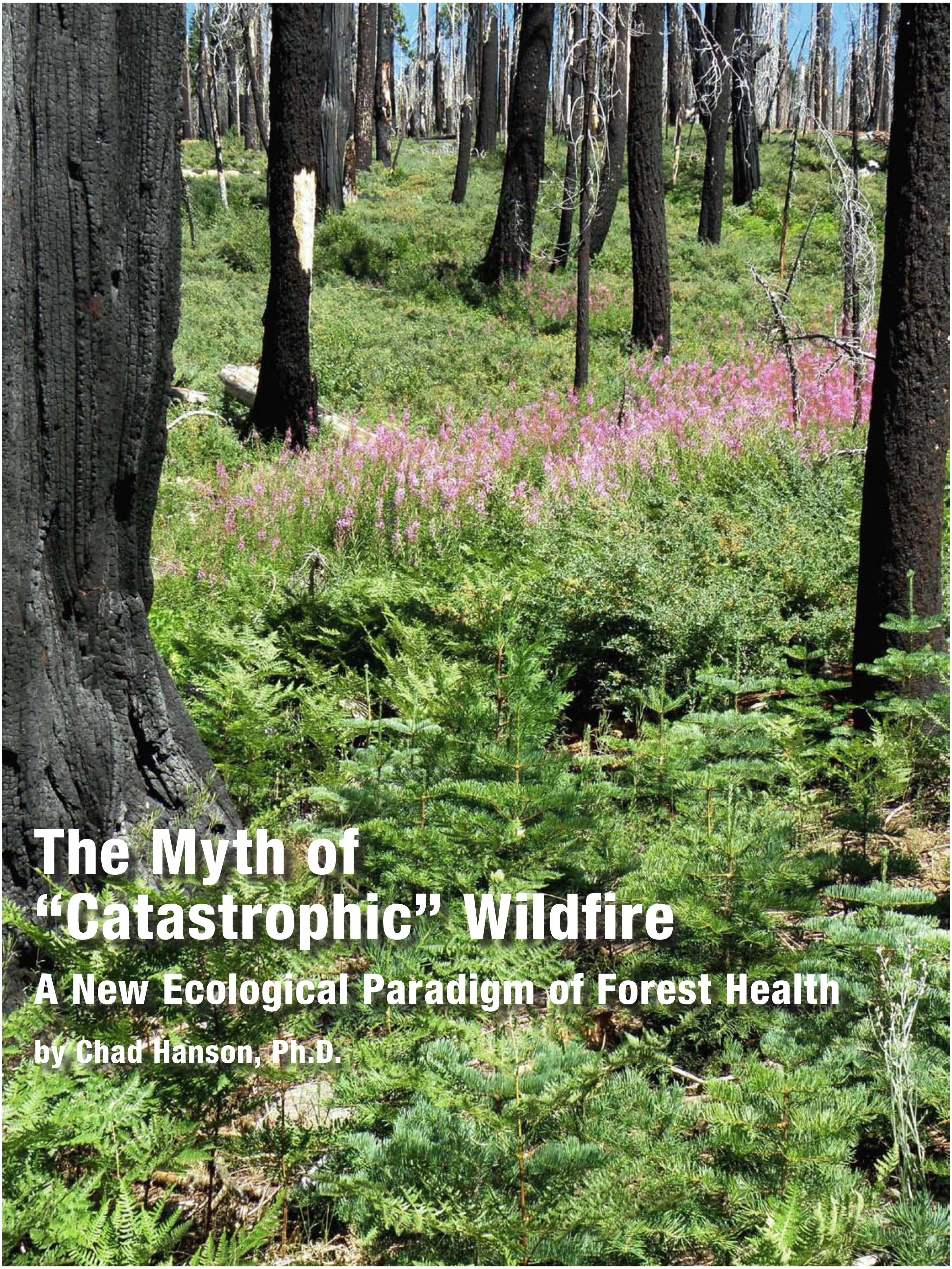

The Myth of “Catastrophic” Wildfire

A New Ecological Paradigm of Forest Health

by Chad Hanson, Ph.D.

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Preface

In the summer of 2002, I came across two loggers felling fire-killed trees in the Star fire area of the Eldorado National Forest in the Sierra Nevada. They had to briefly pause their activities in order to let my friends and I pass by on the narrow dirt road, and in the interim we began a conversation. One of the loggers pointed further down the road to a forest stand in which the fire burned less intensely. Most of the trees were alive and green. "I can see why people wouldn't want us to cut down a stand like that," he said, pointing to the green stand. "But what does it matter if we cut down an area like this?" he asked, referring to the heavily-burned area where high-intensity fire had occurred. "All of the trees have been killed. It's been destroyed. What sort of wildlife is going to live here?" he asked rhetorically.

I told the man that I didn't know the answer, and that his was a question that deserved some investigation. That conversation, and the curiosity it piqued in me, ultimately led me to graduate school to earn my Ph.D. in ecology, with a research focus on fire ecology in forest ecosystems. I found the answers to my questions to be as startling and counter-intuitive as they were undeniable, and increasingly I have wondered at the tremendous gap between the rapidly mounting scientific evidence and the widely held popular notions about wildland fire in our forests.

Every fire season in the western United States, we see on television the predictable images of 100-foot flames spreading through tree crowns, while grim-faced news anchors report how many acres of forest were "destroyed" by the latest "catastrophic" fire. The reaction is understandable. For decades, countless Smokey the Bear advertisements have told us that forest fires are bad and damaging. Until about 25 years ago, land management agencies, such as the U.S. Forest Service, genuinely believed that they could essentially eliminate fire from our forests if they had enough resources to suppress fires – and they sought to do just that.

By the late 20th century, however, forestry officials began to concede that, historically, frequent low-intensity fires were natural in our forests, slowly creeping along the forest floor after lightning ignitions, reducing fuel on the forest floor and naturally thinning-out brush and small trees. Though a begrudging acceptance of the benefits of low-intensity fire began to take hold, it was commonly assumed that areas of high-intensity fire, where tall flames killed most of the trees, were fundamentally the unnatural result of fuel accumulations from decades of fire suppression. Thus began the "catastrophic wildfire" paradigm, which divided fires into two categories: good fires and bad fires depending upon whether they burned at low-intensity or high-intensity, respectively.

A Forest Service public education brochure for the Sierra Nevada from 2004 captured the thinking underlying this paradigm. The brochure, entitled "Forests With A Future", portrayed high-intensity fires as an "eco-disaster" that "destroy wildlife habitat." No scientific studies were cited to support this characterization. Under the heading of "Good fires, bad fires", the brochure opined: "Fire is natural to the forest. But not the kind of fire that burns so hot, and shoots up so high, it destroys everything." The report blamed the perceived threat of high-intensity fire on a build-up of fuel from "fire suppression practices over the last century". It proposed a massive logging program on national forests, under the guise of "thinning", ostensibly to eliminate high-intensity fire from the landscape.

Ironically, in the "catastrophic wildfire" paradigm, land managers have requested, and received from Congress, increasingly more money for increasingly aggressive fire suppression tactics. The Forest Service justifies this by arguing that, except in rare cases, fires simply cannot be allowed to burn, since high-intensity fires will often occur. In these increasingly intensive fire suppression tactics, firefighters have frequently been placed in harm's way to stop fires the land management agencies assumed to be destructive and unnatural – often in remote areas, and all too often with fatal consequences for firefighters.

Simultaneously, land managers have requested, and received, increasingly more money for forest "thinning" operations under the guise of "fuel reduction". Land management agencies, such as the Forest Service, have used these funds to plan and implement thousands of commercial logging projects that remove mature trees, reasoning that they can thin more acres of forest if they sell many of the larger, fire-resistant trees – which are commercially valuable – to timber companies, using the sale of these trees to "offset" their costs. The Forest Service and other land agencies keep the revenues from these timber sales to enhance their budgets, creating a perverse incentive for more and more logging of larger and larger trees over increasingly vast expanses of the forested landscape. In this context, it did not take long for nearly everything to be described as "fuel" that must be removed. Live mature and old-growth trees have been, and are being, cut by the thousands, and dead trees are routinely sold to logging companies and removed, often leading to large areas being clearcut on public lands following wildland fires in the name of fuels reduction.

Commercial logging ostensibly to prevent "catastrophic fire" has been promoted heavily through a Bush-era policy known as the "Healthy Forests Initiative", which essentially defines a healthy forest as one in which the trees are all green, there are few if any dead trees or downed logs, and fire is acceptable so long as it doesn't kill any mature, commercially-valuable trees. This policy provides a compelling narrative to many, because it underscores and capitalizes upon deeply held cultural notions and perceptions about forests and fire. Once again, however, readily available ecological science was ignored.

And so, remarkably, under the "catastrophic wildfire" paradigm, the discredited policies of the past, including fire suppression and removal of mature, fire-resistant trees, has continued – even increased in many cases. Even as land managers and policy-makers lamented the mistakes of past management, essentially the same management has continued day after day, year after year.

Recently, however, a new paradigm has begun to emerge, informed by the latest ecological science. Over the past decade, a surge of scientific discovery has led researchers to fundamentally re-think previous assumptions about fire and forest health. In this new "forest ecology" paradigm, scientists have come to understand that high-intensity fires, or "stand-transforming fires", occurred naturally in most western U.S. conifer forests historically, and we have far less fire now than we did prior to fire suppression policies. Scientists have also come to understand that dead trees, especially large dead trees, or "snags", are not only the most ecologically valuable habitat features in the forest, but are also far too scarce, due to fire suppression and logging conducted under the guise of fuels reduction and forest health.

Most strikingly, recent scientific evidence has revealed that, contrary to previous assumptions, most current fires are predominantly low-intensity and moderate-intensity, and the relatively scarce high-intensity areas support the highest levels of native plant and wildlife biodiversity of any forest type in the western United States. Scientists now understand that, far from being "destroyed", these high-intensity patches are actually natural ecological treasures. High-intensity, or stand-transforming, fire creates ecologically-vital "snag forest habitat", which is rich with large snags, large downed logs, dense pockets of natural conifer regeneration, patches of native shrub habitat, or "montane chaparral", and large live trees.

Figure 1. Snag forest habitat in a mature mixed-conifer forest.

In snag forest habitat, countless species of flying insects are attracted to the wealth of flowering shrubs which propagate after stand-transforming fire – bees, dragonflies, butterflies, and flying beetles. Many colorful species of birds, such as the iridescent blue Mountain Bluebird, nest and forage in snag forest habitat to feed upon the flying insects. In order to feed upon the larvae of bark beetles and wood-boring beetles in fire-killed trees, woodpeckers colonize snag forest habitat shortly after the fire, excavating nest cavities in large snags. The woodpeckers make new nest holes each year, leaving the old ones to be used as nests by various species of songbirds. Many rare and imperiled bat species roost in old woodpecker cavities in large snags, and feed upon the flying insects at dusk. Small mammals, such as snowshoe hares and woodrats, create dens in the shrub patches and large downed logs, and raptors, such as the Spotted Owl, benefit from the increase in the abundance of their prey. Deer and elk browse upon the vigorous new plant growth that follows stand-transforming fire, and bears and wolves benefit from the increased abundance of their prey as well. A number of native wildlife species, such as the Black-backed Woodpecker, are essentially restricted to snag forest habitat for nesting and foraging. Without a continuous supply of this habitat, they won't survive.

Snag forest habitat is alive, and vibrant. It is colorful, and rich with varied sounds, given the sheer density of wildlife activity. It is the most rare, endangered, and ecologically important forest habitat in western U.S. forests, and the stand-transforming fires that create this habitat are not damaging the forest ecosystem. Rather, they are advancing ecological restoration. There is nothing "catastrophic" about wildland fire in these forests, especially where stand-transforming fire effects occur, creating snag forest habitat.

What is tragic, however, is the burning of homes in rural, forested areas. Our focus and our resources must be redirected to ensure protection of homes, rather than conducting pointless and destructive "fuels reduction" and "forest health" logging projects in remote forested areas based upon an outdated and unscientific management paradigm – a paradigm that financially benefits the timber industry and the budgets of land management agencies, but further deprives conifer forest ecosystems of the habitat features they need most to support imperiled species.

Fortunately, the means to protect homes from wildland fires are well understood, and fundamentally practical. The most recent science clearly shows that the only effective way to protect homes from fire is to reduce the combustibility of the home itself, by using fire-resistant roofing and siding and installing simple items like guards for rain gutters (which prevents dry needles and leaves from accumulating), as well as by creating "defensible space" through the thinning of brush and small trees within 100 feet of individual homes. If these simple measures are taken, the evidence clearly indicates that there is very little chance of homes burning, even in high-intensity fires (see, e.g., studies of Dr. Jack Cohen at www.firelab.org). Currently, however, only 3% of U.S. Forest Service fuels reduction projects are conducted adjacent to communities – and much of that 3% is well over 100 feet from homes.

We do not need to be afraid of the effects of fire in forest ecosystems of the western United States. Wildland fire is doing important and essential ecological work. It is keeping countless wildlife species alive. Our challenge, in the new and emerging paradigm, is to make certain that homes are protected so that we can allow wildland fire to do its vital and life-giving work in our forests. In short, we need to stop our futile battle against wildland fire and learn to live well with fire, reminding ourselves that western U.S. conifer ecosystems evolved with fire and are adapted to it. Excluding fire from these ecosystems is like trying to keep rain out of a rainforest.

Executive Summary

Popular myths and misconceptions about the ecology of fire and dead trees in western U.S. conifer forests are numerous, and are strongly at odds with the recent scientific evidence, which indicates the following about these forest ecosystems:

- The only effective way to protect homes from wildland fire is to reduce the combustibility of the homes themselves, and reduce brush and very small trees within 100 feet of the homes. Commercial thinning projects that remove mature trees hundreds of yards – and often several miles – from the nearest home do not protect homes, and often put homes at greater risk by diverting scarce resources away from true home protection, by creating a false sense of security, and by removing large, fire-resistant trees and generating combustible logging "slash debris", which increases potential fire severity. Currently, less than 3% of U.S. Forest Service "fuels reduction" projects are near homes.
- Patches of high-intensity fire (where most or all trees are killed) support the highest levels of native biodiversity of any forest type in western U.S. conifer forests, including many rare and imperiled species that live only in high-intensity patches. Even Spotted Owls depend upon significant patches of high-intensity fire in their territories in order to maintain habitat for their small mammal prey base. These areas are ecological treasures.
- Current fires are mostly low- and moderate-intensity, and high-intensity fire comprises a relatively small proportion of the total area burned. Areas that have not burned in a long time are not burning more intensely.
- Vigorous natural regeneration of conifer seedlings occurs after high-intensity fire. Numerous large trees also survive, and their growth tends to increase substantially after the fire, which converts woody material on the forest floor into highly usable nutrients for tree growth. By contrast, after very long absence of these fires, forests can lose so much of their productivity that, ultimately, sites lose the ability to support forest at all.
- There is far less fire now than there was historically. There is also less high-intensity fire now than there was prior to fire suppression policies.
- Fires are not becoming more intense.

- Predictions vary about the effect of global warming and climate change on forest fire activity, but the most recent projections indicate reduced fire activity in most forests due to changes in combustible vegetation, and increased precipitation in many areas. Even scenarios for increased fire activity would not rectify the current deep deficit of fire in forest ecosystems.

- Ton for ton, dead trees ("snags") are far more important ecologically than live trees, and there are far too few large snags and logs to support native wildlife in most areas. Recent anecdotal reports of forest "destroyed" by beetles are wildly misleading and inaccurate.

- High-intensity fire burns cleaner than low-intensity, and produces fewer particulates.

- Current forests, including old-growth forests, are carbon sinks, meaning that they are absorbing more of the greenhouse gas CO_2 than they are emitting. High-intensity wildland fire promotes high levels of carbon sequestration. Old-growth conifer forests cannot function as carbon sinks without fire. Without large, intense wildland fires to cycle nutrients and rejuvenate the productivity of the soil, forests can become carbon sources after about 600 years of age.

- Mechanical "thinning" decreases total carbon storage in conifer forests.

- Though timber interests have promoted increased logging by describing current forests as "overstocked", the scientific data indicates that, due to past logging, as well as exclusion of wildland fire, forests of today have much less total biomass than historic forests. However, "biomass" thinning is a growing threat to forests, and is now associated with post-fire logging, and logging of unburned old-growth trees.

- Ecologically "healthy forests" are those that have an abundance of low-, moderate-, and high-intensity fire effects, and an abundance of large snags. We need more, not less, fire and large dead trees and downed logs to keep our forest ecosystems healthy. "Thinning" projects designed to prevent high-intensity fire and reduce future large snag densities are not promoting "forest health", and post-fire "salvage" logging is profoundly destructive ecologically. Moreover, if fire suppression policies achieve their stated goal, many wildlife species that depend upon habitat created by high-intensity fire will be put at risk of extinction.

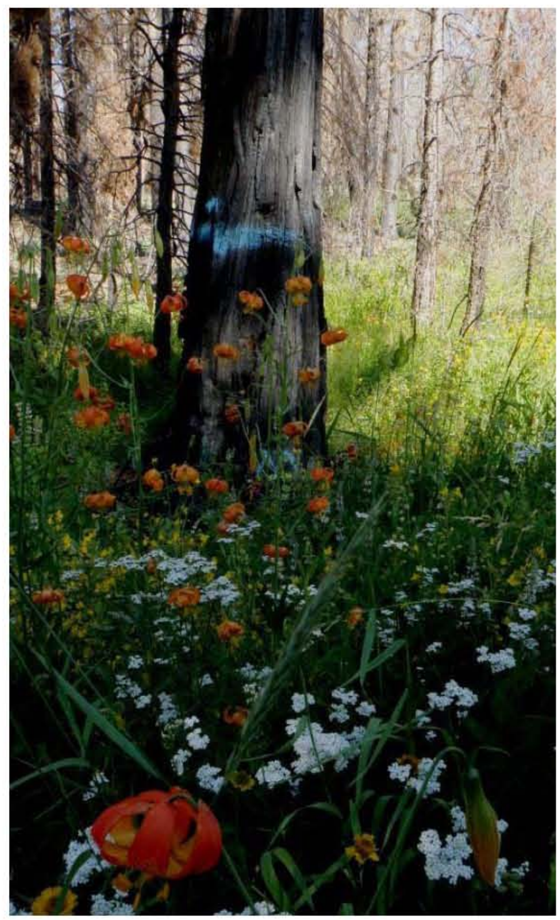

Fig. 2. Post-fire snag tree marked for logging.

Note: Fire studies often use the term "fire severity" to describe the proportion of trees killed, while "fire intensity" is used to describe the energy released by the fire. In this report, I use the term "fire intensity" in reference to the extent of tree mortality. I do this for two reasons. First, high-severity areas and high-intensity areas are generally the same in conifer forests. Second, the term "severity", like "catastrophic", is pejorative in nature, and objective scientific discourse should seek to use value-neutral terms.

Myths and Facts

MYTH 1

Forest “thinning” projects in the Wildland/Urban Interface (WUI) protect homes from wildland fire in forested communities.

FACT 1

Commercial “thinning” logging projects do not protect homes.

The term “Wildland/Urban Interface”, or “WUI”, has been misleadingly used to justify commercial thinning logging projects – under the guise of home protection – miles from the nearest home. The scientific evidence is clear that the only effective way to protect structures from fire is to reduce the ignitability of the structure itself (e.g., fireproof roofing, leaf gutter guards) and the immediate surroundings within about 100 feet from each home, e.g., through thinning of brush and small trees adjacent to the homes (www.firelab.org–see studies by U.S. Forest Service fire scientist Dr. Jack Cohen). This area would be more properly described as the “Defensible Space Zone”. Regardless, only 3% of Forest Service “fuels reduction” projects are conducted within the WUI, adjacent to communities – and much of that 3% is well over 100 feet from homes (Schoennagel et al. 2009).

Moreover, most “thinning” projects allow removal of many of the larger trees in order to make the projects economically attractive to logging companies, and to generate revenue for the public land management agencies, such as the U.S. Forest Service. Where this is done near homes, it can increase the danger of structures burning. The removal of larger, mature trees in thinning operations tends to increase, not decrease, fire intensity by: a) removing large, fire-resistant trees; b) creating many tons of logging “slash” debris – highly combustible branches and twigs from felled trees; c) reducing the cooling shade of the forest canopy, creating hotter, drier conditions on the forest floor; d) accelerating the growth of combustible brush by reducing the mature trees that create the forest canopy, thereby increasing sun exposure; and e) increasing mid-flame windspeeds (winds created by fire) by removing some of the mature trees and reducing the buffering effect they have on the winds associated with fires (Hanson and Odion 2006, Platt et al. 2006). The scientific evidence clearly indicates that, where it is important to reduce potential fire intensity (e.g., immediately adjacent to homes) this can be very effectively accomplished by thinning some brush and very small trees up to 8 to 10 inches in diameter (Omi and Martinson 2002, Martinson and Omi 2003, Strom and Fule 2007). Removal of mature trees is completely unnecessary.

A July 20, 2008 article by Heath Druzin and Rocky Barker in the Idaho Statesman documents an excellent example of effective home protection. The article describes the Idaho town of Secesh Meadows, which decided to get serious about creating defensible space by reducing brush immediately adjacent to the homes. A high-intensity wildland fire approached the town, but dropped down to a slow-moving low severity fire once it reached the populated area. The fire burned right through the town, right past front porches, and kept moving, but did not burn down a single home. As resources are being spent on counter-productive commercial thinning projects that are hundreds of yards, and sometimes several miles, from the nearest town, homes remain unprotected in rural forested areas. This is entirely preventable.

MYTH 2

Low-intensity fire is natural and acceptable, but patches of high-intensity fire are ecologically destructive.

FACT 2

High-intensity fire patches create habitat that supports some of the highest levels of native biodiversity of any forest type in western U.S. forests.

Snag Forest Habitat

"Snag forest habitat", resulting from high-intensity fire patches (generally, stands with 75-80% or greater tree mortality from fire, exclusive of seedlings and saplings) that have not been salvage logged, is one of the most ecologically-important and biodiverse forest habitat types in western U.S. conifer forests (Lindenmayer and Franklin 2002, Noss et al. 2006, Hutto 2008). Noss et al. (2006) observed the following in reference to high severity fire patches: "Overall species diversity, measured as the number of species – at least of higher plants and vertebrates – is often highest following a natural stand-replacement disturbance…" Snag forest habitat is comprised of abundant standing fire-killed trees ("snags") of all sizes, especially larger trees, as well as patches of montane chaparral (dominated by flowering shrubs whose germination is facilitated by fire), dense pockets of natural conifer regeneration, large downed logs, numerous "fire-following" wildflowers, and widely-spaced large surviving trees. At the landscape level, high-intensity fire habitat (when it is left unlogged) is among the most underrepresented, and rarest, of forest habitat types. Noss et al. (2006) observed that "early-successional forests (naturally disturbed areas with a full array of legacies, ie not subject to post-fire logging) and forests experiencing natural regeneration (ie not seeded or replanted), are among the most scarce habitat conditions in many regions." The scarcity of this important natural habitat type is the result of fire suppression and post-fire logging.

Figure 3. Recent snag forest habitat in the Sierra Nevada.

Dr. Richard Hutto, one of the nation's top ornithologists, recently concluded the following, based upon the emerging scientific evidence: "Besides the growing body of evidence that large, infrequent events are ecologically significant and not out of the range of natural variation (Foster et al. 1998, Turner & Dale 1998), an evolutionary perspective also yields some insight into the 'naturalness' of severely burned forests… The dramatic positive response of so many plant and animal species to severe fire and the absence of such responses to low-severity fire in conifer forests throughout the U.S. West argue strongly against the idea that severe fire is unnatural. The biological uniqueness associated with severe fires could emerge only from a long evolutionary history between a severe-fire environment and the organisms that have become relatively restricted in distribution to such fires. The retention of those unique qualities associated with severely burned forest should, therefore, be of highest importance in management circles" (Hutto 2006).

There is strong consensus among ecologists that high-intensity fire, and resulting snag forest habitat, is something that must be preserved and facilitated, not prevented or destroyed. Lindenmayer et al. (2004) noted the following with regard to wildland fire: "…natural disturbances are key ecosystem processes rather than ecological disasters that require human repair. Recent ecological paradigms emphasize the dynamic, nonequilibrial nature of ecological systems in which disturbance is a normal feature… and how natural disturbance regimes and the maintenance of biodiversity and productivity are interrelated…" Smucker et al. (2005) concluded: "Because different bird species responded positively to different fire severities, our results suggest a need to manage public lands for the maintenance of all kinds of fires, not just the low-severity, understory burns…" Kotliar et al. (2007) observed that the results of their study "demonstrated that many species tolerate or capitalize on the ecological changes resulting from severe fires…", and concluded that: "Fire management that includes a broad range of natural variability (Allen et al. 2002), including areas of severe fire, is more likely to preserve a broad range of ecological functions than restoration objectives based on narrowly defined historic fire regimes (Schoennagel et al. 2004)."

Fig. 4. Some of the many species living in snag forest habitat.

Older, mature forests that burn at high-intensity are particularly important, since cavity-nesting species tend to select larger snags for nesting and denning. Hutto (1995) concluded that, because "the most suitable nest trees for cavity excavation are snags that are themselves old-growth elements, one might even suggest that many of the fire-dependent, cavity-nesting birds depend not only on forests that burn, but on older forests that burn." In burned forests, woodpeckers preferentially select larger snags for foraging (Hutto 1995, Hanson 2007, Hanson and North 2008). Scientists have recently recommended that forest managers should ensure the maintenance of moderate-and high-intensity fire patches to maintain populations of numerous native bird species associated with fire (Hutto 1995, Hutto 2006, Kotliar et al. 2002, Noss et al. 2006, Smucker et al. 2005, Hanson and North 2008, Hutto 2008).

Fire-induced heterogeneity, including a mix of low-, moderate-, and high-intensity patches, leads to higher post-fire understory plant species richness compared to homogeneous low-severity fire effects (Chang 1996, Rocca 2004). Mixed-intensity fire, meaning a heterogeneous mix of high-, moderate-, and low-intensity effects, facilitates reproduction of numerous native herbaceous and shrub species (Chang 1996, Rocca 2004), the germination of many of which is triggered by fire-induced heat, charcoal, or smoke (Biswell 1974, Chang 1996). These flowering plants, in turn, increase biodiversity of flying insects, such as bees and butterflies. In addition, fire-caused conifer mortality attracts bark beetles and wood-boring beetles, some species of which have evolved infrared receptors capable of detecting burned forests from over 161 km away (Altman and Sallabanks 2000, Hutto 1995). Other insect species are attracted by the smoke from fires (Smith 2000).

As a result, bird species richness and diversity increases in heavily burned patches, which generally occur within a mix of low- and moderate-intensity effects. Woodpeckers feed upon bark beetle and wood-boring beetle larvae in snags and excavate nest cavities in snags; Mountain Bluebirds and other secondary cavity-nesting species use nest holes created the previous year by woodpeckers; granivores such as the Red Crossbill feed upon seed release from cones following fire; shrub-dwelling species like the Blue Grouse nest and forage within shrub growth scattered throughout high-intensity patches; while aerial insectivores (animals that feed upon flying insects) such as the imperiled Olive-sided Flycatcher prey upon the native bark beetles that are abundant in snag patches (Altman and Sallabanks 2000, Hutto 1995). Likewise, mammalian species, such as the Sierra Nevada Snowshoe Hare, which is listed as a Forest Service Sensitive Species (USFS 2001), depend upon post-fire shrub habitat following intense fire (Smith 2000, USDA 2001). Populations of small mammals experience overall increases shortly after high-intensity fire, and amphibians are positively associated with the large woody material that gradually accumulates in the decades following such fire effects (Smith 2000). As well, ungulates, such as deer and elk, forage upon post-fire flora, and large predators frequently seek their prey in burned patches (Smith 2000). Studies have detected higher overall bird species richness in intensely burned versus unburned forest in the western United States (Bock and Lynch 1970, Hutto 1995, Raphael and White 1984, Siegel and Wilkerson 2005). In one snag forest area resulting from the Manter Fire of 2000 in the southern Sierra Nevada, a total of 111 bird species were observed (Siegel and Wilkerson 2005).

Black-backed Woodpecker

There is perhaps no vertebrate species more strongly representative of the snag forest habitat type than the Black-backed Woodpecker (Picoides arcticus) (Hutto 1995, Hanson 2007, Hanson and North 2008, Hutto 2008). This species is a federally designated Management Indicator Species, acting as a bellwether for the viability of dozens of other species associated with snag forests (USDA 2004). One of only two woodpecker species globally with three toes instead of four, the Black-backed Woodpecker is able to deliver exceptionally hard blows due to added heel mobility resulting from the lack of a fourth toe and, as a consequence, it can reach beetle larvae that other woodpecker species cannot (Dixon and Saab 2000). One bird eats an astounding 13,500 beetle larvae per year (Hutto, unpublished data). From behind, the all-black coloring of this species confers excellent camouflage against the charred bark of a fire-killed tree, indicating a long evolutionary history with high-intensity fire (Hutto 1995). Though Black-backed Woodpeckers are occasionally, but rarely, seen outside of stand-replacement burns, forests outside of snag forest habitat are believed to be "sink" habitats which do not support them (Hutto 1995, Dixon and Saab 2000). In the northern Rocky Mountains, the Black-backed Woodpecker is largely restricted to recently severely burned conifer forest that is unlogged (Hutto 1995, Russell et al. 2007). The same has been found to be true in Sierra Nevada forests (Hanson 2007, Hanson and North 2008).

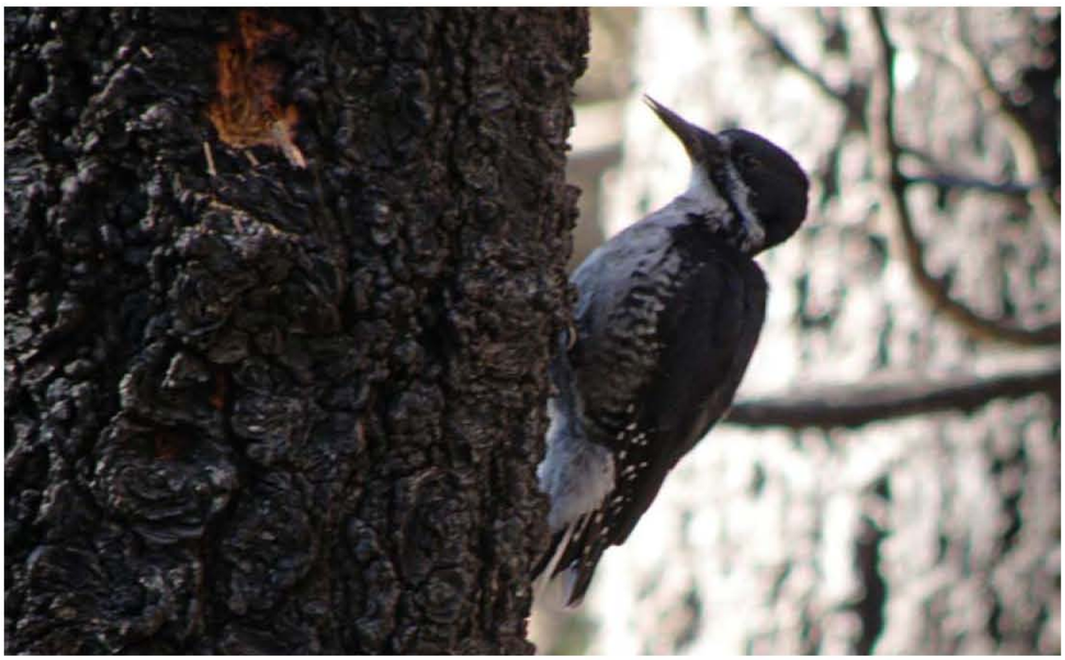

Fig. 5. Black-backed Woodpeckers are just one of the many wildlife species threatened by the loss of snag forest habitat due to fire suppression and "salvage" logging.

Black-backed Woodpeckers are strongly associated with large, unlogged high-intensity patches in areas that were mature/old-growth, closed-canopy forest prior to the fire (which ensures many large snags) (Hutto 1995, Saab et al. 2002, Saab et al. 2004, Russell et al. 2007, Hanson and North 2008, Hutto 2008, Vierling et al. 2008). Pre-fire thinning that reduces the density of mature trees can render habitat unsuitable for Black-backeds even if the area later experiences high-intensity fire, due to a reduction in the potential density of large snags caused by the earlier thinning (Hutto 2008). After approximately 5-6 years, when their bark beetle food source begins to decline and nest predators begin to recolonize the burn area, Black-backed Woodpeckers must find a new large, unlogged high-intensity patch in mature forest to maintain their populations (Hutto 1995, Saab et al. 2004). For these reasons, this species depends upon a continuously replenished supply of high-intensity burn areas (Hutto 1995).

Spotted Owls and Fire

Fig. 6. Snag forest habitat increases the Spotted Owl's small mammal prey and provides foraging habitat for Spotted Owls.

Recent scientific evidence regarding spotted owls in northwestern California and in Oregon found that stable or positive trends in survival and reproduction depended upon significant patches (generally between one-third and two-thirds of the core area) of habitat consistent with high-intensity post-fire effects (e.g., native shrub patches, snags, and large downed logs) in their territories because this habitat is suitable for a key owl prey species, the Dusky-footed Woodrat (Franklin et al. 2000, Olson et al. 2004). This habitat is not mimicked by logging, which removes snags and prevents recruitment of large downed logs, and which seeks to reduce or eliminate shrub cover. Logging can reduce owl survival and reproduction by preventing occurrence of natural post-fire habitat heterogeneity in the spotted owl territories.

In a study conducted several years post-fire, Clark (2007) found that Northern spotted owls in southwestern Oregon were adversely affected by post-fire salvage logging, but his results show the opposite for unlogged moderately and intensely burned patches within the owls' territories. Specifically, he found that, in an area in which the spotted owl territories had been partially or predominantly salvage logged, occupancy decreased. For owls that had not been extirpated by salvage logging, the fire itself did not reduce productivity. Using radio-telemetry, Clark (2007) found that spotted owls used nesting, roosting, and foraging habitat (dense, old forest) that had burned at low-, moderate-, and high-intensity more frequently than would be expected based upon availability of these habitat strata on the landscape so long as these areas had not been salvage logged. The owls avoided salvage logged areas (and the few detections within salvage logged units were, on closer inspection by the author, generally found to be in unlogged retention areas within the logging units, such as stream buffers).

Fig. 7. A California Spotted Owl roosting in a burned area within the McNally fire, Sequoia National Forest.

Interestingly, over four years of study in three fire areas, only one Barred owl was found within burned forests, while many were found just outside the fire perimeter (Clark 2007). Barred owls prey upon Spotted owls and are considered to be a significant threat (Clark 2007). In addition, recent radio-telemetry research in the Sierra Nevada has found that, in post-fire forest (nearly all of which was unmanaged), California spotted owls selected low-intensity areas for roosting and selected high-intensity areas for foraging (Bond et al. 2009). One might think of dense, old forest as the owl's bedroom, and high-intensity fire patches as its kitchen. Recent scientific evidence indicates that there is far less high-intensity fire in Northern Spotted Owl habitat than was previously assumed (Hanson et al. 2009, Hanson et al. 2010 in press in Conservation Biology). We do not yet fully know the potential adverse consequences of the ongoing fire deficit for Spotted Owls.

MYTH 3

Due to decades of fire suppression, and resulting fuel accumulation, most fires are currently dominated by high-intensity effects.

FACT 3

High-intensity fire is the exception, not the rule; and long-unburned areas are not burning more intensely.

Contrary to popular misconception, low- and moderate-intensity fire effects are heavily predominant in western conifer forests, and high-intensity effects comprise a minor portion of the overall area burned (Odion and Hanson 2008, Schwind 2008, Hanson et al. 2009). For example, in the Pacific Northwest since 1984, high-intensity effects occurred on only about 10-12% of the area burned, and on only about 12-15% of the total area burned in California (Schwind 2008).

Contrary to popular misconception, areas that have missed the greatest number of natural fire cycles, due to fire suppression, are burning mostly at low- and moderate-intensity and are not burning more intensely than areas that have missed fewer fire cycles (Odion et al. 2004, Odion and Hanson 2006, Odion and Hanson 2008). The notion that forested areas become increasingly likely to have high-intensity effects the longer they remain unburned is simply inaccurate. Instead, as the time period since the last fire increases, forests become more mature, and develop higher forest canopy cover. This reduces the amount of pyrogenic (combustible) shrubs, which need more sunlight, reducing overall high-intensity fire occurrence, based upon several decades of data from the Klamath mountains in California (Odion et al. 2009). It also reduces the amount of sunlight reaching the forest floor and understory. In such conditions, surface fuels stay moister during the fire season, due to the cooling shade of the forest canopy, and, due to reduced sunlight, forest stands begin to self-thin small trees and lower branches of large trees. This makes it more difficult for flames to spread into the forest canopy during wildland fire.

MYTH 4

Where high-intensity patches occur, the forest will not regenerate naturally due to soil damage or lack of seed sources from surviving conifers.

FACT 4

Forest growth and regeneration is vigorous after high-intensity fire, and fire-adapted forests need fire to maintain productivity. In the few places wherein post-fire conifer regeneration does not quickly occur, these areas provide important montane chaparral habitat, which has declined due to fire suppression.

The increase in available nutrients following fire, particularly higher-intensity fire, can lead to substantial growth pulses (Brown and Swetnam 1994 [Fig. 3], Mutch and Swetnam 1995 [Fig. 4]). This includes post-fire shrub growth, conifer regeneration, and growth release of surviving overstory trees. The conifer seedling/sapling regeneration is very vigorous in high-intensity patches (see, e.g., Donato et al. 2006, Hanson 2007b, Shatford et al. 2007). Ponderosa and sugar pines, which have declined in some western U.S. forests, appear to have a competitive advantage over fir and cedars in regrowth after high-intensity fire, as their post-fire proportions are higher than they were pre-fire, and pines tend to be tallest, fastest-growing conifer saplings in these areas (Hanson 2007b).

Fig. 8. Natural conifer regeneration in a high-intensity patch of mixed-conifer forest.

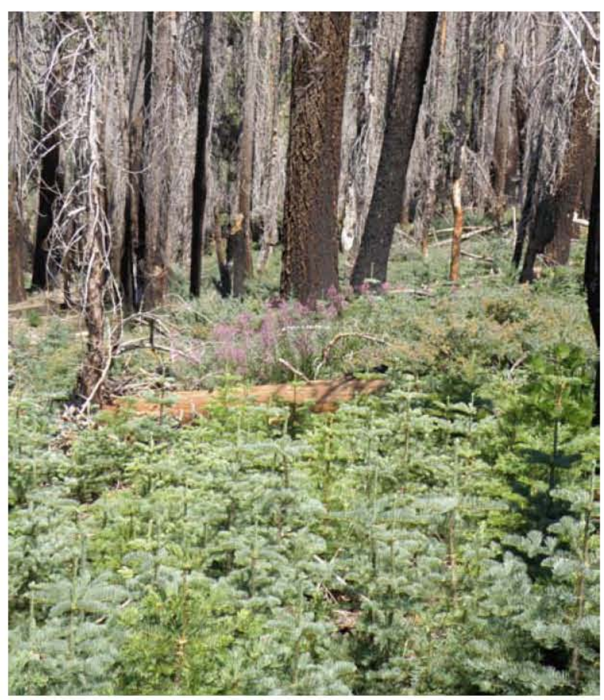

Fig. 9. Natural conifer regeneration in an area of nearly 100% mortality from fire.

In the few places wherein post-fire conifer regeneration does not quickly occur, these areas provide important montane chaparral habitat, which has declined due to fire suppression (Nagel and Taylor 2005). As noted earlier, montane chaparral provides key habitat for a variety for shrub-dwelling species like the Snowshoe Hare and the Blue Grouse, which nests and forages within the shrub growth. The Dusky-footed Woodrat also inhabits these areas, which in turn provides food for the Spotted Owl. Likewise, ungulates, such as deer and elk, forage upon the shrubs, and their predators frequently seek prey in montane chaparral. Therefore, chaparral regeneration is another ecological benefit of high-intensity fire. On the whole, though, high-intensity fires are soon followed by vigorous forest regeneration.

By contrast, in the very long absence of large fires commonly thought of as "catastrophic", forests can lose so much of their productivity that, ultimately, sites lose the ability to support forest at all. Wardle et al. (2004) concluded the following: "Our results have several implications. First, they suggest that the decline of natural forests, which is often observed in the long-term absence of catastrophic disturbance [including wildland fires], may arise through increasing limitation by [phosphorus] and reduced performance of the decomposer subsystem… Second, the results show that the maximal biomass phase (and associated rates of ecosystem processes) attained after primary or secondary succession cannot be maintained in the long-term absence of major disturbances."

MYTH 5

Fire is now burning at unprecedented levels.

FACT 5

We are in a major fire deficit. There is now far less fire overall, and less high-intensity fire, than there was historically.

Fire extent in general remains heavily suppressed in western U.S. forests such that historic annual extent of burning was several times greater than the annual extent of burning under current conditions (Medler 2006, Stephens et al. 2007). Using more conservative estimates of historic fire extent (Baker and Ehle 2001), annual burning in forests prior to fire suppression was still several times higher than it is now. Western U.S. conifer forests remain in a serious "fire deficit" (Medler 2006). Even high-intensity effects are in deficit currently, relative to the extent of high-intensity fire prior to fire suppression and logging.

High-intensity fire was previously assumed to have been rare and of limited extent in most western U.S. conifer forests, largely because fire-scar studies documented frequent fire occurrence in most historic conifer forests, and it was assumed that frequent fire would have kept surface fuel levels low, preventing high-intensity fire. The problem, however, is that fire-scar records cannot detect occurrence of past high-intensity effects, wherein most trees were killed (Baker and Ehle 2001).

Historic data and recent reconstructions of historic fire regimes indicate that high-intensity fire was common in most conifer forests of western North America prior to fire suppression and logging, even in pine-dominated forests with frequent fire regimes "(Baker et al. 2007, Hessburg et al. 2007, Klenner et al. 2008, Whitlock et al. 2008, Baker et al. 2009). For example, a recent reconstruction of historic fire occurrence in a 1,587 ha (unmanaged) research natural area near Lassen Volcanic National Park found mid-elevation slopes to be dominated by moderate-intensity fire, mixed with some low- and high-intensity effects, while upper-elevation slopes were dominated by high-intensity fire (Beaty and Taylor 2001). Other research has found steep declines in montane chaparral within mixed conifer forest ecosystems in the Lake Tahoe Basin of the central and northern Sierra Nevada due to a decrease in high-intensity fire occurrence since the 19th century (Nagel and Taylor 2005).

In the late 19th century, John B. Leiberg and his team of United States Geological Survey researchers spent several years mapping forest conditions, including fire intensity in the central and northern Sierra Nevada. Leiberg recorded all high-intensity patches over 80 acres (32 ha) in size occurring in the previous 100 years

(Leiberg 1902). Using modern GIS vegetation and physiographic information, Hanson (2007a) compared fire locations to forest type and site conditions to examine patterns of high-intensity fire events, excluding areas that had been logged in the 19th century in order to eliminate the potentially confounding effect of logging slash debris (branches and twigs left behind by loggers). Hanson (2007a) used areas that Leiberg had mapped as having experienced 75-100% timber volume mortality.

Hanson (2007a) found that high-intensity fire was not rare in historic Sierra Nevada forests, as some have assumed. Over the course of the 19th century, within Leiberg's study area, encompassing the northern Sierra Nevada, approximately one-fourth to one-third of middle and upper elevation westside forests burned at high-intensity (75100% mortality) (Hanson 2007a). This equates to fire rotation intervals for high-intensity fire of roughly 400 to 300 years (i.e., for a fire rotation interval of 300 years, a given area would tend to burn at high severity once every 300 years on average). Available evidence indicates that current rates of high-intensity fire are considerably lower than this overall (Hanson 2007a). For example, the Final EIS for the 2004 Sierra Nevada Forest Plan Amendment indicates that, on average, there are about 15,000 acres of high-intensity fire occurring per year in Sierra Nevada forests (entire Sierra Nevada included) (USDA 2004). Given the size of the forested area in the Sierra Nevada, about 13 million acres (Franklin and Fites-Kaufman 1996), this equates to a high-intensity fire rotation interval of more than 800 years in current forests (longer rotation intervals correspond to less high-intensity fire).

Nor were pre-fire-suppression high-intensity patches all small, as has often been assumed. In fact, in unlogged areas mapped by Leiberg (1902), some aggregate patches of high-intensity effects were 20,000 to 30,000 acres in size, or larger (Leiberg 1902, Hanson 2007a (Fig. 3.1)), greater than any current high-intensity patches.

The findings of Hanson (2007a) are consistent with those of Beaty and Taylor (2001), whose reconstruction of historic fire regimes in unmanaged forests just north of Leiberg's study area found that, despite relatively frequent low-intensity fire occurrence, moderate- high-intensity fire were common and historically in these forests. Specifically, Beaty and Taylor (2001) found that approximately 15% of montane forests 1370-1770 m in elevation burned at high intensity over a 43-year period from 1883 to 1926 (Beaty and Taylor 2001). This equates to a high-intensity rotation interval of about 300 years. Bekker and Taylor (2001) found historic high-intensity fire rotations of 200 to 250 years in eastside mixed-conifer/fir forests types north of Leiberg's study area (California Cascades region). High-intensity rotation intervals of several hundred years in length, and much more frequent lower-intensity fire, indicates forests in which individual fires would, on average, tend to burn predominantly at low-and moderate-intensity, but would have the potential to burn at high-intensity under certain weather and fuel loading conditions. A high-intensity fire rotation of about 300 years was also found in the mixed-conifer and Jeffrey pine forests of the Sierra San Pedro de Martir in Baja California – forests that have never been subjected to fire suppression and have not been logged (Minnich et al. 2000).

Historic U.S. Geological Survey data gathered by Leiberg (1900b) provides further evidence of an active role for high-intensity fire prior to fire suppression. Leiberg (1900b) gathered comprehensive data on high-intensity fire occurrence for the period 1855-1900 in the Oregon Klamath region, presenting data on high-intensity (75-100% timber volume mortality) acres and acres logged for each township. Excluding the townships with any evidence of logging (in order to eliminate any confounding effects of logging), there were 12,700 acres of high-intensity fire in 72,580 acres of unmanaged forest over a 45-year period prior to fire suppression (Leiberg 1900b). This equates to a high-intensity rotation of 257 years. The high-intensity rotation within the Eastern Oregon Cascades physiographic province (Moeur et al. 2005) prior to fire suppression and logging was 165 years overall, and was 322 years for forests with more than 85% ponderosa pine (Leiberg 1900b), indicating far more high-intensity fire than is occurring currently (889-year high-intensity rotation in mature forests from 1984 to 2005) (Hanson et al. 2009, Hanson et al. 2010 in press in Conservation Biology).

Fig. 10. A recent snag forest patch in the Sierra Nevada.

Taylor and Skinner (1998), in a reconstruction of historic fire occurrence in a 3,878-acre study area in the Klamath Mountains of California, found that 14% of the area burned at high intensity 1850-1950, though they defined high-intensity very narrowly as areas in which fewer than 4 trees per acre survived the fire. Moderate-intensity effects occurred on 27% of the area, where moderate intensity was defined as only 4-8 surviving trees per acre (Taylor and Skinner 1998), which would be categorized as high-intensity in current fire intensity assessments. If all areas in which there were 8 or fewer surviving trees per acre are included in a calculation of a high-intensity rotation, the high-intensity rotation would be approximately 244 years. Their study area was just south of the Oregon/California border at elevations ranging from about 2,100 to 5,200 feet in elevation within Douglas-fir, Douglas-fir/pine, and mixed-conifer forests (Taylor and Skinner 1998). Wills and Stuart (1994) reconstructed fire history in three representative study sites in the Klamath National Forest of California, using fire-scar and tree age class data. They found that the historic, pre-fire suppression interval between high-intensity fire events was approximately 170 to 200 years in the first study site, about 100 years in the second study site, and was intermediate between these two in the third study site. Their study area was in forests dominated by Douglas-fir, sugar pine and tanoak at approximately 3,000 feet in elevation on slopes averaging 56% within the Salmon River Ranger District (Wills and Stuart 1994). In contrast, the estimate of the current high-intensity rotation in Klamath forests, using satellite imagery data for 1984-2005, is about 600 years (Hanson et al. 2009, Hanson et al. 2010 in press in Conservation Biology).

The high-intensity rotation prior to fire suppression (1800-1900) was found to be 385 years in mid-elevation conifer forests of the western Cascades of Oregon (Morrison and Swanson 1990), indicating several times more high-intensity fire than is occurring currently in mature forests of the western Oregon Cascades (Moeur et al. 2005).

Within forests dominated by fir, spruce, and lodgepole pine in Montana prior to fire suppression and the arrival of settlers, high-intensity rotations were 289 years in one area (Leiberg 1904a) and 190 years in another (Leiberg 1904b). In Montana's Bitterroot Forest Reserve (now called the Bitterroot National Forest) prior to fire suppression and the arrival of settlers, out of 2,462,464 acres of fir, spruce, and lodgepole pine forest, 2,270,000 acres burned at high intensity over the course of 140 years prior to fire suppression and the arrival of settlers, equating to a high-intensity fire rotation of 152 years (Leiberg 1900a). Of the 1,149,696 acres of ponderosa pine forest, roughly 25-30% burned at high-intensity over this same time period (Leiberg 1900a), equating to a high-intensity rotation of roughly 450-500 years. In the Bitterroot Reserve as a whole, the historic high-intensity fire rotation was 200-300 years. The current high-intensity rotation for the forests of the northern Rockies is 500 years, using interagency Burned Area Emergency Rehabilitation (BAER) fire intensity data (Rhodes and Baker 2008). This indicates considerably less high-intensity fire now than there was historically.

Even in dry ponderosa pine forests of the southwestern U.S., high-intensity fire naturally occurred prior to fire suppression and logging, with stand age plot data indicating historic high-intensity rotations of 300-400 years during the 1800s (Baker 2006). The current high-intensity rotation is about 625 years in southwestern U.S. forests (Rhodes and Baker 2008). Based on charcoal sediments, researchers have also determined that high-intensity fire was common in low-elevation ponderosa pine forests from about 1000 to 1400 A.D., contradicting the assumption that current high-intensity fire in such forests is uncharacteristic or unprecedented (Pierce et al. 2004, Whitlock et al. 2004).

Overall, the data indicate that there was about 2-4 times more high-intensity fire historically in western U.S. conifer forests than there is currently. This fire deficit translates to serious deficits in ecologically-vital snag forest habitat, and this is greatly exacerbated by the fact that much of the snag forest habitat that is created by fire is lost to post-fire "salvage" logging.

MYTH 6

Climate change and global warming will necessarily cause increased fire activity and intensity.

FACT 6

Current predictions vary, and may differ greatly from region to region. The most recent projections indicate that, in most forested regions of the North America, reduced fire activity is likely to occur, due to vegetation changes that will result in less combustible fuel, and due to increased precipitation in many areas.

Westerling et al. (2006) speculated that climate change may lead to more intense fires, but more recent studies refute this assumption. A comprehensive analysis of high-severity fire since 1984 by the U.S. Geological Survey in California, Oregon and Washington found no increasing fire intensity trend (Schwind 2008). Other research since then has supported that finding for an area in Yosemite National Park (Collins et al. 2009) and within the dry conifer forests of the Klamath and eastern Cascade Mountains in California, Oregon, and Washington (Hanson et al. 2010). Miller et al. (2008) reported an increasing fire intensity trend in Sierra Nevada forests since 1984. However, Miller et al. (2008) was based upon only 60% of the available fire data, and used recent vegetation data to exclude shrub habitat. The results of Hanson et al. 2009 (in review), which was based upon complete fire data, indicate that this method excludes relatively more high-intensity fire in conifer forest within the earlier years of the data set, creating the appearance of an increasing trend where none exists. This implies that recent high-intensity patches generally still visually appear to be conifer forest to those updating Cal-Veg mapping from remote sensing imagery, while older high-intensity patches frequently do not, likely due to greater post-fire snag attrition and maturation of montane chaparral. Another recent study inexplicably claimed that fires would become "more severe" and that there would be "increased proportions of high-severity fire" by 2020-2049 in Yosemite National Park, California, despite the fact that the study explicitly found that the high-intensity fire proportion would remain at 16% from the present through 2020-2049 (Lutz et al. 2009 [Table 1]).

Some previous climate modeling predicted increases in the annual area burned in most forested areas of the western U.S., but predicted decreases in some areas, such as California and Nevada (McKenzie et al. 2004). Increased temperatures are predicted to occur generally, but precipitation, including summer precipitation, is expected to increase as well in most areas (McKenzie et al. 2004). Moisture-related variables, e.g., humidity and precipitation, may be more important than temperature in predicting future fire occurrence (Parisien and Moritz 2009). Actual data from weather stations over the past several decades generally shows increases in precipitation, especially summer precipitation (which can significantly dampen wildland fire), in states comprising the western U.S. (Mote 2003, WRCC 2009), and in Canada's boreal forests (Girardin et al. 2009). Some studies (e.g., Spracklen et al. 2009) still predict some increase in overall fire occurrence but do so by assuming that increases in spring/summer precipitation will be only 1/8 to ¼ of the increases that have actually been occurring over the past 100 years (Mote 2003). Even if some forested areas become hotter and drier, as opposed to warmer and wetter, they may experience decreased, not increased, fire activity due to a reduction in the most combustible vegetation (Parisien and Moritz 2009). This is supported by charcoal and pollen deposits, which allow scientists to correlate past climate to fire activity since the last Ice Age. The evidence indicates that hotter, drier conditions sometimes led to reduced fire effects, and cooler, wetter conditions did not necessarily lead to reduced fire effects (Gavin et al. 2007 [Fig. 6], Parisien and Mortiz 2009). Often, the periods with the largest temperature increases were associated with decreased, not increased, fire occurrence (Marlon et al. 2009 in press in Proceedings of the National Academy of Sciences). The most current research predicts decreased fire activity in most western U.S. conifer forest regions (Krawchuk et al. 2009 [see Fig. 3 of that study]). Westerling et al. (2006) found that, since the 1970s, the total area affected by fire (all intensities included) in western U.S. forests has increased marginally, though it is unclear how much of this is the result of more recent fire management policies allowing more fires to burn in remote areas. Given the massive fire deficit we are in, as discussed above, even if there is some increase in the average annual area affected by fire, we would still have far less fire than we did prior to fire suppression policies, and would remain in an unnatural fire deficit.

MYTH 7

Our forests are "unhealthy" because there are too many dead trees.

FACT 7

There are far too few large dead trees to maintain ecologically healthy forests.

Due in large part to the combined effects of fire suppression and post-fire logging, large snags (dead trees) are currently in severe deficit, contrary to popular belief. For example, recent U.S. Forest Service Forest Inventory and Analysis (FIA) data, using 3,542 fixed plots throughout California, shows that there are less than 2 large snags per acre in all forested areas (Christensen et al. 2008). The Sierra Nevada Forest Plan Amendment recommends having at least 3-6 large snags per acre to provide minimum habitat for the needs of the many wildlife species that depend upon large snags for nesting and foraging (USDA 2001, 2004). Some species need even higher densities of large snags, such as the California Spotted Owl, which prefers to have at least 20 square feet per acre of basal area in large snags (about 6-8 large snags per acre) to maintain habitat for its small mammal prey (Verner et al. 1992). Other species require much higher densities of large snags, such as the Hairy Woodpecker and Black-backed Woodpecker (Hanson 2007a, Hanson and North 2008).

Fig. 11. Black-backed Woodpeckers (center of image) foraging on a large snag.

A study published recently in Science (van Mantgem et al. 2009) found increasing tree mortality in old-growth forest plots, speculating that it is a result of climate change, as opposed to fire suppression. However, the study did not find higher mortality rates in the large, old trees within those plots. Moreover, the study was based on only 76 plots across the western United States (van Mantgem et al. 2009). Two recent U.S. Forest Service Forest Inventory and Analysis (FIA) reports (one for CA and one for OR), each of which used thousands of plots, found that current large snag densities are harmfully low (generally only 1-3 per acre, and less than 1 per acre in eastern Oregon), and management activities should be undertaken to increase large snag densities to prevent harm to wildlife populations (Christensen et al. 2008, Donnegan et al. 2008).

Some recent anecdotal accounts of forest "destroyed" by, or "lost" to, bark beetles across 1.5 million acres of lodgepole pine forests in Colorado are highly misleading and inaccurate. In fact, the beetles only kill a portion of the trees, creating vitally-important snags that benefit wildlife; the largest area found to have 100% tree mortality is only one acre in size (Rocca and Romme 2009). The surviving trees dramatically increase their growth rates following beetle mortality (Romme et al. 1986). Conifer mortality from bark beetles – which are native species in these forests – is a natural and necessary ecological phenomenon that generally occurs every few decades, and which occurred at large scales in western U.S. conifer forests historically as well (Romme et al. 1986, Shinneman and Baker 1997). Prior to the arrival of settlers and the onset of fire suppression, such events were well documented to have occurred across entire landscapes, and were found to play an important role in the natural ecological succession of conifer species as stands matured and aged (Leiberg 1900a, 1904a, 1904b). The recent areas of tree mortality in the Rockies are neither unprecedented nor unnatural (Romme et al. 2006).

Given the overall deficit of large snags, and the serious adverse consequences of this for myriad wildlife species, natural events that create additional snags should be welcomed, not viewed as a problem to be avoided.

MYTH 8

High-intensity fire creates far more particulate emissions.

FACT 8

High-intensity fire burns cleaner, and produces fewer particulate emissions.

Contrary to popular assumption, high-intensity forest fires produce relatively lower particulate emissions (due to high efficiency of flaming combustion) while low-intensity forest fires produce high particulate emissions, due to the inefficiency of smoldering combustion (Ward and Hardy 1991, Reid et al. 2005). For a given ton of fuel consumed, low-severity fires produce 3-4 times more particulate matter than high-intensity fires (Ward and Hardy 1991, Reid et al. 2005).

MYTH 9

Western U.S. conifer forests are becoming carbon sources due to increased fire.

FACT 9

Western U.S. conifer forests are major carbon sinks, where logging has been reduced.

Despite some speculation that western U.S. conifer forests could become carbon sources (Westerling et al. 2006, van Mantgem et al. 2009), the empirical data show the opposite to be true. Studies using very large data sets (several thousand plots), found that western U.S. forests, and old growth forests, are functioning as net carbon sinks (net sequestration of carbon, thus reducing greenhouse gases) and are expected to continue to do so long into the future (Donnegan et al. 2008, Luyssaert et al. 2008). Oregon's forests, which were a substantial carbon source when logging levels on national forests were higher, are now a significant carbon sink (Turner et al. 2007). After accounting for emissions from wildland fire, net carbon sequestration in Oregon's forests is now so great, due to dramatically decreased logging levels on public lands, that it offsets 41% of the state's total emissions from fossil fuel burning (Turner et al. 2007). A recent study found that carbon sequestration would be maximized by ending all logging on U.S. public lands nationwide (Depro et al. 2008). In the continental United States, CO2 emissions from wildland fire are only about 5% of the amount resulting from human fossil fuel consumption, carbon sequestration from growth is about 25 times larger than carbon emissions from fire (Wiedinmyer and Neff 2007), and emissions from fire are offset by post-fire growth and carbon uptake. In a field-based study of four very large fires in two exceptionally large fire years (2002-2003) within the eastern Cascades of Oregon, researchers found that only 1-3% of the mass of living trees was consumed in the fires, and all four fires combined produced only about 2.5% of the statewide carbon emissions during the same two-year period (Meigs et al. 2009).

Fig. 12. Large surviving trees in a moderate/high-intensity patch wherein all small and medium-sized trees were killed.

Moreover, the increase in available nutrients following fire (Schlesinger 1997), particularly higher-intensity fire, can lead to substantial growth pulses (Brown and Swetnam 1994 [Fig. 3 of that study], Mutch and Swetnam 1995 [Fig. 4 of that study]), which results in carbon sequestration. This includes post-fire shrub growth, conifer regeneration, and growth release of surviving overstory trees. The shrub growth and conifer seedling/sapling regeneration alone – which are very vigorous in high-intensity patches (see, e.g., Hanson 2007b, Shatford et al. 2007) – can add many tons of sequestered carbon within just several years post-fire. In a comprehensive analysis of all fires over 15 years (1980-1995) in boreal forests in Canada and Alaska, it was determined that it took an average of only 9 years after fire for forests to once again become net carbon sinks (Hicke et al. 2003). Unlike boreal forests, in most other western U.S. conifer forests, high-intensity effects do not typically equate to 100% conifer mortality, and the largest several conifers per acre, which can comprise the majority of the carbon stocks, tend to survive in a given stand, in most cases. Relatively moderate post-fire growth increases (from nutrient cycling) in these large surviving overstory trees can increase carbon stocks rapidly, and will tend to reduce the time it takes for a postfire area to once again become a net carbon sink, relative to fires in which there is zero tree survival. The magnitude of this effect in mixed-conifer forests warrants careful study. Generally, the existing data indicate abundant natural conifer regeneration after high-intensity fire in western U.S. conifer forests (see, e.g., Hanson 2007b, Shatford et al. 2007).

Researchers recently found that the highest carbon sequestration levels were in forests that had previously experienced considerable occurrence of high-intensity fire (Keith et al. 2009). They concluded the following: “Fire can kill but not combust all of the material in trees, leading to much of the biomass carbon changing from the living biomass pool to the standing dead and fallen dead biomass pools… The dead biomass then decays as the stand grows… Slow decomposition rates can therefore result in large total carbon stocks of dead biomass and regrowing living biomass.” (Keith et al. 2009). The authors noted that the results of their study, which was conducted in Australia, are broadly applicable to other temperate forests globally, including U.S. conifer forests. Conversely, as forest stands become ancient, in the long absence of high-intensity fire effects, they can transition from carbon sinks (net carbon sequestration) to carbon sources (net carbon emission) after about 600 years of age (Luyssaert et al. 2008, S. Luyssaert 2009 pers. comm.).

MYTH 10

Forest "thinning" operations will increase carbon sequestration by reducing fire effects.

FACT 10

Commercial logging, including mechanical "thinning", reduces forest carbon storage.

One recent modeling study found that the areas with moderate/high-intensity wildland fire only (i.e., with no thinning), and areas with prescribed fire only, had greater overall carbon stocks over the course of a century than the forest thinning options (Hurteau and North 2009 [Fig. 1]). In addition, by the end of the century the moderate/high-intensity wildland fire scenario produces considerably fewer carbon emissions when compared to the thinning/prescribed-fire scenarios (about 38 tons C per ha [Fig. 1(a)] versus about 56 or 50 tons C per ha [Fig. 1(d) and (f)]; see also Fig. 2) (Hurteau and North 2009). It should also be noted that nearly half of the carbon from thinned trees becomes surface fuel and is burned, and another quarter is lost as mill residue, which is often burned as fuel (Ingerson 2007). Ultimately, only a minor portion of trees that are logged become wood products, and this carbon is not stored in this form for long, as softwood lumber has a half-life of less than 40 years (Smith et al. 2005), and is obviously not assimilated back into the forest ecosystem.

If Hurteau and North (2009) had used more realistic assumptions for their modeling, the difference between fire-only and thinning would have been even greater. For example, they assumed virtually no mortality from wildland fire in the mechanically thinned areas (Figs. 1(c) and 1(e)), while actual areas thinned similarly (i.e., removal of some mature trees as well as small trees) often tend to burn at moderate- and high-intensity, due to residual slash debris, increases in brush growth due to canopy cover reduction, and drying of surface fuels due to a reduction in the cooling shade created by the forest canopy (see, e.g., Hanson and Odion 2006, Platt et al. 2006). Conversely, Hurteau and North (2009) assumed unrealistically high mortality (moderate/high-intensity) in the fire-only area (Fig. 1(a)). Forests, even those that have not burned in several decades, are burning mostly at low and moderate intensity (Odion and Hanson 2008, Schwind 2008), not high intensity.

Another recent modeling study found that mechanical thinning, whether for wood products or biofuels, generally reduced overall carbon storage in forests relative to fire-only (Mitchell et al. 2009). The study concluded that thinning was not an effective way to maintain or increase carbon storage. Had this study taken into account post-fire growth increases due to nutrient cycling (as discussed above), the differences between fire-only and thinning would have been even greater. Further, this study assumed, unrealistically, that thinning consistently reduces fire intensity, which is inconsistent with the scientific data (Hanson and Odion 2006, Platt et al. 2006).

Further, even if we assume for the sake of argument that thinning will reduce potential fire intensity, Rhodes and Baker (2008) found that, due to post-thinning vegetation regrowth, as well as the extremely low rate of occurrence of high-intensity fire currently, an area would have to be mechanically thinned every 20 years for about 720 years to have a mere 50% chance of encountering high-intensity fire and reducing its intensity. Not only would the adverse impacts of such repeated thinning on soils, watersheds, and wildlife be profound, but such constant thinning would permanently suppress carbon storage levels.

MYTH 11

"Biomass" thinning is benign or beneficial in our forests; such thinning can reduce fire intensity and only removes some of the small trees.

FACT 11

Further reducing snag forest habitat created by high-intensity fire patches – habitat that is already in short supply – would be ecologically devastating to the many wildlife species dependent upon that habitat. Biomass logging also: a) reduces carbon sequestration; b) increasingly seeks to remove old-growth trees; c) is generally tied to larger timber sales; and d) tends to remove all or nearly all of the smaller trees, regardless of species.

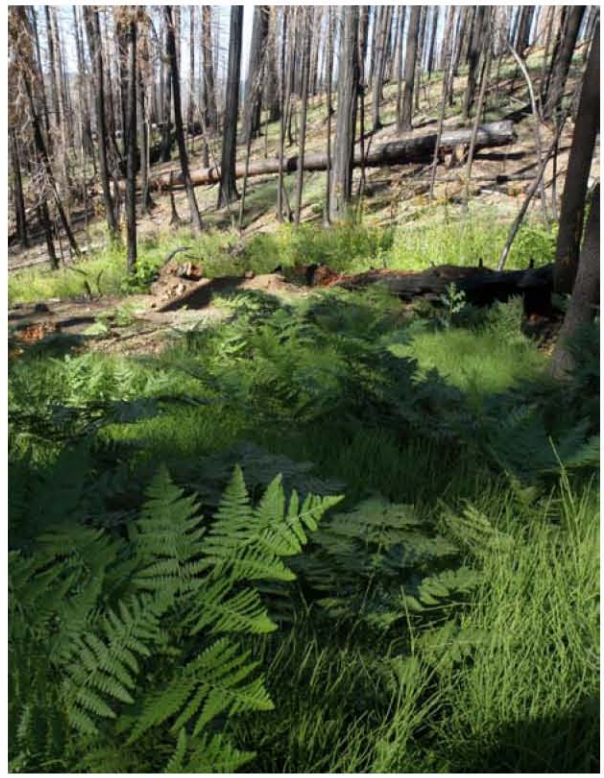

Fig. 13. Understory vegetation in a recent snag forest patch.

The living and dead plant material in a forest is called biomass. This includes everything from the small diameter branches, trees, and shrubs up to the old-growth trees. Today we are seeing increasing aggressive calls – mostly from the timber industry and their political allies – to remove biomass from the forest ostensibly to reduce fire effects. This biomass logging removes trees from the forest to be burned in energy production facilities. However, as discussed above, we remain in a major fire deficit, and snag forest habitat, created by patches of high-intensity wildland fire, is one of the rarest and most endangered habitat types in western U.S. conifer forests; and it is also one of the most ecologically important and biodiverse forest habitat types. Forest management policies designed to further reduce this imperiled habitat would further exacerbate its current deficit, which is already critical. At present, many snag forest wildlife species have been federally listed in one or more regions as "Sensitive Species" or "Species at Risk" – meaning there is a significant concern about the viability of their populations – due to lack of habitat, greatly reduced populations, and/or declining populations. Such species include the Black-backed Woodpecker, the Olive-sided Flycatcher, and the Sierra Nevada Snowshoe Hare. Further degrading and reducing the habitat for such species would create a risk of extinction.

Biomass logging proponents also claim that this type of thinning should be used to maintain or increase carbon sequestration, supposedly by reducing fire effects. However, as discussed above, thinning does not maintain or increase carbon sequestration. The scientific evidence shows that thinning reduces overall carbon sequestration, and increases carbon emissions, relative to areas experiencing wildland fire and no thinning; and carbon sequestration is maximized by halting logging completely.

Though timber interests have promoted increased logging by describing current forests as "overstocked", the scientific data indicates that, due to past logging, as well as exclusion of wildland fire, forests of today have much less biomass than historic forests (Bouldin 1999, Fellows and Goulden 2008). Carbon sequestration is maximized where logging is absent and wildland fire is present (Turner et al. 2007, Depro et al. 2008, Keith et al. 2009). Peak biomass levels have been found in areas that have experienced high-intensity wildland fire – the total biomass being comprised of the fire-killed trees and downed logs, as well as the regenerating post-fire stand of trees (Keith et al. 2009). Small diameter trees and downed woody material on the forest floor play a key role in maintaining forest productivity, and carbon stocks, because this woody material is most easily combusted in a wildland fire, creating a rich supply of available nutrients in the ash (Schlesinger 1997). For this reason, biomass thinning not only reduces carbon sequestration in the short-term, it also diminishes the forest's productive capacity, and carbon sequestration potential, in the longer-term.

Moreover, typically biomass logging is just one portion of larger timber sales. First the larger trees are removed for lumber, then the smaller trees are removed as biomass for energy production; thus biomass logging and logging of mature trees are inextricably linked. Small trees are not merely "thinned". Rather, nearly all of the small trees, including pines and oaks, are removed, eliminating an entire forest regeneration cohort. Moreover, the U.S. Forest Service and private timberland owners are increasingly proposing large post-fire salvage logging projects for biomass production, especially when the lumber market is weak. Entire snag forest ecosystems could be wiped out to produce kilowatts. Further, there have been a growing number of accounts of old-growth trees being proposed for biomass logging. For example, the 2008 Flea project on the west side of the Plumas National Forest proposed removal of old-growth hardwoods up to 30 inches in diameter (over 8 feet in girth) for biomass energy production; and hundreds of acres of old-growth juniper were clearcut in 2008 on U.S. Bureau of Land Management lands in northeastern California to supply a biomass plant near Susanville (Tom Knudson, Sacramento Bee, Sept. 21, 2008).

Further, due to clear carbon accounting errors that ignore emissions from biofuel logging, as well as due to perverse economic incentives favoring biofuel production in climate legislation/rules, recent evidence published in Science indicates that, unless the faulty system is changed, the majority of the world's natural forests could be displaced for biofuel production, releasing as much greenhouse gas as is currently emitted from global fossil fuel consumption (Searchinger et al. 2009). Alarmingly, due to these carbon accounting errors and perverse incentives, this massive loss and degradation of natural forests, and the resulting doubling of current greenhouse gas emissions, would be mistakenly assessed as a 50% "cut" in greenhouse gas emissions – a dangerous fiction that threatens the world's forest ecosystems (Searchinger et al. 2009).

Summary: For Ecologically "Healthy Forests", We Need More Fire and Dead Trees, Not Less.

In light of the foregoing, the term "catastrophic wildfire" is not scientifically credible; rather, it is a term based upon misinformation, as well as cultural fears and misconceptions about fire. There is a major deficiency of wildland fire – including high-intensity fire – and large snags in conifer forests. Yet forest management is still bent upon suppressing fire, reducing snag densities, and eliminating post-fire habitat, which is greatly worsening the current deficits. If this management pattern continues, it could threaten populations of numerous native wildlife species, many of which are already rare and/or declining (Hutto 1995, Altman and Sallabanks 2000, Hutto 2006, Hutto 2008, Hanson and North 2008). Current forest management direction continues to be disconnected from the current scientific data, and remains heavily focused on mechanical thinning projects ostensibly to reduce future tree mortality from competition and wildland fire. This situation is made worse by management direction under the "Healthy Forests Initiative" on public lands, which makes the scientifically-outdated assumption that wildland fire and snag densities should be further reduced, and recommends logging operations to accomplish its stated goals. Current forest management also remains focused on post-fire "salvage" logging. Scientifically, however, there is probably no forest management activity more clearly and profoundly destructive to wildlife and biodiversity than post-fire "salvage" logging. Hutto (2006) concluded the following: "The ecological cost of salvage logging speaks for itself, and the message is powerful. I am hard pressed to find any other example in wildlife biology where the effect of a particular land-use activity is as close to 100% negative as the typical postfire salvage-logging operation tends to be." Lindenmayer et al. (2004), writing in the journal Science, observed that, "…[post-fire] salvage harvesting removes critical habitat for species, such as cavity-nesting mammals, woodpeckers, invertebrates like highly specialized beetle taxa that depend on burned wood, and bryoflora closely associated with recently charred logs…" Hutto and Gallo (2006) found a major adverse impact to the cavity-nesting bird community as a result of post-fire logging. In response to legislation proposed in Congress that would expedite post-fire logging on national forest lands, nearly 600 of the nation's top scientists signed a letter of objection, dated August 1, 2006. The scientists wrote the following: "When we, as scientists, see policies being developed that run counter to the lessons of science, we feel compelled to speak up. Proposed post-disturbance legislation… crafted as a response to recent fires and other disturbances, is misguided because it distorts or ignores recent scientific advances. Under the labels of 'recovery' and 'restoration', these bills would speed up logging and replanting after natural disturbances… such activity would actually slow the natural recovery of forests and of streams and the creatures within them… no substantive evidence supports the idea that fire-adapted forests might be improved by logging after a fire."

Based upon the scientific evidence summarized above, a new ecological paradigm has emerged – one that recognizes: a) historic conifer forests generally had a mix of low-, moderate-, and high-intensity effects; b) current forests have an unhealthy deficiency in wildland fire and large snags; and c) forest management activities should be undertaken to increase occurrence of mixed-intensity wildland fire and increase the density of large dead trees in order to maintain ecologically healthy forests.

Of course, as the new forest ecology paradigm is increasingly reflected in actual forest management policies in the coming years, it is important to ensure that homes are adequately protected. Resources must be focused on creating defensible space within 100 feet of homes in forested areas, and reducing the combustibility of the homes themselves. So-called "fuels reduction" projects far from homes are diverting important resources from home protection, and are creating a false sense of security in forested communities. By focusing our attention on ensuring public safety, we can also facilitate the restoration of the natural role of wildland fire in our forest ecosystems.

Those who benefit from the perpetuation of the "catastrophic wildfire" myth – chiefly the timber industry and their Congressional allies, as well as the federal land management agencies that pad their budgets through timber sale revenue – seek to convince the public that we need to fear the effects of fire in our forests. They would have us continue to spend billions of dollars not only subsidizing logging projects across millions of acres of mature and old-growth forest on public lands, but also funding increasingly aggressive fire suppression policies, while weakening federal environmental laws to expedite such programs. Fire-dependent wildlife species would be put at a growing risk of extinction.

The emerging forest ecology paradigm, in contrast, does not require these costly and destructive programs. It recognizes that wildland fire is doing important and beneficial ecological work in our forests. Moreover, within the forest ecology paradigm, policies are focused on ensuring that rural human communities adapt to wildland fire so that homes are protected. Both our forests and our communities will be healthier for the change.

References

Altman, B., and R. Sallabanks. 2000. Olive-sided flycatcher (Contopus cooperi). In A. Poole and F. Gill, editors. The birds of North America, number 502. The Birds of North America, Philadelphia, Pennsylvania, USA.

Baker, W. L. 2009. Fire ecology in Rocky Mountain landscapes. Island Press, Oxford.

Baker, W. L., and D. S. Ehle, 2001. Uncertainty in surface-fire history: the case of ponderosa pine forests in the western United States. Canadian Journal of Forest Research **31**: 1205-1226.

Baker, W.L. 2006. Fire history in ponderosa pine landscapes of Grand Canyon National Park: is it reliable enough for management and restoration? International Journal of Wildland Fire **15**: 433-437.

Baker, W. L., T. T. Veblen, and R. L. Sherriff. 2007. Fire, fuels and restoration of ponderosa pine-Douglas fir forests in the Rocky Mountains, USA. Journal of Biogeography **34**: 251-269.

Beaty, R.M., and A.H. Taylor. 2001. Spatial and temporal variation of fire regimes in a mixed conifer forest landscape, Southern Cascades, USA. Journal of Biogeography **28**: 955-966.

Bekker, M.F., and A.H. Taylor. 2001. Gradient analysis of fire regimes in montane forests of the southern Cascade range, Thousand Lakes Wilderness, California, USA. Plant Ecology 155: 15-28.

Bock, C.E. and J.F. Lynch. 1970. Breeding bird populations of burned and unburned conifer forest in the Sierra Nevada. Condor **72**: 182-189.

Bond, M.L., D.E. Lee, R.B. Siegel, and J.P. Ward. 2009. Habitat use and selection by California Spotted Owls in a postfire landscape. Journal of Wildlife Management 73: 1116-1124.

Bouldin, J. 1999. Twentieth-century changes in forests of the Sierra Nevada, California. Davis, CA: University of California: Ph.D. dissertation.

Brown, P.M., and T.W. Swetnam. 1994. A cross-dated fire history from coast redwood near Redwood National Park, California. Canadian Journal of Forest Research **24**: 21-31.

Chang, C. 1996. Ecosystem responses to fire and variations in fire regimes. Pages 1071-1099 in Sierra Nevada Ecosystem Project, Final Report to Congress, Volume II. University of California at Davis, Centers for Water and Wildland Resources.

Christensen, G.A., S.J. Campbell, and J.S. Fried, tech eds. 2008. California's forest resources, 2001-2005: five-year Forest Inventory and Analysis report. Gen. Tech. Rep. PNW-GTR-763. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 183 p.

Clark, D.A. 2007. Demography and habitat selection of northern spotted owls in post-fire landscapes of southwestern Oregon. Masters Thesis, Oregon State University.

Collins, B.M., J.D. Miller, A.E. Thode, M. Kelly, J.W. van Wagtendonk, and S.L. Stephens. 2009. Interactions among wildland fires in a long-established Sierra Nevada natural fire area. Ecosystems. doi: 10.1007/s10021-008-9211-7.

Depro, B.M, B.C. Murray, R.J. Alig, and A. Shanks. 2008. Public land, timber harvests, and climate mitigation: Quantifying carbon sequestration potential on U.S. public timberlands. Forest Ecology and Management **255**: 1122-1134.

Donato, D.C., J.B. Fontaine, J.L. Campbell, W.D. Robinson, J.B. Kauffman, and B.E. Law. 2006. Post-wildfire logging hinders regeneration and increases fire risk. Science **311**: 352.

Donnegan, J., S. Campbell, and D. Azuma, tech eds. 2008. Oregon's forest resources, 2001-2005: five-year Forest Inventory and Analysis report. Gen. Tech. Rep. PNW-GTR-765. Portland, OR: U.S. Forest Service, Pacific Northwest Research Station. 186 p.

Fellows, A., and M. Goulden. 2008. Has fire suppression increased the amount of carbon stored in western U.S. forests? Geophysical Research Letters **35**: L12404.

Franklin, A.B., D.R. Anderson, R.J. Gutierrez, and K.P. Burnham. 2000. Climate, habitat quality, and fitness in northern spotted owl populations in northwestern California. Ecological Monographs **70**: 539-590.

Gavin, D.G., et al. 2007. Forest fire and climate change in western North America: insights from sediment charcoal records. Frontiers in Ecology and Environment **5**: 499-506.

Girardin, M.P., et al. 2009. Heterogeneous response of circumboreal wildfire risk to climate change since the early 1900s. Global Change Biology 15: 2751-2769.

Hanson, C.T. 2007a. Post-fire management of snag forest habitat in the Sierra Nevada. Ph.D. dissertation, University of California at Davis. Davis, CA.

Hanson, C.T. 2007b. Expert Report. United States v. Union Pacific Railroad Company, No. 2:06-CV-01740 FCD/KJM.

Hanson, C.T. , D.C. Odion, D.A. DellaSala, and W.L. Baker. 2009. Overestimation of fire risk in the Northern Spotted Owl Recovery Plan. Conservation Biology 23: 1314-1319.

Hanson, C.T., Odion, D.C. 2006. Fire Severity in mechanically thinned versus unthinned forests of the Sierra Nevada, California. In: Proceedings of the 3rd International Fire Ecology and Management Congress, November 13-17, 2006, San Diego, CA.

Hanson, C.T., and M.P. North. 2008. Postfire woodpecker foraging in salvage-logged and unlogged forests of the Sierra Nevada. The Condor **110**: 777-782.

Hessburg, P. F., R. B. Salter, and K. M. James. 2007. Re-examining fire severity relations in pre-management era mixed-conifer forests: inferences from landscape patterns of forest structure. Landscape Ecology **22**: 5-24.

Hicke, J.A., G.P. Asner, E.S. Kasischke, N.H.F. French, J.T. Randerson, G.J. Collatz, B.J. Stocks, C.J. Tucker, S.O. Los, and C.B. Field. 2003. Postfire response of North American boreal forest net primary productivity analyzed with satellite observations. Globall Change Biology 9: 1145-1157.

Hurteau, M., and M. North. 2009. Fuel treatment effects on tree-based forest carbon storage and emissions under modeled wildfire scenarios. Frontiers in Ecology and Environment **7**: 409-414

Hutto, R.L. 1995. Composition of bird communities following stand-replacement fires in northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9: 1041-1058.

Hutto, R.L. 2006. Toward meaningful snag-management guidelines for postfire salvage logging in North American conifer forests. Conservation Biology **20**: 984-993.

Hutto, R.L., and S.M. Gallo. 2006. The effects of postfire salvage logging on cavity-nesting birds. The Condor **108**: 817-831.

Hutto, R.L. 2008. The ecological importance of severe wildfires: some like it hot. Ecological Applications 18: 1827-1834.

Ingerson, A. 2007. U.S. forest carbon and climate change. The Wilderness Society, Washington, D.C.

Keith, H., B.G. Mackey, and D.B. Lindenmayer. 2009. Re-evaluation of forest biomass carbon stocks and lessons from the world's most carbon-dense forests. Proceedings of the National Academy of Sciences **106**: 11635-11640.

Kotliar, N.B., and J.A. Wiens. 1990. Multiple scales of patchiness and patch structure: a hierarchical framework for the study of heterogeneity. Oikos 59: 253-260.

Kotliar, N.B., S.J. Hejl, R.L. Hutto, V.A. Saab, C.P. Melcher, and M.E. McFadzen. 2002. Effects of fire and post-fire salvage logging on avian communities in conifer-dominated forests of the western United States. Studies in Avian Biology 25: 49-64.

Kotliar, N.B., P.L. Kennedy, and K. Ferree. 2007. Avifaunal responses to fire in southwestern montane forests along a burn severity gradient. Ecological Applications 17: 491-507. Krawchuk, M.A., M.A. Moritz, M. Parisien, J. Van Dorn, and K. Hayhoe. 2009. Global pyrogeography: the current and future distribution of wildfire. PloS ONE 4: e5102.

Klenner, W., R. Walton, A. Arsenault, and L. Kremsater. 2008. Dry forests in the southern interior of British Columbia: historic disturbances and implications for restoration and management. Forest Ecology and Management **256**: 1711-1722.

Leiberg, J.B. 1900a. Bitterroot Forest Reserve. In: 20th Annual Report of the U.S. Geological Survey, Part V. Government Printing Office, Washington, D.C.

Leiberg, J.B. 1900b. Cascade Range Forest Reserve, Oregon, from township 28 south to township 37 south, inclusive; together with the Ashland Forest Reserve and adjacent forest regions from township 28 south to township 41 south, inclusive, and from range 2 west to range 14 east, Willamette Meridian, inclusive. In: 21st Annual Report of the U.S. Geological Survey, Part V. Government Printing Office, Washington, D.C.

Leiberg, J.B. 1902. Forest conditions in the northern Sierra Nevada, California. U.S. Geological Survey, Professional Paper No. 8. Government Printing Office, Washington, D.C.

Leiberg, J.B. 1904a. Forest conditions in the Absaroka Division of the Yellowstone Forest Reserve, Montana and the Livingston and Big Timber Quadrangles. U.S. Geological Survey, Professional Paper No. 29. Government Printing Office, Washington, D.C.

Leiberg, J.B. 1904b. Forest conditions in the Little Belt Mountains Forest Reserve, Montana, and the Little Belt Mountains Quadrangle. U.S. Geological Survey, Professional Paper No. 30. Government Printing Office, Washington, D.C.

Lindenmayer, D.B., and J.F. Franklin. 2002. Conserving forest biodiversity. Washington, DC: Island Press.

Lindenmayer, D.B., D.R. Foster, J.F. Franklin, M.L. Hunter, R.F. Noss, F.A. Schmiegelow, and D. Perry. 2004. Salvage harvesting policies after natural disturbance. Science **303**: 1303.

Lutz, J.A., J.W. van Wagtendonk, A.E. Thode, J.D. Miller, and J.F. Franklin. 2009. Climate, lightning ignitions, and fire severity in Yosemite National Park, California, USA. International Journal of Wildland Fire **18**: 765-774.

Luyssaert, S., E. –Detlef Schulze, A. Borner, A. Knohl, D. Hessenmoller, B.E. Law, P. Ciais, and J. Grace. 2008. Old-growth forests as global carbon sinks. Nature **455**: 213-215.

Martinson, E.J., and P.N. Omi. 2003. Performance of fuel treatments subjected to wildfires. USDA Forest Service Proceedings RMRS-P-29.

McKenzie, D., Z. Gedalof, D.L. Peterson, and P. Mote. 2004. Climatic change, wildfire, and conservation. Conservation Biology 18: 890-902.

Medler, M. (abstract), 3rd International Fire Ecology & Management Congress (http://emmps.wsu.edu/firecongress), San Diego, CA, USA, November 13-17, 2006.

Meigs, G.W., D.C. Donato, J.L. Campbell, J.G. Martin, and B.E. Law. 2009. Forest fire impacts on carbon uptake, storage, and emission: the role of burn severity in the eastern Cascades, Oregon. Ecosystems 12: 1246-1267.

Miller, J.D., H.D. Safford, M. Crimmins, and A.E. Thode. 2008. Quantitative evidence for increasing forest fire severity in the Sierra Nevada and southern Cascade Mountains, California and Nevada, USA. Ecosystems. doi: 10.1007/s10021-008-9201-9.

Minnich, R. A., M. G. Barbour, J. H. Burk & J. Sosa-Ramirez, 2000. Californian mixed-conifer forests under unmanaged fire regimes in the Sierra San Pedro Martir, Baja California, Mexico. Journal of Biogeography 27: 105-129.

Mitchell, S.R., M.E. Harmon, and K.E.B.O. O'Connell. 2009. Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems. Ecological Applications **19**: 642-655.

Moeur, M., T.A. Spies, M. Hemstrom, J.R. Martin, J. Alegria, J. Browning, J. Cissel, W.B. Cohen, T.E. Demeo, S. Healey, and R. Warbington. 2005. Status and trend of late-successional and old-growth forest. USDA Forest Service General Technical Report PNW-GTR-646, Pacific Northwest Research Station, Portland, OR.

Morrison, P.H., and F.J. Swanson. 1990. Fire history and pattern in a Cascade Range landscape. Gen. Tech. Rep. PNW-GTR-254. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 77 p.

Mote, P.W. 2003. Trends in temperature and precipitation in the Pacific Northwest during the twentieth century. Northwest Science 77: 271-282.

Mutch, L.S., and T.W. Swetnam. 1995. Effects of fire severity and climate on ring-width growth of Giant Sequoia after burning. In: Brown, J.K., R.W. Mutch, C.W. Spoon, and R.H. Wakimoto, tech. coords. 1995. Proceedings: symposium on fire in wilderness and park management, March 30-April 1, 1993, Missoula, MT. Gen. Tech. Rep. INT-GTR-320. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Nagel, T.A., and A.H. Taylor. 2005. Fire and persistence of montane chaparral in mixed conifer forest landscapes in the northern Sierra Nevada, Lake Tahoe Basin, California, USA. Journal of the Torrey Botanical Society **132**: 442-457.

Noss, R.F., J.F. Franklin, W.L. Baker, T. Schoennagel, P.B. Moyle. 2006. Managing fire-prone forests in the western United States. Frontiers in Ecology and Environment **4**: 481-487.

Odion, D.C., E.J. Frost, J.R. Strittholt, H. Jiang, D.A. DellaSala, and M.A. Moritz. 2004. Patterns of fire severity and forest conditions in the Klamath Mountains, northwestern California. Conservation Biology **18**: 927-936.

Odion, D.C., and C.T. Hanson. 2006. Fire severity in conifer forests of the Sierra Nevada, California. Ecosystems **9**: 1177-1189.

Odion, D.C., and C.T. Hanson. 2008. Fire severity in the Sierra Nevada revisited: conclusions robust to further analysis. Ecosystems **11**: 12-15.

Odion, D. C., M. A. Moritz, and D. A. DellaSala. 2009. Alternative community states maintained by fire in the Klamath Mountains, USA. Journal of Ecology, doi: 10.1111/j.1365-2745.2009.01597.x.

Olson, G.S., E.M. Glenn, R.G. Anthony, E.D. Forsman, J.A. Reid, P.J. Loschl, and W.J. Ripple. 2004. Modeling demographic performance of northern spotted owls relative to forest habitat in Oregon. Journal of Wildlife Management **68**: 1039-1053.

Omi, P.N., and E.J. Martinson. 2002. Effects of fuels treatment on wildfire severity. Final report. Joint Fire Science Program Governing Board, Western Forest Fire Research Center, Colorado State University, Fort Collins, CO. Available from http://www.cnr.colostate.edu/frws/research/westfire/finalreport.pdf .

Parisien, M., and M.A. Moritz. 2009. Environmental controls on the distribution of wildfire at multiple spatial scales. Ecological Monographs **79**: 127-154.

Pierce, J. L., G. A. Meyer, and A. J. T. Jull. 2004. Fire-induced erosion and millennial-scale climate change in northern ponderosa pine forests. Nature **432**: 87-90.

Platt, R.V., Veblen, T.T., and R.L. Sheriff. 2006. Mapping the compatibility of wildfire mitigation and ecological restoration in the wildland-urban interface of Colorado. Annals of the Association of American Geographers **96**: 455-470.

Reid, J.S., R. Koppmann, T.F. Eck, and D.P. Eleuterio. 2005. A review of biomass burning emissions part II: intensive physical properties of biomass burning particles. Atmospheric Chemistry and Physics **5**: 799-825.

Rhodes, J.J., and W.L. Baker. 2008. Fire probability, fuel treatment effectiveness and ecological tradeoffs in western U.S. public forests. The Open Forest Science Journal **1**: 1-7.

Robertson, B.A., and R.L. Hutto. 2007. Is selectively harvested forest an ecological trap for Olive-sided Flycatchers? The Condor **109**: 109-121.

Rocca, M.E. 2004. Spatial considerations in fire management: the importance of heterogeneity for maintaining diversity in a mixed-conifer forest. Ph.D. diss., Duke University, Durham, NC, USA.

Rocca, M.E., and W.H. Romme. 2009. Beetle-infested forests are not "destroyed". Frontiers in Ecology and Environment doi: **10.1890/09.WB.002**.

Romme, W.H., D.H. Knight, and J.B. Yavitt. 1986. Mountain pine beetle outbreaks in the Rocky Mountains: regulators of primary productivity? The American Naturalist **127**: 484-494.

Romme, W.H., J. Clement, J. Hicke, D. Kulakowski, L.H. MacDonald, T.L. Schoennagel, and T.T. Veblen. 2006. Recent forest insect outbreaks and fire risk in Colorado forests: a brief synthesis of relevant research. Colorado Forest Restoration Institute, Colorado State University. Fort Collins, Colorado.

Russell, W.H., J. McBride, and R. Rowntree. 1998. Revegetation after four stand-replacing fires in the Tahoe Basin. Madrono **45**: 40-46.

Russell, R.E., V.A. Saab, and J.G. Dudley. 2007. Habitat-suitability models for cavity-nesting birds in a postfire landscape. Journal of Wildlife Management **71**: 2600-2611.

Saab, V.A., R. Brannon, J. Dudley, L. Donohoo, D. Vanderzanden, V. Johnson, and H. Lachowski. 2002. Selection of fire-created snags at two spatial scales by cavity-nesting birds. Pages 835-848 in P.J. Shea, W.F. Laudenslayer Jr., B. Valentine, C.P. Weatherspoon, and T.E. Lisle (eds.), Proceedings of the symposium on the ecology and management of dead wood in western forests, November 2-4, 1999, Reno, Nevada. U.S. Forest Service, General Technical Report PSW-GTR-181. Saab, V.A., J. Dudley, and W.L. Thompson. 2004. Factors influencing occupancy of nest cavities in recently burned forests. The Condor **106**: 20-36.

Saab, V. A., R. E. Russell, and J. G. Dudley. 2007. Nest densities of cavity-nesting birds in relation to postfire salvage logging and time since wildfire. The Condor **109**:97-108.

Schlesinger, W.H. 1997. Biogeochemistry: An analysis of global change. Second edition. Academic Press, New York, NY.

Schoennagel, T., C.R. Nelson, D.M. Theobald, G.C. Carnwath, and T.B. Chapman. 2009. Implementation of National Fire Plan treatments near the wildland-urban interface in the western United States. Proceedings of the National Academy of Sciences doi: 10.1073/pnas.0900991106.

Schwind, B. 2008. Monitoring trends in burn severity: report on the Pacific Northwest and Pacific Southwest fires (1984 to 2005). Online at: http://www.mtbs.gov/projectreports.htm.

Searchinger, T.D., et al. 2009. Fixing a critical climate accounting error. Science **326**: 527-528.

Shatford, J.P.A., D.E. Hibbs, and K.J. Puettmann. 2007. Conifer regeneration after forest fire in the Klamath-Siskiyous: how much, how soon? Journal of Forestry April/May 2007, pp. 139-146.

Shinneman, D.J., and W.L. Baker. 1997. Nonequilibrium dynamics between catastrophic disturbances and old-growth forests in ponderosa pine landscapes of the Black Hills. Conservation Biology **11**: 1276-1288.

Siegel, R.B, and R.L. Wilkerson. 2005. Short- and long-term effects of stand-replacing fire on a Sierra Nevada bird community. Final report for the 2004 field season. The Institute for Bird Populations. Point Reyes Station, California.

Smith, J.K., ed. 2000. Wildland fire in ecosystems: effects on fire on fauna. U.S. Forest Service General Technical Report RMRS-GTR-42. Volume 1. U.S. Forest Service, Rocky Mountain Research Station, Missoula, MT, USA, 83 p.

Smith, J.E., L.S. Heath, K.E. Skog, and R.A. Birdsey. 2005. Methods for calculating forest ecosytem and harvested carbon with standard estimates for forest types of the United States. Northeast Gen. Tech. Rep. 34, United States Forest Service, Washington, D.C.

Smucker, K.M., R.L. Hutto, and B.M. Steele. 2005. Changes in bird abundance after wildfire: importance of fire severity and time since fire. Ecological Applications ***15***: 1535-1549.

Spracklen, D.V., L.J. Mickley, J.A. Logan, R.C. Hudman, R. Yevich, M.D. Flannigan, and A.L. Westerling. 2009. Impacts of climate change from 2000 to 2050 on wildfire activity and carbonaceous aerosol concentrations in the western United States. Journal of Geophysical Research **114**: D20301, doi: 10.1029/2008JD010966, 2009.

Stephens, S.L., R.E. Martin, and N.E. Clinton. 2007. Prehistoric fire area and emissions from California's forests, woodlands, shrublands, and grasslands. Forest Ecology and Management **251**: 205-216.

Stephenson, N.L., D.J. Parsons, and T.W. Swetnam. 1991. Restoring natural fire to the Sequoia-mixed conifer forest: should intense fire play a role. Pages 321-337 in Proceedings of the 17th Tall Timbers Fire Ecology Conference, May 18-21, 1989. Tall Timbers Research Station, Tallahassee, Florida.

Strom, B.A., and P.Z. Fule. 2007. Pre-wildfire fuel treatments affect long-term ponderosa pine forest dynamics. International Journal of Wildland Fire **16**: 128-138.

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Taylor, A.H. 2002. Evidence for pre-suppression high severity fire on mixed conifer forests on the West Shore of Lake Tahoe Basin. Final report, USDA Forest Service, Lake Tahoe Basin Management Unit.

Taylor, A.H., and C.N. Skinner. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. Forest Ecology and Management **111**: 285-301.

Turner, D.P., W.D. Ritts, B.E. Law, W.B. Cohen, Z. Yang, T. Hudiberg, J.L. Campbell, and M. Duane. 2007. Scaling net ecosystem production and net biome production over a heterogeneous region in the western United States. Biogeosciences Discussions **4**: 1093-1135.

USDA. 2001. Sierra Nevada Forest Plan Amendment, Final Environmental Impact Statement, Volume 3. U.S. Forest Service, Regional Office, Vallejo, CA.

USDA. 2004. Sierra Nevada Forest Plan Amendment, Supplemental Final Environmental Impact Statement. U.S. Forest Service, Regional Office, Vallejo, CA.

van Mantgem, P.J., et al. 2009. Widespread increase of tree mortality rates in the western United States. Science **323**: 521-524.

Verner, J., K, S. McKelvey, B. R. Noon, R. J. Gutiérrez, G. I Gould, Jr., and T. W. Beck, Technical Coordinators. 1992. The California spotted owl: a technical assessment of its current status. Gen Tech. Rep. PSW-GTR-133. Albany, CA. Pacific Southwest Research Station. Forest Service, U. S. Department of Agriculture.

Vierling, K. T., L. B. Lentile, and N. Nielsen-Pincus. 2008. Preburn characteristics and woodpecker use of burned conifer forests. Journal of Wildlife Management **72**: 422-427.

Ward, D.E., and C.C. Hardy. 1991. Smoke emissions from wildland fires. Environment International **17**: 117-134.

Wardle, D.A., L.R. Walker, and R.D. Bardgett. 2004. Ecosystem properties and forest decline in contrasting long-term chronosequences. Science **305**: 509-513.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increases western US forest wildfire activity. Science **313**: 940-943.

Whitlock, C., J. Marlon, C. Briles, A. Brunelle, C. Long, and P. Bartlein. 2008. Long-term relations among fire, fuel, and climate in the north-western US based on lake-sediment studies. International Journal of Wildland Fire **17**: 72-83.

Wiedinmyer, C., and J.C. Neff. 2007. Estimates of CO2 from fires in the United States: implications for carbon management. Carbon Balance and Management **2**: 10.

Wills, R.D., and J.D. Stuart. 1994. Fire history and stand development of a Douglas-fir/hardwood forest in northern California. Northwest Science **68**: 205-212.

WRCC. 2009. Western Regional Climate Center (www.wrcc.dri.edu/). Data accessed 10/18/09.

Wu, J., and O.L. Loucks. 1995. From balance of nature to hierarchical patch dynamics: a paradigm shift in ecology. The Quarterly Review of Biology **70**: 439-466.

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About the Author

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