The Wildland Fire Challenge: Protecting Communities and Restoring Ecosystems

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In recent summers, large forest fires have burned millions of acres and hundreds of homes across western states where drought conditions prevail. Alarmed elected officials agree that fuel loads in forests must be reduced to protect communities and restore ecosystems, but they disagree over where and how much.

In this paper, we evaluate the quality of information that feeds wildland fire policy, assess the challenge of identifying and protecting threatened communities from wildland fire, and outline the first steps in a comprehensive strategy to prioritize where fuel reduction and ecosystem restoration measures are needed.

The wildland fire crisis

Virtually every North American ecosystem has experienced fire over its evolutionary history. In regions such as subalpine forests where precipitation was high and temperatures low, fire was an infrequent visitor; periodic drought and hot weather were required to dry vegetation enough to burn. Between infrequent fires, fuels built up naturally to high levels, ensuring that when fire did return, it was big and hot. In other regions, such as southwestern ponderosa pine forests where "fire weather" is common, fire burned frequently enough to keep fuels from amassing, consuming mostly grass and other surface vegetation.

With the arrival of Euroamerican settlers, land-use patterns changed dramatically. Eastern forests were cleared for agriculture; in the West, vast herds of livestock consumed grasses; across the continent, fire suppression became the norm (Figure 1). Where fire was infrequent, these practices left vegetation and fire regimes essentially unchanged, but in areas with more frequent fire, tree seedlings grew into dense forests capable of carrying roaring crown fires on lands where surface fire once prevailed (Figure 2). More people built houses in fire's way, especially in the growing western states, where settlement encroached on some of the region's most fire-prone, low-elevation forest lands. In addition, current drought has increased both the frequency and severity of wildland fires.

In 2000 and again in 2002, western states witnessed the largest fires in more than a century. Many burned adjacent to, and sometimes in, communities, resulting in the tragic loss of homes and lives. In response, organizations and governments at all levels produced a number of policy initiatives to try to reverse the trend. The National Fire Plan (USFS/DOI 2000), developed in response to the 2000 fire season, recommended reducing fire risks, working with local communities, and improving agency accountability.

In 2002, in a process facilitated by the

Figure 1. Fire suppression continues as an important part of fire management policy on local, state, and federal lands in the United States. While we have made great strides in suppression technology since the early 1900s (note helicopter water drop), the largest fires in more than a century burned adjacent to, and sometimes in, communities in western states in 2000, 2002, and 2003. Photo provided by the California Department of Forestry and Fire Protection.

Western Governors' Association, a broad-based group of state, federal, and other parties signed on to a ten-year comprehensive strategy (Western Governors' Association 2002). Like the National Fire Plan, that initiative sought to protect communities and restore fire-adapted ecosystems, but opened the fire planning process to all stakeholders through a collaborative structure, set priorities on community protection and at-risk watersheds, and recommended accountability through monitoring. In late 2003, Congress passed the Healthy Forests Restoration Act (HFRA), which reduced the level of environmental review required for fuel reduction projects and truncated public involvement in agency decision-making. The act authorized special fuel reduction projects to protect "at-risk communities" on 20 million acres of federal land.

Protecting communities: the scope of the challenge

All of these recent initiatives have made the protection of communities threatened by wildland fire a high priority, emphasizing community involvement in fire planning and reduction of fuel loads by cutting trees and brush adjacent to communities. Exactly where these efforts and scarce resources should be focused, however, has been a subject of debate and confusion. In this section, we review one effort to identify communities at risk and show how these data can be used to estimate the scope of the community protection challenge nationwide.

Identifying communities at risk. In January 2001, the secretaries of agriculture and the interior posted a notice in the *Federal Register* that outlined the community protection issue and included a preliminary list of more than 4,000 "communities at risk," compiled from information received from some states (Federal Register 2001a). The notice provided guidance on how to recognize a community at risk and solicited a second round of names from the states, resulting in a list of 22,127 communities. Some states submitted extensive lists; others were more circumspect, submitting only

Figure 2. Extreme fire behavior: a crown fire. Photo by Kari Greer/NIFC.

those few communities in obvious peril.

Unable to resolve the differences between states, the secretaries applied a screen to include only those communities near federal land most likely to be affected by federal policies (Federal Register 2001b). Of the resulting list of 11,376 communities, 9,339 could be matched with place names in the U.S. Geological Survey's Geographic Names Information System to create a national map of communities at risk (Figure 3).

Such a process of self-nomination obviously results in an inadequate, haphazard catalog of communities at risk. Figure 3 clearly

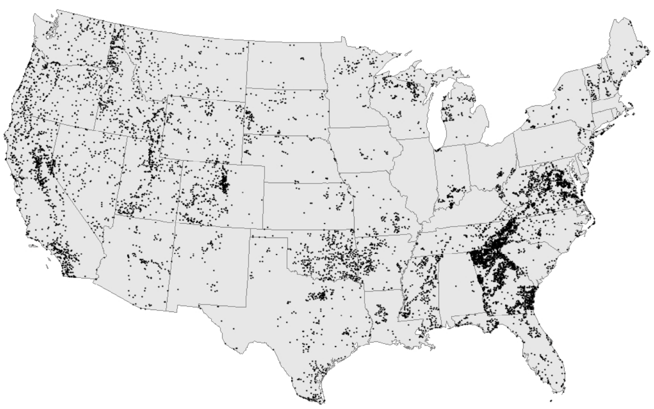

Figure 3. Designated communities at risk from wildland fire. This map was prepared by the U.S. Geological Survey from lists submitted by states and refined by the federal government to include communities near federal lands.

depicts disparities across state boundaries. Georgia, for example, is heavily represented, while neighboring Alabama has almost no representation, and Oklahoma and Kansas, similar both ecologically and demographically, also show large disparities. Still, Figure 3 shows those state-designated at-risk communities that could be mapped and that, in aggregate, represent a first approximation of the location of communities vulnerable to fire in the vicinity of federal land.

Defining the community fire planning zone. Despite its shortcomings, we used the data represented by Figure 3—data representing the states' evaluation of the problem—to assess the size of the community fire protection challenge. In undertaking such an analysis, it is important to determine how much land around each community must be evaluated and, if necessary, treated to reduce the risk of fire. This "community fire planning zone" (CFPZ) is a function of both the size of the community and the width of the fuel treatment "buffer zone" around each community.

To account for community size, we relied on the National Land Cover Dataset to identify "urban footprints" of towns by selecting clusters of urban "pixels" and matching them to communities on the federal list. Where the location of a listed community was more than one mile from an urban footprint, we assumed the town was too small to produce a footprint, and we mapped it as a point.

While an understanding of the outlines of a "community" is important, it does not answer the question of where to apply treatment. Protecting communities requires treating fuels some distance from structures (Figure 4), but how far should community fire planning zones extend?

It has been demonstrated that the most effective way to protect homes is to address the area immediately adjacent to structures (Figure 5). The underlying principle is simply that homes will not burn if they do not ignite, regardless of what happens to the surrounding forest, and it is a very narrow "home ignitability zone" that determines whether a home will burn.

Research by the U.S. Forest Service has shown that there are three primary mecha-

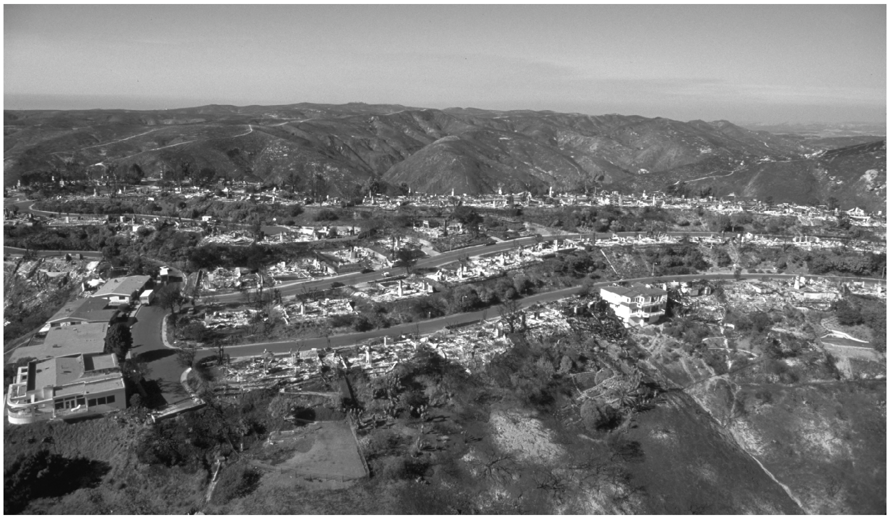

Figure 4. In southern California, during hot, dry, windy conditions in late summer and fall, chaparral fires have brought tragic loss of homes and lives. This occurs because high winds bring fire and fire brands into direct contact with flammable structures. Photo by Robert A. Eplett/OES/CA.

nisms for home ignition. First, houses can ignite when shingles and siding are exposed to direct contact with flames from adjacent fuels, particularly flames carried in fine fuels, such as grasses, needles, leaves, and small branches. The second way homes can catch fire is through radiant heat from nearby flames elevating the temperature of structures themselves above their ignition thresholds. Third, the roofs of houses can ignite when exposed to showers of lofted embers. By reducing fine fuels directly within the home ignitability zone, homeowners can prevent flames from reaching the house itself. Thinning small-diameter trees within 60 m of homes can reduce the potential for radiant heat to ignite a home, and by building rooftops out of non-flammable materials, fire risk to homes can also be drastically reduced (Cohen and Butler 1998; Cohen 2000).

Figure 5. Following "firewise" principles, the owner of this home removed fuels within its "home ignitability zone" in the West Creek Subdivision, Colorado. As a result, it survived a crown fire in the wildland–urban interface during the 2002 Hayman Fire in the Pike National Forest. Photo © Karen Wattenmaker/kwphoto.com.

Together, these three mechanisms for home ignition can only be prevented by focusing on the area directly around individual structures. Appropriate protective steps, such as pruning branches away from homes and moving woodpiles, are well described by fire protection alliances, such as the National Wildland–Urban Interface Fire Program (see www.firewise.org). If done correctly, treatment of the home ignitability zone well in advance of a fire may allow residents to stay with their property and extinguish incidental ignitions once the flaming front has passed (Mutch 2005).

While structure protection demands a focus on the immediate vicinity of the home, there are reasons why treatments may be extended beyond 60 m. Communities may wish to create "defensible space" within which firefighters may work safely, or they may wish to thin trees to reduce the probability of crown fire in order to protect scenic views or watershed quality. Fire physicists and other experts have posited various buffer distances, ranging from a quarter-mile, based on the physics of crown fire behavior, to as far as 20 miles, based on observations of fire spread. The HFRA authorized special fuel reduction projects on federal land within "an area extending ½-mile [and in some cases 1.5 miles] from the boundary of an at-risk community." Therefore, to estimate the size of the CFPZ, we applied a half-mile buffer to the outside of our estimated community footprints. For communities for which we identified a footprint, this resulted in a half-mile-wide strip around the urban core. Communities that had no detectable urban core were mapped as half-mile-radius circles around a point (Figure 6).

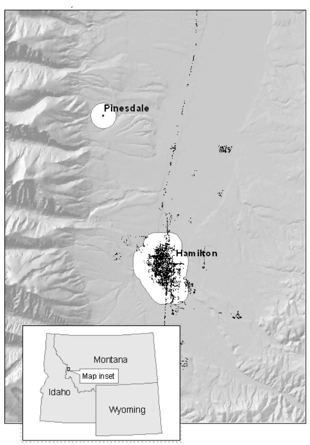

Figure 6. Sample community fire planning zones in Montana. This magnified view of our national analysis of community fire planning zones displays and labels two designated communities at risk from wildland fire and their half-mile buffer zones in the Bitterroot Valley of Montana.

It is important to emphasize here that this logic does not argue for clearing a half-mile buffer around every community. Rather, it is within this half-mile buffer that community members should look for *opportunities* to improve public safety. Within this CFPZ, assessments should be made of infrastructure needs (e.g., fire engine access, hydrants) and strategic fuel reduction (to protect homes and create defensible space). Not every type of vegetation will need to be treated, and there are some vegetation types, such as subalpine forest, within which thinning will be ineffective in lowering the probability of crown fire because fuel structure has such a limited effect on fire behavior.

The results of our analysis revealed that across the 48 conterminous states, community fire planning zones around the 9,339 mapped federal communities at risk cover 11,381,821 acres, an area approximately the size of Vermont and New Hampshire combined. Forty percent of this total is agricultural or developed land.

California ranks first among the states, with 13% of community fire planning zone acreage nationwide. Georgia, Texas, Virginia, Florida, and North Carolina rank next; combined, they account for nearly 37% of the total. Fire-prone western states—Idaho, Montana, Wyoming, Nevada, Utah, Colorado, Arizona, and New Mexico—account for less than 15% of the total. Overwhelmingly, community fire planning zones are where people are, not where forests are.

By overlaying a public land ownership geographic information system database (DellaSala et al. 2001) on our CFPZ data, we determined that the vast majority of land in the community fire planning zones—even

Land Ownership of CFPZ	Acres	Percentage of total acreage
Private/State/Tribal	9,668,977	85.13
Bureau of Land Management	160,504	1.41
Department of Defense	229,741	2.02
U.S. Fish and Wildlife Service	54,273	0.48
U.S. Forest Service	1,097,544	9.04
National Park Service	112,775	0.99
Other Federal Lands	37,917	0.33
Total	11,361,821	100.00

Table 1. Land ownership of community fire planning zones.

for this list of communities in the vicinity of federal land—is non-federal land (Table 1). Just 9.6% of CFPZ acreage is on national forests; only 5% is found on other federal lands.

While this calculation represents the first attempt to assess the land area associated with federal communities at risk, it likely underestimates by several-fold the extent of the problem. It relies for its underlying information on a flawed national map of communities at risk that reveals reporting inconsistencies and leaves out almost one-fifth of the communities on the August 11, 2001, *Federal Register* list (Figure 3). Also, mapping communities only by their urban footprint fails to account for the vast "intermix communities" (Figure 9) where homes are scattered among wildland fuels. Still, our assessment shows the community protection challenge to involve millions of acres, the vast majority of which are private. Community protection cannot be achieved with policies, like the HFRA, aimed primarily at federal land management.

Restoring fire-adapted ecosystems: where are the priorities?

Without a doubt, the protection of homes and lives must be the highest priority of fire management. But it is not the only priority. Centuries of post-colonial land use have disrupted North America's ecological rhythms and left many ecosystems in poor shape. Eastern forests, many of them fire dependent, have been almost entirely logged at least once, and many have been converted to food or fiber farms. In the West, most of the largest trees have been cut, livestock grazing has removed grass cover from formerly productive rangeland, and fire, successfully excluded for most of the twentieth century, has returned with a ferocity unknown to many western ecosystems.

The relatively new field of ecological restoration addresses the poor condition of many ecosystems, and restoration of fire has been at the center of discussion among scientists and land managers. But which ecosystems are most in need of attention? What are the priorities, given limited financial resources and personnel, for restoration? Answers to these questions are a function of both the degree of alteration and the potential for restoration.

Fire regimes and condition classes. The timing and pattern of fire has a tremendous effect on vegetation, and species and ecosystems can be said to be adapted to particular fire regimes, defined in terms of the historical frequency and severity of fire in natural ecosystems (Schmidt et al. 2002). *Fire regime*

I (high-frequency, low-intensity forest fire) occurs only in forests and woodlands that often experience hot, dry weather, where frequent fire (occurring at least once every 35 years) consumes grass, pine needles, and other fuels of the forest floor without killing the trees. *Fire regime II* behaves similarly to fire regime I, except that it occurs in grasslands where no trees are present. *Fire regime III* produces a patchy mosaic of low-intensity surface fires and high-intensity crown fires, sometimes in the same fire event, often occurring in interior Douglas-fir, larch and sagebrush, and, in some instances, lodgepole pine and redwood forests. *Fire regimes IV and V* consist of infrequent, large crown fires that occur every 35 to 200 years (in fire regime IV) or only every 200 years or more (in fire regime V). In both cases, large patches of vegetation are burned.

In an attempt to assess how extensively conditions have been altered in each of these fire regimes, scientists at the U.S. Forest Service's Rocky Mountain Research Station produced a report called *Development of Coarse-Scale Spatial Data for Wildland Fire and Fuel Management* (Schmidt et al. 2002). This study represented the first nationwide look at fire from an ecological standpoint, examining how ecosystems have changed as a result of alterations in fire regimes on a continental scale. The report identified approximately 200 million acres of federal land that are at risk due to changes in vegetation from historical conditions. Because the limited data used for the assessment made it impossible to accurately assess on-the-ground conditions, however, the authors cautioned against inappropriate use of the information and maps included in the report: "The end products were not intended to be used at scales other than a coarse scale" (Schmidt et al. 2002).

Despite such admonitions, the report has been widely cited by policy-makers in their efforts to focus attention on the fire situation. The report's focal map, called "Fire Regime Current Condition Classes," was intended to represent the current condition of vegetation across the conterminous United States. Unfortunately, the map has major shortcomings that diminish its usefulness.

The methods used in the preparation of the condition class map involved a combination of expert opinion, existing maps, and map-based data analyzed in a geographic information system. Teams of experts on vegetation ecology were assembled for each of the Forest Service's eight regions in the conterminous 48 states. Each team was asked to describe the stages of normal vegetation development for various vegetation types in each region. They were then asked to use three condition classes to rate whether current conditions, described as combinations of existing vegetation types and forest density for every square kilometer of the lower 48 states, were consistent with normal vegetation development, moderately departed from normal because of the disruption of natural fire regimes, or significantly departed from normal.

Scientists who developed the map warned of a number of weaknesses in their analysis. First, much of the process of constructing the map involved subjective judgment calls, which make it impossible to determine exactly how condition classes were assigned or to repeat the methods by which teams arrived at those conclusions. Because each regional team of scientists worked independently, identical vegetation types along regional borders were sometimes assigned to different condition classes. These edge-matching problems were later resolved through negotiation among teams, but they strongly indicate the subjective nature of the classifications.

Second, most data used in the construction of the condition class map were collected at a scale that limits their usefulness, and inconsistencies in scale from map to map generated errors, leading to an overestimation of degraded conditions. For example, one of the fundamental maps underlying the entire analysis was Küchler's (1975) map of potential natural vegetation, created at a scale of one inch to 50 miles, hardly sufficient to resolve real vegetation variation at the one-kilometer scale.

The analysis also relied on "forest density" data as a surrogate for "structural stage," warning that this was a weakness in the methodology (Schmidt et al. 2002). Structural stage information is necessary to determine if forests that once flourished in open stands of widely spaced trees have grown denser and acquired a continuous canopy of explosive fuels. Such data require a close look at every acre, a monumentally expensive task. Instead, the scientists used a readily available alternative data set that they acknowledged was not the layer "required by the methodology." Regrettably, the forest "density" data used to construct the condition class map consisted of an estimate of how much of a square kilometer is forested, not how dense the forest is. It thus cannot be used to assess structural stage. Until problems with the methodology can be worked out, the fire regime condition class assessment should not be used as an input into fire management decision-making.

Understory fire: a national priority. Despite the shortcomings of fire regime condition class assessment, fire regimes themselves can be used to help set fire management priorities. The past century of fire exclusion has had a varied effect on North American vegetation. Fire regimes IV and V, which burn infrequently, are still considered largely within their historical range of fire behavior. Grasslands that constitute much of fire regime II have been largely converted to other uses, but where grasslands still exist, the role of fire in their ecology is not well understood. Fire exclusion has likely produced some changes in vegetation in fire regime III, but the complexity of fire and vegetation dynamics obscures obvious solutions. Only in fire regime I has there emerged a broad consensus that fire exclusion has resulted in dramatic changes and that those changes must be addressed (Christensen 2003).

Examples of vegetation in fire regime I include the longleaf pine–wiregrass ecosystem of the southeastern coastal plain, shortleaf pine and pine–oak systems in the interior Southeast, ponderosa pine forests in the Southwest, and extensive oak woodlands rimming California's Central Valley. For each of these systems, studies show that fire exclusion results in dramatic changes in vegetation, including increased forest density and the failure of some species, especially grasses and oaks, to regenerate. From the interior oak woodlands of the Pacific Northwest to the pine forests and wetlands of the Southeast, vegetation that evolved with fire has been starved of a key process, and those ecosystems' composition, structure and function have been altered.

To understand the potential for restoration of fire regime I, we modified a map from Schmidt et al. (2002), removing areas of altered vegetation (agriculture and urban) because of the low potential for restoration in those areas. Our analysis determined that fire regime I accounts for 34.3% of wildland vegetation in the conterminous 48 states. Fire regimes II and III account for 27.2% and 23.4%, respectively, while fire regimes IV (9.8%) and V (5.34%) are decidedly less common.

Figure 7. In April 1994, the Boise National Forest conducted a prescribed burn beneath the green, living ponderosa pine forest shown here in the foreground. Surface and ladder fuels were consumed, leaving the overstory pine. Four months later, a wildfire burned the entire area. Note that pine in the untreated forest in the distance were killed. But when the wildfire reached the prescribed burn area, it became a low-intensity surface fire. Most large pine in the prescribed burn area remain alive. Photo © Karen Wattenmaker/kwphoto.com.

It is now evident that the future health of forests in fire regime I depends on the return of fire as an ecological process (Figure 7). In some places, this will require only the restoration of fire, either naturally or through intentional ignition, but in other places, trees need to be thinned (and fuels otherwise manipulated) to facilitate the reintroduction of fire.

Thinning is the most controversial aspect of forest restoration. Nearly all experts agree that restoration of fire to fire regime I will require breaking the continuity of the fuel ladder from the ground to the canopy and that this will mean thinning small trees (Agee et al. 2000). The controversy arises from uncertainty over how big those trees should be. Some argue that large trees (more than 14 inches in diameter) must be thinned to break up the continuity of canopy fuels, while others insist that only surface fuels, consisting of shrubs and trees less than six inches in diameter, need to be cut. Many conservationists point out that large trees are already a seriously depleted element of many forest ecosystems (Anderson et al. 1996) and should be protected. They view with skepticism any suggestion that large trees should be cut in the name of restoration.

Regardless of the size of the trees, fuel reduction as part of fire restoration is sure to be an enormously expensive undertaking. It may be possible to recover some of the costs of restoration through the sale of by-products, but it will also require substantial investment of public funds.

To gain a better understanding of which areas might be in need of fuel treatment and thus to help prioritize treatment activity and save costs, we examined the current vegetation types found within the area identified by Schmidt et al. (2002) as fire regime I. This area contains a number of vegetation types that are clearly not in fire regime I (for example, maple–beech–birch and grassland), so we eliminated them from further consideration. We then mapped the locations of remaining vegetation types to produce Figure 8. To facilitate interpretation, we distinguish between western woodlands, which are not likely to produce usable timber, and western forest types that may yield commercial by-products.

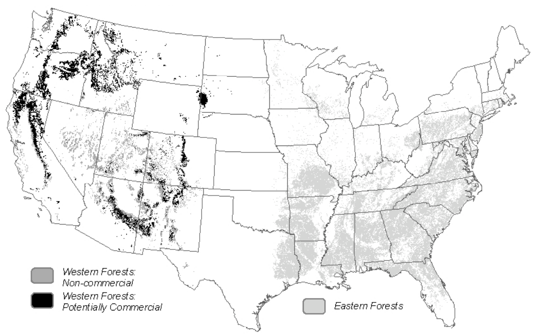

Figure 8. Forests potentially in need of fire restoration. Forests identified on this map represent a subset of forest types that may have suffered from fire exclusion. Further analyses, relying on more accurate data are required to determine if specific fuel treatments are required. These forests do not represent stands that necessarily require treatment.

Several conclusions are immediately apparent from Figure 8. First, fire exclusion is a problem not only in western forests. More than 250 million acres of fire regime I are in the Southeast where fires historically burned with frequency. In many of these forest types, fire exclusion has led to the build-up of a shrubby understory that degrades wildlife habitat and increases fire severity.

Figure 8 also suggests that much of fire regime I in the West is in open woodlands, not forests. Almost 40 million acres of pinyon–juniper and 5 million acres of hardwoods are mapped by Schmidt et al. (2002) as fire regime I. Pinyon–juniper is the most widespread forest type in the West, but wood values are low, suggesting that the sale of by-products will not offset restoration costs (Henderson and Baughman 1987). A similar story is told in the extensive non-commercial oak woodlands of the Willamette Valley in Oregon and in California, where the invasion of tree saplings threatens to carry lethal fire to the oaks.

The remaining 53 million acres of vegetation mapped as fire regime I in Figure 8 consist of dry forest types, primarily ponderosa pine (43 million acres), interior Douglas-fir (10 million acres), and larch (200,000 acres), that may yield commercial by-products through thinning.

As Figure 8 shows, much of the fire restoration challenge lies in the East, not in the western forest types that have been the focus of the debate over forest thinning. Even in the West, much of the area of concern is in woodland types that will not likely yield commercial by-products through restoration, although some thinning may be necessary. Out of the approximately 350 million acres of fire regime I in the conterminous 48 states that likely would benefit from the restoration of fire, only about 15% is in western forest types that may produce usable timber through thinning, and not all of those forests will need thinning.

Conclusions and recommendations

Our analysis identifies almost 100 million acres of fire regime I in the West alone that may benefit from the restoration of surface fire. Recent research (Barbour et al. 2001) shows that the cost of such treatment generally runs from $500 to $1,500 per acre for mechanical thinning and $100 to $500 per acre for prescribed burning. At $100 per acre, it will cost $10 billion dollars just to burn the backlog of fire regime I lands in the West. If 10% of that area requires mechanical treatment prior to burning, that adds another $10 billion, and mechanical treatments in community fire planning zones, even the narrowly defined CFPZ identified here, will cost several billion more. In addition, every acre treated accrues a long-term maintenance need, as both thinned and burned areas must be regularly cleared of regrowth every 5 to 10 years.

There is clearly not enough money to treat every acre. Priorities must be set using the best possible data, and community protection must come first (Figure 9). It is also necessary to identify which parts of the landscape should be the highest priority for fire restoration, whether through prescribed burning or natural fire.

Community protection. A simple half-mile zone around urban footprints of communities at risk exceeds 11 million acres, most of it private, state, and tribal land. Inclusion of surrounding "intermix" communities will likely increase that amount several-fold. Federal policy aimed at logging and thinning (treating fuel loads) on national forests and other federal lands will not address the majority of land associated with communities at risk from wildland fire.

Recommendations:

- Individual homeowners must take action to protect themselves. Simple steps, such as the installation of metal roofs, moving firewood away from the home, and keeping yards clear of fine fuels can dramatically lower the probability of home ignition.
- Funding must be directed to communities for the design and implementation of community-based fire plans. In some cases, money will be needed only for homeowner education or the development of sensible zoning regulations or covenants; in other cases, the less affluent will need assistance to do their part treating fuels.
- Better information, especially derived from remote sensing and geographic information systems, must be developed to help set priorities for community protection, and funding is needed to gather that information.

Ecological restoration. Our analysis of the Forest Service's condition class map shows that the data needed to assess the condition of America's forests are not yet available. Too little is known about historical and current forest conditions, especially forest structure, and the scale of available data is too coarse to produce accurate and meaningful results.

Nevertheless, our analysis suggests that as

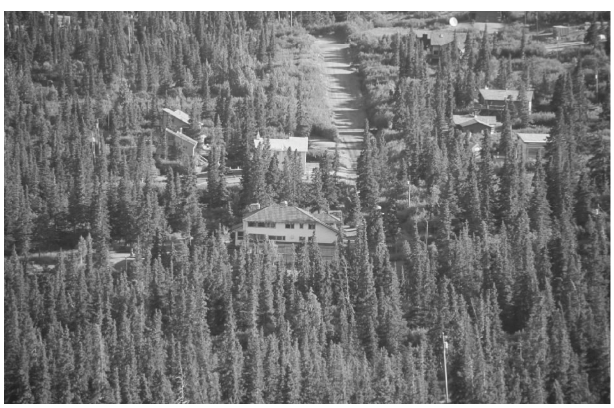

Figure 9. In this intermix community, structures are scattered throughout the surrounding wildlands. There is no clear line of demarcation, thus creating perfect conditions for catastrophic loss of property during a wildland fire. USDA–Forest Service Pacific Northwest photo by Tom Iraci.

many as 350 million acres may benefit from restoration planning in fire regime I alone. Other fire regimes also merit eventual attention. Over such a vast area, restoration cannot be successful unless approached rationally and efficiently. Where restoration is undertaken, we recommend that it be based on the following three principles, developed during a two-year collaborative process involving forest scientists, rural community advocates, and forest activists from across the nation (DellaSala et al. 2003):

- Enhance ecological integrity by restoring natural processes and resiliency. Actions may focus on individual species or the structure of ecosystems, but restoration should aim to repair ecological processes, such as fire cycles and hydrologic regimes, wherever possible.
- Provide economic incentives to encourage ecologically sound restoration. Economic incentives that drive the degradation of forests must be replaced with restoration incentives that protect and restore ecological integrity.
- Make use of or train a highly skilled, well-compensated work force to conduct restoration. Effective restoration depends on strong, healthy, and diverse communities and a skilled, committed work force.

This paper has been adapted by the authors from their original science report "The Wildland Fire Challenge: Focus on Reliable Data, Community Protection, and Ecological Restoration," published in October 2003 by the Wilderness Society. The original paper can be downloaded at: www.wilderness.org/Library/Documents/WildlandFireChallenge.cfm.

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