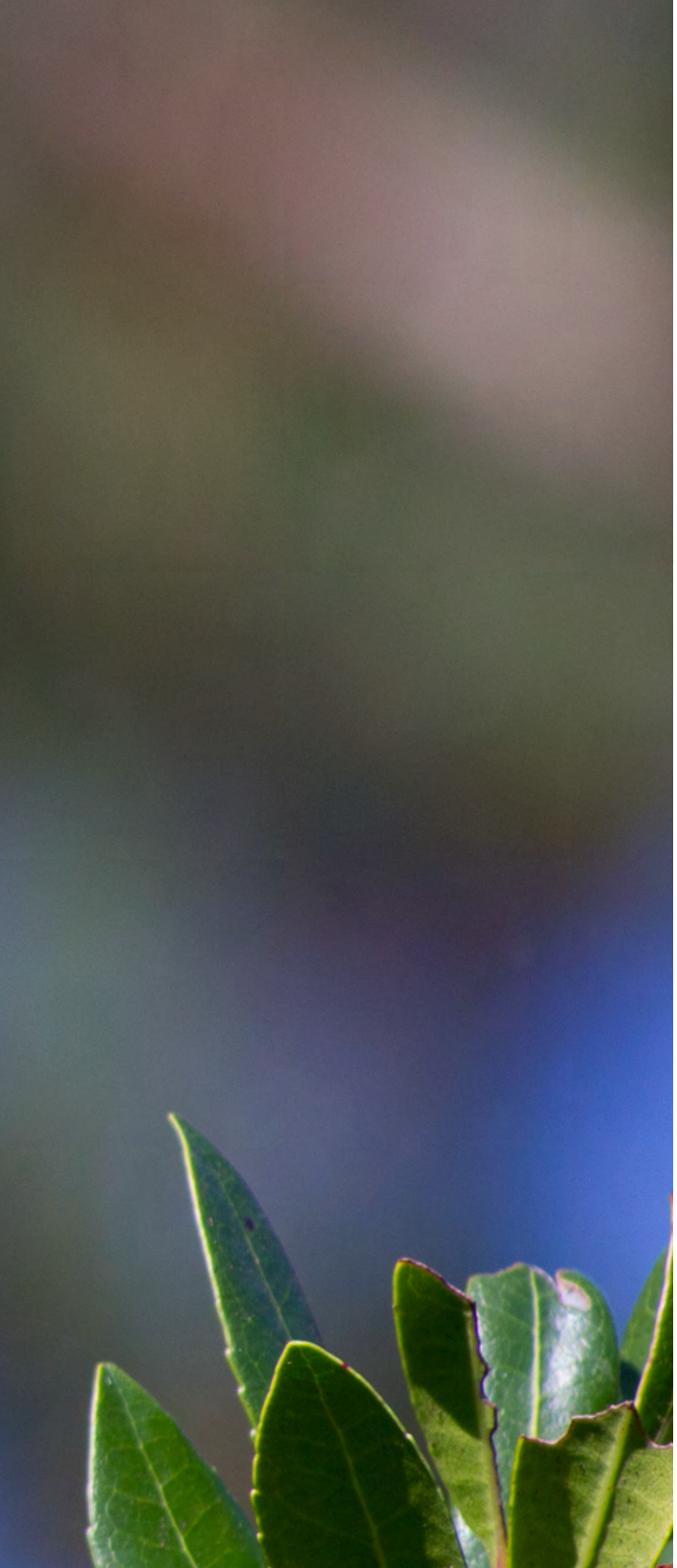
USDA
United States Department of Agriculture

2019 SCIENCE SPOTLIGHT

Pacific Southwest Research Station

Forest Service



Message from the Director

The Pacific Southwest Research Station is a leading forest research organization, conducting work at the national and international levels, and turning contributions into real benefits to the public and for the environment. A century of fire suppression and forest management practices, coupled with an increase in human population, an expanding wildland-urban interface, and anthropogenic climate change, have altered forest composition and hydrologic systems here in California and Hawaii. Federal, state, and private owners of forested land face a range of urgent challenges, among them catastrophic wildfires, invasive species, degraded watersheds, loss of biodiversity, and epidemics of forest insects and disease.

Our research is conducted to advance knowledge and enhance land management in five areas: (1) fire and fuels, (2) forest management and silviculture, (3) forest health and biodiversity, (4) water yield and predictability, and (5) socioeconomics and uses of public lands. We are highlighting here just a few of our research findings and invite you to visit our website (www.fs.fed.us/psw) and learn more about our latest research, discoveries, and tools.

Our focus as we move into the new year is to build our capacity and add to our research arsenal of people and programs that will help yield solutions for the establishment and maintenance of healthy, sustainable, and resilient forests and grasslands.

My sincere gratitude to the Pacific Southwest Research Station staff who work tirelessly to conduct and support stellar research. My thanks to all our partners and collaborators who bring so much value and meaning to our work. I eagerly look forward to working together in the years to come!

Dr. Valerie Hipkins, Ph.D.
Acting Station Director

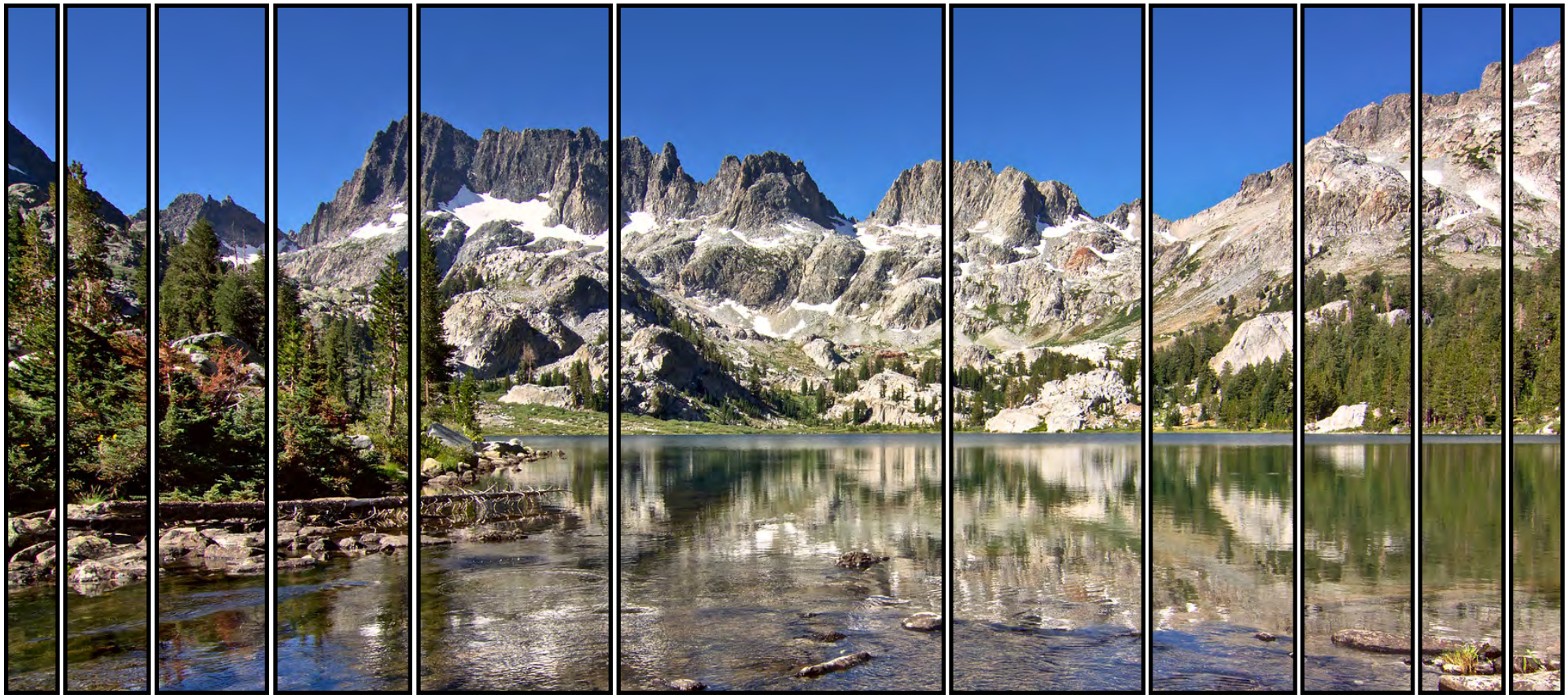
Pacific Southwest Research Station

Headquartered in Albany, California, the Pacific Southwest Research Station is part of the U.S. Forest Service's Research and Development branch. Scientific pursuits are organized into five research units across California, Hawaii, and the U.S.-affiliated Pacific Islands:

- Conservation of Biodiversity
- Ecosystem Function and Health
- Fire and Fuels
- Urban Ecosystems and Social Dynamics
- Institute of Pacific Islands Forestry

Vision and Mission

The Pacific Southwest Research Station is a world leader in natural resources research through our scientific excellence and responsiveness to the needs of current and future generations. Our mission is to develop and communicate science needed to sustain forest ecosystems and their benefits to society.

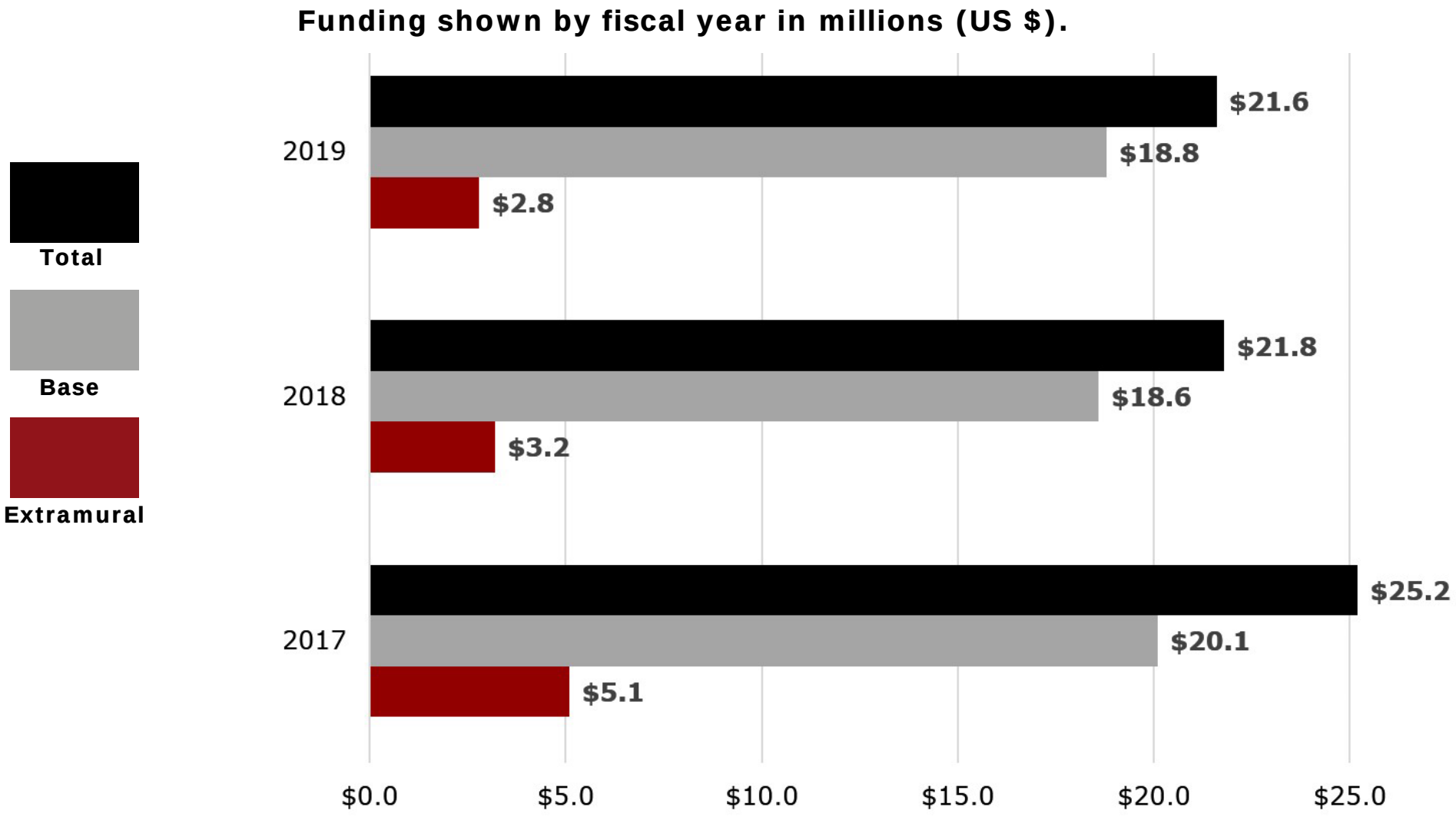


At A Glance

- 8 research locations
- 11 experimental forests
- 2 experimental watersheds
- 1 experimental range
- 30 research scientists
- 129 employees

Funding

Funding for research comes from federal budget allocations (base research operations) and cooperating agreements with other agencies, groups and educational institutions (extramural funding).



Fire's absence heightens forest vulnerability

Eric Knapp
Fire and Fuels

View the publication online.

The traditional growth patterns and arrangement of trees in forests experiencing frequent wildfires were found to become altered within 20 years of wildfire exclusion — much to a forest's peril. "Frequent fire" forests naturally develop into clusters of trees of various species, interspersed with vacant gaps or solitary mature trees, which enhances biodiversity and makes the entire forest more resilient to subsequent wildfires. Pacific Southwest Research Station scientists, in collaboration with Penn State University and National Forest System researchers, however, found that these protective structural characteristics begin diminishing as early as 20 years once wildfire is removed from the landscape.

Researchers mapped all trees in six 2.5-acre plots of old-growth ponderosa pine *(Pinus ponderosa)* and black oak *(Quercus kelloggii)* forest within the Lassen National Forest's Ishi Wilderness in northern California's Sierra Nevada in both 2000 and 2016. The last recorded wildfire in the area was in 1994.

During the 16-year monitoring period, scientists observed a decrease in species diversification as ponderosa pines began to crowd out less shade-tolerant and shorter statured species, most notably black oaks. Black oak acorns were historically a staple tribal food source and are particularly important to a number of wildlife species in the area. Black oaks also help break up the forest canopy, disrupting the potential of severe wildfires spreading through the treetops. The influx of ponderosa pines were found to be filling in the gaps between tree clusters, thereby closing the forest canopy and creating a contiguous source of fuel to sustain higher severity wildfires.

Land management implications

Frequent fire keeps conifer regeneration in check and is, therefore, key to maintaining a diverse mixed-species structure. In landscapes where fire has been excluded, prescribed fire or wildfire burning under milder conditions may help to restore the species composition and forest arrangement of groups and gaps, enhancing forest resilience.

Mixed ponderosa pine and black oak forest within the Beaver Creek Pinery of the Lassen National Forest's Ishi Wilderness. Photo taken 22 years after the last wildfire, showing abundant ponderosa pine regeneration in the background. (Photo credit: Eric Knapp/Pacific Southwest Research Station)

Contemporary fires not more prevalent, but more destructive than early 1900s

Brandon Collins
Fire and Fuels

View the publication online.

Many studies that compare wildfires of today to the past focus on records that pre-date Euro-American settlement. Less is known about changes relative to the early onset of forest management in the early 1900s, such as wildfire suppression and timber harvesting.

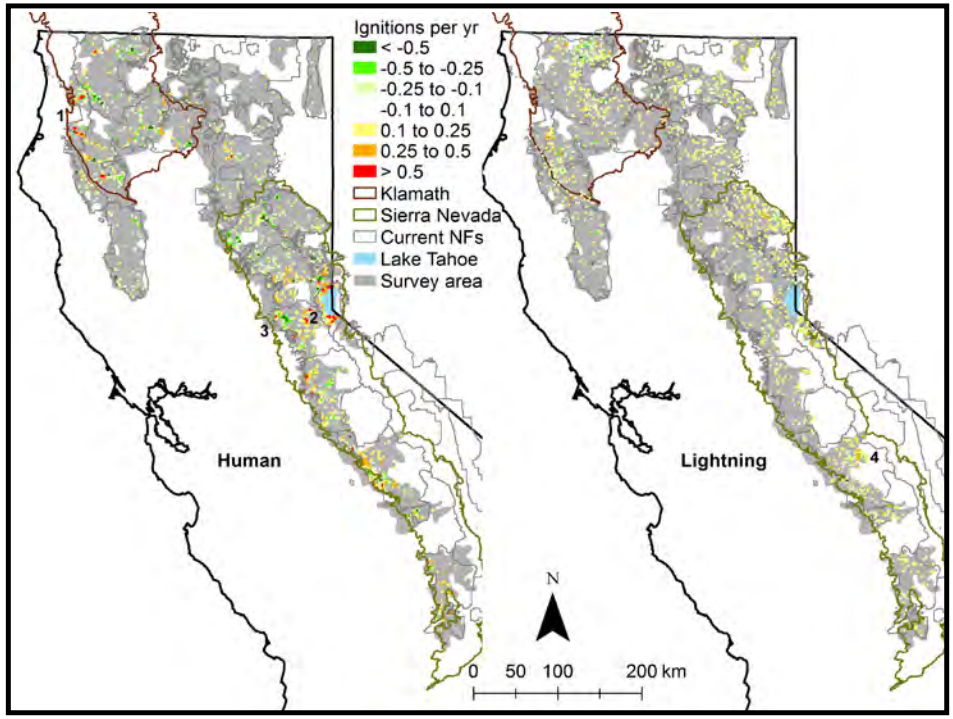
Researchers with the Pacific Southwest Research Station discovered an archive containing records of more than 18,000 individual fires from 1911 through 1924. In particular, the records noted the fire's cause, its location, and amount of acres burned. Similar records from the "contemporary period" of 2002 through 2015 were analyzed, and then mapped to show what differences, if any, existed.

While no statistical difference was found in the number of lightning- or human-caused fires between the two time periods, there was a notable shift in the location of human-caused fires that mirrored the growth of populated areas from previously unpopulated or sparsely populated locales. A major shift, however, was found in the size of wildfires.

Large wildfires (exceeding 30,000 acres) only accounted for 0 to 6 percent of the total burned area in the early suppression period. In the contemporary period, large wildfires accounted for 53 to 73 percent of the total burned area. Researchers noted that although there was no information on fire-caused tree mortality (an indicator of fire severity) in the historical period, large wildfires in the contemporary period generally result in large, contiguous patches of tree mortality. They also found that the percentage of wildfires exceeding 5,000 acres occurred earlier in the year during the contemporary period, compared to the historical period. These shifts in number and timing of large wildfires are likely a reflection of broad-scale changes in fuel loads and continuity, as well as changing climatic conditions.

Land management implications:

These findings provide demonstrable evidence that contemporary wildfires in California forests are burning differently than they did historically. Most importantly, contemporary forests are primarily burning in large wildfires, whereas historical forest tended to burn in small- and moderate-sized wildfires. These large wildfires compromise forest recovery, and ultimately, forest resilience into the future. Large wildfire occurrence during the last several years in California forests has increased, making it clear that wildfire is inevitable. Large-scale fuel reduction and forest restoration efforts are needed to shift wildfire patterns toward smaller and less destructive events. Forests need to be in a condition where they can tolerate fire and persist into the future.



Computer model provides clearer view of 'super fog'

David Weise
Fire and Fuels

View the publication online.

In the southern United States, smoke from prescribed fires can create hazardous visibility conditions on roadways. Called "super fog," this low-visibility phenomena is the result of complex meteorological conditions involving temperature, humidity, barometric pressure, and wind speed, among other things.

Researchers with the University of California – Riverside, working with the Pacific Southwest and Southern Research Stations, performed experiments and developed a computer model that can identify when forecasted conditions are ripe for turning smoke from prescribed fires into super fog.

Land Management Implications

Meteorologists and prescribed fire planners now have a tool they can use to plan prescribed burns that will less likely impact surface level air quality and visibility.

(a)

(b)

Comparison of (a) light smoke formed under ambient temperature of 41 degrees Fahrenheit, 76% relative humidity, and 7% fuel moisture, and (b) super fog formed under ambient temperature of 43 degrees, 88% relative humidity, and 40% fuel moisture. (Photo credit: U.S. Forest Service)

Fire treatments most effective for increasing hazelnut vegetation for tribal basketry

Frank Lake
Fire and Fuels

View the publication online.

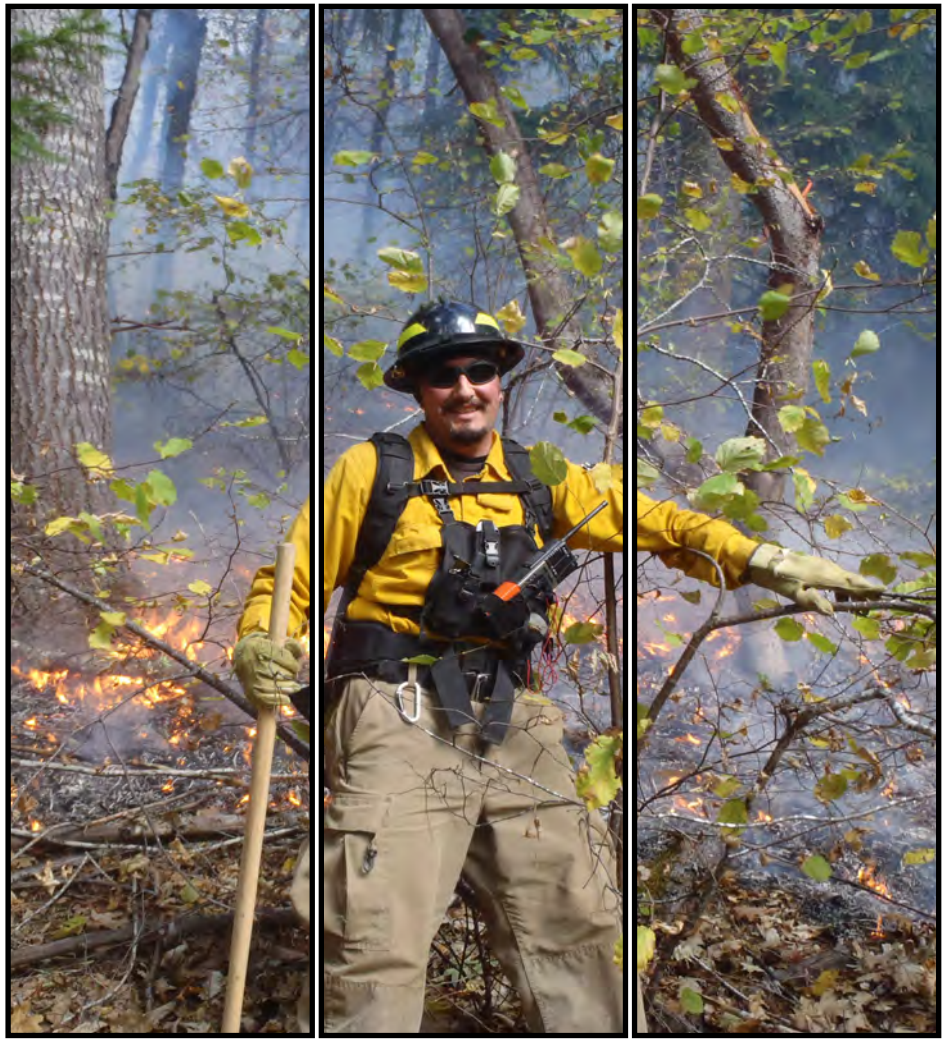
The Karuk and Yurok tribes of northern California have long used fire applied to the landscape to promote responses in the environment conducive to their subsistence and cultural traditions. Scientists with the Pacific Southwest Research Station conducted a study with Stanford University to empirically test the veracity of using fire to increase the abundance of stems from the California hazelnut shrub *(Corylus cornuta* var. *californica)* for traditional basket-weaving.

Researchers and tribal members applied four different treatments within 27 research plots in northern California's Klamath Mountains to measure how the hazelnut shrubs responded to: (1) igniting piled surface fuels to kill the top of brush stems, (2) blistering stems at ground-level through direct application of a propane torch, (3) manually cutting existing stems to the ground, and (4) refraining from any treatments to serve as a control.

Twelve to 18 months post-treatment, researchers returned to measure the number hazelnut stems within the research plots. Bushes exposed to surface burning and blistering from propane torches produced seven to 10 times more stems than the bushes in the control group. Manually cutting the stems only produced a four-fold increase. The study results, "Effects of understory fire management treatments on California hazelnut, an ecocultural resource of the Karuk and Yurok Indians in the Pacific Northwest," were published in the 2019 journal of Forest Ecology and Management.

Land Management Implications:

Prescribed burning is an effective strategy to elicit vegetative responses conducive to sustaining traditional practices within indigenous cultures, as well as to achieve other objectives, such as reduction of hazardous fuels and increasing forest diversity.



Reducing densities, competing vegetation enhances resiliency to climate change

Jianwei Zhang
Ecosystem Function and Health

View the publication online.

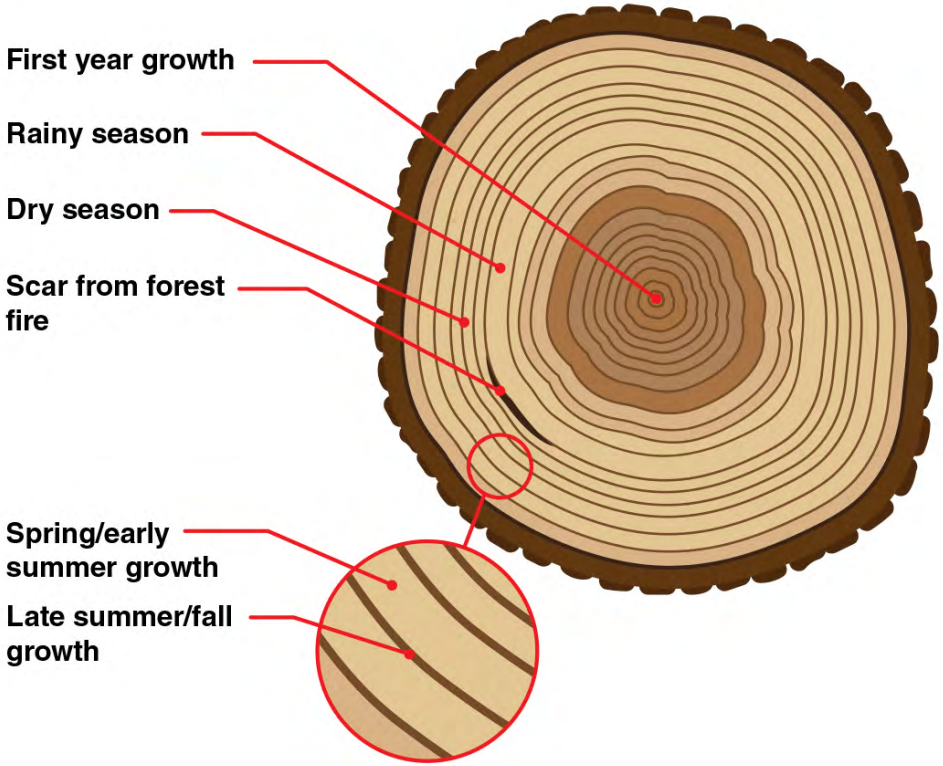
It's long been established in forestry that reducing competition for resources helps promote growth and vigor in tree species. This is often accomplished through harvesting a portion of trees to reduce a forest's density or to remove shrubs and other understory competing vegetation. Little is understood, however, how these management practices improve a tree or forest's resilience to changing climates, particularly warmer, drier conditions.

Scientists with the Pacific Southwest Research Station combined growth records from long-term ponderosa pine (*Pinus ponderosa*) research plots with climate data, and then applied statistical analysis to identify how individual climatic variables, such as moisture availability and temperature, influenced growth following specific silvicultural treatments. While moisture availability seemed to exert the most influence on a tree's growth, regardless of silvicultural treatment, trees within heavily thinned plots or plots with understory vegetation removed seemed less affected than trees within other treatment types during the same time period. The same pattern held true when the scientists isolated the impacts of warmer temperatures.

The findings suggest that forest management practices designed to moderate a forest's density or reduce understory competition can make trees more resilient to future adverse climatic conditions, particularly rising temperatures and reduced precipitation.

Land management implications

Forest managers can appropriately manage stand densities and understory species to enhance a forest's resilience to climate change. Treatments that improve residual tree vigor will have a positive effect on overall stand health.



Tree rings can reveal a lot about a tree's history and growth. Pacific Southwest Research Station scientists have combined tree ring records with climate data to determine how silvicultural practices can temper climate-related growth variables.

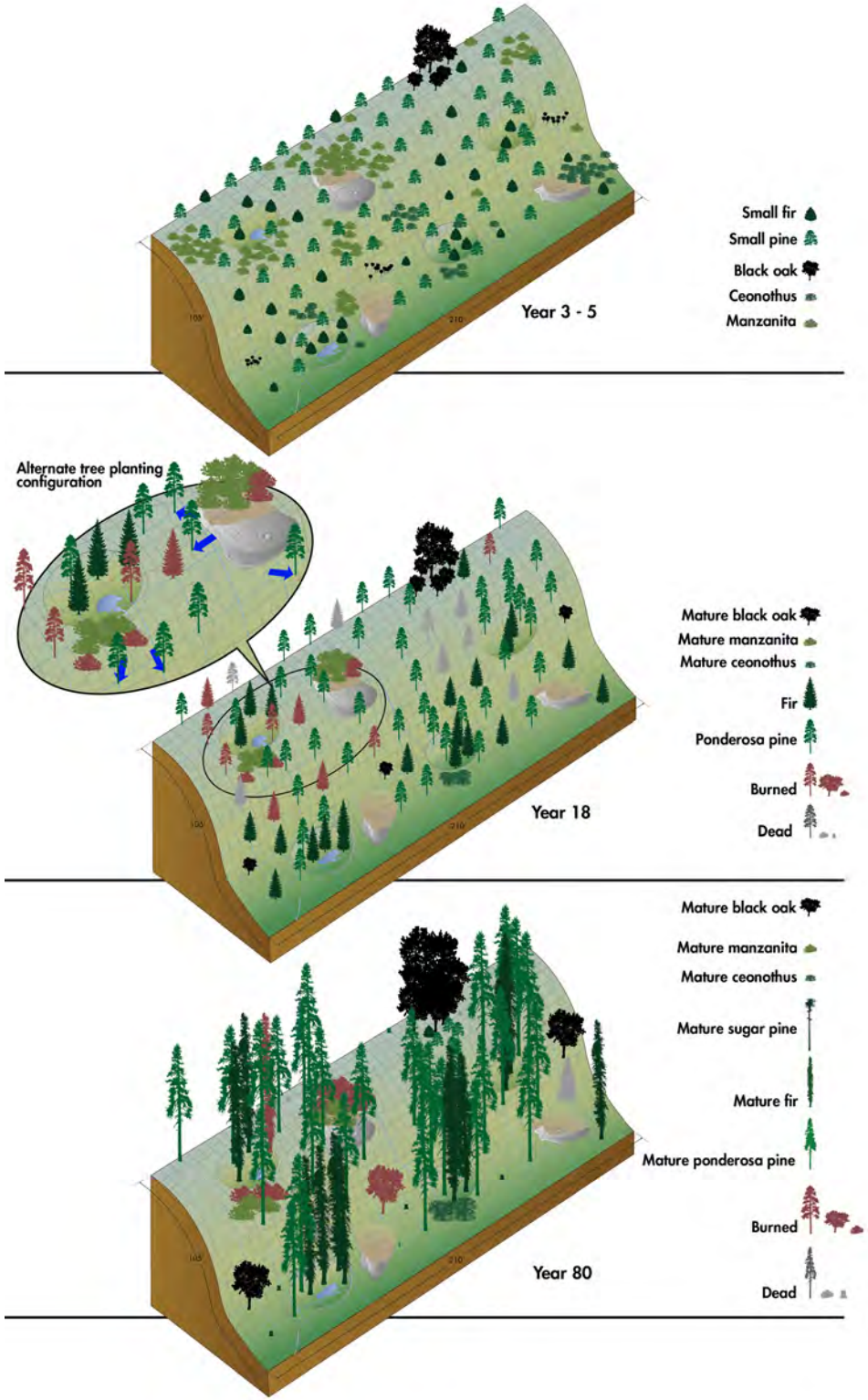
Reforestation strategies for changing times

Malcolm North
Fire and Fuels

View the publication online.

The increasing frequency and severity of wildfires and droughts throughout the western United States has created unique challenges when replanting future forests. The common practice of planting young trees in evenly spaced lines at high densities have left tree plantations highly susceptible to water stress during drought and incineration from wildfires.

Pacific Southwest Research Station scientists, along with partners from academia and the U.S. Forest Service's Pacific Southwest regional headquarters, have synthesized the latest research detailing reforestation strategies that improve survival rates in young plantations, while also setting the stage for more resilient forests in the future. The resulting paper serves as a blueprint for reforestation after a major disturbance, from determining which areas to leave alone for natural tree regeneration to areas needing more intensive human intervention, as well as recommendations for planting configurations and the novel use of prescribed fire within young plantations.



Land management implications

"Reforestation for Resilience in Dry Western U.S. Forests," published in the 2019 issue of Forest Ecology and Management, proposes new approaches for land managers reforesting a landscape after a major disturbance, such as a wildfire or insect infestation. The paper synthesizes the latest research in natural and assisted forest regeneration, planting configurations, and the novel use of prescribed fire within developing plantations (less than 25 years old) to improve resiliency in future forests.

Forest simulations shape restoration strategy for forests at Lake Tahoe

Jonathan Long
Conservation of Biodiversity

Land managers attempting to restore the forests around California's iconic Lake Tahoe have enlisted a team of scientists and the power of computer modeling to guide their strategy. The Lake Tahoe West collaborative has partnered with scientists with the Pacific Southwest Research Station to run hundreds of integrated computer simulations to show the likely outcomes of different management strategies 100 years into the future.

The research team evaluated how several different management strategies would affect important values, including the frequency and severity of wildfire across the landscape, forest composition, abundance of old trees, wildlife habitat, water quality, water quantity, economics, cultural resource quality, carbon sequestration, and air quality. The scenarios included wildfire-suppression only, fuels reduction near communities, extensive restorative thinning, and extensive restorative prescribed burning, all under different future climates.

The team found that expanded thinning and burning treatments would promote the suite of objectives better than no treatment or business-as-usual, with the exception of carbon sequestration. In particular, more treatment would reduce the wildfire threat to communities, the risk of unnaturally large patches of severe burns, and days of extreme emission of smoke into downwind communities. The team also found that the expanded treatments were associated with increased water yield, which could mitigate reduced snowpack from anticipated warming, as well as promoted the growth and occurrence of pine and aspen trees, which have declined from historical levels. Results from field monitoring also indicate that thinning treatments improved drought resistance among the remaining trees.

These effects and others would also promote cultural resources important to the Washoe Tribe, who consider Lake Tahoe the center of their ancestral home. The team did find that ramping up the amount of prescribed burning would carry some risks to water and air quality, which would require careful planning before implementation.

The findings informed the design of a preferred restoration strategy that combined increased thinning with a staggered approach of increased prescribed burning and managed natural ignitions that allowed for other restoration activities to take effect, thereby reducing undesired effects from burning too much too quickly. The team continues to advise managers through the design and permitting of projects and into the implementation of the new strategy.

Land Management Implications

New advances in restoration simulations are allowing land managers to test strategies to optimize desired outcomes that cater to multiple resource objectives, while taking into account changing climatic conditions and the complex interactions of drought, wildfire, and treatments.

The research team investigated how expanding treatments, such as a prescribed burn at Baldwin Meadow in the Tahoe Basin (foreground) may limit large patches of high-severity wildfire, like the Emerald Fire (background). (Photo credit: Jonathan Long/Pacific Southwest Research Station)

Predicting road locations that pose threats to human, wildlife safety

Eric Abelson
Conservation of Biodiversity

Roads and other manmade constructions can have catastrophic effects on wildlife and people alike if unwittingly constructed along wildlife thoroughfares. Researchers with the Pacific Southwest Research Station have developed a way to integrate computer models that predict wildlife movement to help land developers and road engineers accommodate non-human traffic.

Advances in high performance computing (i.e., supercomputers) have made possible research that has historically been impossible. Traditional approaches helped identify the most likely wildlife movement corridors between a limited number of habitat areas. By leveraging supercomputing technologies, researchers now model hundreds. hundreds of millions possible wildlife movement paths. This new approach provides the foundation for decision makers to consider the landscape holistically and better understand wildlife movement across an entire landscape – breaking free of the confines of examining only small areas of a landscape at a time.

The protocol is being used to identify existing problem areas that could benefit from remediation, such as the construction of wildlife underpasses beneath busy highways, and is also planned for use in guiding future projects before construction.

Land Management Implications

Land managers, road engineers, and urban planners can all benefit from knowing which species might be impacted by the location of a proposed project. This information will allow them to reconsider a project's location or design features within the project to lessen their impacts to wildlife while also protecting human safety.

A newly constructed wildlife underpass along Highway 89 in northeastern California was designed to keep both wildlife and motorists safe. Researchers with the Pacific Southwest Research Station are using supercomputers to model wildlife travel patterns to strategically place similar passages where they could benefit wildlife and humans the most. (Photo credit: Paul Meznarich/Pacific Southwest Research Station)

A restoration project in Hawaii where functional approach capitalized on a variety of plant heights and leaf shapes to develop a more resilient forest. (Photo credit: Susan Cordell/Pacific Southwest Research Station)

Using plant characteristics to develop resilient forests

Susan Cordell
Institute of Pacific Islands Forestry

View the publication online.

Restoration, in its broadest sense, involves improving conditions at a site to meet desired objectives. Traditionally, this has meant returning — or attempting to return — a site to its former, less-disturbed state. But this isn't feasible for an increasing number of ecosystems, whether because historical baseline conditions or comparable reference sites don't exist, or conditions have become so impacted that the original suite of species cannot reverse the damage.

Researchers from the Pacific Southwest Research Station's Institute of Pacific Islands Forestry have developed a computer program to help land managers identify substitute plant and tree species that can help restore an ecosystem when it's not possible to rely on the site's original species. The Restoring Ecosystem Services Tool (REST) chooses plants based on their functional traits and how those traits support restoration goals.

For example, a tree's height or the depth or density of a plant's root system might give land managers the upper hand in combatting an invasive species. A "functional trait" restoration project was tested in Hawaii, and researchers found a 60 percent decline in invasive species cover compared to control site that only relied on original species to combat the invasive plants.

Land Management Implications

Land managers can now more easily identify substitute plant species, based on specific characteristics or functions, to help restore severely impacted landscapes that might be difficult to restore using the current population of plants.

Image recognition model 'learns,' identifies hidden cannabis sites

Adam Cummings
Conservation of Biodiversity

Every year cannabis cultivation occurs on National Forest System lands with detrimental impacts to headwaters, forest ecosystems, and wildlife. The clandestine nature of the operations, however, make them hard for law enforcement officials to detect and stop (80 percent of grows are possibly undetected, by some estimates).

Scientists with the Pacific Southwest Research Station partnered with U.S. Forest Service law enforcement and researchers with the Integral Ecology Research Center to develop an advanced remote sensing tool to identify grow sites hidden on public lands. The Detection and Interdiction of Marijuana to aid Enforcement and Conservation (DIMEC) model uses high-resolution aerial imagery and a "deep learning" algorithm to refine its search and detection parameters with every successful detection — in essence, "learning" to do better.

DIMEC has proven effective at detecting both active grows as well as historical grows that were abandoned but still pose a threat due to the presence of remnant toxicants, fertilizers, and trash. Eradication and clean-up of grow sites can now occur year-round.

Example of model output. Aerial view of a cultivation site with a ground photo of damage left by the cultivators. (Photo credit: Adam Cummings/Pacific Southwest Research Station)

Land Management Implications

Land managers and law enforcement personnel can use the DIMEC model with their own repositories of high-resolution aerial photography to identify likely trespass grow sites.

Environmental DNA sampling methods detect rare amphibians in complex habitats

Karen Pope
Conservation of Biodiversity

Determining the occupancy and distribution of imperiled and invasive species can be difficult, especially in complex habitats with few individuals. Surveying for trace genetic evidence (such as shed skin, feces, urine and mucus) of species of interest within aquatic environments can present a viable solution for land managers struggling with limited time, staffing, or resources to conduct more conventional means of surveying.

Scientists with the Pacific Southwest Research Station have developed an environmental DNA (eDNA) sampling methodology specific to two at-risk species (the Sierra Nevada yellow-legged frog and the Cascades frog), as well as two invasive species (the American bullfrog and the Signal crayfish), within meadow habitats of the Sierra Nevada. Using targeted eDNA sampling with visual surveys reduces field time and increases accuracy when conducting species surveys. It only takes a small amount of water to run the test, bypassing the need for more intrusive sampling methods, such as netting or electroshocking the animals.

Land Management Implications

Land managers needing to determine the presence of rare or invasive species in complex aquatic habitats can improve survey accuracy and increase the probability of detecting target species using new eDNA sampling methods that can detect trace genetic material from these species within a small sample of water.

Crew members collect an eDNA sample at Perazzo Meadow on the Tahoe National Forest. (Photo credit: Karen Pope/Pacific Southwest Research Station)

Snag islands provide respite for black-backed woodpeckers after salvage logging

Gina Tarbill
Conservation of Biodiversity

Black-backed woodpeckers thrive in post-wildfire environments where trees killed by the fire provide nesting and foraging habitat. (Photo credit: U.S. Forest Service)

Black-backed woodpeckers (*Picoides arcticus*) thrive in post-fire landscapes, where dead trees provide nesting habitat and an abundant diet of insects capitalizing on the decomposing wood. Acres of dead and dying trees, however, pose significant risks for future catastrophic wildfires. Researchers with the Pacific Southwest Research Station are studying effective strategies to allow for the removal of some fire-killed trees to alleviate wildfire concerns, but still leaving enough to support black-backed woodpeckers and other snag-dependent species.

One strategy for removing dead and dying trees after a wildfire (a practice referred to as “salvage logging”), while supporting wildlife needs, is to retain sporadic patches of snags, called “snag islands.” To test the effectiveness of snag islands, researchers monitored an area slated for salvage logging two years prior and two years following the removal of trees and creation of snag islands.

While black-backed woodpeckers were not found nesting in areas where trees were removed, the birds were found nesting in snag islands and surrounding unlogged habitat, such that overall density was maintained within the 3,100 acre footprint of the fire.

Land Management Implications

Retaining clusters of dead trees within a salvage logging operation is a viable strategy for meeting wildfire mitigation needs while still supporting snag-dependent wildlife. Although recommendations as to the size and spacing of snag islands could not be made, in this particular study, seven snag islands — varying in size from 10 to 27 acres — were retained within the salvage boundary, which was 43 percent of the overall fire size. In this study, salvage occurred four years after the fire.

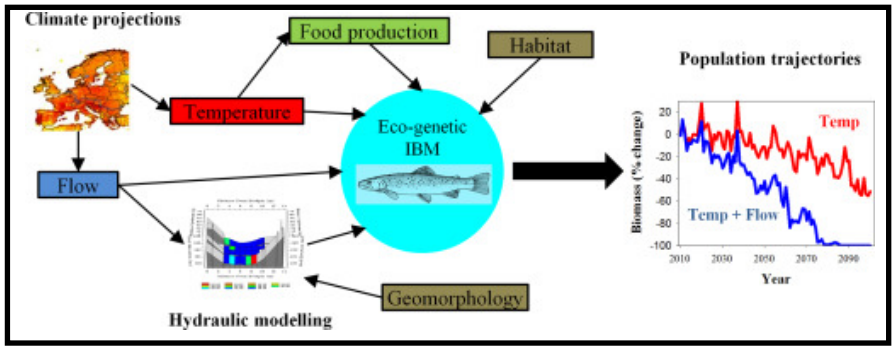
Simulation software models double-effect of climate change on trout

Bret Harvey
Conservation of Biodiversity

Many projections of climate change and its effects on aquatic organisms focus on warming water temperatures. But some locations might also experience changes in rain and snowfall patterns that would affect streamflows.

Researchers with the Pacific Southwest Research Station and their colleagues conducted computer simulations that examined how changes in water temperature and stream flow, either individually or in concert with one another, might affect fish populations. The simulation approach the researchers developed takes into account the ability of fish behavior and evolution to compensate for changes in the environment. Through the simulations, virtual fish seek to maximize their survival and reproduction as they face different environmental scenarios; simulations cover multiple decades.

The researchers ran simulations for a trout species in Spain at particular study sites that represented critical portions of stream networks. They found that although trout were able to sustain their populations under warmer temperatures, they were unable to do so when those realistic warmer temperature regimes were combined with likely future streamflows.



Researchers simulated trout behavior under different climatic scenarios within streams in Spain. The found that trout species could like sustain warmer water temperatures, but warmer water temperatures combined with decreased stream flows.

Computer simulations of trout in Spain indicate that populations would not likely sustain themselves under warmer climatic conditions in combination with lower stream flows. The results could shed insights on climatic effects on similar species, such as Californian coastal steelhead (*Oncorhynchus mykiss*). (Photo credit: John McMillian/NOAA)

Land management implications

The Spanish climate and streams studied resemble those found along coastal regions of California. The simulation results give land managers a clearer idea of threats to certain fish populations. The simulation approach used in this study also can forecast the consequences for fish populations of specific land management decisions, with or without incorporation of large-scale, long-term environmental change.

Hawaiian ecosystems becoming more reliant on non-native pollinators

Christina Liang
Institute of Pacific Islands Forestry

View the publication online.

Researchers with the Pacific Southwest Research Station's Institute of Pacific Islands Forestry tracked visitation patterns of pollinators and seed production of eight Hawaiian plant species (four endangered, four common). They found an overwhelming preponderance of visits came from non-native insects. Furthermore, pollination by non-native species were found to result in greater seed production in six of the eight plant species.

Of all recorded pollinator visits, 85 percent came from non-native insects. Two of the endangered plant species were only pollinated by non-native insects. For six of the eight plant species, the exclusion of all pollinators resulted in significantly reduced seed production.

Land management implications

More than one-third of the native flowering plant species in the Hawaiian Islands are listed as federally threatened or endangered. Lack of sufficient pollination could be contributing to their decline. Supporting non-native pollinators might help in conserving these plants and sustaining their ecological functions.

A European honeybee (*Apis mellifera*) visits the flowers of a native Hawaiian Kokolau shrub (*Bidens menziesii*) (Photo credit: U.S. Forest Service)

Oaks in vineyards increase likelihood of foraging bats

Ted Weller
Conservation of Biodiversity

View the publication online.

A majestic oak standing sentry within a vineyard isn't just for aesthetic appeal in California's iconic wine country. It may also serve as a cost-effective, chemical-free form of pest control. According to researchers with the Pacific Southwest Research Station, vineyards with oak trees were more likely to attract insect-eating bats compared to their treeless counterparts.

Researchers placed bat detector microphones within 14 vineyards throughout California's Central Coast to record bat echolocation calls. The recorders captured calls from 11 species of insectivorous bats. Bat foraging was 50 percent higher within proximity of oak trees than in open or treeless areas of the vineyard. It also allowed species of bats that were normally active only along the edge of vineyards to venture further into the vineyard's interior.

Land Management Implications

Retaining oak trees within vineyards not only enhances scenery, but also provides expanded foraging opportunities for insect-eating bats, which in turn, can provide natural pest control.

Bat detector on the edge of a vineyard in San Luis Obispo County, California. The detector microphone is mounted above a solar panel which powered the unit. (Photo credit: Skylar Giodano/Pacific Southwest Research Station)

Genetic research provides insight into tree adaptations to drought

Andrew Groover
Conservation of Biodiversity

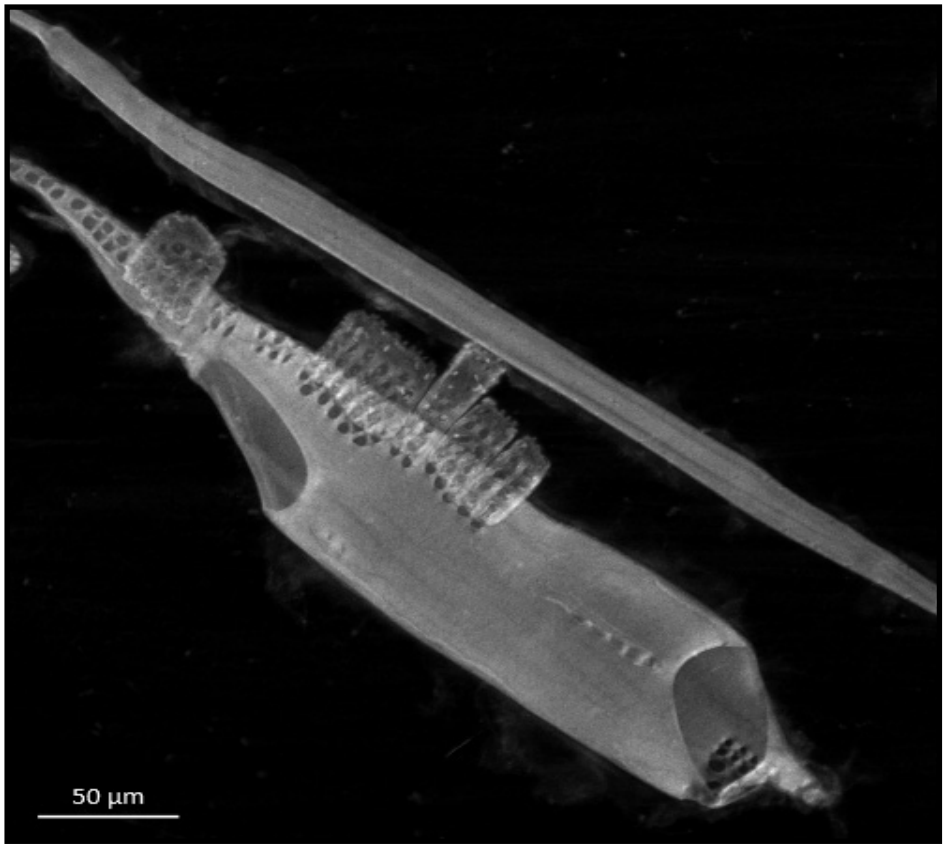
View the publication online.

Drought and water stress can result in failure of a tree's vascular system, causing air bubbles to form in the water-conducting cells of the tree and blocking the transport of water from a tree's roots to its canopy. This hydraulic failure is a leading cause of tree mortality during droughts. Interestingly, trees can modify the size of water-conducting cells to mitigate the effects of drought – smaller diameter pipes are less prone to failure.

Researchers with the Pacific Southwest Research Station are identifying the genes and cellular processes that regulate how trees respond to drought, including how they modify the development of water conducting cells to avoid hydraulic failure. Using a unique population of poplar trees, they are using a functional genomic approach to determine what parts of the genome regulate drought response, and how actions of genes translate to changes in development. Results to date clearly show that these are highly regulated and genetically variable responses by the tree, and now give researchers new insights and tools for the identification and development of more drought-resistant trees.

Land management implications

Identifying the specific genes regulating a tree's response to drought and water stress will pave the way to selective tree breeding for drought-resistant genotypes that could be used for reforestation.



A confocal microscope image of a water conducting vessel element from poplar wood. (Photo credit: Andrew Groover/Pacific Southwest Research Station)

Fences saving native Hawaiian ‘Ōhi’a forests from Rapid ‘Ōhi’a Death

Flint Hughes
Institute of Pacific Islands Forestry

Thousands of native ‘ōhi’a trees (M*etrosideros polymorpha*) have been dying across Hawai’i Island each year from a fungal infection known as Rapid ‘Ōhi’a Death. Researchers with the Pacific Southwest Research Station’s Institute of Pacific Islands Forestry are gaining a better understanding of how the disease is spreading, as well as testing ways to slow its advances and protect remaining healthy native Hawaiian forests.

Rapid ‘Ōhi’a Death comes from the fungal family Ceratocystis, which research elsewhere in the world has shown relies heavily on its spores entering trees through open wounds on the tree. On Hawai’i Island, ‘ōhi’a trees are often injured by feral pigs, cows, and other ungulates, many which can also harbor the fungus amid soil compacted in their hooves or other body parts.

Researchers tested whether restricting ungulate access to ‘ōhi’a using fences would impact how readily the disease spread. They found that test plots were ungulates were restricted from entering had significantly lower rates of infection compared to adjacent areas with unrestricted access.

Land management implications

Fences or other means or reducing damage from ungulates is a practical and effective means of reducing the susceptibility of ‘ōhi’a trees, stands and forests to the lethal effects of Rapid ‘Ōhi’a Death.

An aerial image of fenced, ungulate-free sections of 'ōhi'a forest (fences denoted by white boundaries), surrounded by unfenced, ungulate impacted forest zones. Colored dots denote recently deceased 'ōhi'a trees symptomatic of Ceratocystis-induced Rapid 'Ōhi'a Death. (Photo credit: Greg Asner/ Arizona State University)

Barred owls are native to the eastern United States, but have begun establishing themselves in western states, often displacing native spotted owl populations. (Photo credit: John Hartgerink)

Invasion of the barred owl: Can spotted owls compete?

Linda Long
Conservation of Biodiversity

View the publication online.

Barred owls (S*trix varia*) are forest-dwelling owls native to eastern North America. Populations have expanded westward, where they're threatening the viability of native spotted owls (*S. occidentalis*), and more specifically, the federally-threatened northern spotted owl (*S.o. caurina*).

Scientists with the Pacific Southwest Research Station have reviewed and synthesized published research concerning barred and spotted owl interactions. The resulting technical guide includes information of both species' diets, habitat selection and use, behavioral effects of their interactions, hybridization, parasites, contemporary management methods, and areas of future research needs.

Land management implications

The literature review and synthesis provides managers with the information necessary to develop strategies that mitigate deleterious effects of barred owls at local and landscape scales.

Next phase of 20-year experiment of coast redwood logging underway

Joe Wagenbrenner
Ecosystem Function and Health

In 2000, researchers with the Pacific Southwest Research Station, along with the California Department of Forestry and Fire Protection and numerous academic partners, began planning an extensive, long-range experiment studying how various logging intensities in a coast redwood ecosystem affected watershed conditions. Researchers have been monitoring water quantity, water quality, moisture dynamics in soils and trees, as well as impacts from road construction, removal, and use, landslides, and the dynamics of wood in streams in the Caspar Creek Experimental Watersheds on the northern California coast.

After years of pre-harvest monitoring and data collection, experimental harvesting began in 2017 and concluded in 2019. Researchers are now beginning post-treatment monitoring to assess what effects can be determined across a range of harvest intensities.

The study is unique because of the long history of research in the Caspar Creek Experimental Watersheds. The longer-term trends will help researchers put the current, shorter study in perspective. It is also the most intensively studied watershed experiment in a coast redwood forest, with experiments spanning spatial scales from single trees to hillslopes to full watersheds and at time increments from minutes to years.

Land Management Implications

The results of the study will provide empirical evidence of the effects of timber harvesting on streamflow, water quality, and several other watershed processes and outputs, which can be used by land managers to more accurately plan and anticipate effects from similar timber harvest or road-related projects. Two earlier experiments at the Caspar Creek Experimental Watersheds were foundational in the development of sustainable forest management practices and watershed monitoring practices.

Members of the Caspar Creek Experimental Watersheds team meet during a May 2019 field trip. (Photo credit: Paul Richardson/Pacific Southwest Research Station)

Rainfall simulator used to test potential for erosion from post-fire logging

Joe Wagenbrenner
Conservation of Biodiversity

View the publication online.

Removing dead and dying trees relatively soon after a wildfire, a practice known as salvage logging, may be done for different reasons. How this practice can affect erosion and water quality from soil compaction and ground disturbance has been hard to quantify because many factors control erosion and sediment transport from forests in general and particularly after a fire.

Researchers with the Pacific Southwest Research Station used a portable rainfall simulator to isolate controlling factors while measuring erosion from four soil conditions related to post-fire salvage logging: exposed uncompacted soil (the experimental control), exposed compacted soil found in a high-use skid trail, and then both compaction conditions with soil covered by logging slash.

Applying uniform rainfall from the rainfall simulator in two 30-minute cycles to the various 5-square-foot research plots, researchers determined soil compaction did affect soil hydrological properties, but the lack of surface cover was the main cause for erosion. They also determined that adding slash to the bare soil (increasing surface cover) reduced erosion. The results of the study were published in 2019 in the Journal of Hydrology and presented at the 2019 European Geophysical Union annual meetings in Vienna, Austria.

Land Management Implications

These results help land managers understand the conditions likely to exacerbate erosion during salvage logging, as well as better estimate the amount of erosion that might occur. The results also show that adding slash to skid trails used for post-fire salvage logging can reduce erosion rates.

International Programs fellow Maruxa Malvar with one of the slash-covered field plots prior to simulation. (Photo credit: Joe Wagenbrenner/Pacific Southwest Research Station)

Non-native mangroves might buffer Hawaiian Islands from climate change

Richard MacKenzie
Institute of Pacific Islands Forestry

Mangroves (*Rhizophora mangle*) were initially brought to the Hawaiian Islands from Florida in the early 1900s to trap coastal sediment and protect coral reefs. Efforts are now under way to eradicate them from the archipelago, but perhaps this non-native species can still be of service to the Pacific islands by mitigating the effects of climate change.

Researchers with the Pacific Southwest Research Station's Institute of Pacific Islands Forestry are studying mangroves' astounding capacity to capture and store carbon from the atmosphere, while also raising coastlines through its trapped sediments that are outpacing global sea rise. Hawaiian mangrove forests play an important role in climate change mitigation, storing 398-501 MgC/ha of carbon, compared to 117 Mg/ha stored in ʻōhiʻa-dominated wet forests, one of the archipelago's biggest stores of carbon. Much of this carbon (32 to 44 percent) is stored in anaerobic mangrove sediments that inhibit microbial breakdown. This can result in long-term storage (decades to millennia) if left undisturbed compared to upland forests. Mangroves also provide Hawaii with climate change adaptation. Coastlines with mangroves were found to be rising, on average, by .7 to 1.8 centimeters a year, compared to only .1 to .2 cm a year when mangroves weren't present. The current rate of sea rise is .1 to .3 cm a year.

Land Management Implications

Researchers' results highlight the importance of mangroves as novel systems that can rapidly accumulate carbon and elevate coastlines at rates that outpace current sea level rise. The sequestration potential of mangrove forests should be taken into account when considering their removal or management, especially in the context of mitigating and adapting to anticipated effects of climate change.

The high densities of roots in a mangrove's core result in elevated carbon stocks in mangrove sediments that provide mitigation to climate change. These roots also expand sediments and increase the elevation of mangrove forests relative to sea level rise, providing an important adaptation to climate change. (Photo credit: Richard MacKenzie/ Pacific Southwest Research Station)

Managing forests to better withstand drought

Chris Fettig
Ecosystem Function and Health

From 2012 to 2016, parts of California experienced its most severe drought in the last 1,200 years. Between water stress and increased vulnerability to bark beetle attacks, nearly 50 percent of trees in southern and central Sierra Nevada forests died.

Researchers with the Pacific Southwest Research Station, with colleagues from academia, the California Climate Hub, and the U.S. Forest Service's Pacific Southwest regional headquarters, synthesized current studies on drought management, along with research of their own, to develop strategies to facilitate the recovery of drought-impacted landscapes and to minimize the effects of future droughts. While specific treatments vary by ecosystem, general recommendations focus on shifting systems back within the natural range of variation by using mechanical thinning, prescribed burning, and managed wildfire to decrease stand densities, and facilitating a transition to plant species better adapted to future droughts.

Land management implications

Land managers have access to the latest scientific research detailing ways selective timber harvesting, prescribed burning, and managed wildfire can bring forests back to more historical conditions that are more resilient to disturbances, such as drought. Many of the management strategies identified will also help California reach its objective of maintaining natural and working lands as carbon repositories.

Prescribed burning, such as this prescribed fire on the Mendocino National Forest in California, is a recommended strategy for bringing forest conditions back to historical conditions and making them more resilient to disturbances, such as droughts or wildfires. (Photo credit: Christopher J. Fettig/Pacific Southwest Research Station)

Recreation and incidental exposure to ozone risk in affluent and disadvantaged communities

Pat Winter
Urban Ecosystems and Social Dynamics

View the publication online.

Urban parks are valued for their benefits to both nature and people. However, the ability of parks to provide these benefits hinges on equitable provision and access to quality green spaces. A social–ecological study of urban park use contrasted affluent and disadvantaged communities in the city of Los Angeles.

Twenty-four days of observations were gathered, where observers noted the location, gender, age, ethnicity/race, and level of physical activity of each visitor encountered. In addition, ozone dose exposure was calculated using average hourly ozone in ppb multiplied by METS (metabolic expenditures).

Dose exposure was significantly higher in the disadvantaged, majority Latino community parks. Findings suggest that additional monitoring in disadvantaged communities, may be prudent to facilitate the development of community-based mitigation strategies, as well as to assess potential long-term impacts.

Land management implications

Mitigative strategies placed in urban parks, such as increased tree canopy, may help to reduce degree of risk and improve community resilience.

Ozone exposure was measured using an Ogawa "badge" collector (right), not much larger than a nickel, worn by researchers. (Photo credit: Patricia Winter/Pacific Southwest Research Station)

Fuel treatments reduce wildfire suppression costs, property damage

José Sánchez
Urban Ecosystems and Social Dynamics

Areas treated with prescribed fire or that had their fuel levels lessened through mechanical means, such as timber harvesting, were found to have less property damage and fewer suppression costs when a wildfire occurred than their untreated counterparts.

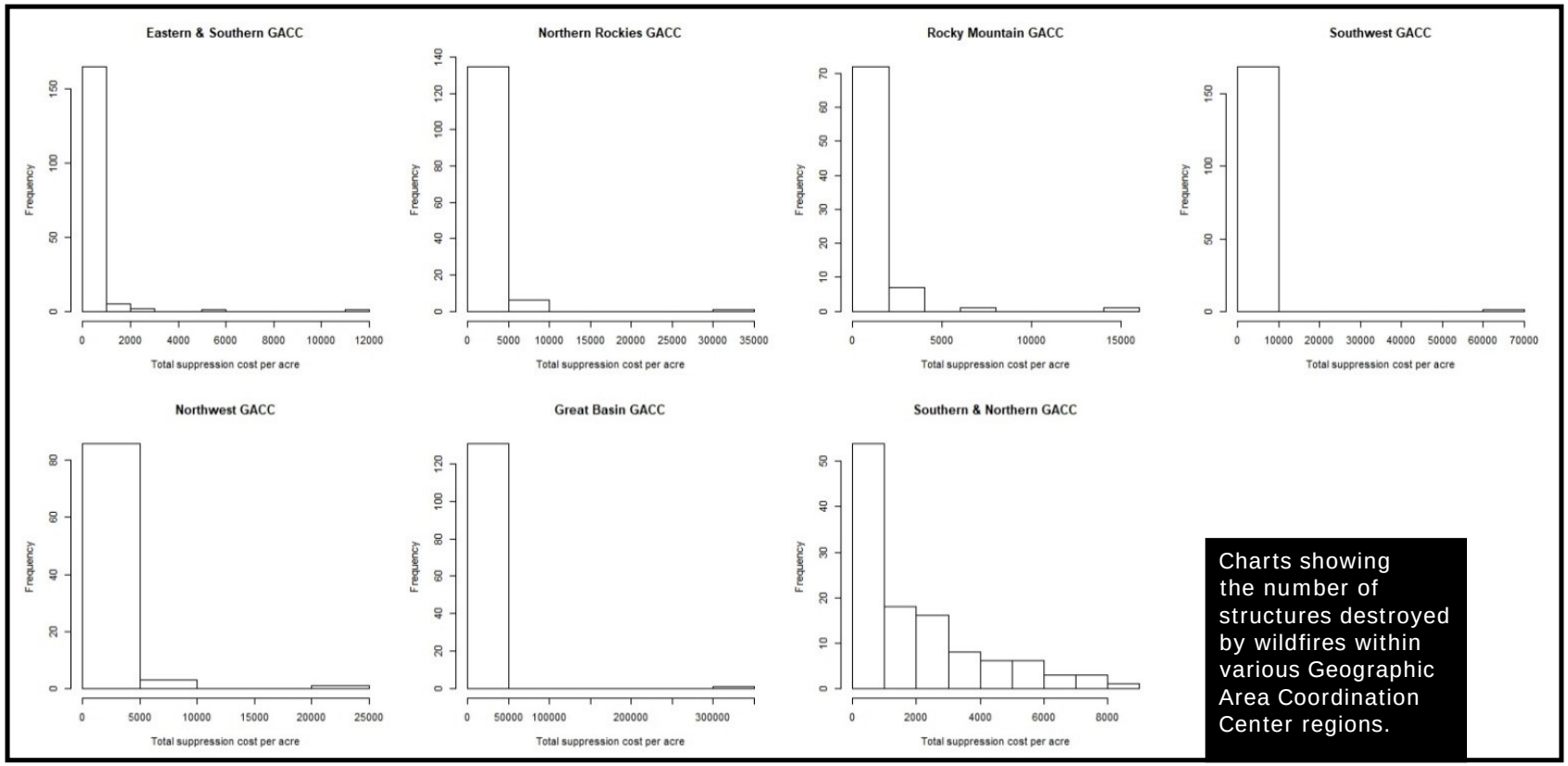
Researchers with the Pacific Southwest Research Station tracked damages and suppression costs of wildfires from the last five years across the continental United States.

Accumulatively, prescribed fire resulted in lower suppression costs across the entire United States, while both prescribed fire and mechanical treatments were found to be effective in reducing property damage.

Broken out geographically, mechanical treatments were also found to decrease suppression costs in California and the Northern Rockies.

Land management implications

Current practices of prescribed burning and the mechanical reduction of fuels have been found to be effective strategies for lowering suppression costs and reducing property damage from wildfires.



Charts showing the number of structures destroyed by wildfires within various Geographic Area Coordination Center regions.

Improved nursery practices may prevent inadvertent plant pathogen introductions from restoration plantings

Susan Frankel
Ecosystem Function and Health

View the publication online.

A pilot test of stricter sanitation protocols to reduce the likelihood of nursery plants transmitting diseases found endangered plant habitats are at risk for pathogen contamination. Researchers with the Pacific Southwest Research Station tested 11 nurseries in the greater San Francisco Bay Area that are participating voluntarily in an accreditation program that attests to their following safe plant handling and increased disease screening.

Researchers discovered *Phytophthora pseudocryptogea*, a relative of the fungus responsible for sudden oak death, on Antioch Dunes evening primrose (*Oenothera detoides,* spp. *howellii*) — a federally listed endangered species — in one of the nurseries. Once outplanted, the pathogen could contaminate the site with the potential of infecting neighboring plants.

Land management implications

Purchasers of plants for restoration may prevent pathogen introductions by knowing their suppliers and including specifications for testing and rigorous phytosanitary practices for native plant nursery stock. For plants destined for rare plant habitat, testing for pathogens prior to plant delivery may prevent environmental degradation.

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