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Fuelbreaks for Wildland Fire Management: A Moat or a Drawbridge for Ecosystem Fire Restoration?

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INTRODUCTION

Construction of fuelbreaks as a pre-suppression fuels treatment strategy in national forests has always been controversial (Omi 1996). Criticisms have been raised over the objectives, prescriptions, locations, methods, costs, impacts, and effectiveness of fuelbreak construction and maintenance (Agee et al 2000). Citizens have actively opposed fuelbreak projects out of fears that the breaks will fragment forests and degrade wildlife habitat, destroy scenic resources and look like industrial logging sites, or open up areas to unauthorized off-road vehicle use (Arno and Allison-Bunnel 2002). Fire scientists have also raised concerns that traditional linear fuelbreaks may not effectively function as wildfire containment lines during extreme weather conditions (Omi 1977a, Finney 2001). Increasingly, critiques have centered on the effects of fuelbreak projects on fire ecological processes, charging that fuelbreaks aid and abet fire exclusion, or, ironically, that fuelbreaks may actually increase fire spread and fireline intensity.

Despite the growing public controversy over fuelbreaks, Congressional acts and Administrative initiatives have made them more prevalent, with extensive fuelbreak systems and specific projects being proposed throughout the western U.S. For example, the Herger-Feinstein Quincy Library Group Forest Recovery Act "(for brevity, "QLG Project") proposes to construct up to 2,415 kilometers (1,500 miles) of fuelbreaks in three national forests in the northern Sierra Nevada, while up to 498 kilometers (309 miles) of fuelbreaks are planned in the portion of the Siskiyou National Forest burned by the 2002 Biscuit Fire (USFS 1999, 2004). This paper will briefly discuss some of the critiques and controversies that have been raised against fuelbreak proposals on public lands managed by the Forest Service, and draw attention to the needs and opportunities for more fire ecology research. It is possible that current public opposition could be converted into future support if the objectives, uses, designs, and methods of fuelbreak projects are reconceptualized and rearticulated. Instead of viewing fuelbreaks solely as "moats" emblematic of reactive wildfire suppression in a fire exclusion paradigm, fuelbreaks could become "drawbridges" symbolizing pathways for a proactive program of community fire preparation and ecosystem fire restoration.

FUELBREAK DEFINITIONS AND RECONCEPTIONS

The classic definition of a fuelbreak is “a strategically located, wide block or strip on which a cover of dense, heavy, or flammable vegetation has been permanently changed to one of lower fuel volume and reduced flammability” (Green 1977). New terms have been created in recent years to describe allegedly new kinds of fuelbreaks, such as "shaded fuelbreaks" (Agee et al 2000), "Defensible Fuel Profile Zones" (Olson 1997, Weatherspoon and Skinner 1996), and "Fuel Management Zones" (Fairbanks 2003).

Given Green’s (1977) generic definition of fuelbreaks, managers have the ability to explore a wider range of designs, methods, and uses for fuelbreaks than has been offered in the typical fuelbreak proposals of the past. By reconceptualizing fuelbreaks and using a genuinely collaborative planning process, it is possible for land managers to develop fuelbreak projects that address the concerns of critics while also meeting the needs of fire managers. A necessary first step in this process is to understand the criticisms that have been raised in the past.

FUELBREAK OBJECTIVES: FURTHERING FIRE EXCLUSION

For most of the past century, fire exclusion was official Forest Service policy and enjoyed widespread support from resource professionals, elected officials, and the public at large. Yet, in combination with commercial logging, livestock grazing, and other land management activities, the indirect and cumulative impacts of fire exclusion are causing a number of "forest health" problems including uncharacteristically large-scale severe wildfires in formerly low-severity fire regimes (Covington and Moore 1994, Mutch et al 1994, Arno and Allison-Bunnell 2002). The adverse ecological effects of fire exclusion, including changes in stand density and structure, species composition, and surface fuel loads, have even impacted remote wildlands such as inventoried roadless areas and designated wilderness areas (van Wagtendonk 1985, Pyne et al 1996, Keane et al 2002).

The adverse effects of past fire exclusion on fuel loads and fire behavior are often considered to be the primary purpose for constructing fuelbreaks, and land managers argue for the need to create infrastructure for future fire suppression activities. But this forms the basis for critiques that challenge the underlying purpose and need for fuelbreak proposals: they are almost exclusively intended to facilitate fire suppression actions and further fire exclusion objectives. Without explicit plans to use fuelbreaks to help reintroduce prescribed fire or manage wildland fire use, there is an inherent contradiction in proposals to construct fuelbreaks to limit the size of wildfires--and thus further fire exclusion--in places identified as fire-adapted or fire-dependent ecosystems.

It is important to understand that although absolute fire exclusion has been attempted, those attempts have not and never will be successful on a landscape or historical scale given the abundance of natural and human ignition sources within a combustible natural and human environment. One of the greatest paradoxes of fire suppression is that it is a significant source of human-caused fire reintroduction. Firing operations such as "burnout" and "backfires" are routine activities on every large wildland fire. Unfortunately, reintroducing fire through suppression firing operations often occurs under severe weather and adverse fuel conditions, resulting in high fire intensity and severity.

A more ecologically beneficial use for fuelbreaks would be to use them for fire reintroduction through proactive prescribed burning rather than reactive wildfire suppression. Firing operations conducted under the best of conditions instead of the worst would enable managers to have greater control over desired fire behavior and effects. Using fuelbreaks primarily for prescribed burning instead of solely for wildfire suppression would conceivably alter the design of fuelbreaks. For example, fuelbreaks proposed under the Herger-Feinstein Quincy Library Group Forest Recovery Act are up to 402 meters (0.25 mile) in width because they are intended for use in wildfire suppression during worst-case conditions, but fuelbreaks could conceivably be just a few meters in width if they were intended for use in prescribed burning during desired "best-case" conditions.

Given that absolute fire prevention or exclusion across the landscape is neither possible nor desirable, the underlying objectives for fuelbreaks need to be reconceptualized and expanded beyond suppression alone to support fire reintroduction and ecosystem restoration objectives. More historical research is needed to assess how extensive was the use of fuelbreaks in past suppression incidents, and whether or not they played a significant role in fire exclusion. This is particularly urgent in light of current proposals to further invest public resources in fuelbreak construction for the purpose of continuing fire exclusion goals. More research using field experiments or computer modeling could help design new fuelbreaks intended primarily for starting prescribed fires or steering wildland fires in addition to stopping wildfires when conditions warrant full suppression. This expanded role for fuelbreaks would thus serve more ecological objectives, answering a primary concern of critics.

FUELBREAK USES: FACILITATING FIRE SUPPRESSION

Typically, the main purpose of fuelbreak projects is to prepare sites for future firefighting activities. Green and Schimke (1971) state that "Planning for and building fuelbreaks is one phase of the standard pre-attack or presuppression work in fire control." Numerous fuelbreak projects conform to this definition. For example, in the Warner Fire Recovery Project, construction of a fuelbreak system was proposed in order to “allow rapid, safe deployment of initial attack firefighting resources,” and to “lower the resistance to control,” a measure of firefighting efficiency based on the ability of fire crews to cut handline (USFS 1994). In the HazRed Project, the stated purpose of the shaded fuelbreaks was to allow safe deployment and evacuation of firefighters, and enhance the penetration of fire retardant through the forest canopy (USFS 1997). The QLG Project proposed construction of DFPZ fuelbreaks in order to “allow fire suppression a safer location from which to take action against a wildfire” (USFS 1999). Omi (1977b) defines fuelbreaks as "preconstructed fire control lines which are intended for, *but not restricted to*, use on wildfires which have escaped initial attack efforts." (emphasis added) Omi's qualifying statement, "not restricted to," hints at possible new purposes for fuelbreaks; however, nearly all past proposals have been explicitly linked to fire suppression uses.

Although the ecological effects of fire exclusion have been given at least a cursory examination, the environmental impacts of fire suppression actions have never been adequately analyzed or disclosed through a programmatic or project-level NEPA process. Routine firefighting methods include using bulldozers and other heavy equipment; felling large-diameter trees, especially snags; spraying fire retardant chemicals; and igniting fires ("burnouts" and "backfires"). Some of the adverse environmental effects of these suppression actions include: soil compaction and erosion; sedimentation in streams; tree and vegetation removal; loss of wildlife habitat structures, especially for cavity-nesting species; soil and water pollution; and high-severity burning or homogenized low-severity fire effects.

During public comment processes for fuelbreak proposals, agencies often state that fire suppression is an emergency action not subject to NEPA. While the precise activities and locations of suppression operations cannot be fully predicted, fuelbreaks are nevertheless places where it is assumed that firefighting actions will occur in the future since that is their primary purpose and intended use. In fact, suppression actions within fuelbreaks are often selectively analyzed, but mostly presented in terms of perceived positive environmental effects, such as reducing future wildfire sizes. Such analyses ignore the adverse cumulative effects of fire exclusion. For example, in documents for the HazRed fuelbreak project, the environmental analysis stated beneficial effects would result from the ability of fire retardant chemicals dropped from air tankers to penetrate the thinned tree canopies and fall directly on the ground surface (USFS 1997). However, this analysis failed to take a hard look at any potential adverse effects of using fire retardant chemicals, such as polluting municipal water supplies, or causing mortality of aquatic species.

A programmatic environmental analysis of standard firefighting actions is long overdue, and provides another critical area for fire ecologists to conduct field research. Taking a hard look at the adverse impacts of suppression operations may actually help build the case in the eyes of the public for proactive fuels treatments. Indeed, the public may be more supportive of carefully planned, well-designed fuelbreaks as a means of preventing poorly planned and ill-designed firelines constructed during emergency suppression operations. Ecological research on the direct, indirect, and cumulative effects of suppression methods would give land managers the ability to analyze the ecological and environmental tradeoffs underlying fuelbreak construction and utilization. Research results would also provide an incentive for experimenting with new techniques, tactics and strategies to help mitigate environmental damage from suppression operations.

FUELBREAK DESIGNS: LOCATIONS

The majority of criticisms of fuelbreaks center on design issues such as their proposed locations and patterns, stand-level prescriptions, and construction methods. Given that the main objective of fuelbreaks is to reduce wildfire spread, the ideal location for fuelbreaks would be alongside topographical or landscape features that offer tactical vantage points for containing wildfires. Placing fuelbreaks atop main ridges is a logical location from a tactical suppression standpoint, but placing fuelbreaks on secondary or lateral ridges presents certain risks of creating a "fuse effect" facilitating rapid upslope fire spread (Green 1977, Omi 1996). The concern is that even when a lateral fuelbreak successfully stops a flanking fire from spreading across a slope, the fire may proceed more rapidly upslope within the fuelbreak than the main headfire. If lateral fuelbreaks provide corridors for wildland fire to spread more rapidly upslope, then this can greatly increase the area needed to create a perimeter containment line. Omi (1977a), in fact, compiled reports of lateral fuelbreaks that failed to contain chaparral fires in southern California partly due to this phenomenon.

Another controversy centers on the choice to locate fuelbreaks in the backcountry versus the wildland/urban interface or intermix zones (for brevity, “WUI zone”). Conservationist organizations strongly advocate that fuels reduction efforts should be focused in the WUI zone to create defensible space around dispersed individual homes and protective buffers around rural communities. The WUI zone is where fuel hazards, ignition risks, and socioeconomic values-at-risk are generally higher. However, the majority of fuelbreak proposals are located in more remote wildlands. In the HazRed project, for example, the Forest Service proposed to construct shaded fuelbreaks several miles away from town, in the interior of the watershed, yet public scoping revealed that the local community was more concerned about reducing dense brushfields that threatened homes along the outer edge of the city of Ashland, Oregon (USFS 1997). Consequently, the HazRed fuelbreak project generated considerable local citizen opposition. On the other hand, in response to public scoping comments critical of a proposed fuelbreak project along the ridges outside of Dixie, Idaho, the project was changed in order to locate the fuelbreak directly adjacent to the town (USFS 2001). As a result, this project was widely praised by local citizens and conservation organizations.

Land managers have potential opportunities to gain citizen support for fuelbreaks if they prioritize locating projects within the WUI zone rather than backcountry wildlands. These kind of fuelbreaks most resemble "moats" designed as barriers to fire spread; however, it could be anticipated that intensive fuels reduction that degrades scenic or habitat values directly adjacent to residential areas might generate citizen complaints. Therefore, more research including social science research would help facilitate the development of operationally effective and socially acceptable fuelbreaks in the WUI zone.

FUELBREAK DESIGNS: PATTERNS

There is an emerging debate within the fire management community over the merits of linear fuelbreaks versus area-wide fuels treatments. In fact, Green and Schimke (1971) originally defined fuelbreaks as "strategically located *wide* strips or *blocks* of land" (emphasis added); however, the convention has been for fuelbreak projects to be relatively narrow linear strips, for example, 30 to 122 meters (100-400 feet) wide. Proponents of the DFPZ concept advocated much wider fuelbreaks from 0.4 to 2.8 kilometers (0.25 to 1.75 miles) wide, but still advocated a contiguously-linked grid-like pattern of parallel strips cut across the landscape (QLG 1994, 1997a, 1997b). Interestingly, in modeling landscapes with area-wide fuels reduction that burned under extreme conditions, Sessions et al (1996) found few differences in fire size or severity between simulations that used DFPZ fuelbreaks versus those that did not use them.

An alternative design to a network of contiguous linear fuelbreak strips are strategically-placed overlapping area-wide treatments (Finney 2001). Area-wide treatments are designed to temporarily blunt headfires while allowing fire to spread into flanking directions as a means of reducing the rate of spread and intensity of wildfire as it moves across an area. In simulated experiments, an overlapping network of treatments in a pattern similar to the Chinese pinball game, *Pachinko*, produced desired changes in fire size, intensity, and severity while limiting treatments to just 20% of the landscape—an important consideration given restricted budgets for fuels treatment programs (Finney 2001). The overlapping area-wide treatments increased fire suppression options for anchoring containment lines or steering small fires into treated sites, and produced benefits in terms of reduced severity even without suppression forces (Finney 2001).

A landscape pattern of area-wide fuels treatments could be rearticulated as fuelbreaks, albeit in a non-traditional non-linear pattern. Agee et al (2000) suggest that area-wide fuels reduction treatments could be conceived as "an *expansion* of the fuelbreak concept" (emphasis added). An added advantage of this kind of fuelbreak pattern is that it more closely resembles a natural fire-maintained landscape mosaic compared to the artificial construct of a linear fuelbreak network. This may also address citizen complaints that fuelbreak strips degrade natural scenic values. As well, since fuelbreaks do not need to be contiguous or linked strips, managers can avoid sensitive or high-value sites (e.g. habitat sites for endangered species, or heritage sites) without compromising the integrity of the fuelbreak system as a whole. More research is needed to determine the optimum locations, patterns, and sizes for fuelbreaks that help stop, start, or steer wildfires, prescribed fires, and wildland fire use ignitions.

FUELBREAK DESIGNS: PRESCRIPTIONS

There are a myriad varieties of fuelbreak prescriptions at the stand level, so it would be more fruitful to discuss the general design principles that should guide construction of restoration-oriented fuelbreaks. Conservationists strongly favor retention of all remaining large-diameter overstory mature and old-growth trees, and prefer vegetation and fuels removal be restricted to small-diameter understory trees and shrubs. In stands with a fairly uniform size or age-class, a suggested strategy is to retain a certain percentage of the largest trees on site. Given that size and age classes of trees vary according to species and site conditions, prescriptions that utilize diameter or age limits must incorporate this variability and include flexibility.

At the stand level, fuelbreak construction (and fuels reduction and forest restoration projects in general) should follow a step-wise progression of working from the ground up rather than the crown down. Moreover, the pathway for making fuels reduction projects serve programmatic long-term forest restoration goals is to slowly raise up the canopy over time through multiple light entries of thinning-from-below, rather than rapidly opening up the canopy in a single intensive overstory treatment. This means that surface and ladder fuels reduction should be the initial treatments (Graham et al 2004). Functionally this may involve reducing ladder fuels by manually pruning lower limbs or mechanically thinning understory shrubs and pole-sized trees before implementing pile-burning or broadcast understory burning. Reducing surface fuels and treating ladder fuels raises the ground-to-crown base height and disrupts the vertical continuity of fuels. This has the combined effect of lowering potential heat output and flame lengths, with the goal of keeping them below a threshold of conditions necessary to initiate crown fires (Agee 1996, Omi and Martinson 2002). In some stands, simply treating the surface and understory layers of the fuels profile could greatly decrease the risk of uncharacteristic crownfire while maximizing the retention of ecologically valuable overstory trees.

The above prescription of "thinning-from-below" would satisfy conservationists who value the retention and protection of big old trees, but it also has practical management values. For wildlife managers, crown fire risk may be reduced in habitat for wildlife species that require high levels of canopy cover. For fire managers, high canopy closure tends to mitigate surface fire behavior (Countryman 1955). In shaded fuelbreak proposals that excessively open up canopy cover, though, the combined growth of flashy surface fuels (e.g. grasses and shrubs) with altered microclimate (e.g. increased solar radiation and wind penetration) can raise fuel temperatures, lower fuel moistures, and lead to increased fireline intensity and rate of surface fire spread (Greenlee and Sapsis 1996, Agee et al 2000). Indeed, in the thinned overstory and flashy fuels of DFPZs, simulations by van Wagtendonk (1996) measured an increase in rate of spread up to four times the original rate--to nearly 7.6 meters (25 feet) per minute--that enabled surface fire to spread across 400 meter wide fuelbreaks in less than one hour.

More research is needed to determine the optimal canopy cover that reduces the risk of crown fire spread while not significantly increasing surface fire spread. Importantly, the analysis of tradeoffs between crown fire and surface fire risks and hazards in shaded fuelbreaks needs to factor in response times for suppression crews, because fuelbreaks alone cannot stop wildfires without firefighters actively using them. More modeling research using a variety of percentages and spatial arrangements of canopy cover would help provide land managers with more options to design fuelbreaks appropriate to site-specific environmental needs and conditions.

FUELBREAK CONSTRUCTION: METHODS

On some forested lands, fuelbreaks are typically constructed with commercial timber extraction as a primary means of funding or implementing the projects. This funding mechanism is a major source of controversy among citizens who are philosophically opposed to commercial logging for private profit on public lands.

This comes from their belief that economic interests function to drive stand-level prescriptions for fuels projects, with the result that managers focus efforts on removal of big, old trees while neglecting treatment of other more flammable but less profitable or submerchantable fuels. The net result of mixing commercial logging with fuelbreak construction is that fuelbreaks themselves have become controversial.

While commercial timber extraction is often seen as the primary economic driver behind management projects, managers attempt to avoid public controversy by framing project proposals around more laudable pursuits, such as hazardous fuels reduction. For example, the purpose and need governing several recent fuelbreak timber sales has been canopy fuel reduction in order to reduce crown fire hazard. Not coincidentally, reducing canopy fuels involves cutting down overstory trees. Typically the first order of business in these projects is to remove the large-diameter boles--the least flammable but most commercially valuable portion of a tree. This in turn involves moving the most flammable components--the small-diameter limbs and foliage--from the canopy layer directly onto the ground surface. In such cases, one could argue that the net result is not fuels reduction, but rather, fuels *relocation*, essentially shifting the location of hazardous fuels from the crown to the ground where they become immediately available for surface fires. If these activity fuels are left untreated or are ineffectively treated, fire intensity and severity can actually increase compared to untreated sites (Graham et al 1999, Weatherspoon 1996). Such fuels projects would not create a functional fuelbreak, for even if an independent crown fire drops to the ground, fireline intensity may still be too high to safely and effectively stage firefighters inside the fuelbreak.

In order to address some managers' concerns for reducing the risk of crown fire propagation, alternative methods to commercial timber sales might include topping overstory trees rather than felling and removing them. This might sufficiently reduce crown fire potential by reducing crown bulk density and disrupting horizontal crown fuel continuity, while also retaining the habitat values of large standing snags. However, fuelbreak prescriptions typically involve the elimination of all snags in order to prevent falling hazards to firefighters. As well, it might behoove managers to think about mechanical fuels treatments that reduce fuel particle size (e.g. through chipping) or fuel bed depth (e.g. through crushing or compaction) rather than physically removing fuels. With these methods, treatments would be focused on qualitatively altering fuel profiles rather than quantitatively reducing the fuel loads.

Lastly, there is concern that prescribed fires are rarely given adequate consideration by land managers even though there is ample support among fire scientists and managers for prescribed burning as a proven hazard reduction and restoration tool in many forest types and conditions (Biswell 1989). Indeed, fire scientists have recommended a "a band of prescribed burns" (i.e. a fuelbreak) facilitated by felling of small trees in Protected Activity Centers (PACs) for the California Spotted Owl, where commercial logging was restricted (Weatherspoon et al 1992). These kind of methods using non-commercial hand-cutting and prescribed burning rather than commercial logging could theoretically meet fire managers' needs while also addressing the concerns of citizens who are opposed to using timber sales as a means for fuelbreak construction or fuels reduction.

FUELBREAK MAINTENANCE: RISKS

An inherent challenge with extensive fuelbreak systems is the need for periodic maintenance to retard the growth of flammable shrubs and saplings that can thrive in the increased sunlight and disturbed soils of logged sites. Numerous scientific reports from California's Sierra Nevada--a region with a long history of fuelbreaks that failed to be maintained--caution that without proper maintenance, fuelbreak sites become ineffective (van Wagtendonk 1996, Weatherspoon 1996, Weatherspoon and Skinner 1996, Sessions et al 1996, Greenlee and Sapsis 1996). This is because the combined effects of vegetation and soil disturbance created during fuelbreak construction, and the increased exposure to sunlight in thinned stands, can lead to prolific growth of grasses, brush, and saplings. Over a relatively short time, this can lead to a type conversion from timber fuels to grass or brush fuels, resulting in increased fireline intensity and rate of spread compared to the newly-constructed fuelbreak or even the original uncut forested stand. This effect would negate its functionality as a fuelbreak for safe, effective firefighting (Fox and Ingalsbee 1998). Many if not most large-scale fuelbreak systems have failed over time due to the high costs of maintaining them (Davis 1965, Pyne 1982, van Wagtendonk 1996). One of the institutional reasons for neglecting fuelbreak maintenance relates to the fact that once commodity timber outputs have been extracted from a site, there are few sources of revenue that would provide financial incentives for managers to return to those sites. Instead, fuelbreak maintenance is almost entirely a cost borne from limited (and shrinking) appropriated budgets.

Methods to maintain fuelbreaks include mechanical, manual, chemical, biological, and prescribed fire treatments--each of which results in different kinds of costs and impacts. Mechanical treatments are expensive, and can cause excessive soil disturbance. Manual cutting can precisely target specific trees or vegetation for maintenance thinning, but this method can be very expensive and time-consuming. Chemical treatments are relatively inexpensive at large scales, but can pollute soil and water. Prescribed burning is a far less precise tool, but is the least expensive method. One challenge of prescribed burning is that fuelbreaks are designed to keep fire "out" not "in," and adjacent stands are often untreated high fuel hazard sites that pose a significant risk of escaped fire. A more preventative strategy to help reduce the frequency and intensity of needed maintenance treatments would be to maximize canopy retention in "shaded fuelbreaks" and minimize soil disturbance during fuelbreak construction in order to curb new growth of shrubs and saplings. More research is needed to help develop maintenance methods that minimize both environmental impacts and economic costs.

CONCLUSION

Fuelbreak proposals routinely face public criticism and opposition because the majority of these projects involve commercial timber extraction and are intended to facilitate fire exclusion goals and fire suppression activities. Critics argue that this kind of fire management does not constitute authentic forest restoration or fuels reduction, and is more part of the problem than part of the solution for sustainable forest management. Elements of an alternative approach to fuelbreaks would involve:

1) expanding the use of fuelbreaks to include landscape fire reintroduction (through prescribed burning and wildland fire use) rather than exclusively fire exclusion and suppression;

2) analyzing the potential environmental effects of future fire suppression actions conducted within or adjacent to fuelbreaks;

3) locating fuelbreaks near communities-at-risk rather than remote backcountry areas;

4) locating fuelbreaks along strategic sites such as main ridges that potentially offer effective fire containment or control sites rather than random sites associated with commercial-grade timber stands;

5) designing fuelbreaks with patterns that more mimic a natural fire-maintained landscape mosaic (e.g. irregular-shaped area-wide treatments) rather than artificial patterns (e.g. straight and narrow linear breaks);

6) retaining rather than removing overstory mature and old-growth trees;

7) prioritizing treatment of surface and ladder fuels rather than reduction of canopy fuels; and

8) constructing and maintaining fuelbreaks with manual cutting and prescribed burning rather than commercial logging and herbicide spraying.

Even though recent fuelbreak proposals have generated considerable scientific and public controversy, there is still a possibility that fuelbreaks can play a useful role in future fire management programs. An essential first step would be to engage all policymakers, experts, and stakeholders in the development of what Franklin and Agee (2003) call a "comprehensive national forest fire policy." Such a policy would consider the full range of ecological and social values in a long-term vision of stewardship of the Nation's forests. In this task, fuelbreak proposals must go beyond concerns with short-term fuels reduction or reactive fire suppression, and be linked with a long-term proactive mission of ecological fire and forest restoration. Accordingly, fuelbreaks could serve a vital role as entry treatments for area-wide fuels treatments using understory prescribed burning (Omi 1996). They could also serve as contingency confinement lines for managing wildland fire use, or containment lines for wildfire suppression when conditions prohibit fire use (Arno and Allison-Bunnell 2002). Fuelbreaks could be the first steps in a progression from site-specific fuels reduction projects to landscape-scale fire restoration programs (Omi and Kalabokidis 1998).

Omi (1996) states that "Managers would be well-advised to involve concerned citizens in planning fuelbreak construction and maintenance, as fuelbreak construction will alter the look and feel of the landscape." Indeed, it should be a strategic goal if not essential need for land management agencies to fully collaborate with citizen groups and local communities to come up with agreements over the model, means, and methods of fuelbreak design, construction, maintenance, and use. Successful collaboration offers the potential for agencies to convert current citizen opposition into endorsement for future fuelbreak proposals. Public support is especially essential in order to sustain taxpayer funding streams necessary to maintain fuelbreaks over the long-term. As well, policy objectives long advocated by conservation organizations--increased wildland fire use and reintroduction of prescribed fire, restoration of fire-adapted ecosystems, hazardous fuels reduction to create community wildfire protection zones--could all conceivably include a role for some kind of fuelbreak. Thus, there are mutual interests and potentially common objectives among agencies, organizations, and communities to explore alternative fuelbreaks objectives, uses, designs, and methods in an expansive fire management mission of community fire preparation and ecosystem fire restoration.

More systematic and empirical field-based research on the uses and effectiveness of past and present fuelbreak programs needs to be conducted in order to address some of the questions and controversies that critics have raised to date. A multitude of scientific disciplines from fire ecology to social psychology will be needed to help create the fuelbreaks of the future. To build support for new fuelbreak programs, the key will be to apply new paradigm "fire restorationist" goals for fuelbreaks on an experimental, small scale, then move to larger scales over time with the aid of effectiveness monitoring and adaptive management (Agee 1993).

There will likely become two main roles for fuelbreaks: some will be needed as "moats" to stop wildfires from burning into rural communities, while others will be needed as "drawbridges" to help start prescribed fires or steer managed wildland fires within remote wildlands. In either case, the role of fuelbreaks in facilitating community protection and fire ecology restoration objectives must be clearly articulated. It may be that for pragmatic political reasons, constructing moats are initially prioritized over creating drawbridges, for the sooner we are able to protect communities from wildfire, the sooner we may be able to restore ecosystems with prescribed fire. In that respect, it is suggested that instead of presenting fuelbreaks as a means of fire "prevention" or "protection," fuelbreaks should be proposed as a means of community fire *preparation* for wildland fires of all kinds--wanted and unwanted, planned and unplanned, wild and prescribed. In this way, moats would be spanned by drawbridges, and fuelbreaks may be used to recreate fire-adapted communities able to live safely and sustainably within restored fire-adapted ecosystems.

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