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FORUM

An Event-Based Approach for Examining the Effects of Wildland Fire Decisions on Communities

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ABSTRACT / Public concern over the consequences of forest fire to wildland interface communities has led to increased resources devoted to fire suppression, fuel treatment, and management of fire events. The social consequences of the decisions involved in these and other fire-related actions are largely unknown, except in an anecdotal sense, but do occur at a variety of temporal and social organizational scales. These consequences are not limited to the fire event itself. Preparation for the possibility of a fire, actions that suppression agencies take during a fire, and postfire decisions all have consequences, if unknown currently. This article presents an ''event-based'' approach that can be useful for constructing and systematizing discussion about the consequences of wildland fire to human communities. For each of the three major periods within this approach, agencies, communities, and individuals make decisions and take actions that have consequences. The article presents an integrated, temporally based process for examining these consequences, which is similar to others developed in the natural hazards and disaster management literature.

Since the Yellowstone fires in 1988, wildland fire has become a central theme in social discourse over management of western public lands in North America. Fires in the Bitterroot Valley of Montana in 2000 followed by large fires in Colorado, Arizona, and Oregon in 2002, as well as more recent fire events in the summer and fall of 2003 in British Columbia, Montana, and California threatened to burn or actually burned into multiple rural communities. These fires destroyed residences and businesses adjacent to or within forested settings and raised questions about the capacity of fire suppression agencies to understand the effects of fire on communities. Large wildland fires in other regions of the world, such as Indonesia, Australia, and Europe, in the past decade have stimulated interest not only in the biophysical consequences, but also the social consequences of such events (Levine and others 1999).

Wildland fire, whether anthropogenically or naturally caused, had been the dominant ecological disturbance shaping the vegetation pattern of landscapes in the western United States before the 20th century (Pyne 1982). Research investigating ecological processes of these landscapes identifies three broad categories of fire ''regimes'' in western North America: the stand-replacement, mixed, and understory types (Arno and Allison-Bunnell 2002). The latter fire regime, sometimes described as a ''low-intensity, high-frequency'' fire regime, occurs mainly in dry forest types, such as Ponderosa pine, that occur commonly across low-elevation mountain zones in the West. A combination of climatic cycles (wet productive years followed by drought), management policy (e.g., fire exclusion, grazing practices, species-specific logging), and land use (growth of the human population in these zones) has led to rapid accumulation of fuels closely juxtaposed to communities and neighborhoods, thereby increasing risks to property and life.

Because the potential has arisen for high-intensity, large-scale wildland fires that threaten communities, rural residences, businesses, and public infrastructure, governmental institutions have increased attention and resources devoted to protecting communities. Whereas the sets of decisions involved in this protection have increased in complexity, our understanding of the consequences of these decisions, whether we are

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dealing with preparedness, suppression, or rehabilitation, remains limited, particularly at the community level. This limited knowledge base remains a particularly important challenge given the 11,000 communities identified by the federal government as at risk from wildland fire (Federal Register, 66 (160) August 17, 2001). Moreover, a framework is lacking that could help guide the development of research, planning, and management strategies to address wildland fire consequences for communities. Such a framework could lead to additional understanding that would be helpful to those responsible to allocate funds and other resources for fire preparedness, prevention, and suppression, as well as restoration and recovery actions.

This article presents and describes an ''event-based'' approach for addressing the growing complexity of decisions affecting communities in this contentious and intricate context. We outline and describe the linked set of decisions that have an impact on communities in a wildland fire context. This depiction is intended to serve as a heuristic framework to enhance understanding of the consequences of wildland fire for communities, to inform planning aimed at reducing the risks of fire, and to suggest an approach for identifying research and information needs. Our fundamental objective is to present an approach to organizing a ''big-picture'' conceptual understanding of community impacts of wildfire events and the decisions inherent therein, not to present a review or synthesis of the literature detailing the effects of wildland fire on communities. Thus, this approach is designed more as a heuristic effort than as a model depicting specific cause–effect relationships. We do, however, identify the temporal linkages among major types of decisions that carry implications for human communities.

Although not a comprehensive literature review, the discussion is grounded in applicable published literature on human disasters and what literature exists on community consequences of wildland fire events (e.g., Bonnicksen and Lee 1979; Couch and Kroll-Smith 1985; Drabek 1986; Fischer 1998; Williams and Lime 2001) and the experience of the authors in observing and researching community–wildland fire interactions (Carroll and others 2000, 2005; Kumagai and others 2004a, 2004b; Rodriguez and others 2003). This article is an outgrowth of several workshops with wildland fire managers in the western United States. Although our experience is limited largely to western North America, the framework may help inform decisions in other regions faced with similar questions and issues.

Concerning the organization of the article, we first briefly depict the context in which community impacts from wildland fire events are studied, assessed, and mitigated. We then discuss the major temporal phases of a wildland fire event in detail, listing and describing the significant decisions in each phase that have a potential impact on communities.

We conceptualize the community [1] consequences of fire as analogous to the human response to other natural and human-caused disasters. Following Drabek (1986), we view wildland fire as an event for which there are human responses at multiple scales (in both temporal and social-organizational senses). Thus, responses or consequences are seen as incident- or ''event-based'' with before, during, and after phases. These consequences are manifest at various social and geographic scale levels from individual to societal. We not only frame the types of wildland fire consequences to communities and other social structural entities, but we also identify, where appropriate, the potential decisions and actions taken to prevent, mitigate, suppress, and recover from these events.

However, decisions about wildland fire events frequently are made in a highly charged context involving debates over appropriate fuel treatments, zoning regulations, funding appropriations, cost containment directives, and certification and availability of firefighting equipment. Such debates are themselves fueled by clashes of political philosophies at all levels of governance. Thus, the social, political, and environmental context within which fire and communities exist is not only complex, controversial, and filled with uncertainty, but also highly varied from one community and biophysical setting to another. This varying context influences not only what and how decisions are made, but also the consequences of those decisions.

The presentation of fire's impacts on communities using an event-based approach provides a logical, temporal view of the significant decisions made in the stages before, during, and after a fire. Research on other types of disasters also apply a ''life cycle'' approach to a consideration of the effects, although Fischer (1998) used five periods to organize his analysis: the pre-impact period, the impact period, the immediate postimpact period, the recovery period, and the long-term reconstruction period. Similarly, Drabek (1986) organized his review involving more than 200 empirical studies of human response to disasters into a four-category time frame including preparedness, response, recovery, and mitigation.

[1]Here we define ''community'' in spatial terms.

Wildland fire differs somewhat from other disasters in that large wildland fires usually occur over a period of days, sometimes weeks, in contrast to the relatively instantaneous nature of other natural disasters such as earthquakes, hurricanes, and tornados. Thus, actions taken *during* the event itself may have important and unanticipated consequences.

Our framework (Figure 1) contains three major stages: (1) decisions that occur before a fire event, (2) decisions that occur during a fire event, and (3) decisions that occur after the event. Through workshops, literature reviews, and our own experience (either with fire managers or, as happened to one of the authors, personally through an emergency evacuation), we have listed the major decisions occurring in each of these periods. Each decision has a number of consequences appearing at different social organizational scales across different dimensions of community life including health, finance, economy, transportation, and access to recreation. The consequences themselves serve as knowledge fed back into future decisions. The decisions that occur during each of these three major periods in the fire event life cycle are influenced by other decisions in the surrounding social and political context involving attributions as to the cause of the event and its consequences as well as interpretations of environmental and climate change and conditions.

Decisions Before Fire Events That Affect Communities

The underlying purpose of decisions and actions before a fire event is to reduce the negative consequences of the fire and to prepare for actions during and after the fire. Preparedness decisions involve actions to prevent fire from occurring; to reduce the probable intensities of a wildland fire event; to mitigate the risk or potential harm from a fire once it starts; to allocate resources and skills for managing people, communities, and resources during a fire event; and to strengthen the capacity to recover and rehabilitate lands and communities once the fire has been controlled.

Based on our review of the literature, research experience, and comments from workshop participants, we suggest that five major decisions are made during the pre-event period: (1) decisions about the content, audience, and media needed for communicating risks of wildland fire threats and responses to them; (2) decisions about management of fuels; (3) decisions to identify and organize local firefighting support (including pre-event certification of equipment and personnel); (4) decisions about how information important to fire suppression strategy is to be managed; and (5) decisions concerning allocation and management of resources among agencies and strategies to be used should a wildland fire event occur.

Communication Decisions

Decisions about public communication, while occurring in all three phases, involve in the pre-event phase a focus on raising public awareness about wildland fire and its role in the local ecosystem; developing better understanding of the risks entailed by individuals while living, working, and recreating in the wildland–urban interface (WUI); preparing residents for evacuations if needed; understanding public concerns about and perceptions of wildland fire; and encouraging homeowners to adopt practices that will reduce the ignitability and exposure of homes to wildland fire (Cohen 1999).

Research on communications shows that the willingness of people to respond to a persuasive message is based on complex processes involving norms, peer pressures, beliefs (including perceptions of risk), and prior experience (see, for example, Fishbein and Ajzen 1975; Manfredo and others 1990; Petty and Cacioppo 1986). Yet the strongest message for building awareness of fire risk is the actual occurrence of fire, and the increasing frequency of seasonally repeated fires elevates public interest in preparedness, in much the same way that the seasonal repetition of tornados and other weather-based disasters heighten involvement (Drabeck 1986). Conversely, a wildland fire event experienced in a community or neighborhood may tend to "dampen" the risk of a future event because individuals may feel that the probability of a repeat fire event is very low.

The choice of communication medium, message content, and message source will influence the consequences in terms of the major purposes of communication at this stage. Common mass communication media, such as brochures, may have little influence on individual behavior, whereas social legitimizers may have an enormous influence. Frameworks such as Rogers' diffusion-of-innovation approach (Rogers 1995) may help fire managers to use scarce resources more efficiently while leveraging other persuasive forces to obtain desirable results. For example, decisions that promote the implementation of visible preparedness treatments around homes in high-volume travel corridors would allow people to observe the effects of "early adopter" behaviors. Because many of these

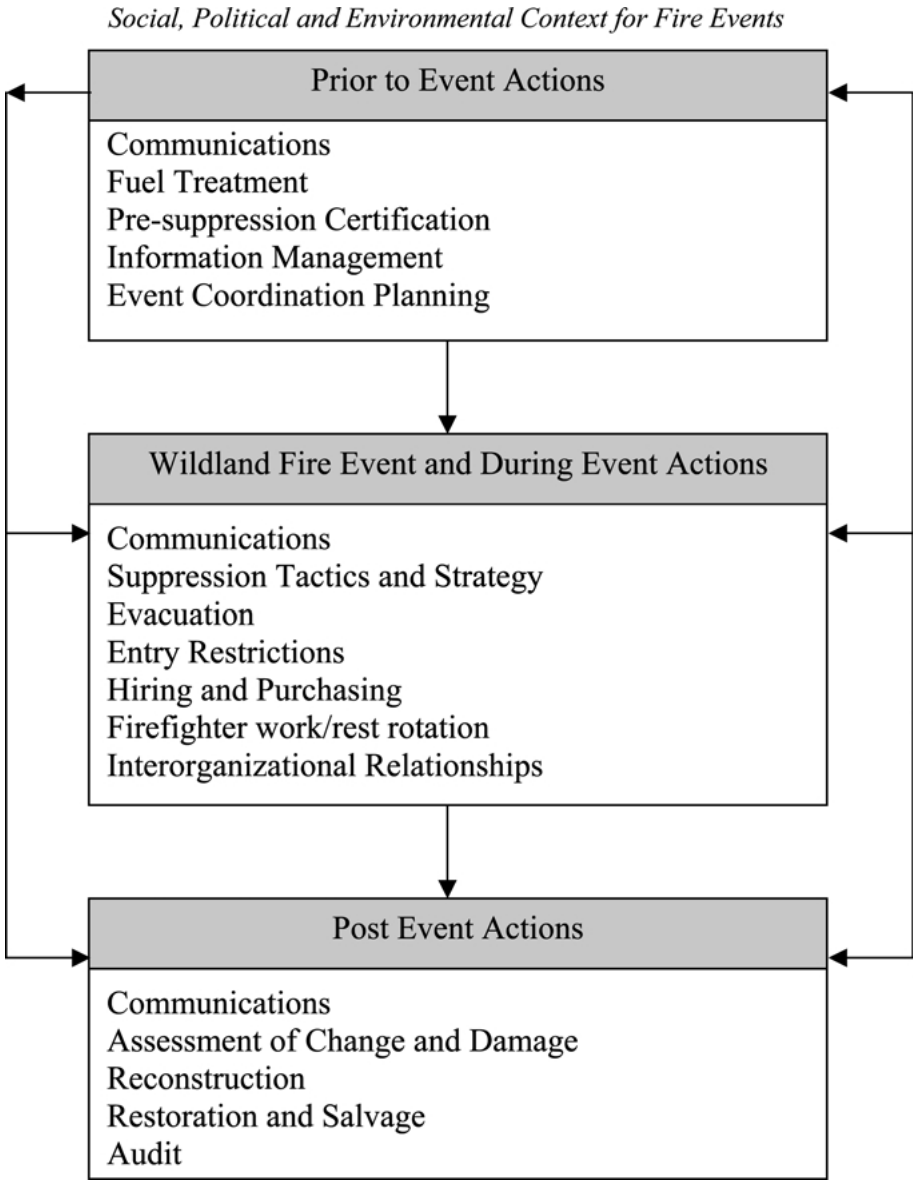

Figure 1. Decisions made before, during, and after the fire event influence the effects of wildland fire on communities. The major decisions made in each of the three stages of a fire event are shown. Decisions made in one stage influence decisions made in other stages.

treatments for defensible space around homes can be designed to create aesthetically pleasing effects, encouraging the adoption of "fire-safe" behaviors also could take advantage of people's desires to do more (e.g., beautify their properties) than simply reduce risks (Daniel and others 2002).

The impact of communication decisions on fire-vulnerable communities is perhaps most obvious in the breach. Negative consequences can occur when such communication does not occur or is not effectively carried out. Community "fire-safing" is less likely to occur or to be less effectively implemented in such situations than in circumstances wherein technical knowledge has been interfaced effectively with local, site-specific knowledge and experience. This sets the stage for blaming behavior after a fire event (Kumagai and others 2004a, 2004b).

Communication strategies are linked to other temporal periods and may change on the basis of the extent or intensity of wildfire occurrence or other factors such as existing community–agency relationships. The postfire recovery stage, described later in this article, is

a particularly ripe period for reminding people of preparedness needs. In the interfire periods, managers must decide on the periodicity of messages, using related events such as droughts or hot weather to capture public concern. Other actions in the forest that are observable, such as timber sales, also can serve as communication vehicles for fire preparedness because slash disposal or the creation of fire breaks remind forest visitors of the fire-adapted environment. Managers will need to consider how their normal activities can create opportunities to keep a fire-safe message consistently in front of a public that is all too forgetful of inevitable periodic wildfires.

Fuel Treatment Decisions

Fire managers also must make decisions about how and where fuels will be treated to reduce fire risk. These treatments generally are based either on protecting specific structures in neighborhoods or on reducing fuel loading in forested areas of the WUI. Although fire managers cannot directly influence the actions of private forest owners, they can encourage "fire-safe" actions through demonstration, technical and financial assistance, and the development of partnerships across land ownership. Individual property owners may reduce the risk of losing structures to wildland fires by constructing defensible space immediately around these structures through treatments of common fuel problems such as overhanging trees, firewood stacks on porches, pine needles in windowsills and gutters, and other woody vegetation near or adjacent to buildings, and through the use of appropriate materials on the roof and siding of the residence (Cohen 2000). High up-front costs associated with these treatments and beliefs about the probability of a fire striking any given property are factors likely to reduce property owners' incentives for these activities. As mentioned earlier, concerted neighborhood-based programs applying a diffusion-of-innovations framework could improve adoption of preventive measures through peer influence.

Fire managers also may desire to treat fuels in nearby forested areas. The effectiveness of fuel reduction or treatment techniques in ameliorating fire risks is subject to considerable complexity. Forest stand conditions, natural fire return intervals, fire history, drought cycles, and other factors combine to make predicting the effectiveness of fuel treatment somewhat uncertain. Recent research shows that reducing stand density in Ponderosa pine forests can lower the intensity of crown fires and improve fire suppression effectiveness (Arno and Fielder 2005; Kalabokidis and Omi 1998). This finding is particularly important given the dominance of such forests in the WUI. However, the ability to treat fuels effectively across broad landscapes is hampered by multiple issues including the extent of the treatment area, costs, competing land use objectives, and the dynamics of the vegetation itself (Pyne and others 1996). Further, research on the potential for either economic or ecological success from fuel treatments is woefully underdeveloped, and there are critical needs for more explicit production functions to evaluate outcomes (Hesseln 2000). Critical breakdowns in these processes lead to the same types of consequences for communities noted in the preceding section.

The connection of fuel reduction treatments to other fire management decisions at later times becomes particularly salient when maintenance of low fuel conditions is considered. Fuel reduction is not a one-time event, especially in the common dry pine forests of the WUI, where grasses and other highly ignitable fuels can become more prominent after thinning. Forest managers must be prepared to follow up their fuel treatment decisions in much the same way that individual landowners need to sustain vigilant care in keeping fuels away from their houses and other structures. Forecasting expenses and labor for ongoing operations will be a part of any fuel treatment decision.

Presuppression Certification Decisions

Fire suppression professionals are well established within land management agency hierarchies in the United States. However, during extended periods of multiple large-scale fires, agency professional resources alone are simply inadequate for suppression activities and associated support services. For example, a large-scale fire may require everything from bulldozers to pickup trucks, from portable toilets to mobile command centers. Much of the needed supply, support personnel, and materiel must be acquired on short notice, and must be of acceptable quality to ensure safety. Currently, procedures to incorporate available resources at the community level are confusing to local entrepreneurs, and in cases of both suppression and prescribed fire, community representatives may be excluded from participating in fire operations because they lack recognized qualifications. Although this has long been an issue of contention between local entities and federal land managers in some areas, its salience is growing as fire complexity and scale increase, and as a greater proportion of wildland fires occur in and around human settlements (Carroll and others 2000, 2005; Kumugai and others 2004a, 2004b).

Advance planning will be necessary to discover, train, and certify key occupational groups, such as

heavy equipment operators, to create greater efficiencies; to take advantage of local site-specific knowledge; and to ease developing tensions between locally available private providers and externally contracted services. Inventories will need to be available for widespread access, and decisions on call-up priorities will need to be communicated to local suppliers so perceptions of preference are minimized in the heat of an emergency. Again, the impact of decisions about certifying local equipment is particularly obvious "in the breach." The studies noted in the preceding paragraph have captured the frustration of local actors (in some cases, even ground-level federal fire managers) about large, destructive fires that "could have been caught" if local action had been taken in the early stages, thus preventing all the later impacts of a large fire event. On the other hand, it also is important to point out that the vast majority of small fires are caught while they are still small, and that the liability issues associated with allowing *noncertified* personnel and equipment onto federal lands are very significant.

Certification decisions also link to the management responsibilities during an event and after the fire has been successfully suppressed. Much emergency postfire rehabilitation requires equipment and qualified operators, and best management practices can be more efficiently incorporated into rehabilitation practices if operators who are disturbing soil and vegetation during suppression (such as bulldozer-created fire breaks) recognize subsequent requirements for rehabilitation.

Information Management Decisions

The availability of current, high-quality data on fire and fuel conditions can greatly affect suppression operations and subsequent decisions on evacuations or the allocation of scarce resources to protect communities. With the advent of geospatial information in support of fire event management, greater efficiencies in fire behavior predictions and priority areas for suppression have emerged. However, problems with data quality, infrastructure, and the training of geospatial analysts have impaired the widespread, effective use of this technology (Burchfield and others 2002). In many rural communities, information on structures and road systems is incomplete or stored in such ways as to be incompatible with fire suppression software, hampering the effectiveness of suppression operations. Incomplete data sets on fuel conditions hinder the creation of necessary wildland fire situation assessments that allow decision makers to evaluate the risk associated with wildland "use" or "let-burn" fire decisions. The manner in which information is accessed, applied, and archived can be critical to the development and application of preparatory measures for wildland fires and will hold consequences for communities similar to those noted in the preceding three sections.

Event Coordination Decisions

Federal land management agencies generally work with community-based institutions to prepare for a wildland fire event. Thus, the character of existing agency–community relationships serves as a context for more specific decisions oriented around coordination. The ability of rural fire departments and privately held resources to address suppression needs depends largely on their prior training and integration into fire suppression strategies and the willingness of firefighting teams to take advantage of their local site-specific knowledge. Decisions about what equipment and personnel are responsible for what land areas are important coordination decisions.

Land management agencies typically hold responsibility for the initial attack on forest and range fires, whereas local fire departments are structure oriented. However, often in a large-scale, complex, rapidly moving fire, such divisions of responsibility become confused as firefighters are faced with difficult choices. Does a federal team with an engine ignore a home whose roof has just caught fire in order to use their pumper on forest fuels nearby? Can homes and businesses be "triaged" before a fire event? Should local, volunteer fire departments, when under a federal command system, be allowed into areas they have traditionally protected?

Regardless of the setting, local organizations and businesses have always provided critical resources to fire suppression efforts such as law enforcement and public safety assistance from local sheriff departments, local public school facilities for command centers and fire camps, or grocery stores for supplemental food supplies. In addition, the emergency nature of fire events engenders a sense of purpose and commitment for local institutions, such that local people display strong desires and expectations for participation in suppression efforts. Sorting out the roles and technical details (e.g., emergency services radio frequencies, location of and access to tool caches, or evacuation routes) before a wildland fire event is an important coordination process that ideally occurs before an event.

The local impacts of event coordination (or lack thereof) are difficult to overstate. A major wildfire is an inherently disordering experience in the life of a community, often highly disruptive of daily routines, place attachments, and internal and external commu-

nity relationships. Coordination decisions made in advance that bring together local knowledge and the expertise of nonlocal experts not only can lead to a more effective response to the physical event itself (perhaps even saving lives), but also may reduce the sense of disorder that community residents feel at the time of the event (Carroll and others 2000, 2005; Kumugai and others 2004a, 2004b). Many of the retrospective objections registered by local people about how a fire was handled center on a lack of coordination during the event. Thus, effective event coordination before an event appears to be a key to minimizing the fragmenting influence of major fire events during and after their occurrence.

During-Event Decisions Affecting Communities

A large-scale fire event in the WUI involves residents, homeowner associations, and a number of organizations and agencies including suppression teams and their leadership, law enforcement officers (potentially from different governments at varying levels), emergency management officials, and disaster nongovernment organizations (e.g., Red Cross, Salvation Army, local organizations). The coordination and cooperation of these varying agencies may have dramatic effects on the impact that the fire actually has on a community. Whereas many consequences of a wildland fire event are immediate, such as destruction of homes, others such as health effects from long-term exposure to smoke may emerge much later. Unlike most catastrophic events (e.g., earthquakes, tornados), wildland fire often involves a protracted period, from a few days to several months, in which authorities attempt to manage, mitigate, and control the extent of damage. On the basis of our literature review (McCool and others 2005), research experience, and comments from workshop participants, we suggest seven decisions that can potentially have an impact on the local community in the vicinity of the fire.

Communication Decisions

As in the pre-event period, communications during a wildland fire are critical to minimizing its negative consequences. In this stage, however, communication with the public plays different roles than in the pre-event period. The primary purposes of communications during the fire are to describe the fire event (size, scope, severity, rate of spread, and location), inform the public of risks and potential consequences, and prepare them for any needed action; to update affected individuals on entry restrictions, evacuations, damages, and suppression actions; to inform people who have been affected about the availability and location of shelters as well as mental and physical health services; to develop a better understanding of public concerns and issues resulting from other during-event decisions; and to direct public inquiry on how to contact appropriate recovery program agencies.

Over the years, federal firefighting agencies such as the Forest Service have developed sophisticated communication strategies with the goal of ensuring that information about the fire flows smoothly between firefighters on the front lines, fire managers overseeing the operation, public affairs specialists monitoring the effort, and those (the public and the media) whose cooperation is crucial to a safe outcome. In large-scale fires, this becomes increasingly challenging because the "fog of war" means that some things may occasionally be overlooked. In some instances, owners of destroyed homes have found out about it through television media reports rather than by official sources.

As in a prefire situation, agencies make decisions about what to communicate to whom, when and how. A number of issues in this regard are significant. For example, information content and timing may affect residents in different ways. Fire managers may emphasize some types of information (e.g., fire behavior) over other kinds of information (e.g., the need for cooperation and calm or a listing of destroyed homes) at different points in a fire event. As a fire event develops, there may be needs for some types of information over other types. Fire managers will need to know what media are best for what types of information. For example, the use of local electronic media may help displaced residents better understand what areas have burned, whereas regional and national media build awareness of the fire to others. Use of Web sites has become increasingly frequent, but to be useful, updates may have to be done several times a day.

Whereas considerable literature on crisis communication exists (see Coombs 1999), research on the effects and effectiveness of fire-related communications in relation to communities is only starting to emerge. Taylor and others (2005) studying communications during the 2003 southern California fires found that official communications tended to focus on what was salient to fire managers but not necessarily important to community residents. They recommend that fire mangers find ways to monitor the often rapidly changing information needs of communities.

Another related problem is maintaining consistency of information management over the course of a large fire as the information management teams rotate in and out of the scene. This further slows down the flow of critical information. In addition, successful com-

munications during a fire are partly the result of effective community collaboration in the prefire planning phase and facilitate the community coming together to address postfire recovery phase efforts (Burns and others 2004).

Suppression Tactics and Strategy

Depending on the size of the fire and other ambient conditions, the administration of individual wildland fires is assigned to suppression teams according to established interagency protocols. Decisions are made that involve the basic strategies of fire suppression (e.g., containment vs property protection, what flanks and fronts to attack and how) and a host of tactical questions such as the use of backfires, the types of equipment used (aerial, ground), and the type and source of personnel (agency vs. local) involved. In addition to basic strategies and tactics, there are important dimensions of attack timing and location that have an impact on communities and particular neighborhoods and residences. The many strategic and tactical decisions involved in managing a large wildland fire open the door for communities to question the decisions of the fire suppression team, particularly when life and property are affected. Thus, although firefighters are often praised for their valiant efforts to protect local property, considerable controversy can develop over how the fire was managed and over policy factors that contributed to the fire in the first place (Carroll and others 2005; Rodriguez and others 2003).

For example, Carroll and others (2000, 2005), Graham and others (2003), Kumagai (2001), Kumagai (2004a, 2004b), and Rodriguez and others (2003) all have reported local–federal conflict over federal forest firefighting, and over relationships between federal forest firefighters and local entities. The issues have revolved generally around aggressiveness of firefighting, protection of homes, priorities for resources and structures to be protected, and the extent to which local personnel, knowledge, and resources were used in fighting fires. Although no focused research on such conflict has been conducted, the underlying reasons appear to be complex and multifaceted. They seem to range from faulty causal attribution by fire victims (see later), to the confusion of activities inherent in large fires similar to the "fog of war," to a focus on the "big picture" of a fire versus a place-specific view, to differences in culture between large government agencies and local communities, to genuine differences in values and priorities vis-à-vis how to fight fires and what level of risk to firefighters should be tolerated to protect homes and property (Carroll and others 2005; Cortner and Gale 1990).

Evacuation Decisions

The mandatory movement of residents and businesses threatened by wildland fire and the various aspects of notification of possible evacuation are likely to be among the most disruptive aspects of a catastrophic wildland fire for a community. Dimensions of evacuation decisions include how much time people have to prepare for evacuation, opportunities for evacuees to gather their most precious possessions, the presence of pets and livestock, and whether the locations of friends and family members are known. Understanding how evacuation decisions are made and communicated to those affected is important, as is identification of specific potential evacuees. The number of households and businesses affected and the lengths of time involved hold important implications for the size of evacuation consequences.

Evacuation may be a traumatic and dangerous process itself, and the very act potentially leads to impacts on individuals (Carroll and others 2005; Drabek 1994; Perry 1994). It occurs at a time of high anxiety and uncertainty about many questions. Will my home burn? Will I lose all my possessions? Is there enough time to evacuate safely? Are my children safe? How can I be sure my dog is safe?

A better understanding of evacuation and impacts would help to mitigate the impacts of evacuation actions and potentially improve relationships between the community and public safety institutions. Here the disaster literature would be helpful in informing fire and emergency managers during the pre-event phase of procedures and expectations during the fire event.

Entry Restrictions

Entry restrictions often are necessary to reduce risks not only to local residents, but also to others who may be visiting forest areas for recreation or business purposes. Such restrictions also may be necessary to reduce congestion and barriers to the efficient movement of emergency vehicles, aircraft, and personnel. The impact of these restrictions may range from inconvenient disruptions of daily life to serious interruption of business activity. These restrictions must be enforced by local public safety personnel or by hired security personnel. The efficacy of handling these tasks is a major question, as is the issue of how access is determined during a closure. Managers are necessarily risk averse, so an explication of the criteria used in determining areas to be closed is important.

Hiring and Purchasing Decisions

Fire suppression requires equipment, people, supplies, lodging, food, portable toilets, and other goods and services. Such hiring and purchases can potentially result in significant local impacts. Although we often think of wildland fires as having negative impacts on local economic activity, one potential positive impact of the fire suppression effort is the generation of economic activity in the local community related to firefighting. It is important to point out, however, that these impacts are likely to redistribute economic activity in ways different from those in the "normal" situation. Some business, such as recreational outfitting, may come to a complete halt, whereas other business, such as lodging, may do booming business accommodating not only firefighters, but also media personnel and evacuees (Butry and others 2001). With respect to social impact, how purchasing and hiring decisions are made and whether there are ways to do this that are minimally disruptive and that reduce the negative distributional impacts remain important questions. In some cases, it may not just be who was hired and what was purchased, but also the very determination of the needs for this hiring or purchasing.

Carroll and others (2000, 2005) and Graham and others (2003) all have reported that specific business sectors suffered disproportional impacts from fire events. Among these were seasonal businesses, businesses with perishable stock such as local nurseries, and businesses that relied on seasonal tourist dollars. Short-term income and job losses from the Rodeo Chediski (Arizona) and Hayman (Colorado) fires that affected families appeared to be heaviest among those with seasonal or temporary employment and business owners whose busy season is the warm weather months. Similar impacts were reported from the Wenatchee National Forest (Washington) fires in 1994. Purchasing and hiring decisions by fire managers may help to ameliorate these impacts or may end up aggravating them.

Firefighter Work–Rest Rotation Decisions

The presence of firefighting personnel in a community setting brings new resources and disruptions to the daily life patterns of local residents. During long fire suppression efforts, the scores of firefighting personnel and other people involved (e.g., media personnel) begin to have a presence in the community. They purchase supplies, eat out at restaurants, take in a movie, and engage in other non–fire-related activities in and around the community. These activities not only have an obvious economic impact, but also potentially create a "behavioral" presence that may produce positive or negative interactions with community residents (e.g., competition between firefighters and locals for services). How firefighters behave in public may leave an important and lasting impression on community residents.

Interorganizational Relations Decisions

This large and complex task of managing interorganizational relations occurs in the midst of a crisis that usually cuts across governance scales. A large fire requires coordinating the activities of varied autonomous groups (multiple firefighting organizations, media, local emergency personnel, aid organizations) with different constituencies to which one must answer. This task may be among the most important for the success of the overall effort. Fire suppression agencies from different jurisdictions at different levels of government having varying experiences with wildland fire and structural fires will have to coordinate and determine appropriate roles and potential triage policy (e.g., are homes with no defensible space protected or allowed to burn?). As indicated earlier, success with the task and the consequences to the community are highly dependent on preparations made in the prefire stage (Burns and others 2004). Research on organizational relationships and the types of organizations involved would help responsible agencies to understand the issues that arise in the development and implementation of coordination strategies, the response to these issues, and how these responses might affect preparedness decisions.

Postfire Event Decisions Affecting Communities

After control of a fire event, five major decisions affect communities: communications, assessment of change and damage, reconstruction of damaged infrastructure, restoration of desired resource conditions, and auditing of the level of change. Postfire decisions are closely linked to the decisions occurring before new events because they offer the greatest opportunity to capture public attention for necessary mitigation of future potential damage and risk.

Communication Decisions

The need for communications with the public does not end once the fire has been suppressed. In this stage, communications might focus on creating an understanding of the breadth and intensity of impacts to both the biophysical and social domains; communicating needs for salvage, restoration, repair, and

reconstruction; developing a sense that the fire event provides lessons on preparation for similar future events; identifying potential new hazards such as floods and mud slides resulting from the fire; and developing strategies to engage the public in more interactive approaches for a better understanding of community responses to the fire event and the acceptability of restoration strategies, and to lay foundations for future prefire event planning.

Communication decisions after a fire must consider the trauma suffered by many residents. The use of community-level organizations to help describe recovery efforts and address specialized needs during the postfire period can offer a legitimacy and sensitivity necessary for effective actions (Halverson 2000). Agency staff will need to focus particular attention on the clarity of communication and explication of decision processes used during the fire and in the recovery period to guide the healing process for the communities (Daniels and others 1996; Duncan 1997). The linkage of communication processes in this phase to desirable mitigation of future events cannot be overstated because the receptivity of the audience to messages of preparedness for future events is at its highest (Drabeck 1986; Passerini 2000).

Assessment

Assessment involves identifying and inventorying the damages and changes resulting from the wildland fire event itself. This would include mapping tree damage and mortality, soil and watershed impacts, erosion potential, and the risks of flash floods and mud flows. In addition, the assessment would include damages done to personal, community, and government property and infrastructure. Assessment also would include the state of the community's "mental health," and actions needed to deal with it. The assessment and how it is done are critical not only to developing estimates of the magnitude and scale of impacts, but also to identifying any distributional impacts to the community. The assessment lays the foundation for reconstruction, restoration, and salvage decisions.

Assessment decisions create complex linkages to other future actions as they lay the groundwork for longer-term rehabilitation. Immediate postfire assessments typically are performed quickly to ameliorate potentially dangerous mud slides or other erosive mass failures, but they do not address the other complex recovery efforts such as salvage operations, reconstruction of transportation systems, and rehabilitation of forests. These assessments can be bogged down by procedural requirements for disclosure of environmental impacts, and opportunities to accomplish timely work can be lost. Managers will need to prioritize the cost–benefits of delaying more complex assessments and choose a flexible, articulated style of assessment based on specific resource deterioration–recovery cycles. For example, some types of salvage may need to be done relatively quickly to protect the public (e.g., from falling trees) or to capture wood volume before predictable decay. This flexible assessment strategy would need to be considered even before a fire event so that existing staff capabilities can be marshaled quickly for assessment tasks. Managers may use varying intensities of assessments to make time-sensitive decisions without compromising long-term environmental health.

Reconstruction and Repair

Homes, businesses, civic facilities and transportation systems, and other community infrastructure may have been damaged or destroyed by the fire. This set of decisions identifies what structures and other infrastructure needs should be addressed, how these should be prioritized, how reconstruction should be financed, and how emergency funds should be distributed. It also involves processes of claims and payments, and in some cases introduces new organizations such as the U.S. Federal Emergency Management Agency (FEMA) into the situation. One dilemma is that residents whose houses were saved may no longer wish to live in a landscape that now has been dramatically altered (Carroll and others 2005; Graham and others 2003). Another is concern about damage to municipal water supplies from high-intensity fires (Graham and others 2003).

Much like the assessment strategy, a reconstruction and repair strategy would need to be in place even before a fire event to allow for timely action. Water systems and other vital services such as electricity need to be restored quickly, and the significance of available, certified personnel to accomplish emergency work applies in the postfire period as much as it does in the prefire period. The burden of being homeless only increases as time progresses, and businesses are not successful if they are shut down for extended periods. Thus, coordination decisions with other agencies such as FEMA need to be well established before a fire event to make sure that postfire events do not exacerbate an already traumatic situation.

Restoration and Rehabilitation Decisions

Natural resources (e.g., vegetation, habitats, landscapes) may have been severely impacted. The proba-

bility of flooding and erosion with additional damage to infrastructure may be high. As the size and intensity of wildland fires have accelerated, so has the need for activities that rehabilitate and stabilize natural environments. Decisions on these actions may involve community members, not only because they tend to be labor intensive, but also because many actions may be needed in the private lands of the WUI. Because restoration and rehabilitation projects for watersheds can be quite complex and expensive (with a high potential to create new problems), the aforementioned assessment decisions are vital to the efficient and effective allocation of scarce restoration resources.

Restoration and rehabilitation decisions are strongly tied to both past and future events. It might not only be a wildfire that has altered the ecosystem. Prior management activities may have been underlying causes for large-scale restoration needs (ironically, the suppression of fire is one of the most commonly cited causes for restoration). The scale of restoration is an important element in any restoration decision, not only because of the cost of these actions, but also because of the uncertainty in recreating integrated, functional ecosystem conditions. Restoration also unearths other latent management controversies, such as debates about the benefits of transportation systems or timber harvesting patterns, that cannot be addressed outside the context of long-term management goals. Again, the link to prior decisions is important because landscape planners are able to map zones in which a fire disturbance could be beneficial within a landscape mosaic, and these areas would receive different types of attention both during and after a fire to restore more natural fire-adapted conditions.

Salvage Decisions

The commodities within affected lands, such as burned trees, still may be usable in an economic sense, and there often is great political pressure to salvage such values to serve utilitarian needs. Salvage operations have become increasingly controversial because some groups feel that timber salvage operations have become just another excuse for logging in areas where no logging should occur, whereas others see not salvaging as an unconscionable waste of useful natural resources. Burned area salvage often is a component of postfire recovery plans, yet these salvage decisions can best occur in advance of the fire event as part of broader restoration strategies so they do not become touchstones for larger debates about the efficacy of timber operations. Whereas the fire event may have worked to encourage cohesiveness among community members, salvage proposals tend to be contentious and divisive because of the need for timely action and the potential for soils or watersheds to be damaged in the wake of a fire. Determining the scale of salvage operations can be a difficult decision for managers, and without considerable forethought concerning overall restoration objectives at a larger landscape scale, it is difficult to develop a rational approach to salvage simply by observing the area of burned trees.

Auditing

The "final" set of decisions involves appraisal of the fire event and the decisions before, during, and after it. The purpose of a fire audit is to examine these decisions, to learn from them, and then to recommend needed changes in fire policy, prevention and preparedness, suppression (and the accompanying activities), and postfire actions. For example, the audit could address the effectiveness of preparedness actions, the efficiency of differing communication strategies and tactics, and problems encountered in salvage and repair actions. The information from the audit can be used to determine what changes are needed both in the prefire setting and during the event to mitigate effects.

The actions taken to suppress and control the fire, any evacuations or entry restrictions that were emplaced, the flow of information to communities as well as individuals, and interagency cooperation and coordination are documented and evaluated to learn what happened and why. This now is done more formally as an after action review (The Wildland Fire Lessons Learned Center 2003). The after action review has as its focus learning lessons that then can be applied to future fire events. This assessment typically is conducted as a technical procedure focused on suppression and control, but, increasingly, as the intensity and scale of fires has increased, there has been more interest in implementing a broader and more inclusive assessment process.

The involvement of the community and its agencies in debriefing and assessment of the fire and associated activities needs to become an increasingly important component of such assessments. An effective framework for community recovery, which would include issues such as restoration of utilities as well as financial and technical assistance to businesses, homeowners, and governments needs to be holistic (Monday 2002). Importantly, assessment decisions provide information that may lead ultimately to reinforcing or changing the ways that agencies make decisions in both the prefire and during-fire periods, thus providing the feedback necessary both to adapt to changing conditions and to

learn from decision outcomes that may not have been favorable.

Discussion

Depicting fire event decisions as involving three relatively distinct temporal periods provides a point of departure for describing impacts of fire on communities. One advantage of this approach is that it provides for a broad overview of the relationships and dynamics involved. Fire managers then can focus on one or another element within this system without losing sight of the "bigger picture." As another advantage, this approach depicts dynamics and decisions occurring in one period that may lead to consequences during other periods.

Another important feature of this framework is that it is applicable to real-world management and decision making because it identifies the major decisions that can affect outcomes of consequence to communities. It is one thing to characterize dynamics (e.g., drought cycles, cold fronts) that are beyond human control. It is another to accept the "uncontrollable" elements as givens and emphasize the impacts of decisions that *can be* controlled or influenced. Our focus is on the latter task. We believe such a framework can give land managers and community leaders new and broader ways to think about the impacts of their decisions relative to fire events and fire risk and to foster longer-term thinking and planning relative to such events. We note that our framework describes the type of decisions that may lead to consequences for communities. However, due to the paucity of site-specific empirical research on social impacts of wildland fire events and the space limitations here, the framework does not go to the level of describing specific impacts in great detail; nor does it attempt to estimate the intensities of such impacts.

Our framework is presented in the spirit of better understanding the consequences not only of wildland fire events themselves, but also of the system of integrated and linked decisions that occur before, during, and after a wildland fire event. Similar to other natural disasters, some consequences of a wildfire event can be mitigated beforehand with appropriate planning and preparation. Others can be mitigated during and after the fire. Understanding that decisions are linked helps to frame the question of assessing consequences.

Processes of communication between agencies and communities emerge as important at all stages of fire events, and how such processes are implemented affects the nature, intensity, and breadth of consequences at the community level. Although there is limited published research on how these communication processes proceed in a fire event, the observation of the authors during various recent large-scale fires shows a wide range of protocols (e.g., community meetings, Web sites, press releases, interviews), some more effective than others, based on differing implicit assumptions of communication intent and media effectiveness. The advent of Internet technology has created an enormously powerful tool for public communication on fire situations during wildland fires. During a few major fires in 2002 and 2003, agency communication officers were able to create Web sites and post high-quality, digital relief maps of the fire perimeter and burned area on a daily basis.

The significance of quality information during an emergency cannot be overstated. However, communication is not an easy task, even under more normal circumstances. During a fire, emergency communication becomes more difficult, but escalates in significance because lives may be at stake. The theoretical models that underlie communication become important foundations for fire managers and scientists, yet the effectiveness and consequences of different types of messages and media within fire events remain uncertain.

Communication processes also include the ongoing interaction among residents, agency staff, and relevant interest groups concerning goals, responsibilities, and implications of evaluation. Effective communication processes and settings that foster learning can help citizens and community groups understand the implications and potential consequences associated with interactions ranging from complex preparatory measures to procedures for receiving compensation in the event of a loss. These interactions also may lead to community-based solutions of issues such as fire prevention or recovery efforts. Furthermore, they may provide fire managers with a better understanding of community concerns and anxieties about wildland fire.

The evaluation of decisions during the cycle of a fire event is a fundamental component of a constructive, adaptive learning environment. Investments in loss prevention or mitigation measures for community protection can be considerable, and comprehensive auditing of the costs and benefits of common management tools will determine the extent of their long-term application. Similarly, assessment and mapping of the dynamics of forest conditions and the extent to which an action affects the relationship between fuels and fire behavior will guide future forest management interventions. Only through careful assessment and evaluation of the multiple components of fire events will individuals be able to make adaptive decisions for future events to mitigate negative consequences. As

Figure 1 shows, feedback loops from the later fire event stages inform subsequent preparedness, and quality data collection and evaluation are vital to the creation of an objective accounting of cause–effect relationships.

Framing our understanding of the effects that fire decisions have on communities, tracking of the community consequences, responses, and adaptations that emanate from large-scale environmental change arguably has important value in preparing society for impacts and decision making associated with global climate changes and other large-scale environmental changes. For example, managers reacting to the 1999 windstorm event that damaged nearly 200,000 ha of forest land in northern Minnesota wanted to know what lessons had been learned from responding to such natural disasters as the eruption of Mount Saint Helens, Hurricane Hugo, and a New England ice storm that damaged large areas of forest land (Williams and Lime 2001). Understanding how a community is affected and how it responds as a social system to catastrophic environmental change provides theoretical, substantive, and methodological insights that can be used to organize and prepare social institutions for a more effective response to environmental changes likely to occur in the future.

Overarching research questions linger. By what criteria are fire decisions measured? How do we assess the costs of preparedness versus the losses incurred? How are the lessons from ongoing investigations bounded in space and time across the range of potentially affected communities? How do we measure the consequences of fire decisions and integrate these consequences at multiple scales? For example, the loss of a home is mentally stressing, but mental health services usually are a community-level responsibility. How does a community organize during the pre-event period for such services, when there may be a low probability of their need?

Like other lessons from the intersection of social and natural sciences, actions aimed at one purpose (e.g., fire exclusion) reverberate through social and ecological systems in unpredictable ways (e.g., increased fire risk in the long term). The framework presented in this discussion provides a relatively straightforward heuristic device for recognizing and observing the multiple interlinked actions and consequences associated with wildland fire. Even if actions result in unanticipated outcomes, factors that will need to be addressed in future events can be considered. The framework also provides an agenda for framing research questions, examining results, and identifying information gaps needing further study. If there can be greater systematic attention to both the conditions and processes that affect communities experiencing wildland fire, then these events that are bound to arise can be accommodated with less anxiety, expense, and uncertainty.

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