in Grand Junction for several years and was recently detected in Delta on the Western Slope and in Rocky Ford and Olney Springs east of Pueblo.

Other Pests of Urban Trees

Oystershell Scale
(Lepidosaphes ulmi)

This insect is one of the most common urban tree pests and can infest a number of species including aspen, ash, cotoneaster and lilac. Large colonies feed on the smooth bark of trunks and branches. After several years of feeding, the infested bark dries and cracks. The scales are armored and when examined under magnification resemble a tiny oyster.



Lilac-ash Borer
(Podesia syringae)

The larvae of lilac-ash borer tunnel in larger branches and trunks of ash, lilac and privet, and heavy infestations can kill branches. The adults are moths with transparent wings and resemble wasps.

Iron Chlorosis

This problem is common in many urban trees. Iron is an essential element for plant growth and in Colorado's alkaline soils it is not always available to the plant. Symptoms of iron deficiency include yellow leaves with green veins, subsequent dead patches on leaves and eventual branch die-back. Silver maple and quaking aspen are especially susceptible to iron chlorosis, but the condition can occur on many other trees and shrubs.

Hackberry Nipple Gall
(Pachypsylla celtismamma)

Hackberry nipple gall produces prominent wart-like galls on the leaves of hackberry trees, and nymphs develop inside the galls, which are

Left: Damage caused by lilac ash borer to an ash tree; note pupal cases protruding from bark. **Center:** Yellow foliage and green veins on silver maple are typical symptoms of iron chlorosis. **Below:** Galls on hackberry caused by hackberry nipple gall. **Below Left:** Infestation of oystershell scale on a young aspen.

present nearly every year. During heavy infestations, the entire leaf may be covered with galls. They are not damaging, but the curled leaves covered with galls are unattractive.

Banded Elm Bark Beetle
(Scolytus schevyrewi)

Native to China, Mongolia, Russia and portions of central Asia, this bark beetle was first detected in Colorado and Utah in 2003. It attacks elms and other broadleaf trees and is closely related to the smaller European elm bark beetle (*Scolytus multistriatus*), which spreads Dutch elm disease. The beetle now is known to occur over much of the central and western United States and has attacked and killed elms in Fort Collins and other Colorado communities during dry summers. Its role as an agent that spreads Dutch elm disease still is unclear.

Mountain Pine Beetle

An Urban Tree Pest

In many Colorado towns, thousands of homes have been built in lodgepole pine forests. MPB has become a major urban tree pest in these communities and homeowners have used preventive sprays to protect susceptible lodgepole pines. In late summer 2008, MPB made its debut as an urban tree pest in Berthoud, Fort Collins, Loveland and other communities along the Front Range.

How did the beetles arrive? They likely were transported on winds during the beetles' summer flight.

The invading beetles have a definite preference for Scotch pine (*Pinus sylvestris*), a tree native to Europe and a popular ornamental tree in many Front Range communities. Other affected pines included Austrian, eastern white, ponderosa and even mugo pine.

Fortunately, only a small number of beetle-infested trees were discovered in Fort Collins. City foresters inventoried many pine trees and identified more than 300 trees that were attacked by beetle, but only about 20 pines actually were infested. The remaining pines were vigorous enough to repel the invading beetles with resin. (The ability of a tree to evict invading beetles with resin is known as a pitchout.) By mid-winter, successful attacks could be readily identified by missing pieces of bark caused by woodpeckers that feed on the larvae and pupae. Needles of successfully attacked pines began to fade by mid-March; these trees were removed and chipped to ensure that the next generation of beetles was killed before they could emerge, fly and attack additional trees.

MPB continued to invade urban forests in 2009; by August, additional

Top: Pine infested by mountain pine beetle is cut and chipped to destroy the beetles developing under the bark. **Above:** An ornamental mugo pine killed by mountain pine beetle in Fort Collins. **Left:** Scotch pine attacked by mountain pine beetle in an urban environment.

MPB attacks were reported in Brighton, northeast Denver, Fort Collins and Greeley. Attacks also were found in pine planted in communities as far east as Sterling. Again, many of the beetles were pitched out before they killed the trees.

An Update on the Health of Colorado's Aspen Forests

Quaking aspen, *Populus tremuloides*, is one of Colorado's most popular trees. Aspen forests occupy about 2.2 million acres of our state. A Colorado community, myriad streets, children, pets, even a beer, have been named after this legendary tree. Aspen diversifies our forests, otherwise dominated by dark pine, spruce and fir. Aspen forests are open, allowing sunlight to reach the forest floor. In turn, the sunlight encourages many wildflower species including columbine, Colorado's state flower, to thrive. They also are a preferred habitat for elk and other wildlife. Mature aspen stands offer abundant forage for elk while younger stands offer cover for hiding from predators. In autumn, aspen-covered hills are ablaze with brilliant hues of yellow, gold and orange. This spectacular display of fall color attracts thousands of visitors and is one of the key reasons tourists travel to Colorado in autumn.

Sudden Aspen Decline

During the past decade, many of Colorado's aspen forests have been dying. This has caused concern among forest health and resource management professionals, as well as the general public. Over the past three years, the location and intensity of areas of dead and dying aspens has been mapped during the annual forest health aerial survey.

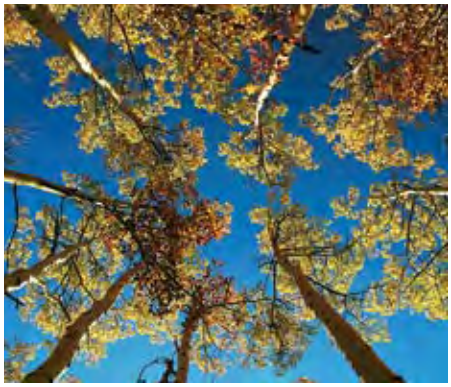
The recent episode of aspen mortality has been referred to as sudden aspen decline or "SAD." Decline or dieback is a complex condition that usually is caused by several interacting biotic and abiotic factors, and may contribute to

Opposite: Aspen foliage at the peak of fall color. **Left:** A mountain cabin sits among aspens at the peak of fall color near Pingree Park. **Below:** Aspen in the fall.

the dynamics of some forests. Prolonged drought, outbreaks of defoliating insects or fungi that cause root disease are among the factors that can be involved in forest decline. Decline and dieback of forests are a worldwide phenomena, and occurrences have been reported in North America, Africa, Asia, Europe and South America. Symptoms of decline are progressive and may include reduced growth, smaller than normal foliage, thin crowns, branch dieback and tree death.

Three classes of factors typically are involved in decline: *predisposing, inciting* and *contributing*. *Predisposing* factors are long-term conditions such as stand age or occurrence of root-infesting fungi, which stress trees and forests over many years. *Inciting* factors are short-term conditions such as drought, excess rainfall, late spring frost or outbreaks of defoliating insects. These conditions place additional stress on already weakened trees and can cause crown thinning or dieback. *Contributing* factors consist of attacks by insects, such as secondary bark beetles or wood-borers, or fungi, which are unable to attack and kill healthy, vigorous trees.

In the American Southwest, quaking aspen colonizes large areas as pure, even-age stands, usually following a disturbance such as fire. Because of Colorado's semi-arid climate, aspen seeds have a low germination rate. Therefore, aspen forests occur as the result of a few trees that originate from seed and produce runners and sprouts. Aspen forests mature at about age 60, but many aspen forests in the Southwest are over 100 years old. At low elevations, where growing conditions are too dry for conifers, aspen stands are the climax forests. The understory usually consists of a dense cover of aspen seedlings that are ready to replace the older trees as



they die. At higher elevations, aspen is a pioneer species and eventually gives way to spruce, fir and other conifers.

As aspen stands mature, their growth rates decline and they are subject to fungal infections. Recent episodes of below-normal moisture, late spring frost and outbreaks of defoliating insects such as western tent caterpillar and large aspen tortrix have placed additional stress on aspen forests, thus causing decline. Several fungi and insects such as the bronze poplar borer (*Agrilus liragus*) and at least two species of bark beetles have attacked and killed weakened aspens.

Most aspen forests affected by recent decline occur at the lower elevational limits of tree growth where aspen is a climax species. Dead trees often occur in bands or waves, appearing first at the forest edge and then progressing inward. In other forests, dead and declining trees are scattered throughout the stand. Many affected stands exhibit dense aspen regeneration in the understory. Once exposed to sunlight and space, aspen seedlings grow faster and eventually replace dead and dying trees in the overstory. However, many climax aspen forests lack natural understory regeneration, often because they have been subject to overgrazing by elk, deer or domestic livestock. These stands likely will revert to grassland vegetation when the mature aspens die.

Managing and protecting young seedlings that grow in the understory of aspen climax forests is essential to the future of Colorado's aspen. This includes timely harvesting of mature aspen stands to release the seedlings before stands become too stressed to produce vigorous natural regeneration. In addition, aspen regeneration should be protected from overgrazing by domestic animals, deer and elk.

In 2009, approximately 342,000 acres of aspen overstory mortality were mapped during the forest health aerial survey, compared with 542,000 acres in 2008. In many areas, patches of dead aspen appeared less distinct in 2009 and some aspen forests with previously thin crowns during the past few years appear to have recovered. Additionally, where the aspen overstory had died, the understory regeneration is growing rapidly in many stands. These observations, in addition to

two winters of above average snowpack and an unusually wet summer in 2009, suggest that the current episode of aspen decline may be slowing. (*See map page 10 for areas affected by aspen decline.*)

Other Factors That Affect Aspen Forest Health

Western Tent Caterpillar *(Malacosoma californicum)*

Western tent caterpillar is the most common insect defoliator of aspen forests in Colorado. The larvae emerge from eggs in spring, just as the buds burst, and build silken tents in the crowns of infested trees to protect them against natural enemies and weather. Larvae feed first in colonies and later as individuals. Outbreaks can strip trees of their foliage within just a few weeks. The larvae then migrate to other sites to continue feeding. During the 1970s, migrating western tent caterpillars made the Cumbres and Toltec Railroad tracks so slick that the engine was unable to gain traction and climb the steep mountain grades. Successive years of defoliation by western tent caterpillar can cause branch dieback and tree death.

Over the past 5 years, western tent caterpillar outbreaks have defoliated aspen forests on thousands of acres in southern Colorado. In 2009, defoliation caused by western tent caterpillar occurred in portions of the Culebra, Sangre de Cristo and San Juan mountains.

Left: Heavy defoliation of aspen by western tent caterpillar in the Culebra Range in southern Colorado. **Below Left:** A colony of western tent caterpillar on quaking aspen. **Below:** Large aspen tortrix in an aspen leaf. *Photo: Ingrid Aguayo.* **Right:** Aspen foliage damaged by Marssonina leaf blight. *Photo: Kelly Rogers.* **Bottom:** A mosaic of aspen stands in southwestern Colorado affected by sudden aspen decline. *Photo: Jim Worrel.*

In northern Colorado, western tent caterpillar is a common defoliating insect of several woody plants, including bitterbrush, choke cherry, wild currant and mountain mahogany. It is found only occasionally on quaking aspen.

Large Aspen Tortrix
(Choristoneura conflictana)

Large aspen tortrix is related to the WSBW. The larvae roll aspen leaves on which they feed and tie them with silken webs to provide protection from natural enemies. This insect often is associated with western tent caterpillar, but can develop into outbreaks on its own. In 2009, an outbreak of large aspen tortrix was detected on Red Mountain Pass near Ouray.

Late Spring Frost

Frosts that occur at the time of bud burst or early leaf development can kill buds, damage foliage and destroy flowers of trees and other woody plants. In Colorado, aspen forests, especially those growing at high elevations, often are subject to late spring frosts that essentially have the same effect on trees as defoliating insects. In 2007, a widespread late spring frost affected many aspen forests, especially on Colorado's Western Slope.

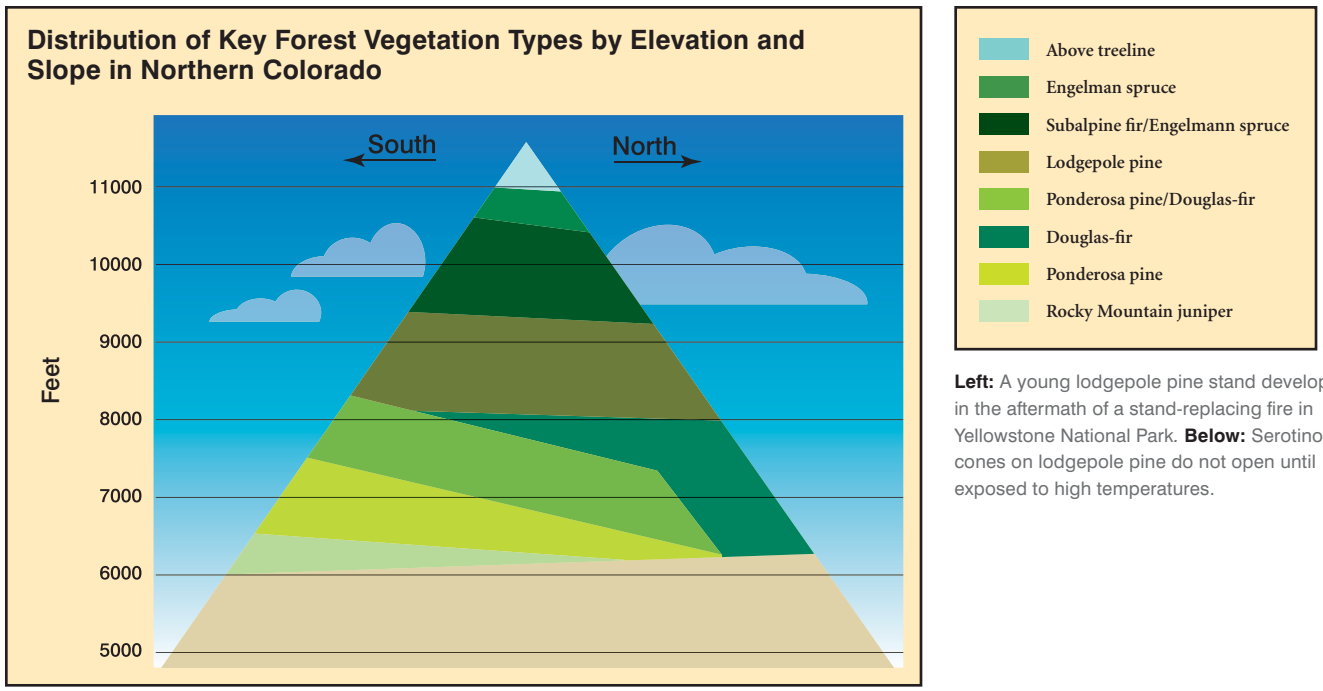
Marssonina Leaf Blight
(Marssonina populi)

Marssonina leaf blight is a disease caused by a fungus that infects the leaves of aspen and other cottonwoods. Symptoms include dark brown flecks and yellow margins on the leaves. The infected areas often merge to form blotches of discoloration. Infected aspen stands may have an orange cast during the middle of the growing season when the foliage should be green. Aspen clones show varying levels of susceptibility to this disease. By the end of the growing season, some clones exhibited near-complete defoliation. In 2009, occurrence of this disease was reported in several areas of the state and was particularly prevalent in the Red Table Mountain and Grand Mesa areas. The development of this fungus undoubtedly was encouraged by the wet weather that characterized the 2009 growing season. Aspen stands affected by this disease likely will recover unless repeated defoliation occurs for several years.

Climate, Forests, Fire, Humans and Insects: A Complex Interaction

Colorado's forests are dynamic; their character is shaped by disturbances caused by climatic events such as drought or severe storms, wildfire, humans and insects. Our forests grow in a semi-arid climate where average annual precipitation is between 11 and 17 inches at the low elevations to about 45 inches near the upper limits of tree growth. As a result, these forests contain relatively few tree species. The most commonly occurring trees are all members of the pine family (*Pinaceae*): ponderosa, lodgepole, limber, bristlecone and piñon pines in addition to conifers, such as Douglas-fir, blue and Engelmann spruce, and white and subalpine fir. Quaking aspen and Gambel oak are among the few broadleaf species found in Colorado's forests. Many of Colorado's forests are composed of stands with only one or two species.

Climate, especially moisture, determines which tree species will grow at a given location. Generally speaking, as elevation increases, so does available moisture. Therefore, trees are confined to specific elevation or moisture zones. Piñon pine and juniper woodlands dominate the lowest elevations and begin at approximately 4,100 feet. As elevation increases, these woodlands transition into pure forests of ponderosa pine. As elevation and available moisture increase, mixed conifer forests with Douglas-fir, and in southern Colorado, white fir, will occur in combination with ponderosa pine. On north facing slopes, which receive less direct sunlight and have a cooler, moister climate, Douglas-fir appears at lower elevations more so than on south facing slopes, which are warmer and drier. In northern Colorado, ponderosa pine/Douglas-fir forests usually are replaced by pure, even-aged forests of lodgepole pine at around 8,000 feet. At elevations of around 9,500 feet, subalpine fir and Engelmann spruce are the dominant trees. As elevation continues to increase, the proportion



Left: A young lodgepole pine stand develops in the aftermath of a stand-replacing fire in Yellowstone National Park. **Below:** Serotinous cones on lodgepole pine do not open until exposed to high temperatures.

of Engelmann spruce also increases; at approximately 11,500 feet (the upper limit of tree growth), nearly pure stands of this species exist.

Fire is an integral dynamic of Colorado's forests. Size, frequency and intensity of fires are factors that determine the character of our forest landscapes. Colorado's forests are subject to prolonged drought, often accompanied by dry lightning, which may trigger wildfires that can burn either small patches or thousands of acres. Human activities such as leaving campfires unattended or carelessly discarding cigarette butts also cause wildfires.

Our native trees have developed adaptations that allow them to coexist with wildfire. Ponderosa pine, for example, has a relatively long life span, often reaching 300-600 years of age. Large, old ponderosa pines have a thick bark that insulates them from high temperatures and allows them to survive low-intensity surface fires. Prior to human settlement, natural fire intervals of between 1 and 50 years occurred in many ponderosa pine forests. These fires typically were low-intensity surface fires that consumed branches, fallen trees, understory vegetation and small living trees. They produced a landscape of open, park-like forests, composed of large pine trees with a grass understory. Along the Front Range, ponderosa pine forests tended to be a mosaic of forests and meadows. A combination of low-intensity surface fires and hotter stand-replacing fires that killed most or all of the trees may have created these mosaics.

Lodgepole pine, on the other hand, has developed a different adaptation to fire. This tree has a relatively short life span, and most stands are considered mature at about age 60 to 100 years. Higher moisture levels and cooler temperatures mean the natural fire interval in lodgepole pine forests can vary from 60 to well over 100 years. Lodgepole pine bark is thin and, therefore, unable to protect the trees from fire. Lodgepole pine produces both non-serotinous and serotinous cones. Serotinous cones open only when exposed to high temperatures. When wildfire occurs in a lodgepole pine forest, most or all of the trees are killed. As fire burns through the forest, high temperatures cause serotinous cones to open, releasing abundant seeds to start a new forest. High-elevation subalpine fir and Engelmann spruce forests also are subject to large, high-intensity, stand-replacing fires, but the average fire-return interval is much longer — often well over 200 years.

Humans have had a profound impact on natural fire intervals in the forests of the western United States. Indigenous tribes used fire to drive game and clear land to grow food. Many years later, in the early 1900s, an aggressive wildfire suppression program began following a series of disastrous wildfires caused by a combination of drought, human settlement and dense re-growth after timber harvesting. As a result, natural fire was either excluded or the fire return interval changed significantly, especially in areas where fires historically burned every 10-50 years. Consequently, fuel

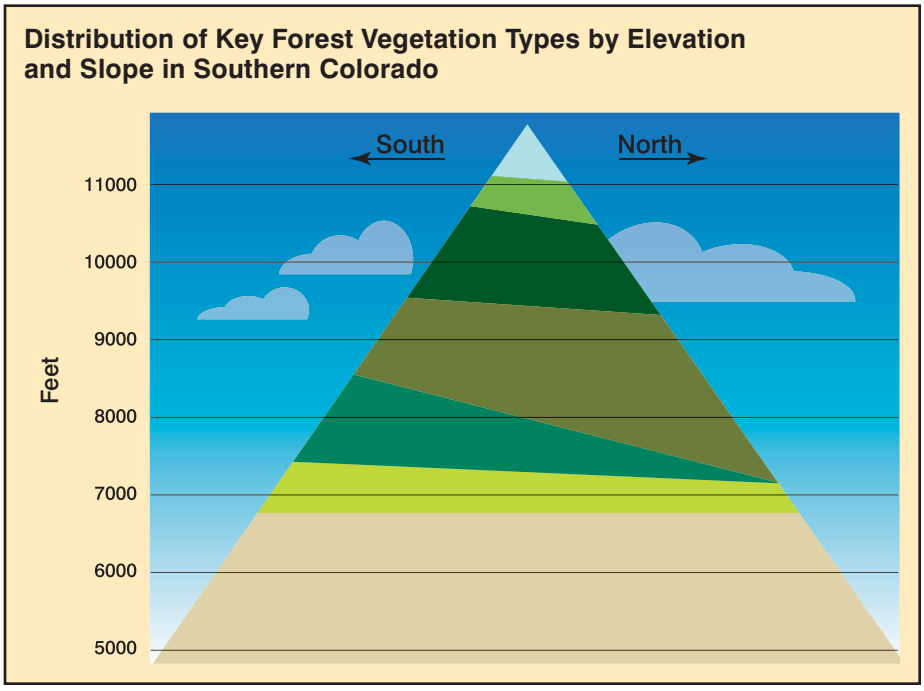
Above: Fallen trees from an old mountain pine beetle outbreak provide ground fuels to support a stand-replacing fire in a lodgepole pine forest.

levels, species composition and the number of trees per acre changed. In ponderosa pine forests, their open, park-like character changed due to fire exclusion; these forests now contain many more trees per acre. In other areas, ponderosa pine forests have been replaced by Douglas-fir and white fir as fire exclusion encouraged the growth of less fire-tolerant species.

A recent analysis of the fire history and forest dynamics in areas affected by the 2002 Hayman Fire, the largest wildfire in Colorado's recorded history, illustrates the effect of fire exclusion on western forest landscapes. The analysis indicated that between 1300 and 1880, average interval between naturally occurring fires was about 50 years, although some fires occurred almost every year. The results illustrated a mosaic of both stand-replacing fires and lower-intensity fires in which the larger, older trees survived. No major fires occurred in the area between 1880 and 2002; from 1900 to 2002, a lack of fire activity resulted in a significant change in species composition and an increase in forest density.

Increased fire-return interval periods not only changed the composition of these forests, they also changed susceptibility to insect outbreaks. Ponderosa pine forests, which now are more densely stocked, are more susceptible to MPB outbreaks. In areas where ponderosa pine has given way to Douglas-fir and white fir, outbreaks of defoliating insects such as WSBW and Douglas-fir tussock moth have become more frequent and widespread. Older lodgepole pine forests with a high proportion of trees greater than 6 inches in diameter that have relatively thick bark provide a wealth of excellent host material for MPB.

Climate, fire exclusion and aging lodgepole pine forests have fostered a "perfect storm" resulting in the massive MPB outbreak currently underway in Colorado. Fire exclusion resulted in the occurrence of extensive areas of pine forests with such characteristics as large-diameter trees and dense stands that are susceptible to MPB. The drought that began in the 1990s and severely increased in 2000 stressed the trees and made them more susceptible to beetle attack. In addition, prolonged cold winter temperatures of –30° to –35° F or less, which occurred regularly in high-elevation lodgepole pine forests killing beetles that overwintered under the bark,



have not occurred during the last decade. Consequently, a higher proportion of overwintering beetles are surviving.

Many people are concerned that the current MPB outbreak will increase the probability of a catastrophic wildfire. Bark beetle epidemics leave thousands of dead trees in their wake and change the character of forest fuels. Dead standing lodgepole pines with red needles and fine dead branches can carry intensive wildfires. However, after a few years, the needles and fine branches drop from the trees. During this period, fires that do occur are likely to be less severe. Over time, many of the beetle-killed trees will fall and new trees will grow, creating conditions favorable for fires capable of burning large areas. An accumulation of downed trees makes fire suppression more difficult and compromises the safety of firefighters and high-country residents and visitors.

Above: Relatively frequent low-intensity ground fires help create open, park-like stands of ponderosa pine. **Left:** Small clearcuts in lodgepole pine forests easily regenerate and create a mosaic of stands composed of different age classes including younger stands that are less susceptible to mountain pine beetle attacks.

The massive wildfires in and around Yellowstone Park in 1988 provide insight into the interaction between MPB outbreaks and wildfire. Approximately 36 percent of Yellowstone's total forest area, dominated by lodgepole pine, burned after the driest period in the park's recorded history. Prior to the 1988 fires, the park and surrounding areas endured two MPB outbreaks — one between 1972 and 1975 and another between 1980 and 1983. An analysis of the relationship between the Yellowstone fires and the earlier MPB outbreaks shows that areas affected by the first outbreak (13 to 16 years prior) were approximately 11 percent more likely to burn. However, no correlation was made between the second MBP outbreak (5 to 8 years prior) and the probability of burning. Scientists who conducted the study contend that one of the reasons the older outbreak areas were more likely to burn was that enough time had passed to allow the understory vegetation to grow, providing ladder fuels that increased fire risk and intensity. A similar study in Utah suggests that within approximately 10-20 years after a spruce bark beetle outbreak, wildfire risk was lower in those forests that suffered heavy mortality (greater than 95 percent) than in unaffected forests. The potential for a severe fire increases as dead trees fall and young trees become established in the aftermath of the outbreak, thus providing the ladder fuels necessary to support devastating wildfires.

While these studies suggest that the probability of a catastrophic fire in areas affected by bark beetle outbreaks may not be as high as expected in the short term, the potential for wildfire occurrence, especially during periods of prolonged drought, remains a major concern. Prompt detection and effective management of wildfires is critical. Forest management tools also are important and may include prescribed fire to reduce fuels and stocking levels, and thinning and timely harvesting of mature trees to support restoration. This is especially true for those areas in which fire-return intervals have been altered due to active fire suppression.

2009 Forestry-Related Legislation in Colorado

Colorado values healthy, resilient forest landscapes, and the state's legislature is willing to invest funds in the stewardship of these resources. In 2009, the Colorado General Assembly passed seven bills addressing forest health, fuels mitigation and public safety. This level of legislative activity is evidence of the importance and value of Colorado's forests. The legislation is aimed at creating legislation to promote healthier, more diverse forests that are resilient to insect and disease epidemics for the benefit of present and future generations.

HB07-1130 Community–Based Forest Restoration

In 2007, the Colorado General Assembly passed HB 07-1130, the Community-Based Forest Restoration Program. This legislation authorized up to $1 million per year over 5 years to fund a cost-share grant program for community-based forest restoration projects in Colorado. The projects are designed to protect critical water supplies and address related forest health issues.

The Colorado Department of Natural Resources (CDNR) appointed a Technical Advisory Panel to review the proposals and recommend project funding. The panel included representatives from the CDNR, two federal agencies (USFS and Bureau of Land Management), two independent scientists with expertise in forest ecosystem restoration, and representatives of conservation organizations, local communities and commodity interests.

Funds were provided to CDNR and subsequently to the CSFS via an interagency agreement. Once the funding mechanism was in place, the CSFS issued a request for proposals in June 2007 and announced the grant awardees that August. The following 12 projects were selected from 43 applications.

- Dalla Park Fire Mitigation, LaPlata County, $24,800
- Forest and Community Wildfire Protection Plan, Lake County, $69,000
- Grand Junction Watershed and Fuel Reduction Program, Mesa County, $140,000
- Grand Lake Beetle Kill Removal Project, Grand County, $140,000
- Heil Valley Ranch 2008 Fuels Reduction–Unit 2, Boulder County, $50,000

Summary of 2009 Forest Legislation

Bill Number	Bill Name	Bill Summary
SB 001	Community Wildfire Protection Plans	CSFS will establish guidelines and criteria for counties to consider in preparing community wildfire protection plans (CWPPs) to address wildfires in fire hazard areas within the unincorporated portion of a county.
SB 013	Civil Immunity to Persons Engaged in Emergency Response Activities	Enacts the "Marc Mullenix Volunteer Firefighter Protection Act", providing limited civil immunity for fire departments and other entities that donate surplus firefighting equipment for later use; volunteer firefighters, their commanders, and the organizations that employ them; and incident management teams, in connection with fires and other emergencies.
SB 020	Responsibility for Responding to Wild Land Fires	Creates a systematic, proactive approach to the management of wildland fire incidents in Colorado, regardless of cause, size, location, or complexity.
SB 021	Incentives for Volunteer Firefighters	Creates a fund in the division of fire safety to provide tuition vouchers to qualified volunteer firefighters who are enrolled in full-time or part-time study and who agree to serve as volunteer firefighters for 4 years after completing their education.
SB 105	Removal of Statutory Limit on the amount that may be raised for the purpose of fighting fires	Removal of the statutory limit on the amount that can be raised in a year by a special property tax levied by a board of County Commissioners for the purpose of fighting specified types of fires in a county.
HB 1162	Intergovernmental Cooperation for the Purpose of Mitigating Wildfires	On or before a specified date, requires each local government that owns any land area that is located either entirely or partially inside the territorial boundaries of a county and that contains a specified percentage of forest land or land that constitutes a wild land area to enter into an intergovernmental agreement with the county for the purpose of mitigating forest land or wild land fires affecting the contiguous land areas of the local government and county.
HB 1199	Colorado Healthy Forests and Vibrant Communities Act of 2009	Increases efforts to address wildfire risk, and provides resources to the Colorado State Forest Service to augment its technical outreach capabilities and provide loans and grants for market-based and forest treatment solutions to reduce wildfire risk.

Above: Beautiful highway vista near the San Juan Mountains. *Photo: Katherine Timm.*

- Horsetooth Mountain Park Fuels Reduction, Larimer County, $80,000
- Platte Canyon Fire/Forest Restoration and Water Protection Project, Park County, $70,000
- Santa Fe Trails Ranch Fuel Break Project, Las Animas County, $125,000
- Straight Creek Forest Restoration Project, Summit County, $10,895
- Summit County Hazardous Fuels Reduction Project, Summit County, $140,000
- Upper South Platte Watershed Forest Health Initiative, Park and Teller counties, $80,000
- West Vail and Lower Gore Creek Fuel Reduction Project, Eagle County, $50,000

HB 07-1130 required only a 40-percent matching contribution; however, funds provided by this legislation leveraged another $2.8 million in matching funds. All but one of the projects was completed by April 30, 2009 (uncooperative weather canceled Larimer County's plans to burn slash piles, as safety to resources and the community is non-negotiable). The 12 projects funded used a total of $876,450 provided by the grant to treat 3,115 acres. The 12 communities contributed an additional $1,355,004 in matching funds to accomplish their respective management objectives.

Since the advent of the pilot Forest Restoration Program authorized by HB07-1130, SB08-071 (SB 71) extended forest management efforts and continued community-based approaches to forest restoration across Colorado's watersheds. Three severance tax increments provide $1 million annually through 2012 to fund forest restoration projects. SB 71 is funding $1.97 million for 29 projects scheduled for completion by September 2010.

Forecasting the Future

What does the future hold for Colorado's forests? Historical evidence suggests that the presence of large numbers of less aggressive bark beetles, as seen in some of our lodgepole pine forests in 2009, may signal the decline of the current MPB epidemic. However, MPB activity is increasing in ponderosa pine forests along the Front Range, which has suffered major outbreaks in the past. The introduction of exotic pests, or those that are expanding their ranges (such as the walnut twig beetle), also will continue to pose a threat. Effective management of insect and disease outbreaks and wildfire will continue to challenge resource management agencies and private forest landowners.

All of the state's forests, regardless of ownership, provide a wealth of diverse benefits —clean water, recreation, wildlife habitat, wood products, wilderness and range for livestock. Our forests require management and protection to meet the needs of present and future generations of Coloradans and the thousands of people who visit our state each year.

Top: Elk bugling in Rocky Mountain National Park. **Above:** Colorado columbines. **Left:** Western tiger swallowtail *(Papilio rutulus)*. **Opposite:** A ponderosa pine forest restoration project on the Upper South Platte. *Photo: Jen Chase.*

The level of insect and disease activity that currently exists in Colorado's forests may be unprecedented, at least in recent history. Changes in the structure and composition of forests often are imperceptible to humans, as we are only present on the landscape for a portion of a forest's life cycle. As forests grow and mature, the changes we observe seem to accelerate, although most of the changes are continuous and subtle to the human eye. Whether the changes are acceptable to us is a function of our values and needs. We have the ability to shape our future forests through sound management to ensure they meet individual and societal needs based on the best available scientific information.

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