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# A NEW CLIMATE- AND HUMAN-INFLUENCED WILDFIRE ERA FOR WESTERN FORESTS

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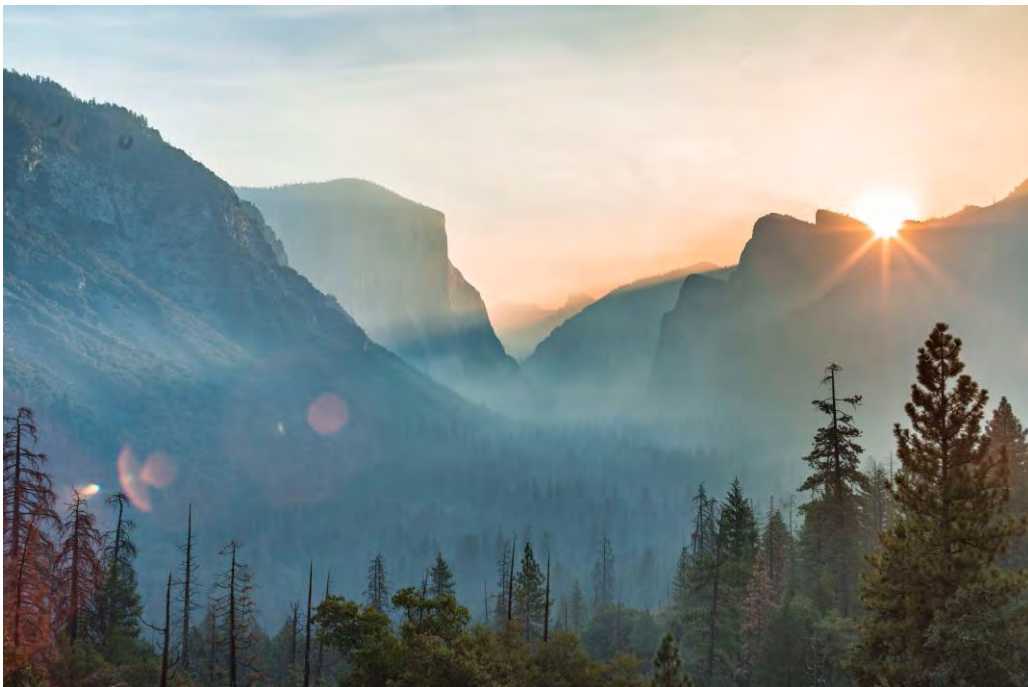
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## EXECUTIVE SUMMARY

Wildfires are greatly impacting human communities in the West that every summer face the prospects of loss of life, homeowner damages, and smoke-filled skies. Legislators and many managers believe wildfire intensity and occurrence can be greatly reduced by removing environmental safeguards to allow more logging in the backcountry to avoid wildfire “disasters.” Wildfires are not ecological catastrophes, rather, they are a keystone natural disturbance agent that has maintained the biologically rich and fire-adapted web-of-life in forests of the western United States for millennia. Wildfire area burned, size of large wildfires (>1,000 ac), and length of the fire season have been increasing in recent decades and these increases are at least partially attributed to the emergence of a new fire-climate era that is interacting with human-caused wildfire ignitions and logging related conversion of native fire-resilient forests to flammable tree plantations. Proposals to radically increase logging of native forests to reduce “fuels” will not achieve their desired outcomes but instead may increase wildfire risks and impair the adaptive capacity of forests to respond to cumulative disturbances in a rapidly changing climate. Responsible wildfire management and climate change policies are needed to: (1) reduce greenhouse gas emissions from fossil fuel burning while storing more carbon in forest ecosystems; (2) prioritize vegetation treatments in “fire-sheds” closest to homes; (3) redesign the built environment with wildfire safety in mind, including limiting ex-urban sprawl, and (4) manage wildfires for ecosystem benefits under safe conditions.



*Yosemite Valley. Photo: Bailey Zindel/Unsplash*

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## WILDFIRE AND PEOPLE: ON A COLLISION COURSE WITH NATURE

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Wildfires have become a menace to people of western communities. Each summer, homes burn up in wildfires, lives are lost, and people are forced to breathe hazardous smoke. In response, a frenzy of fire-hyperbole populates the evening news while decision makers seek solutions that purport to stop (or lessen) the occurrence or intensity of wildfires and the smoke they produce. An objective analysis of

potential solutions; however, is needed to help ensure that appropriate responses are undertaken, and that government expenditures do not worsen problems, as they have in the past through excessive fire suppression, big increases in logging, and wasteful spending of taxpayer dollars. In this report, I argue that the most critical and urgent pathway to responsible fire management is to protect lives, homes, and property



*Photo: Curtis Perry/Flickr*

that otherwise will not be addressed by lifting environmental safeguards to allow for more logging in backcountry areas (e.g., such as proposed in the Resilient Federal Forest Act – HR 2936), especially as climate change and human activities increasingly drive wildfire activity. I also provide an alternative solution to logging with the goal of finding ways to allow for functionally dynamic forest ecosystems to thrive and co-exist with human communities increasingly living in “fire-sheds” (populated areas that abut wildlands– other terms include – the Wildland Urban Interface or WUI). In sum, a rationale and science-based approach to climate change and wildfire management is urgently needed to address the root-causes of wildfire increases rather than just the symptoms and to shift the conversation from wildfires as eco-disasters to wildfires as agents of change that rejuvenate fire-dependent forest ecosystems (DellaSala and Hanson 2015).

While this report focuses on forest-fire relations, huge areas of the Great Basin and chaparral regions in southern California (Halsey and Syphard 2015) have seen increasing wildfire activity and extensive damage to homes mainly because of human-caused fire starts, conversion of fire-adapted vegetation to flammable weed infested grassy areas, and a dramatic increases in home building (Syphard et al. 2013).

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## WILDFIRE IS TO WESTERN FORESTS AS RAIN IS TO RAINFORESTS

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Soon after a wildfire, forests undergo a remarkable transformation. Large dead and remaining live trees, native plants, and seed sources act as “biological legacies” that “lifeboat” a forest from new growth to old growth over a period of decades to centuries. Biological legacies provide habitat for scores of pollinators, songbirds and woodpeckers, small mammals, and big game species that readily populate burn areas, including many species that thrive in them. Burned forests also store carbon long-term in dead trees that slowly decompose while new vegetation rapidly sequesters (absorbs) atmospheric carbon. When a severe fire occurs in a mature forest that is structurally complex (large trees and abundant vegetation) it generates a “complex early seral” or “snag forest.” These newly created forests support a rich assortment of plants and wildlife as diverse as the more heralded old-growth forests (Swanson et al. 2011, DellaSala et al. 2014, DellaSala and Hanson 2015).



Photo: C. Hanson

Despite the ecological importance of wildfires in western forests, there is widespread concern that forest fires are increasing at unprecedented rates along with risks to people and homes (although see Parks et al. 2012 for evidence of a fire deficit throughout the West). The recent spate of wildfires in the West has triggered much needed research into possible causal mechanisms especially because there are now some 46 million homes in fire-unsafe areas (with even more being built) likely at some point to experience a wildfire (Rasker 2015).

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## WILDFIRE INTENSITY VS. SEVERITY

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In any discussion of wildfire activity, it is important to distinguish between fire intensity and burn severity. Fire intensity refers to heat energy released during a wildfire. Fire severity refers to effects of fire intensity on vegetation (Figure 1). A low severity fire (produced by low heat intensity) has minimal effects on overstory trees that mostly survive. Conversely, a high-severity fire (produced by high heat intensity) kills most (>75%) of the overstory trees in an area. When a large burn area is viewed from the window of an airplane (aerial view), a patchwork mosaic of burn severities is evident. This is referred to as pyrodiversity (an assortment of burn severity patches at the landscape scale). The phrase “pyrodiversity begets biodiversity” has been used by researchers to describe the association between fire-mediated landscape mosaics and biologically rich communities (DellaSala and Hanson 2015), including both species that need newly created forests and those that require old growth (firefree-sanctuaries or lightly burned areas).

**FIRE INTENSITY BEGETS FIRE SEVERITY  
MIXED SEVERITY EFFECTS PRODUCE PYRODIVERSE LANDSCAPES**

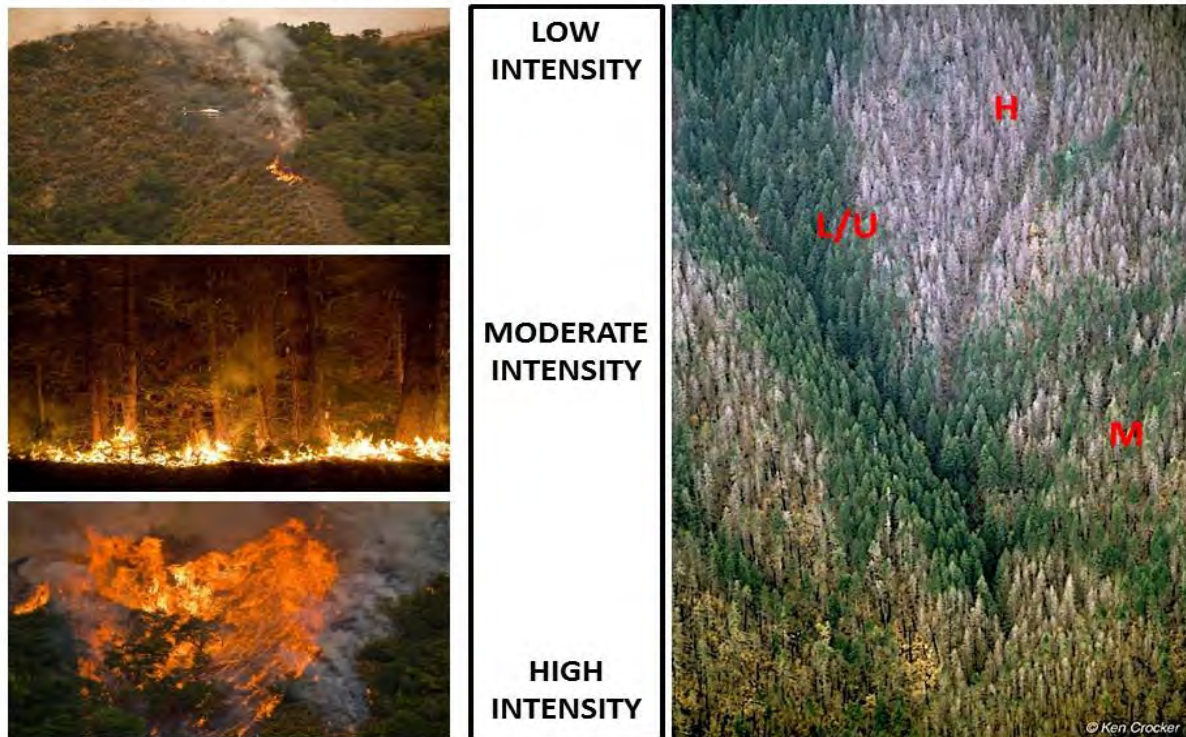


Figure 1. The relationship between fire intensity (left) and fire severity effects on vegetation (right): L/U=low/unburned; M=moderate; H=high severity. Photos: National Interagency Fire Center; K. Crocker.

## EMERGENCE OF A NEW CLIMATE-FIRE ERA: IS WILDFIRE AREA BURNING INCREASING?

As the global climate heats up, mainly from the burning of fossil fuels and the deforestation and degradation of forests over vast areas, we can expect to see more wildfire area burning (WAB) in places. With climate change now a human-caused global phenomenon, extreme-fire weather (dry conditions, low fuel moisture, high temperatures and winds) will become increasingly common and begin to override bottom up influences on fire behavior (Figure 2). Climate effects on WAB are most prevalent in northern and mountainous forested regions of the West, less so in desert areas where the climate already is hot and fuels are naturally low (e.g., southwestern and arid regions; Littell et al. 2009). In other regions, human-caused wildfire ignitions are a major factor that contributes to the duration of the wildfire season (see below).

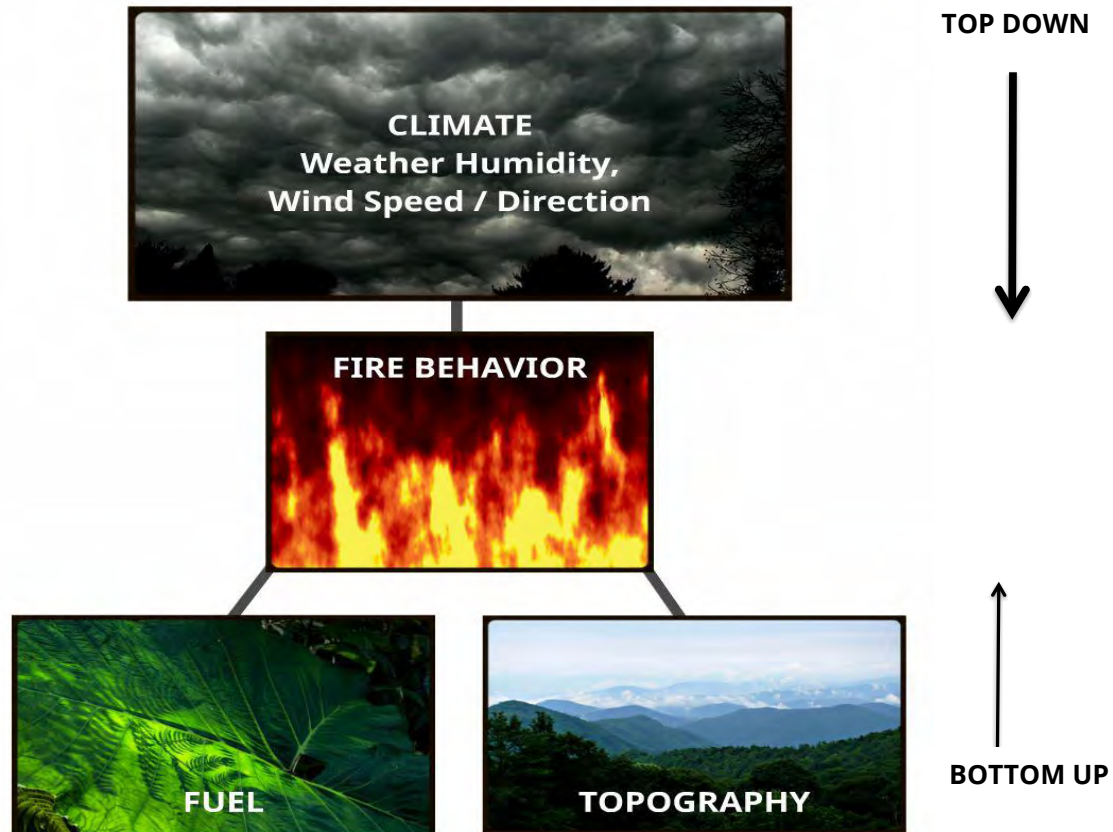


Figure 2. Factors influencing wildfire behavior. With climate change, climate will increasingly override bottom up factors due to increased occurrence of extreme fire-weather. Wildfire behavior in this context refers to the intensity and magnitude of fire spread. The thickness of the arrows refers to relative degree of influence on fire behavior. (DellaSala & Hanson, 2015)

Determining whether climate change is triggering more fires in an area requires tracking WAB over long time periods by projecting backwards (back-casting) in time while also seeing into the future. While there are many methods for monitoring WAB, recent increases can be attributed, at least in part, to variability in large-scale climatic cycles. An important climatic process that influences WAB is the Pacific Decadal Oscillation (PDO), which is an El Niño like oscillating pattern of cool and warm periods in the Pacific Basin that affects regional climates (Figure 3).

**Annual Area Burned - Western U.S.**  
(11 western states: AZ, CA, CO, ID, MT, OR, NM, NV, UT, WA, WY)

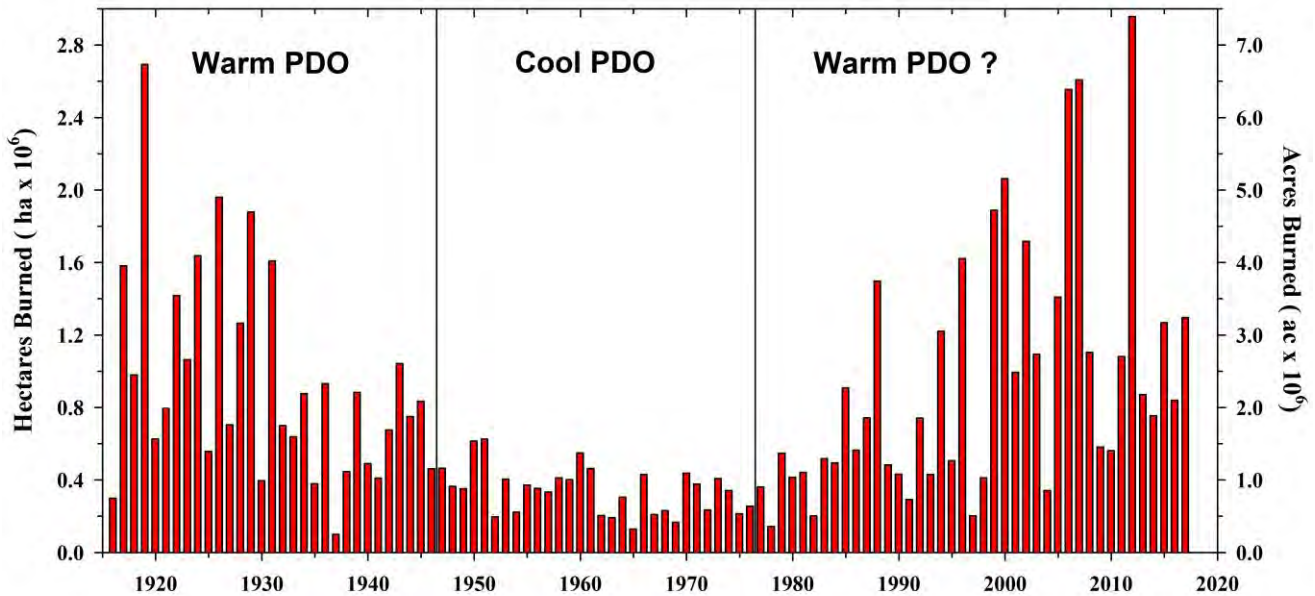


Figure 3. Annual area burned in 11 western states 1916-2018 on federal lands (BIA, BLM, FWS, NPS, USFS), updated from Littell et al. (2009). Figure provided by Jeremy Littell (USGS Research Ecologist).

**Past and Present WAB** – During warm (positive PDO) cycles such as in the early 1900s-1940s, WAB was especially high. Very little fire suppression was occurring during this time. However, the reverse was true during the mid 20<sup>th</sup> century cool (negative PDO) phase, a time when mechanized fire suppression was ramping up. Recent increases in WAB beginning around 1977 are concomitant with a warm (yet incomplete) PDO cycle during which even more fire suppression activity was occurring (e.g., today’s record fire suppression expenditures). Thus, at least one driver of recent increases in WAB appears to be the current warm cycle. Warm PDOs result in reduced spring snowpack and longer fire seasons (Morgan et al. 2008). Cooler vs. warming periods also affect efficacy of fire suppression, which can dampen fire activity in cool phases but have diminished effects in warm phases (Morgan et al. 2008). Notably, while WAB appears to generally track PDO cycles, to establish a causal connection would require more than 2 warm and one cool cycle (J. Littell, pers. comm.; McAfee 2014), although its doubtful that we will enter a cool cycle anytime soon to see if that dampens WAB.

**Future WAB and Climate Change** – Further increases in WAB are expected in places due mainly to the association of wildfires with warm periods caused to a large extent by increases in greenhouse gas emissions. Simply stated, the more emissions we put into the atmosphere, the more WAB we can expect (Figure 4) and the less effective (and more costly) fire suppression will become.

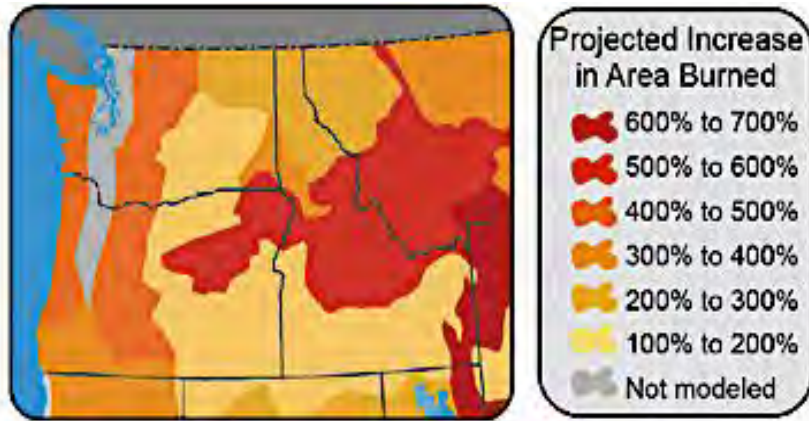


Figure 4. Mid century changes in projected wildfire area burned under a mid-high emissions scenario for the Pacific Northwest (modified from Mote et al. 2014).

## EMERGENCE OF A NEW FIRE-CLIMATE ERA: IS CLIMATE CHANGE TRIGGERING MORE SEVERE FIRES?

High-severity burn patches are a biodiverse component of large, mixed-severity fire complexes (DellaSala and Hanson 2015). They are, however, the subject of a great deal of fire suppression and logging proposals based on an assumption that large high-severity fires (“megafires”) may trigger the onset of ecosystem type shifts –conversion of plant communities to an artificial or novel ecosystem type (e.g., forests shift to shrub-lands).

Using satellites and burn severity data from the US Geological Survey, researchers have been monitoring burn severity data since 1984, the period when this standardized information first became readily available. Despite concerns about burn severity increases, they have not seen an uptick in forested area burning in high severity or proportion of high severity fire patches within large fire complexes (Figure 5). This result is corroborated by other studies of high severity in western forests (e.g., Birch et al. 2014, Morgan et al. 2017, Keyser and Westerling 2017 (although not for Colorado and there is debate about other regions – see key findings)).



Biscuit fire area, southwest Oregon. Photo: D. DellaSala

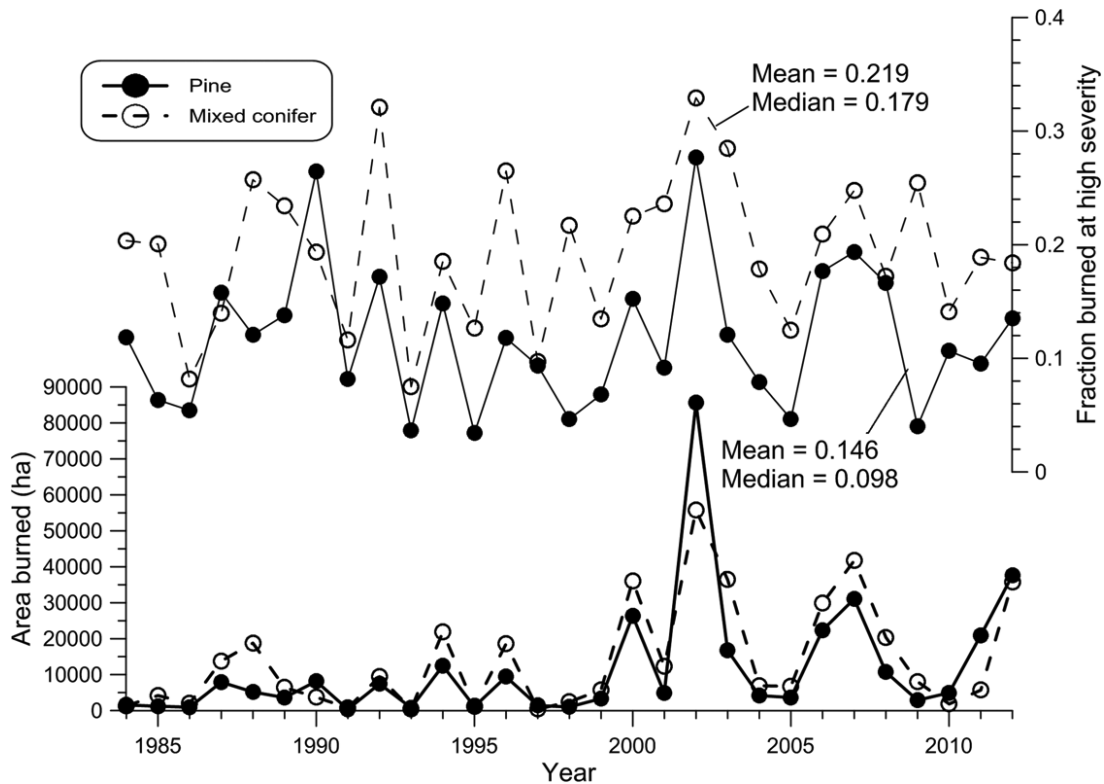


Figure 5. Area and proportion of high-severity fires in dry western forested ecoprovinces from 1984-2012 (Baker 2015).

### Key Findings

- ▶ Climate change does not appear to be presently increasing amount or proportion of high severity fire in most of the dry forests of the West (Birch 2014, Baker 2015, Keyser and Westerling 2017, Morgan et al. 2017) nor leading to widespread type conversions from so called “megafires” (DellaSala et al. in review).
- ▶ Severity levels need to be monitored over long time periods and for individual ecoregions to reduce uncertainty of future projections especially since there is considerable debate about whether severity is increasing or not in some regions (e.g., see Odion and Hanson 2008, Miller and Safford 2012, Odion et al. 2016).
- ▶ Forest management also may increase the amount of high-severity fires with logged areas burning in higher amounts compared to protected areas (see Miller et al. 2012, Bradley et al. 2016, and section on active management below).

## HUMAN-CAUSED WILDFIRES NOW PREDOMINATE WILDFIRE SEASONS

In addition to regional climatic influences, human activities are triggering widespread fire ignitions (Figure 6). However, human-caused fire starts are seldom discussed by land managers and almost never addressed in fire management policies or local fire planning.

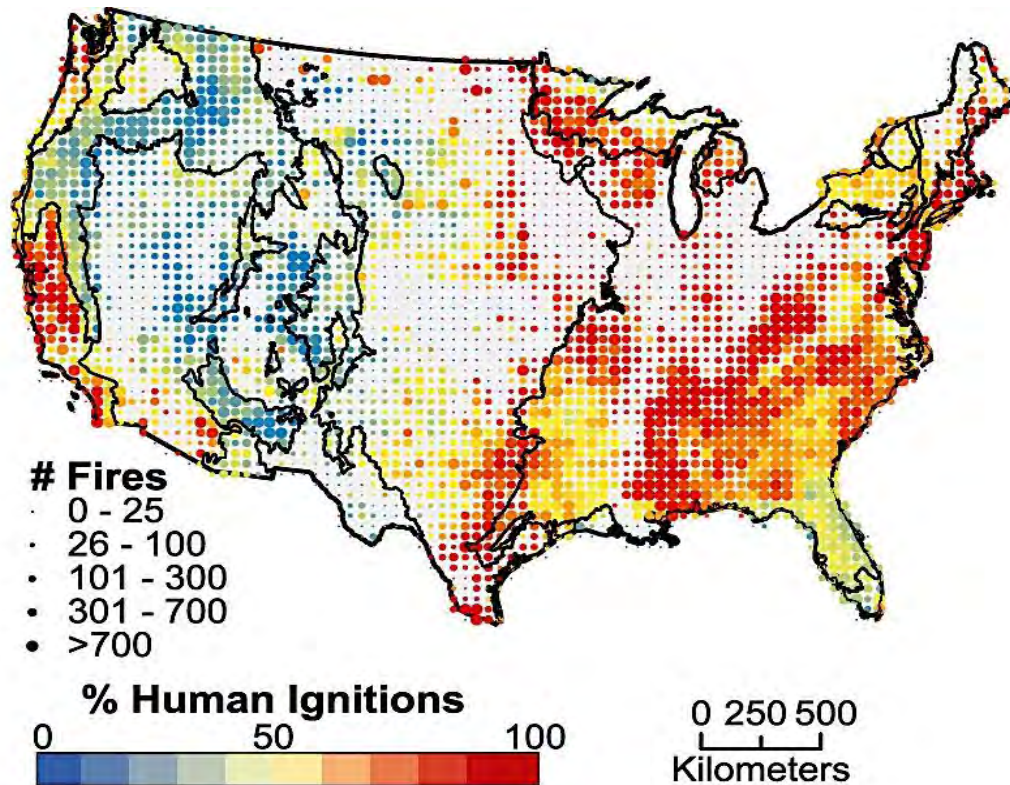


Figure 6. Total number of wildfires (dot size) and percentage of ignitions (color bar) caused by people 1992-2012 (red highest proportion) (from: Balch et al. 2016)

With more than 46 million homes already built in fire-prone areas (Rasker 2015) and many more on the way due to lax land-use zoning standards, human-caused fire starts will increasingly tax already overburdened fire-fighting resources (Ingalsbee and Roja 2015).

### Key Findings

- ▶ We have entered a new era of human-caused wildfire seasons (especially prevalent in chaparral systems in southern California for instance).
- ▶ 84 percent of wildfire ignitions from 1992 to 2012 were human-caused, while lightning was the main ignition factor in unpopulated areas (Balch et al. 2016).
- ▶ An average of 40,000 wildfire starts per year were caused by people over this time span, contributing to increased suppression costs, loss of homes and lives (Balch et al. 2016).

## REDUCING WILDFIRE RISKS TO THE BUILT ENVIRONMENT

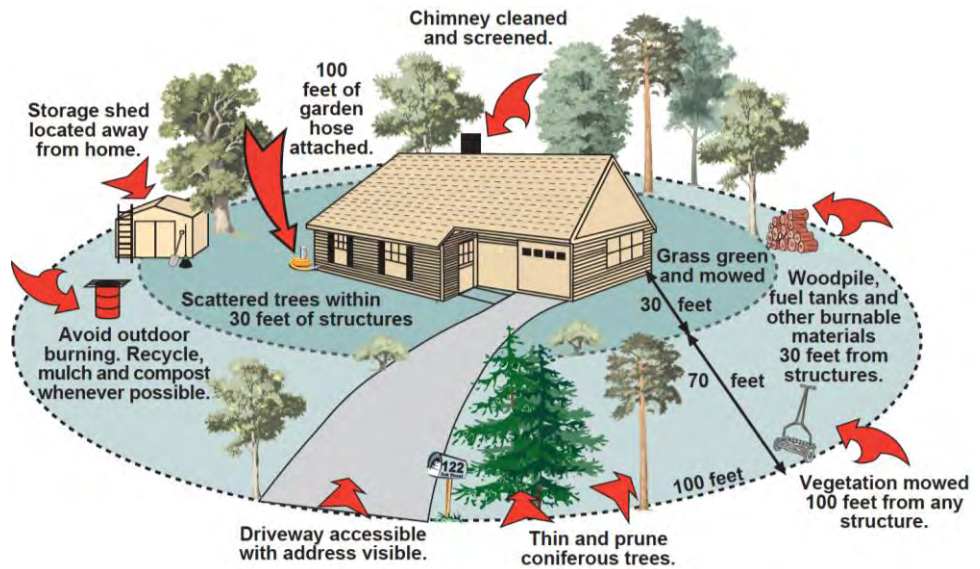
There is no magic bullet or quick fix solution that will reduce WAB in a changing climate. Increasingly, many scientists are calling for coexisting and adapting to the emergence of a new fire-climate and human-caused fire era by focusing on human safety first and foremost (Moritz et al. 2014, Schoennagel et al. 2017). As a prudent risk-reduction measure, this means reconsidering where we build homes. That is, developers and local governments need to be supportive of “smart-growth” initiatives that limit building in places where natural disturbances like wildfires are expected (Rasker 2015). Additionally, instead of re-building homes in the same locations destroyed by fire, the location and arrangement of structures could be repositioned to safer places (Rasker 2015, Syphard et al. 2013). This would mean clustering development away from the WUI, not building in fire-prone areas such as steep canyons or south-facing slopes and along ridges, and planning for escape routes (Figure 7).



Figure 7. A schematic redesign of clustered development in relation to fire-risks. (A. Syphard)

Homeowners also need to take responsibility for home protection measures (Figure 8). Homes that are “fire-wise” are most likely to survive a wildfire (Cohen 2000, Syphard et al. 2013). Nevertheless, no home is 100 percent fire safe as fires racing through steep canyons under high winds (70+mph in some cases) will burn through just about anything, which is why safer developments need to be planned.

Figure 8. Homeowner firesafe guide for Montana (2009).



### Key Findings

- ▶ Limiting sprawl saves lives and structures, keeps fire fighters out of harm’s way, and reduces costs of fire suppression (Rasker 2015, Ingalsbee and Roja 2015).
- ▶ Fire-wise (or home protection) means retrofitting homes with fire-resistant materials (especially metal roofs), gutters and vents screened, and flammable vegetation reduced within a narrow zone of 50-100 feet surrounding the structure (Figure 8).
- ▶ Home protection involves reducing fire risks from the home outward instead of the wildlands inward (Syphard et al. 2013). Logging outside this narrow zone does nothing to reduce the risk of catastrophic home loss.

## STORING MORE CARBON IN FOREST ECOSYSTEMS

No fire strategy is complete without addressing the top-down driver of WAB – climate change. This means moving to a carbon-neutral energy economy as swiftly as possible (e.g., complying with the Paris Climate agreement) and storing more carbon in forest ecosystems (“sinks”). Fortunately, the US has an enormous forest-carbon sink at its disposal that could be managed with carbon as a primary multiple-use objective (Figure 9).

## High-biomass Forests in the Contiguous United States and Alaska

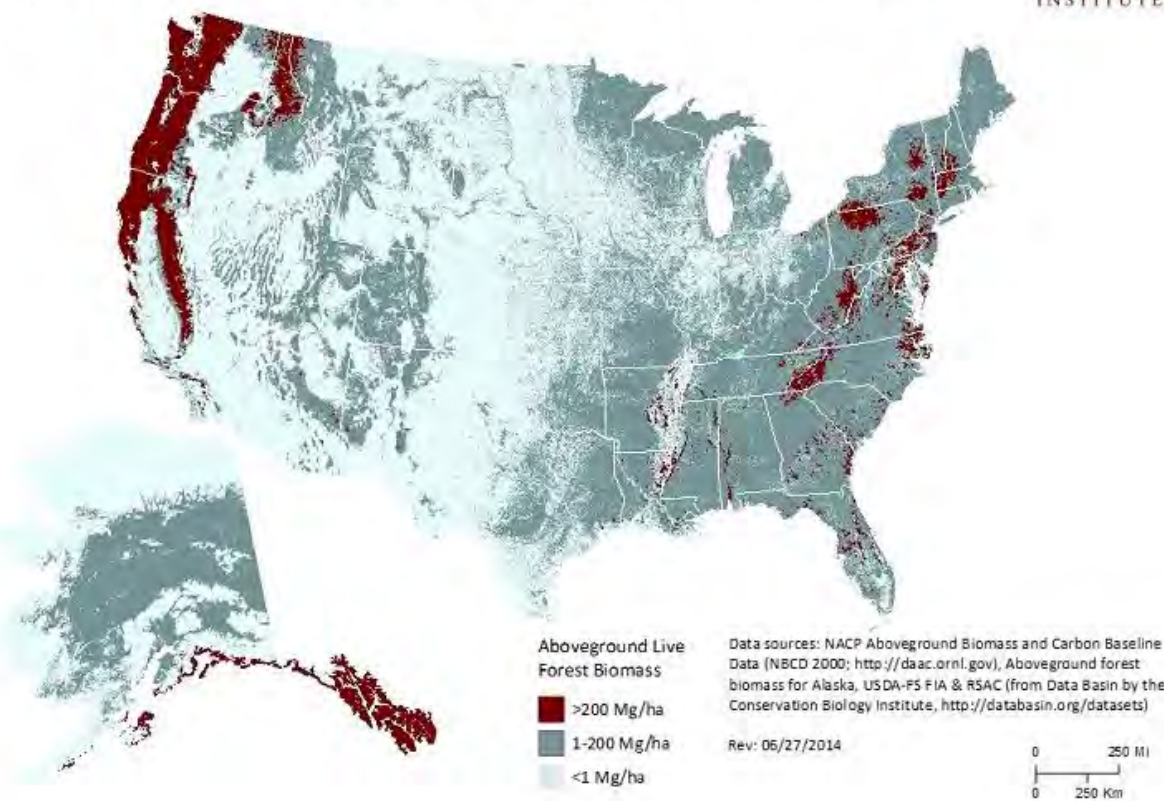


Figure 9. High-biomass forests (sinks) of the United States based on above ground biomass and carbon baseline datasets (see Krankina et al. 2014 for methods).

### Key Findings

- ▶ Forests sequester and store about one-quarter of humanity's annual greenhouse gas emissions with primary (unlogged) forests storing 30-70 percent more carbon than logged forests (Mackey 2014).
- ▶ Deforestation and forest degradation account for ~12 percent of annual global emissions to the atmosphere (van der Werf et al. 2009).
- ▶ The relative percentage of emissions from forest loss has declined recently mainly because fossil fuel emissions have been going up at a faster rate. However, forest loss remains the second largest anthropogenic source of CO<sub>2</sub> to the atmosphere (van der Werf et al. 2009).
- ▶ Storing more carbon in forests will slow the velocity of climate change, including wildfire activity.

## DOES “ACTIVE MANAGEMENT” REDUCE FIRE OCCURRENCE OR FIRE SEVERITY?

Active management is a catchall phrase used by land managers and decision makers to generally describe a wide array of management actions/options directed at reducing the occurrence or severity of wildfires. However, most of what is taking place before and after wildfires (logging) is primarily incompatible with natural disturbance dynamics, particularly resilience of forests to climate change and wildfire activity. Two of the more common treatments are covered here: postfire logging and associated “reforestation” activities and pre-fire forest thinning.

**Postfire clearcut (“salvage”) logging** – Clearcutting (or clear felling) of live and dead trees (Figure 10) over large expanses after a natural disturbance is often followed with herbicides to reduce competing vegetation and to allow for subsequent planting of artificially grown trees (from nursery stock) in dense rows, not unlike a cornfield functionally. As unnatural plantations increasingly replace native, fire-resilient forests, plantations are expected to burn in higher fire intensities due to logging slash and dense packing of small trees (Odion et al. 2004). Postfire logging therefore creates an ecologically damaging feedback loop where fires burn initially in fire-resilient, native forests, complex early seral forests are then clearcut and replanted with small trees in dense rows (with logging slash left behind), only to burn in subsequent fires in high intensities and so on (Figure 11). Logging after a disturbance also removes the most ecologically valuable components of the new forest – standing dead trees (“snags”).



Figure 10. Postfire logging of the Rim fire, Stanislaus National Forest, Sierra Nevada, California. Note removal of large trees (stumps) and extensive logging slash left behind by loggers. Photo: C. Hanson.

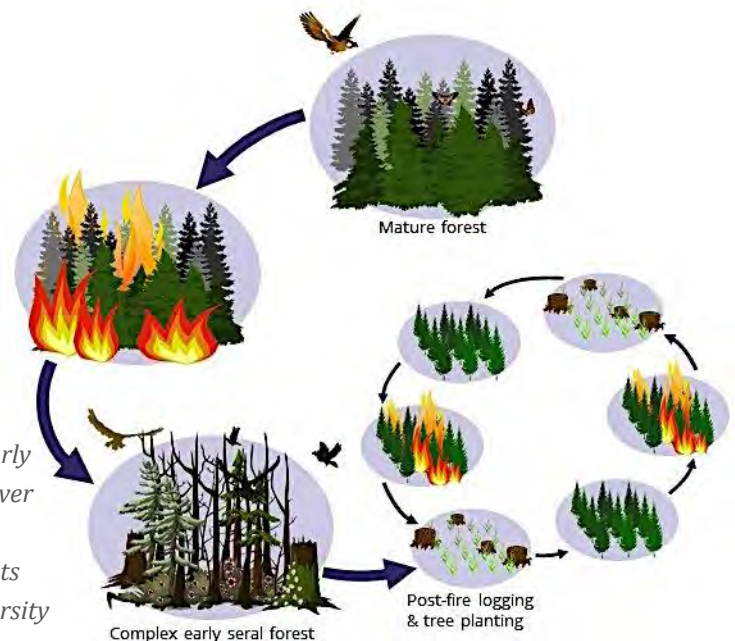


Figure 11. Schematic representation of wildfires, complex early seral forests, and postfire logging feedback loop. Practiced over large landscapes postfire logging can lead to ecosystem type shifts whereby entire landscapes of native fire-adapted forests are shifted to novel fire regimes resulting in losses to biodiversity and ecosystem services (Lindenmayer et al. 2011).

## Key Findings

- ▶ Postfire logging impairs ecosystem resilience by compounding natural disturbance effects in space and time (i.e., cumulative impacts), including compacting soils (heavy machinery), causing runoff of sediment to streams especially on fragile soils and along heavily roaded areas, killing native plant recruitment especially if herbicides are applied, destroying habitat for wildlife dependent on snag forests, and raising fire hazards by removal of fire resistant live and dead trees and accumulation of fine-fuels (slash) left on site (see reviews by Lindenmayer et al. 2008, DellaSala et al. 2015).
- ▶ Snags anchor soils, provide shade for developing seedlings, “nurse logs” for new plant growth and soil moisture retention, habitat for aquatic species when they fall into streams, and store vast amounts of carbon as they slowly (decades to centuries) decompose. Snags also are habitat for scores of insect eating bats, birds, and other small mammals that help keep native insect populations in check.



*Figure 12. Proposed thinning pilot on Bureau of Land Management lands in southwest Oregon showing large trees marked (blue paint) for removal. White numbers on tree trunks refer to diameter in inches at breast height.*

*Photo: L. Ruediger; also see DellaSala et al. 2013.*

**Forest thinning** – Partial removal of usually overstory trees via forest thinning (Figure 12) is used for a variety of commercial and non-commercial purposes, including reducing competition among closely spaced trees to accelerate growth of remaining trees and lower flammable vegetation (“fuels”). Thinning combined with prescribed fire to reduce slash has been shown to lower fire intensity but extreme fire weather can overwhelm fuel conditions and other factors can confound treatment effects (Kalies and Kent 2016).

## Key Findings

- ▶ There is a very low probability (~2-8%) that a thinned site will encounter a fire during the narrow period (15-20 years depending on site productivity) of reduced “fuels.”
- ▶ Excessive thinning (e.g., logging large fire-resistant trees (Figure 12), and opening the tree canopy by removing most (60-70%) of the overstory (which is common) can increase wind speeds, as well as cause greater light penetrance to the understory, resulting in accelerated plant growth and rapid fire spread.
- ▶ Soil type, forest type, and time since treatment can influence treatment need and effects.
- ▶ Thinning needs to be followed by prescribed fire to reduce fine fuels.
- ▶ Thinning requires an expensive and damaging road system. Thinning alone can cost >\$1500 per acre (Kline 2004) and would need to be repeated every 15-20 years over millions of acres as proposed (e.g., Resilient Federal Forest Act – HR 2936), requiring massive taxpayer subsidies that mainly benefit logging companies.

**Road building** – Active management requires an expensive to maintain road system to access forested sites (Figure 13). The Forest Service alone has built some 400,000 miles of roads to access the national forest system. That is enough to circumnavigate the globe >16 times. And while roads are important for suppressing fires that are a danger to towns and fire fighters, they come with substantial ecosystem and financial costs.



Figure 13. Roads, plantations, and clearcuts act synergistically to impair ecosystem resilience (Photo: K. Crocker, Biscuit burn area).

## Key Findings

- ▶ Roads are associated with water quality degradation, aquatic species declines (e.g., salmon), spread of invasive weeds (so called “road-runners” that spread along roads), and loss of wildlife habitat.
- ▶ Roads are chronic disturbances that affect ecosystems over long timelines and vast spatial scales (Ibisch et al. 2017).
- ▶ Roads contribute to increased likelihood of human-caused fire ignitions due to access (Balch et al. 2016).

**Environmental safeguards do not need to be eliminated to reduce wildfire activity** – Most wildfire suppression/logging proposals in Congress center on what is believed to be a lack of access to remote and protected landscapes where “fuels” have accumulated due to management inaction. The framing of this argument goes something like this– if we could only get into more areas for “active management,” then we can reduce fire and smoke, so we need to lift environmental protections that are in the way. However, the activities described above may actually have the opposite effect as determined by recent studies of wildfire severity in relation to land use protection vs. forests in active management (e.g., contrast protected areas vs. private lands; Figure 14, modified from Bradley et al. 2016).

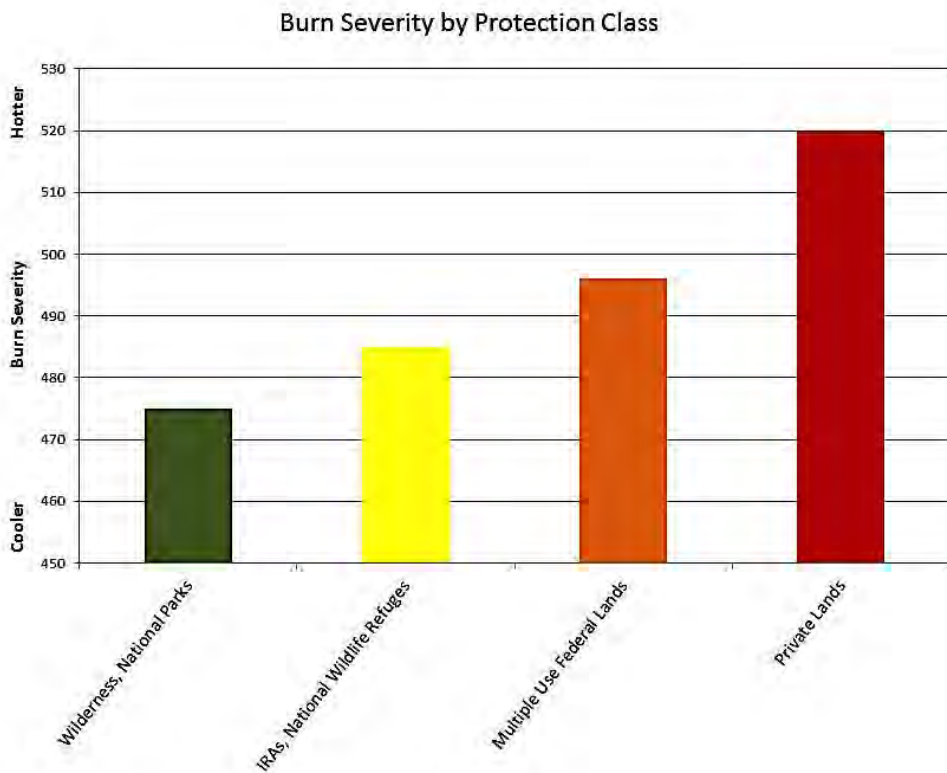


Figure 14. Burn severity (cooler to hotter fires) in relation to land-use designations for 11 western states 1984-2014. Results represent 1500 fires examined on >23 million forested acres affected by high severity fire (From Bradley et al 2016).

### Key Findings

- ▶ Protected forested areas (green, yellow) in the West typically burn at relatively low severities compared to “actively managed” areas (orange, red) (Figure 14).
- ▶ Opening up remote areas to logging and road building will likely result in more area burning in severe forest fires due to accumulation of logging slash and conversion of native fire resistant forests to plantations (Odion et al. 2004).

In sum, there are plenty of ecologically compatible forms of more comprehensive wildfire management (Figure 15) consistent with the resilience of fire-dependent western conifer forests such as:

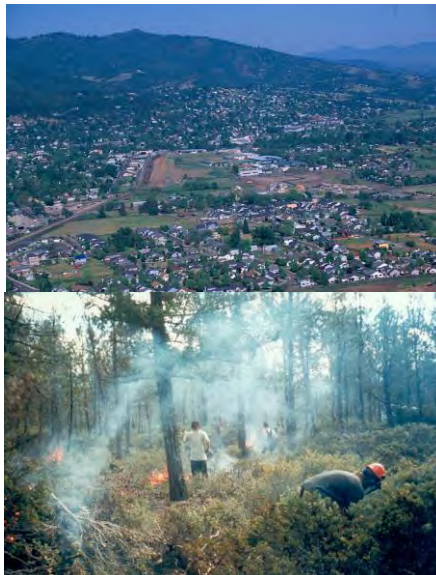
- ▶ Removing or restricting land-use stressors (e.g., mining, livestock, Off Highway Vehicles) that exacerbate fire activity and create cumulative impacts (i.e., this is passive management as it mainly removes human-caused stressors);
- ▶ Maintaining and restoring imperiled wildlife and rare habitats, particularly those that require both complex early seral (e.g., Black-backed Woodpecker, many plant species, songbirds, woodpeckers, small mammals) and mature forests;
- ▶ Eradicating invasive weeds, especially species dispersed along roads (e.g., cheatgrass, star thistle, Sudden Oak Death Syndrome, Port Orford cedar root rot).
- ▶ Thinning and girdling (killing) small trees in plantations created by prior clearcut logging to accelerate development of older forest structures and potentially reduce flammability (see limitations);
- ▶ Removing ineffective culverts (especially important in areas where climate change will trigger more floods) and other barriers to fish passage;
- ▶ Restoring floodplains so they can naturally store more water (e.g., reintroducing beavers) and better attenuate floods;
- ▶ Taking out damaging roads by re-contouring the road surface and road prism to natural features that improve hydrological functions and reduce human-caused wildfire ignitions; and
- ▶ Managing wildfires for ecosystem benefits in the backcountry (e.g., corralling and working with fire) and prescribed fire in appropriate forest types close to towns.

✓ WILDFIRES UNDER SAFE CONDITIONS



✓ THIN LOGGED/REPLANTED AREAS  
 ✓ (Save the big trees from logging)

✓ SUPPRESSION AND HOME SAFETY



✓ PRESCRIBED FIRE - LOW ELEVATIONS  
 ?????????????

Figure 15. Comprehensive wildfire management and risk reduction methods necessary for getting to coexistence with wildfire (Photos: D. DellaSala except lower right KS Wild).

Photos: D. DellaSala

## CONCLUSIONS

There is a widespread perception that wildfires are increasing due to the lack of forest management. However, the absence of a comprehensive root-cause analysis and recent changes in wildfire area burned has led to gross misunderstandings and ecologically inappropriate and ineffective policies. While WAB is increasing in places, recent increases pale in comparison to historical times when fires were burning over much large areas during warm climatic cycles (thus claims about “unprecedented fire activity” are often exaggerated). However, with more people than any time in history living in the WUI (46 million homes and increasing) and with climate change increasingly influencing WAB, we must act in a responsible way that addresses human safety first and foremost while we seek to restore the beneficial relationships between wildfires and fire-dependent ecosystems. Proposals to increase logging will not succeed in changing fire behavior in a changing climate and will do nothing to reduce risks to lives or homes. Instead logging will greatly impair the resilience of forests to disturbances, especially in a changing climate. Prudent policies are needed that:



*Biscuit burn area in Southwest Oregon. Photo: D. DellaSala*

- ▶ Prioritize vegetation treatments to areas closest to homes (i.e., work from the home-outward instead of wildlands inward);
- ▶ Limit ex-urban sprawl and retrofit existing homes to be fire safe;
- ▶ Seasonally close roads and decommission others to reduce chronic ecosystem damages and human-caused wildfires;
- ▶ Rapidly transition to a carbon-neutral economy;
- ▶ Store more carbon in forested ecosystems by protecting carbon sinks such as intact and primary (unlogged) forests and complex early seral forests (protecting carbon sinks also benefits a wide array of ecosystem services— see Brandt et al. 2014);
- ▶ Require congressional oversight to make sure government expenditures do not waste taxpayer dollars;
- ▶ Maintain existing oversight (environmental laws and policies) to safeguard clean water, fish and wildlife habitat; and
- ▶ Reintroduce wildland fire by working with fire (corralling it in places, monitoring in places, suppressing in places – see Ingalsbee and Rota 2015) under safe conditions, including prescribed fire and natural wildfire ignitions to achieve ecosystem benefits.

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