



# 2013 Report on the Health of Colorado's Forests

Caring for Colorado's Forests: Today's Challenges, Tomorrow's Opportunities





# Acknowledgments

*Special thanks to the following Colorado State Forest Service (CSFS) State Office personnel for providing leadership and/or content and photos in the production of this report:*

Joseph A. Duda, Deputy State Forester (project lead); Pete Barry, GIS Technician; Ryan Lockwood, Public and Media Relations Coordinator; Lisa Mason, Outreach Forester; and Katherine Timm Schaubert, Outreach Division Supervisor.

*Thanks also to William M. Ciesla, Forest Health Management International, Fort Collins, Colo., for his contributions as an author and photographer in the development of this report.*

*The following individuals served on the report working group and/or provided information, guidance and feedback:*

Kathleen Alexander, City Forester, City of Boulder, Boulder, Colo.

Whitney Cranshaw, Professor and Extension Entomologist, Bioagricultural Sciences and Pest Management Department, Colorado State University, Fort Collins, Colo.

Lisa Dale, Assistant Director, Parks, Wildlife and Lands, Colorado Department of Natural Resources, Denver, Colo.

John Kaltenbach, Program Coordinator, Cooperative Agricultural Pest Survey (CAPS), Colorado Department of Agriculture, Lakewood, Colo.

Naomi Marcus, Forest Stewardship Coordinator, Forest Management Division, CSFS, Fort Collins, Colo.

Lauren Ris, Legislative Liaison, Colorado Department of Natural Resources, Denver, Colo.

S. Sky Stephens, Entomologist, USDA Forest Service, Lakewood, Colo.

Tim Reader, Utilization and Marketing Forester, Forest Management Division, CSFS, Durango, Colo.

Keith Wood, Community Forestry Program Manager, Forest Management Division, CSFS, Broomfield, Colo.

*The following individuals reviewed and/or provided information for the aerial survey results presented in this report:*

Justin Backsen, Aerial Surveyor, USDA Forest Service, Lakewood, Colo.

Kelly Burns, Forest Pathologist, USDA Forest Service, Lakewood, Colo.

Brian Howell, Aerial Survey Program Manager, USDA Forest Service, Lakewood, Colo.

Meg Halford, Assistant District Forester, Franktown District, CSFS, Franktown, Colo.

Benjamin Pfohl, Assistant District Forester, Boulder District, CSFS, Longmont, Colo.

Kelly Rogers, District Forester, Grand Junction District, CSFS, Grand Junction, Colo.

Jennifer Ross, Geographic Information Systems Specialist, USDA Forest Service, Monument, Colo.

Jeff Witcosky, Forest Entomologist, USDA Forest Service, Lakewood, Colo.

Jim Worrall, Plant Pathologist, USDA Forest Service, Gunnison, Colo.

Front cover photos – Top: Clinton Bellingar. Lower, clockwise from top left: Dan Bihn; Bill Cotton, Colorado State University; David Cappaert, Michigan State University, [www.forestryimages.org](http://www.forestryimages.org); Denver Parks and Recreation

Background photo this page: Bill Cotton, Colorado State University



January 2014



As your new Colorado State Forester, it is my distinct pleasure to present to you the 13th annual report on the health of Colorado's forests. The theme of the 2013 report is *Caring for Colorado's Forests: Today's Challenges, Tomorrow's Opportunities*. How best to care for this vital resource has been a major topic of discussion since I arrived in Colorado in July 2013.

During my travels around the state, and throughout my discussions with many of our stakeholders, I gained an appreciation of how much Coloradans value our state's iconic forest landscapes. I also have learned about many of the collaborative efforts involving public and private forest landowners to address the most pressing issues affecting forest health.

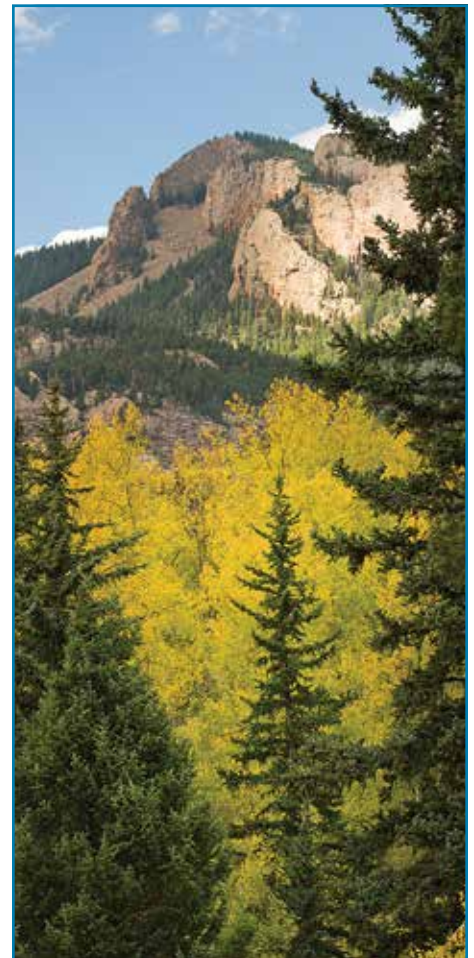
This year's report focuses on the values our forests provide and includes several examples of the successful collaborative forest management programs that were created to address the impacts of mountain pine beetle, threats associated with wildfire, and protection of critical watersheds and other values at risk. It is my hope that these examples will lead to the identification of

other potential solutions to the challenges our forests are facing. One thing is clear: forest stewardship is best achieved through the collective efforts of private landowners, public land managers, non-governmental conservation organizations, elected officials and other interested stakeholders.

The mission of the Colorado State Forest Service is to "achieve stewardship of Colorado's diverse forest environments for the benefit of present and future generations." At no time in Colorado's history has the CSFS mission been so relevant – and working with stakeholders to identify and implement innovative programs will help us further our mission.

We are confident you will find this year's report informative, and we invite you to contact the nearest CSFS office to learn more about Colorado's forest resources and what you can do to help keep them healthy for present and future generations.

Michael B. Lester  
State Forester and Director  
Colorado State Forest Service



▲ The Colorado State Forest Service has implemented forest management projects at Staunton State Park to improve the health and resiliency of the forest. Photo: Bill Cotton, Colorado State University



## Executive Summary

The Colorado State Forest Service (CSFS) is the lead state agency for providing technical forestry assistance and wildfire mitigation expertise to help landowners and communities achieve their stewardship goals and reduce wildfire risk. The CSFS produces an annual report on the health of Colorado's forests, which provides information to the Colorado General Assembly and citizens of our state about emerging and ongoing forest health issues, as well as actions we are taking to reduce their impacts.

Colorado's 24.4 million acres of forests and woodlands provide countless benefits to its citizens and visitors, including fresh water, clean air, wildlife habitat, wood products and many forms of outdoor recreation. In addition, Colorado's headwaters play a crucial role in meeting our nation's need for fresh water. Our state and 17 others derive their water supply from Colorado's high-country watersheds.

The CSFS and other agencies monitor our forests to assess their health and develop adaptive management strategies. Monitoring is accomplished through the annual aerial forest health survey, a cooperative project between the CSFS and the Rocky Mountain Region of the USDA Forest Service; field inspections and contacts with forest landowners; data from the Colorado Forest Inventory and Analysis (FIA) Program; and special surveys designed to ensure early detection of potentially invasive insect species, such as gypsy moth and emerald ash borer, which was discovered in Colorado for the first time in 2013.

For the second consecutive year, the aerial survey identified spruce beetle as the most widespread insect pest of Colorado's forests. In contrast, the area of active mountain pine beetle infestation continued to decline in 2013 due to the depletion of susceptible host trees.



◀ Colorado and 17 other states derive their water supply from Colorado's high-country watersheds. Photo: Bill Cotton, Colorado State University

Other major forest pests detected in 2013 include Douglas-fir beetle, which affects mature Douglas-fir forests; western spruce budworm, which causes widespread damage to mature Douglas-fir, white fir and Engelmann spruce; subalpine fir decline, which affects high-elevation spruce-fir forests; and western tent caterpillar and large aspen tortrix, which are known to defoliate aspen forests in Colorado.

Colorado's urban forests are being affected by thousand cankers disease, which has killed thousands of ornamental black walnut trees in many Colorado communities, and emerald ash borer (EAB), which was confirmed in the state for the first time in September 2013 in the City of Boulder. Colorado is now the western-most state in which the presence of EAB has been confirmed. Due to the known impacts of EAB on ash species, development of a statewide prevention and response plan began in 2010 and was adopted in 2013. The purpose of the plan is to help protect Colorado's ash trees and provide guidance for interagency response.

A more comprehensive list of damaging agents of Colorado's Forests is available in the *2013 Colorado Forest Insect and Disease Update*, a supplement to the *2013 Report on the Health of Colorado's Forests*, available online at <http://csfs.colostate.edu/pdfs/2013FHR-InsectDiseaseUpdate.pdf>.

In addition to insect and disease outbreaks, wildfire is an ever-present threat, particularly in the wildland-urban interface (WUI), which currently is only 20-percent developed in Colorado. As more people live, work and play in the WUI, their exposure to wildfire will increase. Forest management is fundamental in mitigating wildfire risk and improving forest health.

Colorado's forests are managed for many purposes and benefits. Stewardship objectives guide the management actions necessary to promote forest health, and identify the goods, services

and other benefits our forests provide. These objectives determine the level of management that will occur. For example, wilderness and roadless areas are purposefully set aside on federal forestlands to protect and preserve natural areas and minimize human disturbance. While the majority of federal forestlands are unavailable for active management, it is important that we manage the forestlands that are available. Active management of Colorado's diverse forests will provide clean air and water, enhance wildlife habitat, improve resiliency and reduce wildfire risk, while also supplying forest products. It also ensures that our forests can continue to provide the numerous social, economic and ecological benefits on which we rely.



▲ Teaching present and future generations to be stewards of Colorado's forests is essential to ensuring that our forests are healthy and can continue to provide all the benefits on which we rely. Photo: Peggy Ely, CSFS

In addition, management helps us reduce the percentage of forest products Colorado imports from other states and countries, which currently exceeds 90 percent.

Active management of our urban trees and forests also is essential, as they provide shade, buffer wind, reduce noise, help with stormwater management, absorb pollutants and cleanse the air. Trees are perhaps the least expensive investment a community can make, yet they are the only part of a community's infrastructure that increases in value over time.

Historic and current events, environmental factors and human intervention all have helped shape Colorado's forests. As Colorado's primary resource for technical forestry assistance, education and outreach, the CSFS administers or is involved in numerous programs and collaborative efforts. Programs focus on actions that reduce the impacts of forest insects and diseases and the intensity of future outbreaks, improve forest health, strengthen the wood products industry and mitigate wildfire risk to help protect human lives and property. Examples include the Colorado Forest Restoration Grant Program; Bioenergy Alliance Network of the Rockies; Colorado-Big Thompson Headwaters Partnership; Fire Adapted Communities Program; Front Range Fuels Treatment Partnership; and the Wildfire Risk Reduction Grant Program, administered by the Colorado Department of Natural Resources.

Our forests are dynamic and will continue to change, so the management decisions we make today will shape the forests of tomorrow. We all share in the responsibility to achieve forest stewardship. But we must act now, because the most efficient and cost-effective way to reduce the impacts of future large-scale forest threats is to proactively address them, before they arrive.

# The Colorado State Forest Service: Helping Landowners Achieve Forest Stewardship

In Colorado, private landowners ultimately are responsible for deciding how to address forest health concerns on their own properties – properties that collectively account for 30 percent, or 7.2 million acres, of all the state's forested landscapes. However, they are not alone when determining how to accomplish effective forestry practices and reduce the risk of dangerous wildfires. It will take the effort of all forest landowners working together on a landscape scale to effectively address forest health and reduce wildfire risk.

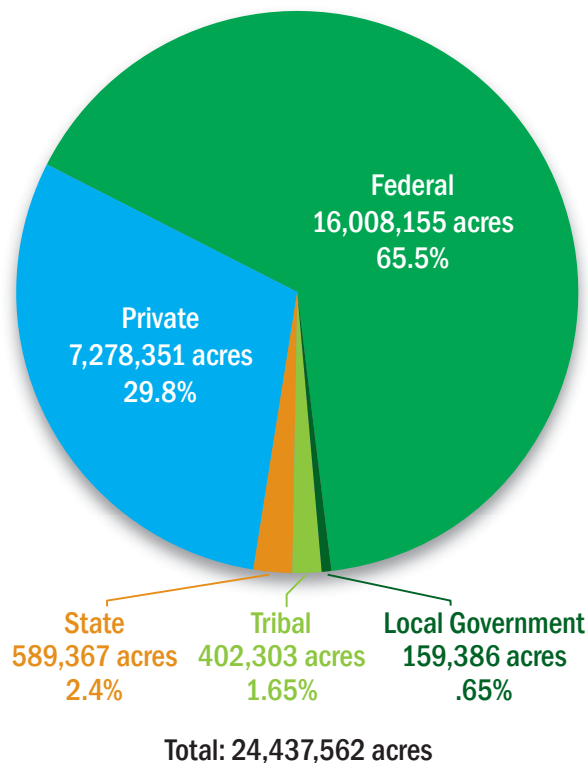
The Colorado State Forest Service, the lead state agency for providing technical forestry assistance and wildfire mitigation expertise, is a service and outreach agency of the Warner College of Natural Resources at Colorado State University. Headquartered in Fort Collins, the agency has approximately 130 full-time and seasonal employees, and 19 field offices across the state. The CSFS also provides staffing to the Division of Forestry in the Colorado Department of Natural Resources.

The CSFS works with private landowners, communities, and other agencies and organizations to help them make informed decisions to achieve their stewardship goals, reduce wildfire risk, and promote healthy and diverse forests for present and future generations. Every year, the CSFS helps treat 20,000 acres of forestland, and assists approximately 6,400 landowners and hundreds of communities to help improve forest health.



▲ A homeowner shows Dave Root, an assistant district forester on the CSFS Woodland Park District, how forest management altered the behavior of the Black Forest Fire on his property. Photo: Bill Cotton, Colorado State University

## Percentage of Forestlands by Ownership/Management





## Introduction

Colorado's 24.4 million acres of forests and woodlands provide countless benefits to its citizens and visitors. They offer fresh water, wildlife habitat, wood products and many forms of outdoor recreation. In addition, they provide clean air and remove carbon dioxide, a greenhouse gas, from the atmosphere.

Our forests also face numerous challenges, and in some cases present risks to Colorado citizens and visitors. The state's ongoing forest health concerns are due to a combination of factors that impact forest health, including poor stand conditions, long-term drought and warmer temperatures. In addition, many of our mountain forests have become unhealthy and overly dense, setting the stage for future insect and disease outbreaks, potentially devastating wildfires and the dangerous floods that often follow. These risks present both challenges and opportunities.

Colorado's forests offer a diverse blend of coniferous and broadleaf tree and shrub species, as well as millions of invaluable trees in urban settings. This diversity is due to a variety of soil types and a unique variability of temperatures and precipitation patterns created by Colorado's complex topography, ranging from 14,000-foot peaks to shortgrass prairies and high-desert landscapes.

The state's diverse forests fall under a variety of ownerships, and nearly 66 percent are managed by federal agencies, including the USDA Forest Service, Bureau of Land Management, National Park Service, Bureau of Indian Affairs and Department of Defense. Another 30 percent of Colorado's forestlands are privately owned, with the remaining forestland located primarily on municipal and state lands, and Native American reservations. This mosaic of ownership requires that everyone – from land managers to private landowners – play a critical role in helping achieve healthy forests.



▲ The San Juan Mountains in southwestern Colorado have been heavily infested with spruce beetle. In the photo below, 70-90 percent of the mature Engelmann spruce trees have been killed by spruce beetle and have turned gray. Infested trees turn a light yellow-green color before turning gray. Photo: William M. Ciesla

## Insect and Disease Update

Following is an overview of the condition of Colorado's forests. As in previous years, the primary source of information for the insect and disease portion of this report is the annual aerial forest health survey, a cooperative project between the Colorado State Forest Service and Rocky Mountain Region of the USDA Forest Service. Other sources include field inspections and contacts with forest landowners by CSFS personnel; data from the Colorado Forest Inventory and Analysis (FIA) Program; and special surveys designed to ensure early detection of potentially invasive insect species, such as gypsy moth and emerald ash borer, which was discovered in Colorado for the first time in 2013.

### Conifer Forests

#### Spruce Beetle

(*Dendroctonus rufipennis*)

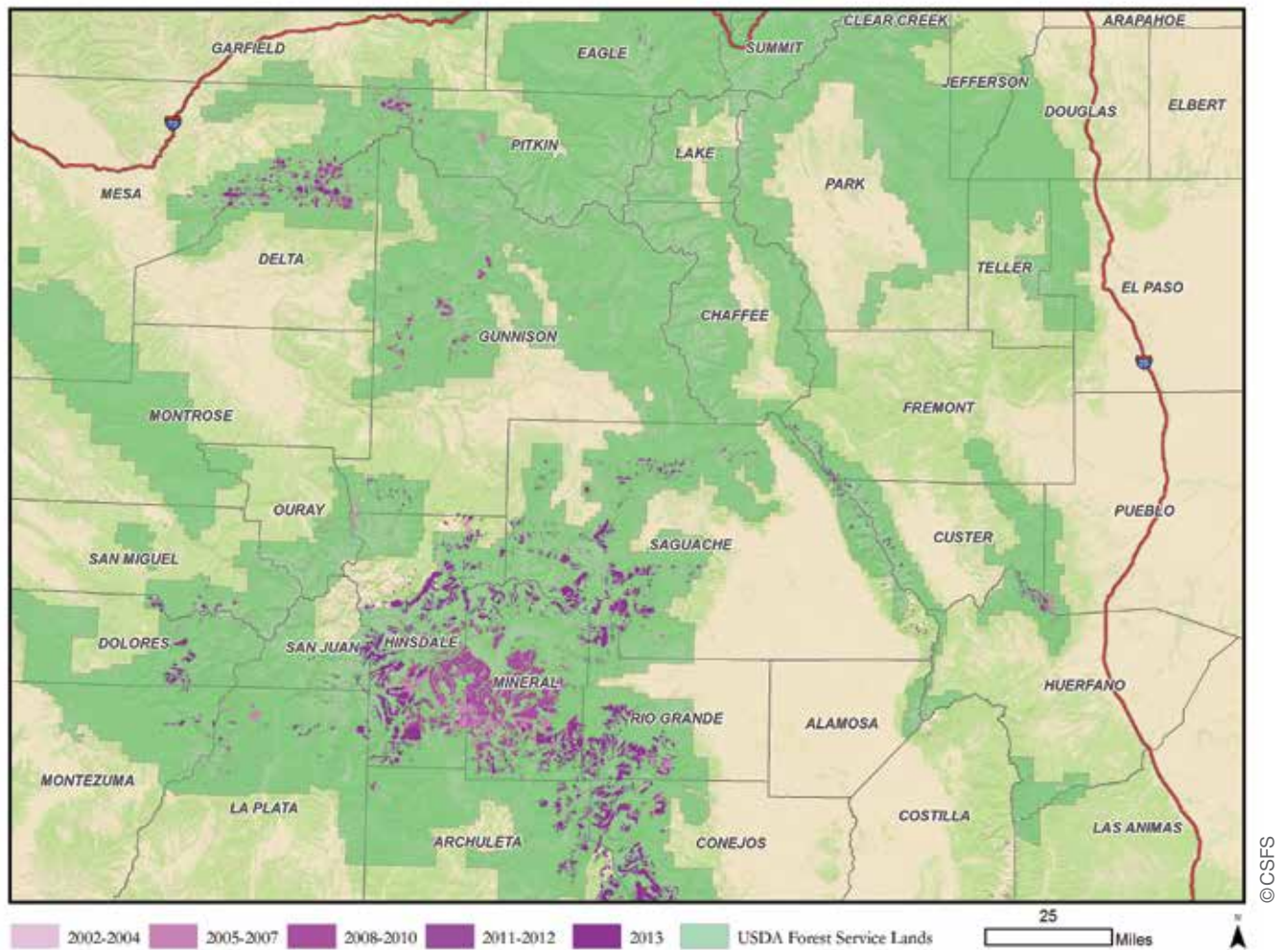
Spruce beetle was the most widespread insect pest of Colorado's forests for the second successive year. In 2013, active spruce beetle infestations were found on 398,000 acres of spruce forests, compared to 326,000 acres in 2012.<sup>1</sup> In November 2011, a heavy winter storm with high winds resulted in substantial windthrow in spruce-fir and mixed conifer forests. This could lead to further increases in spruce beetle activity over the next several years.

Areas of significant spruce beetle impact include the San Juan and La Garita mountains, Grand Mesa, Mt. Zirkel Range, Rabbit Ears Range, Wet Mountains and Sangre de Cristo Range.

<sup>1</sup> The 2012 figure for spruce beetle infestation was revised after the initial release of the aerial survey data.



## Spruce Beetle Progression in Southwestern Colorado, 2002-2013



### Mountain Pine Beetle

(*Dendroctonus ponderosae*)

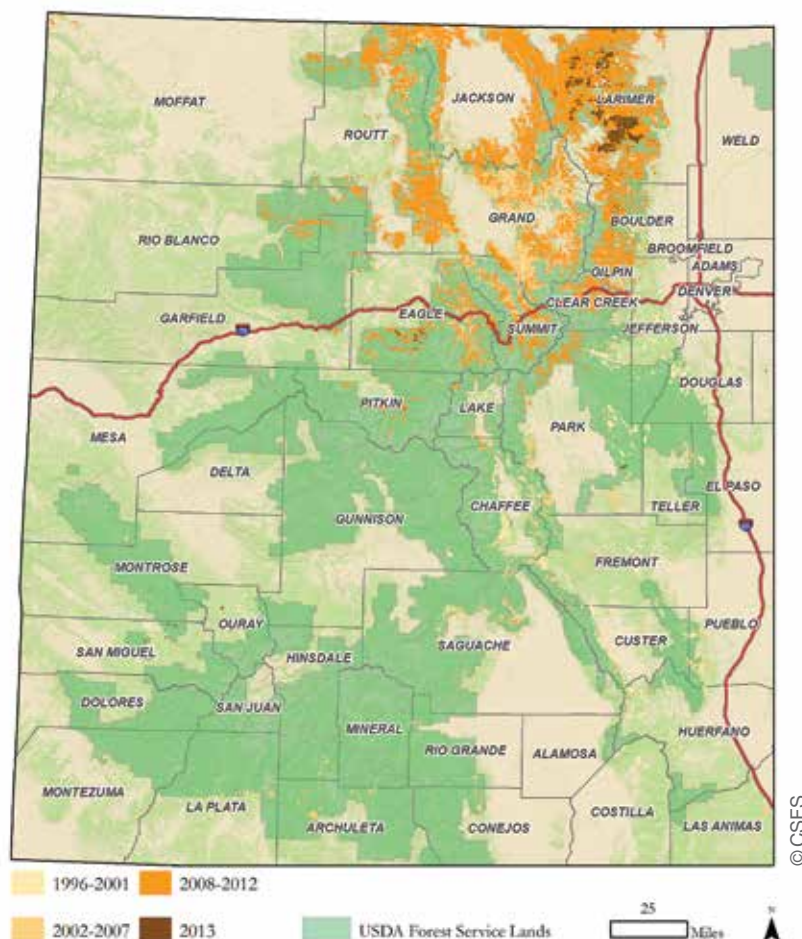
The area of active mountain pine beetle (MPB) infestation continued to decline in 2013, impacting 98,000 acres of limber, lodgepole and ponderosa pine forests. Approximately 3.4 million acres of forest have been impacted by this outbreak in Colorado since it began in 1996. In many areas, MPB activity has declined as a result of the depletion of susceptible host trees. Management of lodgepole pine forests in and around the Aspen/Snowmass ski area and the slopes of Smuggler Mountain have helped reduce the loss of trees to MPB. However, in some areas along the Front Range, from Rocky Mountain National Park south to the I-70 corridor, and in the Geneva Creek Basin and portions of South Park, a



▲ Active mountain pine beetle infestations persisted in mixed lodgepole/ponderosa pine forests in several areas of the northern Front Range, including the Buckhorn Creek Basin in Larimer County. Photo: William M. Ciesla



## Mountain Pine Beetle Progression in Colorado, 1996-2013



substantial population of pine trees suitable for attack and brood development remains.

Areas of significant mountain pine beetle impact include:

- 85,000 acres of MPB activity in Larimer County, representing 87 percent of all MPB activity in the state in 2013;
- limber pine mortality in the Sangre de Cristo Range; and
- ponderosa pine mortality on Miller Mesa, south of Ridgway.

### Douglas-fir Beetle

(*Dendroctonus pseudotsugae*)

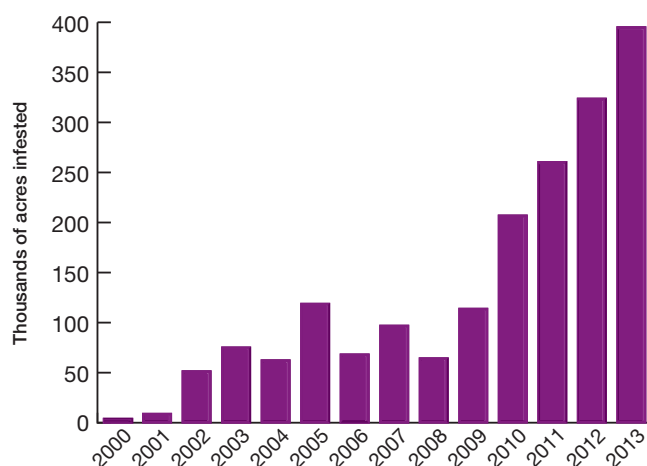
Douglas-fir beetle is a major pest of mature Douglas-fir forests, especially following periods of below-normal precipitation or outbreaks of defoliating insects. In 2013, approximately 43,000 acres with active Douglas-fir beetle infestations were detected over portions of southern Colorado and on the Western Slope.

### Western Spruce Budworm

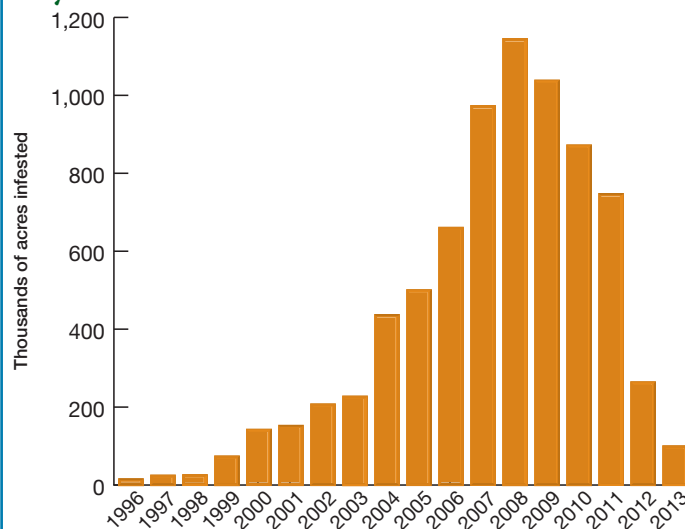
(*Choristoneura freemani* [=occidentalis])

Western spruce budworm continued to cause widespread damage to mature Douglas-fir, white fir and Engelmann spruce forests over portions of southern Colorado during 2013. Statewide, approximately 156,000 acres of aerially visible defoliation were mapped in 2013.

## Acres in Colorado Affected by Spruce Beetle



## Acres in Colorado Affected by Mountain Pine Beetle





## Subalpine Fir Decline

(*Dryocoetes confusus*)

Dying subalpine fir, sometimes referred to as “subalpine fir decline,” was again seen in many high-elevation spruce-fir forests across the state. The mortality is the result of attack by the western balsam bark beetle. Attacks typically occur in trees infected and weakened by two species of fungi (*Armillaria spp.* and *Heterobasidion parviporum*) that attack the root systems of subalpine fir. A total of 178,000 acres of subalpine fir mortality were mapped in Colorado’s forests in 2013.

## Deciduous Forests

### Defoliating Insects of Aspen

Western tent caterpillar (*Malacosoma californicum*) and large aspen tortrix (*Choristoneura conflictana*) are known to defoliate aspen forests in Colorado.

Both species were at outbreak levels in Colorado in 2013, and the area of aerially visible defoliation increased significantly compared to past years, from 22,000 acres in 2011 to 54,000 acres in 2013.

The most significant aspen defoliation from western tent caterpillar occurred in the Spanish Peaks on the Sangre de Cristo Range; the San Juan and San Miguel mountains; portions of the Culebra Range, including the North Fork Purgatory River Basin; and near Bonanza in the La Garita Range. Significant defoliation from large aspen tortrix occurred in the Wet Mountains and the Roaring Judy Basin near Almont.

## Thousand Cankers Disease

(*Geosmithia morbida*)

Thousand cankers disease, which is spread by the walnut twig beetle (*Pityophthorus juglandis*), has killed thousands of ornamental black walnut trees in many Colorado communities. Damage intensified in several communities, including Fort Collins, Denver and Pueblo. Extensive damage also continued in Cañon City.

In 2013, the CSFS conducted a special survey in 47 eastern Colorado communities to assess the condition of black walnut trees and aid future monitoring and detection of thousand cankers disease. The CSFS will evaluate the data to determine where further testing is necessary.

For a more comprehensive list of damaging agents of Colorado’s Forests, please consult the 2013 Colorado Forest Insect and Disease Update, a supplement to the 2013 Report on the Health of Colorado’s Forests, available online at <http://csfs.colostate.edu/pdfs/2013FHR-InsectDiseaseUpdate.pdf>.

Table 1. Important indigenous pests of Colorado’s forests in 2013

Pest	Host trees	Factors favoring outbreaks	Area infested in 2013 (acres)
Spruce beetle	Engelmann spruce	Fresh windthrow, mature/overmature stands, mild winter temperatures and drought	398,000
Mountain pine beetle	Lodgepole, limber, ponderosa and bristlecone pines	Mature/overmature stands (lodgepole/limber pines), overstocked stands (ponderosa pines), mild winter temperatures and drought	98,000
Douglas-fir beetle	Douglas-fir	Mature/overmature stands, below-normal precipitation, outbreaks of defoliating insects	43,000
Subalpine fir decline	Subalpine fir	Root disease fungi that predispose trees to bark beetles	178,000
Fir engraver beetle	White fir	Below-normal precipitation	37,000
Piñon pine insects (insect complex)	Piñon pine	Below-normal precipitation	15,000
Western spruce budworm	Douglas-fir, white fir, Engelmann spruce	Mature/overmature stands, below-normal precipitation	156,000
Defoliating insects of quaking aspen (western tent caterpillar, large aspen tortrix)	Quaking aspen	Unknown	54,000
Thousand cankers disease	Black walnut	Unknown	No new infestations detected; established infestations intensified in Denver, Fort Collins and Pueblo

Table 2. Important exotic pests of Colorado’s forests in 2013

Pest	Host trees	Origin	Status in 2013
Emerald ash borer	Ash (all species)	East Asia	Discovered in Colorado for the first time, in Boulder, where multiple areas of infestation have been detected
White pine blister rust	White or five-needle pines	Asia	New outbreak discovered on the Rampart Range



## Emerald Ash Borer: An Emerging Threat in Colorado's Urban Forests

Emerald ash borer (EAB), an invasive insect responsible for the death or decline of tens of millions of ash trees in more than 20 states, has now been detected in Colorado. EAB was confirmed for the first time in September 2013 in the City of Boulder. Colorado is now the western-most state in which the presence of the insect has been confirmed.

Native to Asia, EAB was first detected in the U.S. in 2002 in southeastern Michigan, most likely arriving prior to 1990, hidden in wood-packing materials commonly used for shipping. The metallic-green beetle already has cost communities in the eastern U.S. billions of dollars to treat, remove and replace ash trees. Infestations are difficult to detect, as the larvae reside under the bark, and ash trees may be infested for up to four years before signs of decline are visible.

EAB attacks only ash trees, and all ash species and sizes are at risk. Beetle larvae feed on the inner bark of infested trees, girdling them and disrupting the transport of water and nutrients. The tunneling and feeding under the bark eventually kills impacted trees, similar to the way mountain pine beetles affect pine trees.



▲ Brad Lalande, a CSFS seasonal forester, inspects an ash tree in the CSFS Seedling Tree Nursery to determine the presence of EAB. Photo: Peggy Ely, CSFS

After EAB larvae mature into adults in the late spring, they emerge from under the bark. Adult beetles may fly up to a half-mile to infest new trees; however, under certain conditions, they are capable of flying up to several miles. When people transport EAB-infested ash firewood, logs, nursery stock or other wood, EAB can spread over much longer distances.

### Potential Impacts of EAB in Colorado

As a non-native insect, EAB has no native natural enemies to help keep populations in check, and North American ash trees have no natural defenses against attack. As a result, the beetle poses a serious threat to Colorado's urban forests, where ash trees comprise an estimated 15-20 percent of all trees.

Ash species have been widely planted in Colorado, due to their fast growth, ability to tolerate urban growing conditions and high aesthetic value. Many of the state's ash trees are located on private property and in parks and other community areas. The Denver Metro area alone has an estimated 1.45 million ash trees.

### Response to EAB

An interagency EAB response plan already is in place to help protect Colorado's ash trees; the plan includes the recent creation of an incident command team in Colorado to help lead response efforts. The Colorado Department of Agriculture, Colorado State Forest Service, USDA Animal and Plant Health Inspection Service (APHIS), Colorado State University Extension, the City of Boulder and other partners already have taken actions to:

- determine the extent of the EAB presence;
- establish a quarantine and detection process to prevent further spread of EAB;
- inform professionals and the public about the importance of not spreading the infestation through the transportation of ash wood;
- help communities recognize how to identify potential host trees, and those that may already be infested by the insect; and
- ensure that landowners and city foresters know when it is appropriate to apply chemical treatments to protect high-value trees, or to remove trees of concern.

The existing EAB quarantine prohibits the movement of all regulated materials – except those that have met treatment requirements – out of regulated areas; as of January 2014, this included all of Boulder County, the City of Erie and the Republic Landfill in Jefferson County. Regulated materials include ash nursery stock, green lumber, ash wood products, and all hardwood firewood and related products.



▲ EAB is responsible for the death or decline of tens of millions of ash trees in more than 20 states. Photo: Howard Russell, Michigan State University, [www.forestryimages.org](http://www.forestryimages.org)



# Emerald Ash Borer: Signs and Symptoms

Signs of EAB infestation include:

- sparse leaves or branch dieback in the upper crown of the tree;
- D-shaped exit holes about 1/8-inch wide;
- new sprouts on the lower trunk or lower branches;
- vertical splits in the bark;
- winding, S-shaped tunnels under the bark; and
- increased woodpecker activity.

More information about EAB in Colorado, including survey progress and quarantine information, is available at [www.eabcolorado.com](http://www.eabcolorado.com).



▲ EAB poses a serious threat to ash trees in Colorado. Dead and dying ash trees are hazardous to people and property, and need to be removed. The Colorado Department of Agriculture estimates that the removal of public and private ash trees would cost approximately \$435 million in the greater Denver Metro area alone. Photo: David Cappaert, Michigan State University, [www.forestryimages.org](http://www.forestryimages.org)



▲ New sprouts grow on the lower branches of an ash tree infested with EAB. Photo: James W. Smith, USDA APHIS PPQ, [www.forestryimages.org](http://www.forestryimages.org)



▲ EAB larvae create tunnels or galleries under the bark of ash trees. Photo: William M. Ciesla



▲ EAB larvae feed on the inner bark of ash trees, girdling the tree and disrupting the transportation of water and nutrients. Photo: David Cappaert, Michigan State University, [www.forestryimages.org](http://www.forestryimages.org)



▲ It can take up to four years for a tree to show signs and symptoms of EAB. D-shaped exit holes indicate that the tree has been infested. Photo: Ryan Lockwood, CSFS



▲ Vertical splits in the bark of ash trees can be a sign that EAB has infested the tree. Photo: Joseph O'Brien, International Society of Arboriculture, [www.forestryimages.org](http://www.forestryimages.org)

# Colorado's Forests: Benefits and Challenges

## An Overview of Colorado's Forests

Colorado's forests provide numerous social, economic and ecological benefits. These benefits include clean air, a reliable source of fresh water, a sustainable forest products industry, ecological diversity and abundant recreation opportunities.

Colorado's headwaters play a crucial role in meeting our nation's need for fresh water. Our state and 17 others derive their water supply from Colorado's high-country watersheds. However, these forested watersheds often suffer the same fate as the forests themselves. The overabundance of vegetation in many of our forests can fuel large, intense wildfires. After these fires, a dramatic decrease occurs in vegetative ground cover, resulting in the loss of soil stabilization. Heavy rains that follow can wash out hillsides, threaten life and property, cause sediment and debris to flow into streams and rivers, and lead to millions of dollars in damage to reservoirs and infrastructure.



▲ Colorado's watersheds provide drinking water to municipalities and irrigation for agriculture. Photo: CSFS

Our forests also provide a renewable supply of wood products, from sawlogs and construction-grade lumber to landscape timbers, wood mulch and pellet-stove fuel. In addition, bluestain wood resulting from the recent mountain pine beetle epidemic is used for wood paneling and custom-made

furniture. Colorado's forests and local economies benefit from the removal of wood that helps create diverse and resilient forests.

The same mountain forests that yield lumber for homes, posts and poles for fencing, and other wood products also provide cover and forage for many species of wildlife. Large mammals, such as elk, mule deer, black bears, moose and mountain lions, dwell within our mountain forests, as do countless other species of animals, plants and fungi vital to ecological health. The riparian forests of the Eastern Plains and Western Slope also sustain some of the most diverse ecosystems in the state.

Colorado's forests, on both mountains and plains, improve the quality of life for Coloradans. Urban forests provide shade, increase property value, reduce noise and mitigate stormwater runoff. Recreation opportunities in our high-country forests include world-class hunting and fishing, mountain biking, wildlife viewing, hiking, camping and snow skiing.

## Colorado's River System Provides Water to 18 States





## The Ever-Present Threat of Wildfire

Wildland fire is an essential, natural process in Colorado's forest ecosystems, but a long history of fire suppression has altered historic fire cycles and led to the dangerous build-up of fuels in some areas. According to data from Headwaters Economics, only 20 percent of Colorado's wildland-urban interface (WUI) is currently developed. As more people live, work and play in the WUI – the area where structures and other human developments meet or intermingle with wildland fuels – their exposure to wildfire will increase. Mitigating fuels and providing education to those living in the WUI are essential to minimizing these threats.

Forest management, including thinning trees to reduce fuels and create fuelbreaks, is intended to alter fire behavior by slowing its spread and reducing its intensity. This can lower the occurrence of catastrophic wildfire, which makes fires that do occur more manageable for firefighters and reduces the footprint of intense burns.

People living in wildfire-prone areas can help reduce the risks by making their properties and communities more



▲ The 2013 Black Forest Fire resulted in the loss of two lives, and burned 509 homes and 14,280 acres. Photo: Bill Cotton, Colorado State University

defensible. When homeowners create defensible space and communities establish fuelbreaks, firefighters have a better chance of saving lives and structures. The Colorado State Forest Service manages numerous programs in the state to help inform landowners, communities and decision-makers about how to reduce wildfire risk in the WUI, including:

- Fire Adapted Communities;
- Firewise Communities/USA®;
- Community Wildfire Protection Plans (development and implementation); and
- Colorado Wildfire Risk Assessment Portal, or CO-WRAP (an online mapping tool that provides access to statewide wildfire risk assessment information).



▲ Reducing fuels in the wildland-urban interface is critical to protecting life and property. Photo: Bill Cotton, Colorado State University

---

*When homeowners create defensible space and communities establish fuelbreaks, firefighters have a better chance of saving lives and structures.*

---



## Active Management and Healthy Forests

Active management is essential to ensuring that our forests continue to provide fundamental benefits, while minimizing risks within them. Stewardship objectives guide the management actions necessary to promote forest health, and identify the goods, services and other benefits our forests provide. These objectives determine the level of management that will occur. For example, wilderness and roadless areas are purposefully set aside on federal forestlands to protect and preserve natural areas and minimize human disturbance.

While the majority of federal forestlands are unavailable for active management, it is important that we manage the forestlands that are available. Active management of Colorado's diverse forests will provide clean air and water, enhance wildlife habitat, improve resiliency, and reduce wildfire risk, while also supplying forest products. It also ensures that our forests can continue to provide the numerous social, economic and ecological benefits on which we rely. In addition, management decreases the percentage of forest products Colorado imports from other states and countries, which currently exceeds 90 percent.



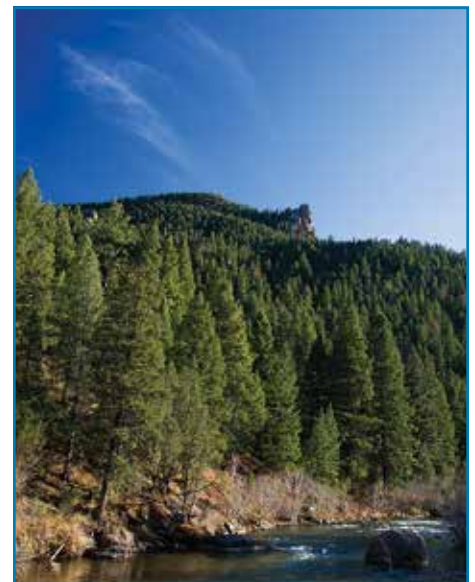
▲ The bluestain fungus in mountain pine beetle-killed trees does not change the structural integrity of the wood, but it often adds aesthetic value. Photo: Dan Bihn

Each forest type possesses a unique set of characteristics that determines where tree species will grow and how they will respond to disturbances, such as wildland fire, insects and diseases, and various forest management practices. Ponderosa pines typically grow in uneven-aged stands and have relatively thick bark and deep roots, making them ideal for coping with dry

conditions and frequent, low-intensity fires; in these forests, selective tree harvesting often is the best strategy. Lodgepole pine, however, is a thin-barked tree with shallow roots that generally grows in even-aged stands adapted to more moisture and less-frequent, more intense fires. In these stands, clearcutting is the best option. Management techniques vary by forest type and are



▲ Kris Williams designs and builds custom furniture and other wood products, and advocates public awareness of the forest products industry in Colorado. Photo: Dan Bihn



▲ Active forest management helps protect water quality and can increase water yield. Photo: Bill Cotton, Colorado State University





▲ Natural regeneration is a benefit of patchcutting, a common forest management technique used in lodgepole pine forests. Photo: Bill Cotton, Colorado State University

largely accomplished by selective thinning to reduce tree stress and competition, but may include other options, such as clearcutting or other forest restoration activities, depending on forest type and desired outcomes.

Another forest management practice is reforestation, which includes the planting of seedling trees. Replanting areas impacted by natural disasters, such as wildfires and

floods, is critical because it helps accelerate regeneration and ultimately protects water supplies, restores wildlife habitat, and reduces flooding and erosion. Conservation seedling trees, such as those grown at the Colorado State Forest Service Nursery in Fort Collins, can be used to replant areas impacted by wildfire and other natural disasters, which helps stabilize soils, protect water quality and restore habitat.



▲ Ponderosa pine seedlings, which now are over 6 feet tall, were planted in 2003 as part of a CSFS forest restoration project at Cheesman Reservoir on Denver Water property to reforest the landscape and mitigate the impacts of the 2002 Hayman Fire. Photo: Kristin Garrison, CSFS

Because Colorado's forests cross ownership boundaries, their stewardship is the responsibility of many stakeholders, including state and federal agencies, counties, municipalities, communities and private landowners. Forest stewardship requires that everyone work together on a landscape scale in order to be successful.

## A Viable Forest Products Industry is Essential to Effective Management

A viable forest products industry is essential to sustainable forest management, which can:

- increase forest health, diversity and resilience;
- reduce forest treatment costs by adding monetary value to harvested trees;
- offer incentives for private and federal landowners to conduct forest management;
- provide valuable wood products; and
- contribute to local and state economies.

Forest management in Colorado can decrease the percentage of forest products we import, which currently exceeds 90 percent.

To help promote and increase awareness of our state's wood products industry, the CSFS maintains the Colorado Forest Products™ Program, a companion of the Colorado Proud™ campaign that focuses on:

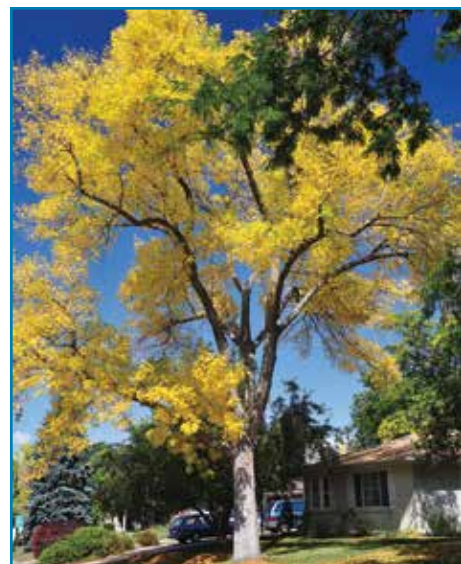
- promoting the use of Colorado wood in new and existing markets;
- encouraging the development of businesses dedicated to the use of Colorado wood;
- educating Colorado citizens on the economic, environmental and social consequences that imported wood has on our state's economy and forestland; and
- informing consumers about the benefits of buying wood products from Colorado growers, manufacturers and retailers.







▲ After planting and maintenance costs are figured in, each urban tree returns on average two-and-a-half times the total investment through higher property values, reduced air and water pollution, and energy savings. Photo: Colorado State University



▲ Ash trees, which have been planted extensively in Colorado over the last 50 years, comprise approximately 15-20 percent of the state's urban trees. They are popular because they grow quickly and can tolerate the growing conditions in urban areas. Photo: William M. Ciesla

## The Many Benefits of Colorado's Urban Forests

Urban trees beautify communities and add to quality of life. They provide shade and buffer wind, which helps reduce heating and cooling bills. They also absorb pollutants and cleanse the air, reduce noise and help with stormwater management. Properties with trees have higher values than those that do not. Trees are the only part of a community's infrastructure that increases in value over time. Trees attract people, which in turn attract business and create tax dollars. They are perhaps the least expensive and most rewarding infrastructure investment a community can make.

---

*Properties with trees have higher values than those that do not.*

*Trees are the only part of a community's infrastructure that increases in value over time.*

---

After planting and maintenance costs are figured in, each tree returns two-and-a-half times the total investment through higher property values, reduced air and water pollution, and energy savings. They work continually to capture and store carbon, and provide a more pleasant

atmosphere where families live and work. Protecting Colorado's community forests from invasive insects and diseases, such as emerald ash borer and thousand cankers disease, is vital to preserving these myriad benefits.



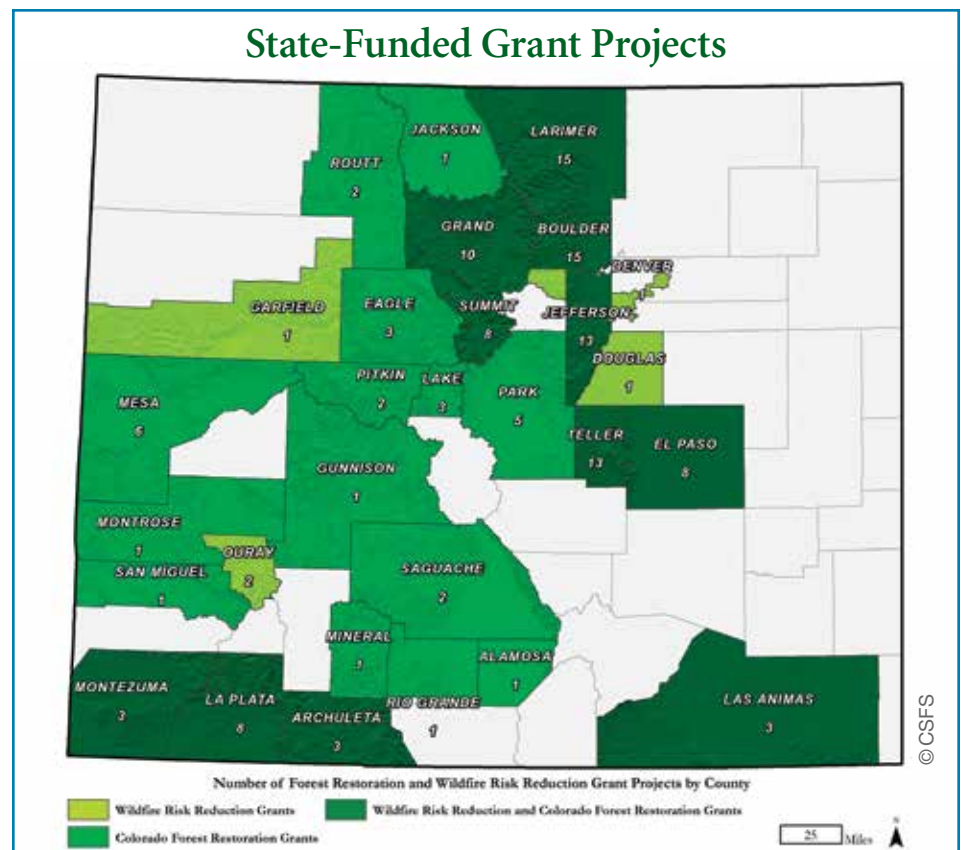
▲ Trees continually capture and store carbon, and provide a more pleasant atmosphere in which families can live and work. Photo: Denver Parks and Recreation



Historic and current events, environmental factors and human intervention have helped shape Colorado's forests. More recent events, including insect and disease outbreaks, and wildfires, have posed unprecedented challenges to public land managers and private landowners alike. Such events also have raised public awareness about the need to manage our forest resources using the best available science.

As Colorado's primary resource for technical forestry assistance, education and outreach, the Colorado State Forest Service administers several programs and collaborative efforts focused on actions that reduce the impacts of forest insects and diseases and the intensity of future outbreaks, improve forest health, strengthen the wood products industry and mitigate wildfire risk to help protect human lives and property. Following are highlights of a few of these programs, as well as a new Colorado Department of Natural Resources-administered program focused on reducing wildfire risk in Colorado's

wildland-urban interface and utilizing woody material generated from fuels treatment projects.



The Colorado Forest Restoration Grant Program, previously a pilot program, has supported the implementation of 104 community-based forest restoration projects across the state through the passage of four pieces of legislation:

- House Bill 07-1130, Forest Restoration Pilot Program;
- Senate Bill 08-071, Forest Restoration Pilot Program (Extends HB07-1130);
- House Bill 09-1199, Colorado Healthy Forests & Vibrant Communities Act; and
- House Bill 12-1032, Continue Forest Restoration Program.

The Colorado Water Conservation Board authorized funds for forest management projects implemented through HB07-1130, and the state's severance tax operation account provided funds for projects implemented by



▲ The CSFS Granby District provided technical assistance to the YMCA's Snow Mountain Ranch to implement a 50-acre fuelbreak to reduce wildfire risk; the project is part of a larger forest stewardship plan that was developed for the ranch. Photo: Bill Cotton, Colorado State University



▲ The Jefferson County Office of Emergency Management, in collaboration with the CSFS Golden District and the Jefferson Conservation District, cleared 20 acres of Gambel oak in the West Ranch subdivision to reduce hazardous fuels. Photo: Bill Cotton, Colorado State University

legislation passed in subsequent years. To date, more than \$5.5 million in state funds, along with \$1 million in leveraged federal funds and \$7.3 million in matching funds, have resulted in 13,000 acres of forest restoration. An additional 31 projects currently in progress will result in treatment on 2,800 acres.

## Wildfire Risk Reduction Grant Program Focuses on Lowering Risk

In 2013, the Colorado General Assembly passed Senate Bill 13-269, which created a new Wildfire Risk Reduction Grant Program to be administered by the Colorado Department of Natural Resources (DNR), Executive Director's Office. The program is being funded with \$9.8 million of general fund dollars, and is designed to reduce wildfire risk in the wildland-urban interface (WUI) throughout the state.

Two types of projects are funded through this competitive grant program:

- Fuels treatment projects located in Colorado that strategically reduce the potential risk for damage to property, infrastructure, water supplies and other high-value assets as a result of wildfire, and/or limit the probability of wildfires spreading into populated areas.

- Projects that address unmet needs for implementation capacity at the local level through the purchase of equipment. Implementation capacity grants are limited to 25 percent of the total available grant funds.

All applicants are required to contribute at least 100 percent in matching funds, which may include in-kind sources. Additionally, projects include utilization plans for the woody material generated during project implementation. In this way, the grant program reduces wildfire risk to homes and communities in high-risk zones, while simultaneously supplying wood, creating jobs and providing opportunities for new forestry businesses.

Monitoring also is an important component of this grant program. The Colorado Forest Restoration Institute at Colorado State University is partnering with DNR to conduct a study that will monitor project implementation and assess effectiveness.

The 2013 grant cycle funded 25 projects in 16 counties to treat more than 6,600 acres in WUI areas. The remaining funds (approximately \$5.8 million) will be granted in the 2014 grant cycle. All grant funds are being used to treat non-federal lands within Colorado.

## Bioenergy Alliance Network of the Rockies Studies Use of Beetle-Kill Trees for Energy

Bark beetle infestations over the past decade have left behind millions of dead trees in Colorado's coniferous forests. The timber represents a vast potential bioenergy resource, but barriers have prevented widespread use of the wood as a fuel source – including the low cost of fossil fuels, such as natural gas and coal, and the costs associated with removal and transport of forest products to markets.

---

*"This innovative research will help take the biomass that results from bark beetle infestation and create clean, renewable energy."*

Agriculture Secretary Tom Vilsack, referring to efforts of the alliance

---

The Bioenergy Alliance Network of the Rockies is a Western-states consortium recently formed to study the primary challenges limiting the use of beetle-kill trees for bioenergy feedstock (any renewable, biological material that can be used directly as a fuel, or converted to another form of fuel or energy product). This effort will support the nation's goal to reduce dependence on foreign oil and increase energy security through the production of regionally appropriate, sustainable bioenergy. The network will help identify ways to surmount barriers to using beetle-kill wood as biofuel by overcoming inefficiencies in bringing raw wood from remote, rugged landscapes to urban industrial centers, and the social and ecological hurdles related to tree removal on impacted landscapes.

Using beetle-kill wood for renewable energy offers benefits over other biofuels, because it requires no cultivation, has no food-versus-fuel concerns for the land





▲ Due to the loss of vegetation after the High Park Fire in Larimer County, heavy rains caused extensive sediment and debris flow into streams and rivers in the burn area. Photo: Tony Simons, Larimer County Emergency Services

it occupies and offers an incentive for removing dense stands of dead timber from the landscape.

In November 2013, the U.S. Department of Agriculture awarded nearly \$10 million over five years to the consortium of academic, industry and government groups. Members of the alliance include Colorado State University (and the university's Natural Resources Ecology Laboratory), Colorado State Forest Service, U.S. Forest Service Rocky Mountain Research Station and industry partner Cool Planet Energy Systems, as well as several out-of-state universities in the northern Rockies. Cool Planet, which recently announced the relocation of its company headquarters to Colorado, will be evaluating its lower capital cost modular conversion facilities to support the conversion of beetle-kill feedstock into conventional transportation fuels.

## Colorado-Big Thompson Headwaters Partnership Protects Northern Colorado Water Supplies

Healthy forests regulate runoff, control soil erosion, and filter rain and snow, delivering clean water for municipal and agricultural use. When forest health declines, so does the quality and quantity of the water yield flowing through and from those forests. Active forest management can help protect water supplies and decrease sedimentation in reservoirs, largely by preventing excessive runoff and erosion in the aftermath of wildfires.

In northern Colorado, the Colorado-Big Thompson Headwaters Partnership is demonstrating how the collaborative efforts of state, federal, local and private organizations can work together, across property lines, to ensure healthy forests and protect shared water resources. Members include the Northern Colorado Water

Conservancy District, Colorado State Forest Service, USDA Forest Service and U.S. Department of the Interior – Bureau of Reclamation, who are working together to proactively improve the health of forested watersheds in areas that provide critical water supplies and hydroelectric power to northern Colorado communities.

---

*“This partnership can serve as a model for the West... to protect our critical water supplies.”*

Interior Secretary Sally Jewell,  
referring to the Colorado-Big  
Thompson Headwaters Partnership

---

The partnership focuses on the headwaters of the Colorado and Big Thompson rivers in Northern Colorado, where the Bureau of Reclamation's Colorado-Big Thompson water diversion, storage and delivery project supplies water for more than 650,000 acres of agricultural land and approximately 860,000 people in eight counties.

This partnership has brought national attention to the importance of watershed health. At a July 2013 ceremony near Fort Collins, the Colorado-Big Thompson Headwaters Partnership was featured as the first of six pilot programs in the Western Watershed Enhancement Partnership. The purpose of this regional effort is to restore forest and watershed health, and plan for post-wildfire response to protect water supplies, hydroelectric power generation and related infrastructure. At the ceremony, Secretary of Agriculture Tom Vilsack and Secretary of Interior Sally Jewell signed a memorandum of understanding to guide interagency efforts.

## Fire Adapted Community Education Promotes Homeowner Action

As more homes are built in or adjacent to forests, more people are at risk of being impacted by a wildfire. Currently, more than 1 million Coloradans live in the wildland-urban interface (WUI), the area where human development meets or intermingles with forests, shrublands or other wildland vegetation at risk to wildfires. Currently, 80 percent of Colorado's WUI is still undeveloped, and growth in these areas of Colorado is expected to increase significantly by 2030.

As the state lead for the Fire Adapted Communities program, the CSFS provides a variety of resources to proactively address risks in the WUI. These resources include

guidance in developing Community Wildfire Protection Plans (CWPPs); assistance in becoming a Firewise Community/USA®; and publications offering science-based guidelines on home construction, defensible space and fuels reduction to help landowners prioritize fire mitigation actions and give their homes the best chance of surviving a wildfire.

To date, Colorado has a total of 85 communities recognized by the National Fire Protection Association's Firewise Communities/USA® Program; 30 of these communities received this designation for the first time in 2013. The nearly 50,000 residents who live in these communities spent more than \$1.7 million in 2013 to reduce wildfire risk by creating defensible space, reducing hazardous fuels and informing their neighbors about the benefits of being Firewise.

In addition, Colorado currently has 211 CWPPs that are in various stages of implementation. This number continues to grow as communities understand and embrace the benefits of planning to reduce wildfire risk. CWPPs foster collaboration among communities and state, county and federal partners; local fire departments; and other stakeholders. Although collaboration varies with each plan, at a minimum, communities are required to involve the CSFS, local government and the local fire authority.

When communities develop a CWPP or receive Firewise Communities/USA® designation, they are making a long-term commitment to help protect their lives, their communities and the lives of firefighters from wildfires.

*“On behalf of the NoCo Rebuilding Network (NCRN), please accept our sincerest thanks for supporting the rebuilding efforts in the High Park Fire area. The booklets and informational packets you... provided altered the way many of us think about construction in the wildland-urban interface.”*

Phil Benstein, NoCo Rebuilding Network in reference to the CSFS *FireWise Construction: Site Design and Materials* publication



▲ The community of Windcliff, near Estes Park, received a 10-year Firewise Community/USA® award in 2013. Windcliff is an example of what a community can accomplish when residents work together to reduce the risk of wildfire. Photo: Katherine Timm Schaubert, CSFS



## Front Range Fuels Treatment Partnership Accomplishes Nearly 300,000 Acres of Hazardous Fuels Reduction

The idea for the Front Range Fuels Treatment Partnership (FRFTP) was conceived in the fall of 2002, following what was then a record fire season. In July 2003, the USDA Forest Service, Bureau of Land Management, National Park Service and Colorado State Forest Service unveiled *The Front Range Fuels Treatment Partnership – A Strategy to Reduce Wildland Fire Risks through Sustained Fuels Treatment along the Colorado Front Range*. The rapid assessment used to develop the strategy revealed that approximately 510,000 acres of land were a high priority for treatment – 440,000 acres on federal land and 70,000 acres on non-federal land.

Representing the partnership are the Arapaho and Roosevelt National Forests, Pike and San Isabel National Forests, Colorado State Forest Service, Rocky Mountain Research Station and Rocky Mountain National Park. Ten counties are included in the partnership: Boulder, Clear Creek, Douglas, El Paso, Gilpin, Grand, Jefferson, Larimer, Park and Teller.



▲ Thinning trees to reduce hazardous fuels in the Pine Glenn subdivision kept the Black Forest Fire on the ground and spared some of the homes. Photo: Bill Cotton, Colorado State University

As of January 2013, FRFTP agencies had treated a total of 291,990 acres of federal and non-federal forestland, and are committed to continuing their efforts to implement fuels treatment projects in areas determined to be most at risk to catastrophic wildfire. Underlying the success of the FRFTP is active forest management on a cross-boundary, landscape scale, which helps make Colorado's Front Range forests more

resilient to catastrophic wildfires, and insect and disease outbreaks. This requires a shared vision and the wisdom to learn from the past, while looking to the future.

Complementing the efforts of the FRFTP is the Front Range Roundtable, whose mission is to serve “as a focal point for diverse stakeholder input into efforts to reduce wildland fire risks and improve forest health through sustained fuels treatment along the Colorado Front Range.” The Roundtable is a coalition of individuals from state and federal agencies, local governments, environmental and conservation organizations, academic and scientific communities, and industry and user groups who are committed to forest health and fire risk reduction along Colorado's Front Range. Since 2006, nearly 440 people from 150 organizations have participated in the Front Range Roundtable.



▲ Thinning understory vegetation in the forest reduces competition between trees, making them more resilient to insects, diseases and wildfire. Photo: Bill Cotton, Colorado State University

## Colorado's Forests: Today's Challenges, Tomorrow's Opportunities

**Our forests are dynamic.** They have changed over thousands of years, and will continue to change in the future. Climate patterns, weather conditions, insects and disease, and wildfires all play a role. Active forest management also plays an increasingly important role in shaping the health and condition of our forests, particularly on forestlands most impacted by society. Forest management helps protect people, property and watersheds, and having an active wood products industry is vital in supporting these efforts.

**Our trees will outlive us.** Forests mature over decades, even centuries, so it's easy to take a shortsighted approach when making management decisions. Forest management is not a short-term solution – it is a long-term investment. The decisions we make

today will shape the forests of future generations. These decisions must take into account the long-term health of forest ecosystems, as well as the benefits that forests provide, from clean air and water to recreation, tourism and wood products.

**Our decisions matter.** As our forests age and become ever more crowded, competition for resources adds stress, contributing to large-scale insect and disease outbreaks, and increasing the risk of catastrophic wildfire. But current forest conditions also provide opportunities. Through active forest management, we can improve forest health, and in the process create jobs, provide biofuel for energy, reduce wildfire risks and supply forest products. But we must act before we face the next wildfire or insect outbreak. The most effective and cost-efficient way to reduce the impacts of future large-scale forest threats is to proactively address them, before they arrive, through active management.

**Our cooperation is essential.** Insects, wildfires and watersheds don't recognize

property boundaries, so it's critical for land managers and private landowners to work together to address forest management across federal, state and private lands. The Colorado State Forest Service assists private landowners to be stewards of their own lands and achieve multiple forest management objectives.

**Our decisions today will dictate the forests of tomorrow.** This report summarized both the challenges we face in addressing forest health concerns, and the actions being taken to address them. We all share in the responsibility to achieve forest stewardship. As more people build homes in the wildland-urban interface, and as our forests continue to age and grow denser, we must take collective actions to reduce threats to human life, ecosystems, infrastructure and economies. The forest management decisions we make now will determine the outcome of Colorado's future forests. It is imperative that we make well-informed choices today as we shape the forests of tomorrow.

The mission of the Colorado State Forest Service is to  
“achieve stewardship of Colorado's diverse forest environments  
for the benefit of present and future generations.”

For more information, please visit the Colorado State  
Forest Service website at [www.csfs.colostate.edu](http://www.csfs.colostate.edu).



▲ Mike Hughes, a CSFS forester on the Fort Collins District, and his son plant trees in the High Park Fire burn area during a volunteer event; planting seedlings in burn areas helps prevent soil erosion and runoff into rivers and streams. Photo: Ryan Lockwood, CSFS



▲ Forest management is essential to Colorado's iconic forests and mountains; skiing and other winter sports contribute over \$2 billion dollars annually to the state's economy. Photo: Monarch/CSC USA



▲ Colorado's forests provide habitat for a variety of wildlife species, including mule deer. Photo: Bill Cotton, Colorado State University



# References and Further Reading

Burakowski E., Magnusson M. 2012. Climate Impacts on the Winter Tourism Economy in the United States. Protect Our Winters and Natural Resources Defense Council. 36 pp.

Ciesla W.M. 2013. Aerial Forest Health Survey: Portions of Colorado – 2013. Report submitted to the Colorado State Forest Service, August 2013, 26 pp.

Colorado Department of Agriculture. 2013. Emerald Ash Borer. [www.eabcolorado.com](http://www.eabcolorado.com) (accessed 19 December 2013).

Colorado Department of Agriculture. 2013. Prevention and Response Plans to Address Invasive Species Attacks on Urban Forests in Colorado. 18 pp.

Colorado State Forest Service. 2010. Colorado Statewide Forest Resource Assessment: A Foundation for Strategic Discussion and Implementation of Forest Management in Colorado. 90 pp.

Colorado State Forest Service. 2010. Colorado Statewide Forest Resource Strategy. 24 pp.

Colorado State Forest Service. 2013. Emerald Ash Borer Quick Guide (Draft). 6 pp.

Colorado State Forest Service. 2012. Report on the Health of Colorado's Forests. 34 pp.

Colorado Tree Coalition. 2013. Why Plant a Tree? <http://coloradotrees.org/why.php> (accessed 17 December 2013).

Lynch D.L. and K. Mackes. 2001. Wood Use in Colorado at the Turn of the Twenty-First Century. Rocky Mountain Research Station, Research Paper RMRS-RP-32, 23 pp.

McPherson E.G., Q. Xiao, C. Wu and J. Bartens. 2013. Metro Denver Urban Forest Assessment. Final report, 28 March 2013, 89 pp.

McPherson G., J.R. Simpson, P.J. Peper, S.E. Maco and Q. Xiao. 2005. Municipal Forest Benefits and Costs in Five U.S. Cities. Journal of Forestry, December 2005, 411-416 pp.

Northern Colorado Water Conservancy District. 2013. The Colorado-Big Thompson Project: Historical, Logistical and Political Aspects of this Pioneering Water-Delivery System. Northern Water. 24 pp.

Rasker, Ray. 2013. Wildfire. Headwaters Economics. Slide 10. (PowerPoint presentation dated 11 September 2013.)

USDA Forest Service. 2013. 2012 Resources Planning Act (RPA) Assessment (Draft). Forest Inventory and Analysis National Program. Washington, D.C. <http://www.fia.fs.fed.us> (accessed 19 December 2013).

USDA Forest Service, Michigan State University, Purdue University and Ohio State University. 2013. <http://emeraldashborer.info> (accessed 17 December 2013).

USDA Office of Communications. 2013. USDA and Interior Announce Partnership to Protect America's Water Supply from Increased Wildfire Risk. USDA Forest Service, News Release No. 0147.13, 19 July 2013.

USDA Office of Communications. 2013. USDA Invests in Research to Convert Beetle-Killed Trees into Renewable Energy. USDA Forest Service, News Release No. 0206.13, 6 November 2013.

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Bioenergy Technologies Office. 2013. [http://www1.eere.energy.gov/bioenergy/biomass\\_feedstocks.html](http://www1.eere.energy.gov/bioenergy/biomass_feedstocks.html) (accessed 7 January 2014).

► World-class fishing is one of the many recreational opportunities Colorado's forests provide. Photo: CSFS









Division of Forestry  
1313 Sherman Street, Room 718  
Denver, Colorado 80203  
(303) 866-3311  
[www.dnr.state.co.us](http://www.dnr.state.co.us)



Colorado State University  
5060 Campus Delivery  
Fort Collins, CO 80523-5060  
(970) 491-6303  
[www.csfs.colostate.edu](http://www.csfs.colostate.edu)



WARNER COLLEGE OF  
Natural Resources  
1401 Campus Delivery  
Fort Collins, CO 80523-1401  
(970) 491-4994  
[www.warnercnr.colostate.edu](http://www.warnercnr.colostate.edu)