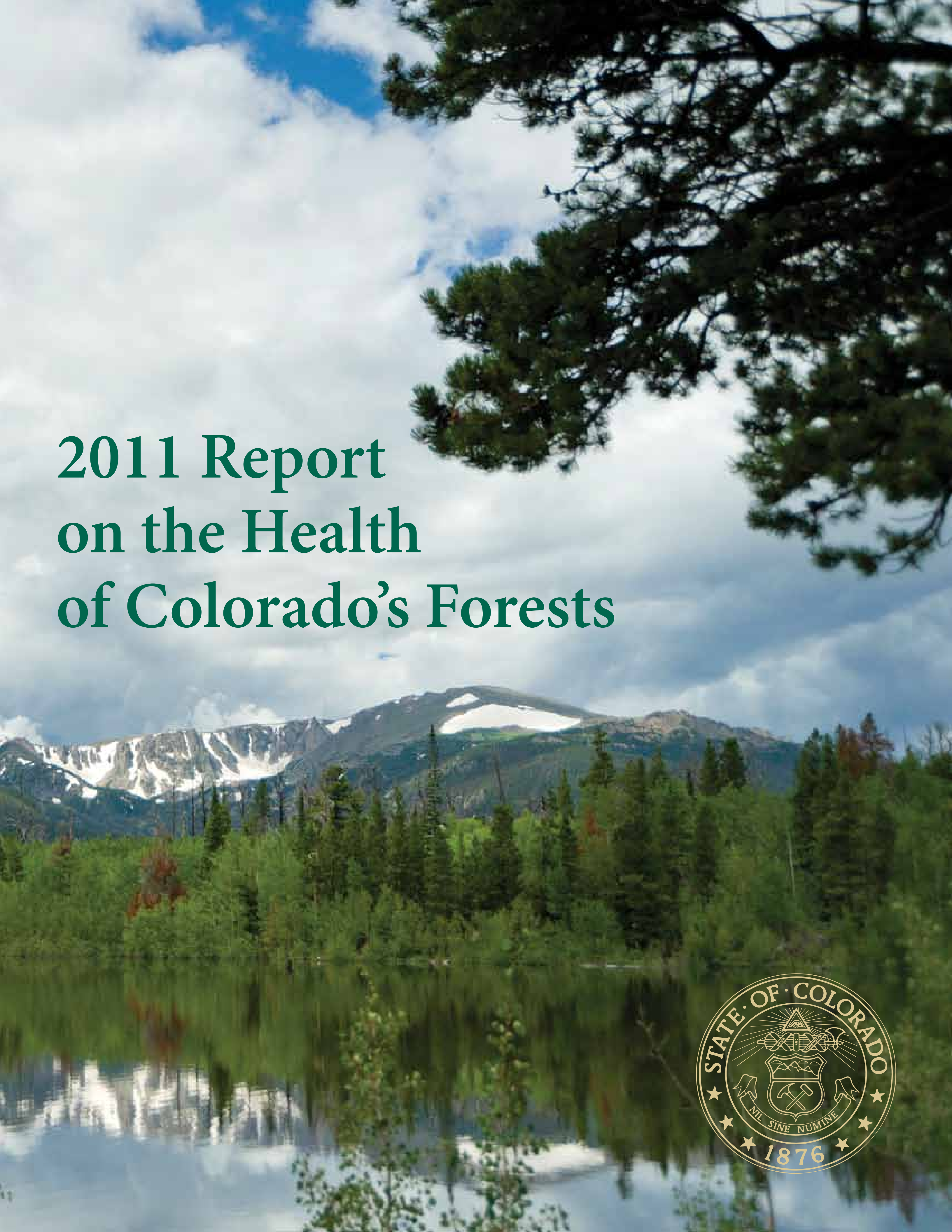
2011 Report on the Health of Colorado's Forests



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January 2012

It is once again my pleasure to present the annual report on the health of Colorado's forests. This is the 11th consecutive year we have produced a report on the issues affecting Colorado's forests, as well as the actions we can take to address those issues for the benefit of present and future generations.

Over the last 10 years, Colorado's forests have undergone significant changes. I have heard the public and political concerns about the condition of our forests, and related questions regarding what the future holds. The information we have developed and presented in this series of forest health reports, along with our collective experience in managing forested land, addresses these concerns and provides a sound foundation for planning. The fundamental questions we need to ask are *What do we want our future forests to look like?* and *What do we want them to provide for us?* Now is the right time to address these questions.

We depend on our forests to provide a variety of resources and values; one of the most important is clean water. Forest planning is a long-term process, and the decisions we make today will have profound impacts on the form, function and productivity of our future forests.

I hope you will find the information contained in this report to be informative and helpful. Please feel free to contact any Colorado State Forest Service office to learn more about our forests and what you can do to help manage and protect this important resource.

Jeff Jahnke
State Forester/Director
Colorado State Forest Service

Executive Summary

The objective of the *2011 Report on the Health of Colorado's Forests* is to provide information on the condition of our forests to the Colorado General Assembly and citizens of Colorado. In the first 10 reports, we provided this information, along with sections that specifically addressed the various forest types in Colorado. This year's report again presents a comprehensive overview of the health of Colorado's forests. It also provides insight on the stewardship of our forests and the wood products they produce, as well as a special section on the forests of the Great Plains.

As always, the primary data source for this report is the annual aerial survey conducted by the Colorado State Forest Service and USDA Forest Service (USFS). Another data source for these reports is the Colorado Forest Inventory and Analysis (FIA) Program, funded by the USFS and conducted on the ground by CSFS personnel. Every year, 10 percent of the 4,500 permanent forest plots in Colorado are surveyed as part of the program. In 2011, the first 10-year cycle of forest inventory data across Colorado was completed. A subset of FIA plots also are revisited annually to measure and track changes to forest conditions. The FIA Program and other forms of forest monitoring data will continue to provide essential information that will guide our forest management activities and help us be proactive in addressing changing forest conditions.

Mountain pine beetle (MPB) continued to be Colorado's most damaging forest pest in 2011, with the heaviest damage again occurring in Larimer County. However, new tree mortality as a result of MPB declined in comparison to past years, with a total area of 752,000 acres infested, compared to 878,000 acres in 2010. The decline in MPB activity is due to the loss of mature lodgepole pines in previous years of the outbreak. Despite the overall decline in acres infested by MPB, the area of active infestation in ponderosa pine forests increased for the third successive year to 275,000 acres in 2011. Most of the mortality in ponderosa pine forests occurred in Larimer County, north of the Big Thompson River.

In the *2007 Report on the Health of Colorado's Forests*, we identified spruce bark beetle as the next forest insect challenge. This year, spruce beetle continued to impact mature Engelmann spruce forests in many areas of the state. The largest outbreak, in the San Juan Mountains and upper Rio Grande Basin, has spread north and now poses a threat to spruce forests on adjacent private lands. Most of the mature spruce trees already have been killed in the Weminuche Wilderness, but active infestations continue in younger stands and in krummholz at the edge of timberline. Spruce beetle infestations also continued to build in the Greenhorn Peak area of the Wet Mountains, where blowdown events occurred in 2007 following a severe storm. Additionally, infestations in Larimer County continued to impact mature spruce stands in the vicinity of Cameron Pass, Long Draw Reservoir and the Cache La Poudre Basin.

Other bark beetles that continued to damage Colorado forests in 2011 include Douglas-fir beetle, which killed many mature Douglas-fir trees in the Sangre de Cristo and San Juan mountains, and western balsam bark beetle, which affected many high-elevation subalpine fir forests. An increase in activity by the piñon ips beetle also was noted in piñon pine forests north of Cañon City.

Defoliation of Douglas-fir and white fir by western spruce budworm continued across portions of the Wet Mountains, Sangre de Cristo and Culebra ranges, and Spanish Peaks and San Juan Mountains, but at lower infestation levels than in the recent past. A total area of 90,000 acres with some western spruce budworm defoliation was mapped in 2011. Forests in portions of the Culebra Range, which have suffered defoliation for a number of years, have extensive top kill and tree mortality due to weakened trees caused by repeated western spruce budworm defoliation.

The area of aspen forests affected by sudden aspen decline (SAD) continued to decrease in 2011. Foresters believe this is due to a return to normal or near-normal precipitation levels, recovery of some individual trees and a release of natural aspen regeneration in the understory of many stands with overstory mortality.

Thousand cankers disease continued to kill ornamental black walnut trees in urban forests and was observed for the first time in Fort Collins. Special surveys once again were conducted to ensure early detection of gypsy moth and emerald ash borer – two exotic insects that pose a threat to Colorado's urban forests. Neither of these insects was detected in Colorado in 2011.

Other pest activity detected in 2011 includes insect defoliation in aspen forests in portions of the Wet Mountains, Sangre de Cristo and Culebra ranges and San Juan Mountains, and an outbreak of an as-yet-unidentified defoliating insect in Gambel oak forests south of Castle Rock in Douglas County.

This year, our report also contains a special section on the forests of the Great Plains. These forests provide a sharp contrast to the dominant conifer forests of western Colorado. Located within the Central Shortgrass Prairie ecoregion, as identified by The Nature Conservancy, the Great Plains of Colorado represent a diverse landscape, primarily dominated by shortgrass prairie. However, intermittent forests also exist on the plains of Colorado; these include riparian forests, piñon-juniper woodlands and forests planted as windbreaks or in urban settings within our communities. These unique forests provide many essential benefits for people and wildlife.

The CSFS continues to work with private forest landowners, other cooperators and stakeholders to manage Colorado's forested lands by providing technical assistance, information and outreach that helps them meet their individual and collective stewardship objectives.

Forest Insect and Disease Update

Aerial surveys using small high-wing aircraft are a key source of information on the status of many insects, diseases and other damaging agents in Colorado's forests.

This section provides an update on the status of the most prominent insects and diseases that affected the health and vitality of Colorado's forests in 2011. The data comes from several sources, including the annual forest health survey, which is the principal source of information.

Annually, the USDA Forest Service (USFS) and Colorado State Forest Service conduct a cooperative aerial survey over most of Colorado's forestlands, excluding low-elevation piñon pine and juniper forests, and dispersed forests of the Great Plains. The survey is conducted from July through early September using high-wing aircraft, such as Cessna models 206 and 210. Trained aerial observers map the location of recent forest damage – usually dying or defoliated trees – using a touch-screen computer equipped with digital mapping software. Often, two observers, one from the USFS and another from the CSFS, work as a team to map the damage. Resulting data are analyzed using a geographic information system (GIS) and then are posted on the Internet for public use (see www.fs.usda.gov/goto/r2/fh). Most of the acreage figures presented in this report were calculated using the aerial detection survey data and represent acres impacted by a specific insect or disease agent. The total numbers of acres impacted by each agent does not reflect the severity of impact, which can vary significantly on each mapped acre.

Other sources of information also were utilized for this report. Special surveys designed to ensure early detection of potentially invasive forest pests such as gypsy moth and emerald ash borer were assessed, as were surveys of the statewide distribution of thousand cankers disease. In addition, CSFS foresters, as part of their day-to-day activities, observe and report forest pest occurrences.

Indigenous Pests

Conifer Forests

Mountain Pine Beetle

(*Dendroctonus ponderosae*)

Mountain pine beetle (MPB) continued to be Colorado's most damaging forest insect pest in 2011. The current outbreak, which started on the Western Slope in

Heavy MPB activity occurred in both lodgepole and ponderosa pines along the Pingree Park Road in Larimer County.

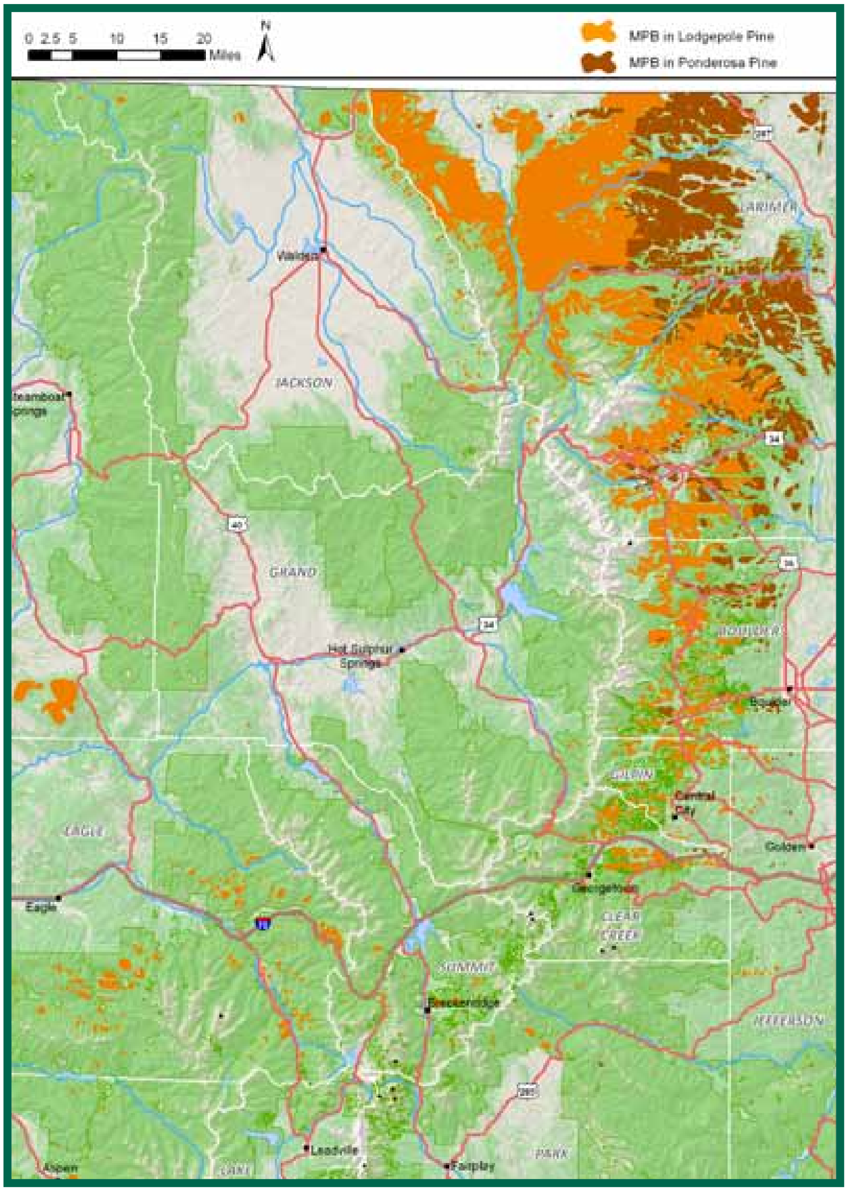
the late 1990s, has continued to spread eastward. In 2011, foresters observed an overall area of 752,000 acres of lodgepole, limber and ponderosa pine forest in which MPB had killed trees during the past year. This represents a decline in the total area damaged statewide compared to recent years (878,000 acres in 2010 and 1,046,000 acres in 2009); however, heavy mortality continued to occur, especially in areas where beetle populations increased during the past few years. While the overall area of active infestation declined in 2011, the area of ponderosa pine forests affected by MPB increased for the third consecutive year, from 22,000 active acres in 2009 and 234,000 acres in 2010 to 275,000 acres in 2011. Most of the observed ponderosa pine infestation occurred in northern Larimer County, north of the Big Thompson River.

Severe and widespread tree mortality occurred in lodgepole pines in portions of the Cache La Poudre (including the South Fork Cache La Poudre) and Buckhorn Creek basins, as well as areas west of Red Feather Lakes in northern Larimer County. Many of these infested areas occur within the viewsheds of homes in the wildland-urban interface. Most of the mature lodgepole pine stands near Cameron Pass and the Upper Cache La Poudre Basin were attacked during previous years of the outbreak; with many trees already dead, MPB populations there are declining.

MPB infestations are declining in areas where most of the mature lodgepole pines have been killed during previous years.

High levels of mortality continued in lodgepole, limber and ponderosa pine forests in the Big Thompson River Basin. Infestations in ponderosa pine forests persisted in Rocky Mountain National Park and in the Estes Park vicinity. Infestations in lodgepole pine stands in the upper Fall River and Big Thompson River basins, near Bear Lake and on the western slope of Rocky Mountain National Park have declined, largely due to loss of mature host trees. Beetle activity

2011 Mountain Pine Beetle Activity by Host Species

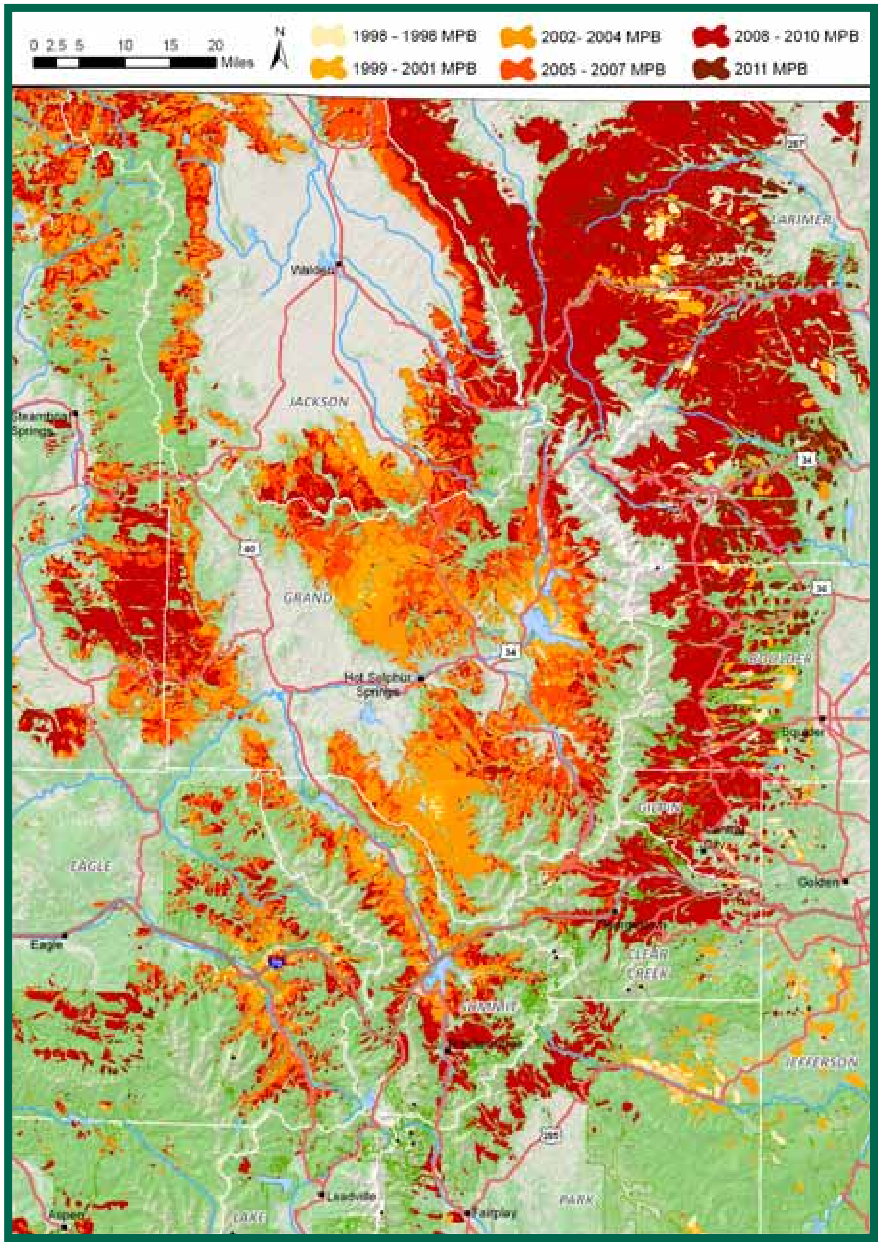


continues at moderate to high levels in most lodgepole pine stands, from Longs Peak in the park south to South Boulder Creek. Infestations also continued in lodgepole pine forests in and near the Snowmass ski area and on the slopes of Smuggler Mountain near Aspen. In addition, MPB continued to attack pines in urban areas along the Front Range and in pine shelterbelts on the Great Plains.

MPB activity continued to decline in lodgepole pine forests in Jackson, Grand and Summit counties, where the outbreak already has killed most mature lodgepole

Mountain pine beetles continued to attack pines in urban areas along the Front Range in 2011.

Mountain Pine Beetle Progression, 1996 – 2011



pines. Some activity still is present in portions of the Colorado State Forest and along the eastern slopes of the Rawah Range in lodgepole pine stands less than 60 years old. Aerial surveyors also noted a decline along the I-70 corridor, from Empire west to Berthoud Pass and the Eisenhower Tunnel; this decline also is attributed to the loss of mature host trees.

A decline in activity was observed in lodgepole pine forests south of I-70, including the area from Georgetown south to Guanella Pass and in the Chicago Creek Basin north of Mount Evans. Reduced activity also was noted in the Geneva Creek Basin south of Guanella Pass, where heavy damage occurred from 2008-2010. Infestations in lodgepole pine forests on the west side of South Park, from Kenosha Pass south to Fairplay, which also have been observed for approximately three years, decreased significantly in 2011. These areas still contain a high percentage of mature lodgepole pines, so the decline in MPB activity in these areas does not appear to be due to host depletion.

Responding to the Mountain Pine Beetle

The current mountain pine beetle outbreak, which was first detected in Colorado in the late 1990s, has impacted 3.3 million acres of our pine forests and caused widespread tree mortality. Numerous activities are underway to prevent future attacks on high-value trees, make use of wood from dead trees and reduce the hazards presented by falling trees. These activities are being undertaken by private landowners, communities and local, state and federal government agencies.

Individual high-value pines can be protected from bark beetle attacks by applying preventive sprays. Currently, three chemical insecticides – carbaryl, permethrin and bifenthrin – are registered for use by the Colorado Department of Agriculture as preventive sprays, which can be up to 95 percent effective when used properly. Private landowners in Colorado's forested and urban communities have been treating individual pines with high rates of success. Preventive sprays also have been used extensively by the USDA Forest Service to protect valuable trees in campgrounds and other high-use recreation areas.

The use of pouches containing the anti-aggregant chemical verbenone is another way to prevent bark beetle attacks. Verbenone is a pheromone produced by attacking beetles, which communicates to other beetles that a tree already has been attacked and is unavailable. Verbenone pouches provide an alternative to spraying trees when chemical use is prohibited or restricted by label instructions, such as near bodies of water. Verbenone has proven less effective than preventive sprays in areas with heavy MPB pressure.

Forest thinning, especially in ponderosa pine forests, also tends to make stands less susceptible to beetle attack. In addition, thinning reduces fuels available for wildfire and can increase growth rates of standing trees. Removal and utilization of beetle-killed trees is an effective way to make use of the dead wood. Trees that are still infested can be cut, chipped, peeled or burned to destroy beetle broods. In addition, cut logs containing MPB can be placed under clear plastic sheeting in direct sunlight to kill developing beetle broods through solar radiation. All of these activities currently are being utilized to help control MPB populations on private and public lands.

Large swaths of MPB-killed trees can threaten infrastructure, including buildings, power lines, roadways and water conveyances because they are subject to windthrow (the uprooting or snapping of trees during high-wind events). Standing dead trees also pose a hazard to travel and outdoor recreation. In many areas, beetle-killed pines already have been cut along roads, hiking trails, campgrounds, recreation sites and other areas to reduce the risks associated with falling trees. These dead and dying trees also are changing the characteristics of wildland fuels in Colorado's forests.

Many foresters and firefighters share concerns about the potential nature and severity of wildland fires in areas impacted by MPB. These concerns have resulted in numerous studies and models to predict fire behavior in beetle-killed stands. As fuel characteristics change over time, and as trees fall, the risk of high-intensity, long-duration fires may increase. Fires of this nature can pose additional threats to public infrastructure and private property. For example, intense fires could drastically alter soil characteristics and negatively impact watersheds. Many landowners and forested communities have begun to remove dead trees from surrounding forests to mitigate fuels and provide for defensible space around structures, should a wildfire occur.

One of the most effective methods for responding to MPB and any other forest insect or disease is active forest management. Forest management can boost local economies, reduce wildfire risk and promote more resilient forests. Actively managing for healthy forests today will ensure future forests that are resilient to change, and will reduce impacts of forest insects, disease and wildfire. The Colorado State Forest Service continues to assist landowners in developing responses to MPB by providing outreach and educational materials on prevention and wood sanitation methods.

Roller-choppers are used to convert infested trees into wood chips and destroy MPB broods.

Spruce Beetle
(*Dendroctonus rufipennis*)

Spruce beetle, a relative of the mountain pine beetle, is the most destructive bark beetle in spruce forests throughout North America. In Colorado, this beetle can cause extensive damage to Engelmann spruce forests. Outbreaks typically occur several years after storms cause windthrow in spruce trees, which are susceptible to blowdown because of their shallow root system. Spruce beetles initially breed in the freshly windthrown trees, and subsequent generations attack and kill live, standing trees. Typically, it takes two years for a generation of the beetles to mature.

Although the spruce beetle currently is causing extensive mortality in Colorado's spruce forests, outbreaks tend to be less conspicuous than those caused by mountain pine beetles or other bark beetles. Following a bark beetle attack, the needles of pines, true firs and Douglas-firs are easily seen because they turn brilliant hues of yellow, red-orange or red as the trees die. The needles of bark beetle-infested Engelmann spruce, on the other hand, turn a subtle shade of yellow-green as the trees die. Needles often drop from dying trees while they are still green, littering the forest floor.

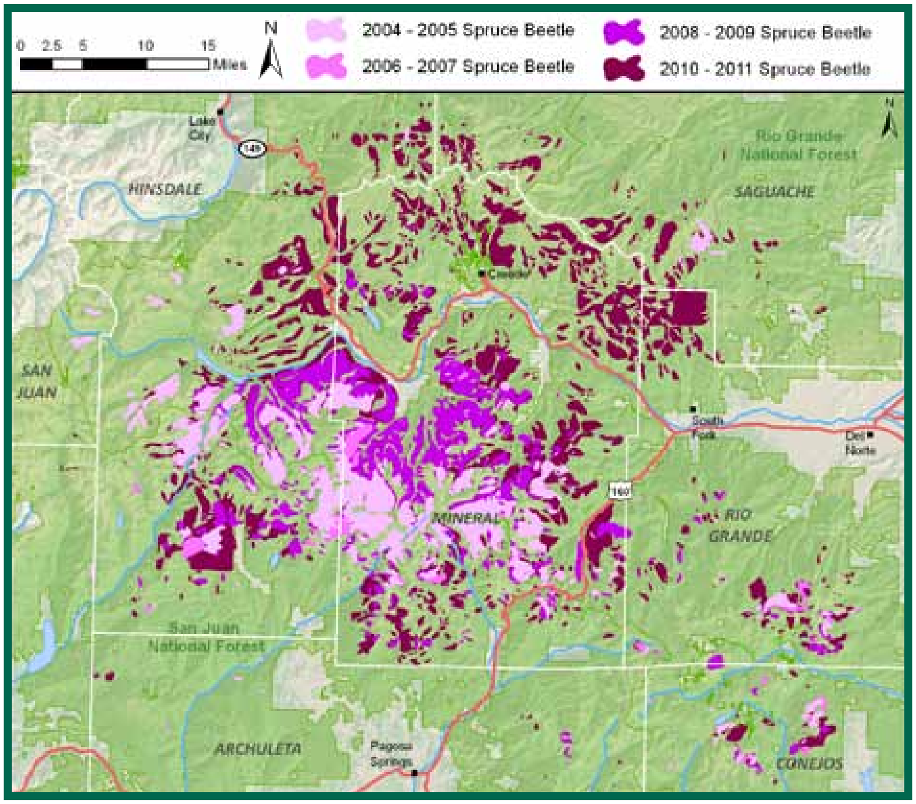
Spruce bark beetle adult (approximately 1/4-inch).

Moreover, because Engelmann spruce is a high-elevation species generally found in Colorado at elevations above 10,000 feet, few people witness the large-scale mortality caused by spruce beetles.

During the 1940s, a spruce beetle outbreak that developed after a severe storm caused extensive windthrow in the Flat Tops Wilderness Area of the White River National Forest resulted in the loss of 3.8 billion board feet of timber. (This is enough to provide framing lumber to build approximately 240,000 2,000-sq. ft. homes). In 1997, high winds caused extensive spruce windthrow in the Mount Zirkel Wilderness Area of the Routt National Forest. This triggered a spruce beetle outbreak that killed much of the mature spruce in the area. During the past six to seven years, spruce beetles have caused extensive damage to many of

In portions of the Weminuche Wilderness, where a spruce beetle outbreak has been underway since approximately 2002, most of the mature spruce trees have been killed and attacks now are occurring in krummholz near timberline.

Spruce Beetle Progression in Southwestern Colorado, 2001 – 2011



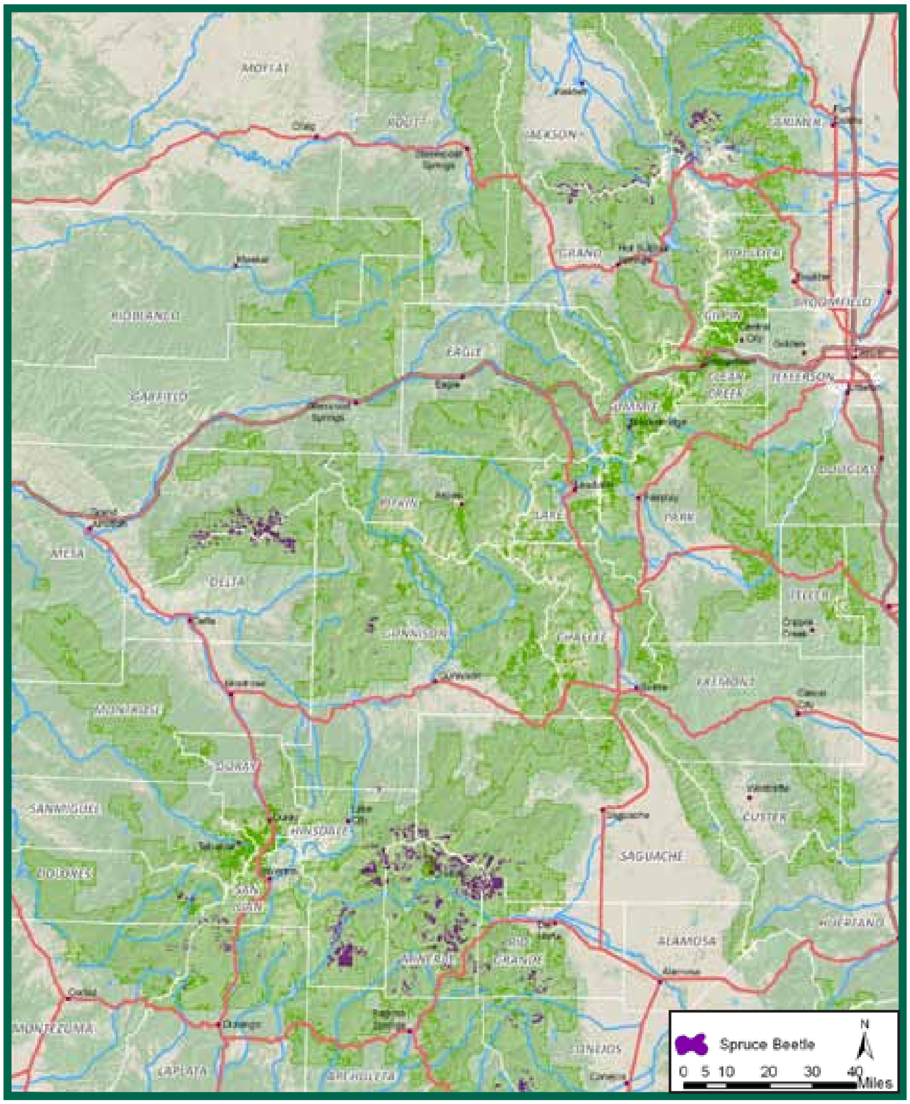
Colorado's high-elevation spruce forests. In 2011, outbreaks continued in several areas across the state, impacting a total area of 262,000 acres, compared to active infestations on 208,000 acres in 2010.

A massive spruce beetle epidemic in the San Juan Mountains and upper Rio Grande Basin has been underway since 2002, expanding northward in 2010 and 2011. As a result, heavy spruce mortality now is visible throughout much of the northern half of the upper Rio Grande Basin, including the La Garita Wilderness. Tree mortality was observed as far north as Spring Creek Pass in Hinsdale County, and many of the mature spruce trees now have been killed over large portions of the Weminuche Wilderness on the Rio Grande and San Juan National Forests. However, new attacks on small pockets of trees are still present throughout the area, often in young spruce stands and krummholz forests at the edge of timberline. In western Colorado, spruce beetles have been active in Mesa, Delta and Gunnison counties.

Tree mortality caused by spruce beetle also continued to increase in Engelmann spruce forests in the Greenhorn Peak area of the Wet Mountains on the San Isabel National Forest. This outbreak is believed

Spruce beetle attacks close to Zimmerman Lake near Cameron Pass.

2011 Statewide Spruce Beetle Activity



to be the result of beetles building up in windthrow following a severe storm that occurred in the area in June 2007.

Severe damage continued in the upper portions of several drainages on the south-facing slopes of the Big Thompson River in Larimer County in the Roosevelt National Forest and Rocky Mountain National Park. High rates of tree mortality also occurred from Cameron Pass to the upper Cache La Poudre River Basin and the upper slopes of the South Fork Cache La Poudre River Basin to the east.

Spruce bark beetle mortality in the upper Rio Grande Basin. [photo: Joe Duda]

Infestations declined over the eastern slopes of the Rawah Range in northern Colorado, where most of the mature spruce has been killed by an outbreak first detected in 2005. However, a few active infestations remained along the banks of the Laramie River.

Many areas where spruce beetle outbreaks occur are remote, inaccessible or in designated wilderness areas. Therefore, in most cases, foresters can take little or no action to reduce losses caused by this aggressive bark beetle. However, individual trees can be protected on some landscapes.

Douglas-fir Beetle

(Dendroctonus pseudotsugae)

The Douglas-fir beetle is a relative of the mountain pine beetle and spruce beetle, and represents an important threat to mature Douglas-fir forests. In 2011, approximately 25,000 acres of Douglas-fir mortality was detected, compared to 37,000 acres in 2010. Infestations occurred in the southern and western regions of the state. Areas with significant tree mortality caused by Douglas-fir beetle included portions of the Sangre de Cristo and Culebra ranges. Continued tree mortality also was detected in several tributaries of the Crystal River near Aspen, and infestations continued in several canyons in El Paso and Fremont counties, from Manitou Springs and Cheyenne Mountain south to Phantom Canyon, east of Cañon City.

Douglas-fir beetle infestations tend to occur in mature stands. Many current infestations have been underway for several years and now appear as groups of trees with bright-red crowns, indicative of recent attacks, amid trees with gray crowns caused by attacks in previous years.

Subalpine Fir Decline

Chronic levels of tree mortality continued in many high-elevation subalpine fir forests across the state. Subalpine fir decline often is the result of two species of fungi, *Armillaria* spp. and *Heterobasidium parviporum* (formerly *H. annosum*), that invade root systems and weaken trees, and the subsequent attack by western balsam bark beetles (*Dryocoetes confusus*). In 2011, approximately 180,000 acres of subalpine fir decline were mapped in Colorado; this represents a decrease from the 265,000 acres detected in 2010. Areas with particularly heavy damage included portions of the Culebra and Sangre de Cristo ranges; the Maroon Bells; the western portion of South Park from Kenosha Pass south to Trout Creek Pass; portions of the Rawah Range; and from Rocky Mountain National Park south to South Boulder Creek and the East Portal of the Moffat Tunnel.

Douglas-fir beetle infestation is visible in mature Douglas-fir in Ouray County. [photo: S. Sky Stephens]

Ips Engraver Beetles

(Ips spp.)

Ips engraver beetles often are found in pines weakened by fire, drought or injury. Elevated populations of engraver beetles also are being observed in lodgepole and ponderosa pine forests impacted by mountain pine beetle, and have been observed throughout much of Colorado.

Scattered dead and dying ponderosa pines at the edge of the 2008 Nash Ranch Fire near Guffey is an indication of ips engraver beetle attack.

In 2011, scattered tree mortality caused by ips engraver beetles occurred in ponderosa pine stands adjacent to the 2008 Nash Ranch Fire that burned near the community of Guffey in Park County. Small groups of fading piñon pines, suggestive of piñon ips beetles (*Ips confusus*) attack, were detected in piñon-juniper forests in Four Mile Canyon, north of Cañon City. Groups of five to 20 fading trees were commonly observed.

Western Spruce Budworm

(Choristoneura occidentalis)

This defoliating insect of Douglas-fir, true fir and spruce trees has been at epidemic levels in portions of southern Colorado since 1998. In 2011, a total of 90,000 acres of visible defoliation were mapped during the annual aerial forest health survey. This represents a significant decrease over the 213,000 acres impacted in 2010 and 382,000 acres impacted in 2009. In 2011, defoliation also appeared to be more scattered and less intense than in the recent past.

Defoliation continued in portions of the Culebra and Sangre de Cristo ranges. Patches of defoliation were mapped from La Veta Pass south to Cucharas Pass on the eastern slopes of the Culebra Range. Many of the stands in this area, which have suffered more than 10 years of defoliation, now contain extensive top kill and tree mortality. Areas with the heaviest damage were mapped on the south-facing slopes of the Spanish Peaks and the north-facing slopes of Mount Maestra, Sheep Mountain and Little Sheep Mountain north of La Veta Pass. Patchy defoliation occurred on the east-facing slopes of the Culebra Range, from Cucharas Pass south to the New Mexico state line. Aerially visible defoliation also was seen for the second successive year in the Wet Mountains, from Saint Charles Mountain south to the southern limit of the range and north along the west-facing slopes to upper Bear Creek.

Most of the Douglas-fir stands in the upper Vallecito Creek, Animas River and Dolores River basins (San Juan County) were defoliated to some degree by western spruce budworm. Scattered defoliation

Buds and new shoots defoliated by western spruce budworm larvae.

also occurred in portions of the upper San Miguel Basin and on the northern slopes of the Mount Sneffels Range in San Miguel County.

Deciduous Forests

Community Forests

Thousand Cankers Disease

Walnut twig beetle (*Pityophthorus juglandis*) is native to portions of Arizona, New Mexico and Mexico, where it breeds in already-stressed branches of Arizona walnut and is not considered a pest. Beginning in 2001, dieback and death of ornamental black walnut trees was reported in several western states, including Colorado. The damage was attributed to walnut twig beetle, which has expanded its range and developed an association with a fungus, *Geosmithia morbida*, which causes thousand cankers disease (TCD) on several species of walnut. The disease results in branch dieback and eventual tree death, as the walnut twig beetle transports the fungus from tree to tree.

Since 2004, thousand cankers disease has caused extensive tree death of ornamental black walnuts in several areas of Colorado. TCD now is known to occur in 16 Colorado counties: Adams, Arapahoe, Boulder, Crowley, Delta, Denver, Douglas, El Paso, Fremont, Jefferson, Larimer, Mesa, Montrose, Otero, Pueblo and Weld. TCD was not detected in any additional counties in 2011; however, the disease was confirmed in two new locations in Fort Collins – the northern-most site in which TCD has been found in the state to date. Damage continued to occur in areas where TCD is present, and many walnut trees in Aurora, Boulder, Denver, Cañon City, Longmont and Pueblo have either been killed or are in decline.

During the past two years, TCD also has established itself in several eastern states, within the natural range of black walnut. In 2010, the disease was detected near Knoxville, Tenn., and in 2011, it was reported near Richmond, Va., and Philadelphia, Pa. The known area of TCD occurrence also expanded in the West and was observed for the first time in western Nevada.

Nine states – Kansas, Michigan, Missouri, Nebraska, Oklahoma, Indiana, Minnesota, North Carolina and Wisconsin – now prohibit, through state quarantines, importation of certain walnut items from states known to be infested with TCD, including Pennsylvania, Virginia, Tennessee and nine western states.

S. Sky Stephens, CSFS forest entomologist, examines a white fir damaged by western spruce budworm near North La Veta Pass.

Branch dieback indicative of thousand cankers disease was detected for the first time in Fort Collins in 2011.

Aspen Forests

Quaking aspen is one of Colorado's most recognizable trees. This is especially true in autumn when the state's aspen forests turn a patchwork of yellow, gold and orange. A number of insects and diseases are detrimental to aspen forests and have caused concern over the past six to seven years.

Sudden Aspen Decline

Beginning in approximately 2004, many mature aspen forests in Colorado and other western states suddenly died off. In Colorado, approximately 541,600 acres of dead and dying aspen were mapped during aerial forest health surveys in 2008. This represented nearly 11 percent of Colorado's 5 million acres of aspen forests. Referred to as sudden aspen decline (SAD), this condition raised serious concerns over the future of aspen forests.

SAD is believed to be the result of several interacting factors, including pervasive maturity in the state's aspen stands. Quaking aspen is a relatively short-lived species, but many trees in the state's aspen forests, which now are more than 100 years old, were subjected to severe stress during the drought that occurred from 1998-2002. The stressed trees were subsequently attacked and killed by several species of fungi, wood boring insects and bark beetles. Aspen stands at the lower elevation limits of tree growth, where conditions are drier and marginally suitable for trees, were more likely to be affected.

Since 2008, progressively smaller areas of SAD have been mapped each year: 342,000 acres in 2009; 190,000 acres in 2010; and only 46,000 acres in 2011. Reasons for the decline in areas where aspens are affected by SAD include a return to normal moisture levels and a decline in overstory mortality. In addition, some declining trees recovered after the drought.

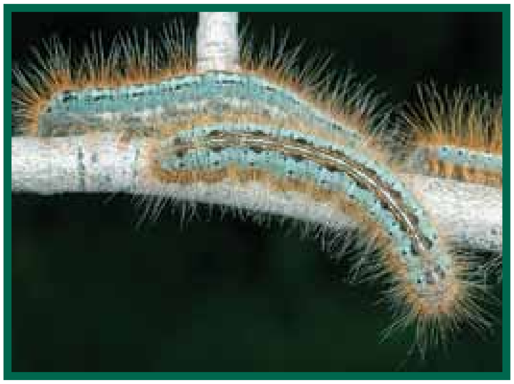
Although there are clear indications that the recent episode of SAD has subsided, a potential for additional episodes of this complex exists, should extended periods of abnormally warm, dry weather occur in the future.

Defoliating Insects in Aspen

Several caterpillar species can defoliate aspen forests. During outbreaks, these caterpillars can cause complete defoliation, usually by mid to late June. In Colorado, two species of defoliating caterpillars can reach epidemic levels and cause widespread defoliation of aspen forests: western tent caterpillar (*Malacosoma californicum*) and large aspen tortix (*Choristoneura conflictana*). The larvae of western tent caterpillar build large nests of silken webbing on aspen trees, which provide protection for the young larvae. Larvae of large aspen tortix roll aspen leaves, tie the leaves with silken strands and feed inside the shelter provided by the rolled leaves.

Defoliation of aspen forests by these insects continued in 2011, but fewer areas were detected compared to the past five years. All areas of aspen defoliation occurred in the southern portions of the state, from the Wet Mountains south and west to the Culebra Range and San Juan Mountains. A large area of aspen

Understory aspen regeneration now is occurring following death of the mature overstory due to sudden aspen decline.


Larvae of western tent caterpillar.


Silken cocoons containing the pupal stage of western tent caterpillar.

defoliation again was detected in the upper North Purgatory River Basin of the San Isabel National Forest, where approximately 1,400 acres were completely defoliated; this outbreak has been underway since 2007. Ground-checks of this area in 2011 again confirmed that defoliation was caused by western tent caterpillar. A large area of aspen defoliation, also caused by western tent caterpillar, occurred for the third consecutive year on the slopes of Grouse Mountain in the Park Creek drainage of the Rio Grande National Forest. Another area of defoliation by western tent caterpillar occurred on the slopes of Baldy Peak near Durango.


Aspen defoliation along the North Purgatory River is due to western tent caterpillar. [photo: S. Sky Stephens]

A smaller area of defoliation was detected on the eastern slopes of the Wet Mountains above Lake San Isabel. Aspen defoliation also was detected for the fourth consecutive year on a ridge between Turkey Creek and Dry Creek Canyon on the western slope of the Wet Mountains, and a new area of defoliation was detected north of Turkey Creek. The insect responsible for defoliation in these areas was not determined.

Gambel Oak Forests

Gambel oak is a low-lying tree that can form dense thickets at elevations between 6,000 and 9,000 feet in Colorado. It is found along the Front Range from Castle Rock south and on the Western Slope as far north as Steamboat Springs. Gambel oak thickets, often considered a nuisance that requires control or removal, are subject to attack by several insects and diseases that can cause concern. Between 2006 and 2007, several thousand acres of Gambel oak and other broadleaf shrubs in Garfield and Delta counties on the Western Slope were defoliated by an inchworm known as the linden looper (*Erannis tiliaria*). In 2011, two additional damaging agents were detected in Colorado's Gambel oak forests.

Defoliating Insects

Several landowners in Douglas County, south of Castle Rock and Franktown, reported seeing large numbers of green caterpillars feeding on Gambel oak foliage in late May and early June. The affected oak thickets, ranging in size from five acres to several hundred acres, suffered moderate to heavy defoliation. An insect observed at these sites has been identified as a moth in the genus *Alsophila*.

This stand of Gambel oak south of Castle Rock shows heavy defoliation caused by Alsophila.

The brown discoloration and leaf curl of Gambel oak foliage is caused by a fungal infection.

Leaf Diseases

Brown foliage discoloration accompanied by leaf curl was observed in a number of Gambel oak stands south of Cucharas Pass in Costilla County. The symptoms are suggestive of infection caused by one of two leaf fungi: taphrina leaf blister, caused by *Taphrina caerulescens*, or anthracnose disease of oaks, caused by *Apiognomonia quercina*. Similar symptoms were reported in late summer in portions of Douglas County.

Exotic Pests

Gypsy Moth
(Lymantria dispar)

Larvae of gypsy moth, an insect native to Eurasia, feed on foliage of both broadleaf trees and conifers. This insect first appeared in the United States in 1869 when it was introduced in Massachusetts by a French scientist trying to develop an alternate source of silk. A few of the insects escaped, became established in the surrounding oak trees and spread rapidly. Today, much of the northeastern and north-central United States is included in what is known as a "generally infested" area, which may experience several million acres of defoliation in a single year. Gypsy moth females can lay eggs on almost any surface, including lawn furniture and hubcaps of motor vehicles. Consequently, the insect is easily transported to distant locations, where new outbreaks can develop.

Colorado is at high risk of gypsy moth introduction, as people and goods move into the state from generally infested areas. The CSFS, in partnership with the Colorado Department of Agriculture and USDA Animal and Plant Health Inspection Service (APHIS), monitors gypsy moth occurrence using traps baited with the female moth's sex attractant, which is highly appealing to male moths. Delimiting trapping and on-site surveys around a trap location with moths in 2010 revealed no additional moths, and no gypsy moths were trapped anywhere in Colorado in 2011.

Emerald ash borer
(Agrilus planipennis)

Emerald ash borer, an insect native to Asia, is a colorful but highly invasive, exotic insect that attacks and kills all ash tree species native to North America. Since its initial detection in and around Detroit, Mich., during the early 1990s, this insect has killed tens of millions of ash trees across 14 states and two Canadian provinces. Several ash cultivars, such as autumn purple ash, which are popular for their spectacular fall colors, are widely planted as landscape trees in Colorado.

In some communities, such as Fort Collins, approximately 20 percent of the shade and ornamental trees are ash. Ash trees also have been planted extensively for windbreaks and shelterbelts across Colorado's Great Plains.

As with gypsy moth, the CSFS conducts a special survey to ensure early detection of potential emerald ash borer infestations in the state. The survey consists of deploying purple-colored panel traps, baited with an attractant that mimics the unique odors produced by stressed ash trees, which are highly attractive to the beetles. To date, the insect has not been found in Colorado.

White Pine Blister Rust
(Cronartium ribicola)

White pine blister rust, native to Asia, was introduced into North America during the early 1900s and has since caused heavy damage to white or five-needle pines across the United States. To complete its life cycle, the fungus that causes this disease requires two separate host plants. Five-needle pines serve as one host, and either currants or gooseberries (*Ribies* spp.), Indian paintbrush (*Castilleja* spp.) or *Pedicularis* spp. serve as the other. This disease causes cankers on the branches of white pines, resulting in dieback and eventual tree death. Infection of regenerating pines can be extensive, and impacted stands display reduced levels of seedling establishment. Mortality of young pines increases the long-term impacts of white pine blister rust infections in stands.

This fungus was not discovered in Colorado until 1998, when damage was detected on limber pine in Larimer County near the Wyoming border. Presently, the disease is known to occur in five other relatively localized areas in the state: Rocky Mountain National Park, Boulder County near Ward, the north slopes of Pike's Peak, the Wet Mountains and the Mosca Pass area of the Sangre de Cristo Range. No new areas of infection were detected in 2011, but the level of infection is increasing in some areas where the disease already is established.

Wild currants are one alternate host of the fungus that causes white pine blister rust.

Branch canker and spores of white pine blister rust on a limber pine.

Colorado's Forests: An Overview

Colorado's forests and woodlands are a critical resource – one that provides many benefits to its residents, as well as visitors and those living elsewhere. They are a source of wood and non-wood products, fresh water and wildlife habitat, and offer many forms of outdoor recreation. Colorado's forests also remove carbon dioxide, a greenhouse gas, from the atmosphere, and store the carbon in woody tissue. Our forests are composed of a mosaic of species that includes both conifers and broadleaf trees. Their distribution and abundance is defined by the state's complex topography of plains, mountains and plateaus; soil types; temperature; past land uses; and available moisture.

Colorado's nine broad types of forests and woodlands (*Table 1*) cover 24.4 million acres of Colorado's land surface. Conifer forests are the most abundant and widespread, dominating the mountains and high plateaus of the Western Slope. These forests are interspersed with stands of quaking aspen, which contribute diversity and beauty to the mountain landscape and comprise nearly 21 percent of Colorado's forest cover. Woodlands of piñon pine and juniper, interspersed with patches of Gambel oak, are the dominant trees of the lower elevations in the southwestern and western portions of the state. Piñon-juniper forests of predominantly one-seed juniper also are common in canyons and the transition zones between canyons and the shortgrass prairie of southeastern Colorado. Collectively, they comprise slightly more than 30 percent of Colorado's forest cover. Many of Colorado's rivers are lined with riparian forests composed of plains cottonwood on the Great Plains, and narrowleaf cottonwood, alders and blue spruce in the western part of the state.

The state's forests fall under a variety of ownerships. Nearly 68 percent of Colorado's forests are managed by federal agencies. The USDA Forest Service is the principal owner, managing approximately 11.3 million acres, or 47 percent of the state's forests, which are subdivided into 11 national forests. Other federal agencies that manage forestlands in Colorado include the Bureau of Land Management (BLM), National Park Service, Bureau of Indian Affairs and Department of Defense. Approximately 30 percent of Colorado's forestlands are privately

Table 1 - Area of forestland in Colorado by forest type, 2002-2009

Forest Type	Area (Thousands of acres)	Percent
Spruce-fir	4,571,066	18.69
Lodgepole pine	1,662,570	6.80
Aspen	5,065,277	20.71
Mixed conifer	1,783,740	7.29
Ponderosa pine	2,527,660	10.34
Montane riparian	934,666	3.82
Piñon-Juniper	5,177,926	21.18
Oak shrubland	2,365,998	9.58
Plains riparian	246,493	1.01
Introduced riparian vegetation	116,899	0.48
Total	**24,452,476**	**100.00**

Source: 2010 Colorado Statewide Forest Resource Assessment

Table 2 - Average net annual growth of forest growing stock on Colorado timberlands by species group, 2002-2009

Species group	Net Annual Growth (Thousand cubic feet per year)
Conifers	
Ponderosa pine	15641
Douglas-fir	18209
Lodgepole pine	-70688
True fir	-29349
Spruce	59186
Other conifers	2979
Subtotal	*-4022*
Broadleaf	
Cottonwood and aspen	49809
Other species	27
Subtotal	***49836***
All species groups	**45814**

Source: USDA Forest Service, Forest Inventory and Analysis

owned by some 186,000 individual landowners. Most of these private forestlands are located at lower elevations. The remaining forestlands in the state are located on a combination of Native American reservations, municipal and state lands. The Colorado State Land Board owns approximately 370,000 forested acres throughout the state. The largest parcel of state forestland is the Colorado State Forest, located east of Walden.

Approximately 11 million acres, or nearly half of all forestlands in Colorado are classified as "timberlands." These are forested lands where trees are either capable of or currently are producing 20 cubic feet of wood per acre annually and, if properly managed, can produce wood products on a sustainable level. Forestlands with special classifications, such as wilderness, are excluded. Approximately 79 percent of Colorado's timberlands are located on public lands.

Recent inventories of Colorado's timberlands indicate that in some of the state's conifer forests, tree mortality has been exceeding tree growth, at least since 2002 (*Table 2*). The heaviest rates of tree mortality currently are located in the lodgepole pine and true fir forest types, with losses of 70,688 cubic feet/year and 29,349 cubic feet/year, respectively (*Table 3*). According to one study of Colorado Forest Inventory and Analysis data, lodgepole pine mortality from 2002-2007 averaged 12.1 million trees per year, compared with 4.1 million trees per year from 1997-2002. Most of this mortality, which averaged 10.5 million

Aspen fall colors are visible during an aerial survey flight in September. [photo: S. Sky Stephens]

trees per year, was attributed to the current mountain pine beetle outbreak. Mortality of true fir averaged 15 million trees per year from 2002-2007, compared with 6.8 million trees per year from 1997-2002. This increase in mortality is largely due to chronically high levels of subalpine fir decline in high-elevation forests. These data clearly demonstrate the destructive capabilities of forest insects and diseases.

The CSFS Statewide Forest Action Plan (Colorado Statewide Forest Resource Assessment and Strategy) identified 5.5 million acres of forestlands that have a high to very high potential for proactive use of forest management to mitigate forest insect and disease damage, through alleviation of tree stress or competition. This type of forest management can restore forest resilience to levels that existed prior to insect and disease infestations (Colorado State Forest Service 2010).

Table 3 – Average annual mortality of growing stock on timberland by species group, 2002-2009

Species group	Average annual mortality (Thousand cubic feet per year)
Conifers	
Ponderosa pine	21,425
Douglas-fir	28,231
Lodgepole pine	142,350
True fir	104,016
Spruce	59,130
Other conifers	2,052
Subtotal	*357,205*
Broadleaf Trees	
Cottonwood and aspen	48,602
Subtotal	*48,602*
All species groups	**405,807**

Source: USDA Forest Service, Forest Inventory and Analysis

Forest Inventory and Analysis –
The Key Data Source for Colorado's Forests

The principal source of information used to assess the status of America's forests is the Forest Inventory and Analysis (FIA) Program. The FIA Program is conducted under the leadership of the Forest Research Stations of the USDA Forest Service. Authorized by the McSweeney-McNary Forest Research Act of 1928, the first forest inventories conducted under this program began in 1930. The program provides statewide, regional and national data on:

- area and location of forest cover type
- tree species composition
- size and health of trees
- tree growth
- tree mortality
- removal by harvesting

These data are obtained from a combination of aerial-image interpretation and on-the-ground observations in a network of permanent sample plots distributed across the nation's forests.

Beginning in 2001, the FIA Program was revised to provide information on an annual rather than periodic basis. In addition, data collection on a subset of sample plots was expanded to include information on soil, understory woody vegetation, tree crown condition, volume of coarse woody debris and lichen composition – a key indicator of air quality.

In Colorado, 4,500 permanent forest inventory plots have been established statewide; approximately 10 percent of these plots are examined annually. Additionally, expanded data is collected each year on 25 of these plots. Colorado is the first state in the Rocky Mountain Region where leadership of the forest inventory process has been assumed by a state agency. The CSFS is responsible for hiring field crews and collecting all data on the sample plots. The USDA Forest Service provides oversight in the process to assure quality of the collected data.

A summary of Colorado's inventory results has previously been published (Thompson 2010). In addition to published reports, the USDA Forest Service provides data collected in each inventory to those interested in further analysis. Data are stored in a nationally consistent standard format referred to as the Forest Inventory and Analysis Database (FIADB). Annual inventories also require a common plot design and common data collection procedures nationwide, resulting in greater consistency among FIA work units than seen in earlier inventories. Users can access this data in a variety of ways, including customized retrieval tools that generate tabular summaries. Currently, Colorado data collected through 2009 are available online; 2010 data also will be available soon.

Standard reports of FIA data always include estimates of forest area, number of trees, wood volume, tree growth, tree mortality and total biomass. Nearly 50 percent of Colorado's forestland is administered by the USDA Forest Service. Softwood forest types, or forestland primarily comprised of conifer species, account for 16 million acres – or 70 percent – of all forestland in Colorado. The most abundant forest type is piñon-juniper woodlands, which account for 5.2 million acres. Forestland comprised of firs and spruce account for another 4.5 million acres. Aspen is by far the most abundant hardwood tree species in Colorado, occupying approximately 5 million acres.

An FIA technician measures downed woody material, duff and litter depth. [photo: Claudia Stout]

One of the primary objectives of the FIA annual inventory is to provide baseline data on forest inventory and condition, and to measure changes in these areas over time. This helps foresters identify major issues that may be of concern to forest resource managers. As previously indicated, Colorado is experiencing one of the largest outbreaks of mountain pine beetle in lodgepole pine forests since record-keeping began in the state. The current epidemic in Colorado has provided an opportunity to test the usefulness of the FIA annual inventory system for quantifying rapid change in mortality of the state's major conifer species. For example, the annual estimate of lodgepole pine mortality volume from just the plots measured by CSFS crews in 2009 averaged 352 million cubic feet. This represents a seven-fold increase from the annual average of 50 million cubic feet of lodgepole pine mortality volume recorded in 2002. One of the benefits of the annual inventory system is that consistent data collection over a period of many years allows for correlation with other time-series data, such as temperature and rainfall. Because the power to detect significant effects related to mortality and trends in forest condition should increase substantially with estimates derived from the re-measurement of plots, a second 10-year cycle of plot measurement in Colorado will begin in 2012.

East of the Mountains

The Forests of the Great Plains

The Great Plains – a vast expanse of rolling grassland interspersed by streams, rivers, wetlands and canyonlands – lie to the east of the Rocky Mountains within the Central Shortgrass Prairie ecoregion (CSP). The CSP ecoregion covers approximately 55.7 million acres, encompassing nearly all of eastern Colorado, parts of southeastern Wyoming, western Kansas and Nebraska, the panhandles of Oklahoma and Texas, and northeastern New Mexico. The climate of this region is semi-arid, and forests develop only where sufficient moisture is available. On the Great Plains of Colorado, shortgrass prairie is the dominant vegetation type. Hundreds of grass species are present, such as blue grama, alkali sacaton, side oats grama, sand dropseed, buffalo grass, western wheatgrass and galleta.

This region sustains some of the most diverse wildlife populations in the state. Colorado's plains are an international destination for birders, as they support several hundred species of birds. This avian abundance is due in large part to the region's location, which falls within key migration paths of both Western and Eastern bird species. Pronghorn antelope, mule and white-tailed deer, sage hens and other wildlife species also are found in relative abundance on the Great Plains.

Colorado's Great Plains provide unique recreational opportunities, as well. Of special note is the longest preserved dinosaur trackway in North America, located in the Picket Wire Canyonlands of the Comanche National Grassland. Other popular tourist destinations include the Santa Fe Trail National Scenic and Historic Byway, Bent's Old Fort National Historic Site and the Sand Creek Massacre National Historic Site.

The Great Plains of Colorado also support a vibrant agricultural economy that sustains both state and local economies, and produces food for the entire country.

A flock of wild turkeys along the Purgatoire River in Otero County. [photo: Shelly Simmons]

Pronghorn antelope are native to the Great Plains.

Native Forests of the Plains

Riparian Forests

Native forests on Colorado's Great Plains are riparian forests, which grow near streams and rivers where there is adequate moisture for tree growth. These forests are composed of plains cottonwoods, willow species and other broadleaf trees, such as boxelder, oak species, netleaf hackberry and western soapberry. Riparian forests dominate areas near rivers and their tributaries that flow across the Great Plains, including the Platte, South Fork of the Republican, Arikaree and Arkansas rivers.

Piñon-Juniper Forests

Conifer forests also exist on the Great Plains. Isolated pockets of Rocky Mountain juniper grow in northeast Colorado's Pawnee National Grasslands and several other areas. Tens of thousands of acres of piñon-juniper forests comprised of one-seed juniper and piñon pine, with a smaller component of Rocky Mountain juniper, dominate canyons and the transition zones between canyons and shortgrass prairie in the southeastern counties of Colorado, including Baca, Bent, Otero, Pueblo, Huerfano and Las Animas. In Douglas, Elbert and El Paso counties, ponderosa pine also ranges east into the prairie.

The native forests of the Great Plains are largely confined to river banks where cottonwoods and willows can obtain adequate moisture.

A healthy riparian ecosystem along Chacuaco Creek in southeast Colorado. [photo: Shelly Simmons]

Great Plains ecosystems in southeast Colorado include piñon-juniper canyonlands dominated by one-seed juniper. [photo: Shelly Simmons]

Planted Forests of the Great Plains

Windbreaks and Living Snow Fences

As the Great Plains were settled, pioneers planted trees to help modify the harsh, windy environment and make it more suitable for humans, domestic animals and crop production. Windbreaks and living snow fences are still valued on the Great Plains of eastern Colorado. Strategically placed rows of trees, in the form of windbreaks and living snow fences, greatly reduce wind speed near home sites, roads, barns, corrals and crop fields. Living snow fences help protect roads and railroad rights-of-way from drifting snow, and windbreaks moderate temperatures around structures, which can help reduce heating and cooling costs. Livestock also benefit from windbreaks, which provide them with protection from extreme weather conditions. In addition, windbreaks provide cover and habitat for wildlife, and keep fertile soil in place.

Windbreak plantings provide protection for homes, agricultural crops and livestock.

Living snow fences provide protection of highways and railroad rights-of-way from drifting snow. [photo: Rich Straight]

Planting Trees Helps Plains Community Heal from Wildfire

In April 2008, areas of Crowley County were hit hard by a 9,000-acre grass fire, driven by winds exceeding 60 mph. The wildfire burned through rural areas of the county and the small town of Ordway, destroying homes, structures and property. Many members of the Crowley County community were impacted by this fire, and immediately afterward, the community was ready to begin rebuilding their lives.

Driven by interest from those affected by the fire who wanted to replant trees lost to the blaze, a partnership of county, state and local organizations was formed to lead the effort. Partners included the Colorado State Forest Service, Crowley County, Colorado State University Extension-Crowley County, West Otero-Timpas Conservation District and the Ordway Tree Board. The partnership received a $7,500 grant from the Colorado Tree Coalition's Reforest Colorado Grant Program, which 80 volunteers from across the state used to plant more than 350 trees for landowners affected by the fire.

After the 2008 Ordway Fire, volunteers planted trees to replace those that were destroyed. [photo: Shelly Simmons]

Planting trees in plains communities offers many aesthetic and environmental benefits. [photo: CSFS archives]

Community Forests

As cities and towns began to emerge on the Great Plains, so did the need to plant trees. Pioneer J. Sterling Morton, who became known as the "Founder of Arbor Day," recognized this need. The first Arbor Day celebration was held on April 10, 1872, in Nebraska City, Neb. Historians estimate that more than 1 million trees were planted in the State of Nebraska that day.

Today, community forests on the plains continue to help purify air and water, moderate temperatures, reduce noise and conserve energy by providing shade and reducing wind speed. Trees also create structure and beauty, add economic value and are a vital part of the infrastructure of plains communities. For example, studies conducted by the University of Washington have shown that people prefer tree-lined shopping districts and are more likely to stay longer, spend more money and make repeat visits if trees are present.

Cities and towns across the Great Plains region still celebrate Arbor Day and actively manage their community forests. Short- and long-term planning is critical for maintaining healthy community forests, and must include such practices as new tree plantings, tree replacement, pruning, watering, mulching, storm-damage mitigation and electrical line clearance. Many eastern Colorado plains communities participate in the National Arbor Day Foundation's annual Tree City USA Program, which recognizes and awards communities that are good stewards of their community forests.

Threats to Forest Health on the Plains

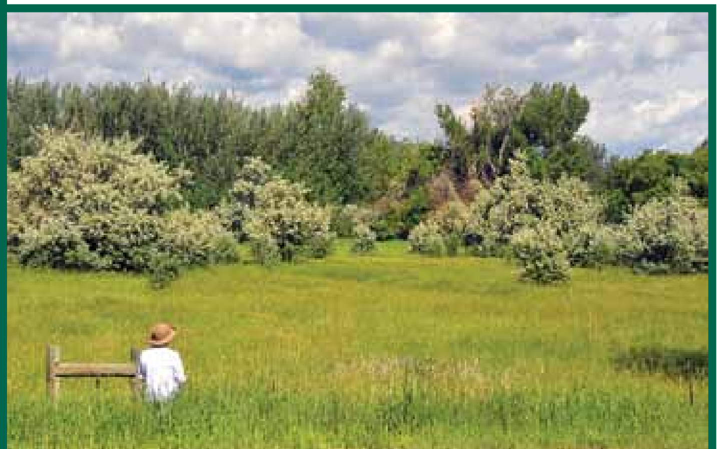
Trees planted on Colorado's Great Plains are especially subject to stress because of the semi-arid climate and high winds. Other agents that can affect the health and productivity of forest ecosystems are both natural and human in origin.

With the exception of Rocky Mountain juniper, most of the trees (ash, elm, pine, Russian-olive, etc.) planted by pioneers were exotic to the Great Plains, being native to portions of eastern North America, Europe or Asia. With proper irrigation and care, many of these trees readily adapted to their new environment and thrived. Some adapted too well, became invasive and began to slowly invade native riparian forests.

Invasive Trees

Many tree species have been introduced to the Great Plains. While most species were beneficial and thrived under irrigation, a few escaped cultivation and became invasive. Trees are considered invasive if they are exotic or non-indigenous species introduced into environments in which they did not evolve. Invasives have no natural enemies to limit their reproduction, and thus can displace native vegetation (Federal Interagency Committee on Management of Noxious and Exotic Weeds 1998). At least two small- to medium-sized trees introduced into Colorado and adjoining states for shelterbelt and windbreak plantings – Russian-olive and tamarisk – have become invasive. Both of these tree species now are listed by the Colorado Department of Agriculture as noxious weeds, which means it's illegal to plant and propagate them.

Russian-olive is a medium-sized tree, native to portions of Europe and Asia, that was introduced into North America as a shelterbelt and windbreak tree during the late 1800s. Russian-olive displays silvery-green foliage, tiny yellow flowers in spring and olive-like fruit in late summer or early fall. It proved to be especially suitable for the harsh growing conditions of the Great Plains, and escaped cultivation. These trees have invaded riparian areas, fields and open areas where they compete with and displace native vegetation. Due to the planting that previously occurred and the dispersion of seed by birds, this invasive tree has been widely distributed in Colorado and other states.



Russian-olives have invaded this field in Larimer County.

Tamarisk established along Chacuaco Creek in southeastern Colorado has impacted this riparian ecosystem. [photo: Shelly Simmons]

Tamarisk, or salt cedar, is a group of small- to medium-sized trees native to southern Europe, northern Africa, the Near East and Central Asia. Like Russian-olive, tamarisk was originally introduced to North America during the late 1800s as an ornamental tree and for use in shelterbelts, windbreaks and stream-bank stabilization. Tamarisk readily adapted to the semi-arid climate of the West, invaded riparian areas – especially in the Great Plains and Great Basin regions – and displaced native forests of cottonwood and willow. Today, tamarisk commonly is found in floodplains and along riverbanks, stream courses, salt flats, marshes and irrigation ditches. This tree can form dense, pure thickets that extend for miles.

Tamarisk thickets alter the ecology and hydrology of riparian areas. These trees have a high evapotranspiration rate, so water loss is caused by tamarisk. Sites invaded by these trees typically dry out over time, resulting in reduced stream flows. Therefore, tamarisk communities generally are less ecologically valuable than the native riparian plant communities they replace. In Colorado, the Arkansas River Basin of the Great Plains accounts for approximately 69 percent of the state's total tamarisk infestation (Colorado State Forest Service 2010; The Tamarisk Coalition 2009; Utah State University 2002; USDA APHIS 2005).

Spores of Gymnosporangium *rust on serviceberry.*

Tree Insects and Diseases of the Plains

Both native and planted forests on the Great Plains are subject to damage by a variety of insects, including defoliators, borers, aphids and scales, as well as damage from fungi, nematodes and bacteria. The following are a few of the more prominent concerns.

Fire blight is a disease caused by a bacterium (*Erwinia amylovora*) that attacks blossoms and growing tips of its host trees. Leaves of infected branches wilt rapidly, giving affected trees a scorched appearance; later, dark cankers form on the branches. Branches eventually die and the tips typically curl into what is known as a "shepherds crook." Fire blight attacks several fruit tree species, including pear, apple and crabapple. Certain cultivars of cotoneaster, which are important plantings in shelterbelt and windbreak plantings, also are affected (Riffle & Peterson 1986).

***Gymnosporangium* spp.** fungi require two separate host plants to complete its life cycle. Juniper and serviceberry, apple, crabapple and hawthorn serve as one host; plants in the rose family are the second host. Infections from these fungi often are referred to as **cedar-apple** or **cedar-hawthorn rusts**. Telial horns, which are fungi in spore form, appear as bright orange, fleshy structures on juniper branches in spring and are especially abundant during wet years. In some cases, masses of orange teliospores appear on the branches. Alternate spore stages form on the leaves of serviceberry, apple, crabapple or hawthorn and can cause premature loss of foliage and reduced fruit crops. One species (*Gymnosporangium nidus-avis*) forms conspicuous witches' brooms on the branches of Rocky Mountain juniper (Riffle & Peterson 1986).

***Melampsora* spp.** leaf rusts infect both cottonwood and willows growing in riparian areas of the Great Plains. Heavy infections cause premature loss of leaves, decreased tree vigor and noticeable declines in windbreak plantings. Like most rust fungi, the life cycle of *Melampsora* leaf rusts is complex and requires two hosts to reproduce. The alternate host varies depending on the species of *Melampsora* leaf rust involved, and can include conifers such as fir or a variety of broadleaf plants. The most conspicuous evidence of *Melampsora* leaf rust infection is the presence of powdery, bright orange spore masses on cottonwood and willow leaves. Heavy infections can cause the foliage to have an orange cast, and result in premature loss of foliage (Ming Han Pei & McCracken 2005, Riffle & Peterson 1986).

Fall webworm larvae construct conspicuous tents in branches of host trees.

Fall webworm (*Hyphantria cunea*) is a common mid- to late-summer defoliating insect of cottonwoods and other broadleaf trees throughout much of North America, including the Great Plains. Larvae feed in colonies and form large, tan-colored tents over portions of infested tree crowns. Heavy infestations can enclose much of the tree crown in webbing. This webbing may be unsightly, but the insects cause little or no permanent damage to infested trees.

Lilac/ash borer (*Podosesia syringae*) is a clearwing moth that somewhat resembles a wasp. Its larvae bore into the boles of ash and lilac trees, making this insect a common pest of ash trees in urban settings, shelterbelts and windbreak plantings, where infestation rates as high as 50 percent have been reported. Repeated infestations scar and can severely weaken or kill trees. Adults emerge from infested trees in early spring.

Elm Insects and Diseases

Elms, which historically were planted in many plains shelterbelts, windbreaks and urban settings, are subject to damage by several insects.

Elm leaf beetle (*Pyrrhalta luteola*) is an introduced species that feeds on all species of elms. Larvae and adults are both damaging. Larvae skeletonize leaves and cause them to turn brown, while adults chew larger holes in the leaves. Damage is unsightly, and heavy infestations can weaken trees. In 2011, this insect caused widespread damage to elms planted in and around Cañon City.

Elm leaf mining sawfly (*Fenusa ulmi*) is another exotic species introduced from Europe. The larvae feed inside the leaves and cause brown, discolored patches. The adult stage is a small wasp that appears in spring, just as the buds burst, and lays eggs on developing leaves.

European elm flea weevil (*Orchestes alni*) also is native to Europe and was first discovered in the United States during the 1980s. Adults chew small holes in elm leaves in spring; later, in summer, larvae mine inside the leaves.

European elm scale (*Gossyparia spuria*) is a sucking insect that infests elm branches and forms large colonies. Heavy feeding can kill branches, and honeydew produced by the feeding scales is a medium for growth of black, sooty mold, which can turn portions of the tree crown black.

Other insects and diseases that pose an immediate threat to the forests of the Great Plains include **emerald ash borer**, **gypsy moth** and **thousand cankers disease** – all described in earlier sections of this report. Emerald ash borer, in particular, is the subject of the Great Plains Tree and Forest Invasives Initiative. This initiative,

Elm leaf beetle adult (approximately 1/4-inch).

funded by a grant from the USDA Forest Service and matching state funds, gives state forestry agencies in four Great Plains states east of Colorado – Kansas, Nebraska, South Dakota and North Dakota – the opportunity to prepare for the arrival of this devastating insect. They are doing this through public awareness, promotion of tree species diversity and by assessing the region's tree resources and the potential impacts of invasive pests on these resources.

Herbicide Use on the Plains

Herbicides are important tools for managing unwanted plants in agriculture and forestry. Misapplied herbicides, however, can damage non-target vegetation. Windbreak plantings can be especially susceptible to herbicide damage because they often are located at the edges of cultivated fields, where they are subject to drift from herbicidal spray. Trees located near rights-of-way, railroads, roadsides or other areas treated for noxious weed control also have a higher risk of herbicide exposure if sprays are applied incorrectly. Symptoms of herbicide exposure include cupped or curled leaves, chlorotic or yellow foliage, abnormal growth, foliage with a pebbled or weather-beaten texture and branch dieback. Repeated exposure can severely weaken and sometimes kill trees. Boxelder, elm, ash, hackberry, hickory, apple, sycamore, willow, birch, horse chestnut and various maple trees are especially susceptible to herbicide exposure.

Many tree plantings in plains communities are declining due to age, herbicides, drought and high winds. Recognizing the importance of healthy community forests, several communities are replacing these dead and dying trees.

Biological Control of Tamarisk

Tamarisk is an invasive tree species found throughout Colorado's riparian forests. Tamarisk often displaces native vegetation and can alter water availability to surrounding plant and animal communities. A biological control program was initiated by the USDA Agricultural Research Service to control tamarisk throughout the western United States. Biological control is a pest management technique that involves the introduction of natural enemies of an invasive species (from its native habitat) to control it in its new (introduced) environment. This technique has been used with varying degrees of success against a number of invasive insects and plants worldwide.

A Diorhabda *beetle adult on tamarisk (approximately 3/16-inch).*

A group of leaf beetles of the *Diorhabda* genus are associated with tamarisk in its natural range. Both the larvae and adults feed on tamarisk leaves and green stems, which causes large portions of the trees to dry and turn yellow beginning in mid to late June (tamarisk foliage normally turns brilliant yellow in autumn). In parts of China and Russia, *Diorhabda* beetles are considered pests of tamarisk planted for shelterbelts or sand-dune stabilization, and infestations often require direct control. In Colorado, however, *Diorhabda* beetles meet an important criterion for an introduced biological control agent: they feed only on tamarisk trees, and therefore do not pose a threat to native vegetation.

The tamarisk biocontrol program in the West started in the late 1960s and gained momentum approximately 20 years later as the magnitude of the tamarisk problem became clearer. By 1998, after extensive safety testing, the first tamarisk biocontrol agent was ready for application. The first trial releases of the tamarisk beetle in North America were made along the Arkansas River in Colorado, below Pueblo Reservoir. The beetles survived and effectively defoliated tamarisk locally. These encouraging results helped launch the program across the western United States.

Following biological control on the Western Slope of Colorado, tamarisk now shows reduced canopy cover and vigor following multiple defoliations by *Diorhabda*. Observations from 10 monitoring sites on the Western Slope show an average of 15 percent mortality in tamarisk stands, with some sites exceeding 40 percent mortality. Vigorous regrowth of native vegetation also has been especially evident along many water courses where *Diorhabda* has been active, and a resurgence of willow stands is occurring at some sites where tamarisk was dominant only a few years ago.

After release of Diorhabda *beetles, tamarisks are dying, while willows are growing back along this portion of the Colorado River. [photo: Dan Bean]*

Weather Patterns and Forest Health

An unusual weather pattern occurred in Colorado during the fall, winter and early spring of 2010-2011. While the high mountains received record snowfall, the Front Range foothills and Great Plains experienced prolonged dry weather accompanied by frequent high winds. These conditions set the stage for large wildfires that burned thousands of acres of forest, woodland and prairie, destroyed numerous homes and other structures, and forced the evacuation of entire communities of people, pets and livestock. In September 2010, the Fourmile Canyon Fire burned near Boulder destroying 169 homes, making it the most costly wildfire in Colorado's recorded history. Then in April 2011, the Crystal Fire destroyed 13 homes and additional structures in the wildland-urban interface of Larimer County.

Aerial view of damage to lodgepole pine and other trees on Tennessee Mountain (Boulder County) caused by a severe hailstorm.

A severe hailstorm that occurred in late July 2010 caused damage to conifer forests on the slopes of Tennessee Mountain and around the community of Eldora in Boulder County. This damage became more visible in 2011. The hail damaged approximately 410 acres of lodgepole pine, spruce and subalpine fir, in addition to several stands of quaking aspen. Affected forests had a distinct gray-brown cast that could be seen for several miles. Hail damage is common in Colorado, particularly on the Great Plains. Hail and other storm-related damage to trees may predispose them to attack by insects and diseases.

In late October 2011, an early snowstorm deposited a blanket of heavy, wet snow over a large area of Colorado. The storm caused severe damage to urban broadleaf trees, many of which were still in full leaf, from Fort Collins south to Denver and east to Greeley and beyond. Broken limbs blocked streets, damaged homes and power lines and left many residents without electricity for several days. In addition, the snowstorm cost municipalities and homeowners several million dollars in repairs and clean-up costs.

Severe tree damage occurred in urban forests along the Front Range after an early season snowstorm struck in late October 2011.

These events serve as a reminder of the importance of weather and climate on the health and condition of Colorado's forests.

Climate and Forest Pests

Climatic anomalies, including prolonged drought, high winds and excessively mild or cold winter temperatures, can influence the abundance of damaging forest insects and diseases, and their resultant damage. For example, tree stress caused by the 1998-2002 drought triggered a major outbreak of the piñon ips bark beetle (*Ips confusus*) throughout much of the natural piñon pine range in the southwestern United States. This same drought also resulted in increased tree mortality from other bark beetles in Colorado, including the Douglas-fir beetle (*Dendroctonus pseudotsugae*) and fir engraver beetle (*Scolytus ventralis*). Moreover, this drought is believed to have incited sudden aspen decline in many of the state's aspen forests.

High winds, often associated with severe storms, can cause blowdown events in conifer forests and set the stage for bark beetle outbreaks. The development of spruce beetle outbreaks in high-elevation spruce forests, such as one following a blowdown in the Mount Zirkel Wilderness in 1997, is a good example. Windthrow in pine forests also can provide an abundance of host material suitable for outbreaks of ips engraver beetle.

Extremely cold winter temperatures can affect winter survival of bark beetles, such as mountain pine beetle and spruce beetle. Although these insects have mechanisms that allow them to survive beneath the bark of infested trees during sub-freezing conditions, excessive periods of extremely low temperatures (approximately 30 to 40 degrees below zero) can kill a high proportion of the bark beetles at all life stages (Gibson et al 2009). Studies in high-elevation forests in western Wyoming indicate that average winter low temperatures have increased steadily since approximately 1980, resulting in higher over-winter survival rates of mountain pine beetle.

Short-term changes in global climate, caused by the El Niño-Southern Oscillation (ENSO) and its counterpart, La Niña, also can affect forest health. ENSO refers to a warming of ocean surface waters in the tropical eastern Pacific Ocean off South America. This causes worldwide changes in normal weather patterns, including increased precipitation in the southern United States in winter and warm, dry winter conditions in the northern United States and Canada. The high winds that caused extensive blowdown in the Engelmann spruce forests of the Mount Zirkel Wilderness in 1997, which set the stage for a spruce beetle outbreak, were associated with an unusually strong ENSO event.

During 2010 and 2011, global climate was influenced by a La Niña event, recognized by a cooling of the same ocean surface waters off South America. La Niña typically has the opposite effect of ENSO events, as was the case when a La Niña event developed in June and July 2010. This resulted in the unusually dry conditions and high fire danger experienced along the foothills of the Rocky Mountains and on the Great Plains during the winter and spring of 2010-2011.

Blowdown in Engelmann spruce forests provides favorable host material for spruce bark beetles, which can lead to outbreaks in live trees.

Keeping Forests Healthy through Forest Management

Improving markets for forest products can help lawnowners meet wildfire mitigation objectives by offsetting the cost of treatments. [photo: CSFS archives]

As has been discussed throughout this report, Colorado's forests provide a wealth of social, economic and ecological benefits. Ensuring that our future forests continue to provide these benefits depends on sustainable forest management.

Forest management defines the goods, services and other benefits we hope to derive from the forest, and the management activities that are necessary to promote the output of those objectives. Forest management also improves forest health and resiliency, and is a useful tool to mitigate wildfire risk. Successful forest management requires an understanding of forest ecosystems and silvics – the science of how environmental factors affect tree growth and health. Through diverse forest management practices, we can satisfy our need for goods and services, while remaining good forest stewards.

An essential component to successful forest management is identifying the particular goods and services obtainable from each forest, and the stands that can best provide them sustainably over time. While some forests may be managed primarily for the production of lumber and other wood products, others are best suited for management practices that focus on wildlife habitat, recreation or water yields. Many forests can provide a variety of benefits with the right management and the application of forest ecology and silvics.

Silvics provides the scientific basis for forest management. It is the study of how climate, soils, available moisture, topography and other factors affect tree growth and health. This science examines the characteristics of individual tree species and their abilities to survive and grow under certain conditions. It also considers the role of fire, insects and diseases in the dynamic ecology of forests. Each tree species and forest type has a unique set of characteristics that defines where they can occur and how they

Tree thinning reduces fuel hazards, promotes forest health, improves wildlife habitat and supports local economies. [photo: Kathryn Hardgrave]

respond to disturbance, including fire, insects, diseases and forest management practices.

Applying forest management practices allows us to foster species and forest types that are best suited for each location and that can be sustained over time. This ensures that the individual characteristics of trees and forests are maximized to sustainably produce the desired goods and services. Forest management also can improve forest health by creating conditions more resilient to the recurrence of wildfire and damaging insect and disease outbreaks.

For example, ponderosa pine is a relatively long-lived tree that typically grows in uneven-aged stands. These trees produce a vigorous tap root that extends far underground, and have exceptionally thick bark. This combination of characteristics allows ponderosa pines to obtain moisture at deeper soil depths and resist damage from frequent, low-intensity fires. Therefore, in the central Rocky Mountains, ponderosa pine is best adapted to grow at relatively low elevations (6,500-8,500 feet) where conditions are dry and frequent, low-intensity fires occur naturally. A forest management approach in ponderosa pine might include stand thinning to reduce tree density. This allows the remaining trees to better use available soil and water resources, making them less susceptible to stress. Maintaining healthy tree densities in ponderosa pine forests also reduces their susceptibility to mountain pine beetle. Prescribed fire also can be used to manage fuels within stands and mitigate the impacts of future fire events.

Other tree species and forest types benefit from similar management practices applied to best suit specific needs. For example, lodgepole pine is a thin-barked tree with a shallow root system that usually grows in even-aged stands. It is best adapted to grow at higher elevations, where there is more moisture and natural fires are less frequent. Lodgepole pine responds very differently to forest thinning than ponderosa pine because of its shallow root system, which makes it susceptible to windthrow. Thinning and tree removal sometimes can be applied to lodgepole pine stands, but are best used at a different scale than thinning done in ponderosa pine stands.

Ultimately, forest management in Colorado can promote forest health and ensure that valuable goods and services

Reducing wood product imports from outside Colorado contributes to both local and statewide economies. [photo: Kathryn Hardgrave] are produced from our forested landscape. Long-term forest management also will ensure that Colorado's forests will be resilient to insects and disease, wildfire and other agents of change. While promoting forest health and forest resiliency, forest management also can provide wood products to local markets, create jobs and bolster local economies. Forest managers and forest landowners have the ultimate responsibility to manage their forests in order to meet defined goals and objectives, while maintaining healthy forests. The Colorado State Forest Service can provide private forest landowners with the technical assistance needed to help meet their individual land-management objectives.

A strong forest products industry not only contributes to local economies, but can offset costs to landowners when reducing hazardous fuels. [photo: Kathryn Hardgrave]

Legislative Support for Colorado's Forests

For the past several years, the Colorado General Assembly has demonstrated a strong commitment to conserving and protecting Colorado's forests by passing numerous bills focused on forest health, fuels mitigation and public safety, including three bills in 2011. The level of legislative support over the past several years is evidence of the importance and value Coloradans place on our forests, and we look forward to continued support as we work together to promote healthier, more diverse forests that are resilient to insect and disease epidemics for the benefit of present and future generations.

Summary of 2011 Forestry Legislation

Bill Number	Bill Name	Bill Summary
SB11-110	County Open Burning Slash Permit Program	Requires counties with 44 percent forest cover to develop an open-burning permit system for unincorporated areas of the county by Jan. 1, 2012. Counties with an existing open-burning permit system are exempt. The bill also exempts prescribed burns that follow federal and state guidelines, and preserves the existing rights of agricultural producers to conduct burning on their properties.
SB11-238	Extend Wildfire Preparedness Funding	For two years, beginning on July 1, 2012, extends the annual $3.25 million transfer to the Wildfire Preparedness Fund of federal mineral lease revenues by the Department of Local Affairs. The funding is used by the Colorado State Forest Service for wildfire preparedness activities, including funding for firefighting resources, agreements and plans.
SB11-267	Forest Health Act of 2011	Promotes forest health efforts, detailing several initiatives for the management and use of biomass derived from forestland located in the state. Also creates the Colorado Forest Biomass Work Group to identify market-based models for forest management and woody biomass energy development.

Learning from the Past to Shape the Future of Colorado's Forests

Throughout this report, information was presented on the condition of Colorado's forests, based on data generated by the Forest Inventory and Analysis Program, ground surveys performed by CSFS field personnel, and the annual aerial survey of insect and disease activity performed by CSFS and USFS personnel. Forest conditions in Colorado have changed throughout history, and we can expect them to continue to change in the future. Climate, weather conditions, fire, insects and disease – as well as how we manage and use our forests – all contribute to their health and condition.

Over the last two decades, the rate of change our forests have experienced has been historically significant. Fire, insect and disease outbreaks, which have increased in size and intensity, have transformed our forests in a relatively short timeframe. Although the processes and conditions that precipitated these outbreaks occurred over a longer timeframe than the outbreaks themselves, they were not readily apparent to the casual observer. Forests mature over decades. The increase in age and density of trees, competition for resources and drought conditions further stressed Colorado's forests, contributing to the insect epidemics we have recently experienced.

Much of Colorado's forestland, including designated wilderness areas, is in protected status and is managed only by natural processes. On the state's remaining forestland, however, we now have the opportunity to take action that will shape our forests for the future. The cost of controlling wildfire, especially where people and infrastructure are at risk, is exceptionally high. An example is the cost to contain and control the 2002 Hayman Fire, which totaled $42,000,000. Additionally, the amount of funds expected to be spent on watershed restoration and rehabilitation after the fire is $74,000,000 (Hayman Fire Case Study 2003). While we must direct resources to control fires when they occur, this practice limits our ability to use these resources in a more proactive manner to reduce the risk and severity of future wildfires. The objective is not to eliminate wildland fire and its important role in ecosystem function, but to reduce unwanted wildfire and its damaging effects.

[photo: Joy Jackson]

Forest management can fulfill an important role in how we help shape Colorado's future forests. Where lands allow for active management to occur, we can enhance forest resilience to fire, insects and diseases. This approach should ensure that at least a subset of managed forests will be resilient. Forest management also will continue to provide much-needed wood products and help diversify local employment. When we maintain a broad array of forest product markets, the economic value they provide assists us in meeting our desired future forest conditions in a cost-effective manner. In the United States, approximately 40 percent of solid wood products are imported from other countries. In Colorado, more than 90 percent of the wood products we consume are imported from other states and countries.

Managing the tracts of Colorado forest that allow for management under current regulations, especially on federal lands, will provide multiple benefits. Forest management provides employment, and businesses that use wood provide revenue that can offset the costs of forest management activities.

Conversely, if forests are left to rely only on natural processes, we can expect insects, diseases and fire to return in the future and have negative impacts on our forests. A balanced approach that recognizes the status of current protected lands, while encouraging remaining forestlands to be actively managed, is the best option for our future. This approach will provide diverse forests for tomorrow, and ensure that we continue to receive the wide range of benefits our forests provide.

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