Beyond Smoke and Mirrors: a Synthesis of Fire Policy and Science

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Abstract: *Fire performs many beneficial ecosystem functions in dry forests and rangelands across much of North America. In the last century, however, the role of fire has been dramatically altered by numerous anthropogenic factors acting as root causes of the current fire crisis, including widespread logging, road building, fire suppression, habitat fragmentation, urban development, livestock grazing, and, more recently, climate change. The intensity and extent of fires in the western United States, specifically, have dramatically increased over the past several decades. Such shifts in fire behavior have triggered sweeping policy changes that were intended to prevent or contain fires but that pose significant risks to the integrity of ecosystems and the role fire historically played in shaping them. Here, we provide a social and ecological context for summarizing this special issue on fires, including general guidelines and principles for managers concerned about balancing the risks of inaction against the risks of action over extensive areas. Fundamental to our understanding of fire is the notion that it is extremely variable, has multiple causes, and requires ecological solutions that are sensitive to spatial scale and context. Therefore, forest managers must recognize that different forest types have different fire regimes and require fundamentally different fire- management policies. Furthermore, to restore or maintain ecological integrity, including the role of fire, treatments need to be tailored to site-specific conditions with an adaptive approach. We provide a conceptual framework for prioritizing fuel treatments and restoration activities in the wildlands-urban intermix versus those in wildland areas farther from human settlement. In general, the science of conservation biology has much to offer in helping to shape wildfire policy direction; however, conservation biologists must become more engaged to better ensure that policy decisions are based on sound science and that ecological risks are incorporated.*

Key Words: ecological integrity, fire restoration, public lands, wildfire policy

Más Allá de Humo y Espejos: una Síntesis de Políticas y Ciencia del Fuego

Resumen: *El fuego desempeña muchas funciones de ecosistema benéficas en bosques secos y pastizales en buena parte de Norte América. Sin embargo, en el pasado siglo el papel del fuego ha sido alterado dramáticamente por numerosos factores antropogénicos, incluyendo tala extensiva, construcción de caminos, supresión de fuego, fragmentación de hábitat, desarrollo urbano, pastoreo y más recientemente, cambio climático, y que actúan como "causas raíz" de la actual crisis del fuego. La intensidad y extensión de incendios, específicamente en el oeste de Estados Unidos, han incrementado dramáticamente en las últimas décadas. Tales cambios en el comportamiento del fuego han provocado cambios en las políticas que intentan prevenir o contener incendios pero constituyen riesgos significativos para la integridad de los ecosistemas y para el papel que históricamente jugó el fuego al moldearlos. Aquí, proporcionamos un contexto ecológico y social para resumir este número especial sobre incendios, incluyendo lineamientos y principios generales para administradores interesados en sopesar los riesgos de la inactividad en comparación con los riesgos de actuar en áreas extensas. La noción de que el fuego es extremadamente variable, tiene múltiples causas y*

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requiere soluciones ecológicas sensibles a la escala y contexto espacial es fundamental para entender el fuego. Por lo tanto, los administradores de bosques deben reconocer que diferentes tipos de bosques tienen diferentes regímenes de fuego y requieren de políticas de gestión de fuego fundamentalmente diferentes. Más aún, para restaurar o mantener la integridad ecológica, incluyendo el papel del fuego, se requieren tratamientos con enfoque adoptivo diseñados con base en las condiciones específicas del sitio. Proporcionamos un marco conceptual para priorizar tratamientos de combustibles y actividades de restauración en la entremezcla tierras silvestres-urbanas versus áreas silvestres alejadas de asentamientos humanos. En general, la ciencia de la biología de la conservación tiene mucho que ofrecer para ayudarnos a delinear la dirección de las políticas para incendios sin control; sin embargo, los biólogos de la conservación deben comprometerse más para asegurar que las decisiones tengan bases científicas sólidas y que consideren los riesgos ecológicos.

Palabras Clave: integridad ecológica, políticas de incendios no controlados, restauración de fuego, tierras públicas

Facing Our Dilemma

For millennia fire has been a key process influencing forests and rangelands across much of North America (Pyne 1982; Agee 1993; Arno & Allison-Bunnell 2002; Turner et al. 2003). The way fire is expressed across the landscape has shifted as a result of modifications in land management that have accompanied our changing perceptions of and priorities regarding fire. Prior to European contact, Native Americans utilized fire for a variety of purposes that shaped the composition and structure of fire-adapted communities (Barrett & Arno 1982; Anderson & Moratto 1996; Arno & Allison-Bunnell 2002). Beginning in the late 1800s, large fires were set by prospectors to locate precious minerals, and public attitudes about the beneficial role of fire were shifting in response to the great fires of 1910 in the American West (Pyne 1982; Agee 1993; Arno & Allison-Bunnell 2002). Society began to view fire as a dangerous force to be suppressed and contained at all costs (Pyne 2001; Dombeck et al. 2004 [this issue]; Kauffman 2004 [this issue]; Pyne 2004 [this issue]). This altered view of fire sank deep into our cultural subconscious, helped along by such icons as Walt Disney's Bambi and the U.S. Forest Service's Smokey Bear.

Since European settlement of the United States, fire has been altered substantially by anthropogenic factors acting as root causes of the current fire crisis, including (1) increases in human-related fire ignitions linked to an extensive network of forest roads, widespread logging, and recreational use and development of wildlands (DellaSala & Frost 2001; Dombeck et al. 2004 [this issue]); (2) reduction in biomass of fine fuels by livestock grazing leading to reduced fire frequency and increased tree invasion in the interior and southwestern United States (Covington et al. 1994; Belsky & Blumenthal 1997); (3) increases in fuel accumulation through active creation of dense tree plantations and a buildup of shade-tolerant conifers from fire suppression (Agee 1993; Arno & Allison-Bunnell 2002; Odion et al. 2004 [this issue]); (4) modifications in the rate of spread and incidence of wildfires related to habitat fragmentation associated with agriculture, urban development, and other firebreaks (Cochrane 2001; Arno & Allison-Bunnell 2002); (5) active fire suppression that has led to a general reduction in fire frequency for forest types characterized by frequent, low-intensity fire (Agee 1993; Arno & Allison-Bunnell 2002); and (6) losses of fire-resilient properties at the stand and landscape levels through the removal of large trees and "legacy" stand components and homogenization of fuels across large landscapes (Lindenmayer & Franklin 2002; Brown et al. 2004 [this issue]; Perry et al. 2004 [this issue]). Such fundamental changes in fire behavior may be amplified by a predicted incremental lengthening of the fire season and increase in fire intensity in the western United States, exacerbated by global warming (McKenzie et al. 2004 [this issue]). Consequently, in many areas of the West, fire regimes have been truncated and now occur in the extreme form as large and uncontrolled fires fought at substantial cost but generally suppressed only by changes in weather conditions (Dombeck et al. 2004; Kauffman 2004). This reduction in the variability of fire in many ways mirrors the alteration of other key ecosystem processes, including the curtailment of predation by top-level carnivores and the modification of hydrological regimes. Such large-scale changes in fundamental processes have the potential for cascading ecological effects. Consequently, the specific root causes underlining altered fire behavior and their human relationships need to be understood in order to develop appropriate management responses.

The sociopolitical landscape surrounding fire is increasingly complex, raising many challenges for conservation biologists. At stake are management decisions that could put ecosystems on long-term trajectories toward diminished ecological integrity and significant consequences for biodiversity and human communities. Such decisions often fail to incorporate relevant scientific knowledge. As a result, policies can result in ecologically inappropriate priorities and treatments. Recognizing these challenges, we provide a social and ecological context for summarizing this special issue on fires, including general guidelines and principles for managers concerned about balancing the risks of inaction against the risks of action over extensive areas. Fundamental to our understanding of fire is the notion that it is extremely variable, has multiple causes, and requires ecological solutions that are sensitive to spatial scale and context. We emphasize the importance of recognizing that different forest types have different fire regimes and therefore may require fundamentally different fire-management policies (Arno & Allison-Bunnell 2002; Franklin & Agee 2003). Furthermore, we acknowledge that to restore ecological integrity, including the role of fire, treatments need to be tailored to site-specific conditions with an adaptive approach. The classic fire behavior triangle consisting of fuels, topography, and climate (Arno & Allison-Bunnell 2002:38) requires significant modification in order for fire management to embrace the spatial, temporal, and geographic variability of fire as well as components reflecting the interaction of fire with other ecological processes.

Defining the Debate

Scientists and managers now understand not only that fire will return to forests of the western United States but also that high fuel loads and changes in climate may trigger drier and more variable weather patterns that result in a near future in which wildfires burn at higher intensities and over broader landscapes than otherwise would occur (McKenzie et al. 2004). During the early 1900s, the annual acreage burned in the western United States generally was higher than in more recent times. The area burned decreased during the 1930s to 1970s with improved technology and diligent organization of fire-suppression efforts, only to increase during the past two decades, reaching a recent annual maximum of 3.4 million ha burned in 2000 (Agee 1997; Pyne 2001; National Interagency Fire Center 2003).

Management is not likely to be able to significantly alter a future of more frequent and expansive wildfires, but it may be able to influence the timing and intensity of wildfires. Reducing fire intensities in areas that historically burned under lower intensities may be critical for maintaining soils, water supplies, and biodiversity and reducing impacts to human communities. Factors potentially under our control that may influence wildfire timing and intensity include prefire fuels treatments, wildfire suppression efforts, decisions to allow wildfires to burn at times when lower intensities are more likely, livestock grazing and logging practices, use of prescribed fire, and postfire management options that range from pursuit of natural recovery to implementation of large-scale timber salvage and herbicide treatments.

Other factors complicate our ability to influence fire behavior. Exotic species, including weeds and non-native grasses, may alter fire regimes by increasing fine fuels and shortening fire-return intervals. For example, the spread of exotic cheatgrass (*Bromus tectorum* L.) into Idaho's Birds of Prey National Conservation Area has shortened fire-return intervals with cascading effects on the ecosystem, including loss and fragmentation of shrub communities, changes in small-mammal populations, and concomitant losses of falcons and eagles (Knick 1999; Dombeck et al. 2003). The sprawl of suburban communities into wildlands and increased home construction within inholdings on public lands restricts management options while increasing fire risk. Unfortunately, rates of human population growth often are highest in western states where concerns over wildfires already are great (U.S. Department of Agriculture Forest Service 2000; Dombeck et al. 2004).

Increasing numbers of endangered species and remnant rare plant communities are of special concern in wildfire management. Whereas most rare species and plant communities are adapted to ecological disturbances resulting from wildfire events, past management and human development may have isolated or otherwise fragmented ecosystems to the point that populations of rare species are fewer, and those that remain are often more vulnerable to loss from wildfire. During high-intensity wildfires, for example, western stream fishes may be eliminated directly by the products of combustion or indirectly by high rates of stream sedimentation. Nonetheless, fish can typically recolonize areas once conditions improve, but only if stream systems retain levels of connectivity adequate to allow upstream or downstream populations to access the burned areas during postfire recovery (Rieman & Clayton 1997; Dunham et al. 2003).

Federal Agencies and Policies

The federal government's response to wildfire can best be characterized as bipolar: on the one hand there is a recognized ecological need to reintroduce fire after decades of active suppression, but on the other hand there is a reluctance to accept the risk associated with allowing fires, wild or prescribed, to burn (Arno & Allison-Bunnell 2002; Dombeck et al. 2004; Kauffman 2004). The result has been a perpetuation of the decades-old policy of striving to put all wildfires out by 10 a.m. and keeping use of prescribed fire to a minimum. But the cost of the existing approach to fire policy, both in agency expenditures and human safety, is escalating as wildfires increasingly become larger and more intense. Dombeck et al. (2004) argue for agency practices that accept some risk in the near term by allowing wildfires to burn within certain prescriptions of less severe weather, under the assumption that the future likelihood of larger and more intense wildfires, with their higher associated risks, will be reduced. However, current administrative policies such as the Healthy Forest Initiative (Office of the White House 2002) put more of the management emphasis on aggressive logging in the name of fire control without acknowledging ecological integrity as the basis for restoration and fuels management (Franklin & Agee 2003; Kauffman 2004). Scientists have been critical of such initiatives because many of their provisions appear designed to use the public's fear of fire as an excuse to continue logging practices that include the harvest of large, fire-resistant trees and road building into ecologically intact areas (DellaSala & Frost 2001; Franklin & Agee 2003). In addition, fire policies that stress logging as a remedial measure for reducing fire intensity may actually increase the rate of fire spread because most logging operations leave behind combustible slash (Lindenmayer & Franklin 2002).

Regardless of the approach ultimately taken, agencies will have limited funds and capabilities to carry out their mission of forest management. A spatially explicit strategy is necessary that prioritizes the types of fuels to be removed and locations where removal is most needed (Fig. 1). Certainly, our financial and personnel resources will not be adequate to treat the entire landscape. Common sense dictates that it would be most efficient to direct efforts to those areas less likely to be socially controversial and tailor treatments to the ecological and human values most at risk.

Bridging the Scientific and Policy Divide

Scientific knowledge has a central role in both defining and resolving issues related to fire and fuels management. We summarize the following issues, largely from the preceding papers in this special feature, that are important for moving beyond the smoke and mirrors of the current fire dilemma.

Ecological Context and Fire

To bridge the scientific and policy divide, policy makers and managers must understand the ecological effects of fire on a forest. They also need to understand that their decisions cannot be just about fire. Because wildfire and fuels exist within an interconnected landscape, managing for fuels directly affects soil, water, air processes and functions, and fish and wildlife habitats (Backer et al. 2004 [this issue]; Beschta et al. 2004 [this issue]; Bury 2004 [this issue]). Fire and fuels policies need to give attention to connectivity, landscape variability, other disturbance

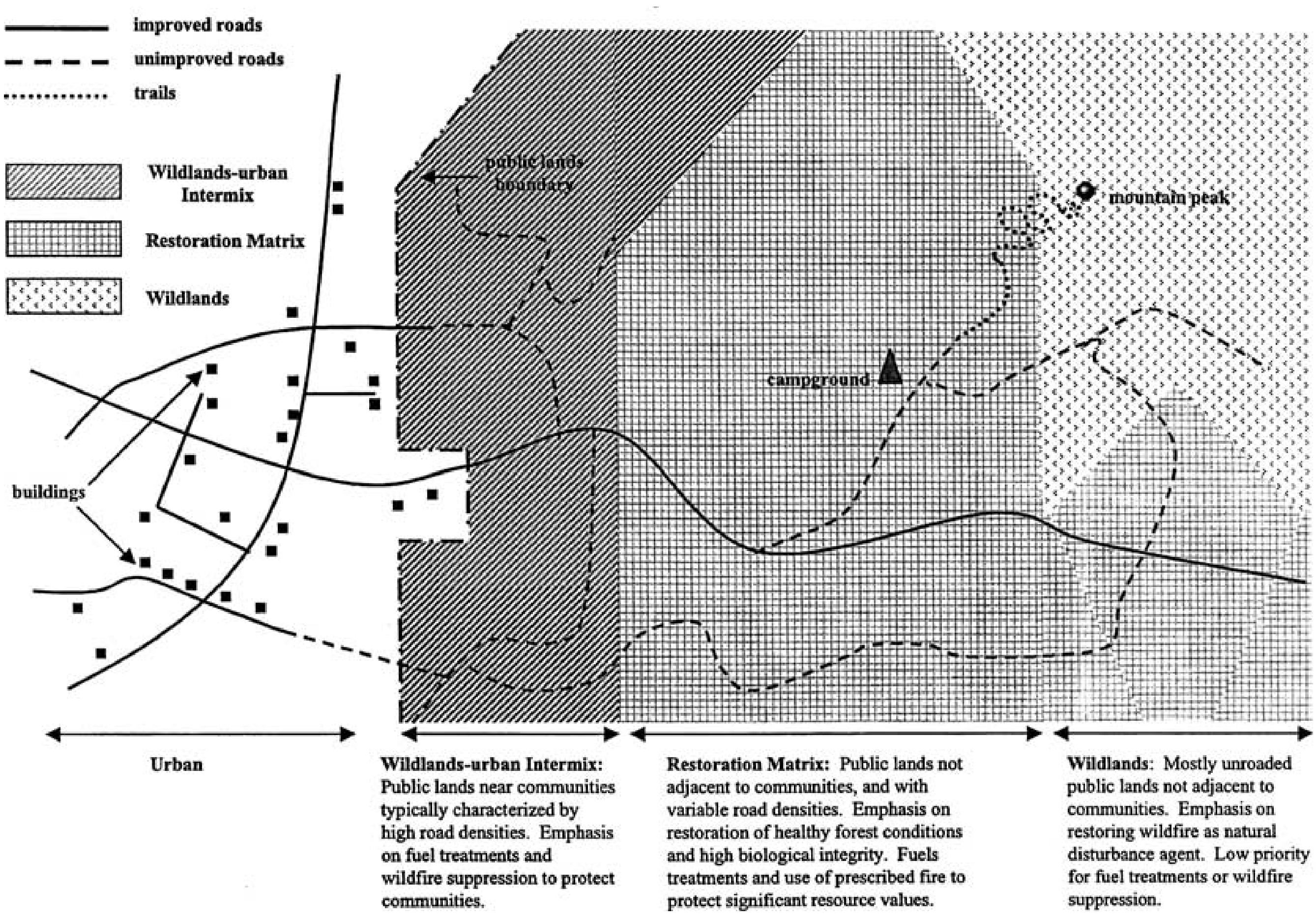

Figure 1. Conceptual map of the continuum of appropriate management priorities from the wildlands-urban intermix to wildlands.

processes such as drought and flood, cumulative effects, and the synergy between natural and human causes of change. At a fundamental level, fire and fuels management cannot simply be about lowering fuel loads; it must contribute to the long-term restoration of sustainable, dynamic ecosystems within the context of approaches to restoring ecological integrity (Karr 2000; DellaSala et al. 2003). Forests generally are enhanced by disturbances that occur at frequencies and intensities that do not exceed the capacity of the ecosystem to recover fully between disturbances. On the other hand, forests are degraded—fall to lower levels of ecological integrity—as a result of disturbance regimes that the component species have not experienced and adapted to over their evolutionary histories.

Management Limitations

From a manager's perspective, sound management must start from the realization that forests cannot be fireproofed (Agee 1997; Kauffman 2004) and must continue with a commitment to address social and ecological factors that confound wildfire policy and management decision making. The opportunities managers actually have to influence future fire behavior often are limited by climate and terrain. The variability and complexity of natural landscapes makes development and implementation of management decisions difficult. In addition, ecological changes resulting from past management, exotic species invasions, climate change, and other variables require that increased attention and innovation be brought to the application of past experience to new management problems. This can be especially difficult for agencies with strong traditions that are often struggling with uncertainties in management direction brought about by periodic and fundamental shifts in policy direction. Nevertheless, managers have many tools at their disposal that if properly employed may reduce the risk of uncharacteristic wildfire, particularly in areas that historically have been influenced by understory fires but now burn more intensely. In these situations, the judicious use of prescribed fire (Kauffman 2004) to reduce surface fuels and low-density thinning to reduce ladder and crown fuels (Brown et al. 2004) can be used responsibly to address fire concerns while maintaining large, fire-resistant trees and other ecosystem values.

Ecologically Appropriate Long-Term Goals

Restoration goals traditionally have been based on reestablishing conditions within the range that existed in some hypothetical "natural" or "presettlement" state that presumably is sustainable with an appropriate fire- and forest-management program. Although restoring forests to an approximation of nineteenth century conditions may be desirable in some cases (Covington et al. 1997), in many areas such restoration is impossible because of changes in climate, the pattern of land use and vegetation types, and the composition of forests and their responses to fire and other disturbances over the last several centuries. Nevertheless, knowledge of historic and current conditions and an understanding of how changes in conditions have occurred can be an important foundation for determining restoration possibilities and defining long-term goals. As such, restoration efforts should be designed to move degraded areas in the direction of some presumed natural condition over time, based on historical accounts and on reference areas as examples of desired future conditions (Angermeier 1997; Karr 2000; DellaSala et al. 2003).

Stratification of Forests for Development of Fuel and Fire Policies

Fundamental to the development and implementation of fuels and fire policies is an appropriate stratification of the landscape. Despite being the criterion most commonly cited during current debates over fire policy, such as that over the Healthy Forest Initiative, fuel condition class (e.g., Schmidt et al. 2002) is inappropriate as the primary criterion for dictating and prioritizing fuel treatments. Such national analyses typically map condition class at such broad spatial scales that the information is not useful for planning on-the-ground management prescriptions. Furthermore, condition class is the wrong parameter for structuring an effective fire policy because it ignores the fact that different forest types naturally have different fuel-condition characteristics (Franklin & Agee 2003).

Although fuel-condition class has proven to be of little use in developing coherent fire policies, initial stratification by forest type holds more promise. Forest types in North America vary dramatically in their historic fire regimes (e.g., fire-return intervals) and characteristic fuel loadings, and, consequently, fire-management policies need to accommodate these differences. Some types, such as the coastal forests of Douglas-fir (*Pseudotsuga menziesii* Mirb.) and western hemlock (*Tsuga heterophylla* [Raf.]Sarg.) (Agee 1993), forests of lodgepole pine (*Pinus contorta* Dougl. ex loud.), and high-elevation forests in the northern Rockies (Turner et al. 2003; Romme et al. 2004) are characterized by very infrequent stand-replacement fires (return intervals of several centuries); high fuel loadings are characteristic and, indeed, define such types. In these areas, our history of fire suppression has had little or no impact on fuel accumulations or potential fire behavior. Many other forest types, such as ponderosa pine (*P. ponderosa* Dougl. ex Laws.) and mixed-conifer forests, are characterized by frequent, low- to moderate-intensity fire regimes and limited fuel accumulations (Agee 1993). Such forests have

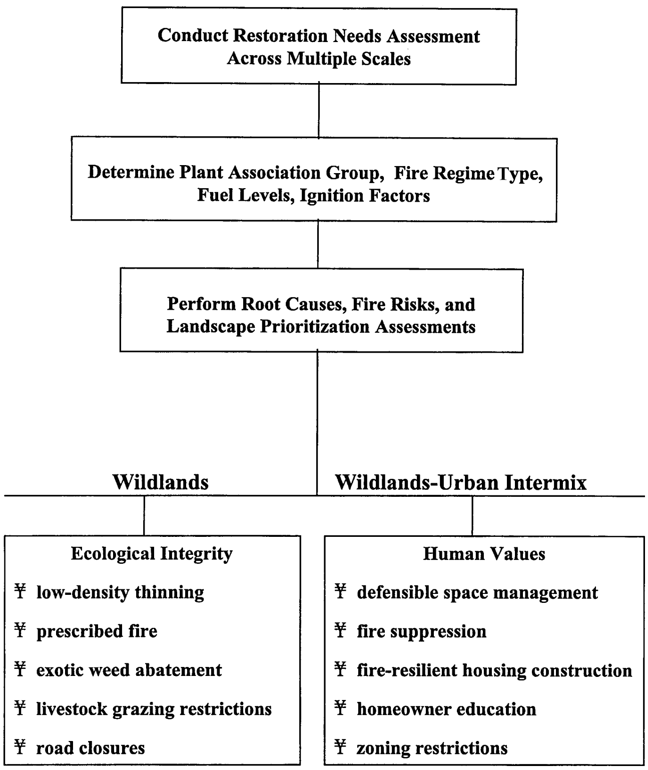

Figure 2. Assessment of restoration needs for wildlands and the wildlands-urban intermix.

often been affected dramatically by fire suppression and other human activities so that the potential for uncharacteristic stand-replacement fire behavior now exists. Although it may be possible to find examples of both forest types that currently display high fuel loads, an appropriate fire-management policy would dictate a different management response in these different forest types, beginning with a restoration-needs assessment (Fig. 2).

Major categories of forest community types, known as plant association groups, can be a useful primary stratification of fire regimes, where such data are available (Fig. 2). As an example, federal agencies have created a comprehensive classification of forest communities for the Cascades and northern Rockies of the United States and have characterized them with regard to natural fire-return intervals and fuel loadings that are more appropriate for site planning. This classification scheme is appropriate for dictating and prioritizing fuel treatments for site planning. However, in places where fires are not correlated with plant association groups (e.g., Klamath-Siskiyou ecoregion; Odion et al. 2004), coarser-level approaches are warranted, at least until better fire history data are available. Nevertheless, as part of this process, managers should conduct an analysis of root causes to identify the specific ecological drivers of altered fire behavior. Such "ecological forecasting" is needed to direct management priorities to be most responsive to ecological needs and human values.

Appropriate Spatial and Temporal Scales for Fuel and Fire Management

Fundamentally, management decisions must "solve for pattern," whereby the whole problem is addressed and not just some handily identifiable and simplifiable aspect of it (Berry 1981). Policies must require that such efforts be designed to accommodate the implications of both spatial and temporal scales; that is, they must be placed carefully on the landscape, they require a long-term commitment to achieve success, and they should be stratified based on risks to ecological integrity and human values.

Recognizing differences in fire regimes among forest types is essential from the highest level of national policy to site-specific prescriptions for fire management. Different landscape types require different approaches, and even similar landscape types in different geographic areas need unique treatment approaches (Keeley & Fotheringham 2001; Odion et al. 2004). Prescriptions for fuels treatments in the context of ecological integrity need to be planned at fine scales but implemented at landscape scales. Treatments of small areas (e.g., stands) embedded in landscapes at risk of stand-replacement fire are unlikely to be effective. Similarly, treatments planned at too broad a spatial scale are unlikely to adequately identify or address the needs of a variable landscape.

Fire- and fuel-management programs require repeated treatments and should be viewed as a continuing process and commitment rather than a single management event. A single fuel treatment such as prescribed burning and thinning cannot resolve fuel and fire issues over the long run and may actually lead to an increase in fuels that require prompt follow-up treatments (DellaSala & Frost 2001; Brown et al. 2004). The repeated, long-term nature of these programs needs to be recognized in policy and budgets.

Treating Both Wildlands and the Wildland-Urban Intermix

One useful tool to facilitate management decisions is the conceptualization of the landscape across an urban-to-wildlands management continuum (Figs. 1 & 2). At the urban end of the spectrum, social concerns should dominate the management framework. In these settings, management should be more proactive, with effort concentrated on wildfire fuels treatments, suppression, and post-fire recovery. Most important, private landowners need to understand that how they manage the landscape within the 40-m home-ignition zone around houses and outbuildings and the materials used to build these structures dictate the likelihood of loss to wildfire (Cohen 1999, 2000). This is especially true in the chaparral-dominated landscapes of southern California and of the recent large fire events that occurred in areas now occupied by thousands of homes (Keeley & Fotheringham 2001). Prioritization of fuel-reduction treatments in the wildlands-urban intermix, a narrow zone of 0.4–0.8 km surrounding communities (Cohen 2000; U.S. Federal Register Notice Vol. 66, p. 753, 4 January 2001; DellaSala et al. 2003), in combination with making homes "fire wise," is the best strategy in these situations.

In wildlands—roadless watersheds, wilderness areas, national parks, reserves, and other areas of high ecological integrity—ecological concerns should dominate. Management actions here should focus on restoring and maintaining ecological integrity by reconnecting fragmented landscapes and restoring ecological functions, protecting remaining rare community elements, and allowing fire more ecological freedom. This does not mean that "nature" should always be allowed to take its own course. In some areas, important resource values are at risk to uncharacteristic wildfire. For example, without significant fuel treatment and prescribed burning, large areas of Sierra Nevada mixed-conifer forest are at risk of stand-replacement fires; losses could degrade watershed conditions and reduce habitat for late-seral species such as the California Spotted Owl (*Strix occidentalis occidentalis*; Sierra Nevada Ecosystem Project 1996). However, prefire treatments, fire suppression, and even postfire restoration activities have ecological consequences (Backer et al. 2004). Scientific analysis and modeling can quantify the values at risk and help identify areas that should receive priority for treatment because the risks from uncharacteristic fire outweigh the risks associated with treatment or suppression as well as those areas where the risks from certain intervention are too high and therefore should not be implemented. Programs that focus solely on hazardous fuels reduction without prioritizing landscapes based on the probability or risk of ignition, as in the Healthy Forest Initiative, are invalid.

The highest priority in a residential setting is to reduce fuels within those portions of the wildland-urban intermix with high fuel loads and high probability of ignition rather than in wildland areas away from communities and/or in naturally functioning areas with few or no roads (DellaSala & Frost 2001; Turner et al. 2003; Brown et al. 2004). Assuming that the management emphasis is on ecological integrity, areas managed for natural resource extraction (i.e., "matrix" lands) and wildland areas with unique resources at risk need to be identified and treated.

Elements of Meaningful Fuel-Reduction Prescriptions

Perhaps the most difficult reality to accept is that no fuel-hazard reduction project can significantly reduce the severity or extent of a fire ignited in the summer, in the middle of a drought, that is burning on a day with high temperatures and winds. So we must focus our attention on those circumstances where our efforts are ecologically justifiable and have the potential to make a difference.

Fuel treatments are not ecologically justified in forests characterized by high-intensity or stand-replacing fires (Keeley & Fotheringham 2001; Turner et al. 2003; Romme et al. 2004). Fuel treatments in coastal Douglas-fir–western hemlock forests or lodgepole pine forests could shift fire behavior only if they were implemented so intensively that they created a fundamentally different and unnatural ecosystem (Turner et al. 2003), one that would be incapable of fulfilling many important functional roles. In other areas, fuel treatments can be ecologically justified where fire suppression and other management actions have led to uncharacteristic fuels and the fire regime has been shifted from low to moderate intensity or to stand-replacing wildfires. Areas with historically low-severity fire regimes typically are the highest priority for treatment (Brown et al. 2004), although site-specific evaluations must be undertaken to determine the priorities in any given area.

Effective fuel-treatment projects need to reflect the best current understanding of the relationship between fuels and fire behavior. For example, prescriptions must consider ground, ladder, and canopy fuels and retention of large trees of fire-resistant species (Brown et al. 2004). Furthermore, to be effective, thinning, prescribed fire, and other wildfire-reduction measures must be considered simultaneously (Brown et al. 2004; Perry et al. 2004). Perhaps most important, treatments must encompass the needs of the ecosystem as a whole with the overarching objective of restoring ecological integrity. Restoration treatments that focus exclusively on fuels in the absence of ecological integrity are fundamentally flawed and may come at the expense of ecosystem services and functions (DellaSala et al. 2003). Thus, as an initial step, fuel treatments should be planned within the context of larger goals of ecological integrity and stratified to promote heterogeneity across spatial scales (Beschta et al. 2004; Brown et al. 2004; Perry et al. 2004).

Retention of large and old trees can be a particularly contentious issue. In general, however, removal of large, old trees is not ecologically justified and does not reduce fire risks (Beschta et al. 2004; Brown et al. 2004; Perry et al. 2004). Such trees contribute to the resistance and resilience of the forest ecosystems of which they are a part. Large, old trees of fire-resistant species are the ones most likely to survive a wildfire and subsequently serve as biological legacies and seed sources for ecosystem recovery (Lindenmayer & Franklin 2002). They also are exceptionally important as wildlife habitat, before and after a wildfire event, and as sources of the large snags and logs that are critical components of terrestrial and aquatic habitats. For all practical purposes, they are impossible to replace. Projects that target removal of small and medium-sized trees are more likely to reduce risks because the density of trees in these size classes has increased dramatically, in some cases as a result of past suppression and forest-management practices (Brown et al. 2004; Perry et al. 2004).

Wildfire Suppression and Planning

The quality of management decisions that must be made once a fire has ignited can be improved dramatically with adequate planning. Rare plant habitats and other ecologically sensitive areas should be located and mapped before the pressure of an active fire compresses the decision-making timetable. Useful topographic features and existing road networks should be identified in the planning process. Such planning minimizes "emergency" situations, increases the knowledge base upon which decisions depend, and decreases the likelihood that suppression will result in ecological degradation.

The decision as to whether or not to undertake suppression must encompass a number of variables that influence fire behavior, including climate, weather, and terrain. In addition, consideration must be given to variables related to the need for and capability of successful intervention, such as the time of year, fuel moisture levels, proximity to urban areas and other important resources, and available financial, personnel, and equipment resources. Once a decision is made to actively engage in suppression activities, coordination and planning are needed to minimize the detrimental effects of such activities (Backer et al. 2004). In particular, efforts to minimize physical ground disturbance in areas not previously subjected to significant management disturbance can reduce the ecological costs of suppression activities. Also, appropriate measures should be taken to prevent the introduction and spread of exotic species, including pathogens and diseases, and the release of hazardous materials, hydrocarbon fuels, and other pollutants used in lighting backfires, especially near water sources (Backer et al. 2004).

Postfire Treatment Policies

Developing ecologically rational approaches to treatment following large and intense wildfires requires critical scientific and social analysis. Our scientific view of how forests are affected by and recover from natural disturbances has been dramatically altered by research that began with the 1980 Mount St. Helens eruption and accelerated after the Yellowstone fires of 1988. For example, the concept of biological legacies has emerged from this research (Franklin et al. 2000). Biological legacies include organisms and organically derived structures—such as snags and downed logs—that survive the disturbances and play important roles in the recovery process. Large trees, snags, and logs are particularly important in "life boating" many plant, animal, and fungal species and structurally enriching the new forest that eventually becomes established. Most fundamentally, almost all natural forest disturbances leave behind much greater biological legacies of organisms and structures than traditional timber-harvest practices such as even-aged management (Lindenmayer & Franklin 2002).

Protection of remaining live trees, snags, and logs needs to guide efforts to rehabilitate or salvage areas affected by wildfire. These biological legacies need to be treasured because of their role in providing habitat both in the immediate postburn period and during the century that follows. Particular scrutiny needs to be given to postfire practices that may adversely affect soil integrity, native species recovery, riparian functions, or water quality (Beschta et al. 2004).

Postfire seeding, reforestation, the use of straw bales for erosion control, and efforts to break up hydrophobic soils can result in significant ecological problems (Backer et al. 2004; Beschta et al. 2004; Beyers 2004 [this issue]). Seeding at densities high enough to affect erosion appears to disrupt postfire recovery of native shrub, tree, and grass species and is unnecessary in most cases (Beyers 2004). Rapid reestablishment of dense conifer stands (plantations) tends to replace spatial variability with spatial uniformity and, on sites where frequent, moderate-intensity fires are characteristic, recreates the uncharacteristic potential for a new stand-replacement fire. Grass seeding and mulching with hay can result in introduction of exotic plants and interfere with natural regenerative processes (Backer et al. 2004; Beyers 2004). Planting with native seeds or conifers, however, may be appropriate in areas previously infested with weeds and exotic grasses and in cases where the results of monitoring indicate that natural recovery is inhibited by a lack of source pools (e.g., where postfire succession limits reestablishment of endemic conifers). In such cases, native seeds from local sources are preferred, and conifer plantings should be at low densities to minimize crowding and fire risks. However, even in intensely burned areas such as those resulting from the Yellowstone fires of 1988, postfire recovery processes have been surprisingly rapid (Turner et al. 2003; Romme et al. 2004). Moreover, there is little indication of negative long-term ecological consequences from hydrophobic soils, a condition that occurs naturally in many areas and typically is "remedied" by the natural progression of the seasons; therefore management to break up such soils is unwarranted (Beschta et al. 2004).

Given the limited circumstances in which postfire seeding, reforestation, or other postfire restoration projects are appropriate (Backer et al., 2004), there is little ecological justification for widespread postfire treatments (Beschta et al. 1995; Turner et al. 2003; Beschta et al. 2004), and they should be avoided. Although the ecological impacts of limited-salvage logging "done right" in nonsensitive habitats can be minimized, such projects typically target removal of large trees that provide ecologically important structure to the postfire landscape (Lindenmayer & Franklin 2002). Beschta et al. (1995) recommend leaving at least 50% of standing dead trees in each diameter class and all trees >150 years old, and Minshall (2003) found negative effects on stream communities when more than 25% of the merchantable timber was removed during salvage activities.

Finally, the ecological importance of naturally recovering postfire landscapes needs to be recognized in fire management-policies (Turner et al. 2003). Despite their importance as hotspots of regional biodiversity, naturally recovering early successional habitats—open areas with their legacies of snags and logs and diverse open communities of herbs, shrubs, and trees—are a rare successional stage in most regions. Clearcuts do not exhibit the ecological properties necessary to provide this kind of habitat, and neither do postfire landscapes subjected to extensive salvage (Lindenmayer & Franklin 2002).

Conceptual Framework for Management

Given the inherent uncertainty and complexity of natural systems, a prudent conceptual starting point for policy development may be adoption of an ecological Hippocratic oath to "first, do no harm" to the environment rather than to harm it unexpectedly or unintentionally. Certainly, much of today's fire crisis is the result of aggressive implementation of resource policies whose ecological implications were either poorly understood or ignored. In many instances, identifying opportunities for passive restoration—that is, ceasing activities that impair the ecosystem's ability to heal itself—is likely to be the most effective approach (Dale et al. 2000; DellaSala et al. 2003). This does not mean, however, that active management is not warranted. Rather, active restoration of degraded or recovering landscapes should be viewed within the larger framework of ecological integrity objectives that also integrate social needs (DellaSala et al. 2003).

Fire Management and Implications for Reserve Design

Fire management has many important implications for conservation planning. In particular, given the dynamic nature of fire-adapted ecosystems and the size of many fire events in the dry forest types of the western United States, conservation strategies that rely on reserves need to include planning for disturbance events. Because the designation of reserves big enough to withstand a major fire is socially charged and politically challenging in most places, conservationists need to plan for adequate redundancy and representation of patch types distributed widely across a network of reserves in disturbance-prone regions (DellaSala et al. 1996). The Northwest Forest Plan in the Pacific Northwest (U.S.) is an example of a conservation plan built on redundancy concepts for ensuring the persistence of late-successional habitats across the range of the Northern Spotted Owl, even in areas where disturbance events exceed the size of individual reserves.

Active management may be needed in some reserves to restore or maintain ecological integrity. In such instances, management goals need to be clearly defined, carefully monitored, and based on ecological risk assessments to determine the most effective strategies. As an example, reserves with large areas in high-hazard condition in relation to fuels and those with elevated risk of critical habitat loss are candidates for active restoration to reduce the risk of stand-replacing fires within the context of restoring ecological integrity (DellaSala et al. 2003). Restoration activities may target high-risk areas initially as a "safeguard" and then build outward from ecologically important sites. For key habitats in small reserves imbedded within landscapes that have been highly altered and fragmented, the focus of restoration should be to reduce the risk of stand-replacing wildfire within the reserve by creating more resilient structures adjacent to the high-value area and extending these areas over time. In contrast, reserves operating within the range of the natural variability of disturbances and those with critical habitats at low risk should be candidates for maintenance, such as allowing wildfire to burn or use of prescribed fire (DellaSala & Frost 2001).

Getting Beyond the Smoke and Mirrors

Most policy makers speak of establishing fire policy for two purposes: restoring the health of the land and reducing the risk of catastrophic fire. However, fire policy must be shaped by an emphasis on fundamental approaches to restoring or maintaining ecological integrity, a real understanding of the nature and extent of all the risks to both humans and wildlands, and a realization of the agencies' budgetary and personnel capabilities.

Implicit in the concept of reestablishing the "health of the land" is restoration of biological, physical, and chemical processes and functions so as to ensure long-term ecological sustainability and ecological integrity (Karr 2000; Dombeck et al. 2003). Accomplishment of such an objective requires the full participation of the entire ecological community. Conservation biologists need to hone their communication skills so they can help construct a more complete ecological foundation upon which society can launch a debate over wildfire policy and accurately refocus its discussions of protection of wilderness, unroaded areas, and other wildlands areas of high conservation value within the context of legitimate forest-restoration measures. Although much of any societal disagreement is at root an argument about values, all controversies are fueled in part by factual misunderstandings. Conservation biologists, as individuals and through their professional societies, can make an invaluable contribution to the debate by infusing ecological knowledge into policy discussions and by countering misleading presentations of ecological principles. Conservation biologists should therefore engage in the fire debate in meaningful ways so as to educate the public and help shape policy.

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