POST-DISTURBANCE LOGGING SUMMARY OF KEY STUDIES AND FINDINGS[1]

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EXECUTIVE SUMMARY:

Post-disturbance recovery, much like fire itself, has been the subject of intense debate and widespread misunderstanding regarding how and whether to treat regenerating landscapes following large disturbance events. As HR4200 – the Forest Emergency Recovery and Research Act – heads to the Senate for debate, it is important that lawmakers and land managers consider the latest science in making informed decisions about the management of public lands following natural disturbances. Numerous scientific studies have demonstrated that natural disturbances, even very large ones such as volcanic eruptions, wildfires, and severe wind storms, are critical to the health of terrestrial and aquatic ecosystems as they are characterized by unique biological communities and generate important structural elements that forests depend on for decades to centuries. The standing dead, dieing, and downed trees (especially large ones) and surviving green and scorched ones transfer their critical functions from the pre-disturbed forest to the regenerating one. When post-disturbance "salvage logging" removes these important forest elements, it sets back recovery triggering ecosystem damages that may exceed the impact of the initial disturbance itself. Based on a review of approximately 38 scientific studies on post-fire logging and additional government

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reports published to date, not a single study indicated that logging benefits ecosystems regenerating after natural disturbance. In fact, post-fire logging impedes regeneration when it compacts soils, removes "biological legacies" (e.g., large dead standing and downed trees), introduces or spreads invasive species, causes soil erosion when logs are dragged across steep slopes, and delivers sediment to streams from logging roads. With post-disturbance logging these impacts occur when forest recovery is most vulnerable to the effects of additional, especially anthropogenic disturbances, creating cumulative effects that exceed logging of undisturbed forests. Such effects can extend for a century or more, because of the removal of long-persisting and functioning wood legacies. These findings are especially relevant to public lands policy and management as post-disturbance logging currently generates ~40 percent of the timber volume on Forest Service lands nation-wide (USFS Washington Office, timber volume spread sheets - Timber Management Staff, 2005 statistics). Therefore, the following conclusions were provided to assist decision makers regarding post-disturbance management decisions: (1) post-disturbance landscapes should be allowed to regenerate naturally as evidence from several locations (Biscuit fire (sw Oregon), Storrie and Starr fires (California Sierra's), Yellowstone 1988 fires, Mt. St. Helens eruption, New England hurricanes and insect infestations) indicates recovery can be surprisingly swift and many species that colonize disturbed areas are adapted to them, contributing to recovery in unique ways; (2) road building (even temporary roads) damages regenerative processes in terrestrial and aquatic ecosystems and should be avoided; (3) natural disturbances are characterized by unique biological legacies (large dead and dying trees) essential to regenerative processes – recovery is not possible in their absence; and (4) if salvage logging is to take place for economic reasons, large trees should be retained to protect their biological legacy functions and "no harvest zones" established on steep slopes with fragile soils, including areas of conservation and public health concern such as late-successional and old-growth forests, riparian areas, aquatic watersheds essential to drinking water municipalities, and roadless areas.

INTRODUCTION

Recent passage of HR4200 – the Forest Ecosystem Recovery and Research Act – in the House and growing interest in post-fire logging have prompted this summary on the state of scientific knowledge regarding post-disturbance landscapes and their management. The objectives of this report therefore were to: (1) summarize current scientific understanding regarding post-disturbance management in the context of disturbance ecology and with application to congressional legislation (HR4200); and (2) provide key findings and recommendations to lawmakers and others on how to properly manage post-disturbance landscapes in a way that contributes ecologically to recovery.

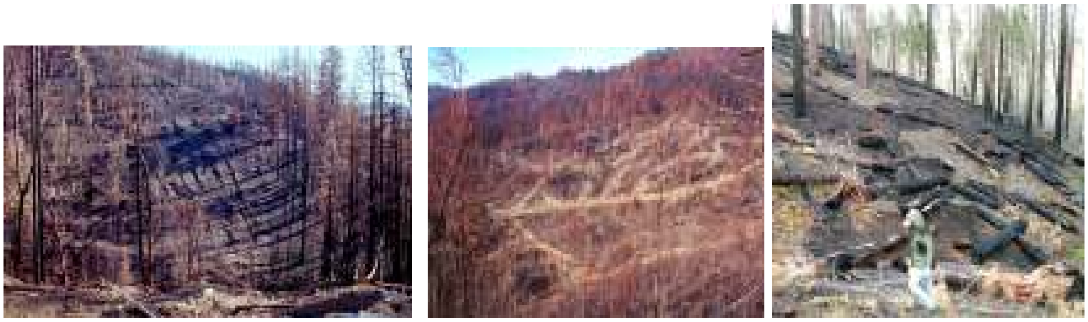
Traditional forestry has viewed fire as bad and dead trees as a waste and has assumed dead trees and burnt landscapes provided little or no ecological value to forest ecosystems and must be replaced through aggressive reforestation methods coupled to post-disturbance logging. These views have skewed public policies about the presumed yet undocumented ecological benefits of post-disturbance logging. Current scientific understanding, however, recognizes that disturbance and dead trees are in fact critical to forest health. Science, therefore, has an important role to play in informing post-disturbance policy so that informed decisions can be made regarding the future of public lands and their many values.

Lessons from disturbance ecology indicate that when natural disturbance events are preceded and/or followed by land management activities they often generate cumulative impacts that can impair the recovery of forest ecosystems (Paine et al. 1998, Schiegelow et al. 2006, Foster and Orwig 2006, Lindenmayer and Noss 2006). While there is much to learn about post-disturbance ecology and post-disturbance logging impacts, the body of published scientific findings indicates that post-disturbance logging and related activities are most often detrimental to ecosystem regeneration and can impede or prevent recovery. The sum of negative effects of salvage operations often does enough damage to inhibit forest recovery; even restocking with conifers will typically not reverse or cancel those effects. Negative impacts of post-disturbance logging can persist for decades to centuries, particularly when large trees (dead and dieing trees, scorched trees, downed logs) are removed as these “legacy” components transfer ecosystem functions from pre-disturbed to post-disturbed conditions and are therefore vital to recovery (Franklin and Agee 2003). Removing biological legacies through salvage logging generates cumulative effects to ecosystems that can exceed the initial disturbance itself (Foster and Orwig 2006, Noss and Lindenmayer 2006).

Of the ~38 scientific papers on post-fire logging and additional government reports published to date, not a single one indicated that logging provides benefits to ecosystems regenerating post-disturbance. In general, post-disturbance logging impedes regeneration when it compacts soils, removes “biological legacies” (e.g., large dead standing and downed trees), introduces or spreads invasive species, causes soil erosion when logs are dragged across steep slopes, and delivers sediment to streams from logging roads (for recent reviews see Lindenmayer et al. 2004, Karr et al. 2004, Beschta et al. 2004, Noss and Lindenmayer 2006, Lindenmayer and Noss 2006).

The severity of impacts to ecosystems recovering from natural disturbance depends on: (1) size and intensity of the logging operation (scale); (2) the logging methods used (e.g., ground-based vs full or partial log suspension vs helicopter hauling); (3) the types of materials removed and retained (i.e., large vs small trees); (4) the inherent sensitivity or resiliency of sites to disturbances (depends on soil types, site conditions, burn severity, plant association group, distance to nearby seed source, past management); and (5) the condition of lands prior to disturbance (lands already degraded by management are slower to recover due to cumulative impacts from past and ongoing practices). In congressional testimony to the House Subcommittee on Resources (November 10, 2005), prominent forest ecologist and University of Washington Professor Jerry Franklin said *“timber salvage is most appropriately viewed as a ‘tax’ on ecological recovery. The tax can either be very large or relatively small depending upon the amount of material removed and the logging techniques that are used.”*

POST-FIRE LOGGING– CURRENT STATE OF SCIENTIFIC KNOWLEDGE



Post-fire logging soil impacts – Quartz Creek fire (left and center, D. DellaSala) and Biscuit fire area (right, C. Frissell), southwest Oregon

Critical Reviews of Post-disturbance Logging

McIvar and Starr 2000 - one of the first syntheses on post-fire logging was published by scientists from the Forest Service's Pacific Northwest Research Station (McIver and Starr 2000). As summarized from a literature review of 21 papers at the time on post-fire logging, the authors note:

- 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 erosion typically observed in burned watersheds;
- the scope and scale of immediate environmental effects of management in the post-fire environment depend on several specific features of burned stands, including the intensity of the burn, slope, soil texture and composition, the presence or building of roads, and post-fire weather conditions;
- log retrieval systems differ substantially in their immediate effect on soils in the post-fire environment, in general, ground-based skidding causes the greatest immediate soil effect, followed by skidding over snow, skyline, and helicopter retrieval;
- proper recovery and rehabilitation techniques by mangers under certain conditions may be capable of mitigating soil loss and erosion problems associated with post-fire logging (although see Reeves et al. 2006 for discussion regarding lack of empirical evidence in riparian areas for this supposition);

- post-fire logging immediately after establishment of new seedlings can increase significantly mortality of tree seedlings (also see Donato et al. 2006);
- post-fire logging followed by broadcast or slash burning can cause significant changes to plant succession, including establishment of non-natives (also see Beschta et al. 2004, Karr et al. 2004, Reeves et al. 2006);
- log skid trails formed in post-fire stands can influence productivity of trees growing directly on them;
- post-fire logging can reduce vegetation biomass, increase exotic plant species, increase graminoid (grass) cover, reduce overall plant species richness and reduce survival of planted seedlings relative to unsalvaged areas (also see Foster and Orwig 2006);
- post-fire logging removes a great percentage of large dead woody structure and has the potential for significantly changing post-fire wildlife habitat (also see Lindenmayer et al. 2004, Beschta et al. 2004, Hutto 2006);
- through removal of vulnerable trees, post-fire logging can reduce probability of insect pest populations, (however, see notes on Don Goheen's seminar presentation below, Foster and Orwig 2006, and Black 2005 for contrary findings on this issue); and
- post-fire logging causes significant decrease in cavity nesting birds in the Rockies (also see Smucker et al. 2005, Hutto 2006).

Based on these studies, McIver and Starr (2000) concluded that "*we know enough about both logging activity and structural change to recommend caution. Although ground-based logging activity could mitigate for erosion problems under certain conditions, it is more likely that it will either have no effect or produce more sediment than that produced by the fire.*"

Lindenmayer et al. 2004 - In a global synthesis of post-fire logging case studies published in *Science*, Lindenmayer et al. (2004) found that "natural disturbances are key ecosystem processes rather than ecological disasters that require human repair" and concluded *"salvage harvesting activities undermine many of the ecosystem benefits of major disturbances."* Examples given by the authors include:

- extensive post-disturbance logging after a 1938 New England hurricane produced a long-lasting shift in hydrological regimes on a regional scale;
- soils in blown down forests in Baxter State Park in Maine where post-fire logging occurred were more affected by a subsequent fire than soils in comparable forests where salvage had not occurred;
- post-fire logging after a 1939 wildfire in Victoria contributed to a shortage of cavity trees for more than 40 species of vertebrates, including some endangered ones;
- post-fire logging in southeast Asia of burned rainforests led to substantial forest deterioration and loss with major negative impacts on regenerative potential of stands; and
- understory plants in southeastern Australia such as tree ferns were reduced by fire and logging.

The authors cautioned against resource managers making hasty decisions that can have long-lasting ecological consequences.

Beschta et al. 2004 - prior to the controversy surrounding the current Donato et al (2006) study published in *Science*, a paper published by Beschta et al. (2004), critical of post-fire logging, drew intense debate (note - most of the controversy over the earlier (1995) version of this paper was because it was not published at the time. The peer-review publication version in 2004 partially resolved the controversy through the normal scientific process). Beschta et al. (2004) indicated that:

- post-fire logging may increase the potential for future fire intensity and rate of spread if it causes shift in fuel composition (also see Perry 1994, Donato et al. 2006, Thompson and Spies in preparation - below);
- affects plant species composition and forest succession through changes in microclimate and mechanical damage to regenerating plants and soils;
- can cause detrimental effects on the microhabitat of organisms associated with recovery (such as soil microbes) and early successional vegetation;

- both ground-based yarding, and to a lesser degree, cable systems can cause significant soil disturbance and compaction; and
- post-fire activities most likely to be inconsistent with ecosystem restoration are: seeding non-native species, livestock grazing, installation of instream structures, ground-based logging and soil disruption, removal of large trees, road and landing construction, and logging of ecologically sensitive areas including roadless areas, riparian areas, and areas with moderate to serve burns.

Based on these findings, the authors concluded that "*the current body of research indicates that the loss of ecosystem services that can result from postfire treatments is significant.*"

Lindenmayer and Noss 2006 – based on literature review of global studies on post-disturbance logging, these authors concluded the logging impacts can be particularly severe when logging:

- removes large biological legacies;
- modifies rare post-disturbance habitats;
- influences populations of disturbance-adapted species;
- alters community composition;
- impairs natural vegetation recovery;
- facilitates colonization of invasive species;
- increases erosion;
- modifies hydrological processes that affect aquatic ecosystems; and
- alters patterns of landscape heterogeneity important to biodiversity.

These damages can exceed the impacts of the initial disturbance itself.

Illinois River – Biscuit fire area, natural recovery – R. Sklar (left); K. Schaffer (center and right)

Impacts Of Post-Disturbance Logging On Aquatic Ecosystems

Karr et al. 2004 - in a review of post-fire logging on aquatic ecosystems, Karr et al. (2004) indicated that post-fire logging tends to have a multiplier effect on ecosystems because fire-affected ecosystems are sensitive to further disturbances. The following conclusions were reached:

- post-fire logging generally damages soils by compacting them, removing vital organic materials, and by increasing the amount and duration of top soil erosion and runoff which in turn harms aquatic systems (potential for damage is especially severe for ground-based machinery);
- removal of burned trees that provide shade may hamper tree regeneration especially on high-elevation or dry sites – the loss of future soil organic matter is likely to translate into soils less able to hold moisture with implications to soil biota, plant growth, and stream flow;
- logging and associated roads carry a high risk of spreading weedy species;
- increased runoff and erosion alter river hydrology by increasing the frequency and magnitude of erosive high flows and raising sediment loads (these changes alter the character of river channels, harming aquatic species);
- construction and reconstruction of roads and landings damage soils, destroy or alter vegetation, and accelerate runoff and erosion harmful to aquatic systems;

- post-fire logging changes forest fuels and can increase the severity of subsequent fires thereby affecting aquatic systems (also see Perry 1994, Donato et al. 2006, Thompson and Spies in preparation - below); and
- post-fire logging undermines the effectiveness of other costly rehabilitation efforts aimed at reducing soil erosion and runoff.

Based on these findings, the authors conclude that *"by adding another stressor to burned watersheds, postfire salvage logging worsens degraded aquatic conditions accumulated from a century of human activity……additional damage impedes the recovery and restoration of aquatic systems, lowers water quality, shrinks the distribution and abundance of native aquatic species, and compromises the flow of economic benefits to human communities that depend on aquatic resources."*

Reeves et al. 2006 – many species in riparian areas exhibit special adaptations to fire; fish tend to rebound relatively quickly and usually within a decade after fire. Fire contributes coarse woody debris essential to fish habitat and channel maintenance. Excessive removal of biological legacies post-disturbance can cause the following aquatic damages:

- by removing coarse-woody debris, logging can exacerbate negative fire effects that delay the recovery of fish habitat, particularly riparian areas already deficient in coarse-woody debris due to past management;
- amphibians that depend on downed logs in riparian areas may be negatively affected;
- removal of streamside live trees and dead boles (trunks) can elevate stream temperate due to loss of shading and can accelerate short- and long-term erosion processes; and
- roads, **even temporary ones**, can increase erosion thereby negatively affecting aquatic habitats (emphasis added **–** this is largely because temporary roads are most often not engineered to road standards and can therefore cause excessive sedimentation and erosion).

Post-fire logging slash, Biscuit fire area, southwest Oregon (D. DellaSala)

Post-fire logging, Biscuit area, southwest Oregon (D.DellaSala)

Regional Analyses of Post-Disturbance Logging

Donato et al. 2006 (seedling survival and logging slash) – surprisingly little work has been done on post-fire natural regeneration compared to logged areas (however, also see Sexton 1996 and Shatford and Hibbs 2005). Donato et al. (2006) received extraordinary coverage and triggered intense debate because the results challenged several widely held assumptions about post-fire logging. While the breadth of sampling has been questioned by some (Newton et al. 2006), Donato et al. (2006) actually used five large study plots placed in the four widely dispersed study areas that were surveyed along transects that were about 250 feet long and 3 feet wide (about 3,300 square feet including 6,000 sampling plots). The area sampled included a broad range of climatic zones, plant associations and soil parent materials in four timber sale areas (Briggs, Flattop, Berry and Indie sale areas). In general, Donato et al. (2006) report that natural conifer regeneration two years after the 2002 Biscuit fire, although variable across the study area, was abundant in high-severity burn areas where conifer densities (>300 per acre) exceeded regional standards for fully stocked stands. The authors concluded:

- post-fire logging reduced median conifer regeneration density by 71%;
- post-fire logging impacted conifer seedlings by damaging soils and by physical burial of seedlings by woody material due to logging;
- post-fire logging significantly increased both fine- and coarse-woody fuel loads;
- if post-fire logging is conducted in part to facilitate reforestation, replanting could result in no net gain in early conifer establishment (due to logging related losses in seedling establishment); and
- post-fire logging can be counter productive to the stated goals of ecosystem restoration.

Hutto 2006 (fire dependent communities and post-fire logging) – many bird species in western North America are restricted to and depend on severely burned conifer forests during the first few years following fire. Post-fire avian specialists (many woodpeckers, for example) are completely absent from burned forests that have been even partially logged due to removal of dead and dieing trees. This is especially the case when large legacy trees are removed.

Foster and Orwig 2006 (hurricanes, insects, post-fire logging, and natural recovery) Intense windstorms in New England forests have historically shaped natural landscape heterogeneity intrinsically important to biodiversity of these forests. Post-disturbance logging that removed host trees in advanced stages of insect infestation and disease initiated substantial changes in ecosystem function and structure worse than the initial windstorm itself. Despite dramatic physical changes in forest structure resulting from hurricanes and insect infestations, little disruption of biogeochemical processes or other ecological functions typically follows hurricanes. These features provide for important habitat heterogeneity often missing from managed forests due to centuries of land use. *Post-disturbance logging may therefore affect a larger area or create a greater impact on forest ecosystems than the natural disturbance itself (emphasis added).*

Schmiegelow et al. 2006 (fire, boreal forests, and post-fire logging) - fire is an important disturbance process that shapes the ecology and biodiversity of Canadian boreal forests. Post-fire logging, however, compromises forest sustainability by diminishing the role of fire as a critical natural process mainly through removal of important forest structure. Maintenance of natural post-fire forests is therefore a crucial component of an ecosystem-based approach to forest management in Canadian boreal forests.

ADDITIONAL STUDIES

In addition to the studies noted above the following field research documents post-fire logging impacts to seedling establishment and short term increases in hazardous fuels following post-fire logging and herbicide application:

- **Post-fire logging erosion in the Sierra** - In a report to Congress on post-fire logging in the Sierra, Kattleman (1996) noted that "if postfire treatments of salvage logging and site preparation prevent rapid reestablishment of low vegetation, resulting erosion can be greater than directly produced by the fire."
- **Post-fire logging seedling impacts on the Winema National Forest (Oregon) -** in research on post-fire logging on the Winema National Forest (Oregon), Sexton (1998) found that post-fire logged sties produced only about 38% of the understory biomass of unlogged sites and one year later produced only about 27% of understory biomass. Salvaged areas, compared to unsalvaged sites, one and two years later had significantly reduced vegetation biomass, reduced species diversity, reduced species richness, reduced growth of planted seedlings, and reduced survival of planted seedlings.
- **Increased fire hazards from post-fire logging in the Biscuit and Silver fire areas** - research on the 1987 Silver Fire (Oregon's second largest fire in the past 100 years), which overlapped with the Biscuit 2002 fire, indicates that fire consumed all Douglas-fir in a plantation that had been treated with herbicides to remove shrubs, however, control plots with hardwoods present did not propagate fire (Perry 1994). This is similar to fire behavior observed by Odion et al. (2004) in the Klamath Mountains, California using historical fire data from several fires.

In particular, Odion et al. (2004) documented higher fire severity in tree plantations and lower severities in closed canopy forests with a hardwood understory. The researchers theorized that the presence of hardwoods may have a dampening effect on fire severity by shading out flammable shrubs thereby "protecting" the conifers from fire damage. Similarly, Morisson (2001) documented higher fire severity in portions of the Silver burn area that were salvage logged and later reburned at high severity in the Biscuit fire (this finding is also now being confirmed by Thompson and Spies – see below).

NEW RESEARCH (UNPUBLISHED)

Although not yet published in peer-reviewed journals, preliminary findings on post-fire management were presented by researchers in a February 8 wildfire symposium, including the following:

- **Insect mortality post-Biscuit –** Don Goheen (US Forest Service) – relatively low post fire insect mortality was observed (10-20%) on the Biscuit in year 3 of 5 year study. Low populations of insects before fire is a good predictor of low populations after fire.
- **Responses of Stream Amphibians to the Quartz and Biscuit Wildfires** - Bruce Bury, Doug Degross, and Erin Hyde – USGS Biological Resources Division, Forest and Rangeland Ecosystem Science Center. Increased stream temperatures from fires and logging have been associated with declines in Pacific giant salamanders, tailed frogs and torrent salamanders. Amphibians are slow to recover and may take decades to rebound.
- **Interpretation of wildfire effects on ecosystems can be misleading without before/after data and without unburned controls** - Bernard Bormann - USDA Forest Service, PNW Research Station. Thinned stands burned hotter in the Biscuit fire than unthinned stands (this is consistent with a study by Odion et al. 2004 who noted that closed canopy forests and hardwoods may shade out flammable understory plants and with Raymond 2004). Plantations burned in Biscuit fire had fewer species post fire.

- **Natural Regeneration 10-20 years after wildfire** - Jeff Shatford, David E. Hibbs - OSU Dept. of Forest Science – researchers examined unlogged unplanted fire killed mature and older stands up to 20 years post fire. Conifers established over a 20-year period post-fire without planting. Highest establishment rate occurred in the first ten years. Shrubs were abundant but conifers established among them. Planting was not required at these sites because stocking was 250 trees per acre. Natural recovery was abundant and healthy. Need to wait and see if conifers eventually overtop the shrubs as other studies indicate. A long conifer establishment period provides tremendous benefits for big game, blue birds, woodpeckers, and a wide variety of other wildlife associated with complex young forests containing abundant legacies, while rapid establishment and dominance of conifers has negative impacts on wildlife diversity that often go unrecognized.
- **Did the burn mosaic left by the 1987 Silver Fire influence the Biscuit Fire?** Jonathan Thompson, OSU Dept. of Forest Science, Thomas A Spies, USFS, PNW Research Station, Corvallis OR - slope, aspect, and fuels explained only 17% of the variability in the Biscuit burn that leads the researchers to believe that local weather is the dominant driver in big wildfires. Areas that burned hot in Silver also burned hot in Biscuit. Areas salvage logged in Silver burned hotter than unsalvaged areas (as also noted by Harma and Morrison 2003 and a recent paper presented by Thompson and Spies - see http://emmps.wsu.edu/firecongress/papers/sala/thompson0526.pdf

KEY FINDINGS

Based on the above findings, we draw the following conclusions related to post-disturbance regeneration and management of post-disturbance lands.

POST-DISTURBANCE LANDSCAPES SHOULD BE ALLOWED TO REGENERATE NATURALLY


Biscuit fire area, southwest Oregon

Studies of forest recovery after natural disturbances indicate that seeding and tree planting following disturbances are often unnecessary in naturally regenerating landscapes and actually may impair forest recovery. For instance, the Yellowstone fires of 1988 produced an abundance of young lodgepole pine (Turner et al. 2003), a fire-adapted conifer favored by intense heat that opens cones and releases seeds. Similar discoveries have been made in other forest types burned by the Biscuit fire of 2002 in southwest Oregon (as noted above), where conifer establishment has been prolific even on severely burned sites due to abundant patches of live and dying trees (containing cones), the Storrie fire of 2000 (Lassen and Plumas National Forests, CA) and Star Fire of 2001 (Tahoe and Eldorado National Forests, CA). The patchy nature of fires in these cases left sufficient local seed trees that survived the fire (including dying trees with abundant seed crops), so there was no need to plant. Notably, post-fire logging often has been justified on the assumption that more than 50% crown scorch is associated with tree mortality and poor conifer establishment. However, western tree species possess many unique adaptations that facilitate survival even when crowns are heavily scorched by fire, rendering determinations of trees likely to die unreliable (Beschta et al. 2004).

Lags in tree regeneration are not unusual, or necessarily ecologically problematic, particularly on semi-arid or xeric sites. In some special and rare cases, however, planting and seeding of native vegetation after disturbance may be appropriate, using local genetic stock, if it is conducted with much caution and is based on scientific understanding of local vegetation types and conditions. In these limited cases, planting should be de-coupled from post-fire logging. In fact, in many cases, post-fire logging is likely to undermine the ultimate success of efforts to restore natural forest vegetation, through its negative effects on overall forest and soil productivity. Post-fire logging, planting, and seeding are separate activities. There is no sound ecological reason to wed these activities.

ROAD BUILDING (EVEN TEMPORARY ROADS) DAMAGES REGENERATIVE PROCESSES AND SHOULD BE AVOIDED

Biscuit logging roads, southwest Oregon – @K. Schaffer

Post-disturbance logging legislation (HR4200) allows temporary road construction, even in roadless areas, which is well-documented as damaging to a wide variety of natural resources, including wildlife, aquatic fauna, soils, and water quality. Temporary roads can be especially disruptive to ecosystem processes as they are typically not designed or engineered to road standards and can be a source of excessive erosion and hydrological damage (Trombulak and Frissell 2001, Karr et al. 2004, Reeves et al. 2006). Roads also act as pathways for exotic species invasions and can elevate fire risks due to greater likelihood of fire ignitions associated with increased human access (DellaSala and Frost 2001). Due to their persistent impacts, "temporary roads" have enduring impacts on forests, especially soil resources. Conversely, roadless areas act as "strongholds" for aquatic and terrestrial species sensitive to land management activities (Strittholt and DellaSala 2001).

NATURAL DISTURBANCES ARE CHARACTERIZED BY UNIQUE BIOLOGICAL LEGACIES ESSENTIAL TO REGENERATIVE PROCESSES – THEY SHOULD NOT BE TREATED AS ECOLOGICAL "CATASTROPHES"

Biscuit burn area, southwest Oregon – K. Schaffer

It is abundantly clear from study of natural disturbances such as the 1980 Mount St. Helens volcanic eruption, the 1988 Yellowstone National Park fires, as well as hurricanes and floods that they create landscape diversity integral to biodiversity and regenerative processes (Smucker et al. 2005, Parsons et al. 2005). The varied effects of fire severity, spatial extent, and frequency of most fires, for instance, are some of the main factors influencing the richness and uniqueness of plant and wildlife communities. Often the regenerative processes following large and severe disturbances are facilitated by biological communities uniquely adapted to post-disturbance landscapes (e.g., Mt. St. Helens, Dale 2005).

Threatened spotted owl, Glade Creek fire, southwest Oregon
D. Clark

Pileated woodpecker in dead tree
E. Bull

Many wildlife species are associated with naturally regenerating areas and quickly recolonize them. In the Pacific Northwest, up to 150 wildlife species, including birds, mammals, amphibians, and reptiles utilize dead and downed logs (Rose et al. 2001). Some species, such as the Black-backed Woodpecker, are nearly restricted to burned areas and their long-term viability depends on them (Hutto 2006). The threatened Northern Spotted Owl also makes use of burned forests because the large dead trees serve as nesting platforms. Many post-disturbance colonizing species such as woodpeckers, other birds, small mammals, and bats are insectivorous and perform vital checks and balances on species that otherwise might become large outbreaks. These insectivorous species require dead and downed wood to carry out their vital ecological functions. Because naturally regenerating post-disturbance areas are often logged, they are among the rarest forest types in the nation (Franklin and Agee 2003), and proposed post-disturbance legislation would make them rarer still, outside of national parks, wilderness areas, and national monuments.

LARGE DEAD AND DYING TREES ARE THE BUILDING BLOCKS OF FUTURE FORESTS AND REGENERATIVE PROCESSES AND SHOULD BE PROTECTED AS "BIOLOGICAL LEGACIES"


Large legacy trees, Biscuit fire area, southwest Oregon – K. Schaffer (left); R. Sklar (right)

Large dead and dying trees, downed logs, and woody debris deposited in terrestrial and aquatic ecosystems following disturbances are essential to ecosystem regeneration (Reeves et al. 2006), but these features are in short supply across the West due to past management. The remnant live vegetation patches, often alternating with extensive patches of dead and dying trees, particularly the large "veteran trees," act as important seed sources, mycorrhizal inoculum (essential for seedling survival and growth of big trees), and provide essential structural materials that hasten regenerative processes (Beschta et al. 2004). Dead trees (standing and down) and especially large ones "life boat" disturbed areas through regenerative stages by: (1) "anchoring" soils; (2) providing shade and substrates (when these trees fall to the ground) for seedlings; (3) generating woody debris essential to developing soils, and capturing, storing, and releasing soil nutrients; and (4) providing habitat for scores of wildlife when standing, and providing habitat for fish and wildlife when the trees fall on the ground or into streams (Lindenmayer and Franklin 2002). As Dr. Jerry Franklin pointed out in his congressional testimony (November 10, 2005), logging large dead trees likely has greater negative impacts on forest ecosystems than even logging green trees. This is especially the case when there are so many green trees that need to be removed fuel reduction purposes around communities at risk of fire and thinning young trees to restore former clearcuts.

LARGE TREE RETENTIONS AND NO HARVEST ZONES SHOULD BE INCLUDED IN POST-DISTURBANCE LOGGING DECISIONS IF SUCH LOGGING TAKES PLACE FOR ECONMIC REASONS

Logging in naturally recovering, post-disturbance landscapes is almost always detrimental to regenerative processes and such damage may persist for decades. Trees that survive disturbances even for a short period of time are critical as seed trees, and dead trees are essential to regenerative processes preceding the development of new forests. However, should economic interests take precedence over ecological consequences of logging, then the following minimum ecological standards, adopted from post-disturbance scientific research, should be employed to reduce damages from logging when forests are most vulnerable:

- intervene only in ways that promote natural recovery;
- retain all large (mature and old) legacy trees, whether live, dead, dying, damaged (i.e., crown scorch), standing or downed;
- of the remaining standing dead trees, retain at least 50% in all tree size classes;
- retain all live trees regardless of age or size within disturbance perimeters;
- prohibit logging on unstable slopes, severely burned soils, and other sensitive areas;
- because soils are irreplaceable in human life times, postfire management practices that compact soils, reduce soil productivity, or accelerate erosion should not be allowed;
- prohibit logging within riparian buffers, critical watersheds for salmonids and other sensitive aquatic species, late successional reserves, and remaining roadless areas; and
- avoid creating new roads and landings in the burned landscape.

APPENDIX – SCIENTIFIC STUDIES AND QUOTES

Beschta, R. et al. 2004 –

- "Human intervention on the post-fire landscape may substantially or completely delay recovery, remove the elements of recovery, or accentuate the damage…In this light there is little reason to believe that post-fire salvage logging has any positive ecological benefits, particularly for aquatic ecosystems. There is considerable evidence that persistent, significant adverse environmental impacts are likely to result from salvage logging."

Lindenmayer, D.B., et al. 2004

- … [N]atural disturbances are key ecosystem processes rather than ecological disasters that require human repair. Recent ecological paradigms emphasize the dynamic, nonequilibrial nature of ecological systems in which disturbance is a normal feature and how natural disturbance regimes and the maintenance of biodiversity and productivity are interrelated … **Salvage harvesting activities undermine many of the ecosystem benefits of major disturbances**.…
- [R]emoval of large quantities of biological legacies can have negative impacts on many taxa. For example, salvage harvesting removes critical habitat for species, such as cavity-nesting mammals, [and] woodpeckers. Large-scale salvage harvesting is often begun soon after a wildfire, when resource managers make decisions rapidly, with long lasting ecological consequences….

Quigley, T. M., tech. ed. 1996; The Interior Columbia Basin Ecosystem Management Project: Scientific Assessment.) Gen. Tech. Rep. PNW-GTR-382; Page 178.

- The ICBEMP analysis showed that traditional salvage logging that removes large trees is not compatible with ecosystem management:

  Can salvage timber sales be compatible with ecosystem-based management? … Our findings suggest that this type of harvesting is not compatible with contemporary ecosystem-based management. Ecosystem-based management would emphasize removing smaller green trees with greater attention to prevention of mortality rather than removal of large dead trees.

Lindenmayer, D. B. and J. F. Franklin. 2002. Conserving Forest Biodiversity: A Comprehensive Multiscale Approach. Island Press. Washington, DC: 69.

Salvage logging and replanting will convert a structurally complex landscape into a simplified and biologically depraved landscape. **Unsalvaged, naturally regenerated, young stands are one of the rarest forest types in the Pacific northwest, and their**

biodiversity rivals that of old-growth forests. Indeed, naturally developed early-successional forest habitats, with their rich array of snags and logs and nonarborescent vegetation, are probably the scarcest habitat in the current regional [Pacific Northwest] landscape.

Franklin, J.F. and J. Agee. 2003 "Forging a Science-Based National Forest Fire Policy," Issues in Science and Technology *Online.* Fall 2003. http://www.issues.org/issues/20.1/franklin.html

- Management of postburn areas, including timber salvage, needs to incorporate the concept of biological legacies. Salvaging dead and damaged trees from burns involves the ecology of a place, not simply economics and fuels. In addition to effects on postfire wildlife habitat, there are also effects of salvage logging on soils, sediments, water quality, and aquatic organisms. Significant scientific information exists on this topic as well as on biological legacies.

  Biological legacies differ by orders of magnitude in natural forests, a fact that should guide restoration programs. Where stand-replacement fires are characteristic, such as with lodgepole pine and Pacific Coast Douglas fir forests, massive areas of standing dead and down trees are usual; salvage operations generally are not needed and do not contribute to ecological recovery, even though they do provide economic return. On the other hand, uncharacteristic stand-replacement fires in dry forests can produce uncharacteristic levels of postfire fuels, including standing dead and down trees. Removing portions of that particular biological legacy may be appropriate as part of an intelligent ecological restoration program, and not simply as salvage. (emphasis added)

Johnson, K.N., J. Franklin, and D. Johnson. The Klamath Tribes' Forest Management Plan. Dec 2003. http://www.klamathtribes.org/forestplan.htm pp 108-109.

- Specific principles to guide removal of trees, snags, and logs from burned sites are as follows:

  Trees (live and dead) and down wood will be retained in sufficient quantities to provide for wildlife and ecological needs, including long-term structural enrichment of the site.

  Retain amounts and distributions of trees as would be characteristic of the pre-burn (historical) landscape …

  Large snags persist for the longest period, and are most difficult to replace. Consequently, snag and log retention will focus on the largest (21"+ DBH) pieces in the post-burn landscape.

  The retention standards should be checked to make sure that they will provide amounts and distributions of snags and down wood that will meet requirements for species at risk, sensitive species, and other species of special interest to the Tribes (such as mule deer). If they will not meet the species requirements, adjust the retention standards accordingly. There is an important caveat: this may not be done if providing for a particular species requires maintaining uncharacteristic levels of post-fire fuels over a significant portion of the burned landscape.

As noted above, proposed levels of snag and down wood retention will be evaluated to determine that they will not result in fuel loadings that are above characteristic levels for the plant association. Where they do, the goal will be to adjust retention to characteristic levels. In such a case retention of the large snags and down wood will be the standard since these structures contribute less to fuels on a cubic foot basis, persist longer, and provide habitat for more species. (emphasis added)

Hutto, R.L., Director of the Avian Science Center and Professor of Ornithology and Ecology at the University of Montana. Through following avian wildlife, a UM scientist has discovered that burned forests play a critical role in the health and diversity of the Western landscape By MICHAEL JAMISON of the Missoulian August 11, 2005.

- "Personally, I've come to think we need to change our thinking on salvage logging. There are other values in the forest. In fact, **a burned area is probably the most sensitive place you could be working in.** The public really hasn't caught on to this yet. People still want to get the cut, get the trees they see as wasting away. They want the economic value. We talk about forest restoration after a fire, but it just got restored. That's what fire does. We know that, but we can't seem to get the message out. Until you start thinking like a black-backed woodpecker, you just ain't going to get it."

Rumbaitis-Del Rio, C.M. and C. A. Wessman**.** 2001. Impact of compound disturbances on N-cycling and forest reorganization in a wind-disturbed and logged forest. Paper presented to the 86th Annual Meeting of the Ecological Society of America, August 6 – 10, 2001. http://www.fs.fed.us/r2/mbr/resourcemgmt/blowdown/CRresearch.pdf

- Compound disturbances have the potential to fundamentally alter an ecosystem structure and function. This study examines the effects of a natural disturbance and a compounded natural and anthropogenic disturbance on soil properties, biogeochemical cycles, and ecosystem reorganization in a windblown and salvage-logged ecosystem in northwestern Colorado. Areas of intact forest are used as a control to compare the disturbance effects. Results indicate that soils in the salvage-logged areas are drier, significantly warmer, denser, and contain less organic matter than soils in blowdown or control areas.

  Significant amounts of erosion occurred in the salvage-logged areas to produce these results. Furthermore, net nitrogen mineralization rates are lower in soils from salvage-logged areas than in blowdown areas. By contrast, net nitrogen mineralization rates are twice as high in blowdown areas than in control areas.

> Seedling density, herbaceous cover, and plant species diversity are greatest in blowdown areas, and least in salvaged-logged areas. The results of this four-year study indicate that the mitigation effects of salvage logging significantly alter ecosystem functions and retard the rate of recovery when compared to unlogged blowdown areas.

Franklin, J.F., K. Cromack, Jr., W. Denison, A. McKee, C. Maser, J. Sedell, F. Swanson, and G. Juday. 1981. Ecological characteristics of old-growth Douglas-fir forests. PNW-GTR-118. USDA Forest Service. PNW Research Station. February 1981.
http://www.fs.fed.us/pnw/pubs/gtr118part1.pdf
http://www.fs.fed.us/pnw/pubs/118part2.pdf

- There are implications for management of old-growth stands selected for perpetuation. **Salvage logging is inappropriate since it removes at least two of the major structural components-dead and down-that are key elements of the system.** In all likelihood, some of the more decadent, live trees would also be removed. Salvage logging is also inappropriate because of the damage inevitably done to root systems and trunks of the residual stand which results in accelerated mortality of trees and overall deterioration of the stand.

Hessburg, P.F., J.K. Agee, and J. F. Franklin. 2005. Dry forests and wildland fires of the inland Northwest USA: Contrasting the landscape ecology of the pre-settlement and modern eras. Forest Ecology and Management (in press).

- … These scattered large trees occurred as a lasting remnant after stand replacement disturbances providing an important structural and habitat legacy that would typically last for many centuries, first as a standing live tree, then as a snag, and ultimately as large down wood.

J. F. Franklin, Professor of Ecosystem Studies, College of Forest Resources, University of Washington. July 15, 2004. TESTIMONY FOR THE RECORD ON OVERSIGHT HEARING ON "RESTORING FORESTS AFTER CATASTROPHIC EVENTS" BY HOUSE COMMITTEE ON RESOURCES, SUBCOMMITTEE ON FOREST AND FOREST HEALTH.
http://resourcescommittee.house.gov/archives/108/ffh/07_15_04.htm

- It is sometimes argued that following a stand-replacement fire in an old-growth forest that snags and logs are present in "excess" of the needs of the site, in terms of ecosystem recovery. In fact, **the large pulse of dead wood created by the disturbance is the only significant input of woody debris that the site is going to get for the next 50 to 150 years** -- the ecosystem has to "live" off of this woody debris until the forest matures to the point where it has again produced the large trees that can become the source for new snags and logs (Maser et al. 1988).

Excerpts from September 22, 2004 testimony submitted by Dr. Jerry F, Franklin, to the Senate Committee on Energy and Natural Resources. The testimony addresses Senate Bill 2709, The National Reforestation Act of 2004 introduced by Senator Gordon Smith (R-OR). Dr. Franklin is Professor of Ecosystem Science, College of Forest Resources, University of Washington.

Post-fire logging sets back natural forest recovery:

> "Timber salvage should be viewed as a "tax" on ecological recovery processes. Removal of large, decay resistant snags and logs is particularly negative because of impacts on long-term recovery and stand development processes—yet it is precisely these structures that are often the prime targets of salvage operations because of their economic value."

Burned dead trees are the building blocks of new forests:

> "In earlier times we believed that once trees were dead they provided little value to the ecosystem or to recovery processes. In fact, they were often viewed as waste, a potential fire hazard, and an impediment to proper management. However, research during the last 30 years has shown the critical role that structures such as snags, logs and wood debris play in the functioning of forest and stream ecosystems including (Harmon et al. 1986; Maser et al. 1988):
>
> - Provision of wildlife habitat; Long-term sources of energy and nutrients;
> - Sites for nitrogen fixation;
> - Seedbed for trees and shrubs; and
> - Creation of fish habitat.

Artificial tree plantations can actually increase the future risk of fire:

> ". . . conditions in naturally disturbed and recovering habitat are not duplicated by clearcuts and plantations. In some cases, reforestation of fire-prone sites with fully stocked plantations is actively recreating the fuels that will feed the next unnatural stand replacement fire!"

Minshall, G.W. 2003. Responses of stream benthic macroinvertebrates to fire. Forest ecology and management. 178: 155-161. NOTE: Volume 178, issues 1-2 was a special issue of Forest Ecology and Management on the effects of wildland fire on aquatic ecosystems in the western USA. The Minshall article as well as all others can be found online at www.sciencedirect.com. The *in press* version is here: http://www.fs.fed.us/rm/boise/teams/fisheries/fire/FAE%20Papers/MinshallFEMFinal.pdf

- Site preference studies show that **elk usually prefer to graze on burned as opposed to unburned sites**. … Fire in a Southwestern ponderosa pine forest increased forbs, grasses, and shrubs, created edge, and provided snags for cover. Elk increased in the burn, reaching a peak 7 years after fire when grasses were

> most abundant. … In Glacier National Park fires increased carrying capacity on winter range by creating a mosaic of thermal and hiding comver [sic] and forage areas. … Standing dead trees may provide adequate cover within burns.
>
> "In places where salvage logging occurs, the amount of snags that can be removed from the uplands without serious adverse effects on stream macroinvertebrate but ecosystem recovery is unknown and is likely to vary with forest type, geology, and topographical relief. However, **it is know that virtually all forms of postfire logging can have various adverse effects on stream ecosystems** (e.g., Mehahan, 1983; Smith et al., 1993a, b; Stout et al., 1993; Ketcheson and Megahan, 1996).
>
> Based on results from watersheds having various proportions of their areas burned by wildfire (e.g., Minshall et al., 1995, 2001b; Minshall, personal observation), it is probable that **the amount of timber removed should not exceed about 25% of the merchantable timber** (unless contradictory information is available). In addition, postfire removal should be appropriately spaced across the landscape and should be in proportion to the size classes (DBH) of trees present at the time of the fire (see also Beschta et al., 1995). This proportional harvesting is necessary because of the important graded inputs (Lyon, 1984) that a mix of such large woody debris contributes to streams over the extended recovery period (Minshall et al., 1989).
>
> In addition, fire lines should be obliterated prior to logging, and road construction or other major ground-disturbing activities should be avoided in order to prevent additional runoff and erosion. Salvage harvest yields responses (e.g., ground disturbance, woody debris removal, interruption of normal infiltration pathways, and acceleration of surface flows) that interact with the direct and indirect effects of fire to make these actions so potentially damaging. In addition, the **negative effects extend many years beyond the actual time of salvage activities** because of the harvest of snags that normally fall and become incorporated into stream channels and forest floors over several decades or more (Lyon, 1984). These wood inputs are important to create habitat, increase nutrients, and retard runoff and channel alteration during what is normally the most critical stage of stream and riparian vegetation recovery (Minshall et al., 1989; Lawrence and Minshall, 1994)."

J. F. Franklin, Professor of Ecosystem Studies, College of Forest Resources, University of Washington, July 15, 2004. TESTIMONY FOR THE RECORD ON OVERSIGHT HEARING ON "RESTORING FORESTS AFTER CATASTROPHIC EVENTS" BY HOUSE COMMITTEE ON RESOURCES, SUBCOMMITTEE ON FOREST AND FOREST HEALTH. (emphasis in original).

> The larger and the most decay resistant snags and logs are the most important ecologically. **Larger snags and logs will serve a large array of organisms and functions than smaller snags and logs as well as persist longer. For example,**

large snags are necessary for large cavity excavators, such as the Pileated Woodpecker and large logs are critical elements in creating stable aquatic habitat. Large snags and logs of decay-resistant species--such as cedars and Douglas-fir—can also persist and fulfill habitat and other ecological functions for several centuries in terrestrial environments or even millennia, in the case of stream and river ecosystems.

The levels of biological legacies such as snags and logs that need to be retained following a major disturbance very much depends upon the natural resource objectives for the property and the natural disturbance regime of the site. Where recovery of natural ecological functions is a primary goal, removal of significant legacies of living trees, snags, and logs through timber salvage is not appropriate. This is particularly true in forest types and on forest sites where stand-replacement ("catastrophic") disturbance regimes are characteristic. It is sometimes argued that following a stand-replacement fire in an old-growth forest that snags and logs are present in "excess" of the needs of the site, in terms of ecosystem recovery. In fact, *the large pulse of dead wood created by the disturbance is the only significant input of woody debris that the site is going to get for the next 50 to 150 years*—the ecosystem has to "live" off of this woody debris until the forest matures to the point where it has again produced the large trees that can become the source for new snags and logs (Maser et al. 1988).

In conclusion, the scientific lessons regarding biological legacies and the importance of retaining snags, logs, and other woody debris are being applied in regular timber harvesting practices (i.e., structural retention) but have not yet been fully incorporated into restoration policy. Timber salvage may be carried out for economic reasons. However, *timber salvage will rarely achieve any positive ecological benefit* **as has been pointed out in a recent article in Science (Lindenmayer et al. 2004). Timber salvage should be viewed as a "tax" or debit on the recovery process. Removal of large, decay resistant snags and logs is particularly negative because of impacts on long-term recovery and stand development processes.**

FEMAT (1993 page IV-37) - The FEMAT scientists recognized that …

- Salvage of dead trees has significant effects on the development of future stands and the suitability as habitat for a number of organisms. Snag removal results in long-term impacts on the forest community because large snags are not produced by the new stand until trees become large and begin to die from natural mortality (often a period of 50-100 years). Snags are used extensively by cavity nesting birds and mammals such as woodpeckers, nuthatches, chickadees, squirrels, red tree voles, and American marten. Removal of snags following disturbance can significantly reduce the carrying capacity of these specie for many years.

Salvage policies of options generally ranged from no salvage to limited salvage as permitted by the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992). This plan would allow removal of small diameter snags and logs but would also require retention of snags and logs likely to persist until the new stand begins to contribute significant quantities of coarse woody debris."

Craig Bobzien, Bitterroot NF Acting Supervisor (Missoula Independent, July 19, 2001)

- "There's no science that demonstrates re-burn potential in areas where there is downed wood or decayed wood."

Environmental Effects of Postfire Logging (USDA Forest Service, 2000)

- "We found no studies documenting a reduction in fire intensity in a stand that had previously burned and then been logged."

Wildfire and Salvage Logging (Beschta, et al., Oregon State University, 1995)

"[We] are aware of no evidence supporting the contention that leaving large dead wood material significantly increases the probability of reburn."

Dept. of Agriculture and Interior, Report to the President (September 2000)

"The removal of large, merchantable trees from forests does not reduce fire risk and may, in fact, increase such risk."

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