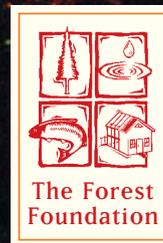


Protecting Communities and Saving Forests

*Solving the Wildfire Crisis
Through Restoration Forestry*

By Thomas M. Bonnicksen, Ph.D.





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Through Restoration Forestry

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In California, 37 million acres – or roughly 48 percent of the state's land base – face high, very high or extreme fire threats. Managing forested resources is critical to protecting communities and meeting the needs of a growing population.



Author Thomas M. Bonnicksen, Ph.D.

I wrote this booklet because I love forests and want our forests to stand tall for generations.

I also know something about forests, having studied them for more than 35 years and authored the definitive book on the history of our forests and the native people who lived in them, *America's Ancient Forests: From the Ice Age to the Age of Discovery* (John Wiley, 2000).

Perhaps it is because I have dedicated my professional life to understanding, conserving and restoring forests that I am alarmed at what we as a society are allowing to happen to forests in California and the nation. Misguided attempts to “save” our forests by leaving them alone and letting them burn are accelerating their decline and endangering thousands of people at the same time.



Wildfires have become larger and more costly to fight.

The problem is that many forests are too crowded with trees. Anyone with a trained eye or who knows forest history can see that. In forests throughout the Sierra Nevada, for instance, history tells us that roughly 50-70 trees stood per acre in a relatively open mosaic. Today 500-700 trees per acre often stand on public forestlands in the Sierra, upwards of 1,000 trees per acre in some areas.

Unnaturally dense forests provide fuel for unnaturally intense and large wildfires. More trees mean more fuel, which translates to bigger, hotter, more damaging fires. Between 2000 and 2006, more than 2 million California acres burned and California taxpayers doled out more than \$1 billion to fight wildfires. Nationwide, 29 million acres burned from 2000-2005 at a cost of about \$1 billion each year.

Today, 37 million California acres face high, very high or extreme fire threats – many filled with dead trees killed by bark beetles because there wasn't enough water, nutrients, or sunlight to keep them healthy.

We are facing a wildfire and an ecological crisis that few people understand. I sincerely hope it will not be too late when we realize and correct what we have done.

The roots of a growing crisis

Part of today's forest health and wildfire crisis can be traced to past fire suppression policies. By putting out forest fires for more than 100 years instead of letting them clear the forest of excess growth and debris, overgrowth now clogs forests, choking out certain plants and destroying wildlife habitat.



Policies that restrict forest management and attempt to preserve forests as static landscapes have led to dangerous conditions in California's forests.

Preservationist policies that restrict public access and forest management in public forests also play a part in our forests' decline. Such policies discount the concept of sustainable forestry and fail to recognize that humans have been a natural part of forests for at least 12,000 years. People have lived in and relied on forest resources like wood, game and clean water for just as long. Renewable resources hold the key to meeting the needs of a growing population and forests must be managed accordingly.



Managing forests can reduce the threat of catastrophic wildfire and provide diverse habitat for wildlife.

The underlying theme for many of the things causing forests to decline is an environmental disconnect – people are removed, or disconnected from the land that feeds and shelters them. Without a connection to forests or an understanding of how natural resources become the comfortable homes, tables, and other products we use every day, it's easy to subscribe to myths about forests and inflict great harm unintentionally.

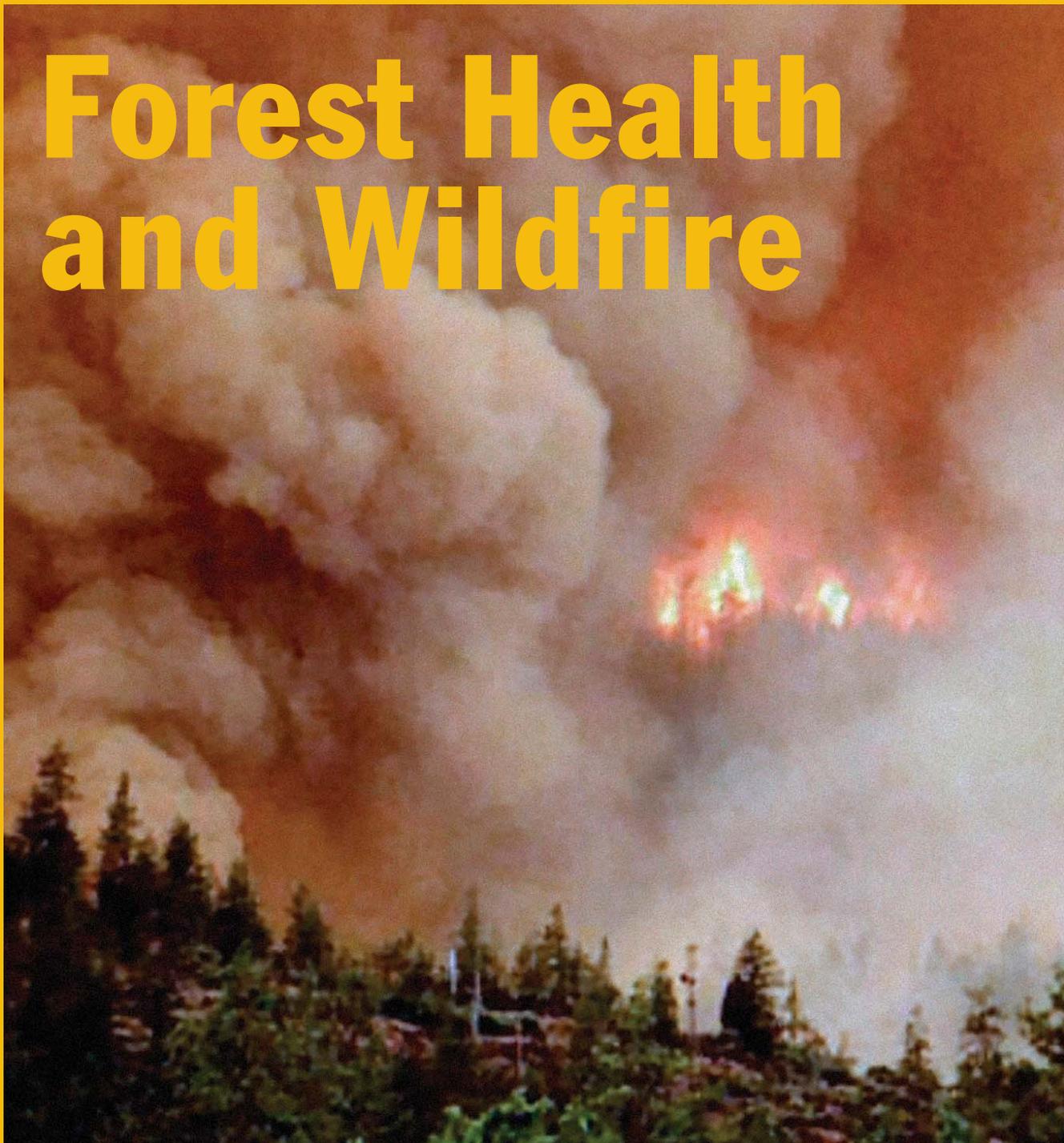
Native people were well connected to the land and managed forests for thousands of years to serve their needs. In the process, they gave us the magnificent forests that everyone treasures and wishes we had again.

The seeds of a solution

Restoration forestry aims to bridge the environmental disconnect, acquaint people with their forests and restore forests to their historic grandeur. Using history as a guide and modern science as its primary tool, restoration forestry acknowledges the many values people expect from forests, such as the need to keep forests biologically diverse and productive, and the importance of ensuring the safety of forest communities. It addresses the economic realities, ecological challenges and social demands of making forests great again.

Restoration forestry will create beautiful, natural forests, and encourage productive use of resources that might otherwise go up in smoke. It sets forth a feasible way to provide abundant wildlife habitat, safe communities, clean air, sustainable energy, greenhouse gas storage to help address global warming and a dependable source of wood products. At the same time, it returns to the landscape forests that look and function much like they did hundreds of years ago. ■

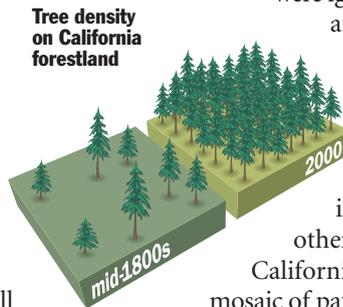
Forest Health and Wildfire



The Forest Health and Wildfire Crisis

California and the nation face a forest health and wildfire crisis. Many forests, particularly those on public lands, have grown dangerously overcrowded due to a century of fire suppression and decades of restricted timber harvesting.

Historically, low-intensity fires were common in California. Most forests burned often and gently, with low flames creeping through grass and pine needles while licking benignly at the base of large trees. Where brush had grown dense or patches of older trees were unusually thick, flames would flare up, leaving in their wake small openings where young trees could flourish.



These low-level fires were the norm for thousands of years. About half the fires were ignited by lightning strikes and the rest by native peoples who used fire to improve hunting conditions, create safer living areas, thin oaks to increase acorn crops and other purposes. They kept California's forests open, with a mosaic of patches of trees of different sizes and ages on the landscape. Large, catastrophic fires were rare and forests teemed with wildlife.



Native peoples used fire as a tool to manage their environment and make productive use of forest resources.

However, that has changed. Starting in the early 1900s, people began putting out forest fires and altered the natural fire regime. Without low-intensity fires to keep them open, forests began to grow more crowded. Many forests we see today are not natural, but far denser versions of their historic predecessors.

California's changing forest landscape

Forests that just 150 years ago were described as being open enough to gallop a horse through without hitting a tree are now so dense you can barely walk through them. In California's mixed-conifer and ponderosa pine forests, 500 or more trees per acre often now stand where less than 70 trees per acre stood historically.

Today, forests in the Lake Tahoe Basin are four times denser than they were in the 1850s, and most government-owned forests in the Sierra Nevada are about

Tahoe National Forest, 1911



10 times denser than natural. Forest density has increased by more than 70 percent in Southern California's San Bernardino Mountains in the last 60 years alone.

This overcrowding has horrific implications on forest health and wildfire behavior. It also can have devastating effects on wildlife. The plants and animals that need sunny openings are disappearing – when grasses and shrubs get crowded out, the wildlife that needs that habitat for food or cover is lost. Streams are drying up as thickets of trees use all the water. Insect infestations and tree mortality are reaching epic proportions.

Beetle invasions

Bark beetles have thrived with the onset of unnaturally dense forests. Bark beetle outbreaks in California increased roughly 30-fold between 1998 and 2004, a year in which more than 1.7 million acres of national forestland in California experienced insect infestations. In Southern California, beetles killed millions of trees between 2001 and 2004. Experts predict more than 21 million additional acres of Western forests will suffer significant tree mortality from bark beetle attacks during the next 15 years.

Bark beetles have already killed up to 33 percent of the trees in some parts of the Lake Tahoe Basin and nearly half of the pine trees are dead in the San Bernardino and San Jacinto Mountains. The same is true on Southern California's Palomar Mountain.



Tahoe National Forest, 2003

Too many trees

Many of California's public lands simply have more trees than the land can sustain, which is causing forest health to suffer. Humans have put out the fires and restricted the timber harvesting that could have thinned these forests. Harvesting on California's public forestlands, for example, has dropped nearly 90 percent since 1990.

In healthy forests, trees can fight bark beetle attacks. They encase the attacking insects in sap and keep them out.



Bark beetles have killed up to 90 percent of the trees in some San Bernardino Mountain forests.

But in overcrowded forests, trees compete for water, food and sunlight. Without enough nutrients to go around, trees become stressed and susceptible to insect attacks.

With forests unnaturally dense, trees have barely enough moisture to produce the sap needed to keep out bark beetles even in relatively wet years. They cannot resist attack during dry years.

A healthy forest can survive a beetle attack during a drought with only moderate mortality. A thick and stressed forest cannot. Drought may have triggered some recent insect epidemics, but it didn't cause them. The real cause is overcrowded forests.

Too many trees is also the reason that catastrophic fires have become more common in recent years. With an abundance of dead, dry trees in the forests, fires burn hotter than natural. They can easily jump 8-lane highways and blow right through or around fuel breaks. Intensely hot fires create strong winds and can hurl firebrands, or bits of burning trees, up to a mile away.



California is expected to add the population equivalent of three Los Angeleses between 2006 and 2020.

There is nothing natural about a 200-foot wall of flames racing across the landscape. California's historic forests were more open, fuels didn't accumulate and fires stayed mostly on the ground.

The wildland-urban interface

Humans have long been a natural part of California's forests, but the combination of an increasing population and overgrown forestland has created extraordinary dangers.

According to the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program (CDF-FRAP), about 8 million people now live in the wildland-urban interface and are at significant fire risk. California is expected to add another 6 million people in the next 15 years, so danger in our forests is only likely to increase.

Living amongst the trees without caring for and thinning the forest has proven to be lethal. In the decades preceding the Southern California firestorm of 2003, forest management came to a

virtual halt in the San Bernardino Mountains and elsewhere. As early as 1994, forestry and fire ecology experts identified the dangers the overcrowded forests in Southern California posed and proposed actions to reduce the fuel loads. Their recommendations went unheeded, the proposals left on the shelf.

In 2003, Southern California wildfires claimed two dozen lives and destroyed some 3,700 homes in a predictable and preventable catastrophic event.

Getting worse, not better

Southern California is still not safe. Millions of dead trees cover the mountains around Lake Arrowhead, Big Bear and Idyllwild. Thousands of acres stand in tinderbox conditions.

Furthermore, conditions similar to those in Southern California's forests before they succumbed to beetles and flames in 2003 are appearing increasingly throughout the Sierra Nevada and Lake Tahoe Basin.

All told, more than 2 million California acres burned between 2000 and 2006, and 8 million acres remain at high risk of catastrophic wildfire. The main reason is that humans have altered the natural fire regime and severely restricted forest management that could mimic natural effects to thin forests.

Leaving forests alone doesn't work. Southern California's 2003 firestorm makes clear what professional foresters have known for years: forests need management to be safe, healthy and productive.

Today, California's historically patchy forests are gone and in their place stand unnatural, dangerously thick forests that spread across the landscape as one continuous blanket of fuel. We have the science, expertise and technology to restore them to their naturally healthy condition if we want to. With restoration forestry, we also have a viable plan for doing so. ■

It has taken a combination of several factors to create the dangerous, unnatural conditions that now dominate California's forests. Misinformation and widely held misconceptions about forests have played a role, as have well-intended policies that had unintended consequences.

The myth of the pristine forest

The vision of pristine, untouched pre-settlement forests may be alluring, but in reality, forests have been managed for at least 12,000 years. The California forests European explorers discovered in the 1800s were neither pristine nor untouched.



Historically, old-growth forests did not dominate the landscape, but appeared in sporadic patches on the landscape.

They were, however, beautiful and far more open and diverse than today's forests.

The vision of pristine forests many people hold – babbling brooks flowing through majestic tall trees and grassy meadows with deer and other wildlife in abundance – are typically images of carefully managed forests. Natural forests to be sure, but forests nonetheless shaped by native people and other influences.

Other mythical pristine forests – dark, mysterious places with huge trees, moss-covered logs under foot and chattering wildlife in tree canopies high overhead – are fleeting glimpses of reality at best. Some such patches historically dotted the land much like today's old-growth forests do, but they were relatively few and far from permanent. Fires may have passed by them for a while, but eventually they burned. Forests are dynamic – once they reach maturity, their next step is to become young again, usually at the hand of a fire.

Fire has played a significant role in developing California's forests for thousands of years. However, because California's historic forests were so different from the dense forests we see today, fires burned differently then.

Fire versus FIRE

The fires that were a natural part of California's historic landscape cleared the forest floor of debris and small trees. The difference between the fires



Natural fires generally burned close to the ground in low-intensity events in California's historic forests.

that historically shaped California's forests and the blazes that ravage thousands of acres at a time today is mostly a matter of degrees.

Historically, forest fires were generally low-intensity affairs. Fires might cover large areas, but flames stayed close to the ground with relatively modest temperatures. Today's infernos sometimes tower above the ground and reach 3,000°F, hot enough to melt metal. They can travel 20 miles in a day and sterilize soils.

In the low to moderate-intensity fires that historically dominated the interior West, animals could generally avoid the immediate effect of flames.



During the 2003 Southern California firestorm, fire jumped freeways and other fuel breaks, melted cars and destroyed more than 3,700 homes.

The high-intensity blazes that have become more common recently have a greater impact on wildlife. It's harder to get away. Fish die in boiling streams.

While fire is a natural part of most American forests, catastrophic blazes were rare historically. For centuries, fire shaped California's forestland in a benign cycle – frequent low-intensity fires cleared the understory and kept the forest open, which guarded against mega fires. Today's high-intensity crown fires, however, often leave in their wake devastated moonscapes of dead trees and baked, eroding soils.

When fire is suppressed

The nature of fire in America's forests began to change about a century ago. Following deadly fires in 1871 (Wisconsin), 1881 (Michigan) and 1884 (Minnesota), public reaction began a shift toward fire suppression – putting fires out before they became dangerous to humans. Those sentiments were driven to a fever pitch following the 1902 Yacoult Fire (Washington and Oregon) and 1910 Great Idaho Fire, which claimed 38 and 85 lives, respectively.

By the 1920s, USDA Forest Service researchers had published reports arguing that fire should be suppressed to ensure public safety. By the mid-1930s, the Forest Service adopted the "10 a.m. Policy," which stipulated that fires should be contained by 10:00 the morning after ignition.

Putting out fires to minimize threats to humans, however, also meant putting out fires before they could burn-off fallen branches and other fuels on the forest floor. With no natural thinning agent, forests began to get more crowded. Shade-tolerant trees filled the understory as forests grew denser and unnatural fuel loads accumulated.

Fire intensity and firefighting costs soon began to escalate. By the late 1970s, the 10 a.m. Policy had become too expensive to apply on a large scale because millions of acres of forestland had become dangerously overgrown with

trees and brush. So, the Forest Service started letting some fires burn, even though they were often catastrophic. Since 1980, the size of wildfires on national forests has doubled and it may double again if we let forests keep getting thicker.

By 2005, two-thirds of America's national forests were at significant risk of severe wildfire. That's more than 130 million acres.

Beware the ladder fuels

In the absence of natural fire, shrubs and small trees that would have been removed by low-intensity flames instead grow aggressively. This understory

Ladder fuels like dead limbs and young and leaning trees can carry flames from the forest floor to tree canopies in seconds.





Crown fires race through treetops and are the most difficult type of forest fire to contain.

vegetation plays a critical role in fire behavior – it becomes “ladder fuel” that allows fire to move upward from the forest floor into the canopy. Ladder fuels can be the difference between a relatively harmless surface fire and a landscape-altering crown fire.

Forest fires generally fit into one of three categories:

- Surface fires
- Ground fires
- Crown fires

Surface fires

Surface fires, slow or fast moving, burn fuels like fallen leaves, needles, grasses, twigs, small trees and shrubs. Their flames seldom reach heights greater than four feet. Surface fires are relatively easy to control.

Ground fires

Ground fires are slow moving, smoldering fires that burn under the forest floor. Ground fires can flare-up into surface fires under certain

conditions, but usually follow fast-moving fires and consume tree roots and other materials they leave behind. Ground fires are relatively easy to control.

Crown fires

Crown fires are the most spectacular and lethal of all fires. In crown fires, flames leap from treetop to treetop with flames anywhere from five to 200 feet high or more. Crown fires move very fast and are almost impossible to control. They tend to be wind-driven,



“Prescribed burns” can be an effective forest-management tool once fuel loads have been reduced to safe levels.

but also burn against the wind, just not as quickly. Crown fires can also change direction as quickly as the wind shifts, making them unpredictable and dangerous to fight.

It usually takes a change in weather – such as a drop in wind, rain or snow – to stop a crown fire. This is what saved the towns of Lake Arrowhead and Big Bear during the 2003 Southern California firestorm. Firefighters worked valiantly to protect lives and homes, but ultimately a shift in the wind and some timely rain staved off near-certain devastation.

Influencing fire dynamics

Fuel loads, weather conditions and landscape topography all influence fire behavior. For instance, fire usually moves faster uphill. During the 2003 Southern California firestorm, however, fuel loads were so extreme that firefighters

reported witnessing fires race downhill as fast they moved uphill.

Unlike weather and topography, we can control fuel loads. We can reduce fuel loads and improve overall forest health. Much like a master gardener will prune roses, fight aphids and slugs, and pull weeds, foresters can remove excess fuels and create conditions that benefit trees and wildlife.

We are still feeling the effects of aggressive 20th century fire suppression. Deliberately set fires, or “prescribed burns,” can be an effective forest-management tool, but many public forests that surround communities are too dangerous and overgrown with trees and debris to safely reintroduce fire without first harvesting some trees to reduce fuel loads.

However, public sentiment toward forest management has swung toward

preservation – leave the forest alone, keep it exactly like it is and let nature take its course. More often than not, efforts to manage California’s forests and reduce fuel loads are blocked by appeals and lawsuits – despite the fact that humans have allowed unnatural fuel loads to accumulate. The forests we would leave to nature are not natural, so the fires that burn them are not natural either.

Such “hands-off” attitudes, often inspired by the myth of the pristine forest, lead to inaction that fosters the kind of catastrophic fire that can erase forests from the landscape for centuries. While court cases drag on, trees keep growing and forests get more crowded. Tinderbox conditions are spreading throughout California’s forests.

By doing nothing in our forests, we are doing something – creating conditions that are far more conducive to unnatural, devastating crown fires than natural low-level surface flames. ■

Environmental Impacts



Wildlife and Biodiversity

The current condition of California's forests is wreaking havoc on wildlife habitat and biodiversity.

Even before they burn, overcrowded forests can have detrimental effects on wildlife. Many species are simply losing their habitat as forests change in response to out-of-control tree growth.

Before the flames

California's once-open forests teemed with abundant, diverse wildlife. Now, however, many forests have up to 10 times more trees per acre than what was historically natural.

Overly dense forests block sunlight and intercept precipitation that once reached the forest floor. Herbaceous plants, grasses and flowering shrubs don't get the moisture, sunlight and nutrients they need, and die out. When grasses and shrubs are lost, the wildlife that needs that habitat suffers, and ultimately may be lost too.

Songbirds, rabbits, deer and other animals are struggling as conifer forests overtake their open habitat environments. Surveys of the Sierra Nevada in 2000 identified 12 bird species as having significant negative population trends because of closing tree canopies (*Saurer, et. al. 2000*). Another study found the number of bird species in the Sierra Nevada dropped markedly in the 20th century due to increased canopy closure (*Bouldin, 1999*).

Butterflies are suffering, too. Lassen National Park, about 50 miles east of Redding, California, is home to 108 species of butterflies. As conifer trees have increased in density, they have



displaced the understory plants that comprise 95 percent of the larval butterfly food supply in the park. The loss of a critical food source is having severe consequences on butterfly populations in the park.

Numerous studies show that most vertebrate species need open or diverse forest conditions. One analysis of Sierra Nevada wildlife found that meadows and open forests provided optimum habitat for more than five times as many vertebrate species as dense, multi-layered forests. Furthermore,

As forests grow overcrowded, many species, like the gray fox, black-tailed jackrabbit and mountain bluebird are losing critical habitat.



a University of California-Berkeley study of 255 species on the western slope of the Sierra Nevada found that no vertebrate animals lived exclusively in any single age or type of forest.

During the fire

California's wildfires are increasingly high-intensity crown fires that burn hotter than their historic predecessors. Whereas coyotes, mule deer, elk, black bears and other animals could outrun most historic fires, catastrophic fires overtake many animals in their path.



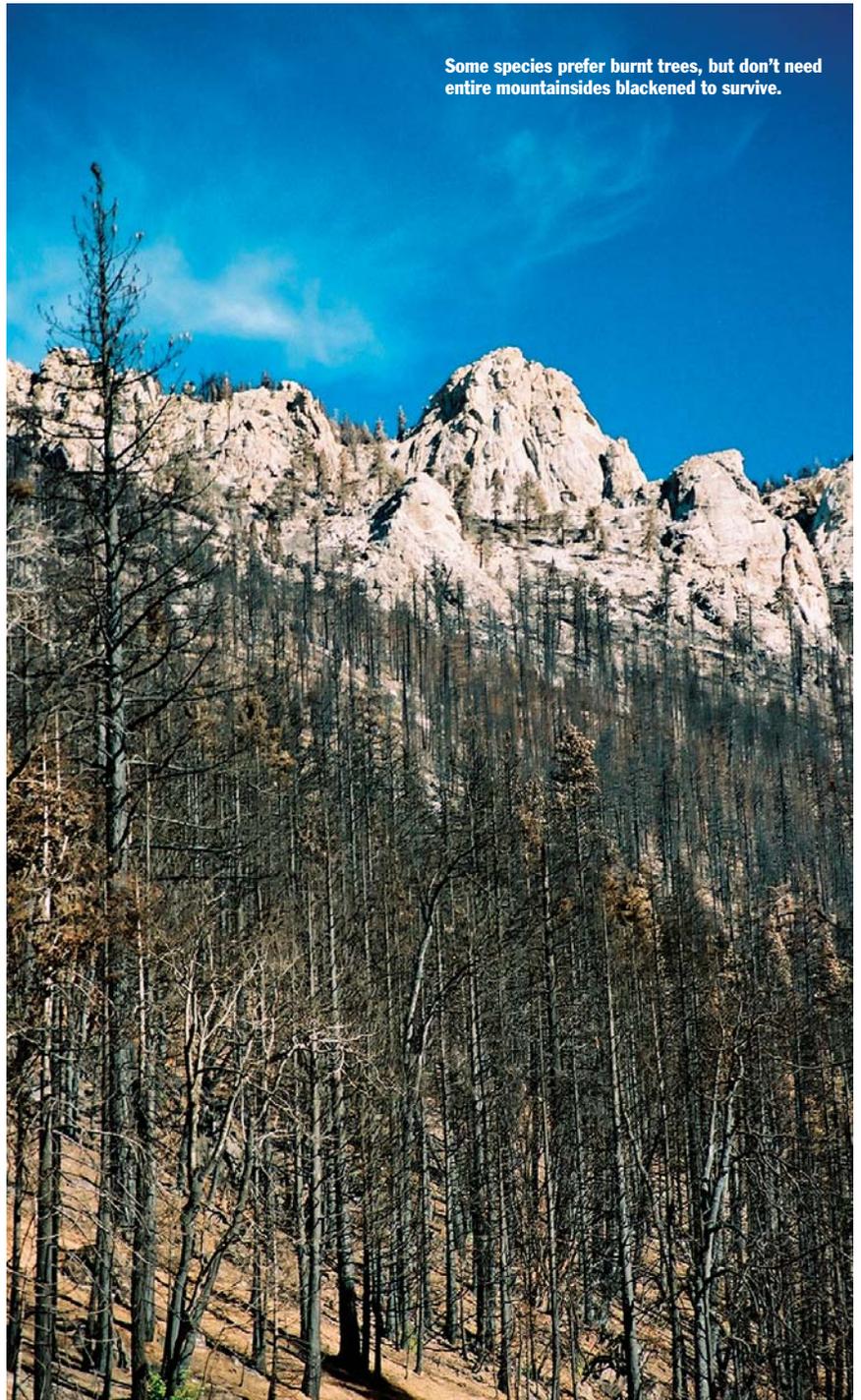
In high-intensity wildfires, smoke frequently overtakes fleeing animals and stream temperatures become lethal to aquatic wildlife.

The leading cause of death in land animals during wildfires is not heat, but smoke inhalation. Billowing clouds of thick smoke often race ahead of crown fires, suffocating mammals and ground-nesting birds.

Fish and amphibians stand little chance when catastrophic fires cause rivers to boil. Studies have shown stream temperatures can increase as much as 62°F even after flames die out. That is more than enough to kill fish and other aquatic life.

After the fire

A relatively lifeless moonscape can frequently replace a dense forest after a catastrophic fire. High-intensity blazes can eradicate virtually all vegetation on a site and sterilize the soil, altering



Some species prefer burnt trees, but don't need entire mountainsides blackened to survive.



The spotted owl is a far more adaptive creature than first believed and nests extensively in managed forests. Wildfire poses the most significant threat to spotted owl habitat in California.

wildlife habitat for centuries if the land is not replanted (studies show the vast majority of severely burned public forestland is not reforested). Many animals simply get displaced.

Furthermore, post-fire erosion can bury fish spawning gravels and choke entire watersheds with sediment for five years or more – once the vegetation that held soils on hillsides is burned, there is very little preventing rain from washing layers of topsoil into rivers and streams. The loss of streamside vegetation also means waterways will receive more sunlight, and fewer leaves will fall into

the water, so the stream's temperature and nutrient mix will certainly change.

After Arizona's 2003 Picture Fire, fish populations in three streams declined by 90 percent. The Lake Complex Fire in New Mexico and the Aspen Fire in Arizona caused the loss of the endangered Gila chub in two streams. An Idaho fire left a stream without adequate food sources to support fish for 11 years.

While some species thrive in burned forest conditions – like wood boring beetles and woodpeckers – those species do not need vast landscapes charred, and only use that habitat for a short time. Foresters replanting burned private forestlands, for instance, leave some snags (standing, dead trees) and charred logs to accommodate certain species. At the same time, they accelerate the return of a healthy forest.

Spotted owl myths

Many forest management and fuel reduction plans in California since the late 1980s have been blocked by efforts to “save” the spotted owl.

It turns out, ironically, that forest management may hold the key to the owl's survival.

By prohibiting tree harvesting near spotted owl nesting locations, or even where owls were thought to potentially nest one day, those forests have become overgrown. That has affected the owl in at least two ways. First, habitat for the owls preferred prey in California, the

dusky-footed woodrat, has diminished greatly. Second, fire has become the main threat to the owl's nesting sites.

Recent research shows that what was once accepted as fact – spotted owls live only in old-growth forests and logging was destroying the owl's last remaining habitat – is a myth. In fact, large tracts of old-growth forests are detrimental to spotted owl habitat, in part because the animals they prey on need a more diverse habitat. In many areas, spotted owls do best in a mix of forest conditions and need young forests that provide suitable hunting grounds. Research also shows that owls will indeed nest in and near managed forests.

Fire, however, is simply destructive. In New Mexico's Cerro Grande Fire, 20 Mexican spotted owl nesting sites were lost. Between 1999 and 2002, the USDA Forest Service identified 11 California spotted owl nesting sites as lost to wildfire. In 2002, the Biscuit Fire destroyed tens of thousands of acres of critical spotted owl habitat in Southern Oregon and Northern California, including 49 known nesting sites.

Unless we thin and manage forests, more habitat loss lies ahead.

Diverse habitats needed

The best way to ensure diverse wildlife is to have diverse habitats on the landscape. In such an environment, catastrophic wildfire is rare and a wide range of animals can find food, water and cover.

What California has now, unfortunately, is increasingly dense forests that threaten biodiversity and a litany of legal action to prevent the forest management that could change that. ■

The tremendous smoke plumes that rise above catastrophic wildfires carry toxic pollutants far and wide. Wildfires in California can foul the air for weeks and affect visibility over the Grand Canyon. In 2004, Alaskan wildfires degraded air quality across much of North America and even Europe.

When overcrowded forests burn, ash can fill the sky for hundreds, even thousands of miles.

Poor air quality causes public health concerns, aggravates asthma and leads to other ailments. Carbon monoxide can cause nervous system and brain damage. Ozone irritates the eyes, nose and respiratory system, and may increase the risk of heart attack.

While historic fires burned close to the ground in most forests and produced some smoke, today's high-intensity fires send smoke thousands of feet high and foul the air for thousands of miles.

Wildfire, climate change and tailpipes

When a forest isn't burning, it's helping to clean the air. Whereas healthy forests



Wildfire smoke can spread toxic pollutants and ash over communities for hundreds of miles.



Smoke from wildfires can cause health problems, cancel outdoor activities and foul the air for weeks.

absorb greenhouse gases like carbon dioxide, catastrophically burning forests release tremendous amounts of carbon and other pollutants in massive outbursts.

Carbon monoxide is one of the main components of wildfire smoke, and chemical reactions in wildfire smoke can trigger ozone production.

According to the National Center for Atmospheric Research, wildfires that in 2004 scorched 11 million acres during two months in Alaska and western Canada raised ground-level ozone by

up to 25 percent in parts of the northern United States and 10 percent as far away as Europe. Those same wildfires spewed as much carbon monoxide into the air as all the cars and factories in the continental United States combined during those same months.

Well managed forests, by contrast, absorb and store vast quantities of greenhouse gases. According to the U.S. Environmental Protection Agency, managed forests in the United States absorb about 17 percent of total annual U.S. greenhouse gas emissions – equivalent to removing the carbon dioxide emissions from 235 million automobiles annually.



Managed forests in the U.S. absorb the carbon dioxide emissions from 235 million automobiles annually.

Catastrophic wildfire smoke spews similar pollutants as automobile tailpipes into the air. Wildfire smoke

can blanket entire cities, affecting more people than at any time in history, and can cancel athletic events and other outdoor festivities. It often prompts health advisories that encourage people with respiratory problems to stay indoors.

Historically, the devastating fires that cause this kind of air quality degradation were rare. With overcrowded forests providing abundant fuel, today they are not.

When trees are harvested and forests replanted, forest resources become wood products like lumber and furniture. With careful management the threat of wildfire goes down and the carbon originally trapped in the forest by vigorously growing trees stays trapped in wood products long-term. Furniture from the Elizabethan era still holds the carbon fixed hundreds of years ago. Replanting forestland continues the cycle of air cleansing and carbon storage.

Clean, abundant water

Roughly 75 percent of California's drinking water originates in forested watersheds. When forests are managed and fires not severe, forests act like natural filters, helping soils absorb nitrates, phosphorus and other nutrients. Tree canopies also deflect rain, allowing soils to soak up water rather than have raindrops wash them away.

California's forest health and wildfire crisis threatens to change the role forests play in filtering drinking water, and in the quality and quantity of water available for aquatic species and people. Today's intense fires also cause water pollution from excess nutrients and sediments from eroded soils.



Healthy forests filter water naturally and help keep soils on hillsides as in this managed, private forestland in Humboldt County.



After a forest burns, soils are exposed and erosion can increase dramatically.

It is the unnatural number of trees, not the amount of precipitation that is at the root of the problem. With 50-70 trees per acre as was historically natural for much of California, forests could survive limited droughts relatively unharmed. However, with five to 10 times that amount of trees, even relatively wet years may not provide sufficient moisture for the trees.

Water is also key to a tree's ability to survive bark beetle attacks. When a tree has sufficient moisture available, it can "pitch out" beetles by blocking the holes they bore into the tree with sap. Moisture-stressed trees, however, cannot. They succumb to insect infestation and become fire hazards.

Predictable pollution

One of the easiest things to predict is that after a catastrophic fire, erosion and the amount of sediment reaching waterways will increase.

When forests burn in a severe wildfire, the soils under the surface can bake so hard that water cannot get through – it forms a hydrophobic crust that repels water. High-intensity wildfire also removes vegetation whose root systems could hold soils on a hillside.

Post-fire rainfall can quickly reach the hydrophobic layer and wash nutrient-rich soil away at more than 100 times pre-fire rates. Ash and sediment in extraordinary levels can clog watercourses, choking fish and burying spawning gravels. It pollutes drinking water, fills aqueducts and blocks downstream irrigation systems.

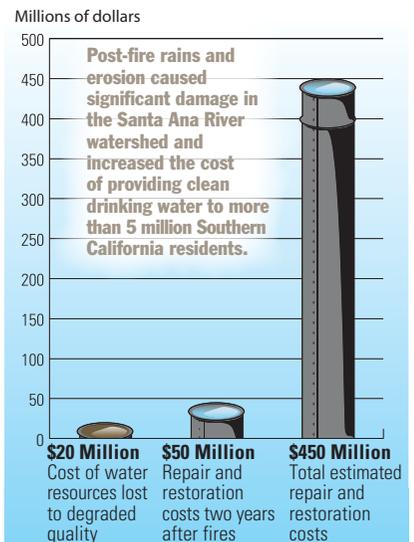
The effects are both immediate and long-lasting, and they can be deadly. More than a dozen people lost their lives during mudslides in burned areas of the San Bernardino Mountains following the 2003 Southern California firestorm.

Sediment and dollars add up

Following the 2003 Grand Prix, Old and Padua fires that burned nearly 175 square miles in the San Bernardino National Forest, rains washed an estimated 700 million cubic yards of rock, sand and debris into the Santa Ana River watershed. In steep terrain, flood-driven sediment blasted out aquatic and riparian species. In flatter places, wildlife habitat was smothered with sediment.

Water delivery systems were clogged and damaged, too. The Santa Ana Watershed Project Authority (SAWPA), which delivers water to more than 5 million Southern California residents, spent more than \$50 million on repairs and restoration by the end of 2005. It estimates total costs to mitigate the fires' effect on water quality and repair damaged flood control and water-delivery infrastructure will reach \$450 million.

Post-fire water quality costs



Source: Santa Ana Watershed Project Authority



When charred landscapes are exposed to rain, debris and sediment can foul watercourses for years.

SAWPA estimates that more than \$20 million in water was lost to the sea due to degraded quality, increasing its reliance on imported water.

After the 2002 McNally Fire burned 150,000 acres near the Giant Sequoia National Monument, more than 50 million cubic yards of topsoil and debris washed into streams and Lake Isabella. The normally clear Kern River ran dark brown, thick with sediment a full year after the fire. Also, a year after the fire the California Water Service Company reported 500 percent sediment increases – power plants were closed because intake valves were clogged and fish hatcheries were closed for lack of clean water.

Comparing sediment loads

While erosion is a natural process and waterways will always have normal, or “background” sediment, the massive influx of debris into streams that follows catastrophic wildfires is neither natural nor normal. Immediate reforestation and erosion control efforts can reduce the amount of debris that reaches streams, but such efforts are rare on public forestlands. Appeals and lawsuits delay on-the-ground regeneration and often stop reforestation leaving watersheds exposed.

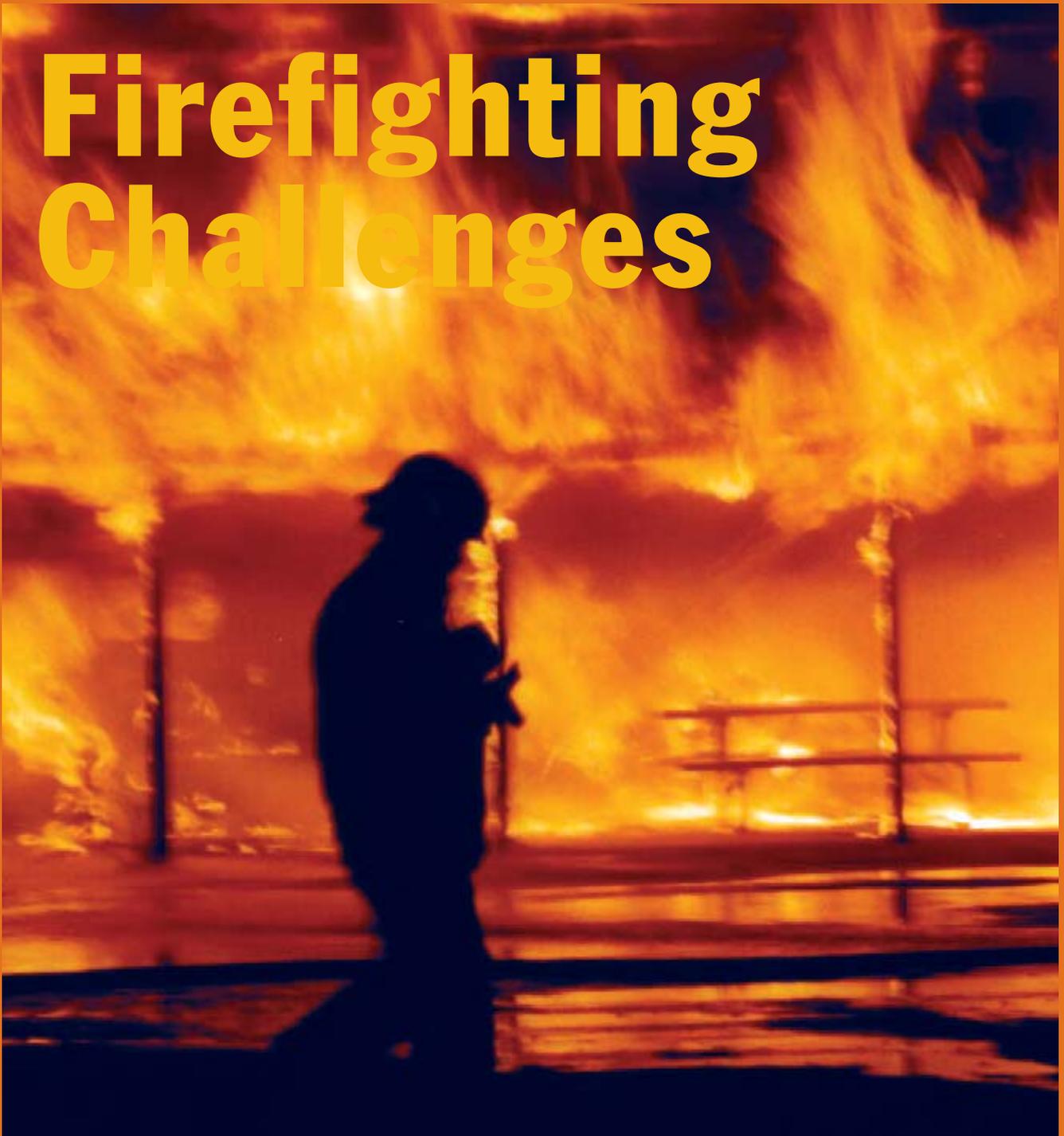


A full year after the McNally Fire, the Kern River ran brown with sediment, mud clogged water delivery systems and fish hatcheries were closed.

Whereas sediment loads can easily top 250 times their pre-fire levels when forests burn in severe fires, the forest management that could dramatically reduce the threat of those fires includes effective erosion-mitigation measures and produces little sediment. A study on California’s North Coast, for instance, found that tree harvesting operations accounted for about 2 percent of sediment in nearby streams, and only for a short time.

The way to break the cycle of fire, flood and mud that fouls our water and air is to manage forests to prevent the gigantic wildfires that cause such extensive damage. Restoring forests to their natural beauty and resistance to catastrophic fire would pay lasting dividends. ■

Firefighting Challenges



The High Cost of Firefighting

Catastrophic wildfire takes its toll in property and lives lost, as well as air and water quality degradation and environmental devastation. While communications and firefighting technology have helped make today's firefighters more efficient and effective than ever, wildfires are getting bigger, more destructive and more expensive to fight.

More than 2 million California acres burned between 2000 and 2006. In that time, more than 7,200 structures were destroyed and the damage caused by those fires exceeded \$1.4 billion.



Wildfires in California claimed more than two dozen lives, destroyed more than 7,200 structures, caused more than \$1.4 billion in damages and cost more than \$1 billion to fight between 2000 and 2006.

Taxpayer dollars up in smoke

Nationwide, taxpayers paid more than \$9 billion to fight fires on federal lands between 1994 and 2004. Californians spent more than \$1 billion on firefighting just between summer 2000 and spring 2006.

The trends behind the numbers are as alarming as the dollar figures themselves. In eight of the last 10 years, the California Department of Forestry and Fire Protection (CDF) has spent more than \$100 million fighting wildfires;

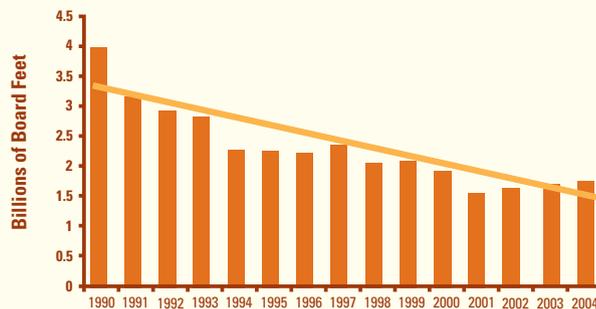
What's wrong with this picture?

Timber harvests in California have decreased 60 percent since 1990 – harvesting on government-owned lands is down about 90 percent. Now, California imports about 75 percent of the wood consumed in the state.

As public forestland has grown increasingly overcrowded over the same time period, California's wildfires have gotten larger and firefighting costs have skyrocketed.

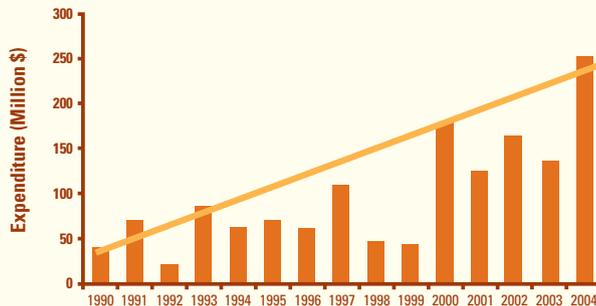
Timber Harvest Volume in California

Source: California Board of Equalization



CDF Fire Suppression Costs

Source: California Department of Forestry and Fire Protection





California's annual fire-suppression costs between 2000 and 2005 averaged nearly \$169 million according to the California Department of Forestry and Fire Protection.

before 1996, the most CDF had ever spent was \$86 million. CDF's average annual firefighting costs between 1990 and 1995 were almost \$63 million; between 2000 and 2005 the annual average jumped to nearly \$169 million. Not entirely coincidentally, timber harvesting plummeted between 1990 and 2005. Timber harvesting on California's government-owned forestland dropped nearly 90 percent during that time. Overall harvesting in California was down nearly 60 percent.

With more trees on the landscape, wildfires burn hotter across larger areas.

The extra fuel – unharvested trees and dense brush in overgrown forests – makes fires harder to put out. Furthermore, wildfires near heavily populated areas can prove more difficult and costly to fight. These fires pose the greatest threat to human lives and must be battled to the fullest extent possible.

Improving firefighting capacity will not solve California's wildfire crisis. Without managing forests to reduce fuel loads, firefighting costs are likely to continue to rise.

A better use of tax dollars

California is home to perhaps the best, most efficient firefighting agency in the world. Unfortunately, making firefighting organizations more effective won't solve the wildfire crisis. Nor will throwing money at the problem without addressing the root cause – overcrowded forests and aging brushfields.

However, we can reduce the fuel loads that drive catastrophic fires in the first place. We can make our forests safer by removing excess growth and dead trees. We can do so cost-effectively while enhancing biodiversity, water quality and air quality.

According to the *Journal of Forestry's* January/February 2006 edition, the average total fire damage and firefighting costs per acre in high-risk forests are:

- Fire suppression: \$481
- Facility losses: \$150
- Timber losses: \$772
- Regeneration: \$120

The same publication states the average costs per acre to reduce fuels and manage those forestlands safely are:

- Operational costs: \$374
- Forest Service contract preparation fees: \$206

Environmental benefit of fuel reduction: Priceless.

Fires are less severe and more easily contained in areas that have been thinned.



A simple analysis proves an old adage to be true: an ounce of prevention is better than a pound of cure. In the case of preventing or fighting wildfires, taxpayers could save an average of about \$940 per acre by investing in forest management. In California, an average of 172,000 acres burn in wildfires every year. In bad years, the number can exceed 300,000 acres.

Managing forests to reduce the threat of wildfire not only saves lives and pays environmental dividends, it can make productive use of a renewable resource that otherwise may burn.

A ray of hope

While fire season is an annual event in California, there are signs of hope.

Harvesting of trees in California forests increased slightly, by 1.1 percent in 2005 as efforts to thin overcrowded forests accelerated. While harvesting on government-owned forests did increase, it remains just 17 percent of what it was

in 1990. The trend of diminishing harvests and increasing firefighting costs must stop.

Following the Southern California firestorm of 2003, Governor Arnold Schwarzenegger convened a Blue Ribbon Commission to study what happened and make recommendations

to prevent such catastrophes in the future. The Commission's report supports forest management and reducing fuel loads. It says:

“The protection of life and property from wildfire cannot simply rely on the availability of firefighting resources.

Until the removal of thousands of acres of dead bark beetle infested trees and sound forest stewardship is achieved, Southern California and other forest areas in the state will continue to have hazardous standing fuel just waiting to become the next conflagration. Fuel reduction and fuel moderation programs are essential to reducing the potential threat of major ... fires.”

Unfortunately, the Commission's encouragement has yet to translate into significant forest management on the ground. Some gains have been made, primarily through Fire Safe Councils, one-time grants and private landowner action. But between 1989 and 2002, more than 700 legal challenges were filed in federal court to stop USDA Forest Service land management. Forest management efforts continue to be blocked by appeals and lawsuits, which makes it difficult to restore forests to safer, more natural conditions. ■

Many people equate protecting communities with constructing fuel breaks. Fuel breaks are areas manipulated to reduce fuel loads and curtail the spread of wildfire in forests, usually through very aggressive thinning. Unfortunately, fuel breaks provide a false sense of security more than effective fire protection.

Safety on the ground

Fuel breaks are strategically located strips of land where trees are heavily thinned and ground fuels removed. They provide attack points and relatively safe access for firefighters to battle a blaze with less severe fire behavior.

Way too much emphasis has been put on fuel breaks. Fuel breaks are part of the solution for protecting communities from wildfire but they won't work by themselves.

Fuel breaks have shortcomings from both fire protection and forest restoration perspectives. While fuel breaks can help drop a crown fire to the ground, for instance, they only provide meaningful protection if a sufficient firefighting force is deployed in the fuel break when the fire enters it. If firefighters aren't on the scene at that precise moment, the fire can actually accelerate through the fuel break at the surface level and erupt out the other side with the same fury it had before reaching the fuel break.

Furthermore, most fuel breaks are too small to stop a catastrophic fire – a 200-foot wall of flame can easily jump highways and other breaks. Catastrophic fires often launch firebrands – bits of



Fuel breaks often provide a false sense of security – wildfires can burn through or around fuel breaks, as happened in the 2001 Star Fire near Lake Tahoe that charred more than 16,000 acres.

burning branches, twigs and cones – a mile or more ahead of the main fire. Firebrands also catapult burning embers on rooftops. During the Los Alamos Fire of 2000, hundreds of homes, even those that had cleared defensible space, burned when firebrands from afar landed on pine needles near homes.

During the 2003 Southern California firestorm, hundreds of homes that were theoretically protected by fuel breaks burned. The Old Fire, for example, simply swept around the east and west

ends of Highway 18 that firefighters were using as a fuel break to protect Lake Arrowhead.

Unsilently scars

Fuel breaks not only provide inadequate community protection, they fail to restore forests or address the root cause of our wildfire crisis.

The extreme thinning used to construct most fuel breaks leaves tracts of forestland devoid of most plant and animal life. With understory and surface

vegetation removed, many fuel breaks look more like a sea of telephone poles than a forest. Biodiversity suffers in fuel breaks because wildlife needs a variety of vegetation for cover and food.

Fuel breaks are also expensive to construct and maintain – the maintenance is particularly important. If a fuel break is not maintained at 10 or 15-year intervals it will soon be overgrown with brush and other highly flammable fuels that can worsen fire conditions. This is happening all too

frequently throughout the West as fuel breaks built in the 1960s and 1970s have been abandoned due to budget constraints.

A better way

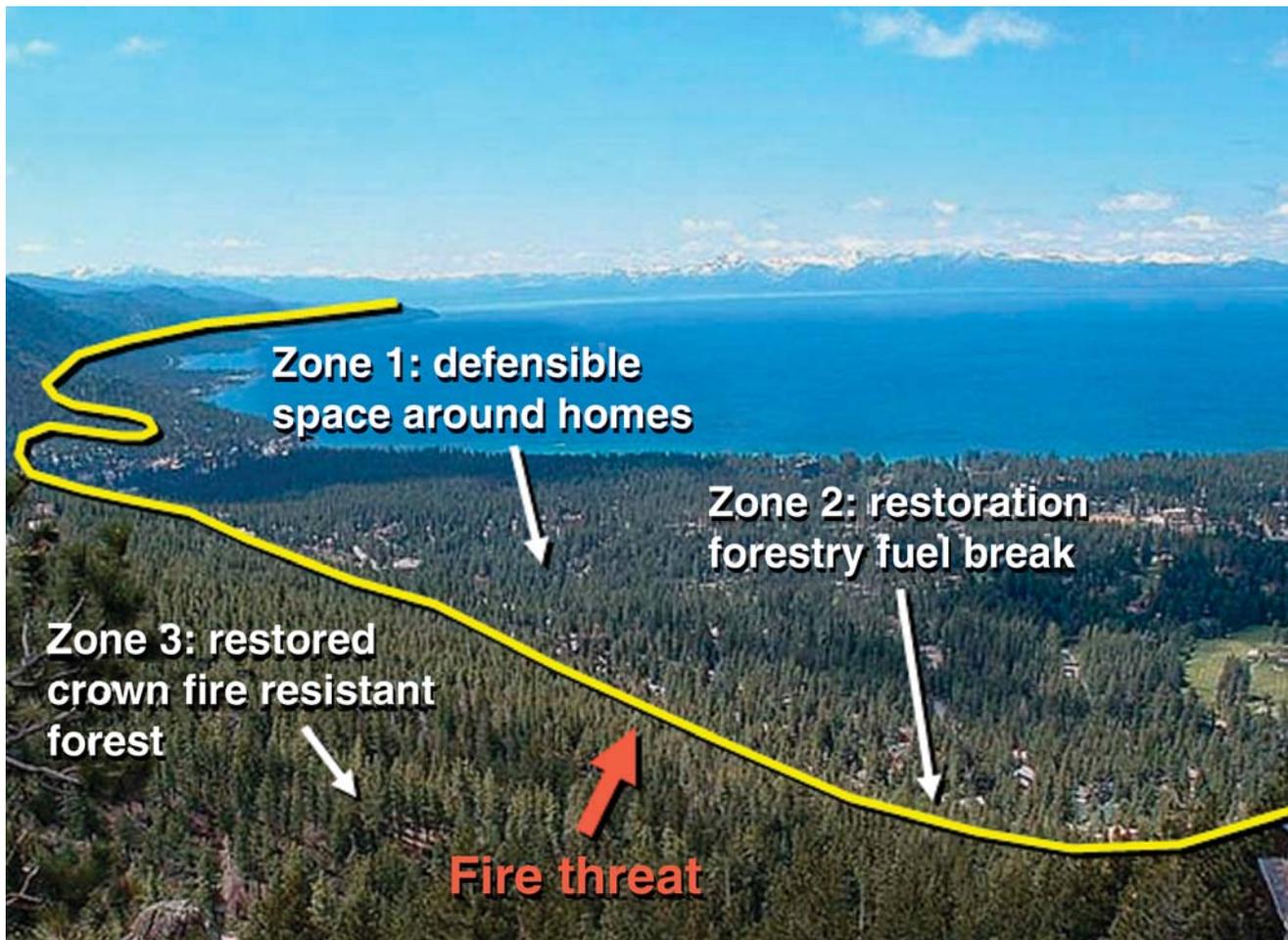
Restoration forestry offers a more effective, sustainable way to protect communities. It incorporates fuel breaks with moderate thinning as part of an overall plan rather than relying on narrow strips of heavily thinned forests that may or may not be placed effectively.

The real problem is that huge tracts of public forestlands are vastly overcrowded. As long as that remains true, communities near those forests will not be safe. Restoration forestry addresses that.

Whereas a fuel break is the last desperate line of defense, a restored forest provides the most effective first line strategy. Restoring forests so they look like historic forests in which catastrophic fire was rare is the best way to protect communities. By recreating a patchy

Fuel breaks, like this one in the Tahoe National Forest created eight years before this photo was taken, need expensive ongoing maintenance.





Meaningful, sustainable protection means establishing multiple layers of defense and fuels reduction.

forest mosaic with openings, young and open older forests and some dense stands of trees, there will be only limited opportunities for fires to reach the extreme temperatures they do today.

Levels of defense

The best way to protect communities is through restoration forestry and its levels of defense that include defensible space around structures, restoration fuel breaks, and restoring the forest at large.

The fires that threaten lives and property frequently start in distant forestlands. Addressing the whole forest and reducing fuel loads in a sustainable fashion, therefore, is essential.

Protecting communities with a practical solution requires establishing multiple zones that break up concentrations of highly flammable fuels. The use of fire-resistant roofing materials also is prudent where possible.

The first zone is defensible space near homes. California law requires that clearings extend at least 100 feet from a building. In the 30 feet closest to the home, grass or other low-lying vegetation is appropriate; firewood should be stored away from houses and tree limbs that hang over houses should be pruned. In the last 70 feet of the clearing, thin large trees so their crowns don't touch. In brushlands, thin 50 percent of the brush and remove lower limbs.



Communities in forested areas are safer when the forests around them are managed to reduce fuel loads.

The second zone is restoration fuel breaks around communities. Fuel breaks should be at least a quarter-mile wide. Restoration fuel breaks feature a patchy distribution of trees and shrubs with each patch a different age. Most patches should be small, generally less than a quarter acre. Surface and ladder fuels are removed, but some large logs and snags should be left near the outer edge. Restoration fuel breaks provide less severe burning conditions and serve as an anchor point for restoring the entire forest. They are also sustainable and provide habitat for wildlife.

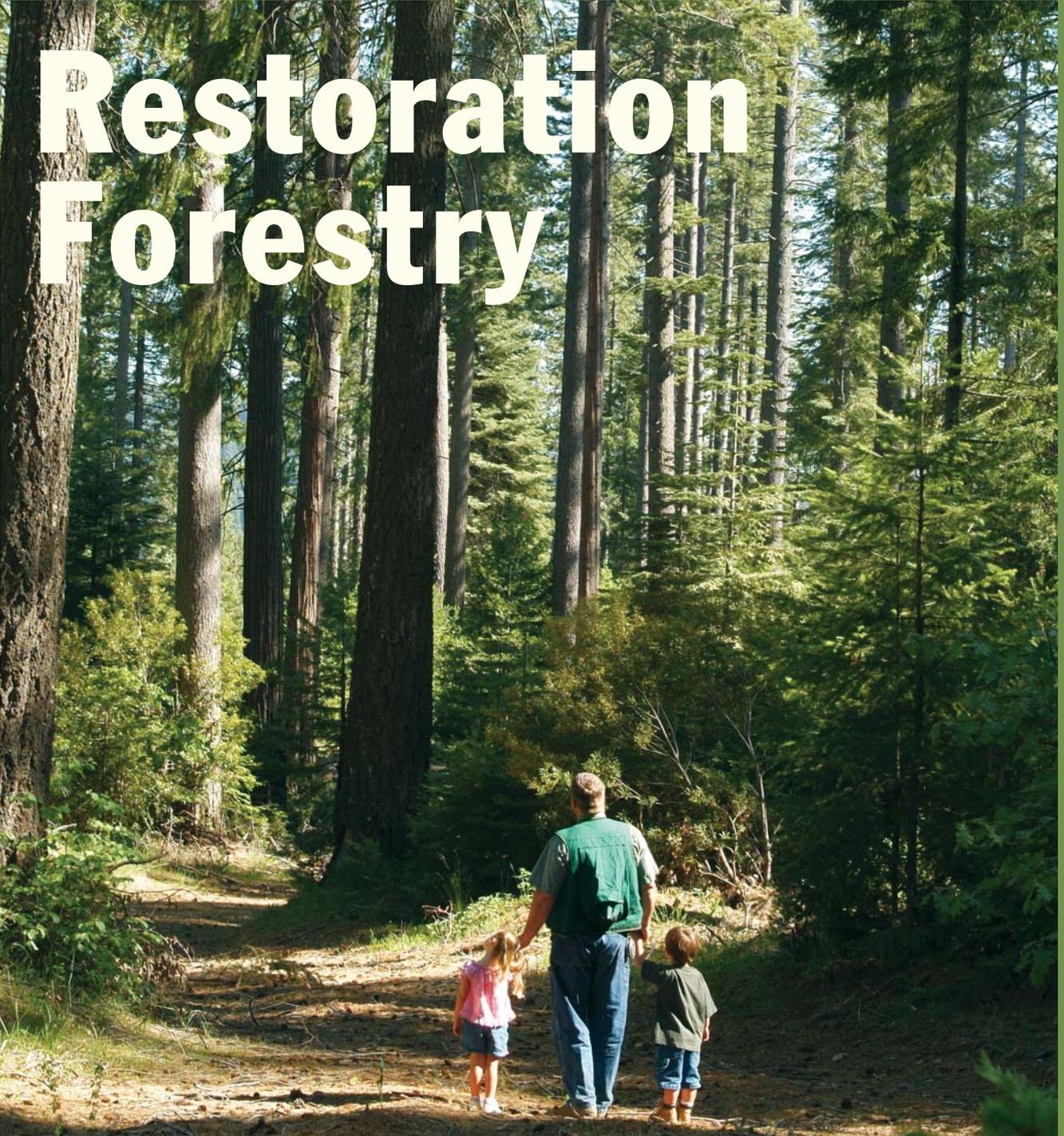
The third zone is restoring the forest beyond fuel breaks. This zone, the largest of all, will ultimately resemble historic forests with lesser concentrations of highly flammable fuels. Re-establishing the patchy forest mosaic that dominated California's lands before European settlement addresses the root cause of the wildfire crisis and can reduce the incidence of catastrophic wildfire.

While the same strategy can also restore brushlands, re-introducing low-intensity fire can help sustain reasonable fuel loads in brushlands. The goal in brushlands is to establish a mosaic in which half of the vegetation is less than 20 years old.

Sustained protection

More than 1,100 California communities face a high risk of catastrophic wildfire. Building and then abandoning isolated fuel breaks will not offer those communities relief. Sustaining a safer, more natural forest with modern forestry supported by a robust forestry infrastructure will protect people, forests and wildlife. ■

Restoration Forestry



Why We Must Restore Forests

Forests are among the most beautiful and renewable natural resources with which we have been entrusted. We have a moral obligation to make wise use of those resources and ensure that forests stand tall for future generations to use and enjoy.



Managing forests helps ensure they stand tall for generations and meet the needs of a growing population.

People expect a great many values from their forests, from recreation and spectacular vistas to clean water and air. Forests can also help reduce greenhouse gas emissions. And though few make the connection between forests and the 2x4s they buy at the hardware store, wood remains the most environmentally friendly available building material on the planet – non-renewable resources like steel and concrete require far more energy to produce and release greenhouse gases into the atmosphere.

The environmental disconnect

Modern conveniences tend to sever our ties to the land that feeds and shelters us. They distance us from how natural resources become homes, dinner tables and things we use every day.

More than 90 percent of Californians now live in urban or suburban environments where highways and mass transit are the norm, not complex ecosystems. That disconnect can do great harm. Not only to California's forests and families whose livelihoods depend on working the land, but also beyond our borders where trees are being harvested aggressively to meet the wood demand Californians create.

California has drastically reduced harvesting in the state, but Californians continue to consume wood at literally world-record levels. As a result, California now imports about 75 percent of the wood used in the state from places where Californians have no say on environmental practices.

While California transfers environmental responsibility for its wood consumption beyond state borders, less than one-third of new growth in California's forests is harvested. New growth, in fact, has exceeded harvest in California for decades – a report for the USDA Forest Service Pacific Northwest Research Station found that growth exceeds harvest on California's national forests by a ratio of almost six to one; thus the overcrowded conditions that now plague our government-owned forests and fuel the wildfire crisis.



Logs being off-loaded in Humboldt Bay. California, a state with more than 30 million acres of forest, now imports about 75 percent of the wood it consumes, according to CDF-FRAP.

As California grows – the state's population is forecast by the U.S. Census Bureau to reach 46.4 million by 2030 – more and more demands will be placed on California's forests. New Californians



California-grown wood is cultivated and harvested in accordance with the highest environmental standards in the world.

will expect abundant clean water and ample recreation opportunities that current Californians have. They will want to build homes for their families too.

Fortunately, California is recognized as a world leader in sustainable forestry, with some of the best education institutions and technology anywhere.

California-grown wood is cultivated and harvested in accordance with the highest environmental standards in the world. When private forestland in California is managed, it is managed sustainably.

Productive forests, safer forests

Better yet, the same management practices that can provide wood products and recreation opportunities can also reduce the threat of catastrophic wildfire. By reducing excess fuels and creating growing conditions that encourage naturally open forests to

return to California's landscape, the monster fires that now strike with shocking regularity can once again become rare occurrences.

California's history has been built on wood – from railroad trestles to the rise of mining towns and the rebuilding of San Francisco after the 1906 earthquake. Wood from the state's productive forests has helped make California what

it is. The state's climate and rich soils are perfect for growing trees. Today, harvesting trees in accordance with laws that require long-term sustainability plans can deliver myriad forest values



and ensure the survival of both forests and the wildlife that calls forests home.

In fact, many threatened and endangered species that concern us today could recover more quickly if

provided the variety of habitats that existed historically. Diverse wildlife, wood, recreation, safe communities, clean water and air are all among the comprehensive benefits of restoration forestry. ■

Wood helped build California. Wood is the only entirely renewable, recyclable and biodegradable resource we have. Sustainable forestry can provide wood and diverse forested landscapes.

How to Restore Forests

There is ample evidence that indicates recent declines in forest management have had undesirable consequences for forest health and wildlife. Yet public attitudes continue to be driven toward total preservation.

Leaving forests alone is not a sustainable approach to managing natural resources. People are dying in high-intensity wildfires, biodiversity is suffering, and the situation is getting worse as an increasing population puts more demands on forests. “Leave it alone” is a simplistic ideology that ignores the fact that native people helped create natural forests. Nor does it acknowledge that through inaction, people are creating dense forest conditions and fueling massive insect infestations and catastrophic wildfires.

Restoration forestry, on the other hand, is a real-world solution for addressing the forest health and wildfire crisis California is facing. It is a practical rather than ideological course of action that uses history as a guide and science as its tool to address the problem.

Restoration forestry is a comprehensive plan that could:

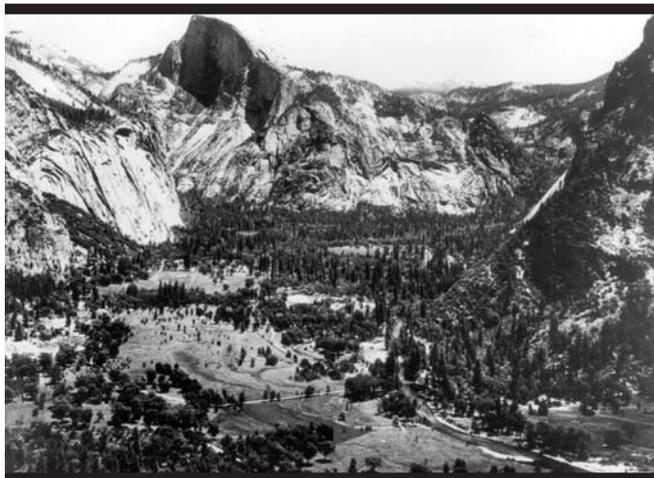
- Restore natural forest conditions to California’s landscape
- Reduce the threat of catastrophic wildfire

- Enhance biodiversity
- Protect water and air quality
- Pay for itself
- Encourage use of renewable resources
- Save taxpayers millions of dollars

Learning from history

Restoring forests must start with the understanding that California’s forests today stand in sharp contrast to historic forests that were more open because of lightning and native American-ignited fire. There is overwhelming evidence that by suppressing fires for more than

Today’s forests stand in sharp contrast to historic forests that were more open because of lightning and native American-ignited fire.



This photo shows the upper Yosemite Valley in 1899 with meadows occupying much of the valley floor.



This photo shows the same location in 1994 crowded with dense conifers and woody plants.

100 years and curtailing tree harvesting for decades, forests have become increasingly overcrowded.

Restoration forestry aims to restore ecologically and economically sustainable native forests that resemble historic forests. Fortunately, a great deal is known about California's forests before European settlement. We know, for instance, that those forests featured small patches of trees about the same age and size. We also know that patches moved through a cycle of development, from young to old, and the relative proportions of each type of patch that appeared on the landscape. In many mixed-conifer forests, for example, patches of old trees with a thick layer of smaller trees growing underneath covered less than 8-12 percent of the landscape.

Young forest patches begin in openings with full sunlight. They attract wildlife because of the lush vegetation. Middle-aged forests are characterized by an open understory because the thick canopy blocks sunlight. Mature and



Middle-aged forests feature an open understory and attract many diverse wildlife species.

older forests have taller, more widely spaced trees that provide enough sunlight for diverse understories, although gentle fires kept most of them open. Older forests tend to have large trees and more downed wood and snags

(dead, standing trees). As the succession cycle continues, older forests eventually become new openings where young forests renew the cycle, usually due to a fire or other disturbance such as bark beetle infestation.

Using pre-European settlement forests as a “reference historic forest,” restoration forestry can recreate similar landscapes with most of their original diversity. Such a reference historic forest is inherently sustainable and diverse. It represents thousands of years of ecological development and use by native people, it existed during a period with similar variations in climate, and it is more thoroughly documented than forests from an earlier time.

Trees must be harvested

Native people shaped their landscape primarily through the use of intentionally set fire, although they also cut trees. And while “prescribed burns” can be an effective forest-management technique today, they are just one tool in a forester’s toolkit.



This photo was taken in the 1890s. The location is along the east branch of the north fork of the Feather River in Plumas County, California. The area had not been logged.



This photo was taken in 1993 at the same location as the photo at left. The ridge to the left had been logged seven years earlier, the remaining landscape was untouched.



Mechanical harvesting allows efficient, precise tree removal.

Prescribed burns have their place in restoration forestry, but they do not make productive use of forest resources, do raise air quality concerns and cannot be used safely where forests are dangerously overgrown. Prescribed fires can and do get out of hand and cause considerable damage to communities that thought they were safe. The Los Alamos fire of 2000 was a prescribed burn that escaped. Research shows prescribed burns are more likely to escape in California than in any other state.

Mechanical tree harvesting also can be an effective forest-management technique. Today's harvesting technology is computer driven, light on the land, and precise. Combined with erosion control and wildlife habitat conservation strategies, mechanical harvesting can create a range of desired

forest conditions and restore forests while making productive use of forest resources.

Mechanical harvesting can be used to implement even-aged and uneven-aged forest management strategies. Even-aged management means harvesting most of the trees of a certain age or size from the landscape, leaving a few trees for wildlife habitat. Even-aged management, sometimes called "clearcutting," is rarely practiced on public lands and heavily regulated on private lands in California, restricted to small patches of land. It can create openings in dense forests and edge zones that allow biodiversity to flourish in a way similar to how fire created openings in historic forests.

Uneven-aged management involves harvesting selected trees of different

ages or sizes, or small patches of trees. When individual trees are removed it is called single-tree selection and when small patches of trees are removed it is called group selection. Single-tree and group selection are the most effective ways to restore and sustain California's public forests. The result is a thinned forest that retains much of its historical character and visual aesthetics.

Most forest management includes replanting harvested land with native species acclimated to a site's elevation and other characteristics. On private forestlands for example, many trees are replanted for every one harvested.

Vision comes first

Restoration forestry focuses on what forests will look like after the land has been treated, not on what vegetation is being removed. While densely packed smaller trees may present the greatest fire danger, for instance, removing only young trees would ultimately result in a senior-citizen forest that would present its own challenges. You don't want just old, decaying trees on the landscape; they are not productive, diverse, nor sustainable.

This is why the reference historic forest is so important. By understanding the forest characteristics that were present historically in a region, forest managers can return those characteristics to the landscape. Restoration forestry simulates the dynamic character of historic forests by maintaining the natural variation of patches of older and younger trees within the forest mosaic.

To get back to a natural forest landscape, trees of all ages must be harvested in different numbers at different times. While older forests must be part of the



Having a vision of what a restored forest should look like when work is completed is essential before work starts.

mosaic, for instance, harvesting some older trees provides space for new, young forests that are essential in establishing a sustainable cycle of forest succession.

Flexibility required

Under the restoration forestry umbrella, foresters must have a full set of tools at their disposal and the flexibility to manage each forest as site-specific characteristics dictate. The one-size-

fits-all regulations that govern private forest management in California and most public forests will likely prove too restrictive to encourage true forest restoration. A focus on results would be preferred.

Different types of forests require customized treatments, even though the restoration concepts are the same. For instance, a forester's approach to a coastal redwood forest would be

markedly different from that of an inland mixed-conifer forest, but in each case, the plan would result in the types of patches historically found on the landscape and in similar proportion. [For more information of restoring specific types of forests, visit www.calforestfoundation.org.]

People have altered the natural fire regime and forest landscape. It's up to people to restore it. ■

What To Do with the Excess Fuel

There is no doubt that California's forests are plagued with excess fuels. What remains to be seen is how those fuels are dealt with. We could simply leave it there and watch it burn, we could remove some of it in prescribed burns or we can harvest it and put it to good use.

Sometimes in their rush to "save" forests, people forget that wood is a renewable resource. We use wood products every day, from lumber and furniture for homes to newspapers, cardboard – even camera film, cosmetics and cellophane wrap are made with wood byproducts.

Wood is the only commercially available renewable, entirely recyclable and biodegradable building material. Dr. Patrick Moore, co-founder of Greenpeace notes, "We have been led to believe that when we use wood we are causing a bit of the forest to be lost. This is not the case. When we buy

Wood and wood products trap greenhouse gases for hundreds of years.



wood we send a signal into the marketplace to plant more trees, and produce more wood."

We have at the same time, too much wood standing in our forests and an increasing demand for wood products. Harvesting trees could play an important role in sustaining forests, enhancing biodiversity and providing the lifestyle Americans have come to expect. Restoration forestry acknowledges the relationship between forest health and the need for wood, and allows for both.

Clean energy

California's ongoing energy crunch, goals of deriving more energy from renewable sources, and efforts to reduce greenhouse gas emissions in the state to 1990 levels by 2020 highlight another possible use for excess forest growth: biomass energy.

Biomass energy is produced by burning organic material and converting the heat to electricity or even converting the biomass to fuel for cars. Because trees can be replanted, forest biomass represents a largely untapped source of renewable energy.

Utilizing biomass energy has several advantages, especially when seen in the

context of global climate change, greenhouse gas emissions and reducing the wildfire threat. Burning fossil fuels to generate energy releases tremendous amounts of carbon dioxide and other greenhouse gases into the atmosphere. Burning biomass to produce energy does not. In fact, biomass energy has a "net zero" carbon impact on the atmosphere.



Burning biomass material from forests can produce clean energy, reduce the threat of catastrophic wildfire and reduce greenhouse gas emissions.

The more energy we derive from renewable sources like biomass, the less need we have to burn fossil fuels that spew greenhouse gases into the air. Furthermore, the more excess fuels we burn to generate electricity, the less we have to watch burn in catastrophic wildfires.



Biomass materials must be chipped in the forest and transported to biomass power plants. Each chip van contains enough fuel to power one home for about 250 hours.

Unfortunately, California does not have a robust infrastructure for generating biomass energy. Plus, the process of harvesting materials from the forest – usually the smaller trees and overgrown brush with little or no commercial value – and transporting those fuels to energy plants is expensive. Without some financial incentives such as long-term stewardship contracts on public forests and tax credits to encourage private-sector investment, California is unlikely to realize the full potential of biomass energy as a substitute for fossil fuels.

Economic realities

Any plan to “save” forests that does not include a feasible way to pay for the expense of caring for forests has no place in meaningful forest-management discussions. Fantasy solutions have no value in the face of the very real dangers plaguing our forests.

Restoration forestry acknowledges what should be obvious but is often overlooked – there are significant costs involved with caring for forests. The technology and training necessary to manage forests are expensive. But the costs can be addressed without burdening taxpayers.

Because restoration forestry is a practical solution, it can improve forest health and biodiversity, reduce the threat of catastrophic wildfire, provide jobs and pay for itself. Selling the excess wood and biomass that must be removed to make forests safe again can cover the cost of restoring forests.

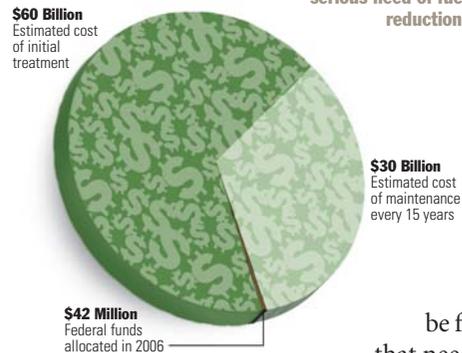
Putting a price on forest care

Exactly how much it costs to thin and care for forests varies from place to place and depends on both the forest-management techniques employed and site characteristics. According to data primarily relating to national forestlands in California, prescribed burning costs range from \$50 to \$400 per acre. Mechanical and manual treatment costs frequently exceed \$1,000 per acre.

In the Lake Tahoe Basin, fire districts report average thinning costs that top \$2,000 per acre. In the San Bernardino National Forest that was devastated by bark beetle attacks, costs in some areas topped \$5,000 per acre.

Some 37 million California acres face high, very high or extreme fire threats, and nationwide approximately 73 million acres of federal land are in serious need of fuel reduction.

Estimated costs for treating the 73 million acres of federal land nationwide in serious need of fuel reduction.



that most forests will require mechanical thinning before prescribed burning can be used safely, and assuming that prescribed burning will

be feasible on all acres

that need treatment, the total initial cost for treating America’s forests would be about \$60 billion.

At the current rate of government funding (\$400 million per year from 2001-2005; \$492 million in 2006), it



More than half of California's sawmills closed between 1990 and 2003.

would take 150 years to complete the initial treatment. By that time, the first forests treated could be even worse than they are now.

Furthermore, treated forests will have to be maintained in order to remain safe – at a cost of about \$30 billion every 15 years.

Public-private partnerships

Solving the wildfire crisis is too expensive to achieve with taxpayer funds alone. A practical solution dictates that the private sector must be involved.

The private sector has already made considerable investments in forestry science and technology. The latest high-technology harvesting equipment can cost upwards of a million dollars per machine. While the forestry and sawmill infrastructure in California has been decimated in the past two decades, it remains the most viable and efficient system for dealing with the volume of

wood that must be removed from the landscape.

The private sector, however, will not invest in making forests safer if it can't access the land that needs to be managed and expect to make a reasonable profit. How much money would you invest in building a new biomass energy facility, for instance, if you couldn't be sure you'd have fuels to burn? Land use restrictions have already reduced California's public forestland

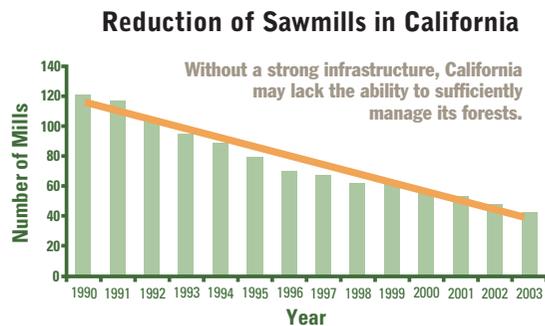
harvests roughly 90 percent since the late 1980s, and the trend of legal action making public lands off-limits to forest management shows no sign of abating – even though California foresters

adhere to some of the highest environmental standards anywhere.

Unless the trend of incessant appeals and lawsuits to block forest management is reversed, and the forestry companies are given reasonable assurances of long-term

access to lands that must be cared for, the private sector is unlikely to make a significant difference in addressing California's

forest health and wildfire crisis. It's time to embrace modern forestry and make managing forests a priority so that we ensure that we have future forests.



Source: California Forestry Association 1990-2003 mill census data

Multiple dividends

Engaging private forestry companies to help manage forestlands that pose a threat to communities would yield many benefits. Safety, biodiversity, greenhouse gas-emission reductions and funds to pay for much-needed forest restoration are chief among them.

While the private sector must be engaged to do much of the on-the-ground work, all efforts on public lands must remain subject to public oversight through the USDA Forest Service. In California, the public has the right to review and comment on forest management plans, whether public or private. California's current oversight processes, however, are in need of serious reform. As it is today, state and federal regulations often impede rather than help effective fire-safe management on private and public lands.

California's private-land regulations are so stringent that two separate studies by Cal Poly State University-San Luis Obispo have found they are having unintended consequences, including encouraging the conversion of forestland to non-forest uses such as housing developments. Regulatory costs also tend to make preventive thinning so expensive that some landowners, particularly with smaller parcels, are not able to treat the land effectively, which

CENTRAL AND EAST COUNTY CONTRA COSTA TIMES

Study: Rules could turn trees to condos

By Don Thompson
ASSOCIATED PRESS

SACRAMENTO — Californians are so proud and protective of their forests that they run the risk of damaging or destroying them, two university researchers warned.

State environmental protections have become cumbersome and expensive enough that small landowners and even large timber operators may throw up their hands in frustration, leaving forests potentially weakened by disease or increasingly vulnerable to devastating wildfires, according to a California Polytechnic State University study released Thursday.

ON THE WEB
Report: www.ufel.calpoly.edu

Dicus said.

To the contrary, California's forest protections aren't stringent enough, allowing wholesale conversion of private timberlands to forest "plantations," said Craig Thomas of the Sierra Nevada Forest Protection Campaign.

Thursday's study was funded and promoted by the California Forest Products Commission, an industry organization, though Dicus said he and CalPoly Un-



STATE ENVIRONMENTAL PROTECTIONS have become cumbersome and expensive enough that landowners may throw up their hands, according to a Cal Poly study released Thursday. ASSOCIATED PRESS/FILE

worsens the fire problem for everyone.

On public lands, abuse of the appeals process costs taxpayers millions of dollars each year. Some fuel-reduction projects are delayed so long the forests they are meant to protect burn before they are treated. Almost every post-fire restoration plan is challenged and often delayed to the point where it becomes impossible to carry out restoration activities. Once-vibrant forests instead become brush fields littered with charred tree trunks and branches.

Focusing on sustainable forestry and positive results should be the goal of forestry policies and regulations. Right now, those goals are absent, and people, wildlife and forests are suffering as a result.

California's strict forest-management regulations are having unintended consequences that harm forest health.

Additional savings

Not only can involving the private sector alleviate the tax burden of paying to restore forests, it can also significantly reduce firefighting costs. Restored forests are far less susceptible to catastrophic wildfire than today's overgrown forests. Restoration forestry is the key to sustaining current and future forests and stopping the trend of escalating firefighting costs. ■

Post-Fire Restoration

Forests that are destroyed by wildfire must be restored.

Most Californians have no idea that California has at least 84,000 acres of scorched public land in need of restoration, or that the USDA Forest Service has replanted and/or released seedlings from being overtopped by brush on less than 5 percent of California's national forests devastated by wildfire in 2001.

The harm in doing nothing

After a catastrophic wildfire, doing nothing to restore the forest can be as destructive as the fire itself. Post-fire rain can lead to massive erosion and mudslides. Once the vegetation has burned and the roots have decayed, there's very little to hold soils on hillsides. Charred trees falling on top of each other also increase future fire danger.

On mixed-conifer forestlands, shrubs and hardwoods often sprout quickly after severe fires. They fiercely compete for nutrients and water, and choke out emerging tree seedlings. In large burns, which are common today, there often are insufficient living trees remaining to re-seed the area, so brush replaces the forest.

The difference between reforesting charred landscapes and leaving them alone to "let nature take its course" can be as stark as night and day. Private forestland owners generally harvest dead trees after fires to accelerate the return of a healthy forest and keep their land productive. They plant native-species, mitigate erosion, and provide snags and logs for wildlife.

But on public lands, it's a different story. In many places where private land borders public forestland, a distinct post-fire property line emerges with green trees on the private side, shrubs and charred dead trees on the other. Without reforestation, forestland conversion to brush fields may be permanent or delayed by a century or more.

Costly delays

Removing dead trees and creating a landscape where trees can grow is a critical first step in post-fire reforestation. Timing, however, is everything.

Taxpayers alone cannot bear the cost of restoring forests – there is far too little public money available to treat the land

Following the 1992 Cleveland Fire in the Eldorado National Forest, the USDA Forest Service replanted some lands and left some untouched in an experimental area. Today, 15-foot tall trees stand on replanted lands (right), but brush dominates the untreated areas (below).



and fund replanting. The solution lies in engaging the private sector, allowing forestry companies to sell the dead wood they harvest to cover the cost of planning, site preparation and reforestation.

But delays can be fatal.

According to the USDA Forest Service, delays from overanalyzing options and scientifically unfounded appeals of post-fire restoration projects cost taxpayers nearly \$5 million in 2001 in the Tahoe National Forest alone. Why? Because fire-killed trees rot and lose their value quickly, usually in a year or two. Delays mean money that the Forest Service could earn by selling the dead trees (which, if not harvested become fuel for the next fire and prolongs forest regeneration) instead becomes lost revenue. Consequently, reforestation that could be self-funding goes largely undone.

For most of the last half-century, charred forests were harvested and replanted as a matter of course and common sense – it was considered irresponsible to waste this resource and let the forest turn to brush. Many forests we enjoy today, like those east of Sacramento that surround the Big and Sugar Pine reservoirs, are the result of post-fire restoration.

Today, more often than not, activist lawsuits and appeals cause delays that make reforestation economically impossible.

Choices must be made. Is it preferable to leave hillsides blackened and bare? Should we harvest other forestland elsewhere more aggressively, or turn to countries with lesser environmental standards to make up for the wood lost? Should we stop using wood in favor of non-renewable materials like concrete

and steel that increase greenhouse gas emissions and rely on fossil fuels?

Reforesting burned forestland makes more sense.

Formula for success

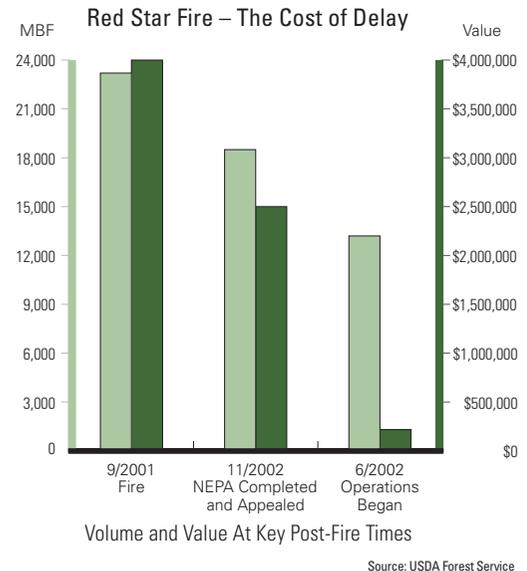
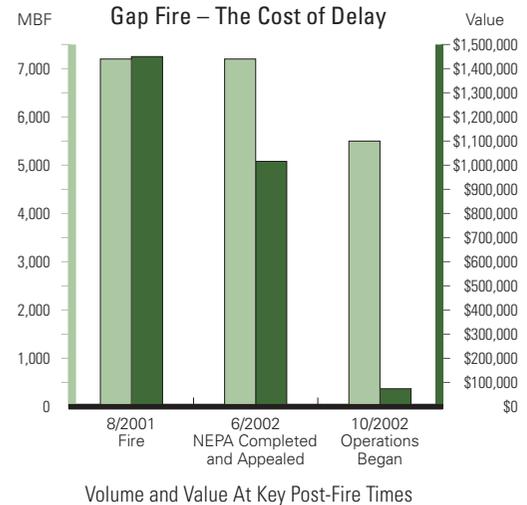
We have the science and technology to harvest, replant and manage forests safely and efficiently after a wildfire. We can harvest wood and mitigate erosion. We can renew forests while providing diverse wildlife habitat and help meet a growing demand for wood.

The recipe for restoring fire-killed forests is straightforward. After careful preparation, cut most, but not all the dead trees, leaving sufficient habitat for species that do well in burned forests. Sell the logs to sawmills to be turned into wood products, and use the revenue generated to pay for removing the slash left behind and replanting the forest. Replant native trees in a patchy mosaic so the forest develops naturally. This includes leaving enough snags and logs for wildlife habitat, and returning a few years after planting to remove competing brush so trees grow quickly and are protected against future wildfires.

It will take several decades, but a natural forest will return to the landscape with active reforestation. The alternative is a brush field that may, or may not, eventually become a forest if left alone. ■

The Costs of Delay in Post-Fire Restoration Projects

■ MBF = thousands of board feet ■ Value in real dollars



Source: USDA Forest Service

Removing burnt trees quickly has economic and ecological advantages. Delays in harvesting fire-killed trees after the Gap and Star Fires in the Tahoe National Forest resulted in \$4.7 million in lost revenue that could have funded restoration of the burned areas. They also resulted in an increased fire risk. If left on the land, dead trees eventually fall to the ground and become fuel for inevitable future fires.

Science and Technology

The science and technology applied to manage California's forests is among the most advanced in the world. The education requirements to become a Registered Professional Forester (RPF) in California are the strictest in the nation, and the environmental standards set by state law rival the most highly respected, independent sustainable-forestry certification programs.

Furthermore, the technology used to carry out forest management plans on the ground, from satellite imaging and mapping systems to light-touch harvesting equipment that use trimmed branches to form a carpet for the machinery to walk on, are state-of-the-art. Even at sawmills – where incoming logs are computer-scanned, laser-guided blades make the most efficient cuts possible, and virtually 100 percent of each log is put to use – innovative technology is the rule in dealing with forest resources.

An army of “ologists”

While many people equate logging – the physical act of cutting trees and loading them on trucks – with forestry or forest management, logging is only one small part of the process. It is perhaps the most visible aspect of forest management, but on private lands, for instance, no legal harvesting can take place until wildlife biologists, hydrologists, archaeologists, fisheries



biologists, geologists and other specialists work with an RPF to develop and approve comprehensive land management plans.

In California, it generally takes seven years of higher education and passing the equivalent of the attorneys' bar exam to become an RPF. Forest management plans must comply with long-term sustainability objectives and frequently encompass a 100-year planning horizon. All plans must be approved by the California

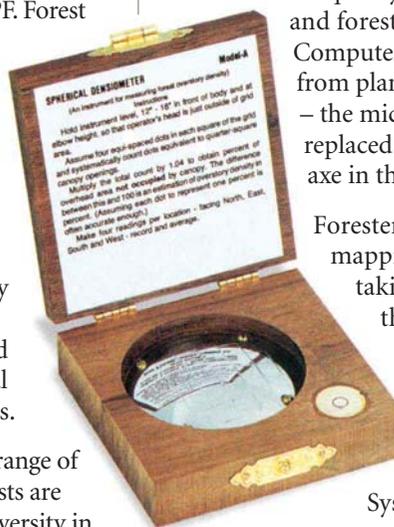
Department of Forestry and Fire Protection and regional water quality control boards.

Foresters depend on a wide range of scientific input because forests are complex. Maintaining biodiversity in productive forests, for example, requires establishing a balance of different age trees, shrubs and meadows on the landscape. This creates a forest that will

support a broad range of wildlife – not just large numbers of one kind of animal, but many kinds of animals – while taking care to conserve clean water and fertile soils.

Tools of the trade

Forestry professionals rely on sophisticated equipment to measure soil quality, canopy density and forest health. Computers are pervasive from planning to harvest – the microchip has replaced Paul Bunyan's axe in the woods.



Foresters often start by mapping a forest and taking inventory of the species, ages and sizes of trees present. They use Global Positioning Systems (GPS),

Today's forester's toolkit includes densiometers, Global Positioning Systems, infrared sensors and plenty of high-tech equipment.

Geographic Information Systems (GIS) and relational databases to capture comprehensive information about geographic characteristics as well as computer modeling software to help predict how a forest will respond to fire or other events.

Foresters also use lasers and Light Detection and Ranging (LIDAR) technology in their survey and mapping efforts. In conjunction with handheld lasers, these tools help foresters collect inventory and measurement data with remarkable precision. To effectively scan larger land areas, foresters employ remote sensors, infrared satellite imagery, laser altimetry and other radar-like equipment.

From densiometers that measure canopy coverage to hand-held, laser-based hypsometers that measure tree height, diameter, volume and other forest attributes, modern forestry has gone high-tech.

Making the cut

Harvesting technology continues to evolve with greater precision and efficiency. Some harvesting machinery actually makes about the same impression on the forest floor as does a person on a hike.

Some of the newest systems feature cabs that look like cockpits, with joysticks, computer screens and remote control saws. Even in dense forests, they can remove one tree without touching the trees next to it. Unfortunately, these machines are very expensive – often more than \$1 million – and harvest restrictions tend to discourage people from investing in the best equipment available.



Modern computer-driven harvesting technology is precise and remarkably light on the land.

One common piece of harvesting technology is called the Feller-Buncher. A Feller-Buncher uses a robotic arm to grip a tree while a circular saw cuts it at its base. The robotic arm then neatly stacks the felled tree in a pile and moves on to the next tree to be harvested.

Cut-to-length (CTL) processors are also popular for mechanical harvesting. CTLs fell and trim trees in one motion with a sophisticated processor head. With a cut-to-length processor, the operator uses onboard computers to measure the tree to be harvested and

adjusts its blades. CTL systems cut the tree at its base, then remove the limbs and cut the tree into desired lengths in just a few seconds.

Masticators are tools with tremendous potential. Masticators chew-up vegetation and leave it on the forest floor. They can convert brush and trees up to 18 inches in diameter into mulch in seconds. Masticators are gentle on the land and the mulch they produce add nutrients to the soil. Masticators can offer a safe and effective way to clear understory trees and heavy brush in



Masticators and other harvesting equipment use tree limbs to create a “slash mat” to walk on, which can protect the ground and enrich soils.

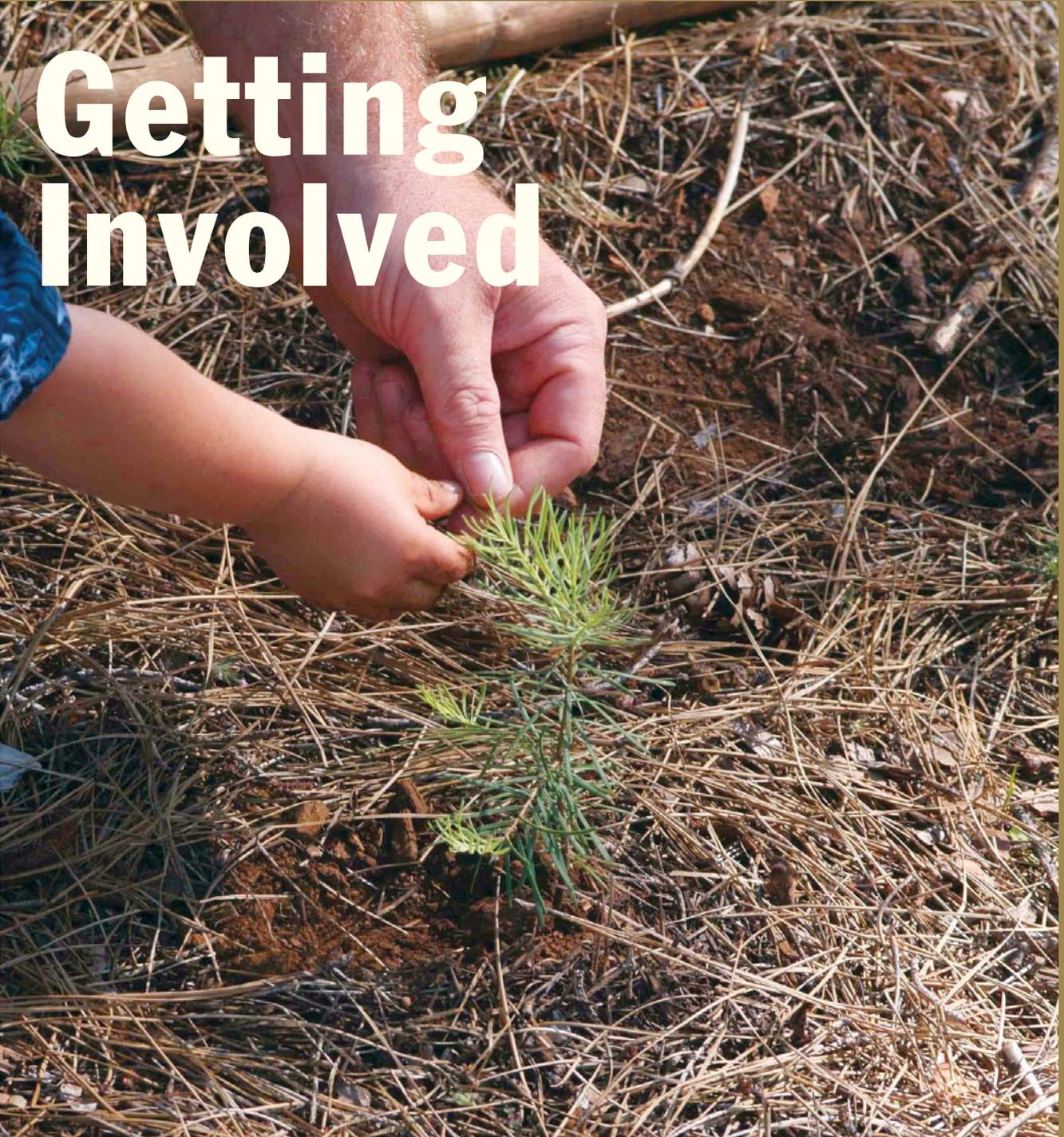
places that are too dangerous for prescribed burning. Because they don't produce a merchantable product, however, they are too expensive for widespread application.

Helicopters are sometimes used in logging efforts in hard to get places or where slopes are steep. Helicopters reduce the need to build roads but are a very expensive way to remove logs from the land.

California advantage

California is a hotbed of both computer technology innovation and world-renowned forest science. The combination bodes well as California continues to stake its claim as a global leader in sustainable forestry. ■

Getting Involved



What You Can Do To Help

How California's forests look 10, 50 or 100 years from now depends on the decisions we make today.

Most Californians sit on the side of forest management debates. As long as they can buy lumber and vacation in forested mountains, all must be right with the world.

But staying silent on the sidelines while our forests decay may very well mean that vacation opportunities disappear and we become even more dependent on imported resources.

Education, priority one

Education must be the agent of change that saves California's forests. There is a practical solution to minimizing the threat of catastrophic wildfire and making our forests safe again – the same solution is also the key to protecting air quality, enhancing biodiversity, ensuring clean water, and saving taxpayers millions of dollars every year on firefighting costs. The solution is restoration forestry, using history as a guide to restore natural forests.

Unfortunately, misinformation is common when it comes to forest management. You must be willing to ask questions and learn how to act in the best interests of your community. There are avenues through which to get involved.

The Forest Foundation supports education programs that bring students into forests and forests into classrooms.



It is important to distinguish between fact and fiction regarding certain myths that may advance agendas but block ecologically sound forest management. Those myths include:

Myth #1: We have to live with catastrophic wildfire. No, we don't. Managing our forests to reduce fuel loads can make them safe again. Catastrophic wildfire was not a frequent occurrence in California's historic forests; it need not be frequent today.

Myth #2: Fire is natural and good. There is a world of difference between the low-intensity fires that shaped California's landscape for thousands of years and the mega-fires that now devastate thousands of acres at a time. Low-level fires cleared the forest floor of debris and regenerated forests. But we have suppressed natural fire for more than 100 years. Wildfires can now feast on unnatural fuel loads, decimate wildlife, sterilize soils and erase forests from the landscape for centuries.

Myth #3: Today's forests are natural forests. Research and photographic evidence show that California's modern forests are vastly different from historic forests. Today's forests are far thicker than their historic predecessors, densely packed with up to 10 times as many trees. Forests have become dangerously overgrown, much to the detriment of wildlife and biodiversity.

Myth #4: Escalating firefighting costs are inevitable. It's true that average firefighting costs have increased by more than \$100 million per year since the early 1990s, but the trend does not have to continue. Spending a fraction of what we spend on fighting fires to manage forests so there are fewer dangerous fires in the first place could save taxpayers millions.

Myth #5: Commercial logging denudes hillsides and kills wildlife. Private forestland owners have proven that modern forest management can provide habitat for diverse wildlife and sustain forests for generations. The most productive forestland in California is privately owned, and research confirms that wildlife and fisheries from salmon and owls to deer and songbirds flourish on managed lands.

The Forest Foundation makes standards-based curriculum materials free to K-12 teachers and offers an interactive forestry-simulation CD for high schools and colleges. Other sources for information on sustainable forestry include the Temperate Forest Foundation (www.forestinfo.org), California Foundation for Agriculture in the Classroom (www.cfaitc.org) and the Northern California Society of American Foresters (www.norcalsaf.org).

Be fire safe

Until our public forests have been restored to their natural condition, they are likely to present certain dangers. Take responsibility for protecting yourself to the best of your ability, and get involved with community or grassroots efforts.

Creating defensible space around dwellings and other structures is of paramount importance. It is neither a complete solution nor a guarantee of safety, but clearing 100 feet of defensible space as required by California law gives you and your home the best chance of surviving a catastrophic fire. Follow all local ordinances as they pertain to fire safety.

All citizens have the right to engage their elected officials regarding forestry and land management policies. Write letters and encourage sustainable forestry at all levels of government. You may also comment on private forest-management plans as well as USDA Forest Service plans through public review processes.

Perhaps the easiest means for getting involved in improving forest health and community safety is through your local Fire Safe Council. Fire Safe Councils are often creative organizations that

promote wildfire protection and have access to grant money to fund projects on the ground. More information about getting involved with the Fire Safe Council program can be found at www.firesafecouncil.org.

Ensuring future forests

The legacy that we pass on to future generations will be determined by the actions we take, or fail to take, to restore our forests. California has never faced such a dire forest health and wildfire crisis. Millions of acres stand overcrowded, diseased and ready to burn. If we embrace restoration forestry and actively care for the resources with which we have been entrusted, California may never face such a crisis again. ■



The choice is clear: We can abandon our forests, restrict forest management and become increasingly dependent on imported resources or we can restore forests, sustain biologically diverse landscapes and spectacular recreational opportunities, and manage California's renewable resources to meet the demands of a growing population.

About the Author

Dr. Thomas Bonnicksen is a distinguished expert on our nation's forests. He has studied California's forests for more than 35 years and his work emphasizes the history and restoration of North America's native forests. He has addressed forest health, policy and fire-related issues before the United States Congress, on national television, with community leaders throughout California and with the U.S. Secretary of Agriculture.

Dr. Bonnicksen earned his B.S. in forestry (with minors in wildlife and range management), an M.S. in forest ecology, and a Ph.D. in forest policy, all from the University of California-Berkeley. He is professor emeritus of forest science and a former department head at Texas A&M University.

Dr. Bonnicksen is visiting scholar and board member of The Forest Foundation in California, and scientific advisor to the

Temperate Forest Foundation in Oregon. He is cofounder of the International Society for Ecological Restoration and a former member of its board of directors. He also has held posts as president, chair, and vice-chair of several other organizations, including the Bay Area Chapter of the Sierra Club and the Southwest Wisconsin Chapter of the Society of American Foresters. Dr. Bonnicksen also is a U.S. Navy veteran, former U. S. National Park Service ranger, and in 2002 received the Presidential Award for Excellence in Public Service.

Dr. Bonnicksen has testified before U. S. House of Representatives and U.S. Senate committees 13 times and has given seven congressional and secretarial briefings. He has served on several congressional fact-finding missions, including the Yellowstone fires of 1988 and the Southern California wildfires of 2003. He has served on many congressional and state advisory committees, most recently as a member of the U.S.

Senate's California Forest EIS Review Committee and the U.S. House of Representatives' Forest Health Science Panel, and briefed several California state government committees. Dr. Bonnicksen also drafted legislation to create a system of national historic forests. Congressman Mike Simpson (2nd District of Idaho) introduced the Act (H.R. 2119) and held congressional hearings in June 2001.

Dr. Bonnicksen has published more than 100 scientific and technical papers, articles, textbook chapters, and other publications, six computer programs and four multimedia CDs. He also authored the book *America's Ancient Forests: from the Ice Age to the Age of Discovery* (John Wiley & Sons, Inc. Copyright 2000). The book documents the 18,000 year history of North America's native forests. It includes the role of Native Americans in the development of these forests, and descriptions by explorers who saw them first. ■

Acknowledgements

Restoration forestry is a specialization within the forestry profession. Its roots go back to four scientists who had the foresight to see that people can play a constructive role in restoring and sustaining historic forests.

It began with Aldo Leopold who advocated constructing samples of Wisconsin's historic forests in the University of Wisconsin Arboretum to show people what they had before farming, urbanization, and other resource uses took their toll. In his dedication speech for the Arboretum on June 17, 1934, Aldo Leopold said, "The time has come for science to busy itself with the earth itself. The first step is to reconstruct a sample of what we had to start with."

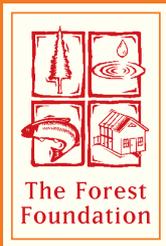
Aldo Leopold's son, the late Dr. A. Starker Leopold, a University of California-Berkeley professor, expanded the concept of restoration by recognizing that Native Americans played an important role in creating and maintaining historic forests.

As chair of the Committee on Wildlife Management in the National Parks (the Leopold Committee), Dr. Leopold also used restoration to clarify the goal of national parks. In 1963, the committee recommended that, "the goal of managing the national parks and monuments should be to preserve, or where necessary to recreate, the ecologic [sic] scene as viewed by the first European visitors." A National Academy of Sciences Advisory Committee supported this goal.

In 1965, the late Dr. Edward C. Stone, also a University of California-Berkeley professor, published a paper in *Science* that advocated training restoration professionals to carry out the recommendations of the Leopold Committee. About that time, the late Dr. Harold H. Biswell, a close colleague of Dr. Leopold and Dr. Stone at Berkeley, led the movement to restore fire to its historic role in native forests.

Dr. Thomas M. Bonnicksen studied under Drs. Leopold, Stone and Biswell, and later worked with them conducting research and teaching about the history and restoration of historic native forests. Dr. Bonnicksen named the field "restoration forestry." ■





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