Annotated Bibliography of Literature on The Ecological Benefits of Fire And the Damage Caused by Post-Fire Logging

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The Center for Biological Diversity and John Muir Project (2014) explain:

> Burned forests are not dead zones, but rather teem with life. The reflex reaction to log after forest fires directly contradicts decades of scientific research showing both the immense ecological importance of post-fire landscapes and the significant harm that can occur when such areas are logged. Forest fires like the Rim fire are essential to maintain biological diversity in the Sierra's ecosystems, and burned and dead trees provide critical habitat to numerous wildlife species. Of course, a legitimate public-safety exception is warranted to protect the public from falling trees in heavily traveled corridors.
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> This report analyzes the Rim fire in relation to the relevant biological science and recommends: **Rather than industrial scale salvage logging, post-fire management should focus on activities that benefit forest health, water quality and the many species that depend upon fire for their very existence.** (Emphasis in the original.)

Numerous studies document the cumulative impacts of post-fire logging on natural ecosystems, which led 250 scientists concerned about post-fire logging to transmit their concerns to Congress. In their open letter to members of Congress (Scientists Post-fire Letter, 2013), the scientists state:

> (N)umerous scientific studies tell us that even in patches where forest fires burned most intensely the resulting post-fire community is one of the most ecologically important and biodiverse habitat types in western conifer forests. …Post-fire conditions serve as a refuge for rare and imperiled wildlife that depend upon the unique habitat features created by intense fire. … Moreover, it is the least protected of all forest habitat types and is often as rare, or rarer, than old-growth forest, due to damaging forest practices encouraged by post-fire logging practices.
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> Numerous studies document the cumulative impacts of post-fire logging on natural ecosystems, including the elimination of bird species that are most dependent on such conditions, compaction of soils, elimination of biological legacies (snags and down logs) that are essential in supporting new forest growth, spread of invasive species, accumulation of logging slash that can add to future fire risks, increased mortality of conifer seedlings and other important re-establishing vegetation (from logs dragged uphill in logging operations), and increased chronic sedimentation in streams due to the extensive road network and runoff from logging operations. We urge you to consider what the science is telling us: that post-fire habitats created by fire, including patches of severe fire, are

> ecological treasures rather than ecological catastrophes, and that post-fire logging does far more harm than good to the nation's public lands.
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> Moreover, it is the least protected of all forest habitat types and is often as rare, or rarer, than old-growth forest, due to damaging forest practices encouraged by post-fire logging practices.

A similar letter was sent to U.S. Senators and President Obama by 264 scientists in September 2015 (Scientists Post-fire Letter, 2013).

Hutto (1995) states, "Fire (and its aftermath) should be seen for what it is: a natural process that creates and maintains much of the variety and biological diversity of the Northern Rockies." Hutto (1995) further notes:

> Fire is such an important creator of the ecological variety in Rocky Mountain landscapes that the conservation of biological diversity [required by NFMA] is likely to be accomplished only through the conservation of fire as a process…Efforts to meet legal mandates to maintain biodiversity should, therefore, be directed toward maintaining processes like fire, which create the variety of vegetative cover types upon which the great variety of wildlife species depend.
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> Unfortunately, we are not currently managing the land to maintain the kind of early successional seral stages that follow stand-replacement fires and, hence, many fire-dependent plant and animal species. . . . Most of the forested landscape in the northern Rockies evolved under a regime of high-intensity, large fires every 50-100 years, not under a regime of low-intensity, frequent understory burns.
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> Indeed, stand-replacing crown fires are part of the fire regime that creates the biodiversity which the agency is required by law to insure. Put bluntly, there is a kind of ignorance, bordering on mass hysteria, that needs to be addressed in today's political climate, which sees all wildland fire as bad and all burned forests as wasted resources, a view which is every bit as dangerous (and actually quite consistent with) the now acknowledged agency ignorance that favored suppression of wildfires at all costs for many decades.

DellaSala and Hanson (2015) state:

> Along with the surge in scientific investigation into historical fire regimes over the past 10-15 years has come enhanced understanding of the naturalness and ecological importance of mixed- and high-severity fire in many forest and shrub ecosystems. Contrary to the historical assumption that higher-severity fire is inherently unnatural and ecologically damaging, mounting evidence suggests otherwise. Ecologists now conclude that in vegetation types with mixed- and high-severity fire regimes, fire-mediated age-class diversity is essential to the full complement of native biodiversity and fosters ecological resilience and integrity in montane forests of North America (Hutto, 1995, 2008; Swanson et al., 2011; Bond et al., 2012; Williams and Baker, 2012a; DellaSala et al., 2014). Ecological resilience is essentially the opposite of "engineering resilience," which pertains

to the suppression of natural disturbance to achieve stasis and control of resources (Thompson et al., 2009). Ecological resilience is the ability to ultimately return to predisturbance vegetation types after a natural disturbance, including higher- severity fire. This sort of dynamic equilibrium, where a varied spectrum of succession stages is present across the larger landscape, tends to maintain the full complement of native biodiversity on the landscape (Thompson et al., 2009).

…As discussed above, in mixed-severity fire regimes, higher-severity fire occurs as patches in a mosaic of fire effects (Williams and Baker, 2012a; Baker, 2014). In conifer forests of North America, higher-severity fire patches create a habitat type, known as complex early seral forest (DellaSala et al., 2014), that supports levels of native biodiversity, species richness, and wildlife abundance that are generally comparable to, or even higher than, those in unburned old forest (Raphael et al., 1987; Hutto, 1995; Schieck and Song, 2006; Haney et al., 2008; Donato et al., 2009; Burnett et al., 2010; Malison and Baxter, 2010; Sestrich et al., 2011; Swanson et al., 2011; DellaSala et al., 2014). Many rare, imperiled, and declining wildlife species depend on this habitat (Hutto, 1995, 2008; Kotliar et al., 2002; Conway and Kirkpatrick, 2007; Hanson and North, 2008; Bond et al., 2009; Buchalski et al., 2013; Hanson, 2013, 2014; Rota, 2013; Siegel et al., 2013; DellaSala et al., 2014; Baker, 2015; see also Chapters 2–6). The scientific literature reveals the naturalness and ecological importance of multiple age classes and successional stages following higher-severity fire, as well as the common and typical occurrence of natural forest regeneration after such fire (Shatford et al., 2007; Donato et al., 2009; Crotteau et al., 2013; Cocking et al., 2014; Odion et al., 2014). These and other studies suggest that mixed-severity fire, including higher-severity fire patches, is part of the intrinsic ecology of these forests and has been shaping fire- dependent biodiversity and diverse landscapes for millennia.

The black-backed woodpecker is a sensitive species. Cherry (1997) states:

The black-backed woodpecker appears to fill a niche that describes everything that foresters and fire fighters have attempted to eradicate. For about the last 50 years, disease and fire have been considered enemies of the "healthy" forest and have been combated relatively successfully. We have recently …realized that disease and fire have their place on the landscape, but the landscape is badly out of balance with the fire suppression and insect and disease reduction activities (i.e. salvage logging) of the last 50 years. Therefore, the black-backed woodpecker is likely not to be abundant as it once was, and continued fire suppression and insect eradication is likely to cause further decline.

USDA Forest Service (2000a) also finds that the removal of dead trees associated with post-fire logging has the potential for significantly changing wildlife habitat both structurally, through removing existing and future snags and large woody material, and functionally, by means such as reducing populations of insect prey. The majority of studies reviewed by USDA Forest Service (2000a) observed substantial adverse habitat impacts associated with post-fire logging. They note that habitat modification associated with salvage logging may particularly impact cavity nesting birds, and that aspects of a post-fire forest provide desirable habitat resources:

> In four recent independent studies conducted in the intermountain West, post-fire logging caused significant changes in abundance and nest density of cavity-nesting birds, although the effect differed somewhat by location (Caton 1996, Hejl and McFadzen 1998, Hitchcox 1996, Saab and Dudley 1998). Most cavity-nesters showed consistent patterns of decrease after logging, including the mountain bluebird and the black-backed, hairy, and three-toed woodpeckers; abundance of the Lewis' wood-pecker increased after logging.
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> Several authors point out that on a landscape scale, wildfire creates patches of highly attractive habitat for a distinct array of species (Hutto 1995). To maintain healthy metapopulations of these species over the landscape, post-fire patches should be managed with great care (Caton 1996, Hejl and McFadzen 1998, Hitchcox 1996, Saab and Dudley 1998).

Many adverse consequences to soil, ecological processes, wildlife, and other elements of the natural environment are associated with logging, including thinning. For example: "Salvage or thinning operations that remove dead or decayed trees or coarse woody debris on the ground will reduce the availability of forest structures used by fishers and lynx." (Bull et al., 2001.)

Considering that these forests have evolved with fire and thus regenerate successfully following fire, "salvage" logging can only disrupt the natural process of regeneration. The scientific understanding of post-fire forest regeneration and potential for major impacts of salvage actions on sensitive post-fire ecosystems suggests that a carefully contemplated rather than a hasty response is essential for seeing that the highest priority—restoration—will be accomplished. Lindenmayer, et al. (2004) note a whole host of ecosystem damaging aspects of post-fire logging:

> Natural disturbances and the biological legacies produced by them are often poorly understood by policy-makers and natural-resource managers. …(N)atural disturbances are key ecosystem processes rather than ecological disasters that require human repair.
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> …Major disturbances also can aid ecosystem restoration by recreating some of the structural complexity and landscape heterogeneity lost through previous intense management of natural resources. … Salvage harvesting activities undermine many of the ecosystem benefits of major disturbances. …
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> (S)alvage 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. …(S)alvage logging can impair ecosystem recovery. …(S)ome taxa may be maladapted to the interactive effects of two disturbance events in rapid succession.

Noss and Lindenmayer (2006) state:

> . . . available evidence points to often severe and long-lasting negative effects of postdisturbance logging on a wide variety of ecosystems and their biota. To log what is

> often the most biologically diverse and threatened forest condition in the landscape is fundamentally irrational.

Beschta et al. (1995) found:

> There is no ecological need for immediate intervention on the post-fire landscape. With respect to the need for management treatments after fires, there is generally no need for urgency, nor is there a universal, ecologically-based need to act at all. By acting quickly, we run the risk of creating new problems before we solve the old ones. Ecologically speaking, fires do not require a rapid human response. We should not talk about a "fire crisis" but rather of managing the landscape with the anticipation that fire will eventually occur. Given the high degree of variability and high uncertainty about the impacts of post-fire responses, a conservative approach is warranted, particularly on sites susceptible to on-site erosion. Although our current understanding of the ecological effects of postfire logging is incomplete, what we do know suggests that such logging can and often has resulted in significant damage to soils, streams and wildlife by: eliminating or significantly reducing large, dead standing trees critical for many wildlife species; damaging the soil through increased soil erosion and compaction; creating warmer, drier microclimate conditions (thereby increasing fire danger); simplifying forest structure; removing important sources of nutrients and organic material (potentially reducing long-term productivity); and, encouraging the spread of noxious weeds into burned areas. In short, post-fire logging reduces important components of the forest ecosystem, and tends to further exacerbate stresses caused by the initial disturbance event.

Beschta et al. (1995) question the ecological justifications of post-fire logging stating that while "there is little reason to believe that post-fire salvage logging has any positive ecological benefits… there is considerable evidence that persistent, significant adverse environmental impacts are likely to result from salvage logging, based on many past cases of salvage projects."

There is also no scientific support that post-fire logging is needed to reduce risk of future fires. Beschta et al. (1995) state they "…are aware of no evidence supporting the contention that leaving large dead wood material significantly increases the probability of reburn." Additionally USDA Forest Service (2000a) states, "no studies have specifically looked at how postfire logging alters the size distribution of fuel and the concomitant changes in future fire risk."

In a response to Beschta et al. (1995) commissioned by R-6 Regional Forester John Lowe, Everett (1995) conceded that there was "little to no evidence" that post-fire salvage removal of trees limits the intensity of future fires." He also found no support for frequent claims by salvage proposals that post-fire logging results in no more environmental damage than green harvest. The Forest Service recently addressed this discussion by reviewing the results of 21 studies of postfire logging (USDA Forest Service, 2000a). We note a general finding, "we know enough about both logging activity and structural change to recommend caution" in post-fire salvage operations.

Evidence that logging can affect vegetative production in the absence of significant ground disturbance was collected by Sexton (1998) in a study in central Oregon in post-fire ponderosa pine stands, logged over snow. Sexton found that biomass of vegetation produced 1 and 2 years after post-fire logging was 38 percent and 27 percent of that produced in post-fire unlogged stands. He also found that post-fire logging decreased canopy cover, increased exotic plant species, increased graminoid cover, and reduced overall plant species richness. Pine seedlings grew 17 percent taller on unlogged sites in this short-term study.

Ground based winter logging may not be effective mitigation for soil impacts and may impede recovery of the burned area. (USDA Forest Service, 2000a.)

Research suggests that post-fire recovery occurs best in the absence of logging and that logging hinders recovery (Donato et al. 2006). Riggers, et al. (2001):

> . . . emphasize the importance of wildfire, including large-scale, intense wildfire, in creating and maintaining stream systems and stream habitat. In western Montana, the two primary natural disturbance mechanisms responsible for initiating stream dynamics that ultimately increase habitat complexity and diversity are fires and floods. In the short-term, fires trigger other processes, such as erosion and woody debris recruitment, which are critical in the formation of young, biologically rich stream systems. Over longer time periods, fires recycle nutrients, regulate forest development and biomass, and maintain biological pathways (Keane, et al. 1999). The effect of fire on these processes is ultimately transferred to stream channels. Fires, and the ecological processes associated with them, are thus an integral part of maintaining our native fish populations.
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> . . . Post-fire activities such as (salvage logging) that increase the probability of chronic sediment inputs to aquatic systems pose far greater threats to both salmonid and amphibian populations and aquatic ecosystem integrity than do fires and other natural events that may be associated with undesired forest stand condition (Frissell and Bayles 1996).

Other research reports similar findings. DellaSala et al. 2006 state:

> Recent controversy concerning post-fire logging in Oregon is emblematic of the problems of "salvage logging" globally. Although tree regeneration after disturbances in forested areas is important, a narrow view of this issue ignores important ecological lessons, especially the role of disturbances in diversifying and rejuvenating landscapes. Scientific advances in recent decades demonstrate that disturbances are not catastrophes, trees in these landscapes are not wasted if they are not harvested, and post-fire logging is not forest restoration. (Disturbances) create and sustain the structure and composition of forests; disturbed areas also support species that are rare or absent from closed-canopy forests, including many that are restricted to recently burned areas.
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> . . . When viewed through an ecological lens, a recently disturbed landscape is not just a collection of dead trees, but a unique and biologically rich environment that also contains many of the building blocks for the rich forest that will follow the disturbance.
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> . . . Ecological damage caused by post-disturbance logging may outweigh short-term economic benefits. If conducted improperly, timber harvest of any kind damages soils and

> below-ground processes, spreads invasive species, increases sediment delivery to streams and destroys or degrades key environments for terrestrial and aquatic species. With post-disturbance logging, however, these impacts occur when forest recovery is most vulnerable to the effects of additional especially anthropogenic, disturbances, creating cumulative effects not associated with logging in undisturbed forests. Such effects can extend for a century or more, because of the removal of long-persisting and functioning biological legacies. Moreover, a focus on post-disturbance logging will divert the attention of forest managers from conducting legitimate fuels reduction in fire-prone areas by, thinning overly stocked trees and undergrowth…

Karr et al. (2004) in an evaluation of the effects of post-fire salvage logging on aquatic ecosystems provides the following background:

> Throughout the American West, a century of road building, logging, grazing, and other human activities has degraded stream environments, causing significant losses of aquatic biodiversity and severe contractions in the range and abundance of sensitive aquatic species, including native salmonid fishes (Reiman et al. 2003). Compounding these problems, federal land management has worsened ecological degradation, rather than conserving or restoring forest ecosystems (Leopold 1937, Langston 1995, Hirt 1996). Land managers' focus on commodity extraction sharpened by recent changes in forest policy, regulations, and laws that encourage salvage logging after fires perpetuates this trend and its harmful impacts.

Karr et al. (2004) also state, "Although often done in the name of postfire restoration, salvage logging typically delays or prevents natural recovery in several important ways (Beschta et al. 1995, 2004, Lindenmayer et al. 2004)." Noss et al. (2006) also shows the problem with post-fire logging. Beschta, et al. (2004) state: "Forest ecosystems in the western United States evolved over many millennia in response to disturbances such as wildfires. …Forest ecosystems area especially vulnerable to postfire management practices because such practices may influence forest dynamics and aquatic systems for decades to centuries." The plethora of information strongly implicates post-fire logging as ecologically detrimental.

Fire is a natural and essential component of forest ecosystems and the presence of fire indicates high degrees of ecosystem function. Beschta et al. (1995) state, "Land managers should be managing for the naturally evolving ecosystems, rather than perpetuating artificial ones we have attempted to create."

Post-fire forests are extremely susceptible to erosion. While roads have extremely detrimental impacts on unburned forests (through changing water flow patterns, increasing erosion, and influencing wildlife habitat and migration), their impacts are greatly intensified on burned landscapes. Your analysis must carefully consider the post-fire stability of roads in the project area. Any roads with high erosion potential must be considered for obliteration. The impacts of the current road network in the project area must be disclosed and analyzed.

The Johnson Bar Fire Salvage Final EIS (Nez Perce/Clearwater National Forests, 2016) states:

> Haul roads can be a source of sediment to project area streams, particularly where there are existing sediment delivery points (roadside ditches leading to stream channels). Increased heavy-truck traffic related to log hauling can increase rutting and displacement of road-bed material, creating conditions conducive to higher sediment delivery rates (Reid and Dunne, 1984).

Roads often have devastating impacts on water quality and fish habitat by increasing landslides, erosion, and siltation of streams. Roads also fragment forests and degrade or eliminate habitat for species that depend on remote landscapes, such as bears, wolves, and other large, wide-ranging predators (Trombulak and Frissell 2000).

USDA Forest Service (2000a) cite several studies that find that "post-fire logging associated with road building, conducted with ground-based log retrieval systems, or undertaken in stands having steep slopes and sensitive soils likely will have the greatest potential for exacerbating the erosion problems typically observed in burned watersheds."

Old-growth forests feature valuable habitat characteristics because of the diversity found only in old growth. Even after a disturbance such as severe fire, these stands retain important habitat characteristics found nowhere else.

In 2015, Dr. Jerry Franklin wrote a letter to the Forest Service concerning a post-fire project proposed for Late Successional Reserves (LSRs) in a national forest covered under the Northwest Forest Plan (NWFP). Dr. Franklin was a principle scientist that assisted the Forest Service in creation of the NWFP as a member of the Forest Ecosystem Management Assessment Team (1993). His letter stated, "Given the important and well defined ecological role assigned the LSRs in the ...(NWFP) I have paid special attention to the scientific rationale offered for the extensive salvage logging that is proposed in LSRs." His specific comments (Franklin, 2015) include:

> Salvage logging of large snags and down boles does not contribute to recovery of late-successional forest habitat; in fact, the only activity more antithetical to the recovery processes would be removal of surviving green trees from burned sites. Large snags and logs of decay resistant species, such as Douglas-fir and cedars, are particularly critical as early and late successional wildlife habitat as well as for sustaining key ecological processes associated with nutrient, hydrologic, and energy cycles.
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> Stand-replacement fires provide large pulses of coarse woody debris (CWD) including snags and logs, which lifeboat dependent species and processes until the regenerating forest begins to produce large and decay-resistant dead wood structures, which is typically not for a century or more. Since this pulse provides all of the large CWD that is going to be available to the ecosystem for at least the next 100 to 150 years, it is not appropriate to use the levels of CWD found in mature and old stands of a particular Plant Association Group (PAG) as a guide to levels of CWD that should be retained after salvage. Effectively none of the large snags and logs of decay-resistant species can be viewed as being in excess of what is needed to assist in natural recovery to late-successional forest conditions and, hence, appropriate for salvage on land allocations where ecological objectives are primary,

such as LSRs. Retention of large snags and logs are specifically relevant to Northern Spotted Owl (NSO) since these structures provide the habitat that sustain most of the owl's forest-based prey species.

Large snags and logs are the most important surviving structural elements or biological legacies of a forest disturbance (Franklin et al. 2002), excepting only surviving large live trees. Importance, in this case, refers to the roles of these structures in:

(1) Providing essential habitat for an immense array of species;
(2) Maintaining important ecosystem functions; and
(3) Structurally enriching the young forest stands, making it possible for mid- and late-successional species to re-colonize the stand much earlier in its chronological development than would otherwise be the case (Franklin et al. 1987).

(Large snags and down wood) ...structures provide habitat for early as well as late successional species and sustain many important ecosystem processes (e.g., Harmon et al. 1986). ...(L)arge Douglas-fir logs continue to fulfill important ecological functions, such as habitat for small mammals and salamanders, for 200 to 250 years after their death. Cedar snags can persist for at least as long as 1½ centuries and as logs for over twice that long.

The massive input of large dead wood is characteristic and critical to stand development processes and the ultimate provision of habitat for late-successional species following stand replacement fires (Maser et al., 1988; Franklin et al. 2002). As noted, these wood structures may persist and play functional roles for several centuries, particularly in the case of decay resistant species. Large pines may also persist as snags for several decades and additional periods as logs on the forest floor. In fact, the entire recovering forest ecosystem will depend upon this pulse of CWD until it reaches a point in its development where the new stand begins to generate snags and logs of comparable size and heartwood content—generally between 100 and 200 years (Maser et al., 1988; Franklin et al. 2002).

Consequently, basing snag and CWD retention following salvage on levels of these structures found in existing mature and old forests is not appropriate; *all of this initial pulse of wood is needed to reach those levels one to two centuries from now!* Indeed, the use of mature forests as a standard for CWD is particularly inappropriate since this is the period when CWD levels are at their lowest level during the entire *natural* developmental sequence from stand-replacement fire to old growth.

Jones and Grant (1996) describe the relationship of roads and clearcutting:

The addition of roads to clear-cutting in small basins produced a quite different hydrologic response than clear-cutting alone, leading to significant increases in all sizes of peak discharges in all seasons, and especially prolonged increases in peak discharges of winter events. These results support the hypothesis that roads interact positively with clear-cutting to modify water flow paths and speed the delivery of water to channels during storm events, producing much greater changes in peak discharges than either clear-cutting or roads alone. Roads alone appear to advance the time of peak discharges and increase them slightly. Road surfaces, cutbanks, and ditches, and culverts all can convert subsurface flow paths to surface flow paths (Harret al., 1975; King and Tennyson, 1984; Wemple, 1994; Wright et al., 1990). Reid (1991) and Reid and Dunne (1984) estimated discharges from culvert outfalls in western Washington and associated them with runoff from road surfaces.

Post-fire logging and pre-fire thinning reduce on-site carbon storage by removing tree boles from the forest as logs. Research finds that tree boles, even in severely burned forests, account for less than 5% of the carbon released during fire, which consumes primarily needles and surface fuels. Even in high severity fires, only about 25% of above-ground carbon stores are released. For these reasons, research finds that forest thinning in anticipation of fire releases more carbon to the atmosphere than would fire (Meigs et al 2009, and Campbell et al 2007).

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