SIERRA NEVADA
CONSERVANCY

Since the last *State of the Sierra Nevada's Forests* report, conditions have worsened. The solutions remain the same, but the need for action is more urgent.

THE STATE OF THE SIERRA NEVADA'S FORESTS

FROM BAD TO WORSE

An update to the 2014 report, this version was released by the Sierra Nevada Conservancy on March 1, 2017.

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The Sierra Nevada Conservancy is a state agency that carries out a mission of protecting the environment and economy in a complementary fashion across 25 million acres, one-quarter of the state. To learn more, visit sierranevada.ca.gov.

Cover photo: Mariposa County tree mortality. Back cover photo: aftermath of the 2015 Butte Fire, courtesy Bureau of Land Management.

EXECUTIVE SUMMARY

THE STATE OF THE SIERRA NEVADA'S FORESTS: *FROM BAD TO WORSE*

When the first *State of the Sierra Nevada's Forests* report was released in 2014, conditions in the Sierra Nevada appeared to be at their worst. The Region had just experienced its largest fire in recorded history, the 2013 Rim Fire, and the trend toward larger, more severe wildfires in Sierra Forests was already clear. Restoration efforts in the Sierra were grossly out of pace with what was needed, and overgrown forests were starting to show signs of stress from only two years of drought. When the 2014 report was released, tree mortality wasn't even mentioned.

What came next poured fuel onto an already raging fire.

Three factors combined to create the perfect storm in the Sierra: overgrown, unhealthy forests; two more years of extreme drought; and one of the warmest winters on record. These three elements opened the door to a significant increase in the native bark beetle population, and led to unprecedented tree die-off across the Region. Between 2014 and 2016, 83 million trees died in the Sierra Nevada from overgrown forests, bark beetles, and drought. Drought, warmer temperatures, and overgrown forests also fueled more large, damaging wildfires. The 2014 King Fire consumed nearly 100,000 acres across the Upper American River watershed. Almost 50 percent of the fire area burned at high severity,[1] leaving little to no living vegetation behind. The Butte Fire in 2015 burned more than 70,000 acres within the Calaveras and Mokelumne River watersheds and destroyed 549 homes.[2] Between 2014 and 2016 these fires, among others, added 30 million dead trees to the already unprecedented total in the Sierra Nevada Region.

Figure 1. In the Sierra, more than 80 million trees have died since 2014 as a result of bark beetles. Add to that total an estimated 30 million more killed by wildfire for a total of more than 110 million trees dead in three years.

Figure 2. Tree mortality near Bass Lake in Madera County.

Drought, bark beetles, and wildfire are all natural occurrences in the Sierra, but what is happening today is not natural or normal.

- Today many Sierra forests host 300 or 400 trees per acre where there used to be 50 to 80.[3]
- Overgrown and unhealthy forests provide optimum conditions for the spread of bark beetles. The overabundance of host trees in close proximity facilitates beetle movement across the stand. Dense forests also limit air flow through the stand, allowing the chemical signals the beetles rely upon for coordinated attacks to persist longer.[4]
- Dead trees provide important habitat and forest structure, but the Sierra Nevada Region is experiencing tree die-off from drought and bark beetles at an unprecedented scale. In many areas of the southern Sierra, more than 50 percent of pines, and as much 80 to 100 percent in the heavily impacted areas, have died.[5]
- Fires that once revitalized forests are instead destroying them, resulting in massive amounts of dead trees. The increasing size of individual wildfires is resulting in larger patches of complete tree die-off, which can eliminate habitat and limit regrowth of the forest due to a lack of seed source.[6, 7, 8, 9, 10]
- Despite the sophistication of our current fire suppression efforts, conditions are leading to fires that burn larger portions of the forests. On the west slope of the Sierra Nevada more acres have already burned this decade, with three fire seasons yet to go, than in any previously recorded decade (figure 3).

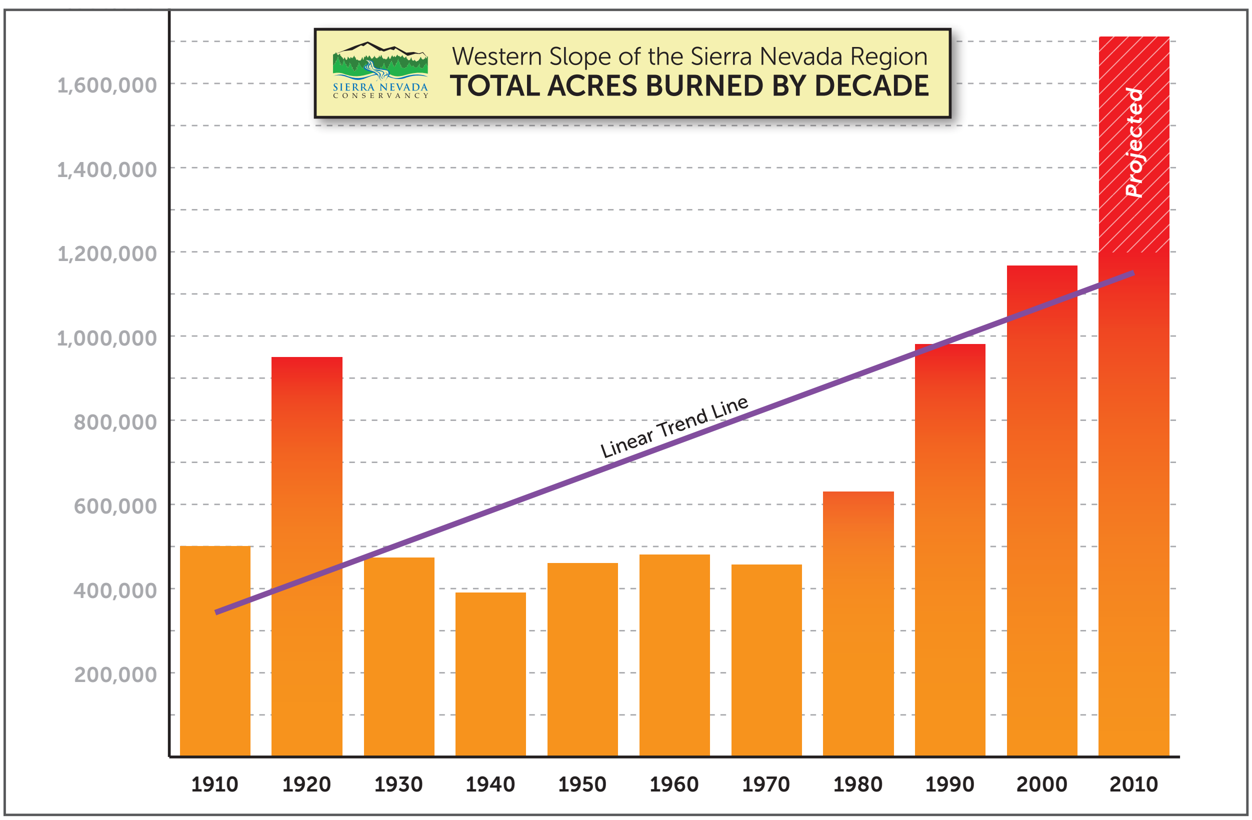

Figure 3. Total acres burned across the west slope of the Sierra Nevada Region over the last century. The hash marks on 2010 indicate the acres projected to burn in the 2017–2019 fire seasons based on the average acres burned each year in the current decade.

Devastating tree die-off from overcrowded forests, drought, and bark beetles, combined with large, severe wildfires is causing key adverse impacts.

- Threats to public safety and infrastructure from falling trees
- Increased sediment production affecting water quality and water infrastructure
- Financial burden on local homeowners and local/state government to remove dead trees and/or clean up after severe wildfire
- Taxpayer burden in the form of inflated costs due to increased fire suppression, fire cleanup, structure damage, and increased sedimentation
- Increased short-term and long-term fire danger
- Loss of a significant amount of carbon absorbed and stored, and an increase in greenhouse gas emissions
- Loss of critical wildlife habitat
- Loss of revenue from tourism and recreation

Overgrown, unhealthy forests are the underlying problem. Restoring our forested watersheds to a more resilient state offers the best protection for the future.[11, 12, 13, 14]

The current conditions and the resulting impacts to California are significant, and this update to the *State of the Sierra Nevada's Forests* report revisits the variety of critical benefits that are being lost. While the conditions have worsened, the proposed solutions remain the same—restoring our forests and watersheds to health and resilience—only with a higher degree of urgency.

A PATH FORWARD

We have the knowledge and tools to restore Sierra forests to a healthy and more resilient state and reduce the adverse impacts that we currently see. A significant increase in the pace and scale of mechanical treatments, prescribed and managed fire, and meadow and stream restoration needs to occur. It is for this reason that the Sierra Nevada Conservancy (SNC) has joined with the U.S. Forest Service (USFS) Region 5 and a variety of other partners in leading the Sierra Nevada Watershed Improvement Program. Successful implementation depends on three primary actions:

- Increasing investment in watershed restoration in the Sierra Nevada
- Addressing policy and process constraints that increase cost and complexity, and have the unintended consequence of impeding needed restoration
- Supporting development of additional infrastructure to utilize material removed as part of restoration

Only with such an effort can the water and ecosystem services our watersheds provide, and the carbon our forests store, be protected. To learn more about the Sierra Nevada Watershed Improvement Program, visit www.restorethesierra.org.

BENEFITS IN PERIL

The broad range of benefits that healthy, resilient forests in the Sierra Nevada provide to California are being lost.

Healthy forests provide a variety of local, state, and national benefits including clean air and water, absorbing and storing carbon from the atmosphere, endangered and other species habitat, recreational opportunities, renewable energy, and wood products. Millions of California residents hundreds of miles away depend on these watersheds for their water supply, as do many California farmers and businesses.

However, with significant portions of the Sierra Nevada forests unhealthy and lacking resilience, many of these benefits are being diminished, including:

CARBON CAPTURE AND STORAGE

Forests are identified as California's largest carbon sink by the California Air Resources Board. In 1990, it was estimated that our forested areas were removing 13 million metric tons (MMT) of carbon dioxide in a year. However, many of today's forests are overgrown, and they are no longer the reliable carbon sink that California has depended on (figure 4).

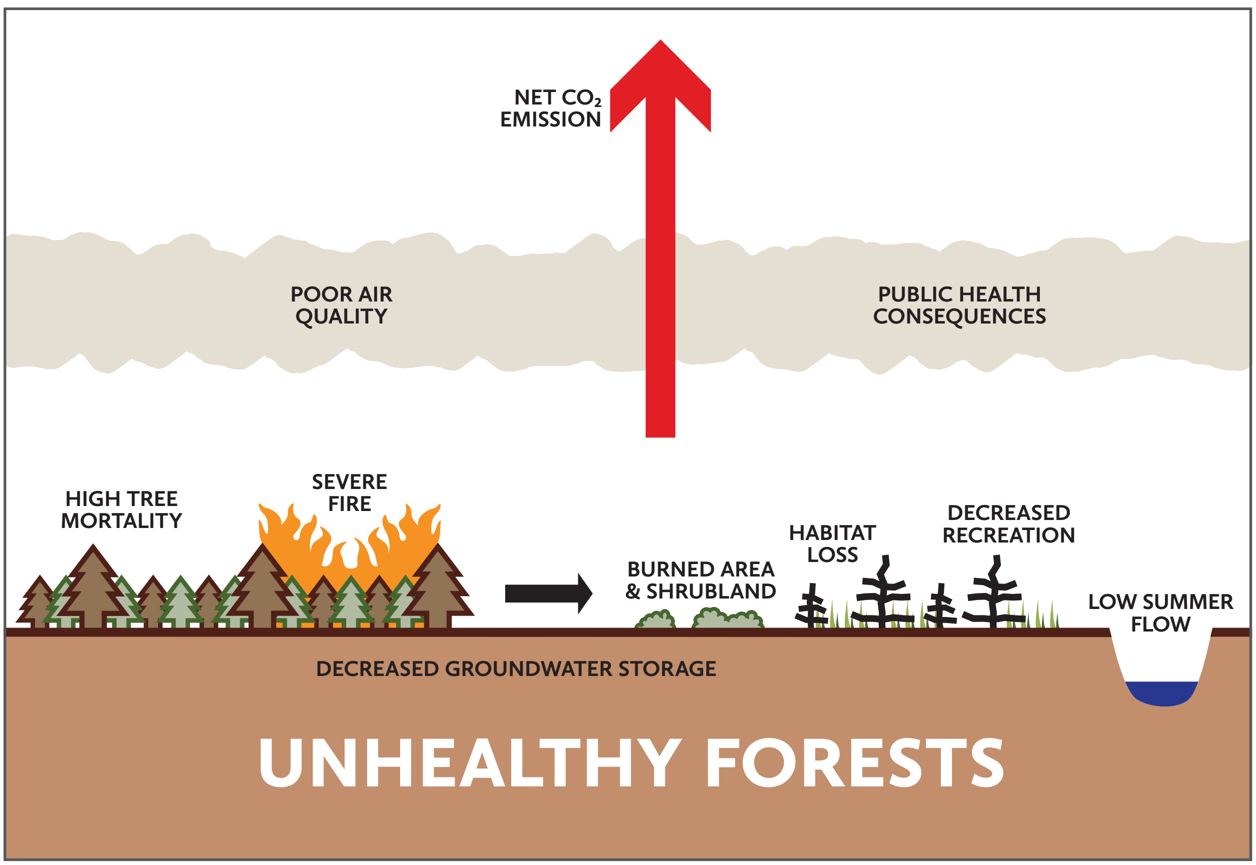

Figure 4. Carbon storage in unhealthy forests is unstable and more likely to contribute to climate change rather than offset it.

Recent tree die off will have both immediate and long-term impacts on the stability of carbon in Sierra Nevada forests.

Figure 5. Tree mortality in Mariposa County.

- The SNC estimates that 53 MMTCO2e (an amount equal to the annual emissions of 11 million cars) of live tree carbon shifted to the dead pool due to tree die off from beetles and drought in the southern Sierra Nevada in 2016.
- Over 50 million trees in the southern Sierra—many of them large trees that were absorbing and storing large amounts of carbon—are no longer actively sequestering carbon, with nothing to replace that loss over the short- to medium-term.
- Beetle-killed forests take much longer than other disturbance areas to become net sequesterers (figure 6).

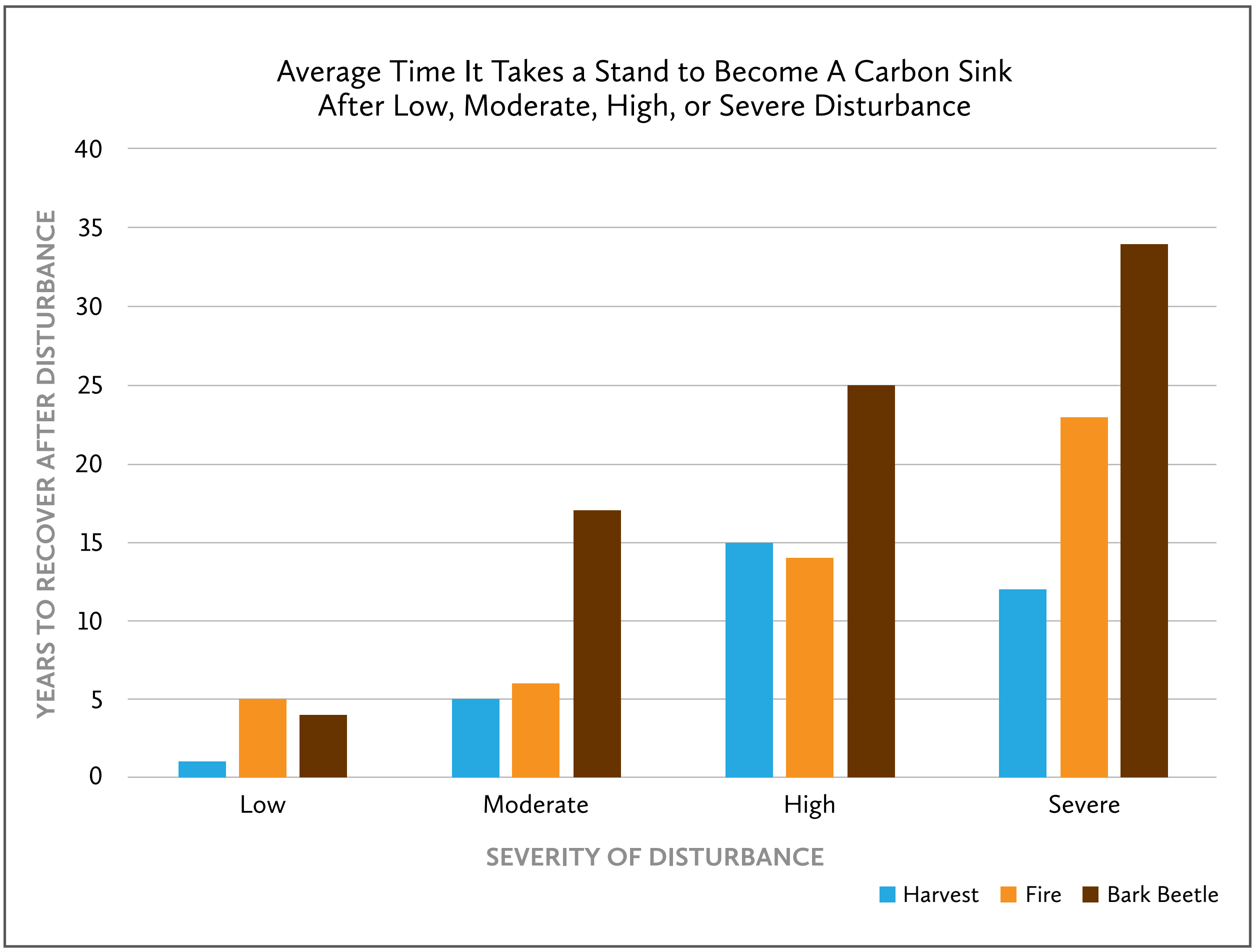

Figure 6. Average time it takes a forest to recover as a carbon sink after a disturbance. Adapted from Raymond 2015.[15]

An increase in high-severity fire is having long-term implications on carbon storage.

- In past decades, the proportion of acres burned at high severity was around 20 percent. In contrast, 40 percent of the 2013 Rim Fire area burned at high severity, while nearly 50 percent of the 2014 King Fire area did.
- Smoke plumes from active, high-severity wildfires emit millions of metric tons of CO2e, and post-fire emissions are estimated to be as much as five times higher than during the fire.
- The Rim Fire released more greenhouse gas emissions in its smoke plume than the city of San Francisco produces in a year, and those emissions represent only 15 percent of what will be released from the burn footprint as dead trees decay (figure 7).
- The King Fire produced 2.3 million tons of greenhouse gas emissions—an amount roughly equivalent to the total production of air pollutants from all sources in the Sacramento area (mobile and stationary) over the course of one-and-a-half years.[16]

Figure 7. The emissions released in the Rim Fire equaled what 2.57 million cars would emit in a year—only a fraction of what will be released as fire-killed trees decay over time.

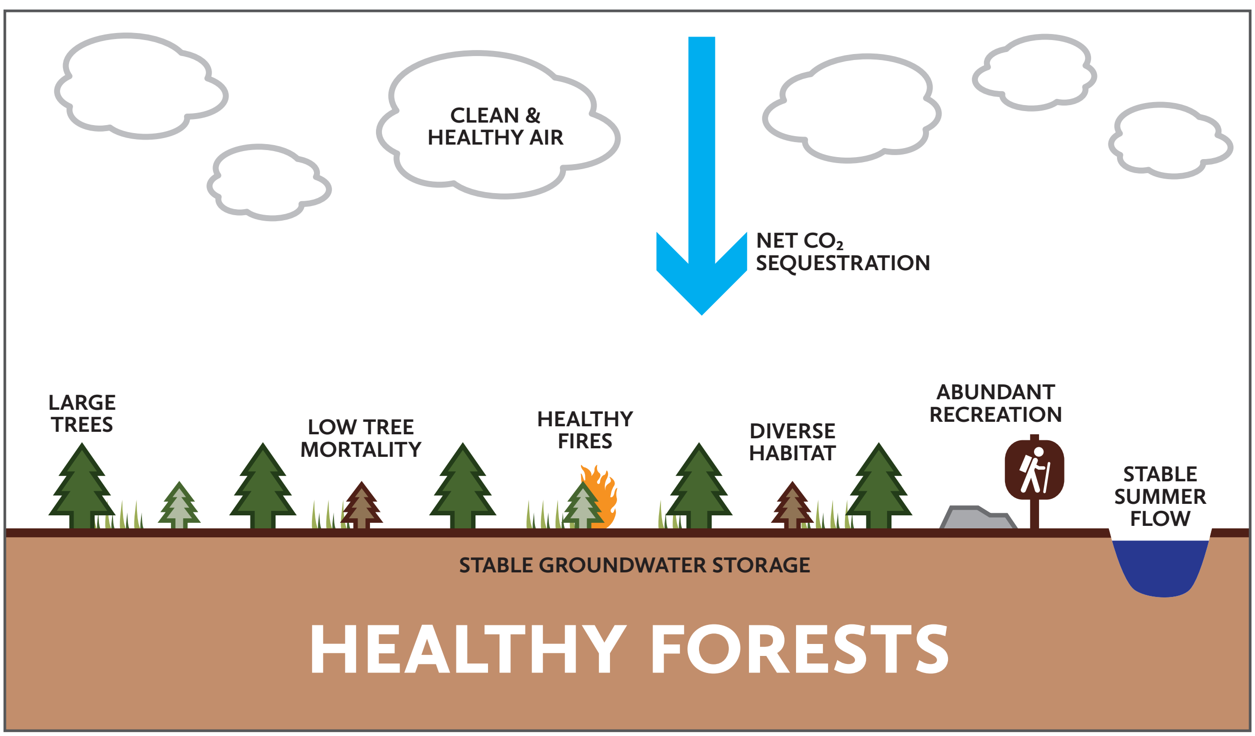

Figure 8. Even during drought, healthy forests sequester carbon from the atmosphere at a significant rate.[17] The larger the tree, the more carbon it will pull from the atmosphere on an annual basis.[18]

We can't count on post-fire regrowth to balance carbon emissions from fire events anymore.

In some areas of the Sierra Nevada, forests that burned at high severity are not regrowing as forest.[19] More and more areas are experiencing a change in vegetation type from forest to shrub or grasslands, which can reburn at high severity in less than a decade[20] and store less than 10 percent of the carbon of the forests they replaced.

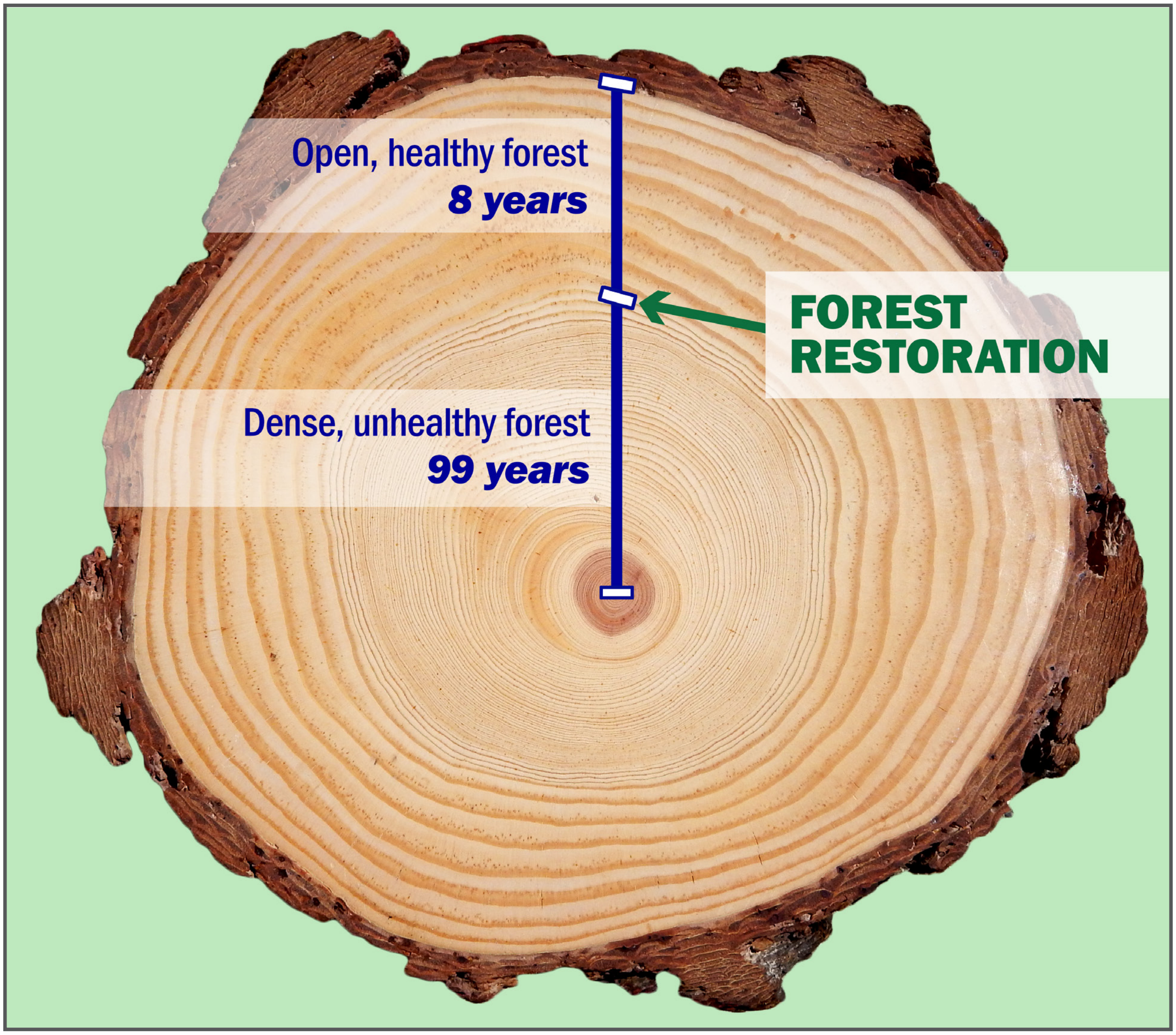

Figure 9. Ecologically sound forest thinning can free up resources for remaining trees, allowing them to put on more growth and sequester more carbon. Photo credit: U.S. Forest Service, Pacific Southwest Research Station.

› Overcrowded trees grow slowly due to resource competition and therefore absorb less carbon than trees in a more natural condition (figure 9).

› A study in the Sierra Nevada published in 2015 highlighted the carbon benefits of recently treated, healthy forests compared to overgrown forests. Over a 10-year period starting in 2002, all treated areas gained in sequestered carbon while the untreated areas actually lost carbon.[21] These observations come from before the drought, and the gap between treated and untreated has likely grown significantly since.

WATER SUPPLY, TIMING, AND QUALITY

The Sierra Nevada is the state's principal watershed.

Healthy forested ecosystems work to maximize the Sierra snowpack, which is our largest form of natural water storage. More than 60 percent of California's developed water supply comes from forested watersheds in the Sierra, and more than 75 percent of the Sacramento-San Joaquin Delta's unimpaired inflow comes from the Sierra (figure 10).[22, 23]

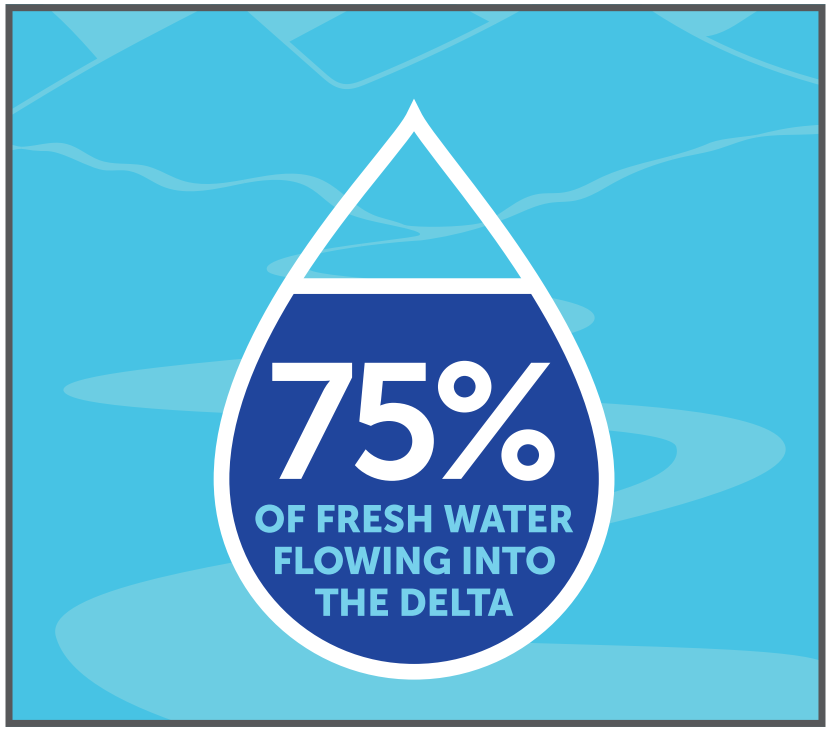

Figure 10. 75 percent of the fresh water flowing into the Delta comes from the Sierra.

Climate change projections suggest that the Sierra of the future will receive more precipitation in the form of rain, and less as snow. Taking actions that allow our forested watersheds to maximize snowpack is critical now.

- Recent climate research on Sierra Nevada snowpack by the UCLA Center for Climate Science estimates that, compared to the snowpack levels of 1981–2000, Sierra snowpack will diminish 48 percent by 2100.
- An Arizona study published in 2015 examined the snow retention rate of a number of locations under a variety of treatments. Compared to untreated forests, treated sites resulted in greater snow accumulation, as well as longer snowpack persistence into the spring.[24]
- There is substantial evidence that healthy resilient forests provide a more reliable water supply.[25, 26]
- In 2015, the Nature Conservancy published a meta-analysis of 150 existing studies on forest management and water supply and analyzed the impacts on potential water yield from a number of diverse forest management strategies. The analysis found an increase of up to six percent in overall potential yield.[27]
- In an area of Yosemite National Park where managed fire has been used to restore forests over the last few decades, water yield has been maintained, and potentially increased. In adjacent forests where no ecological restoration has been done, water yield has decreased.[28]

High-severity burn areas can experience runoff and erosion rates five to ten times greater than low- or moderate-intensity burn areas.

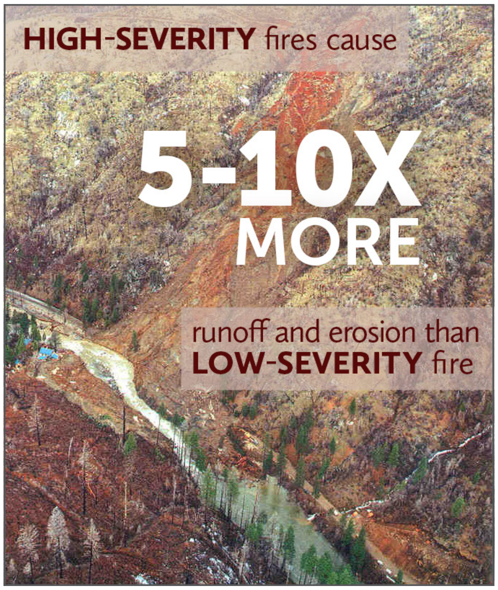

Figure 11. Landscapes that suffer severe fire see dramatic increases in sediment runoff and a change in the timing and capture of snowmelt.

- High-severity fire reduces vegetative cover, exposing more soil to the elements. These high-severity burn areas can experience runoff and erosion rates five to ten times greater than low- or moderate-intensity burn areas (figure 11).[29] Not only does this sediment impact water quality and water infrastructure, it also displaces water storage capacity in reservoirs.
- High-severity fires and extensive tree mortality expose much of that area's snowpack to direct sunlight and shift melt times to earlier in the spring, when the water flowing downstream has less chance of being captured.
- Large quantities of ash and sediment are expected to be transported downstream of the Butte Fire and deposited in Pardee Reservoir and New Hogan Lake, producing high turbidity levels and potentially affecting water chemistry due to ash and sediment loading. Water supply reservoirs may receive significantly higher rates of sediment deposition than would normally occur for a given rainfall event.[30]

PUBLIC HEALTH

- Studies suggest severe "stand-replacing" forest fires are increasing in frequency and extent, and climate change will likely exacerbate the situation, leading to increases in wildfire size and severity.[31, 32, 33]
- According to the American Lung Association's *State of the Air* report, many western states experienced more high-particle air pollution episodes between 2011 and 2013 due to drought and wildfires.[34]
- Fresno County's Department of Public Health reported a 411-percent increase in emergency room visits for respiratory issues over a 72-hour period during the 2015 Rough Fire.[35]
- Black carbon is produced in large quantities by wildfire. Some analyses indicate that black carbon could be worse than methane emissions. It also poses a significant public health risk for cardiovascular and respiratory diseases, as well as cancer and, potentially, birth defects.[36, 37]

When forests burn at high severity, they become a source of massive air pollution.

Figure 12. Smoke from the 2015 Butte Fire. Photo: Bureau of Land Management.

Large wildfire events tend to occur late in the summer, when air quality conditions are already bad, uncontrollably exacerbating health conditions at that time.

Prescribed and managed wildfires are used during times when the smoke impacts are minimal and controlled. Using these tools reduces the likelihood of larger, more severe wildfires.

WILDLIFE HABITAT

Sierra forests are home to 60 percent of California's animal species. Over one-third of them are listed by the Department of Fish and Wildlife as rare, threatened, or endangered, but current forest conditions make the protection of their habitat extremely challenging.

- In the King Fire, almost 34,000 contiguous acres burned at high severity, resulting in a continuous stand of dead trees and almost no habitat diversity.
- Of the more than 10 established California Spotted Owl sites that burned in that 34,000-acre patch of high severity, none were recolonized post-fire. In fact, GPS tracking of local owls showed the owls avoided that patch even for foraging, preferring the adjacent areas that burned in more of a mosaic.[38]
- Research indicates that, if current fire trends continue, all suitable nesting habitat for California Spotted Owls in the Sierra will be lost to large, damaging wildfires within the next 75 years.[39]

Figure 13. Northern Spotted Owl. Recent research shows critical habitat is severely impacted by high-severity wildfire.

HISTORIC AND CULTURAL RESOURCES

While a wide range of people value California forests for the natural resources they provide, the relationships Native Americans and tribes have with these resources is closely tied to their psycho-social-spiritual, cultural, and physical well-being. The loss of access to these resources, and perhaps especially traditional foods and their habitats, can affect more than diets: it can threaten the associated knowledge and identities embedded in stories, ceremonies, songs, and the community processes of collecting, preparing, and sharing foods.[40, 41, 42, 43] A growing number of examples exist that make use of indigenous peoples' legacy knowledge of, and connection with, their lands to shape forests into resilient, carbon-capturing landscapes. In many cases, tribes have legal and financial resources additive to conventional landscape management agencies, and their participation can create synergies in application, permitting, and financing forest management activities. In return, participating tribes have the opportunity to work on and, in some cases, manage landscapes to which they have historic and pre-historic ties.

SUSTAINABLE RURAL ECONOMIES

Rural economies benefit from healthy forests, and the work done to get them to that condition. Wood products and outdoor recreation both contribute significantly to rural communities' economic well-being.

Tree mortality and large, damaging wildfires can devastate the natural areas that many rural Sierra Nevada communities depend on for jobs and to draw visitors and tourists.

- Of the approximately $2 billion in labor income supported by natural resource management in the USFS Pacific Southwest Region, 85 percent went to local employee wages and benefits.[44]
- According to Visit California, the state's primary marketing organization, spending on goods and services by visitors to the Sierra Nevada Region exceeded $7.8 billion in 2015.
- Tuolumne County budget projections showed about $275,000 less in estimated income from the tourism-driven occupancy tax on hotels, campgrounds, and other lodging during the 2013 Rim Fire.

Figure 14. Dead and dying trees threaten public safety and can be a financial burden for homeowners.

Unhealthy forests create a financial burden for rural communities.

- The Sacramento Bee reported that the 2015 Butte Fire caused more than $1 billion in combined damages for Calaveras County.[45]
- Fresno County budgeted $2 million for tree removal activities to address die-off from drought and bark beetle. So far it has cost the county over $180,000 to remove 1,428 trees along a seven-mile stretch of road.[46]
- Calaveras County estimates a need of between $5 million and $10 million for dead and dying tree removal over the next two to four years.[47]

A PATH FORWARD

Sierra Nevada Watershed Improvement Program (WIP)

The USFS estimates that in order to return its lands to ecological health, 500,000 acres a year should be restored. However, the amount actually treated has been in the range of 150,000 to 200,000 acres. It is important to note that the estimate of need was released prior to the massive tree die-off.

The conditions of today's Sierra Nevada forested watersheds are resulting in significant adverse impacts to a range of benefits for California and its residents, and future climate change is expected to substantially imperil these benefits. However, we possess the tools to slow or stop those impacts. Utilizing ecologically sound restoration techniques at a much greater pace and scale is the only way we can address this situation. It is in that context that the Sierra Nevada Watershed Improvement Program was launched in early 2015. The Sierra Nevada Conservancy, in partnership with the USFS and a variety of other state, federal, and non-governmental stakeholders, established the Sierra Nevada Watershed Improvement Program to restore watershed health by increasing the pace and scale of ecologically sound restoration in the Sierra Nevada Region. The WIP targets three primary areas that must be addressed in Sierra Nevada forests if they are to be restored to ecological health:

INCREASE INVESTMENT IN WATERSHED RESTORATION

The level of state, federal, local, and private investment being made in our forested watersheds is inadequate to meet the need. The consequences of overgrown, unhealthy forests result in far greater costs than the restoration work needed, in the forms of fire suppression, loss of property and infrastructure, and other socio-economic costs. A number of funding sources exist where some level of investment is being made, but the opportunity exists for increasing investment:

STATE FUNDING:

- Greenhouse Gas Reduction Fund
- Bond Measures
- Integrated Regional Watershed Management (IRWM) funding
- State Responsibility Area Fund
- Timber Regulation and Forest Restoration Fund (AB 1492)

FEDERAL FUNDING:

Currently, federal fire suppression activities are financed through the U.S. Forest Service's base budget, which results in less funding being available for restoration and other activities. There have been numerous efforts in Congress to address this issue, but it continues to be a significant contributor to the poor health of so many of our public forests.

PRIVATE OR BENEFICIARIES PAY FUNDING:

- Social bonds, or "pay for success" financing: private investors pay for interventions in public sector resources, and then get repaid if the objective(s) is met
- Valuing ecosystem services: place a value on ecosystem services to pay for the benefit received, in a way structured to sustain the resource over the long term
- End-user water fees (public goods charge): place a value on specific services, identify the beneficiaries of those services, and then allocate commensurate charges
- Private and foundation investment targeted at ecological outcomes

ADDRESS POLICY AND PROCESS CONSTRAINTS

Many policy and processes result, often inadvertently, in constraining our ability to restore our landscapes at the appropriate pace and scale. Many policies, processes, and rules are in place to reduce the risk of adverse impacts of actions, but given today's conditions, it is often the failure to act that carries the greatest risk. Finding a balance between the need for restoration and the range of constraints faced is essential. Examples of areas that need to be addressed include the following:

There is growing evidence that large, severe fires are having dramatic impacts on species such as the California Spotted Owl, despite regulatory and management restrictions to protect them.

STATE AND FEDERAL REGULATORY PROCESSES:

› Identify more efficient approaches to landscape restoration planning under the National Environmental Policy Act (NEPA), California Environmental Quality Act (CEQA), state and federal Endangered Species Acts (ESA), and other permitting processes.

› Identify opportunities to improve the efficiency of planning processes and enhance the coordination and integration of various processes to increase ecologically sound restoration activities in the Sierra Nevada.

AIR QUALITY REGULATIONS:

Prescribed and managed fire, under appropriate conditions, is an important restoration tool that improves forest resilience and reduces the risk of large, high-severity fires. However, a number of factors, including air quality regulations, staffing, funding, and liability issues can restrict the use of prescribed and managed fire. Existing policies may have the unintended consequence of enabling larger, more damaging fires to occur and result in far more emissions than would have been released by prescribed fire.

Example: In fall 2015, the USFS Pacific Southwest Region, National Park Service Pacific Region, CAL FIRE, Sierra Nevada Conservancy, multiple environmental organizations, and two prescribed fire councils signed the Memorandum of Understanding for the Purpose of Increasing the Use of Fire to Meet Ecological and Other Management Objectives (MOU). The MOU recognizes that the state's wildland ecosystems have evolved with fire, which provides landscape resilience and renewal. The purpose of the MOU is to increase the use of fire to meet ecological and other management objectives.

Figure 15. Treatments that involve the use of prescribed fire result in some emissions (top), but the scale of those emissions is much smaller compared to a wildfire (bottom).[48] Photos: U.S. Forest Service.

DEVELOP ADDITIONAL INFRASTRUCTURE TO UTILIZE BIOMASS

With the significant amount of material that needs to be removed as part of ecological forest restoration, utilizing this material becomes a key factor. Some of the material removed can be used for production of traditional wood products. By creating value for the other material, costs can be significantly offset and adverse impacts from other means of disposal can be minimized. The state has taken a number of actions to enhance utilization of biomass to create electricity, including the Bioenergy Action Plan (2012), Senate Bill (SB) 1122 (2012), Governor Brown's Tree Mortality Emergency Proclamation, and SB 859 (2016). Nonetheless, the overall capacity of such facilities is significantly less than a decade ago. Opportunities for enhancing utilization include the following:

- Maintain and upgrade existing facilities
- Expand utilization technologies through state and federal funding programs such as the Electric Program Investment Charge Program (EPIC) and Wood Utilization Grants
- Provide incentives for creation of infrastructure

Figure 16. Forest management and biomass utilization can play an important role in maximizing the air quality benefits of forests by reducing wildfire emissions that have impacts on both human health and the climate.

Forest management and biomass utilization can play important roles in maximizing the air quality benefits of forests. By treating forests to reduce the potential for severe wildfires, forest management activities can reduce wildfire emissions that have impacts on both human health and the climate.[49]

Addressing the above barriers to increase the pace and scale of restoration is critical, and timely implementation of the WIP is essential if Californians are to continue to receive the many benefits that come from the Sierra Nevada Region. Failure to do so will continue to result in significant adverse impacts to the state's environment and economy.

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