



PHOTOS: Post-fire rejuvenation following the Rim fire on the Stanislaus National Forest, central Sierra-Nevada, CA. Wildflowers tend to explode in color and richness after fires (top left), most western fires burn in a mixed-severity pattern that is beneficial to wildlife (top right), conifer establishment occurs even in severely burned patches (bottom left), and post-fire logging damages nature's renewal processes after fires (lower right: D. Bevington).

Ways to Co-exist with Large Fires and Their Ecosystem Benefits

Dominick A. DellaSala, Ph.D., Chief Scientist, Geos Institute (Dominick@geosinstitute.org)
and Chad T. Hanson, Ph.D., Ecologist, John Muir Project of Earth Island Institute

July 2015

Geos Institute 84 Fourth St. Ashland, OR 97520 | Ph. 541.482.4459 | www.geosinstitute.org

Using science to help people predict, reduce, and prepare for climate change

Key Findings

- There are proven ways to coexist with fire in the backcountry by focusing on risk-reduction measures in the home-ignition zone (within 100–200 feet from homes).
- A new forest naturally regenerating after a large fire is as ecologically valuable as an old-growth forest and is resilient to future fires. Post-fire logging, tree planting, and herbicides set back forest renewal, raise fire hazards, and increase the risk of uncharacteristically severe future fires.
- Thinning cannot stop large fires burning under severe fire-weather conditions that will increasingly occur as the climate changes in places. Thinned stands must encounter a fire when fuels are at their lowest levels post-treatment (only 5–8% chance) and under average fire-weather. Restoration should focus on priority areas to allow fires to burn safely in the backcountry.
- Insect outbreaks do not contribute to large severe fires and may lower future fire intensity as tree densities and tree crowns are actually reduced by outbreaks.
- Large fires produce much less carbon dioxide emissions than deforestation and fossil fuel burning, and new forests rapidly begin to sequester carbon, as vegetation grows.
- Large and severe fires were always historically prevalent, as they are today, and large severe fires are actually at an historical low and not at a recent surplus.

This fire primer is meant for decision makers concerned about forest fires in the American West. Using best science, we address seven fundamental questions related to the ecological importance of large fires and their appropriate management on public lands. Specifically, we examine: (1) what works best for reducing fire risks to homes and firefighters; (2) are large wildland fires an ecological catastrophe as claimed; (3) are fires increasing from historical levels; (4) does forest thinning reduce fire intensity or lower large fire occurrence; (5) how does post-fire logging affect forest rejuvenation and reburn intensity; (6) do insect outbreaks increase fire occurrence or intensity; and (7) how is climate change affecting fire behavior in the West?

The findings presented in this primer are based on hundreds of studies of forest fires in the American West and elsewhere as presented in “The Ecological Importance of Mixed-Severity Fires: Nature’s Phoenix” published by Elsevier, a world-leading provider of scientific, technical and medical information products and services. This primer is particularly timely given the recent passage of HR 2647 in the House and interest in the Senate on fire legislation. The primer is based on best available science on ways for communities to co-exist safely with fire’s ecological role on public lands, given fire is not going away, no matter how hard managers try to suppress it.

What Works Best for Reducing Risks to Homes and Firefighters?

What managers do miles away from a human settlement has little to do with the probability that a home will burn in a wildland fire. The majority of homes lost in wildland fires have burned because no significant measures were taken to reduce the ignitability of the structure (e.g., fire resistant roofing and siding) or its surroundings.

Key Finding: studies have consistently shown that the most effective strategy for protecting a community is to reduce fuels immediately adjacent to homes, and reduce the ignitability of the homes themselves.

Based on numerous studies, the probability of a home surviving a wildland fire increases to

over 90% if the following precautions are taken (Figure 1):

- Build homes with non-combustible roof covering and siding; keep roof and gutters clear of leaves/needles; keep fire wood away; keep vegetation to minimum adjacent to homes; cut overhanging limbs of trees closest to home; and install ember resistant attic vents.
- Reducing vegetation within 100–200 feet of a home is the most effective treatment: carefully space plants, reduce wood plant cover to <40% around the structure, and use varieties that are low-growing and free of resins, oils and waxes that burn easily; mow lawn regularly and prune trees up to 10 feet or so from ground;

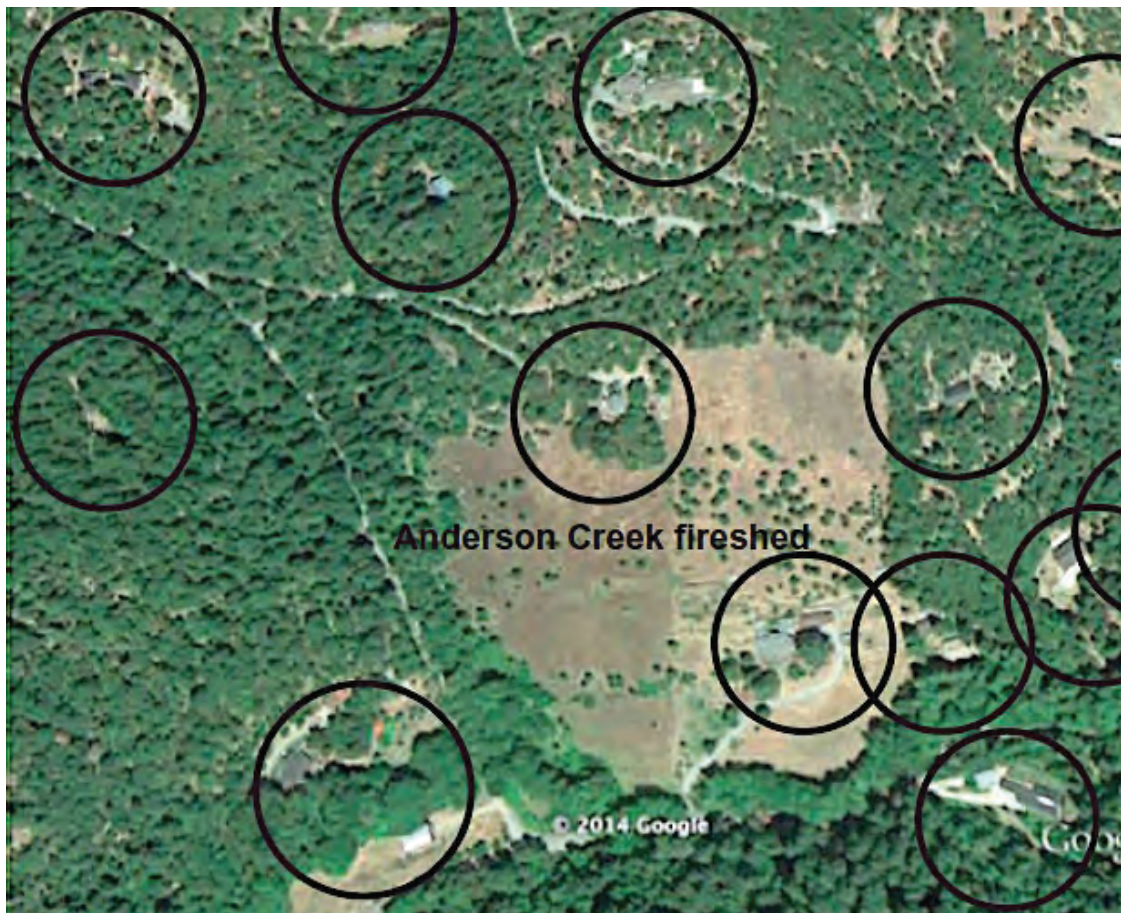


Figure 1 Google Earth image of the Anderson Creek watershed (southwest Oregon) and community fire-shed showing a housing development. Circled areas depict where proper fire risk reduction has the greatest change of saving homes in a fire.

space conifer crowns ~10 feet apart and remove lower limbs; trim back trees overhanging the house; create a “fire-free” area within 5 feet of the house using non-combustible landscaping; remove dead vegetation; use fire-resistant furniture; remove firewood and propane tanks; and water plants or use xeriscaping.

- Additional measures include low-growing, well-irrigated and relatively non-combustible vegetation in low planting densities; a mix of deciduous and conifer trees; and fuel breaks like driveways and gravel walkways and lawns.
- Treatments away from home structures offer no additional protection

Are Large Wildland Fires an Ecological Catastrophe?

Large fires (watershed and landscape scale) that threaten homes or place firefighters at risk are a human catastrophe that can best be avoided through proper risk reduction and fire-safety methods (as above). Large fires in the American West also have been a natural disturbance agent for millennia, shaping the remarkable fire-dependent web-of-life in dry regions regularly and wet regions less frequently. Descriptions of fire effects typically used by the untrained observer include: “catastrophic, destructive, consumed by fire, moonscape, and destroyed.” Decades of fire ecology studies show most fires, including very large ones, are actually quite beneficially ecologically and are not catastrophic to ecosystems.

Even though large wildland fires may seem at first glance as a “catastrophe,” the post-fire landscape springs to life with renewed plant vigor and unique wildlife communities that not only benefit from fire, but many require it as a restorative agent. We refer to this renewal process as “nature’s phoenix” given the new forest literally rises from the ashes soon after fire. Fire provides habitat for scores of fire-dependent plants and animals that prosper in this rich post-fire environment.

Large fires burn in mixed severities that benefit plants and wildlife

In contrast to what some believe, large fires do not burn uniformly through an area killing all the trees, nor do high-severity patches that kill

most trees dominate all, or most, forest fires. Rather, most large fires vary widely in effects on vegetation, producing patches of low severity (understory effects only), moderate severity (25–75% tree kill) and high severity (75–100% tree kill). When viewed at landscape scales, these patches create a kaleidoscope of plants in different stages of post-fire rejuvenation (Figure 2).

Several lines of evidence confirm that almost all forest fires have a natural high-severity component as an integral part of mixed-severity “mosaic” burns, although the proportion of high-severity patches within any burn area varies with forest type and local conditions (from as little as 5–10% to as much as 50–60% of the forest burning at high severity). This has changed very little from historical times as documented by numerous recent studies.

Key finding: The management implications that large and severe fires were always historically prevalent as they are today are profound and underappreciated by many.

Especially important to many wildlife species is the unique habitat created by large and small patches of severe fire within mixed-severity fire complexes. Such fire patches are used nearly exclusively by Black-backed Woodpeckers and as foraging habitat for spotted owls (Figure 3) if not logged. Severe burns create a “pulse” of biological activity that is most notably associated with high

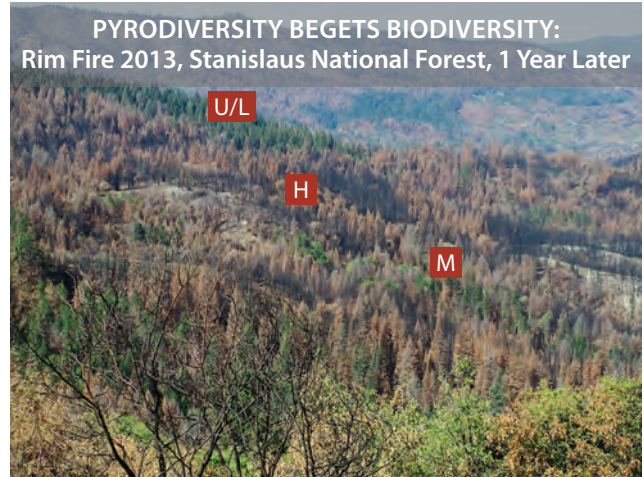
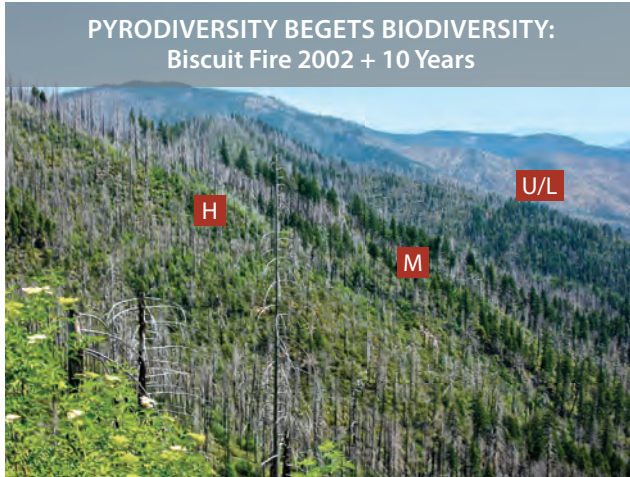


Figure 2 Two views of mixed-severity fire mosaics: Biscuit fire 2002 southwest Oregon (left) and Rim fire 2013 Sierra-Nevada region, California showing unburned (U)/lightly burned (L), moderate (M), and high (H) severity patches. Photos D. Bevington (2014) and D. DellaSala (2012). In both instances, pyrodiversity (the mosaic of mixed-severity burn patches) is associated with high levels of plant and wildlife diversity.

densities of large dead trees (if the fire burned through a mature forest). The dead trees (snags) are vital for forest renewal as they anchor soils, shade seedlings from intense sunlight, provide habitat for scores of insect-eating bats and birds, and lifeboat a forest from young to old-growth forest. This type of young forest is referred to as complex early seral (also called “snag forest habitat”) because it is structurally complex due to abundant dead trees, and live trees that survived the fire, along with shrub and forb growth in the understory (Figure 4). Complex early seral forest is considered among the rarest and most threatened in many regions of the West because it



Figure 3 The Black-backed Woodpecker is mainly restricted to high-severity burn patches and has declined due to post-fire logging and fire suppression (it is currently under consideration for federal ESA listing). The Spotted Owl uses burned patches for foraging and large dead and live trees for nesting in fire complexes (photos: M. Bond, USFWS).



Figure 4 After a forest fire of mixed intensities, stand structure (complexity) and wildlife richness and abundance rivals that of the more herald old-growth forest.¹

1. Donato, D.C., J.L. Campbell, and J.F. Franklin. 2012. Multiple successional pathways precocity in forest development: can some forests be born complex? *J. Vegetation Sci.* 23: 576–584.

is almost always logged following a fire. Removing these essential components can impact forest rejuvenation for decades to centuries as the forest benefits from this pulse of activity over time (see below). In contrast, early seral produced by clearcuts lacks the structural complexity of a fire-produced young forest as there are few if any large trees left to provide “legacy” structures for wildlife. Clearcuts are not equivalent to fire-generated complex early seral forests in any form.

Key finding: Complex early seral forests, in combination with mature forests, provide both nesting/roosting and foraging habitat for spotted owls, and nesting and foraging habitat for numerous birds, including Black-backed Woodpeckers that depend heavily on high severity burns. Clearcuts do not produce these beneficial effects.

Are Forest Fires Increasing from Historical Levels?

This question is on nearly everyone’s mind in the West today given how fire can affect people.

Most people; however, do not have access to historical records and can only witness fire effects over very short timelines (years, decades). Most reports of fire increasing in intensity or acres burned are based on short timelines (decades) relative to the much longer fire intervals that any given forest typically experiences over centuries. Thus, the time chosen as the historical baseline for comparisons to current fire conditions can lead to incomplete or incorrect conclusions about

fire increasing, and misdirected management. For instance, while the onset of fire season is occurring earlier in many parts of the West, due presumably to regional warming, at best most datasets only compare current fire conditions to the last 3–4 decades. With limited datasets, it is easy to understand how one can interpret a recent (last 4 decades) up-tick in fire acres (right side of Figure 5), particularly if the earlier period is ignored (left side of Figure 5) or longer time intervals available from charcoal analysis and historical accounts are not considered.

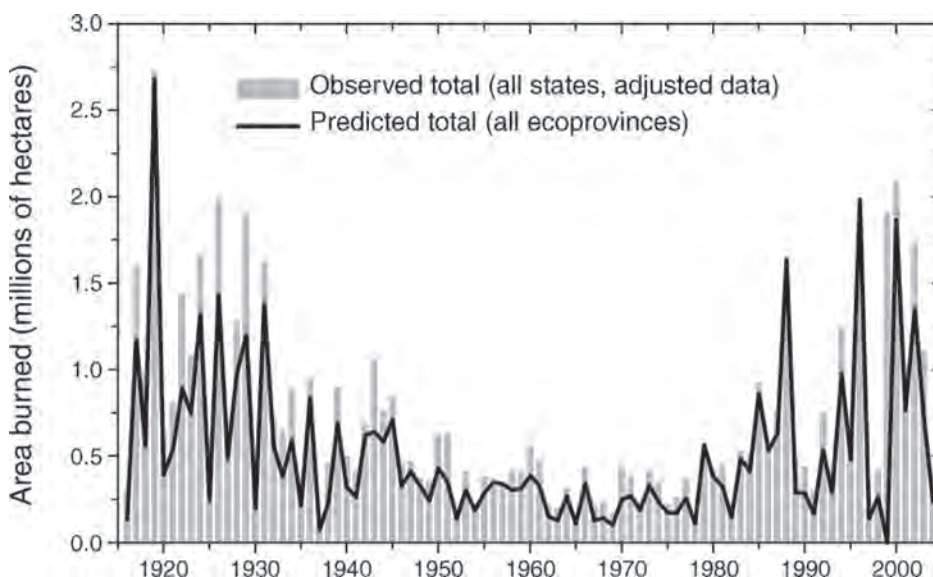


Figure 5 Area burned (predicted based on climate models vs. observed) in the Western US from the early 1900s to 2010². The dip in the middle decades was likely the result of a cooler period of the Pacific Decadal Oscillation (PDO) in combination with fire suppression. Many fire studies focus on the right side of the figure (1980s) due to data limitations, thereby, missing early accounts (left side of the figure, historical accounts, charcoal analysis) when fire was more prevalent. Notably, since the 1980s the PDO is in a warm phase, fire suppression has increased, yet fire acres have increased as well (see Fig. 12).

2. Littell, J.S., et al. 2009. Climate and wildfire area burned in western U.S. ecoprovinces, 1916–2003. *Ecol. Applications* 19:1003–1021.

Key Finding: Based on longer interval historical accounts such as the General Land Surveys of the 1880s and charcoal analysis of pollen cores, on average, fires were much more common historically than today and burned in similar patterns of fire severity in mixed-severity systems.

Based on longer historical (and beyond) timelines, there are actually fewer acres burning in high-severity conditions today compared to an

appropriate baseline. This could change in places as large fires become increasingly propagated by extreme weather events such as droughts driven by climate change. More weather/climate-driven fire behavior will eventually render fire containment increasingly costly (ecologically and financially) and ineffective. Many fire scientists have come to realize that we cannot simply log our way out of forest fires, and must reduce the primary causes of warming: burning of fossil fuels and deforestation on global and regional scales.

Does Forest Thinning Reduce Fire Intensity or Lower Fire Occurrence?

Contrary to belief, older forests where fire has been absent for decades or longer tend to eventually experience mostly low to moderate severities, when fires do occur, rather than high severity as claimed. This is primarily because tree canopies in older forests eventually shade understory fuels that might carry a fire into tree crowns. This has been observed in the Klamath-Siskiyou region of northwest California and southwest Oregon, in the Sierra-Nevada Mountains of California, and northern Rockies. Older forests will not benefit from thinning to reduce fire intensity as in most cases there is no need for this ecologically.

Some scientists believe that thinning of small trees, combined with prescribed burning, can play a role in forest management in certain areas, but that such management should target priority areas where there is greater certainty regarding potential outcomes to fire behavior. This includes vegetation immediately adjacent to homes in order to protect structures, and the most heavily altered areas such as unnaturally flammable tree plantations. Under these conditions, for small-tree thinning and prescribed fire to be effective at reducing fire intensity, several factors need to be in place (see text below).

Key Findings:

- Thinned stands must encounter a fire when fuels are at their lowest levels; that is ~10 years before understory vegetation regrows. Based on computer simulation models, on average, the likelihood of a thinned site encountering a forest fire when fuels are lowest is only 5–8%.
- Thinned stands must encounter a fire when weather conditions are not high or extreme. That is, not during droughts, high winds, or low humidity when weather, not fuels, is the main driver of fire behavior as is often the case in most mixed-severity burns. With climate change, we can expect weather to increasingly be the primary driver of fire behavior and this will overwhelm fire suppression forces.
- Thinning prescriptions must not open up tree canopies to a level that increases wind speeds (e.g., <60% crown closure) and understory vegetation response, which is associated with increased fire spread.
- Slash removal and prescribed fire must follow thinning and if slash is burned it can cause localized soil damages (soils are irreplaceable in human lifetimes).
- Thinning should be limited to small trees and should target high priority areas such as areas



Figure 6 Under certain conditions (indicated above), thinning small trees may reduce fire-line intensity particularly in fire-suppressed forests where dense firs have increased overtime due to lack of fire (left). Thinning of small trees may also reduce fire-intensity in old forests (right) under average fire-weather.

immediately adjacent to homes and flammable plantations that burn uncharacteristically severe in fires.

Thinning to reduce fire-line intensity is not cheap. Typically, thinning costs ~\$800–1,000 per acre, depending on site factors and access. Some thinning simulation studies recommend thinning across at least 22% of a dry forest watershed to reduce fire intensity. As an example, if 22% of 100,000 acres is thinned, estimated costs are \$17.6 million. Such high costs typically result in removing large fire-resistant trees as most thinning projects are not fiscally sound given small trees are most relevant to fire and have the lowest economic return. This has led to many thinning projects that not only open up the overstory canopy too much but that are ineffective at slowing fire spread. It should be also noted that small trees are also important for forest renewal and recent studies have shown that

they are actually an important component of a forest's resilience to climate change. Thinning in stops and gaps can maintain small tree densities while reducing fire risks under average fire-weather conditions.

Other scientists believe that, while noncommercial thinning of small trees immediately adjacent to homes (where prescribed burning may not be feasible) is important, plantations from past logging are best addressed in other ways. This includes mixed-severity prescribed burning to create some snag and shrub patches for wildlife, while creating a more heterogeneous forest structure, as well as snag and downed log creation through girdling and felling of trees. These approaches can increase structural complexity and add important habitat elements that are typically rare or absent in plantations and not created by thinning, which can reduce potential for snag recruitment, and generally emphasizes reducing downed logs and shrub cover.

How Does Post Fire Logging Affect Forest Rejuvenation and Reburn Intensity?



Figure 7 Post-fire logging leaves behind the most flammable portion of a forest as logging slash (A, B), removes large fire-resistant live and dead trees, and damages soils (C, D). Photos are from the Rim and Biscuit post-fire landscapes (D. Bevington, D. DellaSala).

Many well-intentioned land managers believe that forests need to be “restored” through post-fire “salvage” logging and artificial tree planting because they believe the forest renewal process is slowed by fire, particularly reburns. However, this view obscures the incredible richness of plant and wildlife that persists mainly during the very early stages after fire and before tree crowns have closed (usually a few decades or less). High levels of biological diversity in complex early seral forests are associated with standing fire-killed trees (snags) and native fire-adapted shrubs—the very components that post-fire logging and artificial tree planting severely reduce or eliminate (Figures 7,8).

Of the hundreds of studies conducted on post-fire logging and artificial tree planting, most have documented severe impacts to complex early seral forests.

Key Findings: Post-fire logging damages complex early seral forests and can raise fire risks.

- Increase in fine (slash) and coarse (large trees) fuels associated with severe reburns
- Mortality of natural conifer seedlings crushed by logging equipment
- Soil compaction (soils are irreplaceable in human lifetimes)
- Invasive weeds
- Diminished water quality and impacts to aquatic life especially from road-related sediment runoff, and toxic herbicides used to kill native shrubs
- Loss of carbon stored in burned forests and reduced carbon sequestration from lowered plant productivity caused by logging
- Diminished wildlife habitat especially for imperiled species such as the Spotted Owl and Black-backed Woodpecker

Effect of land-use on forest fires — A good place to see the effect of logging on forest fires is the 2013 Rim fire that burned nearly a quarter-million acres primarily on the Stanislaus National Forest, central Sierra-Nevada region. Based on fire severity data overlaid on land-use categories (in preparation), the fire burned most intensely in previously logged over lands (Figure 9). Similarly, the Biscuit fire (2002) of southwest Oregon burned hottest in areas previously post-fire logged during the Silver fire (1987) and higher intensities were presumably due to conversion of fire-resistant native forests to flammable tree plantations and post-fire logging slash left behind in logging operations. This pattern of previously logged areas burning in higher intensity has been repeatedly observed in the Klamath-Siskiyou and Sierra-Nevada regions and documented in peer-reviewed studies.

Key finding: contrary to what some believe, increased forest protections are not associated with more intense burns. Logged over lands tend to burn uncharacteristically severe as observed in the Klamath-Siskiyou and Sierra Nevada regions using remote sensing and GIS analyses.



Figure 8 Post-fire logging, Biscuit fire (A) within a “Late-Successional Reserve” on the Rogue-Siskiyou National Forest Reserve compared to the nearly identical location in 2012 (B: note lack of conifer regeneration). Unlogged botanical area upslope (C, D) showing abundant conifer establishment and native plants shielded from intense sunlight by dead trees (photo series D. DellaSala).

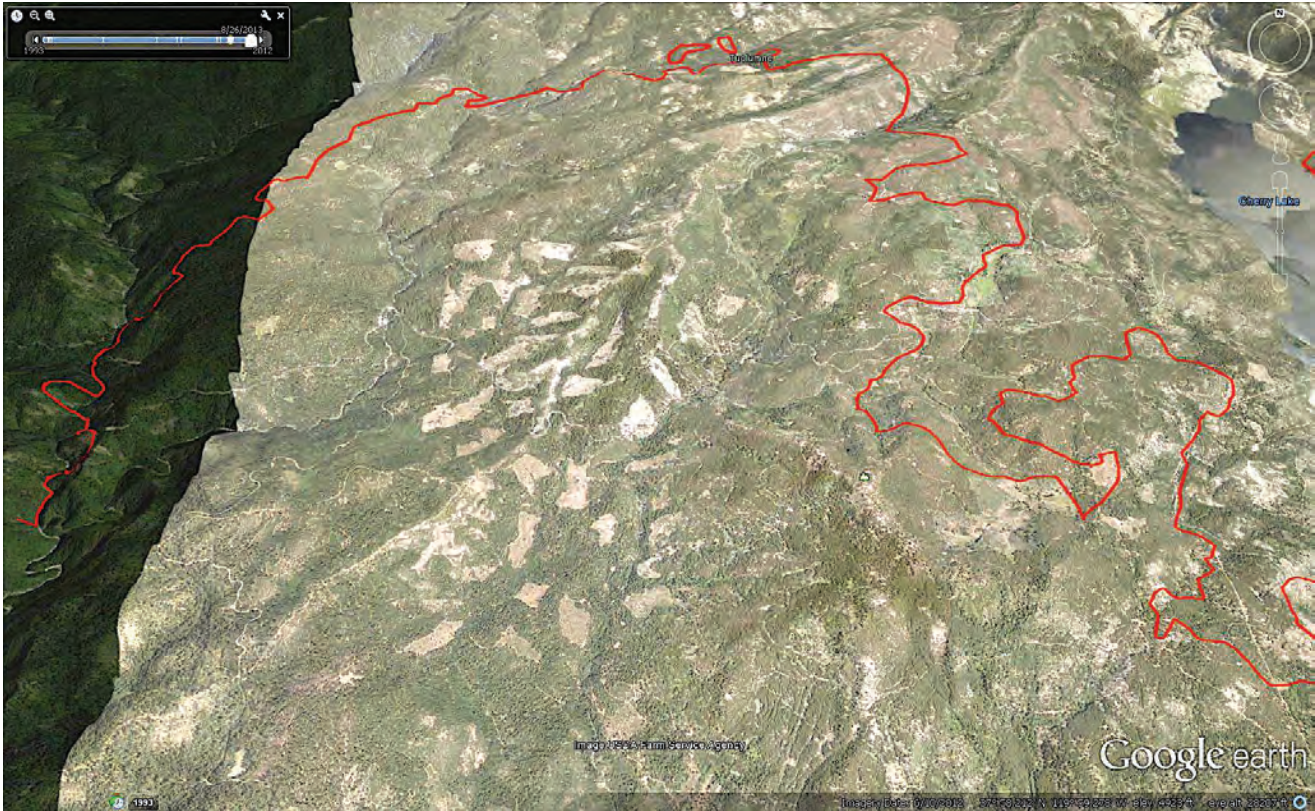


Figure 9 Google image of Rim fire perimeter (red) taken just before the July 2013 forest fire. Based on GIS analysis of fire severity, the center of the image, with numerous clearcuts and tree plantations, burned in the highest intensities.

Do Insect Outbreaks Increase Fire Intensity or Occurrence?

Appropriate response to recent, widespread bark beetle outbreaks in the western United States (Figure 10) has been the subject of much debate in policy circles and with the public. Among the proposed responses have been landscape-level mechanical thinning to prevent the further spread of outbreaks and to reduce the fire risk that is believed to be associated with insect-killed trees.

Preemptive thinning is unlikely to reduce susceptibility to large, landscape-scale epidemics. Once beetle populations reach epidemic levels, thinning aimed at stopping them is not likely to reduce forest susceptibility to outbreaks. Furthermore, such treatments imposed over large areas could have substantial, unintended short- and long-term consequences to forest ecosystems.

Key finding: Based on a comprehensive review of dozens of studies, thinning has limited effects on decreasing the extent or occurrence of insect outbreaks especially during an outbreak, and can often kill as many or more trees than beetles within the boundaries of a given thinning unit, particularly when outbreaks are not occurring.

While research is ongoing and some important questions remain unresolved, to date most available evidence indicates that bark beetle outbreaks do not substantially increase the risk of active crown fire in mid to upper elevation lodgepole pine and spruce-fir forests, or in mixed-conifer forests of California, under most conditions. Instead, active crown fires in these forest types are primarily



Figure 10 Forests in the Rockies are shaped by wildfires (background) and insect outbreaks (foreground) and the potential interactions between these two primary disturbance events (D. Kulakowski).

contingent on dry conditions driven by extreme weather rather than variations in stand structure, such as those brought about by outbreaks.

Key finding: There is no apparent association between the occurrence of insect outbreaks and active crown fires as observed in the Rockies, and in mixed-conifer forests of California.

Extensive research indicates that bark beetle epidemics are mostly driven by a warming climate and host susceptibility to outbreaks. Thus, managers cannot solve for outbreaks without broader policy issues aimed at reducing fossil fuel emissions and deforestation globally and regionally.

How is Climate Change Affecting Fire Behavior in the West?

There is no doubt that today’s climate is changing. The combination of rising temperatures and changes in precipitation patterns seasonally and over longer time periods is going to affect the size, severity, and occurrence of fires in dry regions in the decades to come. In general, drier areas are expected to experience more prolonged droughts – leading potentially to more active fire seasons – and an increase in the length and onset of the fire season among other potential changes. At the same time, increases in summer precipitation could lead to further reductions in fire in some areas that have too little fire currently, while some other forests could see increases. Under these conditions, tree thinning and fire suppression will not slow the climate change trend in fires because top-down forces like climate and weather will increasingly govern fire behavior (Figure 11). Fire acres, in particular, are at least partially explained by changes in large-scale climate processes such as the Pacific Decadal Oscillation and its association with top-down climate change drivers (Figure 12).

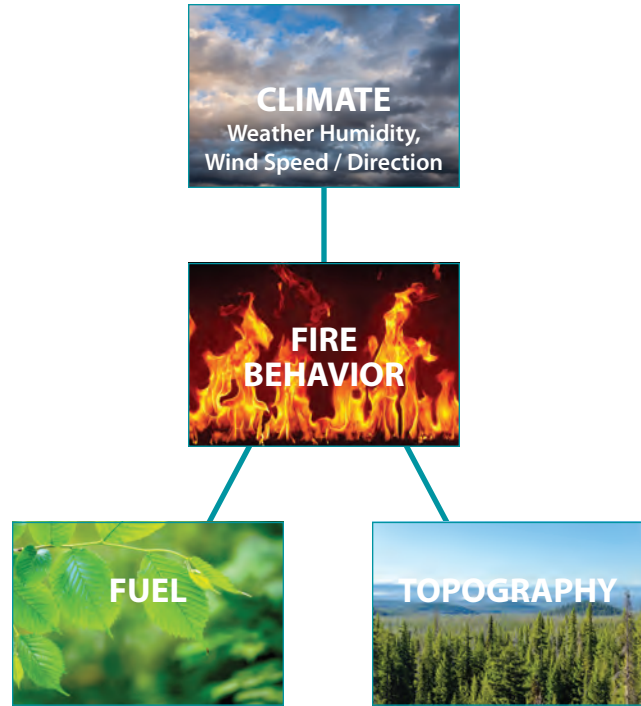


Figure 11 Fire behavior is influenced by top-down climate drivers like extreme weather and bottom up vegetation (fuel) and topography. Mixed-severity fires, the norm in much of the West, are mostly influenced by extreme weather events that trigger large burns. As the climate increasingly warms, fire will increasingly become weather driven regardless of fuels management in the back-country.

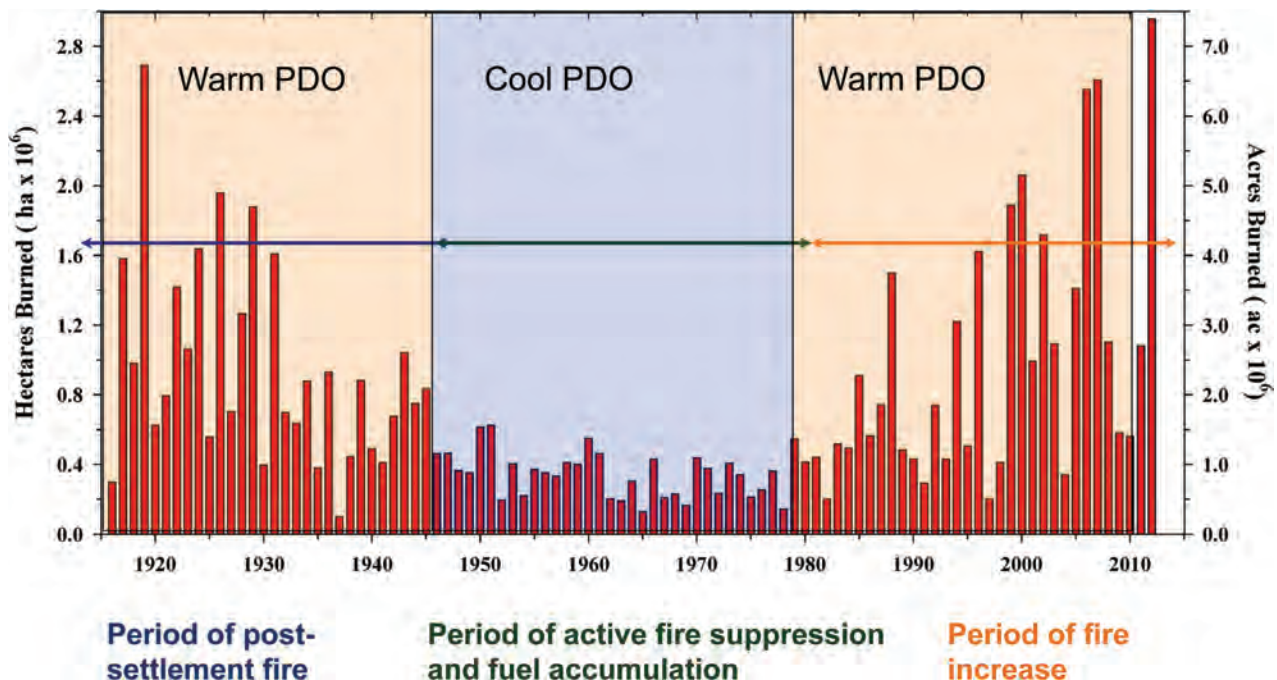


Figure 12 Changes in fire acres in relation to the Pacific Decadal Oscillation (PDO) over a relatively long timeline (figure obtained from J. Littell). Much of the variability in fire acres can be explained by the PDO and its link to global warming.

Key Finding: Because top-down climate drivers will increasingly determine fire behavior, fuels reduction in the backcountry will not be effective.

Proactive climate risk reduction measures should focus fuel reduction in priority areas such as

defensible space management nearest homes and communities, and flammable tree plantations. A clean and renewable energy policy that does not depend on fossil fuels and an end to global deforestation is urgently needed to reduce climatic influences on fire behavior.

Closing Findings:

Fire in general, and high severity fire, in particular, is beneficial to the fire-dependent web-of-life in dry forests, including numerous rare and imperiled fire-dependent wildlife species.

There is a lot more variability in fire regimes and forest structures than previously recognized, particularly when viewed through an appropriate historical baseline and landscape scale.



Managing to allow for wildland fires under safe conditions is consistent with ecological integrity provisions of the national forest planning rule and recognition of fire benefits needs to be a central part of forest planning. A good example of this is the Forest Service's cohesive fire management strategy that allows fires in the backcountry under safe conditions.

- Fighting backcountry fires costs lives and money, is not effective in extreme fire-weather, and is ecologically unnecessary and harmful during extreme conditions. More managed wildland fire should be allowed to occur in backcountry areas.
- Attempting to suppress fire intensity by thinning vegetation is dependent on many factors and reduced fire intensity from thinning is often overstated.
- Removing biological legacies from post-fire landscapes and artificial tree planting and shrub removal damage fire-adapted plants and wildlife; can increase spread of invasive and combustible weeds, and the likelihood of intense reburns; can decrease water quality, and impact soils; and cumulatively sets back forest rejuvenation for decades to centuries.
- Areas with the most logging intensity and least environmental protections have consistently been shown to burn in higher fire severities compared to Wilderness, National Parks, and roadless areas where fire suppression and

logging effects have not altered fire regimes appreciably.

- In recent decades, climate change has lengthened the fire season and increased fire extent in places, but there is still an overall deficit in high-severity fires as compared to historical times and even earlier.
- Fire risk reduction should include small-tree thinning adjacent to homes, building with fire resistant materials, reducing ex-urban sprawl, cohesive and appropriate wildland fire management, and comprehensive efforts aimed at reducing global warming emissions.

