An Ecologically Based Strategy for Fire and Fuels Management in National Forest Roadless Areas

Dominick A. DellaSala and Evan Frost

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During the challenging 2000 fire season, the local and national headlines trumpeted daily news about the "worst fires in recent memory." The media showered us with the latest statistics on wildland fires in the West: "More than 6 million acres charred in 13 Western States…more than 25,000 firefighters deployed…over 80 blazes raging out of control… hundreds of homes consumed."

Some individuals sought to increase logging on Federal lands, citing greatly reduced logging levels during the previous decade as the cause of the 2000 fires. The implication was that the USDA Forest Service's proposed policy for protecting roadless areas was akin to putting a lit match into a tinderbox.

Whereas conservationists advocated roadless area protection on the basis that roadless areas are the last remnants of formerly large and intact forests, logging proponents called for massive logging, roadbuilding, and a rash of prescribed fires as a quick fix for the previous 50 to 100 years of fire suppression. The rest of us pondered: Where is the science in all this? Is every acre doomed to "catastrophic" fire if not intensively managed? Is it appropriate to treat all forests the same, regardless of whether or not they contain existing road systems?

After all the hyperbole—a combination of media hype and misinformation spread to promote special interests—it's time to take a sober look at the questions raised by the 2000 fire season. Specifically, what evidence exists on the relationship between wildland fire and timber management in roaded vs. roadless areas? What effects might silvicultural treatments and prescribed fire have on ecosystems in roadless areas? Is there an ecologically based strategy for identifying, on a case-by-case basis, where active management might be appropriate for maintaining fire-dependent forest ecosystems?

Fire and Roadless Areas

Level of Fire Hazard.

Scientists widely agree that protecting roadless areas on the national forests from roadbuilding, commercial logging, and other forms of development will greatly enhance biodiversity and ecosystem conservation (Ercelawn 1999; Henjum and others 1994; Noss and Cooperider 1994; Strittholt and DellaSala [in press]). However, some critics of roadless area protection (Bernton 1999; Hansen 1999; Schlarbaum 1999) have repeatedly made two assertions:

- Roadbuilding prohibitions in roadless areas will restrict access for timber management, which in turn will increase the frequency of large, intense fires.
- Widespread silvicultural treatments (such as low thinning and crown thinning) in roadless areas will be necessary to reduce the fire hazard.

Does the relevant scientific literature support these claims?

Broad scientific assessments were completed in 1996 and 1997, respectively, for Federal lands in the Sierra Nevada in California and the Interior Columbia River Basin in portions of Idaho, Montana, Nevada, Oregon, Washington, and Wyoming. These studies provide the most comprehensive analysis to date for comparing fire, fuel, and vegetation conditions in intensively managed areas to conditions in roadless areas. Both assessments found the fire hazard to be significantly higher in intensively managed areas.

According to the Sierra Nevada assessment, "Timber harvest, through its effects on forest structure, local microclimate and fuel accumulation, has increased fire severity more than any other recent human activity" (SNEP 1996). The Interior Columbia Basin assessment similarly concluded that "fires in unroaded areas are not as severe as in roaded areas because of less surface fuel….Many of the fires in the unroaded areas produce a forest structure that is consistent with the fire regime, while the fires in the roaded areas commonly produce a forest structure that is not in sync with the fire regime. Fires in the roaded areas are more intense, due to drier conditions, wind zones on the foothill/valley interface, high surface-fuel loading, and dense stands" (Hann and others 1997).

Even within the forest types most altered as a result of fire suppression (such as dry forests with a regime of frequent low-intensity fires), intensively managed forests on Federal lands in the Interior Columbia Basin are denser and carry higher fuel loads than do roadless areas. Accordingly, intensively managed lands were found to be at higher risk of tree mortality from fire, insects, disease, and other disturbance agents (Hann and others 1997).

Others have reported similar findings for portions of the interior West. In the Sierra Nevada, McKelvey and others (1996) and Weatherspoon (1996) identified timber harvest as the single most important factor responsible for an increase in potential fire severity. In the Klamath Mountains of northwestern California, Weatherspoon and Skinner (1995) found that partial-cut stands with fuels treatment (lop and scatter or broadcast burning) burned more intensely and suffered higher levels of tree mortality than adjacent areas left uncut and untreated. Fire and fuel models also suggest that mechanical treatments alone, including silvicultural thinning and biomass removal, are not likely to be effective at reducing fire severity in dense stands (van Wagtendonk 1996).

In eastern Oregon and Washington, Lehmkuhl and others (1995) and Huff and others (1995) reported a positive correlation between logging, on the one hand, and fuel loadings and predicted flame lengths, on the other. They attributed the increased fire hazard in intensively managed areas to leftover slash fuels from tree removal activities (including thinning) and to the creation of dense, early-successional stands through overstory removal. A postfire study of the effectiveness of fuels treatments (including thinning) on previously non-harvested lands on the Wenatchee National Forest in Washington found that harvest treatments likely exacerbated fire damage (USDA Forest Service 1995).

Overall, the scientific literature suggests that forests in areas without roads are less altered from historical conditions and present a lower fire hazard than forests in intensively managed areas, for three reasons:

1.Timber management activities often increase fuel loads and reduce a forest’s resilience to fire.
2.Areas without roads have been less influenced by fire suppression than intensively managed lands.
3.Widespread road access associated with intensively managed lands raises the risk of human-caused ignitions.

As summarized in a recent review of national forest management organized by the Ecological Society of America, "There is no evidence to suggest that natural forests or reserves are more vulnerable to disturbances such as wildfire than intensively managed forest stands. Indeed, there is considerable evidence to the contrary, evidence that natural forests are actually more resistant to many types of both small- and large-scale disturbances" (Aber and others 2000). Assertions about increased wildland fire made by critics of roadless area protection are not based in fact; the evidence is clear that the forests most in need of fuels treatment are not roadless areas but areas that have already been roaded and logged, "where significant investments have already been made" (USDA/USDI 1997).

Effectiveness of Fire Suppression.

Some evidence exists that fire suppression activities have had a lower impact on roadless areas than on roaded portions of the national forests (Hann and others 1997; SNEP 1996). The lower impact may be attributable to limited access and steep terrain, which prevent the application of large, ground-based suppression strategies in roadless areas (Agee 1993; Fuller 1991; Pyne 1996; Schroeder and Buck 1970).

Fires in roadless areas tend to be more remote from human habitations than are fires on roaded lands. Accordingly, they are often the lowest priority for suppression during years when firefighting resources are in short supply. Although data are limited, findings from the Interior Columbia Basin assessment on this topic might apply to other regions as well. The assessment concluded that a "combination of past harvest practices and more effective fire suppression moved the roaded landscapes much further from their unaltered biophysical templates, as measured by dominant species, structures, and patterns, relative to unroaded areas….In general, all forests which show the most change from their historical condition are those that have been roaded and harvested" (Hann and others 1997). Furthermore, the forests that are most susceptible to moisture stress, insects, disease, and unnaturally intense fire tend to be at the lowest elevations, which typically border private, State, tribal, or other landownerships (Everett and others 1994).

Another reason why fire suppression has had less impact on forests in roadless areas is associated with differences in vegetation and fire regimes. A large proportion of roadless areas on the national forests, particularly in the interior West, are found at middle to high elevations (Beschta and others 1995; Henjum and others 1994; Merrill and others 1995).

Some exceptions are in the Eastern United States, where elevational gradients are limited, and the Klamath–Siskiyou ecoregion in northwest California and southwest Oregon, where very steep slopes at lower elevations have limited road construction (Strittholt and DellaSala [in press]).

Higher elevations are cooler, receive more moisture, and have a shorter summer dry season than lower elevations. They are typically characterized by a regime of low-frequency, high-intensity fires (Agee 1993; Baker 1989; van Wagner 1983). Roadless areas are therefore less likely to have current fire regimes that are significantly different from historical conditions (Agee 1997; Beschta and others 1995).

For fires in high-elevation forests, weather rather than fuels is often the primary variable determining fire severity and extent (Agee 1997; Bessie and Johnson 1995; Flannigan and Harrington 1988; Johnson and Wowchuck 1993; Turner and others 1994). Under severe fire weather, the efficacy of fire suppression decreases dramatically in forest types characterized by high-intensity fires (Agee 1998; SNEP 1996). Even substantial investments of financial and human firefighting resources often fail to control large fires; they are extinguished only when the weather changes (Romme and Despain 1989).

Risk of Human-Caused Ignitions.
Roadless areas have a lower potential for high-intensity fires than roaded areas partly because they are less prone to human-caused ignitions (DellaSala and others 1995; USDA Forest Service 2000; Weatherspoon and Skinner 1996). Roads constructed for timber management and other activities provide unregulated motorized access to most national forestlands and are heavily used by the general public.

In the Western United States, most of the more than 378,000 miles (608,000 km) of national forest roads traverse heavily managed forests with the greatest potential for high-severity fire. According to the Forest Service, more than 90 percent of wildland fires are the result of human activity, and ignitions are almost twice as likely to occur in roaded areas as they are in roadless areas (USDA Forest Service 1998, 2000). Although it can be argued that roads improve access for fire suppression, this benefit is more than offset by much lower probabilities of fire starts in roadless areas.

The Case Against Mechanical Fuels Treatments in Roadless Areas

Some land managers and policy makers advocate the widespread use of silvicultural treatments (often mechanical thinning of merchantable trees) in western roadless areas to reduce fuel loads and tree stocking levels and thereby decrease the probability of large, intense fires. Although thinning has long been a part of intensive forest management, its efficacy as a tool for fire hazard reduction at the landscape scale is controversial and remains fundamentally experimental in nature (DellaSala and others 1995; FEMAT 1993; Henjum and others 1994; SNEP 1996; USDA Forest Service 2000).

Few empirical studies have tested the relationship, even on a limited basis, between thinning or other fuels treatments and fire behavior. These studies, supported by anecdotal information and the analysis of recent fires, suggest that thinning treatments have highly variable results. In some instances, thinning intended to reduce the fire hazard appeared to have the opposite effect (Huff and others 1995; van Wagtendonk 1996; Weatherspoon 1996). Thinning might reduce fuel loads, but it also allows more solar radiation and wind to reach the forest floor. The net effect is often reduced fuel moisture and increased flammability (Agee 1997; Countryman 1955).

Moreover, mechanical treatments fail to mimic the ecological effects of fire, such as soil heating, nutrient cycling, and altering forest community structure (Chang 1996; DellaSala and others 1995; Weatherspoon and Skinner 1999). In fact, according to the Sierra Nevada Ecosystem Project report, "although silvicultural treatments can mimic the effects of fire on structural patterns of woody vegetation, virtually no data exist on their ability to mimic the ecological functions of natural fire. Silvicultural treatments can create patterns of woody vegetation that appear similar to those that fire would create, but the consequences for nutrient cycling, hydrology, seed scarification, non-woody vegetation response, plant diversity, disease and insect infestation, and genetic diversity are almost unknown" (SNEP 1996).

Although our current understanding of the ecological effects of thinning is incomplete, evidence indicates that mechanical treatments, even when carefully conducted, can have additional environmental impacts such as:

- Damage to soil integrity through increased erosion, compaction, and loss of litter layer (Harvey and others 1994; Meurisse and Geist 1994);
- Increased mortality of residual trees due to pathogens and mechanical damage to boles and roots (Filip 1994; Hagle and Schmitz 1993);
- Creation of sediment that might degrade streams (Beschta 1978; Grant and Wolff

1991);

- Increasing levels of fine fuels and near-term fire hazard (Fahnestock 1968; Huff and others 1995; Weatherspoon 1996; Wilson and Dell 1971);
- Disruption of mycorrhizal fungi– plant relationships that are important to ecosystem function and to shrubs and perennial native bunchgrasses involved in fungal linkages (Amaranthus and Perry 1994; Massicotte and others 1999; Southwort and Valentine 2000);
- Dependence on roads, which have numerous adverse effects of their own (Henjum and others 1994; Megahan and others 1994); and
- Reduced habitat quality for sensitive species associated with cool, moist microsites or closed-canopy forests (FEMAT 1993; Thomas and others 1993).

These adverse impacts of mechanical treatments should be of particular concern in managing roadless areas, where ecological values are especially high. Moreover, roadless areas are often in steep, unstable terrain that is highly sensitive to human disturbance (Henjum and others 1994; Wilderness Society 1993). According to the Forest Ecosystem Management Assessment Team, most existing roadless areas "are considered inoperable because timber harvest and road construction would result in irretrievable loss of soil productivity and other watershed values. These lands consist of erosion- and landslide-prone landforms such as inner gorges, unstable portions of slump earthflow deposits, deeply weathered and dissected weak rocks, and headwalls" (FEMAT 1993).

Similarly, the Interior Columbia Basin assessment found "a high risk to watershed capabilities from further road development in these [roadless] areas. In general, the effects of wildfires in these areas are much lower and do not result in the chronic sediment delivery hazards exhibited in areas that have been roaded. In contrast, the already roaded areas have high potential for restoration action" (USDA/USDI 1997). Given the potential for adverse impacts from silvicultural treatments in roadless areas, many scientists recommend limiting experimental treatments to previously managed lands already degraded by fire suppression and logging (Aber and others 2000; Beschta and others 1995; DellaSala and others 1995; Franklin and others 1997; Hann and others 1997; Henjum and others 1994; McKelvey and others 1996; Perry 1995).

In summary, scientific assessments of Federal lands in several western regions generally conclude that previously roaded and logged areas should be the highest priority for fuels reduction and forest restoration treatments (FEMAT 1993; Hann and others 1997; SNEP 1996). Silviculture has a role to play in a scientifically based approach to fire and fuels management on Federal lands, but current evidence indicates that widespread mechanical treatments in roadless areas would most likely increase rather than decrease ecosystem degradation. Therefore, experimentation with mechanical treatments for fire hazard reduction should proceed primarily in areas with road access and adjacent to private lands, where the ecological risks are lower and the threat of fire to human lives and property is far greater.

Roadless areas should be considered for mechanical treatment after other, higher priority areas are addressed and only if it can be demonstrated that such treatments will not degrade ecological values. Any experimental treatments in roadless areas should occur in small roadless areas (less than 5,000 acres [2,000 ha]) that have relatively good access, are near the wildland–rural interface, and exhibit high fire hazard due to past suppression. Only small trees (generally less than 12 inches [30 cm] in diameter) should be considered for removal, and under no circumstances should new or temporary roads be built to conduct mechanical treatments.

The Case for Prescribed Fire in Roadless Areas

The Forest Service should treat roadless areas primarily by reintroducing fire, both natural and prescribed. Restoration of ecological processes is key to ecosystem integrity and biological diversity (Samson and Knopf 1993), particularly in unroaded areas. Use of prescribed fire has been successful in restoring wildland fire regimes to many fire-adapted ecosystems (Wright and Bailey 1982), and a widespread consensus exists that additional burning is necessary (Arno 1996; Mutch 1994, 1997; USDA/USDI 1995; Walstad and others 1990).

Prescribed fire has important advantages over mechanical treatments in areas where ecological integrity and biodiversity conservation are important management objectives (Hann and others 1997; SNEP 1996; Weatherspoon and others 1992). Prescribed fire also appears to be the most effective treatment for reducing fire severity and rate of spread (Stephens 1998; van Wagtendonk 1996). In addition to reducing fuel loading and continuity, prescribed fire may decrease pest outbreaks, provide germination sites for shade-intolerant species, release nutrients, and create wildlife habitat (Agee 1993; Biswell 1999; Chang 1996; Walstad and others 1990).

Positive outcomes associated with prescribed fire are, of course, contingent on detailed site-specific planning, adequate budgetary support, and careful execution by trained personnel. In roadless areas with forests characterized by low-intensity, high-frequency fire regimes, repeated prescribed burns within a relatively short timeframe might be required to sufficiently reduce fuels and ensure that fire intensities remain within an acceptable range (Biswell 1999). After initial treatment, the frequency of prescribed burns can be designed to reflect the inherent disturbance regime and range of variability associated with particular forests. Data from the Sierra Nevada suggest that prescribed burning is likely to be considerably cheaper for treating fuels than either mechanical treatments or fire suppression (Husari and McKelvey 1996; see Deeming [1990] for a summary of the literature on the cost-effectiveness of prescribed burning versus other fuel treatments).

In addition to prescribed fire, ecological benefits could flow from allowing some naturally ignited fires to burn in roadless areas under specific environmental conditions. Traditionally, the Forest Service has suppressed most wildland fires without adequately considering the potential resource benefits of a "confine-and- contain" strategy. However, Federal policies introduced in 1995 encourage careful management of naturally ignited wildland fires if they meet resource objectives and are consistent with inherent fire regimes (USDA/USDI 1995). Less than full control strategies for fire suppression could be employed, provided the strategy chosen is projected to incur the least cost of suppression and the least loss of resource values (McKelvey and others 1996).

Carefully planned wildland fire use should be fully considered for roadless areas, based on fire regime, expected fire behavior, and other variables, as an alternative to costly firefighting in large remote areas where there is little or no danger to lives and property. In 2000, the Forest Service spent more than $91 million fighting two large fires in Idaho, the Burgdorf Junction Fire and the Clear Creek Complex Fire. Together, the fires burned more than 280,000 acres (113,000 ha), mostly in remote roadless and wilderness areas (Morrison and others 2000; NIFC 2000a). On such fires, wildland fire is likely to be the most sensible as well as ecologically appropriate strategy.

Instead of suppression, many roadless areas could benefit from proactive fuels management using fire. Fire management in roadless areas should be based on (1) a standard set of guidelines for identifying and prioritizing roadless areas based on their fire hazard and risk at the national or regional level (see [Appendix 2]); and (2) a subsequent step-down process for planning fire treatments at the local level, designed to allow fire to play a more important role while minimizing risks to ecological values.

Integrated Management Strategies Are Needed

Roadless areas do not exist in isolation from other land designations. It follows that an effective fire and fuels management strategy should be developed at the landscape scale. This means first identifying areas of highest priority for fire/fuels treatments, and then planning treatments that are consistent with management standards to ensure protection of soil, water, wildlife, and other ecological values. For roadless areas, high-priority treatment areas should first be identified at the national and regional scale. Then site-specific burn plans can be developed for individual landscapes or watersheds, by integrating spatial information on fire hazard (fuel load, fuel continuity, and topography); fire risk (ignition history and weather); and ecosystem values (old-growth forests, wildlife habitat, and sensitive watersheds) (Agee 1995; Bunting 1996; Crutzen and Goldhammer 1993; Johnson and others 1997; Weatherspoon and Skinner 1996). Through this kind of tiered prioritization, limited resources can be directed to areas that are most in need of fire and fuels reduction.

Over time, as fire is reintroduced into roadless areas—coupled with fire and other fuels treatments on adjacent, intensively managed lands—the occurrence of large, high-intensity wildland fires might become of less concern. In some cases, limited low thinning (removal of small understory trees) might be appropriate in roadless areas as a prerequisite for prescribed fire. However, more experimentation and research on the efficacy of mechanical treatments are needed in intensively managed forests before such treatments are broadly applied to roadless areas. Such a cautious approach is warranted, given that a mere 7 percent of roadless lands present a high fire hazard; the vast majority of areas at risk of uncharacteristically intense fire are in the intensively managed, roaded landscape (USDA Forest Service 2000).

Although much can be done to reduce fire hazards, there is no "magic bullet" to reverse many decades of fire suppression and other management activities. Despite our best intentions, the fire situation might yet worsen as more homeowners build cabins deeper into fire-prone forests and climate change potentially produces hotter and drier conditions in some areas. Moreover, it is important to note that despite all the media hype, the 2000 fire season was relatively light by historical standards: In the 1930's, more than 39 million acres (16 million ha) burned on average each year (NIFC 2000b).

The strategy outlined here is consistent with recent Federal policy recommendations emphasizing treatment of the highest priority areas first in noncontroversial areas—the wildland–rural interface and designated municipal watersheds (Council on Environmental Quality 2000). To ensure that the current fire management policy avoids ecological risks associated with the logging of large trees and other ecosystem values, we recommend that thinning in priority areas target the removal of the small, noncommercial materials that have increased most dramatically as a result of fire exclusion and are of greatest concern for hazardous fuel reduction. Our recommendation is consistent with Forest Service Chief Mike Dombeck's letter to Senator Jeff Bingaman emphasizing that emergency appropriations be used to remove trees smaller in size than 12 inches (30 cm) in diameter at breast height from high-priority areas (Dombeck 2000).

In contrast, timber industry representatives such as Butch Bernhardt of the Western Wood Products Association insist that "cutting some larger trees" is "the incentive" needed to "markedly improve forest health" by allowing "more sunlight and nutrients to reach the remaining growth" (Associated Press 2000). Commercial harvest is designed for profit, not to address ecological need; the timber industry's claims to the contrary are inconsistent with the available science on fire and fuels management. Only through an integrated approach that emphasizes protection of roadless values and focuses treatment where it is most needed—in the roaded landscape—are we likely to make significant progress in restoring the resiliency of western forest ecosystems.

For more information, contactDominick DellaSala, World Wildlife Fund, 116 Lithia Way,

Suite 7, Ashland, OR 97520, 541-482-4878 (tel.), 541-482-4895 (fax), dellasal@wwfks.org (e-mail); or Evan Frost, Wildwood Environmental Consulting, 84-Fourth St., Ashland, OR 97520, 541-488-2716 (tel.), efrost@internetcds.com (e-mail).

Appendix 1: Prioritizing Roadless Areas for Prescribed Fire

Management decisions on whether and where to apply prescribed fire in roadless areas should be based on site-specific analysis of current and historic forest conditions, landscape context, watershed integrity, the status of at-risk fish and wildlife populations, and other ecological values. However, the following criteria provide a general framework for prioritizing treatments to maximize potential benefits and minimize ecological risk.

The most credible efforts will initially apply prescribed fire in areas where:

- The dominant forest types are characterized by relatively frequent, low- and mixed-severity fire regimes (i.e., the forests have most likely been significantly altered from historical conditions).
- Reintroducing fire is operationally feasible with minimal risk of adverse impacts on soils, watersheds, wildlife, and other ecological values. Focusing fire treatments on such areas will help secure their high ecological integrity and resilience to fire, characteristics that might be lost if forest structure and composition are not maintained within their appropriate ranges. Subsequent restoration efforts should be designed to extend and/or connect high-integrity areas at the landscape level
- The risk of losing key habitats (e.g., late-successional forests, aquatic refugia, critical habitat for at-risk species, or rare community types) due to uncharacteristic fire effects is especially high. This type of fire risk is often high where small and/or isolated roadless areas are embedded in landscapes that have been highly simplified and fragmented by intensive timber management. In many cases, the most effective way of protecting these areas without reducing the quality of key habitats will be to treat adjacent, already managed and roaded areas.
- Fire can be reintroduced at the landscape level (as opposed to the stand level), thereby allowing natural ecological processes to function again in shaping ecosystem structure and composition over time. Landscape-level treatments will also allow the most acres to be treated at the least cost.
- Prescribed fire treatments can be strategically located to break up the continuity of fuels at the landscape level, thereby reducing the risk of uncharacteristically large, severe wildland fires. Fuel discontinuities should be located in topographic settings where fire hazard conditions were most likely historically low (e.g., along major ridges or on south- and west-facing upper slopes).

Appendix 2: Principles for Fire and Fuels Management

Land managers need a comprehensive, landscape-level strategy for fire/fuels management that takes into account the important values associated with roadless areas and directs treatments where they are needed the most. The strategy should be based on the following principles:

- Initially limit mechanical treatments to high-priority, low-risk areas, primarily roaded areas of dense, dry forest.

- Reduce the fire risk in the wildland–rural interface by treating areas immediately adjacent to rural settlements as a first line of defense. Provide homeowners with assistance grants to reduce the fire hazard on private land by creating a defensible space around homes.
- Conduct watershed or landscape-scale assessments that identify restoration priorities before widespread fire/fuel treatments are initiated.
- Eliminate commercial incentives for mechanical removal of merchantable trees by decoupling goods from services (that is, pay a fixed fee for tree removal services that is not tied to timber volume).
- Focus on removing small-diameter trees (e.g., trees less than 12 inches [30 cm] in diameter at breast height or intermediate and suppressed understory trees) where current forest stand densities are outside the historical range of variability.
- Minimize impacts to soils, below-ground processes and related species, accumulation of surface fuels from thinning, and exposure to solar radiation and reduction of soil moisture retention.
- Conduct mechanical treatments in high-priority, low-risk areas in compliance with all relevant environmental statutes (e.g., the National Environmental Policy Act, National Forest Management Act, and Endangered Species Act).

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