2014 State of the Forest Report

for Colorado's Roaring Fork Watershed

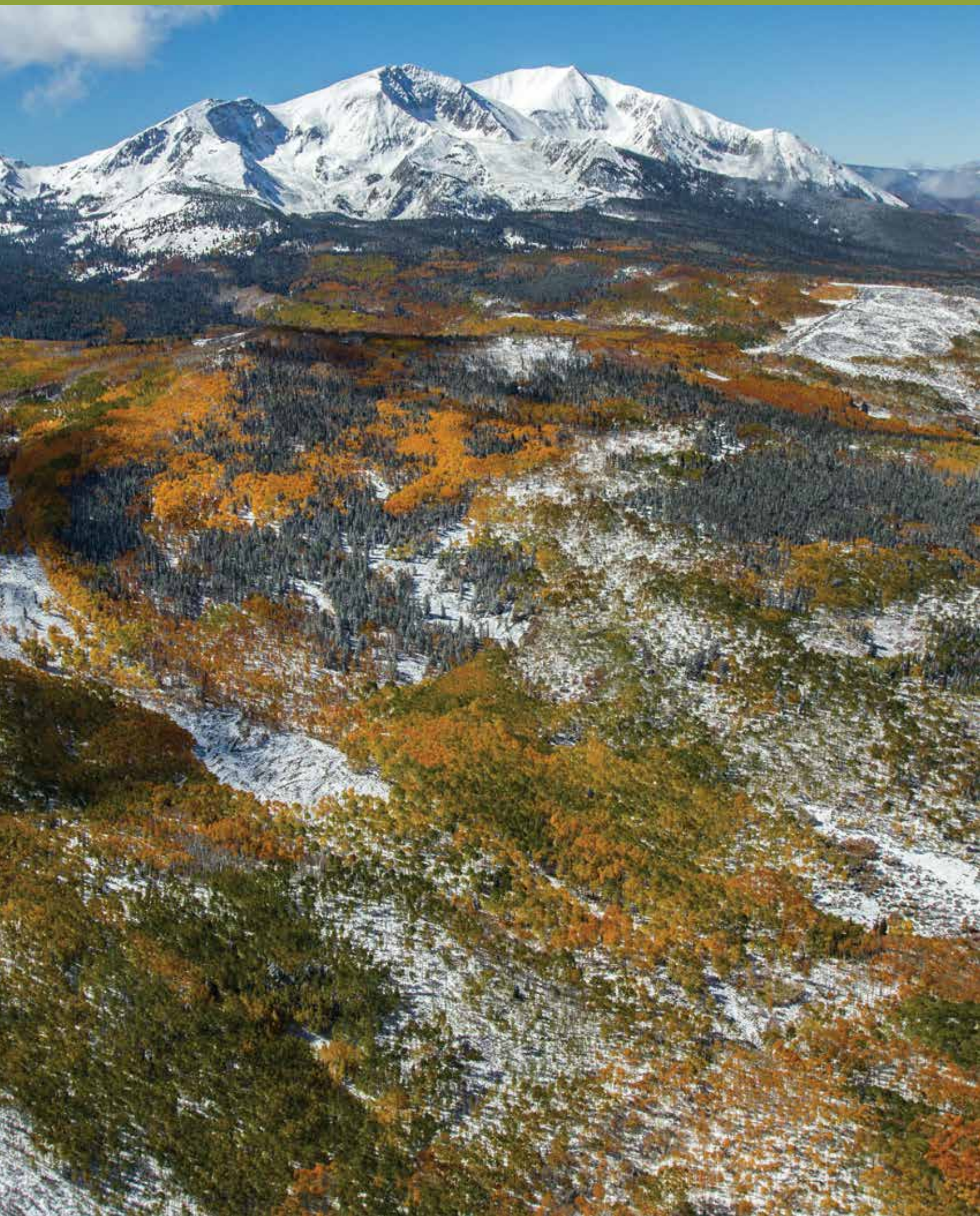

Photo: Jonny Kloberdanz

OUR FORESTS IN THE ERA OF CLIMATE CHANGE

Most of us take for granted how important forests are to our survival. In the 80's, pop icons like Sting and Bono shouted from the rooftops, "Save the world's rainforests, our planet's lungs!" Not since the battles with loggers over the spotted owl have western forest issues moved into the public's top tier of environmental priorities.

But in this new era of climate change, society is finally realizing that forests provide a variety of ecosystem services critical to our well-being. Whether it be more esoteric services such as nutrient cycling, climate regulation, erosion control, soil formation and water regulation or the more overt services such as provision of raw materials, food, and recreation, forests are an ecological foundation for plant, animal and human lives.

Nationally, forests have experienced unprecedented change in the last few decades. Natural climate variability, global climate change, and local human activities within and at the margins of the forest are playing a part in this. Change has already come in the form of tree mortality and insect outbreaks, stand age and composition, and larger and more intense wildfires. More development continues to enter the Wildland Urban Interface (WUI) - where human structures intermingle with forest ecosystems. Each year, up to 70,000 wildfires ravage millions of acres, burn thousands of homes, and cost dozens of lives.

More dramatic changes will likely take place as the climate change projected for the 21st century unfolds. Adequately understanding and responding to these changes will be a critical challenge for conservation and resource management in the coming decades.

In Colorado, warmer and drier conditions brought on by climate change have sustained unprecedented insect and disease infestations in our conifer forests. The mountain pine beetle epidemic that has exceeded anything in the state's recorded history is finally declining because the beetles have consumed most of their food – ponderosa and lodgepole pine trees. However, we now have new bark beetle epidemic – the spruce beetle. Last year, the acreage impacted by the spruce beetle surpassed that of the mountain pine beetle.

Here in the Roaring Fork Watershed, our forests are the engine that drives our tourism-based economy. Now is the time for a resurgence of action to promote and protect the health and resiliency of our forests.

This State of the Forest report is a sort of "report card" on our valley's ecosystem health. It examines trends in climatic variables and insect and disease infestations, and explains what citizens and land managers can do to be a part of the solution. In this report we also introduce the Forest Health Index, which provides comparative analysis of current and past conditions of our local forest. It is our hope that this report and the Forest Health Index will generate discussion and help inform adaptive management efforts to create, among other things, greater forest resiliency, improved wildlife habitat and reduced wildfire danger in our valley.

We hope these efforts will help inform policy that promotes managing for healthy forests by federal, state and local governments as well as NGOs and private citizens living in and around the WUI. While some forests should be protected and left alone, managing for healthy forests in the WUI will promote clean air, clean water, protection of wildlife habitat, enhancement of recreational opportunities, reduced risk of wildfire, and improved local economies.

Hopefully, this combination of protection and management will ensure that our forests provide ecological and human benefits for generations to come. Sting and Bono would be proud!

Chris Lane,
CEO
Aspen Center for Environmental Studies

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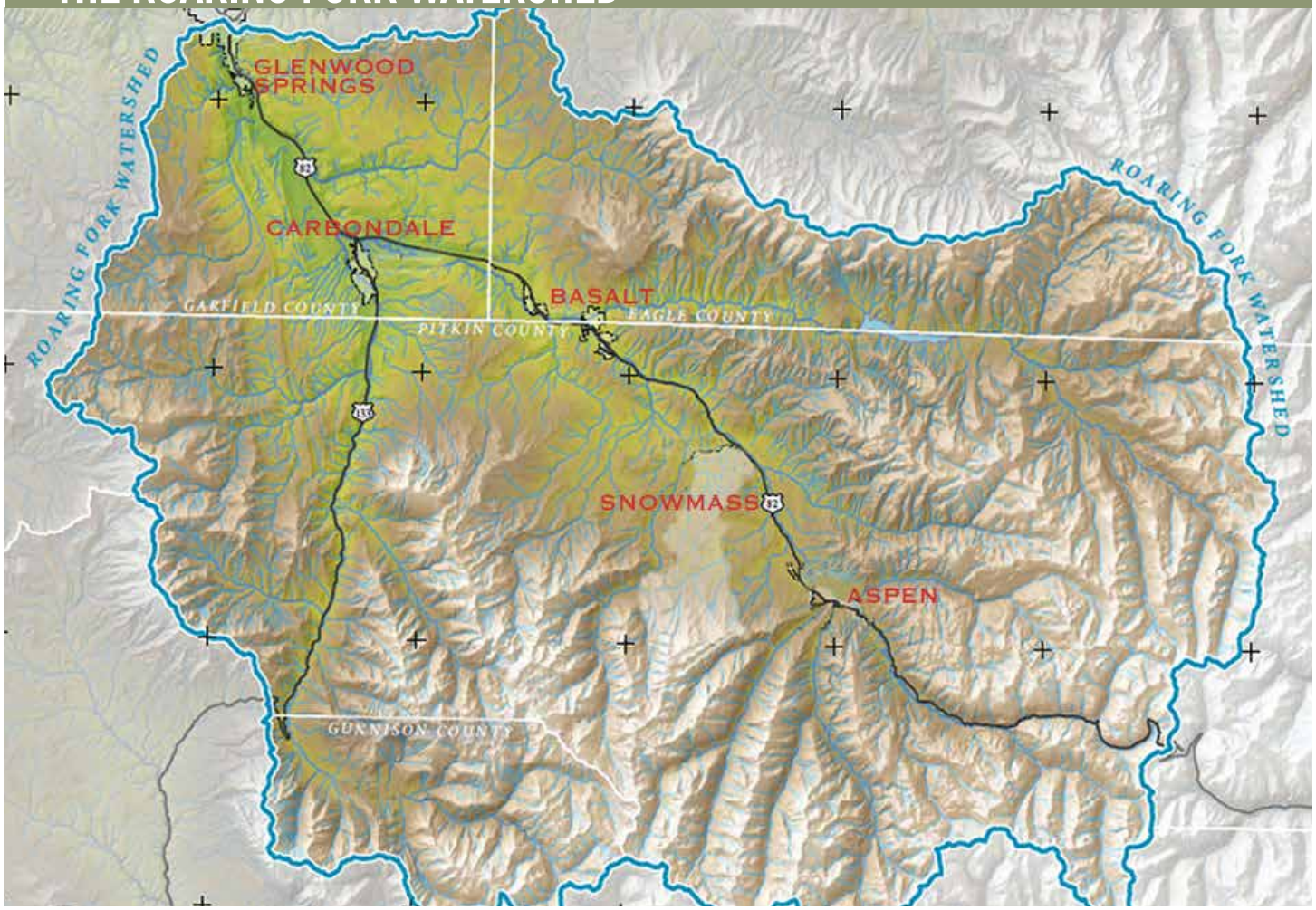
Cover: Colorado aspen groves, pictured here in the fall, spring from vast networks of interconnected root systems. Groves of genetically indentical aspen trees make up some of the largest and longest living organisms on the planet. Inside cover: A patchwork of forest types blankets the flanks of Mount Sopris. The diversity of forest types in the Roaring Fork Watershed helps make our local forest more resilient to insect and disease infestations.

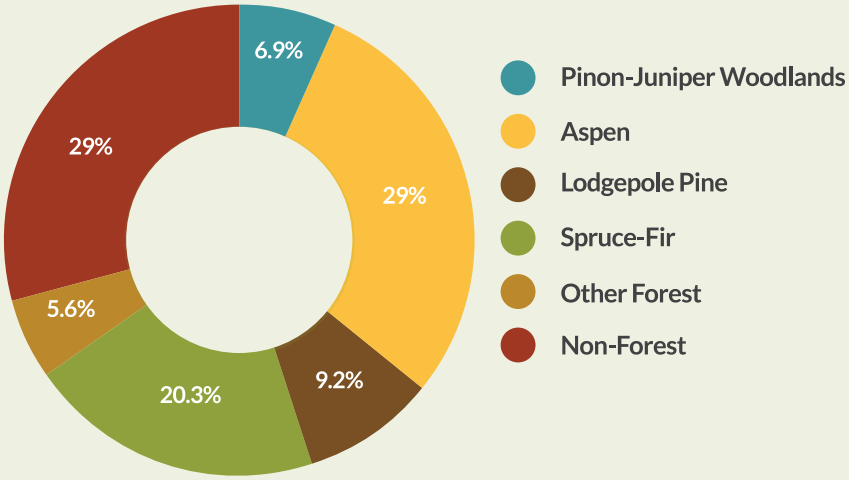
The Roaring Fork Watershed comprises a sweep of elevations ranging from 5,700 feet at the confluence of the Roaring Fork and Colorado Rivers at Glenwood Springs to the alpine heights of the 14,000-foot peaks capping the upper reaches of the valley. Across this gain of over 8,000 feet in elevation, habitats include diverse sets of riparian and wetland ecosystems, mountain shrubland, and upland life zones from montane to sub-alpine and alpine conditions.

THE ROARING FORK WATERSHED



FOREST LAND COVER IN THE ROARING FORK VALLEY

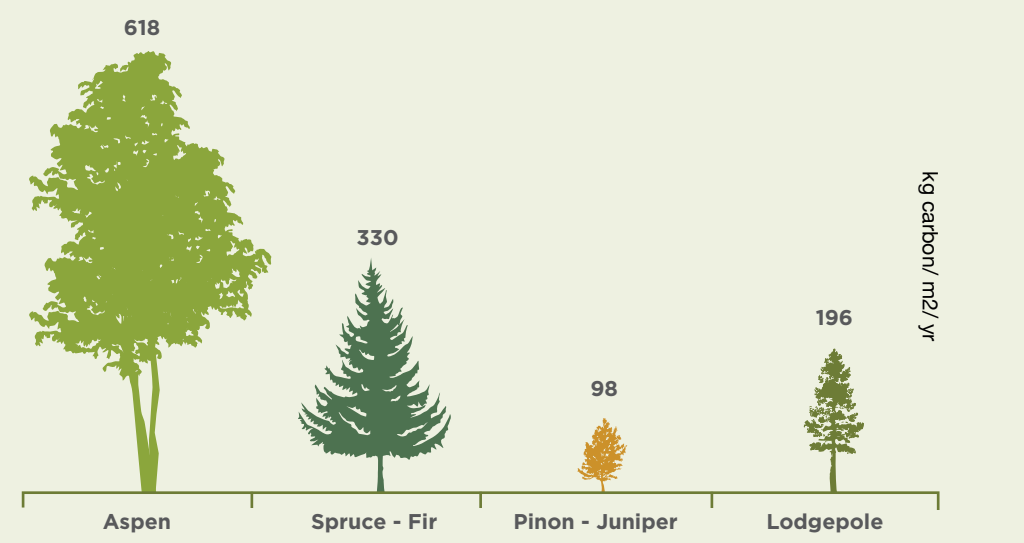
This great diversity of terrain, 69% of which is public land or conservation easement, supports a wide variety of plant and animal species. When broken down into land cover types, it's clear that no single forest type dominates our watershed—an asset that provides critical resiliency against specialized insects and diseases such as the spruce beetle.



FOREST PRODUCTIVITY

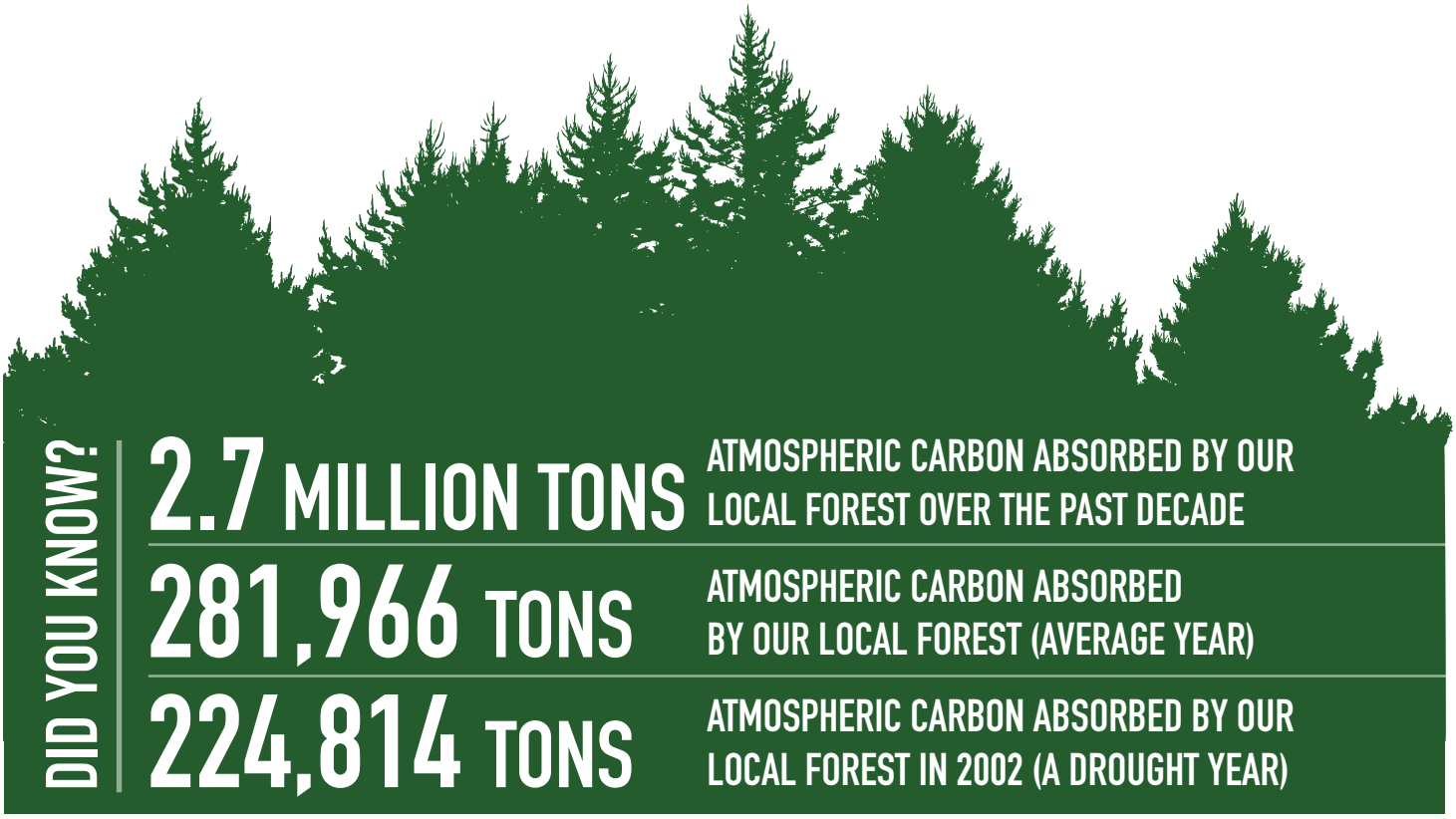
Forest productivity, the level of photosynthetic activity of vegetation in the forest each year, is a fundamental metric of forest vigor. Productivity is measured as "net primary production": the total carbon captured through photosynthesis by a forest minus the amount utilized by respiration. Data derived form NASA satellites shows a slight decline in forest productivity over the past five years. However, this decline is well within the range of typical variability and at this point no clear departure in productivity beyond normal is evident. Annual variability in forest productivity is especially apparent during drought years such as 2002, during which significant declines in productivity are observed in the data record.

AVERAGE ANNUAL NET PRIMARY PRODUCTIVITY
FOR ROARING FORK WATERSHED FOREST TYPES



Net Primary Productivity measures the rate that plants pull carbon from the atmosphere per unit time — or how rapidly they perform photosynthesis.

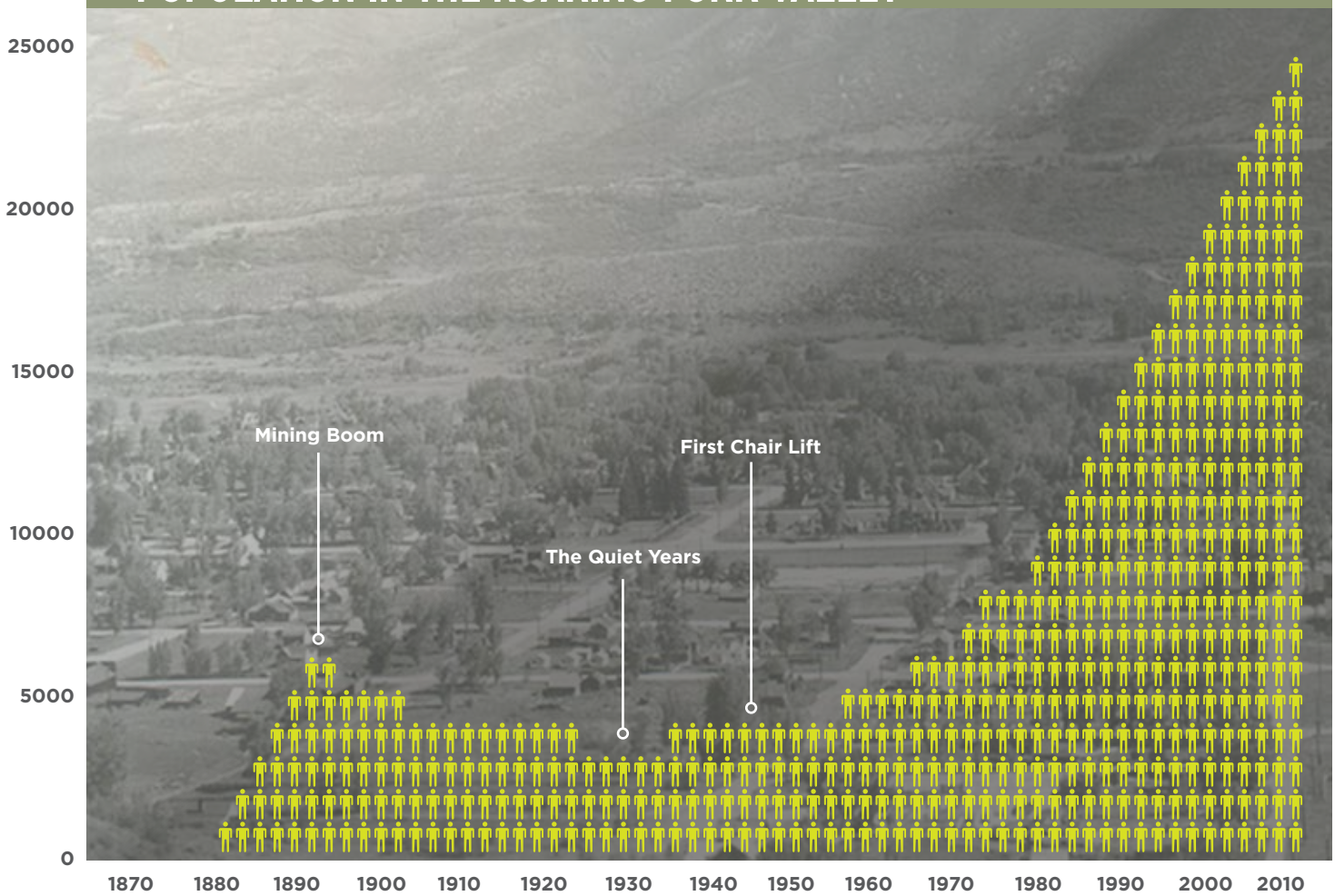
Healthy forests scrub carbon from the atmosphere — yet another critical ecosystem service provided by our local forest.

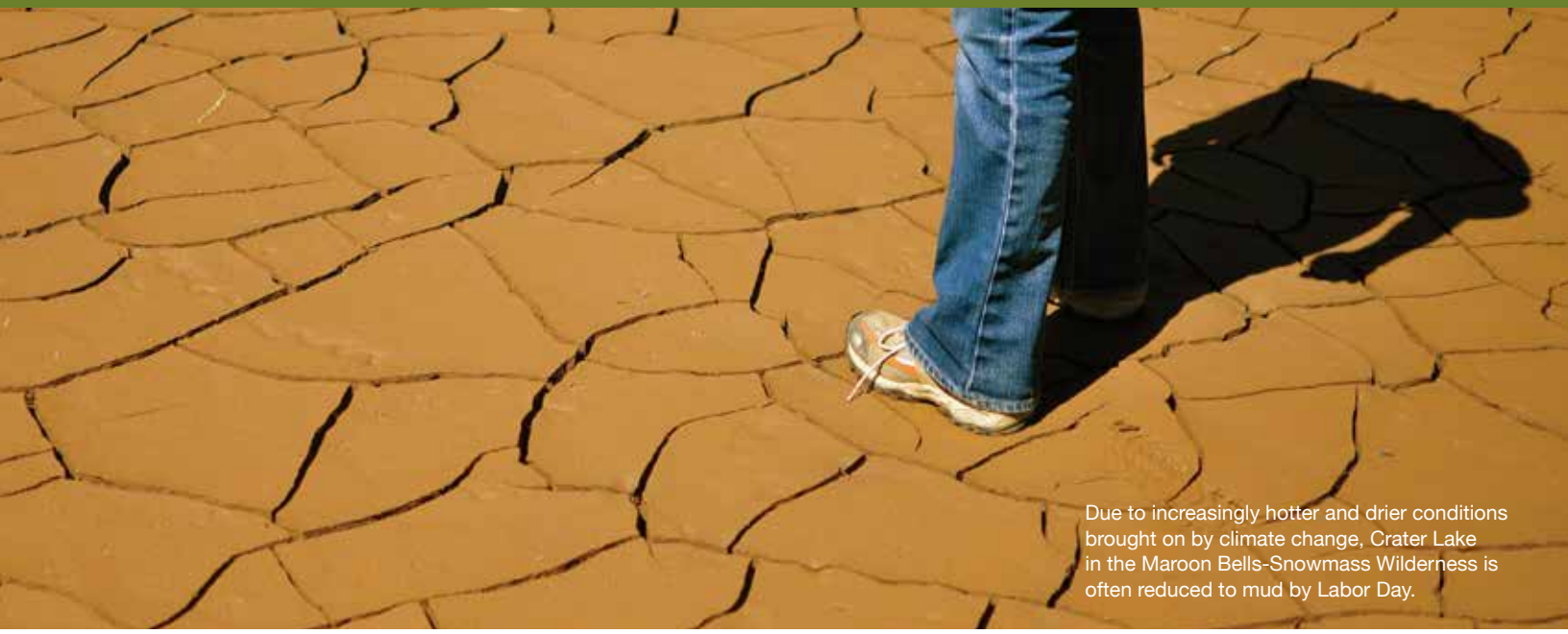


POPULATION

Coincident with the rise of the Roaring Fork Valley's prominence as a recreational and cultural destination in the late 20th century is a significant increase in the human population of our watershed. With this dramatic increase comes added pressure on our forest ecosystems, from water consumption to recreational impact. The population capacity of our watershed provides a crucial point of context when considering sustainability objectives and the pressure placed on resource managers to balance recreational needs and forest management activities.

POPULATION IN THE ROARING FORK VALLEY

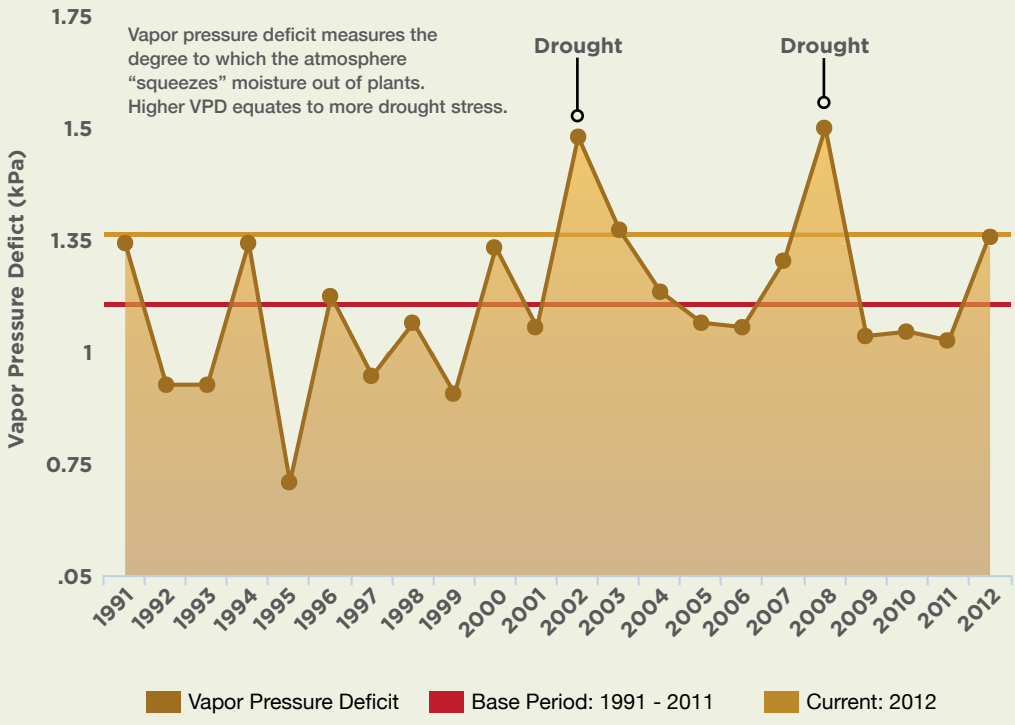




Due to increasingly hotter and drier conditions brought on by climate change, Crater Lake in the Maroon Bells-Snowmass Wilderness is often reduced to mud by Labor Day.

It is impossible to discuss the changing state of our forest without first addressing climate. Monitoring climatic variables such as temperature and precipitation, including the timing and extremities of certain events, provides a closer look at the root causes of many changes taking place in our forest. This section provides a brief introduction to several commonly monitored metrics of climate and details their potential impacts on Roaring Fork Watershed forests.

DROUGHT STRESS: MAY – AUGUST

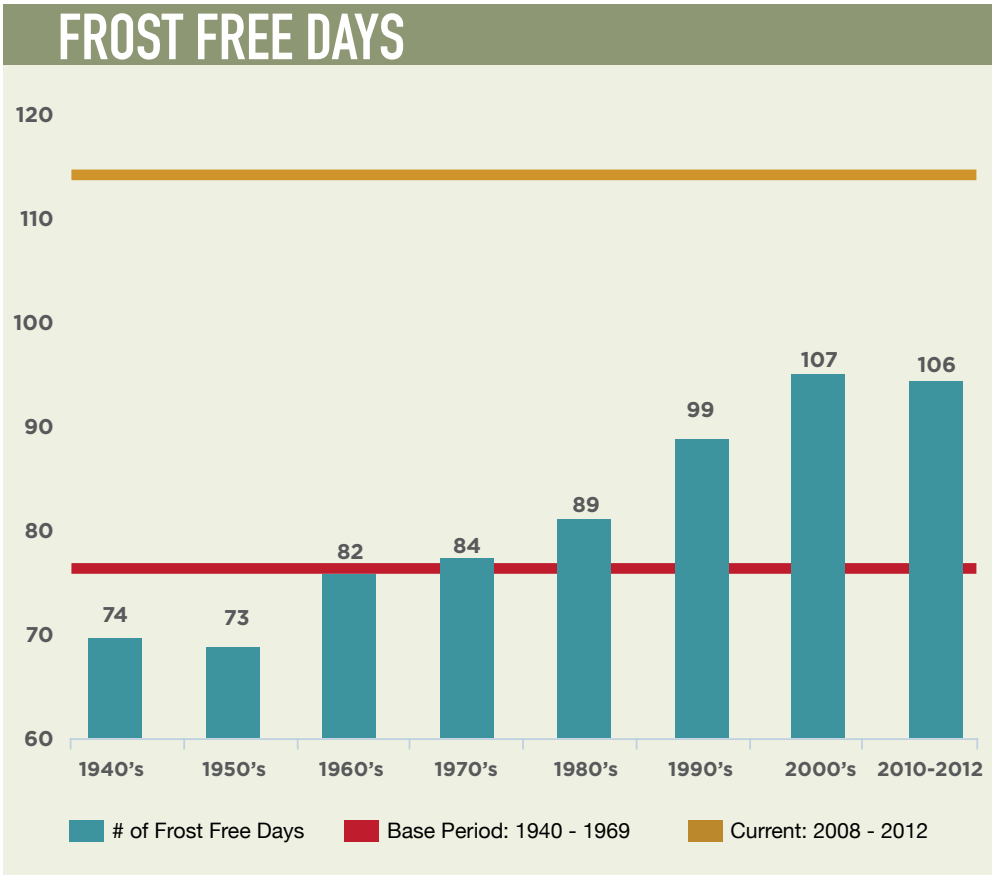


DROUGHT STRESS

Vapor pressure deficit (VPD) is the amount of moisture in the air at a given point in time relative to the potential moisture-holding capacity of the air. Increasing vapor pressure deficit translates to drier air and therefore more drought stress to vegetation. The last decade has seen an increasing trend in drought stress during the summer growing season with the highest vapor pressure deficit levels on record in 2002 and 2008.

In 2012, drought stress was 14% higher than average.

Vapor pressure deficit is an incredibly useful indicator of drought stress in forests. The amount of vapor pressure in the atmosphere indicates the amount of moisture "pushing down" on plants – more vapor pressure pushing down on plants means that plants will "push out" less moisture through transpiration. With a higher vapor pressure deficit, plants dry out and experience drought conditions. In a sense, vapor pressure deficit is a hidden force on plants and is an important metric to make sense of the conditions driving changes in vegetation over time.



FROST FREE DAYS

Frost-free days, a powerful metric of climate change with direct relevance to forest ecosystems, measures the length of a region's growing season. It can be a driver of change within ecosystems, affecting timing of budburst in various plants and trees, timing of water availability from snowmelt, and overall species composition in an area.

Technically speaking, frost-free days tallies the number of days between the last frost in the spring or early summer and the first frost in the late summer or early fall. Between 1940 and 1969, there were an average of 76 frost-free days per year in Aspen, a period of about two and a half months. The length has steadily increased, decade by decade, to an average of 113 days over the last five years, or just over three and a half months.

The number of frost-free days per year in Aspen has grown by more than a month since 1940.

The magnitude of change witnessed over the past 70 years increases the suitability of habitat for some species while reducing the suitability of habitat for others. Although this may be welcome news for local gardeners, we have yet to see the full scope of long-term impacts on the forest landscape and wildlife behavior.

Temperature driven enhancements to insect life cycles can lead to tree mortality, resulting in impacts to water quality, forest resource availability, and the aesthetic character of the forest.

EXTREME TEMPERATURES

Trends in extreme temperatures affect numerous services provided by our local forest ecosystem. For instance, temperature driven enhancements to insect life cycles can lead to tree mortality, resulting in impacts to water quality, forest resource availability, and the aesthetic character of the forest. Moderate high temperatures also help to regulate snowmelt, allowing for reliable water availability from snowpack steadily throughout the summer.

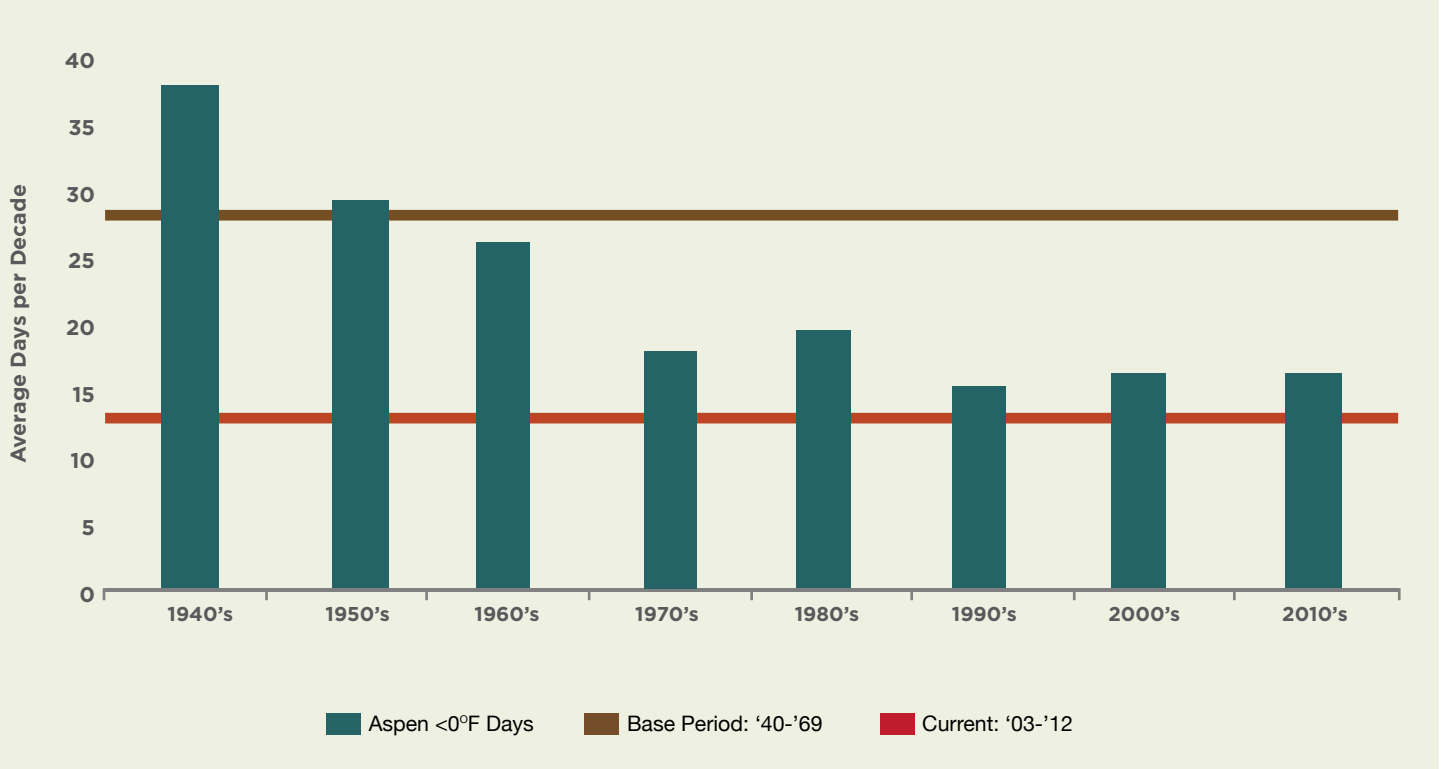
For the purpose of this report, any day in Glenwood Springs that reaches 95°F constitutes a high temperature day and any day that reaches below 10°F constitutes a low temperature day. For Aspen those thresholds are 85°F and 0°F, respectively.

Extreme high temperatures in the valley have not changed significantly in the last ten years, but if trends from recent decades in Aspen and Glenwood Springs continue, more high temperature days can be expected in coming years. For the forest, this has the potential to both increase fire risk and make fire outbreaks more difficult to fight. For human communities, this changes the character of the local environment and may lead to behavioral changes such as increasing use of air-conditioning.

For **extreme low temperatures**, however, a significant decline has been observed valley wide. In Aspen, the downward trend is particularly steep — the number of sub zero days has been reduced by more than half in the last decade compared with the average from 1940 to 1969. Glenwood Springs has seen a 20% decline in low temperature days. This trend could lead to changes in habitat suitability for native tree species and make some areas more prone to invasive species establishment.

The number of sub zero days in Aspen has been reduced by more than half in the last decade compared with the average from 1940 to 1960.

EXTREME LOW TEMPERATURES IN ASPEN



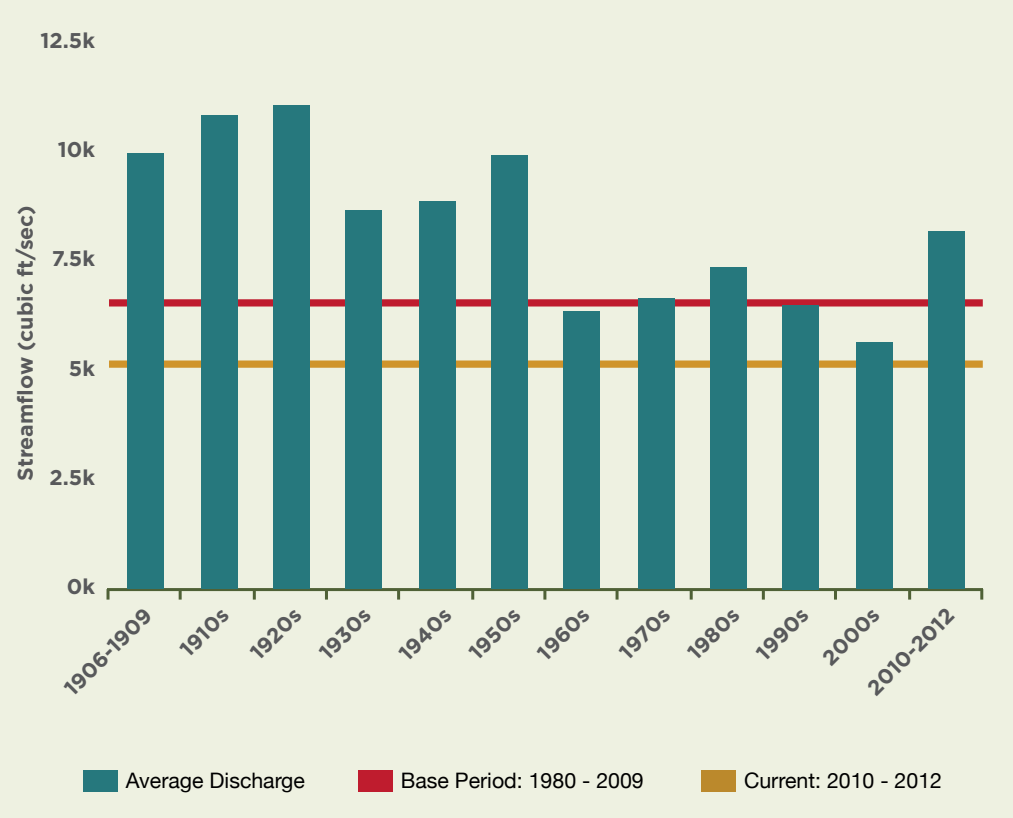
PRECIPITATION, SNOWPACK, & RUNOFF

The timing and quantity of rain and snow events and their associated runoff and melt times have profound consequences on our forest ecosystem. Long-term trends in annual precipitation, including both rainfall totals and the water equivalent of snowfall, have been documented by weather monitoring stations in Aspen since 1981. Average annual precipitation has decreased over the last decade compared with the past thirty years. However, this decrease is small relative to the year-to-year variability within that timeframe.

Photo: Jim Kravitz

Especially when coupled with diversions, lack of precipitation reduced Hunter Creek to a trickle in August 2012.

PEAK STREAMFLOW



Precipitation is the fundamental driver of hydrology within a watershed, and annual precipitation totals largely dictate conditions of forest ecosystem function—whether abundant moisture is available or drought conditions prevail. Lack of precipitation can also exacerbate drivers of disturbance such as water stress for vegetation, leading to greater chance of insect outbreaks and fire.

The decade from 2000 to 2009 had the lowest peak streamflow in the 100+ year record.

Peak streamflow measures the discharge (in cubic feet per second) of the Roaring Fork River during its time of peak runoff. With more than a century of data providing perspective, substantial and sustained changes to the hydrology of the Roaring Fork Watershed have been observed. Partially driving this change are the significant transbasin diversions put in place in the mid 1940s and late 1970s. However, when analyzed since 1981, additional declines in peak streamflow have occurred. In fact, the decade from 2000 to 2009 had the lowest peak streamflow in the 100+ year record.

The **timing of peak runoff**, the date each year when peak runoff occurs, is also important to monitor. This is typically a day in May or June when high elevation snowpack begins to melt in large quantities. A highly variable record of timing of peak runoff has been observed, even when looking at

decadal averages. However, in the past decade, peak runoff occurred two days earlier than average, and the decade from 2000 to 2009 was the second earliest decade of runoff on record.

In 2013, snowpack on April 1st was about 30% lower than the average snowpack from 1981 to 2013.

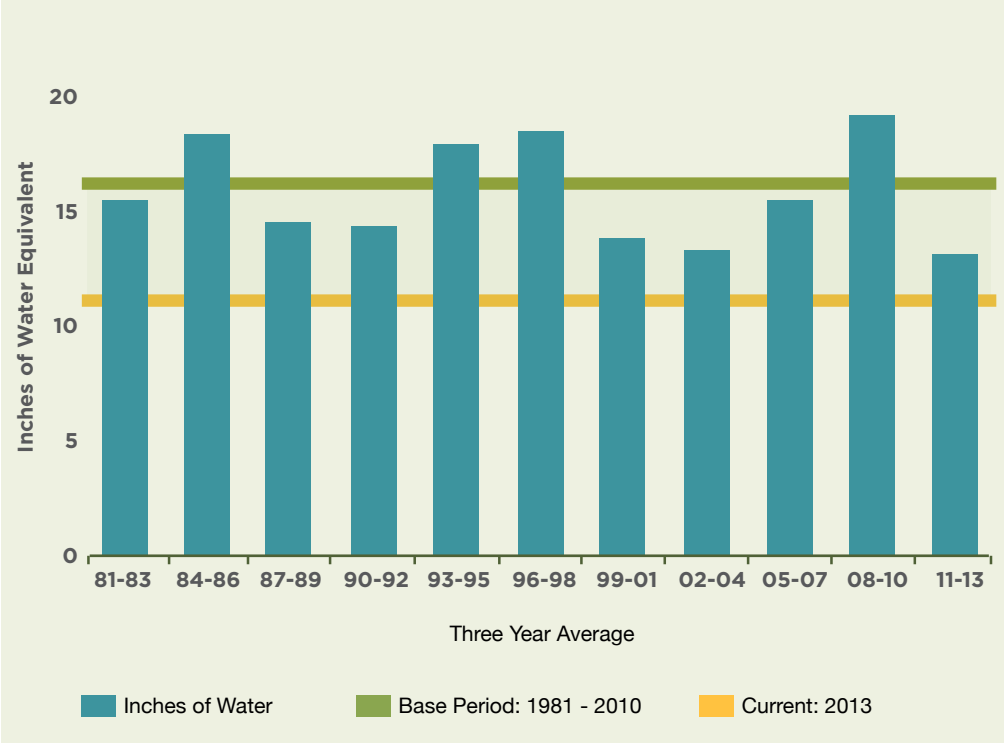
High elevation snowpack measures winter snow accumulation in terms of its water equivalent, or the amount of water that would result if the snow instantaneously melted. For this report, measurements were taken at a site near Independence Pass at 10,600 feet. In 2013, snowpack on April 1st was about 30% lower than the average snowpack from 1981 to 2013. Although one year of low snow accumulation does not imply a trend, just one low snow year can result in significant short and long-term impacts for downstream ecosystems and users of water.

These metrics are important indicators of stream health and water quantity. Robust peak flows rejuvenate riparian areas and recharge groundwater stores. Changes in the timing of peak runoff likely indicate alterations in winter and early spring temperatures as well as shifts in the quantity of water available in the form of snow at higher elevations. Such changes can have important implications for agricultural water use, water rights, recreational use, and dry season water availability.

Independence Pass, a popular scenic drive over the Continental Divide in Colorado, is the site of a snowpack monitoring station.

Flickr: Kent Kanouse /Creative Commons

HIGH ELEVATION SNOWPACK



The current Mountain Pine Beetle outbreak in Western North America is ten times bigger than any previous infestation, and climate change is a significant driver. Historically, insect and disease infestations in forests followed a set pattern: beetles existed at low levels for long periods of time, a trigger such as a warmer and drier climate would weaken trees' defenses and initiate an infestation, and eventually cooler and wetter temperatures would return, strengthen the trees' defenses, and the infestation would subside. However, based upon climate scientists' projections, cooler and wetter conditions are not expected to return to the North American West, and infestations are continuing to persist.

Since 1996, 15.1 million acres of Colorado forest have been impacted by insect and disease infestation to some extent with damage rates ranging from a few scattered trees to entire stands. The sight of brown trees interspersed with green ones has become commonplace with over a million acres of Colorado forest affected by insect and disease infestation in 2012 alone. Of that, 33,900 acres in the Roaring Fork Watershed sustained some level of insect and disease damage.

The effect of insect and disease infestation on the health of our local forest has been at the forefront of community concern and discussion for decades. While indigenous pests have long been understood to be a natural part of disturbance regimes within forests, the extensive and highly visible impact from recent insect and disease outbreaks has led to increased concern and monitoring of trends in infestation.

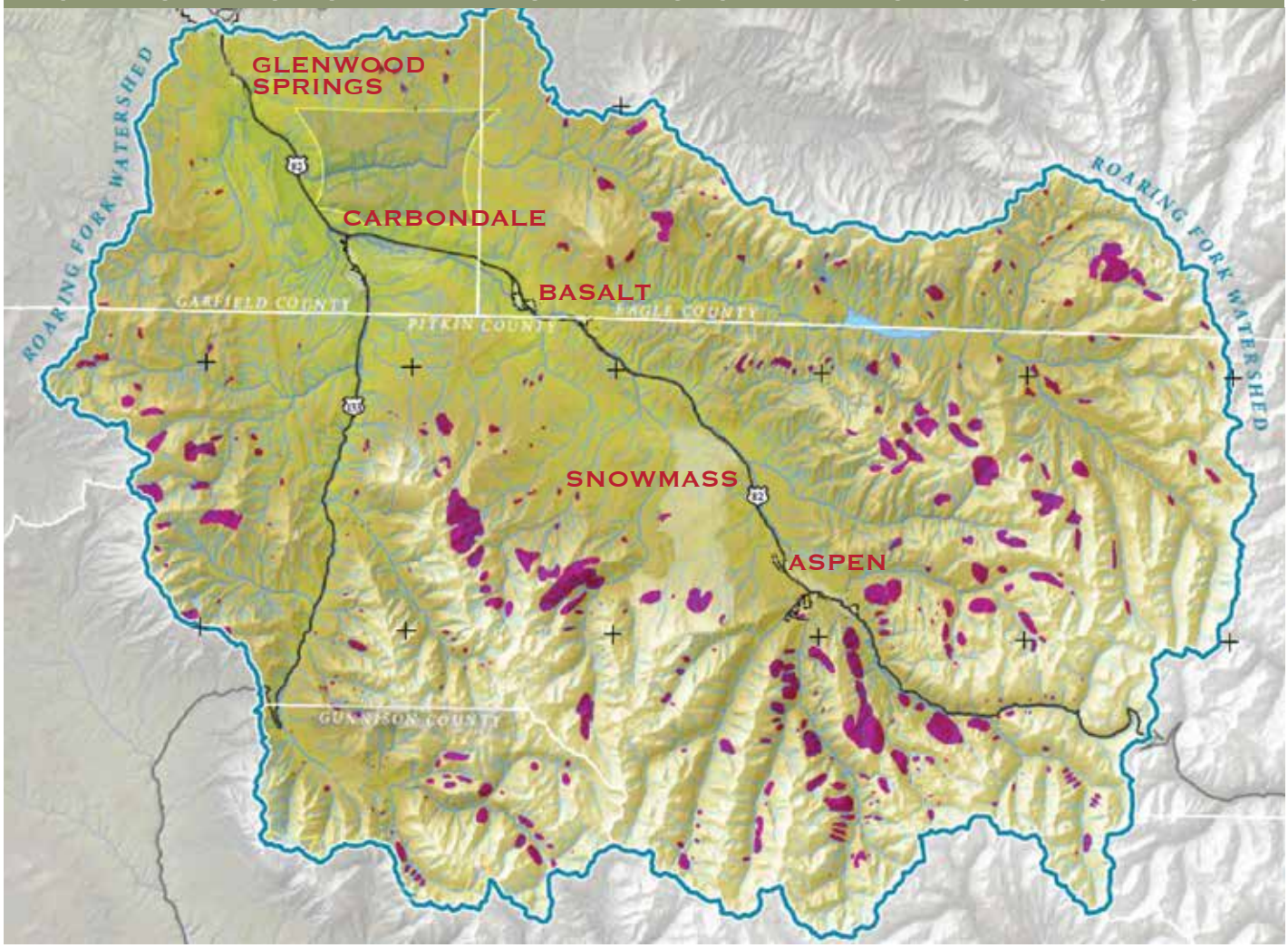
Under normal climatic conditions, bark beetles are a naturally occurring part of a forest ecosystem and can be an important disturbance agent.

Under the increasing temperatures and persistent drought conditions of the last several years, insect outbreaks are demonstrating extreme intensity, duration, and extent, resulting in a broad range of societal and ecological implications. Dead and dying trees from insect infestation can pose fire hazards and threaten water supplies as a result of increased erosion. Infested landscapes can also carry significant economic consequences for surrounding communities, such as decreases in tourist visits. From an ecological perspective, insect infestations can lead to abrupt changes in landscape composition with accompanying abrupt changes to fire ecology, hydrology, and species composition. Further understanding both the societal and ecological consequences of insect and disease outbreaks is a focus of much scientific research.

This section provides a brief introduction to the pests impacting Roaring Fork Watershed forests and goes on to detail their recent activity in our area.

15.1 MILLION ACRES OF COLORADO FOREST IMPACTED BY INSECT AND DISEASE INFESTATION SINCE 1996

2012 ROARING FORK WATERSHED INSECT AND DISEASE INFESTATION



Source: USFS Forest Inventory & Analysis

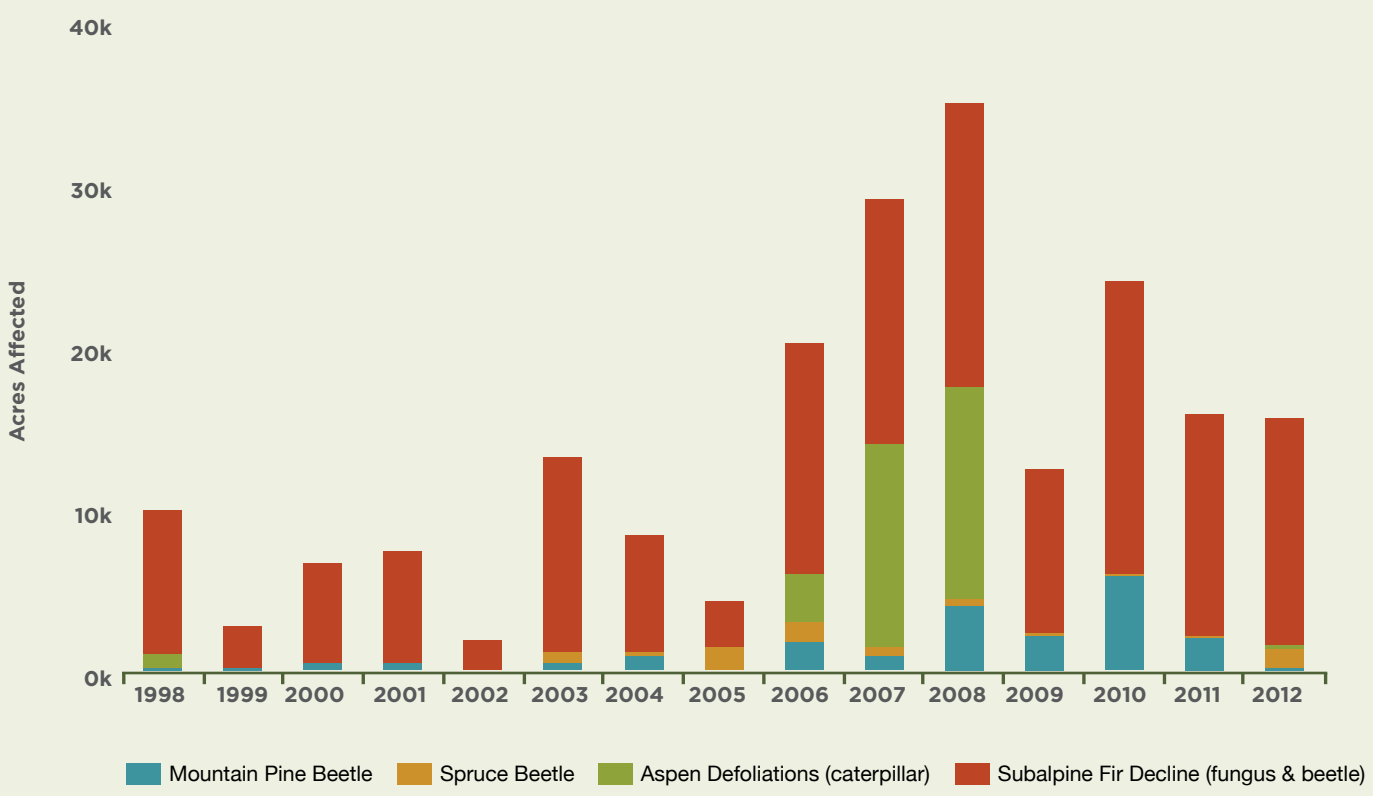
MOUNTAIN PINE BEETLE

Mountain pine beetle (*Dendroctonus ponderosae*), perhaps the most familiar of the pests currently impacting Colorado forests, is often incorrectly classified as an invasive species. On the contrary, mountain pine beetle (MPB) is native to not only our area, but also the forests of greater North America. This misconception stems from endemic versus epidemic levels of beetle activity. When present in endemic, or normal, levels, MPB plays an important role in forest disturbance and nutrient cycling regimes by opening up space for sunlight to reach the forest floor and for new trees to grow.

However, under the current climatic stresses of increased temperatures and drought stress, statewide populations of MPB shifted dramatically from endemic to epidemic levels in the late 1990s. Hotter and drier conditions brought about by climate change triggered a weakening of trees' natural defense systems. Trees naturally defend themselves against beetle invasions by using their sap to expel, or "pitch out" the beetles. Under normal (non-drought) conditions, trees that are already compromised in some way are the most susceptible to beetle infestation. However, under the increasingly dry conditions currently faced by Colorado's forests, there simply isn't enough moisture available for trees to produce enough sap to adequately "pitch out", or expel, beetles. This weakening of trees' defenses, coupled with milder winters that encourage beetle population growth, caused beetle populations to exponentially increase to a point where they were strong enough to kill even healthy trees.

While a tiny mountain pine beetle can't kill a healthy tree on it's own, large populations can launch a successful attack, especially if the tree has been weakened by drought stress.

ROARING FORK WATERSHED INSECT & DISEASE DAMAGE

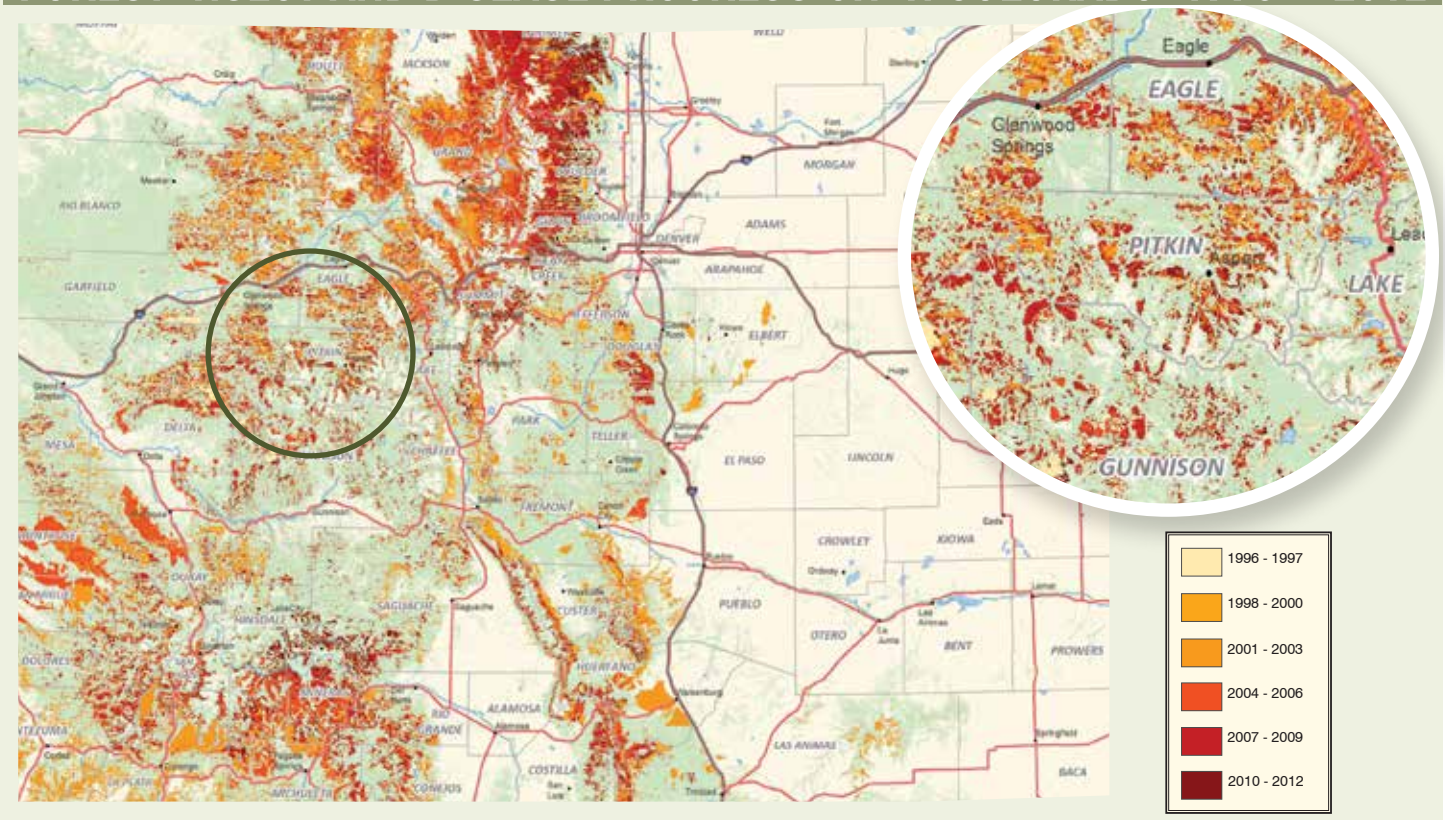


Photos: James Balog

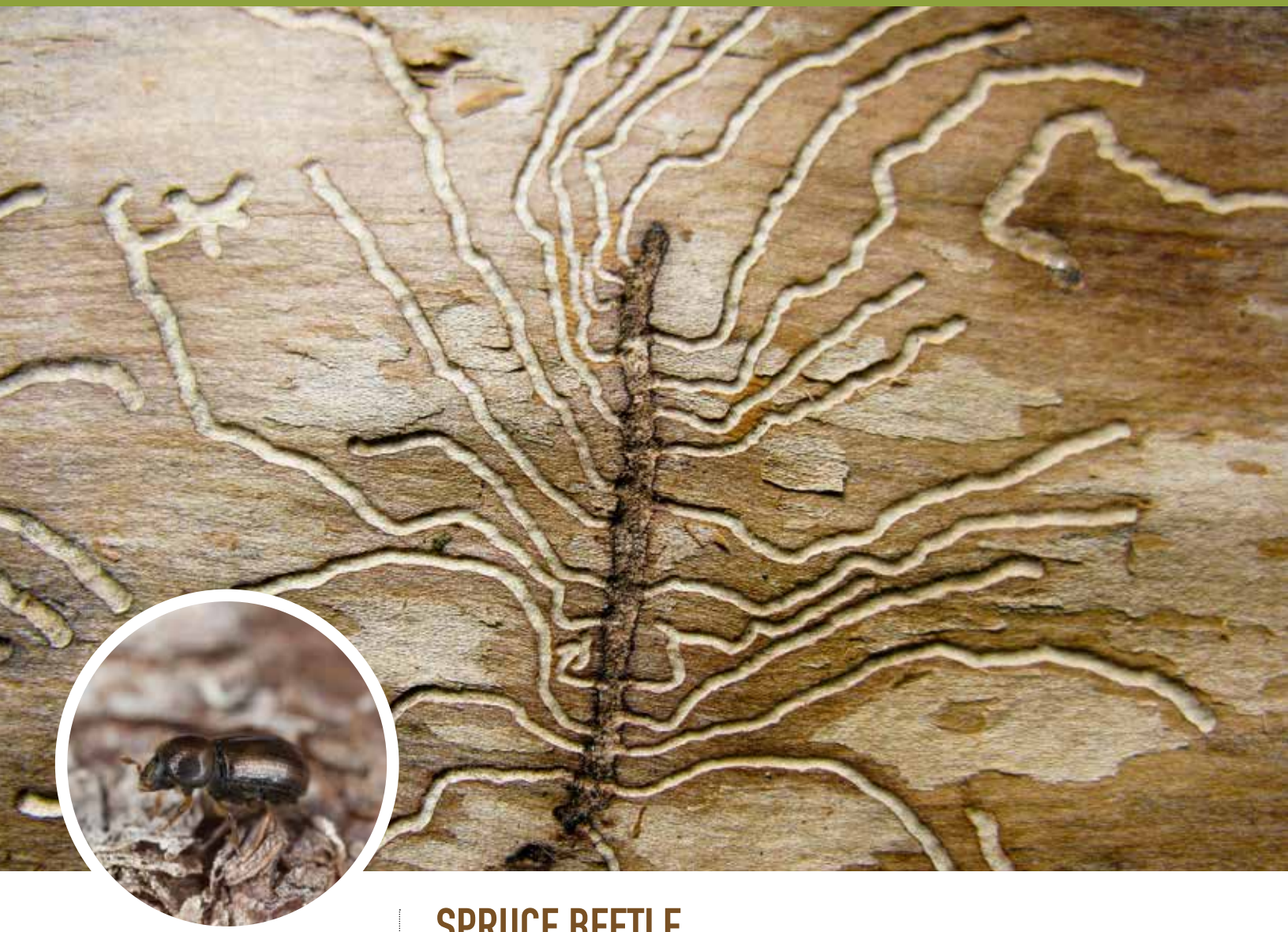
While the MPB epidemic still persists in Colorado, it is decidedly on the decline. Active MPB infestation peaked statewide in 2008, with 1,154,000 acres affected. Since then, the level of annual infestation has steadily declined, with 264,000 acres affected in 2012, primarily in Boulder and Larimer counties. This is partly due to changing climatic conditions (although drought conditions continue to persist across much of the state) and, in some locations, partly due to the fact that large areas of the host species (primarily lodgepole and ponderosa pine in Colorado) had already been infested. In essence, the beetles are running out of the habitat and food provided by live host trees and the epidemic ran its course. This represents a significant departure from historic infestation patterns when outbreaks were quelled not by a shortage of available host trees but by the return of cooler, wetter climate. Under the current climate change projections, the American West is not likely to return to this state.

In the Roaring Fork Watershed, MPB activity decreased to nearly endemic levels in 2012, with 576 acres affected (compared to 12,431 acres at it's peak in 2010). This is mostly due to the relatively low concentration of host species in the area—only 9.2% of Roaring Fork Valley forests are lodgepole pine, the most appealing local host species for MPB. Non-infested stands of lodgepole pine in our area are either successfully repelling invasions, have already been infected, or are too far from a brood tree (the tree where eggs are laid and larvae mature to adults before flying to their own brood tree). MPB generally cannot travel further than one mile from their brood tree; however, there have been rare cases of MPB traveling five miles or more with the help of strong winds. Despite rapidly declining local populations, annual MPB surveys are conducted in the Roaring Fork Watershed to stay abreast of any changes in activity.

FOREST INSECT AND DISEASE PROGRESSION IN COLORADO 1996 – 2012



Source: Colorado State Forest Service (image has been altered to highlight local detail)



The threat of a spruce beetle outbreak is of significant concern to the Roaring Fork Watershed, where 20.3% of forest land cover is spruce-fir forest.

SPRUCE BEETLE

The most destructive beetle to North America's spruce forests, the spruce beetle, is rapidly spreading across the state, laying waste to large swaths of high elevation conifer forests and threatening drinking water supplies. While Colorado's MPB epidemic is subsiding, the spruce beetle (*Dendroctonus rufipennis*) has gained significant momentum in the southwest quarter of the state. Widespread mortality associated with the spruce beetle began in earnest in Colorado around 2001. Since then, affected acreage has increased exponentially, with 311,000 acres of mortality mapped in 2012 alone.

Spruce beetle outbreaks are commonly associated with windthrow events, which occur when whole stands of shallow-rooted spruce trees blow over in intense windstorms. The beetles reproduce in the newly fallen wood. Provided the initial supply of blown down timber is abundant, the beetle population will grow strong enough to attack and kill the surrounding healthy, mature trees.

The threat of a spruce beetle outbreak is of significant concern to the Roaring Fork Watershed, where 20.3% of forest land cover is spruce-fir forest. In 2012, 2,317 acres were impacted by spruce beetle. The impacts of a large-scale spruce mortality event in our watershed go far beyond aesthetic—the high elevation locations of our spruce forests store drinking water for our watershed and beyond to the Colorado River basin. Widespread spruce mortality has the potential to alter groundwater storage mechanisms and poses a huge risk to water quality and reservoir sedimentation rates should the dead trees burn.

Spruce beetle galleries (pictured above) are created when the adult beetle burrows into a host tree and lays their eggs. When the eggs hatch, the larvae eat their way out into the wood until they emerge and fly away.

Subalpine fir decline, pictured above, results when a root fungus and a bark beetle combine forces. The root fungi weaken the trees' defenses and allow the beetles to launch a successful attack.

SUBALPINE FIR DECLINE

While MPB and spruce beetle are the major players in the statewide forest mortality issue, subalpine fir decline accounts for 86% of all tree deaths in the Roaring Fork Watershed in 2012. The term subalpine fir decline does not refer to a specific pest or disease, but rather the collective mortality and degradation of the species. The biggest culprit is the combined efforts of root disease fungi (*Armillaria spp.* and *Heterobasision parviporum*) and western balsam bark beetles (*Dryocoetes confuses*). The root fungi weaken the trees' defenses and allow the beetles to launch a successful attack.

Subalpine fir decline accounts for 86% of all tree deaths in the Roaring Fork Watershed in 2012.

Last year, 221,000 acres of subalpine fir mortality were mapped in Colorado. Of that, 29,195 acres were in the Roaring Fork Watershed, down from a high of 37,878 acres in 2010. Aside from degradation of water availability and quality, subalpine fir decline poses a significant threat to recreation in terms of the hazards associated with falling dead trees and loss of aesthetic value. Prolonged drought conditions will only exacerbate mortality risk for local subalpine fir stands.

ASPEN DEFOLIATION

While not as widespread as conifer mortality, increases in aspen mortality are of significant concern in our watershed. Aspen forests are one the most biologically diverse habitat types in our region (second only to riparian areas), providing critical habitat to a wide variety of plant and animal species. They are also iconic to our community and responsible for much of the scenic beauty that draws visitors to our area, contributing to the economic well-being of our region.

In 2012, 690 acres of the Roaring Fork Watershed were impacted by aspen defoliation, significantly down from a high of 27,590 acres in 2008.

Tree defoliation, the process by which a plant is stripped of it's leaves, is usually the work of hungry insects. In our region, the primary agent of aspen defoliation is the western tent caterpillar (*Malacosoma californicum*), an insect whose larvae feed on the leaves of aspen trees and other mountain shrubs, including chokecherry and mountain mahogany. Trees that are subjected to repeated defoliation events exhibit sparse foliage, minor branch dieback, and even mortality during extreme outbreaks. However, extreme outbreaks generally only last 2-3 years, evidenced locally by high levels of impact from 2006-2008 followed by a dramatic decline to the relatively low levels observed in the last year. This is good news for the wildlife that inhabits our local aspen forests and the people who enjoy them.

A swarm of western tent caterpillars, the primary defoliating agent in our watershed's aspen forests.

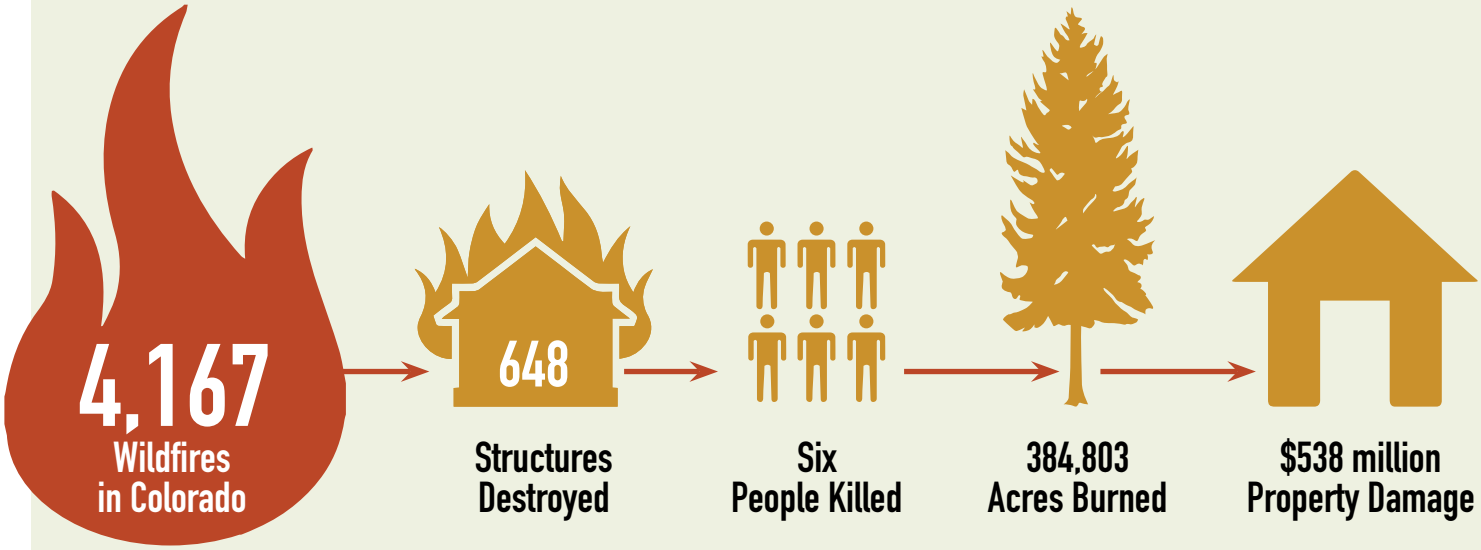
A diversity of forest types can help slow the spread of insect and disease infestations. Here, the mountain pine beetle infestation in the lodgepole pine lost momentum when it encountered the surrounding aspen forest.

WILDFIRES

There were 4,167 wildfires in Colorado in 2012, and together they destroyed 648 structures, killed six people, burned 384,803 acres and caused at least $538 million in property damage. The High Park Fire alone caused $97 million in property damage and cost $38 million to suppress. These figures have put wildfire at the forefront of community consciousness in our state. Repeated slashing of Federal budgets created a feedback loop where many funds for preventative forest management must be diverted to cover suppression efforts.

The presence of fire in the Roaring Fork Watershed is a difficult issue to analyze given the complex interactions between drought conditions, suppression activities, ecological benefits, and threats to human communities. Many of the plant communities in our region are fire-adapted, meaning they rely on periodic fire to reproduce and maintain age class diversity and resilience to insect and disease infestations. At the same time, strong human presence in the

IMPACT OF WILDFIRES IN COLORADO IN 2012



Low intensity ground fires (like the one at left) are important disturbance agents in many Western forests, clearing out overgrown underbrush and encouraging regeneration. However, decades of fire suppression coupled with hotter and drier conditions brought on by climate change are making destructive crown fires such as this one more commonplace.

valley and accumulated fuel loads from decades of fire suppression make prescribed burning and allowing natural ignitions to continue to burn problematic.

Over the past three years, there have been more fires on average in the Roaring Fork Watershed than in the last several decades, though the total number of acres burned in these fires is very small relative to average. The primary reason for this is fire suppression, which has been a traditional practice by forest managers in the United States through much of the 20th century. Since 1980, the number of acres burned annually in the Roaring Fork Watershed has ranged from one acre to 2,603 acres, but overall, there has been very little fire activity during this time.

A mix of changes to management practices as well as overarching climate change will likely alter fire patterns in years to come in the Roaring Fork Valley, carrying both ecological and societal benefits and risks. Natural fire regimes (the pattern, frequency, and intensity of wildfires in an ecosystem) vary greatly over U.S. western mountain forest types, and it is generally believed that many forests in the West burn much less frequently than estimated natural rates since fire suppression began. Fire plays an important role in the ecology of our fire-adapted forests, as many local tree and shrub species have evolved to depend on fire to germinate and reproduce. Allowing more fires to burn in larger areas may enable the return of natural fire regimes, resulting in forest rejuvenation and thus, a healthier forest.

Decades of fire suppression have resulted in dramatic overloading of fuels, making naturally occurring fires hotter, larger and more difficult to contain.

However, the obstacles standing in the way of returning forests to their historic fire regimes are formidable. Decades of fire suppression have resulted in dramatic overloading of fuels, making naturally occurring fires hotter, larger and more difficult to contain. Moreover, hotter and drier conditions brought on by climate change are making forest fuels even more flammable, furthering the risk of catastrophic wildfire. Given rapidly expanding populations residing in Colorado's wildland-urban interface (WUI, any area where structures are built adjacent to natural landscapes), returning to natural fire regimes is currently too risky for many Western forests. Mechanical restoration activities such as thinning and understory fuel removal can help get our forests to a state where returning fire (both natural or prescribed) to the landscape is a more viable option.

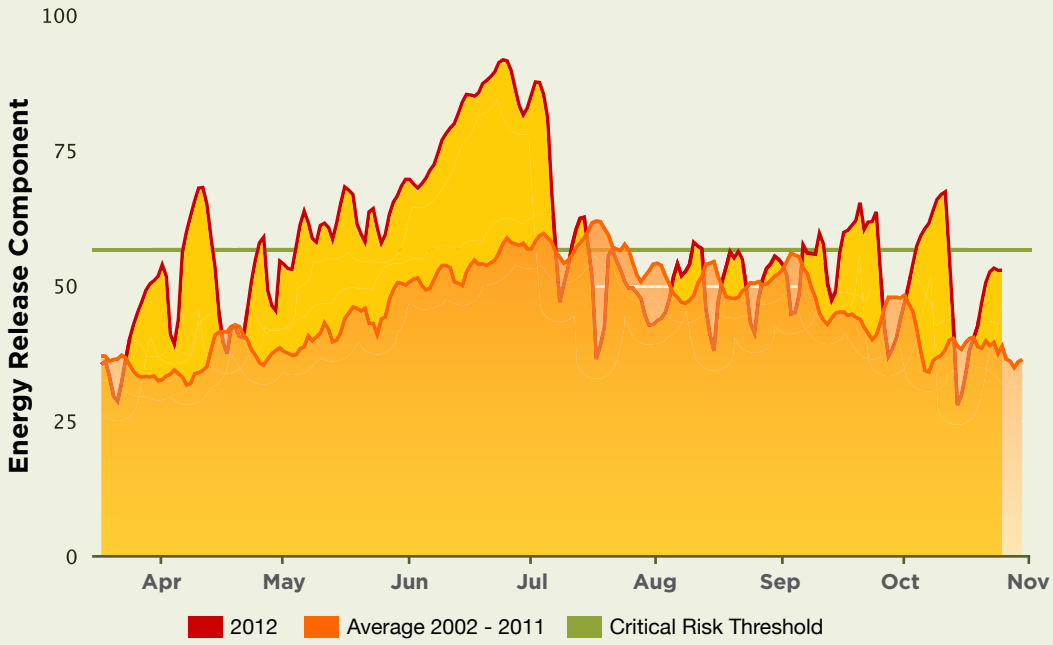
CRITICAL FIRE RISK

The impacts of increased drought stress on vegetation dramatically increase the potential for catastrophic wildfire. Land managers closely monitor changes in composite fuel moisture values (the "dryness" of vegetation) to predict how fire activity patterns may be affected within our watershed. The past few years have seen exceptionally risky periods for forest fires in the region, which generally sees 23 days of critical fire risk per year.

During the 2012 fire season there were 100 days of critical fire risk.

Fire risk places a burden on forest managers, already overstretched and underfunded to meet the landscape scale challenge of fire protection. With increased fire risk, forest management activities intended to promote forest health often get sidelined or, in the case of prescribed burns, are impossible to conduct during risky fire conditions. It also places structures and communities in and around the wild urban interface at heightened risk and leads to restrictions for people using the forests for recreation, such as fire bans.

CRITICAL FIRE RISK



DEFENSIBLE SPACE: PROTECTING YOUR HOME

While management activities in wildland-urban interface (WUI) forests bordering human development can help, as a homeowner, your first defense against wildfire is to create and maintain a defensible space around your home.

Creating defensible space involves clearing or reducing fuels and vegetation around your home to slow the spread of wildfire. Such activities not only help firefighters protect your home from wildfire, they also reduce the likelihood of a house fire spreading to neighboring forestlands and structures. Paying close attention to roof and decking materials can also decrease the likelihood of ignition from falling embers.

For more information on creating defensible space around your home, we recommend the following resources: Firewise: www.firewise.org; Colorado State Forest Service: http://csfs.colostate.edu/

Photos: Colorado State Forest Service

Taking steps to create defensible space around your home can reduce the chance of your home being destroyed by wildfire. (left: before, right: after)

A snowflake that falls atop the Maroon Bells may become drinking water for locales as far away as Los Angeles, emphasizing the need to monitor and maintain air and water quality standards in the Roaring Fork Watershed.

AIR QUALITY

A healthy forest provides the essential ecosystem service of filtering the air we breathe through respiration within trees and soil stabilization, preventing wind-borne dust erosion. High levels of haziness or acidity can interrupt the photosynthesis of plants and acidity can damage plant tissue. Resource managers monitor local air and water quality in a variety of ways.

Visibility monitors how far you can see on a clear day and is measured in deciviews (DV), with 0 DV representing theoretical "perfect" visibility (240 miles). The average visibility on the year's haziest days on Aspen Mountain measured 8.1 DV (~103 theoretical miles) in 2011. This is a 2.4 DV departure from the model-derived 6.5 DV value resource managers consider "natural" for this region. The fact that even our haziest days are close to the natural value is a testament to the outstanding air quality in our watershed.

Acid deposition monitors the acidity of precipitation. The pH of precipitation recorded as an annual average in 2011 was 5.39, a 0.21 departure from the 5.6 level considered "clean" by the EPA. Rain naturally contains some acidity—for reference, precipitation with a pH of 4 is considered highly acidic. Continued monitoring of acid deposition is important as highly acidic rain can damage plant tissue and pollute water sources.

WATER QUALITY

Our watershed's drinking water comes straight from our forest ecosystem, creating a direct link between water quality and human health. One means of examining water quality in our region is by monitoring **macroinvertebrate health**–the abundance of aquatic insects large enough to be seen without a microscope in our local streams. Macroinvertebrates are sensitive to changes in the broader forest ecosystem, such as the pH (acidity), turbidity, and temperature of streams. As a bioindicator, their condition can serve as a valuable symbol of broader ecosystem health over time.

The data for assessing macroinvertebrate health comes from a 2011 study conducted by the Roaring Fork Conservancy on 20 locations in the Roaring Fork Watershed. Based on standards set by the Colorado Department for Public Health and Environment, 17 of the 20 sites surveyed for water quality were considered healthy. These statistics help resource managers target potential sites for restoration projects.

Overall, air and water quality in the Roaring Fork Watershed (as measured by these three indicators) is in good shape. However, it is important to keep annual tabs to ensure the continuity of this achievement.

ACES partnered with Aspen Global Change Institute to install soil moisture monitoring stations throughout the Roaring Fork Watershed.

WHAT CAN YOU DO?

It is critical that we address the larger issues impacting our forests, beginning first and foremost with climate change. Here are a few ways that you can take action in protecting our forest ecosystems:

- Utilize renewable energy resources to decrease the impacts of climate change
- Support policy that reorganizes the Federal budget to allow the Forest Service to undertake proactive forest management activties before catastrophic wildfires occur
- Support management activities that promote the use of prescribed fire as a restoration tool
- Support local government agencies in restoration activities
- Support Aspen Center for Environmental Studies' For the Forest Initiatives

Flickr: C.R. Niemburg/Creative Commons

FOREST MANAGEMENT IN THE "WUI"

The wildland-urban interface, or WUI, is any area where human structures are built close to, or within, natural landscapes. During the past few decades, population in the WUI in Colorado has increased dramatically. Scenic values and urban expansion make homes in the WUI attractive places to live. In 2007, the Colorado State Forest Service predicted a 300% increase of WUI acreage over 30 years—from 715,500 acres in 2000 to 2,161,400 acres in 2030. In 2012, 25% of Colorado's population resided in the WUI. However, most of the WUI in Colorado exists in fire-adapted ecosystems—forests that have not only historically burned but rely on periodic fire to reproduce and maintain vitality and resiliency.

Colorado State Forest Service predicts a 300% increase of WUI [wildland-urban interface] acreage in Colorado over 30 years—from 715,500 acres in 2000 to 2,161,400 acres in 2030.

Especially when coupled with persisting drought conditions and the buildup of fuels following decades of fire suppression, the use of prescribed fire as a means of ecosystem management in the WUI is becoming more and more difficult. The potential for those fires to become unmanageable so close to homes presents an insurmountable risk. Conducting forest management activities such as mechanical thinning of overly dense timber and mastication of over-mature brush in WUI areas decreases fire risk to neighboring communities, especially when coupled with defensible space measures undertaken by homeowners. These management activities also assist in getting forest ecosystems back to a place where prescribed fires may be a more viable management option in the future.

For more information on forest restoration projects on ACES properties, please visit: http://www.aspennature.org/restore/forest-ecosystem-health.

Insect damage on Smuggler Ridge. The Hunter-Smuggler Cooperative Plan seeks to increase forest resiliency, enhance wildlife habitat, and decrease wildfire risk.

THE HUNTER-SMUGGLER COOPERATIVE PLAN

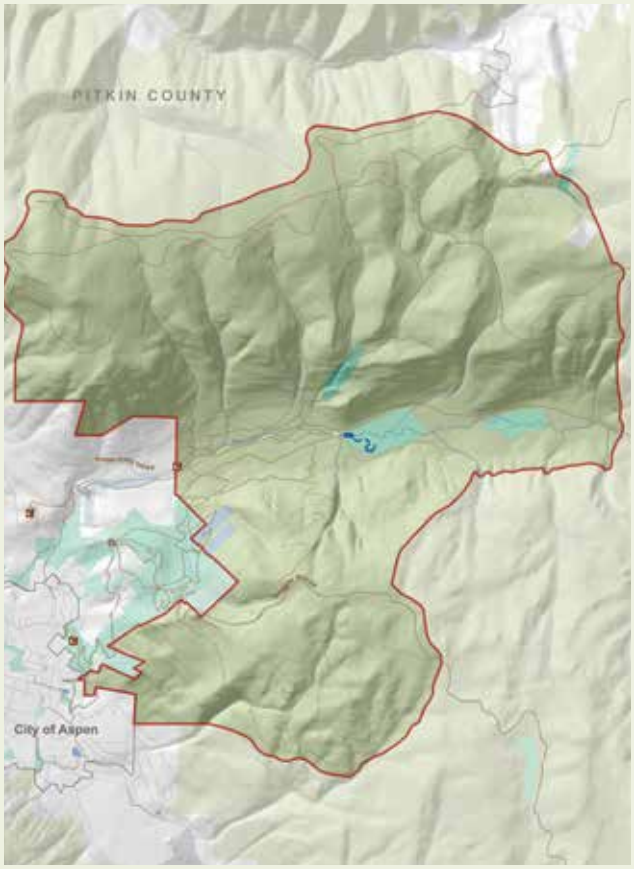
A unique partnership between Aspen Center for Environmental Studies, the US Forest Service, Pitkin County, and the City of Aspen has produced the Hunter Creek-Smuggler Mountain Cooperative Plan, a new way of collaboratively planning management activities for Forest Service lands that have high recreational use, wildlife and ecosystem values, and are adjacent to mountain and resort communities. The community-based plan involves participation from a wide range of stakeholders from local recreation, conservation, and environmental groups, as well as agencies and jurisdictions, and covers 4,681 acres on the White River National Forest adjacent to Aspen.

The creation of the Hunter-Smuggler Plan included an extensive visioning process, and the resulting path forward represents common values shared amongst most stakeholders and provides a foundation for identifying opportunities and actions to meet that vision within the planning area. The collaboratively generated Cooperative Plan outlines recommendations for forest health, wildlife habitat, recreation, and education projects within the planning area.

Using the Cooperative Plan as a baseline, a detailed Environmental Assessment was conducted, published, and reviewed by the US Forest Service. Once the final Decision Notice is signed by the District Ranger, the Plan will be valid for the next twenty years. An initial suite of wildlife habitat improvement and aspen regeneration projects has been mapped and is in the pipeline for Spring 2014. Moving forward, the Project Implementation Team will convene semiannually to recommend project priorities for the coming field season.

Completion of the management activities outlined in the Plan will result in a healthier, more resilient forest, enhanced wildlife habitat, decreased wildfire risk, and improved recreational and educational opportunities on Smuggler Mountain and in Hunter Creek Valley. The collaborative, innovative process undertaken by all parties involved represents real community building and efficiency improvements, and will result in better long-term management of Aspen's backyard ecosystems.

PLANNING AREA



White River National Forest

Public Open Space

Conservation Easement

RESEARCH & EDUCATION

ANIMATED FILM

Last year, Aspen Center for Environmental Studies premiered an animated short film exploring how forests affect, and are affected by, the forces around them. In addition to receiving over 12,000 views on YouTube, the film reached a global audience through its inclusion in multiple film festivals. Most notably, the film received an Honorable Mention from the United Nations Forests for People International Short Film Festival and was screened at the United Nations Forest Forum in Istanbul, Turkey.

FUTURE FOREST DISTRIBUTION MODEL

Aspen Center for Environmental Studies, in partnership with scientists from the University of Arizona, have developed a revolutionary inventory of forest assets for western North America, utilizing hundreds of thousands of species occurrence records to create first-of-their-kind maps of our current forests. When coupled with the most cutting-edge climate models, a high-resolution picture emerges of what our Western forests are likely to look like in the future.

The Model is navigated within a Google Earth Interface, providing the user with the ability to explore current and future distributions of particular charismatic tree species from an aerial or three-dimensional view. With resolutions up to one-kilometer, users can truly grasp the changes in forest composition in treasured landscapes as the forest "fast-forwards" into the future in ten-year time slices. Users can further customize their experience by choosing a best or worst case carbon emissions scenario under which future species distributions are projected. This feature serves to drive home the point that humans, as a global community, play a critical role in the degree to which species distributions are altered.

Armed with this new resource, communities and decision-makers of the American West will be empowered with concrete data to act on climate and influence the fate of our future forests and global climate.

The first iteration of the Future Forest Distribution Model will be online Summer 2014.

FUTURE APPLICATIONS OF THIS TECHNOLOGY INCLUDE:

- Expansion to include forecasts of future distributions of literally every plant species in the new world in response to climate change
- Development of a smartphone app that will show the user all the plant species in their location now and what will likely be there in the future
- Development of scaling theory to use the model to predict future ecosystem functioning and the associated socioeconomic impacts, including how much carbon dioxide forests absorb, impacts on hydrological cycles, and cropland productivity

IN THE CLASSROOM

Aspen Center for Environmental Studies is a leader in Roaring Fork Valley science education, providing in-school and field programs to 62,000 student contacts annually. Through ACES' For the Forest program, our education staff has incorporated forest ecology and research into student curriculums. We consider awareness of local forest processes and issues a critical component of developing an ecologically literate citizenry.

For more information on ACES Ed, please visit: www.aspennature.org/school-programs/overview

Sixth graders from Aspen Middle School practice tree identification at Hallam Lake.

FOREST HEALTH INDEX

The Forest Health Index is a groundbreaking new tool to help the community of the Roaring Fork Valley make sense of the wide range of interlinking environmental conditions that affect the health of our local forest. The Index provides discussion and data on over 20 unique climatic, ecological, and socioeconomic indicators, many of which are included in this report.

The Roaring Fork Watershed forest is the dominant feature of our local landscape—it defines the character of our local ecosystems as well as human communities in the area. Forest health, in large part, equates to environmental health. As a result, the indicators explored in the Index include a broad range of physical environmental indicators, such as climatic and ecological measurements, as well as records on human activity and management practices in and around the forest. The selected indicators include drivers of change and the effects of those changes on the forest ecosystem and neighboring human community.

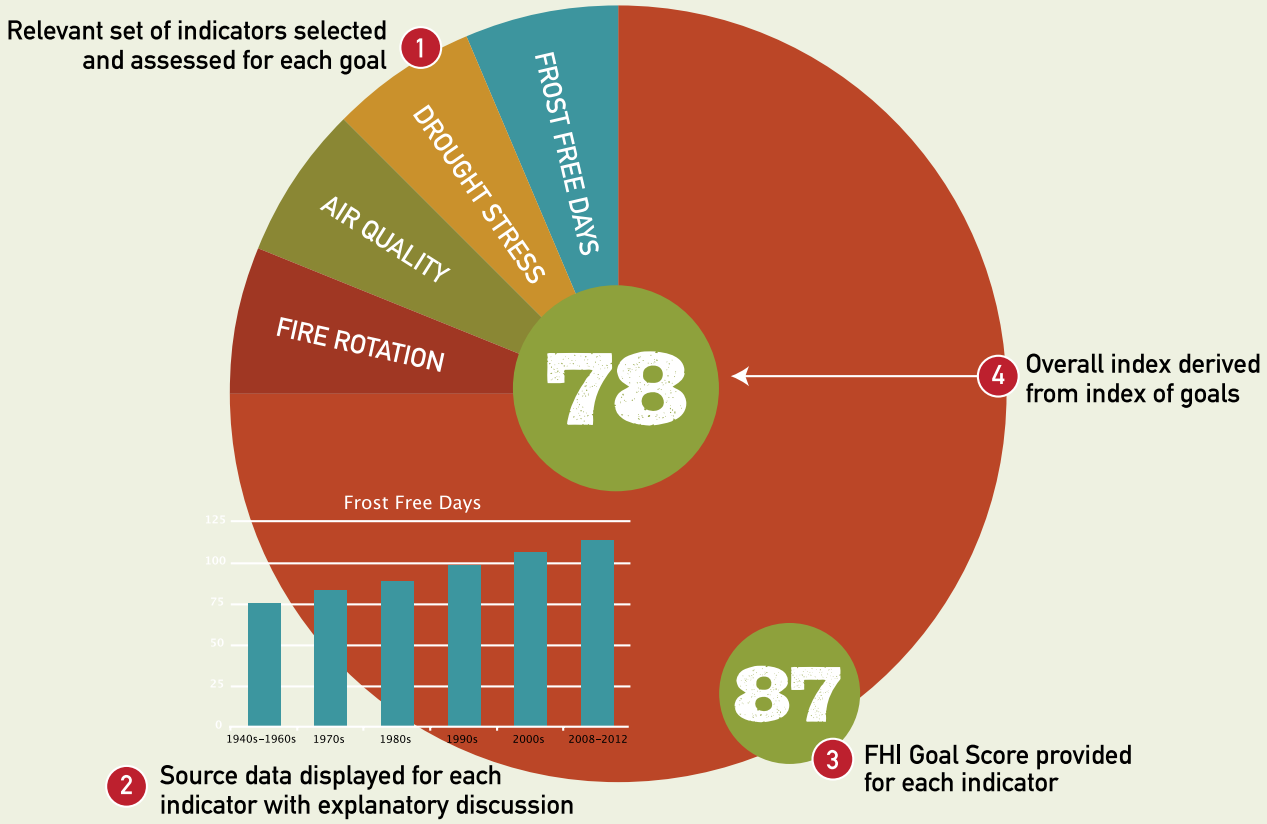
The notion of forest health embraced by the Index is based on the premise that a healthy forest is one that is resilient to change and able to provide for local ecology as well as human goals. In defining forest health in the Index, a single notion of forest health is not presumed. Instead, a view of forest health is presented from four perspectives based on widely agreed upon public goals, which are:

- Ecosystem Services
- Ecological Integrity
- Sustainable Use & Management
- Public Health & Safety

Essential aspects of forest health, such as resiliency to climate change and insect and disease infestations, are difficult to measure, especially within systems as large and complex as a forest. However, the Forest Health Index supports the understanding of local forest health by providing a consistent method to measure any departures from "normal" conditions among indicators relevant to forest health. This process intends to provide a system for communicating these observed changes in novel ways in order to generate and inform discussion.

To explore the first annual iteration of the Forest Health Index, please visit www.foresthealthindex.org.

The Forest Health Index is a project of the Aspen Center for Environmental Studies. ACES is partnering with the Aspen Global Change Institute to design the index, gather and analyze data, engage with stakeholders, and evaluate its scientific accuracy.



Above: ACES citizen scientists participate in a bird survey at Hallam Lake. Below: Community Field Lab participants record observations of important events in plant life cycles, such as bud burst and first leaf.

COMMUNITY FIELD LAB

Aspen Center for Environmental Studies Community Field Lab engages community members in a variety of scientific observation and data collection projects. The utilization of citizen-generated observations complements traditional scientific techniques. As scientists are trying to better understand the impact of climate change on our ecosystems, this method provides new insights into our changing world. This approach efficiently collects large quantities of data and empowers citizens by bringing the climate story to their own backyard. ACES citizen science initiatives include:

- **Project BudBurst**
- **Hallam Lake Avian Migration Monitoring**
- **Hallam Lake Bird Breeding Season Survey**
- **The Pika Project**
- **Community Collaborative Rain, Hail and Snow Network**
- **Hallam Lake Observation Kiosk**

For more information on ACES' Community Field Lab, please visit: www.aspennature.org/act/community-field-lab

DATA REFERENCES

- Aspen Global Change Institute
- BLM RAWS: Station #051506
- City of Aspen
- Colorado Parks and Wildlife
- Colorado State Demographer population data
- Colorado State University: Colorado Ownership, Management and Protection data (COMaP)
- Colorado State University: 2012 Report on the Health of Colorado's Forests
- National Atmospheric Deposition Program: Sunlight Peak Station: CO92
- NASA Moderate Resolution Imaging Spectroradiometer (MODIS) data
- National Climatic Data Center: National Weather Service Stations #050370, #050372, #053359
- Pitkin County
- Roaring Fork Conservancy
- Snow Telemetry Network (SNOTEL): Station #542
- University of Arizona
- Upper Colorado River Interagency Fire Management Unit
- USFS: Aerial Detection Survey
- USFS: Forest Inventory and Analysis
- USFS: Interagency Monitoring of Protected Visual Environments (IMPROVE)
- USFS White River National Forest
- USGS: Gauge Station #09085000

HOW DO WE MONITOR FOREST INSECTS AND DISEASE?

To monitor insect and disease progression in Colorado, the USDA Forest Service and the Colorado State Forest Service partner to conduct aerial surveys of forest lands. For these Aerial Detection Surveys, areas of tree mortality and defoliation are mapped and recorded from above. An acre marked as "infested" may have 100% mortality, or may only have a few damaged trees.

For detailed information on data collection for this report, please visit www.foresthealthindex.org.

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