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A New Forest Fire Paradigm

THE NEED FOR HIGH-SEVERITY FIRES

By Monica L. Bond, Rodney B. Siegel, Richard L. Hutto, Victoria A. Saab, and Stephen A. Shunk



Credit: Derek Lee

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During the 2012 fire season from June through August, wildfires in the drought-stricken western and central United States burned more than 3.6 million acres of forest and shrubland. In the hot, dry, windy conditions seen that season, a single spark can start an understory fire that ascends into the canopies of overstory trees and results in a ‘mega-fire’ that escapes control efforts, threatens human life and property, and chars wide swaths of forest. But in the aftermath, a host of pyrophilic organisms such as fire morel mushrooms (*Morchella elata*), Bicknell’s geraniums (*Geranium bicknellii*), jewel beetles (*Melanophila acuminata*), and black-backed woodpeckers (*Picoides arcticus*) exploit these burned areas for critical habitat elements that are abundant only after such large-scale disturbances. These species are not merely opportunistic. Their distribution is often restricted to severely burned forest conditions.

Forest fires, particularly those that burn at mixed and high severity (collectively called ‘severe’), have been traditionally perceived as catastrophic events, directing public attention and immense forest management budgets toward fire prevention and suppression. These fires may indeed be catastrophic when measured by losses of human lives and property. However, severe fires in wildland areas are both natural and necessary to maintain the integrity of dynamic, disturbance-adapted forest systems. We propose a change in the current paradigm—which holds that severe forest fires are always harmful—to a new one that embraces their ecological necessity.

Fire regimes—the pattern, frequency, and intensity of wildfires—are highly variable among forest types and regions, and fire severity differs with vegetation type, geographical location, management history, and weather. Severe fire is natural in forests in all regions of the U.S., and only mixed- and high-severity fires are intense enough to initiate ecological succession across all regimes. High-severity fires, also called stand-replacement or crown fires, cause

widespread mortality of existing vegetation and result in a forest structure no longer dominated by live trees but by herbs, shrubs, and dead trees or snags (Smith 2000, Saab and Powell 2005). In contrast, low-severity or understory fires consume ground-layer vegetation and duff, but rarely kill overstory trees and do not substantially alter forest structure (Smith 2000, Schoennagel et al. 2004). Mixed-severity fires cause patchwork mortality due to species’ varying fire tolerance or because of a combination of high- and low-severity burn patches. Both mixed- and high-severity fires can create burn patches of different size and severity, resulting in a complex mixture of habitats (Baker 2009).

Forest fire management practices strive to alter natural fire regimes by reducing the frequency, intensity, or extent of fires. On public and private lands, fire-fighting crews target man-made fires of any severity, whereas fires caused by natural ignitions may be permitted to burn under supervision on some public lands. When a fire begins, crews are deployed by the responsible agency to cut firebreaks or set up intentional burns that move in the direction of the fire’s front line, depriving it of the fuel it needs to advance. Under extreme weather conditions such as strong winds and high temperatures, fires are difficult to control, so firefighters often focus instead on protecting structures and evacuating vulnerable areas. Pre-fire treatments such as logging and prescribed burning to reduce fuel load are widespread in managed forests.

Post-fire Winners and Losers

At first glance, a stand of scorched, dead trees in a severely burned forest may appear to be an ecological wasteland. Yet many species of plants and animals actually increase in abundance following high-severity fire, and some species depend on severe fire to meet their ecological requirements. Severe fire is a natural element of healthy, dynamic forest ecosystems and even riparian forests in Canada and the western U.S., as it has been for eons (Arkle and Pilliod 2010). Indeed, fire is as essential as rainfall and sunlight to many forest species.

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As with any natural disturbance, severe fire leaves winners and losers. Species that depend on unburned, green forests will suffer habitat loss in severely burned stands. Golden-crowned kinglets (*Regulus satrapa*) and Townsend's warblers (*Setophaga townsendi*), for example, forage in the canopies of living trees in western coniferous forests, and will lose ground.

But many other species benefit. Some of the earliest to arrive after severe fire are bark beetles (Coleoptera: Curculionidae, subfamily Scolytinae) and wood-boring beetles (Coleoptera: Buprestidae, Cerambycidae). These specially adapted beetles are equipped with sensory organs that detect smoke and heat from kilometers away, prompting them to swarm in huge numbers to newly charred forests where they deposit millions of eggs onto the bark of dead and dying trees (Evans 1964, 1966; Hart 1998; Saint Germain et al. 2004). The eggs soon hatch into larvae that either burrow between the bark and cambium or into the sapwood. Woodpeckers that thrive on beetle larvae arrive next, particularly in areas with a high density of dead trees, their numbers peaking within the first few post-burn years (Saab et al. 2007, Hutto 2008, Hanson and North 2008).

Many specialized shrub and flower seeds require fire for germination, as do those of serotinous pines, and thrive in soils that are enriched by burned vegetation. Blooming annuals and perennial shrubs attract legions of insects which become prey for insectivores. Some insectivorous birds, such as mountain bluebird (*Sialia currucoides*), house wren (*Troglodytes aedon*), olive-sided flycatcher (*Contopus cooperi*), and even the flycatching Lewis's woodpecker (*Melanerpes lewis*), are so well adapted to feed upon the post-fire insect bonanza that they occur at their highest densities in forests that recently burned at mixed and high severity.

For example, in a study of pre- and post-fire bird abundance in coniferous forests of Montana's Bitterroot National Forest, olive-sided flycatchers increased by an average of four birds at moderately burned point count stations and more than 21 at high-severity burned stations. Likewise, mountain bluebirds increased by more than five and 18 birds, respectively (Smucker et al. 2005). In New Mexico mixed-conifer forests, house wren density nearly quadrupled at high-severity burned sites over unburned sites (Kotliar et al. 2007). Similar results were documented in a diversity of mountainous

coniferous forests in Montana, Wyoming (Hutto 1995), Idaho (Saab et al. 2007), Arizona, New Mexico (Bock and Block 2005), southwestern Oregon (Fontaine et al. 2009), and California's Sierra Nevada (Raphael et al. 1987).

Bats also benefit from the fire-induced pulse of insect prey. In central Idaho's mixed-conifer forests,



Credit: Stephen A. Shunk

Portions of a forest burned by a 2,700-acre fire in California's Lake Tahoe Basin were left intact (top), retaining severely burned forest habitat for pyrophilic organisms. In logged areas, however, far fewer burned trees remain. In the 1,800-acre Cougar Butte fire in California's Modoc National Forest (bottom), trees marked with an orange "W" (visible on tree at left) were spared, but such isolated trees cannot satisfy the needs of fire- and snag-dependent wildlife.



Credit: Stephen A. Shunk



emerging adult aquatic insects increased fivefold while bat detections increased fourfold in severely burned versus unburned or lightly burned watersheds (Malison and Baxter 2010). Bats also roost in

burned out basal tree hollows, and they benefit from increased sunlight penetration through fire-created tree canopy gaps, which aids their thermoregulation (Boyles and Aubrey 2006, Johnson et al. 2009, Lacki et al. 2009).

As early as the 1950s, studies of mule deer (*Odocoileus hemionus*) documented increased population size and reproductive rates in a variety of ecosystems, including shrub lands, open woodlands, and conifer forests. For example, in severely burned California chaparral, deer population densities were

two (Ashcraft 1979) to four (Biswell 1961) times greater, and there were nearly twice as many fawns per doe (Taber and Dasmann 1957, Biswell 1974). In addition, deer droppings were significantly more abundant in burned than unburned pinyon-juniper woodlands in Arizona, with 35 pellet groups per acre per month versus 26, respectively (McCullough 1969). The availability (Snyder 1991) and palatability (Zimmerman et al. 2006) of vegetation eaten by deer increased after fire, and deer preferred to forage in burned forests as long as dead trees were left standing to provide protective cover in pinyon-juniper forests in Arizona (McCullough 1969) and lodgepole pine (*Pinus contorta*) forests in Wyoming (Davis 1977).

The ability to use severely burned forests even extends to some unlikely characters, including the spotted owl (*Strix occidentalis*), the classic poster-child for dense, old-growth forests. Spotted owls tend to nest and roost in forests with dense canopies and larger trees, but they may benefit from fires that create more open habitat patches ideal for hunting prey (Bond et al. 2009). Spotted owls have relatively large territories, and they will occupy areas containing high-severity burns, as long as some unburned or lightly burned habitat remains for nesting and roosting (Bond et al. 2002, Jenness et al. 2004, Roberts et al. 2011, Lee et al. 2012).

An Icon for Burned Forests

Controversy over fire management in forests that experience mixed- and high-severity fire regimes has grown, and one pyrophile speaks loudest for species that benefit from severe fire—the black-backed woodpecker. This bird is perhaps the most iconic winner in the post-fire landscapes of the western U.S. and Canada. Abundant research from California to Quebec consistently confirms the bird's strong affinity for severely burned forests throughout its range, positioning it as one of the most specialized North American birds—one with a distribution that matches the historical footprint of severe fire (Hutto et al. 2008).

The black-backed woodpecker makes use of both large and small patches of dead trees for nesting and foraging, reaching its highest densities in forests with numerous trees recently killed by fire (Hutto 1995, 2008, Saab et al. 2007, Vierling et al. 2008, Saab et al. 2009, Saracco et al. 2011). In a survey of 16,465 point count stations spanning 14 years and 20 vegetation types throughout northern Idaho and Montana, Hutto (2008) documented that 96 percent of all black-backed woodpeckers occurred in burned forest stands. The species may be the best-adapted woodpecker in the world for extracting wood-boring beetle larvae from fire-killed trees. The black-backed and many other woodpecker species play a keystone ecological role in burned forests by excavating nest cavities that are later used by secondary cavity-nesting birds (Saab et al. 2004), including western and mountain bluebirds, house wrens, and small forest owls. Woodpecker cavities are also utilized by innumerable forest invertebrates and mammals, such as martens (*Martes americana*), fishers (*Martes pennanti*), and several bat and squirrel species.

A group of conservation organizations recently petitioned the U.S. Fish and Wildlife Service to give the California, Oregon, and South Dakota populations of the black-backed woodpecker protection under the Endangered Species Act. If listed, the bird would become the first protected animal species that is associated with severely burned forests.

Changing the Fire Paradigm

Land management agencies have long embraced the ecological role of low-severity fire in forest ecosystems, that is to maintain sparse, open stands of larger trees by burning grasses and litter and killing smaller trees (Noss et al. 2006). Yet high-severity fire continues to be viewed negatively by some land



Credit: Joseph Leibracht

As it excavates a nest cavity in California's Lassen National Forest, a black-backed woodpecker (*Picooides arcticus*) emerges from a charred tree to dump a beakful of wood. Many species of birds, mammals, insects, and plants depend on high-severity forest fires to complete their lifecycles.



managers and the general public. These attitudes are reinforced by the [Smoky Bear](#) ad campaign of the U.S. Forest Service and the National Association of State Foresters. Videos and posters teach the public that the only good fires are prescribed, low-severity fires that recreate the beneficial effects of natural ones while avoiding catastrophic losses associated with uncontrolled fires. This message, along with management directives promulgating suppression of high-severity fires, persists despite evidence that the creation of abundant snag-dominated stands that occur in the wake of severe fire are critical to many species in Canada and the western U.S. ([Saab and Powell 2005](#), [Kotliar et al. 2007](#), [Hutto 2008](#), [Fontaine and Kennedy 2012](#)).

A growing body of research suggests that the current fire paradigm—that low-severity fire is natural and high-severity fire is unnatural and undesirable—may be changing. Two-thirds of all wildlife species use snags or other woody debris which is abundant in a post-fire landscape for some portion of their life cycles ([Brown 2002](#)). Numerous studies on the widespread practice of post high-severity fire salvage logging have documented adverse effects on the black-backed woodpecker and other cavity-nesting bird species (e.g., [Hutto and Gallo 2006](#), [Hutto 2006](#), [Hanson and North 2008](#), [Cahall and Hayes 2009](#), [Saab et al. 2007, 2009, 2011](#)). Post-fire logging reduces the density and diversity of snag sizes, which in turn reduces nesting habitat. For example, nesting densities of black-backed woodpeckers in western Idaho were five times lower in partially salvage-logged stands than in unlogged stands ([Saab et al. 2007](#)). And in the Sierra Nevada, black-backed woodpeckers preferentially foraged in severely burned stands with larger snags and higher snag densities ([Hanson and North 2008](#)). These studies raise concerns over the impacts of logging in recently burned forests in Canada and the western U.S. and emphasize the unique ecological role of high-severity fire in these habitats.

Some forest managers have begun to recommend retaining some stands of severely burned forests in their management plans. For example, the Sierra Nevada Forest Plan Amendment in California proposes guidelines for retaining at least 10 percent of severely burned forest stands during post-fire logging operations, and actual retention rates have often been higher than that. These are promising recommendations, but unfortunately because they are not based on a thorough analysis of the habitats

required to sustain fire-dependent species, it is not clear whether 10 percent retention is high enough to ensure that the protected areas contain the density and variety of snags needed to provide adequate foraging substrate and nesting and shelter opportunities for wildlife in the post-fire ecosystem.

The U.S. Forest Service Pacific Northwest Region (PNR) took a step in this direction by developing a tool that uses scientific data on wildlife habitat relationships with dead wood to help managers make decisions on sizes and amounts of snags to retain for wildlife needs in Washington and Oregon forests ([Mellen-McLean et al. 2012](#)). The tool—called [DecAID](#)—presents solutions to meet wildlife management objectives in specific, quantitative terms that can be monitored. DecAID has been used in every NEPA document developed by National Forests in the USFS Pacific Northwest Region since 2006, resulting in more scientifically rigorous environmental analyses and reduced litigation (Kim Mellen-McLean, PNR Ecologist, personal communication, October 2012).

Now is the time to recognize the critical ecological value of severely burned forests so that the public and the agencies under its trust can begin to accept and even welcome mixed- and high-severity fires. This can be accomplished by collating the extensive body of scientific literature on the importance of post-fire habitats and the harm caused by snag removal in these systems, and by making this information easily available to decision-makers and the media. Scientists and forest biologists working in fire-adapted forest ecosystems need to become effective spokespeople for the new paradigm.

Only with regulatory protection for burned habitats can fire-dependent organisms thrive. Where conservation of wildlife and maintenance of ecological processes is the management goal, such protections include allowing naturally ignited and man-made fires of all severities to occur in wildland areas, and curtailing post-fire salvage-logging, with a focus on retaining large patches with high snag densities. Continued research into natural post-fire succession and habitat needs of wildlife in unlogged post-fire ecosystems will provide valuable insights into how to best manage disturbance-adapted forests to protect and enhance biological diversity. ■

This article has been reviewed by subject-matter experts.

