Testimony before Subcommittee on Forests and Forest Health
Scientific Research and the Knowledge-Base Concerning Forest Management Following Wildfires and Other Major Disturbances

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I thank the Subcommittee for this opportunity to testify regarding scientific knowledge relevant to appropriate management activities following a major forest disturbance. This testimony supplements a general statement that Drs. Hal Salwasser and K. Norman Johnson of Oregon State University and I prepared on the importance of increasing long-term research and monitoring programs focused post-disturbance management activities. I do reiterate from that statement the critical need for credible data management (e.g., documentation, archiving, and public access) as part of these activities.

At the outset I view it as fundamental that the management objectives for a disturbed area under consideration are an essential consideration in identifying and applying science relevant to post-disturbance activities. Management objectives are probably the most important factor in determining appropriate post-disturbance activities, assuming that we do not want disturbances to automatically result in *de facto* changes in management objectives. If management objectives for the area are focused on timber production, than one knowledge set based on experience and scientific study will be relevant. On the other hand, if management objectives for the area are directed primarily to sustaining biological diversity and important ecological processes, such as watershed protection, than a different knowledge set will be relevant. Of course, there will be overlap in these knowledge sets but the emphasis is certainly going to be very different.

I personally believe that much of the controversy that has arisen over post-fire logging and other activities relates to stakeholders viewing the appropriateness of an activity through the prism of their own experience and values without adequately considering the defined management objectives for the area under consideration.

There is a very large body of ecological science relevant to management of areas following large disturbances, much of which has not yet been fully assimilated by resource management agencies, policy makers, and the public. The sources include recent studies of such diverse major disturbances as the Mount St. Helens eruptions (Dale et al. 2005), the 1988 Yellowstone Fires (Christensen et al. 1989), and Hurricanes Hugo and Andrew (Walker et al. 1991; Pimm et al. 1994) as well as designed disturbances, such as the artificial hurricane experiments created at Harvard Forest in Massachusetts (Foster et al. 1997).

Rapid natural recovery is commonly observed in these studies, particularly in terms of ecological functions. Such recovery does not always equate with rapid re-establishment of a dense forest of commercially important tree species, however! Results of current studies also reiterate findings from much earlier research on the many ways in which human activities--many of them well intended—can interfere with natural recovery processes. The results provided by Donato et al. (2006), for example, should not have surprised anyone. The negative impacts of post-fire logging on natural regeneration have been reported in many past studies, including one conducted on the Tillamook Burn by the guru of Douglas-fir management, Leo A. Isaac (Isaac and Meagher 1938).

Biological legacies are a key factor contributing to rapid ecological recovery (Franklin et al. 2000). The concept of biological legacies emerged from research at Mount St. Helens but it is applicable to essentially all disturbance types. Biological legacies consist of living organisms, organic matter, and organically-created patterns that persist from the pre-disturbance ecosystem and strongly influence the development of the post-disturbance ecosystem. Living legacies are extremely diverse in form and often abundant, typically ranging from spores and seeds to large trees and sexually mature animals. Legacies of organic matter are also abundant since trees and other plants are killed but very little organic matter is actually consumed or removed in natural disturbances, including intense wildfires. Legacies of organic matter are most apparent in the concentrated forms of standing dead trees (snags) and downed boles (logs), material often referred to as coarse wood.

Snags, logs, and other coarse wood are biological legacies of extraordinary significance to ecological recovery, second only to surviving trees. The literature on the ecological role of coarse wood is immense; Harmon et al. (2004) and Maser et al. (1988) provide excellent entry points into this literature. The functions of such material are many. Logs and snags provide critical habitat for probably ½ to 2/3 of forest animal life (mammals, birds, amphibians, reptiles and invertebrates). Coarse wood is a long-term source of energy and nutrients but, unlike other organic matter, coarse wood is also a site for nitrogen fixation. Coarse wood has significant direct physical influences on geomorphic and hydrologic processes, such as

erosion, sediment deposition, and the physical structure of stream and river ecosystems. Residual wood structures significantly modify the microclimatic regime of the disturbed site, which is important in lifeboating diversity and in facilitating the establishment of natural tree reproduction.

Logs, snags and other wood persist and progressively play these and other roles for many decades and even centuries, particularly in the case of larger and more decay-resistant wood and in the case of aquatic ecosystems. *Furthermore,* where a stand-replacement disturbance has occurred, *the resulting pulse of large wood in the form of snags and logs is all of the coarse wood that the recovering ecosystem is going to get for the next 60 to 80 years or more*—i.e., until the new forest is large enough to begin generating large snags and logs on its own (Spies 1988). In part, this is the basis for my comment in earlier testimony that, from an ecological perspective, it is better to harvest living trees from an intact forest than to remove dead trees from an intensely burned site.

Ecological science also provides substantial insight into landscape-level issues that need to be considered in any type of post-disturbance management activity, such as ecological impacts of logging (e.g., Lindenmayer and Franklin 2002). All parts of a landscape are not created equal. The special importance of riparian habitats in a forest landscape exemplifies this principle. As another example, post-fire logging programs that are selectively focused on portions of the landscape with high residual wood volumes can have a disproportionately high impact on overall ecological conditions within the disturbed landscape, even though the activity directly impacts only a small percentage of the total area. The potential is there to effectively “high grade” a large disturbed landscape by logging the majority of the areas with abundant large legacies.

Research on natural forest disturbances has also shown that post-disturbance landscapes are important sites for many biota and important ecological processes, such as nitrogen fixation. Because such areas have a rich array of structural legacies and are free of dominance by tree canopies, very high levels of biological diversity are often present in the form of animal, plant and fungal species as well as diverse plant life forms. Forest guru Leo A. Isaac noted such qualities based on his observations in the Tillamook Burn (Isaac 1963). Such naturally-disturbed early-successional habitats are very different from clearcuts in structure, composition, and duration.

The naturally recovering portions of the Mount St. Helens blast zone provide graphic evidence that such areas can be regional hotspots of biological diversity, as exemplified by the extraordinary species diversity and population levels of amphibians, birds, small mammals, and meso-predators found in this landscape (Dale et al. 2005). Such richness of organisms and processes is not to be found within the reforested portions of the Mount St. Helens region although these dense young forests are producing a lot of wood. This contrast makes explicit the importance of management objectives for a disturbed area.

Resource managers do have much knowledge and experience with post-disturbance landscapes but there has been relatively little systematic research on impacts of post-fire logging. Moreover, some of the science described as relevant has limitations. We cannot assume that research focused on solving regeneration problems following timber harvesting in southwestern Oregon are directly applicable to conditions or to management objectives on naturally disturbed areas in the Biscuit Burn. As I hope we have all learned--clearcuts are not just like wildfires! To which I would add, what is good for timber production may not be good for many other forest values. Hence, the importance of management goals for affected properties.

In conclusion, we certainly do need more credible scientific research as well as systematic monitoring to increase the breadth and depth of the knowledge available to guide management. I would emphasize that the research and monitoring need to be sustained – long term – efforts and, further, that these efforts will be largely wasted without appropriate investments in data management.

Finally, I want to express a concern that all of this attention on salvage and reforestation has diverted us from what I view as a more important task, which is to get on with treatment of green forests at risk of uncharacteristic stand-replacement fires. In eastern Oregon there are hundreds of thousands of acres of forest and millions of irreplaceable old-growth trees at risk of loss. We need to focus on these green forests so that they don’t end up as part of policy debate over salvage!

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Ecological Science Relevant to Management Policies for Fire-prone Forests of the Western United States

Society for Conservation Biology Scientific Panel on Fire in Western U.S. Forests

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EXECUTIVE SUMMARY

Fire is a primary natural disturbance in most forests of western North America and has shaped their plant and animal communities for millions of years. Native species and fundamental ecological processes are dependent on conditions created by fire. However, many western forests have experienced shifts in wildfire regimes and forest structure following a century or more of resource use and management, with some past and present management activities lacking a scientific basis. Changes in wildfire and fuel management policies are needed to address social and environmental problems that have arisen as a result of these activities.

Incorporation of current scientific knowledge into revised policies and practices is essential to insure that the productivity, biological diversity, and ecological values of western forests are sustained. As an example, implementation of the Healthy Forests Restoration Act (HFRA) of 2003 will benefit from adaptive application of the dramatically expanding base of scientific knowledge. Our review addresses the ecological science relevant to developing and implementing forest restoration and fuel management policies, including activities conducted before, during, and after forest wildfires. An essential principle of ecological variability within and among forests underlies all of our findings.

In this summary and in the background report we use the term "characteristic" in referring to the dominant natural disturbance regime of a forest type or site. For example, some types of dry forests are described as being historically or naturally "characterized by a frequent, low-severity fire regime" while some coastal and subalpine forests are "characterized by an infrequent, high-severity fire regime." These are generalized characterizations of the regimes that these types experience and are not necessarily exclusive. For example, forests characterized by high-severity fire regimes may also experience low-severity events and vice versa. The term "uncharacteristic" refers to disturbances, forest structure, or fuel loads of a scale or type outside the historic range of variability based on site-specific vegetation reconstructions using tree rings, fire scars, pollen, charcoal, or early historical records.

Fire in Western Forests

Wildfire is inevitable and ecologically important in forests throughout much of the western United States, given the fuels, ignition sources, and variable climatic conditions. Nevertheless, characteristic fire regimes—especially the extent, frequency, and severity of the wildfires—are immensely variable. For example, fires historically recurred in western forests at intervals ranging from as frequently as a decade or less in some dry ponderosa pine forests to 250 to 800 years or more in forests at high elevations and along the Pacific Coast. Fires provide important services such as recycling nutrients, regulating the density and composition of young trees, and creating and shaping wildlife habitat at the stand level. At larger spatial scales wildfire influences landscape patterns and affects water and sediment delivery in watersheds. Many native plant and animal species are adapted to postfire habitats and suffer population declines with fire exclusion.

Characteristic fire regimes differ markedly among forest types and regions—as well as within major forest types—and these differences need to be considered in fire and fuel management policies to assure that these policies are effective and sustain ecological values. Managers, stakeholders, and policy makers are challenged by the complexity created by this variability, which defies a simple, one-size-fits-all prescription. Fortunately, plant association groups (PAGs) provide a surrogate classification of this diversity in forest wildfire regimes that is effective and scientifically credible, since plant associations have predictable relationships to characteristic fuels and fire regimes.

Forest Management Before Wildfire

How could forests be managed prior to the inevitable wildfires they will experience, so as to insure that fires will play their characteristic roles in maintaining the composition, structure, and function of the forest ecosystem when they do occur? Appropriate management will vary greatly with the type of forest and its dominant fire regime. Determining the appropriate management and restoration goals requires that the effects of past land uses first be identified so that those effects can be specifically remedied. Then appropriate ecologically based restoration and management policies can be developed. Protected areas require particular management approaches that may differ from practices appropriate in managed forests. Each of these topics is addressed in turn below.

Variable Effects of Fire Exclusion, Logging, Livestock Grazing, and Plantations

The effects of fire exclusion, as well as other activities that affect fire regimes (e.g., logging, livestock grazing, plantations) on forest structure are not necessarily easy to identify or demonstrate scientifically; they also vary significantly among forest types and regions. In some forest types change has been dramatic since European settlement due, for example, to fire exclusion, logging, grazing, or tree planting (singly or in combination), and restoration is clearly needed. In other forest types major changes are not apparent and restoration is not needed. In many cases it has been inappropriately assumed that forests in general or all forests dominated by a particular tree species have been altered in the same way. In fact, these effects are known to vary, depending upon the forest type and whether fire was characteristically high, mixed, or low severity, each of which is discussed below.

Key Findings:

- **Fire exclusion and other human activities have led to significant deviations from historical variability in some forests but not in others.** Restoration treatments are warranted, sometimes urgently, in those cases where such activities have led to significant alterations in ecosystem structure, function, or composition, but cannot be justified ecologically in cases where such changes have not occurred. The following sections discuss this for forests with different fire regimes.

- **Land uses and fire exclusion do not universally increase fuel loads or fire risk.** Such activities may alter fuels in divergent or complex ways that lead to a need for decreases in particular fuels and increases in other fuels, if restoration to the historical range of variability is the goal. For example, fire exclusion can increase tree regeneration and ladder fuels in some cases and decrease tree regeneration and ladder fuels in other cases.

Forests Characterized by High-Severity Fires

Forests characterized by high-severity fires are found in several disparate locations: subalpine forests at higher elevations throughout the West (e.g., lodgepole pine and Engelmann spruce-subalpine fir); the moist and highly productive forests in marine-influenced regions of the Pacific Northwest; and certain semi-arid woodlands, including some dominated by pinyon-juniper and by oak-pine-chaparral. High-severity fires, which are usually infrequent, kill most or all of the trees in large portions of the burn, although such fires typically create a landscape mosaic that also includes some areas of unburned forest and of low- to moderate-severity burn. Forests subject to high-severity fires typically support high densities of trees and other woody plants and, consequently, large fuel loadings. When these dense fuels dry out and an ignition source is present, the resulting fires can spread rapidly and quickly become difficult or impossible to suppress. Many large, high-severity fires are probably associated with either infrequent, severe droughts or short-term synoptic weather patterns or both.

Key Findings:

- **Fire exclusion has had little to no effect on fuels or forest structure in forests characterized by high-severity fire regimes**—a fact that is especially relevant to fire policy. High-severity fires are relatively infrequent—coming at intervals of one to many centuries—while the period of active fire exclusion in these remote forests has been less than a century. Land uses, including logging, plantations, and grazing, may have extensively modified the structure of these forests in some areas, but evidence suggests that fire regimes have not been fundamentally modified.

- **Because fuel structures or tree densities are usually well within the historic range of variability, "restorative" treatments are ecologically inappropriate in forests characterized by stand-replacement fire.** Modifying stand densities and fuels to levels that would reduce the potential for stand-replacement fire would render these forests incapable of fulfilling their characteristic ecological roles, including provision of high densities of standing dead trees (snags) and other critical elements of fish and wildlife habitat that are created by fire. Restoration could address other needs, such as restoring native understory plant diversity, where land use is known to have caused changes.

Forests Characterized by Mixed-Severity Fires

Fire is quite variable in severity and frequency in many mid-elevation and some low-elevation forests of moderate to high productivity across variable topography in the interior west and some coastal regions, such as the Klamath-Siskiyou region. In these forests both low- and high-severity fires may occur, with the former often more frequent than the latter. Topographically complex western mountain landscapes may be especially prone to mixed-severity fire, because drier south-facing slopes with lower fuel loads can burn at low severity when adjacent, moister north-facing slopes that support higher tree densities experience high-severity fire. The inherent variability of mixed-severity fire regimes precludes easy detection and analysis of the effects of fire exclusion. Exclusion of fire may have allowed tree densities to increase in some areas but post-fire tree density is naturally high in patches killed by high-severity fire.

Key Finding:

- **Scientific understanding of mixed-severity forest landscapes is limited, making it difficult to provide ecologically appropriate guidelines for restorative treatments.** These are very often very complex landscape mosaics; hence, it is necessary to plan and conduct activities at larger spatial scales. In mixed-severity forest landscapes where sufficient ecological and fire-history information is available, a combination of thinning and prescribed fire may be useful in restoration. However, only portions of these landscapes will warrant treatment from an ecological perspective that recognizes the spatially complex patterns. More scientific research is needed to understand the dynamics of mixed-severity forest landscapes.

Forests Characterized by Low-Severity Fires

The consequences of many human activities—including fire exclusion, logging, tree planting, and livestock grazing—are most serious in forest types that historically were characterized primarily by low-severity fires. Low-severity fire regimes were typical of many (but not all) pine and dry mixed-conifer forests, which occurred on warm, dry sites prior to European settlement. These fires historically burned fine fuels (e.g., grasses and litter on the forest floor) at regular intervals. These surface fires killed few large fire-resistant trees but killed many smaller trees of all species, helping to maintain open-canopied stands of large, old trees. Human activities since European settlement have dramatically modified the fuel structure in these forests. Logging of large fire-resistant trees has eliminated key ecological elements of these forests, including the large trees, snags, and logs essential to many ecological functions, such as provision of fish and wildlife habitat. Logging also has promoted higher stand densities in many dry forests by stimulating dense natural regeneration, even when it was not followed by aggressive replanting.

Key Findings:

- **Restoration of dry ponderosa pine and dry mixed-conifer forests—where low-severity fires were historically most common—is appropriate and desirable ecologically on many sites.** Mechanical thinning of small stems and prescribed fire are effective techniques for restoring stand densities to levels that existed prior to fire exclusion, livestock grazing, logging, and plantation establishment.

- **Retention of large and/or old live trees, large snags, and large down logs in restoration treatments, such as thinning, is critical to restoring and maintaining ecological function.** Also, other key components of these ecosystems, such as native understory plants, must be restored or protected for full restoration of natural conditions, including the potential for characteristic fire behavior.

Priorities and Principles of Ecologically-Based Forest Restoration

Forest restoration varies along a continuum from restoring structure (e.g., reducing densities of small trees and increasing the density of large trees) to restoring the processes (e.g., low-severity fire, competition between grasses and tree seedlings) that create and maintain that structure. The continuum also represents a gradient from symptoms (e.g., uncharacteristically high tree densities) to causes (e.g., exclusion of fire). A well-established principle in land health, as in human health, is that treating symptoms may be necessary in the short term, but that ultimately causes must be identified and treated to restore health.

Appropriate models for restoration will vary with current forest conditions, management objectives, and plant association groups, among other factors. An essential early step in a management program is to identify the Desired Future Condition (DFC) to which treatments are directed. DFCs are often based on conditions that are considered to be within the historical range of variability (HRV). Precisely achieving some past condition is not a reasonable goal, but conditions broadly representative of the historic range of variability can often be approximated through restorative activities. Restoration of processes (e.g., low-severity fire) may allow the re-structured forest to eventually equilibrate with contemporary environmental conditions. The

level of threat to particular natural values—such as critical wildlife habitat, watershed and aquatic values, and existing populations of veteran old trees—should be considered in setting priorities for restoration treatments.

Areas in the wildland-urban interface (WUI) may require fuel reduction and fire management policies that are inconsistent with HRV or with maintaining the biodiversity of those sites, even though carefully tailored treatments can maintain some aspects of biodiversity. Growth-management policies could minimize adverse ecological impacts from the WUI.

We provide two case studies—the Klamath Reservation Forest and Rocky Mountain ponderosa pine–Douglas-fir forests—in the background report to illustrate the wide variety of ecological conditions and ecologically appropriate management and restoration practices in western forests.

Key Findings:

- **From an ecological perspective priorities for restoration need to be determined on the basis of ecological considerations and urgency outside of the wildland-urban interface (WUI).** High-priority cases are likely to include areas where significant ecological values are at risk of undesirable stand-replacement fire. Many of these are outside of the WUI.

- **On lands where ecological objectives dominate, the desired goal will often be a forest ecosystem with its fire regime, fuels, tree population structure, and other living organisms restored to within the historic range of variability.** Ideally, the conditions created must be consistent with the characteristic fire regime of the site—i.e., sustainable in the context of the probable fire regime. Deviation from historic conditions sometimes may be necessary, however, to accommodate an altered biota or environment, or to accommodate appropriate social objectives. In such cases the highest conservation values are likely to be obtained by minimizing deviations from the historic range of variability.

- **Broader conception and implementation of restoration objectives, beyond fuel and fire mitigation, are necessary** to achieve comprehensive, scientifically based approaches to ecological restoration of western forests. An example is the restoration of understory plant communities.

- **Restoration plans must recognize and systematically incorporate fire management needed to maintain the restored forest**. Forests are dynamic; therefore, any restoration program has to provide for sustained fire management in order to maintain the desired condition. A common-sense goal consistent with ecological science is to achieve restored forests that are low maintenance, such as can be achieved through managed natural fire, and, where this is not possible, to use prescribed fire that seeks to mimic as closely as possible the characteristic fire regime.

- **Large trees of fire-resistant species and large snags and logs have high ecological importance and should be retained in restoration projects with ecological goals.** Where present, large and old live trees are the most fire-resistant component of western

forests and are essentially irreplaceable. Snags and logs on the forest floor are key wildlife features that are deficient in many western forests due to logging.

- **There are risks associated with restorative treatment of stands and landscapes including**: (1) Uncertainties associated with basing treatments on inadequate knowledge; and (2) Risks associated with not taking restorative actions, including the potential loss of significant ecological values. An example of the latter is potential loss of spotted owl habitat to stand-replacement fire, which is uncharacteristic in some landscapes, such as on the lands that previously constituted the Klamath Indian Reservation in the Eastside Cascades. Again, we emphasize the need to recognize variability, as portions of landscapes that are generally characterized as falling within a low-severity fire regime did experience high-severity fire, at least on occasion.

- **Adaptive management, including properly designed monitoring activities, needs to be a part of all major restoration programs.** Many proposed research and monitoring activities associated with restoration programs have lacked both sufficient and sustained funding. Creation of a dedicated funding mechanism to support these activities is imperative for proposals to provide critical feedback to managers and, secondarily, to have credibility with stakeholders.

- **Credible, third-party scientific reviews are critical when major controversies arise as to the scientific merits of proposed activities.** Regular processes or mechanisms for the initiation and nature of these scientific reviews need to be established along with appropriate funding mechanisms.

Protected Areas Are Essential for Managing Fire for Ecological Diversity

Not all conservation needs can be met in managed forests. Reserves of various kinds are a fundamental conservation tool whether they are congressionally recognized (e.g., national parks and wilderness), land allocations (e.g., Late Successional Reserves), or de facto reserves (e.g., roadless areas). They provide essential enclaves for species and serve as control or reference sites for lands managed for commodities. The question of how reserves in fire-prone landscapes should be managed cannot be addressed by application of a simplistic "one-size-fits-all" philosophy, but must be guided by consideration of the vegetation structure and composition of the area in question and its characteristic fire regime.

Key Findings:

- **Reserves may be required for species closely associated with late- or early-successional forests in fire-prone landscapes for a variety of reasons.** For example, unreserved forests are often fragmented by periodic logging or consist only of stands of trees too small or too open to meet the needs of late-successional species, such as spotted owls. Species typical of natural post-fire habitats (e.g., many woodpeckers), which contain abundant standing dead trees, require substantial areas reserved from post-fire logging.

- **The reserve concept does provide for appropriate kinds of management and ecologically compatible human use.** Restoring a natural fire regime is most compatible with the reserve concept, but in cases where fully restoring a natural fire regime is not feasible, ecologically appropriate management will likely be needed to restore and maintain biodiversity and the conditions for which reserves were set aside. Some types of management, such as prescribed burning, and some uses, such as ecological research and monitoring, are often essential to the persistence of populations, habitat features, and key ecological processes within reserves. The general goal would be to restore the reserve landscape to a condition within the historical range of variability (where restoration is necessary) and then to maintain it in that state with minimal human intervention, or allow it to equilibrate with contemporary natural conditions.

Management Activities During Wildfire

Fire management policies provide direction regarding responses to wildfire, including such basic issues as whether or not to suppress wildfires. A generalized policy regarding fire suppression is inappropriate as evidenced by the negative ecological (and other) impacts of a universal fire-suppression policy during the 20th century. Decisions regarding appropriate response to fire need to consider many ecological and social factors, beginning with the nature of the forest type and societal goals.

Key Findings:

- **From an ecological perspective, allowing fires to serve their natural role may be most beneficial ecologically.** Certainly, fire must be managed when close to human settlements and infrastructure and in some cases where economic resource values are high. Away from these areas—such as in many wilderness areas, national parks, and large areas of contiguous public lands—there is opportunity to increase the use of wildland fire, thus benefiting the range of species that require a diversity of natural fire regimes.

- **Fire suppression may be beneficial to ecological values in some forest landscapes, particularly where special values are at risk.** For example, fire suppression may be appropriate where rare or unique ecological values (including imperiled species habitat) could be lost, where uncharacteristic fuel accumulations have created the potential for a fire that is outside the historic range of variability, or where infrequent high-severity fires are characteristic but where such fires are not currently viewed as ecologically desirable (e.g., old-growth forests in Pacific Northwest).

Forest Management After Wildfire

Forest landscapes that have been affected by a major natural disturbance—such as a severe wildfire or windstorm event—are commonly viewed as devastated and biologically impoverished. Such perspectives are usually far from ecological reality. Overall species diversity

measured as number of species—at least of higher plants and vertebrates—is often highest following a natural stand-replacement disturbance and before re-development of closed-canopy forest. Important reasons for this include an abundance of biological legacies, such as living organisms and dead tree structures, the migration and establishment of additional organisms adapted to the disturbed, early-successional environment, and temporary release of other plants on the site from dominance by trees.

Currently, natural, early-successional forest habitat—naturally disturbed areas with a full array of legacies (i.e., not subject to post-fire logging) and experiencing natural recovery processes (i.e., not seeded or planted)—are among the scarcest habitat condition in some regions, such as the Pacific Northwest.

Key Findings:

- **Research by both ecologists and foresters provides evidence that areas affected by large-scale natural disturbances often recover naturally.** Post-burn landscapes have substantial capacity for natural recovery. Reestablishment of closed forest following stand-replacement fire characteristically occurs at widely varying rates, providing temporary, but ecologically important and now rare early-successional habitat for a variety of native species and key ecological processes.

- **Post-fire logging does not contribute to ecological recovery; rather it negatively impacts recovery processes, with the intensity of such impacts depending upon the nature of the logging activity.** Post-fire logging in naturally-disturbed forest landscapes generally has no direct ecological benefits and many potential negative impacts from an ecological standpoint. Trees that survive the fire for even a short period of time are critical as seed sources and as habitat that will sustain many elements of biodiversity both above and below ground. The dead wood, including large snags and logs, is second only to live trees in overall ecological importance. Removal of these structural legacies—living and dead—is inconsistent with our scientific understanding of natural disturbance regimes and short- and long-term recovery processes.

- **Post-fire logging destroys much of whatever natural tree regeneration is occurring on a burned site.** This is a fundamental concern since these tree seedlings are derived from local seed sources, which are most likely the best adapted to the site. Furthermore, environmental variables, such as moisture and temperature conditions, are major selective factors in determining which natural tree seedlings survive, which favors genotypes more tolerant of environmental stresses than are nursery- or greenhouse-grown seedlings.

- **Evidence from empirical studies is that post-fire logging typically generates significant short- to mid-term increases in fine and medium fuels.** In some cases this may result in increased reburn potential rather than a decreased reburn potential, as is often claimed. In any case, from an ecological perspective large wood is of demonstrated importance in ecological recovery; removing this wood in an attempt to influence the behavior of a potential reburn event has little scientific support.

- **In forests subjected to severe fire and post-fire logging, streams and other aquatic ecosystems will take longer to return to historic conditions or may switch to a different (and often less desirable) state altogether.** Following a severe fire the biggest impacts on aquatic ecosystems are often increased sedimentation caused by runoff from roads. High sediment loads from roads may continue for years, greatly increasing the time for recovery.

- **Post-fire seeding of non-native plants generally damages natural ecological values, such as reducing the recovery of native plant cover and biodiversity, including tree regeneration.** Non-native plants typically compete with native species, reducing both native plant diversity and cover. Reductions in natural tree regeneration as a result of seeding of non-native plants have also been reported in numerous studies.

- **Post-fire seeding of non-native plants is often ineffective at reducing soil erosion.** Aerial seeding of grasses (primarily non-native) is common on federal lands following moderate- to high-severity fire to reduce postfire erosion. The effectiveness of seeding in reducing erosion is mixed. Grass seeding generally does not mitigate erosion during the first winter following fire, when seeded grasses are not yet well established. Seeding may slow erosion during the second year following fire but is rarely effective during intense storms.

- **There is no scientific or operational linkage between reforestation and post-fire logging; potential ecological impacts of reforestation are varied and may be either positive or negative depending upon the specifics of activity, site conditions, and management objectives. On the other hand, ecological impacts of post-fire logging appear to be consistently negative.** Salvage and reforestation are often presented as though they are interdependent activities, which they are not from either a scientific or operational perspective. From a scientific perspective, policy and practice should consider each activity separately. As noted above, post-fire logging is a consistently negative practice from the standpoint of ecological recovery. Natural tree regeneration is ecologically most appropriate, but intentional reforestation could also be designed to provide significant ecological benefits in some cases.

- **Accelerated reestablishment of extensive closed forest conditions after fire is usually not an appropriate objective on sites managed with a major ecological focus**. Wildfires have been viewed historically as events that destroy valuable standing forest and create undesirable expanses of deforested (i.e., unproductive) landscape. Re-establishment of fully stocked stands of commercially important tree species on burned sites has been a fundamental forest management objective on most private and public forestlands; hence the historic commitment to intensive reforestation. However, timber production is no longer the primary objective on many federal lands, where the focus on provision of biodiversity and ecosystem services equals or exceeds wood production objectives. The ecological importance of biological legacies and of uncommon, structurally complex early-successional stands argues against actions to achieve rapid and complete reforestation except where the primary goal is wood production. In addition, it is also inappropriate to re-establish fully stocked stands on sites characterized by low-

severity fire—the same sites where managers are trying to restore fuel loadings to th/eir historical range of variability.

- **Where timber production, other societal management goals, or special ecological needs are the focus, planting or seeding some native trees and other plants using local seed sources may be appropriate.** Ecological assessments of the post-burn area and considerations of management objectives should be used to determine appropriate activity. Special ecological circumstances might include a need to restore an uncommon plant species or habitat for a threatened or endangered species. Innovative practices, such as low or variable density planting, will likely be more appropriate ecologically than traditional practices that involve dense tree plantations of one or a few commercial species. Dense uniform conifer plantations are always inappropriate on sites characterized by low-severity fire unless the intent is intensive management of such sites for wood production.

More Ecological Science is Needed in Fire Management

Despite the complexity of fire ecology in western forests and uncertainty over the effects of particular management actions, the scientific basis for rational decision-making about fire has improved dramatically in recent years. Some of this improvement is evident in law and policy. For example, there is explicit attention to old-growth and characteristic forest structure in the Healthy Forests Restoration Act (HFRA) of 2003:

> *"In carrying out a covered project, the Secretary shall fully maintain, or contribute toward the restoration of, the structure and composition of old growth stands according to the pre-fire suppression old growth conditions characteristic of the forest type, taking into account the contribution of the stand to landscape fire adaptation and watershed health, and retaining the large trees contributing to old growth structure."*

Nevertheless, current approaches to implementation of HFRA may be flawed; while attempts are being made to incorporate the variability of fire regimes and vegetation dynamics among forest types, there is heavy reliance on expert opinion and unvalidated, over-specified models. Critical review of the scientific basis for HFRA, FRCC (Fire Regime Condition Classes), and LANDFIRE from a credible independent source, such as the National Academy of Sciences, is needed.

More generally, principles of ecological science and the detailed existing knowledge of individual forest ecosystems need to be incorporated more systematically into the development of forest fire and fuel policies. A current example is the need to incorporate ecological principles into proposed legislation dealing with post-fire (salvage) logging and reforestation.

One barrier to better use of ecological science is that scientists involved in developing fire policies and practices have tended to be specialists in fire and fuel management, not ecologists, conservation biologists, or other broadly trained scientists. It is not surprising, then, that current forest law and policy, such as HFRA, does not adequately incorporate ecological science in its

implementation and tends to promote a narrow definition of restoration that focuses almost exclusively on fuels.

True ecological restoration requires the maintenance of ecological processes, native species composition, and forest structure at both stand and landscape scales. Because ecological variability is great, few universal principles exist for integrating insights from ecology and conservation biology into fire management and conservation policies. Nevertheless, one principle that does seem to hold is that as forests are managed or restored, they should not only support the desired fire regime but also viable populations of native species in functional networks of habitat.