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Forest and Wildland Fire Science Synthesis

SUMMARY:

There is a substantial disconnect between what the public believes about fire in our forests and the current state of scientific knowledge. Contrary to common assumptions: **A)** mixed-intensity fire was the dominant fire regime historically in mixed-conifer and ponderosa pine forests; **B)** current fires are mostly low- and moderate-intensity, and fire intensity is not increasing currently in the great majority of western U.S. forests; **C)** high-intensity fire patches (wherein most or all trees are killed), both small and large, were a substantial component of natural fire regimes in these forests historically, and many wildlife species have evolved over millennia to depend upon the habitat created by such fire; **D)** high-intensity fire patches, especially larger patches, create "snag forest habitat", which is rarer than old-growth forest and often has the highest biodiversity of any forest type; it is rich in habitat structures, including "snags" (standing dead trees), which provide homes for cavity-nesting birds and food for woodpeckers (which feed on the larvae of native beetles, which depend upon snags), downed logs (good habitat for small mammals, reptiles, and salamanders), dense pockets of natural conifer regeneration (habitat for mammals and birds), and flowering shrubs that germinate after fire, attracting native flying insects, which in turn provide food for both birds and bats; **E)** there is substantially less high-intensity fire now than there was historically, prior to fire suppression policies, and this post-fire habitat deficit is worsened by extensive post-fire clearcutting on national forests and private lands, and by landscape-level mechanical "thinning" designed to further suppress fire, making snag forest habitat the most endangered forest habitat type in the U.S.; **F)** wildlife species that depend upon snag forest habitat, like the Black-backed Woodpecker and Buff-breasted Flycatcher, are threatened with extinction in the U.S. due to continued fire suppression, thinning, and post-fire logging; **G)** high-intensity fire patches naturally regenerate conifer forests, and do not require artificial replanting; **H)** high-intensity fire patches generally have the highest carbon storage levels, due to the combination of the standing fire-killed trees and downed logs, and the abundant natural post-fire regrowth of conifers and shrubs; **I)** the bark beetles that occasionally kill individual trees, or patches of trees, in unburned forests are native species, and keep forests ecologically healthy by providing "snags" for wildlife; and forests with the highest densities of snags do not burn more intensely; **J)** the only effective way to protect homes from fires is to thin brush and small trees within 100-200 feet from individual homes, and to take simple measures to reduce flammability of the homes themselves; current fire suppression and thinning policies are ineffective and counter-productive because they focus on remote wildlands, divert scarce resources away from homes, and also put firefighters unnecessarily at risk fighting ecologically beneficial fires in remote areas.

<u>Mixed-intensity Fire, Including Patches of High-Intensity Fire, Is Natural</u>:

Mixed-intensity fire is not limited to true fir and lodgepole pine; mixed-intensity fire, including a significant proportion of high-intensity fire and occasional large high-intensity fire patches hundreds or thousands of acres in size, is also a natural condition in ponderosa-pine/Jeffrey-pine and mixed-conifer forest, and generally dominated pre-fire suppression fire regimes historically in these forest types.

Baker, W.L. 2012. Implications of spatially extensive historical data from surveys for restoring dry forests of Oregon's eastern Cascades. Ecosphere 3(3): article 23. *(In dry mixed-conifer forests of the eastside of the southern Cascades, historic fire was 24% low-intensity, 50% mixed-intensity, and 26% high-intensity [Table 5].)*

Baker, W.L. 2014. Historical forest structure and fire in Sierran mixed-conifer forests reconstructed from General Land Office survey data. Ecosphere 5: Article 79. *(Using an enormous U.S. government field survey data set from the 1800s, it was determined that historical ponderosa pine and mixed-conifer forests of the Sierra Nevada were much denser than previously assumed, and were dominated by mixed-intensity fire, while 13-26% were open forests with low-intensity fire. These forests were highly variable in species composition too, historically, with many areas dominated by fir/cedar forests, and others dominated by pine, but with substantial fir/cedar components. High-intensity fire comprised 31-39% of fire effects historically, and high-intensity fire patches hundreds of acres in size were common, with some high-intensity fire patches reaching over 20,000 acres in size. High-intensity fire in historical forests occurred on average about every three centuries, which is much more frequent than the rate of high-intensity fire in these forests currently.*

Baker, W.L., T.T. Veblen, and Sherriff, R.L. 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. *(On the western slope of the southern Cascades in California, historic fire intensity in mixed-conifer forests was predominantly moderate- and high-intensity, except in mesic canyon bottoms, where moderate- and high-intensity fire comprised 40.4% of fire effects [Table 7].)*

Bekker, M. F. and Taylor, A. H. 2001. Gradient analysis of fire regimes in montane forests of the southern Cascade Range, Thousand Lakes Wilderness, California, USA. Plant Ecology 155: 15-28. *(On the western slope of the southern Cascades in California, in mixed-conifer forests, fire was predominantly high-intensity historically [Fig. 2F].)*

Bekker, M. F. and Taylor, A. H. 2010. Fire disturbance, forest structure, and stand dynamics in montane forest of the southern Cascades, Thousand Lakes Wilderness, California, USA. Ecoscience 17: 59-72. *(In mixed-conifer forests of the southern Cascades, the reconstructed fire regime was dominated by high-intensity fire effects, including high-intensity fire patches over 2,000 acres in size [Tables I and II].)*

Collins, B.M., and S.L. Stephens. 2010. Stand-replacing patches within a mixed severity fire regime: quantitative characterization using recent fires in a long-established natural fire area. Landscape Ecology 25: 927939. *(In a modern "reference" forest condition within mixed-conifer/fir forests in Yosemite National Park, 15% of the area experienced high-intensity fire over a 33-year period—a high-intensity fire rotation interval of approximately 223 years.)*

Hanson, C.T., and D.C. Odion. Historical forest conditions within the range of the Pacific Fisher and Spotted Owl in the central and southern Sierra Nevada, California, USA. Natural Areas Journal (in press). *(Based upon early 20th century U.S. Forest Service field surveys, historical ponderosa pine and mixed-conifer forests of the western slope of the central and southern Sierra Nevada had a mixed-intensity fire regime, averaging 26% high-intensity fire effects in the study areas—and ranging from none in one location to 67% in another. Forests varied widely in terms of density and species composition, with some open, pine-dominated forests and many dense, pine and fir/cedar-dominated areas.)*

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. *(Historical mixed-conifer forests of eastern Oregon Cascades were mainly mixed- and high-intensity, and were dominated by dense, early- and mid-successional forests regenerating from past higher-intensity fire, rather than by open and park-like old-growth forests.)*

Iniguez, J. M., T. W. Swetnam, and C. H. Baisan. 2009. Spatially and temporally variable fire regime on Rincon Mountain, Arizona, USA. Fire Ecology 5:3-21.

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

Leiberg, J.B. 1900a. Bitterroot Forest Reserve. USDI Geological Survey, Twentieth Annual Report to the Secretary of the Interior, 1898–99, Part V. Forest Reserves, pp. 317–410. US Government Printing Office, Washington, DC.

Leiberg, J.B. 1900b. Sandpoint quadrangle, Idaho. USDI Geological Survey, Twenty-first Annual Report, Part V. Forest Reserves, pp. 583–595. US Government Printing Office, Washington, DC.

Leiberg, J. B. 1900c. 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. U.S. Geological Survey Annual Report 21(V):209-498.

Leiberg, J. B. 1902. Forest conditions in the northern Sierra Nevada, California. USDI Geological Survey, Professional Paper No. 8. U.S. Government Printing Office, Washington, D.C. *(In the 19th century, prior to fire suppression, high-intensity fire patches thousands of* *acres in size were mapped in mixed-conifer forests of the Sierra Nevada. Composition of mixed-conifer forests in the central and northern Sierra Nevada was quantified in unlogged areas for several watersheds, and in dozens of specific locations within watersheds. The study reported that, while some of these areas were open and parklike stands dominated by ponderosa pine, Jeffrey pine, and sugar pine, the majority were dominated by white fir, incense-cedar, and Douglas-fir, especially on north-facing slopes and on lower slopes of subwatersheds; such areas were predominantly described as dense, often with "heavy underbrush" from past mixed-intensity fire. Natural heterogeneity, resulting from fire, often involved dense stands of old forest adjacent to snag forest patches of standing fire-killed trees and montane chaparral with regenerating young conifers: "All the slopes of Duncan Canyon from its head down show the same marks of fire—dead timber, dense undergrowth, stretches of chaparral, thin lines of trees or small groups rising out of the brush, and heavy blocks of forest surrounded by chaparral." [p. 171])*

Leiberg, J. B. 1903. Southern part of Cascade Range Forest Reserve. Pages 229–289 in H. D. Langille, F. G. Plummer, A. Dodwell, T. F. Rixon, and J. B. Leiberg, editors. Forest conditions in the Cascade Range Forest Reserve, Oregon. Professional Paper No. 9. U.S. Geological Survey, U.S. Government Printing Office, Washington, D.C., USA.

Leiberg, J.B. 1904a. Forest conditions in the Absaroka division of the Yellowstone Forest Reserve, Montana. USDI Geological Survey Professional Paper No. 29, US Government Printing Office, Washington, DC.

Leiberg, J.B. 1904b. Forest conditions in the Little Belt Mountains Forest Reserve, Montana, and the Little Belt Mountains quadrangle. USDI Geological Survey Professional Paper No. 30, US Government Printing Office, Washington, DC.

Minnich, R.A., M.G. Barbour, J.H. Burk and J. Sosa-Ramirez, 2000. Californian mixed-conifer forests under unmanaged fire regimes in the Sierra San Pedro Martir, Baja California, Mexico. Journal of Biogeography27: 105-129.

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

Odion D.C., Hanson C.T., Arsenault A., Baker W.L., DellaSala D.A., Hutto R.L., Klenner W., Moritz M.A., Sherriff R.L., Veblen T.T., Williams M.A. 2014. Examining historical and current mixed-severity fire regimes in ponderosa pine and mixed-conifer forests of western North America. PLoS ONE 9: e87852. *(In the largest and most comprehensive analysis ever conducted regarding the historical occurrence of high-intensity fire, the authors found that ponderosa pine and mixed-conifer forests in every region of western North America had mixed-intensity fire regimes, which included substantial occurrence of high-intensity fire. The authors also found, using multiple lines of evidence, including over a hundred historical sources and fire history reconstructions, and an extensive forest age-class analysis, that we now have unnaturally low levels of high-intensity fire in these forest types in all regions, since the beginning of fire suppression policies in the early 20th century.)*

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

Sherriff, R. L., and T. T. Veblen. 2007. A spatially explicit reconstruction of historical fire occurrence in the Ponderosa pine zone of the Colorado Front Range. Ecosystems 9:1342-1347.

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 Biology11: 1276-1288. *(The authors summarize extensive U.S. government historical records from the 1800s documenting high-intensity fire patches many thousands of acres in size in the ponderosa pine forests of the Black Hills in South Dakota, prior to fire suppression and logging.)*

Show, S.B. and Kotok, E.I. 1924. The role of fire in California pine forests. United States Department of Agriculture Bulletin 1294, Washington, D.C. *(Historically, within ponderosa pine and mixed-conifer/pine forests of the Sierra Nevada, high-intensity crown fires, though infrequent on any particular area, "may extend over a few hundred acres" in patches [p. 31; see also Plate V, Fig. 2, Plate VII, Fig. 2, Plate VIII, Plate IX, Figs. 1 and 2, and Plate X, Fig. 1], with some early-successional areas, resulting from high-intensity fire patches, covering 5,000 acres in size or more [pp. 42-43]. The authors distinguished high-intensity fire patches of this size from more "extensive" patches occurring in the northern Rocky Mountains [p. 31], where high-intensity fire patches occasionally reach tens of thousands, or hundreds of thousands, of acres in size, and noted that patches of such enormous size were "almost" unknown in Sierra Nevada ponderosa pine and mixed-conifer forests. Within unlogged areas, the authors noted many large early-successional habitat patches, dominated by montane chaparral and young, regenerating conifer forest, and explained that such areas were the result of past intense fire patches because: a) patches of mature/old forest and individual surviving trees were found interspersed within these areas, and were found adjacent to these areas, indicating past forest; b) snags and stumps of fallen snags, as well as downed logs from fallen snags, were abundant in these areas; c) the species of chaparral found growing in these areas are known to sprout abundantly following severe fire; and d) natural conifer regeneration was found on most of the area [p. 42], often growing through complete chaparral cover [p. 43].)*

Show, S.B. and Kotok, E.I. 1925. Fire and the forest (California pine region). United States Department of Agriculture Department Circular 358, Washington, D.C. *(Historically, within the ponderosa pine and mixed-conifer/pine belt of the Sierra Nevada, 1 acre out of every 7 on average was dominated by montane chaparral and young regenerating conifer forest following high-intensity fire [Footnote 2, and Figs. 4 and 5]; on one national forest 215,000 acres out of 660,000 was early-successional habitat from high-intensity fire [p. 17].)*

Stephenson, N. L.; Parsons, D,J.; Swetnam, T,W. 1991. Restoring natural fire to the sequoia - mixed conifer forest: should intense fire play a role? Proceedings of the Tall Timbers Fire Ecology Conference 17:321-337.

Taylor A.H. 2002. Evidence for pre-suppression high-severity fire on mixed conifer forests on the west shore of the Lake Tahoe Basin. Final report. South Lake Tahoe (CA): USDA Forest Service, Lake Tahoe Basin Management Unit.

USFS (United States Forest Service). 1910-1912. Timber Survey Field Notes, 1910-1912, U.S. Forest Service, Stanislaus National Forest. Record Number 095-93-045, National Archives and Records Administration—Pacific Region, San Bruno, California, USA. *(Surveys were conducted within primary forest to evaluate timber production potential in 16.2-ha (40-acre) plots within each 259.1-ha (640-acre) section in ponderosa pine and mixed-conifer forest on the westside of the Stanislaus National Forest, using one or more 1.62-ha transect per plot. Surveyors noted that surveys for individual tree size, density and species were not conducted in areas that had experienced high-intensity fire sufficiently recently such that the regenerating areas did not yet contain significant merchantable sawtimber. Surveyors noted that the dominant vegetation cover across the majority of many 259.1-ha sections was montane chaparral and young conifer regeneration following high-intensity fire. For example (from a typical township in the data set): a) T1S, R18E, Section 9 ("Severe fire went through [this section] years ago and killed most of the trees and land was reverted to brush", noting "several large dense sapling stands" and noting that merchantable timber existed on only four of sixteen 16.2-ha plots in the section); b) T1S, R18E, Section 14 ("Fires have killed most of timber and most of section has reverted to brush"); c) T1S, R18E, Section 15 (same); d) T1S, R18E, Section 23 ("Most of timber on section has been killed by fires which occurred many years ago"); T1S, R18E, Section 21 ("Old fires killed most of timber on this section and most of area is now brushland".)*

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 Fire17: 72-83.

Whitlock, C., P.E. Higuera, D.B. McWethy, and C.E. Briles. 2010. Paleoecological perspectives on fire ecology: revisiting the fire-regime concept. The Open Ecology Journal 3: 6-23.

Williams, M.A., W.L. Baker. 2012a. Spatially extensive reconstructions show variable-severity fire and heterogeneous structure in historical western United States dry forests. Global Ecology and Biogeography. DOI: 10.1111/j.1466-8238.2011.00750. *(Historically, fires in western U.S. conifer forests, including those of the Southwest, were mainly mixed-intensity and high-intensity in most areas, and forests were far denser than previously assumed. Even the largest and most intense current fires are well within the natural historical range of variability. The results were based upon historic U.S. government field plots from the 1800s covering entire landscapes, which were extensively field-checked by the authors.)*

Williams, M.A., W.L. Baker. 2012b. Comparison of the higher-severity fire regime in historical (A.D. 1800s) and modern (A.D. 1984-2009) montane forests across 624,156 ha of the Colorado Front Range. Ecosystems 15: 832-847. *(In the ponderosa pine and Douglas-fir/pine forests of the Colorado Front Range, there is less higher-intensity fire now than there* *was historically, and higher-intensity fire patch sizes are smaller now than they were historically.)*

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

<u>Patches of High-intensity Fire Create Some of the Best, Most Biodiverse Wildlife Habitat</u>:

High-intensity fire patches, including large patches, create very biodiverse, ecologically important, spatially rare and unique habitat (often called "snag forest habitat"), which often has higher species richness and diversity than unburned old forest; many wildlife species use this forest habitat type more than any other, and old forest species select it for foraging, while some very rare and imperiled species, such as the Black-backed Woodpecker and Buff-breasted Flycatcher, depend upon it for all habitat, and even old-growth forest species like the Spotted Owl depend upon such post-fire habitat for foraging.

Bond, M. L., D. E. Lee, R. B. Siegel, & J. P. Ward, Jr. 2009a. Habitat use and selection by California Spotted Owls in a postfire landscape. Journal of Wildlife Management 73: 1116-1124. *(In a radiotelemetry study, California spotted owls preferentially selected high-intensity fire areas, which had not been salvage logged, for foraging, while selecting low- and moderate-intensity areas for nesting and roosting.)*

Buchalski, M.R., J.B. Fontaine, P.A. Heady III, J.P. Hayes, and W.F. Frick. 2013. Bat response to differing fire severity in mixed-conifer forest, California, USA. PLOS ONE 8: e57884. *(In mixed-conifer forests of the southern Sierra Nevada, rare myotis bats were found at greater levels in unmanaged high-intensity fire areas of the McNally fire than in lower fire intensity areas or unburned forest.)*

Burnett, R.D., P. Taillie, and N. Seavy. 2010. Plumas Lassen Study 2009 Annual Report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA. *(Bird species richness was approximately the same between high-intensity fire areas and unburned mature/old forest at 8 years post-fire in the Storrie fire, and total bird abundance was greatest in the high-intensity fire areas of the Storrie fire [Figure 4]. Nest density of cavity-nesting species increased with higher proportions of high-intensity fire, and was highest at 100% [Figure 8]. The authors noted that "[o]nce the amount of the plot that was high severity was over 60% the density of cavity nests increased substantially", and concluded that "more total species were detected in the Moonlight fire which covers a much smaller geographic area and had far fewer sampling locations than the [unburned] green forest.")*

Burnett, R.D., P. Taillie, and N. Seavy. 2011. Plumas Lassen Study 2010 Annual Report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA. *(Black-backed Woodpecker nesting was eliminated by post-fire salvage logging. See Figure 11 [showing nest density on national forest lands not yet subjected to salvage logging versus private lands that had been salvage logged.)*

Conway, C.J., and C. Kirkpatrick. 2007. Effect of forest fire suppression on buff-breasted flycatchers. Journal of Wildlife Management 71: 445-457. *(Due to decades of fire suppression, the Buff-breasted Flycatcher, which is strongly associated with high-intensity fire areas in forests of the southwest, has declined dramatically, losing the vast majority of its range in the U.S. The authors conclude the continued suppression of high-intensity fire could lead to the extirpation of this rare bird in the U.S.)*

DellaSala, D.A., M.L. Bond, C.T. Hanson, R.L. Hutto, and D.C. Odion. 2014. Complex early seral forests of the Sierra Nevada: what are they and how can they be managed for ecological integrity? Natural Areas Journal **34**: 310-324. *(High-intensity fire creates a post-fire habitat that is one of the rarest, most biodiverse, and most threatened of all forest habitat types: "complex early seral forest" (CESF). The authors recommend monitoring and conservation programs to recover and maintain this ecologically-vital habitat on the landscape.)*

Donato, D.C., J.B. Fontaine, W.D. Robinson, J.B. Kauffman, and B.E. Law. 2009. Vegetation response to a short interval between high-severity wildfires in a mixed-evergreen forest. Journal of Ecology 97: 142-154. *(The high-intensity re-burn [high-intensity fire occurring 15 years after a previous high-intensity fire] had the highest plant species richness and total plant cover, relative to high-intensity fire alone [no re-burn] and unburned mature/old forest; and the high-intensity fire re-burn area had over 1,000 seedlings/saplings per hectare of natural conifer regeneration.)*

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. *(The authors found that stable or increasing populations of spotted owls resulted from a mix of dense old forest and complex early seral habitat, and less than approximately 25% complex early seral habitat in the home range was associated with declining populations [Fig. 10]; the authors emphasized that the complex early seral habitat was consistent with high-intensity fire effects, and inconsistent with clearcut logging).*

Haney, A., S. Apfelbaum, and J.M. Burris. 2008. Thirty years of post-fire succession in a southern boreal forest bird community. The American Midland Naturalist 159: 421-433. *(By 30 years after high-intensity fire, bird species richness increased 56% relative to pre-fire mature unburned forest.)*

Hanson, C. T. and M. P. North. 2008. Postfire woodpecker foraging in salvage-logged and unlogged forests of the Sierra Nevada. Condor 110: 777–782. *(Black-backed woodpeckers depend upon dense, mature/old forest that has recently experienced higher-intensity fire, and has not been salvage logged.)*

Hanson, C.T. 2013. Pacific fisher habitat use of a heterogeneous post-fire and unburned landscape in the southern Sierra Nevada, California, USA. The Open Forest Science Journal 6: 24-30. *(Pacific fishers are using pre-fire mature/old forest that experienced moderate/high-intensity fire more than expected based upon availability, just as fishers are selecting dense, mature/old forest in its unburned state as well. The proportion of* *high-intensity fire is significantly higher within 0.5 kilometers of fisher detection locations than at random locations. When fishers are near fire perimeters, they strongly select the burned side of the fire edge. Both males and female fishers are using large mixed-intensity fire areas, such as the McNally fire, including several kilometers into the fire area.)*

Hanson, C.T. 2014. Conservation concerns for Sierra Nevada birds associated with high-severity fire. Western Birds 45: 204-212. *(Native forest birds of the Sierra Nevada that are positively associated with the habitat created by high-intensity fire are generally declining in population, as fire suppression, post-fire logging, and post-fire shrub eradication policies continue on national forest lands, and private lands, while no such declining trend is occurring for species associated mainly with unburned forests.)*

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. 2008. The ecological importance of severe wildfires: Some like it hot. Ecological Applications 18:1827–1834.

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.

Lee, D.E., M.L. Bond, and R.B. Siegel. 2012. Dynamics of breeding-season site occupancy of the California spotted owl in burned forests. The Condor 114: 792-802. *(Mixed-intensity wildland fire, averaging 32% high-intensity fire effects, did not decrease California spotted owl territory occupancy, and actually had higher occupancy than unburned mature/old forest, but post-fire salvage logging adversely affected occupancy.)*

Malison, R.L., and C.V. Baxter. 2010. The fire pulse: wildfire stimulates flux of aquatic prey to terrestrial habitats driving increases in riparian consumers. Canadian Journal of Fisheries and Aquatic Sciences 67: 570-579. *(In ponderosa pine and Douglas-fir forests of Idaho at 5-10 years post-fire, levels of aquatic insects emerging from streams were two and a half times greater in high-intensity fire areas than in unburned mature/old forest, and bats were nearly 5 times more abundant in riparian areas with high-intensity fire than in unburned mature/old forest.)*

Raphael, M.G., M.L. Morrison, and M.P. Yoder-Williams. 1987. Breeding bird populations during twenty-five years of postfire succession in the Sierra Nevada. The Condor 89: 614-626. *(At 25 years after high-intensity fire, total bird abundance was slightly higher in snag forest than in unburned old forest in eastside mixed-conifer forest of the northern Sierra Nevada; and bird species richness was 40% higher in snag forest habitat. In earlier post-fire years, woodpeckers were more abundant in snag forest, but were similar to unburned by 25 years post-fire, while flycatchers and species associated with shrubs continued to increase to 25 years post-fire.)*

Roberts, S.L. 2008. The effects of fire on California spotted owls and their mammalian prey in the central Sierra Nevada, California. Ph.D. Dissertation, University of California at Davis. *(California spotted owl reproduction was 60% higher in a mixed-intensity fire area [no salvage logging] than in unburned mature/old forest.)*

Rota, C.T. 2013. Not all forests are disturbed equally: population dynamics and resource selection of Black-backed Woodpeckers in the Black Hills, South Dakota. Ph.D. Dissertation, University of Missouri-Columbia, MO. (*Rota found that Black-backed Woodpeckers only maintain stable or increasing populations (i.e., viable populations) in recent wildland fire areas occurring within dense mature/older forest (which have very high densities of large wood-boring beetle larvae due to the very high densities of medium/large fire-killed trees). And, while Black-backeds are occasionally found in unburned forest or prescribed burn areas, unburned "beetle-kill" forests (unburned forest areas with high levels of tree mortality from small pine beetles) and lower-intensity prescribed burns have declining populations of Black-backed Woodpeckers (with the exception of a tiny percentage of beetle-kill areas). The study shows that unburned beetle-kill forests do not support viable populations, but very high snag-density beetle-kill areas tend to slow the population decline of Black-backed Woodpeckers in between occurrences of wildland fire. Population decline rates are alarmingly fast in low-intensity prescribed burn areas, indicating that such areas do not provide suitable habitat. Black-backed Woodpeckers are highly specialized and adapted to prey upon wood-boring beetle larvae found predominantly in recent higher-intensity wildland fire areas. Moreover, while Black-backed Woodpeckers are naturally camouflaged against the charred bark of fire-killed trees, they are more conspicuous in unburned forests, or low-intensity burned forests, and are much more vulnerable to predation by raptors in such areas. For this reason, even when a Black-backed Woodpecker pair does successfully reproduce in unburned forest or low-intensity fire areas, both juveniles and adults have much lower survival rates than in higher-intensity wildland fire areas.)*

Saab, V.A., R.E. Russell, and J.G. Dudley. 2009. Nest-site selection by cavity-nesting birds in relation to postfire salvage logging. Forest Ecology and Management 257:151–159. *(Black-backed Woodpeckers select areas with about 325 medium and large snags per hectare [about 132 per acre], and nest-site occupancy potential dropped to near zero when snag density was below about 270 per hectare, or about 109 per acre [see Fig. 2A, showing 270 snags per hectare as the lower boundary of the 95% confidence interval].)*

Schieck, J., and S.J. Song. 2006. Changes in bird communities throughout succession following fire and harvest in boreal forests of western North America: literature review and meta-analyses. Canadian Journal of Forest Research 36: 1299-1318. *(Bird species richness increased up to 30 years after high-intensity fire, then decreased in mid-successional forest [31-75 years old], and increased again in late-successional forest [>75 years]).*

Seavy, N.E., R.D. Burnett, and P.J. Taille. 2012. Black-backed woodpecker nest-tree preference in burned forests of the Sierra Nevada, California. Wildlife Society Bulletin 36: 722-728. *(Black-backed Woodpeckers selected sites with an average of 13.3 snags per 11.3-meter radius plot [i.e., 0.1-acre plot], or about 133 snags per acre.)*

Sestrich, C.M., T.E. McMahon, and M.K. Young. 2011. Influence of fire on native and nonnative salmonid populations and habitat in a western Montana basin. Transactions of the American Fisheries Society 140: 136-146. *(Native Bull and Cutthroat trout tended to increase with higher fire intensity, particularly where debris flows occurred. Nonnative brook trout did not increase.)*

Siegel, R.B., M.W. Tingley, and R.L. Wilkerson. 2011. Black-backed Woodpecker MIS surveys on Sierra Nevada national forests: 2010 Annual Report. A report in fulfillment of U.S. Forest Service Agreement No. 08-CS-11052005-201, Modification #2; U.S. Forest Service Pacific Southwest Region, Vallejo, CA. *(Black-backed woodpecker occupancy in post-fire habitat is ephemeral, and declines dramatically by 5-7 years post-fire relative to 1-2 years post-fire, approaching zero by 10 years post-fire [Fig. 15a], due to a decline in the bird's prey [wood-boring beetle larvae] with increasing time since fire.)*

Siegel, R.B., M.W. Tingley, R.L. Wilkerson, M.L. Bond, and C.A. Howell. 2013. Assessing home range size and habitat needs of Black-backed Woodpeckers in California: Report for the 2011 and 2012 field seasons. Institute for Bird Populations. *(Black-backed woodpeckers strongly select large patches of higher-intensity fire with high densities of medium and large snags, generally at least 100 to 200 hectares (roughly 250 to 500 acres) per pair, and post-fire salvage logging eliminates Black-backed woodpecker foraging habitat [see Fig. 13, showing almost complete avoidance of salvage logged areas].)*

Tarbill, G.L. 2010. Nest site selection and influence of woodpeckers on recovery in a burned forest of the Sierra Nevada. Master's Thesis, California State University, Sacramento. *(In post-fire eastside pine and mixed-conifer forests of the northern Sierra Nevada, Black-backed woodpeckers strongly selected stands with very high densities of medium and large snags, with well over 200 such snags per hectare [over 500 snags per acre] on average at nest sites [Table 2], and nesting potential was optimized at 250 or more per hectare, dropping to very low levels below 100 to 200 per hectare [Fig. 5b].)*

<u>There is Much Less Fire, and *Less* High-intensity Fire, Now Than There Was Historically in Conifer Forests</u>:

The scientific data indicate that current rates of high-intensity fire (rotation intervals) are likely lower (longer rotation intervals) than historic rates, indicating less high-intensity fire overall.

Baker, W.L. 2012. Implications of spatially extensive historical data from surveys for restoring dry forests of Oregon's eastern Cascades. Ecosphere 3(3): article 23. *(In dry mixed-conifer forests of the southern Cascades, the historic high-intensity fire rotation was 435 years, and the combined mixed/high-intensity rotation was 165 years.)*

Baker, W.L. 2014. Historical forest structure and fire in Sierran mixed-conifer forests reconstructed from General Land Office survey data. Ecosphere 5: Article 79. *(Historically,* *high-intensity fire occurred about once every three centuries in mixed-conifer and ponderosa pine forests of the Sierra Nevada; this is much more frequent than current rates.)*

Bekker, M. F. and Taylor, A. H. 2001. Gradient analysis of fire regimes in montane forests of the southern Cascade Range, Thousand Lakes Wilderness, California, USA. Plant Ecology155: 15-28. *(Approximately 50% to 60% of the mixed-conifer forest in an unlogged area of the southern Cascades in California experienced high-intensity fire over a 76-year period prior to fire suppression, indicating a high-intensity fire rotation interval of 150-200 years.)*

Collins, B.M., and S.L. Stephens. 2010. Stand-replacing patches within a mixed-severity fire regime: quantitative characterization using recent fires in a long-established natural fire area. Landscape Ecology 25: 927939. *(In a modern "reference" forest condition within mixed-conifer/fir forests in Yosemite National Park, 15% of the area experienced high-intensity fire over a 33-year period—a high-intensity fire rotation interval of approximately 223 years.)*

Miller, J.D., B.M. Collins, J.A. Lutz, S.L. Stephens, J.W. van Wagtendonk, and D.A. Yasuda. 2012b. Differences in wildfires among ecoregions and land management agencies in the Sierra Nevada region, California, USA. Ecosphere 3: Article 80. *(Current high-intensity fire rotation interval in the Sierra Nevada management region overall is over 800 years. The authors recommended increasing high-intensity fire amounts [i.e., decreasing rotation intervals] in the Cascades-Modoc region and on the western slope of the Sierra Nevada, which comprises 75% of Sierra Nevada forests, and where the current high-intensity fire rotation is 859 to 4650 years [Table 3]. The authors noted that "high-severity rotations may be too long in most Cascade-Modoc and westside NF locations, especially in comparison to Yosemite…").*

Minnich, R.A., M.G. Barbour, J.H. Burk, and 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. *(High-intensity fire rotation interval in reference forests that had not been logged or fire-suppressed was 300 years.)*

Odion, D.C., and Hanson, C.T. 2013. Projecting impacts of fire management on a biodiversity indicator in the Sierra Nevada and Cascades, USA: the Black-backed Woodpecker. The Open Forest Science Journal 6: 14-23. *(High-intensity fire, which creates primary habitat for Black-backed Woodpeckers, has declined by fivefold since the early 20th century in the Sierra Nevada and eastern Oregon Cascades due to fire suppression. Further, the current rate of high-intensity fire in mature/old forest (which creates primary, or high suitability, habitat for this species) in the Sierra Nevada and eastern Oregon Cascades is so low, and recent high-intensity fire in mature/old forest comprises such a tiny percentage of the overall forested landscape currently (0.66%, or about 1/150th of the landscape), that even if high-intensity fire in mature/old forest was increased by several times, it would only amount to a very small proportional reduction in mature/old forest, while getting Black-backed Woodpecker habitat closer to its historical, natural levels.)*

Odion D.C., Hanson C.T., Arsenault A., Baker W.L., DellaSala D.A., Hutto R.L., Klenner W., Moritz M.A., Sherriff R.L., Veblen T.T., Williams M.A. 2014. Examining historical and current mixed-severity fire regimes in ponderosa pine and mixed-conifer forests of western North America. PLoS ONE 9: e87852. *(In ponderosa pine and mixed-conifer forests across the western U.S., there is currently only one-fourth to one-half as much high-intensity fire, within any given year or decade, on average, than there was historically, prior to fire suppression, based on an enormous stand age data set in unmanaged forests.)*

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. *(Overall fire occurrence is vastly lower now than it was historically in conifer forests. Also, the estimated high-intensity fire proportion and frequency indicate historic high-intensity fire rotation intervals of approximately 250 to 400 years in historic ponderosa pine and mixed-conifer forests in California.)*

Williams, M.A., W.L. Baker. 2012b. Comparison of the higher-severity fire regime in historical (A.D. 1800s) and modern (A.D. 1984-2009) montane forests across 624,156 ha of the Colorado Front Range. Ecosystems 15: 832-847. *(In the ponderosa pine and Douglas-fir/pine forests of the Colorado Front Range, there is less higher-intensity fire now than there was historically, and higher-intensity fire patch sizes are smaller now than they were historically.)*

<u>The Most Fire-suppressed Forests Are Not Burning More Intensely</u>:

Contrary to widespread, popular assumptions, forest areas that have missed the largest number of fire return intervals are burning predominantly at low/moderate-intensity levels, and are not experiencing higher fire intensity than areas that have missed fewer fire return intervals.

Miller JD, Skinner CN, Safford HD, Knapp EE, Ramirez CM. 2012a. Trends and causes of severity, size, and number of fires in northwestern California, USA. Ecological Applications 22, 184-203.

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. 2010. Alternative community states maintained by fire in the Klamath Mountains, USA. Journal of Ecology, doi: 10.1111/j.1365-2745.2009.01597.x.

van Wagtendonk, J.W., K.A. van Wagtendonk, and A.E. Thode. 2012. Factors associated with the severity of intersecting fires in Yosemite National Park, California, USA. Fire Ecology 8: 11-32.

Below is a more detailed discussion of these studies:

Six empirical studies have been conducted to assess the longstanding forest management assumption that the most fire-suppressed forests (i.e., the forests that have missed the largest number of fire return intervals) burn "almost exclusively at high-severity" (2004 Sierra Nevada Forest Plan Amendment Final EIS, Vol. 1, p. 124). These studies found that the most long-unburned (most fire-suppressed) forests burned mostly at low/moderate-intensity, and did not have higher proportions of high-intensity fire than less fire-suppressed forests. Forests that were not fire suppressed (those that had not missed fire cycles, i.e., Condition Class 1, or "Fire Return Interval Departure" class 1) generally had levels of high-intensity fire similar to, or higher than, those in the most fire-suppressed forests.

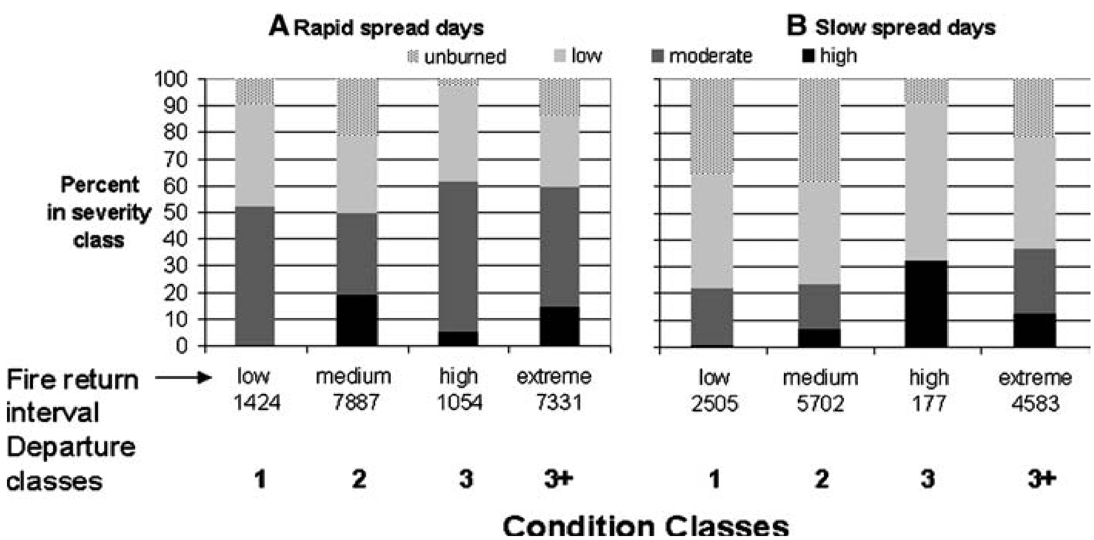

Figure 5 from Odion and Hanson (2006) (*Ecosystems*), based upon the three largest fires 1999-2005, which comprised most of the total acres of wildland fire in the Sierra Nevada during that time period (using fire intensity data from Burned Area Emergency Rehabilitation (BAER) aerial overflight mapping), showing that the most long-unburned, fire-suppressed forests (Condition "Class 3+", corresponding to areas that had missed more than 5 fire return intervals, and generally had not previously burned for about a century or more) experienced predominantly low/moderate-intensity fire.

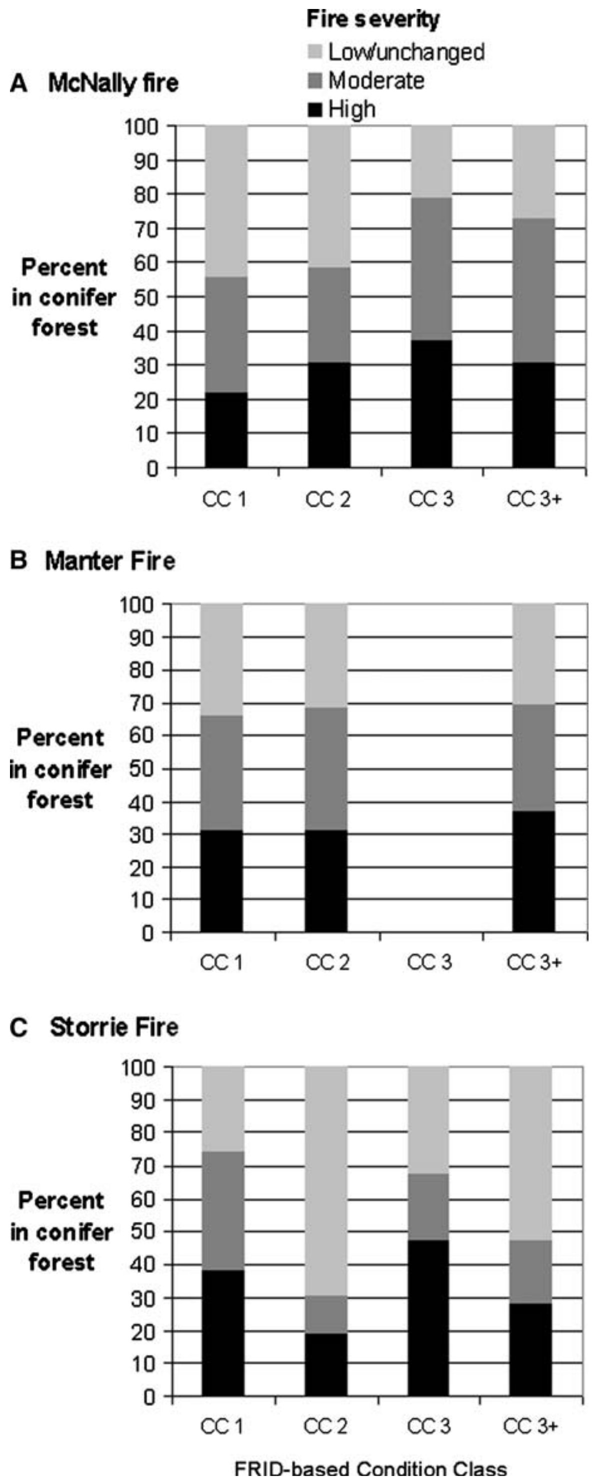

Figure 1 from Odion and Hanson (2008) (*Ecosystems*) (using fire intensity data from satellite imagery for the same three fires analyzed in Odion and Hanson 2006), showing that the most long-unburned, fire-suppressed forests (no fire for a century or more) burned mostly at low/moderate-intensity, and had levels of high-intensity fire similar to less fire-suppressed forests (in one case, even less than Condition Class 1).

Van Wagtendonk et al. (2012) (*Fire Ecology*), analyzing 28 fires from 1973-2011 in Yosemite National Park, found the following:

> "The proportion burned in each fire severity class was not significantly associated with fire return interval departure class…[L]ow severity made up the greatest proportion within all three departure classes, while high severity was the least in each departure class (Figure 4)."

The most long-unburned, fire-suppressed forests—those that had missed 4 or more fire return intervals (in most cases, areas that had not burned since at least 1930)—had only about 10% high-intensity fire (Fig. 4 of van Wagtendonk e al. 2012).

Odion et al. (2004) (*Conservation Biology*), conducted in numerous fires, comprising 98,814-hectares, that burned in 1987 in the California Klamath region, found that the most fire-suppressed forests in this area (areas that had not burned since at least 1920) burned at significantly *lower* severity levels, likely due to a reduction in combustible native shrubs as forests mature and canopy cover increases:

> "The hypothesis that fire severity is greater where previous fire has been long absent was refuted by our study…The amount of high-severity fire in long-unburned closed forests was the lowest of any proportion of the landscape and differed from that in the landscape as a whole ($Z = -2.62$, $n = 66$, $p = 0.004$)."

Odion et al. (2010) (*Journal of Ecology*), empirically tested the hypothesis articulated in Odion et al. (2004)—i.e., that the *reduction* in fire intensity with increasing time-since-fire was due to a reduction in combustible native shrubs as forests mature and canopy cover increases—and found the data to be consistent with this hypothesis.

Miller et al. (2012a) (*Ecological Applications*), analyzing all fires over 400 hectares 1987-2008 in the California Klamath region, found low proportions of high-intensity fire (generally 5-13%) in long-unburned forests, and the proportion of high-intensity fire effects in long-unburned forests was either the same as, or *lower than*, the high-severity fire proportion in more recently burned forests (see Table 3 of Miller et al. 2012a).

<u>Fire Intensity is Not Increasing in the Great Majority of Western U.S. Conifer Forests</u>:

Most studies of current fire trends in western U.S. conifer forests have not found an increase in fire intensity, and studies are mixed on whether fire will increase, or decrease, in future decades as a result of climate change, depending upon the modeling assumptions used (e.g., hotter and drier versus warmer and wetter).

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 12:114–128. *(No increase in high-intensity fire found.)*

Crimmins, S.L., et al. 2011. Changes in climatic water balance drive downhill shifts in plant species' optimum elevations. Science 331:324-327. *(Precipitation was found to be increasing.)*

Dillon, G.K., et al. 2011. Both topography and climate affected forest and woodland burn severity in two regions of the western US, 1984 to 2006. Ecosphere 2:Article 130. *(No increase in fire intensity was found in most forested regions of the western U.S., including no increasing trend of fire intensity in forests of the Pacific Northwest, Inland Northwest, and northern Rocky Mountains, while mixed results were found in the Southwest.)*

Gonzalez, P., R.P. Neilson, J.M. Lenihan, and R.J. Drapek. 2010. Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change. Global Change and Biogeography 19:755-768. *(Precipitation has been increasing in the western U.S. [Fig. 1b], and a decrease in fire is projected over the 21st century in California's forests due to climate change, while increases are projected in desert areas east of the Sierra Nevada [Fig. 3b].)*

Hamlet, A.F., P.W. Mote, M.P. Clark, D.P. Lettenmaier. 2007. Twentieth-century trends in runoff, evapotranspiration, and soil moisture in the western United States. Journal of Climate 20:1468-1486. *(A trend of increasing precipitation was found in western U.S. forests.)*

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. *(Fire intensity is not increasing in forests of the Klamath and southern Cascades or eastern Cascades.)*

Hanson, C.T., D.C. Odion, D.A. DellaSala, and W.L. Baker. 2010. More-comprehensive recovery actions for Northern Spotted Owls in dry forests: Reply to Spies et al. Conservation Biology 24:334–337.

Hanson, C.T., and D.C. Odion. 2014. Is fire severity increasing in the Sierra Nevada mountains, California, USA? International Journal of Wildland Fire 23: 1-8. *(Hanson and Odion (2014) conducted the first comprehensive assessment of fire intensity since 1984 in the Sierra Nevada using 100% of available fire intensity data, and, using Mann-Kendall trend tests (a common approach for environmental time series data—one which has similar or greater statistical power than parametric analyses when using non-parametric data sets, such as fire data), found no increasing trend in terms of high-intensity fire proportion, area, mean patch size, or maximum patch size. Hanson and Odion (2014) checked for serial autocorrelation in the data, and found none, and used pre-1984 vegetation data (1977 Cal-Veg) in order to completely include any conifer forest experiencing high-intensity fire in all time periods since 1984 (the accuracy of this data at the forest strata scale used in the analysis was 85-88%). Hanson and Odion (2014) also checked the approaches used by Miller et al. (2009), Miller and Safford (2012), and Mallek et al. (2013) for bias, due to the use of vegetation layers that post-date the fires being analyzed in those studies. Hanson and Odion (2014) found that there is a statistically significant bias in such studies ($p = 0.025$ and $p = 0.021$, respectively), the effect of which is to exclude relatively more conifer forest experiencing high-intensity fire* *in the earlier years of the time series, thus creating the false appearance of an increasing trend in fire severity. Interestingly, Miller et al. (2012a), acknowledged the potential bias that can result from using a vegetation classification data set that post-dates the time series. In that study, conducted in the Klamath region of California, Miller et al. used a vegetation layer that preceded the time series, and found no trend of increasing fire intensity. Miller et al. (2009) and Miller and Safford (2012) did not, however, follow this same approach. Hanson and Odion (2014) also found that the regional fire intensity data set used by Miller et al. (2009) and Miller and Safford (2012) disproportionately excluded fires in the earlier years of the time series, relative to the standard national fire intensity data set (www.mtbs.gov) used in other fire intensity trend studies, resulting in an additional bias which created, once again, the inaccurate appearance of relatively less high-intensity fire in the earlier years, and relatively more in more recent years. The results of Hanson and Odion (2014) are consistent with all other recent studies of fire intensity trends in California's forests that have used all available fire intensity data, including Collins et al. (2009) in a portion of Yosemite National Park, Schwind (2008) regarding all vegetation in California, Hanson et al. (2009) and Miller et al. (2012a) regarding conifer forests in the Klamath and southern Cascades regions of California, and Dillon et al. (2011) regarding forests of the Pacific (south to the northernmost portion of California) and Northwest.)*

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. *(Fire is projected to decrease in the Sierra Nevada management region over the next several decades due to climate change [Fig. 3].)*

Lenihan, J.M., D. Bachelet, R.P. Neilson, and R. Drapek. 2008. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. Climatic Change 87:S215-S230. *(Fire would increase moderately in California's forests in the coming decades if there are hotter and drier conditions [i.e., models analyzed assumed hotter/drier conditions].)*

Liu, Y., J. Stanturf, and S. Goodrick. 2010. Trends in global wildfire potential in a changing climate. Forest Ecology and Management 259:685-697. *(A decrease in fire is projected in California's forested regions over the 21st century due to climate change [Fig. 1].)*

Miller, J.D., C.N. Skinner, H.D. Safford, E.E. Knapp, and C.M. Ramirez. 2012a. Trends and causes of severity, size, and number of fires in northwestern California, USA. Ecological Applications 22:184-203. *(No increase in fire intensity was found in the Klamath region of California, which partially overlaps the Sierra Nevada management region.)*

Mote, P.W. 2003. Trends in temperature and precipitation in the Pacific Northwest during the twentieth century. Northwest Science 77:271–282. *(Steady increases in summer precipitation were found in the Pacific Northwest and Inland Northwest.)*

__High-intensity Fire Areas Naturally Regenerate Forests__:

Natural conifer regeneration is considerable following large, high-severity fire patches in mixed-conifer forests, indicating substantial natural resilience in these forests, including in the very rare circumstances in which a high-severity fire "reburn" occurs within a short timeframe.

Cocking MI, Varner JM, Knapp EE. 2014. Long-term effects of fire severity on oak-conifer dynamics in the southern Cascades. Ecological Applications 24: 94-107. *(High-intensity fire areas are vitally important to maintain and restore black oaks in mixed-conifer forests.)*

Crotteau JS, Varner JM, Ritchie M. 2013. Post-fire regeneration across a fire severity gradient in the southern Cascades. Forest Ecology and Management 287: 103-112. *(The authors found 710 conifer seedlings/saplings per hectare naturally regenerating in large high-severity fire patches.)*

Donato, D.C., et al. 2009. Vegetation response to a short interval between high-severity wildfires in a mixed-evergreen forest. Journal of Ecology 97: 142-154.

Haire, S.L. and K. McGarigal. 2008. Inhabitants of landscape scars: succession of woody plants after large, severe forest fires in Arizona and New Mexico. The Southwestern Naturalist 53: 146-161. *(A high diversity of tree and shrub species naturally regenerates after high-intensity fire [Table 1].)*

Haire, S.L. and K. McGarigal. 2010. Effects of landscape patterns of fire severity on regenerating ponderosa pine forests (*Pinus ponderosa*) in New Mexico and Arizona, USA. Landscape Ecology 25: 1055-1069. *(Natural post-fire conifer regeneration, within the same fire areas analyzed in Haire and McGarigal 2008, occurs in 100% mortality patches even 200 or more meters from the nearest live tree, and regeneration nearer to the live-tree edge occurs vigorously within a few years post-fire, increasing rapidly after 10-15 years post-fire [Fig. 5]. The proportion of the total high-intensity fire area that is more than 200 meters from the nearest live-tree edge was relatively small [Fig.2].)*

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.

__Beetle-killed Trees Do Not Increase Fire Intensity__:

Bark beetles are native species in western U.S. conifer forests, and areas with higher tree mortality from beetles do not burn more intensely when wildland fire occurs.

Bond, M.L., D.E. Lee, C.M. Bradley, and C.T. Hanson. 2009b. Influence of pre-fire tree mortality on fire severity in conifer forests of the San Bernardino Mountains, California. The Open Forest Science Journal 2: 41-47.

Donato, D.C., B.J. Harvey, W.H. Romme, M. Simard, and M.G. Turner. 2013. Bark beetle effects on fuel profiles across a range of stand structures in Douglas-fir forests of Greater Yellowstone. Ecological Applications 23: 3-20.

Simard, M., W.H. Romme, J.M. Griffin, and M.G. Turner. 2011. Do mountain pine beetle outbreaks change the probability of active crown fire in lodgepole pine forests? Ecological Monographs 81:3-24.

<u>High-intensity Fire Creates the Highest Overall Carbon Storage:</u>

The combination of snags and downed logs, along with post-fire regenerating shrubs and conifers, results in maximal levels of total biomass and carbon sequestration in high-intensity fire areas, and forest thinning operations designed ostensibly to reduce fire effects do not increase but, rather, decrease overall carbon stocks in forests.

Campbell, J.L., M.E. Harmon, and S.R. Mitchell. 2011. Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? Frontiers in Ecology and Environment doi: 10.1890/110057. *(Due to the extremely rare occurrence of high-intensity fire in any given area currently, and the repeated removal of biomass in multiple forest thinning operations over many decades in any given area that would be necessary to intersect high-intensity fire in time and space, thinning strongly tends to reduce forest carbon stocks.)*

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. *(The highest biomass and carbon sequestration is found in eucalypt forests of Australia that naturally experience periodic high-intensity fire.)*

Powers, E.M., J.D. Marshall, J. Zhang, and L. Wei. 2013. Post-fire management regimes affect carbon sequestration and storage in a Sierra Nevada mixed conifer forest. Forest Ecology and Management 291: 268-277. *(In Sierra Nevada mixed conifer forests, the highest total aboveground carbon storage was found to occur in mature/old forest that experienced 100% tree mortality in wildland fire, and was not salvage logged or artificially replanted, relative to lightly burned old forest and salvage logged areas [Fig. 1b]).*

<u>Current Forest Management is Not Effectively Protecting Homes, and Is Unnecessarily Putting Firefighters at Risk by Focusing on Remote Wildlands:</u>

Vegetation management designed to protect homes from fire is ineffective and unnecessary beyond approximately 40 meters from individual homes.

Cohen, J.D. 2000. Preventing disaster: home ignitability in the Wildland-Urban Interface. Journal of Forestry 98: 15-21.

Cohen, J.D., and R.D. Stratton. 2008. Home destruction examination: Grass Valley Fire. U.S. Forest Service Technical Paper R5-TP-026b. U.S. Forest Service, Region 5, Vallejo, CA. *(The vast majority of homes burned in wildland fires are burned by slow-moving, low-intensity fire, and defensible space within 100-200 feet of individual homes [reducing brush and small trees, and limbing up larger trees, while also reducing the combustibility of the home itself] effectively protects homes from fires, even when they are more intense.)*

Gibbons, P. et al. 2012. Land management practices associated with house loss in wildfires. PLoS ONE 7: e29212. *(Defensible space work within 40 meters [about 131 feet] of individual homes effectively protects homes from wildland fire, even intense fire. The authors concluded that the current management practice of thinning broad zones in wildland areas hundreds, or thousands, of meters away from homes is ineffective and diverts resources away from actual home protection, which must be focused immediately adjacent to individual structures in order to protect them.)*

For more information, please contact:

Chad Hanson, Ph.D., Director
John Muir Project of Earth Island Institute
P.O. Box 897
Big Bear City, CA 92314
530-273-9290
cthanson1@gmail.com