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Large Wildfires in Forests: What Can be Done?

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articlehighlights

- *Forest fires have received increased attention from the media, politicians, and the public in the last 20 years.*
- *Wildfires can be dangerous to people and their homes, but most US forests are fire adapted.*
- *Fire regimes vary by forest type, with natural burning occurring at different intervals.*

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Introduction

Forest fires have received increased attention from the media, politicians, and the public in the last 20 years. Visceral pictures of towering flames on the nightly news and Internet routinely depict fire as a disaster that humans are called upon to fight by all means necessary, similar to warfare. This view of fire began in the US in the early 1900's.[1] The Great Idaho Fires of 1910 cemented this view when they burned about 3 million acres (1.2 million ha) and killed 87 people. Early fire exclusion policies were primarily designed to increase wood production from US forests since they were thought to be under stocked with trees because of fires 'destructiveness'.

Forest fires can be dangerous to people and their homes, particularly in the urban-wildland interface where homes are built adjacent to natural areas. However most forests in the US are adapted to fire and its elimination can have profound effects.[2] Although several early fire ecologists such as Herman Chapman, Herbert Stoddard, Harold Weaver, and Harold Biswell were aware of fire's importance and documented their findings in the southern and western US, their ideas were not widely accepted. When discussing fire as an ecological process a key concept is the fire regime, which describes the main characteristics of fire for a particular forest type. [3, 4]

A fire regime includes information on the average and distribution of

- Fire frequency (number of fires in an area)
- Area burned
- Fire season (fall, winter, summer, or spring)
- Fire intensity (flame length and fire rate of spread)
- Fire severity (amount of mortality of the dominant vegetation, i.e. how many trees are killed)

Fire regimes vary with forest type and location. Some forests such as high-elevation Rocky Mountain lodgepole pine in Yellowstone National Park are adapted to infrequent, high severity fire regimes. Fires occur here every 80-200 years and when they burn, most trees are killed (high severity).[5] Lodgepole pine seeds are stored for decades in the tree canopy in resin-sealed closed cones that open after severe fire melts the resin, and releases a rain of seeds that regenerate the forest.

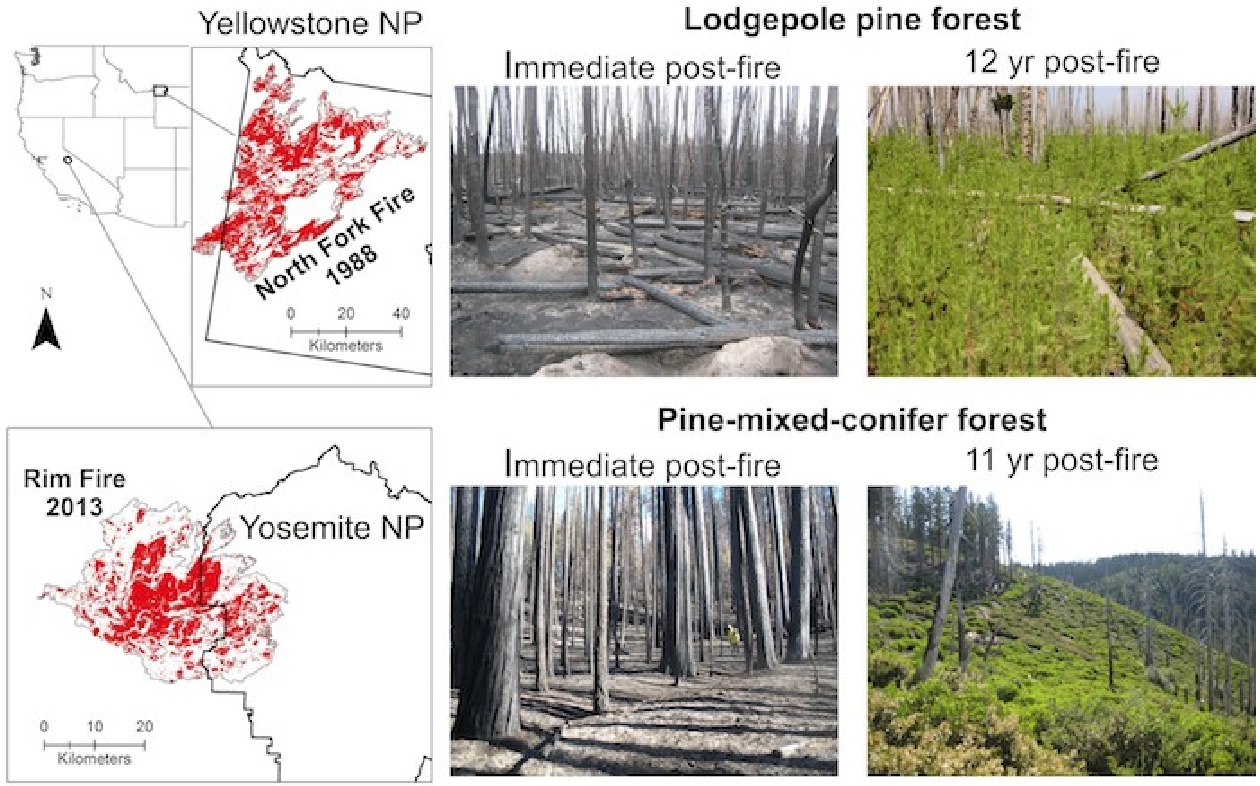

Figure 1. Forest fire patterns (left panels) in Rocky Mountain lodgepole pine in Yellowstone National Park, WY, and pine dominated-mixed conifer forests in the Sierra Nevada, CA. The red regions of the maps are areas where > 95% of the trees were killed by the fires. The photographs show different forest recovery in these areas of high tree mortality; note abundant tree regeneration in Yellowstone but only shrubs in the Sierra Nevada. These fire severity maps are produced using satellite imagery. Photos by S. Stephens and G. Roller.

In contrast, many low to mid-elevation forests are adapted to frequent, low-moderate severity fire regimes. Mature trees in these forests have characteristics that allow them to survive fire (e.g., thick bark, no low hanging branches). Ponderosa pine, Jeffrey pine, and pine-mixed conifer (a mixture of species including ponderosa, Jeffrey, and sugar pines, white and grand fir, incense-cedar, Douglas-fir, and western larch) are the common forest types with this fire regime. Fires in these forests burned every 5-25 years and killed only a small patches trees.[6,7] Forests with low-moderate severity fire regimes have been the most impacted by fire exclusion because over the last 100 years they have missed 4-10 fires compared to high severity regimes areas that at most have only missed 1-2 events.

Current wildfire problems in forests that once burned frequently

Fire is a natural and inevitable process in most forest types. In forests that historically burned frequently fire regulated the amount of live vegetation (e.g., trees, shrubs) and dead fuel (e.g., branches, needles) on the forest floor. By doing so, these fires actually limited the intensity of subsequent fires, so that mature trees generally survived many fires. It would be easy to assume that because of this association with frequent fire these forest types were uniformly open (trees spaced widely apart) with very little vegetation or accumulated fuel on the forest floor.

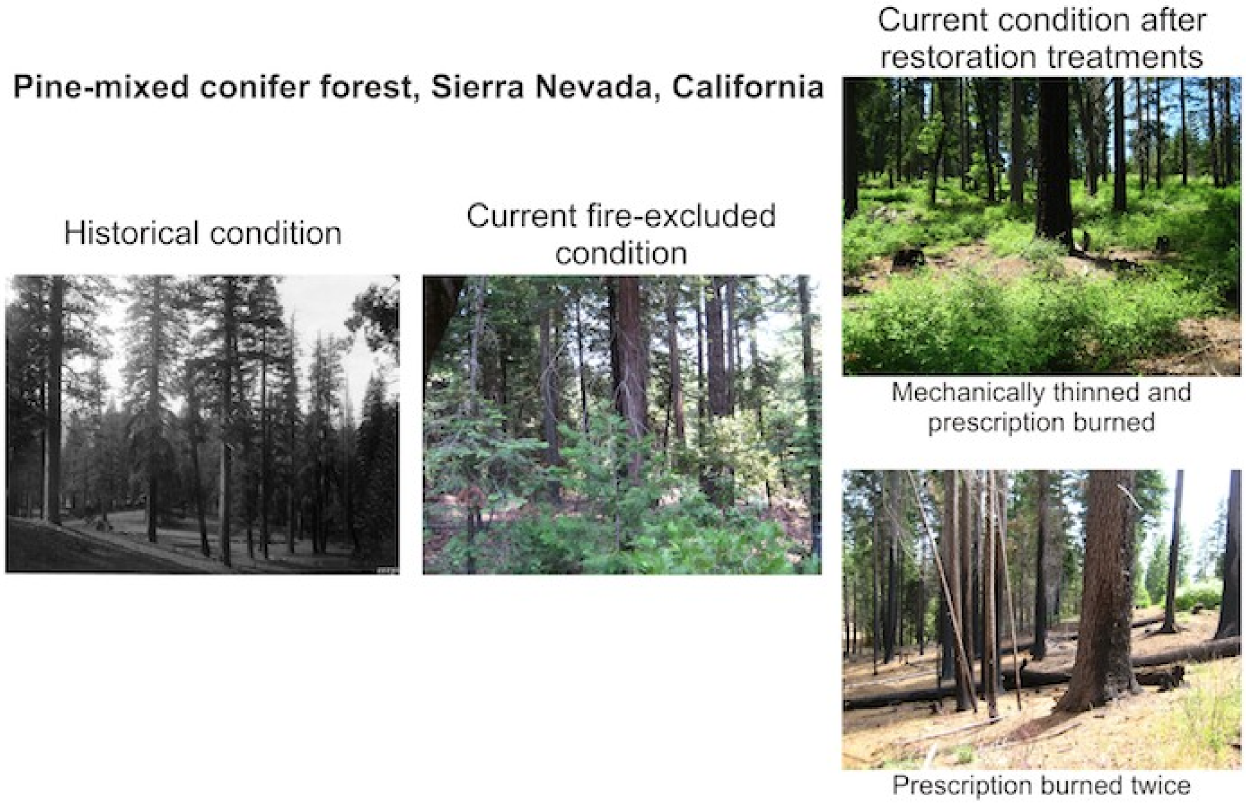

Figure 2. Forest structure in mixed-conifer forests in the Sierra Nevada before Euro-American settlement (left panel), after 100 years of fire suppression and harvesting (center panel), and after forest restoration treatments. Left photo from USFS Bass Lake Ranger District historic photo archives (photo no. HP00971), other photos from S. Stephens.

While this was the case in many areas, there was actually quite a bit of variability in historical forests that created a range of forest conditions.[8] This range of conditions included discrete areas of pure shrubs, where trees were killed by higher intensity fire, as well as areas that fire missed for various reasons, which allowed for higher tree density and greater accumulated fuel.[9, 10, 11]

Figure 3. Forest structure in Sierra Nevada upper elevation mixed-conifer forests in the Illilouette Creek basin, Yosemite National Park, after multiple lightning fires were allowed to burn. The Park Service began to manage lightning fires in 1974 and over 40 fires have burned in this 15,000 ha area. Note the high variability in forest structure produced by these fires. Mt. Starr King is in the center background of this landscape. Photo by M. Meyers.

Over the past 80-120 years our practices of fire suppression, timber harvesting, and livestock grazing have altered forest conditions considerably. Generally these changes include:

- increased tree densities
- fewer large trees, many more small trees
- reduced proportions of fire tolerant-tree species, i.e., trees that have characteristics to withstand fire - thick bark and live branches separated from the ground, such as ponderosa pine
- excess fuel on the forest floor
- reduced shrub and herbaceous plants in the forest understory
- reduced variability in forest conditions

These changes have contributed to larger and more severe fires in recent decades than we have seen in the last 300-500 years.[12] This is not to suggest that all recent fires are uniformly destructive, rather that levels of high-severity effects (i.e., fire kills most or all of the trees in a particular area) far exceed those observed in historical frequent-fire forests.[13] (Figure 1) There are a couple key concerns stemming from these increased levels of high-severity effects. The first concern is the impact to critical resources:

- Soil - Following high-severity fire most or all of the vegetation and fuel on the forest floor is consumed, which exposes bare soil and increases potential for erosion. Once an area’s soil is lost, it cannot be replaced in any reasonable time frame (>1000 years). The loss of soil diminishes the capacity of an area to re-grow trees.
- Water - When soil erodes from an area it ends up in streams and can ultimately move into lakes and reservoirs. This can negatively impact not only the aquatic organisms living in these environments but also domestic water supplies (residential, agricultural).
- Wildlife habitat - For some wildlife species that are in decline, high-severity fire can remove key habitat features such as old, large live and dead trees that these species depend on. When these trees are killed by fire it can take centuries to regrow trees of comparable size.

The second concern is the inability of trees to re-establish where continuous large areas of high-severity fire have occurred. In forests adapted to frequent fire, trees generally do not have a way to regenerate because their seed, which is stored in open cones, is killed by fire. In forests adapted to frequent fire the only way for trees to re-establish in high-severity patches is for seed to be blown in by wind or carried by small mammals from neighboring areas that were not severely burned. There is a limit to how far seed can travel by wind and the general ‘rule of thumb’ is two tree heights, or approximately 50-150 meters. If trees do not establish fairly rapidly after fire (< 5 years) shrubs will dominate and occupy the area for several decades or longer (Figure 1). In these instances, large high-severity patches can lead to a conversion from forest to shrubland.

Recent research has shown that the proportion of high-severity fire has been increasing over the past couple decades in some forest types in the Sierra Nevada.[14, 15] In addition, these studies demonstrate that fire sizes and annual area burned have also risen during the same period. Despite these increases, the western United States as a whole has a large “fire deficit”.[16] This is based on reconstructed fire occurrence over the last 1,500 years using sedimentary charcoal records. These researchers argue that the current divergence between climate (mainly temperature) and area burned is unprecedented throughout their historical record. In other words, with temperatures warming as they have been over the last several decades, we would expect to see much higher fire activity, based on historical fire-climate associations. This divergence is due to fire exclusion policies, which may not remain effective over the long term if warming trends continue, further emphasizing the inevitability of fire in these forests.

Restoration needs

For forests historically adapted to frequent low-moderate intensity fire, the increased density and canopy cover produced by fire exclusion influences more than just how the forest will burn, it also affects ecosystem processes and wildlife habitat.[17, 18]7 Without fire, most of the openings and forest understory fills in with young, regenerating trees (Figure 2), often species more tolerant of shade but less tolerant of fire. Increased competition for scarce soil moisture stresses all trees and makes them susceptible to forest insects such as bark beetles that can sense tree stress.[19] This infilling also significantly reduces the variability in sunlight, canopy cover, and microclimate conditions making the forest understory much more homogeneous. Without the contrast between groups of trees and gaps, the habitat for animals and understory plants is diminished to a fairly uniform shaded environment.[20]

Restoration of forests adapted to frequent fire focuses on recreating variable forest conditions with lower tree densities and more openings. In particular, managers now try to reduce uniformity and create a pattern that has been consistently found in forests with an active, low-moderate intensity fire regime (Figure 3). This pattern has been described as ICO (**I**ndividual trees, **C**lusters of trees, and **O**penings).[21] Managers vary these patterns with topography because differences in slope position, angle, and aspect influenced historical fire intensity and frequency creating different forest structures.[22] These topographic differences also affect water availability, the other main influence on forest conditions. Wetter cooler locations such as lower slopes and forests with a northeast aspect can support higher tree densities and canopy cover, than drier, more frequently burned areas such as steeper slopes and southwest aspects.[23] Restoring forests to these conditions has not only proved to increase their resilience to drought and fire, but also provide variable habitat conditions for rare wildlife species such as the spotted owl and Pacific fisher. For some of their habitat needs, these species prefer dense forest conditions with high canopy cover which worry fire managers. New restoration practices create these conditions in cooler, wetter locations while elsewhere providing a range of forest conditions preferred by prey of these sensitive species.[24] In this way, current restoration practices can reduce forest fuel loads and tree densities making the forest more resilient to drought and fire, while still providing other dense, high canopy cover areas to meet the needs of wildlife that prefer this type of habitat.[17] Even though forest restoration is a proactive approach to forest fires, it is not so much about restoring some assumed “balance of nature” as it is achieving forests better adapted to disturbance and climate change. Natural forests have a great deal of variability so our restoration objectives should not be overly prescriptive since ecosystems are ever-changing and never in equilibrium.

Working with Fire

Over the last twenty years there has been a significant increase in the annual acreage burned by wildfire, percentage of land agency budgets devoted to suppression costs, and fire fighter casualties.[25] Analysis suggests these trends are likely to continue given changing climate conditions, increased rural home construction, and fuel-loaded forest landscapes. Changing this trajectory will require a more proactive approach where much of the landscape has been treated to restore forests and reduce fuels and thereby the intensity of wildfires. Yet there are several forces that make this change difficult. Mechanical thinning projects are sometimes legally challenged by public stakeholders concerned that treatments might adversely impact sensitive species such as the spotted owl although ecological effects of these treatments are generally neutral or positive.[26, 27]28, 29 Much of the fuels reduction requires removing small trees (ladder fuels) and surface litter, branches and logs that cannot ‘pay their way to the mill'.[30] Land management agencies such as the U.S. Forest Service have limited budgets to implement these costly treatments particularly as their fire-fighting costs escalate.

The other fuels treatment method is to make greater use of prescribed burning (Figure 2) and managed wildfire (Figure 3). Prescribing burning is when managers actively burn an area under conditions that limit fire intensity, and managed wildfire is a lightning ignition that is monitored carefully but allowed to burn. Both are used only when favorable weather and smoke dispersal conditions are present. Both types of fire, however, put smoke in the air, to which some people object. When the smoke does not disperse as forecasted it can also negatively affect the health of some people with respiratory illnesses. Furthermore managing fire has inherent risks and has become more difficult with increased rural home construction within otherwise forested landscapes. Fire managers risk high costs and potential liability if a burn escapes containment.[31]

One of the obstacles to greater public and land agency acceptance of fire is the result of a very successful advertising campaign. Smokey Bear emphasizes that 'only you can prevent forest fires.' The implied message is that with increased effort and due diligence wildfire can be eliminated. However after decades of increasing fire and ample research detailing fire history in many forests, it's clear that fire exclusion only delays the inevitable .[2] Today less than 2% of ignitions account for more than 96% of burn area .[25] This means that 98% of all fires are successfully put out. The few fires that escape usually occur during extreme weather or in heavy fuels, or in some cases when lightning storms ignite hundreds or thousands of fires in 1-2 days. Under extreme weather conditions fires can grow rapidly and become virtually unstoppable until there is a substantial change in weather or fuel conditions.[32]

We now face a difficult choice between continuing with an approach that emphasizes fire exclusion or trying to work with fire allowing it to burn under favorable conditions. Working with fire has risks and compared to mechanical treatment often means less precise control over the outcome. However, there may be little choice as costs and ecological damage continues to rise in many areas throughout the western US. Although large, high-intensity wildfires may appear to be 'natural disasters', often they are actually the result of a fire exclusion-focused approach to forest landscapes adapted to frequent fire. To solve this problem will require a dedicated effort to restore and maintain forests at large spatial scales (millions of acres) and public support for such management will have to increase. If we fail in this effort future generations will not enjoy the same type of forests that we have today. It is time to get moving.

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http://www.landfire.gov/fireregime.php

National Park Service Fire and Aviation Management
Read about the National Park Service's Fire and Aviation Management organization, which is tasked with managing wildfires in US national parks.
http://www.nps.gov/fire/

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Wildfire Preparedness
More and more people are making their homes in woodland settings - in or near forests, rural areas, or remote mountain sites. There, homeowners enjoy the beauty of the environment but face the very real danger of wildfire.
http://www.ready.gov/wildfires

educatorresources

Forestry Institute for Teachers
The Forestry Institute for Teachers is a multi-day residence workshop developed by the Northern California Society of American Foresters, University of California Cooperative Extension, Shasta County Office of Education, The California Department of Forestry and Fire Protection, and Project Learning Tree.
http://www.forestryinstitute.org

Lessons of Our California Land
Lessons of Our California Land is a standards-aligned curriculum that increases K-12 students' understanding of the history and meaning of California land, fostering appreciation for the motivations and knowledge of California Native American people who engage in land tenure, planning, and use issues.
http://landlessons.org

FireWorks
FireWorks is an educational program for students in grades 1-10. The program consists of the curriculum in this report and a trunk of laboratory materials, specimens, and reference materials. It provides interactive, hands-on activities for studying fire ecology, fire behavior, and the influences of people on three fire-dependent forest types—Pinus ponderosa (ponderosa pine), Pinus contorta var. latifolia (interior lodgepole pine), and Pinus albicaulis (whitebark pine).
http://www.fs.fed.us/rm/pubs/rmrs_gtr065.pdf

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